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Blood serum osmotic and ionic regulation of wild adults and reared juvenile Persian sturgeon, *Acipenser persicus*

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Abstract: The osmoregulatory system was studied in wild adult and reared juvenile Persian sturgeon, *Acipenser persicus*. The mean osmolarity in blood serum of specimens from the Caspian Sea, estuary, the Kouraneski pools and the rearing tanks were 305.3± 14.3, 308.7±25.8, 265.0±19.1 and 259.3±8.8 mosmol/L, respectively; the mean concentrations of Na^+ were 151.2±6.3, 152.2±8.4, 142.5±5.9 and 131.4±4.1 meq/L whereas mean concentrations of K^+ were 2.7±0.9, 3.6±0.9, 3.1± 0.5 and 2.6±0.5 meq/L, respectively.

The concentrations for Mg^{++} ion in fish of the same four origins were 1.5±0.2; 1.5±0.3, 0.8±0.2 and 0.7±0.2 meq/L, and those of Ca^{++} were 2.31±0.51, 2.61±0.51, 1.85±0.58 and 1.46±0.43, respectively. The Pearson's correlation coefficient and regression equation indicated that Mg^{++} (r =0.38) and Na^+ (r=0.41) were effective ions for determination of blood serum osmotic pressure in *A. persicus* in brackish water and freshwater. This study also showed that blood serum osmotic pressure was independnt of sex.

Keywords: Caspian Sea, Persian Sturgeon, Osmo - Ionoregulation, Blood serum

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Introduction

Osmoregulation has extensively been studied in various Acipenserids around the world, including the Caspian Sea (Krayushkina, 1967, 1983 ; Potts & Rudy, 1972 ; Krayushkina & Moiseenko, 1977 ; Methalov, 1977; Wallace *et al.*, 1993; McEnroe & Cech, 1985 ; Cataldi *et al.*, 1995, 1999; Krayushkina *et al.*, 1996a, 1996b ; Kazemi *et al.*, 2001, 2002 and 2003).

Anadromous migration of sturgeon species in the Caspian Sea involves changes from freshwater to 10–17ppt. salinity (*Huso huso, Acipenser stellatus, A. gueldenstaedtii, A. persicus*). Other sturgeon species migrate up to full strength seawater 24–33ppt salinity (*A. sturio, A. oxyrhynchus, A. medirostris* and *A. transmontanus*). To accomplish the media changes they must be capable to regulate their blood serum osmolarity and ion concentrations (Krayushkina *et al.*, 1996a; Kazemi *et al.*, 2001).

A. persicus enters larger rivers (Sefidroud, Tajan and Gorganroud) along the Iranian coast during the autumn and migrate slowly upstream to spawn (Kohnehshahri & Azari Takami, 1974). Spawning takes place in the spring (between March and May). After spawning they return back to the sea and unlike salmon they may return to spawn annually or interannually for many years (Krayushkina *et al.*, 1996a).

The osmoregulatory potential increases with morphological and functional development of organs during ontogeny, which contribute to osmotic and ionic homeostasis (Kazemi *et al.*, 2003). In this paper, osmotic and ionic regulation of *A.persicus* was studied.

Osmotic adaptation is varied in different life stages such as functional physiologic index in propagation, rearing and stocking.

Therefore, understanding osmotic pressure and ion concentrations of *A. persicus* blood serum in natural condition (sea and estuary), propagation and rearing situation is necessary. To make the best use of water with different salinities in commercial rearing (meat and caviar production) of the Persian sturgeon justifies research on its osmotic regulatory profile and capacity.

Materials and Methods

Seventy-five adult and forty-one juvenile *A. persicus* were collected from four sites: Gilan Province (5-7 kilometers offshore, total n=17, males=8; females=9), Sefidroud estuary (total n=25, males=14; females=11), Kouraneski pools of the Dr. Beheshti Sturgeon Hatchery (total n=33, males= 8; females =25) and the fiberglass tanks of the International Sturgeon Research Institute (total n= 41, 20 in year one; 21 in year two). Fish were captured using gillnets in the Caspian Sea and estuary and purse seine in the Sefidroud. The captured fish (n=33) were transported to the Kouraneski pools (V-shaped 12m×12×m1.50m) and kept them for 10 days providing freshwater exchange (temperature range about 14-18°C). Juveniles (one and two years) were reared in fiberglass tanks (2m×2m×0.53m) with a constant inflow of the Sefidroud water (temperature range 16-17°C).

Immediately after catch and recording the length and weight of fish, blood sample was taken by using 3–4ml syringes from caudal vein (behind anal fin) of each fish. Blood samples were centrifuged at 500g for 7 minutes to separate blood serum and blood cells (at ambient temperature).

Blood serum and water osmolarity were determined using 10 micro liter of blood serum or water with a digital freezing osmometer (Nr. 9610003, Roebling, Germany). Na^{+} and K^{+} were determined with Flame Photometer (Corning 480, England).

Ca^{++} and Mg^{++} were determined using a spectrophotometer (RA1000, USA). Early and final stages of gonad development of both sexes were determined after primary experimentations (determination of osmolarity and ionic concentrations).

The data were statistically processed with the Quattro ver6, SPSS ver5, Stat graph and Excel.

Results

Differences in osmolarity, potentially caused to ion concentrations indicated significant variations ($P<0.05$), which seems mainly to be linked to different media salinities (Table 1), while no significant difference in ionic strength between adult males and females originality from different media was observed.

ANOVA revealed significant differences in blood serum osmolarity of fish originating from different locations $P<0.05$ (Fig.1). According to Turkey's test, there were no significant differences in blood serum osmolarity of adult fish from the sea and estuary; similarly, the adults from Kouraneski and those juveniles reared in the hatchery formed another group that showed no significant differences in their blood serum osmolarity.

ANOVA indicated significant differences in blood serum ion concentrations for Na^+, K^+,Ca^{2+} and Mg^{2+} in fish from different origins ($P<0.05$). Tukey test indicated significant differences in Na^+ concentration in blood serum between adult sturgeon from the sea and estuary compared to the Kouraneski pools and cultured juveniles (Fig.2). However there were no significant differences between sea and estuarine adult fish ($P>0.05$).

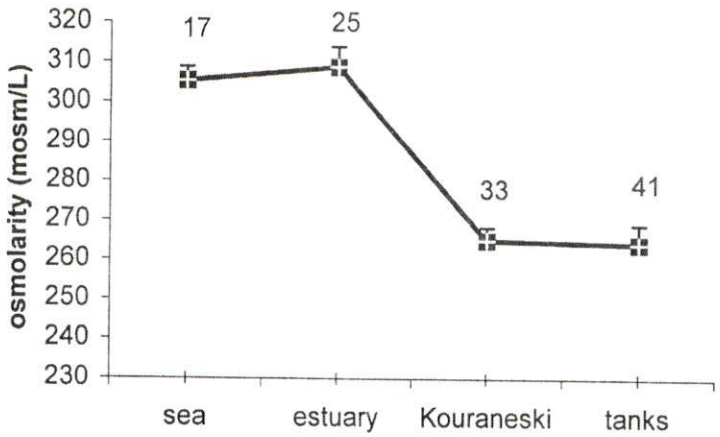

Figure 1: Blood serum osmolarity of *A. persicus* originating from different places. Data represent means (±SD). Numbers of samples are indicated on the curve.

Table 1: Mean (± SD) ionic strength of *A. persicus* and monitored values of sexes combined blood serum and water (n=number of samples

Factors / Samples	Total length (cm)	Total weight (kg)	Osmolarity (mosm/L)	Na^+ (meq/L)	K^+ (meq/L)	Ca^{++} (meq/L)	Mg^{++} (meq/L)
Sea adult (n=17)	143.6± 18.7	13.4±5.3	305.3±14.3	151.2±6.3	2.7±0.9	2.3±0.5	1.5±0.2
Estuary adult (n=25)	153.3±14.5	12.2±5.0	308.7±25.8	152.2±8.4	3.6±0.9	2.6±0.5	1.5±0.3
Kouraneski adult (n=33)	171.7±34.0	25.8±8.3	265.0±19.1	142.5±5.9	3.1±0.5	1.85±0.6	0.8±0.2
One year tank-reared (n=20)	39.9±3.0	0.2±0.1	256.9±9.2	131.4±4.1	2.7±0.7	1.3±0.3	0.6±0.1
Two years tank-reared (n=21)	53.7±3.3	0.5±0.1	261.6±7.9	133.0±3.6	2.5±0.3	1.7±0.4	0.8±0.1
Seawater (n=10)	-	-	380.6±13.3	174.7±7.6	3.2±0.7	5.1±0.6	1.2±0.2
Estuary water (n=10)	-	-	290.7±6.9	135.4±4.2	2.9±0.4	5.1±0.2	1.2±0.1
Freshwater (n=10)	-	-	17.5±0.2	36.9±3.5	0.4±0.1	2.2±0.5	1.3±0.3

Blood serum K^+ attained significantly different concentration in the Kouraneski and in the cultured fish. The same holds for the comparison of cultured and estuarine fish and also estuarine and seawater adult sturgeon (Fig. 2).

Blood serum Ca^{2+} showed no significant difference between adult sturgeon from the sea and estuary ($P>0.05$), while there was significant difference between other groups (Fig. 2).

Blood serum Mg^{2+} showed significant differences between Kouraneski adult fish with adult sturgeon from estuary, cultured juveniles and adult sturgeon from sea, cultured juveniles with adult sturgeon from the sea and estuary. However, there was no significant difference between sea and estuary adult fish (Fig. 2).

ANOVA indicated that osmolarity of media in different places was significantly different ($P<0.01$) from each other (Fig. 3).

ANOVA showed significant differences ($P<0.01$) in concentrations of Na^+ and Ca^{2+} in the water at various locations where sturgeon were sampled (Table 1), while there was no significant difference in K^+ concentration in sea and estuarine water. Freshwater used for sturgeon culture, however, displayed significant differences with sea and brackish water. Concentration of Mg^{2+} showed no significant differences in various living conditions (Fig. 4).

ANOVA showed that there was no significant difference ($P>0.05$) in osmolarity of blood serum samples from males and females (in all origins) (Fig. 5).

ANOVA showed no significant difference ($P>0.05$) in ion concentrations of blood serum from males and females of all origins (Fig. 6).

According to the Pearson's correlation coefficient and regression equation, Mg^{++} ($r=0.38$) and Na^+($r=0.41$) were the most important and effective ions for determination of blood serum osmotic pressure in *A. persicus* in brackish and freshwater respectively.

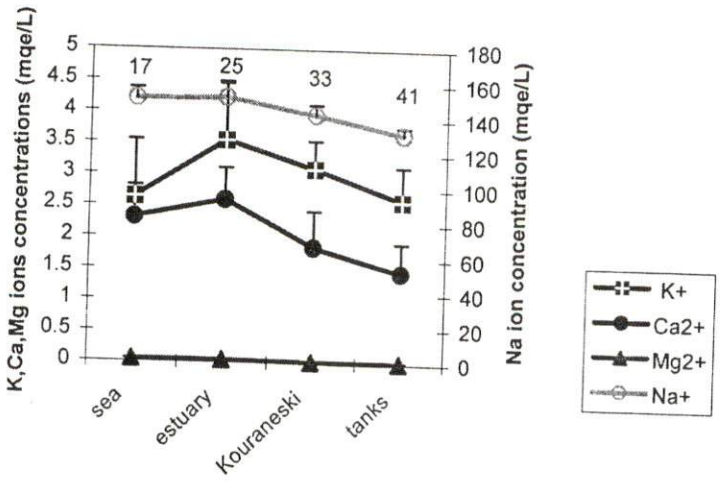

Figure 2: Mean (±SD) Na+, K+, Ca++ and Mg++ concentrations in blood serum of *A. persicus* originating from different places. (See the left scale on the Y-axis); Na+ concentration is identified on the right scale. Numbers of sample are indicated on the curve.

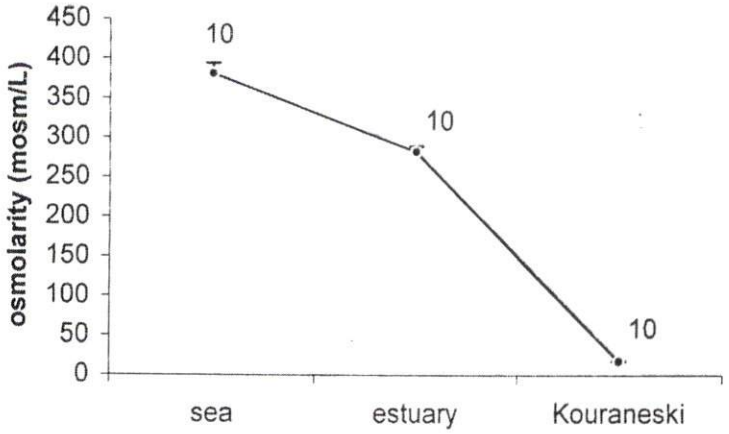

Figure 3: Mean (±SD) water osmolarity of different places. Numbers of sample are indicated on the curve

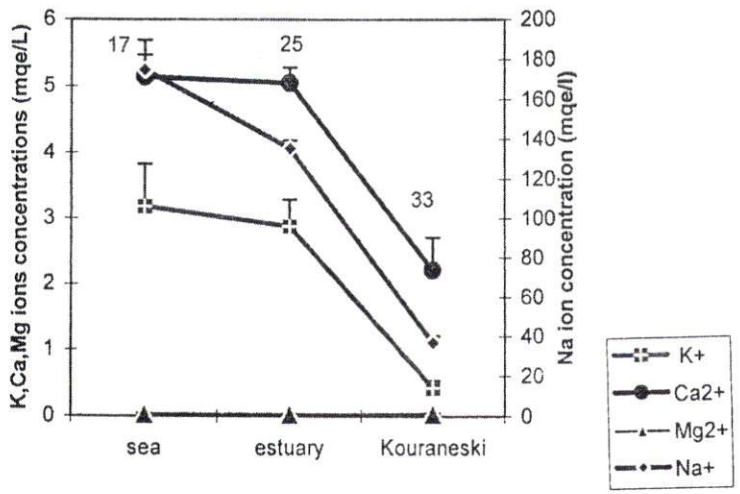

Figure 4: Mean (± SD) Na+, K+, Ca++ and Mg++ concentrations in waters from different media. (See the left scale on the Y-axis); Na+ concentration is identified on the right scale. Numbers of samples are indicated on the curve.

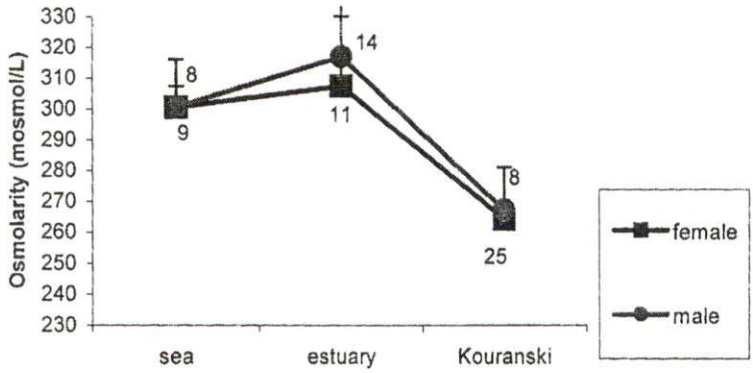

Figure 5: Mean (±SD) blood serum osmolarity of adult *A. persicus* of different sex in all origins (sea, estuary, Kouraneski). Numbers of samples are indicated on the curve

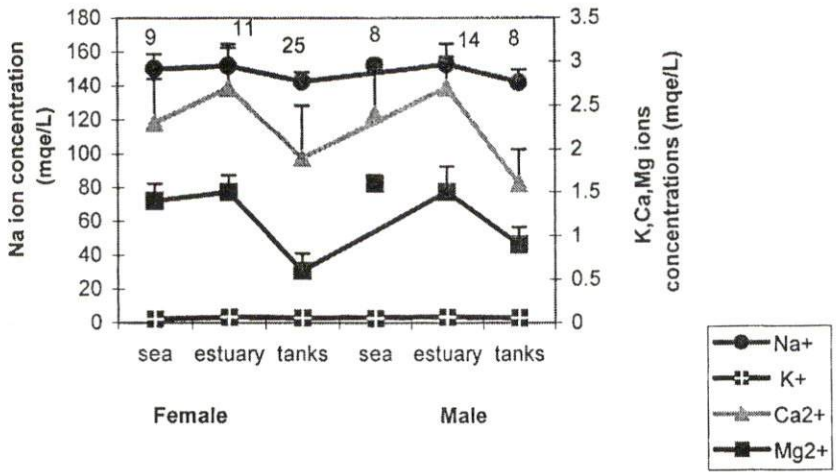

Figure 6: Mean (± SD) blood serum concentrations for four important ions as determined in males and females of *A. persicus*. Na+ concentration is identified on the left scale. Numbers of sample are indicated on the curve.

Discussion

Rochard *et al.* (1990) identified three types of life history in sturgeons and the Persian sturgeon belongs to type 2, accordingly. Spending most of its lifetime in the Caspian Sea with salinity ranging from 10 to 15ppt, mature adult fish migrate to the rivers especially in the south-western Caspian Sea to spawn.

Previous studies on sturgeon osmotic and ionic regulation (Potts and Rudy, 1972) have indicated that sturgeons are hypo-hyper osmotic regulators as are the euryhaline and diadromous teleosts.

Decrease in blood serum osmotic and cation concentration is distinctive characteristics of sturgeon from the northern and central Caspian Sea (Methalov, 1977), white sturgeon, *A. transmontanus* (McEnroe & Cech, 1985), Italian sturgeon, *A. nacarii* (Cataldi *et al.*, 1995), paddlefish, *Polyodon spathula* (Krayushkina et al., 1996b) and Persian sturgeon (present investigation) and even salmonids as they migrate from sea to freshwater. In the present study blood serum osmolarity and cation concentrations (Na^+, K^+, Ca^{++} and Mg^{++}) decreased when *A. persicus* migrated from brackish water of the Caspian Sea to freshwater river (Table.1), but this reduction was not regular and had not any correlation with fluctuations of osmotic pressure and water ion concentrations. Although salinity is proved to be the most important environmental factor influencing functionality of osmotic and ionic regulation in different species (Krayushkina *et al.*, 1996b), it is not the sole factor.

Previous studies have also shown that ecological condition alone could not determine osmotic pressure of blood serum in sturgeons. Therefore, the great sturgeon (*Huso huso*), *A. stellatus* and *A. gueldenstaedtii* living in similar environmental conditions, showed different blood serum osmotic pressure and ion concentrations; the blood serum osmolarity of *H. huso* was 262±35.3 mosmol/l, and those of *A. stellatus* and *A. gueldenstaedtii* were 253±2.6 and 267±1.8 mosmol/l respectively (Methalov, 1977). In this study mean blood serum osmolarity of *A. persicus* was 305.29±14.33 mosmol/l (Table 1). Therefore, it could concluded that individual specific characteristics of sturgeon could be one of the most important factors in determination and regulation of blood serum

osmolarity and ionic concentrations, that was used to study the evolution of sturgeon blood serum ionic and osmoregulation systems.

Comparative analysis of data on osmotic pressure of blood serum and ionic concentrations of *A. persicus* in diverse water bodies showed that Persian sturgeon is hyper-osmotic in brackish water life stage and hypo-osmotic in sea water life stage and employs special osmoregulatory mechanisms for adaptation during its migration from saline water to freshwater and vice versa (Krayushkina, 1996b).
In this study the highest fluctuation in individual blood serum osmolarity of *A. persicus* appeared in the estuary (Table 1), where the highest salinity fluctuations occur. As sturgeons migrate from sea to river, an increase in blood serum osmotic pressure occurs. Within several days this pressure is decreased and stabilized at certain level.

Studies on blood serum osmotic pressure and ionic concentrations in male and female *A. gueldenstaedtii*, *A. stellatus* and *H. huso* showed that there were no differences in factors mentioned above between sexes (Methalov, 1977). Statistical analysis of our data also showed no significant differences in blood serum osmolarity and ionic concentrations between males and females of Persian sturgeon.

The analysis of data which showed the osmotic pressure and ionic concentrations of blood serum, in one and two years old sturgeon cultured in freshwater (fiberglass tanks) were less than the adult sturgeon (adapted to Kouraneski freshwater ponds), which might show their longer adaptation to freshwater has negative effect on their survival. One and two years old *A. persicus* like other sturgeon of the Caspian Sea are capable of regulating its blood serum osmolarity and ionic concentrations in variable salinities, while reared juveniles of Shovelnose sturgeon lack this capability as they do not have any mechanism of osmoregulation (Krayushkina *et al.*, 1996b).

Methalov (1977) evaluated blood serum osmolarity of three sturgeon species in the north and central Caspian Sea and showed that Na^+ was the most important and effective ion for determination of blood serum osmotic pressure, especially in the marine environment. In this study, the Pearson's

correlation coefficient and regression equation indicated that Ma^{++} and Na^{+} were the most important and effective ions for controlling blood serum osmotic pressure of *A. persicus* in brackish and freshwater, respectively. However, Ma^{++} and Ca^{++} are determinative elements of blood serum osmolarity, especially in sturgeons reared in fresh water.

It can be concluded that Mg^{++} and Na^{+} are effective ions for determination of blood serum osmotic pressure in *A. persicus* in brackish and freshwater, and blood serum osmotic pressure is independent of sex. Also, this study shows that Persian sturgeon is hyper-osmotic in brackish water life stage and hypo-osmotic in seawater life stage. The changes of blood serum osmotic pressure and ion concentrations of this fish in both fresh and brackish waters were less than their environmental changes.

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