root, being most distinct, narrower, and more sharply defined anterior to the dorsal. Posterior to that fin it broadens and becomes less sharply defined, whereas anteriorly its width is one-half to three-fourths of the vertebral scale row. Reticulate pattern very pronounced in the darker populations, most so in larger specimens, the elements beneath the 3rd, 4th, and 5th longitudinal scale rows, especially, forming a series of transverse streaks or blotches. Small specimens and members of paler populations show the same effect, though faintly. The supra-anal pigment presents an elongate blotch or thin streak along the base of the anal fin, at the bases of the rays. The sub-peduncular streak is absent or very diffuse. Fins hyalin, except for a slight grayish or yellowish gray wash on their proximal portions, strongest on the caudal.

DISTRIBUTION AND RELATIONSHIPS.—This species is known only from the western and north-central portions of the island of Mindanao in the Philippines and from nearby Basilan Island. It is a member of the *argyrotaenia* species group, and is most closely related to the Philippine subspecies (*R. a. everetti*). *R. philippina* seems almost certain to be a derivative of *argyrotaenia*. The distribution of the forms is clear cut; *philippina* is found only on the islands of Mindanao and Basilan, whereas *R. a. everetti* is confined to the islands of the Palawan-Culion-Busuanga chain. The ancestors of *philippina* apparently reached Mindanao from Borneo at a time when the two islands were connected or only very narrowly separated during the Pleistocene or late Tertiary (J. W. Durham and R. W. Kleinpel, *in litt.*).

Rasbora taytayensis Herre

Rasbora taytayensis Herre, 1924b: 264 (original description; creek near Taytay, Palawan).

DESCRIPTION (after Herre).—Dorsal ii, 7; anal iii, 5; pectoral i, 12; pelvics i, 7. Scales in longitudinal series 26–28; 5 scale rows above lateral line row (scale rows below lateral line not given); predorsal scales 11. Dorsal profile nearly straight, ventral profile strongly convex. Depth 3.25–3.57; head equal to depth or shorter, 3.5–3.77 in length; eye large, 3.0–3.5 in head, and from ¼ to ⅛ longer than the short, blunt snout; interorbital space flat, 2.2–2.55 in head, from ¼–⅛ wider than eye. Lips thin, subequal, or the lower projecting. Symphyseal knob prominent. Origin of dorsal at 10th scale of lateral line, nearer caudal than snout, nearer pelvic than anal, its height slightly less than head-length. Pectoral not reaching pelvics, 1.1–1.3 in head. Origin of pelvics opposite 9th scale of lateral line, not reaching anus. Anal height 1.2–1.37 in head, its least depth 1.25–1.57. Caudal deeply forked, longer than head, longest rays less than twice as long as shortest. Nine rows of scales between the lateral lines, counted over the back in front of dorsal. Lateral line never extending beyond anal, often not reaching it. Reaches maximum (total?) length of 50 mm.

COLORATION (after Herre).—In alcohol, silvery brown, very dark above, paler below. A narrow black stripe from nape to caudal. A blackish or dark silver line along the side on the posterior half of body, with a black circular spot at base of caudal. Below this is a broad, dark band, best developed anteriorly and composed of many fine dots. A dark brown bar behind the posterior margin of gill opening. Scales margined with many fine dark spots. A band of many black spots along the base of anal. Fins colorless, or their rays more or less dark dotted.

DISTRIBUTION AND RELATIONSHIPS.—This species is known from six spawning females, 38–50 mm. long, the basis of the original description, collected in a pool in the bed of a dry stream along the trail between Taytay and Malampay Sound, and 164 specimens, 18–45 mm., collected in a creek near Taytay, Palawan. All of these were apparently lost when the Japanese destroyed the building which housed the Philippine Bureau of Fisheries during the battle for Manila, in February, 1945.

Dr. Herre considered this species to be most closely related to *R. semilineata* Weber and de Beaufort (1916: 80). Structurally, this would seem to be true; the position of both *semilineata* and *taytayensis* within the genus *Rasbora* is in doubt, however. Both show, especially in the reduction of the lateral line and in their small size, affinity to *pauciperforata*, *taeniata*, and *borapetensis* and their relatives. In the less strong reduction of the lateral line, the reduction of the predorsal scales from the usual 12 or 13 for the genus, and the decrease in longitudinal scales from the generic average of 29–31 they resemble the *trifasciata-bankanensis-steni* complex.

It is impossible to tell if *semilineata* and *taytayensis* have a close common ancestor, or are examples of recent convergent evolution from more distantly related precursors. We hope that topotypes of *taytayensis* may be recollected soon, and specimens once more made available to ichthyologists.

LITERATURE CITED

ARNOLD, JOHANN PAUL, AND ERNST AHL. 1936. Fremdländische Süsswasserfische. *G. Wenzel, Braunschweig, 592 pp., many text figs.*

BOULENGER, GEORGE ALBERT. 1895. List of the freshwater fishes collected by Dr. A. Everett on Palawan and Balabac. *Ann. Mag. Nat. Hist., Ser. 6, 15: 185–87.*

DE TERRA, HELLMUT. 1943. Pleistocene geology and early man in Java. *Trans. Amer. Philos. Soc., n. s., 32 (3): 437–464, figs. 100–106, pls. 34–35.*

DICKERSON, ROY E. 1941. Molengraaf River: a drowned Pleistocene stream and other Asian evidences of the lowering of the sea level during the Ice Age. *Univ. Pennsylvania Bicentennial Conf., 13–30, figs. 1–16.*

DICKERSON, ROY E., ELMER D. MERRILL, RICHARD C. McGREGOR, W. SCHULTZ, EDWARD H. TAYLOR, AND ALBERT W. HERRE. 1928. Distribution of life in the Philippines. *Monogr. 21, Philippine Bur. Sci., Manila, 1–22, 42 pls.*

FOWLER, HENRY W. 1941. The fishes of the groups Elasmobranchii, Holocephali, Isospondyli, and Ostariophysi obtained by the United States Bureau of Fisheries Steamer "Albatross" in 1907 to 1910, chiefly in the Philippine Islands and adjacent seas. *Bull. U. S. Nat. Mus., 100 (13): i–x, 1–879, figs. 1–30.*

GÜNTHER, ALBERT. 1880. Report on the scientific results of the voyages of H. M. S. "Challenger" during the years 1873–76. Zoology. Report on the shore fishes, *1 (4): 1–82, pls. 1–32.*

HERRE, ALBERT W. 1924a. Distribution of the true freshwater fishes in the Philippines and its significance. *Proc. Pan-Pacific Sci. Congress, Australia, 1923, 2: 1561–70.*

——— 1924b. Distribution of the true freshwater fishes in the Philippines. I. The Philippine Cyprinidae. *Philippine Jour. Sci., 24 (3): 249–306, pls. 1–2.*

——— 1934. Notes on fishes in the zoological museum of Stanford University. The fishes of the Herre Philippine Expedition of 1931. *Hong Kong, 106 pp.*

HOOIJER, DIRK ALBERT. 1951. Pygmy elephant and giant tortoise. *Scientific Monthly, 72 (1): 3–8, figs. 1–3.*

MAYR, ERNST. 1945. Wallace's line in the light of recent zoogeographical studies. *In* Science and Scientists in the Netherlands Indies, edited by Pieter Honig and Frans Verdoorn. *Nat. Tijd. Ned. Ind., 102 (spec. suppl.): 241–250, figs. 69–70.*

MOLENGRAAF, G. A. F. 1930. The coral reefs in The East-Indian Archipelago, their distribution and mode of development. *Proc. Pan-Pacific Sci. Congress, Java, 1929, 2A: 55–89, figs. 5–12, charts 1 and 4.*

ROXAS, HILARIO, AND CLARO MARTIN. 1937. A checklist of Philippine fishes. *Philippine Dept. Agric. and Commerce, Tech. Bull. 6: 1–314.*

SEALE, ALVIN, AND BARTON A. BEAN. 1907. On a collection of fishes from the Philippine Islands made by Major Edgar A. Mearns, Surgeon, U. S. Army, with descriptions of seven new species. *Proc. U. S. Nat. Mus., 33: 229–48, figs. 1–8.*

UMBGROVE, J. H. F. 1930. The amount of the maximal lowering of the sea level in the Pleistocene. *Proc. Fourth Pan-Pacific Sci. Congress, Java, 1929, 2A: 105–113, figs. 1–3.*

——— 1938. Geologic history of the East Indies. *Bull. Amer. Assoc. Petroleum Geologists, 22 (1): 1–70, figs. 1–24.*

——— 1949. Structural History of the East Indies. *Cambridge Press, Cambridge, 1–63, figs. 1–68, pls. 1–10.*

WEBER, MAX, AND L. F. DE BEAUFORT. 1916. The fishes of the Indo-Australian Archipelago. Ostariophysi: II, Cyprinoidea, Apodes, Synbranchii. *E. J. Brill, Leiden, 3: xv + 455 pp., figs. 1–214.*

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Spawning Habits and Early Development of the Mountain Whitefish, *Prosopium williamsoni*, in Montana[1]

C. J. D. BROWN

THE mountain whitefish is one of the most abundant game fishes in Montana. Very large populations are present in the Yellowstone River and upper Missouri River, of the Missouri River drainage, and in the Flathead River and Clark Fork River, of the Columbia River drainage. Almost none of the cold valley streams is without them but they are not as a rule found in the small mountain tributaries. While *Prosopium williamsoni* (Girard) has been regarded as little better than a sucker by the average fisherman, there is at present a growing respect for this fish. It is sought after most vigorously in winter when the majority of waters are closed

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to trout fishing and when whitefish are more easily caught.

A study of the food habits of this species in Montana has recently been published (Laakso, 1951) and investigations on its growth rate, distribution and taxonomy are in progress. Observations on the spawning habits and early development were begun in 1947 and have continued to the present. These investigations have been confined largely to the Gallatin, Yellowstone, and Madison Rivers.

TABLE I

ACTUAL EGG COUNTS OF 21 WHITEFISH COLLECTED IN THE YELLOWSTONE, GALLATIN AND MISSOURI RIVERS

Total length, inches	Weight, ounces	Number of eggs
10.2	6	1,426
10.3	7	2,160
10.4	6	1,532
10.4	8	1,940
10.7	7	1,955
11.0	7	1,470
11.1	10	4,321
11.2	8	1,773
11.2	8	2,114
11.7	10	4,106
11.7	9	3,465
12.2	10	3,261
12.9	12	3,242
13.1	12	4,131
14.0	13	3,700
15.0	16	5,360
15.2	16	4,494
15.5	20	5,191
16.0	20	5,377
17.0	24	7,271
19.5	48	24,143

The writer is indebted to several students who helped in making collections and to Professor Harold Watling for assistance in interpretation of embryological stages.

NUMBER AND SIZE OF EGGS.—The number of eggs produced by whitefish is generally correlated with the length and weight of the fish (Table I). With some exceptions, the larger the fish, the more eggs it will produce. However, one female with a total length of 11.1 inches produced approximately 2.5 times more eggs than another which was 11.2 inches long. Egg counts of 21 individuals taken just before spawning (egg sacs still intact) show a variation from 1,426 to 24,143 (Table I). The smaller number was produced by a fish weighing six ounces which was 10.2 inches in total length and the largest by a three pound specimen, 19.5 inches long. The average for the 21 specimens was 4,401, or 5,343 per pound of fish. Simon (1946) reported that whitefish from Jackson Lake, Wyoming, produced an average of 6,885 eggs per pound of fish. That the ovaries make up a substantial part of the body weight is described by Sigler (1951). He gave 18.8% as the average. The ovaries of one large female from the Yellowstone River made up 21.8% of the body weight.

Simon (1946) reported that mountain whitefish eggs total 912 per fluid ounce. Diameter measurements based on a sample of 50 water-hardened eggs showed an average of 3.7 mm. with a range of 3.1 to 4.2 mm. Sigler (1951) gave 1.94 to 2.12 mm. as the diameter of whitefish eggs and reported that egg size increased with the size of the fish.

Most of the whitefish become sexually mature in their third year of life although a few mature in their second year.

SPAWNING.—Observations were made during the spawning seasons of several years for the purpose of witnessing the behavior of the fish at that time. No marked mass movement or migrations were observed and no unusual concentrations of fish were seen in areas known to be used for spawning. The whitefish in lakes do move up tributary streams to spawn (Simon, 1946). Large runs come into the traps on the South Fork of the Madison River from Hebgen Lake, along with brown trout spawners. Concentrations of whitefish are reported in the shallower water near shore in Cliff Lake during the spawning season but no evidence has been presented to show that they spawn there. A small number of whitefish move into some of the tributary streams from the larger rivers. On the Yellowstone River, such tributaries as Mission Creek, Tom Miner Creek and Mol Heron Creek are used. Other comparable tributaries in the same general area are not used and the reason for this is not evident. Spawning whitefish were found only in the lower 300 to 500 yards of these streams.

Whitefish spawn in the gravel and rubble riffle areas of the streams. There seems to be little or no selection of bottom materials. An abundance of eggs, in various stages of development, has been found in bottoms ranging from fine gravel to coarse rubble. Water depths varied from five inches to four feet. Spawners undoubtedly use depths much greater than four feet but such areas could not be sampled with our equipment. Eggs were usually most numerous in areas adjacent to strong currents; some were found in the bottom directly below rapid surface velocities, and some where water movement was hardly perceptible.

No evidence was found that whitefish prepare nests as do trout. There was little or no noticeable disturbance of the bottom in the areas used. The only means of detecting spawning beds was by searching for the eggs.

Regular sampling of areas in the West Gallatin River at a place near Manhattan, Gallatin County, showed that spawning did not occur in 1949 until after October 14 when water temperatures had decreased to 42° F. Eggs were abundant in the gravel here on October 28. Several whitefish captured on this date had partially spawned, but none completely, and others were still "green". By November 10, spawning was about over and most of the females caught at this time were completely spawned out. Several still retained a few eggs. All whitefish collected in this area on November 17 (water temperature 40° F.) were without eggs. Several of them showed marked recovery from spawning as evidenced by their ovaries and general body condition.

The peak of whitefish spawning in streams at higher elevations occurs at a later date. Large numbers of "ripe" fish were captured in the South Fork of the Madison River on November 14, 1950, when the water was 36° F.

A collection of 25 whitefish taken on October 14, 1949, in the Yellowstone River 17 miles below Livingston, Park County, showed 12 ripe females, 12 green females and seven ripe males. On October 20, 1951, a collection of 40 adult whitefish from the same area included 32 females, 12 of which were green, 18 in various stages of spawning and two spawned out. The eight males of this collection were ripe and appeared to be partially spent. On November 3, 1950 (water 41° F), all females captured in this area were spawned out and the males were nearly so.

Attempts were made to observe the spawning act of whitefish during three successive spawning seasons in areas known to be used. All observations made during daylight hours were unsuccessful. Whitefish were seen congregating in shallow water on several occasions, usually just before dark and this led the writer to suspect that spawning occurred at night.

With the assistance of spotlights, night observations were made on Mol Heron Creek. Whitefish were seen to spawn in this creek just after dark on November 2, 1951 (water 32° F.), at a place about 50 yards upstream from its confluence with the Yellowstone River. Spawning fish were not much disturbed by a light when partially shaded from it. They moved away from a strong beam of light held directly on them, however, and could be herded to either side, upstream or downstream, depending upon how the light approached them.

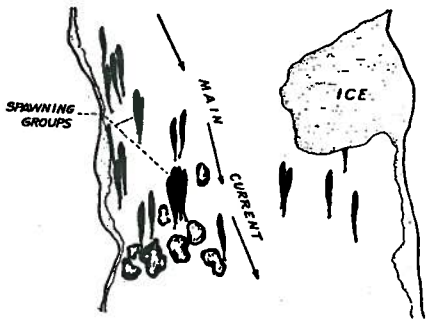

Fig. 1. Sketch showing cross-section through Mol Heron Creek with spawning whitefish.

About 30 whitefish were in the immediate area under observation (approximately 100 square feet). They were in groups of 2 to 5 with several fish remaining apart at least for a time. We had no means of determining the sex composition of the groups although males were known to be predominant as evidenced by a sample of fish taken in the area after observations were completed. All males and females were ripe, for eggs and milt came from these fish even with careful handling. The greatest concentration of fish occurred in water about one foot deep just to the side of the main current (Figure 1).

Fish were just holding their position against the current and at intervals the individuals within a small area would move close together so that their bodies were in contact, and as they did so they came almost to rest on the

ottom. They remained in this position from to 4 seconds and then would move apart, ometimes separating and moving up or down tream. There were no rapid or violent body novements. Individuals from one group were bserved to join others and the process was epeated. It was not possible to see eggs or nilt extruded but freshly laid eggs (not yet vater-hardened) were collected on a screen held directly behind one of these groups. In one instance about 25 eggs were collected. A few water-hardened eggs and small pebbles were also collected on the screen at the same time, indicating that some of the eggs in the bottom were dislodged in the process.

TABLE II

DEVELOPMENT OF WHITEFISH EMBRYOS IN WEST GALLATIN RIVER NEAR MANHATTAN, MONTANA, DURING THE WINTER OF 1949–50

Date	Water temperature, in °F.	Early stages of development
10/28/49	47	Newly fertilized eggs to well formed blastoderm
11/10/49	41	Blastoderm to early neural axis
11/17/49	40	Late neural axis to lateral enlargement of head
12/ 4/49	33	Late neural axis to early eye; some pigmentation
12/16/49	32	Late neural axis with anterior dorsal thickening of body. Eye medium development, lens partly to wholly formed
1/20/50	32	Eye lens large. Posterior body fully formed. Pigmented lateral line
2/15/50	36	Dorsal of head and sides of body pigmented. Entire body raised from yolk
3/ 4/50	42	Yolk much reduced. Body fully formed and pigmented. Hatching just begun

PREHATCHING DEVELOPMENT.—Samples of whitefish eggs were taken at fairly regular intervals throughout one winter from a gravel riffle area of the West Gallatin River near Manhattan in order to ascertain the rate of development under natural conditions. At the beginning, embryos were not all in the same stage of development (Table II) because spawning occurred over about a two week period. However, by January 20, all embryos were fairly uniform in their development. The first eyed embryos were found in the December 4 collection and the first hatching individuals were secured on March 4.

HATCHING AND LATER STAGES.—Spawn was artificially taken from 25 whitefish collected on the South Fork of the Madison River on November 14, 1950. After fertilization, eggs were allowed to stand in river water for about an hour before being transported to the Bozeman Fish Hatchery. In the evening of this same day, eggs were placed on drip trays in the hatchery. The water flowing through the trays had a temperature of 52° F. and varied from this no more than a ±2° F. during the period of development. Dead eggs were picked off on December 6, at which time all living embryos were eyed. The majority of these fish hatched on December 20 and had absorbed all their yolk by December 29. Hatching thus occurred 36 days after fertilization at a water temperature of about 52° F.

TABLE III

SIZE OF WHITEFISH FRY AND FINGERLINGS

Place	Date	Total length (mm.)* Range	Total length (mm.)* Average†
Gallatin river.....	3/ 4/50	11.3–12.2	11.7
Gallatin river.....	4/14/50	14.7–17.0	15.8
Gallatin river.....	5/21/50	26.0–29.6	27.7
Gallatin river.....	6/ 9/50	23.8–40.6	35.3
Gallatin river.....	10/ 2/49	86.0–111.1	94.5
Yellowstone river....	3/23/50	13.5–15.2	14.4
Yellowstone river....	7/21/48	37.6–64.4	52.3
Yellowstone river....	10/22/50	112.3–126.5	120.3
Hebgen reservoir....	6/12/49	42.4–58.0	51.4
Hebgen reservoir.....	7/ 7/49	53.4–85.1	66.1

* All measurements on preserved specimens (10% formalin).
† Ten specimens in each sample.

Practically all of the whitefish hatched in the West Gallatin River near Manhattan between March 4 and 28 (water 40 to 42° F.). A tremendous hatch of whitefish was observed in the Yellowstone River, 17 miles down stream from Livingston, on March 23, 1951 (water 42° F.). Many of the eggs kicked from the gravel on this date hatched on the screen which trapped them.

After considerable searching, many whitefish fry with yolk sacs still visible were found in the Gallatin and Yellowstone Rivers during late March. They were present along the shore where the water was very shallow (2 to 6 inches), in small, well protected pockets created by rubble or boulders and in all back waters connected to the main stream.

A collection of fry taken from the West Gallatin River on April 14, 1950 (water 48° F.), had an average total length of 15.8 mm. (Table III). Another sample from this same area on May 21 had an average length of 27.7 mm. By June 15, all of the fingerling whitefish which had occupied the quiet areas near shore had disappeared and no amount of effort could locate them in water which could be waded or seined. Collections of fingerlings (average total length 94.5 mm.) were made in the deep pools of the West Gallatin River on November 2, 1949, with the assistance of electrical shocking equipment. Whitefish fingerlings deserted the shallow shore waters of the Yellowstone River in late July when they were about 55 mm. in total length. Fingerlings which averaged 120.3 mm. in total length were captured in deep pools on this stream on October 22, 1950. A study of their scales showed them to be young of the year.

If our samples are representative, whitefish fry and fingerlings grow most rapidly in Hebgen Lake of the Madison River and least in the Gallatin River.

LITERATURE CITED

LAAKSO, MARTIN. 1951. Food habits of the Yellowstone whitefish *Prosopium williamsoni cismontanus* (Jordan). *Trans. Amer. Fish. Soc., 80 (1950): 99–109, figs. 1–2.*

SIGLER, WILLIAM F. 1951. The life history and management of the mountain whitefish *Prosopium williamsoni* (Girard) in the Logan River, Utah. *Agri. Exp. Sta. Utah State Agri. Coll., Bull. 347: 1–21, frontis., figs. 1–3.*

SIMON, JAMES R. 1946. Wyoming Fishes. *Wyo. Game and Fish Dept. Bull. 4: 1–129, frontis., figs. 1–92.*

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Herpetological Notes

NOTES MADE BY DR. EDWARD HALLOWELL.—The library of the Academy of Natural Sciences of Philadelphia possesses a set of Holbrook's *North American Herpetology*, second edition, containing numerous pencil notes made by the eminent herpetologist Dr. Edward Hallowell. The author feels that these notes are of sufficient historic interest to warrant transcription before they become completely obscure with age.

Volume I, under the heading of *Cistuda carolina* Edwards; notes at bottom of page 33 to be appended to word 8, line 18: "Major LeConte states that none of the Box Tortises in Florida have more than three toes upon the posterior extremities."

Volume III, under the heading of *Crotalus durissus* Linnaeus; notes at bottom of page 12 to be appended to end of line 2: "Col. McCall states that one of the soldiers on lying down was bitten four times in the back by a durissus, but recovered—the bite was in the month of March. They are said to be most dangerous in August.—E. H."

Volume III, under the heading of *Crotalus adamanteus* Beauvais; notes at bottom of page 18 to be appended to end of last line: "Col. McCall states that he has known several mules to be bitten by the adamanteus, and recover.—E. H."

Volume III, under the heading of *Crotalophorus milarius* Linnaeus; notes at bottom of page 28 to be appended to end of last line: "Col. McCall informed me that one of the privates attached to his regiment was killed by the bite of a milarius.—E. H."

Volume III, under the heading of *Crotalophorus tergeminus* Say; notes at bottom of page 30 to be appended to end of line 24: "found by Col. McCall in the Orapi Indian Country, and in New Mexico, near the Rocky Mountains in sandy, partly prairie—where there was but little grass."

Volume III, under the heading of *Brachyorrhos amaenus* Say; notes at bottom of page 117 to be appended to word 6, line 2: "neighborhood of Philadelphia."

Volume V, under the heading of *Salamandra longicauda* Green; notes at bottom of page 62 to be