

Ecology of the Southernmost Sympatric Population of the Brook Stickleback, *Culaea inconstans*, and the Ninespine Stickleback, *Pungitius pungitius*, in Crooked Lake, Indiana^{1,2}

JOSEPH S. NELSON,³ Indiana University

Abstract

The southernmost locality where *Culaea inconstans*, the brook stickleback, and *Pungitius pungitius*, the ninespine stickleback, occur in sympatry is Crooked Lake, Indiana. Both species were first found in Crooked Lake in 1966 with rotenone, gillnets, and Plexiglas traps. *Culaea* and *Pungitius* occur between 3½ and 10 m and 5 and 30 m, respectively. The summer range in pH for the two species is 7.6 to 8.6 and 7.4 to 8.6, respectively. The temperature range is between 12 and 24 and 6 and 24, respectively.

Both sticklebacks probably spawn in rooted aquatics. *Pungitius* adults, however, generally occur below the zone of rooted aquatics. Fully ripe eggs were found in the limited number of *Culaea* adults between June 26 and July 19. *Pungitius* with fully ripe eggs were found from April to August. Identifiable young of *Culaea* and *Pungitius*, 12 mm standard length, were first collected July 19 and June 15, respectively. The largest *Culaea* was 38 mm while the largest *Pungitius* was 59 mm standard length.

Culaea was found in the stomachs of *Micropterus salmoides* and *Perca flavescens*. Stomachs of the latter two species and of *Esox americanus* contained *Pungitius*.

Introduction

Culaea (= *Eucalia*) *inconstans* (Kirtland), the brook stickleback, occurs in lakes, ponds, and streams across northern North America from northeastern British Columbia to New Brunswick and south to Indiana. *Pungitius pungitius* (Linnaeus), the ninespine stickleback, occurs in the freshwaters and along the coastlines of northern Asia, Europe, and northern North America. The southernmost locality where these two fish of the stickleback family, Gasterosteidae, occur in sympatry is Crooked Lake, Indiana (Fig. 1).

Crooked Lake lies on the border of Noble and Whitley counties at 41°16'N latitude and 85°29'W longitude in the glaciated lake district of northern Indiana. Crooked Lake, part of the Wabash River drainage, is the second deepest lake in Indiana and has a maximum depth of 33 m (108 ft). This marl lake covers 79 ha (195 acres) and is at an elevation of 276 m (906 ft). This report notes some aspects of the comparative ecology of *Culaea* and *Pungitius* in Crooked Lake.

Methods and Materials

Populations of both *Culaea* and *Pungitius* were first found in Crooked Lake by Nelson (6) in 1966 with relatively new collecting

¹Contribution # 806 from the Department of Zoology, Indiana University.

²The author gratefully acknowledges the field help of D. Ort, K. Shan, W. Weaver, and C. Zimmerman. The financial assistance of the Indiana Department of Natural Resources is appreciated.

³Present address: Department of Zoology, The University of Alberta, Edmonton, Alberta, Canada.

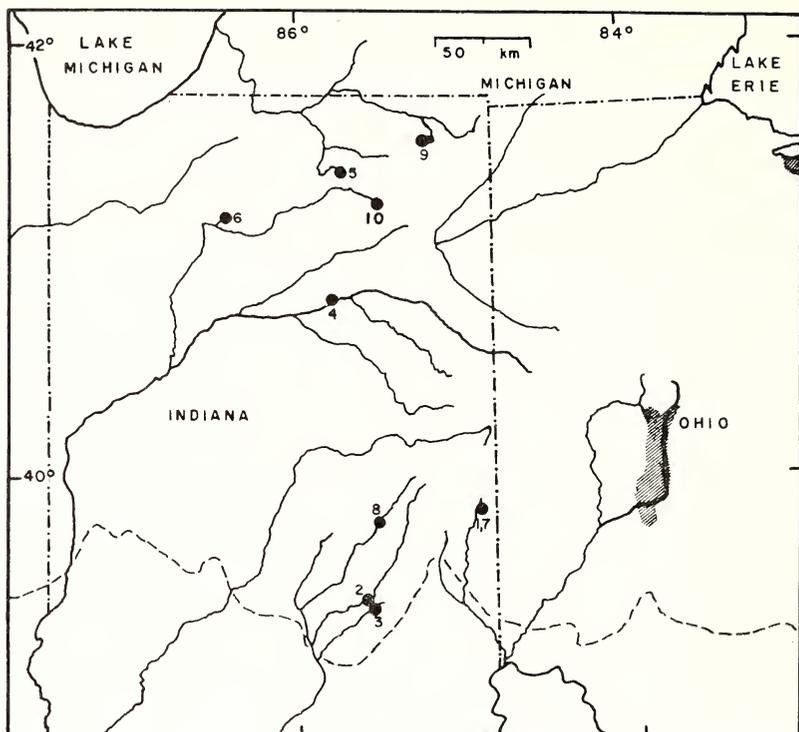


Figure 1. Locality records in Indiana for *Culaca inconstans*. The distribution of the species in western Ohio is included (modified from Trautman (12)). 1—Whitewater drainage near Richmond, Plummer (7); 2—Flat Rock River tributaries, Shannon (9); 3—Clifty Creek and its tributaries, Shannon (9); 4—Kentner Creek, Ulrey (13) and Ind. Mus. No. 5454, in University of Michigan, Museum of Zoology; 5—Turkey Lake (= Lake Wawasee), Ind. Mus. No. 8900, in University of Michigan, Museum of Zoology, collected 1895; 6—Lake Maxinkuckee, Evermann and Clark (4); 7—Whitewater drainage near Richmond, Shoemaker (10); 8—Big Blue River oxbow, collected 1964 by F. R. Lockard; 9—Pretty Lake, collected 1964 by T. D. Beard and 1967 by J. S. Nelson; and 10—Crooked Lake, collected 1966 and 1967 by J. S. Nelson. The long dashed line denotes the maximum southern extent of Wisconsin glaciation.

techniques. Monofilament nylon gillnets of 12 mm stretched mesh, Plexiglas traps (2), and rotenone emulsion (Chem Fish Special) were employed. The rotenone was dispensed by pumping 125 to 175 cc of the liquid, diluted with an equal volume of water, into toy balloons. The balloons were attached to the end of a weighted line and were broken with a messenger armed with sharpened nails. The dead sticklebacks floated on the surface 1 to 4 hours later and were collected with a dip net. Sampling was done at various depths on the lake bottom. The area affected by the rotenone extended for at least 2 m above the point of release.

Temperature was recorded at 1 m intervals with a Yellow Springs

Instrument thermistor thermometer. Oxygen was measured at 2 m intervals with the Azide modification of the Winkler method. The pH was determined at 1 m intervals with a portable Photovolt Instrument, Model 126.

Results and Discussion

Distribution in Indiana

Culaea inconstans was first reported in Indiana by Plummer (7). Since 1851 it has been found in scattered localities in the glaciated portion of Indiana (Fig. 1). Only one or a few specimens have been reported in five of the nine known localities. Except for a population from Merrick Lake, northeastern New Mexico, which available evidence suggests is native (William J. Koster, personal communication), the *Culaea* in Crooked, Maxinkuckee, Wawasee, and Pretty lakes are the southernmost known lake populations of the species. Populations occurring further south in Indiana, Nebraska, and Ohio occupy springs or rivers. The southernmost locality record for the species, except for Koster's New Mexico record, is in Decatur County, Indiana, reported by Shannon (9). *Culaea* is common in the tanks of bait dealers in the northern half of Indiana (and perhaps have been present for about the last 15 years). These *Culaea*, which are mixed in with the bait fish *Pimephales promelas*, are obtained from Minnesota and have shorter spines than native Indiana specimens. Present information, however, cannot exclude the possibility that the Crooked Lake population was introduced. Some bait dealers reported *Culaea* to be present in several northern streams but seining operations did not verify these reports.

The abundant Crooked Lake population of *Pungitius pungitius* is the first verifiable report of the species in Indiana and the only known indigenous population in Mississippi drainage. Blatchley (1) reports it to be known in Indiana from Lake Michigan and the Calumet River but gives no authority. Recent collecting in the Indiana tributaries of Lake Michigan has failed to take *Pungitius* although it is known from the lower Calumet River in Illinois. The species is absent from Ohio and is known from only a few localities in inland Michigan.

All collecting suggested that *Pungitius* was much more numerous in Crooked Lake than *Culaea*. In contrast to *Pungitius*, *Culaea* was very rarely taken in the gillnets or Plexiglas traps. Rotenone collections commonly yielded over 150 *Pungitius* but rarely more than 20 *Culaea*. Little Crooked Lake, connected to Crooked Lake and about 75 m (246 ft) to the southeast, was extensively sampled without finding *Culaea* or *Pungitius*.

Limnology of Crooked Lake

Stahl (11) and Wetzel (14, 15) give details on the limnology of Crooked Lake. The lake has a relatively high oxygen concentration (Fig. 2). Two maxima in the oxygen distribution were very pronounced in 1967. Data from Higgins (5) for 1964 also suggest two oxygen maxima, although less marked than that found in this study. Eberly (3) and Stahl (11) found a metalimnetic oxygen maxima.

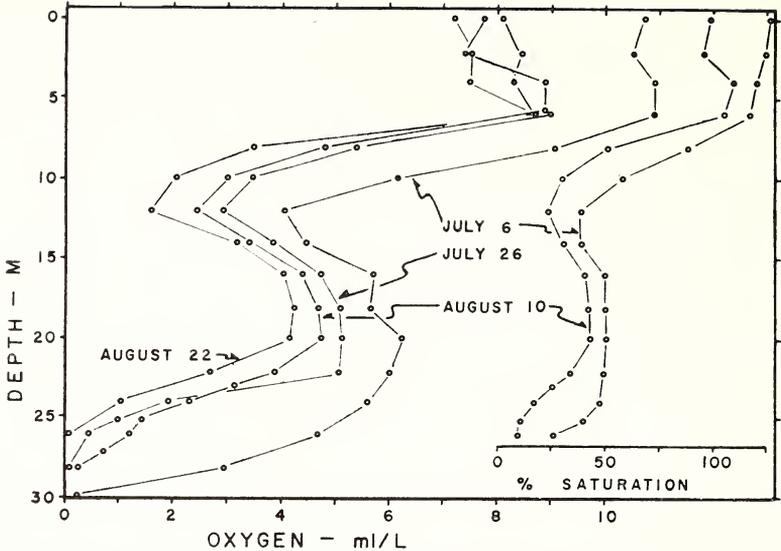


Figure 2. Vertical distribution of oxygen in Crooked Lake, 1967.

Isopleths for pH and temperature are shown in Figure 3. An index of light penetration was obtained with a Secchi disk. Between July 5 and August 8 the mean values stayed within 0.2 m of 5.0 m. Between August 18 and August 28, Secchi disk readings decreased from 3.7 to 2.9 m.

Altogether, 30 species of fish were collected from Crooked Lake in 1966 and 1967. They are as follows: *Lepisosteus oculatus*, *Amia calva*, *Coregonus artedii*, *Salmo gairdnerii*, *Esox americanus*, *Notemigonus crysoleucas*, *Notropis heterodon*, *Notropis volucellus*, *Pimephales notatus*, *Erimyzon sucetta*, *Ictalurus natalis*, *Ictalurus nebulosus*, *Noturus gyrinus*, *Fundulus diaphanus*, *Fundulus notatus*, *Culaea inconstans*, *Pungitius pungitius*, *Ambloplites rupestris*, *Chaenobryttus gulosus*, *Lepomis cyanellus*, *Lepomis gibbosus*, *Lepomis macrochirus*, *Lepomis microlophus*, *Micropterus salmoides*, *Pomoxis nigromaculatus*, *Etheostoma exile*, *Etheostoma microperca*, *Etheostoma nigrum*, *Perca flavescens*, and *Labidesthes sicculus*. Only about half of these species may be readily taken in a seine.

Vertical distribution

Culaea and *Pungitius* were collected between 3½ and 10 m and 5 and 30 m, respectively, in Crooked Lake, between early June and late August, 1967. The two species were frequently taken together between 6 and 8 m in samples collected with rotenone. Sampling in July and August at various depths with rotenone showed that larger *Pungitius* individuals tended to occur in deeper water than smaller individuals. In most localities where *Culaea* and *Pungitius* are known they can be collected in shallow water, although they are known from deep water

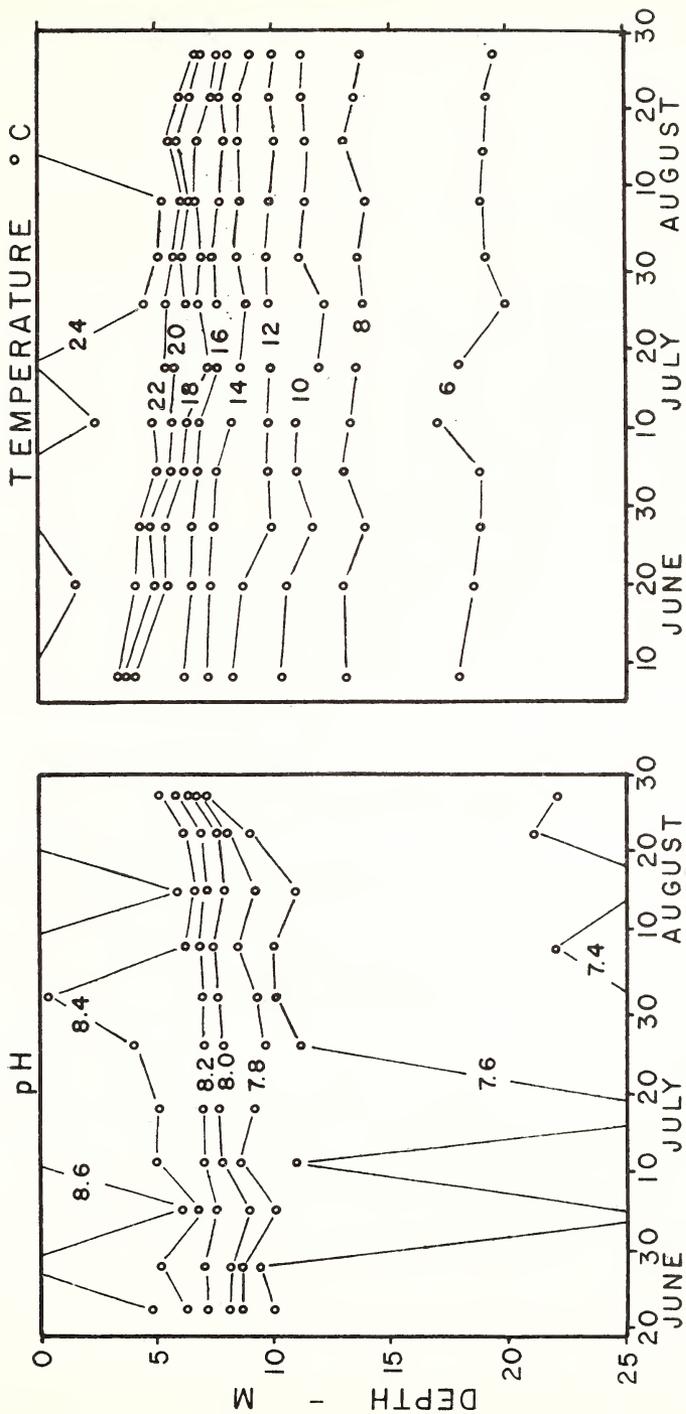


Figure 3. Vertical distribution of pH and temperature in Crooked Lake, 1967.

in the Great Lakes. Extensive seining during every month, except February when the lake was frozen over, failed to take any sticklebacks. Occasionally, dead specimens were found on the shoreline. Indeed, the first specimens of *Culaea* and *Pungitius* were found dead (June 16, 1966 and November 6, 1965, respectively).

During the summer months *Culaea* and *Pungitius* were in water of pH 7.6 to 8.6 and 7.4 to 8.6, respectively. The temperature range was between 12 and 24 and 6 and 24, respectively.

Reproduction

No nests of either species were found. Fully ripe *Culaea* females were found from at least June 26 to July 19, 1967. From the study of Reisman and Cade (8) it would be expected that reproduction in Crooked Lake *Culaea* would be confined to the lower zone of rooted aquatics where the temperature is lower than 19°C. Fully ripe *Pungitius* females were found between April 9 and August 24, 1967. Data from the Plexiglas traps suggest that *Pungitius* moved from deep water into the rooted aquatics, less than 9 m deep, to spawn. After spawning, they apparently moved into deep water. Between June 9 and June 23 the majority of adults were in water between 6 and 18 m. After the above date, the majority of large adults were in water deeper than 18 m. The diameter of fully ripe eggs in *Culaea* ranged between 1.0 and 1.3 mm while in *Pungitius* it ranged between 1.4 and 1.8 mm.

The young of both species first appeared in the rooted aquatics. Identifiable *Pungitius* individuals of 10 mm standard length were first found on June 15. Young of *Culaea* and *Pungitius*, 12 to 14 mm standard length, were first taken together at 7 m on July 19.

Predation

Culaea was found in the stomachs of yellow perch, *Perca flavescens*, and largemouth bass, *Micropterus salmoides*. One 23 mm *Culaea* was found in a *Micropterus* as small as 52 mm standard length. *Pungitius* was commonly found in the stomachs of *Perca*. It was rarely found in *Micropterus* and the grass pickerel, *Esox americanus*.

Morphological distinctions

Culaea and *Pungitius* over 12 mm standard length can be readily distinguished by external characters. In a sample of 100 *Culaea* from Crooked Lake, 93 have 5 spines and 7 have 6 dorsal spines. In a sample of 500 *Pungitius*, 3 have 7 spines, 58 have 8 spines, 345 have 9 spines, 92 have 10 spines, and 2 have 11 spines. *Culaea* has a deeper body and longer spines than *Pungitius* (Table 1). The greatest difference in spine length is among the smaller specimens. Both body depth and spine length in *Culaea* show clinal variation. The greatest difference from *Pungitius* exists in the Wisconsin to Ohio area while the least difference exists in the British Columbia to Saskatchewan area. In *Culaea* the caudal peduncle is deeper than it is wide whereas in *Pungitius* it is wider than it is deep. *Culaea* has a series of 31 to 34 small circular bony scutes along the lateral line (visible only when stained), whereas *Pungitius* has 10 to 16 lateral bony scutes on the caudal peduncle. The

TABLE 1

Proportional measurements of 20 *Culaea* and 20 *Pungitius* and meristic counts of 10 *Culaea* and 10 *Pungitius* from Crooked Lake. Body proportions expressed as thousandths of standard length.

Character	<i>Culaea</i>		<i>Pungitius</i>	
	Range	Mean	Range	Mean
Standard length (mm)	22-37	28	22-37	27
Body depth	200-256	234	148-186	164
Caudal peduncle depth	39-53	46	17-25	21
Pelvic spine length	90-165	124	45-99	77
First dorsal spine length	50-105	77	14-58	39
Precaudal vertebrae	13-14	13.1	15-16	15.1
Caudal vertebrae	18-20	18.7	18-20	19.0
Total vertebrae	31-33	31.8	34-35	34.1
Dorsal soft-rays	9-11	9.7	9-11	9.8
Anal soft-rays	9-11	10.2	7-10	8.8
Pectoral rays	8-10	9.1	9-10	9.9
Caudal rays	12	12	11-12	11.9

opercular opening in *Culaea* does not extend as far past the upper edge of the pectoral fin as it does in *Pungitius*. *Culaea* tends to have a rounded posterior edge to the caudal fin while *Pungitius* has a slightly forked caudal fin. The soft fin rays and first arch gillrakers are about the same in number in both species. *Pungitius* in Crooked Lake attains a larger size than the *Culaea*. The largest *Culaea* obtained was 38 mm while the largest *Pungitius* was 59 mm standard length.

Summary

The southernmost locality where *Culaea inconstans*, the brook stickleback, and *Pungitius pungitius*, the ninespine stickleback, occur in sympatry is Crooked Lake, Indiana. Populations of both species were first found in Crooked Lake in 1966 with rotenone, gillnets, and Plexiglas traps. *Culaea* and *Pungitius* occur between 3½ and 10 m and 5 and 30 m, respectively. The summer range in pH for the two species is 7.6 to 8.6 and 7.4 to 8.6, respectively. The temperature range is between 12 and 24 and 6 and 24° C, respectively.

Fully ripe eggs were found in *Culaea* adults between June 26 and July 19. *Pungitius* with fully ripe eggs were found from April 9 to August 24. Identifiable young of *Culaea* and *Pungitius* were first collected July 19 and June 15, respectively. The largest *Culaea* was 38 mm while the largest *Pungitius* was 59 mm standard length.

Culaea was found in the stomachs of *Micropterus salmoides* and *Perca flavescens*. Stomachs of the latter two species and of *Esox americanus* contained *Pungitius*.

Literature Cited

1. BLATCHLEY, W. S. 1938. The fishes of Indiana. Nature Publishing Co., Indianapolis. 121p.
2. BREDER, C. M., JR. 1960. Design for a fry trap. *Zoologica* **45**(4):155-160.
3. EBERLY, W. R. 1964. Further studies on the metalimnetic oxygen maximum, with special reference to its occurrence throughout the world. *Invest. Indiana Lakes and Streams* **6**:103-139.
4. EVERMANN, B. W., and H. W. CLARK. 1920. Lake Maxinkuckee, a physical and biological survey. Indiana Dept. of Conservation, Indianapolis. Volume 1.
5. HIGGINS, B. E. 1965. Food selection by the cisco, *Coregonus artedii* (Le Sueur), in Crooked Lake (Noble-Whitley Co.), Indiana. Ph.D. Thesis, Indiana University, Bloomington. 131 p.
6. NELSON, J. S. 1968. Deep-water ninespine sticklebacks, *Pungitius pungitius*, in Mississippi drainage, Crooked Lake, Indiana. *Copeia* 1968 (2): **2**:326-334.
7. PLUMMER, J. T. 1851. List of fishes found in the vicinity of Richmond, Indiana. *Proc. Boston Soc. Nat. Hist.* **3**:54-55.
8. REISMAN, H. M., and T. J. CADE. 1967. Physiological and behavioral aspects of reproduction in the brook stickleback, *Culaea inconstans*. *Amer. Midl. Natur.* **77**(2):257-295.
9. SHANNON, W. P. 1887. A list of fishes of Decatur County, Indiana: The fishes inhabiting Clifty Creek within the borders of Decatur County. Greensburg. 2 p. Published privately.
10. SHOEMAKER, H. H. 1942. The fishes of Wayne County, Indiana. *Invest. Indiana Lakes and Streams* **2**:268-296.
11. STAHL, J. B. 1966. Characteristics of a North American *Sergentia* lake. *Gewässer und Abwässer* **41/42**:95-112.
12. TRAUTMAN, M. B. 1957. The fishes of Ohio. Ohio State Univ. Press, Columbus. 638 p.
13. ULREY, A. B. 1894. On the fishes of Wabash County. *Proc. Indiana Acad. Sci.* 1893, **9**:229-231.
14. WETZEL, R. G. 1965. Nutritional aspects of algal productivity in marl lakes with particular reference to enrichment bioassays and their interpretation. *Mem. Ist Ital. Idrobiol., Suppl.* **18**:137-157.
15. WETZEL, R. G. 1966. Productivity and nutrient relationships in marl lakes of northern Indiana. *Verh. Internat. Limnol.* **16**:321-332.