NOTES AND COMMENT

Breeding Habits of the Northern Dace[1]

The spawning activities of the Northern Dace, *Margariscus margarita nachtriebi* Cox, were observed in the Pentwater River, Oceana County, on June 12, 1928, and in Pine Creek, a tributary of the Big Manistee River in Manistee County, Michigan, on the following day. No other fish species were seen breeding in these localities while these observations were being made.

It has been stated (Reighard, '13, p. 99; Shelford, '11, p. 34) that fish are only moderately particular as to their diet, but exhibit a high degree of selectivity in regard to the conditions under which the various species will reproduce. No attempt was made at a thorough analysis of the factors involved in this case, but the following features were noted: spawning was observed in a strong current, a moderate current, and in a pocket where the water was nearly quiet; dace were seen pairing over coarse gravel, fine gravel, and sand, but not over shingle or humus deposits, though both were accessible; both streams were about 15 feet wide and from 1½ to 2 feet deep where the fish were breeding; the waters of both streams were clear and colorless; temperatures taken on the breeding grounds while the fish were active were 63° F. in the Pentwater River, and 65° F. in Pine Creek. To summarize, the Northern Dace were seen spawning in a clear water stream of 1½ to 2 feet depth and 15 feet width, in or out of the current, on sand or gravel bottom, with the water temperature from 63° to 65° F.

On the spawning grounds of the Northern Dace there are three types of individuals, namely, adult males, adolescent males, and adult females, and the behavior of each fish at this time is so characteristic as to classify it at once for the observer. Each adult male maintains a small area of the stream bottom as his private spawning ground, guarding it against intrusion by other males, and apparently restricting his own spawning to it the major share of the time. The adolescent male maintains no such holding and frequently invades the holdings of other males, only to be driven out when their owners return. He also pursues females, and occasionally succeeds in pairing with one of them, sometimes close to, or actually within the holding of another male. The adult females never pursue other fish, being themselves continually pursued by males, and they may be seen at all times either fleeing from a male or yielding to his drive and entering his holding. An individual adult male may be identified and distinguished from his fellows by his size, by the brilliance of his lateral band, and by the number and position of the dark mottling areas of specialized or regenerated scales that characterize this genus of minnows. Moreover, the roving range of a breeding male is so limited that it is possible to keep one individual constantly under observation for long periods, and so avoid confusing him with others.

In addition to behavioristic features, the three types exhibit morphological characteristics that facilitate recognition, and these may be listed as follows: (1) The adult males are marked by a reddish band deep down on their sides, and the other two classes appear dull and plain by contrast. (2) The paired fins, especially the pectorals, differ with the sexes, those of the males being longer, wider, and more rounded than those of the females. (3) At this season the pectoral fins of the males are further specialized by the development of paired rows of small tubercles on the first seven fin rays, and the membranous areas between are greatly swollen. (4) The breeding females range

[1] Contribution from the Department of Zoology, University of Michigan.

from 3¼ to 4¼ inches in length, while adult males average about 3¼ inches and adolescent males about 2½ inches. (5) The belly of the female is swollen with eggs, and her body is obviously thicker and deeper than that of a male.

The holding of an adult male consists of an area of stream bottom about 8 inches across, without definite outline except as its margin is made apparent by the behavior of its proprietor. No transporting of material was witnessed, and there were no signs of either mounding or excavating. The two closest holdings on the areas observed were 6 feet apart.

Breeding Behavior.—The adult male dace is away from his headquarters more of the time than he is there, and his brief periods at home are spent nosing over the bottom as if seeking eggs to eat. The moment another dace reaches his vision he is off in pursuit, but seldom ranges farther than 4 feet from his home. If the stranger proves to be a male he is promptly escorted away, the two fishes swimming with synchronized movements as described by Reighard ('08, p. 1129) for the horned dace. However, the intruder balks before he gets a yard away, and swings back toward the holding, only to be met again and once more led away, and this may happen a number of times before the invader really leaves the premises. Sometimes, at the moment when the intruder apparently refuses to be led farther away, the two males pose for an instant with their heads abreast as if with locked pectoral fins, or as if they had started to pass each other and then stopped suddenly. From this position the stranger almost invariably makes another dash for the holding.

If the stranger should be a female, and if she permits the male to drive her into his holding instead of fleeing, and if, once there, she stays and permits the male to pair with her, the process occurs in this manner. The two fish come to a position side by side, close to bottom, and, if there is a current, heading upstream. The oversized tubercle-roughened pectoral fin of the male is slipped beneath the anterior part of the body of the female, and his tail is crossed over her back, just behind her dorsal fin. Then as his tail presses her vent and tail tightly to the bottom, his pectoral fin raises the forepart of her body to an angle of about 30 degrees from the bottom, in this way stretching tight her belly wall and probably assisting oviposition. When this position has been reached both fishes vibrate the posterior parts of their bodies rapidly, the tail of the female stirring up the bottom behind them while the male's tail fans the bottom alongside and about midway between the female's pectoral and pelvic fins. If the male is considerably shorter than the female his tail may not reach the bottom, and in this case it vibrates in the water at whatever angle it attains. The eggs and milt are without doubt extruded while the fish are vibrating, but they were not seen. When the spawning vibrations have ceased, the female resumes a horizontal position at once, swimming forward out of the holding without the momentary relaxation and floating belly-upward that occurs in the case of the horned dace immediately following the spawning act. It seems probable that the spawning angle of the female northern dace is not great enough to disturb her equilibrium.

The spawning act lasts about two seconds, and since each female repeats the act many times during the breeding season she must extrude but a few eggs each time. Each egg is .036 inch in diameter, and one 4¼-inch female contained 1,686 eggs. Since each male spawns mainly on his individual spawning ground with a number of females for the possession of whom he combats with other males, the condition is similar to that referred to by Reighard ('20, p. 31) as "approaching polygamy."

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T. H. LANGLOIS

UNIVERSITY OF MICHIGAN

THE DETERMINATION OF DISSOLVED OXYGEN WITH THE MICRO-WINKLER APPARATUS OF THOMPSON AND MILLER

The apparatus lately described by Thompson and Miller [1] for use in applying the Winkler method to the micro-determination of dissolved oxygen was designed primarily for use in cases where only small quantities (8–10 cc.) of the sample are available, as in protozoan cultures, etc. Its use by the writer has indicated, however, that the method is suited to a variety of purposes, being at least as accurate as the macro-method, and decidedly more convenient in many cases where the latter would ordinarily be used.

The following tabulation of results obtained by alternate determinations on the same solutions by the macro- and micro-methods will indicate the relative merits of the two methods. The samples consisted of tap water which was allowed to stand until the dissolved oxygen content became constant.

In the final step of both macro- and micro-determinations, 0.002 N or 0.003 N sodium thiosulfate solution was used to titrate the liberated iodine, this solution being freshly prepared and standardized against 0.01 N iodine solution before each set of titrations. By using one drop of starch solution, and titrating in a small Erlenmeyer

Tabulation of Results Obtained by Macro- and Micro-Determinations on the Same Solutions

	Dissolved Oxygen, Milligrams per Liter			
	Macro-method (250 cc. Sample)		Micro-method (4.9 cc. Sample)	
	Average of 3 Determinations	Maximum Deviation from the Mean	Average of 3 Determinations	Maximum Deviation from the Mean
Sample 1.....	7.46	0.07	7.42	0.07
Sample 2.....	9.93	0.05	9.91	0.04
Sample 3.....	9.59	0.05	9.64	0.06

flask which is placed in a large porcelain crucible to furnish a uniform white background, the end-point can be detected with considerable exactness. The use of the same

[1] Thompson, T. G., and Miller, R. C. Apparatus for the micro-determination of dissolved oxygen. Ind. Eng. Chem., 20: 774. 1928.