Illustration of Plains Topminnow Larvae and Early Juveniles

Final Report

Prepared for

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Aquatic Wildlife Research Group
Colorado Division of Parks and Wildlife
Fort Collins Research Center
317 West Prospect Street
Fort Collins, Colorado 80526

July 2012

by

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Knowledge to Go Places

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Background:

The plains topminnow, *Fundulus sciadicus*, is a small (usually 4-6 cm) topfeeding fish characterized by a superior mouth, mid-body vent, dark peritoneum, dorsally flattened head covered with large scales, moderately large scales over the body with about 33-39 (usually 33-37) in the lateral series, lack of an externally visible lateral line, 9-12 (usually 10-11) dorsal-fin rays, 12-15 (rarely 15) anal fin rays, dorsal-fin origin notably behind the anal fin origin (and vent in juveniles and adults), and rounded caudal fin (Rahel and Thel 2004, literature cited therein, and original observations). In Colorado, it is one of only two representatives of the killifish family, Fundulidae, the other being the much more widespread northern plains killifish, *F. kansae* (Woodling 1985). Except for a couple introductions elsewhere in the state, the plains topminnow is found only in the South Platte River Basin, which is part of it's native range. There, Propst and Carlson (1986) assessed it as never having been common and typically inhabiting vegetated waters with little or no velocity, and Woodling (1985), citing Propst (1982), reported that it is "found in isolated colonies in cool foothills streams, intermittent plains streams and the lower mainstem South Platte River," to which can be added associated backwaters, wetlands, and ponds.

Elsewhere in Colorado, plains topminnow have been reported only as non-native introductions in the White River near Rio Blanco Lake (Tyus et al. 1982 via personal communication from Edmund Wick, Wick et al. 1985, Woodling 1985, Walker 1993, and Fuller 2012–the latter three mistakenly referencing Wick et al. 1981 rather than 1985), the Rio Grande (Zuckerman and Behnke 1986, Bestgen et al. 2003, Fuller 2012, CDPW ADAMAS–Colorado Division of Parks and Wildlife Aquatic Data Management System capture records provided by Harry Vermillion), and McElmo Creek (San Juan River Basin; CDPW ADAMAS). Its presence in the White River was based on three juveniles captured by Colorado State University Larval Fish Laboratory (LFL) researchers in 1981 (LFL Collection #56361 and 56363; Wick et al. 1985). Subsequent captures have not been reported and its persistence in the White River remains unknown. For the Rio Grande, Zuckerman and Behnke (1986) stated that accidental transfer had been reported, but not verified, and listed the species as extirpated; they neither referenced the presumed location of the release nor the source for the report. However, in 2002,

20 specimens were collected in the Rio Grande north of Monte Vista, Colorado, by LFL researchers (Bestgen et al. 2003; four adults of these were preserved as LFL Collection #89558), and in 2007, five adults were collected about 8 km east of Monte Vista by John Alves (CDPW ADAMAS), suggesting that the species has persisted in the drainage, perhaps from a more recent release. At least past presence in McElmo Creek is based on a collection of 21 juveniles and adults in 1977 just upstream of the Utah border and two collections of juveniles and adults, two in 1977 and one in 1978, about 1.5 km east of the border (CDPW ADAMAS– collectors were not listed).

The full native range of the plains topminnow, with one possible exception, is confined to portions of the Missouri River Basin, where it has been found in two disjunct regions (Lee et al. 1980, Rahel and Thel 2004, Pflieger 1997). One region is in the central Great Plains occupying much of Nebraska and extending into neighboring states, most notably southern South Dakota, southeastern Wyoming, and northwestern Colorado. The other, much smaller region, is in south-central Missouri. Outside the Missouri River Basin, presumably native populations are known only in a still smaller disjunct region in the central portion of the Neosha River Drainage (Arkansas River Basin) including the very south-western corner of Missouri (where they have been documented since before 1905–Pflieger 1997) and neighboring corners of Kansas and Oklahoma (Lee et al. 1980, Page and Burr 1991).

The conservation status of the plains topminnow, according to the NatureServe (2012) database, ranks as "apparently secure" nationally and in Colorado, but as "critically imperiled" to "vulnerable" in other states. Although Rahel and Thel (2004) and Koupal and Pasbrig (2010) reported that Colorado had listed the plains topminnow as a "species of special concern," the fish is not included by the Colorado Division of Parks and Wildlife (CDPW) on its current list of state threatened, endangered and special-concern species (http://wildlife.state.co.us/). However, Pasbrig et al. (2012) documented declining populations throughout much of its range with the greatest declines in the Platte River and Republican River drainages.

Rahel and Thel (2004) comprehensively reviewed information on the systematics and biology of the plains topminnow and assessed its management and conservation. Reproductively, the plains topminnow is a non-guarding phytophil, typically broadcasting its eggs over aquatic vegetation, including filamentous algae. Spawning occurs from mid-spring to early or mid-summer, beginning when water temperatures of reach 18-21 °C and ceasing by about 25 °C. The fish, which has a life-span of about 4 years, matures at age 1and produces an estimated 30-50 eggs per year.

Kaufmann and Lynch (1991) maintained and bred captive plains topminnow in aquaria and reported on their reproductive behavior, eggs, and development up to 4 days posthatch. They reported that spawned eggs appeared typical of the family with many small oil globules in the yolk and thin chorion filaments for attachment to vegetation (Able 1984), and measured 1.6-2.2 mm in diameter (but rarely over 2.0 mm with a mean of 1.8 mm). Embryonic development was noted as being similar to that described by Koenig and Livingston (1976) for the diamond killifish *Adinia xenica*. Reared at 21-23 °C in petri dishes, the embryos hatched in 13.5-14 days at a total length (TL) of 6.2-7.7 mm. In contrast, they noted that Mayer (1931) had reported hatching for captive bred fish in just 8-10 days at 21 °C. During the first day after hatching, the larvae "hung at the water's edge" but "swam in short jerky movements" if disturbed by tapping on the side of the petri dish; in the next couple days the larvae began swimming away when an observer approached. Four days after hatching, the larvae still lacked fin rays in the dorsal and anal fins and yolk depletion was obvious, but feeding had not yet been observed. Unfortunately, this was the extent of their description and the larvae have not been illustrated or further described.

Successful research on, and monitoring of, fish reproduction and early life history often depends on accurate identification of their collected larvae and early juveniles. Collections of these early life stages can help define spawning grounds, seasons, and requirements, as well as assess larval and juvenile fish production, survival, transport, migration, habitat use, and susceptibility to entrainment in water diversions and other impacts. Furthermore, knowledge of the morphological ontogeny of fish can be correlated with and is often useful in understanding other aspects of its early life history–physiology, ecology, behavior, and environmental effects.

Fortunately, among fishes in Colorado waters (but not necessarily elsewhere), the larvae and early juveniles of plains topminnow are sufficiently distinct that identification at the family level should not be a problem except for possible confusion with western mosquitofish (*Gambusia affinis*), family Poeciliidae. Mosquitofish larvae are born with little or no yolk in a more advanced state with all median fin rays developed but their general appearance (Kuntz 1914, Hardy 1978) is very similar to metalarvae and juveniles of the plains topminnow, including a dorsal-fin origin notably behind the anal-fin origin, but almost always with fewer dorsal-fin rays (5-10, usually 6-9) and anal-fin rays (7-11, usually 8-10) (Hardy 1978, Page and Burr 1991, various other state and regional guides). Able (1984) pointed out that one distinctive characteristic common to the recently hatched larvae of all fundulids is the absence of a preanal finfold.

Within the family Fundulidae, the earlier larvae of the plains topminnow may be difficult to distinguish from the only other species occurring (sometimes together) in Colorado, the plains killifish. Fortunately, the larvae and juveniles of the plains killifish have been described by Koster (1948), specifically a recently hatched 6.6 mm TL flexion mesolarva, an 8.1 mm flexion mesolarva without yolk, a 17.1 mm metalarva, and a 22.1 mm juvenile, but only the two mesolarvae are were illustrated (lateral view only). Comparing the early larvae of the plains killifish with descriptions for two other killifishes, he noted that plains killifish was less pigmented and had oval eyes. The metalarvae and juveniles of plains topminnow can be readily separated from plains killifish based on the latter having a dorsal fin position approximately over, rather than notably behind, the origin of the anal fin (and vent) and more dorsal-fin rays (11-16, but usually 14-15) (Woodling 1985, Page and Burr 1991, various other state and regional guides).

In mid-May through June 2009, Harry Crockett and Lindsy Ciepiela of the CDPW spawned plains topminnow captured from Boulder Open Space ponds in laboratory facilities at the CDPW Fort Collins Research Center and reared the larvae. A preserved series of recently hatched (6.2-6.9 mm TL) through 12-day old larvae (8.9 mm TL) was subsequently contributed in 2009 to the LFL Collection for reference and future study.

In February 2010, during discussions of a contract to illustrate the larvae and early juveniles of mountain whitefish *Prosopium williamsoni* for CDPW (Snyder and Bjork 2011), Crockett inquired about the possibility of doing a similar set of illustrations for plains topminnow if their larvae had not already been described and illustrated and the contributed larvae were sufficient for that purpose. A search of the literature revealed that plains topminnow larvae had not been illustrated, nor described aside from the minimal information reviewed above. Examination of the contributed larvae and uncataloged larvae and juveniles in several local collections by LFL Director Kevin Bestgen from Riverbend Ponds, Fort Collins, in 1986 and 1989 revealed an adequate series of specimens for both illustration and subsequent description. In early 2011, CDPW (Ryan Fitzpatrick) agreed to proceed with the proposed illustrations as part of their cooperative agreement with LFL.

Objective:

The objective of this project was to prepare a series of detailed drawings of plains topminnow larvae and early juveniles to illustrate their early morphological development, aid identification of field-collected specimens, and use in pertinent CDPW reports and publications and future detailed descriptions. The latter could be prepared as a stand-alone descriptive species account (e.g., Snyder et al. 2011 for woundfin), incorporated in a comparative description (e.g., Martinez 1983 and 1984 for brook, brown, rainbow, and cutthroat trout), and (or) incorporated in a guide and key (e.g., Snyder and Muth 2004 for catostomid larvae and juveniles of the Upper Colorado River Basin).

Methods:

Drawings were prepared 8-inch long on 8.5 x 11 inch white translucent vellum paper using continuous-tone graphite (pencil) and black ink. Black ink was used only to represent

surface or near-surface pigmentation and distinguish it from deeper pigmentation, other structures, and shading. Each drawing includes three views portraying the dorsal, lateral, and ventral aspects of the fish–for many species, structure and pigmentation patterns in dorsal and ventral views are useful in the identification of wild-caught specimens. Specimens of typical appearance in good to excellent condition (straight with well-spread fins and little to no damage) were selected as primary, secondary, and often tertiary drawing specimens for each stage to be illustrated. The basic outlines and features of each view were traced from enlarged digital images of the primary drawing specimen to assure proportionally accurate dimensions and position of body structures. Various structures were checked and detail added while drawing specimens were examined under a microscope. If necessary, drawings were idealized (e.g., closed or frayed fins opened and smoothed and curved bodies straightened), and modified to better represent typical melanophore distribution and structure based on secondary and sometimes tertiary drawing specimens (however, only the sources of the primary drawing specimens are included in associated figure legends). Preliminary, base, and final drawings were critically reviewed to further assure accurate representation of the illustrated fish. Completed drawings were professionally scanned and processed as high-, medium-, and low-resolution digital files for storage, copy, transfer, print reproduction, and electronic display. Prints of the drawings are included at the end of this report in a size and format typically used by LFL for its descriptive species accounts. The original drawings are stored and maintained by LFL.

LFL typically illustrates up to eight stages to adequately portray the morphological development of fish larvae and early juveniles–specifically recently transformed and later stages of the protolarval, mesolarval, and metalarval phases of the larval period and also of the early (young-of-the year) portion of the juvenile period. However, because plains topminnow hatch as relatively large (6-7 mm TL), late-stage flexion mesolarvae (notochord fully flexed but only 14-15 of 19-20 principal caudal-fin rays distinctly formed) and there is not much difference in the appearance of recently transformed and later metalarvae or recently transformed and later juveniles, it was determined that illustration of just four stages would be adequate to represent the larval and early juvenile development of the species and optional illustration of a later juvenile was deemed unnecessary. The specific stages selected for illustration were a recently hatched flexion mesolarva with yolk(6.2 mm TL), a recently transformed postflexion mesolarva (all principal caudal-fin rays present; 8.9 mm TL), a recently transformed metalarva (all principal median-fin rays and pelvic buds or fins present; 12.9 mm TL), and a recently transformed juvenile (adult counts of all fin rays present and median finfold absorbed; 19.1 mm TL).

Results and End Products:

The results of this project are presented as Figures 1-4 at the end of this report using the format of the illustration portion of our standard descriptive species account. Regarding the potential difficulty in distinguishing the early larvae of plains topminnow from plains killifish discussed above (background section), Figures 1 and 2 reveal that plains topminnow mesolarvae have round (rather than oval) eyes and are more heavily pigmented.

A CD (compact disk) with copies of high-, medium-, and low- resolution digital images (cleaned scans) of the four drawings has been prepared and accompanies the originally submitted print version of this report for CDPW archival storage and use. Additional copies of the CD or specific image files can be provided upon request.

Acknowledgments:

With the guidance of CDPW Aquatic Research Scientists Ryan Fitzpatrick and Harry Crockett, and LFL Director Kevin Bestgen, this project was funded by the CDPW through a cooperative agreement with LFL. Specimens for these illustrations, LFL Collection reference, and possible future descriptive study were reared by Harry Crockett and CDPW technician Lindsy Ciepiela or collected from local ponds by Kevin Bestgen. Kevin Bestgen reviewed and offered suggestions for improvement of the draft report.

Literature Cited:

Able, K. W. 1984. Cyprinodontiformes. Pages 362-368 *in* Moser et al., editors. Ontogeny and systematics of fishes. American Society of Ichthyology and Herpetology Special Publication No. 1.

Bestgen, K. R., R. I. Compton, K. A. Zelasko, and J. A. Alves. 2003. Distribution and status of Rio Grande chub in Colorado. Final report of Colorado State University Larval Fish Laboratory to Colorado Division of Wildlife, Fort Collins (LFL Contribution 135).

Fuller, P. 2012. *Fundulus sciadicus*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. Available: http:/nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=691, Revision Date: 5 December 2003 (June 2012).

Hardy, J. D., Jr. 1978. Development of fishes of the Mid-Atlantic Bight, an atlas of egg, larval and juvenile stages, volume II, Anguillidae through Syngnathathidae. U.S. Fish and Wildlife Service FWS/OBS-78/12 (volume 2).

Koenig, C. C., and R. J. Livingston. 1976. The embryological development of the diamond killifish (Adinia xenica). Copeia 1976:435-445.

Koster, W. J. 1948. Notes on the spawning activities and the young stages of *Plancterus kansae* (Garman). Copeia 1948:25-33.

Koupal, K. and C. A. Pasbrig. 2010. Development, growth and reproduction of plains topminnow, *Fundulus sciadicus*, in a broodstock pond located at Sacramento-Wilcox Management Area. Final Performance Report, Project No. T-57. Nebraska Game and Parks Commission, Fisheries Division, Lincoln.

Kuntz, A. 1914. Notes on the habits, morphology of the reproductive organs, and embryology of the viviparous fish *Gambusia affinis*. U.S. Bureau of Fisheries, Bulletin 33:181-190, plates 16-19.

Lee, D. S., C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E. McAllister, and J. R. Stauffer, Jr. 1980. Atlas of North American freshwater fishes. North Carolina Biological Survey Publication 1980-12. North Carolina State Museum of Natural History, Raleigh.

Martinez, A. M. 1983. Identification of brook, brown, rainbow, and cutthroat trout. Master's thesis. Colorado State University, Fort Collins.

Martinez, A. M. 1984. Identification of brook, brown, rainbow, and cutthroat trout larvae. Transactions of the American Fisheries Society 113(2): 252-259 (LFL Contribution 23).

NatureServe. 2012. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, VA. Available: http://www.natureserve.org/explorer (June 2012).

Page, L. M., and B. M. Burr. 1991. A field guide to freshwater fishes, North America north of Mexico (Peterson field guide series). Houghton Mifflin Company, Boston, MA.

Pasbrig, C. A., K. D. Koupal, S. Schainost, and W. W. Hoback. 2012. Changes in range-wide distribution of plains topminnow *Fundulus sciadicus*. Endangered Species Research 16: 235-247. Available: http://www.int-res.com/articles/esr_oa/n016p235.pdf (June 2012).

Pflieger, W. L. 1997. The fishes of Missouri, revised edition. Missouri Department of Conservation, Jefferson City.

Propst, D. L. 1982. Warmwater fishes of the Platte River basin, Colorado; distribution, ecology and community dynamics. Ph.D. dissertation. Colorado State University, Fort Collins.

Propst, D. L., and C. A. Carlson. 1986. The distribution and status of warmwater fishes in the Platte River Drainage, Colorado. The Southwestern Naturalist 31:149-167 (LFL Contribution 29).

Rahel, F. J. and L. A. Thel. 2004. Plains topminnow (*Fundulus sciadicus*): a technical conservation assessment. USDA Forest Service, Rocky Mountain Region, Golden, CO. Available: http://www.fs.fed.us/r2/projects/scp/assessments/plainstopminnow.pdf (June 2012).

Snyder, D. E., and C. L. Bjork. 2011. Illustration of mountain whitefish larvae and early juveniles. Final report of Colorado State University Larval Fish Laboratory to Colorado Division of Parks and Wildlife Aquatic Research Group, Fort Collins (LFL Contribution 167).

Snyder, D. E., and R. T. Muth. 2004. Catostomid fish larvae and early juveniles of the Upper Colorado River Basin–morphological descriptions, comparisons, and computer-interactive key. Colorado Division of Wildlife Technical Publication 42 (LFL Contribution 139). Available: http://warnercnr.colostate.edu/larval-fish-lab-downloads/ (June 2012).

Snyder, D. E., J. A. Charles, and C. L. Bjork. 2011. Illustration and description of woundfin larvae and early juveniles—contribution to a guide to larval fishes of the Virgin River. Final report of Colorado State University Larval Fish Laboratory to Virgin River Resource Management and Recovery Program, Salt lake City, UT (LFL Contribution 164).

Tyus, H. M., B. D. Burdick, R. A. Valdez, C. M. Haynes, T. A. Lytle, and C. R. Berry. 1982. Fishes of the upper Colorado River basin: distribution, abundance, and status. Pages 12-70 *in* W. H. Miller, H. M. Tyus, and C. A. Carlson, editors. Fishes of the upper Colorado River system: present and future, Western Division, American Fisheries Society, Bethesda, MD.

Walker, P. 1993. A list of the endemic and introduced fishes of Colorado -- March, 1993. Unpublished manuscript, Colorado Division of Wildlife Aquatic Resources Section–Fish Health Unit, Brush.

Wick, E. J., T. A. Lytle, and C. M. Haynes. 1981. Colorado squawfish and humpback chub population and habitat monitoring [1979-1980]. Endangered Wildlife Investigations, Job Progress Report, Federal Aid Project SE-3-3 (Work Plan 1, Job 1), Colorado Division of Wildlife, Denver.

Wick, E. J., J. A. Hawkins, and C. A. Carlson. 1985. Colorado squawfish and humpback chub population and habitat monitoring 1981-1982. Endangered Wildlife Investigations, Job Progress Report, Federal Aid Project SE-3-6, Colorado Division of Wildlife, Denver.

Woodling, J. 1985. Colorado's little fish: a guide to the minnows and other lesser known fishes in the state of Colorado. Colorado Division of Wildlife, Denver, CO.

Zuckerman, L. D., and R. J. Behnke. 1986. Introduced fishes in the San Luis Valley, Colorado. Pages 435-452 *in* R. H. Stroud, editor. Fish culture in fisheries management; proceedings of a symposium on the role of fish culture in fisheries management at Lake Ozark, Missouri, March 31-April 3, 1985. Fish Culture Section and Fish Management Section, American Fisheries Society, Bethesda, MD.

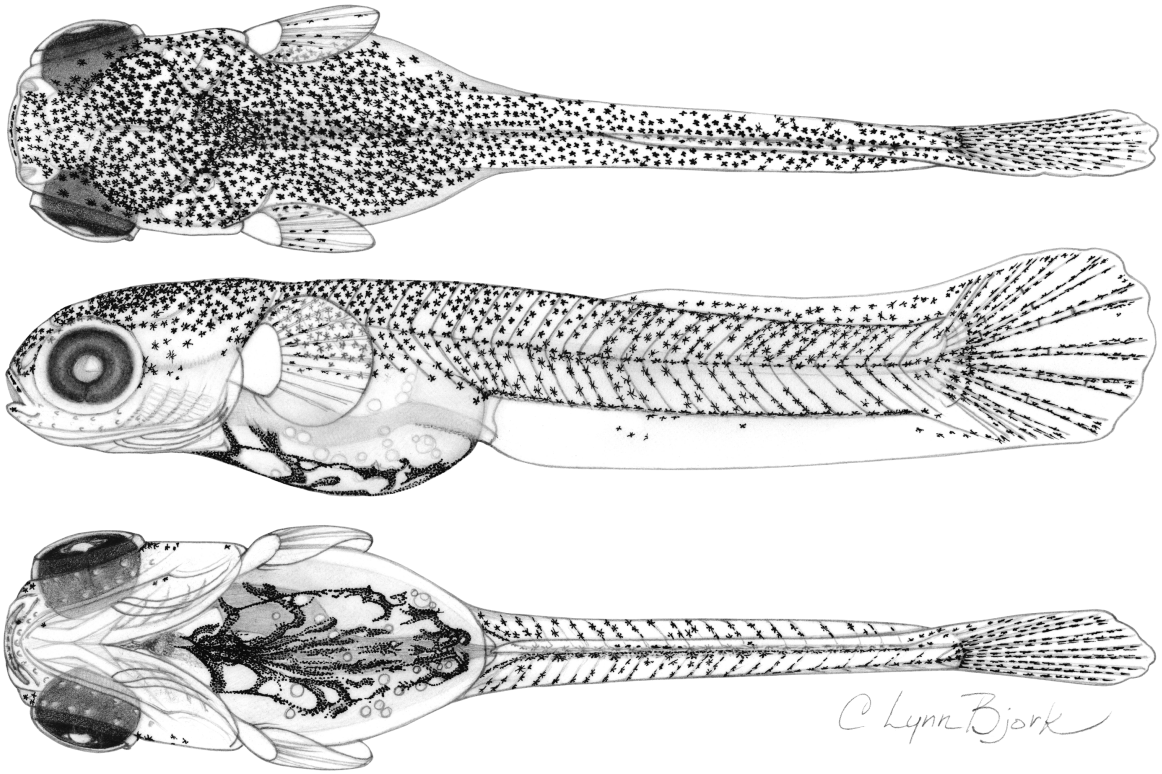

Fig. 1. *Fundulus sciadicus* flexion mesolarva (notochord fully flexed but principal caudal-fin-ray count incomplete), recently hatched, 5.2 mm SL, 6.2 mmTL. (Collected on 3 June 1986 by Kevin Bestgen from Riverbend Ponds at Prospect Road, Fort Collins, Larimer County, Colorado.)

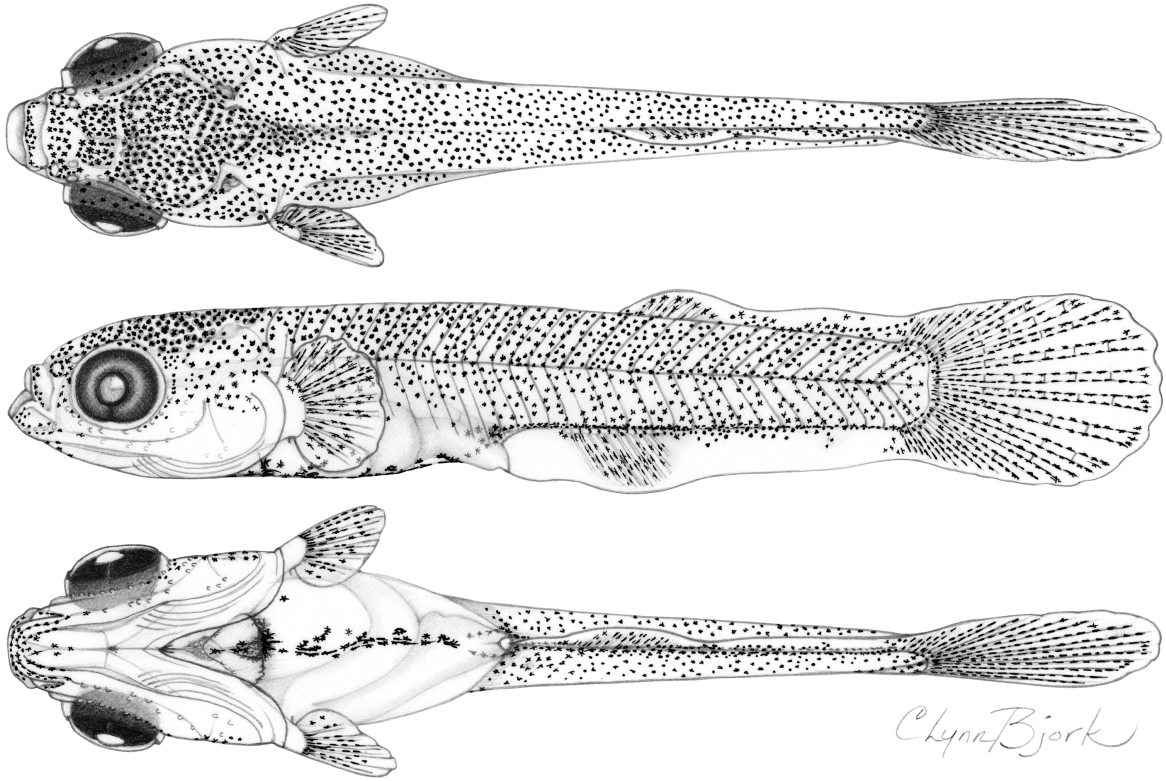

Fig. 2. *Fundulus sciadicus* postflexion mesolarva without yolk,12 d posthatch at 20-21 ℃, 7.2 mm SL, 8.9 mm TL. (Cultured in 2009 and preserved on 15 June by Harry Crockett and Lindsy Ciepiela at CDPW Fort Collins Research Center, with stock from city of Boulder open-space ponds, Boulder County, Colorado.)

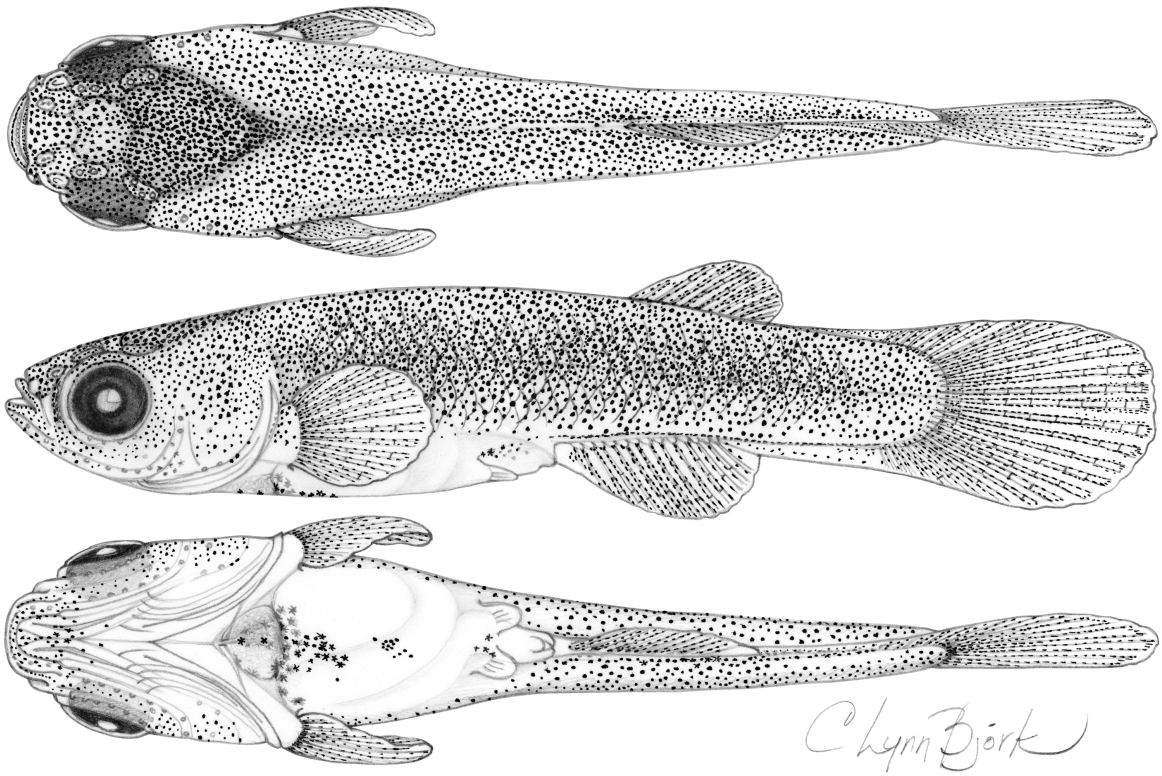

Fig. 3. *Fundulus sciadicus* metalarva, recently transformed, 10.5 mm SL, 12.9 mm TL. (Collected on 3 June 1986 by Kevin Bestgen from Riverbend Ponds at entrance, Fort Collins, Larimer County, Colorado.)

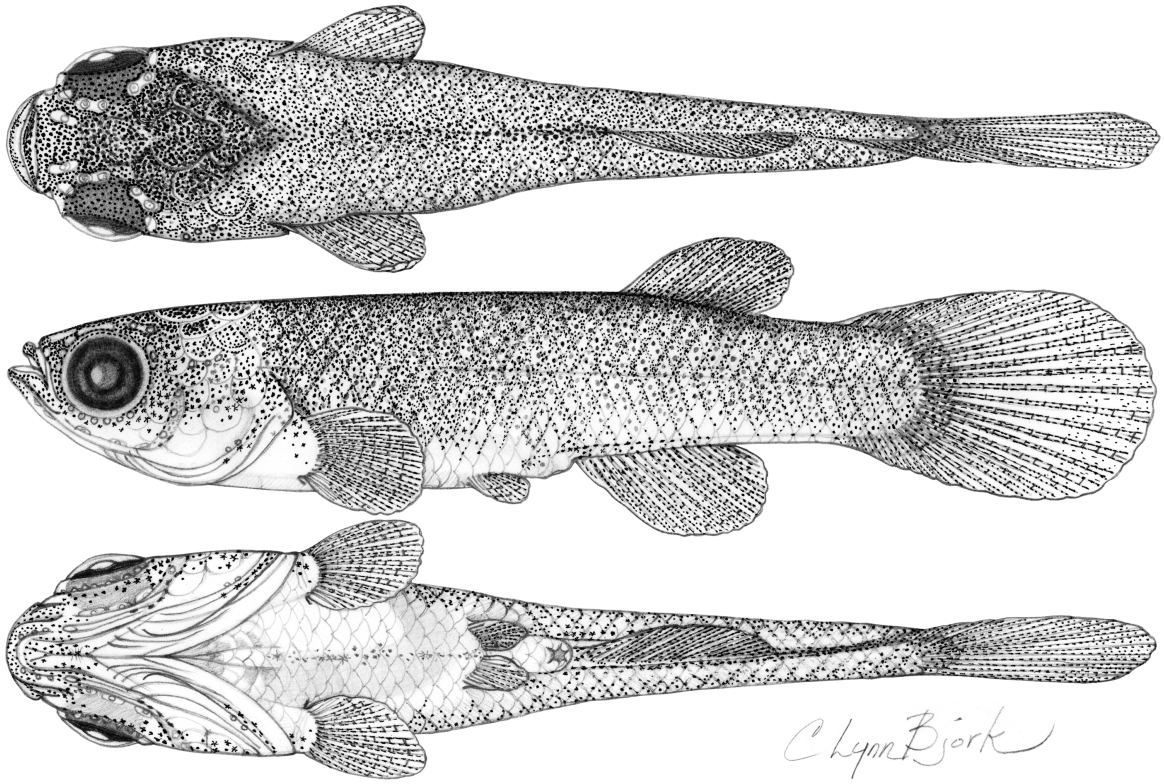

Fig. 4. *Fundulus sciadicus* juvenile, recently transformed, 15.3 mm SL, 19.1 mm TL. (Collected on 3 June 1986 by Kevin Bestgen from Riverbend Ponds at Prospect Road, Fort Collins, Larimer County, Colorado.)