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APPENDIX 1

STURGEON REPRODUCTION IN IRANIAN HATCHERIES IN 1996

	A. persicus	*A. stellatus*	*H. huso*
Broodstock capture (numbers)	644.0	236	17
Injected broodstock (numbers)	381.0	165	10
Spawning rate (%)	86.1	54	83.3
Total fecundity (numbers)	256 946.0	138 091	240 458.0
Relative fecundity (numbers)	7 882.7	9 574	2 766.0
Fertilization rate (%)	67.6	44.4	45
Survival rate in incubator (%)	63.1	32.1	38.7
Survival rate in tank (%)	72.1	72.6	74.7
Stocking density (numbers/ha)	82 860.0	99 833	72 941
Survival rate in pond (%)	58.2	54	55.6
Fingerling production (numbers)	10 779 938	316 214	346 300

(Abdolhay and Baradaran Tahori, 1998)

APPENDIX 2

GENETIC RESOURCES OF CASPIAN STURGEON

Species, subspecies and stocks

There are five species of sturgeon belonging to the genera of *Acipenser* and *Huso* in the Caspian Sea. Significant variations both within and between geographical regions were observed in different sturgeon species (Holcik, 1989).

Beluga sturgeon (Huso huso)

There are a number of forms of beluga sturgeon. A series of morphological differences have been observed between the Danube and the Caspian Sea beluga sturgeon (Pavlov, 1967). The type of beluga sturgeon that was considered by Berg (1948) was *Huso huso* and was typical of the Caspian-Volga populations. However, based on antigenic studies of the blood serum protein, three subpopulations of beluga sturgeon from the Volga, Ural and Kura rivers in the Caspian Sea region have also been identified (Karataeva, Lukyanenko and Terentev, 1971). The largest of these is the beluga, which reaches a length of up to 425 cm and weight of 520 kg. For example, Pour-Qadiri (1996) reported that a 414-cm, 500-kg beluga sturgeon was caught on the east coast of the south Caspian Sea. It yielded 54 kg of high-quality caviar. In the past, individuals have reached the age of 100–120 years, but the present life span does not exceed 50–55 years. Sexual maturity is attained at the age of 11 years for males and 16 years for females. For breeding, the beluga sturgeon enters the rivers Volga, Ural, Terek and Sefidroud. They feed on gobies, shads and carp, and during their first month of life in the sea on Mysidaca. At the beginning of the twentieth century (1904–1913) the beluga

sturgeon accounted for about 40 percent of the sturgeon catch. At present it accounts for no more than 10 percent (annual report of Shilat in Iran).

***Stellate and sterlet sturgeon* (Acipenser stellatus and A. ruthenus)**

There are two forms of stellate surgeon in the Volga basin, the typically resident sterlet (*A. ruthenus*) whose living area is limited to the upper and middle parts of the Volga River, and the semi-migratory stellate that enters the brackish parts of the Caspian to feed. Borozenko (1942) reported two different ecological forms of stellate surgeon in the Caspian Sea, northern and southern forms. The northern form (*A. stellatus stellatus*) has growth rate and fecundity lower than that of the southern form (*A. stellatus cyrensis*).

Immunological studies (Lukyanenko *et al*., 1972) show that the northern and southern Caspian Sea stellate sturgeon are genetically distinct from each other and have distinct spawning periods in the spring and winter (Nikolskii, 1971).

Based on analysis of the average proportion of the head and the dorsal and anal fins, a subspecies *A. stellatus donensis* from the Azov Sea was reported by Lovetsky (1834) and reconfirmed by Chugunova (1964). However, their suggestion was rejected by Holcik (1989), who argued that those characters are not reliable as they undergo a considerable change during growth and depend upon feeding conditions.

Stellate sturgeon are smaller than beluga and other sturgeons, reaching 195 cm in length and a weight of up to 25 kg, and they also have shorter life spans of 28– 30 years. Sexual maturity is reached at 6–8 years. Most of the males attain full growth after 9 years and females after 11 years. Fingerlings in the river and the sea feed on crustaceans. The proportion of stellates in Iranian sturgeon catches has gradually decreased in recent years from 45 percent to 35 percent (Moghim *et al*., 1996).

***Persian sturgeon* (Acipenser persicus)**

The Persian sturgeon (*A. persicus*) prefers warmer water than the beluga and Russian sturgeon. It forages mostly in the Middle and South Caspian Sea and also the Black Sea (Artyukhin and Zarkhua, 1986). It was considered a subspecies of Russian sturgeon (*A. gueldenstaedti persicus*) because of its morphological similarity with the Russian sturgeon. (Berg, 1933). Based on external morphological differentiation, two forms of Persian sturgeon subspecies were recognized as *A. persicus* in the Caspian Sea Basin and *A. persicus colchicus* in the Eastern Black Sea (Marti, 1940). Haematological and biochemical studies during 1984–1988 in coastal waters in Iran and isoelectric focusing clearly identified a significant difference between the Persian and Russian sturgeon (Keyvanfar and Nasrichari, 1997). A partial sequence of the mtDNA ND 5 region gene from five individuals of Persian sturgeon collected from west and east regions from the South Caspian Sea revealed a very low level of divergence. Four of these sequences were identical. The genetic distance between the two different sequences was only 1 percent. Several explanations can be put forward to explain the low levels of sequence divergence observed (Rezvani, 1997). Ovenden (1990) pointed out that it is possible that marine organisms, in general, have a slower rate of mtDNA evolution. However, other factors such as the bottleneck effect can create the low nucleotide divergence (Rezvani, 1997). Spawning grounds are predominantly in the rivers Kura and Volga rather than the Ural. Two races of Persian surgeon spawning at different times in the Sefidroud (Iranian side) were reported by Rostami (1961). The first group spawns at the end of April and in May and the second group spawns during September and October. This sturgeon belongs to the category of fish with mixed

feeding habits (eating other fish and bottom invertebrates). Fingerlings in the rivers and after entering the sea feed on mysids and other crustaceans.

The maximum recorded age of Persian sturgeon in the Kura River is 48 years. An individual taken in the Volga was 38 years old. The maximum size reached by Persian sturgeon in the Caspian Sea region was 231–242 cm but at present individuals do not exceed 205–230 cm (Holcik, 1989, Razavi, 1998). The average length for males is 139 cm and for females 155 cm and the average weight is 20.1 kg and 29.9 kg, respectively (Moghim and Ganinejad, 1994). Persian sturgeon reaches sexual maturity later than Russian sturgeon. In the Kura River the males mature at age 8 years and the females at 12 years. In the Volga and Ural rivers maturity is reached at the age of 15 years for males and 18 years for the females (Holcik, 1989).

Russian sturgeon **(Acipenser gueldenstaedti)**

The Russian sturgeon lives in the Caspian Sea, Volga and Kura rivers, Black Sea (Rioni Dnieper Rivers) and the Azov Sea (Don River). The forms in these rivers are well differentiated from each other. Different stocks of Russian sturgeon from the Volga and Kura rivers have been identified (Belyaeva, 1932, 1972; Kazancheev, 1981). Immunological analysis of all these stocks has revealed a high degree of differences between fish from different geographical regions (Umerov and Altufev, 1968; Lukyanenko, Popov and Terentev, 1968).

Several races of summer and winter migratory forms of Russian sturgeon were also reported in the Volga River (Barannikova, 1991). Marti (1940) classified two varieties of Russian sturgeon inhabiting the Black Sea as *A. gueldenstaedti* var. *tanaica* and *A. gueldenstaedti* var. *colchicus*. However, Berg (1948) called the latter a subspecies *A. guedenstaedti colchicus* (Marti). By contrast, because of a great similarity of this subspecies to Persian sturgeon, Artyukhin and Zarkua (1986) called it *A. persicus colchicus*. Russian sturgeon is representative of sturgeon species that are commercially exploited throughout the Caspian Sea. Identification of its genetic variability and stock structure will provide useful information for conservation and fishery management. Sixty-two fish samples representing two different populations from the South Caspian Sea (west and east areas) were investigated using PCR amplification of the mtDNA ND 5/6 gene regions. PCR fragments of all individuals (2400 bp) were digested with ten restriction enzymes (Rezvani, 1997). Significant differences in the distribution of haplotype frequencies were observed between populations. The average nucleotide and haplotype diversity over all populations were 0.029 and 0.95, respectively. The value of nucleotide divergence between west and east populations was only 0.052 percent but a χ^2 test based on haplotypes showed significant differentiation between the two (Rezvani, 1997). This result was in contrast with that obtained in a study based on the mtDNA 100-bp region of Russian sturgeon from the South Caspian Sea, where no significant differentiation among populations from four wide regions was observed by Pourkazemi in 1996 (Rezvani, 1997). Overall, these data suggest that the Russian sturgeon populations in the South Caspian Sea comprise at least two stocks.

Russian sturgeons enter the rivers Volga, Ural and Terek for reproduction. The largest stocks occur in the Volga, up to the Volgagrad dam. Fish reach 200–210 cm in length with a weight of 60–65 kg, and can live up to 40 years. Males reach sexual maturity at the age of 7 years and females at 8 years. Maximum size for most males occurs at 14–17 years, and for females at 18–21 years. Russian sturgeon are found in coastal shallows at depths from 2 to 100–130 m with large numbers at depths of less than 50 m.

Ship sturgeon (Acipenser nudiventris)

Kazancheev (1981) identified two reproductively isolated groups known as the North and South Caspian ship sturgeon populations. These populations differ slightly from the typical form from the Ural Sea. At the present time, because of the drying of the Ural Sea, *A. nudiventris* as well as other species have become extinct in the wild there.

The ship sturgeon is a large fish; at maturity individuals grow to over 200 cm and 75 kg. For breeding it enters the rivers Kura, Ural and Sefidroud, but it is rarely found in the Volga. Most of the males mature at the age of 9–13 years, and females at 13–16 years. It forages mainly in the middle and South Caspian Sea, along the western shores at depths of 11–25 m, and feeds on fish and bottom invertebrates. Fishing for the ship sturgeon is now prohibited in the Ural River because of depletion of stocks. The ship sturgeon is of relatively minor significance for Caspian catches.

Karyotype

Studies of sturgeon karyotype provide information about both the evolution and the polyploidization event in this group on ancient fish. The karyotype of the sturgeon is among the most complicated of the vertebrates and has not yet been studied in sufficient depth. In most sturgeon species a large number of chromosomes are present, about half of which are microchromosomes (Vasiliev, 1980, and references cited in Birstein and Vasiliev, 1987). Sturgeon can be divided into two groups based on the number of chromosomes.

First group: species carrying 120 chromosomes or tetraploid (e.g. *Huso huso*, *H. dauricus*, *A. ruthenus*, *A. stellatus*, *A. nudiventeris*). Second group: sturgeon with 240 chromosomes or octoploid (e.g. *A. naccarii*, *A. gueldenstaedti*, *A. baeri*, *A. persicus*).

The chromosome numbers of five sturgeon species of the Caspian Sea are given in Table 14. Study of sturgeon genome size using flow cytometry methods has revealed that there is a correlation between the number of chromosomes and genome size (DNA content per nucleus). In *H. huso* (2n = 120), the DNA content reaches 3.6 pg per nucleus, whereas in *A. naccarii* (2n = 240) DNA content = 5.7–6.3 pg per nucleus (Fontana, 1976). Birstein (1993) studied the DNA content in ten Eurasian sturgeon species using flow cytometry methods. They concluded that the average DNA content in tetraploid sturgeon ranges from 3.17 to 4.04 pg and in octoploid sturgeon species (*A. gueldenstaedti*) from 3.17 to 8.31 pg. The DNA content in Sakhalin sturgeon (*A. medirostris* = *A. mikadoi*) is estimated to be twice as high as in the octoploids, 13.93–14.73 pg, and they concluded that the ploidy level of Sakhalin sturgeon may be 16n and number of chromosomes could be 500 (Birstein, 1993).

TABLE 14. Chromosome numbers of sturgeon in the Caspian Sea

No.	Species	Chromosome no. (2n)	References
1	*Huso huso*	118 ± 2	Birstein and Vasiliev (1987)
2	*A. stellatus*	118 ± 2	Birstein and Vasiliev (1987)
3	*A. nudiventeris*	118 ± 2	Sokolov and Vasiliev (1989)
4	*A. gueldenstaedti*	250 ± 8	Birstein and Vasiliev (1987)
5	*A. persicus*	250 ± 10	Norouz Fashkhami, Poukazemi and Baradan Noveiry (1998)