DESCRIPTIONS AND IDENTIFICATION OF RAZORBACK, FLANNELMOUTH, WHITE, UTAH, BLUEHEAD, AND MOUNTAIN SUCKER LARVAE AND EARLY JUVENILES

by

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FOREWORD

As the second decade of intensive research on rare native fishes of the Upper Colorado River Basin comes to an end, it is apparent that a complete understanding of their life histories is paramount in successful management and preservation of these unique species. To fully appreciate the ecology of any species, the ability to identify all of its life stages is essential.

These identification capabilities are especially valuable in the study of rare riverine fishes where sampling habitats and obtaining specimens can be difficult. Typically, however, availability of information on the early life of many fish species is delayed due to the tedious nature of developing taxonomic information for recently-hatched stages. This difficulty in detecting presence or absence of larval and early juvenile fish has hampered data collection on rare species such as the razorback sucker (*Xyrauchen texanus*).

The razorback sucker, currently listed as endangered in Colorado, is truly a unique species endemic to the Colorado River Basin. Its candidacy for federal protection under the Endangered Species Act attests to recent concern about its prospects for future survival. As a sense of urgency concerning its present abundance in the upper basin builds, the need for adequate tools to study its early-life stages is intensified.

This manual consolidates, refines, enhances, and supplements data and keys in existing publications and reports. In addition to morphological, morphometric, meristic, pigmental, and developmental state characters, it incorporates selected skeletal characters to help distinguish larval and early juvenile fishes. The keys and descriptive accounts are the most definitive prepared to date for early-life stages of catostomids occurring in the Upper Colorado River Basin. This work will prove invaluable as we enter the third decade of research on riverine fish communities of the upper basin.

Patrick J. Martinez
Wildlife Biologist

DEDICATION

We dedicate this publication to

Carroll Lynn Bjork

whose drawings have been the heart of descriptions emanating from the Larval Fish Laboratory.

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ACKNOWLEDGMENTS

This publication is the culmination of nearly a decade of work on early life stages of the species covered. It builds upon descriptions and preliminary keys previously sponsored by the Bureau of Land Management (United States, Colorado Office), Colorado Division of Wildlife (former Non-Game Section), Colorado State University Experiment Station, Ecosystem Research Institute (Logan, Utah), United States Fish and Wildlife Service (Colorado River Fishery Project and Reno Fisheries Assistance Office), and Utah Division of Wildlife Resources. Some text and data, and many illustrations were originally published in Snyder (1981, 1983a) and Snyder and Muth (1988).

Developmental studies at the Larval Fish Laboratory have depended on the assistance and cooperation of many individuals, including Colorado State University (CSU) students serving as Larval Fish Laboratory volunteers or employees. Edmund Wick was responsible for obtaining fertilized eggs and rearing developmental study series of many of the species studied. Mark Castagneri, Al Davis, Gary Dean, Carol Jefferson, Philip Harrison, David Herbet, Jeff Pearson, Dale Brown, and Keith Fulsos (Brown and Fulsos via summer CETA Youth Program) assisted with culture or organization of collected specimens for study. James Barrowman, Lynn Bjork, William Emerson, Lyndon Evans, Stephanie Salyer, and Edmund Wick assisted with acquisition of morphometric and meristic data from hundreds of specimens. Timothy Hill, Jack Piccolo, and Steven Platania cleared and stained some specimens. Steve Meismer, Jack Ruppert, and Mark Williams assisted with editing of the keys.

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C. Lynn Bjork prepared original and all previously published drawings, except as follows. Selected drawings of *Catostomus commersoni* larvae were reproduced with permission from Stewart (1926), Buynak and Mohr (1978), and Fuiman (1979, drawings by C. Komar Outlaw). Drawings of adult suckers were reproduced with permission from Miller (1952, drawings by William Brudon) and Behnke and Benson (1983, drawing by Doris Rust).

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Frontispiece. Yearling razorback suckers. Top -- interneural bones of cleared and stained specimen, 65 mm total length. Bottom -- predorsal keel barely evident immediately behind the head of a living specimen, 85 mm total length. Reared by the Larval Fish Laboratory from eggs artificially fertilized on June 8, 1980, from adults collected in gravel pits connected to the Colorado River near Clifton, Colorado.

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ABSTRACT

Larvae of the endangered razorback sucker (*Xyrauchen texanus*) and six other suckers (genus *Catostomus*) in the Upper Colorado River System are broadly similar in appearance. To facilitate identification, developmental series of all species except longnose sucker (*C. catostomus*) were studied for differences in morphology, meristics, pigmentation, size relative to developmental state, and skeletal features. The razorback sucker is most similar to bluehead sucker (*C. discobolus*) as protolarvae and flexion mesolarvae and flannelmouth sucker (*C. latipinnis*) as metalarvae and early juveniles. Some razorback sucker larvae can be distinguished by early yolk absorption, early scattering of dorsal pigmentation, few or no melanophores along the ventral mid-line between heart and vent, and generally lighter or less widely distributed body pigmentation. Later larvae and juveniles can be distinguished by 14 or more dorsal fin rays; a correspondingly long dorsal fin base; a large, fan-shaped, first interneural bone; and a large, oval-shaped, frontoparietal fontanelle. Bluehead sucker and mountain sucker (*C. platyrhynchus*) represent subgenus *Pantosteus* and are best characterized by early scattering of dorsal pigmentation; early folding of the gut; dark peritoneum; a generally smaller dorsal fin; a small, blocky, first interneural bone; a narrow fontanelle; and, for early juveniles, a distinctive mouth. The midventral line of pigment from heart to vent is often complete for mountain sucker larvae and highly variable for bluehead sucker larvae. The remaining species represent subgenus *Catostomus*. Flannelmouth sucker are distinguished by their large size at hatching, yolk absorption, and onset of other developmental events; also by delayed gut folding, generally lighter or less widely distributed body pigmentation, limited midventral pigmentation, distinctive "tractor-tread" pigment pattern on the dorsum of some mesolarvae, and very small scales in juveniles. A complete midventral line of melanophores from the heart or branchial region to vent is typical of white sucker (*C. commersoni*) larvae while large scales, frequently well outlined with pigment, and a series of three large lateral spots characterize larger young-of-the-year juveniles. Utah sucker (*C. ardens*) usually have larger eyes relative to head length than the other species. They are similar to white sucker, but larvae usually have much less midventral pigmentation, sometimes none, and juveniles have only two, if any, prominent lateral spots.

INTRODUCTION

Despite the information explosion and technological advances of the past few decades, knowledge of the biology of many North American fishes remains inadequate for either evaluation of potential environmental impacts on aquatic ecosystems or optimal management of fisheries. Knowledge of early-life stages (eggs, larvae, and early juveniles) is especially weak. For most species, the larvae and early juveniles represent several life-intervals that are ecologically distinct from each other and from their later juvenile and adult counterparts. Knowledge of habitat requirements and limitations, population dynamics, and behavior of these early-life intervals will improve our understanding of aquatic ecosystems and communities and facilitate more effective monitoring and management of fish populations and habitats. Such knowledge is particularly valuable in evaluation of environmental impacts and recovery of endangered species such as the razorback sucker (*Xyrauchen texanus*).

Early-life stages of fishes are or should be a principal focus of many ecological studies (Snyder 1976a). Their distributions and densities are indicative of spawning and nursery areas, spawning seasons, larval behavior, and year-class strength. Even in baseline surveys designed to determine presence and relative abundance of fishes, larval collections can often provide information on certain species that because of gear selectivity, behavior, or habitat are difficult to collect or observe as adults. Studies of fish larvae also can provide information on morphological development, systematics, growth rates, survival rates, food habits, predation, and various other ecological relationships.

Research on ecology of early-life stages and subsequent management efforts depend on accurate identification of collected specimens. Inland fishery managers and researchers often exclude potentially critical larval-fish investigations specifically because they "haven't done it before" or they don't have the taxonomic tools needed for the job. Unfortunately, acquisition of this vital taxonomic information is very time-consuming and expensive. While such information is slowly building, the many individual efforts are piecemeal, uncoordinated, and often "a labor of love" on the part of the researchers involved.

Of approximately 775 species of freshwater and anadromous fishes in North America (Lee et al. 1980), less than 20% are adequately described as larvae for identification purposes (extrapolated from 15% reported by Snyder 1976a). In a relatively comprehensive listing of regional guides, keys, and comparative descriptions of larval fishes by Simon (1986), only about 80 of 230 citations (35%) pertain to freshwater species. Snyder (1983b) listed 11 regionally oriented larval fish identification manuals for or including freshwater species (some of these are for the same regions and all are incomplete in coverage). Since 1983 five local or regional guides for freshwater larvae have been published (Conrow and Zale 1985, McGowan 1984 and 1988, Sturm 1988, and Wang 1986).

The purpose of this publication is to facilitate identification of larval and early-juvenile razorback, flannelmouth, bluehead, mountain, white, and Utah suckers (*Xyrauchen texanus*, *Catostomus latipinnis*, *C. discobolus*, *C. platyrhynchus*, *C. commersoni*, and *C. ardens* respectively). All but Utah sucker are covered to some degree in the metalarva key and descriptions by Snyder (1981), a mountain sucker description by Snyder (1983a) and in an unpublished provisional key to protolarvae and mesolarvae Snyder prepared in 1984 for the Colorado Division of Wildlife and Ecosystems Research Institute of Logan, Utah. However, except for flannelmouth sucker, species accounts in the 1981 publication are incomplete and previously prepared keys are tentative and based on limited descriptive information. By comparison, species accounts and keys in this manual are much more comprehensive for the characters studied and the accounts include full sets of three-view illustrations for all but white sucker. Species accounts for mountain and Utah suckers are modifications of those in Snyder and Muth (1988).

The early-life stages of white sucker have been described or included in identification manuals by many other authors: Crawford (1923), Stewart (1926), Fish (1929,1932), Mansueti and Hardy (1967), Lippson and

Moran (1974), Long and Ballard (1976), Buynak and Mohr (1978), Jones et al. (1978), Loos et al. (1978), Fuiman (1978, 1979), Wang and Kernehan (1979), McElman and Balon (1980), and Auer (1982). The pattern of three large lateral spots typical of early juvenile white suckers was recognized at least as early as Ellis (1914). Although Metcalf (1966) suggested that there is little rationale for subspecies designations (e.g., *C. commersoni suckeyi* for western white sucker), diagnostic comparisons of larvae herein are based on data from western populations rather than previous white sucker descriptions from eastern populations.

Winn and Miller (1954) included mesolarvae of razorback sucker, flannelmouth sucker, and *Pantosteus* species in their photograph-illustrated key. All *Pantosteus* larvae included in that publication have since been recognized as desert sucker (*Catostomus clarki*) by Smith (1966). Pigmentation of bluehead and mountain sucker mesolarvae is typically similar to that documented by Winn and Miller for desert sucker. However, pigmental variation is much greater and for bluehead and mountain suckers of similar size dorsal and lateral pigmentation can be indistinguishable from that illustrated and described by Winn and Miller for razorback sucker.

In the process of documenting hybridization among several species of suckers, Hubbs et al. (1943) described young-of-the-year juveniles (and commented on some larvae) of flannelmouth, white, bluehead, and mountain suckers. Hubbs and Hubbs (1947) did the same for flannelmouth and bluehead suckers. Douglas (1952) published a photograph of a razorback sucker protolarva (or recently transformed mesolarva) without yolk. Douglas's publication also included a photograph of a 10 cm specimen which, as noted by Winn and Miller (1954), is not a juvenile razorback sucker but rather an adult speckled dace (*Rhinichthys osculus*). Minckley and Gustafson (1982) chronicled the early development of the razorback sucker but their illustrations of larvae are poor and misleading. Mountain and Utah sucker larvae have not been described by authors other than ourselves.

This publication covers six of seven species of Catostomidae inhabiting the Upper Colorado River System. The species not covered herein, the longnose sucker (*C. catostomus*), was described by Fuiman and Witman (1979) and included in the Great Lakes manual edited by Auer (1982). All seven species belong to the subfamily Catostominae and tribe Catostomini. *Xyrauchen* is a monotypic genus. Among the *Catostomus* species, the bluehead and mountain suckers represent a distinctive group known as "mountain suckers," subgenus *Pantosteus*; the others represent "valley suckers," subgenus *Catostomus* (Smith 1987).

The biology and distribution of fishes in the Upper Colorado River System (Fig. 1) was most recently reviewed by Behnke et al. (1982), Carlson and Carlson (1982), Miller et al. (1982a), Tyus et al. (1982), Woodling (1985), and Carlson and Muth (1989). Razorback, flannelmouth, bluehead, and mountain suckers are native to the System. The razorback sucker is protected by Colorado and Utah and has long been a candidate for the federal threatened and endangered species list. Flannelmouth and bluehead suckers are common to abundant in mainstem rivers throughout the System. The white sucker is present but less abundant in the Colorado, Gunnison, Yampa, and upper Green Rivers. The mountain sucker is restricted largely to headwater tributaries throughout much of the Green River Subbasin and is rarely found in mainstem rivers. However, individual specimens have been reported in the Green River near the confluence with the Yampa River and in the White River near and above the confluence with Piceance Creek. The Utah sucker is restricted largely to headwater tributaries west of the Green River, particularly the Duchesne River. A few specimens have been reported in the Green River in or below the lower end of Dinosaur National Monument. The longnose sucker (*C. catostomus*) is found only above Flaming Gorge Reservoir, in the Blue Mesa area of the Gunnison River, and in the Lake Granby area of the Colorado River.

The distribution and ecology of sucker larvae and young-of-the-year juveniles in the Upper Colorado River System has not yet been summarized, but selected information can be found in various progress reports, final reports, and formal publications by regional researchers (e.g., Carlson et al. 1979, Miller et al. 1982b, Haynes et al. 1985, and Tyus et al. 1987).

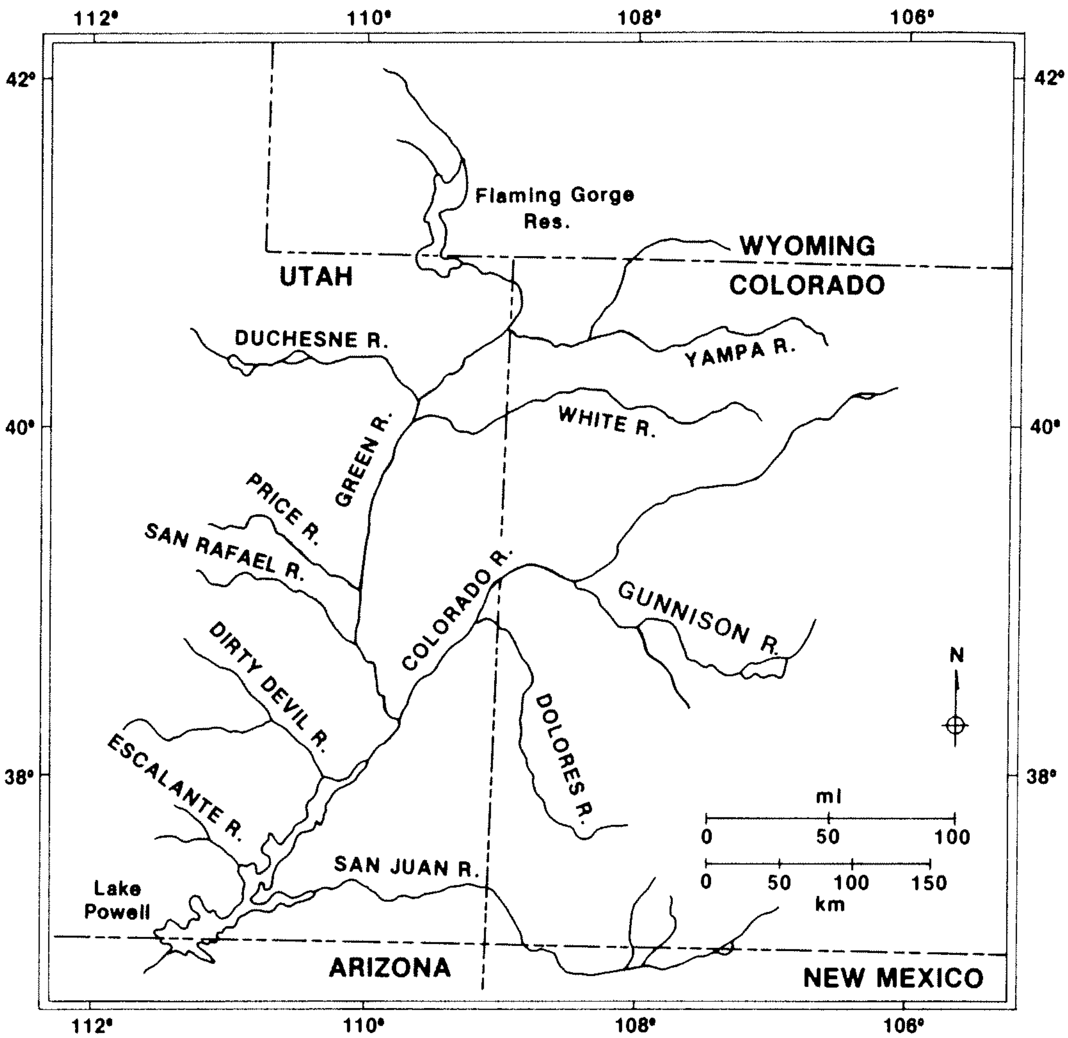

Fig. 1. The Upper Colorado River System.

A COMBINED DEVELOPMENTAL INTERVAL TERMINOLOGY

It is often convenient and desirable to divide the ontogeny of fish into specifically defined intervals. If the intervals selected are used by many biologists as a frame of reference, such division can facilitate communication and comparison of independent results. The largest intervals, periods (e.g., embryonic, larval, juvenile, and adult), are often sub-divided into phases and sometimes into steps (Balon 1975b and 1984); the word "stage," although commonly used as a synonym for period or phase (e.g., Kendall et al. 1984), should be reserved for instantaneous states of development.

The larval phase terminologies most commonly used in recent years, particularly for descriptive purposes, are those defined by Hardy et al. (1978 -- yolk-sac larva, larva, prejuvenile; modified from Mansueti and Hardy 1967), Ahlstrom et al. (1976 -- preflexion, flexion, postflexion; expanded upon by Kendall et al. 1984), and Snyder (1976b and 1981 -- protolarva, mesolarva, metalarva). Definitions for all three terminologies were presented by Snyder (1983b). During a workshop on standardization of such terminologies, held as part of the Seventh Annual Larval Fish Conference (Colorado State University, January 16, 1983), it became obvious that these are not competing terminologies, as they often are treated, but rather complementary options with subdivisions or phases defined for different purposes. As such, it is possible to utilize all three terminologies simultaneously to: (1) facilitate comparative descriptions and preparation of keys based on fish in similar states of development with respect to morphogenesis of finfold and fins; (2) segregate, for fishes with homocercal tails, morphometric data based on standard lengths measured to the end of the notochord prior to and during notochord flexion from those measured to posterior margin of the hypural plates following notochord flexion; and (3) approximate transition from at least partially endogenous nutrition (utilization of yolk material) to fully exogenous nutrition (dependence on ingested food) based on presence or absence of yolk material.

The combined terminology presented below and utilized herein effectively integrates principal subdivisions and functions of the three component terminologies. In doing so, Ahlstrom's "preflexion-flexion-postflexion" terminology is treated, for fishes with homocercal tails, as a subset of Snyder's mesolarva phase. Since notochord flexion in the caudal region usually begins when the first caudal fin rays appear and is essentially complete when all principal caudal fin rays are well defined, and since presence of fin rays can be more precisely observed than the beginning or end of actual notochord flexion, fin rays are used as transition criteria. As a result, all protolarvae are preflexion larvae, and all metalarvae are postflexion larvae. Although most fish pass sequentially through all phase subdivisions designated, some pass pertinent points of transition prior to hatching or birth and begin the larval period in a later phase or possibly skip the period entirely.

The definition for the end of the larval period is necessarily a compromise deleting all requirements (some taxon-specific, others difficult to determine precisely) except acquisition of the full complement of fin spines and rays in all fins and loss of all finfold (last remnants are usually part of the preanal finfold). Provision for taxon-specific prejuvenile (or transitional) phases are also deleted. In some cases, finfold persists through the endpoint for such special intervals, and the intervals are effectively included in the larval period.

Timing of complete yolk absorption varies from well before notochord flexion and initial fin ray formation, as in most fishes with pelagic larvae, to postflexion stages after all or most of the fin rays are formed, as in many salmonids. Accordingly, the interval during which fish larvae bear yolk should not be represented generally as a separate phase preceding phases based on fin formation as it has been treated by Kendall et al. (1984). The Hardy et al. terminology effectively distinguishes between larvae with and without yolk by modifying the period name with the adjective "yolk-sac" when yolk material is present. Any period or phase name of the combined terminology can be similarly modified to indicate presence or absence of yolk material (e.g., yolk-bearing larva, yolk-sac metalarva, postflexion mesolarva with yolk, protolarva without yolk).

The combined terminology is designed to be relatively simple but comprehensive, precise in its transition criteria, applicable to nearly all teleost fishes, and flexible. It can be utilized in part (essentially as one of its component terminologies) or its entirety depending on purposes of the user. For example, if it is necessary to acknowledge only that the fish is a larva and whether it bears yolk, the terms "yolk-sac larva" and "larva without yolk" are all that is needed. Biologists who formerly utilized one of its component terminologies should have no difficulty in adapting to the combined terminology -- essential features and terms of the original terminologies have been retained.

Larva: Period of fish development between hatching or birth and (1) acquisition of adult complement of fin spines and rays (principal and rudimentary) in all fins, and (2) loss beyond recognition of all finfold not retained by the adult.

Protolarva: Phase of larval development characterized by absence of dorsal, anal, and caudal fin spines and rays. (Standard length measured to end of notochord.)

Mesolarva: Phase of larval development characterized by presence of at least one dorsal, anal, or caudal fin spine or ray but either lacking adult complement of principal soft rays in all median (dorsal, anal, and caudal) fins or lacking pelvic fin buds or fins (if present in adult). (Standard length measured to end of notochord or, when sufficiently developed, axial skeleton.)

Preflexion Mesolarva: Among fishes with homocercal tails, phase of mesolarval development characterized by absence of caudal fin rays. (Posterior portion of notochord remains essentially straight and standard length measured to end of notochord. When first median fin ray is a caudal ray, as in most fishes, larva progresses directly from protolarva to flexion mesolarva.)

Flexion Mesolarva: Among fishes with homocercal tails, phase of mesolarval development characterized by an incomplete adult complement of principal caudal fin rays. (Posterior portion of notochord flexes upward and standard length measured to end of notochord.)

Postflexion Mesolarva: Among fishes with homocercal tails, phase of mesolarval development characterized by adult complement of principal caudal fin rays. (Notochord flexion essentially complete and standard length measured to posterior-most margin of hypural elements or plates.)

Metalarva: Phase of larval development characterized by presence of (1) adult complement of principal soft rays in all median fins and (2) pelvic fin buds or fins (if present in adult). (Standard length measured to posterior end of axial skeleton, hypural elements or plates in fishes with homocercal tails.)

Yolk-sac, Yolk-bearing, With Yolk, Without Yolk: Examples of modifiers used with any of the above period or phase designations to indicate presence or absence of yolk material, including oil globules.

CHARACTERISTICS USEFUL IN IDENTIFICATION OF CYPRINIFORM FISH LARVAE

The following discussion of taxonomically useful characters is reprinted with minor modification from Snyder (1981) and Snyder and Muth (1988). Fishes of the families Cyprinidae (minnows and carps) and Catostomidae (suckers) are closely related and morphologically similar. Together the two families account for nearly half of over 50 species in the Upper Colorado River System. Generalizations with respect to the order Cypriniformes refer specifically to North American species of these families. Figures 2 and 3 identify the more obvious morphological features and structures of catostomid (and cyprinid) eggs and larvae.

Identification of fish larvae is in part a process of elimination. Even before examination of a single specimen, the number of candidate species can be substantially reduced by a list of known or likely species based on adult captures in the study area or connected waters. However, there are cases in which the presence of certain species was first documented by collection and identification of larvae. Incidental transport of eggs or larvae from far upstream or distant tributaries also must be considered. Knowledge of spawning seasons, temperatures, habitats, and behavior coupled with information on egg deposition, larval nursery grounds, and larval behavior are also useful in limiting possibilities.

Berry and Richards (1973) noted that "although species of a genus may vary from one geographical area to another, generally

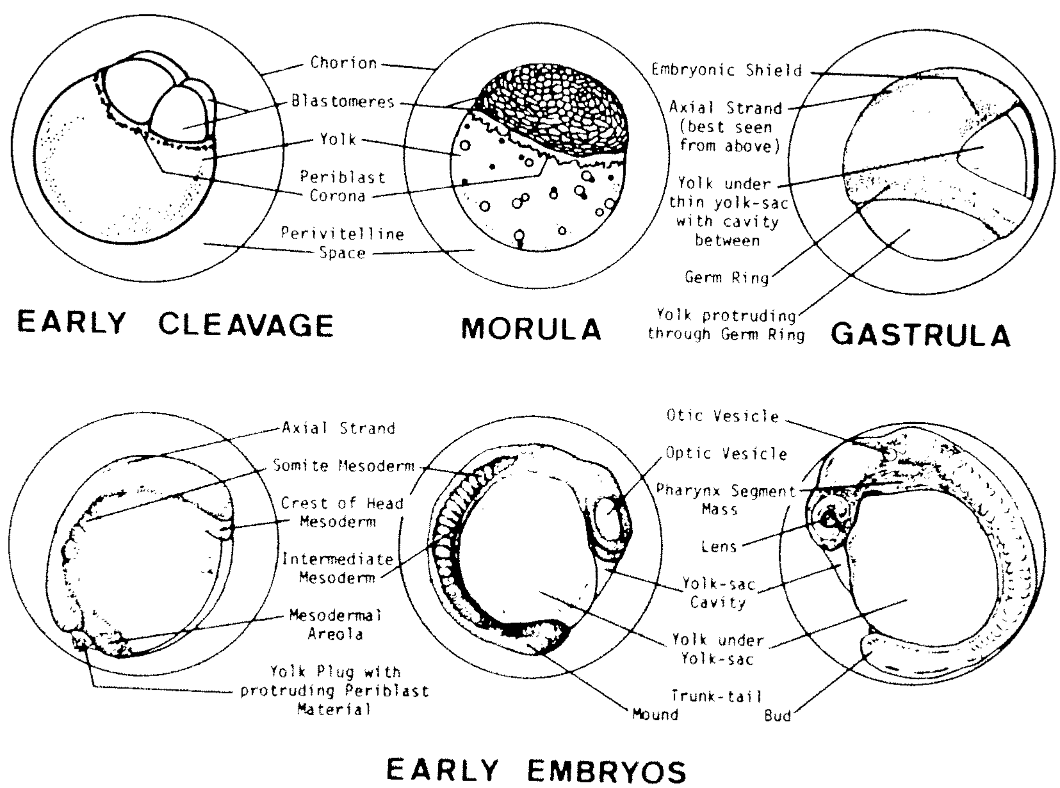

Fig. 2. Selected anatomical features of cypriniform fish eggs and embryos (from Snyder 1981; based on drawings from Long and Ballard 1976).

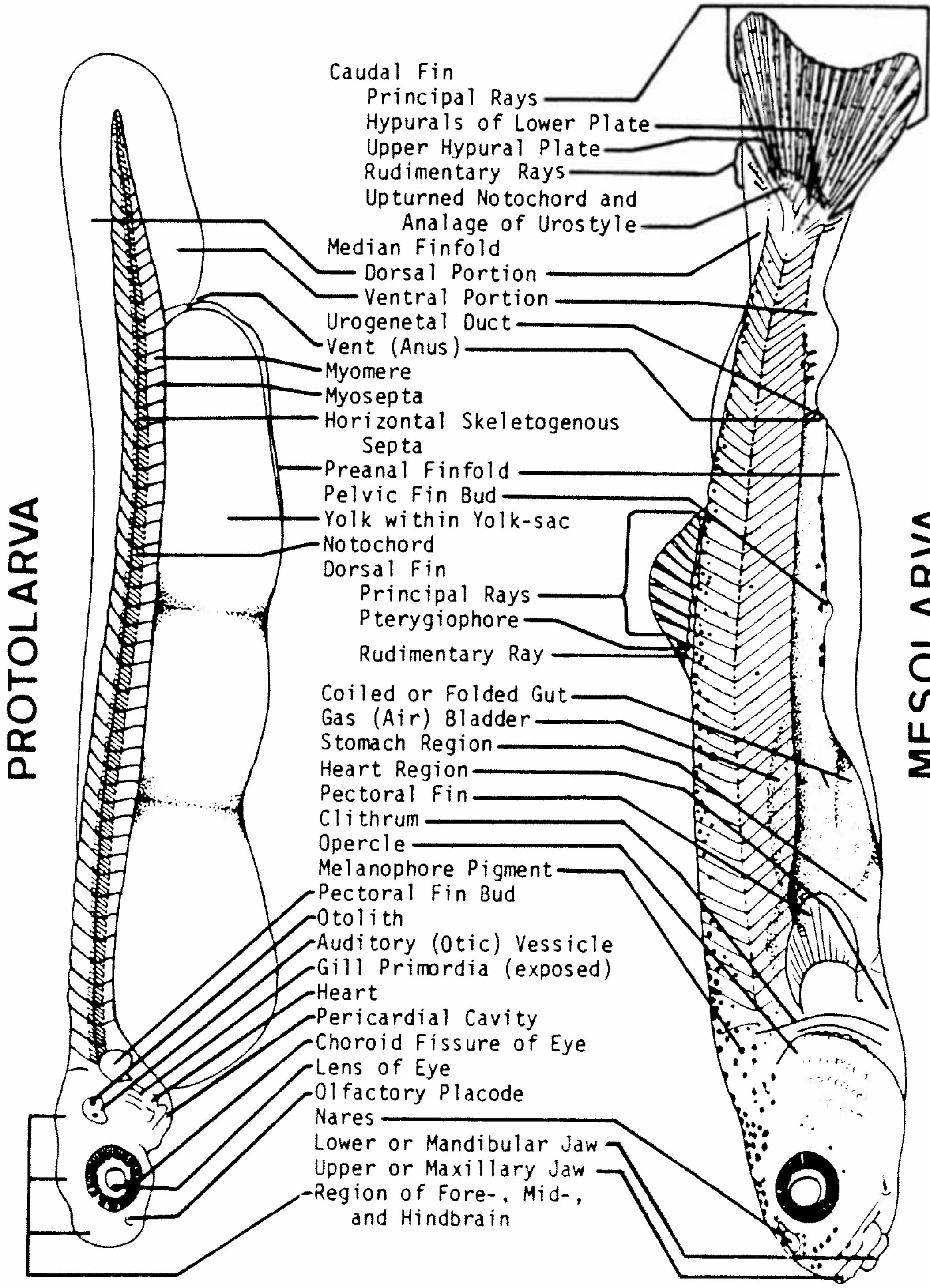

Fig. 3. Selected anatomical features of cypriniform fish larvae (from Snyder 1981).

the larval forms of closely related species look alike. At the same time, larvae of distantly related forms may be closely similar in gross appearance." Cypriniform larvae as a group are distinctive and generally easy to distinguish from larvae of other families. Beginning workers should become familiar with the general larval characteristics of each family likely to be encountered. The guides and keys cited in Snyder (1983b) are most useful in this respect. Auer (1982) is particularly recommended since it covers all families and some species in the Upper Colorado River Basin. Discussions of taxonomic characters by Berry and Richards (1973) and Kendall et al. (1984) are also recommended.

In the Upper Colorado River System, cypriniform larvae are readily categorized as cyprinids or catostomids. But elsewhere, if members of the cyprinid subfamily Cyprininae (carps) and the catostomid subfamily Ictiobinae (carpsuckers and buffalofishes) or tribe Erimyzontini (chubsuckers) are present, identification at the family level can be more difficult.

Within their respective families, and especially at the subfamily level, cypriniform larvae are very homogeneous in gross structure and appearance. Accordingly, they may be especially difficult to discriminate at genus or species levels. This is particularly true of Colorado River System suckers. For the latter, specific identification relies on size at which certain developmental events occur, form of the gut, melanistic (brown or black) pigment patterns, osteological characters, and to a limited extent, morphometrics and meristics (especially dorsal fin ray counts for metalarvae and juveniles).

There is often a noticeable amount of intra- as well as inter-regional variability in many of the characters to be discussed. This variability necessitates confirmation of identity based on as many diagnostic characters as possible.

Myomeres

Myomeres, because they are obvious morphological features and relatively consistent in number and position, are one of the most useful characters available for identification of larvae above (and sometimes at) the species level, especially for protolarvae and mesolarvae. They begin as part of the embryonic somites and are usually formed in their full complement prior to hatching. Throughout the protolarval and much of the mesolarval phase, myomeres are chevron-shaped, but by the metalarval phase they evolve to their typical three-angled adult form. Fish (1932) and many subsequent authors observed that there is a nearly direct, one-to-one correlation between total myomeres and total vertebrae (including Weberian ossicles in cypriniforms). Snyder (1979) and Conner et al. (1980) summarized myomere and vertebral counts for many cypriniform fishes.

The most anterior and most posterior myomeres are frequently difficult to distinguish. The most anterior myomeres are apparent only in the epaxial or dorsal half of the body; the first is often deltoid in shape and is located immediately behind the occiput. The most posterior myomere is defined as lying anterior to the most posterior complete myoseptum. Siefert (1969) describes a "false (partial) myoseptum" posterior to the last complete myoseptum which adds to the difficulty of discerning the last myomere. Early in the larval period, myomeres are most readily observed using transmitted light. Polarizing filters, depending on thickness and certain other qualities of the preserved tissues, can dramatically increase contrast between the muscle tissue of myomeres and the myosepta that separate them. Myomeres of some metalarvae and most juveniles are difficult to observe even with polarizing filters; reflected light at a low angle from one side and higher magnification sometimes facilitates observation.

Typical counts used in taxonomic work include total, preanal, and postanal myomeres. Partial counts are frequently used to reference location of various structures in addition to the vent. The most generally accepted method of making partial counts was described by Siefert (1969) for distinguishing preanal and postanal myomeres: "postanal myomeres include all [entire] myomeres posterior to an imaginary vertical line drawn through the body at the posterior end of the anus . . . Remaining myomeres, including those bisected by the line, are considered preanal." The technique is equally applicable with other structures or points of reference such as origins of fins or finfolds. The opposite approach was used by Snyder et al. (1977), Snyder and Douglas (1978), Loos and Fuiman (1977) and, according to the latter authors, Fish (1932) -- only entire myomeres were included in counts anterior to points of reference. Siefert's method is recommended as standard procedure since resulting counts are expected to more nearly approximate the number of vertebrae to points of reference.

In the United States and Canada, the range of total myomere (and vertebral) counts for cyprinids, 28 to 52, is slightly larger and nearly includes that for catostomids, 32 to 53. Ranges for preanal and postanal myomere counts also overlap with 19 to 35 and 9 to 22, respectively, for cyprinids and 25 to 42 and 5 (possibly 3) to 14, respectively, for catostomids. Despite the magnitude of overlap in these ranges, proportions of postanal to preanal and preanal to total myomeres will distinguish most cyprinids from catostomids (Snyder 1979). The preanal to postanal myomere proportion is at least 2/5 (often greater than 1/2) for cyprinids (exclusive of subfamily Cyprininae, the carps) and less (often less than 1/3) for catostomids. Also, the proportion of preanal to total myomeres is 5/7 or less (often less than 2/3) for cyprinids and greater (often greater than 3/4) for catostomids. For cypriniform fishes in the Upper Colorado River System the degree of overlap in total and preanal myomere counts is less and larvae with fewer than 42 total or 32 preanal myomeres can be cyprinids only.

Fins and Finfolds

Fin ray meristics and fin positions are among the most useful characters for later mesolarvae and metalarvae, especially among the cyprinids. These data can be determined from older juveniles and adults or gleaned from published descriptions of adults. The sequence and timing of fin development, fin lengths, and basal lengths of the dorsal and anal fins are also useful.

The median finfold, one of the most obvious structures in protolarvae and mesolarvae, is a thin, erect, medial fold of tissue that originates on the dorsal surface usually well behind head. It extends posteriorly to and around the end of the notochord, then anteriorly along the ventral surface to the posterior margin of the vent. During the mesolarval phase, the soft-rayed portions of the median fins (dorsal, anal and caudal) differentiate from this finfold. As the median fins develop, the finfold diminishes and recedes before and between the fins until it is no longer apparent during or near the end of the metalarval phase.

The preanal finfold is a second median fold of tissue that extends forward from the vent. In most fishes the preanal finfold is completely separated from the ventral portion of the median finfold by the vent. But in burbot (*Lota lota*), and its marine relatives (Gadidae, codfishes), the preanal finfold is initially continuous with the median finfold and only later are the finfolds entirely separated by the vent (vent initially opens through right side of finfold). The preanal finfold may or may not be present upon hatching, depending upon size and shape of the yolk sac. In cypriniform fishes, it is typically absent or barely apparent upon hatching. As yolk is consumed and the yolk sac decreases in size prior to hatching or during the protolarval phase, a small preanal finfold appears just anterior to the vent. As more yolk is consumed and the larva grows, the preanal finfold enlarges and extends anteriorly. Ultimately, its origin lies anterior to that of the dorsal portion of the median finfold. The preanal finfold remains prominent throughout the mesolarval phase, then slowly diminishes and recedes in a posterior direction during the metalarval phase. It is typically the last finfold to be absorbed or lost.

The caudal fin is the first fin to differentiate from the median finfold in cypriniform and most other fishes with homocercal tails. The portion of the finfold involved first thickens along the ventral side of the posterior end of the notochord and begins to differentiate into the hypural elements of the caudal skeleton. Immediately thereafter, the first caudal fin rays appear (beginning of flexion mesolarval phase) and the posterior portion of the notochord begins to bend or flex upward. Be careful not to confuse striations or folds in the finfold with developing fin rays. As the fin develops and the notochord continues to flex upward, the hypurals and developing caudal fin rays, all ventral to the notochord, move to a posterior or terminal position. The first principal rays are medial and subsequent principal rays form and progressively above below. Principal caudal fin rays articulate with hypural bones of the caudal structure and ultimately include all branched rays plus two adjacent unbranched rays, one above and one below the branched rays. Branching and segmentation of rays can be observed as or shortly after the full complement of principal rays becomes evident and notochord flexion is completed (beginning of postflexion mesolarval phase).

The number of principal caudal fin rays is typically very stable within major groupings of fish. Cyprinids generally have 19 principal rays (ten based on superior hypurals and nine on inferior hypurals), and catostomids usually have 18 principal rays.

Dorsal and ventral rudimentary rays of the caudal fin begin forming sequentially in an anterior direction immediately after all or nearly all principal caudal fin rays are formed. They are often the last group of fin rays among all fins to form their full adult complement. Accordingly, counts of rudimentary caudal fin rays are usually ignored in larval fish identification, but they may be of taxonomic value for juveniles and adults.

The dorsal and anal fins, which typically form either simultaneously (many cyprinids) or dorsal first (most catostomids), usually begin development prior to attainment of the full complement of principal caudal fin rays. Tissue first aggregates in vicinity of the future fin, and basal structures or pterygiophores soon become evident. The latter structures permit limited use of dorsal and anal fin position and meristics about midway through the mesolarval phase. Anterior principal fin rays develop first and subsequent rays are added in a posterior direction. The first rudimentary fin rays (anterior to the principal rays) are frequently evident before all the principal fin rays form. Rudimentary fin rays are added in an anterior direction.

The first or most anterior principal ray in both dorsal and anal fins remains unbranched while all other principal fin rays branch distally as or after ray segmentation becomes evident. The last or most posterior principal ray in each fin is considered to be divided at the base and therefore usually consists of two elements that, except for their close proximity and association with the same pterygiophore, might otherwise be considered as separate fin rays.

Principal dorsal and anal fin ray counts between and within certain genera often vary sufficiently to be of use in identification at the species level, especially anal fin rays of cyprinids and dorsal fin rays of catostomids. Positions of dorsal fin origin (anterior attachment) and insertion (posterior attachment) relative to origin of pelvic fins or fin buds and the vent vary considerably among cyprinids and are useful in identification of genera or species. These position characters are more consistent among catostomids (e.g., dorsal fin origin is always well in advance of the pelvic fins), especially at subfamily level, and therefore, are of less value in identification.

The pelvic fins begin as buds before or upon transition to the metalarval phase. In cypriniform fishes, they originate in an abdominal position along each side of the preanal finfold. They may erupt shortly after dorsal and anal fin development begins or be delayed until just before or shortly after all principal rays are present in the median fins. Pelvic rays begin to form shortly after the buds appear and the adult complement of rays quickly ensues. Among cypriniform fishes, pelvic ray counts are seldom used diagnostically. However, position of the pelvic fins or fin buds, relative to other structures, and their formation in the sequence of developmental events can be useful in identification, especially among cyprinids.

The pectoral fins typically begin as buds immediately behind the head in the late embryo. However, pectoral buds are not evident in some cypriniform fishes until shortly after hatching. Though strongly striated and occasionally with membranous folds and breaks, they typically remain rayless in cypriniforms until late in the mesolarval phase when most of the principal median fin rays are present. With the exception of rudimentary caudal fin rays, the rays of pectoral fins are often the last to establish their full complement. For this reason and because the number of pectoral rays is usually relatively large and difficult to count without excision (especially the smaller ventral rays), pectoral fin ray counts are generally of little value in larval fish identification.

Other Countable Structures

Other structures that may be treated meristically (and in some cases morphologically) include branchiostegals, gill rakers, pharyngeal teeth, and scales. Branchiostegals form early in larval development, but counts are usually constant within major taxon groups. Within the order Cypriniformes, all members of superfamily Cyprinoidea, which includes Cyprinidae and Catostomidae, have three branchiostegals (McAllister 1968). Due to later development, small size or internal location, the other characters are seldom used to diagnose fish larvae. Gill rakers form gradually in postflexion mesolarvae or metalarvae with numbers increasing throughout much of the early portion of the juvenile period. The adult complement of gill rakers on the first gill arch is not achieved in many Catostominae until they reach about 70 mm standard length (Smith 1966). Pharyngeal teeth form relatively early but may not be sufficiently well developed to be readily removed and observed until late in the larval period or early in the juvenile period. Detailed study of gill rakers and pharyngeal teeth might reveal some useful diagnostic qualities, including size, shape, and number. However, most specimens are more easily identified using external characters. Scales typically become apparent late in the larval period or early in the juvenile period. First scales on cypriniforms typically appear midlaterally on the posterior half of the body and from there spread anteriorly, dorsally, and ventrally toward adult coverage. Scales of large-scaled species are sometimes sufficiently obvious by late in the metalarval phase to distinguish certain species or genera.

Morphology

The shape or form of larvae and specific anatomical structures (e.g., gut, air bladder, yolk sac, and mouth) change as fish grow and provide some of the most obvious characters for identification, particularly at family and subfamily levels. Within genera, morphological differences among species are usually much more subtle, but may still be of diagnostic value. Much shape or form-related information can be quantified via proportional measurements or morphometrics.

Morphometric data emphasize the relative position and relative size of various body components and dimensions and may be critical to species identification. Such measurements may be allometric, changing in proportion as the fish grow; thus morphometric data should be related to size, at least for protolarvae and mesolarvae. Some morphometric data, particularly body depths and widths, may be directly affected by the condition of individual specimens and volume and form of food items in their digestive tracts. The source of specimens and the preservative in which they are stored also may affect morphometric data. Some measures in wild fish may differ from those of laboratory reared specimens (e.g., fin lengths). Shrinkage and deformation are notably greater in alcohol than in formalin preservatives.

Morphometric data in this guide are reported as percentages of standard length. Use of standard length avoids the allometric influence of caudal fin growth included in percentages based on total length. As explained later (Methods), data can be easily converted to percent total length for comparison with other works. Prior to hypural plate formation and completion of notochord flexion (protolarvae and flexion mesolarvae), standard length is the length from snout to posterior end of the notochord (notochord length). Thereafter, it is the length from anterior margin of the snout to most posterior margin of the hypural plates (usually the superior plate or hypurals). Use of notochord length for protolarvae and early mesolarvae gives the appearance of greater allometric growth differences than may really exist, at least in comparison with subsequent measures based on posterior margin of the hypural plates. This undesirable effect is a result of upward bending or flexing of the notochord and the switch from use of end of the notochord to posterior margin of the hypurals as the basis for length measurement. These factors must be taken into account when reviewing morphometric data herein.

In contrast to procedures recommended by Hubbs and Lagler (1958) for larger juveniles and adults, measurements of body length and various parts thereof for fish larvae are generally taken along lines parallel to the horizontal axis of the fish. Exceptions are fin lengths, which in studies conducted for this manual were measured from origin of the fin base to most distal margin of the fin rays. Typical measures include total, standard, head, snout, eye, and fin lengths, as well as snout-to-vent and snout-to-origin-of-fin (dorsal, anal and pelvic) lengths.

Snout-to-vent length is measured to the posterior margin of the vent or anus. It is a primary diagnostic character for many species, especially at the family and sometimes subfamily level. In the Upper Colorado River System, most cyprinid larvae are readily differentiated from catostomid larvae by snout-to-vent lengths less than 72% SL. Exceptions are most larvae of common carp (*Cyprinus carpio*) and occasionally mesolarvae of Colorado squawfish. The term "preanal length" is often applied to this measure but might be misinterpreted as length to origin of the anal fin. For many fishes, including cypriniforms, the latter measure is approximately the same as snout-to-vent length since the anal fin begins at or near the posterior margin of the vent.

Head length is typically measured to the posterior margin of the operculum in juveniles and adults, but the operculum may be absent or incomplete throughout much of the larval period. Accordingly, many biologists have redefined head length for larvae to be measured to the posterior end of the auditory vesicle or the anterior or posterior margin of the cleithrum, one of the first bones to ossify in fish larvae (Berry and Richards 1973). Unfortunately, the auditory vesicle and cleithrum are not always easy to observe, especially in postflexion mesolarvae and metalarvae. Also, resultant measures to the auditory vesicle are considerably anterior to the eventual posterior margin of the operculum. Snyder et al. (1977) and Snyder and Douglas (1978) measured larval head length to origin (anterior insertion) of the pectoral fin. This measure has distinct advantages over the alternatives -- the base of the pectoral fin is readily observed throughout the larval period (except in the few species that hatch prior to pectoral bud formation), it somewhat approximates the position of the cleithrum (part of its supporting structure), and it more nearly approximates the posterior margin of the operculum than does the posterior margin of the auditory vesicle. Accordingly, we recommend this definition of head length (Snyder 1983b) and have used it in all our descriptive work. For purposes of consistency, we apply it to juveniles as well as larvae. The measure is most precisely determined while examining the specimen from above or below and, if necessary, holding the fin away from the body.

Body depths and widths are measured in planes perpendicular to the horizontal axis of the fish. Many biologists report these as maximum or minimum measures (e.g., greatest head depth, greatest body depth, and least caudal peduncle depth). However, for comparative purposes, it seems more logical to specify standard reference points for such measures as was done by Moser and Ahlstrom (1970), Fuiman (1979), and Snyder and Douglas (1978). Five specific locations, four corresponding to specific length measurements, are used herein: (1) immediately posterior to eyes, (2) origin of pectoral fin, (3) origin of dorsal fin, (4) immediately posterior to vent, and (5) at anterior margin of most posterior myomere (along the horizontal myosepta). It is often desirable to approximate position of reference points in larvae prior to formation of the referenced structure (e.g., origin of dorsal fin in protolarvae and flexion mesolarvae based on position in later stages). Neither fins nor finfolds are included in depth measurements herein. As mentioned earlier, care must be used in evaluation of depth and width measures affected by body condition and gut contents (e.g., measures at the origin of the dorsal fin).

Other morphological characters such as position, size, and form of the mouth and gut, and related changes, can be among the more useful characters for identification to the species level. Size of the mouth, as well as its position, its angle of inclination, and the form of specific mouth structures are diagnostic for some cypriniforms, especially in metalarvae. Timing of mouth migration from terminal to inferior position can be especially useful for catostomid metalarvae. Gut loop length, timing of loop formation, and eventual degree and form of the gut loops, folds, or coils can be diagnostic for the larvae many fishes. Such characters are especially useful in distinguishing postflexion mesolarvae, metalarvae and early juveniles of certain catostomids.

Pigmentation

Basic patterns of chromatophore distribution, and changes in these patterns as fish grow are often characteristic at the species level. Used with caution, preferably in combination with other characters, and with an awareness of both intra- and inter-regional variation, chromatophore distribution and patterns for many fishes are among the most useful characters available for identification. However, in some instances, differences are so subtle or variation so great that use of pigmentation is impractical and may be misleading.

In cypriniform and most other fishes, chromatophores other than melanophores have not been sufficiently studied for identification purposes. Such chromatophores are typically neither as numerous nor as obvious as melanophores and their pigments are difficult to preserve. In contrast, melanin, the amino acid breakdown product responsible for the dark, typically black, appearance of melanophores (Lagler et al. 1977), remains relatively stable in preserved specimens. However, melanin is subject to fading and bleaching if specimens are stored or studied extensively in bright light for long periods of time, stored in highly alkaline preservatives, or subjected to changing concentrations of preservative fluids. To minimize the latter effects, as well as shrinkage and deformation, dilute formalin solutions (3-5%, unbuffered or buffered to near neutral) are strongly recommended over alcohol solutions as storage media. Most of the following discussion refers to chromatophores in general, but in this manual and others for freshwater species in North America, pigmentation typically refers to that of melanophores.

According to Orton (1953), pigment cells originate in the neural crest region (dorsal portion of body and tail) and migrate in amoeboid fashion in waves to their eventual position. The first wave of chromatophores occurs late in the embryonic period or early in the larval period and establishes a relatively fixed basic or primary pattern of chromatophore distribution. In a few species (mostly marine), such cells acquire pigment prior to chromatophore migration and the actual migration can be observed and documented. But in cypriniform and most other freshwater fishes, pigment is not present in chromatophores until after the cells reach their ultimate destination.

For a specific species and developmental stage, pigmental variation is largely a function of number of chromatophores exhibiting pigment, either in general or in specific areas, and not a change in chromatophore pattern or distribution. Lack of pigment in chromatophores of a particular an area, precludes that portion of the visible pattern. In addition, pigment in chromatophores can be variously displayed from tight, contracted spots, resulting in a relatively light appearance, to widely expanded, reticular networks, resulting in a dark or more strongly pigmented appearance in the affected area. Differences in environmental conditions and food can significantly affect the presence and displayed form of pigmentation. Accordingly, researchers must be aware that pigmentation of cultured specimens can appear quite different from that of field-collected material.

Pigmentation often changes considerably as larvae and early juveniles grow. Most of the change is due to increased numbers and distribution of chromatophores. Observable pigmentation might also be lost from certain areas through loss of pigment in chromatophores, loss of chromatophores themselves, or, in the case of subsurface or internal chromatophores, by growth and increased opacity of overlying tissues. Peritoneal melanophore pigmentation is an obvious character for later stages of some larvae But in late metalarvae and especially juveniles, dark peritoneal pigmentation can be obscured by overlying tissues with silvery iridophores (this silvery pigment often dissipates over time in preservative). If internal melanophore pigmentation is obscured by overlying tissues, it can be observed by selective dissection or careful clearing of specimens.

Osteology

When externally visible characters fail to segregate species conclusively, osteological characters may come to the rescue. While whole-specimen clearing and cartilage- and bone-staining techniques are relatively simple (see Methods), they require much time (a few days, mostly waiting) and a fair amount of attention (monitoring progress and changing fluids). Soft (longwave) X-ray techniques (Tucker and Laroche 1984) may be faster and easier, especially when examining many specimens, but they require appropriate X-ray equipment and a darkroom.

Dunn (1983, 1984) reviewed use of skeletal structures and the utility of developmental osteology in taxonomic studies. Among the first bones to ossify are those associated with feeding, respiration, and orientation (e.g., jaws, bones of the branchial region, cleithrum, and otoliths). The axial skeleton follows with formation of vertebrae and associated bones. Once the axial skeleton is sufficiently established, median- and pelvic-fin supports form, and fins develop. Presence, number, position, and shape of certain bones in many parts of the skeleton can have diagnostic value, even for closely related species. Use of osteological characters for identification of fish larvae has received little attention, but its potential value is great, particularly for confirmation of questionable identities and for species in which external characters are diagnostically inadequate.

SPECIMENS EXAMINED

Cultured specimens were analyzed for each species. Developmental series for all but Utah sucker were reared by the Larval Fish Laboratory from artificially-fertilized eggs during 1978 through 1981. Parental stock for culture of flannelmouth sucker was collected from the Yampa River near Juniper Springs; bluehead sucker from the White River near Rio Blanco Lake; mountain sucker from Willow Creek, headwater tributary to the Elk River (tributary to the Yampa River) northwest of Steamboat Springs; razorback sucker from a gravel pit off the Colorado River near Clifton; and white sucker from a private pond southwest of Fort Collins. Razorback sucker larvae and juveniles were reared also by Dexter National Fish Hatchery in 1982 from Lake Mohave stock. Utah sucker specimens were reared by the Utah Cooperative Fish and Wildlife Research Unit in 1987 from Bear Lake stock.

Wild or field-collected specimens of certain identity were analyzed also for all species except Utah sucker. Flannelmouth, bluehead, and white sucker larvae and juveniles were collected during 1976 through 1979 from the Yampa River from west of Milner to the Lily Park area below Cross Mountain Canyon. Analyzed flannelmouth and bluehead sucker larvae were collected also from the White River between Rio Blanco Lake and Spring Creek. Additional flannelmouth and bluehead sucker specimens were cursorily examined from 1977 through 1979 collections in the Colorado River between Palisade and the Colorado-Utah border and in the Gunnison River between Whitewater and Redlands Dam. Analyzed mountain sucker specimens were collected in 1981 from Willow Creek (and Ways Gulch) in Colorado, and in 1982 through 1986 from the Provo and Spanish Fork Rivers in Utah. Mountain suckers collected in 1973 through 1982 from the Truckee River and Pyramid Lake, Nevada, and in 1966 and 1967 from Rocky Creek, Madison River, and Flathead Creek (all tributaries of the Missouri River) in southcentral Montana were cursorily examined. Partial series of razorback sucker larvae were analyzed from collections in Lake Mohave and a March 20, 1984, collection from the Salt River at Horseshoe Bend in Arizona (the latter were reared at Dexter National Fish Hatchery and stocked a week prior to capture).

Most of the collected and reared specimens were killed and fixed in 10% formalin, then stored in 3% buffered formalin. Some mountain sucker specimens from Montana were preserved in ethyl or isopropyl alcohol solutions. Due to excessive dehydration and shrinkage, none of the latter specimens were analyzed for measures or size relative to developmental state.

All specimens used for morphometric and skeletal analysis, and most of other specimens on which this study is based are maintained in collections of the Larval Fish Laboratory and are available for examination by other researchers. Individual specimen data (counts and measures) are stored in IBM PC-compatible computer files (Lotus 123).

METHODS

Specimen Data and Observations

Specimens were analyzed for counts, measures, developmental state, structural differences, and pigment distribution. Fig. 4 illustrates the various measurements, fin ray counts, and myomere counts that were made on at least two specimens, if available, in each 1-mm TL (total length) interval throughout the larval period of each species. Thereafter, to a length of about 50 mm TL, one or more specimens were similarly processed for each 5-mm interval, if available. Specimens were studied under low-power stereo-zoom microscopes with measuring eyepiece reticles and various combinations of reflected, transmitted, and polarized light. Magnification was adjusted before each series of measurements to calibrate the scale in the eyepiece against a stage micrometer for direct measurement. Measurements were made to the nearest 0.1 mm and occasionally to half that unit. Remeasurement of selected specimens by a second observer indicated that most measurements are repeatable to within 0.1 mm. Most measurements are reported as a percentage of standard length (% SL) but are readily converted to percent total length by dividing the length of interest (as % SL) by total length (AS to PC, as % SL), and multiplying by 100. Some meristic data were obtained from specimens cleared and stained for skeletal study and from available adults.

Size at apparent onset of selected developmental events was documented for fully analyzed and cursorily examined specimens. Selected events were hatching, attainment of eye pigment, formation of pectoral and pelvic fin buds, loss of yolk and preanal finfold, formation of first and last principal fin rays in each of the median fins, formation of first and last fin rays in the paired fins, formation of first and last rudimentary rays of the caudal fin, and initial and complete formation of lateral scales on the body. For each specimen developmental phase (e.g., Protolarva) and extent of gut folding were also determined. The latter was classified as one of five gut phases (Fig. 5). Changes in other structures were only casually noted.

Drawings, including dorsal, lateral, and ventral views, were prepared for the beginning and middle of each larval phase (flexion and postflexion mesolarvae treated as one phase) and the juvenile period (young-of-the-year portion) for all species except white sucker to document typical body form and pigmentation. Enlarged photographs of typical specimens were traced to assure accurate body proportions. Various structures were checked and additional detail was added to drawings while specimens were examined under a microscope. Final drawings were idealized (e.g., closed or frayed fins opened and smoothed and curved bodies straightened). If necessary, melanophore distribution was modified using additional reference specimens to represent a more typical pattern. In addition, pigmentation variation was studied by sketching observed patterns and loosely noting their frequency.

Selected postflexion mesolarvae, metalarvae, and juveniles were cleared and stained for examination of potential osteological characters and vertebra counts as well as to verify fin meristics. Shape and size of the frontoparietal fontanelle, interneurals, and anterior-dorsal maxillary projections; position of mandibles relative to maxillae; and, to a less consistent extent, angle at which the base of postcleithra extend from the cleithra (Fig. 6). Mesolarvae were stained with alcian blue for cartilage and metalarvae and juveniles with alizarin red for bone using the procedures given on the following pages.

Keys were produced with the aid of the DELTA (DEscriptive Language for TAxonomy) system of computer programs (Dallwitz 1974, 1980; Dallwitz and Paine 1986). Characters were encoded using the DELTA format then transformed for use by the program KEY. Due to limitations of the current MS-DOS version of KEY and the numerous overlapping characters of the species considered, output was generated in segments, each restricted to a select set of characters and species. These were then edited to remove repeated branches and phrases and assembled into a complete key for each developmental phase.

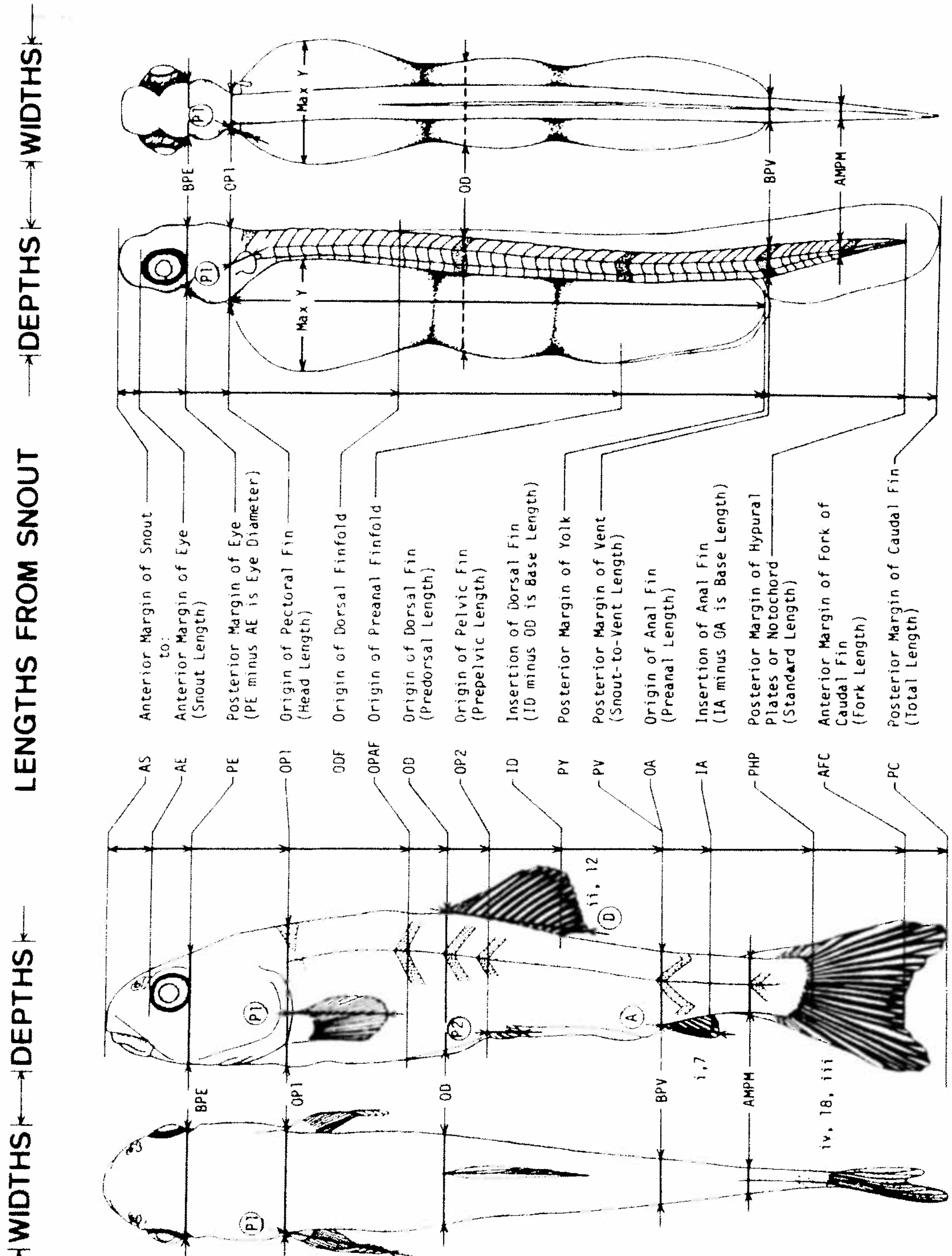

Fig. 4. Measures and counts for larval and early juvenile fishes. Yolk-sac and pterygiophores are included in width and depth measures but fins and finfolds are not. "B" in BPE and BPV means immediately behind. AMPM is anterior margin of most posterior myomere. Location of width and depth measures at OD prior to D formation is approximated to that of later larvae. PHP is measured to end of notochord until adult complement of principal caudal fin rays are observed. Fin lengths (D, A, P1, and P2, encircled) are measured along plane of fin from origin to most distal margin. When reported together, rudimentary median fin rays (outlined above) are given in lower case Roman numerals, while principal median fin rays (darkened above) are given in arabic numerals); rudimentary rays are not distinguished in paired fins. Most anterior, most posterior and last myomeres in counts to specific points of reference are shaded above. (From Snyder 1981.)

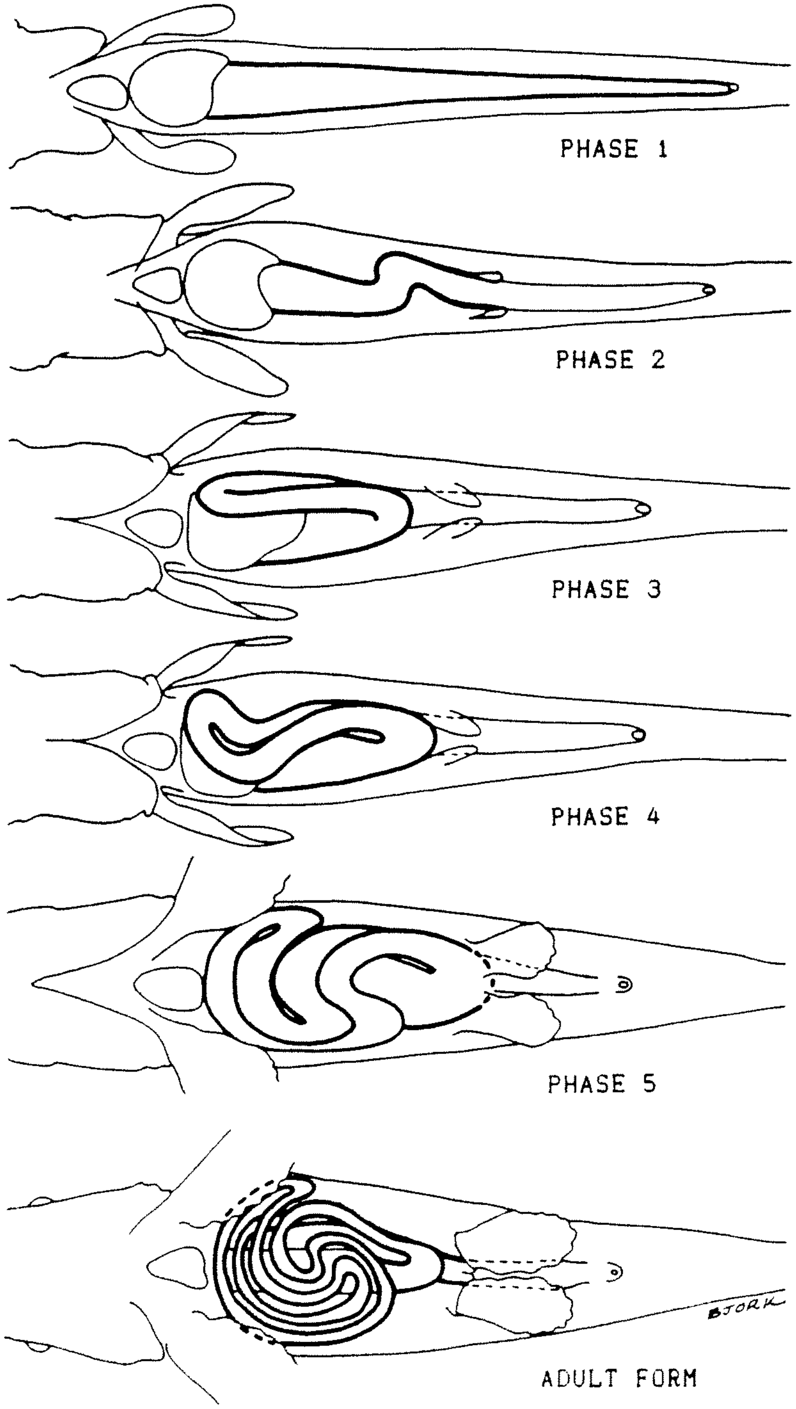

Fig. 5. Phases of gut coil development in catostomid fish larvae and early juveniles with comparison to adult form in *Catostomus commersoni* (latter modified from Stewart 1926). Phase 1 -- essentially straight gut. Phase 2 -- initial loop formation (usually on left side), begins with 90° bend. Phase 3 -- full loop, begins with straight loop extending to near anterior end of visceral cavity. Phase 4 -- partial fold and crossover, begins with crossing of first limb over ventral midline. Phase 5 -- full fold and crossover, begins with both limbs of loop extending fully to opposite (usually right) side, four segments of gut cross nearly perpendicular to the body axis. Later in Phase 5 and in adult form, outer portions of gut folds or coils extend well up both sides of visceral cavity.

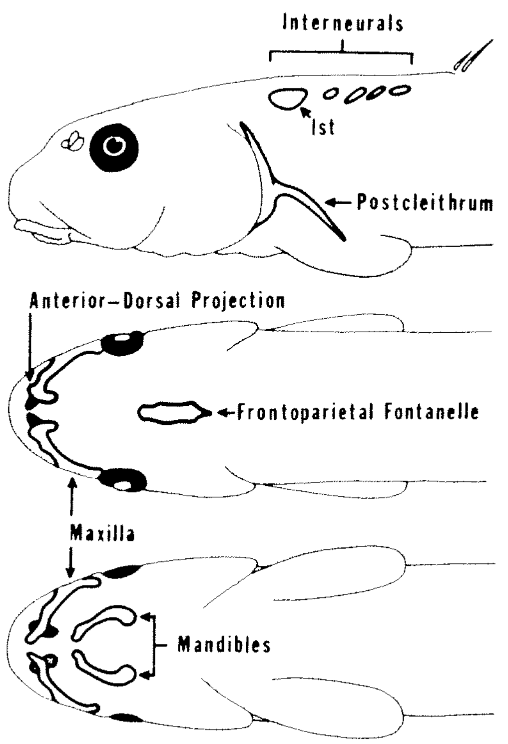

Fig. 6. Location of selected skeletal features of metalarval and early-juvenile catostomids. Top--lateral view. Middle--dorsal view. Bottom--ventral view.

Clearing and Staining Procedures for Skeletal Study of Small Fish

These instructions are modified from Snyder and Muth (1988) and based on procedures detailed by Fish (1932, Method III), Taylor (1967), Potthoff (1984), and Taylor and Van Dyke (1985). See Taylor (1967) and Taylor and Van Dyke (1985) for detailed explanations and discussions of the various steps, factors affecting them, and alternatives.

The procedures that follow are for differential staining of cartilage and bone beginning with living specimens. To begin with previously preserved specimens, stain only for cartilage, only for bone, or clear (make transparent) without staining, skip the relevant steps.

Minimum and maximum times given in the procedures are approximate for single specimens measuring 10 and 25 mm total length, respectively, and processed in 20 ml vials. Times for other sizes and numbers of specimens can be approximated accordingly. Vertebrates as large as 500 mm have been cleared and stained by these procedures but time requirements are considerably greater; clearing alone can take several weeks. Potthoff (1984) provides a diagram of approximate times for specimens 10 to 500 mm standard length. Specimens larger than 30 mm with scales or thick skin may need to be scaled or skinned, or selectively and carefully punctured over the body with a sharp needle, prior to clearing and staining. Some larger specimens may need to be eviscerated. Fatty or oily specimens may need "degreasing" in xylene before staining or clearing and specimens with large amounts of guanine or similar white or silvery substances may needed soaking in 2% or stronger potassium hydroxide solution after clearing by the enzyme method (Taylor and Van Dyke 1985).

Specimens should never occupy more than 25% of solution volume during fixation; lesser percentages (e.g., ≤10%) are recommended. During clearing and staining, results will be better and time requirements may be less if specimens occupy much less than 10% of solution volumes (e.g., down to 2% of solution volume during neutralization and clearing). For specimens 30 mm total length or less, most or all steps can be carried out conveniently in 20 ml or similar-size vials. During each step, periodically turn or move specimens to minimize solution stratification and aid penetration of solutions into tissues of specimens being processed.

For the most reliable results begin with freshly fixed and preserved specimens. Older museum specimens may or may not clear and stain properly depending on original fixative, preservative, and subsequent care. However, properly fixed and preserved specimens should clear and stain nearly as well as fresh material, even after a few decades.

With specific regard to fish embryos and larvae, Taylor and Van Dyke (1985) made the following observations. "The presence of cartilage in embryos and larval fishes is readily determined by this method [differential staining with enzyme clearing]. But, determining the presence and time and/or degree of osteogenesis is more difficult because newly deposited bone mineral is much more labile than mineral that has been deposited for some time. The presence of bone mineral is usually indicated by staining with alizarin Red S. This color may be faint, pink, or bright red in larval fishes with ages from unhatched embryos, through those with complete absorption of the yolk sac or even older. To state in the absence of the red color that osteogenesis or bone development is not present at any of these developmental stages may be incorrect without microscopic examination of tissue structure because bone may be in an early stage of development or the mineral may have been removed during fixation, clearing or staining steps." They further observed that fish larvae with obvious bone, often lose bone stain while in enzyme clearing solution, but that much of it remains in specimens cleared in potassium hydroxide solutions. Accordingly, they recommend that fish larvae be fixed in neutral-buffered (pH 6.5-7.2) formalin and that some be differentially stained for bone and cartilage, while others are stained for bone only and cleared with potassium hydroxide (instead of enzymes) soon after fixation.

Safety: Many of the chemicals and solutions used in clearing and staining can be hazardous and should be handled and disposed of accordingly.

Chemicals: (applicable procedures: FP = fixation and preservation; BL = bleaching; CL = clearing, protein digestion; CS = cartilage staining; BS = bone staining.)

Alcian blue (powder)	CS
Alizarin red S (powder)	BS
Distilled water	ALL
Ethanol (absolute ethanol preferred, denatured or 95% will suffice)	CS
If used as preservative	FP, CL
Formalin (saturated formaldehyde sol.)	FP
Glacial acetic acid	CS
Glycerin (glycerol)	
If used as preservative	CL
Hydrogen peroxide, 3% solution	BL
Potassium hydroxide (KOH)	BL, CL, BS
Sodium borate (powder)	CS, CL
Sodium phosphate monobasic	FP
Sodium phosphate dibasic (anhydrous)	FP
Thymol (crystals) If glycerin is used	CL
Trypsin powder (pancreatic protease, pancreatin; sufficiently purified to be free of collagenase and elastase; trypsin from pig pancreas with an activity of 300 units/mg produces a clear, highly effective solution, but other trypsin preparations with activities as low as 80 units/mg have also been used successfully)	CL

Stock Solutions: (applicable procedures as above.)

10% buffered formalin solution
In distilled water; buffer to pH 7.0 with 4.0 g sodium phosphate monobasic and 6.5 g sodium phosphate dibasic per liter of formalin solution (recommended by Taylor and Van Dyke 1985), or to pH 6.8 with 4 g each of monobasic and dibasic sodium phosphate per liter of formalin solution. The latter is about twice the 1.8 g each of monobasic and dibasic per liter recommended by Markle (1984) for 5% formalin solutions. Formalin solutions can be buffered with excess marble or limestone chips or limestone powder to near neutral, but phosphate buffering is more precise and reliable; borax (sodium borate) buffered formalin is not recommended (Taylor and Van Dyke). FP

3-5% buffered formalin solution
In distilled water; buffer with 1.8 g sodium phosphate monobasic and 1.8 g sodium phosphate dibasic per liter of formalin solution (Markle 1984). Alternatively, fixed specimens can be stored in alcohol (e.g, 75% ethanol via a graded series of concentrations), but expect greater shrinkage, deformation, and, if examined periodically, fading of melanophore pigmentation than if stored in dilute formalin solutions. FP

50% ethanol solution
In distilled water. CS
If used in graded series for specimen preservation (storage). FP, CL

75% (or 70%) ethanol solution
In distilled water if used for specimen preservation. FP, CL

Alcian blue stain solution
20 mg alcian blue per 100 ml of 30% glacial acetic acid in ethanol (solution will keep at room temperature for 3-4 weeks). CS

Saturated sodium borate solution
Excess sodium borate powder in

distilled water; mix well and allow excess sodium borate to settle; use clear supernatant solution. CS, CL

1% Potassium hydroxide (KOH) solution
In distilled water. BL,CL,BS

2% Potassium hydroxide solution
In distilled water.
If KOH clearing used used. CL

Bleaching solution
15% of 3% hydrogen peroxide solution in 1% KOH solution. BL

Trypsin solution
About 0.1-0.2 g (depending on strength or activity level of trypsin) per 100 ml of 30% saturated sodium borate solution in distilled water; mix well but do not allow to froth (Taylor and Van Dyke 1985). Make a fresh solution for each use; it does not keep well.
If enzyme clearing used. CL

Alizarin red stain solution
Dissolve enough alizarin red powder in 1% KOH to turn the solution deep purple (about 0.1 g per 100 ml). Or mix about 1 ml of a saturated alizarin red solution per 100 ml of 1% KOH (saturated alizarin red solution is prepared by dissolving excess alizarin red powder in small amount of distilled water, about 1.5-2.0 g per 20 ml). Alizarin red stain solution will keep at least one week. BS

40% glycerin solution
In 1% KOH (preferred) or distilled water.
If glycerin is used. CL

70% glycerin solution
In 1% KOH (preferred) or distilled water.
If glycerin is used. CL

Fixation and Preservation:

1. Kill and fix specimens in 10% buffered formalin for 24-48 hours.
2. If specimens are to be stored more than a couple days before clearing and staining, preserve them in 3-5% buffered formalin or alcohol (preferably via a graded series of concentrations, e.g., 50% ethanol for 6-24 hours then 75% ethanol). Do not soak in water between fixative and preservative solutions.

Cartilage Staining Procedure:

3. Dehydrate formalin-fixed and preserved specimens in 50% ethanol solution for 6-24 hours, then in 100% or absolute ethanol for 12-24 hours. Replace the absolute ethanol and leave at least another 12-24 hours. A more gradual series of alcohol concentrations can be used, e.g., 50%, 75%, and 100% but is usually unnecessary. If specimens were preserved in alcohol, skip the 50% ethanol step. For embryos and larvae, dehydration is essential to assure minimal loss of bone while in the acid stain for cartilage.
4. Stain specimens in alcian blue stain solution for 6-24 hours, no longer than necessary to adequately stain all cartilage.
5. Rinse specimens in saturated sodium borate solution then soak in fresh saturated sodium borate solution for 6-24 hours to neutralize (change body fluid pH from acid to alkaline).

Bleaching: (Optional)

6. If specimens are heavily pigmented (such that pigments would obscure desired structures), bleach specimens by placing them in bleaching solution and exposing them to strong light until chromatophore pigment is notably faded, about 20 minutes to a few hours.

Initial Clearing:

7. Enzyme method. If specimens were not processed for cartilage staining, soak them in saturated sodium borate solution for 2-12 hours to remove remaining formalin or alcohol and adjust body fluids to well above pH 7. Soak specimens in trypsin solution until 75-90% of the muscle tissue is cleared, typically 1-5 days at 20-30°C, possibly longer depending on specimen volume relative to solution volume and activity or strength of trypsin. Use a volume of trypsin solution at least 10 to 40 times the volume of specimens. Completely change trypsin solution every 2-3 days. This method is preferred for

all fish except embryos and larvae in which some critical bone mineral may be lost. For both freshly fixed and long preserved material, the enzyme method generally provides more consistent results with firmer whole specimens than the KOH method.

or

KOH method. Soak specimens in 2% KOH solution until muscle tissue begins to clear, typically 1 to 12 hours (use 1% KOH for very small and delicate specimens). Monitor specimens closely -- this method of clearing is simpler, less expensive, and tends to be faster than the enzyme method, but it is also more likely to result in fragile specimens with skin that literally splits at the seams if the specimens are inadequately fixed or if digestion of tissues is allowed to go too far. Results are usually better and more consistent if specimens are freshly fixed than if they were preserved and stored for a long time (Taylor and Van Dyke 1985).

Bone Staining Procedure:

8. Stain specimens in alizarin red stain solution until bones are adequately stained, a few hours to one day; monitor specimens closely. Rinse specimens briefly in distilled water.

Final Clearing and Storage:

9. Return specimens to clearing agent (trypsin solution or 1 or 2% KOH solution) until remainder of muscle is adequately transparent (some final clearing will take place in glycerin series if used for storage). Change solution after an hour or two to remove excess stain and continue clearing if necessary. If clearing in KOH solution, monitor specimens closely (this procedure is usually faster and less forgiving than the enzyme method).

10. Specimens may be stored in alcohol (e.g., 75% ethanol), in which they are easier to handle, but "to attain uniformity in clearing and avoid storage problems" (Taylor 1967), most researchers store cleared and stained specimens in pure or 100% glycerin. Glycerin also will reduce or eliminate cloudiness due to water in the remaining soft tissues. In either case, work specimens through at least a minimal graded series to the final concentration, 4-24 hours in each solution (e.g., 50% and 75% ethanol or 40%, 70% and 100% glycerin). If specimens are not as transparent as desired at this point, try adding a 20% glycerin in 1% KOH step to the beginning of the graded glycerin series. Add a few thymol crystals to containers with 100% glycerin to prevent fungus growth.

RESULTS AND CONCLUSIONS

Results are divided into three interrelated sections -- Comparative Summary, Keys, and Species Accounts. Although 445 specimens were analyzed in detail for morphometrics and meristics and hundreds more were documented for size, developmental state, skeletal characters, and pigmentation patterns, there are undoubtedly rare specimens with character extremes beyond those we observed. For example, Kevin Bestgen, an associate studying larvae in the Lower Colorado River Basin, measured reared razorback sucker flexion and postflexion mesolarvae as small as 10 and 11 mm SL, respectively. Those measures are a millimeter less than the smallest specimens we measured and are included in the results that follow. Because of the similarity among larvae of Upper Colorado River Basin suckers, the specific identity of some larvae will remain inconclusive or questionable after application of the keys and diagnostic criteria provided herein. The identity of such specimens must be considered tentative and should be designated as such by use of a question mark ("?") after the more probable taxon name (preferably with a footnote on other possibilities), or leaving the identity at the family level (e.g., "unidentified Catostomidae"). Some inconclusive specimens may be hybrids.

Hybridization among Colorado River System catostomids is well documented (e.g., Holden and Stalnaker 1975, Hubbs et al. 1943, Hubbs and Hubbs 1947, Hubbs and Miller 1953, McAda 1977, McAda and Wydoski 1980, Prewitt 1977, and Smith 1966). Intermediacy of characters for white X bluehead sucker hybrids as small as 25 mm SL and flannelmouth X bluehead sucker hybrids as small as 34 mm SL were documented by Hubbs et al. (1943) and Hubbs and Hubbs (1947) respectively. Using diagnostic characters and descriptive data that follow, hybrid metalarvae and early juveniles might be at least tentatively identified as such; hybrid protolarvae and mesolarvae will likely be identified as the parental species they most closely resemble or remain questionable.

In the species account sections on reproduction, all six suckers are classified according to Balon's (1975a, 1981) reproductive guilds as non-guarding, open-substrate, lithophils. Lithophils prefer to spawn over predominately rock or gravel substrates. Their recently hatched larvae are photophobic and usually hide or remain in the substrate for at least a few days before emerging and drifting with the current. Although considered broad-cast spawners, razorback sucker produce discrete, identifiable redds in reservoirs (Bozek et al. 1984). This may suggest tendency towards a brood-hiding guild.

Comparative Summary

The diagnostic criteria that follow are provided to help confirm identities determined through the keys or, for biologists familiar with the larvae of concern, to serve as a partial alternative to the keys. Since extremes in character states beyond those reported here are likely to occur, identifications should be based on as many criteria as possible.

Size relative to state of development: Flannelmouth sucker eggs are the largest of Upper Colorado River System suckers (3.8-3.9 mm diameter versus 3.3-3.5 for blue-head sucker and 2.3-3.3 for the others) and larvae hatching from them are usually much larger as well. This relative size difference is characteristic of flannelmouth sucker throughout its early development (Table 1). In contrast, razorback, mountain, and some white sucker eggs are notably smaller (2.3-2.8 mm diameter) than other species and their recently hatched protolarvae and recently transformed mesolarvae tend to be correspondingly small. These species also complete yolk absorption at a much smaller size, usually by 12 mm SL; flannelmouth larvae finish their yolk at 15 mm SL.

Size relative to state of development for all species but flannelmouth sucker is nearly the same by the beginning of the metalarval phase. Fin development tends to proceed fastest (at smaller sizes) for white sucker and slowest (at larger sizes) for flannelmouth sucker. White and Utah suckers acquire the adult complement of all fin rays, lose their preanal finfold, and become juveniles at the smallest sizes (19-20 mm SL) while transformation to the juvenile period for some razorback sucker occurs at sizes nearly as large as for flannelmouth sucker (22-23 and 23-24 mm SL, respectively).

Table 1. Comparison of size (mm standard length) at onset or transition of developmental intervals, gut phases, and other developmental events for larvae and early juveniles of Upper Colorado River Basin catostomids. Rare extremes in parentheses. * = "or before hatching."

Character	*Catostomus ardens*	*Catostomus commersoni*	*Catostomus discobolus*	*Catostomus latipinnis*	*Catostomus platyrhynchus*	*Xyrauchen texanus*
Egg diameter:	2.9-3.2	2.6-3.3	3.3-3.5	3.8-3.9	2.3-2.7	2.5-2.8
Phase/period transitions						
Embryo to larva:	(7)8-11	(7)8-10	(8)9-10(11)	(8-)10-11	(7)8	7-9
Proto- to mesolarva:	12-13	10-12	10-12	13	11	(10)11(12)
Flexion to postflexion mesolarva:	13-14	(12)13-15	(11)12-13	15	13-14	(11)12-13
Meso- to metalarva:	15-17	15-16(17)	(16)17	19-20(21)	16-17	15-17
Larva to juvenile:	19-20	(17-)19-20	21-22(23)	23-24(25)	21-22	(21)22-23(24)
Gut phase transitions						
1 to 2 (90° bend):	14-17	14-15(16)	14(15)	(17)18(-20)	14-17	(14)15(-17)
2 to 3 (full loop):	18-19	(16)17-18	15(16)	(19-)21-25(-27)	16-17	17
3 to 4 (partial crossover):	20-22	19-20(21)	(16)17	(22)23-32(-37)	18-20	18-25(26)
4 to 5 (full crossover):	27-28	(20)21-25	(16)17-19(-21)	(29-)35-42	21-23	(22-)26-28(-31)
Onset of selected events						
Eyes Pigmented:	9-10 *	(7)8 *	9-10 *	(9)10 *	8	(7)8(9) *
Yolk Assimilated:	12-13	10-12(-14)	(10-)12-13	15	(10)11	(9)10-11
Finfold Absorbed:	19	(17-)19-20	21-22(23)	23-24(25)	21-22	(21)22-23(24)
Pectoral Fin Buds:	(7) *	(7)8 *	(8) *	(9) *	(7) *	7 *
Pelvic Fin Buds:	13-15	13-15	14	(15)16(17)	13	14
Fin rays first observed						
Dorsal, principal:	13-15	12-13	(11-)13	15	13	14
Anal, principal:	14-15	14-16	14-15	17	16-17	15
Caudal, principal:	12-13	10-12	10-12	13	11	11
Caudal, rudimentary:	14-15	13-15	14	(16)17	14	14
Pectoral:	14-15	14-16	14-15	17	13-15	15
Pelvic:	14-17	15-16	16	17-18	16	15-17
Full fin ray counts first observed						
Dorsal, principal:	14-16	14-16	(14)15	17-18	14-17	15(-17)
Anal, principal:	15-17	15-16(17)	(16)17	19-20(21)	16-17	15-17
Caudal, principal:	13-14	(12)13-15	(11)12-13	15	13-14	12-13
Caudal, rudimentary:	19-20	(17)18	19-20	23	20-21	19-20(-24)
Pectoral:	15-18	16(-20)	16-18(19)	19-22	18-20	16-18
Pelvic:	18-19	16-18	19-20	23	18-20	16-17
Scales, lateral series						
First observed:	21-23	22(23)	28-34	(36)37-39	23-24	24-28
Full series first observed:	24-28	29-31	30-39	39-42	32-36	33-36(37)

Gut folding or coiling proceeds at a faster rate for most bluehead sucker than for other species and at a much slower rate for nearly all flannelmouth sucker. Although gut folding begins only a little later in razorback larvae than in bluehead larvae, it slows during the metalarval phase. As a result, the upper end of the size range for razorback sucker at transition to gut phase 4 overlaps the lower end of the range for flannelmouth sucker.

The size at first appearance of the full series of lateral scales roughly correlates with scale size. The full lateral series of scales appears as early as 24 mm SL for Utah sucker and 29 mm SL for white sucker, both of which have large scales. But it appears no earlier than 39 mm SL for flannelmouth that has very fine scales.

Meristics and morphometrics: Some character differences determined by comparison of species account summaries of meristics and morphometrics are not included in Tables 2 and 3 because corresponding data for an adjacent phase indicate that the differences might not hold up if additional specimens in the size range of concern are analyzed. When comparing morphometric characters, be aware that some characters, especially depths and widths at OD and OP2, are affected by the amount of yolk in early larvae and by health or condition in later larvae and juveniles.

The more useful meristics are counts of lateral line (or series) scales for juveniles in which scales are sufficiently formed; principal dorsal fin rays (and corresponding pterygiophores) and vertebra for late postflexion mesolarvae, metalarvae, and juveniles; and myomeres, both total and to the posterior margin of the vent, for all larval phases (Table 2). White and Utah suckers usually have fewer than 75 lateral rows of scales while bluehead and flannelmouth suckers usually have over 85, and mountain and razorback suckers typically have counts between 75 and 85. Typical counts of principal dorsal fin rays are highest for razorback sucker with 14-15, and lowest for mountain sucker with 10; the other species have typical counts within the 11-13 range. However, when considering observed extremes in these counts, three species have ranges that include the count of 14 and four species include the count of 10.

As would be expected, vertebra counts (based on specimens cleared and stained for cartilage or bone) nearly match or fall within the range of total myomere counts (all larval phases combined). The one notable exception, an upper extreme of 50 vertebrae for the mountain sucker is based on one verified observation over 48. The greater range in values for myomere counts, especially at the lower end, is due to the far greater number of specimens examined for myomere counts (vertebra counts are based on only a few to several observations per species) and the difficulty in observing first and last myomeres in some specimens, especially metalarvae for which polarizing filters are no longer useful. Probably for the latter reason, both total and to-the-vent myomere counts for metalarvae tend to range one or two myomeres less than for protolarvae and mesolarvae. A slightly more anterior vent position in metalarvae (and juveniles) than in earlier larvae might also account for some of the difference in myomere counts to the posterior margin of the vent. Combined total vertebrae and myomere counts are greatest for bluehead and flannelmouth sucker (typically 47 or greater) and least for Utah, white, and mountain sucker (typically 47 or less); razorback sucker

Table 2. Comparison of the more diagnostic differences in meristics for larvae and early juveniles of Upper Colorado River Basin catostomids. Character range is followed by the mean or more typical range. See Fig. 4 for methods of counting myomeres and fin rays. PV = posterior margin of the vent. Vertebra counts include four for the Weberian complex; dorsal fin ray counts are of principal rays; scale counts are of the lateral line or series. Data previously published by other authors is given in parentheses.

Character	*Catostomus ardens*	*Catostomus commersoni*	*Catostomus discobolus*	*Catostomus latipinnis*	*Catostomus platyrhynchus*	*Xyrauchen texanus*
Myomeres to PV						
Proto- and mesolarvae:	35-38, 36-37	34-40, 37-38	37-40, 39	37-40, 39	34-37, 36	37-41, 38-39
Metalarvae:	34-37, 36	34-37, 35	35-38, 37	36-38, 37	32-36, 35	36-39, 37
All larvae:	34-38, 36-37	34-40, 35-38	35-40, 37-39	36-40, 37-39	32-37, 35-36	36-41, 37-39
Myomeres, total						
Proto- and mesolarvae:	45-48, 46	43-49, 46-47	47-49, 48	47-49, 48	43-47, 45-46	46-49, 47-48
Metalarvae:	43-47, 45	44-47, 45	47-48, 47	46-48, 47	43-45, 45	44-48, 46
All larvae:	43-48, 45-46	43-49, 45-47	47-49, 47-48	46-49, 47-48	43-47, 45-46	44-49, 46-48
Vertebrae:	47-48	45-48, 46	47-49	47-50 (44-48)	46-50, 46-48 (45-50, 47-49)	45-47, 46 (42-48, 44-47)
Dorsal fin rays:	10-14, 11-13 (11-13)	10-13, 11-12 (9-15, 10-13)	9-12, 11 (9-12, 10-11)	11-14, 12-13 (10-15, 12-13)	9-11, 10 (8-13, 10)	12-16, 14-15 (12-16, 14-15)
Lateral line scales:	57-68, 62-68 (54-79, 60-70)	56-72, 59-68 (53-85, 56-76)	(78-122, 86-115)	(89-120, 98-105)	76-86 (60-108, 75-97)	(68-95, 76-87)

Table 3. Comparison of the more diagnostic differences in morphometrics for larvae and juveniles (≤40 mm SL) of Upper Colorado River Basin catostomids. Except as otherwise noted for most eye diameters, all data is given as a percentage of standard length. The full range for each character is followed by the mean or more typical range. See Fig. 4 for abbreviations and methods of measurement. HL = head length measured to origin of the pectoral fin (AS to OP1).

Character	*Catostomus ardens*	*Catostomus commersoni*	*Catostomus discobolus*	*Catostomus latipinnis*	*Catostomus platyrhynchus*	*Xyrauchen texanus*
Protolarvae						
Eye diameter:[a]	5-7, 6	5-7, 6	5-6, 5	5-6, 5	6-8, 7	5-6, 6
AS to PE length:	7-9, 8	8-9, 8	6-7, 7	6-9, 7	8-10, 9	7-8, 8
AS to OP1 length:	12-17, 15	13-19, 16	13-15, 14	12-16, 14	16-18, 17	14-17, 16
Yolk length:[b]	49-64, 57	26-63, 51	61-67, 63	54-67, 61	0-67, 47	0-68, 44
Pectoral fin length:[c]	1-8, 5	2-12, 7	3-6, 5	3-9, 6	2-11, 9	3-11, 7
Depth at OD:[b,d]	10-12, 11	8-13, 10	12-17, 14	13-15, 14	10-14, 12	7-13, 10
Width at OD:[b,d]	5-9, 7	5-9, 6	8-12, 10	7-11, 10	6-11, 8	4-9, 6
Max. yolk depth:[b]	3-11, 7	1-11, 6	7-12, 10	9-16, 12	0-13, 5	0-9, 5
Max. yolk width:[b]	5-14, 8	1-10, 6	10-15, 12	9-18, 13	0-14, 6	0-9, 5
Flexion mesolarvae						
Eye diameter, % HL:[a]	34-38, 36	28-38, 34	32-38, 35	32-37, 34	31-38, 35	28-39, 34
AS to PV length:	75-77, 76	76-81, 79	74-79, 77	75-78, 77	75-78, 77	78-81, 79
Yolk length:	0-43, 16	0-50, 18	0-53, 26	23-54, 46	0-14, 3	0-50, 4
Depth at OD:[d]	8-9, 9	8-10, 9	9-12, 10	9-13, 11	10-12, 11	6-11, 9
Max. yolk depth:	0-2, 0	0-3, 1	0-7, 3	2-8, 5	0-1, 1	0-2, 0
Max. yolk width:	0-2, 1	0-4, 1	0-8, 4	1-9, 6	0-2, 0	0-5, 0
Postflexion mesolarvae						
Eye diameter, % HL:[a]	31-38, 34	24-34, 31	24-34, 28	24-35, 27	26-35, 30	27-33, 30
AS to OP2 length:	50-53, 52	52-54, 53	53-57, 55	50-54, 53	52-56, 54	50-54, 52
AS to ID length:[e,f]	60-63, 62	61-64, 63	61-64, 62	62-67, 64	61-64, 62	65-67, 66
AS to PV length:	76-80, 79	78-81, 80	76-81, 79	76-80, 78	77-80, 79	78-84, 81
Dorsal fin (D) length:[f,g]	14-16, 15	16-17, 17	11-17, 15	15-21, 18	11-15, 13	18-21, 19
Dorsal fin base length:[e,f,h]	12-15, 13	12-14, 13	11-14, 12	12-17, 15	11-13, 12	16-18, 17
Yolk length:	0	0	0	0-7, 0	0	0
Metalarvae						
Eye diameter, % HL:[a]	28-33, 30	25-34, 30	22-27, 25	22-25, 24	25-28, 26	24-32, 27
AS to OP2 length:	53-57, 56	54-59, 56	55-61, 58	52-57, 55	53-58, 56	51-58, 56
AS to OD length:	49-52, 50	48-53, 51	49-54, 52	47-51, 49	50-53, 51	47-51, 49
AS to ID length:[f]	64-67, 65	61-67, 65	63-66, 64	62-67, 65	62-65, 63	65-69, 67
Caudal fin length:[i]	18-22, 20	16-26, 21	16-24, 21	17-25, 22	15-20, 18	20-28, 23
Dorsal fin (D) length:[f]	18-20, 19	15-22, 19	17-21, 19	20-24, 22	15-19, 17	21-29, 24
Dorsal fin base length:[f,h]	14-16, 15	12-15, 14	11-15, 13	14-17, 16	11-14, 12	16-21, 18
Juveniles <40 mm SL						
Eye diameter, % HL:[a]	27-32, 30	22-28, 25	21-28, 24	19-26, 23	22-25, 24	21-30, 25
AS to OP1 length:	25-28, 26	24-29, 28	23-27, 25	24-28, 25	24-26, 25	25-31, 28
AS to OP2 length:	55-58, 56	52-59, 57	56-60, 58	52-57, 55	55-60, 57	54-60, 57
AS to OD length:	48-51, 49	48-53, 51	47-54, 51	46-49, 48	48-52, 50	46-52, 49
AS to ID length:[f]	64-66, 65	61-68, 65	62-66, 64	61-66, 65	60-64, 63	65-70, 67
AS to PV length:	73-76, 75	72-78, 76	72-76, 75	72-76, 74	74-78, 75	75-80, 77
Caudal fin length:[i]	23-28, 25	19-24, 22	20-24, 23	21-25, 23	19-23, 21	23-28, 25
Dorsal fin (D) length:[f]	21-26, 24	18-24, 20	19-23, 21	23-26, 24	18-21, 20	23-29, 27
Dorsal fin base length:[f,h]	14-17, 16	13-16, 14	11-16, 13	14-18, 16	12-14, 13	16-20, 18
Depth at OD:	16-22, 20	17-22, 19	16-21, 19	17-22, 19	18-21, 20	18-27, 23

[a] Eye diameter = (AS to PE)-(AS to AE).
[b] Ignore differences in maximum values since they may be affected by developmental state at hatching.
[c] Ignore differences in minimum values since they may be affected by developmental state at hatching.
[d] OD for protolarvae and early flexion mesolarvae is approximated at one-half of standard length (AS to PHP).
[e] Applicable only to specimens with a full complement of dorsal fin pterygiophores or principal rays.
[f] For *Xyrauchen texanus* with a rare count of only 12 or 13 principal dorsal fin rays, lengths for this character may be less than the range reported herein (all specimens analyzed for these measures had ≥14 principal dorsal fin rays or pterygiophores).
[g] Applicable only to specimens with most principal dorsal fin rays formed; ignore differences in minimum values since some data represent specimens with a few fin rays less than the adult count.
[h] Dorsal fin base = (AS to ID)-(AS to OD).
[i] Caudal fin length = (AS to PC)-(AS to PHP), total length minus standard length.

larvae typically has 46 to 48 total vertebrae or myomeres. The number of myomeres to the vent is typically 37 or greater for bluehead, flannelmouth, and razorback sucker, 37 or fewer for Utah sucker, and less than 37 for mountain sucker; white sucker larvae typically have 35 to 38 myomeres to the vent.

For protolarvae and flexion mesolarvae most diagnostically useful measures relate to the amount of yolk remaining as the fish grow (Table 3). By the end of the protolarva phase, mountain and razorback suckers consume most but not all of their yolk and bluehead and especially flannelmouth suckers still retain about half of their original yolk supply by the end of the protolarva phase. All suckers except some flannelmouth complete yolk absorption by the end of the flexion mesolarva phase.

For late postflexion mesolarvae, metalarvae, and juveniles most diagnostic measures relate to the size and position of the dorsal fin. The length of the dorsal fin (from origin of the fin to its most distal margin) and length of the base of the fin correlate well with the number of principal fin rays. As would be expected, these measures are greatest for razorback sucker and least for mountain sucker, but not much larger for bluehead and white suckers. Length to the insertion of the dorsal fin is also greatest for razorback and least for mountain sucker, while length to the origin of the fin is greatest for bluehead sucker, followed by white and mountain suckers, and least for flannelmouth and razorback suckers.

Among the remaining measures, only eye diameter is useful for all developmental intervals. As protolarvae, mountain sucker generally have both the greatest eye diameters and head lengths (measured to the origin of the pectoral fin bud) relative to standard (notochord) length. Bluehead and flannelmouth protolarvae typically have the smallest eyes and heads. For subsequent developmental intervals, differences in eye diameter are best considered as a percentage of head length. For these later stages Utah sucker usually have the largest eyes while flannelmouth sucker continue to average the smallest eyes, although not by much. Head length among juveniles is often greatest for razorback and white suckers and least for bluehead, flannelmouth, and mountain suckers.

In addition to dorsal fin lengths discussed above, pectoral and caudal fin lengths are also useful for specific developmental intervals. Pectoral fin length is sufficiently diagnostic only for protolarvae, and then only with respect to the maximum values for which it is greatest for white, mountain, and razorback suckers and least for Utah and bluehead suc-kers. Caudal fin length is sufficiently diag-nostic only for metalarvae and juveniles; for both intervals, caudal fin length is least for mountain sucker while it is greatest for razor-back metalarvae and both razorback and Utah sucker juveniles.

Lengths from snout to pelvic fin origin and posterior margin of the vent, and body depth at the origin of the dorsal fin are the only remaining length characters considered sufficiently diagnostic to include in Table 3. Snout to pelvic fin origin lengths are applicable only to postflexion mesolarvae and later intervals and, like lengths to the origin of the dorsal fin, are typically greatest for bluehead sucker and least for flannelmouth sucker metalarvae and juveniles, thereby maintaining the pelvic fin origins a more-or-less similar horizontal distance behind dorsal fin origins. For postflexion mesolarvae, length to origin of the pelvic fin is least for Utah sucker but only slightly larger for flannelmouth and razorback suckers. Snout to vent lengths are greatest for Utah and razorback sucker mesolarvae and razorback juveniles.

Body depth measured at the origin of the dorsal fin reflects the amount of yolk remaining in protolarvae and mesolarvae, as noted above, but reflects the health or condition of the fish for later stages and, especially for the larger juveniles, differences in structural depth. The upper end of the range for this measure is notably greater for razorback juveniles and is probably due, at least in part, to enlarging interneural bones behind the head which will eventually form the distinctive predorsal "razor" or keel of older juveniles and adults.

Pigmentation: Capture of these suckers prior to initial eye and body pigmentation is rare. If not pigmented at hatching, at least the eyes and some body pigmentation is usually evident by emergence from the spawning substrate. White and mountain suckers are usually well pigmented by 9 mm SL and Utah, bluehead, and flannelmouth suckers by 11 mm SL (Table 4). Pigmentation throughout early development is generally lightest for flannelmouth and especially razorback suckers.

Of all pigment characters, the most diagnostic for the later larvae and early juveniles of bluehead and mountain suckers is the extent of peritoneal pigmentation (Table 4). In the ventro-lateral region of the peritoneum, sparse to patchy pigment is present in some postflexion mesolarvae as early as 14 or 15 mm SL and uniformly dark pigmentation is present in all metalarvae by 20 to 22 mm SL (Figs. 45-49 and 74-77). In contrast, uniform pigmentation (light or dark) in this region was rare for other species. It was not observed at all for Utah sucker (Figs. 17-21) or in other species less than 35 mm SL, except for rare observations of uniform light pigmentation in razorback juveniles as small as 26 mm SL. Uniform peritoneal pigmentation also is present in the ventral region of some razorback juveniles as small as 29 mm SL but not apparent in other razorback specimens as large as 40 mm SL (observations through surface tissues; specimens were not dissected).

Once melanophore pigmentation is sufficiently established, one of the more useful surface pigment characters is the extent of pigmentation on the ventral midline between the heart region and the vent (Table 5). White and mountain suckers typically have a continuous line of midventral pigment with over 20 melanophores (Fig. 30-32, 34, and 72-73), at least through the larval period. Extension of this pigment line into the branchial region anterior to the heart is common in white sucker but rare in mountain sucker. Among the others, only bluehead sucker occasional have as many melanophores along the ventral midline, but the line is either shorter or distinctly discontinuous (Figs. 44-45). Complete absence of melanophores along the ventral midline is rare among Utah, bluehead, and flannelmouth larvae but common for razorback sucker larvae. Unlike the others, razorback larvae have not been observed to have more than 6 melanophores along the ventral midline (Figs. 85-89).

Table 4. Comparison of size (mm SL) relative to pigmental state (melanin) of eyes and bodies for protolarvae and lateral to ventral regions of the peritoneum for postflexion mesolarvae (P), metalarvae (M), and early juveniles (J, ≤40 mm SL) of Upper Colorado River Basin catostomids. For peritoneal pigmentation, size is preceded by initials for the applicable developmental intervals. The letter "r" indicates that the condition is rare.

Character	*Catostomus ardens*	*Catostomus commersoni*	*Catostomus discobolus*	*Catostomus latipinnis*	*Catostomus platyrhynchus*	*Xyrauchen texanus*
Eye pigmentation, protolarvae[a]						
Unpigmented	≤10	7	≤10	≤10	≤8	≤9
Light to moderate	9-11	7-9	9-11	9-11	8-9	7-10
Dark	≥10	≥8	≥10	≥11	≥8	≥9
Body pigmentation, protolarvae[a]						
Unpigmented	≤11	≤9	≤10	≤10	≤8	≤10
1-12 spots on dorsum	9-12	7-9	9-10	9-11	8-9	8-10
≥13 spots on dorsum	≥11	≥8	≥10	≥11	≥8	≥9
Peritoneal pigmentation[b]						
Lateral, P and M only[c]						
Absent	PM all	PM ≤18	P ≤17	PM ≤22	P ≤14	PM ≤24
Sparse or patchy	PM ≥15	PM ≥14	PM ≤17	PM ≥19	PM ≤22	PM ≥14
Uniformly light	-	-	M 17-19	-	M ≥21	-
Uniformly dark	-	-	M ≥17	-	M ≥21	-
Ventro-lateral surfaces						
Absent (or obscured in J)	PMJ all	PMJ all	P ≤17	PMJ all	PM ≤16	PMJ all
Sparse or patchy	J ≥19	PMJ 16-37	PM 15-17	MJ ≥23	PM 14-18	MJ 20-37
Uniformly light	-	r-J 35-37	M 17-19	r-J ≥35	M 19-21	r-J 26-37
Uniformly dark	-	-	MJ 17-23	r-J ≥38	MJ 20-22	r-J 35-37
Ventral surface						
Absent	PMJ all	PMJ all	PM ≤17	PMJ all	PM ≤21	PMJ all
Sparse or patchy	-	J 22-37	MJ 17-25	MJ ≥22	MJ 17-34	J 23-37
Uniformly light	-	r-J 35-37	MJ 18-25	r-J ≥38	J 26-34	J ≥29
Uniformly dark	-	-	MJ ≥18	r-J ≥38	J ≥26	J ≥32

[a] Some to most specimens of each species will hatch with eyes or eyes and body well pigmented.
[b] Pigmentation of the peritoneum is subsurface and should not be confused with surface or cutaneous pigmentation. Also, pigment might be apparent in the dorsal and dorso-lateral portions of the peritoneum of smaller larvae and should not be interpreted as pigment in the lateral region.
[c] In juveniles, lateral pigmentation of the peritoneum usually is obscured by muscle.

Table 5. Comparison of the more diagnostic melanophore pigmentation patterns for larvae and juveniles (≤40 SL) of Upper Colorado River Basin catostomids. Key to characters and their states is given below. The letter "r" indicates that the character state or range of states it follows is rare.

Character number	*Catostomus ardens*	*Catostomus commersoni*	*Catostomus discobolus*	*Catostomus latipinnis*	*Catostomus platyrhynchus*	*Xyrauchen texanus*
Protolarvae (after pigment is well established)						
1.	3-5	1-2	2-5	3-5	1-3	4-5
2.	1/3	1/2(r)/3	1	1	1/2(r)/3	1/2(r)/3
7.	2-3	1-2	1-3	1-3	1-2	1-3
8.	2-3	1-2	2-3	1-2	2-3	1-2
Flexion Mesolarvae						
1.	3-5	1-2	2-5	3-4	1-2	4-5
2.	1/3	1-3	1	1	1-3	1-3
3.	1-2	2	1-2	1-2	2	1-2
4.	1-2	1-2	1-2	1	1-2	1-2
5.	2	2	1-2	2	1-2	2
7.	2-3	1-3	1-2	2-3	1-2	1-3
8.	1-2	1-3	1-3	1-2	2-3	1-2
9.	1	1-2	1	1-2	1	1
10.	2	2	2	2	2	1-2
11.	1-2	1-2	1-3	1-2	1	1
12.	1-2	1-2	1-2	1	1	1
13.	2-3	2-3	1-3	2-3	2-3	1-3
Postflexion Mesolarvae						
1.	3(r)/4/5(r)	1/2(r)	2-3/4-5(r)	3-4	1/2(r)	4-5
2.	1/2(r)/3	1(r)/2-3	1/3(r)	1/2-3(r)	1(r)/2-3	1/2(r)/3
3.	2	2	1(r)/2	1-2	2	1(r)/2
8.	1-3	1(r)/2(r)/3	2-3	1-3	2(r)/3	1(r)/2-3
9.	1	1(r)/2(r)	1	1(r)/2	1(r)	1
12.	1-2	1-3	1-2/3(r)	1-2	1-3	1-2
13.	2(r)/3	3	2-3	2-3	2-3	2(r)/3
18.	1/2(r)	2	1/2(r)	1-2	1(r)/2	1-2(r)
Metalarvae						
1.	3(r)/4/5(r)	1-2	2-3/4-5(r)	3(r)/4/5(r)	1-3	4(r)/5
2.	1(r)/3	1-3	1/3(r)	1	1-3	1
3.	1(r)/2	2	1-2	1-2	1(r)/2	1/2(r)
6.	1	1	1/2(r)	1	1	1
11.	3	3	3	2(r)/3	3	1(r)/2-3
12.	2(r)/3	1-2(r)/3	3	1(r)/2-3	1-2(r)/3	1/2
19.	1	1/2(r)	1	1/2(r)	1	1(r)/2
20.	1-2/3(r)	1-2/3(r)	1-2	1/2-3(r)	1/2(r)	1(r)/2
21.	1(r)/2-3	1-2/3(r)	1-2	1/2	1(r)/2-3	1/2(r)
Juveniles						
1.	3(r)/4-5	1-3/4-5(r)	3-5	3(r)/4-5	1-2(r)/3/4(r)/5	4-5
2.	1/3(r)	1/2(r)/3	1	1	1/3(r)	1/3(r)
14.	3	2(r)/3	3	2-3	2-3	1-3
15.	2-3	1-2/3(r)	1-2	1-2	1(r)/2-3	1-2/3(r)
16.	1/2(r)	1/3	1	1	1	1
17.	1/2(r)	1-2	1	1	1/2(r)	1
19.	1-2	1-2	1	1(r)/2	1-2	2
20.	1-2/3(r)	1-2/3(r)	1(r)/2	1/2-3<r>	1-2	1-2/3(r)
22.	1-2	1/2(r)	1	1-2	1	2

Key to pigment characters and states:

1. Ventral midline from shortly behind heart region to near vent
    1. with ≥21 melanophores in a continuous or nearly continuous line or narrow band.
    2. with ≥21 melanophores in a shorter or a distinctly discontinuous line.
    3. with 7-20 melanophores.
    4. with 1-6 melanophores.
    5. without pigment.
2. Pigment over ventral to ventro-lateral surfaces of gill covers (opercula)
    1. absent.

   2. present in a distinct oblique row of 3 or more melanophores near or along ventral margin of one or both preopercles.
   3. present but not in distinct oblique rows.
3. Pigment on ventral surface of heart region
   1. absent.
   2. present.
4. Pigment under chin (anterior ventral surface of lower jaw)
   1. absent.
   2. present.
5. Dorsal body pigmentation between head and last myomere
   1. scattered with no distinct lines of melanophores on or lateral (and parallel) to dorsal midline.
   2. including at least a partial distinct line of melanophores on or lateral (and parallel) to dorsal midline.
6. Dorsal body pigmentation between head and last myomere
   1. scattered more or less evenly (with or without emphasis on distinct lines of melanophores on or lateral and parallel to dorsal midline).
   2. scattered but in a blotchy pattern (with or without emphasis on distinct lines of melanophores on or lateral and parallel to dorsal midline).
7. Dorsal midline from shortly behind head to near last myomeres
   1. with ≥25 melanophores in a distinct continuous or nearly continuous line.
   2. with ≥25 melanophores but in one or more shorter segments or a distinctly discontinuous line .
   3. with ≤24 melanophores in one or more short lines, a discontinuous, well-spaced line, or (rarely) with no distinct line of melanophores.
8. Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres
   1. with distinct continuous or nearly continuous lines of melanophores along (parallel to) each side of dorsal midline.
   2. with distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline.
   3. without distinct lines of melanophores along either side of dorsal midline.
9. Melanophores in lines lateral (and parallel) to dorsal midline between head and 2/3 distance to last myomeres mostly
   1. in single file.
   2. in obliquely oriented pairs or groups resulting in a "herring bone" or "tractor tread" pattern.
10. Dorsal surface of head pigmented
    1. only over hindbrain (posterior to middle of eyes).
    2. over both mid- and hindbrain (anterior and posterior to middle of eyes).
11. Lateral surface of body above horizontal myosepta (or lateral midline), exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,
    1. unpigmented.
    2. with 1-5 melanophores.
    3. with ≥6 melanophores.
12. Lateral surface of body below horizontal myosepta (or lateral midline), exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,
    1. unpigmented.
    2. with 1-5 melanophores.
    3. with ≥6 melanophores.
13. Lateral surface of head posterior to eyes
    1. unpigmented.
    2. with 1-5 melanophores.
    3. pigmented with ≥6 melanophores.
14. Pigmentation on lateral surfaces of body above bottom-of-eye level and anterior to vent, exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,
    1. scattered only partially down to the horizontal myoseptum (lateral midline).
    2. scattered fully and evenly down to the horizontal myoseptum with few if any melanophores below the myoseptum.
    3. scattered evenly or in blotchy pattern (continuous with dorsal and dorso-lateral surface pattern) down to horizontal myoseptum and at least partially to bottom- of-eye level below.
15. Pigmentation on lateral to ventro-lateral surfaces of body below bottom-of-eye level, exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,
    1. absent including caudal peduncle.
    2. absent except on caudal peduncle.
    3. present.
16. Lateral surface of body
    1. with no large, distinct, mid-lateral body spots.
    2. with 2 large, distinct mid-lateral body spots, one between head and dorsal fin and the other between pelvic and anal fins.
    3. with 3 large, distinct mid-lateral body spots, one between head and dorsal fin, the second between pelvic and anal fins, and the last on the caudal peduncle near the base of the tail.
17. Pigment outlining scales
    1. absent or light.
    2. bold.

Table 5. Continued

18. Developing dorsal fin
    1. with few (≤5) or no melanophores.
    2. with many (≥6) melanophores.
19. Pigment in dorsal fin
    1. along fin rays with very few, if any, melanophores on membrane between rays.
    2. abundant both along and between rays.
20. Pigment in anal fin
    1. absent.
    2. present but very light with only a few (≤5) melanophores.
    3. present but more prominent with many (≥6) melanophores.
21. Pigment in pectoral fin
    1. absent.
    2. present but very light with only a few (≤5) melanophores.
    3. present but more prominent with many (≥6) melanophores.
22. Pigment in caudal fin
    1. along fin rays with very few, if any, melanophores on membrane between rays.
    2. abundant both along and between rays.

Presence and pattern of melanophores on the ventral to ventro-lateral surfaces of the gill covers can also be diagnostic throughout the early development of these fishes. Such pigment is present on some larvae of all developmental intervals for all species except bluehead and flannelmouth sucker. It is rarely present on bluehead flexion mesolarvae and metalarvae or on flannelmouth flexion mesolarvae. Distinct oblique rows of three or more melanophores are often present along or near the ventral margin of the preopercle of white and mountain suckers (Figs. 31 and 74), but are rarely present for most other species.

Another obvious diagnostic character for protolarvae and mesolarvae is the melanophore pattern of the dorsal surface from behind the head to about two-thirds the distance to the last myomeres. Pigment here tends to be scattered with no distinct lines parallel to the dorsal midline for mesolarvae of most bluehead and mountain suckers (Figs. 44-45 and 72-73). Many flannelmouth and some white sucker mesolarvae have lines of melanophores lateral to the dorsal midline in which the melanophores tend to be in obliquely oriented pairs or groups resulting in a distinctive "herring bone" or "tractor tread" pattern (Figs. 30 and 58).

Extent of lateral body pigmentation is useful for mesolarvae through juveniles. Among flexion mesolarvae, for example, at least a couple melanophores are sometimes present between dorsolateral surface and the horizontal myoseptum of all but flannelmouth and razorback suckers. Even by the metalarval phase, some razorback sucker are still without pigment in this region (Fig. 88). Among juveniles, only white sucker and some Utah sucker display large mid-lateral spots. White sucker have three spots (Fig. 35) while Utah sucker with lateral spots have only two distinct spots anterior to the vent (a faint or indistinct third lateral spot might be apparent in the caudal region of some Utah suckers). The scales of most white sucker and some Utah and mountain suckers greater than 30 mm SL are well outlined with pigment (Fig. 35).

Distribution of pigment in various fins can be diagnostic for later larvae and juveniles. Pigment along the rays of the dorsal and caudal fins is typical of all suckers considered herein. In addition, abundant melanophores on the membranes between dorsal and caudal fin rays are characteristic of all razorback juveniles (Fig. 91) and most razorback metalarvae. In contrast, few melanophores are present on the membranes between caudal fin rays of bluehead and mountain sucker metalarvae and juveniles, dorsal fin rays of bluehead, mountain and Utah sucker metalarvae, and dorsal fin rays of bluehead juveniles.

Mouth characters are important in the diagnosis of adult catostomids. Unfortunately the mouths are insufficiently developed in all but the latest larvae and certain characters remain indistinct in the earliest juveniles (e.g., the lower lip lobes of some bluehead suckers up to 25 mm SL, Table 6).

Mouth position remains terminal for some metalarvae and juveniles of mountain and razorback suckers up to 25 mm SL, but changes to low terminal or subterminal by 19 mm SL for all metalarvae of the other species. Some white, flannelmouth, and razorback suckers have low terminal mouths throughout the metalarval phase and early juvenile period, at least up to 40 mm SL (Figs. 90 and 91). The first subterminal mouths appear as early as 18 mm SL for bluehead metalarvae and as late as 32 mm SL for razorback juveniles. All bluehead sucker juveniles and metalarvae over 19 mm SL have subterminal mouths (Figs. 47-49). Likewise for all mountain sucker greater than 25 mm SL and Utah sucker larger than 31 mm SL.

The median cleft of the lower lip divides the lip of these suckers into two distinct lobes. The cleft is deep in most suckers but is shallow in bluehead and mountain suckers in which it is bridged by a few rows of papillae. Once the lower lips are sufficiently formed to distinguish two lobes, the lower lip lobes of most metalarvae and some juveniles of all species are well separated. This separation continues for some Utah, white, and bluehead sucker up to 25 to 31 mm SL (Figs. 47 and 48), some razorback suckers up to at least 37 mm SL, and many mountain suckers to at least 40 mm SL (Figs. 75-77). The gap closes much more rapidly for flannelmouth sucker with all specimens over 20 mm SL having either adjacent or slightly separated lip lobes (Figs. 61-63). Metalarvae of neither mountain nor bluehead sucker have adjacent or only slightly separated lip lobes; only their juveniles have these traits.

The presence or absence of notches at the corners of the mouth is diagnostic for juveniles as well as adults. For bluehead and mountain suckers, the notches are present and separate the upper and lower lips (Figs. 48 and 49). For the other species, distinct notches are not present and the upper and lower lips are more-or-less smoothly joined (Figs. 62 and 63).

Osteological features can be conclusively diagnostic for late metalarvae and juveniles of razorback sucker, subgenus *Pantosteus*, and subgenus *Catostomus*. Unfortunately these characters, as well as vertebra counts discussed under meristics, require that specimens be cleared and preferably stained for bone (or that the structures of interest be otherwise exposed). They are therefore best used to confirm or refine identities based on more external characters for which special preparation is not required. The frontoparietal fontanelle (opening between the frontal and parietal bones covered with connective tissue) and first interneural bone are observable in some late postflexion mesolarvae while the remaining skeletal characters considered are applicable only to larger metalarvae and juveniles (Fig. 6). Adult descriptions suggest that more detailed study of larval and early juvenile skeletons might reveal additional skeletal differences, but these are probably the more obvious.

As the bones of the skull form, an oval to rectangular fontanelle approximately half as wide as long forms in postflexion mesolarvae and small metalarvae. By 20 mm SL, the fontanelle narrows to a rectangular shape and maximum width less than 45% of maximum length for all but razorback sucker

Table 6. Comparison of size (mm SL) relative to mouth position and lower lip lobe separation for metalarvae (M) and juveniles (J, ≤40 mm SL) of Upper Colorado River Basin catostomids. Size is preceded by initials for the applicable developmental intervals; "r" indicates that the condition is rare.

Character	*Catostomus ardens*	*Catostomus commersoni*	*Catostomus discobolus*	*Catostomus latipinnis*	*Catostomus platyrhynchus*	*Xyrauchen texanus*
Mouth position						
Terminal, above bottom of eye	M ≤19	M ≤18	M ≤17	-	MJ ≤25	MJ ≤25
Low terminal, at or below bottom of eye	MJ ≤31	MJ all	M ≤19	MJ all	MJ ≤25	MJ all
Subterminal, low and not most anterior portion of snout	J ≥23	J ≥19	MJ ≥18	MJ ≥22	J ≥23	J ≥32
Lower lip lobes, median separation						
Indistinct	M ≤18	M ≤18	MJ ≤25	-	M ≤22	-
Well separated	MJ ≤25	MJ ≤31	MJ ≤28	M ≤20	MJ all	MJ ≤37
Slightly separated	MJ ≥18	MJ 17-31	J ≥22	MJ all	J ≥23	MJ 20-37
None, adjacent	J ≥22(r)	MJ ≥17	J ≥22	MJ ≥22	J ≥26(r)	MJ ≥20

(Table 7, Fig. 7). Beyond 20 mm SL, fontanelle length increases proportionately with body length, but width and shape vary with species. Width generally increases in razorback sucker and maintains a more-or-less oval shape, decreases in mountain sucker, and remains relatively constant in the others (greatest in Utah sucker and least in bluehead sucker). For specimens 35-46 mm SL, fontanelle width remains greater than 45% of length in most razorback sucker (rarely as low as 43%), drops to less than 25% in mountain sucker, and ranges between 25 and 45% in the others (generally lowest in bluehead sucker). Observations for Utah sucker may be suspect due to poor culture conditions and growth rates (Appendix C, Snyder and Muth 1988).

Adult descriptions of the subject species reveal that the fontanelle is significantly reduced or lost only in bluehead and mountain suckers. Smith (1966) reported that the fontanelle of bluehead sucker is usually reduced in juveniles and closed in adults, while that of mountain sucker adults is usually reduced to a narrow slit but occasionally obliterated. To document, preliminarily, changes in fontanelle shape and size toward the adult condition, we cleared and stained one 76 to 81 mm SL yearling for each species except Utah sucker (specimen not available). Based on these solitary observations (Table 7), the fontanelle continues to grow in both length and width in razorback sucker and maintains its larger width-to-length ratio (45%). The fontanelle increases significantly only in length for white, flannelmouth, and bluehead suckers, resulting in decreased width-to-length ratios (25-26% for white and flannelmouth and 19% for bluehead sucker). Only in mountain sucker was the fontanelle closed. More yearling and older specimens

Table 7. Comparison of frontoparietal fontanelle size for selected length groups of larval and juvenile catostomids of the Upper Colorado River Basin. "N" is number of specimens examined.

Size group Character	*Catostomus ardens*	*Catostomus commersoni*	*Catostomus discobolus*	*Catostomus latipinnis*	*Catostomus platyrhynchus*	*Xyrauchen texanus*
17-19 mm SL, n	2	2	4	3	0	3
Width, mm	1.0-1.2	0.8-1.0	0.6-0.9	0.8-1.2		1.0-1.2
Length, mm	2.0-2.2	2.0-2.2	1.4-1.8	1.2-2.0		1.7-1.9
Width/length, %	45-60	40-45	41-50	50-67		59-63
20-21 mm SL, n	1	2	2	3	2	5
Width, mm	0.9	0.6-0.8	0.5-0.9	0.6-0.7	0.6-0.8	1.0-1.3
Length, mm	2.1	1.9-2.1	1.7-1.7	1.8-2.0	2.2-2.2	1.8-2.1
Width/length, %	43	32-38	29-35	33-35	27-36	52-68
22-25 mm SL, n	2	1	3	3	1	2
Width, mm	0.9-0.9	0.8	0.5-0.8	0.8-0.8	0.7	1.0-1.3
Length, mm	2.3-2.4	2.0	1.3-2.8	1.8-2.1	2.2	1.9-2.1
Width/length, %	38-39	40	29-38	38-44	32	53-62
26-34 mm SL, n	3	2	2	2	1	2
Width, mm	1.0-1.0	0.8-0.8	0.6-0.7	0.7-0.8	0.5	0.9-1.3
Length, mm	2.3-2.4	2.3-2.6	2.0-2.2	2.2-2.3	2.1	2.1-2.3
Width/length, %	42-43	31-35	27-35	30-36	24	43-57
35-46 mm SL, n	1	1	1	1	2	3
Width, mm	1.1	0.9	0.7	0.7	0.4-0.5	1.1-1.7
Length, mm	2.7	3.0	2.7	2.3	2.5-2.7	2.3-3.4
Width/length, %	41	30	26	30	15-20	48-50
All 22-46 mm SL, n	6	4	6	6	4	7
Width, mm	0.9-1.1	0.8-0.9	0.5-0.8	0.7-0.8	0.4-0.7	0.9-1.7
Length, mm	2.3-2.7	2.0-3.0	1.3-2.8	1.8-2.3	2.1-2.7	1.9-3.4
Width/length, %	38-43	30-40	26-38	30-44	15-32	43-62
76-81 mm SL, n	0	1	1	1	1	1
Width, mm		0.8	0.7	1.0	0.0	2.3
Length, mm		3.1	3.7	4.0	0.0	5.1
Width/length, %		26	19	25	0	45

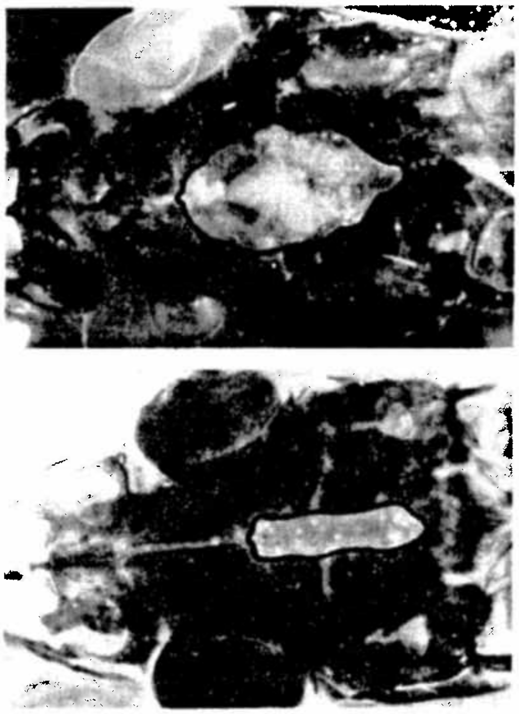

Fig. 7. Frontoparietal fontanelles of early juveniles. Top – *Xyrauchen texanus*; wide and oval. Bottom – *Catostomus* species; moderately wide to narrow and rectangular.

must be examined to determine if fontanelle closure is typical of mountain sucker populations in the Upper Colorado River Basin.

The large, fan-shaped, first interneural bone of razorback sucker metalarvae and juveniles over 16 mm SL readily distinguishes it from the other species (Fig. 8). By late in the metalarval phase, the smaller interneurals posterior to the first also develop enlarged or flared tops. The interneurals eventually form the skeletal basis for the unique predorsal keel or "razor" of the razorback sucker (Fig. 94). By 20 mm SL, the first interneural also segregates the remaining species according to subgenera. Subgenus *Catostomus* (Utah, white, and flannelmouth suckers) have moderate to large, anvil-shaped first interneurals with moderate to long posterior extensions (especially long in flannelmouth sucker). Subgenus *Pantosteus* (bluehead and mountain suckers) have smaller, somewhat blocky first interneurals with short to moderate posterior extensions.

Position of mandibles relative to maxillae also are diagnostic for subgenus *Pantosteus*. For juveniles and metalarvae greater than 22 mm SL, the anterior margins of the mandibles are closer to the posterior ends of the maxillae in bluehead and mountain suckers (Fig. 9). For the other species, they are closer to the anterior ends of the maxillae. However, by about 40 mm SL, at least some flannelmouth suckers have anterior margins

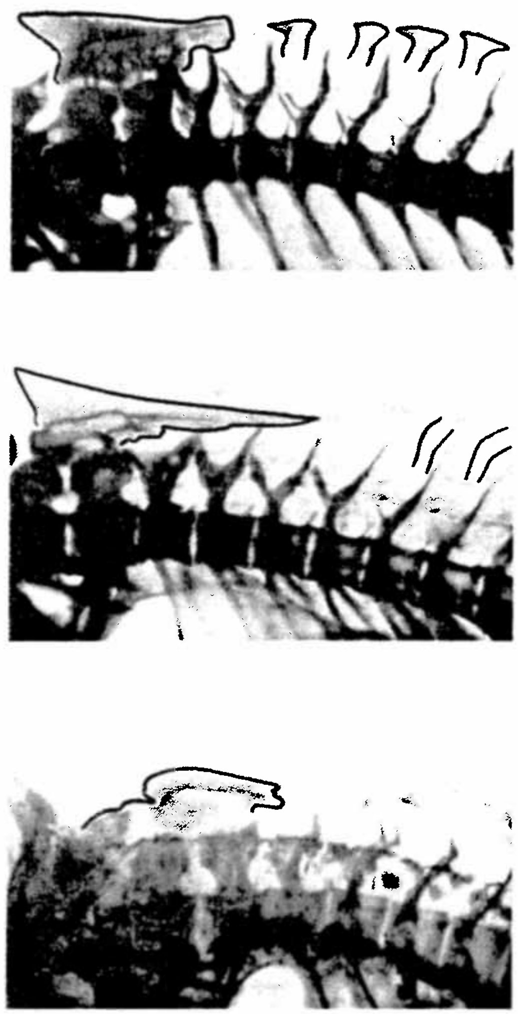

Fig. 8. Interneural bones of late metalarvae and early juveniles. Top – *Xyrauchen texanus*; first interneural large and fan-shaped; posterior inter-neurals well formed and flared dorsally. Middle – subgenus *Catostomus*; first interneural moderate to large, anvil-shaped with prominent posterior extension. Bottom – subgenus *Pantosteus*; first interneural smaller and more blocky with short to moderate posterior projection.

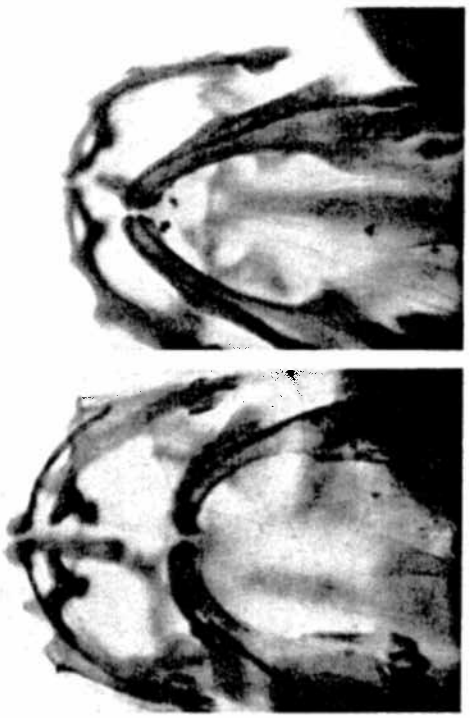

Fig. 9. Position of mandibles relative to maxillae of late metalarvae and only juveniles. Top -- *Xyrauchen texanus* and subgenus *Catostomus*; anterior ends of mandibles far anterior to posterior ends of maxillae. Bottom -- subgenus *Pantosteus*; anterior ends of mandibles slightly anterior to posterior ends of maxillae.

of the mandibles positioned about midway between anterior and posterior ends of the maxillae.

Shape and size of anterior-dorsal projections on the maxillae are diagnostic for razorback sucker and subgenus *Pantosteus* greater than 22 mm SL, sometimes smaller. The anterior-dorsal projections of the maxillae are very shallow to almost absent in razorback sucker, relatively long and pointed (at least as deep as wide at the base) in bluehead and mountain suckers, and intermediate (prominent but blunt and less deep than wide at the base) in subgenus *Catostomus* (Fig. 10).

The angle at which the postcleithrum extends from the cleithrum was initially suspected to be diagnostic for subgenus *Pantosteus*, about 90° for bluehead and mountain suckers and variable, but usually much less for the others (Fig. 11). However, the differences in this character are not always distinct, and perceived postcleithral angle can be affected strongly by angle of view. This character needs further study.

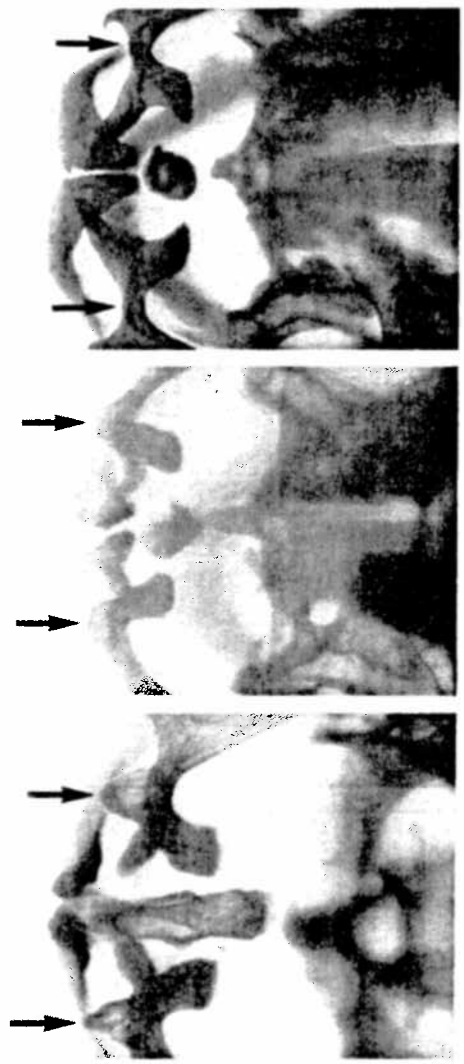

Fig. 10. Anterior-dorsal maxillary projections of late metalarvae and early juveniles. Top -- *Xyrauchen texanus*; very shallow to flat. Middle -- subgenus *Catostomus*; short and blunt. Bottom -- subgenus *Pantosteus*; long and more pointed.

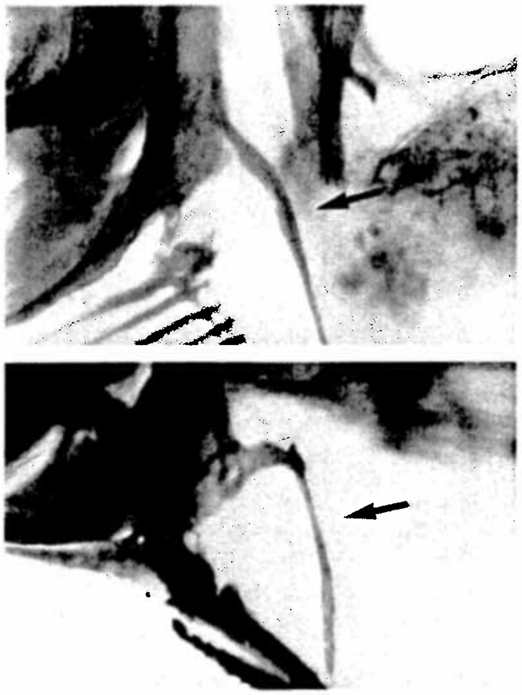

Fig. 11. Postcleithra of late metalarvae and early juveniles. Top -- *Xyrauchen texanus* and subgenus *Catostomus*; postcleithrum base often extends from cleithrum at much less than 90° angle. Bottom -- subgenus *Pantosteus*; often extends from cleithrum at about 90° angle.

Keys -- Upper Colorado River Basin Catostomids

The continual change in available characters and character states and similarity of species during larval and early juvenile development are accommodated by separate keys for eggs, each of four larval phases, and early juveniles up to 40 mm SL (about 50 mm TL). Users must begin by determining the developmental interval of the specimen in question: embryo (egg), protolarva, flexion mesolarva, postflexion mesolarva, metalarva, or early (young-of-the-year) juvenile -- see preceding section on developmental interval terminology for complete definitions. Users must then determine standard length since each key begins with size dependent characers. Although the polychotomous keys are necessarily long and complex, often with multiple paths leading to the same concluion, most specimens will require no more than several steps to reach a terminus. Supplemental keys based on selected skeletal characters are provided to confirm or better resolve the identity of postflexion mesolarvae, metalarvae and juveniles (specimens must be cleared and preferably stained).

A discussion of characters useful in identification of cypriniform larvae and diagrams of anatomical features, methods of counts and measures, gut loop phases, and selected skeletal structures (Figs. 2-6) precede results. The discussion of cypriniform characters includes criteria for distinguishing the families Cyprinidae and Catostomidae (see especially fins and finfolds, last paragraph on myomeres, and fifth paragraph on morphology). A comparative summary of diagnostic characters and species accounts immediately precede and follow this section, respectively. The species accounts include full sets of dorsal, lateral, and ventral view drawings. Users of the keys should be familiar with this material before proceeding.

The drawings in the species accounts are frequently referenced in the keys, especially to illustrate specific patterns of melanophore pigmentation. However, referenced figures are <u>not</u> necessarily of the species, developmental state, or size appropriate to the portion of the key in which the reference is made. Each spot of black or brown pigment (melanin) represents a melanophore. In the keys, melanophores refer only to those with visible pigment (other melanophores may be present but lack pigment or sufficient amounts to be obvious under low power magnification).

These keys require the use of a low-power microscope and some means of measuring to the nearest 0.1 mm, e.g., pointed dial calipers, graduated mechanical stage, or measuring eyepiece reticle with a stage micrometer disc or slide for calibration. If using the latter, be sure to set focus before calibration; any subsequent changes in focus or magnification will require recalibration. If using a zoom microscope and eyepiece reticle, the scale can be calibrated for direct millimeter measurement. A 10 mm reticle scale in a 10X eyepiece focused on the specimen (or stage micrometer) with precisely 1X of objective magnification will measure 10 mm (note that zoom control magnification scales may not be accurate). At 0.5X objective magnification, the reticle scale will measure 20 mm (each 0.1 division then equals 0.2 mm). If the specimen is not too large, adjustment of magnification to calibrate the reticle scale to standard length (Fig. 4) of the specimen will allow direct measurement of specific structures or dimensions as a percentage of standard length.

Except for fin lengths, measurements are made parallel or perpendicular to the body axis (Fig. 4). Specimens must be completely submerged in fluid (usually water) and positioned such that their body axis is horizontal. Flat pieces of glass can be used to prop or hold-down a specimen. For fish which taper from head to tail or have a pectoral fin preventing it from lying flat on the bottom of a dish, try suspending the head and part or most of the body over the edge of a sufficiently thick piece of glass. Lay another, smaller and thinner piece of glass over the tail to hold the specimen in position. Curved or bent specimens that can't be straightened or gently flattened under a cover slip or thicker piece of glass can be measured in sections along the horizontal axis. Specimens larger than the range of the measuring devise also can be measured in sections. Measurement units are the nearest whole or tenth of a millimeter (e.g., a 12 mm specimen covers the range 11.50 to 12.49 mm, and a measure of 6.5 more precisely measures between 6.450 and 6.549).

Some keys require myomere counts (lateral muscle segments; Fig. 3-4). For accurate counts, the first myomere must be identified and included. It is partial (epaxial, dorsal only), sometimes deltoid or triangular in shape, and located above and often slightly anterior to the cleithrum or base of the pectoral fin (Fig. 4). To observe myomeres, experiment with both reflected (from above) and transmitted (from beneath) light. For small, somewhat translucent specimens, bright transmitted light will pass through the larva and make myomeres more visible. In many cases, the addition of a pair of polarizing filters will actually highlight individual myomeres, including the first. One polarizing lens is placed between the light source and specimen (under the dish) and the other is positioned or held between the specimen and the objective lens of the microscope. The highlighting effect is achieved by rotating the upper lens until the background is black or as dark as possible. Only light waves that are turned 90° as they pass through the larva are observed. The position of the specimen relative to the plane of light passed by the lower filter is important as well. Once background light is minimized, rotate the specimen itself, or the dish, for optimal effect. For larger or more opaque specimens, reflected light at a low to near-horizontal angle casts shadows that help define myomeres.

Fin ray counts also are required for some keys. Developing fin rays must not be confused with folds or creases in the finfold or membrane, or with the skeletal structures that precede and support median fin rays, i.e., the hypural elements of the caudal fin and pterygiophores of the dorsal and anal fins (Fig. 3). The hypural elements eventually fuse and form the hypural plates. Externally, the upper or articulating ends of pterygiophores appear as small nodules at the base of the developing dorsal and anal fins. Since pterygiophores appear before the rays they support and since there is a one to one correspondence between pterygiophores and principal fin rays, pterygiophore counts can substitute for principal dorsal and anal fin counts near the end of the mesolarval phase. Also use them to determine presence of all principal dorsal or anal rays (a requirement for transition to the metalarval phase).

For median fins, principal rays also must be distinguished from rudimentary rays (Figs. 3 and 4). Principal dorsal and anal fin rays include all branched rays and the long unbranched ray preceding them. Principal caudal rays include all branched rays and the long unbranched rays immediately above and below them. Terminal branching for some principal rays of the dorsal and anal fins might not be evident until late in the metalarval phase, but the pterygiophores associated with them are obvious on close examination. The most posterior principal ray for dorsal and anal fins consists of two elements that articulate with the last pterygiophore. By convention, these elements are said to branch at the base and are counted together as one principal ray. In early metalarvae, the most posterior element of the last ray is often difficult to observe. Again, rely on the association between principal dorsal and anal fin rays and their pterygiophores to confirm counts. All fin rays are included in pectoral and pelvic fin ray counts. Do not mistake the spine-like pelvic splint at the leading edge of the pelvic fin for a fin ray. Transmitted light and polarizing filters are useful in observing pterygiophores and fin rays.

Keys are seldom perfect. When a specimen is near the boundary between developmental phases, use the adjacent key to help confirm results of the proper key. Similarly, within keys, if a character state is nearly borderline or if the user is unsure which of the criteria the specimen meets, try both branches of the key. In either of these situations, if the conclusions are different, and remain so after review, either the identity via the more appropriate key or branch should be considered tentative (add a question mark, "?", to the name and footnote other possibilities) or the identity of the specimen should be left in question (label to family or genus only). When character states are so similar between species that positive diagnosis is not possible (based on characters studied), the keys conclude with two or more possible species. As previously noted, some of these specimens might be hybrids. Use both the comparative summary and species accounts to help confirm conclusions reached through these keys. Non-morphological data, such as collection date and location, can be used sometimes to delimit possible species (e.g., neither Utah, white, nor razorback sucker have been reported in the White River in

Colorado -- Snyder 1981, Tyus et al. 1982). However, such data must be used cautiously. Positively identified fish larvae are often the basis for revision of previous assumptions regarding spawning seasons and grounds, larval drift or migration, nursery habitat, and sometimes species distribution. The authors appreciate notification of errors, misleading criteria, or problems uncovered by users, as well as suggestions for revisions.

Eggs -- water hardened (embryos with pigmented eyes can be removed from the chorion and further identified using the key for protolarvae).

1. Diameter (maximum)
   - a. 2.3-2.4 mm .... *C. platyrhynchus*
   - b. 2.5 mm .... *C. platyrhynchus*, *X. texanus*
   - c. 2.6-2.7 mm .... *C. commersoni*, *C. platyrhynchus*, *X. texanus*
   - d. 2.8 mm .... *C. commersoni*, *X. texanus*
   - e. 2.9-3.2 mm .... *C. ardens*, *C. commersoni*
   - f. 3.3 mm .... *C. commersoni*, *C. discobolus*
   - g. 3.4-3.6 mm .... *C. discobolus*
   - h. 3.7-3.9 mm .... *C. latipinnis*

Protolarvae -- no caudal fin rays (definition abbreviated for species of concern; Figs. 3, 4, 14, 15)

1. Standard (notochord) length (SL; Fig. 4)
   - a. 7 mm 2
   - b. 8 mm 4
   - c. 9 mm 7
   - d. 10 mm 12
   - e. 11 mm 15
   - f. 12 mm 19
   - g. 13 mm 21

2 (2). Eyes
   - a. unpigmented .... *C. ardens*, *C. commersoni*, *C. platyrhynchus*, *X. texanus*
   - b. lightly to moderately pigmented (Figs. 70, 84) 3

3 (2). Body
   - a. unpigmented (Fig. 84) 129
   - b. sparsely pigmented, ≤12 melanophores (spots of black or brown pigment) on dorsal surface (Fig. 70) .... *C. commersoni*

4 (1). Pectoral fin buds
   - a. absent .... *C. discobolus*, *C. latipinnis*
   - b. present (Figs. 70, 84; buds initially form as minute crescents high on anterior surface of yolk sac and are later above and anterior to yolk sac) 5

5 (4). Eyes
   - a. unpigmented .... *C. ardens*, *C. discobolus*, *C. platyrhynchus*, *X. texanus*
   - b. lightly to moderately pigmented (Figs. 70, 84) 142
   - c. darkly pigmented (Fig. 71) 6

6 (5). Body
   - a. unpigmented to sparsely pigmented, ≤12 melanophores (spots of black or brown pigment) on dorsal surface (Fig. 70) ... 93
   - b. moderately to well pigmented, ≥13 melanophores on dorsal surface (Fig. 71) 24

7 (1). Yolk
   - a. present 8
   - b. absent .... *X. texanus*

8 (7). Pectoral fin buds
   - a. absent .... *C. latipinnis*
   - b. present (Figs. 70, 84) initially form as minute crescents high on anterior surface of yolk sac and are later above and anterior to yolk sac) 9

9 (8). Eyes
   - a. unpigmented .... *C. ardens*, *C. commersoni*, *C. discobolus*, *C. latipinnis*, *C. platyrhynchus*, *X. texanus*
   - b. lightly to moderately pigmented (Figs. 70, 84) 10
   - c. darkly pigmented (Figs. 71, 85) 11

10 (9). Body
   - a. unpigmented (Fig. 84) 122
   - b. sparsely pigmented, ≤12 melanophores (spots of black or brown pigment) on dorsal surface (Fig. 70) 132

11 (9). Body
   - a. unpigmented (Fig. 84) 129

b. sparsely pigmented, ≤12 melanophores (spots of black or brown pigment) on dorsal surface (Fig. 70) 142
c. moderately to well pigmented, ≥13 melanophores on dorsal surface (Figs. 71, 85) 25

12 (1). Yolk
a. present 13
b. absent 26

13 (12). Eyes
a. unpigmented . . . . *C. ardens*
C. discobolus
C. latipinnis
b. lightly to moderately pigmented (Figs. 14, 84) 114
c. darkly pigmented (Figs. 15, 85) 14

14 (13). Body
a. unpigmented to sparsely pigmented, ≤12 melanophores (spots of black or brown pigment) on dorsal surface (Fig. 70) . . . 81
b. moderately to well pigmented, ≥13 melanophores on dorsal surface (Figs. 71, 85) 25

15 (1). Yolk
a. present 16
b. absent 26

16 (15). Eyes
a. lightly to moderately pigmented (Fig. 14) 17
b. darkly pigmented (Figs. 15) 18

17 (16). Body
a. unpigmented (Fig. 14) . . . . *C. ardens*
b. sparsely pigmented, ≤12 melanophores (spots of black or brown pigment) on dorsal surface (Fig. 70) 120

18 (16). Body
a. unpigmented (Fig. 14) . . . . *C. ardens*
b. sparsely pigmented, ≤12 melanophores (spots of black or brown pigment) on dorsal surface (Fig. 70) 120
c. moderately to well pigmented, ≥13 melanophores on dorsal surface (Figs. 15, 71) 34

19 (1). Yolk
a. present 20
b. absent . . . . *X. texanus*

20 (19). Body
a. sparsely pigmented, ≤12 melanophores (spots of black or brown pigment) on dorsal surface (Fig. 70) . . . . *C. ardens*
b. moderately to well pigmented, ≥13 melanophores on dorsal surface (Figs. 15, 71) 27

21 (1). Dorsal midline from shortly behind head to near last myomeres
a. with ≥25 melanophores in a distinct continuous or nearly continuous line (Figs. 43, 71) . . . . (rarely) *C. latipinnis*
b. with ≥25 melanophores but in a shorter or distinctly discontinuous line or with ≤24 melanophores (Figs. 15, 57) 22

22 (21). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres
a. with distinct continuous or nearly continuous lines of melanophores along (parallel to) each side of dorsal midline (Fig. 57) . . . . *C. latipinnis*
b. with distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline (Fig. 15) 23
c. without distinct lines of melanophores along either side of dorsal midline (Fig. 85) . . . . *C. ardens*

23 (22). Pigment on ventral to ventro-lateral surfaces of gill covers (opercula)
a. absent (Figs. 15, 57) 120
b. present (Figs. 16, 17) . . . . *C. ardens*

24 (6). Ventral midline from shortly behind heart region to near vent
a. with ≥13 melanophores in a continuous or nearly continuous line or narrow band, or in a shorter or distinctly discontinuous line (if ≥21 melanophores on midline from heart to vent and pigment line extends into branchial region, anterior to heart, most probably *C. commersoni* -- Fig. 31) (Figs. 29, 71) 38
b. with 7-12 melanophores (Fig. 43) . . . . *C. platyrhynchus*

25 (11,14). Ventral midline from shortly behind heart region to near vent
a. with ≥13 melanophores in a continuous or nearly continuous line or narrow band, or in a shorter or distinctly discontinuous line (if ≥21 melanophores on midline from heart to vent and pigment line extends into branchial region, anterior to heart, most probably *C. commersoni* -- Fig. 31) (Figs. 29, 71) 38
b. with 7-12 melanophores (Fig. 43) . . . . *C. platyrhynchus*
c. with ≤6 melanophores (Fig. 85) *X. texanus*

26 (12,15). Ventral midline from shortly behind heart region to near vent
a. with ≥7 melanophores (Fig. 71) . . . . *C. platyrhynchus*
b. with ≤6 melanophores (Fig. 85) *X. texanus*

27 (20). Ventral midline from shortly behind heart region to near vent
a. with ≥21 melanophores in a continuous or nearly continuous line or narrow band (Fig. 30) . . . . *C. commersoni*

b. with ≥21 melanophores in a shorter or distinctly discontinuous line (Fig. 44) . . . 28
c. with ≤20 melanophores (Figs. 15, 43, 57) 31

28 (27). Pigment on ventral to ventro-lateral surfaces of gill covers (opercula)
a. absent (Fig. 43) 29
b. present (Figs. 29, 30) . . . . . *C. commersoni*

29 (28). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres
a. with distinct continuous or nearly continuous lines of melanophores along (parallel to) each side of dorsal midline (Fig. 30) . . . . *C. commersoni*
b. with distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline (Figs. 43, 85) . . . 30
c. without distinct lines of melanophores along either side of dorsal midline (Figs. 44, 71) . . . . *C. discobolus*

30 (29). Dorsal midline from shortly behind head to near last myomeres
a. with ≥25 melanophores in a distinct continuous or nearly continuous line or in a shorter or distinctly discontinuous line (Figs. 30, 31, 43) 60
b. with ≤24 melanophores (Fig. 85) . . . . *C. discobolus*

31 (27). Pigment on ventral to ventro-lateral surfaces of gill covers (opercula)
a. absent (Figs. 15, 43, 57) 32
b. present (Figs. 16, 17) . . . . *C. ardens*

32 (31). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres
a. with distinct continuous or nearly continuous lines of melanophores along (parallel to) each side of dorsal midline (Fig. 57) . . . . *C. latipinnis*
b. with distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline (Figs. 15, 43, 85) 33
c. without distinct lines of melanophores along either side of dorsal midline (Figs. 44, 71) 48

33 (32). Dorsal midline from shortly behind head to near last myomeres
a. with ≥25 melanophores in a distinct continuous or nearly continuous line (Fig. 43) 113
b. with ≥25 melanophores but in a shorter or distinctly discontinuous line or with ≤24 melanophores (Figs. 15, 57) 73

34 (18). Ventral midline from shortly behind heart region to near vent
a. with ≥21 melanophores in a continuous or nearly continuous line or narrow band (if ventral midline from heart to vent extends into branchial region, anterior to heart, most probably *C. commersoni* -- Fig. 31) (Fig. 30) 38
b. with ≥21 melanophores in a shorter or distinctly discontinuous line (Fig. 71) . . 35
c. with 7 to 20 melanophores (Fig. 43) . . . 39
d. with ≤6 melanophores (Fig. 85) 45

35 (34). Pigment on ventral to ventro-lateral surfaces of gill covers (opercula)
a. absent (Figs. 43, 71) 36
b. present (Figs. 29, 30) 38

36 (35). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres
a. with distinct continuous or nearly continuous lines of melanophores along (parallel to) each side of dorsal midline (Fig. 30) . . . . *C. commersoni*
b. with distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline (Figs. 43, 72) . . . 37
c. without distinct lines of melanophores along either side of dorsal midline (Figs. 44, 71) 43

37 (36). Dorsal midline from shortly behind head to near last myomeres
a. with ≥25 melanophores in a distinct continuous or nearly continuous line or in a shorter or distinctly discontinuous line (Figs. 43, 71) 87
b. with ≤24 melanophores (Fig. 85) . . . . *C. discobolus*

38 (24,25,34,35). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres
a. with distinct continuous or nearly continuous lines of melanophores along (parallel to) each side of dorsal midline (Fig. 30) . . . . *C. commersoni*
b. with distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline (Fig. 72) or without distinct lines of melanophores along either side of dorsal midline (Figs. 29, 71) 93

39 (34). Pigment on ventral to ventro-lateral surfaces of gill covers (opercula)
a. absent (Figs. 15, 43, 57, 71) 40
b. present (Fig. 16) 44

40 (39). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres
a. with distinct continuous or nearly continuous lines of melanophores along (parallel to) each side of dorsal midline (Fig. 57) . . . . *C. latipinnis*
b. with distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline (Figs. 15, 43) . . . 41

c. without distinct lines of melanophores along either side of dorsal midline (Figs. 44, 71) 42

41 (40). Dorsal midline from shortly behind head to near last myomeres
a. with ≥25 melanophores in a distinct continuous or nearly continuous line (Fig. 43) 97
b. with ≥25 melanophores but in a shorter or distinctly discontinuous line (Fig. 15) 105
c. with ≤24 melanophores (Fig. 57) 73

42 (40). Dorsal midline from shortly behind head to near last myomeres
a. with ≥25 melanophores in a distinct continuous or nearly continuous line (Fig. 71) 64
b. with ≥25 melanophores but in a shorter or distinctly discontinuous line (Fig. 45) 76
c. with ≤24 melanophores (Fig. 85) 51

43 (36). Dorsal midline from shortly behind head to near last myomeres
a. with ≥25 melanophores in a distinct continuous or nearly continuous line or in a shorter or distinctly discontinuous line (Figs. 45, 71) 64
b. with ≤24 melanophores (Fig. 85) . . . . *C. discobolus*

44 (39). Dorsal midline from shortly behind head to near last myomeres
a. with ≥25 melanophores in a distinct continuous or nearly continuous line (Fig. 71) . . . . *C. platyrhynchus*
b. with ≥25 melanophores but in a shorter or distinctly discontinuous line (Fig. 15) 54
c. with ≤24 melanophores (Fig. 85) . *C. ardens*

45 (34). Pigment on ventral to ventro-lateral surfaces of gill covers (opercula)
a. absent (Figs. 15, 43, 57, 85) 46
b. present (Figs. 16, 17) 49

46 (45). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres
a. with distinct continuous or nearly continuous lines of melanophores along (parallel to) each side of dorsal midline (Fig. 57) 69
b. with distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline (Figs. 15, 43, 85) 47
c. without distinct lines of melanophores along either side of dorsal midline (Figs. 44, 71) 48

47 (46). Dorsal midline from shortly behind head to near last myomeres
a. with ≥25 melanophores in a distinct continuous or nearly continuous line (Fig. 71) 102
b. with ≥25 melanophores but in a shorter or distinctly discontinuous line or with ≤24 melanophores (Figs. 15, 85) 114

48 (32,46). Dorsal midline from shortly behind head to near last myomeres
a. with ≥25 melanophores in a distinct continuous or nearly continuous line (Fig. 71) . . . . *C. discobolus*
b. with ≥25 melanophores but in a shorter or distinctly discontinuous line or with ≤24 melanophores (Figs. 45, 85) 51

49 (45). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres
a. with distinct continuous or nearly continuous lines of melanophores along (parallel to) each side of dorsal midline (Fig. 57) . . . . *X. texanus*
b. with distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline (Figs. 15, 85) . . . 50
c. without distinct lines of melanophores along either side of dorsal midline (Fig. 71) . . . . *C. ardens*

50 (49). Dorsal midline from shortly behind head to near last myomeres
a. with ≥25 melanophores in a distinct continuous or nearly continuous line (Fig. 43) . . . . *X. texanus*
b. with ≥25 melanophores but in a shorter or distinctly discontinuous line or with ≤24 melanophores (Figs. 15, 85) 56

51 (42,48). Length from anterior margin of snout to posterior margin of eye
a. 6-8% SL 52
b. 9% SL . . . . *C. ardens*

52 (51). Number of myomeres to posterior margin of vent
a. 35-36 . . . . *C. ardens*
b. 37-39 53
c. 40-41 . . . . *C. discobolus*

53 (52). Length from anterior margin of snout to origin of pectoral fin
a. 12-16% SL . . . . *C. ardens* *C. discobolus*
b. 17-19% SL . . . . *C. ardens*

54 (44). Pectoral fin length
a. ≤9% SL 55
b. 10-12% SL . . . . *C. platyrhynchus*

55 (54). Yolk length
a. ≤40% SL . . . . *C. platyrhynchus*
b. 41% SL or more 108

56 (50). Length from anterior margin of snout to posterior margin of eye

a. 6-8% 57
b. 9% SL . . . . *C. ardens*

57 (56). Pectoral fin length
a. ≤9% SL 58
b. 10-12% SL . . . . *X. texanus*

58 (57). Yolk length
a. ≤40% SL . . . . *X. texanus*
b. ≥41% SL 59

59 (58). Number of myomeres to posterior margin of vent
a. 35-36 . . . . *C. ardens*
b. 37-39 . . . . *C. ardens*
X. texanus
c. 40-41 . . . . *X. texanus*

60 (30). Length from anterior margin of snout to posterior margin of eye
a. 6-8% 61
b. 9% SL . . . . *C. commersoni*

61 (60). Yolk length
a. 21-40% SL . . . . *C. commersoni*
b. ≥41% SL 62

62 (61). Pectoral fin length
a. ≤9% SL 63
b. 10-12% SL . . . . *C. commersoni*

63 (62). Length from anterior margin of snout to origin of pectoral fin
a. 12-16% SL 91
b. 17-19% SL . . . . *C. commersoni*

64 (42,43). Pectoral fin length
a. ≤9% SL 65
b. 10-12% SL . . . . *C. platyrhynchus*

65 (64). Length from anterior margin of snout to origin of pectoral fin
a. 12-14% SL . . . . *C. discobolus*
b. 15-16% SL 66
c. 17-19% SL . . . . *C. platyrhynchus*

66 (65). Number of myomeres to posterior margin of vent
a. 34-36 . . . . *C. platyrhynchus*
b. 37-39 67
c. 40-41 . . . . *C. discobolus*

67 (66). Length from anterior margin of snout to posterior margin of eye
a. 6-8% 68
b. 9-10% SL . . . . *C. platyrhynchus*

68 (67). Yolk length
a. ≤40% SL . . . . *C. platyrhynchus*
b. ≥41% SL . . . . *C. platyrhynchus*
C. discobolus

69 (46). Length from anterior margin of snout to posterior margin of eye
a. 6-8% 70
b. 9% SL . . . . *C. latipinnis*

70 (69). Pectoral fin length
a. ≤9% SL 71
b. 10-12% SL . . . . *X. texanus*

71 (70). Yolk length
a. ≤40% SL . . . . *X. texanus*
b. ≥41% SL 72

72 (71). Length from anterior margin of snout to origin of pectoral fin
a. 12-16% SL . . . . *C. latipinnis*
X. texanus
b. 17-19% SL . . . . *X. texanus*

73 (33,41). Length from anterior margin of snout to posterior margin of eye
a. 6-8% 74
b. 9% SL 120

74 (73). Number of myomeres to posterior margin of vent
a. 35-36 . . . . *C. ardens*
b. 37-39 75
c. 40-41 . . . . *C. latipinnis*
C. discobolus

75 (74). Length from anterior margin of snout to origin of pectoral fin
a. 12-16% SL . . . . *C. ardens*
C. discobolus
C. latipinnis
b. 17-19% SL . . . . *C. ardens*

76 (42). Pectoral fin length
a. ≤9% SL 77
b. 10-12% SL . . . . *C. platyrhynchus*

77 (76). Yolk length
a. ≤40% SL . . . . *C. platyrhynchus*
b. ≥41% SL 78

78 (77). Number of myomeres to posterior margin of vent
a. 34-36 108
b. 37-39 79
c. 40-41 . . . . *C. discobolus*

79 (78). Length from anterior margin of snout to origin of pectoral fin
a. 12-14% SL . . . . *C. discobolus*
C. ardens
b. 15-16% SL 80
c. 17-19% SL 109

80 (79). Length from anterior margin of snout to posterior margin of eye
a. 6-8% . . . . *C. platyrhynchus*
C. ardens
C. discobolus
b. 9% SL . . . . *C. platyrhynchus*
C. ardens
c. 10% SL . . . . *C. platyrhynchus*

81 (14). Length from anterior margin of snout to posterior margin of eye

a. 6-8% 82
b. 9% SL .... *C. ardens*

82 (81). Pectoral fin length
a. ≤9% SL 83
b. 10-12% SL .... *X. texanus*

83 (82). Yolk length
a. up-40% SL .... *X. texanus*
b. ≥41% SL 84

84 (83). Number of myomeres to posterior margin of vent
a. 35-36 .... *C. ardens*
b. 37-39 85
c. 40-41 86

85 (84). Length from anterior margin of snout to origin of pectoral fin
a. 12-16% SL .... *C. ardens*
C. discobolus
X. texanus
b. 17-19% SL .... *X. texanus*
C. ardens

86 (84). Length from anterior margin of snout to origin of pectoral fin
a. 12-16% SL .... *C. discobolus*
X. texanus
b. 17-19% SL .... *X. texanus*

87 (37). Pectoral fin length
a. ≤9% SL 88
b. 10-12% SL 93

88 (87). Yolk length
a. ≤20% SL .... *C. platyrhynchus*
b. 21-40% SL 94
c. ≥41% SL 89

89 (88). Length from anterior margin of snout to posterior margin of eye
a. 6-8% SL 90
b. 9% SL 95
c. 10% SL .... *C. platyrhynchus*

90 (89). Length from anterior margin of snout to origin of pectoral fin
a. 12-14% SL 91
b. 15-16% SL 92
c. 17-19% SL 96

91 (63,90). Number of myomeres to posterior margin of vent
a. 34-36 .... *C. commersoni*
b. 37-41 .... *C. commersoni*
C. discobolus

92 (90). Number of myomeres to posterior margin of vent
a. 34-36 .... *C. platyrhynchus*
C. commersoni
b. 37-39 .... *C. platyrhynchus*
C. commersoni
C. discobolus

c. 40-41 .... *C. commersoni*
C. discobolus

93 (6,38,87). Yolk length
a. ≤20% SL .... *C. platyrhynchus*
b. ≥21% SL 94

94 (88,93). Length from anterior margin of snout to posterior margin of eye
a. 6-9% SL 95
b. 10% SL .... *C. platyrhynchus*

95 (89,94). Length from anterior margin of snout to origin of pectoral fin
a. 12-14% SL .... *C. commersoni*
b. 15-19% SL 96

96 (90,95). Number of myomeres to posterior margin of vent
a. 34-39 .... *C. commersoni*
C. platyrhynchus
b. 40-41 .... *C. commersoni*

97 (41). Pectoral fin length
a. ≤9% SL 98
b. 10-12% SL .... *C. platyrhynchus*

98 (97). Yolk length
a. ≤40% SL .... *C. platyrhynchus*
b. ≥41% SL 99

99 (98). Length from anterior margin of snout to origin of pectoral fin
a. 12-14% SL 113
b. 15-16% SL 100
c. 17-19% SL .... *C. platyrhynchus*

100 (99). Number of myomeres to posterior margin of vent
a. 34-36 .... *C. platyrhynchus*
b. 37-39 101
c. 40-41 113

101 (100). Length from anterior margin of snout to posterior margin of eye
a. 6-8% .... *C. platyrhynchus*
C. discobolus
C. latipinnis
b. 9% SL .... *C. platyrhynchus*
C. latipinnis
c. 10% SL .... *C. platyrhynchus*

102 (47). Length from anterior margin of snout to posterior margin of eye
a. 6-8% 103
b. 9% SL .... *C. latipinnis*

103 (102). Pectoral fin length
a. ≤9% SL 104
b. 10-12% SL .... *X. texanus*

104 (103). Yolk length
a. ≤40% SL .... *X. texanus*
b. ≥41% SL 119

105 (41). Pectoral fin length
- a. ≤9% SL 106
- b. 10-12% SL . . . . *C. platyrhynchus*

106 (105). Yolk length
- a. ≤40% SL . . . . *C. platyrhynchus*
- b. ≥41% SL 107

107 (106). Number of myomeres to posterior margin of vent
- a. 34-36 108
- b. 37-39 110
- c. 40-41 113

108 (55,78,107). Length from anterior margin of snout to origin of pectoral fin
- a. 12-14% SL . . . . *C. ardens*
- b. 15-19% SL 109

109 (79,108). Length from anterior margin of snout to posterior margin of eye
- a. 6-9% SL . . . . *C. ardens*
C. platyrhynchus
- b. 10% SL . . . . *C. platyrhynchus*

110 (107). Length from anterior margin of snout to posterior margin of eye
- a. 6-8% SL 111
- b. 9% SL 112
- c. 10% SL . . . . *C. platyrhynchus*

111 (110). Length from anterior margin of snout to origin of pectoral fin
- a. 12-14% SL . . . . *C. ardens*
C. discobolus
C. latipinnis
- b. 15-16% SL . . . . *C. latipinnis*
C. ardens
C. discobolus
C. platyrhynchus
- c. 17-19% SL . . . . *C. platyrhynchus*
C. ardens

112 (110). Length from anterior margin of snout to origin of pectoral fin
- a. 12-14% SL . . . . *C. ardens*
C. latipinnis
- b. 15-16% SL . . . . *C. platyrhynchus*
C. ardens
C. latipinnis
- c. 17-19% SL . . . . *C. ardens*
C. platyrhynchus

113 (33,99,100,107). Length from anterior margin of snout to posterior margin of eye
- a. 6-8% SL . . . . *C. discobolus*
C. latipinnis
- b. 9% SL . . . . *C. latipinnis*

114 (13,47). Pectoral fin length
- a. ≤9% SL 115
- b. 10-12% SL . . . . *X. texanus*

115 (114). Yolk length
- a. ≤40% SL . . . . *X. texanus*
- b. ≥41% SL 116

116 (115). Length from anterior margin of snout to posterior margin of eye
- a. 6-8% 117
- b. 9% SL 120

117 (116). Number of myomeres to posterior margin of vent
- a. 35-36 . . . . *C. ardens*
- b. 37-39 118
- c. 40-41 119

118 (117). Length from anterior margin of snout to origin of pectoral fin
- a. 12-16% SL . . . . *C. discobolus*
C. latipinnis
X. texanus
C. ardens
- b. 17-19% SL . . . . *C. ardens*
X. texanus

119 (104,117). Length from anterior margin of snout to origin of pectoral fin
- a. 12-16% SL . . . . *X. texanus*
C. discobolus
C. latipinnis
- b. 17-19% SL . . . . *X. texanus*

120 (17,18,73,116). Number of myomeres to posterior margin of vent
- a. 35-36 . . . . *C. ardens*
- b. 37-39 121
- c. 40-41 . . . . *C. latipinnis*

121 (120). Length from anterior margin of snout to origin of pectoral fin
- a. 12-16% SL . . . . *C. ardens*
C. latipinnis
- b. 17-19% SL . . . . *C. ardens*

122 (10). Pectoral fin length
- a. ≤9% SL 123
- b. 10-12% SL 129

123 (122). Yolk length
- a. ≤20% SL . . . . *X. texanus*
- b. 21-40% SL 130
- c. ≥41% SL 124

124 (123). Length from anterior margin of snout to posterior margin of eye
- a. 6-8% SL 125
- b. 9% SL 127

125 (124). Number of myomeres to posterior margin of vent
- a. 34-36 . . . . *C. ardens*
C. commersoni
- b. 37-39 126
- c. 40-41 137

126 (125). Length from anterior margin of snout to origin of pectoral fin

a. 12-16% SL . . . . *C. latipinnis*
C. discobolus
X. texanus
C. commersoni
C. ardens
b. 17-19% SL . . . . *C. commersoni*
C. ardens
X. texanus

127 (124). Number of myomeres to posterior margin of vent
a. 34-36 . . . . *C. commersoni*
C. ardens
b. 37-39 128
c. 40-41 141

128 (127). Length from anterior margin of snout to origin of pectoral fin
a. 12-16% SL . . . . *C. latipinnis*
C. ardens
C. commersoni
b. 17-19% SL . . . . *C. commersoni*
C. ardens

129 (3,11,122). Yolk length
a. ≤20% SL . . . . *X. texanus*
b. ≥21% SL 130

130 (123,129). Length from anterior margin of snout to posterior margin of eye
a. 6-8% SL 131
b. 9% SL . . . . *C. commersoni*

131 (130). Number of myomeres to posterior margin of vent
a. 34-36 . . . . *C. commersoni*
b. 37-41 . . . . *C. commersoni*
X. texanus

132 (10). Pectoral fin length
a. ≤9% SL 133
b. 10-12% SL 142

133 (132). Yolk length
a. ≤20% SL 146
b. 21-40% SL 149
c. ≥41% SL 134

134 (133). Length from anterior margin of snout to posterior margin of eye
a. 6-8% SL 135
b. 9% SL 138
c. 10% SL . . . . *C. platyrhynchus*

135 (134). Number of myomeres to posterior margin of vent
a. 34-36 148
b. 37-39 136
c. 40-41 137

136 (135). Length from anterior margin of snout to origin of pectoral fin
a. 12-14% SL . . . . *C. commersoni*
C. ardens
C. discobolus
C. latipinnis
X. texanus
b. 15-16% SL . . . . *C. latipinnis*
X. texanus
C. ardens
C. commersoni
C. discobolus
C. platyrhynchus
c. 17-19% SL . . . . *C. platyrhynchus*
C. commersoni
X. texanus
C. ardens

137 (125,135). Length from anterior margin of snout to origin of pectoral fin
a. 12-16% SL . . . . *X. texanus*
C. commersoni
C. discobolus
C. latipinnis
b. 17 to 19% SL . . . . *X. texanus*
C. commersoni

138 (134). Number of myomeres to posterior margin of vent
a. 34-36 139
b. 37-39 140
c. 40-41 141

139 (138). Length from anterior margin of snout to origin of pectoral fin
a. 12-14% SL . . . . *C. ardens*
C. commersoni
b. 15-19% SL . . . . *C. commersoni*
C. platyrhynchus
C. ardens

140 (138). Length from anterior margin of snout to origin of pectoral fin
a. 12-14% SL . . . . *C. commersoni*
C. ardens
C. latipinnis
b. 15-16% SL . . . . *C. platyrhynchus*
C. ardens
C. commersoni
C. latipinnis
c. 17-19% SL . . . . *C. commersoni*
C. platyrhynchus
C. ardens

141 (127,138). Length from anterior margin of snout to origin of pectoral fin
a. 12-16% SL . . . . *C. latipinnis*
C. commersoni
b. 17-19% SL . . . . *C. commersoni*

142 (5,11,132). Length from anterior margin of snout to posterior margin of eye
a. 6-8% SL 143
b. 9% SL 153
c. 10% SL . . . . *C. platyrhynchus*

143 (142). Number of myomeres to posterior margin of vent
a. 34-36 154
b. 37-39 145
c. 40-41 144

144 (143). Yolk length
- a. ≤20% SL .... *X. texanus*
- b. ≥21% SL .... *X. texanus* / *C. commersoni*

145 (143). Yolk length
- a. ≤20% SL 148
- b. ≥21% SL 152

146 (133). Length from anterior margin of snout to posterior margin of eye
- a. 6-8% SL 147
- b. 9-10% SL .... *C. platyrhynchus*

147 (146). Number of myomeres to posterior margin of vent
- a. 34-36 .... *C. platyrhynchus*
- b. 37-39 148
- c. 40-41 .... *X. texanus*

148 (135,145,147). Length from anterior margin of snout to origin of pectoral fin
- a. 12-14% SL .... *X. texanus*
- b. 15-19% SL .... *X. texanus* / *C. platyrhynchus*

149 (133). Length from anterior margin of snout to posterior margin of eye
- a. 6-8% SL 150
- b. 9% SL 151
- c. 10% SL .... *C. platyrhynchus*

150 (149). Number of myomeres to posterior margin of vent
- a. 34-36 155
- b. 37-39 152
- c. 40-41 .... *X. texanus* / *C. commersoni*

151 (149). Number of myomeres to posterior margin of vent
- a. 34-39 155
- b. 40-41 .... *C. commersoni*

152 (145,150). Length from anterior margin of snout to origin of pectoral fin
- a. 12-14% SL .... *X. texanus* / *C. commersoni*
- b. 15-19% SL .... *X. texanus* / *C. commersoni* / *C. platyrhynchus*

153 (142). Number of myomeres to posterior margin of vent
- a. 34-39 154
- b. 40-41 .... *C. commersoni*

154 (143,153). Yolk length
- a. ≤20% SL .... *C. platyrhynchus*
- b. ≥21% SL 155

155 (150,151,154). Length from anterior margin of snout to origin of pectoral fin
- a. 12-14% SL .... *C. commersoni*
- b. 15-19% SL .... *C. commersoni* / *C. platyrhynchus*

Flexion Mesolarvae -- at least one fin ray present in caudal fin but not the full adult complement of 18 principal rays (definition abbreviated for species of concern; Fig. 16).

1. Standard (notochord) length (SL; Fig. 4)
- a. 10 mm 8
- b. 11 mm 11
- c. 12 mm 23
- d. 13 mm 19
- e. 14 mm 3
- f. 15 mm 2

2 (1). Yolk
- a. present .... *C. latipinnis*
- b. absent .... *C. commersoni*

3 (1). Yolk
- a. present 4
- b. absent 7

4 (3). Maximum depth of yolk
- a. ≥5% SL .... *C. latipinnis*
- b. ≤4% SL 5

5 (4). Length of yolk
- a. ≥19% SL 6
- b. ≤18% SL .... *C. commersoni*

6 (5). Ventral midline from shortly behind heart region to near vent
- a. with ≥21 melanophores (Fig. 30) .... *C. commersoni*
- b. with 1-20 melanophores (Fig. 58) .... *C. latipinnis*

7 (3). Ventral midline from shortly behind heart region to near vent
- a. with ≥21 melanophores (if in a continuous or nearly continuous line and midline pigment extends into branchial region anterior to heart, probably *C. commersoni*; Fig.31) (Figs. 30, 72) 45
- b. with ≤20 melanophores or without pigment (Fig. 16) .... *C. ardens*

8 (1). Yolk
- a. present 9
- b. absent 10

9 (8). Maximum depth of yolk
- a. ≥5% SL .... *C. discobolus*
- b. ≤4% SL 10

10 (8,9). Ventral midline from shortly behind heart region to near vent
- a. with ≥21 melanophores in a continuous or nearly continuous line or narrow band (Fig. 30) .... *C. commersoni*
- b. with ≥21 melanophores in a shorter or a distinctly discontinuous line (Fig. 44) . 26
- c. with 7-20 melanophores (Fig. 17) .... *C. discobolus*

d. with ≤6 melanophores or without pigment (Fig. 86) 16

11 (1). Yolk
a. present 12
b. absent 15

12 (11). Maximum depth of yolk
a. ≥5% SL . . . . *C. discobolus*
b. ≤4% SL 13

13 (12). Length of yolk
a. ≥19% SL 14
b. ≤18% SL 15

14 (13). Ventral midline from shortly behind heart region to near vent
a. with ≥21 melanophores in a continuous or nearly continuous line or narrow band (Fig. 30) . . . . *C. commersoni*
b. with ≥21 melanophores in a shorter or a distinctly discontinuous line (Fig. 44) . 26
c. with 7-20 melanophores (Fig. 17) . . . . *C. discobolus*
d. with ≤6 melanophores or without pigment (Fig. 86) 16

15 (11,13). Ventral midline from shortly behind heart region to near vent
a. with ≥21 melanophores in a continuous or nearly continuous line or narrow band (if midline pigment extends into branchial region anterior to heart, probably *C. commersoni*; Fig. 31) (Figs. 30, 72) . . 45
b. with ≥21 melanophores in a shorter or a distinctly discontinuous line (Fig. 44) 46
c. with 7-20 melanophores (Fig. 17) . . . . *C. discobolus*
d. with ≤6 melanophores or without pigment (Fig. 86) 16

16 (10,14,15). Dorsal body pigmentation between head and last myomere
a. scattered with no distinct lines of melanophores on or lateral (and parallel) to dorsal midline (Fig. 44) . . . . *C. discobolus*
b. including at least a partial distinct line of melanophores on or lateral (and parallel) to dorsal midline (Fig. 86) 17

17 (16). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres
a. with distinct lines of melanophores along one or both sides of dorsal midline (Fig. 86) 18
b. without distinct lines of melanophores along either side of dorsal midline (Fig. 44) . . . . *C. discobolus*

18 (17). Dorsal midline from shortly behind head to near last myomeres
a. with ≥25 melanophores in a distinct continuous or nearly continuous line, one or more shorter segments, or a distinctly discontinuous line (Figs. 45, 86) 51
b. with ≤24 melanophores in one or more short lines, a discontinuous, well-spaced line or (rarely) no distinct line of melanophores . . . . *X. texanus*

19 (1). Yolk
a. present 20
b. absent 44

20 (19). Maximum depth of yolk
a. ≥5% SL 35
b. ≤4% SL 21

21 (20). Length of yolk
a. ≥19% SL 22
b. ≤18% SL 25

22 (21). Ventral midline from shortly behind heart region to near vent
a. with ≥21 melanophores in a continuous or nearly continuous line or narrow band (Fig. 30) . . . . *C. commersoni*
b. with ≥21 melanophores in a shorter or a distinctly discontinuous line (Fig. 44) . 26
c. with 1-20 melanophores (Figs. 16, 58) . . 27
d. without pigment 47

23 (1). Yolk
a. present 24
b. absent 44

24 (23). Maximum depth of yolk
a. ≥5% SL . . . . *C. discobolus*
b. ≤4% SL 25

25 (21,24). Ventral midline from shortly behind heart region to near vent
a. with ≥21 melanophores in a continuous or nearly continuous line or narrow band (Fig. 30) . . . . *C. commersoni*
b. with ≥21 melanophores in a shorter or a distinctly discontinuous line (Fig. 44) . 26
c. with ≤20 melanophores or without pigment (Fig. 16) 47

26 (10,14,22,25). Dorsal body pigmentation between head and last myomere
a. scattered with no distinct lines of melanophores on or lateral (and parallel) to dorsal midline (Fig. 44) . . . . *C. discobolus*
b. including at least a partial distinct line of melanophores on or lateral (and parallel) to dorsal midline (Fig. 30) 79

27 (22). Dorsal body pigmentation between head and last myomere
a. scattered with no distinct lines of melanophores on or lateral (and parallel) to dorsal midline (Fig. 44) . . . . *C. discobolus*
b. including at least a partial distinct line of melanophores on or lateral (and parallel) to dorsal midline (Figs. 16, 58) 28

28 (27). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres

a. with distinct lines of melanophores along one or both sides of dorsal midline (Figs. 16, 58) 29
b. without distinct lines of melanophores along either side of dorsal midline (Fig. 44) .... *C. discobolus*

29 (28). Melanophores in lines lateral (and parallel) to dorsal midline between head and 2/3 distance to last myomeres

a. mostly in single file (Fig. 16) 30
b. mostly in obliquely oriented pairs or groups resulting in a "herring bone" or "tractor tread" pattern (Fig. 58) .... *C. latipinnis*

30 (29). Dorsal midline from shortly behind head to near last myomeres

a. with ≥25 melanophores in a distinct continuous or nearly continuous line (Fig. 43) .... *C. discobolus*
b. with ≥25 melanophores but in one or more shorter segments or a distinctly discontinuous line (Fig. 45) 65
c. with ≤24 melanophores in one or more short lines, a discontinuous, well-spaced line or (rarely) no distinct line of melanophores (Figs. 16, 59) 31

31 (30). Ventral to ventro-lateral surfaces of gill covers (opercula)

a. unpigmented (Fig. 58) 32
b. pigmented (Fig. 17) .... *C. ardens*

32 (31). Chin (anterior ventral surface of lower jaw)

a. unpigmented (Figs. 16, 58) 33
b. pigmented (Fig. 17) .... *C. ardens*

33 (32). Lateral surface of body above horizontal myosepta (lateral midline) and below dorso-lateral surface (exclusive of pigment associated with horizontal myosepta, air bladder, or visceral peritoneum)

a. unpigmented (Figs. 16, 58) 105
b. pigmented (at least 1 melanophore) (Fig. 17) 34

34 (33). Lateral surface of body below horizontal myosepta (lateral midline) (exclusive of pigment associated with horizontal myosepta, air bladder, visceral peritoneum, or gut)

a. unpigmented (Figs. 16, 58) 105
b. pigmented with at least 1 melanophore (Fig. 17) .... *C. ardens*

35 (20). Ventral midline from shortly behind heart region to near vent

a. with ≥21 melanophores (Fig. 44) .... *C. discobolus*
b. with 1-20 melanophores (Fig. 58) 36
c. without pigment .... *C. discobolus*

36 (35). Dorsal body pigmentation between head and last myomere

a. scattered with no distinct lines of melanophores on or lateral (and parallel) to dorsal midline (Fig. 44) .... *C. discobolus*
b. including at least a partial distinct line of melanophores on or lateral (and parallel) to dorsal midline (Fig. 58) ... 37

37 (36). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres

a. with distinct lines of melanophores along one or both sides of dorsal midline (Fig. 58) 38
b. without distinct lines of melanophores along either side of dorsal midline (Fig. 44) .... *C. discobolus*

38 (37). Melanophores in lines lateral (and parallel) to dorsal midline between head and 2/3 distance to last myomeres

a. mostly in single file (Fig. 43) 39
b. mostly in obliquely oriented pairs or groups resulting in a "herring bone" or "tractor tread" pattern (Fig. 58) *C. latipinnis*

39 (38). Dorsal midline from shortly behind head to near last myomeres

a. with ≥25 melanophores in a distinct continuous or nearly continuous line (Fig. 43) .... *C. discobolus*
b. with ≥25 melanophores but in one or more shorter segments or a distinctly discontinuous line (Fig. 45) 40
c. with ≤24 melanophores in one or more short lines, a discontinuous, well-spaced line or (rarely) no distinct line of melanophores (Fig. 58) ..... *C. latipinnis*

40 (39). Chin (anterior ventral surface of lower jaw)

a. unpigmented (Figs. 44, 58) 41
b. pigmented (Fig. 30) .... *C. discobolus*

41 (40). Lateral surface of head posterior to eyes

a. unpigmented (Fig. 44) ..... *C. discobolus*
b. pigmented (at least 1 melanophore) (Fig. 58) 42

42 (41). Lateral surface of body above horizontal myosepta (lateral midline) and below dorso-lateral surface (exclusive of melanophores associated with horizontal myosepta, air bladder, or visceral peritoneum)

a. unpigmented (Fig. 58) ..... *C. discobolus*
C. latipinnis

b. pigmented with 1-5 melanophores (Fig. 44) 43
c. pigmented with ≥6 melanophores (Fig. 46) . . . . *C. discobolus*

43 (42). Lateral surface of body below horizontal myosepta (lateral midline) (exclusive of pigment associated with horizontal myosepta, air bladder, visceral peritoneum, or gut)
a. unpigmented (Fig. 58) . . . . . *C. discobolus* *C. latipinnis*
b. pigmented with at least 1 melanophore (Fig. 45) . . . . *C. discobolus*

44 (19,23). Ventral midline from shortly behind heart region to near vent
a. with ≥21 melanophores in a continuous or nearly continuous line or narrow band (if midline pigment extends into branchial region anterior to heart, probably *C. commersoni*; Fig. 31) (Figs. 30, 72) . . 45
b. with ≥21 melanophores in a shorter or a distinctly discontinuous line (Fig. 44) . 46
c. with 7-20 melanophores (Fig. 17) 47
d. with ≤6 melanophores or without pigment (Figs. 16, 86) 48

45 (7,15,44). Dorsal body pigmentation between head and last myomere
a. scattered with no distinct lines of melanophores on or lateral (and parallel) to dorsal midline (Fig. 44) . . *C. platyrhynchus*
b. including at least a partial distinct line of melanophores on or lateral (and parallel) to dorsal midline (Figs. 30, 72) 76

46 (15,44). Dorsal body pigmentation between head and last myomere
a. scattered with no distinct lines of melanophores on or lateral (and parallel) to dorsal midline (Fig. 44) 72
b. including at least a partial distinct line of melanophores on or lateral (and parallel) to dorsal midline (Figs. 30, 45, 72) . 80

47 (22,25,44). Dorsal body pigmentation between head and last myomere
a. scattered with no distinct lines of melanophores on or lateral (and parallel) to dorsal midline (Fig. 44) . . . . *C. discobolus*
b. including at least a partial distinct line of melanophores on or lateral (and parallel) to dorsal midline (Figs. 16,45) 62

48 (44). Dorsal body pigmentation between head and last myomere
a. scattered with no distinct lines of melanophores on or lateral (and parallel) to dorsal midline (Fig. 44) . . . . *C. discobolus*
b. including at least a partial distinct line of melanophores on or lateral (and parallel) to dorsal midline (Figs. 16, 45, 86) . 49

49 (48). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres
a. with distinct lines of melanophores along (parallel to) one or both sides of dorsal midline (Figs. 16, 86) 50
b. without distinct lines of melanophores along either side of dorsal midline (Fig. 44) . . . . *C. discobolus*

50 (49). Dorsal midline from shortly behind head to near last myomeres
a. with ≥25 melanophores in a distinct continuous or nearly continuous line (Fig. 43) 51
b. with ≥25 melanophores but in one or more shorter segments or a distinctly discontinuous line (Fig. 45) 55
c. with ≤24 melanophores in one or more short lines, a discontinuous, well-spaced line or (rarely) no distinct line of melanophores (Figs. 16, 86) 53

51 (18,50). Dorsal surface of head pigmented
a. only over hindbrain (posterior to middle of eyes; Fig. 86) . . . . *X. texanus*
b. over both mid- and hindbrain (anterior and posterior to middle of eyes; Fig. 44) 52

52 (51). Ventral to ventro-lateral surfaces of gill covers (opercula)
a. unpigmented (Figs. 44, 86) 58
b. pigmented (Figs. 17, 31) . . . . . . *X. texanus*

53 (50). Dorsal surface of head pigmented
a. only over hindbrain (posterior to middle of eyes; Fig. 86) . . . . *X. texanus*
b. over both mid- and hindbrain (anterior and posterior to middle of eyes; Fig. 16) 54

54 (53). Ventral to ventro-lateral surfaces of gill covers (opercula)
a. unpigmented or pigmented but not in distinct oblique rows (Figs. 16, 86) 60
b. pigmented in a distinct oblique row of 3 or more melanophores near or along ventral margin of one or both preopercles (Figs. 17, 31) . . . . *X. texanus*

55 (50). Dorsal surface of head pigmented
a. only over hindbrain (posterior to middle of eyes; Fig. 86) . . . . *X. texanus*
b. over both mid- and hindbrain (anterior and posterior to middle of eyes; Figs. 16, 44) 56

56 (55). Ventral to ventro-lateral surfaces of gill covers (opercula)
a. unpigmented (Figs. 44, 86) 57
b. pigmented in a distinct oblique row of 3 or more melanophores near or along ventral margin of 1 or both preopercles (Figs. 17, 31) . . . . *X. texanus*

c. pigmented but not in distinct oblique rows (Figs. 16) 60

57 (56). Lateral surface of head posterior to eyes
  a. unpigmented (Fig. 44) 58
  b. pigmented (at least 1 melanophore) (Figs. 16, 86) 59

58 (52,57). Lateral surface of body above horizontal myosepta (lateral midline) and below dorso-lateral surface (exclusive of melanophores associated with horizontal myosepta, air bladder, or visceral peritoneum)
  a. unpigmented (Fig. 86) 112
  b. pigmented (at least 1 melanophore; Fig. 44) .... *C. discobolus*

59 (57). Lateral surface of body above horizontal myosepta (lateral midline) and below dorso-lateral surface (exclusive of melanophores associated with horizontal myosepta, air bladder, or visceral peritoneum)
  a. unpigmented (Figs. 16, 86) 113
  b. pigmented with 1-5 melanophores (Fig. 44) 103
  c. pigmented with ≥6 melanophores (Fig. 46) .... *C. discobolus*

60 (54,56). Lateral surface of head posterior to eyes
  a. unpigmented (Fig. 44) .... *X. texanus*
  b. pigmented (at least 1 melanophore) (Figs. 16, 86) 61

61 (60). Lateral surface of body above horizontal myosepta (lateral midline) and below dorso-lateral surface (exclusive of melanophores associated with horizontal myosepta, air bladder, or visceral peritoneum)
  a. unpigmented (Figs. 16, 86) 109
  b. pigmented with 1-5 melanophores (Fig. 17) .... *C. ardens*

62 (47). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres
  a. with distinct lines of melanophores along one or both sides of dorsal midline (Fig. 16 63
  b. without distinct lines of melanophores along either side of dorsal midline (Fig. 44) .... *C. discobolus*

63 (62). Dorsal midline from shortly behind head to near last myomeres
  a. with ≥25 melanophores in a distinct continuous or nearly continuous line (Fig. 43) .... *C. discobolus*
  b. with ≥25 melanophores but in one or more shorter segments or a distinctly discontinuous line (Fig. 45) 64
  c. with ≤24 melanophores in one or more short lines, a discontinuous, well-spaced line or (rarely) no distinct line of melanophores (Fig. 16) .... *C. ardens*

64 (63). Ventral to ventro-lateral surfaces of gill covers (opercula)
  a. unpigmented (Fig. 44) 70
  b. pigmented (at least 1 melanophore; Fig. 16) .... *C. ardens*

65 (30). Ventral to ventro-lateral surfaces of gill covers (opercula)
  a. unpigmented (Figs. 44, 58) 66
  b. pigmented (at least 1 melanophore; Fig. 16) .... *C. ardens*

66 (65). Chin (anterior ventral surface of lower jaw)
  a. unpigmented (Figs. 16, 44, 58) 67
  b. pigmented (at least 1 melanophore; Fig. 17) 70

67 (66). Lateral surface of head posterior to eyes
  a. unpigmented (Fig. 44) ..... *C. discobolus*
  b. pigmented (at least 1 melanophore; Figs. 16, 58) 68

68 (67). Lateral surface of body above horizontal myosepta (lateral midline) and below dorso-lateral surface (exclusive of melanophores associated with horizontal myosepta, air bladder, or visceral peritoneum)
  a. unpigmented (Figs. 16, 58) 107
  b. pigmented with 1-5 melanophores (Fig. 44) 69
  c. pigmented with ≥6 melanophores (Figs. 45, 46) .... *C. discobolus*

69 (68). Lateral surface of body below horizontal myosepta (lateral midline) (exclusive of melanophores associated with horizontal myosepta, air bladder, visceral peritoneum, or gut)
  a. unpigmented (Figs. 16, 44, 58) 107
  b. pigmented (at least 1 melanophore) (Figs. 45, 46) 103

70 (64,66). Lateral surface of head posterior to eyes
  a. unpigmented (Fig. 44) ..... *C. discobolus*
  b. pigmented (at least 1 melanophore; Fig. 16) 71

71 (70). Lateral surface of body above horizontal myosepta (lateral midline) and below dorso-lateral surface (exclusive of melanophores associated with horizontal myosepta, air bladder, or visceral peritoneum)
  a. unpigmented or pigmented with ≤5 melanophores (Figs. 16, 44) 103
  b. pigmented with ≥6 melanophores (Figs. 45, 46) .... *C. discobolus*

72 (46). Ventral to ventro-lateral surfaces of gill covers (opercula)
- a. unpigmented (Figs. 44, 72) 73
- b. pigmented (Fig. 73) ..... *C. platyrhynchus*

73 (72). Ventral surface of heart region
- a. unpigmented (Fig. 45) ..... *C. discobolus*
- b. pigmented (Figs. 44, 72) 74

74 (73). Lateral surface of head posterior to eyes
- a. unpigmented (Fig. 44) ..... *C. discobolus*
- b. pigmented (at least 1 melanophore; Fig. 72) 75

75 (74). Lateral surface of body above horizontal myosepta (lateral midline) and below dorso-lateral surface (exclusive of pigment associated with horizontal myosepta, air bladder, or visceral peritoneum)
- a. unpigmented (Fig. 72) 99
- b. pigmented (at least 1 melanophore; Fig. 44) .... *C. discobolus*

76 (45). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres
- a. with distinct continuous or nearly continuous lines of melanophores along (parallel to) each side of dorsal midline (Fig. 30) .... *C. commersoni*
- b. with distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline (Fig. 43) 77
- c. without distinct lines of melanophores along either side of dorsal midline (Fig. 44) 78

77 (76). Melanophores in lines lateral (and parallel) to dorsal midline between head and 2/3 distance to last myomeres
- a. mostly in single file (Fig. 43) 78
- b. mostly in obliquely oriented pairs or groups resulting in a "herring bone" or "tractor tread" pattern (Fig. 30) .... *C. commersoni*

78 (76,77). Dorsal midline from shortly behind head to near last myomeres
- a. with $\geq$25 melanophores in a distinct continuous or nearly continuous line, one or more shorter segments, or a distinctly discontinuous line (Figs. 30, 45) 89
- b. with $\leq$24 melanophores in one or more short lines, a discontinuous, well-spaced line or (rarely) no distinct line of melanophores (Fig. 16) ... *C. commersoni*

79 (26). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres
- a. with distinct lines of melanophores along one or both sides of dorsal midline (Fig. 30) 81
- b. without distinct lines of melanophores along either side of dorsal midline (Fig. 44) 82

80 (46). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres
- a. with distinct continuous or nearly continuous lines of melanophores along (parallel to) each side of dorsal midline (Fig. 30) 81
- b. with distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline (Fig. 43) 83
- c. without distinct lines of melanophores along either side of dorsal midline (Fig. 44) 84

81 (79,80). Melanophores in lines lateral (and parallel) to dorsal midline between head and 2/3 distance to last myomeres
- a. mostly in single file (Fig. 43) 82
- b. mostly in obliquely oriented pairs or groups resulting in a "herring bone" or "tractor tread" pattern (Fig. 30) .... *C. commersoni*

82 (79,81). Dorsal midline from shortly behind head to near last myomeres
- a. with $\geq$25 melanophores in a distinct continuous or nearly continuous line, one or more shorter segments or a distinctly discontinuous line (Figs. 30, 45) 90
- b. with $\leq$24 melanophores in one or more short lines, a discontinuous, well-spaced line or (rarely) no distinct line of melanophores (Fig. 16) ... *C. commersoni*

83 (80). Melanophores in lines lateral (and parallel) to dorsal midline between head and 2/3 distance to last myomeres
- a. mostly in single file (Fig. 43) 84
- b. mostly in obliquely oriented pairs or groups resulting in a "herring bone" or "tractor tread" pattern (Fig. 30) .... *C. commersoni*

84 (80,83). Dorsal midline from shortly behind head to near last myomeres
- a. with $\geq$25 melanophores in a distinct continuous or nearly continuous line, one or more shorter segments or a distinctly discontinuous line (Figs. 30, 45) 85
- b. with $\leq$24 melanophores in one or more short lines, a discontinuous, well-spaced line or (rarely) no distinct line of melanophores (Fig. 16) ... *C. commersoni*

85 (84). Ventral to ventro-lateral surfaces of gill covers (opercula)
- a. unpigmented (Figs. 44, 72) 86
- b. pigmented (Fig. 16) 89

86 (85). Ventral surface of heart region

a. unpigmented (Fig. 45) . . . . . *C. discobolus*
b. pigmented (Figs. 30, 44, 72) 87

87 (86). Lateral surface of head posterior to eyes
a. unpigmented (Fig. 44) . . . . . *C. discobolus*
b. pigmented (at least 1 melanophore; Figs. 30, 72) 88

88 (87). Lateral surface of body above horizontal myosepta (lateral midline) and below dorso-lateral surface (exclusive of pigment associated with horizontal myosepta, air bladder, or visceral peritoneum)
a. unpigmented (Fig. 72) 100
b. pigmented with 1-5 melanophores (Figs. 30, 44) 94
c. pigmented with ≥6 melanophores (Figs. 45, 46) . . . . *C. discobolus*

89 (78,85). Lateral surface of body above horizontal myosepta (lateral midline) below dorso-lateral surface (exclusive of pigment associated with horizontal myosepta, air bladder, or visceral peritoneum)
a. unpigmented (Fig. 72) 96
b. pigmented with 1-5 melanophores (Fig. 30) . . . . *C. commersoni*

90 (82). Ventral to ventro-lateral surfaces of gill covers (opercula)
a. unpigmented (Fig. 44) 91
b. pigmented (Fig. 30) . . . . . . *C. commersoni*

91 (90). Ventral surface of heart region
a. unpigmented (Fig. 45) . . . . . *C. discobolus*
b. pigmented (Figs. 30, 44) 92

92 (91). Lateral surface of head posterior to eyes
a. unpigmented (Fig. 44) . . . . . *C. discobolus*
b. pigmented (at least 1 melanophore; Fig. 30) 93

93 (92). Lateral surface of body above horizontal myosepta (lateral midline) and below dorso-lateral surface (exclusive of pigment associated with horizontal myosepta, air bladder, or visceral peritoneum)
a. unpigmented or pigmented with 1-5 melanophores (Figs. 30, 44) 94
b. pigmented with ≥6 melanophores (Figs. 45, 46) . . . . *C. discobolus*

94 (88,93). Longitudinal eye diameter
a. up to 29% of head length . . *C. commersoni*
b. 30% of head length or more 95

95 (94). Length from anterior margin of snout to posterior margin of vent
a. up to 80% SL . . . . *C. commersoni*
C. discobolus
b. 81% SL or more . . . . *C. commersoni*

96 (89). Longitudinal eye diameter
a. up to 29% of head length . . *C. commersoni*
b. 30% of head length or more 97

97 (96). Length from anterior margin of snout to posterior margin of vent
a. up to 80% SL 98
b. 81% SL or more . . . . *C. commersoni*

98 (97). Number of myomeres to posterior margin of vent
a. up to 38 . . . . *C. platyrhynchus*
C. commersoni
b. 39 or more . . . . *C. commersoni*

99 (75). Number of myomeres to posterior margin of vent
a. up to 38 . . . . *C. discobolus*
C. platyrhynchus
b. 39 or more . . . . *C. discobolus*

100 (88). Longitudinal eye diameter
a. up to 29% of head length . . *C. commersoni*
b. 30% of head length or more 101

101 (100). Length from anterior margin of snout to posterior margin of vent
a. up to 80% SL 102
b. 81% SL or more . . . . *C. commersoni*

102 (101). Number of myomeres to posterior margin of vent
a. up to 38 . . . . *C. discobolus*
C. commersoni
C. platyrhynchus
b. 39 or more . . . . *C. commersoni*
C. discobolus

103 (59,69,71). Longitudinal eye diameter
a. 30 to 32% of head length . . . *C. discobolus*
b. 33% of head length or more 104

104 (103). Number of myomeres to posterior margin of vent
a. up to 38 . . . . *C. ardens*
C. discobolus
b. 39 or more . . . . *C. discobolus*

105 (33,34). Longitudinal eye diameter
a. 30 to 32% of head length . . . . *C. latipinnis*
b. 33% of head length or more 106

106 (105). Number of myomeres to posterior margin of vent
a. up to 38 . . . . *C. ardens*
C. latipinnis
b. 39 or more . . . . *C. latipinnis*

107 (68,69). Longitudinal eye diameter
a. 30 to 32% of head length . . . . *C. latipinnis*
C. discobolus
b. 33% of head length or more 108

108 (107). Number of myomeres to posterior margin of vent
a. up to 38 . . . . *C. ardens* *C. discobolus* *C. latipinnis*
b. 39 or more . . . . *C. discobolus* *C. latipinnis*

109 (61). Longitudinal eye diameter
a. up to 32% of head length . . . . . *X. texanus*
b. 33% of head length or more 110

110 (109). Number of myomeres to posterior margin of vent
a. up to 38 111
b. 39 or more . . . . *X. texanus*

111 (110). Length from anterior margin of snout to posterior margin of vent
a. up to 76% SL . . . . *C. ardens*
b. 77 to 80% SL . . . . *C. ardens* *X. texanus*
c. 81% SL or more . . . . *X. texanus*

112 (58). Longitudinal eye diameter
a. up to 29% of head length . . . . . *X. texanus*
b. 30% of head length or more 114

113 (59). Longitudinal eye diameter
a. up to 29% of head length . . . . . *X. texanus*
b. 30 to 32% of head length 114
c. 33% of head length or more 115

114 (112,113). Length from anterior margin of snout to posterior margin of vent
a. up to 76% SL . . . . *C. discobolus*
b. 77 to 80% SL . . . . *C. discobolus* *X. texanus*
c. 81% SL or more . . . . *X. texanus*

115 (113). Length from anterior margin of snout to posterior margin of vent
a. up to 76% SL . . . . *C. discobolus* *C. ardens*
b. 77 to 80% SL 116
c. 81% SL or more . . . . *X. texanus*

116 (115). Number of myomeres to posterior margin of vent
a. up to 38 . . . . *C. ardens* *C. discobolus* *X. texanus*
b. 39 or more . . . . *C. discobolus* *X. texanus*

Postflexion Mesolarvae -- adult complement of principal caudal fin rays present but adult complement of principal dorsal or anal fin rays lacking (Figs. 3,17; definition abbreviated for species of concern). Separate skeletal character key at end for confirmation of identity or further diagnosis of specimens cleared (and preferably stained) for bone.

1. Standard length (SL; Fig. 4)
a. 11 mm 2A
b. 12 mm 2B
c. 13 mm 10
d. 14 mm 27
e. 15 mm 43
f. 16 mm 80
g. 17 mm 101
h. 18-21 mm . . . . *C. latipinnis*

2A (1). Ventral midline from shortly behind heart region to near vent with
a. ≥7 melanophores (Fig. 17) . . *C. discobolus*
b. 1-6 melanophores or without pigment (Fig. 87) 7

2B (1). Ventral midline from shortly behind heart region to near vent with
a. ≥21 melanophores in a continuous or nearly continuous line or narrow band (Fig. 31) . . . . *C. commersoni*
b. ≥21 melanophores in a shorter or a distinctly discontinuous line (Fig. 45) 3
c. 7-20 melanophores (Fig. 17) . *C. discobolus*
d. 1-6 melanophores or without pigment (Fig. 87) 7

3 (2B). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres with
a. distinct continuous or nearly continuous lines of melanophores along (parallel to) each side of dorsal midline (Figs. 30, 31) . . . . *C. commersoni*
b. distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline (Figs. 72, 73) 4
c. no distinct lines of melanophores along either side of dorsal midline (Figs. 44, 45) 5

4 (3). Melanophores in lines lateral (and parallel) to dorsal midline between head and 2/3 distance to last myomeres mostly in
a. single file (Fig. 31) 5
b. obliquely oriented pairs or groups resulting in a "herring bone" or "tractor tread" pattern (Figs. 30, 59) *C. commersoni*

5 (3,4). Pigmentation of peritoneum
a. absent on lateral and ventro-lateral surfaces (Figs. 30, 44) 6
b. at least sparse or patchy on lateral surfaces (Fig. 45) . . . . *C. discobolus*

6 (5). Principal dorsal fin rays
a. absent 218
b. present (at least one) 116

7 (2A,2B). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres with

a. distinct continuous or nearly continuous lines of melanophores along (parallel to) each side of dorsal midline (Fig. 17) . . . . *X. texanus*

b. distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline or with no distinct lines of melanophores along either side of dorsal midline (Figs. 45, 87) 8

8 (7). Pigmentation of peritoneum

a. absent on lateral and ventro-lateral surfaces (Figs. 44, 87) 9

b. at least sparse or patchy on lateral surfaces (Fig. 45) . . . . *C. discobolus*

9 (8). Principal dorsal fin rays

a. absent 288

b. present (at least one) . . . . . . *C. discobolus*

10 (1). Ventral midline from shortly behind heart region to near vent with

a. ≥21 melanophores in a continuous or nearly continuous line or narrow band (if midline pigment extends into branchial region anterior to heart, most probably *C. commersoni*; Figs. 31, 73) . . 11

b. ≥21 melanophores in a shorter or a distinctly discontinuous line (Fig. 45) . . . 15

c. 7-20 melanophores (Fig. 17) 20

d. 1-6 melanophores or without pigment (Fig. 87) 23

11 (10). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres with

a. distinct continuous or nearly continuous lines of melanophores along (parallel to) each side of dorsal midline (Figs. 30, 31) . . . . *C. commersoni*

b. distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline (Figs. 72, 73) 12

c. no distinct lines of melanophores along either side of dorsal midline (Figs. 44, 45) 13

12 (11). Melanophores in lines lateral (and parallel) to dorsal midline between head and 2/3 distance to last myomeres mostly in

a. single file (Figs. 31, 72, 73) 13

b. obliquely oriented pairs or groups resulting in a "herring bone" or "tractor tread" pattern (Figs. 30, 59) *C. commersoni*

13 (11,12). Pigmentation of peritoneum

a. absent on lateral and ventro-lateral surfaces (Figs. 30, 72) 14

b. at least sparse or patchy on lateral surfaces (Fig. 73) . . . . *C. platyrhynchus*

14 (13). Principal dorsal fin rays

a. absent 225

b. present (at least one) 119

15 (10). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres with

a. distinct continuous or nearly continuous lines of melanophores along (parallel to) each side of dorsal midline (Figs. 30, 31) . . . . *C. commersoni*

b. distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline (Figs. 72, 73) 16

c. no distinct lines of melanophores along either side of dorsal midline (Figs. 44, 45) 17

16 (15). Melanophores in lines lateral (and parallel) to dorsal midline between head and 2/3 distance to last myomeres mostly in

a. single file (Figs. 31, 43, 72, 73) 17

b. obliquely oriented pairs or groups resulting in a "herring bone" or "tractor tread" pattern (Figs. 30, 59) *C. commersoni*

17 (15,16). Pigmentation of peritoneum

a. absent on lateral and ventro-lateral surfaces (Figs. 30, 44, 72) 18

b. at least sparse or patchy on lateral surfaces (Figs. 45, 73) 19

18 (17). Principal dorsal fin rays

a. absent 211

b. present (at least one) 122

19 (17). Principal dorsal fin rays

a. absent 231

b. present (at least one) 125

20 (10). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres with

a. distinct continuous or nearly continuous lines of melanophores along (parallel to) each side of dorsal midline (Fig. 17) . . . . *C. ardens*

b. distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline or with no distinct lines of melanophores along either side of dorsal midline (Figs. 16, 44, 45) 21

21 (20). Pigmentation of peritoneum

a. absent on lateral and ventro-lateral surfaces (Figs. 17, 44) 22

b. at least sparse or patchy on lateral surfaces (Fig. 45) . . . . *C. discobolus*

22 (21). Principal dorsal fin rays

a. absent 271

b. present (at least one) 146

23 (10). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres with
- a. distinct continuous or nearly continuous lines of melanophores along (parallel to) each side of dorsal midline (Fig. 17) . . . 24
- b. distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline or with no distinct lines of melanophores along either side of dorsal midline (Figs. 45, 87) 25

24 (23). Principal dorsal fin rays
- a. absent 282
- b. present (at least one) . . . . *C. ardens*

25 (23). Pigmentation of peritoneum
- a. absent on lateral and ventro-lateral surfaces (Figs. 17, 44, 87) 26
- b. at least sparse or patchy on lateral surfaces (Fig. 45) . . . . *C. discobolus*

26 (25). Principal dorsal fin rays
- a. absent 248
- b. present (at least one) 146

27 (1). Ventral midline from shortly behind heart region to near vent with
- a. ≥21 melanophores in a continuous or nearly continuous line or narrow band (if midline pigment extends into branchial region anterior to heart, most probably *C. commersoni*) (Figs. 31, 73) . 28
- b. ≥21 melanophores in a shorter or a distinctly discontinuous line (Fig. 45) 31
- c. 7-20 melanophores (Fig. 17) 35
- d. 1-6 melanophores or without pigment (Fig. 87) 37

28 (27). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres with
- a. distinct continuous or nearly continuous lines of melanophores along (parallel to) each side of dorsal midline (Figs. 30, 31) . . . . *C. commersoni*
- b. distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline (Figs. 72, 73) 29
- c. no distinct lines of melanophores along either side of dorsal midline (Figs. 44, 45) 30

29 (28). Melanophores in lines lateral (and parallel) to dorsal midline between head and 2/3 distance to last myomeres mostly in
- a. single file (Figs. 31, 73) 30
- b. obliquely oriented pairs or groups resulting in a "herring bone" or "tractor tread" pattern (Figs. 30, 59) . . . . . *C. commersoni*

30 (28,29). Pigmentation of peritoneum
- a. absent on lateral and ventro-lateral surfaces or present on lateral surfaces only (Figs. 30, 31, 72) 107
- b. at least sparse or patchy on lateral and ventro-lateral surfaces (Figs. 73, 74) . . . . *C. platyrhynchus*

31 (27). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres with
- a. distinct continuous or nearly continuous lines of melanophores along (parallel to) each side of dorsal midline (Figs. 30, 31) . . . . *C. commersoni*
- b. distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline (Figs. 72, 73) 32
- c. no distinct lines of melanophores along either side of dorsal midline (Figs. 44, 45) 33

32 (31). Melanophores in lines lateral (and parallel) to dorsal midline between head and 2/3 distance to last myomeres mostly in
- a. single file (Figs. 31, 73) 33
- b. obliquely oriented pairs or groups resulting in a "herring bone" or "tractor tread" pattern (Figs. 30, 59) *C. commersoni*

33 (31,32). Pigmentation of peritoneum
- a. absent on lateral and ventro-lateral surfaces or present on lateral surfaces only (Figs. 30, 31, 44, 72) 34
- b. at least sparse or patchy on lateral and ventro-lateral surfaces (Figs. 73, 74) . . . . *C. platyrhynchus*

34 (33). Principal dorsal fin rays
- a. present (at least one) but full complement incomplete or unclearly formed . 122
- b. present with full (adult) complement clearly formed and countable (principal fin rays are sufficiently formed when the last principal ray, which consists of two separate ray elements or "branches" based on the most posterior pterygiophore, is well defined) 158

35 (27). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres with
- a. distinct continuous or nearly continuous lines of melanophores along (parallel to) each side of dorsal midline (Fig. 17) . . . . *C. ardens*
- b. distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline or with no distinct lines of melanophores along either side of dorsal midline (Figs. 44, 45) 36

36 (35). Pigmentation of peritoneum
- a. absent on lateral and ventro-lateral surfaces (Figs. 17, 44) 64
- b. at least sparse or patchy on lateral surfaces (Fig. 45) . . . . *C. discobolus*

37 (27). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres with
- a. distinct continuous or nearly continuous lines of melanophores along (parallel to) each side of dorsal midline (Fig. 17) . . . 38
- b. distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline or with no distinct lines of melanophores along either side of dorsal midline (Figs. 45, 87) 40

38 (37). Pigmentation of peritoneum
- a. absent on lateral and ventro-lateral surfaces (Figs. 17, 87) 39
- b. at least sparse or patchy on lateral surfaces (Fig. 45) . . . . *X. texanus*

39 (38). Principal dorsal fin rays
- a. absent 282
- b. present (at least one) but full complement incomplete or unclearly formed . 130
- c. present with full (adult) complement clearly formed and countable (principal fin rays are sufficiently formed when the last principal ray, which consists of two separate ray elements or "branches" based on the most posterior pterygiophore, is well defined) . . . . *C. ardens*

40 (37). Pigmentation of peritoneum
- a. absent on lateral and ventro-lateral surfaces (Figs. 17, 44, 87) 41
- b. at least sparse or patchy on lateral surfaces (Fig. 45) 42

41 (40). Principal dorsal fin rays
- a. absent 282
- b. present (at least one) but full complement incomplete or unclearly formed . 127
- c. present with full (adult) complement clearly formed and countable (principal fin rays are sufficiently formed when the last principal ray, which consists of two separate ray elements or "branches" based on the most posterior pterygiophore, is well defined) 171

42 (40). Principal dorsal fin rays
- a. absent . . . . *X. texanus*
- b. present (at least one) but full complement incomplete or unclearly formed . 133
- c. present with full (adult) complement clearly formed and countable (principal fin rays are sufficiently formed when the last principal ray, which consists of two separate ray elements or "branches" based on the most posterior pterygiophore, is well defined) . . . . . *C. discobolus*

43 (1). Yolk
- a. present . . . . *C. latipinnis*
- b. absent 44

44 (43). Ventral midline from shortly behind heart region to near vent with
- a. ≥21 melanophores in a continuous or nearly continuous line or narrow band (if midline pigment extends into branchial region anterior to heart, most probably *C. commersoni*) (Figs. 31, 73) . 45
- b. ≥21 melanophores in a shorter or a distinctly discontinuous line (Fig. 45) . . 48
- c. 7-20 melanophores (Fig. 17) 54
- d. 1-6 melanophores (Fig. 59) 65
- e. no pigment (Fig. 87) 75

45 (44). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres with
- a. distinct continuous or nearly continuous lines of melanophores along (parallel to) each side of dorsal midline (Figs. 30, 31) . . . . *C. commersoni*
- b. distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline (Figs. 72, 73) 46
- c. no distinct lines of melanophores along either side of dorsal midline (Figs. 44, 45) 47

46 (45). Melanophores in lines lateral (and parallel) to dorsal midline between head and 2/3 distance to last myomeres mostly in
- a. single file (Figs. 31, 73) 47
- b. obliquely oriented pairs or groups resulting in a "herring bone" or "tractor tread" pattern (Figs. 30, 59) . . . . . *C. commersoni*

47 (45,46). Pigmentation of peritoneum
- a. absent on lateral and ventro-lateral surfaces or present on lateral surfaces only (Figs. 30, 31) . . . . *C. commersoni*
- b. at least sparse or patchy on lateral and ventro-lateral surfaces (Fig. 73) . . . . *C. platyrhynchus*

48 (44). Gut (Fig. 5)
- a. essentially straight or with bend less than 90° (gut phase 1) or with at least 90° bend or partial s-shaped loop (gut phase 2) 49
- b. with full loop (s-shape to near anterior end of visceral cavity) but with neither limb of loop completely across ventral midline (gut phase 3) . . . . . . *C. discobolus*

49 (48). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres with
- a. distinct continuous or nearly continuous lines of melanophores along (parallel to) each side of dorsal midline (Figs. 30, 31) . . . . *C. commersoni*

b. distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline (Figs. 72, 73) 50
c. no distinct lines of melanophores along either side of dorsal midline (Figs. 44, 45) 51

50 (49). Melanophores in lines lateral (and parallel) to dorsal midline between head and 2/3 distance to last myomeres mostly in
a. single file (Figs. 31, 73) 51
b. obliquely oriented pairs or groups resulting in a "herring bone" or "tractor tread" pattern (Figs. 30, 59) *C. commersoni*

51 (49,50). Pigmentation of peritoneum
a. absent on lateral and ventro-lateral surfaces or present on lateral surfaces only (Figs. 30, 31, 44) 52
b. at least sparse or patchy on lateral and ventro-lateral surfaces (Figs. 45, 73) . . . 53

52 (51). Principal dorsal fin rays
a. present (at least one) but full complement incomplete or unclearly formed . 116
b. present with full (adult) complement clearly formed and countable (principal fin rays are sufficiently formed when the last principal ray, which consists of two separate ray elements or "branches" based on the most posterior pterygiophore, is well defined) 161

53 (51). Principal dorsal fin rays
a. present (at least one) but full complement incomplete or unclearly formed . 125
b. present with full (adult) complement clearly formed and countable (principal fin rays are sufficiently formed when the last principal ray, which consists of two separate ray elements or "branches" based on the most posterior pterygiophore, is well defined) 167

54 (44). Gut (Fig. 5)
a. essentially straight or with bend less than 90° (gut phase 1) 55
b. with at least 90° bend or partial s-shaped loop (gut phase 2) 62
c. with full loop (s-shape to near anterior end of visceral cavity) but with neither limb of loop completely across over ventral midline (gut phase 3) *C. discobolus*

55 (54). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres with
a. distinct continuous or nearly continuous lines of melanophores along (parallel to) each side of dorsal midline (Figs. 17, 59) 56
b. distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline (Fig. 16) 59
c. no distinct lines of melanophores along either side of dorsal midline (Figs. 44, 45) 60

56 (55). Melanophores in lines lateral (and parallel) to dorsal midline between head and 2/3 distance to last myomeres mostly in
a. single file (Fig. 17) 57
b. obliquely oriented pairs or groups resulting in a "herring bone" or "tractor tread" pattern (Fig. 59) . . . . . . *C. latipinnis*

57 (56). Pigmentation of peritoneum
a. absent on lateral and ventro-lateral surfaces (Figs. 17, 59) 58
b. at least sparse or patchy on lateral surfaces only (Fig. 18) . . . . *C. ardens*

58 (57). Principal dorsal fin rays
a. absent 278
b. present (at least one) but full complement incomplete or unclearly formed . 150
c. present with full (adult) complement clearly formed and countable (principal fin rays are sufficiently formed when the last principal ray, which consists of two separate ray elements or "branches" based on the most posterior pterygiophore, is well defined) . . . . *C. ardens*

59 (55). Melanophores in lines lateral (and parallel) to dorsal midline between head and 2/3 distance to last myomeres mostly in
a. single file (Fig. 17) 60
b. obliquely oriented pairs or groups resulting in a "herring bone" or "tractor tread" pattern (Fig. 59) . . . . . . *C. latipinnis*

60 (55,59). Pigmentation of peritoneum
a. absent on lateral and ventro-lateral surfaces (Figs. 17, 44, 59) 61
b. at least sparse or patchy on lateral surfaces only (Fig. 18) 64
c. at least sparse or patchy on lateral and ventro-lateral surfaces (Fig. 45) . . . . *C. discobolus*

61 (60). Principal dorsal fin rays
a. absent 278
b. present (at least one) but full complement incomplete or unclearly formed . 139
c. present with full (adult) complement clearly formed and countable (principal fin rays are sufficiently formed when the last principal ray, which consists of two separate ray elements or "branches" based on the most posterior pterygiophore, is well defined) 171

62 (54). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres with
a. distinct continuous or nearly continuous lines of melanophores along (parallel

to) each side of dorsal midline (Fig. 17) . . . . *C. ardens*
b. distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline or with no distinct lines of melanophores along either side of dorsal midline (Figs. 44, 45) 63

63 (62). Pigmentation of peritoneum
a. absent on lateral and ventro-lateral surfaces or present on lateral surfaces only (Figs. 17, 18, 44) 64
b. at least sparse or patchy on lateral and ventro-lateral surfaces (Fig. 45) . . . . *C. discobolus*

64 (36,60,63). Principal dorsal fin rays
a. absent . . . . *C. ardens*
b. present (at least one) but full complement incomplete or unclearly formed . 146
c. present with full (adult) complement clearly formed and countable (principal fin rays are sufficiently formed when the last principal ray, which consists of two separate ray elements or "branches" based on the most posterior pterygiophore, is well defined) 171

65 (44). Gut (Fig. 5)
a. essentially straight or with bend less than 90° (gut phase 1) 66
b. with at least 90° bend or partial s-shaped loop (gut phase 2) 73
c. with full loop (s-shape to near anterior end of visceral cavity) but with neither limb of loop completely across over ventral midline (gut phase 3) . . . *C. discobolus*

66 (65). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres with
a. distinct continuous or nearly continuous lines of melanophores along (parallel to) each side of dorsal midline (Figs. 17, 59) 67
b. distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline (Fig. 87) 70
c. no distinct lines of melanophores along either side of dorsal midline (Fig. 45) . . 71

67 (66). Melanophores in lines lateral (and parallel) to dorsal midline between head and 2/3 distance to last myomeres mostly in
a. single file (Figs. 17, 87) 68
b. obliquely oriented pairs or groups resulting in a "herring bone" or "tractor tread" pattern (Fig. 59) . . . . *C. latipinnis*

68 (67). Pigmentation of peritoneum
a. absent on lateral and ventro-lateral surfaces (Figs. 17, 59, 87) 69
b. at least sparse or patchy on lateral surfaces (Fig. 18) 76

69 (68). Principal dorsal fin rays
a. absent 278
b. present (at least one) but full complement incomplete or unclearly formed . 143
c. present with full (adult) complement clearly formed and countable (principal fin rays are sufficiently formed when the last principal ray, which consists of two separate ray elements or "branches" based on the most posterior pterygiophore, is well defined) 183

70 (66). Melanophores in lines lateral (and parallel) to dorsal midline between head and 2/3 distance to last myomeres mostly in
a. single file (Figs. 17, 87) 71
b. obliquely oriented pairs or groups resulting in a "herring bone" or "tractor tread" pattern (Fig. 59) . . . . . . *C. latipinnis*

71 (66,70). Pigmentation of peritoneum
a. absent on lateral and ventro-lateral surfaces (Figs. 17, 44, 59, 87) 72
b. at least sparse or patchy on lateral surfaces only (Fig. 18) 79
c. at least sparse or patchy on lateral and ventro-lateral surfaces (Fig. 45) . . . . *C. discobolus*

72 (71). Principal dorsal fin rays
a. absent 278
b. present (at least one) but full complement incomplete or unclearly formed . 136
c. present with full (adult) complement clearly formed and countable (principal fin rays are sufficiently formed when the last principal ray, which consists of two separate ray elements or "branches" based on the most posterior pterygiophore, is well defined) 169

73 (65). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres with
a. distinct continuous or nearly continuous lines of melanophores along (parallel to) each side of dorsal midline (Fig. 17) . . . 76
b. distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline or with no distinct lines of melanophores along either side of dorsal midline (Figs. 45, 87) 74

74 (73). Pigmentation of peritoneum
a. absent on lateral and ventro-lateral surfaces or present on lateral surfaces only (Figs. 17, 18, 44, 87) 79
b. at least sparse or patchy on lateral and ventro-lateral surfaces (Fig. 45) . . . . *C. discobolus*

75 (44). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres with

a. distinct continuous or nearly continuous lines of melanophores along (parallel to) each side of dorsal midline (Fig. 17) 76
b. distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline or with no distinct lines of melanophores along either side of dorsal midline (Figs. 45, 87) 77

76 (68,73,75). Principal dorsal fin rays
a. absent .... *C. ardens*
b. present (at least one) but full complement incomplete or unclearly formed . 130
c. present with full (adult) complement clearly formed and countable (principal fin rays are sufficiently formed when the last principal ray, which consists of two separate ray elements or "branches" based on the most posterior pterygiophore, is well defined) 183

77 (75). Gut (Fig. 5)
a. essentially straight or with bend less than 90° (gut phase 1) or with at least 90° bend or partial s-shaped loop (gut phase 2) 78
b. with full loop (s-shape to near anterior end of visceral cavity) but with neither limb of loop completely across over ventral midline (gut phase 3) *C. discobolus*

78 (77). Pigmentation of peritoneum
a. absent on lateral and ventro-lateral surfaces or present on lateral surfaces only (Figs. 17, 18, 44, 87) 79
b. at least sparse or patchy on lateral and ventro-lateral surfaces (Fig. 45) .... *C. discobolus*

79 (71,74,78). Principal dorsal fin rays
a. absent .... *C. ardens*
b. present (at least one) but full complement incomplete or unclearly formed . 127
c. present with full (adult) complement clearly formed and countable (principal fin rays are sufficiently formed when the last principal ray, which consists of two separate ray elements or "branches" based on the most posterior pterygiophore, is well defined) 169

80 (1). Ventral midline from shortly behind heart region to near vent with
a. ≥21 melanophores in a continuous or nearly continuous line or narrow band (if midline pigment extends into branchial region anterior to heart, most probably *C. commersoni*) (Figs. 31, 73) 104
b. ≥21 melanophores in a shorter or a distinctly discontinuous line (Fig. 45) ... 81
c. 7-20 melanophores (Fig. 17) 87
d. 1-6 melanophores (Fig. 59) 93
e. no pigment (Fig. 87) 96

81 (80). Gut (Fig. 5)
a. essentially straight or with bend less than 90° (gut phase 1) 104
b. with at least 90° bend or partial s-shaped loop (gut phase 2) 82
c. with full loop (s-shape to near anterior end of visceral cavity) but with neither limb of loop completely across ventral midline (gut phase 3) or with at least one limb of loop fully across ventral midline but not yet with both limbs across fully to opposite side (gut phase 4) .... *C. discobolus*

82 (81). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres with
a. distinct continuous or nearly continuous lines of melanophores along (parallel to) each side of dorsal midline (Figs. 30, 31) .... *C. commersoni*
b. distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline or with no distinct lines of melanophores along either side of dorsal midline (Figs. 72, 73) 83

83 (82). Melanophores in lines lateral (and parallel) to dorsal midline between head and 2/3 distance to last myomeres mostly in
a. single file (Figs. 31, 33) 84
b. obliquely oriented pairs or groups resulting in a "herring bone" or "tractor tread" pattern (Figs. 30, 59) *C. commersoni*

84 (83). Pigmentation of peritoneum
a. absent on lateral and ventro-lateral surfaces or present on lateral surfaces only (Figs. 30, 31, 44) 85
b. at least sparse or patchy on lateral and ventro-lateral surfaces (Figs. 45, 73) ... 86

85 (84). Principal dorsal fin rays
a. present (at least one) but full complement incomplete or unclearly formed .... *C. commersoni*
b. present with full (adult) complement clearly formed and countable (principal fin rays are sufficiently formed when the last principal ray, which consists of two separate ray elements or "branches" based on the most posterior pterygiophore, is well defined) 161

86 (84). Principal dorsal fin rays
a. present (at least one) but full complement incomplete or unclearly formed . 119
b. present with full (adult) complement clearly formed and countable (principal fin rays are sufficiently formed when the last principal ray, which consists of two separate ray elements or "branches" based on the most posterior pterygiophore, is well defined) 158

87 (80). Gut (Fig. 5)

a. essentially straight or with bend less than 90° (gut phase 1) 88
b. with at least 90° bend or partial s-shaped loop (gut phase 2) 90
c. with full loop (s-shape to near anterior end of visceral cavity) but with neither limb of loop completely across ventral midline (gut phase 3) or with at least one limb of loop fully across ventral midline but not yet with both limbs across fully to opposite side (gut phase 4) . . . . *C. discobolus*

88 (87). Pigmentation of peritoneum
a. absent on lateral and ventro-lateral surfaces (Figs. 17, 59) 89
b. at least sparse or patchy on lateral surfaces only (Fig. 18) . . . . *C. ardens*

89 (88). Principal dorsal fin rays
a. present (at least one) but full complement incomplete or unclearly formed . 150
b. present with full (adult) complement clearly formed and countable (principal fin rays are sufficiently formed when the last principal ray, which consists of two separate ray elements or "branches" based on the most posterior pterygiophore, is well defined) . . . . *C. ardens*

90 (87). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres with
a. distinct continuous or nearly continuous lines of melanophores along (parallel to) each side of dorsal midline (Fig. 17) . . . . *C. ardens*
b. distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline or with no distinct lines of melanophores along either side of dorsal midline (Figs. 44, 45) 91

91 (90). Pigmentation of peritoneum
a. absent on lateral and ventro-lateral surfaces or present on lateral surfaces only (Figs. 17, 18, 44) 92
b. at least sparse or patchy on lateral and ventro-lateral surfaces (Fig. 45) . . . . *C. discobolus*

92 (91). Principal dorsal fin rays
a. present (at least one) but full complement incomplete or unclearly formed . . . . *C. ardens*
b. present with full (adult) complement clearly formed and countable (principal fin rays are sufficiently formed when the last principal ray, which consists of two separate ray elements or "branches" based on the most posterior pterygiophore, is well defined) 171

93 (80). Gut (Fig. 5)
a. essentially straight or with bend less than 90° (gut phase 1) 94
b. with at least 90° bend or partial s-shaped loop (gut phase 2) 97
c. with full loop (s-shape to near anterior end of visceral cavity) but with neither limb of loop completely across ventral midline (gut phase 3) or with at least one limb of loop fully across ventral midline but not yet with both limbs across fully to opposite side (gut phase 4) . . . . *C. discobolus*

94 (93). Pigmentation of peritoneum
a. absent on lateral and ventro-lateral surfaces (Figs. 17, 59, 87) 95
b. at least sparse or patchy on lateral surfaces only (Fig. 18) 98

95 (94). Principal dorsal fin rays
a. present (at least one) but full complement incomplete or unclearly formed . 143
b. present with full (adult) complement clearly formed and countable (principal fin rays are sufficiently formed when the last principal ray, which consists of two separate ray elements or "branches" based on the most posterior pterygiophore, is well defined) 183

96 (80). Gut (Fig. 5)
a. essentially straight or with bend less than 90° (gut phase 1) 98
b. with at least 90° bend or partial s-shaped loop (gut phase 2) 97
c. with full loop (s-shape to near anterior end of visceral cavity) but with neither limb of loop completely across ventral midline (gut phase 3) or with at least one limb of loop fully across ventral midline but not yet with both limbs across fully to opposite side (gut phase 4) . . . . *C. discobolus*

97 (93,96). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres with
a. distinct continuous or nearly continuous lines of melanophores along (parallel to) each side of dorsal midline (Fig. 17) . . . 98
b. distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline or with no distinct lines of melanophores along either side of dorsal midline (Figs. 45, 87) 99

98 (94,96,97). Principal dorsal fin rays
a. present (at least one) but full complement incomplete or unclearly formed . 130
b. present with full (adult) complement clearly formed and countable (principal fin rays are sufficiently formed when the last principal ray, which consists of two separate ray elements or "branches" based on the most posterior pterygiophore, is well defined) 183

99 (97). Pigmentation of peritoneum

a. absent on lateral and ventro-lateral surfaces or present on lateral surfaces only (Figs. 17, 18, 44, 87) 100
b. at least sparse or patchy on lateral and ventro-lateral surfaces (Fig. 45) .... *C. discobolus*

100 (99). Principal dorsal fin rays
a. present (at least one) but full complement incomplete or unclearly formed . 130
b. present with full (adult) complement clearly formed and countable (principal fin rays are sufficiently formed when the last principal ray, which consists of two separate ray elements or "branches" based on the most posterior pterygiophore, is well defined) 169

101 (1). Ventral midline from shortly behind heart region to near vent with
a. ≥21 melanophores in a continuous or nearly continuous line or narrow band (if midline pigment extends into branchial region anterior to heart, most probably *C. commersoni*) (Figs. 31, 73) 102
b. ≥21 melanophores in a shorter or a distinctly discontinuous line (Fig. 45) .. 103
c. 7-20 melanophores (Fig. 17) 108
d. 1-6 melanophores (Fig. 59) 111
e. no pigment (Fig. 87) 114

102 (101). Gut (Fig. 5)
a. essentially straight or with bend less than 90° (gut phase 1) .... *C. platyrhynchus*
b. with at least 90° bend or partial s-shaped loop (gut phase 2) 104

103 (101). Gut (Fig. 5)
a. essentially straight or with bend less than 90° (gut phase 1) .... *C. platyrhynchus*
b. with at least 90° bend or partial s-shaped loop (gut phase 2) 104
c. with full loop (s-shape to near anterior end of visceral cavity) but with neither limb of loop completely across ventral midline (gut phase 3) or with at least one limb of loop fully across ventral midline but not yet with both limbs across fully to opposite side (gut phase 4) .... *C. discobolus*

104 (80,81,102,103). Dorsal surface lateral to midline from shortly behind head to about 2/3 distance to last myomeres with
a. distinct continuous or nearly continuous lines of melanophores along (parallel to) each side of dorsal midline (Figs. 30, 31) .... *C. commersoni*
b. distinctly shorter or discontinuous lines of melanophores along one or both sides of dorsal midline or (Figs. 72, 73) 105
c. no distinct lines of melanophores along either side of dorsal midline (Figs. 44, 45) 106

105 (104). Melanophores in lines lateral (and parallel) to dorsal midline between head and 2/3 distance to last myomeres mostly in
a. single file (Figs. 31, 73) 106
b. obliquely oriented pairs or groups resulting in a "herring bone" or "tractor tread" pattern (Figs. 30, 59) ..... *C. commersoni*

106 (104,105). Pigmentation of peritoneum
a. absent on lateral and ventro-lateral surfaces or present on lateral surfaces only (Figs. 30, 31) .... *C. commersoni*
b. at least sparse or patchy on lateral and ventro-lateral surfaces (Fig. 73) 107

107 (30,106). Principal dorsal fin rays
a. present (at least one) but full complement incomplete or unclearly formed . 119
b. present with full (adult) complement clearly formed and countable (principal fin rays are sufficiently formed when the last principal ray, which consists of two separate ray elements or "branches" based on the most posterior pterygiophore, is well defined) 164

108 (101). Gut (Fig. 5)
a. essentially straight or with bend less than 90to (gut phase 1) or with at least 90to bend or partial s-shaped loop (gut phase 2) 109
b. with full loop (s-shape to near anterior end of visceral cavity) but with neither limb of loop completely across ventral midline (gut phase 3) or with at least one limb of loop fully across ventral midline but not yet with both limbs across fully to opposite side (gut phase 4) .... *C. discobolus*

109 (108). Pigmentation of peritoneum
a. absent on lateral and ventro-lateral surfaces (Figs. 17, 59) 110
b. at least sparse or patchy on lateral surfaces only (Fig. 18) .... *C. ardens*

110 (109). Principal dorsal fin rays
a. present (at least one) but full complement incomplete or unclearly formed .... *C. latipinnis*
b. present with full (adult) complement clearly formed and countable (principal fin rays are sufficiently formed when the last principal ray, which consists of two separate ray elements or "branches" based on the most posterior pterygiophore, is well defined) 179

111 (101). Gut (Fig. 5)
a. essentially straight or with bend less than 90° (gut phase 1) or with at least 90° bend or partial s-shaped loop (gut phase 2) 112
b. with full loop (s-shape to near anterior end of visceral cavity) but with neither

limb of loop completely across ventral midline (gut phase 3) or with at least one limb of loop fully across ventral midline but not yet with both limbs across fully to opposite side (gut phase 4) .... *C. discobolus*

112 (111). Pigmentation of peritoneum
- a. absent on lateral and ventro-lateral surfaces (Figs. 17, 59, 87) 113
- b. at least sparse or patchy on lateral surfaces only (Fig. 18) 115

113 (112). Principal dorsal fin rays
- a. present (at least one) but full complement incomplete or unclearly formed . 154
- b. present with full (adult) complement clearly formed and countable (principal fin rays are sufficiently formed when the last principal ray, which consists of two separate ray elements or "branches" based on the most posterior pterygiophore, is well defined) 175

114 (101). Gut (Fig. 5)
- a. essentially straight or with bend less than 90° (gut phase 1) or with at least 90° bend or partial s-shaped loop (gut phase 2) 115
- b. with full loop (s-shape to near anterior end of visceral cavity) but with neither limb of loop completely across ventral midline (gut phase 3) or with at least one limb of loop fully across ventral midline but not yet with both limbs across fully to opposite side (gut phase 4) .... *C. discobolus*

115 (112,114). Principal dorsal fin rays
- a. present (at least one) but full complement incomplete or unclearly formed .... *X. texanus*
- b. present with full (adult) complement clearly formed and countable (principal fin rays are sufficiently formed when the last principal ray, which consists of two separate ray elements or "branches" based on the most posterior pterygiophore, is well defined) 183

116 (6,52). Full complement of dorsal fin pterygiophores (same number as adult complement of principal dorsal fin rays which develop subsequent to the pterygiophores)
- a. incompletely or unclearly formed 185
- b. clearly formed and countable 117

117 (116). Number of dorsal fin pterygiophores
- a. 9 .... *C. discobolus*
- b. 10-12 118
- c. 13 .... *C. commersoni*

118 (117). Length of base of dorsal fin (origin to insertion of dorsal fin)
- a. 11% SL .... *C. discobolus*
- b. 12-14% SL 185

119 (14,86,107). Full complement of dorsal fin pterygiophores (same number as adult complement of principal dorsal fin rays which develop subsequent to the pterygiophores)
- a. incompletely or unclearly formed 187
- b. clearly formed and countable 120

120 (119). Number of dorsal fin pterygiophores
- a. 9 .... *C. platyrhynchus*
- b. 10-12 121
- c. 13 .... *C. commersoni*

121 (120). Length of base of dorsal fin (origin to insertion of dorsal fin)
- a. 11% SL .... *C. platyrhynchus*
- b. 12-13% SL 187
- c. 14% SL .... *C. commersoni*

122 (18,34). Full complement of dorsal fin pterygiophores (same number as adult complement of principal dorsal fin rays which develop subsequent to the pterygiophores)
- a. incompletely or unclearly formed 189
- b. clearly formed and countable 123

123 (122). Number of dorsal fin pterygiophores
- a. 9 126
- b. 10-12 124
- c. 13 .... *C. commersoni*

124 (123). Length of base of dorsal fin (origin to insertion of dorsal fin)
- a. 11% SL 191
- b. 12-13% SL 189
- c. 14% SL 185

125 (19,53). Full complement of dorsal fin pterygiophores (same number as adult complement of principal dorsal fin rays which develop subsequent to the pterygiophores)
- a. incompletely or unclearly formed 191
- b. clearly formed and countable 126

126 (123,125). Length of base of dorsal fin (origin to insertion of dorsal fin)
- a. 11-13% SL 191
- b. 14% SL .... *C. discobolus*

127 (41,79). Full complement of dorsal fin pterygiophores (same number as adult complement of principal dorsal fin rays which develop subsequent to the pterygiophores)
- a. incompletely or unclearly formed 197
- b. clearly formed and countable 128

128 (127). Number of dorsal fin pterygiophores
- a. 9 .... *C. discobolus*
- b. 10-11 148
- c. 12 129
- d. 13-14 132
- e. 15-16 .... *X. texanus*

129 (128). Length of base of dorsal fin (origin to insertion of dorsal fin)
- a. 11% SL . . . . *C. discobolus*
- b. 12-14% SL 149
- c. 15% SL . . . . *C. ardens*
- d. 16-18% SL . . . . *X. texanus*

130 (39,76,98,100). Full complement of dorsal fin pterygiophores (same number as adult complement of principal dorsal fin rays which develop subsequent to the pterygiophores)
- a. incompletely or unclearly formed 195
- b. clearly formed and countable 131

131 (130). Number of dorsal fin pterygiophores
- a. 10-11 . . . . *C. ardens*
- b. 12-14 132
- c. 15-16 . . . . *X. texanus*

132 (128,131). Length of base of dorsal fin (origin to insertion of dorsal fin)
- a. 12-15% SL; length from anterior margin of snout to insertion of dorsal fin 60-63% SL . . . . *C. ardens*
- b. 16-18% SL; length from anterior margin of snout to insertion of dorsal fin 65-67% SL . . . . *X. texanus*

133 (42). Full complement of dorsal fin pterygiophores (same number as adult complement of principal dorsal fin rays which develop subsequent to the pterygiophores)
- a. incompletely or unclearly formed 209
- b. clearly formed and countable 134

134 (133). Number of dorsal fin pterygiophores
- a. 9-11 . . . . *C. discobolus*
- b. 12 135
- c. 13-16 . . . . *X. texanus*

135 (134). Length of base of dorsal fin (origin to insertion of dorsal fin)
- a. 11-14% SL; length from anterior margin of snout to insertion of dorsal fin 61-64% SL . . . . *C. discobolus*
- b. 16-18% SL; length from anterior margin of snout to insertion of dorsal fin 65-67% SL . . . . *X. texanus*

136 (72). Full complement of dorsal fin pterygiophores (same number as adult complement of principal dorsal fin rays which develop subsequent to the pterygiophores)
- a. incompletely or unclearly formed 205
- b. clearly formed and countable 137

137 (136). Number of dorsal fin pterygiophores
- a. 9 . . . . *C. discobolus*
- b. 10 148
- c. 11 141
- d. 12 138
- e. 13-14 145
- f. 15-16 . . . . *X. texanus*

138 (137). Length of base of dorsal fin (origin to insertion of dorsal fin)
- a. 11% SL . . . . *C. discobolus*
- b. 12-14% SL 142
- c. 15% SL 153
- d. 16-17% SL 157
- e. 18% SL . . . . *X. texanus*

139 (61). Full complement of dorsal fin pterygiophores (same number as adult complement of principal dorsal fin rays which develop subsequent to the pterygiophores)
- a. incompletely or unclearly formed 201
- b. clearly formed and countable 140

140 (139). Number of dorsal fin pterygiophores
- a. 9 . . . . *C. discobolus*
- b. 10 148
- c. 11-12 141
- d. 13-14 152

141 (137,140). Length of base of dorsal fin (origin to insertion of dorsal fin)
- a. 11% SL . . . . *C. discobolus*
- b. 12-14% SL 142
- c. 15% SL 153
- d. 16-17% SL . . . . *C. latipinnis*

142 (138,141). Length from anterior margin of snout to insertion of dorsal fin
- a. 60% SL . . . . *C. ardens*
- b. 61% SL 193
- c. 62-63% SL 201
- d. 64% SL 207
- e. 65-67% SL . . . . *C. latipinnis*

143 (69,95). Full complement of dorsal fin pterygiophores (same number as adult complement of principal dorsal fin rays which develop subsequent to the pterygiophores)
- a. incompletely or unclearly formed 203
- b. clearly formed and countable 144

144 (143). Number of dorsal fin pterygiophores
- a. 10 . . . . *C. ardens*
- b. 11 152
- c. 12-14 145
- d. 15-16 . . . . *X. texanus*

145 (137,144). Length of base of dorsal fin (origin to insertion of dorsal fin)
- a. 12-15% SL 153
- b. 16-17% SL 157
- c. 18% SL . . . . *X. texanus*

146 (22,26,64). Full complement of dorsal fin pterygiophores (same number as adult complement of principal dorsal fin rays which develop subsequent to the pterygiophores)
- a. incompletely or unclearly formed 193
- b. clearly formed and countable 147

147 (146). Number of dorsal fin pterygiophores

a. 9 . . . . *C. discobolus*
b. 10-12 148
c. 13-14 . . . . *C. ardens*

148 (128,137,140,147). Length of base of dorsal fin (origin to insertion of dorsal fin)
a. 11% SL . . . . *C. discobolus*
b. 12-14% SL 149
c. 15% SL . . . . *C. ardens*

149 (129,148). Length from anterior margin of snout to insertion of dorsal fin
a. 60% SL . . . . *C. ardens*
b. 61-63% SL 193
c. 64% SL . . . . *C. discobolus*

150 (58,89). Full complement of dorsal fin pterygiophores (same number as adult complement of principal dorsal fin rays which develop subsequent to the pterygiophores)
a. incompletely or unclearly formed 199
b. clearly formed and countable 151

151 (150). Number of dorsal fin pterygiophores
a. 10 . . . . *C. ardens*
b. 11-14 152

152 (140,144,151). Length of base of dorsal fin (origin to insertion of dorsal fin)
a. 12-15% SL 153
b. 16-17% SL . . . . *C. latipinnis*

153 (138,141,145,152). Length from anterior margin of snout to insertion of dorsal fin
a. 60-61% SL . . . . *C. ardens*
b. 62-63% SL 199
c. 64-67% SL . . . . *C. latipinnis*

154 (113). Full complement of dorsal fin pterygiophores (same number as adult complement of principal dorsal fin rays which develop subsequent to the pterygiophores)
a. incompletely or unclearly formed 292
b. clearly formed and countable 155

155 (154). Number of dorsal fin pterygiophores
a. 11 . . . . *C. latipinnis*
b. 12-14 156
c. 15-16 . . . . *X. texanus*

156 (155). Length of base of dorsal fin (origin to insertion of dorsal fin)
a. 12-15% SL . . . . *C. latipinnis*
b. 16-17% SL 157
c. 18% SL . . . . *X. texanus*

157 (138,145,156). Length from anterior margin of snout to insertion of dorsal fin
a. 62-64% SL . . . . *C. latipinnis*
b. 65-67% SL 292

158 (34,86). Number of principal dorsal fin rays
a. 9 167
b. 10-12 159
c. 13 . . . . *C. commersoni*

159 (158). Length of base of dorsal fin (origin to insertion of dorsal fin)
a. 11% SL 168
b. 12-13% SL 160
c. 14% SL 163

160 (159). Dorsal fin length
a. 11-15% SL 192
b. 16-17% SL 186

161 (52,85). Number of principal dorsal fin rays
a. 9 . . . . *C. discobolus*
b. 10-12 162
c. 13 . . . . *C. commersoni*

162 (161). Length of base of dorsal fin (origin to insertion of dorsal fin)
a. 11% SL . . . . *C. discobolus*
b. 12-14% SL 163

163 (159,162). Dorsal fin length
a. 11-15% SL . . . . *C. discobolus*
b. 16-17% SL 186

164 (107). Number of principal dorsal fin rays
a. 9 . . . . *C. platyrhynchus*
b. 10-12 165
c. 13 . . . . *C. commersoni*

165 (164). Length of base of dorsal fin (origin to insertion of dorsal fin)
a. 11% SL . . . . *C. platyrhynchus*
b. 12-13% SL 166
c. 14% SL . . . . *C. commersoni*

166 (165). Dorsal fin length
a. 11-15% SL . . . . *C. platyrhynchus*
b. 16-17% SL . . . . *C. commersoni*

167 (53,158). Length of base of dorsal fin (origin to insertion of dorsal fin)
a. 11-13% SL 168
b. 14% SL . . . . *C. discobolus*

168 (159,167). Dorsal fin length
a. 11-15% SL 192
b. 16-17% SL . . . . *C. discobolus*

169 (72,79,100). Number of principal dorsal fin rays
a. 9 . . . . *C. discobolus*
b. 10-11 172
c. 12 170
d. 13-14 184
e. 15-16 . . . . *X. texanus*

170 (169). Length of base of dorsal fin (origin to insertion of dorsal fin)
a. 11% SL . . . . *C. discobolus*
b. 12-14% SL 173
c. 15% SL . . . . *C. ardens*
d. 16-18% SL . . . . *X. texanus*

171 (41,61,64,92). Number of principal dorsal fin rays
a. 9 .... *C. discobolus*
b. 10-12 172
c. 13-14 .... *C. ardens*

172 (169,171). Length of base of dorsal fin (origin to insertion of dorsal fin)
a. 11% SL .... *C. discobolus*
b. 12-14% SL 173
c. 15% SL .... *C. ardens*

173 (170,172). Length from anterior margin of snout to insertion of dorsal fin
a. 60% SL .... *C. ardens*
b. 61-63% SL 174
c. 64% SL .... *C. discobolus*

174 (173). Dorsal fin length
a. 11-13% SL .... *C. discobolus*
b. 14-17% SL 194

175 (113). Number of principal dorsal fin rays
a. 10 .... *C. ardens*
b. 11 180
c. 12-14 176
d. 15-16 .... *X. texanus*

176 (175). Length of base of dorsal fin (origin to insertion of dorsal fin)
a. 12-15% SL 181
b. 16-17% SL 177
c. 18% SL .... *X. texanus*

177 (176). Length from anterior margin of snout to insertion of dorsal fin
a. 62-64% SL .... *C. latipinnis*
b. 65-67% SL 178

178 (177). Dorsal fin length
a. 15-17% SL .... *C. latipinnis*
b. 18-21% SL 292

179 (110). Number of principal dorsal fin rays
a. 10 .... *C. ardens*
b. 11-14 180

180 (175,179). Length of base of dorsal fin (origin to insertion of dorsal fin)
a. 12-15% SL 181
b. 16-17% SL .... *C. latipinnis*

181 (176,180). Length from anterior margin of snout to insertion of dorsal fin
a. 60-61% SL .... *C. ardens*
b. 62-63% SL 182
c. 64-67% SL .... *C. latipinnis*

182 (181). Dorsal fin length
a. 14% SL .... *C. ardens*
b. 15-16% SL 200
c. 17-21% SL .... *C. latipinnis*

183 (69,76,95,98,115). Number of principal dorsal fin rays
a. 10-11 .... *C. ardens*
b. 12-14 184
c. 15-16 .... *X. texanus*

184 (169,183). Length of base of dorsal fin (origin to insertion of dorsal fin)
a. 12-15% SL; length from anterior margin of snout to insertion of dorsal fin 60-63% SL; dorsal fin length 14-16% SL .... *C. ardens*
b. 16-18% SL; length from anterior margin of snout to insertion of dorsal fin 65-67% SL; dorsal fin length 18-21% SL .... *X. texanus*

185 (116,118,124). Pelvic fin buds
a. absent 218
b. present 186

186 (160,163,185). Length from anterior margin of snout to origin of pelvic fin
a. 52% SL .... *C. commersoni*
b. 53-54% SL 218
c. 55-57% SL .... *C. discobolus*

187 (119,121,133). Pelvic fin buds
a. absent 225
b. present 188

188 (187). Length from anterior margin of snout to origin of pelvic fin
a. 52-54% SL 225
b. 55-56% SL .... *C. platyrhynchus*

189 (122,124). Pelvic fin buds
a. absent 211
b. present 190

190 (189). Length from anterior margin of snout to origin of pelvic fin
a. 52% SL .... *C. commersoni*
b. 53-54% SL 211
c. 55-56% SL 231
d. 57% SL .... *C. discobolus*

191 (124,125,126). Pelvic fin buds
a. absent 231
b. present 192

192 (160,168,191). Length from anterior margin of snout to origin of pelvic fin
a. 52% SL .... *C. platyrhynchus*
b. 53-56% SL 231
c. 57% SL .... *C. discobolus*

193 (142,146,149). Pelvic fin buds
a. absent 271
b. present 194

194 (174,193). Length from anterior margin of snout to origin of pelvic fin
a. 50-52% SL .... *C. ardens*
b. 53% SL 271
c. 54-57% SL .... *C. discobolus*

195 (130). Pelvic fin buds
a. absent 282

b. present 196

196 (195). Length from anterior margin of snout to origin of pelvic fin
a. 50-53% SL 282
b. 54% SL .... *X. texanus*

197 (127). Pelvic fin buds
a. absent 248
b. present 198

198 (197). Length from anterior margin of snout to origin of pelvic fin
a. 50-52% SL 282
b. 53% SL 248
c. 54% SL 288
d. 55-57% SL .... *C. discobolus*

199 (150,153). Pelvic fin buds
a. absent 278
b. present 200

200 (182,199). Length from anterior margin of snout to origin of pelvic fin
a. 50-53% SL 278
b. 54% SL .... *C. latipinnis*

201 (139,142). Pelvic fin buds
a. absent 255
b. present 202

202 (201). Length from anterior margin of snout to origin of pelvic fin
a. 50-52% SL 278
b. 53% SL 255
c. 54% SL 287
d. 55-57% SL .... *C. discobolus*

203 (143). Pelvic fin buds
a. absent 266
b. present 204

204 (203). Length from anterior margin of snout to origin of pelvic fin
a. 50-53% SL 266
b. 54% SL 292

205 (136). Pelvic fin buds
a. absent 236
b. present 206

206 (205). Length from anterior margin of snout to origin of pelvic fin
a. 50-52% SL 266
b. 53% SL 236
c. 54% SL 293
d. 55-57% SL .... *C. discobolus*

207 (142). Pelvic fin buds
a. absent 287
b. present 208

208 (207). Length from anterior margin of snout to origin of pelvic fin
a. 50-52% SL .... *C. latipinnis*
b. 53-54% SL 287
c. 55-57% SL .... *C. discobolus*

209 (133). Pelvic fin buds
a. absent 288
b. present 210

210 (209). Length from anterior margin of snout to origin of pelvic fin
a. 50-52% SL .... *X. texanus*
b. 53-54% SL 288
c. 55-57% SL .... *C. discobolus*

211 (18,189,190). Longitudinal eye diameter
a. 24-25% of head length 218
b. 26-34% of head length 212
c. 35% of head length .... *C. platyrhynchus*

212 (211). Pigment over ventral to ventro-lateral surfaces of gill covers (opercula)
a. absent or present but not in distinct oblique rows (Figs. 30, 45, 72) 213
b. present in a distinct oblique row of 3 or more melanophores near or along ventral margin of one or both preopercles (Figs. 31, 73) 226

213 (212). Pigment on ventral surface of heart region
a. absent (Fig. 45) .... *C. discobolus*
b. present (Figs. 31, 44, 73) 214

214 (213). Lateral surface of head posterior to eyes with
a. ≤5 melanophores. (Fig. 45) 234
b. ≥6 melanophores (Figs. 31, 73) 215

215 (214). Developing dorsal fin with
a. few (≤5) or no melanophores (Fig. 45) 234
b. many (≥6) melanophores (Fig. 73; Fig. 31 by our observations should have more melanophores in the dorsal fin for specimens of the size pertinent to this loop of the key) 216

216 (215). Length from anterior margin of snout to posterior margin of vent
a. 76% SL .... *C. discobolus*
b. 77% SL 235
c. 78-80% SL 217
d. 81% SL 223

217 (216). Number of myomeres to posterior margin of vent
a. 32-33 .... *C. platyrhynchus*
b. 34 230
c. 35-37 309
d. 38-40 224

218 (6,185,186,211). Pigment over ventral to ventro-lateral surfaces of gill covers (opercula)
a. absent or present but not in distinct oblique rows 219
b. present in a distinct oblique row of 3 or

more melanophores near or along ventral margin of one or both preopercles
. . . . *C. commersoni*

219 (218). Pigment on ventral surface of heart region
a. absent (Fig. 45) . . . . *C. discobolus*
b. present (Figs. 31, 44) 220

220 (219). Lateral surface of head posterior to eyes with
a. ≤5 melanophores (Fig. 45) . . *C. discobolus*
b. ≥6 melanophores (Fig. 31) 221

221 (220). Developing dorsal fin with
a. few (≤5) or no melanophores (Fig. 45)
. . . . *C. discobolus*
b. many (≥6) melanophores (Fig. 31 by our observations should have more melanophores in the dorsal fin for specimens of the size pertinent to this loop of the key) 222

222 (221). Length from anterior margin of snout to posterior margin of vent
a. 76-77% SL . . . . *C. discobolus*
b. 78-81% SL 223

223 (216,222). Number of myomeres to posterior margin of vent
a. 34 . . . . *C. commersoni*
b. 35-40 224

224 (217,223). Total number of myomeres
a. 43-46 . . . . *C. commersoni*
b. 47-49 . . . . *C. commersoni*
C. discobolus

225 (14,187,188). Longitudinal eye diameter
a. 24-25% of head length . . . . *C. commersoni*
b. 26-34% of head length 226
c. 35% of head length. . . . . . *C. platyrhynchus*

226 (212,225). Lateral surface of head posterior to eyes with
a. ≤5 melanophores (Fig. 45) *C. platyrhynchus*
b. ≥6 melanophores (Figs. 31, 73) 227

227 (226). Developing dorsal fin with
a. few (≤5) or no melanophores (Fig. 45) . . .
. . . . *C. platyrhynchus*
b. many (≥6) melanophores (Fig. 73; Fig. 31 by our observations should have more melanophores in the dorsal fin for specimens of the size pertinent to this loop of the key) 228

228 (227). Length from anterior margin of snout to posterior margin of vent
a. 77% SL . . . . *C. platyrhynchus*
b. 78-80% SL 229
c. 81% SL . . . . *C. commersoni*

229 (228). Number of myomeres to posterior margin of vent
a. 32-33 . . . . *C. platyrhynchus*
b. 34-37 230
c. 38-40 . . . . *C. commersoni*

230 (217,229). Total number of myomeres
a. 43-47 . . . . *C. commersoni*
C. platyrhynchus
b. 48-49 . . . . *C. commersoni*

231 (19,190,191,192). Longitudinal eye diameter
a. 24-25% of head length . . . . . *C. discobolus*
b. 26-34% of head length 232
c. 35% of head length. . . . . . *C. platyrhynchus*

232 (231). Pigment over ventral to ventro-lateral surfaces of gill covers (opercula)
a. absent or present but not in distinct oblique rows (Fig. 45) 233
b. present in a distinct oblique row of 3 or more melanophores near or along ventral margin of one or both preopercles (Fig. 73) . . . . *C. platyrhynchus*

233 (232). Pigment on ventral surface of heart region
a. absent (Fig. 45) . . . . *C. discobolus*
b. present (Figs. 44, 73) 234

234 (214,215,233). Length from anterior margin of snout to posterior margin of vent
a. 76% SL . . . . *C. discobolus*
b. 77-80% SL 235
c. 81% SL . . . . *C. discobolus*

235 (216,234). Number of myomeres to posterior margin of vent
a. 32-34 . . . . *C. platyrhynchus*
b. 35-37 310
c. 38-40 . . . . *C. discobolus*

236 (205,206). Longitudinal eye diameter
a. 24-26% of head length 237
b. 27-30% of head length 238
c. 31-33% of head length 239
d. 34% of head length 257
e. 35% of head length 279
f. 36-38% of head length . . . . *C. ardens*

237 (236). Pigment over ventral to ventro-lateral surfaces of gill covers (opercula)
a. absent or present but not in distinct oblique rows (Figs. 45, 59) 259
b. present in a distinct oblique row of 3 or more melanophores near or along ventral margin of one or both preopercles (Fig. 73) . . . . *C. latipinnis*

238 (236). Pigment over ventral to ventro-lateral surfaces of gill covers (opercula)
a. absent or present but not in distinct oblique rows (Figs. 45, 59, 87) 241
b. present in a distinct oblique row of 3 or more melanophores near or along ventral margin of one or both preopercles (Fig. 73) 306

239 (236). Pigment over ventral to ventro-lateral surfaces of gill covers (opercula)
- a. absent or present but not in distinct oblique rows (Figs. 16, 45, 59, 87) 240
- b. present in a distinct oblique row of 3 or more melanophores near or along ventral margin of one or both preopercles (Fig. 17) 267

240 (239). Pigment on ventral surface of heart region
- a. absent (Figs. 45, 59) 241
- b. present (Figs. 17, 44, 58, 87) 244

241 (238,240). Lateral surface of body below horizontal myosepta (or lateral midline) exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,
- a. unpigmented or with ≤5 melanophores (Figs. 45, 59, 87) 242
- b. pigmented with ≥6 melanophores (Fig. 46) .... *C. discobolus*

242 (241). Length from anterior margin of snout to posterior margin of vent
- a. 76-77% SL 261
- b. 78-80% SL 243
- c. 81% SL 304
- d. 82-84% SL .... *X. texanus*

243 (242). Number of myomeres to posterior margin of vent
- a. 35 .... *C. discobolus*
- b. 36-40 303
- c. 41 .... *X. texanus*

244 (240). Lateral surface of body below horizontal myosepta (or lateral midline) exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,
- a. unpigmented or with ≤5 melanophores (Figs. 17, 45, 59, 87) 245
- b. pigmented with ≥6 melanophores (Fig. 46) .... *C. discobolus*

245 (244). Length from anterior margin of snout to posterior margin of vent
- a. 76-77% SL 264
- b. 78-80% SL 246
- c. 81% SL 304
- d. 82-84% SL .... *X. texanus*

246 (245). Number of myomeres to posterior margin of vent
- a. 34 .... *C. ardens*
- b. 35 277
- c. 36-38 247
- d. 39-40 303
- e. 41 .... *X. texanus*

247 (246). Total number of myomeres
- a. 43 .... *C. ardens*
- b. 44-45 .... *C. ardens*, *X. texanus*
- c. 46 .... *C. ardens*, *C. latipinnis*, *X. texanus*
- d. 47-48 .... *C. ardens*, *C. discobolus*, *C. latipinnis*, *X. texanus*
- e. 49 .... *C. discobolus*, *C. latipinnis*, *X. texanus*

248 (26,197,198). Longitudinal eye diameter
- a. 24-26% of head length ..... *C. discobolus*
- b. 27-30% of head length 289
- c. 31-33% of head length 249
- d. 34% of head length 272
- e. 35-38% of head length .... *C. ardens*

249 (248). Pigment over ventral to ventro-lateral surfaces of gill covers (opercula)
- a. absent or present but not in distinct oblique rows (Figs. 16, 45, 87) 250
- b. present in a distinct oblique row of 3 or more melanophores near or along ventral margin of one or both preopercles (Fig. 17) 283

250 (249). Pigment on ventral surface of heart region
- a. absent (Figs. 45, 88) 290
- b. present (Figs. 17, 44, 87) 251

251 (250). Lateral surface of body below horizontal myosepta (or lateral midline) exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,
- a. unpigmented or with ≤5 melanophores (Figs. 17, 45, 87) 252
- b. pigmented with ≥6 melanophores (Fig. 46) .... *C. discobolus*

252 (251). Length from anterior margin of snout to posterior margin of vent
- a. 76-77% SL 276
- b. 78-80% SL 253
- c. 81% SL 304
- d. 82-84% SL .... *X. texanus*

253 (252). Number of myomeres to posterior margin of vent
- a. 34 .... *C. ardens*
- b. 35 277
- c. 36-38 254
- d. 39-40 305
- e. 41 .... *X. texanus*

254 (253). Total number of myomeres
- a. 43 .... *C. ardens*
- b. 44-46 .... *C. ardens*, *X. texanus*
- c. 47-48 .... *C. ardens*, *C. discobolus*

X. texanus
d. 49 .... *C. discobolus*
X. texanus

255 (201,202). Longitudinal eye diameter
a. 24-30% of head length 256
b. 31-34% of head length 257
c. 35% of head length 279
d. 36-38% of head length .... *C. ardens*

256 (255). Pigment over ventral to ventro-lateral surfaces of gill covers (opercula)
a. absent or present but not in distinct oblique rows (Figs. 45, 59) 259
b. present in a distinct oblique row of 3 or more melanophores near or along ventral margin of one or both preopercles (Fig. 17) .... *C. latipinnis*

257 (236,255). Pigment over ventral to ventro-lateral surfaces of gill covers (opercula)
a. absent or present but not in distinct oblique rows (Figs. 16, 45, 59) 258
b. present in a distinct oblique row of 3 or more melanophores near or along ventral margin of one or both preopercles (Fig. 17) 279

258 (257). Pigment on ventral surface of heart region
a. absent (Figs. 45, 59) 259
b. present (Figs. 17, 44, 58) 262

259 (237,256,258). Lateral surface of body below horizontal myosepta (or lateral midline) exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,
a. unpigmented or with ≤5 melanophores (Figs. 45, 59) 260
b. pigmented with ≥6 melanophores (Fig. 46) .... *C. discobolus*

260 (259). Length from anterior margin of snout to posterior margin of vent
a. 76-80% SL 261
b. 81% SL .... *C. discobolus*

261 (242,260). Number of myomeres to posterior margin of vent
a. 35 .... *C. discobolus*
b. 36-40 301

262 (258). Lateral surface of body below horizontal myosepta (or lateral midline) exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,
a. unpigmented or with ≤5 melanophores (Figs. 17, 45, 59) 263
b. pigmented with ≥6 melanophores (Fig. 46) .... *C. discobolus*

263 (262). Length from anterior margin of snout to posterior margin of vent
a. 76-80% SL 264
b. 81% SL .... *C. discobolus*

264 (245,263). Number of myomeres to posterior margin of vent
a. 34 .... *C. ardens*
b. 35 277
c. 36-38 265
d. 39-40 301

265 (264). Total number of myomeres
a. 43-45 .... *C. ardens*
b. 46 .... *C. ardens*
C. latipinnis
c. 47-48 .... *C. ardens*
C. discobolus
C. latipinnis
d. 49 .... *C. discobolus*
C. latipinnis

266 (203,204,206). Longitudinal eye diameter
a. 24-26% of head length ...... *C. latipinnis*
b. 27-30% of head length 306
c. 31-33% of head length 267
d. 34-35% of head length 279
e. 36-38% of head length .... *C. ardens*

267 (239,266). Pigment on ventral surface of heart region
a. absent (Figs. 59, 88) 306
b. present (Figs. 17, 58, 87) 268

268 (267). Length from anterior margin of snout to posterior margin of vent
a. 76-77% SL 280
b. 78-80% SL 269
c. 81-84% SL .... *X. texanus*

269 (268). Number of myomeres to posterior margin of vent
a. 34-35 .... *C. ardens*
b. 36-38 270
c. 39-40 308
d. 41 .... *X. texanus*

270 (269). Total number of myomeres
a. 43 .... *C. ardens*
b. 44-45 .... *C. ardens*
X. texanus
c. 46-48 .... *C. ardens*
C. latipinnis
X. texanus
d. 49 .... *C. latipinnis*
X. texanus

271 (22,193,194). Longitudinal eye diameter
a. 24-30% of head length ..... *C. discobolus*
b. 31-34% of head length 272
c. 35-38% of head length .... *C. ardens*

272 (248,271). Pigment over ventral to ventro-lateral surfaces of gill covers (opercula)

a. absent or present but not in distinct oblique rows (Figs. 16, 45) 273
b. present in a distinct oblique row of 3 or more melanophores near or along ventral margin of one or both preopercles (Fig. 17) .... *C. ardens*

273 (272). Pigment on ventral surface of heart region
a. absent (Fig. 45) .... *C. discobolus*
b. present (Figs. 17, 44) 274

274 (273). Lateral surface of body below horizontal myosepta (or lateral midline) exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,
a. unpigmented or with ≤5 melanophores (Figs. 17, 45) 275
b. pigmented with ≥6 melanophores (Fig. 46) .... *C. discobolus*

275 (274). Length from anterior margin of snout to posterior margin of vent
a. 76-80% SL 276
b. 81% SL .... *C. discobolus*

276 (252,275). Number of myomeres to posterior margin of vent
a. 34 .... *C. ardens*
b. 35-38 277
c. 39-40 .... *C. discobolus*

277 (246,253,264,276). Total number of myomeres
a. 43-46 .... *C. ardens*
b. 47-48 .... *C. ardens*
C. discobolus
c. 49 .... *C. discobolus*

278 (58,61,69,72,199,200,202). Longitudinal eye diameter
a. 24-30% of head length ...... *C. latipinnis*
b. 31-35% of head length 279
c. 36-38% of head length .... *C. ardens*

279 (236,255,257,266,278). Pigment on ventral surface of heart region
a. absent (Fig. 59) .... *C. latipinnis*
b. present (Figs. 17, 58) 280

280 (268,279). Number of myomeres to posterior margin of vent
a. 34-35 .... *C. ardens*
b. 36-38 281
c. 39-40 .... *C. latipinnis*

281 (280). Total number of myomeres
a. 43-45 .... *C. ardens*
b. 46-48 .... *C. ardens*
C. latipinnis
c. 49 .... *C. latipinnis*

282 (24,39,41,195,196,198). Longitudinal eye diameter
a. 27-30% of head length .... *X. texanus*
b. 31-33% of head length 283
c. 34-38% of head length .... *C. ardens*

283 (249,282). Pigment on ventral surface of heart region
a. absent (Fig. 88) .... *X. texanus*
b. present (Figs. 17, 87) 284

284 (283). Length from anterior margin of snout to posterior margin of vent
a. 76-77% SL .... *C. ardens*
b. 78-80% SL 285
c. 81-84% SL .... *X. texanus*

285 (284). Number of myomeres to posterior margin of vent
a. 34-35 .... *C. ardens*
b. 36-38 286
c. 41 .... *X. texanus*

286 (285). Total number of myomeres
a. 43 .... *C. ardens*
b. 44-48 .... *C. ardens*
X. texanus
c. 49 .... *X. texanus*

287 (202,207,208). Longitudinal eye diameter
a. 24-34% of head length 294
b. 35% of head length .... *C. latipinnis*

288 (9,198,209,210). Longitudinal eye diameter
a. 24-26% of head length ..... *C. discobolus*
b. 27-33% of head length 289
c. 34% of head length .... *C. discobolus*

289 (248,288). Pigment over ventral to ventro-lateral surfaces of gill covers (opercula)
a. absent or present but not in distinct oblique rows (Figs. 45, 87) 290
b. present in a distinct oblique row of 3 or more melanophores near or along ventral margin of one or both preopercles (Fig. 17) .... *X. texanus*

290 (250,289). Lateral surface of body below horizontal myosepta (or lateral midline) exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,
a. unpigmented or with ≤5 melanophores (Figs. 45, 87) 291
b. pigmented with ≥6 melanophores (Fig. 46) .... *C. discobolus*

291 (290). Length from anterior margin of snout to posterior margin of vent
a. 76-77% SL .... *C. discobolus*
b. 78-81% SL 304
c. 82-84% SL .... *X. texanus*

292 (154,157,178,204). Longitudinal eye diameter
a. 24-26% of head length ...... *C. latipinnis*
b. 27-33% of head length 306
c. 34-35% of head length ...... *C. latipinnis*

293 (206). Longitudinal eye diameter
- a. 24-26% of head length 294
- b. 27-33% of head length 297
- c. 34% of head length 294
- d. 35% of head length .... *C. latipinnis*

294 (287,293). Pigment over ventral to ventro-lateral surfaces of gill covers (opercula)
- a. absent or present but not in distinct oblique rows (Figs. 45, 59) 295
- b. present in a distinct oblique row of 3 or more melanophores near or along ventral margin of one or both preopercles (Fig. 17) .... *C. latipinnis*

295 (294). Lateral surface of body below horizontal myosepta (or lateral midline) exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,
- a. unpigmented or with ≤5 melanophores (Figs. 45, 59) 296
- b. pigmented with ≥6 melanophores (Fig. 46) .... *C. discobolus*

296 (295). Length from anterior margin of snout to posterior margin of vent
- a. 76-80% SL 300
- b. 81% SL .... *C. discobolus*

297 (293). Pigment over ventral to ventro-lateral surfaces of gill covers (opercula)
- a. absent or present but not in distinct oblique rows (Figs. 45, 59, 87) 298
- b. present in a distinct oblique row of 3 or more melanophores near or along ventral margin of one or both preopercles (Fig. 17) 306

298 (297). Lateral surface of body below horizontal myosepta (or lateral midline) exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,
- a. unpigmented or with ≤5 melanophores (Figs. 45, 59, 87) 299
- b. pigmented with ≥6 melanophores (Fig. 46) .... *C. discobolus*

299 (298). Length from anterior margin of snout to posterior margin of vent
- a. 76-77% SL 300
- b. 78-80% SL 302
- c. 81% SL 304
- d. 82-84% SL .... *X. texanus*

300 (296,299). Number of myomeres to posterior margin of vent
- a. 35 .... *C. discobolus*
- b. 36-40 301

301 (261,264,300). Total number of myomeres
- a. 46 .... *C. latipinnis*
- b. 47-49 .... *C. discobolus*, *C. latipinnis*

302 (299). Number of myomeres to posterior margin of vent
- a. 35 .... *C. discobolus*
- b. 36-40 303
- c. 41 .... *X. texanus*

303 (243,246,302). Total number of myomeres
- a. 44-45 .... *X. texanus*
- b. 46 .... *C. latipinnis*, *X. texanus*
- c. 47-49 .... *C. discobolus*, *C. latipinnis*, *X. texanus*

304 (242,245,252,291,299). Number of myomeres to posterior margin of vent
- a. 35 .... *C. discobolus*
- b. 36-40 305
- c. 41 .... *X. texanus*

305 (253,304). Total number of myomeres
- a. 44-46 .... *X. texanus*
- b. 47-49 .... *C. discobolus*, *X. texanus*

306 (238,266,267,292,297). Length from anterior margin of snout to posterior margin of vent
- a. 76-77% SL .... *C. latipinnis*
- b. 78-80% SL 307
- c. 81-84% SL .... *X. texanus*

307 (306). Number of myomeres to posterior margin of vent
- a. 36-40 308
- b. 41 .... *X. texanus*

308 (269,307). Total number of myomeres
- a. 44-45 .... *X. texanus*
- b. 46-49 .... *C. latipinnis*, *X. texanus*

309 (217). Total number of myomeres
- a. 43-46 .... *C. commersoni*, *C. platyrhynchus*
- b. 47 .... *C. commersoni*, *C. discobolus*, *C. platyrhynchus*
- c. 48-49 .... *C. commersoni*, *C. discobolus*

310 (235). Total number of myomeres
- a. 43-46 .... *C. platyrhynchus*
- b. 47 .... *C. discobolus*, *C. platyrhynchus*
- c. 48-49 .... *C. discobolus*

Skeletal Character Key for Postflexion Mesolarvae that have been cleared and preferably stained for bone or cartilage (Fig. 6).

1. Standard length group (Fig. 4)
   a. ≥18 mm ... *C. latipinnis*
   b. 17 mm ... 2
   c. ≤16 mm ... 3

2 (1). First (most anterior) interneural bone (Fig. 8)
   a. unclearly formed ... 3
   b. large and fan-shaped across top *X. texanus*
   c. large and angular or anvil-shaped with a prominent posterior-directed projection or beak ... 4
   d. small and blocky or angular with a small to moderate posterior-directed projection or beak ... 5

3 (1,2). Number of vertebrae (including 4 for Weberian complex)
   a. 42-43 ... *C. platyrhynchus*
   b. 44 ... *C. commersoni*, *C. platyrhynchus*
   c. 45-46 ... *C. commersoni*, *C. discobolus*, *C. platyrhynchus*, *X. texanus*
   d. 47 ... *C. ardens*, *C. commersoni*, *C. discobolus*, *C. latipinnis*, *C. platyrhynchus*, *X. texanus*
   e. 48 ... *C. ardens*, *C. commersoni*, *C. discobolus*, *C. latipinnis*, *C. platyrhynchus*
   f. 49-50 ... *C. discobolus*, *C. latipinnis*, (rarely) *C. platyrhynchus*

4 (2). Number of vertebrae (including 4 for Weberian complex)
   a. 44-46 ... *C. commersoni*
   b. 47-48 ... *C. ardens*, *C. commersoni*, *C. latipinnis*
   c. 49-50 ... *C. latipinnis*

5 (2). Number of vertebrae (including 4 for Weberian complex)
   a. 42-44 ... *C. platyrhynchus*
   b. 45-50 ... *C. discobolus*, (rarely 49-50) *C. platyrhynchus*

Metalarvae -- adult complement of principal fin rays present in dorsal, anal, and caudal fins, but some preanal finfold remaining (Figs. 18, 19; definition abbreviated for species of concern; there may be rare metalarval specimens in which all finfold is lost but not all pelvic fin rays or rudimentary caudal fin rays are yet present). Separate skeletal character key at end for confirmation of identity or further diagnosis of specimens cleared (and preferably stained) for bone.

1. Standard length (SL; Fig. 4)
   a. 15 mm ... 2
   b. 16 mm ... 4
   c. 17 mm ... 9
   d. 18 mm ... 13
   e. 19 mm ... 20
   f. 20 mm ... 28
   g. 21 mm ... 38
   h. 22 mm ... 47
   i. 23 mm ... 52
   j. 24 mm ... 53
   k. 25 mm ... *C. latipinnis*

2 (1). Gut (Fig. 5)
   a. essentially straight or with bend less than 90° (gut phase 1) ... *C. ardens*
   b. with at least 90° bend or partial s-shaped loop (gut phase 2) ... 3

3 (2). Pigmentation on lateral surfaces of peritoneum
   a. absent (Figs. 19, 88, 89) ... 67
   b. sparse or patchy (Figs. 18, 32, 33) ... 72

4 (1). Gut (Fig. 5)
   a. essentially straight or with bend less than 90° (gut phase 1) ... *C. ardens*
   b. with at least 90° bend or partial s-shaped loop (gut phase 2) ... 5
   c. with full loop (s-shape to near anterior end of visceral cavity) but with neither limb of loop completely across over ventral midline (gut phase 3) ... 7
   d. with at least one limb of loop fully across ventral midline but not yet with both limbs across fully to opposite side (gut phase 4) to gut with both limbs of loop across midline fully to opposite side (four segments of gut crossing nearly perpendicular to body axis) or with more extensive coil development (gut phase 5) ... *C. discobolus*

5 (4). Pigmentation on lateral surfaces of peritoneum
   a. absent (Figs. 19, 88, 89) ... 67
   b. sparse or patchy (Figs. 18, 32, 33, 74) ... 6

6 (5). Pigmentation on ventro-lateral surfaces of peritoneum

a. absent (Fig. 18) 78
b. sparse or patchy (Figs. 33, 74) 85

(4). Pigmentation on lateral surfaces of peritoneum
a. absent (Fig. 19) . . . . *C. commersoni*
b. sparse or patchy (Figs. 32, 33, 46, 74, 75) 8

(7). Pigmentation on ventro-lateral surfaces of peritoneum
a. absent (Fig. 19) 85
b. sparse or patchy (Figs. 33, 46, 74, 75) . . 81

(1). Gut (Fig. 5)
a. essentially straight or with bend less than 90° (gut phase 1) . . . . *C. ardens*
b. with at least 90° bend or partial s-shaped loop (gut phase 2) 16
c. with full loop (s-shape to near anterior end of visceral cavity) but with neither limb of loop completely across over ventral midline (gut phase 3) 10
d. with at least one limb of loop fully across ventral midline but not yet with both limbs across fully to opposite side (gut phase 4) to gut with both limbs of loop across midline fully to opposite side (four segments of gut crossing nearly perpendicular to body axis) or with more extensive coil development (gut phase 5) . . . . *C. discobolus*

10 (9). Pigmentation on lateral surfaces of peritoneum
a. absent (Figs. 88, 89) 73
b. sparse or patchy (Figs. 32, 33, 46, 75) . . 11
c. uniformly light to dark (Fig. 47) . . . . *C. discobolus*

11 (10). Pigmentation on ventro-lateral surfaces of peritoneum
a. absent (Fig. 32) . . . . *C. commersoni*
b. sparse or patchy (Figs. 33, 46, 75) 12
c. uniformly light to dark (Fig. 47) . . . . *C. discobolus*

12 (11). Pigmentation on ventral surface of peritoneum
a. absent (Fig. 32; do not confuse peritoneal pigmentation with epidermal or surface pigmentation) 81
b. sparse or patchy (Figs. 46, 74) 88

13 (1). Gut (Fig. 5) with
a. at least 90° bend or partial s-shaped loop (gut phase 2) 14
b. full loop (s-shape to near anterior end of visceral cavity) but with neither limb of loop completely across over ventral midline (gut phase 3) 16
c. at least one limb of loop fully across ventral midline but not yet with both limbs across fully to opposite side (gut phase 4) 19
d. both limbs of loop across midline fully to opposite side (four segments of gut crossing nearly perpendicular to body axis) or with more extensive coil development (gut phase 5) . . *C. discobolus*

14 (13). Pigmentation on lateral surfaces of peritoneum
a. absent (Fig. 19) 72
b. sparse or patchy (Figs. 18, 32, 33) 15

15 (14). Pigmentation on ventro-lateral surfaces of peritoneum
a. absent (Fig. 18) 72
b. sparse or patchy (Fig. 33) . . *C. commersoni*

16 (9,13). Pigmentation on lateral surfaces of peritoneum
a. absent (Figs. 19, 88, 89) 67
b. sparse or patchy (Figs. 18, 32, 33) 17

17 (16). Pigmentation on ventro-lateral surfaces of peritoneum
a. absent (Fig. 18) 72
b. sparse or patchy (Figs. 33, 74) 18

18 (17). Pigmentation on ventral surface of peritoneum
a. absent (Fig. 32; do not confuse peritoneal pigmentation with epidermal or surface pigmentation) 85
b. sparse or patchy (Figs. 74, 75) . . . . *C. platyrhynchus*

19 (13). Pigmentation on lateral surfaces of peritoneum
a. absent (Figs. 88, 89) . . . . *X. texanus*
b. sparse or patchy (Fig. 75) . *C. platyrhynchus* — also ... need to document ... 4/4/03
c. uniformly light to dark (Fig. 47) . . . . *C. discobolus*

20 (1). Gut (Fig. 5) with
a. at least 90° bend or partial s-shaped loop (gut phase 2). 21
b. full loop (s-shape to near anterior end of visceral cavity) but with neither limb of loop completely across over ventral midline (gut phase 3) 22
c. at least one limb of loop fully across ventral midline but not yet with both limbs across fully to opposite side (gut phase 4) 26
d. both limbs of loop across midline fully to opposite side (four segments of gut crossing nearly perpendicular to body axis) or with more extensive coil development (gut phase 5) . . *C. discobolus*

21 (20). Mouth
a. terminal (above bottom-of-eye level) (Fig. 17) . . . . *C. ardens*
b. low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Figs. 18, 60) 61

22 (20). Pigmentation on lateral surfaces of peritoneum
- a. absent (Figs. 19, 60, 88, 89) 23
- b. sparse or patchy (Figs. 18, 32, 33, 75) . . 24

23 (22). Mouth
- a. terminal (above bottom-of-eye level) (Figs. 17, 87) 68
- b. low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Figs. 18, 60, 88,90

24 (22). Pigmentation on ventro-lateral surfaces of peritoneum
- a. absent (Figs. 18, 60) 25
- b. sparse or patchy (Fig. 33) . . *C. commersoni*
- c. uniformly light (Fig. 75) . . *C. platyrhynchus*

25 (24). Mouth
- a. terminal (above bottom-of-eye level) (Fig. 17) . . . . *C. ardens*
- b. low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Figs. 18, 32, 60) . . 59

26 (20). Pigmentation on lateral surfaces of peritoneum
- a. absent (Figs. 88, 89) . . . . *X. texanus*
- b. sparse or patchy (Figs. 32, 33, 75) 27
- c. uniformly light to dark (Fig. 47) . . . . *C. discobolus*

27 (26). Pigmentation on ventro-lateral surfaces of peritoneum
- a. absent or sparse to patchy (Figs. 32, 33) . . . . *C. commersoni*
- b. uniformly light (Fig. 75) . . *C. platyrhynchus*

28 (1). Gut (Fig. 5) with
- a. at least 90° bend or partial s-shaped loop (gut phase 2) . . . . *C. latipinnis*
- b. full loop (s-shape to near anterior end of visceral cavity) but with neither limb of loop completely across over ventral midline (gut phase 3) 29
- c. at least one limb of loop fully across ventral midline but not yet with both limbs across fully to opposite side (gut phase 4) 33
- d. both limbs of loop across midline fully to opposite side (four segments of gut crossing nearly perpendicular to body axis) or with more extensive coil development (gut phase 5) . . *C. discobolus*

29 (28). Pigmentation on lateral surfaces of peritoneum
- a. absent (Figs. 19, 60, 89) 30
- b. sparse or patchy (Figs. 18, 33, 75) 31

30 (29). Mouth
- a. terminal (above bottom-of-eye level) (Fig. 87) . . . . *X. texanus*
- b. low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Figs. 19, 60, 89) . 60

31 (29). Pigmentation on ventro-lateral surfaces of peritoneum
- a. absent (Fig. 18) 32
- b. sparse or patchy (Fig. 33) 37
- c. uniformly light to dark (Fig. 75) . . . . *C. platyrhynchus*

32 (31). Mouth
- a. terminal (above bottom-of-eye level) (Fig. 87) . . . . *X. texanus*
- b. low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Figs. 19, 33, 60, 89) 58

33 (28). Pigmentation on lateral surfaces of peritoneum
- a. absent (Figs. 19, 89) 34
- b. sparse or patchy (Figs. 18, 33, 75) 35
- c. uniformly dark (Figs. 47, 48) *C. discobolus*

34 (33). Mouth
- a. terminal (above bottom-of-eye level) (Fig. 87) . . . . *X. texanus*
- b. low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Figs. 19, 89) 68

35 (33). Pigmentation on ventro-lateral surfaces of peritoneum
- a. absent (Fig. 18) 36
- b. sparse or patchy (Fig. 33) 37
- c. uniformly light to dark (Fig. 75) . . . . *C. platyrhynchus*

36 (35). Mouth
- a. terminal (above bottom-of-eye level) (Fig. 87) . . . . *X. texanus*
- b. low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Figs. 19, 33, 89) . 67

37 (31,35). Mouth
- a. terminal (above bottom-of-eye level) (Fig. 87) . . . . *X. texanus*
- b. low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Figs. 33, 89) 73

38 (1). Gut (Fig. 5) with
- a. at least 90° bend or partial s-shaped loop (gut phase 2) . . . . *C. latipinnis*
- b. full loop (s-shape to near anterior end of visceral cavity) but with neither limb of loop completely across over ventral midline (gut phase 3) 39

c. at least one limb of loop fully across ventral midline but not yet with both limbs across fully to opposite side (gut phase 4) 42
d. both limbs of loop across midline fully to opposite side (four segments of gut crossing nearly perpendicular to body axis) or with more extensive coil development (gut phase 5) . . *C. discobolus*

39 (38). Pigmentation on lateral surfaces of peritoneum
a. absent (Figs. 61, 89) 41
b. sparse or patchy (Fig. 33) 40

40 (39). Pigmentation on ventro-lateral surfaces of peritoneum
a. absent (Figs. 61, 89) 41
b. sparse or patchy (Fig. 33) . . . . . *X. texanus*

41 (39,40). Mouth
a. terminal (above bottom-of-eye level) (Fig. 87) . . . . *X. texanus*
b. low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Figs. 61, 89) 74

42 (38). Pigmentation on lateral surfaces of peritoneum
a. absent (Fig. 89) . . . . *X. texanus*
b. sparse or patchy (Fig. 75) 43
c. uniformly light . . . . *C. platyrhynchus*
d. uniformly dark (Fig. 47) 44

43 (42). Pigmentation on ventro-lateral surfaces of peritoneum
a. absent or sparse to patchy (Fig. 89) . . . . *X. texanus*
b. uniformly light to dark (Fig. 76) . . . . *C. platyrhynchus*

44 (42). Pigmentation on ventro-lateral surfaces of peritoneum
a. uniformly light . . . . *C. platyrhynchus*
b. uniformly dark (Fig. 76) 45

45 (44). Pigmentation on ventral surface of peritoneum
a. absent . . . . *C. platyrhynchus*
b. sparse or patchy (Fig. 75) 46
c. uniformly light to dark (Fig. 47) . . . . *C. discobolus*

46 (45). Mouth
a. terminal (above bottom-of-eye level) or low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Fig. 75) . . . . *C. platyrhynchus*
b. distinctly subterminal (mouth notably posterior to most anterior portion of snout) (Fig. 47) . . . . *C. discobolus*

47 (1). Gut (Fig. 5) with
a. at least 90° bend or partial s-shaped loop (gut phase 2) . . . . *C. latipinnis*
b. full loop (s-shape to near anterior end of visceral cavity) but with neither limb of loop completely across over ventral midline (gut phase 3) 48
c. at least one limb of loop fully across ventral midline but not yet with both limbs across fully to opposite side (gut phase 4) 50
d. both limbs of loop across midline fully to opposite side (four segments of gut crossing nearly perpendicular to body axis) or with more extensive coil development (gut phase 5) . . *C. discobolus*

48 (47). Pigmentation on lateral surfaces of peritoneum
a. absent (Figs. 61, 89) 57
b. sparse or patchy (Fig. 33) 49

49 (48). Pigmentation on ventro-lateral surfaces of peritoneum
a. absent (Figs. 61, 89) 57
b. sparse or patchy (Fig. 33) . . . . . *X. texanus*

50 (47). Pigmentation on lateral surfaces of peritoneum
a. absent (Figs. 61, 89) 57
b. sparse or patchy (Fig. 75) 51
c. uniformly light to dark (Fig. 76) . . . . *C. platyrhynchus*

51 (50). Pigmentation on ventro-lateral surfaces of peritoneum
a. absent (Figs. 61,89) 57
b. sparse or patchy (Fig. 33) . . . . . *X. texanus*
c. uniformly dark (Fig. 76) . . *C. platyrhynchus*

52 (1). Gut (Fig. 5) with
a. at least 90° bend or partial s-shaped loop (gut phase 2) . . . . *C. latipinnis*
b. full loop (s-shape to near anterior end of visceral cavity) but with neither limb of loop completely across over ventral midline (gut phase 3) or gut with at least one limb of loop fully across ventral midline but not yet with both limbs across fully to opposite side (gut phase 4) 54
c. both limbs of loop across midline fully to opposite side (four segments of gut crossing nearly perpendicular to body axis) or with more extensive coil development (gut phase 5) . . *C. discobolus*

53 (1). Gut (Fig. 5) with
a. at least 90° bend or partial s-shaped loop (gut phase 2) . . . . *C. latipinnis*
b. full loop (s-shape to near anterior end of visceral cavity) but with neither limb of loop completely across over ventral midline (gut phase 3) or gut with at

least one limb of loop fully across ventral midline but not yet with both limbs across fully to opposite side (gut phase 4) 54

54 (52,53). Pigmentation on lateral surfaces of peritoneum
a. absent (Fig. 89) .... *X. texanus*
b. sparse or patchy (Fig. 33) 55

55 (54). Pigmentation on ventro-lateral surfaces of peritoneum
a. absent (Figs. 61, 89) 57
b. sparse or patchy (Fig. 33) 56

56 (55). Pigmentation on ventral surface of peritoneum
a. absent (Figs. 61, 89) 57
b. sparse or patchy (Fig. 75) .... *C. latipinnis*

57 (48,49,50,51,55,56). Mouth
a. terminal (above bottom-of-eye level) (Fig. 87) .... *X. texanus*
b. low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Fig. 89) 74
c. distinctly subterminal (mouth notably posterior to most anterior portion of snout) (Fig. 61) .... *C. latipinnis*

58 (32). Ventral midline from shortly behind heart region to near vent with
a. ≥21 melanophores in a continuous or discontinuous line or narrow band (Fig. 32) .... *C. commersoni*
b. 7-20 melanophores (Fig. 17) 61
c. ≤6 melanophores (Figs. 19, 60, 89) 62

59 (25). Ventral midline from shortly behind heart region to near vent with
a. ≥21 melanophores in a continuous or discontinuous line or narrow band (Fig. 32) .... *C. commersoni*
b. ≤20 melanophores (Figs. 17, 19, 60) ... 61

60 (23,30). Ventral midline from shortly behind heart region to near vent with
a. 7-20 melanophores (Fig. 17) 61
b. ≤6 melanophores (Figs. 19, 60, 89) 62

61 (21,58,59,60). Number of principal dorsal fin rays
a. 10 .... *C. ardens*
b. 11-14 63

62 (58,60). Number of principal dorsal fin rays
a. 10 .... *C. ardens*
b. 11 63
c. 12-14 65
d. 15-16 .... *X. texanus*

63 (60,61,62). Lateral surface of body above horizontal myosepta (or lateral midline), exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,
a. with 1-5 melanophores ...... *C. latipinnis*
b. with ≥6 melanophores (Figs. 18, 60) ... 64

64 (63). Lateral surface of body below horizontal myosepta (or lateral midline), exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,
a. unpigmented (Figs. 59) ...... *C. latipinnis*
b. with ≥1 melanophores (Figs. 18, 60) .. 138

65 (62). Lateral surface of body above horizontal myosepta (or lateral midline), exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,
a. unpigmented (Fig. 88) .... *X. texanus*
b. with 1-5 melanophores 91
c. with ≥6 melanophores (Figs. 18, 60, 89) 66

66 (65). Lateral surface of body below horizontal myosepta (or lateral midline), exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,
a. unpigmented (Fig. 88) 91
b. with 1-5 melanophores (Fig. 89) 90
c. with ≥6 melanophores (Figs. 18, 60) .. 138

67 (3,5,16,36). Ventral midline from shortly behind heart region to near vent with
a. ≥21 melanophores in a continuous or discontinuous line or narrow band (Fig. 32) .... *C. commersoni*
b. 7-20 melanophores (Fig. 17) .... *C. ardens*
c. ≤6 melanophores (Figs. 19, 89) 69

68 (23,34). Ventral midline from shortly behind heart region to near vent with
a. 7-20 melanophores (Fig. 17) .... *C. ardens*
b. ≤6 melanophores (Figs. 19, 89) 69

69 (67,68). Number of principal dorsal fin rays
a. 10-11 .... *C. ardens*
b. 12-14 70
c. 15-16 .... *X. texanus*

70 (69). Lateral surface of body above horizontal myosepta (or lateral midline), exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,
a. with ≤5 melanophores (Fig. 88) *X. texanus*
b. with ≥6 melanophores (Figs. 19, 89) ... 71

71 (70). Lateral surface of body below horizontal myosepta (or lateral

midline), exclusive of melanphores assciated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,

a. unpigmented (Fig. 88) .... *X. texanus*
b. with 1-5 melanophores (Fig. 89) 139
c. with ≥6 melanophores (Fig. 19) . *C. ardens*

72 (3,14,15,17). Ventral midline from shortly behind heart region to near vent with

a. ≥21 melanophores in a continuous or discontinuous line or narrow band (Fig. 32) .... *C. commersoni*
b. ≤20 melanophores (Figs. 17, 18, 19) .... *C. ardens*

73 (10,37). Ventral midline from shortly behind heart region to near vent with

a. ≥21 melanophores in a continuous or discontinuous line or narrow band (Fig. 32) .... *C. commersoni*
b. ≤6 melanophores (Fig. 89) .... *X. texanus*

74 (41,57). Ventral midline from shortly behind heart region to near vent with

a. 7-20 melanophores (Fig. 17) .. *C. latipinnis*
b. ≤6 melanophores (Figs. 60, 89) 75

75 (74). Number of principal dorsal fin rays

a. 11 .... *C. latipinnis*
b. 12-14 76
c. 15-16 .... *X. texanus*

76 (75). Lateral surface of body above horizontal myosepta (or lateral midline), exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,

a. unpigmented (Fig. 88) .... *X. texanus*
b. with 1-5 melanophores 91
c. with ≥6 melanophores (Figs. 60, 89) ... 77

77 (76). Lateral surface of body below horizontal myosepta (or lateral midline), exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,

a. with ≤5 melanophores (Fig. 88) 91
b. with ≥6 melanophores (Fig. 60) *C. latipinnis*

78 (6). Ventral midline from shortly behind heart region to near vent with

a. ≥21 melanophores in a continuous or discontinuous line or narrow band (Figs. 32, 75) 86
b. 7-20 melanophores (Fig. 17) 79
c. ≤6 melanophores (Fig. 19) ..... *C. ardens*

79 (78). Number of principal dorsal fin rays

a. 9 .... *C. platyrhynchus*
b. 10-12 80
c. 13-14 .... *C. ardens*

80 (79). Lateral surface of body below horizontal myosepta (or lateral midline), exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,

a. unpigmented .... *C. platyrhynchus*
b. with 1-5 melanophores (Fig. 45) 94

81 (8,12). Ventral midline from shortly behind heart region to near vent with

a. ≥21 melanophores in a continuous or discontinuous line or narrow band (Figs. 32, 75) 82
b. 7-20 melanophores (Fig. 47) 89
c. ≤6 melanophores .... *C. discobolus*

82 (81). Number of principal dorsal fin rays

a. 9 89
b. 10-12 83
c. 13 .... *C. commersoni*

83 (82). Lateral surface of body below horizontal myosepta (or lateral midline), exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,

a. with ≤5 melanophores (Fig. 45) 87
b. with ≥6 melanophores (Figs. 32, 46, 74) 84

84 (83). Mid-lateral surface of body with

a. no large, distinct spots (Figs. 32, 46, 74) 97
b. 3 large, distinct spots, one between head and dorsal fin, the second over the pelvic fin, and the last on the caudal peduncle near the base of the tail (Fig. 35) .... *C. commersoni*

85 (6,8,18). Ventral midline from shortly behind heart region to near vent with

a. ≥21 melanophores in a continuous or discontinuous line or narrow band (Fig. 32) 86
b. 7-20 melanophores (Fig. 47) .... *C. platyrhynchus*

86 (78,85). Number of principal dorsal fin rays

a. 9 .... *C. platyrhynchus*
b. 10-12 87
c. 13 .... *C. commersoni*

87 (83,86). Mid-lateral surface of body with

a. no large, distinct spots (Figs. 33, 75) .. 104
b. 3 large, distinct spots, one between head and dorsal fin, the second over the pelvic fin, and the last on the caudal peduncle near the base of the tail (Fig. 35) .... *C. commersoni*

88 (12). Ventral midline from shortly behind heart region to near vent with

a. ≥7 melanophores (Figs. 46, 74) 89
b. ≤6 melanophores .... *C. discobolus*

89 (81,82,88). Lateral surface of body below horizontal myosepta (or lateral midline), exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,
- a. with ≤5 melanophores (Fig. 45) . . . . *C. platyrhynchus*
- b. with ≥6 melanophores (Figs. 46, 74) . . 101

90 (66). Longitudinal eye diameter
- a. 22-23% of head length . . . . . . *C. latipinnis*
- b. 24-25% of head length 92
- c. 26-27% of head length . . . . *X. texanus*
- d. 28-32% of head length 139
- e. 33% of head length . . . . *C. ardens*

91 (65,66,76,77). Longitudinal eye diameter
- a. 22-23% of head length . . . . . . *C. latipinnis*
- b. 24-25% of head length 92
- c. 26-32% of head length . . . . *X. texanus*

92 (90,91). Length of base of dorsal fin (origin to insertion of dorsal fin)
- a. 14-15% SL . . . . *C. latipinnis*
- b. 16-17% SL 93
- c. 18-21% SL . . . . *X. texanus*

93 (92). Dorsal fin length
- a. 20% SL . . . . *C. latipinnis*
- b. 21-24% SL 107
- c. 25-29% SL . . . . *X. texanus*

94 (80). Longitudinal eye diameter
- a. 25-27% of head length . . . *C. platyrhynchus*
- b. 28% of head length 95
- c. 29-33% of head length . . . . *C. ardens*

95 (94). Length of base of dorsal fin (origin to insertion of dorsal fin)
- a. 11-13% SL . . . . *C. platyrhynchus*
- b. 14% SL 96
- c. 15-16% SL . . . . *C. ardens*

96 (95). Dorsal fin length
- a. 15-17% SL . . . . *C. platyrhynchus*
- b. 18-19% SL 108
- c. 20% SL . . . . *C. ardens*

97 (84). Longitudinal eye diameter
- a. 22-24% of head length . . . . . *C. discobolus*
- b. 25-27% of head length 98
- c. 28% of head length 105
- d. 29-34% of head length . . . . *C. commersoni*

98 (97). Length of base of dorsal fin (origin to insertion of dorsal fin)
- a. 11% SL 103
- b. 12-14% SL 99
- c. 15% SL 100

99 (98). Dorsal fin length
- a. 15-16% SL 123
- b. 17-19% SL 115
- c. 20-21% SL 129
- d. 22% SL . . . . *C. commersoni*

100 (98). Dorsal fin length
- a. 15-16% SL . . . . *C. commersoni*
- b. 17-21% SL 129
- c. 22% SL . . . . *C. commersoni*

101 (89). Longitudinal eye diameter
- a. 22-24% of head length . . . . . *C. discobolus*
- b. 25-27% of head length 102
- c. 28% of head length . . . . . *C. platyrhynchus*

102 (101). Length of base of dorsal fin (origin to insertion of dorsal fin)
- a. 11-14% SL 103
- b. 15% SL . . . . *C. discobolus*

103 (98,102). Dorsal fin length
- a. 15-16% SL . . . . *C. platyrhynchus*
- b. 17-19% SL 114
- c. 20-21% SL . . . . *C. discobolus*

104 (87). Longitudinal eye diameter
- a. 25-28% of head length 105
- b. 29-34% of head length . . . . *C. commersoni*

105 (97,104). Length of base of dorsal fin (origin to insertion of dorsal fin)
- a. 11% SL . . . . *C. platyrhynchus*
- b. 12-14% SL 106
- c. 15% SL . . . . *C. commersoni*

106 (105). Dorsal fin length
- a. 15-19% SL 123
- b. 20-22% SL . . . . *C. commersoni*

107 (93). Caudal fin length (total length minus standard length)
- a. 17-19% SL . . . . *C. latipinnis*
- b. 20-26% SL . . . . *C. latipinnis* *X. texanus*
- c. 27-28% SL . . . . *X. texanus*

108 (96). Pigment over ventral to ventro-lateral surfaces of gill covers (opercula)
- a. absent or present but not in distinct oblique rows of 3 or more melanophores near or along ventral margin of either preopercle (Figs. 19,75) 109
- b. present in a distinct oblique row of 3 or more melanophores near or along ventral margin of one or both preopercles (Fig. 74) . . . . *C. platyrhynchus*

109 (108). Pigment in anal fin
- a. absent or present but very light with only a few (≤5) melanophores (Figs. 19,75) 110
- b. present but more prominent with many (≥6) melanophores . . . . *C. ardens*

110 (109). Number of myomeres to posterior margin of vent
- a. 32-33 . . . . *C. platyrhynchus*
- b. 34-37 111
- c. 38 . . . . *C. ardens*

111 (110). Total number of myomeres
- a. 43-47 112

b. 48 .... *C. ardens*

112 (111). Caudal fin length (total length minus standard length)
- a. 15-17% SL .... *C. platyrhynchus*
- b. 18-20% SL 113
- c. 21-22% SL .... *C. ardens*

113 (112). Length from anterior margin of snout to insertion of dorsal fin
- a. 62-63% SL .... *C. platyrhynchus*
- b. 64-65% SL .... *C. ardens* *C. platyrhynchus*
- c. 66-67% SL .... *C. ardens*

114 (103). Pigment over ventral to ventro-lateral surfaces of gill covers (opercula)
- a. absent or present but not in a distinct oblique row of 3 or more melanophores near or along ventral margin of one or both preopercles (Figs. 47, 75) 117
- b. present in a distinct oblique row of 3 or more melanophores near or along ventral margin of one or both preopercles (Fig. 74) .... *C. platyrhynchus*

115 (99). Pigment over ventral to ventro-lateral surfaces of gill covers (opercula)
- a. absent or present but not in a distinct oblique row of 3 or more melanophores near or along ventral margin of one or both preopercles (Figs. 32, 47, 75) ... 116
- b. present in a distinct oblique row of 3 or more melanophores near or along ventral margin of one or both preopercles (Figs. 31, 74) 123

116 (115). Pigment on ventral surface of heart region
- a. absent (Fig. 47) 117
- b. present (Figs. 32, 46, 74) 120

117 (114,116). Pigment in pectoral fin
- a. absent or present but very light with ≤10 melanophores (Fig. 47) 118
- b. present but more prominent with ≥11 melanophores (Fig. 75) .. *C. platyrhynchus*

118 (117). Number of myomeres to posterior margin of vent
- a. 32-34 .... *C. platyrhynchus*
- b. 35-37 119
- c. 38-40 .... *C. discobolus*

119 (118). Total number of myomeres
- a. 43-46 .... *C. platyrhynchus*
- b. 48-49 .... *C. discobolus* *C. platyrhynchus*
- c. 48-49 .... *C. discobolus*

120 (116). Pigment in pectoral fin
- a. absent or present but very light with ≤10 melanophores (Fig. 47) 121
- b. present but more prominent with ≥11 melanophores (Fig. 75) 124

121 (120). Number of myomeres to posterior margin of vent
- a. 32-33 .... *C. platyrhynchus*
- b. 34 125
- c. 35-37 122
- d. 38-40 133

122 (121). Total number of myomeres
- a. 43-47 .... *C. commersoni* *C. platyrhynchus*
- b. 47-48 .... *C. commersoni* *C. discobolus* *C. platyrhynchus*
- c. 47-48 .... *C. commersoni* *C. discobolus*

123 (99,106,115). Pigment on ventral surface of heart region
- a. absent .... *C. platyrhynchus*
- b. present (Figs. 32, 74, 75) 124

124 (120,123). Number of myomeres to posterior margin of vent
- a. 32-33 .... *C. platyrhynchus*
- b. 34-37 125
- c. 38-40 .... *C. commersoni*

125 (121,124). Total number of myomeres
- a. 43-47 126
- b. 48-49 .... *C. commersoni*

126 (125). Pigment in dorsal fin
- a. along fin rays with very few, if any, melanophores on membrane between rays (Fig. 75) 127
- b. abundant both along and between rays (Fig. 33) .... *C. commersoni*

127 (126). Pigment in anal fin
- a. absent or present but very light with only a few (≤5) melanophores 128
- b. present but more prominent with many (≥6) melanophores .... *C. commersoni*

128 (127). Caudal fin length (total length minus standard length)
- a. 15% SL .... *C. platyrhynchus*
- b. 16-20% SL .... *C. commersoni* *C. platyrhynchus*
- c. 121-126% SL .... *C. commersoni*

129 (99,100). Pigment over ventral to ventrolateral surfaces of gill covers (opercula)
- a. absent or present but not in a distinct oblique row of 3 or more melanophores near or along ventral margin of one or both preopercles (Figs. 32, 46) 130
- b. present in a distinct oblique row of 3 or more melanophores near or along ventral margin of one or both preopercles (Fig. 31) .... *C. commersoni*

130 (129). Pigment on ventral surface of heart region

a. absent (Fig. 47) .... *C. discobolus*
b. present (Figs. 32, 46) 131

131 (130). Pigment in pectoral fin
a. absent or present but very light with ≤10 melanophores (Fig. 47) 132
b. present but more prominent with ≥11 melanophores (Fig. 61) ... *C. commersoni*

132 (131). Number of myomeres to posterior margin of vent
a. 34 .... *C. commersoni*
b. 35-40 133

133 (121,132). Total number of myomeres
a. 43-46 .... *C. commersoni*
b. 47-49 134

134 (133). Dorsal body pigmentation between head and last myomere scattered
a. more or less evenly (with or without emphasis on distinct lines of melanophores on or lateral and parallel to dorsal midline) (Fig. 47) 135
b. but in a blotchy pattern (with or without emphasis on distinct lines of melanophores on or lateral and parallel to dorsal midline) (Fig. 48, 49) . *C. discobolus*

135 (134). Pigment in dorsal fin
a. along fin rays with very few, if any, melanophores on membrane between rays (Fig. 47) 136
b. abundant both along and between rays (Fig. 33) .... *C. commersoni*

136 (135). Pigment in anal fin
a. absent or fin present but very light with only a few (≤5) melanophores (Fig. 47) 137
b. present but more prominent with many (≥6) melanophores (Fig. 61) *C. commersoni*

137 (136). Length from anterior margin of snout to origin of pelvic fin
a. 54% SL .... *C. commersoni*
b. 55-59% SL .... *C. commersoni*
C. discobolus
c. 60-61% SL .... *C. discobolus*

138 (64,66). Longitudinal eye diameter
a. 22-25% of head length ...... *C. latipinnis*
b. 28-33% of head length .... *C. ardens*

139 (71,90). Longitudinal eye diameter
a. 24-27% of head length . *Xyrauchen texanus*
b. 28-32% of head length 140
c. 33% of head length .... *C. ardens*

140 (139). Length of base of dorsal fin (origin to insertion of dorsal fin)
a. 14-15% SL .... *C. ardens*
b. 16% SL 141
c. 17-21% SL .... *X. texanus*

141 (140). Dorsal fin length
a. 18-20% SL .... *C. ardens*
b. 21-29% SL .... *X. texanus*

<u>Skeletal Character Key for Metalarvae</u> that have been cleared and preferably stained for bone or cartilage (Fig. 6).

1. Standard length group (Fig. 4)
a. ≤16 mm 2
b. 17-18 mm 3
c. 19-21 mm 5
d. ≥22 mm 9

2 (1). Number of vertebrae (including 4 for Weberian complex)
a. 42-43 .... *C. platyrhynchus*
b. 44 .... *C. commersoni*
C. platyrhynchus
c. 45-46 .... *C. commersoni*
C. discobolus
C. platyrhynchus
X. texanus
d. 47 .... *C. ardens*
C. commersoni
C. discobolus
C. platyrhynchus
X. texanus
e. 48 .... *C. ardens*
C. commersoni
C. discobolus
C. platyrhynchus
f. 49-50 .... *C. discobolus*
(rarely) *C. platyrhynchus*

3 (1). First (most anterior) interneural bone (Fig. 8)
a. large and fan-shaped across top *X. texanus*
b. large and angular or anvil-shaped with a prominent posterior-directed projection or beak 4
c. small and blocky or angular with a small to moderate posterior-directed projection or beak 11

4 (3). Number of vertebrae (including 4 for Weberian complex)
a. 44-46 .... *C. commersoni*
b. 47-48 .... *C. ardens*
C. commersoni

5 (1). Frontoparietal fontanelle (Fig. 7)
a. wide, ≤54% of fontanelle length 6
b. very wide, 55-64% of fontanelle length (often somewhat oval in shape) 8
c. very wide, ≥65% of fontanelle length (often somewhat oval in shape) *X. texanus*

6 (5). First (most anterior) interneural bone (Fig. 8)
a. large and angular or anvil-shaped with a prominent posterior-directed projection or beak 7
b. small and blocky or angular with a small to moderate posterior-directed projection or beak 11

7 (6). Number of vertebrae (including 4 for Weberian complex)
- a. 44-46 . . . . *C. commersoni*
- b. 47-48 . . . . *C. ardens*
  C. commersoni
  C. latipinnis
- c. 49-50 . . . . *C. latipinnis*

8 (5). First (most anterior) interneural bone (Fig. 8)
- a. large and fan-shaped across top *X. texanus*
- b. large and angular or anvil-shaped with a prominent posterior-directed projection or beak . . . . *C. latipinnis*

9 (1). Frontoparietal fontanelle (Fig. 7)
- a. narrow, ≤30% of fontanelle length 11
- b. moderately wide, 31-40% of fontanelle length 10
- c. wide, 41-47% of fontanelle length . . . . *C. latipinnis*
- d. very wide, ≥48% of fontanelle length (often over 60% and somewhat oval in shape) . . . . *X. texanus*

10 (9). First (most anterior) interneural bone (Fig. 8)
- a. large and angular or anvil-shaped with a prominent posterior-directed projection or beak; anterior ends of mandibles (from ventral view of head) well anterior, at least mid-distance between posterior and anterior ends of maxillae; anterior-dorsal maxillary projections small and rounded to reduced and almost absent . . . . *C. latipinnis*
- b. small and blocky or angular with a small to moderate posterior-directed projection or beak; anterior ends of mandibles (from ventral view of head) well posterior, much closer to posterior than anterior ends of maxillae; anterior-dorsal maxillary projections prominent and pointed 11

11 (3,6,9,10). Number of vertebrae (including 4 for Weberian complex)
- a. 42-44 . . . . *C. platyrhynchus*
- b. 45-50 . . . . *C. discobolus*
  (rarely) *C. platyrhynchus*

Juveniles ≤40 mm SL -- no finfold remaining (Figs. 20, 21; definition abbreviated for species of concern; there may be rare metalarval specimens in which all finfold is lost but not all pelvic fin rays or rudimentary caudal fin rays are yet present). Separate skeletal character key at end for confirmation of identity or further diagnosis of specimens cleared (and preferably stained) for bone.

1. Standard length (SL; Fig. 4)
- a. 17-18 mm . . . . *C. commersoni*
- b. 19 mm 2
- c. 20 mm 3
- d. 21 mm 5
- e. 22 mm 10
- f. 23-25 mm 23
- g. 26-28 mm 40
- h. 29-31 mm 58
- i. 32-34 mm 71
- j. 35-37 mm 76
- k. 38-40 mm 85

2 (1). Gut (Fig. 5) with
- a. at least 90° bend or partial s-shaped loop (gut phase 2) . . . . *C. ardens*
- b. full loop (s-shape to near anterior end of visceral cavity) but with neither limb of loop completely across over ventral midline (gut phase 3) 4
- c. at least one limb of loop fully across ventral midline but not yet with both limbs across fully to opposite side (gut phase 4) . . . . *C. commersoni*

3 (1). Gut (Fig. 5) with
- a. full loop (s-shape to near anterior end of visceral cavity) but with neither limb of loop completely across over ventral midline (gut phase 3) or gut with at least one limb of loop fully across ventral midline but not yet with both limbs across fully to opposite side (gut phase 4) 4
- b. both limbs of loop across midline fully to opposite side (four segments of gut crossing nearly perpendicular to body axis) or with more extensive coil development (gut phase 5) . . . . . *C. commersoni*

4 (2,3). Mouth
- a. low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Figs. 20, 34) . . . 104
- b. distinctly subterminal (mouth notably posterior to most anterior portion of snout) (Fig. 63) . . . . *C. commersoni*

5 (1). Gut (Fig. 5) with
- a. full loop (s-shape to near anterior end of visceral cavity) but with neither limb of loop completely across over ventral midline (gut phase 3) 7
- b. at least one limb of loop fully across ventral midline but not yet with both limbs across fully to opposite side (gut phase 4) 6
- c. both limbs of loop across midline fully to opposite side (four segments of gut crossing nearly perpendicular to body

axis) or with more extensive coil development (gut phase 5) 9

6 (5). Pigmentation on ventro-lateral surfaces of peritoneum
- a. absent, obstructed from view by muscle, sparse, or patchy (Figs. 20, 34, 90) 7
- b. uniformly dark (Fig. 76) . . *C. platyrhynchus*

7 (5,6). Mouth
- a. terminal (above bottom-of-eye level) . . . . *X. texanus*
- b. low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Figs. 20, 24, 90) . . . 8
- c. distinctly subterminal (mouth notably posterior to most anterior portion of snout) (Fig. 63) . . . . *C. commersoni*

8 (7). Scales
- a. not apparent (Figs. 20, 34, 90) 100
- b. present but lateral series incomplete or uncountable . . . . *C. ardens*

9 (5). Pigmentation on ventro-lateral surfaces of peritoneum
- a. absent, obstructed from view by muscle, sparse, or patchy (Fig. 34) . *C. commersoni*
- b. uniformly dark (Figs. 48, 76) 21

10 (1). Gut (Fig. 5) with
- a. full loop (s-shape to near anterior end of visceral cavity) but with neither limb of loop completely across over ventral midline (gut phase 3) 11
- b. at least one limb of loop fully across ventral midline but not yet with both limbs across fully to opposite side (gut phase 4) 13
- c. both limbs of loop across midline fully to opposite side (four segments of gut crossing nearly perpendicular to body axis) or with more extensive coil development (gut phase 5) 17

11 (10). Mouth
- a. terminal (above bottom-of-eye level) . . . . *X. texanus*
- b. low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Figs. 20, 90) 12

12 (11). Scales
- a. not apparent (Figs. 20, 90) 111
- b. present but lateral series incomplete or uncountable . . . . *C. ardens*

13 (10). Pigmentation on ventro-lateral surfaces of peritoneum
- a. absent, obstructed from view by muscle, sparse, or patchy (Figs. 20, 34) 14
- b. uniformly dark (Fig. 76) . . *C. platyrhynchus*

14 (13). Pigmentation on ventral surface of peritoneum
- a. absent (Figs. 20, 34) 15
- b. sparse or patchy (Fig. 63) . . *C. commersoni*

15 (14). Mouth
- a. terminal (above bottom-of-eye level) . . . . *X. texanus*
- b. low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Figs. 20, 34) 16
- c. distinctly subterminal (mouth notably posterior to most anterior portion of snout) (Fig. 63) . . . . *C. commersoni*

16 (15). Scales
- a. not apparent (Figs. 20, 34, 90) 100
- b. present but lateral series incomplete or uncountable 104

17 (10). Pigmentation on ventro-lateral surfaces of peritoneum
- a. absent, obstructed from view by muscle, sparse, or patchy (Figs. 34, 90) 18
- b. uniformly dark (Figs. 48, 76) 21

18 (17). Pigmentation on ventral surface of peritoneum
- a. absent (Figs. 34, 90) 19
- b. sparse or patchy (Figs. 63) . *C. commersoni*

19 (18). Mouth
- a. terminal (above bottom-of-eye level) . . . . *X. texanus*
- b. low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Figs. 34, 90) 20
- c. distinctly subterminal (mouth notably posterior to most anterior portion of snout) (Fig. 63) . . . . *C. commersoni*

20 (19). Scales
- a. not apparent (Figs. 34, 90) 108
- b. present but lateral series incomplete or uncountable . . . . *C. commersoni*

21 (9,17). Pigmentation on ventral surface of peritoneum
- a. sparse or patchy (Figs. 48, 76) 22
- b. uniformly light or dark (Fig. 49) . . . . *C. discobolus*

22 (21). Mouth
- a. terminal (above bottom-of-eye level) or low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Fig. 75) . . . . *C. platyrhynchus*
- b. distinctly subterminal (mouth notably posterior to most anterior portion of snout) (Figs. 48, 76) . . . . *C. discobolus*

23 (1). Gut (Fig. 5) with
- a. at least 90° bend or partial s-shaped loop (gut phase 2) . . . . *C. latipinnis*
- b. full loop (s-shape to near anterior end of visceral cavity) but with neither limb of loop completely across over ventral midline (gut phase 3) 24
- c. at least one limb of loop fully across ventral midline but not yet with both limbs across fully to opposite side (gut phase 4) 26
- d. both limbs of loop across midline fully to opposite side (four segments of gut crossing nearly perpendicular to body axis) or with more extensive coil development (gut phase 5) 34

24 (23). Mouth
- a. terminal (above bottom-of-eye level) . . . . *X. texanus*
- b. low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Figs. 62, 90) 25
- c. distinctly subterminal (mouth notably posterior to most anterior portion of snout) (Fig. 63) . . . . *C. latipinnis*

25 (24). Scales
- a. not apparent (Figs. 62, 90) 115
- b. present but lateral series incomplete or uncountable . . . . *X. texanus*

26 (23). Pigmentation on ventro-lateral surfaces of peritoneum
- a. absent, obstructed from view by muscle, sparse, or patchy (Figs. 20, 34, 62, 90) . . 27
- b. uniformly dark (Fig. 76) . . *C. platyrhynchus*

27 (26). Pigmentation on ventral surface of peritoneum
- a. absent (Figs. 20, 34, 62, 90) 28
- b. sparse or patchy (Fig. 63) 31

28 (27). Mouth
- a. terminal (above bottom-of-eye level) . . . . *X. texanus*
- b. low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Figs. 20, 34, 62, 90) 29
- c. distinctly subterminal (mouth notably posterior to most anterior portion of snout) (Fig. 63) 30

29 (28). Scales
- a. not apparent (Figs. 20, 34, 62, 90) 97
- b. present but lateral series incomplete or uncountable 99
- c. present with lateral series complete and countable (Fig. 21) . . . . *C. ardens*

30 (28). Scales
- a. not apparent (Figs. 20, 34, 62) 102
- b. present but lateral series incomplete or uncountable 104
- c. present with lateral series complete and countable (Fig. 21) . . . . *C. ardens*

31 (27). Mouth
- a. terminal (above bottom-of-eye level) . . . . *X. texanus*
- b. low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Figs. 34, 62, 90) . 32
- c. distinctly subterminal (mouth notably posterior to most anterior portion of snout) (Fig. 63) 33

32 (31). Scales
- a. not apparent (Figs. 34, 62, 90) 105
- b. present but lateral series incomplete or uncountable 107

33 (31). Scales
- a. not apparent (Figs. 34, 62) 113
- b. present but lateral series incomplete or uncountable . . . . *C. commersoni*

34 (23). Pigmentation on ventro-lateral surfaces of peritoneum
- a. absent, obstructed from view by muscle, sparse, or patchy (Figs. 34, 90) 35
- b. uniformly dark (Figs. 48, 76) 37

35 (34). Mouth
- a. terminal (above bottom-of-eye level) . . . . *X. texanus*
- b. low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Figs. 34, 90) 36
- c. distinctly subterminal (mouth notably posterior to most anterior portion of snout) (Fig. 63) . . . . *C. commersoni*

36 (35). Scales
- a. not apparent (Figs. 34, 90) 108
- b. present but lateral series incomplete or uncountable 107

37 (34). Pigmentation on ventral surface of peritoneum
- a. sparse or patchy (Figs. 48, 76) 38
- b. uniformly light or dark (Fig. 49) . . . . *C. discobolus*

38 (37). Mouth
- a. terminal (above bottom-of-eye level) or low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Fig. 75) . . . . *C. platyrhynchus*
- b. distinctly subterminal (mouth notably posterior to most anterior portion of snout) (Figs. 48, 76) 39

39 (38). Scales
a. not apparent (Figs. 48, 76) 182
b. present but lateral series incomplete or uncountable . . . . *C. platyrhynchus*

40 (1). Gut (Fig. 5) with
a. at least 90° bend or partial s-shaped loop (gut phase 2) . . . . *C. latipinnis*
b. full loop (s-shape to near anterior end of visceral cavity) but with neither limb of loop completely across over ventral midline (gut phase 3) 41
c. at least one limb of loop fully across ventral midline but not yet with both limbs across fully to opposite side (gut phase 4) 42
d. both limbs of loop across midline fully to opposite side (four segments of gut crossing nearly perpendicular to body axis) or with more extensive coil development (gut phase 5) 49

41 (40). Pigmentation on ventro-lateral surfaces of peritoneum
a. absent, obstructed from view by muscle, sparse, or patchy (Figs. 62, 90) 47
b. uniformly light . . . . *X. texanus*

42 (40). Pigmentation on ventro-lateral surfaces of peritoneum
a. absent, obstructed from view by muscle, sparse, or patchy (Figs. 20, 62, 90) 43
b. uniformly light . . . . *X. texanus*

43 (42). Pigmentation on ventral surface of peritoneum
a. absent (Figs. 20, 62, 90) 44
b. sparse or patchy (Fig. 63) 47

44 (43). Mouth
a. low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Figs. 20, 62, 90) . . 45
b. distinctly subterminal (mouth notably posterior to most anterior portion of snout) (Fig. 63) 46

45 (44). Scales
a. not apparent (Figs. 62, 90) 115
b. present but lateral series incomplete or uncountable 110
c. present with lateral series complete and countable (Fig. 21) . . . . *C. ardens*

46 (44). Scales
a. not apparent (Fig. 62) . . . . . . *C. latipinnis*
b. clearly present (Fig. 21) . . . . *C. ardens*

47 (41,43). Mouth
a. low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Figs. 62, 90) 48
b. distinctly subterminal (mouth notably posterior to most anterior portion of snout) (Fig. 63) . . . . *C. latipinnis*

48 (47). Scales
a. not apparent (Figs. 62, 90) 115
b. present but lateral series incomplete or uncountable . . . . *X. texanus*

49 (40). Pigmentation on ventro-lateral surfaces of peritoneum
a. absent, obstructed from view by muscle, sparse, or patchy; lips at corners of mouth joined, not separated by distinct notches (Figs. 20, 34, 90) 50
b. uniformly light; lips at corners of mouth joined, not separated by distinct notches . . . . *X. texanus*
c. uniformly dark; lips at corners of mouth separated by distinct notches (Figs. 48, 76) 56

50 (49). Pigmentation on ventral surface of peritoneum
a. absent (Figs. 20, 34, 90) 51
b. sparse or patchy (Fig. 63) 54

51 (50). Mouth
a. low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Figs. 20, 34, 90) . 52
b. distinctly subterminal (mouth notably posterior to most anterior portion of snout) (Fig. 63) 53

52 (51). Scales
a. not apparent (Fig. 90) . . . . *X. texanus*
b. present but lateral series incomplete or uncountable 99
c. present with lateral series complete and countable (Fig. 21) . . . . *C. ardens*

53 (51). Scales
a. present but lateral series incomplete or uncountable 104
b. present with lateral series complete and countable (Fig. 21) . . . . *C. ardens*

54 (50). Mouth
a. low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Figs. 34, 90) 55
b. distinctly subterminal (mouth notably posterior to most anterior portion of snout) (Fig. 63) . . . . *C. commersoni*

55 (54). Scales
a. not apparent (Fig. 90) . . . . *X. texanus*
b. present but lateral series incomplete or uncountable 107

56 (49). Pigmentation on ventral surface of peritoneum

a. sparse, patchy, or uniformly light (Fig. 76) . . . . *C. platyrhynchus*
b. uniformly dark (Fig. 49) 57

57 (56). Scales
a. not apparent (Fig. 48) . . . . . *C. discobolus*
b. present but lateral series incomplete or uncountable 117

58 (1). Gut (Fig. 5) with
a. full loop (s-shape to near anterior end of visceral cavity) but with neither limb of loop completely across over ventral midline (gut phase 3) . . . . *C. latipinnis*
b. at least one limb of loop fully across ventral midline but not yet with both limbs across fully to opposite side (gut phase 4) 59
c. both limbs of loop across midline fully to opposite side (four segments of gut crossing nearly perpendicular to body axis) or with more extensive coil development (gut phase 5) 63

59 (58). Pigmentation on ventro-lateral surfaces of peritoneum
a. absent, obstructed from view by muscle, sparse, or patchy (Figs. 62, 91) 60
b. uniformly light . . . . *X. texanus*

60 (59). Pigmentation on ventral surface of peritoneum
a. absent, sparse or patchy (Figs. 62, 91) . . 61
b. uniformly light . . . . *X. texanus*

61 (60). Mouth
a. low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Figs. 62, 91) 62
b. distinctly subterminal (mouth notably posterior to most anterior portion of snout) (Fig. 63) . . . . *C. latipinnis*

62 (61). Scales
a. not apparent (Fig. 62) . . . . . . *C. latipinnis*
b. present but lateral series incomplete or uncountable . . . . *X. texanus*

63 (58). Pigmentation on ventro-lateral surfaces of peritoneum
a. absent, obstructed from view by muscle, sparse, or patchy; lips at corners of mouth joined, not separated by distinct notches (Figs. 21, 35, 62, 91) 64
b. uniformly light; lips at corners of mouth joined, not separated by distinct notches . . . . *X. texanus*
c. uniformly dark; lips at corners of mouth separated by distinct notches (Figs. 48, 76) 74

64 (63). Pigmentation on ventral surface of peritoneum
a. absent (Figs. 21, 34, 62, 91) 65
b. sparse or patchy (Fig. 63) 68
c. uniformly light . . . . *X. texanus*

65 (64). Mouth
a. low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Figs. 21, 34, 90) 66
b. distinctly subterminal (mouth notably posterior to most anterior portion of snout) (Fig. 63) 67

66 (65). Scales
a. not apparent (Fig. 62) . . . . . . *C. latipinnis*
b. present but lateral series incomplete or uncountable 107
c. present with lateral series complete and countable (Figs. 21, 35) 103

67 (65). Scales
a. not apparent (Fig. 62) . . . . . . *C. latipinnis*
b. present but lateral series incomplete or uncountable . . . . *C. commersoni*
c. present with lateral series complete and countable (Figs. 21, 35) 103

68 (64). Mouth
a. low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Figs. 35, 62, 90) . 69
b. distinctly subterminal (mouth notably posterior to most anterior portion of snout) (Fig. 63) 70

69 (68). Scales
a. not apparent (Fig. 62) . . . . . . *C. latipinnis*
b. present but lateral series incomplete or uncountable 107
c. present with lateral series complete and countable (Fig. 35) . . . . *C. commersoni*

70 (68). Scales
a. not apparent (Fig. 62) . . . . . . *C. latipinnis*
b. clearly present (Fig. 35) . . . *C. commersoni*

71 (1). Gut (Fig. 5) with
a. full loop (s-shape to near anterior end of visceral cavity) but with neither limb of loop completely across over ventral midline (gut phase 3) or gut with at least one limb of loop fully across ventral midline but not yet with both limbs across fully to opposite side (gut phase 4) . . . . *C. latipinnis*
b. both limbs of loop across midline fully to opposite side (four segments of gut crossing nearly perpendicular to body axis) or with more extensive coil development (gut phase 5) 72

72 (71). Pigmentation on ventro-lateral surfaces of peritoneum
a. absent, obstructed from view by muscle,

sparse, or patchy; lips at corners of mouth joined, not separated by distinct notches (Figs. 21, 35, 63, 91) . . 73
- b. uniformly light; lips at corners of mouth joined, not separated by distinct notches . . . . *X. texanus*
- c. uniformly dark; lips at corners of mouth separated by distinct notches (Figs. 49, 77) 74

73 (72). Pigmentation on ventral surface of peritoneum
- a. absent (Figs. 21, 91) 80A
- b. sparse or patchy (Fig. 63) 83A
- c. uniformly light or dark (Fig. 49) *X. texanus*

74 (63,72). Pigmentation on ventral surface of peritoneum
- a. sparse, patchy, or uniformly light (Fig. 76) . . . . *C. platyrhynchus*
- b. uniformly dark (Fig. 49) 75

75 (74). Scales
- a. not apparent (Fig. 49) . . . . . *C. discobolus*
- b. present but lateral series incomplete or uncountable 117
- c. present with lateral series complete and countable 116

76 (1). Gut (Fig. 5) with
- a. full loop (s-shape to near anterior end of visceral cavity) but with neither limb of loop completely across over ventral midline (gut phase 3) or gut with at least one limb of loop fully across ventral midline but not yet with both limbs across fully to opposite side (gut phase 4) . . . . *C. latipinnis*
- b. both limbs of loop across midline fully to opposite side (four segments of gut crossing nearly perpendicular to body axis) or with more extensive coil development (gut phase 5) 77

77 (76). Lips at corners of mouth
- a. joined, not separated by distinct notches (Figs. 21, 35, 63, 91) 78
- b. separated by distinct notches (Figs. 49, 77) 96

78 (77). Pigmentation on ventro-lateral surfaces of peritoneum
- a. absent, obstructed from view by muscle, sparse, or patchy (Figs. 21, 35, 63, 91) . . 79
- b. uniformly light 82
- c. uniformly dark . . . . *X. texanus*

79 (78). Pigmentation on ventral surface of peritoneum
- a. absent (Figs. 21, 91) 80B
- b. sparse or patchy (Fig. 63) 83B
- c. uniformly light 84
- d. uniformly dark . . . . *X. texanus*

80A (73). Mouth
- a. low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Figs. 35, 91) . . . 83A
- b. distinctly subterminal (mouth notably posterior to most anterior portion of snout) (Fig. 63) 81A

80B (79). Mouth
- a. low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Figs. 35, 91) 83B
- b. distinctly subterminal (mouth notably posterior to most anterior portion of snout) (Fig. 63) 81B

81A (80A). Scales
- a. not apparent (Fig. 63) . . . . . . *C. latipinnis*
- b. present but lateral series incomplete or uncountable . . . . *X. texanus*
- c. present with lateral series complete and countable (Figs. 21, 35) 98

81B (80B). Scales
- a. not apparent (Fig. 63) . . . . . . *C. latipinnis*
- b. present but lateral series incomplete or uncountable 115
- c. present with lateral series complete and countable (Figs. 21, 35) 98

82 (78). Pigmentation on ventral surface of peritoneum
- a. absent, sparse or patchy (Figs. 35, 91) . 83B
- b. uniformly light 84
- c. uniformly dark (Fig. 49) . . . . . . *X. texanus*

83A (73,80A,). Scales
- a. not apparent (Fig. 63) . . . . . . *C. latipinnis*
- b. present but lateral series incomplete or uncountable . . . . *X. texanus*
- c. present with lateral series complete and countable (Fig. 35) 106

83B (79,82). Scales
- a. not apparent (Fig. 63) . . . . . . *C. latipinnis*
- b. present but lateral series incomplete or uncountable 115
- c. present with lateral series complete and countable (Fig. 35) 106

84 (79,82). Scales
- a. present but lateral series incomplete or uncountable . . . . *X. texanus*
- b. present with lateral series complete and countable (Fig. 35) 106

85 (1). Gut (Fig. 5) with
- a. at least one limb of loop fully across ventral midline but not yet with both limbs across fully to opposite side (gut phase 4) . . . . *C. latipinnis*
- b. both limbs of loop across midline fully to opposite side (four segments of gut crossing nearly perpendicular to body

axis) or with more extensive coil development (gut phase 5) 86

86 (85). Lips at corners of mouth
 a. joined, not separated by distinct notches (Figs. 21, 35, 63, 91) 87
 b. separated by distinct notches (Figs. 49, 77)96

87 (86). Pigmentation on ventro-lateral surfaces of peritoneum
 a. absent or obstructed from view by muscle (Figs. 21, 35, 91) 88
 b. sparse or patchy (Fig. 63) 93
 c. uniformly light or dark ...... *C. latipinnis*

88 (87). Pigmentation on ventral surface of peritoneum
 a. absent (Figs. 21, 35) 89
 b. sparse or patchy (Fig. 63) .... *C. latipinnis*
 c. uniformly light or dark 92

89 (88). Mouth
 a. low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) (Fig. 35) 90
 b. distinctly subterminal (mouth notably posterior to most anterior portion of snout) (Fig. 63) 91

90 (89). Scales
 a. absent, incomplete, or uncountable (Fig. 63) .... *C. latipinnis*
 b. present with lateral series complete and countable (Fig. 35) 112

91 (89). Scales
 a. absent, incomplete, or uncountable (Fig. 63) .... *C. latipinnis*
 b. present with lateral series complete and countable (Figs. 21, 35) 101

92 (88). Scales
 a. absent, incomplete, or uncountable (Fig. 63) .... *C. latipinnis*
 b. present with lateral series complete and countable 114

93 (87). Pigmentation on ventral surface of peritoneum
 a. absent (Fig. 21) 94
 b. present (Fig. 63) .... *C. latipinnis*

94 (93). Mouth
 a. low terminal (at or below bottom-of-eye level) to slightly subterminal (mouth, including upper lip, not the most anterior portion of snout) .... *C. latipinnis*
 b. distinctly subterminal (mouth notably posterior to most anterior portion of snout) (Fig. 63) 95

95 (94). Scales
 a. absent, incomplete, or uncountable (Fig. 63) .... *C. latipinnis*
 b. present with lateral series complete and countable (Fig. 21) 109

96 (77,86). Scales
 a. present but lateral series incomplete or uncountable (Figs. 49, 77) 117
 b. present with lateral series complete and countable 116

97 (29). Number of principal dorsal fin rays
 a. 10 137
 b. 11 125
 c. 12-13 118
 d. 14 159
 e. 15-16 .... *X. texanus*

98 (81A,81B). Number of lateral rows of scales beginning with first lateral line scale (equals lateral line scale count if lateral line is complete and observable to base of caudal fin)
 a. 53-67 104
 b. 68-79 99
 c. 80-85 107
 d. 86-95 .... *X. texanus*

99 (29,52,98). Pigment outlining scales
 a. absent or light (Figs. 20, 34, 91) 100
 b. bold (Figs. 21, 35) 104

100 (8,16,99). Number of principal dorsal fin rays
 a. 10-11 137
 b. 12-13 130
 c. 14 170
 d. 15-16 .... *X. texanus*

101 (91). Number of lateral rows of scales beginning with first lateral line scale (equals lateral line scale count if lateral line is complete and observable to base of caudal fin)
 a. 53-79 104
 b. 80-85 .... *C. commersoni*
 c. 89-120 .... *C. latipinnis*

102 (30). Number of principal dorsal fin rays
 a. 10 137
 b. 11-13 125
 c. 14 166

103 (66,67). Number of lateral rows of scales beginning with first lateral line scale (equals lateral line scale count if lateral line is complete and observable to base of caudal fin)
 a. 53-79 104
 b. 80-85 .... *C. commersoni*

104 (4,16,30,53,98,99,101,103). Number of principal dorsal fin rays
 a. 10-13 137
 b. 14 .... *C. ardens*

105 (32). Number of principal dorsal fin rays
 a. 10 .... *C. commersoni*

b. 11 149
c. 12-13 142
d. 14 176
e. 15-16 . . . . *X. texanus*

106 (83A,83B,84). Number of lateral rows of scales beginning with first lateral line scale (equals lateral line scale count if lateral line is complete and observable to base of caudal fin)
a. 53-67 . . . . *C. commersoni*
b. 68-85 107
c. 86-95 . . . . *X. texanus*

107 (32,36,55,66,69,98,106). Pigment outlining scales
a. absent or light (Fig. 91) 108
b. bold (Fig. 35) . . . . *C. commersoni*

108 (20,36,107). Number of principal dorsal fin rays
a. 10-11 . . . . *C. commersoni*
b. 12-13 153
c. 14-16 . . . . *X. texanus*

109 (95). Number of lateral rows of scales beginning with first lateral line scale (equals lateral line scale count if lateral line is complete and observable to base of caudal fin)
a. 54-79 . . . . *C. ardens*
b. 89-120 . . . . *C. latipinnis*

110 (45). Pigment outlining scales
a. absent or light (Figs. 20, 91) 111
b. bold (Fig. 21) . . . . *C. ardens*

111 (12,110). Number of principal dorsal fin rays
a. 10-11 . . . . *C. ardens*
b. 12-14 170
c. 15-16 . . . . *X. texanus*

112 (90). Number of lateral rows of scales beginning with first lateral line scale (equals lateral line scale count if lateral line is complete and observable to base of caudal fin)
a. 53-85 . . . . *C. commersoni*
b. 89-120 . . . . *C. latipinnis*

113 (33). Number of principal dorsal fin rays
a. 10 . . . . *C. commersoni*
b. 11-13 149
c. 14 . . . . *C. latipinnis*

114 (92). Number of lateral rows of scales beginning with first lateral line scale (equals lateral line scale count if lateral line is complete and observable to base of caudal fin)
a. 68-88 . . . . *X. texanus*
b. 89-95 115
c. 96-120 . . . . *C. latipinnis*

115 (25,45,48,81B,83B,114). Number of principal dorsal fin rays
a. 11 . . . . *C. latipinnis*
b. 12-14 176
c. 15-16 . . . . *X. texanus*

116 (75,96). Number of lateral rows of scales beginning with first lateral line scale (equals lateral line scale count if lateral line is complete and observable to base of caudal fin)
a. 60-77 . . . . *C. platyrhynchus*
b. 78-108 117
c. 109-122 . . . . *C. discobolus*

117 (57,75,96,116). Pigment outlining scales
a. absent or light (Figs. 49, 77) 182
b. bold (Fig. 21) . . . . *C. platyrhynchus*

118 (97). Mid-lateral surface of body with
a. no large, distinct spots (Figs. 21, 63, 91) 119
b. 2 large, distinct spots, one between head and dorsal fin and the other over the pelvic fin . . . . *C. ardens*
c. 3 large, distinct spots, one between head and dorsal fin, the second over the pelvic fin, and the last on the caudal peduncle near the base of the tail (Fig. 35) . . . . *C. commersoni*

119 (118). Ventral midline from shortly behind heart region to near vent with
a. ≥21 melanophores in a continuous or discontinuous line or narrow band (Fig. 34) . . . . *C. commersoni*
b. 7-20 melanophores 127
c. ≤6 melanophores (Figs. 20, 62, 90) . . . 120

120 (119). Pigment over ventral to ventro-lateral surfaces of gill covers (opercula)
a. absent (Figs. 62, 90) 121
b. present in a distinct oblique row of 3 or more melanophores near or along ventral margin of one or both preopercles (Fig. 31) . . . . *C. commersoni*
c. present but not in distinct oblique rows (Figs. 21, 34) 133

121 (120). Pigmentation on lateral surfaces of body above bottom-of-eye level and anterior to vent, exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,
a. scattered only partially down to the horizontal myoseptum (lateral midline) (Fig. 90) . . . . *X. texanus*
b. scattered fully and evenly down to the horizontal myoseptum with few if any melanophores below the myoseptum (Fig. 62) 146
c. scattered evenly or in blotchy pattern (continuous with dorsal and dorso-lateral surface pattern) down to horizontal myoseptum and at least partially to bottom- of-eye level below (Figs. 20, 35, 63, 91) 122

122 (121). Pigmentation on lateral to ventro-lateral surfaces of body below bottom-of-eye level, exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,
- a. absent including caudal peduncle (Figs. 62, 91) 147
- b. absent except on caudal peduncle (Figs. 20, 21) 123
- c. present anterior to caudal peduncle (Fig. 35) 135

123 (122). Pigment in caudal fin
- a. along fin rays with very few, if any, melanophores on membrane between rays (Fig. 35) 208
- b. abundant both along and between rays (Figs. 63, 91) 124

124 (123). Pigment in dorsal fin
- a. along fin rays with very few, if any, melanophores on membrane between rays (Fig. 62) 208
- b. abundant both along and between rays (Figs. 63, 91) 187

125 (97,102). Mid-lateral surface of body with
- a. no large, distinct spots (Figs. 21, 62) . . 126
- b. 2 large, distinct spots, one between head and dorsal fin and the other over the pelvic fin . . . . *C. ardens*
- c. 3 large, distinct spots, one between head and dorsal fin, the second over the pelvic fin, and the last on the caudal peduncle near the base of the tail (Fig. 35) . . . . *C. commersoni*

126 (125). Ventral midline from shortly behind heart region to near vent with
- a. ≥21 melanophores in a continuous or discontinuous line or narrow band (Fig. 34) . . . . *C. commersoni*
- b. ≤20 melanophores (Figs. 20, 62) 127

127 (119,126). Pigment over ventral to ventro-lateral surfaces of gill covers (opercula)
- a. absent (Figs. 20, 62) 128
- b. present in a distinct oblique row of 3 or more melanophores near or along ventral margin of one or both preopercles (Fig. 31) . . . . . *C. commersoni*
- c. present but not in distinct oblique rows (Figs. 21, 34) 140

128 (127). Pigmentation on lateral surfaces of body above bottom-of-eye level and anterior to vent, exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,
- a. scattered fully and evenly down to the horizontal myoseptum with few if any melanophores below the myoseptum (Fig. 62) 152
- b. scattered evenly or in blotchy pattern (continuous with dorsal and dorso-lateral surface pattern) down to horizontal myoseptum and at least partially to bottom- of-eye level below (Figs. 20, 63) 129

129 (128). Pigmentation on lateral to ventro-lateral surfaces of body below bottom-of-eye level, exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,
- a. absent including caudal peduncle (Fig. 62) 238
- b. absent except on caudal peduncle (Figs. 20, 21) 208
- c. present anterior to caudal peduncle (Fig. 35) 247

130 (100). Mid-lateral surface of body with
- a. no large, distinct spots (Figs. 21, 34, 90) 131
- b. 2 large, distinct spots, one between head and dorsal fin and the other over the pelvic fin . . . . *C. ardens*
- c. 3 large, distinct spots, one between head and dorsal fin, the second over the pelvic fin, and the last on the caudal peduncle near the base of the tail (Fig. 35) . . . . *C. commersoni*

131 (130). Ventral midline from shortly behind heart region to near vent with
- a. ≥21 melanophores in a continuous or discontinuous line or narrow band (Fig. 34) . . . . *C. commersoni*
- b. 7-20 melanophores 139
- c. ≤6 melanophores (Figs. 20, 90) 132

132 (131). Pigment over ventral to ventro-lateral surfaces of gill covers (opercula)
- a. absent or present but not in distinct oblique rows (Figs. 20, 91) 133
- b. present in a distinct oblique row of 3 or more melanophores near or along ventral margin of one or both preopercles (Fig. 31) . . . . *C. commersoni*

133 (120,132). Pigmentation on lateral surfaces of body above bottom-of-eye level and anterior to vent, exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,
- a. scattered only partially down to the horizontal myoseptum (lateral midline) (Fig. 90) . . . . *X. texanus*
- b. scattered fully and evenly down to the horizontal myoseptum with few if any melanophores below the myoseptum (Fig. 62) 157
- c. scattered evenly or in blotchy pattern (continuous with dorsal and dorso-lateral surface pattern) down to horizontal myoseptum and at least

partially to bottom-of-eye level below (Figs. 20, 91) 134

134 (133). Pigmentation on lateral to ventro-lateral surfaces of body below bottom-of-eye level, exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,
a. absent including caudal peduncle (Fig. 91) 157
b. present at least on caudal peduncle (Figs. 20, 21, 35) 135

135 (122,134). Pigment in caudal fin
a. along fin rays with very few, if any, melanophores on membrane between rays (Fig. 35) 247
b. abundant both along and between rays (Fig. 91) 136

136 (135). Pigment in dorsal fin
a. along fin rays with very few, if any, melanophores on membrane between rays (Fig. 21) 247
b. abundant both along and between rays (Fig. 91) 198

137 (97,100,102,104). Mid-lateral surface of body with
a. no large, distinct spots (Figs. 21, 34) . . 138
b. 2 large, distinct spots, one between head and dorsal fin and the other over the pelvic fin . . . . *C. ardens*
c. 3 large, distinct spots, one between head and dorsal fin, the second over the pelvic fin, and the last on the caudal peduncle near the base of the tail (Fig. 35) . . . . *C. commersoni*

138 (137). Ventral midline from shortly behind heart region to near vent with
a. ≥21 melanophores in a continuous or discontinuous line or narrow band (Fig. 34) . . . . *C. commersoni*
b. ≤20 melanophores (Figs. 20, 21, 35) . . 139

139 (131,138). Pigment over ventral to ventro-lateral surfaces of gill covers (opercula)
a. absent or present but not in distinct oblique rows (Figs. 20, 34) 140
b. present in a distinct oblique row of 3 or more melanophores near or along ventral margin of one or both preopercles (Fig. 31) . . . . *C. commersoni*

140 (127,139). Pigmentation on lateral surfaces of body above bottom-of-eye level and anterior to vent, exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,
a. scattered fully and evenly down to the horizontal myoseptum with few if any melanophores below the myoseptum . . . . *C. commersoni*
b. scattered evenly or in blotchy pattern (continuous with dorsal and dorsolateral surface pattern) down to horizontal myoseptum and at least partially to bottom-of-eye level below (Figs. 20, 21, 35) 141

141 (140). Pigmentation on lateral to ventro-lateral surfaces of body below bottom-of-eye level, exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,
a. absent including caudal peduncle . . . . *C. commersoni*
b. present at least on caudal peduncle (Figs. 20, 21, 35) 247

142 (105). Mid-lateral surface of body with
a. no large, distinct spots (Figs. 63, 91) . . 143
b. 3 large, distinct spots, one between head and dorsal fin, the second over the pelvic fin, and the last on the caudal peduncle near the base of the tail (Fig. 35) . . . . *C. commersoni*

143 (142). Ventral midline from shortly behind heart region to near vent with
a. ≥21 melanophores in a continuous or discontinuous line or narrow band (Fig. 34) . . . . *C. commersoni*
b. 7-20 melanophores 151
c. ≤6 melanophores (Figs. 35, 63, 91) . . . 144

144 (143). Pigment over ventral to ventro-lateral surfaces of gill covers (opercula)
a. absent (Figs. 35, 63, 91) 145
b. present in a distinct oblique row of 3 or more melanophores near or along ventral margin of one or both preopercles (Fig. 31) . . . . *C. commersoni*
c. present but not in distinct oblique rows 156

145 (144). Pigmentation on lateral surfaces of body above bottom-of-eye level and anterior to vent, exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,
a. scattered only partially down to the horizontal myoseptum (lateral midline) (Fig. 90) . . . . *X. texanus*
b. scattered evenly or in blotchy pattern (continuous with dorsal and dorsolateral surface pattern) down to horizontal myoseptum and sometimes at least partially to bottom-of-eye level below (Figs. 35, 62, 91) 146

146 (121,145). Pigmentation on lateral to ventro-lateral surfaces of body below bottom-of-eye level, exclusive

of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,
- a. absent anterior to caudal peduncle (Figs. 62, 91) 147
- b. present anterior to caudal peduncle (Fig. 35) 157

147 (122,146). Pigment in caudal fin
- a. along fin rays with very few, if any, melanophores on membrane between rays (Figs. 35, 62) 238
- b. abundant both along and between rays (Figs. 63, 91) 148

148 (147). Pigment in dorsal fin
- a. along fin rays with very few, if any, melanophores on membrane between rays (Fig. 62) 238
- b. abundant both along and between rays (Figs. 63, 91) 188

149 (105,113). Mid-lateral surface of body with
- a. no large, distinct spots (Figs. 34, 63) . . 150
- b. 3 large, distinct spots, one between head and dorsal fin, the second over the pelvic fin, and the last on the caudal peduncle near the base of the tail (Fig. 35) . . . . *C. commersoni*

150 (149). Ventral midline from shortly behind heart region to near vent with
- a. ≥21 melanophores in a continuous or discontinuous line or narrow band (Fig. 34) . . . . *C. commersoni*
- b. ≤20 melanophores (Figs. 35, 63) 151

151 (143,150). Pigment over ventral to ventro-lateral surfaces of gill covers (opercula)
- a. absent (Figs. 35, 63) 152
- b. present, sometimes in a distinct oblique row of 3 or more melanophores near or along ventral margin of one or both preopercles (Fig. 31) . . . . . *C. commersoni*

152 (128,151). Pigmentation on lateral to ventro-lateral surfaces of body below bottom-of-eye level, exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,
- a. absent anterior to caudal peduncle (Fig. 63) 238
- b. present anterior to caudal peduncle (Fig. 35) . . . . *C. commersoni*

153 (108). Mid-lateral surface of body with
- a. no large, distinct spots (Fig. 91) 154
- b. 3 large, distinct spots, one between head and dorsal fin, the second over the pelvic fin, and the last on the caudal peduncle near the base of the tail (Fig. 35) . . . . *C. commersoni*

154 (153). Ventral midline from shortly behind heart region to near vent with
- a. ≥7 melanophores in a continuous or discontinuous line or narrow band (Fig. 34) . . . . *C. commersoni*
- b. ≤6 melanophores (Figs. 35, 91) 155

155 (154). Pigment over ventral to ventro-lateral surfaces of gill covers (opercula)
- a. absent or present but not in distinct oblique rows (Figs. 35, 91) 156
- b. present in a distinct oblique row of 3 or more melanophores near or along ventral margin of one or both preopercles (Fig. 31) . . . . *C. commersoni*

156 (144,155). Pigmentation on lateral surfaces of body above bottom-of-eye level and anterior to vent, exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,
- a. scattered only partially down to the horizontal myoseptum (lateral midline) (Fig. 90) . . . . *X. texanus*
- b. scattered evenly or in blotchy pattern (continuous with dorsal and dorso-lateral surface pattern) down to horizontal myoseptum and sometimes at least partially to bottom-of-eye level below (Figs. 35, 91) 157

157 (133,134,146,156). Pigment in caudal fin
- a. along fin rays with very few, if any, melanophores on membrane between rays (Fig. 35) . . . . *C. commersoni*
- b. abundant both along and between rays (Fig. 91) 158

158 (157). Pigment in dorsal fin
- a. along fin rays with very few, if any, melanophores on membrane between rays (Fig. 35) . . . . *C. commersoni*
- b. abundant both along and between rays (Fig. 91) 229

159 (97). Mid-lateral surface of body with
- a. no large, distinct spots (Figs. 21, 63, 91) 160
- b. 2 large, distinct spots, one between head and dorsal fin and the other over the pelvic fin . . . . *C. ardens*

160 (159). Ventral midline from shortly behind heart region to near vent with
- a. 7-20 melanophores 167
- b. ≤6 melanophores (Figs. 21, 63, 91) . . . 161

161 (160). Pigment over ventral to ventro-lateral surfaces of gill covers (opercula)
- a. absent (Figs. 63, 91) 162
- b. present but not in distinct oblique rows (Figs. 21) 172

162 (161). Pigmentation on lateral surfaces of

body above bottom-of-eye level and level and anterior to vent, exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,

a. scattered only partially down to the horizontal myoseptum (lateral midline; Fig. 90) . . . . *X. texanus*
b. scattered fully and evenly down to the horizontal myoseptum with few if any melanophores below the myoseptum (Fig. 62) 179
c. scattered evenly or in blotchy pattern (continuous with dorsal and dorso-lateral surface pattern) down to horizontal myoseptum and at least partially to bottom-of-eye level below (Figs. 63, 91) 163

163 (162). Pigmentation on lateral to ventro-lateral surfaces of body below bottom-of-eye level, exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,

a. absent including caudal peduncle (Figs. 62, 91) 180
b. absent except on caudal peduncle (Figs. 21, 63) 164
c. present anterior to caudal peduncle (Fig. 35) 174

164 (163). Pigment in caudal fin

a. along fin rays with very few, if any, melanophores on membrane between rays (Fig. 20) 255
b. abundant both along and between rays (Figs. 21, 63, 91) 165

165 (164). Pigment in dorsal fin

a. along fin rays with very few, if any, melanophores on membrane between rays (Figs. 20, 62) 255
b. abundant both along and between rays (Figs. 21, 63, 91) 209

166 (102). Mid-lateral surface of body with

a. no large, distinct spots (Figs. 21, 63) . . 167
b. 2 large, distinct spots, one between head and dorsal fin and the other over the pelvic fin . . . . *C. ardens*

167 (160,166). Pigment over ventral to ventro-lateral surfaces of gill covers (opercula)

a. absent (Fig. 63) 168
b. present but not in distinct oblique rows (Fig. 21) . . . . *C. ardens*

168 (167). Pigmentation on lateral surfaces of body above bottom-of-eye level and anterior to vent, exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,

a. scattered fully and evenly down to the horizontal myoseptum with few if any melanophores below the myoseptum (Fig. 62) . . . . *C. latipinnis*
b. scattered evenly or in blotchy pattern (continuous with dorsal and dorso-lateral surface pattern) down to horizontal myoseptum and at least partially to bottom-of-eye level below (Figs. 20, 21, 63) 169

169 (168). Pigmentation on lateral to ventro-lateral surfaces of body below bottom-of-eye level, exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,

a. absent including caudal peduncle (Fig. 62) . . . . *C. latipinnis*
b. absent except on caudal peduncle (Figs. 21, 63) 255
c. present anterior to caudal peduncle (Fig. 35) . . . . *C. ardens*

170 (100,111). Mid-lateral surface of body with

a. no large, distinct spots (Figs. 21, 91) . . 171
b. 2 large, distinct spots, one between head and dorsal fin and the other over the pelvic fin . . . . *C. ardens*

171 (170). Ventral midline from shortly behind heart region to near vent with

a. 7-20 melanophores . . . . *C. ardens*
b. ≤6 melanophores (Figs. 20, 21, 90, 91) 172

172 (161,171). Pigmentation on lateral surfaces of body above bottom-of-eye level and anterior to vent, exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,

a. scattered partially or fully and evenly down to the horizontal myoseptum with few if any melanophores below the myoseptum (Fig. 62) . . . . *X. texanus*
b. scattered evenly or in blotchy pattern (continuous with dorsal and dorso-lateral surface pattern) down to horizontal myoseptum and at least partially to bottom-of-eye level below (Figs. 20, 21, 91) 173

173 (172). Pigmentation on lateral to ventro-lateral surfaces of body below bottom-of-eye level, exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,

a. absent including caudal peduncle (Fig. 91) . . . . *X. texanus*
b. present, at least on caudal peduncle (Figs. 20, 21) 174

174 (163,173). Pigment in caudal fin

a. along fin rays with very few, if any, melanophores on membrane between rays (Fig. 20) . . . . *C. ardens*

b. abundant both along and between rays (Figs. 21, 91) 175

175 (174). Pigment in dorsal fin

a. along fin rays with very few, if any, melanophores on membrane between rays (Fig. 20) . . . . *C. ardens*

b. abundant both along and between rays (Figs. 21, 91) 220

176 (105,115). Ventral midline from shortly behind heart region to near vent with

a. 7-20 melanophores . . . . *C. latipinnis*

b. ≤6 melanophores (Figs. 63, 91) 177

177 (176). Pigment over ventral to ventro-lateral surfaces of gill covers (opercula)

a. absent (Figs. 63, 91) 178

b. present but not in distinct oblique rows . . . . *X. texanus*

178 (177). Pigmentation on lateral surfaces of body above bottom-of-eye level and anterior to vent, exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,

a. scattered only partially down to the horizontal myoseptum (lateral midline) (Fig. 90) . . . . *X. texanus*

b. scattered evenly or in blotchy pattern (continuous with dorsal and dorso-lateral surface pattern) down to horizontal myoseptum and sometimes at least partially to bottom- of-eye level below (Figs. 63, 91) 179

179 (162,178). Pigmentation on lateral to ventro-lateral surfaces of body below bottom-of-eye level, exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,

a. absent anterior to caudal peduncle (Figs. 62, 62, 91) 180

b. present anterior to caudal peduncle . . . . *X. texanus*

180 (163,179). Pigment in caudal fin

a. along fin rays with very few, if any, melanophores on membrane between rays . . . . *C. latipinnis*

b. abundant both along and between rays (Figs. 63, 90, 91) 181

181 (180). Pigment in dorsal fin

a. along fin rays with very few, if any, melanophores on membrane between rays (Fig. 62) . . . . *C. latipinnis*

b. abundant both along and between rays (Figs. 63, 90, 91) 210

182 (39,117). Ventral midline from shortly behind heart region to near vent with

a. ≥21 melanophores in a continuous or discontinuous line or narrow band (Fig. 75) . . . . *C. platyrhynchus*

b. ≤20 melanophores (Figs. 48, 49, 76, 77) 183

183 (182). Pigment over ventral to ventro-lateral surfaces of gill covers (opercula)

a. absent (Figs. 48, 49, 76) 184

b. present but not in distinct oblique rows (Fig. 77) . . . . *C. platyrhynchus*

184 (183). Pigmentation on lateral surfaces of body above bottom-of-eye level and anterior to vent, exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,

a. scattered fully and evenly down to the horizontal myoseptum with few if any melanophores below the myoseptum . . . . *C. platyrhynchus*

b. scattered evenly or in blotchy pattern (continuous with dorsal and dorso-lateral surface pattern) down to horizontal myoseptum and at least partially to bottom-of-eye level below (Figs. 48, 49, 76, 77) 185

185 (184). Pigmentation on lateral to ventro-lateral surfaces of body below bottom-of-eye level, exclusive of melanophores associated with horizontal myosepta, air bladder, visceral cavity (peritoneum), or gut,

a. absent anterior to caudal peduncle (Figs. 48, 49, 76) 186

b. present anterior to caudal peduncle (Fig. 77) . . . . *C. platyrhynchus*

186 (185). Pigment in dorsal fin

a. along fin rays with very few, if any, melanophores on membrane between rays (Figs. 48, 77) 256

b. abundant both along and between rays . . . . *C. platyrhynchus*

187 (124). Longitudinal eye diameter

a. 19-20% of head length . . . . . . *C. latipinnis*

b. 21% of head length 211

c. 22-26% of head length 189

d. 27-28% of head length 199

e. 29-30% of head length 221

f. 31-32% of head length . . . . *C. ardens*

188 (148). Longitudinal eye diameter

a. 19-20% of head length . . . . . . *C. latipinnis*

b. 21% of head length 211

c. 22-26% of head length 189

d. 27-28% of head length 230

e. 29-30% of head length . . . . *X. texanus*

189 (187,188). Length of base of dorsal fin (origin to insertion of dorsal fin)
- a. 13% SL . . . . *C. commersoni*
- b. 14-15% SL 240
- c. 16% SL 190
- d. 17-18% SL 212
- e. 19-20% SL . . . . *X. texanus*

190 (189). Dorsal fin length
- a. 18-22% SL . . . . *C. commersoni*
- b. 23-24% SL 191
- c. 25-26% SL 213
- d. 27-29% SL . . . . *X. texanus*

191 (190). Caudal fin length (total length minus standard length)
- a. 19-20% SL . . . . *C. commersoni*
- b. 21-22% SL 242
- c. 23-24% SL 192
- d. 25% SL 214
- e. 26-28% SL . . . . *X. texanus*

192 (191). Depth at origin of dorsal fin
- a. 17% SL 242
- b. 18-22% SL 193
- c. 23-27% SL . . . . *X. texanus*

193 (192). Length from anterior margin of snout to insertion of dorsal fin
- a. 61-64% SL 243
- b. 65-66% SL 194
- c. 67-68% SL 235
- d. 69-70% SL . . . . *X. texanus*

194 (193). Length from anterior margin of snout to origin of dorsal fin
- a. 46-47% SL 217
- b. 48-49% SL 195
- c. 51-52% SL 236
- d. 53% SL . . . . *C. commersoni*

195 (194). Length from anterior margin of snout to origin of pelvic fin
- a. 52-53% SL 245
- b. 54-57% SL 196
- c. 58-60% SL 236

196 (195). Length from anterior margin of snout to posterior margin of the vent
- a. 72-74% SL 246
- b. 75-76% SL 197
- c. 77-78% SL 237
- d. 79-80% SL . . . . *X. texanus*

197 (196). Length from anterior margin of snout to origin of pectoral fin
- a. 24% SL . . . . *C. commersoni*, *C. latipinnis*
- b. 25-28% SL . . . . *C. commersoni*, *C. latipinnis*, *X. texanus*
- c. 29% SL . . . . *C. commersoni*, *X. texanus*
- d. 30-31% SL . . . . *X. texanus*

198 (136). Longitudinal eye diameter
- a. 21% of head length . . . . *X. texanus*
- b. 22-26% of head length 230
- c. 27-28% of head length 199
- d. 29-30% of head length 221
- e. 31-32% of head length . . . . *C. ardens*

199 (187,198). Length of base of dorsal fin (origin to insertion of dorsal fin)
- a. 13% SL . . . . *C. commersoni*
- b. 14-15% SL 249
- c. 16% SL 200
- d. 17% SL 222
- e. 18-20% SL . . . . *X. texanus*

200 (199). Dorsal fin length
- a. 18-20% SL . . . . *C. commersoni*
- b. 21-22% SL 250
- c. 23-24% SL 201
- d. 25-26% SL 223
- e. 27-29% SL . . . . *X. texanus*

201 (200). Caudal fin length (total length minus standard length)
- a. 19-22% SL . . . . *C. commersoni*
- b. 23-24% SL 202
- c. 25-28% SL 224

202 (201). Depth at origin of dorsal fin
- a. 16% SL . . . . *C. ardens*
- b. 17% SL 252
- c. 18-22% SL 203
- d. 23-27% SL . . . . *X. texanus*

203 (202). Length from anterior margin of snout to insertion of dorsal fin
- a. 61-63% SL . . . . *C. commersoni*
- b. 64% SL 253
- c. 65-66% SL 204
- d. 67-68% SL 235
- e. 69-70% SL . . . . *X. texanus*

204 (203). Length from anterior margin of snout to origin of dorsal fin
- a. 46-47% SL . . . . *X. texanus*
- b. 48-51% SL 205
- c. 52% SL 236
- d. 53% SL . . . . *C. commersoni*

205 (204). Length from anterior margin of snout to origin of pelvic fin
- a. 52-53% SL . . . . *C. commersoni*
- b. 54-58% SL 206
- c. 59-60% SL. 236

206 (205). Length from anterior margin of snout to posterior margin of vent
- a. 72-74% SL 254
- b. 75-76% SL 207
- c. 77-78% SL 237
- d. 79-80% SL . . . . *X. texanus*

207 (206). Length from anterior margin of snout to origin of pectoral fin

a. 24% SL . . . . *C. commersoni*
b. 25-28% SL . . . . *C. ardens*
C. commersoni
X. texanus
c. 29% SL . . . . *C. commersoni*
X. texanus
d. 30-31% SL . . . . *X. texanus*

208 (123,124,129). Longitudinal eye diameter
a. 19-21% of head length . . . . . . *C. latipinnis*
b. 22-26% of head length 239
c. 27-28% of head length 248
d. 29-32% of head length . . . . *C. ardens*

209 (165). Longitudinal eye diameter
a. 19-20% of head length . . . . . . *C. latipinnis*
b. 21-26% of head length 211
c. 27-30% of head length 221
d. 31-32% of head length . . . . *C. ardens*

210 (181). Longitudinal eye diameter
a. 19-20% of head length . . . . . . *C. latipinnis*
b. 21-26% of head length 211
c. 27-30% of head length . . . . *X. texanus*

211 (187,188,209,210). Length of base of dorsal fin (origin to insertion of dorsal fin)
a. 14-15% SL . . . . *C. latipinnis*
b. 16-18% SL 212
c. 19-20% SL . . . . *X. texanus*

212 (189,211). Dorsal fin length
a. 23-26% SL 213
b. 27-29% SL . . . . *X. texanus*

213 (190,212). Caudal fin length (total length minus standard length)
a. 21-22% SL . . . . *C. latipinnis*
b. 23-25% SL 214
c. 26-28% SL . . . . *X. texanus*

214 (191,213). Depth at origin of dorsal fin
a. 17% SL . . . . *C. latipinnis*
b. 18-22% SL 215
c. 23-27% SL . . . . *X. texanus*

215 (214). Length from anterior margin of snout to insertion of dorsal fin
a. 61-64% SL . . . . *C. latipinnis*
b. 65-66% SL 216
c. 67-70% SL . . . . *X. texanus*

216 (215). Length from anterior margin of snout to origin of dorsal fin
a. 46-49% SL 217
b. 50-52% SL . . . . *X. texanus*

217 (194,216). Length from anterior margin of snout to origin of pelvic fin
a. 52-53% SL . . . . *C. latipinnis*
b. 54-57% SL 218
c. 58-60% SL . . . . *X. texanus*

218 (217). Length from anterior margin of snout to origin of pectoral fin
a. 24% SL . . . . *C. latipinnis*
b. 25-28% SL 219
c. 29-31% SL . . . . *X. texanus*

219 (218). Length from anterior margin of snout to posterior margin of vent
a. 72-74% SL . . . . *C. latipinnis*
b. 75-76% SL . . . . *C. latipinnis*
X. texanus
c. 77-80% SL . . . . *X. texanus*

220 (175). Longitudinal eye diameter
a. 21-26% of head length . . . . *X. texanus*
b. 27-30% of head length 221
c. 31-32% of head length . . . . *C. ardens*

221 (187,198,209,220). Length of base of dorsal fin (origin to insertion of dorsal fin)
a. 14-15% SL . . . . *C. ardens*
b. 16-17% SL 222
c. 18-20% SL . . . . *X. texanus*

222 (199,221). Dorsal fin length
a. 19-22% SL . . . . *C. ardens*
b. 23-26% SL 223
c. 27-29% SL . . . . *X. texanus*

223 (200,222). Depth at origin of dorsal fin
a. 16-17% SL . . . . *C. ardens*
b. 18-22% SL 224
c. 23-27% SL . . . . *X. texanus*

224 (201,223). Length from anterior margin of snout to insertion of dorsal fin
a. 64% SL . . . . *C. ardens*
b. 65-66% SL 225
c. 67-70% SL . . . . *X. texanus*

225 (224). Length from anterior margin of snout to origin of dorsal fin
a. 46-47% SL . . . . *X. texanus*
b. 48-52% SL 226

226 (225). Length from anterior margin of snout to posterior margin of vent
a. 73-74% SL . . . . *C. ardens*
b. 75-76% SL 227
c. 77-80% SL . . . . *X. texanus*

227 (226). Length from anterior margin of snout to origin of pelvic fin
a. 54-58% SL 228
b. 59-60% SL . . . . *X. texanus*

228 (227). Length from anterior margin of snout to origin of pectoral fin
a. 25-28% SL . . . . *C. ardens*
X. texanus
b. 29-31% SL . . . . *X. texanus*

229 (158). Longitudinal eye diameter
a. 21% of head length . . . . *X. texanus*

b. 22-28% of head length 230
c. 29-30% of head length . . . . *X. texanus*

230 (188,198,229). Length of base of dorsal fin (origin to insertion of dorsal fin)
a. 13-15% SL . . . . *C. commersoni*
b. 16% SL 231
c. 17-20% SL . . . . *X. texanus*

231 (230). Dorsal fin length
a. 18-22% SL . . . . *C. commersoni*
b. 23-24% SL 232
c. 25-29% SL . . . . *X. texanus*

232 (231). Caudal fin length (total length minus standard length)
a. 19-22% SL . . . . *C. commersoni*
b. 23-24% SL 233
c. 25-28% SL . . . . *X. texanus*

233 (232). Depth at origin of dorsal fin
a. 17% SL . . . . *C. commersoni*
b. 18-22% SL 234
c. 23-27% SL . . . . *X. texanus*

234 (233). Length from anterior margin of snout to insertion of dorsal fin
a. 61-64% SL . . . . *C. commersoni*
b. 65-68% SL 235
c. 69-70% SL . . . . *X. texanus*

235 (193,203,234). Length from anterior margin of snout to origin of dorsal fin
a. 46-47% SL . . . . *X. texanus*
b. 48-52% SL 236
c. 53% SL . . . . *C. commersoni*

236 (194,195,204,205,235). Length from anterior margin of snout to posterior margin of vent
a. 72-74% SL . . . . *C. commersoni*
b. 75-78% SL 237
c. 79-80% SL . . . . *X. texanus*

237 (196,206,236). Length from anterior margin of snout to origin of pectoral fin
a. 24% SL . . . . *C. commersoni*
b. 25-29% SL . . . . *C. commersoni*
X. texanus
c. 30-31% SL . . . . *X. texanus*

238 (129,147,148,152). Longitudinal eye diameter
a. 19-21% of head length . . . . . . *C. latipinnis*
b. 22-26% of head length 239
c. 27-28% of head length . . . . *C. commersoni*

239 (208,238). Length of base of dorsal fin (origin to insertion of dorsal fin)
a. 13% SL . . . . *C. commersoni*
b. 14-16% SL 240
c. 17-18% SL . . . . *C. latipinnis*

240 (189,239). Dorsal fin length
a. 18-22% SL . . . . *C. commersoni*
b. 23-24% SL 241
c. 25-26% SL . . . . *C. latipinnis*

241 (240). Caudal fin length (total length minus standard length)
a. 19-20% SL . . . . *C. commersoni*
b. 21-24% SL 242
c. 25% SL . . . . *C. latipinnis*

242 (191,192,241). Length from anterior margin of snout to insertion of dorsal fin
a. 61-66% SL 243
b. 67-68% SL . . . . *C. commersoni*

243 (193,242). Length from anterior margin of snout to origin of dorsal fin
a. 46-47% SL . . . . *C. latipinnis*
b. 48-49% SL 244
c. 50-53% SL . . . . *C. commersoni*

244 (243). Length from anterior margin of snout to origin of pelvic fin
a. 52-57% SL 245
b. 58-59% SL . . . . *C. commersoni*

245 (195,244). Length from anterior margin of snout to posterior margin of vent
a. 72-76% SL 246
b. 77-78% SL . . . . *C. commersoni*

246 (196,245). Length from anterior margin of snout to origin of pectoral fin
a. 24-28% SL . . . . *C. commersoni*
C. latipinnis
b. 29% SL . . . . *C. commersoni*

247 (129,135,136,141). Longitudinal eye diameter
a. 22-26% of head length . . . . *C. commersoni*
b. 27-28% of head length 248
c. 29-32% of head length . . . . *C. ardens*

248 (208,247). Length of base of dorsal fin (origin to insertion of dorsal fin)
a. 13% SL . . . . *C. commersoni*
b. 14-16% SL 249
c. 17% SL . . . . *C. ardens*

249 (199,248). Dorsal fin length
a. 18% SL . . . . *C. commersoni*
b. 19-24% SL 250
c. 25-26% SL . . . . *C. ardens*

250 (200,249). Caudal fin length (total length minus standard length)
a. 19-22% SL . . . . *C. commersoni*
b. 23-24% SL 251
c. 25-28% SL . . . . *C. ardens*

251 (250). Depth at origin of dorsal fin
a. 16% SL . . . . *C. ardens*
b. 17-22% SL 252

252 (202,251). Length from anterior margin of snout to insertion of dorsal fin

a. 61-63% SL . . . . *C. commersoni*
b. 64-66% SL 253
c. 67-68% SL . . . . *C. commersoni*

253 (203,252). Length from anterior margin of snout to origin of dorsal fin
a. 48-51% SL 254
b. 52-53% SL . . . . *C. commersoni*

254 (206,253). Length from anterior margin of snout to origin of pectoral fin
a. 24-28% SL . . . . *C. ardens*
C. commersoni
b. 29% SL . . . . *C. commersoni*

255 (164,165,169). Longitudinal eye diameter
a. 19-26% of head length . . . . . . *C. latipinnis*
b. 27-32% of head length . . . . *C. ardens*

256 (186). Longitudinal eye diameter
a. 21-25% of head length 257
b. 26-28% of head length . . . . . *C. discobolus*

257 (256). Length of base of dorsal fin (origin to insertion of dorsal fin)
a. 11-14% SL 258
b. 15-16% SL . . . . *C. discobolus*

258 (257). Dorsal fin length
a. 18% SL . . . . *C. platyrhynchus*
b. 19-21% SL 259
c. 22-23% SL . . . . *C. discobolus*

259 (258). Caudal fin length (total length minus standard length)
a. 19% SL . . . . *C. platyrhynchus*
b. 20-23% SL 260
c. 24% SL . . . . *C. discobolus*

260 (259). Depth at origin of dorsal fin
a. 16-17% SL . . . . *C. discobolus*
b. 18-21% SL 261

261 (260). Length from anterior margin of snout to insertion of dorsal fin
a. 60-61% SL . . . . *C. platyrhynchus*
b. 62-64% SL 262
c. 65-66% SL . . . . *C. discobolus*

262 (261). Length from anterior margin of snout to origin of dorsal fin
a. 47-52% SL 263
b. 53-54% SL . . . . *C. discobolus*

263 (262). Length from anterior margin of snout to posterior margin of vent
a. 72-73% SL . . . . *C. discobolus*
b. 74-76% SL . . . . *C. discobolus*
C. platyrhynchus
c. 77-78% SL . . . . *C. platyrhynchus*

Skeletal Character Key for Juveniles ≤40 mm SL that have been cleared and preferably stained for bone (Fig. 6).

1. Standard length group (Fig. 4)
a. ≤21 mm 2
b. 22-25 mm 4
c. 26-34 mm 5
d. ≥35 mm 9

2 (1). First (most anterior) interneural bone (Fig. 8)
a. large and angular or anvil-shaped with a prominent posterior-directed projection or beak; anterior ends of mandibles (from ventral view of head) well anterior, at least mid-distance between posterior and anterior ends of maxillae; anterior-dorsal maxillary projections small and rounded to reduced and almost absent 3
b. small and blocky, sometimes with a small posterior- directed projection or beak; anterior ends of mandibles (from ventral view of head) well posterior, much closer to posterior than anterior ends of maxillae; anterior-dorsal maxillary projections prominent and pointed 11

3 (2). Number of vertebrae (including 4 for Weberian complex)
a. 44-46 . . . . *C. commersoni*
b. 47-48 . . . . *C. ardens*
C. commersoni

4 (1). Frontoparietal fontanelle (Fig. 7)
a. narrow, ≤30% of fontanelle length 11
b. moderately wide, 31-40% of fontanelle length 6
c. wide, 41-47% of fontanelle length 8
d. very wide, ≥48% of fontanelle length (often over 60% and somewhat oval in shape) . . . . *X. texanus*

5 (1). Frontoparietal fontanelle (Fig. 7)
a. very narrow, ≤24% of fontanelle length . . . . *C. platyrhynchus*
b. narrow, 24-28% of fontanelle length . . . 11
c. moderately wide, 29-40% of fontanelle length 6
d. wide, 41-47% of fontanelle length 7
e. very wide, ≥48% of fontanelle length (usually somewhat oval in shape) *X. texanus*

6 (4,5). First (most anterior) interneural bone (Fig. 8)

a. large and angular or anvil-shaped with a prominent posterior-directed projection or beak; anterior ends of mandibles (from ventral view of head) well anterior, at least mid-distance between posterior and anterior ends of maxillae; anterior-dorsal maxillary projections small and rounded to reduced and almost absent 8
b. small and blocky, sometimes with a small posterior-directed projection or beak; anterior ends of mandibles (from ventral view of head) well posterior, much closer to posterior than anterior ends of maxillae; anterior-dorsal maxillary projections prominent and pointed 11

7 (5). First (most anterior) interneural bone (Fig. 8)
a. large and fan-shaped across top *X. texanus*
b. large and angular or anvil-shaped with a prominent posterior-directed projection or beak 8

8 (4,6,7). Number of vertebrae (including 4 for Weberian complex)
a. 44-46 . . . . *C. commersoni*
b. 47-48 . . . . *C. ardens*
C. commersoni
C. latipinnis
c. 49-50 . . . . *C. latipinnis*

9 (1). Frontoparietal fontanelle (Fig. 7)
a. very narrow ≤24% of fontanelle length . . . . *C. platyrhynchus*
b. narrow, 25-28% of fontanelle length . . . 10
c. moderately wide, 29-35% of fontanelle length 12
d. wide, 36-45% of fontanelle length 14
e. very wide, ≥45% of fontanelle length (often over 60% and somewhat oval in shape) . . . . *X. texanus*

10 (9). First (most anterior) interneural bone (Fig. 8)
a. large and angular or anvil-shaped with a prominent posterior-directed projection or beak; anterior ends of mandibles (from ventral view of head) well anterior, at least mid-distance between posterior and anterior ends of maxillae; anterior-dorsal maxillary projections small and rounded to reduced and almost absent . . . . *C. commersoni*
b. small and blocky, sometimes with a small posterior-directed projection or beak; anterior ends of mandibles (from ventral view of head) well posterior, much closer to posterior than anterior ends of maxillae; anterior-dorsal maxillary projections prominent and pointed 11

11 (2,4,5,6,10). Number of vertebrae (including 4 for Weberian complex)
a. 42-44 . . . . *C. platyrhynchus*
b. 45-50 . . . . *C. discobolus*
C. platyrhynchus

12 (9). First (most anterior) interneural bone (Fig. 8)
a. large and angular or anvil-shaped with a prominent posterior-directed projection or beak; anterior ends of mandibles (from ventral view of head) well anterior, at least mid-distance between posterior and anterior ends of maxillae; anterior-dorsal maxillary projections small and rounded to reduced and almost absent 13
b. small and blocky, sometimes with a small posterior-directed projection or beak; anterior ends of mandibles (from ventral view of head) well posterior, much closer to posterior than anterior ends of maxillae; anterior-dorsal maxillary projections prominent and pointed . . . . *C. discobolus*

13 (12). Number of vertebrae (including 4 for Weberian complex)
a. 44-46 . . . . *C. commersoni*
b. 47-48 . . . . *C. commersoni*
C. latipinnis
c. 49-50 . . . . *C. latipinnis*

14 (9). First (most anterior) interneural bone (Fig. 8)
a. large and fan-shaped across top *X. texanus*
b. large and angular or anvil-shaped with a prominent posterior-directed projection or beak . . . . *C. ardens*

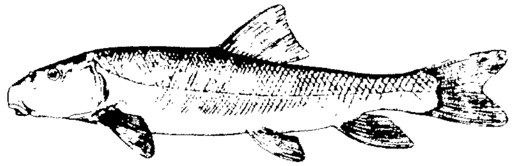

Fig. 12. *Catostomus ardens* adult (from Miller 1952).

Adult Diagnosis: Back without conspicuous predorsal keel. Caudal peduncle deep, about 8-10% of body length. Mouth inferior but well forward. Lips relatively small with papillae, without notches at outer corners; lower lip with deep medial cleft, lobes usually adjacent and not reaching a perpendicular from nostrils. No prominent cartilaginous ridge on anterior margin of lower jaw. Nodules of gill rakers slightly to unbranched. Scales relatively large. Dorsal fin membranes well pigmented. Fontanelle wide. Total length usually 25-35 cm, up to 65 cm. (Also, Table 8.)

Reproduction: Non-guarding, open-substrate lithophil. Spring, usually late May to mid June, ≥18°C. Tributary streams, inlets, or rocky shoals near shore of lakes; sometimes over sand or gravel in water <60 cm deep. Observed in spawning aggregations of 400-500. Water-hardened eggs 2.9-3.2 mm diameter, demersal, initially adhesive.

Young: Hatch in 8-9 days at 17°C. Swim-up 7-8 days after hatching. Young mostly in spawning streams or near shore in shallow water. Observed to graze on filamentous algae or algae on fixed objects.

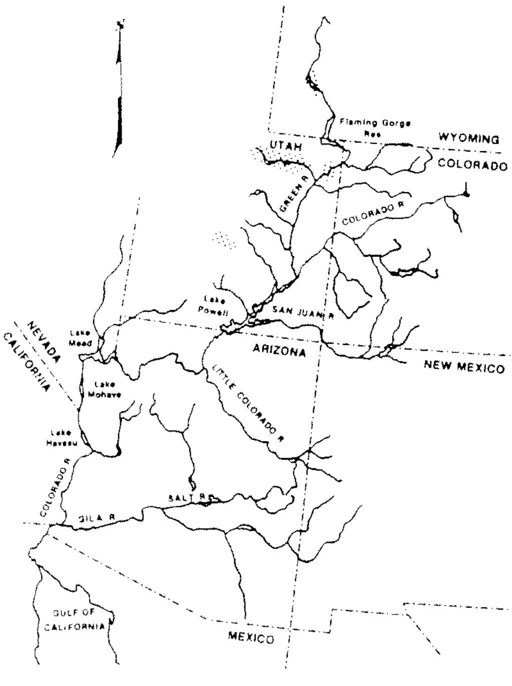

Fig. 13. Regional distribution of *Catostomus ardens*.

Table 8. Selected juvenile and adult meristics for *Catostomus ardens*. P = principal rays; R = rudimentary rays; D = dorsal; V = ventral. Scales are lateral series or line when complete. Four added to vertebral count for Weberian complex. Gill rakers for exterior row of first arch, specimens >70 mm SL. Mean or modal values underlined if known and noteworthy; rare or questionable extremes in parentheses.

Character	Original	Literature	Character	Original	Literature
Dorsal Fin Rays - P:	(10)11-12-13(14)	11-13	Dorsal Fin Rays - R:	2-5	
Anal Fin Rays - P:	7-8	7	Anal Fin Rays - R:	2-4	
Caudal Fin Rays - P:	(17)18		Caudal Fin Rays - RD:	(8)9-10-11	
Pectoral Fin Rays:	(14)15-17		Caudal Fin Rays - RV:	(6)7-8-9	
Pelvic Fin Rays:	10		Lateral Scales:	(57-)62-68	54-60-70(-79)
Vertebrae:	47-48		Gill Rakers:		28-31-34

Table 9. Size at apparent onset of selected developmental events for *Catostomus ardens*, as observed under low power magnification. P = principal rays; R = rudimentary rays; Scales are lateral series. Rare or questionable extremes in parentheses.

Event or Structure	Onset or Formation mm SL	Onset or Formation mm TL	Fin Rays or Scales	First Formed mm SL	First Formed mm TL	Last Formed mm SL	Last Formed mm TL
Hatched:	(7)8-11	(7)8-11	Dorsal - P:	13-15	14-16	14-16	17-19
Eyes Pigmented:	9-10 or *	9-10 or *	Anal - P:	14-15	16-18	15-17	17-19
Yolk Assimilated:	12-13	12-14	Caudal - P:	12-13	12-14	13-14	14-15
Finfold Absorbed:	19	23	Caudal - R:	14-15	15-17	19-20	23
Pectoral Fin Buds:	(7) or *	(7) or *	Pectoral:	14-15	16-18	15-18	17-22
Pelvic Fin Buds:	13-15	14-16	Pelvic:	14-17	17-19	18-19	(19-)22
	* before hatching		Scales:	21-23	26-28	24-28	29-35

References: Andreasen and Barnes 1975, Baxter and Simon 1970, Jordan and Gilbert 1881, Jordan and Evermann 1896, La Rivers 1962, Lee et al. 1980, McConnell et al. 1957, Miller 1952, Miller and Smith 1981, Minckley 1973, Modde (T. C., pers. commun.), Sigler and Miller 1963, Sigler and Sigler 1987, Simon 1946, Simpson and Wallace 1978, Tyus et al. 1982.

Table 10. Size at developmental interval (left) and gut phase (right) transitions for *Catostomus ardens*. See Fig. 5 for phases of gut folding. Rare or questionable extremes in parentheses.

Transition to	mm SL	mm TL	Transition to	mm SL	mm TL
Flexion Mesolarva:	12-13	12-14	2 - 90° bend:	14-17	17-19
Postflexion Mesolarva:	13-14	14-15	3 - Full loop:	18-19	(19-)22-24
Metalarva:	15-17	17-19(20)	4 - Partial crossover:	20-22	26-27
Juvenile:	19-20	23	5 - Full cross over:	27-28	34-35

Table 11. Summary of morphometrics and myomere counts by developmental phase for *Catostomus ardens*. See Fig. 4 for abbreviations and methods of measurement and counting. Protolarvae with unpigmented eyes excluded.

	Protolarvae (N=10)				Flexion Mesolarvae (N=5)				Postflexion Mesolarvae (N=12)				Metalarvae (N=12)				Juveniles (N=12)			
	$\bar{x}$±SD		Range		$\bar{x}$±SD		Range		$\bar{x}$±SD		Range		$\bar{x}$±SD		Range		$\bar{x}$±SD		Range	
SL, mm:	11	1	9	13	13	1	12	14	15	1	13	17	17	1	15	19	25	4	19	36
TL, mm:	11	1	9	14	13	1	12	15	16	2	14	19	21	2	17	23	32	6	24	45
Lengths %SL:																				
AS to AE	2	0	2	3	2	1	1	4	4	1	3	5	6	1	4	8	7	1	6	8
PE	8	1	7	9	8	1	7	10	11	1	10	12	14	1	12	16	15	1	14	16
OP1	15	1	12	17	17	2	15	19	20	1	19	23	26	1	23	27	26	1	25	28
OP2									52	1[b]	50	53	56	1	53	57	56	1	55	58
PY	75	2	72	78	70	2[a]	69	72												
OPAF	41	19	22	67	25	1	22	26	28	2	25	31	41	7[c]	30	51				
ODF	33	2	29	36	35	2	31	36	39	1	37	41	44	3[a]	42	47				
OD									49	1[c]	47	50	50	1	49	52	49	1	48	51
ID									62	1[d]	60	63	65	1	64	67	65	1	64	66
PV	78	1	76	80	76	1	75	77	79	1	76	80	77	1	76	78	75	1	73	76
OA									79	[e]	79	79	77	1	76	78	76	1	74	78
IA									84	[e]	84	84	84	1	84	86	83	1	82	85
AFC									109	1	107	110	112	1[c]	111	114	116	1	114	118
PC	103	1	102	104	105	1	104	106	112	3	109	117	120	2	118	122	125	1	123	128
Y	57	5	49	64	16	22	0	43												
P1	5	3	1	8	10	1	8	11	11	1	9	13	14	2	12	17	20	2	15	22
P2									2	3	0	6	11	1	8	12	14	1	12	16
D									15	1[d]	14	16	19	1	18	20	24	2	21	26
A									7	[e]	7	7	10	1	9	12	15	2	12	18
Depths %SL:																				
at BPE	9	1	7	10	10	1	9	12	13	1	11	15	16	1	15	18	18	0	17	18
OP1	10	1	9	13	10	1	9	12	14	1	12	17	18	1	16	20	20	1	18	21
OD	11	1	10	12	9	1	8	9	12	2	9	15	17	1	16	20	20	1	16	22
BPV	5	1	4	6	5	0	5	6	7	1	6	9	10	1	9	12	12	1	10	14
AMPM	3	0	2	3	3	0	3	4	5	1	4	6	7	0	6	8	8	0	7	8
Max. Yolk	7	2	3	11	0	1	0	2												
Widths %SL:																				
at BPE	8	1	6	10	9	1	9	10	12	1	10	13	15	1	14	16	16	1	15	16
OP1	6	1	4	8	7	1	6	9	10	1	9	11	13	1	11	15	16	1	14	17
OD	7	1	5	9	5	0	5	6	7	1	5	10	12	1	9	13	15	1	12	17
BPV	3	0	3	4	3	0	3	4	5	1	4	6	6	1	5	7	8	1	6	10
AMPM	2	0	2	2	2	0	2	2	3	0	2	3	3	0	3	4	4	0	3	5
Max. Yolk	8	3	5	14	1	1	0	2												
Myomeres:																				
to PY	35	1	34	36	33	1[a]	32	33												
OPAF	15	11	4	32	6	0	6	7	6	1	5	7	12	4[c]	6	17				
OP2									21	1[b]	19	22	21	1	20	22	22	0[d]	21	22
ODF	12	1	10	13	12	0	11	12	13	1	12	14	15	2[a]	13	16				
OD									18	1[c]	17	19	17	1	16	18	17	1[d]	16	18
PV	37	1	36	38	36	1	36	37	37	1	35	38	36	1	34	37	35	1[d]	35	36
Total	46	1	45	47	46	1	45	47	46	1	45	48	45	1	43	47	46	1[d]	45	47

[a]N = 2; [b]N = 10; [c]N = 11; [d]N = 5; [e]N = 1.

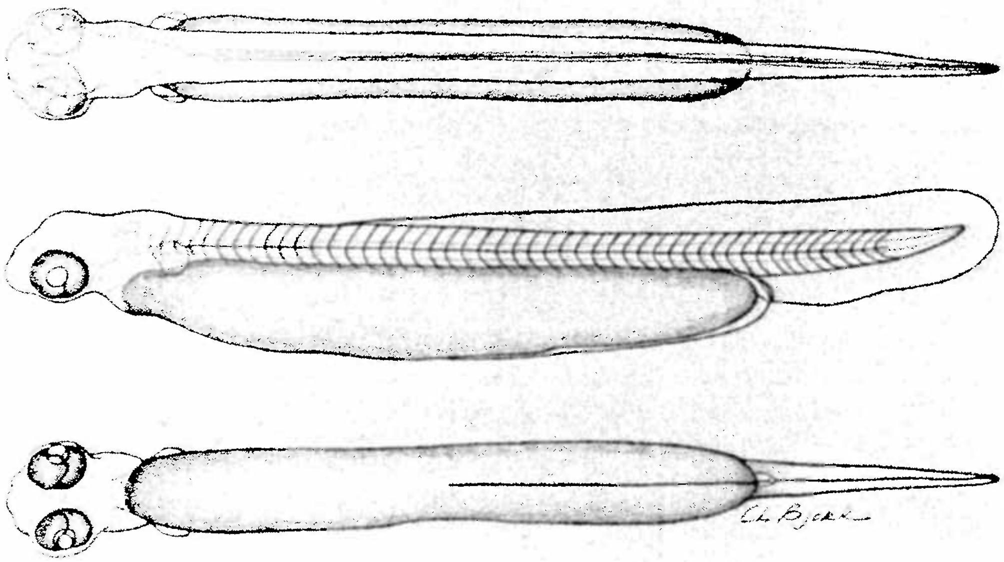

Fig. 14. *Catostomus ardens* protolarva, recently hatched, 10.5 mm SL, 10.8 mm TL. Cultured in 1987 with stock from Bear Lake, Utah.

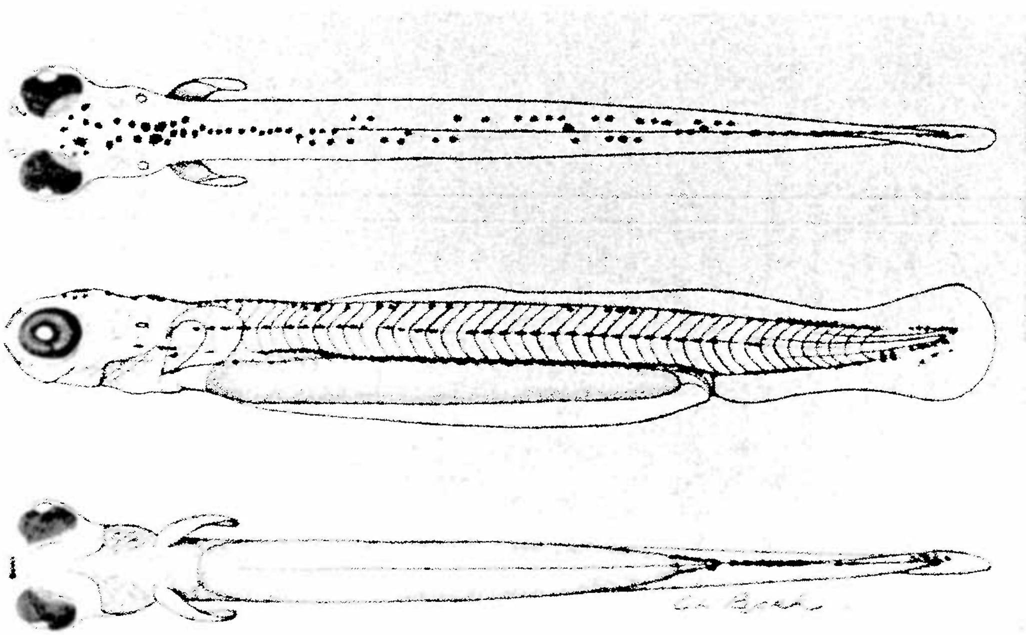

Fig. 15. *Catostomus ardens* protolarva, 11.4 mm SL, 11.9 mm TL. Cultured in 1987 with stock from Bear Lake, Utah.

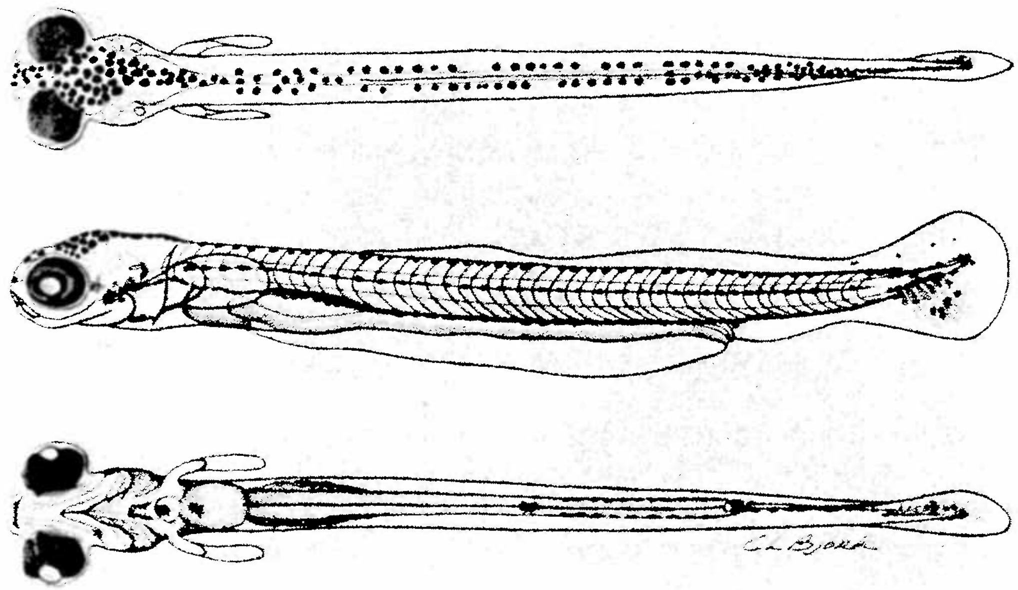

Fig. 16. *Catostomus ardens* flexion mesolarva, recently transformed, 12.2 mm SL, 12.8 mm TL. Cultured in 1987 with stock from Bear Lake, Utah.

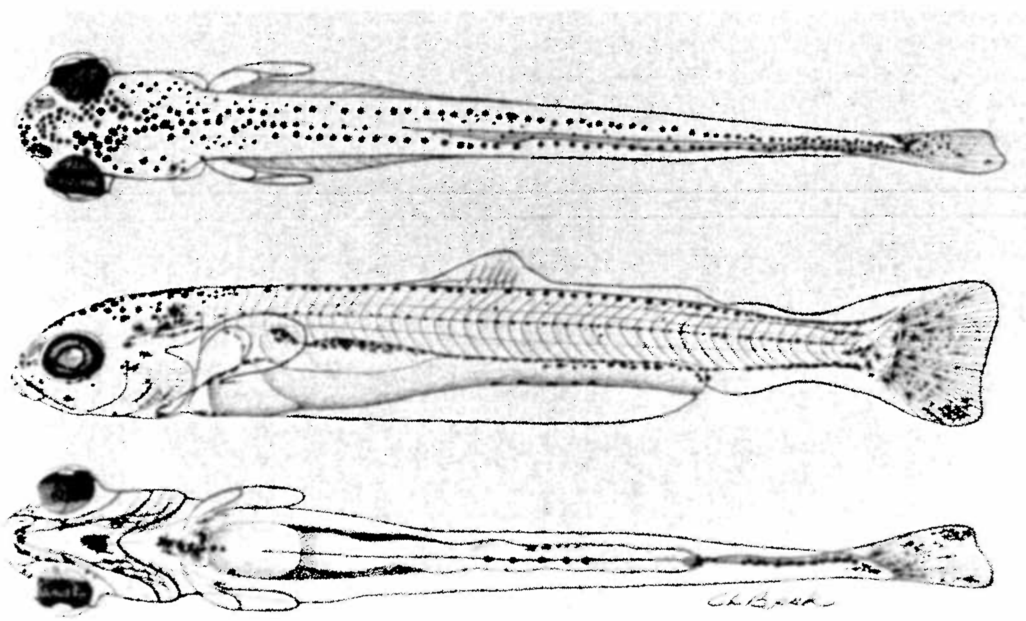

Fig. 17. *Catostomus ardens* postflexion mesolarva, 14.2 mm SL, 15.7 mm TL. Cultured in 1987 with stock from Bear Lake, Utah.

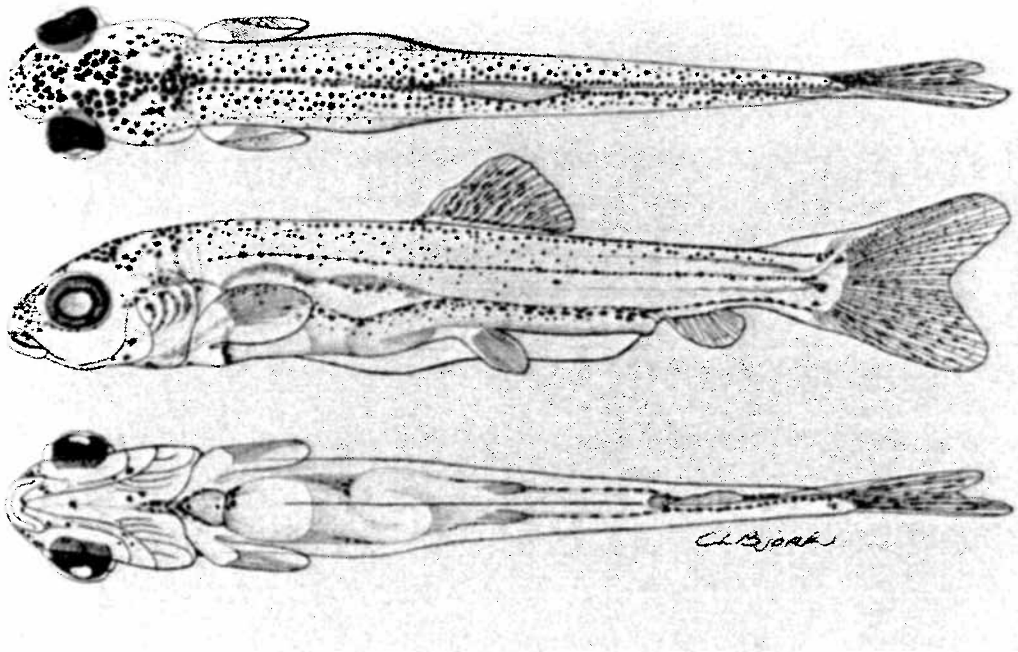

Fig. 18. *Catostomus ardens* metalarva, recently transformed, 15.9 mm SL, 18.7 mm TL. Cultured in 1987 with stock from Bear Lake, Utah.

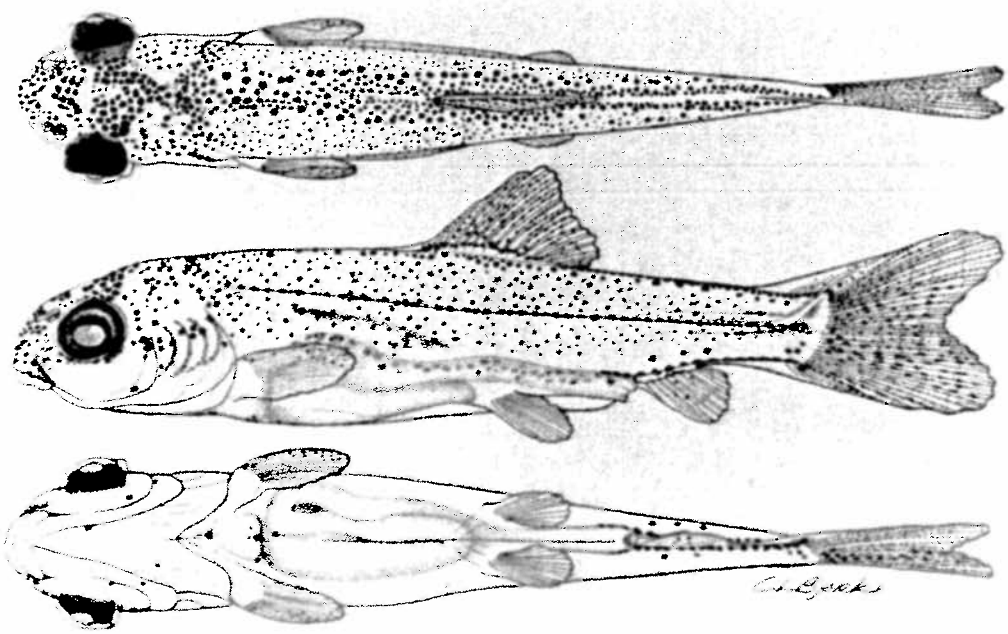

Fig. 19. *Catostomus ardens* metalarva, 17.8 mm SL, 21.5 mm TL. Cultured in 1987 with stock from Bear Lake, Utah.

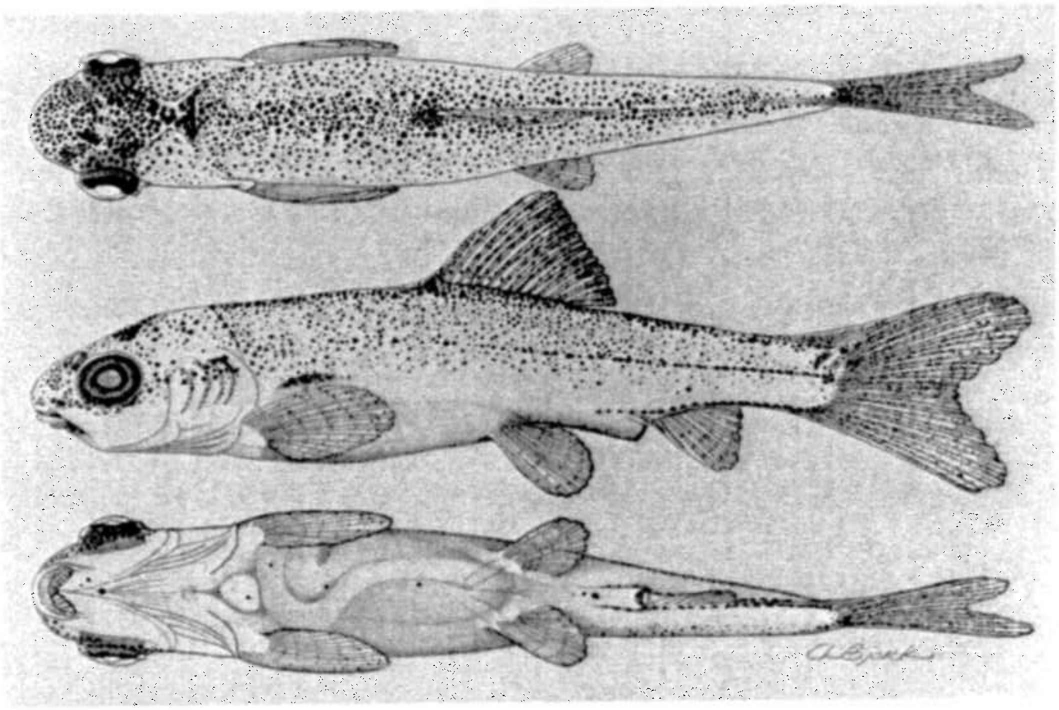

Fig. 20. *Catostomus ardens* juvenile, recently transformed, 21.8 mm SL, 26.9 mm TL. Cultured in 1987 with stock from Bear Lake, Utah.

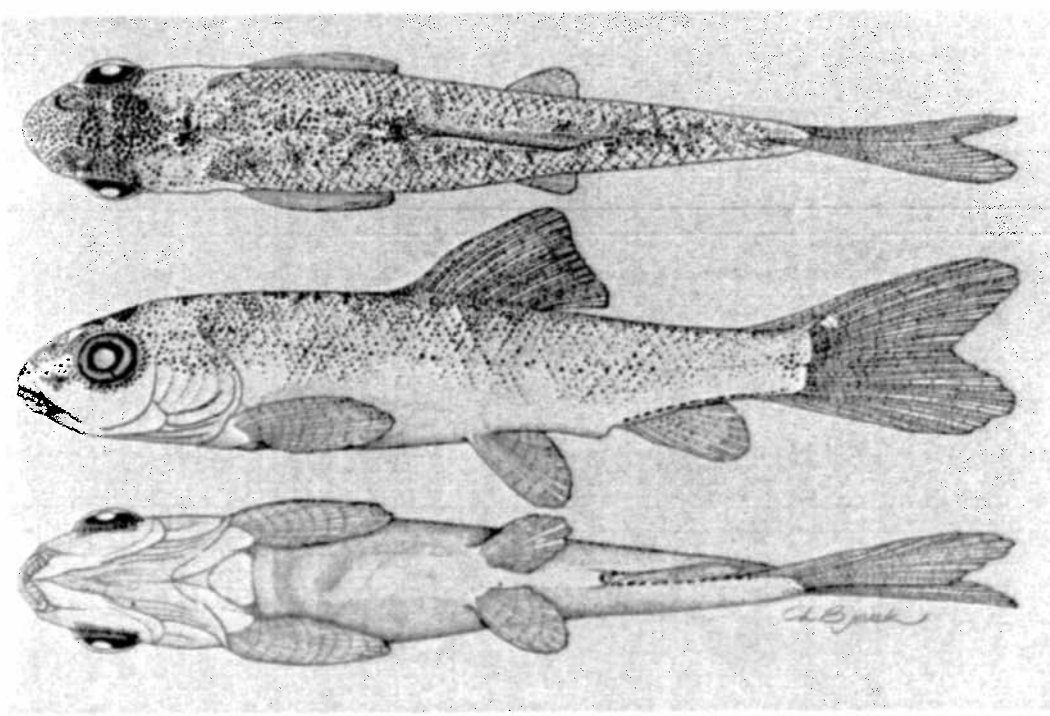

Fig. 21. *Catostomus ardens* juvenile, 28.2 mm SL, 35.6 mm TL. Cultured in 1987 with stock from Bear Lake, Utah.

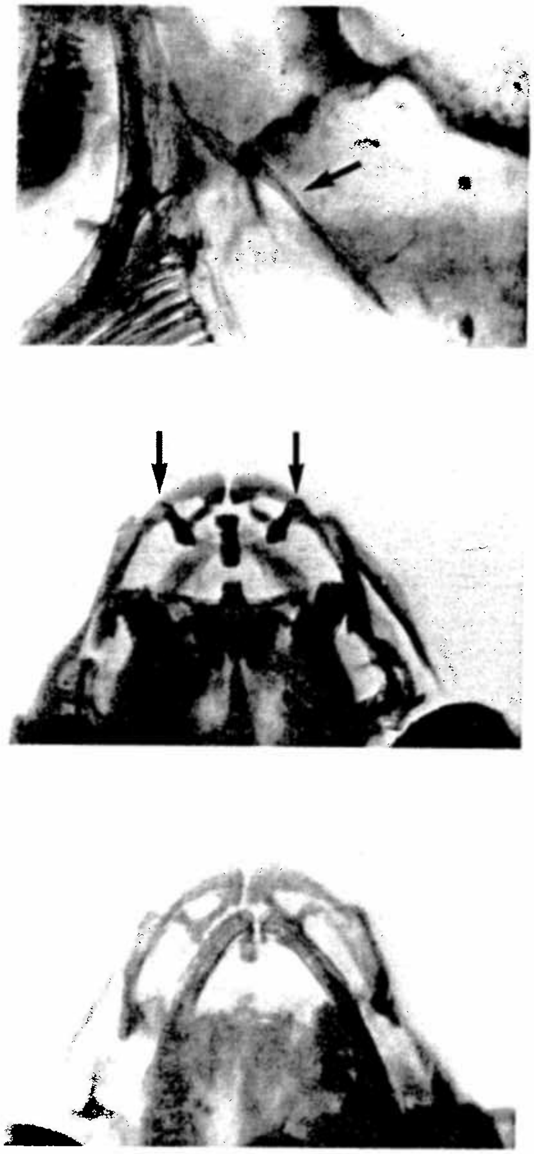

Fig. 22. Selected skeletal features of *Catostomus ardens*, juvenile, 21.4 mm SL, 26.2 mm TL. Top -- postcleithrum. Middle -- anterior-dorsal maxillary projections. Bottom -- mandible position.

Fig. 23. Selected skeletal features of *Catostomus ardens*, juvenile, 39.5 mm SL, 45.4 mm TL. Top -- postcleithrum. Middle -- anterior-dorsal maxillary projections. Bottom -- mandible position.

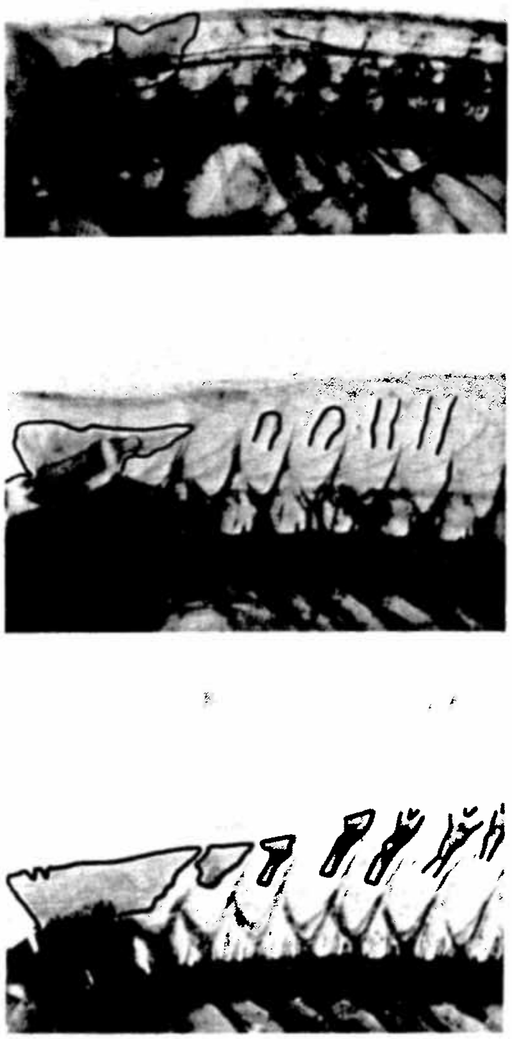

Fig. 24. Interneurals of *Catostomus ardens*. Top -- postflexion mesolarva, 16.8 mm SL, 19.2 mm TL. Middle -- juvenile, 21.4 mm SL, 26.2 mm TL. Bottom -- juvenile, 39.5 mm SL, 45.4 mm TL.

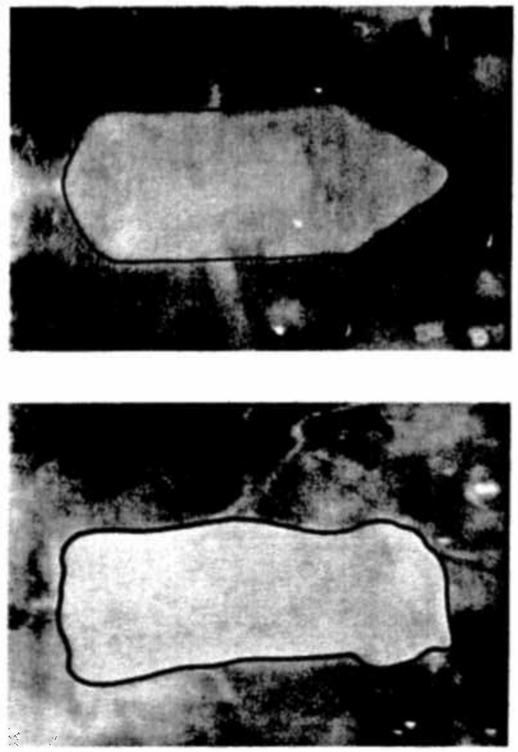

Fig. 25. Frontoparietal fontanelle of *Catostomus ardens*. Top -- juvenile, 21.4 mm SL, 26.2 mm TL. Bottom -- juvenile, 39.5 mm SL, 45.4 mm TL.

Table 12. Dimensions of frontoparietal fontanelle for *Catostomus ardens* larvae >16 mm SL, early (YOY) juveniles, and yearling.

Specimens mm SL	n	Max. width (mm)	Max. length (mm)	Width as % of length
17-19	2	1.0-1.2	2.0-2.2	45-60
20-21	1	0.9	2.0	43
22-25	2	0.9-0.9	2.3-2.4	38-39
26-34	3	1.0-1.0	2.3-2.4	42-43
35-46	1	1.2	2.8	43
76-81	0			

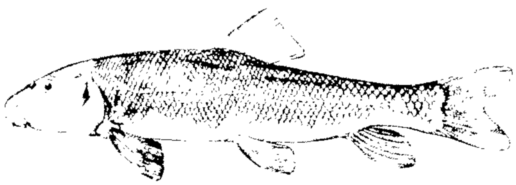

Fig. 26. *Catostomus commersoni* (from Miller 1952).

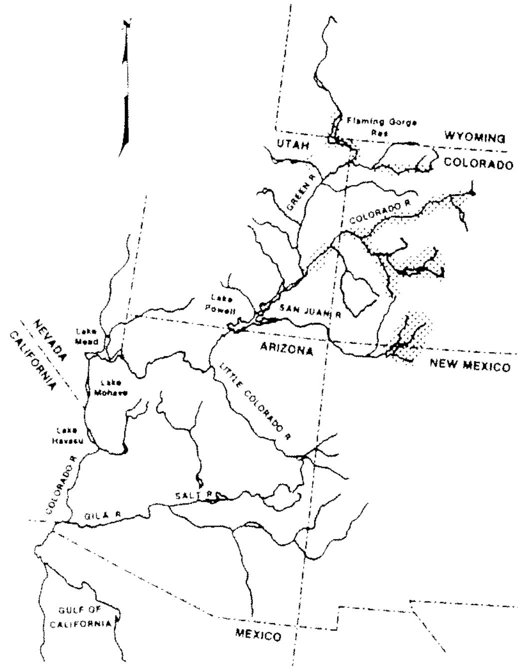

Fig. 27. Regional distribution of *Catostomus commersoni.*

Adult Diagnosis: Back without conspicuous predorsal keel. Caudal peduncle depth about 6.5-8.6% TL. Mouth inferior; no hard, prominent, cartilaginous ridges along inside of jaws. Lips relatively small, papillose, without notches at corners; lower lip wider than long with a deep median cleft, usually without rows of papillae spanning the two lobes. Dorsal fin not large and not falcate. Scales large. Gill rakers relatively few, somewhat knobbed. Peritoneum pale or lightly speckled. TL usually 30-50 cm, up to 64 cm. (Also, Table 13.)

Reproduction: Non-guarding, open-substrate lithophil. April or May to August, 7-19°C, usually >10°C; mostly June to mid-July in the Upper Colorado River Basin. Frequently in large aggregations migrate to streams or lake shores to spawn in shallow water, usually <0.3 m, and moderate currents, mostly 30-49 cm/sec, over sand or gravel; often over riffles in streams. Water-hardened eggs 2.6-3.3 mm diameter, demersal, initially adhesive.

Young: Hatch in 5-11 days at 18-10°C, remain in gravel 1-2 weeks, drift as late protolarvae and mesolarvae, usually at night, and subsequently occupy low velocity shoreline areas, often over sand and gravel or in aquatic vegetation.

Table 13. Selected juvenile and adult meristics for *Catostomus commersoni*. P = principal rays; R = rudimentary rays; D = dorsal; V = ventral. Scales are lateral series or line when complete. Four added to vertebral count for Weberian complex. Gill rakers for exterior row of first arch, specimens >70 mm SL. Mean or modal values underlined if known and noteworthy; rare or questionable extremes in parentheses.

Character	Original	Literature	Character	Original	Literature
Dorsal Fin Rays - P:	10-11-12(13)	(9)10-13(-15)	Dorsal Fin Rays - R:	2-3-4(5)	
Anal Fin Rays - P:	(5-)7(8)	(6)7-8	Anal Fin Rays - R:	2-3	
Caudal Fin Rays - P:	18	18	Caudal Fin Rays - RD:	10-11-13	
Pectoral Fin Rays:	13-15-16(17)	13-19	Caudal Fin Rays - RV:	8-10	
Pelvic Fin Rays:	8-10	9-11	Lateral Scales:	56-59-68-72	53-56-70-76(-85)
Vertebrae:	45-46-48	44-48	Gill Rakers:		20-27

Table 14. Size at apparent onset of selected developmental events for *Catostomus commersoni*, as observed under low power magnification. P = principal rays; R = rudimentary rays. Scales are lateral series. Rare or questionable extremes in parentheses.

Event or Structure	Onset or Formation mm SL	mm TL	Fin Rays or Scales	First Formed mm SL	mm TL	Last Formed mm SL	mm TL
Hatched:	(7)8-10	8-10	Dorsal - P:	12-13	14	14-16	16-17
Eyes Pigmented:	(7)8 or *	8 or *	Anal - P:	14-16	16-17	15-16(17)	18-19(20)
Yolk Assimilated:	10-12(-14)	(10)11-13(-15)	Caudal - P:	10-12	10-13	(12)13-15	(13)14-16
Finfold Absorbed:	(17-)19-20	(21-)23-24	Caudal - R:	13-15	14-16	(17)18	(21)22-23
Pectoral Fin Buds:	(7)8 or *	8 or *	Pectoral:	14-16	16-17	16(-20)	19(-24)
Pelvic Fin Buds:	13-15	(14)15-16	Pelvic:	15-16	18-19	16-18	19-22
	* before hatching		Scales:	22(23)	27	29-31	36-37

References: Auer 1982, Baxter and Simon 1970, Beckman 1952, Carlander 1969, Carlson et al. 1979, Ellis 1914, Fuiman 1979, Fuiman and Trojnar 1980, Geen et al. 1966, Hubbs et al. 1943, Jones et al. 1978, Jordan and Evermann 1896, Lippson and Moran 1974, Miller 1952, Minckley 1973, Prewitt 1977, Reighard 1920, Scott and Crossman 1973, Smith 1985, Stewart 1927, Twomey et al. 1984, Woodling 1985.

Table 15. Size at developmental interval (left) and gut phase (right) transitions for *Catostomus commersoni*. See Fig. 5 for phases of gut folding. Rare or questionable extremes in parentheses.

Transition to	mm SL	mm TL	Transition to	mm SL	mm TL
Flexion Mesolarva:	10-12	10-13	2 - 90° bend:	14-15(16)	(16)17(18)
Postflexion Mesolarva:	(12)13-15	(13)14-16	3 - Full loop:	(16)17-18	(19)20-21(22)
Metalarva:	15-16(17)	18-19(20)	4 - Partial crossover:	19-20(21)	(22)23-24(-26)
Juvenile:	(17-)19-20	(21-)23-24	5 - Full cross over:	(20)21-25	(24)25-30(31)

Table 16. Summary of morphometrics and myomere counts by developmental phase for *Catostomus commersoni*. See Fig. 4 for abbreviations and methods of measurement and counting. Protolarvae with unpigmented eyes excluded.

	Protolarvae (N=11)				Flexion Mesolarvae (N=16)				Postflexion Mesolarvae (N=9)				Metalarvae (N=18)				Juveniles (N=25)			
	$\bar{x}\pm$SD		Range		$\bar{x}\pm$SD		Range		$\bar{x}\pm$SD		Range		$\bar{x}\pm$SD		Range		$\bar{x}\pm$SD		Range	
SL, mm:	10	1	8	12	12	2	10	15	14	1	12	16	17	1	15	20	25	6	19	39
TL, mm:	10	1	9	12	13	2	10	16	16	2	14	19	21	2	18	24	30	7	23	48
Lengths %SL:																				
AS to AE	2	0	2	3	2	1	2	3	4	1	2	6	6	1	4	8	8	1	6	10
PE	8	1	8	9	8	1	7	10	11	1	9	14	14	1	12	15	15	1	13	16
OP1	16	1	13	19	18	1	16	20	22	2	19	25	26	2	20	30	28	1	24	29
OP2									53	1[b]	52	54	56	2	54	59	57	2	52	59
PY	70	12	47	80	63	10[a]	50	75												
OPAF	31	15	22	73	25	1	23	27	30	2	25	33	48	10	32	68				
ODF	37	2	34	42	38	2	35	43	44	3[c]	38	48								
OD									50	1[b]	49	51	51	1	48	53	51	1	48	53
ID									63	1[d]	61	64	65	2	61	67	65	1	61	68
PV	78	2	76	82	79	1	76	81	80	1	78	81	77	1	75	79	76	1	72	78
OA									80	1[d]	79	80	78	1	76	79	77	1	73	79
IA									85	1[d]	84	86	85	1	83	86	84	1	79	86
AFC									110	2	108	113	113	2	110	119	115	1	113	117
PC	104	1	101	106	106	1	104	109	114	4	109	120	121	2	116	126	122	1	119	124
Y	51	13	26	63	18	21	0	50												
P1	7	4	2	12	11	1	10	12	12	1	11	14	15	2[e]	12	19	17	1	15	20
P2									2	2	0	6	9	3	4	16	12	1	10	15
D									17	1[d]	16	17	19	2	15	22	20	1	18	24
A									7	0[d]	7	7	11	2	7	14	13	2	10	16
Depths %SL:																				
at BPE	9	1	7	11	10	1	9	11	13	1	11	15	16	1	14	19	17	1	16	19
OP1	11	1	9	12	11	1	10	13	16	2	14	18	18	1	16	20	20	1	18	22
OD	10	2	8	13	9	1	8	10	12	2	9	16	16	2	13	20	19	1	17	22
BPV	5	1	3	6	5	0	5	6	7	1	6	9	9	1	7	11	11	1	10	14
AMPM	3	1	2	3	4	0	3	4	5	1	4	7	7	1	5	8	8	1	7	9
Max. Yolk	6	3	1	11	1	1	0	3												
Widths %SL:																				
at BPE	9	2	7	11	10	1	9	12	13	1	11	15	15	1	13	17	16	1	14	18
OP1	6	1	5	7	7	1	6	8	10	1	8	12	13	1	11	14	16	2	13	20
OD	6	1	5	9	5	0	5	6	7	1	5	9	10	2	8	14	13	2	10	16
BPV	4	0	3	4	4	0	3	4	5	1	4	6	6	1	4	8	8	1	7	10
AMPM	2	0	2	2	2	0	2	2	3	0	2	3	3	1	2	4	4	0	4	5
Max. Yolk	6	3	1	10	1	2	0	4												
Myomeres:																				
to PY	33	7	18	38	28	6[a]	21	35												
OPAF	9	7	4	30	6	1	5	8	6	1	5	8	16	6	7	28				
OP2									21	1[b]	19	22	21	1	20	23	21	1[f]	20	22
ODF	13	1	12	14	14	1	12	17	15	2[d]	12	17	14	2[a]	11	17				
OD									19	1[b]	17	20	17	1[e]	16	19	17	1[f]	16	18
PV	38	2	35	40	37	2	34	40	38	1	36	40	35	1	34	37	35	1[f]	33	36
Total	47	1	44	48	46	1	43	48	46	1	45	49	45	1	44	47	45	1[f]	43	47

[a]N = 8; [b]N = 7; [c]N = 8; [d]N = 3; [e]N = 17; [f]N = 20.

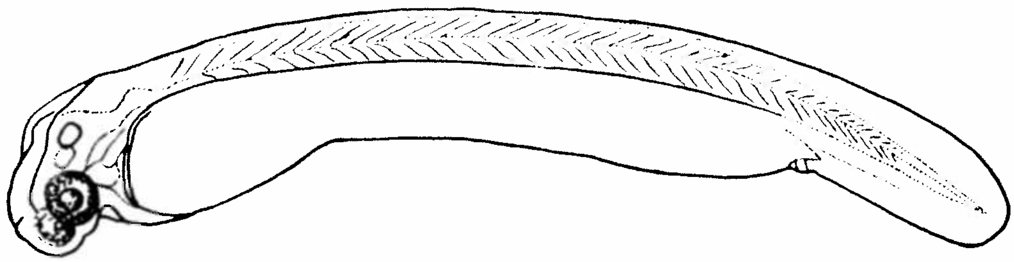

Fig. 28. *Catostomus commersoni* protolarva, recently hatched, 7.8 mm SL, 8.0 mm TL (from Stewart 1926).

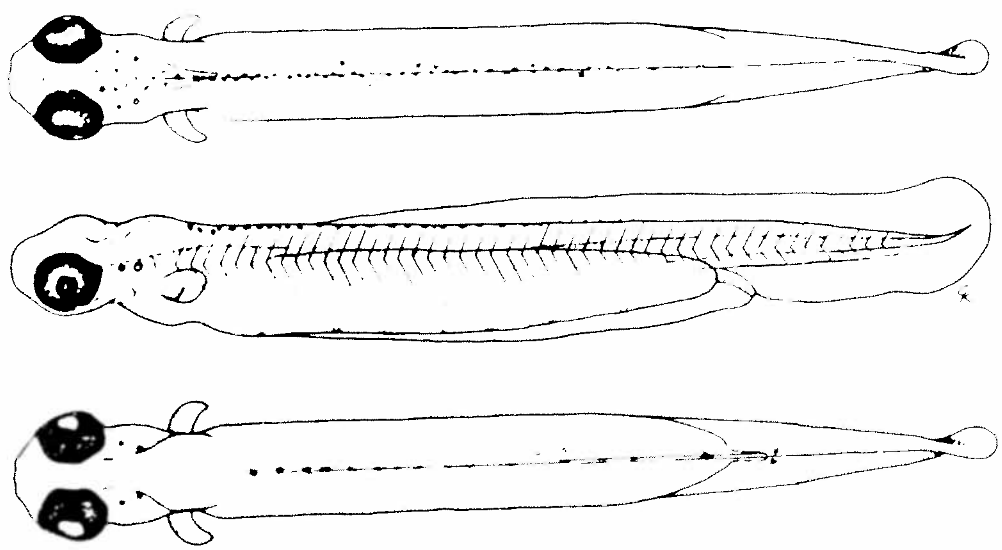

Fig. 29. *Catostomus commersoni* protolarva, 10.5 mm SL, 10.7 mm TL (from Fuiman 1979).

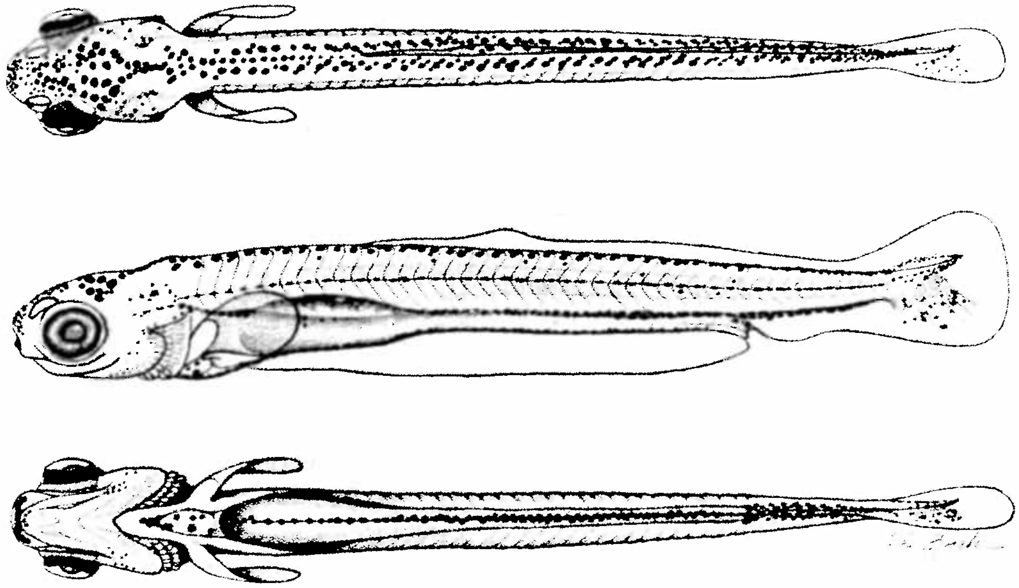

Fig. 30. *Catostomus commersoni* flexion mesolarva, recently transformed, 12.8 mm SL, 13.4 mm TL. Collected in 1977 from the Yampa River, Colorado.

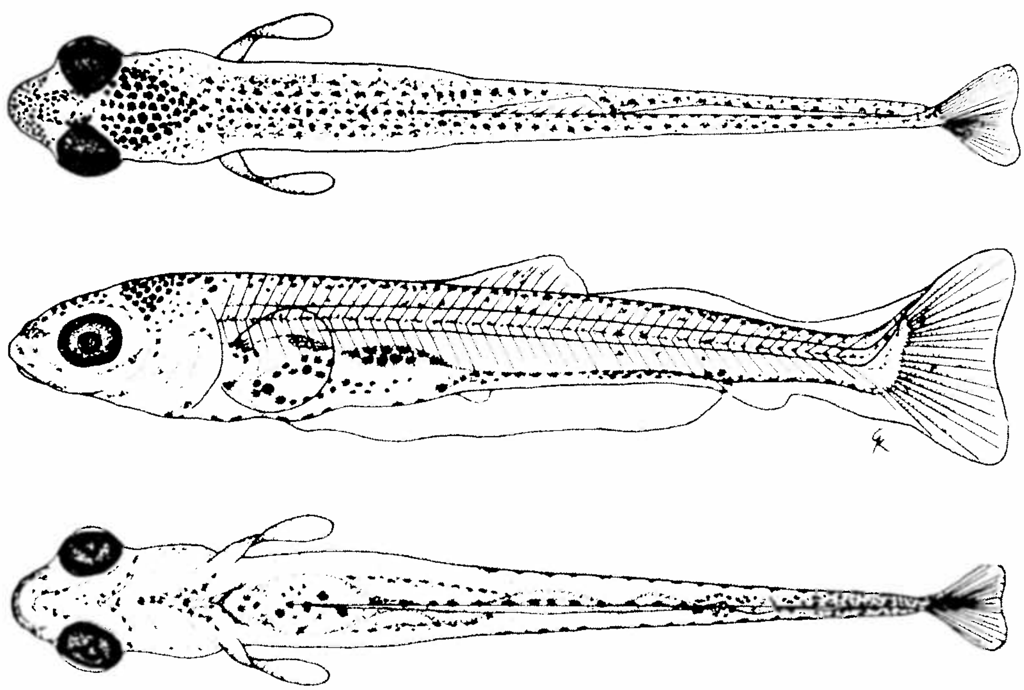

Fig. 31. *Catostomus commersoni* postflexion mesolarva, 16.3 mm SL, 18.2 mm TL (from Fuiman 1979).

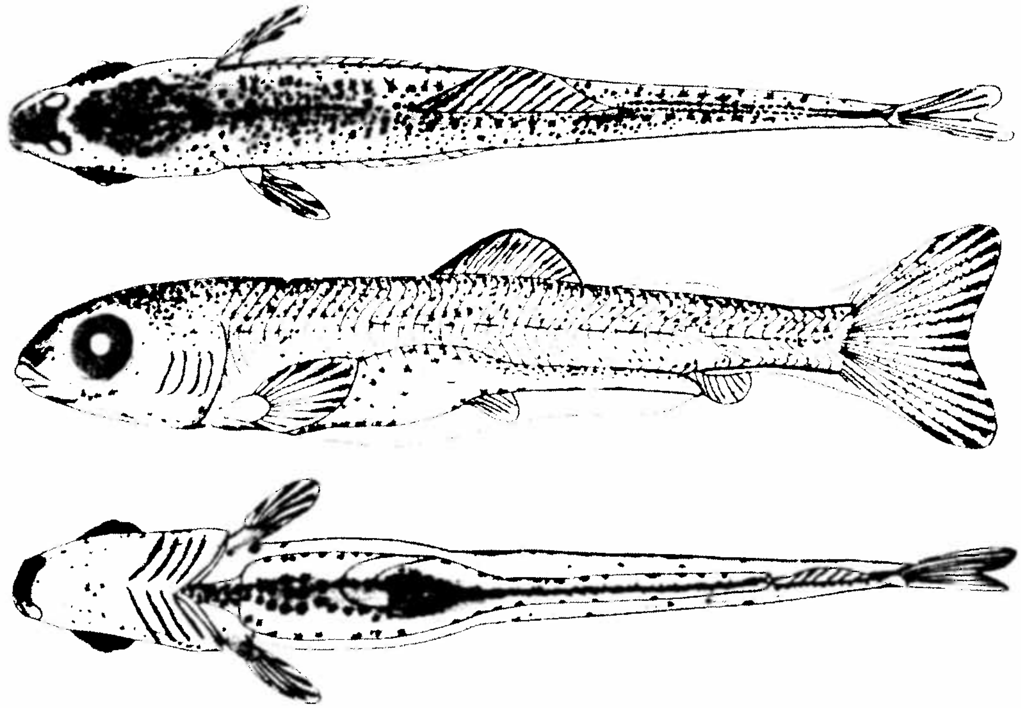

Fig. 32. *Catostomus commersoni* metalarva, recently transformed, 17.8 mm SL, 20.4 mm TL (from Buynak and Mohr 1978).

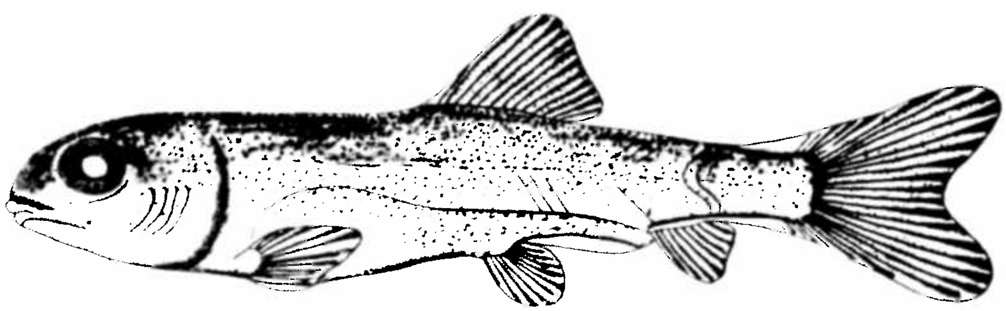

Fig. 33. *Catostomus commersoni* metalarva, 19.8 mm SL, 23.8 mm TL (from Buynak and Mohr 1978).

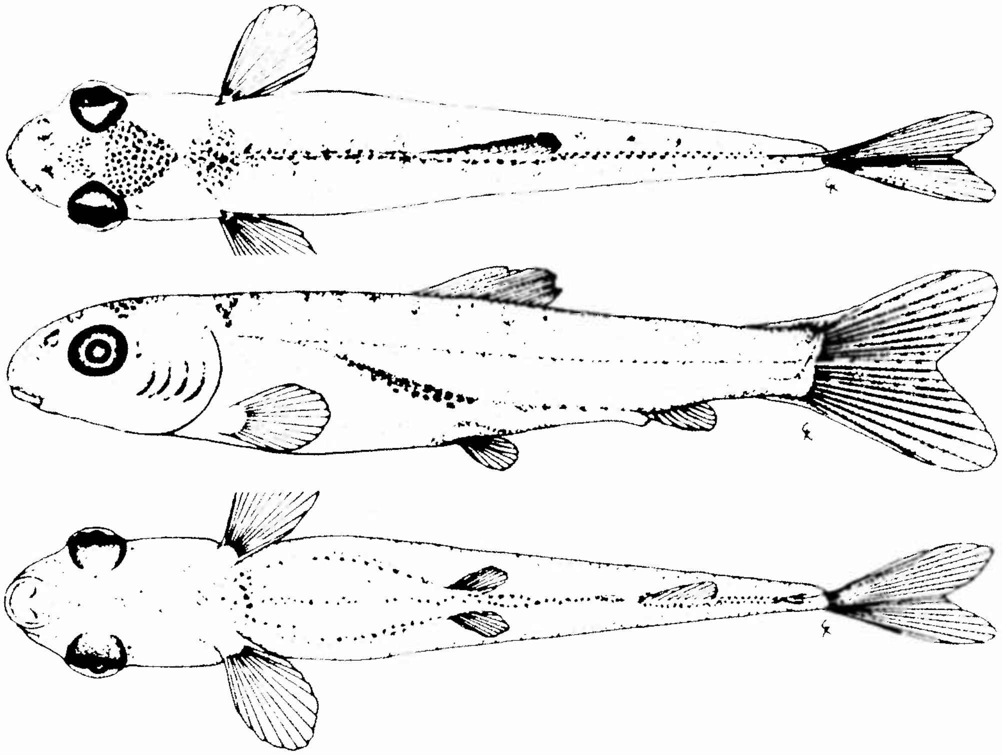

Fig. 34. *Catostomus commersoni* juvenile, recently transformed, 21.3 mm SL, 25.8 mm TL (from Fuiman 1979).

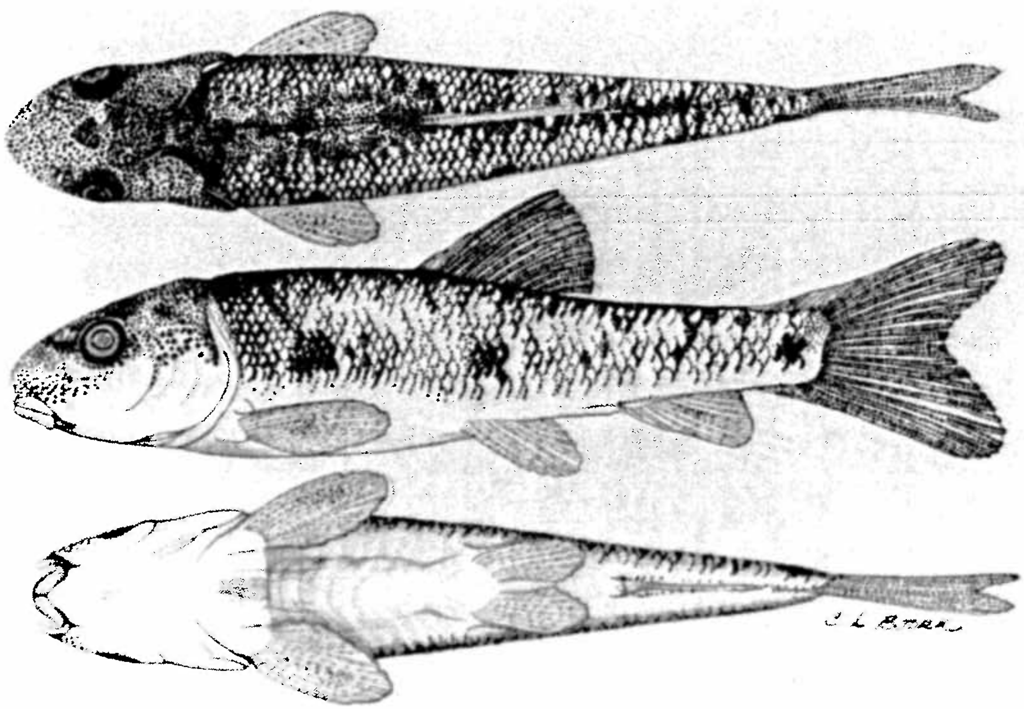

Fig. 35. *Catostomus commersoni* juvenile, 30.8 mm SL, 37.9 mm TL. Collected in 1977 from the Yampa River, Colorado.

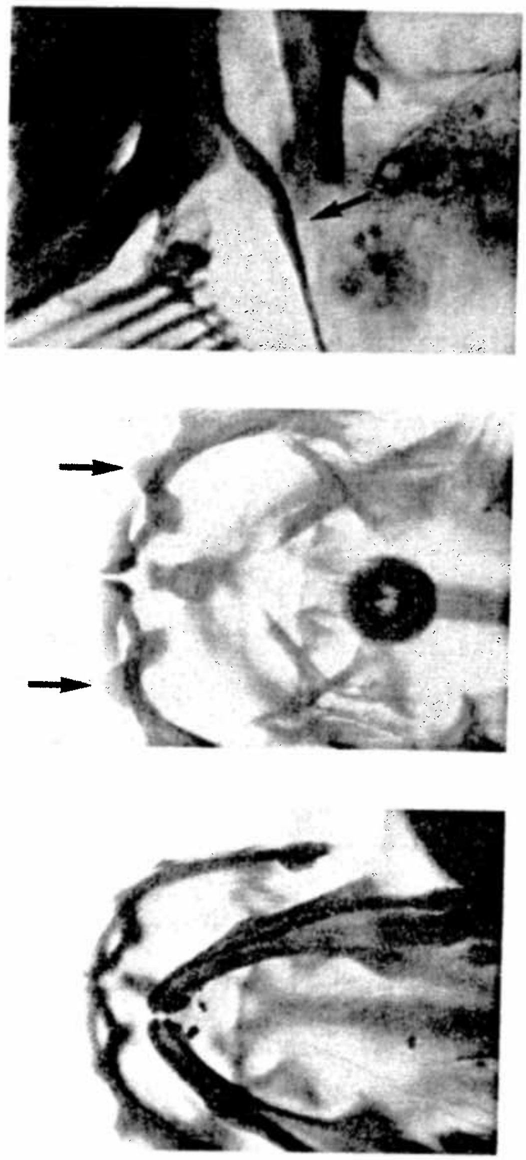

Fig. 36. Selected skeletal features of *Catostomus commersoni*, juvenile, 20.4 mm SL, 25.0 mm TL. Top -- postcleithrum. Middle – anterior-dorsal maxillary projections. Bottom – mandible position.

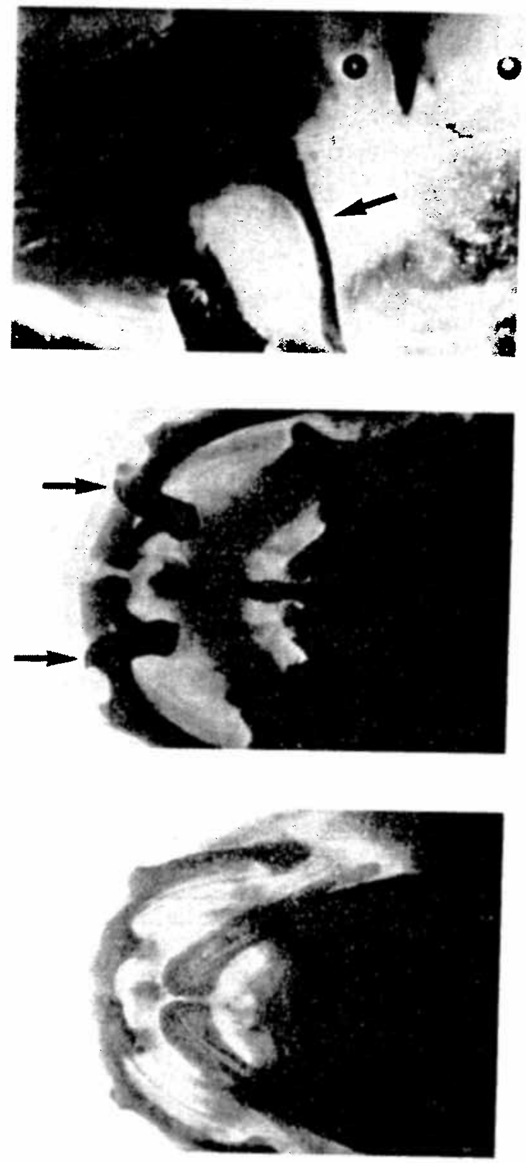

Fig. 37. Selected skeletal features of *Catostomus commersoni*, juvenile, 42.6 mm SL, 52.5 mm TL. Top -- postcleithrum. Middle – anterior-dorsal maxillary projections. Bottom -- mandible position.

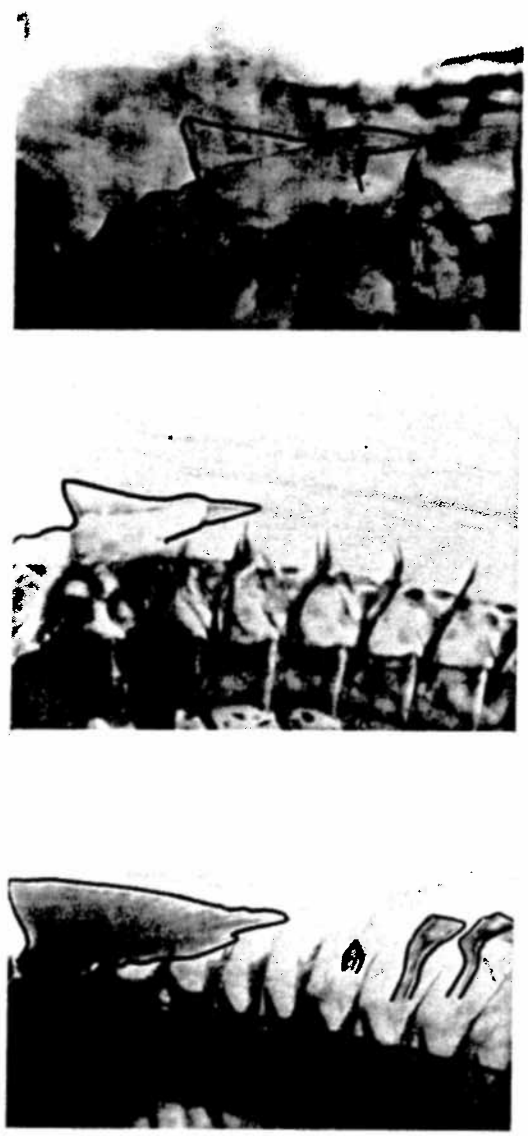

Fig. 38. Interneurals of *Catostomus commersoni*. Top -- postflexion mesolarva, 14.7 mm SL, 17.0 mm TL. Middle -- juvenile, 20.4 mm SL, 25.0 mm TL. Bottom -- juvenile, 42.6 mm SL, 52.5 mm TL.

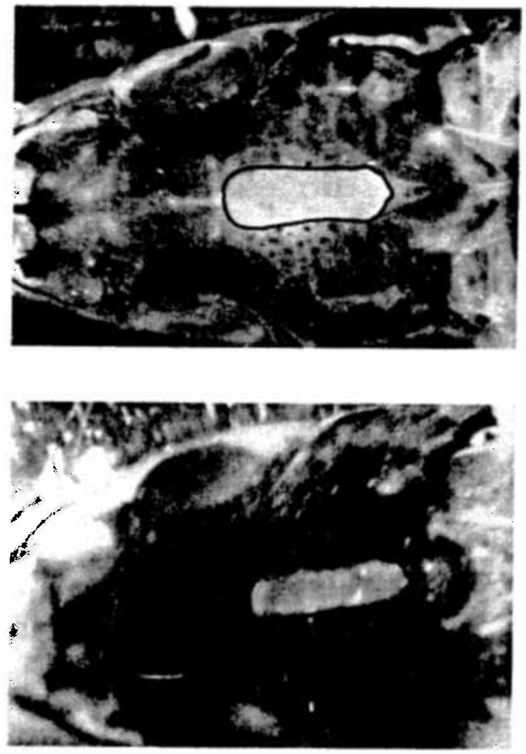

Fig. 39. Frontoparietal fontanelle of *Catostomus commersoni*. Top -- juvenile, 28.0 mm SL, 34.8 mm TL. Bottom -- juvenile, 39.8 mm SL, 49.0 mm TL.

Table 17. Dimensions of frontoparietal fontanelle for *Catostomus commersoni* larvae >16 mm SL, early (YOY) juveniles, and yearling.

Specimens mm SL	n	Max. width (mm)	Max. length (mm)	Width as % of length
17-19	2	0.8-1.0	2.0-2.2	40-45
20-21	2	0.6-0.8	1.9-2.1	32-38
22-25	1	0.8	2.0	40
26-34	2	0.8-0.8	2.3-2.6	31-35
35-46	1	0.9	3.0	30
76-81	1	0.8	3.1	26

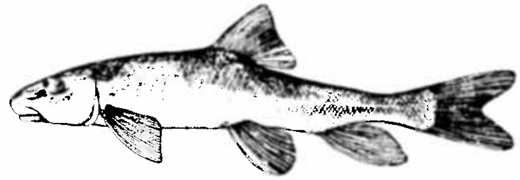

Fig. 40. *Catostomus discobolus* adult (Miller 1952).

Adult Diagnosis: No conspicuous predorsal keel. Caudal peduncle slender to deep, 3.2-10% SL, often correlated with habitat. Mouth inferior and well back. Hard, truncate, cartilaginous ridges along inside of jaws, especially prominent on lower jaw. Lips large with notches at outer corners, papillose except on outer face of upper lip; lower lip with shallow cleft, lobes broadly connected by 3 or more rows of papillae usually concentric with the anterior margin of the lip. Fontanelle typically closed. Pelvic axillary process absent or a simple fold. Interradial membranes of caudal fin well pigmented. Peritoneum black to dusky. TL usually 25-35 cm, up to 40 cm. (Also, Table 18.)

Reproduction: Non-guarding, open-substrate lithophil. May to September, usually June and July, at 15-18°C (possibly also in fall and/or winter in Little Colorado River based on collection of larvae). Water-hardened eggs 3.3-3.5 mm diameter, demersal, initially adhesive.

Young: Later stage protolarvae and mesolarvae drift, predominately at night. Young typically occupy slow, shallow waters, often <0.5 m, near shore and in backwaters; sometimes trapped in cut-off pools or channels. Often associated with juveniles of other species.

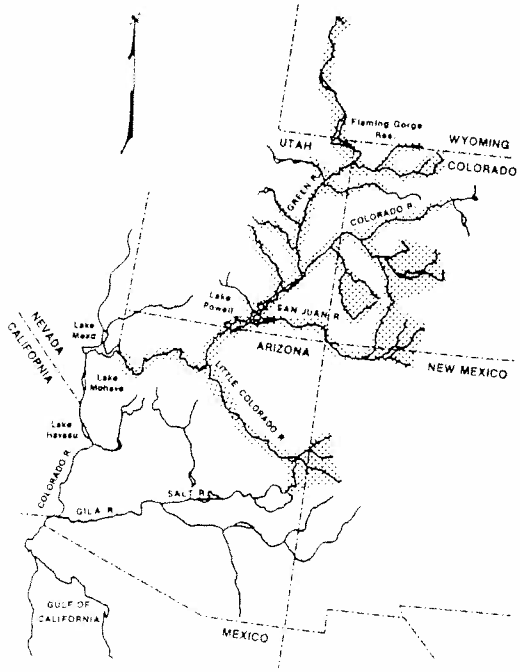

Fig. 41. Regional distribution of *Catostomus discobolus*.

Table 18. Selected juvenile and adult meristics for *Catostomus discobolus*. P = principal rays; R = rudimentary rays; D = dorsal; V = ventral. Scales are lateral series or line when complete. Four added to vertebral count for Weberian complex. Gill rakers for exterior row of first arch, specimens >70 mm SL. Mean or modal values underlined if known and noteworthy; rare or questionable extremes in parentheses.

Character	Original	Literature	Character	Original	Literature
Dorsal Fin Rays - P:	(9)10-11(12)	9-10-11-12	Dorsal Fin Rays - R:	2-3	
Anal Fin Rays - P:	7	7(8)	Anal Fin Rays - R:	2(3)	
Caudal Fin Rays - P:	(17)18		Caudal Fin Rays - RD:	(10)11-12	
Pectoral Fin Rays:	14-15-16		Caudal Fin Rays - RV:	9-10(11)	
Pelvic Fin Rays:	8-9-10	(7)8-9-10(11)	Lateral Scales:		(78-)86-115(-122)
Vertebrae:	47-49	45-47-49-50	Gill Rakers:		28-35-44

Table 19. Size at apparent onset of selected developmental events for *Catostomus discobolus*, as observed under low power magnification. P = principal rays; R = rudimentary rays. Scales are lateral series. Rare or questionable extremes in parentheses.

Event or Structure	Onset or Formation mm SL	mm TL	Fin Rays or Scales	First Formed mm SL	mm TL	Last Formed mm SL	mm TL
Hatched:	(8)9-10(11)	(8)9-11	Dorsal - P:	(11-)13	(12-)14	(14)15	(16)17-18
Eyes Pigmented:	9-10 or *	(9)10 or *	Anal - P:	14-15	16-17	(16)17	(19)20
Yolk Assimilated:	(10-)12-13(14)	(11)12-14	Caudal - P:	10-12	11-12(13)	(11)12-13	(12)13-14
Finfold Absorbed:	21-22(23)	26-27(28)	Caudal - R:	14	15	19-20	23-25
Pectoral Fin Buds:	(8) or *	(8) or *	Pectoral:	14-15	16-17	16-18(19)	18-21(23)
Pelvic Fin Buds:	14	(15)16	Pelvic:	16	18-19	19-20	23-25
	* before hatching		Scales:	28-34	(34)35-42	30-39	36-48

References: Andreasen and Barnes 1975, Baxter and Simon 1970, Beckman 1952, Behnke et al. 1982, Carlson et al. 1979, Cope 1872, Holden 1973, Hubbs and Hubbs 1947, Hubbs et al. 1943, Jordan and Evermann 1896, Lee et al. 1980, McAda 1977, Miller 1952, Minckley 1973, Prewitt 1977, Sigler and Miller 1963, Smith 1966, Tyus et al. 1982, Vanicek 1967, Woodling 1985.

Table 20. Size at developmental interval (left) and gut phase (right) transitions for *Catostomus discobolus*. See Fig. 5 for phases of gut folding. Rare or questionable extremes in parentheses.

Transition to	mm SL	mm TL	Transition to	mm SL	mm TL
Flexion Mesolarva:	10-12	11-12(13)	2 - 90° bend:	14(15)	15-16(17)
Postflexion Mesolarva:	(11)12-13	(12)13-14	3 - Full loop:	15(16)	17-18
Metalarva:	(16)17	(19)20	4 - Partial crossover:	(16)17	18-20
Juvenile:	21-22(23)	26-27(28)	5 - Full cross over:	(16)17-19(-21)	(18)19-23(-25)

Table 21. Summary of morphometrics and myomere counts by developmental phase for *Catostomus discobolus*. See Fig. 4 for abbreviations and methods of measurement and counting. Protolarvae with unpigmented eyes excluded.

	Protolarvae (N=6)				Flexion Mesolarvae (N=7)				Postflexion Mesolarvae (N=16)				Metalarvae (N=22)				Juveniles (N=16)			
	$\bar{x}\pm$SD		Range		$\bar{x}\pm$SD		Range		$\bar{x}\pm$SD		Range		$\bar{x}\pm$SD		Range		$\bar{x}\pm$SD		Range	
SL, mm:	11	1	10	12	12	1	10	13	15	2	11	17	19	2	17	22	28	6	21	40
TL, mm:	11	1	10	12	13	1	11	14	16	2	12	20	23	2	20	28	34	8	26	50
Lengths %SL:																				
AS to AE	2	0	2	2	3	1	2	4	5	1	3	6	7	1	5	8	8	1	6	9
PE	7	0	6	7	9	1	8	10	11	1	9	13	13	1	12	15	14	1	12	16
OP1	14	1	13	15	18	1	17	19	22	2	19	25	25	1	24	27	25	1	23	27
OP2									55	1[b]	53	57	58	2	55	61	58	1	56	60
PY	78	1	77	79	68	12[a]	50	74												
OPAF	40	14	29	62	26	5	22	37	32	4	26	40	54	10	42	70				
ODF	34	6	27	43	39	3	36	43	46	2[c]	43	49								
OD									51	1[d]	49	53	52	1	49	54	51	1	47	54
ID									62	1[e]	61	64	64	1	63	66	64	1	62	66
PV	80	0	79	81	77	2	74	79	79	1	76	81	76	1	75	78	75	1	72	76
OA									78	1[f]	76	80	77	1	76	78	76	1	73	77
IA									83	1[f]	82	85	84	1	82	86	83	1	81	84
AFC									110	1[g]	107	112	114	1	112	115	115	1	113	116
PC	104	1	103	104	106	1	105	107	113	3	109	116	121	2	116	124	123	1	120	124
Y	63	3	61	67	26	26	0	53												
P1	5	1	3	6	10	1	9	11	12	1	11	13	15	1	13	19	18	1	15	20
P2									2	2	0	5	9	2	5	11	13	1	11	15
D									15	2[b]	11	17	19	1	17	21	21	1	19	23
A									7	1[f]	6	8	11	2	8	13	14	1	12	16
Depths %SL:																				
at BPE	8	1	6	9	11	1	9	11	13	2	11	15	15	1	14	16	16	1	14	17
OP1	10	1	9	13	12	1	11	13	15	2	12	17	19	1	16	21	19	1	18	21
OD	14	2	12	17	10	1	9	12	11	3	8	17	17	2	14	20	19	1	16	21
BPV	5	1	4	6	6	0	5	6	7	1	5	8	10	1	9	11	11	1	10	14
AMPM	2	0	2	3	3	0	3	4	5	1	4	6	7	0	6	7	7	0	7	9
Max. Yolk	10	2	7	12	3	3	0	7												
Widths %SL:																				
at BPE	8	1	6	9	10	0	10	11	12	1	10	14	15	1	14	16	15	1	14	16
OP1	6	1	4	7	8	0	7	9	10	2	8	13	14	1	13	17	16	1	15	18
OD	10	1	8	12	6	0	5	6	7	2	6	10	12	2	9	15	15	1	12	17
BPV	3	1	3	5	4	0	3	5	5	1	4	6	6	1	5	7	8	1	6	9
AMPM	2	0	1	2	2	0	2	2	2	0	1	3	3	0	2	3	3	1	2	4
Max. Yolk	12	2	10	15	4	4	0	8												
Myomeres:																				
to PY	38	1	37	39	34	7[a]	23	37												
OPAF	16	7	10	27	7	4	5	15	8	1	6	12	20	7	11	33				
OP2									23	1[f]	21	25	24	1	20	26	23	1[c]	22	24
ODF	13	3	8	18	15	1	14	18	18	2[c]	15	20								
OD									19	2[h]	17	22	19	1	17	21	18	0[c]	18	19
PV	39	1	39	40	39	1	37	40	39	1	38	39	37	1	35	38	36	1[c]	35	38
Total	48	1	47	48	48	1	47	49	48	0	48	49	47	1	47	48	48	1[c]	47	48

[a]N = 4; [b]N = 10; [c]N = 9; [d]N = 14; [e]N = 8; [f]N = 7; [g]N = 15; [h]N = 13.

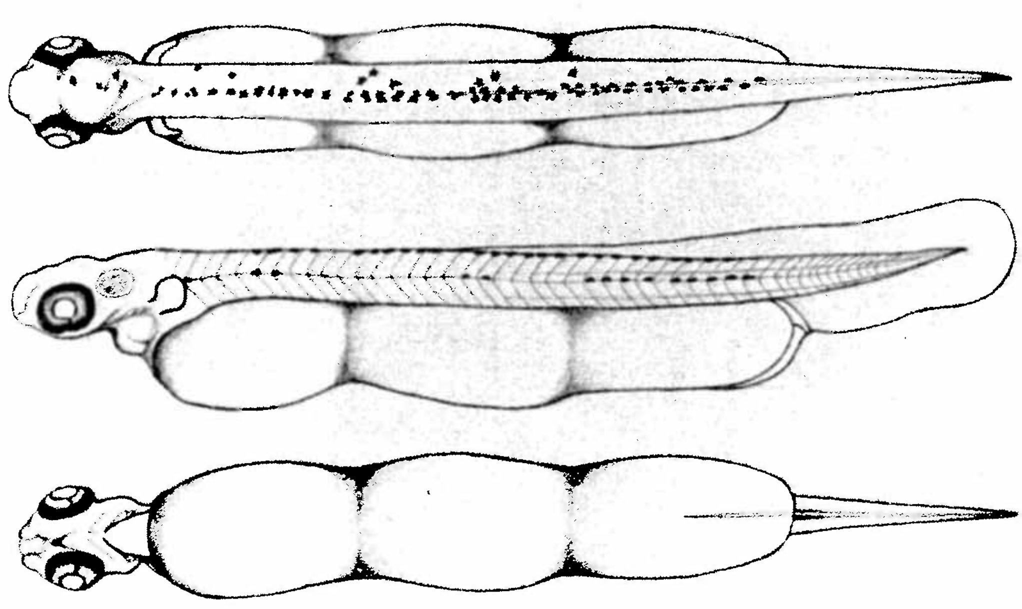

Fig. 42. *Catostomus discobolus* protolarva, recently hatched, 10.5 mm SL, 11.1 mm TL. Cultured in 1978 with stock from the White River, Colorado.

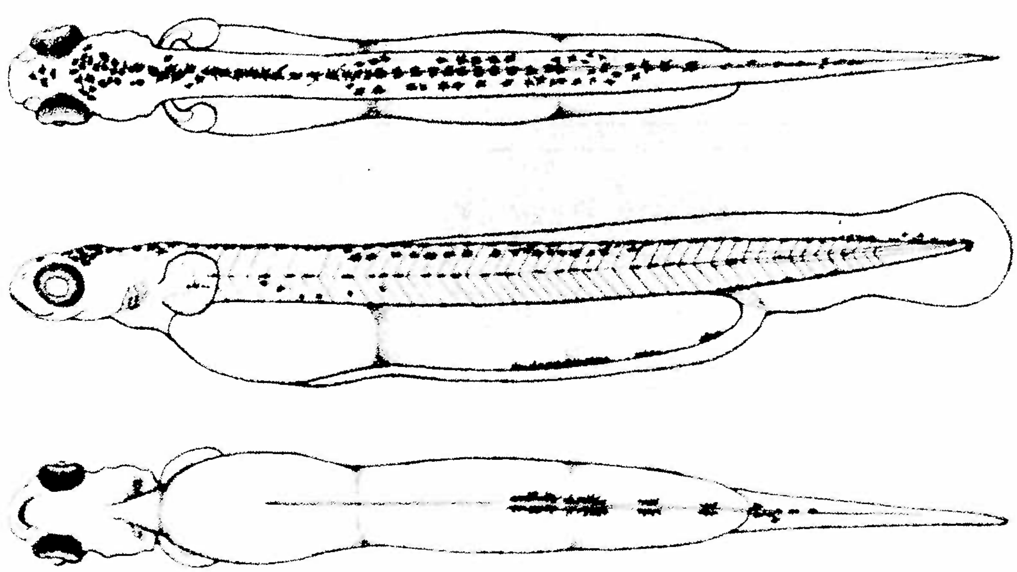

Fig. 43. *Catostomus discobolus* protolarva, 12.0 mm SL, 12.5 mm TL. Cultured in 1978 with stock from the White River, Colorado.

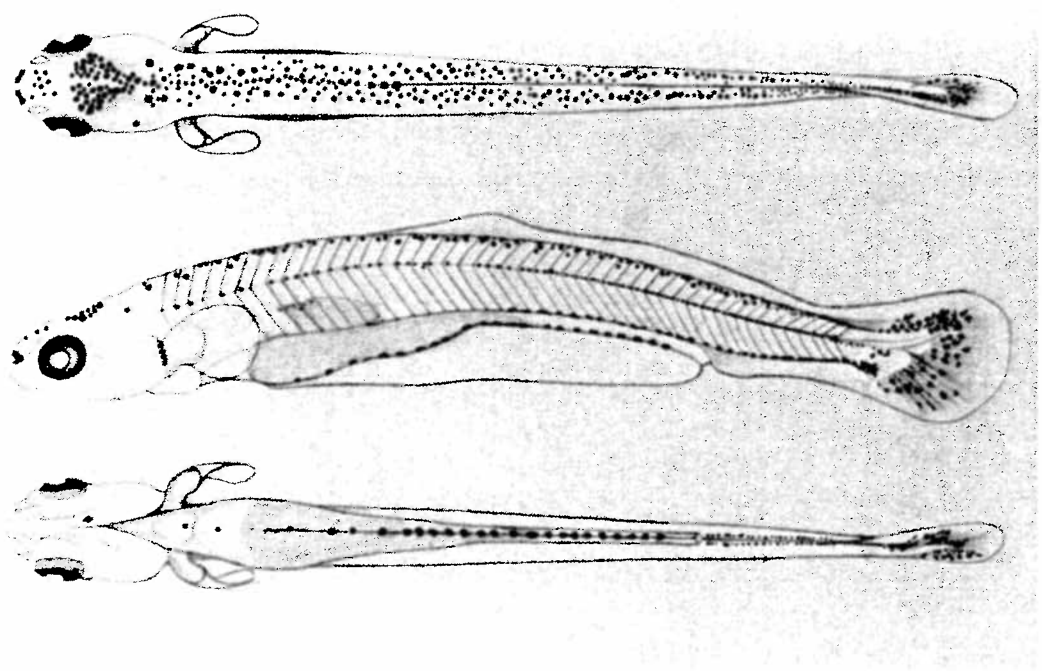

Fig. 44. *Catostomus discobolus* flexion mesolarva, recently transformed, 13.2 mm SL, 14.1 mm TL. Collected in 1978 from the White River, Colorado.

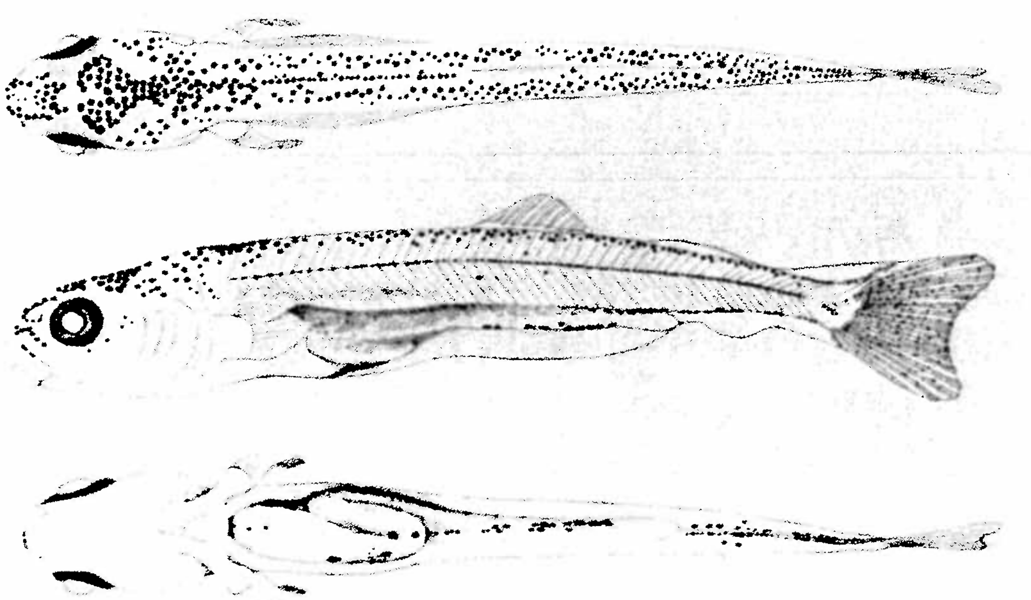

Fig. 45. *Catostomus discobolus* postflexion mesolarva, 14.3 mm SL, 16.4 mm TL. Collected in 1976 from the White River, Colorado.

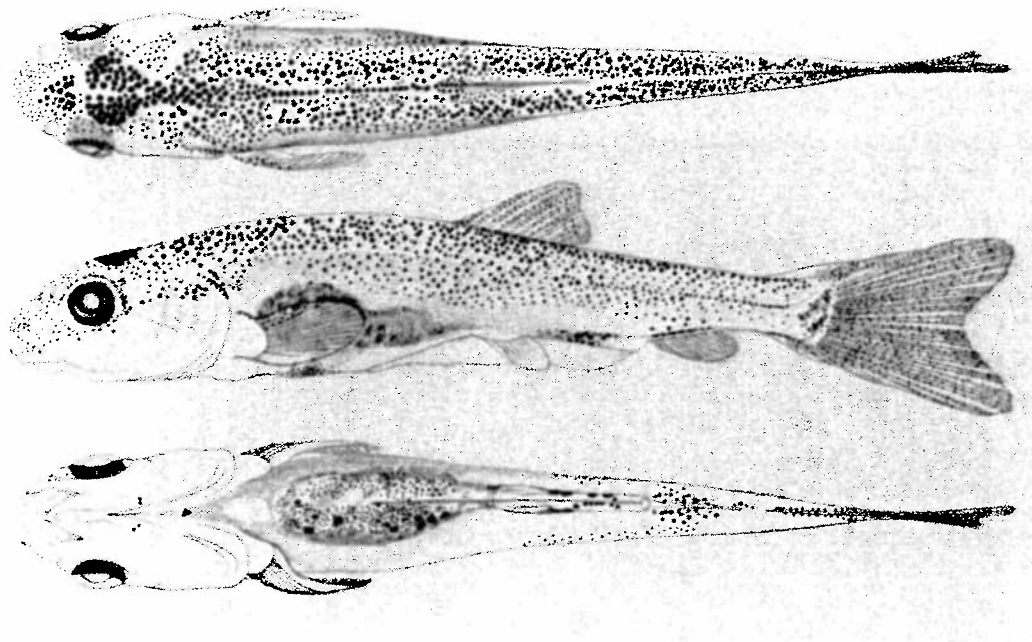

Fig. 46. *Catostomus discobolus* metalarva, recently transformed, 15.4 mm SL, 18.2 mm TL. Collected in 1976 from the White River, Colorado.

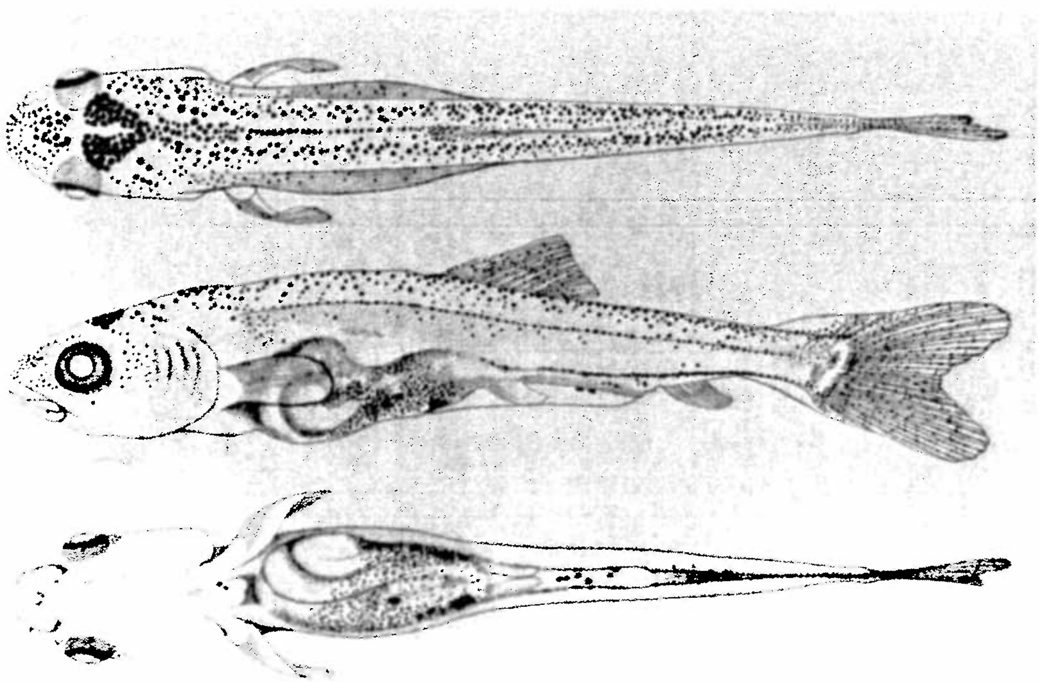

Fig. 47. *Catostomus discobolus* metalarva, 18.1 mm SL, 21.8 mm TL. Collected in 1976 from the White River, Colorado.

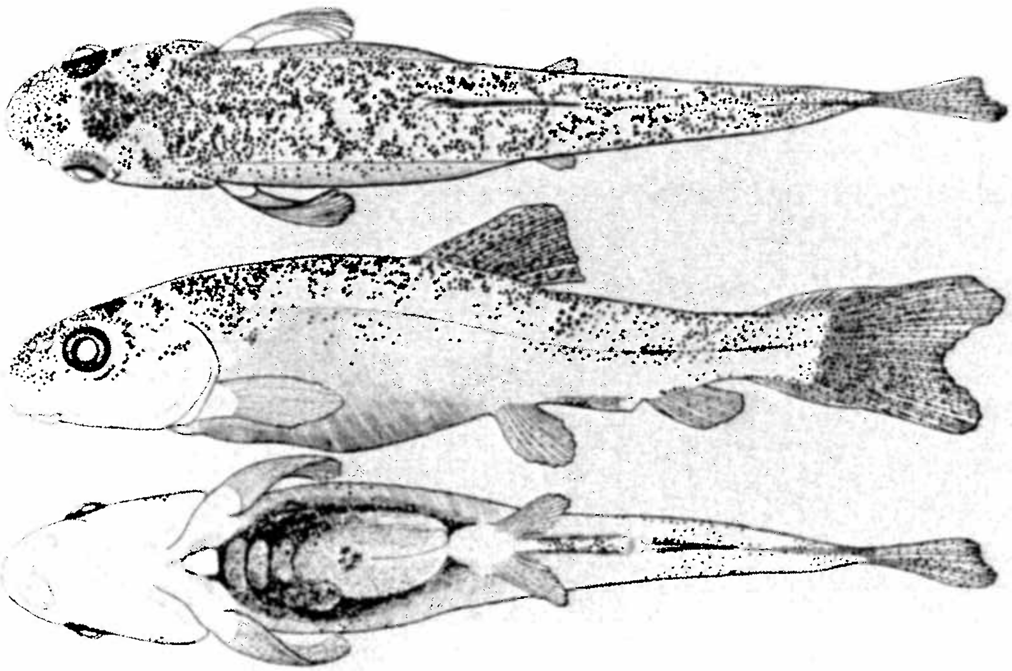

Fig. 48. *Catostomus discobolus* juvenile, recently transformed, 22.7 mm SL, 27.3 mm TL. Collected in 1976 from the White River, Colorado.

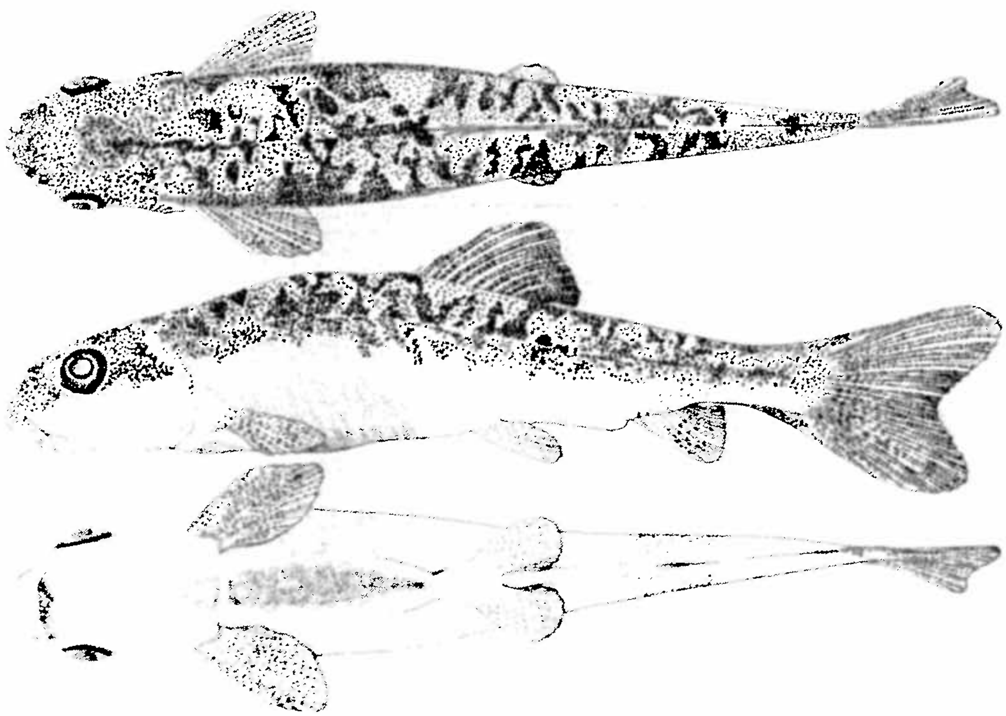

Fig. 49. *Catostomus discobolus* juvenile, 31.8 mm SL, 38.0 mm TL. Collected in 1976 from the White River, Colorado.

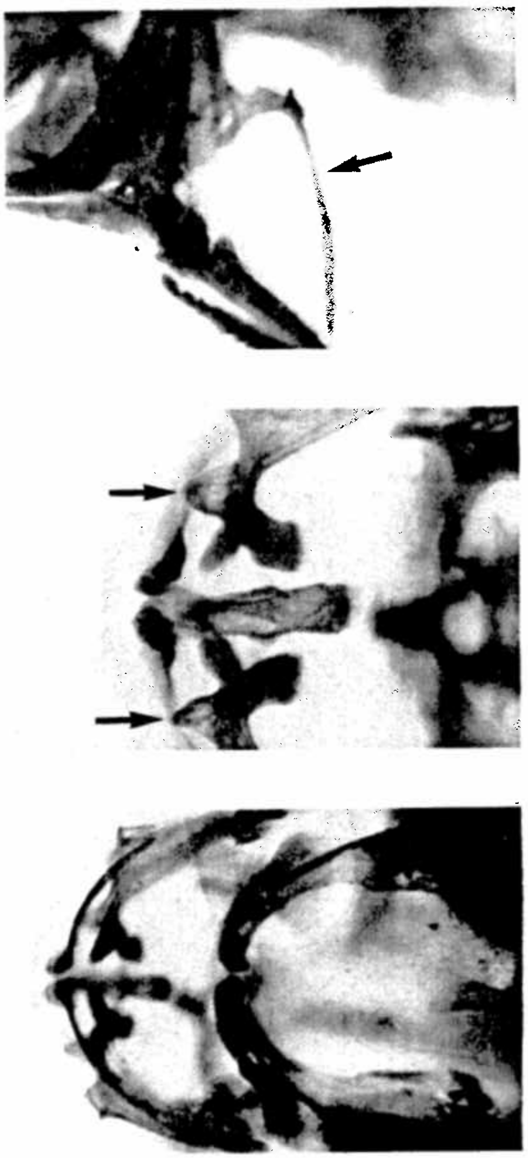

Fig. 50. Selected skeletal features of *Catostomus discobolus*, metalarva, 21.8 mm SL, 25.5 mm TL. Top -- postcleithrum. Middle -- anterior-dorsal maxillary projections. Bottom -- mandible position.

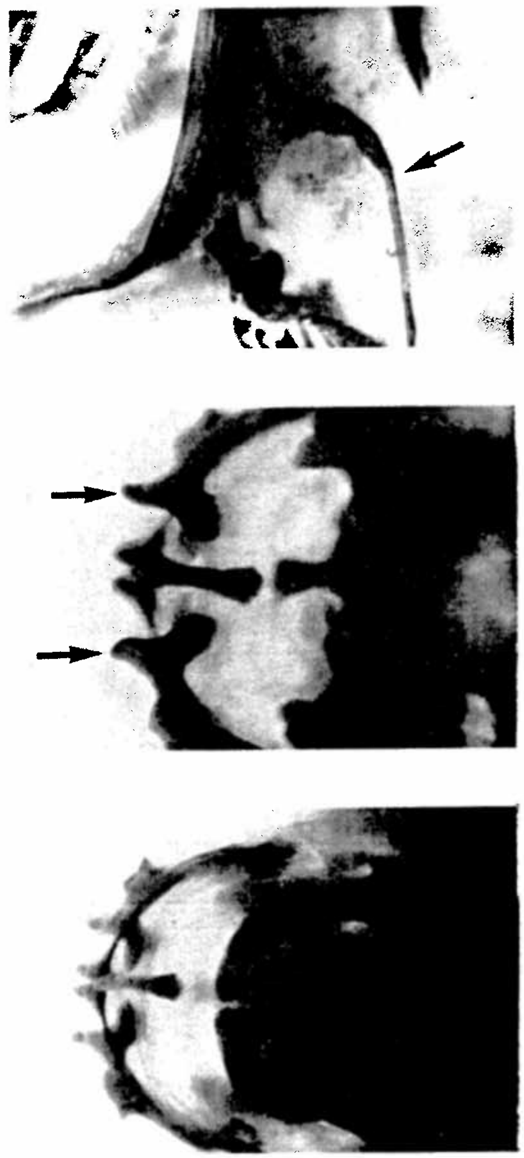

Fig. 51. Selected skeletal features of *Catostomus discobolus*, juvenile, 43.0 mm SL, 52.5 mm TL. Top - postcleithrum. Middle - anterior-dorsal maxillary projections. Bottom - mandible position.

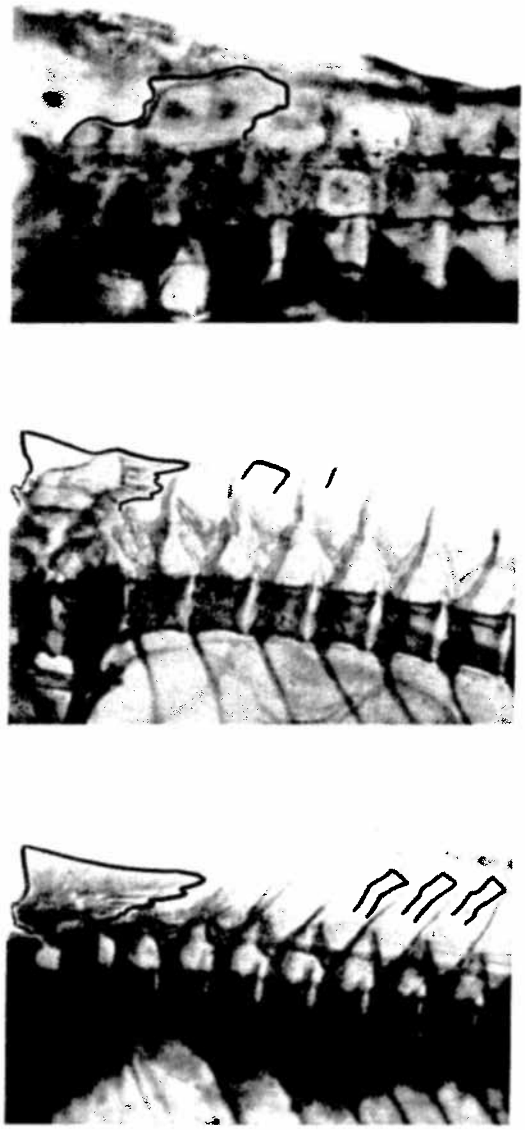

Fig. 52. Interneurals of *Catostomus discobolus*. Top -- postflexion mesolarva, 15.3 mm SL, 17.0 mm TL. Middle -- metalarva, 21.8 mm SL, 25.5 mm TL. Bottom -- juvenile, 43.0 mm SL, 52.5 mm TL.

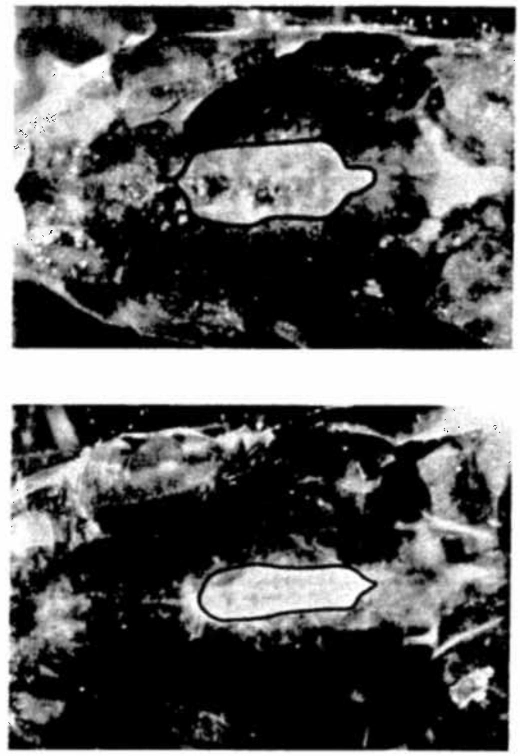

Fig. 53. Frontoparietal fontanelle of *Catostomus discobolus*. Top -- juvenile, 27.1 mm SL, 32.5 mm TL. Bottom -- juvenile, 32.4 mm SL, 38.5 mm TL.

Table 22. Dimensions of frontoparietal fontanelle for *Catostomus discobolus* larvae >16 mm SL, early (YOY) juveniles, and yearling.

Specimens mm SL	n	Max. width (mm)	Max. length (mm)	Width as % of length
17-19	4	0.6-0.9	1.4-1.8	41-50
20-21	2	0.5-0.9	1.7-1.7	29-35
22-25	3	0.5-0.8	1.3-2.8	29-38
26-34	2	0.6-0.7	2.0-2.2	27-35
35-46	1	0.7	2.7	26
76-81	1	0.7	3.7	19

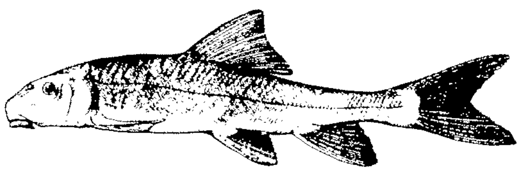

Fig. 54. *Catostomus latipinnis* adult (Miller 1952).

Adult Diagnosis: Back without conspicuous predorsal keel. Caudal peduncle slender, typically ≤6% SL. Mouth inferior, moderate in size; no hard, prominent, cartilaginous ridges along inside of jaws. Lips large, fleshy, profusely papillose, without notches at corners; lower lip with a deep median cleft allowing one or no rows of papillae to span the two lobes; lobes extend beyond vertical from nostrils, often to eyes. Dorsal fin large and falcate. Scales small. Fontanelle present. TL usually 30-40 cm, up to 60 cm. (Also, Table 23.)

Reproduction: Non-guarding, open-substrate lithophil. April to August, mostly May to early July, 6 to at least 13°C. Usually over gravel-cobble bars or riffles, or coarse gravel under <1.2 m of water. May or may not migrate to spawning grounds. Water-hardened eggs 3.8-3.9 mm diameter, demersal, initially adhesive.

Young: Larvae, predominately mesolarvae, drift, mostly at night. Young typically occupy slow to quiet and shallow waters along shore and in backwaters or pools; often in the marginal areas of swift-flowing streams; not common in sluggish, very warm areas.

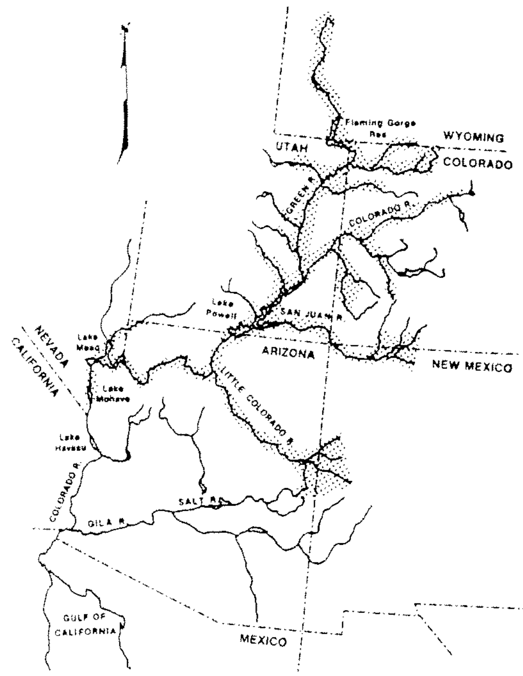

Fig. 55. Regional distribution of *Catostomus latipinnis*.

Table 23. Selected juvenile and adult meristics for *Catostomus latipinnis*. P = principal rays; R = rudimentary rays; D = dorsal; V = ventral. Scales are lateral series or line when complete. Four added to vertebral count for Weberian complex. Gill rakers for exterior row of first arch, specimens >70 mm SL. Mean or modal values underlined if known and noteworthy; rare or questionable extremes in parentheses.

Character	Original	Literature	Character	Original	Literature
Dorsal Fin Rays - P:	(11)12-13(14)	(10)11-12-13-14(15)	Dorsal Fin Rays - R:	3-4	
Anal Fin Rays - P:	7	7(8)	Anal Fin Rays - R:	(1)2-3	
Caudal Fin Rays - P:	18		Caudal Fin Rays - RD:	10-11-14	
Pectoral Fin Rays:	15-16-17	18	Caudal Fin Rays - RV:	9-10-11	
Pelvic Fin Rays:	(9)10(11)	9-10-11	Lateral Scales:		89-98-105-116(-120)
Vertebrae:	47-50		Gill Rakers:		25-27-31-32(-35)

Table 24. Size at apparent onset of selected developmental events for *Catostomus latipinnis*, as observed under low power magnification. P = principal rays; R = rudimentary rays. Scales are lateral series. Rare or questionable extremes in parentheses.

Event or Structure	Onset or Formation mm SL	Onset or Formation mm TL	Fin Rays or Scales	First Formed mm SL	First Formed mm TL	Last Formed mm SL	Last Formed mm TL
Hatched:	(8-)10-11	(8-)10-11	Dorsal - P:	15	16	17-18	20-22
Eyes Pigmented:	(9)10 or *	(9)10 or *	Anal - P:	17	18-19	19-20(21)	23-24
Yolk Assimilated:	15	16-17	Caudal - P:	13	13(14)	15	16
Finfold Absorbed:	23-24(25)	28-29(31)	Caudal - R:	(16)17	18(19)	23	28-29
Pectoral Fin Buds:	(9) or *	(9) or *	Pectoral:	17	18-19	19-22	22-27
Pelvic Fin Buds:	(15)16(17)	17-18	Pelvic:	17-18	19-20	23	(28)29
	* before hatching		Scales:	(36)37-39	(44)45-49	39-42	48-51

References: Baird and Girard 1854, Behnke et al. 1982, Beckman 1952, Carlson et al. 1979, Holden 1973, Hubbs and Hubbs 1947, Hubbs and Miller 1953, Hubbs et al. 1943, Jordan and Evermann 1896, Joseph et al. 1977, La Rivers 1962, Lee et al. 1980, McAda 1977, Miller 1952, Minckley 1973, Prewitt 1977, Sigler and Miller 1963, Tyus et al. 1982, Woodling 1985.

Table 25. Size at developmental interval (left) and gut phase (right) transitions for *Catostomus latipinnis*. See Fig. 5 for phases of gut folding. Rare or questionable extremes in parentheses.

Transition to	mm SL	mm TL	Transition to	mm SL	mm TL
Flexion Mesolarva:	13	13(14)	2 - 90° bend:	(17)18(-20)	(20)21(-24)
Postflexion Mesolarva:	15	16	3 - Full loop:	(19-)21-25(-27)	(23-)26-30(-33)
Metalarva:	19-20(21)	23-24	4 - Partial crossover:	(22)23-32(-37)	(27)28-39(-46)
Juvenile:	23-24(25)	28-29(-31)	5 - Full cross over:	(29-)35-42	(36-)40-51

Table 26. Summary of morphometrics and myomere counts by developmental phase for *Catostomus latipinnis*. See Fig. 4 for abbreviations and methods of measurement and counting. Protolarvae with unpigmented eyes excluded.

	Protolarvae (N=9)				Flexion Mesolarvae (N=10)				Postflexion Mesolarvae (N=20)				Metalarvae (N=15)				Juveniles (N=19)			
	$\bar{x}$ ± SD		Range		$\bar{x}$ ± SD		Range		$\bar{x}$ ± SD		Range		$\bar{x}$ ± SD		Range		$\bar{x}$ ± SD		Range	
SL, mm:	11	1	10	13	14	1	13	15	18	1	15	20	22	1	20	25	32	6	23	43
TL, mm:	12	1	11	13	14	1	14	16	20	2	16	24	27	2[h]	24	31	40	7	29	53
Lengths %SL:																				
AS to AE	2	0	2	3	3	1	3	4	6	1	3	7	7	1	6	8	8	1	7	10
PE	7	1	6	9	9	1	8	10	12	1	9	14	13	1	12	14	14	1	13	15
OP1	14	1	12	16	18	1	16	19	23	2	19	27	26	1	24	28	25	1	24	28
OP2									53	1[a]	50	54	55	1	52	57	55	1	52	57
PY	78	2	75	81	69	9	48	75	50	[b]	50	50								
OPAF	54	19	32	77	26	3	22	32	34	5[c]	27	44	55	11	34	67				
ODF	35	2	33	38	38	2	35	40	44	3[d]	36	48	45	0[i]	45	45				
OD									50	1[a]	49	51	49	1	47	51	48	1	46	49
ID									64	1[e]	62	67	65	1	62	67	65	1	61	66
PV	79	1	77	81	77	1	75	78	78	1	76	80	75	2	74	78	74	1	72	76
OA									78	1[f]	76	80	75	1	74	78	75	1	72	77
IA									84	1[g]	83	84	82	1	81	84	82	1	80	85
AFC									110	1	108	112	113	1	111	114	114	1[j]	112	116
PC	103	1	102	105	105	1	104	107	115	4	109	123	122	2[h]	117	125	123	1	121	125
Y	61	5	54	67	46	9	23	54	0	2	0	7								
P1	6	2	3	9	11	1	9	12	12	1	10	15	16	1	14	18	18	1	16	19
P2									4	2	0	7	11	2	9	13	14	1	11	15
D									18	2[a]	15	21	22	1	20	24	24	1	23	26
A									8	1[d]	5	9	12	2	9	14	14	1	12	16
Depths %SL:																				
at BPE	8	1	7	9	10	1	9	11	13	1	11	16	16	1	15	17	16	1	15	17
OP1	9	1	8	10	11	1	10	12	16	2	13	18	19	1	16	21	19	1	17	22
OD	14	1	13	15	11	1	9	13	14	3[c]	10	19	19	2	16	22	19	1	17	22
BPV	5	1	4	6	6	0	5	6	8	1	6	10	11	1	9	12	11	1	10	13
AMPM	3	1	2	3	3	0	3	4	6	1	4	7	7	0	6	8	7	0	7	8
Max. Yolk	12	3	9	16	5	2	2	8	0	0	0	1								
Widths %SL:																				
at BPE	8	1	6	9	10	1	9	12	13	1	10	15	16	1	14	17	15	1	15	17
OP1	7	1	6	9	7	1	6	8	11	1	8	13	14	1	13	16	16	1	14	17
OD	10	1	7	11	6	1	5	8	8	2	6	12	12	1	10	15	13	2	11	17
BPV	3	0	3	4	4	1	4	6	6	1	4	8	7	1	6	8	8	1	6	9
AMPM	2	0	1	2	2	0	1	2	3	0	2	3	4	0	3	4	4	0	3	5
Max. Yolk	13	3	9	18	6	3	1	9	0	0	0	1								
Myomeres:																				
to PY	38	1	37	39	34	5	22	38	21	[b]	21	21								
OPAF	23	11	10	37	7	2	5	10	9	3[c]	6	15	22	8[e]	9	32				
OP2									21	1[a]	19	23	22	1[e]	21	24	22	1[k]	21	23
ODF	12	2	10	15	13	1	12	15	15	1[h]	12	17	15	1[i]	14	15				
OD									18	1[a]	17	21	18	1[e]	16	19	18	1[k]	17	19
PV	39	1	38	40	39	1	38	40	39	1	37	40	37	1[e]	36	38	37	1[k]	36	38
Total	48	1	47	49	48	1	47	49	48	1	47	49	47	1[e]	46	48	48	1[k]	47	48

[a]N = 17; [b]N = 1; [c]N = 19; [d]N = 12; [e]N = 14; [f]N = 15; [g]N = 7; [h]N = 13; [i]N = 2; [j]N = 18; [k]N = 9

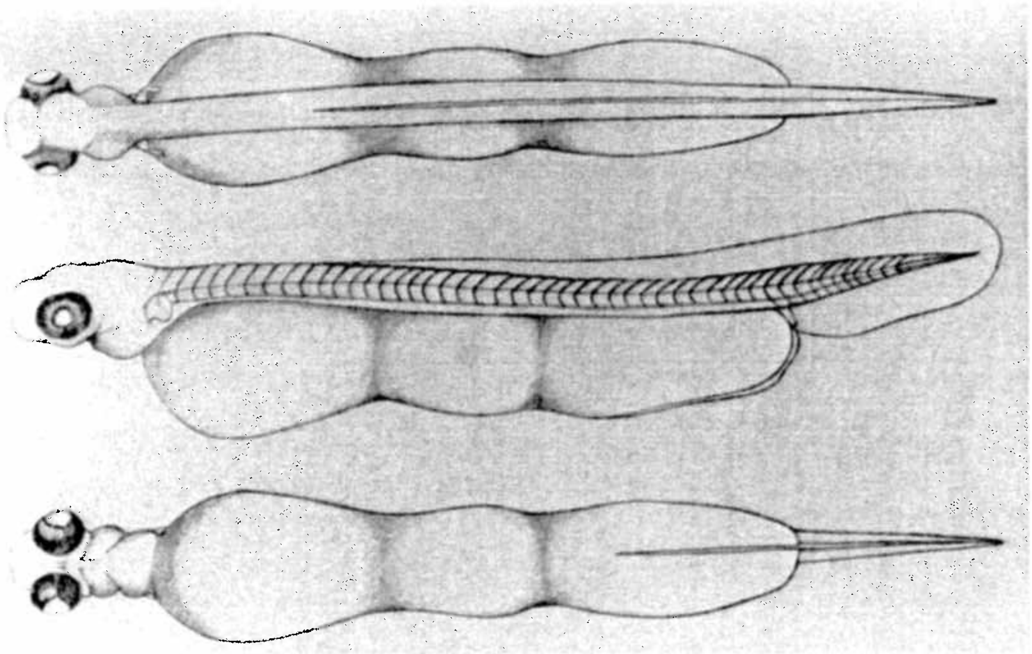

Fig. 56. *Catostomus latipinnis* protolarva, recently hatched, 10.3 mm SL, 10.6 mm TL. Cultured in 1978 with stock from the Yampa River, Colorado.

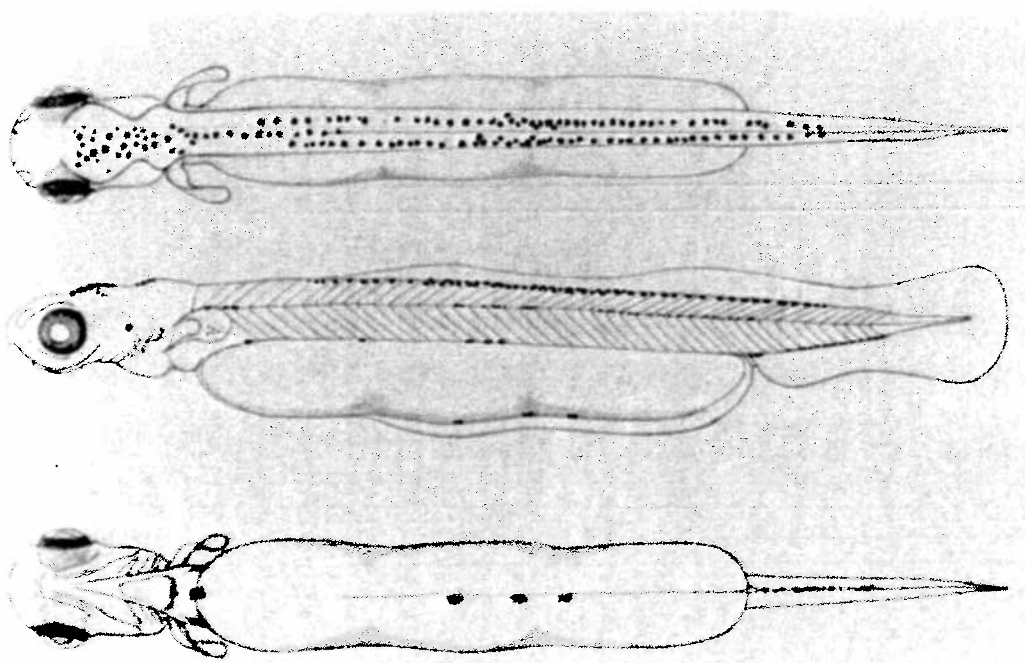

Fig. 57. *Catostomus latipinnis* protolarva, 12.4 mm SL, 12.9 mm TL. Cultured in 1978 with stock from the Yampa River, Colorado.

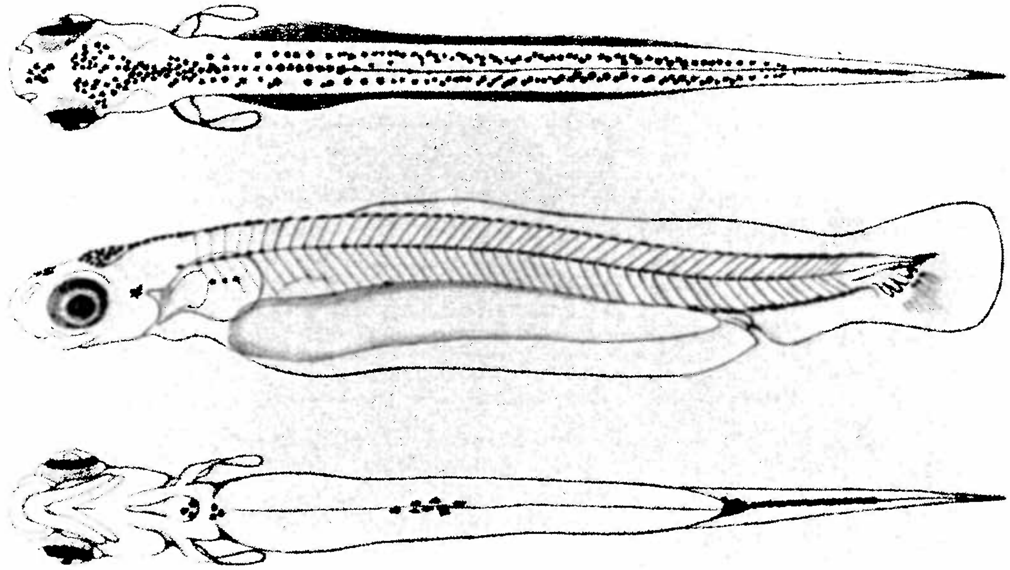

Fig. 58. *Catostomus latipinnis* flexion mesolarva, recently transformed, 13.0 mm SL, 14.0 mm TL. Cultured in 1978 with stock from the Yampa River, Colorado.

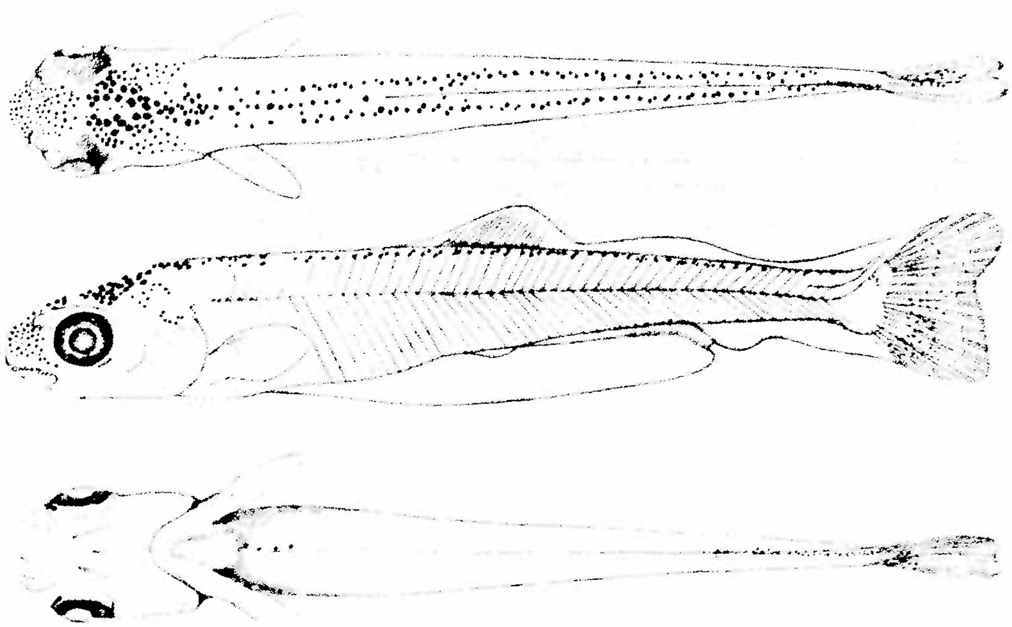

Fig. 59. *Catostomus latipinnis* postflexion mesolarva, 16.8 mm SL, 18.9 mm TL. Collected in 1976 from the White River, Colorado.

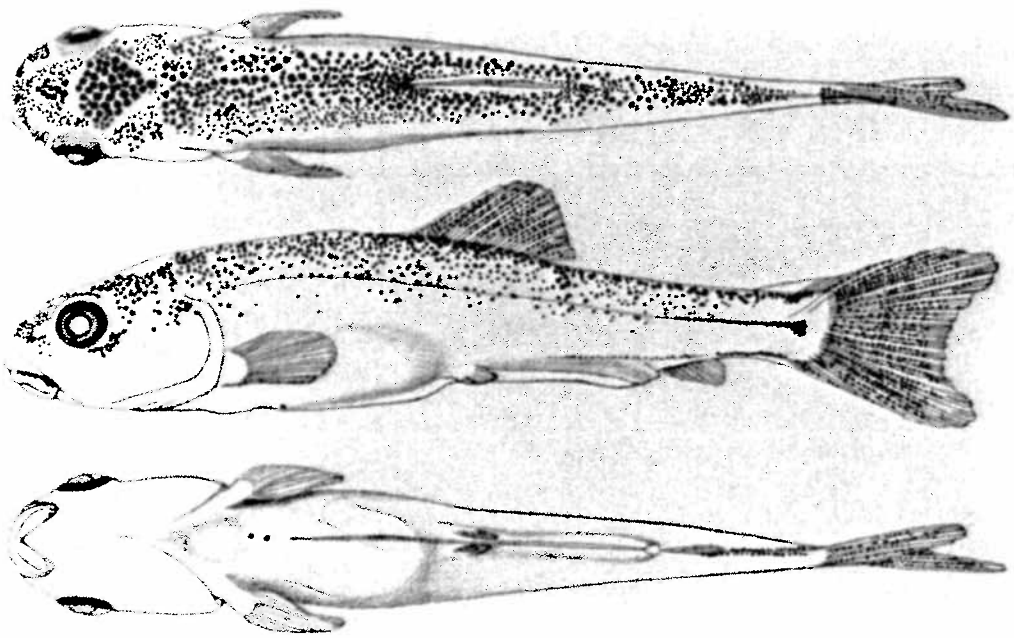

Fig. 60. *Catostomus latipinnis* metalarva, recently transformed, 20.5 mm SL, 24.5 mm TL. Collected in 1976 from the White River, Colorado.

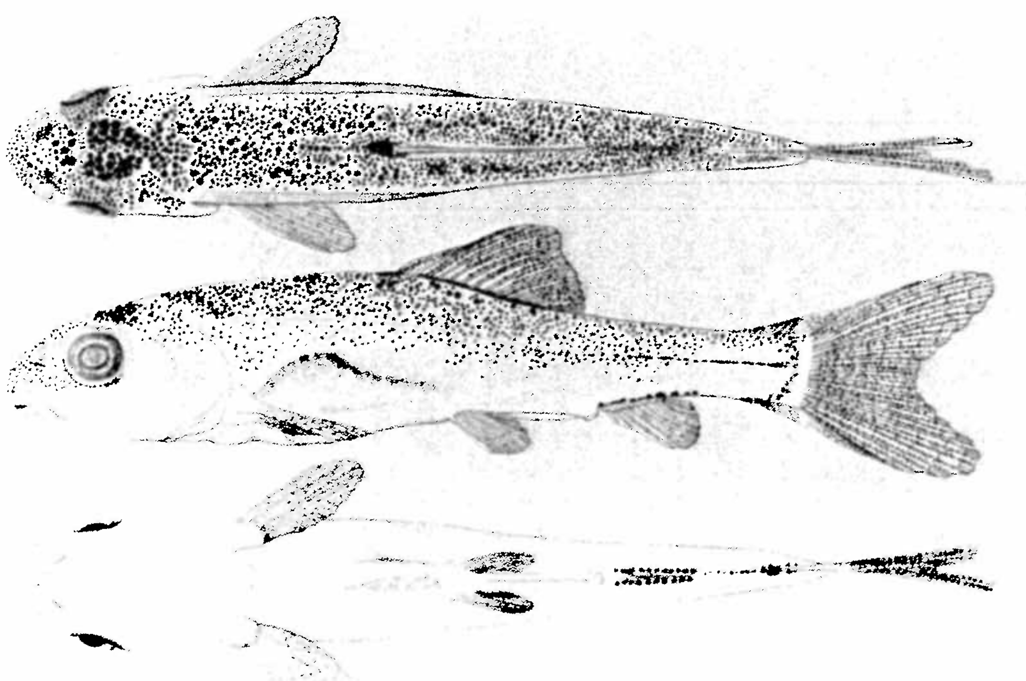

Fig. 61. *Catostomus latipinnis* metalarva, 22.7 mm SL, 27.5 mm TL. Collected in 1976 from the White River, Colorado.

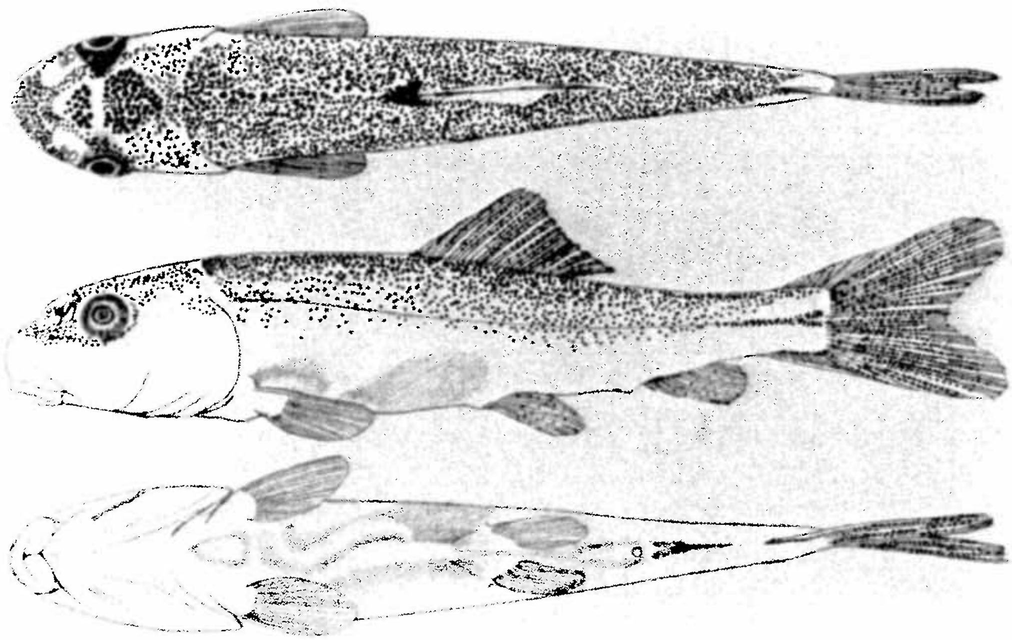

Fig. 62. *Catostomus latipinnis* juvenile, recently transformed, 26.6 mm SL, 32.0 mm TL. Collected in 1976 from the White River, Colorado.

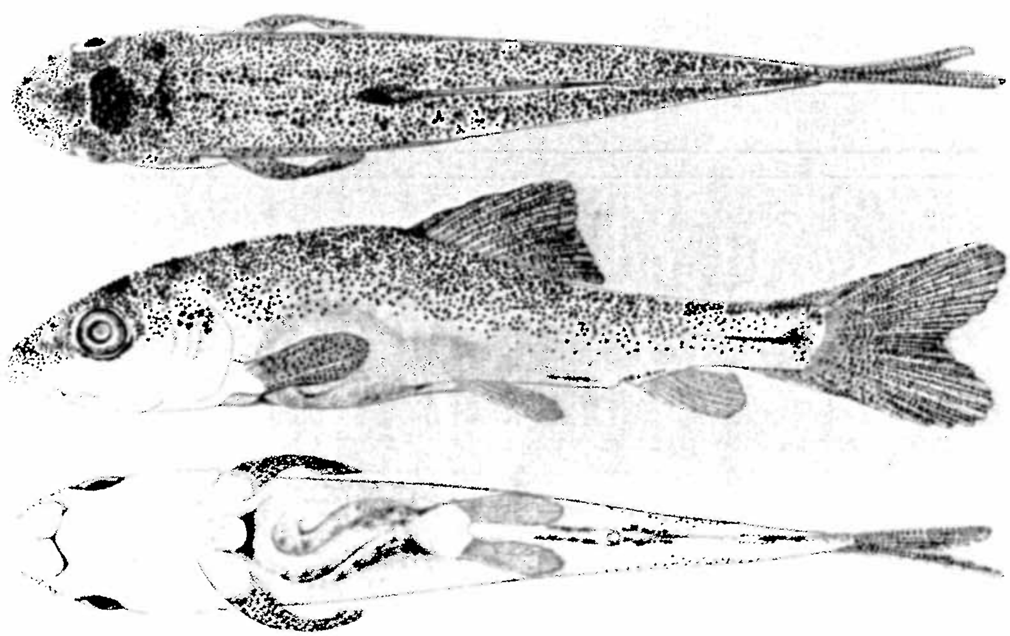

Fig. 63. *Catostomus latipinnis* juvenile, 31.6 mm SL, 38.0 mm TL. Collected in 1976 from the White River, Colorado.

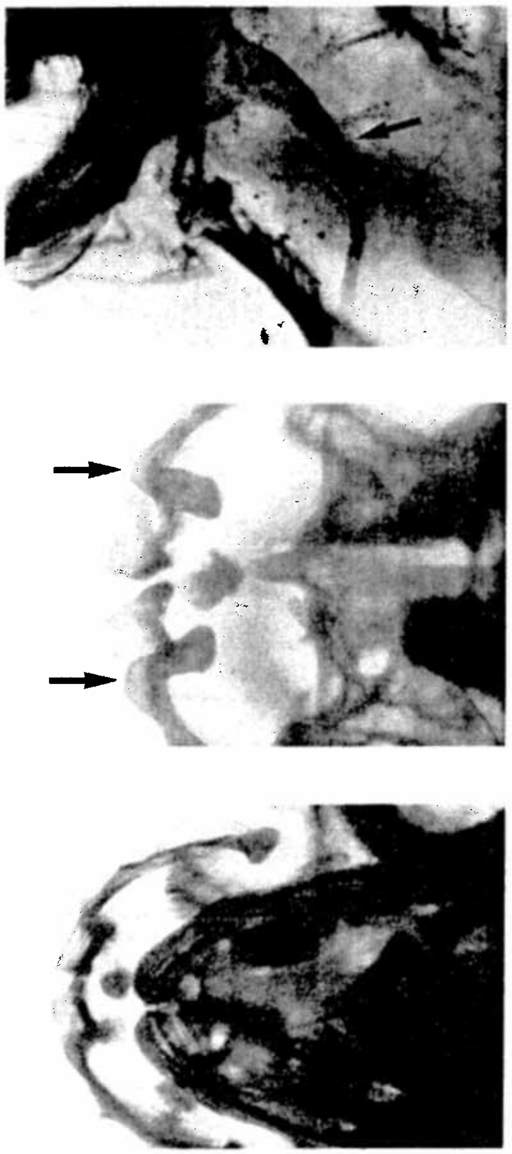

Fig. 64. Selected skeletal features of *Catostomus latipinnis*, metalarva, 24.6 mm SL, 29.0 mm TL. Top -- postcleithrum. Middle -- anterior-dorsal maxillary projections. Bottom -- mandible position.

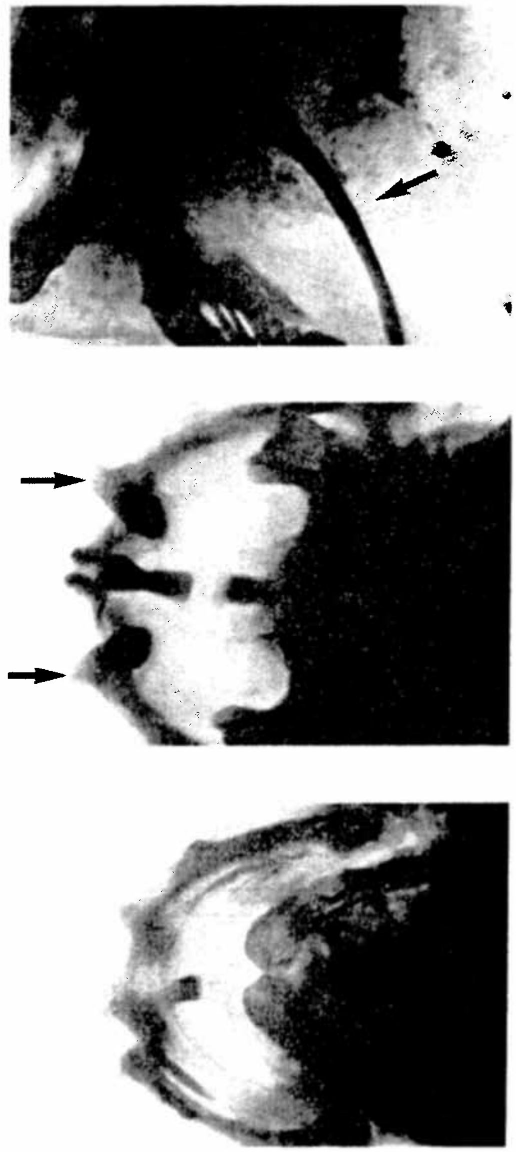

Fig. 65. Selected skeletal features of *Catostomus latipinnis*, juvenile, 42.1 mm SL, 52.0 mm TL. Top -- postcleithrum. Middle -- anterior-dorsal maxillary projections. Bottom -- mandible position.

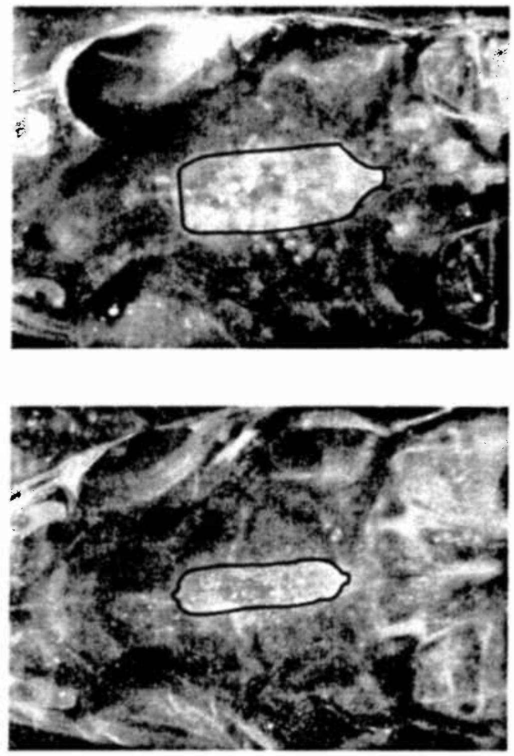

Fig. 67. Frontoparietal fontanelle of *Catostomus latipinnis*. Top -- metalarva, 24.6 mm SL, 29.0 mm TL. Bottom -- juvenile, 33.1 mm SL, 41.0 mm TL.

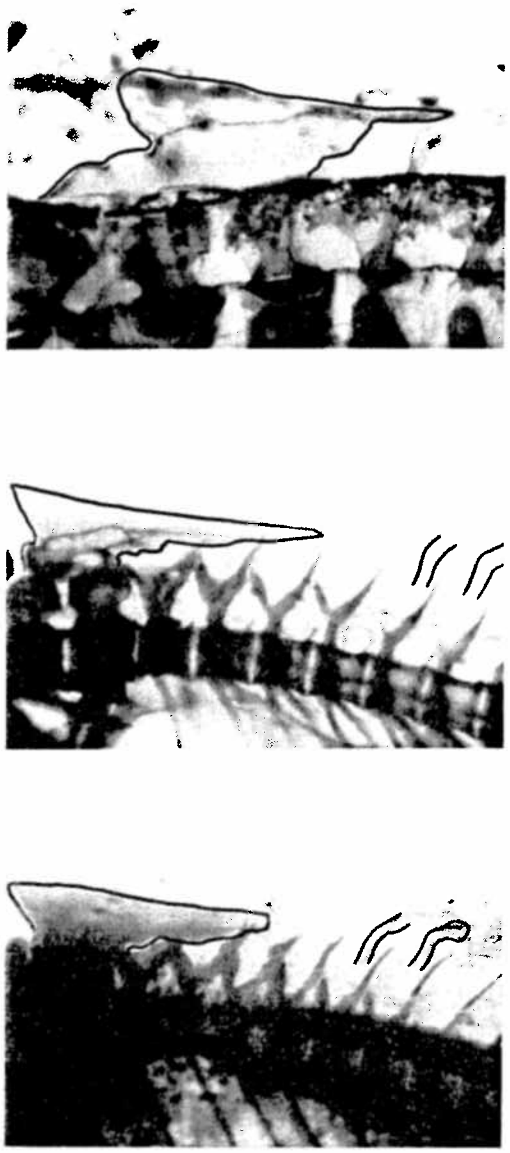

Fig. 66. Interneurals of *Catostomus latipinnis*. Top--postflexion mesolarva, 14.7 mm SL, 17.0 mm TL. Middle -- metalarva, 24.6 mm SL, 29.0 mm TL. Bottom -- juvenile, 42.1 mm SL, 52.0 mm TL.

Table 27. Dimensions of frontoparietal fontanelle for *Catostomus latipinnis* larvae >16 mm SL, early (YOY) juveniles, and yearling.

Specimens mm SL	n	Max. width (mm)	Max. length (mm)	Width as % of length
17-19	3	0.8-1.2	1.2-2.0	50-67
20-21	3	0.6-0.7	1.8-2.0	33-35
22-25	3	0.8-0.8	1.8-2.1	38-44
26-34	2	0.7-0.8	2.2-2.3	30-36
35-46	1	0.7	2.3	30
76-81	1	1.0	4.0	25

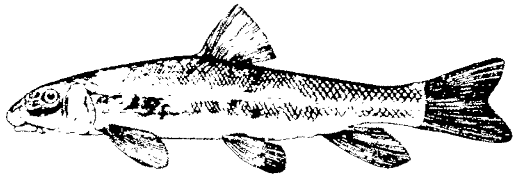

Fig. 68. *Catostomus platyrhynchus* adult (Miller 1952).

Adult Diagnosis: Back without conspicuous predorsal keel. Caudal peduncle deep, 8-10% SL. Mouth inferior and well back. Lips large with notches at outer corners, papillose except on outer face of upper lip and antero-lateral corners of lower lip; lower lip with shallow cleft, lobes broadly connected by 3-5 rows of papillae in a convex arch. Prominent, truncate cartilaginous ridge on anterior margin of lower jaw. Fontanelle narrow, rarely closed. Pelvic axillary process well developed. Inter-radial membranes of caudal fin with little or no pigment. Peritoneum black to dusky. TL up to 25 cm. (Also, Table 28.)

Reproduction: Non-guarding, open-substrate lithophil. Short period during May to mid-August, 11-19°C. Resident or tributary streams over gravel riffles, often adjacent to pools of swift mountain streams. Water-hardened eggs 2.3-2.7 mm diameter, demersal, initially adhesive.

Young: Hatch in 7-8 days at about 18°C. Young in streams, occasionally drift into lakes; often found in cover in shallow water of moderate current. Larger young often associated with aquatic plants in quiet backwaters, pools, eddies and intermittent side channels. Specimens <30 mm TL feed largely on invertebrates.

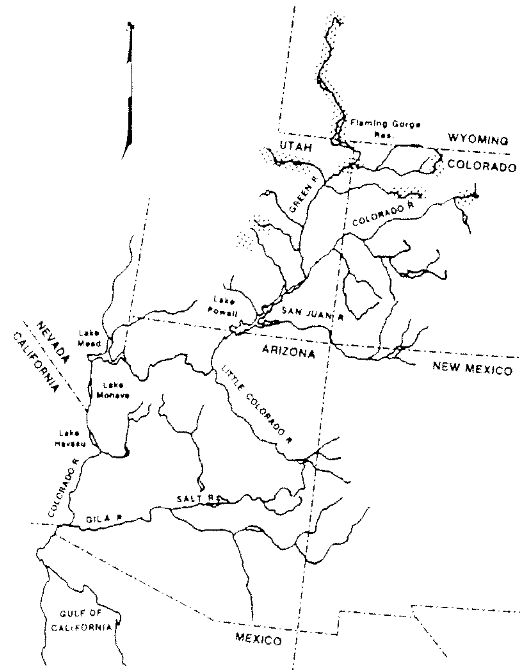

Fig. 69. Regional distribution of *Catostomus platyrhynchus*.

Table 28. Selected juvenile and adult meristics for *Catostomus platyrhynchus*. P = principal rays; R = rudimentary rays; D = dorsal; V = ventral. Four added to vertebral count for Weberian complex. Scales are lateral series or line when complete. Gill rakers for exterior row of first arch, specimens >70 mm SL. Mean or modal values underlined if known and noteworthy; rare or questionable extremes in parentheses.

Character	Original	Literature	Character	Original	Literature
Dorsal Fin Rays - P:	9-10-11	(8)9-10-12(13)	Dorsal Fin Rays - R:	(1)2-4	
Anal Fin Rays - P:	(6)7	7	Anal Fin Rays - R:	2-3	
Caudal Fin Rays - P:	(17)18		Caudal Fin Rays - RD:	(9-)11-12	
Pectoral Fin Rays:	14-15-16	15	Caudal Fin Rays - RV:	(7)8-9(11)	
Pelvic Fin Rays:	9-10	8-9-10	Lateral Scales:	76-86	(60-)75-97(-108)
Vertebrae:	46-48(50)	42-44-47(48)	Gill Rakers:		23-37

Table 29. Size at apparent onset of selected developmental events for *Catostomus platyrhynchus*, as observed under low power magnification. P = principal rays; R = rudimentary rays. Scales are lateral series. Rare or questionable extremes in parentheses.

Event or Structure	Onset or Formation mm SL	mm TL	Fin Rays or Scales	First Formed mm SL	mm TL	Last Formed mm SL	mm TL
Hatched:	(7)8	(7)8	Dorsal - P:	13	14	14-17	16-19
Eyes Pigmented:	8	8	Anal - P:	14-15	16-17	16-17	18-19
Yolk Assimilated:	(10)11	(10)11-12	Caudal - P:	11	11-12	13-14	15
Finfold Absorbed:	21-22	25-27	Caudal - R:	14	15-16	20-21	24-25
Pectoral Fin Buds:	(7) or *	(7) or *	Pectoral:	13-15	15-17	18-20	22-23
Pelvic Fin Buds:	13	14-15	Pelvic:	16	18	18-20	22-23
	* before hatching		Scales:	23-24	28-30	32-38	38-45

References: Baxter and Simon 1970, Beckman 1952, Behnke et al. 1982, Cope 1872, Hauser 1969, Hubbs et al. 1943, Jordan and Evermann 1896, Lee et al. 1980, Moyle 1976, Rutter 1903, Scott and Crossman 1973, Sigler and Miller 1963, Sigler and Sigler 1987., Simpson and Wallace 1978, Smith 1966, Tyus et al. 1982, Woodling 1985, Wydoski and Whitney 1979.

Table 30. Size at developmental interval (left) and gut phase (right) transitions for *Catostomus platyrhynchus*. See Fig. 5 for phases of gut folding. Rare or questionable extremes in parentheses.

Transition to	mm SL	mm TL	Transition to	mm SL	mm TL
Flexion Mesolarva:	11	11-12	2 - 90° bend:	14-17	16-19
Postflexion Mesolarva:	13-14	15	3 - Full loop:	16-17	18-21
Metalarva:	16-17	18-19	4 - Partial crossover:	18-20	22-24
Juvenile:	21-22	25-27	5 - Full cross over:	21-23	25-28

Table 31. Summary of morphometrics and myomere counts by developmental phase for *Catostomus platyrhynchus*. See Fig. 4 for abbreviations and methods of measurement and counting. Protolarvae with unpigmented eyes excluded.

	Protolarvae (N=12)				Flexion Mesolarvae (N=9)				Postflexion Mesolarvae (N=11)				Metalarvae (N=9)				Juveniles (N=8)			
	$\bar{x}$	±SD	Range		$\bar{x}$	±SD	Range		$\bar{x}$	±SD	Range		$\bar{x}$	±SD	Range		$\bar{x}$	±SD	Range	
SL, mm:	10	1	8	11	12	1	11	14	15	1	13	17	19	2	16	22	28	6	21	38
TL, mm:	10	1	8	12	13	1	11	15	16	1	15	19	22	3	18	27	34	7	25	45
Lengths %SL:																				
AS to AE	2	0	1	3	3	1	2	4	5	1	4	6	7	1	6	8	8	1	7	9
PE	9	1	8	10	9	1	8	11	12	1	10	13	13	1	12	14	14	1	13	15
OP1	17	1	16	18	19	1	17	21	23	2	20	26	25	1	23	26	25	1	24	26
OP2									54	1	52	56	56	2	53	58	57	2	55	60
PY	73	5[a]	62	80	51	1[c]	50	52												
OPAF	32	14	25	73	28	2	26	31	35	4	30	44	50	12	35	68				
ODF	40	3	36	46	41	2	38	43	44	2[e]	41	47	49	[f]	49	49				
OD									50	1	49	52	51	1	50	53	50	1	48	52
ID									62	1[b]	61	64	63	1	62	65	63	1	60	64
PV	78	2	75	81	77	1	75	78	79	1	77	80	77	1	75	78	75	1	74	78
OA									79	1[d]	77	79	77	1	76	78	76	1	74	78
IA									83	[f]	83	83	84	1	82	85	84	1	83	85
AFC									111	1	109	114	113	2	110	115	115	1	114	117
PC	104	1	101	106	107	1	105	109	113	2	110	118	118	2	115	120	121	1	119	123
Y	47	17	0	67	3	6	0	14												
P1	9	3	2	11	11	1	10	13	12	1	11	14	14	1	12	16	18	1	15	19
P2									4	2	1	8	8	1	6	11	12	1	10	13
D									13	1[e]	11	15	17	1	15	19	20	1	18	21
A									8	1[c]	7	8	10	2	8	13	14	1	12	15
Depths %SL:																				
at BPE	11	1	9	12	12	1	11	13	15	1	14	16	16	0	15	16	16	1	15	17
OP1	11	1	10	12	14	1	12	15	17	1	15	18	18	1	16	20	20	1	17	21
OD	12	1[b]	10	14	11	1[b]	10	12	13	1[g]	12	16	17	1	15	19	20	1	18	21
BPV	6	1	3	7	7	0	6	7	8	1	7	9	10	1	9	12	13	1	11	14
AMPM	3	1	2	4	4	0	4	5	6	1	5	6	7	1	6	8	9	0	8	9
Max. Yolk	5	4	0	13	0	1	0	1												
Widths %SL:																				
at BPE	10	1	8	11	11	1	10	13	14	1	13	16	15	1	14	16	16	1	15	17
OP1	7	2	6	12	9	1	8	10	12	1	11	13	14	1	13	16	17	1	14	18
OD	8	2[b]	6	11	6	1[b]	5	7	8	1[g]	7	10	12	1	10	14	15	1	13	17
BPV	4	0	3	4	4	0	4	4	5	1	4	5	7	1	6	9	9	1	8	10
AMPM	2	0	2	3	2	0	2	3	3	0	3	4	4	1	3	4	4	0	4	5
Max. Yolk	6	5	0	14	0	1	0	2												
Myomeres:																				
to PY	33	3[a]	26	35	23	1[c]	22	23												
OPAF	10	7	5	29	7	1	6	9	9	2	7	13	18	7	9	28				
OP2									21	1	19	22	21	1	20	22	22	0[d]	21	22
ODF	14	1	12	16	14	1	13	16	15	1[e]	13	17	15	[f]	15	15				
OD									19	1	17	19	18	1	16	19	18	1[d]	17	18
PV	36	1	35	37	36	1	35	37	36	1	34	37	35	1	32	36	34	1[d]	34	35
Total	45	1	44	46	46	1	44	47	45	1	43	46	45	1	43	45	45	1[d]	44	45

[a]N = 11; [b]N = 5; [c]N = 2; [d]N = 6; [e]N = 9; [f]N = 1; [g]N = 10

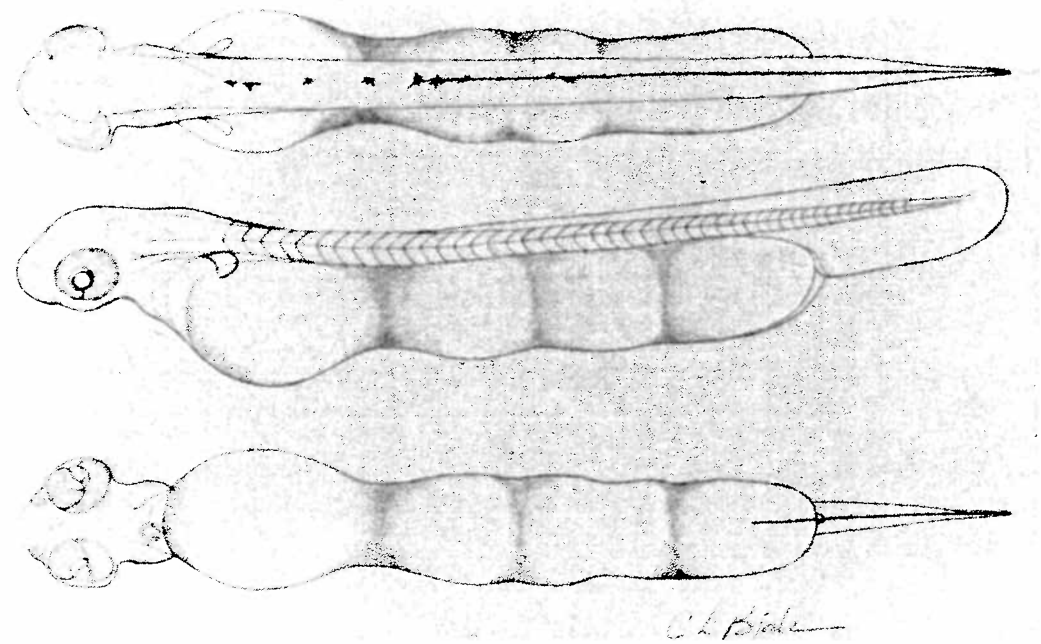

Fig. 70. *Catostomus platyrhynchus* protolarva, recently hatched, 8.1 mm SL, 8.2 mm TL (from Snyder 1983a). Cultured in 1981 with stock from Willow Creek, northwest of Steamboat Springs, Colorado.

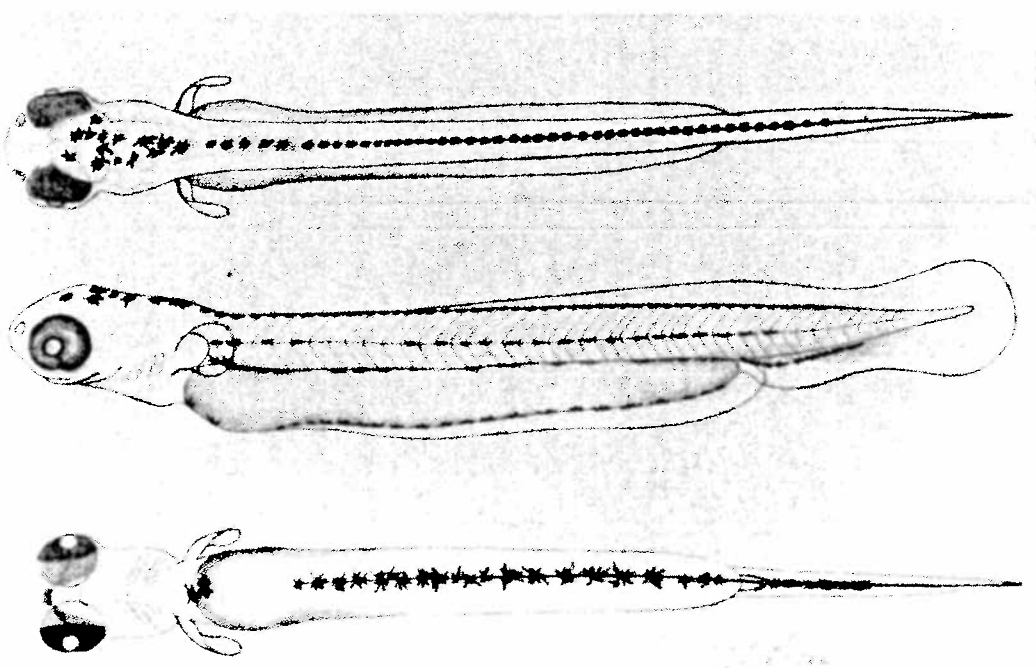

Fig. 71. *Catostomus platyrhynchus* protolarva, 9.5 mm SL, 9.8 mm TL (from Snyder 1983a). Cultured in 1981 with stock from Willow Creek, northwest of Steamboat Springs, Colorado.

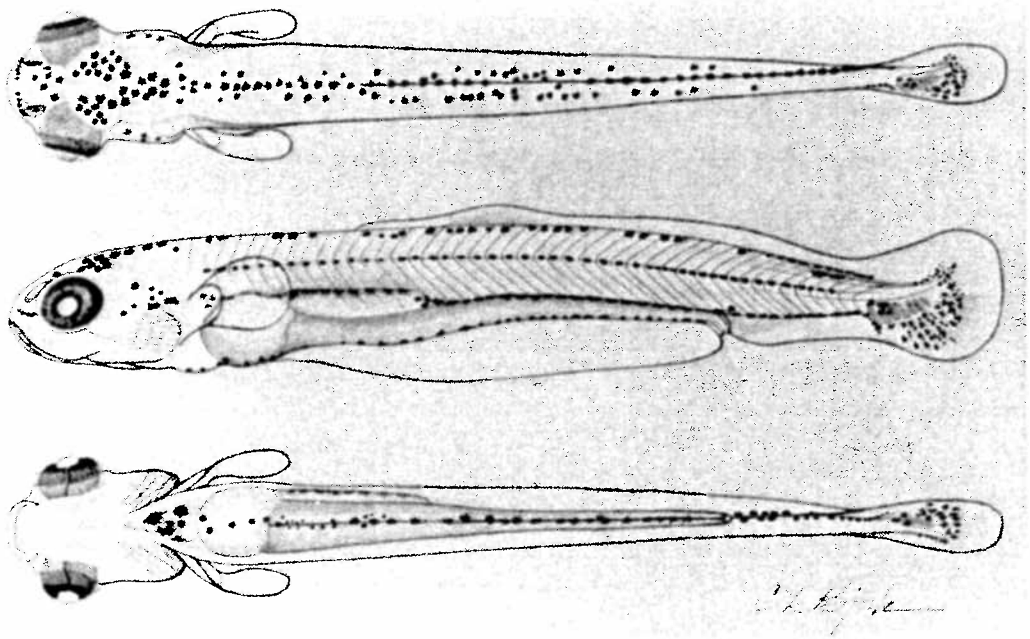

Fig. 72. *Catostomus platyrhynchus* flexion mesolarva, recently transformed, 12.1 mm SL, 12.8 mm TL (from Snyder 1983a). Cultured in 1981 with stock from Willow Creek, northwest of Steamboat Springs, Colorado.

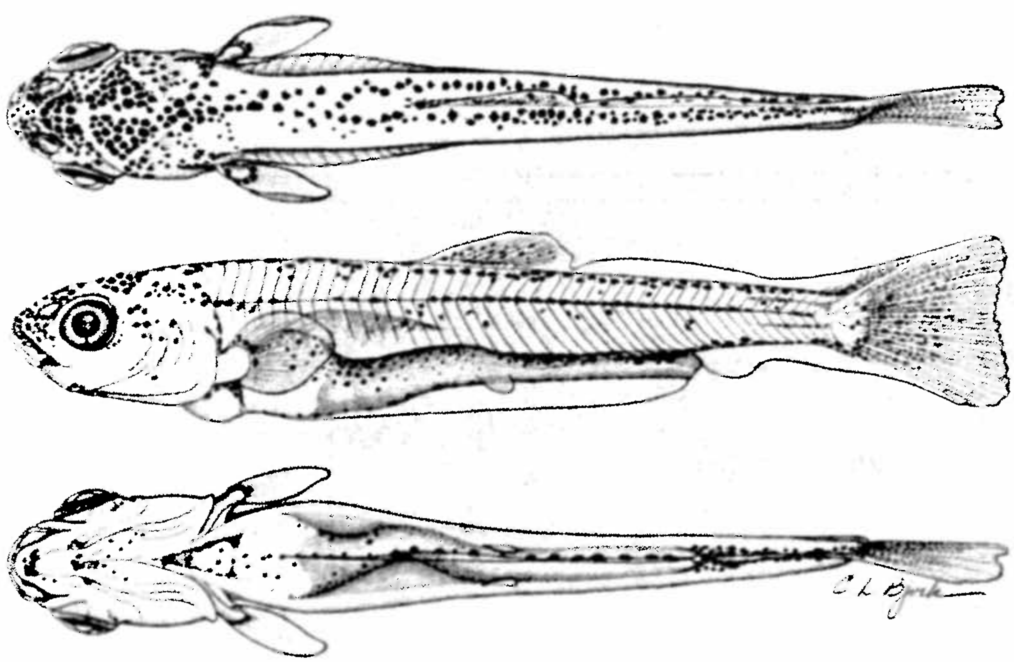

Fig. 73. *Catostomus platyrhynchus* postflexion mesolarva, 13.7 mm SL, 15.6 mm TL. Collected in 1981 from Willow Creek, northwest of Steamboat Springs, Colorado.

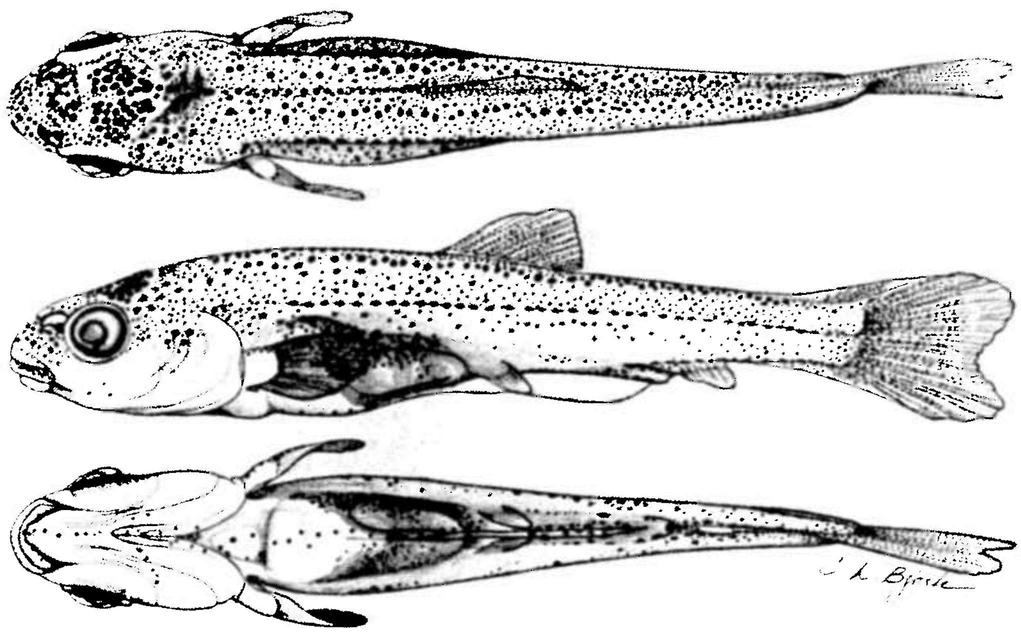

Fig. 74. *Catostomus platyrhynchus* metalarva, recently transformed, 16.3 mm SL, 19.6 mm TL. Collected in 1981 from Willow Creek, northwest of Steamboat Springs, Colorado.

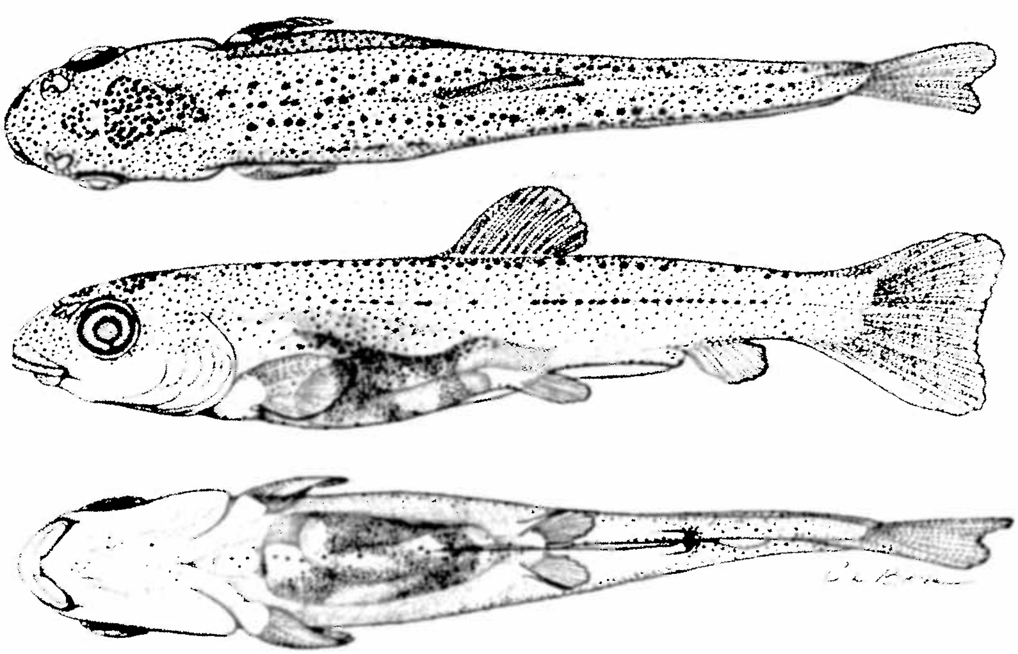

Fig. 75. *Catostomus platyrhynchus* metalarva, 19.6 mm SL, 22.5 mm TL. Collected in 1981 from Willow Creek, northwest of Steamboat Springs, Colorado.

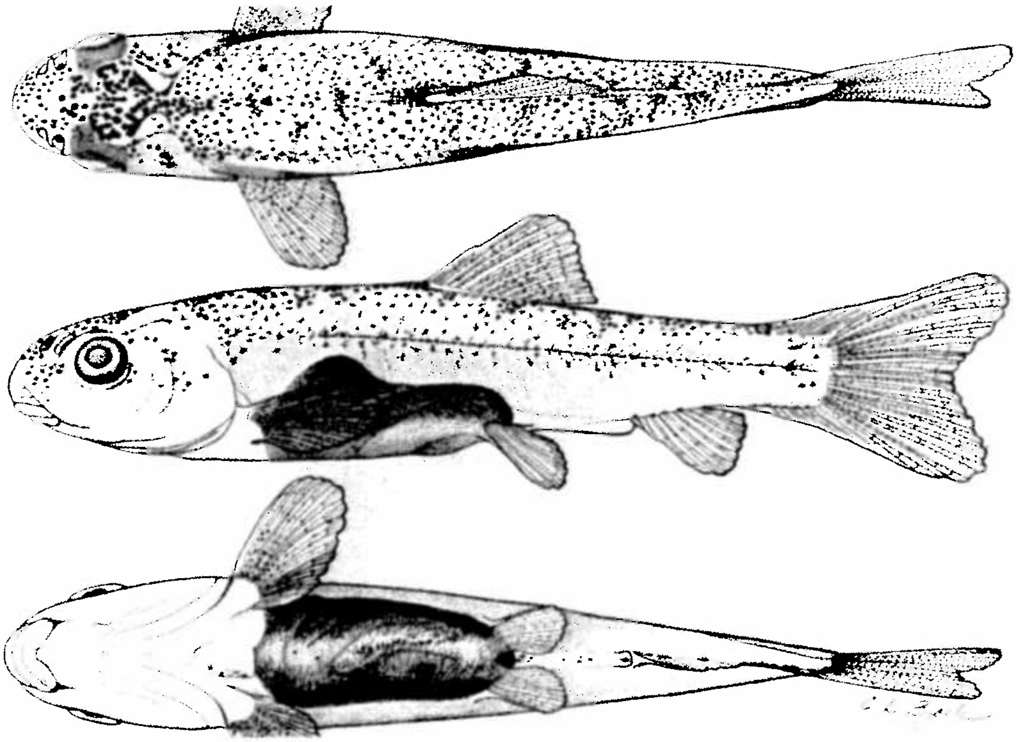

Fig. 76. *Catostomus platyrhynchus* juvenile, recently transformed, 20.6 mm SL, 25.2 mm TL. Collected in 1985 from Spanish Fork River, Utah Lake, Utah.

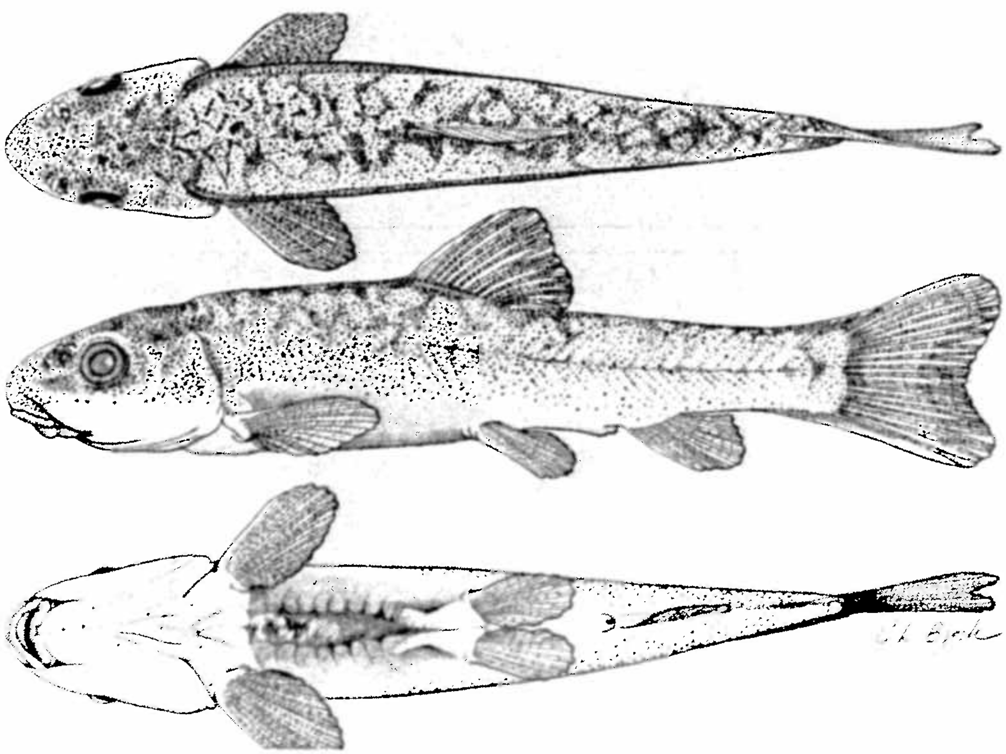

Fig. 77. *Catostomus platyrhynchus* juvenile, 31.5 mm SL, 38.0 mm TL. Collected in 1983 from Provo River, Utah Lake, Utah.

Fig. 78. Selected skeletal features of *Catostomus platyrhynchus*, juvenile, 21.2 mm SL, 24.0 mm TL. Top -- postcleithrum. Middle -- anterior-dorsal maxillary projections. Bottom -- mandible position.

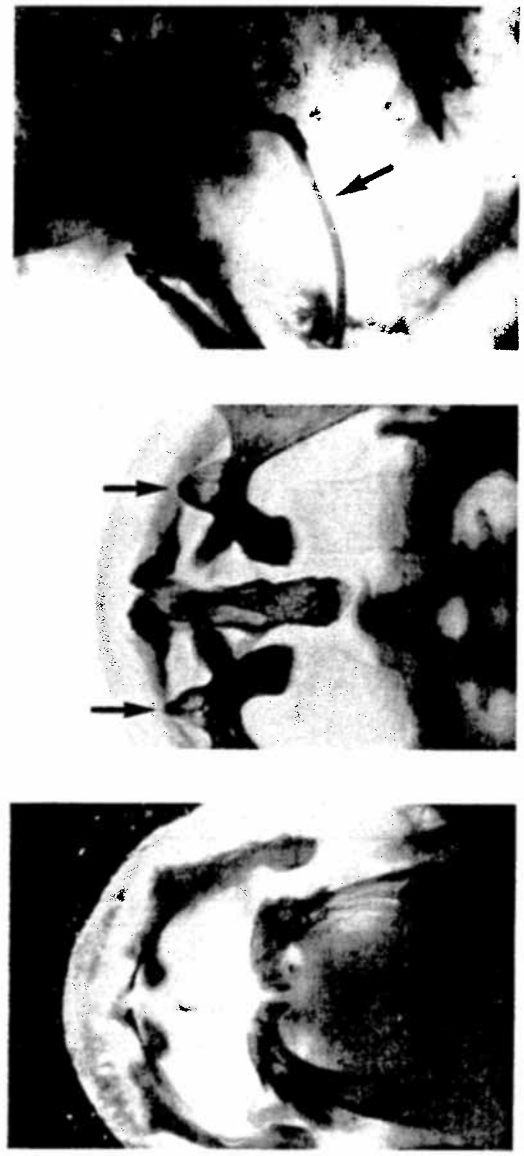

Fig. 79. Selected skeletal features of *Catostomus platyrhynchus*, juvenile, 45 mm SL, 53 mm TL. Top -- postcleithrum. Middle -- anterior-dorsal maxillary projections. Bottom -- mandible position.

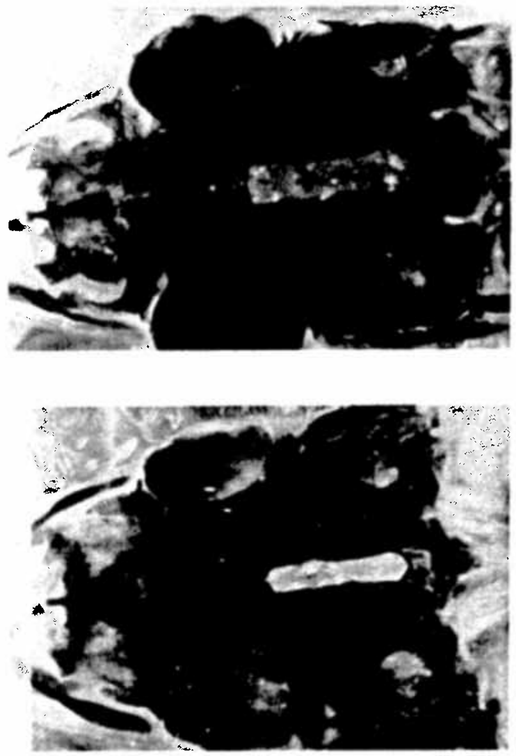

Fig. 81. Frontoparietal fontanelle of *Catostomus platyrhynchus*. Top -- juvenile, 21.2 mm SL, 24.0 mm TL. Bottom -- juvenile, 45.0 mm SL, 53.0 mm TL.

Fig. 80. Interneurals of *Catostomus platyrhynchus*. Top -- postflexion mesolarva, 14.8 mm SL, 17.0 mm TL. Middle -- juvenile, 21.2 mm SL, 24.0 mm TL. Bottom -- juvenile, 45.0 mm SL, 53.0 mm TL.

Table 32. Dimensions of frontoparietal fontanelle for *Catostomus platyrhynchus* larvae >16 mm SL, early (YOY) juveniles, and yearling.

Specimens mm SL	n	Max. width (mm)	Max. length (mm)	Width as % of length
17-19	0			
20-21	2	0.6-0.8	2.2-2.2	27-36
22-25	1	0.7	2.2	32
26-34	1	0.5	2.1	24
35-46	2	0.4-0.5	2.5-2.7	15-20
76-81	1	0	0	closed

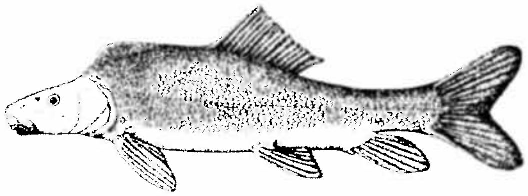

Fig. 82. *Xyrauchen texanus*, adult (from Behnke and Benson 1983).

Adult Diagnosis: Conspicuous predorsal keel. Caudal peduncle deep. Mouth inferior, moderate in size. Lips moderately to weakly papillose, without notches at corners. Lower lip with median cleft that completely separates the two lobes. Fontanelle well developed. Peritoneum black. TL usually 40-60 cm, up to 90 cm. (Also, Table 33.)

Reproduction: Non-guarding, open-substrate lithophil; possible redd creation. May and early June at 6-19°C in the Upper Colorado River Basin; Nov. to May, mostly Jan. to Mar. at 10-21°C in lower basin; usually with rising water levels. Spawn over gravel-cobble bars or riffles in rivers at <1 m/s, or near tributaries, in backwaters or along shore and coves of reservoirs over silt, sand, gravel, and rocks; under <6 m, usually <1 m, of water. Water-hardened eggs 2.5-2.8 mm diameter, demersal, and initially adhesive. Hatching unsuccessful or limited at ≤10°C, best around 20°C.

Young: At 18-20°C, hatch in 6-7, swim up in 12-13, and swim down in 27 days; at 15°C, 11, 17-21, and 38 days respectively. Remain in substrate until ready to migrate. Attracted by light at night. Larvae about 25 mm TL travel in large schools in warm shallows along shore.

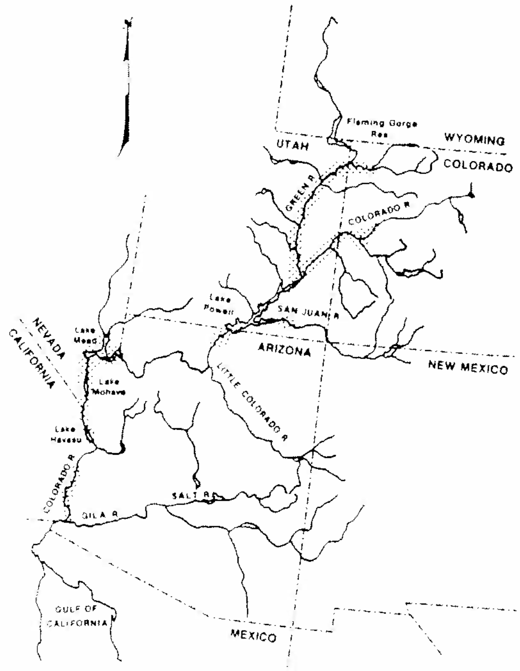

Fig. 83. Regional distribution of *Xyrauchen texanus*.

Table 33. Selected juvenile and adult meristics for *Xyrauchen texanus*. P = principal rays; R = rudimentary rays; D = dorsal; V = ventral. Scales are lateral series or line when complete. Four added to vertebral count for Weberian complex. Gill rakers for exterior row of first arch, specimens >100 mm SL. Mean or modal values underlined if known and noteworthy; rare or questionable extremes in parentheses.

Character	Original	Literature	Character	Original	Literature
Dorsal Fin Rays - P:	(12)13-14-15-16	(12)13-14-15-16	Dorsal Fin Rays - R:	3-4(5)	
Anal Fin Rays - P:	(6)7	7	Anal Fin Rays - R:	(1)2-3	
Caudal Fin Rays - P:	18	18	Caudal Fin Rays - RD:	10-11-12-13	
Pectoral Fin Rays:	15-16-17-18	16	Caudal Fin Rays - RV:	7-8-9-10	
Pelvic Fin Rays:	(9)10-11	10	Lateral Scales:		68-76-78-87(-95)
Vertebrae:	45-46-47		Gill Rakers:		44-50

Table 34. Size at apparent onset of selected developmental events for *Xyrauchen texanus*, as observed under low power magnification. P = principal rays; R = rudimentary rays. Scales are lateral series. Rare or questionable extremes in parentheses.

Event or Structure	Onset or Formation mm SL	mm TL	Fin Rays or Scales	First Formed mm SL	mm TL	Last Formed mm SL	mm TL
Hatched:	7-9	7-10	Dorsal - P:	[illegible]14	[illegible]15	15(-17)	17(-20)
Eyes Pigmented:	(7)8(9) or *	(7)8-9 or *	Anal - P:	[illegible]-15	[illegible]-17	15-17	18-20
Yolk Assimilated:	(9)10-11	(10)11-12	Caudal - P:	(10)11(12)	[illegible]11-12	(11)12-13	(13)14
Finfold Absorbed:	(21)22-23(24)	27-30	Caudal - R:	14	15-16	19-20(-24)	23-24(-30)
Pectoral Fin Buds:	7 or *	7 or *	Pectoral:	[illegible]-15	[illegible]17	16-18	20-22
Pelvic Fin Buds:	14	15	Pelvic:	[illegible]-15-17	[illegible]18-20	16-17	20-21
	* before hatching		Scales:	24-28	30-35	33-36(37)	42-45

References: Abbott 1860, Baxter and Simon 1970, Beckman 1952, Behnke et al. 1982, Bozek et al. 1984, Douglas 1952, Ellis 1914, Hubbs and Miller 1953, Jordan and Evermann 1896, La Rivers 1962, Lee et al. 1980, McAda 1977, Miller et al. 1982, Minckley 1973, Moyle 1976, Sigler and Miller 1963, Toney 1974, Tyus et al. 1982 and 1987, Wick et al. 1982, Woodling 1985.

Table 35. Size at developmental interval (left) and gut phase (right) transitions for *Xyrauchen texanus*. See Fig. 5 for phases of gut folding. Rare or questionable extremes in parentheses.

Transition to	mm SL	mm TL	Transition to	mm SL	mm TL
Flexion Mesolarva:	11(12)	11-12	2 - 90° bend:	(14)15(-17)	(16)17(-20)
Postflexion Mesolarva:	12-13	(13)14	3 - Full loop:	17	20
Metalarva:	15-17	18-20	4 - Partial crossover:	18-25(26)	22-30(-32)
Juvenile:	(21)22-23(24)	27-30	5 - Full cross over:	(22-)26-28(-31)	(27-)32-35(-38)

Table 36. Summary of morphometrics and myomere counts by developmental phase for *Xyrauchen texanus*. See Fig. 4 for abbreviations and methods of measurement and counting. Protolarvae with unpigmented eyes excluded.

	Protolarvae (N=25)				Flexion Mesolarvae (N=13)				Postflexion Mesolarvae (N=25)				Metalarvae (N=30)				Juveniles (N=33)			
	$\bar{x}$±SD		Range		$\bar{x}$±SD		Range		$\bar{x}$±SD		Range		$\bar{x}$±SD		Range		$\bar{x}$±SD		Range	
SL, mm:	10	1	8	11	12	1	11	13	14	1	12	17	19	2	15	24	28	4	22	37
TL, mm:	10	1	9	12	12	1	11	14	16	2	13	20	23	3	18	30	36	6	27	47
Lengths %SL:																				
AS to AE	2	0	1	3	2	1	2	3	5	1	3	7	7	1	4	9	8	1	6	9
PE	8	0	7	8	9	1	7	10	11	2	9	14	14	1	12	17	15	1	13	16
OP1	16	1	14	17	18	1	16	20	22	2	20	27	27	1	25	30	28	2	25	31
OP2									52	1[c]	50	54	56	2	51	58	57	2	54	60
PY	76	4	66	82	75	[b]	75	75												
OPAF	30	12	22	66	27	2	24	30	31	3	27	36	42	9	34	69				
ODF	34	2	32	39	37	3	33	44	42	3	36	45	45	2[g]	43	47				
OD									49	1[d]	47	51	49	1	47	51	49	1	46	52
ID									66	1[e]	65	67	67	1	65	69	67	1	65	70
PV	79	2	76	81	79	1	78	81	81	1	78	84	77	2	75	81	77	1	75	80
OA									81	1[f]	79	82	77	1	76	79	78	1	75	80
IA									86	0[f]	85	86	84	1	83	86	84	1	82	86
AFC									110	2	107	114	114	1	111	117	115	1	113	118
PC	105	1	103	106	106	1	104	108	113	4	108	119	123	2	120	128	125	1	123	128
Y	44	23	0	68	4	14	0	50												
P1	7	3	3	11	10	1	9	11	11	1	9	13	15	1	12	18	17	1	15	19
P2									3	3	0	7	12	2	8	14	15	1	12	16
D									19	1[e]	18	21	24	2	21	29	27	1	23	29
A									7	1[g]	5	9	12	1[h]	9	15	15	1	12	16
Depths %SL:																				
at BPE	9	1	8	10	11	1	9	13	13	2	11	16	16	1	15	18	18	1	16	20
OP1	11	1	9	12	13	1	10	14	16	2	13	20	20	1	18	23	22	1	20	23
OD	10	2	7	13	9	1	6	11	14	3	9	20	19	2	16	23	23	2	18	27
BPV	5	1	4	6	6	0	5	6	7	1	5	9	11	1	8	14	13	1	11	14
AMPM	3	0	2	4	4	1	3	5	6	1	4	7	8	1	7	9	8	0	7	9
Max. Yolk	5	3	0	9	0	1	0	2												
Widths %SL:																				
at BPE	9	1	7	11	11	1	10	12	12	1	11	14	15	1	14	17	16	1	15	18
OP1	6	1	5	8	8	1	6	9	10	2	8	14	15	2	12	17	18	1	15	20
OD	6	2	4	9	5	0	5	6	8	2	5	11	11	2	8	15	16	2	12	20
BPV	3	0	2	4	3	0	3	4	5	1	3	6	6	1	4	9	8	1	6	9
AMPM	2	0	1	3	2	0	2	2	3	0	2	4	3	0	2	4	4	0	3	4
Max. Yolk	5	3	0	9	0	1	0	5												
Myomeres:																				
to PY	37	2[a]	30	38	37	[b]	37	37												
OPAF	10	6	5	31	7	0	6	8	7	1	6	9	10	5[i]	6	30				
OP2									20	1[c]	19	22	20	1[i]	19	22				
ODF	12	1	10	16	13	1	12	16	14	1	12	17	14	1[g]	12	15				
OD									18	1[d]	16	20	16	1[i]	15	18				
PV	39	1	37	41	38	1	37	39	39	1	38	40	37	1[i]	36	39				
Total	48	1	46	49	47	1	46	49	47	1	46	49	46	1[i]	44	48				

[a]N = 20; [b]N = 1; [c]N = 18; [d]N = 17; [e]N = 7; [f]N = 5; [g]N = 6; [h]N = 29; [i]N = 27

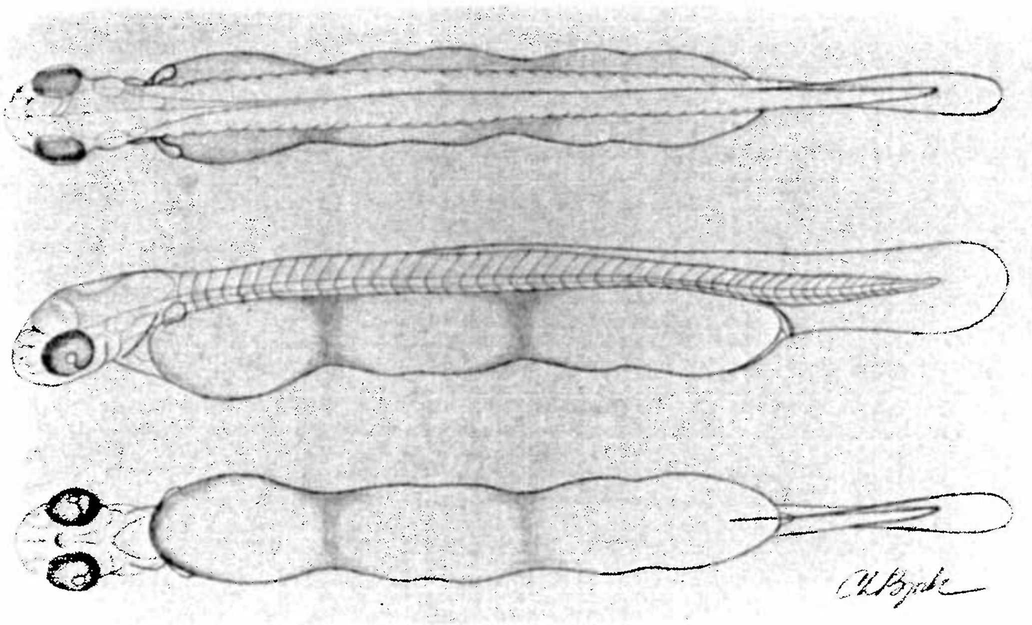

Fig. 84. *Xyrauchen texanus* protolarva, recently hatched, 9.2 mm SL, 9.4 mm TL. Cultured in 1980 from stock in Colorado River gravel pits near Clifton, Colorado.

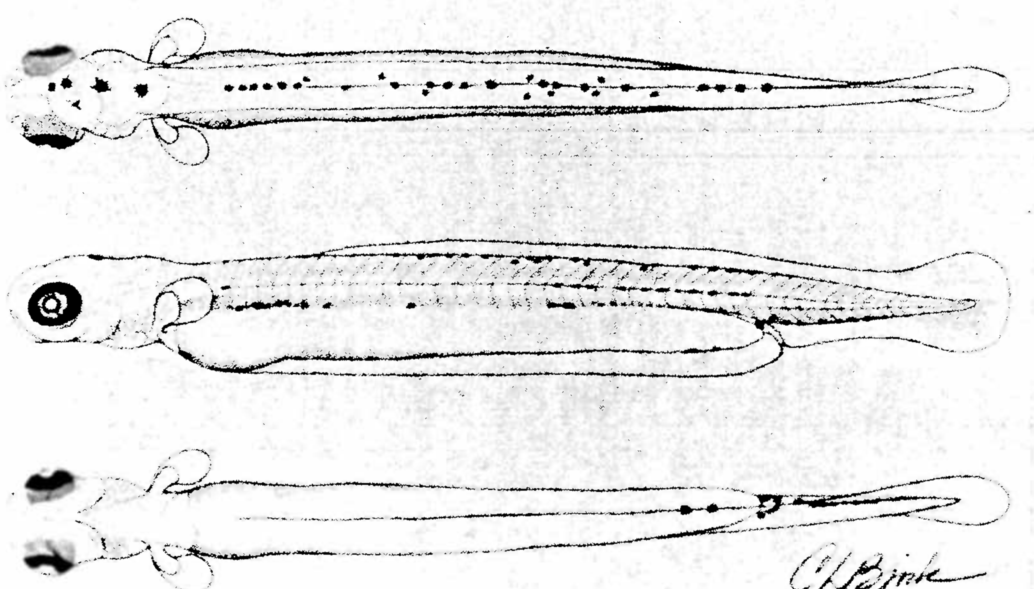

Fig. 85. *Xyrauchen texanus* protolarva, 10.5 mm SL, 10.9 mm TL. Cultured in 1980 from stock in Colorado River gravel pits near Clifton, Colorado.

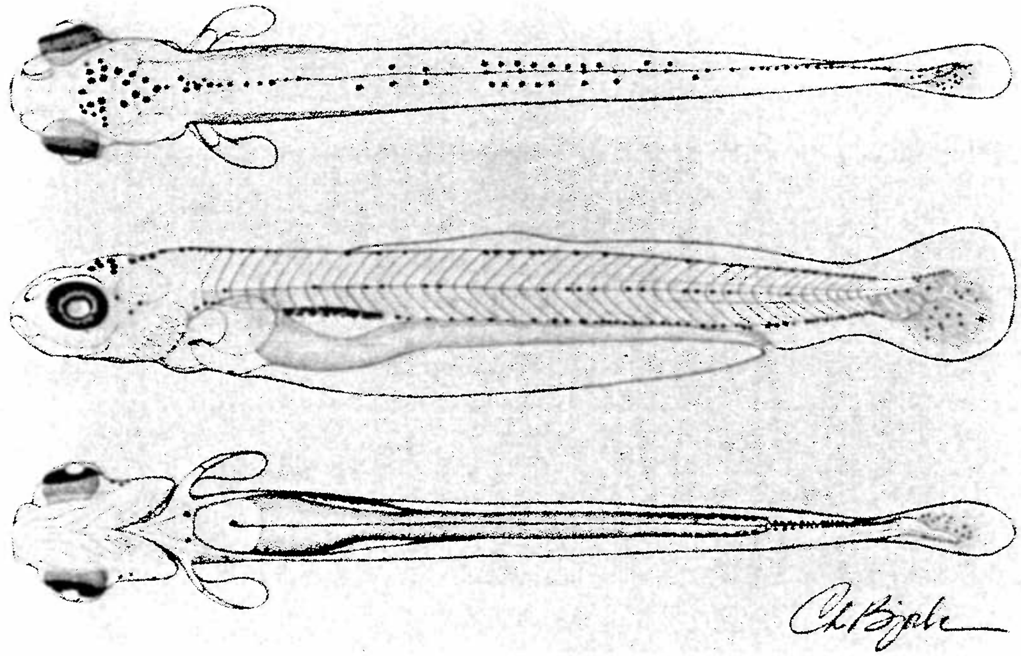

Fig. 86. *Xyrauchen texanus* flexion mesolarva, recently transformed, 12.5 mm SL, 12.9 mm TL. Cultured in 1980 from stock in Colorado River gravel pits near Clifton, Colorado.

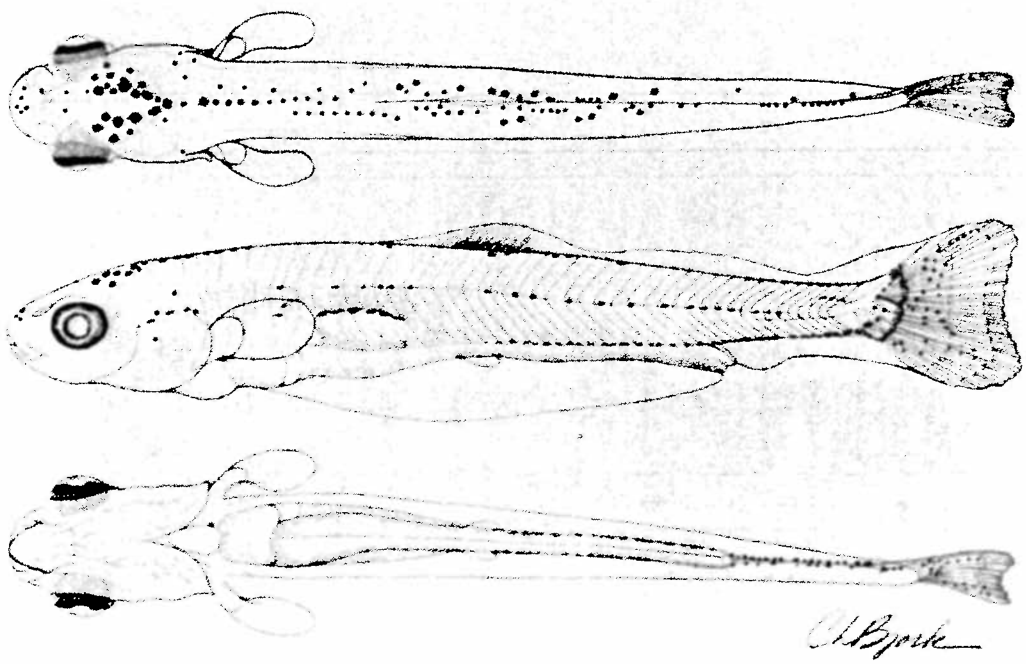

Fig. 87. *Xyrauchen texanus* postflexion mesolarva, 14.4 mm SL, 16.0 mm TL. Cultured in 1980 from stock in Colorado River gravel pits near Clifton, Colorado.

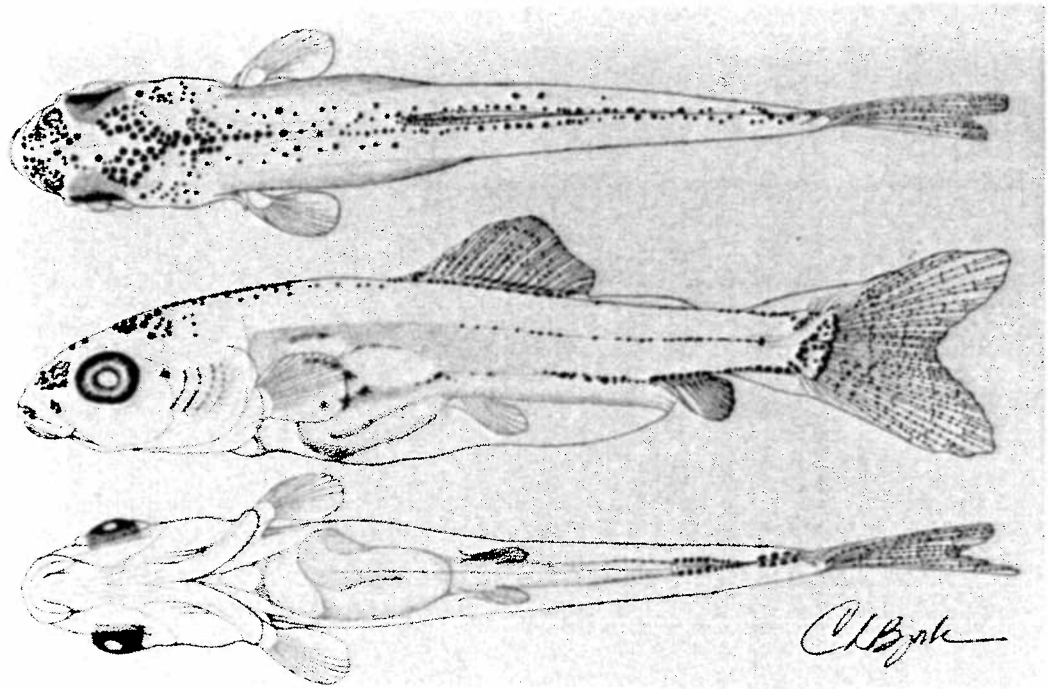

Fig. 88. *Xyrauchen texanus* metalarva, recently transformed, 16.2 mm SL, 19.4 mm TL. Cultured in 1980 from stock in Colorado River gravel pits near Clifton, Colorado.

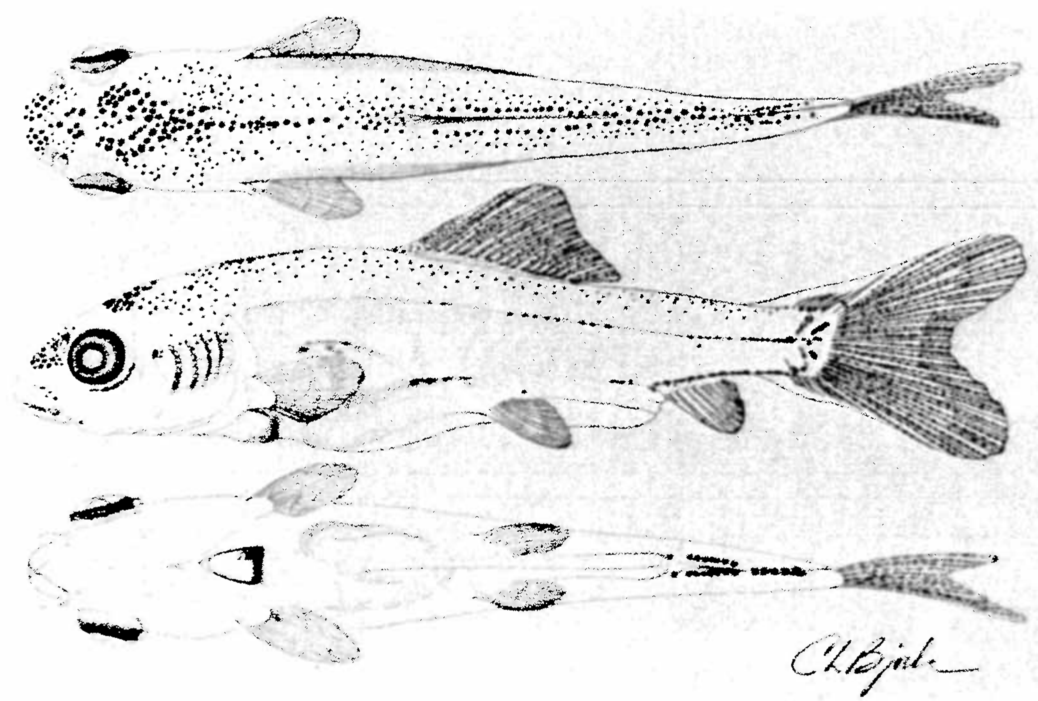

Fig. 89. *Xyrauchen texanus* metalarva, 18.8 mm SL, 22.8 mm TL. Cultured in 1980 from stock in Colorado River gravel pits near Clifton, Colorado.

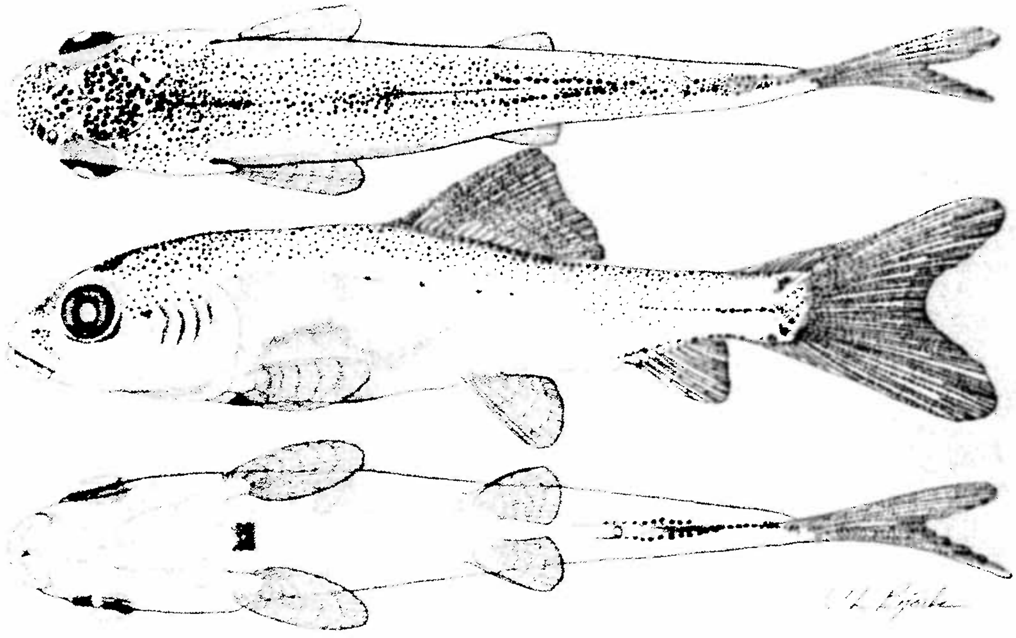

Fig. 90. *Xyrauchen texanus* juvenile, recently transformed, 21.6 mm SL, 27.0 mm TL. Cultured in 1980 from stock in Colorado River gravel pits near Clifton, Colorado.

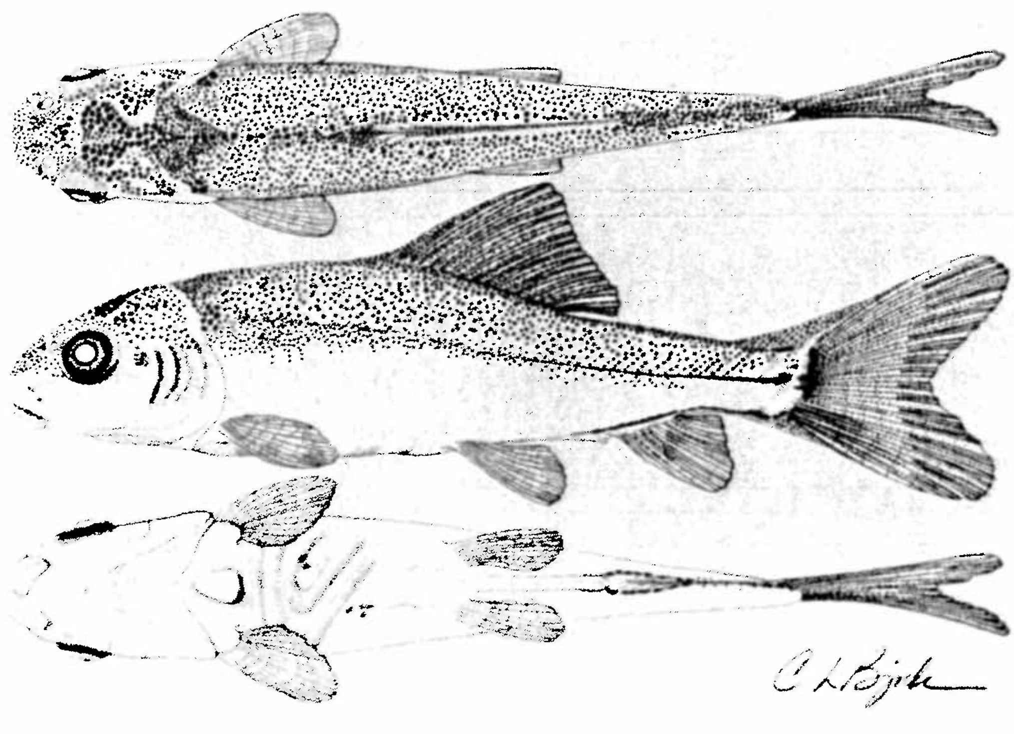

Fig. 91. *Xyrauchen texanus* juvenile, 30.2 mm SL, 37.4 mm TL. Cultured in 1980 from stock in Colorado River gravel pits near Clifton, Colorado.

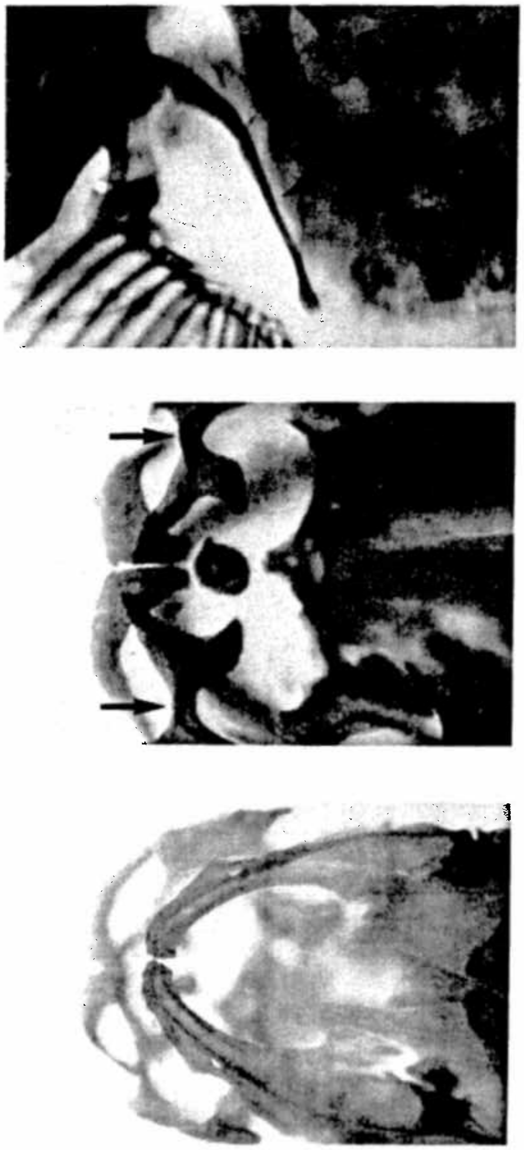

Fig. 92. Selected skeletal features of *Xyrauchen texanus*, metalarva, 20.0 mm SL, 23.8 mm TL. Top -- postcleithrum. Middle -- anterior-dorsal maxillary projections. Bottom -- mandible position.

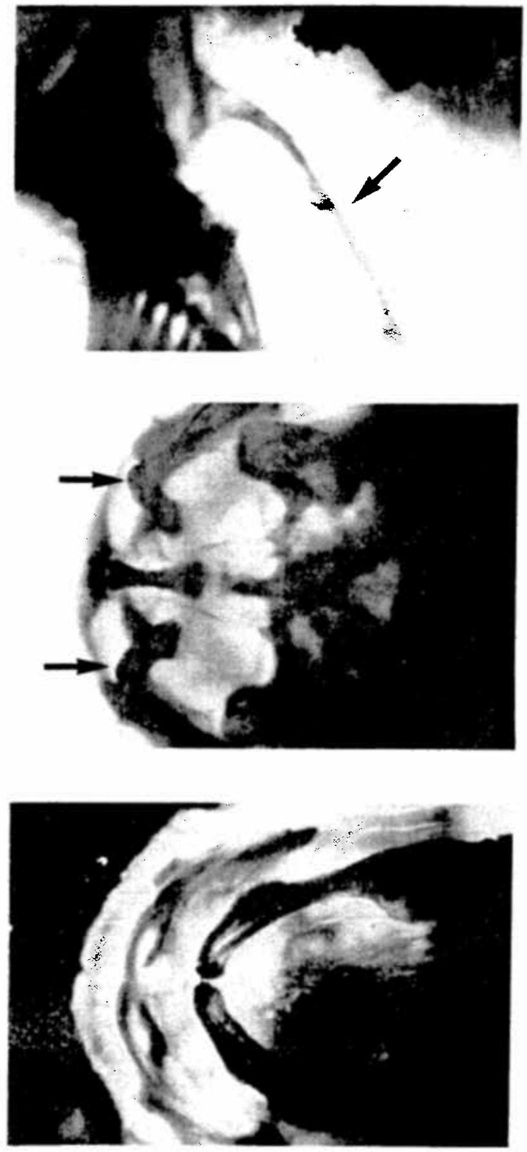

Fig. 93. Selected skeletal features of *Xyrauchen texanus*, juvenile, 40.5 mm SL, 51.0 mm TL. Top -- postcleithrum. Middle -- anterior-dorsal maxillary projections. Bottom -- mandible position.

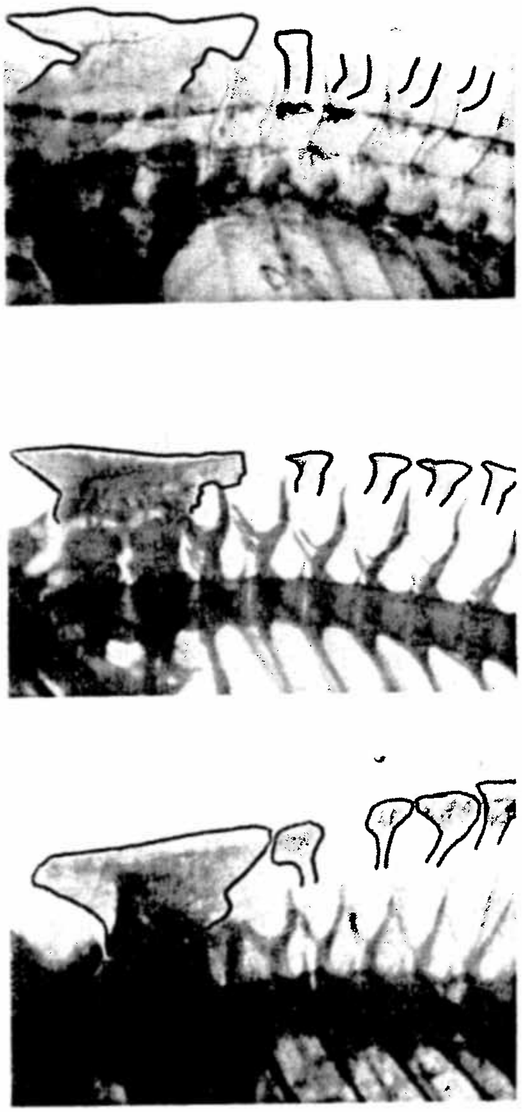

Fig. 94. Interneurals of *Xyrauchen texanus*. Top -- postflexion mesolarva, 14.3 mm SL, 17.0 mm TL. Middle -- metalarva, 20.0 mm SL, 23.8 mm TL. Bottom -- juvenile, 40.5 mm SL, 51.0 mm TL.

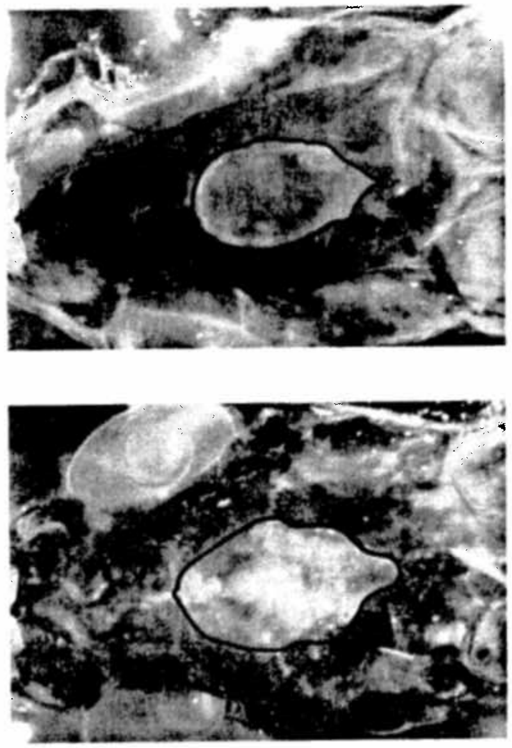

Fig. 95. Frontoparietal fontanelle of *Xyrauchen texanus*. Top -- metalarva, 21.5 mm SL, 27.4 mm TL. Bottom -- juvenile, 26.1 mm SL, 32.0 mm TL.

Table 37. Dimensions of frontoparietal fontanelle for *Xyrauchen texanus* larvae >16 mm SL, early (YOY) juveniles, and yearling.

Specimens mm SL	n	Max. width (mm)	Max. length (mm)	Width as % of length
17-19	3	1.0-1.2	1.7-1.9	59-63
20-21	5	1.0-1.3	1.8-2.1	52-68
22-25	2	1.0-1.3	1.9-2.1	53-62
26-34	2	0.9-1.3	2.1-2.3	43-57
35-46	3	1.1-1.7	2.3-3.4	48-50
76-81	1	2.3	5.1	45

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