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# Food Habits of Stellate Sturgeon, *Acipenser stellatus* Pallas, 1771, in South-Eastern Parts of the Caspian Sea, Iran

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**Abstract:** One hundred and thirty-five specimens of *Acipenser stellatus* were collected from the fishery stations of Babolsar, Farahabad and Bandar-e-Torkaman, south-eastern Caspian Sea between the winter of 2001 and spring 2003. The content of the alimentary canal was studied fresh, prey items were separated and then fixed in 10% formalin for identification. The probability percentage and frequency of various prey items, the percentage of empty stomachs along with prey dominance were calculated. Nine of the registered food items were considered to be the principle and dominant food items and had very high importance as demonstrated by the dominance index. The percentage of alimentary canal emptiness in spring was lower than that in other seasons. Seasonal changes in food composition were observed. ANOVA analysis showed no significant difference of prey preference among sampling sites while we found significant differences among seasons.

**Key words:** Feeding preferences, *Acipenser stellatus,* Caspian Sea

## Introduction

For centuries, sturgeons have been of economic importance because of their meat and eggs (caviar); they are among the most important and valuable species in the Caspian Sea (Haddadi *et al.* 2009). Six species of sturgeons have been identified in the Caspian Sea: beluga (*Huso huso*), Persian sturgeon (*Acipenser persicus*), Russian sturgeon (*A. gueldenstaedti*), ship sturgeon (*A. nudiventris*), stellate sturgeon (*A. stellatus*) and starlet (*A. ruthenus*) (Haddadi *et al.* 2009). Recent decline of the population of *A. stellatus* due to overfishing and water pollution has triggered a change in species status in the IUCN Red List to critically endangered. Sturgeon fishing without approved license is forbidden in many countries, including Iran (Mousavi & Ghafor 2014; IUCN 2016). Unfavourable environmental conditions and increasing river pollution have imposed deleterious impacts on the composition and abundance of aquatic populations, including sturgeon stocks (Mousavi & Ghafor 2014; IUCN 2016). Since knowledge of the feeding habits of endangered species and determining the dominant diet composition are very important in conservation planning, we studied the stellate sturgeon feeding preferences to find its dominant feeding items. Physiological and anatomical properties of the species digestive system are adapted to its feeding behaviour. The amount and type of food items found in their digestive tract depends on several factors, such as the specific food chain, seasonal variation of food items, and the size and digestibility of the food items (Holcik 1989; Chechun 1998). Stellate sturgeons stop feeding after the beginning of the spawning migration. After spawning, they return downstream into the sea where they begin feeding actively. The juveniles of stellate sturgeon also migrate into the Caspian Sea for feeding (Mousavi & Ghafor 2014; IUCN 2016). The feeding area in the Caspian Sea extends from the shallow water area of the northern part of the sea to the Iranian coast. The present investigation is aimed at determining the feeding habits of *A. stellatus* and different types of main and secondary prey consumed by the fish caught in southeast parts of the Caspian Sea.

## Materials and Methods

We examined stomach content of 135 individuals caught from the south-eastern parts of the Caspian Sea in 2001-2003. The specimens were sampled from three fishery stations: Babolsar, Farahabad and Bandar-e-Torkaman. During the examination period, the sampling stations were visited every month and the specimens were transferred to the lab in portable freezing tanks. Morphological properties of the specimens including sex, weight, total length, fork length and the presence of caviar were recorded. The percentage occurrence (%F) and the relative abundance (%A) of the prey type i were calculated using the following equations (Kasymov 1994):

$$\%F_i=\left(\frac{Ni}{N}\right)\times 100$$

$$\%A_i=\left(\frac{\sum Si}{\sum St}\right)\times 100,$$

where $N_i$ is the number of predators with i^th^ prey in their stomach; N – total number of predators with stomach content; Si – stomach content (prey number) of i^th^ prey; St- total stomach content of all stomachs in the entire sample.

Determination of the main food, the secondary and accidentally prey, were done following Amundsen *et al.* (1996):

$$F_p=\frac{Np\times 100}{Ni},$$

where $F_p$ is the frequency of prey p; $N_p$ – number of stomachs with prey p; $N_i$ – number of full stomachs: accidental ($F_p$< %10), secondary (%10<$F_p$ < %50) and main food source($F_p$> %50)

The following formula was used to calculate the rate of the accessibility of fish to the prey (Biswas 1993):

$$V=\frac{Ev\times 100}{N},$$

where V is the percentage of empty stomachs; Ev – number of empty stomachs that has been studied; N – number of stomachs that has been studied.

The feeding frequency was calculated following the formula (Haddadi *et al.* 2009):

$$C_n=\frac{A\times 100}{B},$$

where $C_n$ is the feeding frequency; A – number of prey items in each stomach; B – number of different types of prey items in all studied stomachs.

Dominance index was calculated following Euzen (1987):

$$I_p=\frac{ViOi}{\sum(ViOi)},$$

where Ip is the dominance index; $V_i$ – frequency percentage of the consumed food items; $O_i$: percentage of the consumed food items counted;

In evaluating the nutritional composition of species, the dominance index is used for the categorisation of prey according to the mathematical dominance within food sources (Marshall & Elliott 1997). These parameters were studied for stellate sturgeon (*A. stellatus*) from the southeast parts of the Caspian Sea in different seasons. ANOVA was used to determine significant differences among the sites and seasons based on prey abundance and diversity.

## Results

We found *Neogobius*, digested fish (further referred to as "fish"), Corophiidae, Mysidae, Bivalvia, Xanthidae, *Nereis*, *Balanus* and Asellota in the stomach content of the studied specimens of stellate sturgeon (Table 1). According to the results obtained in spring, Bivalvia and *Neogobius* had the highest relative abundance (%A), while Bivalvia and fish had the highest percentage occurrence (%F). In autumn, Mysidae and *Neogobius* had the highest relative abundance, while fish, Mysidae, and Xanthidae had the highest percentage occurrence. In winter, Corophiidae and *Nereis* had the highest relative abundance, while fish and Corophiidae had the highest percentage occurrence. In addition, Bivalvia was the main prey; *Neogobius* and fish were determined as the secondary food sources. Other preys (Table 1) were determined as the casual food in spring. In autumn, *Neogobius*, fish, Bivalvia and Xanthidae were determined as the main prey of stellate sturgeon. In winter, fish was the main food source, while Corophiidae, Xanthidae, *Neogobius*, *Nereis*, *Balanus*, Asellota and Bivalvia were determined to be secondary food sources (Table 1). Furthermore, Bivalvia had the highest relative abundance at Babolsar fishery stations, *Nereis* at Farahabad and *Neogobius* at Bandar-e-Turkaman. Generally, fish was the main food source at all three stations (Table 2).

The dominance index was examined in spring. Fish (digested) and *Neogobius* were dominated in autumn, Mysidae and *Neogobius* in winter, and Corophiidae and digested fish in spring (Table 1).

The percentage of empty stomachs was higher in winter than in other seasons (Table 3).

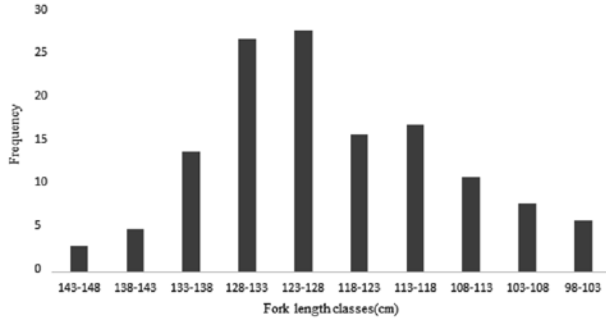


**Fig. 1.** Fork length classes of examined fish individuals and their frequencies in the present study

**Table 1.** Seasonal dynamics of food of *Acipenser stellatus* from the southeast coast of the Caspian Sea. The percentage of occurrence (%F) and relative abundance (%A) of prey type i and dominance index ($I_p$) of *A. stellatus*, $\%F_i = F_p$; $\%A_i = C_n$; N is the number of examined stomachs

| Prey items \ Seasons | Spring, N= 99 | | | Autumn, N= 4 | | | Winter, N=32 | | |
|---|---|---|---|---|---|---|---|---|---|
| | $\%F_i$ | $\%A_i$ | $I_p$ | $\%F_i$ | $\%A_i$ | $I_p$ | $\%F_i$ | $\%A_i$ | $I_p$ |
| Gobiidae, *Neogobius* | 18.18 | 25.53 | 0.3 | 50 | 33.33 | 0.33 | 28.57 | 11.11 | 0.103 |
| Fish (digested) | 36.36 | 17.02 | 0.4 | 50 | 11.11 | 0.11 | 57.14 | 14.81 | 0.28 |
| Corophiidae: *Corophium nobile* *Corophium spinulosum* | 9.09 | 2.13 | 0.013 | 0 | 0 | 0 | 42.86 | 22.22 | 0.31 |
| Mysidae: *Paramysis/ Mysis* | 0 | 0 | 0 | 50 | 44.44 | 0.44 | 0 | 0 | 0 |
| Bivalvia, Cardiidae *Cerastoderma lamarcki* Scrobiculariidae: *Abra ovata* | 50 | 29.78 | 0.14 | 0 | 0 | 0 | 14.29 | 3.7 | 0.017 |
| Xanthidae: *Rhithropanepeaus harrasii* | 9.09 | 10.64 | 0.063 | 50 | 11.11 | 0.11 | 28.57 | 14.81 | 0.14 |
| Nereidae: *Nereis diversicolor* | 9.09 | 12.77 | 0.075 | 0 | 0 | 0 | 14.29 | 18.52 | 0.086 |
| Balanus | 0 | 0 | 0 | 0 | 0 | 0 | 14.29 | 11.11 | 0.052 |
| Asellota, Janiridae: *Jaera* | 4.55 | 2.13 | 0.0063 | 0 | 0 | 0 | 14.29 | 3.7 | 0.017 |

**Table 2.** Food of *Acipenser stellatus* from the southeast coast of the Caspian Sea at different stations. The percentage occurrence (%F) and the relative abundance (%A) of i[th] prey, $\%F_i = F_p$; $\%A_i = C_n$

| Preys \ Stations | Babolsar, N=101 | | Farahabad, N=21 | | Bandar-e-Torkaman, N=13 | |
|---|---|---|---|---|---|---|
| | $\%F_i$ | $\%A_i$ | $\%F_i$ | $\%A_i$ | $\%F_i$ | $\%A_i$ |
| Gobiidae: *Neogobius* | 16.67 | 20.45 | 0 | 0 | 75 | 64.29 |
| Fish (digested) | 37.5 | 22.73 | 60 | 12.5 | 25 | 7.14 |
| Corophiidae: *Corophium nobile; Corophium spinulosum* | 8.3 | 4.55 | 40 | 20.83 | 0 | 0 |
| Mysidae: *Paramysis mysis* | 4.17 | 6.82 | 0 | 0 | 0 | 0 |
| Bivalvia, Cardiidae *Cerastoderma lamarcki* Scrobiculariidae: *Abra ovata* | 45.83 | 31.82 | 40 | 8.3 | 0 | 0 |
| Xanthidae: *Rhithropanepeaus harrasii* | 8.3 | 4.55 | 40 | 20.83 | 25 | 21.43 |
| Nereidae: *Nereis diversicolor* | 4.17 | 2.27 | 40 | 41.67 | 0 | 0 |
| Balanus | 4.17 | 6.82 | 0 | 0 | 25 | 7.14 |
| Asellota, Janiridae: *Jaera* | 4.17 | 2.22 | 0 | 0 | 0 | 0 |

**Table 3.** The percentage of empty stomachs of *Acipenser stellatus* in south-eastern parts of Caspian Sea

| Season | Spring | Autumn | Winter |
|---|---|---|---|
| Percent | 49.49 | 50 | 62.5 |
| Number of gut analyzed | 99 | 4 | 32 |

Analysis of Variance showed that there was significant difference among the seasons in prey selection (ANOVA: F= 64.22, P<0.05) while the prey preference showed no significant differences between sampling sites (ANOVA: F= 45.11, P>0.05).

# Discussion

Data on the diet composition of the Caspian fishes are scanty and almost exclusively limited to the northern Caspian Sea. Over the last 50 years, some new species of benthic invertebrate were introduced into the Caspian Sea; the abundance of *Hypaniola kowalewskii* and the biomass of *Nereis diversicolor* have become dominant (Marshall & Elliott 1997). The present study showed that these species had less importance than preys like Gobiidae and Bivalvia for the feeding of the stellate sturgeon. Data collected on the feeding regime of breeders from the fishery stations at the southern shores of the Caspian Sea indicate that gobiid fishes and bivalves are the main prey for *A. persicus,* while mullets, crabs and herring were secondary prey (Bordit 1994; Abhari & Tavakkoli 1999; Hajimoradloo *et al.* 2002) At sea, fish constitute a large part of the food for the younger age groups of Persian sturgeon (Chechun 1998). As the Persian sturgeons grow, their feeding becomes more selective, with increased role of larger food items and gobiid fishes. This can be due to the high density and slow movement of gobiid fishes (Mousavi & Koutanaei 1984) in the Caspian Sea which makes them an easy prey.

In spring, Mysidae and *Balanus* were not found in the stomachs of stellate fish, while in autumn Corophiidae, Bivalvia, *Nereis*, *Balanus* and Asellota were also absent. In winter, Mysidae did not participate in the diet of stellate sturgeon. These findings could be an indicator of the low abundance of this prey during the corresponding season. Seasonal changes are also characteristic for the Persian sturgeon diet, i.e. in spring the main food items are gammarids and fishes, and in summer are gammarids and cumaceans (Ivanov *et al.* 1997). According to the result of the present study, the percentage occurrence (%F) and the relative abundance (%A) of prey items of the stellate sturgeon also differ between seasons.

Our results demonstrate that the most numerous fishes with empty digestive system are recorded in winter, which suggests that the temperature is a limiting factor in the feeding of the stellate sturgeon. Temporary changes in the diet of young sturgeons may be linked to their seasonal migrations (Zolotarev 1996). We recorded a high percentage of fishes with empty digestive systems even in the spring, likely owing to the low density of invertebrates in this season. Out of the 135 fish examined, 71 had a completely empty stomach, representing c. 50% of examined individuals in spring. According to Rochard *et al.* (2001), the differences in the frequency of food items in the fish digestive tract are reflecting their distribution and abundance in the studied region. The feeding intensity of fish is influenced by several factors such as feeding grounds, season, water temperature, distribution pattern and the density of food items (Nikolskii 1963; Rochard *et al.* 2001). Our findings also confirmed these observations relative to the stellate sturgeon in the south-eastern parts of the Caspian Sea.

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