# COMPARATIVE ANALYSIS OF CHEMOSENSORY SYSTEMS

# IN FEEDING BEHAVIOR OF STURGEONS

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## Introduction

In most fish species the main source of information about the presence, localization and qualitative features of food organisms is vision. In sturgeons visual reception is not functionally well developed and allows only the distinction of sharp variations in illumination and large moving contrasting objects. Sturgeons. At such fishes, having functionally extremely poorly advanced vision, to which concern many bottom, deep-water and cave fishes and fishes with night peak of activity the large development received the chemosensory systems, first of all olfaction and taste (Kleerekoper, 1969). As was shown (Pevzner, 1981; Pjatkina, 1991; Devitsina, Kazhlaev, 1995, etc.) sturgeons have a well-developed olfactory organ as well as both external and intraoral taste buds.

Olfaction is the main distant sense enabling sturgeon to receive the information concerning the food presence (Pavlov et al., 1970) or presence of ripe male and female are ready for spawning (Kasumyan, 1993). Extraoral and intraoral taste systems play very significant role in latest stages of feeding behavior in which sturgeon as other fish estimate the palatability of food items.

During last less than 10 years it was performed intensive investigations of olfactory, extraoral and intraoral taste sensitivity different acipenserid species to many natural and art chemical stimuli - water extract of living food organisms and both artificial feeds and their components, free amino acids and classical taste substances (Kasumyan, 1992, 1994, 1995; Kasumyan et al., 1992, 1993, 1995; Kasumyan and Kazhlaev, 1993; Kasumyan and, Taufik, 1994) . In all these studies it was used original methods based on fish feeding behavioral responses. In present paper it will be compare the behavioral responses and functional peculiarities of olfaction, extraoral and intraoral taste systems in different species belonging to family *Acipenseridae.*

## Materials and methods

The subject of our investigations were Russian sturgeon, *Acipenser gueldenstaedti,* Siberian sturgeon, *A. baeri,* stellate sturgeon, *A stellatus,* green sturgeon, *A.medirostris* and hausen, *Huso huso.* It was used the hatchery fish of several age-groups, beginning with larvae at the stage of mixed feeding and ending with juveniles at the age of yearling. For the control of food

consumption motivation (feeling of hunger) fish were feed with living chironomid larvae only once a day after finishing the experiments.

**Olfaction.** The individuals (6-10 specimens) were permanently kept in special aquaria or basins with closed water closed circulation and a biological water-cleaning filter. From the biofilter the water went into parallel compartments of the aquarium constantly and at equal speed. In the course of the experiment the supply of clean water in one of the compartments was replaced by the test solution for 2-3 minutes.

The intensity of the fish behavioral responses was estimated on a 5-point scale which took into account the degree of disturbance of the initial organization of the fish in the aquarium, their ability to localize the compartment with the test solution, and their display of special behavioral patterns. The procedure of the experiments, evaluation of the intensity of the observed behavioral responses, deprivation of the sense of smell and the features of keeping the test fishes are detailed in (Kasumayn and Kazhlaev, 1993; Kasumyan and Taufik, 1993).

**Taste.** About 10-15 minutes before the start of the experiment some 5-10 fishes were placed in a rectangular aquarium with low depth of water (5 cm). Then 50-100 special food pellets containing any one of the test substances were introduced in the middle of the aquarium and the acts of bites the pellets were recorded for 5-10 minutes. This indicator was regarded as the extra-oral taste response of the fish since sturgeons grab only after preliminary touching of the pellet with barbels bearing external taste buds. After the experiment the remaining pellets were counted. As criterion reflecting the intensity of the intraoral taste response we used the percentage of consumed pellets per number of bites acts. The size of the aquarium, water level, the number of fish, the number of placed pellets and their size and shape, the duration of the experiment were the same in all experiments of the same series.

The pellets were prepared from either starch (12%) or agar-agar (2%) gels. After dissolving, starch or agar-agar solutions were added the day and one of test substances. Shortly before the experiment pellets were cutted out from cool gel using stainless steel tube. The pellet size was altered in accordance with fish body length. A detailed outline of the techniques employed is presented before (Kasumyan, 1992; Kasumyan and Kazhlaev, 1993; Kasumyan and Sidorov, 1995).

Free amino acids (l-isomers), water extracts and exometabolites of live daphnia, *Daphnia pulex,* or chironomid larvae, *Chironomidae,* two sturgeon's artificial feeds (ST-4Az, ST-07) and their 17 components (fish meal, krill meal, squid meal, PVF yeast, etc.) were used as olfactory stimuli. Free amino acids (l-isomers), classical taste substances and water extract of live chironomids larvae and were used as taste stimuli.

## Results

**Olfaction.** The water extract and exometabolites of living food organisms were strong olfactory ecitants provoking the fish to display the specific food search response. This response is rather similar by its manifestation in the all five sturgeon species and consists in quick (after a few seconds) transition of the specimens to swimming only near the aquarium bottom, in the zone where the maximum concentrations of the food odor are created. Having sunk to the bottom the fish starts moving actively along searching trajectories in the form of circles and "S"-shape loops, their size being similar to the fish body length. In the process the fish touches surface of the bottom with their barbels and performs quick testing act - bites on the surface of

the bottom. When moving along the searching trajectories , scouring was observed in the fish, i.e. successive removals by the body's fore part in a horizontal plane to both sides from the main direction of the motion. Scouring enabled the fish to cover a rather wide stripe, when moving, and owing to it, to investigate quickly and in detail bottom surface. After 30-60 seconds all specimens gathered near the compartment where the extract solution was added. The response was short by time (3-5 minutes) and strong depended on extract concentration. The chironomid larvae extract threshold was $10^{-4}$ g/l for juveniles of Russian sturgeon, Siberian sturgeon and stellate sturgeon.

This strong and remarkable behavioral response of sturgeons to extract of living food organisms is fully lost in olfactory deprivated specimens. So, the ability of sturgeons find the food by the chemical signals emanated from prey is based on olfaction.

Free amino acids are common chemical substances in exometabolites of various hydrobionts, solution many of amino acids induces food search behavior in different fish species. Only two amino acids from 20 were tested - glycine and alanine - exerted a behavioral effect for most sturgeon species were used: glycine ($10^{-4}$ M) promoted an intense reaction in all five species of sturgeon, and alanine in the same concentration did so in the Russian sturgeon (8-10 cm in body length), Siberian sturgeon (8-12 cm) and stellate sturgeons (9-12 cm). For the hausen (15-20 cm) alanine was indifferent; in experiments with green sturgeon (30-40 cm) this amino acid was not used. The threshold concentrations of glycine and alanine were determined for Russian and stellate sturgeons at $10^{-6}$ M for both. The response pattern of sturgeons to effective amino acids was the same as to water extract of living food organisms. This is the clearly indicator for the signaling significance of these two amino acids. The anosmic sturgeons by cauterization of the olfactory rosettes completely loss the ability to react to glycine ($10^{-4}$ M), showing that the response of the intact fish to the amino acid solutions is ensured exclusively by olfaction.

**Taste.** It was shown that a large proportion of free amino acids give a significant increase in the number of pellets grabs - 14 from 19 for the Siberian sturgeon (4-6 cm in body length), 16 from 21 for the Russian sturgeon (6-7 cm) and 19 (!) from 21 for the stellate sturgeon (6-8 cm). Common to all three sturgeon species were 12 amino acids although the correlation coefficient was high only for Russian-stellate sturgeon pair ($r=0.84$; $p<0.001$). The greatest effectiveness for extraoral taste sensitivity of these two fish species was displayed by aspartic and glutamic acids and cysteine and for Siberian sturgeon - asparagine, threonine and methionine. Only two amino acids - proline and tyrosine - were ineffective for all three species.

The spectra of the effective amino acids for the intraoral taste sensitivity were far narrower. Significant increase in the relative consumption of pellets was given only by 3 amino acids in stellate sturgeon, 6 - in the Russian sturgeon and 7 - in the Siberian sturgeon, 1 amino acid (alanine) having a deterrent effect for last species. Among amino acids stimulating consumption of the pellets there was nothing common to all three species nor were significant correlations discerned between species in term of the intraoral taste responses to the amino acids.

Comparison of the extraoral and intraoral taste responses within one species revealed a high correlation in the Russian ($r=0.76$; $p<0.001$) and lower correlation in the Siberian ($r=0.47$; $p<0.05$) and stellate ($r=0.49$; $p<0.05$) sturgeons.

Extracts of 13 from 17 components included into agar-agar pellets provoked the significant increase in the number of pellet bites for stellate sturgeon. Fish protein concentrate, PVF enzymated yeast and premixes had the highest activity for extraoral taste sensitivity of stellate sturgeon. Five components (PF-2V premix, krill meal, fish protein concentrate, Eprin yeast and

couarsely cut soya-bean) had a stimulatory effect on intraoral taste receptors of fish. Fish meal stabilized by various antioxidant had different olfactory, and especially, extraoral and intraoral taste attractiveness.

**Discussion**

Thus it was establish that in different sturgeon species the olfactory spectra of the amino acids which evoking the search feeding behavior in fish largely concur both in breadth and composition. In sturgeons this spectrum is a very narrow, in most fish species now was investigated olfactory amino acids spectrum induced feeding behavioral responses is far broader (Jones, 1992). Glycine and alanine, effective in the case of the sturgeon, exert, as a rule, a behavioral effect also on a number of other species belonging to different systematic and ecological fish groups. However, for many fish species these two amino acids do not possess maximum activity as compared with other amino acids, for some species glycine and alanine are in behavioral terms inert.

Absence of appreciable species specificity of the behavior of fish to the odorous properties of free amino acids sharply contrasts with the fundamental species differences in the taste responses to free amino acids demonstrated by us in the same sturgeon species. The extraoral and intraoral taste sensitivity of the sturgeons sharply differ in the breadth of the spectrum of effective stimuli although they correlate well within the same fish species. The interspecies differences in the taste responses to the amino acids are considerable, especially in the case of intraoral taste sensitivity so suggesting clearly pronounced species specificity of the set of taste receptors and their tendency towards perception of different spectra of taste stimuli even in closely related species.

The result is that the same substances not only differ significantly in their taste qualities for the different sturgeon species but give responses diametrically opposed in character. For example, alanine displayed the most marked stimulating action in the stellate sturgeon, whereas it had a deterrent effect on the Siberian sturgeon including significant rejection of the captured pellets with this amino acid. Aspartic acid was one of the most palatable amino acid for Russian sturgeon and, in the same time, was ineffective stimuli for Siberian and stellate sturgeon.

The species specificity is the highest for the olfactory system followed by the external and intraoral taste systems. The biological significance of the different degree of definition of the species specificity in the olfactory and taste sensitivity of sturgeons to chemical stimuli resides in the different roles of these two types of chemosensory systems in the feeding behavior of fish. It is known that olfaction is a distant sense organ ensuring orientation and search by the fish for remote sources of the odor (Atema, 1980; Pavlov and Kasumyan, 1990). Many of free amino acids form part of exometabolites of hydrobionts and these substances are the natural odor markers of food organisms. The resemblance of the olfactory sensitivity to free amino acids in sturgeons like in many other fish species leads of different species to the site favorable for feeding. Then, in the next stages of the feeding behavior on the basis of taste reception the quality of the prey and its correspondence to the species food requirements of the fish are more finely evaluated. The high degree of species specificity of extraoral and, especially, intraoral taste spectra in sturgeons reflects the different food specialization of the fish species and the difference in the spectra of the objects of feeding preferred by them.

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