Computer-Interactive Key to Sucker Larvae and Early Juveniles of the Upper Colorado River Basin: Rearing of and Descriptive Species Account for Longnose Sucker

Final Report

MOU-CSU- 689-01

to

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Contribution 123 of the Larval Fish Laboratory, Colorado State University

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Final Report to Colorado Division of Wildlife
MOU-CSU-689-1

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The Memorandum of Understanding between Colorado Division of Wildlife (CDOW) and Colorado State University (CSU) for this project was signed and transmitted on 14 December 2001 (the effective start date) but not processed by the university's office of Sponsored Programs until after the new year. The university account for this project (5-30036) was finally established on 8 January 2001. In consideration of the late contractual arrangements and start of this project, the 31 December 2000 progress report was waived by Tom Nesler, principal investigator for CDOW (e-mail message of 2 January 2001). The 31 March quarterly progress report was submitted on schedule (30 March 2001 memorandum to Tom Nesler).

This project, was intended to begin July or October 2000 at the latest and started very much behind original schedule except for acquisition of fertilized eggs for the rearing of new developmental series of longnose sucker. However, all tasks have been completed on schedule except as precluded by logistical circumstances, and the end product of the project, a descriptive species account for longnose sucker larvae and early juveniles, is provided in the Appendix. The logistically delayed new-developmental-series data and illustration for the species account and setup of the interactive key software (awaits a new computer) will be completed under a related Colorado River Fishes Recovery Program (CRFRP) project for which contractual arrangements have also been delayed from 1 October 2000. That associated project will complete rearing of the new developmental series of longnose sucker, supplement data and illustrations in the species account, extract other longnose sucker developmental data needed for comparison with other Upper Colorado River Basin (UCRB) suckers, produce a computer interactive key to UCRB sucker larvae and early juveniles, and prepare a manuscript for publication to update Snyder and Muth (1990) by the end of February 2001. The following is a detailed description of the tasks and work accomplished under this project.

Task 1:

- Acquire fertilized eggs of longnose sucker, preferably from west-slope brood stock (e.g., Gunnison River, Blue Mesa Reservoir).

We applied for and secured a scientific collection license (State License Number 01-AQ902, 2 May 2001, expiration 31 December 2001) for the collection of adult longnose sucker in spawning condition from a west-slope population and, as backup, from a local east-slope population (Larimer, Gunnison, and Saguache Counties). The license was verbally amended on

6 June by Steve Puttman (CDOW) to include Boulder County (confirmation of amendment via e-mail dated 7 June 2001). We began an effort in late March and April to identify likely collection sites and times for west-slope fish with the assistance of Dan Brauch (CDOW, Gunnison) and Steve Braylee (commercial bait dealer, Upper Cochetopa Basin) and for east slope fish with the assistance of Dr. Kevin Bestgen (LFL director and associate), and Kevin Rogers and Kenny Kehmeier (CDOW, Fort Collins). We planned and made arrangements for use of our department's Aquatic Research Laboratory facilities for incubating eggs and rearing larvae. Collection, holding, hormone injection, rearing, and euthanasia of fish under this project was approved by university's Animal Care and Use Committee earlier in the year (Animal Welfare Assurance Number A3572-01, Protocol Number 00-313A-01, 4 January 2001, expiration 4 January 2002).

Most efforts to locate and capture ripe or near ripe longnose sucker through May and early June failed, but in mid-June Kenny Kehmeier came through for us with a gill-net collection in Upper Big Creek Lake (Jackson County). The following accounts of collecting efforts, gamete acquisition, and rearing are edited summaries by assistant Sean Seal who has responsibility for these aspects of the project.

Scouting and collecting trips:

Late April and May – Dan Brauch and Steve Braylee agreed to contact us if they encountered or became aware of notable aggregations of longnose sucker in or likely staging for spawning condition during collecting efforts for other purposes. Braylee encountered mostly white sucker and Brauch failed to capture or observe enough individuals in mature or maturing condition to warrant a trip on our part.

17 May – Dr. Kevin Bestgen, Dr. Dan Beyers, Nick Bezzerides, Marian Allen, and Sean Seal electrofished Lone Pine Creek and Buck Horn Creek in Larimer County. Permission to access private property was denied several times. The first site on Lone Pine Creek was a private property that was for sale and vacant. It had a pond with the creek flowing behind it and was located at approximately 105° 31' longitude and 40° 47' 25" north latitude. The stream flowed slowly above of a small beaver dam and more swiftly below. We shocked one sucker upstream and one downstream of the dam. The second, also on Lone Pine Creek was on private property across from Parvin Lake; permission to electroshock was granted. No suckers were taken. At these sites several brown trout were shocked and released without harm. The third site sampled was Buckhorn Creek halfway between 44H and Masonville on Stove Prairie Road. It produced a single longnose dace. Both suckers collected from Lone Pine Creek were females and were brought back to the Aquatic Research Laboratory (ARL) at CSU in the event a male could be captured in the near future. The electroshocker was operated on pulsed DC at 50 pulses per second with an output of 300-350 volts.

25 May – Darrel Snyder and Sean Seal scouted the South Fork of Cache la Poudre Creek at Pingree Park. Only nets and seines were used. Trout were observed and caught, including a few late larvae or early juvenile brook trout, but no suckers.

29 May – Sean Seal observed and capture by hand net a very small male longnose sucker from the east spillway of a storm retention pond about half a mile south of Colorado State University near Center Ave. White sucker, fathead minnow, and creek chub were also present. The male, which showed some spawning coloration and tuberculation was returned to ARL and held with the two Lone Pine Creek females.

7 June – Koreen Zelasko, Bobby Compton, and Sean Seal scouted St. Vrain Creek and Left Hand Creek in Boulder County. They also shocked a short section of Spring Creek in Fort Collins starting at the west end of the retention pond (same location as May 29) and worked their way west (upstream). No longnose sucker were obtained, but fathead minnow and small white sucker were present. The electroshocker was operated on pulsed DC at 50 pps with an output of 150 volts.

8 June – Koreen Zelasko, Bobby Compton, and Sean Seal electroshocked South and North St. Vrain Creek and Left Hand Creek. Multiple sites were sampled on the south and middle forks of St. Vrain Creek in Roosevelt National Forest west of Lyons along Highway 72 to Peaceful Valley Campground. Two sites were shocked on the Left Hand Creek between the city of Ward and Highway 75, just before Rowena and Glendale. Sampling was not conducted on private property. No longnose sucker were observed or captured, but there were a lot of brown trout and brook trout was taken and released at Peaceful Valley Campground.

13 June – Ken Kehmeier, Davies, Grooms, and Bolton of the CDOW sampled Upper Big Creek Lake using gill nets. There they collected 8 longnose sucker and 1 white sucker, which they brought back to the CDOW office in Fort Collins. From there, Darrel Snyder and Sean Seal transported the fish to the ARL. There were two obvious small males, five obvious large females, one moderately small fish of uncertain sex (turned out to be an immature female), and one large white sucker or hybrid.

Maintenance and treatment of longnose sucker held at ARL:

17 May – The Lone Pine Creek females captured; held until June 14.

29 May – The Spring Creek male captured; held until June 19. This male initially had tubercles on the caudal and anal fin, none on the head and a faded red lateral band. He eventually lost color and tubercles.

1 June – Lone Pine and Spring Creek suckers were injected with carp pituitary obtained from CSU grass carp culled on April 26. Nothing happened, but we kept the fish for another possible set of injections.

13 June – Upper Big Creek Lake (UBCL) Suckers were introduced and held with the Lone Pine and Spring Creek suckers at the ARL. The fish were stressed and a few were in poor condition on arrive at CDOW quarters in Ft. Collins. One male died during transport to ARL; one large female in ripe condition was also dying. Darrel Snyder stripped the dying female of eggs and successfully fertilized them by mixing them with the macerated testes from the recently dead male then adding and mixing water to activate the sperm. Another female, either already spawned out or not yet ripe yielded a small quantity of bloody eggs

that did not fertilize, but the stress of capture, transport, poor water quality, and handling was too much and she too died. While working with the latter female, the second male also died, but upon dissection, we found that he was spent. The dead fish were either frozen whole for subsequent examination or had a muscle sample frozen for possible DNA analysis at some later date.

14 June – The Lone Pine Creek females were judged unlikely to ripen (perhaps had spawned prior to capture or immature) and were euthanized; smaller specimen preserved in formalin . The white sucker/hybrid was not needed and was also euthanized; a muscle sample was frozen for possible DNA analysis.

14 June – The five remaining suckers, one very small male (Spring Creek) and three large females and one medium unknown (UBCL), were injected with human chorionic gonadotropin (HCG) to induce a ripe spawning condition. Dr. Kevin Bestgen provided the injection procedure he used previously with white sucker. Each sucker was weighed and examined for marks that would identity the fish for subsequent injections.

15 June – The medium size fish of uncertain sex died. Upon dissected, it was found to be an immature female.

15 June – The three remaining females received the second of three HCG injections. Tuberculation of the anal and caudal fins was again becoming apparent.

6 June – Last day of HCG injections. Male gave just a couple of drops of sperm and largest female is readily giving eggs.

16 June – Stripped the large female, and tried to strip the male, but he gave only a few drops of milt, perhaps enough to fertilize at least some eggs (about 10% made it to hatching).

19 June – Male will not yield more milt. All remaining adults euthanized; small male preserved in formalin.

Rearing:

17 June – Batch one, artificially fertilized on June 13, started hatching.
21 June – Batch one, artificially fertilized on June 13, finished hatching.
21 June – Batch two, artificially fertilized on June 16, started hatching.
23 June – Batch one, starting feeding brine shrimp nauplii, twice a day.
24 June – Batch two, artificially fertilized on June 16, finishing hatching.
25 June – Batch one, started feeding brine shrimp nauplii four times a day.
(End of records for this report).

The eggs were maintained in a Heath Incubator with flow-through filtered well water at 18 °C. They were monitored and tended at least twice a day. Dead eggs were removed when observed, and the larvae were removed when found. The eggs were treated on 17 June for one hour with malachite green to control fungus.

The removed larvae were kept in breeder boxes of 500-micron netting. They were initially kept in the top tray of the egg incubator with moving water until the complete batch was hatched. After the hatching was complete, the larvae were moved to a trough with a constant

water flow, also filtered well water at 18 °C, but were still maintained in breeder boxes. The trough was covered with plastic to shade the larvae.

Task 2: (based only on existing developmental series and other specimens held by the Larval Fish Laboratory, LFL, and excluding consideration of skeletal features).

- Conduct detailed study of morphological ontogeny of longnose sucker larvae and early juveniles comparable to that previously done for other Upper Colorado River Basin suckers (Snyder and Muth 1990).

Existing specimens in the LFL collection (including specimens collected from the lower Gunnison River in 1993 and 1995, from the Illinois and Poudre River drainages in 1979 and 1980, and a limited developmental series reared by LFL in 1979 from Parvin Lake stock) were assembled, scanned, and measured (selected specimens) in preparation for morphometric and meristic analysis. Decided not to use Illinois River and Poudre River specimens because some are in alcohol other are suspect as possible hybrids. Likewise for smaller Gunnison River specimens since identity of some is not absolutely certain (based on morphological characters). However this leaves a data and illustration gap for later metalarvae. A total of 59 specimens (plus three less certain collected specimens tentatively withheld from summarized data) were analyzed in detail by Darrel Snyder, Diane Miller, and Sean Seal via microscopic examination and computer (mensural) image analysis for 32 morphometric and 20 meristic characters. Specimens were also examined to determine phase of gut development and assess scale development in juveniles. Supplemental data on state of development relative to size was extracted from the rest of the preserved developmental series and some specimens of certain identity from Gunnison River collections. Morphometric and some meristic data were summarized by developmental phase in a spreadsheet.

- Prepare a standard set of eight three-view drawings representative of selected early-life stages of development [or as many as of those drawings as are adequately represented by existing specimens].

Seven of the eight planned drawings were prepared by illustrator Lynn Bjork using specimens from the 1979 developmental series for the protolarval, mesolarval, and recently transformed metalarval stages, and confidently identified near-transition metalarvae and juveniles from Gunnison River collections. They have been digitally scanned and incorporated in the developmental species account for longnose sucker that was prepared as an end product for this project. The planned eighth drawing, that for the later-stage metalarva, awaits the rearing of new series of larvae currently under way and, assuming continued rearing success, will be included in an update of the species account for the final report of the associated CRFRP project next winter.

- Prepare a descriptive species account identical in format to that for other suckers in Snyder and Muth (1990).

The species account has been completed based on existing specimens and is appended to this report as the end product of the project. It will be updated with the currently missing metalarval illustration and data and supplemented with other data from the new developmental series for the February 2002 final report of the associated CRFRP project. An extensive literature search was conducted to complete the first page of the species account which includes descriptive background on adult diagnostic characters, reproduction, and the young, as well as tables of meristic and size relative to developmental state data, an illustration of the adult, and a map of distribution in the Colorado River System. State and university biologists in Colorado (Dan Brauch, Bill Elmblad, Pat Martinez, Kevin Rogers, Harry Vermillion), Wyoming (Wayne Hubert, Frank Rahel, Ron Remmick), and Utah (Roger Schneidervin, Randy Radant) were contacted regarding known occurrences of longnose sucker populations in the UCRB. The authors Scott and Crossman (1973, Freshwater Fishes of Canada) and Tomelleri and Eberle (1990, Fishes of the Central United States) were contacted for permission to reproduce their adult longnose sucker illustrations in the species account and subsequent publication thereof. Tomelleri granted permission.

Task 3:

- Obtain and setup the latest versions of DELTA and INTKEY programs (Dallwitz 1993; Dallwitz et al. 1995) or alternative programs (e.g., LucID) if found more suitable.

Recent versions of these programs were downloaded, and licensed by LFL prior to this project and await acquisition of a new computer for setup and use. That computer was to have been purchased last winter via the associated CRFRP project which is only now being funded. If newer versions of the programs have been released, they will be downloaded at that time. Alternative programs were investigated but I am familiar with DELTA software (used for preparation of the text key in Snyder and Muth 1990) and have determined that alternative programs are not likely to be any better for development of a computer interactive key for fish larvae.

Task 4:

- Prepare and submit final report in accord with CDOW GOCO reporting policy (actually in accord with the MOU contract).

Task 4 is now completed with submission of this report.

Literature Cited

Dallwitz, M. J. 1993. DELTA and INTKEY. Pages 287-296 *in* R. Fortuner, editor. Advances in computer methods for systematic biology: artificial intelligence, databases, computer vision. The John Hopkins University Press, Baltimore, MD.

Dallwitz, M. J., T. A. Paine, and E. J. Zurcher. 1995. User's guide to INTKEY, a program for interactive identification and information retrieval. Division of Entomology, Commonwealth Scientific and Industrial Organization (CSIRO), Canberra, Australia.

Scott, W. B., and E. J. Crossman. 1973. Freshwater fishes of Canada. Bulletin of the Fisheries Research Board of Canada 184.

Snyder, D. E., and R. T. Muth. 1990. Descriptions and identification of razorback, flannelmouth, white, bluehead, mountain, and Utah sucker larvae and early juveniles. Colorado Division of Wildlife Technical Publication 38.

Tomelleri, J. R., and M. E. Eberle. 1990. Fishes of the Central United States. University Press of Kansas, Lawrence, Kansas.

Appendix

Descriptive species account of longnose Sucker larvae and early juveniles

(Seven pages, numbered independently)

Species Account – *Catostomus catostomus*

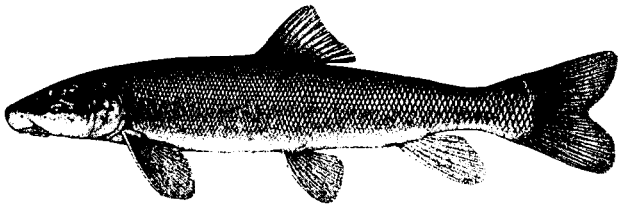

Fig. 1. *Catostomus catostomus* (from Tomelleri and Eberle 1990).

Adult Diagnosis: Elongate, cylindrical body with deep caudal peduncle and no predorsal keel. Long, bulbous, somewhat pointed snout extending well beyond ventral mouth. Cartilaginous ridge along lower jaw but not hard and prominent. Mouth moderate in size but with large, fleshy, coarsely papillous lips, not notched at corners; lower lips flaring widely well behind mouth, medially divided to base or single row of papillae. Dorsal fin short, not falcate. Pelvic axillary process present but small. Scales small. Gill rakers relatively few, short, and fleshy. Fontanelle long and relatively narrow. Peritoneum variable, silvery or dusky with silvery areas to uniformly black. TL usually 30-43 cm, up to 64, possibly 76 cm. (Also, Table 1).

Reproduction: Non-guarding, open-substrate lithophil. April through July, probably May to early July in Upper Colorado River Basin. Migrate at >5 °C. Spawn mostly at 10-15 °C for 1-3 weeks, usually <10 d. Spawn primarily in small tributary or inlet streams at depths of 15-30 cm over gravel with a current of 30-45 cm/sec; occasionally in lakes over sand, gravel, or rocks at depths of 1.5-76 cm. Eggs (2.3-)2.6-3.0 mm diameter, demersal, initially adhesive.

Young: Hatch in 5-14 days at 18-10°C, remain in gravel 1-2 weeks, then emerge and begin drifting downstream at 10-12 mm TL, usually at night. Young occupy low velocity shoreline areas in streams or lakes, often with aquatic vegetation. Aggregate in top 15 cm of water within 2 m of shore. Those 11-18 mm TL feed on plankton, 20-90 mm graze on weeds and solid surfaces and feed on larger organisms.

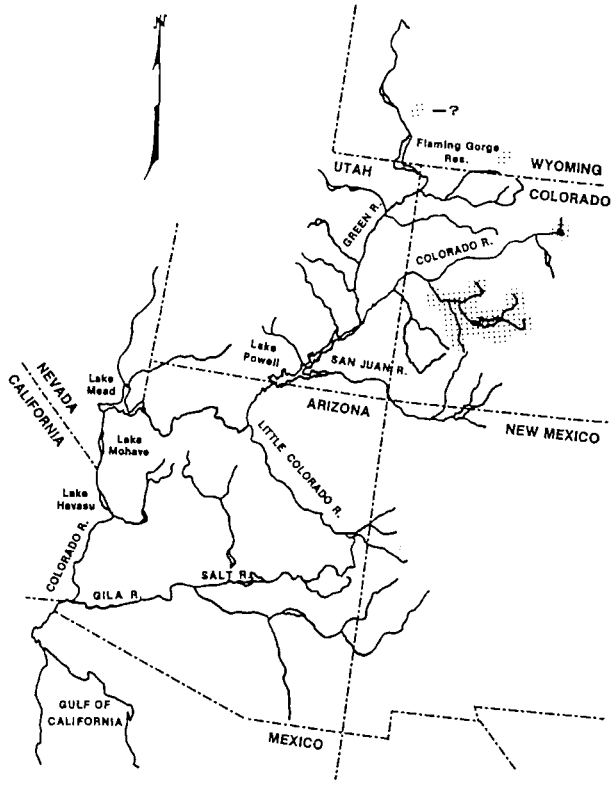

Fig. 2. Regional distribution of *Catostomus catostomus*.

Table 1. Selected juvenile and adult meristics for *Catostomus catostomus*. 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	9-10-11(12)	Dorsal Fin Rays - R:	2-3 (4)	
Anal Fin Rays - P:	7	7 (-9)	Anal Fin Rays - R:	2-3	
Caudal Fin Rays - P:	18	18	Caudal Fin Rays - RD:	(9) 10-12	
Pectoral Fin Rays:	15-16-17(18)	16-18	Caudal Fin Rays - RV:	(8) 9-10 (12)	
Pelvic Fin Rays:	(8) 9-10 (11)	9-11	Lateral Scales:	103-106 (116)	(85-)90-95-115-120
Vertebrae:		45-47 (48)	Gill Rakers:		23-30

Table 2. Size at apparent onset of selected developmental events for *Catostomus catostomus*, 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	mm SL	Last Formed mm TL
Hatched:	(7) 8 (9)	8-9	Dorsal - P:	13	14-15	(13) 14	15-16
Eyes Pigmented:	(7) 8 or *	8 or *	Anal - P:	13-14	15-16	14-15	17-18
Yolk Assimilated:	10-11	10-11	Caudal - P:	11	11-12	13	14
Finfold Absorbed:	22	27	Caudal - R:	13-14	15	>16, <21	>20, <25
Pectoral Fin Buds:	*	*	Pectoral:	13-14	15-16	21	25-26
Pelvic Fin Buds:	12	13	Pelvic:	14	16-17	15-16	18-19
* before hatching			Scales:	>23, <28	>28, <35	>28, <31	>35, <37

References: Auer 1982, Baxter and Simon 1970, Baxter and Stone 1995, Becker 1983Beckman 1952, Brauch PC, Carlander 1969, Eddy and Underhill 1974, Everhart and Seaman 1971, Fuiman and Witman 1979, Geen et al. 1966, Harris 1962, Hubbs et al. 1943, Jordan and Evermann 1896, Kay et al. 1994, Lee et al. 1980, Nelson and Paetz 1992, Martinez PC, Morrow 1980, Radant PC, Rahel PC, Remmick PC, Scarola (1973), Schneidervin PC, Scott and Crossman 1973, Simpson and Wallace 1978, Smith 1979, Smith 1985, Snyder 1981, Sturm 1988, Tomelleri and Eberle 1990, Tyus et al. 1982, Wheeler 1997, Wiltzius 1978, Woodling 1985, Wydoski and Whitney 1979.

Table 3. Size at developmental interval (left) and gut phase (right) transitions for *Catostomus catostomus*. See Figure 2 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	16
Postflexion Mesolarva:	13	14	3 - Full loop:	16	(18) 19
Metalarva:	14-15	17-18	4 - Partial crossover:	21-22	25-27
Juvenile:	22	27	5 - Full cross over:	25-27	31-33

Table 4. Summary of morphometrics and myomere counts by developmental phase for *Catostomus catostomus*. See Figure 1 for abbreviations and methods of measurement and counting. Protolarvae with unpigmented eyes excluded.

	Protolarvae (N=13)				Flexion Mesolarvae (N=8)				Postflexion Mesolarvae (N=12)				Metalarvae (N=11)				Juveniles (N=15)			
	$\bar{x}$	±SD	Range		$\bar{x}$	±SD	Range		$\bar{x}$	±SD	Range		$\bar{x}$	±SD	Range		$\bar{x}$	±SD	Range	
SL, mm:	9	1	7	11	12	1	11	13	14	1	13	15	17	3	15	22	31	7	22	41
TL, mm:	10	1	8	11	12	1	11	14	16	1	14	17	20	4	17	27	38	8	27	50
Lengths %SL:																				
AS to AE	3	1	2	4	3	1	2	4	4	1	3	5	6	2	4	8	9	1	7	11
PE	8	0	8	9	9	1	8	10	11	1	10	13	13	2	12	16	15	1	13	17
OP1	16	1	13	17	18	1	17	20	23	2	19	25	26	3	22	30	28	2	25	31
OP2					55	2[a]	53	56	52	1	50	54	56	2	53	59	57	1	55	59
PY	76	2[b]	73	78																
OPAF	39	19	22	69	26	2	24	28	31	4	25	40	48	11[c]	35	66				
ODF	42	3	39	49	43	1	41	44	45	1	44	47	47	1[a]	46	47				
OD					48	1[d]	47	49	48	1	48	50	49	2	46	52	51	1	49	53
ID									62	1[e]	61	63	62	2	59	66	64	1	62	66
PV	78	1	75	80	77	1	76	79	78	1	76	80	77	1	75	79	75	1	73	77
OA									78	1[f]	76	80	77	1	75	78	76	1	74	78
IA									84	0[g]	84	84	84	1	82	85	83	1	82	85
AFC					106	1[e]	105	107	112	2	108	115	115	1	114	119	116	1	115	118
PC	104	1	103	106	107	2	105	109	115	3	109	118	120	2	117	122	122	1	120	124
Y	57	4[b]	51	64																
P1	7	2	4	11	12	1	11	12	13	1	11	15	15	1	13	17	17	2	14	19
P2									6	1[c]	4	8	9	2	6	12	13	2	10	15
D									17	1[e]	16	18	19	1	17	21	20	1	18	22
A									8	1[g]	7	9	11	2	9	14	14	1	10	16
Depths %SL:																				
at BPE	9	1	8	13	11	1	10	12	13	1	11	15	15	1	14	17	17	1	15	18
OP1	11	1	10	12	12	1	11	14	16	1	15	17	17	2	16	21	20	1	18	22
OD	11	2	8	14	11	0	10	11	13	1	12	15	16	2	13	19	19	1	18	21
BPV	6	1	5	7	6	0	5	6	7	1	6	8	8	2	6	11	12	1	11	13
AMPM	3	0	2	4	4	1	3	5	6	0	5	6	6	1	5	7	9	1	7	10
Max. Yolk	8	3[b]	4	12																
Widths %SL:																				
at BPE	8	1	7	10	11	1	10	12	14	1	12	15	15	1	14	16	16	1	14	18
OP1	6	0	6	6	8	1	7	9	10	1	9	12	13	2	11	16	17	1	16	18
OD	7	2	4	10	6	0	5	6	7	1	6	9	10	2	8	13	15	1	13	17
BPV	4	0	3	4	4	0	4	4	5	0	4	5	6	1	4	8	9	1	7	10
AMPM	2	0	2	3	2	0	1	2	2	1	1	3	2	1	2	5	3	1	2	6
Max. Yolk	8	3[b]	4	13																
Myomeres:																				
to PY	36	1[b]	34	39																
OPAF	15	10	5	31	7	1	6	7	8	2	6	13	18	7[c]	11	30				
OP2					22	1[a]	22	23	21	1	20	23	23	1[c]	21	25				
ODF	16	1	15	18	16	1	15	17	17	1	16	18	16	0[a]	16	16				
OD					19	1[4]	19	20	19	1	18	20	18	1[c]	16	19				
PV	38	1	37	41	38	1	37	39	38	1	37	40	37	1[c]	36	38				
Total	48	1	47	51	48	1	47	49	47	1	46	49	47	1[c]	46	48				
After PV	10	1	9	11	9	1	8	11	9	1	8	10	10	1[c]	9	11				

[a]N = 3; [b]N = 11; [c]N = 10; [d]N = 4; [e]N = 5; [f]N = 7, [g]N = 2.

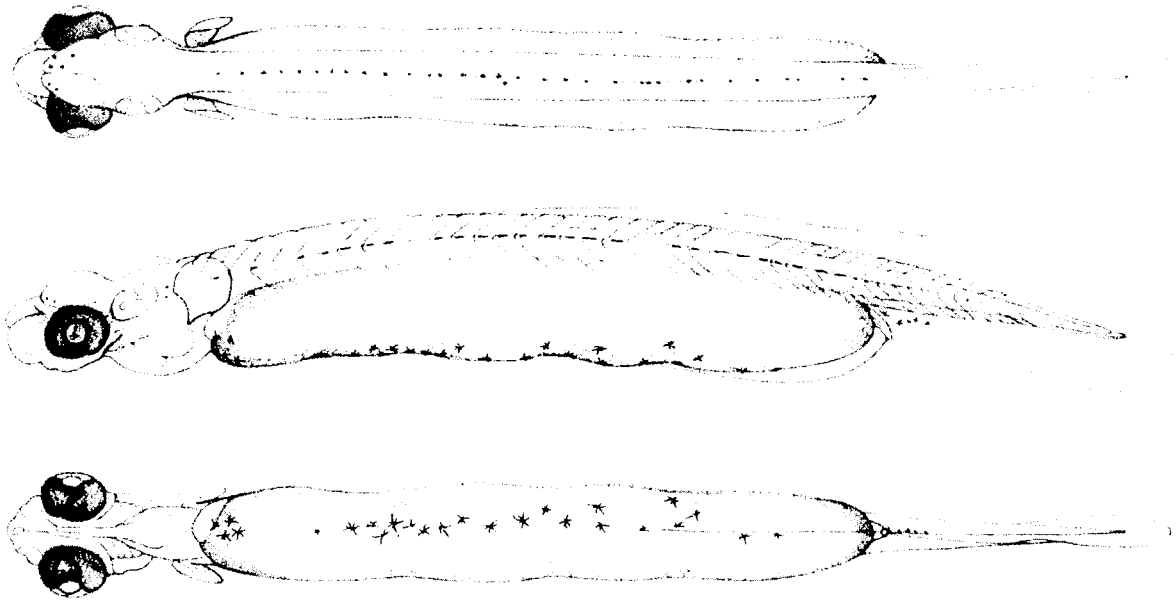

Fig. 3. *Catostomus catostomus* protolarva, recently hatched (day 1), 8.2 mm SL, 8.5 mm TL. Cultured in 1979 with stock from Parvin Lake, Larimer County, Colorado.

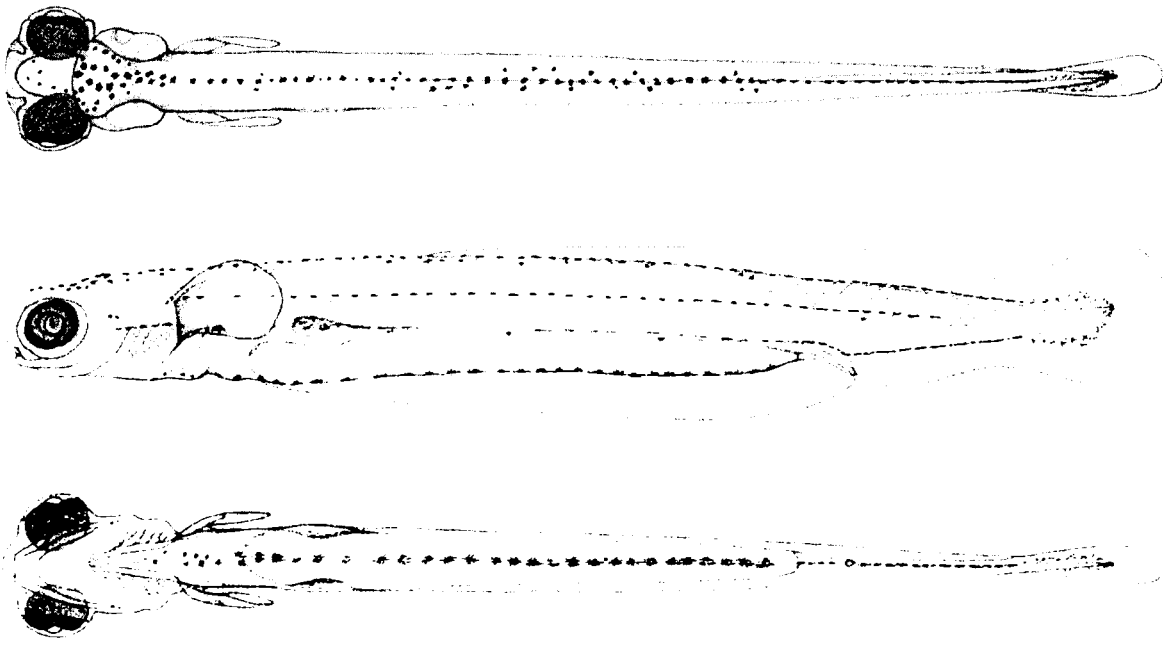

Fig. 4. *Catostomus catostomus* protolarva, 10.2 mm SL, 10.6 mm TL. Cultured in 1979 with stock from Parvin Lake, Larimer County, Colorado.

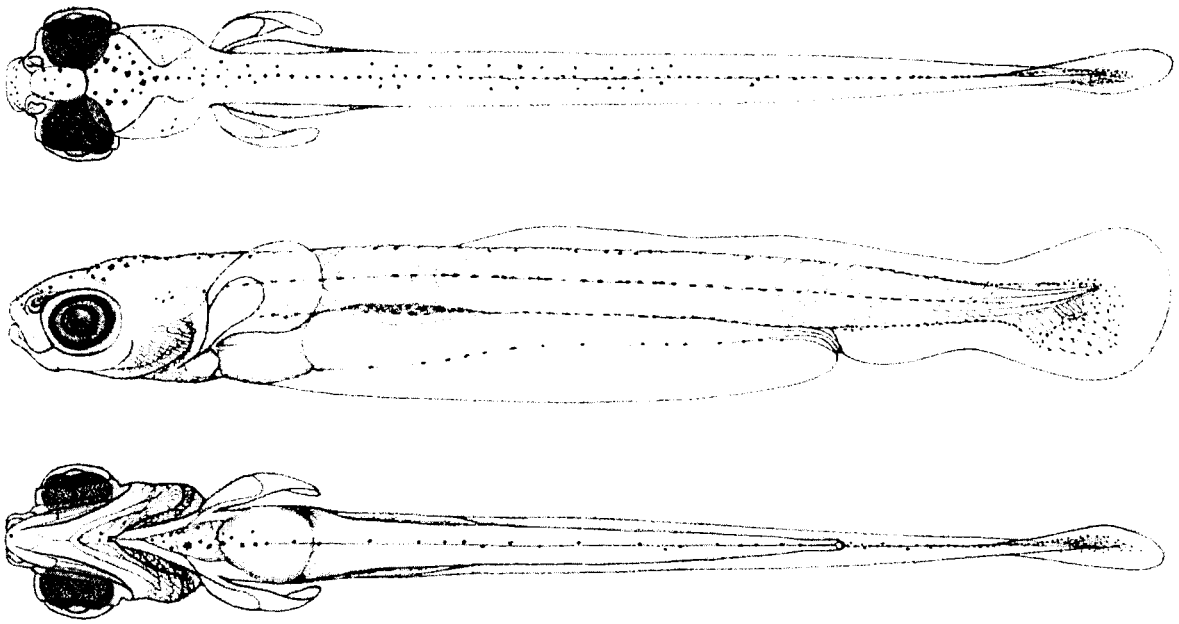

Fig. 5. *Catostomus catostomus* flexion mesolarva, recently transformed, 11.9 mm SL, 12.5 mm TL. Cultured in 1979 with stock from Parvin Lake, Larimer County, Colorado.

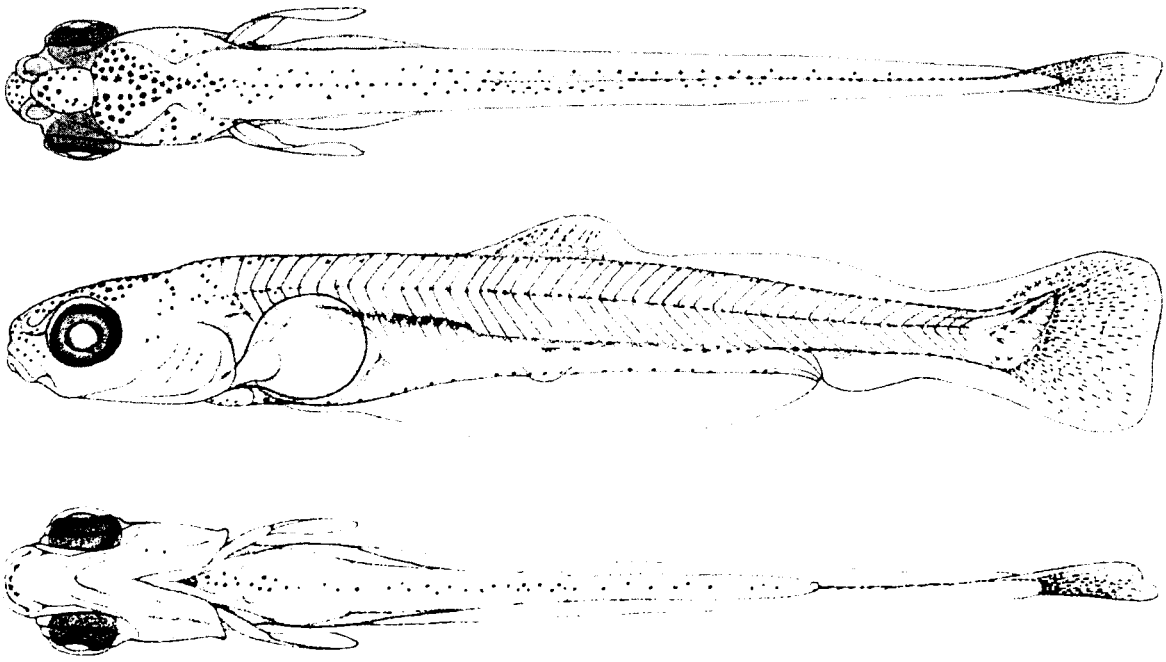

Fig. 6. *Catostomus catostomus* postflexion mesolarva, 13.5 mm SL, 15.1 mm TL. Cultured in 1979 with stock from Parvin Lake, Larimer County, Colorado.

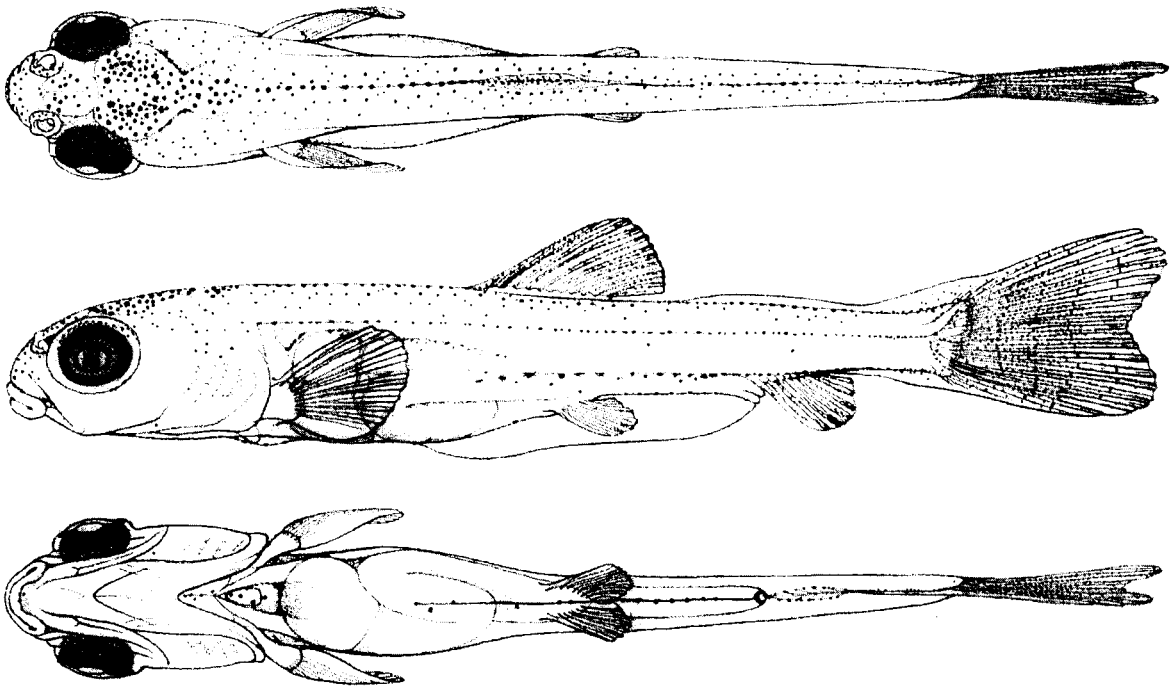

Fig. 7. *Catostomus catostomus* metalarva, recently transformed, 14.6 mm SL, 17.5 mm TL. Cultured in 1979 with stock from Parvin Lake, Larimer County, Colorado.

Future Illustration

(Culture in progress for developmental series from which this illustration will be prepared–DES June 2001)

Fig. 8. *Catostomus catostomus* metalarva, xx.x mm SL, xx.x mm TL. Cultured in 2001 with stock from Upper Big Creek Lake, Jackson County, Colorado.

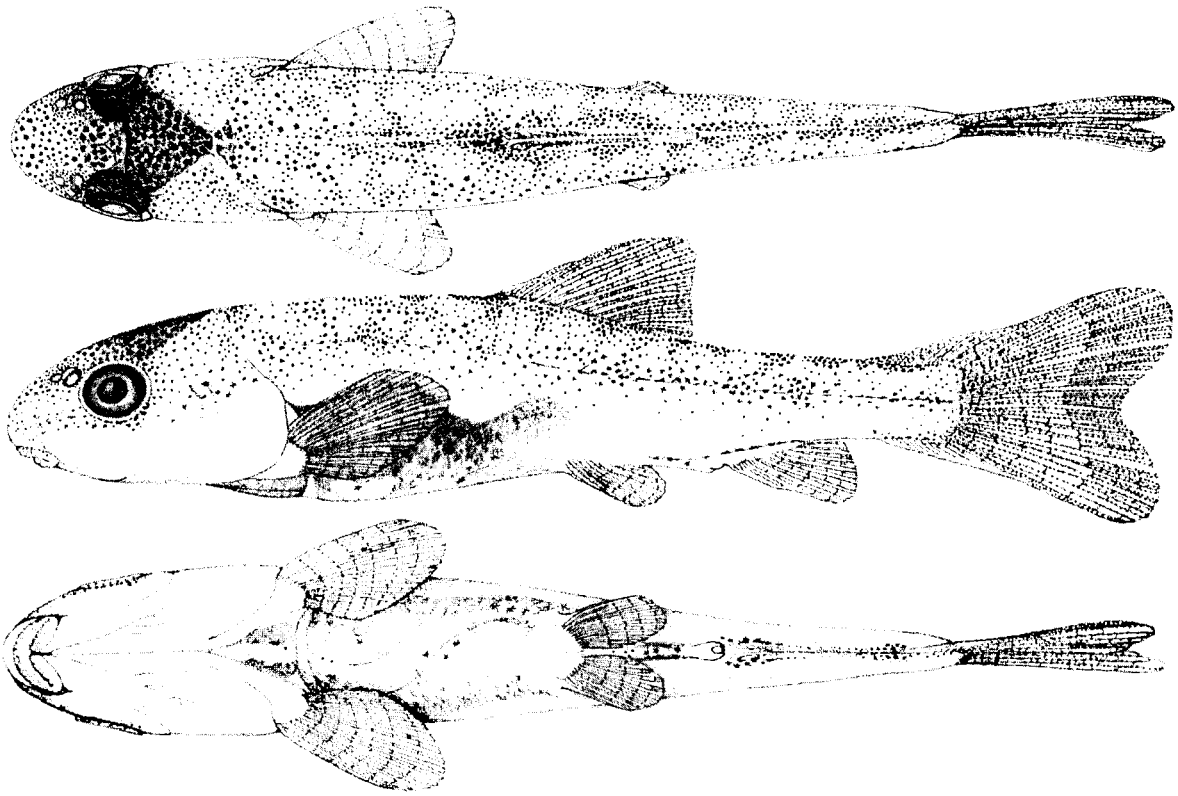

Fig. 9. *Catostomus catostomus* juvenile, recently transformed, 22.9 mm SL, 27.8 mm TL. Collected in 21 September 1995 from Gunnison River, Kilometer 94.0, near Escalante, Delta County, Colorado.

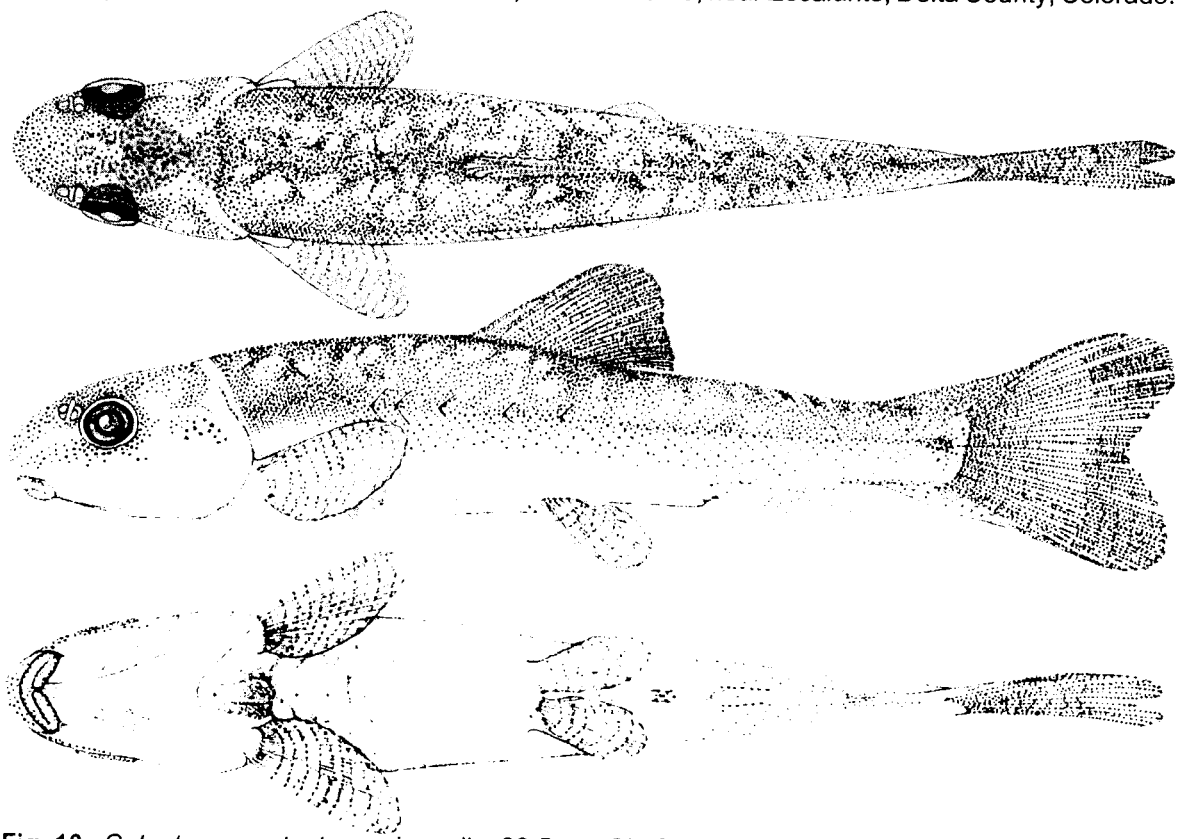

Fig. 10. *Catostomus catostomus* juvenile, 30.5 mm SL, 37.0 mm TL. Collected 21 September 1993 from Gunnison River, Kilometer 96.1, near Escalante, Delta County, Colorado.

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