

# SMITHSONIAN MISCELLANEOUS COLLECTIONS

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## THE ARCHER-FISH AND ITS FEATS

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A group of fishes of great interest on account of a most remarkable feat of which some at least are capable is that of the family called *Archer-fishes* or *Toxotids*. These have a characteristic form; the contour is mostly of the rhomb-oval type, but from the middle of the back and front of the dorsal fin there is a downward slope, which is sometimes in so straight a line that the front half of the fish looks as if it may have been planed off. The head is conical, the mouth deeply cleft, so that its front is in the same line as the decline of the snout; the upper jawbones (*maxillaries*) are unusually narrow, and the lower jaw projects. The eyes are very large, lateral, convex, variously mobile and in the type species at least the irises are golden-yellow. The dorsal fin is set far backward and has only 4 or 5 stout spines and a short soft portion. Other characteristics will be noticed in the account of the habits of the best known species. All the known species belong to a single genus—*Toxotes*.

The osteological characters are so significant that a few points may be noticed. The skeleton in its essential characteristics is of the percoidean type, but the vertebral column is almost quite straight, the neural spines have low set bases of insertion and the ribs are inserted directly and rather high up on the centra of the vertebræ behind parapophyses on the third and succeeding vertebræ; the recession of the dorsal fin backwards is coördinated with extremely receding interneurals and with three free styliform interneurals in front; the suborbital chain is narrow and without a subocular shelf.

### I

The *Toxotids* are mostly inhabitants of the littoral waters and mouths of rivers of southern and southeastern Asia and numerous outlying islands from India to Polynesia. In brackish waters some

seem to be quite at home, and Zolotnitsky, who had living specimens sent from Singapore to Russia, thought that water with about one per cent of salt was most congenial to the fishes he was cultivating. Nevertheless, they seem, from the testimony of many others, to be equally well accommodated in ordinary salt water. There may be a

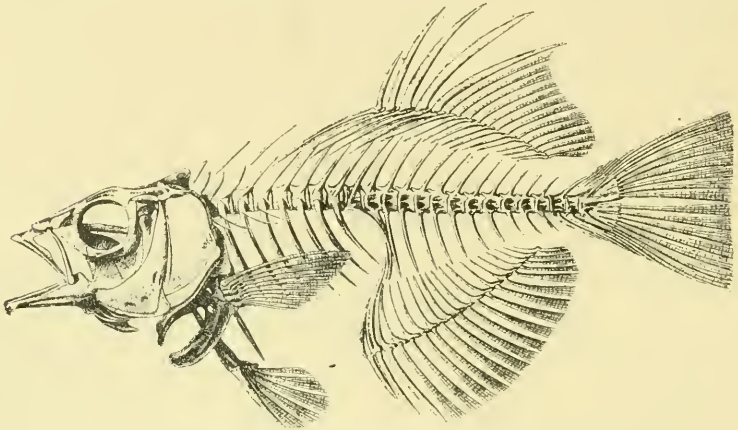


FIG. 58.—Skeleton of Archer-fish. (After Agassiz.)

specific difference, however, in preference manifested for certain conditions. Day, for instance, asserted that the *Toxotes jaculator* affected the sea waters of the coast while the *Toxotes chatareus* was mostly to be found in estuaries and brackish or freshened water. All such characteristics, however, require further evidence.

## II

Vague accounts of fishes which secured food by shooting drops of water at insects had reached Europe before, but not till 1764 was there published any notice of such sufficiently precise to give an idea of the character of the shooter. In that year and in 1766, Governor Hommel, of Batavia, sent descriptions and illustrations of two species which were published in different volumes of the Philosophical Transactions of the Royal Society of London.<sup>1</sup> One of these was


<sup>1</sup>The observations of Governor Hommel were published in two communications to the Royal Society by Dr. John Albert Schlosser, viz:

(1) An Account of a Fish from Batavia called Jaculator: In a letter to Mr. Peter Collinson, F. R. S., from John Albert Schlosser, M. D., F. R. S., in *Phil. Trans.*, LIV, 1764, pp. 89-91, pl. 9, 1765. (*Chelmo* only noticed.)

(2) Some further Intelligence relating to the Jaculator Fish [etc.], in *Phil. Trans.*, LVI, 1766, pp. 186-188, pl. 8, fig. 6, 1767. (*Toxotes* noticed.)

Schlosser was only the intermediary for publication.

a Chaetodontid subsequently named *Chelmo rostratus*, and the other a species called "the Jaculator fish," now universally known as the *Toxotes jaculator*. In the second article the author jumped at once into a notice of the characteristic habits.

"When the Jaculator fish intends to catch a fly or any other insect, which is seen at a distance, it approaches very slowly and cautiously, and comes as much as possible perpendicularly under the object; then the body being put in an oblique situation, more or less in this manner  and the mouth and eyes being near the surface of the water, the Jaculator stays a moment quite immovable, having its eyes directly fixed on the insect, and then begins to shoot, without ever showing its mouth above the surface of the water, out of which the single drop, shot at the object, seems to rise. With the closest attention," continues Hommel, "I never could see any part of the mouth out of the water, though I have very often seen the Jaculator fish shoot a great many drops one after another, without leaving its place and fixed situation."

The after history of the fish is a remarkable one. Hommel's notice was the basis of all the accounts of the Archer-fish subsequently published, but not of the illustrations. In spite of Hommel's repeated statement that the fish never projected "its mouth above the surface of the water," later artists (as in Brehm's *Tierleben*) represented the entire head and more thrust out of the water and drop after drop ejected vertically at an insect. The illustration, like many other artistic effects, reflected the imagination of the artist rather than either the narrative or Nature.

Year after year passed along—one century and much of a second—and no later observers corroborated Hommel's account. Instead of doing so, inhabitants of countries in which the fish in question was common denied that such a habit as had been attributed to it was practiced or known. The most active ichthyologist that ever lived, long a resident of the same city (Batavia) as Hommel, Dr. von Bleeker, in vain sought corroboration of the ancient account, and in 1875 declared that then the species was only fished for in the bay and he had never been able to obtain living individuals. It was no longer raised as appears to have been the case in the past century, either by Europeans or Chinese, and neither the Chinese nor natives, either at Batavia or elsewhere, practiced or knew about the pretended industry. Consequently he believed that the celebrity of the fish was undeserved and arose from some mistake; "la célébrité n'est pas méritée et ne repose que sur une erreur" were his exact words.

This conclusion was quite generally accepted afterwards. It was apparently justified by the absence of any special physiological aptitude in the mechanism of the mouth and throat of the fish itself for shooting drops. Nevertheless, at last, in 1902,<sup>1</sup> a Russian ichthyologist, N. Zolotnitsky, who had secured a number of living specimens from Singapore, fully corroborated the discredited account and gave many new and interesting details.<sup>2</sup> So remarkable—almost incredible—are some of the statements that they should perhaps be given in the observer's own words; they are here paraphrased so as to give his meaning, but with considerable alteration in the sequence of the paragraphs to accord with that adopted for other species.

### III

The Archers are gregarious fishes, not consorting indeed in very large compact shoals like herrings, but in small and loose companies. Considerable activity is often displayed and they may jump entirely out of water; leaps, it has been claimed, sometimes extend to as high as 13 or 14 feet ("4 mètres de hauteur"), but this is incredible. This activity is generally guarded against by would-be captors of the fish who surround the effective net with another or perhaps still more nets.

They frequently swim backwards as well as forwards. This habit of swimming backwards, remarks Zolotnitsky, is very curious and quite customary; indeed, they often swim in this manner for several minutes at a time. They reconnoiter a possible prey and back from it until they secure a good position for observation or attack. The eyes work in harmony.

### IV

The action of the eyes deserves special notice. They can be moved in almost every direction—to the left, to the right, upwards and backwards—backwards so that the fish can see everything that goes on behind. Their vision is also very penetrating; they can see small insects at a great distance and drench them with astonishing correctness of aim. But the eyes can not be turned downwards and consequently, when the fish would see what is below, it plunges

<sup>1</sup>The habit was recognized by some able men. H. Milne-Edwards, for instance, in his admirable *Leçons sur la Physiologie* (xiii, p. 502, 1879), accepted the old statement without any expression of doubt.

<sup>2</sup>Zolotnitsky (N.). *Le Poisson Archer* (*Toxotes jaculator*) en Aquarium. in *Archives Zool. Expér. et Gén.* (3), x, 1902, pp. lxxiv-lxxxiv.

downward head foremost; it rarely, indeed, sees what is at the bottom, and although worms may be there in abundance, it finds them only when hunger impels it to search for them there. And it is not alone the mobility of the eyes which engages attention; instead of the expressionless stare which is characteristic of fishes generally, the Archer's eyes sparkle with intelligence. Especially when the fish becomes sick or is dying is expression manifested; then it looks at you as if it would implore your attention and would like to speak. The gaze of one of Zolotnitsky's fishes, which was dying, produced on him such a painful impression that he could never forget it! Still another noteworthy feature exists. The eyes may be operated jointly or severally; if the eye of one side is pushed outwards, the opposite one may sink inwards.

## V

Another characteristic feature is the susceptibility to external conditions and its manifestation by change of color. The faculty of changing the color of the body as well as the fins is, indeed, developed to a high degree. Every change to which Zolotnitsky's fishes were subjected was accompanied by a change in their colors. The want of oxygen, the temperature of the water, clearness or cloudiness, abundance or deficiency of food, good or bad health, fright, joy. The color is in truth a barometer of their life. They avail themselves of this susceptibility or capability, too, in assuming protective and dissembling hues. When for example they had a nocturnal feast, they discarded their bands and became greenish, accommodating themselves to the color of the water. Zolotnitsky, noticing this, experimented. He covered the aquarium with a paper,—the fishes soon settled to rest and assumed their normal banded condition; then the paper was removed and they immediately became greenish again. He was with good reason astonished at the disappearance of the bands and spots, and naturally puzzled to account for it.

Not only is the coloration a barometer, it is also a thermometer; the fishes are very sensitive to the weather and show its gradations by coloration of the body. At 70° Fahr. and upwards the colors are clear and lively; at 66° Fahr. they begin to fade, and at 60° Fahr. or 61° Fahr., they are quite dull; a little further fall of temperature entails loss of appetite and sluggishness. Zolotnitsky did not venture to experiment with a temperature less than 55° Fahr. (10° R.), for he was convinced that such would be fatal. (Zolotnitsky, 78, 80.)<sup>1</sup>

<sup>1</sup> The pages of the original are numbered in Roman figures.



## VI

The Archers subsist largely on insects and their larvæ, and the common species (*Toxotes jaculator*), under some conditions at least, practices what has been called "a singular industry" in pursuit of insects. Numerous kinds of these hover over the water and alight on the vegetation in or close by the water. When the approach of one is sufficiently near, an Archer-fish may take advantage of it to secure a tit-bit or meal. The fish will advance towards the insect, turn its head in a proper direction, direct its eyes forward, and take



FIG. 59.—Archer-fish Shooting at Insect. (Modified after Zolotnitsky.)

a good look. (Zolotnitsky, 76.) If the insect is badly placed, the fish will back away or change position for a more favorable base for attack. Having found this, it will apply the front of its mouth to the surface of the water, nearly close its jaws, leaving a narrow opening, and shoot a drop of water or perhaps drop after drop at the fly. Ordinarily the drops are projected to distances of from 12 to 20 inches (76), but sometimes they may be sent even 40 inches or more ("1 mètre et davantage") away. The aim is almost always true ("Il vise toujours juste"). The insect, drenched by a shower of such drops, falls into the water, but the true archer may not be

the captor. Its companions, like it, dart towards the victim and this naturally becomes the prize of the most adroit or lucky one.

Discrimination and selection were exercised in the choice of insects. The common house-fly was distasteful and only taken, it was thought, when the demands of hunger could not be otherwise appeased. Ants were the chosen food, and small black ants were preferred to the red ones, presumably because the former were less penetrated by formic acid than the latter. (Zolotnitsky, 76.)

Considerable ingenuity is sometimes manifested in the attempt to secure food. On one occasion a larva (bloodworm) of a midge (*Chironomus*) was thrown by Zolotnitsky into the aquarium, but it lodged by the side and an Archer tried several times in vain to secure it, merely pushing it closer against the glass with its projecting lower jaw; at length, it backed a little and blew on the larva, so that the latter was sent toward the middle, and then the Archer readily captured it. The experiment was twice repeated and the fish applied the same strategy to the capture of both larvæ.

Zolotnitsky was very much impressed with the apparent reason which the fish applied. He thought, too, that the old archers could and did measure and proportion the distance and the force used in projecting the drops. The old fishes directed their efforts so successfully that the insects aimed at always fell within reach, but the young ones sometimes used such force as to shoot the flies so that they fell outside of the aquarium.

Although chiefly day-feeders, the Archers are also active and may feed during a bright moon-light night. One hot summer day Zolotnitsky (78) left the aquarium in the open air, and near it a lamp with a great moon-like globe, which attracted a number of insects—mosquitoes, moths and others; many of these came within reach of the archers' shots and the fishes became greatly excited and very active, feeding to repletion. The next day, however, they were in excellent condition and exhibited renewed brilliancy of colors.

## VII

Nothing is known respecting the reproductive habits. Zolotnitsky (80) believed that the temperature suitable for spawning was about 73° F. to 75° F. (18° R. à + 19° R.). At such a temperature he found that they were very lively and playful and would be attracted by their own images reflected from the mirror-like sides of the aquarium. Their play was so persistent that they even ceased

to eat and ascended continuously to the surface to inhale atmospheric air.

### VIII

Zolotnitsky found that they did not require great care and that they soon accommodated themselves to new conditions. He used the water of the Black Sea freshened with a little fresh water. At first they were very wild and timorous, and whirled round and round in the aquarium "like autumn leaves driven by the wind;" several were killed by dashing against the glass sides in attempts to escape. They soon became accustomed to their owner's presence, however, and in a fortnight were so tame that they would approach the hand containing flies and shoot them off into the water.

The chief difficulty experienced was in supplying them with the requisite food. They will never eat dead insects and it is no easy matter to secure a liberal supply of living ones, especially during winter. Zolotnitsky (87) discovered a method of securing a supply of ants by wetting a stem or blade of grass with sea-water and inserting it into an ant's nest. The ants were so much attracted by it that they would not leave it and could be carried thereon as desired. In winter the active larvæ of mosquitoes were obtained and these were eaten by each fish; each larva, it must be remembered, should be alive and they should be fed one at a time.

### IX

Five well-defined species of the genus *Toxotes* are known and these are most readily distinguishable by the number of fin rays, size of scales, and coloration. The most generally distributed and best known is the *Toxotes jaculator*. The specific characteristics of that form here given contrast with those of the others.

The dorsal fin has only four spines, the scales are of medium size (28 to 30 in a longitudinal row). The color is distinctive of the species; the ground-color is silvery, and on it are six transverse velvety black bands alternating with citron-yellow areas; the fins are mostly clear yellow, but the dorsal has a black spot and the anal is more or less black. The popular Siamese name, Pla-kat, or Tiger-fish, alludes to a certain analogy between its color and that of a tiger.

All the species are of rather small or medium size, about 5 or 6 inches long, but some individuals of the common Archer, *Toxotes*



*jaculator*, reach a maximum of nearly ten inches, and Day obtained specimens of *Toxotes chatareus* over a foot long.



FIG. 60.—Archer-fish. (After Bleeker.)

## X

This summary is a true version of the article by Zolotnitsky and will doubtless excite skepticism among physiologists at large as well as psychologists. It contravenes certain assumptions respecting the power and range of vision among fishes, as well as of the intelligence and reasoning powers of such lowly animals. The extent of expression assigned to eyes destitute of mobile surroundings and accommodative adjustments may also be deemed to be exaggerated. Distinction therefore must be exercised between the facts observed (or alleged to have been observed) and the inferences respecting such facts. It must be conceded, however, that fishes which manifest such peculiar action as the Archers should be subjects for still more elaborate observations and experiments, and it appears that they are neither very difficult to procure nor hard to keep.

While Zolotnitsky's account of the Archer-fish is more complete and graphic than any other, it is not the only one, nor the first. As long ago as 1899, two articles appeared in the popular periodical named *Natur und Haus*,<sup>1</sup> published in Berlin, and it is probable that other observations have been made known later. As, however, the

<sup>1</sup> The following articles are known to the writer :

NITSCHÉ (PAUL). Der Schützenfische (*Toxotes jaculator*), in *Nat. und Haus*, VIII, 1899, pp. 22-25.

LAMPERT (K.). Der Schützenfische. *Nat. und Haus*. VIII, 1899, pp. 43, 44.

sets of this periodical in the Library of Congress and the National Museum are incomplete, the idea can not here be verified or disproved. A supplementary account may be given later. As Zolotnitsky, who must have been acquainted with the two articles, made no comments on them, none are called for here. It is to be hoped that some American institution (the New York Aquarium, for instance) may be sufficiently enterprising to import some fishes and enable us to confirm or correct the published observations.