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Metal accumulation in Caspian sturgeons with different feeding niches, condition factor, body size and age

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ABSTRACT

The present study investigated metal accumulation in the muscle of the Caspian sturgeons, *Acipenser nudiventris*, *Acipenser persicus*, *Acipenser stellatus* and *Huso huso* with different feeding niches, condition factor, body size and age, sampled in the spring of 2014, using an ICP-OES (Shimadzu). We used redundancy analysis to examine relationship between metals concentrations and the measured variables in the species. *Huso huso* specimens tended to have a higher concentration of Ba, Cr, K and Mn relative to the other species. Most metals had positive correlations with the body length, weight and age. Condition factor was not correlated with other parameter measured. The mean concentrations of the measured metals in muscles were higher than those of previous studies of sturgeons from the Caspian Sea suggesting increased pollution. The present study suggests that non-dietary sources of metals may play an important role in the accumulation of metals in the muscles of sturgeons.

1. Introduction

There are 17 families of fishes in the Caspian Sea [1]. Of those present, Acipenserids are the most valuable fishes. There are over 20 species of sturgeons worldwide with four having high commercial values being found in the Caspian Sea, i.e., the Ship sturgeon (*A. nudiventris*), the Persian sturgeon (*A. persicus*), the stellate sturgeon (*A. stellatus*) and the beluga sturgeon (*Huso huso*) [2].

Sturgeon catches in the Caspian Sea have been decreasing [3]. Sturgeon populations are being harmed by two major anthropogenic factors: over-fishing and degradation of habitats by the construction of dams across rivers and/or river modifications [4]. Contamination of the Caspian Sea is increasing. It received about 100.000 t of oil, 1500 t of Cu, 800 t of phenol and unknown amounts of metals each year between 1986 and 1990 [1]. Chemical contaminants can drastically decrease wild stocks through a change in fish physiology, oogenesis, muscle atrophy and hepatotoxicity [4].

The sturgeon species of the Caspian Sea are separated in terms of feeding niche and age. Ship and Persian sturgeon are zoobenthivores with medium age among other Caspian sturgeons, stellate sturgeon is mainly zoobenthivore although nektons are included in its diet and they have the shortest lives among the sturgeons. The beluga sturgeon is piscivorous with the longest life [5]. Accumulation of metals in fishes is highly influenced by feeding mode [6], and trophic position [7,8]. In this respect, diet is considered to be an important factor. Since most sturgeons rely on benthic organisms [4], this feeding characteristic may put them at risk given that there are several studies on the accumulation of pollutants in Caspian Sea sediments [9–11]. Among various chemical contaminants, the major threat may stem from metals since they do not decompose in tissues [12]. Over the last decade the level of pollution has increased in the Caspian Sea [9,11]. Many of the pollutants have a relatively long residence time [12]. The Caspian Sea is a landlocked body of water, hence, a progressive accumulation of pollutants is expected which is a major threat to both human health and the fisheries industry.

The Caspian Sea is impacted by wastes originating from agricultural, industrial and urban life. It is known that sturgeons will reflect some of these pollution parameters i.e., higher metal content, because of their nutritional characteristics and long life. There are some studies investigated the accumulation of metals in sturgeons dating back to over a decade ago (Table 1). Most studies have examined effects of anthropogenic activities on metal concentrations in various tissues or aimed to compare concentrations of metals in the body with those of standards developed for human consumption. Influences of feeding regime, body weight, length and age on metal accumulation in body tissues have been rarely been studied in sturgeons.

Hence, the present study investigated the effects of species and, in particular, feeding mode, body length, weight and age on the accumulation of metals in Caspian sturgeons, which are widely consumed

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Table 1
A review of studies on metals concentrations measured in different tissues of fishes, with various techniques and objectives.

Species	Tissue	Metal	Technique	Objective	Reference
Acipenser persicus, *Acipenser stellatus*, *Huso huso*	Caviar, muscle, liver, kidney, gills, ovary, heart	Cd, Pb, Zn	Flame and graphite furnace atomic absorption spectrophotometry	Analytes in caviar and muscles were compared with MAFF's standards	[31]
Acipenser persicus	Caviar, muscle	Cu, Mn, Zn	Atomic absorption spectroscopy	Analytes concentrations were compared with those of other studies	[31]
Acipenser persicus	Caviar	As, Co, Cr, Fe, Pb	Inductively-coupled plasma-optic emission spectroscopy	Analytes concentrations were compared with FAO/WHO permissible limits	[32]
Alosa immaculata	Muscle, liver, gill	B, Ba, Co, Cr, Cu, Fe, Li, Mg, Mn, Mo, Ni, Pb, Sr, Zn	Inductively-coupled plasma-optic emission spectroscopy	Investigating patterns of the analytes distribution among the tissues	[33]
Acipenser oxyrinchus desotoi	Blood, muscle	As, B, Ba, Be, Cd, Cr, Cu, Fe, Hg, Mg, Mn, Ni, Pb, Se, Zn	Inductively coupled plasma emission	Investigating effects of anthropogenic activities on the analytes concentration in the blood and muscle	[34]
Acipenser transmontanus	Muscle, liver	Hg		Investigating effects of anthropogenic activities and potential of bioaccumulation	[29]
Acipenser gueldenstaedtii, *Acipenser nudiventris*, *Acipenser persicus*, *Acipenser stellatus*, *Huso huso*	Muscle	Ag, Ba, Bi, Cd, In, Co, Cr, Cs, Cu, Ga, Hg, Mn, Mo, Pb, Rb, Sb, Sn, Sr, Tl, V, Zn	Inductively coupled plasma-mass spectrometry, cold vapor atomic absorption spectroscopy	Examining effects of species, location and growth on metals concentrations in muscles	[28]
Acipenser stellatus, *Acipenser nudiventris*, *Acipenser persicus*, *Acipenser guldenstaedti*, *Huso huso*	Muscle	Ag, Ba, Bi, Cd, Co, Cr, Cs, Cu, Ga, In, Mn, Mo, Pb, Rb, Sb, Sn, Sr, Ti, V, Zn	Inductively coupled plasma-mass spectrometry	Concentrations of heavy metals were compared with those of the guidelines developed for human consumptions	[12]
Acipenser transmonatus	Gonad, liver, muscle	Hg	Cold vapor atomic fluorescence spectroscopy	Assessing the relationship between tissue mercury concentrations and various physiologic parameters	[19]

because of their flavorful flesh. This paper also provides updated information on metals in their muscles so appropriate public health decisions can be made.

2. Materials and methods

2.1. Preparation of samples

Twenty four specimens (six individuals of each of the four species) were collected in the spring of 2014 from the largest sturgeon fishing station (Babolsar) in Iran (36° 42′ 26″ E, 52° 38′ 35″ N; Fig. 1) where all the sturgeons caught in the Iranian Caspian Sea along a 320–345 km stretch of shoreline are landed [13]. The total length and weight of each fish were measured to the nearest 0.01 cm and 0.1 g, respectively. The age was determined using the first ray the pectoral fin [14]. Dorsal muscle was sampled (15 ± 1 g) from each fish using a clean plastic knife at a position posterior to the head and close to the dorsal fin [13], put in a plastic bag, kept in ice, transferred to the laboratory within 1 h and stored at −20 °C for up to a week for later analyses. Special care was taken to prevent metal contamination of the samples by the hauling and laboratory equipment. All laboratory equipment and glassware were soaked in 2 M HNO_3 for 24 h, and rinsed three times with distilled water, and then three times with de-ionized (Milli-DI, Merck Millipore) water prior to use.

Each sample was analyzed three times for Ba, Ca, Co, Cr, Cu, Fe, K, Mn and Zn using inductively coupled plasma-optical emission spectrophotometer (ICP-OES; Optima 2100DV, Perkin Elmer Inc., Waltham, MA, USA). The instrumental parameters have been provided in Table 2.

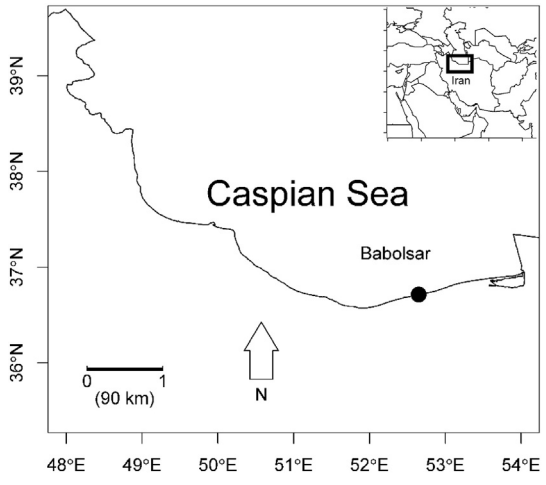

Fig. 1. Map of the Caspian Sea showing the area of sample collection. (●) Babolsar sturgeon fisheries, Mazandaran catch area.

Table 2
ICP-OES instrumental parameters.

Parameters	Information [reference]
RF generator power (W)	1200 [35]
Plasma flow rate ($L\ min^{-1}$)	15 [36]
Auxiliary gas flow rate ($L\ min^{-1}$)	0.2 [36]
Nebulization gas flow rate ($L\ min^{-1}$)	0.8 [36]
Sample flow rate ($1.5\ mL\ min^{-1}$)	1.5 [36]
Chamber type	Cyclonic
Nebulizer type	Pneumatic nebulizers
View of observation	Axial
Wavelength (nm)	Ba: 455.403, Ca: 317.933, Co: 228.616, Cu: 327.393, Cr: 267.716, Mn: 257.610, Zn: 206.200, K: 404.721, Fe: 236.204