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LFL contrib. #31

The larvae and juveniles of Cottus ricei and sympatric Cottidae

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ABSTRACT

Metalarvae and juveniles of Cottus ricei were collected from the Eastmain River and Estuary, on the east coast of James Bay, Quebec. The specimens were readily distinguished from other cottid species within their range by the presence of prickles (small bony spines) along both sides of the dorsal and anal fins of metalarvae and over most of the body of juveniles. This material coupled with other recent contributions to our knowledge of cottid larvae lead to a reassignment of several early descriptions of Lake Erie fish larvae to C. ricei.

Among the cottids of the interior waters of Canada, C. ricei hatch as protolarvae at less than 7 mm TL (total length), probably with moderate-size yolk sacs, while C. bairdi and C. cognatus hatch at about 6 or 7 mm TL as very late protolarvae, or as mesolarvae, with large yolk sacs. C. ricei mesolarvae bear little if any yolk while C. bairdi and C. cognatus retain large yolk sacs until the beginning of the metalarval phase. Myoxocephalus thompsoni and M. quadricornis are suspected to hatch at about 7 to 9 mm TL with moderate-size yolk sacs and remain protolarvae until 10 or 11 mm TL, by which size the Cottus species are already metalarvae.

INTRODUCTION

Cottus ricei (spoonhead sculpin) is an inhabitant of the Great Lakes and the rivers, lakes, and occasionally estuarine and brackish waters of much of interior Canada from the St. Lawrence drainage northwest to the mouth of the MacKenzie River (Scott and Crossman 1973, Lee et al. 1980). It is sympatric throughout its range with the more broadly distributed Cottus cognatus (slimy sculpin) and in the southern and eastern portions of its range with Cottus bairdi (mottled sculpin). In the Great Lakes and some of the deeper, cooler, inland lakes of its range it is sympatric with Myoxocephalus thompsoni (deepwater sculpin). In the estuarine and brackish waters of James Bay and probably the estuaries of southwestern Hudson Bay and the MacKenzie River, its range is also occupied by Myoxocephalus quadricornis (fourhorn sculpin).

Scott and Crossman (1973) considered C. ricei "the most distinctive member of the genus Cottus in North America." However, no published descriptions of the larvae or early juveniles, apart from that of a 27.5 mm specimen described and illustrated by Fish (1932), were recognized prior to Heufelder (1982). Heufelder (1982) illustrated and described C. ricei larvae measuring 7 to 11 mm TL as well as a 21.5 mm TL juvenile. He also included data on the 27.5 mm juvenile described by Fish (1932) and noted that Fish's descriptions and illustrations of C. bairdi larvae (6 to 11 mm TL) might have been based on misidentified C. ricei. Khan and Faber (1974) had previously reassigned those same C. bairdi descriptions to the freshwater form of Myoxocephalus quadricornis, now recognized as M. thompsoni (Robins et al. 1980). Snyder and Douglas (1978), who also recognized that Fish's (1932) descriptions were not of C. bairdi, were in turn suspicious of Khan and Faber's alternative identification. All the above mentioned descriptions were based on field-collected specimens from Lake Erie (Fish's descriptions) and Lake Superior (original descriptions by Heufelder).

Heufelder (1982) also included descriptive accounts of the larvae and juveniles of C. bairdi (6 to 15 mm TL) and C. cognatus (6 to 11 mm TL) based in part on Heufelder and Auer (1980), Khan (1971), Koster (1936), and Van Vliet (1964); and the larvae of M. thompsoni (10 to 18 mm TL) based in part on Khan (1971) and Khan and Faber (1974). The latter two authors also covered the larvae of M. quadricornis. Heufelder (1982) questioned the identity of 12.5 and 16.2 mm TL M. thompsoni (Triglopsis thompsoni) described by Fish (1932) and suggested they might be C. bairdi. Descriptions by Fish (1932) of a 19.0 mm TL C. bairdi, and 18 and 21.5 mm TL C. cognatus remained undisputed in the published literature. Some of the descriptions and illustrations in Fish (1932) were previously published in Fish (1929); for convenience we refer only to the former in this paper.

Our primary purpose in this paper is to fill critical voids in recognized accounts of C. ricei larvae and juveniles by providing original descriptive data and illustrations and by reassignment of previously published

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descriptions. Our second objective is to compare C. ricei larvae and juveniles with those of sympatric cottids to illucidate and confirm diagnostic characters.

MATERIALS AND METHODS

Young-of-the-year C. ricei were collected, along with other cottids, from May to September 1980 in the lower portion of the Eastmain River and its estuary on the east shore of James Bay, Quebec (Ochman and Dodson 1983). The specimens were fixed and preserved in 5% buffered formalin. Measurements were made to the nearest tenth of a millimeter under dissecting microscopes fitted with ocular micrometers. Specimen lengths reported in the text are total lengths. Fin ray and myomere counts were verified by clearing selected specimens in 5% KOH and staining the bone with alizarin red. For comparative purposes, the morphometric and meristic characters utilized in our study of C. ricei include those recorded for cottids by Heufelder and Auer (1980) and Heufelder (1982). Additional data were summarized from the literature and original observations on the larvae and juveniles of other species from various sources. Developmental phase terminology follows Snyder (1976, 1981).

RESULTS AND DISCUSSION

DESCRIPTION OF METALARVAE AND JUVENILES FROM EASTMAIN RIVER AND ESTUARY

Specific length measures for these specimens are graphed in Figure 1. These data as well as data on meristics (countable structures) and size at the onset of selected developmental events are summarized and combined with

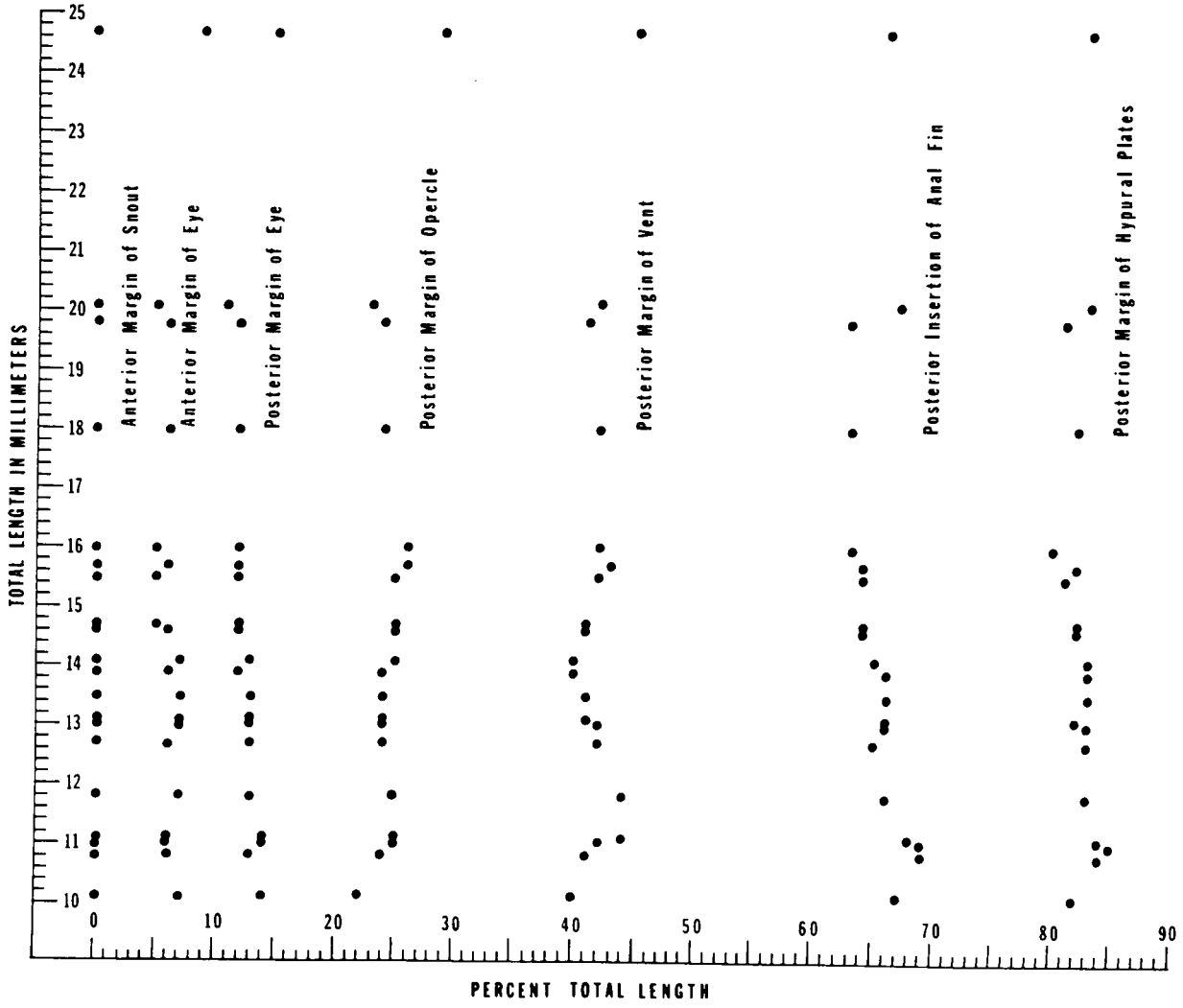

Figure 1. Proportional lengths to selected structures or points for Cottus ricei metalarvae and early juveniles from the Eastmain River and Estuary, James Bay, Quebec.

previously published data in Tables 1, 2, and 3 for comparison with sympatric cottids.

Even the smallest C. ricei collected, about 10 mm, are without yolk and possess a full complement of adult fin elements except for the procurrent caudal rays. The smallest specimens also have a finfold anterior to the developing procurrent rays (Figure 2). The adult count of procurrent caudal rays is attained by 11 to 12 mm but the metalarval phase continues until the finfold is lost, at about 13 mm.

C. ricei juveniles have a slender elongate body and head flattened in profile but wide and spatulate when viewed from above. From a terminal mouth, the dorsal profile rises gently to the back of the head and is slightly depressed between small dorsally oriented eyes. The gill membrane is broadly attached to the isthmus. A long, backward-extending, but upwardly-curved preopercular spine, and three

Table 1. Summary of selected morphometric data by developmental phase or period for larvae (Pr-protolarvae, Ms-mesolarvae, Mt-metalarvae) and juveniles (Jv) of Cottus ricei and sympatric cottids.

Species:		Cottus ricei	Cottus bairdi	Cottus cognatus	Myoxocephalus thompsoni	Myoxocephalus quadricornis
Sources of data[a]:		H,F,O	A,H,O	A,H,O	H,K	K
Maximum number of specimens examined or reported (number of illustrations from which additional data was extracted in parentheses)	Pr	1(1)	-[b]	≥2(1)[b]	≥2(1)	-
	Ms	≥3(3)	≥2(1)	≥2(1)	≥2(3)	-(1)
	Mt	≥10(7)	≥20(3)[c], 5	≥22(2)[c] 7(1)	≥2(1) -	-(2) -
	Jv	18(4)				
Total lengths, millimeters	Pr	7	-	6	8-10	-
	Ms	6-8	6-7	6-8	10-15	13
	Mt	9-13	7-15[c]	7-14[c]	15-18	14-17
	Jv	13-28	16-23	18-26	-	-
Lengths, %total length:						
Standard	Pr	96	-	95-98	93-98	-
	Ms	93-99	91-94	78-92	93-97	95
	Mt	81-95	82-90	80-89	93-96	88-91
	Jv	78-88	-	78-83	-	-
Snout-to-vent	Pr	39-42	-	44-49	36-38	-
	Ms	42-47	45-54	46-50	38-42	35
	Mt	39-47	42-52	39-48	40-43	35-40
	Jr	40-45	-	43-44	-	-
Head	Pr	16-17	-	17-20	14-17	-
	Ms	16-22	18-25	22-25	16-20	16
	Mt	18-26	18-26	18-27	20-26	20
	Jv	20-29	23-28	24-28	-	-
Yolk sac	Pr	-[d]	-	28-33	14[d]	-
	Ms	-[d]	32-37	28[d]	-	-
	Mt	-	27-31[d]	-[d]	-	-
Caudal peduncle	Ms	-	-	18	33	-
	Mt	13-27	13-15	13-20	30	21-30
	Jv	11-19	-	10	-	-
Lengths, % head length:						
Eye	Pr	26-27	-	35-41	40-54	-
	Ms	27-42	31-41	29-44	27-35	36
	Mt	18-36	28-39	27-41	30	32
	Jv	18-30	25-31	25-38	-	-
Postorbit head	Pr	44-47	-	43	43	-
	Ms	32-46	54	62	31-48	46
	Mt	36-54	35-54	37-50[e]	43	42-43
	Jv	42-55	-	45-49	-	-

[a] A-Heufelder and Auer (1980), Fish (1932, including reassigned descriptions), H-Heufelder (1982), K-Khan and Faber (1974), O-Original observations.

[b] This species either hatches as a mesolarva or achieves that state very shortly after hatching.

[c] Largest specimens might qualify as juveniles if caudal finfold has been lost.

[d] Yolk present in some or additional specimens but either not measured or too little to measure accurately.

[e] Does not include datum for 7.9 mm specimen erroneously calculate in Heufelder (1982) from Heufelder and Auer (1980 -- 35% value should be 44%.

smaller preopercular spines below and oriented downward, are easily seen even in the smallest specimens examined. In larger specimens (17 mm) the smallest spines become partially overgrown with skin.

Small bony prickles, usually directed backward, are present on the bodies of all specimens (Figure 2). Those measuring 10 to 13 mm have two solitary series of prickles along both the dorsal and ventral surfaces. The dorsal series begin as a patch behind the head and extend with one series along each side of the dorsal fin, to the last myomere. Likewise, the two ventral series extend from the vent to the last myomere along each side of the anal fin and ventral midline of the caudal peduncle. Juveniles between 13 and 15 mm have additional series of prickles on their lateral surfaces. Larger specimens are covered densely with prickles or small spines on the entire body posterior to the head.

Body pigmentation is faint on the smallest specimens, but quite prominent shortly after transition to the juvenile period with four or five irregular, saddle-like, dorsal to lateral splotches and a broad band or splotch at the base of the caudal fin (Figure 2). Most specimens exhibit a series of melanophores

Table 3. Summary of size, in millimeters total length, at the apparent onset of selected developmental events for larvae of Cottus ricei and sympatric cottids based on a combination of original observations and data reported in literature. Rare or questionable extremes are enclosed in parentheses.

Species:	Cottus ricei			Cottus bairdi	Cottus cognatus	Myoxocephalus thompsoni	Myoxocephalus quadricornis
Source of Data [a]:	H,O	F	Combined	A,H,O	A,H,O	H,K	K
Events							
Hatching:	<7	≤6	≤6	6-7	6	≤8	<12
Eyes pigmented:	<7	≤6	≤6	Embryo	Embryo	≤8	<12
Pectoral fin bud formation:	<7	≤6	≤6	Embryo	Embryo	≤8	<12
Pelvic fin bud formation:	9	<10	9	7	(6) 7 (8)	10-11	<12
Yolk completely absorbed:	8	(6) 7	(6) 7-8	8-10	8-9	10	<12
Finfold completely absorbed:	13		13	14-15[b]	(11) 14-15[c]	>18	>17
First body prickles:	10-12	11-12	10-12	<17[d]	10-12		
First pigment on dorsal surfaces:	10-11	11	10-11	Embryo-6-7	7	≥10-12	≥12
First fin rays -							
Caudal, principal:	7	(6) 7	(6) 7	Embryo-6-7	6-7	(10) 11	≥12
Caudal, procurrent:	(9) 10		(9) 10	8-9	7-8(9)	(12) 14-16	14-15
First Dorsal:	(9) 10	10-11	(9) 10-11	7	7	15-16	15 (16)
Second Dorsal:	(8) 9	>7, <10	(8) 9	7	6-7	12-13	≥12-14
Anal:	(8) 9	>7, <10	(8) 9	7	6-7	12-13	≥12-14
Pectoral:	≤7	>7, <10	7 (8)	Embryo-6-7	Embryo-6	10-11	≥12-14
Pelvic:	10	>7, <10	(9) 10	(7) 8	7-8	17-18	(16) 17
Full complement of fin rays -							
Caudal, principal:	9	<10	9	7	7	13-15	14-15
Caudal, procurrent:	11-12		11-12	11[e]	<12	>18	>17
First Dorsal:	10-11	11	10-11	8	7-8	≥16-17	>17
Second Dorsal:	9	>7, <10	9	7 (8)	(6) 7	14-15	(12) 13-14
Anal:	9	>7, <10	9	7 (8)	(6) 7	14-15	(12) 13-14
Pectoral:	7	>7, <10	7-8	(7) 8	(7) 8	12-14	14 (15)
Pelvic:	10-11	11	10-11	Embryo-6-7	7	≥10-12	≥12

[a] A-Heufelder and Auer (1980), F-Fish (1932, descriptions reassigned to Cottus ricei), H-Heufelder (1982), K-Khan and Faber (1974), O-Original observations.

[b] Lake Michigan specimens; Colorado specimens about 13mm TL.

[c] The 11 mm value was reported by Heufelder (1982) for Lake michigan specimens; the 14-15 mm values are based on original observations on Eastmain River or Estuary specimens.

[d] No prickles were obseved on young-of-the-year juveniles from Colorado, some of which were much larger in size

[e] Colorado specimens.

Table 2. Summary of selected meristics for Cottus ricei and sympatric cottids based on a combination of original observations and data reported in literature. Mean or modal values are underscored if notable. Rare or questionable extremes are enclosed in parentheses. Myomere counts are based on larvae and early juveniles; other counts are based on juvenile and adult observations.

Species: Source of Data[a]:	Cottus ricei	Cottus ricei	Cottus bairdi	Cottus cognatus	Myoxocephalus thompsoni	Myoxocephalus quadricornis
Attribute	F1	F2,H	A,H,M,S,O	A,F2,H,M,S,O	H,K,S	K
Myomeres[b],						
Preanal:	12-13	(11)12-13-14	9-11(12)	(9)10-12(13)	11-12	
Postanal:	20-21-22	20-21-22-23	(19)20-21	19-20(21)	24-26	
Total:	32-33-34-35	(31)32-33-35	(28)29-31-32	(28)29-30-31-32(33)	(33)35-39-42	41-46
Vertebrae:		34-35	31-32-33	31-32-33(35)	37-39	
Fin Meristics[c],						
1st Dorsal:	VII-VIII	VII-VIII-IX (X)	VII-VIII (IX)	(VI) VII-VIII-IX	VII-VIII-IX (X)	
2nd Dorsal:	16-19	15-16-18-19(20)	15-17-18(19)	(14)15-16-17-18(19)	11-13-14-16	13-16
Anal:	12-15	(11)12-14-15(16)	(10)11-13-14-15(16)	10-11-12-13(14)	(11)12-13-14-15(18)	14-17
Caudal:		viii-ix-12-13,viii-ix	viii-ix,12,vii-ix[d]	vi-viii,12,v-vii		
Pectoral:	15	14-16	(12)13-15(17)	(12)13-14-15(16)	(15)16-18	15-16-17
Pelvic:	I,4(3)	I,4	I,4(3)	I,3(4)	I,3(4)	

[a] A - Heufelder and Auer (1980), F1 - Fish (1932, descriptions reassigned to Cottus ricei), F2 - Fish (1932, other descriptions), H - Heufelder (1982), K - Khan and Faber (1974), M - McAllister (1964), S - Scott and Crossman (1973), and O - Original.

[b] Counts from Fish (1932) adjusted + 2 for preanal and - 2 for postanal myomeres to approximate Siefert (1969) approach used by most current biologists.

[c] Spines - upper case Roman numerals; secondary or procurrent rays - lower case Roman numerals; principal soft rays of median fins and all rays of paired fins - Arabic numerals.

[d] Original observations from Lake Ontario specimens; Colorado specimens examined have fewer procurrent caudal rays (v-vii, 12, v-viii).

Table 4. Reassignment of descriptions by Fish (1932) to Cottus ricei.

Original Identification	Total Length (mm)	Text (Page #) (Page #)	Illus-trations (Fig. #)
Cottus bairdii bairdii*	6.0	389-390	133
Cottus bairdii kumlieni	6.6	387	128
Cottus bairdii kumlieni	7.2	387-388	129
Cottus bairdii kumlieni	10.0	388	130
Cottus bairdii kumlieni	10.0	388	131
Cottus bairdii kumlieni	11.0	388-389	132
Triglopsis thompsoni	12.5	385-386	125-126
Triglopsis thompsoni	16.2	386	127

* Tentative

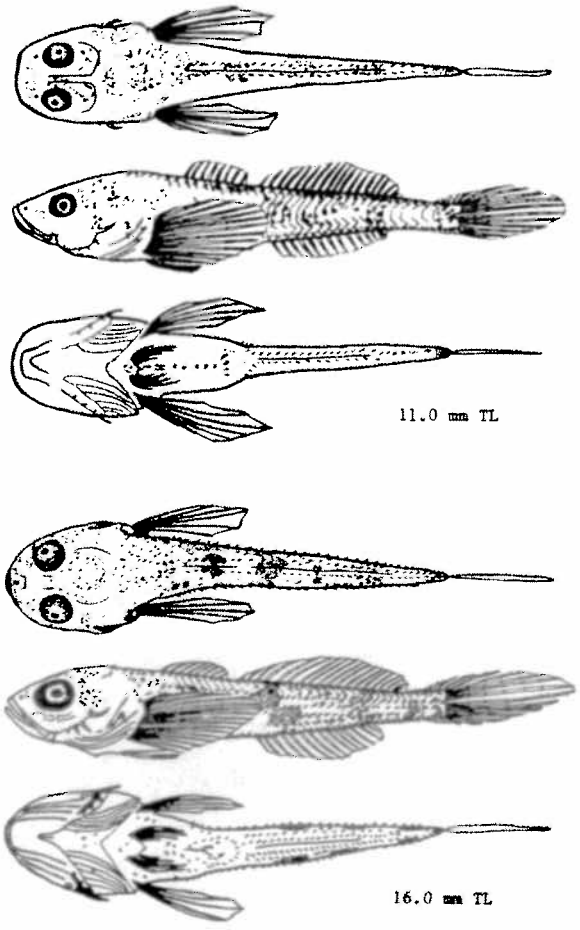

Figure 2. Cottus ricei from the Eastmain River or Estuary, James Bay, Quebec. Dorsal, lateral and ventral views of metalarva (11 mm TL) and juvenile (16 mm TL).

(sometimes just a few) from the pelvic girdle to the vent, usually ending in an irregular aggregation or short perpendicular line of melanophores. Another midline series of melanophores can sometimes be observed deep in the tissues under the anal fin and ventral surface of the caudal peduncle.

REASSIGNMENT OF DESCRIPTIONS BY FISH (1932) TO COTTUS RICEI

Fish (1932) reported the collection of and described larvae and (or) juveniles of what she believed to be Lake Erie representatives of each of the four sculpins recognized as inhabiting the Great Lakes. Unfortuately and as with her descriptions for several other species (Snyder and Douglas 1978, Auer 1982, Fuiman et al. 1983), eight of the twelve cottid specimens she described were misidentified (Table 4, Figures 3 and 4).

Contrary to suspicions by Heufelder (1982), Fish's illustrated descriptions of 12.5 and 16.2 mm specimens attributed to Triglopsis thompsoni (now M. thompsoni), are certainly descriptions of C. ricei and strongly resemble Eastmain River specimens of similar size (Figures 2 and 3).

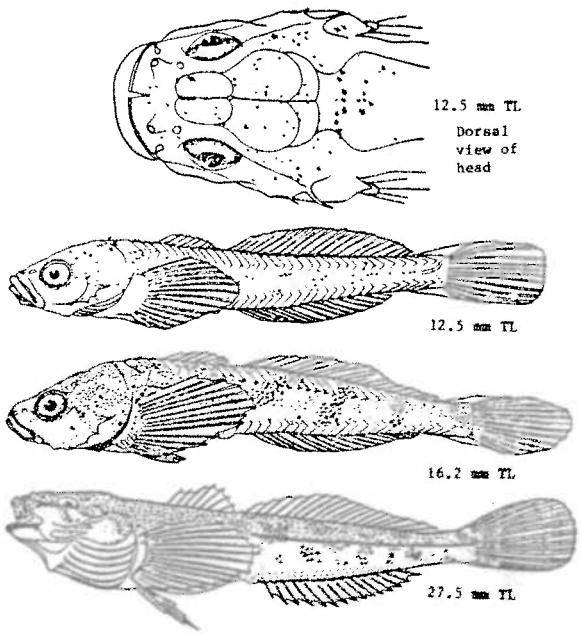

Figure 3. Cottus ricei from Lake Erie. Metalarva (possibly juvenile, 12.5 mm TL) and juveniles (16.2 and 27.5 mm TL) reproduced from Fish (1932). The 12.5 and 16.2 mm specimens were originally described as Triglopsis thompsoni (Myoxocephalus thompsoni).

They differ from similar-sized M. thompsoni larvae described by Khan (1971), Khan and Faber (1974) and Heufelder (1982) in body form, pigmentation, and especially developmental state relative to size (Table 3, Figures 3 and 6). Khan and Faber (1974) themselves mistakenly considered the 16.2 mm description valid for M. thompsoni. Fin and myomere meristics of both specimens fit C. ricei rather than M. thompsoni (Table 2). However, Fish did note that other of the five Lake Erie specimens she assigned to M. thompsoni (all between 12.5 and 16 mm) had pelvic fin counts of I,3 on both sides. The illustrations of Fish's 12.5 and 16.2 mm specimens did not include procurrent caudal rays; we suspect they were overlooked. Fish apparently included only entire myomeres anterior to the posterior margin of the vent in her preanal counts. Most early-life-history biologists now follow Siefert (1969) by including all myomeres transected by a vertical from the vent. If Fish's preanal and postanal counts are adjusted for the difference (on average, a shift of two from postanal to preanal), these counts are nearly the same as those reported by Heufelder (1982) and observed by ourselves.

Fish's 12.5 and 16.2 mm specimens are described as possessing series of prickles (spiny armature) on the body similar to those observed on our specimens. However, the ventral series do not continue beyond the anal fin as in our specimens and while our specimens over 13 mm

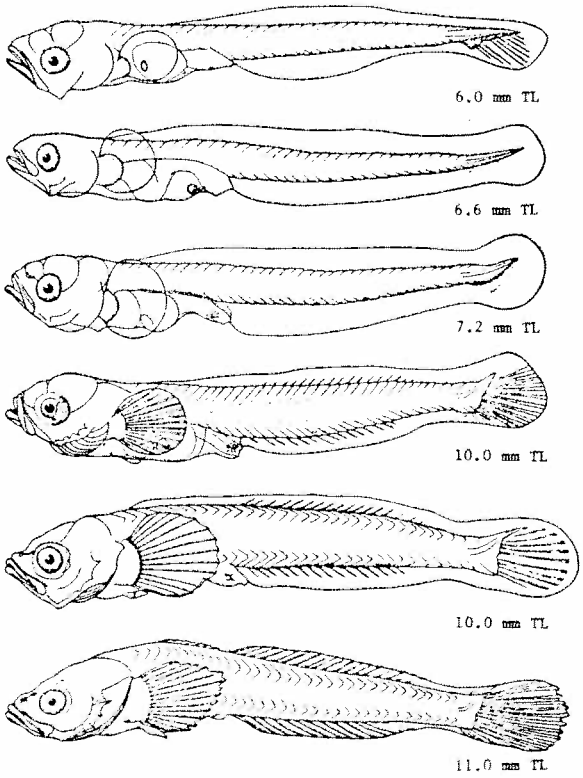

Figure 4. Cottus ricei from Lake Erie. Protolarva (6.6 mm TL), mesolarvae (6.0 and 7.2 mm TL) and metalarvae (10.0, 10.0, and 11.0 mm TL) reproduced from Fish (1932). Although not clearly illustrated as such, the 7.2 mm specimen is assumed to have a few caudal rays and the 10 mm specimens are assumed to have a full complement of 12 principal caudal rays. The 6.0 mm specimen was originally described as Cottus bairdii bairdii and the others, 6.6 through 11.0 mm, were originally described as Cottus bairdii kumlieni. The reassignment of the 6.0 mm specimen to Cottus ricei is tentative.

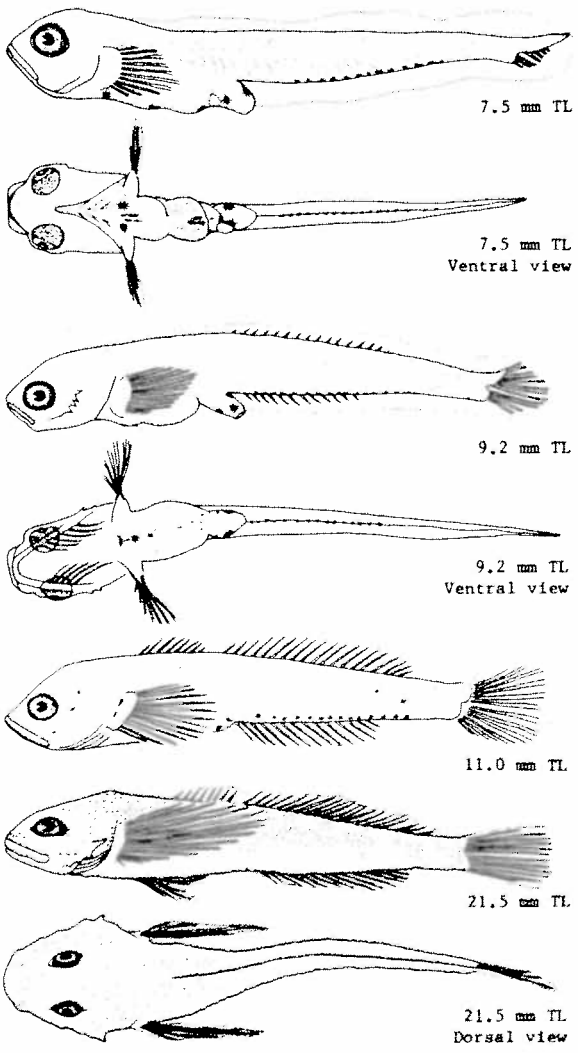

Figure 5. Cottus ricei from Lake Superior. Mesolarva (7.5 mm TL), metalarvae (9.2 and 11 mm TL), and juvenile (21.5 mm) reproduced from Heufelder (1982) with permission from Nancy A. Auer.

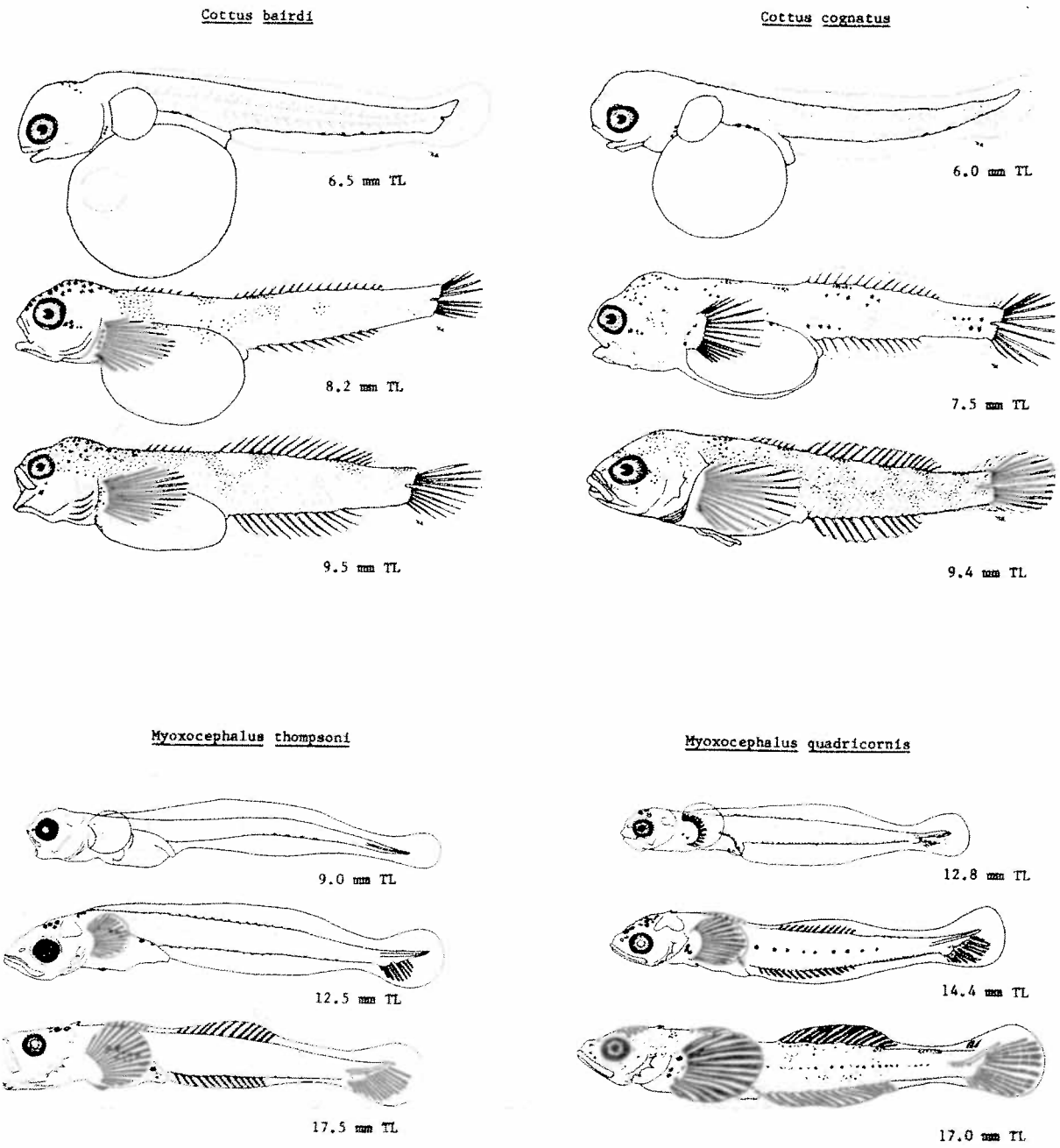

Figure 6. Larvae of Cottus bairdi (6.5 mm TL mesolarva, and 8.2 and 9.5 mm TL metalarvae), Cottu cognatus (6.0 mm TL protolarva; 7.5 mm TL mesolarva, no pelvic fin buds; and 9.4 mm T metalarva), Myoxocephalus thompsoni (9 mm TL protolarva, 12.5 mm TL mesolarva, and 17.1 mm Tl metalarva), and Myoxocephalus quadricornis (12.8 mm mesolarva, and 14.4 and 17.0 mm metalarvae) All specimens were from Lake Michigan except the smallest of the Cottus species which were laboratory reared in Michigan, and the series of M. quadricornis which were from Tuktoyatuk Harbor, Kugmallit Bay, N.W.T. The illustrations were selected from Heufelder (1982 - Cottus species) and Khun and Faber (1974 - Myoxocephalus species) and reproduced with permission from Nancy A. Auer and Daniel J. Faber, respectively.

are covered with prickles over most of the body, her 16.2 mm specimen has only one additional series between the initial dorsal and ventral series. Even her 27.5 mm specimen correctly assigned to C. ricei is described as lacking prickles between the lateral line and a few ventral series along the anal fin. Scott and Crossman (1973) reported prickles only above the lateral line of adult M. thompsoni but none are reported or illustrated for that species through 18 mm by Khan and Faber (1974). C. bairdi and C. cognatus develop prickles only behind the pectoral fins (sometimes extending onto the back in C. bairdi; Scott and Crossman 1973), but even these were not observed or obvious in young C. bairdi from Colorado.

Fish's illustrated descriptions of 6 to 11 mm specimens attributed to C. bairdi were also mistakenly identified. Khan and Faber (1974) ignored their own meristic and developmental state observations on M. thompsoni when they reassigned these descriptions to M. thompsoni (Tables 2 and 3). We confirm Heufelder's (1982) belief that these descriptions represent C. ricei. However, we consider our reassignment of the 6 mm specimen to be tentative. Assuming the size and description reported for the latter specimen is accurate, its size relative to state of development is a bit inconsistent with the other descriptions (Figure 4). It certainly does not represent any of the other cottids known to inhabit the Great Lakes region and based on our current knowledge of fish larvae does not fit in any other family of Great Lakes fishes. These reassigned descriptions correspond reasonably well to C. ricei descriptions by Heufelder and with the smaller C. ricei (10-11 mm) that we examined (Figures 2, 4 and 5). They differ dramatically from C. bairdi and C. cognatus described by Heufelder and Auer (1980) and Heufelder (1982) (Figures 4 and 6). C. ricei bear little or no yolk at sizes for which the other Cottus species possess relatively immense yolk sacs. They hatch at a smaller size but develop fin structure at slightly larger sizes than C. bairdi and C. cognatus. Although the fin meristics for Fish's 10 and 11 mm specimens could apply to either C. bairdi or C. ricei, the adjusted myomere counts for all of Fish's presumed C. bairdi are more appropriate for C. ricei (Table 2).

The information provided by Fish (1932) for an unillustrated 19 mm specimen attributed to C. bairdi is inadequate to positively confirm as C. bairdi. The myomere count of 35 (14 preanal, 21 postanal when adjusted) fits C. ricei, while the fin meristics and morphometrics reported are consistant with both C. bairdi and C. ricei. However, the pigmentation described is probably more applicable to C. bairdi. Also, if the specimen described were indeed C. ricei, it probably would have been characterized by body armature (prickles) and assigned by Fish to either M. thompsoni or C. ricei. Perhaps the myomere count is in error.

Without realizing it, Fish (1932) actually provided a rather comprehensive series of descriptions for C. ricei larvae and juveniles in her section on Cottidae. Only a recently hatched, yolk-bearing specimen is needed to complete the series.

Indeed, the senior author suspects that Fish (1932) also described such a specimen (and the 1.4 to 1.5 mm eggs from which it came) but attributed its identity to Boleosoma nigrum nigrum (now Etheostoma nigrum) in her section on Percidae (page 374, Figure 104). Auer (1982) accepted the description as valid and included the illustration and pertinent data in her own account of E. nigrum larvae. The 5.0 mm specimen is reported to have a myomere count of 33 (13 preanal, adjusted), a snout-to-vent length about 45% of total length (40% in the illustration), an oil globule in the yolk, and no pigmentation except for the eyes. These characters appear consistent with descriptions of the smallest larvae reassigned above to C. ricei, as well as those provided by Heufelder (1982) for C. ricei (Tables 1, 2 and 3, and Figures 4 and 5). In contrast to the 5.0 mm specimen described, E. nigrum have a few more preanal and total myomeres, a snout-to-vent length generally equal to or greater than 50% of total length, a vent located a short distance rather than immediately behind the yolk-sac, and a distinctive pigmentation over the yolk-sac and ventral surface of the body. Like the specimen described, recently hatched E. nigrum possess an obvious oil globule.

However, Dr. Wayne Roberts of the Museum of Zoology, University of Alberta in Edmonton, has reared C. ricei and while he agreed with our reassignment of Fish's 6 through 11 mm C. bairdi, he refuted the above suspected identity of Fish's 5.0 mm E. nigrum. He noted that his recently hatched C. ricei are larger, bear a larger yolk-sac, and exhibit some ventral pigmentation. Accordingly, we await Dr. Roberts' description of recently hatched specimens and consider the description of Fish's 5.0 mm specimen uncertain.

Fish (1932, pages 299 through 305) reported on the collection of 56 cottid larvae and juveniles (6 to 35 mm) in 1928 and 1929 Lake Erie surveys. Based on her identifications and according to her text, these collections provided the first records of M. thompsoni, C. cognatus and C. ricei in Lake Erie. If her descriptions are indeed representative of other specimens designated by her as M. thompsoni and C. bairdi, no M. thompsoni were actually collected and specimens designated as M. thompsoni (12.5 to 16 mm) and C. bairdi, (6 to 12 mm) are actually C. ricei. Distributional or ecological data and conclusions for cottids based on these collections and subsequent work based on the descriptions should be revised accordingly.

DIAGNOSTIC CHARACTERS

At comparable states of development, the larvae of C. ricei vaguely resemble the Myoxocephalus species in form and pigmentation. However, C. ricei, as well as the more distinctly appearing C. bairdi and C. cognatus, are unquestionably distinguished from the larvae of the Myoxocephalus species by the latter's substantially greater size relative to state of development (Table 3). The Cottus species are already metalarvae by the size at which the Myoxocephalus species transform from protolarvae to mesolarvae. They are juveniles by the size at which the Myoxocephalus species acquire their first dorsal fin spines. Myomere counts will also readily segregate most of the Cottus larvae (≤35 total, ≤23 postanal) from Myoxocephalus larvae (≥35 total, ≥24 postanal) (Table 2). There are many additional meristic, morphometric, and pigment differences that at least in combination will segregate the two genera or specifically C. ricei from M. thompsoni or M. quadricornis (Tables 1 and 2, Figures 2 through 6), but in nearly all cases their utilization will be unnecessary for identification purposes.

C. ricei protolarvae, mesolarvae, and even the earlier metalarvae are readily distinguished from those of C. cognatus and C. bairdi by general body form, state of development relative to size, and pigmentation (Tables 3, Figures 2 through 6). C. ricei hatch as protolarvae, probably with moderate-size yolk sacs, and absorb most or all of their yolk by 7 mm when they approach or achieve the mesolarval state. In contrast, C. bairdi and C. cognatus hatch at about 6 or 7 mm as either protolarvae (near transition) or mesolarvae with large yolk sacs, become metalarvae by 7 or 8 mm and complete yolk absorption between 8 and 10 mm. C. ricei become metalarvae at about 9 mm. Pigmentation is sparse and restricted to the ventral surfaces on C. ricei less than 10 or 11 mm. While also sparse and restricted to the ventral surfaces in the earliest larvae of the other Cottus species, pigmentation develops rapidly on the head and body and a juvenile-like pattern is well established by 9 or 10 mm. A juvenile-like pigmentation pattern is not achieved in C. ricei until about 11 to 12 mm. Later mesolarvae, and metalarvae of C. bairdi and C. cognatus typically bear very little or no mid-ventral pigmentation while at least some populations of C. ricei exhibit rather distinctive mid-ventral series or aggregations of melanophores both anterior and posterior to the vent. This mid-ventral pigmentation, as mentioned earlier is also present on C. ricei juveniles from Eastmain River.

The presence of prickles along each side of the bases of the dorsal and anal fins of at least later metalarvae and early juveniles of C. ricei readily and conclusively distinguish these specimens from the later metalarvae and juveniles of C. bairdi and C. cognatus. Prickles on juvenile C. ricei can cover most or all of the lateral surfaces while on the other Cottus species they are restricted generally to patches behind the pectoral fins, if present at all.

Although unnecessary in view of the above, some meristic and morphometric characters are useful diagnostically for separating C. ricei from the other Cottus species, especially when used in combination with each other and previously mentioned characters (Tables 1 and 2). The position and size of the eyes are among the more readily observed morphometric characters for diagnosis of metalarvae and early juveniles. The eyes of C. ricei are typically smaller and the distance between them (interorbital distance) greater than for comparably-sized C. cognatus and C. bairdi. Based on 5 specimens of each species between 13 and 20 mm TL, C. ricei eye diameters and interorbital distances ranged 22 to 25% and 16 to 19% of head length, respectively, while corresponding measures were 27 to 31% and 8 to 18% of head length, respectively, for C. bairdi and 28 to 32% and 10 to 15%, respectively, for C. cognatus. However, variation in these characters is great, especially outside the specified size range, and they should not be used by themselves for separating the species. As in most taxonomic work, use of several characters is preferred to assure accurate identification.

OBSERVATIONS ON COTTUS RICEI SPAWNING SEASONS

The occurrence and size distribution of C. ricei in Eastmain River collections suggests that the fish spawned during mid to late spring in 1980. Heufelder (1982) reported that C. ricei in Lake Superior spawn during mid spring (early May). Assuming that Fish's (1932) descriptions are representative of the cottid larvae she reported in 1928 and 1929 collections, the Lake Erie C. ricei population also spawned predominately in mid to late spring (some spawning continued well into July). These observations are contrary to the late summer and early fall spawning season suspected by Scott and Crossman (1973).

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