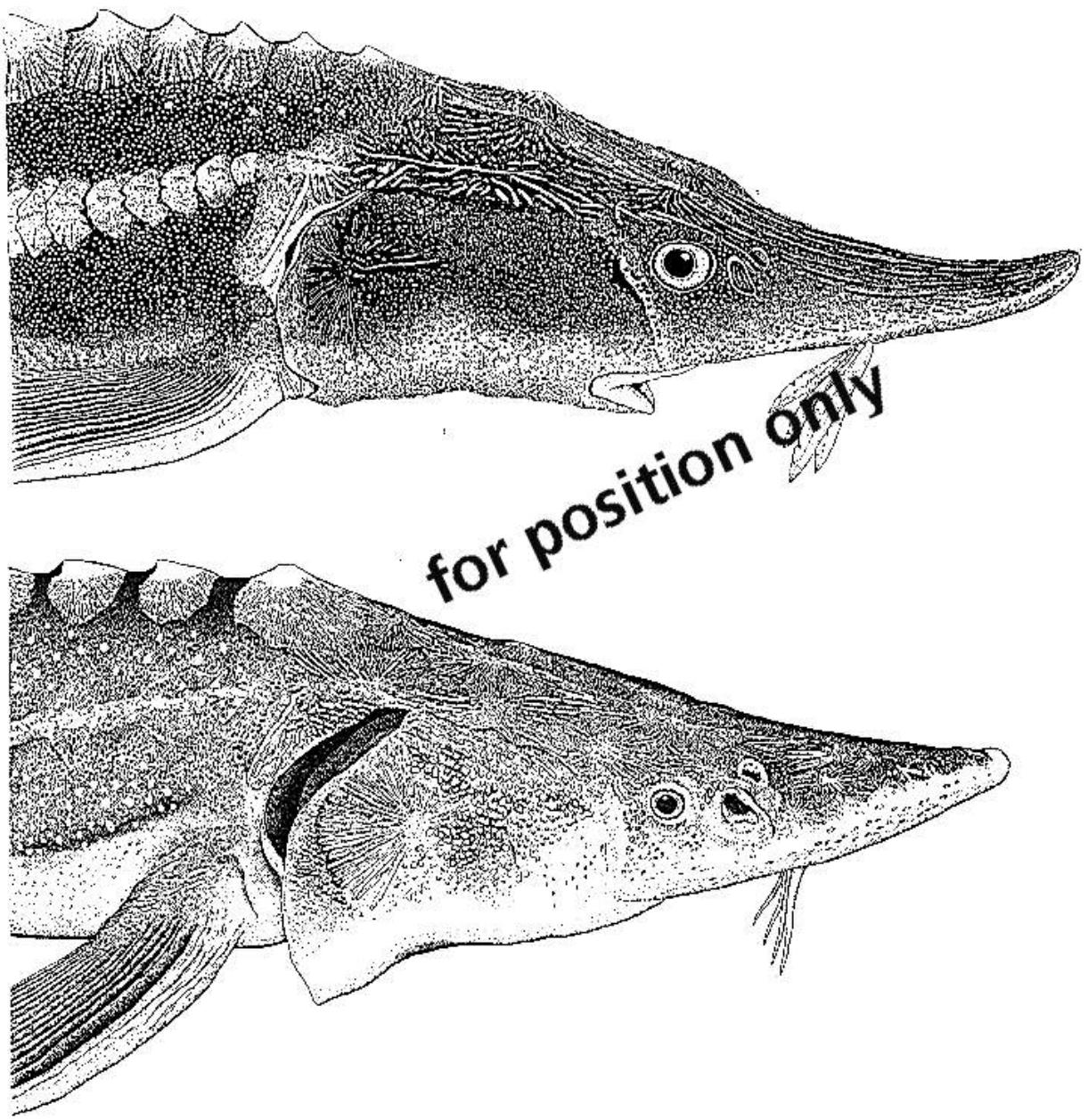

Portraits of a juvenile *Huso huso* 23 cm TL from the Ryal Ontario Museum collection (given originally as Caspian Sea fish to Montreal Expo 1967) above the head of *Acipenser schrenckii* 81 cm TL from the Amur River stock held at the Propa-Gen International, Komadi, Hungary. Originals by Paul Vecsei, 1996.

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How many species are there within the genus *Acipenser*?

Vadim J. Birstein[1] & William E. Bemis[2]
[1] *The Sturgeon Society, 331 West 57th Street, Suite 159, New York, NY 10019, U.S.A.*
[2] *Department of Biology and Graduate Program in Organismic and Evolutionary Biology, University of Massachusetts, Amherst, MA 01003, U.S.A.*

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In their paper in this volume Bemis et al. (1997) ask: 'How many valid species of *Acipenser* should we recognize?' Although a partial answer to this question is presented in their Table 5, we discovered in the course of preparing this volume that some additional commentary is needed. In fact, there are two questions: (1) how many species should be recognized? and (2) what scientific names should be used for some of the species? The sympatric distributions of most species of sturgeons set the stage for much confusion about species boundaries, but the situation is actually much more complicated. Confusion about the number of species of sturgeons living within the same basin can result from the often close morphological and meristic similarities of certain species of *Acipenser*, particularly during juvenile period. Moreover, we still have remarkably inadequate knowledge of the comparative anatomy of the species of *Acipenser*: no modern study has ever attempted a comprehensive examination of all species, and it is impossible to rely on literature for the sorts of comparisons that must be made (for more on this general problem, see Grande & Bemis 1991, 1997). Most classical descriptions and comparative anatomical studies relied upon small sample sizes. Voucher specimens of large sturgeons are especially rare in most historical collections, and type specimens (if available at all) are seldom prepared in ways that are suitable for making detailed anatomical comparisons (e.g., many skins are simply overstuffed with straw, so that all internal structures are lost). Intraspecific morphological and meristic polymorphisms occur in all species of acipenserids, and in most cases we have very poor knowledge of differences that develop during ontogeny, particularly changes in such features as the shape of the rostrum (Bemis et al. 1997). Another problem is the ease of hybridization between different species of sturgeons (reviewed in Birstein et al. 1997 this volume). In many of these cases, it is not easy to discriminate between parental species and the hybrids.

Two opposite tendencies appeared in the literature on the genus *Acipenser*. (1) Recognizably different species have been considered to be the same species. This situation is illustrated below by two species pairs, *A. gueldenstaedtii* and *A. persicus* and *A. medirostris* and *A. mikadoi*. (2) Some authors elevated many forms to the rank of species. For instance, Duméril (1870) described six subgenera of *Acipenser* with more than 30 species of *Acipenser* in five of them (he considered *Huso* as the sixth subgenus of *Acipenser*). Most of the species described by Duméril (1870) have long since been recognized as conspecific with other well-known species.

We still do not know the number of species of *Acipenser*, and may never know it because of overfishing and habitat destruction in Europe and Asia,

which have quickly eliminated sturgeons from certain river basins (see discussions in this volume by Bacalbaşa-Dobrovici 1997, Khodorevskaya et al. 1997, Krykhtin & Svirskii 1997, Wei et al. 1997). Therefore, we probably have already lost forever the opportunity to study some species of *Acipenser*. In the meantime, it is clear that genetic and molecular phylogenetic approaches are increasingly crucial for the recognition of sturgeon species and their relationships (for discussion, see Birstein et al. 1997 this volume).

In Eurasia, the genus *Acipenser* is centered upon three main basins: (1) the Black Sea and Sea of Azov, (2) Caspian Sea, and (3) the Aral Sea. Each of three main species of *Acipenser*, *A. gueldenstaedtii* Brandt, 1833, *A. stellatus* Pallas, 1771, and *A. nudiventris* Lovetsky, 1828 were described as having subspecies or forms in these basins (see Berg 1948, Shubina et al. 1989, Sokolov & Vasilev 1989a, Vlasenko et al. 1989a). If we follow the view on nomenclature of species discussed by Holčík & Jedlička (1994), then the concept of subspecies and trinomial nomenclature is inefficient. Therefore, we consider all intraspecies forms and subspecies of *A. gueldenstaedtii*, *A. stellatus*, and *A. nudiventris* invalid until detailed molecular and morphological studies of different forms within these species can be performed.[1] The same is true for *A. ruthenus* Linnaeus, 1758, for which a few intraspecies forms were described by different authors (see Berg 1948, Sokolov & Vasilev 1989b).

An example helps to illustrate the taxonomic frustration of sturgeon biologists. *Acipenser persicus* was described as a valid species by Borodin in 1897 (Borodin 1897, 1926), but it was later considered to be a subspecies (Berg 1934), and, still later, again regarded as a valid species (see Vlasenko et al. 1989b, Birstein & Bemis 1997 this volume, for discussion). Moreover, Artyukhin & Zarkua (1986) described two subspecies within *A. persicus*: the population inhabiting the Caspian Sea they named as *A. persicus persicus* Borodin, 1897, and the population inhabiting the Black Sea, as *A. persicus colchicus* Marti, 1940. Although some Russian authors follow this nomenclature (Pavlov et al. 1994), additional support from genetic and molecular data is desirable.

The validity of some Asian species and subspecies of *Acipenser* is questionable. For example, Ruban (1997 this volume) reviewed and presented new data on the Siberian sturgeon, *A. baerii* Brandt, 1869, which has an extremely wide range. Ruban's new work supports the traditionally recognized subspecies (*A.b. baerii*, *A.b. baicalensis* and *A.b. stenorrhynchus*, e.g., Sokolov & Vasiliev 1989c). No genetic study on the subspecies of *A. baerii* is yet available.

The three far eastern Asian species, *A. schrencki* Brand, 1869 of the Amur River, and *A. dabryanus* Duméril, 1868, and *A. sinensis* Gray, 1834 of the Yangtze River are certainly valid (see Krykhtin & Svirskii 1997, Wei et al. 1997, Zhuang et al. 1997, all this volume). Chinese sturgeon, *A. sinensis*, from the Pearl River differ morphologically from those of the Yangtze River, but whether this difference warrants separate species status is not clear (Wei et al. 1997).

The nomenclature and species status of the so-called 'green sturgeon' and 'Sakhalin sturgeon' of the Pacific Northwest of America and northeastern Pacific in Asia has been particularly confusing. Ayres (1854) described the American green sturgeon, *A. medirostris*. Nearly 40 years later, Hilgendorf (1892) described an Asian species caught in the northern waters of Japan as *A. mikadoi*, and Schmidt (1904) soon thereafter referred a sturgeon caught in the Aniwa Bay of Sakhalin Island to *A. mikadoi*. However, Berg (1911, 1948) considered this Sakhalin sturgeon to be conspecific with the American green sturgeon, *A. medirostris*. Schmidt (1950) eventually reconsidered his 1904 view, and named Sakhalin sturgeon as a subspecies of *A. medirostris*, *A. medirostris mikadoi* (Schmidt, 1950). Therefore, three names coexisted in the literature for the Sakhalin sturgeon: *A. mikadoi* (Okada & Matsubara

[1] In the literature on genetics, molecular phylogenetics and systematics, the taxonomic unit subspecies is often preserved (Avise 1994, Mallet 1995). Avise & Ball (1990) and Avise (1994, p 253) suggested that we recognize 'by the evidence of concordant phylogenetic partitions at multiple independent genetic attributes'. 'When phylogenetic concordance is exhibited across genetic characters solely because of extrinsic barriers to reproduction, subspecies status is suggested'. It is evident that according to these terminology, populations of the same species of sturgeon in disjunct sea basins (e.g., Caspian and Black seas), could be considered as subspecies.

1938, Matsubara 1955), *A. medirostris* (Berg 1948, Andriyashev & Panin 1953, Masuda et al. 1984, Houston 1988, Artyukhin & Andronov 1990, Pavlov et al. 1994), and *A. medirostris mikadoi* (Lindberg & Legeza 1965, Shilin 1995). Recently Birstein (Birstein et al. 1993, Birstein 1993) noted the difference in ploidy between the Sakhalin sturgeon and American green sturgeon, and suggested that they should be considered different species, *A. mikadoi* Hilgendorf, 1892, and *A. medirostris* Ayres, 1854, respectively. Molecular data on three mitochondrial genes presented in this volume (Birstein & DeSalle 1997) also show great differences between these two species. Other molecular data obtained show a close genetic relationship of *A. medirostris* to another American Pacific sturgeon species, *A. transmontanus* (Brown et al. 1996, Birstein et al. 1997). Therefore, *A. mikadoi* and *A. medirostris* should be considered as morphologically similar, but genetically different, species. The Sakhalin sturgeon inhabits the Sea of Japan up to the Korean Peninsula and waters to the north from Hokkaido Island (Berg 1948, Lindberg & Legeza 1965). It occurs in the mouths of small rivers of the Asian far east and Korean Peninsula, as well as the Amur River, and rivers of the Sakhalin Island. Now it spawns in the Tumnin (Datta) River in the Russian far east (Artuykhin & Andronov 1990), and historically it also spawned in the Ishikari and Teshio rivers of Hokkaido Island (Okada 1955). *Acipenser medirostris* ranges from the Gulf of Alaska to southern California (Houston 1988), with three known spawning rivers: the Sacramento and Klamath rivers in California and the Rogue River in Oregon (Moyle et al. 1994).

Two other species of sturgeons are usually mentioned in descriptions of the fish fauna of Japan, *A. kikuchii* Jordan & Snyder, 1901, and *A. multiscutatus* Tanaka, 1908 (Okada 1959–1960, Masuda et al. 1984, Rochard et al. 1991). Only one specimen of *A. kikuchii* is known (Jordan & Snyder 1901, 1906), and this species was re-identified as *A. sinensis* (Takeuchi 1979). Only a few specimens of *A. multiscutatus* were described (Tanaka 1908, Fowler 1941, Matsubara 1955). It seems that these specimens are morphologically similar to *A. schrenckii* (Lindberg & Legeza 1956) and are probably conspecific with *A. schrenckii*. It is most improbable that a sturgeon species could be restricted only to Japan and not inhabiting Asian continental waters (Artyukhin & Andronov 1990). There are no new reports on the catch of *A. multiscutatus* in Japanese literature (see a compilation of data in Honma 1988) since the review of Okada (1959-1960). Therefore, *A. multiscutatus* is most probably a synonym of *A. schrencki*.

It is easy to distinguish the second Pacific North American species, *A. transmontanus* Richardson, 1836, the freshwater North American *A. fulvescens* Rafinesque, 1817, and one of the two Atlantic North American sturgeons, *A. brevirostrum* Le Sueur, 1818 (Vladykov & Greeley 1963, Scott & Crossman 1973, Lee et al. 1980). Molecular data on the structure of the control region of mtDNA not only supported close relationships of two Pacific North American sturgeon species, *A. medirostris* and *A. transmontanus*, but also showed a significant genetic difference between these species, *A. fulvescens*, and the second Atlantic North American species, *A. oxyrinchus* (Brown et al. 1996).

American and the European Atlantic sturgeon were long considered to be one species, *A. sturio* Linnaeus, 1758. In this older terminology, the American Atlantic sturgeon was regarded as subspecies *A. sturio oxyrinchus*, with the European Atlantic sturgeon being known as *A. sturio sturio* (see Smith 1891, Vladykov & Greeley 1963). Magnin & Beaulieu (1963) suggested elevation of these subspecies to species ranks, with the European form retaining the name *A. sturio* Linnaeus, 1758, and American form named *A. oxyrinchus* Mitchill, 1815. Two subspecies, the Atlantic sturgeon, *A.o. oxyrinchus*, and the Gulf coast sturgeon, *A.o. desotoi*, were described within *A. oxyrinchus* (Vladykov 1955, Vladykov & Greeley 1963).[2] These two subspecies of *A. oxyrinchus* are morphologically similar, with the most significant known difference be-

[2] Since the description of the species, the name *A. oxyrinchus* has changed a few times. Mitchill described this species in 1815 under the name *A. oxyrinchus* (Mitchill, 1815). Later, the name was changed to *A. oxyrhynchus* and an incorrect date of publication (1814) began to be cited widely (e.g., Vladykov & Greely 1963). Also, *A. oxyrinchus desotoi* was first described under the name *A. oxyrhynchus de sotoi* (Vladykov 1955). In this volume we follow Smith & Clugston (1997) and use the names *A. o. oxyrinchus* and *A. oxyrinchus desotoi*.

ing the length of the spleen (in *A.o. oxyrinchus* the spleen is statistically smaller than it is in *A.o. de sotoi*, Wooley 1985). Molecular data are more informative for the discrimination between subspecies. Comparison of the control region of mtDNA sequences of both subspecies showed three fixed nucleotide changes in that region (Ong et al. 1996). Bowen & Avise (1990) suggested that there is genetic structuring among *A. oxyrinchus* from various drainages of the North American Atlantic coast. Recently, analyses of the control regions of mtDNA supported this hypothesis: Atlantic sturgeon populations in the Saint Lawrence and Saint John rivers (Canada), the Hudson River (U.S.A.), and rivers of Georgia (U.S A.) are genetically distinct (Waldman et al. 1996a,b).

Unpublished results of Birstein & DeSalle on the sequences of three more genes of mtDNA (cytochrome *b*, 12S rRNA, and 16S rRNA) also show a genetic difference between the two subspecies of *A. oxyrinchus* (one fixed nucleotide change in cytochrome *b* gene). The analysis of these genes demonstrated that the European *A. sturio* is the only sturgeon species closely related to *A. oxyrinchus*. Moreover, it appeared that there is a significant genetic differentiation within *A. sturio*. Birstein & DeSalle studied samples from two specimens of *A. sturio* caught in the Gironde estuary system (Dorgonne and Garonne rivers) and in the North Sea. The genetic difference between two individuals of *A. sturio* (6 nucleotide changes in the region of cytochrome *b* analyzed) was even more than the difference between subspecies of *A. oxyrinchus* (one change). These data seem to support the difference in some meristic characters between specimens from the Baltic Sea, from one side, and specimens from the Atlantic Ocean, Mediterranean and Black seas, from the other (Marti 1939, Magnin 1963, Ninua 1976, Holčík et al. 1989). Because *A. sturio* has almost disappeared in the wild (Holčík et al. 1989), more work should be done in museum collections on the comparison of specimens from different populations. This is especially important in terms of recovery projects for this species (Hochleithner 1995, Williot et al. 1997, this volume).

The last species in the genus *Acipenser* is the Adriatic sturgeon, *A. naccarii* Bonaparte, 1836. It is restricted to the Adriatic only and resembles *A. gueldenstaedtii* in meristic characters (Tortonese 1989).

Since Berg (1904), *Huso huso* Brandt, 1869 and *H. dauricus* Georgi, 1775 were considered as representatives of a distinct genus *Huso*, not *Acipenser* as they were usually considered in the 19th century (also see Findeis 1997, this volume). Results of recent molecular studies, however (see Birstein et al. 1997 this volume) showed that the two species of *Huso* do not form a separate monophyletic group, but are inserted among species of *Acipenser*. This result reactivates the old discussion on the validity of the genus *Huso*. In the absence of detailed work on this problem, it makes sense for now to regard *Huso* as a genus based on morphological and anatomical data (Findeis 1997 this volume). Also, a few subspecies were described within *H. huso* (reviewed in Pirogovskii et al. 1989). For instance, some authors still consider the Sea of Azov population of *H. huso* as *Huso huso maeoticus* Salnikov & Myatskii, 1934 (Pavlov et al. 1994). Until genetic differences can be shown in combination with morphology, we recommend the name *H. huso* for the Mediterranean, Black, Azov, and Caspian sea populations of beluga.

In conclusion, we recognize 17 valid extant species within *Acipenser*. For the moment, we accept that two species (*A. baerii* and *A. oxyrinchus*) contain subspecies. Further genetic and molecular studies will generate new data for correction of our contemporary knowledge about some of the species, including *A. sturio*.

A final note regarding the names of sturgeon species concerns the need to return to the originally published spellings for names of genera and species[3]. In addition to two recent clarifications on the correct spelling of species names for Siberian (*A. baerii*, see Ruban 1997, this volume) and American Atlantic sturgeon (*A. oxyrinchus*, see Gilbert 1992), we note the following correct spelling for two other

[3] Such decisions to use the originally published spellings of names, regardless of subsequent practices, are based on the International Code of Zoological Nomenclature (Ride et al. 1985). For a specific explanation of rules, see Chapters 31 and 33 of the International Code of Zoological Nomenclature. 1985, 3rd ed. International Trust for Zoological Nomenclature, London.

species of *Acipenser*. The scientific name of the Russian sturgeon should be spelled *Acipenser gueldenstaedtii* Brandt, 1833, and the scientific name of the Amur River sturgeon should be spelled *Acipenser schrenckii* Brandt, 1869.

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