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## AN UNUSUALLY LARGE (53 MM.) TWO-HEADED BROOK TROUT, *SALMO FONTINALIS*

By E. W. Gudger

In May, 1925, I learned that Mr. A. A. Townsend, fish culturist at Yama Farms Brook Trout Hatchery, Napanoch, N. Y., had an unusually large two-headed young trout which he was rearing by hand. I at once wrote Mr. Townsend saying that since, such teratological fishes never survive long, I would after its death very much like to have this specimen for study. He kindly replied that when this took place he would send me the fish. And on November 2 there came to me the two-headed trout shown in dorsal and ventral views, respectively, in Figs. 1 and 2.

Double-headed fish embryos are not uncommon. Every fish hatchery handling large numbers of eggs has a few every hatching season. Hence, it would seem unnecessary to describe this particular specimen but for the fact that it has grown to the unusual size of 53 mm.—outside or "over all" measurements. As will be seen later, not many grow to this size and few larger, and this only in hatcheries where they are artificially fed. In the wild state such fish, even if they survive hatching, soon fall prey to their enemies, because of their inability to move rapidly through the water.

The measurements of this little monster, after being in alcohol for over 3½ years are as follows: length from tip to tip 53 mm. (note that the left head is the larger and that it is used for taking measurements), length to point of junction (dorsal) 18 mm., to point of junction (ventral) 12 mm., to base of anal fin 30 mm., to base of caudal 42 mm.; width between inside eyes 3 mm., between outside ones 17 mm.

The bodies are separate for slightly less than one-third of the standard length (12 out of 42 mm.), but as usual one head (in this case the left) is slightly larger. Each dorsal fin starts on its own body but ends on the common tail. Each fin, however, is separate even to the hinder portion, although the hinder thirds are separated by a mere groove. This groove extends along the dorsum slightly beyond the adipose dorsals. These begin as separate structures each on its own side of the groove but become united behind into one structure. However, just before the point of junction each has a small wing-like lappet about where the highest point would be in a normal adipose fin. The paired adipose fins are visible in Fig. 1, but not the united terminal portion. The inner lateral lines come together at the point of junction of the two heads. Extending backward from this point until lost between the two dorsals is a raphe quite distinct from the lateral line structures.

The outer sides of this little monster possess no abnormal structures, the pectoral fin and lateral line of each being seemingly entirely normal. The ventral surface, however, has a groove running back from the point

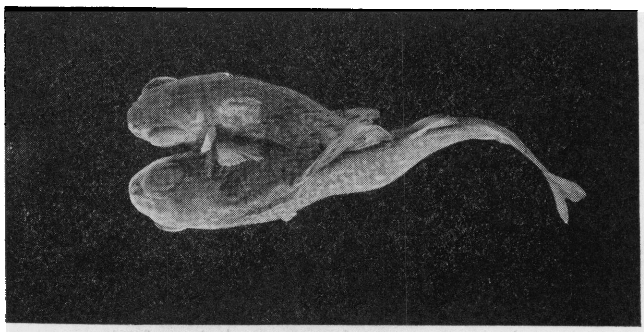

Fig. 1. A double-headed young trout, 53 mm. (2.12 in.) in total length, seen from above. The bifurcation measures 18 mm. out of 42 mm. standard.

of junction of the two heads along the mid-ventral region to the anus. It cannot be said how much this groove, like the dorsal one, may be accentuated by reason of the long stay in the preservative. The ventral fins are two, closely opposed along the sides of the groove but wholly separate in origin. The anal fin shows no trace of duplication. The doubling then extends much farther back on the dorsum than on the venter.

In the region between the two heads are to be found the greatest evidences of abnormality. Seen from above the two inner pectorals are closely opposed and point backward and sharply upward at an angle of about 75°. This has prevented the gill covers from lying flat in their normal position, they being curled forward, the right much more than the left. However, the gills on the left head (four sets of them) are much more visible than those on the right, perhaps because of the better development of the left head. These points may be made out in Fig. 1 by using a glass.

Viewed from below, the left head appears quite normal even in the appearance of the inner or right gill cover. Serious disturbances are visible in the hyoid region of the right head. The hyoid parts are so displaced downward and forward as to come to lie in the general plane of the underside of the body. This has caused the gill covers on the inside of the right head to gape widely and to reveal the gills. How much of this is natural and how much is artifact due to contracting and hardening in alcohol is impossible to say. These points are clearly brought out in Fig. 2. The mouth on the left head is larger and more normal than that on the right one.

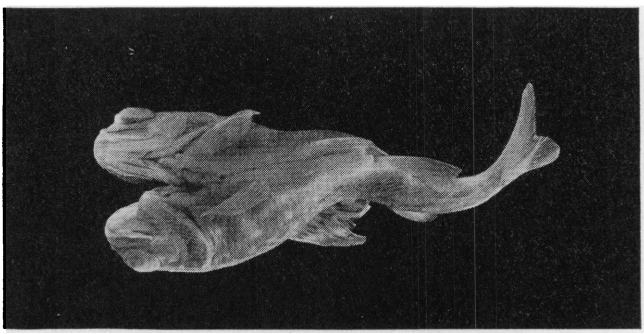

Fig. 2. Ventral view of the same fish. Note that the bifurcation extends backward for a shorter distance (12 mm.) than on the dorsum. Note also the distortion of the hyoid region of the right head and the smaller mouth on this head.

As to the history of the monster shown in Figs. 1 and 2, I am privileged to quote Mr. Townsend as follows:

This little two-headed brook trout was hatched in February, 1925, and died on November 2nd of the same year—9 months later. I kept it in a small box 2 feet long, 8 inches wide, and 9 inches high. I kept the water at a depth of about 5 inches in the box with a flow of about a quart a minute going through it. The only diet of the little fish was fresh pig's liver ground through a 5/64ths inch plate of an Enterprise meat chopper five times. It died with a fungus growth on the gills. This was caused by the larger [left] head working the smaller head into the sand at feeding time. This was kept up until inflammation set in in the gills of the smaller head, then fungus came and killed it.

It seems not improbable that the abnormal condition of the hyoid region of the right head seen in Fig. 2 may, in part at least, be due to this fungus infection. While both the size (53 mm.) and the age (9 months) of this specimen are unusual, Mr. Townsend writes me that he has raised two larger ones by isolating them and feeding them carefully.

The first of these reached a length of 5 inches (127 mm.) and an age of about 11 months. Of the other he writes:

> The other little two-headed trout lived 11 months and grew to be 5 ⅛ inches long [130 mm.]. It was kept separate in a box as was the one I sent you, and when it grew pretty large was transferred to a larger box. While I was away for a few days, a heavy thunderstorm came up and flooded everything and, as the attendant forgot about it, the box and fish were washed away. One head was larger than the other and in feeding it dragged the other about on the bottom. This is the great difficulty in rearing two-headed fish. Whenever one head of the 5⅛ inch fish got sore by reason of the other head rubbing it on the bottom, I would take the fish out and put a mild solution of peroxide or iodine over the head and body at the same time protecting the eyes. This would always stop the growth of fungus. It was a perfectly healthy fish and if I could have kept it, I am sure that I could have raised it to be a large trout.

As will be seen in the next section, these three trout are the largest two-headed fishes of which we have records, and great credit is due Mr. Townsend for his patient care and marked success in rearing these fish.

## HISTORICAL NOTES

There is no intention here of giving a review of the literature of bicephalism in fishes. The references are too numerous, there being forty-one direct ones to double monsters in the 'Bibliography of Fishes' and its continuation card catalogue. It would be a lengthy task to review even the twenty-four of this list which refer particularly or solely to the Salmonidæ. Furthermore, since all such double-heads resemble each other very closely, differing chiefly in the extent of bifurcation, the task would be a rather fruitless one. This large number of citations to this peculiar type of teratological phenomenon is, of course, due to the fact that fishes are extensively propagated by artificial hatching. And the fact that more than half of the references pertain to the Salmonidæ results from the further fact that these fishes are the ones most abundantly reared in hatcheries since they are of especial value for the restocking of streams in the interest of angling.

Frequency of Occurrence.—With reference to the frequency of occurrence of double monstrosities, the data is widely scattered and when brought together shows that there is much variation of its occurrence in any given species. The following statement is condensed from the great work of J. F. Gemmill,[1] references to the authors quoted by him being omitted for the sake of brevity. The reader interested in looking up these citations will find them given on page one of his work. For the Salmonidæ, the following figures are given: 1 double-head in 50 eggs, 1 in 200, 1 in 280, 1 in 350, 1 in 600, 68 in 900, over 100 in 400,000, while one investiga-

[1] 'The Teratology of Fishes,' Glasgow, 1912, 73 pp., 25 Pls., 6 text-figs. Folio.

tor found as high as fifty per cent in one brood to be two-headed monsters. In *Perca fluviatilis*, two double embryos were found in a set of 40 eggs. In 203,962 eggs of the pike (*Esox lucius*) 222 double-heads were found, an average of 1 in 920. For this fish another investigator found 1 monster in a brood of 325 eggs, and another 6 in a hatch of 917 fishlets. And, finally, for *Petromyzon* there is a record of 40 eggs with twin gastrulæ out of a batch of 100.

On the other hand, examination of 4,000 eggs of *Cyprinus blicca* by an investigator interested in twin-heads showed not a single monster. Again, Stockard (to be referred to later), in 1921, stated that in fourteen, seasons' experimental work with the eggs of *Fundulus heteroclitus*, he had never found such monsters in many hundred control embryos. My own experience is of like kind. In four or five years hatching of thousands of eggs of the toadfish, *Opsanus tau*, I did not find a single double-head. Further, in six years' work with the orally incubated eggs of the marine catfish, *Felichthys felis*, involving the study of hundreds of eggs, I found but three monsters—one having three eyes (the third formed of two fused eyes) and two Siamese twins.

From the above, it must be concluded that this teratological condition in fishes is a relatively rare one. For a study of the relativity of occurrence, even in the same species, the conditions of temperature, purity of the water, crowding, etc., would have to be brought to the same standard. This, so far as I know, has never been done.

ADULT TWO-HEADED FISHES.—I have sought in vain for data on adult two-headed fishes. None of the references cited indicate by their titles unusual size in the fishes considered, nor is there any reference to large double-heads in Gemmill's great work. However, I have gone to the trouble of looking up all the references in the 'Bibliography of Fishes' in the hope that some of them might pertain to large double-heads. Practically all of these articles, however, have to do with embryos recently hatched, or else are discussions of the theories of origin of this abnormality. The oldest for which age was noted was four months, size not given, and the greatest size noted was 20 to 21 mm. (slightly under an inch), while the little fish under consideration is 9 months old and 53 mm. (2.12 inches) long over all. There may be accounts of larger specimens hidden in the general works in teratology but, if so, they have been overlooked by ichthyological teratologists.

What seemed a promising "lead"—more seeming than real—to an exception to the above statement was discovered in an article by A.

Audeville published in 1888.[1] This man, who operated a private trout hatchery, became interested in the abnormal embryos and like Mr. Townsend determined to try to rear some by hand, so to speak. He soon found that they habitually died at the time of resorption of the last remnant of the yolk, and he thought that his efforts were doomed to failure. However, he finally got one little double-head to feed at this critical period, and it was at once isolated and watched constantly. This little fish had two distinct and perfect heads attached just behind the eyes (unfortunately he gives no figure), and from there back a single body.

During the first weeks, the little fish fed freely and the two heads seemed to develop simultaneously and equally. Soon, however, the right head began to gain over the left which grew smaller, in fact, atrophied. Three months after hatching Audeville says that it was hardly visible. The fish (right head), when twenty months old (at the time of the writing of his article), no longer showed as a double-head. "There now remains a little above and slightly behind the left eye, almost at the point where the two heads were joined, only a little fleshy 'mamelon,' about 2 mm. in diameter and height, on which with the naked eye one can distinguish no trace of any organ." During the first months, probably by reason of two mouths doing the feeding, the monster grew faster than the average of the others of the same hatching. Presently, however, as the left head grew smaller, the fish lost this gain and at the age of twenty months was slightly smaller than the average. It was then, however, a troutlet 170 mm. (6.7 in.) long, and entirely able to maintain its equilibrium. In fact, says our author, there was at first glance nothing to distinguish it from others of the same species.

So far as I know, there is no account (other than in Mr. Townsend's letters to me) of the rearing beyond the hatching stage of a two-headed monster. This and the extraordinary condition of his fish at the age and size noted have made it well worth while giving the history of this specimen. However, as will be shown in another paper later, the only authenticated records of adult twin salmonids, and indeed the largest twin teleosts, are of those Siamese-twin forms in which the fishes are united laterally or are joined ventrally in the belly region. Of such, there are figures extant of fishes 5 and 6 inches in length, and accounts of specimens measuring 8 and 13.2 inches.

There are now to be presented three poorly authenticated accounts of adult double-headed fishes. Jonathan Couch in his 'History of the

[1] 'Un Cas Singulier de Teratologie sur un Salmonide Monstreux.' Bulletin Societé Acclimatation France. 1888, (4) V, pp. 990–993.

Fishes of the British Islands' (London, 1869, IV, p. 239), in speaking of malformed fishes, says that "Among the casual malformations, a trout was caught in Cornwall which had a second or smaller head, which appeared projecting from this natural part." However, Couch does not say that he had seen this, but seems rather to speak from hearsay. Another and even less authentic account is from Frank Buckland, who says that he "once read an account of a double-headed catfish (*Anarrichas lupus*) having been caught in the North Sea" ('Logbook of a Fisherman and Zoologist,' London, 1883, p. 151).

Of two-headed sharks there are quite a few records, only, however, of very young forms and generally of embryos still attached to the yolk-sac. These have been obtained by opening the mother, or have been extruded by her when caught or when hurt. However, there are on record the figure and description of what purports to be an adult or at least a fairly large two-headed shark. This, the oldest known record of a bicephalous fish, is found in the 'Monstrorum Historia,' one of the components of the encyclopedic 'Historiæ Omnium Animalium' of the

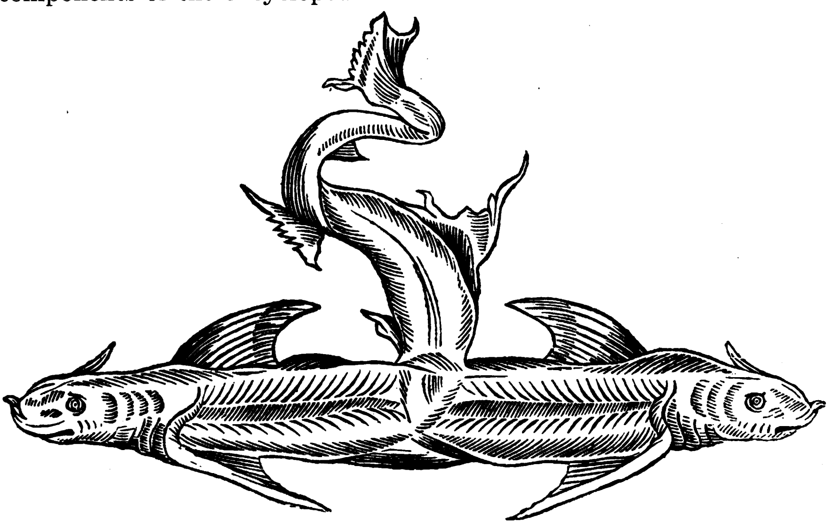

Fig. 3. A two-headed shark "from the River Nile," the oldest known figure of a bicephalous fish. After Aldrovandi, 1642.

distinguished Ulysses Aldrovandi. This huge folio, published after Aldrovandi's death by his loyal pupil, Bartholomæus Ambrosinus, bears imprint, "Bononiæ, 1642."

On page 428 is the figure of this fish, which is reproduced herein as No. 3. It is said to have been taken in the River Nile near the town of

Latislana, and in size is said to have about equalled a crocodile. Now there are several criticisms to be made of this account. In the first place, there are no sharks known in the Nile, not even in the delta, for the tides in the eastern Mediterranean are so low (practically non-existent) that even the delta region has no brackish water. What the town of Latislana was is not known. Lippincott's 'Gazetteer' (1902 ed.) says that there is a town of that name near Udine, Italy. Furthermore, although the size of the crocodile is not stated, it is probable that a fish of at least two feet was indicated. There may have been such a large double-headed shark, but there is in the literature no other reference to such. Probably Aldrovandi or Ambrosinus had a double-headed embryo or just hatched young shark, which served as a basis for this account, and his artist did the rest. Or possibly his account is merely a bit of folk lore. At any rate, the figure is reproduced herein because of its historical interest.

## THE CAUSE OF DOUBLE MONSTROSITIES IN FISHES

A variety of causes have been alleged in explanation of the origin of such monstrous fish as have been described above. No attempt will be made here to discuss these, and only brief mention of the chief ones will be made. At the close of this section reference will be given to a book in which the various theories are discussed.

Stephen Ludwig Jacobi[1] seems to have been the first professional breeder of trout and the first to note two-headed monstrous fish embryos. Jacobi described various kinds of these double monsters from two-headed to Siamese-twin forms, noted that such always die at the end of four or five weeks when the yolk is absorbed, and gave it as his opinion that "double fish have been generated when two spermatic animalcules have slipped into the egg." Further on he alleged that double fish and all monstrous productions result "when an egg is fructuated by more than one spermatic animalcule."

Under the heading "Causation," Gemmill in the great work previously referred to says: "There is strong reason for believing that the occurrence of double monstrosity is due in the main not to environmental factors but to conditions which are inherent in the fertilized germ cell." He recognizes that twin production has been brought about experimentally in many cases in invertebrate ova and in some holoblastic vertebrate eggs by separation of individual cells or masses of cells in early

[1]Hannoverisches Magazine, 1763, No. 23; idem, 1765, No. 62 (both in German); English translation in Philosophical Magazine, 1890, XXXIV, pp. 324–333; also in Yarrell's 'History of British Fishes,' 1841, II, pp. 87–96.

stages of segmentation. He concludes, however, that such would be difficult to effect in meroblastic fish ova where the early cells are cut out of a syncytium. Still he notes that such experimental results have been brought about. And finally he says of polyembryony: "The view has often been suggested that the blastoderm may be looked upon as a stock, able to give rise vegetatively so to speak to more than one embryo." Then he concludes: "More probably, however, in animals, twinning, double and multiple monstrosity, and polyembryony provide instances in which a common 'potentiality' has become realized, and beyond that are not necessarily connected by any nexus of a direct or phylogenetic character."

C. R. Stockard[1] in an extensive paper, in which he summed up his long years of experimental work, declares that double monsters may be produced by developmental arrests by lowering the temperature or by reducing the oxygen supply. He notes that the notches around the edges of some plants have the power to give rise to buds and concludes that: "At a certain place along the germ-ring in the fish's egg a peculiarly rapid cell multiplication begins and the embryonic shield with the axis of the embryo buds away from this place." There is evidence then that more than one such place may be capable of forming the axis of an embryo. Probably there are a number of such potential points, but when one point has begun to proliferate cells, the others are normally inhibited. "The origin of two embryonic axes or growing points on the germ-ring of the fish probably results from a rather mild or slight reduction in the normal developmental rate at the time of gastrulation or embryonic-shield formation." And this may be brought about by lowering the temperature or decreasing the oxygen supply. Certain eggs after relief from low temperatures

resume their cleavage processes, form a typical blastoderm and begin the formation of a germ-ring, which indicates the commencement of gastrulation, but just here the degree of energy necessary for normal developmental processes is insufficient and a single embryonic bud is not formed with that normal rate of growth which suppresses the appearance of other embryonic buds. Therefore, instead of the one point proliferating at a disproportionate rate to form the embryonic shield, two such points are established with more or less equal rates of proliferation, both of which may be somewhat less active than the single one should be. The formation of two embryonic shields, or the initiation of two points of rapid gastrulation away from which will grow the axes of the embryos, is in fact the initial or primary step in double formations.

[1] 'Developmental Rate and Structural Expression: an Experimental Study of Twins, "Double Monsters" and Single Deformities, and the Interaction among Embryonic Organs during their Origin and Development.' American Journal of Anatomy, 1921, XXVIII, pp. 117, 163–166, 173–181, 255–257.

Then follows a recital of the experiments and descriptions of the monsters produced. However, Stockard notes that he got but relatively few monsters while he was working with the eggs of *Fundulus heteroclitus*, a form little given to producing monsters.

Noting that cell proliferation, which is fundamental for the production of embryos, is a great oxygen-consuming process, Stockard carried on experiments in which the eggs were allowed to clump together with a relative reduction of the amount of oxygen available for each egg, or they were placed in water from which the oxygen had been driven off by boiling. The results were directly comparable with those noted above.

Stockard experimented with the very hardy eggs of *Fundulus*, but he recognizes that double-monster formation is more common in salmonid eggs. This is probably due, in part at least, to the crowding of eggs in hatcheries and the resulting deficient aëration, but for all this there seems to be in salmonid eggs some inherent tendency to form monsters. Here is Stockard's own brief summary:

> By an interruption of development [by lowering the temperature or reducing the oxygen supply] during late cleavage stages, a considerable percentage of twins and double individuals may be produced. When the eggs of the sea-minnow, *Fundulus heteroclitus*, are subjected to temperatures of 5° or 6° C. during cleavage stages, development is almost stopped. On returning such eggs to a summer temperature, after several days' sojourn in the refrigerator, there will follow a high mortality, but many specimens will resume development producing a significant percentage of twins and a number of variously deformed conditions along with a good proportion of normally formed young fish.
>
> Arresting or stopping development of the same eggs during the same developmental stages by diminishing the available supply of oxygen will be followed by closely similar results.
>
> The eggs of the trout are naturally much more inclined to develop into double individuals than are those of *Fundulus*. When the oxygen supply during early development is not abundant, a great many twin and double trout specimens are frequently found to occur.

The whole subject of the nature, scope, and causation of twin formation has been admirably treated by H. H. Newman in his valuable book.[1] To this and especially to chapters IV and V, dealing with the various theories advanced to explain twin formation in fishes, the interested reader is referred.

[1] 'The Physiology of Twinning.' Chicago, 1923, 230 pp., 71 text-figs.