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Past and current status of sturgeons in the upper and middle Danube River

Karol Hensel[1] & Juraj Holčík[2]
[1] *Department of Zoology, Faculty of Natural Sciences, Comenius University, Mlynská dolina B-1, 842 15 Bratislava, Slovakia*
[2] *Department of Ichthyology, Institute of Zoology, Slovak Academy of Sciences, Dúbravská cesta 9, 842 06 Bratislava, Slovakia*

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Synopsis

Of the six species of sturgeons native to the Danube basin, five occurred in the upper and middle Danube. Among anadromous sturgeons were the large winter races of beluga, *Huso huso*, Russian sturgeon, *Acipenser gueldenstaedtii*, and stellate sturgeon, *A. stellatus*, which ascended the middle, and sometimes also the upper Danube, to spawn. Due to overfishing, followed by severe habitat alteration including damming and pollution, these anadromous sturgeons are critically endangered or extirpated from the upper and middle Danube. *Acipenser gueldenstaedtii* and *A. nudiventris* are represented only as resident non-migratory races with very small populations. The most abundant and widely distributed species is the sterlet, *A. ruthenus*, although it is presently limited to the middle Danube. Its population increased in some sections of the middle Danube during the past 15 years, presumably because of improving water quality, but this species remains at risk because of continuing habitat degradation.

Introduction

Six species of sturgeons historically occurred in the Danube River and some of its tributaries. The European Atlantic sturgeon, *Acipenser sturio*, was the rarest, and it only occasionally entered the Danube estuary. Beluga, *Huso huso* (Linnaeus, 1758), ship sturgeon, *A. nudiventris* Lovetski, 1828, stellate sturgeon, *A. stellatus* Pallas, 1771, Russian sturgeon, *A. gueldenstaedtii* Brandt, 1883, and sterlet, *A. ruthenus* (Linnaeus, 1758), however, were common to abundant (also see Bacalbaşa-Dobrovici 1997 this volume). Anadromous populations, especially winter races (= autumnal races of some authors; see Birstein & Bemis 1997 this volume, for discussion of this terminology) of beluga and Russian sturgeon, moved from the Black Sea into the Danube, ascending the middle and sometimes even the upper Danube and larger tributaries. Freshwater resident populations of some species of sturgeons also existed. Because sturgeons had such great economic importance, many historical records are available. However, overfishing and habitat alteration caused populations to collapse (Rochard et al. 1990, Birstein 1993). In particular, construction of the Đerdap I Dam (= Iron Gates Dam I) at the village of Sip (Iron Gate, river kilometer 942) in 1969 and later construction of the Đerdap II Dam (= Iron Gates Dam II) at Kusjak (river km 863) in 1984 blocked further upstream migration of anadromous sturgeons, and most species are now extirpated from the middle and upper Danube.

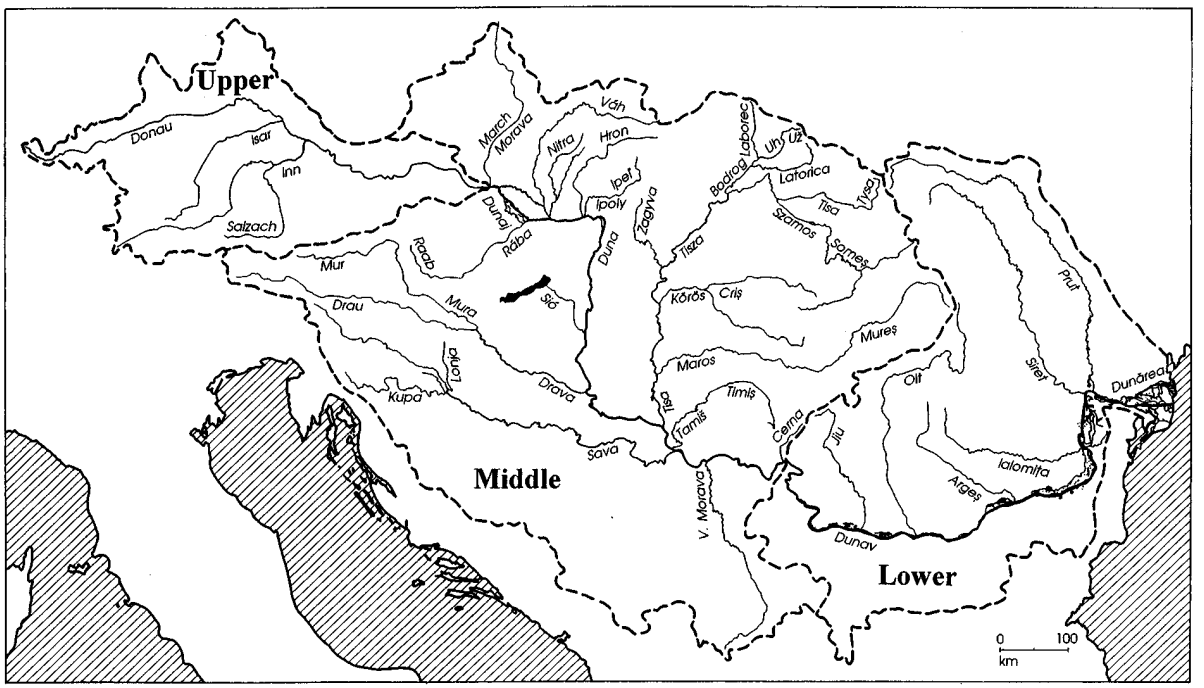

Figure 1. The Danube River basin showing rivers inhabitated by sturgeons (Acipenseridae). Original figure by K. Hensel.

Geographically the Danube is divided into three parts (Figure 1). The lower Danube (shared by Ukraine, Moldova, Romania, Bulgaria and Serbia) extends from the estuary up to the mouth of the Cerna River (river km 955) in the Iron Gates region. The middle Danube (shared by Romania, Serbia, Croatia, Hungary and Slovakia) runs from the Cerna up to the mouth of the Morava River (river km 1880), and the upper Danube flows through Austria and Germany (Balon et al. 1986).

This paper summarizes the history and status of five species of sturgeons in the middle and upper Danube. We report sizes as total length (TL, the distance between the anterior tip of the rostrum and the tip of the caudal fin) and weight (BW, total body weight). Data on catches of particular species are from proceedings of the JCIAFD.[1,2] We report locations of capture at either towns or particular river kilometers from the mouth.

[1] Joint Commission of the International Agreement on Fishing in the Danube River.

Huso huso – beluga or great sturgeon

Vernal races (= spring races of some authors; see Birstein & Bemis 1997 this volume for terminology) and winter races of this anadromous species annually ascended the Danube River in large numbers (Figure 2). Although migrations of beluga continued year round, two peak periods were regularly observed, one for the winter and the second one for the spring strain. Upstream migration of the winter strain usually started in August and culminated in October or November. Migration of the spring strain lasted from January until April (Bănă-

[2] Anonymous. 1983. Appendix. pp. 207–229. *In:* Documents from the 24. session of the Joint Commission of the International Agreement on the Fishing in the Danube River between the governments of the Soviet Union, People Republic of Bulgaria, People Republic of Hungary, Socialistic Republic of Romania, Czechoslovak Socialistic Republic and Socialistic Federative Republic of Yugoslavia. Moscow (in Russian).

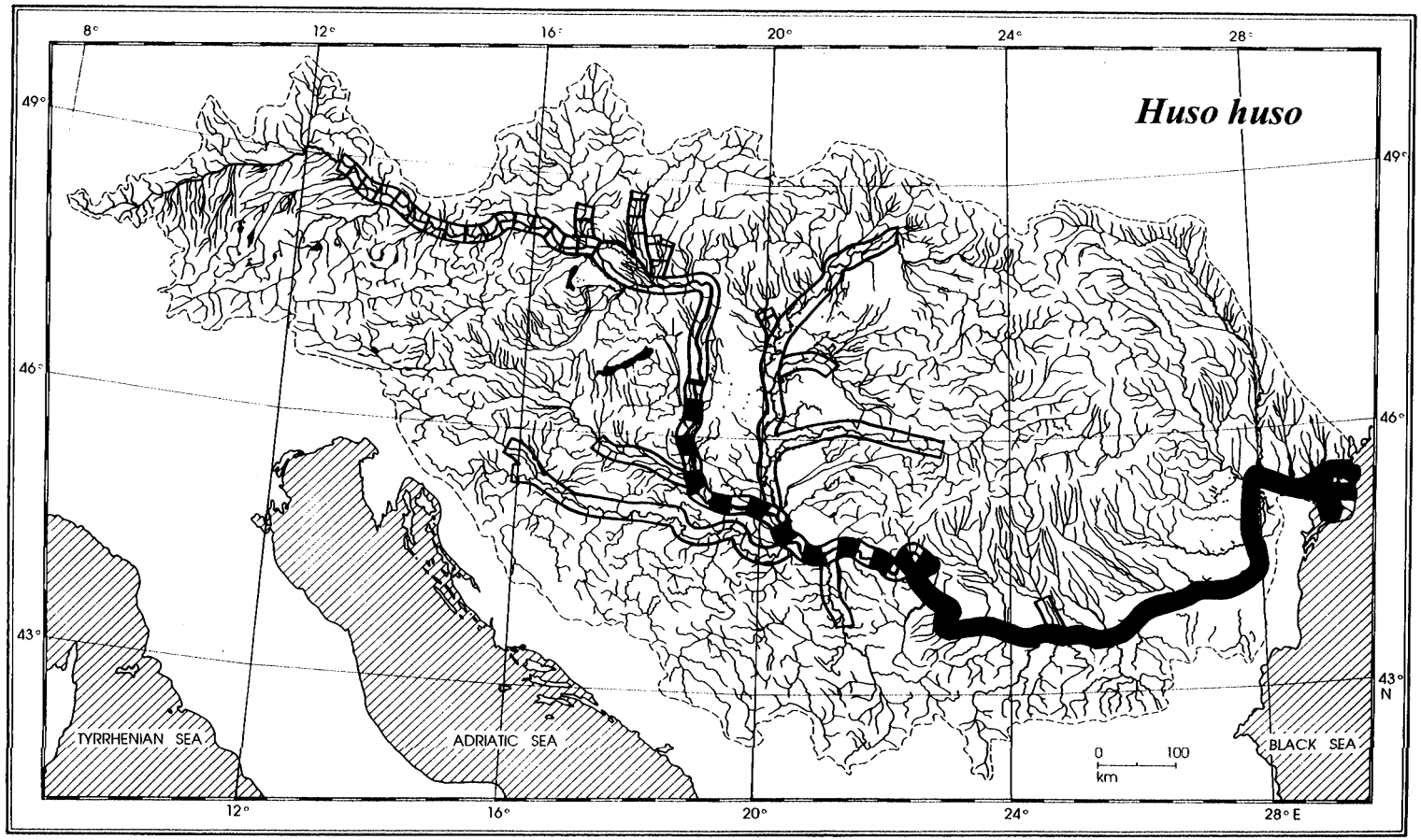

Figure 2. Distribution of the beluga, *Huso huso*, in the Danube drainage system. Regular (continuous black area) and occasional (black and white area) occurrence at present; regular (continuous white area) and occasional (striped white area) occurrence in the past. Original figure by K. Hensel.

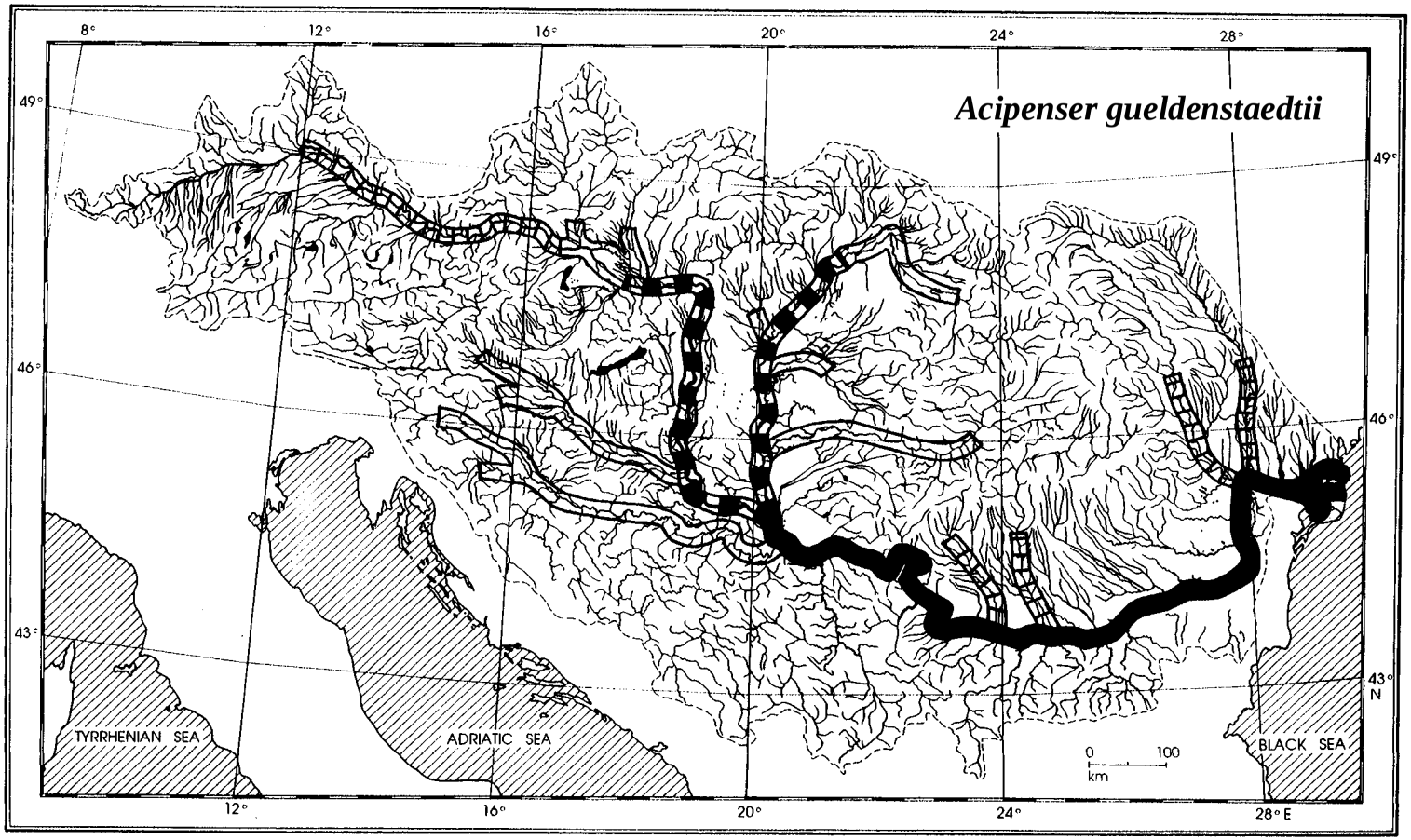

Figure 3. Distribution of the Russian sturgeon, *Acipenser gueldenstaedtii*, in the Danube drainage system. Regular (continuous black area) and occasional (black and white area) occurrence at present; regular (continuous white area) and occasional (striped white area) occurrence in the past. Information on distribution was compiled from Grossinger (1794), Fitzinger & Heckel (1835), Heckel & Kner (1858), Kornhuber (1863), Siebold (1863), Herman (1887), Ortvay (1902), Antipa (1909), Vutskits (1913), Munda (1926), Kähsbauer (1961), and Holčík (1995). Original figure by K. Hensel.

rescu 1964, Manea 1966, Kirilyuk & Rovnin[3]). The winter strain overwintered in the river and spawned in the following spring. Winter beluga ascended up to Bratislava (= Presburg, Preßburg or Pozsony, see Gesner 1575), rarely also entered the Austrian part of the Danube (Fitzinger & Heckel 1835) and occasionally even the Bavarian stretch up to Straubing (river km 2320; Siebold 1863). The main spawning grounds of beluga were located in the contemporary Slovak – Hungarian stretch of the river in the Žitný Ostrov reach below Bratislava (river km 1766–1866). The major fishery for beluga was concentrated in the Little Danube (which is the northern branch of the Danube River) near the mouth of the Váh River at the village of Kolárovo, see Figure 1) and in the Danube proper between Komárno and Sap (= Palkovičovo, see Balon 1967).

Beluga also entered other tributaries of the Danube, including the lower course of the Morava (= March) River (Jeitteles 1864), where a 2 m TL specimen was caught at Lanžhot (Zbořil & Absolon 1916). In the Váh River, beluga ascended up to Trnovec nad Váhom (Herman 1887) and exceptionally even up to Trenčín (Kornhuber 1861). Beluga also occurred in the Žitava River up to Nesvady (Holčík 1995), the Drava (= Drau) River (Taler 1953), the Tisa (= Tisza or Tysal) River (Heckel & Kner 1858) up to Trakany (Anonymous 1975) and its tributaries the Zagyva River, Körös (= Criş) River (Vutskits 1913) and Maros (= Mureş) River (Heckel & Kner 1858) where it occurred even at Hunedoara (Bănărescu 1964). In the Sava River, beluga were recorded at Zagreb (Glowacki 1896) and also in the Sava River's tributary, the Kupa River (Taler 1953). Beluga also entered the lower course of the Velika Morava River (Vutskits 1913) and the Olt River (Heckel & Kner 1858).

Beluga was among the most abundant of Danubian anadromous fishes, and it was the most valuable. Due to overfishing of brood fish during spawning migrations (Heckel 1851, Heckel & Kner 1858), catches of beluga started to decline after the 16th century (Balon 1967, 1968). Beluga were taken by means of special nets and particular hooks, called 'samolov'; however, the most effective method was the catching weir (Rohan-Csermák 1963). Because most of the fish migrating to spawn for the first time

[3] Kirilyuk, M.M. & A.A. Rovnin. 1983. The status of the brood stock, age structure and breeding conditions of sturgeons in 1981. pp. 28–36. *In:* Materials of the 24th Session of the joint Commission of the International Agreement on the Fishing in the Danube River between the Governments of the Soviet Union, Peoples Republic of Bulgaria, Peoples Republic of Hungary, Socialistic Republic of Romania, Czechoslovak Socialistic Republic and Socialistic Federative Republic of Yugoslavia, Moscow (in Russian).

Table 1. Specimens of *Acipenser gueldenstaedtii* recorded in Slovak and Hungarian segment of the Danube River since 1900[1,2].

1932:	lower stretch of the Morava River between its confluence with the Danube and Suchohrad (a 35 km long segment); 7 kg BW, estimated TL 950 mm.
1949:	mouth of the Little Danube at Komárno; 20.4 kg BW, estimated TL 1118 mm.
1960:	confluence of the Little Danube with the Nitra River, TL 375 mm, estimated BW 0,4 kg.
1962:	Danube at Zlatná na Ostrove (river km 1779); TL 850 mm, 10.5 kg BW.
1964:	Danube at Vel'ké Kosihy (river km 1787); two specimens 10.2 and 10.6 kg BW, estimated TL 1072 and 1085 mm.
1965:	same locality as above (Gunda 1966, erroneously writes 'Danube at Malé Kosihy' however, the latter village is on the right bank of the Ipel'River, where this species was never found); 10.4 kg BW, estimated TL 1079 mm.
1967:	Danube at Radvaň nad Dunajom (river km 1749); 355 mm, estimated BW 331 g; this specimen seems to be an anadromous form, as its calculated TL (295 mm) is substantially higher than that of the resident form (190 mm according to Lukin 1937).
1968:	Danube at Radvaň nad Dunajom, 424 mm TL; this was a hybrid between *A. ruthenus* and *A. gueldenstaedtii* (Hensel 1969).
1970:	Danube at Paks (river km 1827); 400 mm TL, estimated BW 643 g.
1980:	Tisza River at Tiszafüred; estimated TL 852 mm, 5 kg BW.

[1] Sturgeons caught in the Danube at Štúrovo in 1937 and 1957, BW 12 and 18 kg, respectively, where *A. guendelstaedtii* and not *H. huso* as said by Kux & Weisz (1962) because *H. huso* only matures at BW > 20 kg (Chugunov & Chugunova 1964). Moreover, beluga of such low weight have never been caught in the middle Danube (Khin 1957).

[2] Lengths or weights calculated from the GM regression: $BW = 0.000003994 \times TL^{3.10452}$; where BW = weight in grams, and TL = total length in mm (Holčík 1995).

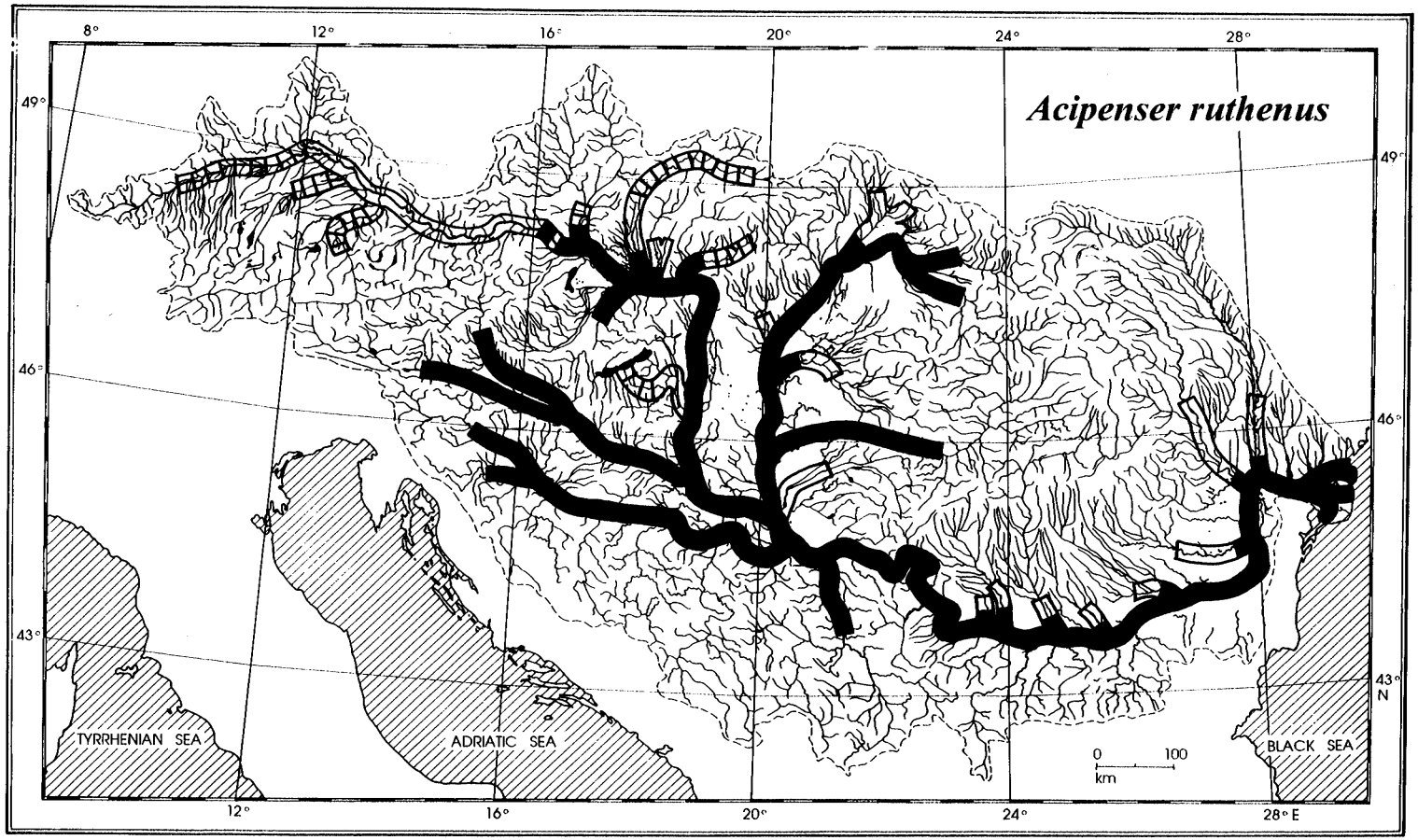

Figure 4. Distribution of the sterlet, *Acipenser ruthenus*, in the Danube drainage system. Regular (continuous black area) and occasional (black and white area) occurrence at present; regular (continuous white area) and occasional (striped white area) occurrence in the past. Information for this map was compiled from Grossinger (1754), Kornhuner (1861), Siebold (1863), Jeitteles (1864), Herman (1877), Moscáry (1877), Chyzer (1882), Malesevics (1892), Glowacki (1896), Antipa (1909), Vutskits (1913), Munda (1926), Mahen (1927), Vladykov (1931), Mihályi (1954), Kux (1956), Sedlár (1959, 1960, 1969), Žitňan (1963, 1965), Holčík (1968), Anonymous (1975), Sedlár et al. (1989), Sokolov & Vasil'ev (1989) and Holčík (1995). In the following list, towns or locations in parentheses give the farthest upriver record. Right hand tributaries include: the Isar River (Landshut), Inn River and its tributary Salzach River (Laufen), Sió River (Lake Balaton), Rába (= Raab) River, Drava River (Maribor), Mura River (Graz), Sava River (Sevnica) and its tributaries Kupa River (Karlovac) and Lonja River. Left hand tributaries include: the Morava River (Moravská Nová Ves), Váh River (Trenčín, exceptionally Liptovský Svätý Mikuláš) and its tributaries Nitra (Lándor) and Žitava rivers. Hron River (Kamenica and Hronom), Ipel' (= Ipoly) River, Tisa River (Sighetul Marmaţie) and its tributaries Bega River, Mureş River (Auid), Zagyva River and Bodrog River (Brehov) with tributaries Latorica River, Laborec River and Uh (= Už) River, Someş River (Dej), Tamiš (= Temes, Timiş) River. Original figure by K. Hensel.

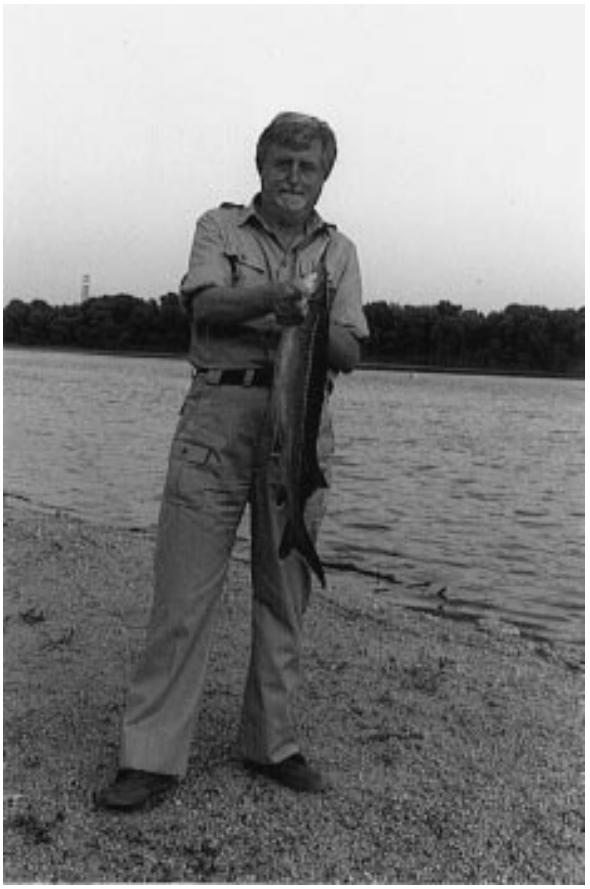

Figure 5. Unusually large specimen of *Acipenser ruthenus* captured among over 100 sterlets in one seine haul on 9.6. 1993 in the Danube River at Čenkov (river km 1730). Photograph by K. Hensel.

were caught, mortality surpassed recruitment. Beluga has a long life span and late sexual maturation (Pirogovskii et al. 1989), and the Danube population began to decrease rapidly (Rohan-Csermák 1963). Weir fishing disappeared from the middle Danube at the end of the sixteenth and from the Tisa River at the end of the seventeenth century, but Serbian fishermen employed it up to World War I at the Iron Gate, near the village of Sip. In the 17th and 18th centuries the last remnants of the beluga populations were so severely undermined that in the 19th century only a few beluga were caught in the foothills and in the lower Danube. The last beluga recorded in the Slovakian – Hungarian stretch of the Danube was a female, 3.1 m TL and 150 kg BW, taken at Štúrovo in 1925 (Khin 1957). According to Kornhuber (1901), Ortvay (1902) and Khin (1957), only 16 beluga were taken in this segment of the Danube between 1857 and 1957, of BW between 78 to 500 kg, and TL estimated to range from 2.2–7.4 m.[4] Beluga lose weight after the 1700 km migration up the Danube, as do other anadromous fishes (Nikol'skii 1974).

Construction of the Đerdap Dams (= Iron Gates Dams) greatly impacted the remaining beluga. Janković (1993) reported that catches of beluga and Russian sturgeons (separate data sets for the two species are not available) peaked during the five year period after construction of Iron Gates Dam I. In the period from 1972 to 1976, catches amounted to 115.7 metric tons, which is 23.1 tons higher than in the five years before construction of the dam. The higher catch was due to mass gathering of individuals below the dam, which allowed intensive fishing (see Wei et al. 1997 this volume for similar impact of construction of Gezhouba Dam on Yangtze River sturgeons). However, by a later five year period (1980 to 1984), the combined catch decreased to 78.2 tons. In the period from 1985 to 1989, the five years following construction of the Iron Gates Dam II, the combined catch dropped to 37.3 tons. Beluga only exceptionally overcome the dams via shiplocks: a male 3 m in TL weighing 181 kg was caught in Hungary at Paks (river km 1526–1528) on 16 May 1987, and this individual must have negotiated the locks at both dams (Pintér 1989).

According to the JCIAFD, the annual catch of beluga in the Danube between 1958 and 1981 varied from 19.7 to 240.4 tons, with a decrease in the last four years of the period. Most fish were taken by Romania (59.1%) and the former Soviet Union (30.7%) and the remainder were shared by Bulgaria and former Yugoslavia. Beluga is now extirpated from the upper Danube, critically endangered in the middle Danube and vulnerable in the lower Danube.

[4] The TL of these fish was estimated by Holčík (1994) using data from 9 specimens recorded by Khin (1957) to calculate a length-weight regression: BW = – 101975.47 + 81.69821 TL (BW in grams TL in mm). This regression differs from that for beluga in the Sea of Azov calculated by Chugunov & Chugunova (1964; BW = – 4.41087 + 2.78706 log TL).

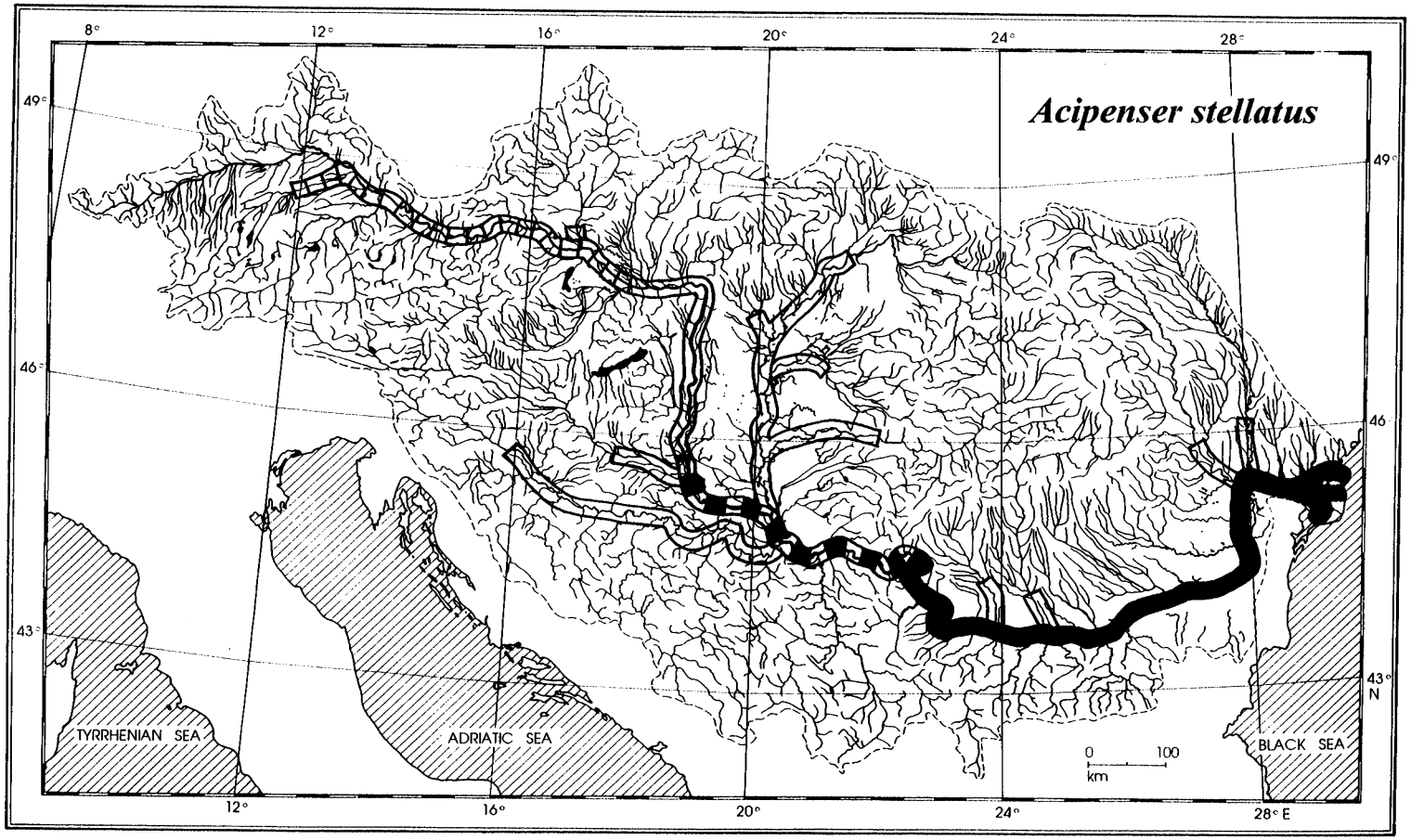

Figure 6. Distribution of the stellate sturgeon, *Acipenser stellatus*, in the Danube drainage system. Regular (continuous black area) and occasional (black and white area) occurrence at present; regular (continuous white area) and occasional (striped white area) occurrence in the past. Original figure by K. Hensel.

Acipenser gueldenstaedtii – Russian sturgeon

This is the largest Danubian species of the genus *Acipenser*, and was the most widely distributed anadromous species in the Danube River (Figure 3). According to Kornhuber (1863), Bănărescu (1964) and Manea (1966), the largest specimens reached 2–4 m in TL, with estimated BW of 70–600 kg. Anadromous Russian sturgeons weighing 60–90 kg regularly migrated upstream to Bratislava (river km 1869) and spawned in this section of the middle Danube in May and June. They rarely reached Vienna (river km 1925) and Regensburg (river km 2381).

In northern, or 'left bank' tributaries of the middle Danube, Russian sturgeons occurred in the Morava River (at Suchohrad), Váh River, Tisza River (up to Versényi) and its tributaries, the Szamos (= Someş) River, Zagyva River, Körös River, and the Mureş River (up to Mihalţ). It occasionally entered the tributaries of the lower Danube, including the Olt River, the Jiu River (up to Transylvania), the Prut River, and the Siret River. It occurred in southern, or 'right bank' tributaries of the Danube including the Drava River (and its tributary the Mura (= Mur) River, via which Russian sturgeon reached as far inland as Austria) and the Sava River up to Litija (as well as its tributary the Kupa River, up to Karlovac).

In the Volga River of Russia, *A. guendelstaedtii* occurred as both resident, non-migratory form and an anadromous migratory form (Lukin 1937). Heckel & Kner (1858) first noted that Russian sturgeon also occur in the Danube throughout the year, and the resident non-migratory form still occurs both in the lower (Manea 1966) and middle Danube (Sedlár 1960, Sedlár et al. 1989, Gunda 1966, Balon 1968a, Hensel 1969, Hárka 1980, and Holčík 1995). Table 1 lists all specimens of *A. gueldenstaedtii* recorded in the Slovak and Hungarian segment of the Danube River since 1900.

Holčík (1995) reported that until 1939, 10 to 15 Russian sturgeon weighing 2 to 3 kg were caught annually in the lower course of the Morava River. In the middle Danube, especially between river km 1749 and 1987, 3 to 4 specimens were caught annually until 1983. At present, this species is extremely rare in the middle Danube. In 1987 we learned that in the Danube near Bratislava one angler caught two large sturgeons, each about 1 m TL. Both specimens were released, but according to the description, these must have been *A. gueldenstaedtii*. Unverified records of Russian sturgeon exist also from the Hungarian stretch of the river (Pintér 1991).

According to the JCIAFD, annual catches from 1958 to 1981 varied from 7.1 to 42.3 metric tons (24.9 metric tons average). The greatest catch was recorded in Bulgaria (45% of the total) followed by former Yugoslavia (33.6%), former Soviet Union (13.1%) and Romania (8.3%). As already noted under the description of *H. huso*, the combined catch of beluga and Russian sturgeon dropped after construction of the dams at the Iron Gates (see Janković 1993). The Russian sturgeon is critically endangered in the Danube Basin.

Acipenser ruthenus – sterlet

The sterlet is the smallest species among Danube sturgeons. It is a potamodromous resident species. Tagging performed by Unger (1953) and Ristić (1970a) revealed maximum migration distances in the Danube of 322 km. In the Danube, sterlet regularly occurred up to Vienna, frequently to Linz, Passau and Regensburg, and even up to Ulm (Figure 4; Fitzinger & Heckel 1835, Heckel & Kner 1858, Siebold 1863). It was very abundant in the Danube near Bratislava (Kornhuber 1863, Ortvay 1902). According to Kinzelbach (1994), the large sterlet population in the upper Danube between Regensburg and Passau was autochthonous and not the result of migration as generally been thought. Sterlet also ascended or occurred in some of the Danube's tributaries (Figure 4).

Sterlet now has a very limited distribution in the middle and upper Danube. The species is extirpated from the German section of the Danube (Reichenbach-Klinke 1968, Balon et al. 1986), endangered in the Austrian section (Jungwirth 1975, Schiemer & Spindler 1989), and greatly diminished in the Slovakian section. Between 1962 and 1978, sterlet generally contracted in the Slovakian section to the 82 km stretch from Štúrovo to Číčov (Balon 1964, 1968b), and only occasionally was it found at Gab-

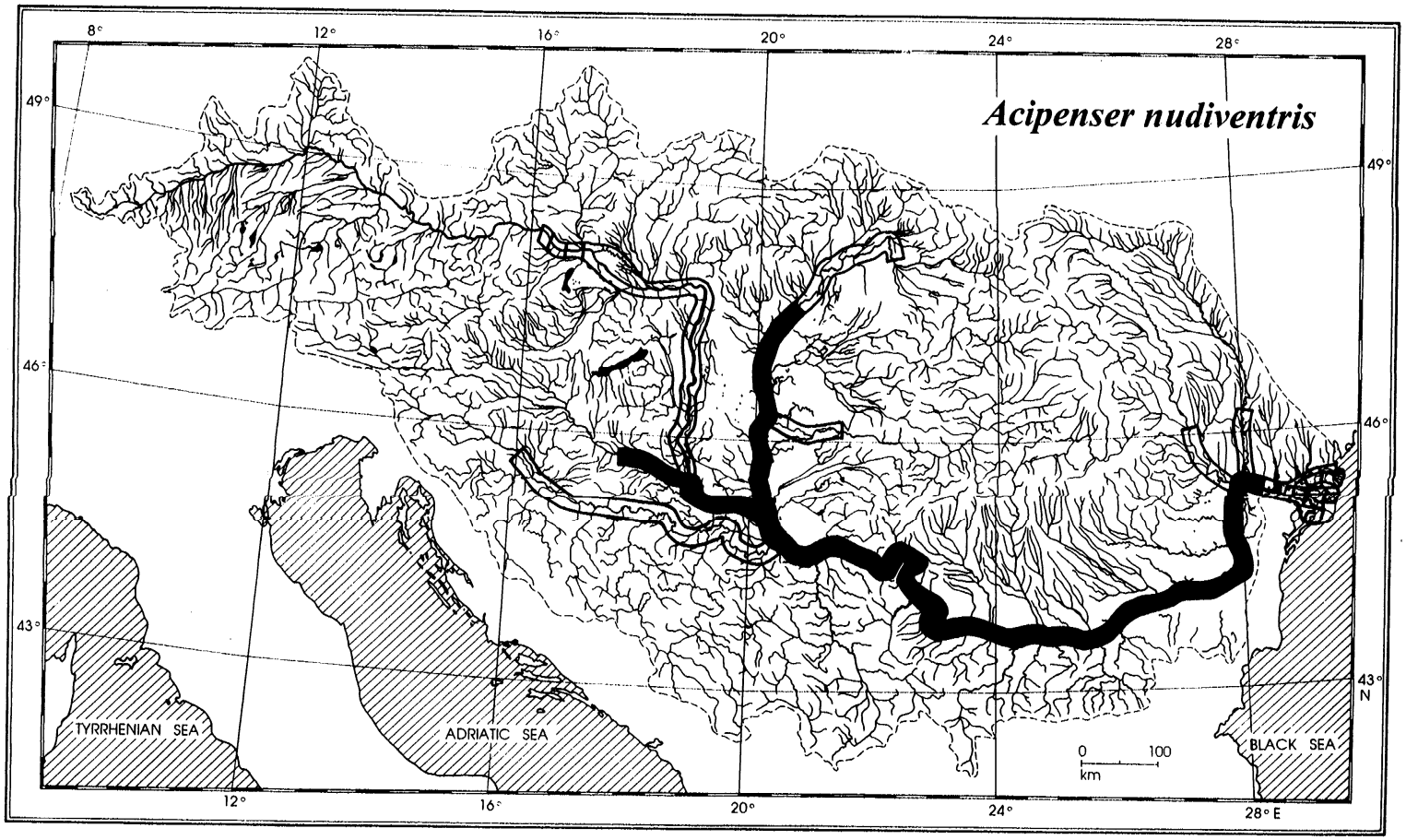

Figure 7. Distribution of the ship sturgeon, *Acipenser nudiventris*, in the Danube drainage system. Regular (continuous black area) and occasional (black and white area) occurrence at present; regular (continuous white area) and occasional (striped white area) occurrence in the past. Original figure by K. Hensel.

čikovo (Holčík et al. 1981). It disappeared from the Hron River (Sedlár et al. 1983), and now occurs only in the mouth of the Váh River. It also disappeared from the lower course of the Morava River sometime after 1966 (Holčík 1995). However, since 1975, water quality has improved and sterlet began to reappear above river km 1820 (Gabčíkovo, Slovakia). It is again found at Bratislava and in the lower course of the Morava, where 2 to 3 specimens have been caught annually by commercial fishermen since 1980 (Holčík 1995). Catches of sterlet are highest between river km 1749 and 1762 (Radvaň nad Dunajom – Iža), at Zlatná na Ostrove (river km 1778–709), at Vel'ké Kosihy (river km 1786–1789) and lowest at Čenkov (river km 1732–1733; but see Balon 1995a, b, figure 5) and Štúrovo (river km 1717). Population increases were presumably due to increasing water quality (Sedlár 1985, Sedlár et al. 1989) and stocking of juveniles from the Hungarian side of the Danube (Jaczó 1974, Tóth[5, 6, 7]). At the beginning of the 1980s, as many as 300 specimens of sterlet were caught by Slovak fishermen in one haul of a 300 m beach seine. Increases in sterlet catch in the Hungarian part of the Danube started in 1971 (Toth[8]), presumably caused by its emigration from the Tisza River where upstream migrations to spawning grounds were halted by dams. In the Serbian stretch of the Danube, the most abundant population of sterlet occurs near Belgrade and in the upstream section near Vojvodina, as well as in the lower (Serbian) parts of the Sava and Tisa rivers (Janković 1993). In the Slovak – Hungarian stretch of the Tisza River, the sterlet does not migrate (Holčík 1995). Its continuing presence was also recorded in the Rába River (Sokolov & Vasi'lev 1989), the Drava River (up to Carinthia, Honsig-Erlenburg & Schultz 1989), the Sava River (up to Sevnica), the Mura River (up to Mursko Središće) and the Kupa (= Kolpa) River up to Krasinec (see Povž & Sket 1990).

Annual catches of sterlet in the Danube between 1958 and 1981 varied between 36–117 metric tons (average 63.5 metric tons). The highest catches were former Yugoslavia (57.5%), followed by Bulgaria (28.0%), Romania (10.5%), Hungary (3.5%) and former Czechoslovakia (0.5%). The catch in the former USSR was so low that the JCIAFD did not record it. The Đerdap Dams are blamed for decreasing the catch of sterlet by 50% (Janković 1993). Ongoing construction activities of the Gabčíkovo hydropower station further threaten sterlet in the uppermost part of the middle Danube and the lower course of the Morava River. Tagging performed by the second author between 1992 and 1994 revealed that the barrages constructed at Čuňovo (river km 1840) and Gabčíkovo (river km 1820) are insurmountable obstacles for the upstream migration of any fishes, including sterlet.

Acipenser stellatus – stellate sturgeon

The stellate sturgeon was always rare in the middle

[5] Tóth, J. 1978. Information of the Hungarian part. pp. 278–287. *In:* Materials of the 19th Session of the Joint Commission of the International Agreement on the Fishing in the Danube River between the Governments of the Soviet Union, Peoples Republic of Bulgaria, Peoples Republic of Hungary, Socialistic Republic of Romania, Czechoslovak Socialistic Republic and Socialistic Federative Republic of Yugoslavia, Moscow (in Russian).

[6] Tóth, J. 1979. Information of the Hungarian part. pp. 125–150. *In:* Materials of the 19th Session of the Joint Commission of the International Agreement on the Fishing in the Danube River between the Governments of the Soviet Union, Peoples Republic of Bulgaria, Peoples Republic of Hungary, Socialistic Republic of Romania, Czechoslovak Socialistic Republic and Socialistic Federative Republic of Yugoslavia, Moscow (in Russian).

[7] Tóth, J. 1980. A Magyar fél tájekoztatója (Information of the Hungarian part). pp. 129–147. *In:* Materiály z 22. zasadania Zmiešanej komisie pre uplatňovanie dohody o rybolove vo vodách Dunaja, Bratislava.

[8] Tóth, J. 1979b. Catch results changes of the sterlet (*Acipenser ruthenus* L.) in the Hungarian Danube. pp. 151–157. *In:* Materials of the 19th Session of the Joint Commission of the International Agreement on the Fishing in the Danube River between the Governments of the Soviet Union, Peoples Republic of Bulgaria, Peoples Republic of Hungary, Socialistic Republic of Romania, Czechoslovak Socialistic Republic and Socialistic Federative Republic of Yugoslavia, Moscow (in Russian).

Danube (Figure 6). It ascended upstream to Komárno (Grossinger 1794, Fitzinger & Heckel 1835, Kornhuber 1901), Bratislava (Kornhuber 1863, Orvay 1902), the Austrian part of the Danube (Fitzinger & Heckel 1835), and occasionally even reached the Bavarian stretch near Straubing (Gesner 1575) and the Isar River (Siebold 1863). During spawning migrations, stellate sturgeon entered tributaries of the lower Danube, such as the Prut, Siret, Olt and Jiul rivers (Antipa 1909); it was encountered also in some tributaries of the middle Danube, such as the Tisza River up to Tokaj (Heckel & Kner 1858) and in the lower courses of its tributaries the Maros and Körös rivers, in the mouth of the Zagyva River (Herman 1887) and in the lower course of the Drava and Sava rivers (Heckel & Kner 1858, Glowacki 1896, Vutskits 1913). Mahen (1927) mentioned stellate sturgeon from the mouth of the Morava River. However, this seems doubtful, as it has only rarely been recorded in the adjacent stretch of the Danube.

We consider *A. stellatus* to be extirpated not only from the upper Danube but also from the upper stretch of the middle Danube (the Slovakian and Hungarian section). The last known specimen from this section was caught at Komárno on 20 February 1926. The head of this specimen, measuring 325 mm, is at the Slovak National Museum in Bratislava (Holčík 1959), and is estimated to be from a specimen 1282 mm TL and 9.8 kg BW (Holčík 1995). The last stellate sturgeon in Hungary (100 cm TL) was caught in the Danube at Mohács in 1965 (Pintér 1991).

Construction of the Iron Gates dams blocked most migration of stellate sturgeon to the middle Danube, as few individuals succeed in passing through the shipping locks (Djisalov[9]). Janković (1993) analyzed catch of stellate sturgeon in the Serbian section of the Danube: from 1967–1970, the annual catch was around 1.4–2.0 tons but, in 1971, when the first dam was finished, the catch dropped to 184 kg. During the next 8 years this species was not recorded in the catch, except in 1975 when 284 kg was caught. In 1980, a catch of 80 kg was reported, but after construction of Iron Gates Dam II, the stellate sturgeon disappeared from the middle Danube catch. At present stellate sturgeon is only seldom taken, with an estimated annual catch < 100 kg. This species was never economically significant in the middle Danube, with a mean annual catch of only 7.8 tons in 1958–1981. Of this, 34.2% was shared by Bulgaria, 22.7% by the former USSR, 22.5% by former Yugoslavia and 20.6% by Romania (data from JCIAFD).

[9] Djisalov, N. 1983. Analysis of the migratory sturgeon fishery in the Yugoslavian part of the Danube in 1981. pp. 150–157. *In:* Materials of the 24th Session of the joint Commission of the International Agreement on the Fishing in the Danube River between the Governments of the Soviet Union, Peoples Republic of Bulgaria, Peoples Republic of Hungary, Socialistic Republic of Romania, Czechoslovak Socialistic Republic and Socialistic Federative Republic of Yugoslavia. Moscow (in Russian).

Acipenser nudiventris – ship sturgeon

The ship sturgeon forms both anadromous and resident populations, but in the Danube River, only the resident strain occurred (Bănărescu 1964, Manea 1966). This species was recorded in the lower Danube (occasionally in the Danube delta) and in the middle Danube, upstream to Bratislava (Figure 7, Kornhuber 1863). Only exceptionnally did it migrate to the Austrian segment of the river (Fitzginger & Heckel 1835). Ship sturgeon also occurred in some tributaries: the lower course of the Váh River (Heckel & Kner 1858, Herman 1887), the Tisza River at Mándok (Mihályi 1954), the Sava and Drava rivers (Heckel & Kner 1858, Vutskits 1913, Munda 1926), the Maros River (Hankó 1931), and also from two tributaries of the lower Danube, the Prut and Siret rivers (Bănărescu 1964).

Ship sturgeon was never abundant in the lower Danube (Manea 1970), although, as Pintér (1991) noted, it is difficult to verify this based on historical documents, particularly because fishermen did not always distinguish larger ship sturgeon from Russian sturgeon, and small ship sturgeon were confused with sterlet. The ship sturgeon is now very rare in the Danube, and only occasionally found in the catch of Romania and Serbia (Manea 1970, Bacalbaşa-Dobrovici 1991, Stamenković 1991, Janković 1993). Ship sturgeon completely disappeared from the Austrian and Slovak segment of the Da-

nube, and in the Hungarian section it is extremely rare. The largest specimen recorded (170 cm TL and 32 kg BW) was taken at Ercs in 1932 (Pintér 1989).

From tributaries of the middle Danube, ship sturgeon is known only from the Tisza and Drava rivers. Vásárhely (1957) reported many juveniles of ship sturgeon from the upper segment of the Tisza River at the Tiszalök Dam and suggested that adults are rare. Pintér (1991) recorded one specimen caught in August 1975 (about 70 cm in TL) in the Tisza River near Kiskör and other two specimens taken in the Tisza River at Tiszalök (however, their identification is questionable). From the Drava River one male 147 cm in TL, 20.5 kg BW was taken at Heresznye in August 1989 (Pintér 1991, 1994). The ship sturgeon in the Danube River basin is critically endangered.

Conclusions

Anadromous populations of beluga, Russian sturgeon and stellate sturgeon, represented by winter races, were heavily damaged by overfishing during previous centuries, and were then completely eliminated from the middle and upper Danube by construction of Đerdap I and Đerdap II dams (Iron Gates Dams I and II). Small stocks of the resident races of ship and Russian sturgeons occur in the middle Danube and some of its tributaries. The most abundant sturgeon in the Danube is the sterlet, but this species also experienced population declines. It disappeared from almost all of the upper Danube, where single specimens are now found only in its Austrian part. At present the sterlet is limited to the middle Danube and to lower courses of some tributaries.

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References cited

Anonymous [Speer, D.]. 1975. Uhorský Simplicissimus (Hungarian Simplicissimus). According to the Latin edition from 1683 translated by J. Vlachovič. Tatran, Bratislava 231 pp.

Antipa, G. 1909. Fauna ihtiologică a României (Fish fauna of Romania). Publ. fond. Adamachi, Bucureşti. 294 pp.

Bacalbaşa-Dobrovici, N. 1991. Status des differentes espèces d'esturgeon dans le Danube Roumain: problèmes lies a leur maintenance. pp. 185–192. *In:* P. Willot (ed.) *Acipenser,* Actes du premier colloque international sur l'esturgeon, Bordeaux 3–6 Octobre 1989, CEMAGREF, Bordeaux.

Bacalbaşa-Dobrovici, N. 1997. Endangered migratory sturgeons of the lower Danube River and its delta. Env. Biol. Fish. (this volume).

Balon, E.K. 1964. Predbežný zoznam kruhoústych a rýb Slovenska (Petromyzones et Teleostomi) (Preliminary list of lampreys and fishes of Slovakia (Petromyzones et Teleostomi). Biológia (Bratislava) 19: 343–358.

Balon, E.K. 1967. Vývoj ichtyofauny Dunaja, jej súčasný stav a pokus o prognózu d'alších zmien po výstavbe vodných diel (Development of the fish fauna of the Danube river, its present status, and an attempt for the prediction of further changes after the construction water works). Biologické práce 15: 5–121.

Balon, E.K. 1968a. Ďalší nález mlade *Acipenser güldenstädti colchicus* Marti, 1940 v československom úseku Dunaja (Further findings of the *Acipenser güldenstädti colchicus* Marti, 1940 in the Czechoslovak stretch of the Danube River). Acta Rer. Natur. Mus. Nat. Slovacae, Bratislava 14: 95–100.

Balon, E.K. 1968b. Ichtyofauna pozdl'žneho a priečneho profilu československého úseku Dunaja, druhové a početné zmeny rybích populácii a ich ochrana (Fishfauna of the longitudinal and cross profile of the Czechoslovak stretch of the Danube River, specific and density changes of the fish populations and their conservation). Československá ochrana prirody 1968: 203–229.

Balon, E.K. 1968c. Einfluß des Fischfangs aud die Fischgemeinschaften der Donau. Arch. Hydrobiol. (Suppl. Donauforschung 3) 34: 228–249.

Balon, E.K. 1995a. Origin and domestication of the wild carp, *Cyprinus carpio*: from Roman gourmets to the swimming flowers. Aquaculture 129: 3–48.

Balon, E.K. 1995b. The common carp, *Cyprinus carpio*: its wild origin, domestication in aquaculture, and selection as colored nishikigoi. Guelph Ichthyology Reviews 3: 1–55.

Balon, E.K., S.S. Crawford & A. Lelek. 1986. Fish communities

of the upper Danube (Germany, Austria) prior to the new Rhein-Main-Donau connection. Env. Biol. Fish. 15: 243–271.

Bănărescu, P. 1964. Pisces – Osteichthyes. Fauna Republicii Populare Romîne, Vol. 13. Editura Acad. Republicii Populare Romîne, Bucureşti. 962 pp.

Birstein, V.J. 1993. Sturgeons and paddlefishes: threatened fishes in need of conservation. Cons. Biol. 7: 773–787.

Birstein, V.J. & W.E. Bemis. 1997. Leo Semenovich Berg and the biology of Acipenseriformes: a dedication. Env. Biol. Fish. (this volume).

Chugunov, N.L. & N.I. Chugunova. 1964. Comparative commercial and biological characteristics of the Azov Sea sturgeons. Trudy VNIRO 51: 87–182 (in Russian).

Chyzer, K. 1882. Die Fische des Zempliner Komitates. Jahrb. d. ungar. Karpaten Ver. 9: 1–16.

Fitzinger, L.J. & J. Heckel. 1835. Monographische Darstellung der Gattung *Acipenser*. Ann. Wiener Mus. Nat. 1: 269–326.

Gåßner, C. [= Gesner, K.] 1575. Fischbuch. Zůrych, Ch. Froschower. × + 403 pp.

Głowacki J. 1896. Die Fischfauna der Save und der Isonzo. I. Jahresbericht d. k.k. Staats-Untergymnasiums in Cilli, 1895–1896: 1–37.

Grossinger, J.B. 1794. Universa historia physica Regni Hungariae secundum tria regna naturae digesta. Regni animalis pars III. Ichthyologia, sive historia piscium, et amphibiorum. S.P. Weber, Posonii et Comaromii, xiv + 400 pp.

Gunda, M. 1966. Lov jesetera v Dunaji (Sturgeon fishing in the Danube). Československé rybářství 1966: 182.

Hankó, B. 1931. Ursprung und Verbreitung der Fischfauna Ungarns. Archiv. fúr Hydrobiologie 23: 520–556.

Hárka, Á. 1980. Vágótok a Tiszában (Russian sturgeon from the Tisza River). Halászat 26: 82.

Heckel, J. 1951. Über die in den Seen Oberösterreichs vorkommenden Fische. Sitzungsberichte math. – naturh. Cl. kaiser. Akad. Wiss. in Wien 6: 145–149.

Heckel, J. & R. Kner. 1858. Die Süsswasserfische der Österreichischen Monarchie. W. Engelmann, Leipzig. 388 pp.

Hensel, K. 1969. The first find of natural sturgeon hybrid *Acipenser ruthenus* Linnaeus, 1758 × *Acipenser güldenstädti colchicus* Marti, 1940. Věstník Československé společnosti zoologické 33: 328–330.

Herman, O. 1887. A Magyar halászat könyve (Book of the Hungarian fisheries), Vol. I & II. Természettudományi Társulat, Budapest. 860 pp.

Holčík, J. 1968. Nález jesetera malého (*Acipenser ruthenus* Linnaeus, 1758) vo Váhu pri Liptovskom Mikuláši (Finding of the sterlet in the Váh river at Liptovský Mikuláš). Acta Rer. Natur. Mus. Nat. Slovacae, Bratislava 14: 109–112.

Holčík, J. 1959. About the occurrence of the stellate sturgeon (*Acipenser stellatus* Pall. 1771) in the River Danube near Komárno. Acta Rer. Natur. Mus. Nat. Slovenici 5: 44–48.

Holčík, J. 1995. Acipenseriformes. pp. 372–397. *In:* V. Baruš & O. Oliva (ed.) Mihulovci Petromyzontes a ryby Osteichthyes (1). (Lampreys Petromyzontes and bony fishes Osteichthyes), Fauna ČR a SR, Vol. 28/1, Academia, Praha.

Holčík, J., I. Bastl, M. Ertl & M. Vranovský. 1981. Hydrobiology and ichthyology of the Czechoslovak Danube in relation to predicted changes after the construction of the Gabčíkovo – Nagymaros river basin barage system. Práce Laboratória rybárstva a hydrobiológie 3: 19–158.

Honsig-Erlenburg, W. & N. Schultz. 1989. The fishes of Carinthia. Verl. Naturwiss. Verein f. Kärnten, Klagenfurt.

Jaczó, I. 1974. A kecsege mennyiségének változása folyóink-ban az 1947–1970. évi fogások és vizsgálatok alapján (Changes in the sterlet stocks in Hungarian rivers between 1947–1970 based on the investigations and catch statistics data). Halászat 20: 12.

Janković, D. 1993. Populations of Acipenseridae prior and after the construction of the HEPS Đerdap I and II. Acta Biologica Iugoslavica, Seria E. Ichthyologia 25: 29–34.

Jeitteles, L.H. 1864. Die Fische der March bei Olmütz. II. Abtheilung pp. 4–26. *In:* Bericht über das k. k. Gymnasium in Olmütz während des Schuljahres 1864, Olmütz.

Jungwirth M. 1975. Die Fischerei in Niederösterreich. Wiss. Schrift. Niederösterreich 6: 1–31.

Kähsbauer, P. 1961. Cyclostomata, Teleostomi (Pisces). Catalogues Faunae Austriae, T. XXI aa. Springer Verlag, Wien 56 pp.

Khin, A. 1957. A Magyar vizák története (History of beluga sturgeon catches in Hungary). Mezögazadasági Múzeumi Füzetek 2: 124.

Kinzelbach, R. 1994. Ein weiterer alter Nachweis des Sterlets, *Acipenser ruthenus*, in der württembergischen Donau. pp. 281–291. *In:* R. Kinzelbach (ed.) Biologie der Donau, Limnologie aktuell 2, Gustav Fischer Verlag Stuttgart, Jena.

Kornhuber, G.A. 1861. Betrag zur Kenntnis der Fische in Waag Gebiet. Verhandlungen des Vereins für Naturkunde zu Presburg 5: 40–44.

Kornhuber, G.A. 1863. Bemerkungen über das Vorkommen der Fische um Presburg und an einigen anderen Orten Ungarns. Correspondezblatt der Vereins für Naturkunde zu Presburg 2: 205–213.

Kornhuber, A. 1901. Zoologische Bemerkungen, 2. Vom Scherg oder Sternhausen, *Acipenser stellatus* Pallas. Verhandlungen des Verereins für Natur- und Heilkunde zu Presburg, N.F. 12: 32–33.

Kux, Z. 1956. Příspěvek k ichthyofauně dolní Moravy a Dunaje (Contribution to the fish fauna of the lower reach of the Morava and the Danube rivers). Časopis Moravského musea, věd, přír. 41: 93–112.

Kux, Z. & T. Weisz. 1962. Ichtyofauna hlavního toku Dunaje a jeho některých přítoků v jihoslovenské nížině (Fish fauna of the main channel of the Danube and some of its tributaries in the south Slovakian lowland). Časopis Moravského musea, věd. přír. 47: 151–180.

Lukin, A.V. 1937. Biological analysis of the sturgeon catches in the middle course of the Volga River (Tartarian Republic). Izvestiya Akademii Nauk SSSR, Otdelenie matematicheskikh i estestvennykh nauk, seriya biologicheskaya 1: 211–220 (in Russian).

Mahen, J. 1927. Částečná revise ryb dunajské oblasti (Partial revision of the Danubian fish fauna). Sborník klubu přírodovědeckého v Brně 9: 56–69.

Malesevics, E. 1892. Loszoncz faunája (Fauna of the Losoncz (= Lučenec) region). Losoncz, Kárman – Társulat könyvnyomdája. 47 pp.

Manea, Gh. 1966. Contribuţii la studiul sturionilur din apele Romîîniei şi al reproducerii lor în legatura cu construcţiile hidroenergetice pe Dunarea inferioara. I. Une aspecte ale biologiei sturionilor (Contribution to the study on sturgeons in Rumanian waters and their reproduction in relation to the hydroenergetic construction in the Lower Danube. I. Aspects of the sturgeons biology). Bululetinul Institutului de Cercetări şi Proiectări Piscicole 25: 62–86.

Manea, G. 1970. Producţia şi reservele de sturioni de pe glob (Sturgeon world production and stocks). Buletinul de Cercetări Piscicole 29: 52–65.

Mihályi, F. 1954. Revision der Süsswasserfische von Ungarn und der angrenzenden Gebieten in der Sammlung der Ungarischen Naturwissenschaftlichen Museums. Annal. Hist.-Natur. Mus. Nat. Hungarici, Ser. nov. 5: 433–456.

Mocsáry, S. 1877. Adatok Zemplén és Ung megyék faunájahoz (Data on the fauna of the Zemplén and Ung counties). A magyar tud. Akad. 13: 131–185.

Munda, A. 1926. Ribe v Slovenskih vodah (Fishes in Slovenian waters). Izd. Slovensko Ribarsko Društvo v Ljubljani, Ljubljana. 63 pp.

Nikol'skii, G.V. 1974. Ecology of fishes, 3rd ed. Vysshaya shkola, Moscow. 365 pp. (in Russian).

Ortvay, T. 1902. Pozsonyvármegye és a területén fekvö Pozsony, Nagysyombat, Bazin, Modor s Szentgyörgy városok állatvilága (Animal world of Pozsony county and on its territory located cities, viz. Pozsony [= Bratislava], Nagyszombat [= Trnava], Basin [= Pezinok], Modor [= Modra], and Szentgyörgy [= Sväty Jur]). K. Stampfel, Pozsony, xvi + 448 pp.

Pintér, K. 1989. Magyarország halai, biológiájuk és hasznosításuk (Fishes of Hungary, their biology and management). Akademiai Kiadó, Budapest, 202 pp.

Pintér, K. 1991. Sturgeons in Hungary, past and present situation. pp. 173–178. *In:* P. Willot (ed.) *Acipenser*, Actes du premier colloque international sur l'esturgeon, Bordeaux 3–6 octobre 1989, *CEMAGREF*, Bordeaux.

Pintér, K. 1994. A tokalakúakkal (Acipenseriformes) foglalkozó magyar közlemények válogattot bibliográfiája (Selected bibliography of Hungarian papers on sturgeons (Acipenseriformes)). Halászat 87: 37–39.

Pirogovskii, M., L.I. Sokolov & V.P. Vasil'ev. 1989. *Huso huso* (Linnaeus, 1758). pp. 156–200. *In:* J. Holčík (ed.) The Freshwater Fishes of Europe, Vol. 1, pt. II, General Introduction to Fishes, Acipenseriformes, AULA-Verlag, Wiesbaden.

Povž, M. & B. Sket. 1990 Naše sladkovodne ribe (Our freshwater fishes). Mladinska knjiga, Ljubljana. 374 pp.

Reichenbach-Klinke, H. 1968. Fischfauna und Fischerei in der deutschen Donau. Archiv Hydrobiol., Suppl. 34 (Donauforschung): 12–23.

Ristić, M.D. 1970. Migracija riba u reci Dunav i njegovim pritokama, njen uticai na stanke i dinamiku populacija ekonomskih važnih riba kao i na ribolov (Fish migration in the Danube River and its tributaries, its influence on the status and population dynamics of the economically important fishes and on fisheries). Ribarstvo Jugoslavije 25: 1–15.

Rochard, E., G. Castelnaud & M. Lepage. 1990. Sturgeons (Pisces: Acipenseridae); treats and prospects. J. Fish Biology 37 (Suppl. A): 123–132.

Rohan-Csermák, G. de. 1963. Sturgeon hooks of Eurasia. Viking Fund Publications in Anthropology 35: i-xvi + 1–155.

Schiemer, F. & T. Spindler. 1989. Endangered fish species of the Danube River in Austria. Regulated Rivers 4: 397–407.

Schiemer, F. & H. Waidbacher. 1992. Strategies for conservation of a Danubian fish fauna. pp. 363–382. *In:* P.J. Boon, P. Calow & E. Petts (ed.) River Conservation and Management. John Wiley and Sons, New York.

Sedlár, J. 1959. Naše jeseterovité (Our sturgeons). Pol'ovníctvo a rybárstvo 11: 31.

Sedlár, J. 1960. Nález druhov *Acipenser ruthenus* Linneé 1758 a *Acipenser güldenstädti colchicus* Marti 1940 v Malom Dunaji (Finding of *Acipenser ruthenus* Linneé 1758 and *Acipenser güldenstädti colchicus* Marti 1940 in the Little Danube). Biológia (Bratislava) 15: 612–614.

Sedlár, J. 1969. Súčasný stav zarybnenia povodia rieky Nitry (Present status of the fish stock in the Nitra River). Biologické práce 15: 3–79.

Sedlár, J. 1985. Jeseter malý sa vracia (Sterlet is returning). Pol'ovnictvo a rybárstvo 37: 40.

Sedlár, J., A. Makara, I. Stráňai & J. Holčík. 1989. Atlas rýb (Fish atlas). Obzor, Bratislava. 372 pp.

Sedlár, J., I. Stráňai & A. Makara. 1983. Súčasný stav zarybnenia povodia Hrona. I. Druhové zloženie obsádky horskej a podhorskej zóny Hrona (Present status of fish stocks of the Hron River basin. I. Species composition of the stocks of the mountain and submountain zone of the Hron River). Pol'nohospodárstvo 29: 515–524.

Siebold, C.T.E. 1863. Süsswasserfische von Mitteleuropa. W. Engelmann, Leipzig. 430 pp.

Sokolov, L.I. & V.P. Vasil'ev. 1989. *Acipenser ruthenus* Linnaeus, 1758. pp. 227–262. *In:* J. Holčík (ed.) The Freshwater Fishes of Europe, Vol. 1, pt. II, General Introduction to Fishes, Acipenseriformes, AULA – Verlag, Wiesbaden.

Stamenković, S. 1991. Evolution des captures de trois espèces d'esturgeons *Huso huso, Acipenser gueldenstaedti* et *Acipenser stellatus* dans la partie Yougoslave du Danube. pp. 179–183. *In*: P. Willot (ed.) *Acipenser*, CEMAGREF, Bordeaux.

Taler, Z. 1953. Rasprostranjenje i popis slatkovodnih riba Yugoslavije (The distribution and description of the freshwater fishes of Yugoslavia). Glasnik Prirodnjačkog Muzeja Srpske Zemlje, ser. B 5/6: 425–455.

Unger, E. 1953. Die Fischmarkierung in den freien Gewässern Ungarns and die mit Gummiringen markierten Donau-Fische. Verh. Int. Ver. Limnol 7: 388–397.

Vásárhely, I. 1957. Felsö-Tiszai színtokok – és a tiszalöki vizlépsö (Ship sturgeon catches in the upper Tisza River and the Tiszalök water step). Halászat 50: 105.

Vladykov, V.D. 1931. Les Poissons de la Russie Souscarpathique (Tchécoslovaquie). Mém. Soc. Zool. France 29: 217–373.

Vutskits, G. 1913. Classis Pisces. Fauna Regni Hungariae. 1. Vertebrata Regia Soc. Sci. Natur. Hungarica, Budapest. 42 pp.
Wei, Q, F. Ke, J. Zhang, P. Zhuang, J. Luo, R. Zhou & W. Yang. 1997. Biology, fisheries, and conservation of sturgeons and paddlefish in China. Env. Biol. Fish. (this volume).
Zbořil, J. & K. Absolon. 1916. Zoologická pozorování z okolí hodonínského (Zoological observation from the Hodonín region). Časopis moravského musea zemského 15: 3–12.
Žitňan, R. 1963. Ryby rieky Hrona (Fishes of the Hron River). Pol'ovníctvo a rybárstvo 15: 16–17.
Žitňan, R. 1965. Ichtyofauna československého úseku Tisy (Fish fauna of the Czechoslovak reach of the Tisa River). Sbornik Východoslovenského múzea 6B: 61–67.