Observations on the Life-History and Breeding Habits of the Montana Grayling[1]

By C. J. D. Brown

THE Montana grayling (*Thymallus montanus*), like other species of the Thymallidae, breeds in the spring of the year. Milner (1874) gave April as the time of spawning for the Michigan species (*T. tricolor*), while Whitaker (1886) included March and April ("and perhaps even earlier"). Norris (1883) considered it to be a late spring spawner, referring to April and early May as the breeding period. According to von Siebold (1863: 270) the European grayling (*T. thymallus*) begins to spawn in March and may continue into April.

The actual period of spawning for the Montana grayling has been found to vary greatly between different years and between different localities in the same year. Whereas the controlling factors which initiate the breeding activity of this species have not been carefully studied, it is safe to say that the temperature of the water has great influence. In 1936 on Lower Odell Creek, tributary to Madison River, Montana, the first grayling came into the U. S. Bureau of Fisheries traps on March 15. The peak of the run was attained April 16 and the last individual observed appeared April 24. The same year a few spawners were taken in the Meadow Creek traps (a few miles downstream from the Odell Creek station) between May 1 and May 15. The spawning period seems to be much more concentrated in the artificially stocked lakes of the region. Experience has shown that grayling often run in advance of the rainbow and cutthroat trout and that the males frequently appear in advance of the females. At Grebe Lake, Yellowstone National Park, the run usually begins the day after the ice goes off. During the 5 years previous to 1937 the spawning period occurred at Grebe Lake between May 15 and June 20; at Rogers Lake, Flathead County, Montana, between May 1 and June 1; and at Georgetown Lake, Granite County, Montana, between May 10 and June 5. In these lakes the grayling run is much more concentrated than the trout run, usually lasting not over a week and often being confined to 2 or 3 days.

Henshall (1907) reported that the Montana grayling will travel long distances to find suitable spawning grounds. This is in contrast to published records for the Michigan species, which according to Norris (1883) does not migrate as do the trout. Bissel (1893) said of the Michigan grayling, " . . . they use the channel of the main stream not seeking the brooklets and shoals as trout usually do." Von Siebold (1893: 270) observed that the European grayling did not migrate during the breeding period. Certain observers, however, describe this species as running with the trout in English streams. There is no doubt that the Montana grayling migrates during the spawning period. Those in lakes move out into whatever streams are available and those in streams go varying distances depending upon the stream in question. Henshall

[1] Contribution from the Institute for Fisheries Research, Michigan Department of Conservation and University of Michigan. This paper reports one phase of researches on the Montana grayling, made with

(1907) had no evidence to support his contention, however, that the grayling be observed to use Red Rock Creek for spawning grounds came from the Jefferson River many miles below. More than likely most of these fish came from Beaverhead River and the Red Rock Lakes in the vicinity of Red Rock Creek.

No one has recorded evidence to show that either the Michigan or Montana grayling build nests. Heckel and Kner (1858), in describing the nest building process of the European grayling, stated that the nest is dug by means of the tail and that after the eggs are laid and fertilized the fish then cover the nest with small stones.

Dr. I. H. Treece described the breeding habits of the Montana species as follows: "Grayling are not particular where they spawn; that is they will spawn on a gravel bed or out in the weeds along shore where there is gravel. They pair off to spawn and I never saw any other fish spawn just as they do; the male and the female will get just as close together as you could place your two fingers and then both spawn at the same time. I do not believe they make any effort to cover the eggs with gravel as do trout; in fact I believe the most of the eggs hatch without any cover." (Quotation from Laird, 1929.)

On June 6, 1936, through the courtesy and help of Mr. A. G. Stubblefield, Superintendent of the Montana State Fish Hatchery at Anaconda, the writer had an opportunity to observe the spawning process of grayling congregated in the inlet creek to Agnes Lake, Beaverhead County, Montana. This small stream, flowing about 1½ cubic second feet, enters the lake from the west end and has its source in the not far distant snowbanks. Due to the location of a newly built beaver dam, only about 100 yards of the stream adjacent to the lake was available for spawning. The water was brownish in color and its temperature on June 6 was 10° C., which is rather warm considering elevation and the type of stream. Both the color and temperature of the water were no doubt influenced by the series of beaver ponds immediately upstream. The bottom of the creek was composed of sand and fine gravel at a ratio of about 3:1.

At the time we approached the stream there were between 100 and 200 fish in the available section. These were mostly congregated so that several pairs were together, with a scattering of odd males moving slowly at random in the stream. One of the larger groups was composed of 13 males and 8 females. The ratio of males to females for the entire section was about 3:2. Most of the fish were concentrated directly downstream from riffles, although several pairs were in the swiftest water of the riffles. We were surprised at the lack of fear exhibited by the fish, as this was quite in contrast to the reactions of trout under similar circumstances. After our first approach they seemed to ignore our presence completely, even though we moved slowly about. It was possible to stand in the stream only 2 or 3 feet from the fish and observe their spawning behavior somewhat in detail.

There was no indication that these grayling had built or were attempting to build nests. All of them seemed to move around at random, changing positions frequently.

A spawning pair on a swift riffle was closely watched, where the water,

of coarse sand. After the male had come abreast of a female so that their bodies were 2 to 5 inches apart, and the fish had remained in this position for 2 or 3 minutes, the male moved nearer to the female until his body touched hers for much of their length. As he did so the huge dorsal fin was extended and arched so that it folded over her back. She then moved away quickly in an upstream direction, soon to be followed by the male, whereupon the original position of the pair was again established. This whole activity was repeated three times, with only one interruption when another male moved in directly behind the spawning pair. After several sideward motions of the body, the spawning male chased the intruder away but not with as much pugnacity as is usually exhibited by trout. The fourth time the spawning male approached the female she did not move as previously described, but seemed to crowd nearer to him so that their bodies were in direct contact from the head to the vent and at the same time the dorsal fin of the male was completely and tautly curved over her back. The fish at this moment were parallel with the current and as near abreast as one could have placed them.

Immediately upon contact, their bodies seemed to stiffen and then vibrate. The motion increased in intensity to a climax which was reached in 10 to 12 seconds. During the last part of this activity the tails of both fish approached the bottom so that their bodies were at an acute angle with it. As a result of this position and the vibration of their caudal fins, the sand beneath was greatly agitated and stirred momentarily into the lower water, making a depression 3 or 4 inches deep and decreasing the visibility so that it was impossible to see eggs or milt that might have been extruded.

A screen was placed directly behind the fish in an attempt to recover any eggs which might float downstream with the current. None appeared, however, and as the pair moved apart, sand was scooped up from both sides and from the bottom of the depression which was fast filling with sand from upstream. About 20 soft, newly laid eggs were found, no more in the pit of the depression than on either side. It was quite apparent that the very adhesive nature of the eggs had enabled them to become completely covered with the agitated sand grains and by means of this added weight be carried into the depression below, there to be at least partially covered and protected. The adhesiveness of the eggs may represent an adaptation to spawning in a current over sand or fine gravel, without a previously prepared nest.

Many water-hardened eggs, most of them of odd shape as compared to the round eggs kept under artificial conditions, were found in the sand over the spawning areas of this stream. The oldest embryos from these eggs had reached a stage similar to the 9-day-old individuals kept under hatchery conditions at a water temperature of 50° F. We secured no information regarding the further development of eggs deposited here.

Three other pairs of grayling were observed to spawn in this same stream. One female repeated the spawning act twice in 45 minutes, with two different males. It is probable that the egg laying interval for individual fish lasts about 2 to 4 days.

The spawning procedure itself should not have been greatly altered by the semi-artificial conditions afforded at Agnes Lake. However, there was no opportunity to test the selection which these fish might show as to the

type of stream and kind of stream bottom. The question still remains unanswered, therefore, as to what constitutes a natural spawning ground for this species. An attempt was made to locate the spawning grounds used by the grayling of the Madison River, but without success.

There has been considerable discussion among fish culturists as to the number of eggs produced by an individual female grayling. Whitaker (1886) recorded 3,555 eggs as having been produced by one Michigan grayling which weighed only 9 ounces after the eggs were removed. In a discussion of Mr. Whitaker's paper, a Mr. Clark mentioned having taken 25,000 eggs from 6 or 8 females, and 5,200 eggs from one fish that weighed 1¼ pounds.

According to reports, the Montana grayling trapped at Grebe Lake in 1935 averaged 1,650 eggs per female. One ¾-pound specimen taken from this lake had 5,563 eggs by actual count. Two ⅓-pound (2-year-old) fish taken at the same time contained 1,248 and 416 eggs respectively. Two grayling from the traps at Rogers Lake contained 9,059 and 4,904 eggs respectively, and 9 others from the same place, ranging in total length from 12¼ to 14½ inches and averaging 15 ounces in weight, showed a maximum of 7,068 and an average of 5,828 eggs per fish. Three large females from Georgetown Lake, averaging 2 pounds in weight, contained 12,946, 12,642 and 8,135 eggs respectively. In comparison with trout, grayling males produce very small quantities of milt. It is often difficult in artificial spawning operations to secure enough sperm to fertilize the eggs.

For many years fish culturists expected about a 40% mortality in grayling eggs during the period before hatching. According to Mr. Fred J. Foster of the U. S. Bureau of Fisheries, the mortality of the grayling hatched at Grebe Lake has not exceeded 10% in the past few years.

The interim between fertilization and hatching has been found to vary from 11 to 22 days depending upon the water temperature and certain other factors not understood. When the water temperature is 50° F., the average time is about 16 days with a variation of 7 days. The hatching process is ordinarily of short duration, lasting only a day or so.

Grayling fry, although considerably smaller than trout fry, grow much faster than the latter for the first year or so of life. Hatchery reared Montana grayling reached one inch in length at the end of the second month; 2½ inches at the end of the fifth month; and 7 inches at the end of a year.

Norris (1883) gave the age and length of the Michigan grayling as follows: first year 6 inches; 2nd year 10–12 inches; 3rd year 13–15 inches; 4th year 16–17 inches.

Creaser and Creaser (1935) computed the average total lengths of grayling from the Otter River in Michigan as follows: first year 4⅛ inches; second year 8⅛ inches; third year 10½ inches. They also gave computations made on the Montana grayling from Georgetown and Rogers lakes as follows: first year 4⅜ inches; second year 10⅜ inches; middle of third year 13¾ inches; middle of fifth year 15½ inches.

A considerable number of the Montana grayling spawn at the end of their second year. The majority of spawners taken at Grebe and Rogers lakes were in the 3 and 4 year classes as determined by scale studies, which will be reported in a later paper.

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Institute for Fisheries Research, Museum of Zoology, Ann Arbor, Michigan.

Studies on the Genera of Cyprinodont Fishes.
XIV. *Aplocheilichthys* and Its Relatives in Africa

By George S. Myers

THE present contribution is the fourteenth of a series of papers (Myers 1924 to 1936) in which I have attempted to introduce some order into the exceedingly confused generic classification of the fishes of the order Cyprinodontes, or Microcyprini, particularly the oviparous groups. Since these papers are widely scattered in various journals, I believe it will be useful to fellow workers to list them.

The first two of these papers (1924a, 1924b) gave preliminary notes, a few of which subsequently proved to be ill-founded. The third (1924c) showed that the supposed Japanese cyprinodont *Fundulichthys* was mythical, having been based on the figure of a cyprinid. In the fourth (1925), besides diagnosing the remarkable genus and species *Trigonectes strigabundus* and presenting miscellaneous notes on American forms, I proposed that the Neotropical genera clustering about *Rivulus* be recognized as a distinct group, or tribe (Rivulini). In the fifth (1927), the genera of this tribe were revised; additions to and emendations of this revision were introduced in the ninth (1932) and eleventh (1935a) papers of the series. In the sixth (1928a) I endeavored to show that the Phallostethidae, formerly considered to be cyprinodonts, are not members of the order. The seventh (1928b) relegated the sole European *Fundulus*-like species to a monotypic genus, *Valencia*, similar to *Profundulus* in its primitive features.[1]

The eighth paper (1931) was devoted to a delineation of the primary groups of the oviparous genera, and forms a key to the general classification adopted.[2] The tenth (1933) revised the Old World genera related to the American *Rivulus*. In the twelfth (1935b), I gave my views on the classification of the New and Old World genera of the subfamily Cyprinodontinae, and in the thirteenth (1936) I presented osteological and other notes on the subfamily Lamprichthyinae.

Of the oviparous cyprinodonts, there remain several groups not yet treated in detail. The Indo-Malayan tribe Oryziatini [3] contains but a single genus and will not be considered further in this series. Material is in hand for further supplementary notes on my 1927 revision of the *Rivulus*-like Neotropical genera, and for osteological work on the family Adrianichthyidae. Dr. Hubbs and I will shortly consider in some detail the strange oviparous South American genus *Tomeurus;* its unrelated but amazing counterpart in the Bombay Presidency will soon be announced by Mr. Kulkarni.

The present paper defines the genera of the African tribe Aplocheilichthyini as I delimited it in 1931. In the classification of the oviparous Cyprinodontidae it will be noted that I have placed much less reliance in the dentition than has Ahl (1924). Only in a few instances (*Lucania, Leptolucania, Chriopeops, Cubanichthys, Crenichthys*) do I feel that really good generic differences can be based on the form and arrangement of the teeth. Throughout the African Fundulinae the teeth of the forms I have seen are of one general type, with very minor modifications. There is usually a band of three or more rows of sharp, conical, slightly recurved teeth, often with the outer or inner series enlarged. The rows between the inner and outer series may be regular, or so irregularly placed that it is impossible to determine the number of rows. The form and size of the teeth of this fundamental pattern vary so much interspecifically, as well as individually, that their use as a prime classificatory character seems to lead more to confusion than to clarity. Moreover, it is possible that there are sexual differences in the dentition of a number of species. In dried specimens, or ones preserved in very strong spirits, the teeth appear to be much longer and more hooked than in well-preserved specimens. In contrast to the variability and difficulty of interpre-

[1] *Valencia* needs further study, for which I do not now have the material. Though apparently close to *Profundulus*, it is probably not phylogenetically close to that Central American genus. The single species, *V. hispanica*, is confined to eastern Spain. *Fundulus letourneauxi* Sauvage, from Corfu, which I once thought to be a *Valencia*, seems to be an *Aphanius*.

[2] As have other writers, I utilized the conical teeth to distinguish the subfamily Fundulinae from the Cyprinodontinae, which have tricuspid teeth. Hubbs (1932) has recently described a funduline, *Cubanichthys*, with bicuspid teeth.

[3] Dr. Hugh M. Smith will shortly show that the name *Aplocheilus* must be transferred to those species which I (1933) have called *Panchax*, and that *Oryzias* should be substituted for *latipes*, *melastigma*, and their allies. I introduce this note in order to point out that my tribe Rivulini (Myers 1931) becomes Aplocheilini and my Aplocheilini of 1931 becomes Oryziatini.