IDENTIFICATION OF LARVAL FISHES OF THE GREAT LAKES BASIN

WITH EMPHASIS ON THE LAKE MICHIGAN DRAINAGE

Edited by

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The Great Lakes Fishery Commission, established by the 1955 Convention on Great Lakes Fisheries between Canada and the United States, was organized in April 1956 and assumed its duties as set forth in the Convention on July 1, 1956. The Commission has three major responsibilities: to develop and coordinate fishery research programs, to advise governments on measures to improve the fisheries, and to develop measures and implement programs to manage sea lamprey. The Commission is also required to publish or authorize the publication of scientific or other information obtained in the performance of its duties.

IDENTIFICATION OF LARVAL FISHES OF THE GREAT LAKES BASIN WITH EMPHASIS ON THE LAKE MICHIGAN DRAINAGE[1]

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FOREWORD

The results of three major initiatives are coming together to give fishery scientists, managers, and administrators a better understanding of the spawning and early life history processes of Great Lakes fishes: 1. synthesis of information via symposia, 2. a text to provide greater ability to identify fish eggs and larvae, and 3. an atlas of fish spawning and nursery areas.

1. The Symposia

The 1955 Convention on Great Lakes Fisheries charges, in part, the Great Lakes Fishery Commission to determine what measures are best adapted to make possible the maximum:‘; sustained productivity of any stock of fish in the convention area which is of common concern to the fisheries of Canada and the United States. In its efforts to execute this charge and rehabilitate the fishery resources of the Great Lakes, the Commission views as its ultimate goal development and maintenance of balanced fish communities of desired species supported by natural reproduction. In determining measures to reach its goal, the Commission feels a great responsibility to ensure continuing development of knowledge, synthesis of what is al ready known, and its application to Great Lakes fishery management.

As one way to meet this responsibility, the Commission has promoted, by active participation and varying degrees of financial and developmental support, symposia which focus, in part, on fish reproduction and early life hi story. These symposia include, in 1971, the international symposium on Salmonid Communities in Oligotrophic Lakes (SCOL) (J. Fish. Res. Board Can., Vol. 29, No. 6); 1972, Bio-Engineering Symposium for Fish Culture - I; 1976, the Percid international Symposium (PERCIS) (J. Fish. Res. Board Can., Vol. 34, No. 10) ; 1978, a symposium on Selected Coolwater Fishes of North America (Kendall, R. L., Spec. Pub. Am. Fish. Soc.); 1979, the Sea Lamprey international Symposium (SLIS) (Can. J. Fish. Aquat. Sci., Vol. 37, No. 11); 1979, Bio-Engineering Symposium for Fish Culture - II (Allen, L. J. and E. C. Kinney, Spec. Pub. Am. Fish. Soc.); 1980, the Stock Concept International Symposium (STOCS) (Can. J. Fish. Aquat. Sci., Vol. 38, No. 12); 1981, the international symposium on Acidic Precipitation and Fishery Impacts (Johnson, R., Spec. Pub. Am. Fish. Soc.) ; and most recently, 1981, the Fish Health Workshop (Cairns, V. and P. V. Hodson ed., tentative title - Techniques for monitoring effects of contaminants on fish. In preparation. John Wiley and Sons.) On line for 1983 is the Urban Fishing Symposium and the Conference on Lake Trout Research - Strategies for Rehabilitation in the Great Lakes (CLAR). Major topics at CLAR dealing with reproduct ion and early life history will include genetics, stocking practices, species interactions, contaminants and water quality, physiology and behavior, and habitat requirements. The conferees will determine and rank research needs to accelerate further rehabilitation of Great Lakes lake trout and recommend optimum methods.

* In line with current fishery management philosophy and practice, the Commission also considers the options associated with opt i mum sustained productivity.

2. The Text

Concurrent with these symposia, there have been other trends and events more directly associated with development and synthesis of Great Lakes information on fish spawning and early life history. In the mid-1960s officials of the Federal Water Pollution Control Administration (FWPCA) became alarmed at the proliferation of thermal-electric generating stat ions employing once-through cooling and the large number planned for the future. The Great Lakes offered "unlimited" cooling water and Chicago FWPCA personal were particularly concerned with thermal effects on fish and aquatic life in Lake Michigan. At the urging of federal and state water pollution control agency officials, the power-generating industry and other industries with heated discharges began examining plume behavior and effects. There were no established guidelines for such studies under state laws or the Federal Water Pollution Control Act. Designs were negotiable between discharger and agency. Many utilities hired environmental scientists to conduct studies, and others contracted with consultants.

Heat was the cause *célèbre*, and in 1970 the FWPCA, backed by the Department of the Interior, called for limiting the discharge of waste heat at the point of discharge to not more than 1 F over the ambient temperature of the receiving water. The public and some scientists and administrators feared waste heat would cause undesirable changes in local thermal regimes and biological communities. As the power producers argued against the limitation and the consequent need for cooling towers on the basis of thermal discharge control, the controversy raised intense public interest which resulted in emotional confrontations involving utility and regulatory representatives, public interest groups, and private citizens.

During one of the State-Federal Lake Michigan Enforcement Conferences attended by more than a thousand people, Tom Edsall, Great Lakes Fishery Laboratory, Fish and Wildlife Service (FWS), Ann Arbor, citing a 1970 FWS white paper, expressed hi s concern for entrainment and destruction of larval fish in the once-through cooling process of electricity-generating plants. From that beginning, the investigative emphasis in the Great Lakes shifted gradually from thermal effects to entrainment effects.

In this turbulent period the U.S. federal enforcement mantle was passed from FWPCA to the short-lived Federal Water Quality Administration, and thence to the Environmental Protection Agency which quickly stated its intent to give the public better water quality than dreamed possible, and then showed its teeth in the Water Quality Act Amendments of 1972. Known as the Clean Water Act - Public Law 92-500, it addressed thermal discharges in Section 316 and in paragraph (a) invited demonstrations by dischargers that the thermal component of their waste "assured the protection and propagation of a balanced, indigenous population of shellfish, fish and wildlife in and on the body of water" into which the discharge was made. "Guidelines" evolved in 1973 for highly-structured demonstrations of the physical, chemical and biological effects of thermal discharges. This led to a mountain of tremendously expensive studies and huge, generally inconclusive reports. Many, however, provided new information on fish spawning seasons, habitats, success, and early life history.

There was parallel concern over thermal discharges in the Ontario Ministry of Natural Resources (OMNR). The Ministry emphasized management of its Great Lakes waters for cool water or cold water fish species and believed that overlapping heated plumes eventually would adversely affect the littoral zone critically important for spawning and nursery areas. Canadian researchers, pioneers in developing thermal tolerance data for fish, were well aware of the potential for damage and their data and principles were used extensively to establish thermal criteria and standards. The management of waste heat discharges and evaluation of the environmental effects of power plants in Ontario were uniquely complicated in that Ontario Hydro, Environment Ontario, and OMNR fell under the same resource policy field and each was represented on the same cabinet committee, Resource Development. The public controversy in Ontario never reached the emotional level of that in the United States, but the internal conflict among the agencies was intense at that time. Canadian federal task forces subsequently prepared evaluation guidelines for steam-electric stations and fish screening.

Section 316(b) of U.S. Public Law 92-500 was the sleeper which riveted attention on the need for larval fish identification capability. It required the examination of cooling water intake structures to determine if the best available technology was being utilized to minimize adverse environmental impact. About 1974 environmental and fishery agencies and the utilities and their consultants turned their expertise to this fresh aspect of the question. In examining intakes of the 89 thermal-electric generating stations which drew water directly from the Great Lakes and connecting channels, it became quickly and painfully obvious that the existing literature on identification of Great Lakes larval fishes was fragmentary, conflicting and generally inadequate. Kelso and Milburn (1979. J. Great Lakes Res. 5, 2) estimated the number of fish entrained and impinged annually in the Great Lakes as 1.18×10^9 and 9.87×10^7, respectively. It was important that better taxonomic tools be available if investigators were to evaluate confidently the potential for impact on the fishes and fisheries of a water body from losses at individual intakes or from the combined losses at several intakes.

In 1976, the National Power Plant Team, Office of Biological Services, U.S. Fish and Wildlife Service, sponsored a workshop on "Great Lakes Fish Egg and Larvae Identification" to assess the state-of-the-art of Great Lakes fish egg and larvae identification and to develop a strategy for future larval taxonomic work in the Great Lakes region (FWS/OBS-76/23, NTIS, Springfield, VA), The proceedings documented the profound need for developmental studies and assemblage of a comprehensive illustrated key or guide to the eggs and larvae of Great Lakes fishes, and provided recommendations.

The need for the key was formally established, but no one stepped forward. Dr. John Dorr, then a Ph.D. candidate at the University of Michigan, was active in the field, was organizing the Great Lakes Regional Fish Larvae Collection at the university (Dorr, J. A. III and D. J. Jude. 1981. J. Great Lakes Res. 7, 2). and was offering identification advice in conjunction with ongoing power plant studies. However, John was not in a position to develop the text, and it wasn't until 1977 that the idea and the confidence to produce a text on identification of larval fishes began to form in Nancy Auer's mind. The University of Michigan Great Lakes Research Division had a contract with Consumers Power Company for both 316 (a) and 316 (b) demonstrations and a team of biologists capable of putting together a text was in place. In 1978, Nancy and Dr. David J. Jude, both members of the team, made a proposal to Michigan Sea Grant, but it was not funded. In late 1979 a revised proposal was submitted to the Great Lakes Fishery Commission by Auer and Jude which contained sample pages. Positive recommendations were received from several peer reviewers. The proposal was funded, but I'm sure every Commissioner questioned whether Nancy and her team could produce a quality manual on such a small budget in such a short time. The team of Auer, Lee A. Fuiman, George R. Heufelder, Heang T. Tin, and Jude essentially completed the text in August 1981.

The initial contract did not include publication, which was sought subsequently through EPA at a time when its publication policy was undergoing revision and its budget was being slashed. Time was lost until the Fishery Commission was requested to examine the final draft and consider publication. The Commission responded positively, believing the text to be a major contribution to the Great Lakes fishery literature and that its availability would permit further understanding of fishery ecology as a step toward further rehabilitation and improved management.

. The Atlas -

So the Great Lakes community is holding symposia leading to synthesis of information on fish reproduction and is establishing research priorities, and you have just read the story of the need for and development of fish egg and larvae identification capability. There was yet another major piece missing from the efforts to increase understanding of Great Lakes fish reproduction - - - a current knowledge of where fish spawn and the larvae mature - - - and where they did in the past. Several studies by a variety of individuals and agencies have recorded such information throughout the Great Lakes, but it remained for Carole D. Goodyear, Thomas A. Edsall, Diane M. Ormsby Dempsey, G. David Moss, and Paul E. Polanski of the Great Lakes Fishery Laboratory, U.S. Fish and Wildlife Service, under contract to the U.S. Army Corps of Engineers, to put the available information together into a 14-volume "Atlas of spawning and nursery areas of the Great Lakes fishes." The atlas includes the U.S. and Canadian waters of the five Great Lakes, Lake St. Clair, and the five Great Lakes connecting waters. One volume describes the reproductive characteristics of the 117 fish species covered, and concise descriptions of general spawning and nursery requirements were also compiled. These volumes are available from the Fish and Wildlife Service, Washington, D.C. as FWS/OBS-82/52.

Fishery and environmental administrators, managers, and scientists are in the midst of a great experiment - - - rehabilitation of the Great Lakes and their fishery resources. The combined total economic impact of the commercial and recreationa1 fishery has risen to about $1.16 billion annually. However, much of the fishery recovery to date has been bioengineered through sea lamprey management, artificial replenishment of native species by stocking, introduction of Pacific salmon, and knowledgeable application of regulations controlling harvest.

The Commission's goal for the development and maintenance of balanced fish communities of desired species supported by natural reproduction has not yet been attained. With publication of this manual, another tool for use in attaining that goal becomes available.

Carlos M. Fetterolf, Jr.
Executive Secretary
Great Lakes Fishery Commission
December 1982

PREFACE

The production of this manual was undertaken as part of employment responsibilities and frustration at the lack of adequate and specific materials available for identification of larval fishes. Although initiated as a "pipe dream" involving only myself, it soon became apparent that the production of a fish larva identification manual would require the assistance, expertise and experience of others.

This manual is NOT meant to be a last testament to larval fish identification in the Great Lakes region. Obviously, several gaps are present and much information and knowledge are lacking. This book is a consolidation of the current knowledge. The format and layout were purposely chosen so that additions and corrections could be incorporated either personally or through future publication of complete species accounts. It was also chosen to keep costs to a minimum, thus allowing students and laboratory technicians to purchase personal copies, and to allow for easy handling in the laboratory or field.

It cannot be stressed enough that this is a summary of past and present literature. Techniques and procedures for larva identification have varied over the years. While all available literature has been incorporated, remember that various myomere counts quoted in a species description may be inconsistent due to techniques used by various authors. Preanal myomere counts reported by Fish (1932) , Nelson (1977), Norden (1961) and in other older works are the number of entire myomeres from the nape to the end of the anus. A more recent method used by Buynak and Mohr (1978-1980), Cooper (1978), Fuiman and Loos (1977), Hardy (1978), Lippson and Moran (1974), Mansueti (1964), Mansueti and Hardy (1967) and Siefert (1969) describe preanal myomeres as those from the nape to an imaginary vertical line drawn at the posterior edge of the anus, including any bisected by that line. Original data are denoted by an asterisk (*) and were obtained using the latter method. The work of Fish (1932) is specific to the Lake Erie drainage, and therefore covers many of the same species as this manual, however since most of her counts do not correspond with recent data and she employed the older method in evaluating myomeres we have omitted her counts from the species accounts to reduce confusion.

Nancy A. Auer

Nancy A. Auer
March 1, 1982

ABSTRACT

This manual for the identification of larval fishes of the Great Lakes basin with emphasis on the Lake Michigan drainage treats 24 families and 145 species. In addition to a key to the families, keys were constructed for selected species within some families. Species accounts include descriptions of adult ecology, reproductive biology, diagnostic characters and meristics. A description of the egg is given, as are morphometric, morphological and pigmentation characteristics of yolk-sac larvae, larvae and juveniles. Illustrations of yolk-sac larvae, larvae-and juveniles have been included wherever possible and informative.

ABBREVIATIONS

C = centigrade
ca. = approximately
cm = centimeter
° = degree
FL = fork length
g = gram
> = greater than
kg = kilogram
km = kilometer
< = less than
m = meter
mm = millimeter
N = number
% = percent
s = second
SL = standard length
TL = total length
* = original data

ACKNOWLEDGEMENTS

This volume would never have been possible without the assistance and support of many kind people; most of all my husband, Marty. Special thanks goes to him for his guidance and love throughout the two year duration of this intense project despite moving 575 miles and having me commute the distance six times for its completion.

To four fine colleagues I wish to express my gratitude individually. Professionalism and experience provided by Lee A. Fuiman were the most significant contributions. His editorial and mechanical skills were of great value. Words of encouragement and forbearance from George R. Heufelder were appreciated when times got tough. George also assisted in producing many of the rough pencil sketches of larval sculpins, sticklebacks and minnows, as well as in helping others with literature reviews. Although burdened by illness, Heang T. Tin is greatly respected for doing an unbelievably thorough job. Lastly, but certainly not meant to be least in significance, I wish to express accolades to David J. Jude. He gave me the privilege and freedom which enabled me to direct the project. For these things and many more he shall always have my esteem.

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	A. Maiden	K. N. Mueller	L. G. Perry
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At the University of Michigan many people deserve recognition for their contributions. Dr. R. M. Bailey is appreciated for his loan of specimens, x-rays, access to Fish Division and Bailey Library materials and other assistance. The technical skills of Robert M. Berry, camera operator, Division of Research Development and Administration, were outstanding. Nelson W. Navarre is appreciated for his patience in handling the financial paperwork generated during the project. Within the Great Lakes Research Division Fishery Laboratory the help of many individuals working full and part time was invaluable. All the authors appreciate the assistance given by the following people:. Laura Black, Jeffrey Braunscheidel, Linda Cooley, Sheryl Corey, Pam Downie, Susan Harris, Philip Hirt, Janet Huhn, Gerard Lillie, Pamela Mansfield, Mary Jo Rathwell, Jodie Schlott and Mary Van der Weert. The eager support of secretaries Linda Gardner and Jan Farris was greatly valued as they typed many difficult species descriptions from scribbled copy.

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INTRODUCTION

The need for a publication to assist in the identification of larval fishes of the Great Lakes region has been documented. The workshop sponsored by the U. S. Fish and Wildlife Service, National Power Plant Team in Ann Arbor during 1976 was convened to organize such a compendium. The Great Lakes region is unique in that five large connected bodies of freshwater, very different in trophic status, contain different combinations of one general fish fauna. Although there are published works dealing with the identification of adult fishes in the Great Lakes region only two current publications deal with larval fish identification in the area (Drewry 1979, Lippson 1976). Both provide simplified identification of the families of Great Lakes fish larvae. Several other publications have dealt with specific regions or groups of fishes in the Great Lakes (Dorr et al. 1976, Fish 1932, Nelson and Cole 1975).

OBJECTIVES

The objective of this undertaking was to prepare a concise, descriptive manual for the separation and identification of larval fishes from Lake Michigan and its drainage. The manual is a step toward evaluation and advancement of "the state of the art" of larval fish taxonomy in the Great Lakes region. Obviously, consideration must always be given to the fact that larval fish meristics and size at a particular stage of development will vary from region to region and depend on temperatures during development. This manual must be used with those precautions in mind.

STUDY AREA

The Great Lakes comprise the largest freshwater system on earth and cover an extensive geographic area from 41° 30' N to 49° N and from 76° W to 92° w. This manual primarily deals with fishes from Lake Michigan and its drainage basin; however species from other Great Lakes proper are included. Figure 1 illustrates the entire Great Lakes basin. Species of fish known only from the drainage areas of Lakes Superior, Huron, Erie and Ontario were not described. Figure 2 illustrates Lake Michigan and its drainage.

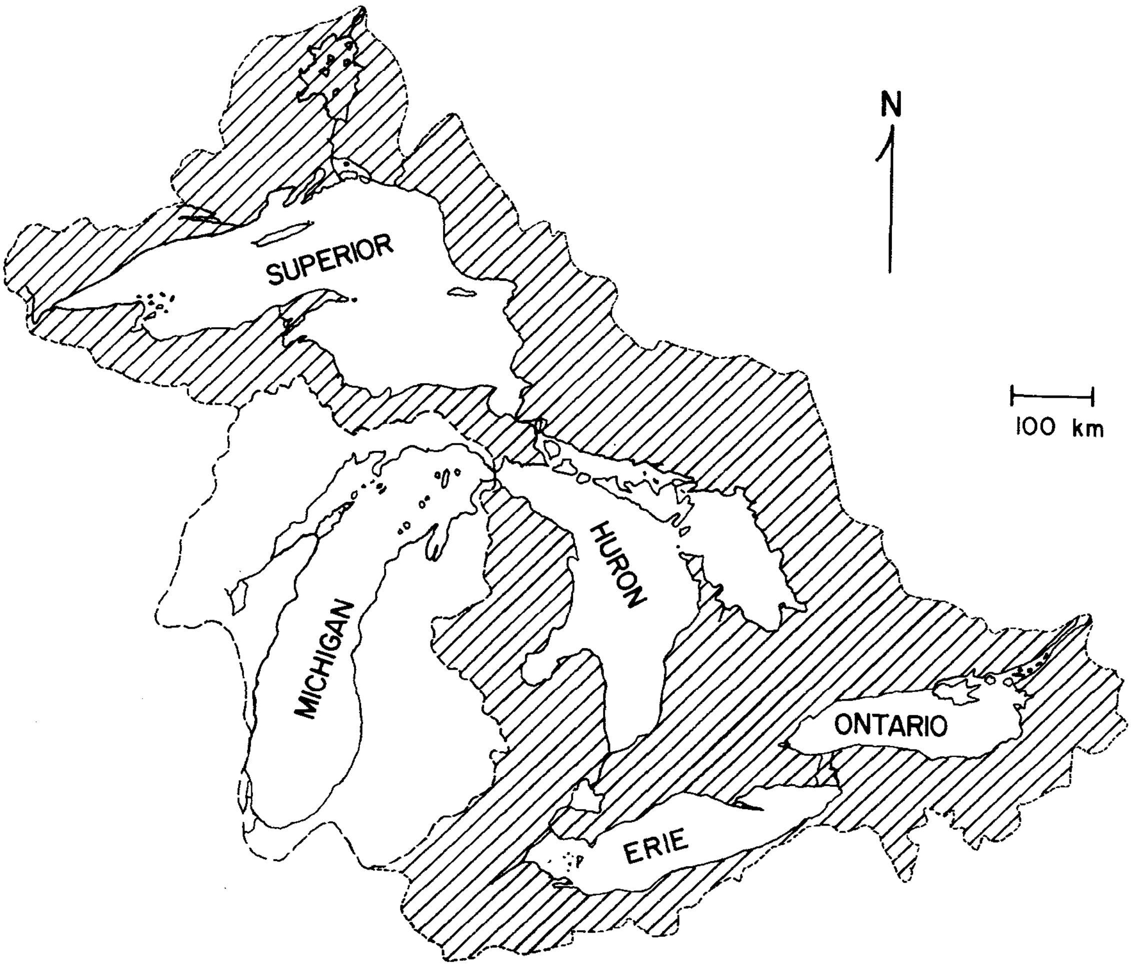

Fig. 1. Map of the Great Lakes basin. Larval fishes known to occur only in the drainages of Lakes Superior, Huron, Erie and Ontario (shaded areas) were not included in this undertaking.

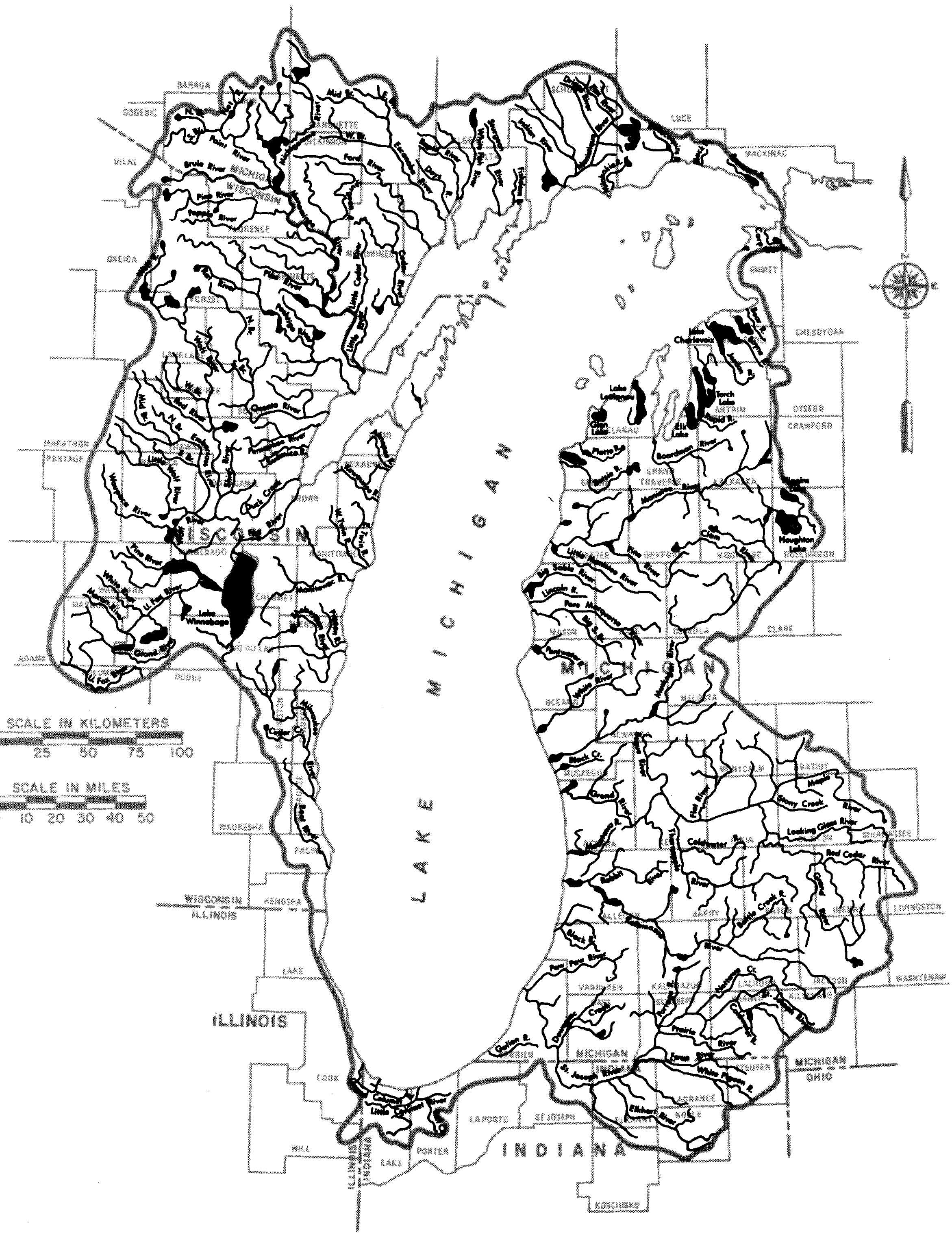

Fig. 2. Map of the Lake Michigan drainage (from Becker 1976).

Between 164 (Lee et al. 1986) and 173 (Hubbs and Lagler 1958) species of fish have been reported from the Great Lakes region. Some of the physical features of this vast and diverse area are summarized in Table 1. Within each lake there are extremes in habitat which encourage species diversity, yet since the lakes interconnect, there is a group of fishes unique to the Great Lakes basin (Emery 1976).

Table 1. Physical features of the Great Lakes (Schelske and Roth 1973).

Features	Lake					
	Superior	Michigan	Huron	St. Clair	Erie	Ontario
Surface Area (km^2)	82,367	58,016	59,570	1,268	25,666	19,684
Drainage Area (km^2)						
Land	124,838	117,845	128,464	17,948	58,793	70,448
Land and Water	207,200	175,860	188,034	19,217	87,434	90,132
Maximum Depth (m)	406	281	228	6	60	244
Average Depth (m)	148	84	53	3	17	86
Discharge (m^3/s)	2,067	1,556		5,041	5,551	6,627

Twenty-four families and 148 species of fishes are discussed. This manual covers all but three species, _Percina shumardi_, _Polyodon spathula_, and _Thymallus arcticus_, listed by Becker (1976) as occurring in the Lake Michigan drainage. Fifteen additional species which may occur in the remaining Great Lakes proper and not in the Lake Michigan drainage or which were not covered by Becker (1976) are:

Carpiodes carpio	_Lepomis humilis_	_Percina copelandi_
Esox niger	_Lepomis microlophus_	_Prosopium cylindraceum_
Etheostoma olmstedi	_Morone americana_	_Prosopium coulteri_
Gasterosteus aculeatus	_Noturus miurus_	_Salmo salar_
Hybopsis storeriana	_Oncorhynchus nerka_	_Semotilus corporalis_

Species which have been extirpated from the Great Lakes region, which occur only rarely or which are in the drainages of the Great Lakes other than Lake Michigan, have not been described here. These include:

Ammocrypta Clara	Notropis ariommus	Noturus stigmosus
Ammocrypta pellucida	Notropis bifrenatus	Percina evides
Etheostoma spectabile	Notropis boops	Percina shumardi
Exoglossum laurae	Notropis buchanani	Phenacobuis mirabilis
Exoglossum maxillingua	Notropis lutrensis	Polydon spathula
Gambusia affinis	Notropis photogenis	Thymallus arcticus
Hybopsis x-punctata	Notropis procne	
Ictalurus catus	Noturus furiosus	
Notropis analostanus	Noturus insignis	

Table 2. Endangered and Threatened Species in the Lake Michigan Drainage.

State	Status: Endangered	Status: Threatened
Michigan	Coregonus alpenae Coregonus johannae Coregonus nigripinnis Coregonus reighardi Coregonus zenithicus Noturus stigmosus Stizostedion vitreum glaucum	Acipenser fulvescens Ammocrypta pellucida Clinostomus elongatus Coregonus artedii Coregonus hoyi Coregonus kiyi Erimyzon oblongus Hybopsis amblops Moxostoma carinatum Notropis photogenis Phoxinus erthrogaster
Wisconsin	Fundulus notti Hybopsis x-punctata Notropis chrysocephalus Percina evides	Ictiobus niger Lepomis megalotis Moxostoma carinatum Notropis anogenus
Illinois	Coregonus alpenae Hybopsis amblops	Acipenser fulvescens Catostomus catostomus Coregonus artedii Coregonus clupeaformis Notropis anogenus Notropis heterolepis
Indiana	Coregonus artedii	Ammocrypta pellucida Clinostomus elongatus Percina evides

IDENTIFICATION OF FISH LARVAE

FORMAT

The text contains two sections, the first is a provisional, dichotomous key for the identification of families. The family sections consist of species accounts arranged in alphabetical order and, where possible, a dichotomous key to species or genera within that family. Common and scientific names follow Robins et al. (1980). Each species account is divided into the following major divisions:

DISTRIBUTION - Occurrence of species in the Great Lakes region and within the Lake Michigan drainage.

SPAWNING SEASON - Months during which spawning has been documented for the Great Lakes region, unless otherwise stated.

SPAWNING TEMPERATURE - Water temperatures at which spawning has been documented.

SPAWNING HABITAT - Description of the environment in which spawning has been documented.

SPAWNING SUBSTRATE - Type of material upon which spawning is known to occur.

FECUNDITY - Average number or range of ovarian eggs per female, unless otherwise noted.

NATURAL HYBRIDS - Other species in the study area with which interbreeding has occurred naturally.

EGGS - Description of fertilized, water hardened eggs, unless otherwise noted; diameter, color, adhesive properties, buoyancy, yolk and oil globule characteristics and incubation period.

Descriptions of development are within the following three divisions, then subdivided by length intervals. Length is expressed as total length unless otherwise stated. Each length interval contains four sections, whenever such data were available: Myomeres, Morphometry, Morphology and Pigmentation. Myomeres are usually expressed as a total range followed, in parentheses, by the ranges of preanal plus postanal myomeres, e. g. 34 to 36 (22 to 24 + 12 to 16) . Values used in the morphometry section are taken directly from the literature or from unpublished data. Values derived from illustrations are documented as such.

YOLK-SAC LARVAE - Phase of development from the moment of hatching to complete absorption of yolk.

LARVAE - Phase of development from complete absorption of yolk to development of the full complement of adult fin rays and absorption of finfold.

JUVENILES - Phase of development from complete fin ray development and finfold absorption to sexual maturity.

ADULTS - Brief description of meristics including enumeration of fin rays, vertebrae and lateral line scales. Occasionally the number of pyloric caeca, gill rakers and Pharyngeal teeth is given. Methods by which anatomical features were counted, measured and reported conform to those used by Hubbs and Lagler (1958). Diagnostic characters are included which enable separation of species within each family and are of use for identifying larger larvae.

LITERATURE CITED - Brief citations of sources of information are noted by superscript numerals. Complete citations can be found in the LITERATURE CITED section at the end of the text.

ILLUSTRATIONS

Whenever available, illustrations have been included with each species account. In most cases illustrations have been limited to those of yolk-sac larvae and larvae. Illustrations of juveniles were added where available or deemed important in identification. In many cases dorsal, lateral and ventral views are shown. Lengths given with each illustration represent total length.

Several of the illustrations used in this publication are original. These were drawn from both wild-caught and laboratory-reared specimens. Some were drawn from projected photographs while others were drawn using a Bausch and Lomb microprojector, model 42-63-59.

ANATOMICAL FEATURES AND TERMS

Some of the terminology used throughout the text is illustrated in Figure 3 and defined below. Original data (*) were obtained according to these definitions. No "correction" of published information to conform to this system was made, nor were the measuring and counting techniques used by others documented. However, myomere counts reported in Fish (1932) were omitted (see Preface) .

<u>Definition</u> of terms

Actinotrichia - horny fin supports which are the precursors of fin rays or spines (lepidotrichia).

Adhesive - referring to eggs, those which stick to each other or to a substrate after water hardening, unless otherwise noted.

Adnate - joined to; grown together.

Anlage - rudimentary form of an anatomical structure.

Antero-hyal - anterior bone to which branchiostegal rays attach: formerly ceratohyal.

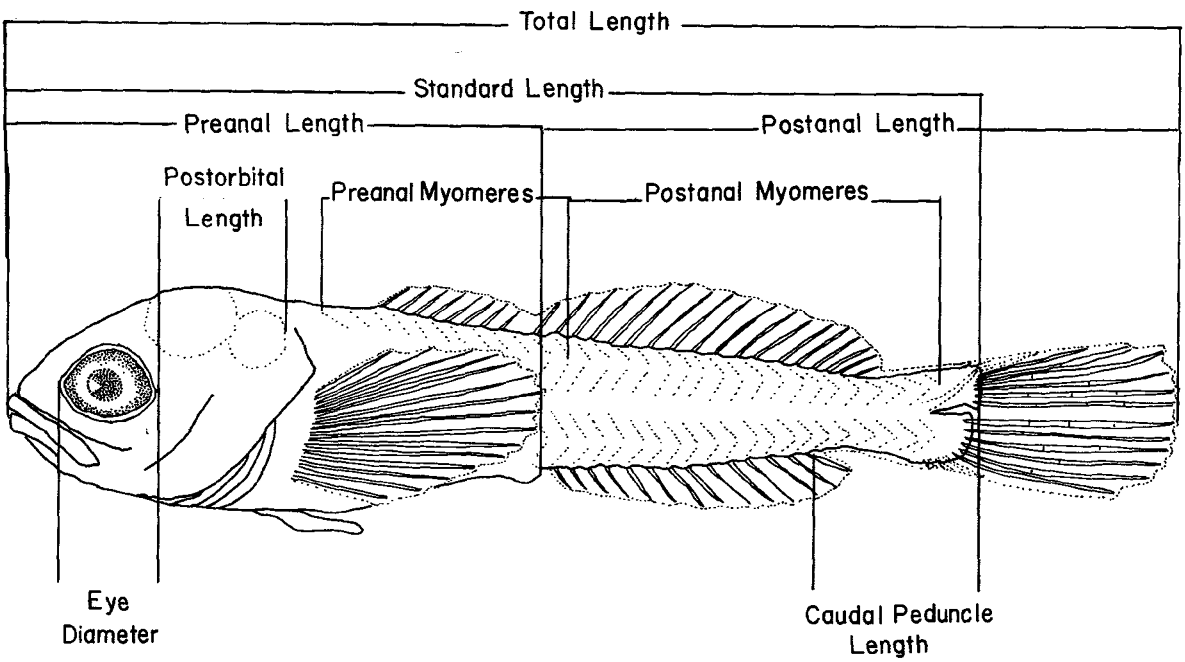

Fig. 3. Diagrammatic representation of morphology of a teleost larva.

Basibranchials - three median bones on the floor of the gill chamber, joined to the ventral ends of the five gill arches.

Basin - a large complex of rivers or lakes with a single outlet to the ocean (e.g., Great Lakes).

Bicuspid - having or ending in two points; a tooth with two points.

Body depth at anus - vertical distance of body at anus.

Branchial region - in petromyzontids, area between the anterior margin of the first gill opening and the posterior margin of the last.

Branchiostegal rays - bony rays supporting the membranes which close the gill (branchial) cavity under the head.

Cardiform - brush-like; referring to teeth of uniform length in patches or bands.

Cement glands - discrete or diffuse structures which permit a larva to adhere to a substrate.

Cephalic - belonging to the head.

Chevron-shaped - the earliest developmental form of myomeres in larvae; describing the angle formed by the epaxial and hypaxial portions of the myosepta.

Choroid fissure - a cleft in outer layers of the eye visible in early larvae.

Chorion - after water hardening, the outermost membrane of a fish egg.

Chromatophore - pigment-bearing cell.

Cleithrum - large bone of support for the pectoral fins.

Coelomic - belonging to the body cavity.

Confluent - coming together to form one.

Ctenoid - scales having small, needle-like projections on the posterior margin.

Deciduous - referring to scales that are easily rubbed off and thus not firmly attached.

Demersal - referring to an egg which rests upon the substrate as a result of deposition or settling.

Dentary - major bony element of the lower jaw, usually bearing teeth.

Drainage - a group of lakes or streams within a basin (e.g., Lake Michigan).

Emarginate - caudal fin possessing a slight notch or indentation.

Emergence - the act of leaving the substrate and beginning to swim; swim-up.

Epaxial - the portion of the body above the horizontal myoseptum.

Epurals - modified vertebral elements which lay above the vertebrae and support part of the caudal fin.

Eye diameter - horizontal distance of the iris of the eye.

Falcate - scythe-shaped; referring to an anal fin.

Fontinelle - a gap or space between bones in the roof of the skull covered only by a membrane.

Foramen - an opening through a bone.

Fork length (FL) - distance from the most anterior point on the snout to the end of the shortest central caudal fin ray.

Frenum - a fold of skin that limits movement of the upper jaw.

Gape - the border of the mouth.

Glossohyal - a median bone of the tongue.

Gular plate - median ventral bony plate or plates located behind the chin and between the sides of the lower jaw.

Greatest body depth - greatest vertical distance of body excluding fins and/or finfolds.

Head length - distance from the most anterior point on the snout to the posterior edge of the auditory vesicle, cleithrum or opercle as each develop.

Head width - greatest dimension between opercles.

Horizontal myoseptum - division between epaxial and hypaxial regions composed of connective tissue.

Hypaxial - the portion of the body below the horizontal myoseptum.

Hypochordal - below the notochord; referring to the lower lobe of the caudal fin.

Hypurals - the expanded hemal spines of the posterior vertebrae which support most of the caudal fin.

incipient - beginning to be apparent.

Inferior mouth - snout projecting beyond the lower jaw.

Internarial - area between the nares on one side of the head or the other.

Interorbital width - least distance between the orbits across dorsum of head.

Interradial - area between the fin rays.

Interspaces - spaces between parr marks in salmonids.

Isocercal - vertebral column ending along the median line, caudal fin rays arising symmetrically from it.

Isthmus - fleshy space beneath the head and between the gill openings.

Lanceolate - slightly broad at the base and tapering to a point.

Lateral teeth - in petromyzontids, teeth of oral disc lateral to esophageal opening.

Lepidotrichia - replacements of actinotrichia; soft fin rays or spines.

Maxilla - the posterior, lateral bones of the upper jaw.

Micropyle - principle path of sperm entry through the chorion (vitelline membrane) of an egg.

Melanophore - melanin-bearing pigment cell.

Mesencephalon - midbrain; serves optic functions.

Mesopterygoid - middle of three dermal bones of the upper jaw.

Metencephalon - portion of the brain immediately behind the mesencephalon.

Molariform - referring to a tooth with a flat grinding surface.

Myoseptum - thin partition of connective tissue which joins myomeres.

Nares - nostrils, openings leading to the olfactory organs.

Narial - pertaining to the nares.

Obtuse - with a blunt or rounded end; an angle greater than 90 degrees.

Palatines - paired bones on the roof of the mouth, often bearing teeth.

Paravertebral - along the same plane as the spinal column.

Parietal - paired bones of the roof of the skull.

Pectoral fin length - distance from base to farthest tip of fin.

Peduncle - fleshy end of the body between the anal and caudal fins.

Pelagic - living in the open water habitat, as opposed to bottom living or inshore inhabitants.

Pericardium - cavity in which the heart lies.

Peritoneum - membranous lining of the abdominal cavity.

Perivitelline space - fluid-filled space between the chorion and yolk material.

Pharyngeal teeth - bony tooth-like projections derived from the fifth (Pharyngeal) gill arch.

Physostomous - having the swim bladder connected to the esophagus by the pneumatic duct.

Plicae - wrinkle-like folds found on the lips of some catostomids.

Postanal length - distance from the most posterior point of the anus to the most posterior point on the caudal fin or median finfold.

Postanal myomeres - number of whole myomeres posterior to an imaginary vertical line at the most posterior point of the anus, including one urostylar element.

Postero-hyal - posterior bone to which branchiostegal rays attach, formerly epihyal.

Postorbital length - distance from posterior margin of eye to posterior edge of opercular membrane.

Preanal length - distance from the most anterior point on the snout to the most posterior point of the anus.

Preanal myomeres - number of myomeres from the nape to, and including any myomeres bisected by, an imaginary vertical line at the most posterior point of the anus.

Prebranchial length - in petromyzontids, distance between the tip of the snout and the anterior margin of the first gill opening.

Predorsal length - distance from the most anterior point on the snout to the anterior margin of the base of the first dorsal fin ray when formed.

Predorsal myomeres - number of myomeres from nape to dorsal origin of median finfold.

Premaxilla - primary bone of the upper jaw in most fish, usually bearing teeth.

Preorbital - large bone anterior to the eye.

Protractile - describing premaxillae which can be extended.

Pterygoid - dermal bone of the upper jaw.

Pterygiophore - bone of the internal skeleton supporting the dorsal and anal fins.

River system - a group of streams or lakes which lead into a drainage (e.g., Fox River system).

Saddle markings - pigment patterns which cover the dorsal and lateral aspects and give an overall appearance of a saddle.

Semibuoyant - referring to eggs which do not float nor sink, but remain suspended in the water column.

Spatulate - having a rounded apex and tapering to a base; spoon-shaped.

Squamation - covering of scales.

Standard length (SL) - distance from the most anterior point on the snout to the most posterior point of the notochord or hypural complex.

Stellate - referring to a melanophore which is expanded into a star-like shape.

Stomodeum - primordial mouth; the anterior pitted portion of the embryonic gut.

Submandibular - beneath the lower jaw; along the edge of the lower jaw.

Superior mouth - condition when the lower jaw extends upward and the mouth opens dorsally.

Supramaxilla - small dermal bone attached posterior and dorsal to the maxilla.

Supraoral - above the mouth; referring to the teeth of the oral disc in lampreys which are anterior to the mouth opening.

Supraoral tooth plate - in petromyzontids, tooth plate immediately anterior to esophageal opening.

Tail length - in petromyzontids, distance from cloaca1 slit to tip of caudal fin.

Tesselated - markings or colors arranged into squares.

Terminal mouth - condition when lower and upper jaws are equal in length and the mouth opens terminally.

Total length (TL) - distance from the most anterior point on the snout to the most posterior point on the caudal fin or finfold.

Truncate - ending abruptly along a vertical line.

Trunk length - in petromyzontids, distance between posterior margin of last gill opening and cloaca1 slit.

Trunk myomeres - in petromyzontids, myomeres between the most posterior gill opening and the cloaca1 slit.

Urostyle - final vertebral segment usually modified for caudal fin support.

Vermiculate - having worm-like markings.

Villiform - in the form of finger-like projections.

Vitelline membrane - after water hardening, the membrane surrounding the egg proper (animal and vegetal material).

Vomer - anterior, median bone of the roof of the mouth (=prevomer).

Water hardening - process of membrane delamination and fluid formation which forms the perivitelline space bordered by the chorion and vitelline membrane.

Weberian vertebrae - first four vertebrae in cyprinids, catostomids, and ictalurids which are modified to connect the swim bladder to the inner ear.

Xanthophores - chromatophores bearing yellow pigment.

Yolk-sac length - horizontal distance from most anterior to most posterior portion of yolk-sac.

Yolk-sac depth - vertical distance from dorsum to venter of yolk sac.

PROVISIONAL KEY TO THE FAMILIES OF GREAT LAKES LARVAL FISHES

Before using these keys is advised to first examine the specimen in question and record the following characteristics: TL, SL, preanal length, head length, snout length, preanal myomeres, postanal myomeres and total myomeres. Measurements should be made in millimeters to the nearest 0.1 mm.

YOLK-SAC LARVAE
(Excluding Anguillidae, Umbridae)

1a. Body elongate, eel-shaped; several gill openings on each side . . . . Petromyzontidae

b. Body not eel-shaped; single gill opening on each side. 2

2a. Chin barbels present. . . . . Ictaluridae

b. Chin barbels absent. 3

3a. Adhesive disc present on snout 4

b. Adhesive disc absent 5

4a. Adhesive disc with papillae; recently hatched larvae 8 to 15 mm TL. . . . . Lepisosteidae

b. Adhesive disc smooth with sausage-shaped enlargement; recently hatched larvae 5 to 8 mm TL . . . . Amiidae

5a. Preanal length less than 30% TL; preanal myomeres less than 10 . . . . Atherinidae

b. Preanal length greater than or equal to 30% TL; preanal myomeres greater than or equal to 10. 6

6a. Preanal myomeres greater than or equal to postanal myomeres 7

b. Preanal myomeres significantly less than postanal myomeres (difference greater than five myomeres) 8

7a. Preanal myomeres approximately equal to postanal myomeres (difference of five myomeres or less). 12

b. Preanal myomeres significantly greater than postanal myomeres (difference greater than five myomeres) 21

8a. Postanal myomeres greater than 30 . . . . Gadidae

b. Postanal myomeres less than or equal to 30 9

9a. Numerous oil globules; mouth superior; eye large, diameter usually greater than 8% TL. . . . . Cyprinodontidae

b. Single or no oil globule; mouth terminal or inferior; eye smaller, diameter usually less than or equal to 8% TL. 10

10a. Gut terminates immediately posterior to yolk sac; pectoral buds large; mouth terminal; swim bladder absent; pigment usually restricted to dorsum of head and dorso-lateral aspect of yolk sac. . . . . .Cottidae

b. Gut does not terminate immediately posterior to yolk sac; pectora buds small; mouth terminal or inferior; swim bladder usually present; pigment not restricted to dorso-lateral aspect of yolk-sac. 1

11a. Mouth inferior; pigment concentrated on venter of yolk sac and from anus to caudal fin; preanal myomeres usually 14; greatest body depth usually 16 to 18% TL. Percopsidae

b. Mouth terminal ; pigment variable: preanal myomeres usually 8 to 14; greatest body depth usually greater than 20% TL . . . . Centrarchidae

12a. Total myomeres greater than 50; preanal length greater than 60% TL; preanal myomeres greater than or equal to 30. . . . . . . Hiodontidae

b. Total myomeres less than 50; preanal length less than 60% TL; preanal myomeres less than 30. 13

13a. Postanal myomeres usually less than or equal to 12. 14

b. Postanal myomeres usually greater than or equal to 12 16

14a. Numerous oil globules; yolk sac small: pectoral buds large; yolk-sac larvae large (5 to 9 mm TL); greatest body depth usually 16 to 17% TL; eye large, diameter 9 to 12% TL. . . . . Gasterosteidae

b. Single oil globule; yolk sac large: pectoral buds small: yolk-sac larvae small (1 to 5 mm TL); greatest body depth usually greater than 15 to 28% TL; eye small, diameter 6 to 9% TL 15

15a. Preanal myomeres usually greater than postanal myomeres. . Sciaenidae

b. Preanal myomeres equal to postanal myomeres (difference of one myomere) . . . . Percichthyidae

16a. Total myomeres less than 30. 17

b. Total myomeres greater than or equal to 30 18

17a. Postanal myomeres usually less than 15; oil globule anterior in yolk sac. . . . . , , ... , Aphredoderidae

b. Postanal myomeres usually greater than or equal to 15; oil globule posterior in yolk sac. . . . , . , ...Centrarchidae

18a. Total myomeres less than 35; preanal myomeres less than or equal to 14 19

b. Total myomeres greater than or equal to 35; preanal myomeres greater than 14. . . . . , . , ... 20

19a. Preanal myomeres usually 14; oil globule anterior in yolk sac; mouth developed; greatest body depth 16 to 18% TL. . . . . . . .Percopsidae

b. Preanal myomeres usually less than 14; oil globule posterior in yolk sac; mouth not well developed; greatest body depth usually greater than 20% TL. . . . . , ...Centrarchidae

20a. Oil globule absent; yolk sac bulbous; anus immediately posterior of yolk sac . . . . Cyprinidae

b. Anterior oil globule; yolk sac round; anus located far posterior to yolk sac. . . . . .Percidae

21a. Total myomeres usually greater than 48 22

b. Total myomeres usually less than or equal to 48 26

22a. Preanal myomeres less than or equal to 39. 23

b. Preanal myomeres greater than 39, (except Esox niger). 24

23a. Total length usually 7 to 9 mm; yolk sac large, yolk-sac length 30 to 33% TL; venter of yolk sac pigmented, little dorsal pigment. . . . . Hiodontidae

Total length usually 8 to 30 mm; yolk sac large or small, if large usually greater than 40% TL; if yolk sac large no pigment on venter, pigment most common on dorsum of larvae. . . . . Salmonidae

24a. Postanal myomeres 13 to 17; larvae long and narrow; yolk sac small, round and far forward; total length usually 4 to 6 mm. . . .Osmeridae

b. Postanal myomeres greater than or equal to 17; larvae long but robust; yolk sac elongate, extending to anus; total length greater than 6 mm. 25

25a. Preanal myomeres 40 to 43; postanal myomeres 17 to 22; spiral valve evident; larvae unpigmented; eye undeveloped and unpigmented, diameter less than 5% TL . . . . .Acipenseridae

b. Preanal myomeres 41 to 48; postanal myomeres 18 to 24; spiral valve absent; dark lateral stripe evident; dorsum pigmented; eye developed and dark, diameter greater than or equal to 5% TL. . . . . . Esocidae

26a. Postanal myomeres greater than 10 (Minytrema melanops may key here also). . . . . Cyprinidae

b. Postanal myomeres less than or equal to 10 27

27a. Preanal myomeres 25 to 39; yolk sac elongate extending to anus, sometimes bulbous; oil globlue absent; total length usually greater than 5 mm . . . . .Catostomidae

b. Preanal myomeres 37 to 41; yolk sac small and round; single or multiple oil globules present; total length usually 2 to 6 mm . . . .* . . . . Clupeidae

LARVAE

(Excluding Umbridae and Ictaluridae, which do not have a larval period as defined in this manual)

1a. Body elongate, eel-shaped, round in transverse section; uniformly pigmented. 2

b. Body not as above. 3

2a. Mouth in a sucking disc; eye small; several pairs of gill openings . . . . Petromyzontidae

b. Mouth with jaws; eye large; single pair of gill openings. . . . . Anguillidae

3a. Chin barbel(s) present. 4

b. Chin barbel(s) absent. , ...5

4a. Mouth terminal; single barbel on lower jaw; usually 10 to 20 mm TL; pigment restricted to dorsum of stomach and head; no dark lateral band . . . . .Gadidae

b. Mouth inferior; several barbels anterior -to upper jaw; usually greater than 20 mm TL; dark lateral band evident. . . . Acipenseridae

5a. Snout produced; dorsal and anal fins set far back on body. 6

b. Snout short, its length usually less than 10% TL; median fins otherwise. 7

6a. Snout produced but narrow; numerous teeth visible on jaws; snout length usually 18 to 21% TL. . . . . .Lepisosteidae

b. Snout produced but thick (resembles duck bill); teeth not readily apparent; snout length usually 6 to 15% TL. . . . . .Esocidae

7a. Median fins or finfolds continuous, or nearly so. 8

b. Median fins or finfolds showing distinct separation. 10

8a. Pectoral fins poorly developed, may be buds; single barbel on lower jaw; notochord straight; caudal fin rays developed on dorsal and ventral aspects. . . . . .Gadidae

b. Pectoral fins large and usually well developed; lower jaw without barbel ; urostyle upturned or notochord straight, if straight caudal fin rays developed on ventral half only. 9

9a. Larva entirely dark with pigment; head large; gular plate developing; notochord straight, caudal fin rays develop on ventral half only; mouth terminal; opercle without spine(s). . . . . .Amiidae

b. Larva sparsely pigmented; of ten exhibiting “saddle markings” on dorsum; opercle of ten with spine(s) ; notochord flexed; mouth subterminal . . . . .Cottidae

10a. Adipose fin, or its position, evident 11

b. No adipose fin, or demarcation of one, in finfold. 14

11a. Total myomeres 32 to 34. . . . . .Percopsidae

b. Total myomeres greater than 40 OR larva too opaque to count myomeres. 12

12a. Larva robust; small melanophores over body; myomeres not enumerable . . . . Salmonidae (Salmoninae)

b. Larva elongate; melanophores large or restricted in distribution; myomeres enumerable. 13

13a. Pigment restricted to venter; swim bladder evident; myomeres easy to enumerate; eye small 3 to 4% TL; preanal length greater than 70% TL . . . . Osmeridae

b. Large melanophores on dorsal and lateral aspects; swim bladder not evident: myomeres difficult to distinguish; eye large, greater than 5% TL; preanal length less than or equal to 70% TL. . . . . .Salmonidae (Coregoninae)

14a. Preanal myomeres greater than or equal to postanal myomeres. . . . 15

b. Preanal myomeres significantly less than postanal myomeres (difference greater than five myomeres) . . . . . . , ...16

15a. Preanal myomeres approximately equal to postanal myomeres (difference five myomeres or less) 20

b. Preanal myomeres significantly greater than postanal myomeres (difference greater than five myomeres). 26

16a. Postanal myomeres greater than 35; total myomeres greater than 50; single chin barbel in specimens greater than 12 mm TL . . . . Gadidae

b. Postanal myomeres less than 35; total myomeres less than 50; chin barbel absent. 17

17a. Postanal myomeres greater than or equal to 25; preanal length less than or equal to 40% TL. . . . . .Atherinidae

b. Postanal myomeres less than 25; preanal length usually greater than 40% TL . . . . , . . . 18

18a. Mouth superior; single dorsal fin. . . . . .Cyprinodontidae

b. Mouth terminal or inferior; usually two dorsal fins. 19

19a. Pectoral fins well developed; head depressed; swim bladder not visible. . . . . Cottidae

b. Pectoral fins poorly developed; head and body compressed; swim bladder visible. . . . . , ...Centrarchidae

20a. Total myomeres greater than or equal to 35. . . . . .Percidae

b. Total myomeres less than 35. 21

21a. Total myomeres less than 26. 22

b. Total myomeres between 26 and 34. 23

22a. Preanal myomeres greater than postanal myomeres; head large and blunt; mouth very large; maxilla extending to or beyond posterior margin of eye; caudal fin lancealate at 12 mm TL. . . . . .Sciaenidae

b. Preanal myomeres usually equal to postanal myomeres (or difference of one) ; head smaller, pointed; mouth smaller, maxilla extending to middle of eye; caudal fin forked at 12 mm TL. . . . . .Percichthyidae

23a. Adipose fin or its position present. . . . . .Percopsidae

b. Adipose fin or its position absent. 24

24a. Double dorsal fin . . . . .Centrarchidae

b. Single dorsal fin 25

25a. Caudal peduncle thick; total myomeres less than or equal to 31. . . . . .Aphredoderidae

b. Caudal peduncle narrow; total myomeres greater than or equal to 31 . . . . .Gasterosteidae

26a. Postanal myomeres usually less than or equal to 10 27

b. Postanal myomeres greater than 10 28

27a. Preanal length 77 to 89% TL; ratio of preanal t0 postanal myomeres greater than 5.0. . . . . Clupeidae

b. Preanal length 59 to 73% TL; ratio of preanal to postanal myomeres less than or equal to 5.0 . . . . .Catostomidae

28a. Preanal myomeres usually less than 30. . . . . Cyprinidae

b. Preanal myomeres usually greater than 30 29

29a. Preanal myomeres usually greater than 40 30

b. Preanal myomeres usually less than 40. 31

30a. Postanal myomeres 14 to 15; preanal length 72 to 75% TL; adipose fin present; swim bladder present. . . . . .Osmeridae

b. Postanal myomeres 15 to 22; preanal length 67 to 72% TL; adipose fin absent; swim bladder not visible. . . . . .Esocidae-

31a. Preanal length greater than 67% TL; snout elongate. . . . . .Esocidae

b. Preanal length less than or equal to 67% TL; snout short and blunt. 32

32a. Adipose fin present; anal fin rays less than 20; body usually heavily pigmented. . . . . Salmonidae

b. Adipose fin absent; anal fin rays greater than 20; body relatively unpigmented. . . . . .Hiodontidae

SPECIES ACCOUNTS

Family Petromyzontidae, lampreys

By

Lee A. Fuiman

This family contains about 30 species in 8 genera. They occur in temperate marine and freshwater systems of the northern and southern hemispheres. There are five species in three genera in the Great Lakes region. Lampreys are eel-like fishes which lack jaws but have an oral sucking disc armed with horny teeth. They also lack paired fins. The skeleton is cartilaginous. There is a single, median nostril and seven pairs of gill openings.

Adult Great Lakes lampreys primarily inhabit streams, although the non-endemic sea lamprey, *Petromyzon marinus*, is typically found in the lakes proper. They all spawn in the spring and summer in shallow streams. Larvae, called ammocoetes, lack the toothed sucking disc of adults. Their eyes are covered with skin. Ammocoetes burrow in sand, mud or organic debris where they live for several years before transforming into juveniles. Young ammocoetes of all species tend to be less pigmented than older ammocoetes (V. D. Vladykov, personal communication).

The sea lamprey is widespread in the Great Lakes, though not native. It has been the subject of great concern to commercial and sport fisheries of the region because of its parasitism of valued fishes. *Ichthyomyzon castaneus* and I. *unicuspis* are parasitic species smaller than the sea lamprey, and giant specimens of *Lampetra appendix* are thought to be parasitic (Manion and Purvis 1971). Only six specimens of giant L. *appendix* have been collected over the past 20 years. Vladykov and Kott (1980) present several hypotheses which attempt to explain the existence of these peculiar forms. Adults of the generally non-parasitic species (I. *fossor* and L. *appendix*) live for only a few months (through winter), spawn, then die (Vladykov 1949).

Provisional Keys to Great Lakes Petromyzontid Larvae

Larvae 20 to 40 mm TL (by R. H. Morman) :

la. Pigmentation in tail confined to notochord; chromatophores usually absent from dorsal and caudal finfolds; myomeres relatively prominent in tail. . . . . _Ichthyomyzon_ spp.

b. Pigmentation in tail not confined to notochord; chromatophores present in dorsal and caudal finfolds; myomeres not prominent in tail. . . . 2

2a. Head and trunk sparsely pigmented; chromatophores in tail concentrated unevenly along outer margins of notochord (more widespread and extending closer to tip of notochord on lower side), but not extending to tip of notochord; pigmentation in branchial area not descending into upper margins of gill openings. . . . . _Lampetra appendix_

b. Head and trunk uniformly well pigmented; chromatophores in tail evenly widespread, symmetrically distributed in relation to notochord, extending nearly to tip of notochord; pigmentation in branchial area descending into upper margins of gill openings. . . _Petromyzon marinus_

Larvae greater than 60 mm TL (from Vladykov 1960 and Vladykov and Kott 1980) :

la. Dorsal fin continuous, no distinct notch to trunk present; trunk myomeres 47 to 58 . . . . _.Ichthyomyzon_ spp.

b. Dorsal fin distinctly notched to trunk, if a low membrane connects lobes it contains no fin rays; trunk myomeres 63 to 74. 4

2a. Lateral line organs darkly pigmented. . . . . . _Ichthyomyzon castaneus_

b. Lateral line organs unpigmented. 3

3a. Caudal fin and head usually darkly pigmented. . _Ichthyomyzon unicuspis_

b. Caudal fin and head usually lightly pigmented. . . _Ichthyomyzon fossor_

4a. Branchial region pigmented from dorsum ventrad, unpigmented band above branchial groove; central prong (bulb) of tongue precursor pigmented; caudal fin somewhat pointed, its upper profile elevated, its pigmentation triangular and nearly confined to the notochord; lower half of upper lip unpigmented; trunk myomeres 63 to 70 . . . . .Lampetra appendix

b. Branchial region pigmented from dorsum nearly to branchial groove, bulb of tongue precursor unpigmented; caudal fin rounded, not elevated above, pigmented from notochord to its margin; lower half of upper lip pigmented; trunk myomeres 67 to 74. . . . . Petromyzon marinus

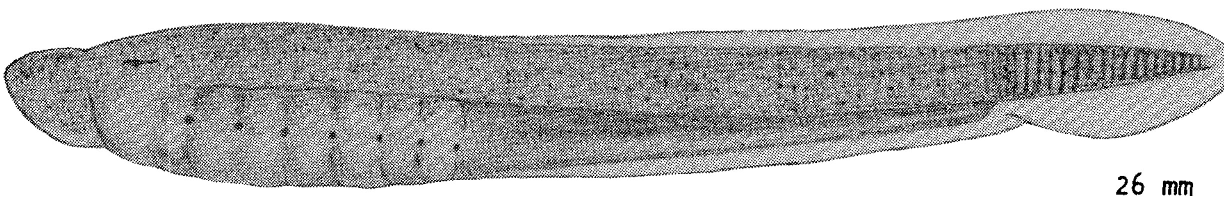

Fig. 4. Ichthyomyzon sp., lamprey. Ammocoetes (larva) . (Wild-caught, Michigan, original illustration by R. Fletcher, modified by R. H. Morman).

Ichthyomyzon castaneus Girard, chestnut lamprey

DISTRIBUTION

Found in many eastern tributaries of Lake Michigan[1 7] with only a few records from Wisconsin streams.' Once recorded from western Lake Huron drainage,' but recent collections failed to find specimens there.[7]

SPAWNING SEASON

Spawns from mid-April in central Wisconsin' to late June in Michigan.[5 7]

SPAWNING TEMPERATURE

Spawns at temperatures between 16 and 22 C.[7]

SPAWNING HABITAT

Spawns in small streams'[7] or rivers 6.5 to 43 m wide,' approximately 0.4 to 0.9 m deep[5 7 8] with a current velocity of about 1 m/s.[8]

SPAWNING SUBSTRATE

Deposits eggs in a gravel nest (0.6 m X 1 m X 5 cm) with long axis parallel to current.[8] Sometimes builds nests under logs.[5] Sometimes spawns in nests with Petromyzon marinus or P. marinus and Lampetra appendix.'

FECUNDITY

Not reported.

NATURAL HYBRIDS

Possibly Ichthyomyzon unicuspis.'[6]

EGGS

Demersal, nonadhesive (inferred from spawning mode);* elliptical, 0.64-and 0.56-mm axes (tentative identification);* incubation period: 9 days at 18 C.[2]

YOLK-SAC LARVAE

Not described.

LARVAE

Dorsal fin often slightly indented but never with a deep notch to the trunk (> 40 mm).[10]

JUVENILES (recently transformed individuals).

Total length	Description
90-165 mm	Transformation size.[3 4 7]
	Myomeres: trunk myomeres 49 to 56, usually 51 to 54, mean 52.6.[4]
	Morphometry: oral disc diameter 5 to 9% TL.[4]
	Morphology: dorsal fin often slightly indented.[10]

ADULTS

Diagnostic characters: dorsal fin single, without a notch (some individuals may have a slight indentation), one or more pairs of bicuspid inner lateral teeth, supraoral single and bicuspid, trunk myomeres 49 to 56.

LITERATURE CITED

1. Becker (1976)
2. Smith et al. (1968)
3. Scott and Crossman (1973)
4. Hubbs and Trautman (1937)
5. Hall (1963)
6. Starrett et al. (1960)
7. Morman (1979)
8. Case (1970)
9. Hubbs and Lagler (1958)
10. R. H. Morman (pers. Comm.)

Ichthyomyzon fossor Reighard and Cummins, northern brook lamprey

DISTRIBUTION

This species is found throughout most of the Great Lakes region,’ [10] but may be absent from the Lake Ontario drainage.[13] In the Lake Michigan drainage, it has been collected from many streams,[1 9] except in Illinois.[1]

SPAWNING SEASON

Spawning occurs from late May[2 8] to early July[9] in Michigan and April to May in Wisconsin.’

SPAWNING TEMPERATURE

This species apparently has a eurythermal spawning preference. Ranges of 13 to 16 C,[4] 13 to 23 C,[9] and not less than 18 C (optimally 20 to 22 C)[8] have been reported.

SPAWNING HABITAT

Spawns in riffles of streams,[1 2 8 9] 3.5 to 8 m wide,[9] 0.1 to 0.6 m deep, I [9] with a steep gradient,* [9] or sluggish flow.[9]

SPAWNING SUBSTRATE

Spawns among coarse gravel 3 to 15 cm in diameter.[1 1 4 8 9] Nests are ill-defined in gravel or are 8 to 10 cm in diameter in sand and small gravel .[8] May spawn in nests with I. *unicuspis* or *Petromyzon marinus*.[9]

FECUNDITY

780 to 1,979.[6 11]

EGGS

Demersal, adhesive (in a “glue-like mass");[6] diameter 1.0 to 1.2 mm;[5] incubation period: 9 days at 18 C;[3] 12 days in situ.’

YOLK-SAC LARVAE

Not described.

LARVAE

Total length	Description
94-161 mm	Myomeres: trunk myomeres 45 to 50;[12] or 47 to 56;[7] usually 48;[12] or 50 to 52.[7 8]

Morphometry: (as % TL) preanal length 69 to 74, predorsal length 47 to 54;[8] trunk length 50 to 54;[8,12] last gill opening to dorsal fin origin 29 to 34;[8] prebranchial length 6 to 9;[8,12] snout to last gill opening 18 to 21.[8]

JUVENILES (recently transformed individuals).

Transformation size 84 to 182 mm.[6 o 9]

ADULTS

Diagnostic characters: dorsal fin single, slightly bilobed (no notch to trunk present), all lateral teeth unicuspid, supraoral bicuspid teeth with knob-like cusps, trunk myomeres 47 to 56.

LITERATURE CITED

1. Becker (1976)
2. Hankinson (1932)
3. Smith et al. (1968)
4. Scott and Crossman (1973)
5. Vladykov (1949)
6. Leach (1940)
7. Hubbs and Trautman (1937)
8. Reighard and Cummins (1916)
9. Morman (1979)
10. Hubbs and Lagler (1958)
11. Vladykov (1951)
12. R. H. Morman (pers. Comm.)
13. Crossman and Van Meter (1979)

Ichthyomyzon unicuspis Hubbs and Trautman, silver lamprey

DISTRIBUTION

Known from the drainages of all Great Lakes.' [9] Scattered records exist for collections made in the western tributaries of Lake Michigan, primarily near Green Bay and the upper peninsula of Michigan.' Essentially absent from eastern tributaries of Lake Michigan (confined to a small section at the most eastern portion of the northern end of the lake),[a]

SPAWNING SEASON

Spawns during May and June in Michigan[6] and Quebec.[3]

SPAWNING TEMPERATURE

Spawns at temperatures between 13 and 23 C.[6]

SPAWNING HABITAT

Spawns in shallow, 45 to 50 cm, riffles of streams, 3.5 to 30 m wide, 2 to 13 m from shore.[6]

SPAWNING SUBSTRATE

Eggs are deposited in a nest, 33 to 122 cm in diameter,[8] composed of gravel 0.4 to 3 cm in diameter.[11] Sometimes occupies nests with I. fossor or Petromyzon marinus or Lampetra appendix and p. marinus.[6]

FECUNDITY

10,800' to 29,412.[10]

NATURAL HYBRIDS

Possibly Ichthyomyzon castaneus.[5] [6]

EGGS

Demersal (inferred from spawning mode);* diameter 1.4 mm;[4] incubation period: 11 days at 18 C.[2]

YOLK-SAC LARVAE

Not described.

LARVAE

Not described.

JUVENILES (recently transformed individuals).

Total length	Description
76-155 mm	Transformation size.[3 7 6]
	Myomeres: trunk myomeres 47 to 55, usually 48 to 53, mean: 50.5.[5]

ADULTS

Diagnostic characters: dorsal fin single, slightly bilobed (no notch to trunk present), all lateral teeth unicuspid, supraoral bicuspid teeth with sharp cusps, trunk myomeres 48 to 57.

LITERATURE CITED

1. Becker (1976)
2. Smith et al. (1968)
3. Scott and Crossman (1973)
4. Vladykov (1949)
5. Hubbs and Trautman (1937)
6. Starrett et al. (1960)
7. Hubbs (1925)
8. Morman (1979)
9. Hubbs and Lagler (1958)
10. Vladykov (1951)
11. Manion and Hanson (1980)

Lampetra appendix (DeKay) , American brook lamprey

This species has been known most recently as Lampetra lamottei or L. lamottenii. A manuscript by R. M. Bailey and F. C. Rohde recommends that I. appendix be adopted as the correct name for the American brook lamprey (Robins et al. 1980). V. D. Vladykov and associates recognize yet another name, Lethenteron lamottenii. In accord with our decision to follow the nomenclature of Robins et al. (1980), we accept the suggestion of Bailey and Rohde.

DISTRIBUTION

Occurs throughout the Great Lakes basin,' but is rare in eastern Lake Ontario.[20] It is rare in western tributaries of Lake Michigan but common in eastern tributaries.'[14]

SPAWNING SEASON

Spawns from April to late June in Michigan and Wisconsin.'[11 14]

SPAWNING TEMPERATURE

Spawns at temperatures between 7 and 12,[17] or 14 and 19 C,[1 2 4 7 8] with extremes of 7 and 21 C.[14]

SPAWNING HABITAT

Spawns in riffle areas of streams,[1 12] 1.5 to 18 m wide,[14] in 0.2 to 0.6 cm of water.6 [11 14]

SPAWNING SUBSTRATE

Deposits eggs in a sand or gravel depression nest 18 to 20 cm long[1] or 18 to 30 cm in diameter.[8 11] May spawn in nests with Petromyzon marinus or Ichthyomyzon castaneus and p. marinus or I. unicuspis and p . marinus.[14]

FECUNDITY

Ca. 860[8] to 3,648,' [4 17] or 2,698 to 5,185.[18]

EGGS

Demersal, adhesive;[6 12 17] diameter 1.2 to 1.6 mm, perivitelline space 0.2 to 0.6 mm wide, egg pale yellow to light green, incubation period: 20 to 22 days at 5 to 17 C;[17] 8 days at 18 C;[5] 18 days in situ.[12]

YOLK-SAC LARVAE

Hatching size 2.2 to 2.8 mm, eye spot visible, caudal region flexed ventrad;[17] yolk greenish at 8 to 10 mm;[12] younger larvae less pigmented than older ones.[15]

LARVAE

Total length	Description
19-60 mm	Myomeres: trunk myomeres 63 to 74.[13]
	Morphometry: (as % TL) trunk length 55, tail length 17, branchial region length 16, prebranchial length 12.[15]
	Morphology: dorsal fin with two distinct lobes (separated by a notch to the trunk), first caudal and posterior dorsal fin rays formed (40 mm), first anterior dorsal fin rays formed (50 to 55 mm) , al 1 fins rayed (60 mm).[13]
	Pigmentation: pigment-free area on dorsum behind nostril, dark cephalic pigment line present, few irregularly placed chromatophores on dorsum of myosepta, prebranchial area unpigmented, unpigmented bands also above gill openings and on lower edge of peduncle (19 to 60 mm) , tongue pigmented (> 41 mm) .[13]
60-110 mm	Myomeres: trunk myomeres 63 to 74, usually 68 to 69.[9, 16, 17]
	Morphometry: (as % TL) trunk length 54, tail length 24, branchial region length 13, prebranchial length 9.[15]
	Morphology: caudal fin bluntly pointed, its upper outline elevated.)
	Pigmentation: pigment lacking on prebranchial area, present in bands over gill openings and on ventral edge of caudal peduncle, triangular pigmentation on base of caudal fin rays, pigmentation along notochord; ventral edge of caudal peduncle, suborbital area and lower half of upper lip unpigmented (60 to 70 mm).[9]

JUVENILES (recently transformed individuals).

Total length	Description
102-187 mm	Transformation size;[7, 19] perhaps as large as 200 mm.[12] May decrease in size after transformation.[12]
	Myomeres: trunk myomeres 64 to 74.[6, 10, 16, 17, 18]
	Morphometry: (as % TL) trunk length 54, tail length 24 to 32, branchial region length 9 to 12;[16, 17] prebranchial length 8.[15]

ADULTS

Diagnostic characters: dorsal fin double or deeply notched, inner lateral teeth bicuspid, supraoral teeth on broad curved bar with two lateral cusps, trunk myomeres 64 to 70 or more.

LITERATURE CITED

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3. Vladykov (1951)
4. Gage (1928)
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7. Vladykov (1949)
8. Dean and Sumner (1997)

9. Vladykov (1950)
10. Manion and Purvis (1971)
11. Young and Cole (1900)
12. Gage (1993)
13. Vladykov (1960)
14. Morman (1979)
15. V. D. Vladykov (pers. Comm.)
16. Kott (1974)
17. Rhode et al. (1976)
18. Kott (1971)
19. Vladykov and Kott (1980)
20. P. Rugen (pers. Comm.)

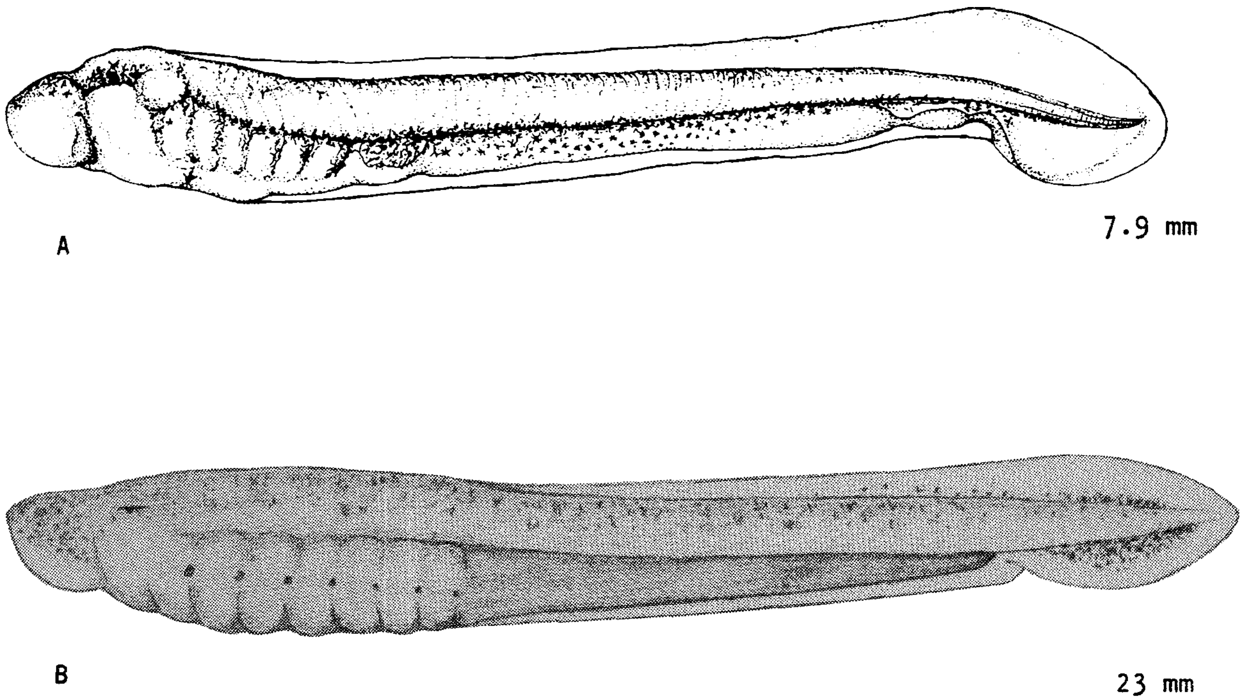

Fig. 5. Lampetra appendix, American brook lamprey. A and B. Ammocoetes (larvae) . (A, wild-caught, Del aware, Wang and Kernehan 1979; B, wild-caught, Michigan, original illustration by R. Fletcher, modified by R. H. Morman) .

Petromyzon marinus Linnaeus, sea lamprey

DISTRIBUTION

Found throughout the Great Lakes region [19 20] including numerous tributaries of Lakes Michigan' [18] and Huron.[18]

SPAWNING SEASON

Spawns from mid-May through July,[11 14] extending to early September.[18]

SPAWNING TEMPERATURE

Spawning migrations begin at 4 C.[1] Spawning usually occurs between 14 and 18 C,[5 6 10 11 18] but extremes of 7 to 12 C[1 3 14 18] and 21 to 26 C[6 6 18] have been reported.

SPAWNING HABITAT

Spawns in shallow, 13- to 170-cm deep, rapids.' [5] Successful nest construction requires a constant, unidirectional flow of water, at about 0.5 to 1.5 m/s.[15]

SPAWNING SUBSTRATE

Deposits eggs in an oval depression nest[1 4 5 11 14] in sand and 1- to 5-cm[4 15] gravel. Nests range from 25 to 100 cm in diameter' [5 10 11 14] and [25] c m deep.[11] May spawn in nests with Ichthyomyzon castaneus or I. fossor or I. unicuspis[18] or Lampetra appendix,' [18] as well as with combinations of L. appendix and I. castaneus, and C. appendix and I. unicuspis.[16]

FECUNDITY

14,000 to 85,000[3 4 10 21] or as much as 108,000.[6]

EGGS

Demersal;" [5] adhesive[3] (not adhesive after 15 minutes);[5] diameter 1.0 mm;[6 6 10 17] yolk light tan or cream colored;[10] incubation period: 11 to 14 days at 12 to 16 C;[14] 13 to 14 days at 14 to 18 C;[10] 10 to 13 days at 18 c,[6 17] 10 to 12 days at 19 to 22 C;[12] 9 days at 20 C.[6]

YOLK-SAC LARVAE

Total length	Description
3.0-5.0 mm	Newly hatched.[8 17] Myomeres : incomplete at hatching, total myomeres 18 to 35."

Morphology: yolk sac spatulate;[6 17] tail flexed 90 degrees ventrad.[10]
Pigmentation: body transparent;[6 17] anterior-most portion of yolk greenish.[6]

4-9 mm

Myomeres: total myomeres 35 to 50.[8 17]
Morphology: tail straight (ca. 4 mm, 2 to 3 days posthatching) ;[10] tail flexed 10 degrees, yolk nearly tubular (5 to 6 mm), tail straight, eye spots present., caudal and anal fins developed (6 to 7.5 mm).[6 17]
Pigmentation: yolk white;[5] or greenish, bilateral melanophores over midbrain (5 to 6 mm) , melanophores along dorsum and sides, lip and head pigmented (6 to 7.5 mm), melanophores on pronephric region, caudal end of notochord, gut and venter (7.5 to 9.0 mm) .[6 17]

LARVAE

Total length	Description
9-60 mm	Myomeres: trunk myomeres 65 to 74, usually 70.[9 16 22] Morphology: yolk absorbed (9 to 10 mm;[6 17] 2 to 3 weeks posthatching;' [12] 33 to 40 days postfertilization[6]); caudal fin rounded;) dorsal fin with two lobes, first rays in caudal, posterior dorsal (> 40 mm) , and anterior dorsal fins (50 to 55 mm) formed, all fins with rays (60 mm) .[16] Pigmentation: caudal fin rays pigmented to margin, ventral edge of caudal myomeres grayish, suborbital area pigmented, lower half of lip partly pigmented;' chromatophores regularly placed on dorsum of myosepta, prebranchial area pigmented, narrow pigment-free band on dorsum (19 to 24 mm) , chromatophores extending from dorsum to gill openings (anteriorly) and to ventral edge of peduncle (posteriorly) (> 19 mm), pigment-free area on dorsum behind nostril, cephalic pigment line absent (> 30 mm) , tongue unpigmented (> 44 mm) . [16]
95-185 mm	Morphometry: (as % TL) preanal length 70 to 74, predorsal length 48 to 51;[4] eye diameter 1, snout length 4.[7] Pigmentation: dorsum dark brown to black, venter light yellow to pale brown.'

JUVENILES (recently transformed individuals).

Total length	Description
93-194 mm	Transformation size;[4 22] largest larvae 170 mm;[13 22] to 203 mm;[2] age at transformation: 4 to 5;[6 11] 7;[10] or 5 to 18[22] 23 years. Myomeres: trunk myomeres 67 to 74.[9 24]

ADULTS

Diagnostic characters: dorsal fin with two separate lobes, supraoral teeth consisting of a single median bicuspid tooth.

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4. Gage (1993)
5. Coventry (1922)
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8. Piavis (1961)
9. Vladykov (1950)
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11. Applegate (1950)
12. Lennon (1955)
13. Hubbs (1925)
14. Manion and McLain (1971)
15. Manion and Hanson (1980)
16. Vladykov (1960)
17. Piavis (1971)
18. Morman (1979)
19. Hubbs and Lagler (1958)
20. Scott and Crossman (1973)
21. Vladykov (1951)
22. Manion and Smith (1978)
23. Purvis (1980)
24. Vladykov and Kott (1980)

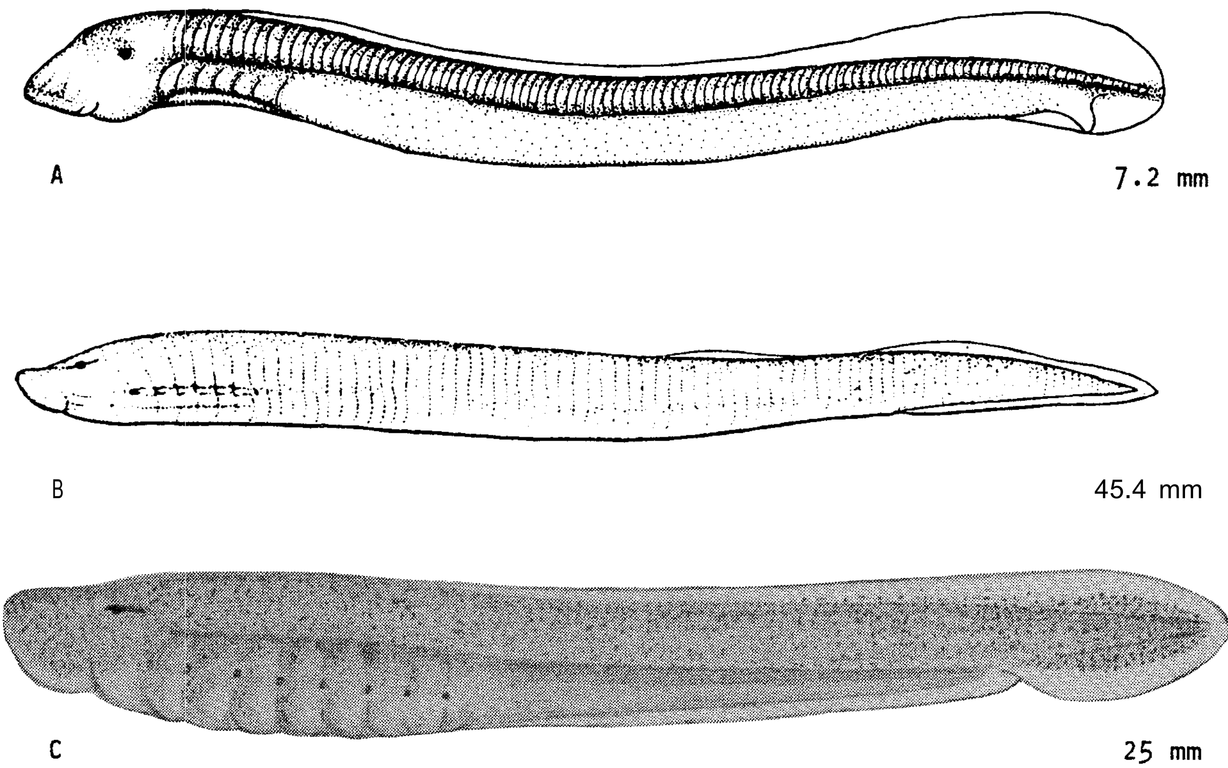

Fig. 6. Petromyzon marinus, sea lamprey. A-C. Ammocoetes (larvae) . (A, and B, wild-caught, Del aware, Wang and Kernehan 1979; C, wild-caught, Michigan, original illustration by R. Fletcher, modified by R. H. Morman).

Family Acipenseridae, sturgeons

BY

David J. Jude

The Acipenseridae is a primitive family of bony fishes occurring throughout the northern hemisphere. The family includes 23 species in 4 genera. Acipenser is composed of 16 species, 7 of which occur in the United States and Canada, yet only Acipenser fulvescens is known from the Great Lakes region. Sturgeons are freshwater anadromous fishes characterized by the presence of four barbels in front of an inferior mouth, body with rows of large bony scutes evident on larvae and juveniles, becoming less prominent in adults, dorsal and anal fins located far back on the body, skeleton partially cartilaginous and a large heterocercal tail.

Unfortunately,. the reproductive biology of the sturgeons has been poorly studied. This is the case with Acipenser fulvescens whose populations had been so diminished by intense fishing pressure in the 1 ate 1800's that it is currently listed as a "threatened" species in the states of Michigan and Illinois. It is estimated that only 1% of its original population exists today (F. P. Binkowski, personal communication). Lake sturgeon reach sexual maturity at ca. 20 to 23 years. Some females live 80 years while males live somewhat shorter lives of about 55 years.

Lake sturgeon eggs are usually very tough, adhesive and 3.2 to 3.5 mm in diameter. Underdeveloped, unpigmented young hatch at 8 to 12 mm. Development is slow, the four barbels are evident at 15 mm and the shovel nose is apparent at 20 mm.

Acipenser fulvescens Rafinesque, lake sturgeon

DISTRIBUTION

Found in the Miss ssippi, Great Lakes, St. Lawrence and Hudson Bay basins.[1 5]

SPAWNING SEASON

Spawns from late' May to June in Michigan,' and various locations in Ontario, Quebec, Minnesota and Wisconsin.[5 7] Spawns from late April to early May in central Wisconsin.[4] Sturgeons are in spawning condition for a very brief period and a single female may spawn once every four to six years.'

SPAWNING TEMPERATURE

Spawning occurs at 11 C[6] to 15 C with an optimum between 14 and 16 C.[1 4 5]

SPAWNING HABITAT

Spawns on wave-washed rocky lake shores,[4 5 6] in areas of upwelling currents, the outside bends[4] and rapid moving water of rivers,[5 6 7] and near dams.[3] Spawns in 1.0[5] to 5.0[1] m of water.

SPAWNING SUBSTRATE

Eggs and milt are scattered over large, clean rubble and abandoned.6

FECUNDITY

50,000 to 700,000.[4]

EGGS

Demersal;[5] adhesive;"[6] deposited singly;[5] diameter (2-cell stage) 3.2 to 3.5; ;[5 *] dark brown with greenish cast, heavier than water;[5] incubation period: 7 to 9.6 days postfertilization at 15 C.[3]

YOLK-SAC LARVAE

Total length	Description
6.5-9.6 mm	A few hours posthatching;[5] newly hatched average 8.0 to 8.5 mm.[1 5]
11-12 mm	Newly hatched.*
	Myomeres: 57 to 64 (40 to 43 + 17 to 22).*
	Morphometry: (as % TL) preanal length 67 to 69, head length 10 to 11, body depth at anus 14 to 18, yolk-sac length 34 to 37, yolk-sac depth 19 to 25, eye diameter 3 to 4.*

Morphology: body short and deep, anus opens to the exterior upon hatching, mouth opening appears (2 to 3 days posthatching);[5] finfold continuous, breaking only at anus.*
Pigmentation: eye and body lack pigment, yolk sac covered with fine melanophores producing dusky appearance.*

12-13 mm

Myomeres: see 11-12 mm.
Morphometry: (as % TL) preanal length 66, head length 11 to 12, body depth at anus 15 to 17, yolk-sac length 33 to 35, yolk-sac depth 20 to 24, eye diameter 4.*
Morphology: spiral valve visible through intestinal wall (1 day old).*
Pigmentation: little change from previous stage.*

15-17 mm

Morphometry: (as % TL) preanal length 58 to 65, head length 16 to 19, body depth at anus 14 to 17, yolk-sac length 26 to 30, yolk-sac depth 15 to 21, eye diameter 4 to 5, pectoral fin length 6 to 8.*
Morphology: barbels appear (3 to 4 days posthatching);[5] opening of nasal capsule not yet divided in two by fleshy bridge, cleithrum present, maxilla and teeth beginning to form;[2] snout rounded, spiral valve still evident.
Pigmentation: eye fully pigmented, dark band of chromatophores extends from snout, through eye to caudal fin just below lateral line, a few small melanophores on posterior region of yolk sac and on spiral valve give dusky appearance, venter immaculate except for a few melanophores on posterior of gut, dorsum evenly covered with fine melanophores, some melanophores present on finfold between dorsal actinotrichia and tip of caudal fin.*

18-19 mm

Morphometry: (as % TL) preanal length 58 to 60, head length 17 to 19, yolk-sac length 19 to 21, greatest body depth 14 to 18, body depth at anus 13 to 14, pectoral fin length 8 to 9, snout length 5 to 6, eye diameter 3 to 4.*
Morphology: snout rounded, actinotrichia present in areas of future dorsal and anal fins, finfold remains continuous.*
Pigmentation: little change from previous stage.*

LARVAE

Total length	Description
22-23 mm	Morphometry: (as % TL) preanal length 57, head length 22 to 24, body depth at anus 10 to 11, pectoral fin length 10 to 11, pelvic fin length 8, snout length 10, eye diameter 4.*

Morphology: yolk absorbed;* yolk absorbed (9 days at 8.5 to 22.2 mm[6] or 10 days at 20 C[4]); nasal openings evident, pectoral fin rays developing;[2] * dorsal fin rays more developed;* snout longer, more slender and depressed fins differentiating from finfolds. *
Pigmentation: venter immaculate except for a few chromatophores on snout, dorsum completely covered with small, even 1 y spaced melanophores, most dense between dorsal fin and tip of caudal fin, dark band of chromatophores extends from snout through eye and gradually blends into dense pigmentation near the dorsal fin.*

23-31 mm

Morphometry: (as % TL) preanal length 53 to 58, body depth at anus 9 to 11, pectoral fin length 7 to 13, head length 24 to 29, snout length 11 to 14, eye diameter 4 to 5.*
Morphology: yolk absorbed, mouth and barbels fully developed;' larvae approximately 60-days old at 15 C.*
Pigmentation: little change from previous stage.*

42-44 mm

Morphology: infraorbital canal complete, 20 rays in pectoral fin, dorsal rostral plates appear.[2]

75 mm

Morphology: pectoral fin with 28 rays.[2]
Pigmentation: two large, black spots on upper surface of snout between dorsal and lateral aspects, one opposite base of dorsal fin, one below dorsal fin, smaller black spots on head, back, sides and caudal peduncle;' dark blotches on the side disappearing with age, considerable variation in color ranging from tan, buff, brown, olive, gold to gray, black, brown, red and yellow-red.[s]

JUVENILES

Total length 196-762 mm

Description

Morphometry: head length usually 24% FL (400 to 700 mm), snout length greater-than postorbital length (< 500 mm FL), skull broad, interorbital width 21.6 to 40.0% head length, mouth width (excluding lips) 66 to 93% interorbital width.[1]
Morphology: no fontinelle, eyes midway between mouth and barbels, protrusible suctorial ventral mouth, far back and large;[1] branchial skeleton largely cartilaginous, five rows of scutes on body, scutes with well developed keels terminating in a sharp pointed hook or spur, worn off and grown over with skin in specimens greater than 1 m.[5]

ADULTS

Fin rays: caudal 80;* dorsal 35 to 40, anal 25 to 30;[1] pectoral 40;[2] pelvic 28 to 30.*

Bony plates: dorsal 9 to 17;[1 2] lateral 29 to 42,[1] 28 to 29;[2] ventral 7 to 12.'

Gill rakers: 25 to 40.[1]

Diagnostic characters: covering of large bony plates, especially in young, heterocercal tail, mostly cartilaginous skeleton, large cellular swim bladder, retractile and suctorial mouth.

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2. Jollie (1980)
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4. Priegel and Wirth (1971)
5. Harkness and Dymond (1961)
6. Baker (1980)
7. Magnin (1966)

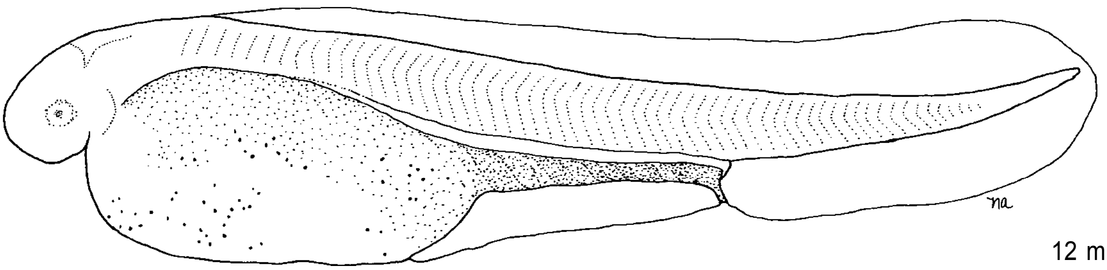


Fig. 7. Acipenser fulvescens, lake sturgeon. Yolk-sac larva, newly hatched. (Laboratory-reared, Wisconsin, original illustration by N. A. Auer, specimens provided by F. P. Binkowski, Center for Great Lakes Studies, University of Wisconsin-Milwaukee).

Acipenser fulvescens

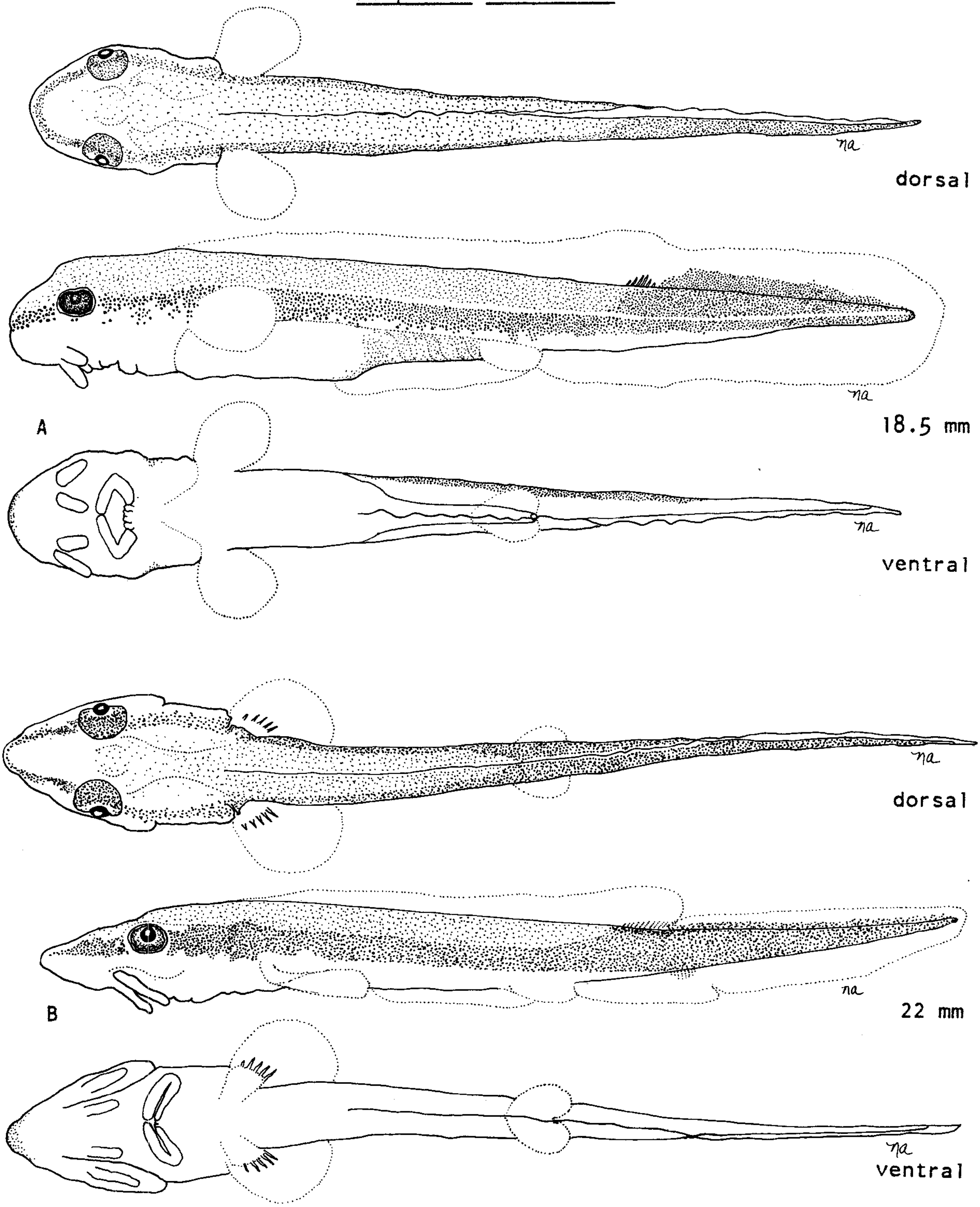


Fig. 8. Acipenser fulvescens, lake sturgeon. A and B. Larvae. (A and B, laboratory-reared, Wisconsin, original illustrations by N. A. Auer, specimens provided by F. P. Binkowski, Center for Great Lakes Studies, University of Wisconsin-Milwaukee).

Acipenser fulvescens

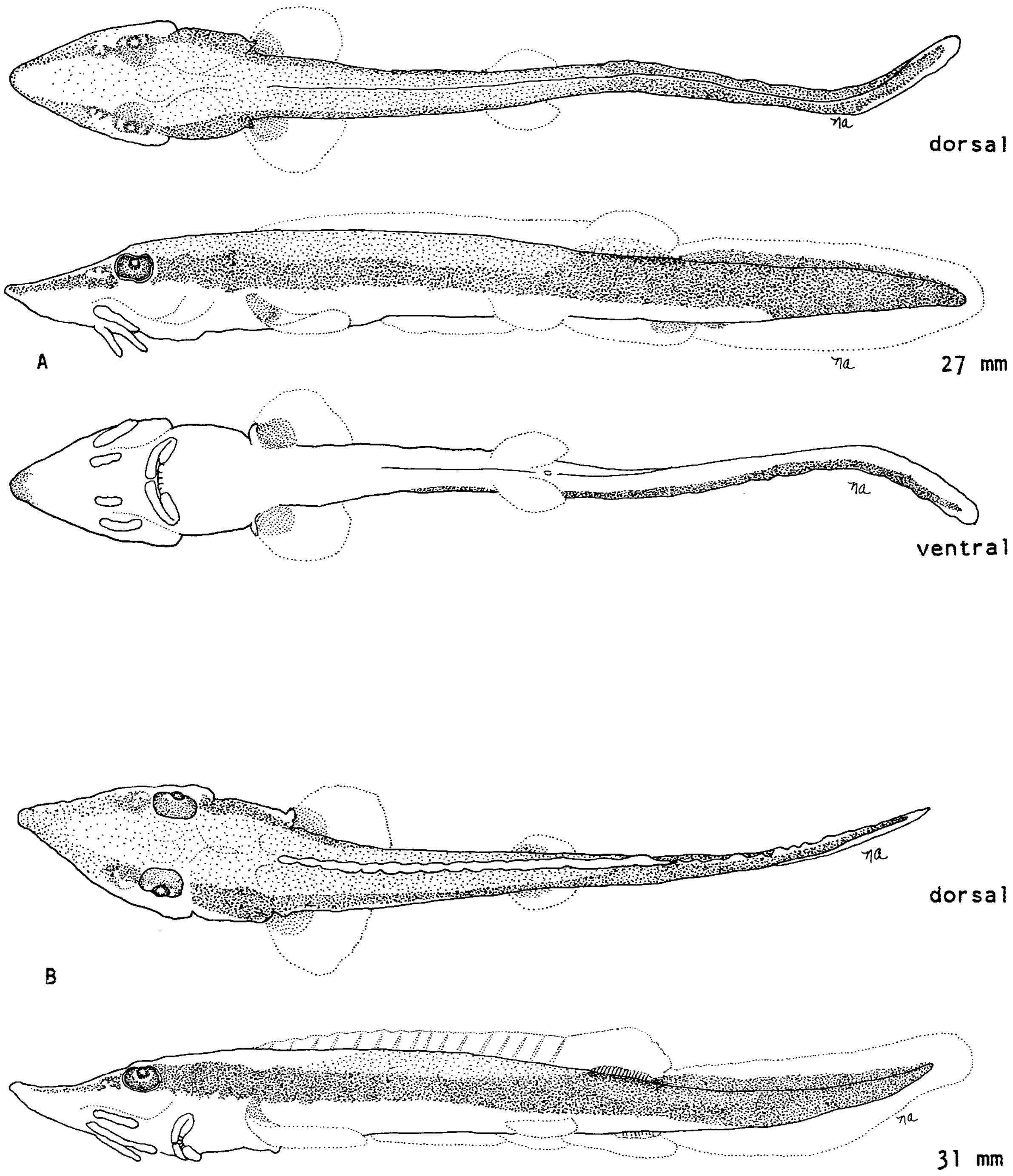


Fig. 9. Acipenser fulvescens, lake sturgeon. A and B. Larvae. (A and B, laboratory-reared, Wisconsin, original illustrations by N. A. Auer, specimens provided by F. P. Binkowski, Center for Great Lakes Studies, University of Wisconsin-Milwaukee).

Family Lepisosteidae, gars

By

George R. Heufelder

The gars belong to a primitive family having both living representatives as well as members known only from fossil record. The Lepisosteidae is comprised of 16 species from 2 genera, Lepisosteus and Atractosteus (Wiley 1976). Fossil records indicate that gars inhabited North America, Central America, Europe, India and Africa. Living representatives, however, are restricted to the western hemisphere from Costa Rica to southern Canada. Of the five living gars of North America, three are known from the Great Lakes basin. The longnose gar, C. osseus, occurs in the drainages of all of the Great Lakes, although to a limited extent in Lake Superior, while the shortnose gar, C. platystomus, and spotted gar, L. oculatus, have a more restricted range in the basin.

The gars are unique among North American fishes, being characterized by a long, attenuated snout with numerous teeth, abbreviated heterocercal tail and overlapping ganoid scales. The body is long and somewhat tubular. Spawning takes place in the spring in shallow vegetated areas. Eggs are broadcast and adhere to the underlying vegetation and substratum. No parental care is given.

With the exception of I. osseus, very little has been published regarding the larval development of gars. Larval gar superficially resemble the larvae of esocids, but can readily be distinguished by the presence of a “caudal appendage,” which is the upturned distal portion of the notochord, appearing as a large upper lobe of the caudal fin. Larva1 gar remain attached to vegetation by an adhesive disc on the tip of the snout and are relatively inactive until the yolk is absorbed.

Lepisosteus oculatus (Winchell), spotted gar

DISTRIBUTION

This species occurs in Lakes Michigan, Huron (only from Saginaw Bay) and Erie.' [2] It has been reported from Indiana and the southern third of lower Michigan in the Lake Michigan drainage.'

SPAWNING SEASON

Spawning occurs in the spring.[2] Spawning was observed during April in Texas[4] and Missouri .[8]

SPAWNING TEMPERATURE

Spawning was observed at 16 C[4] and 20 to 30 C.[5]

SPAWNING HABITAT

Spawns in shallow, warm water where vegetation is abundant.[2]

SPAWNING SUBSTRATE

Spawns over dead vegetation and algal mats.[5]

FECUNDITY

Not reported.

EGGS

Smaller than those of I. *osseus*.[5]

YOLK-SAC LARVAE

Minimum size observed 7 to 8 mm,[5] otherwise not described.

LARVAE

Total length	Description
38-50 mm	Morphometry: (as % TL) preanal length 63 to 71, head length 30 to 33, (as % head length) snout 60 to 63.* Morphology: pelvic buds evident, pectoral fin bases broad, flap-like and fin rays absent, preanal finfold present, rays formed in caudal, dorsal and anal fins (38 mm) , pelvic fin rays evident, pectoral fin rays slightly differentiated, caudal appendage pronounced, extending into upper caudal lobe (50.0 mm).* Pigmentation: body covered with numerous diffuse chromatophores, body below sensory lateral line darker than above lateral line, dark lateral pigment makes irregular intrusions into lighter dorso-lateral area,

pectoral buds dark except dorsal margin, pelvic buds with dark spot at base, caudal, dorsal and anal fins darkly pigmented except near dorsal and ventral margins, pigmentation extends irregularly onto caudal appendage (38 mm), wide midlateral dark band evident (50.0 mm), with dorsal intrusions of dark band on lighter dorso-lateral aspect, dark midlateral band extends on to head, dorsal and anal fins pigmented at base and tips, caudal fin and caudal appendage darkly pigmented except irregularly shaped areas on the margins lacking pigment, faint, wide midventral band of melanophores evident (50.0 mm).*

100-150 mm — Morphology: lateral line fully developed, scales evident on lateral aspect from caudal peduncle to region of pelvic fins, pectoral fin rays starting to develop (100 mm), anterior belly and pelvic area without scales, pectoral fin rays one-half to completely developed (130 mm), squamation complete (140 to 150 mm).'

JUVENILES

Total length	Description
ca.150-250 mm	Morphology: caudal appendage adnate to dorsal margin of caudal fin (210 to 250 mm);' partially atrophied (160 mm), completely atrophied (225 mm).[7]

ADULTS

Fin rays: caudal 12 to 13, dorsal 6 to 9, anal 7 to 9, pectoral 9 to 13, pelvic 5 to 6.”[7]

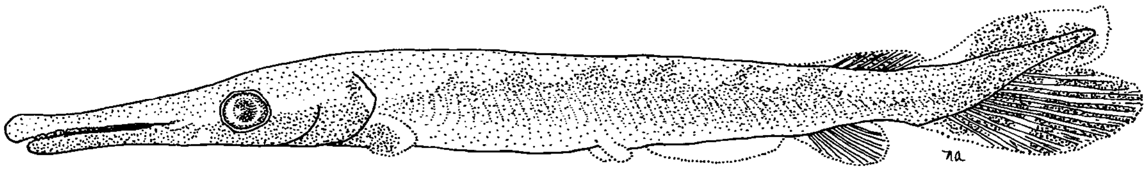
Vertebrae: 58 (incomplete) at 57 mm TL.*

Lateral line scales: 53 to 59.[7]

Diagnostic characters: snout length less than 75% head length, lateral line scales 53 to 59.

LITERATURE CITED

1. Hubbs and Lagler (1958)
2. Scott and Crossman (1973)
3. Becker (1976)
4. Taber (1969)
5. Echelle and Riggs (1972)
6. Wiley (1976)
7. Suttkus (1963)
8. Pflieger (1975)
9. Riggs and Moore (1960)



17.5 mm

Fig. 10. Lepisosteus oculatus, spotted gar. Larva. (Wild-caught, Florida, original illustration by N. A. Auer, specimen provided by University of Michigan Museum of Zoology, UMMZ 165168).

Lepisosteus osseus (Linnaeus), longnose gar

DISTRIBUTION

This species is found in the drainages of all of the Great Lakes except Lake Superior.[1 2] In the Lake Michigan drainage it is generally found in large rivers and lakes and is becoming increasingly rare northward.'

SPAWNING SEASON

Spawns in late spring and early summer in the Lake Erie drainage[5] and from May to June in Maryland[6] and New York.[4]

SPAWNING TEMPERATURE

Spawning occurs at ca. 19 to 21 C[15] or 17 C[7] in New York.[9]

SPAWNING HABITAT

Spawns in shallow, grassy areas of smaller streams and shoals,[5] windswept shorelines and rocky points of lakes.[11]

SPAWNING SUBSTRATE

Spawns over flooded weeds, grass,[5] algae and bare rock.[11 15]

FECUNDITY

1,110 to 77,156;[12] 4,273 to 59,422.'"

EGGS

Demersal ;[6] adhesive;[5 6] diameter 3.3 to 5.5 mm;[6] 2.1 to 3.2 mm;[13] color ranges from "slate grey" after extrusion to cream yellow 3 hours later or a dull shade of greenish brown;[15] or yellowish-green;' incubation period: 5 to 6 days at 18.9 to 21.2 C;[11] 7 to 9 days at unspecified temperatures.[4]

YOLK-SAC LARVAE

Total term	Description
8-10 mm	Newly hatched.'[9]
8-15 mm	Morphology: yolk sac ovoid;, suctorial disc prominent on, snout;[7 9] central papillae of suctorial disc arranged in groups;[v] eye poorly developed (newly hatched) ;[7] choroid fissure persisting, median fins and pelvic fins undeveloped (11 mm), pectoral buds prominent as vertical ridges, mouth reduced to a slit, opercula extend over base of pectoral buds, opercular folds meet

ventrally, considerable elongation of preoral part of head gives appearance of a snout with terminal suctorial disc, pelvic buds present posterior to yolk sac, pectoral fin bases appear horizontal on side of body (15 mm).[9]

Pigmentation: body colorless, yolk opaque or blue-gray (new1 y hatched);[7] concentrations of pigment in finfold indicate position of caudal, dorsal and anal fins (11 mm), becoming more pronounced (15 mm);[9] upper edge of yolk sac covered with melanophores, minute melanophores on dorsum of gut in later development, entire body covered with small melanophores, more numerous on dorsum and head (3 days old), melanophores becoming more dense around head, dorsum, over intestine and dorsum of yolk sac (5 days old), venter yellow-gray, location of median fins marked by dense patches of melanophores.'

LARVAE

Total length	Description
20-23 mm	Morphology: yolk absorbed (ca. 20 mm, 3 weeks);[7] suctorial disc reduced to swelling on tip of upper jaw, both jaws more elongate;'[9] dorsal and anal fin positions indicated by indentation in f infold, incipient dorsal, anal and pectoral fin rays evident (ca. 20 mm), teeth apparent;[7] incipient pelvic fin rays evident (ca. 23.0 mm);[9] pelvic fin rays may develop before pectoral fin rays.[10] Pigmentation: dorsal region mottled with broad, irregular patches of brown, ventro-lateral band of pigment extends from posterior of eye to extremity of caudal peduncle.'
41 mm	Morphometry: (as % TL) preanal length 67, predorsal length 71, head length 29, greatest body depth 7, (as % head length) eye diameter 25.[5] Morphology: caudal appendage pronounced.[5] Pigmentation: several dark colors evident on live specimens, dorsum and dorsal fin with round, red-brown chromatophores, lateral aspect with large brown chromatophores on jaws extending to eye encircling orbit, brown pigment on lateral aspect blends into white venter, base of pectoral fins white with median brown band not extending to tip of fin, brown chromatophores on anal fin.[5]

JUVENILES

Total length	Description
50-120 mm	Morphometry: postorbital length 29 to 33% head length.[17]

Morphology: caudal appendage adnate to caudal fin (247 to 301 mm);[16] vertebral constrictions in notochord (55 mm).[8]
Pigmentation: belly brown, rest of body light yellow with a dusky lateral band (< 76 mm);[17] dark lateral band extends through eye (< 120 mm).*

ADULTS

Fin rays caudal 11 to 14, dorsal 6 to 9, anal 8 to 10, pectoral 10 to 13;[14] pelvic 6.[10]

Vertebrae: 61 to 66 for 6 Michigan specimens.*

Lateral line scales: 57 to 63.[14]

Diagnostic characters: snout length 79 to 83% of head length, lateral line scales 57 to 63.

LITERATURE CITED

1. Scott and Crossman (1973)
2. Hubbs and Lagler (1958)
3. Becker (1976)
4. Beard (1988)
5. Fish (1932)
6. Lippson and Moran (1974)
7. Agassiz (1979)
8. Balfour and Parker (1881)
9. Balfour and Parker (1882)
10. Suttkus (1963)
11. Echelle and Riggs (1972)
12. Holloway (1954)
13. Netsch and Witt (1962)
14. Wiley (1976)
15. Dean (1995)
16. Riggs and Moore (1960)
17. Trautman (1957)

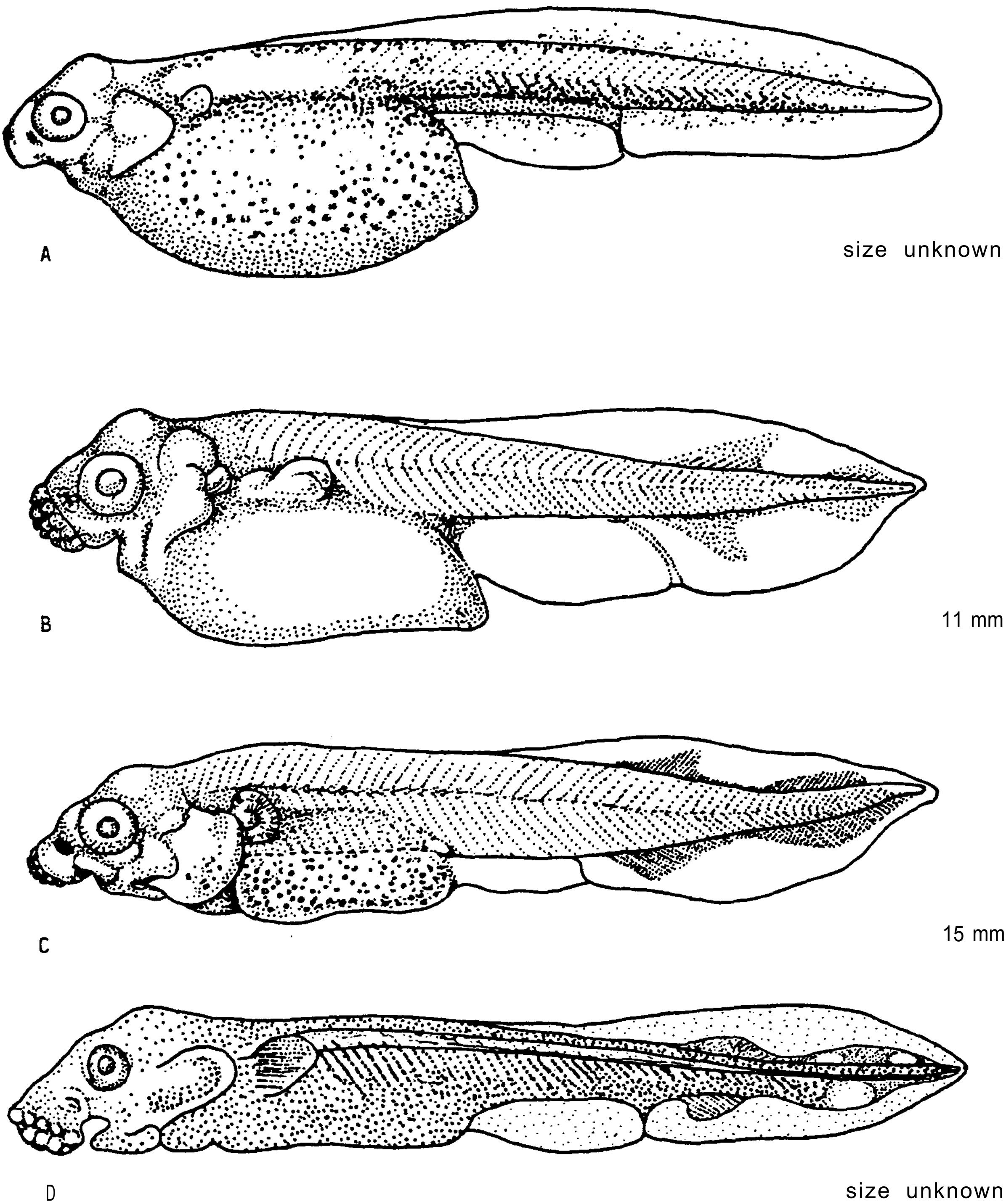


Fig. 11. Lepisosteus osseus, longnose gar. A-D. Yolk-sac larvae. (A, wild-caught, Kerr 1919 (by permission of MacMillan, London & Basingstoke), delineated by J. Ellis; B and C. laboratory-reared, New York, Balfour and Parker 1882, delineated by J. Ellis; D, laboratory-reared, New York, Agassiz 1879, delineated by M. A. Cole).

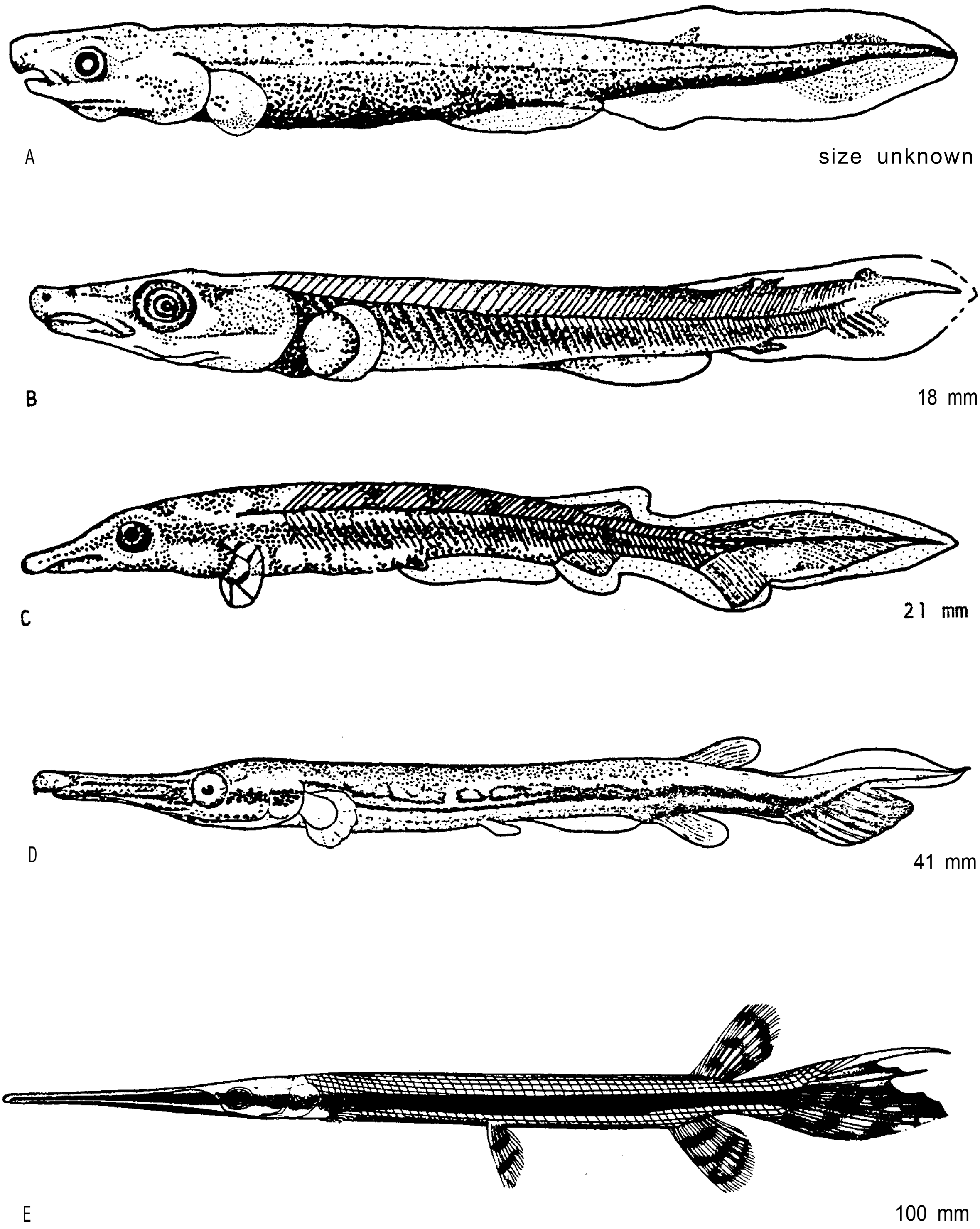


Fig. 12. Lepisosteus osseus, longnose gar. A-D. Larvae. E. Juvenile. (A, wild-caught, Kerr 1919 (by permission of MacMillan, London & Basingstoke) , delineated by M. A. Cole; B, Wilder 1877, delineated by M. A. Cole (reprinted with permission from Popular Science 1877, D. Appleton and Company) ; C, laboratory-reared, Agassiz 1879, delineated by M. A. Cole; D, wild-caught, Lake Erie, Fish 1932; E, wild-caught, Pennsylvania, Fowler 1945).

Lepisosteus platostomus Rafinesque, shortnose gar

DISTRIBUTION

Generally common throughout the Mississippi Valley,[1] but with the exception of Lake Michigan, is absent from the Great Lakes basin.[2 3] Its occurrence in the Fox River system and Green Bay leads to the hypothesis that this species invaded the area via the Fox-Wisconsin canal at Portage, Wisconsin.[4]

SPAWNING SEASON

Spawns in spring, usually June,[5] May to June in Illinois' or late July in Iowa.[7]

SPAWNING TEMPERATURE

Not reported.

SPAWNING HABITAT

Spawns in grassy sloughs.[5]

SPAWNING SUBSTRATE

Spawns over aquatic plants, grass,[5] debris and vegetation.[6]

FECUNDITY

A 4,082 g female contained 36,460 eggs.'

EGGS

Demersal;" adhesive;' [8] diameter 3.5 mm;[5] color greenish;[5] or dirty yellow with clear gelatinous substance surrounding it;' incubation period: 8 to 9 days at unspecified temperature.[6 7]

YOLK-SAC LARVAE

Not described.

LARVAE

Total length	Description
36-50 mm	Morphometry: (as % TL) preanal length 66 to 69, head length 29 to 33, (as % head length) snout 50 to 57.* Morphology: caudal appendage prominent, dorsal, anal and caudal fin rays formed (ca. 36 mm), actinotrichia evident in pelvic fins, pectoral fin base wide, actinotrichia evident (ca. 50 mm).*

Pigmentation: wide band of melanophores from ventral half of eye to lower jaw, posterior band of melanophores on head widens, covering entire ventro-lateral surface, melanophores smaller and more diffuse over venter, dorso-lateral area devoid of pigment, dorsum covered with minute, diffuse melanophores, dorsal fin lightly pigmented at base, anal fin pigmented, pectoral fin bases with large melanophores, pelvic fins unpigmented.*

JUVENILES

Not described.

ADULTS

Fin rays: caudal 11 to 12, dorsal 8 to 9, anal 8 to 9, pectoral 11 to 12;’ pelvic 6.*

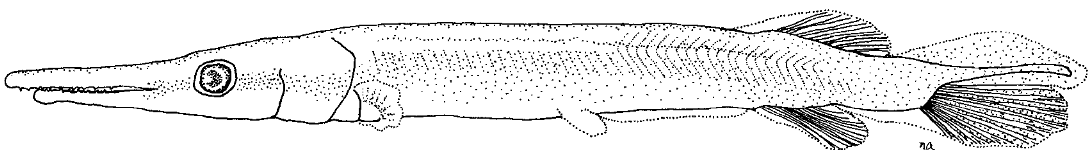
Vertebrae: 61 in specimen from Missouri.*

Lateral line scales: 59 to 65.’

Diagnostic characters: snout short, less than 75% head length, lateral line scales usually 60 to 64, dorsum of head, pectoral and pelvic fins without dark, rounded markings.

LITERATURE CITED

1. Forbes and Richardson (1909)
2. Scott and Crossman (1973)
3. Hubbs and Lagler (1958)
4. Becker (1976)
5. Eddy and Underhill (1974)
6. Richardson (1913)
7. Potter (1927)
8. Pflieger (1975)
9. Wiley (1976)



38.0 mm

Fig. 13. Lepisosteus platostomus, shortnose gar. Larva. (Wild-caught, Nebraska, original illustration by N. A. Auer, specimen provided by University of Michigan Museum of Zoology, UMMZ 134778).

Family Amiidae, bowfins

By

George R. Heufelder

The Amiidae is represented by only one living member, Amia calva, which is restricted in range to the freshwater of eastern North America. Bowfins are predatory fish with robust bodies, often attaining lengths of over 600 mm. The mouth has numerous pointed teeth and between the lower jaws there is a bony gular plate which is a diagnostic character for this species among North American fishes. The body, except the bony head, is covered with cycloid scales. A highly vascularized physostomous swim bladder gives this species the ability to assimilate atmospheric oxygen.

The bowfin generally inhabits vegetated areas of warm lakes and rivers. During spawning, male bowfin construct nests by clearing circular areas amidst vegetation, leaving exposed roots on the bottom of the nest on which the adhesive eggs attach. After spawning, the male remains and guards the nest. After hatching, bowfin larvae remain attached to the vegetation by means of an adhesive disc on the tip of the snout. When the larvae become free-swimming, the male bowfin accompanies the young on their daily foraging activities and may provide shelter for them in his mouth when their safety is threatened. Parental care continues for several weeks after hatching until the young reach 102 mm (Scott and Crossman 1973).

Amia calva Linnaeus, bowfin

DISTRIBUTION

Throughout the Great Lakes basin, with the exception of the Lake Superior drainage, where it is found only in the St. Mary's River outlet.[1 2] In the Lake Michigan drainage it is common in the lower Wolf and Fox River systems of Wisconsin and throughout the eastern region of the Lake Michigan drainage in the southern portion of Michigan's upper peninsula.[3]

SPAWNING SEASON

A nest was prepared and eggs were found in late April and early May in Michigan.' [11] Eggs were collected from late March to early June in Wisconsin.[5]

SPAWNING TEMPERATURE

Spawns at water temperatures between 16 and 19 C.[4 8]

SPAWNING HABITAT

Spawns along lake margins, stream mouths, bays and similar places.' *

SPAWNING SUBSTRATE

Spawns in areas partially cleared of debris over decaying vegetation[10] * and fibrous roots of water plants, less often among gravel or water-soaked leaves and sometimes under logs, stumps or bushes.[11]

FECUNDITY

23,000 to 64,000.[12]

EGGS

Ovoid, diameter 2.14 to 2.16 mm;[4] 2.0 to 3.0 mm;[5] egg surrounded by adhesive envelope becoming progressively distended with a jelly-like fluid until dimensions of envelope are twice original size, thread-like extensions of adhesive surface attach egg to nest and adjacent eggs; [4] yolk dark gray-brown;[5] to charcoal-gray, animal pole white;' to light yellow-brown;[5] incubation period: 6 days at 16 to 17 C,[4] 7.5' to 14[5] days at unspecified temperatures.

YOLK-SAC LARVAE

Total length	Description
5-8 mm	Newly hatched.' [5 6] Myomeres: total ca. 60.4

Morphology: body flexed over yolk, eye lens not completely formed, myomeres not differentiated near the bulbous tip of caudal fin, pectoral buds absent (newly hatched);[7] vitelline vessels prominent on dorsum of spherical yolk sac, adhesive organ large[7,4] and sausage-shaped (5.5 mm);[4] trunk straight, pectoral buds conspicuous, yolk sac elongate, head region enlarged, dermal operculum enclosing gill slits, auditory vesicle clearly defined (2 days old, ca. 7.0 mm), yolk sac reduced and pointed posteriorly, anteriorly yolk sac overlapped by gular isthmus of opercular flaps, chin prominent, pectoral fins much enlarged (3 days old, ca. 7.2 mm);[7] pectoral fins shift from horizontal to oblique (6 to 8 mm).[5]

Pigmentation: body pale, flesh-colored, yolk sac deep brown[5] or pale-slate color[7] (newly hatched); traces of pigment in peye, diffuse melanophores concentrated in cephalic region and over dorsum to yolk sac, distribution associated with deep inner layer of ectoderm, melanophores in midbody region concentrated on dorsum and dorso-lateral surface of somites gradually diminishing near caudal fin.[7]

9-13 mm

Morphology: mandible distinct, lateral line evident in region of urostyle which has turned ventrad (5 days old, 9.3 mm), maxilla forming concurrent with reduction of adhesive organ, beginning of gular plate evident (6 days old, ca. 9.8 mm);[7] adhesive organ reduced to tubercle, maxilla and premaxilla established (7 days old, ca. 10.0 mm), pelvic buds appear (10 to 11 mm);[4] incipient rays evident on caudal (16), dorsal (47), anal (9) and pectoral (14) fins (all incomplete ca. 10 mm), nasal openings established, opercle evident, adhesive organ reduced to small flattened pad, yolk may persist (10 days old, ca. 13.2 mm);[7] or yolk absorbed (9 to 10 mm), pelvic buds appear (12 to 14 mm), pectoral fins assume vertical position (9 to 11 mm).[5]

Pigmentation: little change from previous stage.*

LARVAE

Total length	Description
16-27 mm	Morphology: body tadpole-like, incipient caudal, dorsal and anal fin rays visible, some specimens with no anal fin ray development, lower jaw slightly shorter than upper jaw, pelvic buds originate ca. 1.5 to 2.0 mm anterior to anus, adhesive organ reduced to small pad on snout, urostyle slightly flexed (16 to 17 mm), caudal fin heterocercal (ca. 25 mm), incipient pelvic fin rays evident (27 mm), preanal finfold remains (27 mm).*

Pigmentation: entire body covered by diffuse small brown chromatophores extending to median finfold, pigment absent from small midventral area of gut anterior to finfold (16 to 18 mm), this pigmentation pattern intensifies (23 to 27 mm), with addition of diffuse melanophores on venter and light underlying tissue, giving off-white appearance.*

JUVENILES

Total length	Description
30-70 mm	Pigmentation: predominantly black;[8] to dusky brown (30 to 40 mm);* dorsum and sides green, side of head olive-green with three black stripes, the two most dorsal stripes bordered by orange, small black spot at caudal fin base (40 to 50 mm), dorsum olive-green or nearly black, venter silvery, ventro-lateral aspect of head green-white, dark stripes bordered by yellow, black spot on caudal fin bordered with orange, opercula edges black (60 mm), black stripe lengthwise through dorsal fin sometimes evident, caudal fin with vertical black band, opercula have yellow stripes (70 mm).[8]

ADULTS

Fin rays: caudal 24;[1] dorsal 46 to 50;[1] 58;[7] anal 9 to 10;[1] 13;[7] pectoral 16 to 18;[1] 22;[7] pelvic 9.

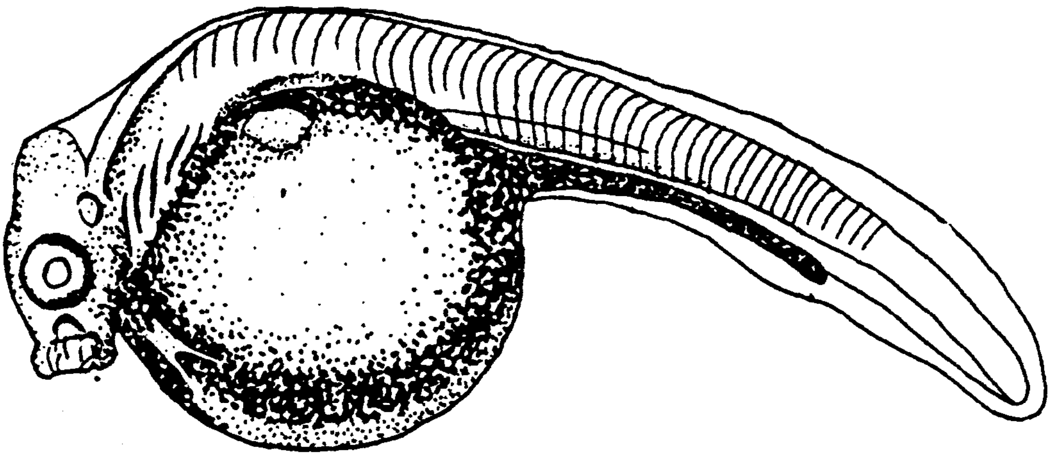
Vertebrae: 80 and 87 in 2 Great Lakes specimens.[7]

Lateral line scales: 64 to 68.[1]

Diagnostic characters: strong bony plate between lower jaws (gular plate) ; dorsal fin long, heterocercal tail, caudal fin spot large in male.

LITERATURE CITED

1. Scott and Crossman (1973)
2. Hubbs and Lagler (1958)
3. Becker (1976)
4. Pierson (1953)
5. Whitman and Eycleshymer (1897)
6. Reighard and Phelps (1908)
7. Dean (1896)
8. Reighard (1903)
9. Adams and Hankinson (1928)
10. Doan (1938)
11. Reighard (1900)
12. Eddy and Underhill (1974)



A

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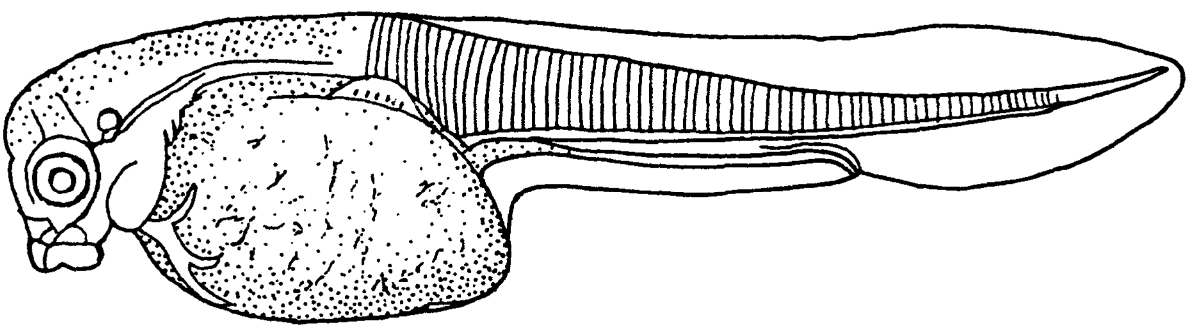

B

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Fig. 14. Amia calva, bowfin. A and 9. Yolk-sac larvae. (Laboratory-reared, Dean 1896).

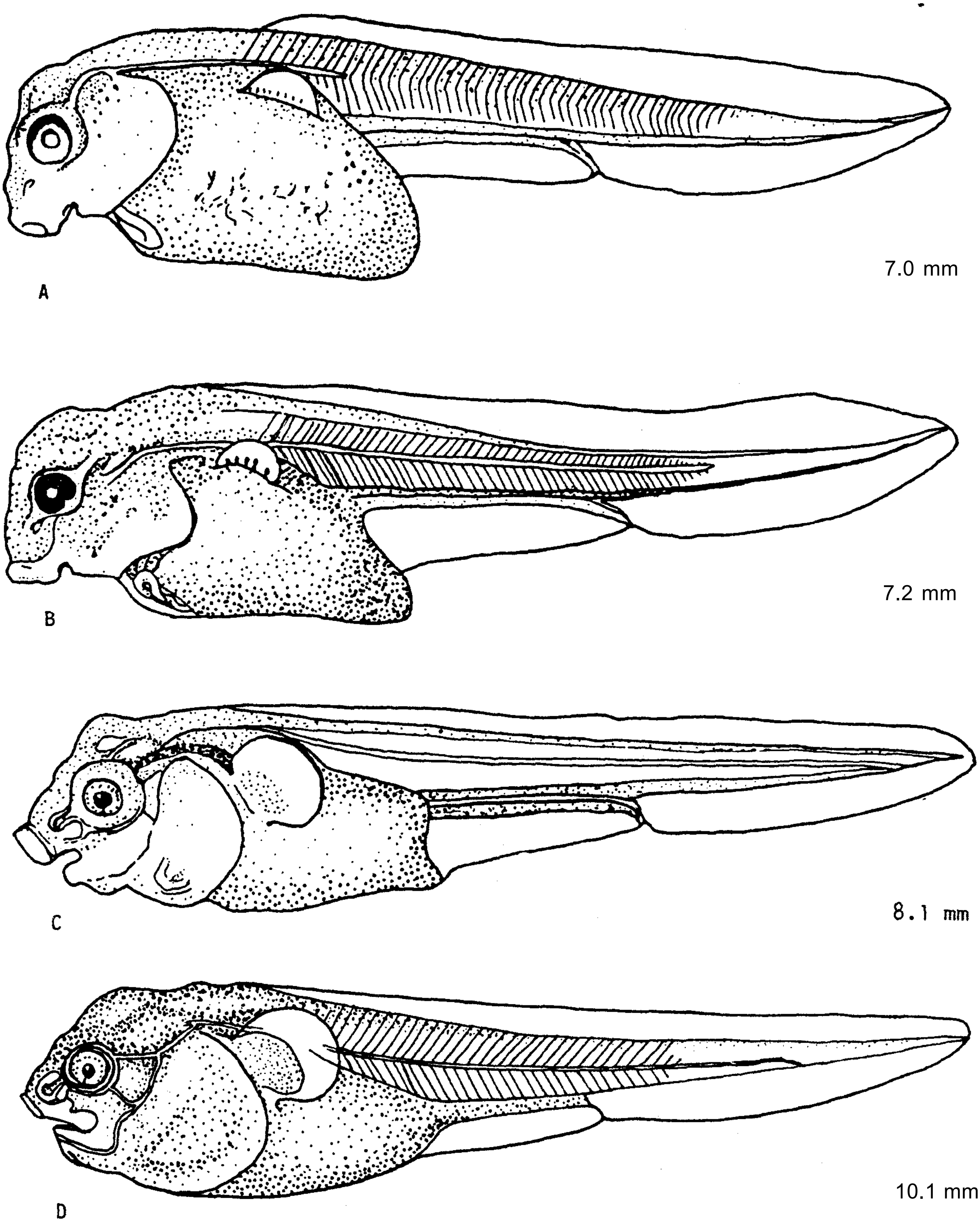

Fig. 15. Amia calva, bowfin. A-D. Yolk-sac larvae. (Laboratory-reared, Dean 1896) .

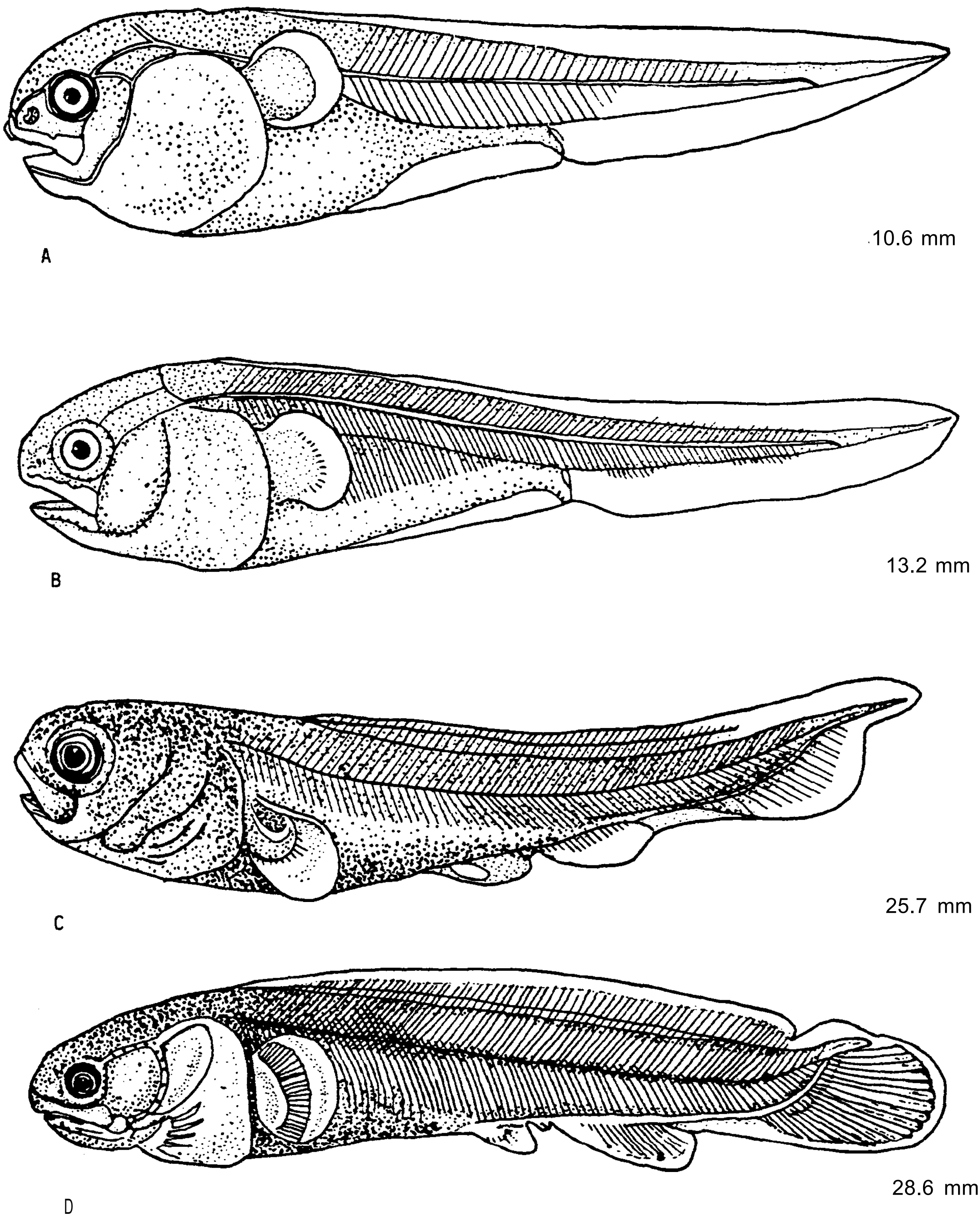

Fig. 16. <u>Amia calva</u>, bowfin. A and 9. Yolk-sac larvae. C and D. Larvae. (Laboratory-reared, Dean 1896).

Family Anguillidae, freshwater eels

BY

Nancy A. Auer

Anguilla rostrata (LeSueur), American eel

All 16 species of the family Anguillidae belong to the single genus, Anguilla; however only one species, Anguilla rostrata, occurs in North America. This catadromous species is found along the Atlantic and Gulf coasts. in the Great Lakes basin it is native only to Lake Ontario. Its introduction and migration through canals has resulted in its current distribution throughout the Great Lakes. Adults return to a region of the tropical Atlantic Ocean, believed to be the Sargasso Sea, to spawn. Within one year young appear in coastal waters. The freshwater eel has a true larval stage known as a leptocephalus or glass eel. Metamorphosis occurs at 60 to 65 mm during the winter approach to freshwater. Between 65 and 90 mm the young eel, or elver, assumes adult pigmentation and a freshwater existence (Scott and Crossman 1973).

In the last few years several small American eels have been recovered from the Great Lakes region. in February 1978, an unusually small specimen, 157 mm TL, was collected from the Nemadji River in the Lake Superior drainage (Cochran 1981). This species is discussed briefly to draw attention to the fact that freshwater eels can be, and have been, confused with larval lampreys (ammocoetes) due to form and coloration. Al though small, they may be separated from lampreys by the presence of true jaws, a single pair of gill openings, continuous caudal, dorsal and anal fins and a larger eye.

Family Clupeidae, herrings

By

Heang T. Tin

The Clupeidae is a large family containing approximately 190 species and 50 genera (Scott and Crossman 1973). Members of this family are widely distributed throughout the world except in the polar regions. They are primarily marine fishes, but many species are anadromous and a few species have become landlocked.

Clupeids are small to medium-sized fishes with a slender and compressed body, conspicuous adipose eyelids, small to moderate terminal mouth, teeth small or absent, gill rakers long, slender and numerous, scales deciduous and cycloid and confined to the body, scute-like scales usually present on midline of belly anterior to pelvic fins, lateral line and adipose fin absent.

Spawning generally takes place during spring. Eggs may be demersal or pelagic. Clupeid eggs are round and have granular or segmented yolk. One oil globule is of ten present, but eggs of some species have several oil globules. Yolk-sac larvae are generally long and slender, with poor1y developed pigment. The anus is located relatively far behind the midpoint of the body.

Provisional Keys to Great Lakes Clupeid Larvae

Yolk-Sac Larvae

Ia. Postanal myomeres 7 or 8, preanal length 70 to 85% TL, yolk sac round, oil globule absent, several small oil globules scattered around periphery of yolk, eyes slightly pigmented at hatching. . . . . I . . Alosa pseudoharengus

b. Postanal myomeres 1 to 3, preanal length 80 to 91% TL, yolk sac elongate, oil globule single, located in posterior position of yolk sac, eyes not pigmented at hatching. . . . . Dorosoma cepedianum

Larvae

Ia. Preanal myomeres 35 to 43, postanal myomeres 6 to 9, preanal length 77 to 81% TL, anal fin rays 15 to 20, dorsal fin rays 12 to 16, severa1 chromatophores usually present on caudal fin, above and below notochord . . . . . . - . . . . Alosa pseudoharengus

b. Preanal myomeres 42 to 46, postanal myomeres 3 to 8, preanal length 80 to 91% TL, anal fin rays 22 to 34, dorsal fin rays 10 to 13, no chromatophores on caudal fin around notochord . . .Dorosoma cepedianum

Alosa pseudoharengus (Wilson), alewife

DISTRIBUTION

An anadromous species native to eastern North America. Landlocked populations were first reported in Lake Ontario in 1873[1] and began to spread to other Great Lakes in 1930.[30] Currently abundant in Lakes Michigan, Huron and Ontario, less successful in Lakes Superior and Erie.[1,9]

SPAWNING SEASON

Spawns from May to August in Lakes Michigan,’[8,14,18,29] and Ontario,[25,27] July to early August in Lake Huron[26] and June in Lake Erie.’

SPAWNING TEMPERATURE

Spawning occurs at 10 to 27 C.[2,6,7,14]

SPAWNING HABITAT

Anadromous forms spawn in streams and ponds.[10,26,28] Spawning of landlocked populations takes place in shallow areas of lakes, ponds and small and large streams.[1,6,24]

SPAWNING SUBSTRATE

Spawns over various bottom types.’ Eggs may be deposited over gravel, sand, detritus or vegetation.[6,24,25,28]

FECUNDITY

10,000 to 22,407 (landlocked);[3,8] 48,000 to 360,000 (anadromous).[10]

EGGS

Pelagic;[2,12] semibuoyant[12] or demersal;[11,28] adhesive;’ 28 pink or pale yellow;[21] diameter 0.95 to 1.27 mm;[2,12,13,23] oil globule absent;[3,11] tiny oil droplets may be present;[2] incubation period: 15 days at 7.2 C;[14] 6 days at 15.6 C;[11,22] 3 to 5 days at 20 C;[15] 2.1 days at 28.9 C.[14]

YOLK-SAC LARVAE

Total length	Description
2.5-5.0 mm	Newly hatched.[8,12,17,20,23,28]
	Myomeres: (37 to 41 + 7 to 8) at 3.3 to 5 mm.[2,5]
	Morphometry: (as % TL) preanal length 70 to 85, head length 11 to 14;[2,5] greatest body depth 6, eye diameter 4 to 5 (3.3 to 5.0 mm);2 preanal length 78 to 84% SL (4 to 4.9 mm).[19]

Morphology: body slender, yolk sac round;[5 17] eyes large;[28] head slightly deflected;[2] mouth absent or barely evident;[5] pectoral buds present, no large oil globule present, several small oil droplets around periphery of yolk, yolk granular;’ auditory vesicle triangular’” (immediately posthatching); caudal fin rays developing (3.3 to 5.0 mm);[2] opercula and branchiostegal rays visible (1 day old), head straight, mouth functional with maxilla extending to under anterior edge of eye (2 days old);[5] finfold complete extending from second somite around caudal fin to anus and on to base of yolk sac.[15]

Pigmentation: eyes slightly pigmented;[17] ca. 10 rows of chromatophores across ventral half of yolk sac (newly hatched);[15] eyes completely pigmented (1 day old), body pigmentation sparse and irregular in yolk-sac larvae, two chromatophores located below pectoral fin insertion, three to six chromatophores posterior to these;[5] double row of chromatophores extending along dorsum of gut from posterior end of yolk sac to body midpoint, narrow1 y spaced double row lying below intestine from body midpoint to anus;[5 18 20] four to seven chromatophores on caudal fin, usually two above the notochord, three to five below (3.3 to 5.0 mm).[2]

LARVAE

Total length	Description
4-12 mm	Myomeres: (36 to 43 + 5 to 8) at 4.3 to 11.8 mm;[2] 45 to 50 (40 or 41 + 5 to 9) at 4 to 16 mm.[12]
	Morphometry: (as % TL) preanal length 77 to 81, head length 14 to 16, greatest body depth 7, eye diameter 4 (4.3 to 11.8 mm);[2] preanal length 80 to 84% SL (5.0 to 11.9 mm).[19]
	Morphology: yolk absorbed (4.3 to 6.4 mm,[2 5 8] 3 to 5 days posthatching[3 21]; body slender, rays developing in caudal, dorsal and pectoral fins (4.3 to 11.8 mm), maxilla reaching anterior third of eye (ca. 4.5 mm) (derived from figure);[2] lower jaw projected beyond upper jaw (8 days old[15] or 9[5] mm); notochord begins to bend upward (9.0 mm SL);[16] rays formed in caudal and pectoral fins, rays beginning to develop in dorsal fin (10.4 mm).[5]
	Pigmentation: increased chromatophores in region of pectoral fins and anus;[2] chromatophores above gut anterior to anus become more expanded and caudal melanophores more stellate (9.3 mm), melanophores along venter between pectoral fins forming an unjoined “V” (10.4 mm);[5] pigment patterns on venter similar to those of previous stage.:‘;

12-19 mm

Myomeres: (35 to 43 + 6 to 9) at 12.4 to 17.8 mm.[2]

Morphometry: (as % TL) preanal length 77 to 81, head length 12 to 19, greatest body depth 8, eye diameter 2 to 4;[2] (as % SL) preanal length 82 to 85 (12.0 to 13.9 mm), 81 to 84 (14.0 to 15.9 mm), 73 to 82 (16.0 to 18.9 mm).[19]

Morphology: body elongate, folds begin to develop in posterior portion of intestine, ossification of rays in median and paired fins (12.4 to 19.8 mm);[2] swim bladder visible above pelvic fins (15.0 mm).[16]

Pigmentation: pigment increases in gill and otic region and on caudal fin, a dorso-lateral row of chromatophores appearing above lateral line;[2] ventral pigmentation patterns similar to those of previous stage.*

JUVENILES

Total length	Description
19-32 mm	Myomeres: (33 to 42 + 9 to 14).[2]

Morphometry: (as % TL) preanal length 59 to 64, head length 16 to 18, greatest body depth 9 to 17, eye diameter 4 to 7;[2] (as % SL) preanal length 73 to 75 (lg.0 to 19.9 mm).[19]

Morphology: teeth present on maxilla, premaxilla and dentary, dorsal and anal fins located farther forward, anus situated at beginning of posterior two-fifths of total body length (19.1 to 32.2 mm);[2] body still slender (20 to 30 mm):[17] scales appear (29 mm).[2]

Pigmentation: chromatophores increasing on dorso-lateral surface from head to caudal fin, pigment on lower jaw, snout tip, top of head, caudal fin and dorsal margin of swim bladder.[2]

ADULTS

Fin rays: caudal 19;* dorsal 13 or 14 (12 to 16), anal 17 or 18 (15 to 19), pectoral 14 to 16, pelvic 10.[1]

Vertebrae: 47 to 49.[1]

Lateral line scales: 42 to 50.[1]

Gill rakers: 38 to 43 on lower limb.[1]

Diagnostic characters: snout sharp, lower jaw terminal, eye diameter usually greater than snout length, maxilla extends only to midpoint of eye, gill rakers fewer than 55, one prominent black spot near upper edge of opercula, last dorsal fin ray is shortest, anal fin rays fewer than 25.

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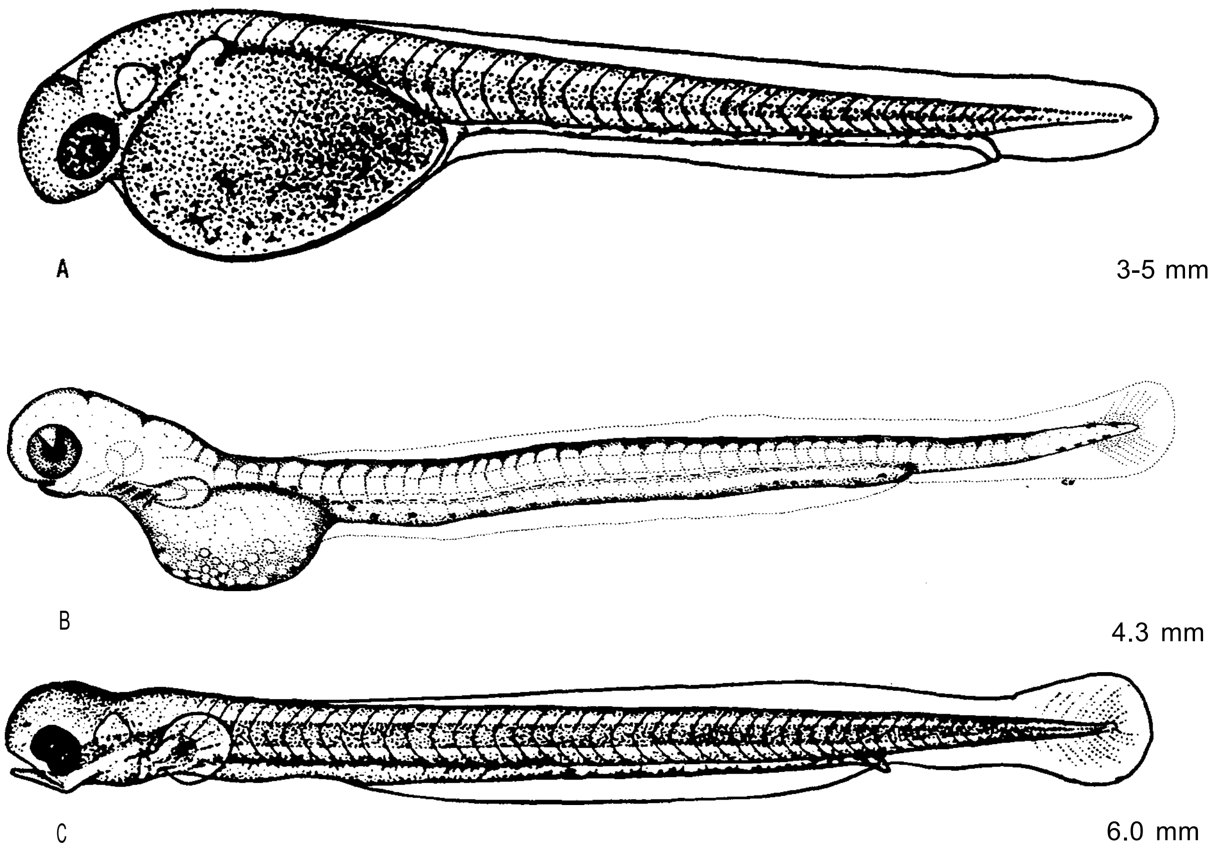
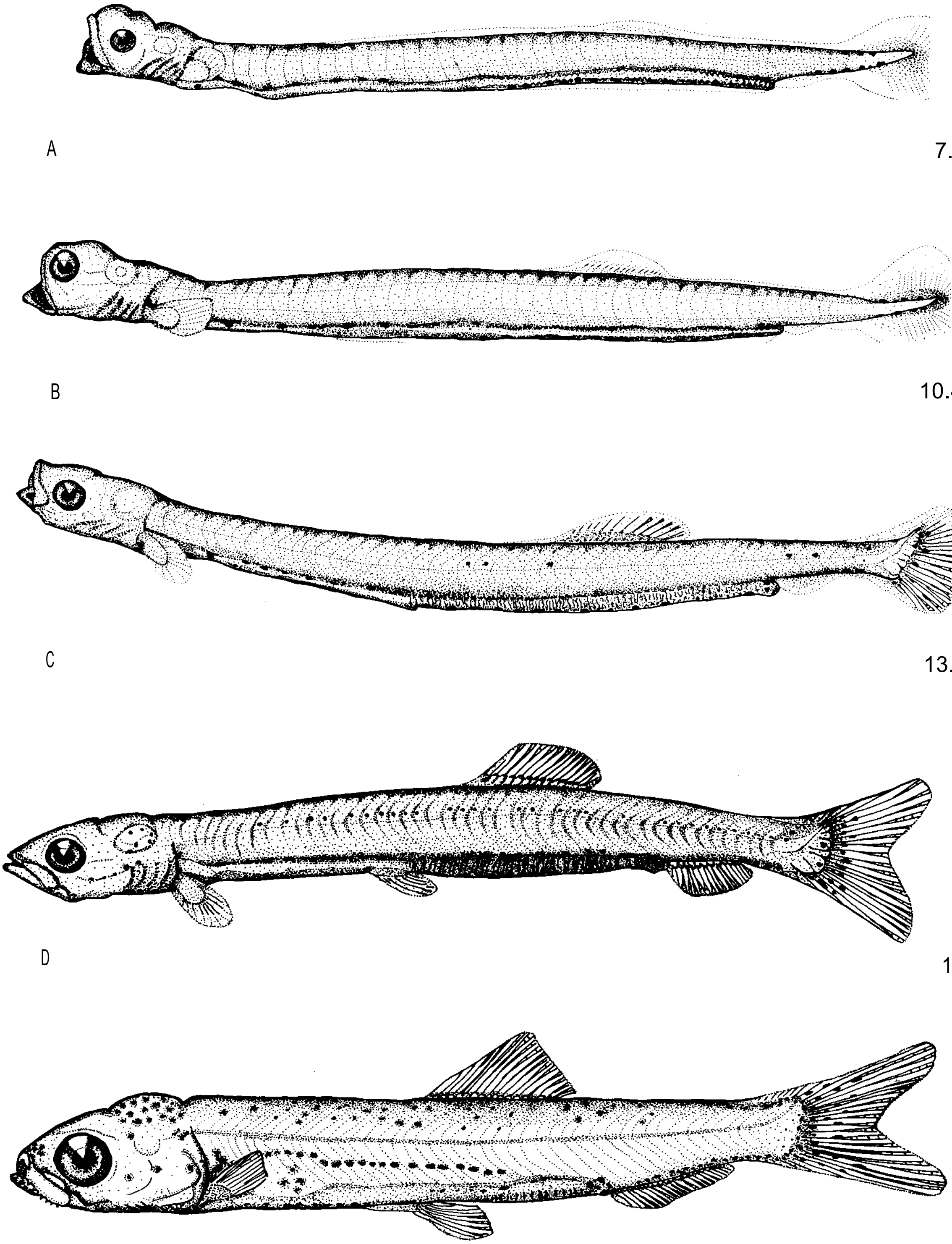


Fig. 17. Alosa pseudoharengus, alewife. A and B. Yolk-sac larvae. C. Larva. (A and C, wild-caught, Chesapeake Bay, Mansuetti and Hardy 1967; B, wild-caught, Lake Michigan, Norden 1967a).



A 7.7 mm

B 10.4 mm

C 13.0 mm

D 19 mm

E 24.3 mm

Fig. 18. Alosa pseudoharengus, alewife. A-D. Larvae. E. Juvenile. (A-E, wild-caught, Lake Michigan, Norden 1967a).

Dorosoma cepedianum (LeSueur), gizzard shad

DISTRIBUTION

Occurs in all Great Lakes; common in Lake Erie, rare in Lake Ontario,[13] rare to uncommon in Lake Michigan." Appears to be on the increase in southeastern Lake Michigan;[16] rare in Lake Superior where the only record of occurrence was a 675-g individual caught in a commercial gill net in 1961.[13]

SPAWNING SEASON

Spawns during April, May and June in Illinois,[17] late April and early May in Iowa,[18] early April and May in Missouri[6] and May to July in Lake Erie.[3 5 15]

SPAWNING TEMPERATURE

Spawning was observed at 10 to 24 C.[1 2 3]

SPAWNING HABITAT

Spawning takes place in shallow areas, usually 30 to 150 cm deep,'[2 3 8] in sloughs, ponds and large rivers.'[2 8]

SPAWNING SUBSTRATE

Eggs may be attached to sand, gravel, boulders;'[5] algae covering rocks or to other submerged objects.[1 2 6]

FECUNDITY

22,400 to 350,280.[2 3]

EGGS

Demersal, adhesive;[1 2 3 6 11] opaque[11] or creamy yellow;' diameter 0.9 to 1.1 mm, oil globule large, single, diameter 0.2 mm;[11] 1 to 5 smaller oil droplets also present;[1] incubation period: 36 hours at 27 C;[1] 73 hours at 18 C;[11] 3 days at 25 C;[17] 106 hours at 15 C.[11]

YOLK-SAC LARVAE

Total length	Description
3-3-3.5 mm	Newly hatched.'[3 11]
3-7 mm	Myomeres: ca. 32 (newly hatched);[1] 40 at 4 to 5.5 mm;[1 4] usually one to three postanal myomeres in yolk-sac larvae.[9]

Morphometry: (as % TL) preanal length 80 to 90, head length 11 to 13, greatest body depth 6 to 9, eye diameter 3 to 5 (3.3 to 5.9 mm) ;* (as % SL) preanal length 85 to 87 (3.0 to 5.9 mm) .[7]

Morphology: body long, slender, yolk sac oval to elongate, oil globule in posterior of yolk sac;" yolk granular;' head deflected downward, choroid fissure prominent, myomeres developed only anterior to anus;[1 11] auditory vesicle conspicuous;' (newly hatched, 3.3 to 3.5 mm), pectoral buds evident;'[11] head more straightened, mouth formed but pharynx not open into mouth cavity, choroid fissure closed;[1] lower jaw partly formed;" (1 day old, 4.5 to 5.5 mm), four gill arches present but filaments not developed , alimentary canal complete (3 days old, 6.5 mm) .[1]

Pigmentation: unpigmented from hatching to 5.5 mm;[1 4 11] eyes pigmented (2 or 3 days old[11] or 6.34 mm); conspicuous row of chromatophores on each side of body along dorsum of intestine, dorsum of yolk sac and extending to preanal finfold, row of chromatophores along base of finfold from yolk sac to anus (3 days old, 6.5 mm) .[1]

LARVAE

Total length	Description
6-20 mm	Myomeres: 47 to 51 (43 to 44 + 3 to 8) at 6 to 14 mm; [10] 42 to 46 + 4 to 6.[19]
	Morphometry: (as % TL) preanal length 80 to 89, head length 12 to 20, greatest body depth 6 to 12, eye diameter 3 to 5 (7.5 to 15.0 mm) ;* (as % SL) preanal length 85 to 88 (6.0 to 16.9 mm), 80 to 86 (17.0 to 19.9 mm) .[7]
	Morphology: yolk absorbed (6 to 8 mm);'[7 10] larvae elongate, gill filaments developing, opercula covers gills, intestinal folds evident, finfold reduced, caudal fin round with 14 rays (10.8 mm) ;[1] dorsal fin well formed (12 mm), anal fin completely differentiated (15 to 19 mm) ;[4] anal fin rays 22 (17.5 mm) .[1 12]
	Pigmentation: one lateral row of elongate chromatophores on each side of gut extending from gular region to midpoint of body (7.5 to 15.0 mm);[16] double row of melanophores on venter extending from body midpoint to anus;* body pigment may be completely absent, scattered pigment may be present on lower half of caudal fin (7.5 to 15.0 mm) .[16]

JUVENILES

Total length	Description
20-50 mm	Myomeres: (37 to 45 + 5 to 10) at 21 to 26 mm.*

Morphometry: (as % TL) preanal length 61 to 71, head length 21 to 24, greatest body depth 14 to 19, eye diameter 5 to 6 (21 to 26 mm).*

Morphology: body elongate (20 to 26 mm);* gill rakers 90, a few minute teeth on lower edge of maxilla;[2] mouth terminal to subterminal;' dorsal fin with 10 to 13 rays (20 mm), body deeper and more laterally compressed (> 30 mm);[4] last dorsal fin ray begins to elongate (> 50 mm).[10]

Pigmentation: scattered pigment on dorsal and caudal fins, pectoral and pelvic fins almost unpigmented (20 to 26 mm).[1]

ADULTS

Fin rays: caudal 19;l dorsal 10 to 12 (10 to 13), anal 27 to 34, pectoral 16 or 17, pelvic 8 to 10.[13]

Vertebrae: 47 to 49.[13]

Lateral line scales: 52 to 70.[1,12]

Gill rakers: 100 to 400.[13]

Diagnostic characters: last ray of dorsal fin elongated into long filament, snout round, mouth slightly subterminal.

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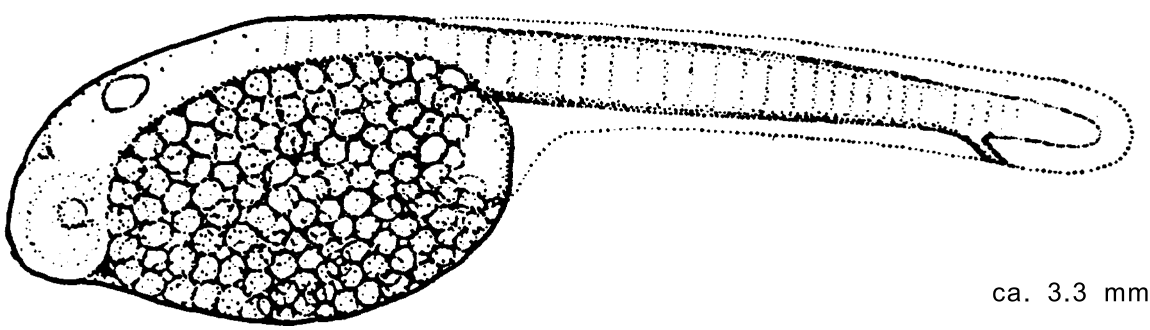

ca. 3.3 mm

Fig. 19. Dorosoma cepedianum, gizzard shad. Yolk-sac larva. (Laboratory-reared, Ohio, Warner 1940 in Miller 1960).

Dorosoma cepedianum

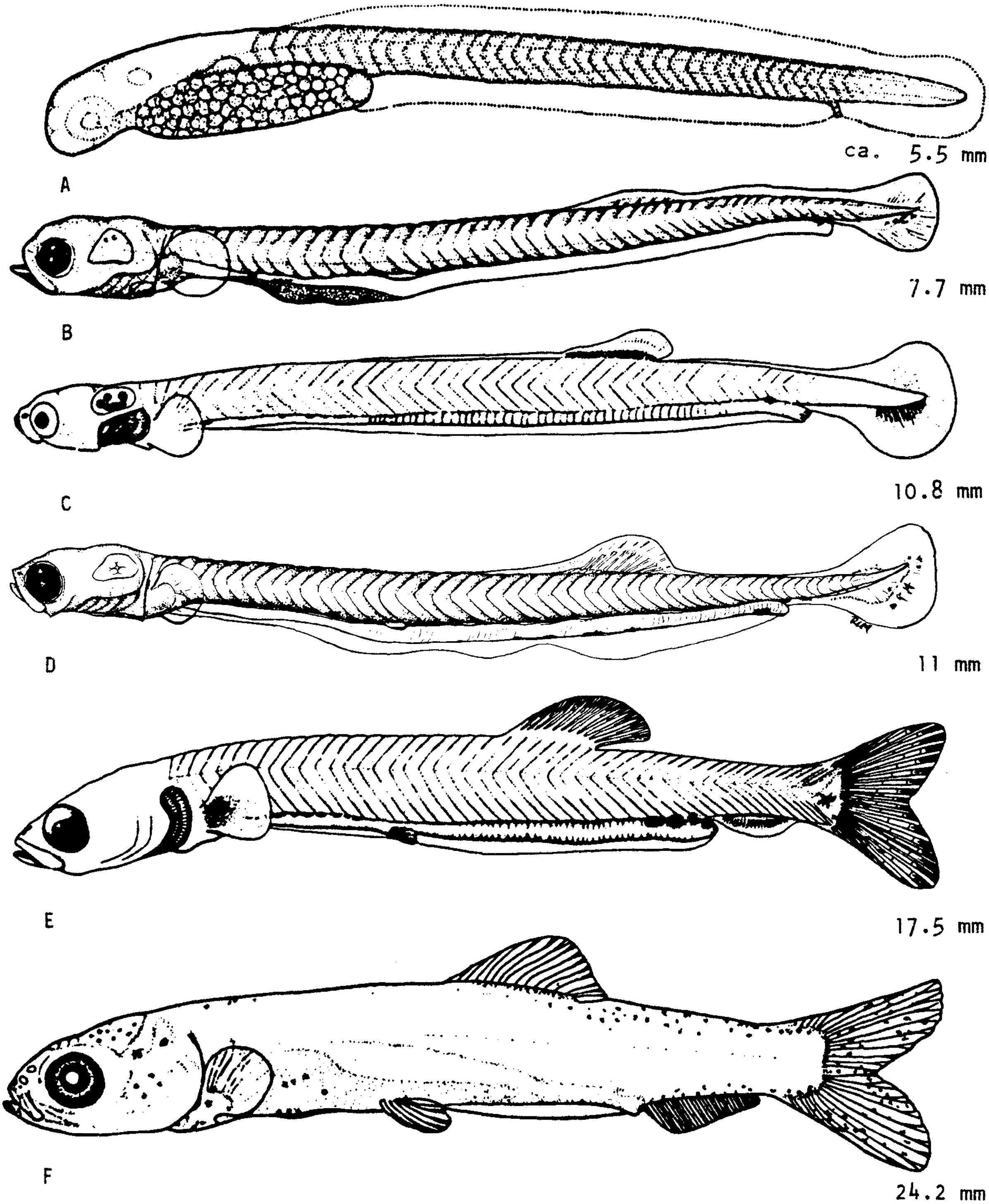

Fig. 20. Dorosoma cepedianum, gizzard shad. A. Yolk-sac larva. B-E. Larvae. F. Juvenile. (A,C and E, laboratory-reared, Ohio, Warner 1940 in Miller 1960; B and D, wild-caught, Potomac River, Lippson and Moran 1974; F, redrawn from Taber 1969).

Family Hiodontidae, mooneyes

BY

David J. Jude

Mooneyes comprise a small family of fishes with a single living genus, Hiodon. As adults, mooneyes superficially resemble clupeids, having laterally compressed bodies, small mouths and large eyes with adipose eyelids. They may be distinguished from clupeids by the presence of a lateral line and teeth, absence of scute-like scales on the venter anterior to the pelvic fins and a more posterior dorsal fin. The genus is composed of two species which are restricted to North American freshwater. The range of i. tergisus, the mooneye, includes the Great Lakes, while H. alosoides, the goldeye, occurs primarily northwest to south of the Great Lakes basin, with isolated populations in Quebec and Ontario.

Both species seem to prefer quiet areas of large streams, rivers, backwaters and lakes. While the life history of H. alosoides is fairly well documented, comprehensive studies of H. tergisus are lacking. It migrates in the spring into streams and backwaters to spawn, dispersing eggs randomly. Eggs of H. alosoides, described by Battle and Sprules (1960), are semibuoyant with a diameter of 4 mm. Larva descriptions of both species are available and Snyder and Douglas (1978) gave characters for distinguishing the two species as well as the family. Hiodon tergisus hatches at approximately 7.0 mm and superficially resembles yolk-sac larvae of Acipenseridae and Polyodontidae.

Hiodon tergisus LeSueur, mooneye

DISTRIBUTION

Occurs primarily in the lower Great Lakes (excluding Georgian Bay), being uncommon in Lakes Erie and Ontario[9] and rare in Lakes Huron and Michigan.[1 2] It is absent from Lake Superior.' In the Lake Michigan drainage, most numerous populations were found in the Wolf and lower Fox Rivers, Wisconsin.[3]

SPAWNING SEASON

Spawning occurs during April and May,[5] possibly through early June[7] in Lake Erie. Begins to spawn in mid- to late March in Tennessee with peak spawning during April.[10]

SPAWNING TEMPERATURE

Spawns at temperatures of 8 to 14 C.[10]

SPAWNING HABITAT

Spawns in large, clear streams.[5]

SPAWNING SUBSTRATE

Not reported.

FECUNDITY

10,000 to 20,000.[5]

EGGS

Not described, however H. alosoides has semibuoyant, spherical eggs, diameter 4 mm, perivitelline space wide, yolk coarse, granular, oi1 globule large.[6]

YOLK-SAC LARVAE

Descriptions and illustrations of a 6.5-mm H. tergisus given by Fish (1932) are thought to be based on a misidentified cyprinid.[8]

Total length	Description
7 mm	Morphology: newly hatched (7.0 mm), stomodeum and pectoral buds not evident, head deflected over upper anterior portion of yolk;* yolk sac large and oval, oil globule single, located in anterior third of yolk sac.[10]

8-10 mm

Myomeres: 54 to 57 (33 to 34 + 20 to 23) ;[10] 53 to 55 (29 to 30 + 24 to 26), to dorsal origin of median finfold 21 to 23, to posterior margin of yolk sac 12 to 14, to origin of preanal finfold 11.[8]

Morphometry: (as % TL) standard length 95[10] to 98;[8] preanal length 61[10] to 67, snout to origin of predorsal finfold 56 to 60, snout to origin of preanal finfold 39 to 43, yolk-sac length 30 to 33, head length 19 to 21 (8.0 to 9.3 mm) ;[8] greatest body depth 9.[10]

Morphology: stomodeum evident (8.0 mm) ;[8] pectoral buds evident (9 to 10 mm) ;[10] lower jaw developed, dorsal and anal pterygiophores evident (ca. 10.0 mm), eyes large.[8]

Pigmentation: eyes pigmented, melanophores scattered over venter of yolk, some melanophores over dorsal and lateral surface of gut, few over anterior dorsum of body, dense series middorsally on posterior third of body following base of finfold around urostyle to anus (described from i 1 lustration) ;[8] few melanophores present on the caudal peduncle along horizontal myoseptum.[10]

1O-12 mm

Myomeres: 55 to 58 (33 to 35 + 21 to 23) ;[10] 54 (30 + 24) , predorsal myomeres 21 to 23, to origin of preanal finfold 9 to 10, to posterior margin of yolk sac 12 to

Morphometry: (as % TL) standard length 96 to 97;[8] preanal length 60[10] to 64, predorsal length 50 to 55, snout to origin of preanal finfold 33 to 37, yolk-sac length 22 to 27, head length 18 to 19 (10.1 to 11.2 mm) ;[8] greatest body depth 9.[10]

Morphology: 10 dorsal and 15 anal pterygiophores evident, dorsal fin origin distinctly anterior to anus, few pectoral fin rays present, pelvic buds and swim bladder not formed, caudal fin rays evident, mouth and lower jaw formed (12.0 mm) .[8 10]

14-19 mm

Myomeres: 54 to 57 (34 to 36 + 18 to 22) .[10]

Morphometry: (as % TL) standard length 93[7] to 94;[10] preanal length 62[10] to 63;[7] predorsal length 57;[11] head length 18, snout length 4, eye diameter 6, body depth at anus 7;[7] greatest body depth 12 to 14.[7 11]

Morphology: elements of 12 dorsal and about 20 anal fin rays apparent;[7] pelvic buds present (17.0 mm) ;[10] body slender, snout blunt, mouth inferior, gape of mouth extends to anterior margin of pupils, yolk sac greatly reduced.[7]

Pigmentation: brownish chromatophores on venter, over oil globule and continued posteriorly approximately one quarter distance to anus, few widely spaced melanophores along dorsum of stomach, irregular double series of small chromatophores on dorsum from dorsal fin to caudal fin, single partly subsurface series on venter from just posterior of anus to caudal fin, small melanophores at caudal fin base;' two or three melanophores on venter, between pectoral fins, double row of melanophores on postanal venter (19.0 mm).[10]

LARVAE

Total length	Description
21-25 mm	Myomeres: 52 to 56 (34 to 36 + 17 to 20).[10] Morphometry: (as % TL) standard length 91 to 92, preanal length 60, predorsal length 55 to 56, greatest body depth 14 to 16.[10] Morphology: oil globule and yolk absorbed (21 mm), mouth well developed, premaxilla extends posteriorly to ca. first third of eye, hypurals complete, all rays in caudal, dorsal, anal (23.0 mm), and pectoral fins (25.0 mm).[10] Pigmentation: melanophores scattered over brain (21.0 mm), dorsal pigmentation in double row on either side of finfold, in later development scattered melanophores present dorso-laterally near dorsal fin.[10]

JUVENILES

Total length	Description
30 mm	Morphometry: (as % TL) standard length 86, preanal length 55, predorsal length 51, greatest body depth 19.[10] Pigmentation: scattered melanophores along entire length of dorsum, small melanophores profuse dorso-laterally almost to midlateral myoseptum, dorsum of head covered with melanophores, becoming fewer toward snout.[10]

ADULTS

Fin rays: caudal 18;[10] dorsal 12 (10 to 14), anal 26 to 29, pectoral 13 to 15, pelvic 7.[1]

Vertebrae: 53 to 57.[1]

Lateral line scales: 52 to 57.[1]

Diagnostic characters: venter keel-like from pelvic fins to anal fin, origin of dorsal fin in advance of origin of anal fin, maxilla extends to, or just short of, middle of pupil.

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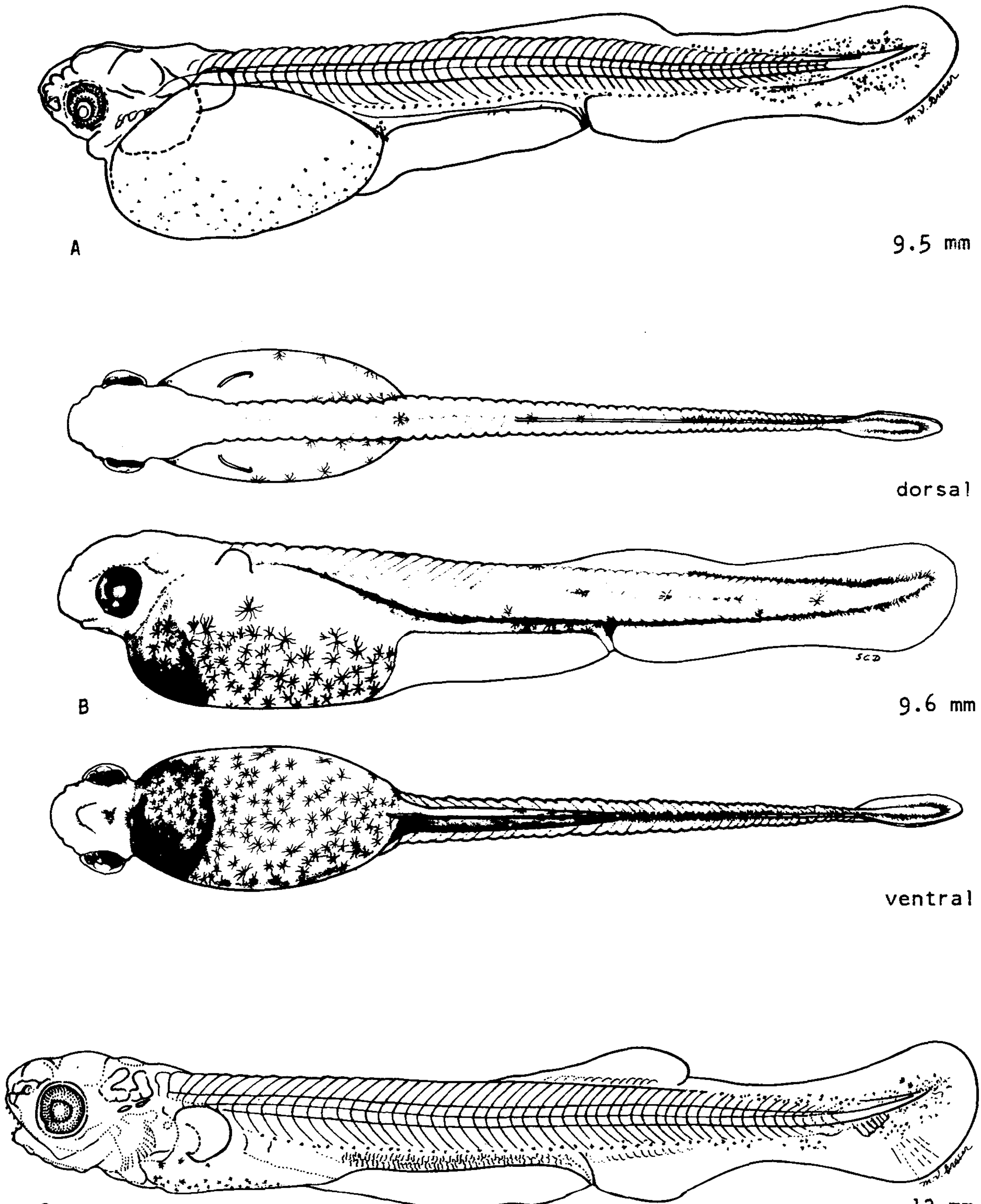

Fig. 21. Hiodon tergisus, mooneye. A-C. Yolk-sac larvae. (A and C, wild-caught, Alabama, Wallus in press, illustrated by M. Graser; B, wild-caught, Minnesota, Snyder and Douglas 1978).

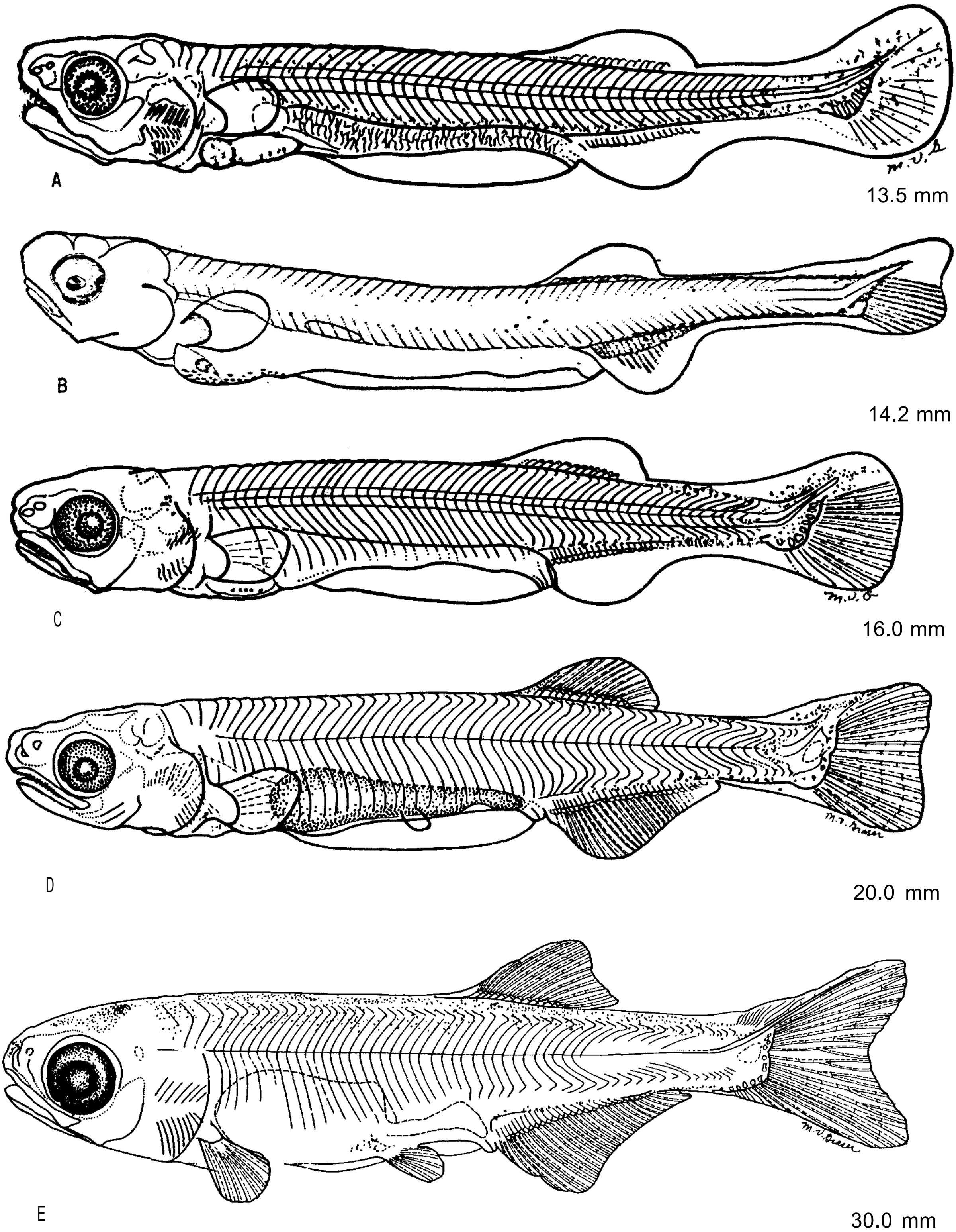

Fig. 22. Hiodon tergisus, mooneye. A-E. Larvae. (A, C-E, wild-caught, Alabama, Wallus in press, illustrated by M. Graser; B, wild-caught, Lake Erie, Fish 1932).

Family Salmonidae, trouts

BY

Nancy A. Auer

The Salmonidae is often separated into three subfamilies, sometimes given familial status. These include the Salmoninae (salmon, trout and chars), the Coregoninae (whitefish and ciscoes) and the Thymallinae (graylings). In the United States and Canada this family is represented by 3 genera and 15 species of Salmoninae, 3 genera and 22 species of Coregoninae and 1 species of Thymallinae. Due to stocking, introductions of non-endemic species and hybridization many different types of salmonids have been collected from the Great Lakes. Commercial fishing pressure and environmental changes have extirpated many Coregonus spp. These factors plus introgression have caused taxonomic problems.

Members of the Salmonidae are freshwater or anadromous fishes, distributed in the northern hemisphere throughout Eurasia, North America and the arctic. The majority of species live and spawn in cool or cold, clear water. They usually possess more than 100 scales in the lateral line, an adipose fin, a pelvic axillary process and usually have well developed teeth in a large mouth. The Coregoninae also possess an adipose fin and pelvic axillary process but usually have fewer than 100 scales in the lateral line and a small, toothless or weakly toothed mouth.

Of the Coregoninae, whitefish, Coregonus clupeaformis, and lake herring, 5. artedii, usually spawn late in the fall, broadcasting eggs on shoal areas; whereas the bloater, C. hoyi, broadcasts its eggs in spring and early summer. Fall eggs, 1.5 to 3.5 mm in diameter, incubate slowly during winter and hatch in early spring. Larvae are 10 to 13 mm at hatching, they possess a few large melanophores on the dorso-lateral surface of the intestine and usually have no parr marks.

Members of the Salmoninae migrate upstream or shoreward to spawn and all but one species, Salmo gairdneri, in the Great Lakes region spawn in the fall. The large eggs, 4.0 to 6.5 mm in diameter, incubate over winter and larvae hatch at 15 to 25 mm in early spring. The large amount of yolk is quickly absorbed and growth and development are fast. Parr marks are often present on young salmonines.

Provisional Keys to Great Lakes Salmonid Larvae and Juveniles
Coregoninae keys adapted from Hinrichs (1979) and Salmoninae key
(Juveniles 5 to 13 cm) adapted from McPhail and Lindsey (1970).
Excluding Prosopium coulteri and Oncorhynchus gorbuscha,
0. nerka and Salmo salar (except in the Juvenile section).

Salmonidae Yolk-Sac Larvae less than 20 mm TL.

Ia. Yolk-sac length less than 35% TL; eye diameter less than 7% TL; dense pigment restricted to dorsal and lateral aspects; body depth at anus usually less than 10% TL. . . . . .Coregoninae

b. Yolk-sac length greater than 35% TL; eye diameter greater than or equal to 7% TL; pigment evenly and lightly distributed overall; body depth at anus usually greater than or equal to 10% TL . . . Salmoninae

Coregoninae
(from hatching to first fin ray development)

la. Yolk-sac larvae usually 12 to 18 mm TL; multiple oil globules their diameter 17% or more of yolk-sac length: large, ovate, stellate dorsal melanophores, these greater than or equal to width of one myomere and alternate or are at least irregular across median finfold. . . . . l . . . . Prosopium cylindraceum

b. Yolk-sac larvae usually 9 to 13 mm TL; single oil globule, its diameter 25% or less of yolk-sac length; small or large dorsal melanophores ovate or square and paired or irregular across dorsum . 2

2a. Yolk-sac larvae 11.5 to 18.0 mm TL; preanal myomeres 38 to 40; squared stellate dorsal melanophores paired across median finfold and largest greater than width of one myomere . . . . Coregonus clupeaformis

b. Yolk-sac larvae less than 11.4 mm TL; preanal myomeres 32 to 38; stellate dorsal melanophores ovate to square, irregular across median finfold. 3

3a. Dorsal melanophores larger than width of one myomere. . Coregonus hoyi

b. Dorsal melanophores smaller than or equal to width of one myomere, usually one-half width of myomere . . . . .Coregonus artedii

(from first fin ray development to stage when all median fins basally rayed, pelvic buds appear toward end of stage)

la. Total length at least 18.0 mm. 2

b. Total length at least 11.0 mm but not 18.0 mm. 3

2a. Melanophores usually square and paired across dorsal median finfold, largest greater than width of one myomere; length from snout to highest point on dorsal fin greater than or equal to 50% SL; without cluster of melanophores on peritoneum posterior to base of pelvic fins. . . . . , , ... Coregonus clupeaformis

b. Melanophores irregular across dorsal median finfold, stellate or contracted, less than width of one myomere, length from snout to highest point on dorsal fin less than 50% SL; cluster of several melanophores on peritoneum posterior to base of pelvic fins . . . . I . . . . I . . Prosopium cylindraceum

3a. Largest ovate melanophore smaller than or equal to width of one myomere . . . . .Coregonus artedii

b. Largest ovate melanophore larger than width of one myomere. . . . . Coregonus hoyi

(full complement of median fin rays appear and pelvic buds or fins present)

la. Parr marks present and cluster of melanophores at base of pectoral fin present; TL at least 28.2 mm. . . . . Prosopium cylindraceum

b. Parr marks and cluster of melanophores at base of pectoral fin absent; TL usually less than 26 mm. . . . . , ...2

2a. Lower jaw does not extend beyond snout: predorsal length greater than or equal to 50% SL; 39 to 40 preanal myomeres; TL at least 23.0 mm . . . . Coregonus clupeaformis

b. Lower jaw equal with snout: predorsal length less than or equal to 50% SL; 38 or fewer preanal myomeres; total length at least 18.0 mm. . . . . Coregonus artedii or C. hoyi

(Juveniles-all fin rays are apparent yet not sexually mature)

la. Parr marks on dorsal and lateral aspects: single internarial flap; body round: predorsal length less than 50% SL . Prosopium cylindraceum

b. Parr marks absent; double internarial flap; body compressed; predorsal length greater than 50% SL (Coregonus spp.) 2

2a. Lower jaw equal to or extending beyond snout. . . . . Coregonus artedii or 5. hoyi

b. Lower jaw inferior. . . . . Coregonus clupeaformis

Salmoninae

(from hatching and prior to first dorsal or anal fin ray development).

la. Body too opaque to count myomeres; usually 16 to 19 mm TL; finfold continuous down posterior edge of yolk sac (Oncorhynchus spp.) . . .2

b. Myomeres enumerable; TL usually 12 to 16 mm; finfold does not extend down posterior edge of yolk sac (Salmo and Salvelinus) 3

2a. Body and caudal fin without pigment . . . . Oncorhynchus kisutch

b. Body and caudal fin pigmented. . . . . .Oncorhynchus tshawytscha

3a. Body lightly pigmented, no pigment on snout; lateral line with pigment (Salmo) 4

b. Body heavily pigmented on dorsum, dorsal aspect of brain and snout; lateral line noticeably unpigmented (Salvelinus). 5

4a. Total length usually 12 mm; little or no pigment present . . . . .Salmo gairdneri

b. Total length greater than 14.5 mm; pigment intense on dorsum of head and nape, some on each dorsal myoseptum. . . . . .Salmo trutta

5a. Dense dorsal pigmentation continuous from snout to caudal fin, pigment on dorso-lateral surface . . . . Salvelinus fontinalis

b. Dorsal pigment light, broken near forehead, diminishing near dorsal fin and absent posterior to dorsal fin, pigment confined to either side of lateral line but not on lateral line. . . Salvelinus namaycush

(from first median fin ray development to presence of pelvic fin rays, parr marks absent, finfold and yolk sac persist).

la. Larvae large, usually greater than 25 mm TL; pigment on finfold just anterior and posterior to dorsal fin (Oncorhynchus) 2

b. Larvae small, usually 17 to 21 mm TL; entire finfold unpigmented (Salmo and Salvelinus). 3

2a. Melanophores present on interradial membrane of anal fin and evenly distributed over rest of body. . . . . .Oncorhynchus kisutch

b. Melanophores absent from interradial membrane of anal fin and along midlateral myoseptum, evenly distributed over rest of body . . . . .Oncorhynchus tshawytscha

3a. Pigment extends below pectoral fin insertion on lateral surface of yolk sac, intense at base of dorsal, adipose and anal fins. . . . . Salmo trutta

b. Pigment does not extend below pectoral fin insertion on yolk-sac surface, may be intense at base of dorsal or adipose fins but usually not at base of anal fin. 4

4a. Pigment evenly distributed over body including lateral line, none on dorsal median finfold . . . . <u>.Salmo gairdneri</u>

b. Pigment otherwise, usually some pigment on finfold posterior to future adipose fin.. 5

5a. Large, stellate melanophores on myomeres but absent from myosepta, intense pigmentation covering dorsal and lateral surfaces evenly . . . . <u>Salvelinus fontinalis</u>

b. Small melanophores concentrated on dorsum and along either side of lateral line. <u>. Salvelinus namaycush</u>

(Juveniles-50 to 130 mm) .

la. Principal anal fin rays 8 to 12. 2

b. Principal anal fin rays 13 to lg. .6

2a. Dorsal fin without dark spots in center, first ray not black or lightly pigmented, width of single parr mark less than or equal to width of interspaces; tip of lower jaw white. . . S<u>alvelinus namaycush</u>

b. Dorsal fin with distinct dark spots in center or first ray black; width of single parr mark greater than width of interspaces; tip of lower jaw speckled. 3

3a. No colored spots on lateral aspect of body, combined width of parr marks less than width of light interspaces; parr marks almost round . . . . <u>.Salmo gairdneri</u>

b. Colored spots (red or yellow) on lateral line, between or on parr marks, combined width of parr marks greater than or equal to width of light interspaces 4

4a. Pectoral fin long, as long as depressed dorsal fin; caudal fin deeply forked, center rays 50% length of longest . . . . .Salmo salar

b. Pectoral fin shorter than depressed dorsal fin; caudal fin not deeply forked, center rays greater than 50% length of longest. 5

5a. Black spots, in addition to parr marks, above and below lateral line; about 11 parr marks, none as wide as eye diameter; caudal fin truncate. . . . . Salmo trutta

b. No dark spots, other than parr marks, below lateral line; 8 to 9 wide parr marks, widest about equal to eye diameter, caudal fin rounded. . . . . Salvelinus fontinalis

6a. Parr marks absent. . . . . Oncorhynchus gorbuscha

b. Parr marks present. 7

7a. Parr marks small and oval, none much greater than eye diameter; marks on or above lateral line. . . . . Oncorhynchus nerka

b. Parr marks long and narrow, longest much greater than eye diameter. 8

8a. Adipose fin uniformly pigmented; anal fin with some dark pigment behind white leading edge, length of leading edge greater than length of fin base; spaces between parr marks wider than parr marks; parr marks divided equally by lateral line; caudal fin tips rounded . . . . Oncorhynchus kisutch

b. Adipose fin with unpigmented “window,” anal fin without dark pigment behind white leading edge, length of leading edge always less than length of fin base; parr marks wider than interspaces; parr marks usually three-fourths above lateral line; caudal fin tips pointed. . . . . Oncorhynchus tshawytscha

Coregonus artedii LeSueur, lake herring

DISTRIBUTION

Once common throughout the Great Lakes and inland lakes.[3]

SPAWNING SEASON

In the Great Lakes region spawning occurs between mid-November and mid-December.[2,3,5,6,9,10,11,13,16]

SPAWNING TEMPERATURE

Breeding migration to shallow water (1 to 3 m) begins at 5 C or less.[15] They arrive on spawning grounds when water temperatures reach 6 C and spawning occurs between 3 and 5 C.[2,4,5,8,10,15]

SPAWNING HABITAT

In inland lakes spawning has been observed at 0.5 to 3.5 m[2,6] and 2 to 5 m.[5] In Lake Superior at 14 to 36 m,[10] in Saginaw Bay at 5 to 14 m,[9] in Green Bay from 3 to 42 m.[11] Throughout the Great Lakes spawning usually occurs at 3 to 7.6 m.[16]

SPAWNING SUBSTRATE

These pelagic spawners[10,11] broadcast eggs which settle to the bottom[11] and are abandoned.[3] They spawn over mud,[6] sand[9,16] or gravel.[9]

FECUNDITY

4,314 to 10,250;[10,11] 13,723 to 48,999.[6,7,13,15]

EGGS

Demersal;[11] adhesive, chorion colorless;[18] egg yellow;' diameter 2 mm;[18] 2.1 mm (2.0 to 2.2 mm);'[17] 2.9 to 3.1 mm;[2] 100 to less than 200 spherical oil globules, oil globule diameter 0.2 mm, yolk yellow, pale yellow or amber, diameter 1.7 to 1.8 mm.[18]

Incubation period:

Temperature C	Days to Eye	Days to Hatch
0.5		236[2,4,12]
1.7		187[2,4]
2.3-6.0		96-103[5]
3.2-8.1	35'"	99(77-104)[18]
		146[2,4]
3.3-3.4		[4]
5.6		9274-85[4,12]
7.7-7.8		
8.9		60 [2,4,7,4,4]
9.9-10		37[2,4]
10.0	15[17]	37-49[17]

December 1 to February 19 at 6 C;[12] 10 to 12 weeks (in situ).[15]

YOLK-SAC LARVAE

Total length	Description
8.5-12.8 mm	Newly hatched, length dependent on water temperature.[2 4 17 18] Myomeres: total 46 to 48;[17] 50 (38 + 12);[14] 53 to 56 (35 to 38 + 18 to 19) at 8.5 to 10.0 mm.[18] Morphology: single oil globule present, single, pitted nares present[18] (9.5 mm);[17] fin rays begin to form on venter of caudal fin and anterior portion of pectoral fin, finfold deeply notched between dorsal and adipose fins, notochord straight (9.9 to 10 mm);[17 18] notochord begins to flex in caudal fin (12.2 mm);[17] lower jaw even with anterior margin of eye.[18] Pigmentation: body pale yellow or off-white, line of melanophores along gut, several large melanophores on dorsum of head and on posterior portion of yolk sac, irregular line of melanophores on either side of dorsal finfold, largest melanophore is half the width of one myomere, eye pigmented.[18]

LARVAE

Total length	Description
13 mm	Morphology: yolk and oil globules absorbed[18] or almost absorbed;” urostyle slightly flexed, caudal fin rays eight, pelvic buds appear.” [18]. Pigmentation: melanophores on dorsal and ventral finfolds, on intestine and an oval patch on dorsum of head.[18]
18-20 mm	Morphology: 33 days old;[18] 10 or 11 dorsal fin rays, 11 anal fin rays, caudal fin forked and 18 rays, pelvic fins begin to show thickening but not yet rayed.[17 18] Pigmentation: little change from previous stage, dorsal melanophores increase in size from half to entire width of one myomere.[18]
20-24 mm	Morphometry: predorsal length less than or equal to 50% SL.[17]
20-24 mm	Morphology: swim bladder well developed, scales not yet developed, fin ray development incomplete: caudal 24, dorsal 11, anal 13, pectoral 10 and pelvic 9.[17]

JUVENILES

Total length	Description
23-55 mm	Morphology: all fin rays developed;[17,18] lower jaw terminal, swim bladder evident;‘* scales first appear (34 mm);[1] row of vomerine teeth apparent (39.5 mm);[18] fully scaled (55 mm).[1] Pigmentation: melanophores more numerous on posterior half of lateral line and on dorsum above lateral line, largest melanophore half the width of one myomere, margin of gill arches pigmented, heart-shaped pattern of pigmentation on head (39.5 mm), stellate melanophores along and just below lateral line, caudal and dorsal fins with pigmentation.[18]

ADULTS

Fin rays: caudal 28;[17] dorsal 10 to 15, anal 11 to 15;[3,15] pectoral 14 to 18, pelvic 11 to 12.[3]

Vertebrae: 50 to 63.[3,15]

Lateral line scales: 63 to 97;[3,15] 77 to 87 (64 to 105).[16]

Gill rakers: 38 to 64;[3] 46 to 50 (38 to 55).[16]

Diagnostic characters: lower jaw protruding slightly, gill rakers usually greater than 45, premaxillae and upper portion of body moderately dark; 45 to 50 long, slender gill rakers; mature specimens usually 450 mm TL.

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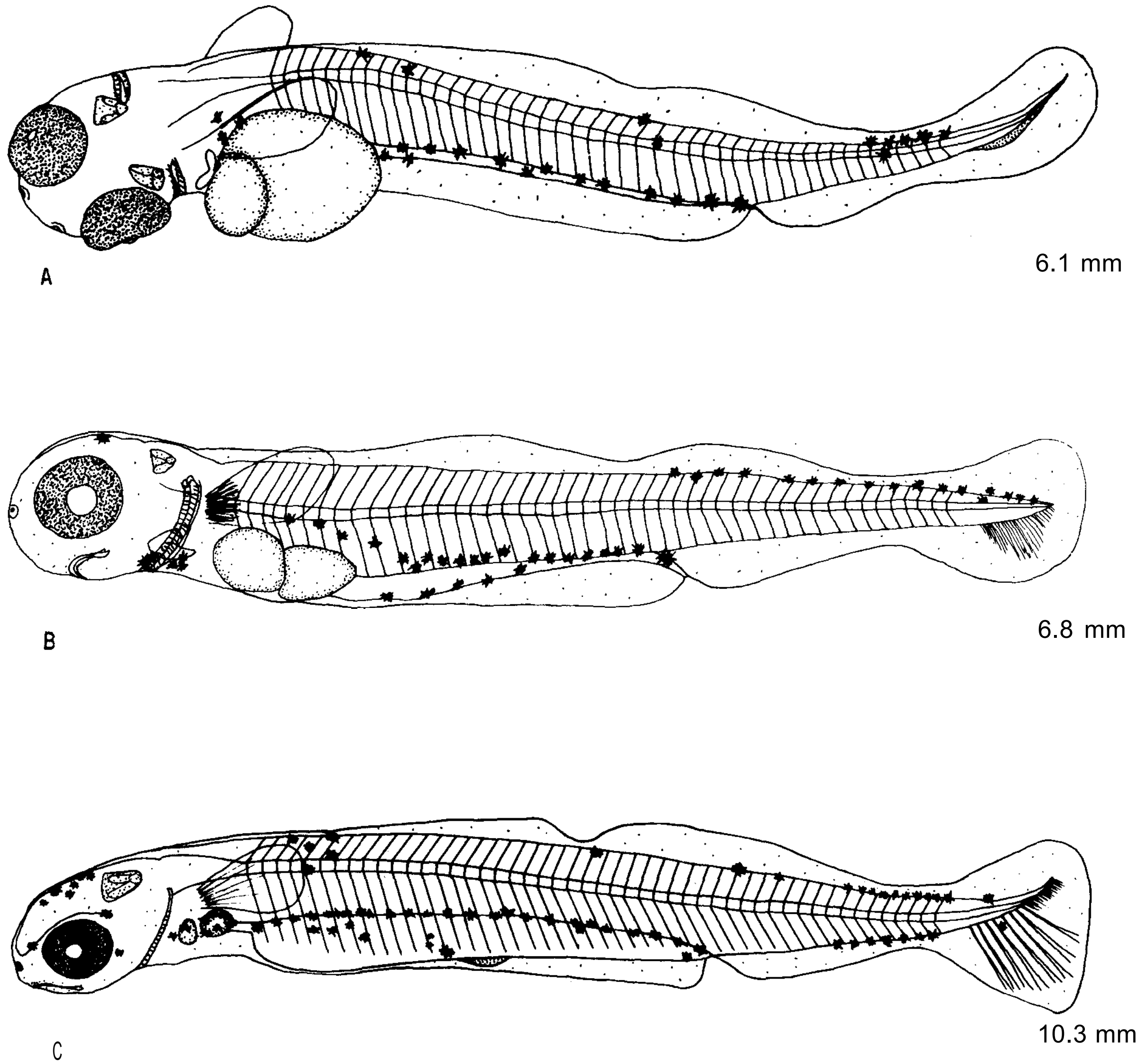

Fig. 23. Coregonus artedii, lake herring. A-C. Yolk-sac larvae. (Laboratory-reared, Wisconsin, Hinrichs 1979.)

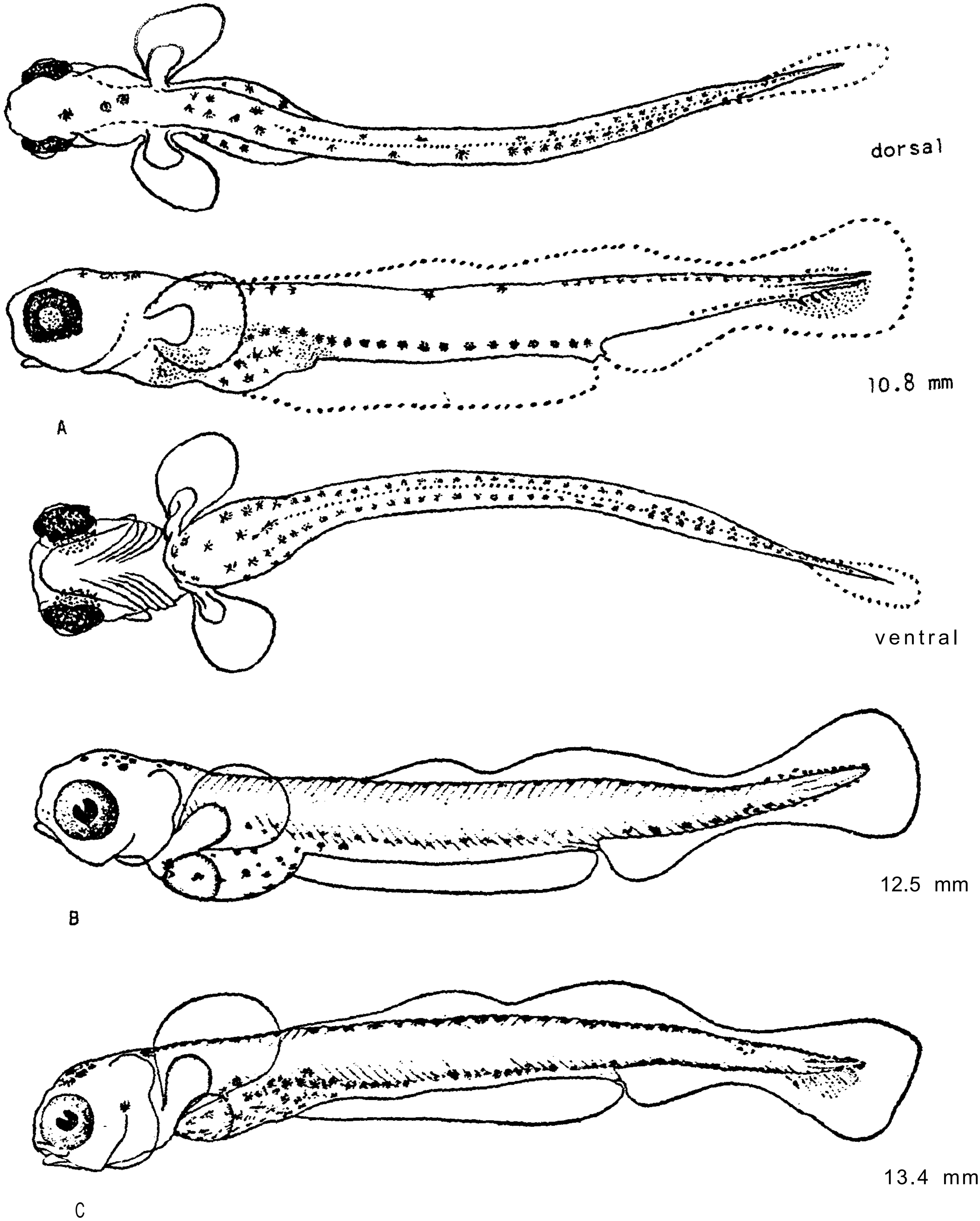

Fig. 24. Coregonus artedii, lake herring. A-E. Yolk-sac larvae. (A-C wild caught, Lake Huron, Faber 1970, National Museum Canada, Ottawa; D and E, hatchery-reared, Lake Erie, Fish 1932).

Coregonus artedii

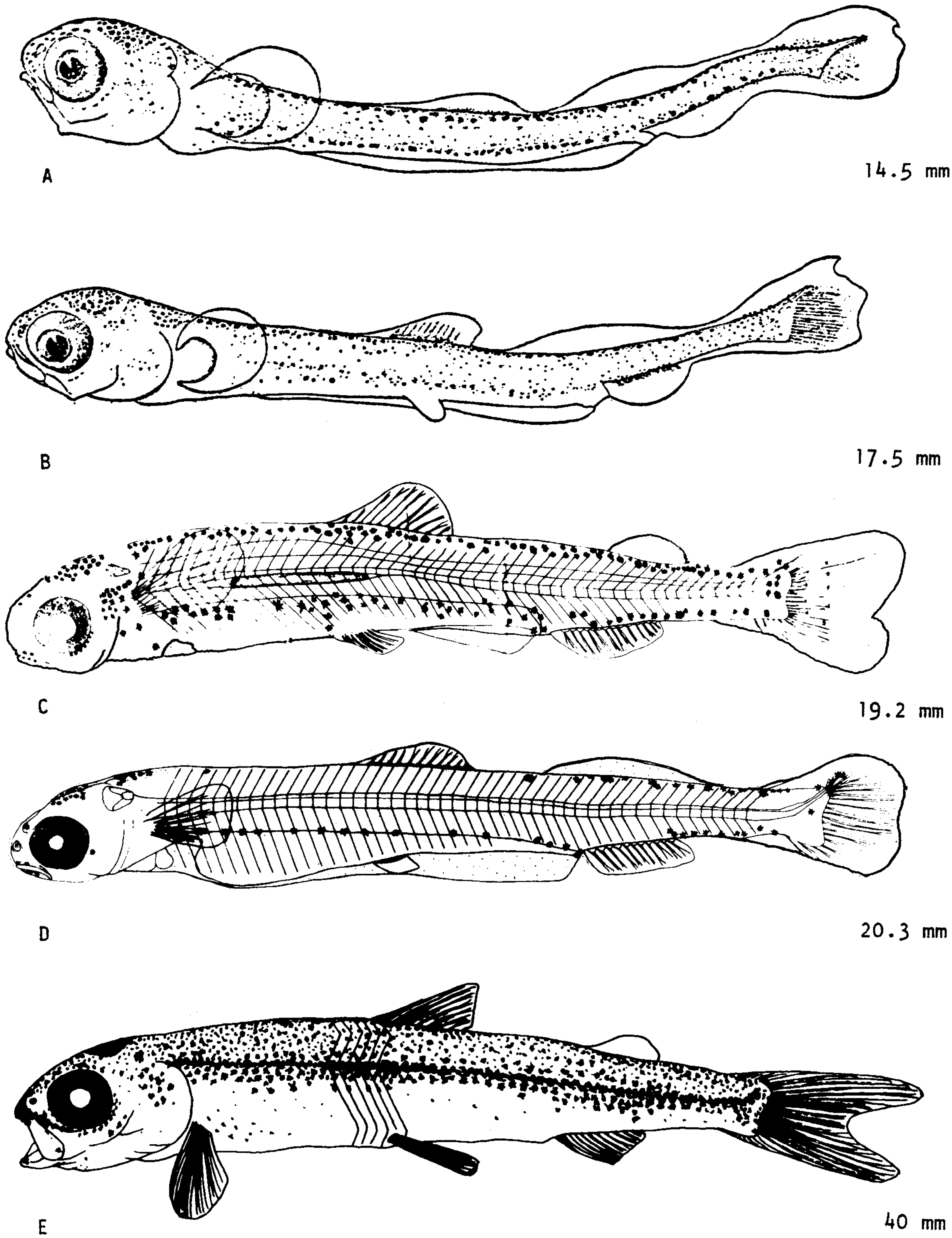

Fig. 25. Coregonus artedii, lake herring. A-D. Larvae. E. Juvenile. (A and B, hatchery-reared, Lake Erie, Fish 1932; C-E, laboratory-reared, Wisconsin, Hinrichs 1979).

Coregonus clupeaformis (Mitchill), lake whitefish

DISTRIBUTION

Occurs in varying abundance in all of the Great Lakes.3

SPAWNING SEASON

Migration to spawning grounds begins in October." In the Great Lakes region spawning commences in mid- to late November[5 6 16 18 21] and continues into December.[2 22 23] In northern Canada spawning occurs from October to December' [9 10 13] and in late October in northern Lake Michigan.[20]

SPAWNING TEMPERATURE

Spawns at temperatures between 4 and 12 C.[5 8 10 11 21] Peak spawning occurs at 8 C,[11] or below 7.8 C.[23]

SPAWNING HABITAT

Spawns at depths less than 7.6 m,[2 10] between 1.6 and 18.2 m,[22] but most commonly at 2.4 m.[21]

SPAWNING SUBSTRATE

Eggs are broadcast over silt and aquatic plants,' sand,[10 21] gravel or stones 5 to 91 cm in diameter,[21 22] rubble, boulders,[10] honeycomb rock,[22] or on rocky offshore reefs.[23]

FECUNDITY

11,112 to 121,700.[1 9 10 15 16 17]

EGGS

Demersal;' slightly adhesive;[23] orange-yellow;[12] chorion colorless;[21] diameter 2.4 to 2.6 mm;[7] 3.0 mm ± 0.1;[12] 2.8 mm (2.3 to 3.0 mm);[23] oil globules number between 100 and 200, diameter of largest 0.2 mm, yolk amber, diameter 2.0 mm (1.8 to 2.1 mm).[23]

Incubation period:

Temperature C	Days to Eye	Days to Hatch
(in situ)		130-149[8]
(in situ)		107-231[10]
(in situ)	40[21]	139[21]
(in situ)		61 (155-170)[18 20]
0.5		1415
1.5-1.7		131-140[3 4 13]
2.0		121-193[5 10 14]
3.2-8.1		65 (56-79)[23]
4.0		80.3-156[5 10 14]
5.5-5.9		81.5-135[11 14]
6.0		58[5]

7.8 59[14]
10.0 41.7[14]

Mid-November to early or late April;' 23 weeks (November 1 to April 1 10);[21] November 10 to April 20 in Green Bay.[18 20]

YOLK-SAC LARVAE

Total length	Description
8.8-15 mm	Newly hatched, 12 to 13 mm[3 5 10 11 14 10 19 20 21 23] most often reported.
11-14 mm	Myomeres: 52 (39 + 13) at 13.6 mm.[6] Morphometry: (as % TL) preanal length 63 to 68, greatest body depth 9 to 11, body depth at anus 6 to 7, head length 13, head depth 9 to 11, eye diameter 5 to 6, snout length 2, dorsal origin of median finfold 20 to 30, snout to pectoral fin insertion 14 to 15.[21] Morphology: oil globule large and single, near anterior portion of yolk sac, mouth subterminal;[21 23] snout barely extends beyond eye;[21] pectoral buds present, large and ovate;[21 23] pelvic buds not evident;[21] caudal fin rays 10 (13.7 mm) .[23] Pigmentation: body pale yellow or off-white;[23] well developed melanophores on dorsum of head, over cranium and between eyes, two bilateral symmetric lines along either side of dorsal median finfold, square, stellate dorsal melanophores paired across finfold, largest greater than width of one myomere, a few melanophores scattered over yolk sac becoming more numerous on mid-lateral line, yolk sac vaguely outlined with melanophores, pigment along both sides of finfold from yolk sac to anus, on dorsum of gut continuing back along either side of finfold to caudal fin;[21 23] pigmentation around urostyle;[23] a few chromatophores extend along posterior margins of opercula and just posterior to pectoral fins.[21]

LARVAE

Total length	Description
14-16 mm	Morphometry: (as % TL) preanal length 63 to 74, greatest body depth 7 to 12, head length 14 to 17, head depth 10 to 13, eye diameter 7 to 8, snout length 2, snout to dorsad median finfold 23 to 30, snout to ventrad median finfold 26 to 38, snout to pectoral fin 17 to 21, snout to pelvic fin 48 to 52, snout to adipose fin 74.[21] Morphology: yolk absorbed[18 21] (3.5 to 4.5 weeks posthatching) ;[18 20] urostyle flexion beginning, maxilla extends to middle of eye, 13 to 16 caudal fin rays, 11 and 12 dorsal and anal fin rays respectively.[21]

Pigmentation: additional pigment on dorsum of head to anterior margin of eye, some melanophores on snout, premaxilla, maxilla, operculum and lower jaw, two faint rows of pigment along anterior edge of mandible, scattered chromatophores extend posteriorly to isthmus, chromatophores concentrated at posterior and ventral margins of eyes and posterior angle of operculum, double row of pigment on dorsum consists of large and small melanophores, little pigment between the dorsal rows and dorsum of head, chromatophores extend from between pectoral fins to origin of preanal finfold then continue on either side of finfold to anus.[21]

18-25 mm

Morphometry: (as % TL) preanal length 67 to 69, greatest body depth 11 to 17, head depth 11 to 12, head length 18 to 19, eye diameter 7, snout to dorsad median finfold 33, snout to ventrad median finfold 35 to 38, predorsal length 42 to 49, snout to adipose fin 72 to 73, snout to anal fin 68 to 69, snout to pectoral fin 19 to 20, snout to pelvic fin insertion 45 to 49, snout to highest point on dorsal fin greater than or equal to 50% SL.[21]

Morphology: 11 to 12 dorsal fin rays, 9 to 12 anal fin rays, 8 to 17 caudal fin rays;[21] 23 caudal fin may have three lobes, (two develop as result of fork in homocercal tail, another separates the isocercal and rayed portions of the membrane), mouth distinctly inferior as in adult (20 mm);[21] preanal finfold present from pelvic fin insertion to anus.[23]

Pigmentation: increased 'pigmentation;" pigment on premaxillae increases, three rows of pigment on mandible, a concentration of chromatophores at angle of operculum and along ventral margin of eye, these eventually continuing al 1 around eye, melanophores usually square and paired across dorsum becoming indistinguishable, two lines of internal melanophores form a "V," with the closed end just posterior to the anus and the open end in the region of the yolk sac, increase in mid-ventral pigment posterior to pelvic fin insertion and posterior to anus;[21] a few melanophores on caudal fin rays (23 mm) . 23

JUVENILES

Total length	Description
34-54 mm	Morphometry: (as % TL) standard length 85, preanal length greatest body depth 16, head depth 10, head length 21: eye diameter 6, snout length 8, predorsal length 40, snout to adipose fin 57, snout to anal fin 65, snout to pectoral fin 21, snout to pelvic fin 45.[21] Morphology: remnant finfold just anterior to anus, fully scaled (54.0 mm) .[21]

Pigmentation: body pigmented except for belly, parr marks evident (45.4 mm).[21]

ADULTS

Fin rays: caudal 19;* dorsal 11 (10 to 13), anal 11 (10 to 14), pectoral 15 to 16 (14 to 17), pelvic 11 (10 to 12).[2, 22]

Vertebrae: 55 to 64.[2]

Lateral tine scales: 81 to 88 (70 to 97)[1, 2, 22]

Gill rakers: 26 to 28 (19 to 33).[2, 22]

Diagnostic characters: mouth subterminal, snout rounded, gill rakers usually greater than 20 but less than 32 (not as long and slender as 5. artedii or 5. hoyi but longer and thinner than those of Prosopium cylindraceum), lateral line scales usually less than 85.

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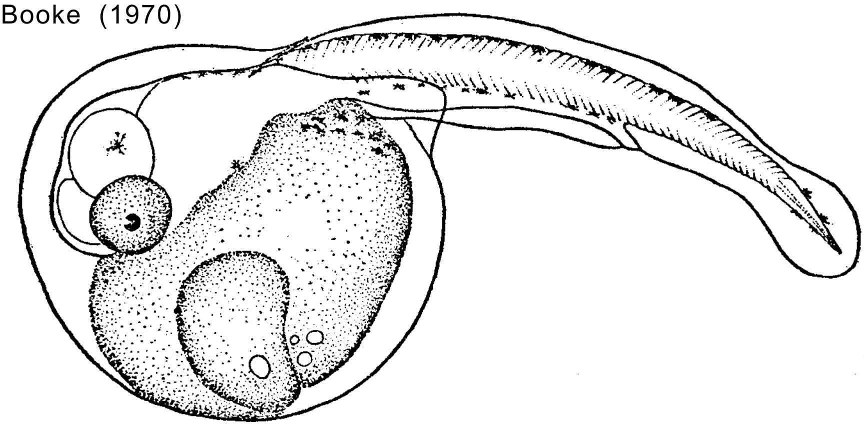

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Fig. 26. Coregonus clupeaformis, lake whitefish. Yolk-sac larva. (Laboratory-reared, New York, Fish 1932).

Coregonus clupeaformis

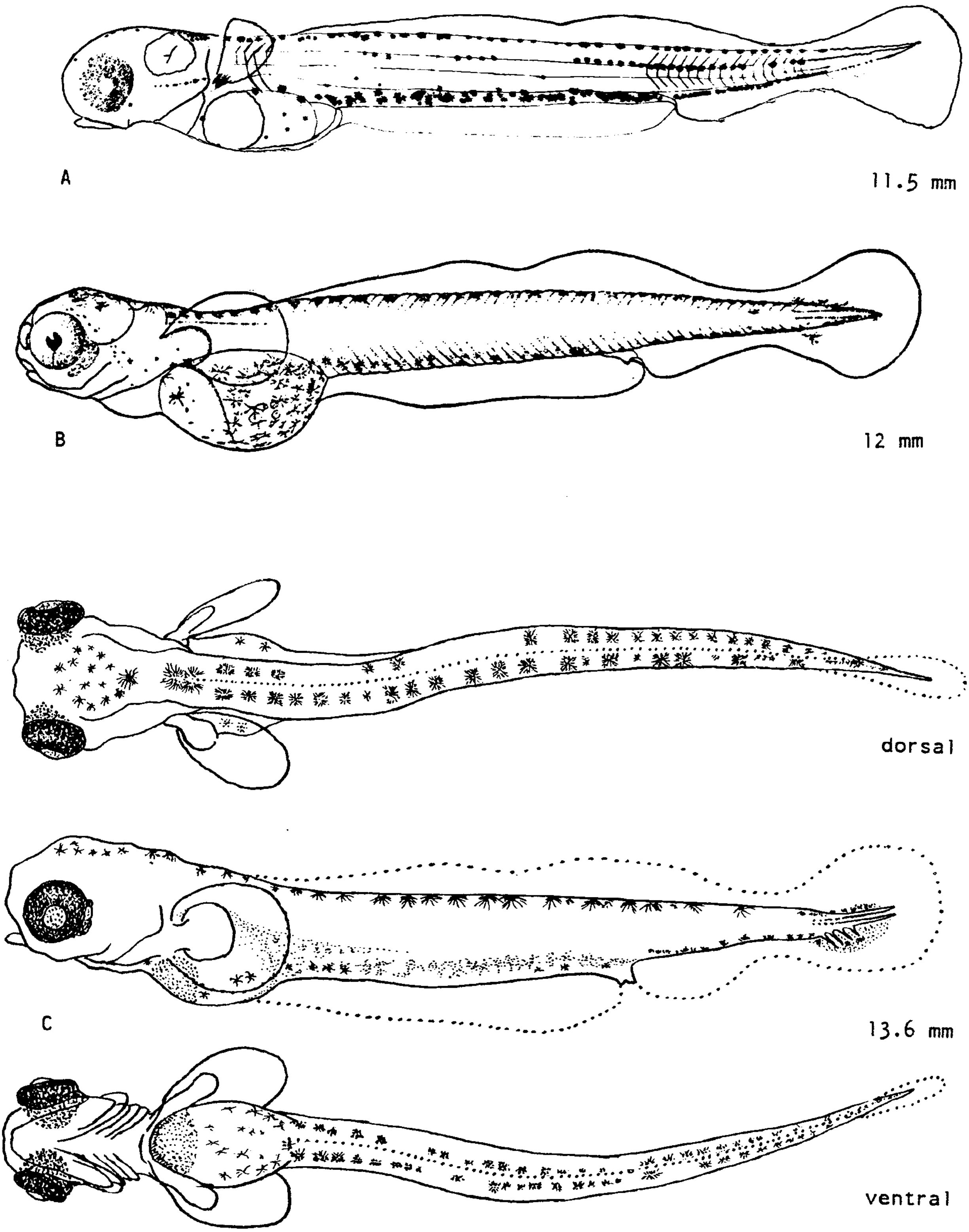
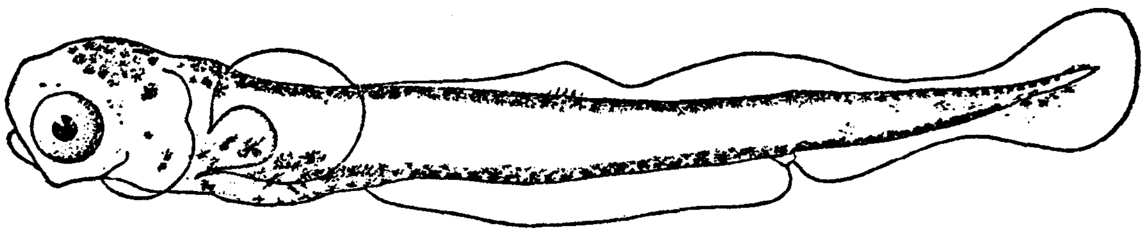
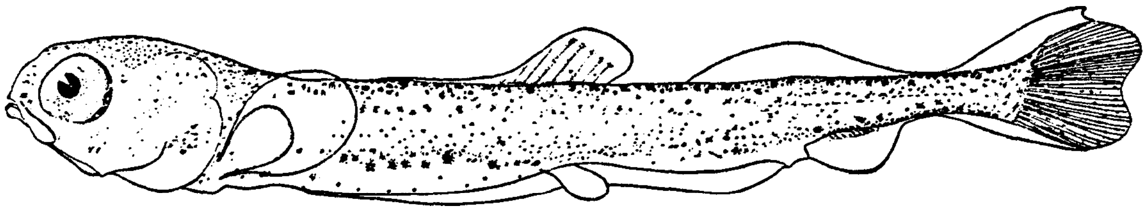


Fig. 27. Coregonus clupeaformis, lake whitefish. A-C. Yolk-sac larvae. (A, laboratory-reared, Wisconsin, Hinrichs 1979; B, laboratory-reared, New York, Fish 1932; C, wild-caught, Lake Huron, Faber 1970, National Museum Canada, Ottawa) .



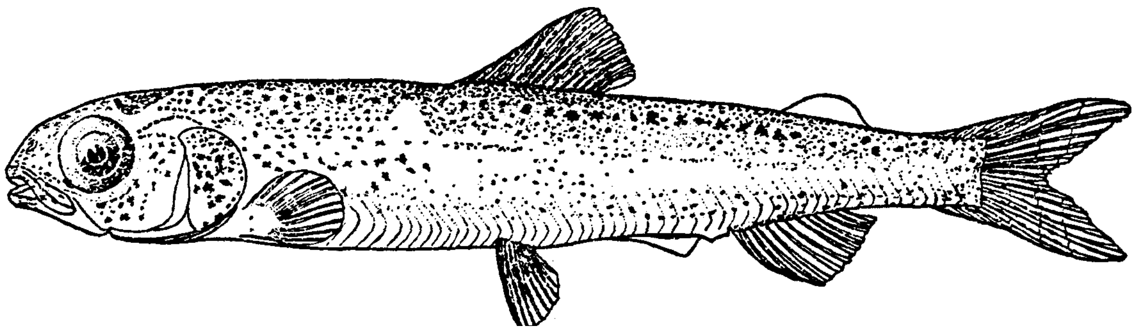
A

13.5 mm



B

18.5 mm



C

31.5 mm

Fig. 28. Coregonus clupeaformis, lake whitefish. A-C. Larvae. (A-C, laboratory-reared, New York, Fish 1932).

Coregonus hoyi (Gill), bloater

DISTRIBUTION

Endemic to all of the Great Lakes.' Due to reproductive plasticity and commercial fishing pressure current status of the populations is changing. Is now present only in the upper three Great Lakes.[1 6]

SPAWNING SEASON

Spawning usually takes occurs in February and March in the upper three Great Lakes.[1 2 5 6]

SPAWNING TEMPERATURE

Not reported.

SPAWNING HABITAT

Spawns at 36 to 91 m;[1] 51 m[5] in the Great Lakes proper.

SPAWNING SUBSTRATE

Not reported.

FECUNDITY

6,533 (3,116 to 12,045).[2]

EGGS

Adhesive, diameter 1.9 mm (1.8 to 2.1 mm),[6] 1.97 ± 0.02 mm, yellow;[3] chorion colorless, oil droplets number from 100 (0.1 mm diameter) to less than 25, yolk pale yellow to amber, diameter 1.6 mm (1.4 to 1.6 mm), incubation period: 84 days at 3.2 to 8.1 C.[6]

YOLK-SAC LARVAE

Total length	Description
10-11 mm	Recently hatched.[6] Myomeres: 52 (37 + 15);[4] 50 to 52 (32 to 34 + 16 to 18).[6] Morphometry: (as % TL for 9-mm specimens) yolk-sac length 22 (reduces to 15 at 10.1-mm), head length 17, predorsal length 44, snout to adipose fin 59.[6] Morphology: urostyle flexed, lower jaw extends to anterior margin of eye, single oil globule now present (11.3 mm).[6] Pigmentation: body pale yellow or off-white, a few stellate melanophores on yolk sac, oval patch on dorsum of head, irregular pattern across dorsal median finfold, near urostyle and on venter posterior to anus,

stellate melanophores on posterior half of yolk sac and "interlaced" along gut, largest dorsal melanophore greater than the width of one myomere.[6]

LARVAE

Total length	Description
15-20 mm	Morphology: yolk absorbed, 13 caudal fin rays, adipose and dorsal fins nearly separate, lower jaw extends forward to snout tip (15 to 16 mm), swim bladder filled, preanal finfold origin posterior to that of dorsal fin, 18 caudal, 9 dorsal and 13 anal fin rays (20 mm).[6] Pigmentation: melanophores equal to or greater than width of one myomere, pigment increased from previous stage especially along intestine, large stellate melanophores along lateral line and intestine, contracted melanophores on dorsum and caudal fin, about 20 me 1 anophores on dorsum of head, pigment on gill arches and tip of lower jaw.[6]
25 mm	Myomeres: (35 to 38 + 15 to 16).[6] Morphometry: lower jaw length equal to snout length, predorsal length greater than 50% TL.[6] Morphology: finfolds absorbed, 21 caudal, 12 dorsal, 13 anal and 10 pectoral fin rays.[6] Pigmentation: heart-shaped group of melanophores on dorsum of head, gradation from stellate to contracted melanophores from dorsum to below lateral line.[6]

JUVENILES

Total length	Description
45 mm	Pigmentation: two bands of pigment, one along lateral line from operculum to caudal peduncle, the other on dorsum from base of skull to caudal peduncle, venter immaculate between pectoral fin insertion and anus.[6]

ADULTS

Fin rays: caudal 19* or 21;[6] dorsal 9 to 11, anal 11 (10 to 13), pectoral 15 to 16 (14 to 17), pelvic 11 (10 to 12).[1] [5]

Vertebrae: 55 to 57.[1]

Lateral line scales: 63 to 89;[1] 67 to 77 (60 to 85).[5]

Gill rakers: 37 to 48;[1] 41 to 44 (37 to 50).[5]

Diagnostic characters: distinctly protruding lower jaw, terminal mouth, 37 to 48 long slender gill rakers, premaxilla lightly pigmented, upper portion of body dusky, total length usually less than 200 mm.

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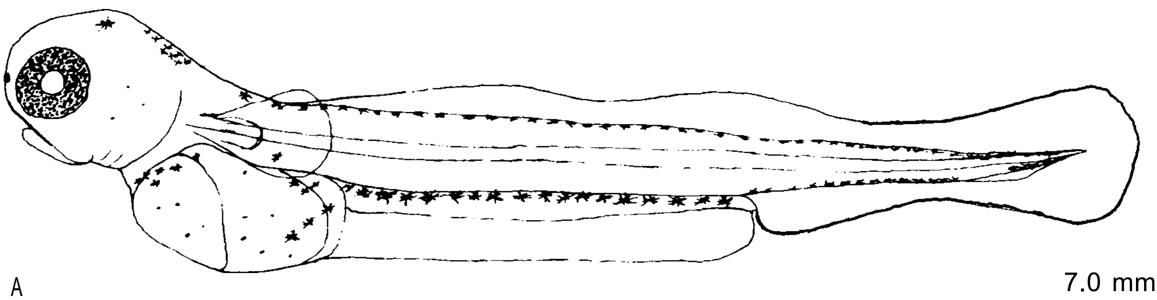
6. Hinrichs (1979)



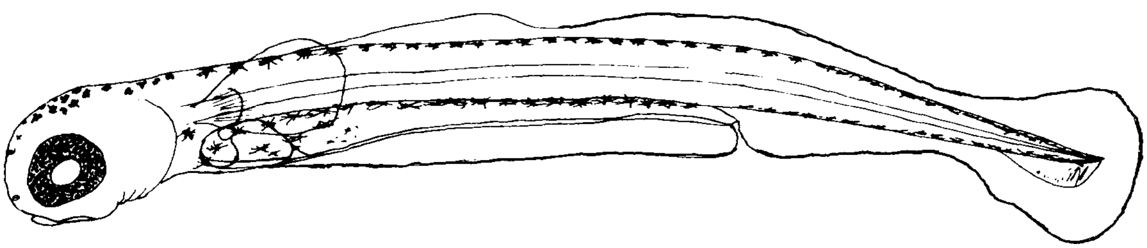


Fig. 29. Coregonus hoyi, bloater. A and B. Yolk-sac larvae. (Laboratory-reared, Wisconsin, Hinrichs 1979).

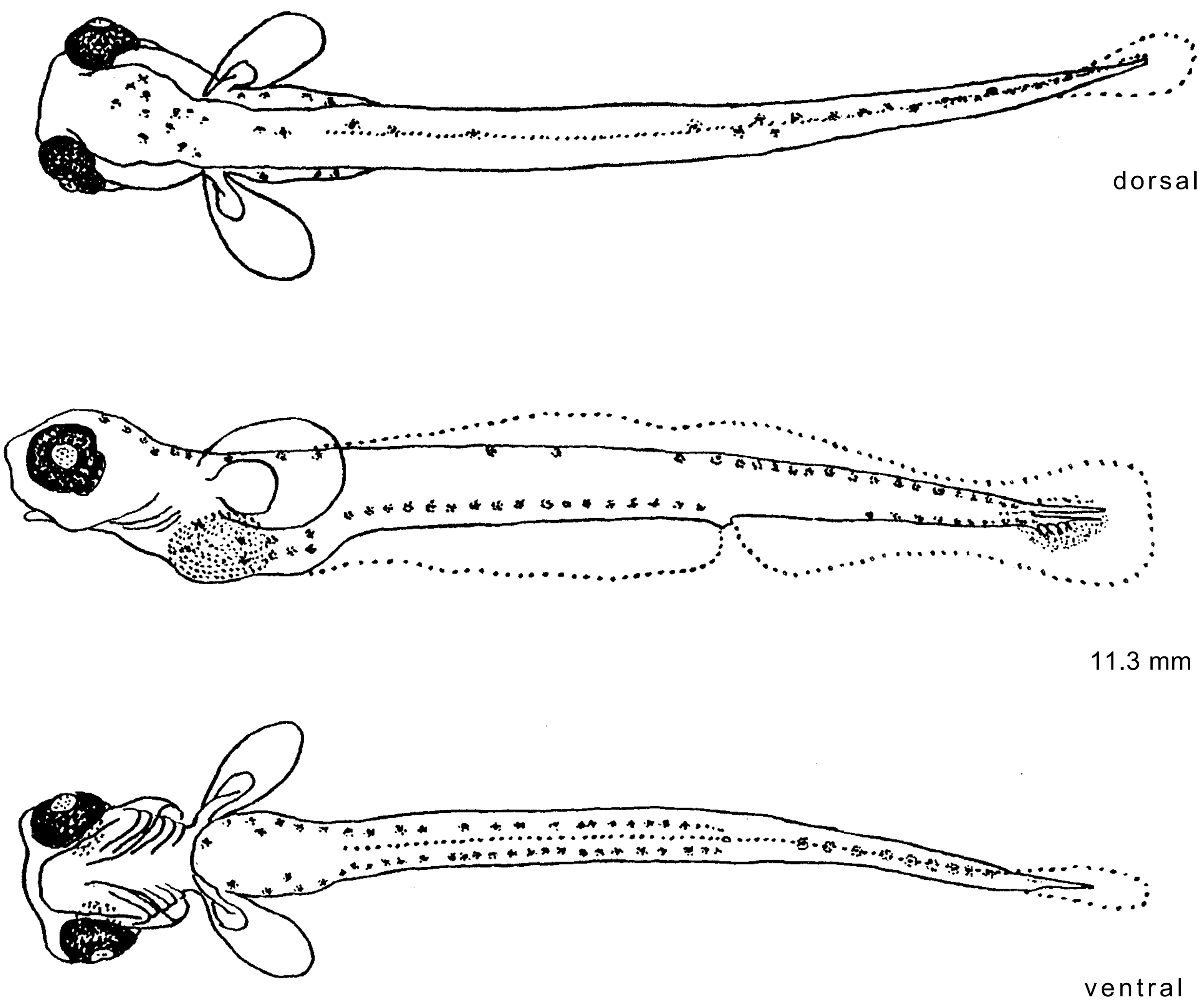


Fig. 30. Coregonus hoyi, bloater. Yolk-sac larva. (Wild-caught, Lake Michigan, Faber 1970, National Museum Canada, Ottawa).

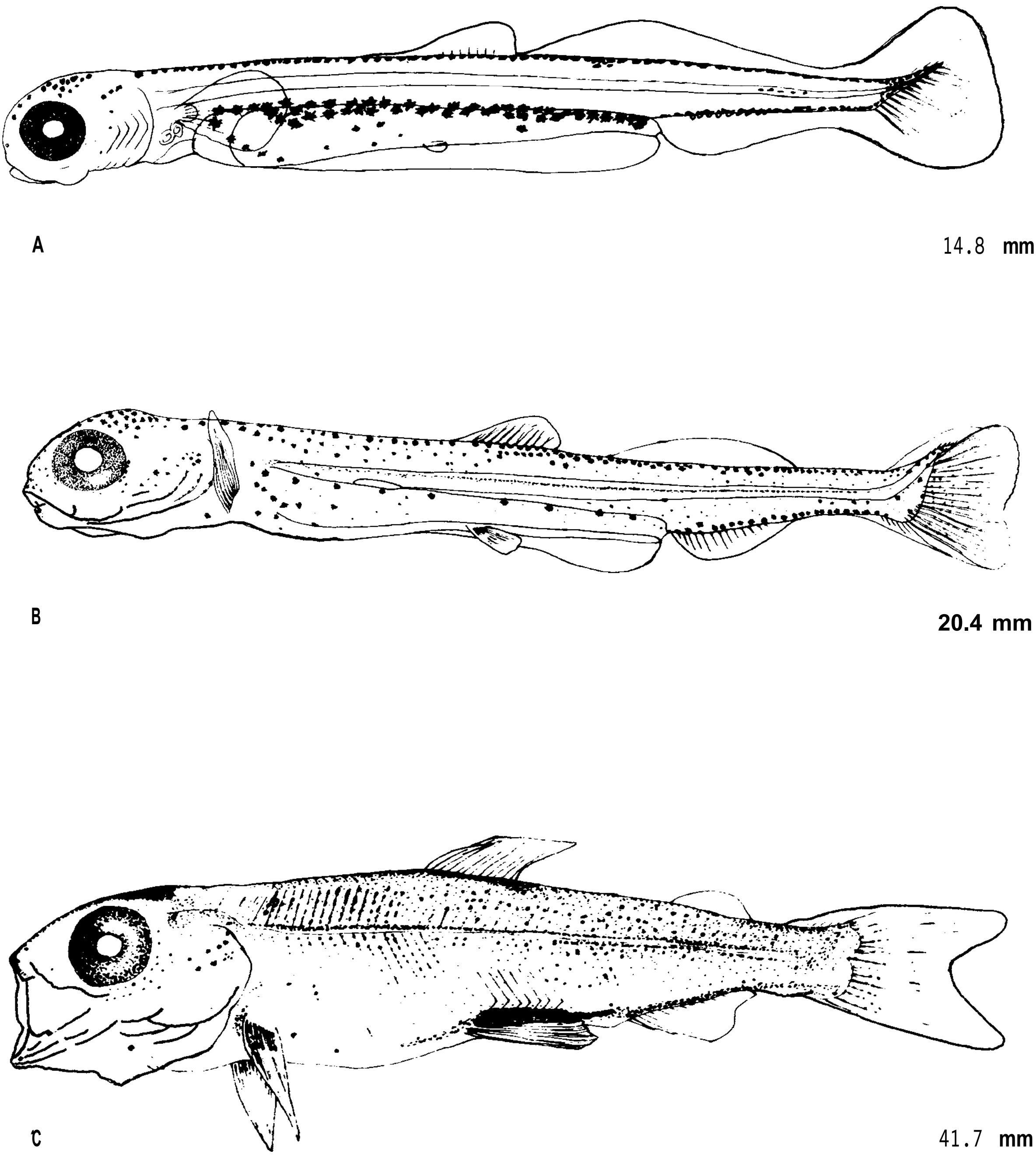


Fig. 31. Coregonus hoyi, bloater. A and B. Larvae. C. Juvenile. (A-C, laboratory-reared, Wisconsin, Hinrichs 1979).

Oncorhynchus gorbuscha (Walbaum), pink salmon

DISTRIBUTION

Introduced into Lake Superior in 1956.[3, 8] Naturally reproducing in Lakes Superior[6] and Huron,[5] spawning runs have been observed in all five Great Lakes.*[9]

SPAWNING SEASON

Spawns from mid-July to late October' in Lakes Huron[5] and Superior.[8] *

SPAWNING TEMPERATURE

Spawning has been reported at water temperatures of 11 to 13 C.[7, 6]

SPAWNING HABITAT

Migrates upriver to spawn.'[8]

SPAWNING SUBSTRATE

Spawns over gravel less than 5 cm in diameter,'[6] at upstream end of riffles in water 22 to 110 cm deep.[8] Redds from 50 to 80 cm wide and 80 to 120 cm long are constructed where water velocities are 4.6 to 15.5 cm/s.[8]

FECUND ITY

1,077.'

EGGS

Orange-red;[2] diameter 6.4 mm;[7] incubation period: September and October to April (in situ).[8]

YOLK-SAC LARVAE

Newly hatched (26 mm).[7]

LARVAE

Newly emerged, black pigment, no parr marks (30 mm).[7]

JUVENILES

Parr marks absent.'

ADULTS

Fin rays: caudal 19;* dorsal 10 to 15, anal 13 to 19, pectoral 14 to 17, pelvic 9 to 11.[1]

Vertebrae: 63 to 72.[1]

Lateral line scales: 147 to 205.[1]

Pyloric caeca: 95 to 224.[2]

Diagnostic characters: large, black spots (some as large as eye) on dorsum and caudal fin, lateral line scales usually 147 to 205, gill rakers usually 26 to 34.

LITERATURE CITED

1. Scott and Crossman (1973)
2. McPhail and Lindsey (1970)
3. Wagner (1978)
4. Kwain and Chappel (1978)
5. Collins (1975)
6. Parsons (1973)
7. W. Kwain (pers. Comm.)
8. Kwain and Lawrie (1981)
9. Emery (1981)

Oncorhynchus kisutch (Walbaum), coho salmon

DISTRIBUTION

Introduced into all of the Great Lakes[9] and some inland lakes of the basin.' It is reproducing naturally in Lakes Superior,[6] Michigan[6] and Huron.[9]

SPAWNING SEASON

Spawns from early September to early October in the upper three Great Lakes.'

SPAWNING TEMPERATURE

Not reported.

SPAWNING HABITAT

Migrates upriver to spawn.[1]

SPAWNiNG SUBSTRATE

Spawns over gravel areas.'

FECUNDITY

2,016 to 2,518 (Lake Superior), 2,643 to 3,553 (Lake Michigan).[6]

EGGS

Demersal, red-orange, incubation period: eggs incubate all winter, fry emerge from March to late July;[1] 60 to 63 days at 7 C;[2] 48 days at 8.9 C;[1] 36 days at 10 C;[4] 38 days at 10.7 C.[1]

NATURAL HYBRIDS

Oncorhynchus tshawytscha."

YOLK-SAC LARVAE

Total length	Description
16.0-18.2 mm	Newly hatched.[4] * Myomeres: body too opaque to observe myomeres.* Morphometry: (as % TL) preanal length 63 to 68, body depth at anus 12 to 13, head length 19 to 21, snout length 3, eye diameter 9, yolk-sac length 46 to 61, yolk-sac depth 28 to 36.* Morphology: eyes fully developed;' finfold continuous, pelvic and pectoral buds present, dorsal fin partially differentiated, actinotrichia present in dorsal and anal fins, 11 caudal fin rays (18 mm).*

Pigmentation: eyes pigmented, a few melanophores on snout, dorsum of brain and yolk sac (18 mm).*

25-29 mm

Morphometry: (as % TL) preanal length 59 to 61, body depth at anus 14 to 16, head length 22 to 23, snout length 3 to 5, eye diameter 5 to 9, yolk-sac length 25 to 34, yolk-sac depth 15 to 23.*

Morphology: finfold continuous, 12 dorsal, 14 anal and 10 pectoral fin rays, adipose fin differentiated, nares developed (26 mm) .*

Pigmentation: snout, dorsal and lateral surface of head pigmented, melanophores evenly distributed over entire body but absent from lower jaw to anus, melanophores present on entire interradial membrane of dorsal, anal and caudal fins, concentrated between tips of first few rays of dorsal fin, pigment also present at base of finfold membrane along entire dorsum, concentrated at base of adipose and between adipose and caudal fins (26 mm) .*

30-33 mm

Morphometry: (as % TL) preanal length 59 to 62, body depth at anus 14 to 16, head length 21 to 24, snout length 4, eye diameter 8 to 9, yolk-sac length 21 to 24, yolk-sac depth 9 to 14.*

Morphology: finfolds absorbed except preanal portion, median fin rays complete (32 mm).*

Pigmentation: parr marks 9 to 10, pigment more dense on snout and over brain, melanophores evenly distributed elsewhere on body, becoming more dense on dorsum, adipose and membrane above and below caudal peduncle pigmented, melanophores concentrated between distal tips of first few dorsal fin rays, decreasing toward poster i or portion of fin, melanophores restricted to interradial membrane in center of anal fin and concentrated near tips of first three rays, melanophores restricted to interradial membrane of proximal portion of caudal fin (32 mm).*

LARVAE

Total Length	Description
33-49 mm	Morphometry: (as % TL) preanal length 54 to 58, body depth at anus 15 to 18, head length 22 to 25, snout length 3 to 5, eye diameter 8 to 9.* Morphology: yolk absorbed; * (28 days posthatching;' 134 days postfertilization at 4.5 C and 92 days postfertilization at 10.5 C[8]); finfold absorbed except preanal portion, all fin rays formed (37 mm).* Pigmentation: melanophores evenly distributed over body, 11 parr marks, several smaller marks present on dorsum, pigment concentrated over snout, on dorsum of brain, on dorsum between dorsal and adipose fins and between

adipose and caudal fins, entire interradial membrane pigmented on dorsal, caudal and anal fins with melanophores concentrated near tips of first few rays of anal fin and along first half and between base of last two dorsal fin rays (37 mm).*

JUVENILES

Morphometry: leading edge of anal fin greater than length of fin base.[11]

Pigmentation: yellow-brown with dark brown back, parr marks narrow and dark brown, fins bright orange, height of dorsal and anal fins greater in coho than chinook salmon, leading edge of dorsal fin is black proximally and white distally at emergence, two weeks after emergence coloration more vivid, leading edge white, backed by black with the rest of the fin orange, anal fin similarly colored.[10]

ADULTS

Fin rays: caudal 19;* dorsal 9 to 12, anal 12 to 17;[1,2] pectoral 13 to 16, pelvic 9 to 11.[1]

Vertebrae: 61 to 69.[1]

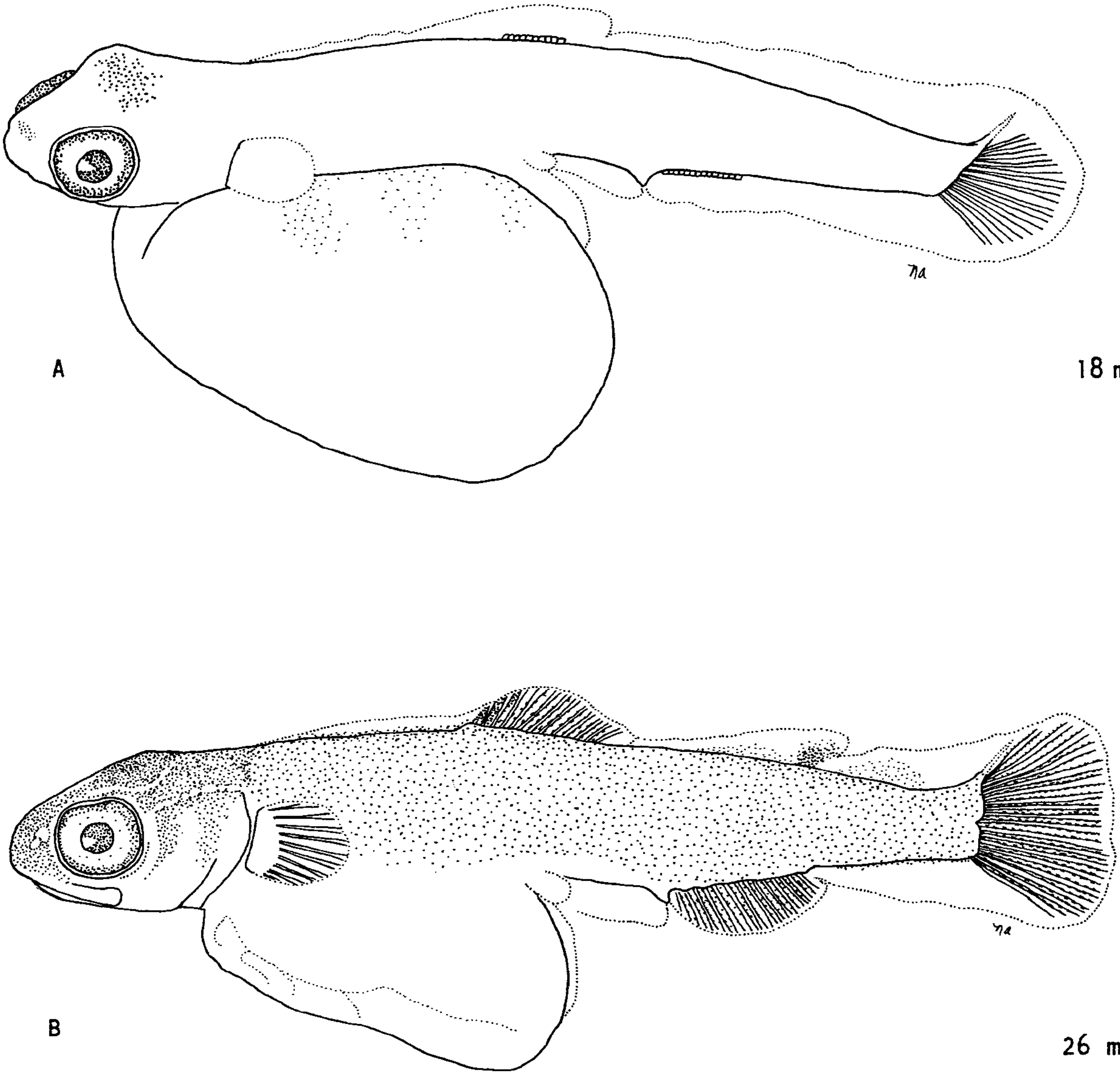
Lateral line scales: 121 to 148.[1]

Pyloric caeca: 45 to 114.[3]

Diagnostic characters: anal fin with greater than 12 rays, small dark spots on dorsum and only upper half of caudal fin, pyloric caeca usually less than 85, fleshy gums of lower jaw not black, gill rakers usually 19 to 25.

LITERATURE CITED

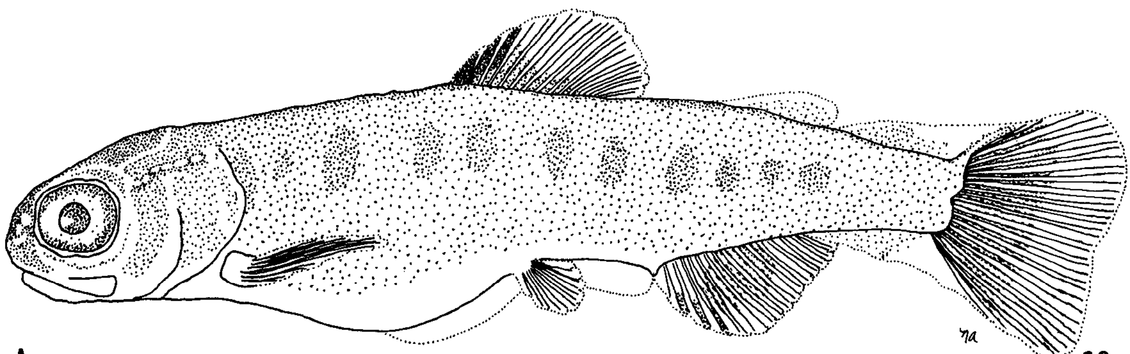
1. Scott and Crossman (1973)
2. Siefert and Spoor (1974)
3. McPhail and Lindsey (1970)
4. Zeitoun and Tack (1974)
5. Bonham and Seymour (1949)
6. Stauffer (1976)
7. Avery (1973)
8. Brannon et al. (1976)
9. Parsons (1973)
10. Stein et al. (1972)
11. Decker et al. (1978)



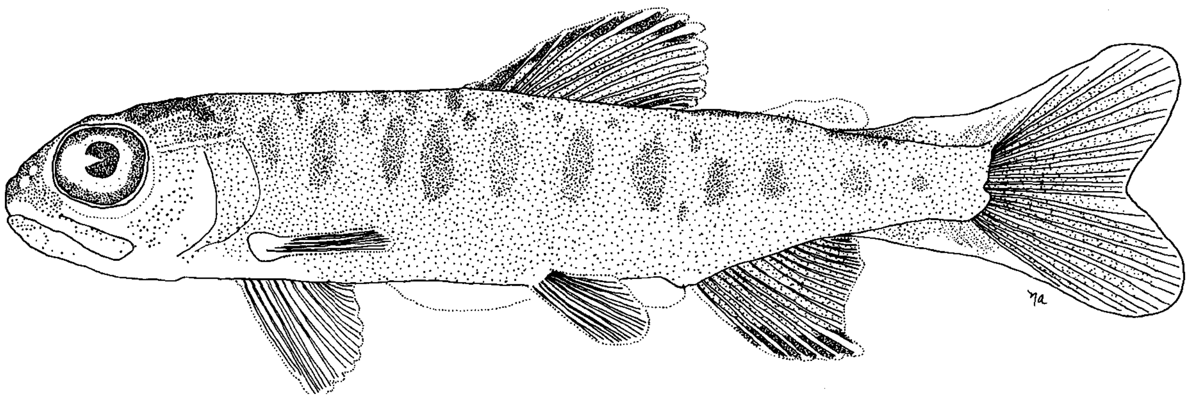
A 18 mm

B 26 mm

Fig. 32. Oncorhynchus kisutch, coho salmon. A and B. Yolk-sac larvae. (A and B, laboratory-reared, Wisconsin, original illustrations by N. A. Auer. specimens provided by F. P. Binkowski, Center for Great Lakes Studies: University of Wisconsin-Milwaukee).



A 32 mm



B 37 mm

Fig. 33. Oncorhynchus kisutch, coho salmon. A. Yolk-sac larva. B. Juvenile. (A and B, laboratory-reared, Wisconsin, original illustrations by N. A. Auer, specimens provided by F. P. Binkowski, Center for Great Lakes Studies, University of Wisconsin-Milwaukee).

Oncorhynchus nerka (Walbaum), kokanee salmon

DISTRIBUTION

Introduced into all of the Great Lakes,[3] natural reproduction has been documented for Lake Huron.[2 3]

SPAWNING SEASON

Spawning runs begin in mid-August, peak spawning occurs from late September to early October in Lake Huron.[2]

SPAWNING TEMPERATURE

Not reported.

SPAWNING HABITAT

Migrates upriver or to nearshore of lakes.[2]

SPAWNING SUBSTRATE

Not reported.

FECUNDITY

250 to 2,000;[2] or 4,000.[4]

EGGS

Orange-red.'

YOLK-SAC LARVAE

Not described.

LARVAE

Not described.

JUVENILES

Not described.

ADULTS

Fin rays: caudal 19;* dorsal 11 to 16, anal 13 to 18, pectoral 11 to 21, pelvic 9 to 11.[1]

Vertebrae: 56 to 67.[1]

Lateral line scales: 120 to 150.[1]

Pyloric caeca: 45 to 115.[1,4]

Diagnostic characters: no black spots, however black speckling on fins, gill rakers long, crowded 30 to 40, pyloric caeca usually 60 to 115.

LITERATURE CITED

1. Scott and Crossman (1973)
2. Collins (1971)
3. Parsons (1973)
4. McPhail and Lindsey (1970)

Oncorhynchus tshawytscha (Walbaum), chinook salmon

DISTRIBUTION

Introduced into of all the Great Lakes.[6] Natural reproduction from these introductions has been documented for Lakes Superior[8] and Michigan.[9]

SPAWNING SEASON

Spawning occurs in the fall in Lake Superior* and from late September to early October throughout the Great Lakes region.[1]

SPAWNING TEMPERATURE

Not reported.

SPAWNING HABITAT

Not reported.

SPAWNING SUBSTRATE

Not reported.

FECUNDITY

2,500 (New Hampshire);' 3,760 to 7,454 (California).[3]

NATURAL HYBRIDS

Oncorhynchus kisutch.'

EGGS

Demersal, red-orange.*

Incubation period:

Temperature C	Days to 50% Hatch
1.6-1.7	204.0-206.3[7]
3.0	157.5-160.3[7]
4.3-4.5	120.1-128.6[7]
5.0-5.9	92.4-110.0[7]
7.1-7.3	73.4-79.1[7]
8.6	63.4'
9.6-9.9	52.2-55.4'
10.1-10.3	50.0-50.9
11.0-11.4	43.0-47.37
12.6-12.8	38.8-42.0'
13.0-13.1	38.0-39.7[7]
14.2-14.3	34.0-36.7'
15.3-15.7	32.1-34.3'
16.7-16.9	30.7-31.4[7]
18.1	28.07

YOLK-SAC LARVAE

Total length	Description
19.0-19.2 mm	Newly hatched;* 23.6 to 24.8 mm.[2]
19-21 mm	Myomeres: body too opaque to observe myomeres.* Morphometry: (as % TL) preanal length 60 to 62, body depth at anus 12 to 13, head length 14 to 20, snout length 1 to 3, eye diameter 7 to 8, yolk-sac length 47 to 54, yolk-sac depth 32 to 39.* Morphology: slight indentations and actinotrichia in finfold mark area of future dorsal and anal fins, some caudal fin rays formed, pectoral and pelvic buds apparent (19 mm).* Pigmentation: eyes pigmented, small amount of pigment on dorsum of head and nape, melanophores evenly spaced over dorsum and dorso-lateral surf ace, venter immaculate from snout to insertion of anal fin, a few melanophores on interradial membrane of central caudal fin (19 mm).*
22-24 mm	Morphometry: (as % TL) preanal length 60, depth at anus 13, head length 19, snout length 3, eye diameter 7, yolk-sac length 41 to 48, yolk-sac depth 26 to 28.* Morphology: little change from previous stage, dorsal fin more distinct, rays evident only in caudal fin, vitelline vein evident on anterior surface of yolk sac (23 mm).* Pigmentation: melanophores present on tip of snout, more dense on dorsum of brain and nape, evenly distributed over rest of body, a few melanophores on finfold membrane at dorsal origin, near and between rays of caudal fin (23 mm).*
27-30 mm	Morphometry: (as % TL) preanal length 58 to 61, body depth at anus 13 to 15, head length 20 to 22, snout length 3 to 4, eye diameter 7 to 8, yolk-sac length 33 to 41, yolk-sac depth 17 to 22.* Morphology: dorsal (14 rays), anal (18 rays) and adipose fins distinct, yolk sac almost absorbed, nares developed (29 mm) .* Pigmentation: melanophores more numerous in area of snout, brain, dorsum of body and either side of unpigmented lateral line, venter unpigmented from lower' jaw to insertion of anal fin, pigment present on finfold membrane anterior and posterior to dorsal fin, on adipose fin and just posterior to adipose fin, melanophores also present on interradial membrane of caudal fin and tips of dorsal fin (29 mm).*

31-35 mm

Morphometry: (as % TL) preanal length 57 to 59, body depth at anus 15 to 16, head length 23 to 24, snout length 4 to 5, eye diameter 8 to 9, yolk-sac length 20 to 26, yolk-sac depth 9 to 17.*

Morphology: yolk still evident al though much reduced, median fin rays formed, pectoral and pelvic fin rays incomplete, finfold still present from nape to dorsal fin, near adipose and from posterior portion of yolk sac to anus (34 mm).*

Pigmentation: melanophores more numerous in head region and on dorsum, 15 parr marks (each over half above the lateral line), several more smaller spots on dorsum, venter from lower jaw to insertion of anal fin unpigmented, melanophores on interradial membrane of entire caudal fin, on anterior and posterior adipose fin and just posterior to adipose, melanophores also present on interradial membrane of dorsal fin except between last two rays and pigment very dense at tips of second and third rays (34 mm).*

LARVAE

Total length	Description
36-59 mm	Morphometry: (as % TL) preanal length 55 to 58, body depth at anus 13 to 17, head length 22 to 25, snout length 4 to 6, eye diameter 7 to 9.*

Morphology: yolk absorbed, finfolds absorbed except for small preanal portion, fin rays complete (41.0 mm).*

Pigmentation: melanophores more numerous over brain and on head overall, 10 parr marks present (41.0 mm), several smaller spots over dorsum, anterior edge Of pectoral fin with melanophores, anal fin pigmented in center, interradial membrane of dorsal and caudal fins fully pigmented, more pigment near tips of first few rays, pigment on adipose and on membrane above and below caudal peduncle, a few melanophores on lower jaw, venter lacking pigment from mid-jaw to just anterior of pelvic fins (41.0 mm).*

JUVENILES

Morphometry: length of leading edge of anal fin less than length of fin base.[12]

Pigmentation: body silvery or light yellow with blue-green or brown back, parr marks wide, black and sharply contrasting, fins yellow, height of dorsal and anal fins greater in coho than chinook salmon, at emergence a few chromatophores scattered over dorsal fin, subsequent band of black developed with white and orange distally, at two weeks dorsal fin leading edge white distally, black proximally, orange band follows the white leading edge, fin yellow, anal fin similarly colored.[10]

ADULTS

Fin rays: caudal 18 to 19;* dorsal 10 to 14, anal 14 to 19,[1] [5] pectoral 14 to 17, pelvic 10 to 11.[1]

Vertebrae: 67 to 75.[1]

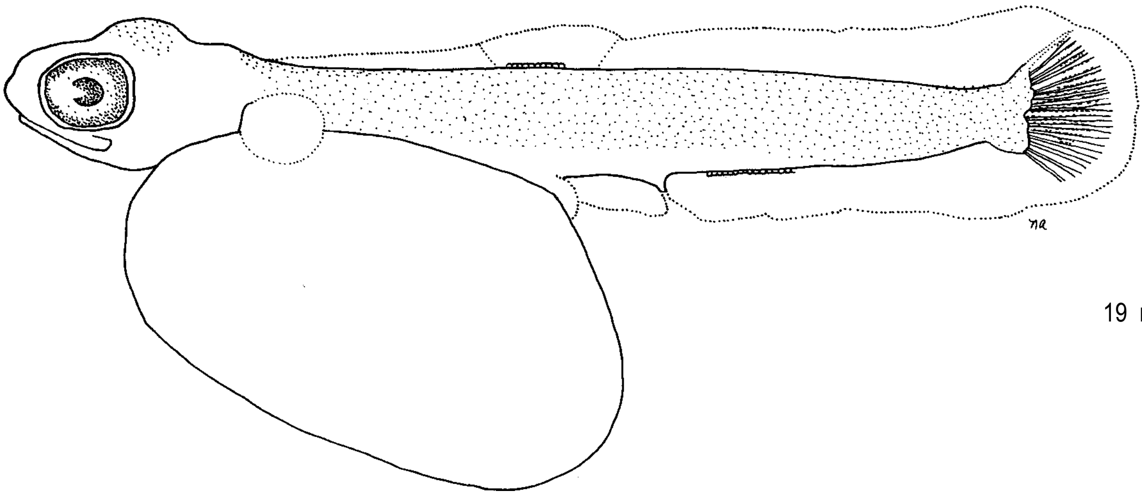
Lateral line scales: 130 to 165.[1]

Pyloric caeca: 90 to 240.[11]

Diagnostic characters: less than 12 anal fin rays, small dark spots on back and both lobes of caudal fin, pyloric caeca usually 140 or more, fleshy gums of lower jaw black, gill rakers usually 20 to 28.

LITERATURE CITED

1. Scott and Crossman (1973)
2. Silver et al. (1963)
3. McGregor (1923)
4. Bonham and Seymour (1949)
5. Foerster and Pritchard (1935)
6. Emery (1976)
7. Alderdice and Velsen (1978)
8. Berg (1978)
9. Parsons (1973)
10. Stein et al. (1972)
11. McPhail and Lindsey (1970)
12. Decker et al. (1978)



19 mm

Fig. 34. Oncorhynchus tshawytscha, chinook salmon. Yolk-sac larva. (Laboratory-reared, Wisconsin, original illustration by N. A. Auer, specimen provided by F. P. Binkowski, Center for Great Lakes Studies, University of Wisconsin-Milwaukee).

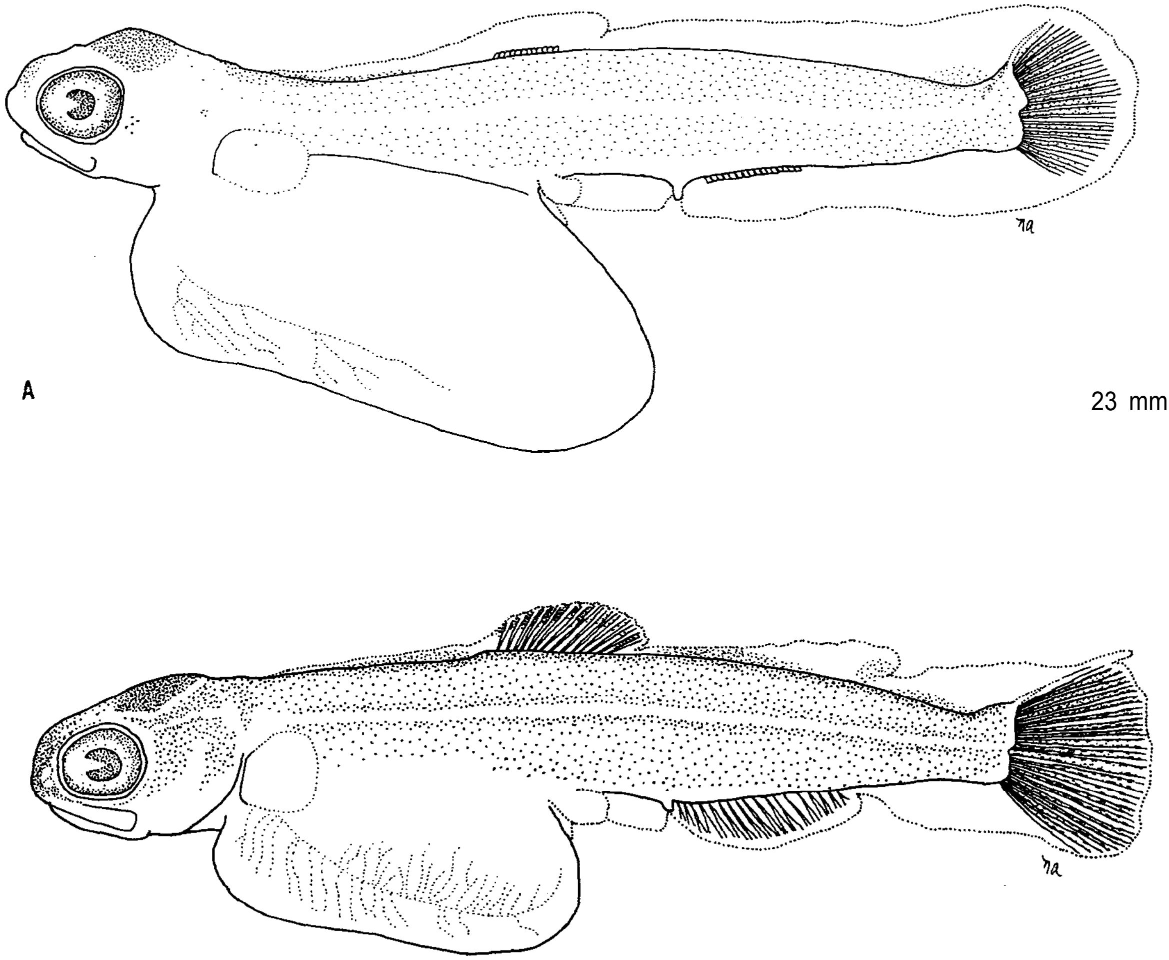
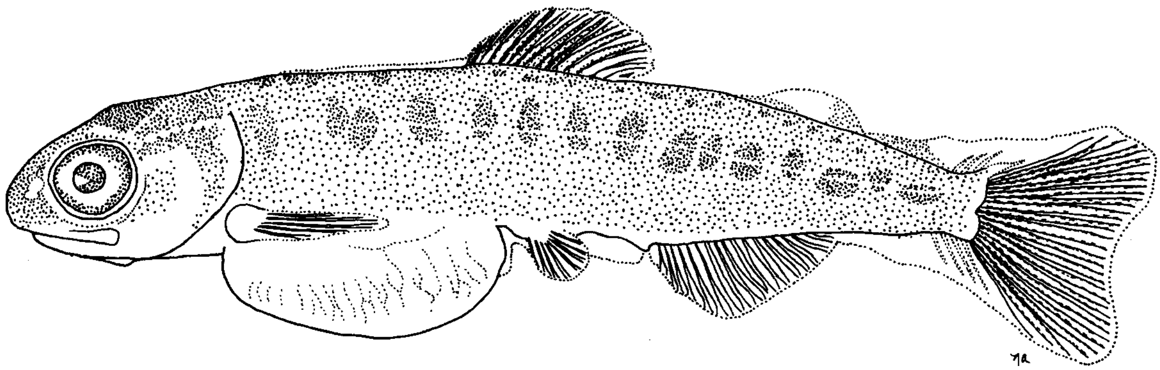
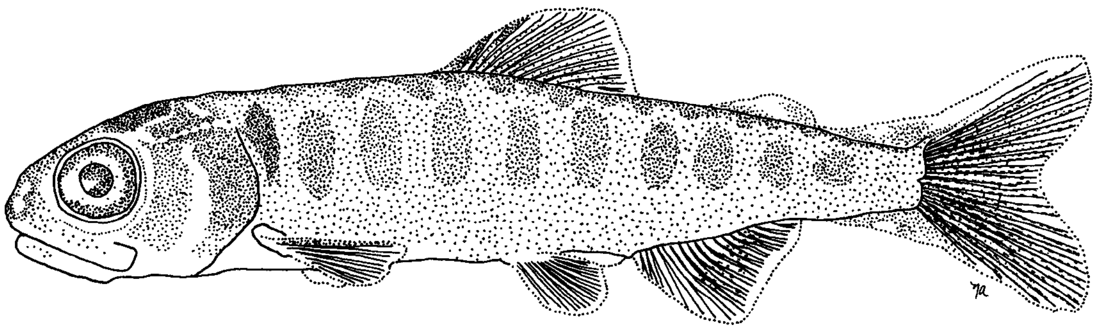


Fig. 35. Oncorhynchus tshawytscha, chinook salmon. A and B. Yolk-sac larvae. (A and B, laboratory-reared, Wisconsin, original illustrations by N. A. Auer specimens provided by F. P. Binkowski, Center for Great Lakes Studies, University of Wisconsin-Milwaukee).



34 mm



B

41 mm

Fig. 36. **<u>Oncorhynchus tshawytscha</u>, chinook salmon. A. Yolk-sac larva. B. Larva. (Laboratory-reared, Wisconsin, original illustrations by N. A. Auer, specimens provided by F. P. Binkowski, Center for Great Lakes Studies, University of Wisconsin-Milwaukee).**

Prosopium coulteri (Eigenmann and Eigenmann), pygmy whitefish

DISTRIBUTION

Found 'only in Lake Superior in deep water 18 to 89 m, most commonly at 45 to 71 m.[1 2]

SPAWNING SEASON

Spawns in November or December.'[2]

SPAWNING TEMPERATURE

Not reported.

SPAWNING HABITAT

Not reported.

SPAWNING SUBSTRATE

Not reported.

FECUNDITY

392 (93 to 597).[2]

EGGS

Orange;[3] diameter (ovarian) 2.0 mm;*[2] (water hardened, unfertilized) 2.57 mm ± 0.03.[3]

YOLK-SAC LARVAE

Not described.

LARVAE

Not described.

JUVENILES

Pigmentation: body pale tan, a few melanophores on dorsal and lateral surfaces, venter unpigmented, 8 to 11 subcircular parr marks along lateral line, diffuse near margins in juveniles but distinct in adult, dark bar on preorbital parallels upper jaw, a few dark markings on dorsum of head behind eyes.[2]

ADULTS

Fin rays: caudal 19, dorsal 11 (10 to 12), anal 13 or 14 (12 to 14), pectoral 13 to 16, pelvic 9 to 11.[2]

Vertebrae: 50 to 55.[1]

Lateral line scales: 50 to 70.[1]

Gill rakers: 13 to 20 (length 1.3 to 2.1% SL).[2]

Diagnostic characters: the smallest coregonine (rarely exceeds 203 mm) with the largest scales and fewest vertebrae, subterminal mouth, teeth on tongue, number of gill rakers similar to those of p. *cylindraceum* but longer, eye large.

LITERATURE CITED

1. Scott and Crossman (1973)
2. Eschmeyer and Bailey (1955)
3. Booke (1970)

Prosopium cylindraceum (Pallas), round whitefish

DISTRIBUTION

Located in all of the Great Lakes except Lake Erie.[1 8]

SPAWNING SEASON

Spawns from October to November in the Great Lakes region[1 8] and November to December in Canada and the northern United States.[1 4 5 7]

SPAWNING TEMPERATURE

Spawning reported at a temperature of 0 C.[2]

SPAWNING HABITAT

Spawns in shallow regions of lakes,[1] 0.2 to 0.6 m,[4] 3.6 to 14.5 m,[1 7] 7 m.[8]

SPAWNING SUBSTRATE

Spawns over stone,[2] gravel,[2 7] rocky reefs[4] and honeycomb rock.[7]

FECUNDITY

2,200 to 14,300.[1 3 4]

EGGS

Yellow-orange;[1] orange;[9] chorion orange;[8] diameter 2.9 to 3.5 mm;[5 8 9] more than 200 oil droplets, largest less than 0.7 mm in diameter, yolk amber, diameter 2.6 mm (2.4 to 3.0 mm);[8] incubation period: 140 days at 2.3 C;[4] 87 (70 to 96 days) at 3.2 to 8.1 C;[8] eggs spawned the last two weeks of November to the end of December hatch the end of March to the last week of April.[1]

YOLK-SAC LARVAE

Total length	Description
12-13 mm	Newly hatched, mean length 12.3 mm.[8] Myomeres: 48 (35 + 13);[6] (34 to 35 + 15 to 16).[8] Morphometry: yolk-sac length 33% TL.[8] Morphology: lower jaw subterminal, multiple oil globules present.[8] Pigmentation: oval patch of melanophores on dorsum of head, two distinct rows of melanophores on intestine from posterior portion of yolk sac to anus, some on lateral line, dorsal melanophores equal to width of one myomere.[8]
13-18 mm	Morphometry: yolk-sac length 10% TL.[8]

Morphology: nares present, urostyle begins to flex, fin rays absent.'
Pigmentation: dorsal pigment on median finfold irregular, dorsal melanophores less than width of one myomere.[8]

LARVAE

Total length	Description
19 mm	Morphometry: length from snout to highest point on dorsal fin less than 50% SL.[8] Morphology: yolk absorbed.[8] Pigmentation: stellate and constricted melanophores present on dorsum and along lateral line, largest ones one-half the width of a myomere, pigment also present on opercle, snout and caudal and dorsal fins, circular cluster of melanophores on peritoneum behind pectoral fin base.[8]
28-29 mm	Morphology: all median fin rays developed.* Pigmentation: entire dorsal and lateral surf ace pigmented, pectoral, pelvic and anal fins and preanal venter unpigmented, parr marks and/or cluster of melanophores at base of pectoral fin present.[8]
35 mm	Morphology: pectoral fin rays present, squamation begins.[8] Pigmentation: seven irregular oval parr marks on dorso-lateral surface, four or five parr marks on each lateral surface.[8]

JUVENILES

Total length	Description
44-45 mm	Morphology: squamation complete.[8] Pigmentation: density and number of parr marks increases, eight parr marks along lateral surface between opercle and caudal peduncle, dark margins develop on first four rows of dorsal scales, between dorsal fin and lateral line. [8]

ADULTS

Fin rays: caudal 19;* dorsal 13 (11 to 15), anal 9 to 13, pectoral 14 to 17, pelvic 9 to 11.[1 7]

Vertebrae: 58 to 65.[1]

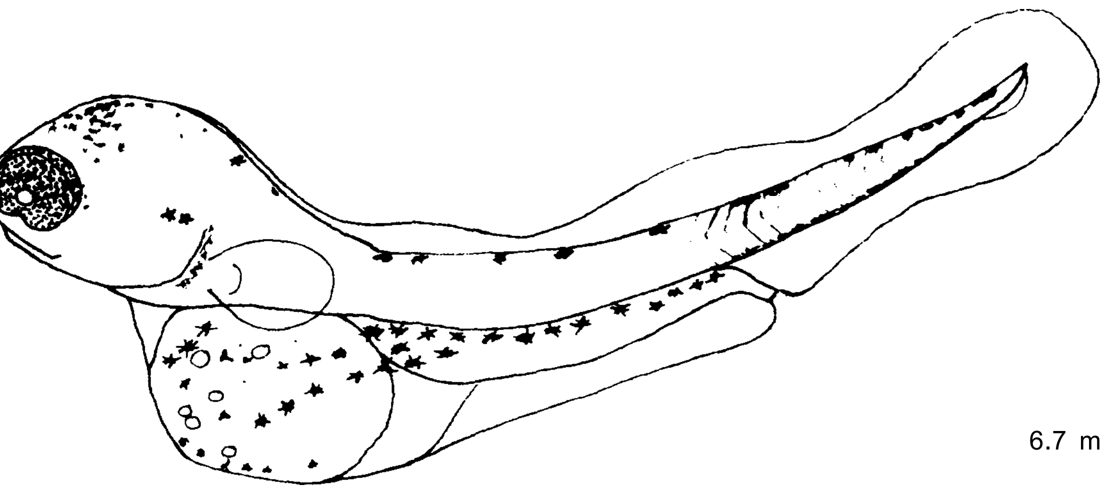
Lateral line scales: 87 to 95[7] (74 to 108).[1 7]

Gill rakers: 16 to 18[7] (14 to 21) .[1 7]

Diagnostic characters: fusiform body, short head, subterminal mouth, usually less than 20 short thick gill rakers, pointed snout, usually more than 85 lateral line scales, single flap of skin between nostrils.

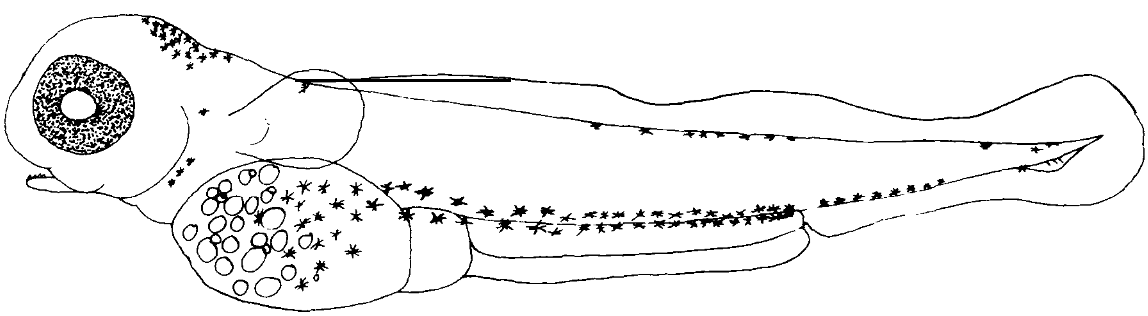
LITERATURE CITED

1. Scott and Crossman (1973)
2. Krasikova (1968)
3. Bailey (1963)
4. Normandeau (1969)
5. Bryan and Kato (1975)
6. Faber (1970)
7. Koelz (1929)
8. Hinrichs (1979)
9. Booke (1970)



A

6.7 mm



7.3 mm

Fig. 37. Prosopium cylindraceum, round whitefish. A and B. Yolk-sac larvae. (A and B, laboratory-reared, Wisconsin, Hinrichs 1979).

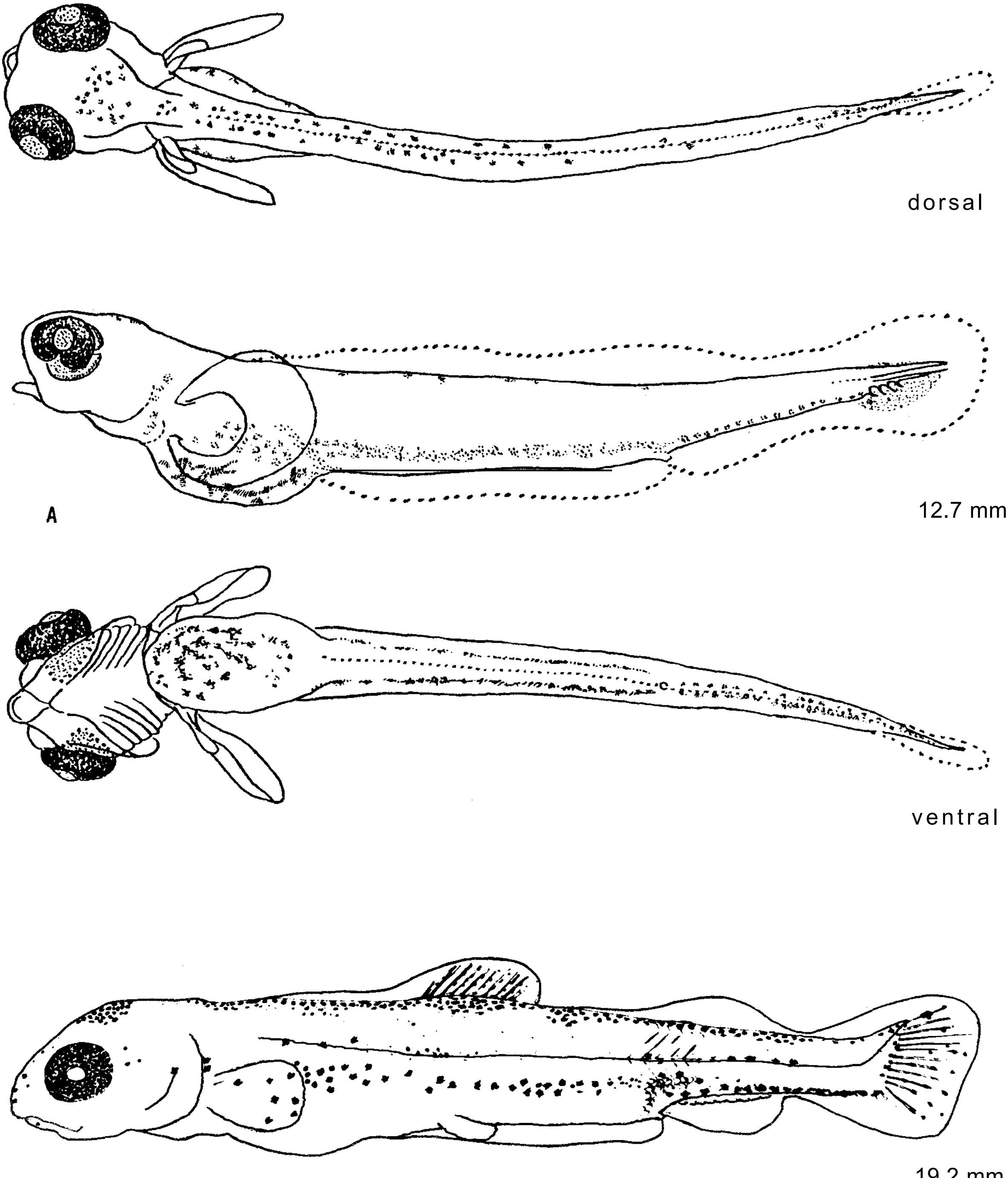


Fig. 38. Prosopium cylindraceum, round whitefish. A. Yolk-sac larva. B. Larva. (A, wild-caught, New Hampshire, Faber 1970, National Museum Canada, Ottawa: B, laboratory-reared, Wisconsin, Hinrichs 1979).

Prosopium cylindraceum

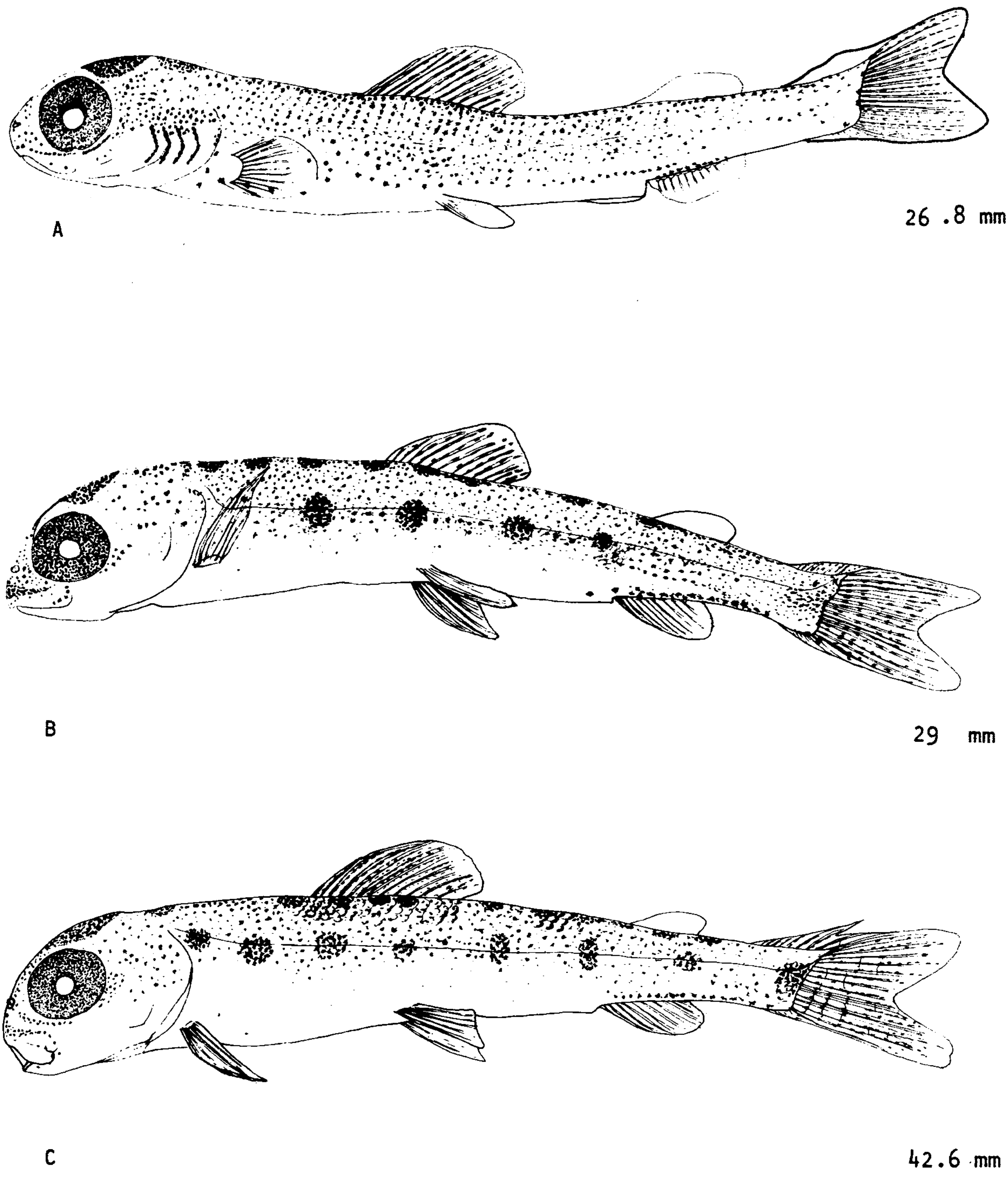


Fig. 39. Prosopium cylindraceum, round whitefish. A and B. Larvae. C. Juvenile. (A-C, laboratory-reared, Wisconsin, Hinrichs 1979).

Salmo gairdneri Richardson, rainbow trout or steelhead

DISTRIBUTION

Stocked into all of the Great Lakes and known to reproduce naturally.[14]

SPAWNING SEASON

Usually spawns in the spring, mid-April to June,[1] however some reported spawning occurs in both the spring and fall.[14]

SPAWNING TEMPERATURE

Spawns at water temperatures of 10.0 to 15.5 C.[1]

SPAWNING HABITAT

Spawns in tributary streams and rivers.[1]

SPAWNING SUBSTRATE

Spawns over gravel in riffle areas,[14] hard compact clay or large rocks.[15] There is usually groundwater flow.[15] Females fan a depression in the gravel, spawn, then cover eggs with 10 to 20 cm of gravel.[15]

FECUND ITY

1,315 to 3,894;[6,9] 3,120 to 5,302.[7]

EGGS

Pink-orange,' diameter 4.46 mm ± 0.19.[10]

Incubation period:

Temperature C	Days to Hatch
2.0-2.5	102[13] (95-119)[4]
3.2	101[12]
4.8	75[12]
5.0-5.76	63-65[12,13] (58-73)[4]
6.1-6.2	61[12]
7.0-7.9	43.0-50.0[12,13] (38-47)'
8.0	41[12]
9.5	34-37'
10.0-10.8	27-30[5,12,13] (29-36)[4]
11.5	27-28[12]
12.0-12.8	23-25[8,12] (9.8-15.8) 4
13.0	25[13]
14.5	21[12]
15.0-15.5	18[12] (9.3-14)[4]
17.0	g-124

4 to 7 weeks;[1] 8 to 10 weeks, fry emerge from gravel when water temperatures reach 4.4 to 10.0 C.[15]

YOLK-SAC LARVAE

Total length	Description
12.4-13.2 mm	Newly hatched* or 19.4 to 20 mm.[3]
12-15 mm	Myomeres: 56 to 60 (38 to 40 + 18 to 20).* Morphometry: (as % TL) preanal length 63 to 66, body depth at anus 10 to 13, head length 14 to 20, snout length 3 to 5, eye diameter 7 to 8, yolk-sac length 47 to 60, yolk-sac depth 24 to 31.* Morphology: actinotrichia present in dorsal and anal fins, some caudal fin rays evident, pelvic and pectoral buds present (12 mm).* Pigmentation: eyes pigmented, other pigment absent (12 mm).*
16-22 mm	Morphometry: (as % TL) preanal length 61 to 64, depth at anus 10 to 14, head length 17 to 22, snout length 3 to 5, eye diameter 7 to 9, yolk-sac length 26 to 41, yolk-sac depth 12 to 27.* Morphology: finfold continuous yet constricted near future dorsal, anal and adipose fins, preanal finfold present, median fin rays forming (17 mm).* Pigmentation: body lightly pigmented over all, melanophores concentrated on snout and over brain but not along dorsum, no pigment on yolk sac or on venter from jaws to middle of caudal peduncle, a few melanophores on proximal portion of interradial membrane of caudal fin (17 mm).*

LARVAE

Total length	Description
23-25 mm	Morphometry: (as % TL) preanal length 60 to 62, depth at anus 12 to 13, head length 22 to 25, snout length 4 to 5, eye diameter 8 to 9.* Morphology: yolk absorbed, median fin rays developed, finfold evident just anterior and posterior to pelvic fins (24 mm).:‘: Pigmentation: melanophores more numerous, evenly distributed over body except 11 small parr marks developing on lateral line, melanophores on proximal interradial membrane of posterior two-thirds of dorsal fin, very dense pigment on distal portion of first few rays, caudal fin also pigmented on proximal portion of interradial membrane and pigment on membrane just posterior to adipose and anal fins (24 mm).*

JUVENILES

Total length	Description
38 mm	Pigmentation: anterior margin of dorsal fin pigmented, chin speckled.[11]

ADULTS

Fin rays: caudal 19;* dorsal 10 to 12, anal 8 to 12, pectoral 11 to 17, pelvic 9 to 10.[1]

Vertebrae: 60 to 66.[1,2]

Lateral line scales: 100 to 150.[1]

Pyloric caeca: 27 to 80.[16]

Diagnostic characters: maxilla barely extends beyond eye, usually less than 140 lateral line scales, many small black spots on back, sides, top of head and on caudal fin, red-orange band along each side.

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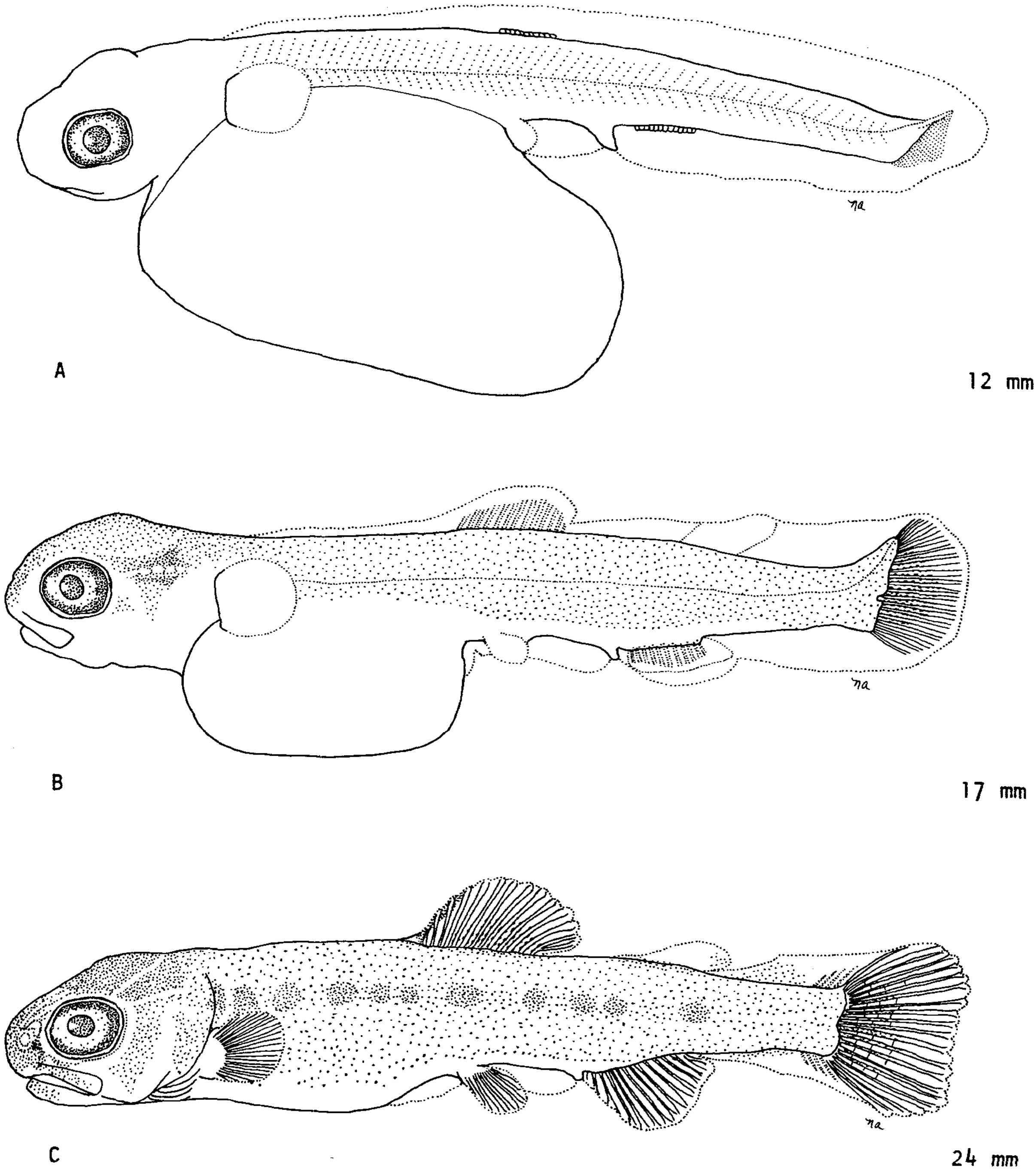

Fig. 40. Salmo gairdneri, rainbow trout. A-C. Yolk-sac larvae. (A-C, laboratory-reared, Wisconsin, original illustrations by N. A. Auer, specimens provided by F. P. Binkowski, Center for Great Lakes Studies, University of Wisconsin-Milwaukee).

Salmo salar Linnaeus, Atlantic salmon

DISTRIBUTION

Once native to Lake Ontario and tributaries of the upper St. Lawrence River, it has been extirpated from Lake Ontario.[12] Introduced into Lakes Michigan and Huron.[7]

SPAWNING SEASON

Spawns from October through November in Canada.[1,7,10]

SPAWNING TEMPERATURE

Not reported.

SPAWNING HABITAT

Spawns in shallow, swift-running rivers, 15 mm to 120 mm deep,[10] with clear, cool water, abundant shoals with gravel and sharp stream gradient.'

SPAWNING SUBSTRATE

Deposits eggs among coarse gravel and stone.[10]

FECUNDITY

1,779 (632 to 4,578).[8]

EGGS

Diameter 6.6 mm (5.0 to 7.0 mm).[4]

Incubation period:

Temperature C	Days to Eye	Days to Hatch
1.6		178-184[3]
2.2		114[11]
3.0	78	155[5]
3.9		110[1]
4.0	51-60	117-126[5]
4.9-5.0		77-83[6]
5.0		41-60[9]
6.0	38-48	75-85[5]
7.2		90.0[11]
8.0	31-36	59-64[5]
8.3		65[2]
9.9-10.0		43-49[6]
10.0	27-32	44-49[5]
11.7		56[2]
12.0	22-29	31-385

YOLK-SAC LARVAE

Newly hatched (22 mm), total myomeres 60.3

LARVAE

Not described.

JUVENILES

Not described.

ADULTS

Fin rays: caudal 18;* dorsal 10 to 12, anal 8 to 11, pectoral 14 to 15, pelvic 9 to 10.[1]

Vertebrae: 58 to 61.[1]

Lateral line scales: 109 to 121.[1]

Diagnostic characters: anal fin rays 8 to 11, fewer than 165 lateral line scales, caudal fin not spotted, 2 to 3 large spots on gill cover, vomerine teeth not well developed.

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Salmo trutta Linnaeus, brown trout

DISTRIBUTION

Introduced into the Great Lakes region, it reproduces naturally in many tributaries.[1]

SPAWNING SEASON

Spawns in October and November in the Great Lakes.[1,5,8]

SPAWNING TEMPERATURE

Spawning usually occurs at temperatures between 6.7 and 8.9 C.[1]

SPAWNING HABITAT

Spawns in streams or along rocky reefs.[1]

SPAWNING SUBSTRATE

Female excavates redd in gravel, riffle area or near lip of pool.[8]

FECUNDITY

107 to 2,419.[1,2,8,9]

NATURAL HYBRIDS

Salvelinus fontinalis,[6] resulting in "tiger" trout.

EGGS

Amber color, diameter 4.4 to 4.5 mm.[3,4]

Incubation period:

Temperature C	Days to Hatch
1.9	148[1]
2.2-2.9	155-120[7]
3.6-3.7	119-108[7]
4.6	97.5[1]
5.1-5.5	95-86[7]
6.4	73[7]
7.0-7.9	59-66[7]
8.3	49[3]
9.2	46[1]
10.7	39[7] (48-52)[8]
11.1-11.2	33-36[7]

YOLK-SAC LARVAE

Total length	Description
13.7-15.0 mm	Newly hatched.*
	Myomeres: 50 to 54 (35 to 37 + 17 to 19).*

Morphometry: (as % TL) preanal length 65 to 67, body depth at anus 11 to 13, head length 14 to 22, snout length 2 to 5, eye diameter 7 to 8, yolk-sac length 49 to 55, yolk-sac depth 34 to 44.*

Morphology: finfold continuous, differentiating near dorsal, anal and adipose fins, actinotrichia evident in dorsal and anal fins, pelvic and pectoral buds present, 12 caudal fin rays (14.5 mm).*

Pigmentation: dorsum of brain and nape pigmented, small melanophores on dorsal lines of myosepta, a few melanophores on dorsum of yolk sac, posterior to anal fin on caudal peduncle and on finfold membrane on dorsum of caudal peduncle (14.5 mm).*

16-17 mm

Myomeres: see 13.7-15.0 mm.

Morphometry: (as % TL) preanal length 65 to 67, body depth at anus 11 to 12, head length 15 to 21, snout length 3 to. 5, eye ‘diameter 7 to 8, yolk-sac length 58 to 59, yolk-sac depth 27 to 39.*

Morphology: little change from previous stage, dorsal fin rays more developed, 16 caudal fin rays formed (16.0 mm).*

Pigmentation: pigment increased on dorso-lateral surface of head, on opercula and just posterior to dorsal fin on the finfold membrane, pigment on myosepta extends to ventro-lateral area, no pigment observed on yolk sac (16.0 mm).*

18-20 mm

Morphometry: (as % TL) preanal length 59 to 65, body depth at anus 10 to 13, head length 19 to 23, snout 3 to 4, eye diameter 7 to 8, yolk-sac length 39 to 53, yolk-sac depth 14 to 24.*

Morphology: median finfold still evident, distinctly decreased, anal and dorsal fins distinct, future position of adipose fin evident, myomeres no longer distinguishable, yolk sac much reduced, nares developed (19.5 mm).*

Pigmentation: melanophores evenly distributed on body except along lateral line, proximal portion of interradial membrane of caudal fin pigmented (19.5 mm).*

20-23 mm

Morphometry: (as % TL) preanal length 59 to 65, body depth at anus 11 to 13, head length 20 to 23, snout length 3 to 4, eye diameter 7 to 9, yolk-sac length 28 to 46, yolk-sac depth 11 to 13.*

Morphology: yolk sac apparent although greatly reduced, median fin rays formed, rays developing in pelvic fins, finfold evident posterior to dorsal fin around to anal fin insertion (21 mm).*

Pigmentation: lateral line unpigmented, parr marks beginning to form, melanophores concentrated on dorsum at base of dorsal and adipose fins and at base of anal fin, pigment on interradial membrane of dorsal and caudal fins, melanophores extending on ventro-lateral aspect of remaining yolk, adipose fin and adjacent finfold pigmented (21 mm).*

LARVAE

Total length	Description
24 mm	Morphometry: (as % TL) preanal length 63 to 65, body depth at anus 12, head length 20 to 22, snout length 3 to 4, eye diameter 7 to 8, yolk-sac length 25 to 30, yolk-sac depth 11 to 15.* Morphology: yolk absorbed or nearly so, fin rays complete (24 mm).* Pigmentation: six broad parr marks extending from lateral line downward, pigment more intense on dorsum of brain, tip of lower jaw and along dorsum, membrane anterior to dorsal fin pigmented and proximal portion of interradial membrane of central caudal fin pigmented, preanal venter immaculate, adipose fin unpigmented, median membrane just posterior to adipose with some pigment (24 mm).*

JUVENILES

Abdominal surface and chin speckled with pigment (38 mm).[6]

ADULTS

Fin rays: caudal 19;* dorsal 12 to 14, anal 10 to 12, pectoral 13 to 14, pelvic 9 to 10.[1]

Vertebrae: 56 to 60.[1]

Lateral line scales: 120 to 130.[1]

Diagnostic characters: maxilla barely extends beyond eye, less than 140 lateral line scales, few black and brown spots on dorsum, few red spots on sides, dorsum of head and caudal fin not spotted.

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Salmo trutta

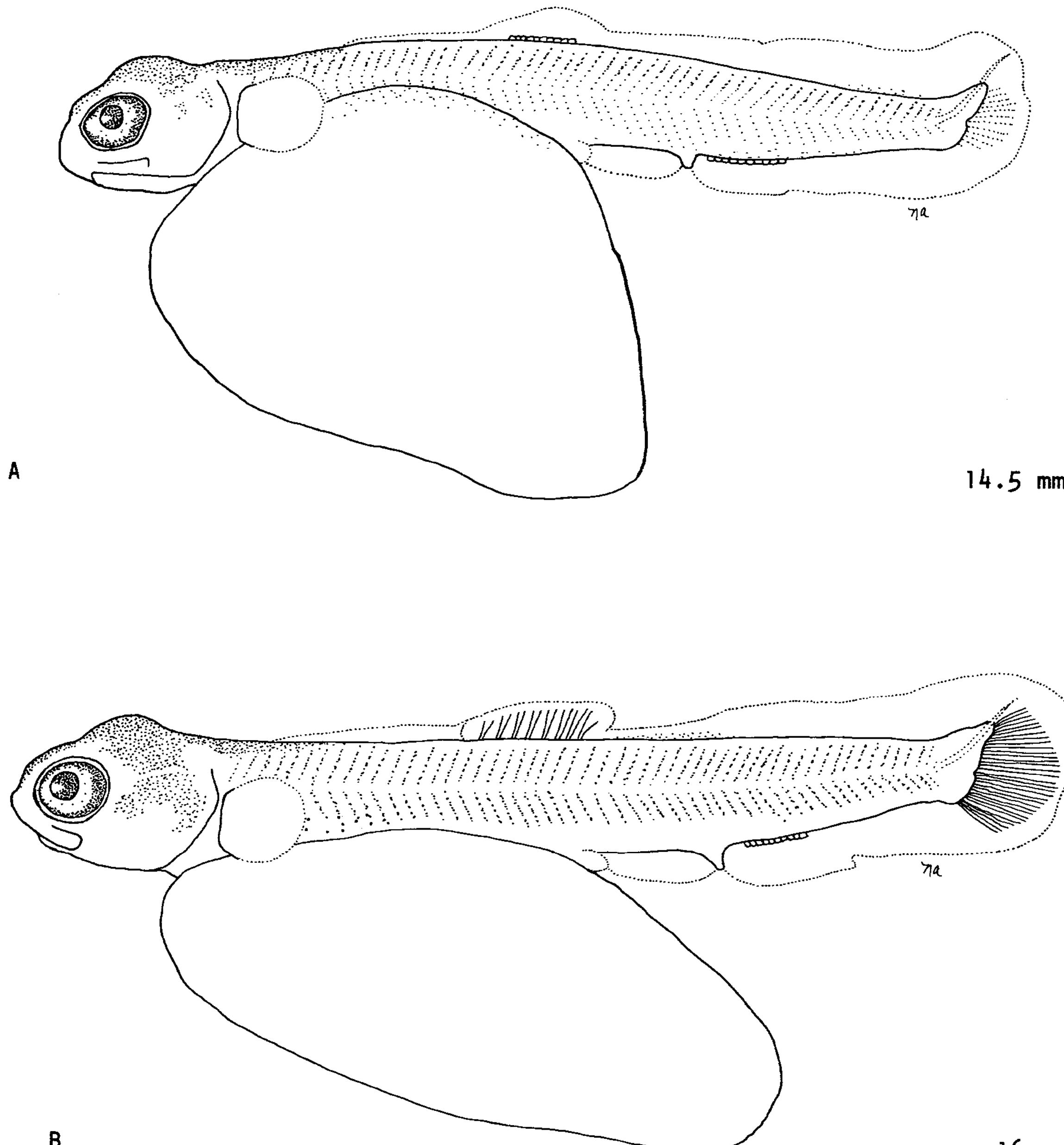

Fig. 41. Salmo trutta, brown trout. A and B. Yolk-sac larvae. (A and B, hatchery-reared, Wisconsin, original illustrations by N. A. Auer, specimens provided by F. P. Binkowski, Center for Great Lakes Studies, University of Wisconsin-Milwaukee).

Salmo trutta

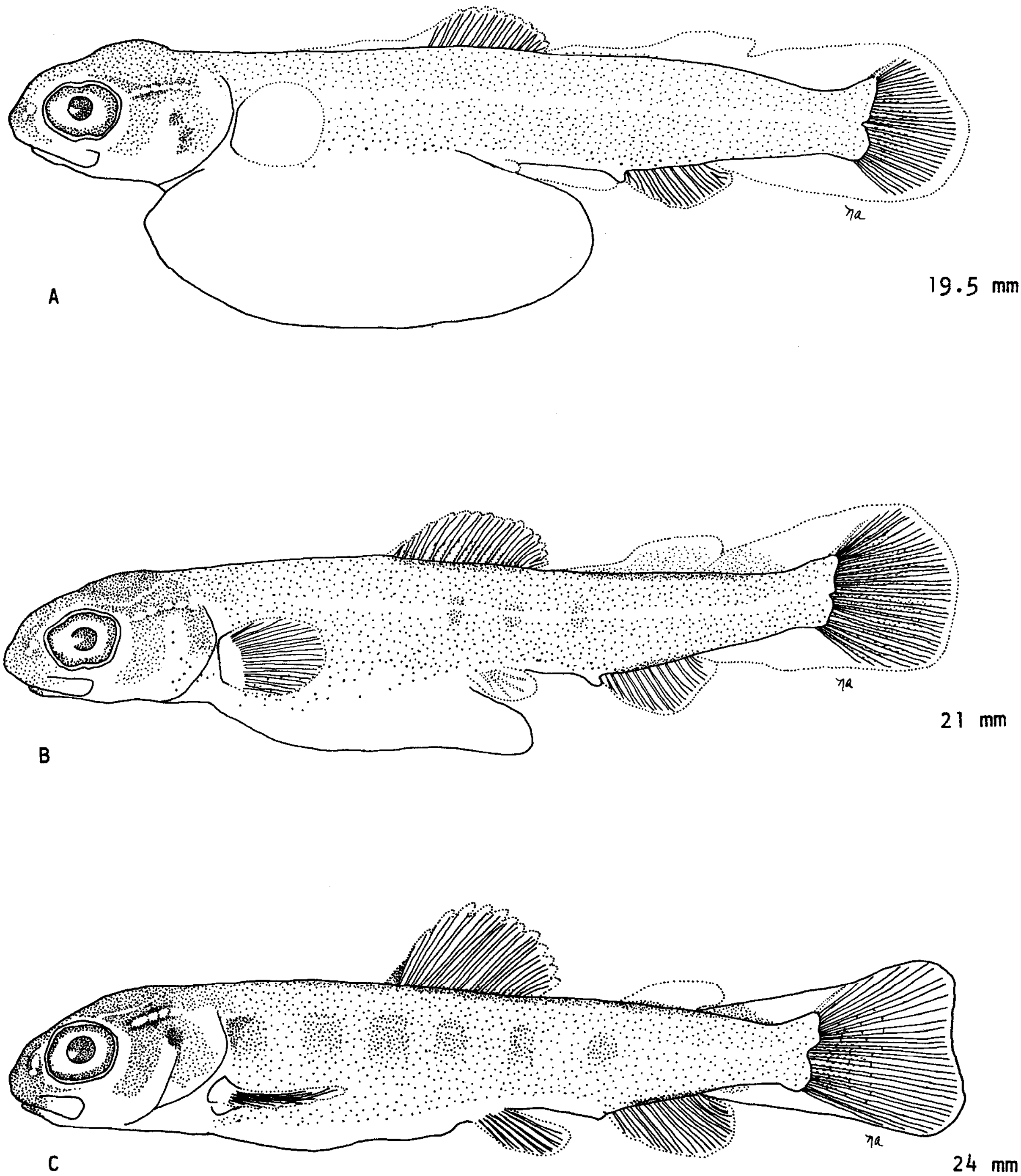

Fig. 42. Salmo trutta, brown trout. A and B. Yolk-sac larvae. C. Larva. (A-C, laboratory-reared, Wisconsin, original illustrations by N. A. Auer, specimens provided by F. P. Binkowski, Center for Great Lakes Studies, University of Wisconsin-Milwaukee).

Salvelinus fontinalis (Mitchill), brook trout

DISTRIBUTION

This species is endemic to the Great Lakes basin, occurring most often in rivers and streams.’

SPAWNING SEASON

Spawns from late September to late November in the Great Lakes area.[1 6 14 15]

SPAWNING TEMPERATURE

Spawns at temperatures near 9.4 C.[15]

SPAWNING HABITAT

Spawns on gravel beds in cool, clear streams.[1]

SPAWNING SUBSTRATE

Deposits eggs in coarse sand, gravel and stones, 7.6 to 10.2 mm in diameter.[15]

FECUNDITY

18 to 213;[5] 99 to 4,765;[3] 131 to 1,691.[10]

NATURAL HYBRIDS

Salmo trutta[8] called “tiger” trout; *Salvelinus namaycush*’ called “splake;” these initially artificial hybrids continue to spawn naturally and support populations.

EGGS

Diameter 4.1 mm.11

Incubation period:

Temperature C	Days to Hatch
1.6-1.9	138-147[13]
2.2-3.0	119-140[13 16]
3.0-3.9	105-138[13]
4.5	93[13]
5.0-5.7	83-100[1 13]
6.1-6.8	72-75[1 7 13]
7.4-7.9	60-71[13]
8.0	62-67[2]
10.0-10.3	42-50[1 13]
11.7	53[1]
12.3-13-O	34-37[13]
13.2-13.5	31-35[13]
14.0-14.8	28-31[13]

YOLK-SAC LARVAE

Total length	Description
11.3-11.8 mm	Newly hatched;* 2.5 to 4.0 cm SL, mean 59.3 myomeres.[11]
11-14 mm	Myomeres: 52 to 55 (33 to 35 + 19 to 20).* Morphometry: (as % TL) preanal length 61 to 65, body depth at anus 10 to 13, head length 15 to 20, snout length 2 to 5, eye diameter 7 to 9, yolk-sac length 42 to 52, yolk-sac depth 20 to 33.* Morphology: yolk sac large, finfold slightly differentiated near areas of dorsal and anal fins, pectoral and pelvic buds present, notochord flexed, caudal fin rays evident (11.0 mm).* Pigmentation: eyes pigmented, small chromatophores cover snout, dorsum of head and continuing to caudal fin, these chromatophores also present dorso-laterally, myosepta unpigmented and distinct, a few melanophores on proximal portion of interradial membrane of central caudal fin (11.0 mm).*
15-18 mm	Myomeres : see 11-14 mm. Morphometry: (as % TL) preanal length 59 to 63, body depth at anus 11 to 13, head length 18 to 23, snout length 2 to 5, eye diameter 8 to 9, yolk-sac length 25 to 42, yolk-sac depth 9 to 25.* Morphology: 8 dorsal, 9 anal and 17 caudal fin rays, finfold differentiating at adipose fin, yolk approximately half absorbed (15.5 mm).* Pigmentation: melanophores more dense on snout and dorsum of head, large brown melanophores on myomeres, myosepta unpigmented, yolk sac and preanal venter unpigmented, more pigment evident on interradial membrane of caudal fin and on finfold just over caudal peduncle (15.5 mm).*

LARVAE

Total length	Description
18-19 mm	Morphometry: (as % TL) preanal length 58 to 62, body depth at anus 11 to 12, head length 17 to 23, snout length 3 to 4, eye diameter 7 to 9, yolk-sac length 21 to 34, yolk-sac depth 8 to 14.* Morphology: yolk absorbed (32 days posthatching at 10.5 to 13 C);[4] median fins developed, pectoral and pelvic fins incomplete, finfold persists between pelvic fins and anus and posterior to anal and dorsal fins (18.0 mm).* Pigmentation: melanophores more numerous on snout, tip of lower jaw, dorsum of head, dorsal and dorso-lateral surfaces of body, myomeres outlined with melanophores, five to six parr marks developing, pelvic, pectoral and

anal fins immaculate, dorsal fin pigmented on interradial membrane between last two to three rays, interradial membrane of central proximal portion of caudal fin pigmented, some melanophores near posterior edge of developing adipose fin (18.0 mm).*

JUVENILES

Total length	Description
38-50 mm	Morphology: scale formation beginning (40 to 50 mm).[1,15] Pigmentation: adipose fin pigmented, chin without coloration (38 mm).[12]

ADULTS

Fin rays: caudal 19;* dorsal 10 to 14, anal 9 to 13, pectoral 11 to 14, pelvic 8 to 10.[1]

Vertebrae: 55 to 62.[1,2]

Lateral line scales: 110 to 130.[1]

Pyloric caeca: 23 to 55.[16]

Diagnostic characters: maxilla extends beyond eye, more than 110 lateral line scales, caudal fin slightly forked, first ray of pectoral, pelvic and anal fins white, blue and red spots on dorsal surface.

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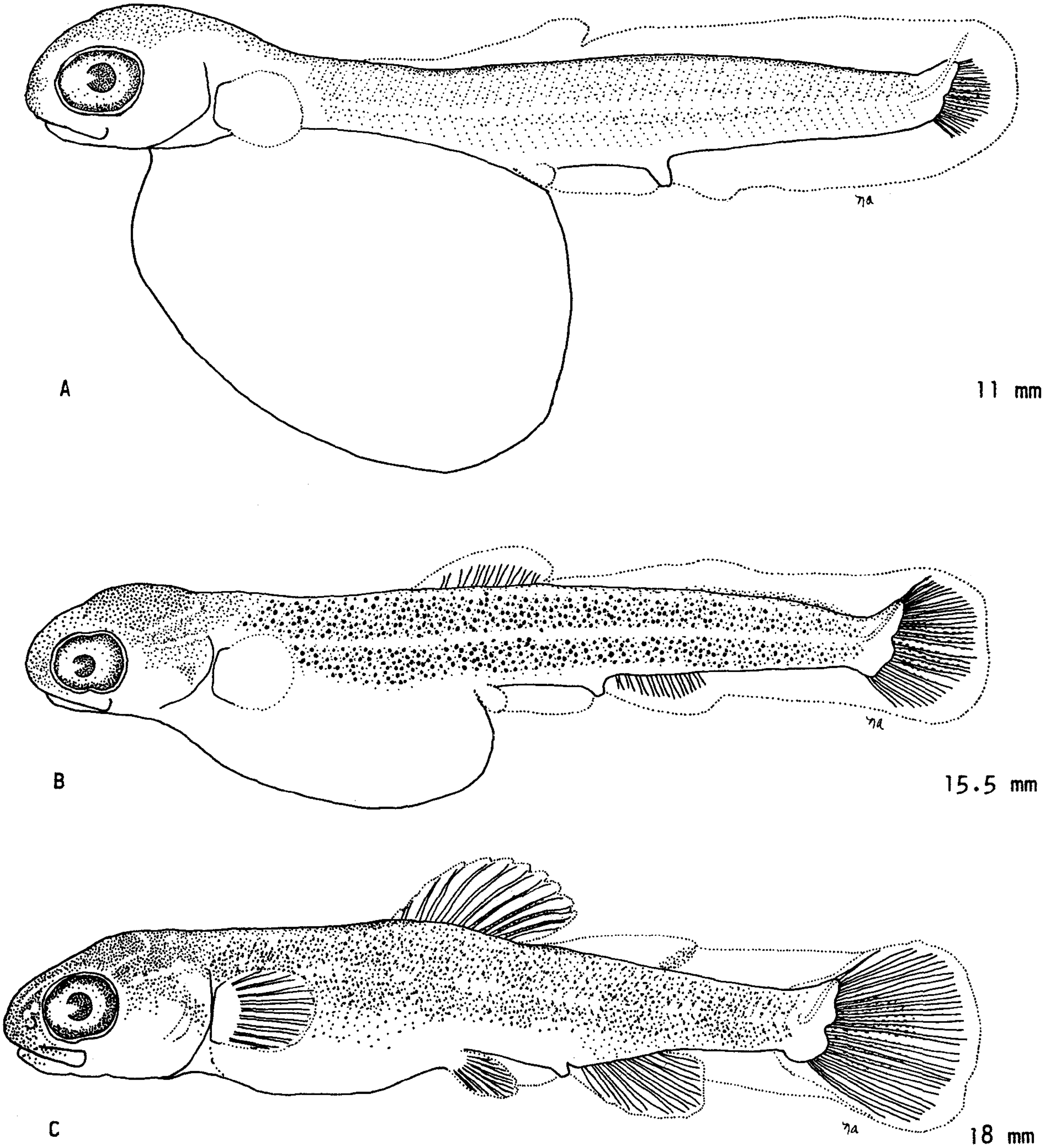

Fig. 43. Salvelinus fontinalis, brook trout. A-C. Yolk-sac larvae. (A-C, laboratory-reared, Wisconsin, original illustrations by N. A. Auer, specimens provided by F. P. Binkowski, Center for Great Lakes Studies, University of Wisconsin-Milwaukee).

Salvelinus namaycush (Walbaum), lake trout

Three types of lake trout have been distinguished, "leans," "fats" or "siscowetts;"[7] and "humpers."[13] "Lean" lake trout are common, occur at depths less than 110 m and spawn from October to November. The short, thin-bellied "humper," most often known from Lake Superior, occurs in water deeper than 91 m and spawns in mid-September.[13] The very fatty "siscowetts" are taken from 146 to 183 m[12] and spawn from August to September.'

DISTRIBUTION

Native to all of the Great Lakes and occurring primarily in the lakes proper and major bays,' rarely in tributaries.[18]

SPAWNING SEASON

Spawning occurs from late August to early December[2 4 7 11 12] with peak spawning occurring from mid-October to early November.[10 15 18]

SPAWNING TEMPERATURE

Spawning activities begin when water temperatures fall below 4.4 C,[12] spawning occurs between 2.8 and 14.4 C.[1 4]

SPAWNING HABITAT

Spawns over rocky, current- or wave-swept shoals or bars,[11 14] 0.15 to 36 m deep,[12 14 15] commonly on reefs with honeycomb rock bottom[12] and among coarse gravel and large boulders of rivers.[1 8]

SPAWNING SUBSTRATE

Spawns among large boulders and rubble[1] (25.4 cm to 1 m in diameter).[15] A few large, protective boulders may be necessary.[15] Eggs are cast indiscriminately among rocks[11 15] or the male may precede female and clean the substrate of silt by fanning and rubbing.[14] Eggs settle to the bottom and lodge in small crevices.[15]

FECUNDITY

919 to 14,766;[2 7 9 10 11] "siscowett" 1,093 to 10,476;[7] "humper" 411 to 2,640.[13]

NATURAL HYBRIDS

Salvelinus fontinalis,[3] called "splake;" these initially artificial hybrids spawn naturally and support populations.

EGGS

Semibuoyant;[15] diameter 5.0 to 5.6 mm.[6 17] *

Incubation period:

Temperature C	Days to Hatch
0.3-1.0	105-147[1]
1.8	162[8]
4.5	106[8]
5.0-5.7	92-86[5, 8]
6.7	80-81[8]
7.0-7.5	60-81[2, 5]
8.5	59[8]
10.0-10.2	46-56[2, 5, 6]

At 7 C hatchery-reared eggs eyed-up at 42 to 44 days, hatched at 83 days, attained swim-up stage at 118 days and at 6 weeks after swim-up averaged 33.5 to 33.8 mm TL.[17]

YOLK-SAC LARVAE

Total length	Description
15.2 mm	Newly hatched.).*[14] Myomeres: 56 to 59 (37 to 40 + 17 to 20).* Morphometry: (as % TL) preanal length 63, head length 13, snout length 3, eye diameter 7, yolk-sac length 45, yolk-sac depth 30.* Morphology: finfold showing constrictions near future dorsal fin, pelvic and pectoral buds present, a few caudal fin rays formed, head deflected over yolk sac.* Pigmentation: eyes pigmented, yolk sac unpigmented, a few light melanophores over dorsum from tip of snout to caudal fin, melanophores concentrated above and below lateral line between myomeres, pigment present on venter from dorsal fin insertion to caudal fin, a few melanophores concentrated on interradial membrane near proximal portion of caudal fin.:‘:
16-18 mm	Myomeres: see 15.2 mm. Morphometry: (as % TL) preanal length 63 to 66, body depth at anus 10, head length 14 to 19, snout length 1 to 3, eye diameter 6 to 8, yolk-sac length 39 to 439 yolk-sac depth 25 to 31.* Morphology: head no longer deflected over yolk sac, actinotrichia in anal fin present (17.0 mm).* Pigmentation: a few more melanophores on dorsum, dorso-lateral aspect of myosepta and on caudal peduncle (17.0 mm).*
19-22 mm	Myomeres: see 15.2 mm. Morphometry: (as % TL) preanal length 61 to 64, body depth at anus 11, head length 14 to 21, snout length 2 to 4, eye diameter 7 to 8, yolk-sac length 28 to 35, yolk-sac depth 15 to 26.*

Morphology: incipient rays beginning to form in dorsal (10) and anal (9) fins, finfold decreasing anterior and posterior to adipose fin and posterior to anal fin, preanal finfold persists (21 mm).*
Pigmentation: pigment more dense along lateral surfaces and head (2 1 mm).*

LARVAE

Total length	Description
22-24 mm	Morphometry: (as % TL) preanal length 61 to 65, body depth at anus 10, head length 15 to 23, snout length 2 to 5, eye diameter 7 to 8, yolk-sac length 21 to 30, yolk-sac depth 6 to 19.* Morphology: small remnant of yolk remains, median fin rays formed, pectoral fins incomplete, pelvic buds persist, finfold persists just anterior to adipose fin and just posterior to adipose and anal fins (23 mm).* Pigmentation: body uniformly pigmented except preanal venter, where there is no pigment, no pigment on midlateral myoseptum, none on fins except spot on proximal interradial membrane of caudal fin, subsurface pigment just anterior to stomach and between opercula and to pectoral fin base (23 mm).*

JUVENILES

Total length	Description
27-38 mm	Myomeres: mean total 64.2.[6] Morphometry: (as % TL) preanal length 60 to 65, body depth at anus 11 to 12, head length 20 to 26, snout length 4 to 5, eye diameter 7 to 9.* Morphology: all fin rays present, finfold absorbed (30 mm).* Pigmentation: entire body pigmented except preanal venter, increased pigment on caudal fin, parr marks distinct, only caudal and dorsal fins pigmented, pigment on dorsal fin restricted to tip of membrane between first few rays (30 mm).*

ADULTS

Fin rays: caudal 19;* dorsal 8 to 10, anal 8 to 10, pectoral 12 to 17, pelvic 8 to 11.[1]

Vertebrae: 61 to 69.[1]

Lateral line scales: 116 to 138.1

Pyloric caeca: 93 to 198.[16]

Diagnostic characters: maxilla extends beyond eye, irregular white spots on back and sides, no dark spots on back or fins, caudal fin deeply forked, mouth large, more than 116 lateral line scales, young usually have seven dark parr marks separated by spaces as wide as marks.

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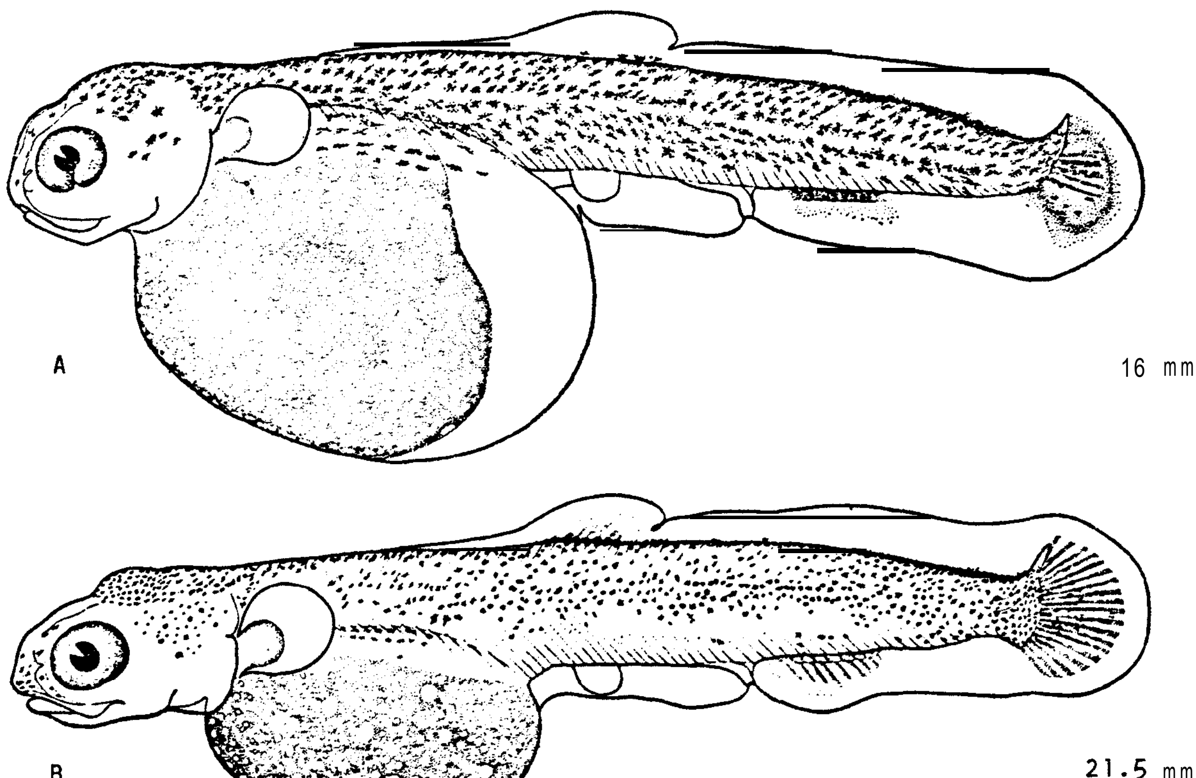


Fig. 44. Salvelinus namaycush, lake trout. A. Yolk-sac larva. B. Larva. (A and B, hatchery-reared, St. Lawrence River, Fish 1932).

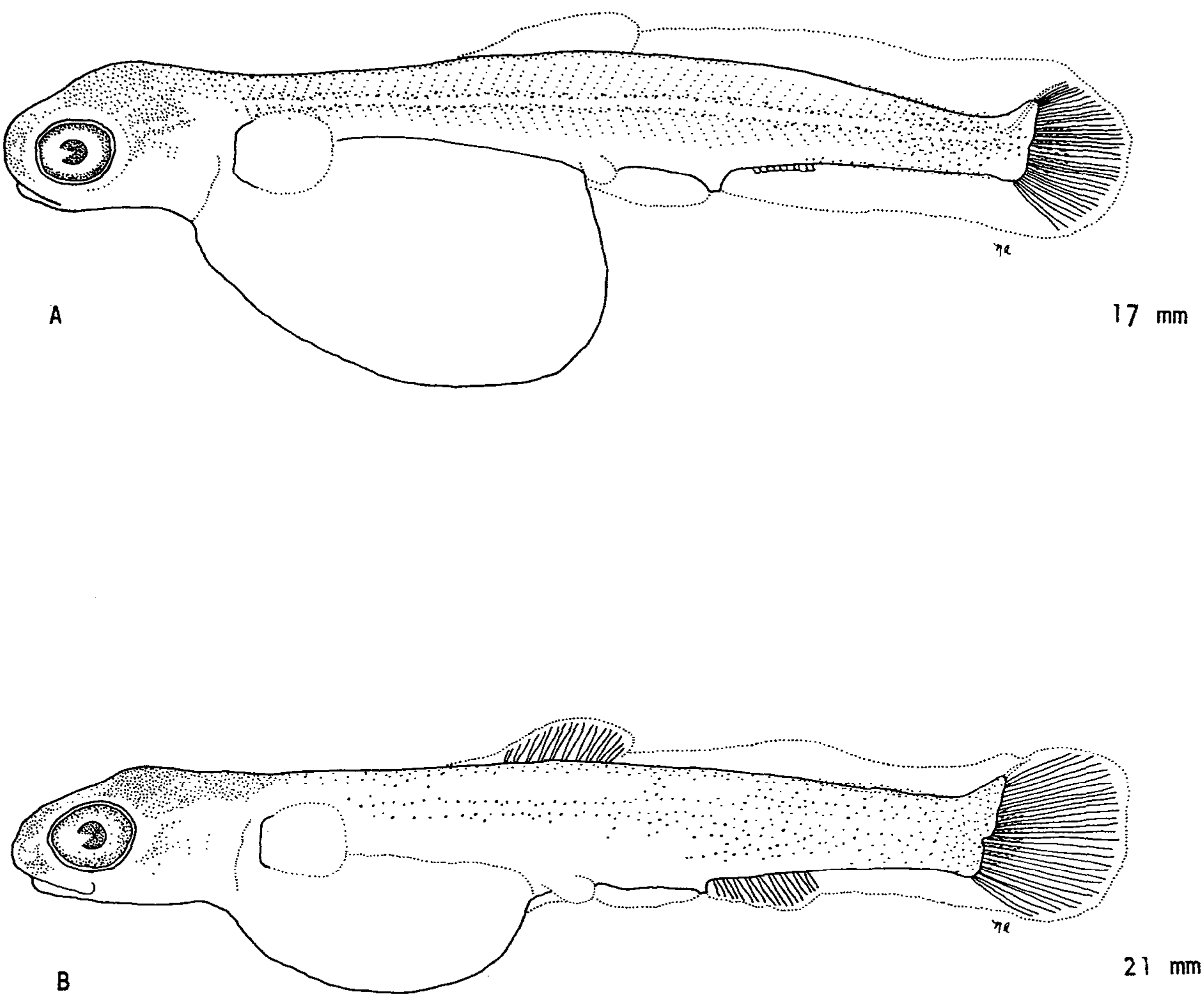
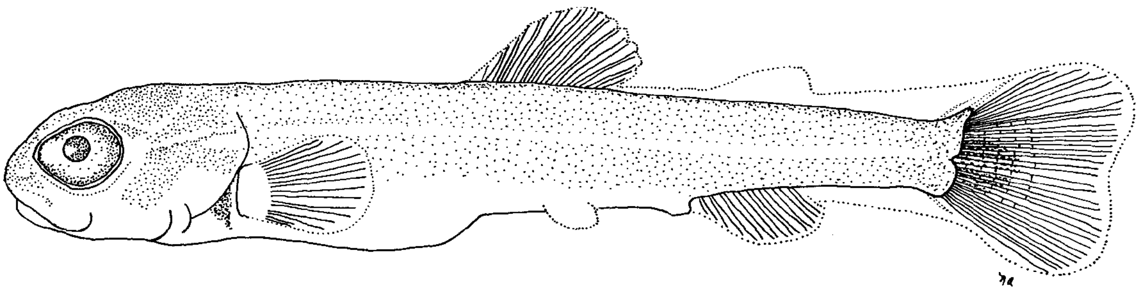
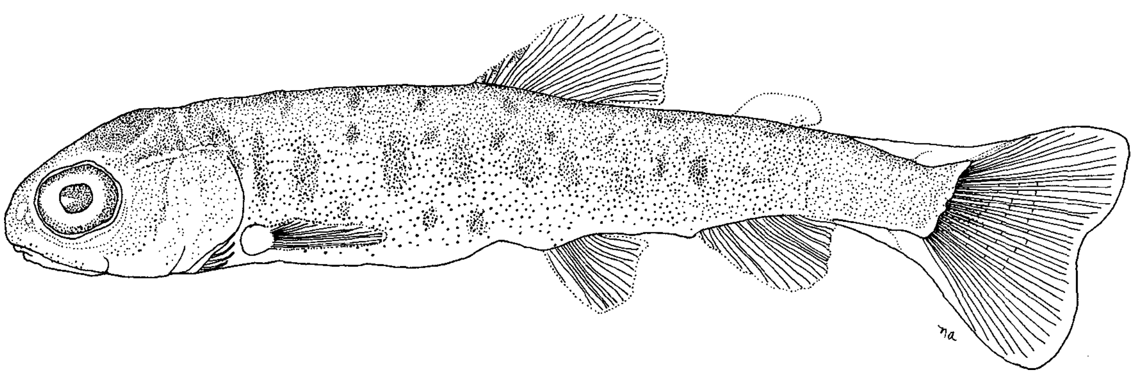


Fig. 45. Salvelinus namaycush, lake trout. A and B. Yolk-sac larvae. (A and B, laboratory-reared, Lake Michigan, original illustrations by N. A. Auer, specimens provided by F.P. Binkowski, Center for Great Lakes Studies, University of Wisconsin-Milwaukee).



A

23 mm



B

30 mm

Fig. 46. Salvelinus namaycush, lake trout. A. Yolk-sac larva. B. Larva. (Laboratory-reared, Lake Michigan, original illustrations by N. A. Auer, specimens provided by F. P. Binkowski, Center for Great Lakes Studies, University of Wisconsin-Milwaukee).

Family Osmeridae, smelts

By

Heang T. Tin

The smelt family includes 6 genera and 10 species, all of which are restricted to arctic and north temperate regions (Scott and Crossman 1973). Members of this family are marine, anadromous or freshwater. Only one species occurs in the Great Lakes region. Smelts are small fishes with an elongate, compressed body and large mouth; teeth are well developed or weakly developed on the mesopterygoid, glossohyal, vomer, palatine, premaxilla, maxilla and dentary; spines and pelvic axillary scales are lacking; an adipose fin is present; scales are thin and cycloid; pyloric caeca number 11, 1 or are absent.

Spawning generally takes place during spring and summer. One species is known to spawn in the fall. Smelt usually migrate upstream a short distance to spawn. Landlocked populations may also in shallow areas of lakes. Eggs are generally small, 1.0 to 1.1 mm and adhere to the substrate by a pedicel. Larvae are long and slender.

Osmerus mordax (Mitchill), rainbow smelt

DISTRIBUTION

Native to the Atlantic Ocean coastal drainage, it has been established through introductions in all of the Great Lakes and several inland lakes.'[9] It is more abundant in the northern portion of the Lake Michigan drainage than in the southern portion."

SPAWNING SEASON

Usually spawns in April and May in Lakes Michigan,[13 19 21] Superior,[2 18] and Erie.[10] In Lake Mich igan spawning may start during late March.'

SPAWNING TEMPERATURE

Spawns at 4.0 to 15 C,[3 4 6 8 18 22] with peak spawning at 10 C.[13 19]

SPAWNING HABITAT

Spawns in many types of lotic environments from small brooks to large rivers.[2 5 8 16 20] Landlocked populations may also spawn in shallow areas of lakes.[2 8 9 19] Spawning sometimes occurs in the deep water of lakes.[10 23]

SPAWNING SUBSTRATE

Deposits eggs on boulders, gravel, sand, mud, aquatic vegetation, debris.'[8 9 20]

FECUNDITY

1,700 to 69,600.[3 6 7 16]

EGGS

Adhesive;[3 8 16] transparent;[3] diameter 0.9 to 1.3 mm;[1 4 7] oil globules numerous;'[6] after egg deposition, chorion separates and everts to form a pedicel, which attaches egg to substrate;[1 3 15] incubation period: 29 days at 6 to 7 C, 19 days at 9 to 10 C;[3] 8 days at 9 to 21 C (mean 16.5 C) .[1]

YOLK-SAC LARVAE

Total length	Description
4.1-6.0 mm	Newly hatched.[1 7 11 15 21]
	Myomeres: (42 to 48 + 13 to 17) ;[1] 58 to 67 (43 to 49 + 15 to 21) at 4.1 to 25.4 mm.*
	Morphometry: (as % TL) preanal length 65 to 75;[1 12] head length 14, eye diameter 4 to 6.[25]

Morphology: body long, very slender;[1,21] oil globule single, located near anterior end of yolk sac;[1,21] pectoral buds present’[12] (newly hatched), mouth well formed (6.0 mm);[1] yolk sac positioned near a point located one-third total body length during yolk-sac stage.’[21]

Pigmentation: body transparent (newly hatched);[14] two rows of pigment on venter extending from pectoral buds to anterior end of yolk sac, single row of pigment on midventral line between posterior end of yolk and anus (6.0 mm);[1] several (often three) widely spaced, elongate chromatophores may be present on venter between anus and base of caudal fin;[12,21] venter of yolk sac sometimes covered with small chromatophores which will disappear in later development;* pigment on venter of yolk sac and in later stages variable.’ *

LARVAE

Total length	Description
6-17 mm	Myomeres: 59 to 60 (45 + 14 to 15) at 7.5 to 15.5 mm;[1] see 4.1-6.0 mm. Morphometry: (as % TL) preanal length 72 to 75, head length 14 to 15, eye diameter 3 to 4 (6.5 to 15.5 mm).[1] Morphology: yolk absorbed (6.4 mm, 4 days posthatching)’ or (6.9 mm, 7 days posthatching);[24] jaws well formed, no teeth present, pectoral buds not rayed (9.3 mm), fin ray development begins in caudal, dorsal and anal fins, adipose fin detectable (14 mm), dorsal and anal fin rays well developed (10 and 15 rays, respectively), caudal fin complete, adipose fin partially formed (17 mm);[1] in some specimens all fins formed (15 mm);[14] in others, pelvic buds not apparent, teeth present in upper jaw (17.0 mm).[1] Pigmentation: paired row of elongate melanophores on venter between pectoral fins and pelvic buds, becoming a single row between pelvic buds and anus, several (often three) widely-spaced elongate melanophores may be present on venter between anus and caudal fin base[12,21]
22-33 mm	Myomeres: see 4.1-6.0 mm. Morphometry: (as % TL) preanal length 68 to 69, head length 17 to 18, eye diameter 4.[1] Morphology: anal and caudal fin rays complete, rudimentary fin rays in dorsal fin, swim bladder distinct, gut forced downward anterior to pelvic buds (22 mm), all fin rays formed except in pectoral fins, adipose fin developed, teeth present on both jaws and tongue (30 mm).[1]

Pigmentation: numerous melanophores on dorsum of swim bladder (22 mm), melanophores on caudal fin arranged in lines following individual rays (30 mm);[1] other pigment patterns similar to those in previous stage.*

JUVENILES

Total length	Description
32-42 mm	Myomeres: 60 to 62 (43 to 48 + 14 to 17) at 32 to 38 mm.[1] *
	Morphometry: (as % TL) preanal length 65, head length 18, eye diameter 4 (32.5 to 38 mm).[1]
	Morphology: full complement of fin rays formed (36[1] to 45[14] mm).
	Pigmentation: two rows of melanophores on venter from base of pectoral fins to anterior end of swim bladder and from pelvic fin base to anal fin base, single row of elongate melanophores on midventral line from pelvic fin to anal fin base and between anal and caudal fins, a few chromatophores on gill cover (32 to 42 mm); additional pigment present on head and in irregular rows on dorsum from behind head to base of caudal fin (≥ 42 mm).*

ADULTS

Fin rays: caudal 19;* dorsal 8 to 11, anal 12 to 16, pectoral 11 to 14, pelvic 8.[9]

Vertebrae: 58 to 70.[9]

Lateral line scales: 62 to 72.[9]

Diagnostic characters: adipose fin present, mouth large, maxilla extends to middle of eye or beyond, lower jaw protruding, teeth present on vomer, palatine, pterygoid, basibranchial, dentary, maxilla, premaxilla and glossohyal.

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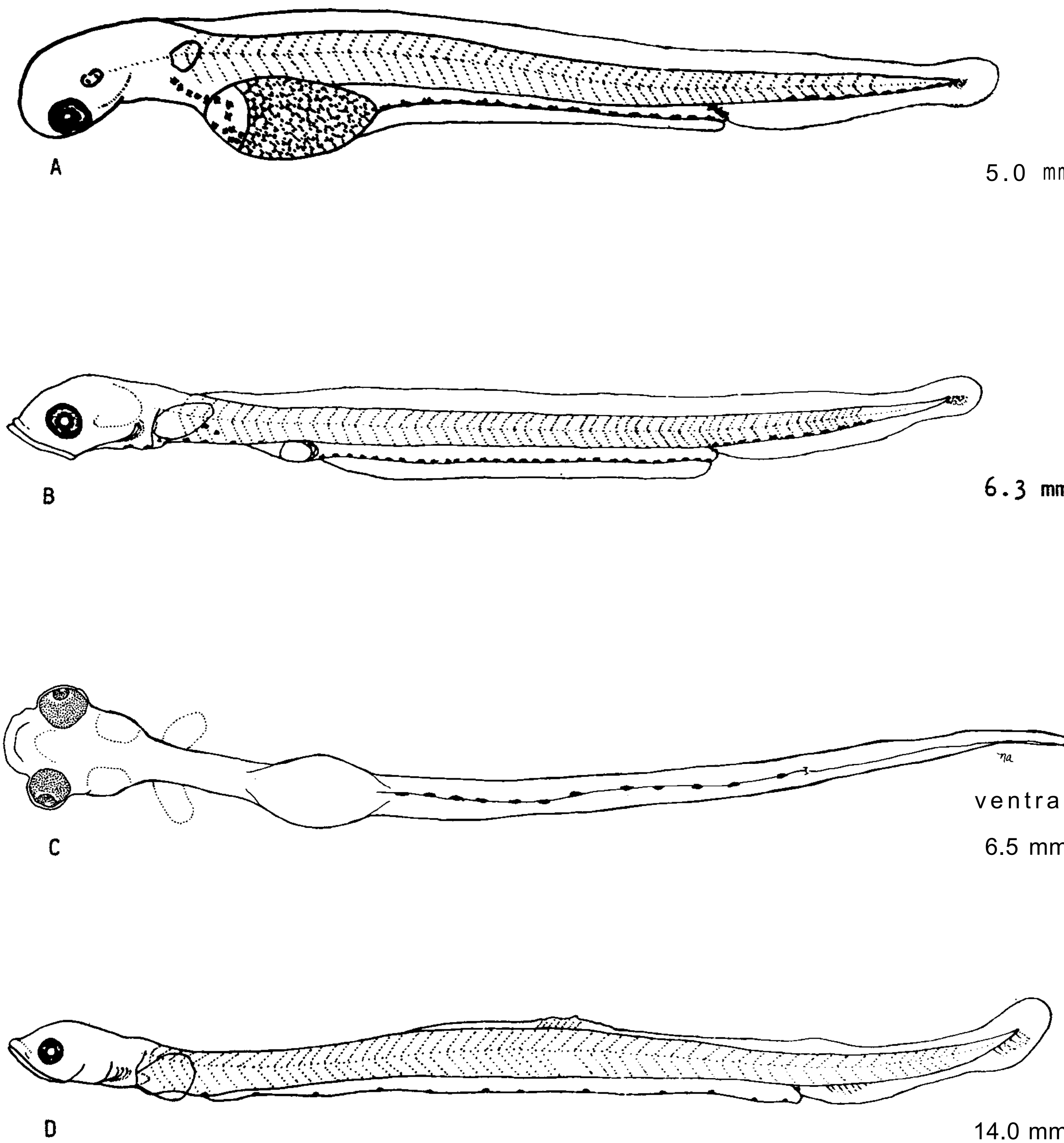

Fig. 47. Osmerus mordax, rainbow smelt. A-C. Yolk-sac larvae. D. Larva. (A, B and D, laboratory-reared, Pennsylvania, Cooper 1978a; C, wild-caught, Lake Michigan, original illustration by N. A. Auer).

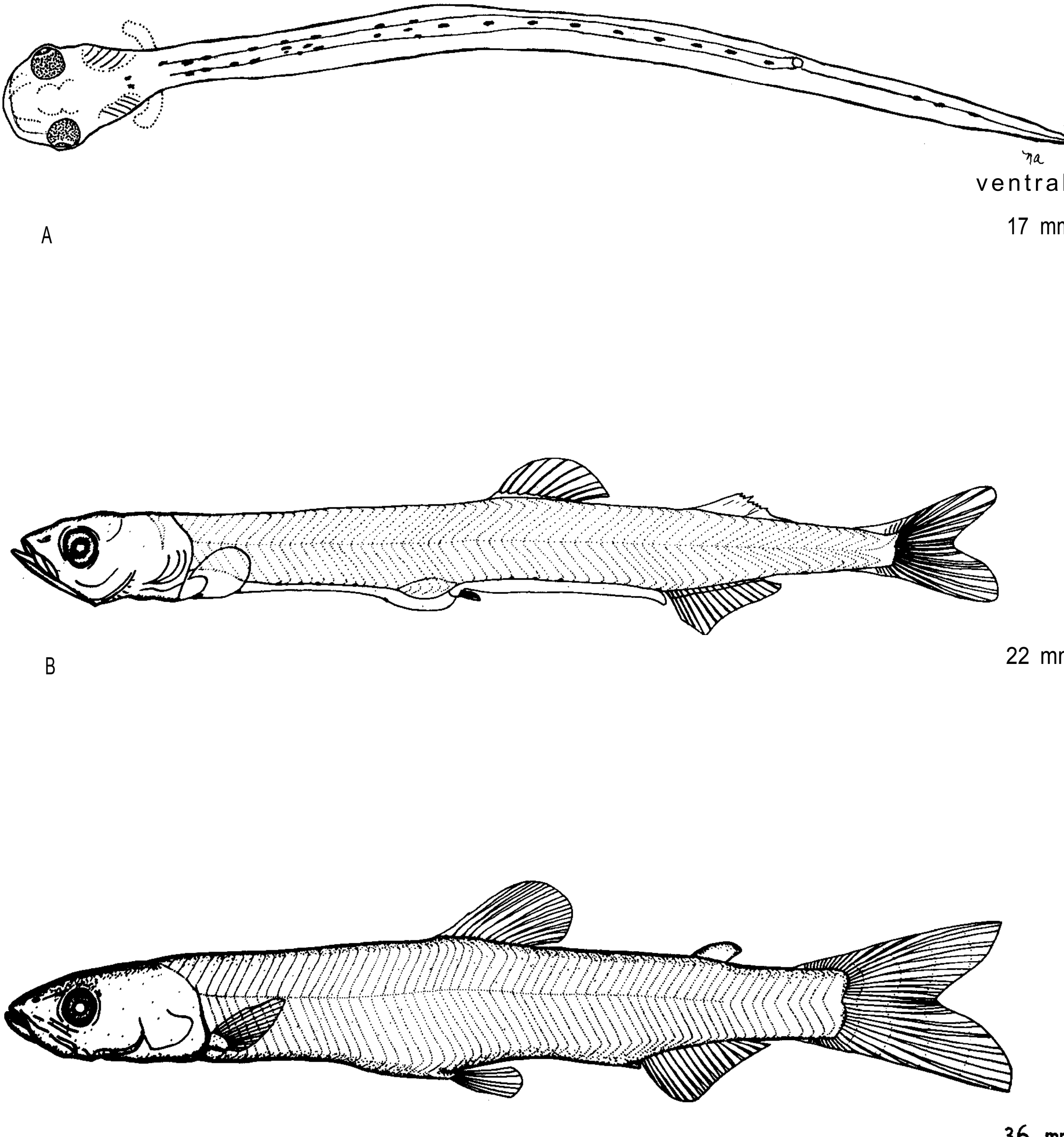

Fig. 48. Osmerus mordax, rainbow smelt. A and B. Larvae. C. Juvenile. (A, wild-caught, Lake Michigan, original illustration by N. A. Auer; B and C, laboratory-reared, Pennsylvania, Cooper 1978a).

Family Umbridae, mudminnows

By

Nancy A. Auer

Representatives of the family Umbridae occur in both North American and southeastern European freshwater. In North America three genera and four species are recognized, however, only Umbra limi occurs within the Lake Michigan drainage.

Mudminnows prefer the mud and weed bottoms of freshwater ponds, slow moving streams, stagnant pools and ditches. They are physostomus and are able to breath atmospheric oxygen. Adults of this species rarely exceed 130 mm and can be recognized easily by the position of the dorsal and anal fins (far back on the body) , the rounded caudal fin preceded by a vertical bar of dark pigment and the absence of pores on the lateral line.

These small fish spawn early in the spring in nests constructed of aquatic vegetation upon which adhesive eggs are deposited singly. Females may guard the nest. Larvae hatch at approximately 5.0 mm and are characterized by the anus position being slightly posterior to the body midpoint, a large yolk sac with several small oil globules and the urostyle extending to the edge of the finfold.

Umbra limi (Kirtland), central mudminnow

DISTRIBUTION

Common in the Lake Michigan drainage[1] and known throughout the Great Lakes basin.[3]

SPAWNING SEASON

Spawns in early spring in the Great Lakes region,' [3] April in southwestern Michigan' and March and April in New York.[6]

SPAWNING TEMPERATURE

Spawning is reported to occur between 12.8 and 15.6 C.[1 3 5]

SPAWNING HABITAT

Migrates upstream into spring riverlets,[7 9] or in streams and ponds.[1]

SPAWNING SUBSTRATE

Deposits eggs singly[8] on aquatic plants or submerged terrestrial vegetation.[1 1]

FECUNDITY

220 to 2,286;[3 9] 420 to 450.[10]

EGGS

Adhesive, diameter 1.6 mm;[7 8] oil globules small, highly refractive and clustered.[8]

YOLK-SAC LARVAE

Total length	Description
5 mm	Newly hatched.[3 8] Morphometry: preanal length just greater than 50% TL.[6] Morphology: yolk sac large with numerous oil globules, tip of urostyle extending to margin of finfold; swim bladder evident behind pectoral buds and above foregut as a fusiform vesicle (3 days posthatching).[8]

LARVAE

Total length	Description
24-25 mm	Morphometry: (as % TL) preanal length 57, greatest body depth 19, head length 29, eye diameter 8.[4]

Pigmentation: small, gray chromatophores cover body, except on venter from head to anus, surface of head, dorsum and venter posterior to anus are darkly pigmented, dark spot at base of caudal fin.[4]

JUVENILES

Body thick, dark urostyle extends to posterior margin of caudal fin which becomes rounded with growth, body heavily pigmented.[5]

ADULTS

Fin rays: caudal 12 to 13;[3, 11] dorsal 13 to 15, anal 7 to 10, pectoral 14 to 16, pelvic 6 to 7.[3]

Vertebrae: 35 to 37.[3]

Lateral line scales: 34 to 37.[3, 4]

Diagnostic characters: body short and oblong, tail rounded, vertical black bar of pigment at base of caudal fin, no lateral line pores, supramaxilla forms lateral margin of mouth, teeth small and villiform, dorsal fin positioned far behind midpoint of body.

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Family Esocidae, pikes

BY

Lee A, Fuiman

The single genus in this family, _Esox_, contains five species. Four species occur in the Great Lakes region, including Esox lucius which has a circumpolar distribution in the northern hemisphere. _Esox niger_ is the only species of the four which has not been reported from the Lake Michigan drainage. It occurs only in the drainages of Lakes Erie and Ontario.

Pikes are moderate to large freshwater fishes with an elongate appearance accented by a long snout. The dorsal and anal fins are placed far back on the body and the scales are small. Members of this family often inhabit ponds, lakes and rivers where juveniles and adults usually prey on other fishes. They spawn in early spring over vegetation.

Esocid eggs are moderately large (about 2 to 3 mm) and the yolk contains numerous small oil globules. Larvae hatch at about 5 to 10 mm and, in some species, attach themselves to vegetation by means of an adhesive organ located on the front of the head. Larvae are characterized by a dark stripe of melanophores along the hypaxial musculature which extends most of the length of the body. As they grow, the snout becomes elongate.

Provisional Key to Great Lakes Esocid Larvae

1a. Total myomeres less than 50 . . . . Esox _americanus_

b. Total myomeres more than 49 2

2a. Preanal myomeres less than 37; total myomeres less than 56 . . . . I . . . . _Esox niger_

b. Preanal myomeres more than 36; total myomeres more than 55. 3

3a. Preanal myomeres 40 to 46; yolk-sac larvae with numerous melanophores on yolk sac and dorsum. . . . . Esox _lucius_

b. Preanal myomeres 44 to 48; yolk-sac larvae lacking melanophores on yolk sac. . . . . _Esox masquinongy_

Esox americanus, redfin and grass pickerels

There are two widely recognized subspecies of this species. Much of the information available is for the eastern form (E. americanus americanus Gmelin, redfin pickerel), but morphological differences are minimal and so data for both subspecies are combined here and intended to apply to the Great Lakes form, E. a. vermiculatus LeSueur.

DISTRIBUTION

This subspecies occurs in southern and northern tributaries of Lake Ontario,[17] southern tributaries of Lakes Erie, Huron and Michigan, and in southern Ontario (Canada) near Lakes Erie and Huron.[4 11] In Lake Michigan it is common in the lower half of the drainage.*

SPAWNING SEASON

Usually spawns in early spring in the Lake Michigan drainage." Eggs have been found in early to mid-May.[2] Collection of very small, 27- to 30-mm, specimens in mid-November suggests occasional fall spawning at least in Michigan.'

SPAWNING TEMPERATURE

Spawning was reported at 10 C[3] and between 4 and 12 C.[1 4 13]

SPAWNING HABITAT

Spawns in sloughs,[2] temporary marshes and on grassy banks in water less than 0.3 m deep.[3]

SPAWNING SUBSTRATE

Eggs are broadcast over vegetation, such as aquatic moss (Dreplanoclaudus spp.), leaves, twigs[2] and various species of aquatic vegetation.[3]

FECUNDITY

ca. 600 to 4,600;[2 3 15] 15,732 (with 803 of these ready to be spawned).[14] Note: egg number in E. a. vermiculatus is nearly two times that of E. a. americanus.3

NATURAL HYBRIDS

Esox lucius;*[12] E. niger.[8 9 10]

EGGS

Demersal, adhesive;[3] diameter larger than E. lucius, yolk yellow, incubation period: 15 days at 7.8 C, 14 days at 8.3 C, 11 days at 8.9 C;[2] 12 to 14 days in situ.[15]

YOLK-SAC LARVAE

Total length	Description
5.0-6.0 mm	Newly hatched.[2]
7-10 mm	Morphology: mouth formed (9.0 mm), gut formed, feeding begins (10.0 mm,[2] 1 week posthatching[3]). Pigmentation: eyes black (7.0 to 8.0 mm).[2]

LARVAE

Total length	Description
11-18 mm	Myomeres: ca. 46 (31 + 15+), indistinct at 17.8 mm.[5 6] Morphometry: preanal length greater than 67% TL.[16] Morphology: snout blunt (11.6 mm), becoming elongate (17.8 mm), pelvic buds formed, incipient caudal and anal fin rays formed (11.6 mm), notochord flexed, incipient dorsal fin rays formed (17.8 mm).[5 6] Pigmentation: body darker below, dark midventral stripe present, dark chromatophores dorso-laterally, middorsal pigment-free stripe, dark stripe from snout through eyes to pectoral buds (11.6 mm), venter with less pigment, melanophores concentrated over brain and over pectoral buds (17.8 mm).[5 6]

JUVENILES

Total length	Description
20-125 mm	Morphometry: snout length 11% TL at sizes less than 150 mm.[5 6] Morphology: all fin rays formed (20 mm);[13] 11 to 13 branchiostegal rays present (extreme: 16 rays);[3 16] finfolds absorbed (22 mm), first scales formed (50 mm), squamation nearly complete, vertebral column complete (65 mm).[5 6] Pigmentation: pigment-free stripe on side for entire length of body (20 to 125 mm);[2 6] dark lateral stripes above and below pigment-free stripe (less than 60 mm); middorsal and midlateral stripes obscure, vertical bars forming;[3 5 6] subocular bar directed postero-ventrally (60 to 100 mm);[3 13] adult pigmentation present at 130 to 140 mm.[3]

ADULTS

Fin rays: caudal 19;* dorsal 17 to 21, anal 16 to 18, pectoral 14 to 15, pelvic 9 to 10.[3]

Vertebrae: 44 to 46 (42 to 47).[3]

Lateral line scales: 93 to 118.3

Branchiostegal rays: 9 to 14 (usually 5 antero-hyal + 7 postero-hyal, or 6 + 7).[3]

Submandibular pores: 8 (7 to 9).[3]

Diagnostic characters: submandibular pores usually less than 9, cheek and opercle fully scaled, branchiostegal rays usually 12 to 13 (5 + 7 or 6 + 7).

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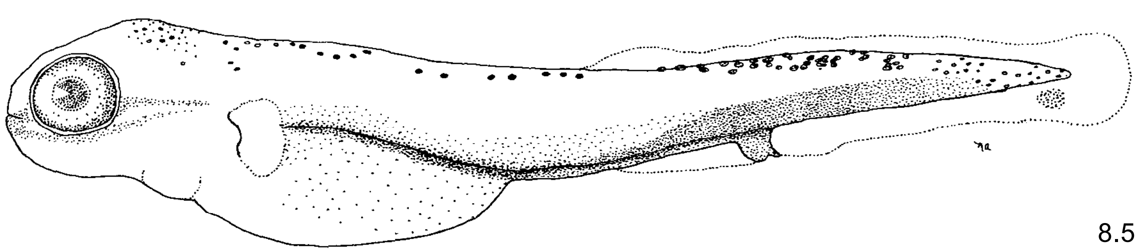
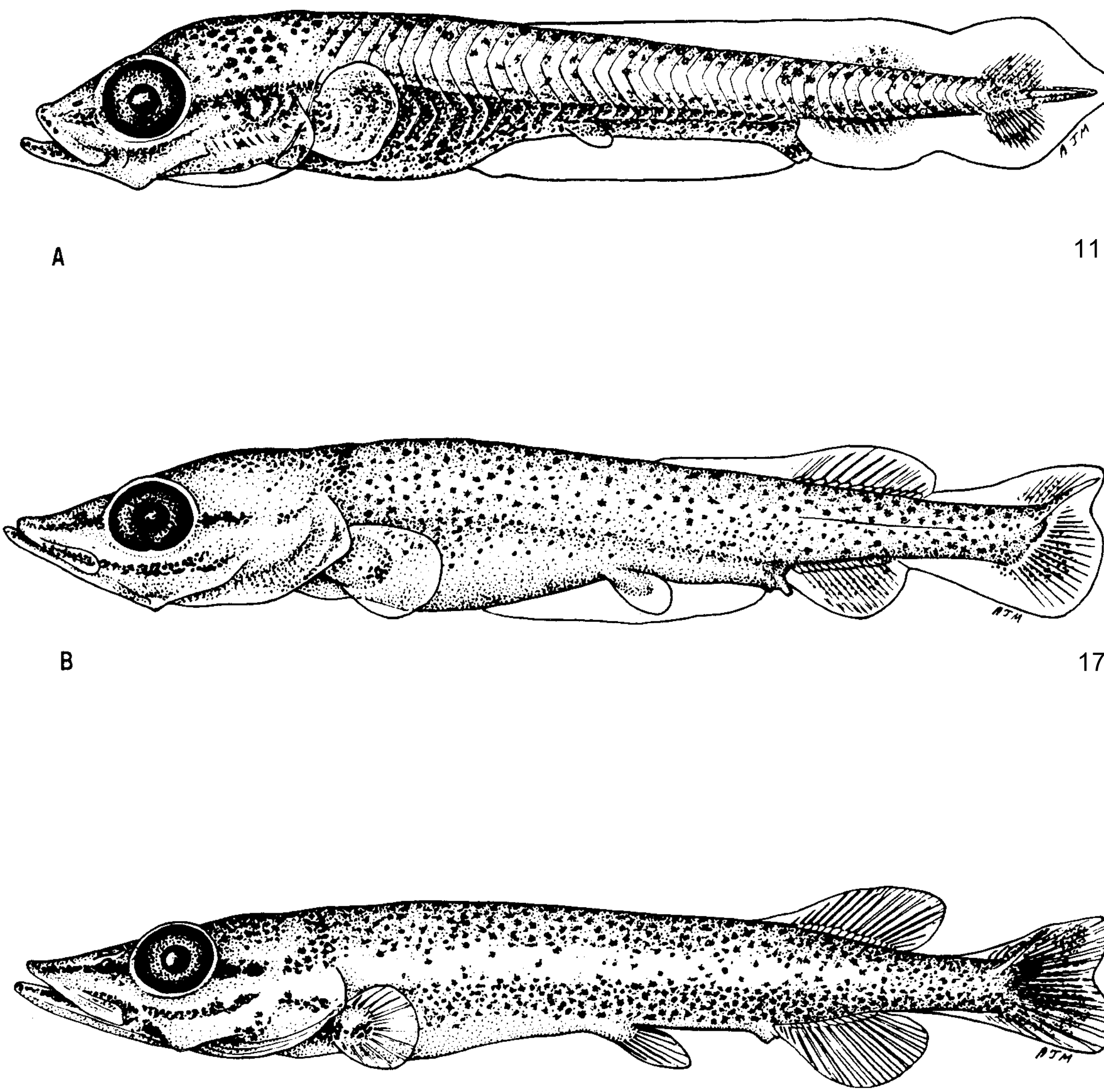


8.5 mm

Fig. 49. Esox americanus, grass pickerel. Yolk-sac larva. (Laboratory-reared, Wisconsin, Kleinert and Mraz 1966, delineated by N. A. Auer).



A 11.6 mm

B 17.8 mm

C 22 mm

Fig. 50. Esox americanus, grass pickerel. A and B. Larvae. C. Juvenile. (A-C, laboratory-reared, Maryland, Mansueti and Hardy 1967).

Esox lucius Linnaeus, northern pike

DISTRIBUTION

A holarctic species which is found in most of the Great Lakes region.[32] Common throughout the Lake Michigan drainage.'

SPAWNING SEASON

Spawns from March through May in the Lake Michigan drainage,' usually during April.[5 14] Canadian populations spawn as late as mid-May.[22]

SPAWNING TEMPERATURE

Most reports range from 4 to 11 C,[1 7 8 10 13 16 17] extremes of 11 to 17 C have been noted.[14]

SPAWNING HABITAT

Spawns in a variety of vegetated habitats,'[13 22 29] including flooded marshes, drainage ditches[5 13] and sloughs.[25] Usually spawns at depths between 5 and 30 cm[7] or 38 and 53 cm.[13 17]

SPAWNING SUBSTRATE

Eggs are broadcast over various types of vegetation (mosses, grasses, leaves, reeds) and mud.[17 19]

FECUNDITY

7,691 to 97,273;[4] 28,000 to 290,000.[29]

NATURAL HYBRIDS

Esox americanus;[20 21] *E masquinongy*;[21,23] *E. niger*.[21 23 26]

EGGS

Demersal;[7 12 16 17 29 30] not semibuoyant* as previously described;[30] adhesive;[7 12 17 29] diameter 2.2 to 3.0 mm;[11 14 16 17 18 30] extreme: 3.4 mm;[24] surface of chorion obscurely reticulate;[30] perivitelline space moderate;" yolk diameter 2.3 mm;[17] yolk yellow (various hues);[2 11 14 17 30] or dusky green;[29] oil globules (absent[14]) numerous, small, and in clusters at surface of yolk;[11 17 28 31] incubation period: 120 degree-days;[27] 21 days at 4 C, 14 days at 7 C, 13 days at 8 C;[2] 14 to 21 days at 7 to 13 C;[29] 12 to 17 days at 9 to 11 C;[12] 10 to 12 days at 10 C;[15] 7 to 10 days at 11 C;[13 24] 8 days at 13 C;[17] 5 to 10 days at 15 C, 3 to 4 days at 19 C;[9] 10 to 12 days in situ.[17]

YOLK-SAC LARVAE

Total length	Description
6-10 mm	Newly hatched, many hatching sizes reported in this range;[2 6 11 12 25 27 28 34] most reliably between 7 and 9 mm;[15 17 24 29 30 31] lower, water temperatures tend to produce smaller hatching sizes.[3] Morphometry: (as % TL) preanal length 75;[17] predorsal finfold length 35;[24] eye diameter 5.[30] Morphology: pectoral buds present;[6 15 24 30 34] head deflected over large round yolk sac;‘[17 24 30] or not so;[15] mouth inferior;” adhesive organ on front of head.[12 15 29] Pigmentation: eyes pigmented;[28] or not;[2] melanophores over body, dorsum of gut and head;[17 28] lateral stripe from snout to caudal fin;[17 24 30] middorsal stripe present.[3o]
8-13 mm	Myomeres: 61 to 68 (41 to 46 + 20 to 24).[24] Morphometry: (as % TL) preanal length 70, head length 17;[24] eye diameter 6 to 8;[24 30] greatest body depth 24;[24] snout length 5.[30] Morphology: mouth parts formed (9.3 to 11.0 mm);[2 17 3o] feeding begun (12.0 mm);[2] notochord flexed, five dentary, two maxillary and premaxillary teeth present (10.5 mm, 3 days);[3o] swim bladder inflated (12 mm).[17 24] Pigmentation: eyes pigmented (7.0 to 8.0 mm;[2] 9.3 mm[24]); dark pigment over body and yolk sac, brown pigment in dorsal and anal fin anlage (10.2 mm), yellow-brown pigment in dorsal fin anlage (12 mm).[17]

LARVAE

Total length	Description
10-19 mm	Myomeres: 62 to 66 (42 to 45 + 19 to 22).[24] Morphometry: (as % TL) preanal length 68, head length 27, eye diameter 8, greatest body depth 14.[24] Morphology: yolk absorbed (ca. 10 to 13 mm,[16 24 29] 14 to 15 mm[31] or 15 to 20 mm;[12] at 6 to 10 days posthatching;[8 29] or 160 to 180 degree-days postfertilization[27]); pelvic buds formed (13 mm;[3o] 15 mm;[24] and 16 to 19 mm[28]); first caudal fin rays formed (13.2 mm), lower jaw protruding (15 mm);[24] adhesive organ not functional (4 to 6[29] 10[17] days posthatching); pectoral fin rays formed (15.9 mm), dorsal and anal fin rays present, notochord flexed (18.2 mm).[24] Pigmentation: patch of pigment at anus faded, (13.5 mm);[17] dorsum with two stripes separated by pigment-free median stripe, preorbital stripe below midlateral

	stripe present (18.2 mm);[24] midlateral stripe from snout to pelvic fins, scattered melanophores posteriorly.[30]
19-50 mm	Myomeres: 57 to 63 (40 to 44 + 17 to 19).[24] Morphometry: (as % TL) preanal length 69;[24] head length 30 to 36, eye diameter 8;[24 30] greatest body depth 15;[24] snout length 14.[30] Morphology: notochord flexed (20 mm,[11] but see 13 to 19-mm and 8 to 13-mm descriptions): first scales formed (30.5 to 32.0 mm);[34] nearly al 1 fin rays formed (38.6 mm).[24] Pigmentation: median pigment-free stripe covered with melanophores, several vertical bands from dorsum to midlateral area (38.6 mm).[24]

JUVENILES

Total length	Description
50-67 mm	This period may begin as early as 26 to 35 mm.[11 14] Morphometry: (as % TL) preanal length 66;[24] head length 30 to 32;[11 24] eye diameter 5;[24] greatest body depth 8 to 9.[11 24] Morphology: 15 branchiostegal rays present (50.5 mm);[11] al 1 scales formed (66.5 mm).[34] Pigmentation: dark band on head through eye, no parallel band below, fins spotted."

ADULTS

Fin rays: caudal 19;* dorsal 15 to 19, anal 12 to 15, pectoral 14 to 17, pelvic 10 to 11.[33]

Vertebrae: 57 to 65."

Lateral line scales: 105 to 148.[33]

Branchiostegal rays: 13 to 16 (usually 7 antero-hyal + 8 postero-hyal, or 6 + 8).[35]

Submandibular pores: 9 to 11.[35]

Diagnostic characters: submandibular pores 9 to 11, cheek fully scaled, opercle partly scaled, branchiostegal rays usually 14 to 16 (7 + 8 or 6 + 8).

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27. Huet (1970)
28. Browne (1906)
29. Frost and Kipling (1967)
30. Embody (1910)
31. Bracken and Kennedy (1967)
32. Hubbs and Lagler (1958)
33. Scott and Crossman (1973)
34. Franklin and Smith (1960)
35. Crossman (1962a)

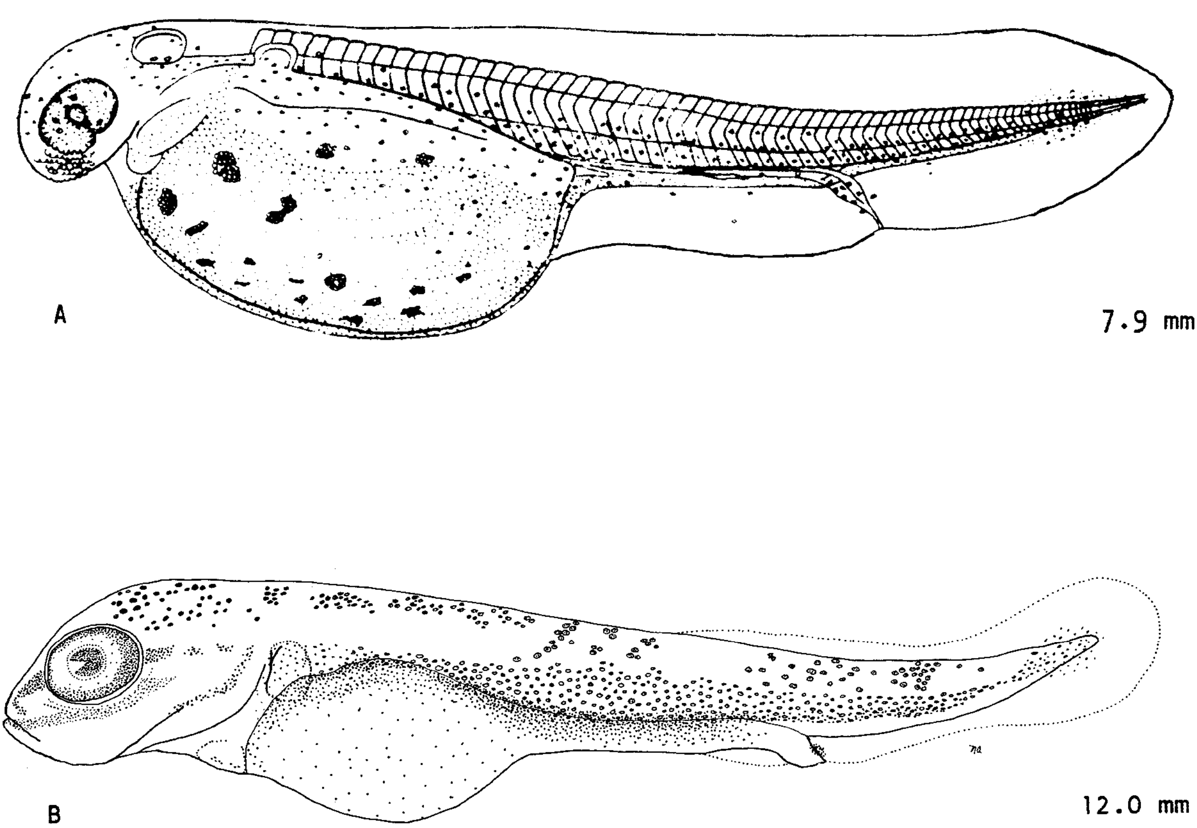


Fig. 51. Esox lucius, northern pike. A. Yolk-sac larva, newly hatched. B. Yolk-sac larva. (A, laboratory-reared, Soviet Union, Kotlyarevskaya 1969; B, wild-caught, Kleinert and Mraz 1966, delineated by N. A. Auer).

Esox lucius

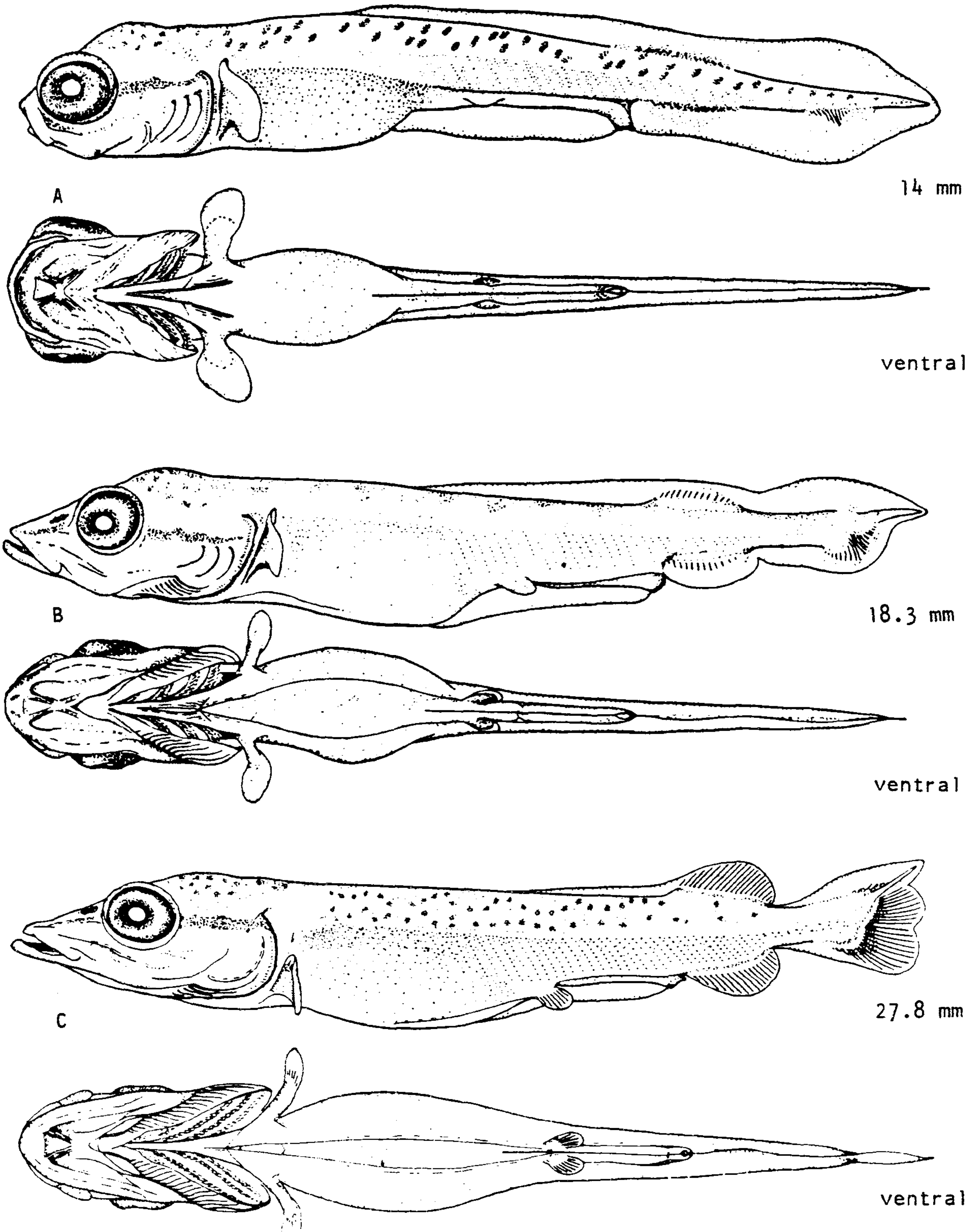
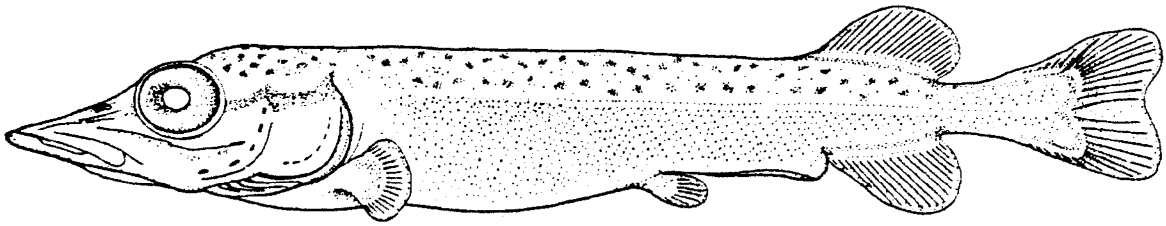
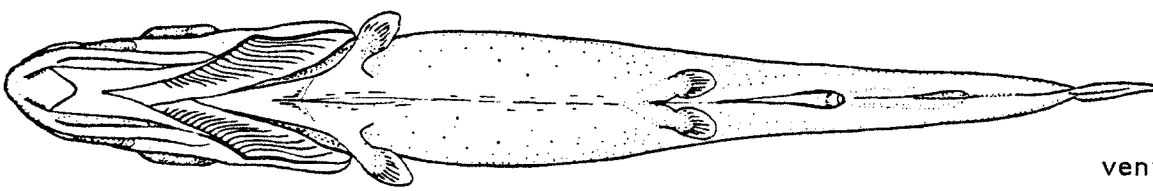


Fig. 52. *Esox lucius*, northern pike. A. Yolk-sac larva. B and C. Larvae. (A-C, laboratory-reared, West Germany, Gihr 1957).

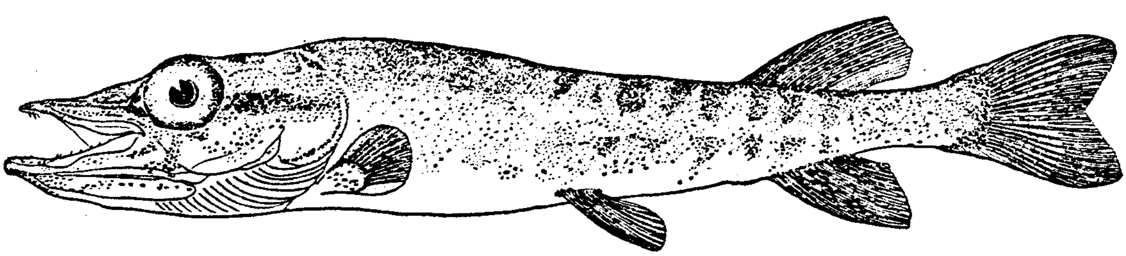


A

36 mm



ventral



B

50.5 mm

Fig. 53. Esox A lucius, northern pike. . Larva. B. Juvenile. (A, laboratory-reared, West Germany, Gihr 1957; B, wild-caught, Lake Erie tributary, Fish 1932).

Esox masquinongy Mitchill, muskellunge

DISTRIBUTION

Scattered throughout the Great Lakes region except tributaries of the northern shore of Lake Superior.[15] Uncommon to rare in the northern half of the Lake Michigan drainage.[1]

SPAWNING SEASON

Spawns from mid-April to late May in Wisconsin tributaries of Lake Michigan[1 2] and in Lake Erie,' only slightly earlier in New York.' [9]

SPAWNING TEMPERATURE

Spawns at temperatures from 9 to 16 C.[1 2 3 7 9]

SPAWNING HABITAT

Usually spawns in shallow, 0.2- to 1.0-m,[2 13] marshy areas,[2] or at edges of pools in streams,[16] but has been reported to spawn in deeper water (3 to 4 m).[4]

SPAWNING SUBSTRATE

Eggs are broadcast over dead vegetation or detritus,[2]

FECUNDITY

10,000 to 15,000;" 22,000 to 180,000,' extreme values of 225,000[2 9 10 11] and 250,000[13] have been reported.

NATURAL HYBRIDS

Esox lucius.[5 14]

EGGS

Demersal ;[13] * or semibuoyant;[10] nonadhesive;[10 13] * diameter 2.5 to 3.3 mm;[3 4] * blastodisc reddish brown;' oil globules numerous, small;[4] incubation period: 62 days at 7 C;[10] 12 to 20 days at 11 c;[11] 13 to 21 days at 10 to 21 C;[3] 8 to 14 days at 12 to 17 C;[2] 13 to 15 days at 13 C;[8 10 11] 10 days at 13 to 18 C;[16] 8 days at 17 C;[12] 6 days at 20 C.[3]

YOLK-SAC LARVAE

Total length	Description
7.9-9.2 mm	Newly hatched, mean length 8.7 mm;[12] erroneously reported as 13 to 18 mm.2
	Morphology: head deflected downward over yolk sac, pectoral buds present.[12]

Pigmentation: dark lateral stripe;[4 12] melanophores on yolk sac;[4] eyes pigmented.[12]

8-15 mm

Myomeres: 64 to 70 (44 to 48 + 18 to 24).[12]
Morphometry: (as % TL) preanal length 67 to 73, head length 14 to 23, eye diameter 5 to 7, greatest body depth 13 to 19;[4 12] snout length 1 to 5, body depth at anus 13 to 14, maxilla length 6.[4]
Morphology: mouth open, swim bladder inflated, pectoral fin rays forming (11.4 mm);[12] lower jaw protruding;' [12] pectoral fin rays not formed, maxi 1 la reaches just beyond front of eye (13.9 mm) .[12]
Pigmentation: eyes pigmented, no melanophores dorsally or ventrally (10.6 mm), melanophores on head (11.4 mm) ;[12] of ten very small;* epaxial pigmentation darker behind anus, melanophores in caudal finfold, many chromatophores on top of head (11.6 mm) .[4]

LARVAE

Total length	Description
15-21 mm	Myomeres: 64 to 68 (45 to 48 + 19 to 21).[12] Morphometry: (as % TL) preanal length 70 to 72, head length 22 to 29, eye diameter 6, greatest body depth 11 to 12;' [12] snout length 6, body depth at anus 12, maxilla length 12.[4] Morphology: yolk absorbed[12] (14.4 mm;[12] 13 mm;[3] after 10 to 15 days[3 4 9 10 11]); hypural elements forming (16 mm);* caudal, dorsal and anal fin rays visible (17.4 mm).[12] Pigmentation: occiput heavily pigmented;* or with median pigment-free stripe, melanophores scattered laterally on dorsum, ventral pigment minimal (17.4 mm) .[12] *
22-57 mm	Myomeres: 61 to 66 (44 to 47 + 17 to 20).[12] Morphometry: (as % TL) preanal length 72;[12] head length 31 to 34, eye diameter 5 to 6, greatest body depth 11 to 12;' [12] snout length 15, body depth at anus 9.[4] Morphology: pelvic buds present, notochord flexed (24.9 mm), lower jaw protruding (25.7 mm) ; [12] maxi 1 la extending to posterior margin of eye, teeth present on jaws, tongue, roof of mouth, pharynx, and gill arches, 20 dorsal and 18 anal fin rays, 17 branchiostegal rays, 64 vertebrae not completely ossified (33.8 mm);[4] fin ray development nearly complete (37.5 mm).[12] Pigmentation: more pigment throughout, venter portion of gut pigmented, several vertical bands on sides (25.7 mm);[12] horizontal stripe from snout to behind eye, anal fin base, posterior caudal fin and just below eye without pigment (33.8 mm) .[4]

JUVENILES

Total length	Description
75 mm	Morphometry: (as % TL) preanal length 66, head length 30, eye diameter 5, greatest body depth 9.[12] Morphology: eye placed high on head.[12] Pigmentation: two lateral bands separated by midlateral pigment-free area.[12]

ADULTS

Fin rays: caudal 19;* dorsal 15 to 19, anal 14 to 16, pectoral 14 to 19, pelvic 11 to 12.[15]

Vertebrae: 64 to 66.[15]

Lateral line scales: 132 to 167.[15]

Branchiostegal rays: 16 to 19;[15] usually 8 antero-hyal + 10 postero-hyal or 8 + 9.[17]

Submandibular pores: 12 to 20.[15 17]

Diagnostic characters: submandibular pores 12 to 20, cheek and opercle not fully scaled, branchiostegal rays 16 to 19 (usually 8 + 10 or 8 + 9) I

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16. Miles (1978)
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Esox masquinongy

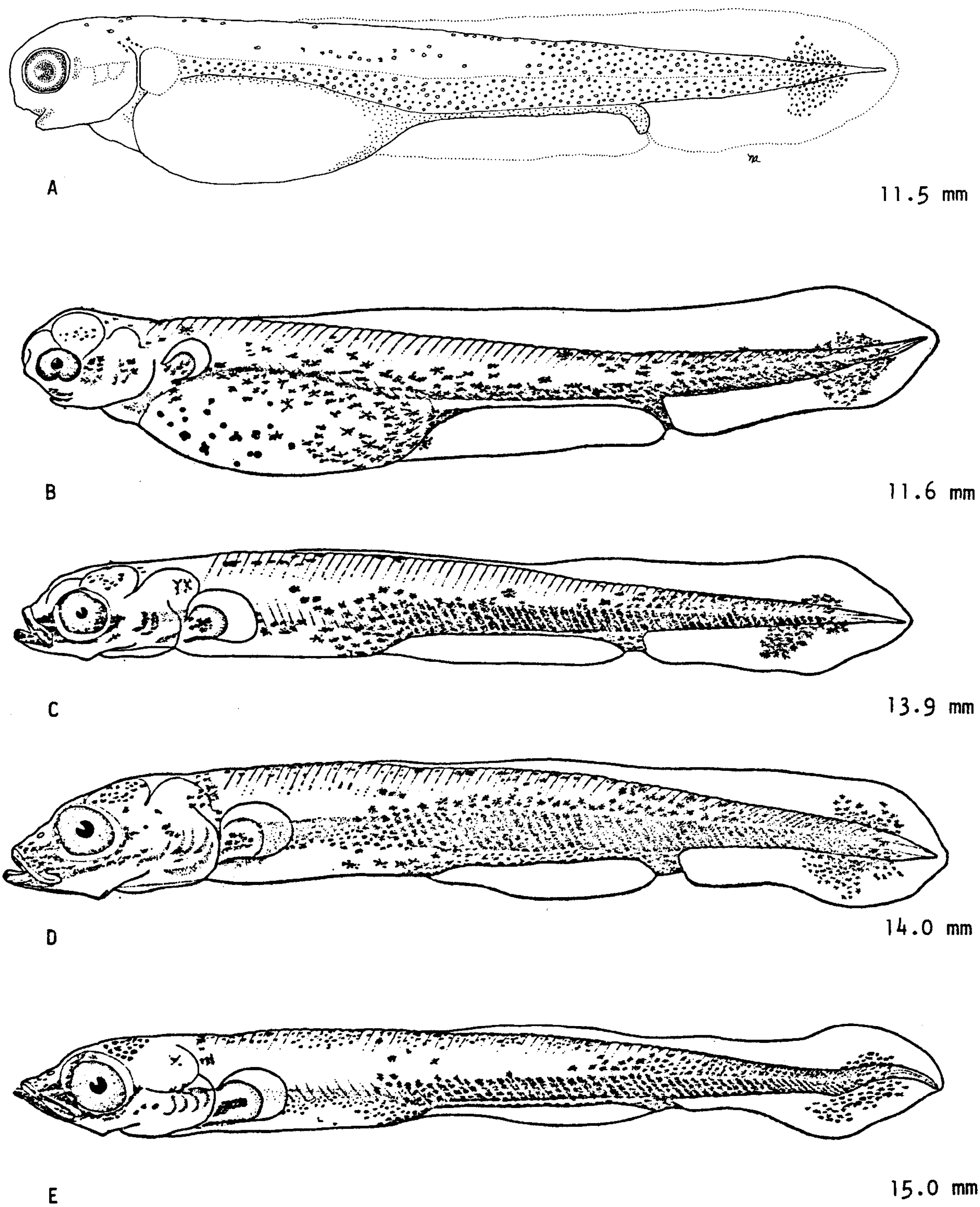

Fig. 54. Esox masquinongy muskellunge. A and B. Yolk-sac larvae. C-E. Larvae. (A, hatchery-realed, New York, original illustration by N. A. Auer; B-E, hatchery-reared, New York, Fish 1932).

Esox niger LeSueur, chain pickerel

DISTRIBUTION

In the Great Lakes, found only in the New York drainages of Lakes Ontario [21] and Erie (introduced into the latter).[1 18]

SPAWNING SEASON

Spawns from March[3 7] to May,[4] but primarily in April.[1 3 7 8 10 12] Ripe adults collected in the fall indicate a possible late spawning time.[5]

SPAWNING TEMPERATURE

Spawning occurs from 7 to 13 C[1 3 10] with upper extremes of 11 to 13 C[8] and 9 to 18 C.[11]

SPAWNING HABITAT

Spawns in water 1 to 3 m deep usually in coves, mouths of inlets, marshes, flooded areas[7] and vegetated sloughs and tributaries.[8]

SPAWNING SUBSTRATE

Eggs are broadcast over submerged terrestrial and aquatic vegetation,[1 3 4 11 12] occasionally over gravel.[1]

FECUNDITY

Generally 6,000 to 8,000[1 3 9] with extreme ranges of 936 to 12,750[10] and 1,716 to 29,928.[14]

NATURAL HYBRIDS

Esox americanus;[15 17 23] E. lucius.[15 16 23]

EGGS

Demersal;[1 11 12 22] slightly adhesive;[1] or nonadhesive;[1 11] diameter 2 mm[1 3] or 2.3 to 3.0 mm, mean 2.5 mm;[2 22] yolk diameter 1.5 to 2.3 mm;[2] yolk light yellow[1] or amber;[6 22] eggs not in glutenous strings[1 11 22] as previously reported;[1 13] incubation period: 11 days at 10 C;[5] 13 days at 11 to 18 C, 7 days at 18 C;[11] 5 to 6 days (120 hours) at 12 to 17 C;[2] 6 days at 18 C;[22] 6 to 12 days in situ.[1 3 7 9 11]

YOLK-SAC LARVAE

Total length	Description
4-8 mm	Newly hatched, reported sizes for newly-hatched larvae vary: 4.2 to 7.0 mm;[1] 5.0 to 7.9 mm;[2] 6 mm.[3 7 11]

Morphology: head deflected over yolk sac, pectoral buds present;[2] mouth poorly developed.[7]
Pigmentation: living specimens with yellow-green finfold and body, chromatophores scattered over head, dorso-lateral yolk surface, along gut, and below caudal peduncle.[22]

6-10 mm

Myomeres: preanal 30 to 34.[2]
Morphology: mouth open (8.0 mm), incipient pectoral fin rays developing (9.1 mm, 3 days), head free from yolk sac (10 mm).[2]
Pigmentation: pigmentation increased on head and yolk (2 days old), pigment on venter of yolk sac (3 days old), eyes black (10 mm).[2]

LARVAE

Total length	Description
10-14 mm	Myomeres: total 53 to 54.[2] Morphology: yolk absorbed (9.5[11] to 10.2 mm[1,7] at 1 week or 6 to 8 days[3,7,9,11]), anal (10 to 11.8 mm) and dorsal (14 mm) fin anlage visible, notochord straight (to 14 mm), snout becoming elongate, lower jaw projecting.[2] Pigmentation: continuous lateral band through eye (14 mm).[2]

JUVENILES

Total length	Description
24-150 mm	Morphology: scales present on caudal peduncle (24.3 mm).[2] Pigmentation: body yellow-green dark stripe through eye (24.3 mm), body greenish or yellowish with dusky punctations;[2] subocular bar directed obliquely forward;[20] adult pigmentation (ca. 150 mm).[19,20]

ADULTS

Fin rays: caudal 19;* dorsal 14 to 15, anal 11 to 13, pectoral 12 to 15, pelvic 9 to 10.[1]

Vertebrae: 52 to 54.[1]

Lateral line scales: 117 to 135.[1]

Branchiostegal rays: 14 to 17;[1] usually 6 antero-hyal + 9 postero-hyal or 7 + 9.[20]

Submandibular pores: 9 to 11.[20]

Esox niger

Diagnostic characters: submandibular pores 8 to 9, cheek and opercula fully scaled, branchiostegal rays 14 to 17 (usually 6 + 9 or 7 + 9), lateral pigmentation reticulate.

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13. Wich (1958)
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19. Trautman (1957)
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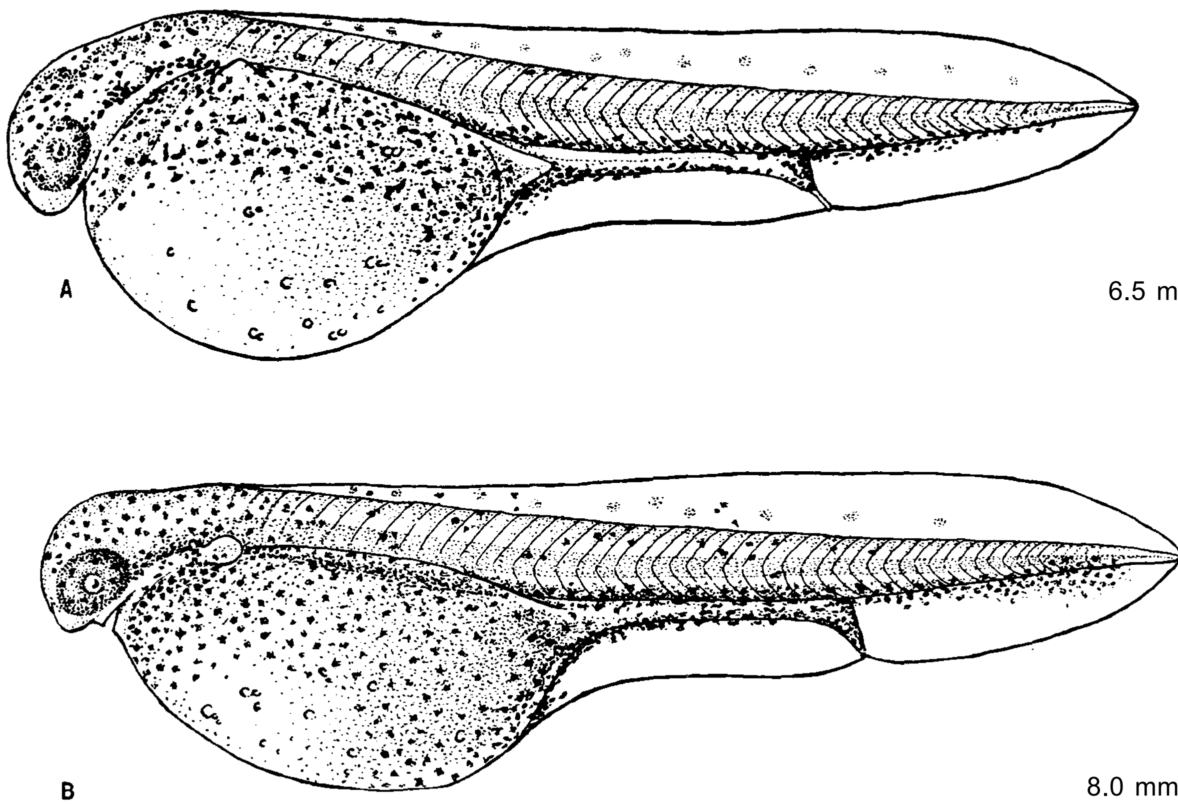
23. Crossman and Buss (1965)



A 6.5 mm

B 8.0 mm

Fig. 55. Esox *niger*, chain pickerel. A. Yolk-sac larva, newly hatched. B. Yolk-sac larva, 2 days old. (A and B, laboratory-reared, Maryland, Mansueti and Hardy 1967).

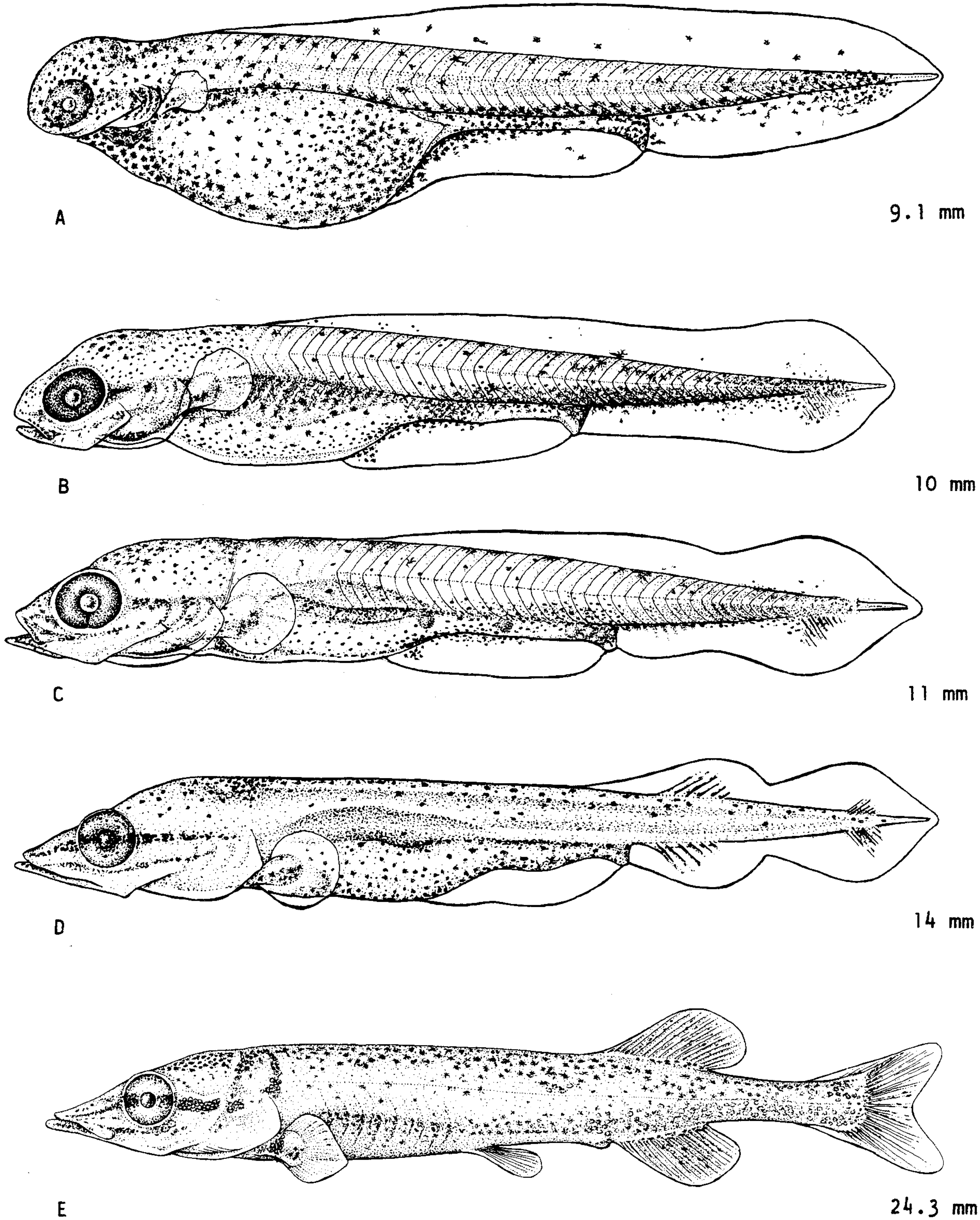


Fig. 56. Esox niger, chain pickerel. A. Yolk-sac larva, 3 days old. B. Yolk-sac larva, 5 days old. C and D. Larvae. E. Juvenile. (A-E, laboratory-reared, Maryland, Mansueti and Hardy 1967).

Family Cyprinidae, carps and minnows

BY

George R. Heufelder and Lee A. Fuiman

The Cyprinidae is a large family, containing about 1600 species in approximately 275 genera (Nelson 1976) . Cyprinids are found on all continents except South America and Australia. In the Lake Michigan drainage, there are about 40 species and 15 genera. There are several additional species in the drainages of the other Great Lakes.

Great Lakes cyprinids are usually small fishes with abdominal pelvic fins, 19 principal fin rays and no adipose fin. They have no teeth in the jaws but have well developed Pharyngeal teeth; the arrangement of wh ich is of ten an important taxonomic character of the adults. Native forms have a single dorsal fin with less than ten rays. All fins are soft-rayed.

Cyprinids are primarily freshwater fishes which are abundant in most lakes, streams and rivers within their range. Most Great Lakes species are omnivorous. They spawn during the spring and summer. Many species scatter their eggs among the gravel in streams; Others construct nests of gravel for their eggs but provide no parental care after spawning. Still others guard their eggs until hatching or until the young are able to swim. Most cyprinid eggs are small, 1.5 to 2.5 mm in diameter, demersal and nonadhesive. They contain granular yolk and lack distinct oil globules. Larvae usually hatch at lengths between 4 and 7 mm. Most have a club-shaped yolk sac. The anus is located at a point 50 to 65% TL from the snout. Preanal myomeres usually range between 19 and 30.

Table 3. Ranges of preanal myomeres among Great Lakes cyprinids. Data were taken from several sources cited in the individual species accounts.

Species	Number of Preanal Myomeres
Semotilus corporalis	29–32
Campostoma anomalum	26–30
Couesius plumbeus	25–30
Semotilus atromaculatus	25–30
Nocomis biguttatus	27–29
Notropis chrysocephalus	26–28
Nocomis micropogon	24–28
Notropis cornutus	25–27
Rhinichthys cataractae	25–27
Ericymba buccata	25–26
Hybognathus hankinsoni	24–26
Notropis atherinoides	23–26
Rhinichthys atratulus	22–26
Pimephales notatus	23–25
Cyprinus carpio	22–25
Notemigonus crysoleucas	20–25
Pimephales promelas	19–25
Pimephales vigilax	24
Notropis hudsonius	21–24
Hybognathus regius	21–23
Notropis stramineus	20–23
Notropis volucellus	20–23
Notropis rubellus	19–23
Notropis spilopterus	21–22
Notropis dorsalis	20–22
Carassius auratus	19–22
Notropis blennius	21

Campostoma anomalum (Rafinesque), central stoneroller

DISTRIBUTION

Found in southern portions of Wisconsin and Michigan eastward to, and including, southern tributaries of Lake Ontario.[10] In Lake Michigan it occurs in southern and eastern tributaries south of the White River with a few reports from southern Wisconsin.[1]

SPAWNING SEASON

Spawns during May and June in Wisconsin.[1] Spawning extends from mid-April to early July in the southern drainage of Lake Ontario.[1]

SPAWNING TEMPERATURE

Spawns between 13 and 27 C, usually from 16 to 21 C.[2 4 9 14 22]

SPAWNING HABITAT

Spawns in shallow portions of streams near deep pools.[4 18] Also builds nests on nests of other cyprinids,[1] such as Semotilus atromaculatus,[4] and Nocomis micropogon.[5 11 13 16]

SPAWNING SUBSTRATE

Constructs a pit-type nest in gravel,[1 4 18] approximately 15 cm in diameter and 5 cm deep.[18]

FECUNDITY

438 to 4,801.[22]

NATURAL HYBRIDS

Notropis cornutus;[23] Phoxinus eos;[25] P. erythrogaster;[24] Rhinichthys cataractae;[26] Semotilus atromaculatus.[15]

EGGS

Demersal;[2] * nonadhesive;[22] * diameter 2.3 to 2.4 mm;[2 20] or mean: 2.7 mm;[19] yolk bright yellow;[2] incubation period: ca. 93 hours at 17 to 23 C;[20] 69 to 71 hours at 21 C.[2]

YOLK-SAC LARVAE

Total length	Description
5.8-6.2 mm	Newly hatched;[2 19] also reported as 6.3 to 6.9 mm SL.[3]
	Myomeres: (27 to 28 + 11 to 15).[3]
	Morphology: pectoral buds present;[2 19] yolk sac club-shaped:[3 6 19] head deflected over yolk sac.[6 19]

Pigmentation: absent;[3] scattered finely over dorsum to sides;[21,19] eye tan;[2,8] or clear.[8,19]

6-9 mm	Myomeres: 40 to 45[19] (27 to 30 + 11 to 15);[8,19] usually 43 to 45 (28 to 30 + 15);[19] see 5.8-6.2 mm. Morphometry: (as % TL) preanal length 64 to 68;[8,19] predorsal length 39 to 44;[8] head length 16, eye diameter 8, greatest body depth 19.[19] Morphology: first caudal fin rays formed (6.7 to 8.1 mm[8] or 9.3 mm[19]); mouth open, swim bladder inflating (9.0 mm).[19] Pigmentation: dorsal pigment scattered anterior to finfold;[19] melanophores along midlateral area and yolk-sac dorsum (7.2 mm), two dorsal rows from occiput to caudal peduncle, several melanophores on anterior yolk-sac venter (7.6 mm).[19]

LARVAE

The identity of a 7.5-mm specimen illustrated by Fish (1932) is dubious.[12]

Total length	Description
9-13 mm	Myomeres: 40 to 41[19] (26 to 29 + 11 to 14);[8,19] usually 41 (28 + 13);[19] see 5.8-6.2 mm. Morphometry: (as % TL) preanal length 61 to 66;[7,8,19] predorsal length 40 to 45;[8] head length 19 to 20, eye diameter 7 to 8;[7,19] greatest body depth 13[7] to 17;[19] body depth at anus 6.[7] Morphology: yolk absorbed (8.5[19] to 9.2[3] mm); notochord flexed (9.3 mm);[19] pelvic buds formed (9.1 to 11.2);[8] dorsal and anal fin rays forming;[3,19] pectoral fin rays forming (11 mm);[19] gut S-shaped (13 mm);[21] mouth subterminal after pelvic buds appear.[6] Pigmentation: pigment scattered on dorsum of head, two rows on dorsum of body, midlateral stripe present, paired row on postanal venter;[3,7] ventro-lateral stripes along sides of gut converging at isthmus;[3] pigment on dorsum of gut, "short double series of about nine chromatophores] in the jugular region" (ca. 9 to 10 mm);' caudal spot formed on hypural area, not extending much into caudal fin, midlateral stripe more prominent (11 mm).[3,19]

JUVENILES

Total length	Description
20-50 mm	Morphology: all finfold absorbed, pelvic fin rays present (20.3 mm), mouth inferior (30 mm);[19] gut coiled as in adult (35 to 50 mm).[21]

ADULTS

Fin rays: caudal 19;* dorsal 8, anal 7, pectoral 15, pelvic 8.9

Vertebrae: 40 to 42 (including Weberian vertebrae).'

Lateral line scales: 47 to 58, usually 52.[17]

Pharyngeal teeth: 0,4-4,0.[9]

Diagnostic characters: circumferential scales 38 to 50, lateral line scales 47 to 58, intestine wound around swim bladder, lower jaw with cartilaginous ridge, dorsal fin short (eight rays).

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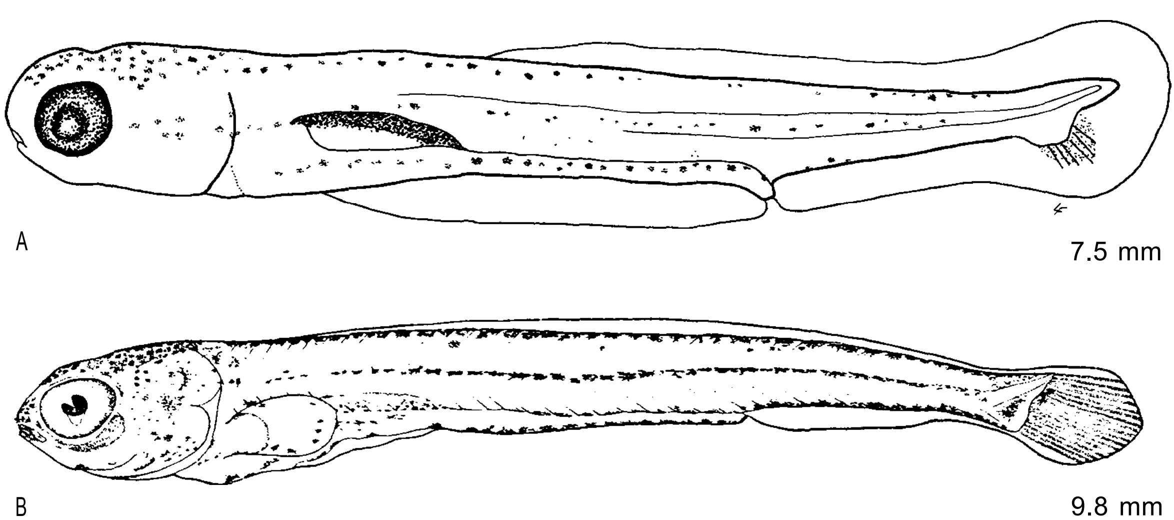

Fig. 57. Campostoma anomalum, central stoneroller. A and B. Larvae. (A, wild-caught, Iowa, photograph by Perry and Menzel 1979, delineated by L. A. Fuiman; B, wild-caught, Lake Erie tributary, Fish 1932).

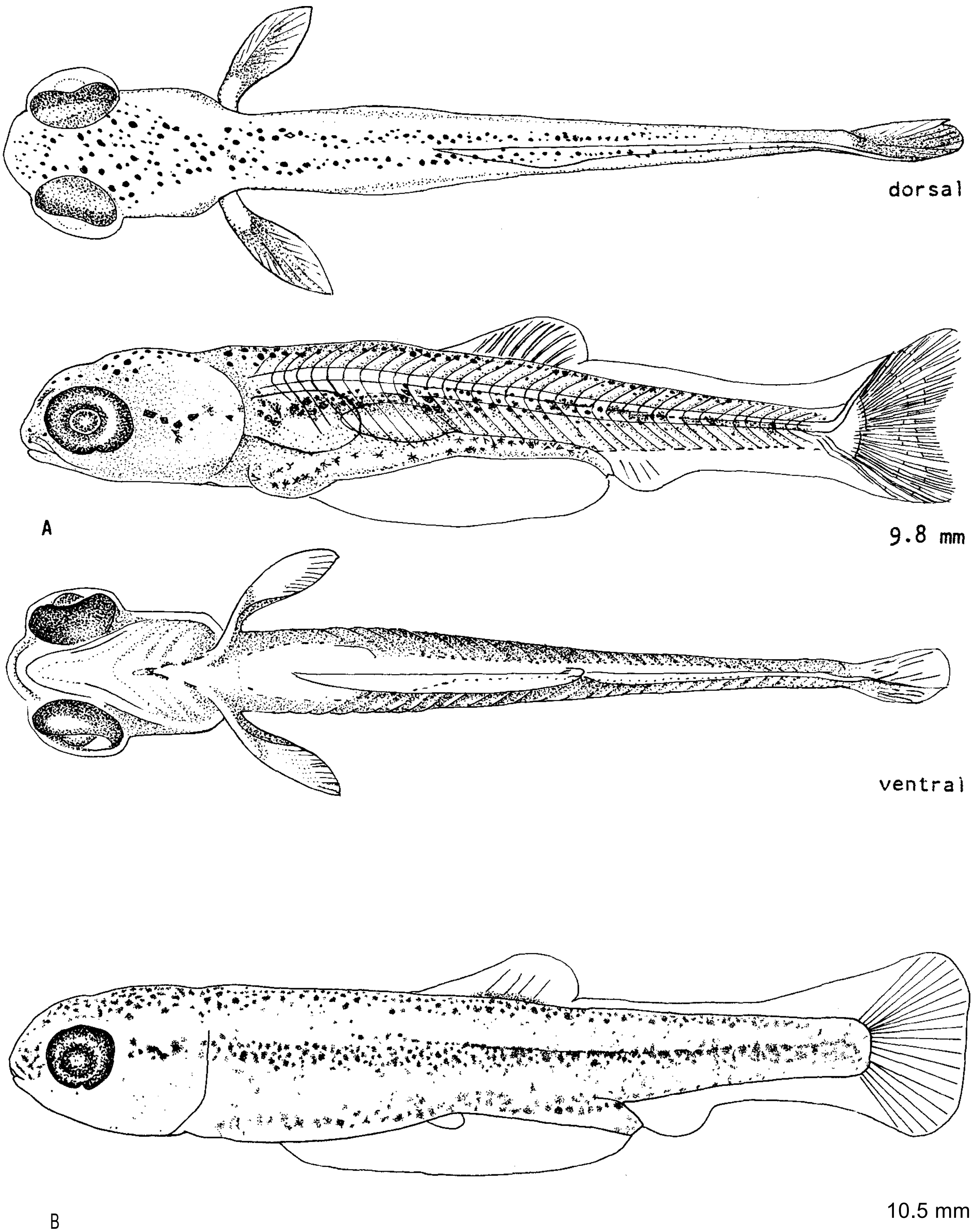

Fig. 58. Campostoma anomalum, central stoneroller. A and B. Larvae. (A, laboratory-reared, Pennsylvania, Loos et al. 1979; B, wild-caught, photograph by Perry and Menzel 1979, delineated by L. A. Fuiman).

Campostoma oligolepis Hubbs and Greene, largescale stoneroller

DISTRIBUTION

In the Great Lakes region, it is restricted to Lake Michigan where it occurs in western tributaries (including those of southern Green Bay) southward from southern Wisconsin.'

SPAWNING SEASON

Spawns from mid-March to early June,' primarily during May,2 in Missouri.

SPAWNING TEMPERATURE

Spawns at temperatures between 12 and 20 C.[4]

SPAWNING HABITAT

Spawns in shallows (to 30 cm) of streams.'

SPAWNING SUBSTRATE

Constructs a pit nest, several centimeters in diameter, in gravel.'

FECUNDITY

Not reported.

EGGS

Demersal;* diameter 2.6 mm, larger than C. anomalum, yolk darker than C. anomalum, incubation period: 93 hours at 17 to 23 C, '(usually 20 C), 62 hours at 19 to 24 C (develops faster than C. anomalum).'

YOLK-SAC LARVAE

Hatches at 5.6 to 6.4 mm, eyes unpigmented. Eyes pigmented 16 to 24 hours posthatching (sooner than C. anomalum).[4]

LARVAE

Not described.

JUVENILES

Not described.

ADULTS

Fin rays: caudal 19;* dorsal 8, anal 7 to 8, pectoral 17, pelvic 8 to 9.[5]

Vertebrae: 41 to 44[6] (including Weberian vertebrae).

Lateral line scales: 41 to 49.[3, 5]

Pharyngeal teeth: 0,4-4,0.[5]

Diagnostic characters: circumferential scales 29 to 38, usually 33, lateral line scales 41 to 49, usually 45, intestine wound around swim bladder, lower jaw with cartilaginous ridge, dorsal fin short (eight rays).

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Carassius auratus (Linnaeus), goldfish

DISTRIBUTION

Occurs sporadically throughout the southern half of the Great Lakes basin, particularly in western Lake Erie, the Detroit River and Lake St. Clair.' it has been collected from the southern half of the Lake Michigan drainage.[2] *

SPAWNING SEASON

Spawns in May or June.[3] Developing eggs were found as late as August in Lake Erie.'

SPAWNING TEMPERATURE

Spawns when water temperatures reach 16 C.[4 10]

SPAWNING HABITAT

Spawns in lakes, ponds[4] and backwaters of rivers.*

SPAWNING SUBSTRATE

Deposits eggs over floating aquatic plants,[5 6 7] grass, roots and leaves.[4]

FECUNDITY

A female may lay 2,000 to 4,000 eggs at one time and spawn several times during a season.'

NATURAL HYBRIDS

Cyprinus carpio.[3] *

EGGS

Demersal, adhesive (until water hardened) ;[7 11] diameter 1.0 to 1.6 mm;[6 7 8] usually 1.5 to 1.6 in feral populations;'[11] perivitelline space narrow, 0.1 mm;[7] transparent;[8] or yellow-white;'[8] yolk with many sparse1 y scattered oil droplets, droplet diameter 0.01 to 0.05 mm, number diminishing with age, incubation period: 64 to 72 hours at 24 to 28 C.[7]

YOLK-SAC LARVAE

Total length	Description
3-6 mm	Hatching length 3.0 mm;[9] 4.5 to 5.0 mm.[6 7] Myomeres: 26 to 32 (17 to 20 + 8 to 14) ;[12] 33[6] (21 to 22 + 11 to 12).[6 7]

Morphometry: (as % TL) standard length 90 to 96, preanal length 67 to 71, head length 18 to 22, greatest body depth 15 to 21, (as % head length) eye diameter 27 to 38, snout length 21 to 37.[7]

Morphology: yolk sac bulbous anteriorly, tapering posteriorly;[6 7] upper and lower jaws not developed, head projecting from yolk sac, pectoral buds present (newly hatched);[6] mouth open (ca. 24[8] to 36[7] hours posthatching); yolk sac tubular (ca. 36 hours), swim bladder developed (after 20 hours);[8] opercular membrane covers gills (5.8 mm);[7] pectoral buds large, fan-shaped, lower jaw developed (6.0 to 6.2 mm).[6]

Pigmentation: stellate melanophores around jaws, on dorsum of head;'[8] and body (newly hatched);[6 7] xanthophores in dorsal head musculature (5.8 mm);[7] internal melanophores form a "Y" pattern (characteristic of goldfish and common carp) with dorsal branch along venter of otic capsule extending beyond anterior edge of capsule (goldfish only), interorbital area with little or no pigment;[12] melanophores along dorsum of abdominal cavity (double or triple series);' and venter of caudal fin;" melanophores fewer on sides of head and body at level of lateral line, dense mass of subsurface melanophores over gill arches;[7] stellate melanophores near end of notochord;'[8] melanophores numerous and distributed irregularly along both sides of dorsal lines (6.2 mm), some yolk-sac larvae show light green coloration mixed with melanophores.[6]

LARVAE

Total length	Description
7-8 mm	Myomeres: 34 (22 + 12),[7] see 3-6 mm.

Morphometry: (as % TL) standard length 83 to 90, preanal length 67 to 69, head length 21, greatest body depth 15, (as % head length) eye diameter 36 to 43, snout length 21.[7]

Morphology: yolk absorbed (6.5 to 7.0 mm);[6 7] mouth enlarged, jaws functional, operculum covers most gill filaments, notochord slightly flexed, incipient caudal fin rays present, concentration of mesenchyme in area of future dorsal fin, opercula well developed (6.8 mm), caudal fin forked, finfold elevated in area of dorsal fin, anal fin marked by an accumulation of mesenchyme in finfold, incipient rays evident in pectoral buds, operculum completely covers gills, swim bladder partially divided into two chambers (7.9 mm).'

Pigmentation: round melanophores on dorsum of head, melanophores on ventral margin of operculum, yellow pigment over entire body surface (6.8 mm), midlateral myoseptum marked with melanophores, elongated melanophores present among incipient dorsal fin rays and area of anal fin mesenchyme, minute spherical partly pigmented elevations present on lips (7.9 mm).[7]

9-12 mm — Myomeres: 34 (22 + 12),[7] see 3-6 mm.
Morphometry: (as % TL) standard length 83 to 88, preanal length 68 to 71, head length 26 to 27, greatest body depth 18 to 20, (as % head length) eye diameter 31 to 35, snout length 22.[7]
Morphology: dorsal fin with nine rays, finfold reduced between median fins, anal and pectoral fins with distinct rays, pelvic buds evident (9.4 mm), pelvic fin rays evident, preanal finfold reduced, caudal fin rays show some branching (11.6 mm);' Weberian ossicles present (10.0 mm).[9]
Pigmentation: melanophores over entire body contracted, concentrated above midlateral myoseptum, body opaque, appearing greenish yellow to fawn (9.4 mm), pigment intensified (11.6 mm) and becoming iridescent.'

JUVENILES

Total length	Description
15-16 mm	Morphometry: (as % TL) standard length 80, preanal length 64, head length 25, greatest body depth 29, (as % head length) eye diameter 35, snout length 20.[7] Morphology: all fin rays formed, rudimentary scales formed (15.0 mm);[6] squamation complete (15.7 mm).[7] Pigmentation: color varies from olive green or brown to orange-red.[7]

ADULTS

Fin rays: caudal 19;* dorsal I, 17 (15 to 18), anal I, 5 (5 to 6), pectoral 15 to 17, pelvic 8 to 9.[3]

Vertebrae: 28 to 29 (including Weberian vertebrae).[3]

Lateral line scales: 27 to 30.[3]

Pharyngeal teeth: 0,4-4,0.[3]

Diagnostic characters: barbels absent, Pharyngeal teeth not molar-like, gill rakers 37 to 43, lateral line scales usually less than 32, dorsal fin base long, more than 11 soft rays, dorsal and anal fins each with strong spine serrated on posterior edge.

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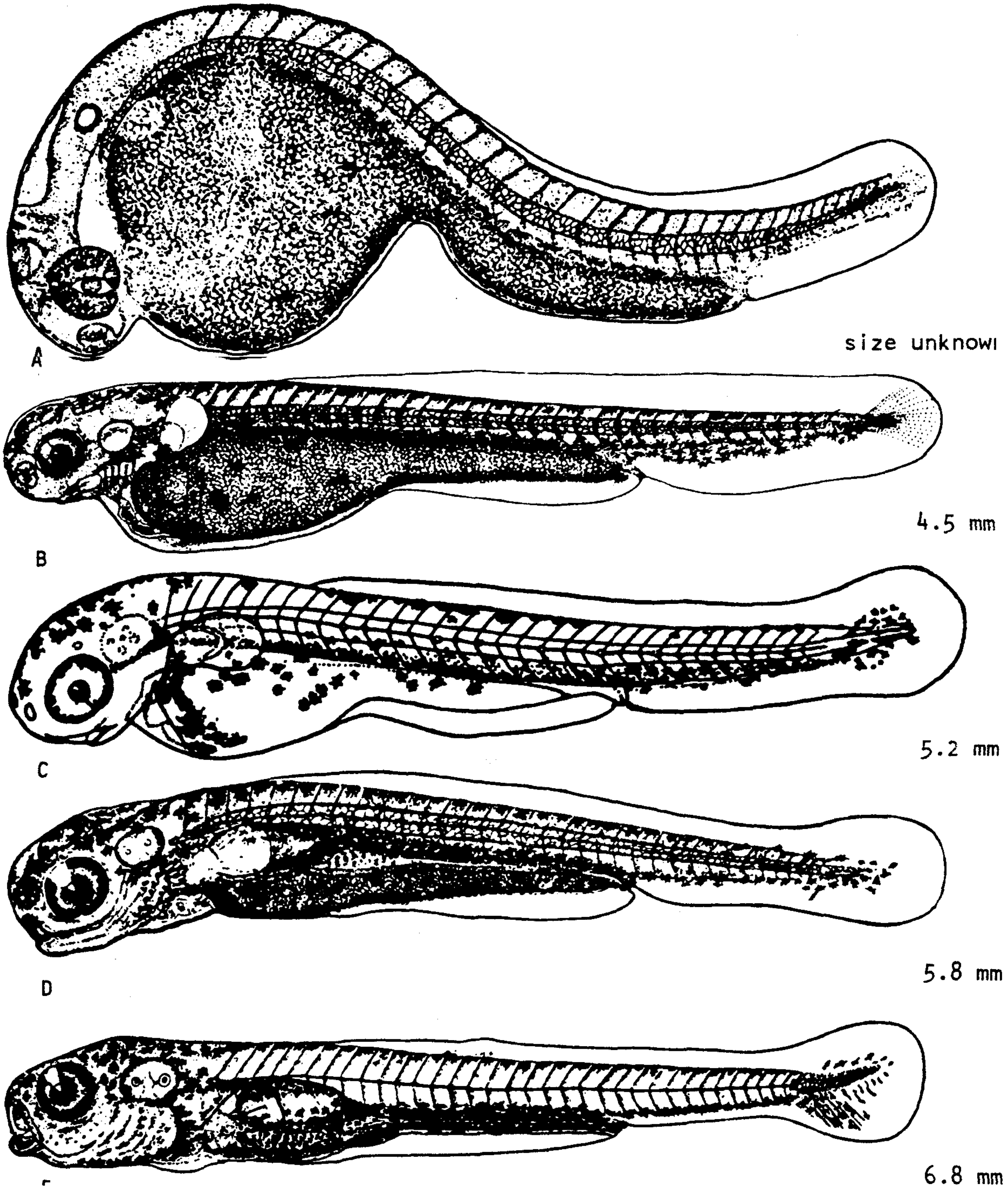

Fig. 59. Carassius auratus, goldfish. A-D. Yolk-sac larvae. E. Larva. (A,B,D and E, laboratory-reared, Lake Erie, Battle 1940; C, Japan, Nakamura 1969).

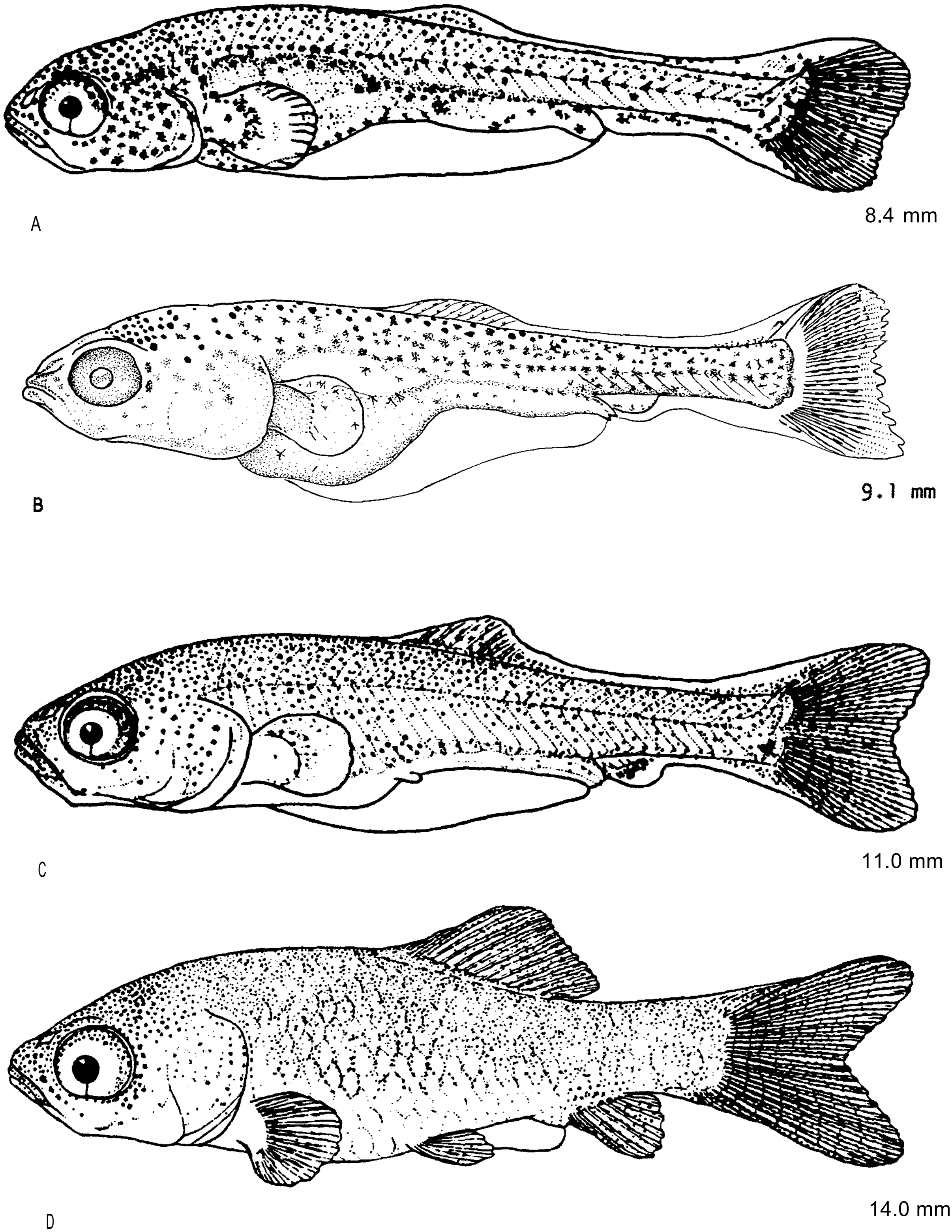

Fig. 60. *Carassius auratus*, goldfish. A-D. Larvae. (A,C and D, Japan, Nakamura 1969; B, laboratory-reared, Maryland, Loos et al. 1979).

Clinostomus elongatus (Kirtland), redside dace

DISTRIBUTION

Scattered populations in the Great Lakes, including Lake Michigan, Erie and Ontario tributaries.[5] Lake Michigan populations are discontinuous in southern and central Wisconsin. May be extirpated in these areas.'

SPAWNING SEASON

Spawns from mid-May to early June in New York.[3 4]

SPAWNING TEMPERATURE

Spawns at temperatures near 18 C.[4]

SPAWNING HABITAT

Spawns in, or upstream of, riffle areas of streams[3] or in nests of Semotilus atromaculatus.[4]

SPAWNING SUBSTRATE

Spawns over gravel.[3]

FECUNDITY

409 to 1,526.'

NATURAL HYBRIDS

Notropis cornutus, Semotilus atromaculatus.[3 4]

EGGS

Demersal, nonadhesive, diameter 1.2 to 2.4 mm[4] (may include immature ova);* yolk yellow.[4]

YOLK-SAC LARVAE

Not described.

LARVAE

Not described.

JUVENILES

Total length	Description
23 mm	Morphometry: (as % TL) preanal length 54, predorsal length 43, head length 25, eye diameter 7, snout length 5, greatest body depth 18, body depth at anus 11.[2] Morphology: all fin rays complete, caudal fin deeply forked, mouth oblique, lower jaw projecting slightly.[2] Pigmentation: melanophores on jaws and dorsum of head, single dorsal stripe, lateral stripe somewhat diffuse, ventral pigmentation sparse, rays of median fins outlined by melanophores.[2]

ADULTS

Fin rays: caudal ; * dorsal 7 to 8, anal 8 to 10, pectoral 14 to 16, pelvic 8.6

Vertebrae: 38 to 41 (including Weberian vertebrae).[6]

Lateral line scales: 63 to 70.6

Pharyngeal teeth: 2,5-4,2 1,4-3,1.[6]

Diagnostic characters: pelvic fin origin anterior to dorsal fin origin, peritoneum silvery or speckled, lateral line complete, mouth terminal, lateral line scales 63 to 70, barbels absent, premaxillae protractile, dorsal fin short (seven to eight rays).

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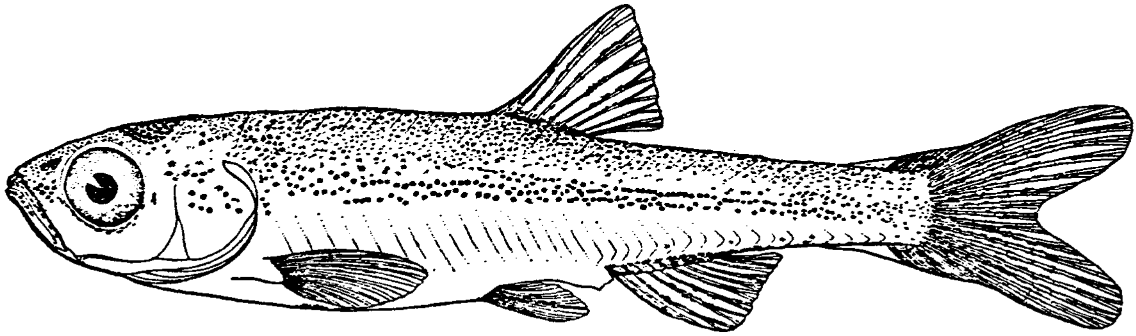

23.3 mm

Fig. 61. Clinostomus elongatus, redside dace. Juvenile. (Wild-caught, Lake Erie tributary, Fish 1932).

Couesius plumbeus (Agassiz), lake chub

DISTRIBUTION

This northern species occurs throughout the Great Lakes region, except Lake Erie and its tributaries.[3] In Lake Michigan it inhabits the coastal zone of the lake, penetrating tributaries to a minor extent. It is found along all shores except the southern most tip.[1]

SPAWNING SEASON

Usually spawns in April in Wisconsin* or mid-May to mid-June near Montreal, Quebec.[2]

SPAWNING TEMPERATURE

Spawns at 10 C.[2] Eggs were collected at 12 to 13 C.[4]

SPAWNING HABITAT

Migrates only a short distance upstream from lakes.' [3] Spawns along margins of streams and rivers in 5 cm of water.[2]

SPAWNING SUBSTRATE

Scatters eggs among rocks[2] and gravel' or builds a pit-like nest.[8]

FECUNDITY

214 to 1,540[9] or 700 to 2,500.'

NATURAL HYBRIDS

Rhinichthys cataractae;[6] [7] possibly Semotilus margarita.[10]

EGGS

Demersal, nonadhesive, diameter 1.8 to 2.4 mm;[4] mean: 2.1[4] to 2.3 mm;[2] perivitelline space narrow, yolk dark golden, oil globule absent;' incubation period: 10 days at 8 to 19 C.[2]

YOLK-SAC LARVAE

Total length	Description
5.8-6.4 mm	Newly hatched.[4]
	Myomeres: 39 to 45 (25 to 30 + 12 to 17), unchanged after hatching, mean: 41.8 (27.3 + 14.5).[4]
	Morphometry: (as % TL) preanal length 68 to 69, head length 18, eye diameter 7 to 8, body depth at anus 11 to 12.[4]
	Morphology: pectoral buds present, yolk sac club-shaped, head deflected over yolk sac.[4]

Pigmentation: eyes light brown, further pigmentation sparse.[4]

6-8 mm	Myomeres: see 5.8-6.4 mm. Morphometry: (as % TL) preanal length 63 to 68, head length 18, eye diameter 7, body depth at anus 12.[4] Morphology: head free from yolk sac (6.5 mm), cleithrum ossified (6.0 to 7.6 mm), posterior swim bladder chamber inflated (7.4 mm).[4] Pigmentation: eye black, occipital pigmentation dense, two dorsal rows of melanophores, midlateral stripe of single, rod-like melanophores, dorsum of yolk sac pigmented, anteriorly descending diagonal row of melanophores across anterior portion of yolk sac, postanal ventral midline pigmented (6.4 mm), few melanophores near cleithrum, diagonal rows on yolk sac converge at ventral midline, short median ventral series extending posteriad (7.6 mm).[4]

LARVAE

Total length	Description
8-17 mm	Myomeres: see 5.8-6.4 mm. Morphometry: (as % TL) preanal length 56 to 62, head length 20 to 23, eye diameter 7 to 8, body depth at anus 10 to 14.[4] Morphology: yolk absorbed (7.4 to 7.6 mm, 7 days posthatching), mouth parts formed (8.0 mm), first caudal fin rays formed (7.9 to 9.5 mm), anterior swim bladder chamber inflated (10.1 mm), notochord flexed (8.8 to 9.2 mm), first dorsal (9.1 to 9.6 mm) and anal (9.5 to 9.9 mm) fin rays formed, pelvic buds present (11.3 mm), all median and first pelvic fin rays present (12.0 mm), gut S-shaped (15 to 17 mm).[4] Pigmentation: dorsum of snout and interorbital area pigmented, triangular pericardial pigment on venter (7.4 to 8.7 mm), melanophores developing between dorsal rows (8.1 to 8.8 mm), scattered melanophores among caudal fin rays. concentrated pigment on distal, hypaxial tip of caudal peduncle, ventro-lateral stripe along gut, few melanophores on operculum (9.2 to 10.0 mm), two caudal spots (base of central caudal fin rays and hypaxial peduncle) (15 mm).[4]

JUVENILES

Total length	Description
17-35 mm	Myomeres: see 5.8-6.4 mm. Morphometry: (as % TL) preanal length 50 to 54, head length 22 to 25, eye diameter 7 to 8, body depth at anus 13 to 15.[4]

Morphology: all finfold absorbed (17.5 to 18.1 mm), squamation started (ca. 29 mm), complete (> 31 mm).[4]
Pigmentaion: melanophores surrounding eye (18 mm), dorsum uniformly pigmented extending to midlateral stripe, diagonal series across breast indistinct, ventral pigment sparse.'

ADULTS

Fin rays: caudal 19;[4] dorsal 8, anal 8 (7 to 9), pectoral 15 to 16 (13 to 18), pelvic 8 (7 to 8).[3]

Vertebrae: 41 to 43 (including Weberian vertebrae).'

Lateral line scales: 53 to 79;[3] typically 60 to 72 for the Great Lakes basin.[11]

Pharyngeal teeth: usually 2,4-4,2;[3,5] but highly variable.[5]

Diagnostic characters: lateral line scales usually 60 to 72, premaxillae protractile, maxillary barbel subterminal and thread-like, dorsal fin short (eight rays).

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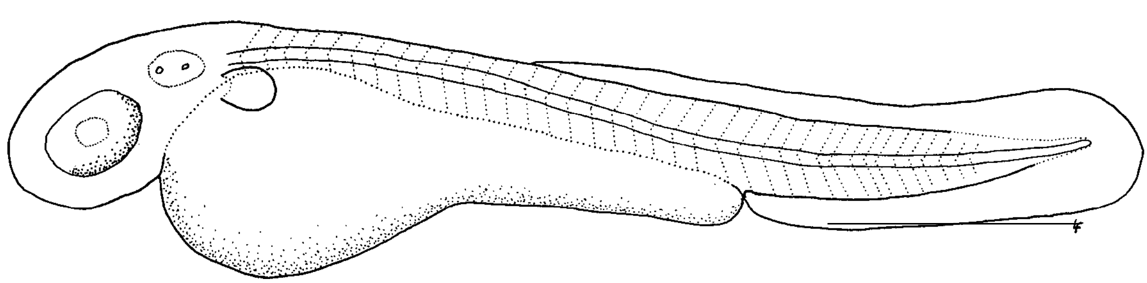


5.8 mm

Fig. 62. Couesius plumbeus, lake chub. Yolk-sac larva, newly hatched. (Laboratory-reared, New York, Fuiman and Baker 1981).

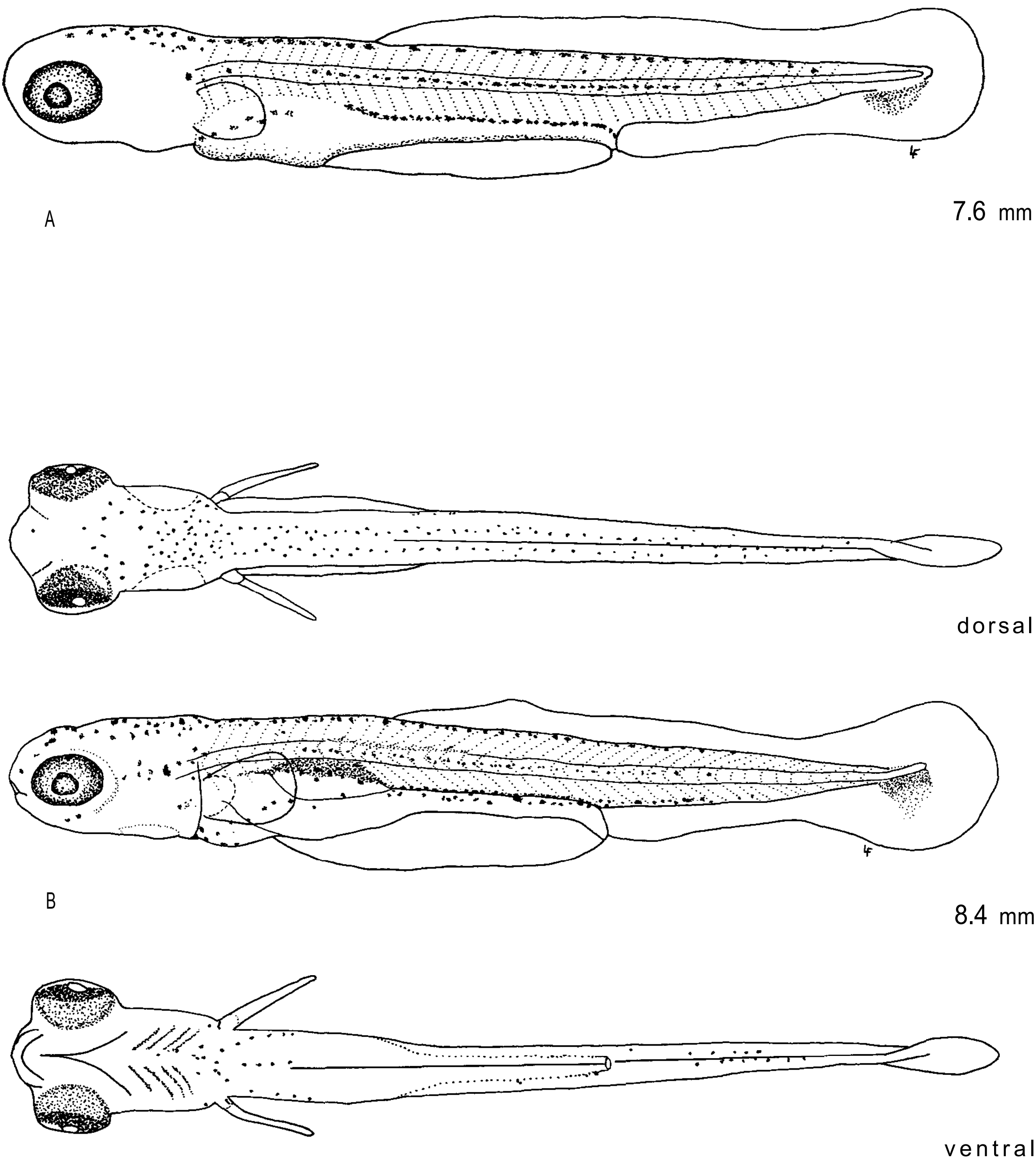
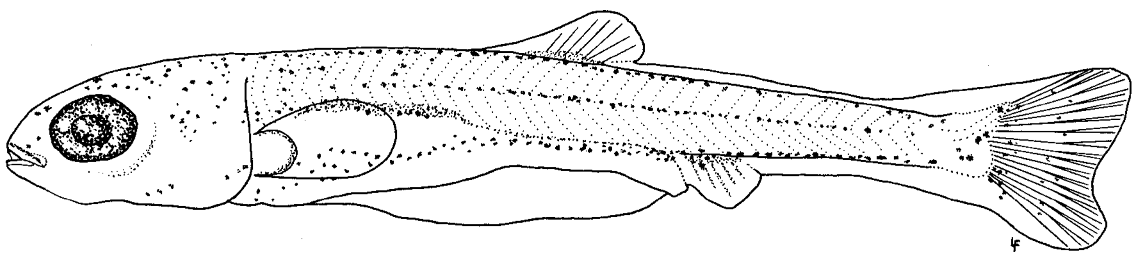
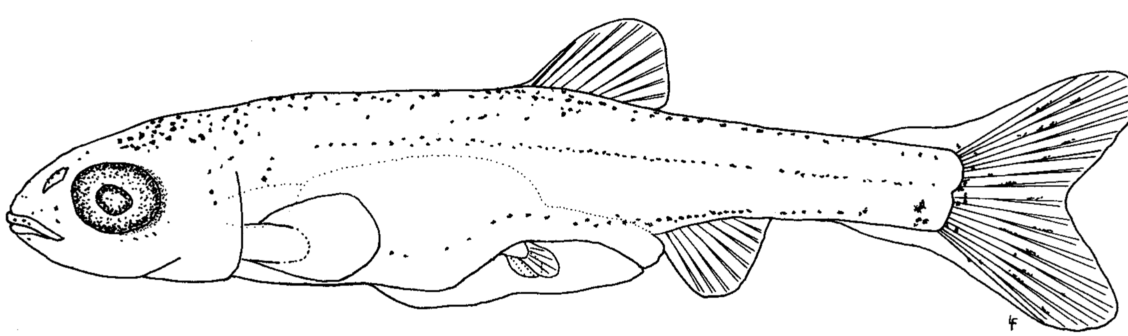


Fig. 63. Couesius plumbeus, lake chub. A. Yolk-sac larva. B. Larva. (A and B, laboratory-reared, New York, Fuiman and Baker 1981).



A

11.2 mm



14.8 mm

Fig. 64. Couesius plumbeus, lake chub. A and B. Larvae. (A and B, laboratory-reared, New York, Fuiman and Baker 1981).

Cyprinus carpio Linnaeus, common carp

DISTRIBUTION

Occurs in the drainages of all of the Great Lakes.' In Lake Michigan carp are generally distributed northward through Wisconsin and the lower and upper peninsula of Michigan.[8]

SPAWNING SEASON

Spawns from mid-May to early August in the Great Lakes region.[3]

SPAWNING TEMPERATURE

Spawns at 15 to 25 C[1] with an optimum between 18 and 23 C.[3 4 14]

SPAWNING HABITAT

Spawns in rivers, lakes, marshes, forested swamps, 5. ponds and sheltered, vegetated areas of streams.*

SPAWNING SUBSTRATE

Spawns over aquatic vegetation,' [3 5] * tree roots, on mud bottoms[1] and over debris covering the bottom.*

FECUNDITY

36,000 to 2,208,000.[3 14]

NATURAL HYBRIDS

Carassius auratus.[6] *

EGGS

Demersal, adhesive, diameter 1.5 to 2.1 mm;[1 2 14] perivitelline space, 0.2 to 0.3 mm;[2] incubation period: 90 hours at 13 to 17 C;[13] 50 hours at 25 to 32 C.[3]

YOLK-SAC LARVAE

Total length	Description
3-8 mm	Hatching length 3.0 to 3.5 mm[9 12] or 4.8 to 5.6 mm.[1 10 11 19] Myomeres: 32 to 37 (21 to 24 + 10 to 14);[21] 34 to 36[13 14] (22 to 24[12 14] + 12 to 16[12 14] or 10 to 11[1]). Morphometry: preanal length 65 to 75% TL (5.3 to 6.0 mm TL).[1] Morphology: yolk sac club-shaped;[1 11 13 15] head slightly deflected over yolk sac;[11 14] or straight;[1 16] mouth open;[14] or not;[11] median finfold origin at myomere

three (newl y hatched) ;[17] head straight (5.5 mm);[11] Pharyngeal teeth present (5.1 to 6.8 mm), mouth terminal;" incipient posterior swim bladder chamber evident,[10 14 19] (5.5 to 6.7 mm); jaws partially developed (6.3 mm) ;[14] mouth open (6.5 mm), jaws functional;" posterior swim bladder chamber filled (ca. 7.0 mm) ;[10] caudal fin rays present (6.3 to 6.7 mm);[18] lateral line organs hair-like (7.0 to 7.7 mm).[13]

Pigmentation: sometimes lacking;[13] usually present (newly hatched) ;* eye black, melanophores on dorsum of head, dorsum of anterior body, dorso-lateral aspect of yolk sac, along dorsum of alimentary canal, on venter of tail and in region of urostyle (5.0 to 5.6 mm);[14] * internal melanophores form a "Y" pattern (characteristic of common carp and goldfish) with dorsal branch along venter of otic capsule not reaching beyond anterior edge of capsule (common carp only), interorbital area pigmented;[21] dense patch of melanophores over dorsum of swim bladder (ca. 6.0 mm);* dark pigmentation midventrally anterior to yolk sac (5.3 to 6.0 mm);[1] midlateral pigment present (5.1 mm);[13] or absent (6.5 to 6.8 mm);[14] melanophore density increased over head, dorsum of swim bladder and urostyle (7.0, mm), antero-dorsal surface of swim bladder silvery (6.0 mm) ;[13] dorsum of head and body light greenish yellow (6.3 mm);[14] yellow pigment on head and middorsal surface well developed, also evident on swim bladder (6.0 to 7.7 mm) .[13]

LARVAE

Total length	Description
8-10 mm	Myomeres: 38 (25 + 13) ,[14] see 3-8 mm. Morphology: yolk absorbed (6.5 to 6.8 mm,[14] or 8.0 mm[10]); operculum completely covers gills, auditory vesicle enlarged, jaws fully formed, mesenchymal rudiments of caudal fin rays developed, swim bladder (posterior chamber*) enlarged (8.5 mm) ;[11] notochord flexed (8.0 to 8.5);' [11] first caudal fin rays evident (8.2 mm) ;[15] dorsal fin outline evident (7.8 to 9.5 mm).[13]
10-15 mm	Myomeres: see 3-8 mm. Morphometry: (as % TL) standard length 83 to 84, preanal length 64, head length 25 to 28, greatest body depth 19 to 21, (as % head length) eye diameter 27 to 32, snout length 18 to 30.[20] Morphology: pelvic buds evident (9.5 to 15.0 mm) ;[11 13] anterior swim bladder chamber developed (9.6 to 12.0 mm) ;[10 13] caudal fin rays apparent (10.0 mm);[11] finfold between median fins absent (11.0 mm);[1] actinotrichia in

pectoral, dorsal and anal fins (15.0 mm);[11] or rays present in dorsal and anal fins (11.0 mm);[1] pectoral fins may be fully developed (12 to 13 mm).[10]

Pigmentation: large stellate chromatophores on jaws, dorsum of head and body, double subsurface series along midlateral myoseptum, subsurface chromatophores on gills and dorsum of intestine, sides of head and body with fewer melanophores ventrally, approaching midlateral myoseptum, double broken series ventrally, all fins marked with pigment (10.0 mm);[20] melanophores on lateral surface of body, arranged longitudinally on base of caudal fin (10.5 mm);[14] pigmentation darker (13.3 mm);[20] concentrated pigment forms a patch over the head (15.0 mm).[16]

16-21 mm Myomeres: see 3-8 mm.

Morphology: anal and pelvic fins fully developed (20 to 21 mm);[10] preanal finfold absorbed;[11] or partially present;[1] squamation initiated (16 to 18 mm);[16] barbels evident (18.5 to 19 mm);[13] sometimes with all four barbels (ca. 20.0 mm).[1,13]

JUVENILES

Total length	Description
21-31 mm	Morphometry: (as % TL) standard length 81, preanal length 63, head length 28, greatest body depth 28, (as % head length) eye diameter 31.[20] Morphology: all fins complete (ca. 21 mm);[1,10] body stout (21 mm);[20] squamation complete (22 to 26 mm).[10] Pigmentation: dense chromatophores on upper lip, top of head, over snout, below eye and over dorsum at least to dorsal fin (30.8 mm);[20] dense melanophores laterally above midlateral myoseptum, scarcer below, venter with subsurface postanal series, some melanophores near anus, preanal venter not marked, all fins except pelvic fins pigmented.[6]

ADULTS

Fin rays: caudal 19;* dorsal I, 18 to 20, anal I, 5, pectoral 15 to 16 (14 to 17), pelvic 8 or 9.[6]

Vertebrae: 35 to 36 (including Weberian vertebrae).[6]

Lateral line scales: 35 to 39.[6]

Pharyngeal teeth: 1,1,3-3,1,1.[6]

Diagnostic characters: two pairs of long barbels on upper jaw, Pharyngeal teeth molariform, gill rakers 21 to 27, dorsal fin long (more than 11 rays), dorsal and anal fins with strong spine (serrated on posterior edge).

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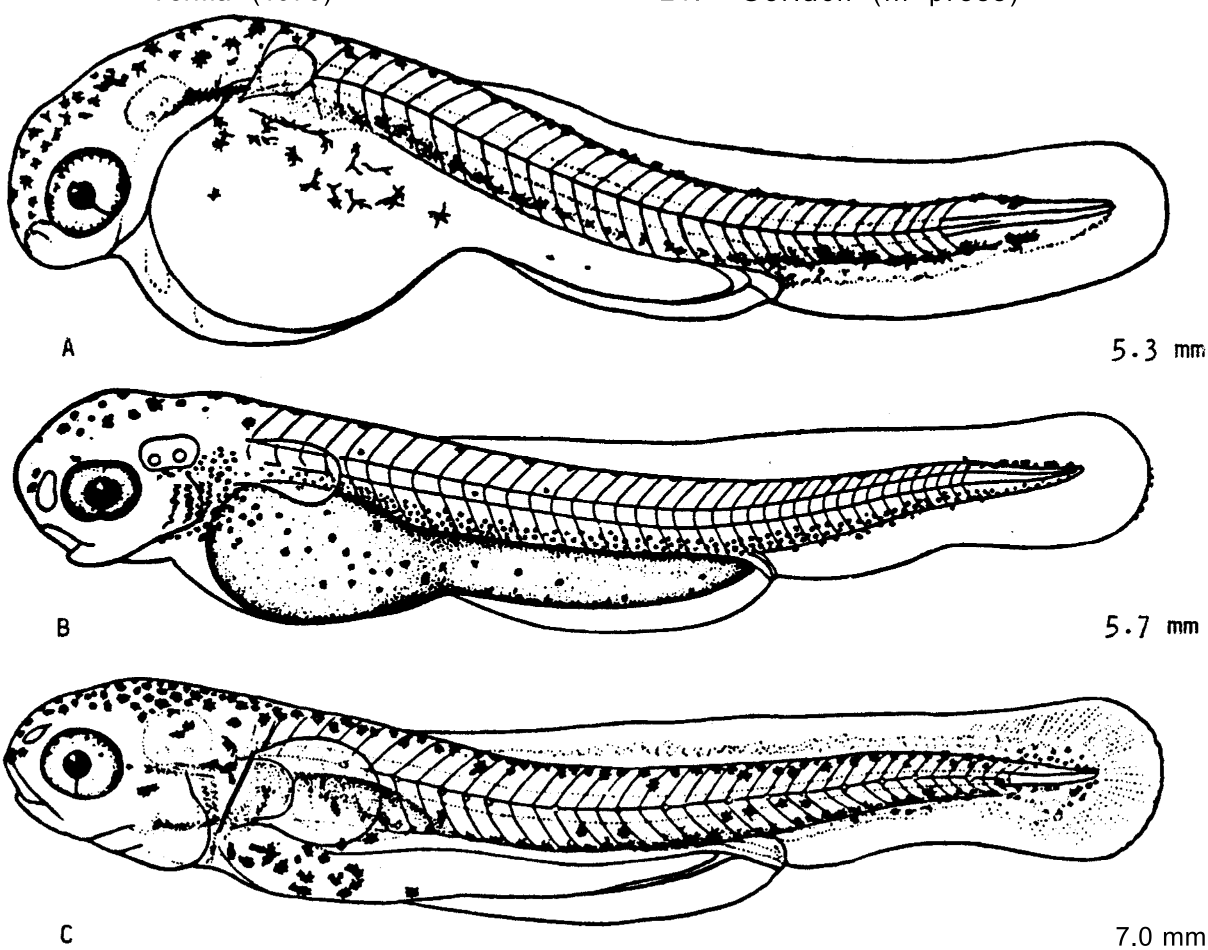

Fig. 65. Cyprinus carpio, common carp. A-C. Yolk-sac larvae. (A and C, Japan, Nakamura 1969; B, Soviet Union, Bragensky 1960).

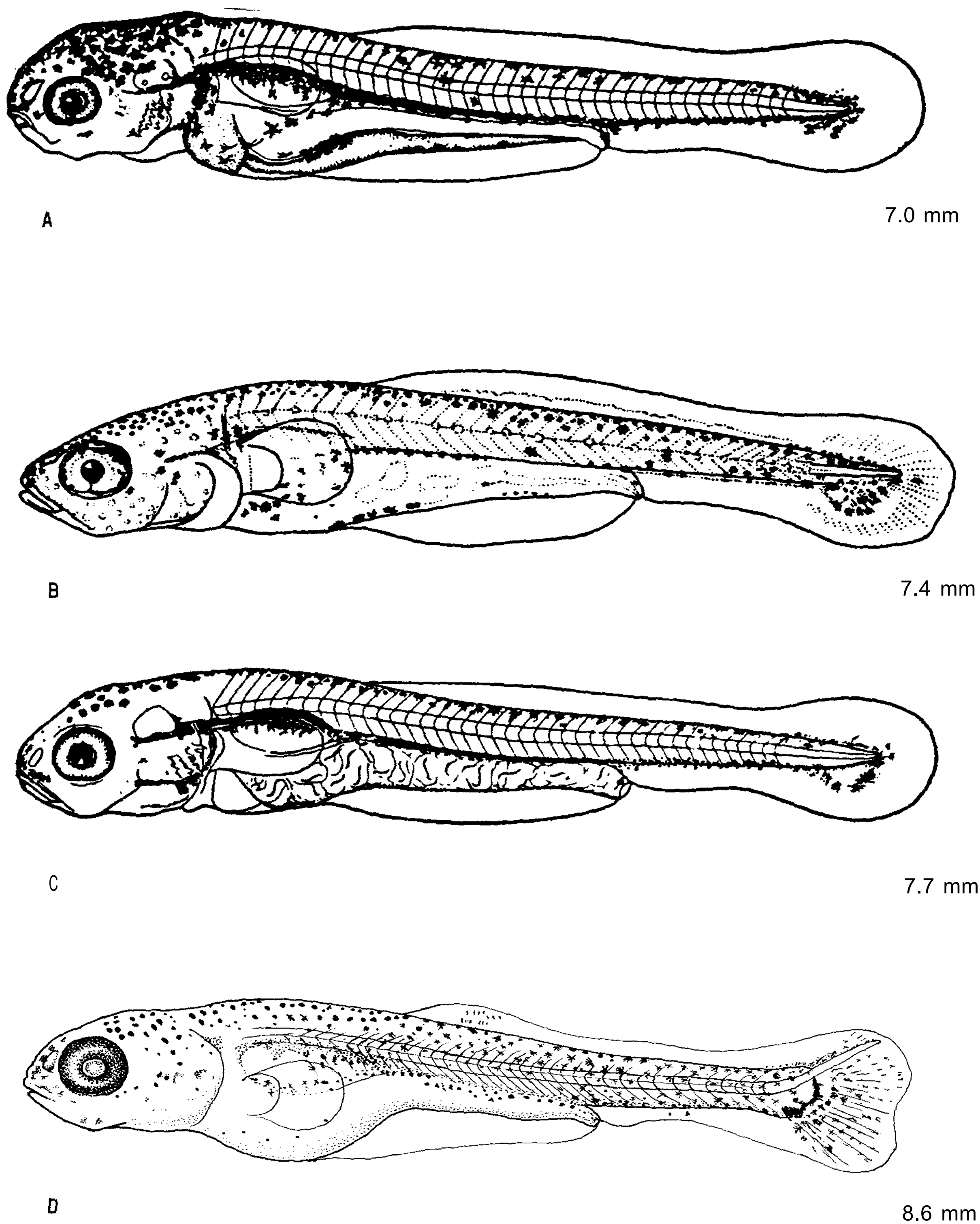

Fig. 66. *Cyprinus carpio*, common carp. A-D. Larvae. (A and C, Soviet Union, Bragensky 1960; B, Japan, Nakamura 1969; D, laboratory-reared Maryland, Loos et al. 1979).

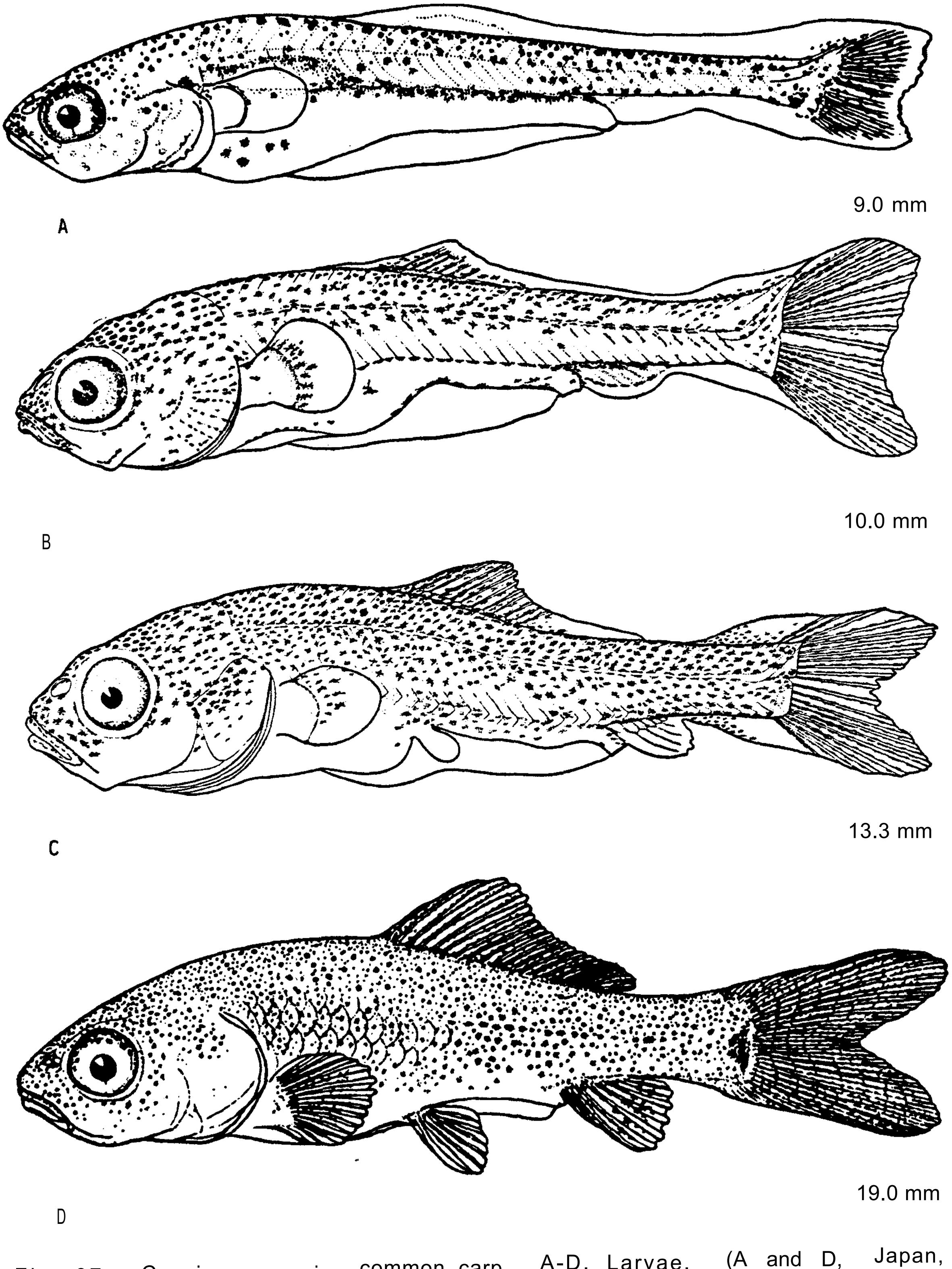

Fig. 67. Cyprinus carpio, common carp. A-D. Larvae. (A and D, Japan, Nakamura 1969; B and C, wild-caught, Lake Erie, Fish 1932).

Ericymba buccata Cope, silverjaw minnow

DISTRIBUTION

This species occurs in the Lake Erie[5] * and Lake Michigan drainages.' Lake Michigan drainage records are from Indiana tributaries.' [5]

SPAWNING SEASON

Spawns from late April to late July in Indiana, with two major peaks.' Spawns from late April to early June in Michigan[4] and March to June in Kentucky.[3]

SPAWNING TEMPERATURE

Spawns at temperatures between 13 and 19 C.[9]

SPAWNING HABITAT

Spawns in creeks.[2 3 4]

SPAWNING SUBSTRATE

Deposits eggs over sand[2 4] or fine gravel.'

FECUNDITY

127 to 1,454.[3]

EGGS

Not described.

YOLK-SAC LARVAE

Not described.

LARVAE

Myomeres: 38 to 39 (25 to 26 + 13).[8]

JUVENILES

Not described.

ADULTS

Fin rays: caudal 19;* dorsal 8, anal 8 (7 to 9);[6 7] pectoral 13* to 15;[9] pelvic 9.*

Vertebrae: not reported.

Ericymba buccata

Lateral line scales: 31' to 36.[7 9]

Pharyngeal teeth: 1,4-4,1 0,4-4,1 0,4-4,0.[10]

Diagnostic characters: cavernous chambers on lower cheeks and ventral surface of head.

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Hybognathus hankinsoni Hubbs, brassy minnow

DISTRIBUTION

The brassy minnow is found in parts of all Great Lakes basin. It is apparently absent from northern portions of the Lake Superior and Huron drainages, as well as southern drainages of Lakes Ontario and Erie.[1 5] It occurs throughout the Lake Michigan drainage with the exception of the southern tip.[2] It prefers still waters[3] of small streams and lakes.[2]

SPAWNING SEASON

Spawns in late May and early June in Wisconsin.[3]

SPAWNING TEMPERATURE

Water temperatures during spawning range from 16 to 27 C.[3 8]

SPAWNING HABITAT

Spawns in still water[1] among vegetation.'

SPAWNING SUBSTRATE

Scatters eggs among vegetation.[3 8] Probably does not spawn naturally over mud, silt or detritus,: as suggested elsewhere.[7]

FECUNDITY

Ca. 120 to 550, mean: 269 to 309.[8]

NATURAL HYBRIDS

Notropis heterolepis;[6] possibly *N. stramineus*.'

EGGS

Demersal, slightly adhesive.[3 7]

YOLK-SAC LARVAE

Not described.

LARVAE

Total length	Description
5-7 mm	Myomeres: (24 to 25 + 9 to 13), usually 36 (25 + 11).[4] Morphometry: (as % TL) preanal length 63 to 66, predorsal length 36 to 40.[4] Morphology: first caudal fin rays forming (5.8 to 7.0 mm, usually 6.5 mm).[4]

Pigmentation: midventral stripe prominent from head to anus, conspicuous melanophore on pectoral bud base.[4]

7-10 mm

Myomeres: (24 to 26 + 11 to 13), usually 38 (26 + 12).[4]
Morphometry: (as % TL) preanal length 56 to 64, predorsal length 41, to 44.[4]
Morphology: pelvic buds developed (8.1 to 9.6 mm, usually 8.8 mm).[4]

1O-12 mm

Myomeres: (25 to 26 + 11 to 13), usually 37 (25 + 12).[4]
Morphometry: (as % TL) preanal length 64 to 66, predorsal length 37 to 40.[4]
Pigmentation: no lateral stripe present.[4]

JUVENILES

Scales present (20 and 26 mm).[3]

ADULTS

Fin rays: caudal 19;* dorsal 8 (7 to 8), anal 8 (6 to 9), pectoral 8, pelvic 13 (13 to 15).[1]

Vertebrae: 35 to 37 (including Weberian vertebrae).'

Lateral line scales: 36 to 41.1

Pharyngeal teeth: 0,4-4,0.[1]

Diagnostic characters: scales with about 20 radii; intestine long and coiled, mouth subterminal, anal fin rays usually seven or eight, dorsal fin without dark spot, lateral line not strongly decurved, lateral line scales 36 to 41, barbels absent, premaxillae protractile, dorsal fin short (eight rays).

LITERATURE CITED

1. Scott and Crossman (1973)
2. Becker (1976)
Copes (1975)
43: Perry and Menzel (1979)
5. Bailey (1954)
6. Hubbs (1951)
7. Dobie et al. (1956)
8. Ableson (1973)
9. Bruekelman (1940)

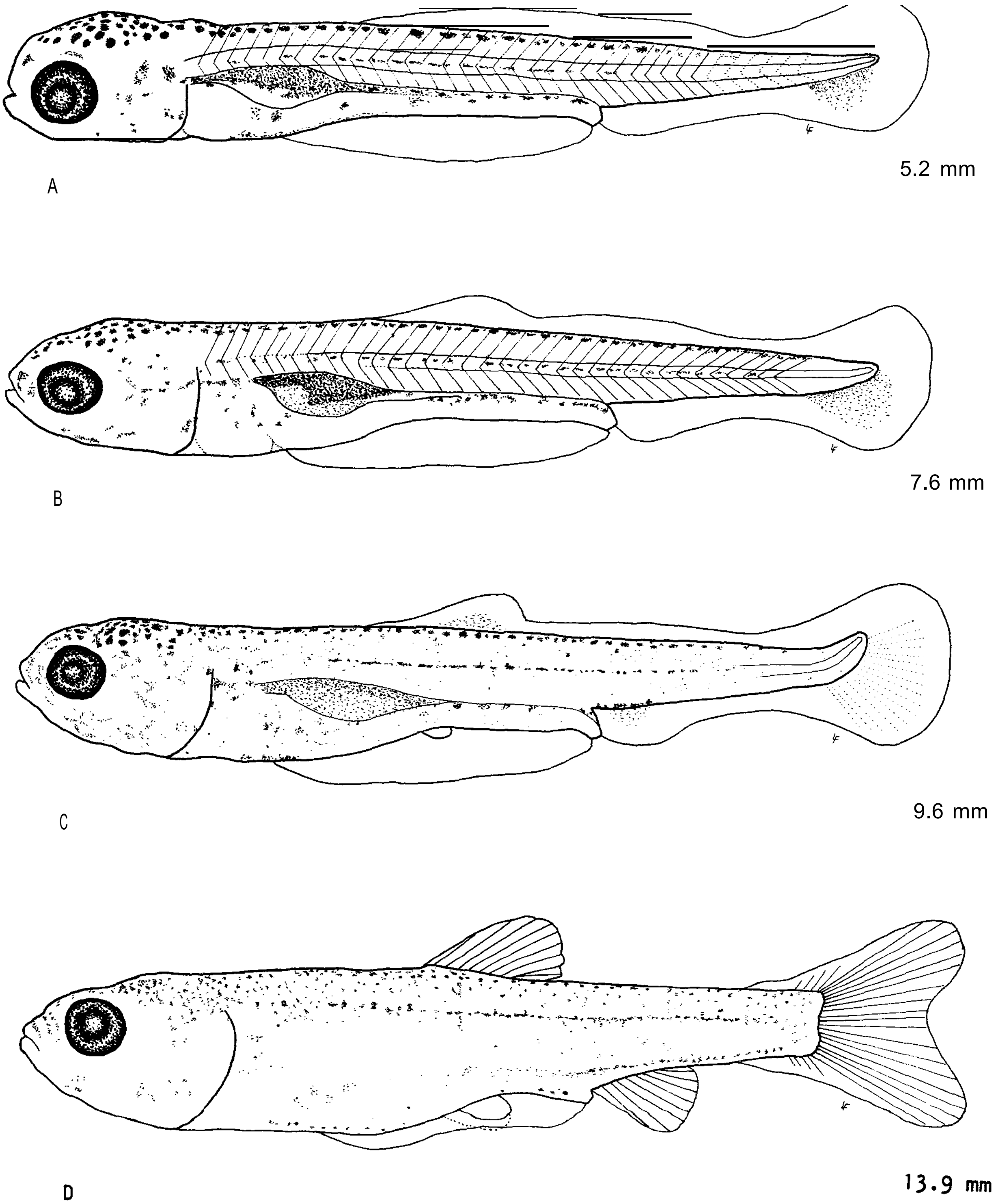


Fig. 68. Hybognathus hankinsoni, brassy minnow. A-D. Larvae. (A-D, wild-caught, Iowa, photograph by Perry and Menzel 1979, delineated by L. A. Fuiman).

Hybognathus regius Girard, eastern silvery minnow

The eastern form of the silvery minnow, previously known as Hybognathus nuchalis regius, is considered a distinct species by Robins et al. (1980) as a result of evidence provided by Pflieger (1971).

DISTRIBUTION

The Great Lakes distribution of this species is confined to eastern Lake Ontario and its drainage.[1]

SPAWNING SEASON

Spawns from late April to June in central New York.[2 3 9]

SPAWNING TEMPERATURE

Water temperature during spawning period ranges from 13 to 21 C.[2 3]

SPAWNING HABITAT

Migrates from lakes to lower portions of streams. Spawns in shallows, usually 5 to 15 cm deep[2] and in quiet waters and riffles.'

SPAWNING SUBSTRATE

Deposits eggs over grasses, decaying vegetation and ooze.[2 3]

FECUNDITY

2,000 to 6,600.[2]

NATURAL HYBRIDS

Notropis chrysocephalus.[10 11]

EGGS

Demersal, nonadhesive;[2] but may form clumps;[6] incubation period: 6 to 7 days in situ (13 to 21 C) .[2]

YOLK-SAC LARVAE

Hatching size about 6 mm TL.[2]

LARVAE

Total length	Description
6-8 mm	Myomeres: 35 to 36 (21 + 14 to 15) .[5 8] Morphology: incipient caudal (6.1 mm), dorsal, anal and pectoral (7.9 mm) fin rays present.[5]

Pigmentation: two dorsal rows of melanophores, scattered pigment on top of head, midlateral row of melanophores present, melanophores concentrated on dorsum of swim bladder;’ caudal spot absent.[7,8]

9-15 mm	Myomeres: 36 (21 + 15).[8] Morphology: all median fin rays formed (14 mm).[7]

JUVENILES

Total length	Description
15 mm	Myomeres: 36 (23 + 13).[5] Pigmentation: no lateral stripe or caudal spot.[8]

ADULTS

Fin rays: caudal 19;[4] dorsal 8, anal 8, pectoral 15 to 16, pelvic 7 to 8.[1,4]

Vertebrae: 37 (36 to 38) (including Weberian vertebrae).[1,4]

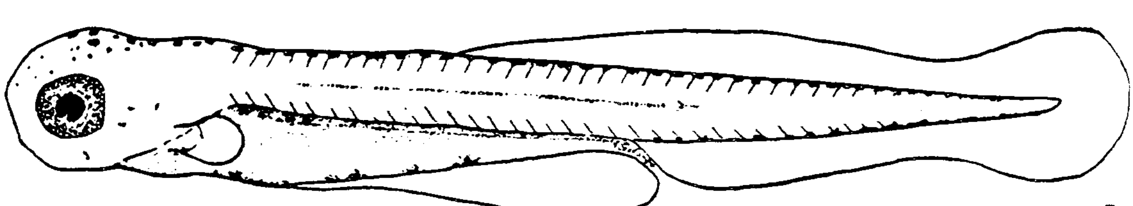
Lateral line scales: 38 to 40;[1] 31 to 44.[4]

Pharyngeal teeth: 0,4-4,0.[1,4]

Diagnostic characters: scales with about ten radii, intestine long and coiled, anal fin rays usually eight, no spot in dorsal fin, lateral line not strongly decurved, scales 38 to 40, barbels absent, premaxillae protractile, dorsal fin short (eight rays).

LITERATURE CITED

1. Scott and Crossman (1973)
2. Raney (1939)
3. Raney (1942)
4. Fingerman and Suttkus (1961)
5. N. S. Smith, in Mansueti and Hardy (1967)
6. J. C. S. Wang, in Lippson and Moran (1974)
7. Lippson and Moran (1974)
8. Wang and Kernehan (1979)
9. Wright and Allen (1913)
10. Luce (1933)
11. O’Donnell (1935)



5.7 mm

Fig. 69. Hybognathus regius, eastern silvery minnow. Yolk-sac larva. (Laboratory-reared, New York, Raney 1939).

Hybognathus regius

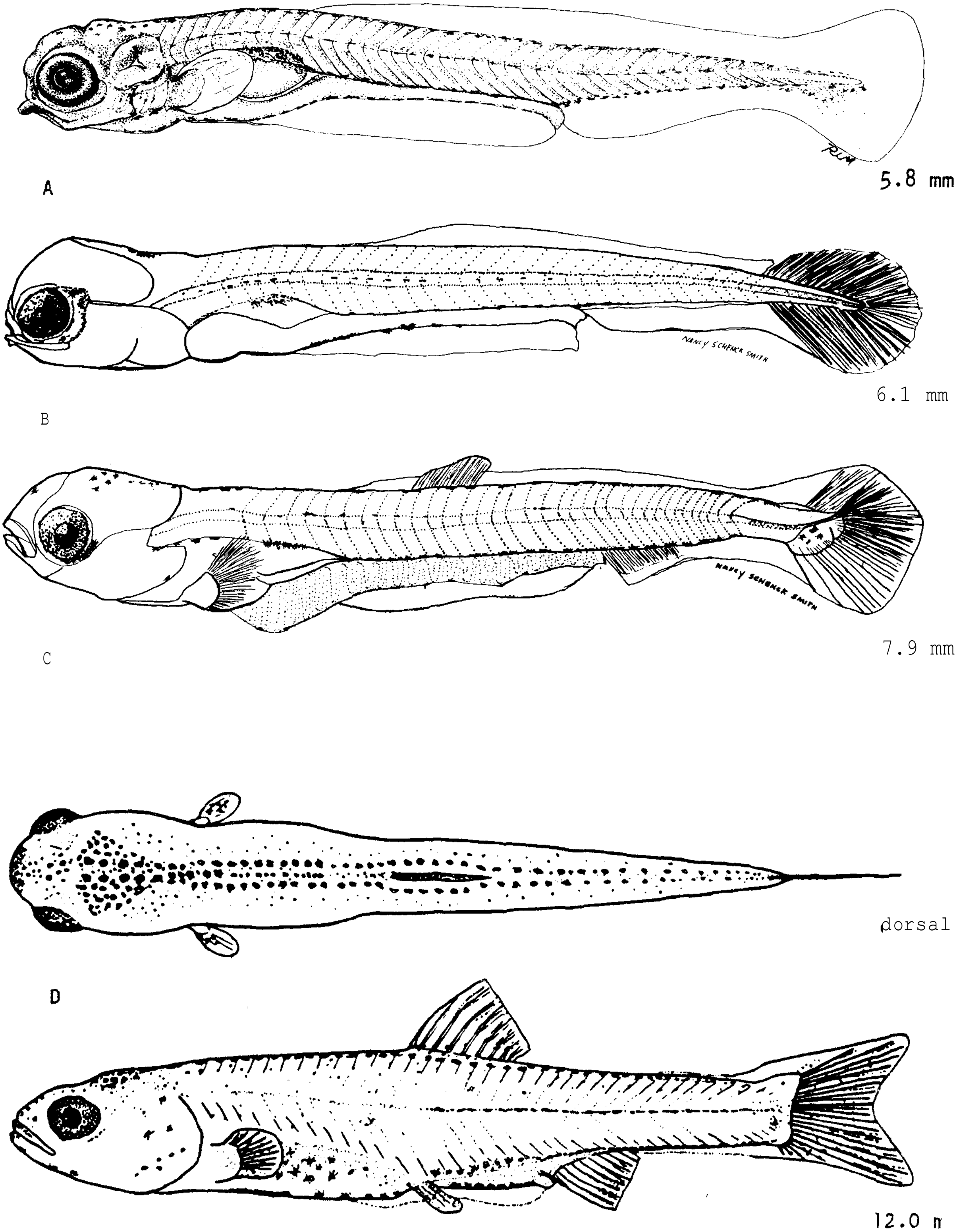


Fig. 70. Hybognathus regius, eastern silvery minnow. A-D. Larvae. (A-C, Lippson and Moran 1974; D, laboratory-reared, New York., Raney 1939).

Hybopsis amblops (Rafinesque), bigeye chub

DISTRIBUTION

Sparsely scattered in the Great Lakes. Occurs in southern tributaries of western Lake Ontario[3] and Lake Erie,[8] southeastern Michigan[3] and a single record (1894) from a stream in the southern most Michigan drainage of Lake Michigan.'

SPAWNING SEASON

Spawns from late May through June in New York.[2] Ripe females were collected in early June.[4 5]

SPAWNING TEMPERATURE

Not reported.

SPAWNING HABITAT

Spawns in large streams with hard bottoms.[6]

SPAWNING SUBSTRATE

Probably deposits eggs in vegetation.[7]

FECUNDITY

Not reported.

EGGS

Not described.

YOLK-SAC LARVAE

Not described.

LARVAE

Not described.

JUVENILES

Not described.

ADULTS

Fin rays: caudal 19;* dorsal 8, anal 8, pectoral 15, pelvic 8.[9]

Vertebrae: 36 to 37 (including Weberian vertebrae).[9]

Lateral line scales: 35 to 36.9

Pharyngeal teeth: 1,4-4,1.'

Diagnostic characters: caudal fin with white edge, anal fin rays eight, mouth subterminal and horizontal, lateral line scales 35 to 36, most of breast anterior to pelvic fins scaled, premaxillae protractile with terminal barbel, dorsal fin short (eight rays).

LITERATURE CITED

1. Becker (1976)
2. Raney (1969a)
3. Hubbs and Lagler (1958)
4. Forbes and Richardson (1909)
5. Pflieger (1975)
6. Cook (1959)
7. Smith (1979)
8. Trautman (1957)
9. Cross (1967)

Hybopsis storeriana (Kirtland), silver chub

Fish (1932) described 5-mm, 7-mm, and 9.5-mm specimens. These were probably misidentified percids.* A 6.5-mm specimen illustrated by Taber (1968) may be Pimephales vigilax.[9]

DISTRIBUTION

This species has been reported from Lake Erie and the southern shore of Lake Ontario.[1 2] However, it has not been taken recently.[2] It generally inhabits lakes and deep pools of low gradient streams.[3]

SPAWNING SEASON

Spawns from mid-June to mid-August in Lake Erie,[5] mostly in June and July in Ohio.[3]

SPAWNING TEMPERATURE

Begins to spawn at 18 C,[5] but most spawning occurs at temperatures above 21 C.[5 8]

SPAWNING HABITAT

Possibly spawns in streams[4] or perhaps in pelagic zones.[8]

SPAWNING SUBSTRATE

Not reported but may be pelagic.'

FECUNDITY

140 to 4,850;[8] 1,000 to 14,000.[5]

EGGS

Not described but may be buoyant[8] as in other Hybopsis species.[10]

YOLK-SAC LARVAE

Not described.

LARVAE

Similar to Pimephales vigilax, but more slender, having a longer snout and larger fins.'

JUVENILES

Total length	Description
21 mm	Morphometry: (as % TL) preanal length 52, head length 21, eye diameter 7, greatest body depth 16, body depth at anus 10.[6]
	Pigmentation: melanophores on dorsum of snout and head, two dorsal rows from head to caudal peduncle, dark lateral stripe absent, small melanophores mark lateral line, melanophores on dorsum of hindgut, two postanal ventral rows of melanophores, base of dorsal and anal fins pigmented, melanophores present in dorsal and caudal fins.[6]

ADULTS

Fin rays: caudal 19;* dorsal 8, anal 8 (7 to 8), pectoral 17 (16 to 18), pelvic 8 (8 to 9) .[2]

Vertebrae: 38 to 41 (including Weberian vertebrae).[2]

Lateral line scales: 38 to 41.[2]

Pharyngeal teeth: 1,4-4,1.[2]

Diagnostic characters: snout overhanging mouth, lateral line scales 38 to 41, maxillary barbel terminal, premaxillae protractile, dorsal fin short (eight rays).

LITERATURE CITED

1. Hubbs and Lagler (1958)
2. Scott and Crossman (1973)
3. Trautman (1957)
4. Breder and Rosen (1966)
5. Kinney (1954)
6. Fish (1932)
7. Taber (1969)
8. Williams (1963)
9. J. V. Conner (pers. Comm.)
10. Bottrell et al. (1964)

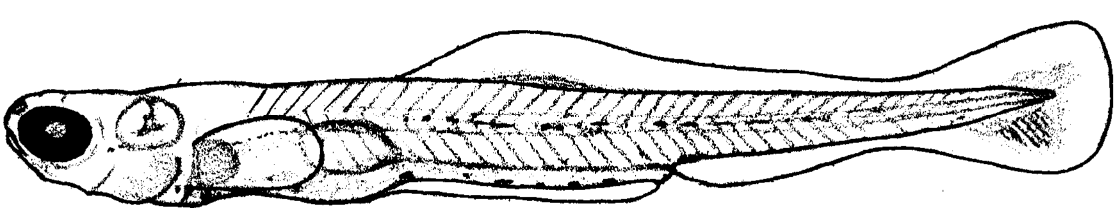


Fig. 71. Hybopsis storeriana, silver chub (tentative identification). Larva. (Wild-caught, Oklahoma, Taber 1969).

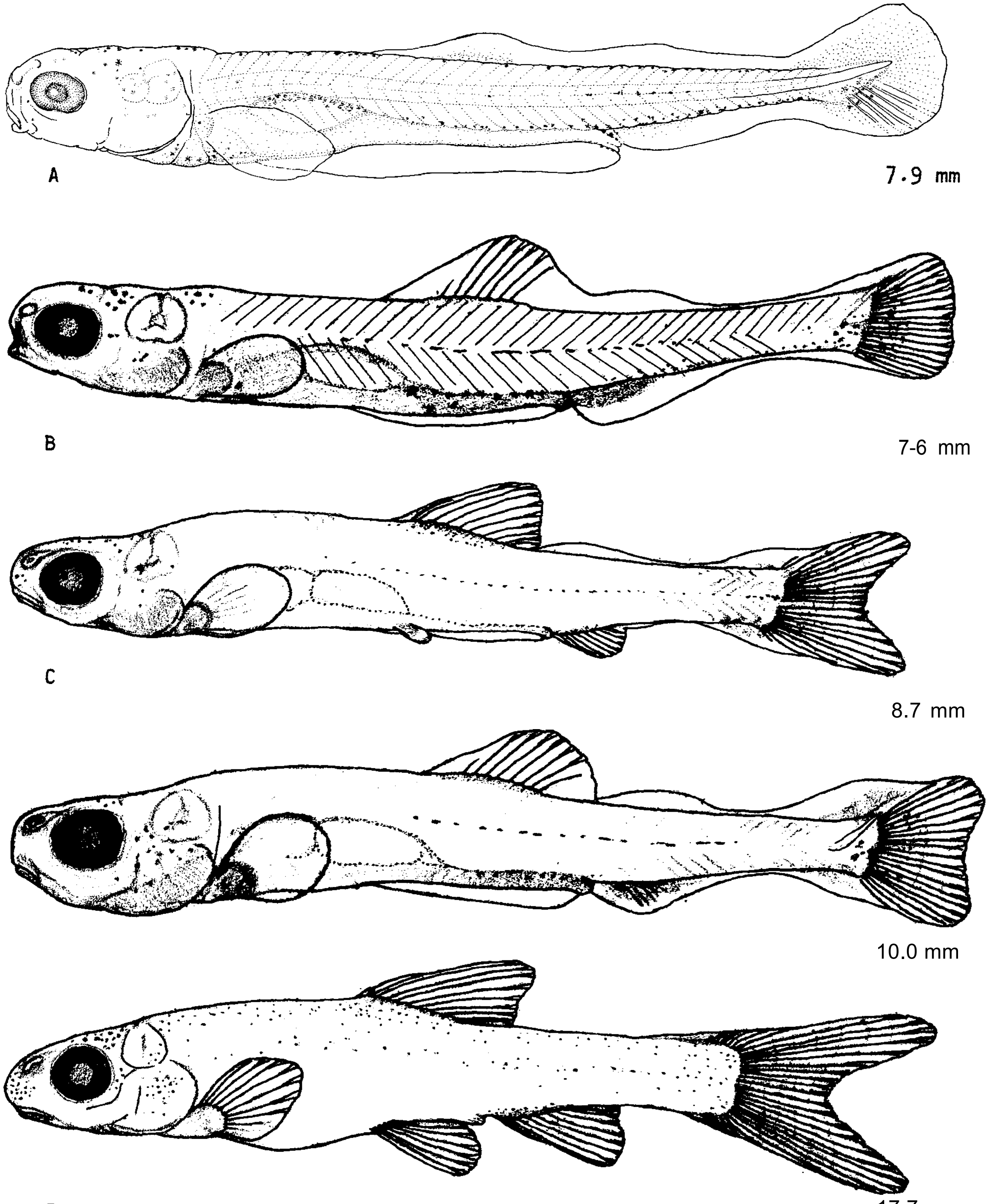


Fig. 72. Hybopsis storeriana, silver chub. A-D. Larvae. E. Juvenile. (A, wild-caught, Louisiana, Conner et al . 1980, specific identification subsequently verified by J. V. Conner; B-E, wild-caught, Oklahoma, Taber 1969).

Nocomis biguttatus (Kirtland), hornyhead chub

DISTRIBUTION

Occurs in southern tributaries of Lake Superior, through the Lake Michigan, Huron and Erie drainages and only the southern portion of the Lake Ontario drainage.‘ Common in most tributaries south of Green Bay and the Manitou Islands, Lake Michigan.’

SPAWNING SEASON

Spawns from mid-May in Ontario[2] to June in New York.[4] Eggs were collected in late June in southern Michigan.*

SPAWNING TEMPERATURE

Probably spawns at temperatures near 24 C.[2]

SPAWNING HABITAT

Spawns in shallow riffles[2] or in shallow runs, 15 to 40 cm deep, close to shore.*

SPAWNING SUBSTRATE

Deposits eggs in a large mound nest of small to medium-sized gravel. Nests are 30 to 70 cm in diameter and about 15 cm high.’ *

FECUNDITY

460 to 1 ,000.[2] [3]

NATURAL HYBRIDS

Notropis’ chrysocephalus;[5] E. cornutus.’ [8]

EGGS

Demersal, nonadhesive, diameter 2.4 to 2.7 mm, mean: 2.6 mm, perivitell ine space narrow, yolk transparent-yellow, oil globules absent.*

YOLK-SAC LARVAE

Total length	Description
8-10 mm	Myomeres: 41 to 44 (27 to 29 + 13 to 16).* Morphometry: (as % TL) preanal length 66 to 70, head length 15 to 19, eye diameter 8, body depth at anus 9 to 10.*

Morphology: pectoral buds present, head slightly deflected over yolk sac, yolk sac spherical anteriorly, tapering posteriad (8.9 mm), head free from yolk sac, mouth open (10.0 mm).*
Pigmentation: eye light brown, other pigmentation absent (8.9 mm), eye black, melanophores covering occiput, two dorsal rows from head to caudal fin, melanophores on dorsum of yolk sac (10.0 mm).*

LARVAE

Total length	Description
9-15 mm	Myomeres: see 8-10 mm. Morphometry: (as % TL) preanal length 59 to 63, head length 20 to 24, eye diameter 8, body depth at anus 11 to 14.5: Morphology: yolk absorbed, hypural and caudal fin elements formed, swim bladder inflated (9.6 mm), all median fin rays formed (10.6 to 11.2 mm), pelvic buds formed (10.6 mm) .* Pigmentation: melanophores covering dorsum of snout, midlateral stripe broad (three melanophores wide), dorsum of swim bladder and hindgut heavily pigmented, melanophores among caudal fin rays, ventro-lateral stripe on sides of hindgut, descending to midventral line anteriorly, two short midventral series of melanophores posterior to heart and anterior to anus, pericardium pigmented (9.6 mm), caudal spot black, melanophores among dorsal and anal fin rays, two ventral postanal rows of melanophores (10.6 to 11.2 mm), dorsum uniformly covered with small melanophores, spreading to sides, pigment-free stripe between dorsal pigmentation and midlateral stripe. (13.0 to 14.7 mm).*

JUVENILES

Total length	Description
17-23 mm	Myomeres: see 8-10 mm. Morphometry: (as % TL) preanal length 57, head length 23, eye diameter 8, body depth at anus 14 to 16.* Morphology: all finfolds absorbed (17 mm) , squamation complete (22 mm).* Pigmentation: small melanophores outlining scales.*

ADULTS

Fin rays: caudal 19;* dorsal 8 (7 to 8) , anal 7 (6 to 7), pectoral 15 to 16 (14 to 17), pelvic 8.[5]

Vertebrae: 37 to 39 (including Weberian vertebrae).[5]

Lateral line scales: 40 to 48.[5]

Pharyngeal teeth: 1,4-4,1 0,4-4,0 0,4-3,0.[5]

Diagnostic characters: caudal spot large and distinct, mouth terminal, not reaching eye, lateral line scales 40 to 48, premaxillae protractile with terminal barbel, dorsal fin short (eight rays).

LITERATURE CITED

1. Becker (1976)
2. Carter (1940) in Scott and Crossman (1973)
3. Lachner (1952)
4. Raney (1969a)
5. Scott and Crossman (1973)
6. Jenkins and Lachner (1979)
7. Luce (1933)
   O'Donnell (1935)

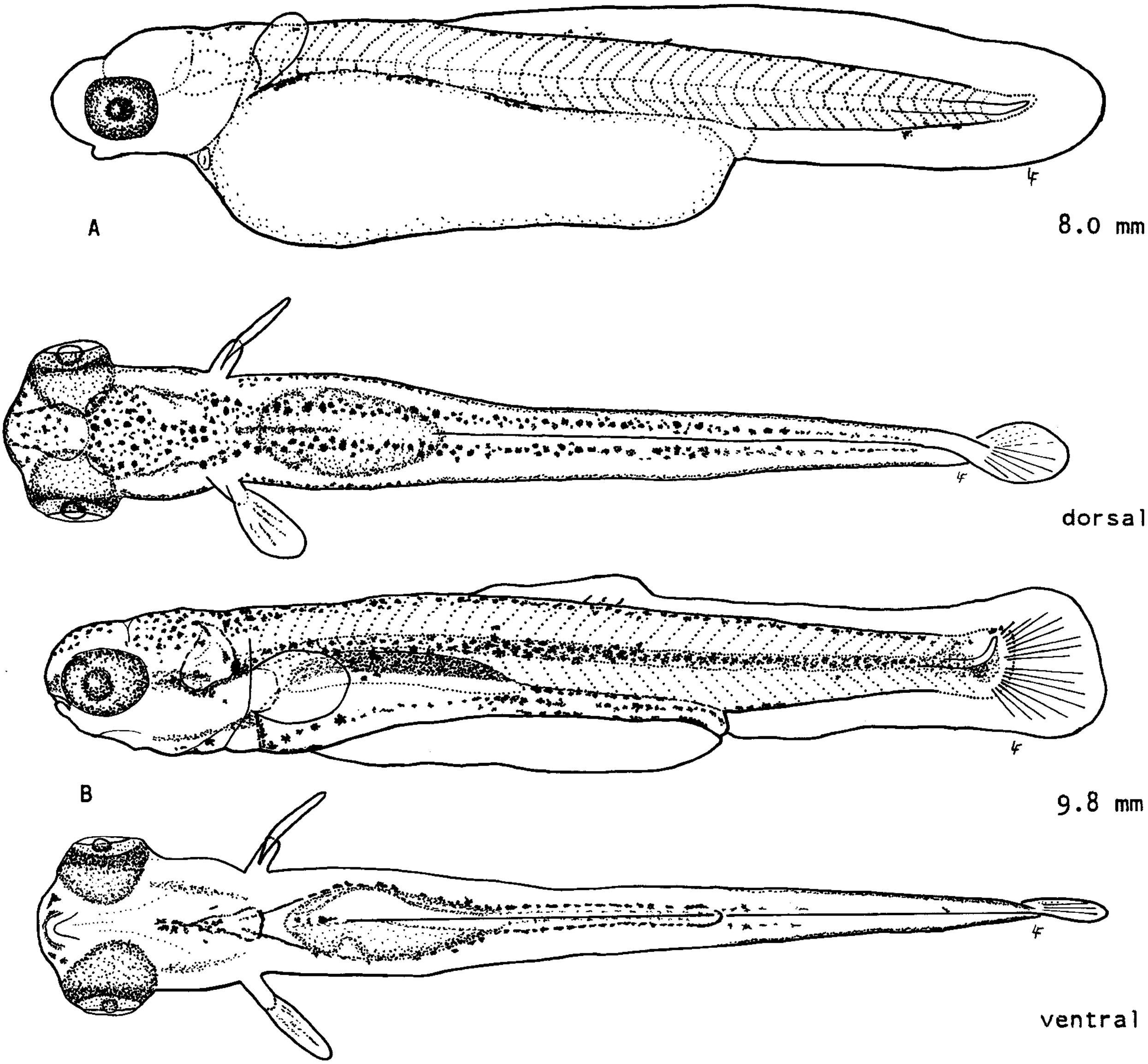
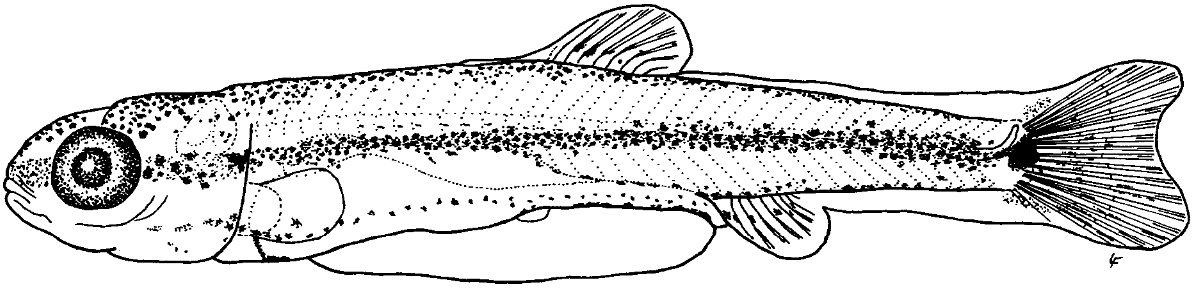
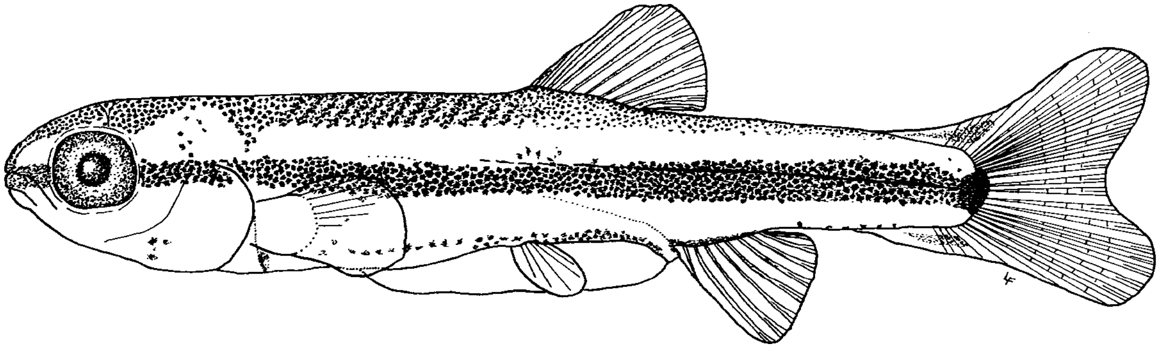


Fig. 73. Nocomis biguttatus, hornyhead chub. A. Yolk-sac larva. B. Larva. (A-B, laboratory-reared, Michigan, original illustrations by L. A. Fuiman).



A

11.9 mm



B

14.2 mm

Fig. 74. Nocomis biguttatus, hornyhead chub. A and B. Larvae. (A and B, laboratory-reared, Michigan, original illustrations by L. A. Fuiman).

Nocomis micropogon (Cope), river chub

DISTRIBUTION

This species is found in the Lake Ontario and Erie drainages, as well as most of lower Michigan (Lake Huron and Michigan tributaries), and the southern portion of the Lake Huron drainage in Ontario.[2] It is common in most streams of lower Michigan which are tributary to the lake.[1]

SPAWNING SEASON

Spawns in the latter part of May in Michigan[9] and into June in New York.[7,8]

SPAWNING TEMPERATURE

Spawning occurs at temperatures between 15 and 21 C.[3,7,9]

SPAWNING HABITAT

Spawns in shallow (15 to 61 cm, usually 30 to 46 cm deep) streams.[7,8,9,10]

SPAWNING SUBSTRATE

Eggs are buried in a mound nest of gravel, approximately 30[10] to 124[9] cm in diameter and 15 to 30 cm high.’[11]

FECUNDITY

400 to 625[6] or up to 1,000.[2]

NATURAL HYBRIDS

<u>Notropis chrysocephalus</u>;[3,12] N. <u>cornutus</u>;[5] <u>Rhinichthys cataractae</u>.[3,12]

EGGS

Demersal, nonadhesive;* diameter 2 mm;[4] 2.6 to 2.7 mm;[3,12,13] yolk yellow;[3,5,12] incubation period: 5 to 6 days at 21 C.[3,12]

YOLK-SAC LARVAE

Total length	Description
5.7-6.1 mm	Newly hatched;[3,12,13] also reported as 7 mm.[5] Morphology: pectoral buds absent;[12] or present;” head deflected over yolk sac.[3,12,13] Pigmentation: absent.[3,12,13]
6-11 mm	Myomeres: 38 to 42 (25 to 28 + 12 to 15);[3,12,13] usually 38 to 39 (26 + 13).[13]

Morphometry: (as % TL) preanal length 67, head length 18, eye diameter 8, greatest body depth 24.[13]

Morphology: pectoral buds present, head straight (8.0 mm), mouth complete;' [12] notochord flexed, hypural anlage present (9.5 mm), hypural bones complete, incipient caudal and dorsal fin rays present, posterior swim bladder chamber inflated, incipient anal fin rays present, anterior swim bladder chamber inflated (10.0 to 10.5 mm).[3,12,13]

Pigmentation: margin of eye pigmented, chromatophores on each side of dorsal median finfold and on yolk-sac dorsum (8.0 to 8.8 mm), melanophores on dorsum behind head and in midlateral myoseptum, eye fully pigmented, two dorsal rows of melanophores;[3,12,13] strongly divergent anteriorly (9.5 mm);[5] dorsum of posterior swim bladder chamber and yolk sac pigmented, spot at base of caudal fin, internal melanophores on snout;[3,12,13] pigment on vertical myoseptum, pigment on dorsal and caudal fin rays (10.0 to 10.8 mm).[13]

LARVAE

Total length	Description
11-18 mm	Myomeres: 36 to 38 (24 to 27 + 11 to 13), usually 37 to 38 (25 to 26 + 12);[3] see 6-11 mm. Morphometry: (as % TL) preanal length 57 to 60, head length 22 to 23, eye diameter 8, greatest body depth 17 to 18.13 Morphology: yolk absorbed (10.8 mm), pelvic buds and anal fin rays present, lower jaw included (11.6 mm), anal fin complete (13.5 to 14.0 mm);[3,12] incipient paired fin rays present (12.9 to 14.5 mm);[3,12,13] paired fin rays well developed (15.5 mm).[3,12] Pigmentation: midlateral stripe wider, widest on caudal peduncle, caudal spot extending onto caudal fin (18 mm).[3,12]

JUVENILES

Total length	Description
17-30 mm	Myomeres: see 6-11 mm. Morphometry: (as % TL) preanal length 53, predorsal length 52, head length 24, eye diameter 7, snout length 6, greatest body depth 19, body depth at anus 14.[4] Morphology: squamation started (17 mm);[3,12,13] finfold absorbed (17.3[13] to 19.0 mm[3,12]); barbels present (20 mm), squamation complete (29 to 30 mm).[3,12] Pigmentation: head with numerous melanophores, gut darkly pigmented;[13] upper jaw pigmented, dorsum of body with scattered pigment (20 mm);[3,12] scale margins pigmented;' lines of melanophores connecting dorsal and midlateral stripe at each myomere (26 mm).[3,12]

ADULTS

Fin rays: caudal 19;* dorsal 8 (7 to 8), anal 7 (7 to 8), pectoral 16 (15 to 17), pelvic 8.2

Vertebrae: 38 to 39 (including Weberian vertebrae).[2]

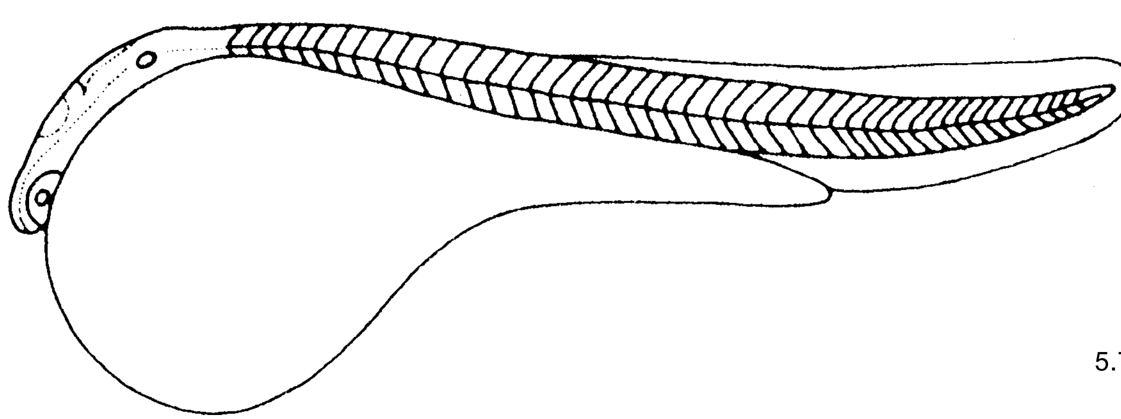
Lateral line scales: 39 to 43.[2]

Pharyngeal teeth: 0,4-4,0 0,3-4,0.[2]

Diagnostic characters: caudal spot absent, lateral band indistinct, mouth terminal, not reaching eye, lateral line scales 39 to 43, premaxillae protractile with terminal barbel, dorsal fin short (eight rays) .

LITERATURE CITED

1. Becker (1976)
2. Scott and Crossman (1973)
3. Cooper (1978b)
4. Fish (1932)
5. Loos et al. (1979)
6. Lachner (1952)
7. Miller (1964)
8. Raney (1969a)
9. Reighard (1943)
10. Hankinson (1920) - may refer to Nocomis biguttatus
11. Raney (1940b)
12. Cooper (1980)
13. Buynak and Mohr (1980a)



5.7 mm

Fig. 75. Nocomis micropogon, river chub. Yolk-sac larva, newly hatched. (Laboratory-reared, Maryland, Cooper 1980).

Nocomis micropogon

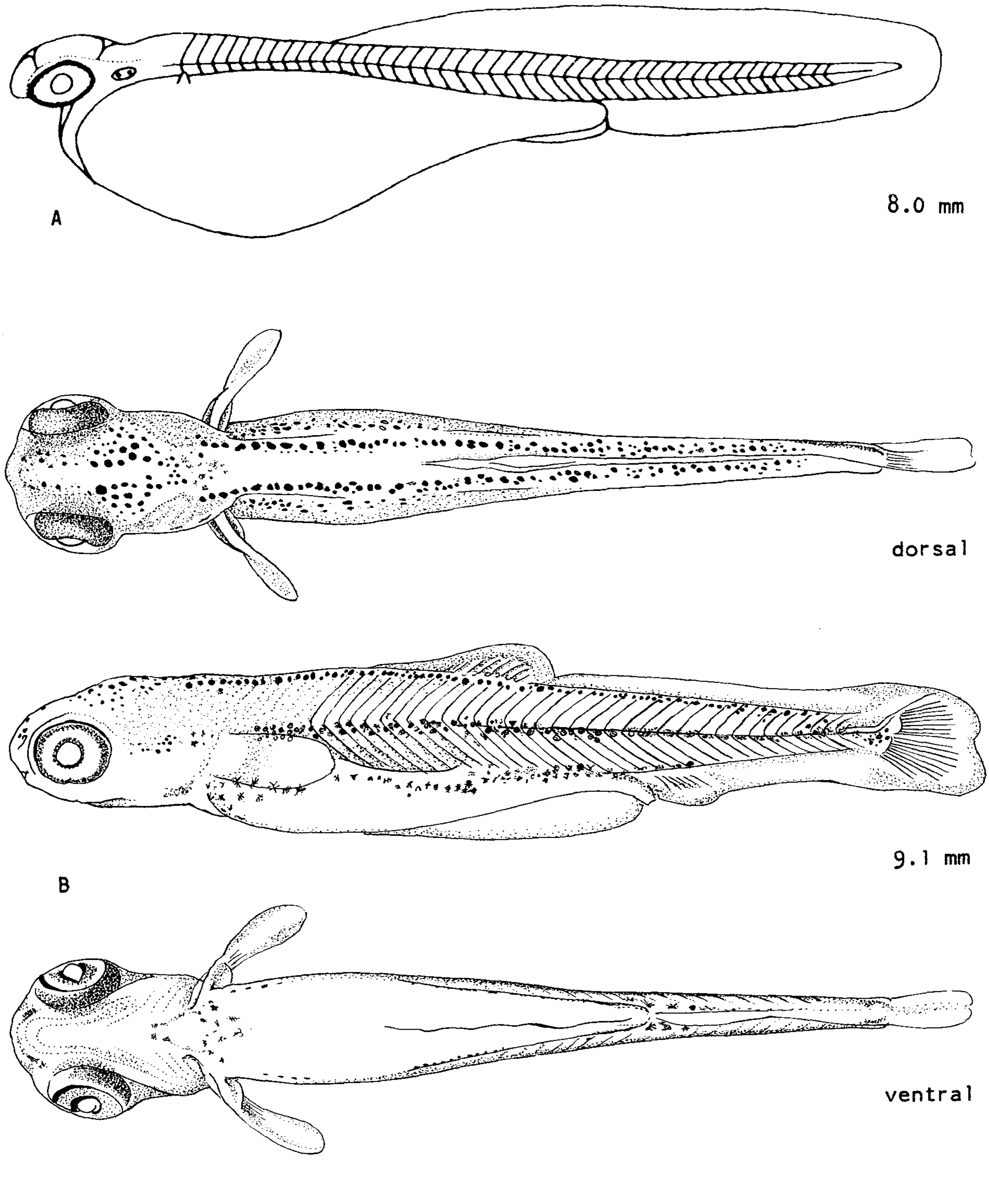


Fig. 76. Nocomis micropogon, river chub. A. Yolk-sac larva. B. Larva. (A, laboratory-reared, Maryland, Cooper 1980; B, laboratory-reared, Maryland, Loos et al. 1979).

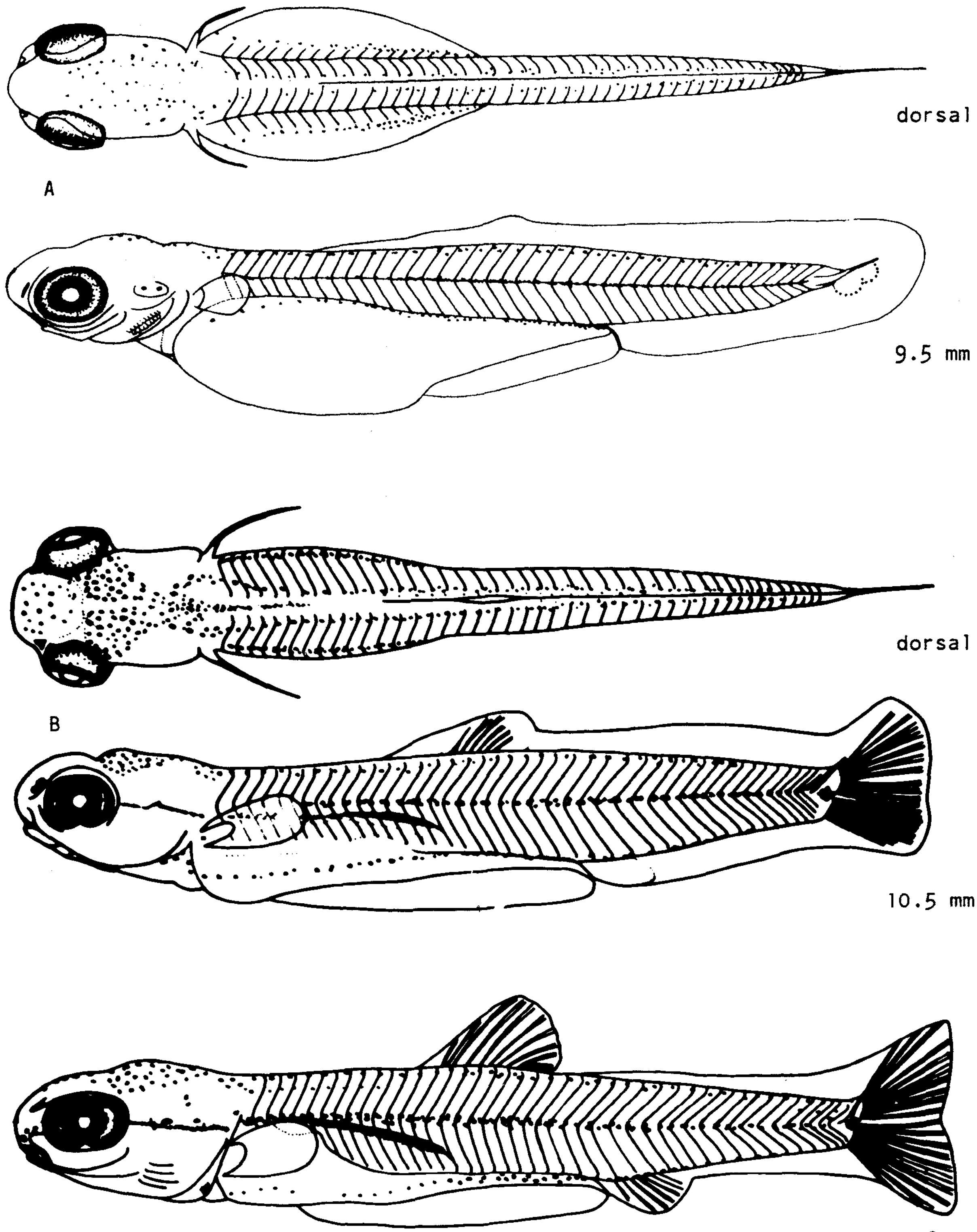


Fig. 77. Nocomis micropogon, river chub. A. Yolk-sac larva. B and C. Larvae. (A-C, laboratory-reared, Maryland, Cooper 1980).

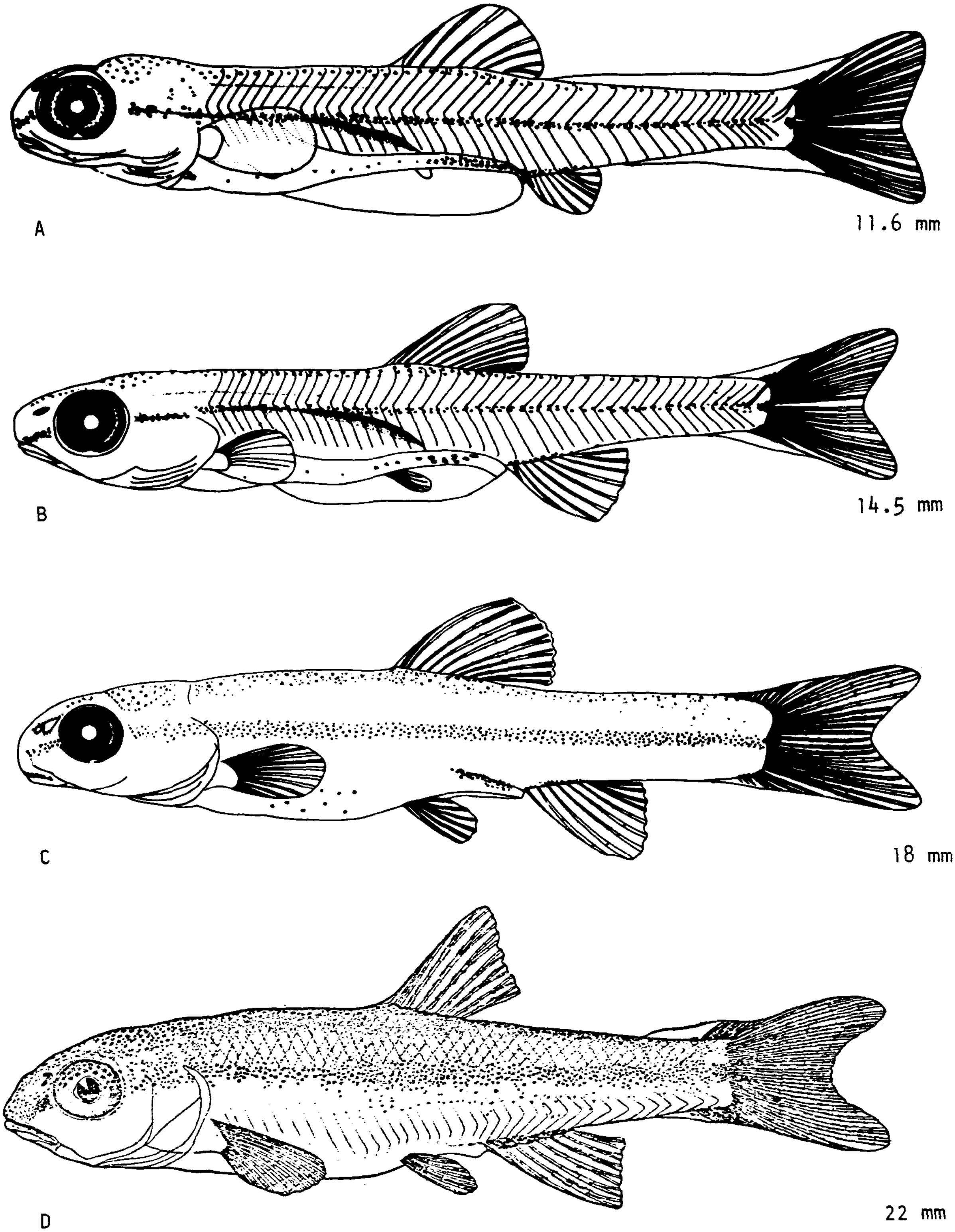


Fig. 78. Nocomis micropogon, river chub. A-C. Larvae. D. Juvenile. (A-C, laboratory-reared, Maryland, Cooper 1980; D, wild-caught, Lake Erie tributary, Fish 1932).

Notemigonus crysoleucas (Mitchill), golden shiner

DISTRIBUTION

Occurs throughout the Great Lakes basin.[1 2] It is common to abundant throughout the Lake Michigan drainage.[3]

SPAWNING SEASON

Spawns from May to August in Michigan,' or may only spawn from late June to early August.'

SPAWNING TEMPERATURE

Spawning begins at 20 to 21 C[5 8] and ceases above 27 C.[5]

SPAWNING HABITAT

Spawns in ponds[5 7 13] and lakes.[7 13]

SPAWNING SUBSTRATE

Deposits eggs over filamentous algae[8 9] or less frequently over rooted aquatic plants.[5 7] Also spawns over nest of Micropterus salmoides.[15 16]

FECUNDITY

To 200,000.[6]

EGGS

Demersal, adhesive;'[5 7 9 12] diameter 1.0 mm;[8] 1.2 to 1.4 mm;[10] oil globules absent;[9] incubation period: 2 to 3 days at 21 to 24 C;[10] within 4 days at 24 to 27 C.[5]

YOLK-SAC LARVAE

Total length	Description
3-6 mm	Hatching length: ca. 3 mm;[10] 4.0 to 4.3 mm.[14] Myomeres: 35 to 39[10 14] (21 to 24[14] + 13 to 16[10 14]); predorsal 8 to 11.[10] Morphometry: (as % TL) standard length 92 to 96[10] or 96 to 98;[14] preanal length 59 to 62[10] or 62 to 65;[14] predorsal length 37 to 41;[10] head length 15 to 18[10] or 18 to 19;[14] snout length 2 to 3;[10] eye diameter 7 to 8[10] or 9 to 10;[14] pectoral fin length 10 to 11, greatest body width 7 to 22;[10] greatest body depth 11 to 26;[10 14] greatest head depth 11.[10]

Morphology: pectoral buds indistinct;[10] head deflected over yolk sac, notochord straight, mouth incomplete (newly hatched), mouth open, swim bladder inflated (5.4 mm).[14]

Pigmentation: eye pigmented, body unpigmented (newly hatched), prominent midventral line of melanophores present, particularly under finfold;[10,14] series of melanophores under ventral surf ace of gill cover;[10] subsurface row of melanophores behind eye extending to swim bladder;” midlateral series of melanophores evident from just posterior to swim bladder to caudal peduncle;[10] this pattern may be vague;[14] melanophores concentrated over swim bladder (ca. 4.6 mm).[10,11]

LARVAE

Total length	Description
5-11 mm	Myomeres: 36 to 38[10,14] (23 to 25[14] + 13 to 15[14] or 15 to 17[10]); predorsal 11 to 13.[10]
	Morphometry: (as % TL) standard length 86 to 91[10] or 89 to 94;[14] preanal length 57 to 60[10] or 62 to 63;[14] predorsal 38 to 43;[10] head length 18 to 22;[10,14] snout length 2 to 3, eye diameter 5 to 6[10] or 7 to 8;[14] pectoral fin length 9 to 12, greatest body width 7 to 11, greatest body depth 11 to 13[10] or 12 to 15;[15] greatest head depth 11 to 14.[10]
	Morphology: pelvic buds large;[10] notochord flexed (7.5 mm);[14] anal and dorsal fin rays evident (ca. 9.5 mm).[10]
	Pigmentation: distinct preanal midventral line of melanophores, patch of melanophores over head, with two distinct middorsal rows from nape to caudal fin;[10] concentration of melanophores around urostyle is diagnostic among cyprinids with a midventral line of melanophores.[17]

JUVENILES

The identity of an 18-mm juvenile golden shiner illustrated in Fish (1932) was questioned by Snyder et al (1977), who pointed out that the description of this specimen had fin ray counts incongruous with the illustration.

Total length	Description
14-21 mm	Myomeres: 35 to 38[10,14] (20 to 22[10] or 23 to 25[14] + 12 to 13" or 15[10]); predorsal 13 to 16, prepelvic 10 to 12.[10]
	Morphometry: (as % TL) standard length 79 to 84[10] or 81 to 86;[14] preanal length 49 to 58[10] or 45 to 49;[14] predorsal length 45 to 49, prepelvic length 36 to 42, head length 20 to 23;[10,14] snout length 4 to 5;[10] eye diameter 6 to 8;[10,14] pectoral fin length 10 to 16,

pelvic fin length 1 to 12, greatest body width 9 to 12, greatest body depth 13 to 16, greatest head depth 14 to 15.[10]

Morphology: all fin rays formed (ca. 14.5 mm), pelvic fins distinctly anterior to origin of dorsal fin, finfold completely absorbed (20 to 21 mm).[10 14]

Pigmentation: underside of lower lip and ventral edge of gill covers with pigment, occasionally under eyes, midventral line of melanophores evident until late in this interval, lateral band of pigment broadened and prominent late in this stage.[10]

ADULTS

Fin rays: caudal 19;* dorsal 8 (7 to 9), anal 12 to 14 (8 to 19), pectoral 16 or 17 (16 to 18), pelvic 9 (8 to 9).[2]

Vertebrae: 37 to 39 (including Weberian vertebrae).[2]

Lateral line scales: 44 to 54.[2]

Pharyngeal teeth: 0,5-5,0.[2]

Diagnostic characters: fleshy keel posterior to pelvic fins lacking scales, lateral line strongly decurved, following ventral line of body, anal fin rays 12 or 13.

LITERATURE CITED

1. Hubbs and Lagler (1958)
2. Scott and Crossman (1973)
3. Becker (1976)
4. Hubbs and Cooper (1935)
5. Dobie et al. (1956)
6. North Carolina Wildlife Resources Commission (1962)
7. Schwartz (1963)
8. Cooper (1935)
9. Forbes and Richardson (1909)
10. Snyder et al. (1977)
11. Lippson and Moran (1974)
12. Smith (1979)
13. Adams and Hankinson (1928)
14. Buynak and Mohr (1980b)
15. Kramer and Smith (1960)
16. Chew (1974)
17. Loos et al. (1979)

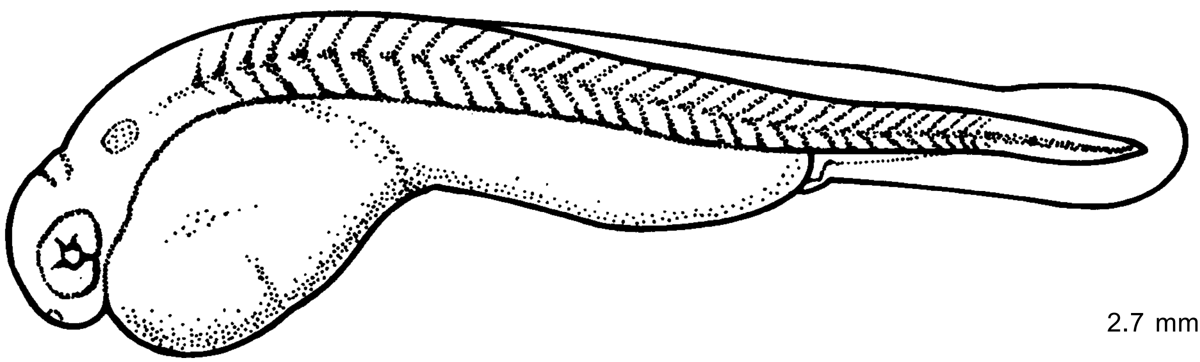


Fig. 79. Notemigonus crysoleucas, golden shiner. Yolk-sac larva. (Laboratory-reared, Pennsylvania, Snyder et al. 1977).

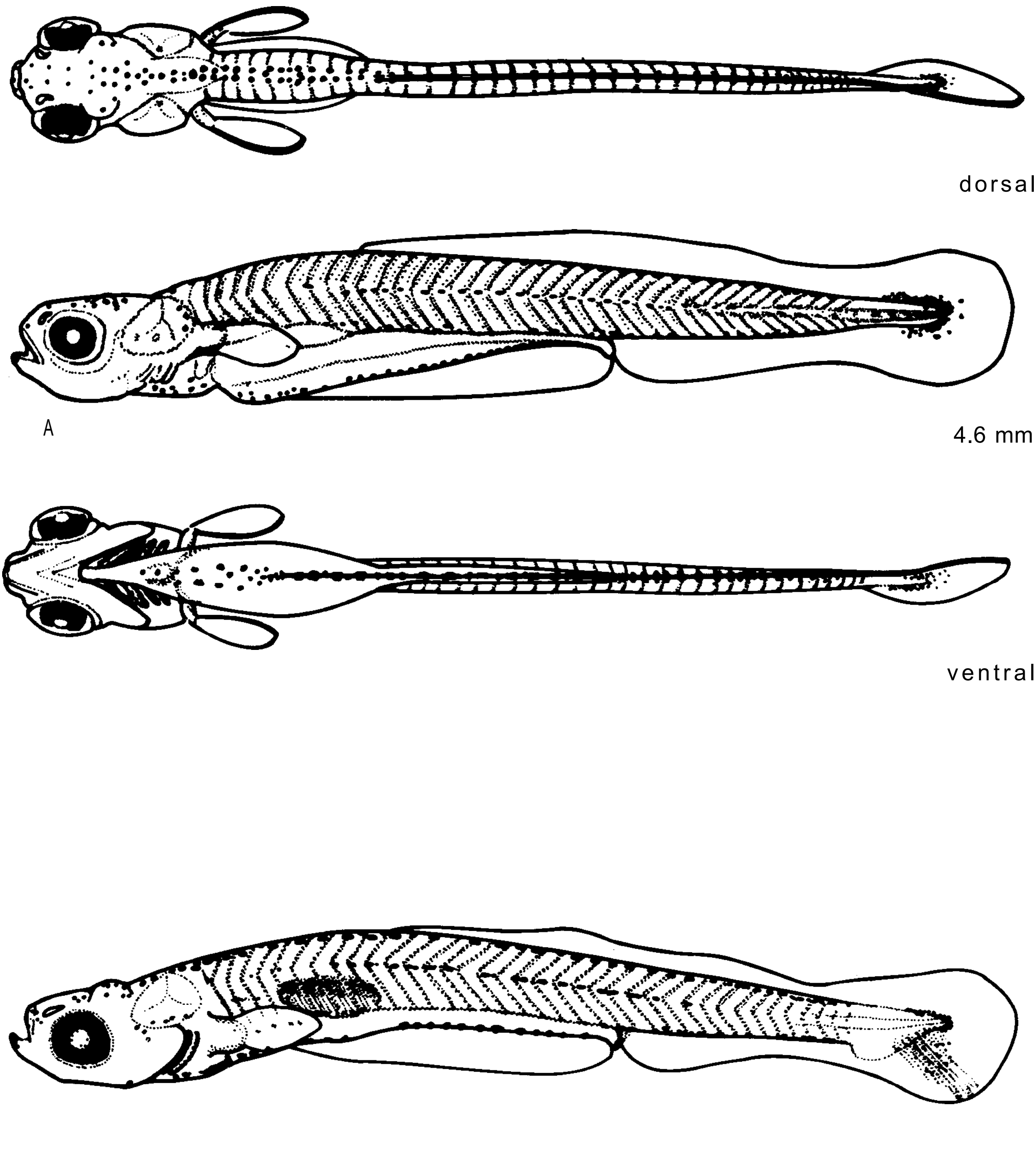


Fig. 80. Notemigonus crysoleucas, golden shiner. A. Yolk-sac larva. B. Larva. (A and B, laboratory-reared, Pennsylvania, Snyder et al. 1977).

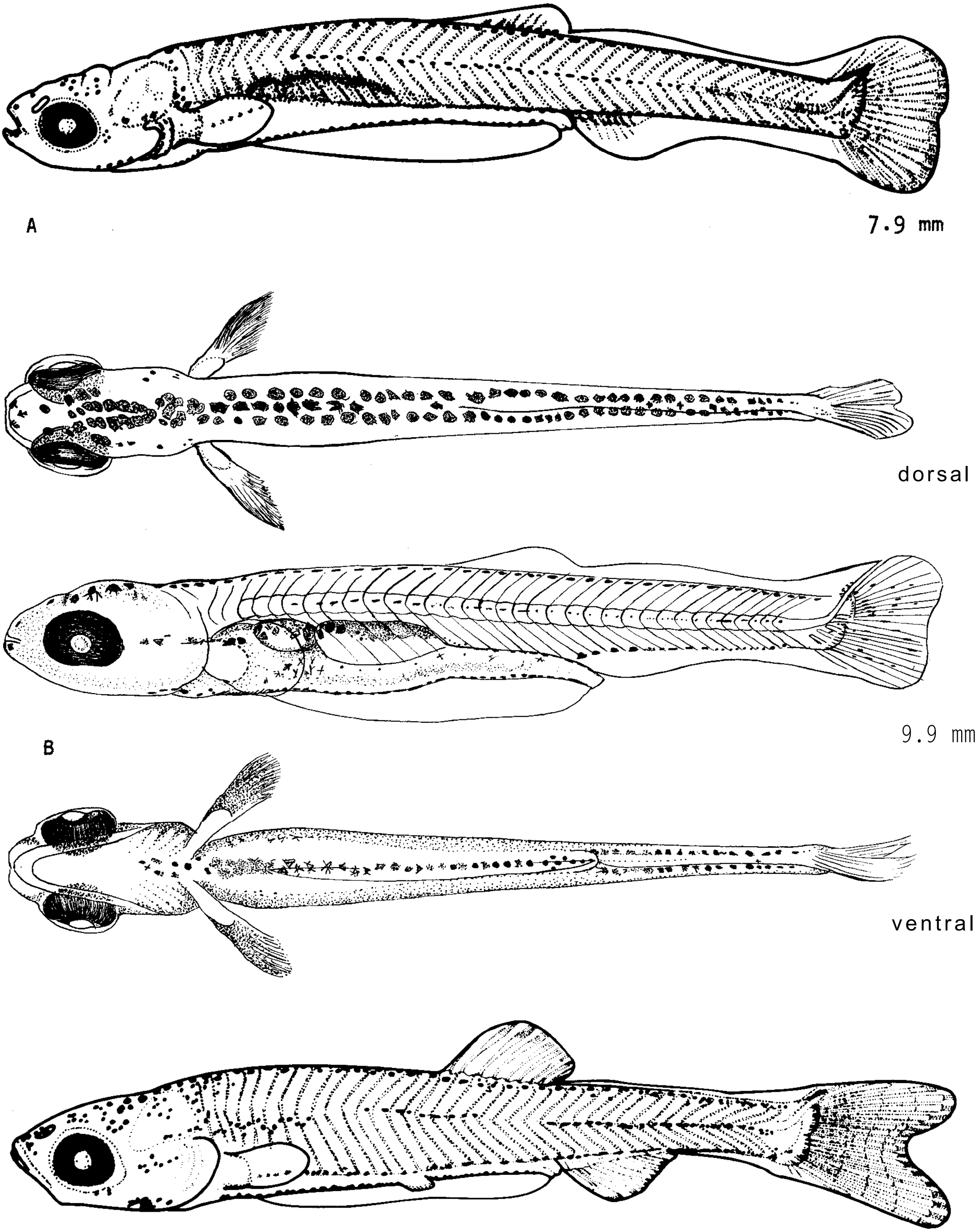


Fig. 81. Notemigonus crysoleucas, golden shiner. A-C. Larvae. (A and C, laboratory-reared, Pennsylvania, Snyder et al. 1977; B, laboratory-reared, Maryland, Loos et al. 1979).

Notemigonus crysoleucas

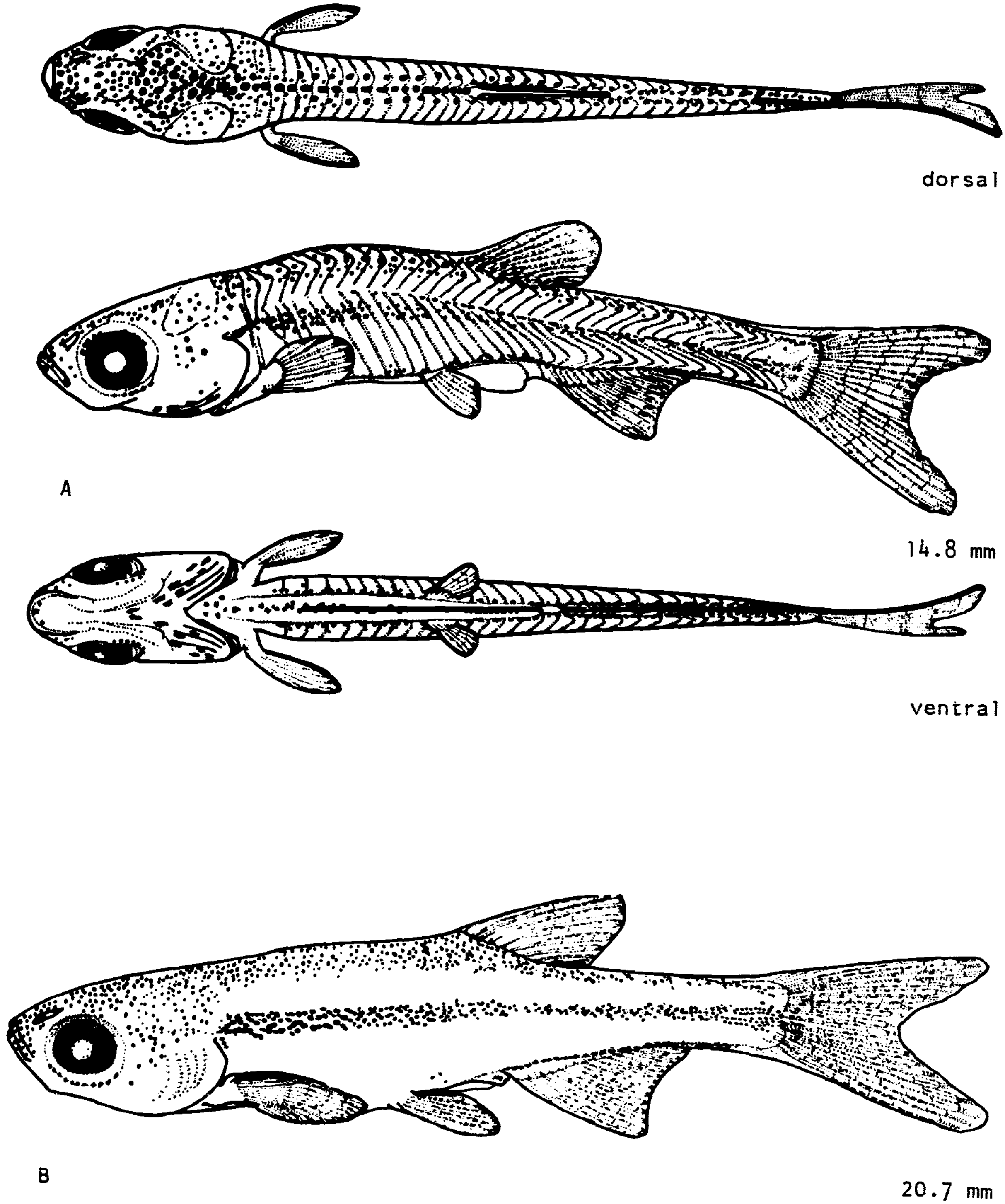


Fig. 82. Notemigonus crysoleucas, golden shiner. A and B. Larvae. (A and B, laboratory-reared, Pennsylvania, Snyder et al. 1977).

Notropis anogenus Forbes, pugnose shiner

DISTRIBUTION

Occurs sporadically throughout the drainages of Lakes Michigan, Huron, Erie and Ontario.’ This species has been recorded at approximately 25 disjunct localities in the Lake Michigan drainage.’

SPAWNING SEASON

Ripe females were found in early May and early June in Illinois.[3]

SPAWNING TEMPERATURE

Not reported.

SPAWNING HABITAT

Inhabits very clear water of glacial lakes and low gradient streams containing profuse vegetation.’ No specific spawning habitat has been reported.*

SPAWNING SUBSTRATE

Not reported.

FECUNDITY

Not reported.

EGGS

Not described.

YOLK-SAC LARVAE

Not described.

LARVAE

Not described.

JUVENILES

Not described.

ADULTS

Fin rays: caudal 19;* dorsal 8 (7 to 8), anal 8 (7 to 8), pectoral 12 (11 to 13), pelvic 8 (7 to 8) .[5]

Vertebrae: 32 to 36 (including Weberian vertebrae).[5]

Lateral line scales: 34 to 38.5

Pharyngeal teeth: 0,4-4,0.[5]

Diagnostic characters: mouth very small, almost vertical, upper jaw extending only to vertical through nostril, lateral line complete, or nearly so, peritoneum black, lateral band usual 1 y dark and obvious, continuing forward through eye or onto snout.

LITERATURE CITED

1. Hubbs and Lagler (1958)
2. Becker (1976)
3. Forbes and Richardson (1909)
4. Trautman (1957)
5. Scott and Crossman (1973)

Notropis atherinoides Rafinesque, emerald shiner

DISTRIBUTION

Common throughout all of the Great Lakes.[1,2] In Lake Michigan it is found in the shoal waters and lower portions of tributaries,[3]

SPAWNING SEASON

Spawning occurs from early April to mid-August in the Great Lakes.'

SPAWNING TEMPERATURE

Begins spawning at 22 C.[4]

SPAWNING HABITAT

Spawns in nearshore areas of large lakes at depths averaging 3 m.[4]

SPAWNING SUBSTRATE

Spawns over hard sand and mud which has been swept free of detritus.'

FECUNDITY

888 to 5,443.'

EGGS

Diameter 3.0 to 3.3 mm, yolk diameter 0.8 to 1.0 mm;[4] perivitelline space large;[5] yolk and embryo colorless;' star-shaped micropyle, incubation period: 24 to 36 hours at approximately 25 C.[5]

YOLK-SAC LARVAE

Total length	Description
4-5 mm	Hatching length: ca. 4.0 mm.[4] Myomeres: 35 to 41[6,8] (23 to 26 + 10 to 15).[6,7,8] Morphometry: (as % TL) preanal length 67, greatest body depth 13, body depth at anus 12, head length 14, (as % head length) eye diameter 31, snout length 11.[6] Morphology: body and yolk sac elongate,'[6] head deflected over anterior portion of yolk, median finfold highest between eighth and tenth myomeres, auditory vesicle conspicuous containing two small otoliths, gill arches and pectoral buds not evident (ca. 4.0 mm), median finfold origin over myomere 12 or 13;[4] mouth inferior (4.9 mm) ;[6] yolk reduced, mouth opening visible (5.0 mm) ;[4] pectoral buds small;[6] near posterior margin of auditory vesicle, median finfold elevated just anterior to anus, gut straight.' Pigmentation: none evident.*

LARVAE

Total length	Description
6 mm	Morphometry: (as % TL) standard length 97, preanal length 66, greatest body depth 13, body depth at anus 9, head length 15, (as % head length) eye diameter 36, snout length 17.[6] Morphology: mouth small, terminal, notochord slightly flexed (6.1 mm).[6] Pigmentation: eye black, underside of intestine with nine to ten inconspicuous chromatophores at wide intervals and along postanal midventral ridge, line of melanophores on dorsum of intestine at anus (6.1 mm).[6]
9 mm	Morphometry: (as % TL) standard length 93, preanal length 62, greatest body depth 11, eye diameter 4.[6] Morphology: snout more pointed than larvae in 6-mm stage, body long, slender, strongly compressed, lacking elevation on back, mouth very oblique, upper lip on level with upper part of pupil, eye large, lateral line decurved, dorsal fin location indicated by opaqueness in finfold near myomere 17 (8.9 mm).[6] Pigmentation: about 12 large melanophores on top of head, melanophores over dorsum of intestine and swim bladder less obvious, melanophores on venter of intestine (in 6-mm stage) absent, except one large melanophore near anus, ventral line of melanophores follows notochord upward posteriorly;[6] double postanal ventral series of melanophores, merging at base of caudal fin to form a "V," midlateral row of melanophores evident (ca. 9.0 mm).[7]
10-12 mm	Morphometry: (as % TL) standard length 90, preanal length 64, head length 19, greatest body depth 16, body depth at anus 9, '(as % head length) eye diameter 35, snout length 22.[6] Morphology: dorsal fin with eight partially formed rays its origin at about myomere 16, median finfold persisting posterior to dorsal fin, caudal fin rays formed, distal margin emarginate;[6] anal fin ray anlagen present (12 mm).[7] Pigmentation: chromatophores on snout and caudal fin, subsurface chromatophores in gill and isthmus region, on dorsum of single-chambered swim bladder, along dorsum of notochord and at end of body forming caudal spot.[6]
14 mm	Morphometry: (as % TL) standard length 85, preanal length 59, head length 22, greatest body depth 15, body depth at anus 11, (as % head length) eye diameter 27, snout length 35.[6]

Morphology: dorsal and anal fins complete, minute amount of finfold persists posterior to dorsal fin, preanal finfold persists, pelvic buds apparent and situated about four myomeres before dorsal fin origin, caudal fin deeply forked, body elongate, snout pointed, eye large, mouth terminal and oblique reaching the anterior margin of the eye (13.5 mm) .[6]

Pigmentation: dorsum of head with many chromatophores posteriorly, forming an irregular double series to caudal fin, most prominent at base of dorsal fin and near caudal fin, chromatophores on jaws, single series of melanophores on midlateral myoseptum, few chromatophores on cheek and lateral aspect of gut before pelvic fins, about ten chromatophores at wide intervals in *a* series on the preanal ventral midline, subsurface melanophores on brain, gills, isthmus, swim bladder, over dorsum of notochord and forming a subsurface caudal spot, al1 fins colorless, except caudal fin (13.5 mm) .[6]

JUVENILES

Total length	Description
15 mm	Myomeres: 39 (25 + 14) .* Morphology: all fin rays formed, dorsal fin origin at myomere 17, pelvic fin origin at about myomere 14 (14.7 mm) . *
25-30 mm	Squamation complete.'

ADULTS

Fin rays: caudal 19;* dorsal 8 (7 to 8), anal 11 (10 to 13), pectoral 15 (13 to 17), pelvic 8 (8 to 9) .[1]

Vertebrae: 39 to 40 (38 to 41) (including Weberian vertebrae).'

Lateral line scales: 38 to 43.[1]

Pharyngeal teeth: 2,4-4,2.[1]

Diagnostic characters: snout blunt, its length less than two-thirds distance from posterior margin of eye to posterior margin of gill cover, pigmentation on sides terminating above lateral line, no black spot at base of dorsal fin.

LITERATURE CITED

1. Scott and Crossman (1973)
2. Hubbs and Lagler (1958)
3. Becker (1976)
4. Flittner (1964)
5. Loos and Fuiman (1978)
6. Fish (1932)
7. Hogue et al. (1976)
8. Snyder (1979a)

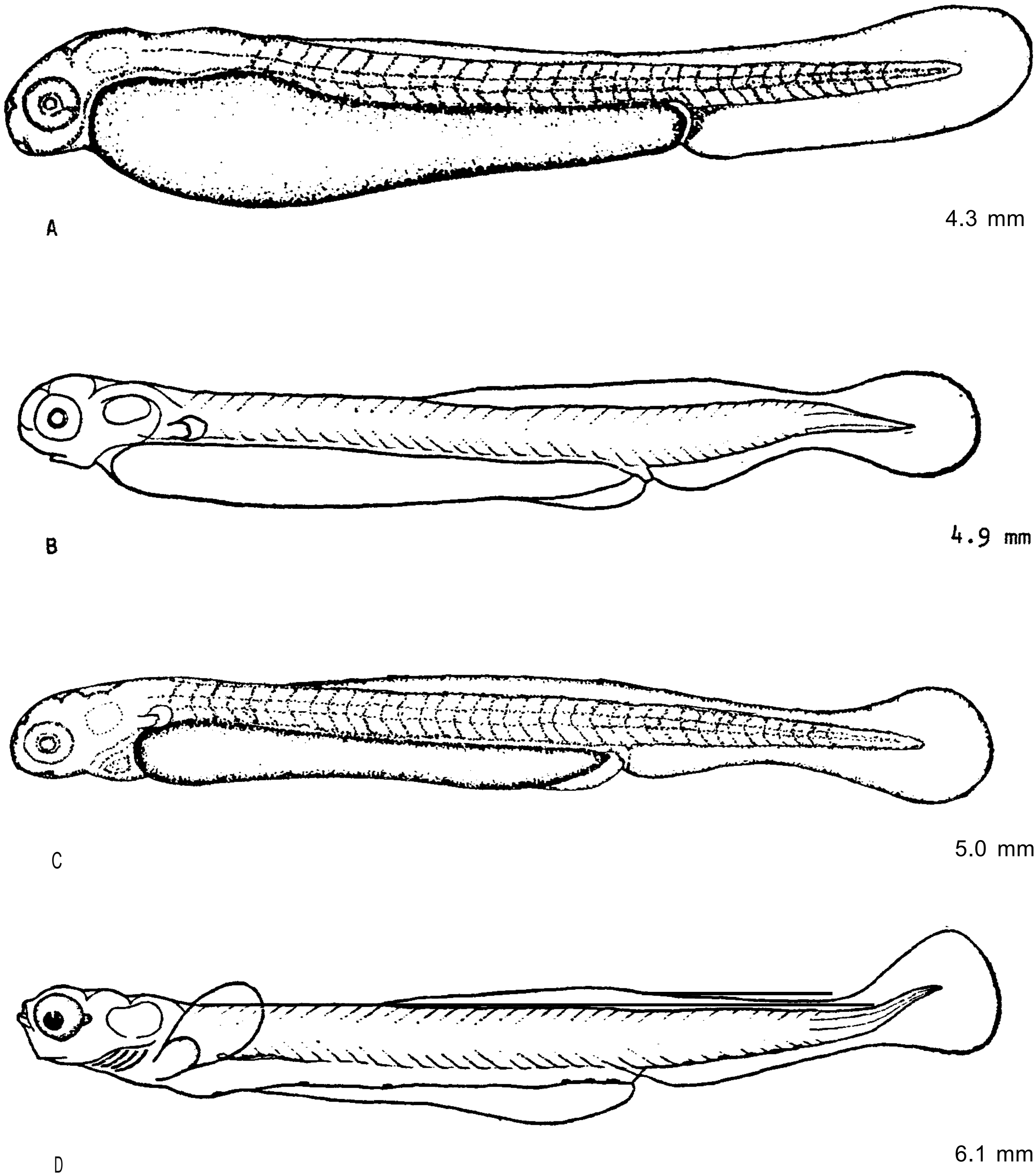


Fig. 83. Notropis atherinoides, emerald shiner. A-C. Yolk-sac larvae. D. Larva. (A and C, laboratory-reared, Lake Erie, Flittner 1964; B and D, wild-caught, Lake Erie, Fish 1932).

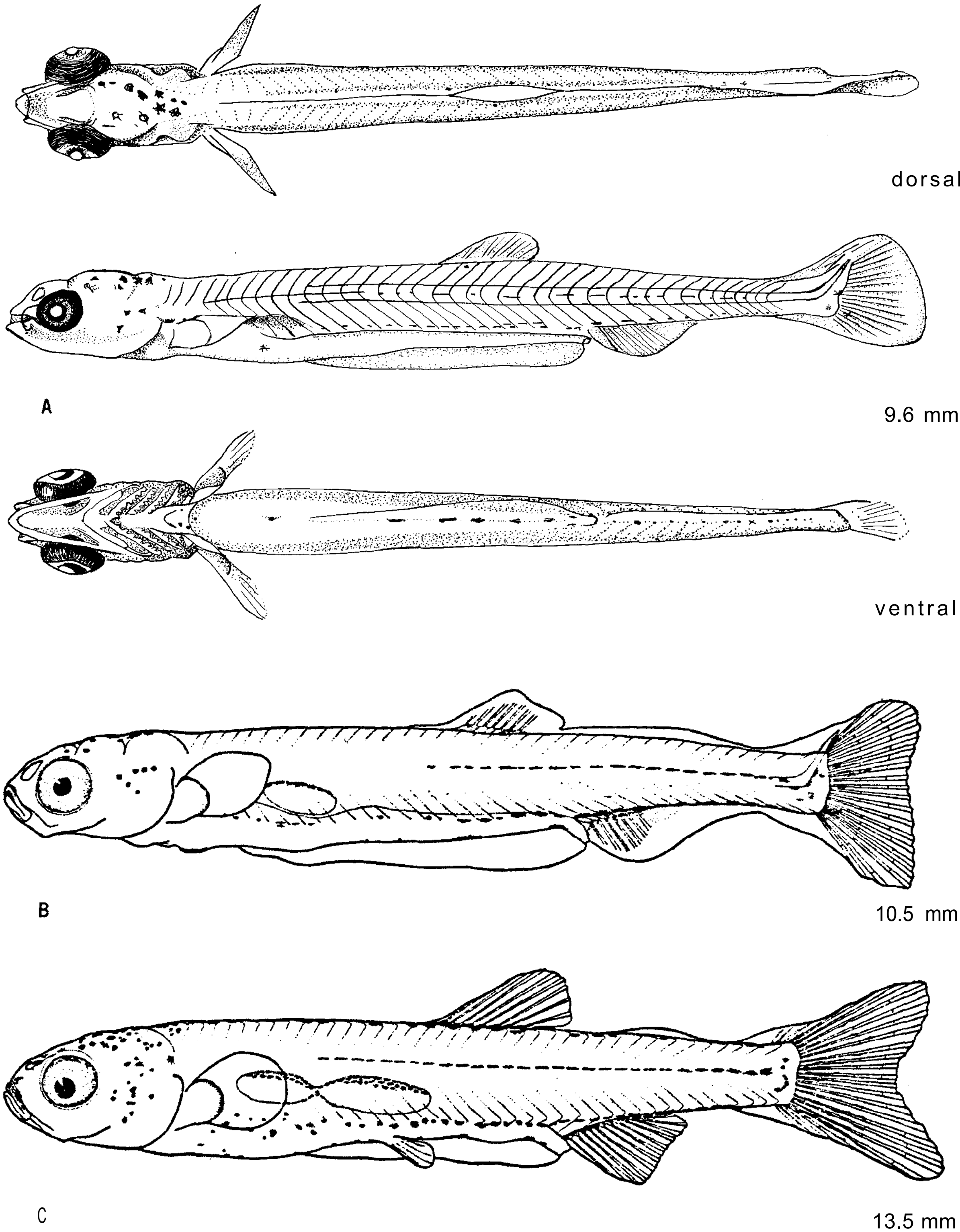


Fig. 84. Notropis atherinoides, emerald shiner. A-C. Larvae. (A, wild-caught, Lake Erie, Loos and Fuiman 1978; B and C, wild-caught, Lake Erie, Fish 1932).

Notropis blennius (Girard), river shiner

DISTRIBUTION

In the Great Lakes basin, the river shiner is known only from Lake Winnebago'[2] where it is well established.[2]

SPAWNING SEASON

Spawns throughout the summer until late August in Ohio.' Spawns in late July and August in Iowa.[3]

SPAWNING TEMPERATURE

Not reported.

SPAWNING HABITAT

Spawns in rivers or streams.'

SPAWNING SUBSTRATE

Deposits eggs over sand and gravel.'[5]

FECUNDITY

Not reported.

EGGS

Not described.

YOLK-SAC LARVAE

Not described.

LARVAE

Not described, but illustrated.[7]

JUVENILES

Not described.

ADULTS

Fin rays: caudal 19;* dorsal 8 (7 to 8), anal 7, pectoral 14 (13 to 15), pelvic 8.[6]

Vertebrae: 36 to 37 (including Weberian vertebrae).[6]

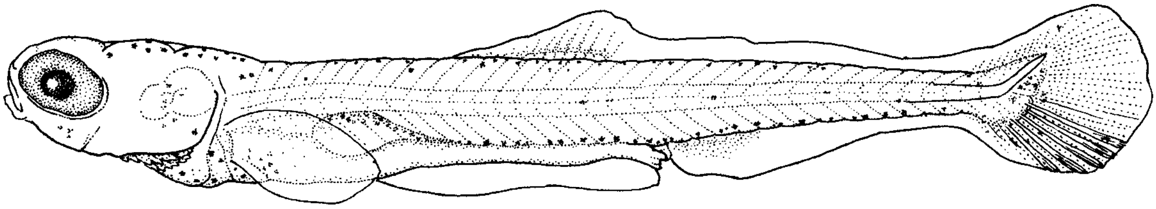
Lateral line scales: 34 to 37;[5] or 38 to 45.6

Pharyngeal teeth: 2,4-4,2.[6]

Diagnostic characters: no black spot at caudal fin base, anal fin rays seven, lateral band indistinct or absent, sometimes diffuse posteriorly, body somewhat compressed and deep, mouth subterminal.

LITERATURE CITED

1. Hubbs and Lagler (1958)
2. Becker (1976)
3. Starrett (1951)
4. Trautman (1957)
5. Smith (1979)
6. Scott and Crossman (1973)
7. Conner et al. (1980)



6.1 mm

Fig. 85. Notropis blennius, river shiner. Larva. (Wild-caught, Louisiana, Conner et al. 1980).

Notropis chalybaeus (Cope), ironcolor shiner

DISTRIBUTION

In the Great Lakes basin, restricted to the Lake Michigan drainage.’ It has been reported in the St. Joseph River system, Michigan,[2] as well as the Fox River and Blake Creek, Wisconsin.’

SPAWNING SEASON

Spawns from April to September in Florida.* Females were distended with eggs in June and July in Illinois[6] and late spring in Maryland.’

SPAWNING TEMPERATURE

Spawns at ca. 16 C.[4]

SPAWNING HABITAT

Spawns in clear, well vegetated creeks with sand bottoms, in swamp areas[6] and larger rivers.[3]

SPAWNING SUBSTRATE

Eggs are randomly broadcast over a sand bottom.’

FECUNDITY

ca. 50 eggs stripped from a single female.’

EGGS

Demersal, adhesive, pale-cream colored, incubation period: 52 to 56 hours at 17 C.[4]

YOLK-SAC LARVAE

Total length	Description
2.3 mm	Newly hatched.’ Morphometry: (as % TL) standard length 98, preanal length greatest body depth 35, head length 19, (as % head length) eye diameter 36, head width 100.’ Morphology: large amount of yolk, head curved over yolk sac, myomeres indistinct, pectoral buds absent.[4] Pigmentation: eye and body unpigmented.’
3 mm	Morphometry: (as % TL) standard length 97, preanal length 69, greatest body depth 21, head length 19, (as % head length) eye diameter 27, head width 73.[4] Morphology: yolk much reduced, eyes undeveloped (3.2 mm).[4]

3-4 mm — Morphometry: (as % TL) standard length 94 to 95, preanal length 59 to 63, greatest body depth 14 to 17, head length 15 to 16, (as % head length) eye diameter 40 to 47, head width 80 to 83.[4]
Morphology: yolk sac cylindrical, pectoral buds evident (3.9 mm) I 4
Pigmentation: melanophores on middorsum and postanal region, few anterior to anus, little pigment in eye (3.9 mm).[4]

LARVAE

Total length	Description
4-9 mm	Morphometry: (as % TL) standard length 80 to 95, preanal length 54 to 62, greatest body depth 12 to 16, head length 15 to 21, (as % head length) eye diameter 33 to 60, head width 78 to 120.[4] Morphology: head free from yolk sac, mouth functional, swim bladder evident, median finfold slightly constricted at caudal peduncle (4.3 mm), body elongate (4.6 mm), notochord flexed, first caudal fin rays evident (5.7 mm), finfold nearly absorbed, position of dorsal fin evident, mouth position as in adult (7.0 mm), dorsal and anal fins differentiated, pelvic buds apparent, caudal fin forked (9.2 mm).[4] Pigmentation: melanophores over most of dorsal and ventral surfaces except fins (4.3 mm), concentration of melanophores covering posterior end of notochord (6.2 mm);[4] intense concentration of melanophores on caudal fin rays below flexed notochord (7.0 mm);[5] midlateral line of melanophores from head to caudal fin spot (9.2 mm).[4]

JUVENILES

Total length	Description
15-16 mm	Morphometry: (as % TL) standard length 78, preanal length 49, greatest body depth 15, head length 19, (as % head length) eye diameter 46, head width 79.' Morphology: fins complete or nearly so (14.8 mm), appearance much like adult, scales not formed.' Pigmentation: midlateral band from base of caudal fin through eye and onto snout wider and more dense, concentration of melanophores at base of anal fin and on venter of caudal peduncle, dense patch of melanophores on dorsum of head (16 mm).[8]

ADULTS

Fin rays: caudal 19, dorsal 8;* anal 8[6] * (7 to 9);[9] pectoral 13 to 15, pelvic 8.*

Vertebrae: not reported.

Lateral line scales: 32 to 36.[9]

Pharyngeal teeth: 2,4-4,2.[6]

Diagnostic characters: roof of mouth heavily pigmented, breast unscaled, lateral line poorly developed and incomplete, chin with some pigment, mouth almost terminal, sharply oblique, anal fin rays modally eight, last three or four anal fin rays like preceding rays, scales below black lateral band not outlined with melanophores.

LITERATURE CITED

1. Hubbs and Lagler (1958)
2. Becker (1976)
3. Johnson and Becker (1970)
4. Marshall (1947)
5. Loos and Fuiman (1978)
6. Smith (1979)
7. Schwartz (1963)
8. Fowler (1945)
9. Pflieger (1975)

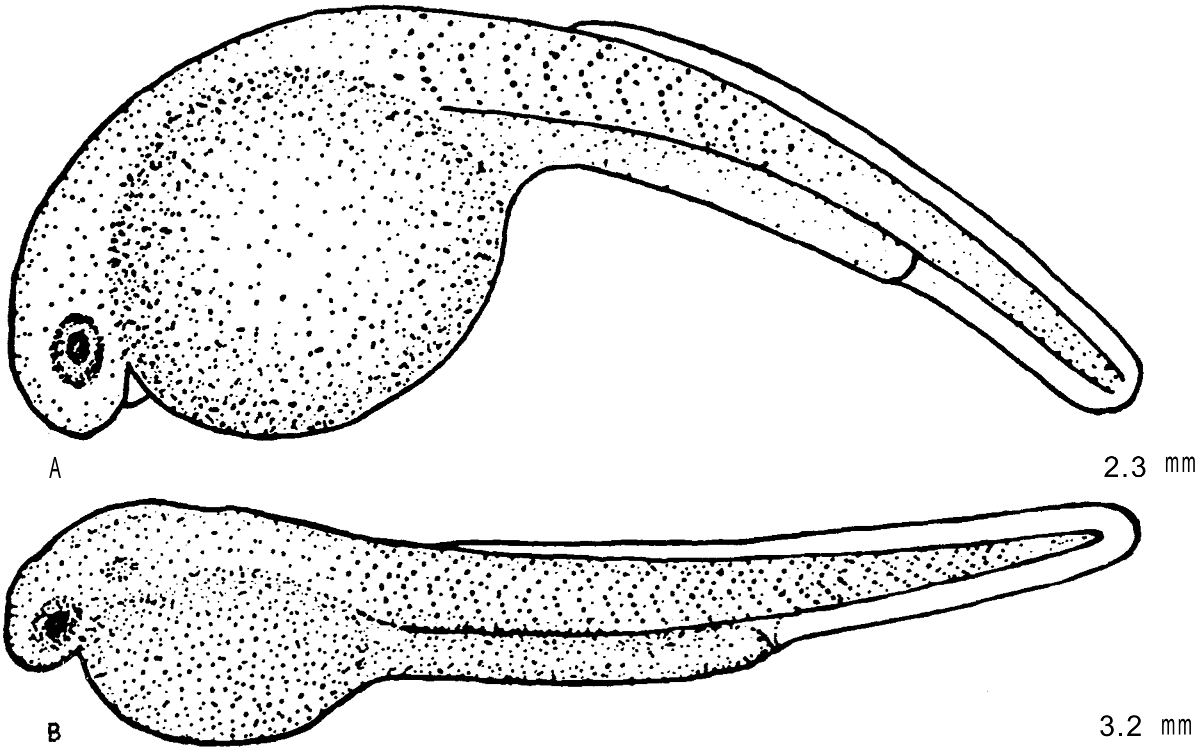


Fig. 86. <u>Notropis chalybaeus</u>, ironcolor shiner. A and B. Yolk-sac larvae. (A and B, laboratory-reared, Florida, Marshall 1947).

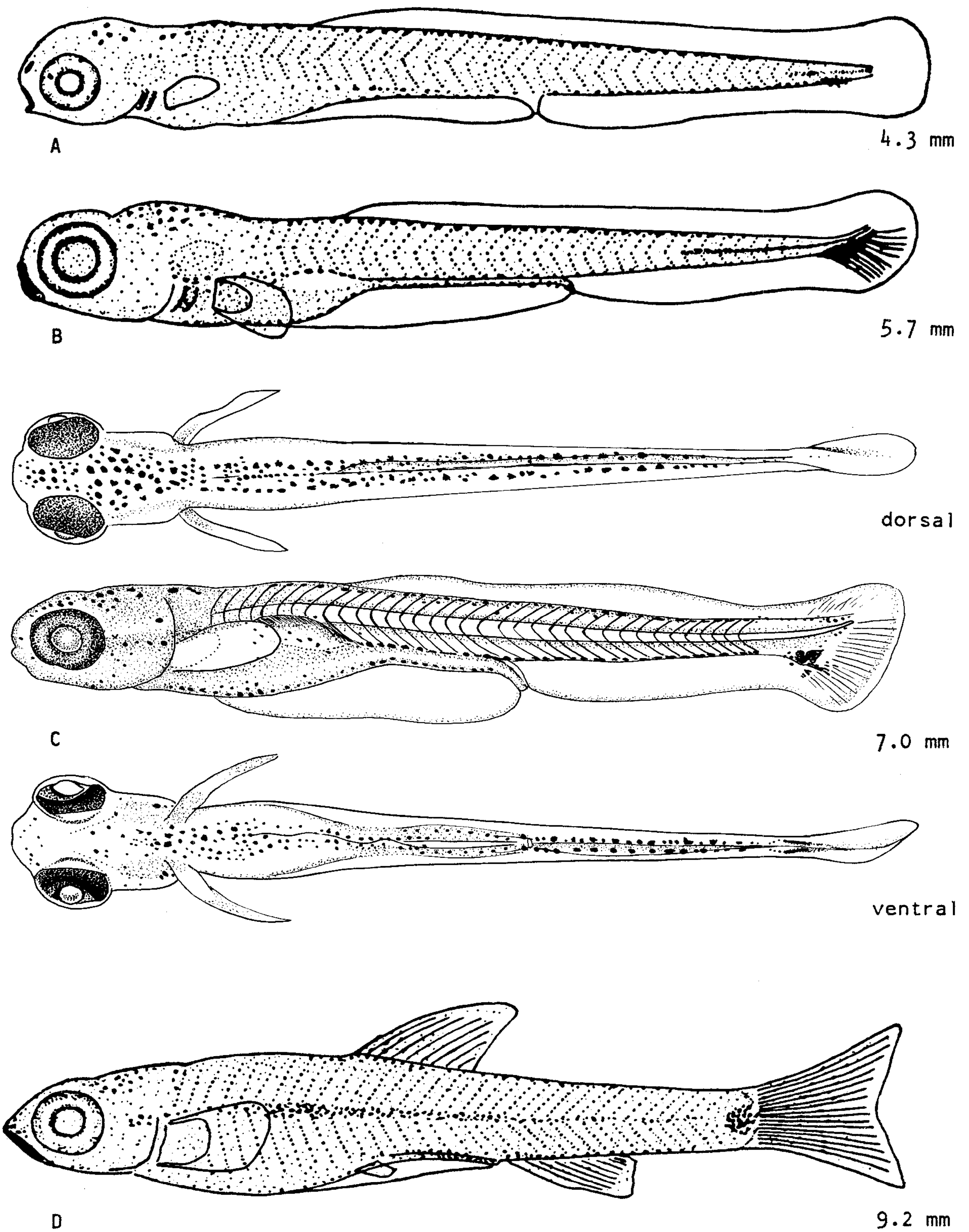


Fig. 87. Notropis chalybaeus, ironcolor shiner. A-D. Larvae. (A,B and D, laboratory-reared, Florida, Marshall 1947; C, wild-caught, North Carolina, Loos and Fuiman 1978).

Notropis chrysocephalus (Rafinesque), striped shiner

DISTRIBUTION

Occurs in southern parts of the Great Lakes basin, from western New York, Lake Ontario, to southern Wisconsin.[1] In Lake Michigan it occurs in the southern half of the drainage.[2]

SPAWNING SEASON

Spawns from June to mid-July in the Lake Erie drainage,[8] spawns in May and June in Illinois,[4] May in Tennessee[6] and late April to mid-June in Missouri.[7]

SPAWNING TEMPERATURE

Ripe adults were found at 13 C.[6]

SPAWNING HABITAT

Spawns in brooks and smaller streams[3,10] where the gradient is moderate.”

SPAWNING SUBSTRATE

Spawns over a variety of substrates, including gravel,[3,8] boulders, bedrock and sand.[3] Commonly spawns over gravel nests of Nocomis species.[7,10]

FECUNDITY

Not reported.

NATURAL HYBRIDS

Hybognathus nuchalis, Nocomis biguttatus;[12,13] N. micropogon;[3] Notropis cornutus;[5] N. rubellus.[13]

EGGS

Demersal, adhesive, diameter 2.0 to 2.3 mm;[6] oil globule absent;[14] incubation period: 152 to 160 hours at 13 to 15 C.[6]

YOLK-SAC LARVAE

An egg and a 6.9-mm specimen illustrated by Fish (1932) is misidentified.* The oil globule illustrated by her is not found in this species.[14]

Total length	Description
6-8 mm	Hatching length ca. 5.6 to 5.9 mm.[6] Myomeres: (26 to 28 + 12 to 14).[6]

Morphometry: (as % TL) preanal length 63 to 70, head length 16 to 17, greatest body depth 14 to 21, (as % head length) eye diameter 46 to 51, snout length 11 to 12, head depth 74 to 84. 6

Morphology: head deflected over club-shaped yolk sac, gills not developed, otoliths present, median f infold arising from myomere nine, pectoral buds as opaque thickenings on dorso-lateral aspect of yolk sac (new1 y hatched), head free from yolk sac (1 day old), gill arches as three or four tissue folds (2 days old), opercular flaps present, mouth formed and subterminal (7.2 mm), pectoral buds paddle-shaped (> 7.2 mm).[6]

Pigmentation: unpigmented, except eyes (newly hatched) few melanophores widely dispersed over yolk sac (1 day old), several melanophores on either side of heart area form a "V" ventrally, double postanal row of melanophores, head moderately pigmented, double row of melanophores from occiput to caudal fin, two or three chromatophores on finfold in peduncle area and on caudal fin, opercula, otoliths and dorsum of incipient swim bladder pigmented, midlateral row of melanophores from incipient swim bladder to caudal fin, large stellate chromatophores present on lateral and ventral portions of yolk sac (3 days old, 7.2 mm), caudal pigmentation outlines urostyle, in some specimens dorsal and ventral pigment lines continuous around urostyle, snout pigmentation moderate, premaxillae outlined with pigment (7.7 mm), later yolk-sac larvae with diffuse spot on lower caudal fin lobe.[6]

LARVAE

Descriptions of larvae presented by Fish (1932) were exe cluded due to possible misidentification.*

Total length	Description
8-10 mm	Myomeres: (26 to 27 + 12 to 14).[6] Morphometry: (as % TL) preanal length 62 to 63, head length 16 to 19, greatest body depth 13 to 14, (as % head length) eye diameter 42, snout length 11 to 13, head depth 65 to 71.[6] Morphology: yolk absorbed (ca. 7.9 mm), five or six caudal fin rays evident, notochord slight y flexed, swim bladder filled, operculum covers gills, dorsal fin position anlage evident (7.8 mm), apex of dorsal fin over myomere 19 or 20, anal fin anlage apparent (8.2 to 8.6 mm), hypurals, five or six dorsal fin rays and five anal fin rays apparent (8.5 mm), opelrculum extends beyond posterior edge of auditory vesicle (8.8 mm), caudal fin emarginate and 19 fin rays present (9.0 mm).[6]

Pigmentation: double row of melanophores from head to caudal fin, head heavily pigmented, premaxillae outlined by melanophores, dorsum of gut and swim bladder pigmented, internal row of melanophores from dorsum of swim bladder to base of skull, midlateral stripe from back of eye to caudal fin base, arching slightly anteriorly, most prominent between swim bladder and caudal fin, urostyle outlined, pigment increased in lower half of caudal fin, some specimens with three large chromatophores on operculum, nares outlined (8.1 mm), sides of swim bladder pigmented, upper and lower edges of mouth well pigmented, dorsal fin with few chromatophores, "V" pattern of pigmentation evident in branchiostegal region, foregut with characteristic trident-shaped pattern (also found in N. cornutus);* with outer lines extending dorsally and posteriorly to fuse with pigmentation on dorsum of swim bladder and gut (8.9 mm).[6]

10-13 mm

Myomeres: (26 to 27 + 12 to 14).[6]

Morphometry: (as % TL) preanal length 59 to 62, head length 21 to 22, greatest body depth 17 to 18, (as % head length) snout length 16 to 18, head depth 69 to 70, eye diameter 39 to 41, (as % preanal length) predorsal length 72 to 74, body width 17 to 20.[6]

Morphology: pelvic buds apparent (11.3 to 12.2 mm), midgut begins to bend (12 to 13 mm).[6]

Pigmentation: middle extension of trident pattern below swim bladder faded, ventral midline pigment extends the length of gut, gill arches pigmented (12.2 mm), midlateral stripe heaviest on peduncle, head and opercula heavily pigmented, caudal fin rays moderately pigmented, dorsal fin rays pigmented on proximal half, double dorsal row of melanophores with increased pigment within rows.[6]

13-17 mm

Myomeres: (26 to 27 + 12 to 14).[6]

Morphometry: (as % TL) preanal length 51 to 59, head length 22 to 23, greatest body depth 17 to 18, (as % head length) snout length 20 to 21, head depth 69 to 71, eye diameter 37 to 35, predorsal length 73 to 77% preanal length.[6]

JUVENILES

Total length	Description
17-23 mm	Morphometry: (as % TL) preanal length 55 to 57, head length 22 to 23, greatest body depth 20, (as % head length) snout length 19 to 20, head depth 71, eye diameter 36 to 37, (as % preanal length) predorsal length 76 to 78, body width 25.[6]

Morphology: adult complement of fin rays present (17.0 mm, but as early as ca. 14.0 mm), squamation begins (17.2 mm), finfold absorbed (19.0 mm), squamation complete (23.0 mm).[6]

Pigmentation: double row of melanophores present from anus along both sides of anal fin, forming single diffuse line to caudal fin base.[6]

ADULTS

Fin rays: caudal 19;* dorsal 8, anal 9 (8 to 10), pectoral 16 (15 to 17), pelvic 9 (8 to 10).[11]

Vertebrae: 39 (38 to 42) (including Weberian vertebrae).[9]

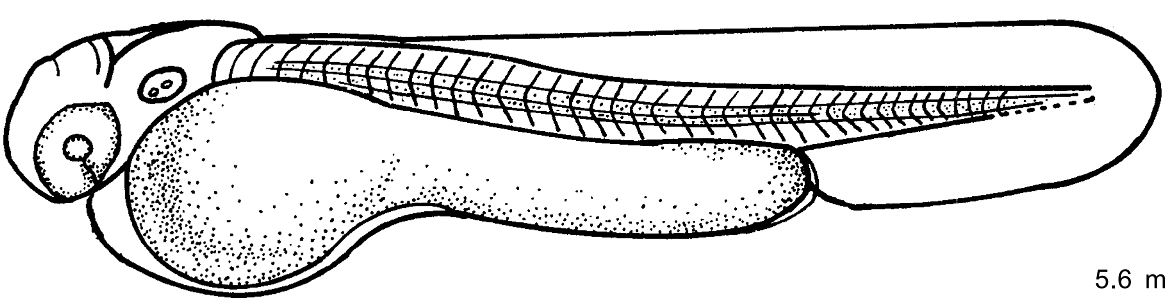
Lateral line scales: 38 to 39 (36 to 42).[9]

Pharyngeal teeth: 2,4-4,2.[11]

Diagnostic characters: predorsal scales less than 17, tip of chin heavily pigmented, numerous parallel dark lines converging at the midback.

LITERATURE CITED

1. Gilbert (1980)
2. Becker (1976)
   Trautman (1957)
4. Smith (1979)
5. Gilbert (1961)
6. Yeager (1978)
7. Pfleiger (1975)
8. Fish (1932)
9. Gilbert (1964)
10. Hankinson (1932)
11. Scott and Crossman (1973)
12. Lute (1933)
13. O'Donnell (1935)
14. Loos and Fuiman (1978)



5.6 mm

Fig. 88. Notropis chrysocephalus, striped shiner. Yolk-sac larva. (Laboratory-reared, Tennessee, Yeager 1979).

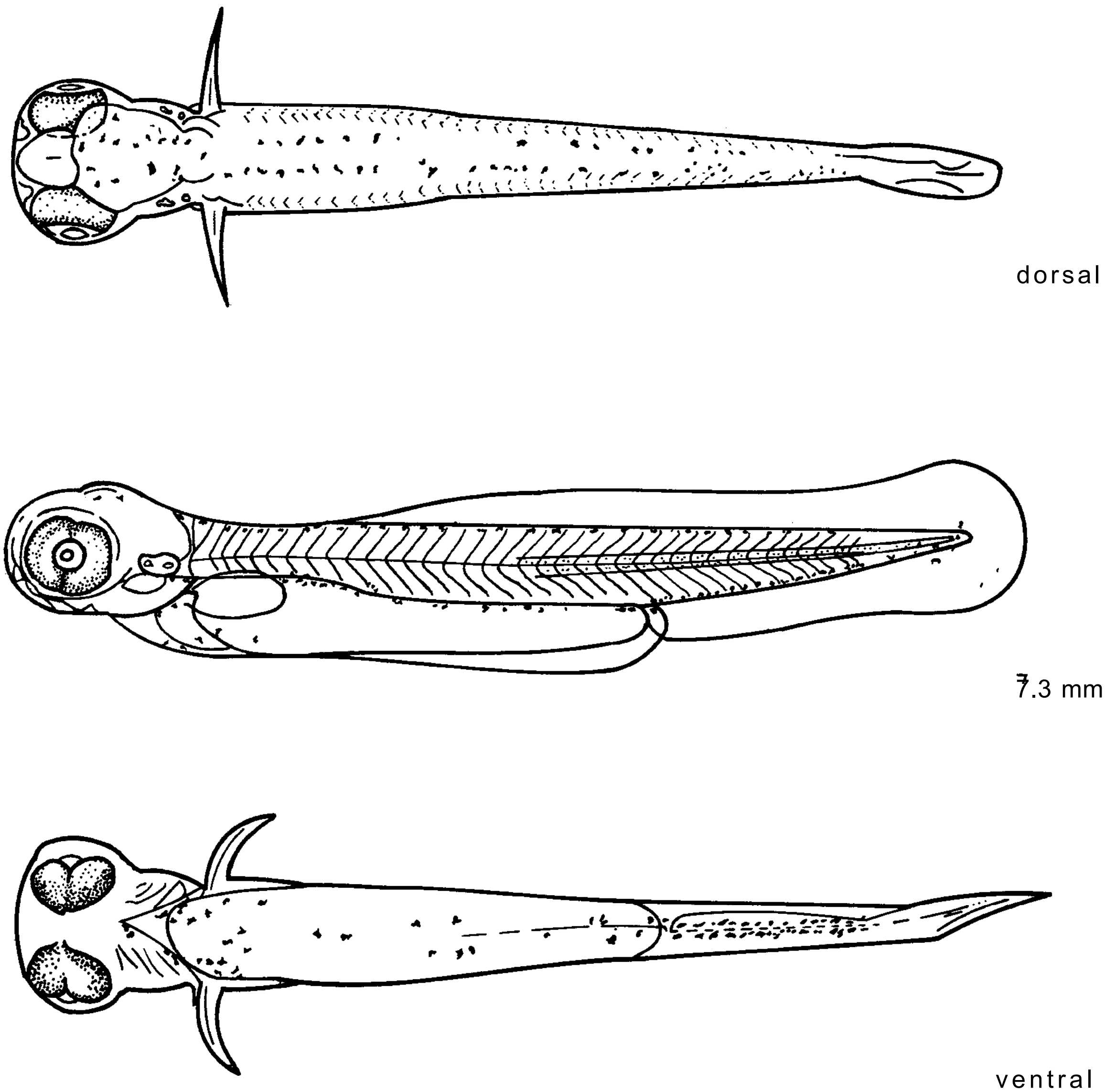


Fig. 89. Notropis chrysocephalus, striped shiner. Yolk-sac larva. (Laboratory-reared, Tennessee, Yeager 1979).

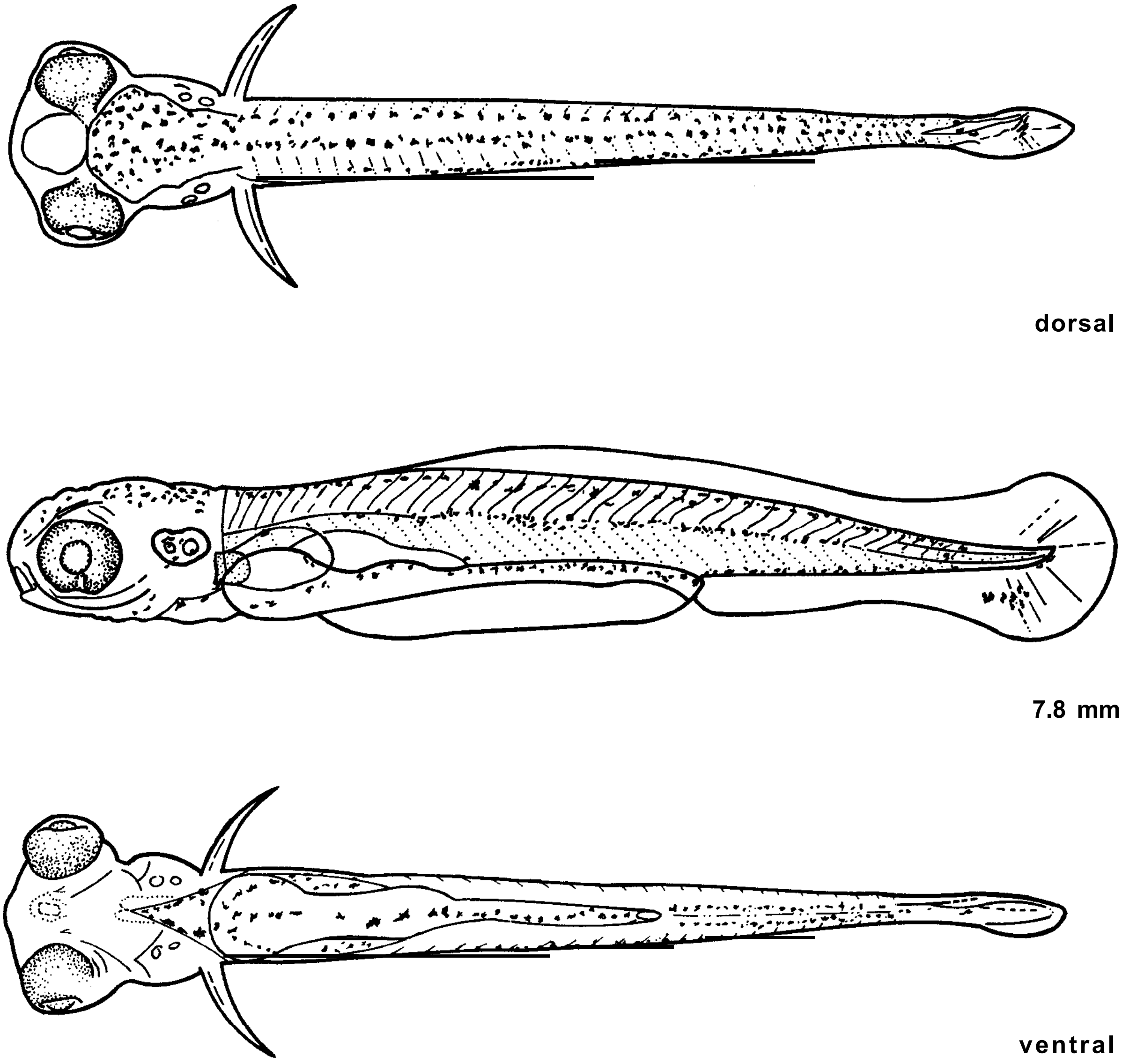


Fig. 90. Notropis chrysocephalus, striped shiner. Larva. (Laboratory-reared, Tennessee, Yeager 1979).

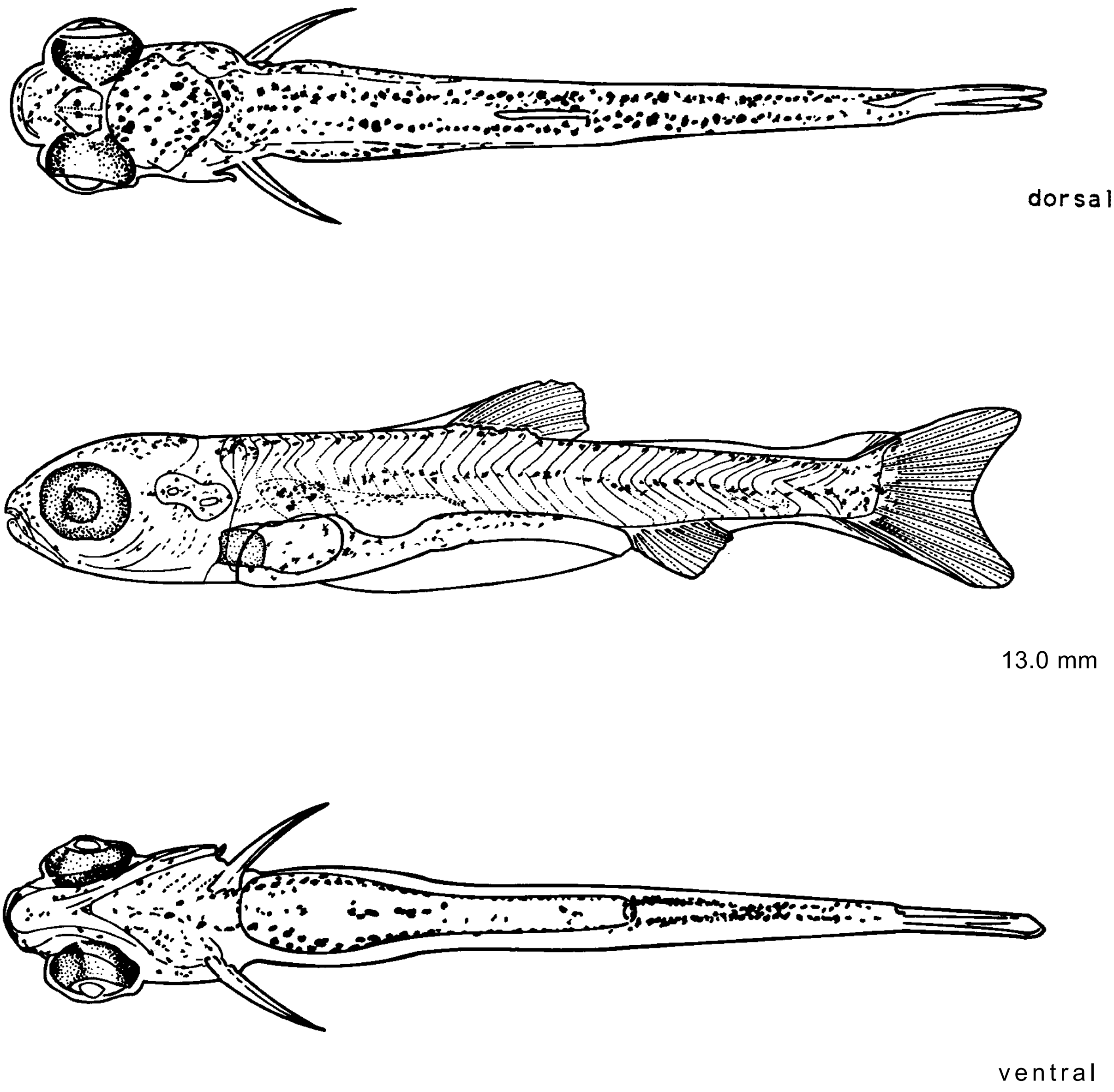


Fig. 91. Notropis chrysocephalus, striped shiner. Larva. (Laboratory-reared, Tennessee, Yeager 1979).

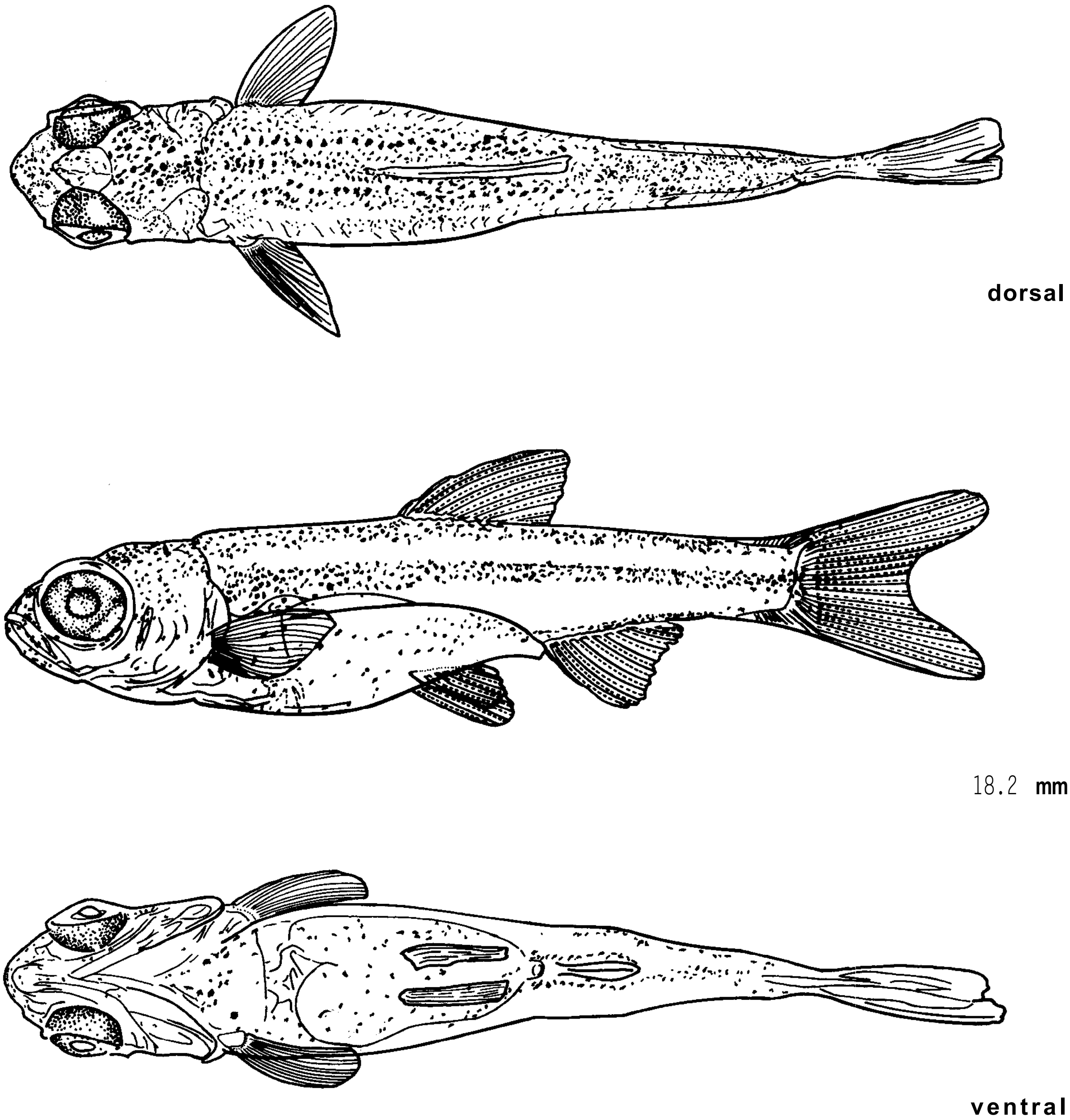


Fig. 92. Notropis chrysocephalus, striped shiner. Juvenile. (Laboratory-reared, Tennessee, Yeager 1979).

Notropis cornutus (Mitchill), common shiner

DISTRIBUTION

Occurs in streams throughout the Great Lakes basin,l and is common throughout the Lake Michigan drainage.'

SPAWNING SEASON

Spawns from late May to June in Michigan[3] and May to July in New York.[4]

SPAWNING TEMPERATURE

Spawns at 15 to 25 C.[3 4 5 6]

SPAWNING HABITAT

Deposits eggs in riffles of streams[4 5] at depths 8 to 20 cm,[1] possibly over shoals in lakes.[3]

SPAWNING SUBSTRATE

Spawns over gravel or rubble where it may excavate depressions[3 5] or use nests built by other cyprinids.'[3 4 5 6 7 13]

FECUNDITY

900 to 1,150.[8]

NATURAL HYBRIDS

Campostoma anomalum;[15] Clinostomus elongatus;[6 19] Nocomis biguttatus;[11 20] N. micropogon;[6] Notropis chrysocephalus;[14] N. rubellus;[16] Phoxinus eos;[14] P. erythrogaster;[16 17] Rhinicthys cataractae;[18] Semotilus atromaculatus.[17]

EGGS

Demersal, adhesive (until water hardened*), sometimes in loose clumps;[5 9] diameter 1.7 to 1.8 mm[9] or 1.5 mm;[5] yolk diameter 1.3 mm.[9]

YOLK-SAC LARVAE

Total length	Description
5-7 mm	Newly hatched ca. 5.0 mm.[9] Myomeres: (25 to 26 + 12 to 14), usually 39 (26 + 13).[10] Morphometry: (as % TL) standard length 95 to 96, preanal length 61 to 65, predorsal length 34 to 38.[10]

Morphology: yolk elongate, notochord straight, swim bladder formed (ca. 5.3 mm), preanal finfold extending to anterior portion of swim bladder (5.3 to 6.8 mm), notochord flexed (6.5 mm).*

Pigmentation: dorsal patch of melanophores over head proceeding posteriorly as two distinct rows (ca. 5.4 mm), midlateral line of melanophores from above swim bladder to caudal peduncle, a few melanophores outline gill arches, three rows of melanophores over abdomen converge at most anterior part of gut near heart (al so in N. chrysocephalus), central row continues to anus;* but sometimes absent;' other two rows diverge and outline ventro-lateral portion of gut for approximately one-half its length, dense patch of melanophores on dorsum of swim bladder, seri es of melanophores on dorsum of gut to anus.*

LARVAE

Total length	Description
7-11 mm	Myomeres: (26 to 27 + 12 to 15), usually 39 (26 + 13).[10] Morphometry: (as % TL) standard length 90 to 95, preanal length 63 to 64, predorsal length 36 to 40.[10] Morphology: hypurals formed, some caudal fin rays evident (8.5 mm), all caudal fin rays formed (9.2 mm), actinotrichia of dorsal fin evident (10.5 mm).* Pigmentation: intensified pigmentation on all aspects, lateral series prominent, double postanal series of melanophores (9.2 mm), scattered pigment on lateral surface of head posterior to eyes;* posterior end of urostyle often outlined with melanophores.[9]
12-15 mm	Myomeres: (25 to 27 + 12 to 14), usually 39 (26 + 13).[10] Morphometry: (as % TL) standard length 85 to 87, preanal length 58 to 61, predorsal length 40 to 43. Morphology: nine anal fin rays present, median finfold reduced, still persistent anterior to anus.* Pigmentation: numerous scattered smaller melanophores between two dorsal rows, lateral series of melanophores prominent, lateral band beginning to form, midventral row of melanophores from heart region to anus.*

JUVENILES

Total length	Description
16 mm	Morphology: al 1 fin rays formed, mouth terminal (15.5 mm).* Pigmentation: broken midventral series of melanophores from heart region to anus, numerous scattered melanophores on sides of head, lateral band well developed, composed of many small chromatophores;* chin unpigmented.[12 18]

ADULTS

Fin rays: caudal 19;* dorsal 8;[11] anal 9 (8 to 1O), pectoral 14 to 17;[1] pelvic 8 to 9.[11]

Vertebrae: 40 to 41 (36 to 42) (including Weberian vertebrae).'

Lateral line scales: 36 to 43.1

Pharyngeal teeth: 2,4-4,2.[10 11]

Diagnostic characters: origin of dorsal fin over or anterior to insertion of pelvic fins, predorsal lateral scales twice as high as wide, anal fin rays usually nine, predorsal scales more than 17, middorsal stripe and one or two paravertebral dark stripes.

LITERATURE CITED

1. Gilbert (1964)
2. Becker (1976)
3. Hubbs and Cooper (1936)
4. Miller (1964)
5. Raney (1940c)
6. Raney (1969b)
7. Hankinson (1932)
8. Ball (1937) in Carlander (1969)
9. Loos and Fuiman (1978)
10. Perry and Menzel (1979)
11. Scott and Crossman (1973)
12. Smith (1979)
13. Reighard (1943)
14. Gilbert (1961)
15. Trautman (1957)
16. Lachner (1952)
17. Cross and Minckley (1960)
18. Bartnik (1970)
19. Koster (1939)
20. Bailey and Allum (1962)

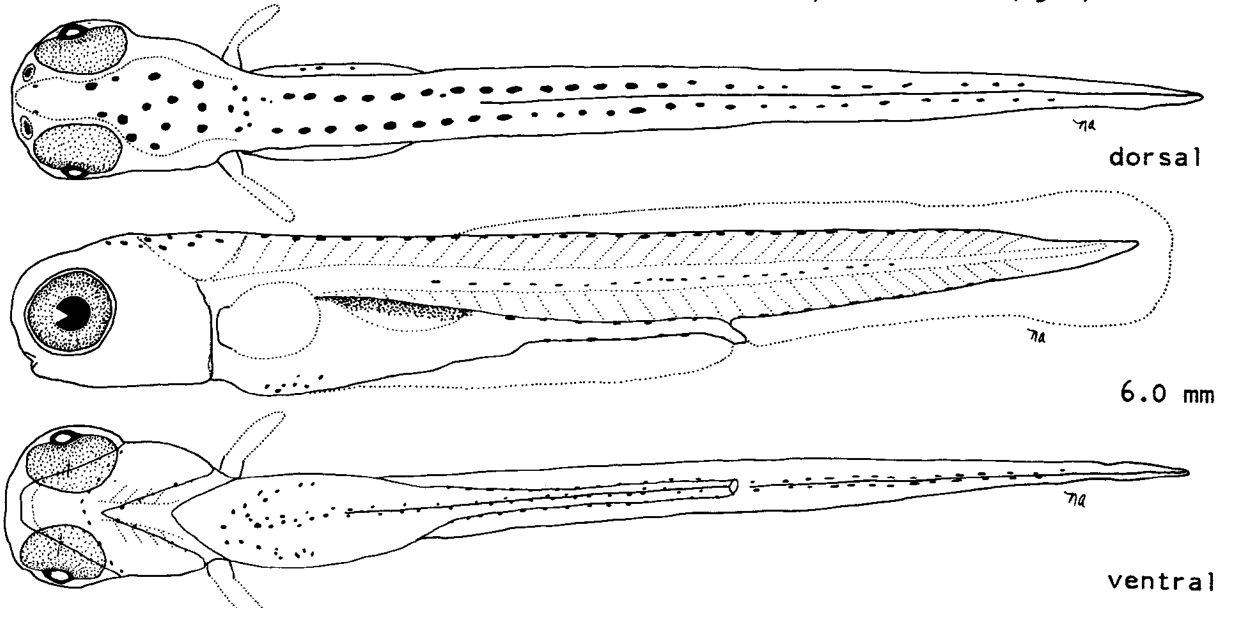
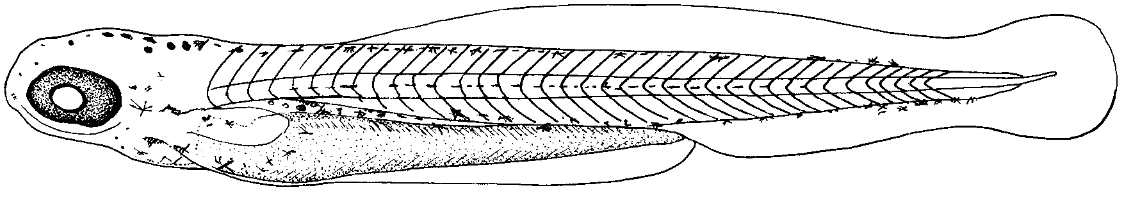
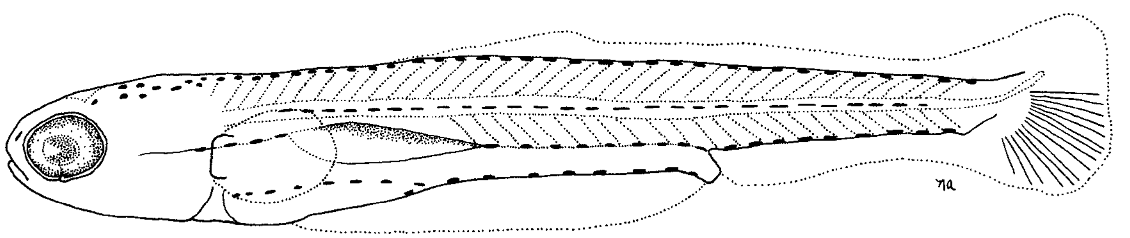


Fig. 93. Notropis cornutus, common shiner. Yolk-sac larva. (Wild-caught, Iowa, original illustrations by N. A. Auer, specimens provided by L. G. Perry).



A

7.2 mm



B

8.4 mm

Fig. 94. Notropis cornutus, common shiner. A and B. Larvae. (A, laboratory-reared, Pennsylvania, Loos and Fuiman 1978; B, wild-caught, Iowa, original illustration by N. A. Auer, specimen provided by L. G. Perry).

Notropis cornutus

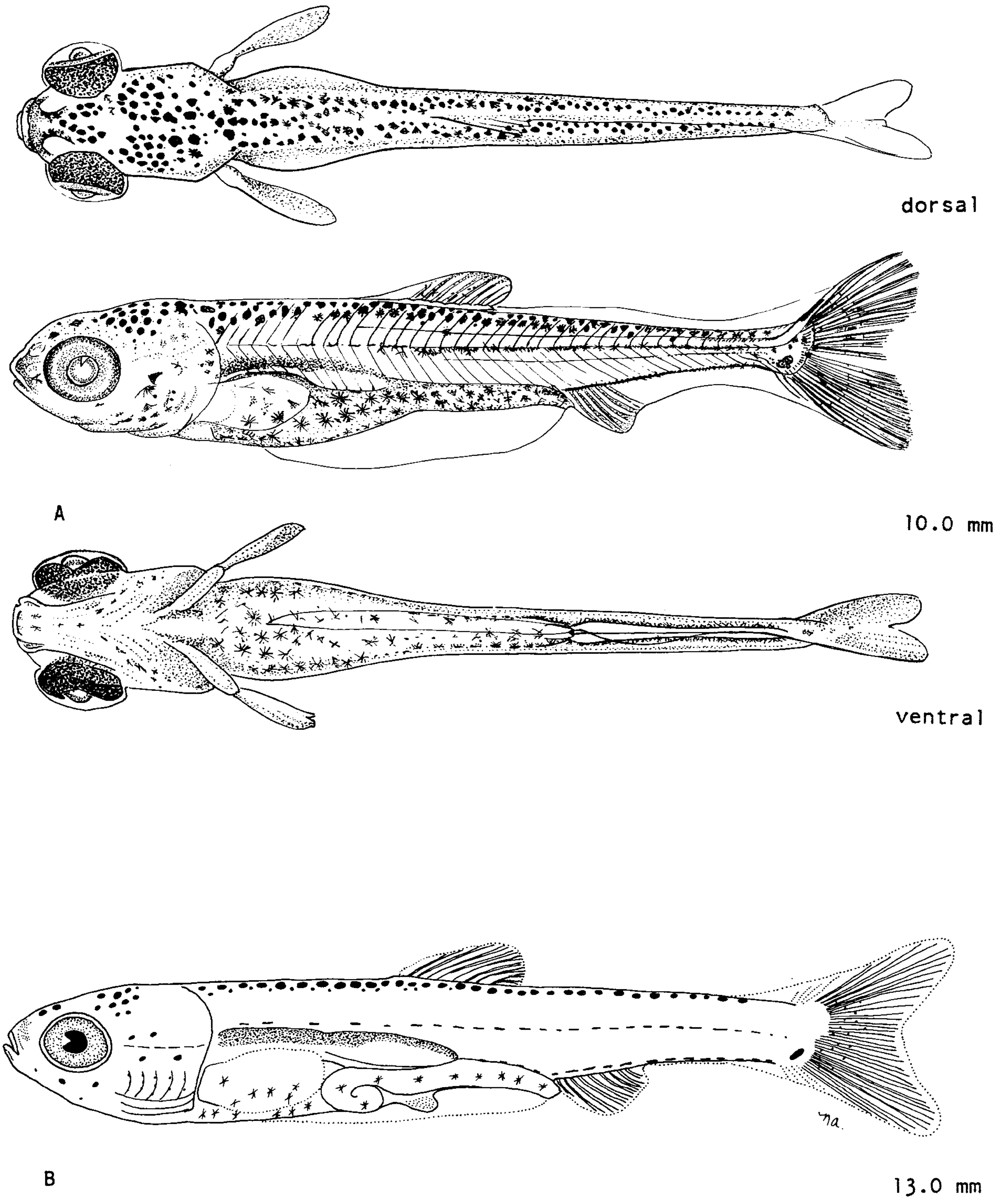


Fig. 95. Notropis cornutus, common shiner. A and B. Larvae. (A, laboratory-reared, Pennsylvania, lateral view: Loos and Fuiman 1978, dorsal and ventral views: original illustrations by M. Fuges, courtesy of J. J. Loos; B, wild-caught, Iowa, original illustration by N. A. Auer, specimen provided by L. G. Perry).

Notropis dorsalis (Agassiz), bigmouth shiner

DISTRIBUTION

This species occurs in scattered populations throughout the Great Lakes region. It occurs in the Genesee River and Oneida Lake, Lake Ontario drainage; Ohio and New York drainages of Lake Erie; and the Keweenaw Peninsula, Lake Superior.' In the Lake Michigan drainage, it is found in the Fox, Manistique, Muskegon, Grand and Kalamazoo River systems of Michigan,[1] as well as the Wolf and Root River systems of Wisconsin.[2]

SPAWNING SEASON

Spawns from May to June in Illinois[5] and mid-July[4] through August in Iowa.[3]

SPAWNING TEMPERATURE

Not reported.

SPAWNING HABITAT

Spawns in creeks and small rivers, occasionally in large rivers (inferred from adult habitat).[5]

SPAWNING SUBSTRATE

Probably spawns over sand and gravel.[6]

FECUNDITY

Not reported.

EGGS

Not described.

YOLK-SAC LARVAE

Total length	Description
4-5 mm	Hatching size: ca. 3.7 mm.[7] Myomeres: (20 to 21 + 13 to 14).[7] Morphometry: (as % TL) standard length 95 to 96, preanal length 59 to 63, predorsal length 38 to 44.[7] Pigmentation: early yolk-sac larvae may lack pigment entirely, melanophores scattered on dorsum of head and body (3.8 mm).[7]

LARVAE

Total length	Description
5-9 mm	Myomeres: (21 to 22 + 12 to 14).[7] Morphometry: (as % TL) standard length 89 to 95, preanal length 59 to 62, predorsal length 40 to 44.[7] Morphology: yolk absorbed (5.0 mm).[7] Pigmentation: entire dorsum densely pigmented, scattered melanophores ventrally between heart region and anus may be diagnostic for this species (ca. 5.0 mm), prominent melanophore in nasal pit, dorsal pigment dense on head, two rows of melanophores on dorsum (6.9 mm).*
10-13 mm	Myomeres: (20 to 21 + 12 to 14).[7] Morphometry: (as % TL) standard length 86 to 89, preanal length 56 to 59, predorsal length 43 to 44.[7]

JUVENILES

Not described.

ADULTS

Fin rays: caudal 19;* dorsal 8, anal 8, pectoral 14 to 15, pelvic 8.[8]

Vertebrae: 34 to 37 (including Weberian vertebrae).[8]

Lateral line scales: 34 to 37.[5]

Pharyngeal teeth: 1,4-4,1.[8]

Diagnostic characters: mouth large, upper jaw longer than eye, exposed surface of lateral line scales not elevated, peritoneum silvery, mouth horizontal or nearly so, lateral line complete.

LITERATURE CITED

1. Hubbs and Lagler (1958)
2. Becker (1976)
3. Starrett (1951)
4. Paloumpis (1958)
5. Smith (1979)
6. Loos and Fuiman (1978)
7. Perry and Menzel (1979)
8. Scott and Crossman (1973)

Notropis dorsalis

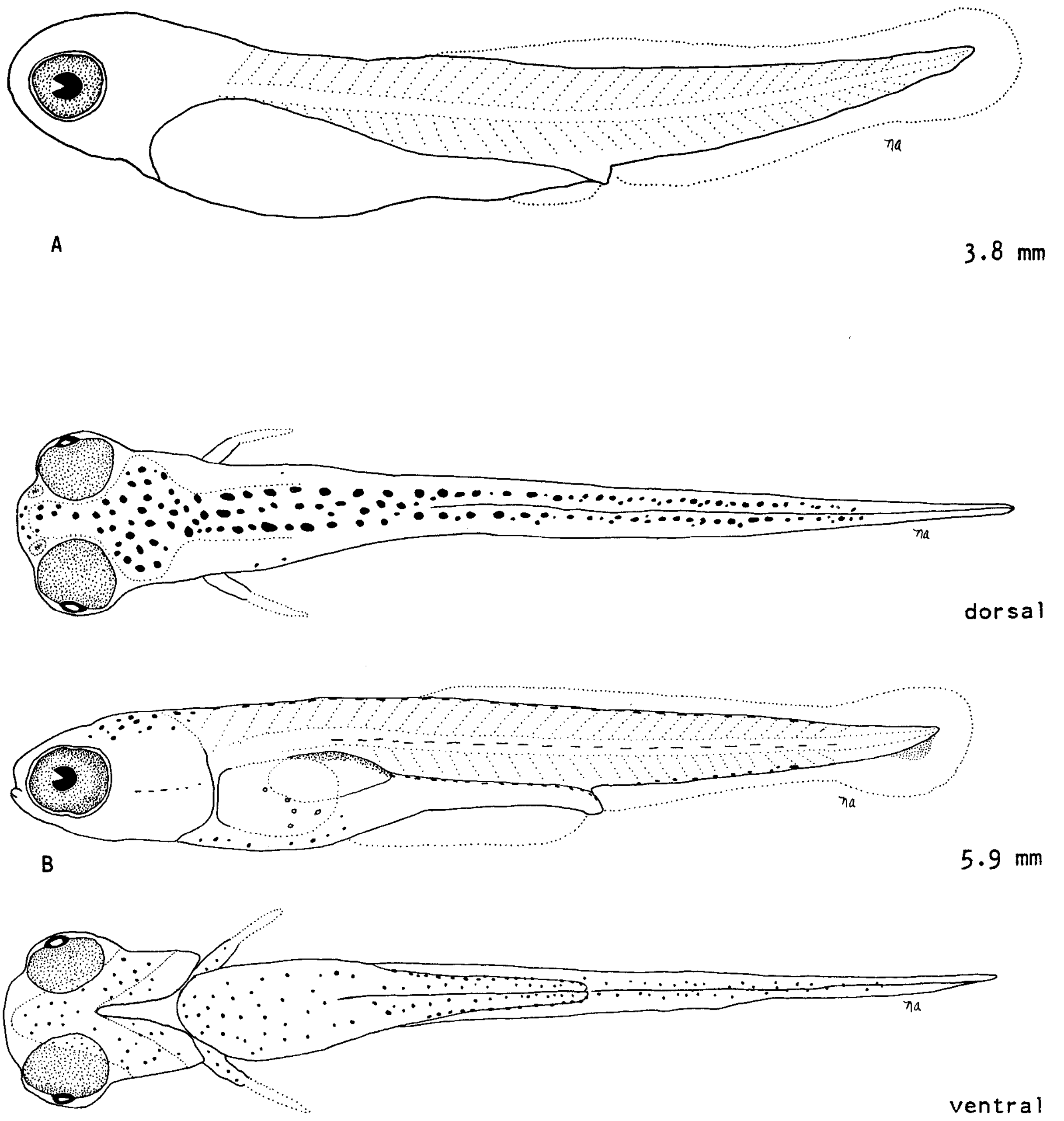
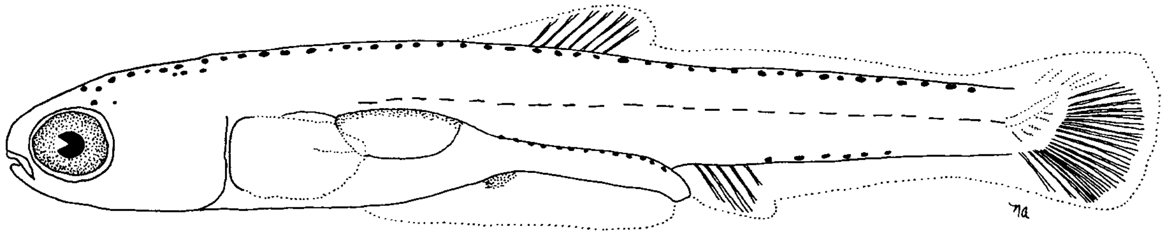
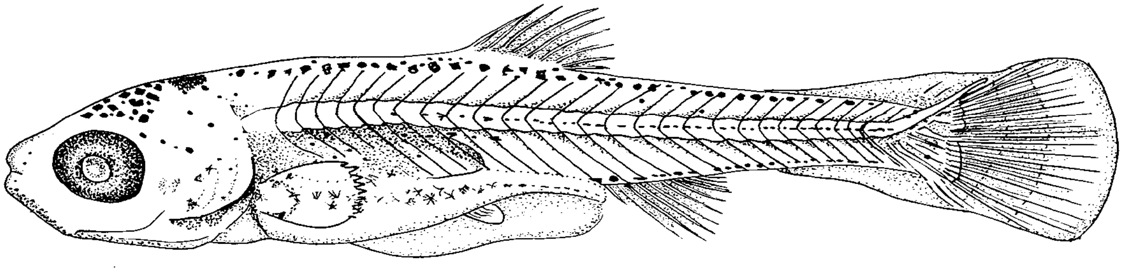


Fig. 96. Notropis dorsalis, bigmouth shiner. A. Yolk-sac larva. B. Larva. (A and B, wild-caught, Iowa, original illustrations by N. A. Auer, specimens provided by L. G. Perry).



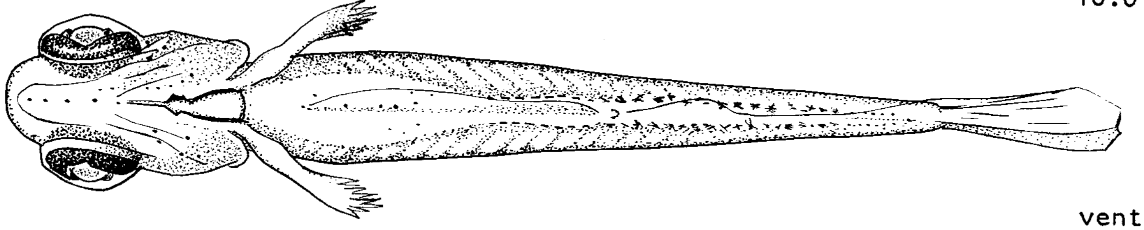
A

9.8 mm

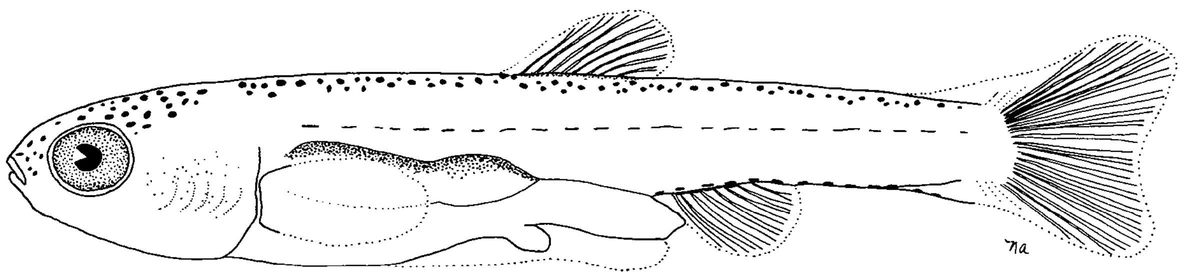


B

10.0 mm



ventral



C

12.0 mm

Fig. 97. Notropis dorsalis, bigmouth shiner. A-C. Larvae. (A and C, wild-caught, Iowa, original illustrations by N. A. Auer, specimens provided by L. G. Perry; B, wild-caught, Illinois, Loos and Fuiman 1978).

Notropis emiliae (Hay), pugnose minnow

DISTRIBUTION

In the Great Lakes basin, this species has been reported from the Detroit River, Lake St. Clair and western Lake Erie, west to southern Wisconsin and southern Minnesota.[1 2] In the Lake Michigan drainage, it is rare, known only from the Wolf River system including Wolf Lake, Wisconsin, were it probably has been extirpated.[3]

SPAWNING SEASON

Gravid females and tuberculate males were taken in mid-June in Illinois.[4] Summarized data indicate a longer spawning season, March to September, in Florida.[5]

SPAWNING TEMPERATURE

Not reported.

SPAWNING HABITAT

Not reported.

SPAWNING SUBSTRATE

Not reported.

FECUNDITY

Not reported.

EGGS

Not described.

LARVAE

Not described. However, the presence of nine principal dorsal fin rays is a unique character among Great Lakes cyprinids. See adult meristics below.

JUVENILES

Not described.

ADULTS

Fin rays: caudal 19;* dorsal 9 (7 to 10), anal 8 (7 to 9), pectoral 8 (8 to 9), pelvic 8 (8 to 9).[5]

Vertebrae: 38 to 39 (36 to 39) (including Weberian vertebrae).[5]

Lateral line scales: 36 to 39.[1,5]

Pharyngeal teeth: 0,5-5,0.[1]

Diagnostic characters: Pharyngeal teeth in a single row, dorsal fin rays usually nine, mouth small, oblique, forming an angle of 31 to 47 degrees with the plane of the lower profile.

LITERATURE CITED

1. Scott and Crossman (1973)
2. Hubbs and Lagler (1958)
3. Becker (1976)
4. Forbes and Richardson (1909)
5. Gilbert and Bailey (1972)

Notropis heterodon (Cope), blackchin shiner

DISTRIBUTION

Occurs throughout the Great Lakes basin.[1,2] Common in some lakes of the Lake Michigan drainage, but generally uncommon.[3]

SPAWNING SEASON

Spawns in May and June in Illinois[4] and New York.[5]

SPAWNING TEMPERATURE

Not reported.

SPAWNING HABITAT

Spawns in shallow water.[6]

SPAWNING SUBSTRATE

Not reported.

FECUNDITY

Not reported.

EGGS

Not described.

LARVAE

Not described.

JUVENILES

Not described.

ADULTS

Fin rays: caudal 19;* dorsal 8 (7 to 8), anal 7 (7 to 8), pectoral 12 (11 to 13), pelvic 8 (7 to 8).[1]

Vertebrae: 35 to 36 (including Weberian vertebrae).[1]

Lateral line scales: 34 to 37.[1]

Pharyngeal teeth: 1,4-4,1.[1]

Diagnostic characters: lateral band of pigment in zig-zag pattern, extends onto chin and on premaxillae, mouth large, upper jaw reaching beyond a vertical through nostril, peritoneum silvery.

LITERATURE CITED

1. Scott and Crossman (1973)
2. Hubbs and Lagler (1958)
3. Becker (1976)
4. Forbes and Richardson (1909)
5. Raney (1969b)
6. Adams and Hankinson (1928)

Notropis heterolepis Eigenmann and Eigenmann, blacknose shiner

DISTRIBUTION

Found throughout the Great Lakes basin.[1,2] It is distributed sporadically in the Lake Michigan drainage, of Wisconsin and Michigan's upper peninsula. It has probably been extirpated in the Illinois portion of the drainage.[3]

SPAWNING SEASON

Spawns in late spring and early summer' or June and July in New York.[8] Females, in spawning condition, were found in late July[5] in the Niagara River, New York and early June to August in Illinois.[6]

SPAWNING TEMPERATURE

Not reported.

SPAWNING HABITAT

Spawns in lakes and ponds. [7]

SPAWNING SUBSTRATE

Not reported.

FECUNDITY

Not reported.

NATURAL HYBRIDS

Hybognathus hankinsoni.[9]

EGGS

Not described.

LARVAE

Not described.

JUVENILES

Total length	Description
20 mm	Morphometry: (as % TL) standard length 83, preanal length 55, predorsal length 45, head length 23, greatest body depth 17, body depth at anus 12, (as % head length) eye diameter 26, snout length 31.[4]

Morphology: eight dorsal and anal fin rays, pelvic fins inserted in advance of dorsal fin, body slender, snout longer than eye, mouth small, subterminal, nearly horizontal.'

Pigmentation: melanophores restricted to upper jaw and dorsal and dorso-lateral aspects of head, about four irregular lines of melanophores on dorsum to caudal fin, single or irregular double series comprise midlateral stripe, continuing from band on snout and head, few melanophores under head, around anal fin base, and on median fins, generally less pigmented than other cyprinids this size.'

ADULTS

Fin rays: caudal 19;* dorsal 8 (7 to 9), anal 8 (7 to 8), pectoral 12 (12 to 14), pelvic 8 (7 to 8) .[1]

Vertebrae: 38 to 40 (including Weberian vertebrae).'

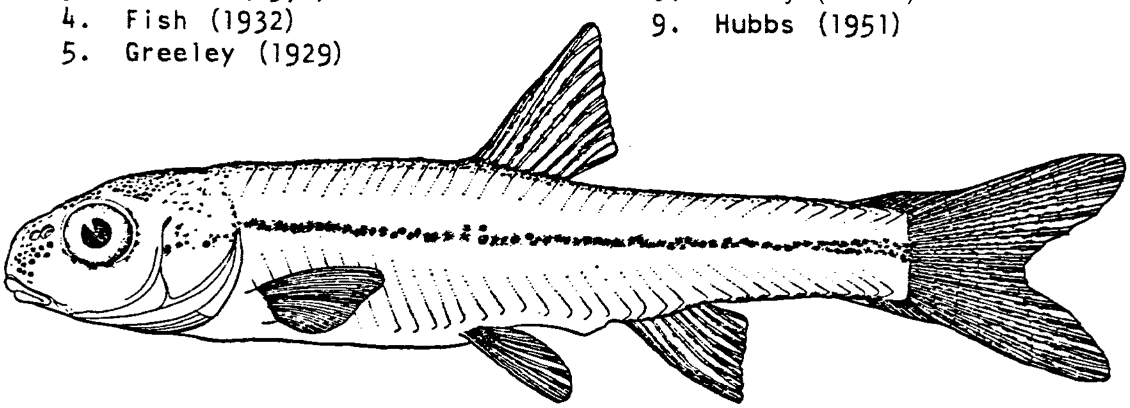
Lateral line scales: 33 to 40.1

Pharyngeal teeth: 0,4-4,0.[1]

Diagnostic characters: anal fin rays typically eight, dorsal fin over or behind pelvic fin insertion, lateral line complete, lateral band of pigment extends to snout, chin not black, mouth large, upper jaw reaching beyond a vertical through nostril, peritoneum silvery.

LITERATURE CITED

1. Scott and Crossman (1973)
2. Hubbs and Lagler (1958)
3. Becker (1976)
4. Fish (1932)
5. Greeley (1929)
6. Forbes and Richardson (1909)
7. Adams and Hankinson (1928)
8. Raney (1969b)
9. Hubbs (1951)



20.0 mm

Fig. 98. Notropis heterolepis, blacknose shiner. Juvenile. (Wild-caught, Lake Erie, Fish 1932).

Notropis hudsonius (Clinton), spottail shiner

DISTRIBUTION

Distributed throughout the Great Lakes basin.[1 2] It is common in Lake Michigan, being found along the shore, in larger tributaries, streams and lakes.[3]

SPAWNING SEASON

Spawns from June to July in Lakes Michigan' and Erie[5] and probably throughout the Great Lakes basin.*

SPAWNING TEMPERATURE

Estimated spawning temperature is 15 to 20 C.[6] *

SPAWNING HABITAT

Spawns in shallow, inshore waters of Lakes Michigan' and Erie.[5] Also spawns in mouths' and riffles[8] of small tributaries.

SPAWNING SUBSTRATE

Spawns on sandy shoals' amidst Cladophora,[4] * over gravel in riffle areas[8] and on sand or gravel.'

FECUNDITY

100 to 2,600;[10] 915 to 8,898.[4]

EGGS

Demersal, adhesive (until water hardened); [6] not attached to substrate (common in drift samples from rivers);[13] diameter 1.0 to 1.4 mm;[11] yolk yellow;* oil globule absent.' [8] *

YOLK-SAC LARVAE

Descriptions by Fish (1932) are based on incorrect identifications.&

Total length	Description
4 mm	Newly hatched.* Myomeres: (22 to 24 + 12 to 15) .* Morphometry: (as % TL) standard length 94, preanal length 64, predorsal length 42, eye diameter 9.)* Morphology: yolk sac club-shaped, elongate, notochord straight, pectoral buds small, head blunt.*

Pigmentation: generally variable, double postanal row of melanophores on venter continuing anteriorly on some specimens and branching over enlarged portion of yolk sac, melanophores on dorsum of gut from swim bladder to anus, dorsal pigmentation absent.*

4-5 mm

Myomeres: 38 (21 to 24 + 12 to 15);[11] see 4 mm.
Morphometry: (as % TL) standard length 96, preanal length 62, predorsal length 39, eye diameter 9.*
Morphology: yolk sac elongate, constricted, head blunt, mouth inferior;[6,11]* head not deflected;[11]* lower jaw included, eye large, interorbital space wide, cement glands absent;[11] pectoral buds small.*
Pigmentation: melanophores present on venter of yolk sac, sides of head, dorsum of yolk and postanal midventer (4.9 mm);[6] bulbous portion of yolk absorbed, ventro-lateral pigmentation in a series (but not distinct rows), proceeding anteriorly to thoracic region, one or two melanophores sometimes evident on dorsum of head (5.0 mm), most specimens without dorsal pigmentation.*

LARVAE

Total length	Description
7 mm	Myomeres: see 4 mm. Morphometry: (as % TL) standard length 94, preanal length 61, predorsal length 49, eye diameter 7.* Morphology: yolk absorbed (ca. 6.5 to 7.0 mm), notochord slightly flexed.* Pigmentation: dorsal pigmentation developing, patch of eight to ten melanophores on dorsum of head, few melanophores on middorsal surface, melanophores in series on the venter of gut and swim bladder (particularly on dorso-lateral aspect of swim bladder), wide series of melanophores on venter over heart and gut, narrowing toward anus and proceeding posteriorly in a series to caudal fin.,‘:
9-11 mm	Myomeres: see 4 mm. Morphometry: (as % TL) standard length 90, preanal length 63, predorsal length 42, eye diameter 7.* Morphology: notochord flexed, hypurals formed, caudal fin rays evident, actinotrichia in dorsal and anal fins evident (10.0 mm).* Pigmentation: pigmentation intensified;* double row of melanophores present on middorsal surface from occipital to caudal region;‘[12]* this series varies considerably and may be discontinuous on one or both sides (10 mm);* patch of melanophores present on dorsum of head, elongate melanophores along midlateral myoseptum.[6,12]*

JUVENILES

Total length	Description
19 mm	Morphometry: (as % TL) standard length 84, preanal length 55, head length 22, greatest body depth 17.[5] Morphology: head conical, snout blunt, mouth small, nearly horizontal, lower jaw short.[5] Pigmentation: black spot at base of caudal fin, head sparsely pigmented, three rows of chromatophores on dorsum to caudal fin, small chromatophores widely and irregularly placed in dorso-lateral region, few surface and subsurface chromatophores over operculum, subsurface chromatophores forming lateral stripe, few melanophores below, double dorsal row of melanophores from head to vertical through anus, dorsal and caudal fins pigmented.'

ADULTS

Fin rays: caudal 19;* dorsal 8 (8 to 9), anal 8 (7 to 8), pectoral 14 (12 to 17), pelvic 8 (7 to 8) .[2]

Vertebrae: 38 (37 to 39) (including Weberian vertebrae).[2]

Lateral line scales: 38 to 42.2

Pharyngeal teeth: 2,4-4,2.[2]

Diagnostic characters: large, conspicuous black spot at base of caudal fin, anal fin rays eight, scales in lateral line 38 to 42, lateral band indistinct or absent, sometimes diffuse posteriorly, body somewhat compressed and deep, mouth subterminal.

LITERATURE CITED

1. Hubbs and Lagler (1958)
2. Scott and Crossman (1973)
3. Becker (1976)
4. Wells and House (1974)
5. Fish (1932)
6. Wang and Kernehan (1979)
7. Hubbs and Cooper (1936)
8. Forbes and Richardson (1909)
9. Raney (1969b)
10. McCann (1959)
11. Jones et al. (1978)
12. Lippson and Moran (1974)
13. J. J. Loos (pers. Comm.)

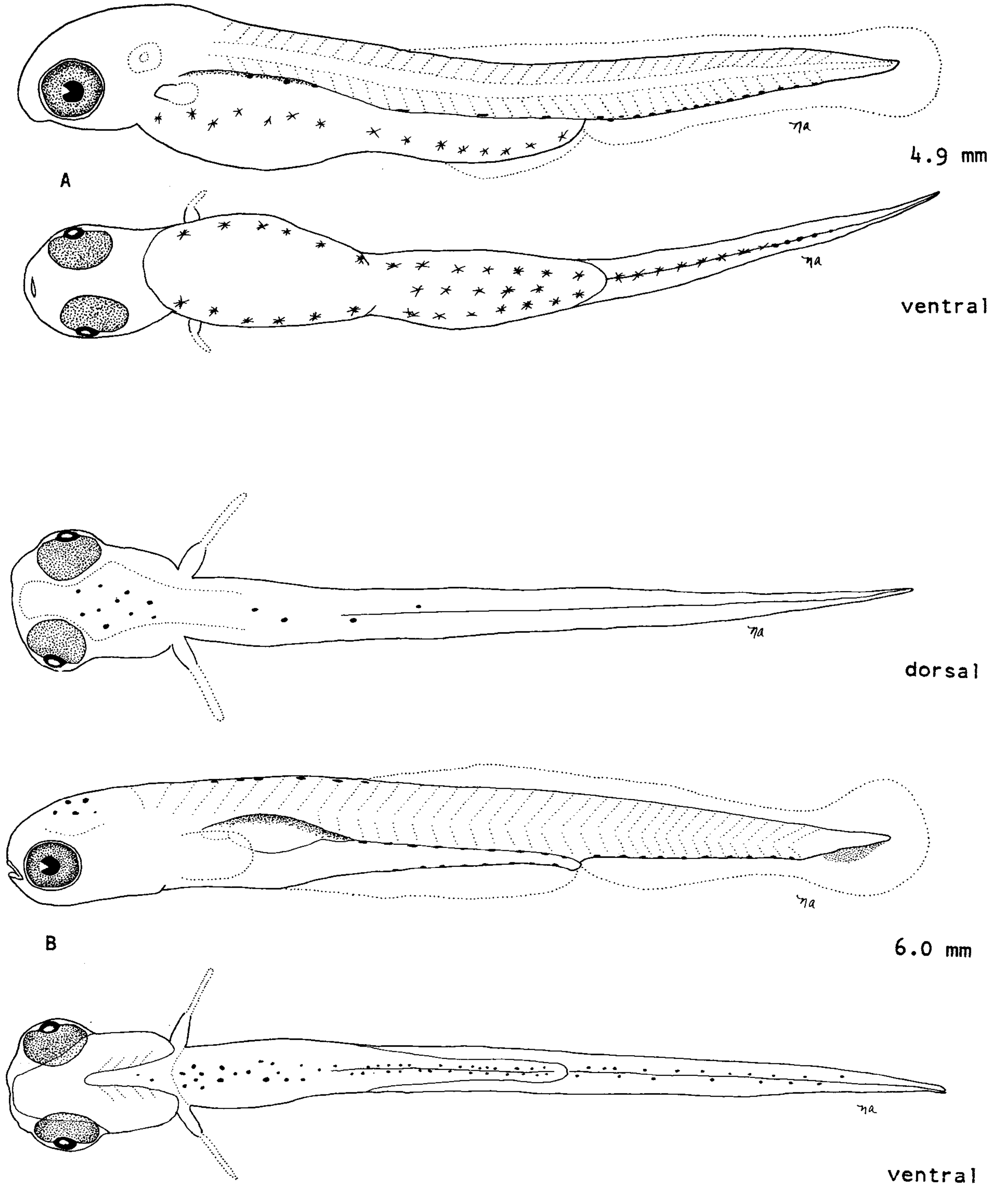


Fig. 99. Notropis hudsonius, spottail shiner. A and B. Yolk-sac larvae. (A and B, wild-caught, Lake Michigan, original illustrations by N. A. Auer).

Notropis hudsonius

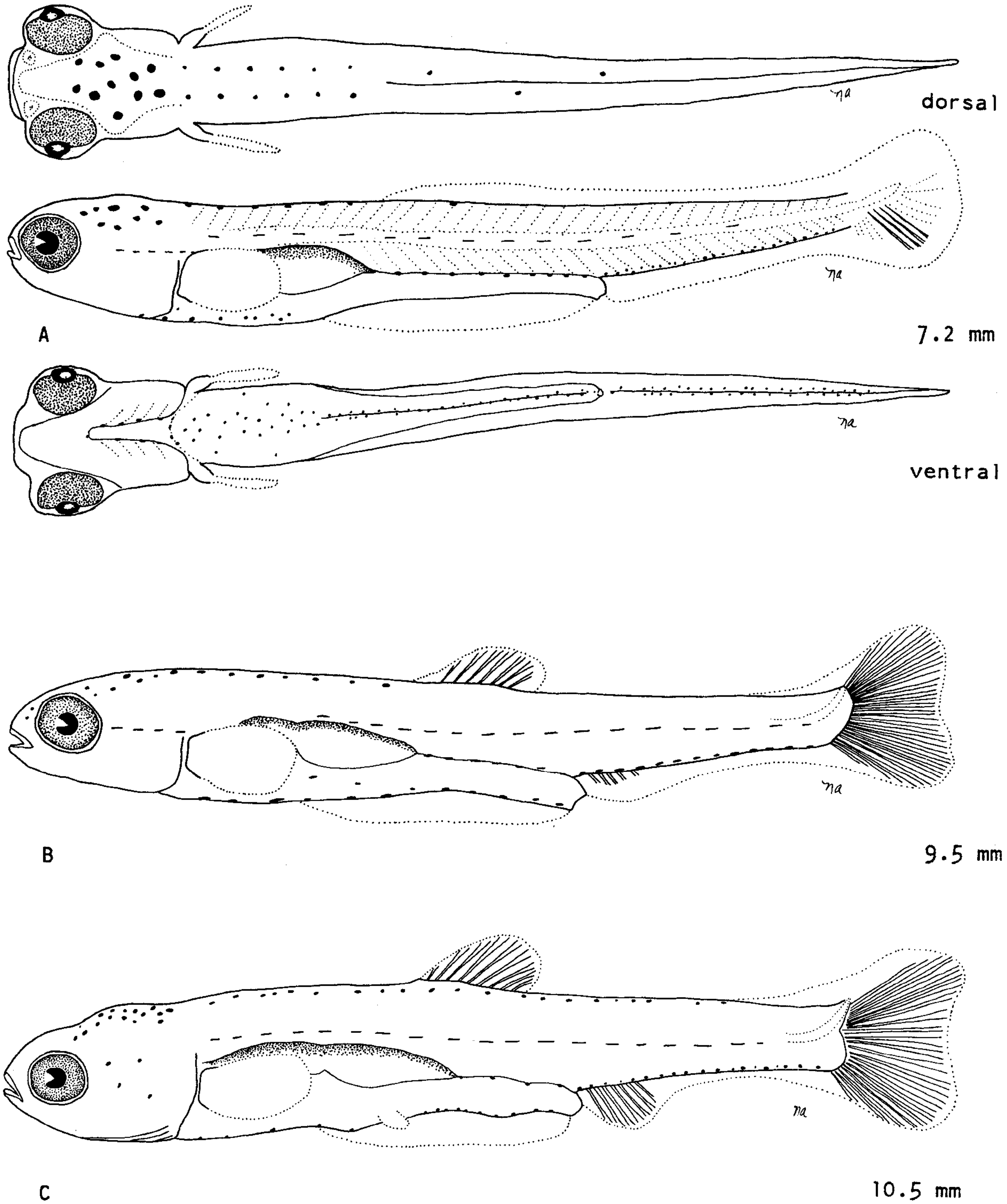


Fig. 100. Notropis hudsonius, spottail shiner. A-C. Larvae. (A-C, wild-caught, Lake Michigan, original illustrations by N. A. Auer).

Notropis rubellus (Agassiz), rosyface shiner

DISTRIBUTION

Occurs throughout the Great Lakes but its distribution in Lake Superior is restricted to the eastern shore and tributaries.[9 13] In Lake Michigan tributaries, the distribution is sporadic and irregular.'

SPAWNING SEASON

Spawns from April [11] or May[3 4 6] to June[3 6 10] or July.'

SPAWNING TEMPERATURE

Spawns at 20 to 22 C[3 6] or 25 to 29 C.[5]

SPAWNING HABITAT

Spawns near riffles of streams.[3 5 12]

SPAWNING SUBSTRATE

Deposits eggs in gravel[6] or other silt-free substrates.[10] Usually uses nests of other species, most commonly Nocomis spp.;[7 8] but also Campostoma, Moxostoma, Lepisosteus and petromyzontids.[11]

FECUNDITY

450 to 1;482. [5]

NATURAL HYBRIDS

Notropis chrysocephalus;[15] N. cornutus;[16] N. volucellus.[14]

EGGS

Demersal, adhesive;[2] diameter 1.5 to 2.5 mm;[1 5] * yolk bright yellow;2 to red-orange;[5] incubation period: 57 to 59 hours at 21 C.[2]

YOLK-SAC LARVAE

Total length	Description
4.4-5.1 mm	Newly hatched.' [2] Morphology: large amount of yolk;[1 2] but not prominent;' pectoral buds present, cement glands absent.' * Pigmentation: eye unpigmented.[2]

LARVAE

Total length	Description
6-8 mm	Myomeres: 37 to 39 (19 to 23 + 15 to 18);* counts given by Snyder (1979a) were based on an error in an unpublished manuscript.[17]
	Morphometry: (as % TL) standard length 90 to 96, preanal length 60 to 62, predorsal length 36 to 38, head length 16 to 21, (as % head length) eye diameter 36 to 42.*
	Morphology: yolk absorbed (ca. 5.5 mm), pectoral buds large, mouth developed, notochord straight, gut elongate (6.6 to 6.7 mm), lower jaw pointed, slightly longer than upper jaw (7.2 mm), urostyle flexed, actinotrichia in caudal fin (7.6 mm).*
	Pigmentation: patch of melanophores on dorsum of occiput, double series of melanophores continue posteriorly from head for 50 to 67% of body length, single widely spaced series of large melanophores from thoracic region to anus, irregular, postanal series of smaller melanophores, few melanophores on venter of gut, midlateral myoseptum marked by small irregularly spaced melanophores posterior to swim bladder (6.7 mm), appearing elongate and more regularly spaced, internal patch of melanophores over swim bladder, proceeding posteriorly on dorsum of gut to anus, double dorsal row extends to caudal fin, few melanophores on snout (7.6 mm);* no melanophores around urostyle.[18]
9 mm	Myomeres: see 6-8 mm.
	Morphology: caudal fin rays formed (9.2 mm), snout sharply pointed in dorsal view.*
	Pigmentation: short series of melanophores anterior to swim bladder on each side, continuing to base of skull, increased number of melanophores on snout, midlateral myoseptum and midventer.*
12-13 mm	Myomeres: see 6-8 mm.
	Morphology: dorsal and anal fins formed, pelvic fins with some rays, actinotrichia or lepidotrichia in pectoral fins (12.5 mm).*
	Pigmentation: double postanal ventral series, diverges around anal fin base, diffuse patch of melanophores anterior to swim bladder, nearly entire surface of gut covered by large diffuse melanophores.*

JUVENILES

A 15-mm specimen illustrated by Fish (1932) is probably misidentified because the pelvic fins are located below the dorsal fin origin.*

Notropis rubellus

Total length	Description
15-21 mm	Morphometry: (as % TL) standard length 82 to 85, preanal length 53 to 56, predorsal length 47 to 50, head length 23 to 24, eye diameter 31 to 33.* Morphology: al 1 fin rays formed (ca. 14.9 mm), mouth oblique, snout long, pointed, maxillae extend to front of eye.* Pigmentation: melanophores numerous over head, dorsum of body with at least four widely spaced rows to caudal fin, dense triangular patch on nape, venter of gut with large melanophores in broad series over heart, proceeding posteriorly as a single series to anus, sides with wide bands, lateral series more prominent than was observed in previous stages, caudal and dorsal fins with sparsely scattered melanophores.*

ADULTS

Fin rays: caudal 19;* dorsal 8 (7 to 8), anal 10 (9 to 11), pectoral 12 (11 to 14), pelvic 8.’

Vertebrae: 37 to 41 (including Weberian vertebrae).’

Lateral line scales: 38 to 45.9

Pharyngeal teeth: 2,4-4,2.’

Diagnostic characters: snout sharp, length more than two-thirds distance from posterior-margin of eye to posterior margin of gill cover, body slender, depth equal to or less than head length, no black spot on base of dorsal fin, dorsal fin origin posterior to insertion of pelvic fins, scales round or nearly so.

LITERATURE CITED

1. Loos and Fuiman (1978)
2. Reed (1958)
3. Reed (1957)
4. Becker (1976)
5. Pfeiffer (1955)
6. Raney (1969b)
7. Hankinson (1932)
8. Reighard (1943)
9. Scott and Crossman (1973)
10. Smith (1979)
11. Pflieger (1975)
12. Miller (1964)
13. Hubbs and Lagler (1958)
14. Bailey and Gilbert (1960)
15. O’Donnell (1935)
16. Lachner (1952)
17. J. J. Loos (pers. Comm.)
18. Loos et al. (1979)

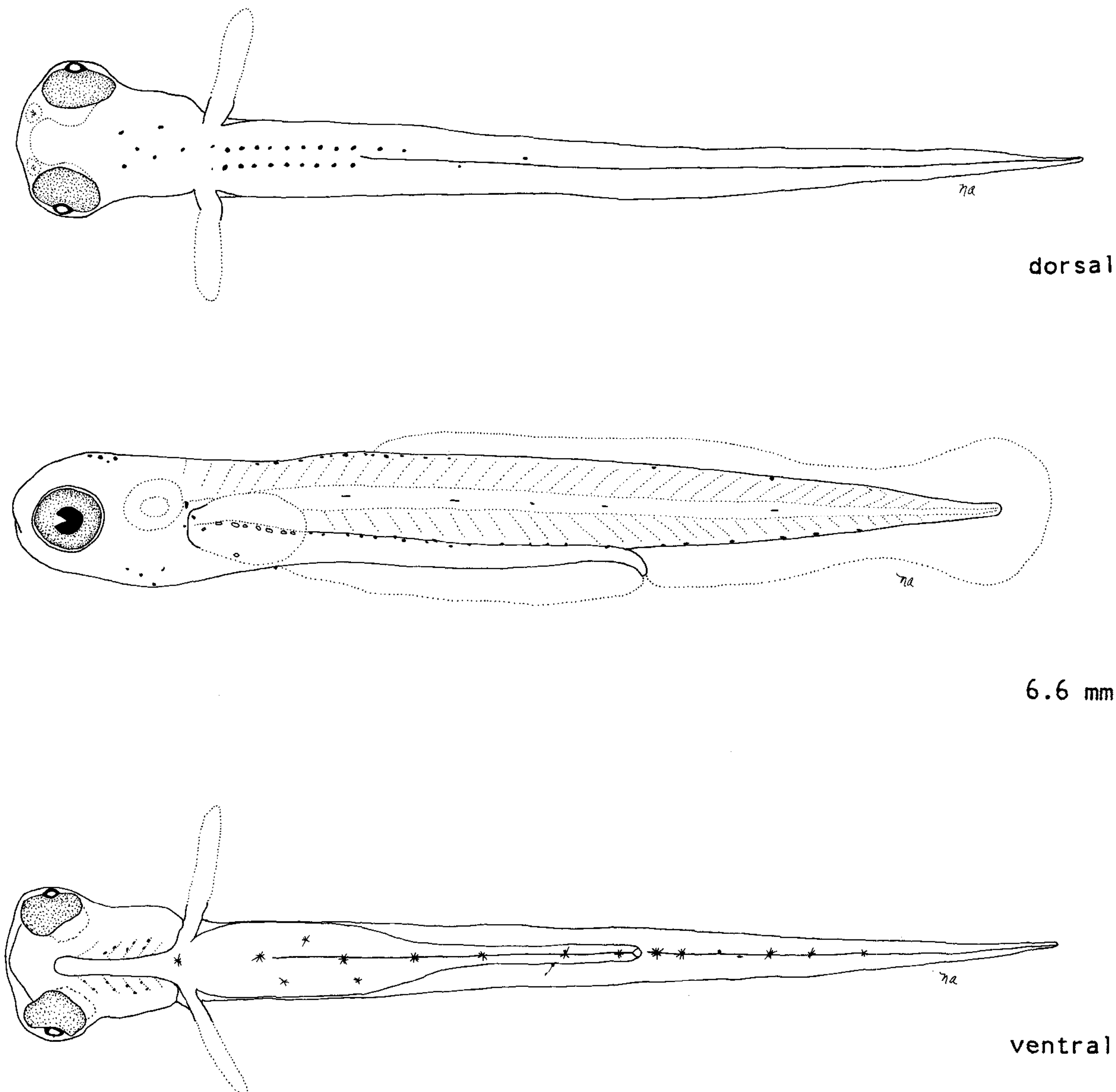


Fig. 101. Notropis rubellus, rosyface shiner. Larva. (Laboratory-reared, Michigan, original illustrations by N. A. Auer).

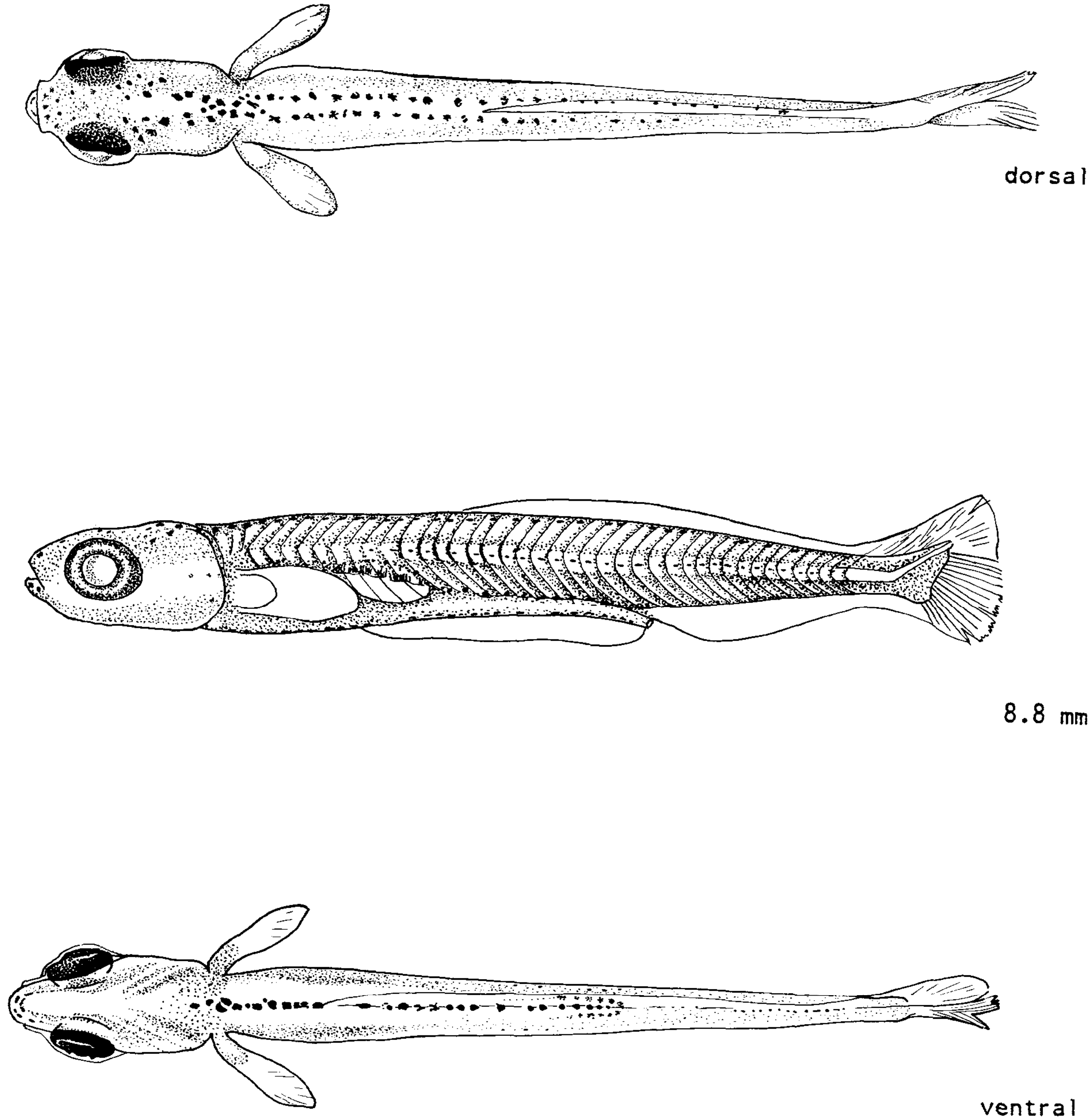


Fig. 102. Notropis rubellus, rosyface shiner. Larva. (Laboratory-reared, Loos and Fuiman 1978).

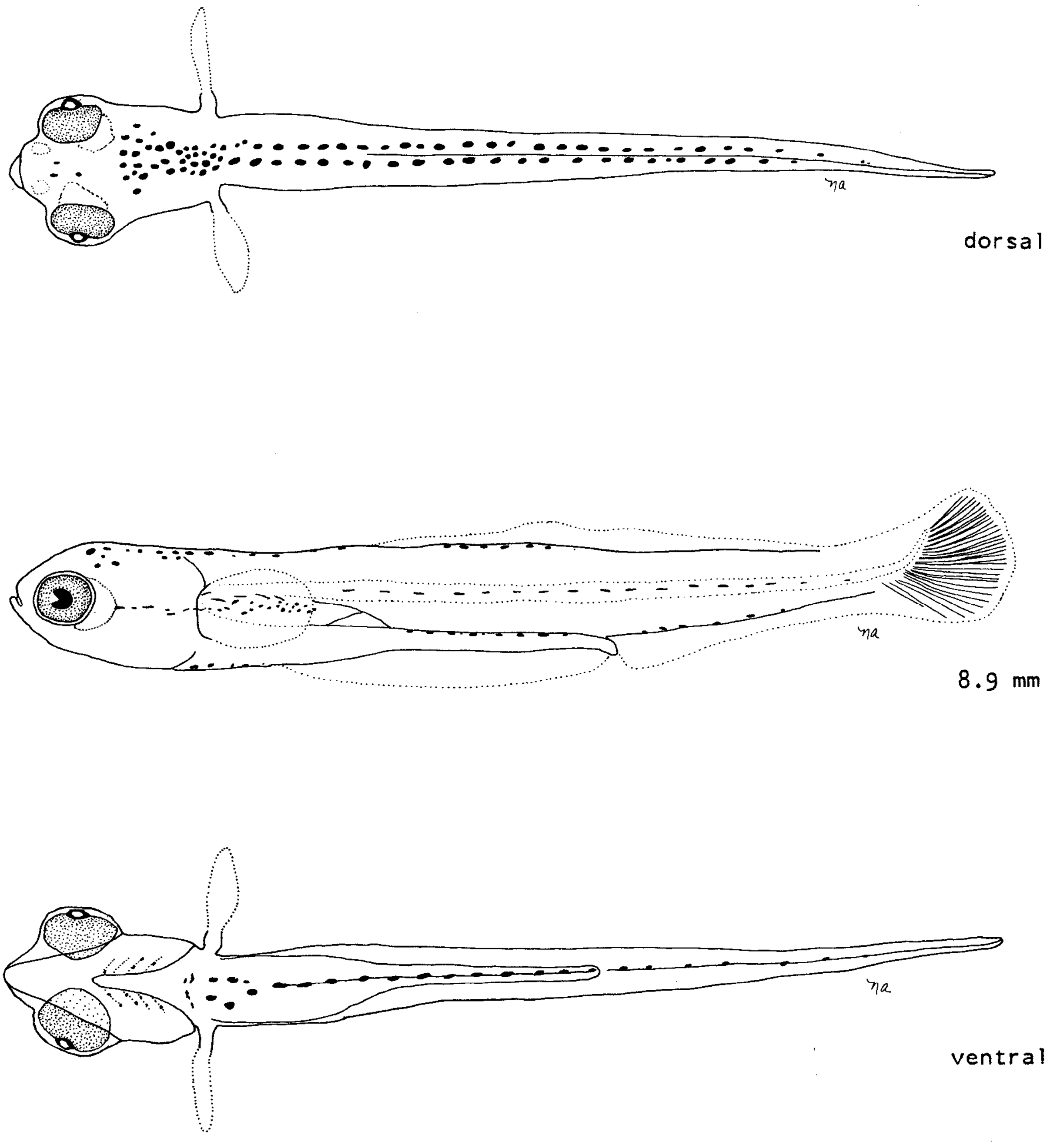


Fig. 103. Notropis rubellus, rosyface shiner. Larva. (Laboratory-reared, Michigan, original illustrations by N. A. Auer).

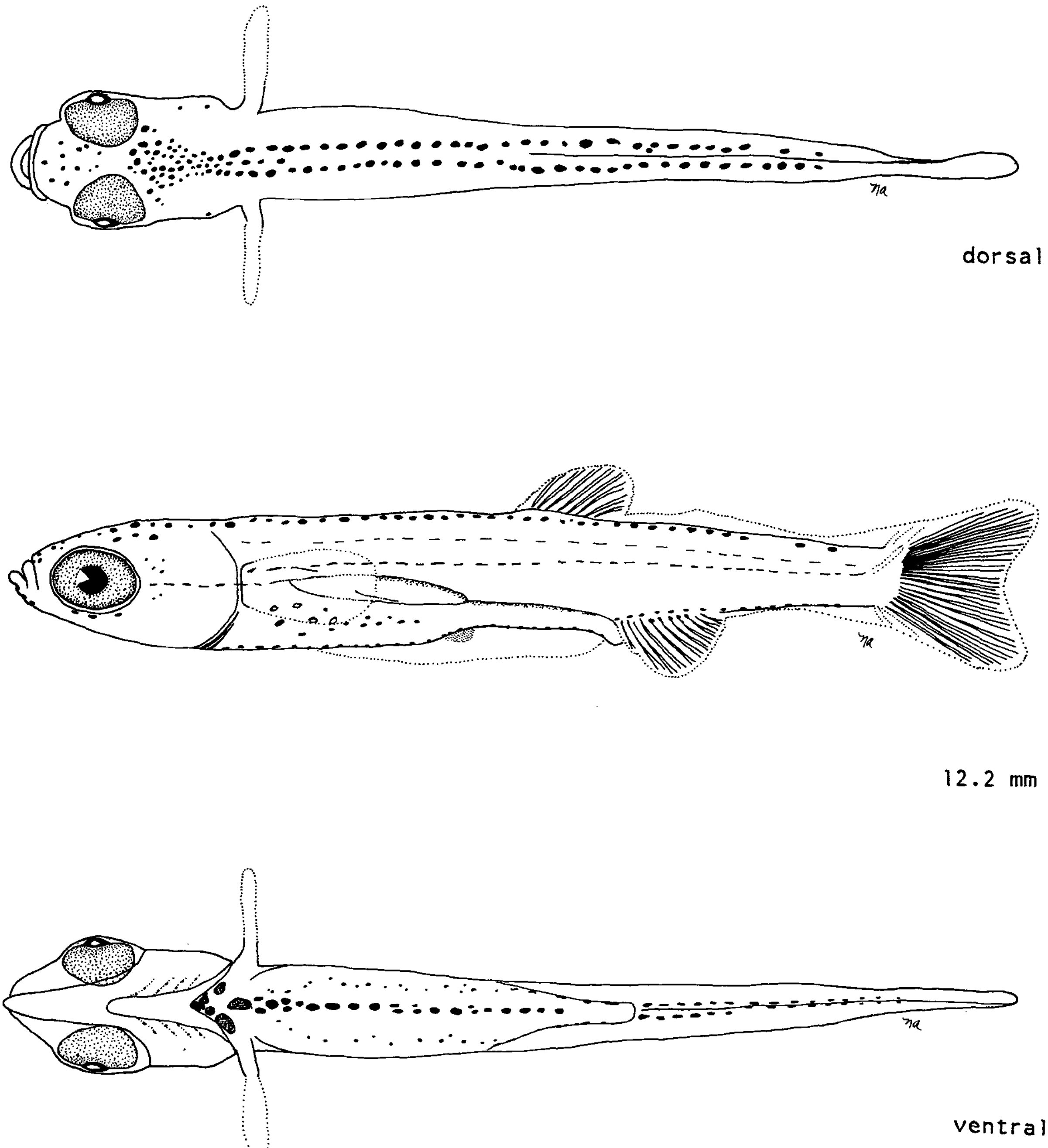


Fig. 104. Notropis rubellus, rosyface shiner. Larva. (Laboratory-reared, Michigan, original illustrations by N. A. Auer).

Notropis spilopterus (Cope), spotfin shiner

DISTRIBUTION

Occurs throughout the Great Lakes basin with the exception of Lake Superior.[1,2] In the Lake Michigan drainage, absent from the upper peninsula of Michigan, the northwestern part of lower Michigan and northern Wisconsin. Lake Michigan is near the northern range limit for the species.[3]

SPAWNING SEASON

Spawns late, from May[4,6,7] to July[7] or August[4,6] in the Great Lakes basin, and from July to August, in iowa.[5]

SPAWNING TEMPERATURE

Spawns at temperatures of 18 C or more.[1]

SPAWNING HABITAT

Spawns in riffles of streams[8,9] or shoals of lakes.[8]

SPAWNING SUBSTRATE

Spawns primarily in crevices;[1,9,13] also on undersides of logs or rocks[7,9] and flat stones,[6,10] dock pilings or sandy shoals.[8] A report of spawning over gravel and sandy shoals[8] seems unusual.[8]

FECUNDITY

225 to 1,580.[4]

EGGS

Demersal, adhesive;[10] diameter 1.4 to 1.6 mm, incubation period: 5 to 7 days at 21 to 24 C.[11]

YOLK-SAC LARVAE

Total length	Description
4-6 mm	Hatching length: ca. 4.0 mm.[11] Myomeres: 36 to 39[10,11] (21 to 22[10] + 15 to 17[10,11]); predorsal 10 to 11.[11] Morphometry: (as % TL) standard length 91 to 95, preanal length 58 to 61, predorsal 37 to 42, head 15 to 19, greatest body width 6 to 12, greatest body depth 10 to 15, greatest head depth 10 to 12, eye diameter 6 to 7, snout length 2, pectoral fin length 12 to 15.[11] Morphology: pectoral buds present, anterior portion of yolk sac enlarged, tapering toward anus, notochord straight (from illustration).[11]

Pigmentation: eye dark, melanophores scattered over yolk sac (ca. 4.0 mm), few melanophores near urostyle, dorsal pigmentation sparse, no pigment on venter of head, two diverging rows of melanophores ventrally, few melanophores present at base of pectoral buds and immediately posterior to heart region.[11]

LARVAE

Total length	Description
6-8 mm	Myomeres: 35 to 38[10,11] (22[10] + 15 to 16[10,11]); predorsal 11 to 12.[11] Morphometry: (as % TL) standard length 86 to 91, preanal length 57 to 59, predorsal length 40 to 44, head length 17 to 21, greatest body width 9 to 11, greatest body depth 10 to 14, greatest head depth 10 to 14, eye diameter' 6 to 7, snout length 2 to 3;[11] pectoral fin length 11 to 14[11] (longer than most cyprinids).[12] Pigmentation: patch of melanophores on dorsum of head, two discontinuous middorsal rows from nape to caudal fin, venter of head with few melanophores under chin forming a midventral line, midventral pigmentation from heart to anus sparse;* often with two short rows of melanophores on breast joining in an acute angle below the pectoral fins;[12] distinct double midventral postanal series, midlateral series from over swim bladder to caudal fin.*
9-14 mm	Myomeres: 36 to 38[10,11] (21 to 22[10] + 14 to 16[10,11]); prepelvic 12 to 13, predorsal 13 to 15.[11] Morphometry: (as % TL) standard length 82 to 87, preanal length 54 to 58, predorsal length 34 to 44, prepelvic length 39 to 42, head length 19 to 23, greatest body width 9 to 11, greatest body depth 11 to 13, greatest head depth 10 to 13, eye diameter 6 to 7, snout length 3 to 5, pectoral fin length 10 to 13.[11] Pigmentation: venter of head nearly devoid of pigment except for midventral series under chin, few melanophores under eye, melanophores along underside of lower lip, breast and abdomen devoid of pigment.[11]

JUVENILES

Total length	Description
16-20 mm	Myomeres: 37 (21 + 16).[10] Morphometry: (as % TL) standard length 82, preanal length 55, predorsal length 44, head length 23, (as % head length) eye diameter 34.[10] Morphology: all fin rays formed (16.3 mm), mouth superior.[10]

Pigmentation: midlateral series of melanophores more prominent, wide midlateral band forming (16 to 20 mm), dorso-lateral aspect of gut with many melanophores.*

ADULTS

Fin rays: caudal 19;* dorsal 8 (7 to 8), anal 8 (7 to 9), pectoral 13 or 14 (12 to 15), pelvic 8 (7 to 9).[2]

Vertebrae: 37 to 39 (including Weberian vertebrae).[2]

Lateral line scales: 39 (35 to 41).[2]

Pharyngeal teeth: 1,4-4,1 1,4-4,0.[2]

Diagnostic characters: dorsal fin with black blotch on posterior membranes (except in young), eye usually less than one-quarter head length in adult, always less than one-third, snout sharp and pointed.

LITERATURE CITED

1. Hubbs and Lagler (1958)
2. Scott and Crossman (1973)
3. Becker (1976)
4. Hankinson (1930)
5. Starrett (1951)
6. Stone (1941)
7. Raney (1969b)
8. Dobie et al. (1956)
9. Pflieger (1965)
10. P. J. Mansfield (pers. Comm.)
11. Snyder et al. (1977)
12. B. F. Lathrop (pers. Comm.)
13. Loos et al. (1979)

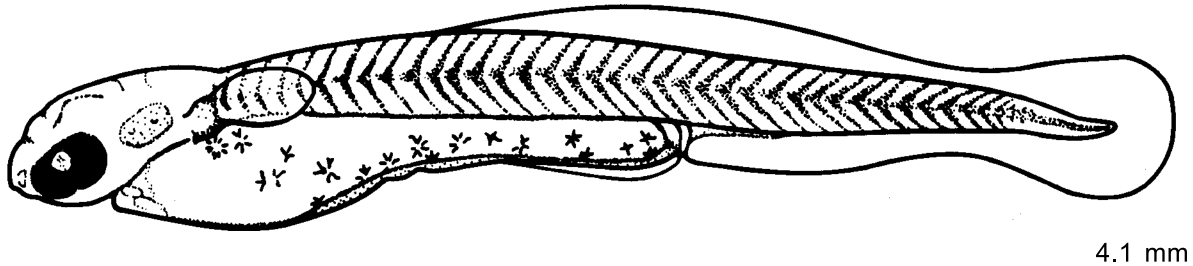


Fig. 105. Notropis spilopterus, spotfin shiner. Yolk-sac larva. (Laboratory-reared, Pennsylvania, Snyder et al. 1977).

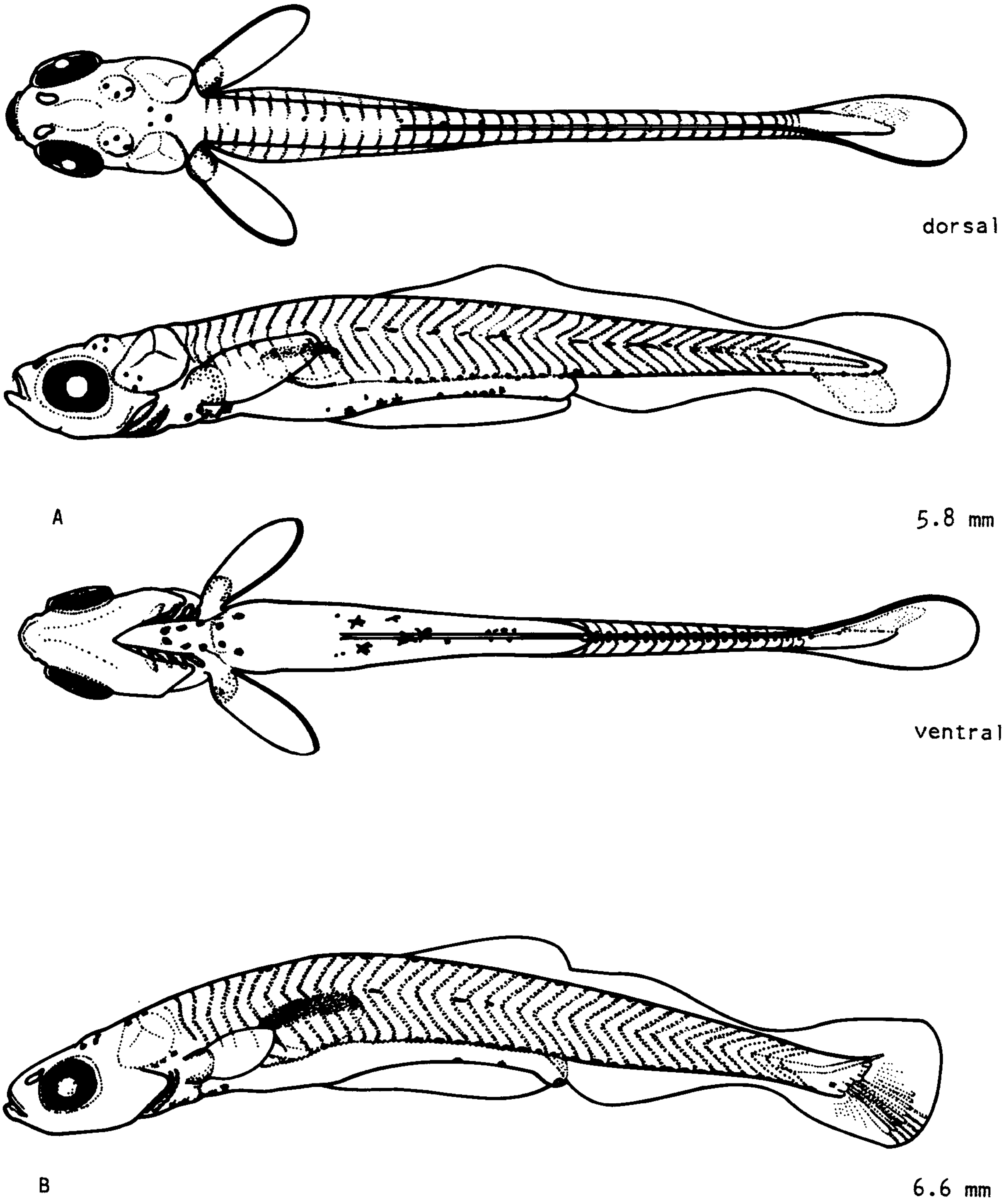


Fig. 106. Notropis spilopterus, spotfin shiner. A and B. Larvae. (A and B, laboratory-reared, Pennsylvania, Snyder et al. 1977).

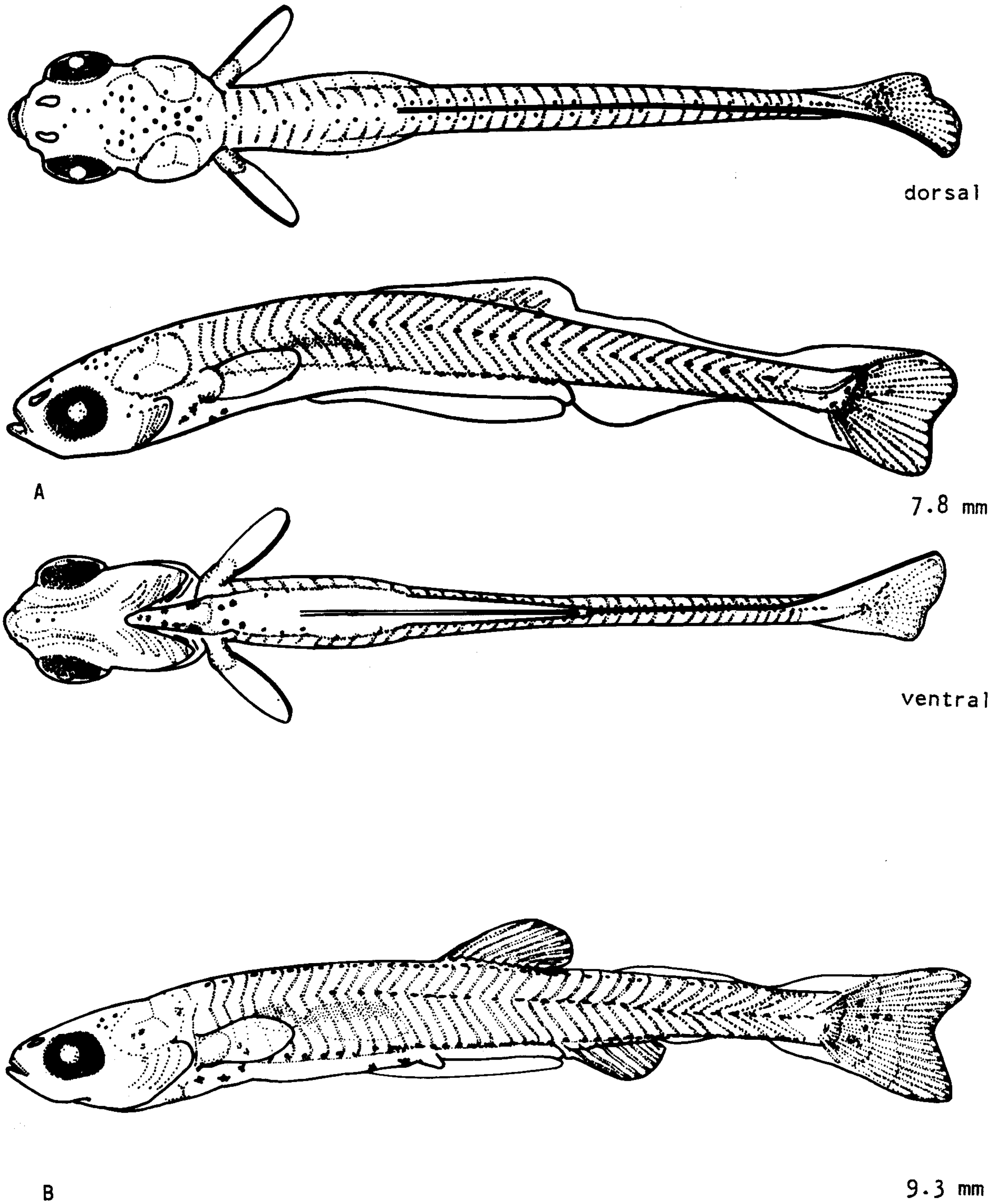


Fig. 107. Notropis spilopterus, spotfin shiner. A and B. Larvae. (A and B, laboratory-reared, Pennsylvania, Snyder et al. 1977).

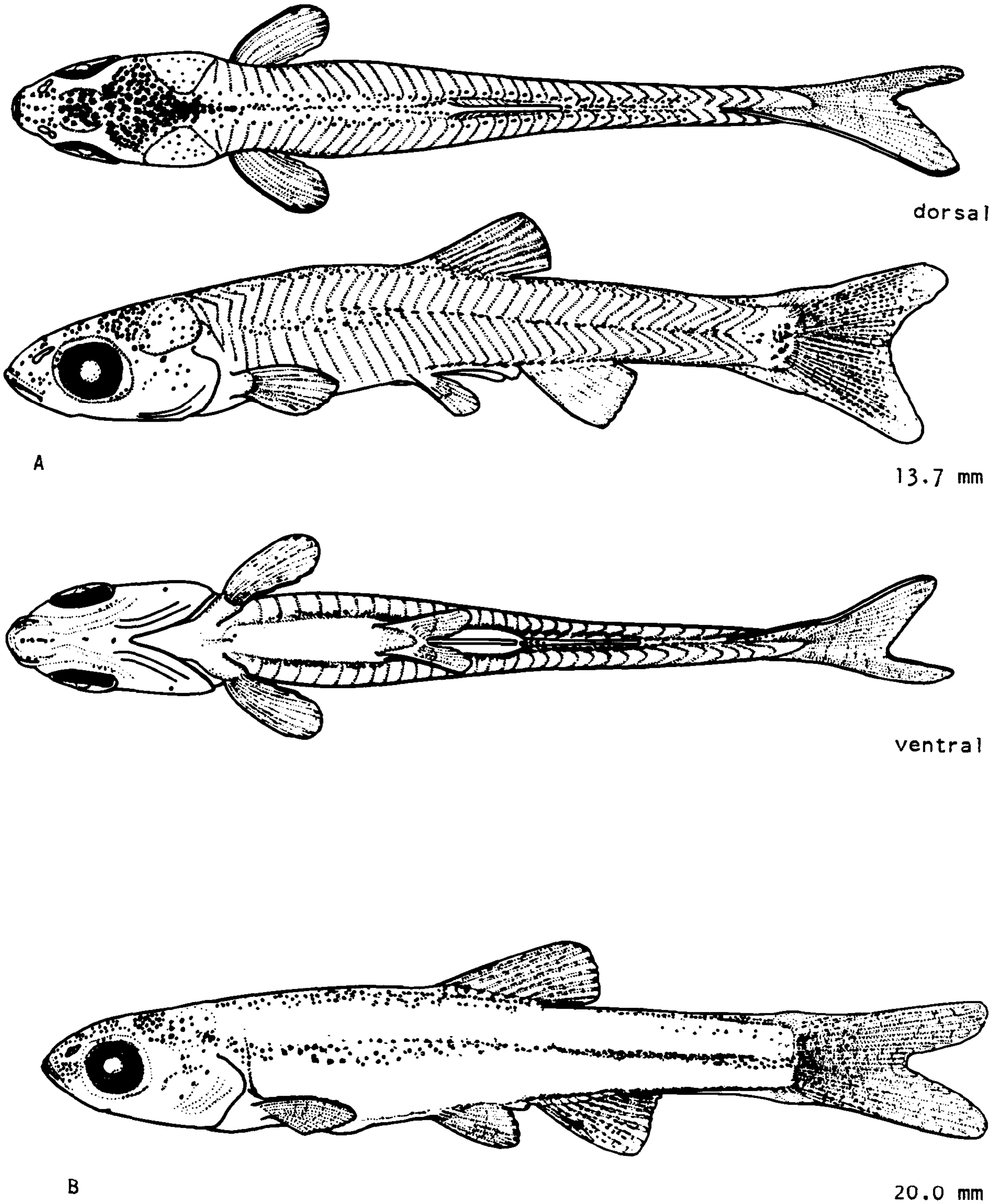


Fig. 108. Notropis spilopterus, spotfin shiner. A and B. Larvae. (A and B, laboratory-reared, Pennsylvania, Snyder et al. 1977).

Notropis stramineus (Cope), sand shiner

DISTRIBUTION

Found throughout the Great Lakes basin.[1,2] It occurs in tributary streams close to Lake Michigan in Michigan's upper peninsula[3] and occasionally in lakes and along the shores of Lake Michigan.[3] *

SPAWNING SEASON

Spawns in late June and July in Lake Erie,[4] late May to July in New York[5] and late July to August in Iowa.[6]

SPAWNING TEMPERATURE

Spawns at temperatures between 21 and 27 C.[10]

SPAWNING HABITAT

Spawns in shallows of lakes[4,7,6,8] and creek mouths.[5]

SPAWNING SUBSTRATE

Deposits eggs on sand.[1,8]

FECUNDITY

Less than 300;[5] 150 to 785;[10] 250 to 1,800.[6]

NATURAL HYBRIDS

Possibly Hybognathus hankinsoni.[12]

EGGS

Not described.

YOLK-SAC LARVAE

Total length	Description
4-6 mm	Newly hatched ca. 3.9 mm.[9] Myomeres: (22 to 23 + 13 to 14), usually 35 (22 + 13).[9] Morphometry: (as % TL) standard length 93 to 96;[9] preanal length 59 to 64;[4,9] predorsal length 36 to 41;[9] (as % head length) eye diameter 39.[4] Morphology: swim bladder single, head much 'broader than deep, snout short, very obtuse, (5.0 mm).' Pigmentation: eye and body may lack pigment (3.9 mm);[9] eye pigmented, series of chromatophores on dorsum and venter of intestine and along ventral ridge (4.7 mm), dorsum of swim bladder darkly pigmented, subsurface

chromatophores on venter of stomach region, continuing as uneven double series to anus (5.0 mm), few melanophores on ventral ridge posterior to anus.[4]

LARVAE

Total length	Description
6-10 mm	Myomeres: 33 to 35 (20 to 23 + 12 to 13);[9,11] usually 36 (23 + 13).[9] Morphometry: (as % TL) standard length 90 to 96, preanal length 62 to 65,[4,9] predorsal length 39 to 44;[9] head length 20, body depth at anus 13, (as % head length) eye diameter 37, snout length 13.[4] Morphology: yolk absorbed (ca. 5.0[4] to 5.5 mm*) ; head broader than deep, dorsal fin anlage present (6.5 mm), anal fin anlage evident, notochord flexed, some caudal fin rays developed (7.5 mm) .[4] Pigmentation: regular series of melanophores on dorsum and venter of intestine and on postanal ventral ridge (6.5 mm), few round melanophores on top of head;[4] followed posteriorly by a broken double series along dorsal ridge;' [9] series along midlateral myoseptum from swim bladder to caudal peduncle, ventral series extends from jugular region to caudal fin, becoming a double postanal series (7.5 mm) .[4]
10-13 mm	Myomeres: (21 to 23 + 11 to 13), usually 34 (22 + 12) ;[9] Morphometry: (as % TL) standard length 79[4] or 85 to 88;[9] preanal length 56 to 53, predorsal length 42 to 46;[4,9] greatest body depth 17, body depth at anus 10, (as % head length) eye diameter 29, snout length 21.[4] Morphology: median fins complete, pelvic buds apparent immediately before vertical through first dorsal fin ray, swim bladder two chambered (12.0 mm) .[4] Pigmentation: melanophores larger and more conspicuous, chromatophores on caudal fin (12.0 mm) ;[4] melanophores concentrated along base of dorsal fin.'

JUVENILES

Total length	Description
29 mm	Morphometry: (as % TL) standard length 80, preanal length greatest body depth 16, head length 22, (as % head length) eye diameter 34.[4] Morphology: all fin rays formed:* caudal fin deeply forked, pelvic fins inserted slightly before origin of dorsal fin, mouth small, inferior, horizontal.+ Pigmentation: dorsum with one to four rows of round melanophores along entire length, small melanophores scattered between, concentration of melanophores around base of dorsal fin and behind, forming scale-like pattern to caudal fin, midlateral myoseptum marked by

small chromatophores to anus, series continues posteriorly with larger, stellate chromatophores, heavy pigmentation over upper jaw, double series on venter from thoracic region to anus, venter otherwise unmarked, pectoral, dorsal and caudal fins pigmented, pelvic fins not.[4]

ADULTS

Fin rays: caudal 19;* dorsal 8, anal 7 (6 to 8), pectoral 13 (12 to 16), pelvic 8.[2]

Vertebrae: 35 (33 to 36) (including Weberian vertebrae).[2]

Lateral line scales: 34 to 39.[2]

Pharyngeal teeth: 0,4-4,0.[2]

Diagnostic characters: anal fin rays usually seven, little or no black pigment about anus, base of anal fin or below lateral line; thin but distinct middorsal stripe, lateral line complete, lateral band not continued through eye.

LITERATURE CITED

1. Hubbs and Lagler (1958)
2. Scott and Crossman (1973)
3. Becker (1976)
4. Fish (1932)
5. Raney. (1969b)
6. Starrett (1951)
7. Adams and Hankinson (1928)
8. Hubbs and Cooper (1936)
9. Perry and Menzel (1979)
10. Summerfelt and Minckley (1969)
11. Snyder (1979a)
12. Bruekelman (1940)

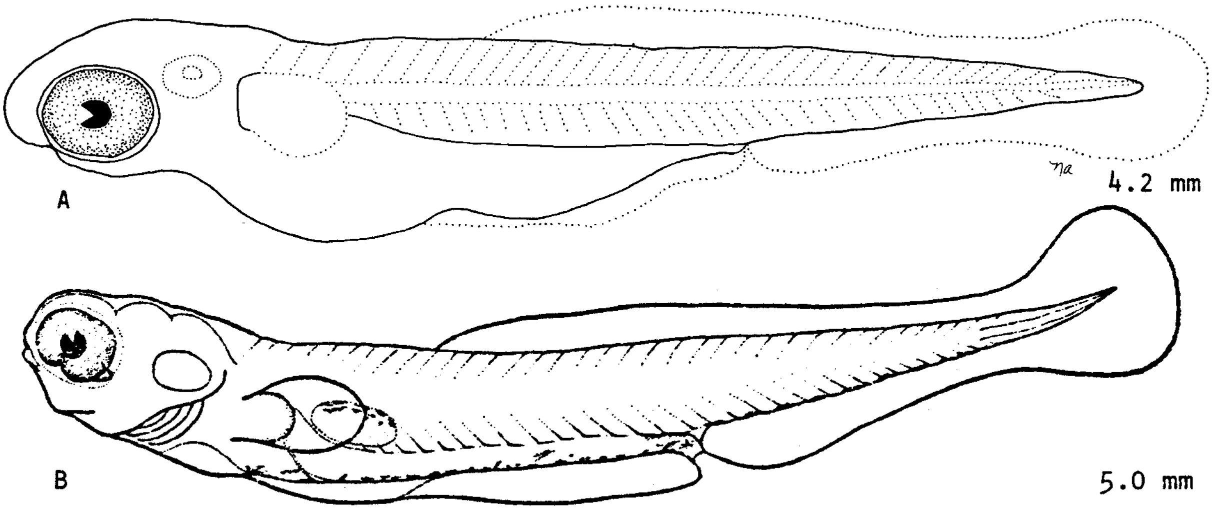
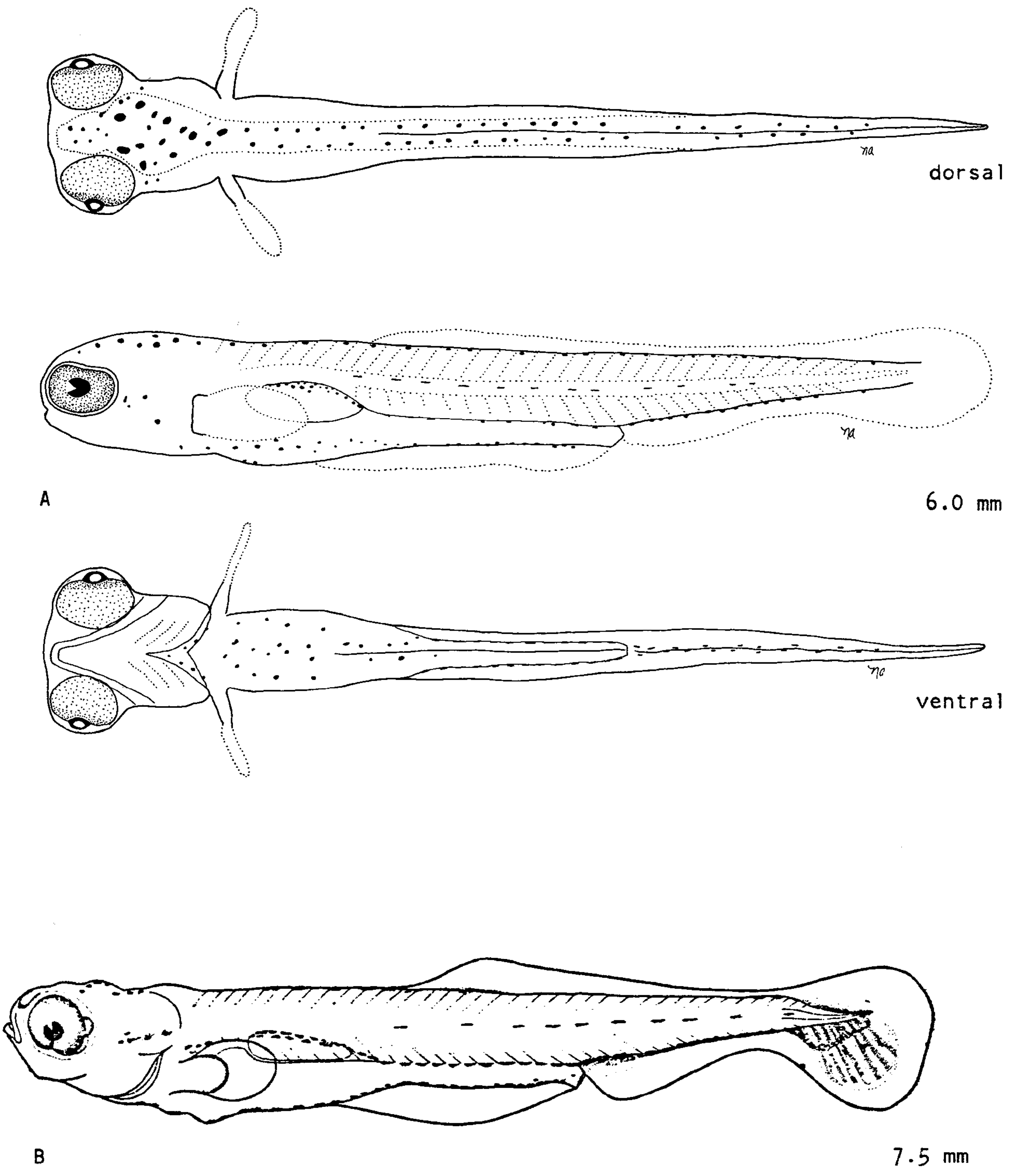


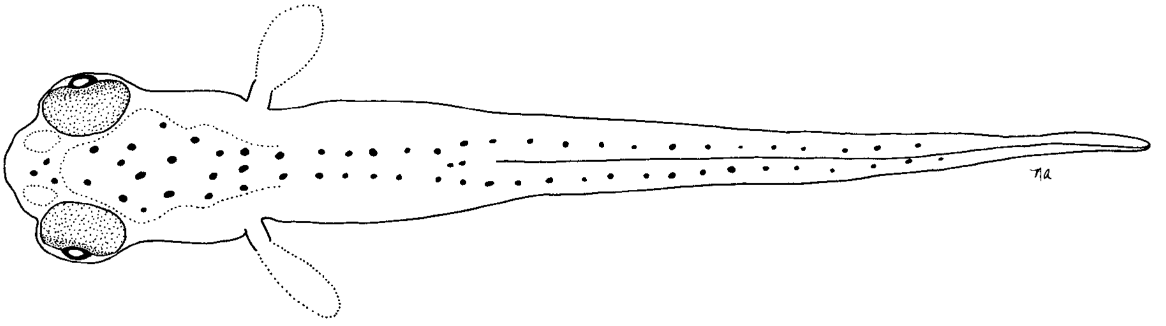
Fig. 109. Notropis stramineus, sand shiner. A. Yolk-sac larva. B. Larva. (A, wild-caught, Iowa, original illustration by N. A. Auer, specimen provided by L. G. Perry: B, wild-caught, Lake Erie, Fish 1932).

Notropis stramineus

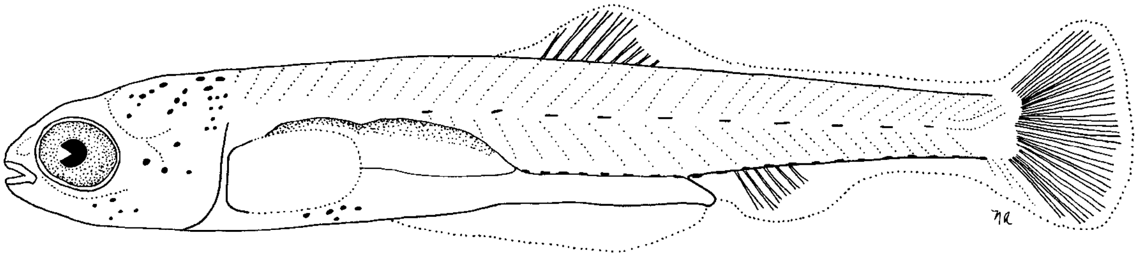


ig. 110. Notropis stramineus, sand shiner. A and B. Yolk-sac larvae. (A, wild-caught, Iowa, original illustrations by N. A. Auer, specimen provided by L. G. Perry; B, wild-caught, Lake Erie, Fish 1932).

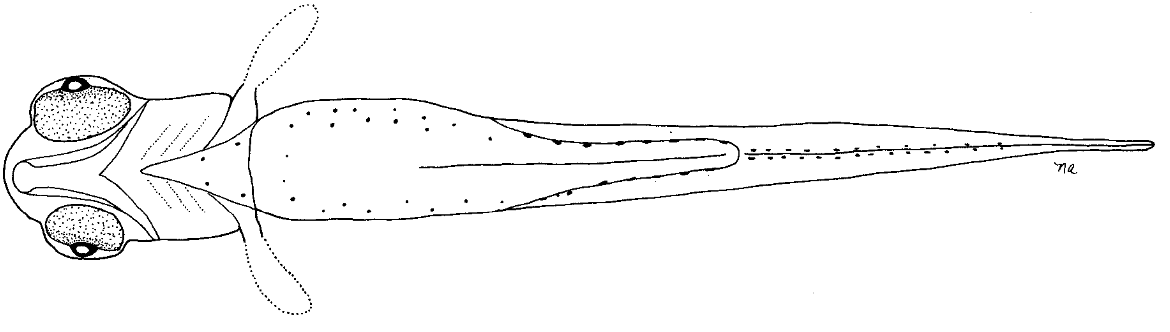
Notropis stramineus



dorsal

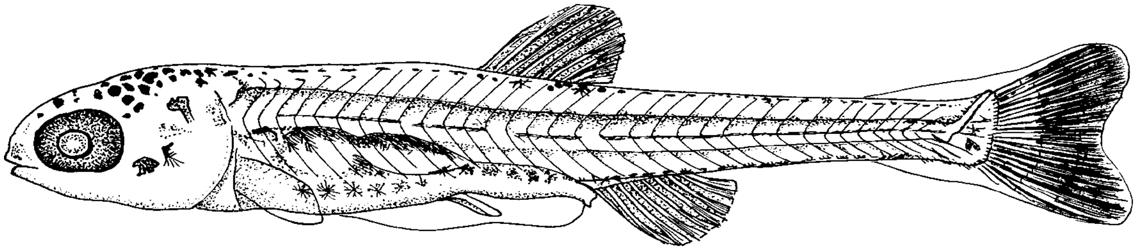


8.5 mm

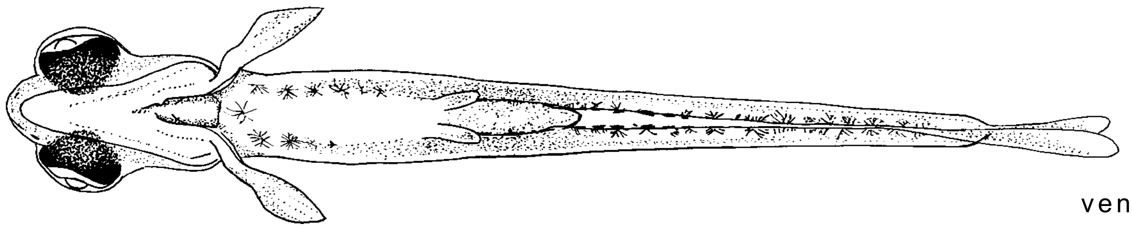


ventral

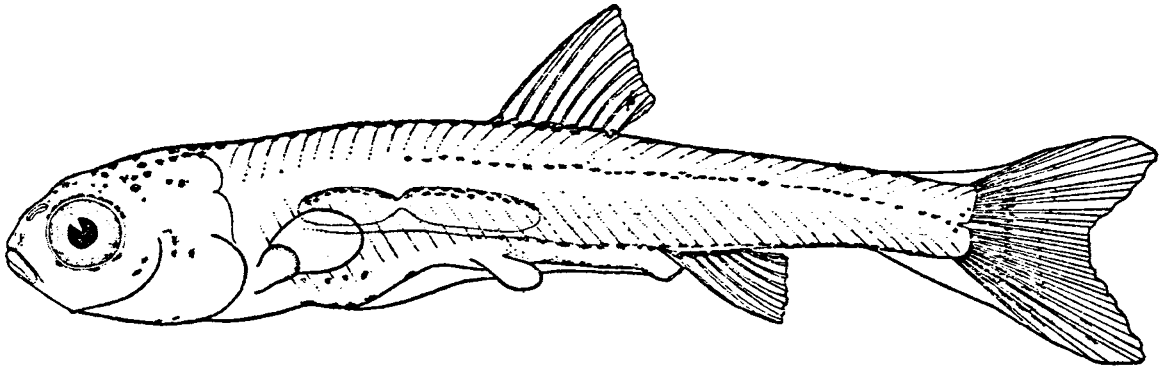
Fig. 111. Notropis stramineus, sand shiner. Larva. (Wild-caught, Iowa, original illustrations by N. A. Auer, specimen provided by L. G. Perry).



A 9.6 mm



ventral



B 12.0 mm

Fig. 112. Notropis stramineus, sand shiner. A and B. Larvae. (A, laboratory-reared, Tennessee, Loos and Fuiman 1978; B, wild-caught, Lake Erie, Fish 1932).

Notropis texanus (Girard), weed shiner

DISTRIBUTION

Occupies large, slow streams of the Lake Michigan drainage, although rare.[1]

SPAWNING SEASON

Males with dense, minute tubercles and females distended with eggs were collected in late August in Illinois.[2]

SPAWNING TEMPERATURE

Not reported.

SPAWNING HABITAT

Not reported.

SPAWNING SUBSTRATE

Possibly spawns over sand and gravel.[3]

FECUNDITY

Not reported.

EGGS

Not described but members of this subgenus (Alburnops) generally have adhesive eggs.[3]

LARVAE

Not described but members of the subgenus Alburnops hatch with large amounts of yolk, unpigmented eyes and no cement glands, pectoral buds are not prominent.[3]

JUVENILES

Not described.

ADULTS

Fin rays: caudal 19, dorsal 8;* anal 7 (7 to 8);[5] pectoral 13 to 14, pelvic 8 to 9.*

Vertebrae: 34 to 38 (including Weberian vertebrae).'

Lateral line scales: 31 to 36.[5]

Pharyngeal teeth: 2,4-4,2.[5]

Diagnostic characters: anal fin rays usually seven, dorsal fin origin in advance of pelvic fin insertion, peritoneum silvery, mouth terminal , not oblique.

LITERATURE CITED

1. Becker (1976)
2. Smith (1979)
3. Loos and Fuiman (1978)
4. Swift (1970) in Loos and Fuiman (1978)
5. Pflieger (1975)

Notropis umbratilis (Girard), redfin shiner

DISTRIBUTION

Occurs in the southern part of the Great Lakes basin.[1 2] In the Lake Michigan drainage, it occurs in disjunct populations which appear to be decreasing.[3]

SPAWNING SEASON

In Illinois females distended with eggs were found in early June and tuberculate males were collected from mid-May to early August.' Reports for the Great Lakes basin include June,' July[3 5 7] and August.[3]

SPAWNING TEMPERATURE

Not reported.

SPAWNING HABITAT

Spawns in sluggish riffles and pools in streams[5] or over sunfish nests.[8 9] The association with sunfishes seems invariable in Missouri.[6]

SPAWNING SUBSTRATE

Spawns over sand[3 5] and gravel.[3 5]

FECUNDITY

Not reported.

EGGS

Not described, but probably transparent (typical of cyprinids using similar substrates).[10]

LARVAE

Not described.

JUVENILES

Not described.

ADULTS

Fin rays: caudal 19;* dorsal 8 (7 to 8), anal 11 (10 to 12), pectoral 12 to 13, pelvic 8 (7 to 9).[2]

Vertebrae: 35 to 36 (including Weberian vertebrae).[2]

Lateral line scales: 39 to 46.[2]

Pharyngeal teeth: 2,4-4,2.[2]

Diagnostic characters: body depth equal to or more than head length, dorsal fin with black pigmented area at anterior base, sides stippled with pigment, origin of dorsal fin behind vertical through insertion of pelvic fins, scales round or nearly so.

LITERATURE CITED

1. Hubbs and Lagler (1958)
2. Scott and Crossman (1973)
3. Becker (1976)
4. Forbes and Richardson (1909)
5. Trautman (1957)
6. Pflieger- (1975)
7. Raney (1969b)
8. Hunter and Wisby (1961)
9. Hunter and Hasler (1965)
10. Loos and Fuiman (1978)

Notropis volucellus (Cope), mimic shiner

DISTRIBUTION

Occurs throughout the Great Lake basin.[1,2] In the Lake Michigan drainage, it occurs at disjunct locations and is uncommon.[3]

SPAWNING SEASON

Spawns from May to early July in Indiana.[1]

SPAWNING TEMPERATURE

Not reported.

SPAWNING HABITAT

Possibly spawns at depths of 5 to 6 m in lakes.[4]

SPAWNING SUBSTRATE

Possibly spawns in weedy areas.[1]

FECUNDITY

Average less than 400.[4,5]

NATURAL HYBRIDS

Notropis rubellus,[6] such hybrids are probably rare because of different spawning habits.[7]

EGGS

Demersal, adhesive[8] (until water hardened[8]); yolk amber, incubation period: 3 days at 23 C.[8]

YOLK-SAC LARVAE

Not described, (single specimen described[8]) .

LARVAE

Total length	Description
6.3 mm	Myomeres: 35 to 37 (22 to 23 + 13 to 14);[9] or 34 (20 +
	Morphometry: (as % TL) standard length 95 preanal length 60, head length 17, eye diameter 8, snout length 3, body depth at anus 6.9

Morphology: yolk absorbed, eye oval, mouth subterminal, swim bladder inflated, finfold origin at myomere 12, partial outline of dorsal fin apparent, notochord slightly flexed, ca. five incipient caudal fin rays.[9]

Pigmentation: dorsum of head with ca. five melanophores (two interorbital and three larger occipital), other dorsal pigment absent, two external melanophores behind eye on preopercle, two or three melanophores internally above and below pectoral bud base, few light melanophores on postanal midlateral myoseptum, dorsum of swim bladder pigmented, internal line of melanophores from swim bladder along dorsum of gut to anus, melanophores tightly scattered (or in a line) ventrally from breast through caudal region, most close together preanally, small and single arranged melanophores postanally.

7.6 mm

Myomeres: see 6.3 mm.

Morphometry: (as % TL) standard length 93, preanal length 61, head length 18, eye diameter 7, snout length 3, body depth at anus 8.[9]

Morphology: eye nearly circular, ca. 13 caudal fin rays developed, notochord flexed (ca. 30 to 35 degrees).[9]

Pigmentation: V-shaped patch of pigment on dorsum of occiput, other dorsal pigment absent, one melanophore on anterior of preopercule, few along postanal midlateral myoseptum, dorsum of swim bladder and gut pigmented, four or five prominent melanophores on dorsum of gut near anus, thin line of small, light melanophores from between pectoral fins to caudal fin, line is distinctly single postanally.[9]

8.3 mm

Myomeres: see 6.3 mm.

Morphometry: (as % TL) standard length 95, preanal length 61, head length 13, eye diameter 7, snout length 5, body depth at anus 8.[9]

Morphology: eye round, eight partially formed dorsal fin rays, anal fin anlagen forming, caudal fin emarginate, notochord flexed (ca. 45 degrees or more).[9]

Pigmentation: melanophores on opercle and internally near otolith (10 or more), row of melanophores in midlateral myoseptum from under dorsal fin to caudal peduncle, posterior section of gut outlined with pigment, uneven line of small melanophores from breast to anus, line becomes double near incipient anal fin.[9]

9.7 mm

Myomeres: see 6.3 mm.

Morphometry: (as % TL) standard length 91, preanal length head length 21, eye diameter 7, snout length 5, body depth at anus 10.[9]

Morphology: dorsal, anal and caudal fins complete, pelvic buds present, finfold present behind dorsal fin, preanally and behind anal fin.[9]

Pigmentation: dorsal head pigment more intense, more pigment on snout, darkest head pigment on dorsum of occiput, two rows of small, irregularly spaced melanophores on dorsum, merging into a single middorsal line behind the dorsal fin, midlateral stripe more intense, some specimens without portions of ventral gut pigment, with only a few melanophores on the breast.'

JUVENILES

Total length	Description
13 mm	Myomeres: see 6.3 mm. Morphometry: (as % FL) standard length 88, preanal length 58, head length 25, eye diameter 8, snout length 6, body depth at anus 13.[9] Pigmentation: lightly pigmented, darkest pigment over top of head and bordering anal fin, snout with scattered pigment, dark patch of pigment on either side of dorsal fin (separate from two faint dorsal rows), midlateral stripe posterior to dorsal fin, becomes wider near caudal peduncle, venter of head (chin, gill covers, isthmus etc.) never pigmented, scattered light pigment from breast to anus where it intensifies to caudal fin.[9]

ADULTS

Fin rays: caudal 19;* dorsal 8, anal 8 (8 to 9), pectoral 15 (12 to 6), pelvic 9 (8 to 10).[2]

Vertebrae: 36 (34 to 47) (including Weberian vertebrae).[2]

Lateral line scales: 36 to 39.[2]

Pharyngeal teeth: 0,4-4,0.[2]

Diagnostic characters: anal fin rays usually eight (sometimes nine), black pigment about anus and base of anal fin, pigmentation extending below lateral line, no distinct middorsal stripe, lateral band weakly developed or dusky, not continued forward through eye, lateral line complete.

LITERATURE CITED

1. Hubbs and Lagler (1958)
2. Scott and Crossman (1973)
3. Becker (1976)
4. Black (1945)
5. Raney (1969a)
6. Bailey and Gilbert (1960)
7. Snyder (1979a)
8. Potter and Potter (1981)
9. B. F. Lathrop (pers. Comm.)

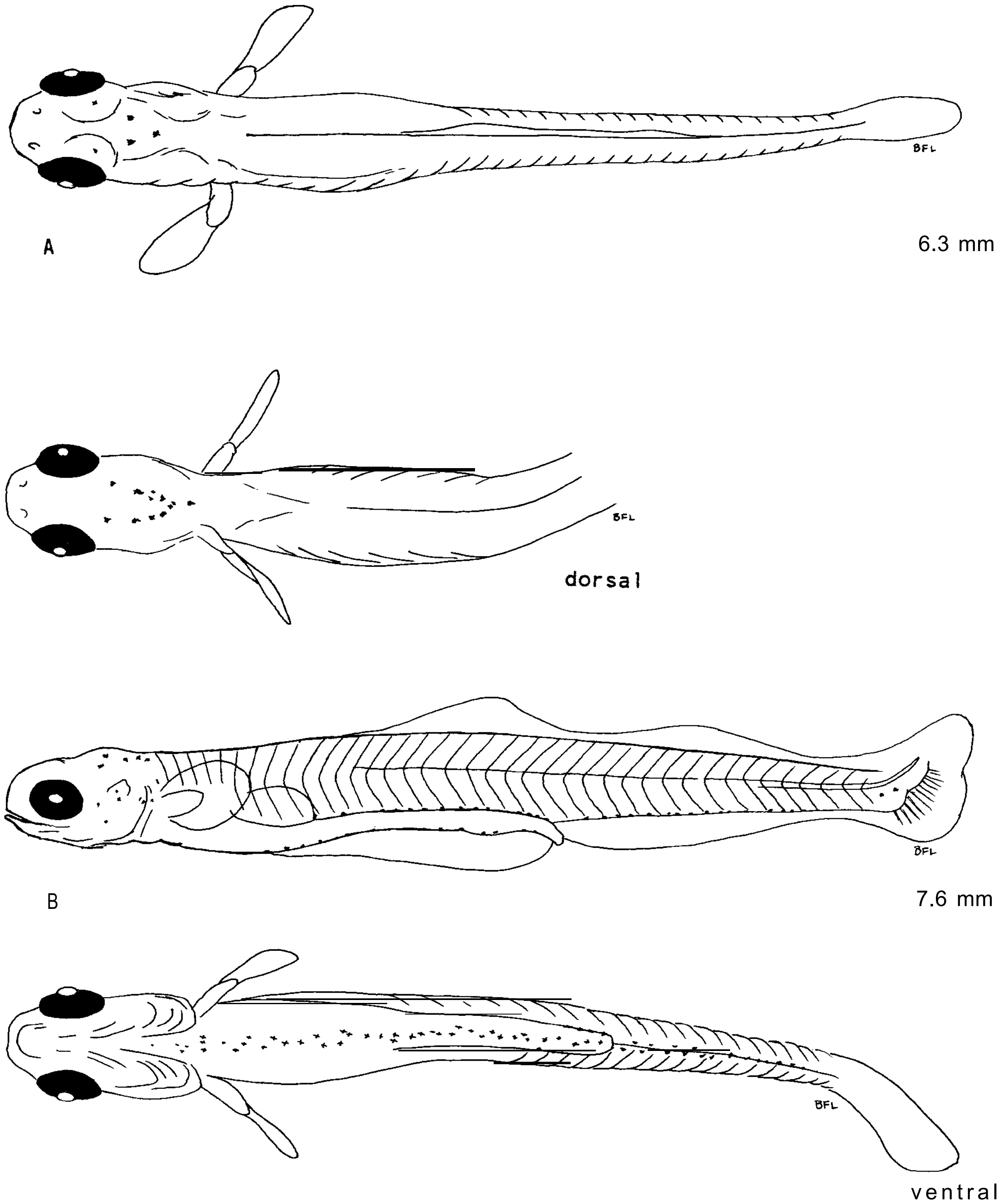


Fig. 113. Notropis volucellus, mimic shiner. A and B. Larvae. (A and B, wild-caught, Pennsylvania, original illustrations by B. F. Lathrop).

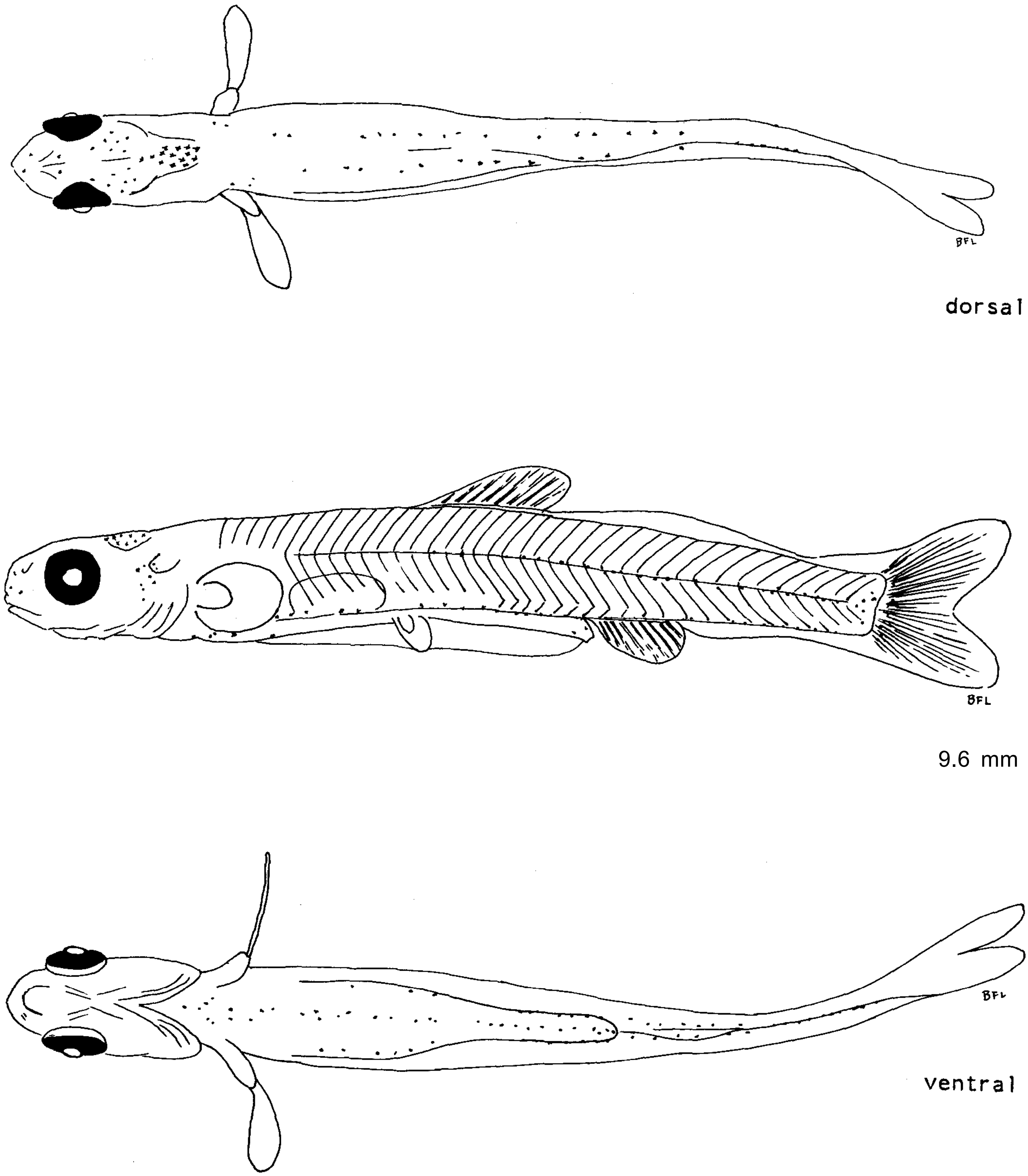


Fig. 114. Notropis volucellus, mimic shiner. Larva. (Wild-caught, Pennsylvania, original illustrations by B. F. Lathrop).

Phoxinus eos (Cope), northern redbelly dace

DISTRIBUTION

Occurs throughout the Great Lakes region, except the Ohio drainage of Lake Erie.[1 7] Commonly found in sluggish tributaries and bog ponds[2] of Lake Michigan, north of the Kalamazoo River, Michigan and Kenosha, Wisconsin.[1]

SPAWNING SEASON

Spawns from late May to August.[3 5] An individual female may spawn two times a year.[5]

SPAWNING TEMPERATURE

Spawns at temperatures between 21 and 27 C.[3]

SPAWNING HABITAT

Spawns in ponds[3] and probably slowly moving streams.*

SPAWNING SUBSTRATE

Deposits eggs among filamentous algae[3] and other vegetation.[5]

FECUNDITY

Not reported.

NATURAL HYBRIDS

Campostoma anomalum, Notropis cornutus;[8] Phoxinus neogaeus.[1]

EGGS

Demersal, nonadhesive;[5] incubation period: 8 to 10 days at 21 to 27 C.[3]

YOLK-SAC LARVAE

Not described.

LARVAE

Not described.

JUVENILES

Not described.

ADULTS

Fin rays: caudal 19;* dorsal 8 (7 to 9), anal 8 (7 to 9), pectoral 14 (13 to 16), pelvic 8.[7]

Vertebrae: 35 to 37 (including Weberian vertebrae).'

Lateral line scales: 70 to 90.[7]

Pharyngeal teeth: 0,5-5,0 0,5-3,0 0,5-4,0.[7]

Diagnostic characters: mouth oblique, terminal and small, not reaching eye, peritoneum black, lateral line incomplete, scales 70 to 90; premaxillae protractile, barbel absent, dorsal fin short (eight rays) .

LITERATURE CITED

1. Becker (1976)
2. Hubbs and Cooper (1936)
3. Cooper (1935)
4. New (1962)
5. Raney (1969a)
6. Hubbs and Lagler (1958)
7. Scott and Crossman (1973)
8. Gilbert (1964)

Phoxinus erythrogaster (Rafinesque), southern redbelly dace

DISTRIBUTION

The Great Lakes distribution of this species is restricted to western Lake Erie drainages in Michigan,[a] and Indiana and southern Wisconsin tributaries of Lake Michigan.[1]

SPAWNING SEASON

Spawns from May to June in New York[6] and Illinois.'

SPAWNING TEMPERATURE

Spawns at temperatures between 10 and 16 C.[3]

SPAWNING HABITAT

Spawns in shallow streams near riffles.[' 7 9]

SPAWNING SUBSTRATE

Deposits eggs in nests of other cyprinids (e.g., Nocomis spp.[3 6 9] and Campostoma spp.') or among gravel.[9]

FECUNDITY

5,708 to 18,888[5] (may include immature ova*); but number of mature eggs per season seldom exceeds 2,500 in other members of the genus.[12]

NATURAL HYBRIDS

Campostoma anomalum;[3 4] Clinostomus elongatus;[10] Notropis cornutus;[3 4] Phoxinus neogaeus;[11] Semotilus atromaculatus.[3 4]

EGGS

Probably demersal and nonadhesive;* yolk light brown.'

YOLK-SAC LARVAE

Not described.

LARVAE

Not described.

JUVENILES

Not described.

ADULTS

Fin rays: caudal 19;* dorsal 8, anal 7 to 8, pectoral 14 or 15, pelvic 8.[2]

Vertebrae: 37 to 39 (including Weberian vertebrae).[2]

Lateral line scales: more than 65.[2]

Pharyngeal teeth: 0,5-5,0.[2]

Diagnostic characters: mouth terminal, small, not reaching eye and nearly horizontal, peritoneum black, lateral line scales more than 65, premaxillae protractile, barbel absent, dorsal fin short.

LITERATURE CITED

1. Becker (1976)
2. Cross (1967)
3. Lachner (1952)
4. Cross and Minckley (1960)
5. Phillips (1969)
6. Raney (1969a)
7. Smith (1908)
8. Hubbs and Lagler (1958)
9. Pflieger (1975)
10. Trautman (1957)
11. Hubbs and Brown (1929)
12. W. C. Starnes (pers. Comm.)

Phoxinus neogaeus Cope, finescale dace

DISTRIBUTION

Occurs in the drainages of all Great Lakes.*[5] In the Lake Michigan drainage, it is found in tributaries north of, and including, the Muskegon River, Michigan and the Milwaukee River, Wisconsin.1

SPAWNING SEASON

Spawns during June and July in Wisconsin' and New York.[7]

SPAWNING TEMPERATURE

Not reported.

SPAWNING HABITAT

Not reported.

SPAWNING SUBSTRATE

Probably spawns in algae or other vegetation.'[3]

FECUNDITY

Not reported.

NATURAL HYBRIDS

Phoxinus eos[2]

EGGS

Not described.

YOLK-SAC LARVAE

Not described.

LARVAE

Not described.

JUVENILES

Not described.

ADULTS

Fin rays: caudal 19;* dorsal 8 (7 to 9), anal 8 (7 to 9), pectoral 14 (12 to 16);[4] pelvic 8.*

Vertebrae: 37 to 39 (including Weberian vertebrae).'

Lateral line scales: 63 to 85.[4]

Pharyngeal teeth: 2,5-4,2 2,5-5,2 1,5-4,1.[4]

Diagnostic characters: mouth horizontal, terminal and nearly reaching anterior margin of eye, peritoneum black, lateral line scales 63 to 85, premaxillae protractile, barbel absent, dorsal fin short (eight rays) .

LITERATURE CITED

1. Becker (1976)
2. New (1962)
3. Raney (1969a)
4. Scott and Crossman (1973)
5. Hubbs and Lagler (1958)

Pimephales notatus (Rafinesque), bluntnose minnow

DISTRIBUTION

Occurs throughout the Great Lakes region.[1,2] In the Lake Michigan drainage it is the most common inland minnow.[3]

SPAWNING SEASON

Spawns from May through August.[3,4,5,7,8,10]

SPAWNING TEMPERATURE

Spawning begins at 19 C[6] and continues to 21 C or higher.’ [8]

SPAWNING HABITAT

Spawns in rivers, streams or lakes.’

SPAWNING SUBSTRATE

Spawns on the undersides of submerged objects.[3,6,7] Often excavates nests below such objects in areas of sand, gravel’ [13] or occasionally marl-bottom shoals in water 5 cm to 2.4 m deep.’

FECUNDITY

1,743 to 2,223.[6]

NATURAL HYBRIDS

Pimephales promelas, P. vigilax.[11]

EGGS

Demersal, adhesive;‘ diameter 1.5 mm;[5,6] incubation period: 6 to lo days at 19 to 25 C.[6]

YOLK-SAC LARVAE

Total length	Description
4.9-5.9 mm	Newly hatched.[5] Morphometry: (as % TL) preanal length 65, greatest body depth 27, eye diameter 10.[5] Morphology: yolk sac large, club-shaped, oil globule absent;[5,12] mouth and anus not open, finfold low and even, origin at myomere 10, pectoral buds developed;[5] but small.[5,12] Pigmentation: colorless except for deep gray eye with golden tinge, some deep orange over yolk, two large stellate chromatophores on underside of yolk sac at anus, barely discernible.[5]

5-7 mm

Myomeres: 36 to 38 [12] (23 to 25 + 12 to 15[9,12]).
Morphometry: (as % TL) standard length 94 to 98;[9,12] preanal length 57 to 64;[5,9,12] predorsal length 39 to 41;[9] head length 18 to 23;[12] eye diameter 8 to 9;[5,12] greatest body depth 12 to 24.[12]
Morphology: bulbous part of yolk sac reduced (5.5 to 5.7 mm), pectoral buds large (4 days old, 6.0 mm);[5] swim bladder beginning to inflate (6.3 mm), locations of incipient dorsal and anal fins apparent, caudal fin rays present (6.4 mm).[12]
Pigmentation: few large melanophores on ventral and ventro-lateral aspects of yolk sac (some specimens without pigment);[5] uneven series on postanal venter;[5,12] few melanophores on midlateral myoseptum (5.0 mm), ventral melanophores in double series from middle of yolk sac to caudal peduncle, many melanophores over swim bladder, row of four over posterior third of yolk sac, row of five on midlateral myoseptum at posterior third of yolk sac, two melanophores before and behind pectoral buds;[5] melanophores on dorsum of head and gut and venter of gut, midlateral stripe from under median finfold to caudal peduncle (6.3 mm).[12]

LARVAE

Total length	Description

6-10 mm

Myomeres: 36 to 38[12] (23 to 25 + 12 to 15[9,12]).
Morphometry: (as % TL) standard length 89 to 95;[9,12] preanal length 62 to 64;[5,9,12] predorsal length 40 to 44;[9] head length 22 to 24;[12] eye diameter 6 to 8;[5] greatest body depth 12 to 16.[5,12]
Morphology: yolk absorbed (6.0 mm;[5,9] 6.4 mm;[12] 1 week old[5]); snout blunt, mouth subterminal, upper jaw below center of eye;[9,12] notochord flexed (6.9 mm).[12]
Pigmentation: more intense, melanophores sparse on dorsum of head, series along midlateral myoseptum from swim bladder to caudal fin, one large subsurface melanophore at base of pectoral bud, dorsum of swim bladder darkly pigmented, three large melanophores follow curve of gill arch below at each side of throat, paralleled posteriorly by six to eight stellate melanophores, four lines of melanophores on venter from middle of gut to anus, conspicuous double postanal series on ventral ridge extends onto caudal fin (6.0 mm, 1 week old), yellow tinge on dorsum of body and gut, short region of iridescence over swim bladder (6.5 mm, 2 weeks);[5] internal row of melanophores between head and dorsal fin (6.9 mm), pigment concentrated on occiput, few melanophores between eyes and snout, two rows on dorsum, fusing behind dorsal fin to caudal fin, epaxial

portion of postanal myomeres outlined, caudal spot faint, ventral pigment sparse, melanophores outlining isthmus and posterior gut (8.3 mm).[12]

9-11 mm Myomeres: 37 to 39 (25 + 12 to 14).[9]
Morphometry: (as % TL) standard length 85 to 91, preanal length 60 to 61, predorsal length 44 to 46.[9]
Morphology: anal fin rays present (10.1 mm).[12]

JUVENILES

Total length	Description
12-16 mm	Myomeres: 35 to 36 (23 to 25 + 11 to 12).[12] Morphometry: (as % TL) standard length 83 to 85, preanal length 585 to 62;[12] predorsal length 46;[5] head length 21 to 22, eye diameter 8;[5,12] snout length 17;[5] greatest body depth 13 to 16;[5,12] body depth at anus 8, (as % head length) eye diameter 38, greatest body depth 62, body depth at anus 38.5 Morphology: mouth inferior, horizontal, lower jaw included, body slender, dorsum somewhat depressed, caudal peduncle slender.[5] Pigmentation: black spot at base of caudal fin, diffuse melanophores over snout and cheek, lateral band originating behind head, melanophores on top of head and along dorsum in irregular longitudinal rows, more concentrated at base of dorsal fin and on intestine, peritoneum light (although a 17.8-mm specimen was quite dark), many melanophores grouped around base of anal fin, hence a double row to base of caudal fin, few melanophores on pectoral and caudal fins, sides of body unpigmented, except lateral band and belly.[5]

ADULTS

Fin rays: caudal 19;* dorsal 8, anal 7 (7 to 8), pectoral 15 (14 to 17), pelvic 8.[11]

Vertebrae: 37 to 38 (including Weberian vertebrae).[1]

Lateral line scales: 42 to 50.[1]

Pharyngeal teeth: 0,4-4,0.[1]

Diagnostic characters: predorsal scales small and crowded, lateral line complete continues through eye, caudal spot present, mouth subterminal, intestine long and much coiled, peritoneum black.

LITERATURE CITED

1. Scott and Crossman (1973)
2. Hubbs and Lagler (1958)
3. Becker (1976)
4. Hankinson (1919)
5. Fish (1932)
6. Westman (1938)

7. Hubbs and Cooper (1936)
8. Dobie et al. (1956)
9. Perry and Menzel (1979)
10. Smith (1979)
11. Trautman (1957)
12. Buynak and Mohr (1979f)
13. Van Cleave and Markus (1929)

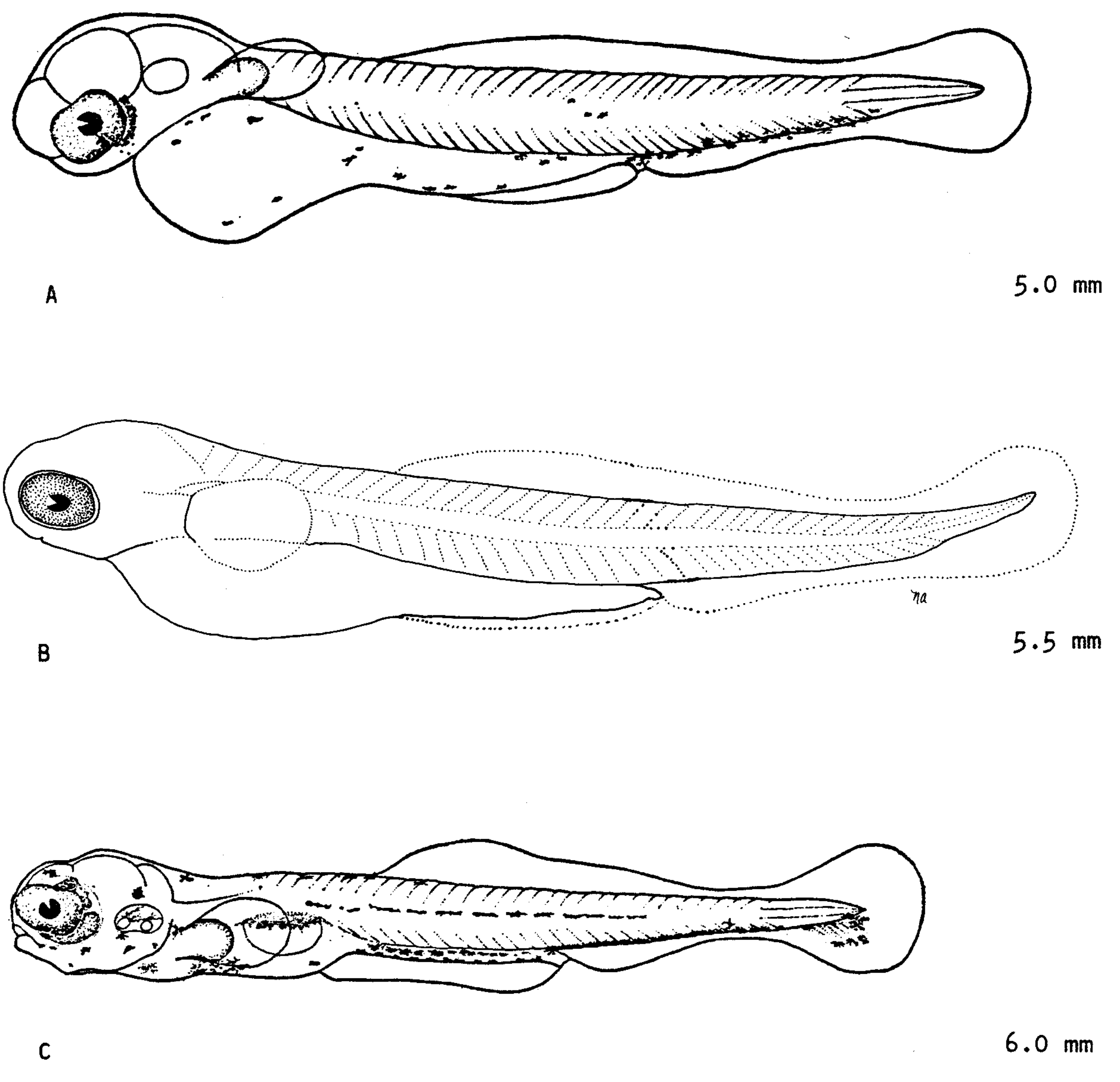


Fig. 115. Pimephales notatus, bluntnose minnow. A and B. Yolk-sac larvae. C. Larva. (A and C, laboratory-reared, Lake Erie tributary, Fish 1932; B, wild-caught, Iowa, original illustration by N. A. Auer, specimen provided by L. G. Perry).

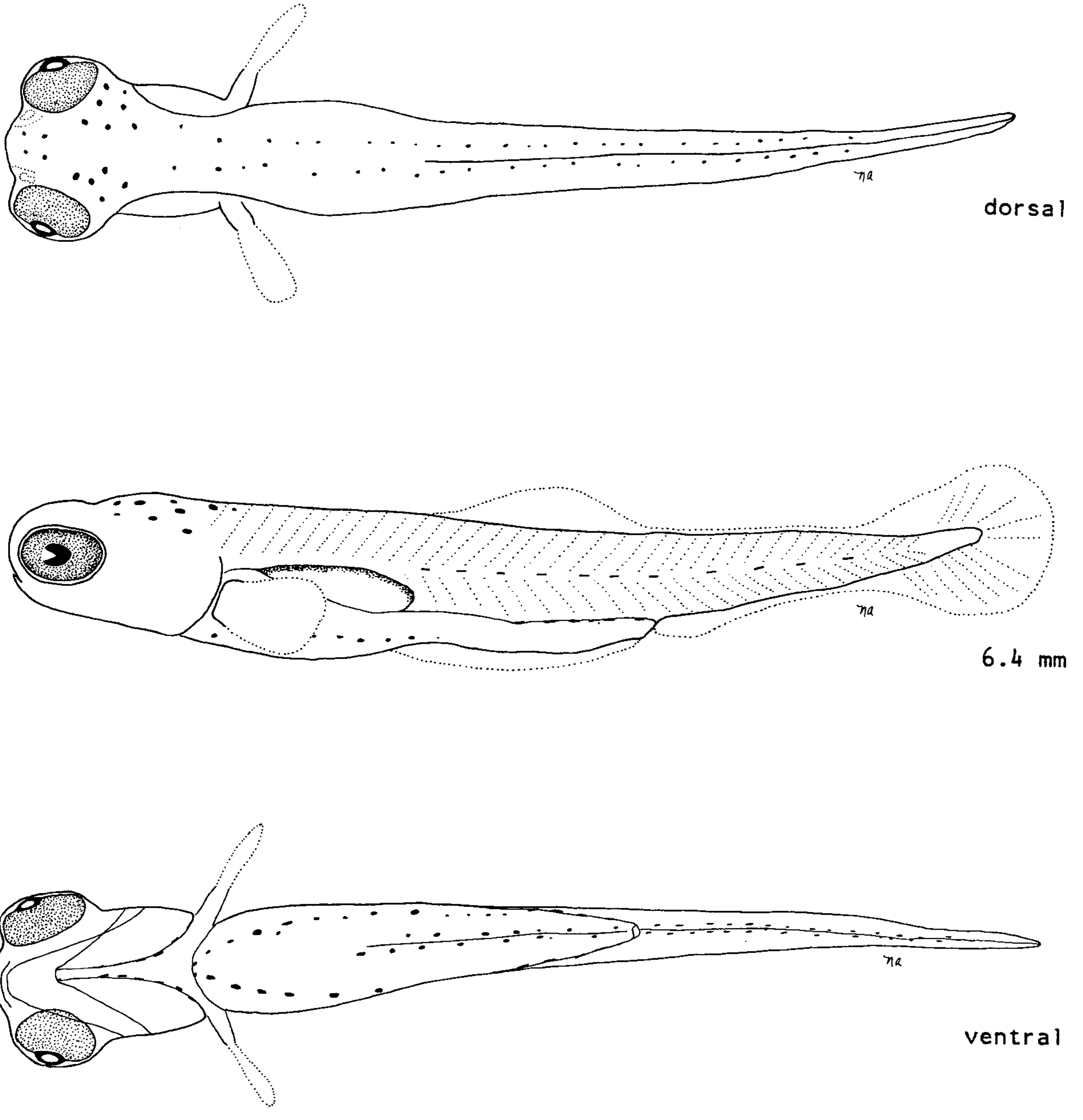


Fig. 116. Pimephales notatus, bluntnose minnow. Larva. (Wild-caught, Iowa, original illustrations by N. A. Auer, specimens provided by L. G. Perry).

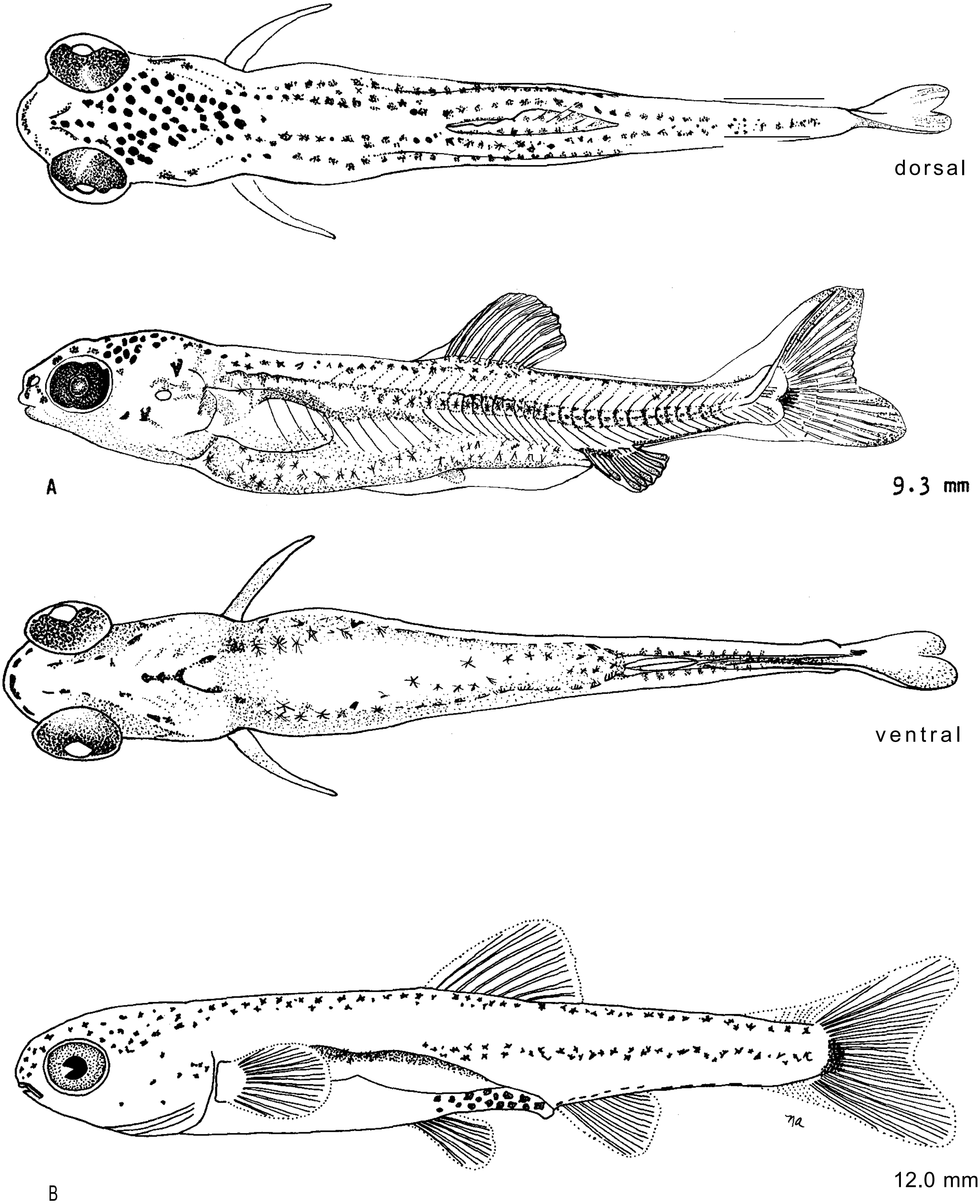


Fig. 117. Pimephales notatus, bluntnose minnow. A. Larva. B. Juvenile. (A, laboratory-reared, Maryland, Loos et al. 1979; B, wild-caught, Iowa, original illustration by N. A. Auer, specimen provided by L. G. Perry).

Pimephales promelas Rafinesque, fathead minnow

DISTRIBUTION

Generally distributed throughout the Great Lakes basin.[1] In Lake Michigan, it is found throughout the western and northern watersheds and from the Grand River system northward in the east.[2]

SPAWNING SEASON

Spawns from May to late summer in Illinois[2,7] and Pennsylvania.[17]

SPAWNING TEMPERATURE

Eggs were found at 18 C[3,5,6] and 16 C.[2]

SPAWNING HABITAT

Spawns in ponds[5,6,*] and slower-moving sections of streams.*

SPAWNING SUBSTRATE

Deposits eggs on the undersides of objects.[3,14,*]

FECUNDITY

Numerous references; summary indicates 255 to 2,622 ova per female.[10] A single female may deposit 391 to 480 eggs at a time and 4,144[3,6] to 10,164[17] eggs throughout a season in 12[3,6] to 26[17] spawnings.

NATURAL HYBRIDS

Pimephales notatus.[15]

EGGS

Demersal, adhesive, diameter 1.4 to 1.6 mm;[4,8] yolk diameter 0.8 mm;[4] mean 1.2 mm, incubation period: approximately 5 days at 23 to 30 C.[3]

YOLK-SAC LARVAE

Total length	Description
4-6 mm	Hatching length: ca. 4.0 mm; or 4.9 or to mm.[16] Myomeres: 34 to 39 (21 to 25 + 12 to 15);[9] 34 to 36 (19 to 21 + 15), predorsal 9 to 11.[8] Morphometry: (as % TL) standard length 94 to 97, preanal length 58 to 62;[8,9,16] predorsal length 37 to 42;[8,9] head length 17 to 21, eye diameter 7 to 9;[8,16] snout length 1 to 2, greatest body width 7 to 19;* greatest body depth 12 to 23;"[16] greatest head depth 12 to 15.[8]

Morphology: pectoral buds present;[8] eye round, (oval in *P. notatus*);[9] head decurved over bulbous yolk sac (newly hatched), mouth open (5.3 mm), swim bladder inflating (5.7 mm).[11]
Pigmentation: eye dark, melanophores scattered over yolk sac, a few faint melanophores on head, opercle, postanal dorsum and venter;[8 16] pigment on swim bladder and midlateral myoseptum (5.3 mm), melanophores on occiput, dorsum behind head, venter of yolk sac and caudal peduncle and faintly on tip of urostyle (5.7 mm);[16] or heavy pigmentation dorsally over head and body (5.0 to 5.5 mm);[9] series along ventral surface of gill cover.[8]

LARVAE

Total length	Description
6-9 mm	Myomeres: 34 to 37[8 16] (22 to 25[9 16] + 12 to 15[8 9 16]); predorsal 9 to 11.[8] Morphometry: (as % TL) standard length 86 to 95, preanal length 53 to 63, predorsal length 38 to 43;[8 9] head length 19 to 21, eye diameter 8 to 9, snout length 3, greatest body width 9 to 11, greatest body depth 12 to 14, greatest head depth 14 to 15.[8] Morphology: yolk absorbed (ca. 5.6 to 6.5 mm);[8 16] median fin rays forming (7.9 mm);[8] mouth terminal;[8 9] snout not decurved, upper jaw level with the center of eye.[9] Pigmentation: pigment on snout (6.3 mm);[16] and prominent along venter of gill cover, little pigment in midventral region, subsurface concentration of melanin on lower hypurals.[8]
9-17 mm	Myomeres: 34 to 37[8 16] (23 to 25[9 16] + 11 to 14[8 9 16]); predorsal 11 to 14.[8] Morphometry: (as % TL) standard length 81 to 88, preanal length 56 to 61, predorsal length 43 to 46;[8 9 11] prepelvic length 44 to 46;[8] head length 21 to 24, eye diameter 7 to 9;[8 11] snout length 4;[8] greatest body width 10 to 16;[8] greatest body depth 14 to 19;[8 11] body depth at anus 12;[11] greatest head depth 14 to 18.[8] Morphology: notochord flexed, pectoral fin rays present (9.6 mm[12] or 14.5 mm[16]); dorsal and anal fin rays formed (11.6 mm), pelvic buds small, inserted immediately below dorsal fin origin, caudal fin moderately forked, body robust, snout obtuse, mouth very small, terminal, oblique.[11] Pigmentation: wide dorsal series present (three to six lines wide) to caudal fin, single lateral series, many melanophores on dorsum of gut, double postanal series on ventral ridge, spreading widely around anal fin

base;[11] caudal spot not observed but faint intensification of pigment near hypurals;[16] few chromatophores on dorsal fin, many on caudal fin.[11]

JUVENILES

Total length	Description
17-28 mm	Morphometry: (as % TL) standard length 80, preanal length 57, head length 22, eye diameter 6, greatest body depth 18.[16] Morphology: finfold absorbed (17 mm);[8] mouth terminal;" squamation complete (28 mm).[12] Pigmentation: pigment concentrated on dorsal fin base and gut, distinct lateral band and caudal spot absent.[16]

ADULTS

Fin rays: caudal 19, dorsal 8, anal 7, pectoral 15 (14 to 18), pelvic 8.[13]

Vertebrae: 37 (35 to 38) (including Weberian vertebrae).[13]

Lateral line scales: 41 to 54.[13]

Pharyngeal teeth: 0,4-4,0.[13]

Diagnostic characters: predorsal scales small and crowded, peritoneum brownish black, lateral line incomplete, mouth oblique, predorsal stripe present.

LITERATURE CITED

1. Hubbs and Lagler (1958)
2. Becker (1976)
3. Markus (1934)
4. Wynne-Edwards (1932)
5. Dobie et al. (1948)
6. Dobie et al. (1956)
7. Smith (1979)
8. Synder et al. (1977)
9. Perry and Menzel (1979)
10. Carlander (1969)
11. Fish (1932)
12. Andrews (1970)
13. Scott and Crossman (1973)
14. Richardson (1937)
15. Trautman (1957)
16. Buynak and Mohr (1979f)
17. Gale and Buynak (1982)

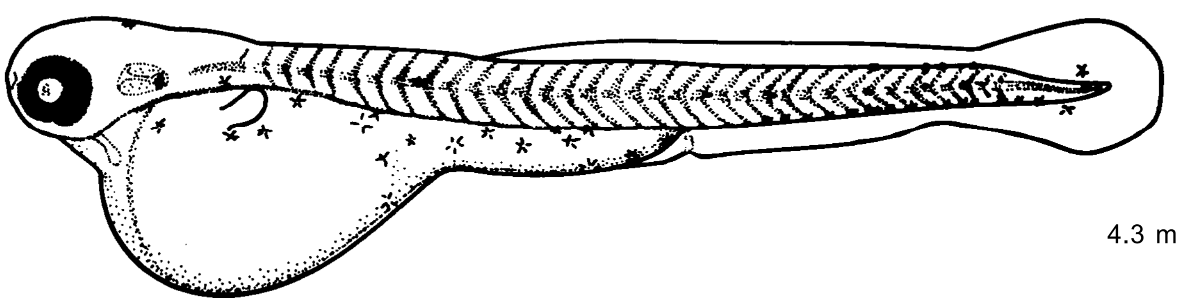


Fig. 118. Pimephales promelas, fathead minnow. Yolk-sac larva. (Laboratory-reared, Ohio, Snyder et al. 1977).

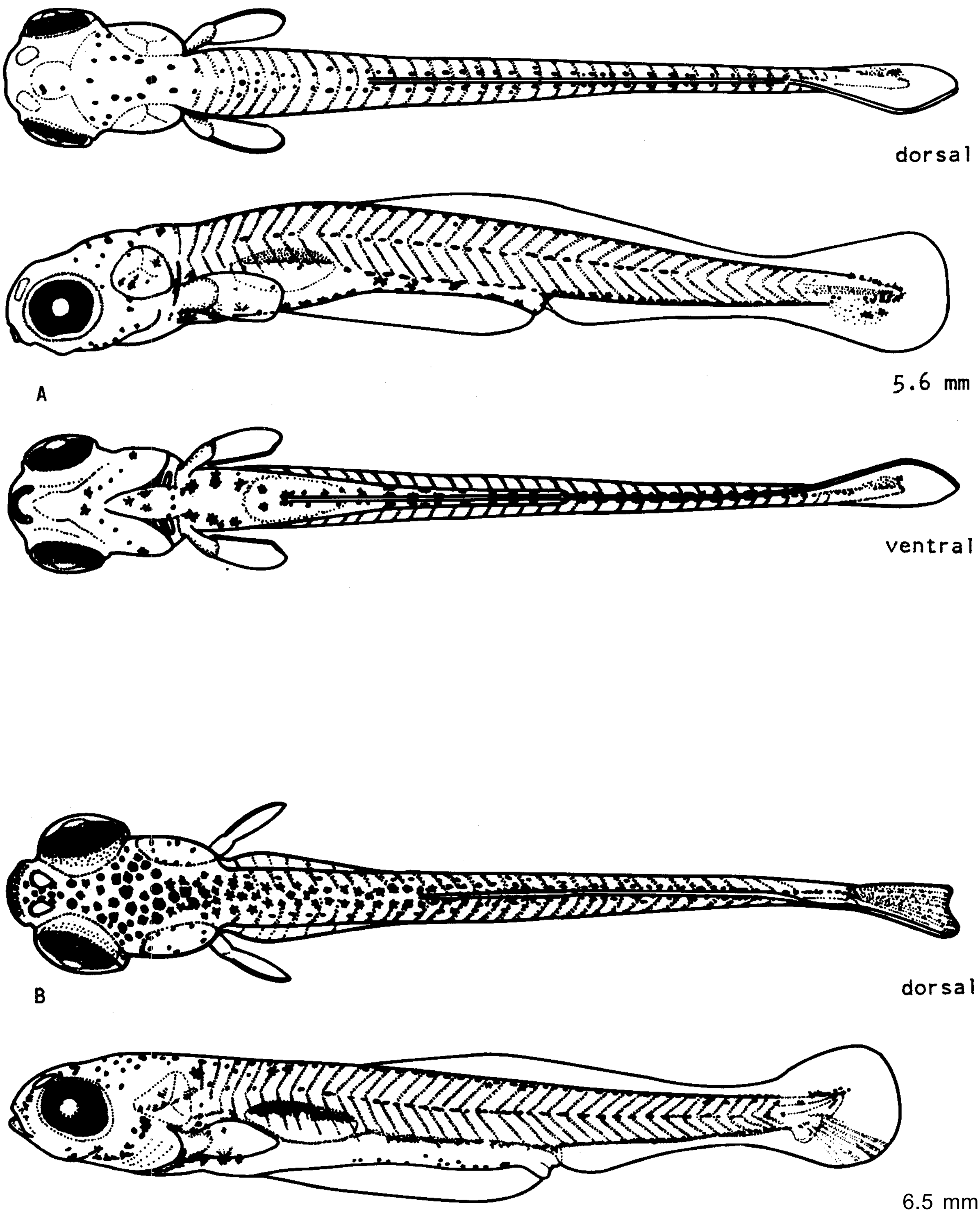


Fig. 119. Pimephales promelas, fathead minnow. A and B. Larvae. (A and B, laboratory-reared, Ohio, Snyder et al. 1977).

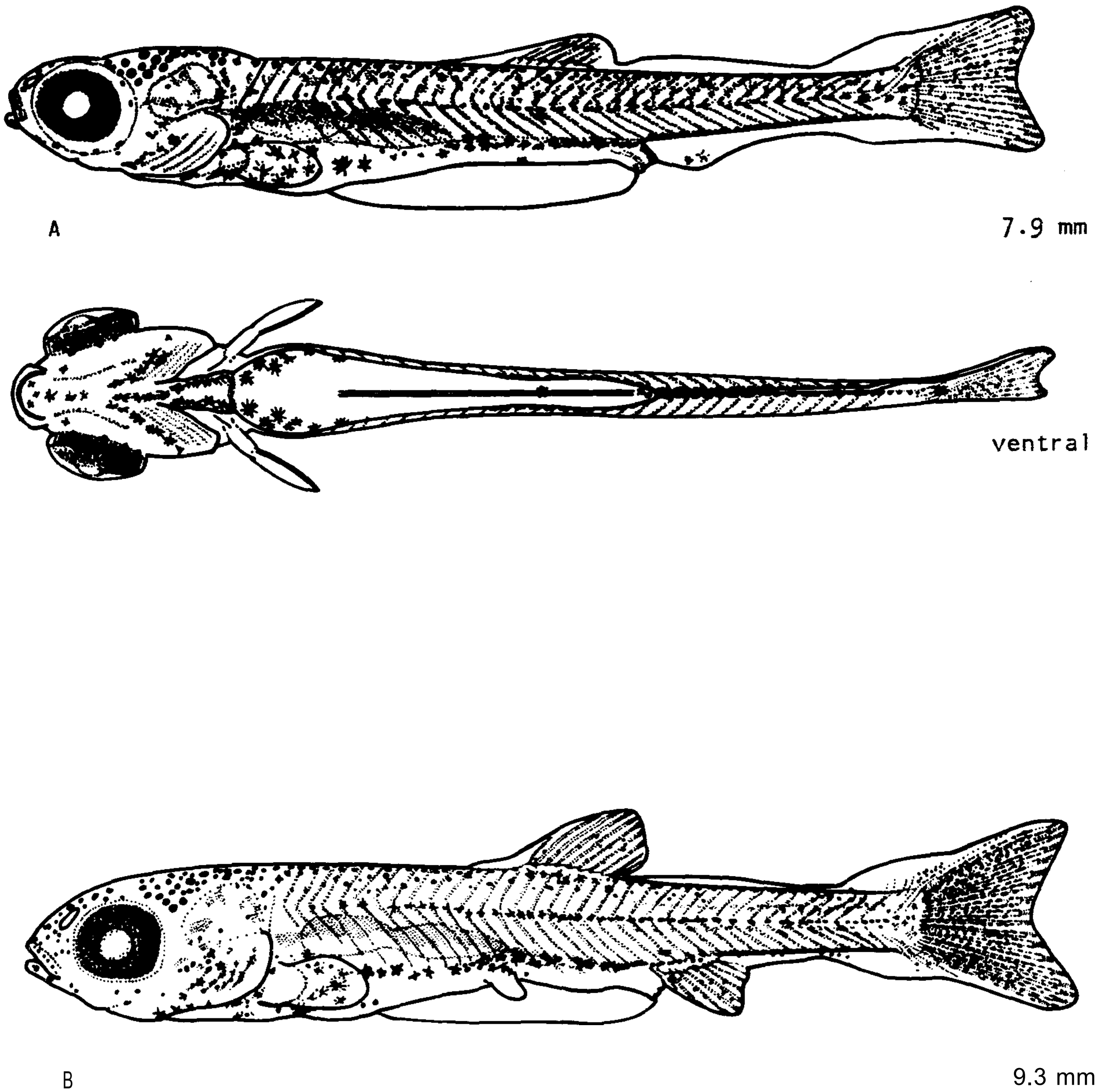


Fig. 120. Pimephales promelas, fathead minnow. A and B. Larvae. (A and B, Ohio, Snyder et al. 1977).

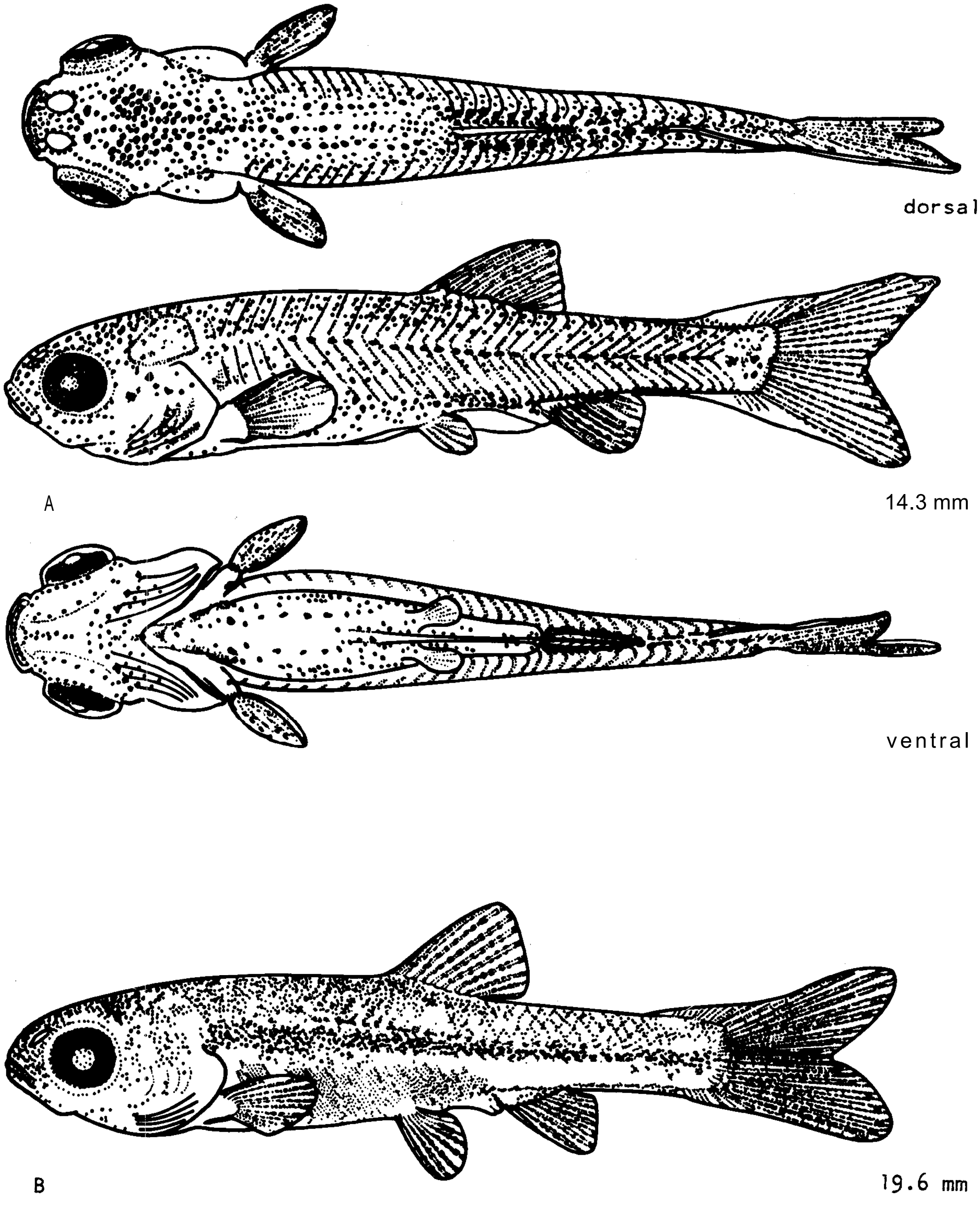


Fig. 121. Pimephales promelas, fathead minnow. A and B. Larvae. (A and B, Ohio, Snyder et al. 1977).

Pimephales vigilax (Baird and Girard), bullhead minnow

DISTRIBUTION

The only verified reports of this species in the Great Lakes region are from the upper Fox River, Wisconsin' and Lake St. Marys in Ohio.[2] It is common in the Mississippi River system.' [2]

SPAWNING SEASON

Spawns in June and July in Wisconsin,' late May to late July in Illinois[4] and mid-Hay to September in Oklahoma.[5]

SPAWNING TEMPERATURE

Spawns at 21[5] to 26 C.[3]

SPAWNING HABITAT

Spawns in shallow pools or slowly flowing water of medium to large streams, [1] also in small ponds."

SPAWNING SUBSTRATE

Deposits eggs on the undersides of submerged objects.' [3]

FECUNDITY

Not reported.

NATURAL HYBRIDS

Pimephales notatus.[6]

EGGS

Adhesive, diameter 1.0 to 1.5 mm, reflecting purple, blue, red and green colors, incubation period: 4.5 to 6 days at 26 to 28 C.[3]

YOLK-SAC LARVAE

Not described, but illustrated.[5]

LARVAE

Yolk absorbed (ca. 6.0 mm, seen from illustration).[5]

JUVENILES

All fin rays formed (ca. 11.0 mm, seen from illustration).[5]

ADULTS

Fin rays: caudal 19;* dorsal 8, anal 7 (7 to 8);[6] pectoral 14 to 15, pelvic 8 to 9.*

Vertebrae: not reported.

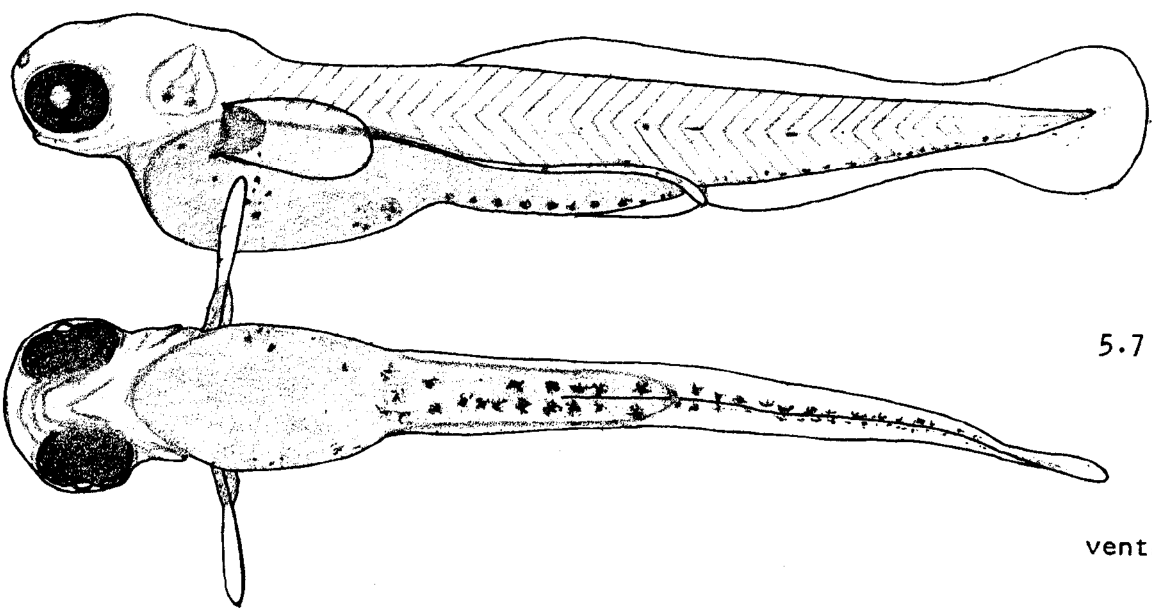
Lateral line scales: 37 to 42;[4] 41 to 49.[6]

Pharyngeal teeth: 0,4-4,0.[4]

Diagnostic characters: predorsal scales crowded and smaller, silvery peritoneum, short gut, terminal mouth.'

LITERATURE CITED

1. Becker (1976)
2. Hubbs and Lagler (1958)
3. Parker (1964)
4. Pflieger (1975)
5. Taber (1957)
6. Trautman (1957)



5.7 mm

ventral

Fig. 122. *Pimephales vigilax*, bullhead minnow. Yolk-sac larva. (Wild-caught, Oklahoma, Taber 1969).

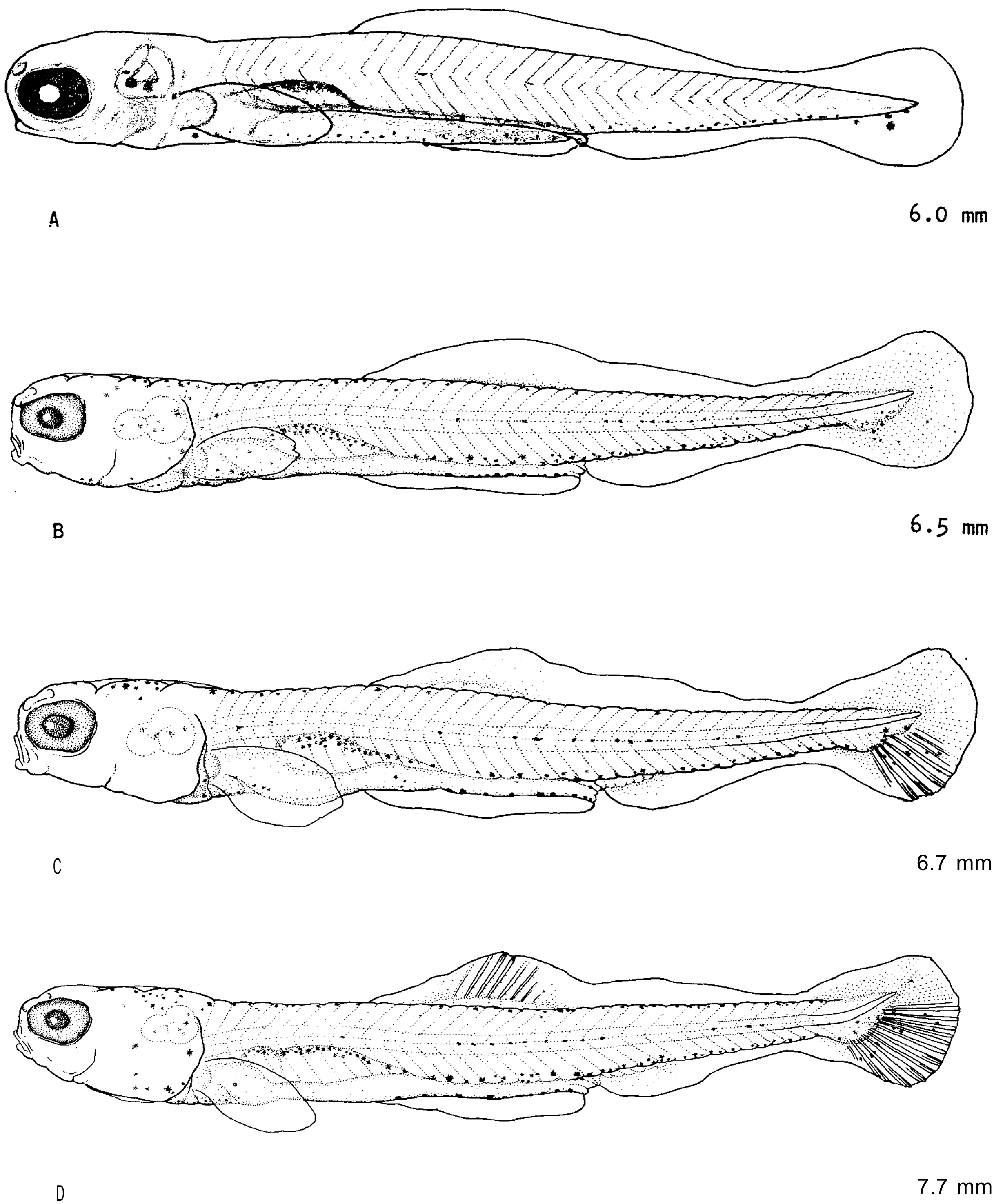


Fig. 123. Pimephales vigilax, bullhead minnow. A-D. Larvae. (A, wild-caught, Oklahoma, Taber 1969; B-D, wild-caught, Louisiana, original illustrations by J. V. Conner).

Pimephales vigilax

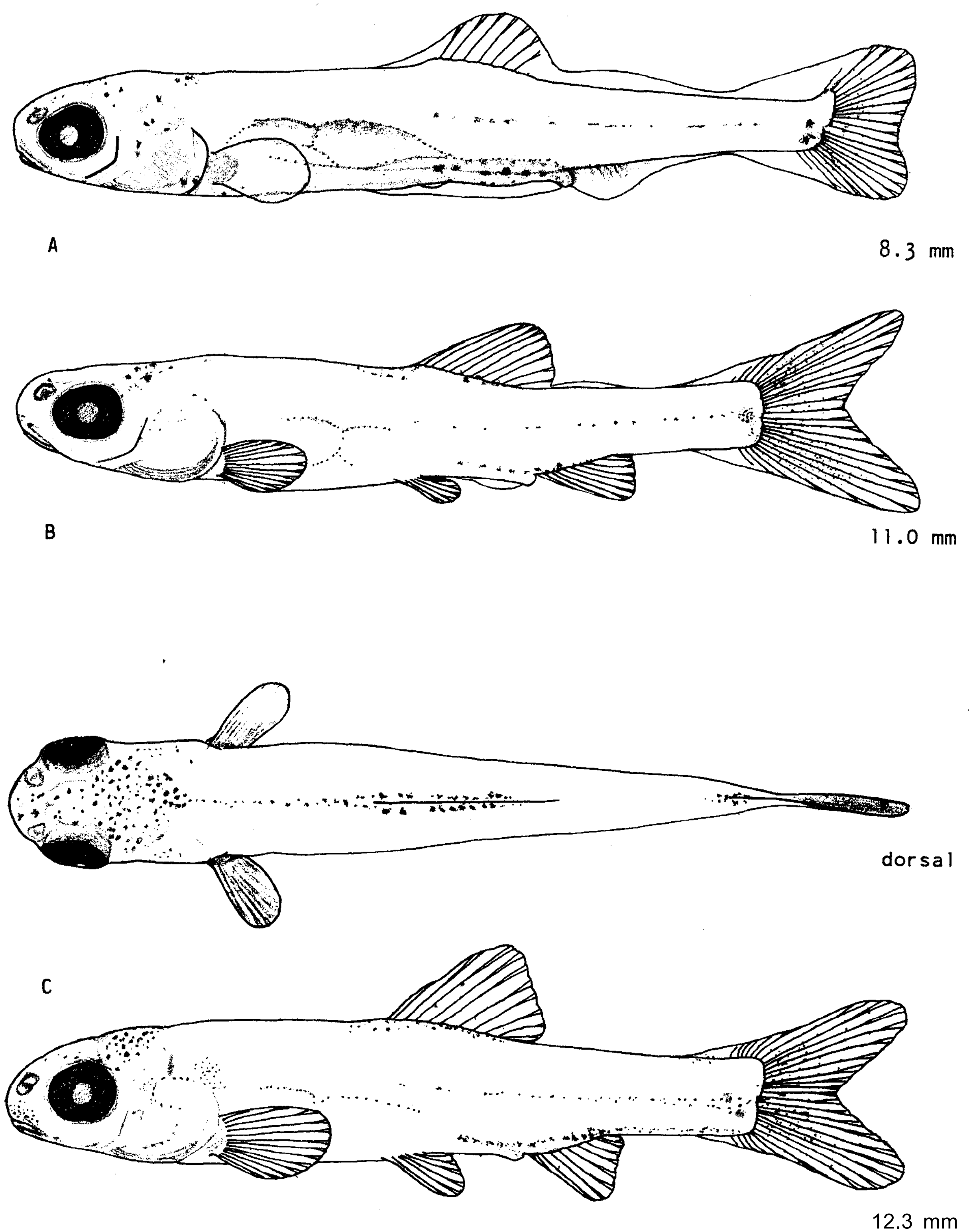


Fig. 124. Pimephales vigilax, bullhead minnow. A and B. Larvae. C. Juvenile. (A-C, wild-caught, Oklahoma, Taber 1969).

Rhinichthys atratulus (Hermann), blacknose dace

DISTRIBUTION

This species occurs throughout the Great Lakes region.[16 17] It is common in most tributaries of Lake Michigan, but not in the lake proper.'

SPAWNING SEASON

Spawns from late May to early June in Michigan.[2] Spawning may occur as early as April in Wisconsin.[1]

SPAWNING TEMPERATURE

Spawning temperatures of 12 to 20 C have been reported," but peak activity probably occurs between 18 and 22 C.[2 10 13]

SPAWNING HABITAT

Spawns in shallow streams, 10 to 20 cm deep,[12] over riffles.2 However, subspecies may vary.[12]

SPAWNING SUBSTRATE

Deposits eggs among fine gravel and sand' [7 12] or rarely in nests of other cyprinids.[3 4 14] Commonly spawns in riffles with Catostomus commersoni and R. cataractae.[5]

FECUNDITY

375' to 2,674.' [11]

EGGS

Demersal, adhesive, diameter 2.1 to 2.5 mm;[5 6] (a report of 0.8 mm[10] probably represents ova not water hardened*); yolk amber;[6 10] oil globule absent, incubation period: 110 hours at 16 to 20 C;[6] 7 days at 19 C.[15]

YOLK-SAC LARVAE

Total length	Description
4.9-6.5 mm	Newly hatched.[6 10 15] Morphometry: (as % TL) preanal length 60, head length 21, eye diameter 9.[6] Morphology: pectoral buds present, head deflected over yolk sac;[6 15] yolk sac club-shaped.[6] Pigmentation: eye partly pigmented;[6 15] two dorsal rows of melanophores from head to midbody;[15] faint midlateral stripe, melanophores on dorsum of yolk sac.[6]

5-7 mm	Myomeres: 37 to 41[15] (23 to 26[6 15] + 13 to 16[15]), usually 40 (25 + 15).[15] Morphometry: (as % TL) preanal length 63, head length 17, eye diameter 8, greatest body depth 19.[15] Pigmentation: eye completely pigmented;[15] two rows on dorsum extending to tail, faint median predorsal row (subsurface), midlateral stripe present (6.8 mm);[6 15] perimeter of yolk sac (in lateral view) outlined with melanophores, few melanophores on postanal venter.[6]

LARVAE

Total length	Description
7-14 mm	Myomeres: 38 to 39 (23 to 26 + 13 to 16), usually 39 (25 + 14).[15] Morphometry: (as % TL) preanal length 59, head length 22, eye diameter 8, greatest body depth 16.[15] Morphology: yolk absorbed (7.0 to 7.2 mm);[6 15] mouth open, swim bladder inflated (7.8 mm), first caudal fin rays formed, notochord flexed (8.2 mm), first dorsal fin rays formed (9.2 mm), pectoral and anal fin rays present (12.8 mm), pelvic buds present (ca. 11.0 mm;" 12.0 mm[13] or 13.6 mm[15]). Pigmentation: midlateral stripe wide;[6 7 15] melanophores on caudal, dorsal, anal and pectoral fin membranes;[6 15] caudal spot on end of peduncle, extending onto fin.[7 15]
14-20 mm	Myomeres: 36 to 39 (22 to 24 + 13 to 15), usually 37 (23 + 14) I 15 Morphometry: (as % TL) preanal length 54;[15] head length 21 to 22, eye diameter 7;[5 15] greatest body depth 17.[15] Morphology: first scales forming (15 mm);[9] pelvic fin rays present (16.6 mm), all fin rays complete (19.5 mm).[15] Pigmentation: melanophores scattered on predorsal area, two rows behind dorsal fin vague;[15] melanophores in caudal fin aligned with rays.[6]

JUVENILES

Total length	Description
14-32 mm	Morphometry: (as % TL) preanal length 55;[16] head length 21[15] to 24;[6] eye diameter 6[15] to 7;[6] greatest body depth 18.[15] Morphology: mouth slightly inferior;[15] all f infolds absorbed.[6] Pigmentation: caudal spot extending into caudal fin ray;' [8 15] midlateral stripe reticulate, scattered speckling on sides.[6]

ADULTS

Fin rays: caudal 19;* dorsal 8 (7 to 8), anal 7 (6 to 8), pectoral 13 to 16, pelvic 8.[16]

Vertebrae: 38 to 39 (37 to 40) (including Weberian vertebrae).[16]

Lateral line scales: 56 to 68.[16]

Pharyngeal teeth: 2,4-4,2.[16]

Diagnostic characters: terminal maxillary barbel present, mouth nearly terminal, frenum present, premaxillae not protractile, dorsal fin short (eight rays) .

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12. Raney (1940a)
13. Wang and Kernehan (1979)
14. Raney (1969a)
15. Buynak and Mohr (1979d)
16. Scott and Crossman (1973)
17. Hubbs and Lagler (1958)

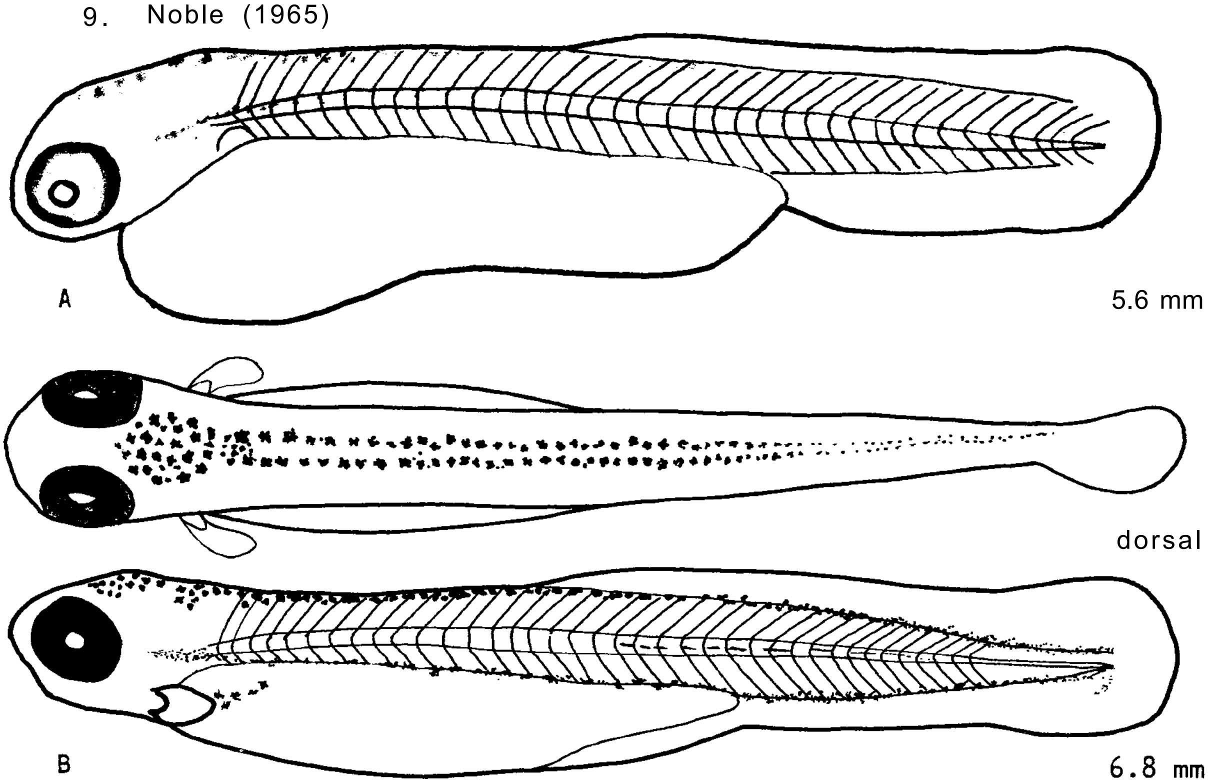

Fig. 125. Rhinichthys atratulus, blacknose dace. A and B. Yolk-sac larvae. (A and B, laboratory-reared, Pennsylvania, Buynak and Mohr 1979d).

<u>*Rhinichthys atratulus*</u>

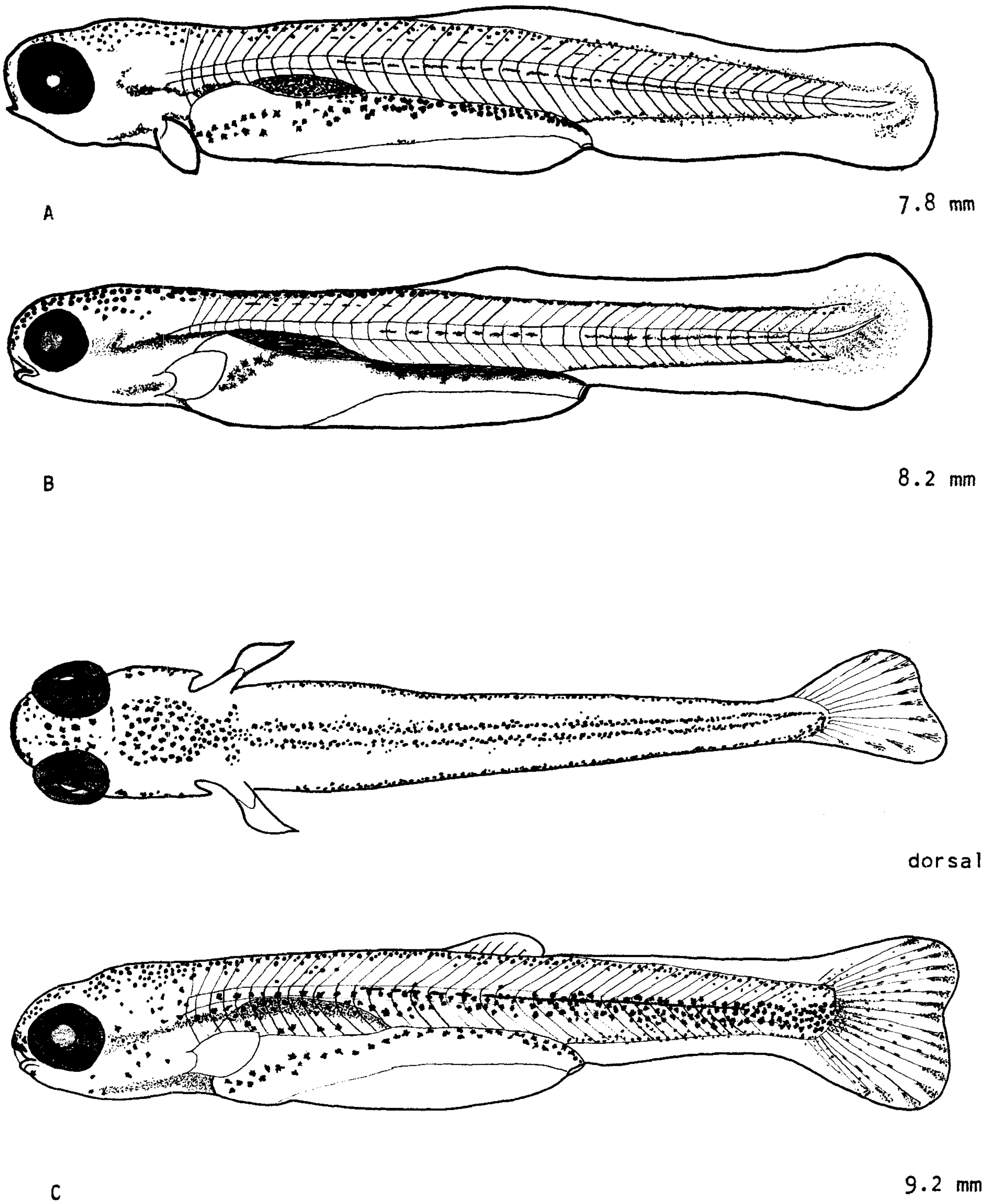

Fig. 126. *Rhinichthys atratulus*, blacknose dace. A. Yolk-sac larva. B and C. Larvae. (A-C, laboratory-reared, Pennsylvania, Buynak and Mohr 1979d).

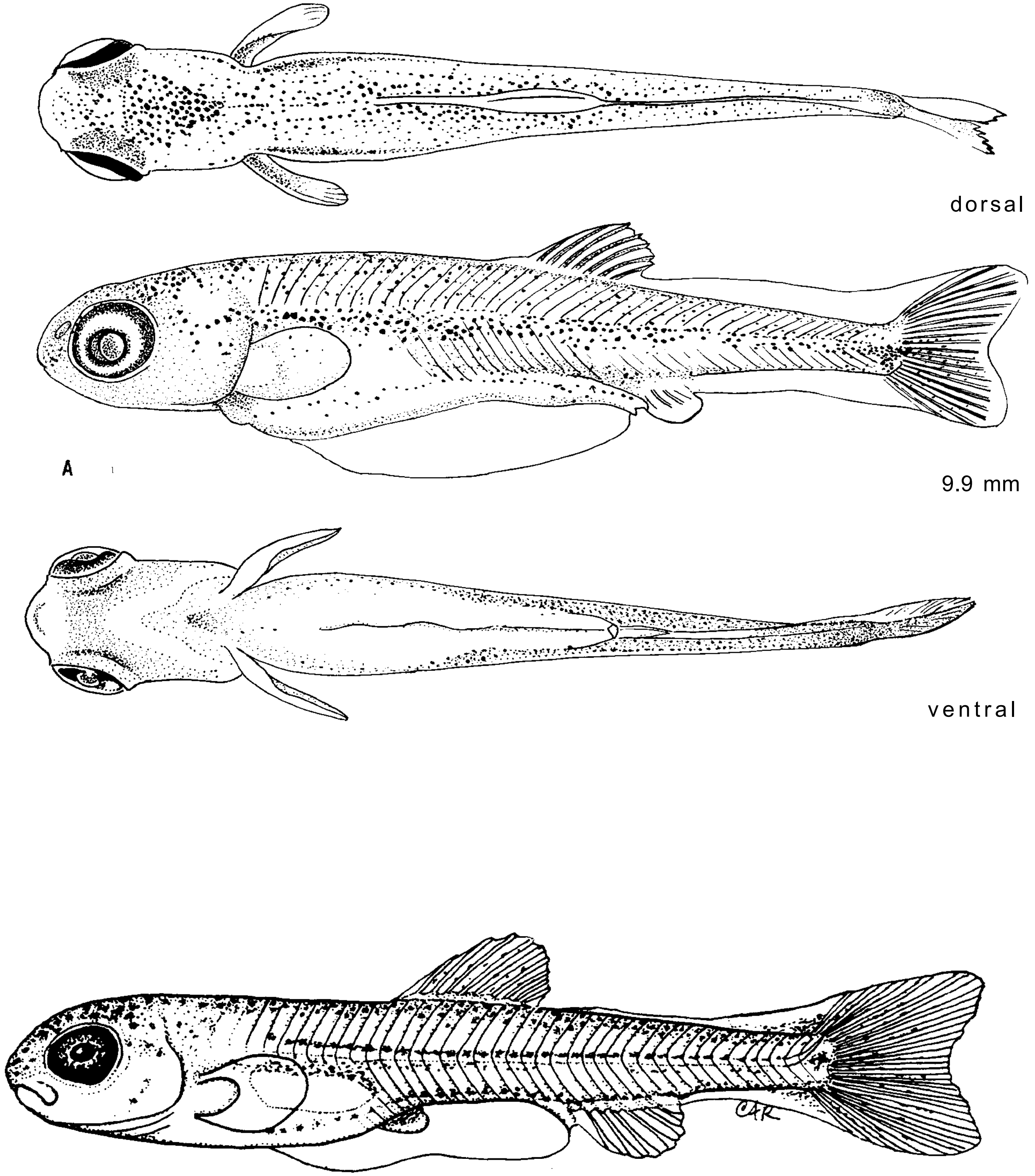

Fig. 127. Rhinichthys atratulus, blacknose dace. A and B. Larvae laboratory-reared, Maryland, Loos et al. 1979; B, laboratory-rear::', Delaware, Wang and Kernehan 1979).

Rhinichthys atratulus

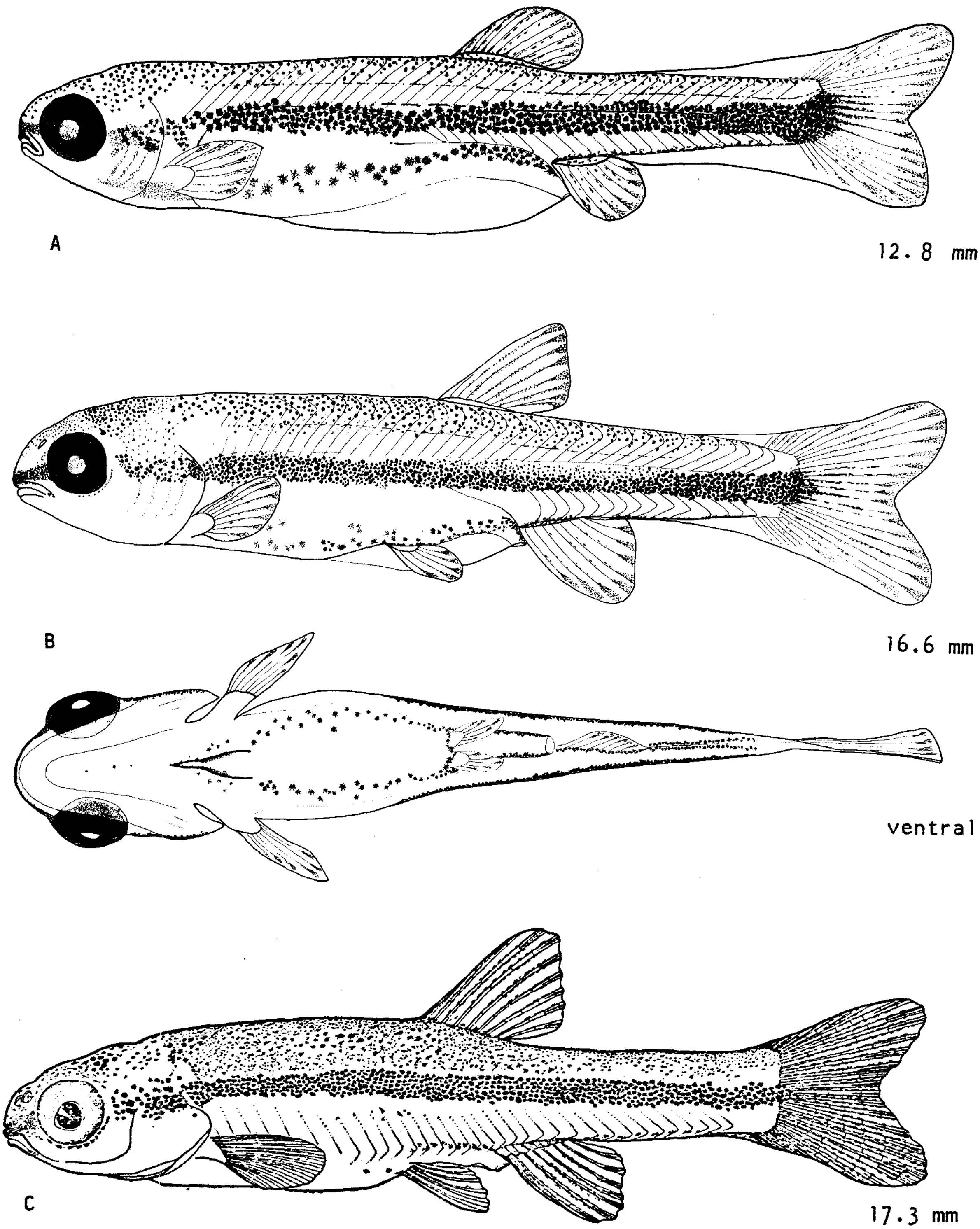

Fig. 128. Rhinichthys atratulus, blacknose dace. A and B. Larvae. C. Juvenile. (A and B, laboratory-reared, Pennsylvania, Buynak and Mohr 1979d; C, wild-caught, Lake Erie tributary, Fish 1932).

Rhinichthys cataractae (Valenciennes), longnose dace

DISTRIBUTION

This species is distributed throughout the Great Lakes region.[11 12] It occurs in the shallow coastal waters and along the entire western shore of Lake Michigan. On the eastern shore it occurs north of the Muskegon River.[1]

SPAWNING SEASON

Spawns during late June and early July in Lake Michigan.'

SPAWNING TEMPERATURE

Spawns at temperatures over 15 C,[4] usually between 14 and 19 C.[2]

SPAWNING HABITAT

Spawns in streams' and along the shoreline of lakes.[5] Sometimes spawns in association with Catostomus commersoni.[8]

SPAWNING SUBSTRATE

Deposits eggs among gravel' or rarely in nests of other cyprinids.[3 6 8] Spawning in such nests may occur when the attending male abandons the nests.[15]

FECUNDITY

Maximum: 10,000.[2]

NATURAL HYBRIDS

Campostoma anomalum;' Couesius plumbeus;'[13 14] Nocomis micropogon, Notropis cornutus.'

EGGS

Demersal, adhesive;' diameter 2.1[3 6] to 2.7 mm;[7] yolk amber, oil globule absent;[7] incubation period: 3 to 4 days at 18 to 24 C;[3 6] 6 days at 18 C.[10]

YOLK-SAC LARVAE

Total length	Description
5.8-6.2 mm	Newly hatched;'[10] values as low as 4.5' and 5.5 to 6.0 mm[3 6] have been reported.
	Morphology: head flexed over yolk sac;[6 7 10] yolk sac club-shaped;'[10] pectoral buds absent in illustrated specimen.[3 6]

Pigmentation: margins of eyes pigmented;[3,6,7] body pigment absent.[3,6,7,10]

6-g mm

Myomeres: 39 to 41[10] (25 to 277[10] + 13 to 15[10]), usually 39 (26 + 14).[10]

Morphometry: (as % TL) preanal length 64[10] to 67;[7] head length 17[10] to 19;[7] eye diameter 8;[7,10] greatest body depth 19.[10]

Morphology: head straight (7.1 mm);[7] mouth opened, swim bladder inflated (8.56 to 8.7[10] mm); caudal fin rays forming, hypural bones forming, notochord flexed, dorsal and anal fin anlage present (9 mm).[3,6]

Pigmentation: first body pigment formed (7.7 mm);[10] melanophores in two dorsal rows, midlateral row present, dense occipital pigmentation, melanophores on yolk-sac dorsum;[3,6,7,10] (7.7 to 8.7 mm);[10] interorbital pigment present (8.7 mm);[10] melanophores on operculum and ventral edge of postanal myomeres.'

LARVAE

Total length	Description
9-20 mm	Myomeres: 38 to 40 (25 to 26 + 12 to 14), usually 39 (26 + 13).[10]

Morphometry: (as % TL) preanal length 61 to 62, head length 20 to 23, eye diameter 7 to 8, greatest body depth 16 to 17;[9,10] body depth at anus 12.[9]

Morphology: yolk absorbed (9.0 to 9.5 mm;[3,6,10] 9 days posthatching;[7] 10 to 11 days postfertilization[6]); caudal fin rays forming;[3,6,7,10] hypural bones complete, notochord flexed (9.2 to 9.6 mm);[3,6,10] dorsal and anal fin rays forming, pelvic buds present, two swim bladder chambers filled (10.8[10] to 11.6 mm[3,6]); mouth subterminal (9.5[4] to 11.6 mm[3,6,10]; paired fin rays forming (13.7 mm);[3,6] all fin rays complete (15 to 18 mm;[3,6] 20.6 mm[10]).

Pigmentation: caudal spot formed, snout pigmented, (9.4 to 9.6 mm);[4,6,7] internal melanophores from dorsum of gut to head (10.8 mm);[3,6] melanophores concentrated on caudal, dorsal and anal fin bases (10.8[3,6] to 12[7] mm); melanophores along caudal and dorsal fin rays (13.7 mm);[3,6] dorsal pigmentation uniformly scattered (12 to 17 mm).[3,6,7]

JUVENILES

A 13.7-mm specimen described and illustrated by Fish (1932) is probably misidentified, based on the length of the snout and position of the mouth.*

Total length	Description
20-40 mm	Morphometry: (as % TL) preanal length 55;[10] head length 20 to 22, eye diameter 4 to 6;[7,10] greatest body depth 16.[10] Morphology: squamation beginning (19 to 21 mm), barbels formed (23 to 25 mm), squamation complete (39 to 40 mm);[6] mouth inferior.[10] Pigmentation: dorsal pigmentation extending laterally, anterior portion of dorsal fin base and dorsal portion of caudal fin base white (most obvious in life).'

ADULTS

Fin rays: caudal 19;* dorsal 8, anal 7, pectoral 12 to 15, pelvic 8 (7 to 8).[12]

Vertebrae: 37 to 41 (including Weberian vertebrae).[12]

Lateral line scales: 61 to 72.[12]

Pharyngeal teeth: 2,4-4,2 1,4-4,1 1,4-4,0.[12]

Diagnostic characters: snout projecting beyond mouth, maxillary barbel terminal, frenum present, premaxillae not protractile; dorsal fin short (eight rays).

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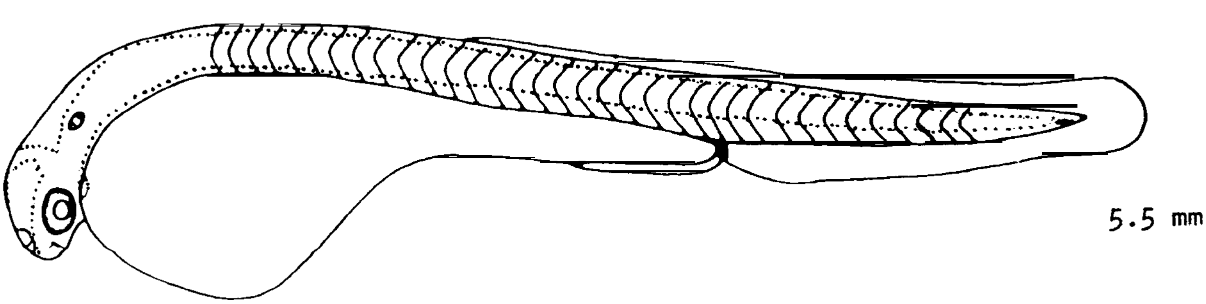
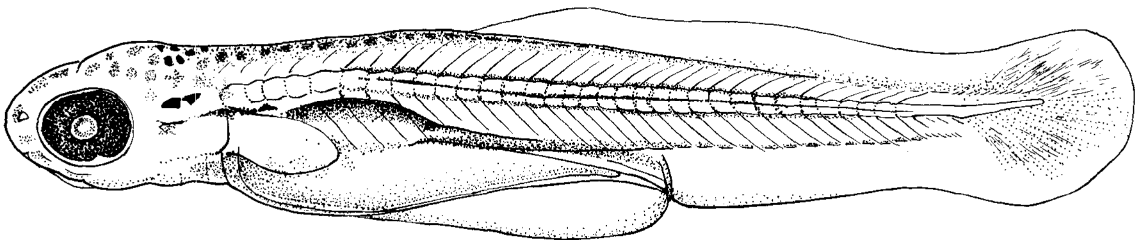
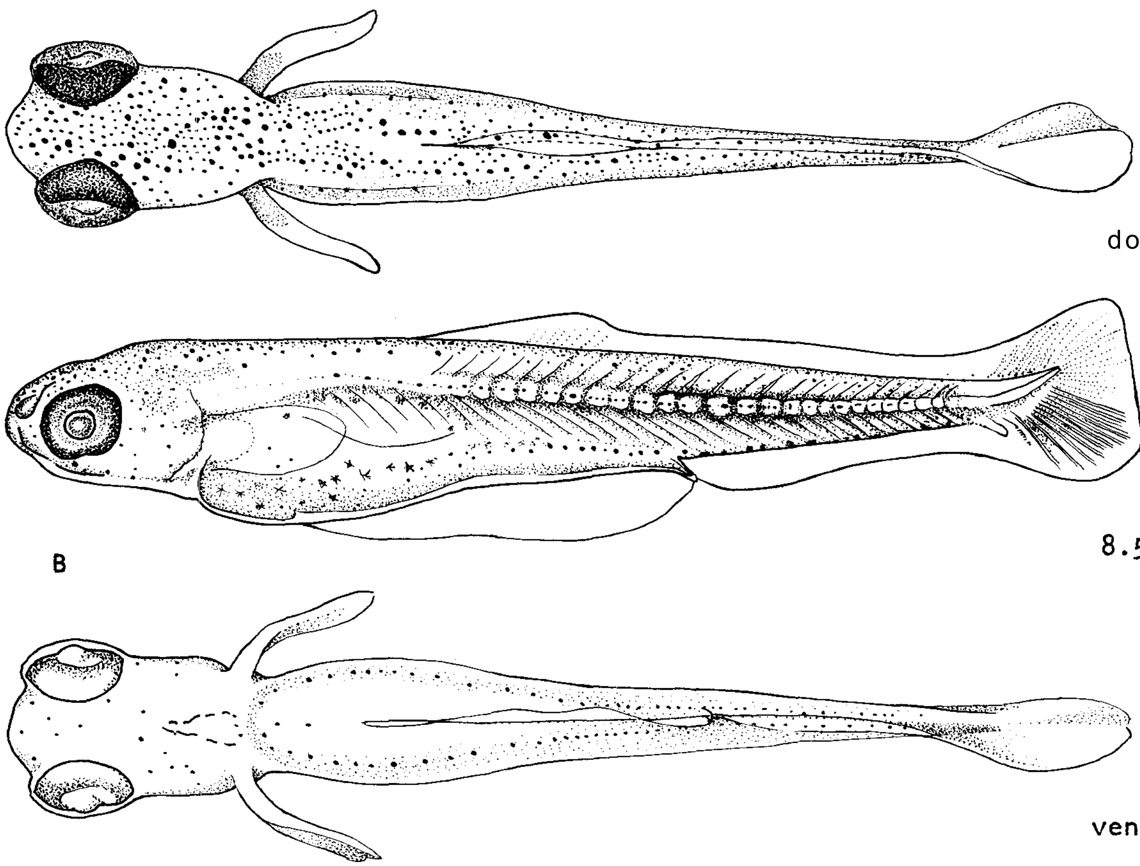


Fig. 129. Rhinichthys cataractae, longnose dace. Yolk-sac larva, newly hatched. (Laboratory-reared, West Virginia, Cooper 1980).



A

size unknown



dorsal

8.5 mm

B

ventral

Fig. 130. Rhinichthys cataractae, longnose dace. A . Yolk-sac larva. B. Larva. (A and B, laboratory-reared, Maryland, Loos et al. 1979).

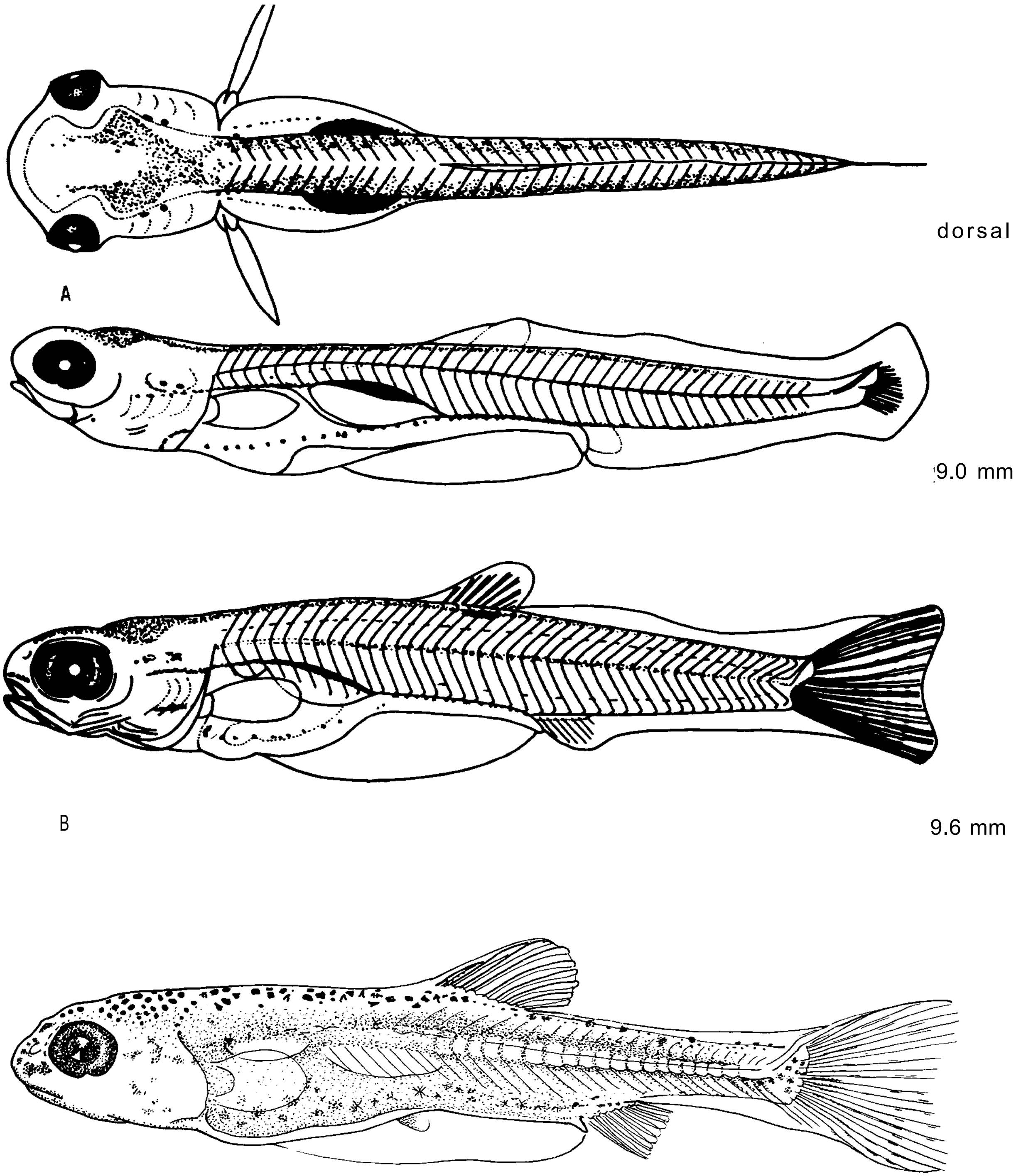


Fig. 131. Rhinichthys cataractae, longnose dace. A-C. Larvae. (A and B laboratory-reared, West Virginia, Cooper 1980; C, laboratory-reared, Maryland, Loos et al. 1979).

Rhinichthys cataractae

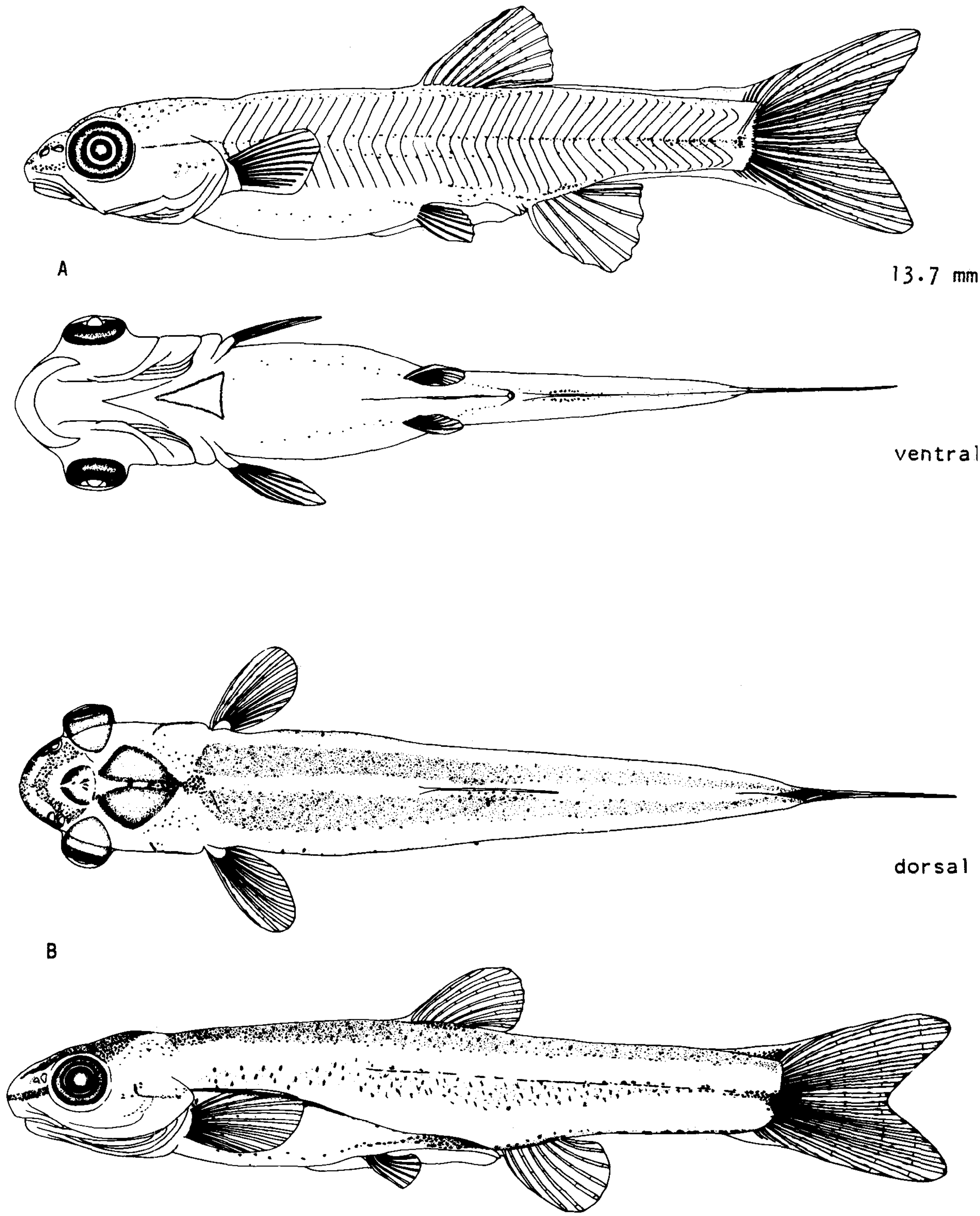


Fig. 132. Rhinichthys cataractae, longnose dace. A and B. Larvae. (A and B, laboratory-reared, West Virginia, Cooper 1980).

Semotilus atromaculatus (Mitchill), creek chub

DISTRIBUTION

This widespread species occurs throughout the Great Lakes region, except northern tributaries of Lake Superior.[2 16] Commonly found in small to moderate sized creeks throughout the Lake Michigan drainage.'

SPAWNING SEASON

Spawns from mid-April to June in Michigan.[8 13]

SPAWNING TEMPERATURE

Spawns between 13 and 18 C.[2 8 9 11] Nesting stops at temperatures below 11 C.[8 11]

SPAWNING HABITAT

Spawns in streams usually at the lower end of a pool.[11 13]

SPAWNING SUBSTRATE

Deposits eggs in a pit-and-ridge nest of gravel.[2 4 9 13 14] The ridge may be 25 to 30 cm wide, 0.3 to 5.5 m long and 5 to 8 cm high.[2 9 13] The pit lies at the downstream end of the ridge and is 25 cm in diameter and 5 to 10 cm deep.[11 13 14] This species sometimes builds nests on nests of Campostoma anomalum' or Nocomis micropogon.[7 18]

FECUNDITY

3,500 [8] to 7,539.[9]

NATURAL HYBRIDS

Campostoma anomalum, Clinostomus elongatus;[10 11 17] Notropis cornutus;[10] Phoxinus erythrogaster.[10 15]

EGGS

Demersal, nonadhesive;[12] diameter 2.0 to 2.2 mm;[4 12] oil globule absent;[12] incubation period: 246 hours at 13 C;[8] 6 days at 18 C.[12]

YOLK-SAC LARVAE

Total length	Description
5.3-6.2 mm	Newly hatched. [4 12 14] Morphology: head slightly flexed over yolk sac, yolk sac club-shaped, pectoral buds present;[12] adhesive organ on front of head[14] (a curious report not since confirmed*) . Pigmentation: absent.[12]

6-10 mm

Myomeres: 41 to 44[6,12] (27 to 30[4,5,6,12] + 11 to 15[5,6,12]), usually 42[12] (28[12] to 29[5] + 12[5] to 14[12]).

Morphometry: (as % TL) preanal length 63 to 65;[5,6,12] predorsal length 42 to 43;[5] or 46 to 47;[6] head length 17 to 20, eye diameter 8;[6,12] body depth at anus 10;[6] greatest body depth 17.[12]

Morphology: mouth opened, posterior swim bladder chamber filled, notochord flexed, caudal fin rays forming (8.3[12] or 9.3 to 9.6 mm[6]).

Pigmentation: eye pigmented (8.2 mm;[12] 2 to 3 days posthatching[8]); melanophores on snout, interorbital area and occiput;[6,12] two dorsal rows anterior to f infold, fused posteriorly[12] or rows continuing to tail;[6] midlateral stripe of few melanophores anteriorly or most of body length;[12] melanophores over yolk sac and swim bladder, on urostyle, and among caudal fin rays, melanophores on ventral midline at chin, postanal myomeres[6] and anterior yolk sac;[5] triangle of pigment ventral to heart;[6] two rows on lateral margins of yolk sac in ventral view.[12]

LARVAE

Total length	Description
9-15 mm	Myomeres: 38 to 44[6,12] (25 to 29 + 11 to 15);[5,6,12] usually 41 to 42 (27 to 28 + 12 to 14).[6,12]
	Morphometry: (as % TL) preanal length 59;[3] 61 to 66;[5,6,12] predorsal length 43 to 50;[3,5,6,12] head length 19 to 24, eye diameter 7 to 8;[3,6,12] greatest body depth 17 to 20;[3,12] body depth at anus 10 to 14.[3,6]
	Morphology: yolk absorbed (9.2[12] to 9.6 mm[6]); pectoral rays forming (9.8 mm);[12] first dorsal and anal fin rays forming (10 to 12 mm), pelvic buds present (14 to 15 mm);[6,12] maxilla reaching eye, median fins complete (14 to 15 mm);[3,6]
	Pigmentation: elongate spot on tip of urostyle (10 to 11 mm);[6] dorsal pigmentation dark and uniform, midlateral stripe wide, extending onto head and snout, including premaxillary and dentary bones (11 to 13 mm), dark spot on caudal peduncle (13 to 14 mm);[3,6,12] melanophores along all fin rays[3] (14.2 mm);[12] body below midlateral stripe without melanophores, paired midventral postanal row of melanophores, melanophores concentrated in anterior dorsal fin base (14.0 mm).[3]
15-23 mm	Myomeres: 40 to 43 (26 to 29 + 12 to 15);[6,12] usually 40 (27 + 13);[12] or 42 (27 + 15).[6]

Morphometry: (as % TL) preanal length 55 to 64;[6,12] predorsal length 45 to 49, prepelvic length 44;[6] head length 21 to 23, eye diameter 6 to 7;[6,12] greatest body depth 12 to 15;[6] body depth at anus 12 to 16.[12]
Morphology: all fin rays complete (19.2 to 23.0), squamation started, all finfolds absorbed (23.0 mm).[6]

JUVENILES

Total length	Description
28-34 mm	Morphometry: (as % TL) preanal length 58, head length 23, eye diameter 7, greatest body depth 20.[6] Morphology: squamation complete (33.5 mm).[6]

ADULTS

Fin rays: caudal 19;* dorsal 8 (8 to 9), anal 8 (7 to 9), pectoral 15 to 17 (13 to 18), pelvic 8.[2]

Vertebrae: 42 to 43 (39 to 44) (including Weberian vertebrae).[2]

Lateral line scales: 53 to 61.[2]

Pharyngeal teeth: 2,5-4,2 2,4-4,2 2,4-5,2.[2]

Diagnostic characters: black spot on base of anterior three dorsal fin rays, lateral line scales 53 to 61, subterminal maxilla barbel usually present (often absent on one or both sides in juveniles), premaxillae protractile, dorsal fin short (eight rays).

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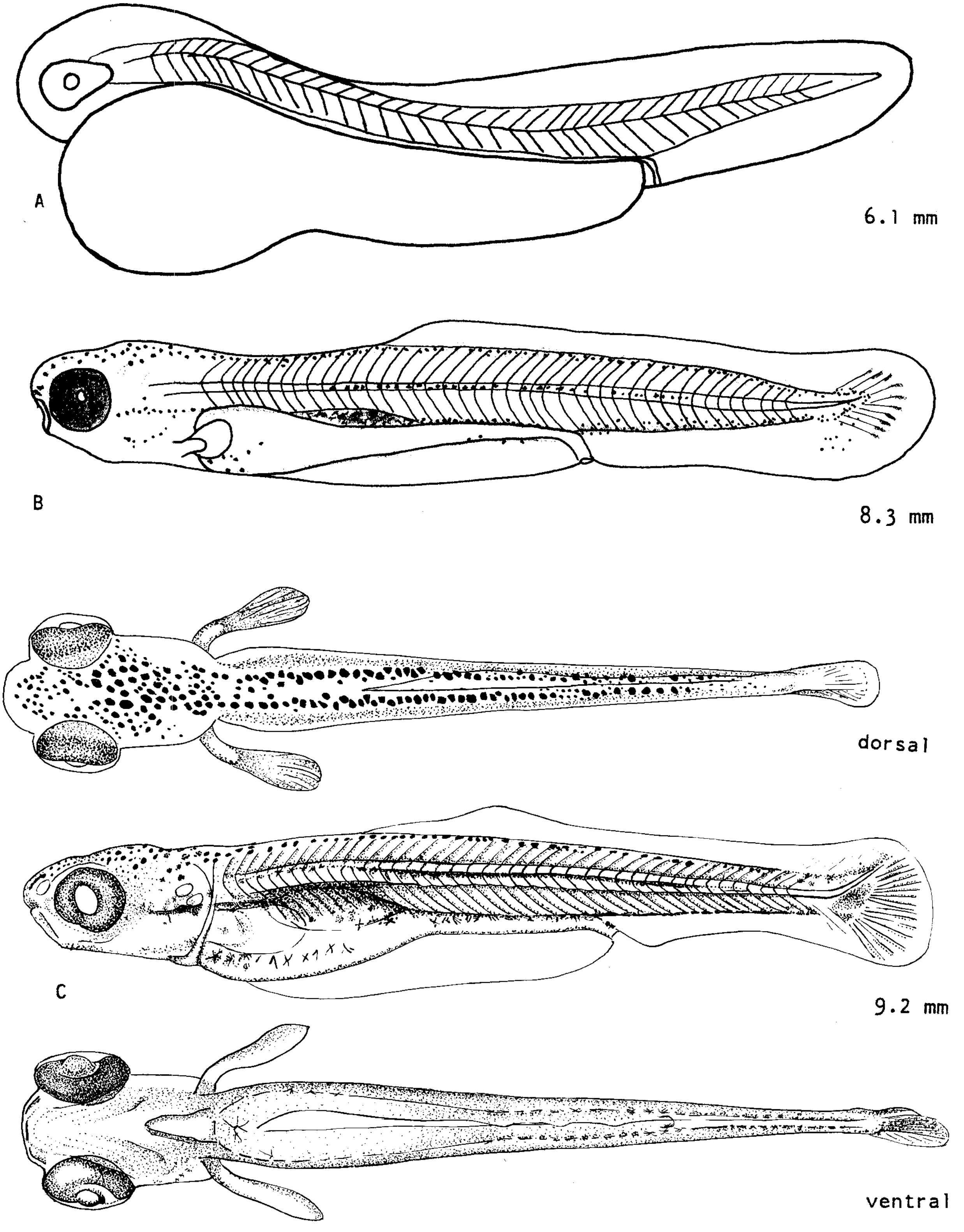


Fig. 133. Semotilus atromaculatus, creek chub. A and B. Yolk-sac larvae. C. Larva. (A and B, laboratory-reared, Pennsylvania, Buynak and Mohr 1979e; C, laboratory-reared, Maryland, Loos et al. 1979).

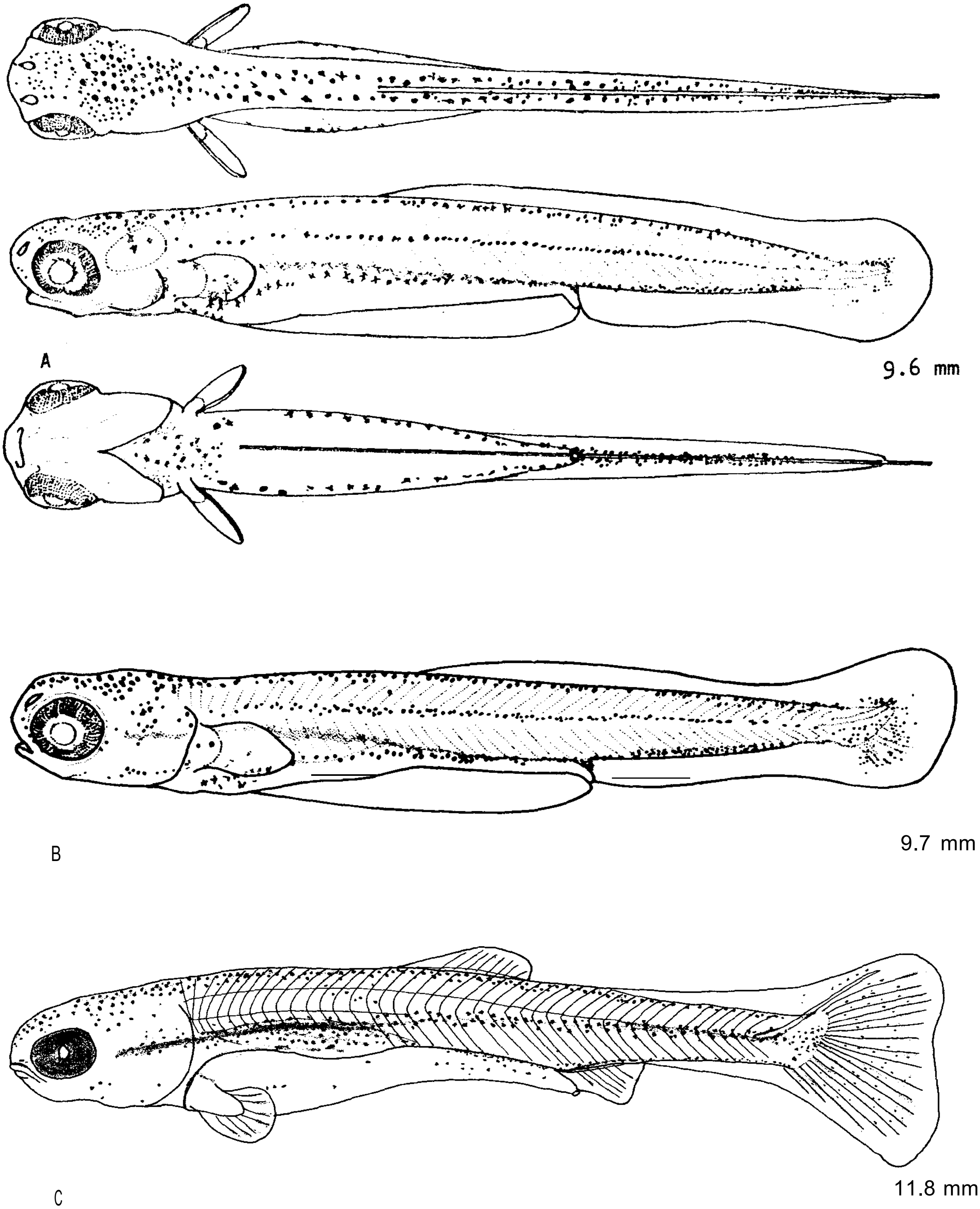
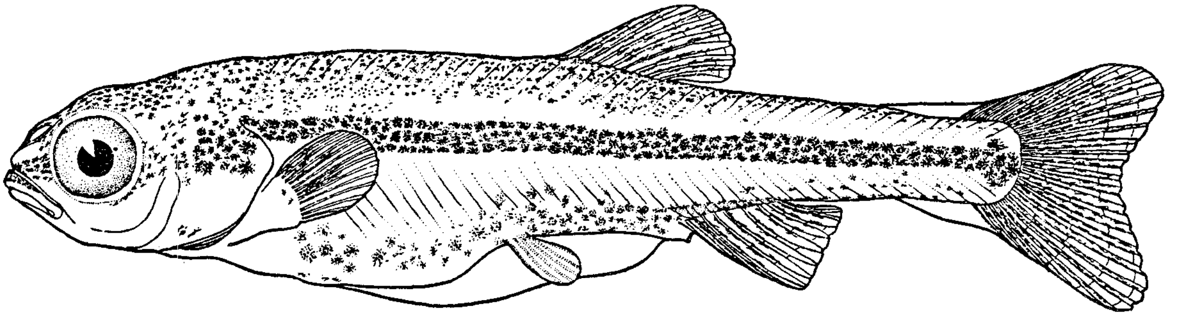
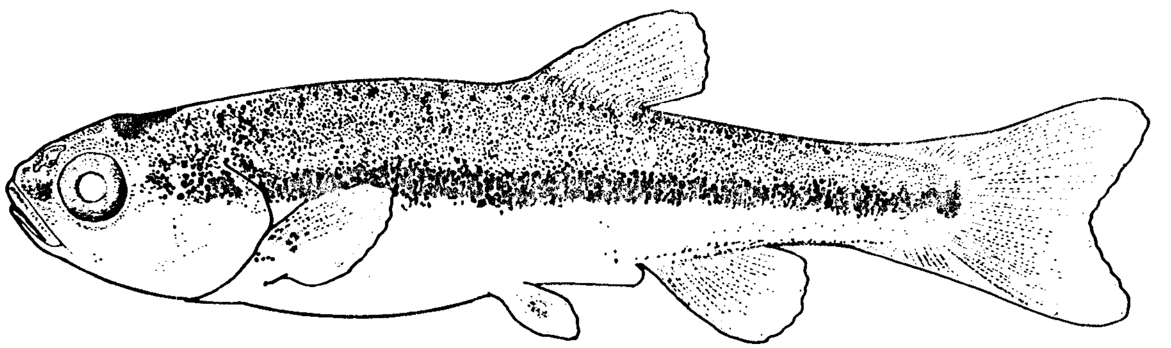


Fig. 134. Semotilus atromaculatus, creek chub. A-C. Larvae. (A and B, laboratory-reared, wild-caught, Wisconsin, Kranz et al. 1979; C, Pennsylvania, Buynak and Mohr 1979e).



A

14.0 mm



B

23.0 mm

Fig. 135. Semotilus atromaculatus, creek chub. A. Larva. B. Juvenile. (A, wild-caught, Lake Erie tributary, Fish 1932; B, wild-caught, Kranz et al. 1979).

Semotilus corporalis (Mitchill), fallfish

DISTRIBUTION

This eastern minnow is restricted, in the Great Lakes region, to the northeastern shore of Lake Ontario and its tributaries.'

SPAWNING SEASON

Spawns from late April to mid-May.[1 6 7 8]

SPAWNING TEMPERATURE

Spawning activities begin at temperatures near 14 C.[1] Successful spawning coincides with minimum temperatures of 17 C.[11]

SPAWNING HABITAT

Spawns in streams or shallow margins of lakes,[5] approximately 0.5 m deep.[6]

SPAWNING SUBSTRATE

Eggs are deposited in a mound nest of gravel.[1 3 6 8 10] Nests vary from 0.3 to 1.8 m in diameter and 10 to 91 cm high.'- [6 8 10]

FECUNDITY

2,000 to 12,000.[1]

NATURAL HYBRIDS

Notropis cornutus.[10]

EGGS

Demersal, adhesive' or nonadhesive;' [7] diameter 2.6 to 3 mm;[1 2] yolk yellow, oil globule absent;[2] incubation period: 7 to 9 days at 13 to 18 C;[7] 138 to 144 hours (6 days) as 17 C.[1]

YOLK-SAC LARVAE

Total length	Description
6.8-7.5 mm	Newly hatched.[1 2 9] Morphology: pectoral buds absent;[1 9] head flexed over bulbous yolk sac.[9] Pigmentation: absent.[1 9]
7-11 mm	Myomeres: 41 to 45 (30 to 32 + 11 to 15), usually 43 (30 + 13);[9] preanal myomeres 28 to 29.[3] Morphometry: (as % TL) preanal length 69, head length 17, eye diameter 8, greatest body depth 20.[9]

Morphology: pectoral buds formed (7.4 mm);[9] caudal and pectoral fin rays forming, mouth opened, swim bladder inflating, notochord flexed (9 to 10 mm;[1] or 10.5 mm[9]).
Pigmentation: eye, occiput and nape pigmented (9.3 mm), melanophores from pectoral buds, over yolk sac, to anus (10.5 mm);[9] double row of melanophores on dorsal and ventral surfaces, single mid-lateral row (9.0 to 10.0 mm).[1]

LARVAE

Total length	Description
10-15 mm	Myomeres: 41 to 44 (29 to 31 + 10 to 14), usually 42 (30 + 12).[9] Morphometry: (as % TL) preanal length 64, head length 21, eye diameter 8, greatest body depth 16.9 Morphology: yolk absorbed (9.0[1] to 9.7 mm;[9] at 5 days Posthatching at 17 C[1]); caudal, dorsal, anal and pectoral fin rays formed (12.2 mm);[9] all anal fin rays formed (14.0 mm);[1] pelvic buds present (14.0[1] or 15.6 mm[9]). Pigmentation: two predorsal rows of melanophores, fused posteriorly, internal median predorsal row present, midlateral row and row along sides of. gut to anus and on ventral edge of postanal myomeres, few melanophores on venter of head and gut (13.4 mm);[9] caudal spot present (12.0,[1] 14.8[9] or 16.7 mm[2]); lateral stripe wider than earlier stage (14.0 to 15.6 mm).'[9]
15-22 mm	Myomeres: 40 to 42 (29 to 31 + 11 to 12), usually 41 (29 + 12).[9] Morphometry: (as % TL) preanal length 59, head length 23, eye diameter 8, greatest body depth 17.9 Morphology: first scales forming (18 mm);[1] fin rays complete (18.0 to 20.1 mm).[1,9] Pigmentation: dorsal pigmentation uniformly dark (17 to 18 mm).[9]

JUVENILES

Total length	Description
26-33 mm	Morphometry: (as % TL) preanal length 58, head length 21, eye diameter 7, greatest body depth 18.[9] Morphology: squamation complete (33 mm).[1] Pigmentation: caudal spot fading (65 to 75 mm).[1]

ADULTS

Fin rays: caudal 19;* dorsal 8, anal 8 (7 to 9), pectoral 16 to 18, pelvic 8 to 9.[4]

Vertebrae: 43 (42 to 44) (including Weberian vertebrae).'

Lateral line scales: 43 to 50.[4]

Pharyngeal teeth: 2,5-4,2 2,4-5,2 2,4-4,2.[4]

Diagnostic characters: pigment on anterior field of scales, lateral line scales 43 to 50, subterminal maxillary barbel present, premaxillae protractile, dorsal fin short (eight rays) .

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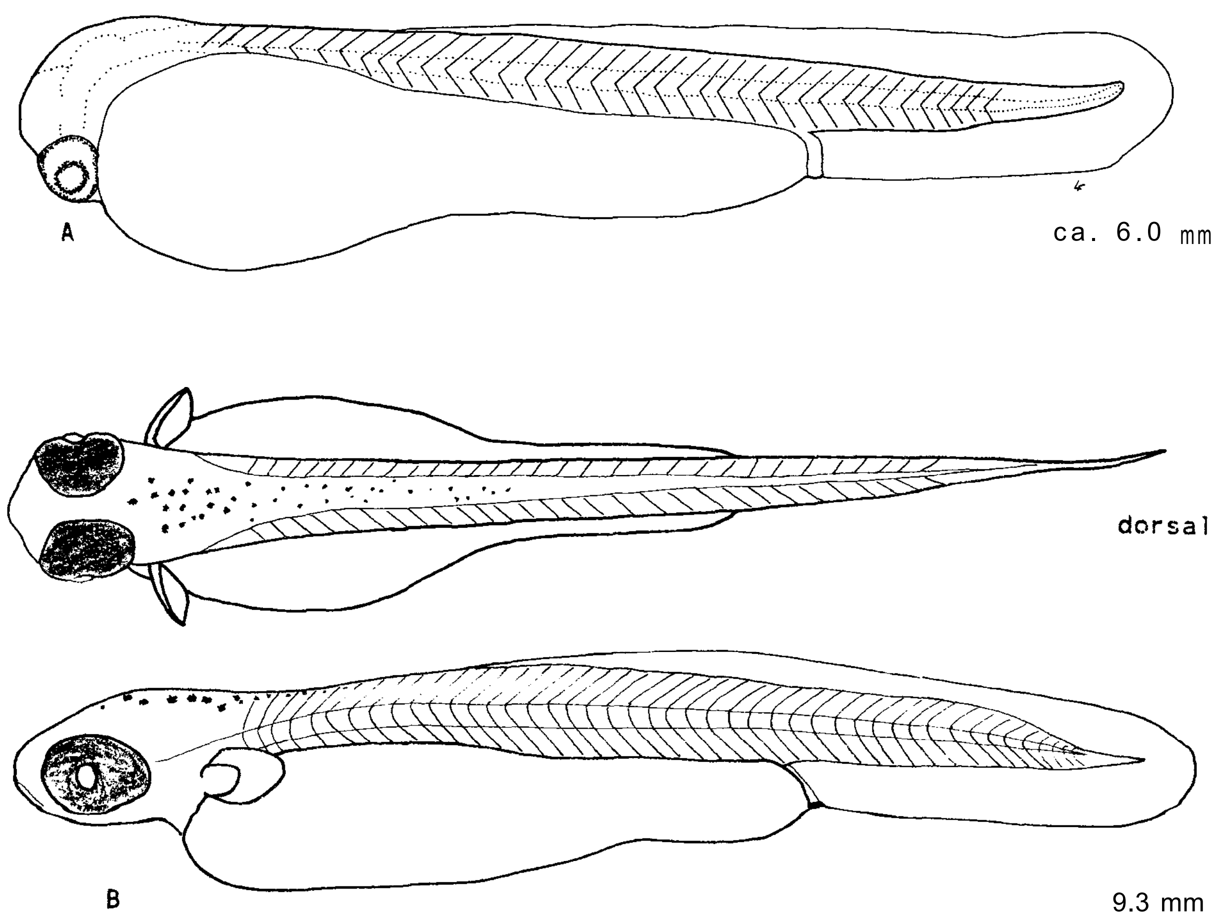


Fig. 136. Semotilus corporalis, fallfish. A. Yolk-sac larva, newly hatched. B. Yolk-sac larva. (A, laboratory-reared, New York, photograph by B. C. Victor, delineated by L. A. Fuiman; B, laboratory-reared, Pennsylvania, Buynak and Mohr 1979e).

Semotilus corporalis

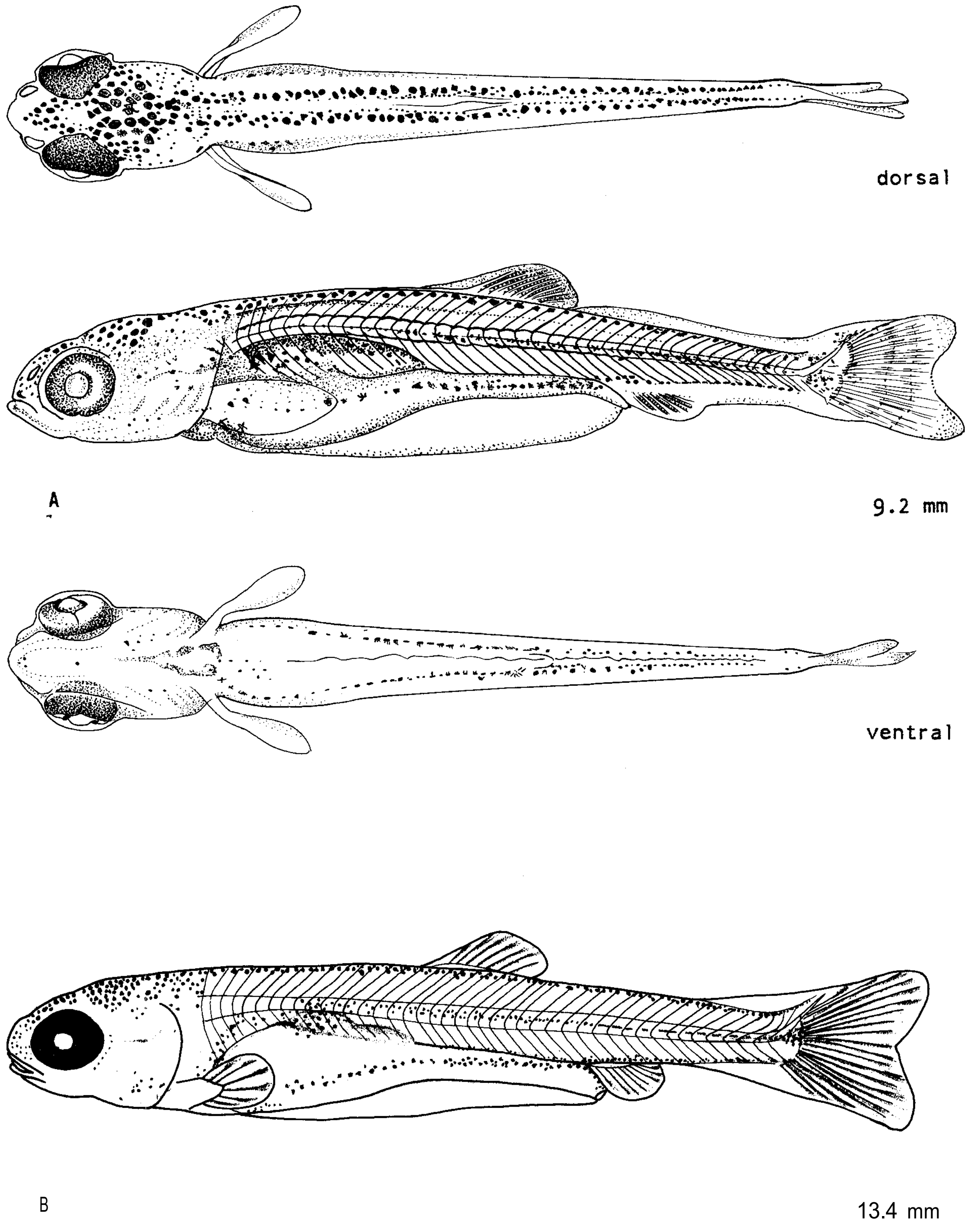


Fig. 137. Semotilus corporalis, fallfish. A and B. Larvae. (A, laboratory-reared, Maryland, Loos et al. 1979; B, laboratory-reared, Pennsylvania, Buynak and Mohr 1979e).

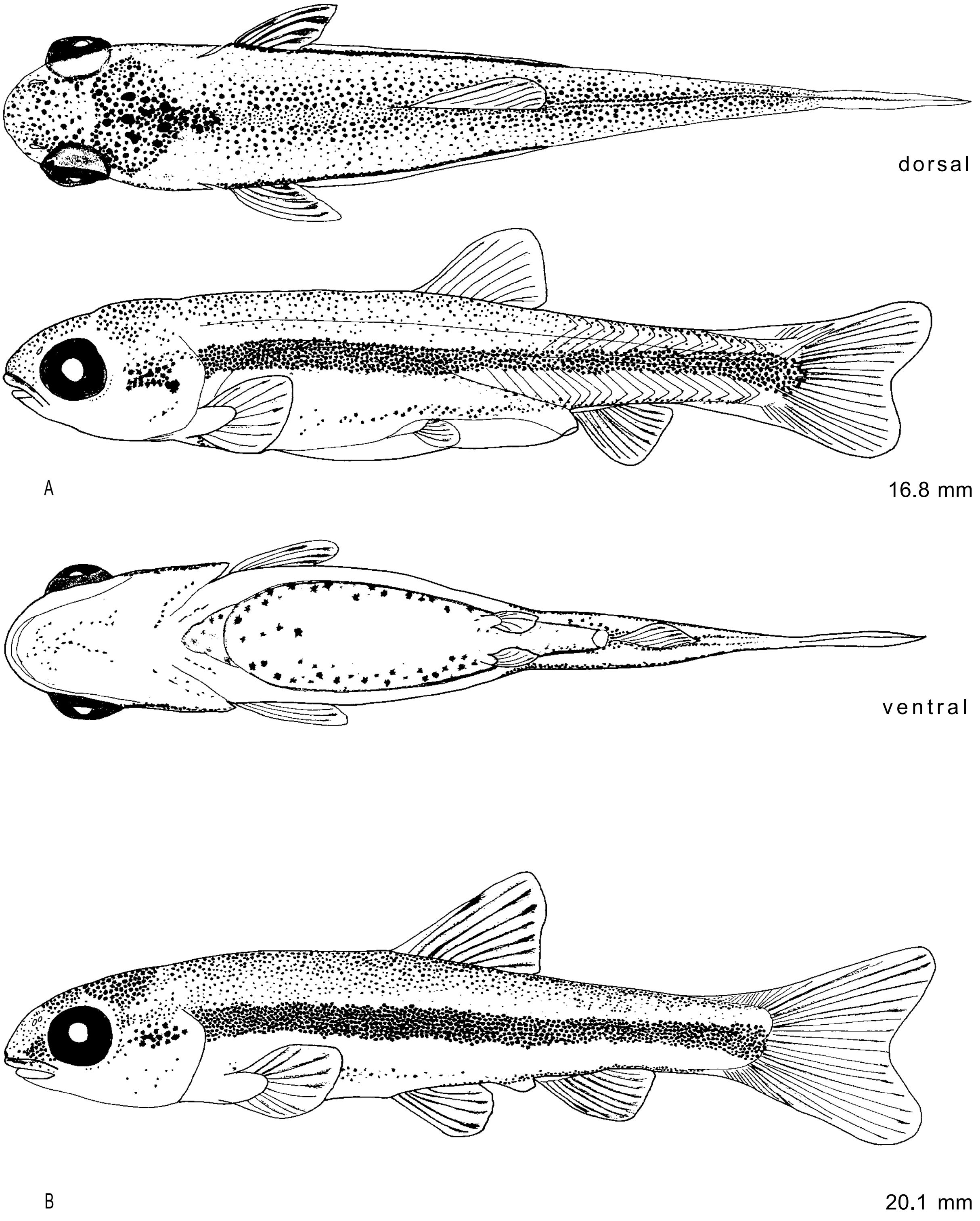


Fig. 138. Semotilus corporalis, fallfish. A. Larva. B. Juvenile. (A and B, laboratory-reared, Pennsylvania, Buynak and Mohr 1979e).

Semotilus margarita (Cope), pearl dace

DISTRIBUTION

This species occurs in most drainages of the Great Lakes, except southern portions of Lakes Erie and Michigan.' [5] In Lake Michigan, it inhabits streams and lakes of the northern drainage, south to Milwaukee, Wisconsin and the Grand River, Michigan.[1]

SPAWNING SEASON

Spawns from April to June in Wisconsin' and Michigan.[2]

SPAWNING TEMPERATURE

Spawns at temperatures between 17 and 18 C.[2]

SPAWNING HABITAT

Spawns in streams approximately 4.5 m wide and at 46 to 61 cm depth.[2]

SPAWNING SUBSTRATE

Spawns over sand to coarse gravel.[2]

FECUNDITY

913 to 2,140.[2 3]

NATURAL HYBRIDS

Possibly Couesius plumbeus.'

EGGS

Not described.

YOLK-SAC LARVAE

Not described.

LARVAE

Not described.

JUVENILES

Not described.

ADULTS

Fin rays: caudal 19;* dorsal 8 (7 to 8), anal 8 (7 to 8), pectoral 15 to 16 (14 to 19), pelvic 8 (8 to 9).[4]

Vertebrae: 38 to 40 (including Weberian vertebrae).'

Lateral line scales: 66 to 72, variable.'

Pharyngeal teeth: 2,5-4,2 2,4-4,2 2,4-4,1.[4]

Diagnostic characters: dorsal fin and anterior field of scales without spots, lateral line scales 65 to 75, maxilla sometimes with subterminal barbel, premaxillae protractile, dorsal fin short (eight rays) .

LITERATURE CITED

1. Becker (1976)
2. Langlois (1929)
3. Fava and Tsai (1974)
4. Scott and Crossman (1973)
5. Hubbs and Lagler (1958)
6. Wells (1981)

Family Catostomidae, suckers

By

Lee A. Fuiman

There are approximately 65 species of catostomids in 11 genera. All species (except one Asiatic form) occur in North America. In the Great Lakes region, there may be as many as 18 species, all except one (Carpiodes carpio) have been reported from the Lake Michigan basin. Suckers are moderate to large fishes and usually have fleshy lips around an inferior mouth. The anal fin is far posterior which separates them from native cyprinids. Suckers are mostly benthonic fishes of lakes and streams, which feed on invertebrates. Most suckers ascend streams to spawn over a gravel substrate in the spring.

Catostomid eggs are demersal, of moderate size (between 1.5 and 3.5 mm) and lack obvious sculpturing or modification of the chorion. Yolk is granular and contains no distinct oil globules. Larvae hatch at sizes between 5 and 10 mm TL and spend the first several days among the gravel substrate. The long preanal length relative to total length (greater than 65%) is diagnostic of this family, as well as the coregonids. The latter have large melanophores along the gut, more myomeres and are considerably larger at a given developmental stage. Larger Coregonid larvae develop an adipose fin which is lacking in suckers.

Provisional Key to Lake Michigan Catostomid Larvae

The following key includes 10 species which are likey to be encountered in the waters of the Lake Michigan basin. They are: Carpiodes cyprinus, Catostomus catostomus, C. commersoni, Erimyzon oblongus, E. sucetta, Hypentelium nigricans, Ictiobus niger, Minytrema melanops, Moxostoma erythrurum, and M. macrolepidotum. The remaining eight species of catostomids are known from old or unverified records from Lake Michigan, occur in other areas of the Great Lakes region or their larvae are undescribed.

1a. Preanal myomeres 32 or less 2

b. Preanal myomeres 33 or more . . . . . , ... 6

2a. Pigmentation dark all over: middorsal pigment-free space on occiput (greater than 8 mm TL) 3

b. Pigmentation lighter; occiput with scattered pigment 4

3a. Preanal myomeres 23 or less . . . . Erimyzon sucetta

b. Preanal myomeres 30 or more . . . . _Erimyzon oblongus_

4a. Preanal length long (86% TL at 4 to 7 mm TL, 79% at 8 to 11 mm, 67% at 11 to 24 mm). . . . . _Minytrema melanops_

b. Preanal length short (70% TL at 5 to 13 mm TL, 65% at 13 to 19 mm).. 5

5a. Dorsal profile of head flattened; eye elliptical (greater than 8 mm TL). . . . . _Carpiodes cyprinus_

b. Dorsal profile of head convex; eye round. . . . . _Ictiobus niger_

6a. Preanal myomeres few (33 to 35) ; prominent dorsal pigmentation restricted to single middorsal row of melanophores. . . . . _Minytrema melanops_

b. Preanal myomeres usually more numerous (33 to 39); prominent dorsal pigmentation in two or three rows or uniform over dorsum. 7

7a. Posterior swim bladder chamber long, horizontal length of anterior chamber enters that of posterior chamber more than 3.2 times. . . . . _Catostomus commersoni_

b. Posterior swim bladder chamber small, horizontal length of anterior chamber enters that of posterior chamber less than 3.2 times, or two chambers not developed. 8

8a. Eye large, diameter greater than 46% of head length until first caudal fin rays form; central caudal fin rays unpigmented when complete; melanophores of dorsal fin present only along leading edge (at about 17 mm TL). . . . . _Hypentelium nigricans_

b. Eye small, diameter less than 46% of head length until first caudal fin rays form; central caudal fin rays pigmented when complete; dorsal fin pigment absent or not confined to leading edge of fin. . 9

9a. Total myomeres (including occipital and urostylar segments) 46 or more; body slender, depth at anus relative to head length small (48% of head length at 12 mm TL, 34% at 13 mm, 42% at 18 mm). (_Catostomus_). 10

b. Total myomeres 45 or less; body robust, depth at anus relative to head length large (ca. 62% of head length at 11 mm TL, 46 to 53% at 13 to 14 mm , 42 to 50% at 15 to 18 mm) (_Moxostoma_). 11

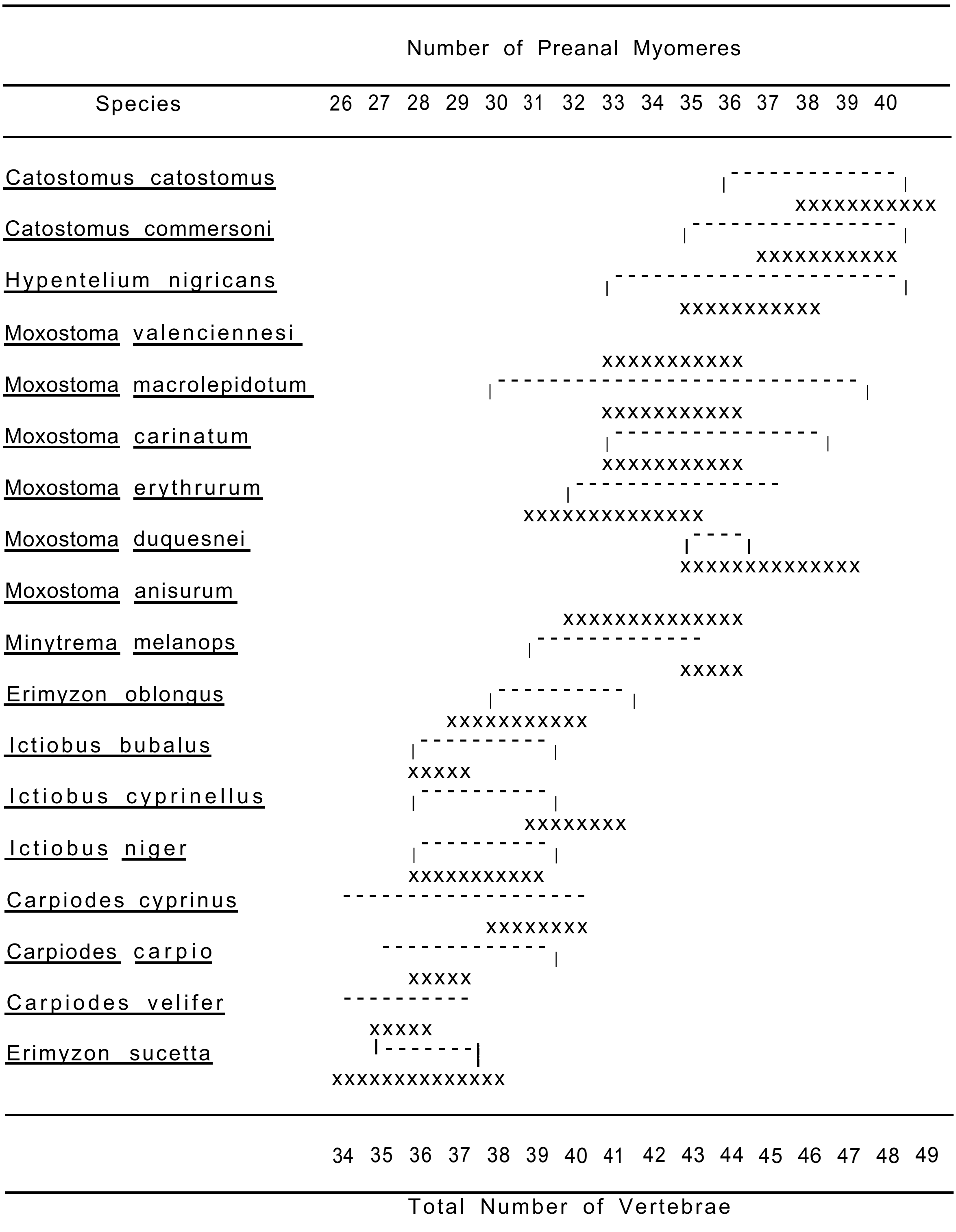
10a. For larvae less than 13 mm TL (for larger specimens, see couplet 7): dorsal pigmentation anterior to median finfold in three rows. . . . . I . . . . Catostomus commersoni

b. For larvae less than 13 mm TL: dorsal pigmentation in a single, median row. . . . . , ... Catostomus catostomus

11a. Total myomeres (including occipital and urostylar segments) 43 or more; preanal myomeres 36 or more. . . . . . Moxostoma macrolepidotum

b. Total myomeres 42 or less; preanal myomeres 35 or less. . . . . Moxostoma erythrurum

Table 4. Ranges of preanal myomeres (-) and total vertebrae (x) among Great Lakes catostomids. Data were taken from several sources cited in the individual species accounts.



Carpiodes carpio (Rafinesque), river carpsucker

DISTRIBUTION

There is a single record of this species from the Great Lakes. The specimen was collected from the Maumee River, Ohio, in the Lake Erie drainage.'

SPAWNING SEASON

Not known for the Great Lakes region. Mid-June to mid-July in South Dakota[4] and Iowa.[5]

SPAWNING TEMPERATURE

Spawning occurs between 19 and 23 C,[3, 4] with the peak at 21 C.[3]

SPAWNING HABITAT

Spawns on the bottom of rivers and some tributaries, not in reservoirs.[3]

SPAWNING SUBSTRATE

Deposits eggs on silt or sand.[5]

FECUNDITY

Reports of ca. 4,450 to 149,750[1, 2] and 18,150 to 195,700.[3]

EGGS

Demersal, adhesive;' [9] diameter 1.7 to 2.1 mm, mean 2.1 mm, yolk pale yellow, oil globules absent.[9]

YOLK-SAC LARVAE

Total length	Description
5.0-5.5 mm	Newly hatched, mean 5.3 mm.[9]
	Myomeres: 34 to 39 (27 to 31 + 5 to 10), usually 35 to 38 (29 to 30 + 6 to 9).[9]
	Morphometry: (as % TL) preanal length 73, head length 18, eye diameter 8, body depth at anus 8, (as % head length) eye diameter 41, body depth at anus 41.[9]
	Morphology: head deflected, yolk sac bulbous, pectoral buds present.[9]
	Pigmentation: eye moderately pigmented, midventral stripe on yolk sac, scattered melanophores on lateral yolk sac.[9]

6-8 mm

Myomeres: see 5.0-5.5 mm.

Morphometry: (as % TL) preanal length 70 to 73, head length 17 to 18, eye diameter 7, body depth at anus 8, (as % head length) eye diameter 36 to 41, body depth at anus 43 to 45.[9]

Morphology: mouth open, head not deflected (5.6 mm), posterior swim bladder chamber inflated (7.7 mm).[9]

Pigmentation: double postanal ventral row of melanophores (6.0 mm), two dorsal rows, scattered melanophores on top of head, "stitched" midlateral line present (6.7 to 7.5 mm), dorsum of incipient gut and swim bladder pigmented (7.6 to 8.3 mm).[9]

LARVAE

Total length	Description
8-16 mm	Myomeres: 34 to 38 (28 to 31 + 5 to 9), usually 35 (29 + 6).[9]
	Morphometry: (as % TL) preanal length 68 to 73, head length 19 to 23, eye diameter 6 to 7, body depth at anus 9 to 11;[9] (as % head length) eye diameter 27 to 36, body depth at anus 46 to 50.[6,9]
	Morphology: yolk absorbed (7.7 to 8.2 mm), slight notochord flexion (8.4 to 9.2 mm), first caudal fin rays (9.7 to 9.9 mm), dorsal head profile flattened and angled downward, dorsal fin outline apparent, head profile with indentation over eye (10.2 mm), pelvic buds apparent under myomeres 16 to 18 (12.3 mm), anterior swim bladder chamber developing (12.5 mm) and complete (14.2 to 14.6 mm), first dorsal fin rays present and gut coiling begins (12.5 to 13.4 mm), hypurals complete (13.0 mm), first pectoral fin rays present (13.8 to 14.2 mm) caudal fin complete (14.2 to 14.7 mm), first anal fin rays present (15.6 to 16.1 mm), pelvic fin rays present (16.9 mm), anal fin complete (17.7 to 19.4 mm).[9]
	Pigmentation: midventral line from pectoral fins to caudal fin diffuse (7.7 to 8.2 mm), ventral edge of opercle pigmented (8.0 to 8.7 mm), sides of gut pigmented, melanophores on hypochordal caudal finfold (8.5 mm), heart and foregut areas lightly pigmented, postanal ventral pigment in double row, pectoral fin base with single large melanophore, gill arches and snout pigmented, caudal fin pigmented to edge (11.6 to 12.7 mm).[9]
16-23 mm	Morphometry: (as % TL) preanal length 59 to 65, head length 24, eye diameter 6 to 7, body depth at anus 12 to 15, (as % head length) eye diameter 26 to 28, body depth at anus 50 to 62.[9]

Morphology: dorsal (19.1 to 19.3 mm), pelvic (20.9 to 22.8 mm) and pectoral (22.3 to 23.1 mm) fins complete, mouth subterminal, squamation beginning (20.2 mm), all finfolds absorbed (22.8 to 23.1 mm).[9]
Pigmentation: melanophores between two dorsal stripes present, dorsal and caudal fins pigmented to edge, anal fin partially pigmented.[9]

JUVENILES

Total length	Description
23-48 mm	Morphometry: (23 to 25 mm TL, as % TL) preanal length 59 to 60, head length 23 to 24, eye diameter 6, body depth at anus 15, (as % head length) eye diameter 26 to 27, body depth at anus 62 to 63.9 Morphology: squamation complete (31.8 to 34.0 mm).[9] Pigmentation: lower jaw heavily pigmented, paired fins unpigmented (to 48.2 mm).[9]

ADULTS

Fin rays: caudal 18, dorsal 24 to 30, anal 7 to 9, pectoral 15 to 18, pelvic 8 to 10.[9]

Vertebrae: 36 to 37 (including Weberian vertebrae).[8]

Lateral line scales: 34 to 36.[8]

Diagnostic characters: dorsal fin long (usually 24 to 27 rays), scales large (34 to 36 in lateral series), mouth inferior, knob-like projection on middle of lower lip, length of first dorsal fin ray less than half the length of the dorsal fin base.

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1. Behmer (1969)
2. Buchholz (1957)
3. Jester (1972)
4. Walburg and Nelson (1966)
5. Behmer (1967)
6. May and Gasaway (1967) - data from photographs therein
7. Hubbs and Lagler (1958)
8. Cross (1967)
9. Yeager (1980)

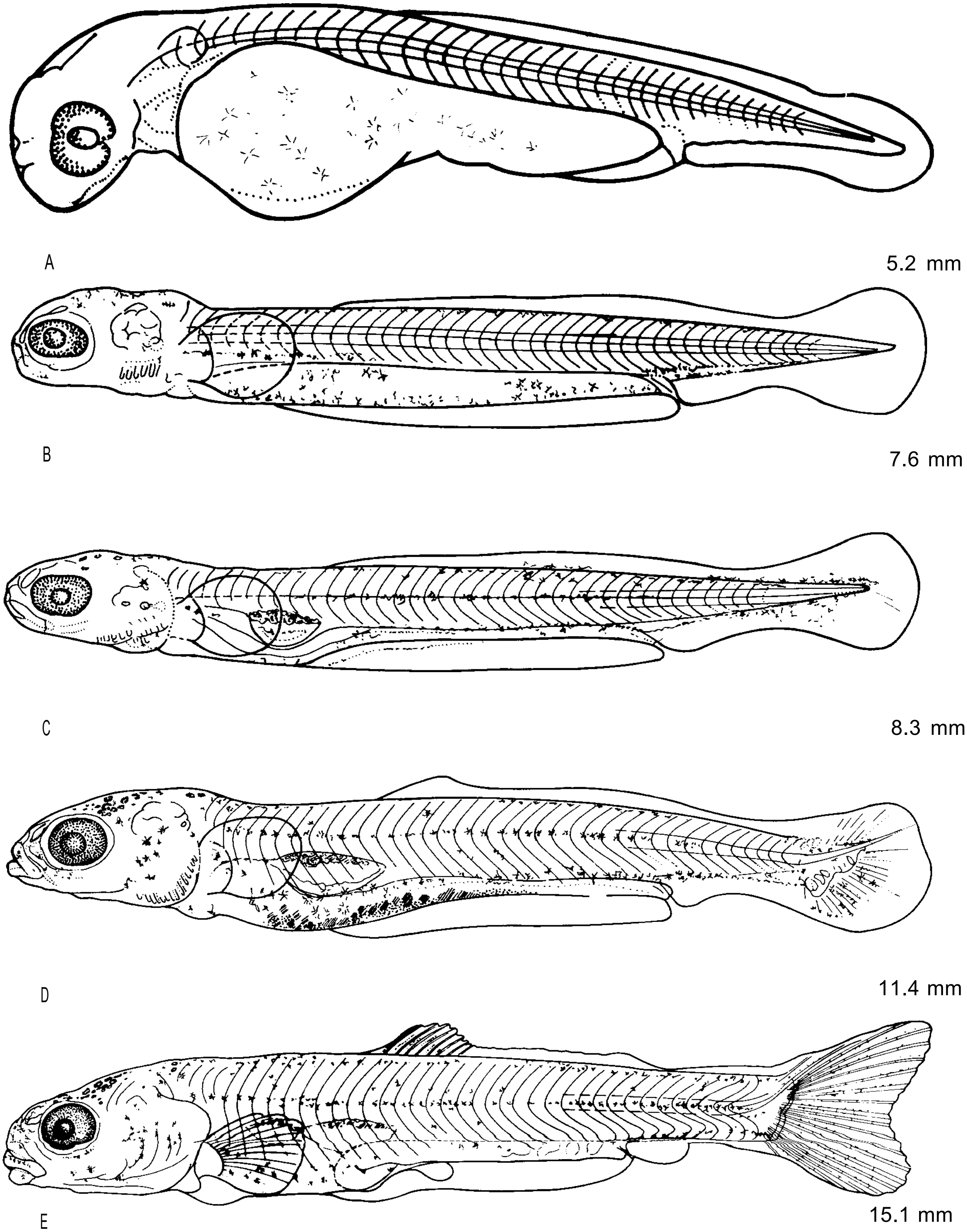
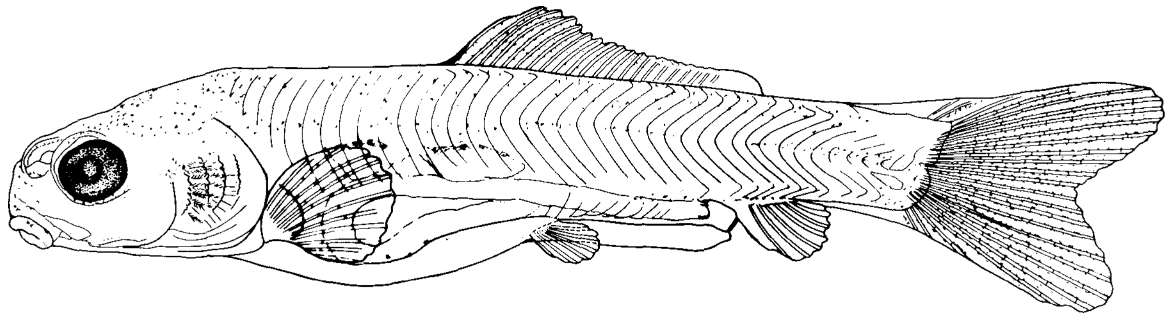
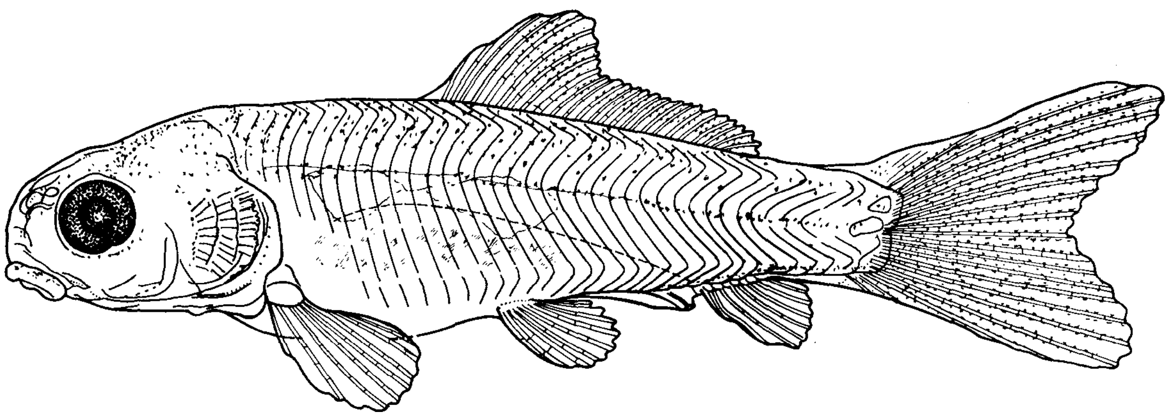


Fig. 139. Carpiodes carpio, river carpsucker. A. Yolk-sac larva, newly hatched. B. Yolk-sac larva. C-E. Larvae. (A-E, laboratory-reared, Tennessee, Yeager 1980) .



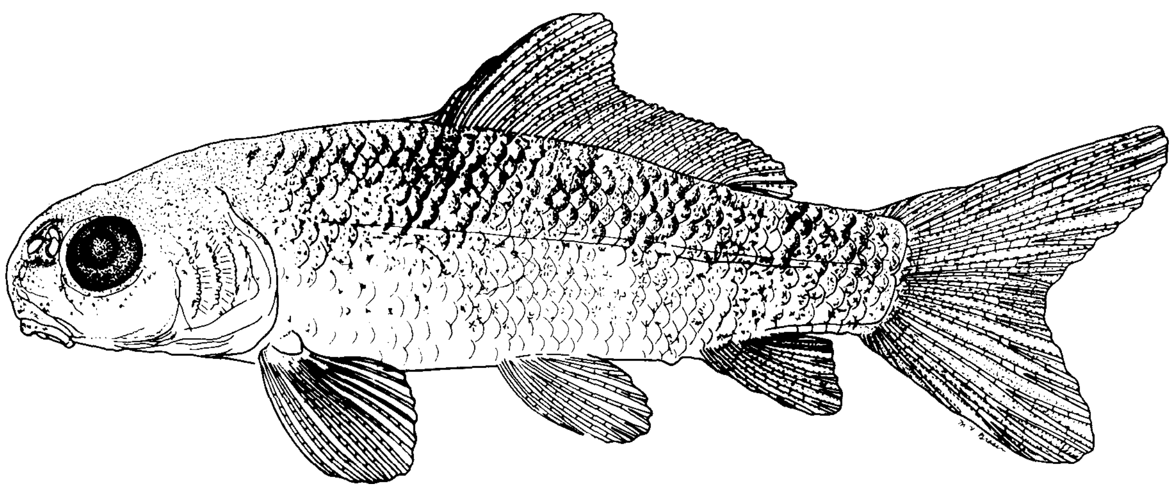
A

17.6 mm



B

21.1 mm



C

30.1 mm

Fig. 140. Carpiodes carpio, river carpsucker. A and B. Larvae. C. Juvenile. (A-C, laboratory-reared, Tennessee, Yeager 1980).

Carpiodes cyprinus (LeSueur), quillback

DISTRIBUTION

Occurs throughout the Great Lakes except Lake Superior.[13] In Lake Michigan, localized populations exist in the lower Green Bay drainage and the Grand and Macatawa Rivers, Michigan.'

SPAWNING SEASON

'Spawns from late April through May in Iowa' and through mid-June in Pennsylvania.' A protracted season (late June through September) evidenced by ripe adults has been reported for southern Ohio.[2]

SPAWNING TEMPERATURE

Water temperatures during collection of ripe adults ranged from 19 to 28 C.[2] Eggs were collected between 10 and 20 C[4] and at 22 C.[3]

SPAWNING HABITAT

Spawns in quiet waters of streams, overflow areas[6] and large rivers.' Sometimes migrates upstream.[12]

SPAWNING SUBSTRATE

Not specific.' Scatters eggs over sand, mud,[5] [6] gravel and organic matter .[8]

FECUNDITY

15,235 to 63,779.[2]

EGGS

Demersal, adhesive;' [14] oil globules absent, diameter 2.0[14] to 2.2 mm,[3] [14] yolk pale yellow.'

YOLK-SAC LARVAE

Total length	Description
5.5 mm	Newly hatched.[7]
	Myomeres: 33 to 34 (27 to 29 + 5 to 6) . [7]
	Morphometry: (as % TL) preanal length 70, head length 16, eye diameter 6, greatest body depth 13 to 18, (as % head length) eye diameter 36 to 39.[7]
	Morphology: pectoral buds present, yolk constricted near middle.[7]
	Pigmentation: eyes heavily pigmented, few melanophores on occiput, melanophores scattered on venter of yolk sac and in a short postanal series.[7]

5.7-7.0 mm

Newly hatched, mean: 6.5 mm TL.[14]
Myomeres: 34 to 42 (28 to 32 + 5 to 11), modally 35, 36, 39 or 40 (28 to 31 + 6 to 10).[14]
Morphometry: (as % TL) preanal length 73, head length 17, eye diameter 7, body depth at anus 8, (as % head length) eye diameter 42, body depth at anus 50.[14]
Morphology: head deflected over bulbous yolk sac, pectoral buds present."
Pigmentation: yolk sac pigmented laterally and ventrally, eye pigmented, several large melanophores internally on dorsum of notochord.[14]

6-g mm

Myomeres : usually 38 to 40 (30 to 31 + 8 to 9) remaining unchanged with size;[3] 35 to 37 (28 to 29 + 7 to 9);[7] see also 5.7-7.0 mm.
Morphometry: (as % TL) preanal length 70[3 7] to 73;[14] head length 16[14] to 17;[3 7] eye diameter 6 to 7;[3 7 14] greatest body depth 9;[7] body depth at anus 7, (as % head length) eye diameter 363 to 37[7] or 40 to 42;[14] body depth at anus 44[3] or 48 to 50.[14]
Morphology: head straight, not deflected, mouth open, yolk sac tubular (7.2 to 7.9 mm), eye elliptical (8.1 to 8.7 mm).[14]
Pigmentation: melanophores scattered on dorsum of occiput, two longitudinal stripes on dorsum, converging at peduncle (6 to 7 mm;[3 7] or 7.9 to 8.1 mm[14]); midlateral stripe present'[14] or absent;[3] midventral stripe diffuse, distinct postanal ventral series present, melanophores over yolk sac and presumptive swim bladder (7.2 mm).[3 14]

LARVAE

Total length	Description
8-13 mm	Myomeres: 37 to 38 (28 to 29 + 8 to 10);[7] see al so 6-9 mm and 13-19 mm. Morphometry: (as % TL) preanal length 70 to 71, head length 16 to 20;[3 7 14] eye diameter 6[7] to 7;'[14] greatest body depth 12;[7] body depth at anus 8 to 9;[3 14] (as % head length) eye diameter 30[7] to 40;[3 14] body depth at anus 41[3] to 48.[14] Morphology: yolk absorbed (7.0[7] to 8.1 mm[3 9] or 9.1 to 9.6 mm at 8 days posthatching[14]); mouth parts ossified and posterior swim bladder chamber developed between myomeres 6 and 11 (8.2 mm;[3] or 8.6 to 9.2 mm[14]); notochord flexed (9.0 mm);[3 7] hypural elements and first caudal fin rays formed (9.5 to 9.7 mm;[3] or 9.9 to 11.0 mm[14]); anterior swim bladder chamber between myomeres 5 and 7;[3] (at 9.9 mm;[3] or 12.0 to 13.4 mm[14]); mouth sometimes subterminal (12.0 mm)[7]; first dorsal fin rays (12.5 mm)[3 7] at myomeres 15 and 16;[3] but see 13-19 mm.

Pigmentation: pigmentation spreading laterally from dorsum;[7] narrow, midlateral stripe developed (9.0 mm), lateral longitudinal series on intestine;[7,14] median predorsal series present (9.6 mm);[3] upper jaw outlined, ventral edge of opercle pigmented (10.2 to 11.0 mm).[14]

13-24 mm

Myomeres: 34 to 37 (28 to 29 + 6 to 8);[7] 34 to 42 (28 to 32 + 5 to 11);[14] see 6-g mm.

Morphometry: (as % TL) preanal length 64[7] to 68;[3,14] head length 18[7] to 23;[3,14] eye diameter 5 to 7;[3,7,14] greatest body depth 13;[7] body depth at anus 6[3] or 9 to 12;[14] (as % head length) eye diameter 28[7] to 29[3] or 30 to 33;[14] body depth at anus 44 to 59.[3,14]

Morphology: pelvic buds developed (12.0 to 13.2 mm);[3,7,14] below myomeres 16 through 19;[3] mouth subterminal (12.0[7] to 14.2[3] mm); first anal (14.9 to 15.4 mm[7] or 16.4 to 16.9 mm[14]) and dorsal (14.2 to 15.1 mm[14]) rays formed; gut S-shaped, mouth inferior, first pelvic fin rays formed (15 to 16 mm[3,7,10] or 17.6 to 19.2 mm[14]); all median fin rays formed (17 to 18 mm[3,7,10] or 19.7 to 20.6 mm[14]); pelvic (21.6 to 22.3 mm) and pectoral (22.8 to 23.9 mm) fin rays complete.[14]

Pigmentation: dorso-lateral surfaces uniformly pigmented, sparse pigmentation below lateral line, melanophores along dorsal, anal and pectoral fin rays (13[3] to 18[7,14] mm), and caudal fin rays;" broad postanal band ventrally (13 mm), all fins except pelvic fins with melanophores (18 mm);[3] irregular double row of melanophores on venter of gut and anal fin, heavy pigmentation ventro-laterally behind pelvic fins (19.7 mm).[14]

JUVENILES

Total length	Description
20-40 mm	Myomeres: 33 to 35 (26 to 27 + 6 to 8);[7] also see 6-g mm.
	Morphometry: (as % TL) preanal length 56[7] or 58 to 64;[14] head length 24[7,14] to 26;[11] eye diameter 7;[7,11,14] greatest body depth 22;[7,11] body depth at anus 12[11] to 15;[14] (as % head length) eye diameter 27[11] to 29;[14] body depth at anus 45[11] or 57 to 62.[14]
	Morphology: all finfolds absorbed (21 mm), squamation started (20 mm);[7,14] squamation complete (35 to 37 mm).[3,7,14]
	Pigmentation! seven to nine langitudinal stripes on sides, ventral pigmentation sparse, scales outlined on posterior edges (25 to 34 mm).[14]

ADULTS

Fin rays: caudal 18;* dorsal 25 to 30, anal 7 to 9;[5] pectoral 16 to 18;[14] pelvic 8 to 10.[5]

Vertebrae: 38 to 40 (including Weberian vertebrae).[5]

Lateral line scales: 35 to 41.[5]

Diagnostic characters: dorsal fin long (25 to 30 rays) with very elongate anterior lobe (first ray 4 to 6 times length of last ray), mouth inferior, no knob-like projection on lower lip.

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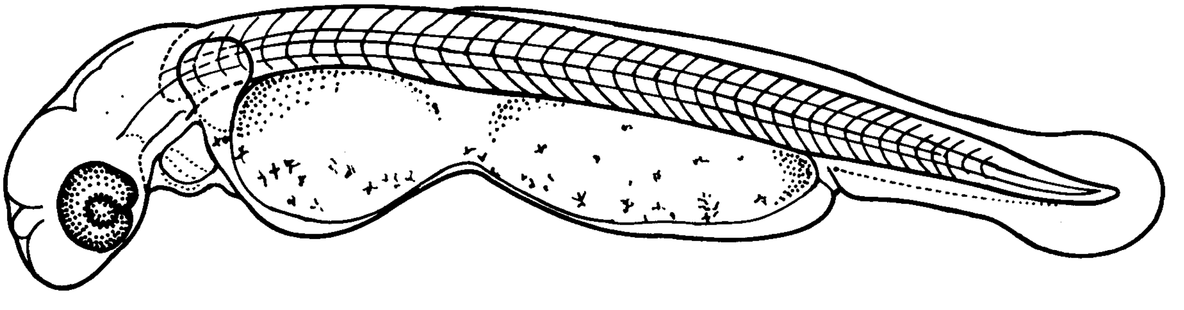
2. Woodward and Wissing (1976)
3. Fuiman (1979a)
4. Gale and Mohr (1976)
5. Scott and Crossman (1973)
6. Harlan and Speaker (1969)
7. Gerlach (1973)
8. Loos et al. (1979)
9. Jones et al. (1978)
10. Lippson and Moran (1974)
11. Fish (1932)
12. Madsen (1971)
13. Hubbs and Lagler (1958)
14. Yeager (1980)



6.5 mm

Fig. 141. Carpiodes cyprinus, quillback. Yolk-sac larva, newly hatched. (Laboratory-reared, Tennessee, Yeager 1980).

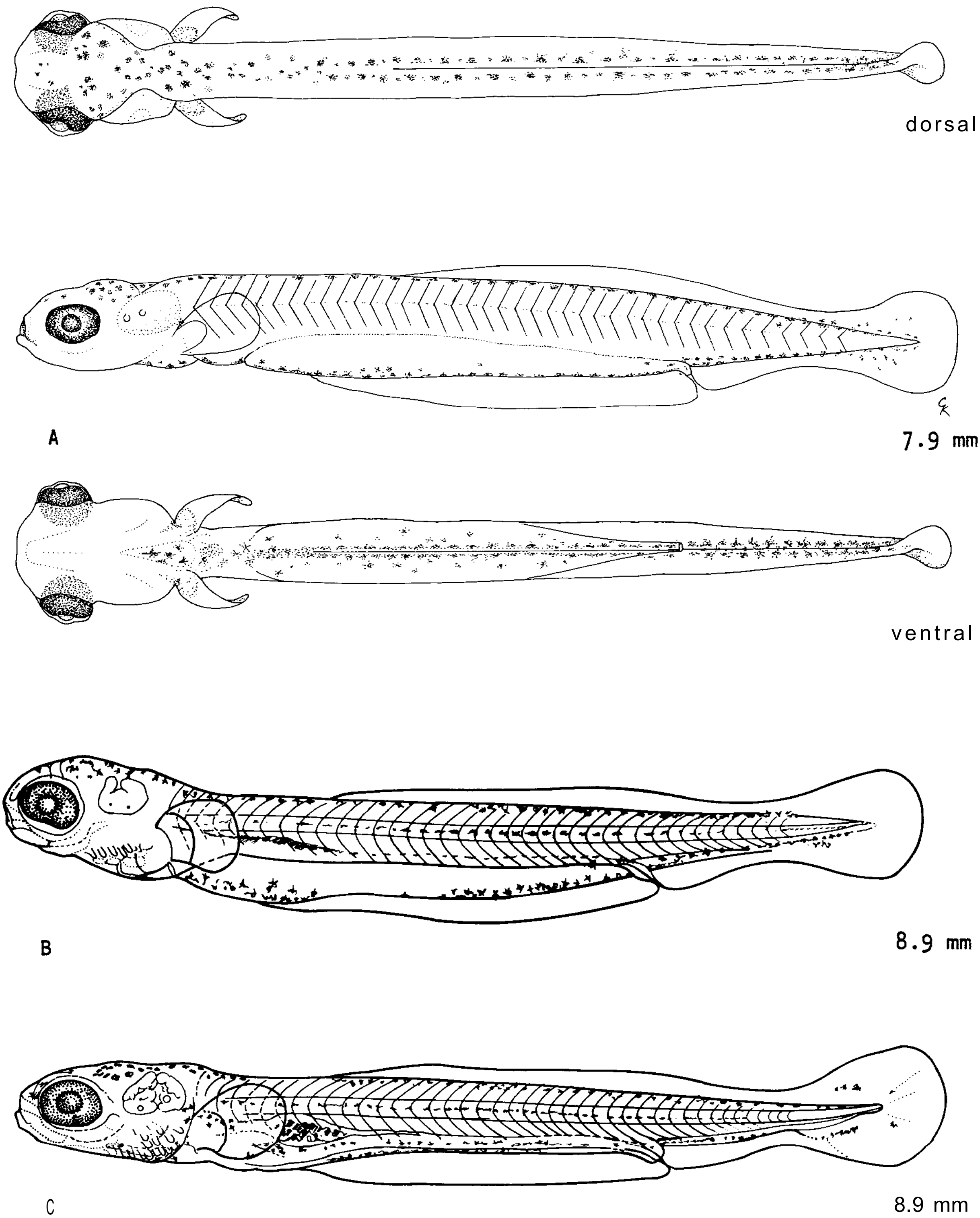


Fig. 142. Carpiodes cyprinus, quillback. A and B. Yolk-sac larvae. C. Larva. (A, wild-caught, Pennsylvania, Fuiman 1979a; B and C, laboratory-reared Tennessee, Yeager 1980).

Carpiodes cyprinus

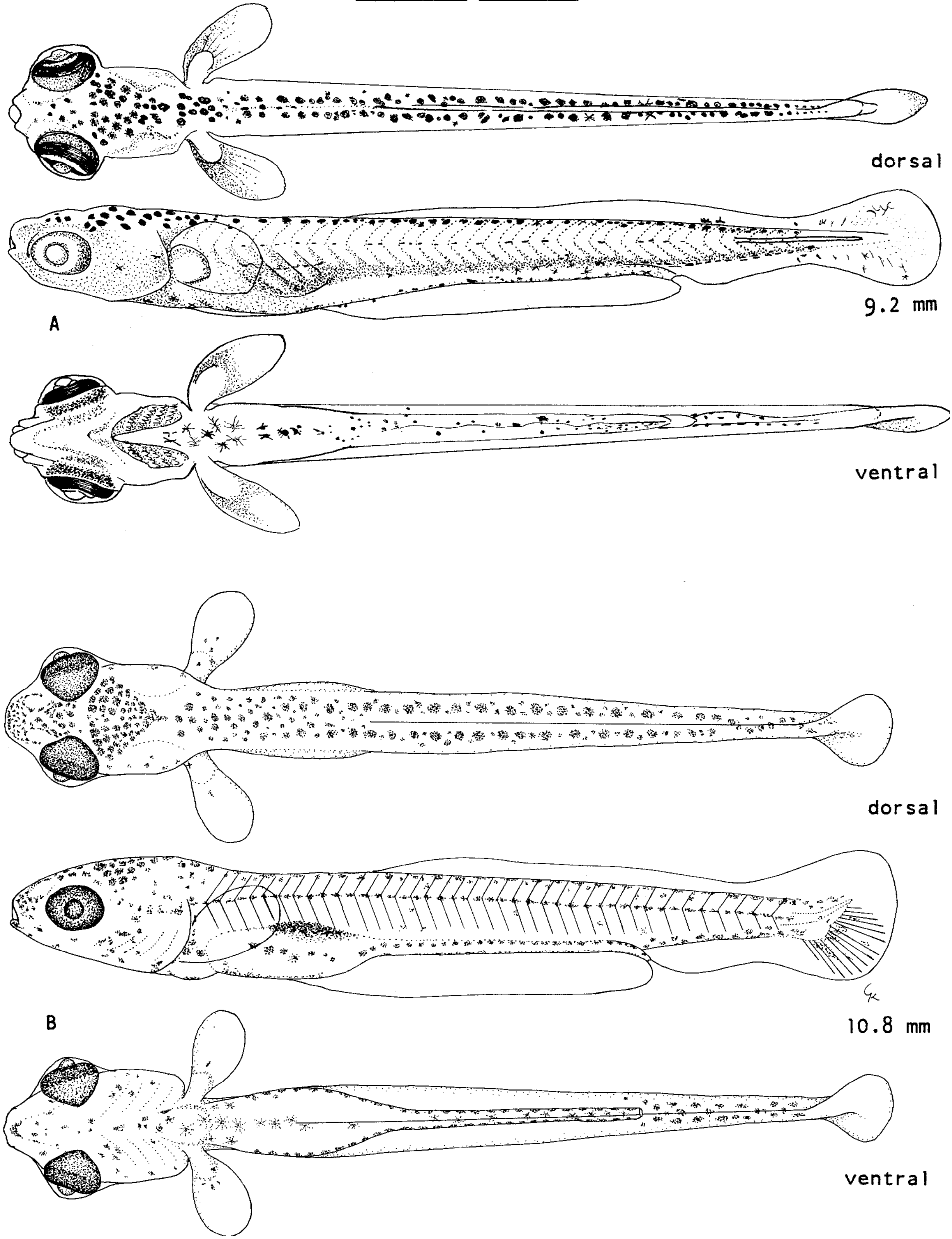


Fig. 143. Carpiodes cyprinus, quillback. A and B. Larvae. (A, laboratory-reared, Virginia, Loos et al. 1979; B, wild-caught, Pennsylvania, Fuiman 1979a).

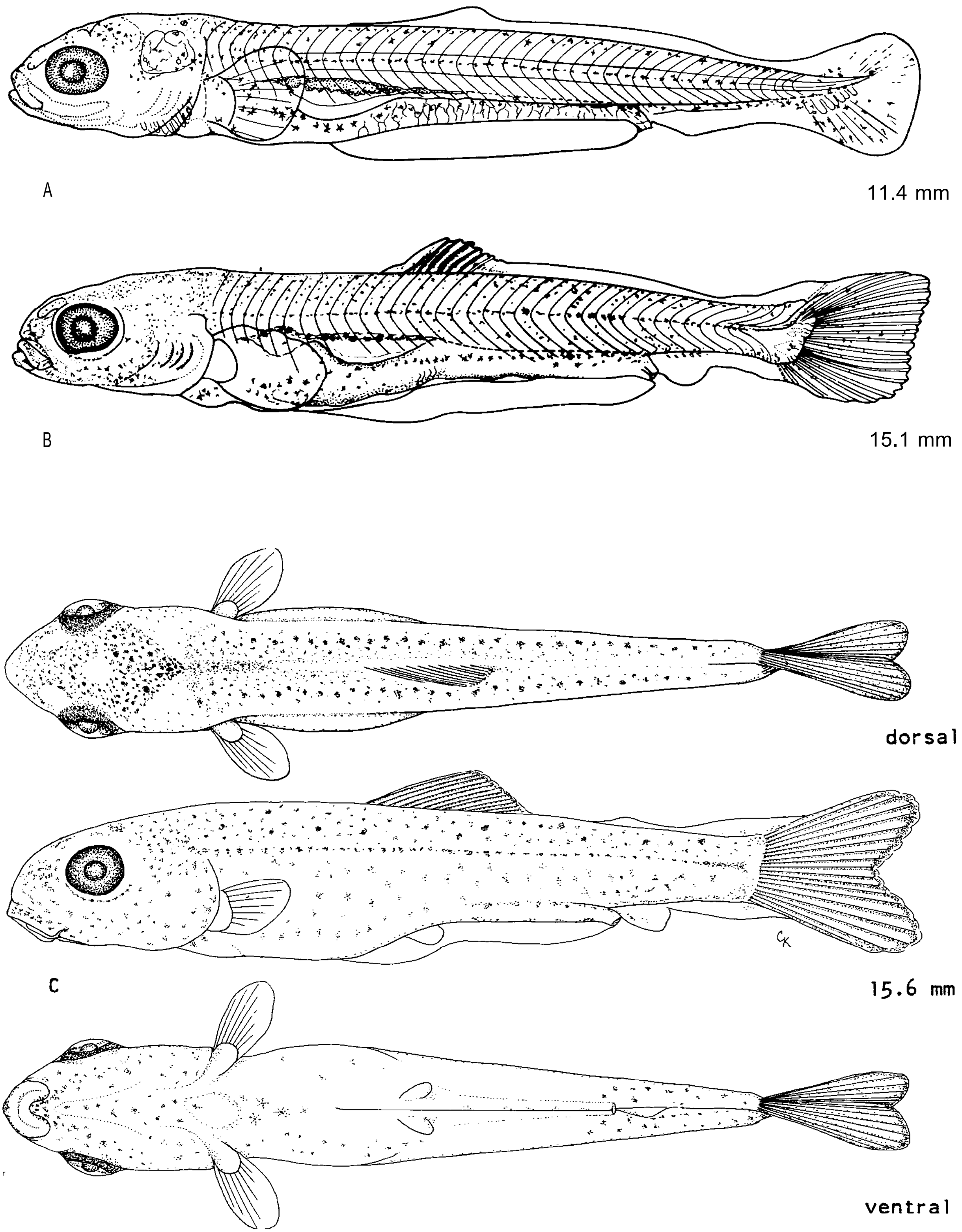


Fig. 144. Carpiodes cyprinus, quillback. A-C. Larvae. (A and B, laboratory-reared, Tennessee, Yeager 1980; C, wild-caught, Pennsylvania, Fuiman 1979a).

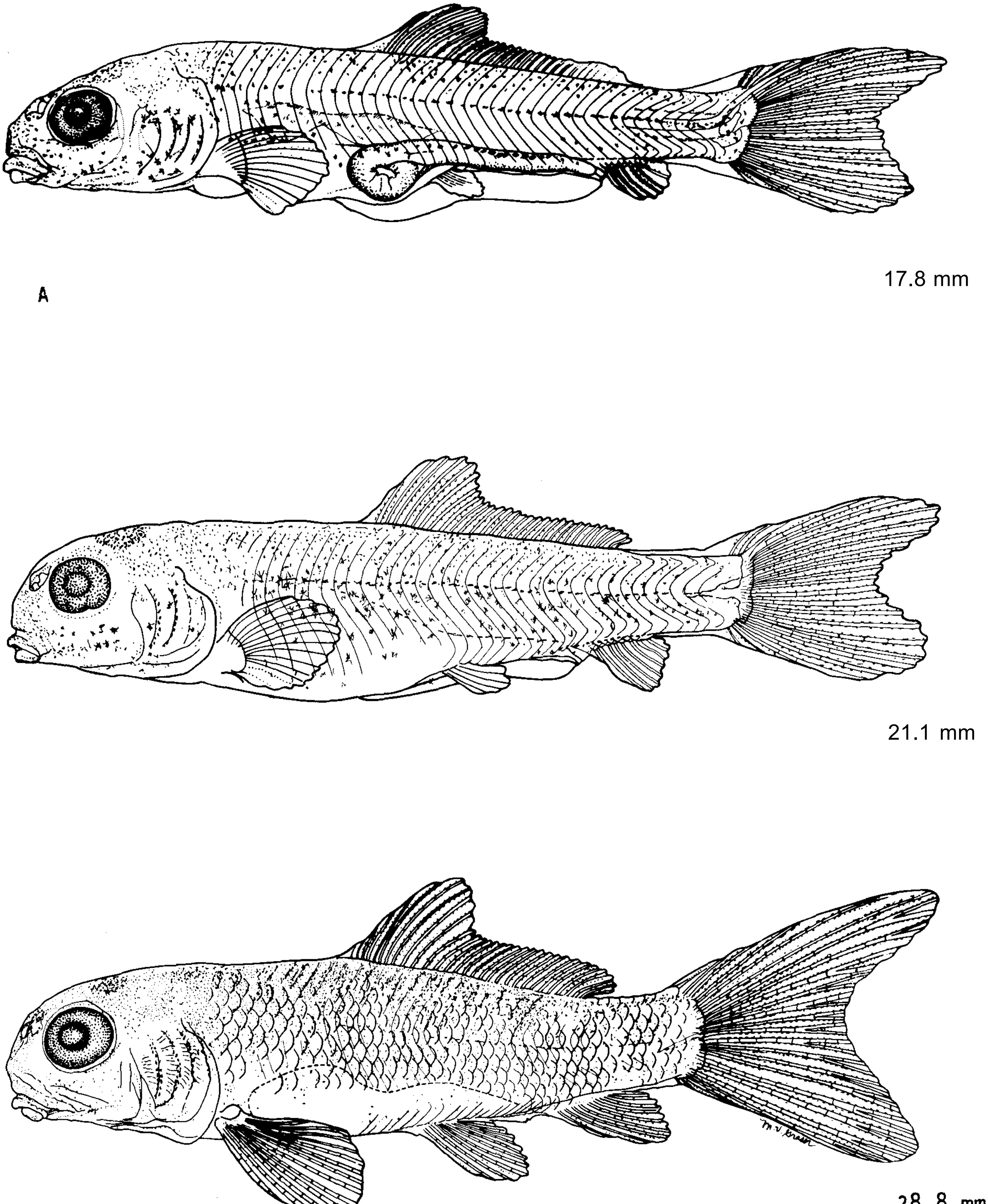


Fig. 145. Carpiodes cyprinus, quillback. A and B. Larvae. C. Juvenile. (A-C, laboratory-reared, Tennessee, Yeager 1980).

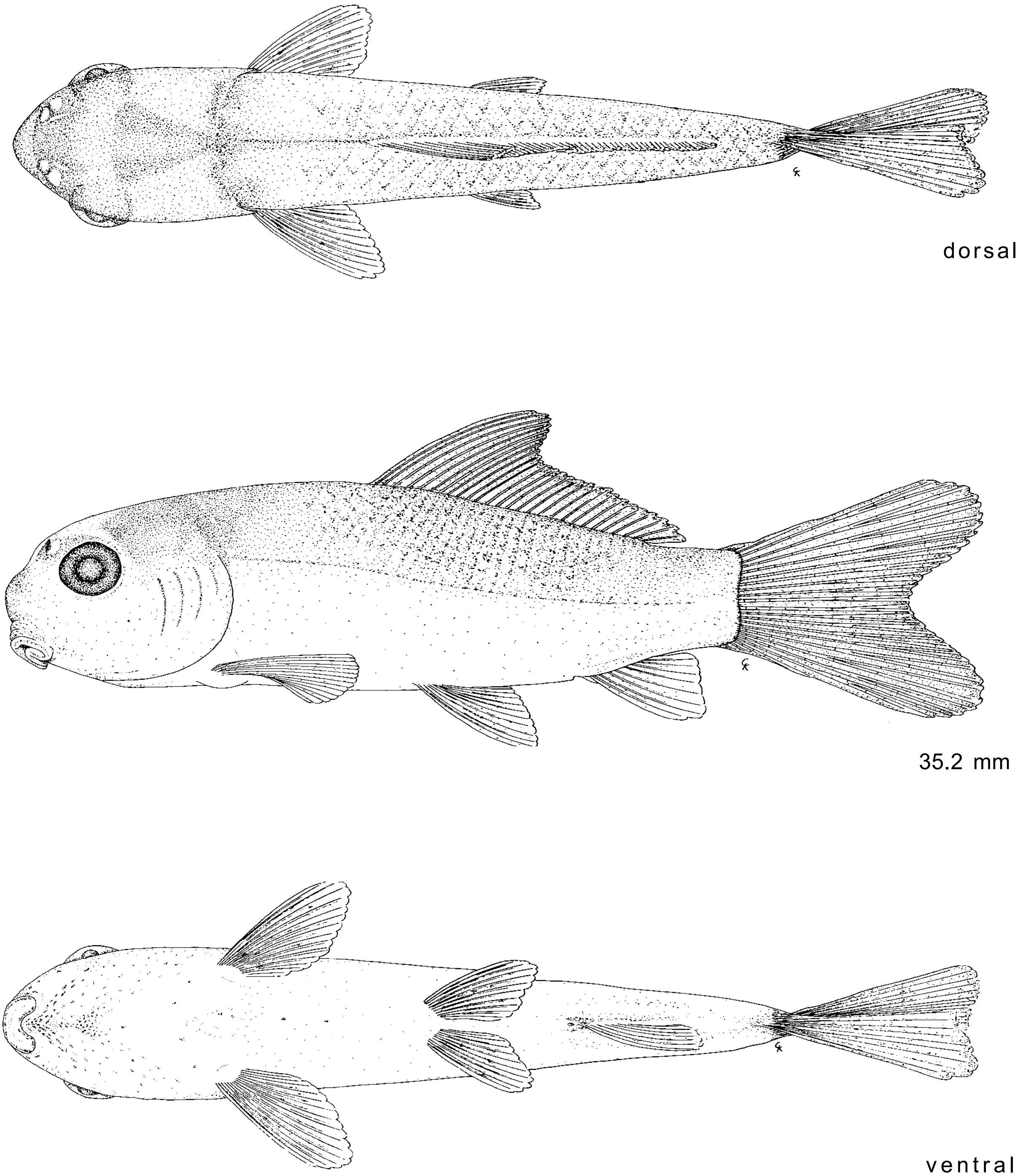


Fig. 146. Carpiodes cyprinus, quillback. Juvenile. (Laboratory-reared, Virginia, Fuiman 1979a).

Carpiodes velifer (Rafinesque), highfin carpsucker

DISTRIBUTION

This species may not be present in the Great Lakes.1 Two records from southern and southwestern Lake Michigan are known.[5]

SPAWNING SEASON

Spawns in May in Iowa,[2] late July in Missouri[3] and June through September in Ohio.'

SPAWNING TEMPERATURE

Water temperatures during collection of ripe adults ranged from 19 to 28 C.[4]

SPAWNING HABITAT

Adults migrate to shallows[2] or spawn in deep gravelly riffles.[3]

SPAWNING SUBSTRATE

Deposits eggs among gravel.[3]

FECUNDITY

41,644 to 62,355.[4]

EGGS

Demersal, adhesive, diameter 1.9 to 2.0 mm.[7]

YOLK-SAC LARVAE

Total length	Description
5-9 mm	Myomeres: 32 to 39 (25 to 29 + 5 to 11) ;[7 8] usually 35 to 37 (27 to 29 + 7 to 10) .[8] Morphometry: (as % TL) preanal length 70 to 72;[7 8] head length 17 to 18;[8] eye diameter 6 to 7;[7 8] body depth at anus 8;[8] (as % head length) eye diameter 36 to 43, body depth at anus 41 to 50.[7] Morphology: head slightly deflected over bulbous yolk sac, mouth open, pectoral buds present (5.6 mm), head straight, eye elliptical (6.0 mm);[8] yolk sac bilobed, oil globule absent, eye pigmented (6 to 7 mm) mouth terminal, posterior swim bladder chamber present (7.5 mm) .[7 8] Pigmentation: eye pigmented, oval patch of melanophores on venter of yolk sac, midlateral stripe present (6 mm), heart-shaped pattern over hindbrain, double row of

melanophores on dorsum (7 to 8 mm), eye pigmented, oval patch of melanophores on venter of yolk sac, midventral row present on caudal peduncle.'

LARVAE

Total length	Description
7-20 mm	Myomeres: 32 to 38 (26 to 29 + 6 to 10);[7] see 5-9 mm. Morphometry: (as % TL) preanal length 64, head length 26, eye diameter 7.[7] Morphology: yolk absorbed (7 to 9 mm), first caudal (9 mm), dorsal, pectoral (10 mm), anal (11 mm), and pelvic (12 mm) fin rays formed, pelvic buds developed (10 mm), gut coiled (12 mm), f infolds absorbed (17 mm), first scales formed (19 mm).[7] Pigmentation: double row of melanophores on dorsum (15 mm) and midlateral stripe (16 mm) indistinct, ventral row on each side of anal fin joined with midventral peduncle row, dorsum of gut pigmented, breast and belly pigment restricted (7 to 10 mm) or absent (10 mm), melanophores in caudal (9 mm), dorsal (12 mm) and anal (16 mm) fins scattered.[7]

JUVENILES

Total length	Description
20-57 mm	Morphometry: (as % TL) preanal length 57, head length 26, eye diameter 7.[7] Morphology: all scales formed (20 mm).[7] Pigmentation: pectoral (36 mm) and pelvic (37 to 57 mm) fins pigmented.[7]

ADULTS

Fin rays: caudal 18;* dorsal 23 to 30, anal 7 to 9;[6,8] pectoral 14 to 18;[8] * pelvic 8 to 10.[6,8]

Vertebrae: 35 to 36 (including Weberian vertebrae).[6]

Lateral line scales: 33 to 35.[6]

Diagnostic characters: dorsal fin long (23 to 27 rays), scales large (33 to 35 in lateral series), mouth inferior, knob-like projection on middle of lower lip, first dorsal fin ray greater than length of dorsal fin base.

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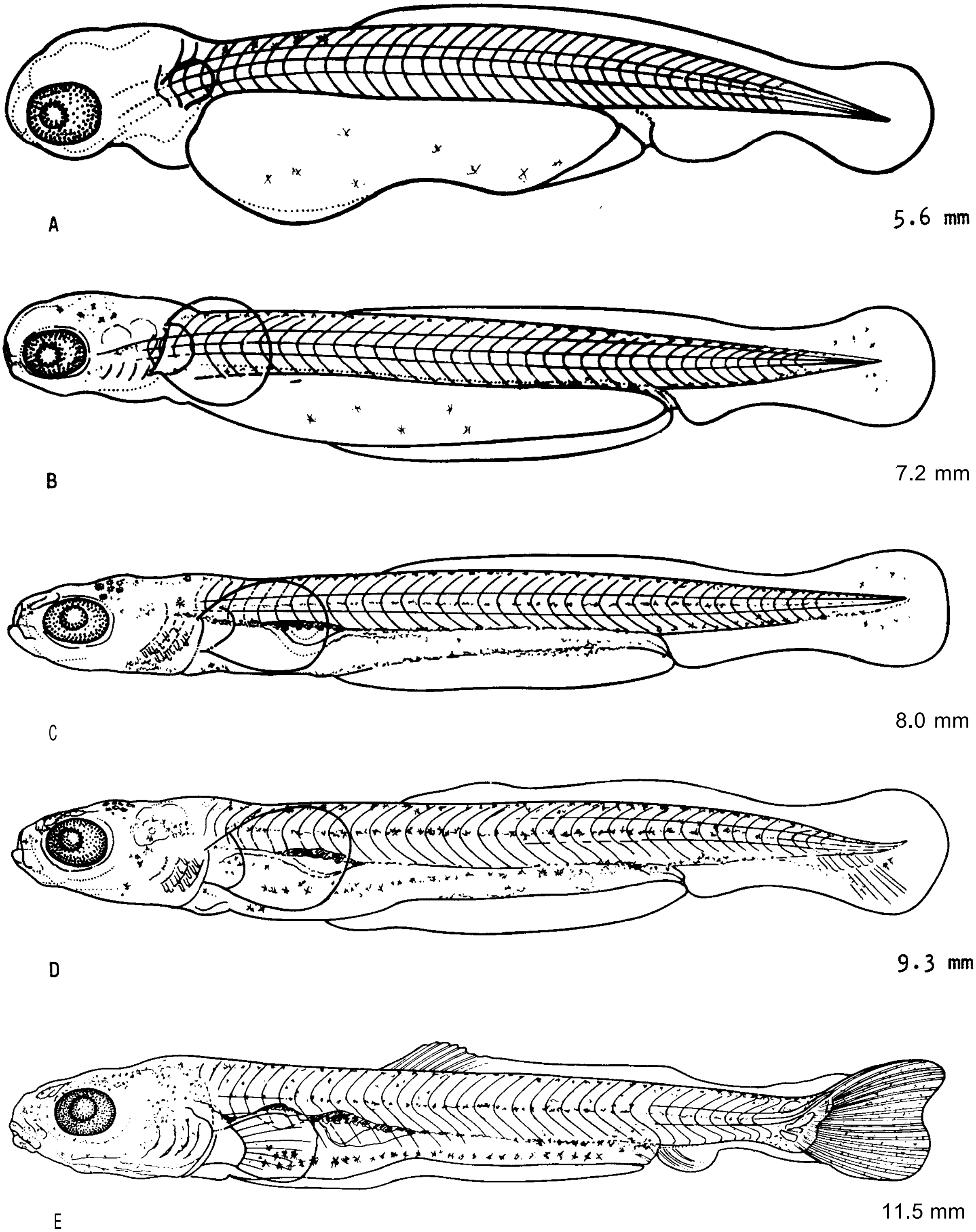

Fig. 147. Carpiodes velifer, highfin carpsucker. A and B. Yolk-sac larvae. C-E. Larvae. (A-E, laboratory-reared, Arkansas, Yeager 1980).

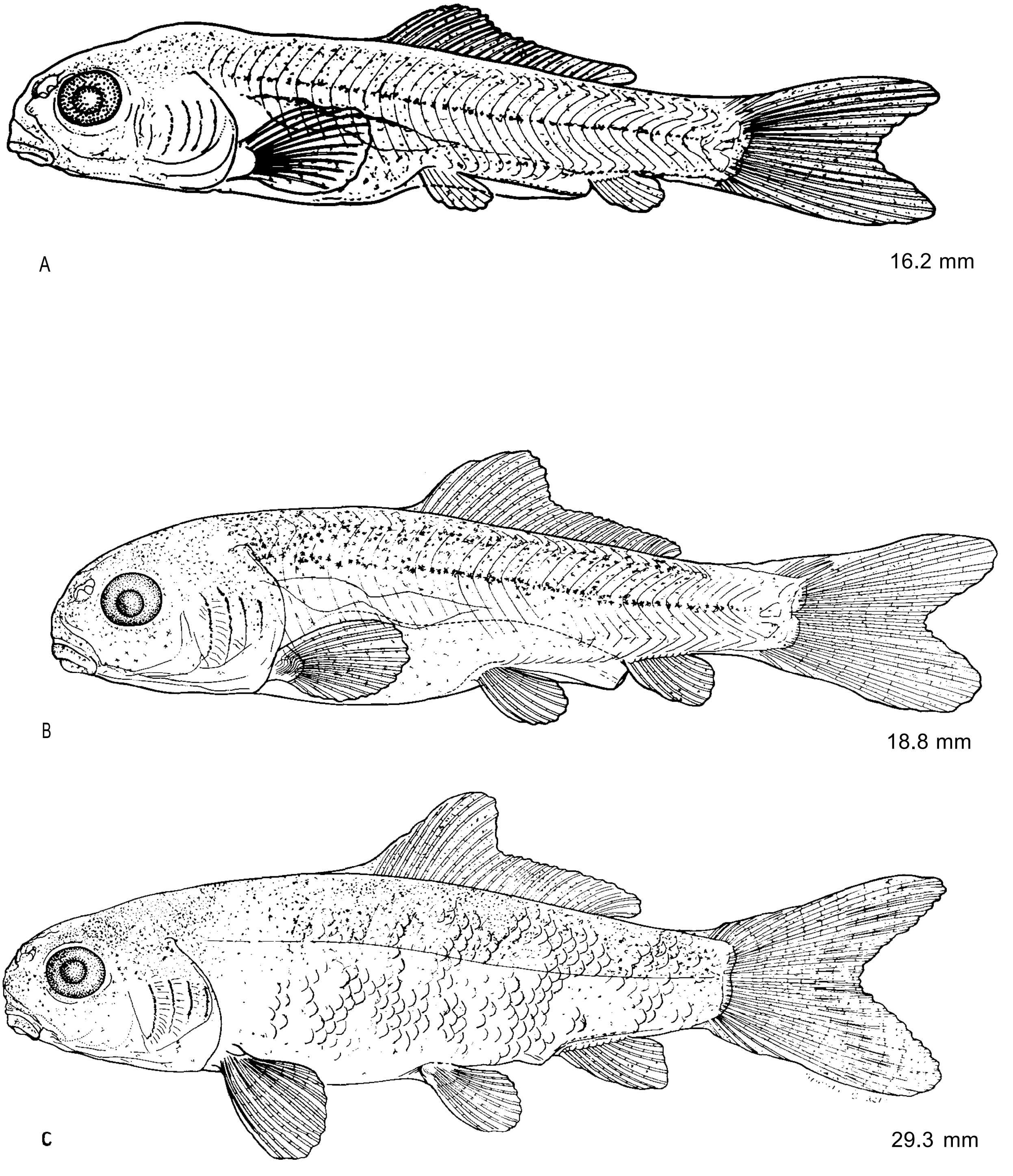

Fig. 148. Carpiodes velifer, highfin carpsucker. A and B. Larvae. C. Juvenile. (A-C, laboratory-reared, Arkansas, Yeager 1980).

Catostomus catostomus (Forster), longnose sucker

DISTRIBUTION

Throughout the Great Lakes region, occurring primarily in the lakes proper.[10] Common along the shores of Lake Michigan and entering its tributaries during spawning.'

SPAWNING SEASON

Spawns in early May in northern Lake Huron,' mid-April to May in western Lake Superior.*

SPAWNING TEMPERATURE

Spawning is triggered at 5 C.[6] Spawning occurs between 10 and 15 C.[4 5 6 7 8]

SPAWNING HABITAT

Spawns primarily in streams,[10] 15 to 30 cm deep.[6] Occasionally spawns over shallow reefs in lakes.[7 9]

SPAWNING SUBSTRATE

Usually spawns over moderately sized, 0.5 to 10 cm, gravel.[6]

FECUNDITY

14,000[8] to 60,000.[5]

NATURAL HYBRIDS

Rarely *Catostomus commersoni*.[13]

EGGS

Demersal, nonadhesive, lacking oil globules, diameter 3 mm, yolk light yellow;[3] incubation period: 8 days at 15 C, 11 days at 10 C.[6]

YOLK-SAC LARVAE

Total length	Description
8 mm	Newly hatched,[3] not described further.
1O-13 mm	Myomeres: usually 46 to 48 (37 to 39 + 8 to 10).[z] Morphometry: (as % TL) preanal length 75, head length 16, eye diameter 7, body depth at anus 8, (as % head length) eye diameter 42, body depth at anus 48.[2]

Morphology: yolk sac tubular (9.9 mm), mouth parts ossified (11.4 mm), notochord flexed (11.9 mm), posterior swim bladder chamber inflated (12.2 mm), hypural elements and first caudal fin rays formed (12.0 to 13.1 mm).[2]
Pigmentation: dorsal melanophores cover nape, narrowing to single middorsal row to tail (11.3 mm), three longitudinal rows of melanophores on dorsum, single midlateral stripe with usually one melanophore per myomere, melanophores along dorsum of yolk sac, single midventral stripe (11.9 mm), dorsal head pigmentation leaving a pigment-free interorbital space (12.0 mm).[2]

LARVAE

Total length	Description
11-15 mm	Myomeres: counts unchanged with size.[2]
	Morphometry: (as % TL) preanal length 73, head length 20, eye diameter 7, body depth at anus 7, (as % head length) eye diameter 37, body depth at anus 34.[2]
	Morphology: yolk absorbed (about 11 days posthatching at 20 C), posterior swim bladder chamber lying between myomeres 7 and 15, anterior chamber inflated (12.7 mm) between myomeres 5 and 7, 18 principal caudal fin rays formed (13.4 mm), first dorsal fin rays formed (14.3 mm) between myomeres 22 and 25.[2]
	Pigmentation: short horizontal row of melanophores behind pectoral bud insertion, melanophores among caudal fin rays, midlateral stripe sometimes with multiple melanophores per myomere, interorbital space obscure, longitudinal dorsal rows less distinct, few melanophores scattered on sides of body (12.8 mm).[2]
15-23 mm	Morphometry: (as % TL) preanal length 68, head length 23, eye diameter 8, body depth at anus 10, (as % head length) eye diameter 34, body depth at anus 42.2
	Morphology: pelvic buds formed (14.9 mm) between myomeres 20 and 21, mouth subterminal (15.7 mm), gut S-shaped (17.0 mm), eight anal fin rays formed, pelvic fin rays ossified (18.4 mm).[2]
	Pigmentation: melanophores line all dorsal fin rays but most pronounced on anterior four (15.7 mm), ventral pigment fading, dorsal pigment uniformly scattered.[2]

JUVENILES

Total length	Description
28 mm	Morphometry: (as % TL) preanal length 64, head length 24, eye diameter 7, body depth at anus 14, (as % head length) eye diameter 28, body depth at anus 57.[2]
	Morphology: squamation complete.[2]

Pigmentation: mottled dorsal pigmentation, less intense on lateral surfaces.[3]

ADULTS

Fin rays: caudal 18;[2] dorsal 9 to 11, anal 7, pectoral 16 to 18, pelvic 9 to 11.[11]

Vertebrae: 45 to 48 (including Weberian vertebrae).[12]

Lateral line scales: 99 to 108.[11]

Diagnostic characters: dorsal fin short (9 to 11 rays), scales small (99 to 108 in lateral series), swim bladder with two chambers.

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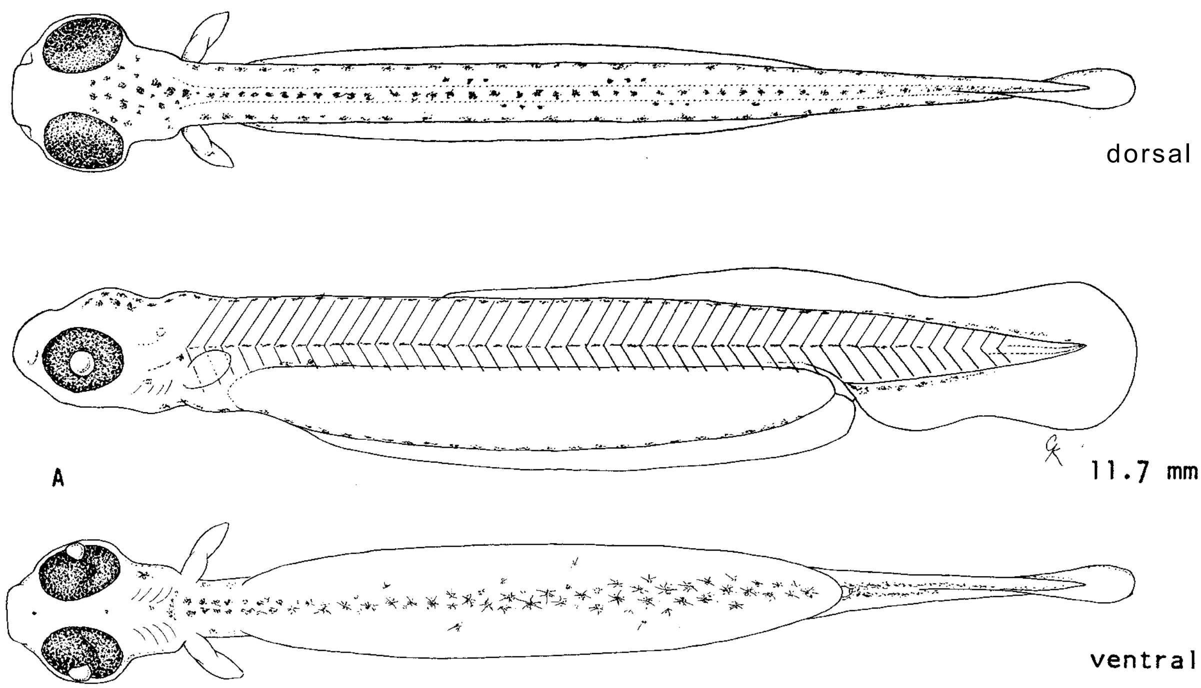

Fig. 149. Catostomus catostomus, longnose sucker. Yolk-sac larva. (Laboratory-reared, Michigan, Fuiman and Witman 1979).

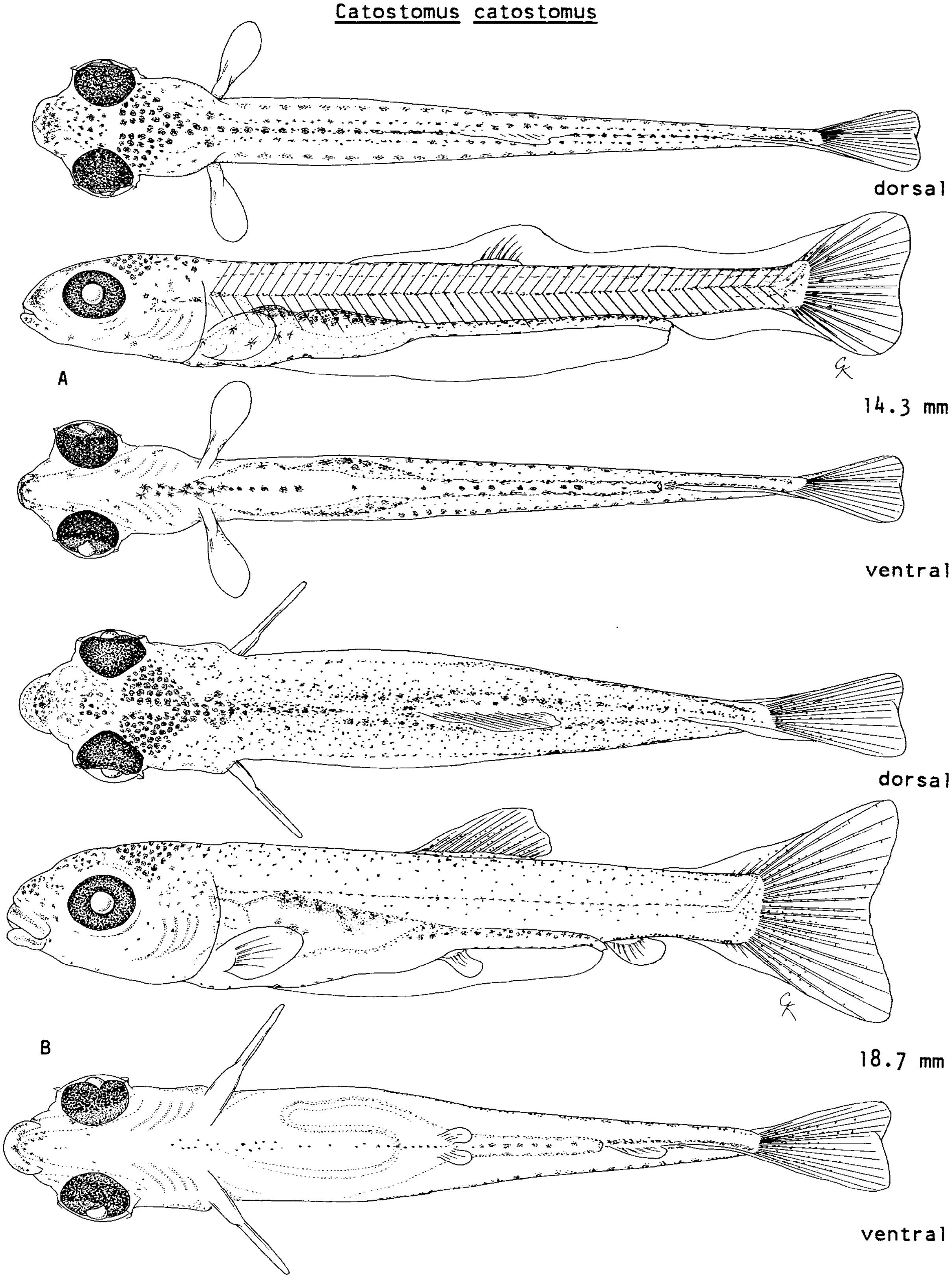

Fig. 150. Catostomus catostomus, longnose sucker. A and B. Larvae. (A and B, laboratory-reared, Michigan, Fuiman and Witman 1979).

Catostomus commersoni (Lacepede), white sucker

DISTRIBUTION

Throughout the Great Lakes region, occurring in streams and lakes.[2] Common in shallow coastal areas of Lake Michigan, but more frequent in its tributaries.'

SPAWNING SEASON

Spawns from April to mid-May in Michigan [12] and Wisconsin. [1]

SPAWNING TEMPERATURE

Spawning is triggered at 10 C.[3] Spawning occurs between 7.2 and 10 C.[1 3]15

SPAWNING HABITAT

Spawns primarily in streams,' in both riffles and pools.[15] Occasionally spawns in shallows of lakes.[10]

SPAWNING SUBSTRATE

Deposits eggs among loose gravel.'

FECUNDITY

20,000 to 50,000.' [15]

NATURAL HYBRIDS

Rarely Catostomus catostomus.[11]

EGGS

Demersal, nonadhesive (forming loose attachments during water hardening* which accounts for reported adhesiveness'), oil globule absent, diameter 2 to 3.6 mm; [6 10 14 15] yolk light yellow;[6] diameter of dechorionated egg 2[5] to 2.5 mm;[14] incubation period: 17 to 19 days at 10 C;[5] 8 days at 11 C;[3] 12 days at 11.7 C;[8] 8 days at 14.3 C;[16] 7 days at 15.6 C;[7 15] 4 days at 21.1 C.[7]

YOLK-SAC LARVAE

Total length	Description
8-10 mm	Newly hatched;[6 10 15 16] hatching size varies, extremes of 6.09 and 12.0 mm[5] have been reported.
	Myomeres: usually 45 to 48 (37 to 39 + 7 to 10) all myomeres formed (newly hatched) .[6]
	Morphometry: (as % TL) preanal length 82, head length 12, greatest body depth 17.[10]

Morphology: head usually not flexed downward over yolk sac (in less than 30% of specimens 8.6 to 11.0 mm);[6] or usually flexed downward (8.7 to 9.2 mm);[16] mouth parts not developed;[6 16] gill filaments partly exposed;[6] pectoral buds present;[5 6 16] yolk sac cylindrical.[6]
Pigmentation: eyes partially pigmented;[6 10] other body pigmentation absent.[6 10 16]

11-13 mm

Myomeres: 43 to 47 (36 to 38 + 8 to 10), mean 46 (37 + ·[16] see 8-10 mm
Morphometry: (as % TL) preanal length 77;[6 16] head length 13'" to 15;[6] eye diameter 6;[6 16] greatest body depth 13;[16] body depth at anus 8, (as % head length) eye diameter 42, body depth at anus 52.[6]
Morphology: mouth parts ossified (12.5[6] to 13.9 mm[16]); posterior swim bladder chamber inflated (12.0[6] to 14.4 mm[16]); first caudal fin rays (12.7[6] to 14.4 mm[16]).
Pigmentation: dorsal melanophores on occiput narrowing to single middoral stripe (11.2 mm);[6] stripe of one melanophore per myomere along midlateral myoseptum, short subdermal diagonal stripe extending postero-ventrad from otic region, three rows of melanophores on dorsum, dense pigmentation on top of head with small pigment-free interorbital space, dorsum of swim bladder heavily pigmented (12.7 mm).[6]

LARVAE

Total length	Description

12-18 mm

Myomeres: 45 to 47 (37 to 38 + 7 to 9), mean 46 (37 + 9)[16] see 8-10 mm.
Morphometry: (as % TL) preanal length 73[16] to 74;[6 13] head length 17[16] to 19;[6] eye diameter 7;[6 16] greatest body depth 12;[16] body depth at anus 7;[6] (as % head length) eye diameter 36, body depth at anus 40.[6]
Morphology: yolk absorbed (11[15] to 14.4 mm;[16] ca. 6 to 8 days posthatching;[10 15] and 60 days postfertilization[3]); posterior swim bladder chamber between myomeres 8 and 16, anterior chamber inflated (12.7 to 13.9 mm) between myomeres 6 and 8;[6] notochord flexed (12.86 to 14.7[16] mm): hypural elements formed (14.5 mm), first dorsal fin rays formed (15.3 mm) between myomeres 18 and 24;[6] pelvic buds formed (14.2[14] to 15.4 mm[6]) between myomeres 19 and 22;[6 10] first pectoral fin rays formed (16.8 mm).[6 10]
Pigmentation: three dorsal stripes extending posteriad from above pectoral fin insertion;[6 14] and merging on caudal peduncle, interorbital pigment-free space obscure (12.8 mm), scattered melanophores on epaxial musculature (13.6 mm);[6] diagonal series downward and

backward from pectoral fins toward gut (14.4 mm[16] probably same as subdermal diagonal series described earlier*); dorsal rows obscure (16.0 mm).[6]

18-30 mm Myomeres: 44 to 46 (35 to 39 + 7 to 10), mean 45 (36 + 9);[16] see 8-10 mm.
Morphometry: (as % TL) preanal length 67 to 68, head length 22, eye diameter 6 to 7;[6,16] greatest body depth 16;[16] body depth at anus 7, (as % head length) eye diameter 31, body depth at anus 35.[6]
Morphology: first anal and pelvic fin rays ossified (17.5 mm), al 1 dorsal fin rays ossified (24 mm), mouth subterminal (18.2 mm), gut S-shaped (21 mm).[6]
Pigmentation: melanophores on interradial dorsal fin membrane (18.2 mm) and outlining dorsal and caudal fin rays;[6] pigmentation diffuse (20.4 mm).[16]

JUVENILES

Total length	Description
23-51 mm	Morphometry: (as % TL) preanal length 61[6] to 63;[16] head length 23, eye diameter 6;[6,16] greatest body depth 17;[16] body depth at anus 11, (as % head length) eye diameter 28, body depth at anus 50.[6] Morphology: mouth inferior (26 mm), first scales formed (34 mm), squamation complete (38 mm).[6] Pigmentation: uniform and diffuse (20.4 mm);[16] scale margins outlined;[10,16] median and pectoral fin rays outlined, midventral row persisting (26 mm), dorsum mottled (34 mm), extending onto sides (38 mm);[6] three dark lateral blotches (50 mm).[6,10]

ADULTS

Fin rays: caudal 18;[6] dorsal 10 to 13, anal 7, pectoral 13 to 15, pelvic 10 to 11.[4]

Vertebrae: 44 to 47 (including Weberian vertebrae).[17]

Lateral line scales: 55 to 75.[4]

Diagnostic characters: dorsal fin short (10 to 13 rays), scales small (55 to 75 in lateral series), swim bladder with two chambers.

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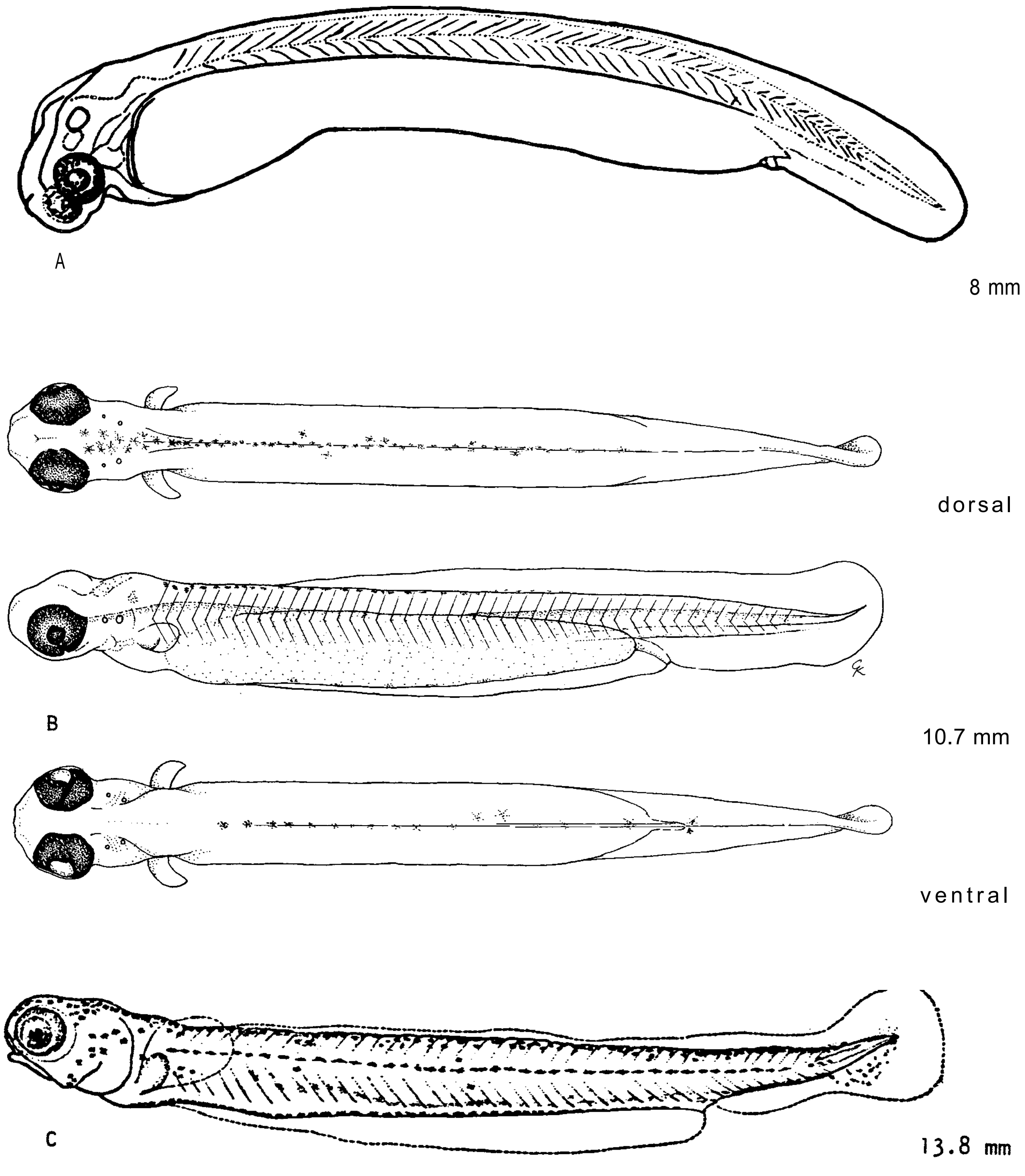


Fig. 151. Catostomus commersoni, white sucker. A. Yolk-sac larva, newly hatched. B. Yolk-sac larva. C. Larva. (A, laboratory-reared, New York, Stewart 1926; B, laboratory-reared, New York, Fuiman 1979a; C, wild-caught, Lake Erie, Fish 1932).

Catostomus commersoni

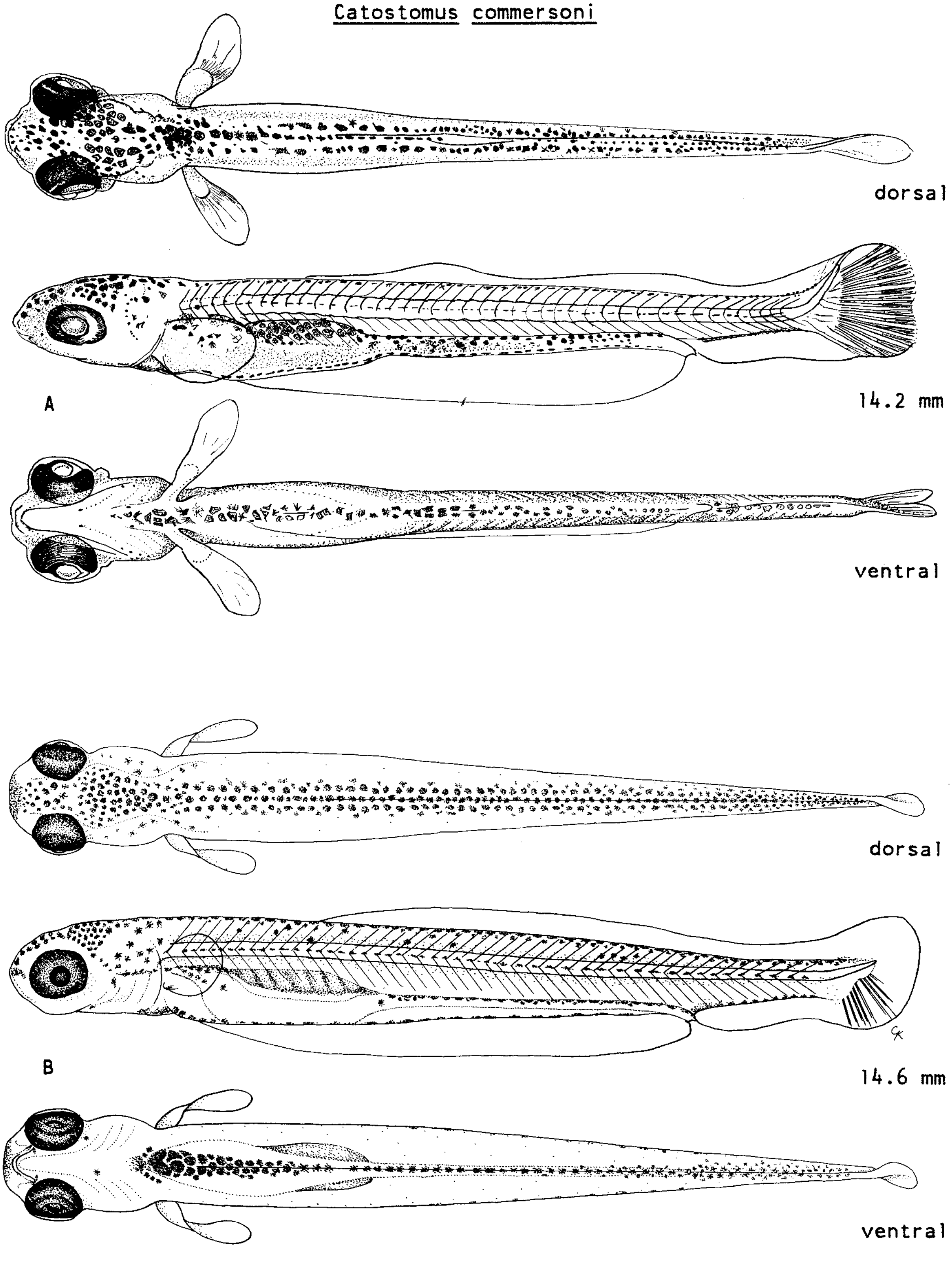
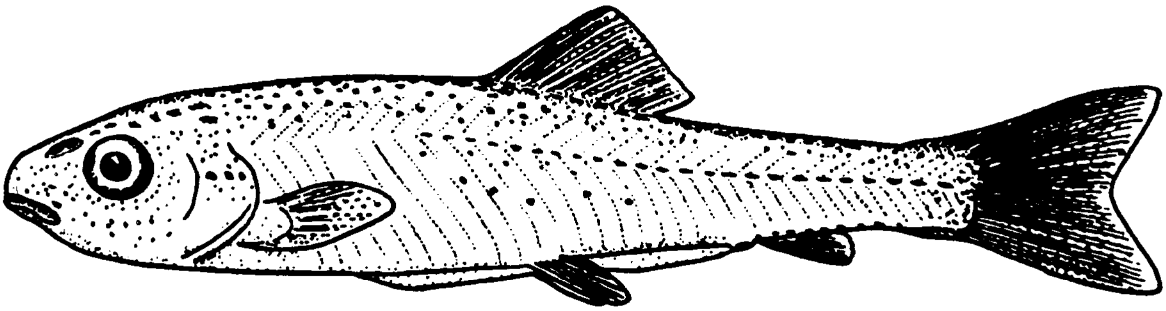
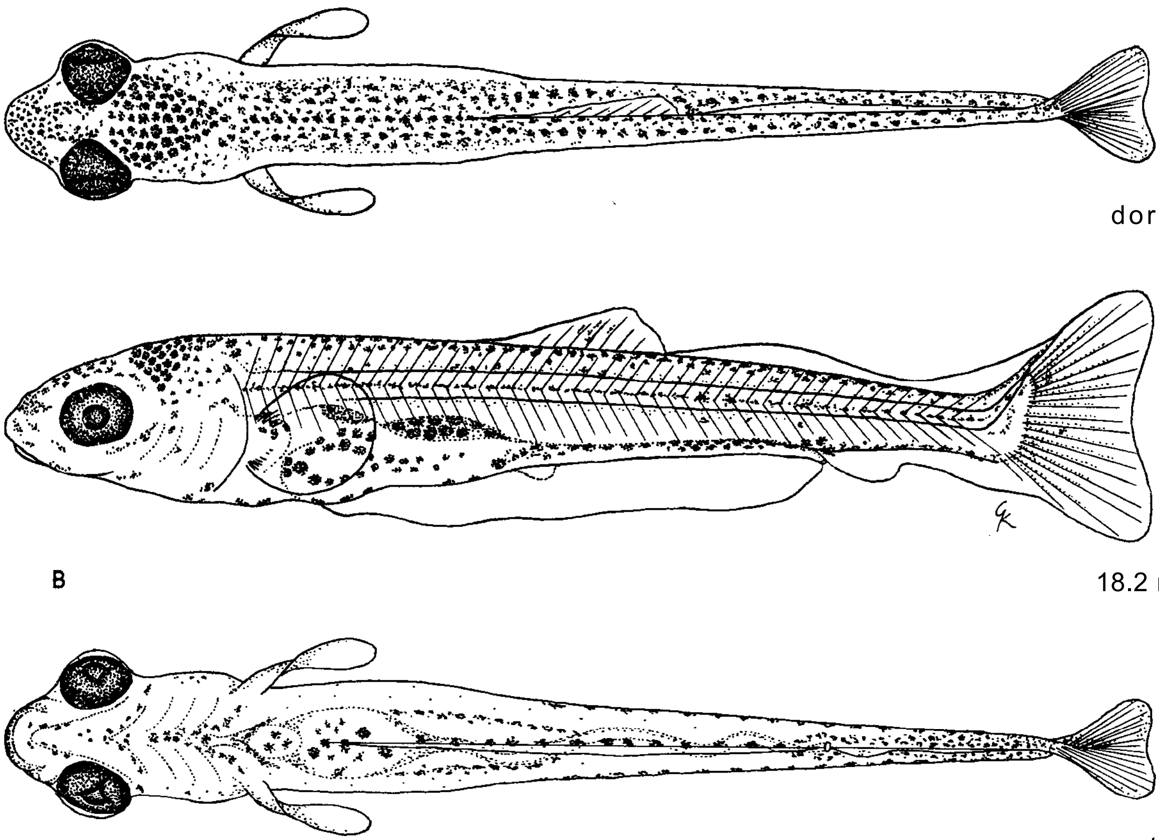


Fig. 152. Catostomus commersoni, white sucker. A and B. Larvae. (A, wild-caught, Virginia, Loos et al. 1979; B, laboratory-reared, Pennsylvania, Fuiman 1979a).



A

18 mm



dorsal

B

18.2 mm

ventral

Fig. 153. Catostomus commersoni, white sucker. A and B. Larvae. (A, laboratory-reared, New York, Stewart 1926; B, laboratory-reared, New York, Fuiman 1979a).

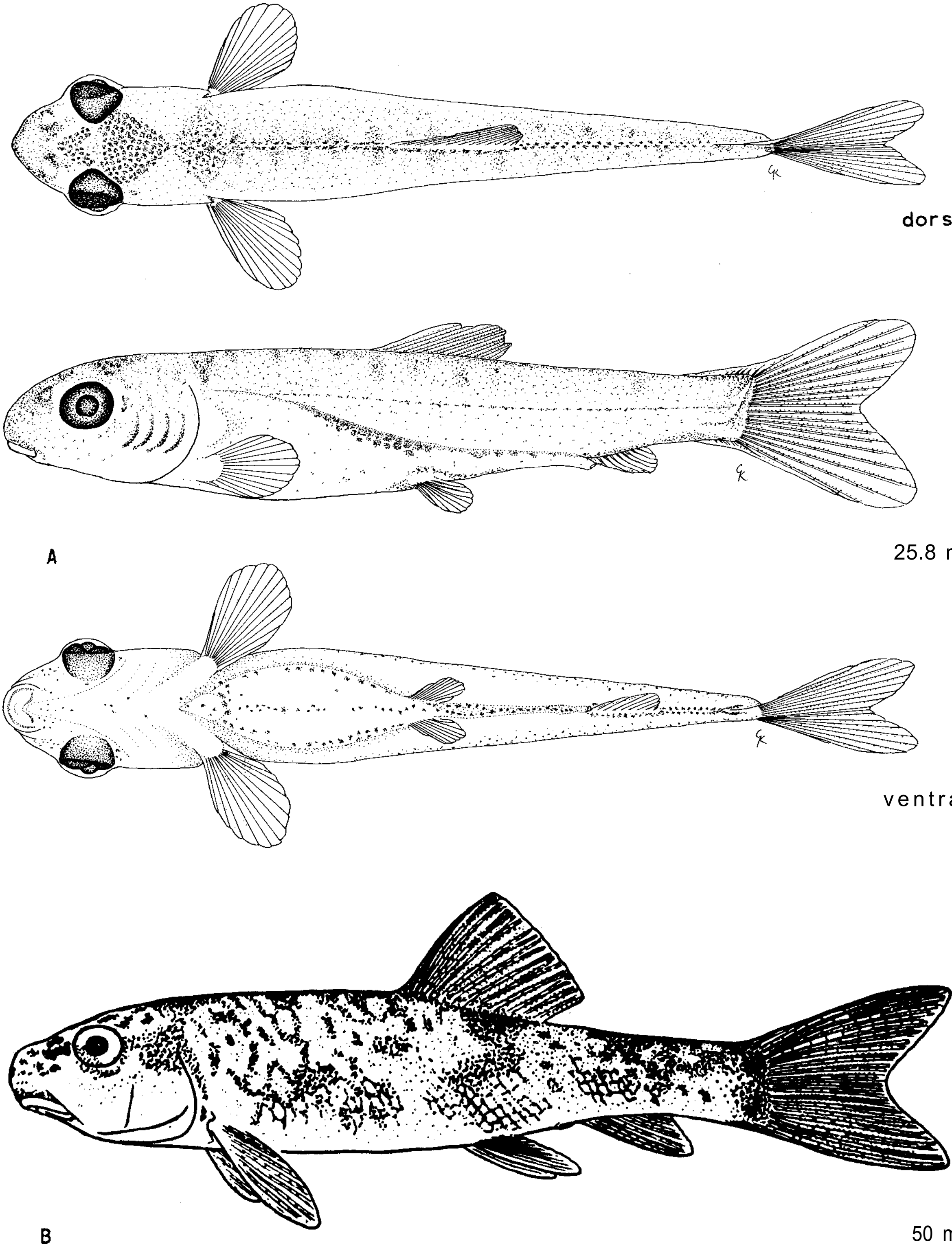


Fig. 154. Catostomus commersoni, white sucker. A and B. Juveniles. (A, laboratory-reared, New York, Fuiman 1979a; B, laboratory-reared, New York, Stewart 1926).

Erimyzon oblongus (Mitchill), creek chubsucker

DISTRIBUTION

Populations scattered around the Great Lakes region, including southern Lake Erie and eastern Lake Ontario.[6] Confined, in the Lake Michigan drainage, to the St. Joseph River system of southern Michigan.[1]

SPAWNING SEASON

Spawns between April and May in central New York (Lake Ontario drainage) and Pennsylvania,[3] and from mid-March to late April in North Carolina [4] and Delaware.[5]

SPAWNING TEMPERATURE

Spawning run starts at 11 C,[4] but spawning occurs at 15 C.[3]

SPAWNING HABITAT

Spawns primarily in shallow riffles of small streams,[5] but will spawn in ponds, lakes[1 3] and sluggish water.[5]

SPAWNING SUBSTRATE

Gravel or sand in streams,’ [3 5] at the base of aquatic vegetation in ponds. [3]

FECUNDITY

7,500 to 29,000[2] or 7,980 to 83,013.[4]

EGGS

Demersal, adhesive;’ [4 5] lacking oil globules;’ [4 5] diameter 1.2 to 1.7 mm[5] or 1.6 to 2.0 mm;[3 4] perivitelline space 0.2 mm wide;[5] yolk light yellow to deep golden;[3 4 5] incubation period: 8 days (198 hours) at 15 C;[4] 6 days at 18.5 C;[5] 4 days (96 hours) at 20 C, 3 days (70 hours) at 26 C.[4]

YOLK-SAC LARVAE

Total length	Description
4.4-4.8 mm	Newly hatched;’ [5] larger hatching size (6.0 mm) reported.’ Morphometry: (as % TL) preanal length 75.[5] Morphology: pectoral buds present, head flexed downward over anterior surface of yolk sac, yolk bulbous anteriorly. [4 5] Pigmentation: none.’

5-8 mm

Myomeres: 39 to 41 (30 to 32 + 8 to 10), all myomeres formed (newly hatched).[3]

Morphometry: (as % TL) preanal length 71, head length 18, eye diameter 7, body depth at anus 9, (as % head length) eye diameter 41, body depth at anus 49.[3]

Morphology: yolk bulbous anteriorly, tubular posteriorly;[3] becoming tubular;[5] head free from yolk sac (6.0 mm, 54 hours posthatching at 20 C);[4] first caudal fin rays formed (178 hours posthatching[4]), posterior swim bladder chamber inflated between myomeres 8 and 13, mouth parts ossified[3] (104 hours postfertilization[4]).

Pigmentation: first pigmentation developed (104 hours posthatching);[4] retinae brown, melanophores on dorsum of head, single middorsal series present, few midlateral melanophores, mi dventral series under yolk sac and caudal peduncle (6.0 mm);[3,5] eyes black, short longitudinal series from mi dopercle to above anterior surface of yolk sac (7.6 mm) wide middorsal pigment-free space on occiput, three longitudinal dorsal stripes, midlateral stripe of one melanophore at lateral apex of each myomere, little scattered pigment on sides.[3]

LARVAE

Total length	Description

8-11 mm

Myomeres: see 5-8 mm.

Morphometry: (as % TL) preanal length 69, head length 20, eye diameter 7, body depth at anus 8, (as % head length) eye diameter 37, body depth at anus 43.[3]

Morphology: yolk absorbed (7.9 mm), anterior swim bladder chamber inflated between myomeres 6 and 9, notochord flexed (8.5 mm), hypural elements forming (9.4 mm).[3]

Pigmentation: midlateral stripe more prominent, melanophores among rays of lower caudal fin lobe, dorsum of anterior swim bladder chamber pigmented.[3]

11-18 mm

Myomeres: see 5-8 mm.

Morphometry: (as % TL) preanal length 66, head length 21, eye diameter 7, body depth at anus 11, (as % head length) eye diameter 33, body depth an anus 51.[3]

Morphology: pelvic buds present (11.7 mm) between myomeres 15 and 17, all anal fin rays ossified (12.6 mm), first pelvic fin rays formed (13.5 mm), first dorsal fin rays formed (13.9 mm) between myomeres 15 and 16, all median fin rays and first pectoral fin rays developed (14.4 mm), all finfolds absorbed (17 to 19 mm).[3]

Pigmentation: median pigment-free space on occiput and midlateral body stripe prominent, triangular pigmentation under heart (13.3 mm), dorsal pigmentation scattered, three rows not distinguishable, ventral triangle not apparent, darkened caudal spot confluent with midlateral stripe (14.3 mm).[3]

JUVENILES

Total length	Description
18-36 mm	Morphometry: (as % TL) preanal length 60, head length 23, eye diameter 7, body depth at anus 12, (as % head length) eye diameter 29, body depth at anus 54.[3]
	Morphology: mouth subterminal (19.2 mm), squamation started (18 mm) and completed (lg.6 mm), mouth nearly inferior (24 mm).[3]
	Pigmentation: pigmentation on sides of middorsal pigment-free space uniform, midlateral stripe extending onto caudal fin rays, leading edge of dorsal fin and interradial membranes well pigmented, rays of all other fins out lined (24 mm).[3]

ADULTS

Fin rays: caudal 18;[3] dorsal 9 to 10;[7] anal 7, pectoral 10 to 13, pelvic 7 to 8.*

Vertebrae: 37 to 40 (including Weberian vertebrae).*

Lateral line scales: 39 to 41.[8]

Diagnostic characters: dorsal fin short (9 to 10 rays), pored lateral line scales absent, 39 to 41 scales in lateral series.

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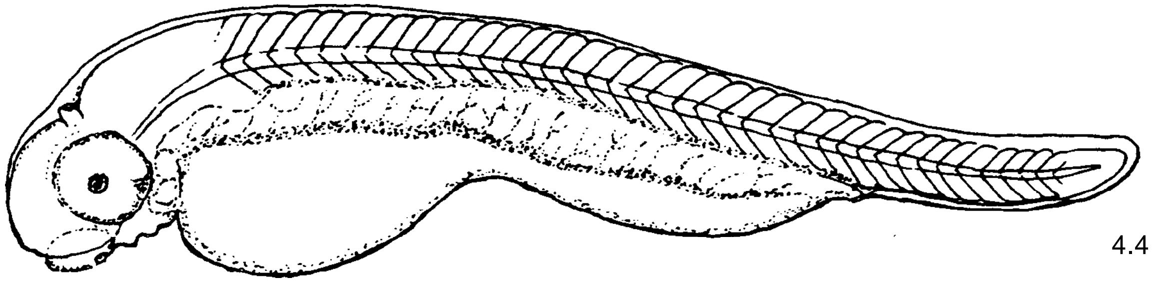


Fig. 155. Erimyzon oblongus, creek chubsucker. Yolk-sac larva, newly hatched. (Wild-caught, Delaware, Wang and Kernehan 1978).

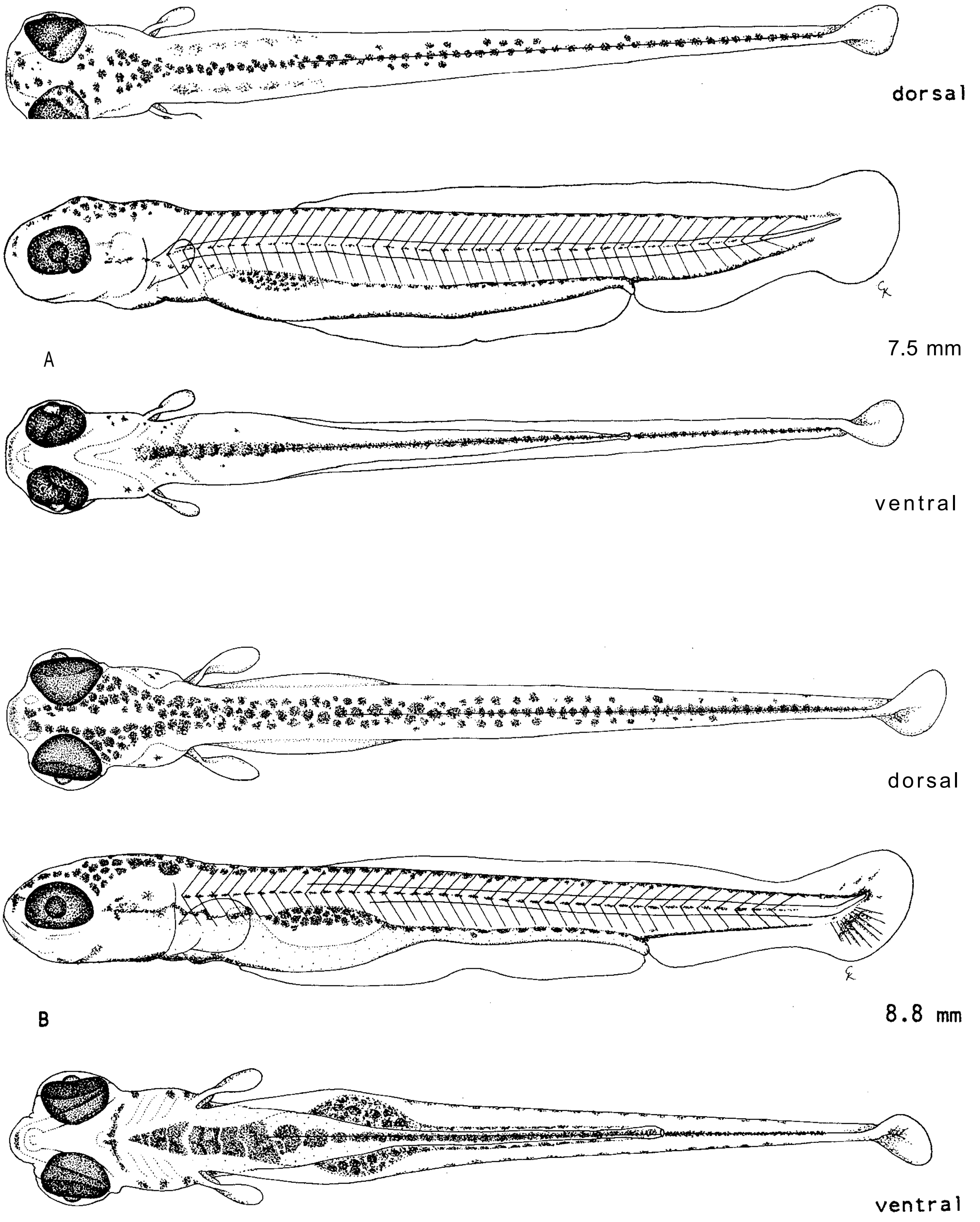


Fig. 156. Erimyzon oblongus, creek chubsucker. A and B. Larvae. (A, laboratory-reared, New York, Fuiman 1979a; B, laboratory-reared, Pennsylvania, Fuiman 1979a).

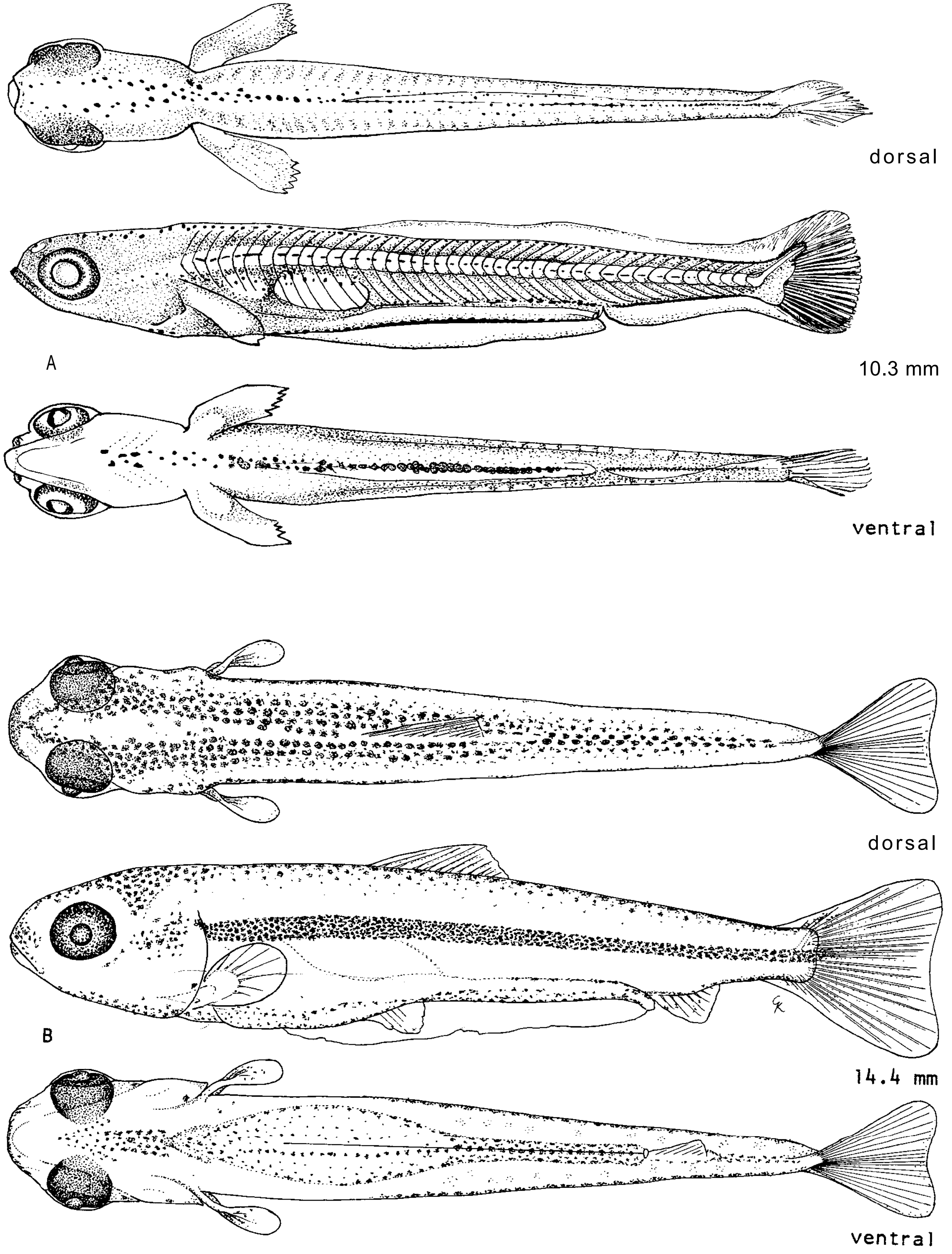


Fig. 157. Erimyzon oblongus, creek chubsucker. A and B. Larvae. (A, laboratory-reared, Maryland, Loos et al. 1979; B, wild-caught, New York, Fuiman 1979a).

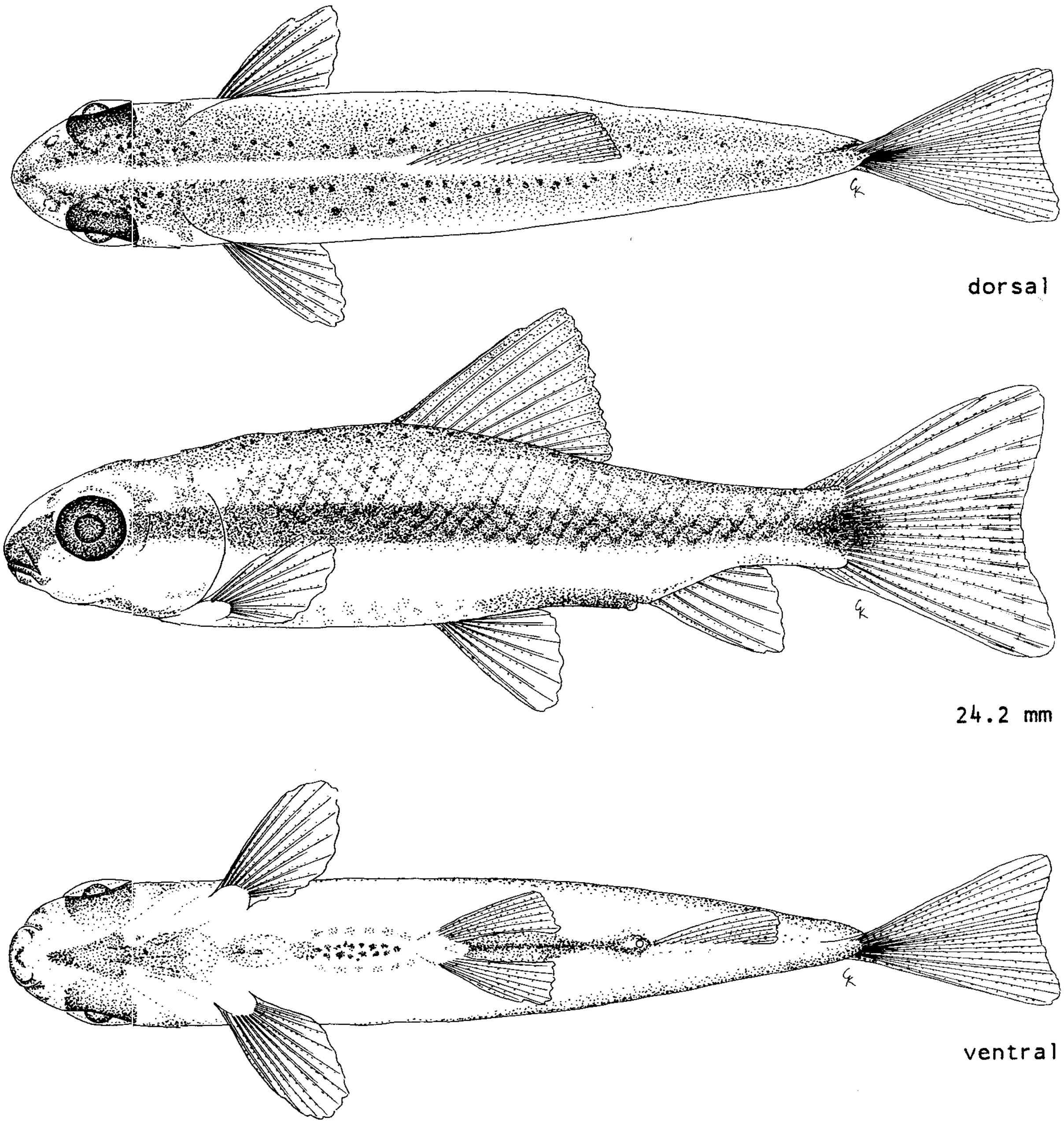


Fig. 158. Erimyzon oblongus, creek chubsucker. Juvenile. (Laboratory-reared, Pennsylvania, Fuiman 1979a).

Erimyzon sucetta (Lacepede), lake chubsucker

DISTRIBUTION

Usually in lakes and quieter streams of the southern portions of Lakes Michigan and Huron and parts of the Lake Erie drainage.' In Lake Michigan it is found in tributaries of the south, extending on the west shore to include Green Bay tributaries.[2]

SPAWNING SEASON

Spawns from May to June in Lake Michigan[2] and March through April in Illinois.'

SPAWNING TEMPERATURE

Not reported, but probably similar to Erimyzon oblongus.,*

SPAWNING HABITAT

Spawns in still waters of streams, ponds, and lakes.'

SPAWNING SUBSTRATE

Spawns in gravel areas[2] and on vegetation (filamentous algae, grasses, etc.).[6]

FECUNDITY

18,478 ± 5,477.[1] Number of deposited eggs ranges from 3,000 to 20,000.[6]

EGGS

Demersal, nonadhesive, diameter 2 mm, incubation period: 6 to 7 days at 23 to 30 C;[6] 4 to 5 days (112 hours) at 20 to 22 C.[8]

YOLK-SAC LARVAE

Total length	Description
5-6 mm	Newly hatched.' Morphology: anterior portion of yolk sac bulbous, head deflected over anterior end.* Pigmentation: eyes slightly pigmented.[8]
unstated	Morphology: swim bladder inflated (3.5 days posthatching);[8] between myomeres 7 and 11.[5] Pigmentation: body pigment developed (3.5 days posthatching).[8]

LARVAE

Total length	Description
7-10 mm	Myomeres: 36 to 38 (27 to 29 + 8 to 10).[5] Morphometry: (as % TL) preanal length 69, head length 18, eye diameter 7, body depth at anus 10.[5] Morphology: yolk absorbed prior to 6.8 mm;[5] 9 days posthatching at 20 to 22 C;[8] first caudal fin rays formed (7.4 to 8.2 mm), all caudal fin rays present (9.1 mm).[5] Pigmentation: identical to similar stages of E. oblongus, but without me anophores on vertical myosepta.[5]
1O-15 mm	Myomeres: see 7-10 mm. Morphometry: (as % TL) preanal length 64, head length 22, eye diameter 8, body depth at anus 11.[5] Morphology: similar to E. oblongus, four dorsal fin rays present (10.8 mm), all dorsal fin rays formed (12.1 mm), first anal fin rays formed (10.8 to 12.1 mm).[5] Pigmentation: same as E. oblongus, but without scattered melanophores on operculum.[5]

JUVENILES

Total length	Description
25-36 mm	Morphometry: (as % TL) preanal length 58, head length 21, eye diameter 7, body depth at anus 13.[5] Morphology: all scales formed.[5] Pigmentation: same as E. oblongus, but without melanophores in at least three interradial membranes of dorsal fin.[5]

ADULTS

Fin rays: caudal 18;* dorsal 10 to 12, anal 7, pectoral 15 to 16, pelvic 8 to 9.[3]

Vertebrae: 34 to 38 (including Weberian vertebrae).*

Lateral line scales: 35 to 37.[9]

Diagnostic characters: dorsal fin short (10 to 12 rays), pored lateral line scales absent, scales in lateral series 35 to 37.

LITERATURE CITED

1. Shireman et al. (1978)
2. Becker (1976)
3. Scott and Crossman (1973)
4. Hubbs and Lagler (1958)
5. Fuiman (1979b)
6. Cooper (1935)
7. Bennett and Childers (1966)
8. Shaklee et al. (1974)
9. Pflieger (1975) (1974)

Hypentelium nigricans (LeSueur), northern hogsucker

DISTRIBUTION

Found in tributaries of southern Lake Ontario, Lake Erie, southern Lake Huron, and Lake Michigan.[8 10] Within the Lake Michigan drainage it is uncommon to locally common in streams and rivers of Wisconsin and upper Michigan. It is also found in parts of lower Michigan, south of the White River.[1 10]

SPAWNING SEASON

Spawns from mid-April to mid-May in lower Michigan.[2 3]

SPAWNING TEMPERATURE

Spawning has been observed between 14 and 22 C,' usually 15 to 17 C.[3] Ripe adults have been collected at temperatures of 12[5] to 16[4] C.

SPAWNING HABITAT

Spawns in shallow riffles or sides of pools.[2 3 4 5]

SPAWNING SUBSTRATE

Deposits eggs among loose grave1.[2 3 5]

FECUNDITY

Not reported.

EGGS

Demersal, nonadhesive;' [6] oil globules absent;[5] diameter 2.8 to 3.2 mm (mean 3.0 + 0.1 mm, N = 115);[5] or 3.5 mm;[6] yolk deep yellow;[5 6] incubation period: 10 days at 17.4 C.[6]

YOLK-SAC LARVAE

Total length	Description
9.0-10.6 mm	Newly hatched.[5 6] Myomeres: usually 44 to 47 (37 to 39 + 7 to 10), all myomeres formed (newly hatched) .[5] Morphology: head flexed downward over yolk sac, anterior portion of yolk sac bulbous, mouth parts not developed, pectoral buds present;[5 6] some newly hatched specimens reported without these head and yolk characteristics.[5] Pigmentation: none present.[5 6]
9-14 mm	Myomeres: 41 to 43 (36 to 38 + 5 to 6), mean 43 (38 + 5);[6] see 9-10 mm.

Morphometry: (as % TL) preanal length 80, head length 14, eye diameter 6;[5] [6] greatest body depth 16;[6] body depth at anus 8, (as % head length) eye diameter 48, body depth at anus 60.[5]

Morphology: first caudal fin rays developed and notochord flexed (12.0 to 12.5 mm);[5] [6] first pectoral fin rays (12.6 mm[6] but also reported as 15.9 mm[5]); posterior swim bladder chamber inflated (12.8 mm) between myomeres 6 and 12, anterior chamber at 13.2 mm between myomeres 3 and 6, mouth parts ossified (13.3 mm), hypural elements ossified (13.4 mm) .[5]

Pigmentation: reportedly without body pigment until 14.0 mm[6] or single, middorsal row of melanophores, a midlateral stripe in midlateral myoseptum, melanophores along base of postanal finfold (10.0 mm), eyes black, melanophores scattered on top of head and dorsum of yolk sac, broad but faint midventral stripe (11.2 mm);[5] interorbital pigment-free space (12.0 mm) ;[5] [6] three dorsal rows, few melanophores on lateral epaxial musculature (12.9 mm), melanophores among al 1 but central caudal fin rays.[5]

LARVAE

Total length	Description
14-18 mm	Myomeres: 40 to 44 (33 to 38 + 5 to 8), mean 42 (35 + 7) ;[6] see 9-10 mm. Morphometry: (as % TL) preanal length 72, head length 17[5] to 18;[6] eye diameter 6;[5] [6] greatest body depth 13;[6] body depth at anus 8, (as % head length) eye diameter 37, body depth at anus 47.[5] Morphology: yolk absorbed (13.5" to 14.0 mm[6]); first dorsal fin rays ossified (14.1 mm) between myomeres 14 and 16;[5] pelvic buds formed (14.3[5] to 16.8 mm[6]) below myomeres 18 and 19;[5] first anal fin rays formed (14.9 mm), mouth subterminal (16.2 mm), pelvic rays forming (16.4), all anal fin rays present (16.7 mm).[5] Pigmentation: three dorsal stripes no longer distinct, pigmentation nearly uniform, melanophores develop among first three or four dorsal fin rays (17.0 mm).[5]
18-22 mm	Myomeres: 40 to 42 (33 to 34 + 7 to 8) , mean 41 (34 + 7);[6] see 9-10 mm. Morphometry: (as % TL) preanal length 66;[5] [6] head length 20[6] to 21;[5] eye diameter 6 to 7;[5] [6] greatest body depth 15;' body depth at anus 9, (as % head length) eye diameter 31, body depth at anus 50.[5] Morphology: mouth inferior and gut S-shaped (19 mm), al 1 dorsal fin rays formed (21 to 22 mm);[5] all finfolds absorbed (22.0 mm) . [6]

Pigmentation: three dark "saddles" on dorsum, extending onto sides (19 to 20 mm);[5,6] located at anterior and posterior edges of dorsal fin and on caudal peduncle, anterior dorsal fin rays strongly pigmented;[5] melanophores present on all fins (22 mm).[6]

JUVENILES

Total length	Description
22-30 mm	Morphometry: (as % TL) preanal length 60;[5] head length 20[6] to 23;[5] eye diameter 6;[5,6] greatest body depth 16;[6] body depth at anus 10, (as % head length) eye diameter 26, body depth at anus 43.[5]
	Morphology: squamation complete (29 mm).[5]
	Pigmentation: top of head strongly pigmented;[5] five dark saddle markings on dorsum and sides;[5,6] melanophores among anterior dorsal fin rays (29 mm).[5]

ADULTS

Fin rays: caudal 18;[5] dorsal 10 to 13, anal 7 to 8, pectoral 15 to 17, pelvic 9.[8]

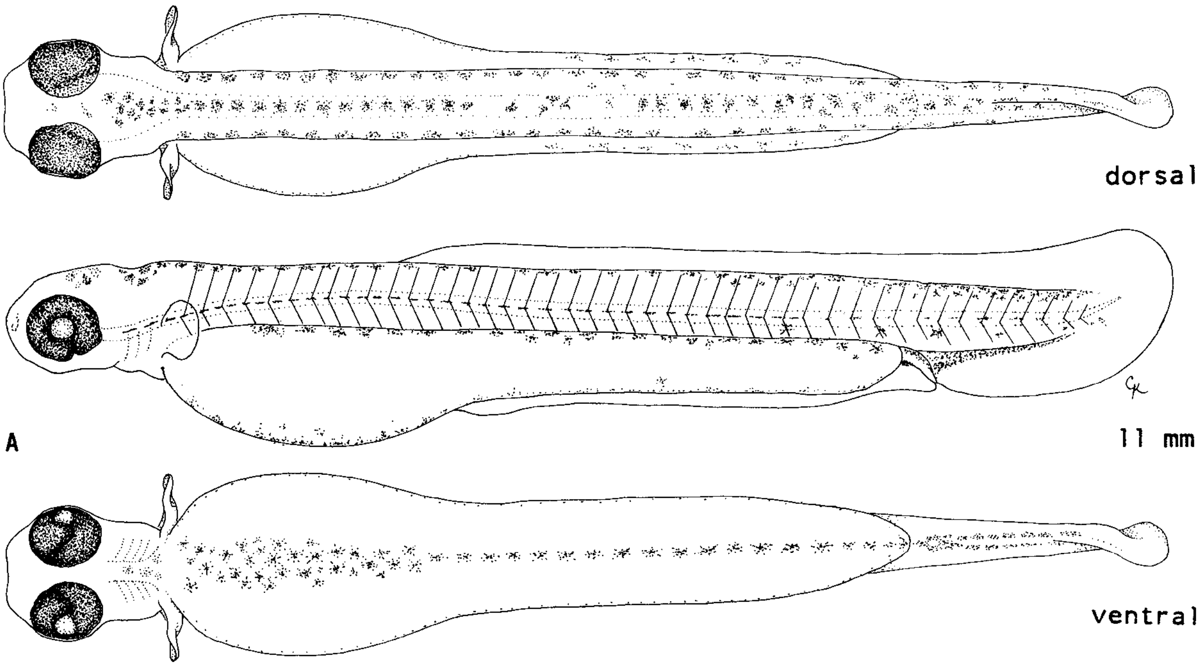
Vertebrae: 41 to 46 (including Weberian vertebrae).[7,9]

Lateral line scales: 49 to 51.[8]

Diagnostic characters: dorsal fin short (10 to 13 rays), head with depression between eyes, dark saddles on sides.

LITERATURE CITED

1. Becker (1976)
2. Reighard (1920)
3. Hankinson (1932)
4. Raney and Lachner (1946)
5. Fuiman (1979a)
6. Buynak and Mohr (1978)
7. Snyder (1949)
8. Scott and Crossman (1973)
9. Jenkins (1970)
10. Hubbs and Lagler (1958)



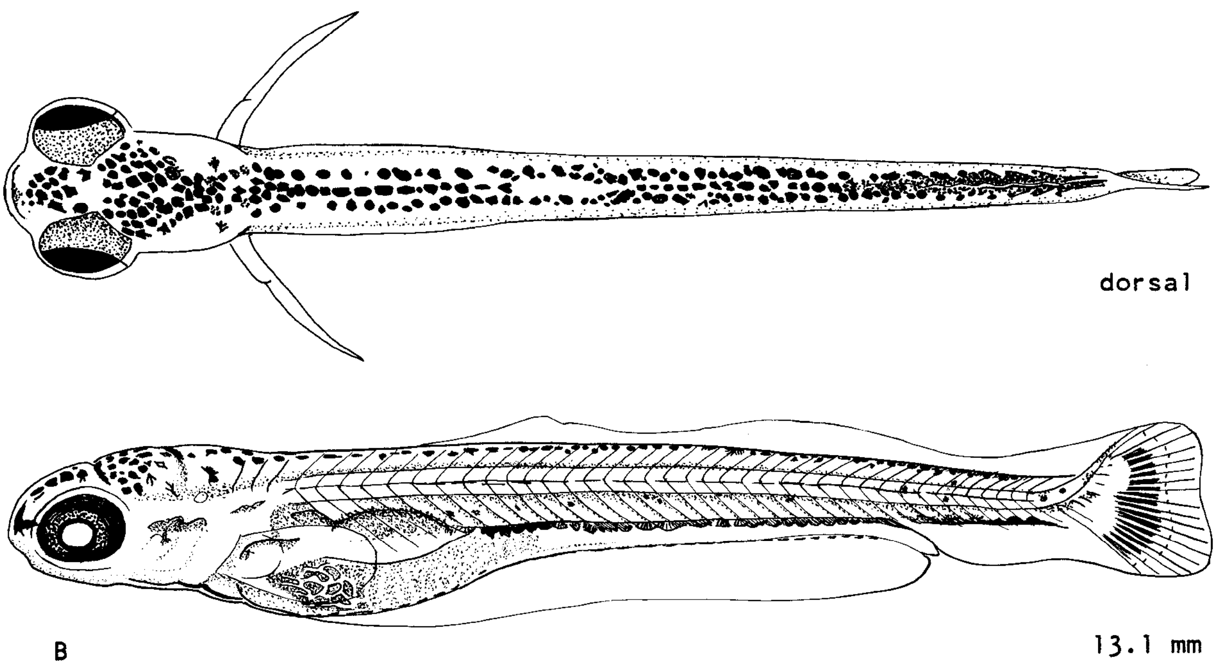


Fig. 159. Hypentelium nigricans, northern hog sucker. A. Yolk-sac larva. B. Larva. (A, laboratory-reared, New York, Fuiman 1979a; B, laboratory-reared, Maryland, Loos et al. 1979).

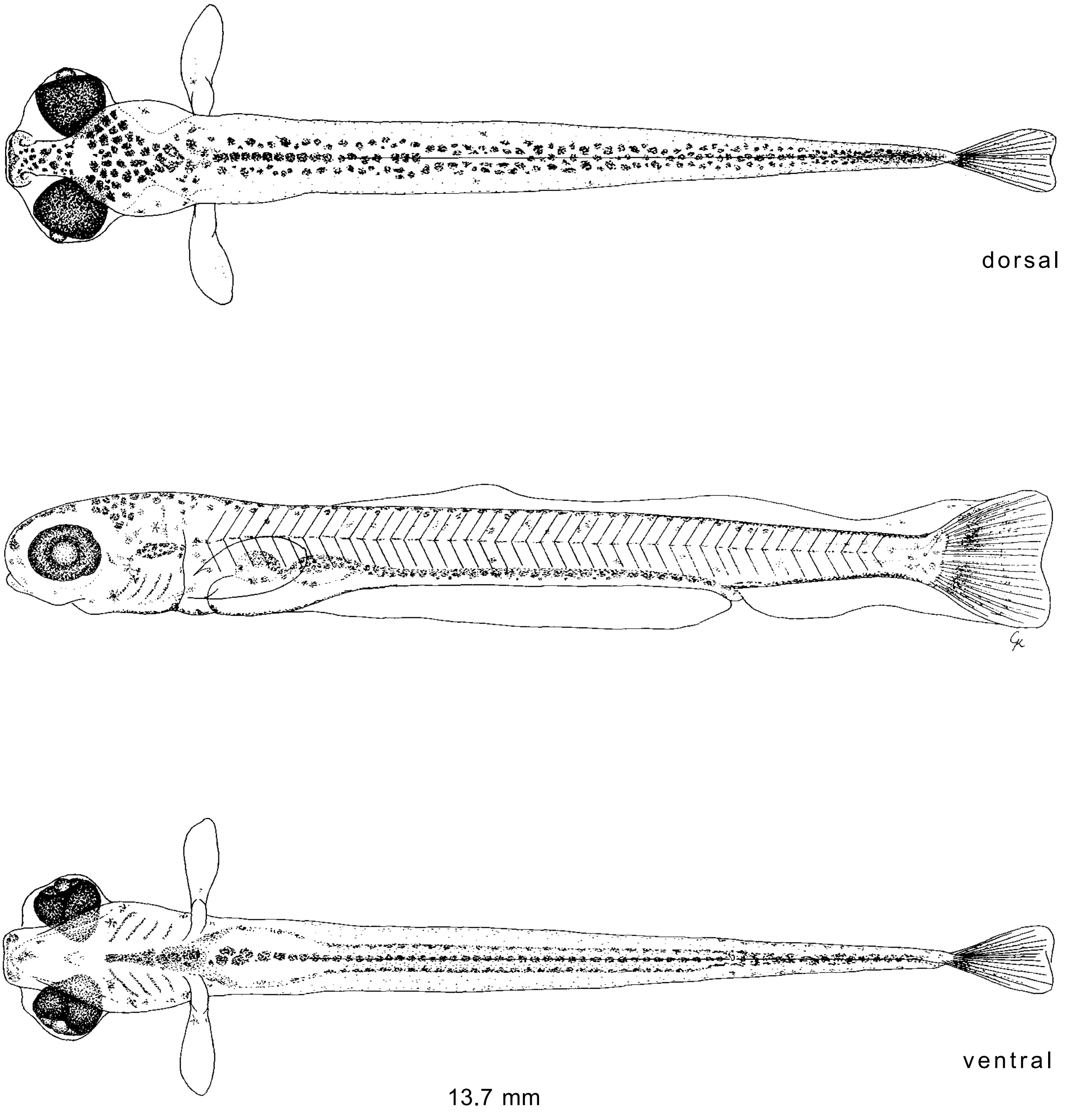


Fig. 160. Hypentelium nigricans, northern hog sucker. Larva. (Laboratory-reared, New York, Fuiman 1979a).

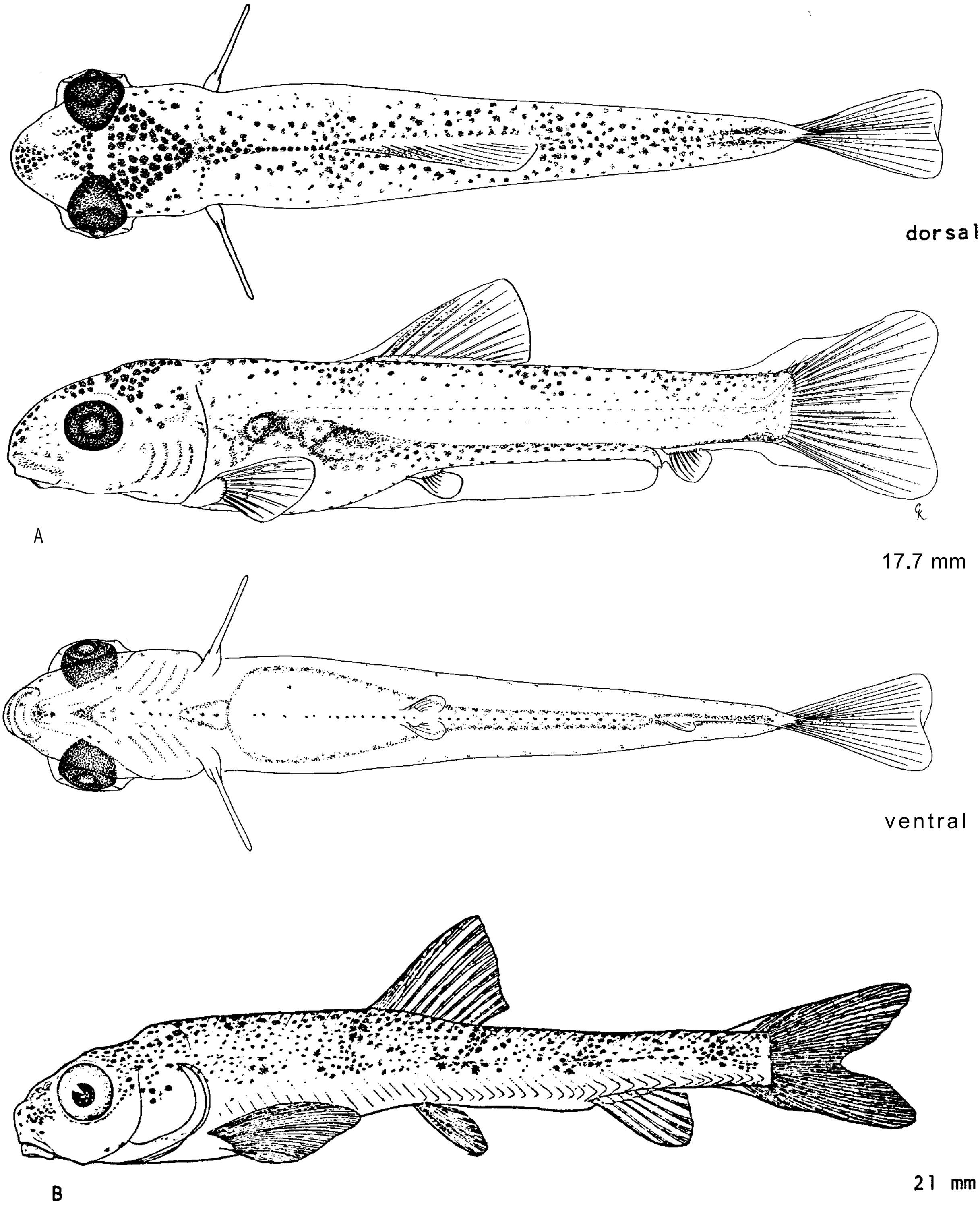


Fig. 161. Hypentelium nigricans, northern hog sucker. A. Larva. B. Juvenile. (A, laboratory-reared, New York, Fuiman 1979a; B, wild-caught, Lake Erie, Fish 1932).

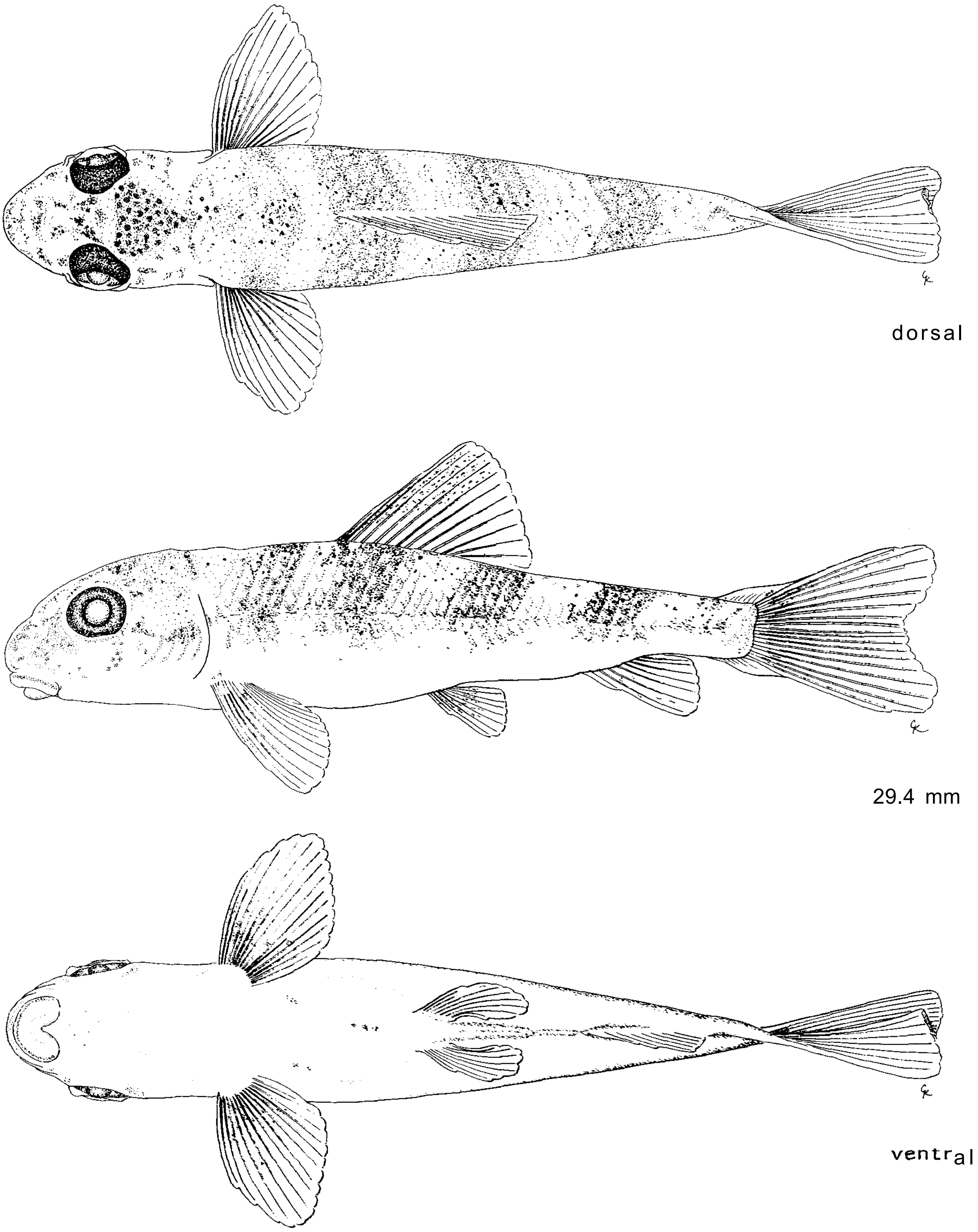


Fig. 162. Hypentelium nigricans, northern hog sucker. Juvenile. (Laboratory-reared, New York, Fuiman 1979a).

Ictiobus sp., buffalofish

Heard (1958) described many details of the eggs and larvae of *Ictiobus*. However, there were two species of buffalofishes (*I. bubalus* and *I. niger*) in his study area and he was unable to specifically-identify his larvae. The following data are from that study.

SPAWNING SUBSTRATE

Spawns over submerged vegetation.

EGGS

Demersal, adhesive, diameter 1.9 to 2.5 mm (mean 2.1 mm), opaque, incubation period: 109 to 140 hours at 21 to 22 C, 83 to 95 hours at 27 c,

YOLK-SAC LARVAE

Total length	Description
5.5-6.5 mm	Newly hatched. Myomeres: 27. Pigmentation: only in retinae.
7 mm	Morphology: single swim bladder chamber present (60 hours posthatching), mouth parts developed (98 hours posthatching). Pigmentation: melanophores over swim bladder (98 hours posthatching), middorsal and midlateral stripe present (120 hours posthatching).

LARVAE

Total length	Description
7.5-13 mm	Myomeres: 30 to 32 at 7.5 mm, 31 to 33 at 10 mm. Morphology: yolk absorbed (3 to 5 days posthatching, 7.5 mm), notochord flexed with 3 to 5 caudal fin rays (10 mm), caudal fin forked with 10 to 12 rays, 6 dorsal fin rays present, anal fin margin and pelvic buds forming (13 mm). Pigmentation: melanophores on dorsum of intestine and midventral line (7.5 mm).

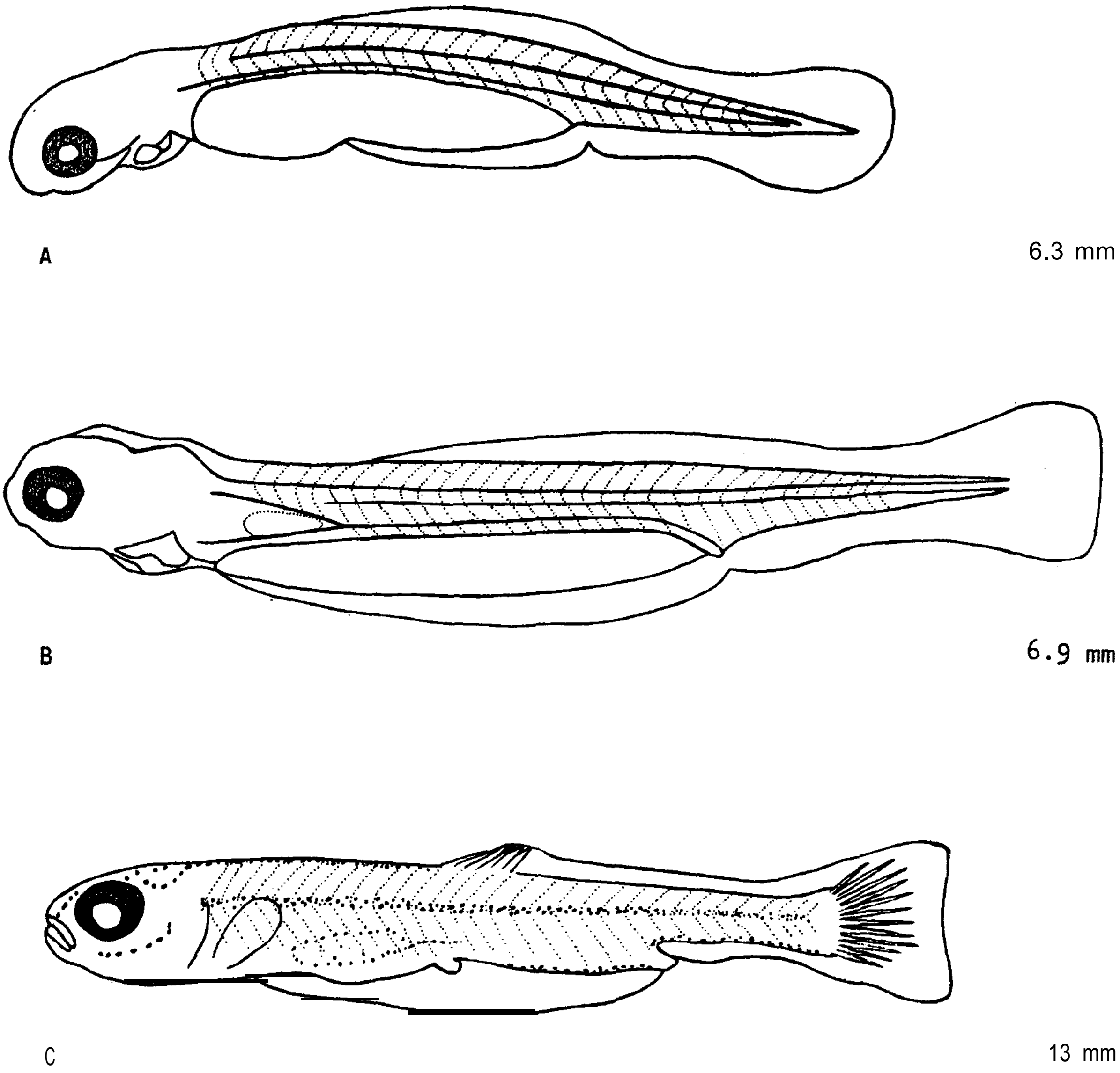


Fig. 163. Ictiobus sp., buffalofish. A. Yolk-sac larva, newly hatched. B. Yolk-sac larva. C. Larva. (A-C, laboratory-reared, Oklahoma, Heard 1958).

Ictiobus bubalus (Rafinesque), smallmouth buffalo

See Ictiobus sp. account.

DISTRIBUTION

Probably not present in the Great Lakes region.[1 13] Two reports exist, both from the southern drainage of Lake Michigan.'

SPAWNING SEASON

Spawning occurs in May in Iowa.[3] Capture of ripe adults indicates a spawning period from May to June in South Dakota' and late March to late May in Alabama, with a peak in mid-April.[2]

SPAWNING TEMPERATURE

Spawning usually occurs between 16 and 18 C,[1 2 4 11] extending to 21 C.[2 4]

SPAWNING HABITAT

Spawns in shallows.[1]

SPAWNING SUBSTRATE

Often spawns randomly over the bottom,[3 7 8] in shoal areas[8] or over vegetation[3 7] (submerged or floating).[11]

FECUNDITY

Usually between 150,000 and 500,000,[2 8 10] but as few as 14,470.[8]

NATURAL HYBRIDS

Possibly Ictiobus cyprinellus.[12 15 16]

EGGS

Demersal;[5] adhesive;[5 11] diameter 1.6 to 2.1 mm;[15] 2.2 mm;[5] incubation period: 9 to 10 days in ponds;[3 11] 36 hours at 18 C;[6] 96 to 100 hours[2] and 100 to 108 hours[5] at 21 C; 24 hours at 23 C.[6]

YOLK-SAC LARVAE

Total length	Description
5-6 mm	Newly hatched;[2 5 17] mean length 6.0 mm.[5]
	Myomeres: 35 to 39 (28 to 31 + 6 to 9).[14]
	Morphology: head flexed downward over yolk sac;[5 14] yolk sac slightly bulbous anteriorly, pectoral buds present (determined from illustration[5]).

Pigmentation: eyes pigmented, several midventral melanophores.[5 14]

6-8 mm — Morphology: mouth open and movable (6.7 mm, 1 day posthatching); swim bladder inflated (6.6 to 7.3 mm);[14] head straight with body axis (8.0 mm, 3 days posthatching) ;[5] free swimming (86 hours posthatching) .[2]

Pigmentation: middorsal, dorsal head and midlateral pigment developing (6.7 mm), middorsal pigment in a stripe of 20 to 25 melanophores, melanophores on dorsum of yolk (8.0 mm) .[9]

LARVAE

Total length	Description
8--20 mm	Myomeres: 33 to 39 (28 to 31 + 5 to 9);[15] 33 (25 + 8) .[5] Morphometry: preanal length greater than 67% TL at 13.0 to 16.5 mm.[5] Morphology: yolk absorbed (6.8 to 7.4;[14] or 8.1 mm[5]); notochord flexed (9.0 mm), hypural elements and 12 caudal fin rays (unossified) forming (11.0 mm);[14] pelvic buds present (12.0[14] to 13.5 mm[5]); first dorsal fin rays formed (14.5” to 15.1 mm[14]); two swim bladder chambers (14.2 to 15.1 mm);[5 14] first anal fin rays developing (14.7 mm[5] or 16.4 to 16.8 mm[14]); first pelvic fin rays and S-shaped gut formed (16.0[5] to 17.8 mm[14]); gut coiled (17.0 mm), all median fin rays present (17 to 20 mm) , mouth subterminal (20.1 mm) .[14] Pigmentation: gill arches pigmented (9.0 mm), melanophores along sides of gut (11.0 mm), melanophores along caudal fin rays (14.3 mm), body well pigmented (particularly on occiput) .[5]

JUVENILES

Total length	Description
19-32 mm	Morphometry: preanal length more than twice postanal length (greater than 67% TL) at 17 to 32 mm.[5] Morphology: all finfold absorbed (18.5 mm[5] or 27.5 to 30.6 mm[14]); pectoral fin rays formed (20.1 mm) squamation started (21.7 to 23.1 mm);[5 14] and completed (26.0 mm), mouth inferior, five intestinal loops.[5]

ADULTS

Fin rays: caudal 18;[5] dorsal 26 to 31;[9] anal 7 to 9;[9 14] pectoral 15 to 17;[14] * pelvic 8 to 11.[9 14]

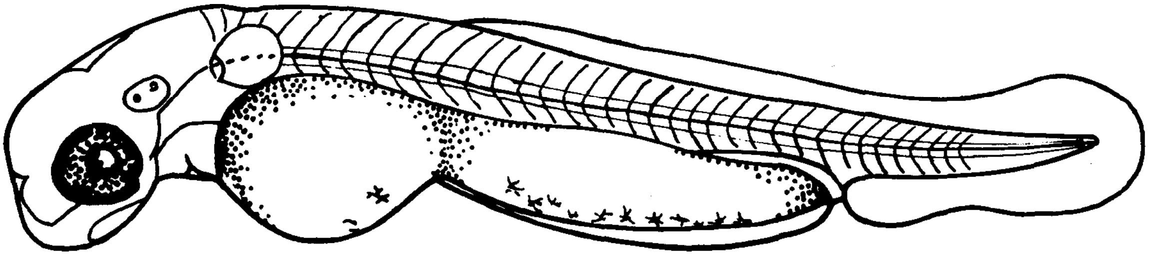
Vertebrae: 36 to 37 (including Weberian vertebrae).’

Lateral line scales: 36 to 38.9

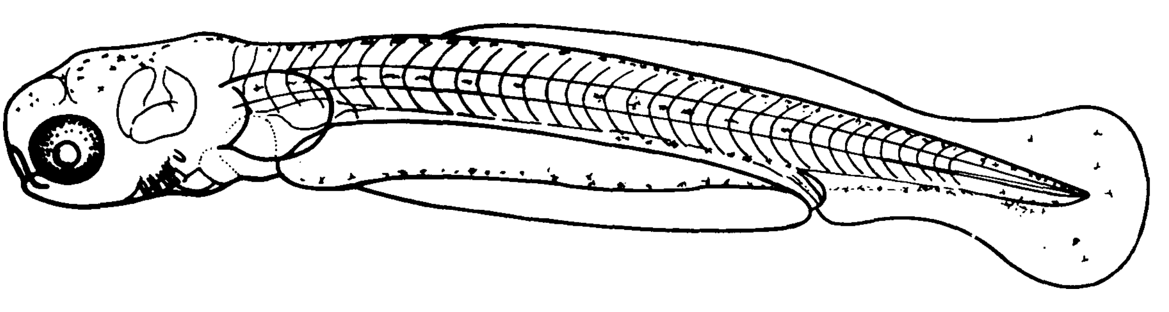
Diagnostic characters: dorsal fin long (26 to 31 rays), lateral line scales 36 to 37, mouth subterminal to inferior (upper lip below eye) , body depth less than 2.8 times into standard length.

LITERATURE CITED

1. Becker (1976)
2. Wrenn (1968)
3. Harlan and Speaker (1969)
4. Walburg and Nelson (1966)
5. Wrenn and Grinstead (1971)
6. Giudice (1964)
7. Heard (1958)
8. Jester (1973)
9. Cross (1967)
10. Osborn and Self (1966)
11. Canfield (1922)
12. Trautman (1957)
13. Hubbs and Lagler (1958)
14. Yeager and Baker (in press)
15. Yeager (1980)
16. Johnson and Minckley (1969)



A 5.6 mm



B 6.8 mm

Fig. 164. Ictiobus bubalus, smallmouth buffalo. A and B. Yolk-sac larvae. (A and B, laboratory-reared, Tennessee, Yeager and Baker in press).

Ictiobus bubalus

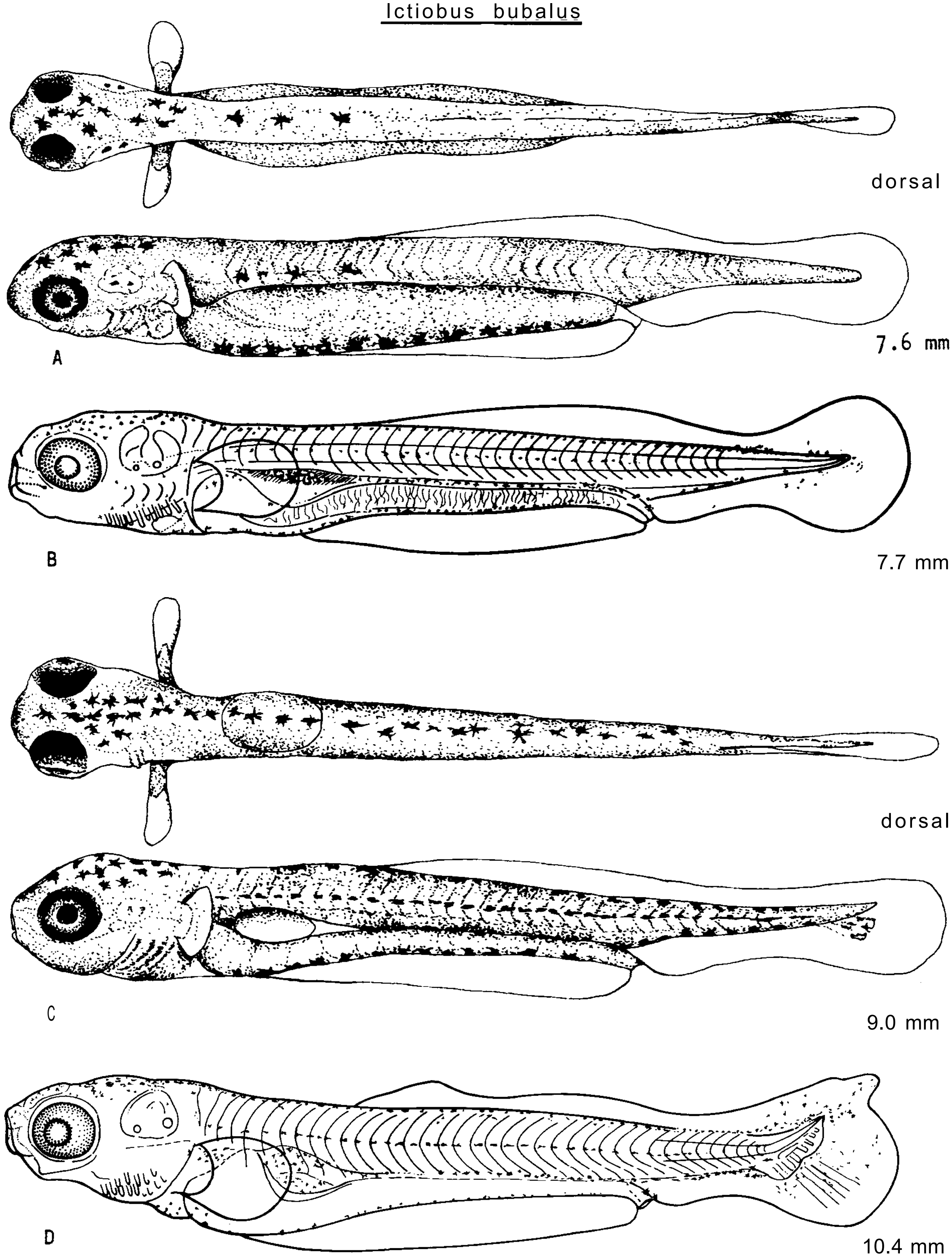


Fig. 165. Ictiobus bubalus, smallmouth buffalo. A. Yolk-sac larva. B-D. Larvae. (A and C, laboratory-reared, Alabama, Wrenn and Grinstead 1971; B and D, laboratory-reared, Tennessee, Yeager and Baker in press).

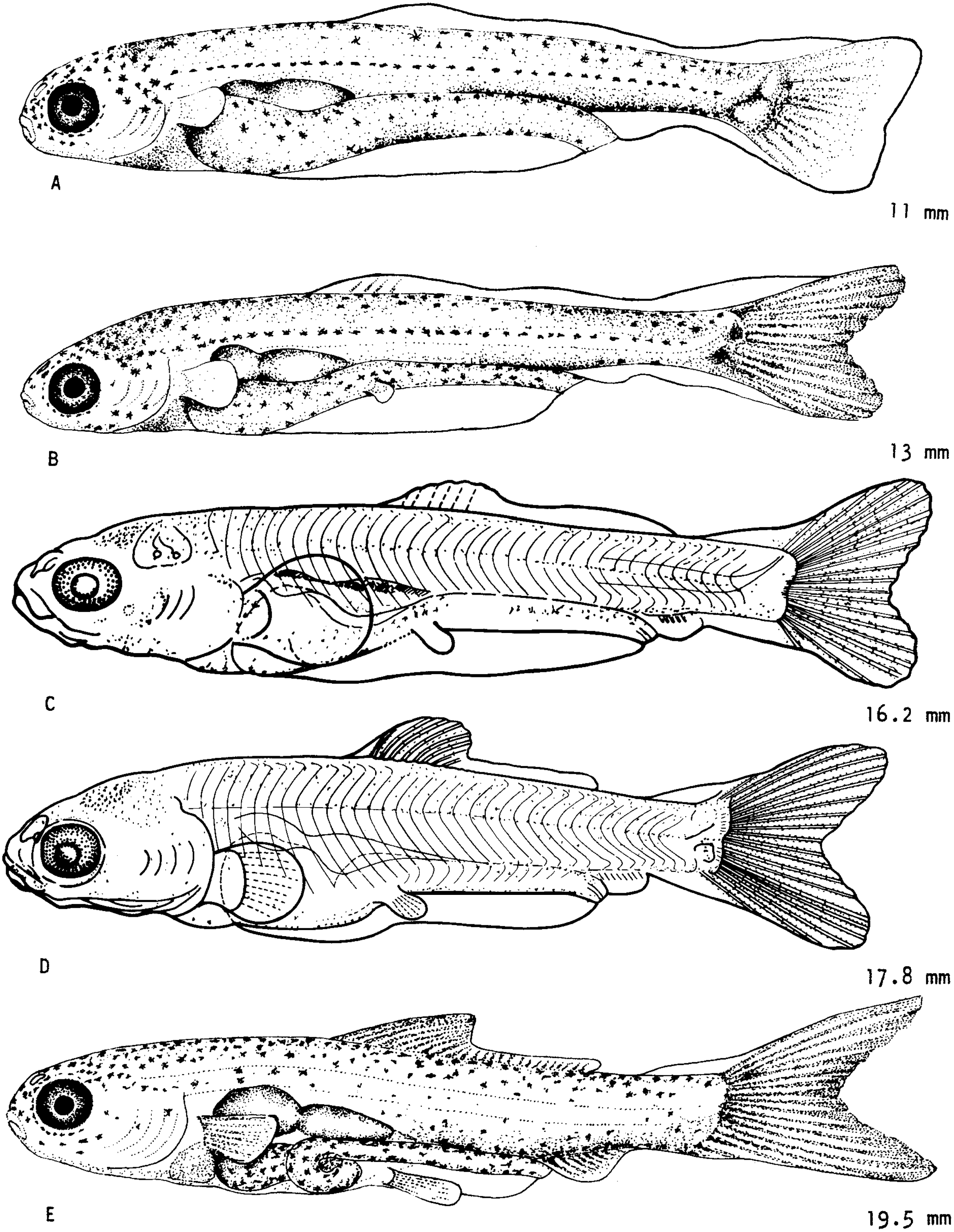
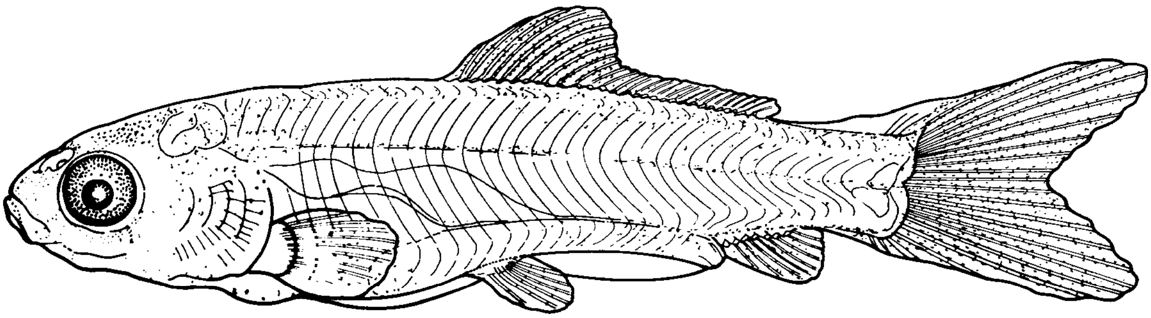
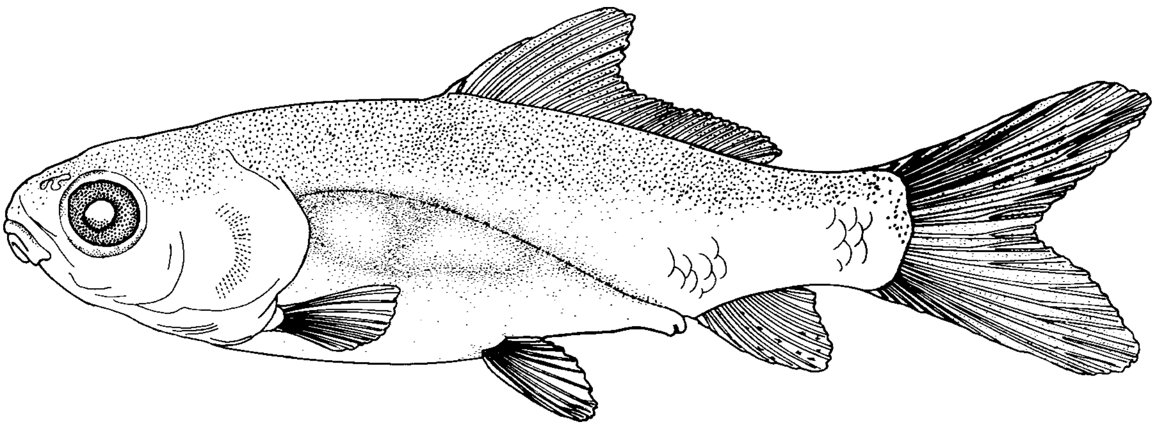


Fig. 166. Ictiobus bubalus, smallmouth buffalo. A-D. Larvae. (A,B and E, laboratory-reared, Alabama, Wrenn and Grinstead 1971; C and D, laboratory-reared, Tennessee, Yeager and Baker in press).



21.5 mm



29.1 mm

Fig. 167. Ictiobus bubalus, smallmouth buffalo. A. Larva. B. Juvenile. (A and B, laboratory-reared, Tennessee, Yeager and Baker in press).

Ictiobus cyprinellus (Valenciennes), bigmouth buffalo

DISTRIBUTION

Primarily a fish of the Mississippi River drainage. A population occurs in western Lake Erie[10] and a few unverified reports have been made from the Wolf and Fox River systems of eastern Wisconsin.[1]

SPAWNING SEASON

Spawns from April to June[1 2] and March until May,[12] triggered by rising water levels.[3 4]

SPAWNING TEMPERATURE

Spawning reported between 16 and 18 C,[1 3 4 7] but with extremes of 14[3] and 27 C.[4]

SPAWNING HABITAT

Spawns in ponds (sometimes brackish),[5] lakes, floodplains, oxbows,[1 3 7] streams and ditches."

SPAWNING SUBSTRATE

Deposits eggs over aquatic vegetation.[3 4]

FECUNDITY

347,641 to 800,000.~ [9]

NATURAL HYBRIDS

Ictiobus bubalus;[12 13 14] possibly Ictiobus niger.[15]

EGGS

Demersal, adhesive;' diameter 1.7 to 2.3 mm;1[3] incubation period: 12 to 13 days at 14 to 17 C;[8] 9 to 10 days at 17 C[1] and in ponds;[3] 5 days at 18 to 21 C;[7] 36 hours at 19 C, 24 hours at 24 C.[6]

YOLK-SAC LARVAE

Total length	Description
4.9-5.8 mm	Newly hatched.[16] Morphology: head flexed downward over yolk sac.[16] Pigmentation: eye pigmented, seven to eight melanophores scattered on dorsum, dark midventral stripe.[16]
5-7 mm	Morphology: swim bladder inflating (6.5 to 6.8 mm).[16] Pigmentation: dorsum of head darkly pigmented, mid-lateral stripe present.[16]

Ictiobus cyprinellus

LARVAE

Total length	Description
9-24 mm	Myomeres: 34 to 39 (28 to 31 + 5 to 9).[13] Morphology: yolk absorbed (6.7 to 7.3 mm;[14] 3 days, in ponds[3]); first caudal fin rays formed (9.4 to 10.7 mm), pelvic buds present (11.9 to 12.4 mm), two swim bladder chambers forming (14.2 mm), dorsal (13.9 mm), anal, pelvic and pectoral fin rays forming (15.3 mm), gut coiling (15.5 mm), squamation beginning (21 mm).[16]

JUVENILES

All finfolds absorbed, all fin rays complete (29 to 30 mm).[16]

ADULTS

Fin rays: caudal 18;* dorsal 27 to 28 (23 to 30), anal 7 to 8, pectoral 14 to 15, pelvic 10 to 11.[11]

Vertebrae: 36 to 37 (possibly including Weberian vertebrae).[11]

Lateral line scales: 39 to 41.[11]

Diagnostic characters: dorsal finlong (27 to 28 rays), lateral line scales 38 to 41, mouth terminal (upper lip above lower edge of eye), first dorsal fin ray moderately elongate (half the length of the dorsal fin base).

LITERATURE CITED

1. Becker (1876)
2. Johnson (1963)
3. Canfield (1822)
4. Swingle (1954)
5. Perry (1976)
6. Giudice (1964)
7. Swingle (1957)
8. Walker and Frank (1952)
9. Osborn and Self (1966)
10. Hubbs and Lagler (1858)
11. Scott and Crossman (1973)
12. Trautman (1857)
13. Yeager (1980)
14. Johnson and Minckley (1968)
15. Johnson and Minckley (1972)
16. Yeager and Baker (in press)

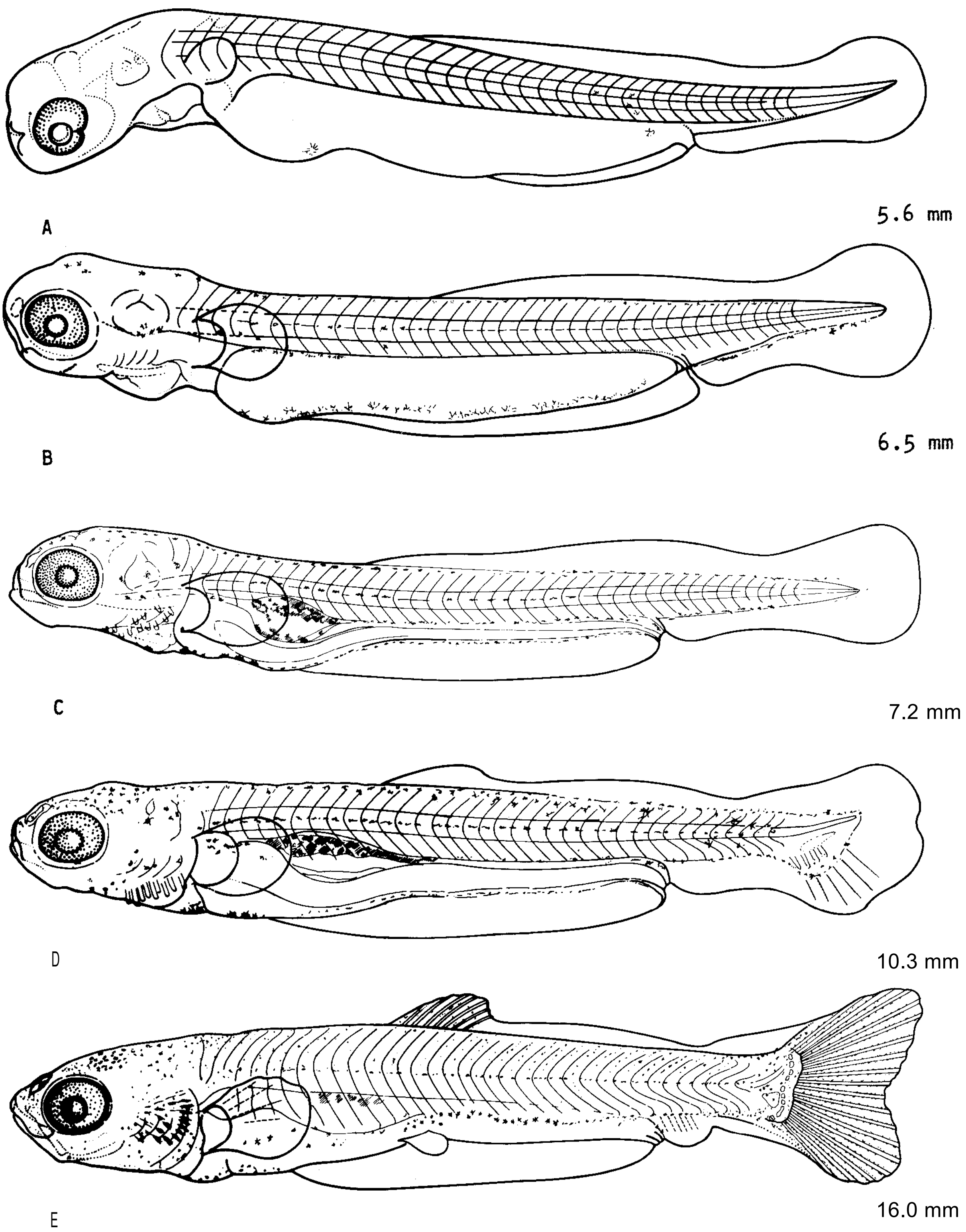
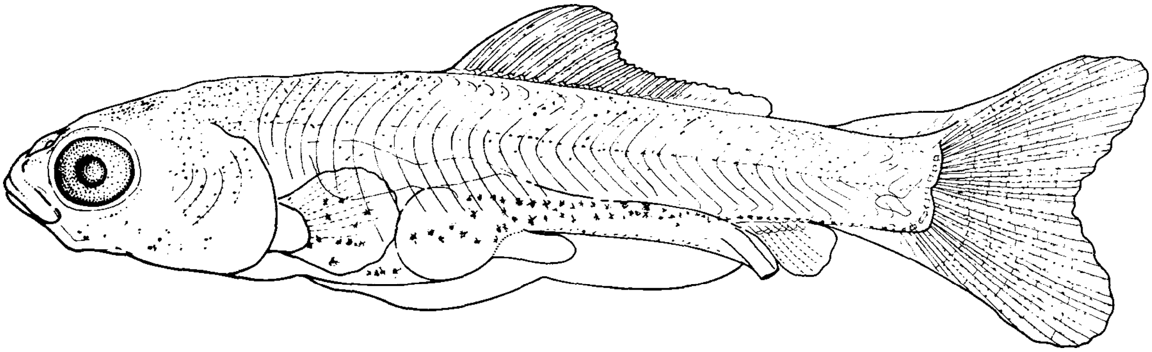
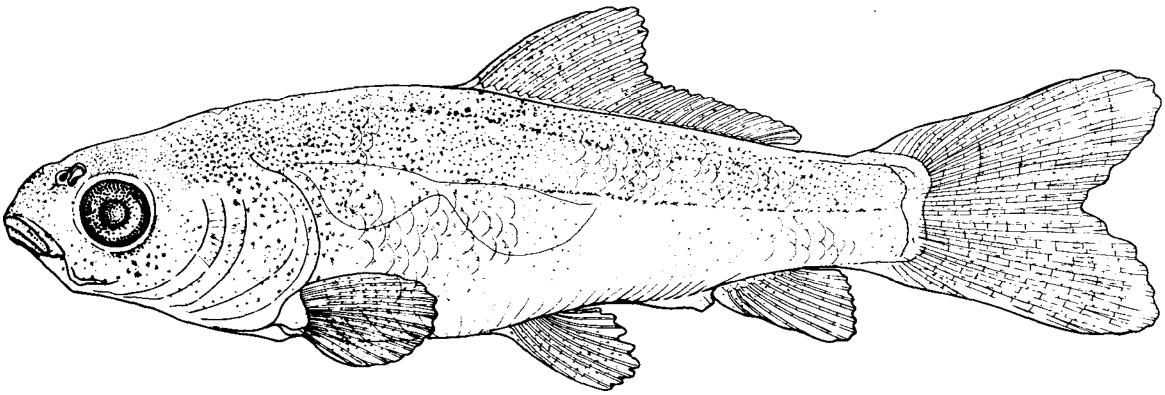


Fig. 168. Ictiobus cyprinellus, bigmouth buffalo. A and B. Yolk-sac larvae, C-E. Larvae. (A-E, laboratory-reared, Tennessee, Yeager and Baker in press).



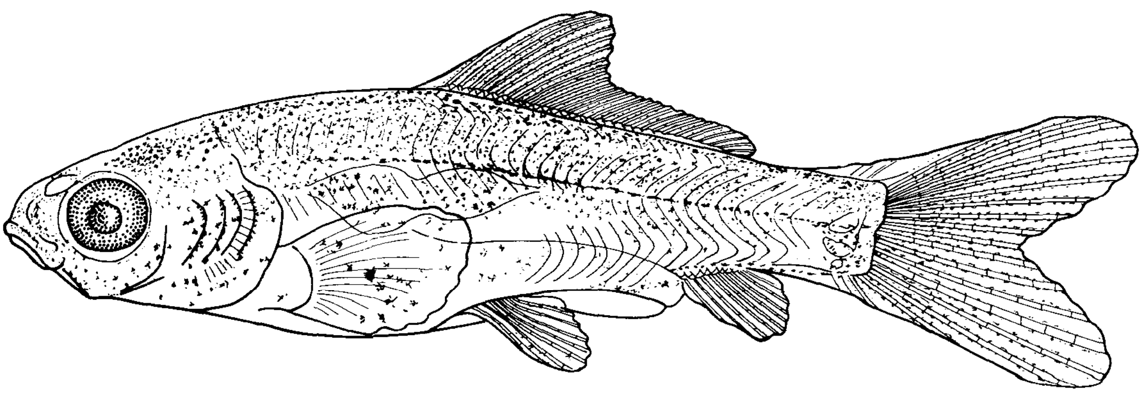
A

17.4 mm



B

21.3 mm



C

28.4 mm

Fig. 169. Ictiobus cyprinellus, bigmouth buffalo. A and B. Larvae. C. Juvenile. (A-C, laboratory-reared, Tennessee, Yeager and Baker in press),

Ictiobus niger (Rafinesque), black buffalo

See Ictiobus sp. account.

DISTRIBUTION

Reported from Lake Erie[6 7] and a few collections from southern and southeastern tributaries and lakes of the Lake Michigan drainage.'[6]

SPAWNING SEASON

Not reported for the Great Lakes region. Spawns in late April in Mississippi .[4]

SPAWNING TEMPERATURE

Not reported.

SPAWNING HABITAT

Reported in a cypress swamp in 0.3 to 1.0 m of water[4] and in brackish ponds.[2]

SPAWNING SUBSTRATE

Spawns over submerged terrestrial (and probably aquatic) vegetation.'

FECUNDITY

Not reported.

NATURAL HYBRIDS

Possibly Ictiobus cyprinellus.[9]

EGGS

Demersal, adhesive;' diameter 1.8 to 2.2 mm;[8] incubation period: 36 hours at 19 C, 24 hours at 24 C[3] (note: these values were given for a composite of all three species of Ictiobus and their hybrids).

YOLK-SAC LARVAE

Total length	Description
5.3-5.8 mm	Newly hatched.[10] Morphology: head flexed downward over yolk sac.[10] Pigmentation: eye and ventral midline of yolk sac pigmented.[10]
6-7 mm	Morphology: free-swimming (45 to 56 hours posthatching at 19 C, 36 hours at 24 C);[3] swim bladder inflating (6.6 to 7.2 mm) .[10]

Pigmentation: dorsal row of melanophores diffuse, dorsum of head darkly pigmented, midlateral stripe present (not complete);[10] larvae appear black.[3]

LARVAE

Total length	Description
7-18 mm	Myomeres: 35 to 40 (28 to 31 + 6 to 10).[8] Morphology: yolk absorbed (7.2 to 7.5 mm;[10] 3 days at 19 C[3]); first caudal fin rays formed (8.8 to 9.0 mm), pelvic buds present (11.5 to 12.6 mm), dorsal (12.8 to 13.3 mm), pectoral (17.7 mm), anal and pelvic (17.7 to 17.9 mm) fin rays forming, two swim bladder chambers present (13.3 mm).[10]

JUVENILES

Minimum size ca. 25.8 mm.10

ADULTS

Fin rays: caudal 18;* dorsal 27 to 31, anal 8 to 9;[5] pectoral 15 to 16;* pelvic 9 to 11.[5]

Vertebrae: usually 37 (including Weberian vertebrae).[5]

Lateral line scales: 36 to 39.[5]

Diagnostic characters: dorsal fin long (27 to 31 rays), lateral line scales 36 to 39, mouth inferior (upper lip below eye), first dorsal fin ray moderately elongate, body depth into standard length greater than 2.8 times.

LITERATURE CITED

1. Becker (1076)
2. Perry (1976)
3. Giudice (1964)
4. Yeager (1936)
5. Cross (1967)
6. Hubbs and Lagler (1958)
7. Crossman and Nepszy (1979)
8. Yeager (1980)
9. Johnson and Minckley (1972)
10. Yeager and Baker (in press)

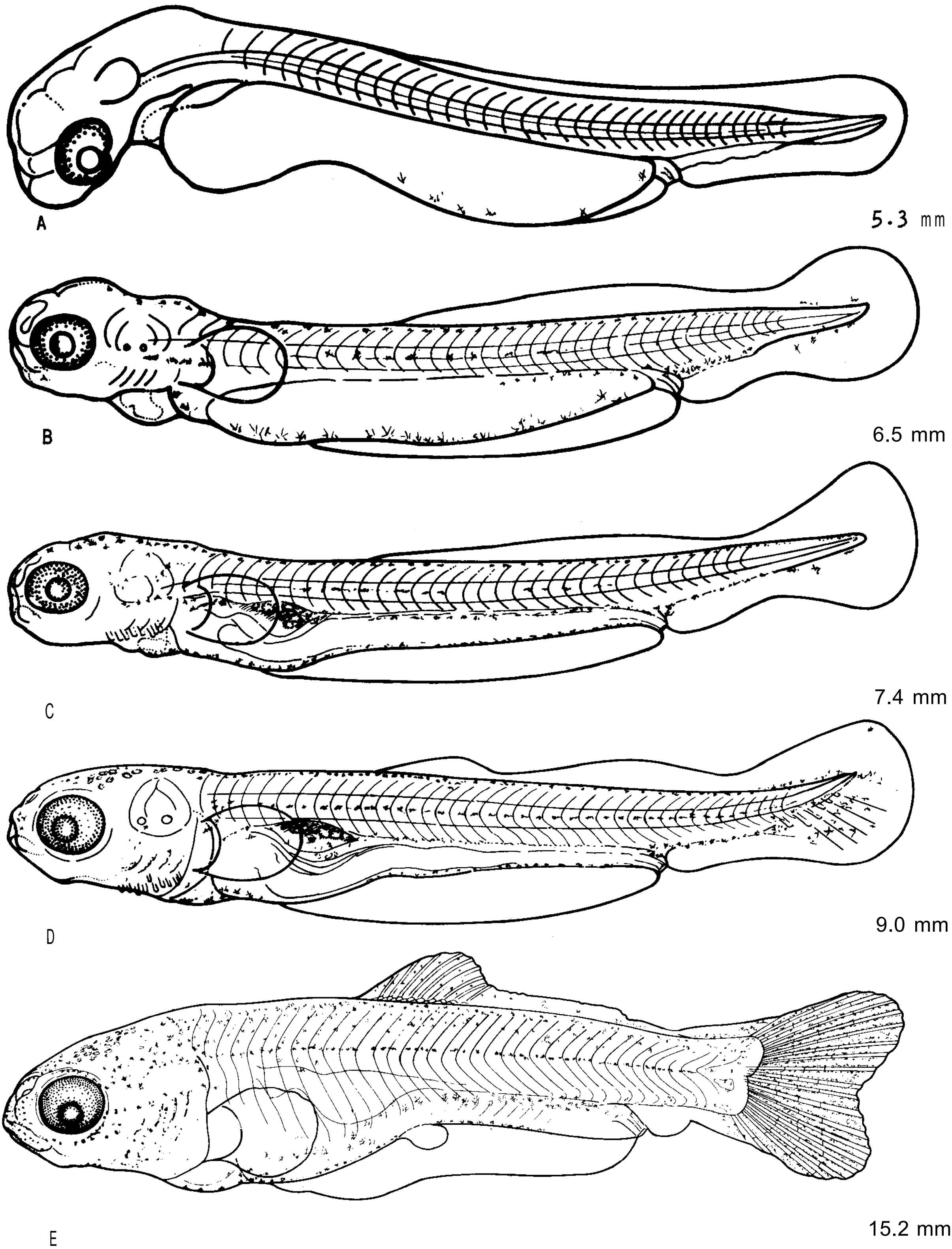
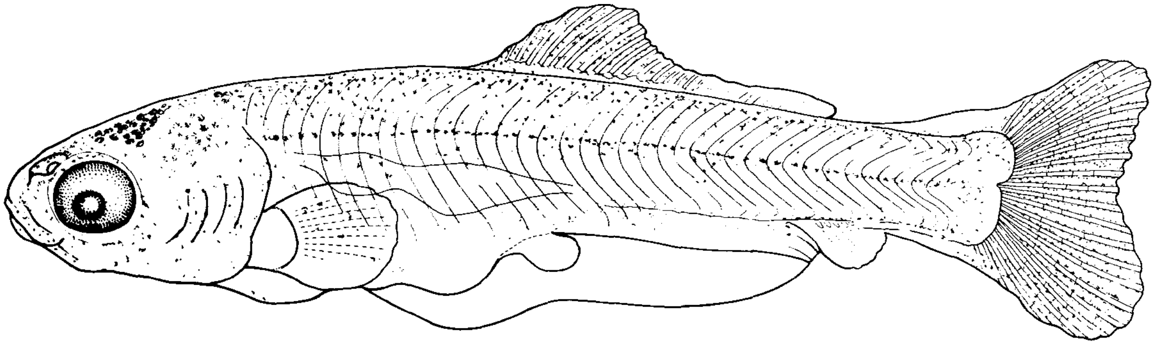
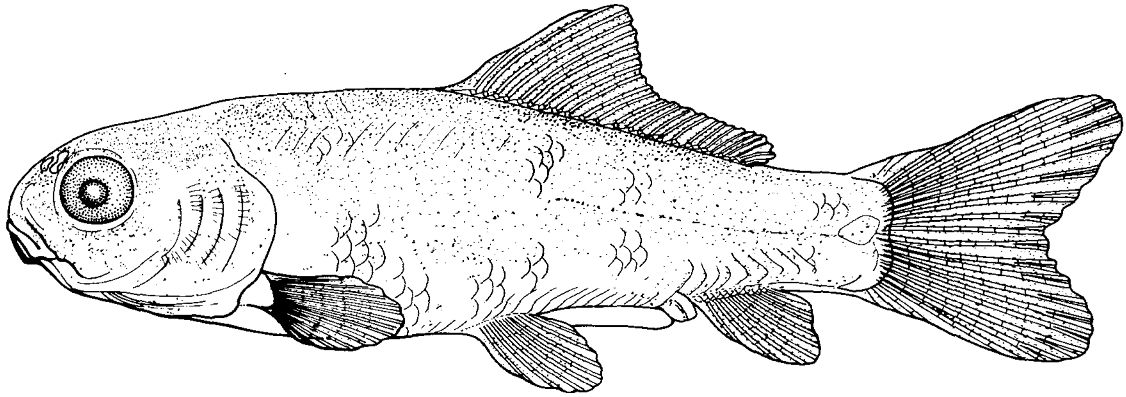


Fig. 170. Ictiobus niger, black buffalo. A and B. Yolk-sac larvae. C-E. Larvae. (A-E, laboratory-reared, Tennessee, Yeager and Baker in press).



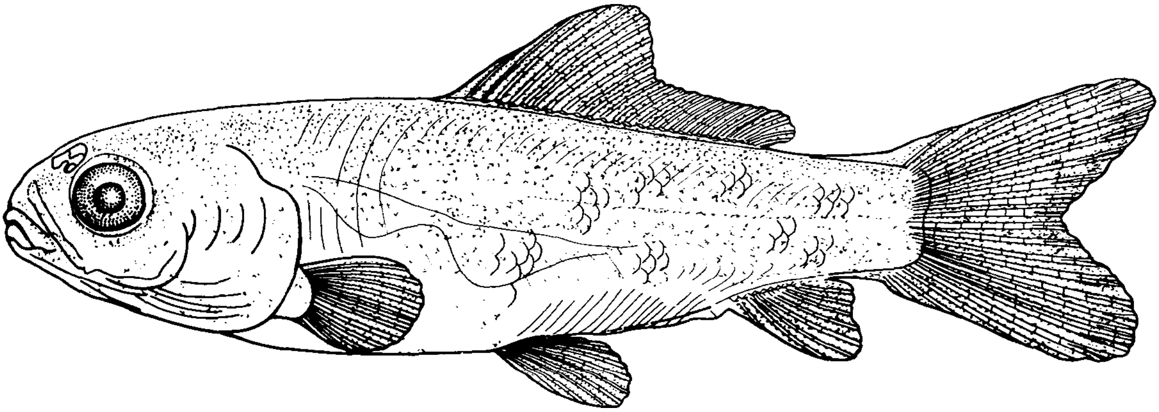
A

17.1 mm



B

24.9 mm



C

25.0 mm

Fig. 171. Ictiobus niger, black buffalo. A and B. Larvae. C. Juvenile. (A-C, laboratory-reared, Tennessee, Yeager and Baker in press)

Minytrema melanops (Rafinesque), spotted sucker

DISTRIBUTION

Found in United States drainages of Lakes Erie, St. Clair, Huron and Michigan and in parts of Ontario, Canada which drain into Lake St. Clair.‘ It is common in many streams and rivers of the Lake Michigan drainage including Wisconsin and southern lower Michigan,’

SPAWNING SEASON

Spawning occurs from mid-March to early May in Georgia,[2] Alabama’ and Oklahoma[5].

SPAWNING TEMPERATURE

Adults are ripe and spawning runs occur at temperatures between 12 and 20 c.2 Spawning has been observed between 15 and 18 C.[5]

SPAWNING HABITAT

Spawns in riffles;[2 5] 0.3 to 0.5 m deep, with a current velocity of 0.24 m/s.[2]

SPAWNING SUBSTRATE

Spawns over coarse limestone rubble.[2]

FECUNDITY

Not reported.

EGGS

Demersal, adhesive;’ oil globules absent;’ diameter 2.3 to 2,6 mm, mean 2.5[4] or 3.1[3] mm; incubation period: 108 to 156 hours (4.5 to 6.4 days) at 16 to 20 C;[4] 7 to 12 days at 15 to 18 C.[5]

YOLK-SAC LARVAE

Total length	Description
4.2-6.8 mm	Newly hatched’, but see 8-11 mm. Myomeres: incomplete (newly hatched).[4] Morphometry: (as % TL) preanal length 86, head length 15, eye diameter 7, greatest body depth 18, (as % head length) eye diameter 49.[4] Morphology: head flexed downward over yolk sac, pectoral buds absent, anterior portion of yolk sac bulbous (newly hatched), notochord flexed (6.0 mm).[4] Pigmentation: melanophores absent from eyes and body (newly -hatched).[4]

8-11 mm	Newly hatched (8.0 to 9.2 mm);[3] but see 4.2-6.8 mm. Myomeres: (30 to 31 + 13 to 14);[3] (31 to 35 + 4 to 7) and completely formed at 7.5 mm.[4] Morphometry: (as % TL) preanal length 79[4] and 87;[3] head length 15, eye diameter 6 to 8;[3,4] greatest body depth 25;' (as % head length) eye diameter 41.[4] Morphology: head and tail flexed downward, pectoral buds absent, yolk sac with three bulbous lobes (newly hatched);[3] pectoral buds formed (8.5 mm), hypural bones formed (ca. 10 mm).[4] Pigmentation: retinae lightly pigmented (9.0 mm) and darkly pigmented (10.0 mm), midlateral stripe (9.5 mm), midventral stripe (10.0 mm) and single middorsal stripe (11.0 mm) present, melanophores over midbrain and hindbrain.'

LARVAE

Total length	Description
11-24 mm	Myomeres: (31 to 33 + 6 to 9).[4] Morphometry: (as % TL) preanal length 67, head length 20, eye diameter 7, greatest body depth 14, (as % head length) eye diameter 35.[4] Morphology: yolk absorbed (10.5 to 11.0 mm, at 7 to 12 days posthatching);'[4] first caudal fin rays (11.5[4] to 123 mm); pectoral buds formed (12 mm);[3] but see 8-l 1 mm; single swim bladder chamber developed (12 mm), notochord flexed posteriorly;[3] but see 4.2-6.8 mm; first dorsal fin rays formed, second swim bladder chamber formed;[3] first anal' fin rays formed, mouth inferior[4] or subterminal[3] (15 mm); dorsal fin complete (16.0 mm), anal fin and all median fin rays complete;[4] first anal, pectoral and pelvic fin rays formed, gut coiled (18 mm);[3] pectoral fin complete (20.0 to 23.0 mm), al 1 f infolds absorbed (24.0 mm).[4] Pigmentation: three longitudinal stripes on dorsum, area over swim bladder darkened, interorbital melanophores present (11.5 mm), dorsal pigmentation darker (12.0 mm), progressively darker through juvenile period.'

JUVENILES

Total length	Description
25-33 mm	Morphology: squamation started (24 to 26 mm), completed (32 to 33 mm).

ADULTS

Fin rays: caudal 18;* dorsal 11 to 12, anal 7, pectoral 16, pelvic 9 to 10.6

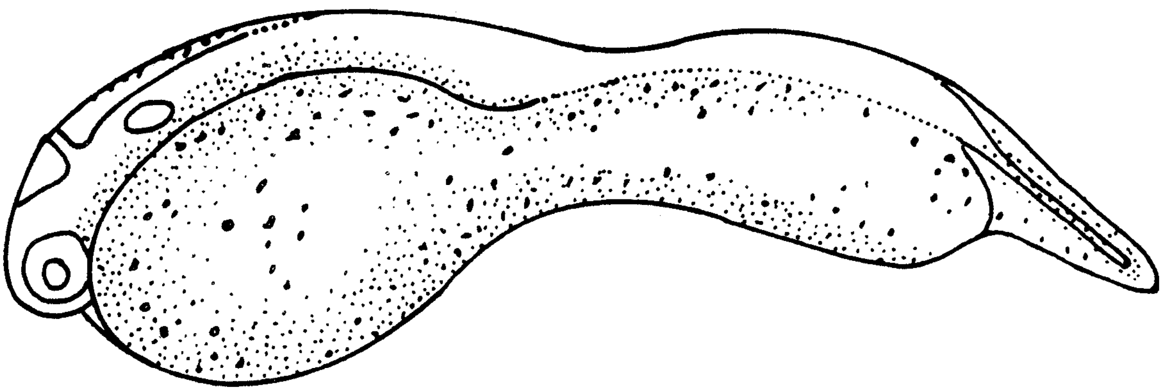
Vertebrae: 43 or 44 (possibly including Weberian vertebrae) in southern areas of the United States.[6]

Lateral line scales: 44 to 47.[6]

Diagnostic characters: dorsal fin short (11 to 12 rays), lateral line absent or with only a few pored scales, scales in lateral series 44 to 47, spots at bases of scales forming about 10 rows on sides of body.

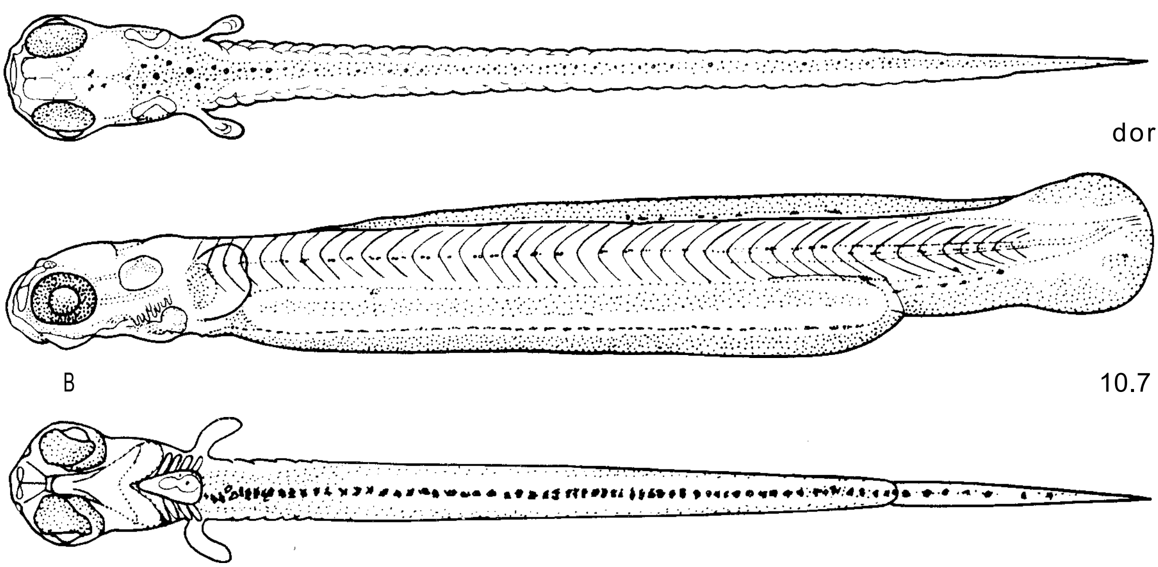
LITERATURE CITED

1. Becker (1976)
2. McSwain and Gennings (1972)
3. White (1977)
4. Hogue and Buchanan (1977)
5. Jackson (1957)
6. Scott and Crossman (1973)



A

5.8 mm



dorsal

B

10.7 mm

ventral

Fig. 172. Minytrema melanops, spotted sucker. A and B. Yolk-sac larvae. (A and B, laboratory-reared, Alabama, Hogue and Buchanan 1977).

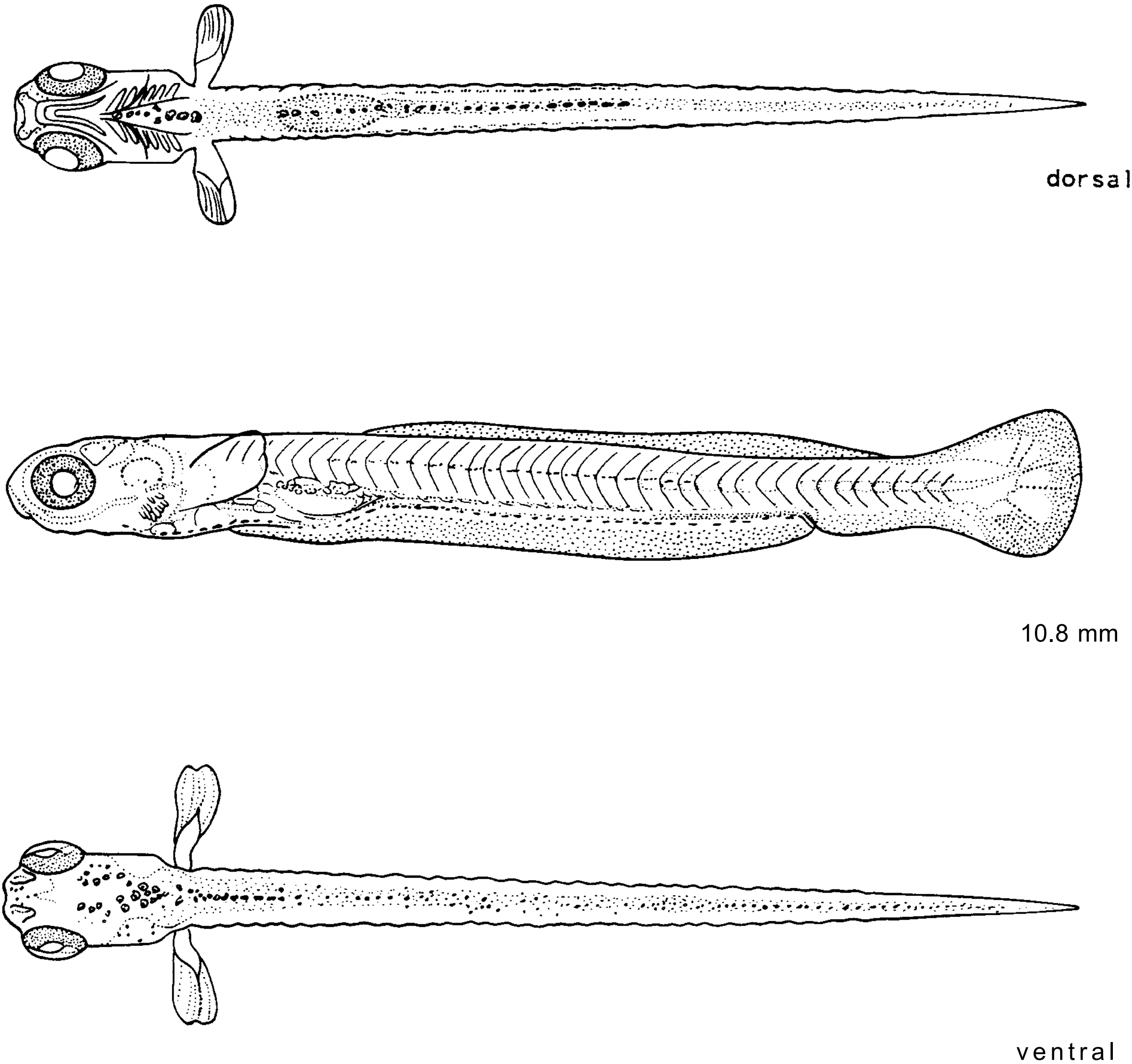


Fig. 173. Minytrema melanops, spotted sucker. Larva. (Laboratory-reared, Alabama, Hogue and Buchanan 1977).

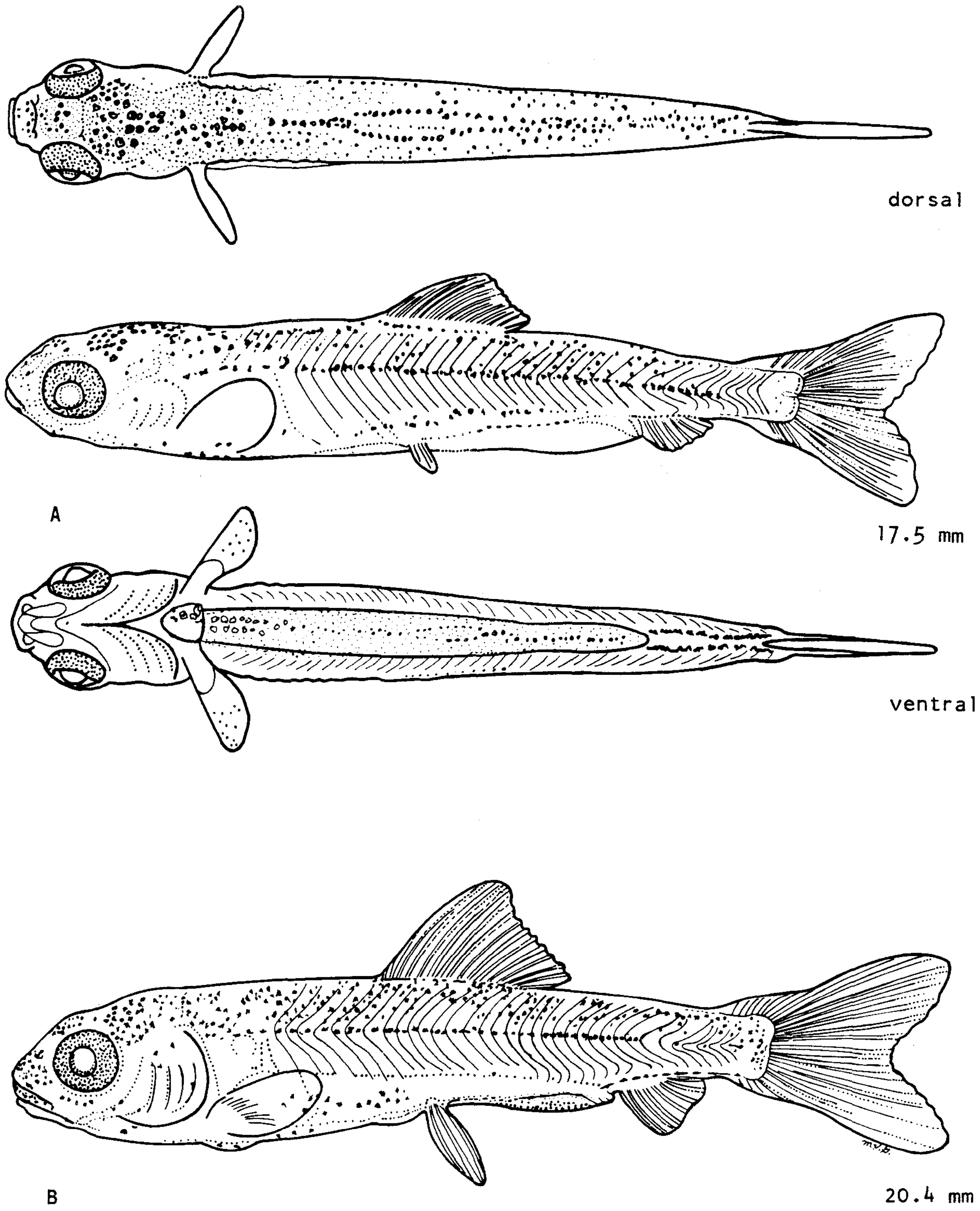


Fig. 174. Minytrema melanops, spotted sucker. A and B. Larvae. (A and B, laboratory-reared, Alabama, Hogue and Buchanan 1977).

Moxostoma anisurum (Rafinesque), silver redhorse

DISTRIBUTION

Occurs in the lakes and large rivers of all of the Great Lakes. In Lake Superior it occurs only in the southern and western portions.[5] It is scattered throughout the central portion of the Lake Michigan drainage.'

SPAWNING SEASON

Spawns in early April in Alabama' to early May in Iowa.[3] Migrates upstream for spawning when ice goes out.[2]

SPAWNING TEMPERATURE

Ripe adults have been collected at 13 C.[3] Spawns at 14 C.[4]

SPAWNING HABITAT

Spawns in main river channels, 0.4 to 1.0 m deep[3] or in shallow riffles.'

SPAWNING SUBSTRATE

Deposits eggs among rocks, gravel and rubble.[3 4]

FECUNDITY

14,910 to 36,340.[3]

EGGS

Not described.

YOLK-SAC LARVAE

Not described.

LARVAE

Not described.

JUVENILES

Total length	Description
20 mm	Morphometry: (as % TL) preanal length 63, head length 23, eye diameter 7, greatest body depth 15, body depth at anus 8, (as % head length) eye diameter 28, body depth at anus 34.[2] Morphology: all caudal, dorsal and anal fin rays developed, three chambers in swim bladder.[2]

Pigmentation: chromatophores over snout and top of head, two dorsal stripes present, midlateral stripe present, melanophores covering top of swim bladder and intestine, irregular midventral series to anus, double row from anus to tail, pectoral and pelvic fins lightly pigmented; caudal, dorsal and anal fins heavily pigmented.[2]

ADULTS

Fin rays: caudal 18, dorsal 14 to 15 (12 to 17), anal 7, pectoral 17 to 18 (16 to 20), pelvic 9.[6]

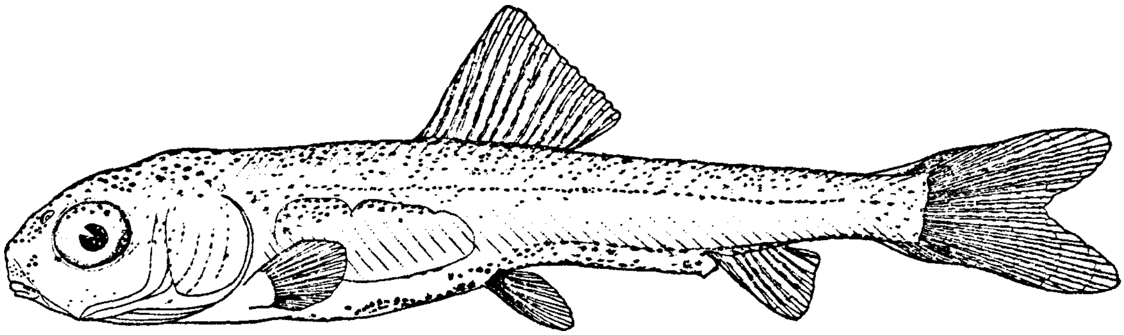
Vertebrae: 40 to 44 (including Weberian vertebrae).[6]

Lateral line scales: 42 to 44 (38 to 46).[6]

Diagnostic characters: dorsal fin short (usually 14 to 15 rays), scales large (usually 42 to 44 in lateral series, caudal peduncle scales 12 to 13), three chambered swim bladder, transverse lines across plicae of lips, pelvic fin origin anterior to midpoint of dorsal fin base, posterior edge of lower lip forming angle approximately 90 degrees.

LITERATURE CITED

1. Becker (1976)
2. Fish (1932)
3. Meyer (1962)
4. Hackney et al
5. Hubbs and Lagler (1958)
6. Jenkins (1970)



19.5 mm

Fig. 175. Moxostoma anisurum, silver redhorse. Juvenile. (Wild-caught, Lake Erie, Fish 1932).

Moxostoma carinatum (Cope), river redhorse

The data designated as original (*) in the following EGGS, YOLK-SAC LARVAE, LARVAE and JUVENILES sections were obtained from specimens provided by Bruce L. Yeager. He intends to write a more complete description of this species.

DISTRIBUTION

Scarce in the Great Lakes region. Restricted to southern drainages of Lakes Erie and Ontario.[5] Probably not found in the Lake Michigan drainage. A single record exists from the Muskegon River system.[1]

SPAWNING SEASON

Probably spawns in spring in the north.[2] Spawns from mid-April to early May in Alabama.[3]

SPAWNING TEMPERATURE

Spawns at temperatures between 22 and 24 C.[3,4]

SPAWNING HABITAT

Probably spawns in large tributaries,[2] 15 to 100 cm deep, in redds 1.3 to 2.7 m wide.[3]

SPAWNING SUBSTRATE

Spawns over gravel shoals.[3]

FECUNDITY

6,078 to 23,085.[3]

EGGS

Demersal, nonadhesive;* diameter 3 to 4[3] or 3.7 to 4.4 mm;[6] yolk amber, oil globules absent;* incubation period: 3 to 4 days at 22 C.[3]

YOLK-SAC LARVAE

Total length	Description
10.4-11.0 mm	Newly hatched.* Myomeres: 39 to 46 (33 to 38 + 5 to 8).[6] Morphometry: (as % TL) preanal length 77 to 83, head length 12 to 15, eye diameter 5 to 6, body depth at anus 9 to 15.* Morphology: head deflected over yolk sac, front of yolk sac bulbous, pectoral buds minute or absent.* Pigmentation: yolk bright yellow, other pigmentation absent.*

13-14 mm	Myomeres: 40 to 43 (33 to 35 + 7 to 8);* see 10.4-11.0 mm. Morphometry: (as % TL) preanal length 68 to 74, head length 15 to 16, eye diameter 6 to 7, body depth at anus 11 to 12.* Morphology: yolk sac tubular;[3] * head free from yolk sac, mouth and hypural bones forming.* Pigmentation: eyes black, melanophores covering occiput, narrowing to middorsal stripe on nape, two dorsal stripes behind nape and merging on caudal peduncle, midlateral stripe present (sever a 1 melanophores in midlateral myoseptum of each myomere), broad midventral stripe behind head to tip of tail,*

LARVAE

Total length	Description
15-16 mm	Myomeres : see 10.4-11.0 mm and 13-14 mm. Morphometry: (as % TL) preanal length 69 to 70, head length 18 to 20, eye diameter 6 to 7, body depth at anus 10 to 11.* Morphology: yolk absorbed (ca. 15.8 mm), caudal fin rays and hypural bones complete, two swim bladder chambers present, dorsal fin rays forming, mouth subterminal to inferior, pelvic buds forming.* Pigmentation: dorsum of snout, head and occiput pigmented, prominent median predorsal series of melanophores, two dorsal rows from dorsal fin to caudal peduncle indistinct, pigment on dorsum of caudal peduncle dark, melanophores scattered on side of head behind eye, midlateral stripe narrow, internal melanophores on dorsum of gut and swim bladder, midventral stripe prominent.*
19-20 mm	Myomeres : see 10.4-11.0 mm and 13-14 mm. Morphometry: (as % TL) preanal length 62 to 66, head length 20 to 21, eye diameter 6, body depth at anus 10 to 11.* Morphology: all median fin rays present, preanal f infold remaining.* Pigmentation: melanophores on occiput and in median predorsal series, midlateral stripe absent or confined to caudal peduncle, midventral stripe nearly absent, scattered melanophores on distal portion of dorsal fin and along proximal portion of caudal fin rays.*

JUVENILES

Total length	Description
19-26 mm	Myomeres : see 10.4-11.0 mm and 13-14 mm.

Morphometry: (as % TL) preanal length 60 'to 62, head length 21 to 23, eye diameter 6 to 7, body depth at anus 12 to 13.*

Morphology: all finfolds absorbed, squamation started (19.3 mm) and complete (ca. 26.3 mm) .*

Pigmentation: single middorsal stripe present, sides above midlateral line with scattered melanophores, melanophores on venter of caudal peduncle, scales outlined with melanophores.*

ADULTS

Fin rays: caudal 18, dorsal 12 to 14, anal 7, pectoral 16 to 18, pelvic 9.[4]

Vertebrae: 41 to 44 (including Weberian vertebrae).'

Lateral line scales: 42 to 44 (41 to 46) .[4]

Diagnostic characters: dorsal fin short (12 to 14 rays), scales large (usually 42 to 44 in lateral series, caudal peduncle scales 12 to 13), three-chambered swim bladder, no transverse lines on plicae of lips, pelvic fin origin anterior to midpoint of dorsal fin base, lower Pharyngeal teeth molariform.

LITERATURE CITED

1. Becker (1976)
2. Scott and Crossman (1973)
3. Hackney et al. (1969)
4. Jenkins (1970)
5. Hubbs and Lagler (1958)
6. yeager (1980)

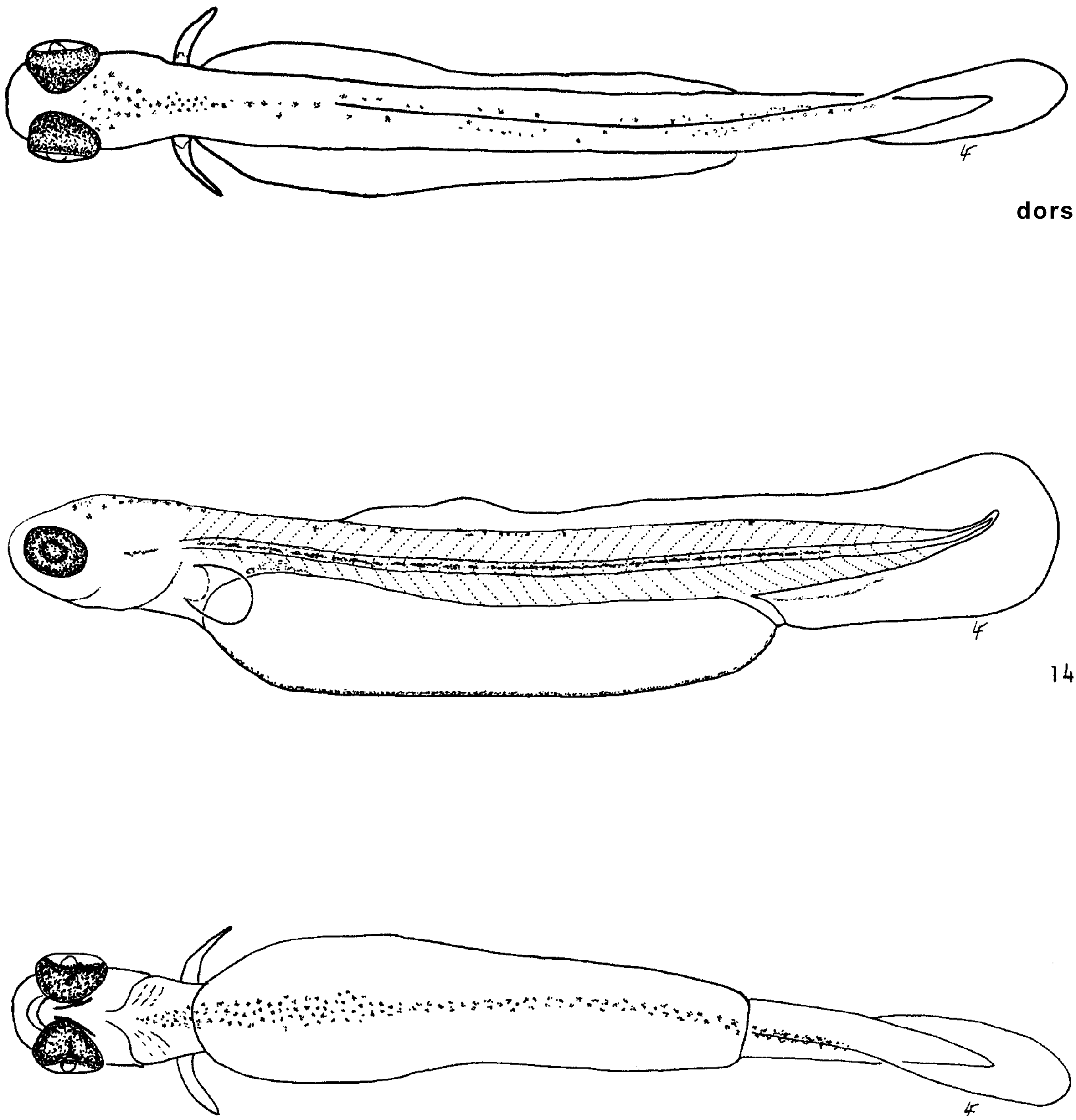
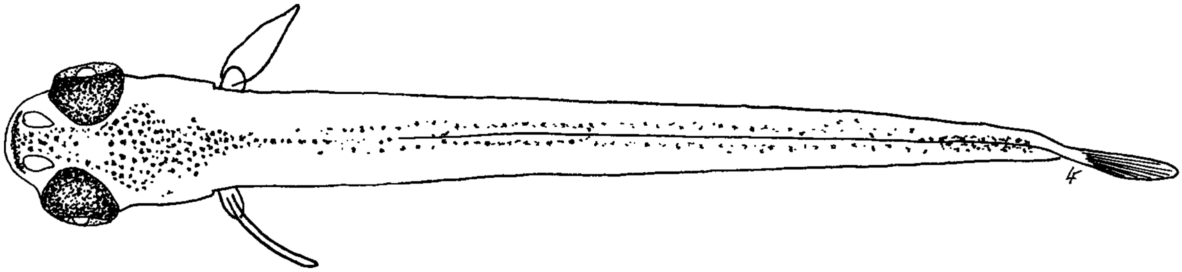
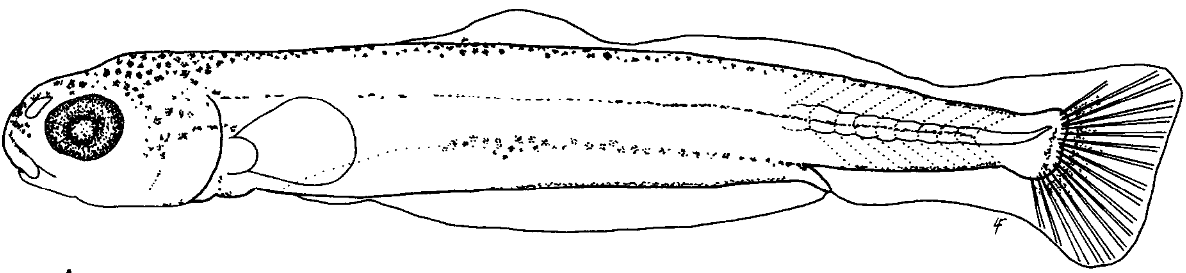


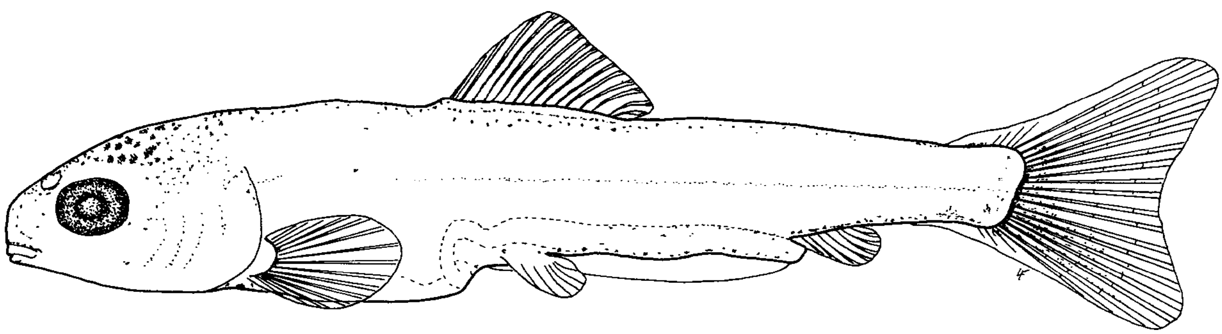
Fig. 176. **Moxostoma carinatum**, **river redhorse. Yolk-sac larva. (Laboratory-reared, Tennessee, original illustrations by L. A. Fuiman,** specimens provided by B. L. Yeager).



dorsal



A 16.3 mm



B 18.7 mm

Fig. 177. Moxostoma carinatum, river redhorse. A and B. Larvae. (A and B, laboratory-reared, Tennessee, original illustrations by L. A. Fuiman, specimens provided by B. L. Yeager).

Moxostoma duquesnei (LeSueur), black redhorse

The data designated as original (*) in the following EGGS, YOLK-SAC LARVAE, LARVAE and JUVENILES sections were obtained from specimens provided by Bruce L. Yeager. He intends to write a more complete description of this species.

DISTRIBUTION

Rare in southern drainages of the Great Lakes,[5 6] few reports in the Lake Michigan drainage, all in the southern half.[1]

SPAWNING SEASON

Spawns in late April in Missouri' to early May in Kansas.'

SPAWNING TEMPERATURE

Spawns at temperatures from 13 to 23 C.[2 3 4]

SPAWNING HABITAT

Spawns in swift riffles,[3] 10 to 60 cm deep.*

SPAWNING SUBSTRATE

Deposits eggs over fine rubble.[2]

FECUNDITY

Not reported.

EGGS

Demersal, nonadhesive, diameter 3.4 mm, yolk amber, oil globules absent.*

YOLK-SAC LARVAE

Total length	Description
ca. 9 mm	Newly hatched.* Morphometry: preanal length 88% TL.* Morphology: head deflected over yolk sac, front of yolk sac bulbous, pectoral buds absent.* Pigmentation: light yellow yolk, other pigmentation absent.*
14 mm	Myomeres: 43 to 45 (35 to 36 + 8 to 9) * Morphometry: (as % TL) preanal length 73, head length 16, eye diameter 6, body depth at anus 9.*

Morphology: mouth, hypural bones and swim bladder forming, yolk sac tubular, head free from yolk sac, pectoral buds present.*

Pigmentation: eye black, dorsum of occiput with scattered melanophores, narrowing to median predorsal series, dorsal pigment scattered posteriad, melanophores in midlateral myoseptum forming stripe from pectoral buds to posterior end of yolk sac, midventral stripe broad.*

LARVAE

Total length	Description
18-20 mm	Myomeres: see 14 mm. Morphometry: (as % TL) preanal length 67 to 71, head length 22, eye diameter 7, body depth at anus 10.* Morphology: pelvic buds present, mouth inferior, caudal and dorsal fin rays complete (17.5 mm), anal fin rays forming (20.5 mm) and complete, paired fin rays forming (21.2 mm).* Pigmentation: sparse throughout, darkest over occiput, fine melanophores scattered on dorsum, midlateral line of melanophores faint, midventral stripe intermittent, darkest under hindgut.*

JUVENILES

Total length	Description
24-39 mm	Myomeres : see 14 mm. Morphometry: (as % TL) preanal length 61 to 64, head length 21 to 22, eye diameter 6, body depth at anus 10 to 11.* Morphology: all finfolds absorbed, squamation present (by 24 mm), complete (prior to 38.5 mm).* Pigmentation: pale, melanophores on scale margins forming cross-hatched pattern on dorsum.*

ADULTS

Fin rays: caudal 18, dorsal 12 to 14, anal 7, pectoral 16 to 18, pelvic 9 to 10.[4]

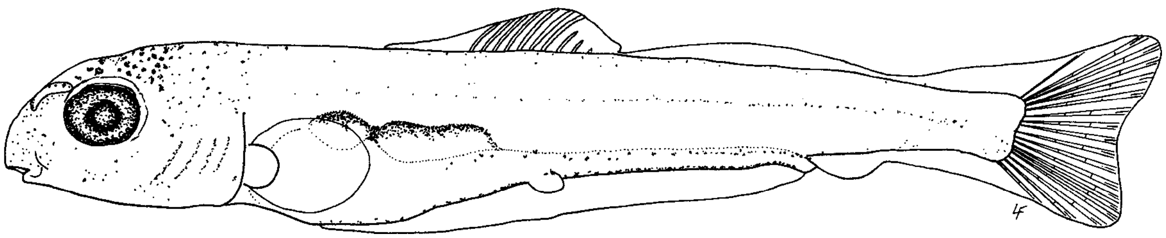
Vertebrae: 43 to 47 (including Weberian vertebrae).'

Lateral line scales: 45 to 47 (43 to 51).[4]

Diagnostic characters: dorsal fin short (12 to 14 rays), scales large (usually 45 to 47 in lateral series, caudal peduncle scales 12 to 14), three-chambered swim bladder, no deep transverse creases on plicae of lips, pelvic fin origin opposite midpoint of dorsal fin base.

LITERATURE CITED

1. Becker (1976)
2. Bowman (1970)
3. Cross (1967)
4. Jenkins (1970)
5. Hubbs and Lagler (1958)
6. Scott and Crossman (1973)



18.4 mm

Fig. 178. Moxostoma duquesnei, black redhorse. Larva. (Laboratory-reared, Tennessee, original illustration by L. A. Fuiman, specimen provided by B. L. Yeager).

Moxostoma erythrurum (Rafinesque), golden redhorse

DISTRIBUTION

Found in clear creeks and rivers of the Lake Michigan and Lake Erie drainages.' It is common in tributaries of the lower two-thirds of the Lake Michigan drainage' and in the lake proper.*

SPAWNING SEASON

Spawns from mid-May in Michigan[2] to late Hay in Wisconsin.[1]

SPAWNING TEMPERATURE

Adults with well developed gonads were collected at 16 C.[4] Spawning has been observed between 17 and 22 C.[2 6]

SPAWNING HABITAT

Spawns at the lower ends of pools[2] in rivers[2 3] and moderate size streams.[8] Does not spawn in small streams.[2 3]

SPAWNING SUBSTRATE

Spawns over loose gravel.*

FECUNDITY

6,100 to 25,350.'

EGGS

Demersal, nonadhesive;& oil globules absent, yolk pale yellow.[5]

YOLK-SAC LARVAE

Total length	Description
9.5-10.8 mm	Newly hatched, mean: 9.4 mm.[5]
	Myomeres: usual 1 y 40 to 42 (33 to 35 + 7 to 8) unchanged after hatching.[5]
	Morphometry: (as % TL) preanal length 82, head length 14, eye diameter 6, body depth at anus 9, (as % head length) eye diameter 45, body depth at anus 63.[5]
	Morphology: yolk sac slightly bulbous anteriorly, head deflected over anterior end of yolk sac, pectoral buds minute.[5]
	Pigmentation: eye slightly pigmented, other pigmentation lacking.[5]

11-14 mm	Myomeres: see 9.5-10.8 mm. Morphometry: (as % TL) preanal length 75, head length 20, eye diameter 7, body depth at anus 9, (as % head length) eye diameter 38, body depth at anus 46.5 Morphology: first caudal fin rays (11.1 mm), hypural elements formed (12.0 mm), mouth parts ossified (12.3 mm), first dorsal fin rays formed (12.2 to 12.8 mm) between myomeres 14 and 18, notochord flexed (12.9 mm) anterior and posterior swim bladder chambers inflated (13.0 mm) between myomeres 5 and 7, and 8 and 12, respectively, yolk absorbed (13.4 mm).[5] Pigmentation: occiput heavily pigmented, median predorsal stripe present, two stripes lateral to predorsal stripe from pectoral buds to tail (where fused), eye black, midlateral stripe composed of two to three melanophores per myomere, dorsum of yolk sac dark, melanophores among caudal fin rays, narrow midventral stripe (12.3 mm), three dorsal stripes indistinct (13.2 mm).[5]

LARVAE

Total length	Description
14-20 mm	Myomeres: see 9.5-10.8 mm. Morphometry: (as % TL) preanal length 70, head length 22, eye diameter 8, body depth at anus 9, (as % head length) eye diameter 36, body depth at anus 42.[5] Morphology: pelvic buds formed between myomeres 15 and 17 (12.0 to 14.4 mm), first anal fin rays (14.5 mm), mouth subterminal (14.7 mm) to inferior (15.3 mm), pelvic fin rays formed (15.0 mm), gut S-shaped (15.5 mm), all median fin rays formed (15.9 mm), squamation started (18.7 mm), finfolds absorbed (19.9 to 21.3 mm).[5] Pigmentation: melanophores along all dorsal fin rays, midventral stripe faint (15.3 mm).[5]

JUVENILES

Total length	Description
20-25 mm	Myomeres: see 9.5-10.8 mm. Morphometry: (as % TL) preanal length 61, head length 23, eye diameter 7, body depth at anus 11, (as % head length) eye diameter 32, body depth at anus 52.[5] Morphology: squamation complete (23 mm).[5] Pigmentation: lateral pigmentation scattered, darkest dorsal fin pigmentation on distal margin.[5]

ADULTS

Fin rays: caudal 18, dorsal 12 to 14, anal 7, pectoral 16 to 18, pelvic 9.[6]

Vertebrae: 39 to 43 (including Weberian vertebrae).'

Lateral line scales: 40 to 42 (37 to 45).[6]

Diagnostic characters: dorsal fin short (12 to 14 rays), scales large (usually 40 to 42 in lateral series, caudal peduncle scales 12), swim bladder three-chambered, no deep transverse creases on plicae of lips, pelvic fin origin at midpoint of dorsal fin base, posterior edge of lower lip forming angle of approximately 100 to 120 degrees,

LITERATURE CITED

1. Becker (1976)
2. Hankinson (1932)
3. Gerking (1953)
4. Meyer (1962)
5. Fuiman and Witman (1979)
6. Jenkins (1970)
7. Hubbs and Lagler (1958)
8. R. E. Jenkins (pers. Comm.)

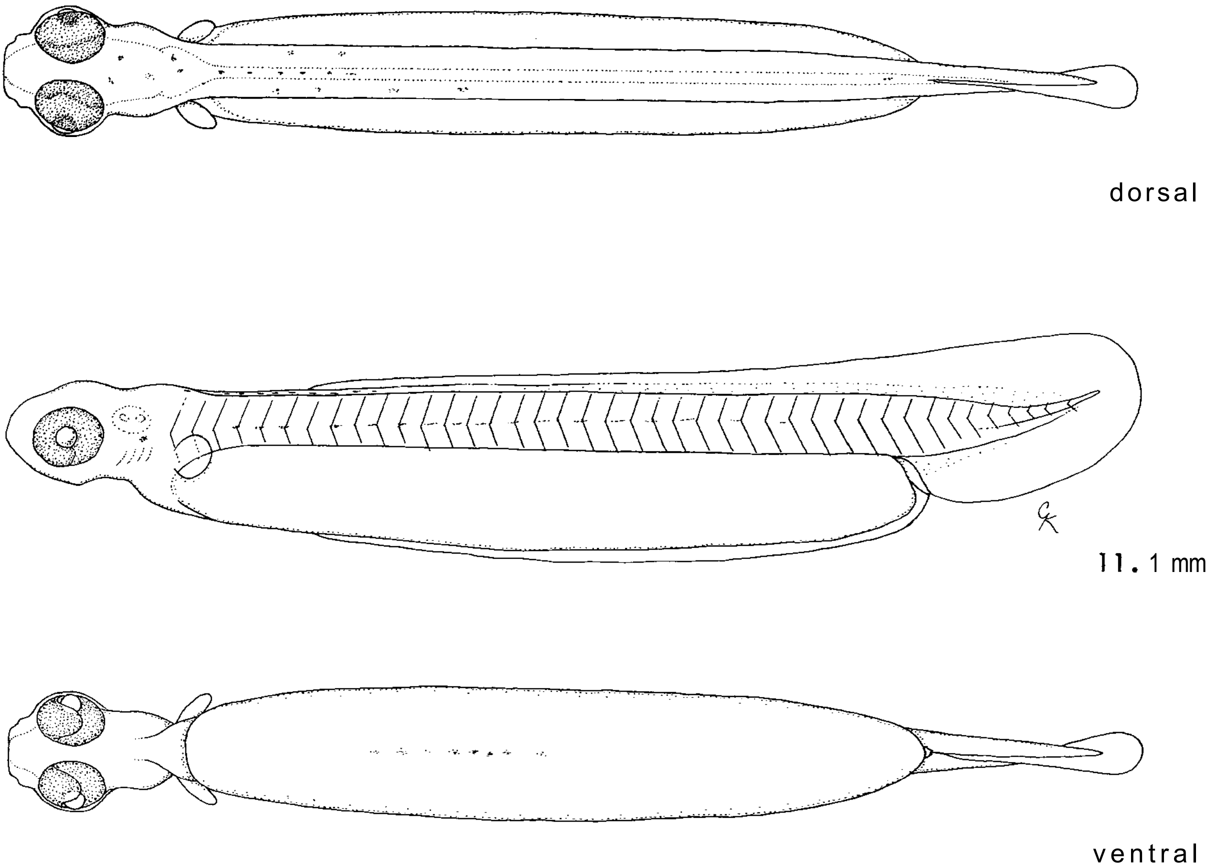


Fig. 179. Moxostoma erythrurum, golden redhorse. Yolk-sac larva. (Laboratory-reared, Pennsylvania, Fuiman and Witman 1979).

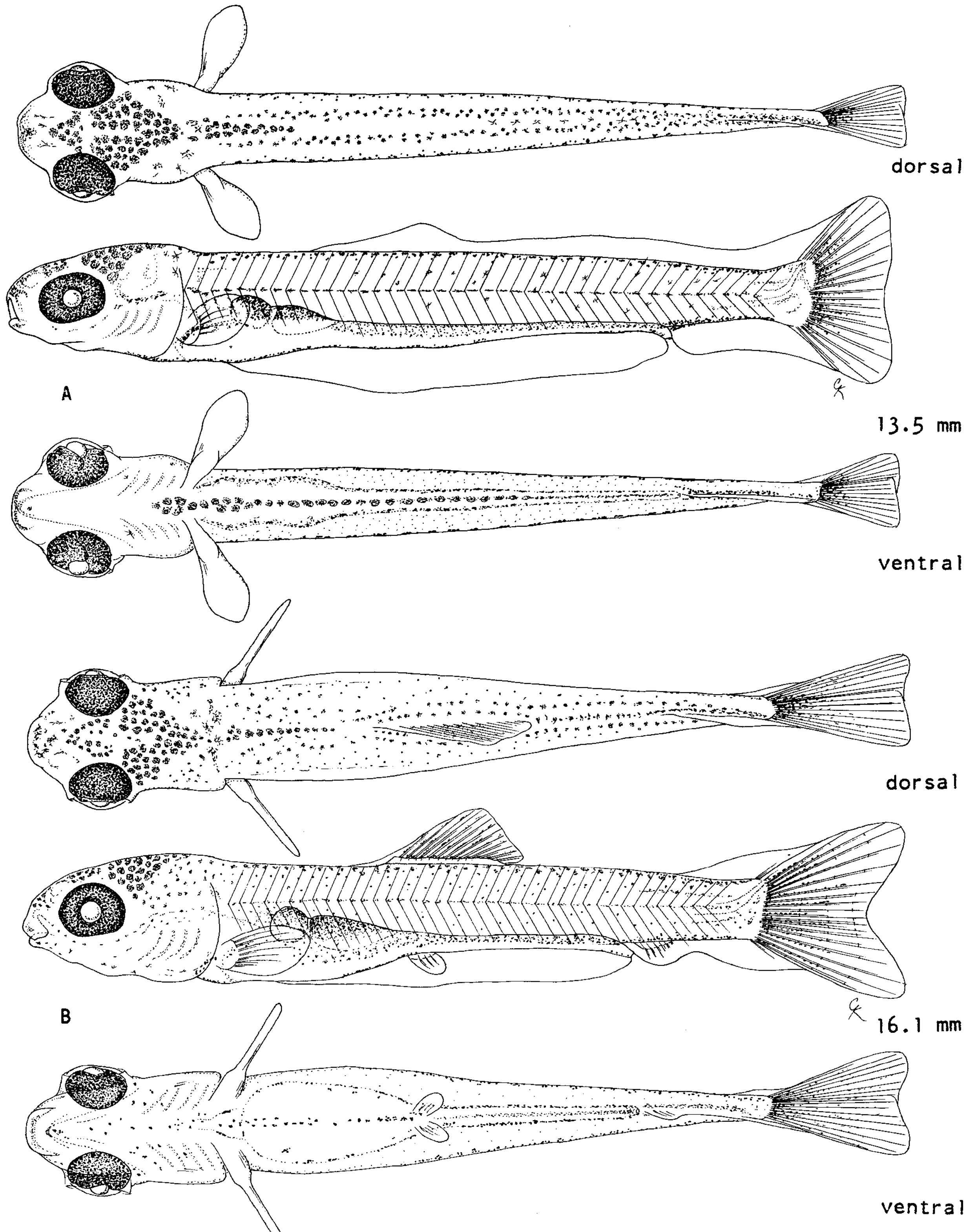


Fig. 180. Moxostoma erythrurum, golden redhorse. A and B. Larvae. (A and B, laboratory-reared, Pennsylvania, Fuiman and Witman 1979).

Moxostoma macrolepidotum (LeSueur), shorthead redhorse

DISTRIBUTION

Occurs throughout the Great Lakes basin.’ Uncommon to common in most moderate and large streams of Lake Michigan’ and in the lake proper.*

SPAWNING SEASON

Spawns in early and mid-May in Wisconsin[10] and lower Michigan.*

SPAWNING TEMPERATURE

Spawning occurs between 11 and 16 C.[3 5 8 10] Ripe adults have been collected at 18 C.[6]

SPAWNING HABITAT

Spawns in shallow, 15 to 21 cm, ri ffles of large streams.[2 5]

SPAWNING SUBSTRATE

Deposits eggs over fine sand, coarse stones and rubble (2.5 to 8.0 cm diameter) .[5]

FECUNDITY

13,500[3] to 29,732.[4]

EGGS

Demersal, nonadhesive;[7] oil globules absent;[6 7] diameter 3.0 to 3.3 mm[6] (mean: 3.2[6] to 3.3 mm[7]); yolk pale yellow;[6] incubation period: 8 days at 16 C.[7]

YOLK-SAC LARVAE

Total length	Description
7.7-10.4 mm	Newly hatched.[6 7] Myomeres: usually 43 to 45 (36 to 38+6 to 8), all myomeres at hatching.[6] Morphology: head flexed downward over yolk sac;[6 7] anterior fourth of yolk sac bulbous, pectoral buds absent[6] or present, urostyle slightly upturned.’ Pigmentation: absent in newly-hatched individuals.[6 7]
9-13 mm	Myomeres: 40 to 41 (34 to 35 + 5 to 6) , mean: 40 (35 + 6);[7] see also 7.7-10.4 mm. Morphometry: (as % TL) preanal length 77[7] to 79;[6] head length 14, eye diameter 6;[6 7] greatest body depth 15;[7] body depth at anus 8, (as % head length) eye diameter 43, body depth at anus 62.[6]

Morphology: first caudal fin rays developed (12.9 mm);[6 7] mouth parts ossified (12.4' to 13.2 mm[6]).
Pigmentation: eye and occiput pigmented (10.2' to 12.2 mm[6]); single middorsal stripe, usually three melanophores per myomere in midlateral myoseptum, melanophores scattered on lateral and dorsal surfaces of yolk sac, midventral stripe present (12.2 mm).[6]

13-14 mm
Myomeres: 39 to 41 (33 to 35 + 5 to 7), mean: 41 (34 + 6);[7] see also 7.7-10.4 mm.
Morphometry: (as % TL) preanal length 73, head length 17, eye diameter 6;[6 7] greatest body depth 13;[7] body depth at anus 9, (as % head length) eye diameter 36, body depth at anus 53.[6]
Morphology: notochord flexed, hypural bones forming (13.2 mm), al 1 caudal fin rays formed (13.3 mm);[6] posterior swim bladder chamber inflated (13.7 mm);[6 7] between myomeres 5 and 11.[6]
Pigmentation: three dorsal stripes and uniform pigmentation on dorsum of head and swim bladder (13.2 mm), some specimens with interorbital pigment-free space, proximal third of caudal fin rays pigmented (13.9 mm).[6]

LARVAE

Total length	Description
14-19 mm	Myomeres: 38 to 41 (30 to 35 + 6 to 8), mean: 38 (32 + 7);[7] see also 7.7-10.4 mm. Morphometry: (as % TL) preanal length 67 to 69, head length 19 to 20, eye diameter 7;[6 7] greatest body depth 15;[7] body depth at anus 10, (as % head length) eye diameter 34, body depth at anus 50.[6] Morphology: yolk absorbed (13.9 mm);[6] pelvic buds developed (14.86 to. 16.7' mm); below myomeres 16 to 18;[6] first dorsal fin rays formed (15.1[6] to 15.8[7] mm); between myomeres 18 and 20;[6] first anal fin rays formed (15.5 mm), first pelvic fin rays developed (16.4 mm);[6] all median fin rays formed (16.46 to 18.8[7] mm); mouth inferior, gut S-shaped (17.0 mm).[6] Pigmentation: single middorsal, midlateral and midventral stripes (described above) and pigment over swim bladder present (15.1 mm);[7] melanophores developed in dorsal and pectoral fins (15.6[6] to 18.8[7] mm).

JUVENILES

Total length	Description
19-32 mm	Morphometry: (as % TL) preanal length 61;[6] head length 217 to 23;[6] eye diameter 7;[6] greatest body depth 18;[7] body depth at anus 11, (as % head length) eye diameter 31, body depth at anus 48.[6]

Morphology: squamation complete (27 mm).[6]
Pigmentation: body covered with small melanophores, dense pigmentation on caudal and dorsal fins.[6,7]

ADULTS

Fin rays: caudal 18, dorsal 12 to 14, anal 7, pectoral 16 to 17, pelvic 9 to 10.[8]

Vertebrae: 41 to 44 (including Weberian vertebrae).[8]

Lateral line scales: 42 to 44 (39 to 46).[8]

Diagnostic characters: dorsal fin short (usually 12 to 13 rays), scales large (usually 42 to 44 in lateral series, caudal peduncle scales 12 to 13), swim bladder three-chambered, lower lip with deep transverse grooves, pelvic fin origin opposite midpoint of dorsal fin base, posterior edge of lower lip straight.

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1. Becker (1976)
2. Reighard (1920)
3. Meyer (1962)
4. Moore and Cross (1950)
5. Burr and Morris (1977)
6. Fuiman (1979a)
7. Buynak and Mohr (1979a)
8. Jenkins (1970)
9. Hubbs and Lagler (1958)
10. Hawley (1967) in Becker (1976)

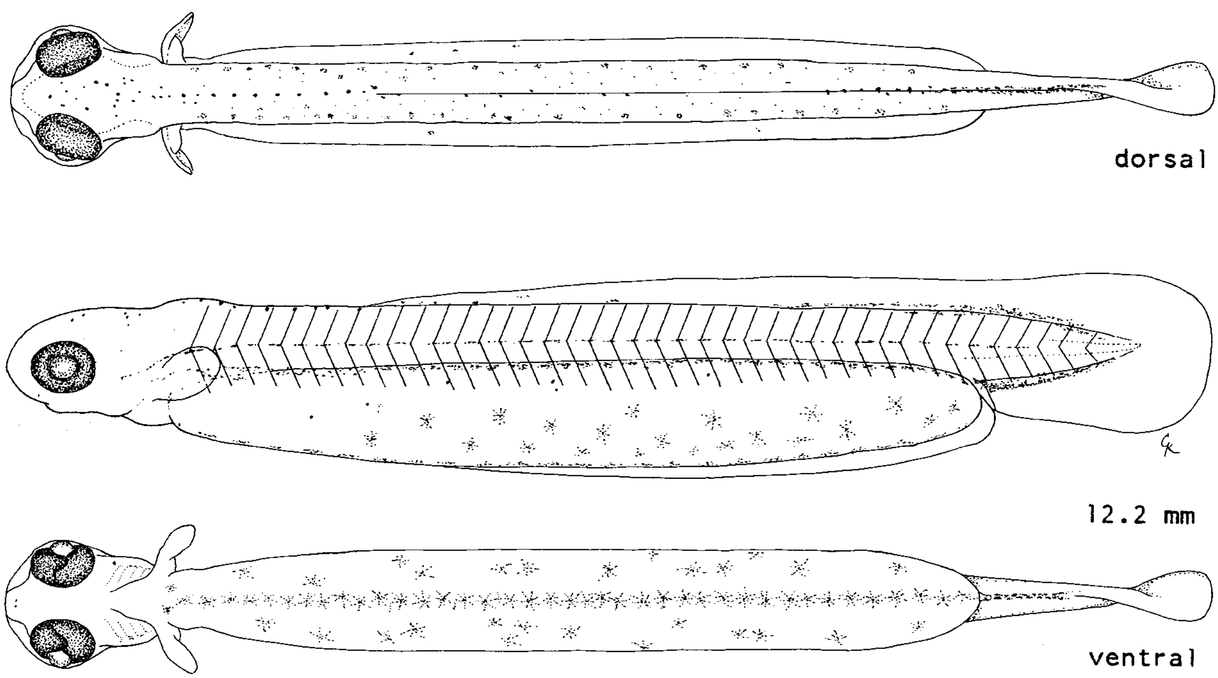

Fig. 181. Moxostoma macrolepidotum, shorthead redhorse. Yolk-sac larva. (Laboratory-reared, Maryland, Fuiman 1979a).

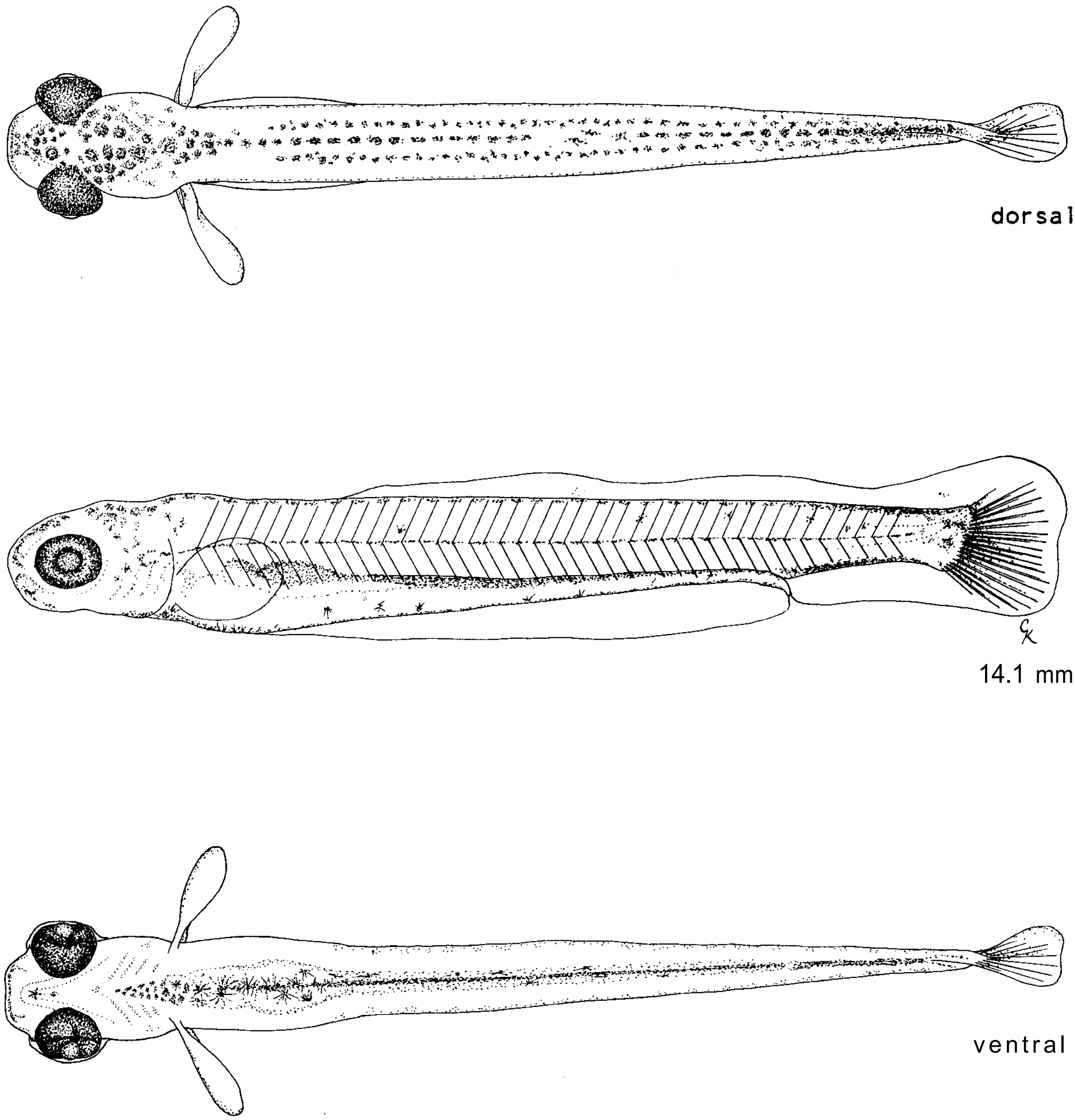

Fig. 182. Moxostoma macrolepidotum, shorthead redhorse. Larva. (Laboratory-reared, Maryland, Fuiman 1979a).

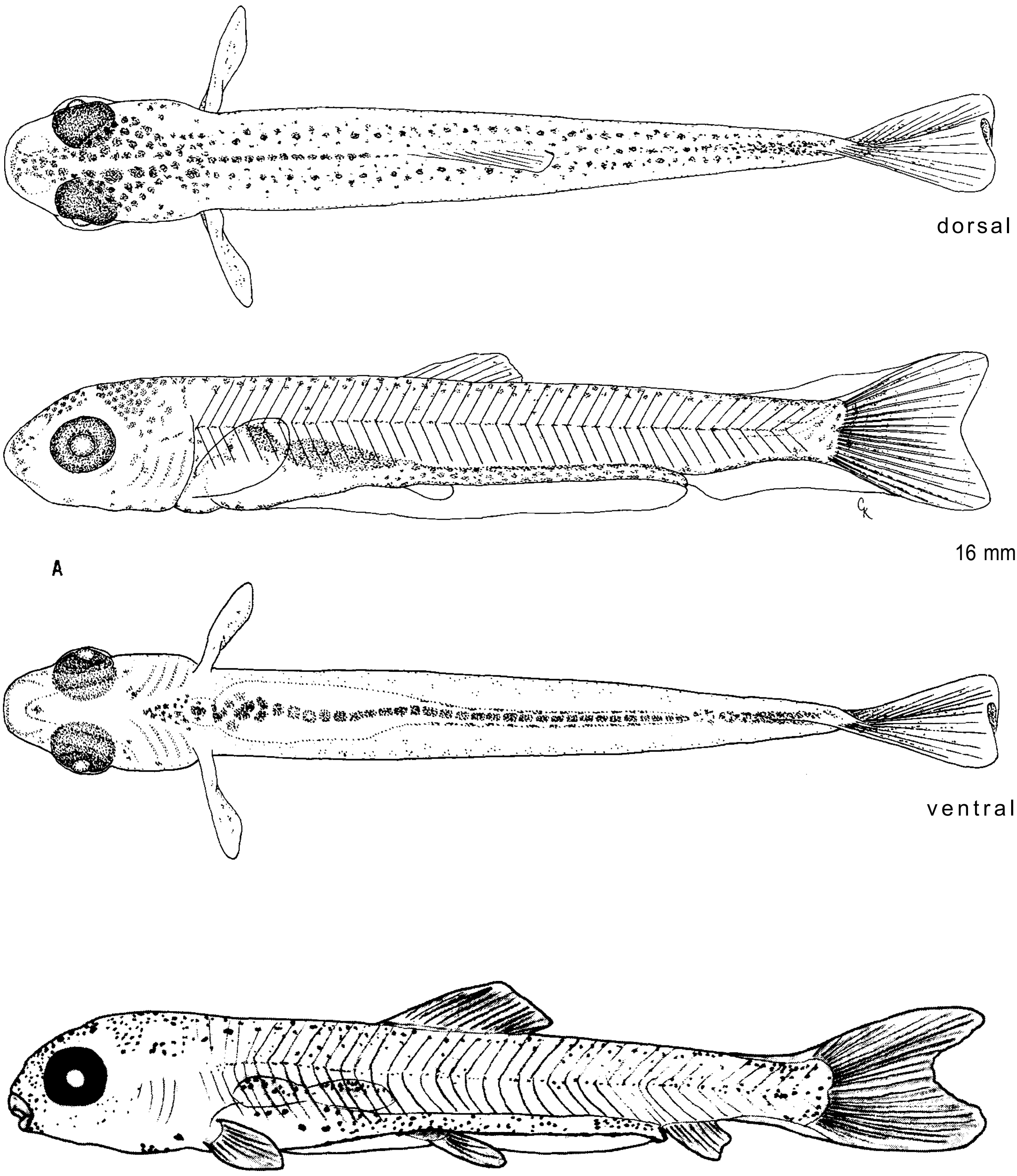

Fig. 183. Moxostoma macrolepidotum, shorthead redhorse. A and B. Larvae. (A, laboratory-reared, Maryland, Fuiman 1979a; B, laboratory-reared, Pennsylvania, Buynak and Mohr 1979a).

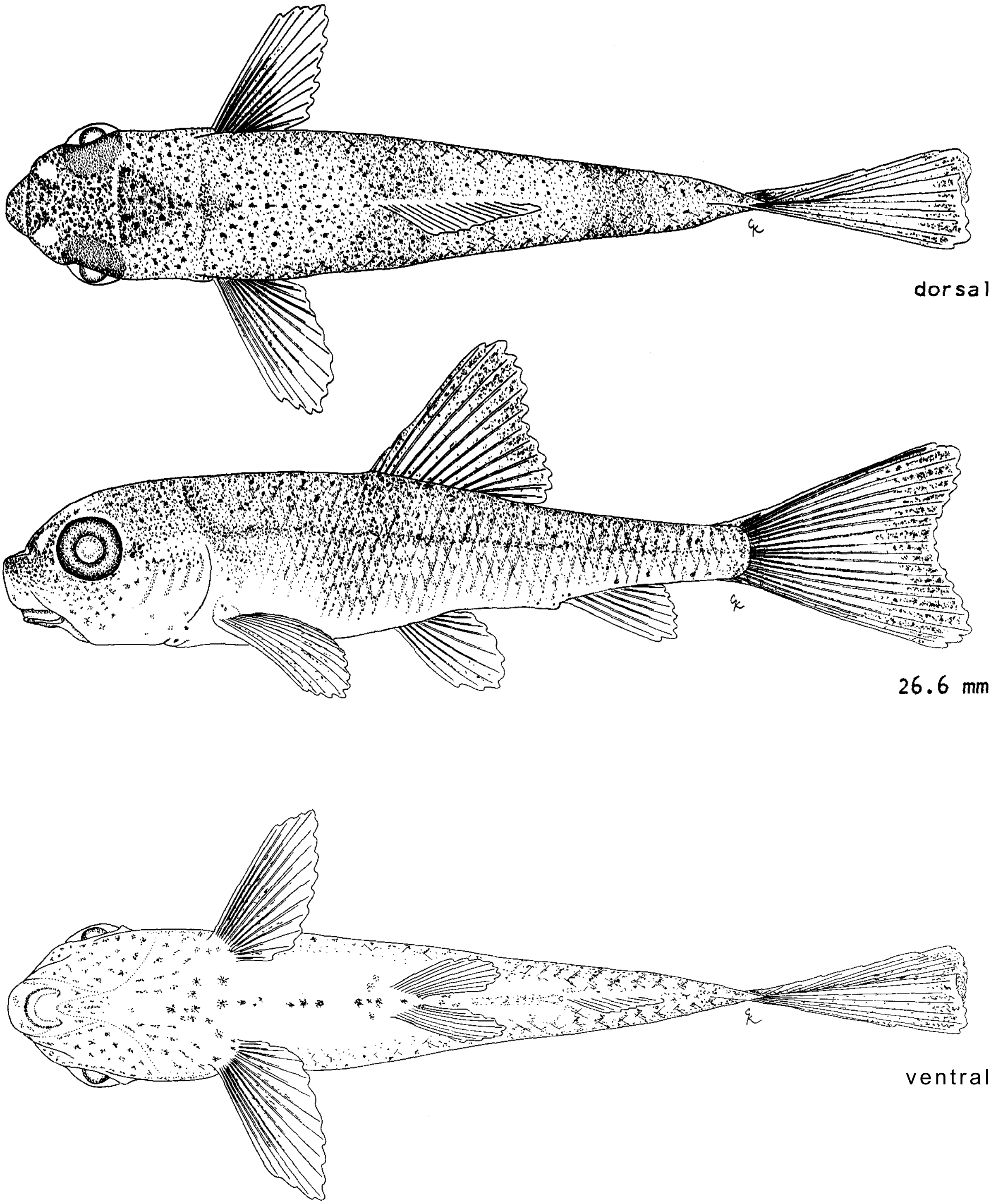

Fig. 184. Moxostoma macrolepidotum, shorthead redhorse. Juvenile, (Laboratory-reared, Maryland, Fuiman 1979a).

Moxostoma valenciennesi Jordan, greater redhorse

DISTRIBUTION

Occurs in all Great Lakes drainages,[3] except Lake Superior. Scattered reports from the lower reaches of many Lake Michigan tributaries.[1]

SPAWNING SEASON

Spawns from late June to early July in the St. Lawrence River.[2]

SPAWNING TEMPERATURE

Spawns at temperatures between 16 and 19 C.[1 2]

SPAWNING HABITAT

Spawns in streams with moderate to swift current about 0.5 to 1 m deep.*

SPAWNING SUBSTRATE

Deposits eggs over large gravel mixed with rubble and sand.[2]

FECUNDITY

Not reported.

EGGS

Not described.

YOLK-SAC LARVAE

Not described.

LARVAE

Not described.

JUVENILES

Not described.

ADULTS

Fin rays: caudal 18, dorsal 12 to 14, anal 7, pectoral 16 to 18, pelvic 9.[1]

Vertebrae: 41 to 44 (including Weberian vertebrae).[1]

Lateral line scales: 41 to 45.[1]

Diagnostic characters: dorsal fin short (12 to 14 rays), scales large (41 to 44 in lateral series, caudal peduncle scales 15 to 16), swim bladder three-chambered, lips with only longitudinal grooves.

LITERATURE CITED

1. Jenkins (1970)
2. Jenkins and Jenkins (1980)
3. Hubbs and Lagler (1958)

Family Ictaluridae, bullhead catfishes

By

Heang T. Tin

The catfish family, Ictaluridae, is restricted to freshwater of North and Central America. There are 5 genera and 39 species in the United States and Canada (Robins et al. 1980). Three genera and seven species occur in the Lake Michigan drainage. Noturus miurus is discussed but occurs only in the Lake Erie and Ontario drainages. Ictalurids have four pairs of barbels, smooth scaleless skin, an adipose fin and a stout spine on the dorsal and pectoral fins. The head is large and flattened, the body is laterally compressed behind the dorsal fin and the caudal fin is forked, square or rounded. Teeth on jaws are small and cardiform.

Catfishes are most active at night; they often hide in natural cavities or remain in deep water during daylight. Members of this family spawn during spring and summer, in nests built in well protected areas of lakes and streams. Eggs are generally large (2.5 to 6.0 mm in diameter, Jones et al. 1978), adhesive and deposited in masses. Newly hatched larvae have a well formed mouth, maxillary and mandibular barbels and a large yolk sac. One or both parents guard the eggs and young. The adult complement of fin rays is evident when yolk is completely absorbed, thus the juvenile phase is reached after yolk absorption. The larval phase, as defined in this manual, does not occur.

Provisional Key to Great Lakes Ictalurid Juveniles (15 to 25 mm)
(Ictalurus catus, Noturus furiosus and N. insignis are not discussed due to scarcity in the Great Lakes basin.

1a. Barbs present on posterior margin of pectoral spine. 2

b. No barbs on posterior margin of pectoral spine. 5

2a. Caudal fin forked or notched; anal fin rays 25 to 29. . . . . Ictalurus punctatus

b. Caudal fin rounded or truncate; anal fin rays 12 to 27. 3

3a. Anal fin rays 12 to 16; melanophores large. . . . . . . Noturus miurus

b. Anal fin rays 19 to 27; melanophores small. 4

4a. Chin barbels dark; anal fin rays 19 to 24. . . . . Ictalurus nebulosus

b. Chin barbels light; anal fin rays 22 to 27. . . . . . Ictalurus natalis

3. Upper jaw slightly projecting; mouth inferior. . . . , . _Noturus flavus_

b. Jaws equal in length, or lower one longer; mouth terminal , , , , . . . 6

6a. Anal fin rays 17 to 27. 7

b. Anal fin rays 12 to 17 8

7a. Chin barbels light; anal fin rays 22 to 27. . . . . . . _Ictalurus natalis_

b. Chin barbels dark; anal fin rays 17 to 24. . . . . _Ictalurus melas_

8a. Pectoral fin rays I,9; pelvic fin rays 9 or 10; middle rays of truncate caudal fin darkly pigmented. . . . . _Pylodictis olivaris_

b. Pectoral fin rays 1,6 (6 to 9); pelvic fin rays 8 or 9; rounded caudal fin unpigmented or uniformly darkly pigmented. . . . . _Noturus gyrinus_

Ictalurus melas (Rafinesque), black bullhead

DISTRIBUTION

Occurs in all of the Great Lakes except Lake Superior.’ in the Lake Superior drainage it is found only in the St. Louis river.’ Distributed throughout the Lake Michigan drainage, being less common in the northern and eastern portions.[7]

SPAWNING SEASON

Late April to early June in Minnesota;’ May or early June in the Lake Michigan drainage’ and June to August in Iowa.‘

SPAWNING TEMPERATURE

Spawning observed at 21 C.[3]

SPAWNING HABITAT

Spawns in weedy or muddy shallow water[5] of ponds, pools or streams.[8]

SPAWNING SUBSTRATE

Spawns on gravel, silt, debris,[3] mud or sand.[7] Nests are concealed under protective cover, including matted vegetation.[4]

FECUNDITY

2,000 to 6,000.[6,12]

NATURAL HYBRIDS

Ictalurus nebulosus.[11]

EGGS

Demersal, adhesive;[3] pale cream to golden;[3,4] diameter 3 mm;[3] eggs adhere together in one mass when deposited;[4] incubation period: 5 days[3] to 1 week[5] at unspecified temperature.

YOLK-SAC LARVAE

Total length	Description
9-10 mm	Morphometry: (as % TL) preanal length 50 or 51, head length 29 or 30, greatest body depth 25 to 28, eye diameter 5 or 6 (9.5 to 10.2 mm).* Morphology: anal fin rays 16, pelvic fin rays begin to form, caudal fin truncated (9.5 to 10.2 mm).* Pigmentation: small chromatophores cover body and fins, chin barbels dark, venter pigmented.*

LARVAE

Larva 1 phase, as defined in this manual, does not occur.

JUVENILES

Total length	Description
13-30 mm	Morphology: no barbs on pectoral fin spine (13.5 to 23.0 mm);* caudal fin truncate or emarginate (30.0 mm).[1] Pigmentation: body dark brownish gray to black, maxillary barbels dark gray to black, chin barbels dusky gray to black.'

ADULTS

Fin rays: caudal 15 (branched rays);[10] dorsal I,5 to 6;[3] anal 17 to 24'[14] (including rudiments);[13] pectoral I,8, pelvic 8.[5]

Vertebrae: 38 to 38 (including Weberian vertebrae).[3]

Diagnostic characters: adipose fin free, chin barbels dark, no barbs on posterior edge of pectoral spines, anal fin rays 17 to 24.

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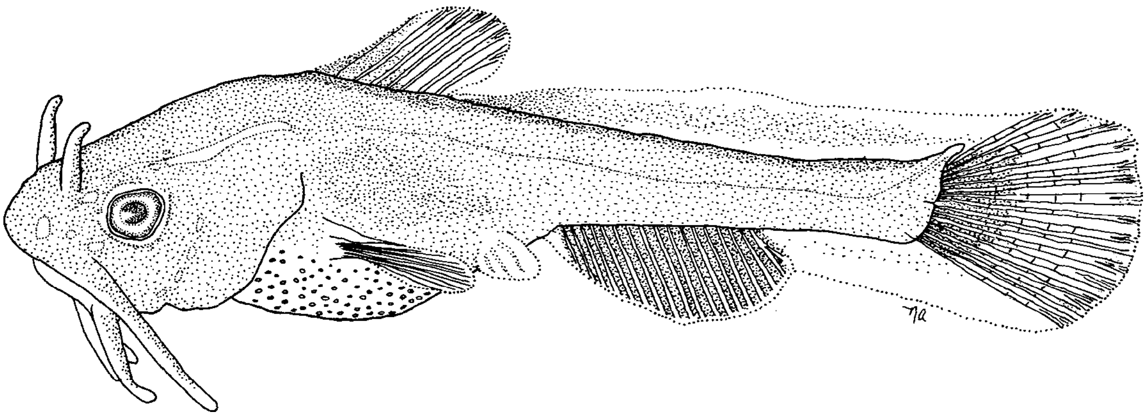
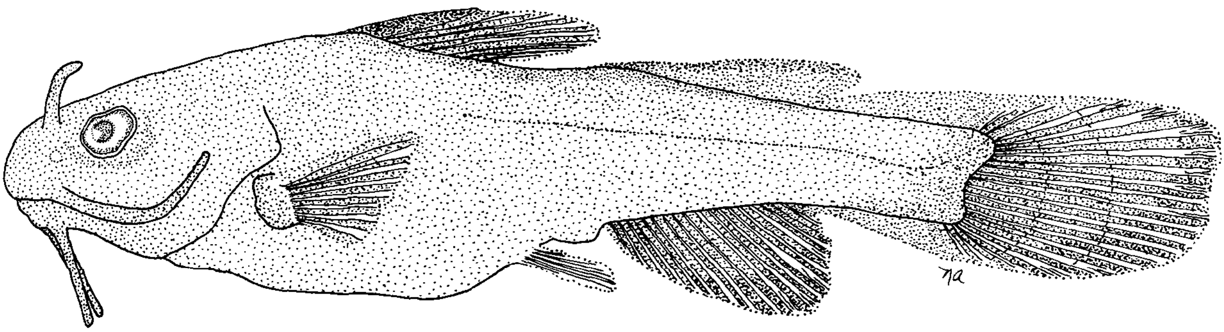
3. Scott and Crossman (1973)
4. Cross (1967)
5. Harlan and Speaker (1969)
6. Forney (1955)
7. Becker (1876)
8. Langlois (1954)
9. Eddy and Underhill (1974)
10. Taylor (1968)
11. Trautman (1957)
12. Cook (1959)
13. Hubbs and Lagler (1958)
14. W. R. Taylor (pers. Comm.)



A

10.2 mm



B

13.5 mm

Fig. 185. Ictalurus melas, black bullhead. A. Yolk-sac larva. B. Juvenile. (A, wild-caught, Ohio, original illustration by N. A. Auer, specimen provided by Great Lakes Regional Fish Larvae Collection, GLRFC 0306; B, wild-caught, Michigan, original illustration by N. A. Auer, specimen provided by the University of Michigan, Museum of Zoology, UMMZ 13887).

Ictalurus natalis (LeSueur), yellow bullhead

DISTRIBUTION

Occurs in all of the Great Lakes.[12] Common throughout the Lake Michigan drainage except in the upper peninsula of Michigan.'

SPAWNING SEASON

Spawns in May and June in Lake Michigan,[8] June in Lake Erie,[3] May in Illinois[10] and May or June in New York.[14]

SPAWNING TEMPERATURE

Not reported.

SPAWNING HABITAT

Shallow areas, 0.5 to 1.2 m deep,[15] in lakes or rivers.[9]

SPAWNING SUBSTRATE

Nests are constructed under overhanging stream banks, in holes, burrows or near the protection of stones or stumps.[1]

FECUNDITY

1,650 to 7,000.[4,7]

EGGS

Demersal, adhesive;[2] creamy white to yellowish;'[2] diameter 2.5 to 3.0 mm;[11] incubation period: 5 to 10 days at unspecified temperature.'

YOLK-SAC LARVAE

Not described.

LARVAE

Larval phase, as defined in this manual, does not occur.

JUVENILES

Total length	Description
15-18 mm	Morphometry: (as % TL) preanal length 45, head length 26, eye diameter 5, greatest body depth 29, body depth at anus 16 (17.0 mm).[3]

Morphology: caudal fin rounded, maxillary barbels as long as head, dorsal and pectoral fin spine very strong (17.0 mm) ;[3] barbs on posterior edge of pectoral spine relatively short;[5] posterior edge of adipose fin free (17.6 mm).*

Pigmentation: small, round, closely set chromatophores give gray color to head, body and fins, underside of body from jaw to anus colorless (17.0 mm);[3] body light yellowish brown to brown, maxillary barbels brown to dark brown;[5] chin barbels light, cream-colored or whitish (15 mm and larger) .[3 5 16]

ADULTS

Fin rays: caudal 15 or 16 (branched rays);[13] dorsal I,6;[1] anal 22 to 27 (including rudiments) ;[6 16] pectoral I,8, pelvic 8.1

Vertebrae: 42 (including Weberian vertebrae).'

Diagnostic characters: adipose fin free, chin barbels light, anal fin rays 24 to 27.

LITERATURE CITED

1. Scott and Crossman (1973)
2. Mansueti and Hardy (1967)
3. Fish (1932)
4. Ulrey et al. (1938)
5. Cloutman (1979)
6. Hubbs and Lagler (1958)
7. Harlan and Speaker (1965)
8. Becker (1976)
9. Cahn (1927)
10. Forbes and Richardson (1909)
11. Wallace (1972)
12. Eddy and Underhill (1974)
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15. Miller (1966b)
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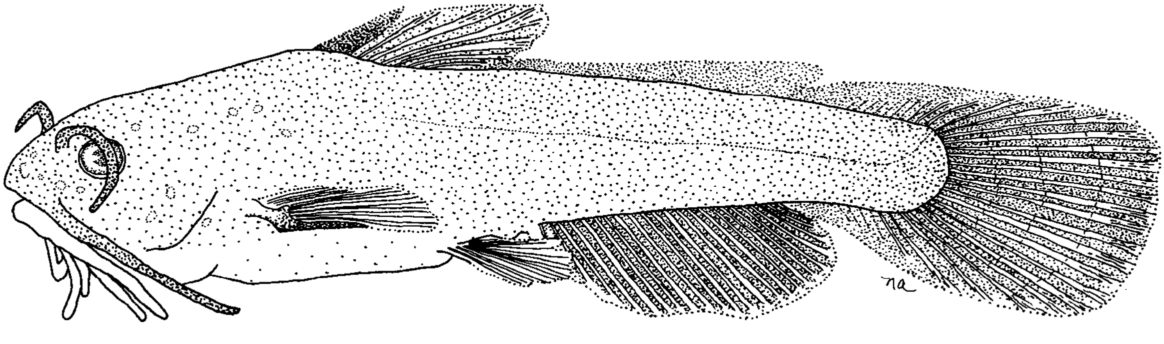

18.0 mm

Fig. 186. Ictalurus natalis, yellow bullhead. Juvenile. (Wild-caught, Michigan, original illustration by N. A. Auer, specimen provided by University of Michigan Museum of Zoology, UMMZ 136806)'.

Ictalurus nebulosus (LeSueur), brown bullhead

DISTRIBUTION

Occurs throughout the Great Lakes region in lakes and sluggish rivers.[15] Dispersed throughout the Lake Michigan drainage.[14]

SPAWNING SEASON

Spawns from April to late June in Minnesota,[17] May to June in Illinois[12] and Canada[3] and in June in Michigan and Wisconsin.[13]

SPAWNING TEMPERATURE

Spawning has been observed at 18.5 to 25.8 C.[7,8,9,10,20]

SPAWNING HABITAT

Spawns in streams, ponds[11] or lakes,[5] in water less than 1.2 m deep.[16]

SPAWNING SUBSTRATE

Spawns on a firm bottom including coarse sand, gravel and stone.[11] Nests are sheltered under logs, rocks, boards or stumps.[5] Eggs may be deposited in an old submerged pail, stove pipe or other object.[5]

FECUNDITY

2,000 to 13,800.[3,21]

NATURAL HYBRIDS

Ictalurus melas.[19]

EGGS

Demersal, adhesive;[3] light orange;[9] to pale cream;” diameter 3.0 mm;[8,19] deposited in masses;[3] incubation period: 8 days at 20 to 21 C;[11] 5 days at 25 C.[7]

YOLK-SAC LARVAE

Total length	Description
6-8 mm	Newly hatched.[1,5,7,11]
6-12 mm	Morphology: shape tadpole-like, head large, yolk sac large;[2] caudal fin with incipient rays (newly hatched);[11] fin rays well developed in caudal, dorsal, anal and pectoral fins, adipose fin attached to caudal fin, tail rounded or truncated (12.0 mm);[2] yolk absorbed (7 to 9 days posthatching).[7,11]

Pigmentation: transparent and yellowish' or cream white' (newly hatched); dorsum darkened (2 days old), upper parts uniform blueish black (4 days old), under parts whitish;' barbels transparent (newly hatched), but become darkly pigmented in later development.[2]

LARVAE

Larval stage, as defined in this manual, does not occur.

JUVENILES

Total length	Description
15-22 mm	Morphometry: (as % TL) preanal length 45, head length 26, eye diameter 5, greatest body depth 21, body depth at anus 16 (22 mm).[4]
	Morphology: full complement of adult fin rays (15 mm);[2,4,6] pectoral fin spine with four to eight long recurved barbs on posterior edge;' caudal fin truncate or rounded;'[4,6] maxillary barbels as long as head (22 mm).[4]
	Pigmentation: body dark brownish gray to black, maxillary barbels dark gray to black, chin barbels dusky gray to black;[6] chromatophores heaviest over top and sides of head, on dorsum of body and fins and lightest in belly region.[4]

ADULTS

Fin rays: caudal 15 (branched rays);[18] dorsal I,6 to 7;[2,3] anal 19 to 24 (rudiments included);[15] pectoral I,7 to 9, pelvic 8.[3]

Vertebrae: 38 to 43 (including Weberian vertebrae).[3]

Diagnostic characters: adipose fin free, pectoral fin spines with strong recurved barbs on posterior edge, chin barbels dark.

LITERATURE CITED

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7. Smith and Harron (1904)
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9. Stranahan (1910)
10. Titcomb (1920)
11. Armstrong and Child (1962)
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13. Gill (1906)
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15. Hubbs and Lagler (1958)
16. Lagler (1956)
17. Eddy and Underhill (1974)
18. Taylor (1969)
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20. Raney (1959)
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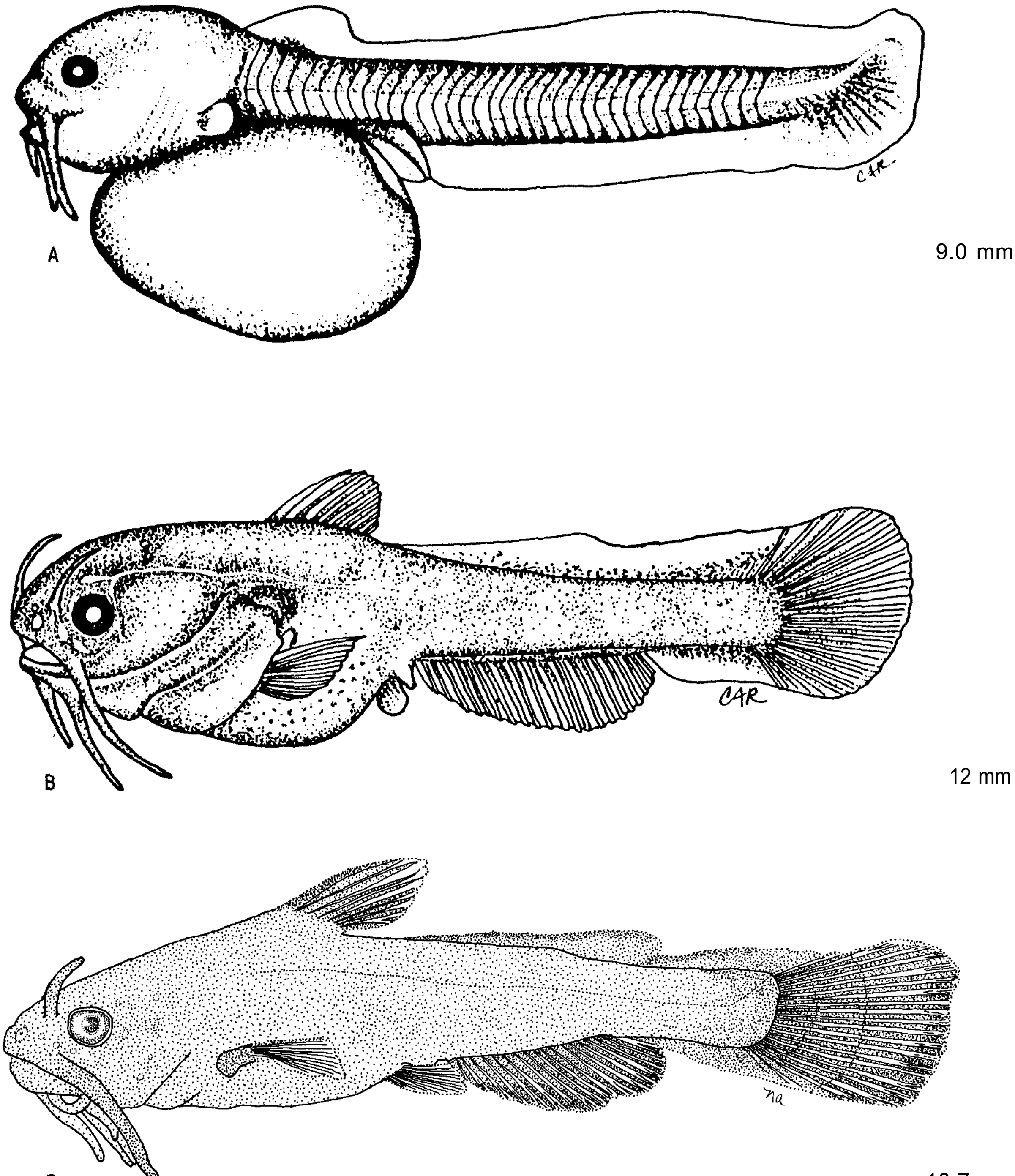

Fig. 187. Ictalurus nebulosus, brown bullhead. A and B. Yolk-sac larvae. C. Juvenile. (A and B, wild-caught, Delaware River, Wang and Kernehan 1979; C, wild-caught, Michigan, original illustration by N. A. Auer, specimen provided by University of Michigan Museum of Zoology, UMMZ 65876).

Ictalurus punctatus (Rafinesque), channel catfish

DISTRIBUTION

In the Lake Michigan drainage, occurs more commonly in Indiana, Wisconsin and the southern edge of the upper peninsula of Michigan, than in lower Michigan." Found in Lakes Huron, Erie and Ontario[4 23] and only the St. Louis River of the Lake Superior drainage.[22]

SPAWNING SEASON

Spawns in spring and summer in the Great Lakes,' May to July in Missouri [2] and June and July in New York.[23]

SPAWNING TEMPERATURE

Spawning occurs at 21.1 to 29.5 C.[4 5 7]

SPAWNING HABITAT

Spawns in secluded, darkened areas,[4 7 17] near the shore[14] of rivers and lakes,' [7] also in muddy ponds.[2 19]

SPAWNING SUBSTRATE

Nests are constructed in holes or burrows, in undercut banks, under rocks, logs[4 7 17] or on a muddy bottom.[19] Eggs may be deposited in submerged man-made containers such as milk cans and nail kegs.[6 13 18]

FECUNDITY

2,660 to 52,000.[4 7 18]

EGGS

Demersal, adhesive, deposited in gelatinous mass;[3 6 11] yellow, opaque, diameter 3.5 mm;[1] incubation period: 9 or 10 days at 15.6 to 18.4 C;[18] 8 to 10 days at 23.9 C;[6] 6 or 7 days at 26.7 to 27.8 C.[5]

YOLK-SAC LARVAE

Total length	Description
6.0-9.8 mm	Newly hatched.' [10 11]
6-15 mm	Myomeres: 45 to 48 (18 to 19 + 26 to 29).* Morphometry: (as % TL) preanal length 43 to 49, head length 18 to 22, greatest body depth 22 to 26, eye diameter 4 to 6 (8.8 to 14.3 mm).* Morphology: body more slender than other catfishes, yolk sac oval and large;[11] spines present[10] (newly hatched); incipient rays in caudal fin (9.4 mm), anal and dorsal fins (10.9 mm) and pelvic fins (13.2 mm), caudal fin

rounded (10.7 mm), truncate (12.3 mm), notched (13.1 mm) ;* yolk sac elongate, bluntly pointed posteriorly (ca. 13 mm);[8] caudal fin emarginate (13.5 mm) ;* anal fin rays well formed (15 mm).[11]

Pigmentation: body transparent[15] or golden;[6 9] yolk sac pink[6] or light amber[10] (newly hatched); eye pigmented (10.3 mm), patch of chromatophores on top of head (12.3 mm), head pigment increases, chromatophores on dorsum of swim bladder and along base of dorsal and anal fins (13.2 mm);* pigment present over most of snout and sides of head, in a line from head to caudal fin base and at all fin bases (ca. 14.5 mm).[8]

LARVAE

Larva 1 phase, as defined in this manual, does not occur.

JUVENILES

Total length	Description
15-42 mm	Morphometry: (as % TL) preanal length 41, head length 23, greatest body depth 16, body depth at anus 15, eye diameter 6 (16 mm).* Morphology: yolk absorbed (3 to 6 days posthatching);*[10 18] posterior margin of adipose fin not attached to body (15.0 mm);* barbs on pectoral spine hooked;[12] caudal fin forked (15.0 mm and larger);[12 14] maxillary barbels longer than head, body slender (32.6 mm);[14] tips of both dorsal and ventral lobes of caudal fin become sharply pointed (42 mm).[11] Pigmentation: body nearly white with small brownish chromatophores sparsely distributed over the entire surface, subsurface spots pronounced over stomach, chromatophores over all fins (32.6 mm).[14]

ADULTS

Fin rays: caudal 15 (branched rays);[21] dorsal I,6;[4] anal 24 to 30 (including rudiments);[4 20] pectoral I,8 or 9, pelvic 8.[4]

Vertebrae: 46 to 48 (including Weberian vertebrae).[1]

Diagnostic characters: adipose fin free, caudal fin forked, body often spotted, anal fin rays 24 to 30.

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15. Doze (1925)
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17. Harlan and Speaker (1969)
18. Brown (1942)
19. Miller (1966a)
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21. Taylor (1969)
22. Eddy and Underhill (1974)
23. Raney (1967)

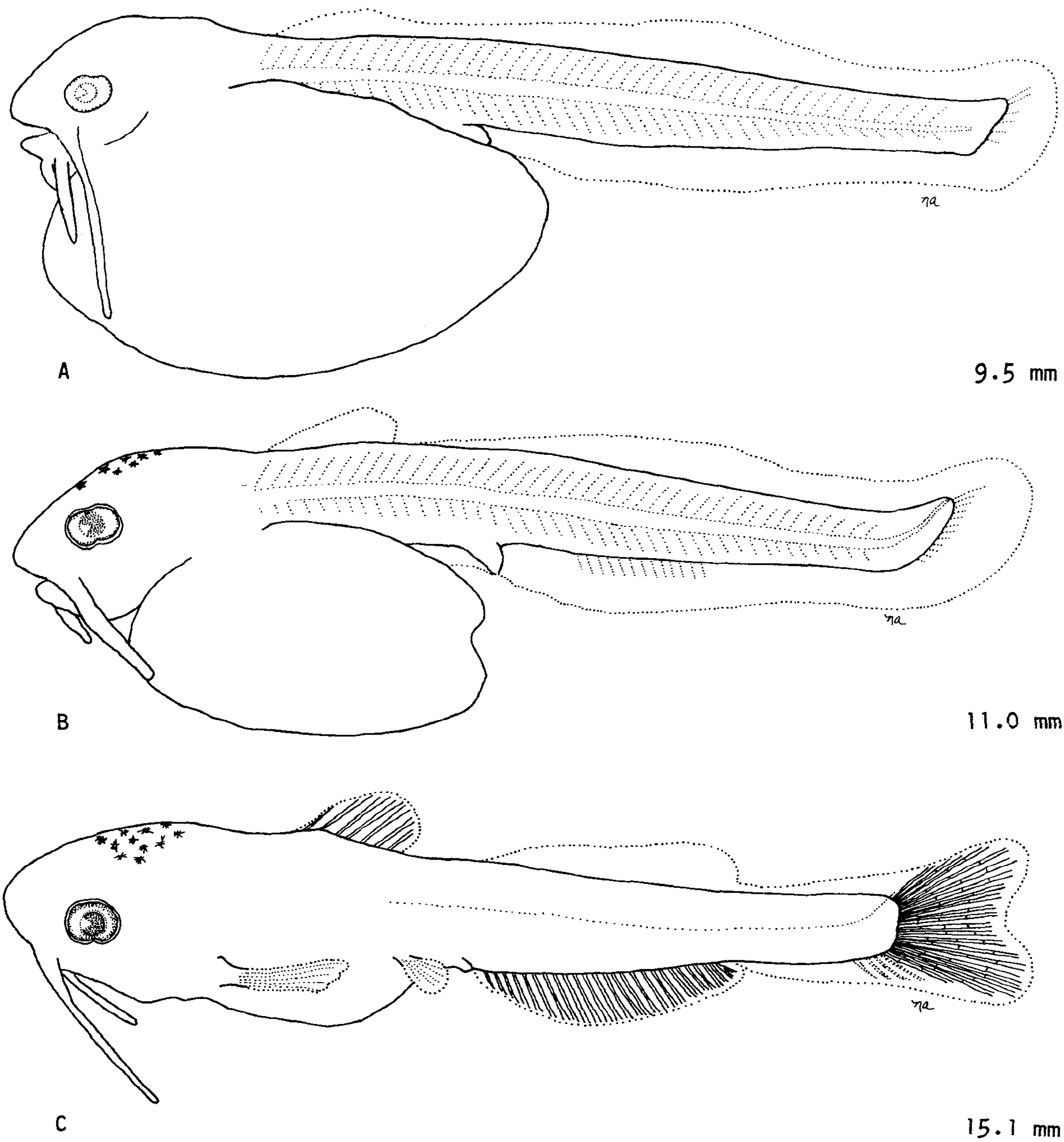


Fig. 188. Ictalurus punctatus, channel catfish. A and B. Yolk-sac larvae. C. Juvenile. (A-C, laboratory-reared, Alabama, original illustration by N. A. Auer, specimens provided by J. M. Grizzle and D. D. Moss, Auburn University, Alabama).

Noturus flavus Rafinesque, stonecat

DISTRIBUTION

Occurs in all of the Great Lakes.[3] It is found primarily in the southern and western portions of the Lake Michigan drainage.[5]

SPAWN I NC SEASON

Spawns in June or July in the Great Lakes,[3] April or May in Missouri[6] and late June in Indiana.'

SPAWNING TEMPERATURE

Spawning observed at 27.8 C.[3]

SPAWNING HABITAT

Spawns in streams or shallow, rocky areas of lakes.[3 5 9]

SPAWNING SUBSTRATE

Eggs are deposited under rocks or logs.[2 4 5]

FECUNDITY

500 to 1,205.[2 8 9]

EGGS

Demersal, adhesive;[5] yellow opaque, diameter 3.5 to 4.0 mm;[2 3] deposited in jelly-like mass.[2]

YOLK-SAC LARVAE

Not described.

LARVAE

Larval stage, as defined in this manual, does not occur.

JUVENILES

Total length	Description
20-26 mm	Morphometry: (as % TL) preanal length 51, head length 25, eye diameter 6, greatest body depth 20, body depth at anus 14.[1] Morphology: head very depressed, nearly as broad as long, barbels short, pectoral fin spine retrorsely serrate in front, slightly rough behind (20 mm);[1] or no barbs on pectoral fin spine, upper jaw projecting slightly (26 mm).*

Pigmentation: yellowish with small black chromatophores uniformly distributed over top and sides of body, most concentrated over head, chromatophores extend to adipose and caudal fins, other fins unpigmented, barbels with little pigmentation.'

ADULTS

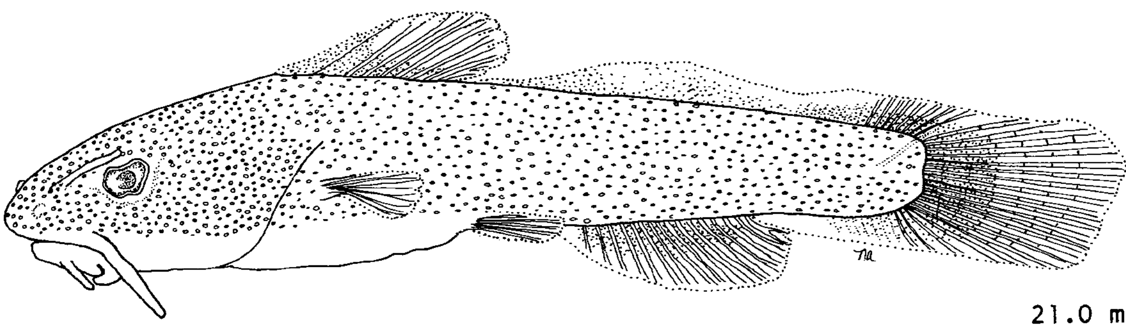
Fin rays: caudal 54 to 65 (total rays);[8] dorsal I,6, anal 15 to 17, pectoral I,9 or 10 (8 to 11) ;* pelvic 8 (8 to 10) .[3, 8]

Vertebrae: 42 to 43 (41 to 45) (including Weberian vertebrae). [3] *

Diagnostic characters: adipose fin adnate, pectoral spines smooth, upper jaw projecting beyond lower jaw, body plain with dark blotches or bars.

LITERATURE CITED

1. Fish (1932)
2. Greeley (1929)
3. Scott and Crossman (1973)
4. Beckman (1952)
5. Becker (1976)
6. Pflieger (1975)
7. Forbes and Richardson (1909)
8. Taylor (1969)
9. Langlois (1954)



21.0 mm

Fig. 189. Noturus flavus, stonecat. Juvenile. (Wild-caught, Michigan, original illustration by N. A. Auer, specimen provided by University of Michigan Museum of Zoology, UMMZ 136805).

Noturus gyrinus (Mitchill), tadpole madtom

DISTRIBUTION

Distributed throughout the Lake Michigan drainage except for the extreme northern portion.' Occurs in Lakes Huron, Ontario, Erie[4] and the St. Louis River in the Lake Superior drainage."

SPAWNING SEASON

Spawns in late May in Wisconsin,[9] May to July in Ohio[4] and late June and July in Canada.[2]

SPAWNING TEMPERATURE

Not reported.

SPAWNING HABITAT

Spawns in shallow water of lakes,[2,4] artificial impoundments and low gradient streams.'

SPAWNING SUBSTRATE

Nests are constructed on a bottom of organic debris with or without aquatic vegetation' or on a gravel substrate.[5] Eggs may be deposited in cavities[2] under submerged logs, boards or in tin cans.[4,5]

FECUNDITY

43 to 160.[5,6]

NATURAL HYBRIDS

Noturus miurus.'[8,10]

EGGS

Demersal, adhesive;[3,5] light yellow;[2] diameter 2.8 to 3.5 mm;[1,5] deposited in a mass surrounded by gelatinous matrix.[3,5]

YOLK-SAC LARVAE

Total length	Description
13-15 mm	Morphology: rays developed in all fins.[5] Pigmentation: body covered with small, stellate chromatophores except for midventral region between chin and anus, maxillary barbels dark, chin barbels lighter.[5]

LARVAE

Larva 1 phase, as defined in this manual, does not occur.

JUVENILES

Total length	Description
15-21 mm	Morphometry: (as % TL) preanal length 44 to 46, head length 22 to 25, eye diameter 3 or 4, greatest body depth 22 to 24 (16.5 to 21 mm).*
	Morphology: caudal fin rounded, adipose fin continuous with caudal fin, no barbs on posterior edges of pectoral spines, upper jaw not projecting (16.5 to 21 mm).*
	Pigmentation: barbels and most of body dark, underside light.[5]

ADULTS

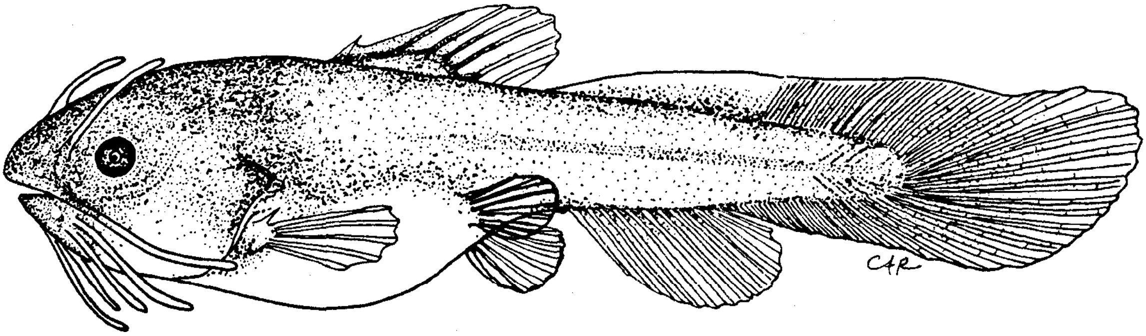
Fin rays: caudal 50 to 66 (total rays);[10] dorsal 1,6, anal 14 to 16, pectoral 1,6 to 9, pelvic 8 or 9.[2,10]

Vertebrae: 37 to 38 (36 to 41) (including Weberian vertebrae).[2,10]

Diagnostic characters: adipose fin adnate, no barbs on pectoral fin spines, pad on upper jaw without backward extensions.

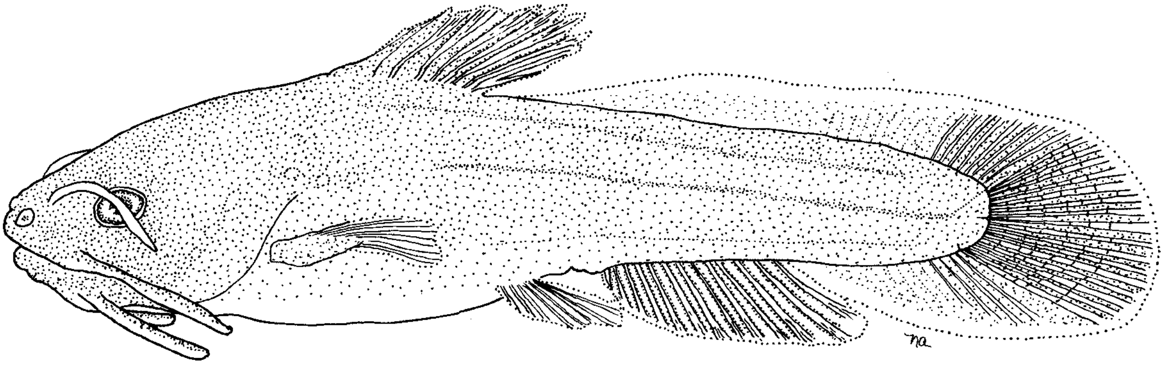
LITERATURE CITED

1. Bailey (1938a)
2. Scott and Crossman (1973)
3. Mansueti and Hardy (1967)
4. Trautman (1948)
5. Wang and Kernehan (1979)
6. Mahon (1977)
7. Becker (1976)
8. Trautman (1957)
9. Cahn (1927)
10. Taylor (1969)
11. Eddy and Underhill (1974)



A

15.5 mm



B

19.0 mm

Fig. 190. Noturus gyrinus, tadpole madtom. A and B. Juveniles. (A, wild-caught, Delaware River, Wang and Kernehan 1979; B, wild-caught, Michigan, original illustration by N. A. Auer, specimen provided by University of Michigan Museum of Zoology, UMMZ 116339).

Noturus miurus Jordan, brindled madtom

DISTRIBUTION

Occurs in Lakes Erie and Ontario.[1 2 3]

SPAWNING SEASON

Spawns in May, June and July in Ohio[6] and July to early August in Michigan.' [4]

SPAWNING TEMPERATURE

Spawning observed at 25.6 C.[1]

SPAWNING HABITAT

Spawns in well developed riffles or pools in flowing water having a gradient of more than 0.6 m/km.[5]

SPAWNING SUBSTRATE

Spawns on silt or a mud bottom with scattered vegetation.' Eggs may be deposited in submerged tin cans[1 4] or under rocks, boards or similar objects.[5]

FECUNDITY

34 to 46 (number of eggs collected from nests).[4]

NATURAL HYBRIDS

Noturus gyrinus.[3 4 5]

EGGS

Demersal;' [5] adhesive, large and amber;' [4] adhere to each other in clusters when deposited.' [5]

YOLK-SAC LARVAE

Total length	Description
9-11 mm	Morphology: yolk sac large, pelvic and pectoral fins with distinct rays present, dorsal fin with six rays and well developed but poorly ossified spine, caudal fin with 29 or 30 rays, anal fin rays 14 or 15, pectoral fin spine poorly ossified and lacking barbs (3 days posthatching).[4] Pigmentation: larvae not pigmented at this stage.'

LARVAE

Larval phase, as defined in this manual, does not occur.

JUVENILES

Total length	Description
14-16 mm	Morphometry: (as % TL) preanal length 42 to 46, head length 21 to 23, greatest body depth 14 to 18, eye diameter 5 to 6 (14.7 to 16.0 mm).*
	Morphology: yolk absorbed, full complement of rays in dorsal, pectoral, pelvic and anal fins, 80% of total adult caudal fin ray count present, pectoral fin spine has two barbs on posterior edge (14.7 to 16.0 mm).*
	Pigmentation: body and head covered with relatively large pigment spots, venter from chin to pelvic fins not pigmented, chin barbels light (14.7 to 16.0 mm).*

ADULTS

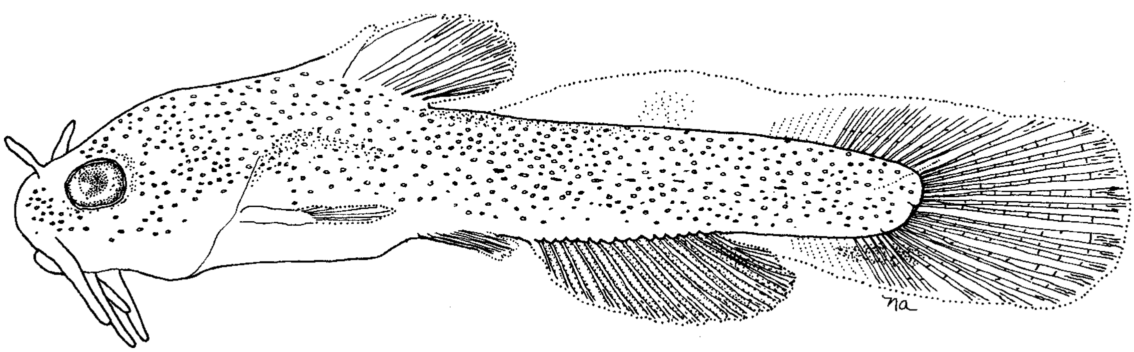
Fin rays: caudal 54 to 65 (total rays);[4] dorsal I,6, anal 13 to 15, pectoral I,7 to 9, pelvic 8 or 9.[1 4]

Vertebrae: 38 to 39 (36 to 41) (including Weberian vertebrae).[1 4]

Diagnostic characters: adipose fin adnate, pectoral spine with barbs, upper jaw projecting well beyond lower jaw, dark blotch or bar on adipose fin extending upward to near fin margin.

LITERATURE CITED

1. Scott and Crossman (1973)
2. Hubbs and Lagler (1958)
3. Trautman (1957)
4. Taylor (1969)
5. Trautman (1948)



15.2 mm

Fig. 191. Noturus miurus, brindled madtom. Juvenile. (Wild-caught, Michigan, original illustration by N. A. Auer, specimen provided by University of Michigan Museum of Zoology, UMMZ 165836).

Pylodictis olivaris (Rafinesque), flathead catfish

DISTRIBUTION

Uncommon in the Lake Michigan drainage, occurring in the Black and Grand River systems in Michigan and in the lower Wolf and Fox River systems in Wisconsin.[8] Rare in Lake Erie, not reported from the other Great Lakes.'

SPAWNING SEASON

Spawns in June and July in the Lake Michigan drainage,[8] Minnesota[12] and Kansas.[5]

SPAWNING TEMPERATURE

Spawning observed at 23.9 to 25 C.[5]

SPAWNING HABITAT

Spawns in secluded and obscure areas[10] of lakes[3] and rivers.[3 6]

SPAWNING SUBSTRATE

Nests are built under logs, stumps or brush piles.[12] Eggs may be deposited in holes dug in a clay bank[3] or saucer-shaped depression excavated near submerged objects.[2]

FECUNDITY

9,300 to 15,000.[5 6]

EGGS

Demersal, adhesive;"[4] cream color;[4 5] diameter 5 mm;[6] yolk dark;[5] eggs adhere together in a single mass when deposited;[3 4] incubation period: 8 days at 23.9 to 25.9 C;[5] 6 days at 23.9 to 27.8 C.[11]

YOLK-SAC LARVAE

Total length	Description
11 mm	Newly hatched.[5]
15 mm	Morphology: yolk sac prominent (3 days posthatching). Pigmentation: eye black, yolk sac opaque, body not pigmented (newly hatched);' larvae cream to brown (2 days old);[7] head almost black, body turning darker.[5]

LARVAE

Larva 1 phase, as defined in this manual, does not occur.

JUVENILES

Total length	Description
15-25 mm	Morphometry: (as % TL) preanal length 46 to 50, head length 26 or 27, greatest body depth 16 or 17, eye diameter 4 or 5 (18.5 to 21 mm).* Morphology: yolk absorbed (6 days posthatching);[7] caudal fin emarginate or truncate;' no barbs on posterior edge of pectoral fin spines (18.5 to 25 mm).* Pigmentation: diffuse pigment in middle of caudal fin, body and barbels turning darker with increasing size (15 mm);[1] almost black after yolk absorption.[5 7]

ADULTS

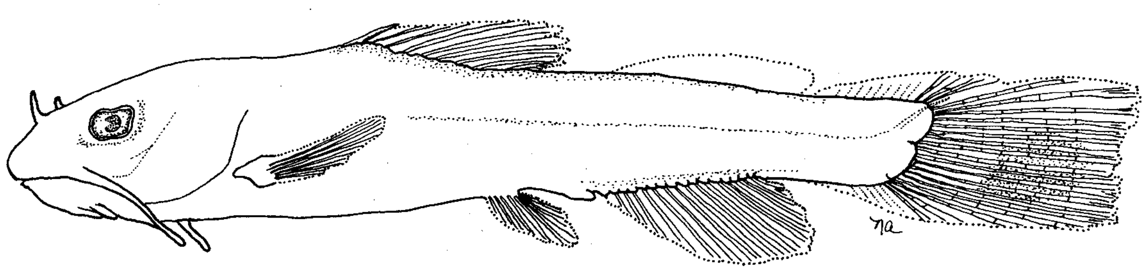
Fin rays: caudal 15 (branched rays), dorsal I,6;[13] anal 14 to 17;[3] pectoral I,9;* pelvic 9 or 10.[13]

Vertebrae: 50 to 51.[3]

Diagnostic characters: adipose fin free, head extremely broad and flattened, lower jaw projecting far beyond upper jaw except in smallest young (<25 mm TL) , anal fin short, tail not forked, truncate.

LITERATURE CITED

1. Cloutman (1979)
2. Pflieger (1975)
3. Cross (1967)
4. Breder and Rosen (1966)
5. Snow (1959)
6. Minckley and Deacon (1959)
7. Fontaine (1944)
8. Becker (1976)
9. Hubbs and Lagler (1958)
10. Harlan and Speaker (1969)
11. Giudice (1964)
12. Eddy and Underhill (1974)
13. Taylor (1969)



18.0 mm

Fig. 192. Pylodictis olivaris, flathead catfish. Juvenile. (Wild-caught, Texas, original illustration by N. A. Auer, specimen provided by University of Michigan Museum of Zoology, UMMZ 120321).

Family Aphredoderidae, pirate perches

By

Nancy A. Auer

Aphredoderus sayanus is the single living member of the family Aphredoderidae. This species only occurs throughout the central, southern and eastern United States in lowland, weedy or muddy lakes, streams, creeks, swamps and ponds. It has been known to enter brackish water.

Pirate perch possess spiny rayed fins and ctenoid scales. They rarely exceed 100 mm. As juveniles and adults they are easily distinguished from other spiny rayed fishes by the presence of the anus near the isthmus. The opercle has a sharp spine and the edge of the preopercle is strongly serrated.

Spawning takes place in the spring and the parents reportedly guard the nest and young. This species as yolk-sac larvae can be distinguished from those of similar looking Centrarchidae and Sciaenidae by the presence of an oil globule anterior in the yolk sac. Total myomeres are usually less than 30. As larvae, this count separates them from the Percopsidae and Gasterosteidae. In larvae the anus is located below the posterior half of the dorsal fin but it migrates forward at about the time that pelvic fin rays appear (9.0 mm) . The transition is complete by the juvenile phase.

Aphredoderus sayanus (Gilliams), pirate perch

DISTRIBUTION

Found in Indiana and lower Michigan as far north as the Pere Marquette River system and in the headwaters of the Wolf River system in Wisconsin.[1]

SPAWNING SEASON

Spawns in May in Illinois.[10]

SPAWNING TEMPERATURE

Not reported.

SPAWNING HABITAT

Builds a nest and both parents guard the young[7] until they are about 8.5 mm.[10] Possibly broods young orally.[2 4]

SPAWNING SUBSTRATE

Not reported.

FECUNDITY

129 to 160.[5]

EGGS

White, diameter 1.0 mm;[2] or 0.50 to 0.75 mm;[5] oil globule single, diameter less than 0.4 mm;[2] incubation period: 5 to 7 days at 19 to 20 C.2

YOLK-SAC LARVAE

Total length	Description
4 mm	Myomeres: 25 to 31 (12 to 15 + 13 to 16).[3] Morphology: yolk diminished, swim bladder evident, caudal fin rays visible (10 days postfertilization); gill clefts visible, heart begins to move dorsad to long axis of body;[3] notochord flexed (7 days postfertilization).[5] Pigmentation: large stellate melanophores over entire body, profuse on dorsal margin of head, lateral margin of gut and along midlateral line, subocular pigment present, developing into vertical bar in later stages.[3]

LARVAE

Total length	Description
8 mm	Morphology: incipient rays visible in dorsal and anal fins, primordial swim bladder appears along the dorsal margin of the visceral cavity between myomeres two and six.[3]
9-10 mm	Morphology: anus just anterior to anal fin;[9] pelvic fin buds appear.' Pigmentation: few melanophores on head, opercula and in caudal fin membrane.[5]

JUVENILES

Total length	Description
11-15 mm	Morphology: pelvic fin rays visible, all median fins with complete ray development, the number of preanal myomeres decreases as anus migrates forward (> 13 mm);[3] first anal ray transforming to third anal fin spine, preanal finfold evident;[5] keel-like structure on newly formed third anal fin spine visible.[9] Pigmentation: more intense, additional pigment in region of pectoral fins, along dorsal fin rays and a crescent band of large melanophores on caudal fin.[5]
17 mm	Morphology: preopercle with few spines, pelvic girdle not ossified, intestine straight.[5]
19 mm	Morphology: intestine curved back on itself, immature gonads just posterior to intestine, urogenital duct slightly back and to left of intestine.[9]
31-35 mm	Morphology: first spine in anal fin one-half the length of second, second one-half the length of the third, anal fin covered with thin transparent skin, spines easily visible.[9]
35-40 mm	Morphology: keel-like structure now visible on first soft anal fin ray.[9]
45 mm	Morphology: pelvic girdle ossified, intestine through the foramen.[9]

ADULTS

Fin rays: caudal 18 (from figure[5]); dorsal II I (II to IV), 10 (9 to 13), anal II to III,5 to 8;[4 5 8 10] pectoral 10 to 14;[5] pelvic I,7.[5]

Vertebrae: 29.[5 6]

Lateral line scales: 44 to 60;[5] 49 to 56.[10]

Diagnostic characters: anus near isthmus, dorsal fin with two to four spines, anal fin usually with three spines, preopercle serrate, opercle with sharp spine, lateral line incomplete or absent.

LITERATURE CITED.

1. Becker (1976)
2. Martin and Hubbs (1973)
3. Hogue et al. (1976)
4. Wang and Kernehan (1979)
5. Hardy (1978)
6. Bortone (1972)
7. Abbott (1871)
8. Gerking (1955)
9. Mansueti (1963)
10. Hubbs and Lagler (1958)

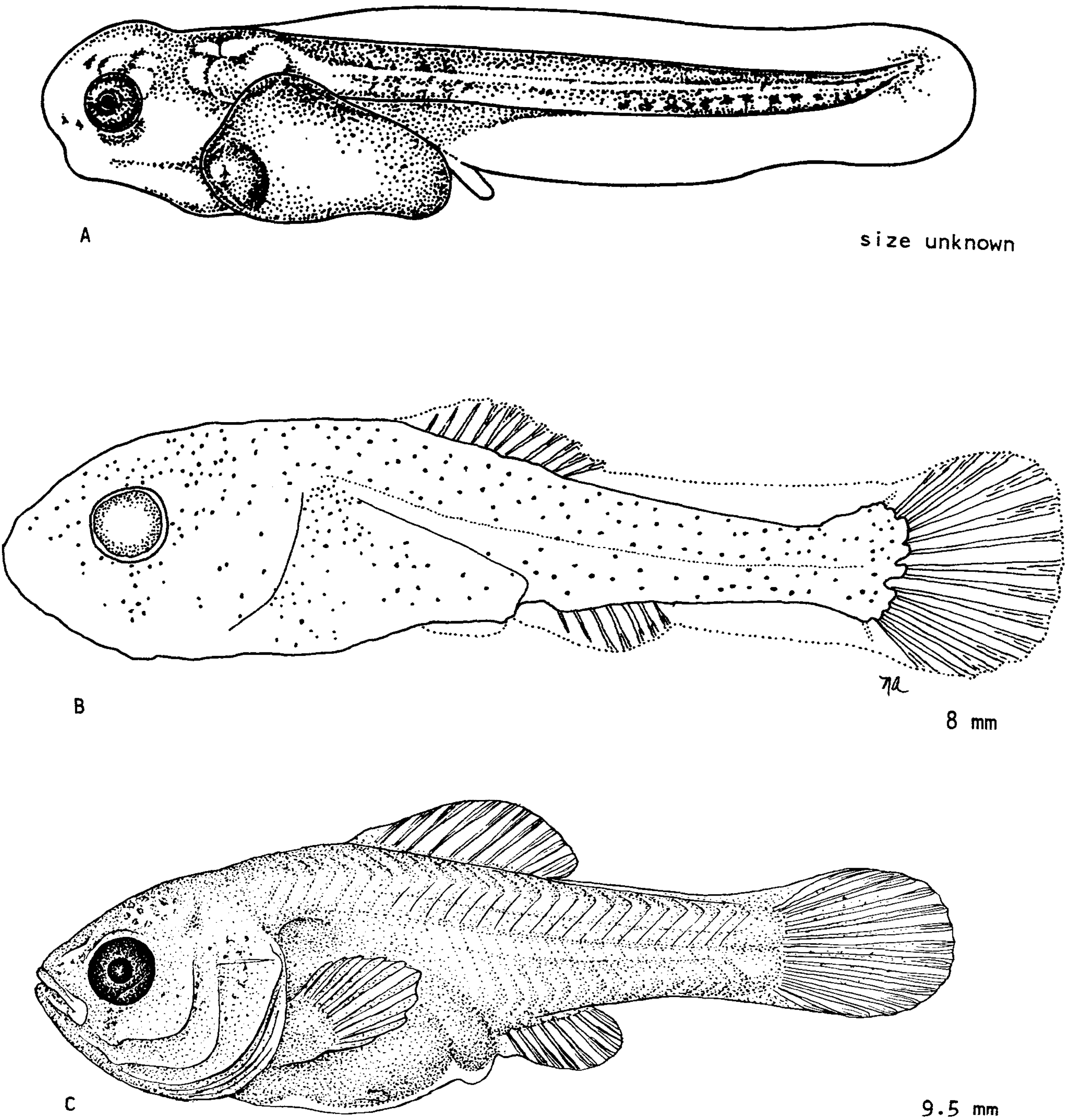


Fig. 193. Aphredoderus sayanus, pirate perch. A. Yolk-sac larva. B and C. Larvae. (A, Hardy 1978; B, wild-caught, Tennessee, Hogue et al. 1976, delineated by N. A. Auer; C, wild-caught, Maryland or Virginia, Mansueti 1963).

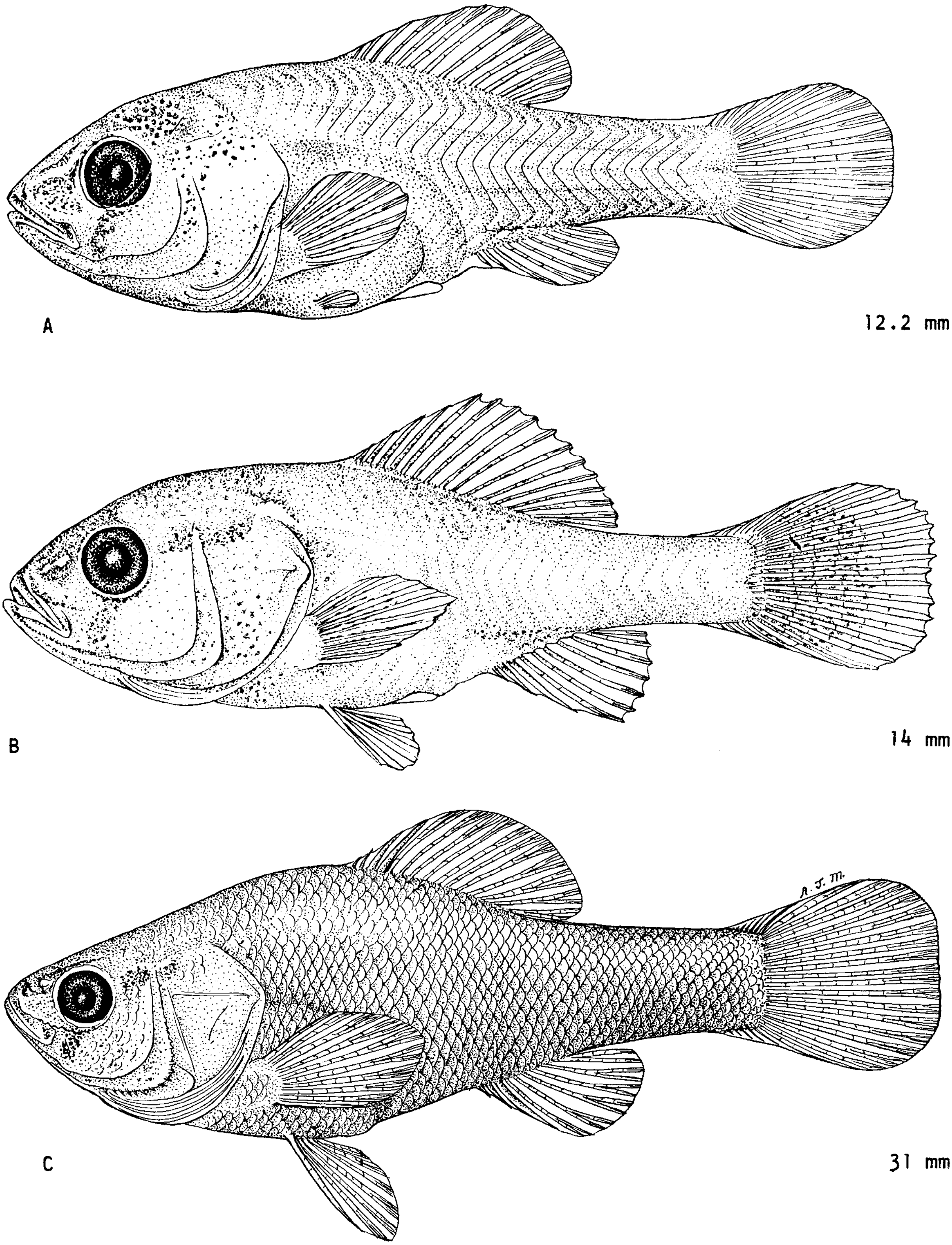


Fig. 194. Aphredoderus sayanus, pirate perch. A and B. Larvae. C. Juvenile. (A-C, wild-caught, Maryland or Virginia, Mansueti 1963).

Family Percopsidae, trout-perches

By

Nancy A. Auer

This family of fishes is endemic to temperate and northern North America. The single genus, *Percopsis*, contains two species. *Percopsis omiscomaycus* occurs throughout much of Canada and the north central United States, including the Great Lakes basin. *Percopsis transmontana* inhabits portions of the Columbia River system in the northwestern United States.

As adults *Percopsis* spp. rarely exceed 150 mm and they have both spiny rayed and adipose dorsal fins. Dark spots are present on the dorsal and dorso-lateral areas of these silvery fish, scales are small and weakly ctenoid.

P. *omiscomaycus* occurs lakes and streams. Spawning takes place during the spring in shallow water or the lower reaches of tributary streams. Although various aspects of the reproductive biology of this family have been studied, a complete description is unavailable. Yolk-sac larvae possess an oil globule anterior in the yolk sac. Preanal myomeres usually number 14. As larvae, this species develops an adipose fin.

Percopsis omiscomaycus (Walbaum), trout-perch

DISTRIBUTION

Widely distributed throughout lakes and streams in the Great Lakes area.[4] Most common in shallow water of the Great Lakes and in lower extremities of large tributaries.[7]

SPAWNING SEASON

Spawns from late June or early July to late September in Lake Michigan,[1] early May to early July in Lake Erie[5] and May to August in Minnesota.[3]

SPAWNING TEMPERATURE

Spawning occurs at temperatures of 4.4 to 10.0 C,[2] 15.0 C,[8] and 15.6 to 20.0 C.[7]

SPAWNING HABITAT

Spawns along beaches and in streams in water 2 m deep or less[3] and over gravel riffles in streams.[8]

SPAWNING SUBSTRATE

Deposits eggs on a sandy bottom. Eggs drift with current until they touch the sand to which they adhere.[3] Spawns randomly.'

FECUNDITY

126 to 1,349;[1] 346 to 349.[2] [8]

EGGS

Demersal, adhesive;[3] diameter 1.3 to 1.9 mm;[3] [5] oil globule single, diameter 0.7 mm;[5] incubation period: 6.5 days at 20 to 27 C.[3]

YOLK-SAC LARVAE

Total length	Description
5.3-6.0 mm	Newly hatched.[3] [5] [6]
6-7 mm	Myomeres: 32 to 33 (14 + 18 to 20).* Morphometry: (as % TL) preanal length 44 to 45; ' * or 50;[5] greatest body depth 16 to 18;[5] head length 19 to 21, snout length 4 to 6;* eye diameter 6 to 8.[5] * Morphology: yolk absorbed (6.2 mm)[3] or not absorbed (6.7 mm);* small inferior mouth, median finfold origin at dorsal myomere seven or eight, remaining low and even around caudal fin to anus, anus ventrad from body, preanal finfold evident, pectoral buds developed.[5]

Pigmentation: a few large, stellate melanophores situated in the antero-ventral portion of stomach (or yolk sac*), extending dorsad only on right side, ventral line of melanophores (one at the base of every other myomere) extends from anus to caudal fin;[5] * eyes pigmented, dorsum of single-chambered swim bladder covered with dense mat of small subsurface melanophores (6.0 mm).[5] *

LARVAE

Total length	Description
7-8 mm	Myomeres: 32 to 34 (14 to 16 + 17 to 20).* Morphometry: (as % TL) preanal length 48 to 49, head length 18 to 22, snout length 6 to 7, eye diameter 6 to 7.* Morphology: yolk absorbed, incipient dorsal and anal fin rays evident, finfold constricted near adipose.* Pigmentation: pigment on venter reduced to a few large melanophores just anterior to stomach and near base of pectoral fins primarily on right side, pigment unchanged on venter from anus to caudal fin, dorsum of swim bladder densely covered with melanophores, a few melanophores on dorsum of head and near mouth.*
9-12 mm	Myomeres: see 7-8 mm. Morphometry: (as % TL) standard length 85;[5] preanal length 50 to 52;* greatest body depth 21;[5] head length 23 to 24, snout length 8 to 9, eye diameter 7 to 8.[5] * Morphology: head long, snout pointed, mouth with teeth on both jaws, single-chambered swim bladder, 11 dorsal and 8 anal fin rays evident, finfold visible posterior to dorsal fin rays, pelvic buds developed (9.5 mm).[5] Pigmentation: a few melanophores on jaws and over top of head, a few on cheeks and below angle of jaws, very few on underside near gills, many on dorsum of swim bladder, a few on either side of dorsal fin, a double series around anus and a single series of about 20 irregular spots from anus to caudal fin, a few melanophores at base of caudal fin and on the fin itself.[5]

JUVENILES

Total length	Description
35-36 mm	Morphometry: (as % TL) standard length 79, preanal length 48, greatest body depth 19, predorsal length 38, head length 25, eye diameter 7.[5] Morphology: caudal peduncle long, mouth small, maxilla short, teeth on premaxilla and mandible small, fully scaled.[5]

Pigmentation: chromatophores over entire body, six lateral bands.[5]

ADULTS

Fin rays: caudal 17 to 18;[4] dorsal II,9 to 11, anal I,5 to 8;[4 5] pectoral 12 to 15;[4] pelvic 1,8 to 9.[4 5]

Vertebrae: 33 to 34.[4]

Lateral line scales: 43 to 60.4

Diagnostic characters: adipose fin present, first rays of dorsal, anal and pelvic fins spinous, pectoral fins overlap base of pelvic fins at most anterior point, jaws toothed, premaxillae nonprotractile, scales weakly ctenoid, frenum present.

LITERATURE CITED

1. House and Wells (1973)
2. Lawler (1954)
3. Magnuson and Smith (1963)
4. Scott and Crossman (1973)
5. Fish (1932)
6. Jude et al. (1979b)
7. Becker (1976)
8. Muth and Tarter (1975)

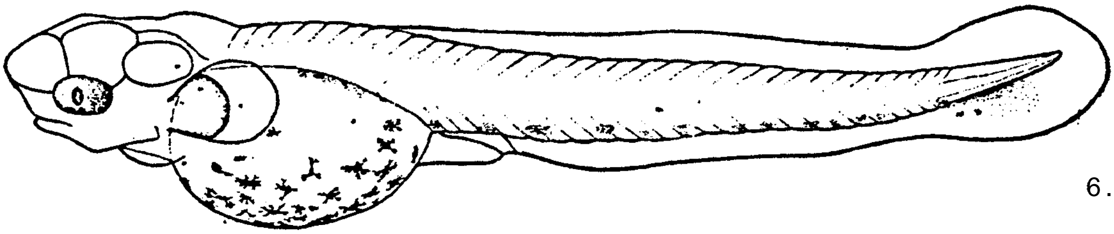


Fig. 195. Percopsis omiscomaycus, trout-perch. Yolk-sac larva. (Wild-caught, Lake Erie, Fish 1932).

Percopsis omiscomaycus

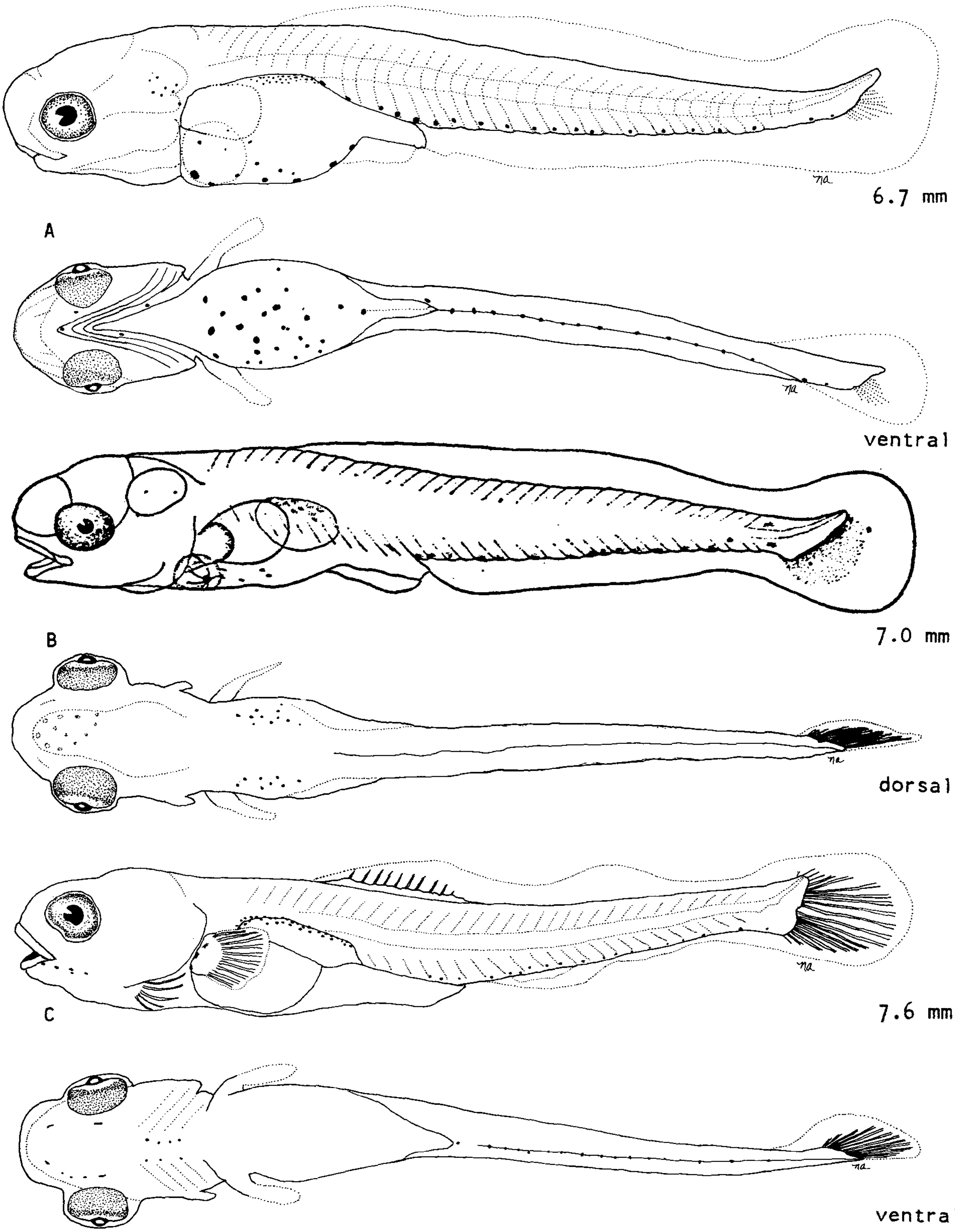


Fig. 196. Percopsis omiscomaycus, trout-perch. A and B. Yolk-sac larvae. C. Larva. (A and C, wild-caught, Lake Michigan, original illustrations by N. A. Auer; B, wild-caught, Lake Erie, Fish 1932).

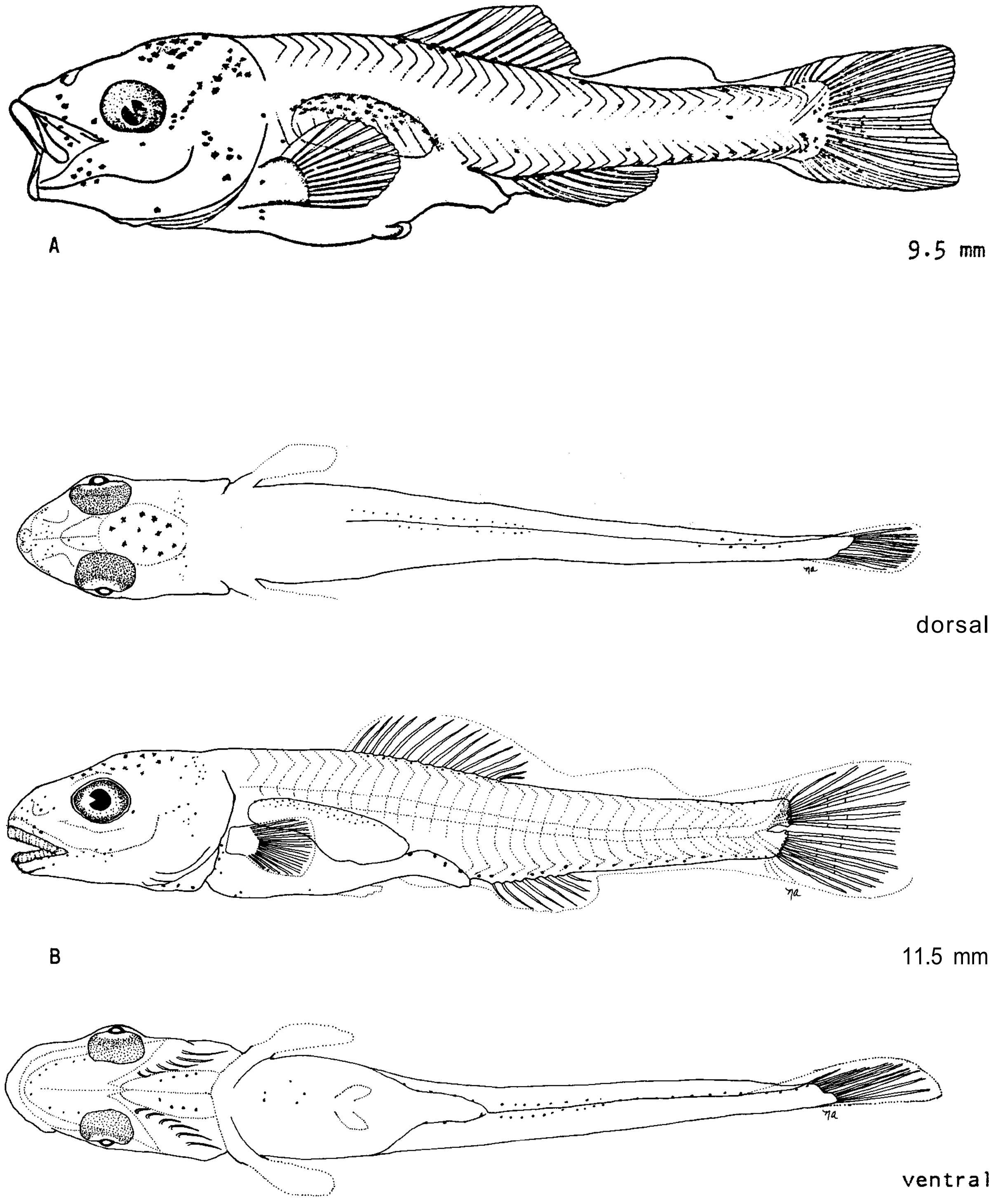


Fig. 197. Percopsis omiscomaycus, trout-perch. A and B. Larvae. (A, wild-caught, Lake Erie, Fish 1932; B, wild-caught, Lake Michigan, original illustrations by N. A. Auer).

Family Gadidae, codfishes

BY

David J. Jude

The cod family has a circumpolar distribution and is almost wholly marine, comprising some 60 species, only one of which, Lota lota, is a truly freshwater species. Another species, Microgadus tomcod, is marine, but sometimes invades freshwater on the eastern seaboard of North America. Adult cods are predaceous fish with large heads, wide gill openings, terminal jaws, a characteristic single barbel located at the tip of the chin, small embedded cycloid scales and a vomer equipped with numerous small teeth in wide bands. They have one to three soft dorsal fins and one or two anal fins. The tail is isocercal.

The burbot is one of the few Great Lakes fishes which spawns in the winter, sometimes under the ice, usually in shallow water over sand or gravel shoals. Some river spawning is suspected (Bjorn 1939). Eggs are small (1.3 to 1.8 mm), semibuoyant, with an oil globule and are broadcast randomly over the substrate. Larvae are small (approximately 3 to 4 mm) at hatching with the anus well anterior. The anus migrates to adult midbody position in later larval stages. As is typical of the family, the median finfold of the early larval stages is continuous across the anal region, with the anus opening on one side of the finfold.

Lota lota (Linnaeus), burbot

DISTRIBUTION

Known from all the Great Lakes proper and their drainages.[3]

SPAWNING SEASON

Spawns from December to January in Lake Michigan,' March to April in Lake Erie,[14] February to March in Lake Superior' and January to March in Canada.[3]

SPAWNING TEMPERATURE

Burbot eggs have been collected from the Lake Michigan beach zone in January at 0.4 C.[2] Spawning temperature reported as 4 C in Swedish lakes.'

SPAWNING HABITAT

Spawns in shallow water 0.3 to 1.3 m[15] or 1.5 to 4.5 m[12 16] deep. Sometimes migrates upstream to spawn." Spawning most often occurs at night,[13] but is also known to occur in the evening or morning.[8] In Lake Winnipeg, spawning occurred near the surface in shallow water.[20]

SPAWNING SUBSTRATE

Spawns on sand,'[2 12] hard clay,[1] or coarse gravel,[12 16] rubble and stones, in deep shoal areas.[12] Specialized swimming movements by the female ensure dispersal of eggs under slow current and' ice-covered conditions.'

FECUNDITY

812,282 (268,800 to 1,154,000) in Lake Superior;[9] 64,000 to 1,380,640.[5 6 10 11 19]

EGGS

Semibuoyant;[1 5 11] chorion clear, yolk light yellow;[5 11] diameter 1.0 to 1.3 mm;[5 11 13] or 1.7 mm;[19] oil globule single, large and clear;[6 18] incubation period: 71 days at 0 C, 46 days at 1 ± 0.5 C;[5 12] 41 days at 2 C;[8] 4 to 5 weeks at 4 C;[7] 30 days at 6.1 C;[11] hatching occurs when water temperatures warm to 1.5 C;[12] 4 to 5 weeks at 4 C.[7]

YOLK-SAC LARVAE

Total length	Description
3.87-5.0 mm	Newly hatched.[4 5 6 18 21]
	Myomeres: 56 (16 + 40);[18] 51 to 62 (14 to 20 + 35 to 42).*

Morphometry: (as % TL) standard length 93 to 98, preanal length 39 to 43;[17 18] greatest body depth 20 to 21;[17] eye diameter 7 to 9;[17 18] (as % head length) eye diameter 50.[18]

Morphology: median finfold origin dorsal to myomeres five to eight, rising to highest point just behind anus then tapering gradually to tail, continuing forward along venter nearly identical to dorsum, anus on right side at a distance ventrad from the body, but not at edge of finfold, forehead bulbous, mouth terminal, lower jaw protruding slightly, eye slightly forward in head, larva transparent, colorless, robust anteriorly, slender posteriorly, intestine short, coiled, pectoral buds well developed, forehead starts to recede, it projects no further than tip of upper jaw (4.5 mm).[17 18]

Pigmentation: eye pigmented;[17 21] yellow oil globule in antero-ventral portion of yolk sac;[21] one to many melanophores evident on each side over posterior portion of swim bladder;" varying to considerable pigmentation along the dorsum of head, body, gut and lateral and ventral surfaces of yolk sac.[18] *

LARVAE

Total length	Description
6-7 mm	Myomeres: see 3.87 to 5.0 mm. Morphometry: (as % TL) standard length 95 to 97, preanal length 42 to 44, greatest body depth 18 to 22, eye diameter 7.[17] Morphology: dorsal contour of head more sloping, mouth terminal, lower jaw slightly projecting (6.8 mm).[17] Pigmentation: transparent, double line of five large stellate subsurface chromatophores over dorsum of swim bladder, a few more chromatophores develop over stomach region (6.8 mm).[17]
10-11 mm	Morphometry: (as % TL) standard length 88, preanal length 46, greatest body depth 19, eye diameter 7.[17] Morphology: Fin rays first apparent, second dorsal (67 rays) and anal (64 rays) fins incomplete, many adult characteristies evident, especially head and mouth contours, barbel represented by a fleshy protuberance, intestine open at margin of body, pelvic buds apparent below pettoral buds, deep notch in finfold between forming dorsal fins.[17] Pigmentation: chromatophores confined to subsurface patch above stomach region and about 25 rather large, rounded black spots over top of head, subsurface chromatophores hardly discernible over anterior part of notochord.[17]

14-19 mm	Morphometry: (as % TL) standard length 90 to 94, preanal length 50, greatest body depth 17 to 20, eye diameter 6 to 7." Morphology: jaw shorter than in adult, median fin rays complete, pelvic fins larger and completely rayed, all fins and barbel complete (19 mm).[17] Pigmentation: a few stellate chromatophores occur on jaws followed by distinct preorbital, postorbital and opercular patches, giving the impression of a lateral band on head, lateral line marked by a single broken series of large chromatophores extending to tip of urostyle, becoming wider with more numerous and smaller subsurface spots posteriad, dorsum has numerous pigment spots arranged irregularly in 10 to 12 groups, each one consisting of a double row of large close set chromatophores outlining dorsal fins and others more sparsely distributed, extending half way to lateral line.[17]

JUVENILES

Total length	Description
30-31 mm	Morphometry: (as % TL) preanal length 51, greatest body depth 16, eye diameter 6.[17] Pigmentation: top and sides of head down to posterior margin of eye thickly pigmented, most heavily in a band through eye from tip of snout to opercle, occasional chromatophores evident below eye, a few outline lower jaw, dorsal and lateral aspect with irregular groups of chromatophores giving checkered effect, venter unmarked except for double series of about 20 chromatophores along base of anal fin, a few occur on all fins except anal.[17]

ADULTS

Fin rays: caudal 34 to 37;* first dorsal 8 to 16, second dorsal 60 to 79, anal 59 to 76, pectoral 17 to 21, pelvic 5 to 8.[3]

Vertebrae: 50 to 66.[3]

Diagnostic characters: single chin barbel, head and anterior body robust, with rest of elongate body tapering posteriorly to isocercal tail, elongate and soft-rayed median fins, pelvic fins under or anterior to pectoral fins.

LITERATURE CITED

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2. Jude et al. (1979b)
3. Scott and Crossman (1973)
4. Muth (1973)
5. Muth and Smith (1974)
6. Chen (1969)
7. Evhrenbaum (1909)
8. Vallin (1942)
9. Bailey (1972)
10. Lawler (1963)

11. Bjorn (1939)
12. McCrimmon (1959)
13. Cahn (1936)
14. Clemens (1950)
15. McPhail and Lindsey (1970)
16. McCrimmon and Devitt (1954)
17. Fish (1932)
18. Snyder (1979b)
19. Fish (1930)
20. Hewson (1955)
21. Sorokin (1968)

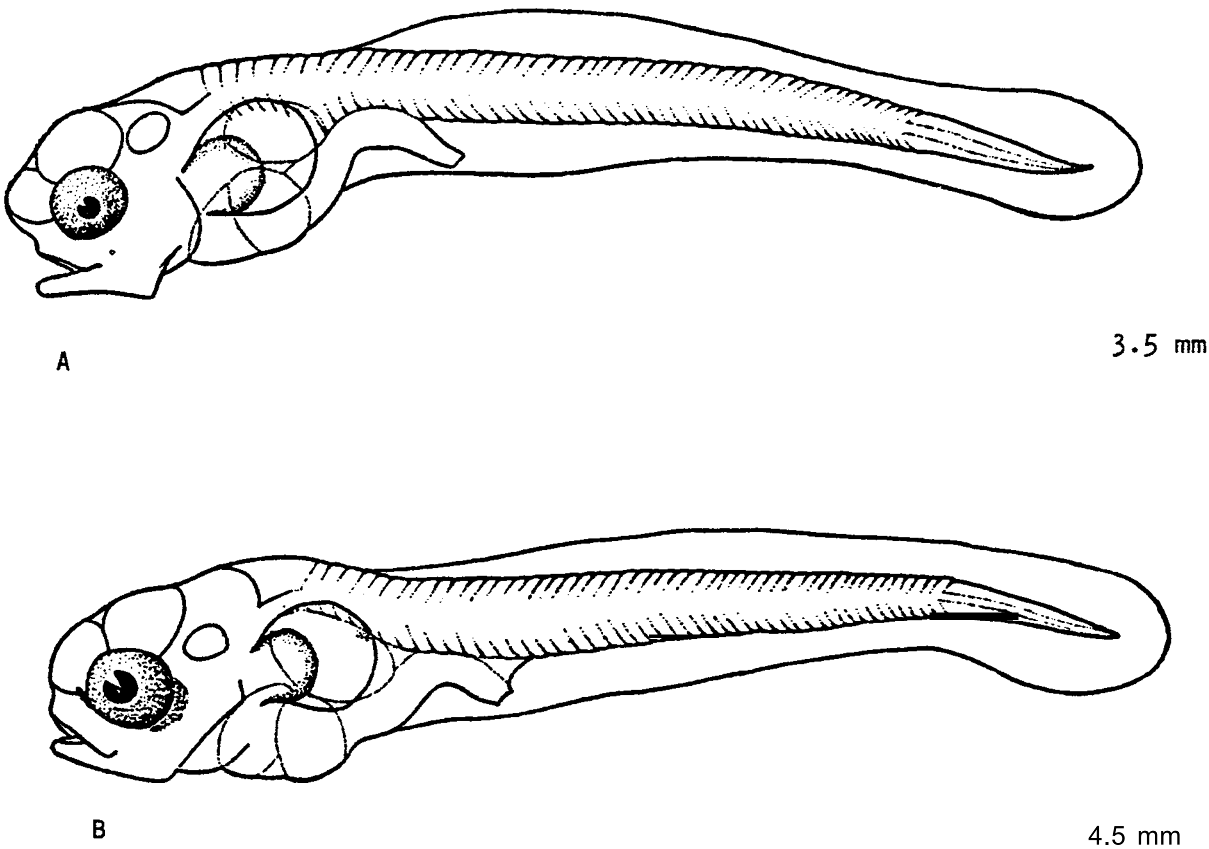

Fig. 198. Lota lota, burbot. A and B. Yolk-sac larvae. (A and B, wild-caught, Lake Erie, Fish 1932).

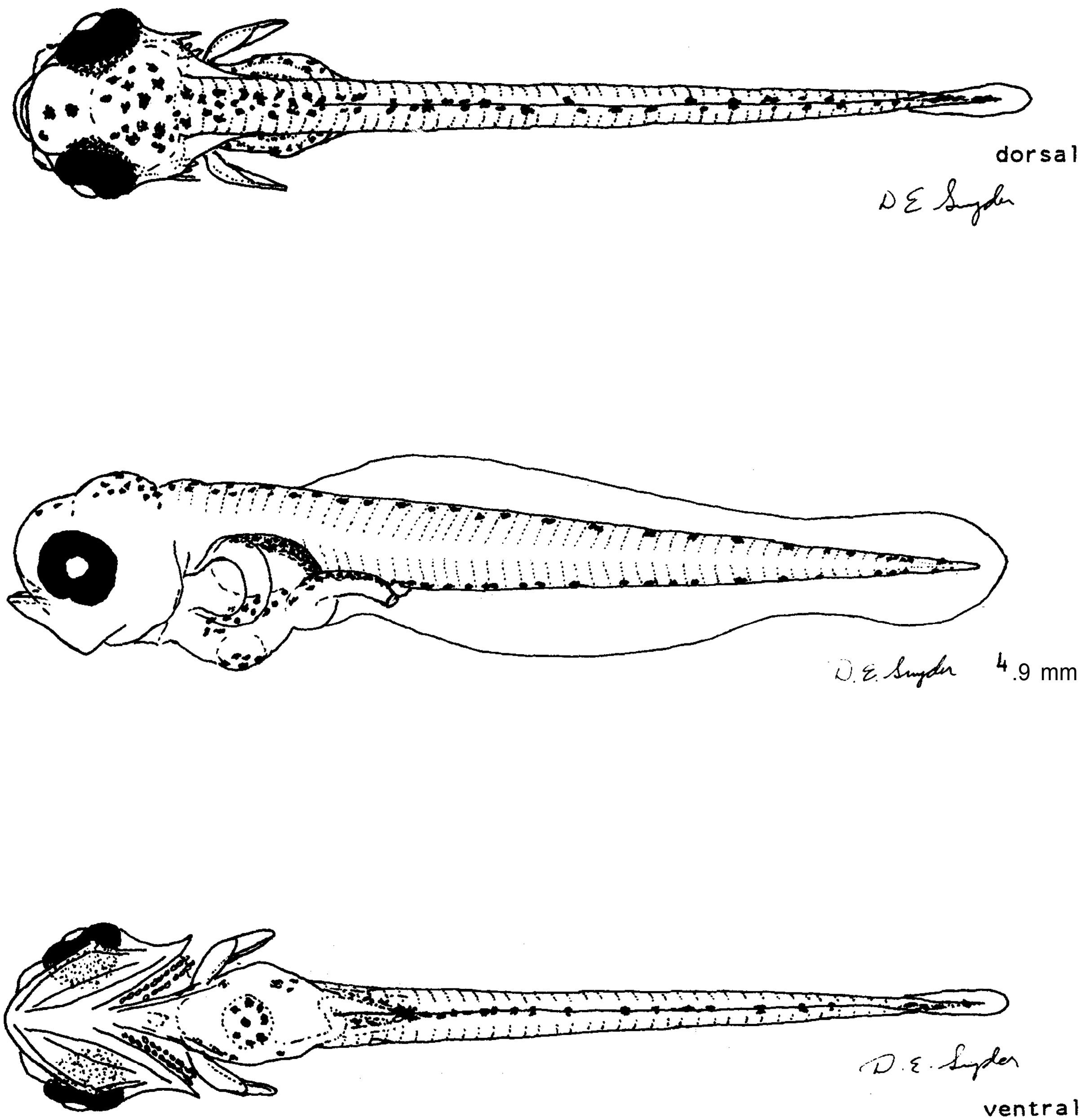

Fig. 199. Lota lota, burbot. Yolk-sac larvae. (Wild-caught, Minnesota, Snyder 1979b).

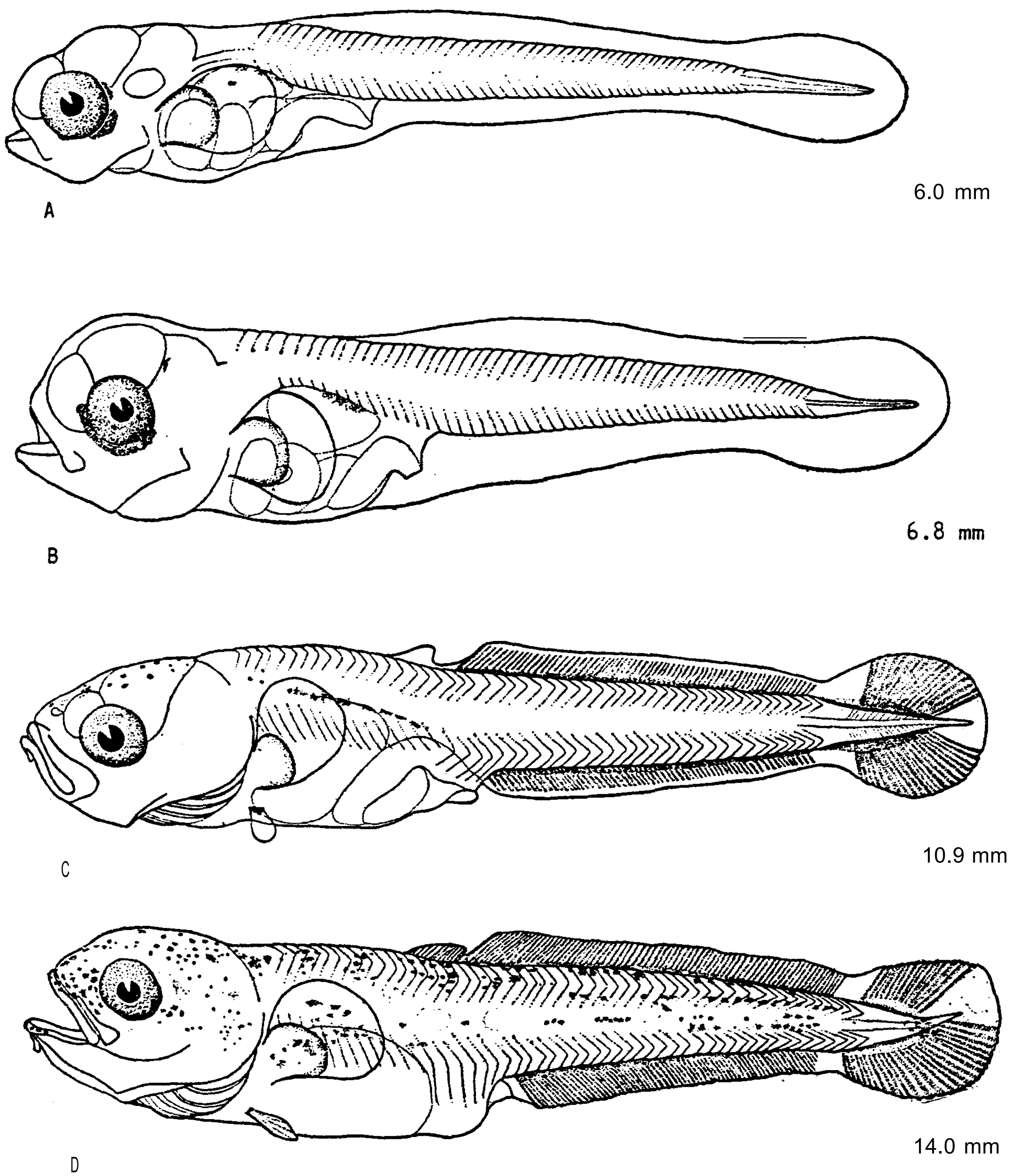

Fig. 200. Lota lota, burbot. A and B. Yolk-sac larvae. C and D. Larvae. (A-D, wild-caught, Lake Erie, Fish 1932).

Family Cyprinodontidae, killifishes

By

David J. Jude

Cyprinodontidae is a large family of atheriniform fish, comprising about 50 genera with over 300 species (Nelson 1976). Members of the killifish family are generally less than 100 mm TL and are characterized by small, elongate and cylindrical bodies which are moderately compressed. All fins are soft-rayed and there is a single, relatively short dorsal fin. These fish superficially resemble minnows from which they can be distinguished by teeth in their jaws. Scales are cycloid and the protrusible mouth is adapted for feeding near the surface or in muddy or sandy substrate.

Killifishes are found in shallow freshwater, brackish and, less frequently, marine habitats in the western hemisphere from southern Canada through South America. In the eastern hemisphere they are found in Africa (including Madagascar), southern Europe and southern Asia. A comprehensive study and review of the reproductive behavior of killifishes (Foster 1967) showed that members of the family exhibit a wide variety of reproductive and territorial behaviors; for some species this includes complex courtship behavior.

Fundulus is the only genus of the killifishes occurring in the Great Lakes basin. Both F. notatus and F. notti have more restricted ranges within the basin. While F. notatus is a fairly stable species taxonomically, E. notti exhibits considerable variability throughout its range which has resulted in controversy over the status of this species. Some sources (Lee et al. 1980) recognize the designation as separate species of some members of the F. notti complex, suggested by Wiley and Hall (1975). Robins et al. (1980) list only a single species.

Fundulus spawn generally during the spring and summer in shallow areas and vegetated sloughs of rivers, streams, ponds or lakes. The eggs are laid, a few at a time, and fertilized amid algae-covered substrate. Individual fish spawn repeatedly during the breeding season. No parental care is given. Larval stages of F. diaphanus are well described, whereas those of F. notatus and F. notti are not. The smallest specimens of these two species, available to the author, were about 20.0 mm, at which size typical adult pigment patterns and fin ray complements were present.

Fundulus diaphanus (LeSueur), banded killifish

DISTRIBUTION

Occurs throughout the Great Lakes basin except the drainage of Lake Superior where it is restricted to the extreme eastern portion of the upper peninsula of Michigan.' It is common throughout the Lake Michigan drainage but appears to be absent in the northwestern corner.[2] Two subspecies of Fundulus diaphanus have been described; F. d. diaphanus which is present in eastern Lake Ontario and its drainage and F. d. menona which is present throughout the rest of the species range in the Great Lakes.'

SPAWNING SEASON

Spawns in late spring and early summer in Illinois[3] and late May to mid-August throughout most northern states.[4]

SPAWNING TEMPERATURE

Spawning activity initiated at 21 C[5] and was observed at water temperatures as warm as 32.2 C.[6]

SPAWNING HABITAT

Spawns in lakes,[10] * ponds,'[10] brooks,[5] creeks[8 9] and rivers[4] in shallow areas with vegetation.[10]

SPAWNING SUBSTRATE

Spawns over a sandy bottom containing beds of Vallisneria,[6] amid filamentous algae[4 7 8] growing on rocks[4 8] or aquatic plants.[4]

FECUNDITY

Ca. 200[6] to 252.[11]

EGGS

Diameter ca. 1.7 to 1.8 mm (preserved);[4] 2.0 mm;[12] oil globules small and numerous, eggs attached to substrate by outer layer of adhesive filaments.[12]

YOLK-SAC LARVAE

Early yolk-sac larvae, 4.7 to 5.0 mm, presented by Jones and Tabery (1980), are believed to be prematurely hatched and are therefore not included in the YOLK-SAC LARVAE description.::

Total length	Description
5-6 mm	Morphology: head slightly deflected ventrally, dorsal origin of median finfold posterior to ventral origin.[12]

Pigmentation: dark pigment on ventral perivitelline vessels of yolk, head and entire body pigmented.[12]

LARVAE

Total length	Description
7-10 mm	Myomeres: 35 (11 to 13 + 22 to 24).[13] Morphometry: (as % TL) standard length 83 to 85, preanal length 39 to 43, head length 23 to 24, eye diameter 9 to 10;[13 14] greatest body depth 18 to 19, caudal peduncle depth 6 to 7.[13] Morphology: yolk absorbed (7.1 mm[14] or 7.6 to 10 mm[13]); head and mouth developed, teeth present on premaxilla and mandible (8.3 mm), six branchiostegal rays formed (complete), caudal fin differentiated (8.0 mm), lower jaw extended beyond upper jaw, rays in dorsal and anal fins, incipient rays in pectoral buds (9.5 mm).[13] Pigmentation: may be less pigmented than recently hatched (7.6 to 8.2 mm);[13] may have melanophores over entire body, especially head, dorsal (may be sparse) and ventral ridges (7.1 mm);[14] lateral melanophores (may be lacking[13]) stellate and outlining myomeres, dense pigmentation on isthmus continuing onto midventral aspect of stomach;[13 14] margins of caudal fin rays pigmented and a few melanophores on pectoral buds.[14]
11-15 mm	Myomeres: 34 to 36 (13 to 15 + 21 to 22).[13] Morphometry: (as % TL) standard length 82 to 89, preanal length 45 to 47, head length 23 to 28, eye diameter 8 to 9.[13 14] Morphology: pelvic buds present on abdomen;[13] dorsal and anal fin rays incomplete (12.3 mm);[14] complete (14.5 mm);[13] finfold absorbed.[13 14] Pigmentation: body evenly covered with stellate melanophores except venter of gut, caudal, dorsal, anal and pectoral fins with melanophores along rays (12.3 mm);[14] pigment in area of isthmus and midthoracic area persists, no pigment on pelvic buds;[13] vertical bars not evident (12 mm);[12] or may be evident (12.5 mm).[15]

JUVENILES

Total length	Description
15-20 mm	Myomeres: 33 to 36 (13 to 15 + 20 to 22).[13] Morphometry: (as % TL) standard length 81, preanal length 48, head length 24, eye diameter 9, greatest body depth 16, caudal peduncle 9.[13] Morphology: all fin rays complete, scales begin to form on caudal peduncle (15.9 to 17.4 mm), squamation complete (17.9 mm).[13]

Pigmentation: vertical bars present (13.4 to 19.8 mm), preanal venter without pigment, increased pigmentation along upper jaw, nasal and occipital regions.[13]

ADULTS

Fin rays: caudal 16;* (14 to 17), dorsal 13 (12 to 15) ;[1] anal 10 to 13, pectoral 16 (14 to 19) ;[1 16] pelvic 6.'

Vertebrae: 34 (33 to 36).[1]

Lateral line scales: 43 to 49.[1]

Diagnostic characters: dorsal fin originating in advance of anal fin origin, vertical bands evident.

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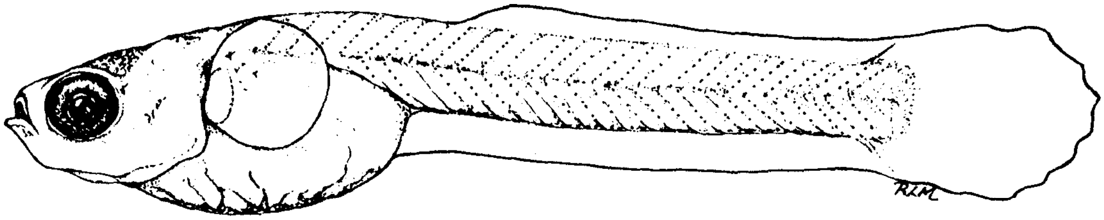
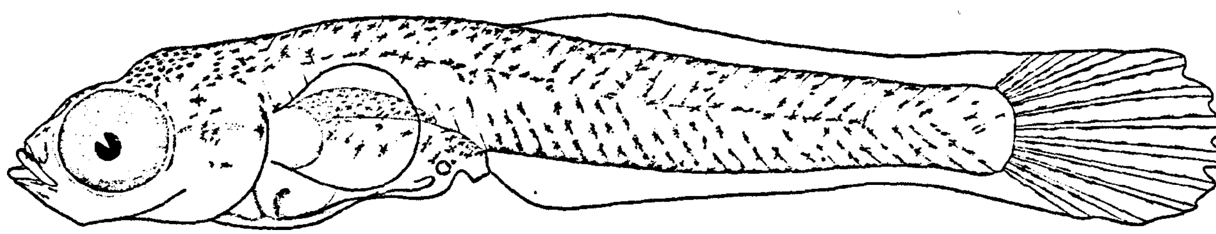
2. Becker (1976)
3. Smith (1979)
4. Foster (1967)
5. Richardson (1939)
6. Webster (1942)
7. Cooper (1936)
8. Greeley (1935)
9. Fowler (1922)
10. Adams and Hankinson (1928)
11. Hildebrand and Schroeder (1928)
12. Foster (1974)
13. Jones and Tabery (1980)
14. Fish (1932)
15. Wang and Kernehan (1979)
16. Hubbs and Lagler (1958)



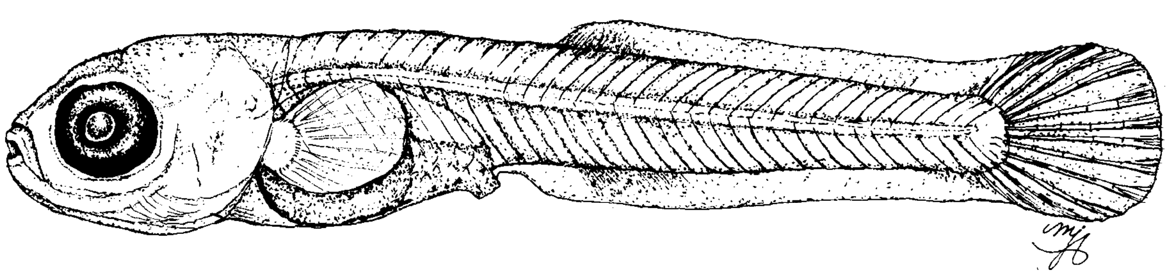
5.6 mm

A



7.1 mm

B



8.0 mm

C

Fig. 201. Fundulus diaphanus, banded killifish. A. Yolk-sac larva, newly hatched. B and C. Larvae. (A, laboratory-reared, New Jersey, Lippson and Moran 1974; B, wild-caught, Niagara River, Fish 1932; C, laboratory-reared, Hudson River, Jones and Tabery 1980, illustrated by M. J Fairman).

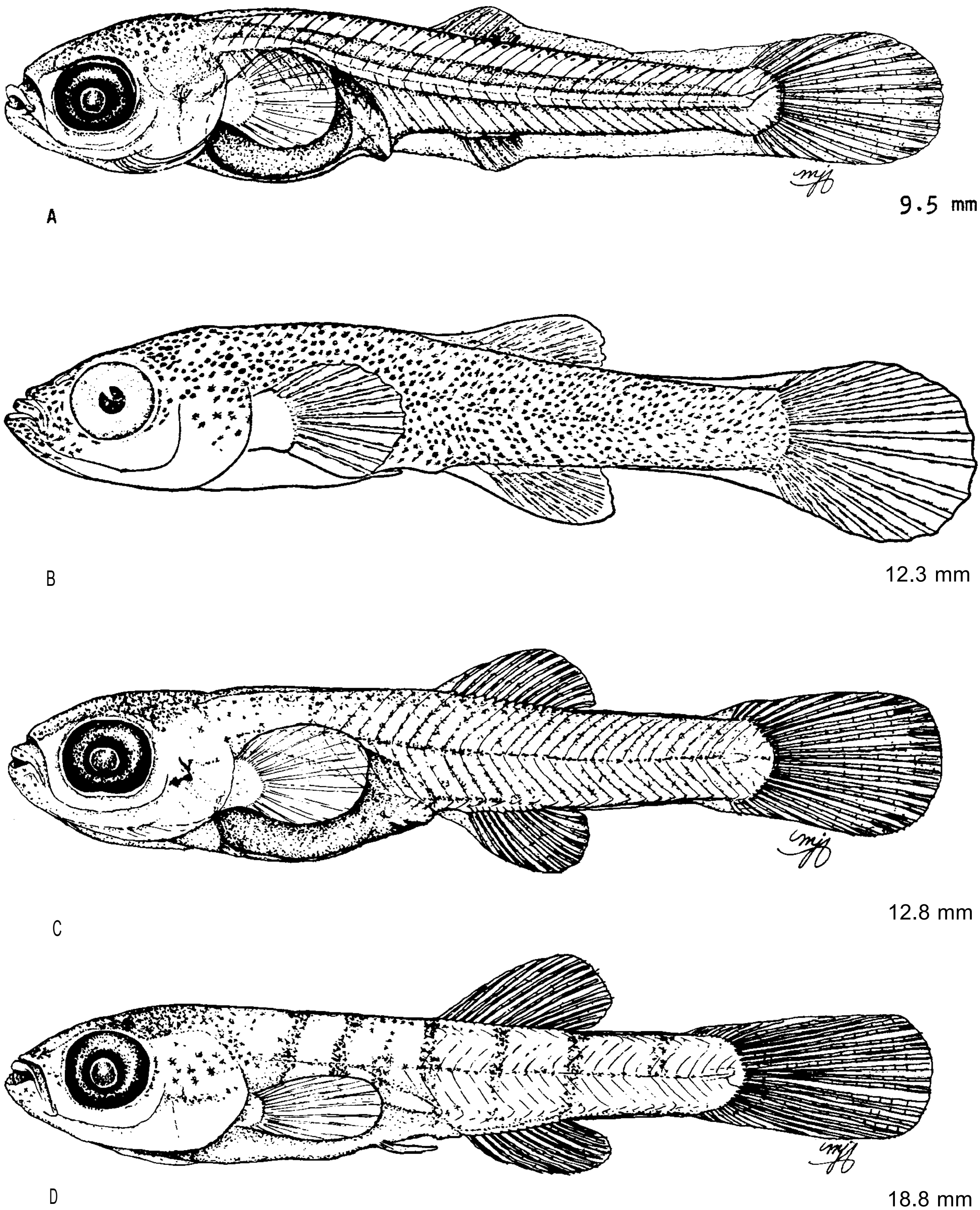


Fig. 202. Fundulus diaphanus, banded killifish. A-D. Larvae. (A, C and D, laboratory-reared, Hudson River, Jones and Tabery 1980, illustrated by M. J. Fairman; B, wild-caught, Niagara River, Fish 1932).

Fundulus notatus (Rafinesque), blackstripe topminnow

DISTRIBUTION

Within the Great Lakes basin it occurs only in the drainages of Lakes Michigan and Erie.’ Its distribution in the Lake Michigan drainage is distinctly southern, being found in headwater streams from the Grand to the St. Joseph River systems. A population also exists in the upper Fox River, Wisconsin.[2]

SPAWNING SEASON

Ripe females were taken in late June in Indiana[3] and late May in Illinois.[4] Reproductive activity begins in early May in Michigan, eggs are laid before late May and until late August.[5] Gravid females were collected from June to July in Wisconsin.*

SPAWNING TEMPERATURE

Not reported.

SPAWNING HABITAT

Not specifically noted but this species is reported to occur in creeks, rivers, lakes, swamps and ponds.[7]

SPAWNING SUBSTRATE

Spawns on a fibrous bottom.@

FECUNDITY

20 to 30, laid over a short period of time, individual fish spawn repeatedly over several weeks.[5]

EGGS

Diameter 1.8 mm, chorion exhibits scattered adhesive filaments closely arranged at one point to form a tuft, oil globule single, incubation period: 7 to 21 days (usually about 10 to 14 days).[8]

YOLK-SAC LARVAE

Not described.

LARVAE

Total length	Description
unstated	Morphometry: (as % TL) predorsal length ca. 50, snout to preanal f infold 33.” Morphology: ten caudal fin rays present.[8]

Pigmentation: dorsal and ventral stripe of melanophores, stripe irregular on dorsum, a few melanophores on pectoral fin.O

JUVENILES

Total length	Description
20 mm	Morphometry: (as % TL) preanal length 48 to 50, head length ca. 25.* Pigmentation: wide, dark lateral band increasing at various points to appear as blotches, dorsum with numerous small melanophores outlining scales, no melanophores on isthmus.*

ADULTS

Fin rays: caudal 14;* dorsal 9[9] (8 to 12);[10] anal 12[9] (11 to 13);[10] pectoral 14 to 15;[10] pelvic 6.'

Vertebrae: 32 to 35.[9]

Lateral line scales: 32 to 34.'

Diagnostic characters: wide lateral band extends from tip of snout and chin through eye to base of caudal fin.

LITERATURE CITED

1. Shute (1980)
2. Becker (1976)
3. Eigenmann (1996)
4. Richardson (1913)
5. Carranza and Winn (1954)
6. Cahn (1927)
7. Smith (1979)
8. Foster (1967)
9. Cross (1967)
10. Brown (1957)

Fundulus notti (Agassiz), starhead topminnow

DISTRIBUTION

In the Great Lakes basin it is found only at the southern edge of Lake Michigan in Illinois and Indiana; also occurs in the St. Joseph River system of Michigan and Indiana.[1,2]

SPAWNING SEASON

Spawns from late spring to early summer in Illinois.[3] Gravid females were found in May in Illinois.[4]

SPAWNING TEMPERATURE

Not reported.

SPAWNING HABITAT

Spawns in lakes, swamps and marshes.[3]

SPAWNING SUBSTRATE

Deposits eggs among dense beds of vegetation[3] and fibrous substrates on the bottom in shallow water.[5]

FECUNDITY

Not reported.

EGGS

Diameter 2.2 to 2.3 mm, oil globules numerous, adhesive filaments of chorion well developed;[5] incubation period: 12 to 14 days at 22.8 C;* 10 days at 26.1 C.[5]

YOLK-SAC LARVAE

Not described.

LARVAE

Not described.

JUVENILES

Total length	Description
20 mm	Morphometry: (as % TL) preanal length 47 to 50, head length ca. 25.*

Pigmentation: seven to nine distinct lateral lines of melanophores from posterior of head to caudal fin, dark middorsal band, melanophores on isthmus, dense patch of melanophores on posterior half of head, melanophores forming subocular patch.*

ADULTS

Fin rays: caudal 14;* dorsal 6 to 7, anal 8 to 9;[7] pectoral 13 to 15, pelvic 6.*

Vertebrae: 34.[5]

Lateral line scales: 30 to 34.[7]

Diagnostic characters: prominent blue-black subocular patch, males with thin, well separated, dark vertical bars, females with several thin horizontal dark lines, greatest body depth contained in less than four times in SL, dorsal fin origin behind anal fin origin, fewer than 38 lateral line scales, dorsum not distinctly tesselated with brown, iridescent silvery patch atop head in live fish. sunlight when live fish are near water surface.

LITERATURE CITED

1. Wiley (1980)
2. Becker (1976)
3. Smith (1979)
4. Richardson (1913)
5. Foster (1967)
6. Ferrari (1939)
7. Pflieger (1975)

Family Atherinidae, silversides

By

Heang T. Tin

This family includes about 39 genera and over 150 species (Martin and Drewry 1978) distributed around the world between latitudes 50 degrees north and 50 degrees south (Scott and Crossman 1973) I Atherinid fishes inhabit salt, brackish and freshwater. Eight genera and 12 species of atherinids are found in the United States and Canada. Silversides are small fish, usually from 50 to 150 mm, with a translucent body and pronounced lateral band. They are compressed and fusiform with a terminal mouth and usually scaled head. Teeth are usually present on the jaws, often on the palatines and vomer. Two well separated dorsal fins are almost always present, the spinous dorsal fin has three to eight spines. Pelvic fins have one spine and five soft rays. Pectoral fins are high on the body and the anal fin has a weak spine. The lateral line is discontinuous in many species: scales are cycloid.

Two genera, Labidesthes and Menidia, occur in the freshwater of the United States. A marine silverside, Membras martinica, reportedly enters streams (Hildebrand and Schroeder 1928). Spawning usually takes place in spring or summer. The spawning season of Menidia beryllina may extend until fall. Eggs of several species have one or several long, adhesive filaments which adhere to substrate or vegetation. Oil globules are present. Eggs are usually small, diameter 0.7 to 0.9 mm in Menidia beryllina and 1.1 to 1.4 mm in Labidesthes sicculus. Atherinid larvae are slender with the anus located in a forward position.

Labidesthes sicculus (Cope), brook silverside

DISTRIBUTION

Common in the Lake Michigan drainage,' also found in Lakes Erie, Huron and Ontario.' [8 11] Prefers lakes and quiet water of rivers and large streams. [7]

SPAWNING SEASON

Spawns from May to July in Michigan,[2] May and June in Wisconsin* and June to August in Indiana.'

SPAWNING TEMPERATURE

Spawning occurs at 20 to 23.2 C.[2 6]

SPAWNING HABITAT

In water to 1 m deep,[2 4] along the shore of rivers and lakes.[2 6]

SPAWNING SUBSTRATE

Eggs may be deposited over gravel, sand,[2 6] aquatic vegetation [4 6 10] or an unprepared bottom.* [10]

FECUNDITY

Not reported.

EGGS

Demersal;[2 6] diameter 1.1 to 1.4 mm;' chorion nonadhesive[2 9] with one to three long, adhesive filaments[2 4 6] oil globules numerous;[2 9] diameter from less than 0.1 to 0.5 mm;[9] incubation period: 8 to 9 days at 23 C.[6]

YOLK-SAC LARVAE

Total length	Description
4 mm	Newly hatched.[4]
4-6 mm	Myomeres: 35 to 37 (6 to 7 + 28 to 31) .[3 9] Morphometry: (as % TL) preanal length 27 to 28, head length 16, eye diameter 6 to 8, greatest body depth 15 to 17, body depth at anus 8 to 10.[9] Morphology: body slender, mouth small and terminal, pectoral buds present, oil globule single, diameter 0.1 to 0.4 mm.[9] Pigmentation: melanophores concentrated on occipital region, scattered single row of melanophores begins posterior to occipital region then branches into double

row near dorsal origin of median finfold continuing to caudal portion of finfold;' single midlateral row of melanophores behind head (4.7' mm to 6[3] mm); single row of melanophores midventrally from posterior margin of yolk to caudal portion of finfold, melanophores visible on maxilla, mandible, yolk sac, caudal fin base, in front of eyes, below auditory vesicles and in interorbital region.'

LARVAE

Total length	Description
6-g mm	Myomeres: 36 to 39 (6 to 9 + 29 to 32).[5] '
	Morphometry: (as % TL) preanal length 28 to 33;[5] ' head length 17 to 20, eye diameter 7 or 8.'
	Morphology: yolk absorbed (5.5 to 6 mm);[5] swim bladder visible (6 mm);' caudal fin differentiated (6.2 mm);[5] caudal fin ray anlage visible (8 mm);' anal fin rays visible (8.3 mm), soft dorsal fin rays visible (8.6 mm);[5] finfold between soft dorsal and caudal fin absorbed (8 to 10.3 mm).'
	Pigmentation: dorsum of swim bladder heavily pigmented;[3] [5] ' four to six large melanophores on breast and abdomen, three or four small melanophores on mandible (5.5 to 6 mm);[5] melanophores on maxilla and venter of gut (5.5 to 7.3 mm);' single middorsal row of melanophores visible on anterior quarter of body and along finfold base on caudal peduncle;[5] or from head to caudal fin; [3] three ventral rows of melanophores (one on each side of the midventral line and one on the midventral line) from anus to posterior margin of anal fin (6.2 to 8.8 mm);[3] or to caudal fin;[5] ' double ventral row of melanophores from anal to caudal fin.[3]
9-16 mm	Myomeres: 37 (9 + 28) at 11.3 mm, 37 (12 + 25) at 15.3 mm;' 36 to 39 at 11 to 15 mm.[5]
	Morphometry: (as % TL) preanal length 35 to 40, head length 18 or 19, eye diameter 6 (11.3 to 15.5 mm).'
	Morphology: pelvic buds appear (9.4[5] mm or 10.3 ' mm); 11 to 12 pectoral fin rays, 4 to 5 spines in spinous dorsal fin (9.4 mm), cfalcate anal fin I,22 to 25 (15 mm);[5] caudal fin complete (11.3 to 15.5 mm), body elongate and slender;' preanal finfold visible, soft dorsal fin with 10 or 11 rays (16.5 mm). [5]
	Pigmentation: dorso-lateral rows of small melanophores forming behind head (10.3 mm);' extending to posterior margin of soft dorsal fin (14 to 15.5 mm);' * midlateral line of dark pigment present (14 to 16.5 mm);[5] * additional pigment on dorsum of coelomic cavity and venter of gut, all fins except pelvic fins have some pigment.'

JUVENILES

Total length	Description
16-43 mm	Myomeres: 36 to 39 (14 to 15 + 24 to 25) at 17.4 to 42.9 mm.[5] Morphometry: (as % TL) preanal length 41 to 42;[5,9] head length 20, eye diameter 6 or 7 (20.1 to 27 mm).[9,12] Morphology: teeth visible, scales begin to form on caudal peduncle (20.1 mm), squamation from caudal peduncle to pelvic fin (24 mm);[9] snout becoming beak-like (17.4 to 42.9 mm);[5,12] caudal fin forked (27 mm).[12] Pigmentation: midlateral band of melanophores begins to form.[5,9]

ADULTS

Fin rays: caudal 17;* first dorsal IV, second dorsal I,10 to 11, anal I, 23 to 27, pectoral 12 to 13, pelvic I,5.[1]

Vertebrae: 40 to 43.[1]

Lateral line scales: 95.[1]

Diagnostic characters: snout long and pointed, snout length much greater than postorbital head length, mouth relatively large, beak-like, gape terminating in advance of eye, origin of spinous dorsal fin usually in advance of, or almost directly above, origin of anal fin, anal fin long and falcate, gill rakers long and slender, 24 to 29.

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1. Scott and Crossman (1973)
2. Hubbs (1921)
3. Hogue et al. (1976)
4. Nelson J. S. (1968c)
5. Frietsche et al. (1979)
6. Cahn (1927)
7. Becker (1976)
8. Hubbs and Lagler (1958)
9. Rasmussen (1980)
10. Adams and Hankinson (1928)
11. Emery (1976)
12. Fish (1932)

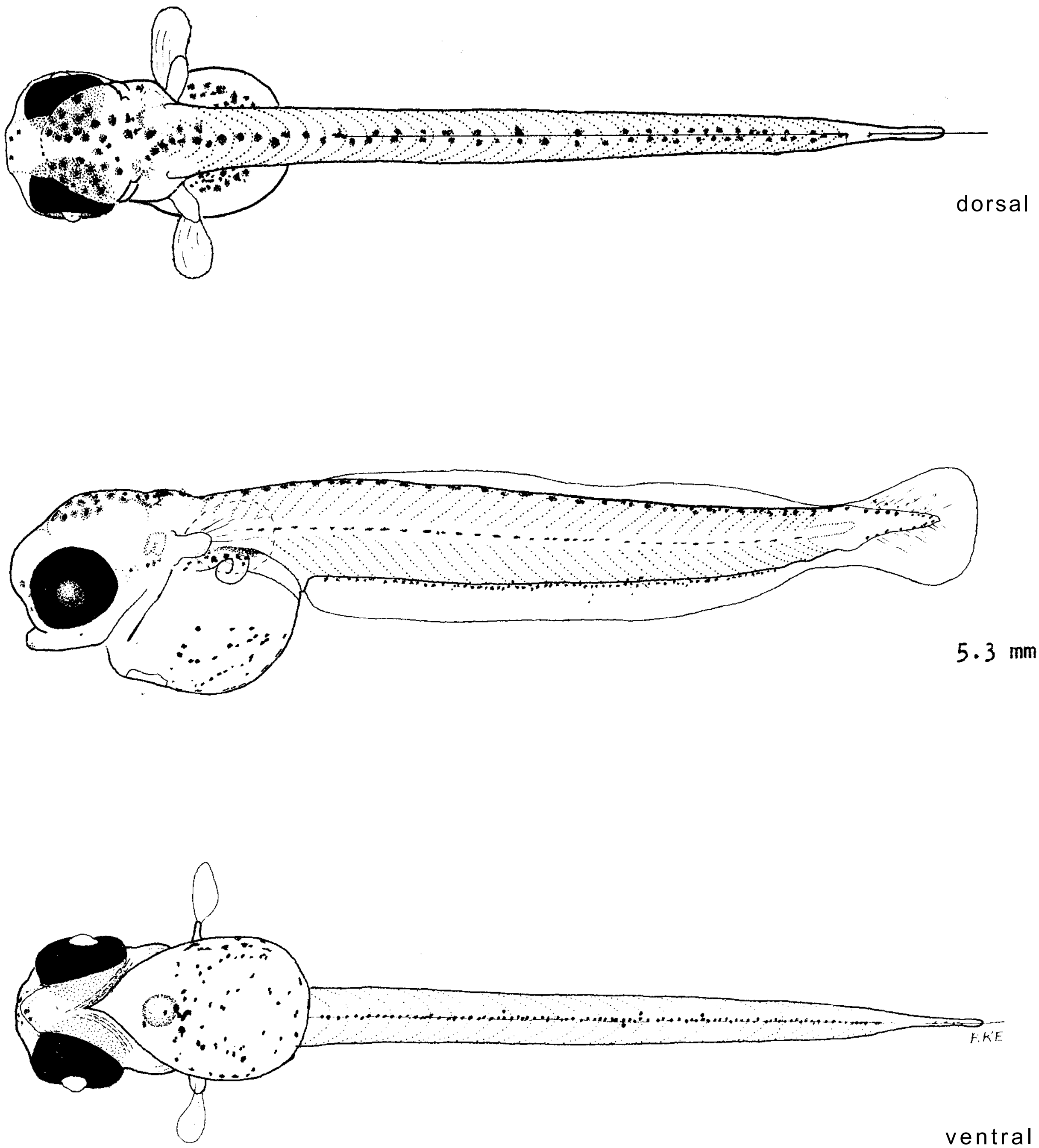

Fig. 203. Labidesthes sicculus, brook silverside. Yolk-sac larva. (Wild-caught, Florida, Rasmussen 1980).

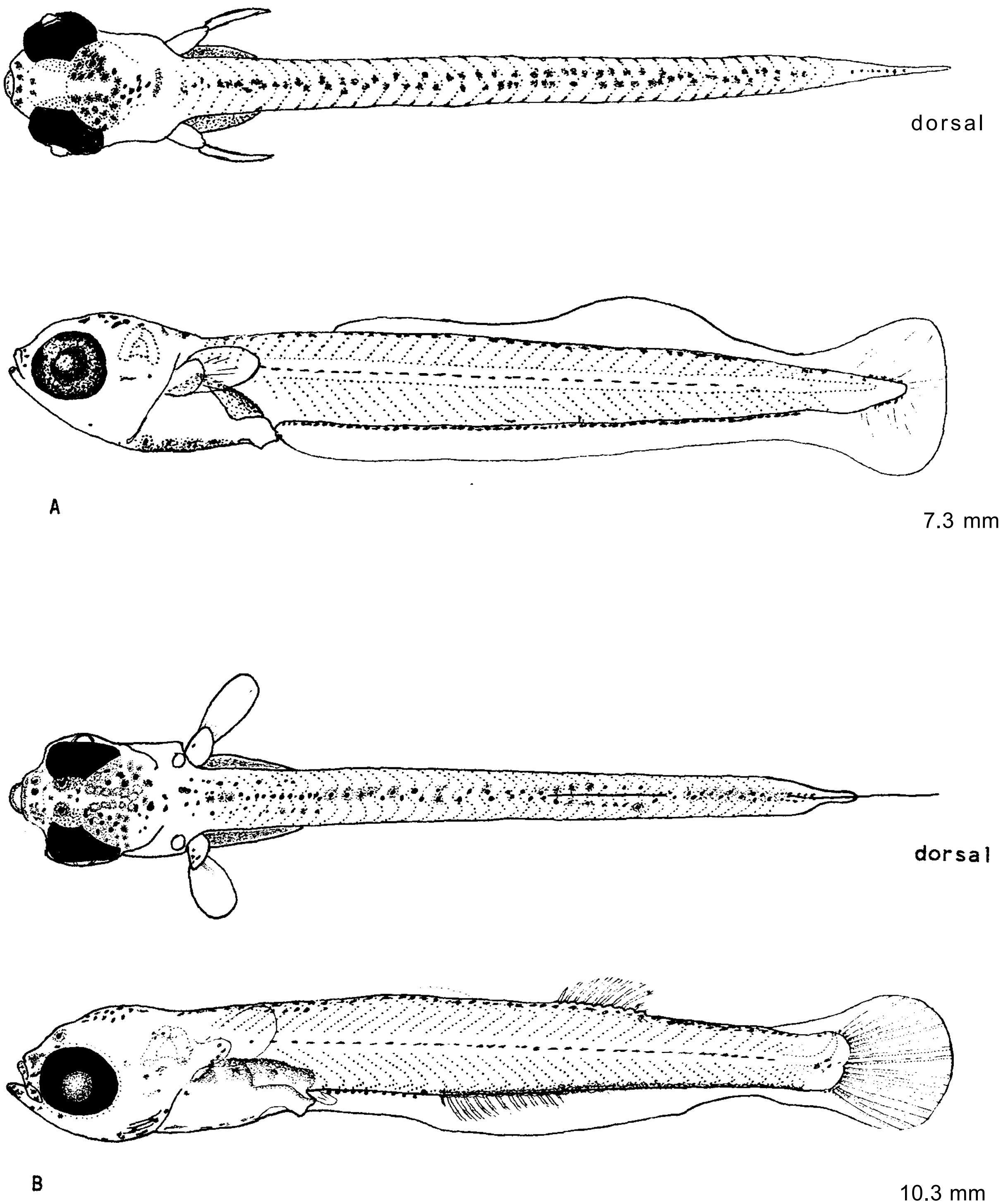

Fig. 204. Labidesthes sicculus, brook silverside. A and B. Larvae. (A and B, wild-caught, Florida, Rassmussen 1980).

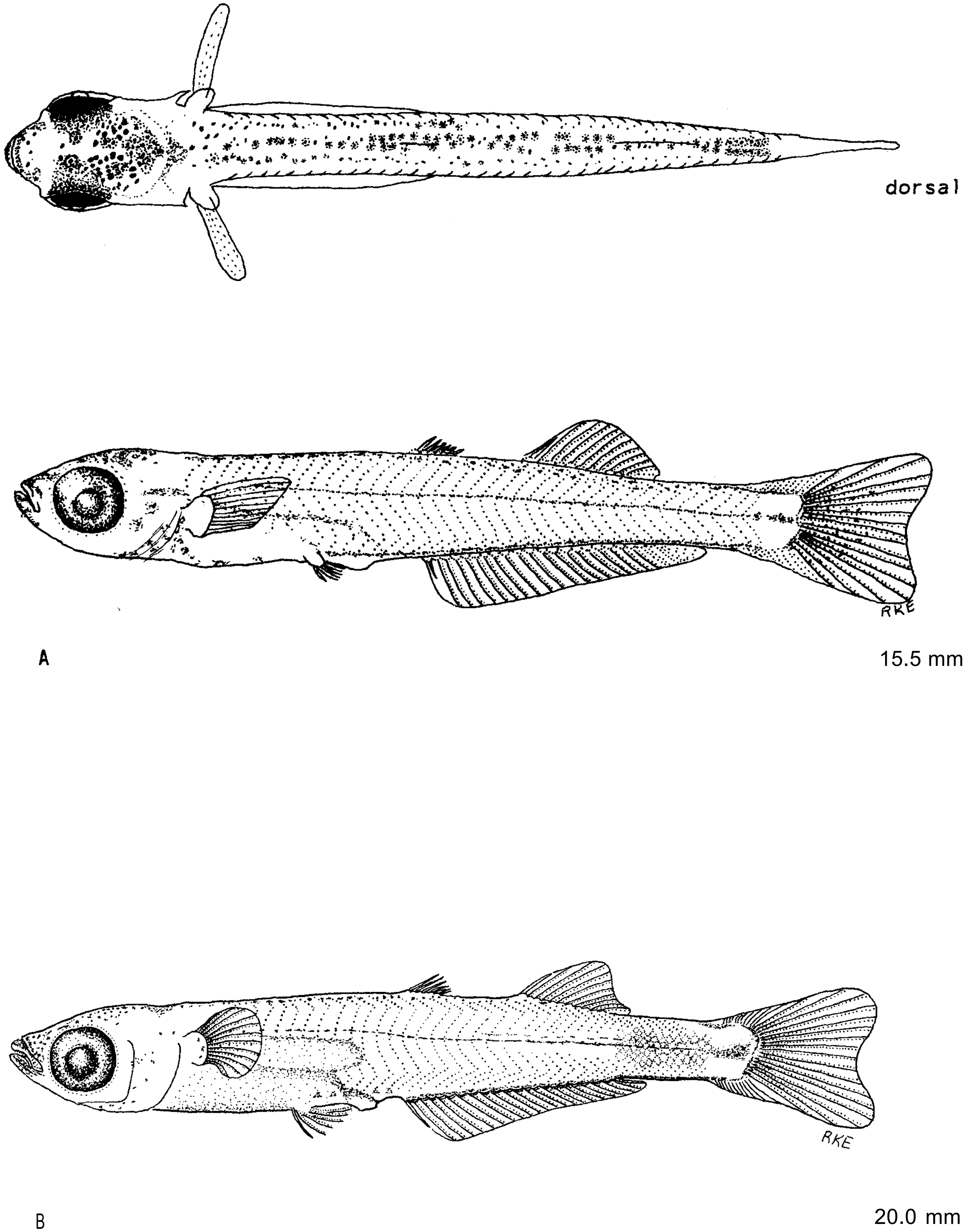

Fig. 205. Labidesthes sicculus, brook silverside. A. Larva. B. Juvenile. (A and B, wild-caught, Florida, Rasmussen 1980).

Family Gasterosteidae, sticklebacks

By

George R. Heufelder

Members of the Gasterosteidae are generally small, fusiform fishes with a slender caudal peduncle and well developed dorsal and pelvic spines. The mouth is small with numerous well developed teeth. Sticklebacks are found throughout most of the northern hemisphere. The family consists of five genera and about eight species, three of which inhabit the Great Lakes basin.

The most widespread species of stickleback known from the basin is the brook stickleback, Culaea inconstans (Kirtland). This species ranges throughout all of the basin where it generally inhabits cold, clear, densel y vegetated streams and spring-fed ponds and is less frequently encountered in larger lake habitats. The brook stickleback is a freshwater species but is tolerant of various salinity levels.

The ninespine stickleback, Pungitius pungitius (Linnaeus), is found throughout the Great Lakes basin with the exception of Lake Erie. Unlike the brook stickleback, this species is commonly found in the open water habitat of the Great Lakes. Ninespine sticklebacks enter salt water in many areas.

Perhaps the most studied species of stickleback is the threespine stickleback, Gasterosteus aculeatus Linnaeus. The distribution of this species in the Great Lakes basin was previously restricted to Lake Ontario and its basin; however, it has recently been reported from Lake Huron (D. W. Gibson personal communication). Adult threespine stickleback exhibit considerable variation in the number and distribution of lateral plates throughout their range. This has resulted in the recognition of at least three forms or morphs. The complete morph, trachurus, has an uninterrupted row of plates from the shoulder girdle to the caudal peduncle, where it forms a lateral keel. The low morph, leirus, has anterior plates only. The intermediate form, semiarmatus, has anterior and peduncular plates, with a plateless gap between. In Lake Ontario, a landlocked population of the trachurus form exists (Wootton 1976).

The peculiar reproductive behavior of sticklebacks has made them the subject of intense study. Male sticklebacks of all three species of the Great Lakes region build nests of pieces of debris or substrate. Nests may be spherical to tubular and generally have an entrance and an exit. Nests are suspended on various structures or vegetation or may be built on the bottom. The nest is held together by a secretion of the kidney. The male attends the nest, protecting it from predators and circulating water through the nest by fanning or by pushing water through its mouth. Eggs generally adhere to each other, and if they are displaced from the nest are returned by the male. When larvae hatch and begin to disperse the male returns them to either the nest or a small nursery area of loosely packed debris constructed by the male, until he can no longer contain them.

Although the three regional sticklebacks have been the subject of much behavioral study, larval descriptions are scarce, with the exception of the threespine stickleback. Brook and ninespine sticklebacks are common in the Lake Michigan drainage, but have not been previously described from there. Larvae of these species probably hatch at approximately 5.0 mm and, due to the tendency to remain near nests, may not be vulnerable to capture by traditional larval fish sampling gear. Until a size of approximately 7.5 mm, there is no known character to separate *Pungitius pungitius* from *Culaea inconstans*.

Culaea inconstans (Kirtland), brook stickleback

DISTRIBUTION

This species occurs throughout the Great Lakes basin.' [2] In the Lake Michigan drainage it is common with the exception of the southern tip where it is rare to absent.'

SPAWNING SEASON

Spawns in late April or early May to June in southern Michigan and to July in northern Michigan.' Spawning extends from late March or early April to June in Minnesota[4] and April to May in New York.[6]

SPAWNING TEMPERATURE

Minimum temperature at which spawning has been observed is 8 C.[4] Spawns most commonly between 15 to 19 C,[3] but spawning is inhibited above 19 C.[3] Nesting was observed at 4.5 to 10 C.[6]

SPAWNING HABITAT

Spawns in heavily vegetated, lentic habitats[3 5] including ditches where water velocity is 8.0 cm/s or less.5 Nests are made in water 10 to 30 cm deep[4] and are constructed under some type of cover (overhanging banks, dead leaves, etc.)[4] or in the open.[3]

SPAWNING SUBSTRATE

Males construct spherical nests, 15 to 50 mm in diameter[3 4] of fibro-vascular bundles of plants (some monocots),[4] organic debris, algae, small sticks, duckweed or other materials." [4] The nest is attached to branched twigs or aquatic plant stems just above the bottom.[3 4] The bottom is organic debris, sand or a combination of both.[3]

FECUNDITY

Ca. 250 eggs laid at a single spawning.[4]

EGGS

Demersal and adhesive;[3 6] diameter 1.0[6] to 1.3 mm;[4] colorless;[4 6] or light yellow;[6] incubation period: 8 to 9 days at 18.4 C;[6] 203 to 232 hours at 16 to 17 C, 220 to 259 hours at 17 to 18 C.[3]

YOLK-SAC LARVAE

Total length	Description
ca. 5 mm	Newly hatched.[6]
5-6 mm	Myomeres: 30 to 32 (14 to 16 + 15 to 18) .*

Morphometry: (as % TL) preanal length 51 to 54, head length 22 to 24, greatest body depth 16 to 17, body depth at anus 7 to 8, (as % head length) eye diameter 46 to 50, snout length 8 to 17.*
Morphology: yolk inconspicuous, most obvious on specimens 5.1 to 5.5 mm, barely visible (5.9 mm), snout blunt (< 5.3 mm), appearing pointed (> 5.5 mm), pectoral buds flap-like, actinotrichia evident (ca. 5.5 mm), mouth well developed and oblique, urostyle straight or slightly flexed (5.1 mm).*
Pigmentation: many small chromatophores over dorsal and dorso-lateral surface of head and dorsum of body except a middorsal band devoid of melanophores, dorso-lateral aspect of yolk and gut with scattered melanophores, midventral band of melanophores on gut which continues posteriorly to anus, patch of melanophores over swim bladder extends on dorso-lateral aspect of gut to anus, midventral series continues to caudal fin, single series of melanophores outlines venter of gill arches, widely spaced series of melanophores marks lateral line (5.5 to 5.7 mm).*

LARVAE

Total length	Description
6-8 mm	Myomeres: see 5-6 mm. Morphometry: (as % TL) preanal length 51 to 54, head length 22 to 25, greatest body depth 16 to 17, body depth at anus 8 to 9, (as % head length) eye diameter 37 to 44, snout length 11 to 23.* Morphology: urostyle flexed and notably elongate (7.3 mm) extending nearly to tip of finfold, actinotrichia evident in caudal fin (6.9 to 8.0 mm), finfold origin at myomere five.*
9-16 mm	Myomeres: see 5-6 mm. Morphometry: (as % TL) preanal length 50 to 53, head length 24 to 28, (as % head length) eye diameter 33 to 39, snout length 20 to 21.* Morphology: second dorsal and anal fin rays formed (ca. 10.2 mm), dorsal spines evident (ca. 12.5 to 14 mm), pelvic buds evident (12.5 to 16.0 mm).*

JUVENILES

Total length	Description
18 mm	Morphology: preanal and caudal finfolds persist.* Pigmentation: numerous small chromatophores over entire body, many outlining myosepta giving dusky brown appearance, five to seven lateral bands apparent, fin rays and membranes have many small chromatophores.*

ADULTS

Fin rays: caudal 12, dorsal V (IV to VII), 9 or 10 (8 to 12), anal 1,9 to 11 (9 to 12), pectoral 9 to 11, pelvic I,1.[1]

Vertebrae: 29 to 35.[1]

Diagnostic characters: dorsal spines usually five or six, scarcely divergent, tail without keel, caudal peduncle deeper than wide, caudal fin rounded, gill membrane confluent, forming a broad free fold across isthmus,

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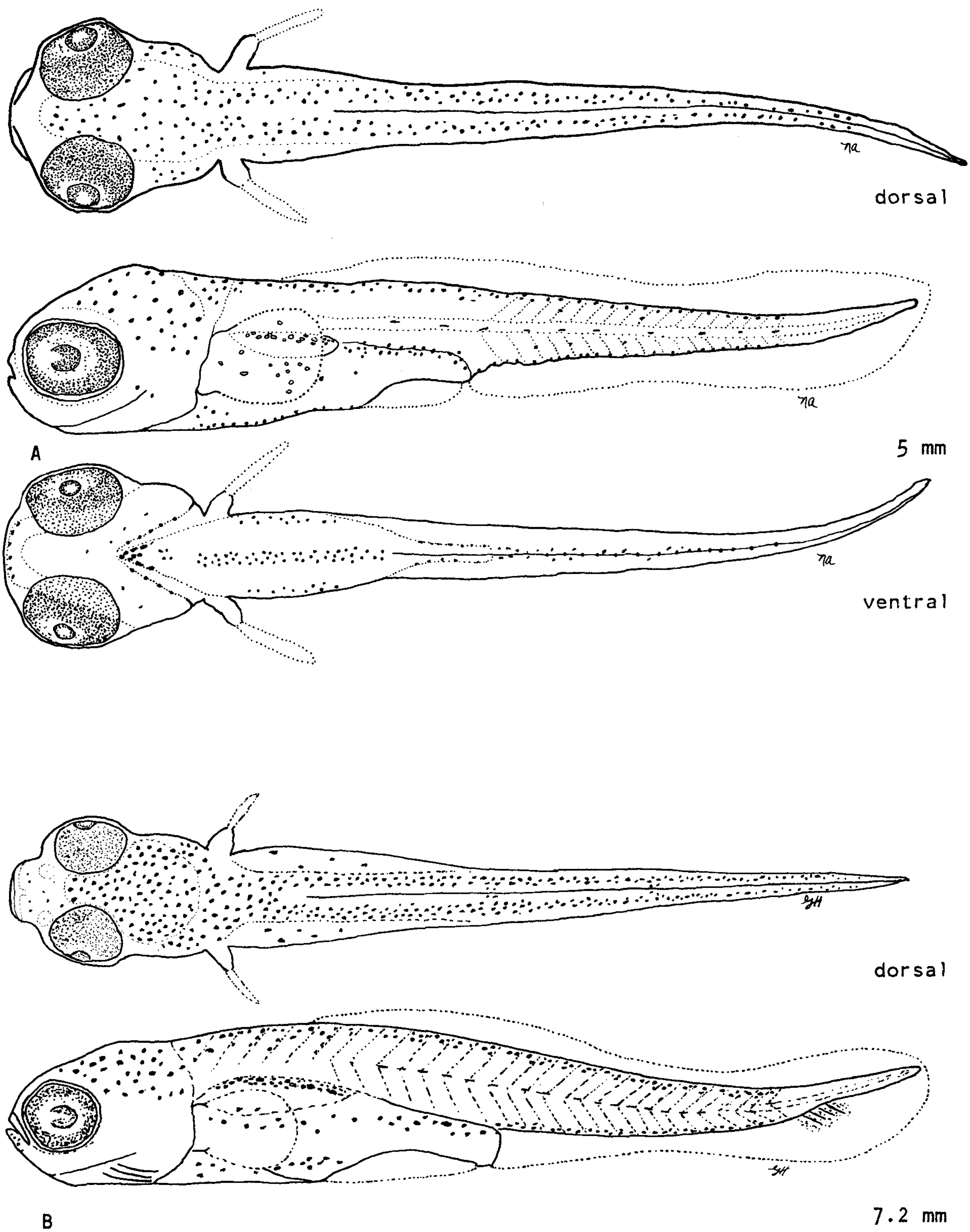

Fig. 206. Culaea inconstans, brook stickleback. A. Yolk-sac larva. B. Larva. (A and B, wild-caught, Michigan, original illustrations by N. A. Auer and G. R. Heufelder).

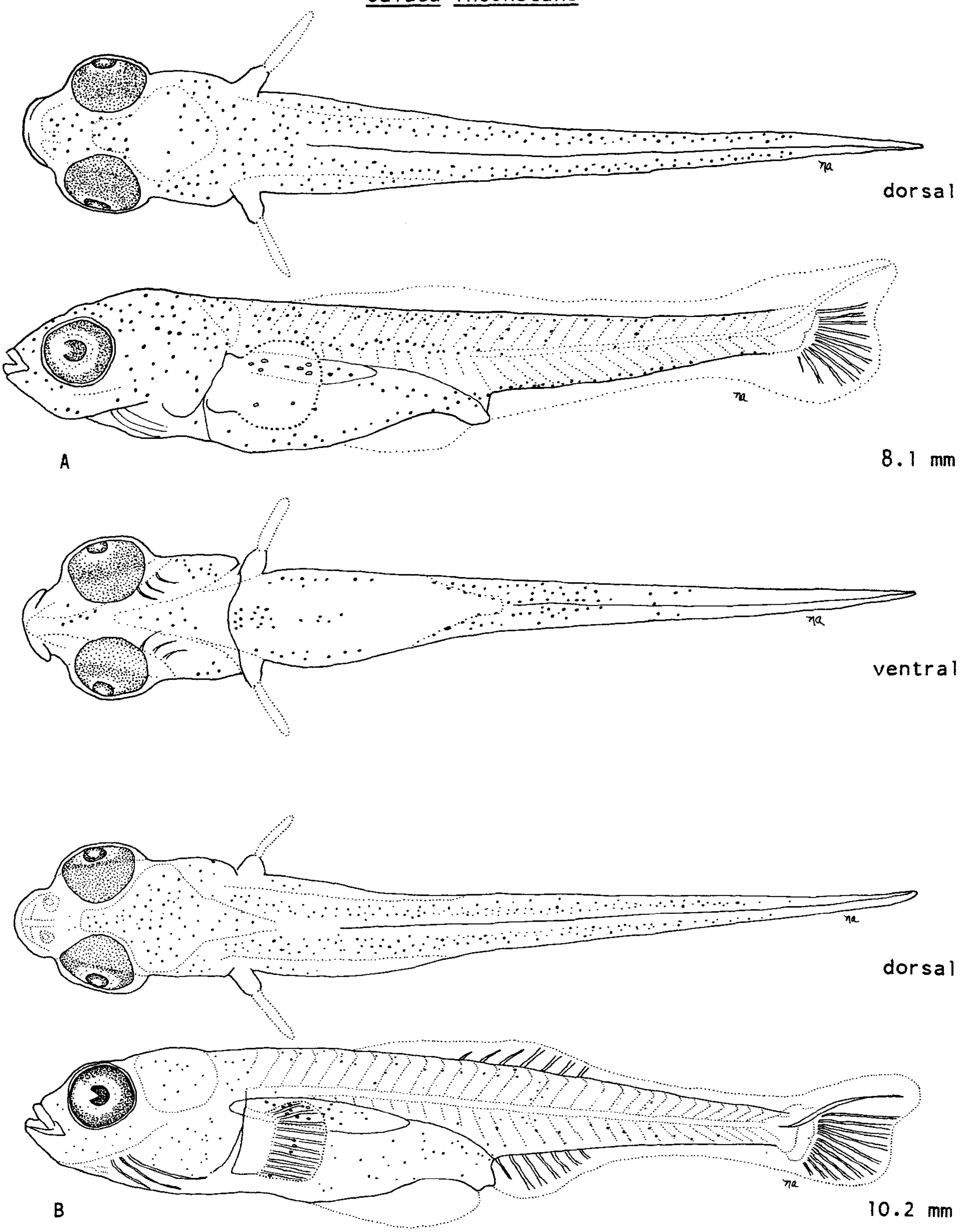

Fig. 207. Culaea inconstans, brook stickleback. A and B. Larvae. (A and B, wild-caught, Michigan, original illustrations by N. A. Auer).

Gasterosteus aculeatus Linnaeus, threespine stickleback

DISTRIBUTION

In the Great Lakes basin reported only from Lake Ontario and it's basin,[1,2] but recently observed in Lake Huron.[10]

SPAWNING SEASON

Spawns in June or July in Canada.[1]

SPAWNING TEMPERATURE

Spawns at temperatures from 14 to 22 C.[4,c]

SPAWNING HABITAT

Spawns in rivers,[4] streams,[4,5] ditches and backwaters,[3] with currents from 3 to 6 cm/s at an average depth of 50 cm.[4]

SPAWNING SUBSTRATE

Spawns on a sand bottom[4,5] where the male constructs a nest of plant fibers, grass roots (usually fresh), bits of leaves, stems or twigs[4,5] or other available material.[3] May spawn within or just downstream from patch of Elodea.[1]

FECUNDITY

157 to 292.[4]

EGGS

Demersal, adhesive to each other, spherical, diameter 1.5 to 1.9 mm;[6,7,8,9] pale yellow to light-tan yellow when freshly laid;[6] attaining a light-yellow brown hue[6,8] or colorless;[8] oil globules 12 or more;[8,9] 25 or more;[6] diameter to 0.73 mm;[6] tending to merge during incubation;[8] incubation period: ca. 6 days at 17 C;[6] 6 to 8 days at 18 to 19 C.[7]

YOLK-SAC LARVAE

Total length	Description
3-6 mm	Newly hatched;[6,7,9] (3.0[7] to 4.9 mm[6,9]). Morphometry: preanal length greater than 50% SL.[9] Morphology: mouth open[7] or closed (newly hatched);[6] median finfold origin over middle of yolk, preanal finfold evident;[6,7,9] eye large[6,7] otoliths present;[6] pectoral buds fan-like;[6] half of yolk absorbed (4.0 mm).[7]

Pigmentation: body yellowish;[6 9] large melanophores more or less closely aggregated on dorsum of body, rest of body covered with smaller melanophores.[7 9]

LARVAE

Total length	Description
6-10 mm	Morphology: yolk absorbed (ca. 6.0 mm[7] or 7.0 to 7.5 mm[6 9]); finfold continuous, rudiments of caudal fin rays evident, swim bladder and gill cover developed, intestine elongate, jaws and mouth developed (ca. 6.0 mm);[7] head sharply defined, mouth functional (7.0 to 7.5 mm);[6 9] eyes fully developed, choroid fissure disappears, constriction in finfold indicates position of median fins, notochord flexed, ventral lobe prominent with caudal fin rays formed, basal thickenings in dorsal and anal fins, pelvic fin spines formed, snout elongate, lateral line visible (ca. 8.0 mm), dorsal and anal fins separate from caudal fin, becoming triangular, rays in dorsal, anal and pectoral fins, third dorsal and first anal fin spine formed (9.5 mm).[7]

JUVENILES

Total length	Description
ca. 11 mm	Morphology: preanal finfold persists (described from illustrations).[7]
16-17 mm	Morphometry: (as % TL) standard length 85, preanal length 59, head length 30, (as % head length) snout length 32, eye diameter 33.[5] Morphology: caudal peduncle short, slender, distinctly keeled, bony plates not obvious;[5] plates appear (2 months posthatching). Pigmentation: body greenish, chromatophores dense on dorsum of head and in about 10 short patches along dorsal ridge, five patches of chromatophores on lateral line connected more or less with dorsal pigment by oblique bars, pigment patches in tail region meet venter, few chromatophores on fins, except near dorsal spine and distal portion of caudal fin.[5]

ADULTS

Fin rays: caudal 12, dorsal III (rarely IV), 11 to 13 (rarely 10 or 14), anal I,8 to 10, pectoral 10 to 12, pelvic I,1.[1]

Vertebrae: 31 to 33 (rarely 29 or 30).[1]

Diagnostic characters: dorsal spines three (rarely two or four), pelvic skeleton with large, wide median posterior process.

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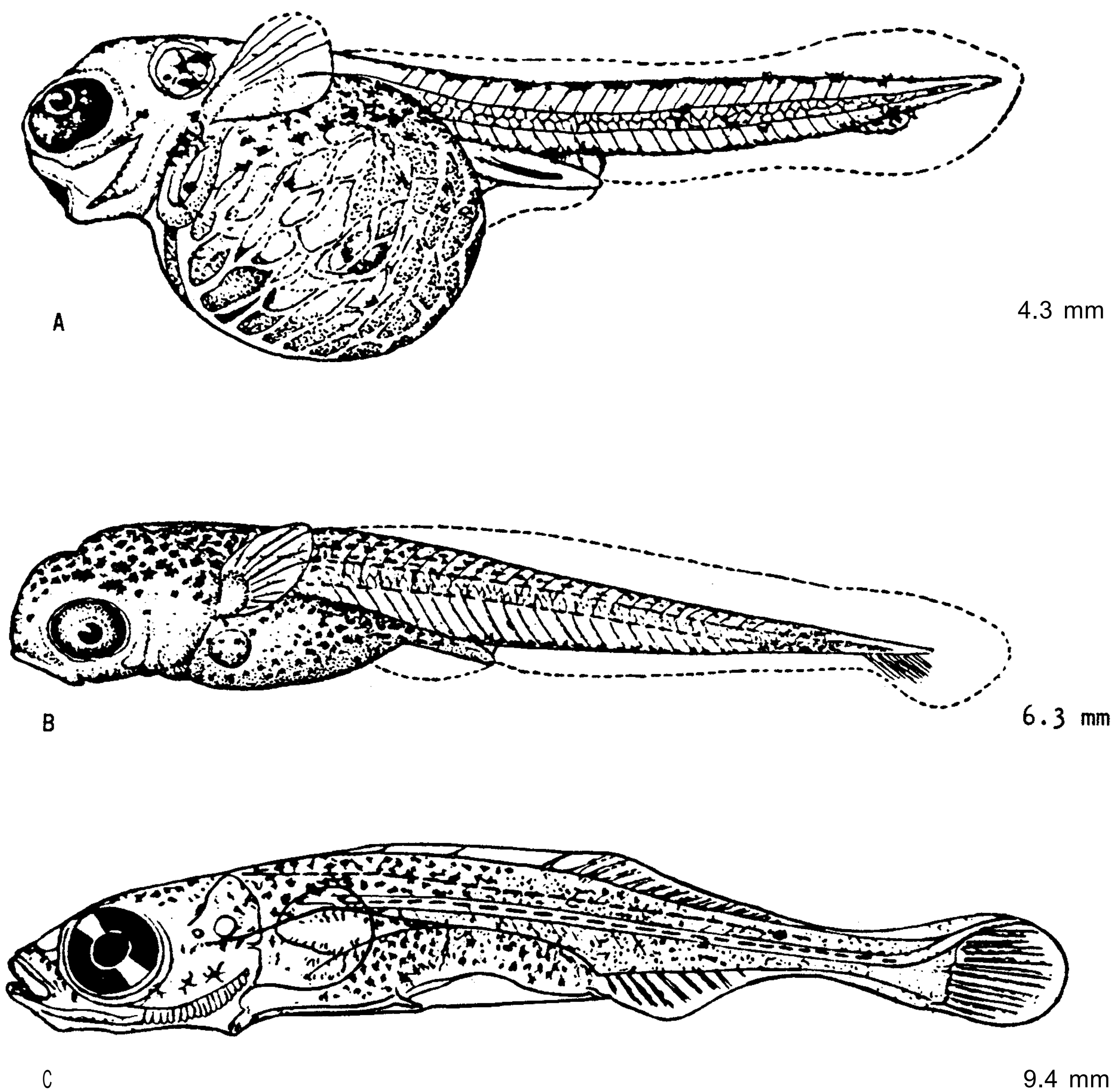

Fig. 208. Gasterosteus aculeatus, threespine stickleback. A and B. Yolk-sac larvae. C. Larva. (A and B, wild-caught, Massachusetts, Kuntz and Radcliff 1918; C wild-caught, Germany, Ehrenbaum 1909).

Pungi tius pungitius (Linnaeus), ninespine stickleback

DISTRIBUTION

This species occurs in all of the Great Lakes except Lake Erie.[1 2]

SPAWNING SEASON

Spent females were found from early June to mid-July in Lakes Superior[3] and Michigan.* Nests were observed in Lake Huron sometime between 1 May and 1 July.[5] Fully ripe individuals were found from April to August in Crooked Lake, Indiana (Mississippi River drainage).[4]

SPAWNING TEMPERATURE

Spawning peaks at 11 to 12 C.[6] Ripe and spent females were collected at 14.8 to 16.0 C in Lake Michigan.* Nesting was observed at temperatures between 9.5 and 16.5 C in Lake Huron.[5]

SPAWNING HABITAT

Spawns in vegetated areas of lakes and rivers.'

SPAWNING SUBSTRATE

Males construct a tubular to spherical nest, approximately 4 cm long, of various types of debris and plant material.' Nests may be attached to vegetation and suspended off the bottom or may be on or partly beneath the bottom.' In Lake Huron, this species builds nests of algae and other debris, between or under rocks.[5]

FECUNDITY

61 to 111.[3]

EGGS

Demersal, adhesive;' diameter 1.5 to 1.9 mm;[3 8 9] colorless to straw colored;[8] oil globules 12 or more, moderately sized, tending to merge during incubation;'[9] incubation period: 5 days at 12 C.[6]

YOLK-SAC LARVAE

Total length	Description
5-6 mm	Newly hatched (4.9 to 5.7 mm).[6 9] Myomeres: 30 (14 + 16).* Morphometry: (as % TL) preanal length 52 to 53, head length 21 to 22.*

Morphology: swim bladder formed, mouth distinctly terminal, lower jaw formed (5.7 mm), notochord straight or slightly flexed, yolk may contain a few oil globules.*

Pigmentation: numerous melanophores over entire dorsum of head, body and gut (5.2 mm), dense band of melanophores on venter from heart to midgut, continues to anus as broken series, ventro-lateral band of melanophores originates midventrally in heart region and proceeds posteriad to midgut area.*

7-9 mm

Myomeres: 31 to 33 (14 to 16 + 16 to 18).[10] *

Morphometry: (as % TL) standard length 96 to 99, preanal length 51 to 58, head length 20 to 24;[10] * snout length 2 to 6, eye diameter 7 to 9, greatest body depth 15 to 19, body depth at anus 7 to 10.[10]

Morphology: yolk sac twice as long as deep, occasionally containing oil globules in anterior portion, four pairs of gill arches visible under opercle, all three branchiostegal rays present, gut developed and functional (8.9 mm); 10 zero to five caudal fin actinotrichia evident.[10]

Pigmentation: much as in previous stage, with 9 or 10 bands of melanophores on dorsum posterior to head (7.2 mm);[10] * additional bands evident (8.9 mm);[10] one short ventral line of melanophores on each side of dentary near articulation with maxilla, melanophores scattered over interorbital and occipital regions and between maxilla and eye, internal melanophores on isthmus (7.2 to 7.6 mm) appearing external (7.7 to 8.0 mm);[10] midventral band of pigment (7.5 mm), becoming less distinct (8.5 mm) as ventral pigment appears more scattered.*

LARVAE

Total length	Description
11-12 mm	Morphometry (as % TL) preanal length 52, head length 20.*

Morphology: yolk absorbed (7.2 to 8.2 mm);[10] caudal and pectoral fin rays formed, anal fin spine and seven actinotrichia evident, last dorsal fin spine with more anterior spine position indicated by slight concentrations of mesenchyme, soft dorsal fin rays indicated by five to seven actinotrichia, pelvic buds not formed;* dorsal origin of median finfold over anterior of swim bladder, preanal finfold persists, notochord extends to edge of finfold, body much resembles adult at this stage.*

Pigmentation: dorsal bands persist, ateral banding evident but less distinct, pigment on venter scattered and sparse, no definite pattern.*

Pungitius Pungitius

JUVEN I LES

Not described.

ADULTS

Fin rays: caudal 12 (12 to 13), dorsal IX (VIII to XI), anal I,8 to 10 (rarely 11), pectoral 10 to 12, pelvic I,1.[1]

Vertebrae: 32 to 34 (rarely 30, 31 or 35).[1]

Diagnostic characters: dorsal fin spines usually nine, short and inclined alternately to left and right, gill membranes united, but entirely free from isthmus.

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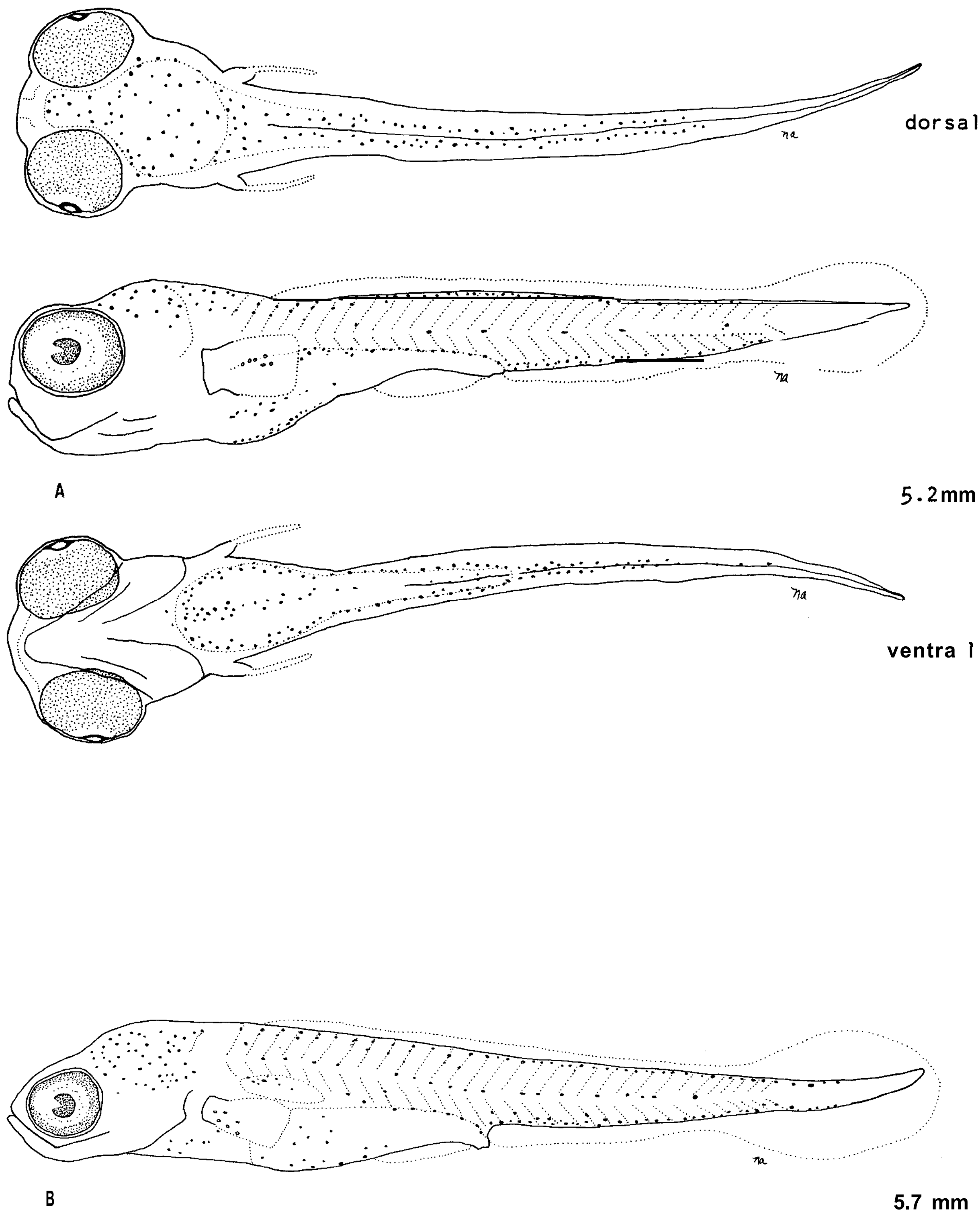
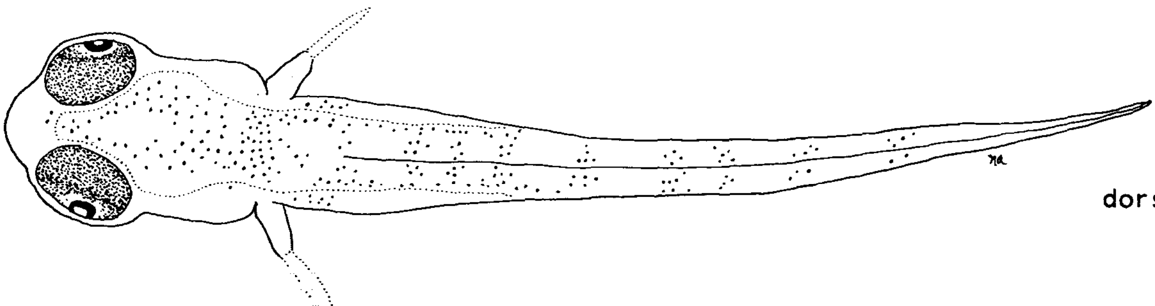
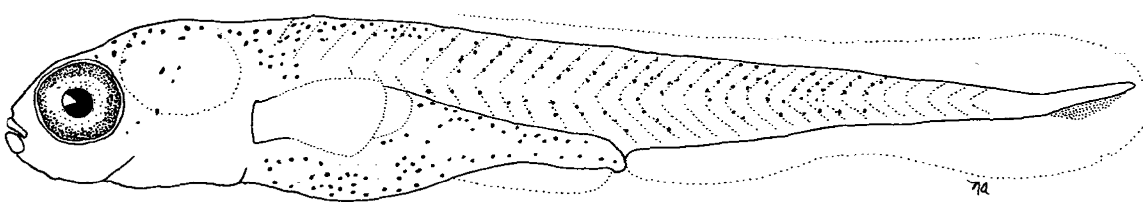


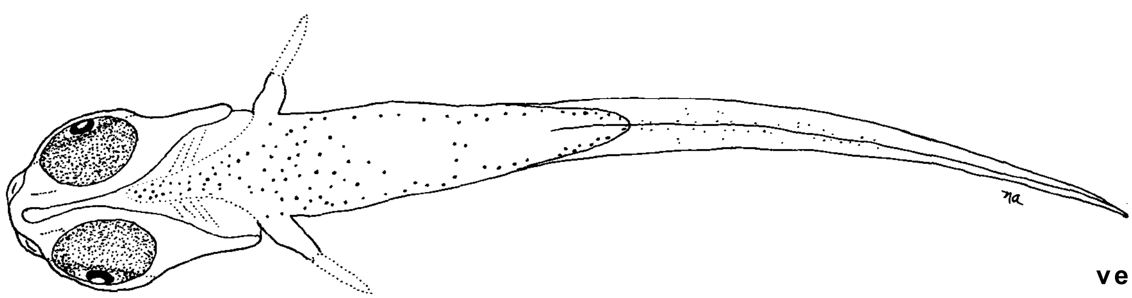
Fig. 209. Pungitius pungitius, ninespine stickleback. A and B. Yolk-sac larvae. (A and B, wild-caught, Lake Michigan, original illustrations by N. A. Auer).



dorsal



7.5 mm



ventral

Fig. 210. Pungitius Pungitius, ninespine stickleback. Yolk-sac larva. (Wild-caught, Lake Huron, original illustrations by N. A. Auer, specimens provided by R. P. Rassmussen).

<u>Pungitius pungitius</u>

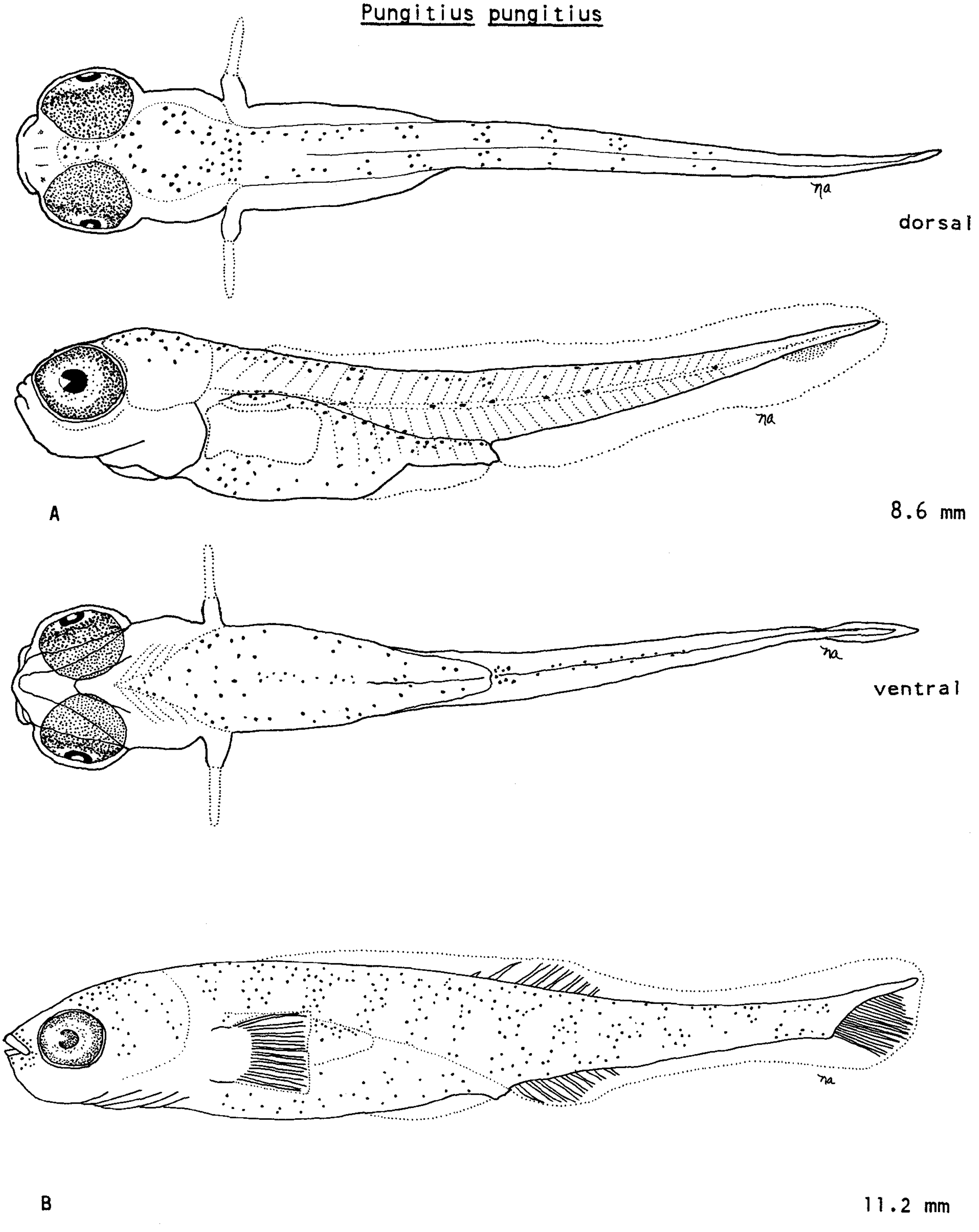


Fig. 211. Pungitius pungitius, ninespine stickleback. A. Yolk-sac larva. B. Larva. (A and B, wild-caught, Lake Michigan, original illustrations by N. A. Auer).

Family Percichthyidae, temperate basses

By

Lee A. Fuiman

Percichthyids are found in temperate and tropical waters worldwide. They inhabit marine, estuarine and freshwater systems. There are about 40 species in 17 genera (Hardy 1978). The predominant genus in North America is *Morone*. Three species have been reported from the Great Lakes region. One, 5. *americana*, has invaded the Great Lakes through the St. Lawrence River from its estuarine stocks in the Atlantic Ocean (Scott and Christie 1963).

Temperate basses, once included in the family Serranidae (sea basses), usually have two opercular spines (true serranids have three). Percichthyids in the Great Lakes have three anal fin spines and the spinous first dorsal fin is entirely separated, or nearly so, from the predominantly soft-rayed second dorsal fin.

The local species spawn in the spring in shallow water, over a variety of substrates. Their eggs are small (0.7 to 1.0 mm), demersal and adhesive. Larvae are also quite small, hatching at approximately 1 to 3 mm TL. They are transparent and have little pigmentation. The anus is positioned near midbody and there are 25 (13 + 12) myomeres. Specific identification of *Morone* larvae is likely to be a problem only in the lower Great Lakes (Ontario and Erie) where 1. *americana* and 5. *chrysops* occur together. Separation of these species as larvae, using morphological characters, is impossible with information currently given in the literature.

Morone americana (Gmelin), white perch

This species, unlike the other local representatives of the family, is primarily estuarine. Much of the literature dealing with its development pertains to marine or estuarine stocks. There may be significant differences between these and freshwater populations. (I have not found a published account of such a comparison.) Therefore, the reader is urged to consider this possibility when consulting this species account.

DISTRIBUTION

This species occurs in Lakes Ontario and Erie but does not occur in the remaining Great Lakes.[1 12]

SPAWNING SEASON

Spawns from mid-May to late June in Lake Ontario.[2]

SPAWNING TEMPERATURE

Spawns between 11 and 15 C.[2 4] Estuarine populations often spawn at higher temperatures of 18 to 20 C.[7 17]

SPAWNING HABITAT

Spawns in shallow water, less than 1 m to 3.7 m,[3 7] of quiet ponds,* lakes and rivers.[11 14]

SPAWNING SUBSTRATE

Spawns over gravel or shoals[11 14] or shows no preference.[3]

FECUNDITY

5,210 to 321,000.[2 17]

EGGS

Demersal, adhesive;[8 9 13 14 19] diameter 0.7 to 0.8 mm;[9 13 16 18 19] but as large as 0.9 to 1.0 mm;[4 13 15] single attachment disc on chorion;[19] yolk diameter 0.5 to 0.9 mm, perivitelline space less than 30% of diameter, yolk amber or whitish-yellow;[13] oil globule usually single;[13 18 19] sometimes many small globules present, oil globule amber, diameter 0.2 to 0.4 mm;[13] incubation period: 51 to 58 hours at 9 to 20 C;[18] 6 days at 11 to 12 C;[9 14 16] 70 to 73 hours at 11 to 22 C;[18] 4 to 4.5 days at 14 C;[4] 48 to 52 hours at 16 C;[15] 44 to 54 hours at 17 C;[13] 44 to 50 hours at 18 C;[18 19] 44 to 52[13] or 30[4] hours at 20 C; 34 to 42 hours at 22 to 25 C.[18]

YOLK-SAC LARVAE

Total length	Description
1.7-3.0 mm	Newly hatched;[13] mean: 2.3;[9 10 14 16] 2.6[13] or 2.8 mm.[19] Myomeres: (mean values) ca. 25 (12.6 to 14.0 + 10.0 to 11.6).[13] Morphometry: (as % TL) preanal length 57 to 65, head length 15 to 18, eye diameter 8 to 9, greatest body depth 24 to 28.[13] Morphology: head deflected downward over yolk sac;[9 13] oil globule anterior, under head, pectoral buds absent.[13] Pigmentation: eyes not pigmented;[13] body sparsely pigmented.[10 13]
3-4 mm	Myomeres: (mean values) (12.0 to 12.5 + 11.7 to 12.4).[13] Morphometry: (as % TL) preanal length 52 to 56, head length 13 to 14, eye diameter 6 to 7, greatest body depth 15 to 18.[13] Morphology: head free from yolk sac, median finfold elevated near incipient dorsal and anal fins (3.0 to 3.5 mm), pectoral buds present (3.5 mm);[13] mouth parts[13] and swim bladder formed (3.8 mm);[13 19] first caudal fin actinotrichia and cleithrum forming (3.9 mm).[13] Pigmentation: pigment sparse, chromatophores on head;[13] anterior surface of oil globule;[10 13] posterior portion of yolk sac;[9 13 19] edges of dorsum and venter and ventrally on hindgut, eyes pigmented;[13 19] chromatophores on sides of tail;[9] chromatophores orange and brown in living specimens.[13 19]

LARVAE

Total length	Description
4-10 mm	Myomeres: (mean values) (12.0 to 12.3 + 11.5 to 12.8).[13] Morphometry: (as % TL) preanal length 49 to 57, head length 13 to 15, eye diameter 5 to 6, greatest body depth 11 to 20.[13] Morphology: yolk absorbed (3.8[13] to 4 mm;[19] 5 to 6[14] or 8 to 13 days posthatching[19]); dorsal and anal fin rays forming (8.0 to 10.0 mm);[13] first dorsal fin pterygiophore between neural spines 2 and 3, first predorsal bone slightly curved (> 8 mm).[5 20] Pigmentation; see 3-4 mm.
10-20 mm	Myomeres: (mean values) (12.0 to 13.5 + 12.5 to 13.0), usually 25 (12 + 13).[13] Morphometry: (as % TL) preanal length 50 to 56, head length 25 to 30, eye diameter 6 to 9, greatest body depth 16 to 25.[13]

Morphology: hypural bones and pelvic buds present (10.0 to 12.0 mm), first dorsal fin spines forming, second dorsal fin complete (12 mm);[13] vertebrae 25 (11 to 12 abdominal, 13 to 14 caudal);[20] pectoral fin rays forming, pelvic (13 to 14 mm), first dorsal (17 to 18 mm), and pectoral (19 to 20 mm) fins complete;[13] however all paired fin rays may not develop until 30 mm.[6]

JUVENILES

Total length	Description
20-43 mm	Myomeres: (mean values) (11.8 to 12.8 + 12.0 to 13.0), usually 25 (12 + 13).[13]
	Morphometry: (as % TL) preanal length 48 to 55, head length 26 to 31, eye diameter 7 to 10, greatest body depth 22 to 26.[13]
	Morphology: scales present (18 to 24 mm).[13]
	Pigmentation: vertical bars on dorso-lateral surface to 75 mm), faint horizontal stripes sometimes present.[13]

ADULTS

Fin rays: caudal 17, dorsal IX-I,11 to 12, anal III,8 to 10, pectoral 15, pelvic I,5.[3]

Vertebrae: 24[3] to 25.[20]

Lateral line scales: 46 to 51.[3]

Diagnostic characters: second and third anal fin spines large and nearly equal in length, dorsal fins slightly connected, preorbital bone narrow, barely overlapping upper half of maxilla.

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Morone americana

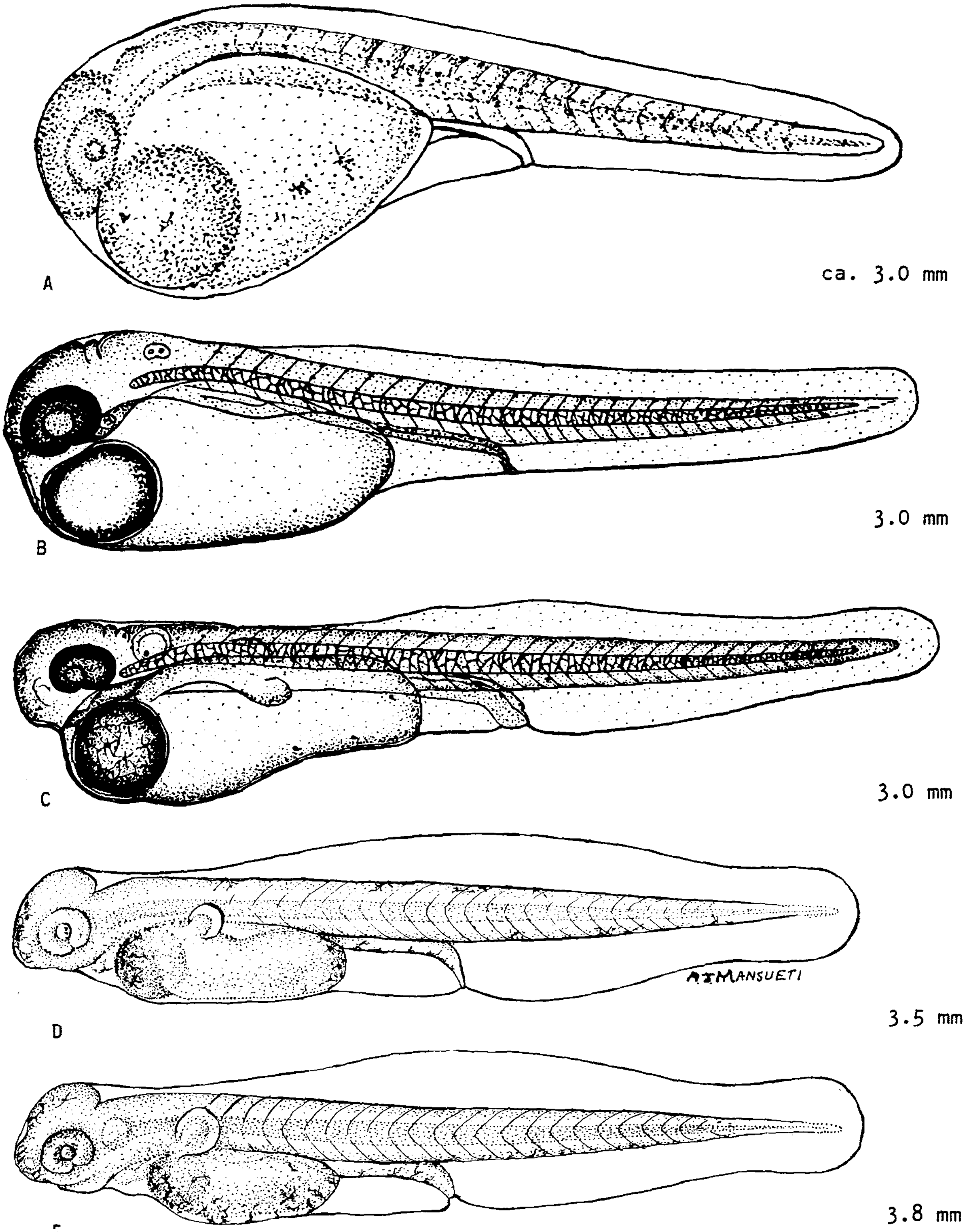

Fig. 212. Morone americana, white perch. A. Yolk-sac larva, newly hatched. B-E. Yolk-sac larvae. (A, D and E, wild-caught, Maryland, R. J. Mansueti 1964; B and C, Ryder 1887) .

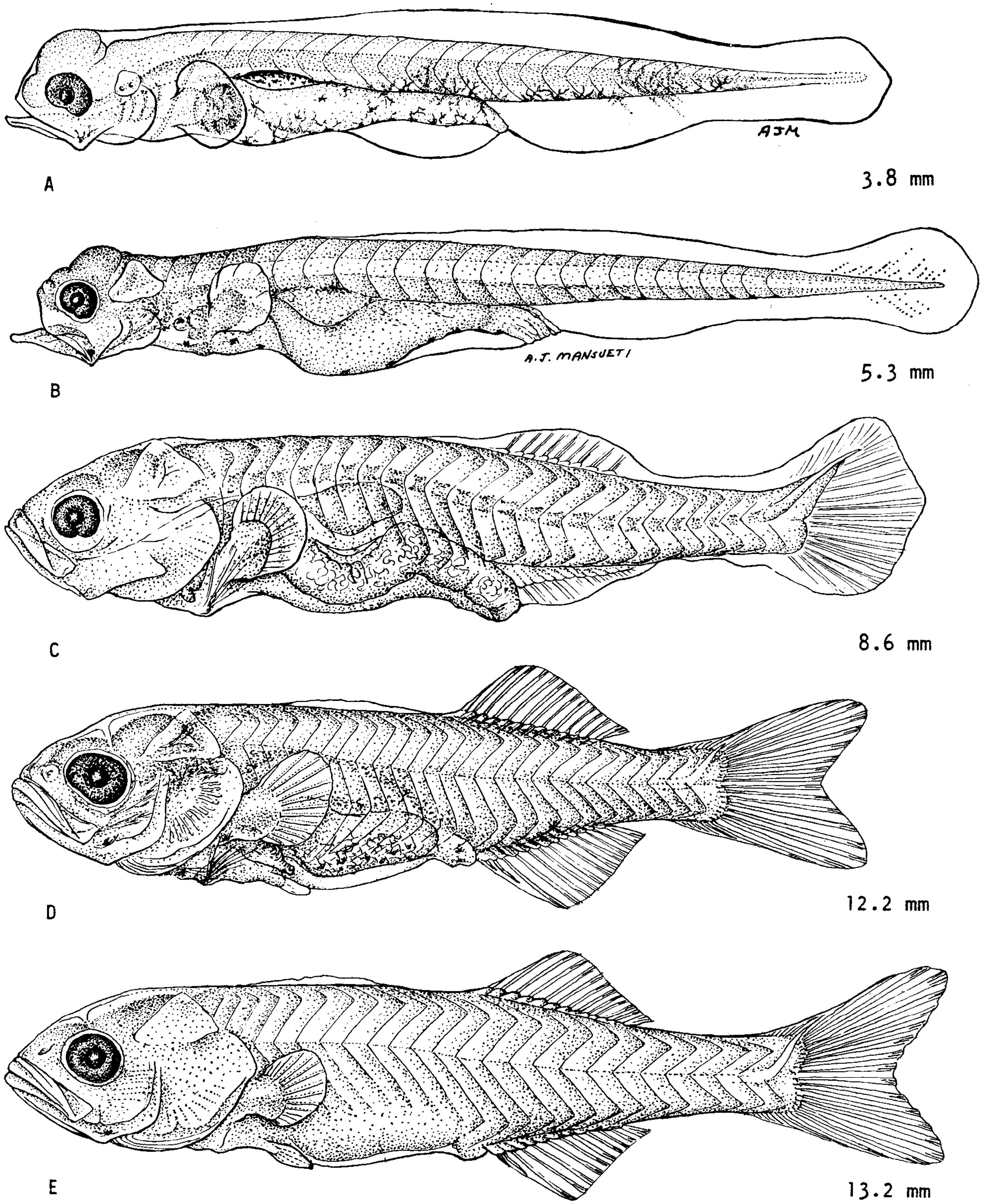

Fig. 213. Morone americana, white perch. A-E. Larvae. (A-E, wild-caught, Maryland, R. J. Mansueti 1964).

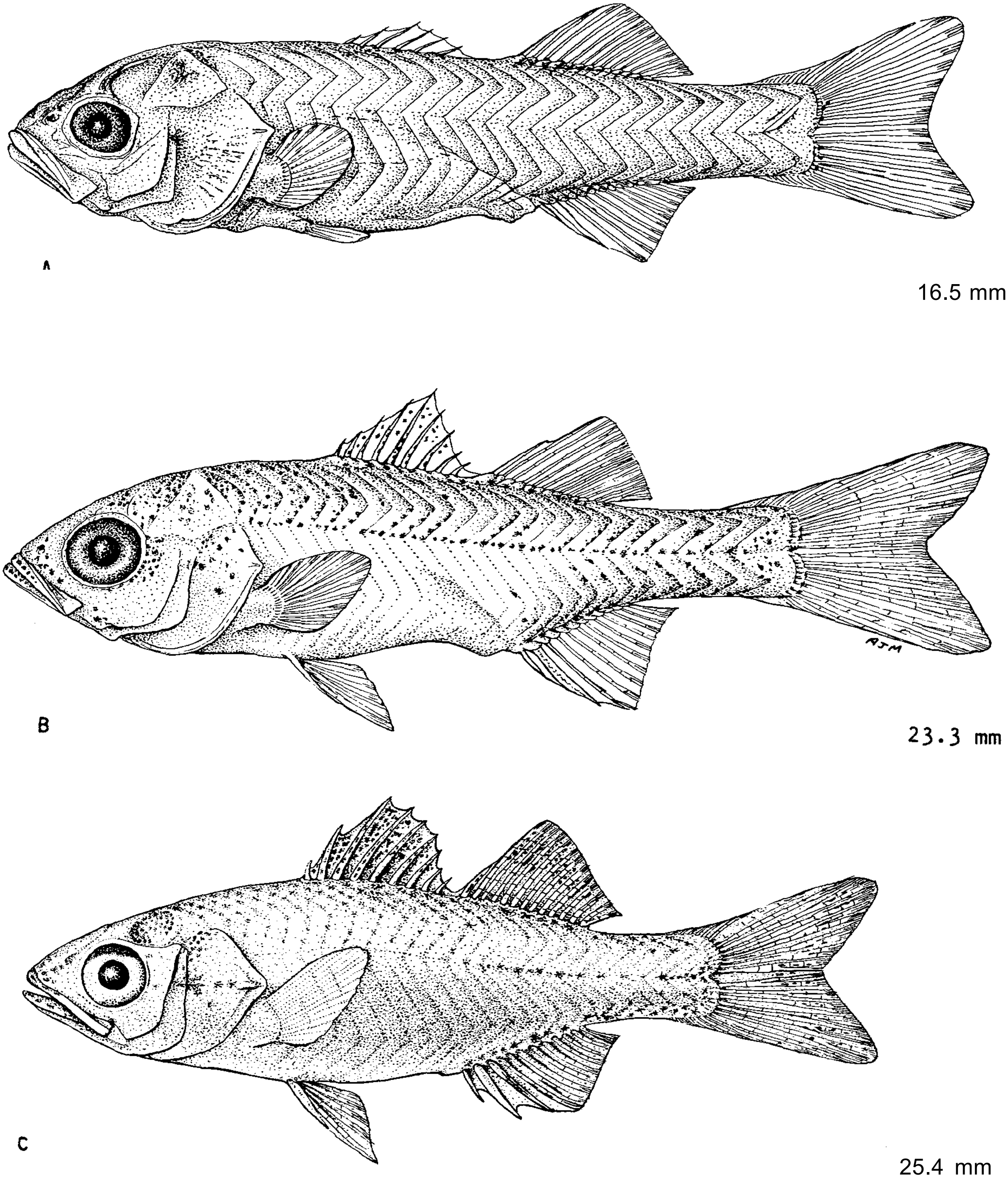

Fig. 214. Morone americana, white perch. A-C, Juveniles. (A-C, wild-caught, Maryland, R.J. Mansueti 1964).

Morone chrysops (Rafinesque), white bass

DISTRIBUTION

Reported from all Great Lakes (however, the Lake Superior record is quite old).[17] In Lake Michigan it is found in bays and riverine populations occur in the southern tributaries of Green Bay and along central lower Michigan, with scattered reports elsewhere around the drainage.[1]

SPAWNING SEASON

Spawns from late April to June in the Great Lakes.[1 3]

SPAWNING TEMPERATURE

Usually spawns between 12 and 16 C,[1 2 7] with extremes up to 24 C reported.[10 13 14]

SPAWNING HABITAT

Spawns in shallows of lakes,[1 13] creek mouths[3] and in streams,[5] near the surface or in midwater[13] of areas 1 to 2 m deep.[5 13] Selects moving water.[10]

SPAWNING SUBSTRATE

Eggs are laid over rocks, algae, logs,[5 10 13] sand and gravel.[10]

FECUNDITY

140,000 to 994,000.[9 10 13 15]

NATURAL HYBRIDS

Possibly Morone mississippiensis.[1 9]

EGGS

Demersal, adhesive;[8 10 11 13 14] diameter 0.7 to 1.0 mm;[8 11 13] yolk diameter 0.6 to 0.8 mm;[8] perivitelline space 0.04 to 0.08 mm, yolk whitish yellow;[11] oil globule single;[8 11] diameter 0.25 to 0.30 mm[8] to 0.4 mm;[11] incubation period: 4.5 days at 14 C;[6] 462 or 77 to 93 hours[12] at 16 C; 48 to 50 hours at 16 to 17 C;[8] 3.5 days at 18 C, 2 days at 20 C;[6] 40 to 45 hours at 20 to 23 C;[11] 2 days at 22 C, 1.5 days at 24 C.[6]

YOLK-SAC LARVAE

Specimens (5.0 and 5.1 mm) described by Fish (1932) were probably misidentified specimens of Aplodinotus grunniens.*

Total length	Description
1.7-2.8 mm	Newly hatched." Myomeres: (11 to 13 + 7 to 9).[11] Morphometry: (as % TL) preanal length 58, predorsal length 45, body depth at anus 17.[11] Morphology: head deflected over yolk sac, lens not developed, oil globule amber, at anterior end of yolk sac;[11] pectoral buds absent.* Pigmentation: melanophores on lateral and anterior surfaces of oil globule, few scattered on sides of body.[11]
2-5 mm	Morphology: head free from yolk sac (22 to 24 hours posthatching), pectoral buds formed (70 to 72 hours posthatching), oil globule indistinct, mouth formed (3.6 to 3.9 mm, 90 to 92 hours posthatching), gut complete (4.0 to 4.5 mm, 98 to 100 hours posthatching).[8] Pigmentation: chromatophores along body, more frequent posteriorly (3.6 to 3.9 mm, 90 to 92 hours posthatching).[8]

LARVAE

Total length	Description
8-13 mm	Morphometry: (as % TL) preanal length 52, head length 19 to 25, eye diameter 6 to 7;[3] greatest body depth 18 to 20;[3] [4] body depth at anus 11 to 13.[3] Morphology: first caudal fin rays and basal elements of second dorsal fin forming (7 to 9 mm, from figured specimens[l]*); second dorsal fin rays 11, anal fin rays 12 (10.5 mm), teeth in lower jaw, pelvic buds below pectoral buds, second dorsal fin 1,4, anal fin 111,12.[3] Pigmentation: one or two large subsurface chromatophores near ventral margin of caudal peduncle;' pigment absent in most stages.'[18]

JUVENILES

Total length	Description
19 mm	Morphometry: (as % TL) preanal length 46, head length 28, eye diameter 10, greatest body depth 24.[3] Morphology: head depressed above eye, lower jaw projecting.' Pigmentation: small melanophores around jaws over snout, and poster i or head, double dorsal line from below second dorsal fin to caudal fin, single series along lateral line, single series on either side of anal fin, single midventral series behind, median fins heavily pigmented.'

ADULTS

Fin rays: caudal 17, dorsal IX-I,12 to 14, anal III,12 to 13, pectoral 15 to 17, pelvic I,5.[2]

Vertebrae: 24[2] to 25.[16]

Lateral line scales: 52 to 60.2

Diagnostic characters: second anal fin spine shorter than third, dorsal fins not connected, preorbital bone barely overlapping maxilla.

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6. McCormick (1978)
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14. Vincent (1969)
15. Sigler (1949)
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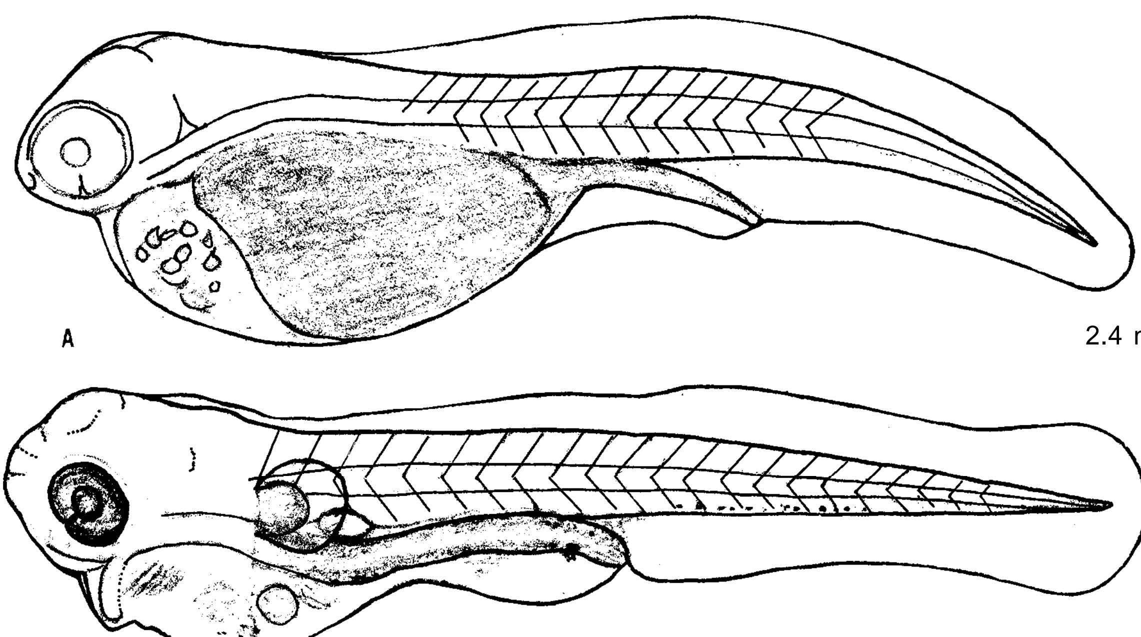
17. Hubbs and Lagler (1958)
18. Taber (1969)
19. Helm (1958)



A 2.4 mm

B 3.5 mm

Fig. 215. Morone chrysops, white bass. A. Yolk-sac larva. B. Larva. (A and B, wild-caught, Oklahoma, Taber 1969).

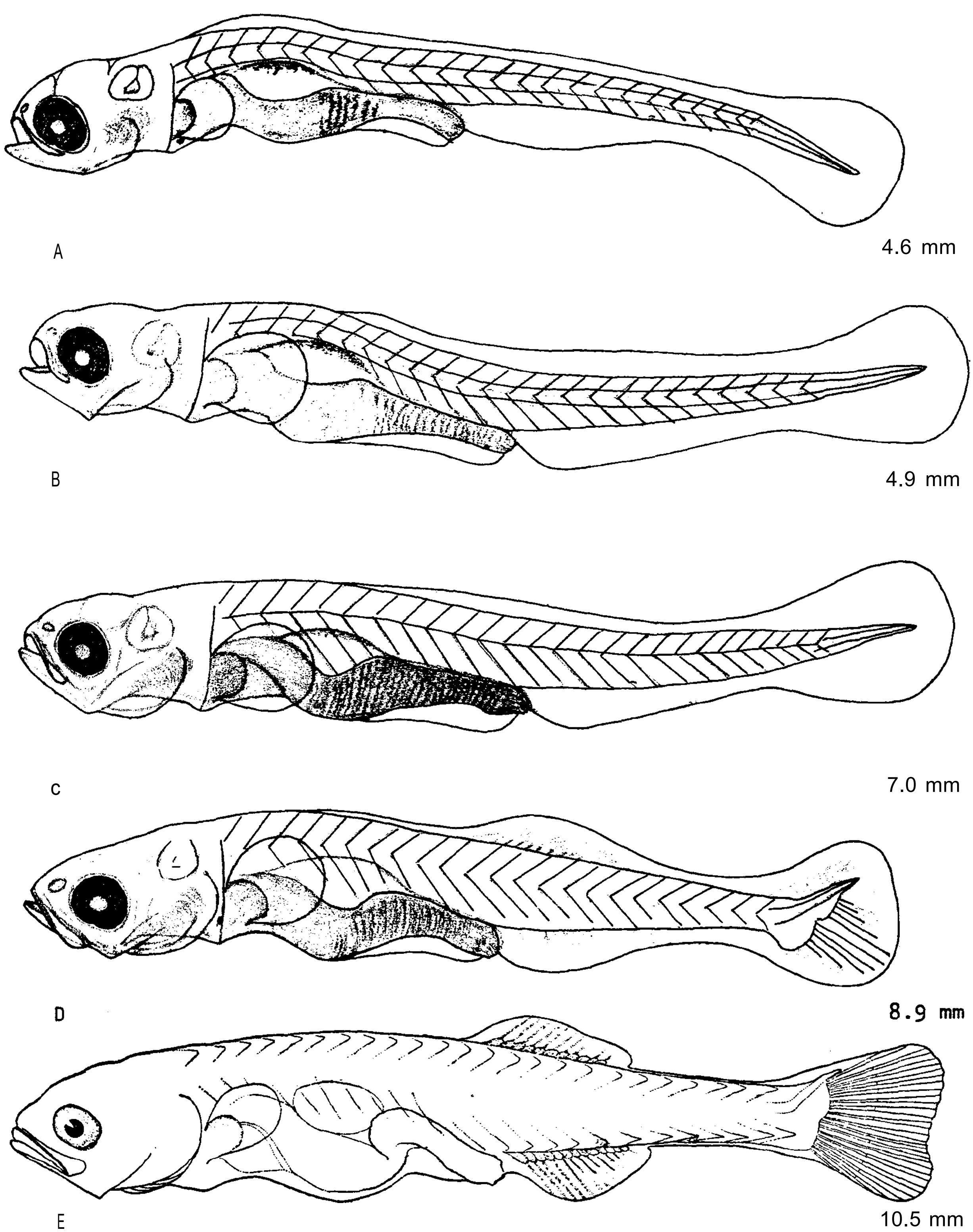
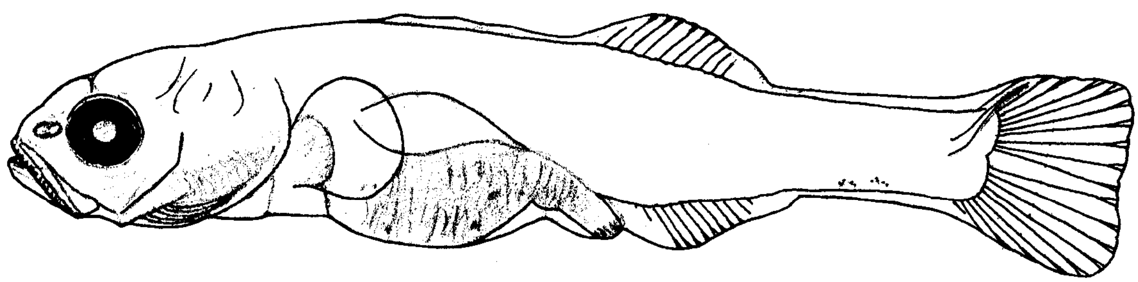
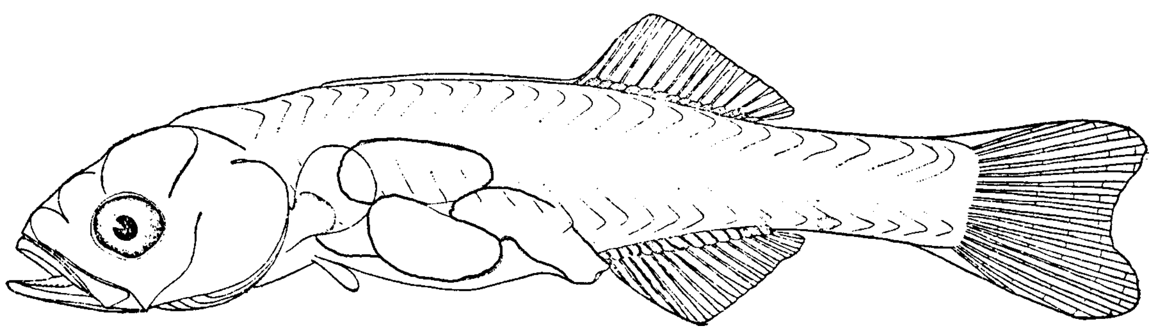


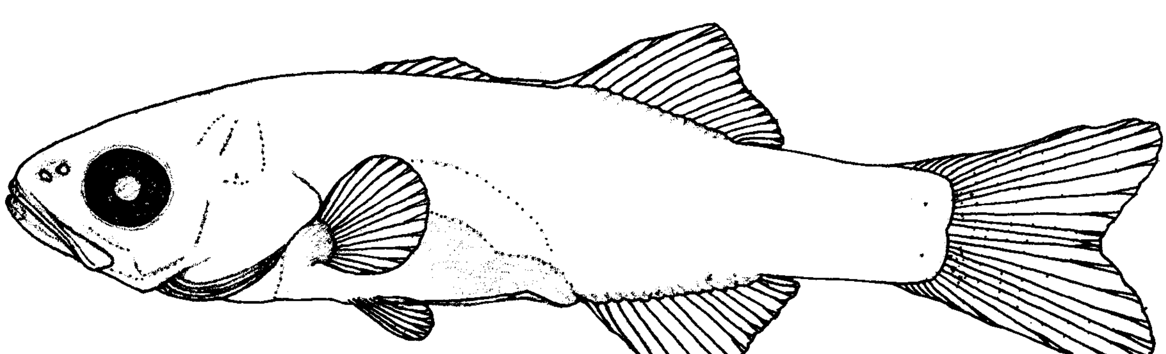
Fig. 216. Morone chrysops, white bass. A-E. Larvae. (A-D, wild-caught, Oklahoma,Taber 1969; E, wild-caught, Lake Erie, Fish 1932).



A 11.4 mm



B 12.6 mm



C 19.0 mm

Fig. 217. Morone chrysops, white bass. A-C. Larvae. (A and C, wild-caught, Oklahoma, Taber 1969; B, wild-caught, Lake Erie, Fish 1932).

Morone mississippiensis Jordan and Eigenmann, yellow bass

DISTRIBUTION

The Great Lakes distribution of this species is limited to the western tributaries of Lake Michigan in southern Wisconsin and Illinois.[1]

SPAWNING SEASON

Spawns during May in Wisconsin[1] and into early June in Iowa.[4]

SPAWNING TEMPERATURE

Usually spawns between 16 and 20 C,[1 4 6] but may spawn between 20 and 22 C.[2]

SPAWNING HABITAT

Prefers shallow, 0.7 to 1.0 m,[2 7] open, lacustrine areas with wave action.'

SPAWNING SUBSTRATE

Spawns over gravel, rocks,[1 4] submerged vegetation, or sand.[6]

FECUNDITY

11,124 to 18,980;' 18,488 to 182,346;[6] ca. 1,000,000.[1]

NATURAL HYBRIDS

Possibly Morone chrysops.[5]

EGGS

Demersal, adhesive;'[6] probably not semibuoyant as reported;[2] diameter 0.762[4 6] to 0.94 mm;[6] oil transparent, globule single, diameter 0.26 to 0.32 mm;[6] incubation period: at 10 C;[3] 66 hours at 17 C, 54 hours at 19 C, 48 hours at 21 C:[4] 36 40 hours at 20 C;[6] 4 to 6 days at 21 C[2] (a dubious report).*

YOLK-SAC LARVAE

Total length	Description
2-8 mm	Newly hatched 2.1 to 2.7 mm;' 2.5 to 3.0 mm;' and 3.2 to 4.8 mm.2 Pigmentation: first pigmentation (50 to 64 hours posthatching);[6] eyes pigmented (4.0[6] or 6.4 to 7.8 mm;[2] at 4 days posthatching);[4] two dorsal rows of melanophores, few melanophores scattered dorsally and ventrally on postanal region, pigment scattered over yolk sac.[6]

Morone mississippiensis

LARVAE

Total length	Description
8-15 mm	Myomeres: 23 to 24 (11 to 12 + 12) .[6]
	Morphometry: preanal length 60% SL.[6]
	Morphology: yolk absorbed (3.1 to 4.3 mm SL;[6] 3 mm at 5 days;[4] 6.4 mm at 4 days'); fin rays: caudal 17, dorsal 6 to 12, anal 5 to II,10 pelvic buds present.[6]
	Pigmentation: melanophores on snout and dorsum of head, many on operculum, melanophores along postanal midlateral area and bases of second dorsal and anal fins, melanophores on either side of ventral midline and distal edge of hypural elements, few scattered over second dorsal, caudal and anal fins.[6]

JUVENILES

Not described.

ADULTS

Fin rays: caudal 17, dorsal 1X-1,12, anal III,9 or 10, pectoral 11 to 15, usually 14 to 15, pelvic I,5.[6]

Vertebrae: 25.'

Lateral line scales: 49 to 52.8

Diagnostic characters: second and third anal fin spines large and nearly equal in length, dorsal fins slightly connected, preorbital bone broad, overlapping upper half of maxilla.

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5. Helm (1958)
6. F. E. Schultz (pers. Comm.)
7. Bulkley (1970)
8. Cook (1959)
9. Woolcott (1957)

Family Centrarchidae, sunfishes

BY

Heang T. Tin

Sunfishes are endemic to North America. Various species, especially the basses, however, have been introduced throughout the world. There are 9 genera and 30 species of centrarchids, all of which are freshwater fishes, inhabiting shallow areas of warm lakes, ponds and slowly moving streams.

Centrarchids are generally small to moderately sized, spiny-rayed fishes with compressed bodies, villiform teeth on the jaws, vomer, palatines and tongue of most species, soft and spiny portions of the dorsal fin joined as one fin, three to nine spines present in anal fin, caudal fin forked or rounded, pectoral fin moderately high on body, pelvic fin with one spine and five soft rays and ctenoid scales. present or absent.

Spawning takes place during spring and summer; nests consist of a small depression excavated in shallow areas. Males guard the eggs and young for several days to two weeks posthatching. Eggs are generally 0.8 to 2.8 mm in diameter, demersal and attached to the substrate after being deposited. Sunfish eggs usually have one large oil globule, however small oil droplets may sometimes be present. At hatching, larvae are unpigmented, have a large yolk sac and the mouth is not formed. In recently hatched larvae, the position of the oil globule is variable, but it is typically near the posterior end of the yolk sac. The anus is anterior to the midpoint of the body.

Provisional Key to Genera of Great Lakes Centrarchid Larvae (late yolk-sac larvae and larvae)

1a. Gut massively coiled; swim bladder confined to area above or anterior to gut coils; larvae sparsely or heavily pigmented. 2

b. Gut uncoiled in specimens less than 5 mm TL; if gut is coiled, swim bladder encroaches on space posterior to gut coils; little pigment. 3

2a. Pigmented with large, widely spaced chromatophores scattered over entire body; body posterior to anus deep. . . . Ambloplites rupestris

b. Pigmented with small dense chromatophores giving body a dusky appearance, or not heavily pigmented; chromatophores confined to top of head, breast and along lateral line; body posterior to anus slender. . . . . Micropterus spp.

3a. Postanal myomeres usually 14 to 18; a prominent melanophore on each side of body above anus; anus located posterior to swim bladder. . . . . *Lepomis* spp.

b. Postanal myomeres usually 19 to 21; no melanophores on side of body above anus: swim bladder extends to or beyond anus. . . . *Pomoxis* spp.

Table 5. Ranges of preanal myomeres (-) and postanal myomeres (x) among Great Lakes centrarchid larvae. Data were taken from several sources cited in the individual species accounts.

```
                               Number of Preanal Myomeres

Species                      8   9  10  11  12  13  14  15

Pomoxis annularis                 |---------------|
                                          xxxxxxxxxxxxxxxxxxxxxxxxx
Pomoxis nigromaculatus            |-------------------|
                                          xxxxxxxxxxxxxxxxxxxxxxxxx
Micropterus dolomieui             |-------|
                                              xxxxxxxxxxxxxxxxxx
Lepomis gibbosus                  |---------------|
                                      xxxxxxxxxxxxxxxxxxxxxx
Micropterus salmoides             |-------|
                                      xxxxxxxxxxxxxx
Lepomis gulosus             |-------------|
                                  xxxxxxxxxxxxxxxxxx
Ambloplites rupestris             |-------------------|
                                  xxxxxxxxxxxxxxxxxx
Lepomis macrochirus             |-----------------------|
                              xxxxxxxxxxxxxxxxxxxxxx
Lepomis cyanellus                      |-----------|
                              xxxxxxxxxxxxxx
Lepomis humilis                                |-----------|
                          xxxxxxxxxxxxxxxxxx
Lepomis megalotis                 |--|
                                      xxx

                            14  15  16  17  18  19  20  21  22  23  24
                                  Number of Postanal Myomeres
```

Ambloplites rupestris (Rafinesque), rock bass

DISTRIBUTION

Occurs in all of the Great Lakes;[1] common to abundant throughout the Lake Michigan drainage.[14]

SPAWNING SEASON

Spawning occurs from May to July in Michigan,[15] May to early June in Iowa,[10] May and June in Minnesota,[2] June in Illinois[12] and from April to June in Missouri.‘

SPAWNING TEMPERATURE

Nesting activity is triggered at 12.8 to 15.6 C[6] and spawning occurs at 15.6 to 21.1 C.[1,16]

SPAWNING HABITAT

Spawns in shallow water along shores of lakes and streams[12,15] near aquatic vegetation.[2,7,11]

SPAWNING SUBSTRATE

Spawns over sand or gravel.[5,6,11] The nest is sometimes constructed on a marl bottom.[13]

FECUNDITY

2,000 to 11,000.~ [4]

EGGS

Demersal;[17] adhesive;’ [7,17] clear, pale yellow or whitish, diameter 2.0 to 2.1 mm;[16] * oil globule single, diameter 0.76 mm;[16] incubation period: 3 to 4 days at 20.5 to 21 C.[8]

YOLK-SAC LARVAE

Total length	Description
4-7 mm	Newly hatched (4.7 to 5.6 mm).[16,17] Myomeres: 30 to 32 (12 to 14 + 17 to 19);[17] (10 to 13 + 16 to 18).[9] Morphometry: (as % TL) preanal length 45 or 46, head length 16 to 21;[16,17] greatest body depth 30, eye diameter 10.[17] Morphology: yolk sac ovoid;[17] oil globule located in posterior portion[17] or middle[16] of yolk sac; head straight, gut not apparent[16] (newly hatched); pectoral buds evident (5.6[17] mm or 6.4[16] mm); notochord upturned slightly (6.4 mm), anus faintly visible, maxilla and

dentary developing, epural and hypural elements evident (6.7 mm);[16] swim bladder beginning to inflate, mouth open (6.8 mm);[17] caudal fin rays visible (6.9[17] or 7.4 mm[16]).

Pigmentation: unpigmented (newly hatched);[16 17] eye pigmented (6.4[16] to 6.8 mm[17]); large melanophores on top of head, swim bladder, lateral and ventral aspects of body and yolk sac (6.7 to 6.8 mm);[16 17] a few dorsal melanophores on each side of median finfold (6.8 mm);[17] melanophores scattered over entire body (7.0 mm).'

LARVAE

Total length	Description
7-10 mm	Myomeres: 29 to 31 (12 or 13 + 17 or 18).[17] Morphometry: (as % TL) preanal length 41 to 46, head length 23 to 27;[16 17] greatest body depth 27, eye diameter 12.[17] Morphology: yolk absorbed (7.4 to 8.6 mm);[16 17] rays developing in dorsal and anal fins (7.4[16] or 8.6 mm[17]); pectoral fin rays visible (8.6 mm);[17] pelvic buds evident, dorsal fin with nine short spines and eight or more soft rays (9.0 mm).[16] Pigmentation: two dense patches of pigment on dorsum of head, behind eyes and a less dense patch on snout between eyes (7.4 to 8.6 mm);[16 17] melanophores on postero-dorsal portion of swim bladder, some pigment on caudal, anal and dorsal fin rays (7.4 mm);[16] pigment increased on dorsal, lateral and ventral surfaces (10.3 mm).[17]
10-17 mm	Myomeres: 28 to 31 (12 to 13 + 16 to 18).[17] Morphometry: (as % TL) preanal length 41 to 51, head length 28 to 31;[3 16 17] greatest body depth 29 to 30, eye diameter 11.[3 17] Morphology: body compressed, rather short and stout;[19] * eye large, mouth large, terminal or oblique, maxilla extending posteriorly beyond anterior margin of pupil (10.5 mm);[3] pelvic fin rays visible (11 to 13.5 mm);[16 17] caudal fin forked, dorsal fin with 10 or 11 spines and 9 to 11 soft rays (12.9 to 14 mm);[16] 6 or 7 pectoral fin rays evident (13.0 mm).[16] Pigmentation: stellate chromatophores cover body especially on tip of jaws, snout, top of head, along dorsum and venter and around fins, less pigment on venter than in previous stages, few chromatophores on caudal, anal and pectoral fins, subsurface pigment on dorsum of swim bladder (10.5 mm);[3] large melanophores on gut and saddle-like bands of pigment on lateral surface of body, other pigmentation patterns similar to those as in previous stages (13.5 to 16.5 mm).[16 17]

JUVENILES

Total length	Description
17-40 mm	Morphometry: (as % TL) preanal length 42 or 43, head length 31 to 33;"[17] greatest body depth 37, eye diameter 11.[17] Morphology: full complement of adult fin rays (17 mm[9] * or 22 mm[16]); eye large, maxilla reaching middle or posterior edge of pupil, base of dorsal fin twice as long as anal fin base (30.6 mm);[17] squamation complete (36.0 mm).[16] Pigmentation: several vertical bands;[9 *] indistinct "saddles" on lateral aspect;[17] each scale below lateral line with a black spot, blackish spot on opercular flap, pigment on dorsal and anal spines and interconnecting membranes."

ADULTS

Fin rays: caudal 17;[18] dorsal X to XII,10 or 11, anal V to VII,9 or 10, pectoral 13 (12 to 14),, pelvic I,5.'

Vertebrae: 29 to 32.[1 18]

Lateral line scales: 37 to 51.[1]

Diagnostic characters: anal fin base about one-half length of dorsal fin base, margin of preopercle entire or nearly so, body with 7 to 9 horizontal rows of black spots below lateral line, anal fin spines arise in a scaled groove.

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9. Hogue et al. (1976)
10. Harlan and Speaker (1969)
11. Cahn (1927)
13. 12. Forbes and Richardson (1909) Hankinson (1908)
14. Becker (1976)
15. Carbine (1939)
16. Powles et al. (1980)
17. Buynak and Mohr (1979b)
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19. P. M. Powles (pers. Comm.)

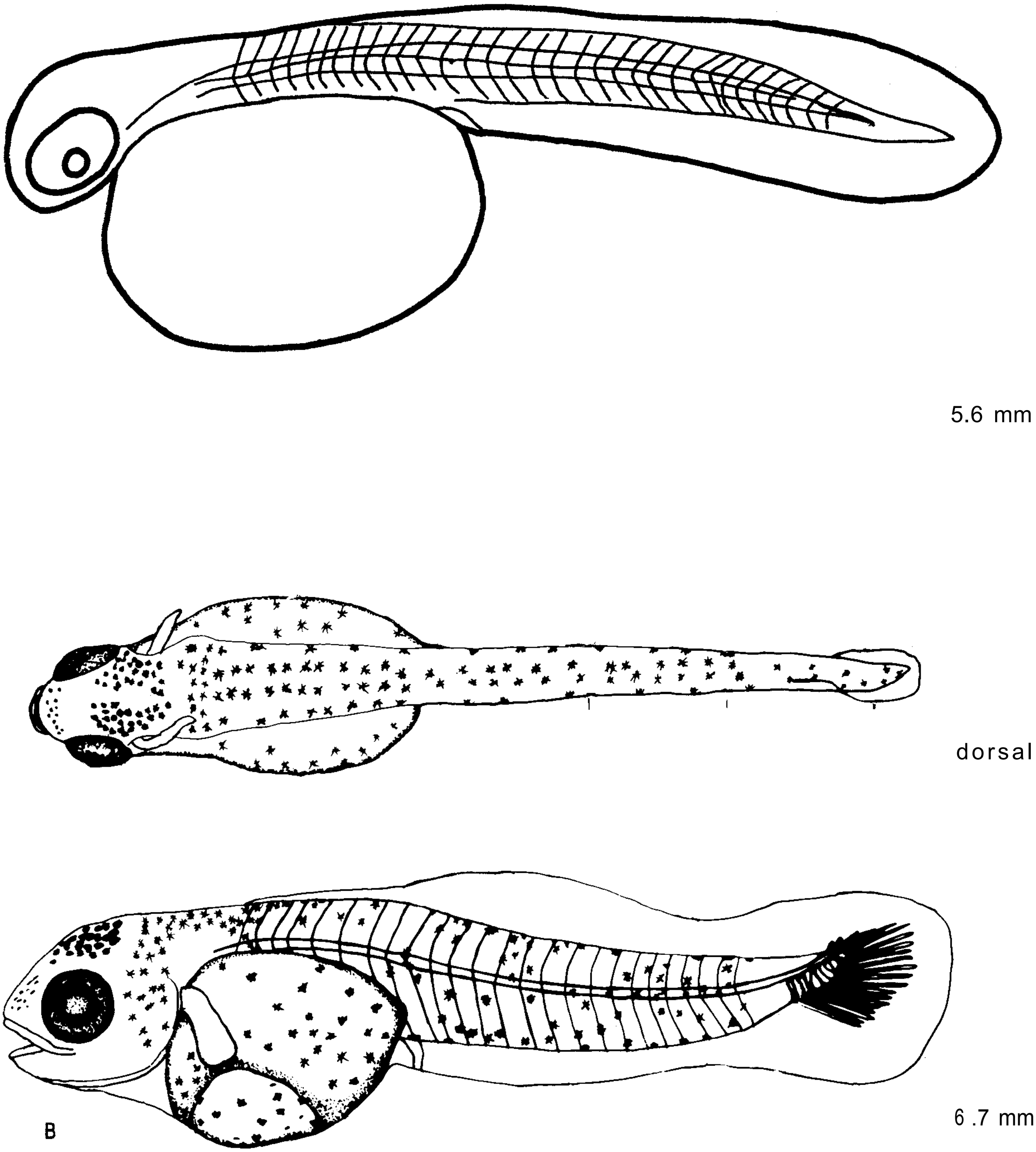


Fig. 218. Ambloplites rupestris, rock bass. A and 8. Yolk-sac larvae. (A, laboratory-reared, Pennsylvania, Buynak and Mohr 1979b; B, wild-caught, Ontario, Powles et al. 1980).

Ambloplites rupestris

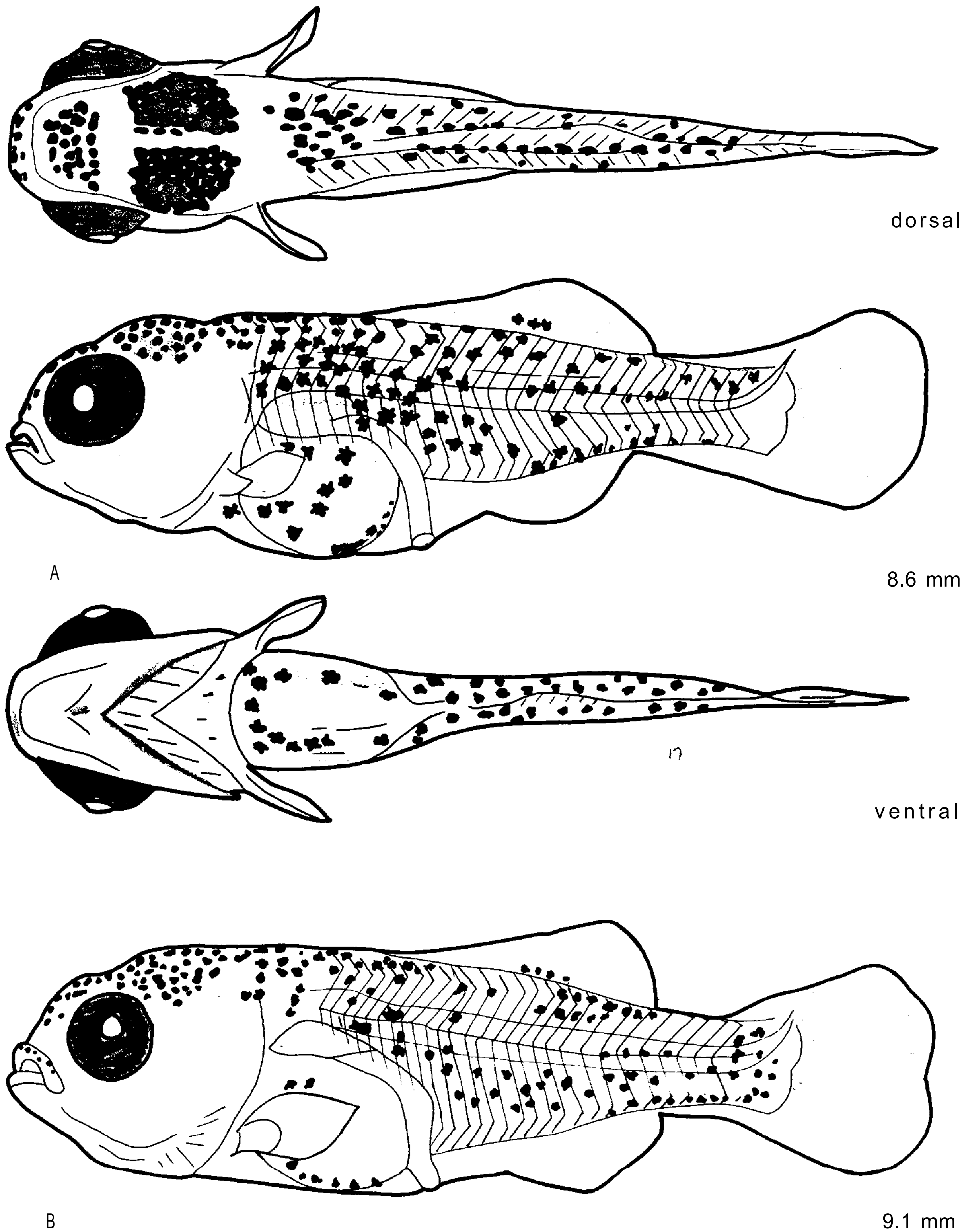


Fig. 219. Ambloplites rupestris, rock bass. A and 8. Larvae. (A and B, laboratory-reared, Pennsylvania, Buynak and Mohr 1979b).

<u>Ambloplites rupestris</u>

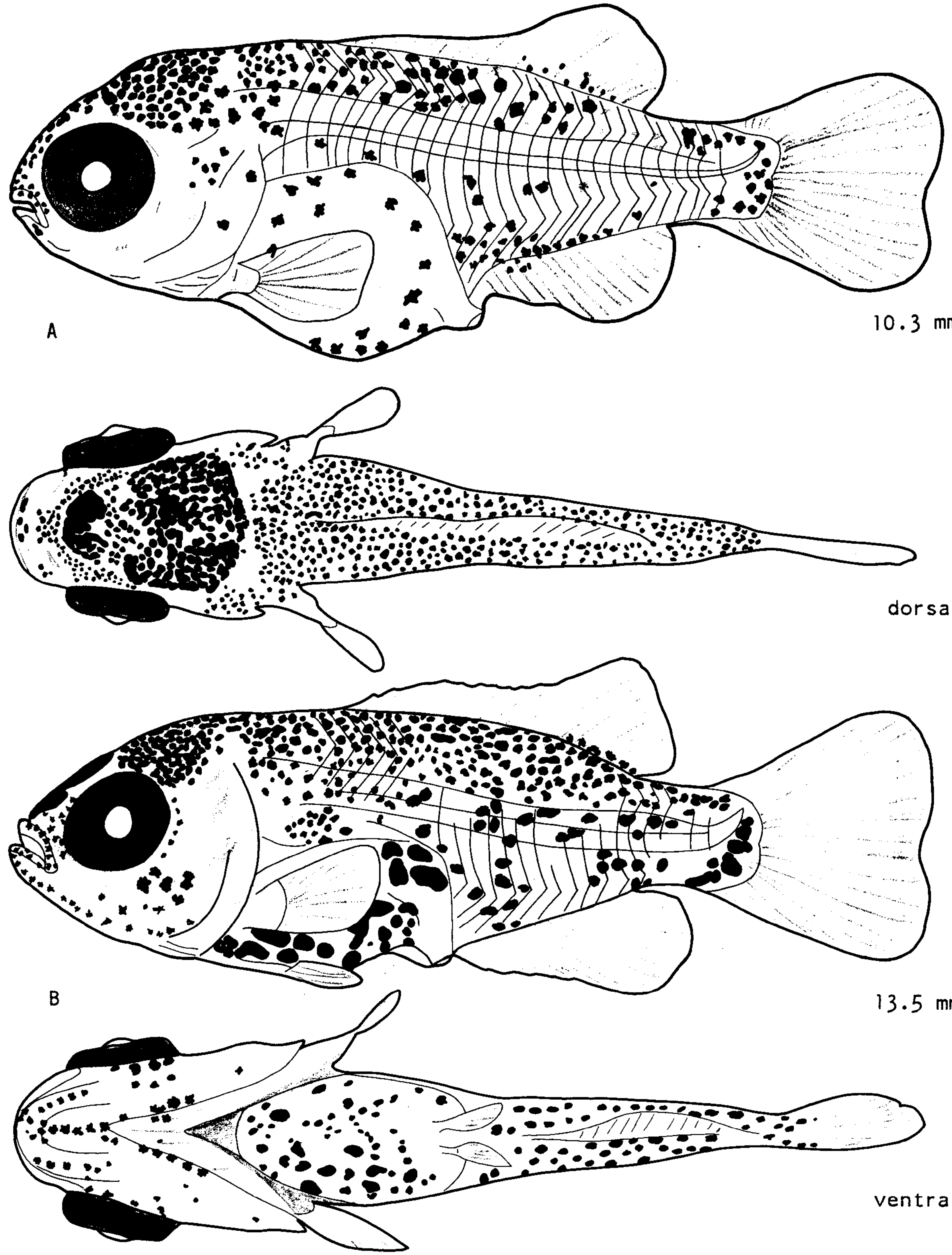
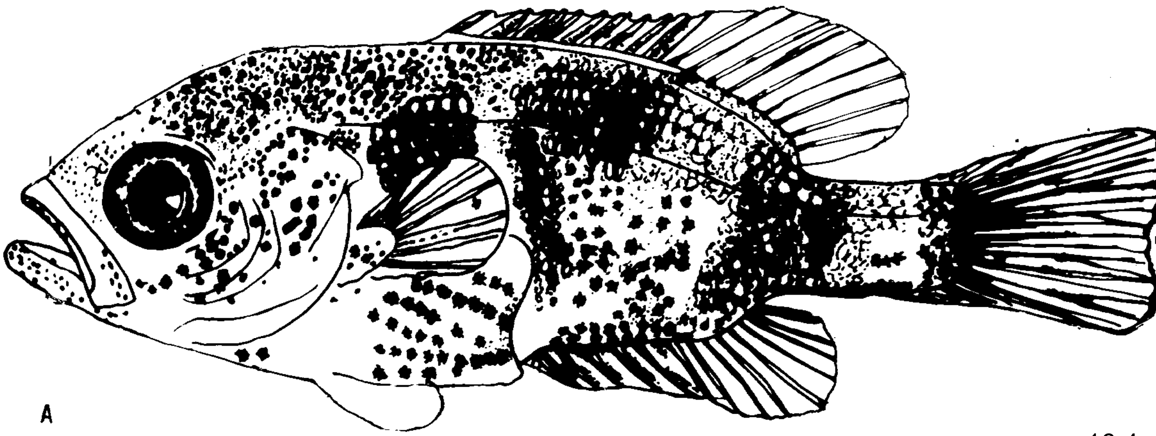
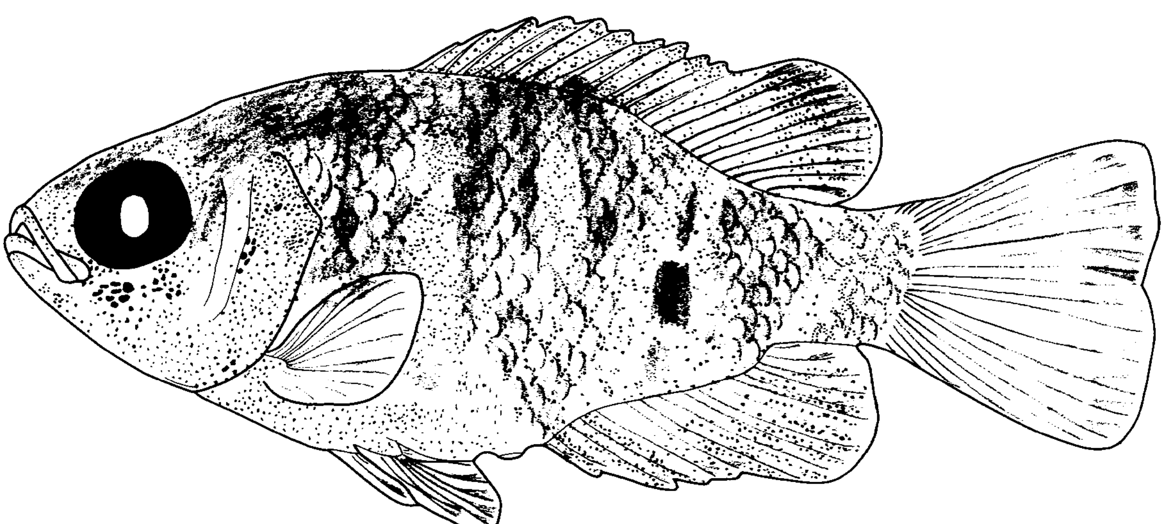


Fig. 220. Ambloplites rupestris, rock bass. A and 8. Larvae. (A and B, laboratory-reared, Pennsylvania, Buynak and Mohr 1979b).



A

16.4 mm



B

30.6 mm

Fig. 221. Ambloplites rupestris, rock bass. A. Larva. 8. Juvenile. (A, wild-caught, Ontario, Powles et al. 1980; B, laboratory-reared, Pennsylvania, Buynak and Mohr 1979b) .

Lepomis cyanellus Rafinesque, green sunfish

DISTRIBUTION

Distributed throughout the Lake Michigan drainage where it is common to uncommon.[18] Rare in upper Michigan[12] and Lake Erie.[13] Disjunct populations found in Ontario.[4] Not reported from Lakes Superior and Ontario.[20]

SPAWNING SEASON

Spawning occurs from late May to early August in Wisconsin,[8 16] June to August in Michigan,[10 17] late April to early September in Illinois,[5 9] May to August in Iowa[14] and May to July in Minnesota.[11]

SPAWNING TEMPERATURE

Spawning takes place at 15.6 to 28 C.[4 15 16]

SPAWNING HABITAT

Spawns in shallow areas of lakes and ponds,[8 15 16] usually in locations sheltered by rocks, logs or clumps of vegetation.[4 8]

SPAWNING SUBSTRATE

Nests are constructed on sand, gravel, mud or marl bottom.[10 11 14] Eggs may also be attached to roots of aquatic vegetation.[10]

FECUNDITY

2,000 to 10,000.[3 19]

NATURAL HYBRIDS

Lepomis gibbosus;[21 27 28] L. gulosus;[28] L. humilis;[28 29] L. macrochirus;[21 22 23 24 25] C. megalotis;[26 27] L. microlophus.[24]

EGGS

Demersal;' adhesive, yellow;' or white, deposited in a mass;[8] diameter 1.0 to 1.4 mm;[1 7] oil globule single, diameter 0.45 mm;[7] incubation period: 3 days at 21.1 C;[1] 50 hours at 23.8 C;[5] 35 to 55 hours at 24 to 27 C;[6 7] 31 hours at 27.1 C.[5]

YOLK-SAC LARVAE

Total length	Description
3-6 mm	Newly hatched (3.6 to 3.7 mm).[7]
	Myomeres: 27 or 28 (11 + 16 or 17).[7]
	Morphometry: preanal length 47% TL.'

Morphology: pectoral buds present;' oil globule located in posterior portion of yolk sac[6] (newly hatched); swim bladder developed (36 hours posthatching); mouth forming (70 to 90 hours postfertilization);' jaws movable (84 hours posthatching); caudal fin rays developing (5.3 to 5.6 mm);[1] swim bladder filled with air, gill buds present, gill cover well developed (5.6 to 5.7 mm).[7]

Pigmentation: unpigmented (newly hatched); [6 7] eye pigmented (4.1 to 4.4 mm);[7] 10 stellate chromatophores dorsal to swim bladder, three near anus (one being supraanal), two contracted melanophores on head (5.0 to 5.1 mm), stellate melanophores on dorsum, venter of yolk sac, dorsum of swim bladder and in a ventral row from immediately anterior to anus to last myomere, increase in contracted melanophores on head (6.0 to 6.3 mm).[7]

LARVAE

Total length	Description
7-11 mm	Myomeres: 28 (13 + 15).[7] Morphometry: preanal length 45 to 47% TL.' Morphology: yolk absorbed (240 hours posthatching;[6] 292 hours postfertilitation[2]); anal and dorsal fin rays developing (7.0 to 9.1 mm);[1 7] incipient rays in caudal fin, gut coiled (7.8 to 9.1 mm), pelvic buds developing (8.3 to 9.1 mm).[7] Pigmentation: melanophores on cheeks and caudal fin membrane, row of pigment along lateral line (7.8 to 9.1 mm), melanophores developed on dorsal and anal fin membranes and on lips (8.6 to 9.4 mm);[7] increase of pigment on head, on lower side of body between anus and caudal fin and on dorsum, midlateral row of pigment more distinct (10.2 mm, derived from figure).[1]

JUVENILES

Total length	Description
15-24 mm	Pigmentation: whole body, except breast covered with widely spaced chromatophores, pigment on lips and on dorsal and anal fins, dense patch of pigment on head (15.1 mm derived from figure), a dark spot on tip of opercle, vertical bands on lateral aspect of body, pigment on dorsal, anal and caudal fins, dark spot on head still evident (23.7 mm, derived from figure).'

ADULTS

Fin rays: caudal 17;[30] dorsal X(IX to XI), 10 or 11 (10 to 12), anal III,9 or 10, pectoral 13 (12), pelvic I,5.[4]

Vertebrae: 28 to 30.[4,30]

Lateral line scales: 40 to 50.[4]

Diagnostic characters: opercular flap as deep as long, rear margin of gill cover stiff, gill rakers long and slender, pectoral fin short, contained about four times in standard length, no teeth on tongue, mouth large, upper jaw extending to beneath pupil of eye except in small young, body depth usually about one-half standard length.

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17. Hubbs and Cooper (1935)
18. Becker (1976)
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21. Bailey and Lagler (1938)
22. Bennett (1943)
23. Branson (1967)
24. Childers and Bennett (1961)
25. Cross (1950)
26. Cross and Moore (1952)
27. Hubbs (1920)
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29. Bailey and Allum (1962)
30. Bailey (1938b)

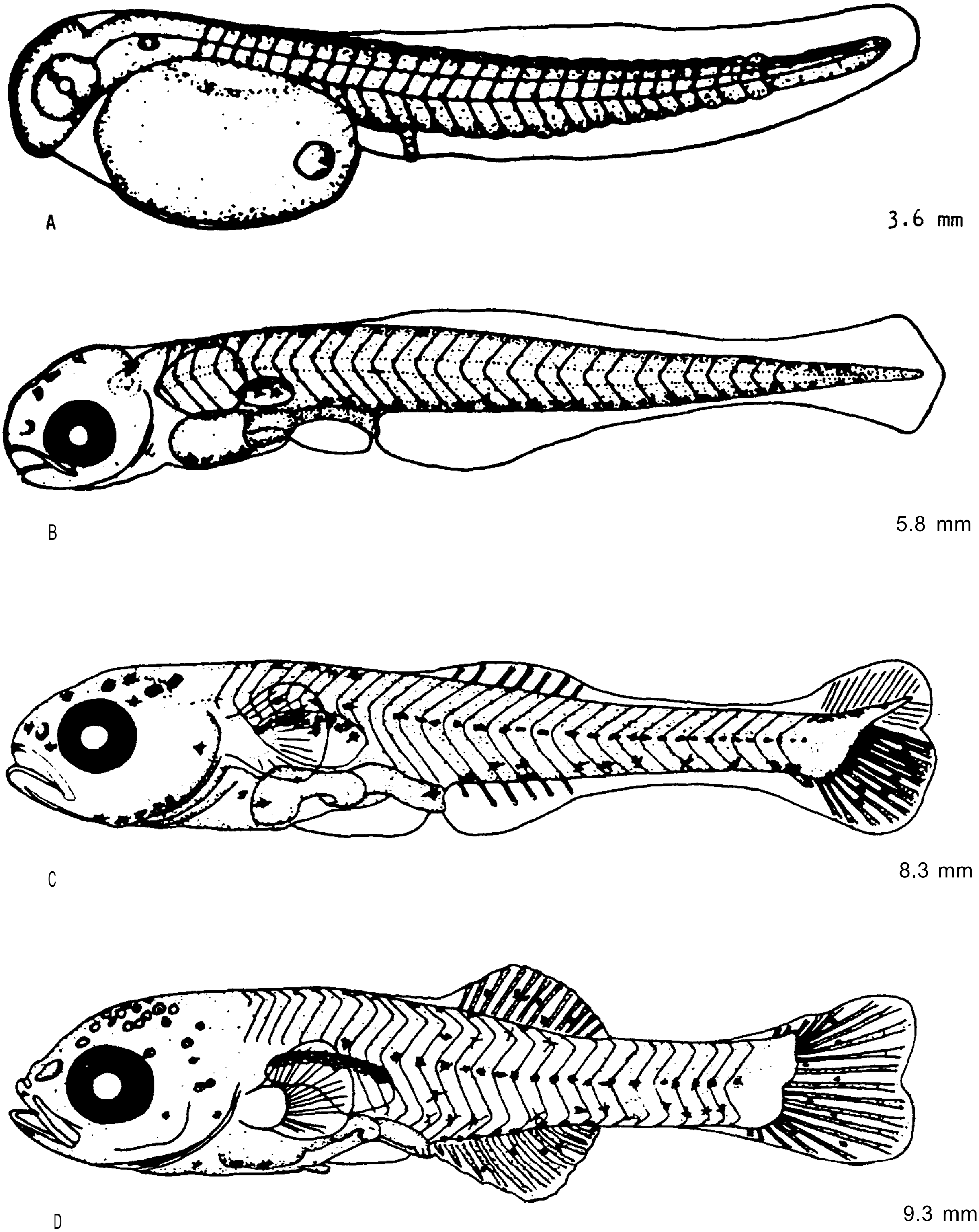

Fig. 22.2. Lepomis cyanellus, green sunfish. A and B. Yolk-sac larvae. C and D. Larvae. (A-D, laboratory-reared, Wisconsin, Taubert 1977).

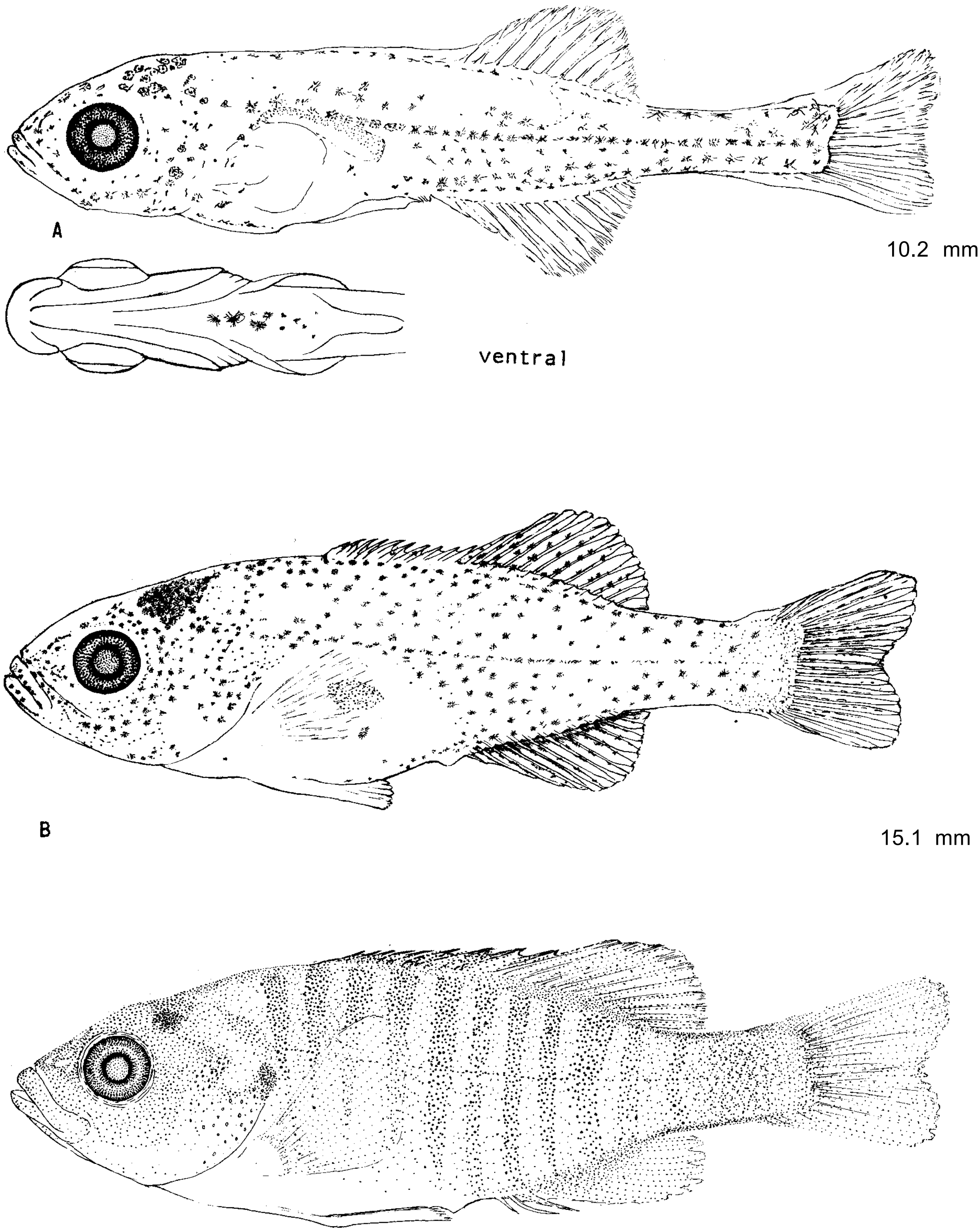

Fig. 223. Lepomis cyanellus, green sunfish. A. Larva. B and C. Juveniles. (A-C, laboratory-reared, California, Meyer 1970, illustrated by C. Corson).

Lepomis gibbosus (Linnaeus), pumpkinseed

DISTRIBUTION

Occurs in all of the Great Lakes, except Lake Superior.[9,15] Introduced into some lakes in the Lake Superior drainage. Common in the Lake Michigan drainage.[10]

SPAWNING SEASON

Spawning takes place from late May to July in Michigan[18,22] and Wisconsin[2,19] and May to June in Illinois[20] and Minnesota.[23]

SPAWNING TEMPERATURE

Spawns at 17.5 to 29 C.[2,14,15]

SPAWNING HABITAT

Spawns in shallow quiet areas of lakes, ponds and creeks,[3,7] usually in water less than 70 cm.[7,15,16,18]

SPAWNING SUBSTRATE

Spawns over a gravel, rock, sand, clay or muck bottom with roots of aquatic plants.[2,14,18,22]

FECUNDITY

600 to 5,000.[15,17]

NATURAL HYBRIDS

Lepomis cyanellus;[25,26] *L. macrochirus*;[25,26,27] *L. megalotis*.[26]

EGGS

Demersal;[14,21] adhesive;[4,14] transparent;[13] diameter 0.8 to 1.2 mm;[15,21] oil globule single;[5,6,14] diameter 0.3 to 0.4 mm[5,14,21] to 1 mm;[12] one or two minute oil droplets may sometimes be present;[5] incubation period: 48 hours at 19 to 25 C;[6] 3 days at 28 C.[7]

YOLK-SAC LARVAE

Total length	Description
2-5 mm	Newly hatched (2.4 to 3.1 mm).[1,5,6,8,14,21] Myomeres: 27 to 34 (10 to 13 + 17 to 21).[8] Morphometry: (as % TL) preanal length 37 to 45, head length 13 to 18, eye diameter 8 to 9.*

Morphology: yolk sac ovate;[21] oil globule located near posterior portion of yolk sac (newly hatched);[1 14 21] pectoral buds evident (3.2 mm);[1] dorsal median finfold more ventral median finfold, gut thin and uncoiled (3.0 to 4.6 mm).[14]

Pigmentation: unpigmented (newly hatched), eye darkly pigmented (3.0 to 4.6 mm);[14] a few melanophores present on venter between anus and caudal fin, yolk sac and posterior part of gut with yellow pigment (4.6 mm), melanophores increased between anus and caudal fin, a few melanophores present on tip of notochord and above notochord about half way between anus and caudal fin, dense pigment on dorsum of swim bladder (5.2 mm).[6]

LARVAE

Total length	Description
4-15 mm	Myomeres: see 2-5 mm. Morphometry: (as % TL) preanal length 37 to 42, head length 17, eye diameter 7 to 10 (5.2 to 5.4 mm), preanal length 44 to 45, head length 26, eye diameter 9 (11.0 mm).* Morphology: yolk absorbed (4.5 to 5.2 mm);[1 6] larvae elongate, oil globule absorbed (4.7 to 5.6 mm);[14] swim bladder present (5.2 mm);[6] anterior portion of gut coiled (4.5 to 5.0 mm);[1] body compressed (10 to 15 mm).[24] Pigmentation: melanophores present on dorsum of head, intestine and swim bladder, at base of pectoral fin and in thoracic region, two rows of melanophores on venter between anus and caudal fin (4.7 to 5.6 mm);[14] a few or no melanophores on breast between anus and opercula (10 to 15 mm);[24] prominent melanophores on each side of anus.[1]

JUVENILES

Total length	Description
16-19 mm	Morphometry: (as % TL) preanal length 41, head length 24, eye diameter 8, greatest body depth 24 to 26.[12 24] Morphology: body deep, compressed, a slight depression on head over eyes;[12 14] snout short, mouth small, oblique, maxilla reaching anterior margin of eye;[12] origin of spinous portion of dorsal fin considerably anterior to anal fin, gill rakers shorter and more widely spaced than those of L. macrochirus (greater than 14 mm).[1] Pigmentation: faint vertical bars may be present between head and caudal peduncle;[14] chromatophores along myosepta, dark pigmentation jaws, top of head and cheeks, a row of pigment along midlateral line from above anal fin origin to caudal fin, rows of spots

around base of dorsal and anal fins, chromatophores on all fins, fewer on paired fins, belly unpigmented (18.5 mm).[1]

ADULTS

Fin rays: caudal 17;[11] dorsal X (X to XI), 10 to 12, anal III,9 (8 to 11), pectoral 13 (12 to 14), pelvic I,5.[15]

Vertebrae: 29 to 31.[11 15 21]

Lateral line scales: 35 to 47.[15]

Diagnostic characters: gill rakers short and stubby, opercular flap black in center with white or yellow margin and a prominent red spot on posterior edge, greatest depth into standard length about 2.0 to 2.5 times.

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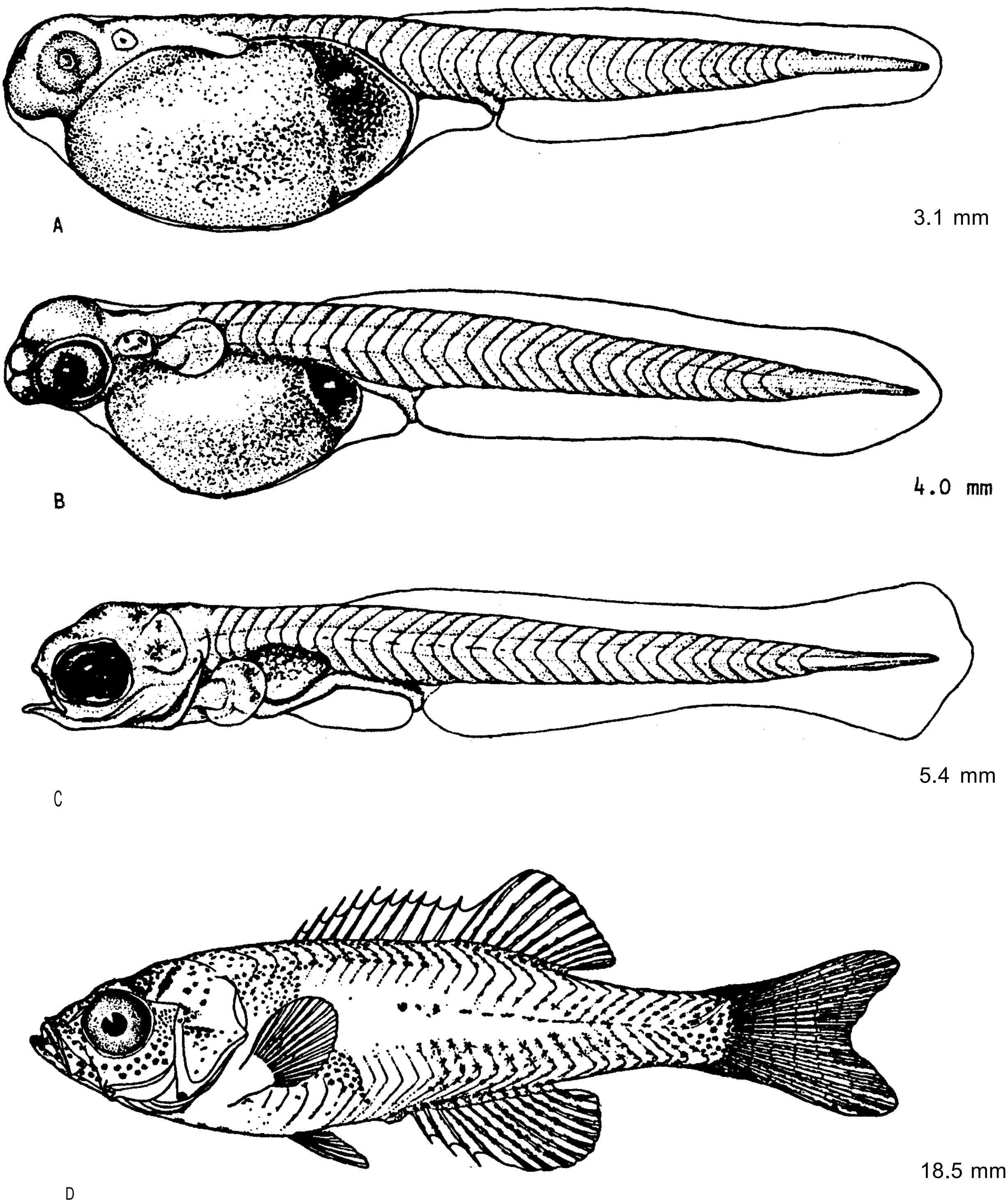

Fig. 224. *Lepomis gibbosus*, pumpkinseed. A and B. Yolk-sac larvae. C. Larva. D. Juvenile. (A-C, wild-caught, Potomac River, Anjard 1974; D, wild-caught, Lake Erie, Fish 1932).

Lepomis gulosus (Cuvier), warmouth

DISTRIBUTION

Common in Indiana and Michigan; rare to uncommon in Wisconsin where it occurs only in the headwaters of the Wolf and Fox River systems.[12] Not reported from other Great Lakes except Lake Erie."

SPAWNING SEASON

Spawning occurs from mid-May to August in Illinois[2] and Missouri[6] and late June to late July in Iowa.[2 4]

SPAWNING TEMPERATURE

Spawning has been observed at 21.1 to 25.5 C.[14]

SPAWNING HABITAT

Spawns in shallow water, usually 5 to 150 cm deep,[1 2 13] near rocks, stumps or clumped vegetation.[1 6]

SPAWNING SUBSTRATE

Spawns over rubble lightly covered with detritus,[2 6] silt or sand covered with leaves and sticks.'[2]

FECUNDITY

4,500 to 63,200.[2 9 13]

NATURAL HYBRIDS

Lepomis cyanellus, L. gibbosus;[18] C. macrochirus.[15 16 17]

EGGS

Adhesive, amber;' diameter 1.0 to 1.1 mm;[1 2 5] oil globule single, diameter 0.35 mm;[2] incubation period: 44 to 53 hours at 25.5 C;[14] 33 or 34 hours at 25 to 26.2 C;[2] 29 hours at 28.1 C.[3]

YOLK-SAC LARVAE

Total length	Description
2-5 mm	Newly hatched (2.3 to 3.1 mm).[1 2] Myomeres: 25 (8 + 17) at 3.4 mm, 29 (10 + 19) at 4.6 mm.2 Morphometry: (as % TL) preanal length 44 to 50, head length 14, greatest body depth 15, body depth at anus 8, eye diameter 7 to 8.2

Morphology: head deflected downward over yolk sac (newly hatched), pectoral buds present, incipient rays in caudal fin, mouth indistinct, branchial elements forming (4.6 mm).[2]
Pigmentation: unpigmented (newly hatched), eye pigmented (4.6 mm).[2]

LARVAE

Total length	Description
5-12 mm	Myomeres: 29 to 30 (10 to 11 + 19);[2] (12 to 13 + 16 to 18).[7]
	Morphometry: (as % TL) preanal length 42, head length 17, greatest body depth 11, body depth at anus 7, eye diameter 8 (5.3 mm). preanal length 44 or 45, head length 20 to 23, greatest body depth 15 to 20, eye diameter 7 to 9 (7.6 to 12.0 mm).[2]
	Morphology: yolk absorbed (5.3 mm;[2] 4 to 5 days posthatching[1 2]); pectoral buds well developed, rays begin to form in anal and dorsal fins, caudal fin rays distinct above and below notochord, branchial arch well formed, mouth oblique, extending to point below middle of eye (5.3 mm), urostyle upturned, rays distinct in anal, caudal and pectoral fins (7.6 mm), anal and soft dorsal fins separated from caudal fin (8.8 mm), pelvic fins with indistinct rays, spinous dorsal fin beginning to form, small piece of preanal finfold remains (12.0 mm).[2]
	Pigmentation: two large chromatophores between bases of pectoral fins (5.3 mm), a row of pigment on each side of ventral median finfold spreading as stellate chromatophores over venter, a row of elongate melanophores along lateral line, dense chromatophores above anus, six stellate chromatophores on venter between pectoral fins and a row of five chromatophores on each side across branchiostegal rays, chromatophores scattered on head (7.6 mm), increase of pigment on head, ventral spots becoming larger, midlateral row more distinct (8.8 mm), pigmentation similar to 8.8-mm larvae, with additional chromatophores around mouth and a vertical row of pigment at base of caudal fin rays (12.0 mm).[2]

JUVENILES

Total length	Description
15-16 mm	Morphometry: (as % TL) preanal length 45, head length 28, greatest body depth 24, eye diameter 9.[2]
	Pigmentation: increase in pigment on head and caudal peduncle, many large chromatophores scattered over back, chromatophores behind eye, on soft dorsal, anal and caudal fins.[2]

ADULTS

Fin rays: caudal 17;[19] dorsal X, (IX to XI), 9 to 11;[6 20] anal III,8 or 9;[8] pectoral 13 or 14, pelvic I,5.[19]

Vertebrae: 28 to 30.[10 19]

Lateral line scales: 36 to 46.[6]

Diagnostic characters: tongue with patches of teeth, mouth large, upper jaw extending to or behind middle of eye, several distinct dark lines radiating back from eye, body depth less than three times into SL.

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18. Hubbs and Hubbs (1933).
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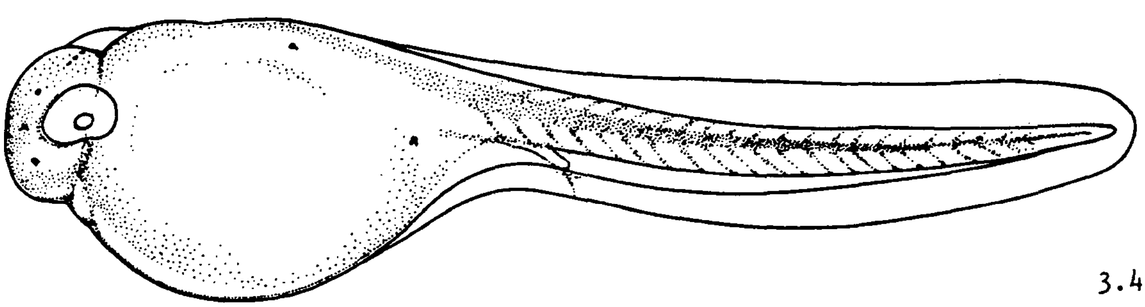

Fig. 225. Lepomis gulosus, warmouth. Yolk-sac larva. (Laboratory-reared, Illinois, Larimore 1957).

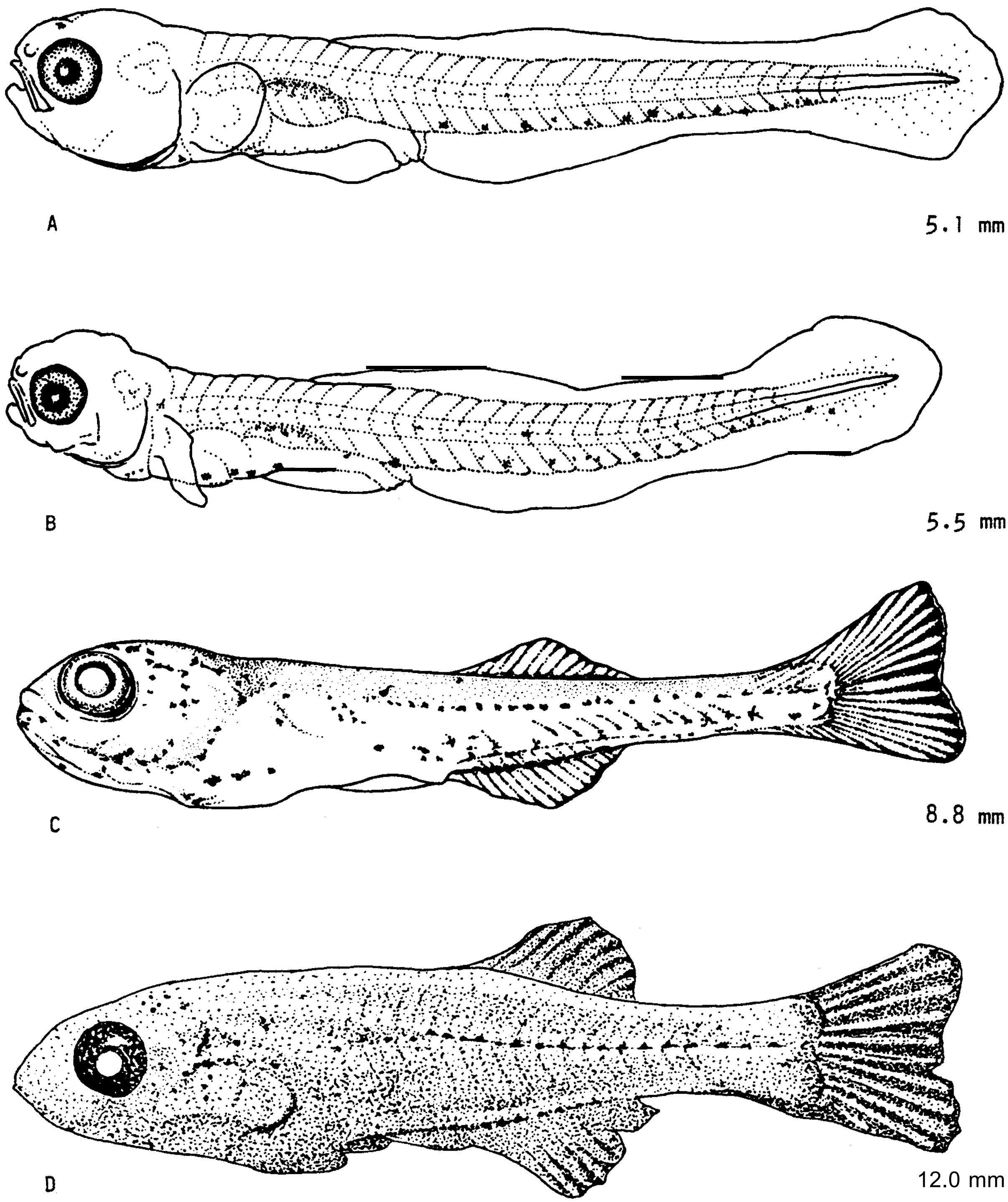

Fig. 226. Lepomis gulosus, warmouth. A-C. Larvae. D. Juvenile. (A and B, wild-caught, Louisiana, Conner 1979, specific identity subsequently verified by J. V. Conner; C and D, laboratory-reared, Illinois, Larimore 1957).

Lepomis humilis (Girard), orangespotted sunfish

DISTRIBUTION

Uncommon in Lake Erie, not reported from other Great Lakes.[14] Not found in the Lake Michigan drainage.[12] Common in Illinois[5] and Indiana.[13] In Michigan, found only in the extreme southeastern portion of the state.[10]

SPAWNING SEASON

Spawns from May to July in Illinois'[8] and late May to August in Iowa[7] and Missouri .[2] Peak spawning occurs during May and June in Kansas.[4]

SPAWNING TEMPERATURE

Spawning occurs at 18.4 to 31.6 C.[4 c]

SPAWNING HABITAT

Shallow areas of lakes and impoundments,[6] usually in water 5 to 61 cm deep.[1 4]

SPAWNING SUBSTRATE

Fine gravel, sand and probably mud bottom.[4 6]

FECUNDITY

50 to 4,700.[6 11]

NATURAL HYBRIDS

Lepomis cyanellus;[17 18] L macrochirus;[15 16] L. megalotis.[19]

EGGS

Adhesive, nearly colorless;[4] diameter 1 mm;[6] incubation period: 5 days at 18.4 to 21.1 C.[6 9]

YOLK-SAC LARVAE

Total length	Description
5.3 mm	Myomeres: 27 to 31 (13 to 14 + 14 to 17).[21] Morphometry: preanal length 44 to 49% TL.[21]

LARVAE

Total length	Description
7-9 mm	Myomeres: 29 to 31 (13 to 15 + 14 to 17).[21] Morphometry: preanal length 44 to 48% TL.[21]

JUVENILES

Total length	Description
14-40 mm	Pigmentation: eight or nine dusky orange vertical bars on sides of body, extending from dorsum to venter (14.0 mm);[6] vertical bars fewer and wider than on young bluegill;[5] all fins transparent on young;[3] body becoming mottled and spotted (40 mm).[6]

ADULTS

Fin rays: caudal 17;[20] dorsal X,9 to 10, anal III,8 to 9, pectoral 12 to 14, pelvic I,5.[4]

Vertebrae: 28 to 30.[20]

Lateral line scales: 32 to 39.[2]

Diagnostic characters: sensory cavities of head between eyes very large, gill rakers on first arch moderately long and thin, rear margin of gill cover thin and flexible, membranous ear flap elongated in adults, pectoral fins long and pointed, longest near dorsal side of fin contained a little less to a little more than three times into SL, no teeth on tongue, mouth small, upper jaw not extending beyond middle of eye, body depth about one-half SL.

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11. Beckman (1952)
12. Becker (1976)
13. Nelson and Gerking (1968)
14. Emery (1976)
15. Branson (1967)
16. Cross and Moore (1952)
17. Hubbs and Hubbs (1933)
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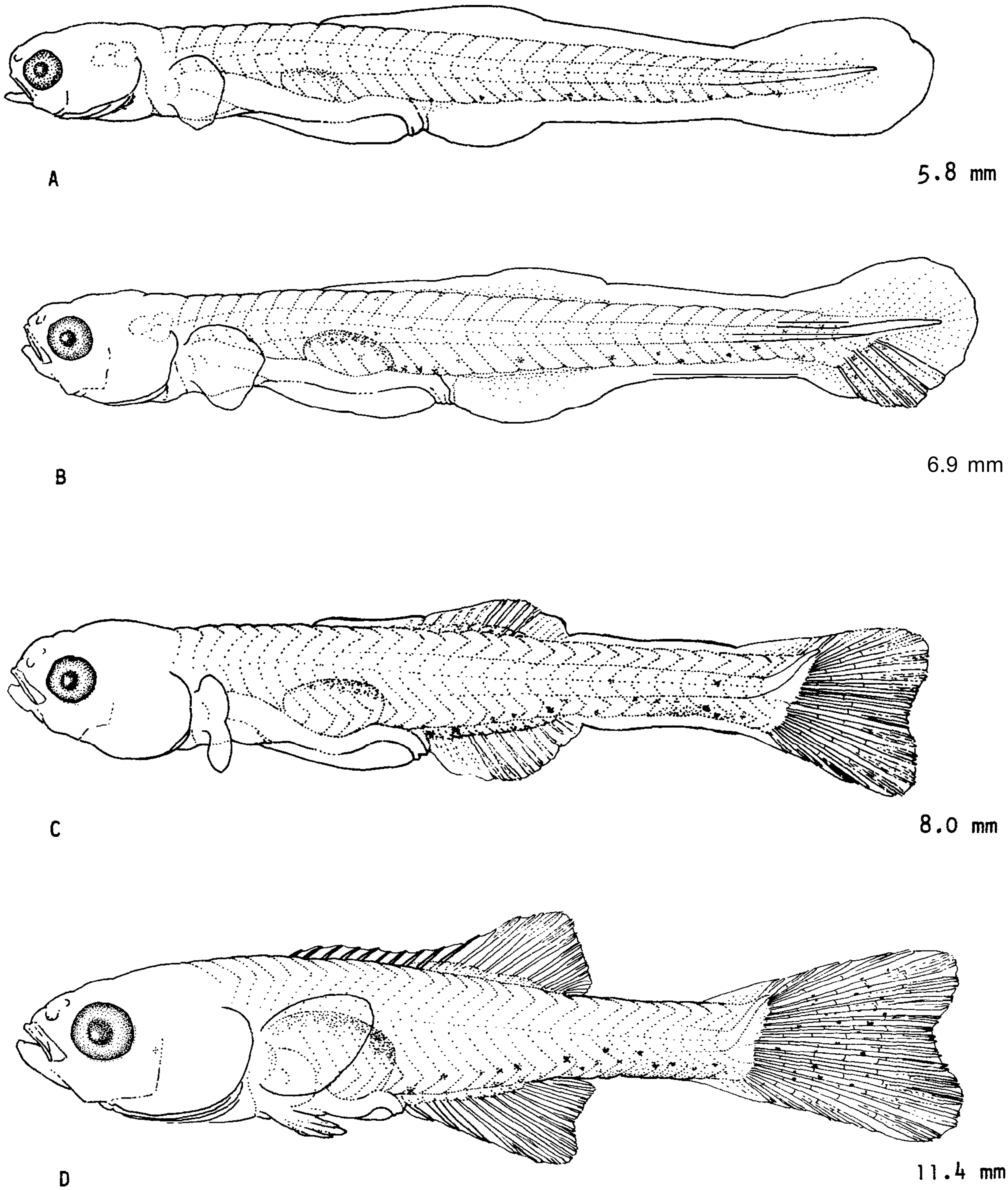

Fig. 227. Lepomis humilis, orangespotted sunfish. A-D. Larvae. (A-D, wild-caught, Louisiana, Conner 1979, specific identify subsequently verified by J. V. Conner).

Lepomis macrochirus Rafinesque, bluegill

DISTRIBUTION

Common to abundant throughout the Lake Michigan drainage;[21] also occurs in Lakes Erie, Ontario and Huron.[2] Introduced to many parts of the Lake Superior drainage.[3,24]

SPAWNING SEASON

Spawns from late May to early August in Wisconsin,[3] Ohio[5] and Indiana.[1,22] May to September in Illinois,[18,19] June to August in Michigan,[12,25] late May to early July in Minnesota.[24]

SPAWNING TEMPERATURE

Spawning occurs at 17.2 to 30.5 C.[1,3,5,23]

SPAWNING HABITAT

Spawns in shallow areas of lakes and ponds,[4] usually in water 15 to 120 cm deep,[1,2,12] with little vegetation.[1]

SPAWNING SUBSTRATE

Nests may be constructed on gravel, sand, clay or mud bottom.[2,3,23,24] Fine gravel is preferred.[14]

FECUNDITY

2,450 to 38,184;[2,3,5,25] 67,000.[28]

NATURAL HYBRIDS

Lepomis cyanellus;[29,30,33,34,35] *L. gibbosus*;[29,30,37] *L. gulosus*;[30,32,37] *L. humilis*;[33,36] *L. megalotis*;[31,32,37] *L. microlophus*.[36]

EGGS

Demersal;[1,2] adhesive;[3,4,5] amber;[2] diameter 1.2 to 1.4 mm;[5,7] oil globule single, diameter 0.38 mm;[26] incubation period: 75 to 85 hours at 18.5 C;[27] 72 hours at 21 C;[7] 39 hours at 24 C;[15] 32 to 33 hours at an average of 27 C.[26]

YOLK-SAC LARVAE

Total length	Description
2-5 mm	Newly hatched (2.2 to 3.2 mm).[3,5,17,27] Myomeres: 27 to 31 (11 to 13 + 15 to 18);[16] 23 to 30 (9 to 11 + 15 to 19).[10]

Morphometry: (as % TL) preanal length 55, head length 23, greatest body depth 23, eye diameter 5 (2.8 mm), preanal length 44 to 48, eye diameter 6 to 8 (3.5 to 4.5 mm).[5]

Morphology: oil globule located in posterior portion of yolk sac (newly hatched);[6] pectoral buds evident (3.3 to 3.7 mm);[9 11] anus open (3.5 to 4.4 mm);[9] swim bladder developing (3.5" or 4.6 mm[9 11]); rays beginning to form in caudal fin (4.3 to 5.5 mm[5 11] or 7.0 mm[7]); head relatively large, trunk narrow, incipient rays in pectoral buds, jaw developed but mouth not open (4.3 to 5.5 mm);[9 11] mouth open (4.6 to 4.8 mm);[9] operculum formed (4.8 mm);[5] oil globule located in anterior portion of yolk sac (4.9 to 5.7 mm).[9]

Pigmentation: unpigmented (newly hatched), eye pigmented (3.5' to 3.8 mm[10]); ventral row of chromatophores posterior to anus (4.5 mm, 148 hours postfertilization), several chromatophores along midlateral line and prominent spot on each side of body dorsal to anus (4.5 mm, 168 hours postfertilization);[10] pigment cells present in pairs dorso-laterally to anus, along abdomen and posterior to liver (5.0 to 5.8 mm).'[11]

LARVAE

Total length	Description
5-12 mm	Myomeres: 29 to 31 (12 to 14 + 15 to 18).[16]

Morphometry: (as % TL) preanal length 42, eye diameter 6 (5.0 mm).[5]

Morphology: yolk absorbed (4.9 to 5.8 mm; 7 to 10 days posthatching[9 11]); gut coiled (5 mm and larger);[17] pelvic buds developing (4.9 to 5.8[11] mm, 10.5[8] mm); dorsal and anal fin rays evident (10.5 mm), dorsal spines forming (11 to 12 mm), pectoral fins with rays (12.0 mm).[8]

Pigmentation: pigment on swim bladder (4.9 to 5.8 mm), 11 pigment spots on postanal venter, two to three lateral and dorsal to anus and three to four on venter between heart and anus (5.4 to 5.6 mm);[9 11] top of head unpigmented (5.5 mm[7] and 7.7 to 12.0 mm[8]); pigment present at base of pectoral fins, dorsum of gut and swim bladder, thoracic region and on myosepta of caudal region (5 to 8 mm);[6] a series of three to five melanophores on venter between opercle and anus (10 mm and smaller);[17] head entirely pigmented (9.0 to 10.3 mm), chromatophores forming an egg-shaped pattern on isthmus, this pattern not evident at 11.1 mm, a row of pigment along midlateral line and a ventral row along each side of anal fin base (described from figure).'

JUVENILES

Total length	Description
12-22 mm	Myomeres: 29 to 32 (12 to 15 + 15 to 17).[16] Morphometry: (as % TL) preanal length 41 to 47;[16] preanal length 45, greatest body depth 19 to 22;[5 20] eye diameter 8[5] (14.5 to 15.0 mm). Morphology: gill rakers long and slender (> 14 mm);[17] scales first evident (17.0 mm SL);[13] or squamation complete (14 to 15 mm).[27] Pigmentation: a small patch of chromatophores on dorsum of head, another patch on operculum between eye and pectoral fin base, a row of pigment on midlateral line of posterior third of body, scattered pigment below midlateral line from anal fin base to caudal fin, chromatophores on anal and caudal fins (13.5 mm, described from figure);* a row of interrupted melanophores on venter, except belly (15 mm);[20] about 11 narrow, vertical bars on lateral aspect between head and caudal fin (21.5 mm).[8]

ADULTS

Fin rays: caudal 17;[38] dorsal X (XI), 10 to 12, anal III, 11 (rarely 8 to 10), pectoral 13 (14), pelvic I, 5.[2]

Vertebrae: 28 to 30.[2 38]

Lateral line scales: 40 to 44.[2]

Diagnostic characters: opercular flap all black, not edged by yellow, orange or red, gill rakers long and slender, very deep body, greatest body depth less than three times into SL, anal fin spines three.

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10. Carver (1976)
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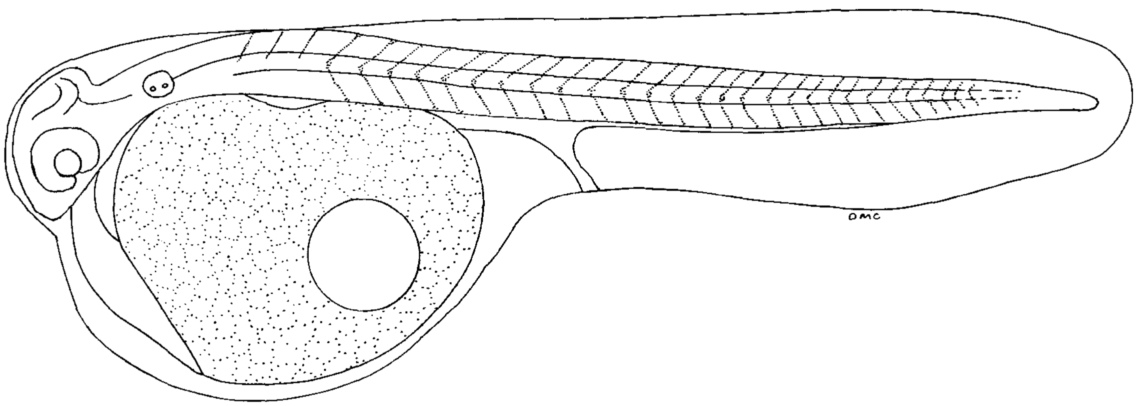
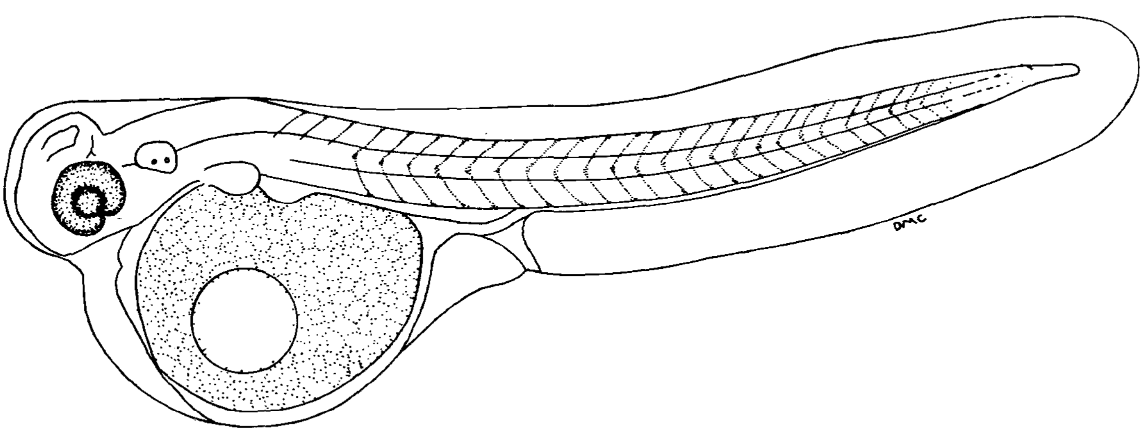
37. Hubbs (1920)
38. Bailey (1938b)



A

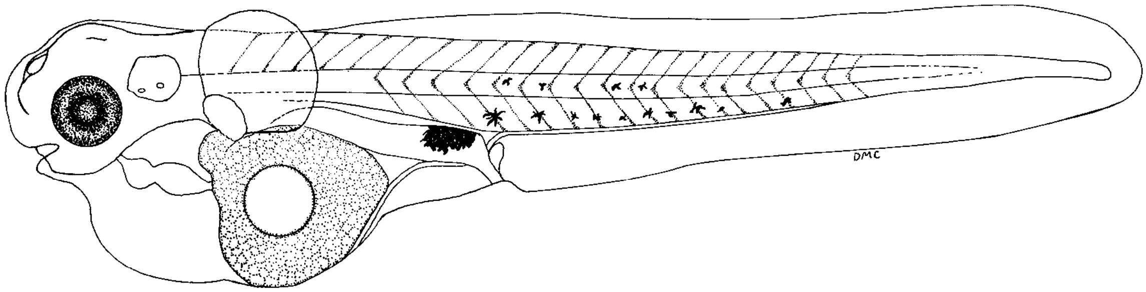
3.6 mm



B

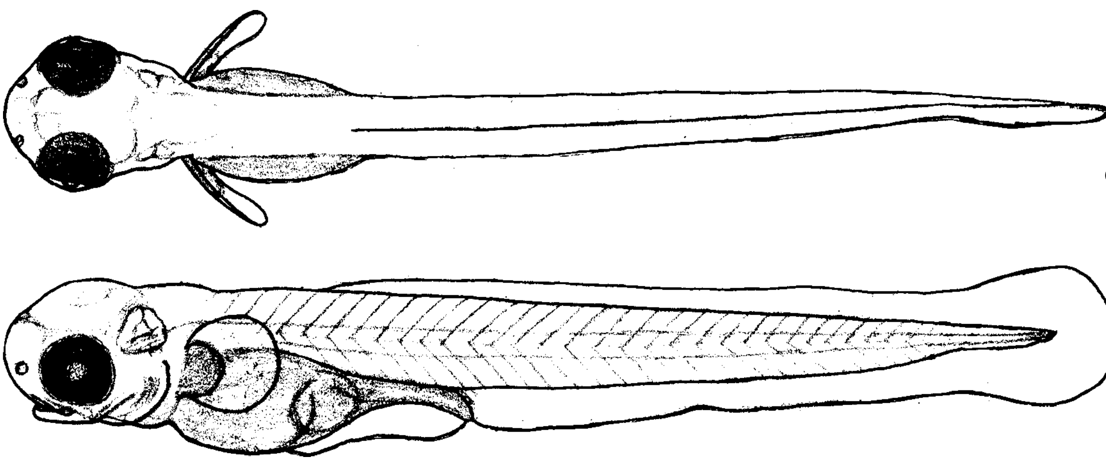
3.9 mm

Fig. 228. Lepomis macrochirus, bluegill. A and B. Yolk-sac larvae. (A and B, laboratory-reared, Maryland, Carver 1976).



A

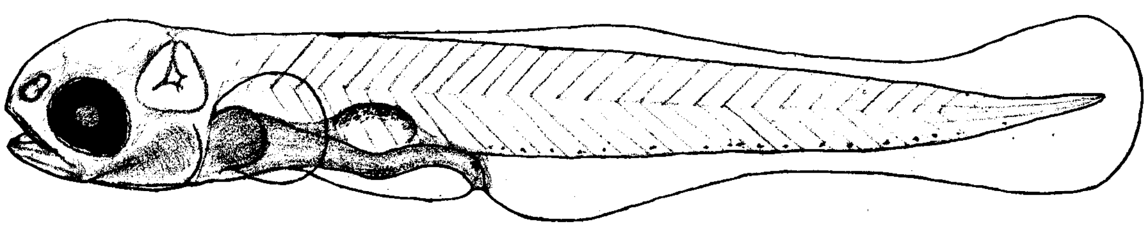
4.5 mm



dorsa 1

B

5.2 mm



C

6.8 mm

Fig. 229. Lepomis macrochirus, bluegill. A and 8. Yolk-sac larvae. C. Larva. (A, laboratory-reared, Maryland, Carver 1976; B and C, wild-caught, Oklahoma, Taber 1969).

Lepomis macrochirus

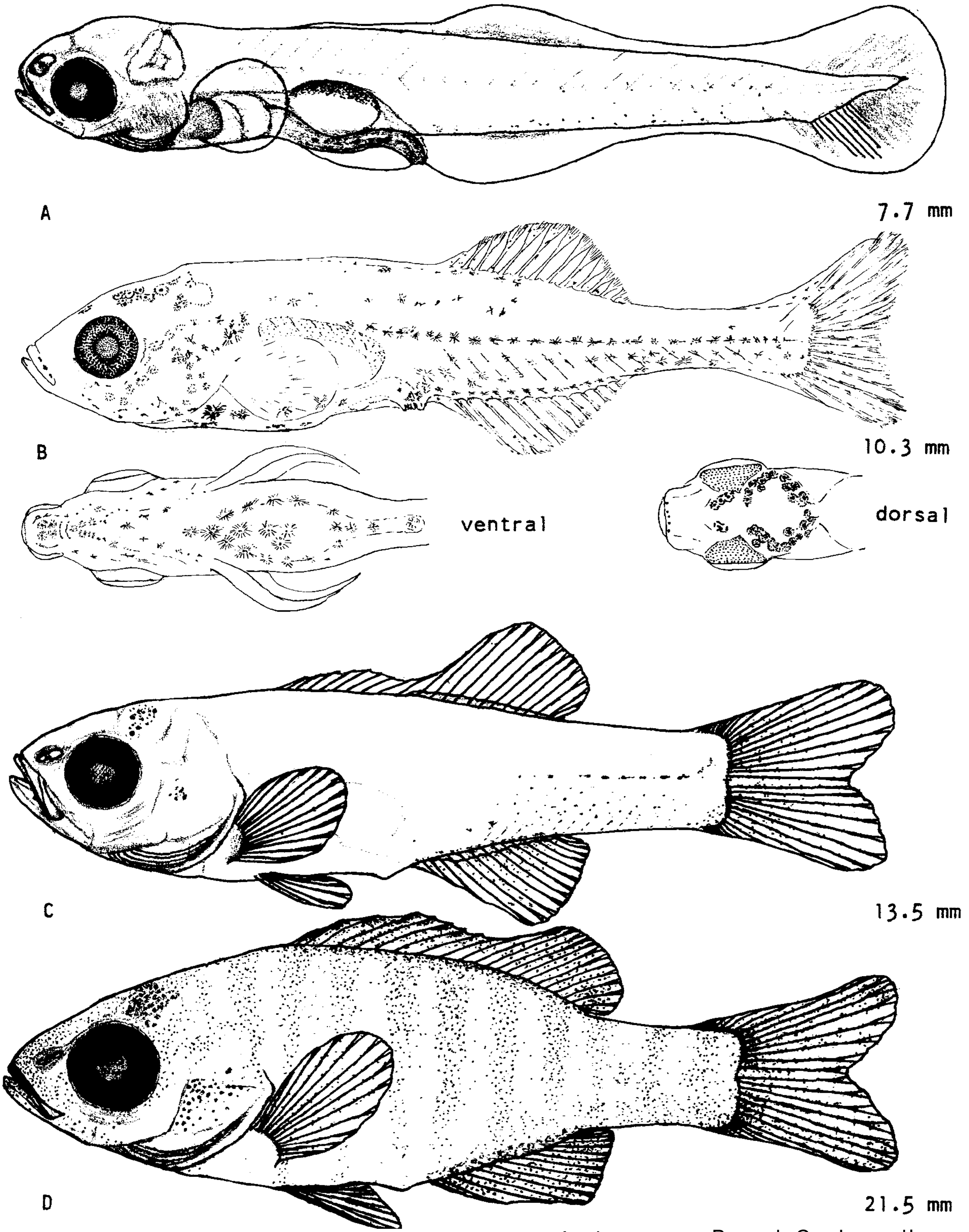


Fig. 230. Lepomis macrochirus, bluegill. A. Larva. B and C. Juveniles. (A, laboratory-reared, California, Meyer 1970 illustrated by C. Corson; B and C, wild-caught, Oklahoma, Taber 1969).

Lepomis megalotis (Rafinesque), longear sunfish

DISTRIBUTION

Common in Indiana and lower Michigan, uncommon to rare in Wisconsin[15] and rare in the Illinois portion of Lake Michigan drainage.[10 15] Also found in Lake Erie and the drainages of Lakes Huron and Ontario[2 16] but not reported from Lakes Superior, Huron or Ontario.'

SPAWNING SEASON

Spawning takes place from late June to August in Michigan,'[12] late May to August in Illinois,[11] May to August in Missouri[18] and during July in New York.[8]

SPAWNING TEMPERATURE

Spawning occurs at 21.6 to 31 C.[13 15 17]

SPAWNING HABITAT

Spawns in shallow areas of streams, lakes or reservoirs,"[18 19] usually in water 20 to 60 cm.[7 11 13]

SPAWNING SUBSTRATE

Builds nests in gravel, pebbles, sand or hard mud.[2 5 13 14 19]

FECUNDITY

2,360 to 22,119.[2 15]

NATURAL HYBRIDS

Lepomis cyanellus;[21 23] L. gibbosus;[23] L. humilis;[21] C. macrochirus.[20 22 24]

EGGS

Demersal, adhesive;[1 5 6 7] pale yellow to amber;[2] diameter 1.0 mm;[1 2] incubation period: 3 days at 25 C.[13]

YOLK-SAC LARVAE

Total length	Description
2.5-3.0 mm	Newly hatched.'
	Caudal fin rays developed in yolk-sac larvae.'

LARVAE

Total length	Description
6-11 mm	Myomeres: 27 (10 + 17) (derived from figure).[4]

Morphology: pectoral buds well developed (6.0 mm), spines developing in dorsal fin (8.0 mm), pelvic fins first evident (9.3 mm, derived from figure).[1]

Pigmentation: pigment on dorsum of swim bladder, a row of chromatophores on preanal venter (6.0 mm), ventral pigment increases particularly above anal fin, few chromatophores on head and abdomen, a faint pigment spot on upper part of operculum (6.5 to 7.1 mm), pigment on head and body increases, chromatophores developed on caudal, dorsal and anal fins and upper jaw (11.3 mm, observed on figures).[1]

JUVENILES

Total length	Description
13-19 mm	Pigmentation: chromatophores scattered over posterior portion of body, a patch of pigment behind eye, chromatophores on spinous dorsal fin (13.4 mm), pigment spots on all fins except pelvic fins, ca. 10 vertical bands on lateral aspect between head and caudal fin, pigment bands wider than interspaces (19.0 mm).[4]

ADULTS

Fin rays: caudal 17;[3] dorsal X or XI,11 (10 to 12), anal III,10 (10 to 12), pectoral 12 (10 to 13), pelvic I,5.[1]

Vertebrae: 29 (28 to 30).[2]

Lateral line scales: 35 (33 to 38).[2]

Diagnostic characters: gill rakers reduced to knobs, rear margin of bony gill cover thin and flexible, ear flap considerably elongated.

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4. Taber (1969)
5. Adams and Hankinson (1928)
6. Breder (1936)
7. Hankinson (1908)
8. Raney (1965)
9. Emery (1976)
10. Smith (1979)
11. Hankinson (1919)
12. Hubbs and Cooper (1935)
13. Huck and Gunning (1967)
14. Witt and Marzolf (1954)
15. Becker (1976)
16. Hubbs and Lagler (1958)
17. Cross (1967)
18. Pflieger (1975)
19. Boyer and Vogele (1971)
20. Benson (1959)
21. Cross (1950)
22. Cross and Moore (1952)
23. Hubbs and Hubbs (1933)
24. Branson (1967)

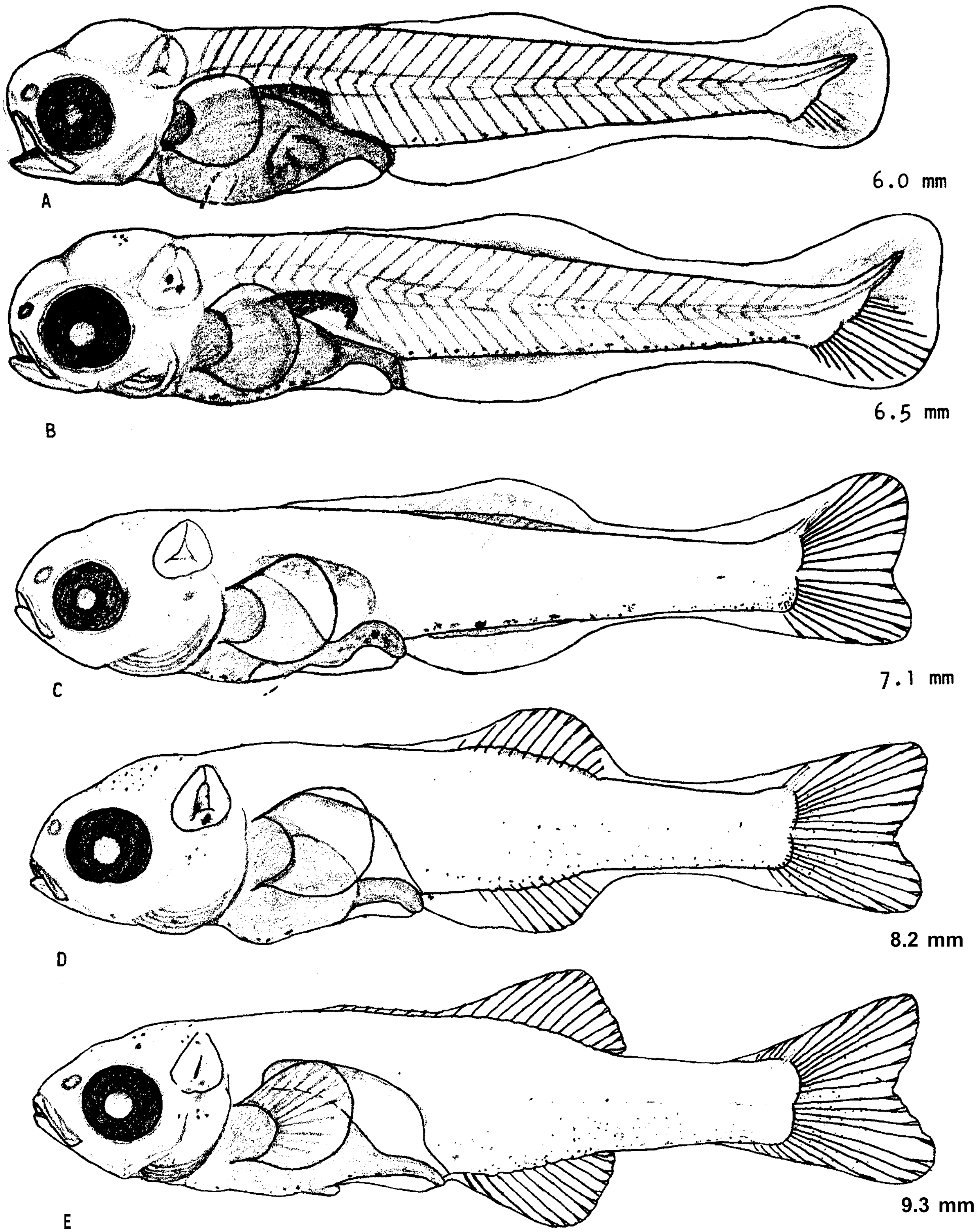

Fig. 231. Lepomis megalotis, longear sunfish. A. Yolk-sac larva. B-E. Larvae. (A-E, wild-caught, Oklahoma, Taber 1969).

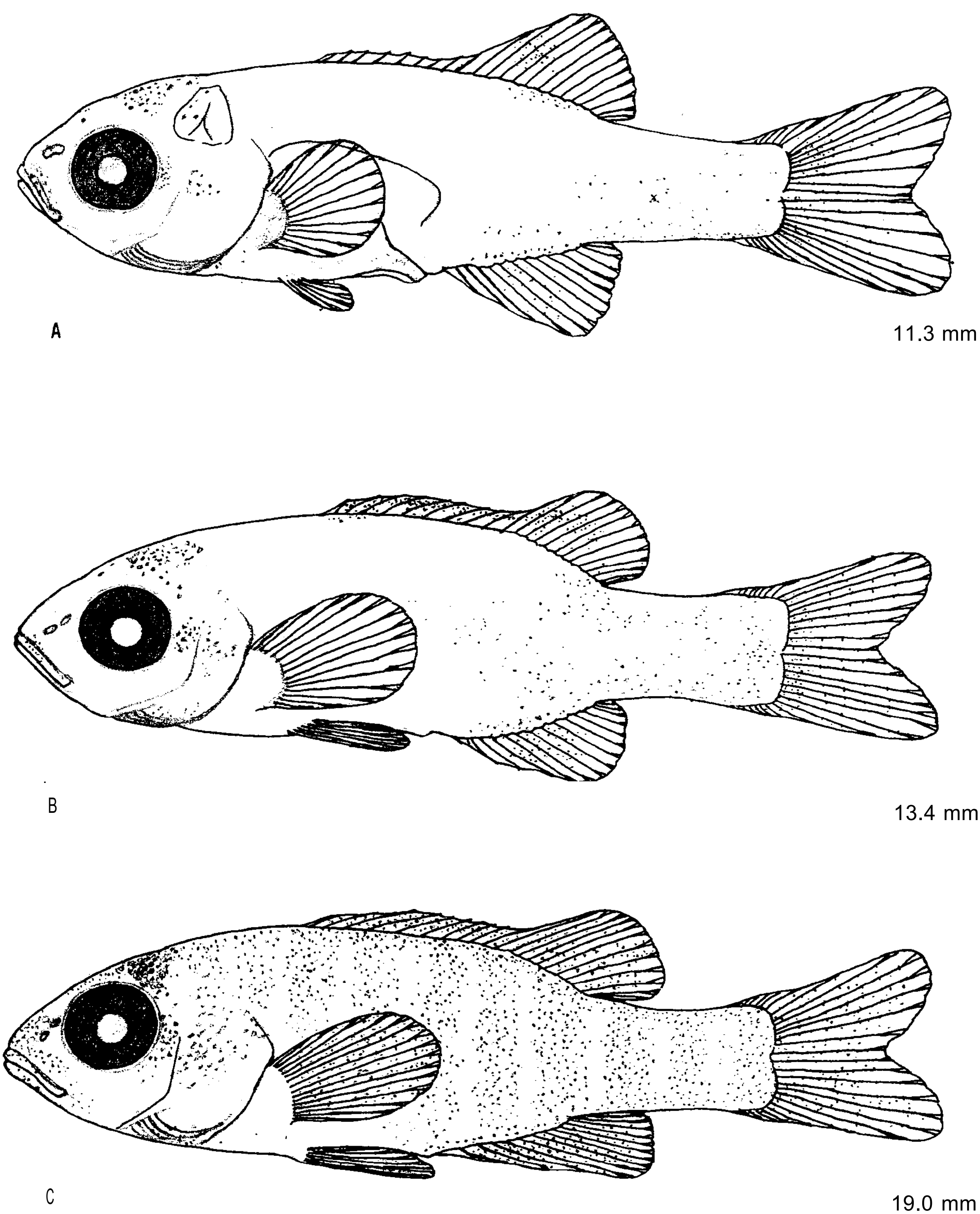

Fig. 232. Lepomis megalotis, longear sunfish. A. Larva. B and C. Juveniles. (A-C, wild-caught, Oklahoma, Taber 1969).

Lepomis microlophus (Gunther), redear sunfish

DISTRIBUTION

Occurs only in Indiana and lower Michigan in the Lake Michigan drainage,[9 13] not reported from the other Great Lakes except Lake Erie.[6]

SPAWNING SEASON

Spawns during May and June in Illinois," from May to August in Missouri' and late June to early July in Ohio.'

SPAWNING TEMPERATURE

Spawning occurs at 20 to 32 C.[11 13]

SPAWNING HABITAT

Spawns in shallow water of lakes and ponds[11] in water up to 3 m deep.[8]

SPAWNING SUBSTRATE

Nests are constructed on gravel, sand or mud bottom.[13]

FECUNDITY

2,000 to 10,000."

NATURAL HYBR IDS

Lepomis cyanellus;[14] L. macrochirus.[12 15]

EGGS

Demersal;[11] adhesive;[13] diameter 1.3 to 1.6 mm;[1] incubation period: 3 days at 21.1 C;[1] 49 to 52 hours at 23.6 c, 27 to 28 hours at 28.7 C.[2]

YOLK-SAC LARVAE

Total length	Description
5 mm	Pigmentation: pigment on dorsum of swim bladder, gut and yolk sac, a few pigment spots on head, a row of chromatophores on postanal venter (observed on figure).'

LARVAE

Total length	Description
5-15 mm	Morphometry: greatest body depth 24% TL.[5]

Morphology: incipient rays in caudal fin (6.2 mm), noticeable hump on head (7 to 11 mm), dorsal and anal fin rays developing (8.3 mm), pelvic fins evident, incipient spines in dorsal fin (14.0 mm);[1] body compressed (10 to 15 mm).[5]

Pigmentation: two patches of broad, chromatophores on top of head (5.1 to 7.0 mm), a dark bar of chromatophores forming on isthmus (7.0 mm) becoming prominent (9.0 mm), a row of chromatophores on midlateral line, a prominent patch of pigment on top of head, pigment scattered over body, dorsum of swim bladder pigmented (10.2 mm), pigment on body increased, chromatophores developing along rays of soft dorsal fin and upper rays of caudal fin (14 mm, observed from figures);[1] a ventral row of pigment on breast and belly from angle of gill covers to anus, a double row on venter behind anus, one on each side of anal fin, body speckled throughout, vertical fins pigmented (10 to 15 mm).[5]

JUVENILES

Total length	Description
32 mm	Pigmentation: body covered with pigment except breast which is unpigmented, narrow vertical bands on sides of body, chromatophores on all median fins.[1]

ADULTS

Fin rays: caudal 17;[3] dorsal X,11 or 12, anal 111,10 or 11, pectoral 13, pelvic I,5.[10]

Vertebrae: 30.*

Lateral line scales: 39 to 44.'

Diagnostic characters: rear margin of gill cover thin and flexible, soft dorsal fin without distinct spots, cheeks without wavy blueish lines in adults, ear flap with a prominent red or orange spot in adults, gill rakers short and thick, pectoral fin long and pointed and longest rays near dorsal side of fin, pectoral fin contained about three times in SL, mouth small, upper jaw not extending to beneath pupil of eye, tongue without teeth, body depth about one-half SL, precaudal vertebrae 12.

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3. Bailey (1938b)
4. May and Gasaway (1967)
5. Werner (1966)
6. Emery (1976)
7. Pflieger (1975)
8. Emig (1966b)
9. Hubbs and Lagler (1958)
10. Cross (1967)
11. Lopinot (1961)
12. Moore and Paden (1950)
13. Becker (1976)
14. Childers and Bennett (1961)

15. Cross and Moore (1952)

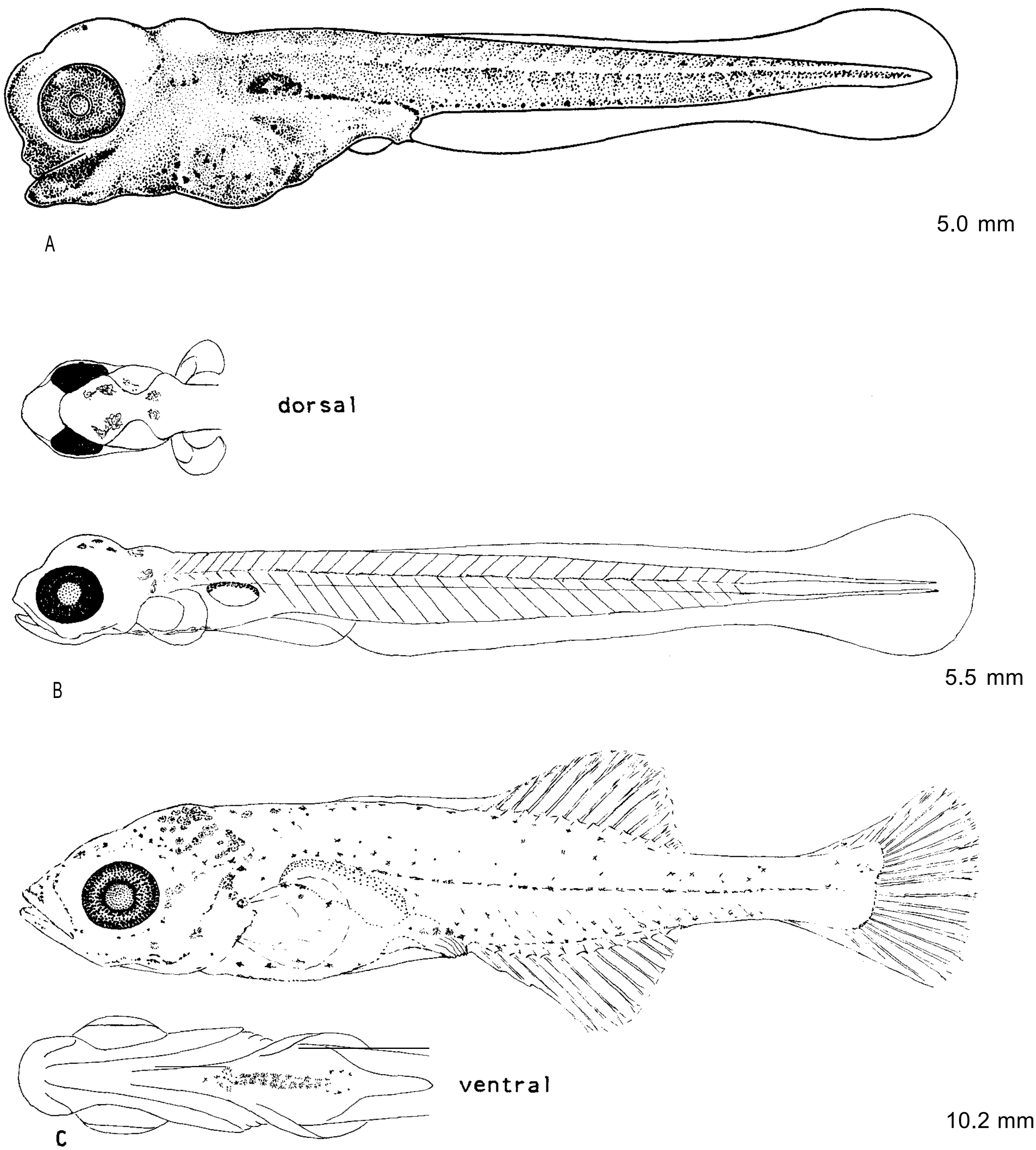
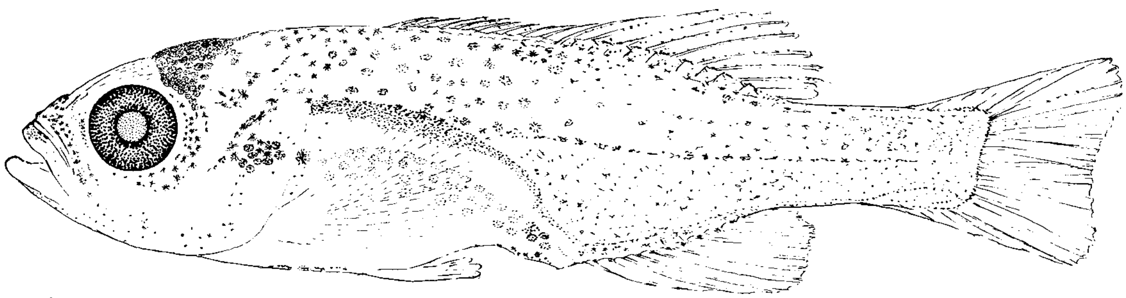
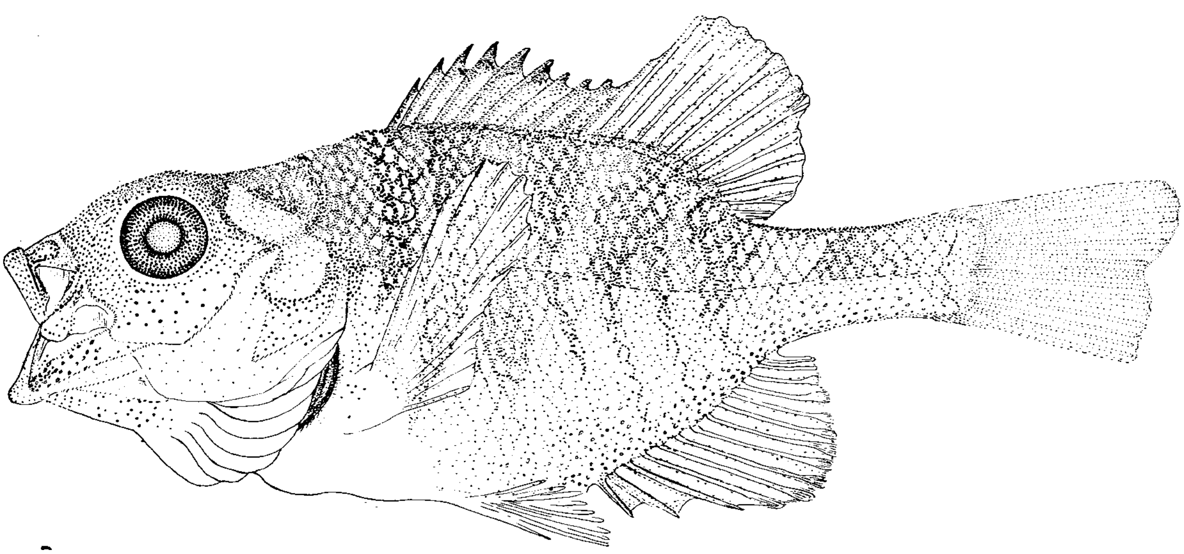


Fig. 233. Lepomis microlophus, redear sunfish. A. Yolk-sac larva. B and C. Larvae. (A, laboratory-reared, Illinois, Childers 1967; B and C, laboratory-reared, California, Meyer 1970, illustrated by C. Corson).



A

14.0 mm



32.0 mm

Fig. 234. Lepomis microlophus, redear sunfish. A. Larva. B. Juvenile. (A and 8, laboratory-reared, California, Meyer 1970, illustrated by C. Corson) .

Micropterus dolomieui Lacepede, smallmouth bass

DISTRIBUTION

Occurs in all of the Great Lakes.' Distributed throughout the Lake Michigan drainage except in Illinois, more common northward.[16]

SPAWNING SEASON

Spawning takes place from April to June in Michigan' and Ohio[3], May in Wisconsin,[23] May and June in Lake Erie[19] and may extend to August in Minnesota.'

SPAWNING TEMPERATURE

Spawning occurs at 12.8 to 23.9 c.[1 18 21 22 23]

SPAWNING HABITAT

Spawns in rivers, streams and along shores of lakes, in locations protected from waves and wind.[12 18] Nests are found in water 30 to 610 cm.[1 2 12 18]

SPAWNING SUBSTRATE

Spawns on rock, gravel and coarse sand.[2 5 20]

FECUND ITY

2,000 to 20,825.[5 7 14]

EGGS

Demersal;' adhesive;[2 6 18] grayish white;[7] opaque;[6 7] light amber or pale yellow;' diameter 1.8 to 2.8 mm;[7 8 12 17] oil globule large and single;[7 17] diameter 0.9 to 1.7 mm;[17] numerous small oil droplets present;[7] incubation period: 6 days at 15.6 C;[10] 5 days at 18.9 C;[20] ca. 4 days at 21.1 C;[5] 2.5 days at 22.2 C.[20]

YOLK-SAC LARVAE

Total length	Description
4-10 mm	Newly hatched (4.6 to 5.0 mm).[7 17] Morphometry: (as % TL) preanal length 45, greatest body depth 20, eye diameter 10 (8.8 mm).[11] Morphology: head deflected over yolk sac (newly hatched), pectoral buds present as low ridges parallel to body axis (5.4 mm), mouth open, jaw not formed, pectoral buds semi-circular (6.0 mm), lower jaws evident (6.8 mm), pectoral buds triangular and shifted to 45 degree angle (7.5 mm), jaws of equal length, caudal fin

beginning to develop (8.3 mm) ;[7] mouth large, maxilla extending to middle of pupil (8.8 mm);[11] swim bladder developing, notochord turned upward (9.3 mm).[7]

Pigmentation: body transparent, yolk pale yellow, oil globule bright golden (newly hatched), eye pigmented (1 day old, 5.4 mm), band of pigment along junction of yolk sac and body, eye black (6.0 mm), a second band of pigment parallel to first on body from auditory vesicle to posterior limit of yolk sac, eye becoming iridescent (6.8 mm), sides of body, yolk sac, head and lower jaws covered with pigment (7.5 mm);[7] body except fins and venter of yolk sac pigmented (8.8 to 9.3 mm).[7 11]

LARVAE

Total length	Description
8-16 mm	Morphometry: (as % TL) preanal length 53 to 54, greatest body depth 22, eye diameter 10 or 11 (9.5 to 10.0 mm).[11] Morphology: yolk absorbed (8.7 to 9.9 mm);[1] head large, body gradually tapering to tail, intestine becoming coiled (9.5 mm) ;[11] dorsal and anal fin rays forming (9.5 to 10.0 mm) ;[8 11] finfold continuous between dorsal, anal and caudal fins (11.1 mm), pelvic buds evident (11.5 mm);[7] dorsal fin spines developing (15.6 mm, observed on figure).[6] Pigmentation: pigmentation similar to that in previous stage, but with concentrations of chromatophores on top of head, over gut and caudal region (10.2 mm, observed on figure);[6] body covered with black pigment tinged with green and bronze (12 mm);[7] dark spot on top of head, pigment even on body, venter less pigmented (15.6 mm, observed on figure).[6]

JUVENILES

Total length	Description
16-27 mm	Morphometry: (as % TL) preanal length 51, greatest body depth 23, eye diameter 8 (19.0 mm) .[11] Morphology: lower jaw projecting, maxilla extending to middle of pupil;[11] caudal fin notched, dorsal and anal fins separated from caudal fin[7] (19.0 mm), scales first evident (18 to 22 mm) .[13] Pigmentation: large melanophores covered entire body, faint, narrow midlateral stripe developing (16.1 mm SL);[15] ten dark vertical bands present on each side of body (27 mm) .[7]

ADULTS

Fin rays: caudal 17;[9] dorsal X,12 to 15, anal III,11 (10 to 12), pectoral 13 to 15, pelvic I,5.[1]

Vertebrae: 31 or 32.[1 9]

Lateral line scales: 68 to 78.1

Diagnostic characters: upper jaw extending to midpupil, but not beyond eye, dorsal fin shallowly emarginate, the shortest spines at emargination being more than one-half the longest, pelvic fins joined by a membrane, membrane connecting fin to body hidden, body depth about one-third SL.

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3. Langlois (1936)
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6. James (1930)
7. Reighard (1906)
8. Meyer (1970)
9. Bailey (1938b)
10. Breder (1936)
11. Fish (1932)
12. Tester (1930)
13. Everhart (1949)
14. Culler (1938)
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16. Becker (1976)
17. Mansueti , R. J. (1964)
18. Hubbs and Bailey (1938)
19. Langlois (1954)
20. Curtis (1949)
21. Pflieger (1966)
22. Latta (1963)
23. Cahn (1927)

Micropterus dolomieui

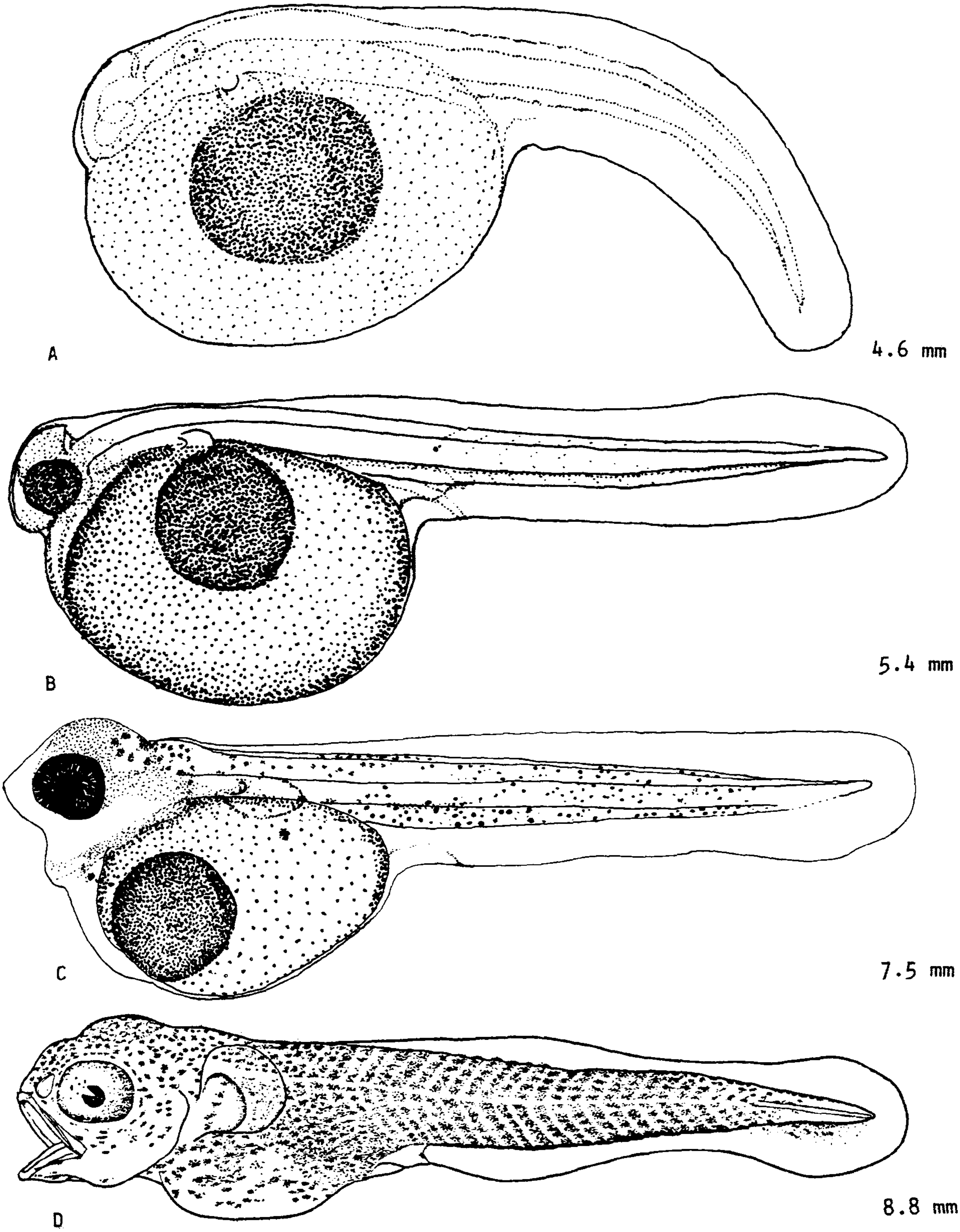

Fig. 235. Micropterus dolomieui, smallmouth bass. A-D. Yolk-sac larvae. (A-C, wild-caught, Michigan, Reighard 1906; D, laboratory-reared, New York, Fish 1932).

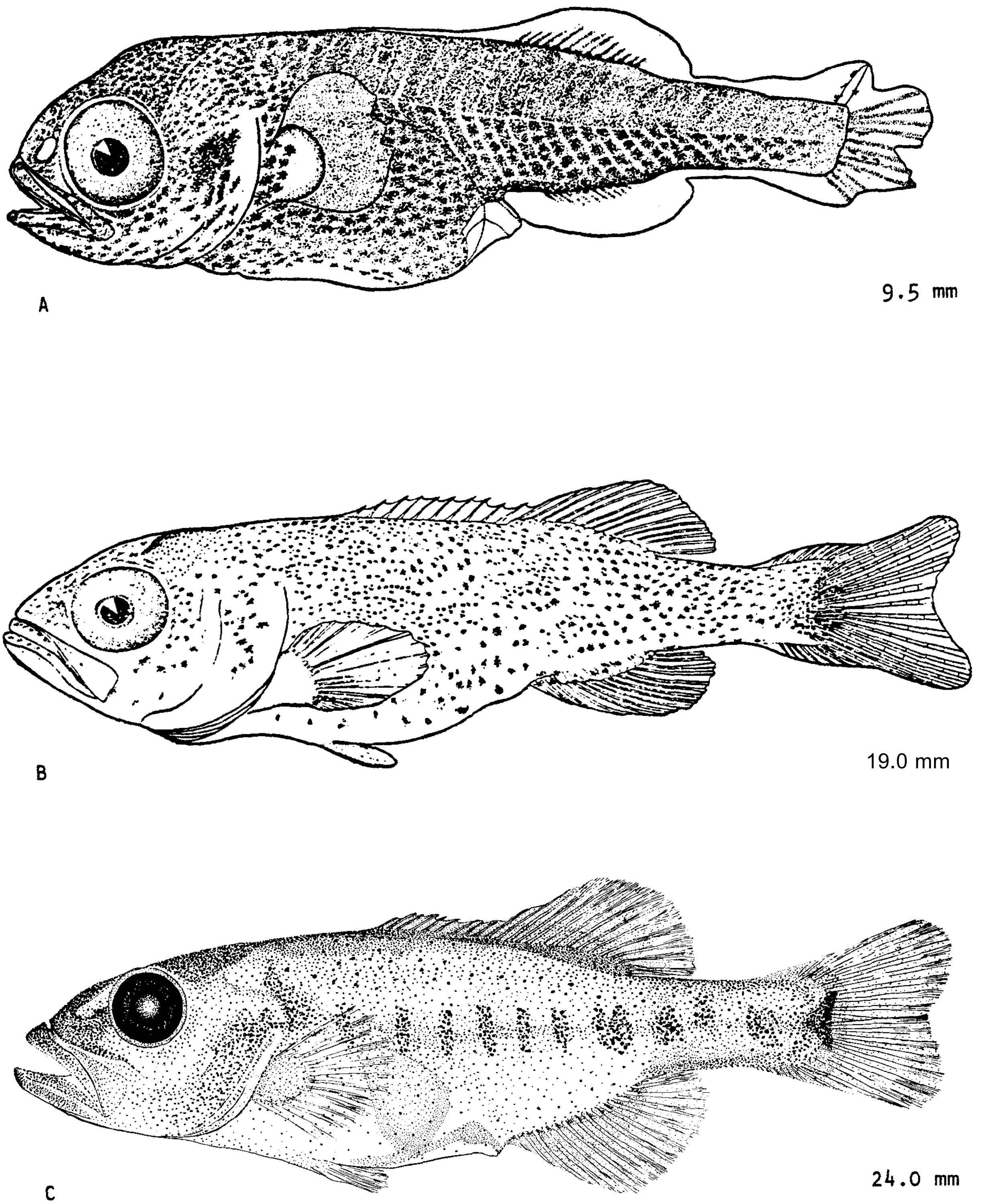

Fig. 236. Micropterus dolomieui, smallmouth bass. A. Larva. B and C. Juveniles. (A, hatchery-reared, New York; B, wild-caught,. Lake Erie, Fish 1932; C, laboratory-reared, California, Meyer 1970, illustrated by C. Corson) .

Micropterus salmoides (Lacepede), largemouth bass

DISTRIBUTION

Occurs in all of the Great Lakes except Lake Superior[15 34] and is uncommon in the Lake Superior drainage.[20] Common to abundant in the Lake Michigan drainage,[30] extensively introduced into many parts of the United States.[7 15]

SPAWNING SEASON

Spawning takes place from late April to June in Wisconsin,[21 24] May to June in Michigan[29] and Illinois;[25 26] May to July in Ohio" and April to July in Minnesota.[19 20]

SPAWNING TEMPERATURE

Spawning usually occurs at 16 to 23.9 C.[2 7 10 20 22 26]

SPAWNING HABITAT

Spawns in shallow, sheltered areas of rivers, lakes and ponds,[20 21] usually with aquatic vegetation.[10 22 28] Nests are constructed in water up to 2 m deep,[10 31] but more often in water 30 to 122 cm.[7 28]

SPAWNING SUBSTRATE

Spawns on gravel, sand[10 13 17 21 22 29] or soft mud.[26] Eggs are attached to stones, roots, detritus or other objects.I[6 9 17]

FECUNDITY

2,000 to 81,582.[10 20 31]

EGGS

Demersal, adhesive;[6 6 9 27] light yellow, orange[12] or cream;[11] diameter 1.4 to 2.0 mm;[1 3 27] oil globule, usually single, diameter 0.65 to 0.7 mm;[6 27] a few smaller oil globules may be present;[6] incubation period: 5 days at 18.9 C;[32] 4 days at 15.6 to 16.8 C, 3 days at 16.8 to 19.6 C;[10] 2 days at 22.2 C;[32] 2 days at 21.7 to 23.9 C.[33]

YOLK-SAC LARVAE

Total length	Description
3-6 mm	Newly hatched (2.3 to 5.5 mm).[6 12 17 27] Myomeres: 34 to 36 (11 + 23 to 25) .[6] Morphometry: (as % TL) preanal length 62, greatest body depth 41, eye diameter 7 or 8.6

Morphology: body robust, finfolds wide, yolk sac large, head strongly deflected downward over anterior margin of yolk sac;[4] oil globule located in posterior portion of yolk sac;[6, 27] choroid fissure wide, pectoral buds evident[6] (newly hatched;" or 1 day posthatching, 4.8 mm[27]); swim bladder developing (5.0 mm);[6] or formed (4.0 mm).[16]
Pigmentation: unpigmented from hatching to 4.75 mm;[6, 7] pigment appearing in eye (5.0 to 5.4 mm).[16, 17]

5-8 mm

Myomeres: 29 or 30 (11 + 17 to 19).[5, c, 27]
Morphometry: (as % TL) preanal length 44 to 46;[6] to 49;* greatest body depth 20 to 23, eye diameter 6 to 9.[6]
Morphology: lower jaw developing (5.0 mm);[6] mouth cavity evident (5.3 mm);[17] upper jaw formed, opercle developing (6.2 mm), mouth functional, swim bladder filled, first pectoral fin rays present (6.5 to 7.2 mm).[c]
Pigmentation: chromatophores evident above and below swim bladder (5.0 mm);[16] a few chromatophores along junction of body and yolk sac and on yolk sac (5.6 mm);[17] melanophores on head, dorsum, lateral line and yolk sac (5.0 to 6.2 mm);[6, 27] ventral band of pigment distinct, dorsal band beginning to form (6.3 mm);[4, 17] pigment over whole body and yolk sac (7.3 to 8.0 mm).[17]

LARVAE

Total length	Description
6-16 mm	Myomeres: 30 (11 + 19).[27]
	Morphometry: preanal length 45 to 50% TL.[27]
	Morphology: yolk absorbed (6.5 to 8.0 mm;[5, 17, 27] 9 to 15 days posthatching[10, 17]); larvae stocky anteriorly;[27] deepest in the head and thoracic region;' caudal fin rays forming (7.26 or 9.6[17] mm); gut massively coiled (8.0 mm);[5, 23] pelvic buds developing (11 to 15 mm).[27]
	Pigmentation: dorsal and anal fins pigmented (9.6 mm);[17] an indefinite lateral band of pigment begins to form, pigment concentrated on head, behind eyes and on abdomen, sparse pigment on body and caudal fin (observed on figure);[1] snout tip pigmented'[5] (10.2 mm). pigment patterns similar to those of 10.2 mm larvae (15.5 mm), lateral band well defined from snout to caudal fin base, chromatophores on venter of abdomen and a patch of pigment on top of head (observed on figure).[1]

JUVENILES

Total length	Description
16-40 mm SL	Myomeres: 30 (11 + 19).[27]
	Vertebrae: 32 or 33 (16 + 16 or 17).[27]

Morphology: body robust, less compressed than other centrarchids, maxilla reaching to or beyond posterior margin of eye;[5] scales first appear (16.8 mm SL).[18]
Pigmentation: lateral stripe conspicuous, wide and uninterrupted (16.8 mm SL), submarginal caudal band forming (35 mm SL), well developed (40 mm SL), lateral stripe disrupted (35 mm SL).[18]

ADULTS

Fin rays: caudal 17;[14] dorsal X,12 (12 to 14), anal III,11 (10 to 12), pectoral 13 to 15, pelvic I,5.[7]

Vertebrae: 30 to 33.[7 14]

Lateral line scales: 60 to 68.7

Diagnostic characters: upper jaw extends beyond eye, dorsal fin almost divided, the shortest spine at the emargination less than half as long as the longest, pelvic fins not joined by membranes, membrane connecting fins to body obvious, body depth about one third of SL.

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10. Kramer and Smith (1962)
11. Snow (1971)
12. Heidinger (1975)
13. Emig (1966a)
14. Bailey (1938b)
15. Hubbs and Lagler (1958)
16. Johnston (1953)
17. Reighard (1906)
18. Ramsey and Smitherman (1972)
19. Turner and Kraatz (1921)
20. Eddy and Underhill (1974)
21. Johnson (1971)
22. Mraz and Cooper (1957)
23. Conner (1979)
24. Cahn (1927)
25. Forbes and Richardson (1909)
26. James (1946)
27. Mansueti, R. J. (1964)
28. Hankinson (1908)
29. Carbine (1939)
30. Becker (1976)
31. Kelly (1962)
32. Curtis (1949)
33. Stranahan (1908)
34. Emery (1976)

Micropterus salmoides

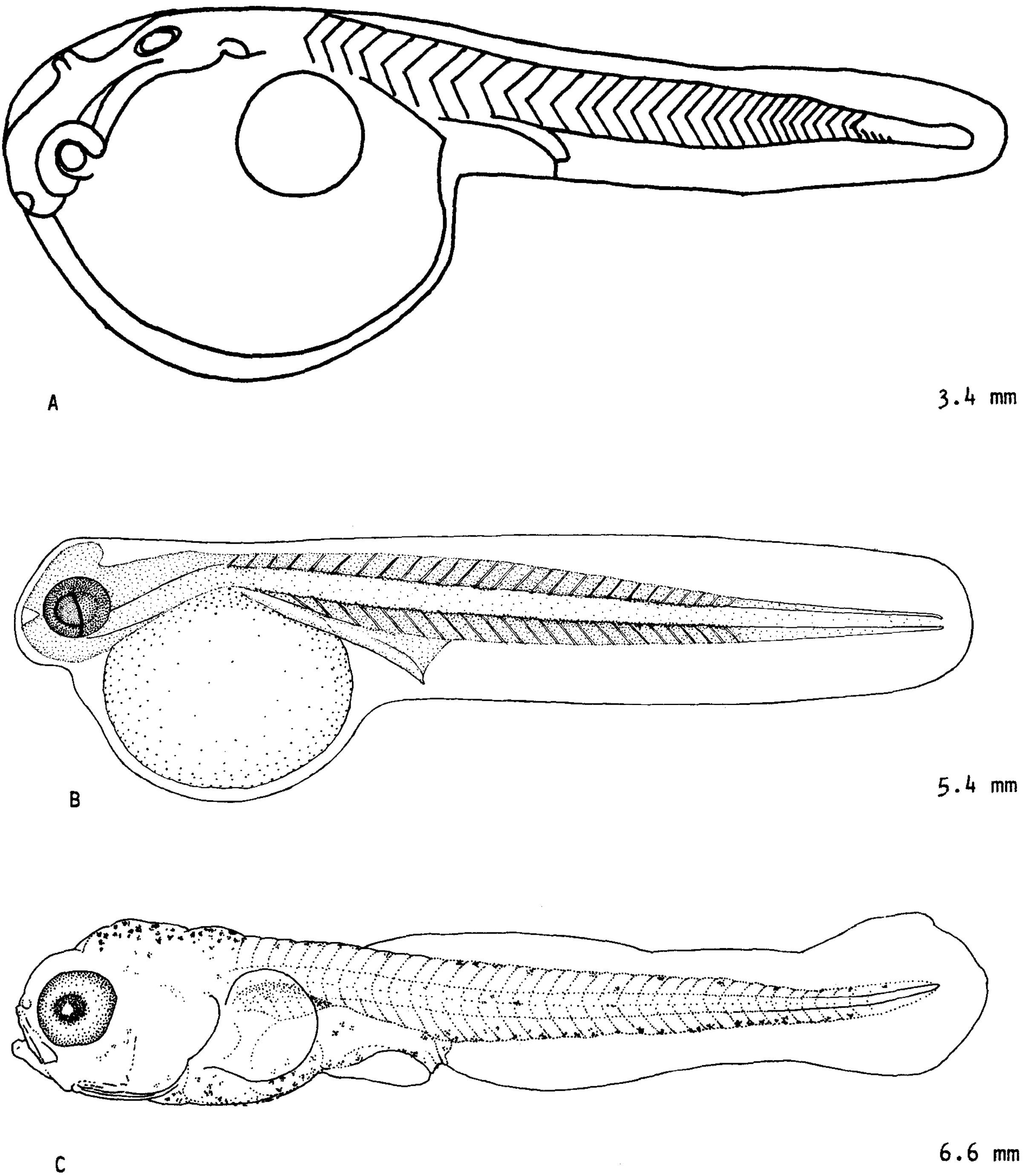


Fig. 237. Micropterus salmoides, largemouth bass. A-C. Yolk-sac larvae. (A, laboratory-reared, Florida, Carr 1942; B, laboratory-reared, California, Meyer 1970, illustrated by C. Corson; C, wild-caught, Louisiana, Conner 1979, specific identity subsequently verified by J. V. Conner) .

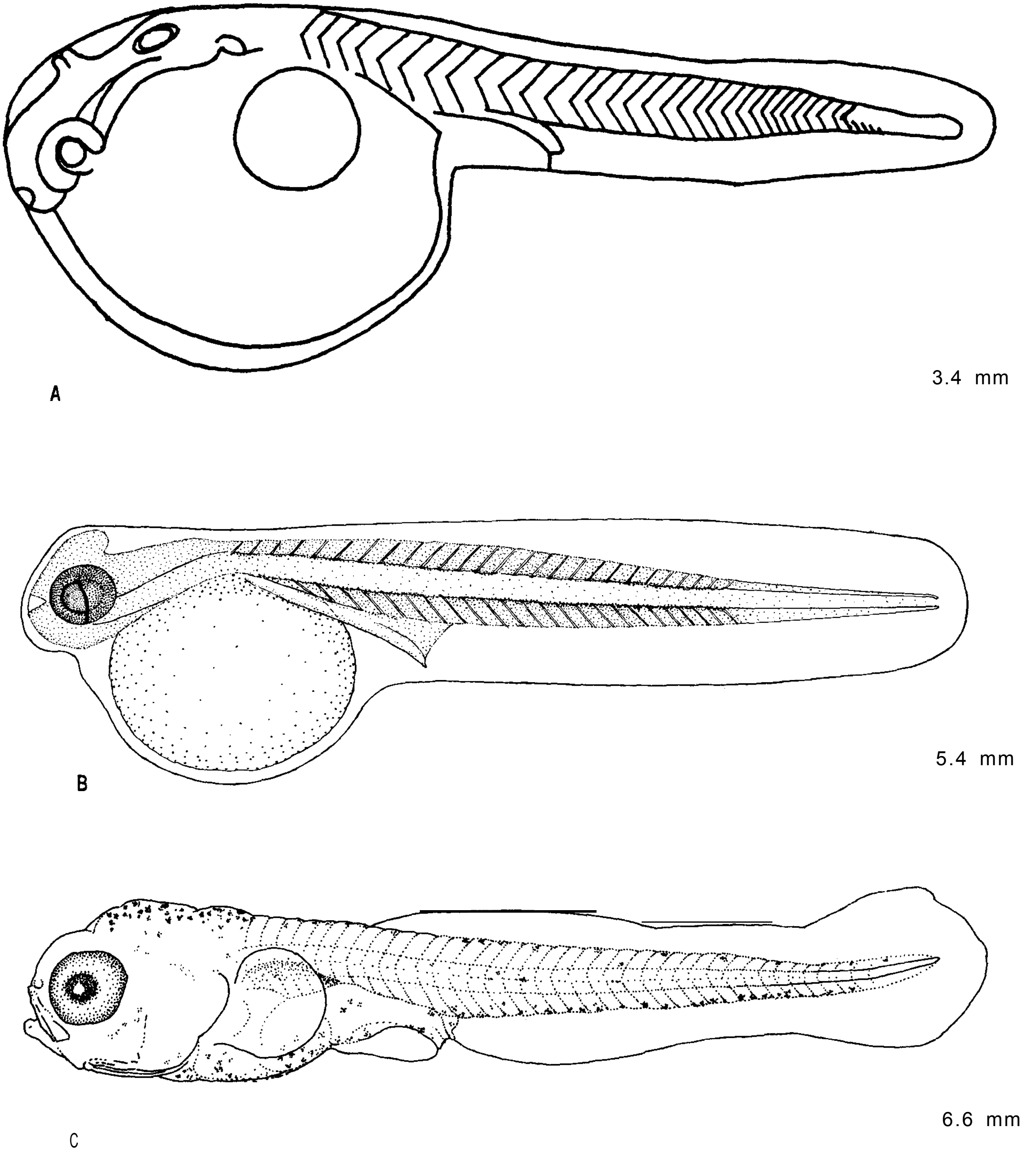
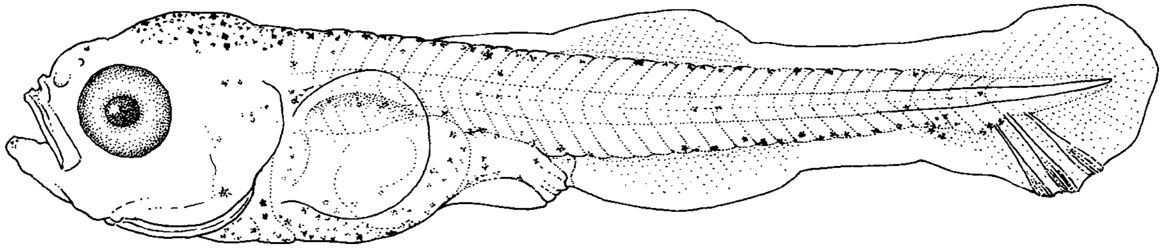
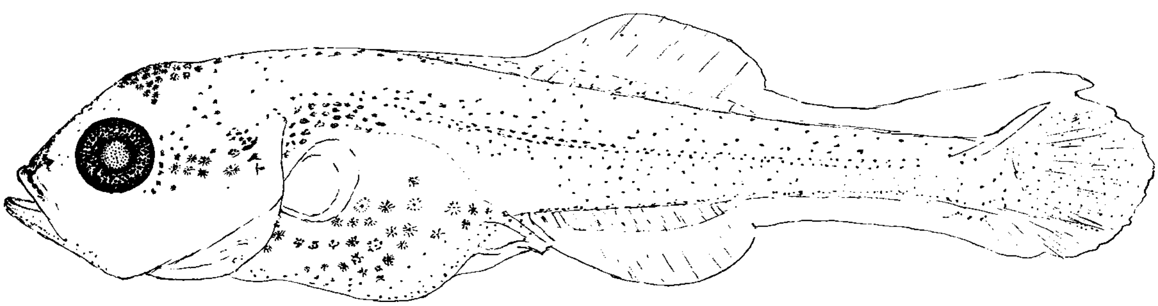


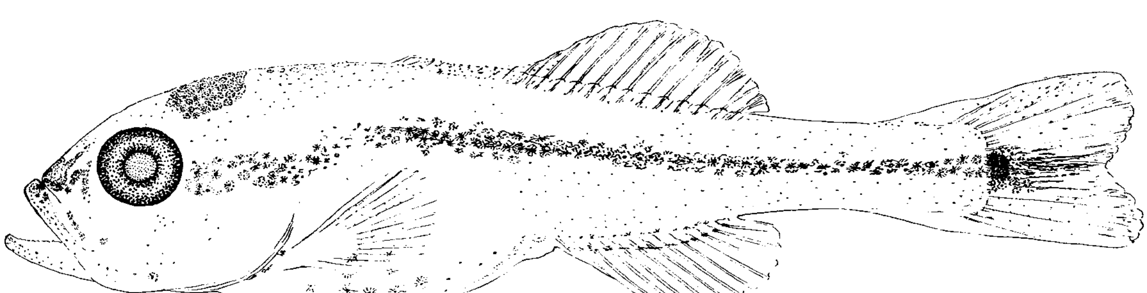
Fig. 237. Micropterus salmoides, largemouth bass. A-C. Yolk-sac larvae. (A, laboratory-reared, Florida, Carr 1942; B. laboratory-reared, California, Meyer 1970, illustrated by C. Corson; C, wild-caught, Louisiana, Conner 1979, specific identity subsequently verified by J. V. Conner).



A 8.4 mm



B 10.2 mm



C 15.5 mm

Fig. 238. Micropterus salmoides, largemouth bass. A. Yolk-sac larva. B and C. Larvae. (A, wild-caught, Louisiana, Conner 1979, specific identity subsequently verified by J. V. Conner; B and C, laboratory-reared California, Meyer 1970, illustrated by C. Corson).

Pomoxis annularis Rafinesque, white crappie

DISTRIBUTION

Occurs in all of the Great Lakes except Lake Superior.[10,11] Widely disjunct populations occur through the southern half of the Lake Michigan drainage.”

SPAWNING SEASON

Spawning takes place from late April to early July in Ohio,[1] May to June in illinois[12,17] and New York[3] and late May to June in Minnesota.[16]

SPAWNING TEMPERATURE

Spawning occurs at 14 to 23 C.[11,13]

SPAWNING HABITAT

Spawns in ponds, lakes or reservoirs,’[9] in bays or coves well protected from wave action.’[14] Nests are found in deeper water deeper (5 to 610 cm) than those of other sunfishes,[3,9,14] often near logs or other large objects.”

SPAWNING SUBSTRATE

Spawns on rocks, boulders, gravel, sand, clay or mud.[1,5,9] Eggs may also be deposited on grass roots or tree leaves.[12]

FECUNDITY

970 to 325,677.[1,21]

NATURAL HYBRIDS

Pomoxis nigromaculatus.[20,21,22]

EGGS

Demersal, adhesive;[1,6,9,12] colorless;[11] diameter 0.8 to 0.9 mm;[9,12] oil globule large and single;[1] incubation period: 93 hours at 14.4 C, 43 to 51 hours at 18.3 to 19.4 C, 42 hours at 22.8 C;[5] 27 hours at 21 to 22.2 C.[1]

YOLK-SAC LARVAE

Total length	Description
1.2-4.0 mm	Newly hatched (1.2 to 2.6 mm).[1,4]
	Myomeres: 29 to 33 (10 to 13 + 19 to 23).[4,18]

Morphometry: (as % TL) preanal length 36 to 41 (*Pomoxis* spp.);[2] distance from eye to swim bladder greater than 15 (4 to 12 mm).[18]

Morphology: larvae curved around yolk (newly hatched), straightened (1.8 mm), gill clefts developing in pharynx (3.0 mm);[1] oil globule near dorsum of yolk sac (1.8 to 3.5 mm);[7] in posterior half of yolk sac (3.5 to 3.7 mm);[18] pectoral buds evident, jaws present but not movable, incipient rays in caudal fin (3.7 mm), jaws movable, gill arches and gill filaments present, swim bladder visible, intestine beginning to fold (3.9 mm), fin rays beginning to develop in dorsal and anal fins (4.2 mm).[1]

Pigmentation: eye unpigmented (newly hatched);[1] pigment on swim bladder (3.7 to 3.9 mm);[1,6] on venter between anus and caudal peduncle (3.9 mm).[1]

LARVAE

Total length	Description
4-16 mm	

Myomeres: 29 to 33 (11 to 13 + 17 to 22).[4,18]

Morphology: yolk absorbed (4.0 to 4.6 mm);[5,18] incipient caudal fin rays (7.0 to 8.3 mm[8,18] or 11.5 mm[4]); first dorsal fin rays (9 to 11.5 mm);'[18] anal fin rays developing (11 to 11.5 mm), spines beginning to form in anal and dorsal fins (13.5 to 14 mm), five or six dorsal fin spines (16.0 mm).[4]

Pigmentation: body transparent (4.1 to 4.6 mm);[5] dorsum of swim bladder pigmented (4.3 mm, derived from figure);[8] large and widely spaced chromatophores on swim bladder, a row of melanophores along postanal venter, another row just beneath notochord between swim bladder and caudal peduncle (4 to 6 mm, derived from figure);[1] increased pigment spots on venter, dorsum of swim bladder lightly pigmented (11.2 mm), a few chromatophores on top of head, ventral row and row beneath notochord not visible (13.5 mm, derived from figures).[8]

JUVENILES

Total length	Description
16-27 mm	

Myomeres: 29 to 33 (11 to 13 + 17 to 20).[18]

Morphometry: greatest body depth 22% TL (25.5 mm).[1]

Morphology: scales first evident (16 to 19 mm), squamation complete (27 mm).[15]

Pigmentation: pigment on head, snout and lower jaw, a row of pigment on venter from midpoint of anal fin to caudal fin, few chromatophores on dorsal fin, caudal fin and caudal peduncle (25.5 mm, derived from figure).[8]

ADULTS

Fin rays: caudal 17;[23] dorsal VI (Vi I), 14 or 15 (13 to 15), anal VI (VI I), 17 (16 to 18), pectoral 13, pelvic I,5.[11]

Vertebrae: 30 to 32.[11,23]

Lateral line scales: 34 to 44.[11]

Diagnostic characters: base of anal fin longer than base of dorsal fin, eye diameter five to six times in head, two times in snout, body with pale vertical bars, branchiostegal rays seven, dorsal spines six, rarely five.

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4. Siefert (1969)
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10. Emery (1976)
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12. Hansen (1951)
13. Nelson et al. (1967)
14. Pflieger (1975)
15. Siefert (1965)
16. Eddy and Underhill (1974)
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18. Chatry and Conner (1980)
19. Becker (1976)
20. Hubbs (1955)
21. Bailey and Allum (1962)
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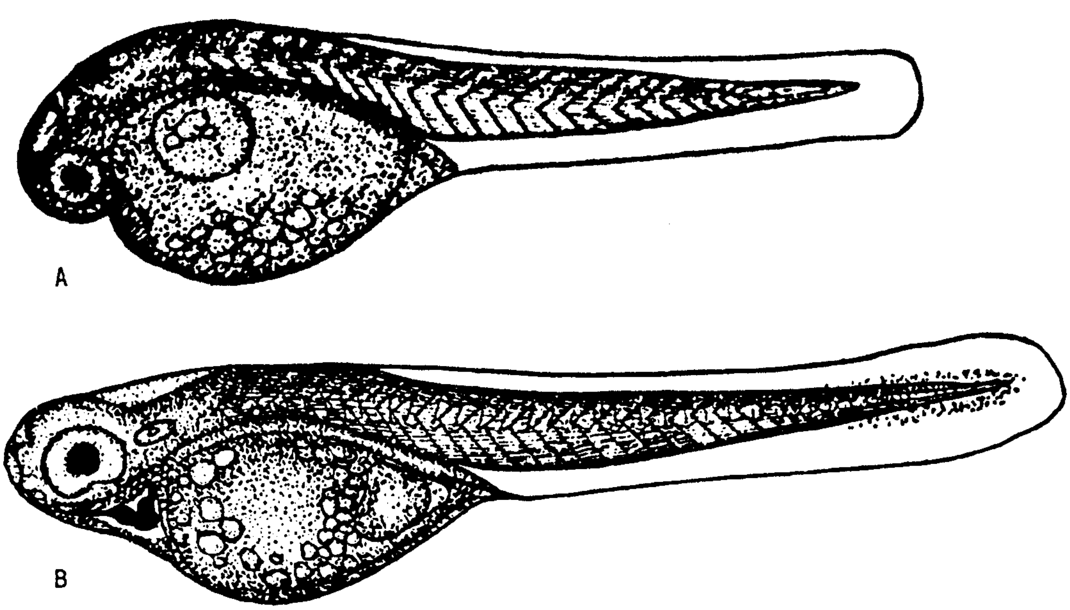
23. Bailey (1938b)



1.8 mm

3.0 mm

Fig. 239. Pomoxis annularis, white crappie. A and B. Yolk-sac larvae. (A and B, laboratory-reared, Ohio, Morgan 1954).

<u>Pomoxis annularis</u>

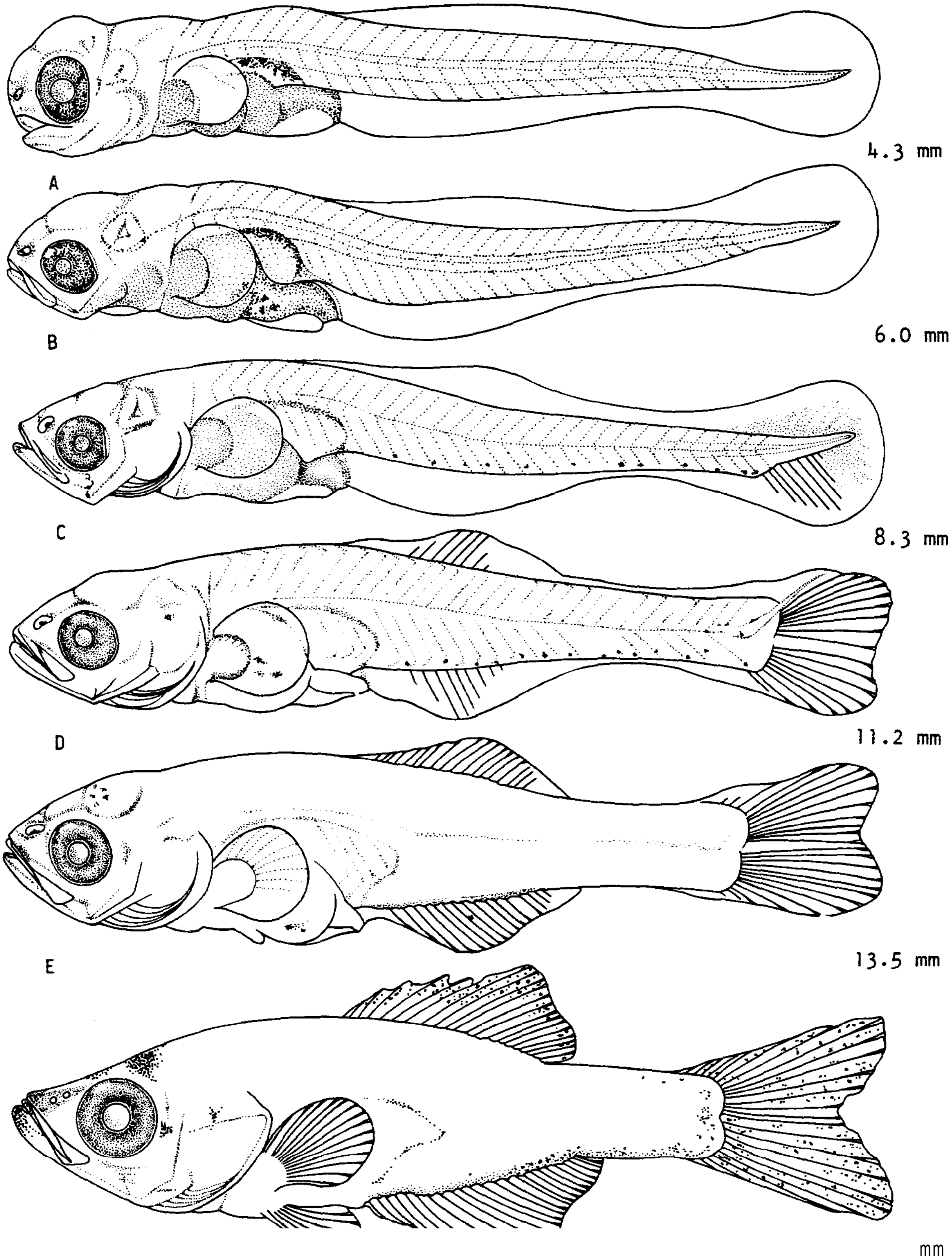


Fig. 240. Pomoxis annularis, white crappie. A-E. Larvae. F. Juvenile. (A-F, wild-caught, Oklahoma, Taber 1969).

Pomoxis nigromaculatus (LeSueur), black crappie

DISTRIBUTION

Occurs in all of the Great Lakes[5] and common throughout the Lake Michigan drainage,”

SPAWNING SEASON

Spawns from May to July in Wisconsin,[11,17,18] May to early June in Michigan,[21] April to June in New York,[3,28] during May in Illinois[14] and during July in Indiana.[15]

SPAWNING TEMPERATURE

Spawning occurs at 17.4 to 20 C.[14,16,20,22]

SPAWNING HABITAT

Spawns in shallow areas of lakes and ponds,[3,14,21] usually in water 25 to 610 cm.[19] Nests are often constructed near aquatic vegetation.[22]

SPAWNING SUBSTRATE

Nests may be constructed on a clay or muddy bottom,[19,22] but sand and fine gravel are preferred.[16]

FECUNDITY

20,000 to 188,000.[17,19,24,25,26,28]

NATURAL HYBRIDS

Pomoxis annularis.[10,11,12]

EGGS

Demersal, adhesive;[5,14,16] amber;[33] diameter 0.9 mm;[6] oil globule single, incubation period: 48 to 68 hours at 18.3 C.[27]

YOLK-SAC LARVAE

Total length	Description
2-4 mm	Newly hatched (2.3 mm).[1] Myomeres: 29 to 31 (10 to 13 + 19 to 23).[1,23] Morphometry: distance from eye to swim bladder less than 15% TL.[23] Morphology: gut coiled (< 3 mm);[2] swim bladder formed (3.4 to 3.8 mm);[23] oil globule located in middle or anterior portion of yolk sac (3.5 to 8 mm).[4,23]

LARVAE

Total length	Description
3-6 mm	Myomeres: 31 to 35 (10 to 13 + 19 to 23).[1,23] Morphometry: (as % TL) preanal length 36 to 37, head length 13 to 16, greatest body depth 13 to 16, eye diameter 6 to 7.[4] Morphology: yolk absorbed (3.5 to 3.9 mm).[23]
6-18 mm	Myomeres: 31 (11 to 14 + 18 to 21) at 6 to 16 mm.[1] Morphometry: (as % TL) preanal length 39 to 41, head length 17 to 19, greatest body depth 15 to 16, eye diameter 5 to 6 (7.5 to 8.0 mm), preanal length 40 to 43, head length 20 to 23, greatest body depth 17 to 20, eye diameter 7 (10.5 to 11.0 mm), preanal length 39 to 41, head length 23 to 25, body depth 19 to 22, eye diameter 7 to 8 (13.5 to 14.0 mm);[4] length of dorsal fin greater than eye to dorsal fin distance.[23] Morphology: incipient caudal fin rays (7 to 9.0 mm);[1,23] urostyle upturned (8 mm);[4] rays developing in soft dorsal and anal fins (9.5 to 10.0 mm), first spines in dorsal and anal fins (11.5 to 11.9 mm);[1] pelvic buds forming (11 mm), incipient rays in pectoral and pelvic fins (14 mm);[4] dorsal fin with seven spines (16 mm and larger);[1] scales appear (mean length 17.7 mm).[9] Pigmentation: melanophores on dorsum of swim bladder, sides of head, anterior part of stomach and along midventral line, subsurface spots on dorsum just posterior to head, melanophores on both sides of myomeres below midlateral myoseptum, in some specimens pigment in a ventro-lateral line (8 mm), melanophores on caudal fin, ventro-lateral row of pigment distinct, a double ventral row of pigment along anal fin, lateral row on posterior half of body, ventro-lateral row less conspicuous, melanophores on top and sides of head, lower and upper jaw and lateral aspect of stomach (11 to 14 mm), a double dorsal row of pigment along dorsal fin, melanophores on anal and dorsal fins in some specimens (14 to 17 mm).[4]

JUVENILES

Total length	Description
21 mm	Myomeres: 31 to 34 (11 to 13 + 19 to 21).[23] Morphometry: body depth 30 to 33% TL (21 mm).[8] Morphology: dorsal fin base about equal to anal fin base, caudal peduncle shorter and wider than in *P. annularis*.[8] Pigmentation: pigment on head and sides of body, dark blotches on caudal, dorsal and anal fins.[8]

ADULTS

Fin rays: caudal 17;[7] dorsal VI I I (VII), 14 (14 to 16), anal VI (VII), 17 (17 to 18), pectoral 13 to 15, pelvic I,5.[5]

Vertebrae: 31 to 33.[5,7]

Lateral line scales: 36 to 41.[5]

Diagnostic characters: base of anal fin almost equal to base of dorsal fin, eye diameter four to five times in head, less than two times in snout, body with irregular dark blotches, branchiostegal rays seven.

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   Adams and Hankinson (1928)
4. Faber (1963)
   Scott and Crossman (1973)
6. Merriner (1971a)
7: Bailey (1938b)
8. Wang and Kernehan (1979)
9. Ward and Leonard (1952)
10. Hubbs (1955)
11. Becker (1976)
12. Bailey and Allum (1962)
13. R. E. Seifert (pers. Comm.)
14. Richardson (1913)
15. Everman and Clark (1920)
16. Breder and Rosen (1966)
17. Eddy and Surber (1943)
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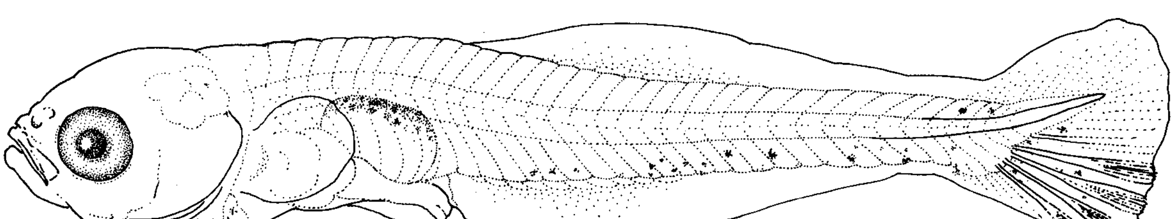
21. Jude et al. (1978)
22. Pearse (1919)
23. Chatry and Conner (1980)
24. Culler (1938)
25. Vessel and Eddy (1941)
26. Ulrey et al. (1938)
27. Merriner (1971b)
28. Raney (1965)



8.3 mm

Fig. 241. Pomoxis nigromaculatus, black crappie. Larva. (Wild-caught, Louisiana, Conner 1979, specific identity subsequently verified by J. V. Conner) .

Pomoxis nigromaculatus

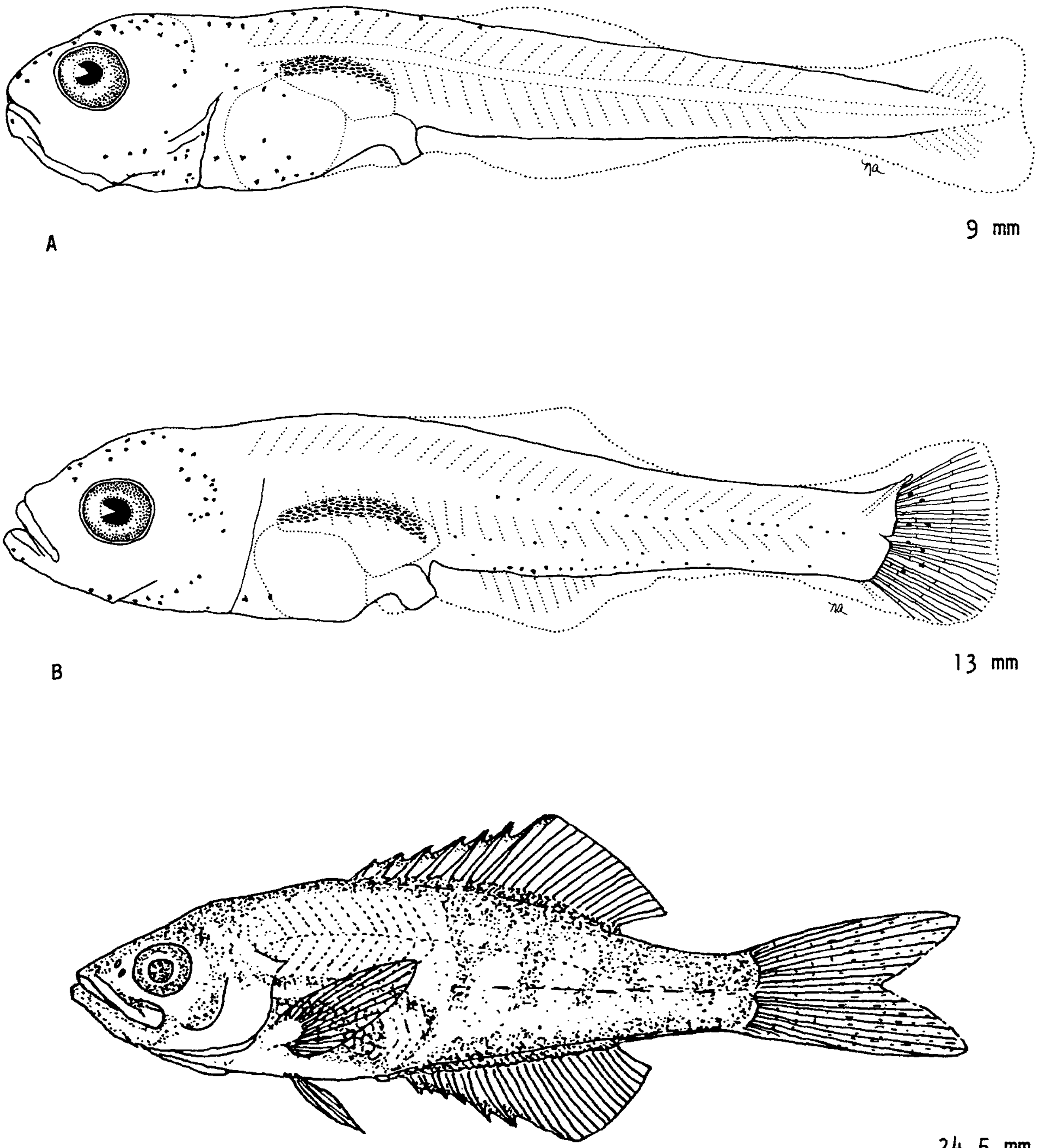


Fig. 242. Pomoxis nigromaculatus, black crappie. A and B. Larvae. C. Juvenile. (A and B, wild-caught, Michigan, original illustrations by N. A. Auer; C, wild-caught, Delaware River, Wang and Kernehan 1979).

Family Percidae, perches

BY

Nancy A. Auer

Members of the Pertidae are present throughout the northern hemi sphere except Alaska, the western third of the United States, northeastern Canada, Greenland, Iceland and eastern Siberia. The family contains 9 genera and 121 species; 5 genera and about 100 species occur in North America.

Percids inhabit freshwater streams, rivers and lakes from warm temperate regions to the cold subarctic. They are spiny-rayed fishes with two distinctly separate dorsal fins and one or two spines in the anal fin. All possess ctenoid scales, gill membranes are free from the isthmus and there are teeth on jaws, palatines and vomer. A few species have canine teeth, in others the teeth are small and inconspicuous.

Perca flavescens, Stizostedion canadense and S. vitreum are the largest members of the family in the Great Lakes area, mature fish range from 30 to 70 cm total length. S. canadense and S. vitreum broadcast their eggs across rubble shoreline and shoal areas, whereas P. flavescens lays its eggs in a gelatinous mass in vegetated or protected areas of quiet lakes and ponds. Eggs of these three species are usually 1.5 to 2.5 mm in diameter and possess a single, large oil globule. Lengths of larvae at hatching range from 4.5 to 8.5 mm.

Remaining members of the Percidae in the Great Lakes region, the darters, usually attain lengths of only 75 to 180 mm. These fish often deposit eggs which adhere to the substrate or vegetation and range from 1.5 to 2.0 mm in diameter. Some species guard the eggs and young, whereas others show no protective tendencies. These fish hatch at lengths of 4.5 to 6.5 mm.

Early development of most percids has been poorly studied. The difficulty in the separation of larvae of this family is compounded by the extreme similarity in number of myomeres, pigmentation patterns, size at hatching and possession of a single, anterior oil globule.

Table 6. Ranges of preanal myomeres (-) and total myomeres (x) among Great Lakes percids. Data were taken from several sources cited in the individual species accounts.

```
                               Number of Preanal Myomeres

       Species                 14 15 16 17 18 19 20 21 22 23 24 25

Stizostedion vitreum                |-----------------------------|
                                                       xxxxxxxxxxxxxx
Perca flavescens                       |-----------------------|
                                     xxxxxxxxxxx
Etheostoma blennioides                             |-----------|
                                           xxxxxxxxxxx
Percina caprodes                                |-----------|
                                        xxxxxxxxxxxxxxxxxxxx
Stizostedion canadense              |--------------------|
                                                    xxxxxxxx
Etheostoma zonale             |-----------------|
                                     xxxxxxxxxxx
Etheostoma caeruleum                |--------|
                         xxxxxxxxxxxxxx
Etheostoma flabellare            |--|
                      xxxxxxxxxxxxxx

                  32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48

                                     Number of Vertebrae
```

Etheostoma blennioides Rafinesque, greenside darter

DISTRIBUTION

Collected from the headwaters of the St. Joseph and Grand Rivers, Michigan.[1] Found in Ontario tributaries of Lakes St. Clair and Erie and in the southern tributaries of Lake Ontario.[6]

SPAWNING SEASON

Spawns in April to June in Michigan[1,4] and mid-April to mid-June in the Lake Ontario drainage.[5]

SPAWNING TEMPERATURE

Spawning is initiated at 10.6 C.[1,3,3]

SPAWNING HABITAT

Spawns in swift riffles over large rocks,[1] riffles with algae or moss[2,4,7] or the deepest, swiftest parts of riffles.[5]

SPAWNING SUBSTRATE

Deposits eggs near the point of attachment of filamentous algae (*Cladophora*)[1,5] or moss (*Fontinalis*).[1] Male establishes and defends a large territory.[1]

FECUNDITY

404 to 1,832;[3,4,5] usually 4 to 7 eggs are laid at one time, a female spawns several times.[1]

EGGS

Spherical, demersal, adhesive;[5,6] transparent, diameter 1.9 mm (1.8 to 2.0 mm);[5] yolk diameter 1.4 mm;[6] oil globule yellow and single;[5,6] diameter 0.63 mm;[5] incubation period: 17 to 20 days at 13 to 15 C.[1,3,5,6]

YOLK-SAC LARVAE

Total length	Description
7-11 mm	Newly hatched (6.8 to 7.5 mm).[5,6] Myomeres: 45 to 50 (21 to 23 + 23 to 28).[6] Morphometry: (as % TL) standard length 97, preanal length 49 to 51, head length 16, snout length 2, greatest body depth 9 to 10, eye diameter 7 to 10, head depth 11 to 13.[6]

Morphology: mouth well developed and terminal, median finfold origin at dorsal myomere five, continuous to yolk sac;‘ only pectoral fins show incipient ray development.[5] [6]

Pigmentation: eyes pigmented;[5] no dorsal pigment;[6] branched melanophores on yolk sac;[5] [6] and peritoneum;[5] row of four to five melanophores on each side of gut from posterior edge of yolk sac to anus;[6] melanophores on cheeks and opercula (5 to 6 days old);[5] small melanophores on postanal venter;[5] one to two immediately anterior to anus, large melanophore within each auditory vesicle, single chromatophore anterior to each pectoral fin base.‘

LARVAE

Total length	Description
11-14 mm	Myomeres: 43 to 49 (22 to 24 + 21 to 26).[6] Morphometry: (as % TL) standard length 92 to 95, preanal length 51, head length 16 to 17, snout length 2 to 3, body depth at anus 11, eye diameter 7, head depth 12 to 13.‘ Morphology: yolk absorbed (11 mm TL, at 13 to 15 C[6] or 6 days, 15.6 c[5]); caudal fin rays appear, mouth moderately subterminal, snout bluntly rounded, pelvic buds evident, incipient rays in soft dorsal and anal fins (12 to 13 mm), dorsal fin spines and pectoral fins begin development (13 to 14 mm).[6] Pigmentation: pigment on venter from posterior anal fin to caudal fin.[6]
14-17 mm	Myomeres: 42 to 45 (21 to 23 + 19 to 22).[6] Morphometry: (as % TL) standard length 87 to 88, preanal length 50, head length 19 to 20, snout length 4, body depth at anus 13, eye diameter 7, head depth 12 to 13.[6] Morphology: dorsal median finfold absorbed, small amount of postanal finfold remains, pelvic fin ray formation begins (14 to 15 mm), adult complement of fin rays in anal (14 to 15 mm), caudal and pectoral (15 to 16 mm) and soft dorsal fins (17.1 mm).[6] Pigmentation: melanophores scattered over midbrain and opercle, otic vesicle heavily pigmented, some midlateral line pigmentation present, hypural complex margin outlined with small melanophores.[6]
17-19 mm	Myomeres: 41 to 43 (21 to 22 + 20 to 21).[6] Morphometry: (as % TL) standard length 86 to 87, preanal length 49 to 50, head length 20 to 21, snout length 4, body depth at anus 13, eye diameter 7, head depth 12 to 13.”

Morphology: fin ray development complete, mouth subterminal, snout rounded, median finfold absorbed (19.3 mm).[6]
Pigmentation: chromatophores between dorsal fins and at posterior margin of soft dorsal fin (18 to 19 mm), midlateral pigmentation intensified, six dorsal "saddle markings" appear (19 to 20 mm).[6]

JUVENILES

Total length	Description
25-26 mm	Myomeres: 41 (21 + 20).[6] Morphology: spinous dorsal fin complete, squamation complete.[1] Pigmentation: lateral pigmentation as six U-shaped blotches, a mark on caudal peduncle and one above each pectoral fin, six dorsal "saddle marks".[1]

ADULTS

Fin rays: caudal 17, dorsal XIII to XV-13 or 14, anal II,7 or 8, pectoral 14 or 15, pelvic 6 or 7.[6]

Vertebrae: 40 to 44.[3,8]

Lateral line scales: 54 to 60;[3] mean: 58.6.[1]

Diagnostic characters: maxillae fused to preorbitals at sides, short groove near tip of snout, snout bulbous and overhanging, upper lip may have knob on tip, five to eight bright green bands on the sides meet across back or underside of caudal peduncle, broadly connected gill membranes free from isthmus, frenum not visible, anal fin rays seven to nine.

LITERATURE CITED

1. Becker (1976)
2. Hubbs and Lagler (1958)
3. Scott and Crossman (1973)
4. Winn (1958a)
5. Fahy (1954)
6. Baker (1979)
7. Miller (1968)
8. Bailey and Gosline (1955)

Etheostoma blennioides

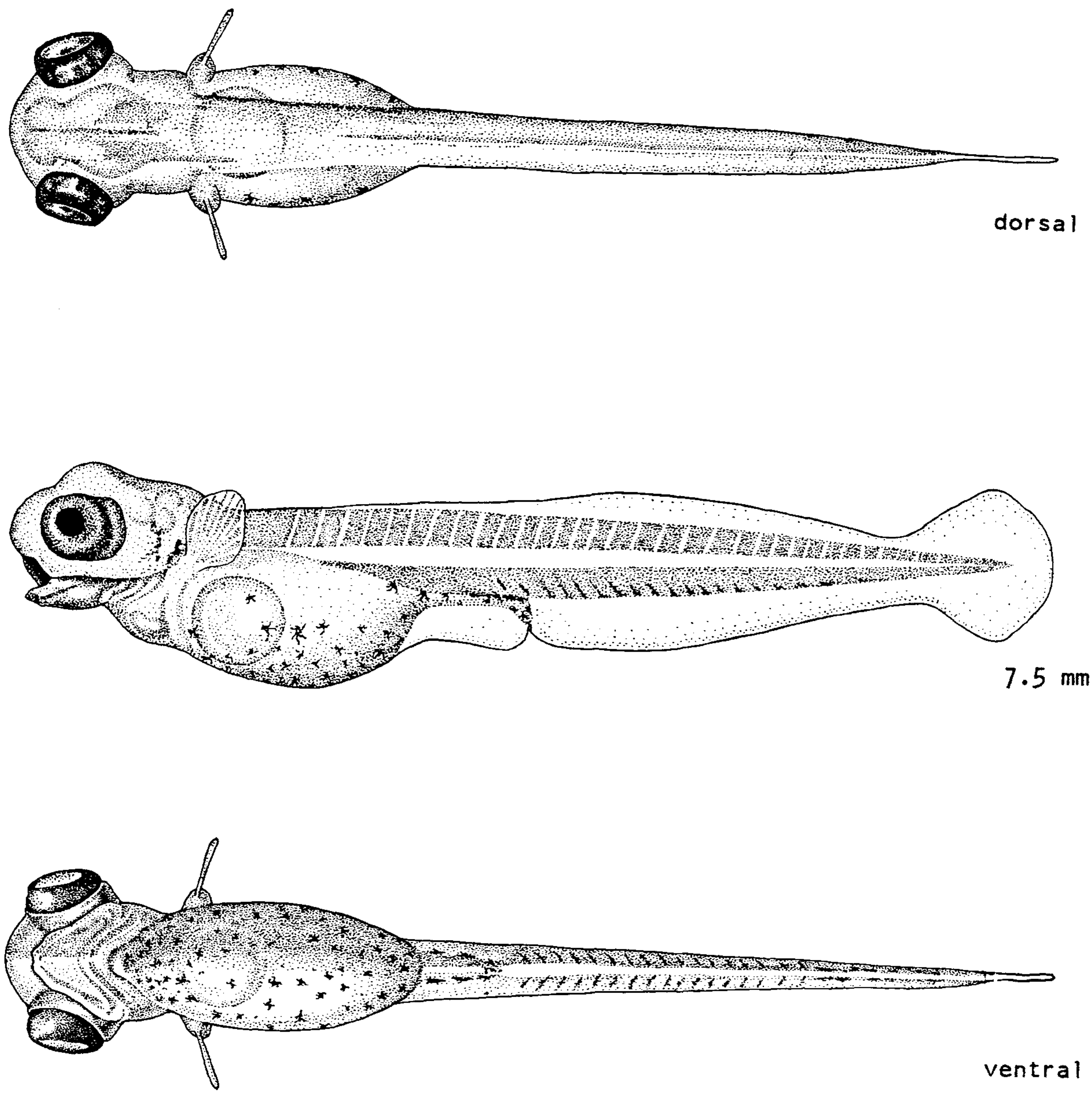


Fig. 243. Etheostoma blennioides, greenside darter. Yolk-sac larva. (Laboratory-reared, New York, Fahy 1954, illustrated by C. E. Fallon).

Etheostoma blennioides

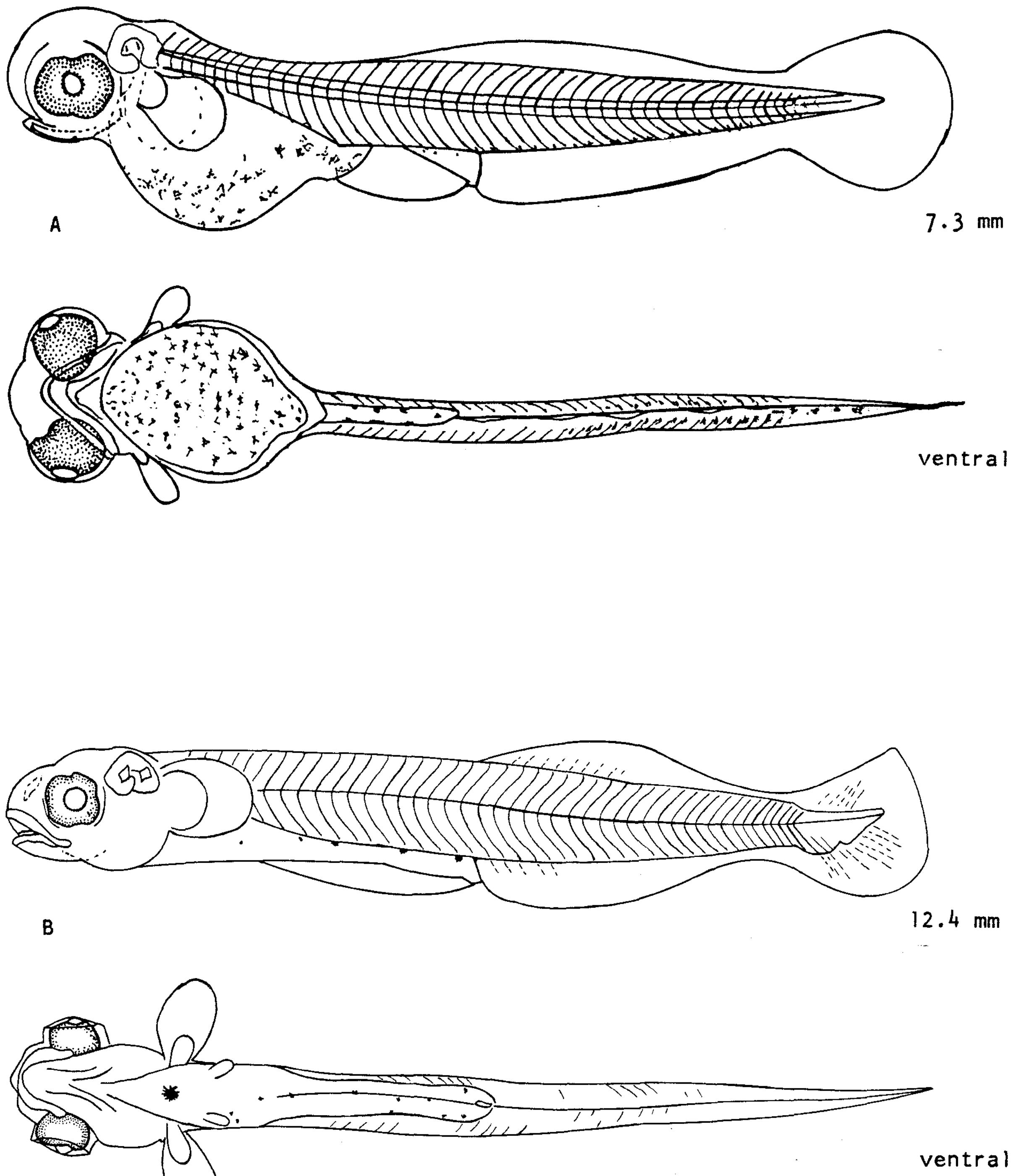


Fig. 244. Etheostoma blennioides, greenside darter. A. Yolk-sac larva. B. Larva. (A and B, wild-caught, Tennessee, Baker 1979).

<u>Etheostoma blennioides</u>

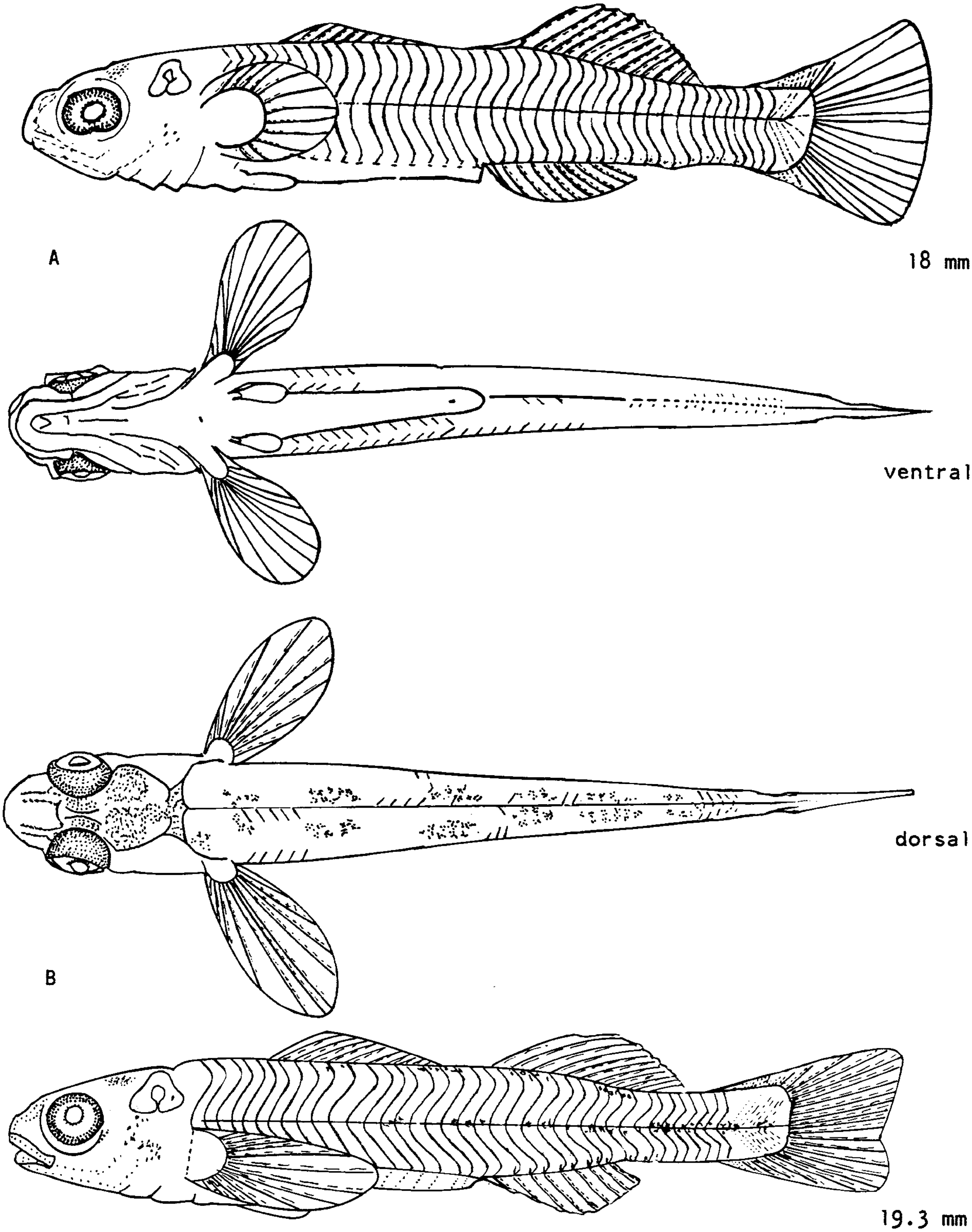


Fig. 245. Etheostoma blennioides, greenside darter. A and B. Larvae. (A and B, wild-caught, Tennessee, Baker 1979).

Etheostoma caeruleum Storer, rainbow darter

DISTRIBUTION

Throughout the Great Lakes basin except Lake Superior.[3] Found in gravel creeks,[2] small rivers and streams in the lower half of the Lake Michigan drainage.’

SPAWNING SEASON

Spawns in spring,[3] April to late May in the Lake Michigan drainage’ [7] and late March in Michigan.‘

SPAWNING TEMPERATURE

Spawns at temperatures of 15 C or greater.[1,6]

SPAWNING HABITAT

Migrates to riffle areas,‘ congregates on gravel or rubble substrate near the head of rapids,’ [5] with stones usually 12 to 50 mm in diameter,[5] in water 10 to 60 cm, most commonly 25 to 35 cm.[6]

SPAWNING SUBSTRATE

Deposits eggs in coarse to fine gravel.’ [3,7] Male establishes and guards territory approximately 60-cm square[5] or male is strongly defensive around female while spawning.9 Female buries head and half of her body in gravel.‘

FECUNDITY

800;[3] 880 (508 to 1,462).[7] Usually only 3 to 7 eggs are laid during one spawning act. Female spawns once to several times.’

EGGS

Demersal, adhesive to gravel;[5,9] pale yellow, diameter 1.5 mm;[5] or 1.8 mm (1.7 to 1.9 mm);’ oil globule single and large;‘ surface of chorion and yolk finely reticulate;[9] incubation period: 10 to 12 days at 17 to 18.5 C.[1,3,7]

YOLK-SAC LARVAE

Total length	Description
6-8 mm	Newly hatched (6.0 to 6.2 mm).[9]
	Myomeres: 35 to 36 (16 to 18 + 18 to 19), usually 35 (17 + 18).[9]
	Morphology: mouth formed, teeth not evident, rudimentary operculum and gills formed (6.8 mm).[9]

Pigmentation: large melanophores cover venter of yolk sac, eye pigmented, a few melanophores on ventral edge of caudal peduncle.’

LARVAE

Total length	Description
7-10 mm	Myomeres: 35 to 36 (16 to 17 + 18 to 20), usually 35 (16 + 19).[9] Morphology: incipient rays in caudal, second dorsal, anal and pectoral fins evident (7.8 to 8.2 mm, 2 to 5 days posthatching), actinotrichia in spiny dorsal fin (8.0 mm), pelvic buds just posterior to pectoral fin base (8.5 to 9.5 mm, 15 days posthatching), jaws well developed, minute teeth (8.5 to 9.4 mm).[9] Pigmentation: anterior dorsum of gut shows solid band of pigmentation, less dense posteriorly, later developing into outline of gut, a few melanophores on dorsum of head, ventral pigmentation from anal fin to caudal fin present (8.5 to 9.4 mm), as well as under dorsal fins and on preopercle.’
10-11 mm	Morphology: myomeres not distinguishable (27 days posthatching).[9] Pigmentation: chromatophores present on snout, dorsum of head, under dorsal fins and along the midlateral myoseptum, concentrated at base of anal fin rays, subsurface pigmentation anterior to pelvic fins and along spiny dorsal fin rays.[9]

JUVENILES

Total length	Description
13-18 mm	Morphology: fin rays segmented (13.0 mm, 47 days posthatching), scales from caudal fin base to first dorsal fin, squamation complete (15 mm).[9] Pigmentation: narrow band of melanophores passes horizontally through eye, dense patches of pigmentation on dorsum of head;[9] ten patches cross dorsal ridge (26.0 mm), pigment beneath dorsal fins, approximately 13 crossbars on lateral line;’ (where they are elongated vertically);’ bar near caudal fin darkest with pigment spot above and below (26 mm),[4] two bands of pigment present on spiny dorsal fin (17 to 18 mm).[9]

ADULTS

Fin rays: caudal 18;[9] dorsal X (IX to XI) - 13 (12 to 14);[3] anal II,6 to 7, pectoral 13 (12 to 14);[3] pelvic 6.[9]

Vertebrae: 34 to 35;[3] 35 to 38.[8]

Lateral line scales: 42 to 45.[3]

Diagnostic characters: incomplete lateral line, decurved snout, two anal fin spines, six to seven anal fin rays, gill membranes not joined but meet in "V" over isthmus, premaxillae nonprotractile joined to snout by median frenum, spiny dorsal fin having horizontal blue and red bands.

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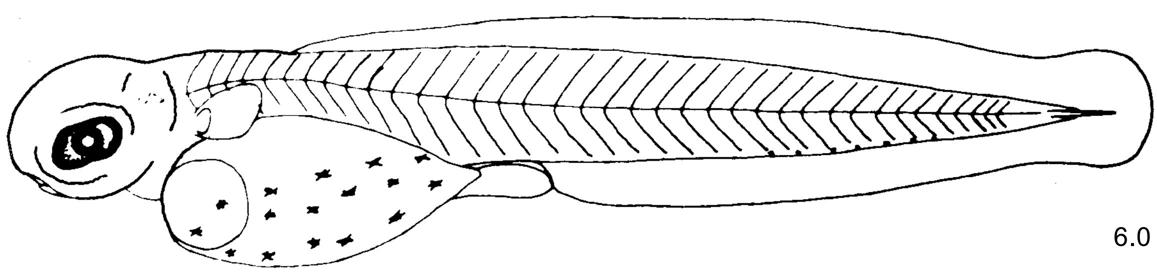
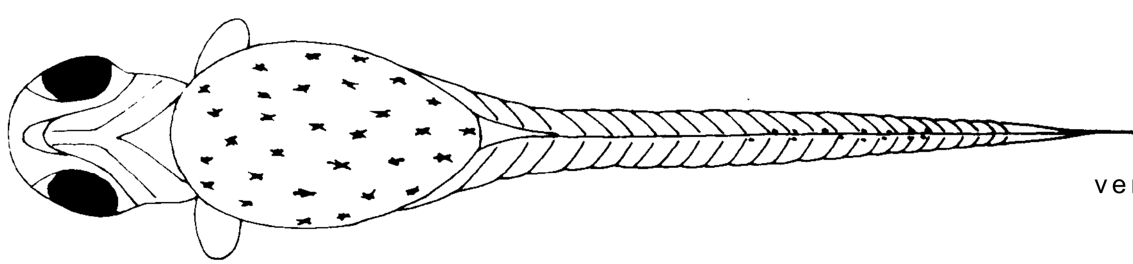
2. Hubbs and Lagler (1958)
   Scott and Crossman (1973)
4. Fish (1932)
5. Reeves (1907)
6. Winn (1958b)
7. Winn (1958a)
8. Bailey and Gosline (1955)
9. Cooper (1979)



6.0 mm



ventral

Fig. 246. Etheostoma caeruleum, rainbow darter. Yolk-sac larva. (Laboratory-reared, Pennsylvania, Cooper 1979).

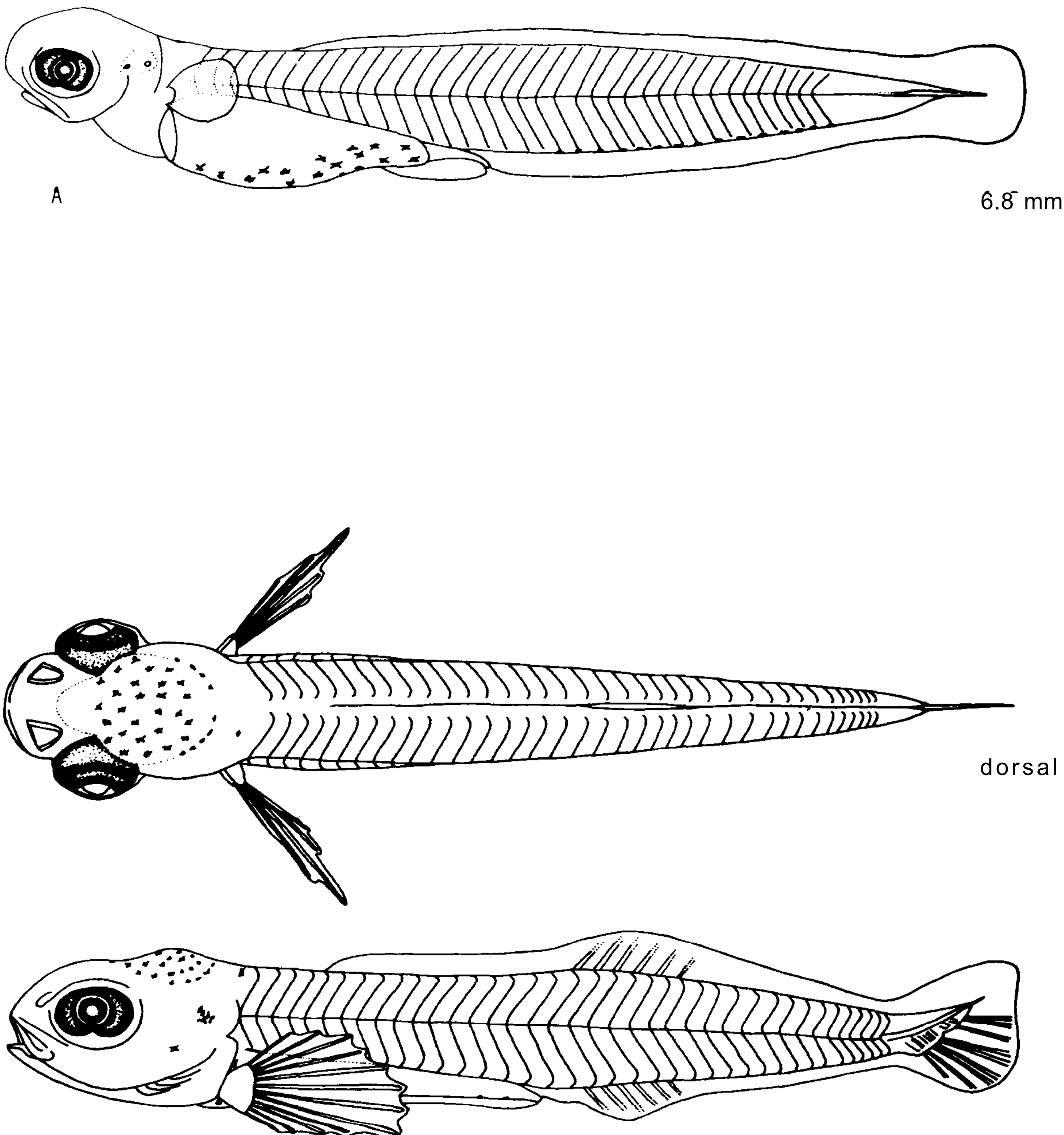


Fig. 247. Etheostoma caeruleum, rainbow darter. A. Yolk-sac larva. B. Larva. (A and B, laboratory-reared, Pennsylvania, Cooper 1979).

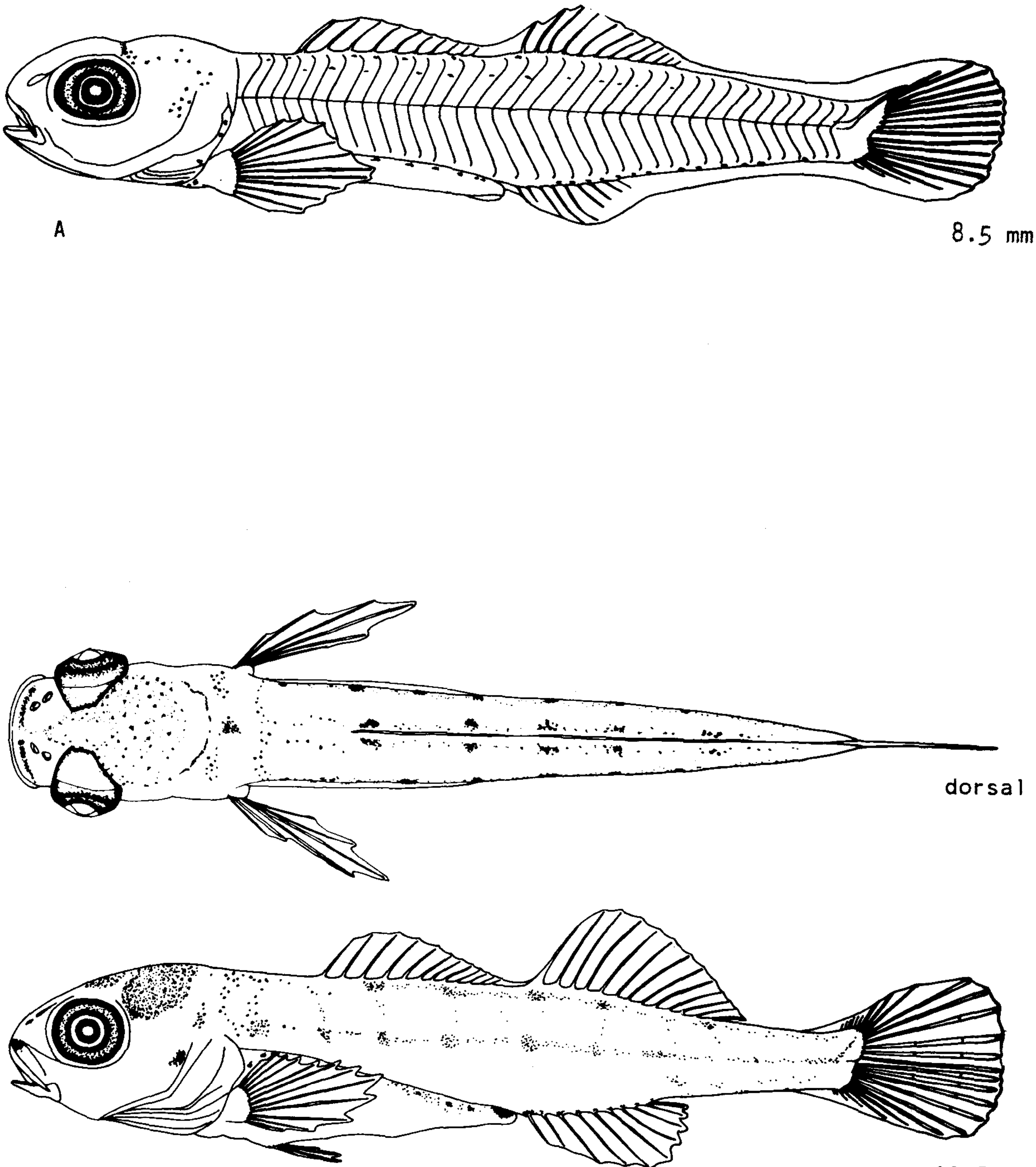


Fig. 248. Etheostoma caeruleum, rainbow darter. A. Larva. B. Juvenile. (A and B, laboratory-reared, Pennsylvania, Cooper 1979).

Etheostoma chlorosomum (Hay), bluntnose darter

DISTRIBUTION

Found in quiet, slow-moving streams, sloughs and backwaters in the. Illinois portion of the Lake Michigan drainage,' now believed to be extinct in the drainage.[7]

SPAWNING SEASON

Spawns during April in Kansas.[1]

SPAWNING TEMPERATURE

Not reported.

SPAWNING HABITAT

Eggs are usually laid on plants or debris.[1]

SPAWNING SUBSTRATE

Not reported.

FECUNDITY

Not reported.

EGGS

Water-hardened, unfertilized egg diameter 1.05 mm.[2]

YOLK-SAC LARVAE

Not described.

LARVAE

Not described.

JUVENILES

Not described.

ADULTS

Fin rays: caudal 17;* dorsal VIII or IV-10 or 11, anal 1,7 or 8;[4] pectoral 13;[5] pelvic I,5.[6]

Vertebrae: 38 to 40.[3]

Lateral line scales: 55 to 61.4

Diagnostic characters: premaxillae protractile, one anal fin spine, lateral line absent on posterior portion of body, dorsal fins widely separated, pale color with bridle-shaped dorsal markings, incomplete lateral line extends from operculum to just below first dorsal fin.

LITERATURE CITED

1. Becker (1976)
2. Hubbs (1967)
3. Bailey and Gosline (1955)
4. Clay (1975)
5. Page (1981)
6. Scott and Crossman (1973)
7. R. M. Bailey (pers. Comm.)

Etheostoma exile (Girard), Iowa darter

DISTRIBUTION

Abundant throughout the Great Lakes basin,[2] in clear, cool lakes and sluggish streams.[1 2]

SPAWNING SEASON

Spawns from May to early June in Lake Michigan.' Migrates to shallow edges of lakeshores in late March to early April in Michigan.[5] Spawns during April to May in Michigan.‘

SPAWNING TEMPERATURE

Spawns at temperatures of 12 to 15 C.[7]

SPAWNING HABITAT

Spawns along lakeshores or streams with organic debris‘ or on fibrous root material of undercut banks,[3] in water 10 to 40 cm[3 5] or 90 to 122 cm.[7]

SPAWNING SUBSTRATE

Deposits eggs among fibrous roots, stones, pebbles,' organic debris or fibrous mud banks.‘ Male establishes and defends a territory.[5 6]

FECUNDITY

1,619 (550 to 2,048) ;[3 6] Eggs are laid in clumps of 2 to 7.[5] A female spawns once to several times.‘

EGGS

Unfertilized, preserved ripe egg diameter 1.1 mm;[3] incubation period: 18 to 26 days at 13 to 16 C.[7]

YOLK-SAC LARVAE

Newly hatched (3.4 mm).[7]

LARVAE

Total length	Description
19-20 mm	Morphometry: (as % TL) standard length 83, preanal length 51, head length 26, eye diameter 8, greatest body depth 14.4 Pigmentation: chromatophores heavily distributed over both jaws, back of head, in three to five longitudinal rows on dorsum to caudal fin tip (showing five interspaces), on opercle, preopercle and in 12 clusters

along lateral line from head to caudal fin, entire body speckled dorsally, in single postanal line, in heavy subsurface patches over stomach region and on fins.[4]

JUVENILES

Not described.

ADULTS

Fin rays: caudal 17;* dorsal VI I I to X-11 (10 to 12), anal II,7 to 8, pectoral 12 to 14, pelvic I,5.[3]

Vertebrae: 36 to 37; [3] 36 to 39 (34 to 40) .[5]

Lateral line scales: 45 to 60.3

Diagnostic characters: premaxillae not protractile, joined to snout by fleshy median frenum, two anal fin spines, seven to eight anal fin rays, gill membranes just barely connected, lateral line extending only to end of dorsal fin base, cheeks scaled.

LITERATURE CITED

1. Becker (1976)
2. Hubbs and Lagler (1958)
   Scott and Crossman (1973)
2: Fish (1932)
5. Winn (1958b)
6. Winn (1958a)
7. Jaffa (1917)
8. Bailey and Gosline (1955)

Etheostoma flabellare Rafinesque, fantail darter

DISTRIBUTION

The Lake Michigan drainage represents the northern limit of the range. This species is found in riffle areas of streams in Wisconsin, along the southern edge of the upper peninsula of Michigan and in the Grand and Kalamazoo River systems of the lower peninsula.’ Known throughout the southern Great Lakes basin.[2,3]

SPAWNING SEASON

Spawns from April to June in the Lake Michigan drainage,’ in May in southeastern Michigan[8,9] and late June to early July in Lake Erie.[4]

SPAWNING TEMPERATURE

Prespawning activity begins at 6.7 to 14.4 C.[5] Spawning occurs at 17.2 to 24.4 C.[1,4,5]

SPAWNING HABITAT

Migrates from swift water to shallow, slow water,[5] of streams to spawn over riffle or rubble.*

SPAWNING SUBSTRATE

Male builds and guards nest under rocks.[1,3,8] Female lays eggs on underside of rocks.[5] Several females use one nest.[3] Nest may have from 8 to 10 to 562 eggs.[3,7,9]

FECUNDITY

120 to 467;[3,4,5,8] 496 (407 to 586).[6] Clutches of approximately 34[3] to 45[5] eggs laid singly by one female.

EGGS

Demersal, adhesive;[1,3] diameter 2.0 mm;[9] 2.3 mm;[3,5] 2.7 mm (2.5 to 2.9 mm), oil globule single and amber, diameter 0.7 to 0.8 mm;[10] incubation period: 21 days at 21.1 to 21.7 C, 30 to 35 days at 17.2 to 20 C, 14 to 16 days at 23 C.[5]

YOLK-SAC LARVAE

Total length	Description
5.8-7.0 mm	Newly hatched.’[5,10] Myomeres: 34 to 36 (15 + 18 to 21), usually 36 (15 + 21).[10] Morphometry: (as % TL) standard length 96, preanal length 52, head length 19, eye diameter 10, yolk-sac length 31.[10]

Morphology: gills and rudimentary opercula formed, oil globule in anterior part of yolk sac flattened, pectoral buds present.[10]

Pigmentation: eye pigmented, scattered melanophores on yolk membrane, on top of head, dorsum and venter of caudal peduncle and near anus.[10]

LARVAE

Total length	Description
7-11 mm	Myomeres: 34 to 36 (15 + 19 to 21).[10]
	Morphometry: (as % TL) standard length 83 to 87, preanal length 48 to 49, head length 19 to 20, eye diameter 7 to 8.[10]
	Morphology: yolk absorbed (9 to 10 mm, 8 to 10 days posthatching at 14 C);[10] incipient rays evident in caudal, soft dorsal, anal and pectoral fins (9 hours posthatching at 14 C), tip of notochord upturned, spine formation in dorsal fin (11 hours posthatching), jaws well developed, teeth lacking, pelvic buds just posterior to oil globule (8.8 mm), full complement of spines in dorsal and principal rays in pectoral fins evident (9.5 mm, 6 days posthatching).[10]
	Pigmentation: melanophores present along dorsum and venter of body and on midlateral myoseptum (7.2 to 7.8 mm), melanophores on anus and along base of anal fin (8.8 mm), a line of melanophores from snout to opercle, around to posterior edge of head (8.8 mm), square patterns of melanophores develop on dorsum (9.5 mm), stellate pattern of melanophores on dorsum of head, snout to opercle melanophore series present.[10]
11-16 mm	Morphometry: (as % TL) standard length 83 to 84, preanal length 50 to 52, head length 23 to 24, eye diameter 8.[10]
	Morphology: scale formation initiated at base of caudal fin and extends to posterior base of second dorsal fin (13.0 mm, 14 to 15 days posthatching), pelvic fin rays complete (14.0 mm).[10]
	Pigmentation: melanophore series from snout to opercle developed into band (11.5 mm, 12 days posthatching), melanophores present along spines and rays of dorsal fins and along caudal fin, each ray has melanophore at base, some melanophores may be present along pectoral fin rays, 12 to 14 patches of melanophores developed on midlateral myoseptum, dorsum of gut near anus and underneath opercle pigmented, outer margin of upper jaw and dorsum of head also with melanophores, outer margin of lower jaw and anterior to pelvic fins on venter develops pigmentation later (14.0 mm).[10]

Etheostoma flabellare

JUVENILES

Total length	Description
18-19 mm	Morphometry: (as % TL) standard length 80 to 83, preanal length 49 to 51, head length 24 to 25, eye diameter 6.[10] Morphology: squamation complete to opercle, lacking on dorsum near first dorsal fin, principal median fin rays segmented (18.5 mm), teeth present around margins of jaws (19.0 mm, 24 to 28 days posthatching).[10] Pigmentation: melanophores concentrated on snout, opercula and lateral line.[10]
22-23 mm	Morphometry: (as % TL) standard length 86, preanal length 51, head length 27, greatest body depth 17, (as % head length) eye diameter 25.[4] Pigmentation: band of pigmentation from snout through eye to back of head, chromatophores scattered on jaws and front of head, increasing in intensity on dorsum of brain, also present on opercula, dark patches of pigment on dorsal and lateral surfaces, those on lateral aspect in horizontal or criss-cross pattern, ventral pigmentation limited to postanal region, border of anal fin, lateral patterns meet on lower caudal peduncle, all fins except pelvic fins pigmented.[4]

ADULTS

Fin rays: caudal 21;[10] dorsal VII[3] to VIII[3,10]-13[3] or 14;[10] anal II,8;[10] pectoral 12[10] or 13;[3] pelvic 6.[10]

Vertebrae: 33 (32 to 34) ;[3] 33 to 36 (32 to 37) .[11]

Lateral line scales: 47 to 51.[3]

Diagnostic characters: premaxillae not protractile, joined to snout by fleshy median frenum, anal fin II,8, head naked, 10 to 12 dark vertical bars on body, gill covers broadly joined at isthmus, lower jaw projecting beyond upper, spiny dorsal fin higher than soft dorsal fin, pigment bar from snout through eye to tip of opercle.

LITERATURE CITED

1. Becker (1976)
2. Hubbs and Lagler (1958)
3. Scott and Crossman (1973)
4. Fish (1932)
5. Lake (1936)
6. Karr (1964)
7. Winn (1958b)
8. winn (1958a)
9. Hankinson (1932)
10. Cooper (1978)
11. Bailey and Gosline (1955)

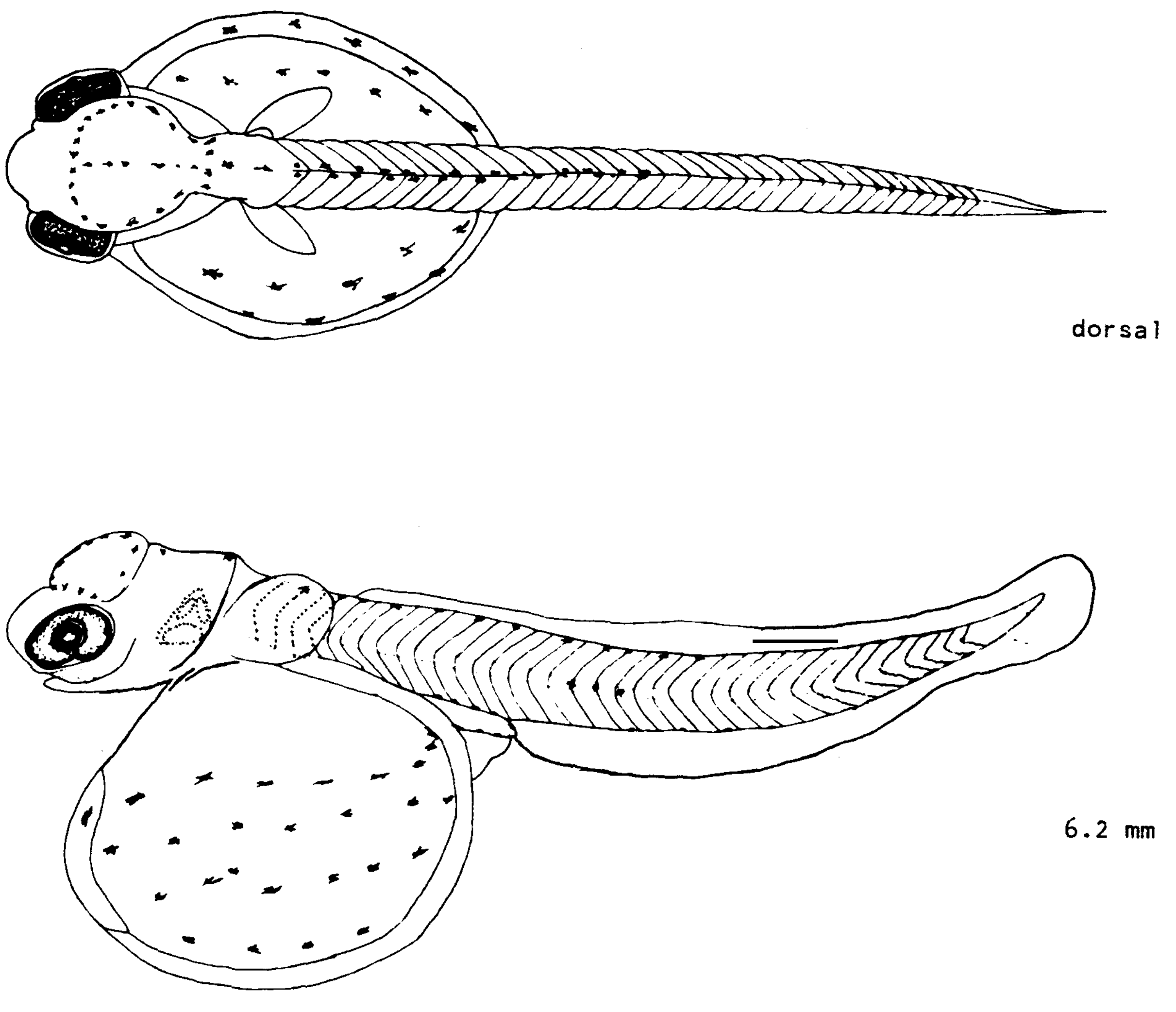


Fig. 249. Etheostoma flabellare, fantail darter. Yolk-sac larva. (Laboratory-reared, Pennsylvania, Cooper 1979).

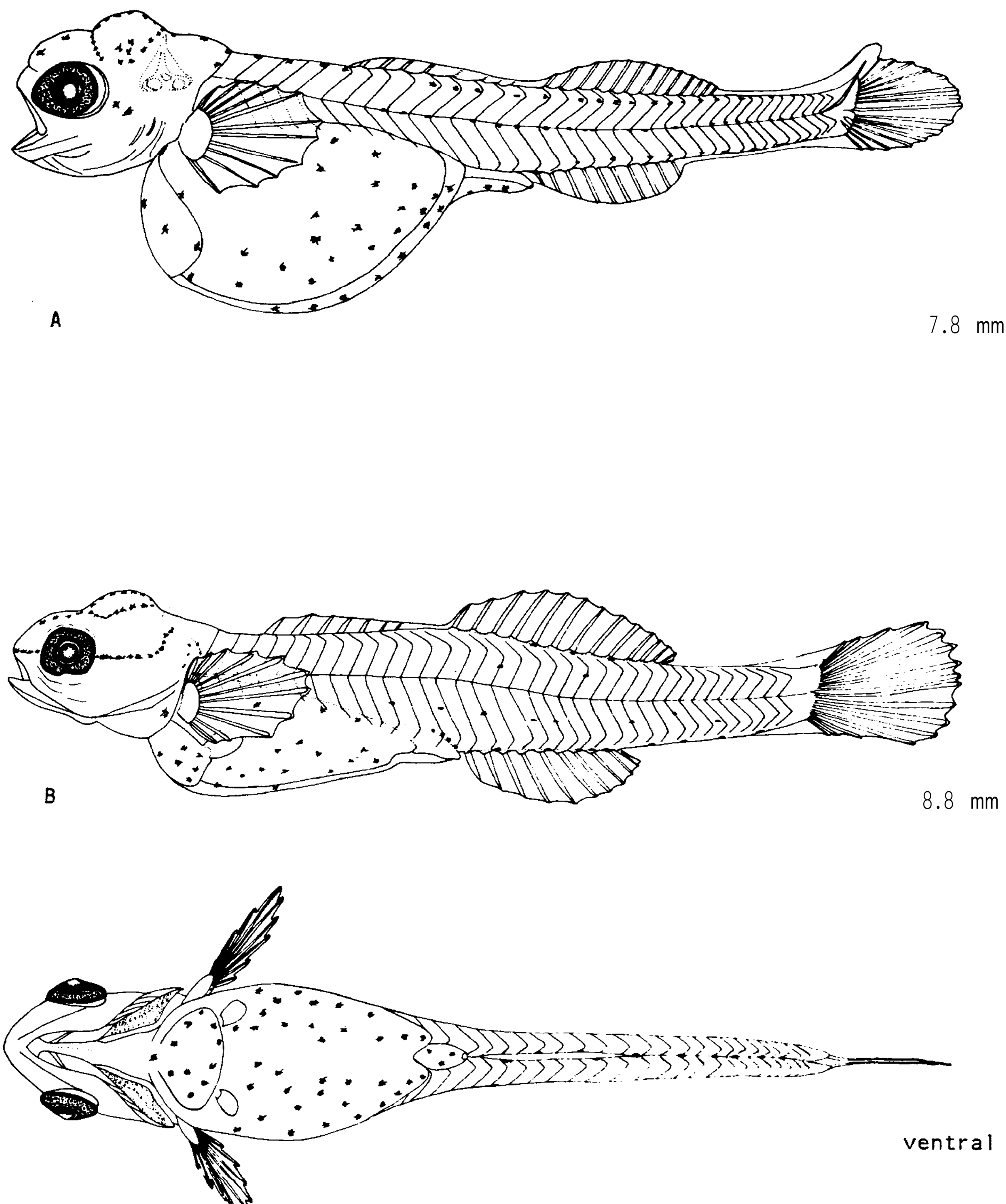


Fig. 250. Etheostoma flabellare, fantail darter. A and B. Yolk-sac larvae. (A and B, laboratory-reared, Pennsylvania, Cooper 1979).

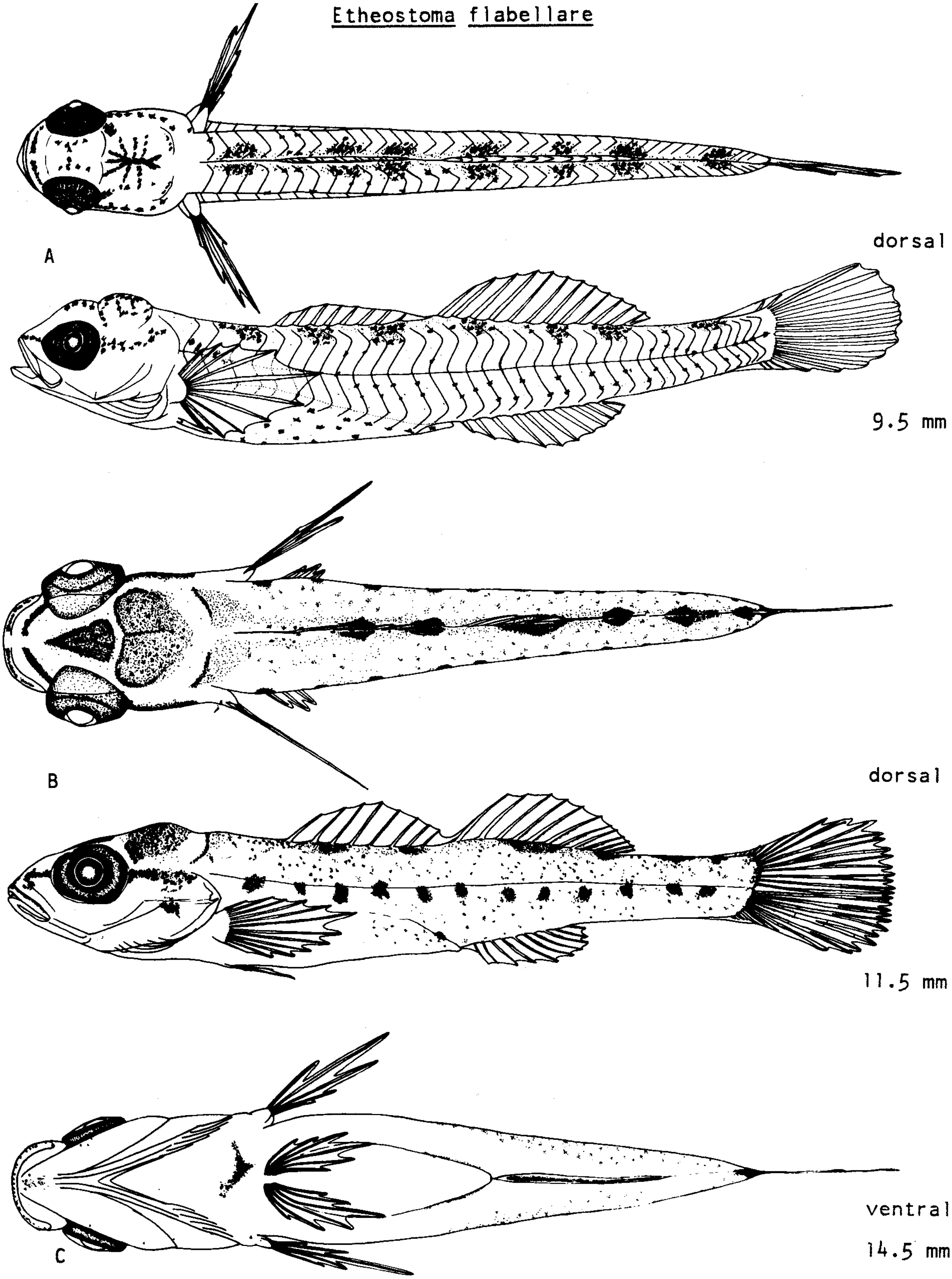


Fig. 251. Etheostoma flabellare, fantail darter. A-C. Larvae. (A-C, laboratory-reared, Pennsylvania, Cooper 1979).

Etheostoma microperca Jordan and Gilbert, least darter

DISTRIBUTION

Occurs in lakes and streams in Wisconsin, along the southern edge of the upper peninsula of Michigan and from the Little Manistee River in the lower peninsula of Michigan to the southern edge of the Lake Michigan drainage.’ Found also in the Lake Huron and Erie drainages, the southern tributaries of Lake Superior and the western tributaries of Lake Ontario.[2,3]

SPAWNING SEASON

Migrates shoreward during April in Michigan[5] and spawns from April to June in Michigan’ [4,6] and Illinois.[8]

SPAWNING TEMPERATURE

Spawning was observed at temperatures of 12 to 15.5 C[1,4] and 16 to 23 C.[8]

SPAWNING HABITAT

Spawns along vegetated lakeshores or stream pools,[6] in slowly moving water,[3,8] in dense beds of filamentous algae.[8]

SPAWNING SUBSTRATE

Eggs are spawned singly[1,3,6] on the bottom or the sides of submerged stems and 1 eaves of aquatic vegetation’ [4,5] or dead leaves, twigs, debris and filamentous algae.*

FECUNDITY

31 to 240;[8] 435 to 1,102;’ [6] 30 eggs maybe laid singly in 1 day.’ One to 3 eggs are laid at one time.*

EGGS

Adhesive;’ [8] diameter 0.7’ to 1.0[3] mm; oil globules one or two;[8] incubation period: 264 ± 13 hours at 15.5 C;[8] 144 to 150 hours (6 to 7 days) at 18 to 20 C;[3,4] 181 ± 7 hours at 20 C, 144 + 12 hours at 22 to 23 C.[8]

YOLK-SAC LARVAE

Total length	Description
3.0-3.5 mm	Newly hatched.[3,4,8] Morphology: pectoral fins large.[8] Pigmentation: single melanophores on head, yolk sac and some myomeres.[8]

4 mm — Morphology: pectoral fin rays ten, several caudal fin rays developed.[8]

LARVAE

Total length	Description
4-5 mm	Morphology: yolk absorbed or nearly so, pectoral and caudal fins developed, dorsal, anal and pelvic fins not yet visible.[8]

JUVENILES

Total length	Description
7 mm	Morphology: scales not evident.[8] Pigmentation: single melanophores scattered over head and body outlining fin rays and myomeres.[8]
8-11 mm	Pigmentation: ten lateral patches and six to seven dorsal "saddle" marks visible, melanophores outline anal fin rays, scales present on dorsal and lateral aspects of body.[8]
12-13 mm	Morphology: squamation complete, opercular spine developed.[8]

ADULTS

Fin rays: caudal 13 to 14;* dorsal VI to VII[3] - 8 to 9;[3] anal I to II,5 to 6;' pectoral 9.6;[9] pelvic I,5.[3]

Vertebrae: 31 to 33;[3] 32 to 34.[7]

Lateral line scales: 24 to 32.[3]

Diagnostic characters: premaxillae protractile, fleshy median frenum present, lateral line absent, anal fin usually II,5 to 6, dorsal fin spines six, usually less than 40 mm TL.

LITERATURE CITED

1. Becker (1976)
2. Hubbs and Lagler (1958)
3. Scott and Crossman (1973)
4. Petravicz (1936)
5. Winn (1958b)
6. Winn (1958a)
7. Bailey and Gosline (1955)
8. Burr and Page (1979)
9. Page (1981)

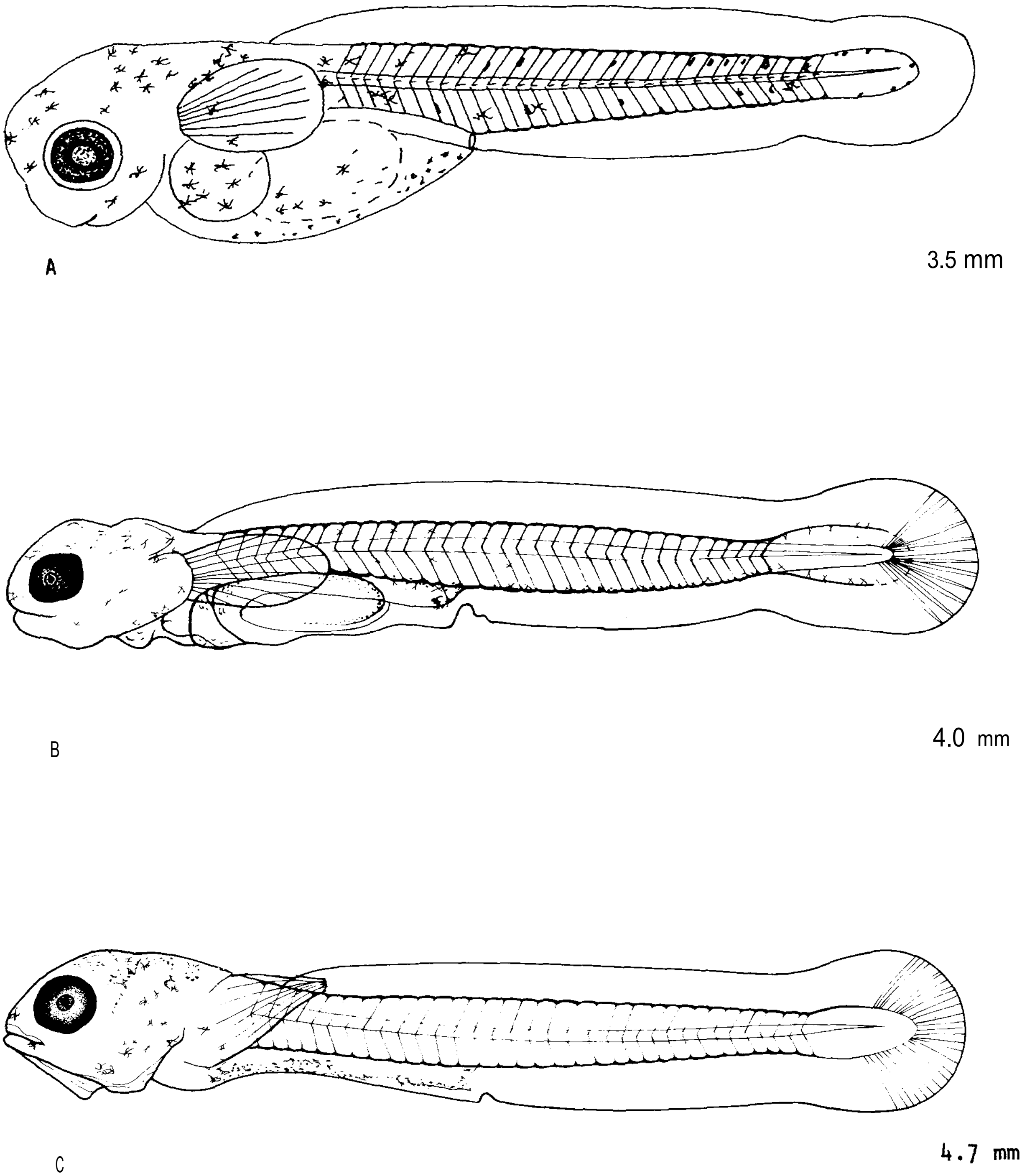


Fig. 252. Etheostoma microperca, least darter. A. Yolk-sac larva. B. Larva. C. Juvenile. (A-C, laboratory-reared, Illinois, Burr and Page 1979, illustrations provided by Illinois Natural History Survey).

Etheostoma nigrum Rafinesque, johnny darter

DISTRIBUTION

Abundant throughout the Great Lakes drainage in quiet shallow water of lakes and streams possessing sand, sand-silt or sand-gravel substrates.[1 2 3] Observed in the Great Lakes to depths of 42 m.[3]

SPAWNING SEASON

Migration to spawning grounds begins during April in Michigan.[8] Spawning takes place from April to June[1 5 9] in the Lake Michigan drainage.

SPAWNING TEMPERATURE

Spawning occurs at 11.7 to 21.1 C in southwestern Michigan.[5]

SPAWNING HABITAT

Spawns in shallow, quiet waters of lakes, pools and raceways which posses large rocks, logs and other debris.[1]

SPAWNING SUBSTRATE

Deposits eggs on the underside of rocks, logs and other debris,[1 8 9] usually on the portion nearest the bottom.[8] The male constructs and guards a nest.[1 8 9]

FECUNDITY

go to 164;[5] 388 (198 to 650) ;[7] 1,043 (436 to 1,248) .[9] Eggs laid singly in 5 to 6 clutches of 30 to 200 eggs.[8] Eggs in a single nest total 30 to 1, 150.[8]

NATURAL HYBRIDS

Possibly E. olmstedi.[1]

EGGS

Demersal;[9] adhesive;[5 9] attached to one another, bright orange;[5] diameter 1.4 to 1.5 mm;[4 5] oil globule large and single;[5] incubation period: 16 days at 12.8 C;[5] 10 days at 20 C, 6 days at 20.8 C;[5] 5.5 to 8 days at 22 to 24 C.[9]

YOLK-SAC LARVAE

Total length	Description
5 mm	Newly hatched.[1] Morphometry: (as % TL) preanal length 45. eye diameter 8.[4]

Morphology: oil globule near venter of yolk sac, intestine terminates just posterior to yolk at finfold margin, median finfold origin directly behind head, pectoral buds present.'
Pigmentation: no pigmentation except in eye.[4]

5-7 mm Morphometry: (as % TL) preanal length 54 to 56, greatest body depth 14 to 16, eye diameter 7.[4]
Morphology: pectoral fins large, yolk sac reduced, large anterior oil globule.'
Pigmentation: four lines of stellate chromatophores are on venter of yolk sac, four large patches of pigment on subsurface of yolk, last one just anterior to anus, four patches on venter from anus to caudal fin, a few scattered melanophores on head (5 to 6 mm), a few large masses of melanophores on ventral and lateral aspects of gut, four large chromatophores on dorsum of intestine and six on venter posterior to anus, some chromatophores above ventral ones and on myomeres above notochord (7 to 8 mm) .[4]

LARVAE

Total length	Description
9-10 mm	Morphometry: (as % TL) standard length 84, preanal length 53, greatest body depth 16, eye diameter 9.[4] Morphology: spines and rays partially developed.' Pigmentation: chromatophores more numerous over head, dorsal aspect of body and lateral line.[4]

JUVENILES

Total length	Description
15 mm	Morphometry: (as % TL) standard length 84, preanal length 53, greatest body depth 16, eye diameter 7.4 Pigmentation: more chromatophores on snout, head and sides.[4]

ADULTS

Fin rays: caudal 16;* dorsal VIII to XI[3]-12 to 13, (10 to 14) ;[3 6 11] anal I,9 (7 to 10) ;[3] pectoral 11 to 12;[3 6] pelvic I,5.[3]

Vertebrae: 37 to 39.[3 10]

Lateral line scales: 41 to 52.3

Diagnostic characters: six to seven lateral X's or W's, premaxillae protractile, separate from snout by deep furrow, lateral line complete, anal fin I,7 to 10, second dorsal fin rays 12 to 13, dorsal fins narrowly separated. This species is separated from

E. olmstedi by the absence of scales on breast, cheek and nape, 10 to 12 dorsal fin rays, upper lip even with snout tip and two to four bars of pigment crossing caudal fin.

LITERATURE CITED

1. Becker (1976)
2. Hubbs and Lagler (1958)
3. Scott and Crossman (1973)
4. Fish (1932)
5. Speare (1965)
6. Cole (1967)
7. Karr (1963)
8. Winn (1958b)
9. Winn (1958a)
10. Bailey and Gosline (1955)
11. McAllister et al. (1972)

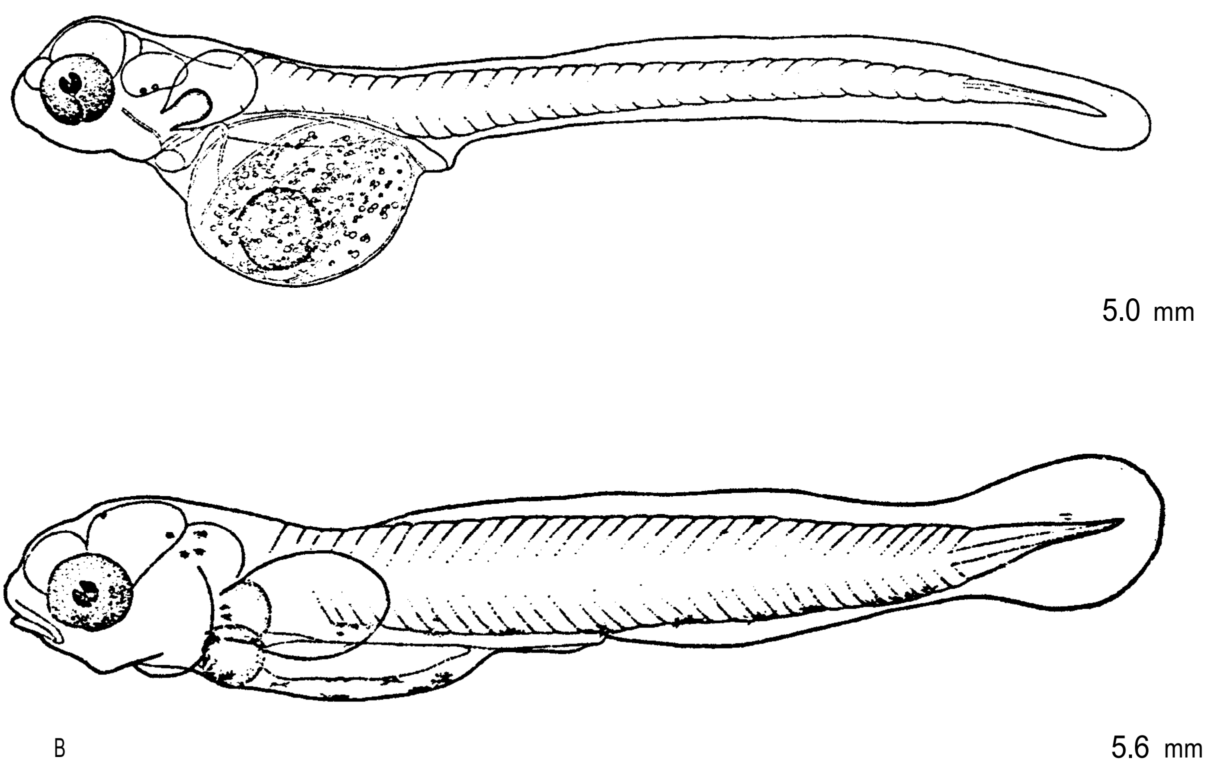


Fig. 253. Etheostoma nigrum, johnny darter. A. Yolk-sac larva. B. Larva. (A and B, wild-caught, Lake Erie, Fish 1932).

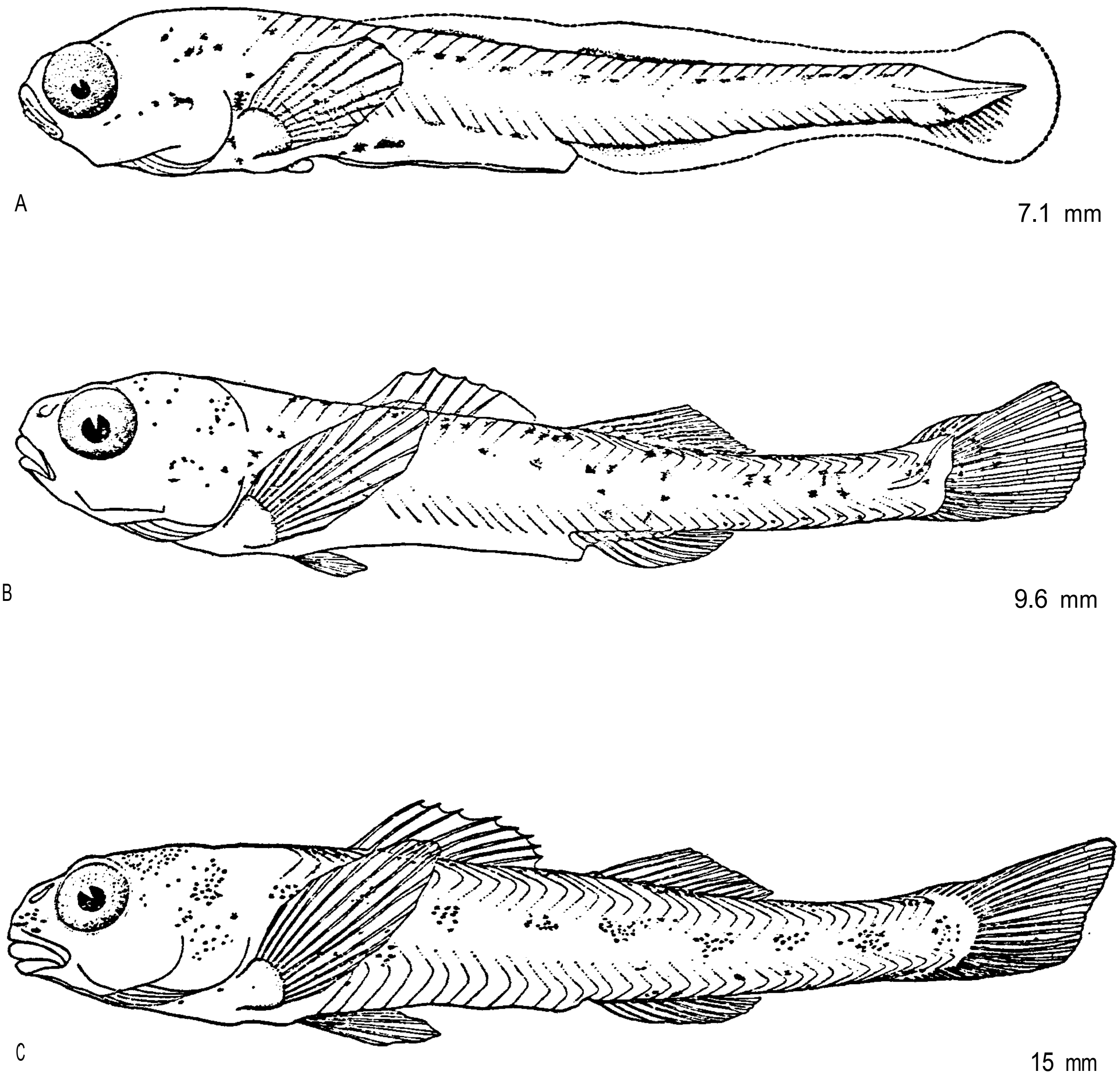


Fig. 254. Etheostoma nigrum, johnny darter. A and B. Larvae. C. Juvenile. (A-C, wild-caught, Lake Erie, Fish 1932).

Etheostoma olmstedi Storer, tessellated darter

DISTRIBUTION

In the Great Lakes basin it is restricted to Lake Ontario and its drainage.[1] [5]

SPAWNING SEASON

Spawns from April to late May in the Lake Ontario drainage,' late April to June in Maryland[2] and May to June in the Atlantic drainage.[6]

SPAWNING TEMPERATURE

Spawns at temperatures of 12.5 to 14.5 C[2] or 18.3 C.[6]

SPAWNING HABITAT

Spawns in moderate current of streams, creeks and rivers usually in water less than 30.5 cm but up to 61.0 cm deep.[6]

SPAWNING SUBSTRATE

Spawns under rocks on marl, sand, gravel or stone bottoms.' [6]

FECUNDITY

54 to 668;[6] 117 to 543.2

NATURAL HYBRIDS

Possibly E. nigrum. [7]

EGGS

Demersal, adhesive, diameter 1.5 mm, yolk amber, oil globule single dark amber.'

YOLK-SAC LARVAE

Total length	Description
5-6 mm	Pigmentation: eye pigmented, stellate chromatophores on yolk sac, double row of chromatophores on postanal venter and between yolk sac and body (5.1 mm), pigment on yolk sac concentrated along vitelline vessels (5.3 mm), evidence of pigment on dorsum of head (5.5 mm).[6]

LARVAE

Not described.

JUVENILES

Not described.

ADULTS

Fin rays: caudal 16;* dorsal VIII to X[6]-13 to 14[5] (10 to 17);' [6] [7] anal I to II,7 to 9 (5 to 10), pectoral 12 to 13 (9 to 15) ;[5] [6] pelvic I,5.[8]

Vertebrae: 37 to 39.[6]

Lateral line scales: 34 to 64.[5] [6]

Diagnostic characters: premaxillae protractile, separate from snout by deep furrow, lateral line complete, anal fin I,5 to 10, second dorsal fin rays usually 13 to 15, dorsal fins narrowly separate. This species is separated from E. nigrum by the presence of scales on breast, cheek and nape, dorsal fin rays usually 13 to 15, upper lip extends past snout tip and five to eight bars of pigment crossing caudal fin.

LITERATURE CITED

1. Hubbs and Lagler (1958)
2. Tsai (1972)
3. Atz (1940)
4. Raney and Lachner (1943)
5. Cole (1967)
6. Hardy (1978)
7. McAllister et al. (1972)
8. Scott and Crossman (1973)

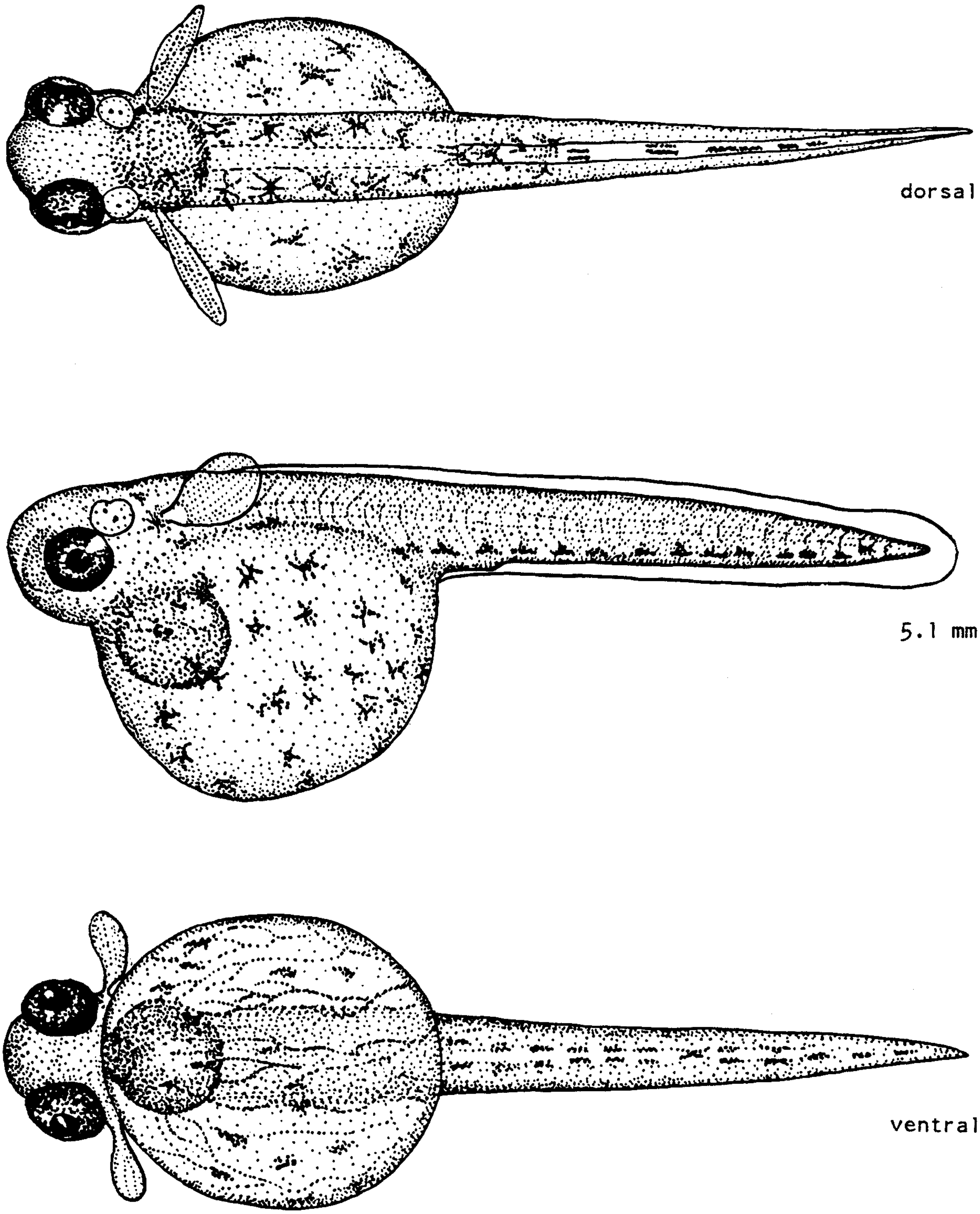


Fig. 255. Etheostoma olmstedi, tessellated darter. Yolk-sac larva. (Hardy 1978, original illustrations by D. C. Kennedy).

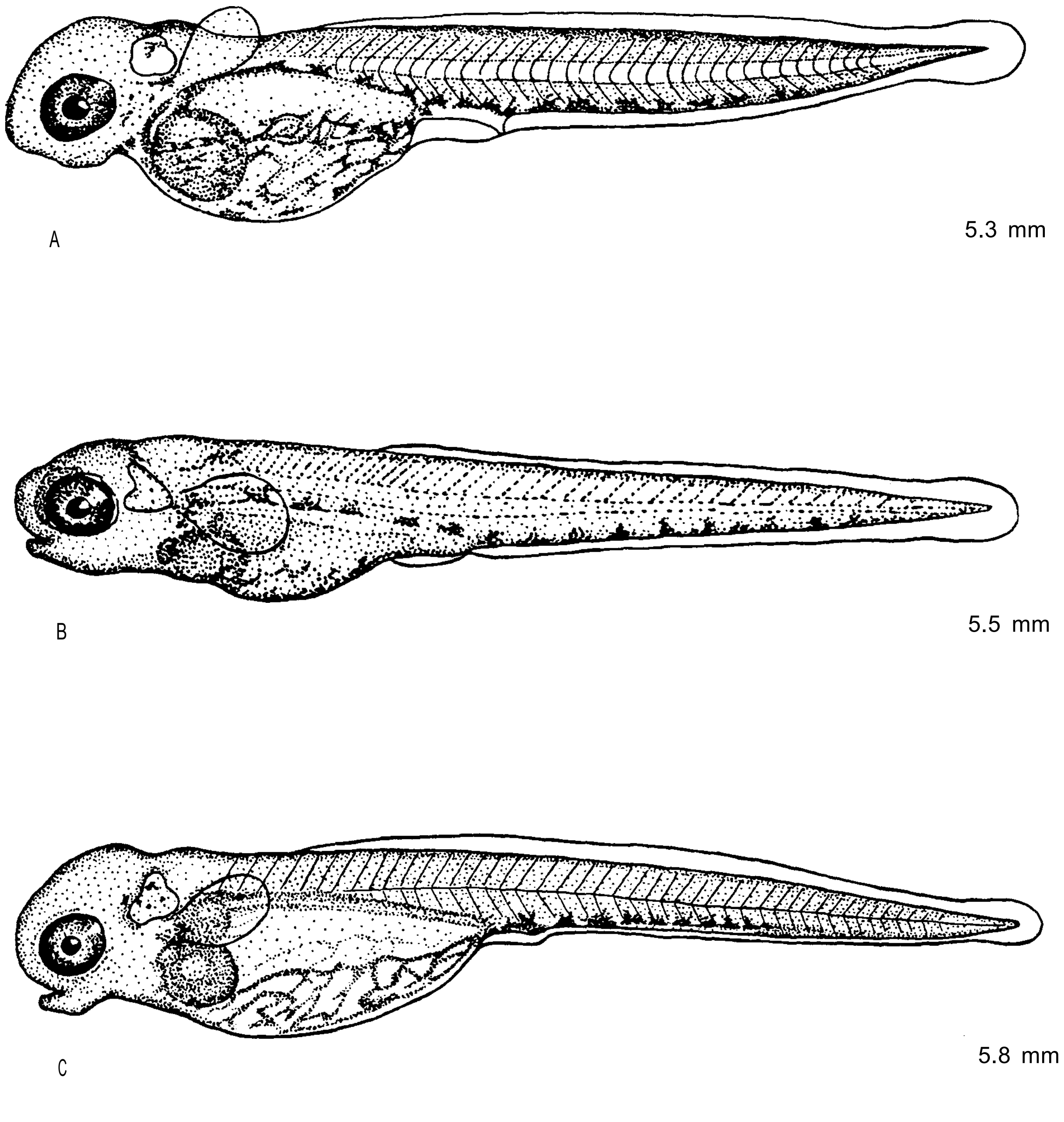


Fig. 256. Etheostoma olmstedi, tessellated darter. A-C. Yolk-sac larvae. (A-C, Hardy 1978, original illustrations by D. C. Kennedy).

Etheostoma zonale (Cope), banded darter

DISTRIBUTION

Known from small streams and creeks in the Wisconsin portion of the Lake Michigan drainage.'

SPAWNING SEASON

Spawns from late May to early June in northern Illinois.'

SPAWNING TEMPERATURE

Not reported.

SPAWNING HABITAT

Spawns in stream riffles in water less than 0.6 m in depth.[3]

SPAWNING SUBSTRATE

Deposits eggs in filamentous algae, aquatic mosses or plant debris.[3]

FECUNDITY

Not reported.

EGGS

Water-hardened, unfertilized egg diameter 1.4 to 1.6 mm.[2]

YOLK-SAC LARVAE

Total length	Description
5-7 mm	Myomeres: 36 to 37 (14 to 15 + 22).[6] Morphometry: preanal length less than 50% TL.[6] Morphology: yolk sac bulbous, short, large near anterior oil globule, vitelline vessels numerous and reticulate, pectoral buds small and round.' Pigmentation: melanophores abundant, scattered on venter of yolk sac, ventral pigment between each postanal myomere varies from one melanophore per myoseptum to short streaks of pigment from venter to lateral line, one row either side of "keel", a few melanophores scattered on dorsum and dorso-lateral aspect of head.[6]

LARVAE

Total length	Description
7-8 mm	Morphology: yolk absorbed, fin rays forming in lower section of caudal fin, pectoral fin small, round.[6]

Pigmentation: pigment ventral to gut less concentrated, a few melanophores remain near breast and under gut region, pigment on gut concentrated on right side of ventral midline, a few melanophores continue to anus, postanal pigment similar to previous stage, a few melanophores may appear near lower portion of caudal finfold below notochord, pigment may be present on head and operculum, chin with one or two melanophores, posterior tip of dentary with spot.’

11-12 mm — Myomeres: preanal myomeres 17 to 19.[6]
Morphology: pelvic fins develop, rays in dorsal and anal fins develop.‘
Pigmentation: pigment increases over dorsal and lateral aspect of head, decreases to several large melanophores over belly and increases posterior to anus near caudal fin, green sheen on anterior portion of body when alive.[6]

JUVENILES

Total length	Description
16-17 mm	Morphology: fin ray counts may be incomplete, spiny dorsal last to develop, caudal fin slightly emarginate (16.7 mm), premaxillae overhang mandible slightly, pelvic fins close together, distance between bases less than length of one pelvic fin, pectoral fins large and rounded.[6] Pigmentation: banding pigment appears on dorsum first (16.7 mm), increases laterally later.‘

ADULTS

Fin rays: caudal 15 to 17, dorsal X to XI (IX to XII)-11 to 12, anal II,7, pectoral 15, pelvic 6.[3]

Vertebrae: 38 to 41.[5]

Lateral line scales: 43 to 47 (42 to 53);[3] 46 to 53.[4]

Diagnostic characters: premaxillae not protractile, connected to snout by fleshy median frenum, anal fin II,7, lateral line complete, gill membranes very broadly connected, 7 to 11 brown “saddle” marks on dorsum, 9 to 11 vertical bars.

LITERATURE CITED

1. Becker (1976)
2. Hubbs (1967)
3. Trautman (1957)
4. Smith (1979)
5. Bailey and Gosline (1955)
6. Lathrop (1978)

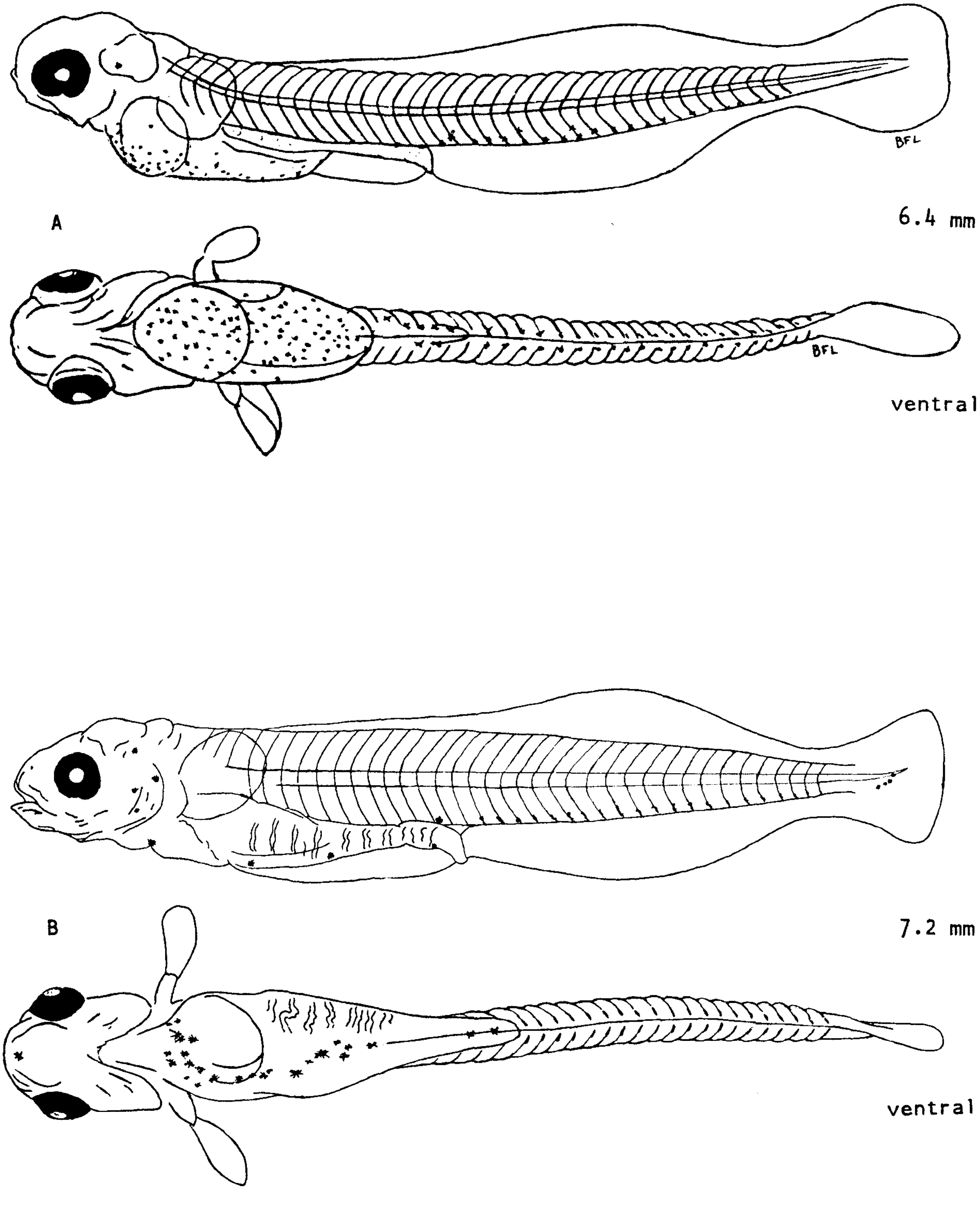


Fig. 257. Etheostoma zonale, banded darter. A. Yolk-sac larva. B. Larva. (A and B, wild-caught, Susquehanna River, Lathrop 1978).

Etheostoma zonale

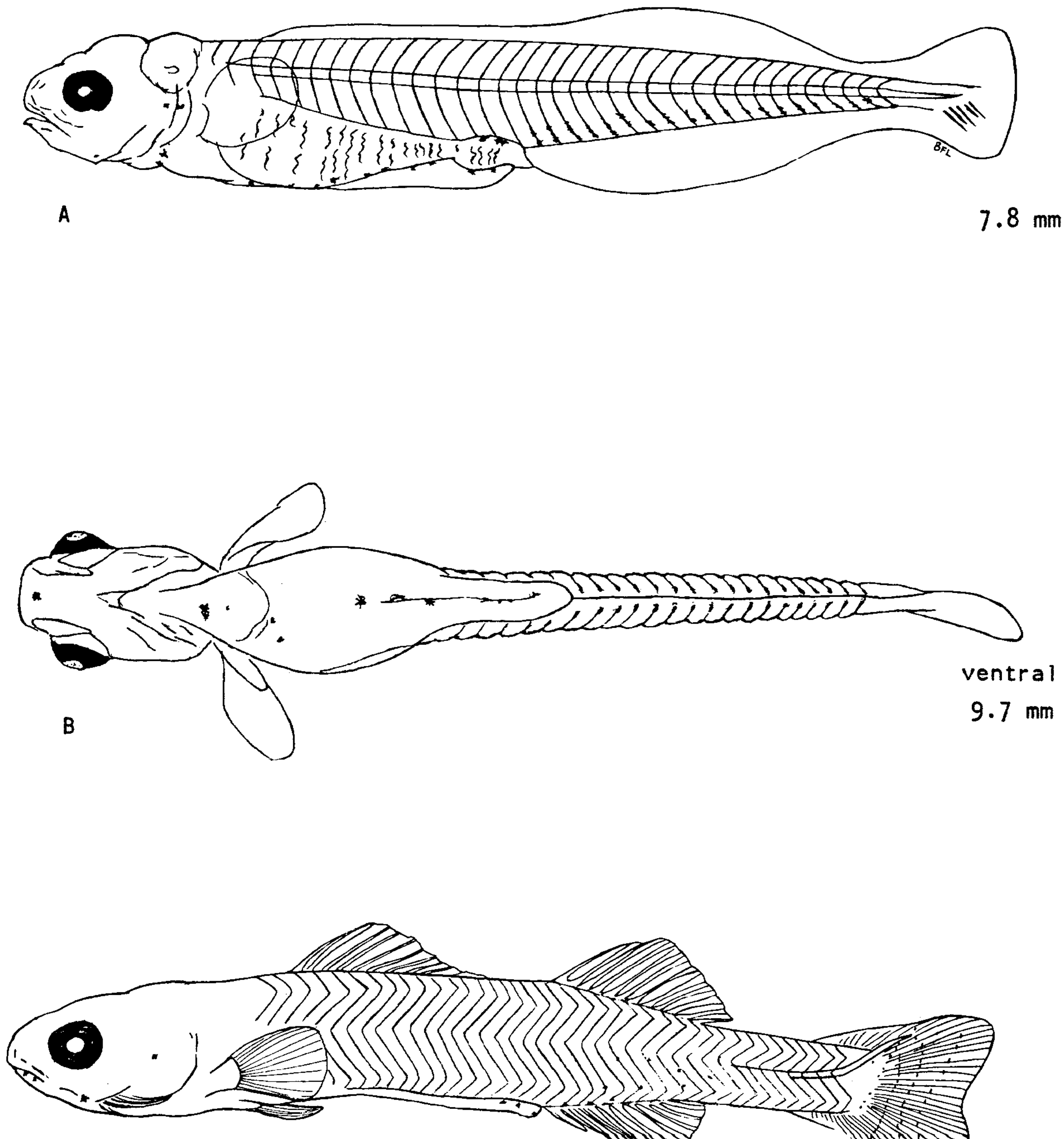


Fig. 258. *Etheostoma zonale*, banded darter. A-C. Larvae. (A-C, wild-caught, Susquehanna River, Lathrop 1978).

Perca flavescens (Mitchill), yellow perch

DISTRIBUTION

Common to abundant throughout the Great Lakes basin to depths of 45 m, preferring lakes, ponds and quiet portions of streams.' [2]

SPAWNING SEASON

Spawns from mid-May to late June in Lake Michigan, [17 20] early May to July [3] in Lake Erie [4 6] and early April to late May in smaller lakes and bays. [3 7 8 9 10 11 12 14 16 23 24]

SPAWNING TEMPERATURE

Migrates shoreward as temperatures rise from 1.5 to 6.0 C, [12] most often spawning between 7.2 and 11.1 C, [6 9 10] but spawning occurs over a range of 5.6 to 18.5 C in the Great Lakes basin.' [6 9 10 11 16 18]

SPAWNING HABITAT

Moves into shallow bays, shoreline and/or littoral areas' [3 8] to spawn in water 0.6 to 1.8 m, [16] 1.5 to 3.0 m [9] or 8 to 10 m deep. [12] In rocky trenches within hard clay shoals in 12 m of water in southeastern Lake Michigan."'

SPAWNING SUBSTRATE

Spawns over sand, gravel, rubble, submerged vegetation or debris-covered bottoms.' [3 8]

FECUNDITY

3,035 to 157,594 in the Great Lakes basin; [6 11 12 14 20] and outside the basin; [5 7 5 16 22 23 24] averaging 23,000 [9] to 48,000. [28]

EGGS

Semi-demersal;* released in long bands; [1] flat ribbon-like,' accordion-folded, transparent; [3] gelatinous [1 3] masses approximately 0.6 to 2.0 m long and 51 to 76 mm wide, eggs semi-transparent or light-colored; [9] diameter 3.5 mm; [3 25] or 2.3 mm (1.9 to 2.8 mm), yolk light amber, oil globule single, deep amber; [27] or clear yellow, diameter 0.4 mm; [4] 0.64 mm (0.49 to 0.92 mm) ; [27] incubation period: 51 days at 5.4 C; [19] 27 days at 8.3 C; [24] 25 to 27 days at 8.5 to 12.0 C (in situ); [27] 6 days at 19.7 C; [19] 8 to 14 days (in situ) ; [3 6 9] 17 to 20 days (in situ) . [16]

YOLK-SAC LARVAE

Total length	Description
5-8 mm	Newly hatched (4.7 to 6.6 mm).' [10 13 19 21 27 30]

Myomeres: 34 to 42 (17 to 24 + 13 to 20);[26 28 30] usually 36 (18 or 19 + 17 to 18);[26 30] or 36 (22 + 14).[28]

Morphometry: (as % TL) standard length 96 to 97;[27] preanal length 52 to 53;[27 30] greatest body depth 14 to 16[27] or 17;[4] body depth at anus 13;[4] head length 13[4] or 17 to 18;[27] snout length 3;[4] eye diameter 5 to 6.[4 27] Preanal length (3.0 to 3.8 mm) greater than postanal length (2.6 to 3.5 mm) at 5.5 to 7.0 mm.[26]

Morphology: notochord straight, finfold origin at base of first myomere continuous to posterior margin of yolk sac breaking at anus;[26] continuous to just posterior to oil globule;[28] yolk sac 1.1 to 2.3 mm long, ovate, 0.4 to 0.8 mm wide, intestine straight, 0.5 to 1.1 mm from posterior margin of yolk sac to anus;[26] pectoral buds present;[26 27 28] four gill arches, preopercle and opercle present, yolk absorption nearly complete (7.0 mm), head becomes elongate and flattened (7.2 mm).[27]

Pigmentation: eye heavily pigmented;[27 30] large stellate chromatophores scattered on venter of yolk sac;[26] on dorsum and venter of intestine;[4 26 27 28] one to three chromatophores near anus;[26] little pigmentation on dorsum of swim bladder;[28] postanal myoseptum marked by chromatophores running from venter to myoseptum;[4 26 27 28] a pair of chromatophores present at base of each pectoral fin.[28]

LARVAE

Total length	Description
8-10 mm	Myomeres: 35 to 43 (18 to 22 + 17 to 21);[30] usually 38[28] to 39 (20 + 19).[30]
	Morphometry: (as % TL) standard length 97;[27] preanal length 52;[27] or 56;[4] greatest body depth 14;[27] or 12;[4] head length 19;[27] eye diameter 6.[4 27]
	Morphology: yolk and oil absorbed;[28] notochord beginning to bend upward, finfold present only on posterior end, five to six rays forming on venter of caudal fin;[28] teeth present on premaxillae and ossification begins in maxillae and branchial arches (8.3 mm), rays in caudal fin begin to ossify (8.0 mm to 9.0 mm), quadrates, branchiostegal rays and vertebrae start to ossify (9.0 to 10 mm).[26]
	Pigmentation: single postanal line of pigment, double line around anal fin;[28] pigment over swim bladder becomes more intense;[27] stellate melanophores appear on occipital region of head and on edge of lower jaw.[27 28]
11-15 mm	Myomeres: 35 to 37 (21 to 23 + 14 to 16), usually 36 (21 + 15).[28]

Morphometry: (as % TL) standard length 90 to 96;[4] 84;[27] preanal length 50 to 52;[4] 54;[27] greatest body depth 16 to 17;[4 27] body depth at anus 14;[4] head length 24;[4 27] snout length 6;[4] eye diameter 5 to 6;[4] 7.[27]

Morphology: finfold persisting anterior to soft dorsal fin, along dorsum and venter of caudal peduncle and just anterior to anus;[27 28] yolk nearly absorbed (13.0 mm);[26] teeth on jaws, gut completely looped;[27] opercle, preopercle and frontal bones ossified (10.0 to 11.0 mm);[26] pelvic buds appear;[4 28] preopercular spines few and proportionally larger than in adults, rays appear in soft dorsal and anal fins;[27] begin to ossify (12 to 13 mm);[26] first dorsal fin shows developing rays, pectoral buds with actinotrichia;[28] beginning to ossify (13 to 14 mm);[26] rays visible in entire caudal fin;[28] pelvic fin rays ossify (15 to 16 mm).[26]

Pigmentation: stellate chromatophores on narial and interorbital areas of head;[28] pigment on upper lip, each side of gut and beside second dorsal fin;[28] pigment on preopercle and a subsurface group over gut.[4]

15-20 mm

Myomeres: 35 to 38 (20 to 24 + 13 to 14), usually 36 (22 + 14).[28]

Morphometry: (as % TL) standard length 80;[27] 85;[4] preanal length 53;[4 27] greatest body depth 19 to 20;[4 27] body depth at anus 16, predorsal length fin 31, length to second dorsal fin 52, head length 24;[4] 26;[27] snout length 5;[4] eye diameter 8.[4 27]

Morphology: finfolds absorbed;[28] preopercular spines more numerous but smaller;[27] rays completely formed (20 mm).[4]

Pigmentation: melanophores scattered over entire body, double row of pigment from head to posterior soft dorsal fin, single row just before caudal fin, double row of pigment from pelvic fins to posterior anal fin, single row beyond to caudal fin;[28] six to seven definite vertical bands on scaleless body (20 mm).[27]

JUVENILES

Total length	Description
20-40 mm	Myomeres: 34 to 41 (18 to 21 + 16 to 20), usually 38 (20 + 18).[30]
	Morphometry: (as % TL) standard length 84;[4] 79;[27] preanal length 51;[4] 55;[27] greatest body depth 18;[4] 21;[27] predorsal length 29;[4] head length 27;[27] maxilla length 10;[4] eye diameter 7.[4 27]
	Morphology: scales first appear (20 to 22 mm);[26 15] scales appear along back and around caudal peduncle (28 mm);[27] squamation complete (36 to 37 mm).[15]

Pigmentation: vertical bands contrast sharply against body, dark pigment over brain, concentrated along edge of spiny dorsal fin.[27]

ADULTS

Fin rays: caudal 19;[29] dorsal XI to XII;[27] XIII to XV[3]-I to 11, 12 to 15;[3] [27] anal 11,6 to 8;[3] [27] pectoral 13 to 15;[3] [27] pelvic I,5.[3] [27]

Vertebrae: 38 to 41;[3] 40 to 41 (39 to 42).[31]

Lateral line scales: 53 to 57 (51 to 61).[3]

Diagnostic characters: six to nine vertical bands of dark pigment on lateral aspect, preopercle strongly serrate, no canine teeth, anal fin 11,6 to 8.

LITERATURE CITED

1. Becker (1976)
2 Hubbs and Lagler (1958)
3: Scott and Crossman (1973)
5. Fish (1932)
6. Tsai and Gibson (1971)
Van Meter (1960)
I Clady and Hutchinson (1975)
;: Nelson (1977)
9. Herman et al. (1959)
10. Clady (1976)
11. Kernen and Hawley (1978)
12, Sztramko and Teleki (1977)
13. J. H. Peterson (pers. Comm.)
14. Sheri and Power (1969)
15. Pycha and Smith (1955)
16. Weber (1975)
17. Wells (1968)
18. Muncy (1962)
19. Hokanson and Kleiner (1974)
20. Brazo et al. (1975)
21. Houde (1969)
22. Vessel and Eddy (1941)
23. Bandow (1969)
24. Raney (1959)
25. Ryder (1887)
26. Norden (1961)
27. Mansueti, A. J. (1964)
28. Faber (1963)
29. Carlander (1949)
30. Mansueti, R. J. (1964)
31. Bailey and Gosline (1955)
32. J. A. Dorr, III (pers. Comm.)

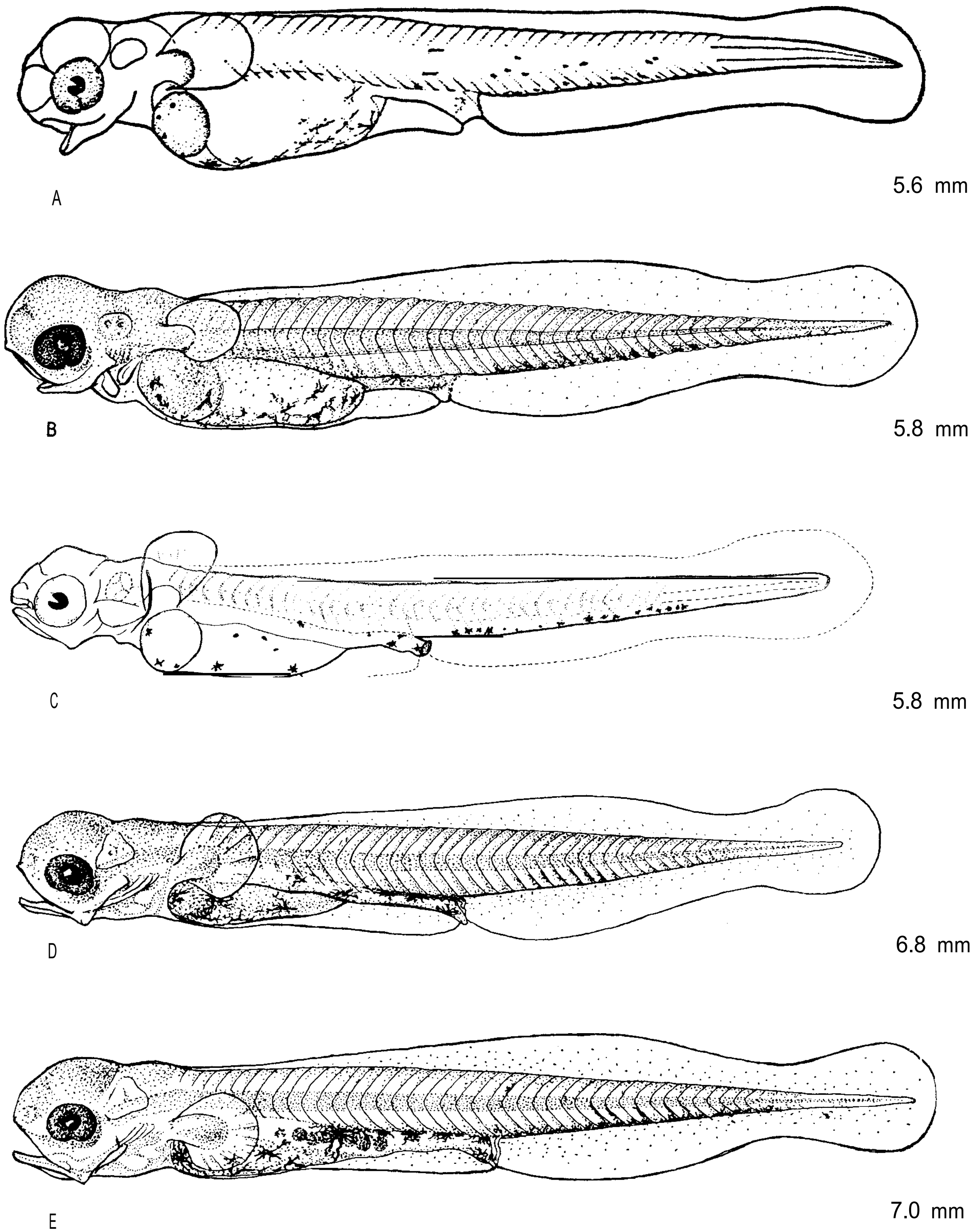


Fig. 259 Perca flavescens, yellow perch. A-E. Yolk-sac larvae. (A, wild-caught, Lake Erie, Fish 1932; B,D and E, laboratory-reared, Maryland, A. J. Mansueti 1964; C, wild-caught, Lake Erie, Norden 1961).

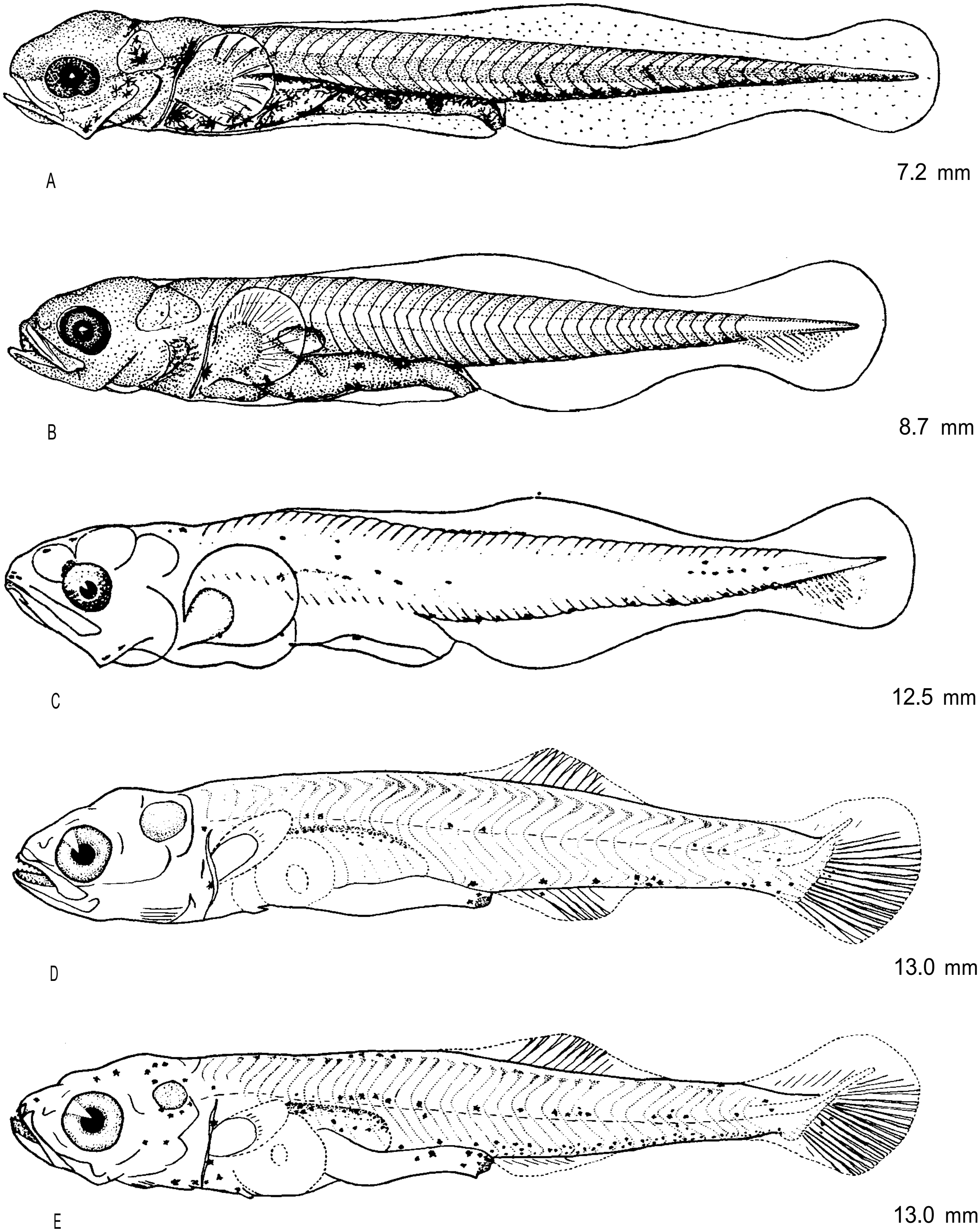


Fig. 260. Perca flavescens, yellow perch. A-E. Larvae. (A and B, laboratory-reared, Maryland, A. J. Mansueti 1964; C, wild-caught, Lake Erie, Fish 1932; D and E, wild-caught, Lake Erie and Lake Michigan, Norden 1961).

Percina caprodes (Rafinesque), logperch

DISTRIBUTION

Occurs in lakes, rivers and streams possessing sand and gravel substrate throughout the Great Lakes basin.' Has been collected at a depth of 29 m in Lake Huron[2] and 40 m in Lake Erie.[3]

SPAWNING SEASON

Spawns from April to late June in southern Michigan'[,] and late June to early July in northern Michigan.[6]

SPAWNING TEMPERATURE

Spawns at temperatures between 10 and 15 C.[5]

SPAWNING HABITAT

Spawns in a large, sandy area in water 10 to 30 cm deep over which they school prior to spawning.'[6] Selects lakeshores, stream riffles and raceways.'

SPAWNING SUBSTRATE

Spawns on fine sand[3 6 * 9 10] and gravel[9 10] and thus the vibration of the spawning fish creates a pit.[6] Eggs are buried.[6]

FECUNDITY

1,060 to 3,085.[3 9] Each spawning 10 to 20 eggs are laid,[3] * female spawns once or twice.'

EGGS

Demersal, adhesive;[5 6 10] colorless;[3] or amber, attachment disc present, diameter 1.12 mm (1.09 to 1.15 mm), granular yolk;[10] diameter 0.77 mm, oil globule large and single,[5 10] or numerous small globules, diameter 0.43 mm, incubation period: 8 days at 16.5 C;[10] 5 to 7 days at 21 to 23 C.[7]

YOLK-SAC LARVAE

Total length	Description
5-6 mm	Newly hatched (4.5 mm).[10] Myomeres: 37 to 38 (20 + 17 to 18).[5] Morphometry: (as % TL) preanal length 56, yolk-sac length 33, oil globule diameter 10, eye diameter 6, pectoral fin length 8.[10] Pigmentation: eyes pigmented.[10]

LARVAE

Total length	Description
6-7 mm	Morphometry: (as % TL) standard length 95 to 97;[10] preanal length 55 to 56;[10] 62;[4] greatest body depth 9 to 11;[10] 13;' head length 15 to 16;[10] 17;[4] snout length 3;[4] eye diameter 4 to 5.[4 10] Morphology: yolk absorbed (6.3 to 7.0 mm), pectoral buds evident;[10] jaws and teeth developed (6.6 mm;[4] 7.5 mm[10]). Pigmentation: single, large chromatophores below base of pectoral fin, three chromatophores on venter of gut evenly spaced with last at anus, one chromatophore on dorsum of gut just above the anus and irregular single postanal series.[4]
7-9 mm	Morphometry: (as % TL) standard length 95, preanal length 59, greatest body depth 11, head length 18, eye diameter 5.[10] Morphology: caudal fin rays visible.[10]
10-13 mm	'Myomeres: 40 (23 + 17).[10] Morphometry: (as % TL) standard length 92:[4] 93 to 98;[10] preanal length 54;[4] 57 to 58;[10] greatest body depth 11 or 12;[4 10] body depth at anus 8;[4] head length 17;[4] 18 to 20;[10] eye diameter 5 or 6.[4 10] Morphology: some dorsal and anal fin rays developed;'[10] urostyle upturned, caudal fin rays formed (12.0 mm).[10] Pigmentation: single subsurface chromatophore below base of pectoral fin, a few along venter of intestine and a few subsurface marks on venter of caudal peduncle beginning at anus.[4]
14-15 mm	Myomeres: 41 (23 + 18).[10] Morphometry: (as % TL) standard length 90;[10] 89;[4] preanal length 56;[10] 58;[4] greatest body depth 13;[10] 14;[4] postanal body depth at anus 10;[4] head length 19;[10] 21;[4] eye diameter 7;[10] 6;[4] snout 5.[4] Morphology: pelvic fin rays forming, little finfold remaining (14.0 mm), all fin rays except spiny dorsal and pelvic fin formed;[10] or al 1 spines and rays of median fins apparent (15.0 mm).[4] Pigmentation: a few chromatophores apparent over swim bladder.'
16-19 mm	Myomeres: 41 to 42 (23 + 18 to 19).[10] Morphometry: (as % TL) standard length 87 to 89, preanal length 55 to 56, greatest body depth 13 to 15, head length 20, eye diameter 6.[10] Morphology: anal fin I,11.[10]

JUVENILES

Total length	Description
20-21 mm	Morphometry: (as % TL) standard length 80 to 87;[10] 83;[4] preanal length 50 to 53;[10] 53;[4] greatest body depth 11 to 12;[10] 15;[4] body depth at anus 12, predorsal length 30, head length 18 to 20;[10] 23;[4] snout length 5;[10] eye diameter 6;[4] 7.[10] Morphology: anal fin II,10.[10] Pigmentation: chromatophores on snout, jaws, above eye, and dorsum posterior to brain;[1] patches on dorsum, one between dorsal fins, one below middle of soft dorsal, one at end of soft dorsal and one near caudal fin, a few patches of pigment on lateral line below dorsal patches with a few chromatophores between;[4] double row of pigment on venter between caudal fin and anus, heaviest near base of anal fin, some at proximal end of caudal fin rays, median fins with pigment, paired fins without pigment.[4]
25-26 mm	Myomeres: 40 (20 + 20) ;[4] 41 to 43 (23 to 24 + 18 to 19).[10] Morphometry: (as % TL) standard length 82, preanal length 53, greatest body depth 16, head length 24, eye diameter 8, (as % head length) 33.[4] Morphology: mouth small, inferior, small teeth on vomer and palatines.[1] Pigmentation: pigment in eight bars crossing dorsum, which are opposite ten lateral bars, scattered chromatophores on jaws, head and median fins, single postanal series of dark chromatophores, double around anal fin, black spot at base of caudal fin.[4]

ADULTS

Fin rays: caudal 38 to 39;[10] dorsal XIV to XV (XIII to XVI)[3,10], 15 to 16[3,10] (14 to 18);[3] anal II, 10 to 11 (9 to 12);[3,10] pectoral 13 to 14;[3] 15;[10] pelvic I,5.[10]

Vertebrae: 41 to 42 (39 to 44);[10] 42 to 44 (41 to 45).[11]

Lateral line scales: 71 to 85;[3] 71 to 103.[5]

Diagnostic characters: midline of belly with single series of enlarged scales, premaxillae not protractile, bound to snout by median fleshy frenum, snout extends beyond upper lip, lateral line scales 78 to 103, 15 to 25 cross bars on lateral surf ace narrow and numerous, dark spot on caudal peduncle.

LITERATURE CITED

1. Becker (1976)
2. Hubbs and Lagler (1958)
3. Scott and Crossman (1973)
4. Fish (1932)

5. Hardy (1978)
6. Reighard (1913)
7. Grizzle and Curd (1978)
8. Winn (1958b)
9. Winn (1958a)
10. Cooper (1978c)
11. Bailey and Gosline (1955)

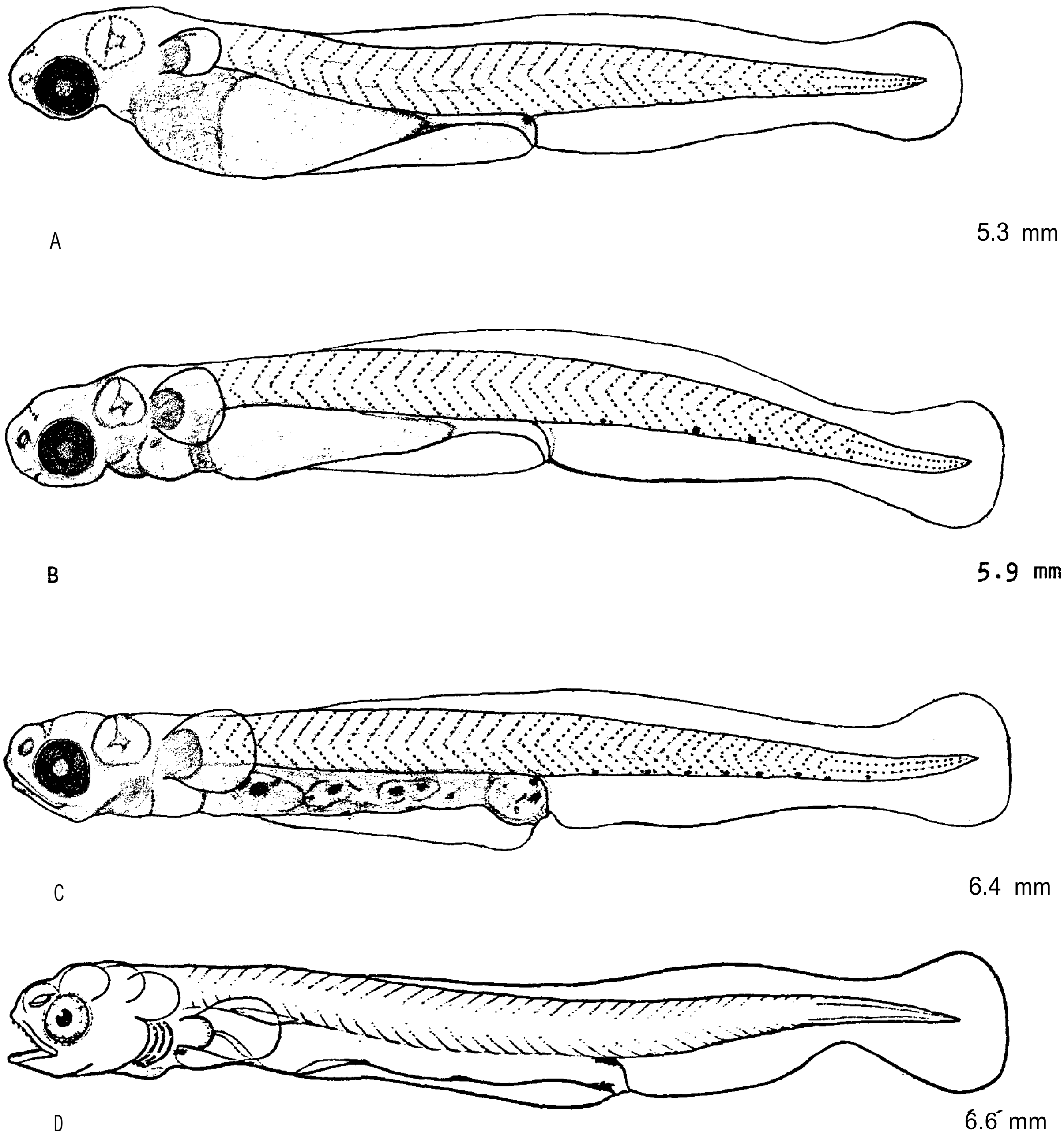
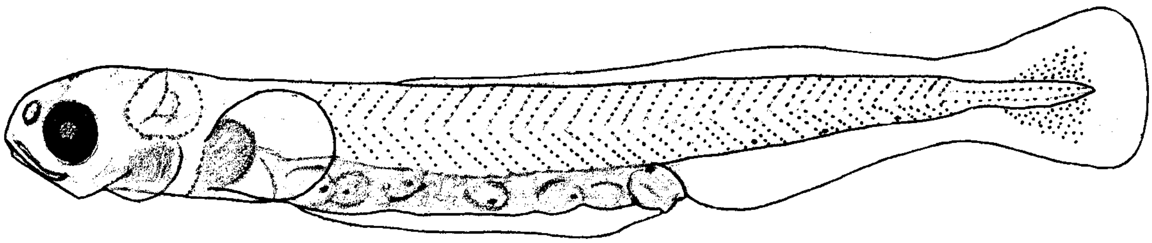
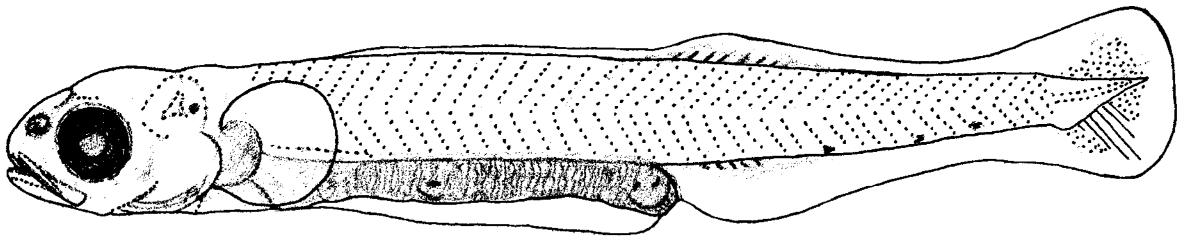


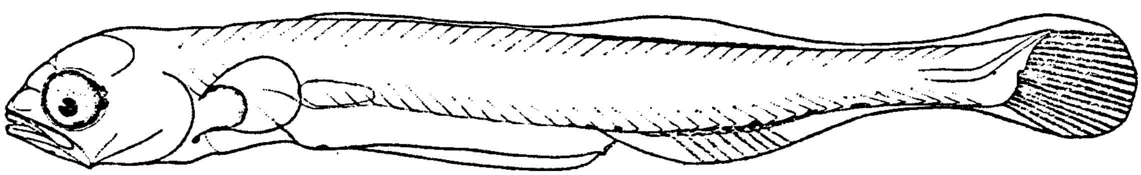
Fig. 261. Percina caprodes, logperch. A and B. Yolk-sac larvae. C and D. Larvae. (A-C, wild caught, Oklahoma, Taber 1969; D, wild-caught Lake Erie, Fish 1932).



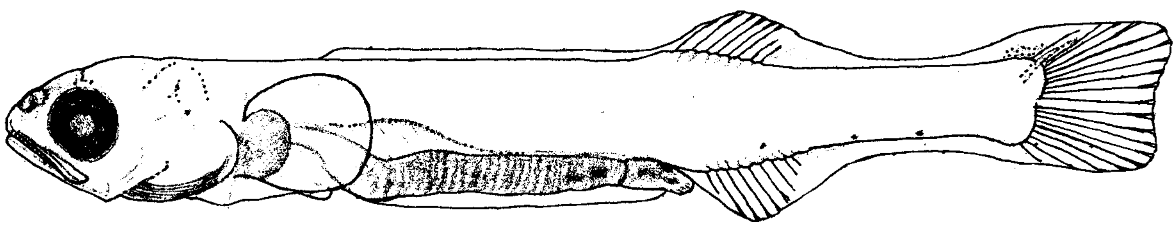
A 8.3 mm



B 10.5 mm



C 12.5 mm



D 13.4 mm

Fig. 262. Percina caprodes, logperch. A-D. Larvae. (A,B and D, wild-caught and laboratory-reared, Oklahoma, Taber 1969; C, wild-caught Lake Erie, Fish 1932).

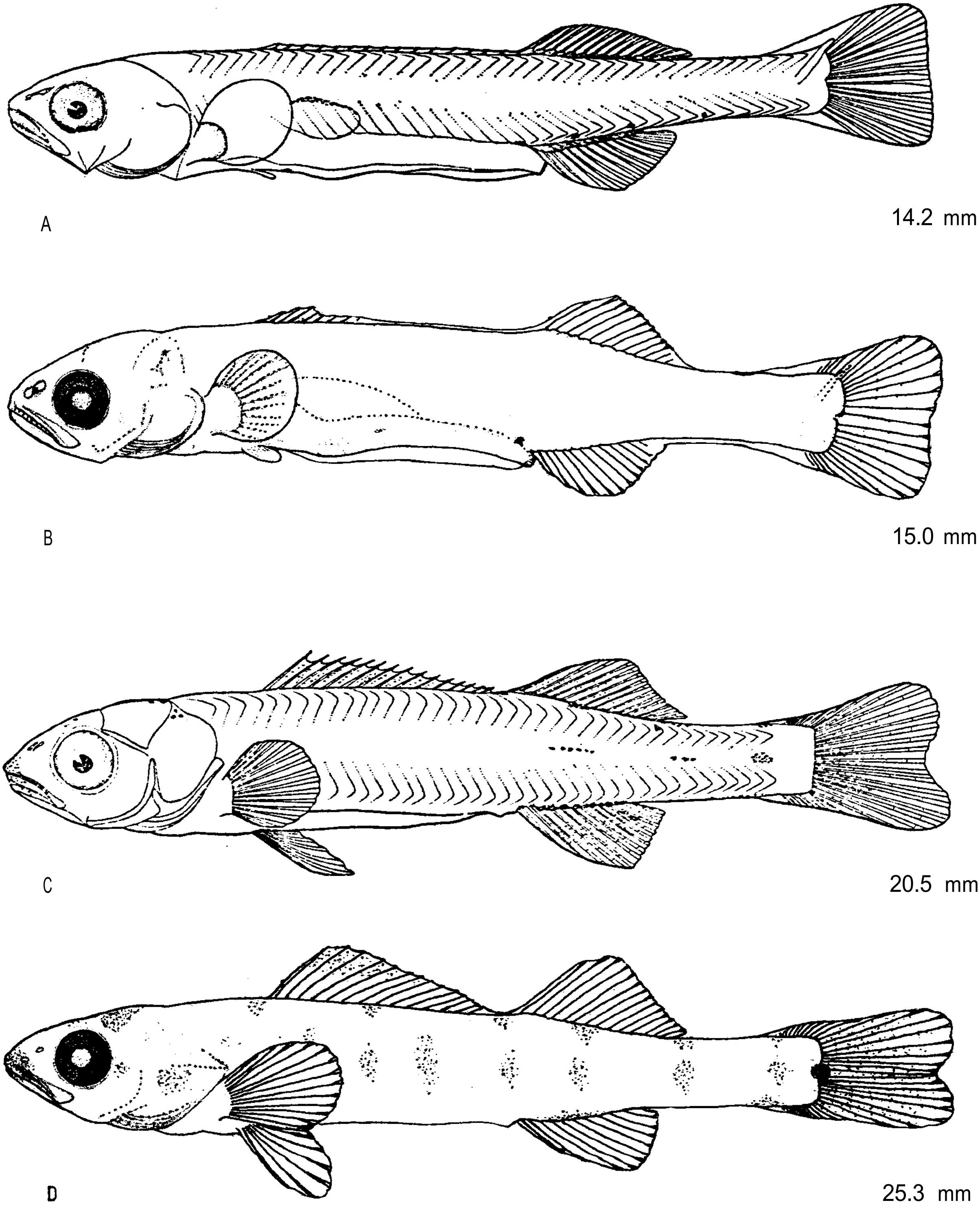


Fig. 263. Percina caprodes, logperch. A and B. Larvae. C and D. Juveniles. (A and C, wild-caught, Lake Erie, Fish 1932; B and D, wild-caught and laboratory-reared, Oklahoma, Taber 1969).

Percina copelandi (Jordan), channel darter

A description and illustration of a 6.1-mm p. copelandi given by Fish (1932) are thought to be based on a misidentified larva. The coiled gut and myomere counts are not characteristic of the percids.

DISTRIBUTION

From the eastern margin of the lower peninsula of Michigan throughout Lakes Huron and Erie and their drainages.' Occurs in lakes and lower portions of main tributaries,[14] to depths of 9 m in Lake Huron.[1]

SPAWNING SEASON

Spawns during the spring in the Great Lakes region,[2] specifically during July in Michigan.[4 6]

SPAWNING TEMPERATURE

In Michigan spawning occurs at 20.6 to 22.2 C.[4]

SPAWNING HABITAT

Spawns in streams possessing sand, gravel and rock bottoms with swiftly moving water 0.5 to 1.5 m deep.[4]

SPAWNING SUBSTRATE

Eggs are laid in gravel usually behind large rocks [4 5 6] and the male guards a large territory.[6]

FECUNDITY

357 to 415;' [6] 4 to 10 eggs laid at one time.[4 6] A female spawns once to several times.[6]

EGGS

Demersal, adhesive, transparent, diameter 1.4 mm, oil globule orange.[4]

YOLK-SAC LARVAE

Not descr ibed.

LARVAE

Not descr ibed.

JUVENILES

Total length	Description
43 mm	Morphometry: (as % TL) standard length 83, preanal length 52, greatest body depth 14, predorsal length 27, head length 20, (as % head length) snout 29, eye diameter 31.3 Morphology: single row of enlarged, thickened, spinous scales on midline of belly.’ Pigmentation: dorsum checkered with dark markings, vertical brown patches along lateral line form interrupted lateral band, dark pigmentation extends from eye to snout, few chromatophores on fins, a dark patch at base of caudal fin and one just anterior to spiny dorsal fin.”

ADULTS

Fin rays: caudal 17;* dorsal XI-12 to 14, anal II,9 to 10;[2,3] pectoral 13, pelvic I,5.'

Vertebrae: 37 to 38,[2] 38 to 40.[7]

Lateral line scales: 43 to 51.[2]

Diagnostic characters: midline of belly with single series of enlarged scales, premaxillae protractile, separated by deep groove from snout.

LITERATURE CITED

1. Hubbs and Lagler (1958)
2. Scott and Crossman (1973)
3. Fish (1932)
4. Winn (1953)
5. Winn (1958b)
6. Winn (1958a)
7. Bailey and Gosline (1955)

Percina maculata (Girard), blackside darter

DISTRIBUTION

Throughout the Great Lakes basin except Lake Superior and middle to eastern Lake Ontario.[2,3] Occurs in slow-moving streams, rarely lakes of the Lake Michigan drainage, to the lower-most portion of the upper peninsula of Michigan.’

SPAWNING SEASON

In Michigan and throughout the Great Lakes region spawning occurs from early May to mid-June.[1,3,5,7] Migrates to spawning grounds during March and April.[6]

SPAWNING TEMPERATURE

Spawning has been observed at 16.5 C.[1,3,5]

SPAWNING HABITAT

Spawns in gravel-bottom pools or raceways, not riffles[3,7] in water 30 to 60 cm.[6]

SPAWNING SUBSTRATE

Spawns in sand and gravel depressions,’[5,7] undersides of rocks in streams, in rubble riffles.’ Male is slightly defensive around female during spawning act.[7]

FECUNDITY

630 to 860;[8] 1,000 to 1,758.[3,7] Eggs are laid singly in masses averaging 65 eggs.’

EGGS

Demersal, adhesive, spherical;[5] colorless;[3] diameter 2 mm;[3,5] incubation period: 142 hours or 6 days (in situ).[5]

YOLK-SAC LARVAE

Total length	Description
5.8 mm	Newly hatched.[5] Pigmentation: little pigmentation, a few melanophores on yolk sac, anal and postanal ventral regions, single melanophore on caudal fin close to body, four lines of pigment radiate from eye (3 weeks old), three posterior, one anterior, pigment also observed on venter.[5]

LARVAE

Not described.

JUVENILES

Total length	Description
41 mm	Morphometry: (as % TL) standard length 85, preanal length 52, greatest body depth 16, head length 22, (as % head length) eye diameter 6.4 Pigmentation: black streak of pigment on upper jaw, longitudinal streak from snout through eye to back of head, surface of head and interorbital space heavily pigmented, entire dorsum covered with chromatophores which outline scale development, five large and two small patches of pigment on midlateral aspect, dorsolateral scales irregularly outlined with pigment, a series of melanophores along and just posterior to margin of anal fin.

ADULTS

Fin rays: caudal 17;* dorsal XIII to XIV (XII to XV)-13 to 14 (11 to 15), anal 11,10 to 11 (9 to 13), pectoral 13 to 14, pelvic I,5.[3]

Vertebrae: 41 to 42;[3] 42 to 44.[10]

Lateral line scales: 56 to 67;[3] 60 to 85;[2] 65 to 75.[9]

Diagnostic characters: midline of belly with single series of enlarged scales, premaxillae bound to snout by fleshy frenum, scales in lateral line usually 60 to 85, 8 to 10 dorsal "saddle" marks, 6 to 10 lateral patches, dark spot on caudal peduncle, gill covers not connected at isthmus.

LITERATURE CITED

1. Becker (1976)
2. Hubbs and Lagler (1958)
   Scott and Crossman (1973)
2. Fish (1932)
5. Petravicz (1938)
6. Winn (1958b)
7. Winn (1958a)
8. Thomas (1970)
9. Smith (1979)
10. Bailey and Gosline (1955)

Percina phoxocephala (Nelson), slenderhead darter

DISTRIBUTION

In the Great Lakes basin occurs only in the Fox River system of Wisconsin preferring riffle areas over sand or fine gravel.[1,2]

SPAWNING SEASON

Breeding coloration intensifies during April and spawning occurs from early to mid-June in central Illinois.[4]

SPAWNING TEMPERATURE

Spawning has been observed at 21.1 C.[1]

SPAWNING HABITAT

Spawns in swiftly flowing water 15 to 60 cm deep.[4]

SPAWNING SUBSTRATE

Deposits eggs among gravel.[4]

FECUNDITY

83 to 270 (50 to 720).4

EGGS

Transparent;' diameter 1.2 mm (water hardened, unfertilized);[S] oil globule large and single.[4]

YOLK-SAC LARVAE

Not described.

LARVAE

Not described.

JUVENILES

Fully scaled (33 mm).[4]

ADULTS

Fin rays: caudal 16 to 17;" dorsal X (IX to XI)-13 to 15, anal II,11 (10 to 12), pectoral 13 to 14, pelvic I,5.[3]

Vertebrae: 37 to 39;[3] 38 to 40.[7]

Lateral line scales: 49 to 57;[3] 60 to 70.[6]

Diagnostic characters: midline of belly with single series of enlarged scales, premaxillae not protractile, bound to snout by fleshy frenum, lateral line scales usually less than 60 to 85, gill membranes broadly connected, brown dorsal "saddle" marks" separate from 10 to 12 lateral greenish blotches, dark spot on caudal peduncle.

LITERATURE CITED

1. Becker (1976)
2. Hubbs and Lagler (1958)
3. Scott and Crossman (1973)
4. Page and Smith (1971)
5. Hubbs (1967)
6. Smith (1979)
7. Bailey and Gosline (1955)

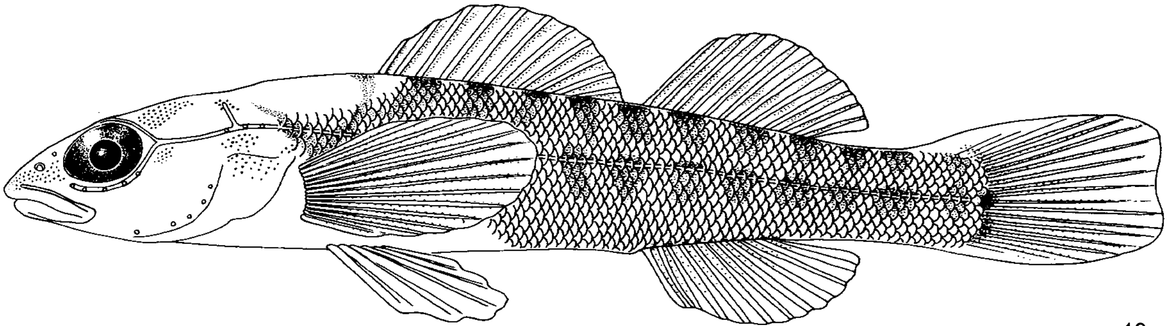


Fig. 264. Percina phoxocephala, slenderhead darter. Juvenile. (Wild-caught, Illinois, Page and Smith 1971).

Stizostedion canadense (Smith), sauger

A description and illustration of a 14.6-mm S. canadense given by Fish (1932) are believed to be based on a misidentified Percina caprodes.

DISTRIBUTION

Known from the lower Wolf and Fox Rivers in Wisconsin and the Menominee and Muskegon Rivers of Michigan.’ Abundant in Lake Erie and Saginaw Bay, Lake Huron, less common elsewhere in the Great Lakes region.[2]

SPAWNING SEASON

Spawning takes place from late April to early May in the Lake Michigan basin, Wisconsin and South Dakota,[1 5 17] late May to early June in Canada[3] and June in Minnesota.” In North Dakota spawning extends from late April to the end of June; however, peak spawning occurs from early to mid-May.[11]

SPAWNING TEMPERATURE

Spawning occurs at 3.9 to 6.1 C;[3 17] 6.1 to 11.1 C;[1 5] 3.9 to 11.7 C.[11]

SPAWNING HABITAT

Spawns in shallow, 0.6 to 3.7 m, sand and gravel shoals or bars in turbid lakes or streams.’[3 4 5]

SPAWNING SUBSTRATE

Spawns on sand, gravel, rubble shoals, bars or shorelines.[1 3 4 5]

FECUNDITY

9,360 to 152,110;[3 11 12 13 14] averages 15,871 (4,208 to 43,396).[5]

NATURAL HYBRIDS

Stizostedion vitreum.[16]

EGGS

Demersal, adhesive after water hardening;[10 17] or semibuoyant and nonadhesive after water hardening;[5] diameter 1.7 mm (1.4 to 1.9 mm);[7] 1.3 mm (1.0 to 1.5 mm);[5] 1.8 mm.[8]

Incubation period:

Temperature C	Days to Hatch
4.5-12.8	25-29[3]
6.0	37-58[9]
8.3	18-21[10 17]
8.9	22-35[9]

10.0	12-18[1]
11.1	13-15[5]
10.0-12.2	9-14[8]
12.0	12-219
12.8	9-13[7]
15.0	8-139
18.1	7-10[9]
20.9	5-89

YOLK-SAC LARVAE

Total length	Description
4-10 mm	Newly hatched (4.5 to 5.8 mm).[3,5,7,9] Myomeres: (16 to 21 + 21 to 26), mean 41.8 (18.7 + 23.1).[7] Morphometry: (as % TL) standard length 98;[4] preanal length 47;[4] 49 to 51;' head length 20;[4] 12 to 18;' greatest body depth 16;[4] 16 to 27;[7] body depth at anus 7;[4] eye diameter 5;[4] 6 to 8.[7] Morphology: notochord straight, finfold complete starting at myomeres two to five, pectoral buds present, single oil globule at anterior of oval yolk sac, sac 0.8 to 2.2 mm deep and 1.6 to 2.8 mm long.[7] Pigmentation: single, large chromatophore on venter about half way from pectoral fin base to anus, a few chromatophores on dorsum of swim bladder;[4] a few chromatophores on yolk sac;[5,7] increasing and concentrating along venter of yolk sac with one to three along postanal venter.'

LARVAE

Total length	Description
10-15 mm	Myomeres: (19 to 22 + 21 to 24), mean usually 42.7 (20.8 + 22.6).[7] Morphometry: (as % TL) preanal length 50 to 53;' greatest body depth 14 to 19, body depth at anus 11;[4] head length 21 to 29;[4,7] eye diameter 5 to 7.[4] Morphology: yolk absorbed, actinotrichia of dorsal and anal fins present, urostyle beginning to turn upward, caudal fin rays present, anus opening at edge of finfold (13.0 mm);[4] caudal fin rays begin to ossify (10 to 11 mm), anal, dorsal and pectoral fin rays start to ossify (13 mm), pelvic fins ossify (15 mm).[7] Pigmentation: a few chromatophores on venter of myomeres, increasing in concentration with growth, one to four chromatophores per myomere along lateral line, dentary, maxilla and occipital region pigmented, pigment first appears on caudal and anal fins (13 mm);[7] single chromatophore on dorsum of intestine at anus, double row of about 25 small pigment spots (12 around anal

fin) from anus to caudal fin, some chromatophores in the thoracic region and on the posterior portion of the lateral line.[4]

27 mm — Morphometry: (as % TL) standard length 97, preanal length 51, greatest body depth 15, body depth at anus 12, predorsal length 30, head length 29, snout length 7, eye diameter 7.[4]

Pigmentation: chromatophores present on tips of both jaws, top of head, behind eye and on operculum, double row of chromatophores on dorsum, most intense near base of dorsal fins, double row near anal fin base followed by single row to caudal fin, a few chromatophores on caudal peduncle, caudal fin base and on posterior portion of lateral line.[4]

JUVENILES

Total length	Description
39 mm	Morphometry: (as % TL) standard length 85, preanal length 51, greatest body depth 16, body depth at anus 13, predorsal length 31, head length 27, snout length 12, eye diameter 7.[4] Morphology: body slender, head pointed, maxilla reaches posterior margin of pupil, dorsal fins separate.[4] Pigmentation: chromatophores over entire body, most numerous on jaws and top of head, larger chromatophores occur at base of each median fin and along lateral line posterior to dorsal fins, caudal fin is only fin with many chromatophores;[4] melanophores absent on dorsum of head in area of parietal bones, outline of mesencephalon and metencephalon visible through parietal bones, in _S. canadense_ this area is pale, in _S. vitreum_ it appears black.[6]

ADULTS

Fin rays: caudal 17;* dorsal XIII to XV-I,16 to 21, anal II,11 to 14, pectoral 12 to 14, pelvic I,5.[3]

Vertebrae: 43 to 45;[3] 44 to 45.[15]

Lateral line scales: 88 to 95 (82 to 100).[3]

Pyloric caeca: 5 to 6.[6]

Diagnostic characters: lateral aspect with oblique blotches of pigment, several rows of dark spots on dorsal and caudal fins, black spot at base of pectoral fin, tip of anal fin white, anal fin II,12 to 13, preopercle strongly serrate, enlarged canine teeth, 5 to 8 pyloric caeca.

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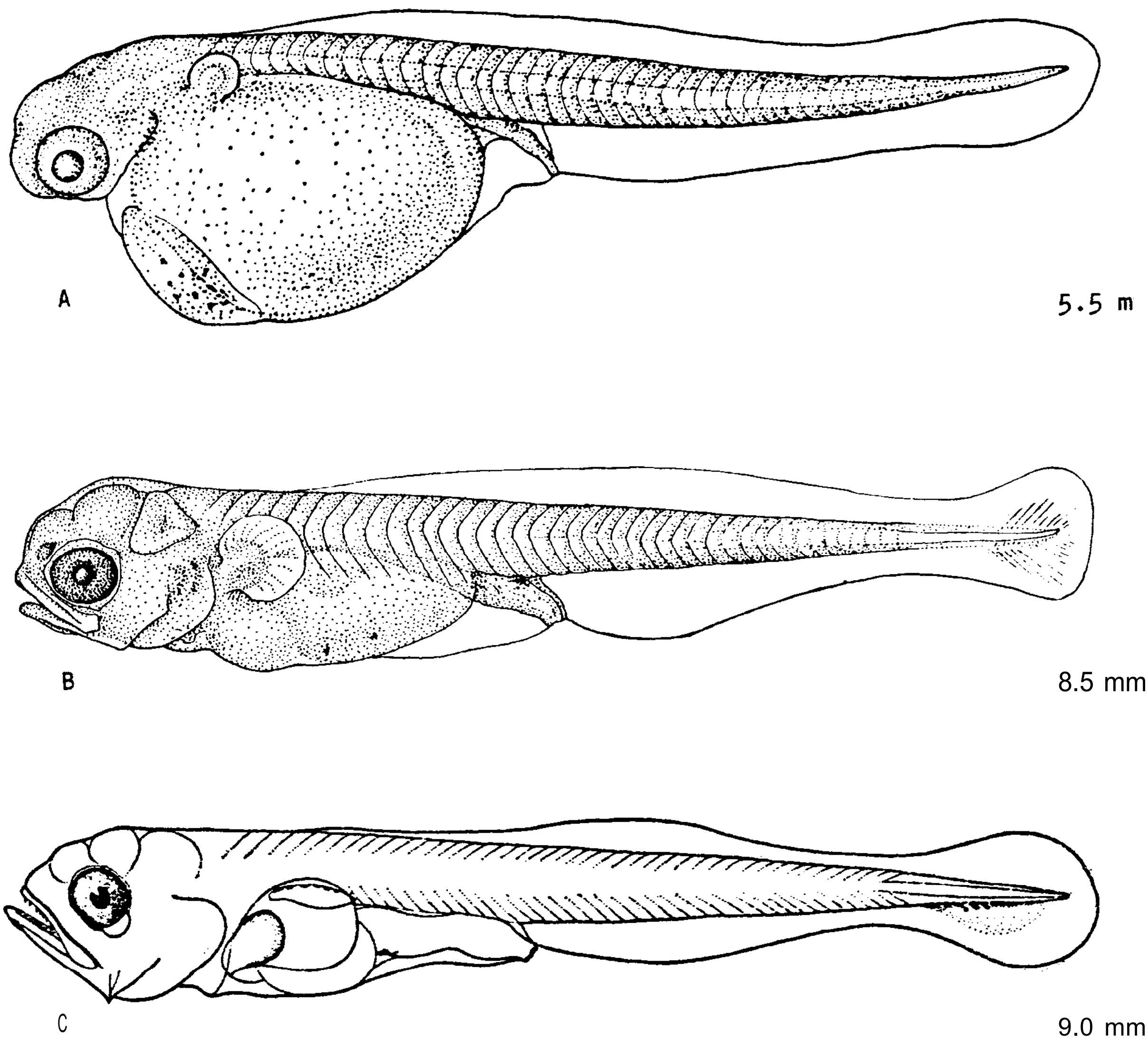

Fig. 265. Stizostedion canadense, sauger. A-C. Yolk-sac larvae. (A and B, laboratory-reared, South Dakota, W. R. Nelson 1968a; C, wild-caught, Lake Erie, Fish 1932).

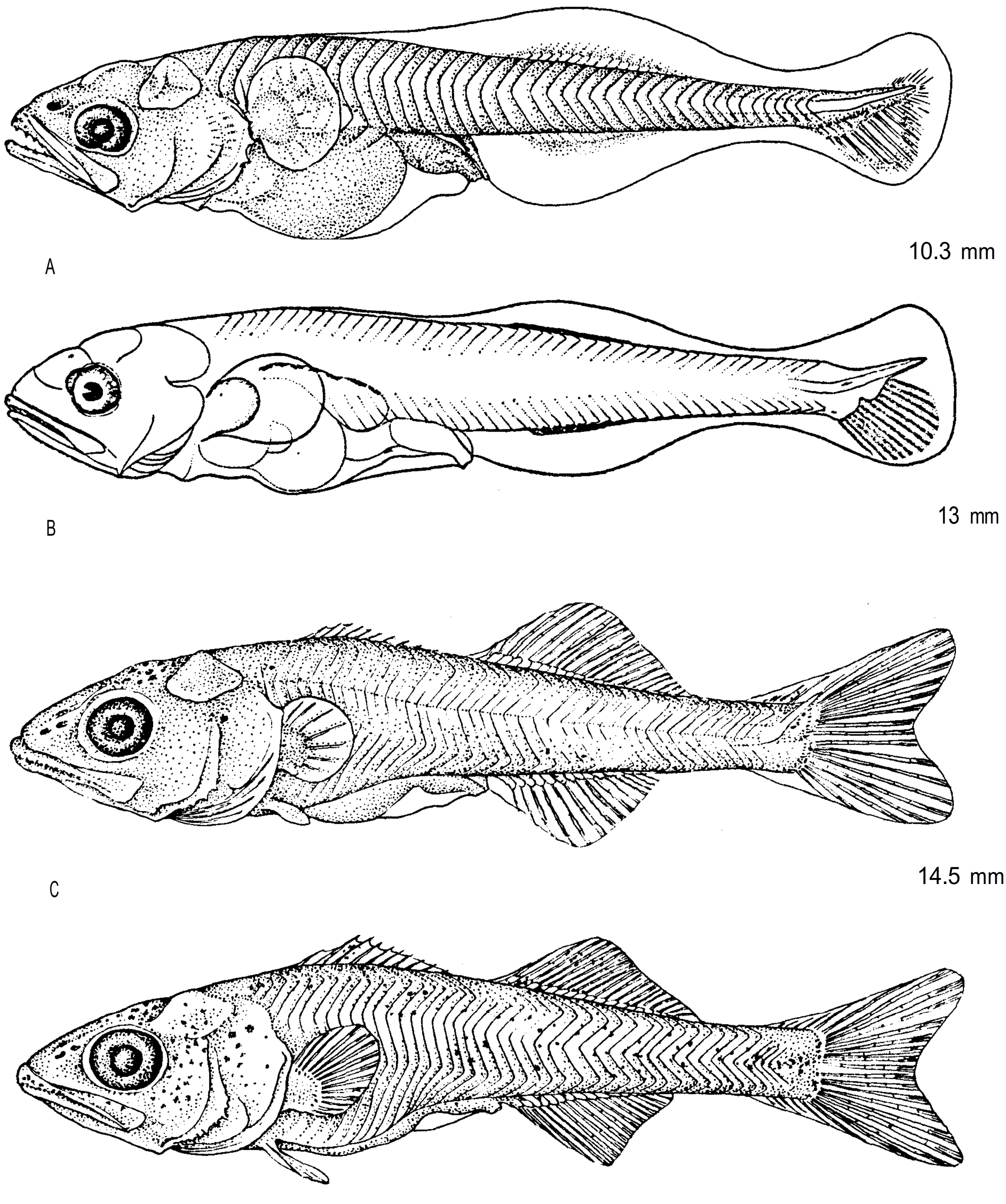

Fig. 266. Stizostedion canadense, sauger. A-C. Larvae. D. Juvenile. A, C and D, laboratory-reared, South Dakota, W. R. Nelson 1968a; B, wild-caught, Lake Erie, Fish 1932).

Stizostedion vitreum (Mitchill), walleye

S. vitreum has been assigned two subspecies, walleye S. v. vitreum and blue pike S. v. glaucum (Robins et al. 1980). However, since S. v. glaucum is believed to have been extinct since 1971, we shall refer to the walleye as S. vitreum.

DISTRIBUTION

Scattered throughout the Great Lakes basin.[1 2] Once common in major bays and inshore areas of the Great Lakes but has declined in abundance in all areas except northwestern Lake Huron, Georgian Bay, Lake St. Clair, southern Lake Huron and eastern Lake Erie.[10]

SPAWNING SEASON

Spawning takes place from April through May,[3 5 6 11 12 13 15 26 28] just after ice-out,[6 11 13] in Michigan, Wisconsin and southern Canada.

SPAWNING TEMPERATURE

Spawning occurs at temperatures between 3.3 and 14.4 C.[6 11 13 15 23 26 28] Start to congregate and migrate at 3.3 C,[15] 3.9 C[6] or just after ice-out.[5 11 12] Begin spawning at 4.4 to 5.6 C[15] and most actively spawn at 7.7 to 10.0 C,[15] 7.8 to 8.9 C[6] or 5.6 to 7.8 C.[12]

SPAWNING HABITAT

Selects moving water and clean substrate,[1 11 26] rocky areas in white water,[3] shoals and shorelines of lakes and streams[6 11 12] in water 5 cm to 3 m[5] or 0.6 to 1.5 m.[11 12]

SPAWNING SUBSTRATE

Eggs are broadcast over large, unguarded areas of coarse gravel to boulder and rock substrate,[1 5 11 17 26] or sand and fine gravel,[6] at night.[12]

FECUNDITY

23,000 to 227,181;[1 3 5 6 11 12 22 23 39] average 50,000 to 60,000.[31]

NATURAL HYBRIDS

Stizostedion canadense.[19]

EGGS

Demersal, adhesive prior to water hardening;[6 7 11] translucent and pinkish;[28] diameter 1.5 to 2.1 mm;[5 8 28] 2.1 mm (1.9 to 2.3 mm);[24] oil globule single;[5] diameter 0.67 mm (0.60 to 0.77 mm).[7]

incubation period:

Temperature C	Days to &	Days to Hatch
2.2-18.9	7[12]	10-20[12]
		26[11]
5.6-15.6	15-16[30]	25-29[30]
6.0		30-49[20]
7.2-10.3	13[5]	24.5[5]
8.3		20-24[17]
8.9		23-31[20]
10.5-11.1	16	12-18[17]
10.0-12.2	8[16]	13[16]
10.0		18[18]
10.0-12.8		21[11]
12.0		12-18[25]
12.8	7[27]	10,[27] 14-18[24]
13.9		7[11 23]
14.4	6[27]	10[27]
15.0		9 (6-11)[26] 8-11[20]
16.0	5[a7]	8[27]
17.0	4[27]	8.5[27]
18.1		6-8[20]
19.4	3.5[27]	6[27]
20.9		5-6[20]

YOLK-SAC LARVAE

Total length	Description
5.8-8.7 mm	Newly hatched;[5 7 8 12 18 21 24 26] or 4.8 mm,[23] 12.7[11] Myomeres: 45 (20 to 21 + 24 to 25).[26] Morphology: preanal length 46 to 49% TL.[26]
6-10 mm	Myomeres: (18 to 22 + 20 to 28), mean 45.5 (lg.7 + 25.8);[24] 41 to 48 (16 to 20 + 25 to 28), usually 44 (18 + 26);[7 25] 49 to 51 (28 to 30 postanal).[26] Morphometry: yolk-sac depth 0.63 to 1.25 mm;[24] 0.8 to 1.3 mm;[25] yolk-sac length 2.13 to 2.88 mm;[24] 2.1 to 2.6 mm.[25] Preanal length (3.5 to 4.5 mm) less than postanal length (3.6 to 5.5 mm) at 7.4 to 9.6 mm;[25] (as % TL) preanal length 47 to 48;[4 26] greatest body depth 19, eye diameter 6 (7.75 mm).[4] Morphology: notochord straight;[24 25] finfold continuous, dorsal origin between myomeres two and five[24] or three and six, anus bends abruptly downward;[25] pectoral buds present;[4 24 25] single, clear, round oil globule at anterior portion of yolk sac.[24 25] Pigmentation: eye pigmented;' chromatophores on yolk sac and postanal venter, later developing into a continuous chain of interlocking stellate chromatophores, one to five chromatophores present over notochord;[8 24] large stellate chromatophores over heart and oil globule;[4] two to four chromatophores on intestine between anus

and yolk sac, a few possibly present in lower jaw, one to two chromatophores per myomere:[25] a few chromatophores on dorsum near caudal fin.[4,25]

LARVAE

Total length	Description
1O-20 mm	Myomeres: 45.6 23.2 (21.2 to 25.0) + 22.5 (20.9 to 25.0)];[24] 38 to 53 (16 to 24 + 22 to 29), usually 45 (19 + 26) .[17,25] Morphometry: (as % TL) standard length 94;[4] preanal length 52 to 58;[4,7,24] greatest body depth 20, body depth at anus 22;[4] head length 21 to 28;[4,24] snout length 79;[4] eye diameter 6 at 12.5 mm.[4] Morphology: yolk absorbed (9.5 to 10.5 mm,[7,8,19,21] 3 to 5 days posthatching;[12] 9.0 to 9.7 mm at 15 days postfertilization[26]); large swim bladder present;[4] small canine teeth develop[4] (10.5 mm), maxilla extends to posterior edge of pupil, finfolds absorbed (13.0 mm) ;[25] caudal fin rays begin to ossify in ventral half (10 to 11 mm) ;[24,25] anal, spinous dorsal and pectoral fin rays begin to ossify (13 to 14 mm,[24] 15 to 16 mm[25]); pelvic fin rays ossify (16 to 17 mm) ;[24,25] opercle, preopercle, frontal bones and vertebrae begin to ossify (12 to 13 mm) .[25] Pigmentation: one to three chromatophores present on venter of each myomere;’[24,25] some on lateral line and on dentary, maxilla and occipital, becoming more intense with development;[24] double row of chromatophores on dorsum, one row dorsal to notochord with one to four chromatophores per myomere, second row along middorsum with one to two chromatophores per segment;[25] or single row present becoming double around dorsal fin;’ pigmentation on lateral line consisting of one to four chromatophores per myomere located subdermally with and just below notochord;[25] or irregular series of pigmentation on lateral line with myomeres above and below marked with irregular black lines;[4] chromatophores over swim bladder, decreasing along gut to anus;[4,24] stellate chromatophores on head, cheeks, tip of both jaws, base of pectoral fin and in region of heart.[25]

JUVENILES

Total length	Description
18-30 mm	Myomeres: 38 to 53 (16 to 24 + 22 to 29), usually 45 (19 + 26) .[7]

Morphometry: (as % TL) standard length 81, preanal length 53, greatest body depth 18, body depth at anus 13, predorsal length 31, length to second dorsal fin 53, head length 28, snout length 6, eye diameter 6, maxilla length 13.[4]

Morphology: full complement of pelvic and anal fin rays (15.0 mm);[7] full complement of all fin rays (18.0 mm,[24] 20 to 30 mm[7]) ; scales appear (24 mm), gradually increasing from caudal peduncle along lateral line, fully scaled (45 mm).[14]

Pigmentation: chromatophores present on surface of head, in seven patches or bars across dorsum. extending short distance down each side, oblique bands begin in interspaces, cross lateral line and extend midway to venter, venter unpigmented except from anal fin origin to caudal fin, dorsal and caudal fins show pigmentation, a little present at base of pectoral fins, other fins colorless;[4] chromatophores on dorsum of head in area of parietal bones, outlining mesencephalon and metecephalon.[9]

ADULTS

Fin rays: caudal 17;* dorsal XII to XVI-1,18 to 22;,[3] anal II,12 to 13 (11 to 14);[3 5] pectoral 14 (13 to 16);[3 5] pelvic I,5.[3]

Vertebrae: 44 to 48;[3] 46 to 47 (45 to 48).[32]

Lateral line scales: 83 to 104;[3] 86 to 92 (80 to 108).[5]

Pyloric caeca: 3 to 4.[9]

Diagnostic characters: lateral aspect finely vermiculate, 5 to 12 faint vertical bars, sometimes evident at young stages, black pigment spot in posterior membrane of first dorsal fin and at base of pectoral fin, tip of anal fin and lower lobe of caudal fin white, anal fin II,12 to 13, preopercle strongly serrate, enlarged canine teeth, three to four pyloric caeca, cloudy eye.

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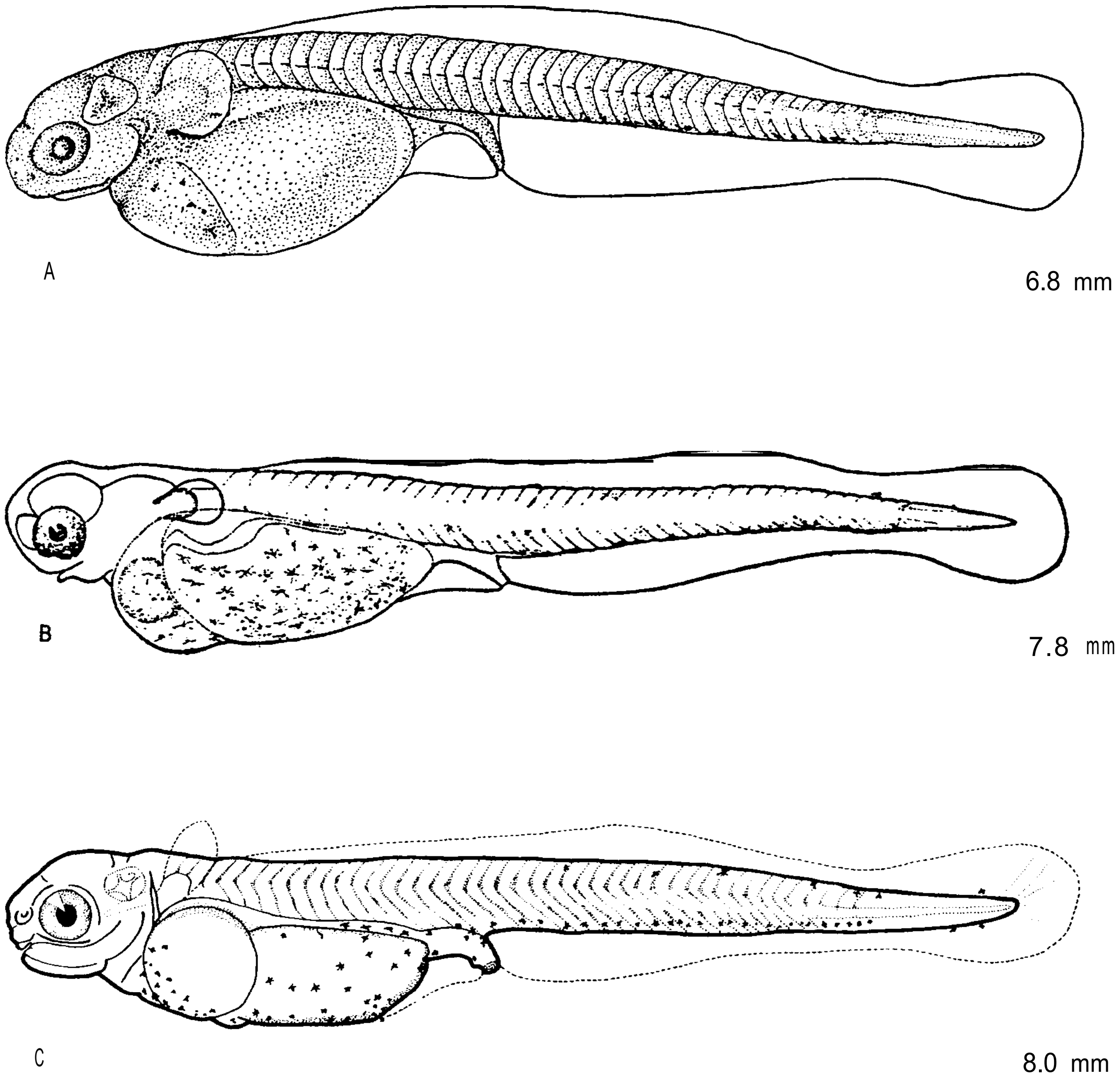

Fig. 267. Stizostedion vitreum, walleye. A-C. Yolk-sac larvae. (A, laboratory-reared, South Dakota, W. R. Nelson 1968a; B, wild-caught, Lake Erie, Fish 1832; C, wild-caught, Lake Erie, Norden 1961).

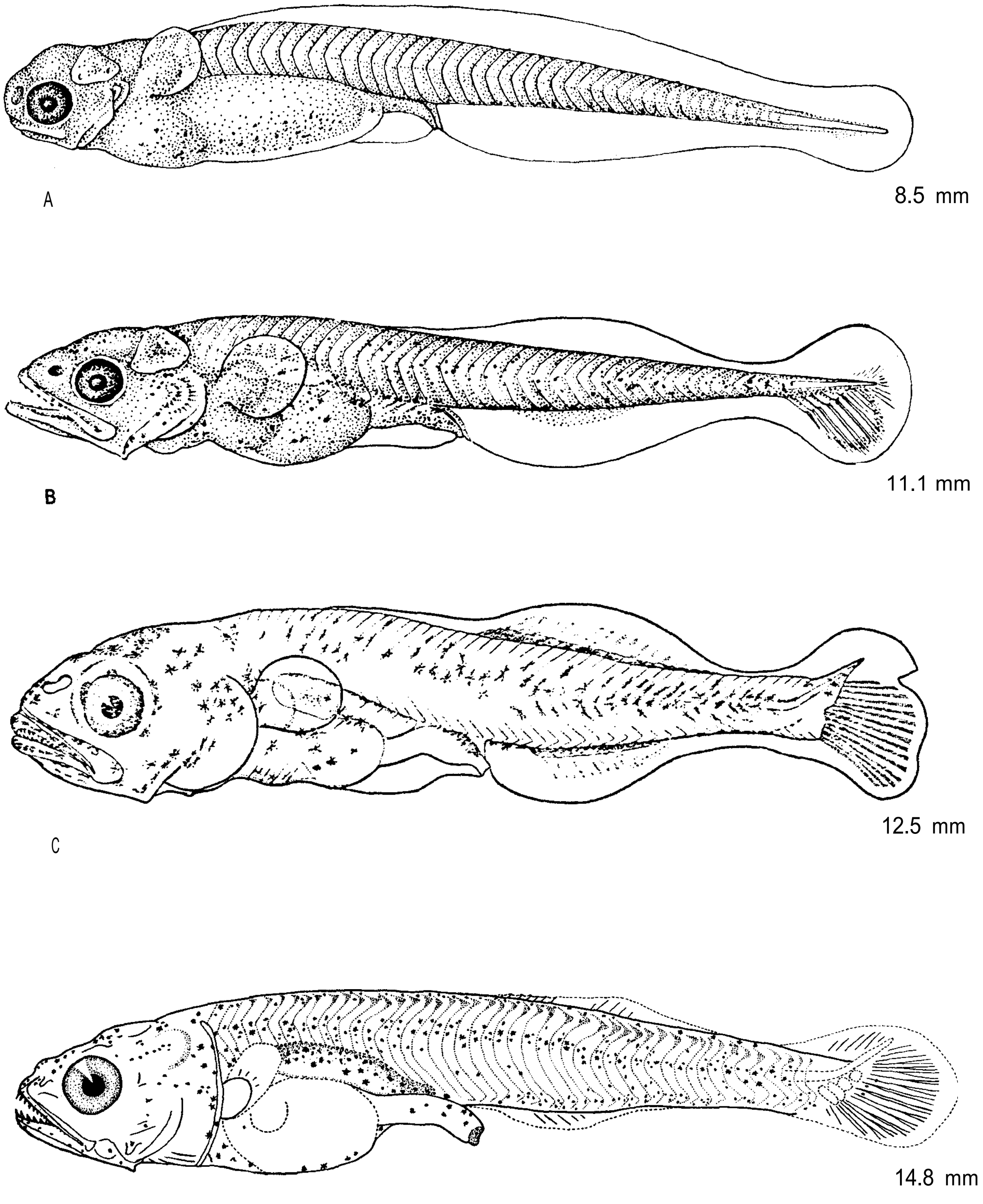

Fig. 268. Stizostedion vitreum, walleye. A. Yolk-sac larva. B-D, Larvae. (A and B, laboratory-reared, South Dakota, W. R. Nelson 1968a; C, wild-caught, Lake Erie, Fish 1932; D, wild-caught, Lake Michigan, Norden 1961).

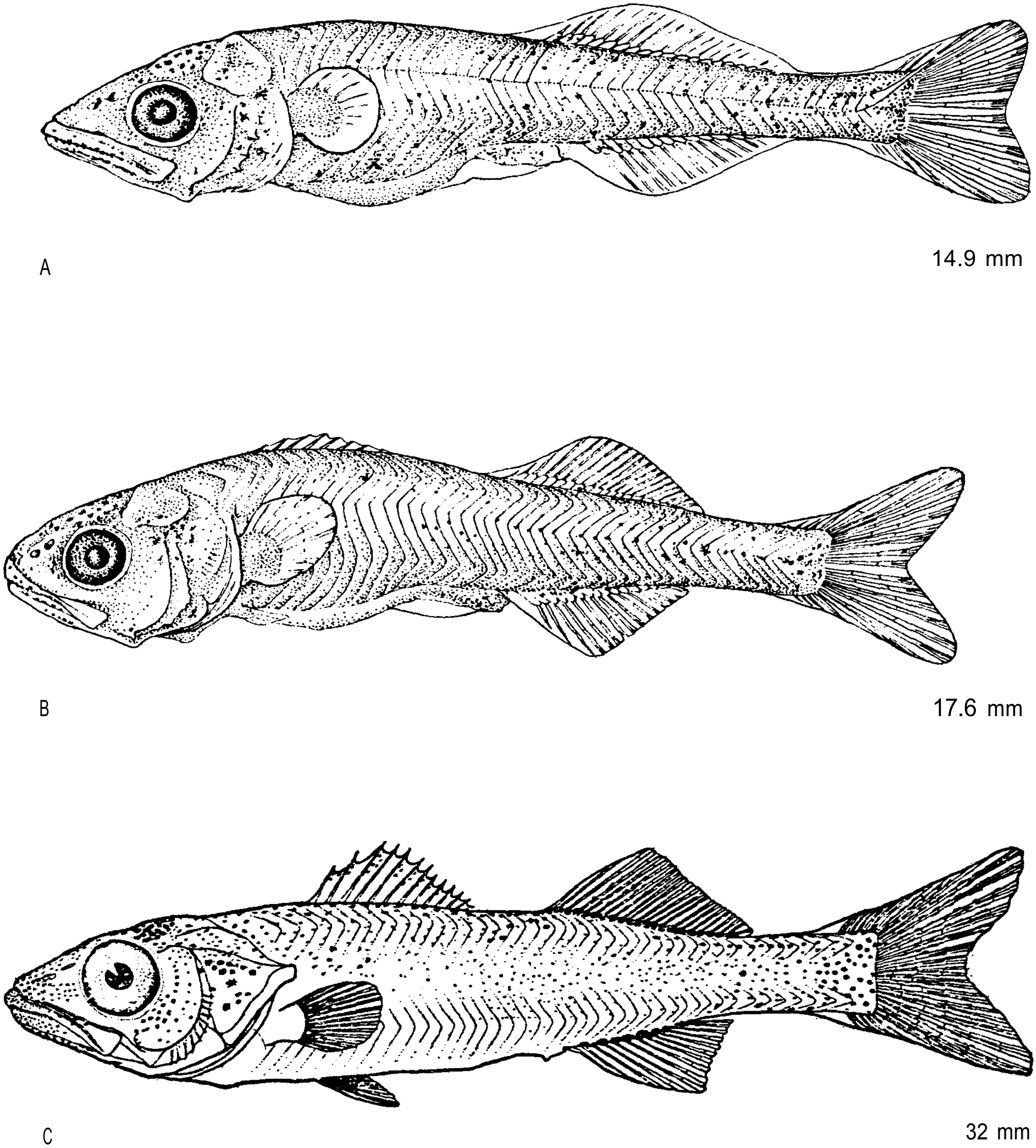

Fig. 269. Stizostedion vitreum, walleye. A and B. Larvae. C. Juvenile. (A and B, laboratory-reared, South Dakota, W. R. Nelson 1968a; C, wild-caught, Lake Erie, Fish 1932).

Family Sciaenidae, drums

By

Lee A. Fuiman

Sciaenids are primarily marine fishes of tropical and temperate waters; few species occur in freshwater. There are about 160 species and 28 genera worldwide. They are typical advanced bony fishes with spinous and soft-rayed dorsal fins, one or two spines in the anal fin and one spine with five soft rays in the thoracic, pelvic fins. The lateral line extends to the end of the caudal fin. Pharyngeal teeth are often modified for crushing prey, such as molluscs. The common name stems from the sounds produced by members of this family. These sounds are made quite audible through the use of the enlarged swim bladder as a resonator.

A single species, Aplodinotus grunniens (freshwater drum), occurs in the Great Lakes. It spawns during the summer. Eggs are pelagic, unlike most other freshwater species of the region (except Clupeids and perhaps Hiodon tergisus). Larvae hatch at a small size and differ from other forms encountered in the lakes in that they have quite a large mouth relative to their body size and are known to be piscivorous (Clark and Pearson 1979).

The freshwater drum has an interesting report history. Scott and Crossman (1973) discuss evidence of this species attaining great dimensions (as much as 441 kg) . Recently caught specimens rarely have been over 44 kg. Stocks in the Great Lakes still support a commercial fishery.

Aplodinotus grunniens Rafinesque, freshwater drum

DISTRIBUTION

This species occurs in all of the Great Lakes, except Superior.[10 15] The freshwater drum is found in the lower two-thirds of Lake Michigan, including the lower portions of many tributaries."

SPAWNING SEASON

Spawning occurs from April through early June in Wisconsin.[2 12 13] A protracted season has been reported for a population in Lake Erie.14

SPAWNING TEMPERATURE

Spawns at water temperatures from 18 to 25 C.[3 * 12 13]

SPAWNING HABITAT

Spawns in open water at or near the surface.[12]

SPAWNING SUBSTRATE

Spawns over gravel and sand.'

FECUNDITY

34.0003 to 850,000.[8 14]

EGGS

Demersal;[2 13] semibuoyant[1 3] or pelagic;[5 12] adhesive;[2] or nonadhesive;[1] diameter ca. 1 mm;[12] (1.2 to 1.7 mm[3 5]); yolk diameter 0.9 to 1.1 mm;[5] oil globule single;[3 5 7] sometimes with additional smaller globules, located centrally in yolk sac, diameter 0.6 to 0.7 mm, antero-dorsum of oil globule with darkly pigmented chromatophores;[5] incubation period: 36 hours at 21 C;[3] 25 to 30 hours at 22 C;[5] 27[3] to 30[4] hours at 23 C; 22 hours at 25 C.[3]

YOLK-SAC LARVAE

Total length	Description
3.2-4.2 mm	Newly hatched.[3 5] Morphology: oil globule posterior in yolk sac;[3 5 7 17] pectoral buds present, head flexed over yolk sac.[3] Pigmentation: eye not pigmented;' small chromatophores on yolk-sac dorsum and head.[3]
4 mm	Morphology: mouth parts developed (20 hours posthatching), head free from yolk, caudal fin rays forming (25 hours);[3] needle-like teeth on lower jaw.[9] Pigmentation: head and eye pigmentation more intense.[3]

LARVAE

Total length	Description
4-8 mm	Morphology: yolk absorbed (4.4 mm, 45 hours posthatching at 23 C;[3] or 6.0 to 8.8 mm SL[9]); gut functional (4.5 to 4.7 mm);[3] head and mouth large, trunk slender.’
8 mm	Myomeres: 25[14] (10 to 14 + g to 11) .[17] Morphometry: (as % TL) preanal length 48, head length 23 to 25, eye diameter 7 to 9, snout length 9 to 10, jaw length 11, pectoral fin length 7 to 8, (as % head length) eye diameter 28 to 37, snout length 38 to 39, jaw length 43, pectoral fin length 30 to 32.[14] Morphology: dorsal fin rays forming, notochord flexed, caudal fin rays present, teeth on maxillae and dentary, mouth terminal and oblique, swim bladder present (7.9 mm), anal and pectoral fin rays forming, teeth on premaxillae (8.1 mm) .[14] Pigmentation: few melanophores on dorsum of swim bladder, branchiostegal rays, ventral midline at pelvic girdle, anus and posterior to anus, eyes pigmented (7.9 mm) .[14]
11-17 mm	Morphometry: (as % TL) preanal length 53, head length 26, eye diameter 6, (as % head length) eye diameter 23.[6] Morphology: all median fin rays and spines present (11[14] to 13[6] mm) ; pectoral fin rays 15, pelvic fins I,4 (11 mm);[14] first scales formed (13.5” to 15[11] mm); paired fins complete (16.5 mm) .[14] Pigmentation: sparse pigmentation all over, melanophores on dorsum of head;‘ [14] and ventral midline posterior to anus (11 mm);[14] chromatophores around jaws;[6] [14] preopercle;[6] opercle, and dorso-laterally (anterior to dorsal fin) ; [14] dorsal and lateral pigment lacking, chromatophores in double series on anal fin base, single series posteriorly (14 mm) .[6]

JUVENILES

Total length	Description
15-22 mm	Morphology: fin development complete (15 mm) ;[3] mouth subterminal;” squamation complete (21 to 22 mm) .[11] [14]

ADULTS

Fin rays: caudal 17;* dorsal VIII-I,25 to 33, anal II,7, pectoral 17, pelvic I,5.[10]

Vertebrae: 24.[10]

Lateral line scales: 48 to 53.[10]

Diagnostic characters: lateral line pores extend onto caudal fin, anal spines two, second larger than first, pelvic fins thoracic, adipose fin absent.

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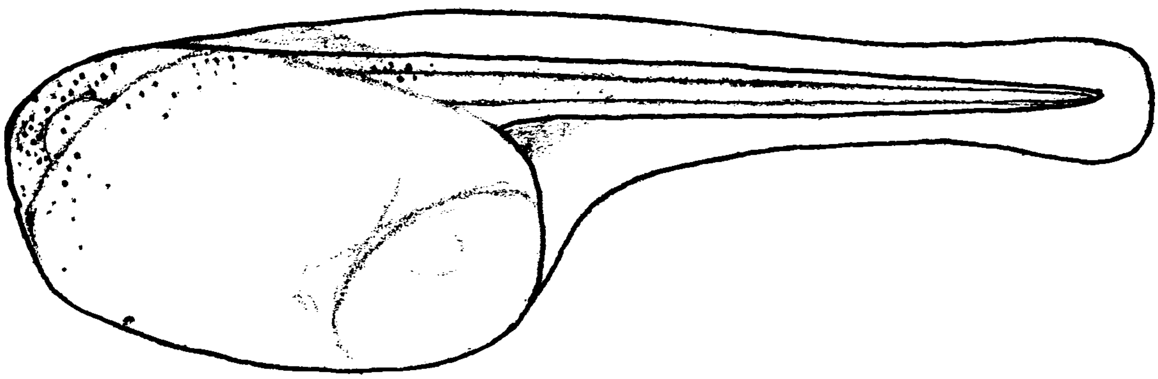
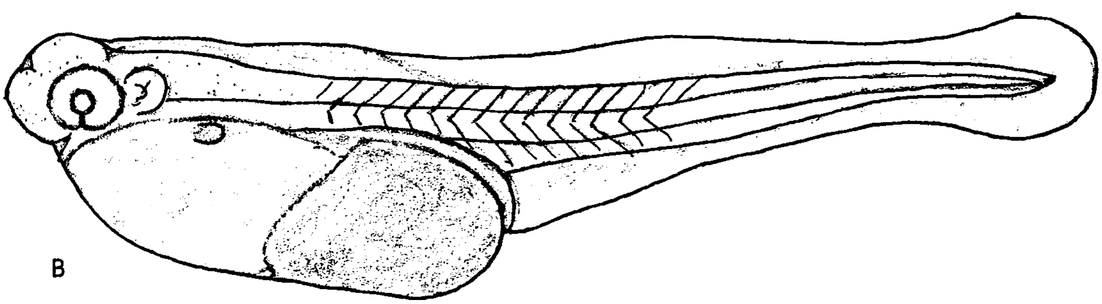


A

3.2 mm



B

4.4 mm

Fig. 270. Aplodinotus grunniens, freshwater drum. A and B. Yolk-sac larvae. (A and B, wild-caught, Oklahoma, Taber 1969).

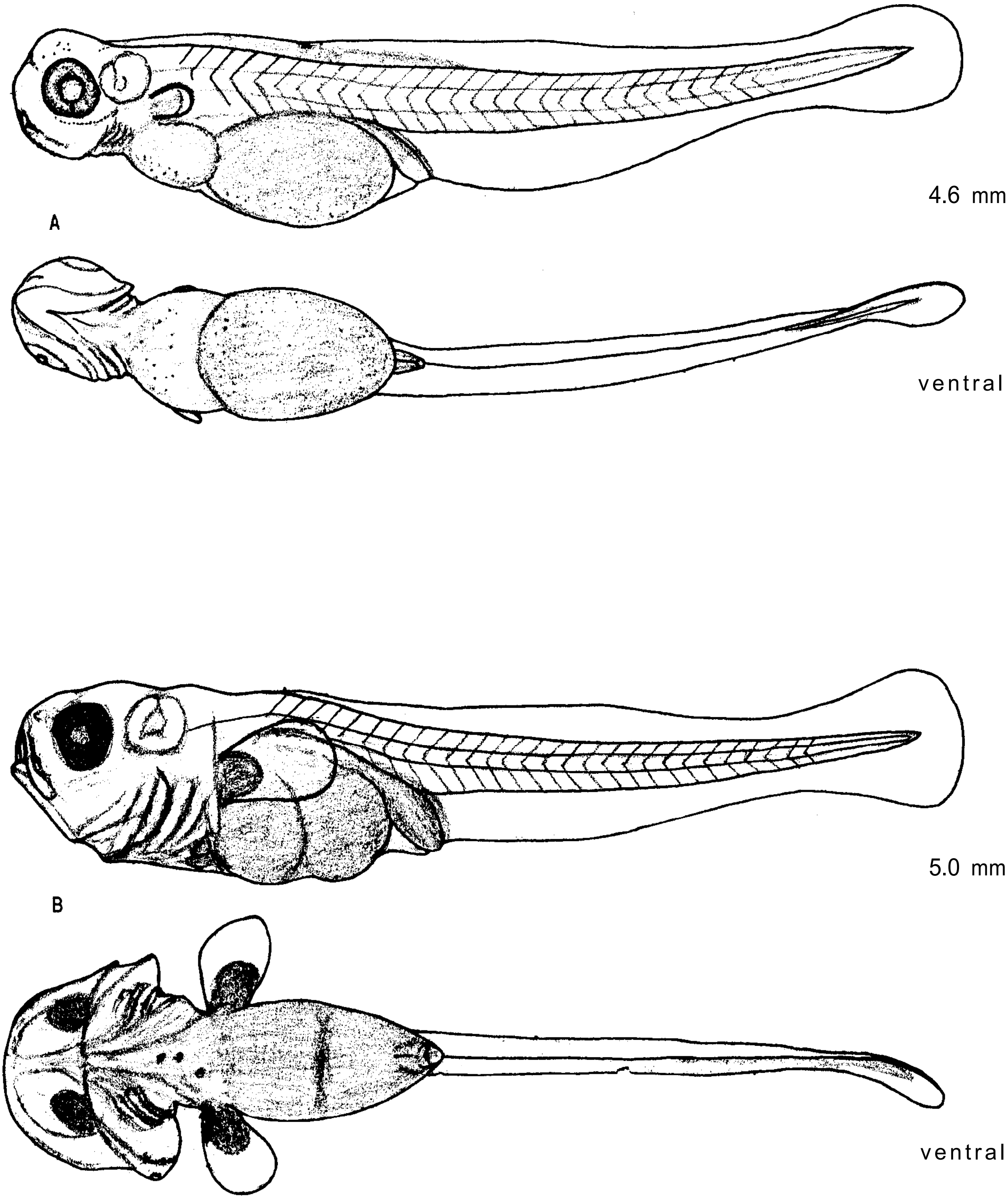


Fig. 271. Aplodinotus grunniens, freshwater drum. A. Yolk-sac larva. B. Larva. (A and B, wild-caught, Oklahoma, Taber 1969).

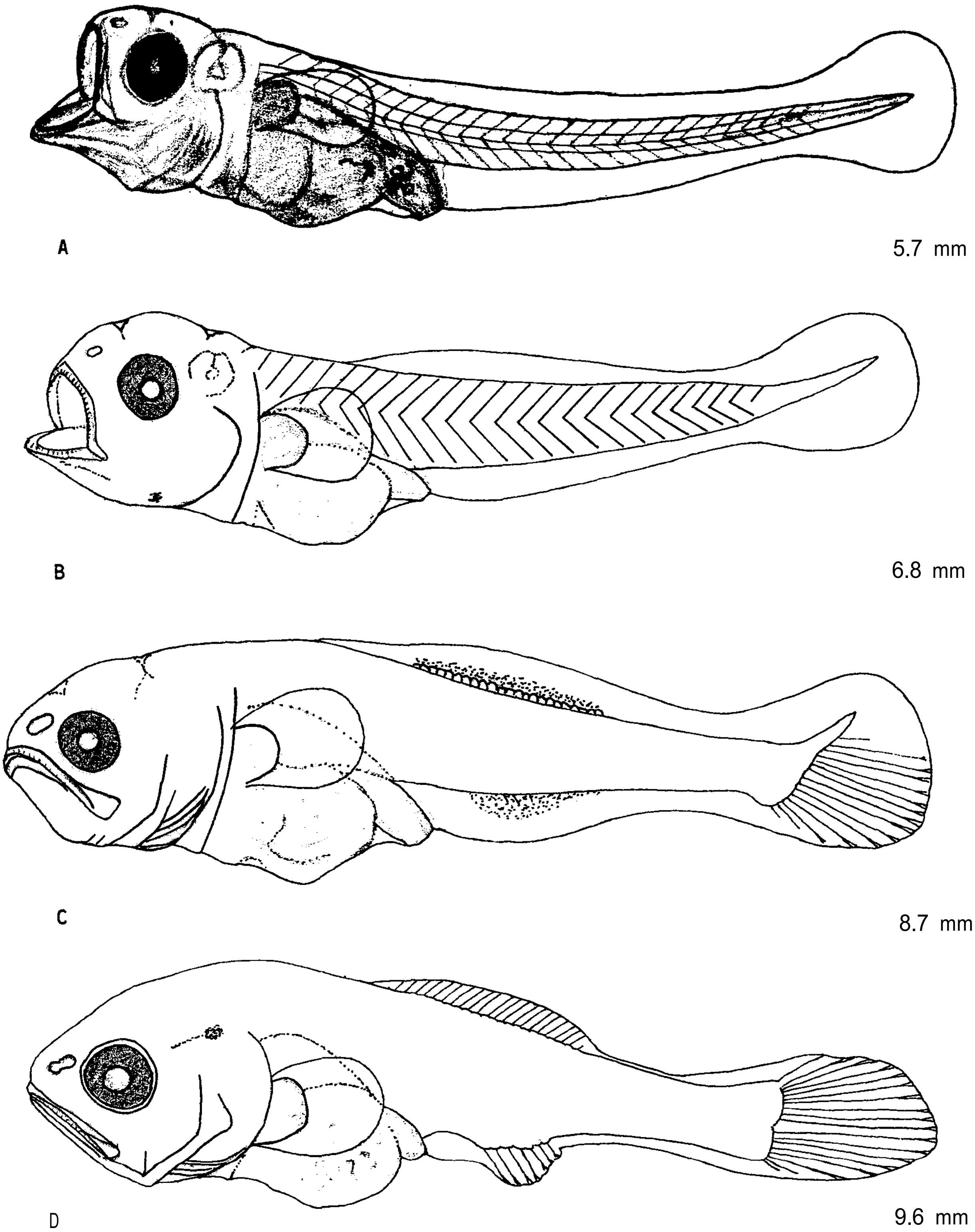


Fig. 272. Aplodinotus grunniens, freshwater drum. A-D. Larvae. (A-D, wild-caught, Oklahoma, Taber 1969).

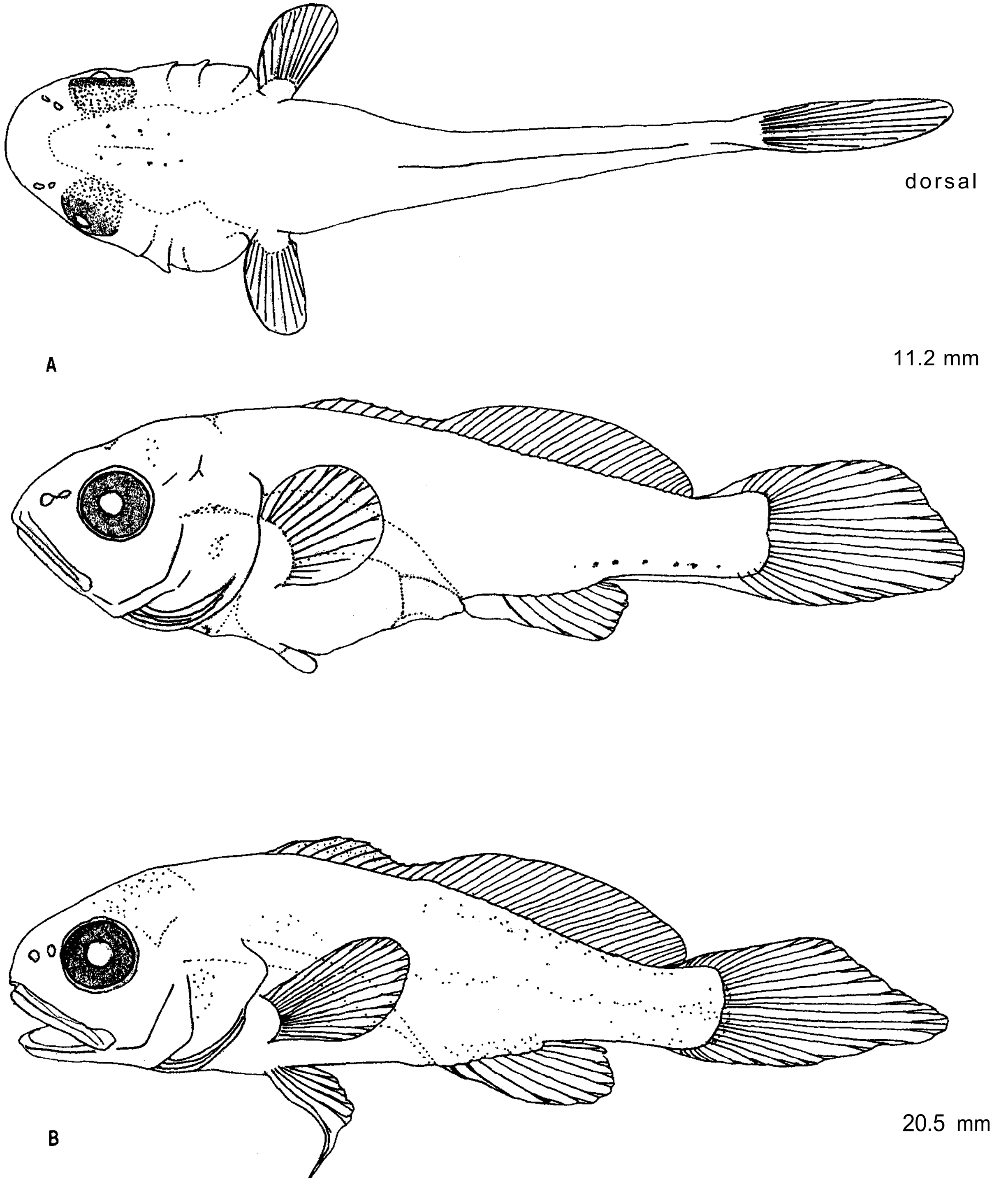


Fig. 273. Aplodinotus grunniens, freshwater drum. A. Larva. B. Juvenile. (A and B, wild-caught, Oklahoma, Taber 1969).

Family Cottidae, sculpins

By

George R. Heufelder

Sculpins are bottom-dwelling fishes distributed primarily in north temperate and arctic regions. They generally are compressed dorso-ventrally and have large, broad heads and bodies which taper toward a relatively narrow caudal peduncle. The eyes are situated dorso-laterally. Cottids are primarily marine fishes, however one genus, Cottus, is found exclusively in fresh and brackish waters of North America and Eurasia. Three species of Cottus occur in the Great Lakes basin. Another genus, Myoxocephalus, is primarily marine with one freshwater representative (Myoxocephalus thompsoni) in North America. This species is very similar to M. quadricornis which has a circumpolar distribution in cold, brackish water.

Although very little is known of the biology of C. ricei, it is likely that all three Cottus spp. present in the Great Lakes basin have similar reproductive habits. Spawning occurs on the undersides of submerged objects which are later guarded by the male. Eggs are large, 2 to 3 mm in diameter, and are guarded throughout their incubation period. Newly hatched C. bairdi and C. cognatus larvae have a large spherical to round yolk sac, but otherwise resemble the adult in body form. Larvae are quite precocious and exhibit many adult morphological, meristic and pigment characteristics by the time the yolk is absorbed. It is unlikely that yolk-sac larvae of C. bairdi and 5. cognatus would be captured by the majority of larval fish sampling gear since the larvae remain in or near the protected nest until yolk absorption.

Little is known of the reproductive habits and early life history of M- thompsoni. Larval stages from about 8.2 mm were described, but length newly hatched was not reported. In contrast to Cottus, the larval period of M. thompsoni is protracted and fin ray formation is completed later in development. Pigment development in this species apparently varies greatly in the Great Lakes with many Lake Michigan specimens lacking pigmentation at lengths up to 20 mm. Unlike cottus spp., early larval stages of M. thompsoni are readily caught in fish larvae sampling gear, occasionally some distance off the bottom.

The following larval descriptions are based primarily on laboratory-reared larvae or are from larvae housed in the Great Lakes Regional Fish Larvae Collection (GLRFLC) . A review of the literature showed that a few detailed studies are available. Of particular interest were descriptions given by Fish (1932) from collections taken from the Lake Erie drainage, of which only the juveniles are believed to be correctly identified.

Provisional Key to Lake Michigan Cottid Larvae

Yolk-sac larvae

1a. Postanal myomeres 25 to 26; total myomeres usually 36 to 43. . . . . Myoxocephalus thompsoni

b. Postanal myomeres less than 23; total myomeres usually 28 to 32. . . 2

2a. Yolk sac small: oil globule may or may not be present; pigment on venter of yolk sac and near anus . . . . Cottus ricei

b. Yolk sac large and round; one oil globule; pigment on dorsum of yolk sac. 3

3a. Anal fin rays usually 13 or 14; first dorsal fin usually 8; second dorsal fin usually 17 to 18 . . . . .C. bairdi (characters approximately 85% reliable in the Lake Michigan basin)

b. Anal fin rays usually 11 or 12; first dorsal fin usually 6 or 7; second dorsal fin usually 15 to 17 . . . . C. cognatus (characters approximately 85% reliable in the Lake Michigan basin)

Larvae

1a. Postanal myomeres 24 to 26; total myomeres usually 33 to 42. . . . . Myoxocephalus thompsoni

b. Postanal myomeres less than 23; total myomeres usually 28 to 32. . . 2

2a. Body sparsely pigmented on dorsal and lateral aspects; pigment restricted to postanal venter. . . . . Cottus ricei

b. Body heavily pigmented; no pigment posterior to anus. 3

3a. Anal fin rays usually 13 or 14; dorsal fins continuous . . . C. bairdi

b. Anal fin rays usually 11 or 12; dorsal fins nearly separate . . . . .C. cognatus

Cottus bairdi Girard, mottled sculpin

Ail figures and descriptions given by Fish (1932) of C. b. kumlieni, may have been misidentified. A characteristic pigment pattern on the venter as well as lack of pigment on the dorsum of the head leads me to believe these illustrations are of 5. ricei. Figure 133 in Fish (1932), reported to be C. b. bairdi is also questionable. C. bairdi at this stage (6.0 mm), would likely have a much larger yolk sac and exhibit pigment on the dorsum of the head. It is likely that this illustration is also of C. ricei.

Subspecies of the mottled sculpin, which are reported to occur in the Great Lakes basin, are 5. bairdi bairdi and C. bairdi kumlieni.[1] In consideration of the morphological variation of C. bairdi throughout its range, I contend that current knowledge does not allow for subspecific designation.

DISTRIBUTION

Throughout the Great Lakes basin,' occasionally inhabiting shoal waters of the lakes proper.[2 *]

SPAWNING SEASON

Spawns from March to May.[3 6 7 * *] The actual time of spawning in any locale is very short (2 to 5 days).[3 7]

SPAWNING TEMPERATURE

Spawning occurs at 5.6 to 16.7 C.[3 4 5 7]

SPAWNING HABITAT

Spawns in streams,[3 4 5 6 7 *] at depths of 15 to 35 cm,[3 4] and shoreline areas of lakes.' *

SPAWNING SUBSTRATE

Spawns on undersides of objects,'[4 5 6 7 *] occasionally on plants,[3 4] in firmly packed soil cavities,' or in rubble bottom sections of streams.'[7] Utilizes other bottom types if sufficient shelter is present.[7]

FECUNDITY

56 to 341;' 111 to 635;' 336 to 949."

NATURAL HYBRIDS

Possibly Cottus cognatus.[14]

EGGS

Demersal, adhesive;[3,4,5,6,7,*] diameter 1 to 3 mm;[6] 2 to 3 mm;[7,9,*] yolk white to orange-yellow;[6,7,9,*] oil globule single;[*] incubation period: 36 days at 5 to 16 C (in situ);[3] 17 days at 11.1 to 12.8 C;[4] 20 days at 15 C.[3]

YOLK-SAC LARVAE

Total length	Description
6.3-6.9 mm	Newly hatched.* Myomeres: 28 to 32 (9 to 12 + 19 to 21).[11,*] Morphometry: (as % TL) standard length 91 to 94, preanal length 52 to 54, head length 22 to 25, yolk-sac length 32 to 37, (as % head length) eye diameter 31 to 41.* Morphology: large spherical to round yolk sac with oil globule in anterior portion (newly hatched), eye, jaws and opercula developed, notochord flexed, two hypurals evident, three fin rays associated with each (ca. 6.7 mm), pectoral fins with actiniotrichia, pelvic fins represented by slight elevations (6.9 mm).* Pigmentation: eye pigmented, no other pigment evident (newly hatched), patch of melanophores on dorsum of head, one to four melanophores between opercle and pectoral buds, one to four melanophores on postanal midventer (12 to 24 hours posthatching).*
7-8 mm	Myomeres: see 6.3-6.9 mm. Morphometry: (as %-TL) standard length 85 to 89, preanal length 48 to 52, head length 22 to 25, yolk-sac length 27 to 31, (as % head length) eye diameter 35 to 38.* Morphology: rays in all fins except pelvic fins (ca. 7.0 mm), pelvic buds evident or rays formed in pelvic fins (7.5 mm).[10] Pigmentation: numerous small melanophores over dorsal and dorsal-lateral surface of head and yolk, (ca. 7.0 mm), lateral bands evident on trunk (7.5 mm);[10] small patch of melanophores on antero-ventral portion of yolk sac, a few melanophores ventrally between bases of pectoral fins (7.9 mm).*

LARVAE

Total length	Description
8-9 mm	Myomeres: see 6.3-6.9 mm. Morphometry: (as % TL) standard length 82 to 90, preanal length 44 to 49, head length 20 to 23, (as % head length) eye diameter 35 to 38.*

Morphology: yolk absorbed (8.1 to 8.9 mm);[11] or not (8.0 to 9.5 mm);[7] * general appearance much like adult;[11] all fin rays developed (8.1 mm);[11] or pelvic fins still undifferentiated (8.2 mm), median finfold evident on dorsum and venter of caudal peduncle.[11] *

Pigmentation: numerous small melanophores over dorsal and dorso-lateral surface of head and yolk if present, dorsal and lateral surfaces of trunk show definite "saddle" marks characteristic of adult, ventral pigmentation restricted to a patch of chromatophores in between pectoral fin bases.*

JUVENILES

Total length	Description
9-15 mm	Myomeres : see 6.3-6.9 mm.
	Morphometry: (as % TL) standard length 82 to 83, preanal length 42 to 45, head length 22 to 26, (as % head length) eye diameter 32 to 35.[11] *
	Morphology: may still retain yolk (ca. 9.5 mm), median finfold evident on caudal peduncle;[11] * all fin rays developed;[11] * finfold absorbed (14 to 15 mm) .*
	Pigmentation: lateral banding more evident.[11] *

ADULTS

Fin rays: caudal 12;* dorsal VII to 1x-16 to 19; [12] anal 10 to 14,[13] or 12 to 16;[12] pectoral 13 to 17;[12] pelvic I,4 rarely I,3.[13]

Vertebrae: 31 to 33. [13]

Diagnostic characters: pelvic fins I,4, dorsal fins continuous and palatine teeth present, caudal peduncle length less than postorbital length in specimens from Ontario and Quebec.

LITERATURE CITED

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2. Becker (1976)
   Hann (1927)
;: Ludwig and Norden (1969)
5. Savage (1963)
6. Smith (1923)
7. Koster (1936)
8. Ludwig and Lange (1975)
9. Bailey (1952)
10. Khan (1971)
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12. McAllister (1964)
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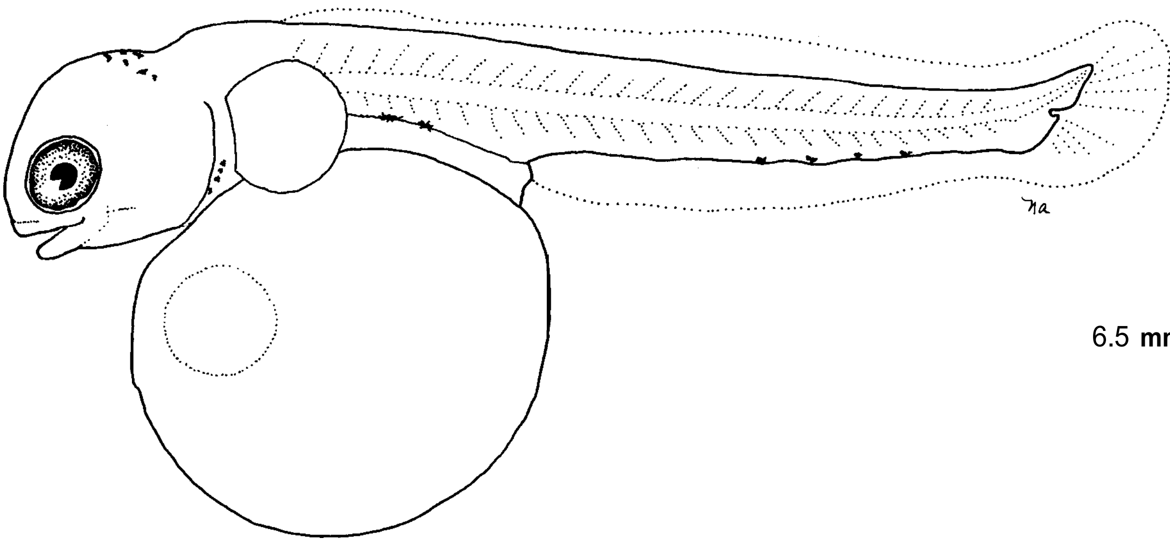
14. D. E. McAllister (pers. comm.)



6.5 mm

Fig. 274. Cottus bairdi, mottled sculpin. Yolk-sac larva, newly hatched. (Laboratory-reared, Michigan, original illustration by N. A. Auer).

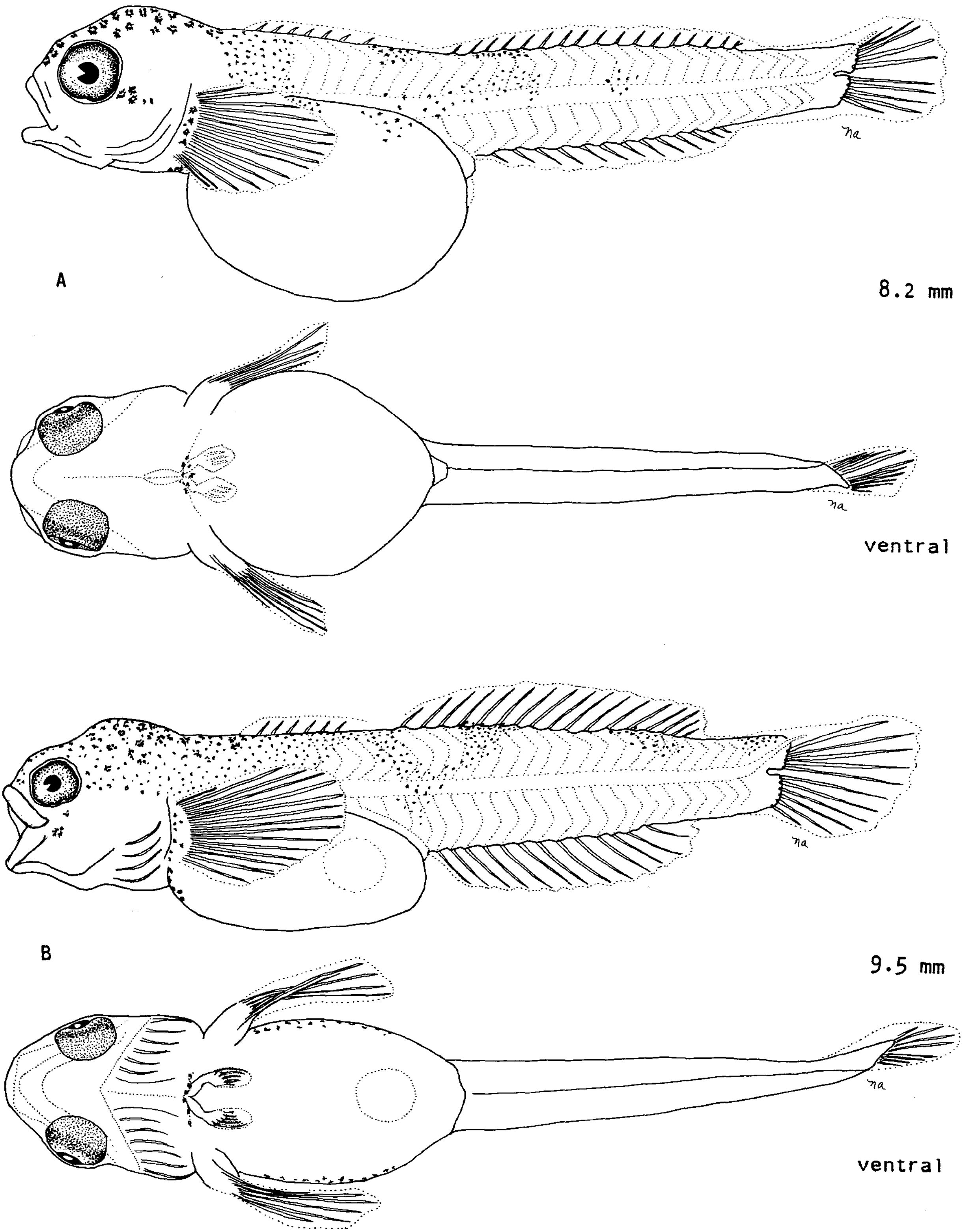


Fig. 275. Cottus bairdi, mottled sculpin. A and B. Yolk-sac larvae. (A and B, laboratory-reared, Michigan, original illustrations by N. A. Auer).

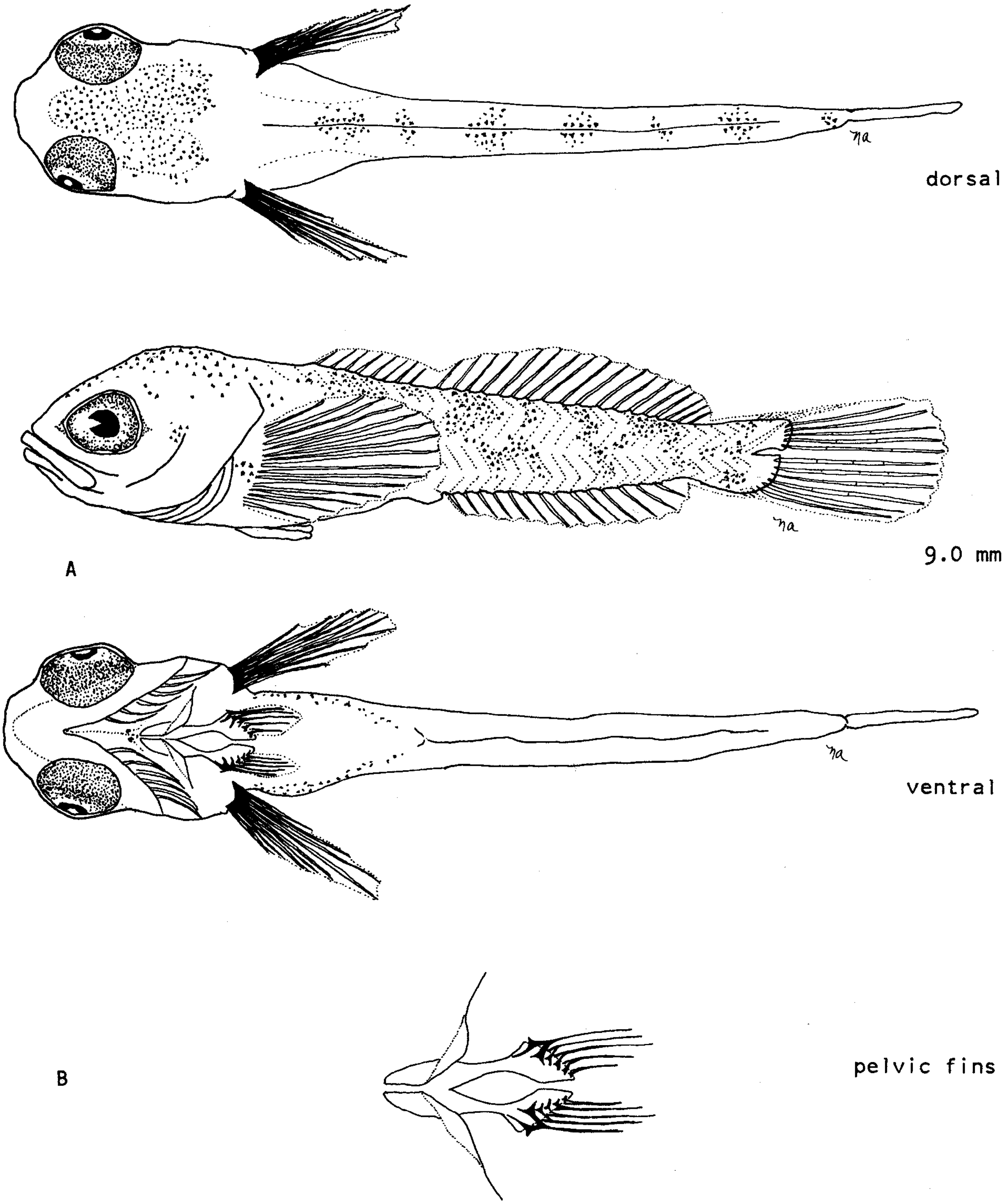


Fig. 276. Cottus bairdi, Mottled sculpin. A. Juvenile. B. Pelvic fins, showing five elements. (A and B, wild-caught, Lake Michigan, Heufelder and Auer 1980).

Cottus cognatus Richardson, slimy sculpin

DISTRIBUTION

Throughout the Great Lakes region, occurring in drainages as well as the lakes proper.' [2] In the Lake Michigan drainage it is common in streams of the upper half of lower Michigan[3] and in nearshore Lake Michigan to a depth of 91 m.[4 5]

SPAWNING SEASON

Spawns from late April to May in Lake Michigan,[6] * May to June in the Montreal River, Canada' and March to May in New York.[8]

SPAWNING TEMPERATURE

Spawning occurs at 3.0 to 11.5 C (optimum at 6 C or less) in Lake Michigan,[6] 4.5 C in Cayuga Lake, New York, 10.0 C in streams[8] and 8 C in the Montreal River, Canada.'

SPAWNING HABITAT

Spawns at 34 to 90 m in Lake Michigan;[6] and in shallower (3 m) water.[10] In rivers and streams this species selects shallow flats with medium to little current, but can nest over a range of depths and water velocities.[7]

SPAWNING SUBSTRATE

In Lake Michigan spawns over fine sand to mud[6] on the undersides of submerged objects.' [8 *] In streams, usually spawns on rubble[7 8] but it is not unusual to see other substrate used, providing adequate cover is available.*

FECUNDITY

84 to 784.' [7 8 9]

NATURAL HYBRIDS

Possibly *Cottus bairdi*."

EGGS

Demersal, adhesive, diameter 2 to 3 mm;[7 8 *] yolk white, pink or yellow;* * incubation period: 28 to 29 days at 8 to 18 C (in situ).[7]

YOLK-SAC LARVAE

Total length	Description
5.7-6.3 mm	Recently hatched.* Myomeres: 30 to 32 (9 to 11 + 20 to 21) .*

Morphometry: (as % TL) standard length 95 to 98, preanal length 44 to 49, head length 17 to 20, yolk-sac length 28 to 33; (as % head) eye diameter 35 to 41.*
Morphology: large spherical yolk sac, one large oil globule in anterior portion, sometimes one to four smaller oil globules adjacent to large one, mouth functional, large pectoral fins with rays sometimes evident, median finfold continuous from nape around urostyle to anus, urostyle turned slightly upward, pelvic buds and median fins not developed.*
Pigmentation: eye black, no other pigmentation (new1y hatched), one to three melanophores on dorsum of yolk sac, one or two melanophores on midventral surface near caudal fin, may have one or two melanophores posterior to opercle (24 hours posthatching).*

6-7.5 mm

Myomeres: 30 (11 + 19).[11]
Morphometry: (as % TL) standard length 78 to 92, preanal length 46 to 50, head length 23 to 25, (as % head length) eye diameter 38 to 44.[8]
Morphology: pelvic buds barely visible (6.8 mm), yolk one-half to three-quarters absorbed, median finfold continuous hypurals well developed, pectoral fins large, incipient fin rays evident in dorsal and anal fins (7.0 to 7.5 mm), with rays formed in pectoral and caudal fins.*
Pigmentation: numerous melanophores over head, dorsal and dorso-lateral aspects of yolk sac, sparse lateral pigmentation may be evident (6.5 mm), intensifying to show lateral bands, one or two melanophores present on venter over heart region and near isthmus (7.5 mm).*

LARVAE

<u>Total length</u> — <u>Description</u>

7.5-8 mm

Myomeres: 30 (11 + 19).[11]
Morphometry: (as % TL) standard length 87, preanal length 43, head length 23; (as % head length) eye diameter 33, postorbital length 35.[11]
Morphology: yolk absorbed (7.5 to 8.0 mm) or present (8.0 to 9.5 mm);* median finfold on dorsum and venter of caudal peduncle only, adult complement of fin rays present;[11] * or pelvic fins not be differentiated.*
Pigmentation: lateral bands and dorsal "saddle" marks typical of the adult form present.[11] &

JUVENILES

<u>Total length</u> — <u>Description</u>

8-11 mm

Myomeres: 28 to 31 (9 to 12 + 19).[11]

Morphometry: (as % TL) standard length 80 to 89, preanal length 42 to 47, head length 19 to 24, (as % head length) eye diameter 31 to 41;[11] postorbital length 43 to 50.[11]

Morphology: median finfold evident on caudal peduncle (8.9 mm), small prickles may occur in a patch posterior to pectoral fins (10.7 mm), median finfold absorbed (ca. 11.2 mm).*

Pigmentation: same as previous stage with lateral banding becoming more evident, increased density of melanophores over the head and dorsum.*

ADULTS

Fin rays: caudal 12; * dorsal VII to IX[2]-14[13] * to 19; [12] anal 10 to 14; [12] pectoral 12 to 16;[2] pelvic 1,3 to 4.[12]

Vertebrae: 31 to 35.[13]

Diagnostic characters: pelvic fins I,3, distinct separation between dorsal fins, palatine teeth absent, caudal peduncle length more than postorbital length in specimens from Ontario and Quebec.

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3. Becker (1976)
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6. Rottiers (1965)
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8. Koster (1936)
9. Foltz (1976)
10. Jude et al. (1979a)
11. Heufelder and Auer (1980)
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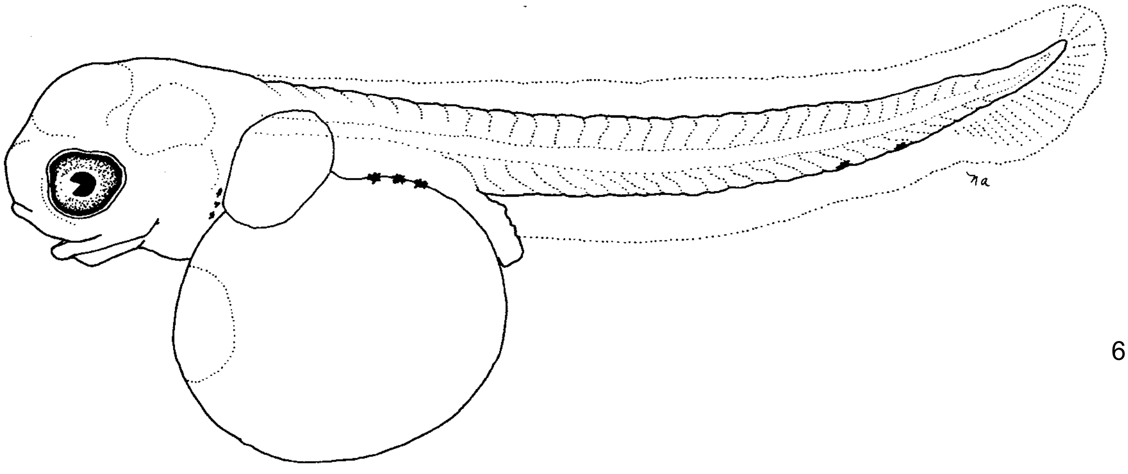

Fig. 277. Cottus cognatus, slimy sculpin. Yolk-sac larva, newly hatched. (Laboratory-reared, Lake Michigan, original illustration by N. A. Auer).

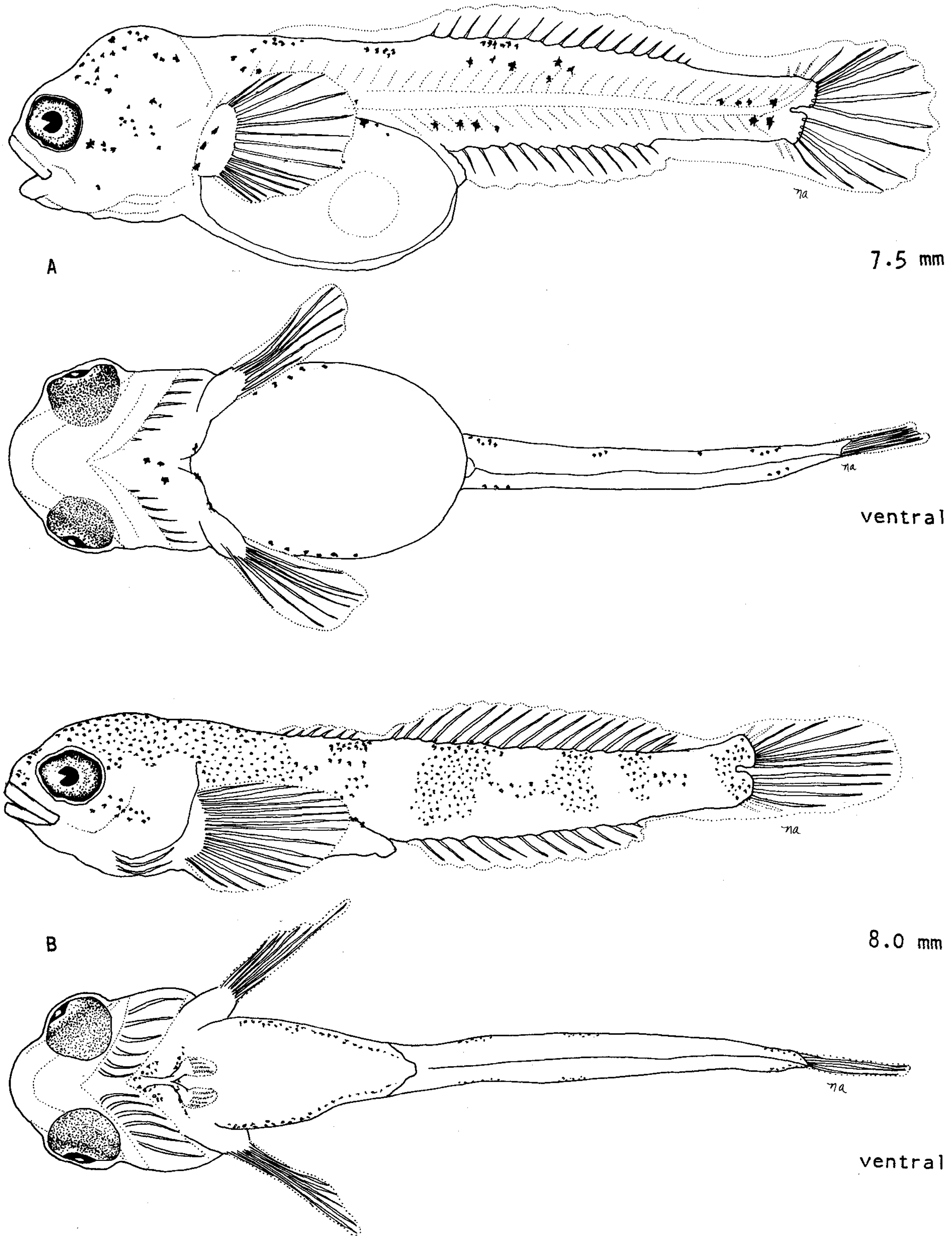

Fig. 278. Cottus cognatus, slimy sculpin. A. Yolk-sac larva. B. Larva. (A and B, laboratory-reared, Lake Michigan, original illustrations by N. A. Auer).

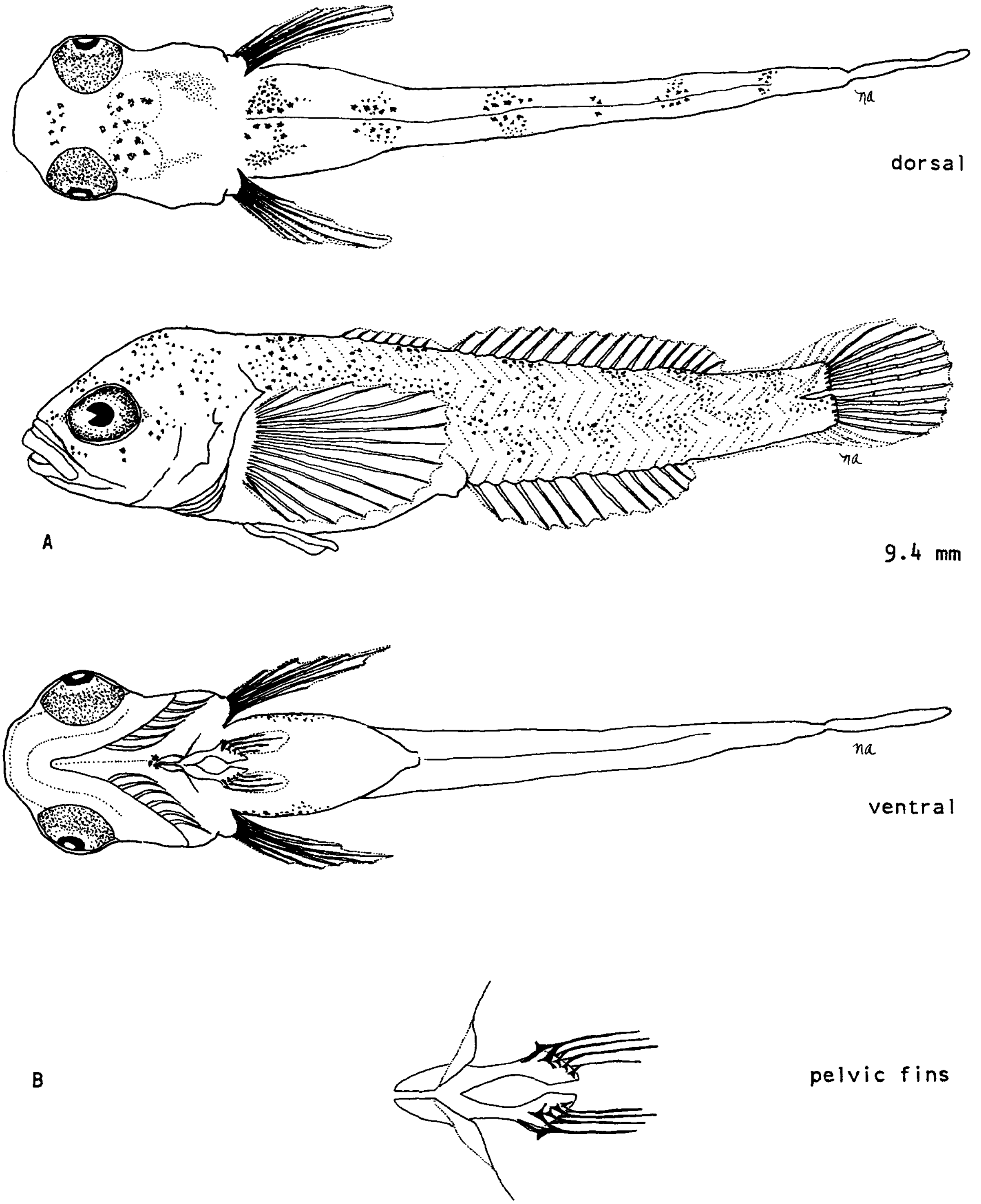

Fig. 279. Cottus cognatus, slimy sculpin. A. Juvenile. B. Pelvic fins, showing four elements. (A and B, wild-caught, Lake Michigan, Heufelder and Auer 1980).

Cottus ricei (Nelson), Spoonhead sculpin

DISTRIBUTION

Occurs in all of the Great Lakes proper.[1] In Lake Michigan it is reported to occur at depths to 156 m. None have been collected in tributary streams.[2] Recent records indicate it is rare in Lake Michigan and absent from the southern tip of the lake.[3] Food habit studies of lake trout in the northern half of Lake Michigan indicate C. ricei is still present.'

SPAWNING SEASON

Spawns in early May in Lake Superior' or approximately 3 weeks after ice-out.[5] Spawns in late summer or early fall.[6]

SPAWNING TEMPERATURE

Spawning occurs at 4.5 C[7] or less than 10 C.[4]

SPAWNING HABITAT

In Lake Superior, probably spawns in shallow areas.'

SPAWNING SUBSTRATE

In Lake Superior, probably spawns in rocky areas.'

FECUNDITY

Not reported.

EGGS

Deep orange.'

YOLK-SAC LARVAE

Total length	Description
7-8 mm	Myomeres: 31 (11 + 20) .* Morphometry: (as % TL) preanal length 45 to 47, head length 20 to 22.* Morphology: yolk not conspicuous, oil globule sometimes situated between enlarged anterior section of yolk and anus, actinotrichia present in pectoral and caudal fins, mouth large and well formed, notochord flexed.* Pigmentation: two large melanophores at anterior base of pectoral fin, midventral line of elongate melanophores extends over yolk sac to anus, six or more large melanophores from anus to caudal fin.:';

LARVAE

Total length	Description
9-10 mm	Myomeres: 35 (13 to 14 + 21 to 22) .* Morphometry: (as % TL) preanal length 43 to 47, head length 20 to 22.5: Morphology: yolk absorbed, no oil globule, preopercular spines evident, dorsal and anal fin rays partially formed, pelvic buds evident (9.2 mm).* Pigmentation: internal melanophores on anterior portion of pectoral fin insertion.*
11 mm	Morphometry: (as % TL) preanal length 42 to 45, head length 22.* Morphology: all fin rays formed except pelvic fins.* Pigmentation: a few subdermal melanophores outline pectoral girdle.*

JUVENILES

Total length	Description
21-22 mm	Morphometry: (as % TL) standard length 88, preanal length 42, head length 24; (as % head length) eye diameter 25, snout length 29.* Morphology: all fin rays formed, large upturned preopercular spine evident, remaining three preopercular spines directed posteriorly, prickles evident over entire body, more pronounced over a middorsal ridge, mandibular pores large, one pore on midline of chin.* Pigmentation: irregular dark mottling over dorsum, irregular barred markings on lateral aspects.*
27-28 mm	Morphometry: (as % TL) standard length 84, preanal length 44, head length 22, head width 23, greatest body depth 15, (as % head length) eye diameter 25, snout length 33, interorbital width 23.[9] Morphology: pectoral fins reaching anal fin origin, head depressed, broad and flat, its breadth greater than its length, preopercular spine very long, hooked backward and upward, other spines hooked downward the lowest is concealed, stiff prickles above lateral line, largest prickles on either side of dorsal ridge, extending over top of head and between eyes, lateral line complete.' Pigmentation: irregular brown mottling especially over head and dorsum becoming more scarce over sides, venter and pelvic fins colorless, other fins mottled.[9]

ADULTS

Fin rays: caudal 12;* dorsal VII to X[10]-15 to 18;[6] anal 11 to 14 or 16;[6] pectoral 14 to 16;[6] pelvic I,4.[6]

Vertebrae: 34 or 35.[6]

Diagnostic characters: lateral line complete to base of caudal fin without deflection, upper preopercular spine usually longer than two-thirds eye diameter and curved strongly upward, mandibular pores large, one mandibular pore on midline at tip of chin.

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8. Wright (1968)
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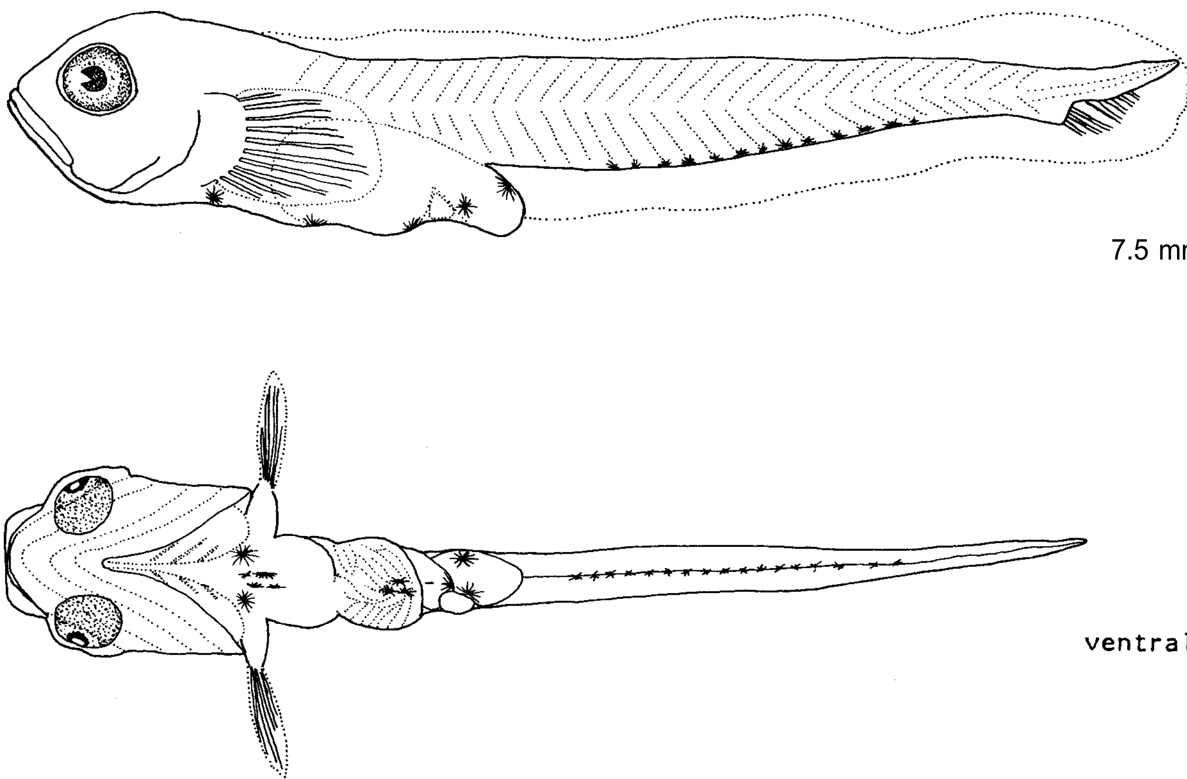

Fig. 280. Cottus ricei, Spoonhead sculpin. Yolk-sac larva. (Wild-caught, Lake Superior, original illustrations by N. A. Auer, specimens provided by J. H. Selgeby, U.S. Fish and Wildlife Service, Ashland, Wisconsin).

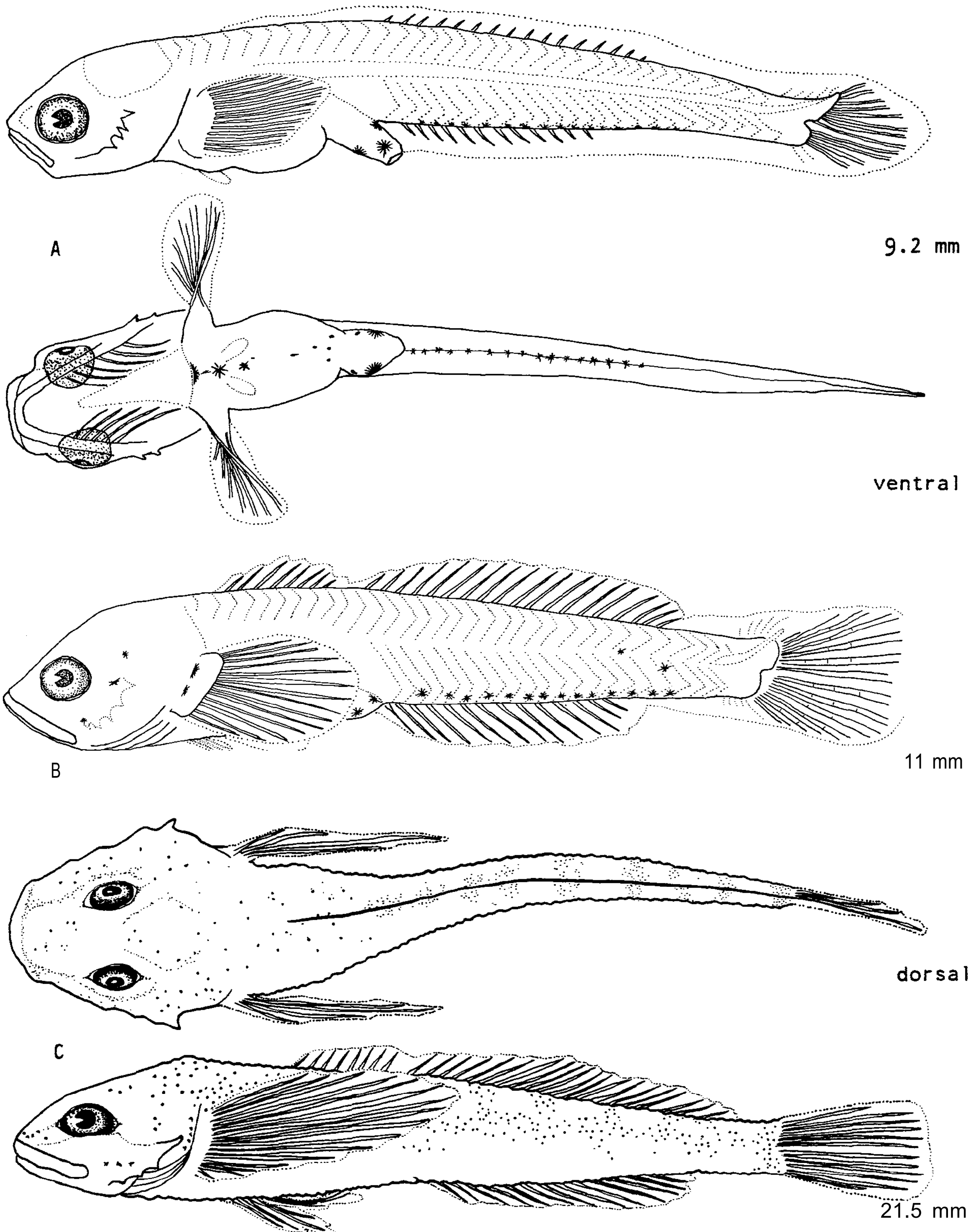

Fig. 281. Cottus ricei, Spoonhead sculpin. A and B. Larvae. C. Juvenile. (A-B, wild-caught, Lake Superior, original illustrations by N. A. Auer, specimens provided by J. H. Selgeby, U. S. Fish and Wildlife Service, Ashland Wisconsin; C, wild-caught, Lake Superior, University of Michigan Museum of Zoology, UMMZ 81702).

Myoxocephalus thompsoni (Girard), deepwater sculpin

Figures 125 to 127 in Fish (1932) and her descriptions were supposedly M. thompsoni. A high dorsal fin ray count, low myomere count and uncharacteristic pigmentation pattern makes this identification questionable. The lateral banding pattern as well as fin ray counts make it probable that these were Cottus bairdi.

DISTRIBUTION

Occurs in all of the Great Lakes.[1 2] In Lake Michigan at depths of 45 to 183 m.[2] Larvae have been observed at depths less than 18 m.*

SPAWNING SEASON

Spawns in winter, spring and early summer.[3] Some evidence suggests year-round spawning at least in the Great Lakes.[2] In Lake Superior spawns primarily in mid-winter, but may extend from late November through mid-May.[4]

SPAWNING TEMPERATURE

Not reported.

SPAWNING HABITAT

Not reported.

SPAWNING SUBSTRATE

Not reported.

FECUNDITY

165 to 1,187 in Lake Superior.[5]

EGGS

Not described.

YOLK-SAC LARVAE

Total length	Description
8-10 mm	Myomeres: chevron-shaped, 36 to 43[3] * (11 + 25 to 26).* Morphometry: (as % TL) standard length 96 to 98, preanal length 36 to 38, head length 16 to 17;* (as % head length) eye diameter 50 to 54.* mm).* Morphology: body elongate, median finfold continuous notochord straight, mouth parts formed, pectoral bud fan-shaped with broad base, rays not formed;[3 6] * yolk may be absorbed (9.7 mm) * or yolk present (10 mm) .[3 6]

Pigmentation: eye pigmented, specimens may lack additional pigment;[3] * if present up to five melanophores appear in a midventral row (ca. 9.0 mm);[3] four to eight melanophores may appear along dorsum of peritoneum, most obvious in the lateral view (9.0 to 9.7 mm).[3] *

LARVAE

Total length	Description
10-12 mm	Myomeres: chevron-shaped, 36 to 41[3] * (11 + 26).*
	Morphometry: (as % TL) standard length 93, preanal length 40, head length 19;* (as % head length) eye diameter 38.*
	Morphology: finfold continuous, mesenchyme in second dorsal and anal fins, small section of finfold present anterior to anus, hypurals and caudal fin rays become visible (10.5 to 10.9 mm), pectoral fin rays and pelvic buds appear (10.5 mm);[3] although some 10.8-mm specimens show little pectoral fin ray differentiation;* one to two preopercular spines visible.[3]
	Pigmentation: may be lacking" * or four to eight melanophores may appear on dorsum of peritoneum sometimes appearing as two rows extending posteriorly to anus, most evident in lateral views (10.8 mm),* peritoneal and cephalic concentrations begin to develop.[3]
12-14 mm	Myomeres: piscine-shaped, 33 to 42[3,6] * (12 + 24).*
	Morphometry: (as % TL) preanal length 40 to 42, head length 18 to 20.*
	Morphology: slight differentiation of hypural complex (12.0 mm);* or hypural complex formed (ca. 12.0 mm);[3,6] finfold continuous;[3,6] * no differentiation in fins (12.0 mm)* or rays in second dorsal and anal fins (ca. 12.0 mm), pelvic fins undifferentiated (12.2 to 14.0 mm);[3,6] actinotrichia in pectoral fins (13.2 mm), hypural complex formed, but other fins essentially undifferentiated, basal elements in dorsal and anal fins (13.2 mm);* two to four preopercular spines, one to two parietal spines, (ca. 13.0 mm);[3,6] * nostrils completely constricted (14.0 mm).[3,6]
	Pigmentation: a midventral row of melanophores (1 to 6) may be present on trunk;[3,6] a few round melanophores may occur on top of head and on nape, numerous melanophores on dorsum of stomach large and stellate, extending posteriorly toward anus, one melanophore in heart region (13.2 mm), some specimens in this size range may lack pigment.*
15-16 mm	Myomeres: piscine-shaped, 35 to 39[3,6] * (11 + 24).A

Morphometry: (as % TL) standard length 96, preanal length 40, head length 20, (as % head length) eye diameter 30.*

Morphology: urostyle upturned, pectoral and caudal fins differentiated, remaining fins not complete (15.4 mm);* or all fins except pelvic fins differentiated;[3,6] first dorsal fin with three to eight spines (incomplete).[3,6]

Pigmentation: melanophores increase on dorsal and dorso-lateral aspect of gut and cephalic region, one to six melanophores in midventral region of trunk;[3,6] or pigment absent (15.4 mm).*

16-18 mm

Myomeres: 36 to 42[3,6,*] (11 + 25).*

Morphometry: (as % TL) preana1 length 40 to 43, head length 24 to 26.*

Morphology: pelvic fin rays begin to appear (17 mm);[3] or pelvic buds present (17.8 mm);* preopercular spines four, parietal spines two.[3,6]

Pigmentation: pigment on dorsal and dorso-lateral aspect of gut continuing to develop, cephalic concentrations continue to enlarge, midventral row of melanophores (maxi mum of six) may be evident;[3,6] some specimens in this size range may lack pigment.*

JUVENILES

Not descri bed.

ADULTS

Fin rays: caudal 11 to 16, dorsal VII to X-11 to 16, anal 11 to 16;[2,7] pectoral 15 to 18;[2,8] pelvic 1,3 to 1,4.[2,7]

Vertebrae: 37 to 39.[2]

Diagnostic characters: margin of gill membrane free from isthmus, dorsal fins separated by a distinct gap, second preopercular spine directed backwards.

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8. McPhail and Lindsey (1970)

Myoxocephalus thompsoni

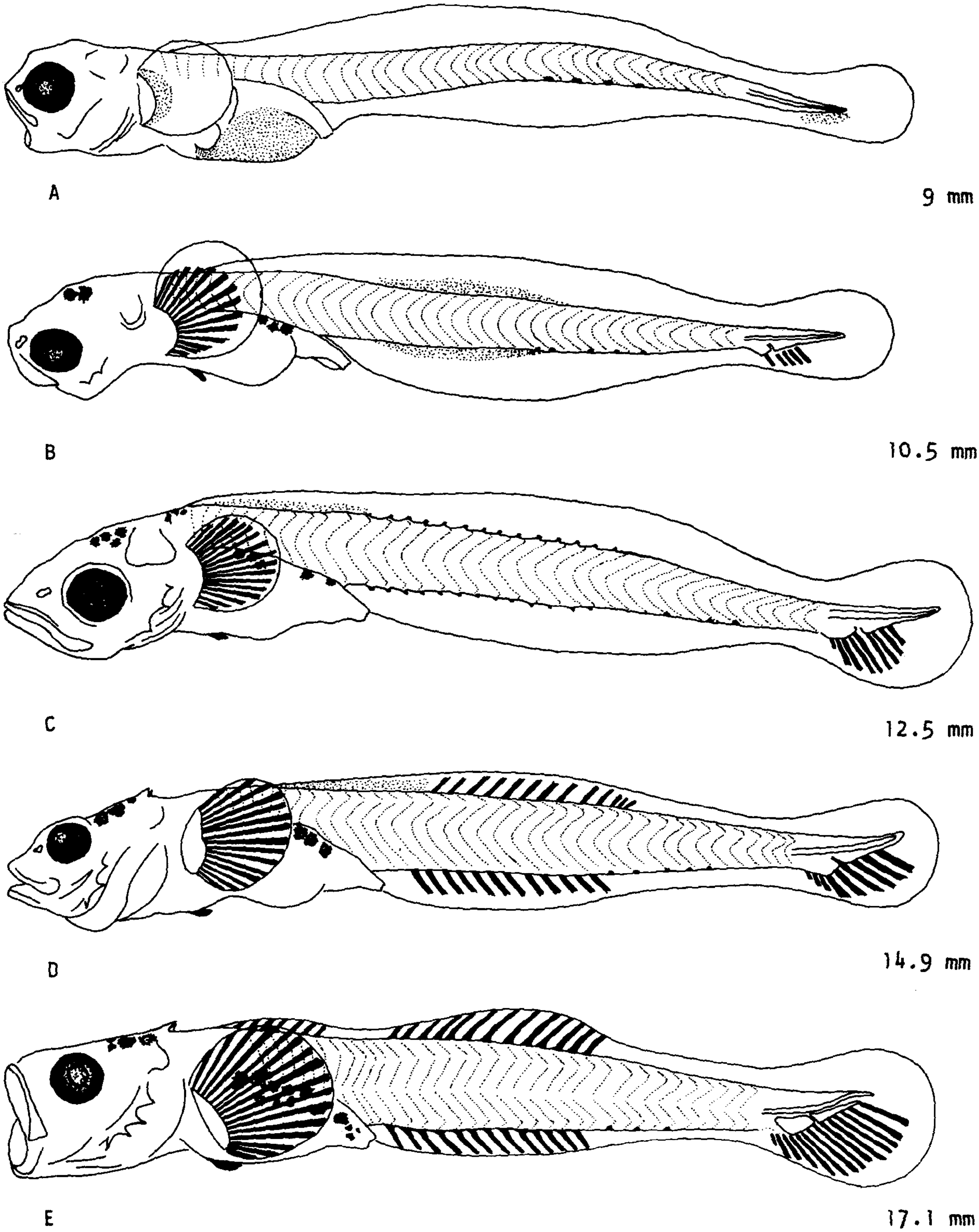

Fig. 282. *Myoxocephalus thompsoni*, deepwater sculpin. A. Yolk-sac larva. B-E. Larvae. (A-E, wild-caught, Lake Michigan, Khan 1971).

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