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BULLETIN

The Bantam Sunfish, *Lepomis symmetricus:* Systematics and Distribution, and Life History in Wolf Lake, Illinois

[Bro]oks M. Burr

[STAT]E OF ILLINOIS
[DEP]ARTMENT OF REGISTRATION AND EDUCATION

[NA]TURAL HISTORY SURVEY DIVISION
[UR]BANA, ILLINOIS

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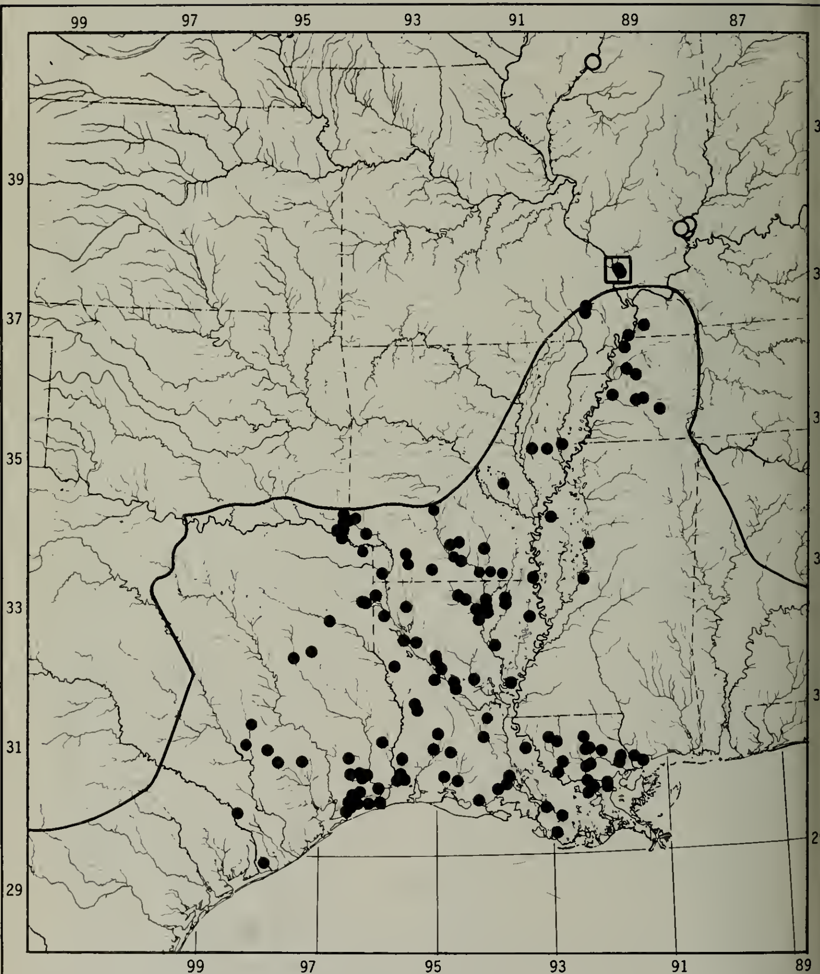

Fig. 1—Distribution of *Lepomis symmetricus* in relation to the Coastal Boundary (solid black line). Solid circles represent recent localities (1938 to the present); large open circles represent old records (pre-1900) where the species is presumably extinct. The most northern open circle also represents the type-locality. The life-history study area is enclosed within the square.

The Bantam Sunfish, *Lepomis symmetricus:* Systematics and Distribution, and Life History in Wolf Lake, Illinois

Brooks M. Burr

The bantam sunfish, described as *Lepomis symmetricus* by Stephen A. Forbes in 1883, is one of the least known species in the genus, probably because of its small size, rarity over parts of its range, occurrence in rather inaccessible swamp habitats, and drab and nondescript appearance. This effort to remedy the gaps in our knowledge of the species reviews all published references to *L. symmetricus.* To supplement the meager information available, this report includes an analysis of morphological variation based on the study of museum specimens, an assessment of the species' distribution, and a life-history study based on periodic collections made at a study site in southern Illinois.

ACKNOWLEDGMENTS

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For information about the location of syntypes and other pertinent study material, I am indebted to museum officials Reeve M. Bailey; James E. Böhlke; Garrett S. Glodek; Tomio Iwamoto, California Academy of Sciences, including the Stanford University (SU) collection; Robert K. Johnson; Craig E. Nelson; Donn E. Rosen, Robert Schoknecht, Museum of Comparative Zoology (MCZ) at Harvard University; and Keith S. Thompson. For providing laboratory space and/or the loan of specimens I thank Reeve M. Bailey, University of Michigan Museum of Zoology (UMMZ); Thomas M. Buchanan, Westark Community College at Fort Smith, Arkansas (ARP); Neil H. Douglas, Northeast Louisiana University (NLU); David A. Etnier, University of Tennessee (UT); Robert K. Johnson, Field Museum of Natural History (FMNH); Ernest A. Lachner, U.S. National Museum of Natural History (USNM); Robert F. Martin, Texas Natural History Collection at Austin (TNHC); John D. McEachran, Texas Cooperative Wildlife Collection at College Station (TCWC); William D. Pearson, University of Louisville, Kentucky (UL); Henry W. Robison, Southern State College at Magnolia, Arkansas (HWR); and Royal D. Suttkus and Michael M. Stevenson, Tulane University, Louisiana (TU). For providing lists of locality records and/or distribution maps I thank Thomas M. Buchanan; B. E. Gandy, Mississippi Museum of Natural Science; Henry W. Robison; Morgan E. Sisk, Murray State University, Kentucky; Neil H. Douglas; and Glenn H. Clemmer, Mississippi State University.

Unless stated otherwise, the majority of the specimens used in this study are deposited at the Illinois Natural History Survey (INHS).

Most of the illustrations for this paper were prepared by Larry Farlow, Technical Photographer; Lloyd LeMere, Technical Illustrator; and Craig Ronto, all of the Illinois Natural History Survey; the drawing of the subadult was done by Alice A. Prickett of the University of Illinois School of Life Sciences. Computer analysis of some of the data was undertaken by Stephen D. Cowan of the Survey. The manuscript was edited by Shirley McClellan, Assistant Technical Editor at the Survey, and Dr. Neil H. Douglas, Northeast Louisiana University, served as guest reviewer. Partial support for the field work was provided by the U.S. Department of Agriculture Forest Service; the Illinois Natural History Survey rendered the other support. Special permission to collect specimens of the bantam sunfish, which is protected by the Illinois Fish Code, was given by the Department of Conservation. Permits to take specimens in the National Park were issued by Joe L. Newcomb of the Forest Service. Paul Brown of the Trojan Powder Plant granted permission to collect on powder plant property.

METHODS AND MATERIALS

An attempt was made to compile as complete a synonymy as possible for *Lepomis symmetricus,* and it is believed that virtually all published references to it have been examined. Morphological data were taken on selected series that could be expected to show geographical variation, allometric variation, or sexual dimorphism in the species. Meristic and morphometric data were taken in the conventional manner of Hubbs & Lagler (1964: 19–26). One-way analysis of variance tests were run to determine significant differences in means of samples determined by sex. Unless stated otherwise, measurements are standard lengths (SL).

Observations and minnow-seine collections were made in Wolf Lake in Union County, Illinois, at approximately 1-month intervals, except during the spawning season, when more frequent observations were needed. The life-history study began 2 June 1973 and ended 27 May 1975.

Specimens were preserved in 10-percent formalin and were returned to the laboratory for study. In all, 233 specimens from Wolf Lake were preserved and examined. Because the species is protected by the Illinois Fish Code, usually no more than 20 specimens were taken on one visit even when the species was commonly encountered, so as not to seriously decimate the population. Collecting was done by bag seine; minnow seine; dip net; and, in one instance, by electrofishing. Potential predators of the bantam sunfish were occasionally collected for examination of stomach contents. Field notes were routinely taken. In the laboratory, specimens were sexed, measured, and aged, and their gonads and stomachs were excised and studied. During the spawning season, breeding adults were brought to the laboratory and placed in observation tanks.

Aging to year class was done by counting scale annuli removed from the dorsum. Aging to month was done by using May, the month of greatest breeding activity in Wolf Lake, as month zero. Thus, a sunfish collected in October with one scale annulus was estimated to have lived 1 year and 5 months. For certain comparisons sunfishes were divided into young (through 12 months) and adult (over 12 months) age groups.

Weights of the ovaries of 30 females were obtained and recorded as a proportion of the adjusted body weight (the specimen minus the ovaries, stomach, intestine, and liver) of the female. Mature ova from 14 preserved breeding females were counted. Indicators used for ascertaining probable spawning periods in other localities and other years were that males exhibited breeding color patterns and that females were heavy with ova.

The relative survival of each year class of the study population was calculated by expressing the number of individuals in that year class as a proportion of the number of individuals in a younger year class.

SYSTEMATICS

SYNONYMY

Lepomis symmetricus Forbes

Lepomis symmetricus McKay 1882: 88 *(nomen nudum);* Forbes *in* Jordan & Gilbert 1883: 473–474 (original description, Illinois River [at Pekin] Illinois); Forbes 1884: 68 (Illinois range); Jordan 1884: 320–321 (redescription, museum specimens cited); Jordan 1888: 117 (redescription); Bollman 1892: 566, 571 (key, range); Evermann & Kendall 1894: 84, 93, 111 (redescription, Texas records); Hay 1894: 255, 261 (redescription, key, not taken in Indiana); Richardson 1904: 31, 33 (relationships, key, Illinois range); Forbes & Richardson 1908: 251–252 (redescription, key, Illinois range); Forbes 1909: 388 (Illinois range); Pratt 1923: 118 (key, range); Greene 1927: 309 (not in Wisconsin); Hildebrand & Towers 1927: 133–134 (Greenwood, Mississippi, food habits in Mississippi); Summers 1937: 434 (new trematode parasite, Baton Rouge, Louisiana); Mizelle 1938: 160 (trematode transferred to new genus); Mizelle & Hughes 1938: 351 (trematode parasite cited); Summers & Bennett 1938: 248 (trematode parasite cited); Kuhne 1939: 110 (Tennessee list, redescription, sexes figured); Lamb 1941: 45 (Willow Creek, San Jacinto drainage, Texas); Fowler 1945: 364, 370 (Louisiana and Mississippi records, figure erroneous); Gerking 1945: 115 (possible in Indiana); Seamster 1948: 165, 168 (trematode parasite cited); Baughman 1950: 247 (Texas list); Moore & Cross 1950: 146 (recorded from Oklahoma); Reeves & Moore 1951: 42 (Oklahoma Coastal Plain); Böhlke 1953: 71 (SU syntypes listed); Moore 1952: n.p. (Oklahoma list); Jurgens & Hubbs 1953: 15 (Texas list); Knapp 1953: 115 (key, Texas range); Gunning & Lewis 1955: 556 (habitat, food habits in Illinois); Gunning & Lewis 1956: 24 (Wolf Lake and Pine Hills, Illinois); Eddy 1957: 191 (key, range); Hubbs 1957*a*: 97 (Texas range); Hubbs 1957*b*: 9 (Texas list); Moore *in* Blair *et al.* 1957: 170 (key, range); Hubbs 1958: 10 (Texas list); Boudreaux *et al.* 1959: 8, 10 (Sour Lake, Hardin County, Texas); Cook 1959: 180 (redescription, ecology, Mississippi range); Bailey *et al.* 1960: 27 (list); Smith & Bridges 1960: 254 (INHS syntypes); Hubbs 1961: 10 (Texas range); Branson & Moore 1962: 9, 15, 24, 27, 29, 31, 33, 41, 48, 65, 72, 91, 99 (relationships, acoustico-lateralis system); Clay 1962: 119 (Kentucky range); Collette 1962: 146, 177 (associate of slough darter and swamp darter); Lambou 1962: 78 (Lake Bistineau, Louisiana); Walker 1962: 40 (Jackson, Lincoln, and Bienville parishes, Louisiana); Walker 1963: 48 (Choudrant Bayou, Louisiana); Sharma 1964: 533 (mucus cells in canal linings); Burton & Douglas 1965: 94 (Bayou De Siard, Louisiana); Smith 1965: 9 (Illinois range); Pflieger 1966: 53 (Missouri key); Breder & Rosen 1966: 413 (breeding habits unknown); Childers 1967: 160 (tribe Lepomini); Douglas & Davis 1967: 23 (Louisiana list); Hoffman 1967: 340 (known parasites); Pflieger 1968: 54 (Missouri key); Moore *in* Blair *et al.* 1968: 128–129 (key, range); Whitaker 1968: 96–97 (key, range); Eddy 1969: 217 (key, range);

Smith & Sisk 1969: 66 (Obion Creek, Kentucky); Bailey *et al.* 1970: 36 (list); Jenkins *et al.* 1971: 74 (possibly present in lower Tennessee or Cumberland rivers); Pflieger 1971: 413–414 (habitat, zoogeography, Missouri range); Smith *et al.* 1971: 10 (not in upper Mississippi River); Hubbs 1972: 6 (Texas range); Miller 1972: 244 (threatened in Illinois and Missouri); Rozenburg *et al.* 1972: iii, 22, 28, 30, 32, 33, 36, 40, 45, 51, 82, 111 (Navasota River, Texas); Buchanan 1973*a*: 29 (Arkansas list); Buchanan 1973*b*: 51 (key, Arkansas range); Miller & Robison 1973: 184–185 (key, redescription, ecology, Oklahoma range); Moore 1973: 6 (McCurtain County, Oklahoma); Smith 1973: 33 (Illinois key); Lopinot & Smith 1973: 46–47 (status in Illinois); Buchanan 1974: 89 (status undetermined in Arkansas); Douglas 1974: 312–313 (redescription, Louisiana range); Pflieger *in* Holt *et al.* 1974: n.p. (rare in Missouri); Ackerman 1975: 10 (endangered in Illinois); Boyd *et al.* 1975: 11, 21 (status in Illinois); Clay 1975: 267, 276, 280 (redescription, key, Kentucky range); Douglas & Davis 1975: 23 (Louisiana list); McReynolds 1975: 253 (LaRue Swamp, Illinois); Pflieger 1975: 254, 265 (figure, key, redescription, Missouri range); Robison 1975: 54, 56 (Saline River, Arkansas, evidence of recent spawning); Webb & Sisk 1975: 63, 67, 69 (Bayou de Chien, Kentucky, endangered in Kentucky); Hubbs 1976: 6 (Texas list); Hubbs & Pigg 1976: 116 (indeterminate status in Oklahoma); Seehorn 1976: 21 (Southeastern National Forest list).

Apomotis symmetricus: Boulenger 1895: 21 (redescription); Jordan & Evermann 1896: 998–999 (redescription); Evermann 1899: 310 (Lake Lapourde, Louisiana); Large 1903: 24 (Illinois range); Jordan *et al.* 1930: 299 (list, range); Gowanloch 1933: 348, 351 (Louisiana range); Schlaikjer 1937: 12 (phylogeny); Schrenkeisen 1938: 243–244 (redescription, range).

Lethogrammus symmetricus: Hubbs *in* Jordan 1929: 147 (transfer to new genus erected by C. L. Hubbs); Greene 1935: 220 (not in Wisconsin); O'Donnell 1935: 486 (Illinois range); Breder 1936: 28 (breeding habits unknown); Baker 1937: 48 (redescription, rare at Reelfoot Lake); Baker & Parker 1938: 162 (Reelfoot Lake list); Baker 1939*a*: 34 (redescription, sexes figured, common at Reelfoot Lake); Baker 1939*b*: 45 (Reelfoot Lake key).

TYPES

Lepomis symmetricus was described by Forbes *in* Jordan & Gilbert (1883: 473-474) from a syntypic series consisting of 15 specimens collected 16 April

Table 1.—Frequency distribution for number of caudal peduncle scales in selected populations of *Lepomis symmetricus*.

Drainage	Number of Scales						N	Mean	Standard Deviation	Coefficient of Variation
	17	18	19	20	21	22				
Illinois R., Ill.	..	..	6	4	1	..	11	19.5	0.69	3.5
Wabash R., Ill.	..	..	..	3	7	2	12	20.9	0.67	3.2
Mississippi R., Ill., Mo., Ky.	..	3	13	13	17	5	51	20.2	1.21	6.0
Mississippi R., Tenn.	..	..	12	13	..	..	25	19.5	0.51	2.6
Mississippi R., Ark., La.	1	3	10	9	2	..	25	19.3	0.95	4.9
Ouachita R., Ark., La.	4	5	11	4	2	..	26	18.8	1.13	6.0
Red R., Okla., Tex., Ark., La.	5	12	10	5	1	..	33	18.5	1.03	5.6
Gulf Slope, Tex., La.	7	7	10	9	6	..	39	19.0	1.34	7.1

Table 2.—Frequency distribution for number of lateral line scales in selected populations of *Lepomis symmetricus*.

Drainage	Number of Scales									N	Mean	Standard Deviation	Coefficient of Variation
	30	31	32	33	34	35	36	37	38				
Illinois R., Ill.	..	..	7	2	2	..	..	..	..	11	32.5	0.82	2.5
Wabash R., Ill.	..	..	..	..	3	5	1	2	1	12	35.4	1.51	4.3
Mississippi R., Ill., Mo., Ky.	..	2	12	15	9	5	3	4	1	51	33.6	2.87	8.5
Mississippi R., Tenn.	..	2	4	6	7	4	2	..	..	25	33.5	1.39	4.2
Mississippi R., Ark., La.	1	1	5	7	4	4	3	..	..	25	33.4	1.58	4.7
Ouachita R., Ark., La.	2	3	5	4	4	4	3	1	..	26	33.3	1.95	5.9
Red R., Okla., Tex., Ark., La.	6	4	10	7	6	..	..	..	..	33	32.0	1.39	4.3
Gulf Slope, Tex., La.	5	4	10	8	8	3	1	..	..	39	32.6	1.57	4.8

Table 3.—Frequency distribution for number of dorsal soft rays in selected populations of *Lepomis symmetricus*.

Drainage	Number of Rays				N	Mean	Standard Deviation	Coefficient of Variation
	9	10	11	12				
Illinois R., Ill.	..	7	3	1	11	10.5	0.69	6.6
Wabash R., Ill.	2	9	1	..	12	9.9	0.51	5.2
Mississippi R., Ill., Mo., Ky.	..	23	24	4	51	10.6	0.40	3.8
Mississippi R., Tenn.	..	17	6	2	25	10.4	0.65	6.3
Mississippi R., Ark., La.	3	18	4	..	25	10.0	0.54	5.4
Ouachita R., Ark., La.	3	19	3	1	26	10.1	0.63	6.2
Red R., Okla., Tex., Ark., La.	4	17	12	..	33	10.2	0.66	6.5
Gulf Slope, Tex., La.	4	22	10	3	39	10.3	0.77	7.5

Table 4.—Frequency distribution for number of anal soft rays in selected populations of *Lepomis symmetricus*.

Drainage	Number of Rays				N	Mean	Standard Deviation	Coefficient of Variation
	9	10	11	12				
Illinois R., Ill.	..	10	..	1	11	10.2	0.60	5.9
Wabash R., Ill.	1	9	2	..	12	10.1	0.51	5.0
Mississippi R., Ill., Mo., Ky.	11	22	17	1	51	10.2	0.61	6.0
Mississippi R., Tenn.	7	17	1	..	25	9.8	0.52	5.3
Mississippi R., Ark., La.	8	15	2	..	25	9.8	0.60	6.1
Ouachita R., Ark., La.	8	17	1	..	26	9.7	0.53	5.5
Red R., Okla., Tex., Ark., La.	3	21	9	..	33	10.2	0.58	5.7
Gulf Slope, Tex., La.	9	27	3	..	39	9.8	0.54	5.5

and 2 June 1880 from the Illinois River (Mississippi drainage) at Pekin, Tazewell County, Illinois (Fig. 1). All 15 of the original syntypes are extant: INHS 220 (8, 32.7–39.5 mm SL); INHS 226 (2, 50.1–51.2 mm SL); MCZ 25014 (1, 49.5 mm SL); SU 1276 (3, 49.8–56.9 mm SL); USNM 29864 (1, 51.0 mm SL). All 15 are in a good state of preservation. To preserve customary nomenclature and in accordance with the International Code of Zoological Nomenclature Article 74, recommendation 74D, a lectotype of *L. symmetricus* Forbes is herewith designated (INHS 75004, 39.5 mm SL). The specimen, a juvenile, conforms to the characterization of the species given under Description and in Tables 1–4. The incomplete lateral line has 34 scales with 6 scales above and 13 scales below the lateral line. There are 19 caudal peduncle scales, 5 cheek row scales, and 6 branchiostegal rays. Fin ray counts are: dorsal spines, 10; anal spines, 3; pectoral rays, 12–12; dorsal soft rays, 10; anal soft rays, 10. The nine other specimens originally accessioned as INHS 220 and 226 are paralectotypes, now INHS 75005 and INHS 75006, respectively. The USNM, SU, and MCZ syntypes also became paralectotypes, keeping their original catalogue numbers.

It is unlikely that the original material of *L. symmetricus* collected by Forbes and associates was captured from the Illinois River proper. Although the Illinois River has changed rather drastically since Forbes's era, it probably never maintained habitat suitable for *L. symmetricus*. More likely the specimens came from one of the natural floodplain lakes in the Pekin area, where favorable habitat has been present in past years.

DIAGNOSIS

The most diminutive species of *Lepomis* (the largest specimen measured is 75.5 mm SL) is distinguished from other members of the genus by this combination of characters: Lateral line incomplete (1–18 scales unpored) or interrupted (as many as 6 times). Gill rakers long (longest in the genus,

Table 5.—Proportional measurements of *Lepomis symmetricus* from throughout the range, expressed in thousandths of standard length.[a]

Measurement	10 Males (54–64 mm SL)				10 Females (50–64 mm SL)			
	Range	Mean	Standard Deviation	Coefficient of Variation	Range	Mean	Standard Deviation	Coefficient of Variation
Head length	375–423	396	013	3.5	361–403	390	012	3.2
Body depth	471–531	491	018	3.6	468–527	494	017	3.4
Caudal-peduncle depth	150–169	160	006	3.6	142–192	163	014	8.8
Pectoral fin length	245–285	263	014	5.4	248–291	263	012	4.7
Pelvic fin length	227–255	238	009	3.9	212–243	225	010	4.6
Longest dorsal spine	116–153	139	010	7.2	126–164	140	014	9.7
Head width	180–219	203	013	6.5	191–234	213	013	6.0
Bony interorbital width	078–096	087	006	6.6	074–093	084	007	7.8
Snout length	071–086	078	005	6.7	074–088	081	006	7.4
Upper jaw length	123–151	140	009	6.2	124–158	133	010	7.8
Predorsal length	439–480	459	014	3.0	445–483	462	014	2.9
Base dorsal fin length	461–508	478	015	3.1	455–517	480	017	3.6
Longest anal spine	120–151	137	010	6.9	124–157	139	012	8.7
Base anal fin length	216–297	244	022	8.8	206–257	234	015	6.6
Orbit length	087–105	095	005	5.7	083–105	095	002	7.8

[a] Based on NLU 29918, 12804, 1954; UT 90.116, 90.140; TCWC 3643; HWR 74–8; INHS 75020, 75021, 75022, 75023, 18151, 18143, 17547.

longest rakers 2.3–2.9 mm), and slender (0.3–0.5 mm wide, 7–9 times longer than wide), numbering 12–15, modally 13. Opercle stiff to its bony margin, the dark opercular spot slightly diffuse on narrow, bordering membrane. Dorsal coloration dusky with dark coffee-colored spots on body, spots occasionally forming irregular vertical bands. Head and cheeks darkened and without patterns. Juveniles often more vertically barred than adults and have a prominent black blotch in the posterior rays of the soft dorsal fin, becoming less intense with age. Branson & Moore (1962) showed these additional characters to be distinctive: only one posterior pore on the post-temporal, lateralis ending under the soft dorsal fin, preopercle angle 110° to 115°, lachrymal bone nearly twice as tall as wide, supramaxilla shorter than maxilla, and no teeth on tongue or pterygoids.

DESCRIPTION

Forbes (*in* Jordan & Gilbert 1883: 473–474) and Forbes & Richardson (1908: 251–252) adequately described the specimens available to them. The following description is an amplification, which includes additional meristic and morphometric data, and a more comprehensive description of coloration. Body proportion values are presented in Table 5. When no geographic variation was noted, the variation data from throughout the range of the species are merely summarized. When geographic variation was noted, the ranges and modes are given in the description, but their frequencies are discussed under Variation. Counts of lateral-line scales, caudal-peduncle scales, dorsal soft rays, and anal soft rays, all of which show slight clinal variation, are presented in Tables 1–4. General physiognomy and pigmentation of adults and juveniles are shown in Fig. 2 and 3.

Lateral line scales 30–38, modally 32 (Table 2). Bailey (1938) reported one specimen with 40 lateral line scales. Scales above the lateral line 5 (in 7

Fig. 2—Breeding male *Lepomis symmetricus* 53.6 mm in standard length collected in Wolf Lake on 27 May 1975. Pigmentation in the fins is somewhat subdued by preservation.

specimens), 6 (92), 7 (11), $\bar{x} = 6.1$. Scales below the lateral line 12 (in 48 specimens), 13 (52), 14 (15), $\bar{x} = 12.7$. Caudal peduncle scales 17–22, modally 19 (Table 1). Scales on cheek 4–6, modally 5. Scales well developed on preopercle, subopercle, interopercle, and opercle, all such scales about the same size and shape. No scales on top of head.

Dorsal spines 9 (in 22 specimens), 10 (133), 11 (6), $\bar{x} = 9.9$. Dorsal soft rays 9–12, modally 10 (Table 3). Anal spines 2 (in 1 specimen), 4 (2), 3 in all others. Anal soft rays 9–12, modally 10 (Table 4). Pectoral rays 11 (in 8 specimens), 12 (66), 13 (32), $\bar{x} = 12.2$. All pelvic fins counted had 1 spine. Pelvic rays 4–4 (in 1 specimen), 4–5 (2), 5–5 (42). Principal caudal rays 17 (in 41 specimens), 18 (1).

Gill rakers on first arch (all rudiments counted) 12 (in 12 specimens), 13 (36), 14 (22), 15 (6), $\bar{x} = 13.3$. Rakers long and slender (see Diagnosis). Rudimentary rakers (usually 3–5) are shorter and more blunt. The lateral line on the body is incomplete or interrupted (see Diagnosis and Fig. 3). The cephalic lateral-line system was described in detail by Branson & Moore (1962). Caudal fin slightly emarginate. No teeth on tongue and pterygoids. Teeth present on vomers and palatines. Pharyngeal arches narrow with many small, blunt subconical teeth present (Richardson 1904). Peritoneal color is usually fleshy with many scattered melanophores, but occasional specimens have a more silvery ground color with melanophores scattered throughout.

Dorsal coloration is dusky olive-brown or, in life, dark green with a somewhat lighter venter of yellowish brown. Many dark coffee-colored spots occur over the body, often one spot per scale, creating vague, irregular vertical bands or longitudinal rows. The belly, breast, throat, and chin have many tiny, dark melanophores. Some spec-

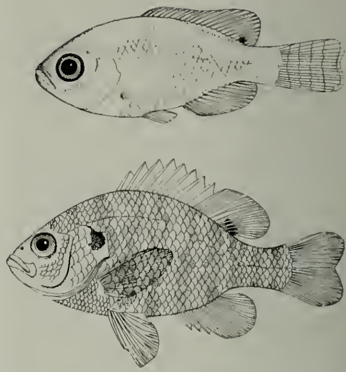

Fig. 3—*Lepcmis symmetricus* prejuvenile 12.0 mm in standard length (above) and juvenile 30.0 mm in standard length (below).

imens are almost solid black on the midbody with discrete black punctate marks on the cheeks. The fins, except the pectorals, are dusky overall with the soft dorsal and anal usually having several light spots. The pectoral fin rays are outlined by melanophores but are otherwise clear. The cheeks and head are very dark and have no patterns. The dark opercular spot is usually bordered with a light area on its posterior margin.

Juveniles contrast with adults in generally having more distinct vertical bands, in always having a black spot in the soft dorsal, and in having some red-orange pigmentation in both the soft dorsal and soft anal fins. Juveniles are lighter overall than adults and generally have seven to nine rather distinct vertical bands that are darker (brown) than the overall light greenish ground color. The vertical barring is occasionally obscured by flecks of darker pigment over the body, giving it a spotted appearance. The juveniles of both sexes have a distinct black blotch on the last five to eight rays of the soft dorsal fin; the pigment is distributed both on the radial and interradial membranes. Rarely, there is a black spot in the soft anal fin (NLU 2907, 2 of 21 specimens; INHS 18151, 1 of 45 specimens) on the last three rays, and again the pigment is both on the radial and interradial membranes. Red-orange pigmentation is also present in the soft dorsal and soft anal fins of both sexes, on the radial and interradial membranes, and is very prominent in specimens collected during the fall and winter months. The belly, breast, throat, and chin sometimes are marked with discrete, tiny brown melanophores. Jordan (1884:320–321) remarked that small specimens from New Orleans had faint blue spots on the sides of their heads. Breeding coloration is discussed under Reproductive Cycles of both sexes.

VARIATION

Sexual

No sexual variation in meristic characters was noted, but some dimorphism in one proportional character and in sex organs was evident. Pelvic fin length is significantly greater at the 0.05 level (F = 8.29) in the male than in the female (Table 5). The urogenital papilla of the adult female is enlarged and protruding during the spawning season, whereas that of the adult male is only slightly enlarged (Fig. 4). The male is not appreciably larger than the female. The largest individuals from the study area were females (61 and 63 mm SL), the largest specimen examined from throughout the range was a female (75.5 mm SL). The largest male was 73.5 mm SL.

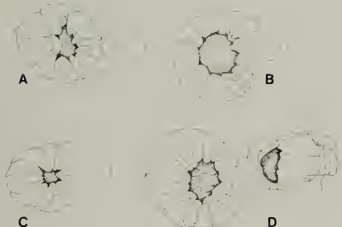

Fig. 4—Genital papillae of *Lepomis symmetricus*. A, nonbreeding male; B, breeding male; C, nonbreeding female; D, breeding female. The nonbreeding specimens were 1+ years old, collected on 19 October 1973; the breeding specimens were 2 years old, collected on 27 April 1974.

Allometric

No allometric variation in meristic characters was found. Although allometric variation in morphometric characters was not investigated, adults are more robust than juveniles, as in other sunfishes. Moreover, it is the adult that is symmetrical in shape and thus is responsible for the trivial name of the species. Juveniles have body proportions similar to those of other juvenile sunfishes. The number of vertical bands, if present at all, is the same in the juvenile and adult. The most notable allometric variation is the tendency for the black spot in the soft dorsal fin to become more diffuse and weak with age. It is prominent in the smallest young and absent in the adult, except in an occasional female. The soft anal and soft dorsal fins have a red-orange coloration that disappears when the fish becomes adult.

Geographic

Geographic variation in some meristic characters was evident when samples were grouped according to major river systems and arranged in a north-to-south order from the Mississippi drainage of Illinois; through the Ouachita and Red river drainages of Arkansas, Oklahoma, Louisiana, and Texas; to the Gulf Coast drainages of Texas and Louisiana (Tables 1–4).

No significant geographic variation was found in any of the body proportions measured (Table 5). In fact, in this respect *L. symmetricus* is remarkably conservative for a species with a rather long north-to-south distribution (Fig. 1). These meristic characters varied clinally: numbers of caudal-peduncle scales, lateral-line scales, and anal soft rays. The number of dorsal soft rays showed a slight but somewhat irregular trend toward more ray elements in the north (Table 3). The Mississippi drainage samples from Arkansas, Louisiana, Tennessee, Missouri, Illinois, and Kentucky were intermediate in caudal-peduncle and lateral-line scale counts between Red River-Gulf Coast samples and those from the Wabash drainage of Illinois. In these counts (Tables 1 and 2) the samples showed a gradual increase toward the north, whereas the soft-ray counts (Tables 3 and 4) were more discordant, with specimens from the Red River-Gulf Coast samples having means close to that of the Illinois River specimens.

The most aberrant samples are those that formerly occurred in oxbow ponds along the Wabash River in White County, Illinois. They have a slightly higher mean number of lateral-line scales and slightly higher mean number of caudal-peduncle scales, but they have lower means for the soft fin ray counts than samples from the upper Mississippi drainage (Tables 1–4).

No apparent geographic trends in coloration or pattern could be perceived. Individual variation occurs in the prominence of the vertical bars and overall darkness, due perhaps in part to the strength of the preservative and age of the individuals.

RELATIONSHIPS

Because of various features of morphology, cytology, and paleontology, *L. symmetricus* has been considered to be most closely related to *L. cyanellus* (Bailey 1938; Branson & Moore 1962) as a highly specialized congener with several unique characters. Hubbs (*in* Jordan 1929) considered *L. symmetricus* distinctive enough to warrant placement in a new monotypic genus, *Lethogrammus,* and Bailey (1938), adopting the use of subgenera, placed *L. symmetricus* in the subgenus *Lethogrammus.*

More recent studies on species of *Lepomis* using the techniques of electrophoresis (Avise & Smith 1974), hybridization (Hester 1970), and chromosome analysis (Roberts 1964) have not included specimens of *L. symmetricus.* Thus, it is not known where the species would be placed in the classification schemes presented by these authors.

SPECIMENS STUDIED

The following list includes only those collections of *L. symmetricus* that were used for meristic and morphometric features. Others were used for the assessment of distribution, descriptive features, and life-history data. Collections are listed generally from north to south. The number of specimens examined is given in parentheses following the catalog number. Specific locality data may be obtained upon request from the author.

Ohio River Drainage

WABASH RIVER SYSTEM.—ILLINOIS, White County: 2 October 1882, INHS 75008 (1); 1 October 1882, INHS 75009 (4); 3 October 1882, INHS 75007 (10).

Mississippi River Drainage

ILLINOIS RIVER SYSTEM.—ILLINOIS, Tazewell County: 16 April 1880, INHS 75004 (1), INHS 75005 (7), USNM 29864 (1); 2 June 1880, INHS 75006 (2).

CLEAR CREEK SYSTEM.—ILLINOIS,

Union County: 18 July 1883, INHS 75102 (5); 16 September 1959, INHS 17547 (6); 27 April 1963, INHS 17566 (1); 27 May 1965, INHS 17583 (1); 31 August 1970, INHS 17557 (1); 21 June 1973, INHS 18143 (5); 25 July 1973, INHS 18151 (2); 24 January 1974, INHS 75025 (6); 28 March 1974, INHS 75022 (1); 30 May 1974, INHS 75021 (1); 27 May 1975, INHS 75020 (1).

Obion Creek system.—KENTUCKY, Hickman County: 21 January 1964, INHS 75024 (1); no date, UL 5617 (10). Fulton County: 15 June 1948, UL 10691 (4).

Saint Francis River system.—MISSOURI, Stoddard County: 25 October 1973, INHS 75023 (10).

Natural Lakes and Backwaters.—TENNESSEE, Lake County: 11–13 March 1968, UT 90.27 (8); 8 April 1950, FMNH 80532 (2). Lauderdale County: 9 October 1972, UT 90.102 (2). ARKANSAS, Chicot County: 17 August 1974, HWR 74-35 (8).

Forked Deer River system.—TENNESSEE, Haywood County: 3 November 1973, UT 90.138 (1); 27 April 1974, UT 90.140 (6). Gibson County: 19 October 1973, UT 90.139 (10).

L'Angville River system.—ARKANSAS, St. Francis County: 7 August 1939, UMMZ 128537 (2).

Arkansas River system.—ARKANSAS, Arkansas County: 13 August 1974, ARP-79 (10).

Ouachita River system.—ARKANSAS, Bradley County: 23 May 1974, UT 90.116 (1), HWR 74-8 (1); 10 August 1974, HWR 74-26 (7). Calhoun County: 6 October 1974, JLS 74-14 (2). Union County: 25 April 1975, NLU 31455 (10). LOUISIANA, Ouachita Parish: 17 October 1964, NLU 894 (5).

Red River system.—ARKANSAS, Little River County: 13 September 1940, UMMZ 170879 (1). OKLAHOMA, McCurtain County: 20 August 1948, UMMZ 155830 (1). LOUISIANA, Red River Parish: 22 June 1965, NLU 1954 (7). Winn Parish: 23 June 1965, NLU 1989 (7). Caddo Parish: 22 February 1969, NLU 12804 (5). TEXAS, Bowie County: 24 May 1957, TNHC 4984 (10). Harrison County: 17 March 1972, TCWC 4068.14 (2).

Lake Pontchartrain.—LOUISIANA, Orleans Parish: 15 April 1974, NLU 29918 (5).

Gulf Coast Drainage

Calcasieu River system.—LOUISIANA, Calcasieu Parish: 10 August 1965, NLU 2534 (6). Allen Parish: 10 August 1965, NLU 2907 (5). Jefferson Davis Parish: 10 August 1965, NLU 2909 (4).

Mermentau-Teche River system.—LOUISIANA, Avoyelles Parish: 20 April 1975, NLU 31572 (3).

Neches River system.—TEXAS, Jefferson County: 2 May 1970, TCWC 3643 (14). Hardin County: August 1950, TNHC 585 (1). Newton County: 7 June 1952, TNHC 2889 (3).

Trinity River system.—TEXAS, Chambers County: 14 July 1953, TNHC 3873 (2).

San Jacinto River system.—TEXAS, Montgomery County: 23 March 1951, TNHC 1211 (1).

DISTRIBUTION

All known locality records for *L. symmetricus* are plotted in Fig. 1. Along the Gulf Coast the species extends from Eagle Lake (Colorado River drainage, UMMZ 129793) in Texas east to marshes of the Jordan River system in Mississippi. In the Mississippi Valley it presently extends north to the bottomland oxbow lakes and swamps of southern Illinois. A published record for the St. Joseph River of Michigan (Dolley 1933) is clearly based on a misidentification, as Michigan is far out of the range of the bantam sunfish.

L. symmetricus is now almost entirely restricted to the Coastal Plain. It formerly traversed the Coastal Plain boundary far northward to the Illinois River (at Pekin) and backwater ponds and sloughs of the Wabash River system in White County, Illinois (Fig. 1). The species has not been collected from the type-locality since 1880, a fact which Richardson (1904) noted only 24 years after its original description. Indeed, it was collected only twice from Pekin. It has not been collected from the Wabash valley since 1882, whence it was known from three localities and 12 specimens (INHS 75007, 75008, 75009). The distribution of *L. symmetricus* has thus changed rather dramatically in Illinois, the decimation probably being the result of radical changes brought on by human modifications, notably the stocking of nonnative sunfishes, a reduction in aquatic vegetation, draining of lowland swamps and sloughs, and various forms of agricultural and industrial pollution (Smith 1971). Mills *et al.* (1966) clearly demonstrated the effects of human modification on the fauna and flora of the Illinois River, and the factors listed above almost surely caused the extirpation of the species from the Pekin area. It is also possible that the relatively short life span of the species (3+ years) is somehow associated with its fairly rapid extirpation from disturbed or polluted areas in the Mississippi Valley of Illinois, Missouri, and Kentucky.

The species is virtually absent east of the Mississippi River in Mississippi. Perhaps the Mississippi River has been an effective barrier to dispersal in this region, or the species' apparent absence there may be because collectors tend to avoid swamps, sloughs, and lowland streams. The species is statewide in occurrence in Louisiana, where it is common, and it is rather common in eastern Texas, southern Arkansas, and parts of western Tennessee (Fig. 1).

The distribution of *L. symmetricus* suggests that it is autochthonous to the lower Mississippi River valley (Pflieger 1971:413–414). It apparently dispersed through oxbow lakes, swamps, and sloughs, created by varying water levels during the history of the Mississippi River. (Pflieger (1971:414) suggested that *L. symmetricus* may have had its origin in the lower Mississippi valley, dispersed northward to central Illinois during the postglacial Climatic Optimum, and become disjunct in its northern distribution subsequently.

CONSERVATION STATUS

Miller (1972) listed *L. symmetricus* as rare in both Illinois and Missouri in a compilation of threatened fishes of the United States. At that time it was known in those states from only two localities: the LaRue-Pine Hills area of southwestern Illinois (Union County) and the Duck Creek Wildlife Area of southeastern Missouri (Bollinger County), where it has been reported to be common (Pflieger 1971:413). It has since been found to be common in Wolf Lake, Illinois, and Mingo National Wildlife Refuge, Missouri (Pflieger 1975:265). The species is on the protected list of both states but not presently endangered in either because its habitat is now rigidly protected in refuges. Recently, Webb & Sisk (1975:69) recommended that *L. symmetricus* be placed on Kentucky's rare and endangered species list in view of its rarity in Kentucky.

In Oklahoma the species is found only in the swamps of McCurtain County in the southeastern corner of the state (Fig. 1). *L. symmetricus* was not considered threatened by Robison *et al.* (1974) in their list of threatened Oklahoma fishes, but it may presently be reduced in numbers according to Hubbs & Pigg (1976:116). In Arkansas the status of the species was listed as indeterminate by Buchanan (1974), but *L. symmetricus* was not cited by Robison (1974) in his list of threatened Arkansas fishes. The species is apparently in no danger in southern Arkansas (Fig. 1), where it is known from many localities.

LIFE HISTORY IN WOLF LAKE

STUDY AREA

Wolf Lake is a long (ca. 1.9 km), narrow (ca. 0.1 km), and ancient oxbow of the Big Muddy River (Mississippi drainage) situated south of the LaRue-Pine Hills Ecological Area to which it is connected by bottomland swamp. The lake is apparently still in a fairly natural, undisturbed condition and is estimated to be at least 2,000 years old (E. Donald McKay III, personal communication). The northern portion of the lake was recently acquired by the U. S. Forest Service, whereas the southern portion of the lake is privately owned by the Trojan Powder Plant. Most observations and collections in Wolf Lake were made near the powder plant bridge, where access to the lake was easy although other portions of the lake were sampled.

HABITAT

Wolf Lake is characterized by two predominant habitats: a heavily vegetated shoreline with many submerged logs and stumps (Fig. 5) and an open deepwater area in the center of the lake free from vegetation and submerged objects. The lake is not shaded and the water is usually turbid. The vegetated shoreline, where *L. symmetricus* occurs (Fig. 5), is dominated by spatterdock (*Nymphaea advena*), American lotus (*Nelumbo lutea*), common arrowhead (*Sagittaria latifolia*), coontail (*Ceratophyllum demersum*) and duckweed (*Lemna* spp., *Wolffia* spp.). The bottom consists mostly of decomposed veg-

Fig. 5—Vegetated margin of Wolf Lake, Union County, Illinois, illustrating the preferred habitat of *Lepomis symmetricus*. Photo taken in May 1974.

etation, silt, and mud, with some sand. Water depth ranges from 300 mm to 18 meters. Dissolved oxygen averages 9.0 ppm; temperatures range from 4° to 8° C from December to February and are as high as 29° C in July and August.

L. symmetricus was found in similar habitat during a 1-year study of fishes in the adjacent LaRue-Pine Hills swamp (Boyd *et al.* 1975). During the fall and winter months *L. symmetricus* was characteristically found at a depth of 150–300 mm usually near the shoreline in Wolf Lake. During the summer months the species could be found at depths of 600–1200 mm but still within the vegetated periphery of the lake.

Elsewhere in its range *L. symmetricus* is invariably found in lentic waters characterized by standing timber, submerged logs and stumps, and rich vegetation. Sloughs, oxbows, ponds, backwaters, lakes, and swamps typical of the undisturbed portions of the Coastal Plain are optimal habitat. *L. symmetricus* is found in greatest numbers over substrates consisting of mud, detritus, and decayed plant material.

Although *L. symmetricus* is syntopic with several other species of *Lepomis* in Wolf Lake, it was almost always collected by itself in the areas mentioned. The other *Lepomis* were usually taken in more open areas and generally in deeper water. In Wolf Lake the fishes most often found with *L. symmetricus* in descending order of association were *L. macrochirus*, *L. gulosus*, *Pomoxis nigromaculatus*, *Notemigonus crysoleucas*, *Gambusia affinis*, *Micropterus salmoides*, *Elassoma zonatum*, and *Etheostoma gracile*. Other inhabitants of the habitat of *L. symmetricus* occurring in less frequent numbers are *Lepisosteus oculatus*, *L. platostomus*, *Dorosoma cepedianum*, *Umbra limi*, *Cyprinus carpio*, *Ictiobus cyprinellus*, *Ictalurus natalis*, *I. nebulosus*, *Fundulus dispar*, *Aphredoderus sayanus*, *Centrarchus macropterus*, *Lepomis microlophus*, and *L. punctatus*.

REPRODUCTION

Reproductive Cycle of the Male

The genital papilla (Fig. 4) of ripe *L. symmetricus* males enlarged slightly as the spawning season approached. The testes, normally small, translucent, and elongate, became large, opaque white, and thickened.

Breeding males (Fig. 2), in contrast to non-breeding males and females (which were nearly identical in color and pattern), became very dark on the head, and the irregular vertical cross bars grew subdued. The venter from the chin and throat to the anterior rays of the anal fin became grayish black. Many small greenish flecks were present on the head and opercle, and the dark opercular spot was outlined by a silvery-cream color with a hint of suffused red. The pectoral fins were relatively dusky overall but with no definite patterns. The posterior edges of the pelvic fins were almost solid black with the remainder of the fins cream color. The dorsal fin had many light spots surrounded by dusky brown or black areas. The iris of the eye was brilliant red with a distinct black transverse bar through it.

Because of the silty darkly-stained water of Wolf Lake, no nests of *L. symmetricus* could be observed in nature, and nothing is known of territory size. However, Robison (1975:56) reported that on 23 May 1974 in a roadside pool, Saline County, Arkansas, *L. symmetricus* had recently spawned, inasmuch as "depressions in the mud and leaf litter substrate were filled with numerous eggs." Since males were observed to be highly aggressive toward females and other sunfishes are known to be territorial (Larimore 1957), it is assumed that *L. symmetricus* defends an area in nature. An aquarium-held male collected in May was seen on several occasions to form a shallow nest by rapidly swimming forward, then turning his body straight up in a vertical position and descending, sweeping his tail vigorously back and forth until a nest depression was formed. Such nests were formed over both sand and gravel substrates. These nests were approximately 90–120 mm in diameter. It is likely that *L. symmetricus* males build shallow depressions in the mud bottom of Wolf Lake along the shallow edges close to the vegetation where egg attachment may take place. This behavior has been described for *L. cyanellus* (Hankinson 1908:210–211).

Only large males developed the breeding patterns, the slightly enlarged genital papilla, and the enlargement of the testes. Only males of at least 1+ years and 40 mm or longer appeared to be sexually mature, according to coloration and condition of the testes. The largest males probably do most or all of the spawning.

Reproductive Cycle of the Female

Generally the largest females developed the earliest mature ova and probably contributed most to the spawning effort. Females as short as or shorter than 34 mm and 1 year of age developed mature ova and were potential spawners.

Females underwent some changes in coloration associated with the breeding season. In contrast to males and nonbreeding individuals, the breeding female had 9 or 10 distinct vertical bars of a dark bluish-purple color with light greenish flecks in the spaces between the bars. The cheek and opercle contained bright spots of golden green, but the fins were relatively clear and not dusky. Some females retained a diffuse ocellus in the posterior rays of the dorsal fin. As in males, the iris was bright red. Other marked morphological changes were the distended belly caused by the maturing ova and the enlargement of the genital papilla (Fig. 4). Enlargement of the papilla was noticeable only in ripe females.

Small white ova were present in females 1+ years of age and 35 mm long as early as September but were difficult to distinguish in younger and smaller females. By January and February larger yellowish ova were found in 1+-year females of 40 mm or longer. Large, coarse, maturing orange ova were present from March to May in larger and older females and in some smaller females over 34 mm and approaching 1 year of age. Just prior to spawning time, the mature ova became a translucent orange.

The largest and oldest females produced the largest number of mature ova. In 14 ripe females collected in April and May the number of ova varied from 219 to approximately 1,600 (Table 6). For these females the relationship between the number of mature ova (F) and the adjusted body weight (W) was $F = -50.94 + 210.70W$, with $r = 0.818$, and between the number of mature ova and the standard length (L) was $\log F = -2.785 + 3.383 \log L$, with $r = 0.663$.

Ovaries of postspawning females collected in June were smaller than those of females collected in April and May. They averaged slightly heavier than ovaries from females collected in March. Ovaries from females taken in July and August were small. A relative increase in ovary size was evident by late fall and continued to the spawning period the following spring (Fig. 6). For the females examined, the relationship between the weight of the ovaries divided by the adjusted body weight (Y) and the month (X), with July = 1 and May = 11, was $\log Y = 0.699 + 0.099X$, with $r = 0.782$ (Fig. 6). The proportionally largest ovaries (equaling 30.8 percent of the adjusted body weight) were found in a 51-mm, 2-year-old female collected on 27 April 1974 (UT 90.140). In the 14 females represented in Table 6, overy-weight-to-adjusted-body-weight ratios ranged from 0.070 to 0.308 and averaged 0.107.

Table 6.—Relationship between size, age, and ovary weight of *Lepomis symmetricus* females and the number of mature ova produced. An age of 1 year = 11–13 months, 2 years = 23–25 months. Data from TCWC 3643, UT 90.140, and INHS 17583, as well as that from Wolf Lake, are included.

Standard Length in mm	Adjusted Body Weight in Grams[a]	Age in Years	Ovary Weight in Grams	Number of Mature (orange or translucent, 0.6–0.9 mm) Ova
34	1.42	1	0.10	326
34	1.49	1	0.12	219
36	1.78	1	0.13	491
37	1.65	1	0.20	368
37	2.06	1	0.18	403
38	2.32	1	0.20	330
39	2.11	1	0.21	432
40	2.43	1	0.18	417
42	2.44	1	0.26	421
43	2.75	1	0.20	374
45	3.22	1	0.33	364
45	3.34	1	0.31	378
51	4.51	2	1.39	ca 1600
52	7.57	2	0.88	ca 1400

[a] Adjusted body weight is the specimen's weight after removal of the ovaries, stomach, intestine, and liver.

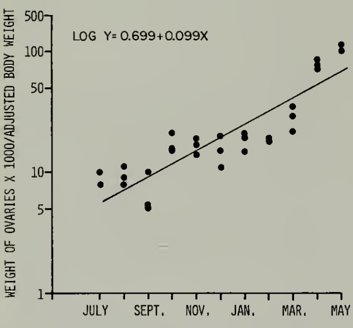

Fig. 6—Monthly variations in ovarian weight relative to adjusted body weight of *Lepomis symmetricus*. The vertical axis is on a logarithmic scale. Ovaries from specimens collected June to April were from all age classes, but ovaries from specimens collected in May were from 2-year-old (24 months) fish.

Spawning

In Wolf Lake breeding individuals were captured as early as 24 April and as late as 30 May. Most spawning probably occurred in May when water temperatures ranged from 18° to 22° C. Field observations and examination of museum specimens collected during all months of the year indicated that mid-April to early June was the typical spawning period for the species throughout its range (Table 7).

Although spawning was not observed in the study area, ripe aquarium-held individuals collected 27 May 1975 engaged in prespawning activity for 7 days at water temperatures varying from 24° to 26° C. After presumed stimulation from a recent feeding the male began to court the female by nudging her with his snout along the posterior regions of her body and continually nipping at her caudal fin. The female did not respond to these actions but the male continued to nip at her fins and nudged the female with his snout between the pelvic fins while chasing her. The female remained unresponsive. After 3 days of this behavior the male began to charge the female at rapid speeds with his opercles flared out and with the irises of his eyes more intense in color than before.

Table 7.—Collections of breeding *Lepomis symmetricus*.

Locality	Collection Date	Remarks
Wolf Lake, Union Co., Ill. (INHS 75020, 75021)	24 April–30 May 1974	Males and females in extreme breeding condition.
Pine Hills Swamp, Union Co., Ill. (INHS 17583)	27 May 1965	Female in breeding condition.
Illinois River, Tazewell Co., Ill. (INHS 75006)	2 June 1880	Females in breeding condition.
Swamp, Haywood Co., Tenn. (UT 90.140)	27 April 1974	Males and females in extreme breeding condition.
Reelfoot Lake, Lake Co., Tenn. (FMNH 80532)	8 April 1950	Males and females in breeding condition.
Roadside Ditch, Bradley Co., Ark. (UT 90.116) (HWR 74-8)	23 May 1974	Male and female in breeding condition.
Ouachita River, Union Co., Ark. (NLU 31455)	25 April 1975	Females in extreme breeding condition.
Big Hill Oil Field, Jefferson Co., Tex. (TCWC 3643)	2 May 1970	Males and females in breeding condition.
Marsh, Orleans Parish, La. (NLU 29918)	15 April 1974	Males and females in breeding condition.
Creek, Avoyelles Parish, La. (NLU 31572)	20 April 1975	Males in breeding condition.

When he approached the female, he abruptly turned himself to a vertical position (with his snout pointing upward) and gently swam around her in a close circle while fanning his tail. Similar courtship patterns were described by Larimore (1957) for *L. gulosus.* After 7 days of constant nipping, nudging, badgering, and displaying other prenuptial behavior, the male had succeeded in completely mutilating the uncooperative female's caudal fin, and on the 8th day the female was found dead. Even though an actual egg-laying session did not take place, it is evident that the nest building and prespawning behavior of *L. symmetricus* does not vary greatly from that described for other species of *Lepomis* summarized by Breder & Rosen (1966).

DEVELOPMENT AND GROWTH

Mature ova ranged in size from 0.6 to 0.9 mm in diameter, were translucent orange, and contained a single oil droplet. No data are available on incubation temperatures of eggs, the length of time required for hatching, or the morphology of hatchlings.

The smallest *L. symmetricus* individual from the study area was 12 mm, collected 21 June 1973 (Fig. 3). At this size the nape, breast, and sides of the head were the only regions incompletely scaled, but no definite pigment pattern was present. Small melanophores outlined the scale borders on the body and some of the fin rays but were concentrated heavily on the top of the head, on the lips, and around the eye. The soft dorsal fin ocellus was just beginning to develop (Fig. 3).

A series of 43 young *L. symmetricus* from 14.0 mm to 25.0 mm was collected in the study area on 25 July 1973. At 14 mm squamation patterns were like that at 12 mm, but many more melanophores were present in the fins and they began to form patterns on the body. The ocellus was dark at this size. At 19 mm vague vertical bars had formed, and squamation was nearly complete. At 25 mm the lateralis system was developed, and the overall pigment pattern was similar to that of adults. Squamation was complete at this stage. At a slightly larger size juveniles began to take on the form, pattern, and coloration illustrated in Fig. 3.

L. symmetricus from Wolf Lake grew at a decreasing rate (Fig. 7) and reached

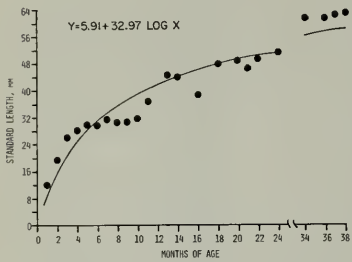

Fig. 7—Size distribution by age of *Lepomis symmetricus* collected in Wolf Lake between 21 June 1973 and 30 May 1974. Data from 27 May 1975 and 12 December 1974 are included. Black dots represent sample means for both sexes combined. In total, 233 specimens are represented.

one-half of the first year's mean growth in approximately 10 weeks. The relationship between standard length (Y) and age in months (X) expressed for the sexes combined is $Y = 5.91 + 32.97 \log X$, with $r = 0.943$. Males grew at a slightly more rapid rate than females but were not significantly larger than females. At 13–18 months males averaged 45.9 mm and females averaged 42.7 mm ($t = 1.39$, df $= 11$). At 19–24 months males averaged 49.3 mm and females averaged 47.5 mm ($t = 1.00$, df $= 14$). The largest specimen examined from Wolf Lake was a 63.0-mm female collected 25 July 1973. In other parts of its range *L. symmetricus* is known to attain a greater length, and specimens as long as 75.5 mm have been collected (TU 148—St. Tammany Parish, Louisiana). Based on the collections examined, such large size is unusual, with most adults ranging between 55 and 60 mm.

DEMOGRAPHY

Density

The nature of the habitat of *L. symmetricus* made population density measurements difficult, since submerged logs, brush, and vegetation prevented thorough sampling of a given area. However, on two occasions approximately 5 months apart quantitative samples of *L. symmetricus* were taken in Wolf Lake by repeatedly seining a measured shallow margin of the lake until no more individuals could be collected. The number collected was translated into the number per square meter. The greatest density found for *L. symmetricus* in Wolf Lake was 0.69 sunfish per square meter (Table 8).

In the nearby LaRue-Pine Hills swamp, the density of *L. symmetricus* may approach 0.72 sunfish per square meter (Table 8) or, at best, 1 individual per 3 square meters in optimal habitat (Boyd *et al.* 1975). Of 31 individuals collected during 9 months at several collecting sites in Pine Hills, *L. symmetricus* made up 2.3 percent of the total sample of fishes captured.

Table 8.—Number of *Lepomis symmetricus* per square meter collected in vegetated margins of Wolf Lake and LaRue-Pine Hills swamp.

Date	Number Collected	Number of *L. symmetricus* per square meter in Wolf Lake and Pine Hills
25 October 1973, Wolf Lake	9	0.313
28 March 1974, Wolf Lake	20	0.694
Mean		*0.504*
24 October 1973, Pine Hills	6	0.723
28 November 1973, Pine Hills	4	0.542
27 March 1974, Pine Hills	1	0.114
Mean		*0.460*

However, more than 80 percent of the individuals were captured at one site where the habitat was judged to be optimal (Boyd *et al.* 1975). Gunning & Lewis (1955) found that *L. symmetricus* made up 5 percent of their total sample of fishes at Pine Hills.

Composition

Of the 233 *L. symmetricus* collected in Wolf Lake, 85.4 percent were up to 1 year of age, 12.4 percent were over 1 and up to 2 years of age, 0.8 percent were over 2 and up to 3 years of age, and 1.2 percent were over 3 years of age (Table 9).

Table 9.—Distribution of sexes and year classes in samples of *Lepomis symmetricus* collected in Wolf Lake between 21 June 1973 and 30 May 1974, and on 27 May 1975 and 12 December 1974.

Sex	Number by Year Class				Total
	−1	1+	2+	3+	
Males	81	16	1	..	98
Females	118	13	1	3	135
Total	*199*	*29*	*2*	*3*	*233*

Females predominated in the young-of-the-year (−1) age class [1.5 females to 1 male ($\chi^2 = 6.87$; $P < 0.01$)], and in the total sample (N = 233) the ratio was 1.4 females to 1 male ($\chi^2 = 5.97$; $P < 0.025$). Although predominating significantly in the −1 age class and in the total, females were slightly less common than males in the 1+ age class.

Survival

Relative survival values (Table 10) for each year of life were calculated for males, females, and the total sample of *L. symmetricus,* using the data in Table 9. It was assumed that each age class was collected in proportion to its relative number in the population, that the population was neither increasing nor decreasing, and that the number of fry entering the population each year was constant.

Table 10.—Relative survival of year classes of *Lepomis symmetricus* in Wolf Lake expressed as proportions of the −1 year class ($1 \times^1$) and the 1+ year class ($1 \times^2$).

Sample	Year Class	Number of Specimens	Survival	
			$1 \times^1$	$1 \times^2$
Males	−1	81	1.000	...
	1+	16	0.198	1.000
	2+	1	0.012	0.063
	3+	..	...	...
Females	−1	118	1.000	...
	1+	13	0.110	1.000
	2+	1	0.008	0.077
	3+	3	0.025	0.231
Total sample	−1	199	1.000	...
	1+	29	0.146	1.000
	2+	2	0.010	0.069
	3+	3	0.015	0.103

Because of the difficulty in collecting in Wolf Lake, the numbers of 1+ and older individuals in Tables 9 and 10 are probably lower than their actual proportion in the population.

The shapes of the survival curves for males, females, and total sample were quite similar. All showed a very low survival rate after the 1st year of life. Only three individuals 3 years or older were found. The oldest *L. symmetricus* from Wolf Lake examined was a female 3 years and 2 months old (assuming May hatching) collected 25 July 1973.

Specimens from throughout the range further confirm a 3+ -year life span for the species: INHS 17547—from LaRue-Pine Hills Ecological Area collected 16 September 1959, containing three individuals all 3 years and 4 months of age (assuming May hatching); NLU 31572—collected 20 April 1975 from a creek, Avoyelles Parish, Louisiana, containing three individuals 3 years of age. Most other species of *Lepomis* are much longer lived.

DIET

Stomach contents of 176 *L. symmetricus* from Wolf Lake were examined.

Twenty-nine of these contained no food items and eight contained green algal material. A large variety of food organisms was found (Tables 11–14). The predominant food items of the Wolf Lake population were gastropods, cladocerans, ostracods, amphipods, dragonfly naiads, chironomids, and ceratopogonids.

Small *L. symmetricus* (less than 21 mm) fed predominantly on microcrustacea, dragonfly naiads, and chironomids; large individuals (more than 40 mm) fed primarily on gastropods, dragonfly naiads, and amphipods (Tables 11 and 12). Some seasonal variation in diet (Tables 13 and 14) was evident. Gastropods were eaten in the winter and spring months. The largest percentages of most food items, including gastropods, stratiomyids, chironomids, and some microcrustacea, were eaten in the months prior to and during the spawning season, presumably reflecting an increase in consumption associated with spawning preparedness (Page 1974:17). Aquatic Hemiptera were eaten exclusively in the summer months, when they were most abundant. The presence in the diet of the exclusively terrestrial hemiteran family Fulgoridae reflects surface feeding by

Table 11.—Stomach contents of *Lepomis symmetricus* from Wolf Lake, by size class of sunfish. Figures in parentheses are numbers of stomachs examined.

Food Organism	Percent of Stomachs in Which Food Organism Occurred					
	<21 mm (25)	21–30 mm (44)	31–40 mm (56)	41–50 mm (19)	51–60 mm (5)	>60 mm (5)
Gastropoda	..	..	12.5	31.6	4.0	4.0
Arachnida						
Araneae	..	2.2	1.8	..	..	..
Acarina	..	..	10.7	..	..	..
Crustacea						
Cladocera	4.0	40.9	66.1	5.2	..	..
Ostracoda	12.0	34.1	42.9	..	..	..
Copepoda	8.0	18.2	32.1	..	..	..
Amphipoda	56.0	20.0	17.9	15.8	20.0	..
Insecta						
Odonata	36.0	29.5	16.1	10.5	20.0	60.0
Coleoptera						
Helodidae	..	2.2	..	..	..	20.0
Noteridae	..	4.5	..	..	..	..
Haliplidae	..	..	10.7	..	..	..
Diptera						
Psychodidae	..	..	3.6	..	..	..
Chaoboridae	..	..	1.8	..	..	..
Tipulidae	..	..	1.8	..	..	..
Stratiomyidae	..	..	8.9	15.8	40.0	..
Ceratopogonidae	..	4.5	5.4	5.3	20.0	..
Culicidae	..	..	1.8	..	..	..
Chironomidae	52.0	4.5	25.0	..	..	..
Ephemeroptera	..	6.8	7.1	..	..	20.0
Trichoptera	..	..	5.4	5.3	..	..
Hemiptera						
Corixidae	..	9.1	8.9	21.1	..	..
Naucoridae	..	6.8	1.8	..	..	..
Fulgoridae	..	..	1.8	..	..	20.0
Pleidae	8.0	2.2	..	..	..	40.0
Mesoveliidae	..	2.2	..	..	..	..

Table 12.—Stomach contents of *Lepomis symmetricus* from Wolf Lake, by size class of sunfish. Figures in parentheses are numbers of stomachs examined.

Food Organism	Mean Number of Food Organisms Per Stomach					
	<21 mm (25)	21–30 mm (44)	31–40 mm (56)	41–50 mm (19)	51–60 mm (5)	>60 mm (5)
Gastropoda	..	..	0.29	0.84	0.60	2.40
Arachnida						
Araneae	..	0.02	0.02	..	..	..
Acarina	..	..	0.32	..	..	..
Crustacea						
Cladocera	0.36	6.41	2.14	1.26	..	..
Ostracoda	0.48	2.57	0.07	..	..	..
Copepoda	0.12	0.91	1.25	..	..	..
Amphipoda	1.92	0.91	1.20	0.47	12.8	..
Insecta						
Odonata	0.52	0.45	0.32	0.11	0.20	1.60
Coleoptera						
Helodidae	..	0.05	..	..	..	0.20
Noteridae	..	0.07	..	..	..	..
Haliplidae	..	..	0.54	..	..	..
Diptera						
Psychodidae	..	..	0.02	..	..	..
Chaoboridae	..	..	0.52	..	..	..
Tipulidae	..	..	0.04	..	..	..
Stratiomyidae	..	..	0.25	0.21	4.00	..
Ceratopogonidae	..	0.02	0.07	0.05	3.00	..
Culicidae	..	..	0.03	..	..	..
Chironomidae	0.08	0.16	0.52	..	..	..
Ephemeroptera	..	0.07	0.07	..	..	0.20
Trichoptera	..	..	0.05	0.05	..	..
Hemiptera						
Corixidae	..	0.18	0.29	0.26	..	..
Naucoridae	..	0.06	0.02	..	..	..
Fulgoridae	..	..	0.02	..	..	0.20
Pleidae	0.08	0.02	..	..	..	0.60
Mesoveliidae	..	0.02	..	..	..	..

L. symmetricus when these insects alight on the water surface.

Aquarium-held *L. symmetricus* fed in the typical *Lepomis* manner. When food was dropped into the water near them, they sucked it in or swam up near the food item and gulped it down before the food item fell to the bottom of the aquarium. Occasionally they fed off the bottom by sucking up food items. Spawning males and other individuals fed readily on dragonfly naiads, chironomids, and live and frozen earthworms. Miller & Robison (1973:184) reported aquarium-held specimens from Oklahoma feeding on "daphnia and small earthworms."

L. symmetricus has been reported to eat "dragon-fly nymphs and midge larvae" near Greenwood, Mississippi (Hildebrand & Towers 1927:134; Cook 1959:180). In 22 specimens from LaRue-Pine Hills, Illinois, the major food items were "aquatic snails, green algae, amphipods, and miscellaneous insects and insect larvae" (Gunning & Lewis 1955:556).

INTERACTION WITH OTHER ORGANISMS

Competition

L. symmetricus occurs syntopically with all other described species of *Le-*

pomis (including the introduced *L. auritus*) except *L. gibbosus,* from which it is geographically separated. Because of its preferred habitat of heavily vegetated, shallow, lentic or slow-moving water and its relative abundance there, it is doubtful that the species is geographically limited to a great degree by its several congeners.

Predation

There are no literature reports of predation on *L. symmetricus* and no evidence of such predation was found in the Wolf Lake study. As potential predators five *Micropterus salmoides* (71.6–240.3 mm SL), four *Pomoxis nigromaculatus* (76.4–144.8 mm SL), one *P. annularis* (141.1 mm SL), five *Lepomis gulosus* (19.7–127.4 mm SL), four *L. macrochirus* (131.8–140.1 mm SL), one *Centrarchus macropterus* (82.4 mm SL), and one *Ictalurus natalis* (124.8 mm SL) were preserved and later examined for ingested *L. symmetricus.* These predators were collected from all months of the year except July and December. A number of large gar (*Lepisosteus oculatus, L. platostomus*) were seen during the summer and fall months but were not collected. Perhaps these large, relatively common

Table 13.—Stomach contents of *Lepomis symmetricus* from Wolf Lake by month of collection.[a] Figures in parentheses are numbers of stomachs examined.

Food Organism	Percent of Stomachs in Which Food Organism Occurred										
	Jan. (17)	Feb. (18)	Mar. (15)	April (9)	June (7)	July (43)	Aug. (17)	Sept. (10)	Oct. (9)	Nov. (13)	Dec. (18)
Gastropoda	29.4	11.1	13.3	55.6	14.3	..	..	..	..	..	11.1
Arachnida											
Araneae	..	..	..	..	..	..	..	..	..	7.7	5.6
Acarina	..	..	26.7	22.2	..	..	..	..	..	..	..
Crustacea											
Cladocera	17.6	44.4	20.0	33.3	..	..	76.5	90.0	77.7	61.5	16.7
Ostracoda	..	50.0	73.3	22.2	..	11.6	52.9	..	11.1	23.1	16.7
Copepoda	5.9	33.3	33.3	33.3	..	4.7	5.9	10.0	..	23.1	33.3
Amphipoda	..	..	13.3	11.1	71.4	44.2	35.3	10.0	..	7.7	11.1
Insecta											
Odonata	5.9	11.1	26.6	..	..	32.6	64.7	..	..	30.8	..
Coleoptera											
Helodidae	..	..	..	..	..	4.7	..	..	..	..	..
Noteridae	..	..	..	..	..	..	11.8	..	..	..	..
Haliplidae	..	..	..	66.7	..	..	..	..	..	..	..
Diptera											
Psychodidae	..	5.5	..	..	..	..	..	..	..	..	..
Chaoboridae	..	5.5	..	..	..	..	..	..	..	..	..
Tipulidae	..	..	..	..	..	..	..	..	..	7.7	..
Stratiomyidae	29.4	11.1	..	33.3	..	..	..	..	..	..	..
Ceratopogonidae	..	5.5	6.6	11.1	14.3	..	11.8	..	..	7.7	..
Culicidae	..	..	..	..	..	..	5.9	..	..	..	..
Chironomidae	5.9	22.2	..	55.6	..	7.0	5.9	20.0	..	..	11.1
Ephemeroptera	..	..	..	..	14.3	..	..	..	..	..	38.8
Trichoptera	..	..	..	33.3	..	..	..	..	..	..	5.6
Hemiptera											
Corixidae	..	..	..	..	57.1	7.0	..	70.0	..	..	..
Naucoridae	..	..	..	..	14.3	4.7	11.8	..	..	..	..
Fulgoridae	..	..	..	..	..	4.7	5.9	..	..	..	..
Pleidae	..	..	..	..	14.3	9.3	..	..	..	..	..
Mesoveliidae	..	..	..	..	..	4.7	..	..	..	..	..

[a] Stomach contents were not examined for May-collected specimens.

predators take some toll on the Wolf Lake population of *L. symmetricus.*

Hybridization

Schwartz (1972) did not report any accounts of hybridization involving *L. symmetricus.* No evidence of hybridization was found in the Wolf Lake study area or in specimens examined from elsewhere. The small size of *L. symmetricus,* its preference for shallow, vegetated water, and its distinct breeding coloration probably preclude mismating of the parental species. Since there is ample habitat available in Wolf Lake and the fishes are presumably not unduly crowded, chances of hybridization are small (Hubbs 1955: 2, 18).

Parasitism

The Wolf Lake study population was rather heavily parasitized by plerocercoids of the cestode *Haplobothrium globuliforme.* These plerocercoids occurred in a total of 44 of 176 stomachs (25 percent) examined. From one to five plerocercoids were found in each stomach. Usually the highest numbers occurred in stomachs of the −1 year class. Specimens were found during all months of the year except May and June. The plerocercoid stage of *H. globuliforme* normally encysts in the

Table 14.—Stomach contents of *Lepomis symmetricus* from Wolf Lake by month of collection.[a] Figures in parentheses are numbers of stomachs examined.

Food Organism	Mean Number of Food Organisms Per Stomach										
	Jan. (17)	Feb. (18)	Mar. (15)	April (9)	June (7)	July (43)	Aug. (17)	Sept. (10)	Oct. (9)	Nov. (13)	Dec. (18)
Gastropoda	0.71	0.17	0.93	1.56	0.29	..	..	..	..	..	0.11
Arachnida											
Araneae	..	..	..	..	..	..	..	..	..	0.08	0.06
Acarina	..	..	0.93	0.44	..	..	..	..	..	..	..
Crustacea											
Cladocera	0.06	3.61	0.93	1.67	..	..	11.35	20.00	13.22	17.23	0.72
Ostracoda	..	7.11	10.40	0.56	..	0.44	3.00	..	0.11	0.38	0.78
Copepoda	0.06	1.00	3.40	1.00	..	0.07	0.06	0.40	..	0.69	2.11
Amphipoda	..	..	0.13	0.11	14.28	1.79	2.59	0.10	..	0.08	0.11
Insecta											
Odonata	0.06	0.11	0.73	..	..	0.42	1.47	..	..	0.31	..
Coleoptera											
Helodidae	..	..	..	..	..	0.07	..	..	..	..	..
Noteridae	..	..	..	..	..	..	0.18	..	..	..	..
Haliplidae	..	..	..	3.33	..	..	..	..	..	..	..
Diptera											
Psychodidae	..	0.05	..	..	..	..	..	..	..	..	..
Chaoboridae	..	1.61	..	..	..	..	..	..	..	..	..
Tipulidae	..	..	..	..	..	..	..	..	..	0.15	..
Stratiomyidae	1.41	0.11	..	1.22	..	..	..	..	..	..	..
Ceratopogonidae	..	0.06	0.06	0.11	2.14	..	0.12	..	..	0.77	..
Culicidae	..	..	..	..	..	..	0.12	..	..	..	..
Chironomidae	0.41	0.39	..	1.11	..	0.09	0.06	0.40	..	..	0.22
Ephemeroptera	..	..	..	..	0.14	..	..	..	..	..	0.39
Trichoptera	..	..	..	0.33	..	..	..	..	..	..	0.06
Hemiptera											
Corixidae	..	..	..	..	1.00	0.14	..	1.60	..	..	..
Naucoridae	..	..	..	..	0.14	0.02	0.12	..	..	..	..
Fulgoridae	..	..	..	..	..	0.02	0.14	..	..	..	..
Pleidae	..	..	..	..	0.14	0.02	..	..	..	..	..
Mesoveliidae	..	..	..	..	..	0.02	..	..	..	..	..

[a] Stomach contents were not examined for May-collected specimens.

liver of fishes and has been reported from a number of other fishes in both this and the adult stage (Hoffman 1967: 233). No adults were found in the study population.

One adult specimen of the acanthocephalan *Pomphorynchus bulbicolli* was found in the stomach of an *L. symmetricus* collected 24 April 1974 at Wolf Lake. Neither the cestode nor the acanthocephalan had been known to parasitize *L. symmetricus*.

Dolley (1933) reported cestodes and trematodes from "*Lepomis symmetricus* in the St. Joseph River of Michigan," but the misidentification of the host species is obvious, since *L. symmetricus* has never occurred in Michigan. Hoffman (1967), who compiled a list of fish parasites, cited for *L. symmetricus* the trematodes *Actinocleidus symmetricus, Cleidodiscus diversus,* and *Anchoradiscus triangularis.* Dr. Mary H. Pritchard informed me that Hoffman (1967) evidently cited as the species name (*A. symmetricus*) that of the host instead of the parasite and that "*A. symmetricus*" does not exist. She also noted that *Cleidodiscus diversus* was described from *Lepomis cyanellus* and that its listing for *L. symmetricus* was an error in the 1964 Index-Catalogue, Trematoda and Trematode Diseases, Part 2, that was perpetuated by Hoffman (1967) and the 1969 Index-Catalogue.

One collection examined during this study from Texas (TCWC 3643) collected 2 May 1970 was heavily infested (all 32 specimens in the lot) with a monogenetic trematode, presumably *Anchoradiscus triangularis.* No external parasites were observed during the present study.

SUMMARY

The life-history information on *L. symmetricus* collected in Wolf Lake between 2 June 1973 and 27 May 1975 is summarized in Table 15.

Table 15.—Summary of life-history information on Wolf Lake *Lepomis symmetricus*.

Characteristics	Life-History Data
Principal habitat	Shallow, heavily vegetated margins of standing water
Age at reaching sexual maturity	1 year
Size at reaching sexual maturity	Females about 34 mm; males about 40 mm
Sexual dimorphism	Adult males are darker on the head and body have duskier pelvic fins and longer pelvic fins; females tend to have more distinct vertical bars
Number of mature ova in preserved females	219–1,600
Description of egg	About 0.8 mm in diameter, translucent orange
Spawning period	From mid-April to early June
Spawning habitat	Presumably in shallow water, over soft mud bottom, near plant material
Spawning site	Shallow nest depression, about 90–120 mm in diameter
Influence of sex on growth rate	Virtually none
Density	Up to 0.69 sunfish per square meter
Sex ratio among young	1.5 females : 1 male
Longevity	3+ years
Maximum size	63.0 mm standard length
Principal diet	Aquatic gastropods, insect immatures, and microcrustaceans

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