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Egg and Larval Development of the Striped Fantail Darter, *Etheostoma flabellare lineolatum* (Agassiz), and Duskytail Darter, *E. Percnurum* Jenkins, with Comments on the *Etheostoma flabellare* Species Group

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ABSTRACT

The *Etheostoma flabellare* species group comprises 6 recognized forms, including *E. f. lineolatum* and *E. percnurum*. The wide ranging *E. f. lineolatum* and the relict *E. percnurum* both exhibit large spherical yolk sacs, with a mid-ventral vitelline vein plexus; 34–36 total myomeres; well developed jaws at hatching; and head not deflected over the yolk sac. Eggs of *E. f. lineolatum* range between 2.0–2.8 mm in diameter. Hatching in *E. f. lineolatum* occurs between 4.5–5.9 mm TL and first ray formation occurs at 5.0 mm in the pectoral fins. *Etheostoma percnurum* has the largest eggs of the group with diameters between 2.6–3.3 mm. Larvae hatch between 4.5–5.4 mm TL and possess six incipient rays in the pectoral fin. Fin-ray formation occurs at later length intervals than *E. f. lineolatum*, except for the spinous dorsal fin. Orbit shape and initiation of squamation for *E. percnurum* is similar to *E. kennicotti*.

The fantail darter, *Etheostoma flabellare*, is the most widespread member of the subgenus *Catonotus*, ranging from the Great Lakes basin, south through the upper and middle Mississippi basin, and east onto the central Atlantic slope (1). This highly variable taxon, consists of 3 to 5 subspecies. However, *E. f. lineolatum*, was not recognized by McGeehan (2) because of the erratic geographical distribution of striped and non-striped forms. *Etheostoma flabellare* inhabits gravelly or rocky riffles (occasionally slow runs or pools) in headwater creeks to moderate-sized rivers, and is potentially sympatric with at least 11 other species of *Catonotus* (1, 3, 4). In contrast, the duskytail darter, *Etheostoma percnurum*, is a relict species restricted to only 4 large streams of the upper Tennessee and middle Cumberland River drainages, where it inhabits rocky pools (4, 5). It is accorded threatened status by the state of Tennessee (6), and endangered in Virginia (7, 8). It occurs sympatrically with only 1 species of *Catonotus*, *E. flabellare*. The fantail and duskytail darters represent distributional extremes within *Catonotus*, but are closely related, comprising, with *E. kennicotti*, the *E. flabellare* species group (3, 9).

There is a growing body of comparative information for distinguishing larvae and juveniles of different species of *Catonotus* (10, 11). Embryonic and larval development of *E. flabellare flabellare*, the subspecies occupying the Great Lakes and upper Ohio River basins (2), has been characterized by Lake (12), Cooper (13), Auer (14), and Paine (15); however, descriptions are lacking for other subspecies. Also, given the high degree of sympatry between *E. flabellare* and other species of *Catonotus*, comparative data are needed for separating their larvae. Layman (5) described larval stages of the duskytail darter but did not report his observations of embryonic development or provide meristic and morphometric characteristics of larvae. Such information may become critical in implementing future recovery plans for this jeopardized species. Larval

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characters may also prove to be useful in resolving phylogenetic relationships within the *E. flabellare* species group.

This paper describes larval development of *Etheostoma flabellare lineolatum*, the striped fantail darter, a widespread taxon found in the lower Ohio River basin and tributaries of the Mississippi River, and embryonic and larval development of *E. percnurum*, the duskytail darter. Meristic, morphometric, and pigmentation features are used to separate these taxa from *E. f. flabellare*, *E. kennicotti*, and other sympatric species of *Catonotus*.

MATERIALS AND METHODS

Laboratory cultured and wild collected specimens were studied for differences in morphology, meristics, pigmentation, and sequential development relative to size. A series of meristic and morphometric features was measured from 128 eggs and 237 larvae and early juvenile striped fantail darters, and 20 eggs and 24 larvae and early juvenile duskytail darters.

A total of 21 morphometric and nine meristic characters was measured for each specimen following methods outlined in Simon (10). Eggs and embryos were preserved in 5% formalin, while larvae were preserved in 10% formalin after removal from nests. The middle of the spawning episode (i.e., fertilization of ova) was used as time zero in estimating ages of embryos. All measurements were made to the nearest 0.1 mm using a dissecting microscope with an ocular micrometer. Measurements in the text are expressed as a proportion of total length (TL) unless otherwise noted. Illustrations were delineated following Sumida et al. (16).

Embryonic and larval descriptions of the duskytail darter were based on adults collected and spawned by Layman (5) from the Tennessee River drainage, Little River, Blount County, Tennessee. Little River contains 1 of 3 extant populations for the species in the upper Tennessee River drainage. Eggs were obtained from nests in Little River and from spawnings of aquarium-held adults. All eggs were incubated in aquaria at 18–27°C. Larval descriptions of striped fantail darter were based on adults collected and reared by Simon (17) from the Mississippi River drainage, Spring Coulee Creek, Vernon County and Coon Creek, La Crosse County, Wisconsin; Root River, Fillmore County, Minnesota; and upper Iowa River, Houston County, Iowa. Eggs were obtained from spawnings of aquarium-held adults and incubated at 2 temperatures (20° and 23°C) in the laboratory. Larvae of both species were fed live *Artemia* nauplii.

SPECIES ACCOUNTS

Striped fantail darter, *Etheostoma flabellare lineolatum* (Agassiz)

Eggs.—Three size classes of ova were observed in the dissected ovary of *E. flabellare lineolatum*. The smallest ova ranged 1.0–1.5 mm (n = 13, $\bar{x}$ = 1.3 mm), and were spherical, opaque, and pale yellow. The intermediate sized ova were ovoid, opaque, and pale yellow and ranged 1.5–2.0 mm (n = 15, $\bar{x}$ = 1.6 mm). Mature eggs collected from Spring Coulee Creek, Wisconsin, the Rock River, Illinois, and the upper Iowa River, Iowa, were all equivalent in diameter and ranged from 2.0–2.8 mm (n = 100, $\bar{x}$ = 2.4 mm). Mature eggs are spherical, demersal, and adhesive with translucent yellow yolk. Generally, mature eggs have a single oil globule, a narrow perivitelline space, an unsculptured chorion, and are unpigmented. Based on presence of various size classes of ova and aquarium observations, the striped fantail darter is considered a multiple spawner depositing more than a single clutch of eggs.

Eggs are attached to the undersides of slab rocks in the margins and slower portions of riffles and raceways (2, 12, 18, 19, 20).

Embryonic Development.—Embryonic development for the fantail darter has been previously described by Lake (12), Cooper (13), and Paine (15). Eggs incubated at 20°C hatched after 240 ± 18 hr (9.25–10.75 days); at 23°C, hatching occurred in 144 ± 10 hr (5.50–6.50 days). Lake (12) reported eggs of *Etheostoma f. flabellare* to hatch in 30–35 days at 17°–20°C; after 21 days at 21°–22°C; and in 14–16 days at 26°C.

Larvae

Morphology.—The size of initial formation for selected structures is summarized for larval and early juvenile *E. f. lineolatum* with morphometric features shown in Table 1. At 4.5–5.9 mm, newly hatched, well developed pec-

TABLE 1. Morphometry of *Etheostoma flabellare lineolatum* larvae and early juveniles grouped by selected intervals of total length (N = sample size). Characters expressed as percent total length or head length[a] with a single standard deviation.

		Length (% TL)					Depth (% TL)			
Total length	N	Standard	Preanal	Snout[a]	Eye[a]	Head	Head	Shoulder	Anus	Caudal Peduncle
4.5–6.9	61	89.7 ± 2.2	54.0 ± 2.9	7.9 ± 3.0	47.0 ± 5.5	18.4 ± 2.1	19.6 ± 1.4	32.2 ± 4.9	10.4 ± 1.4	6.5 ± 0.8
7.0–12.8	147	85.4 ± 2.4	51.0 ± 1.2	16.1 ± 3.6	38.7 ± 5.9	22.8 ± 2.3	18.2 ± 1.3	18.8 ± 2.9	12.8 ± 1.3	8.7 ± 1.1
13.0–15.9	16	82.7 ± 0.4	50.5 ± 1.2	19.0 ± 1.5	28.7 ± 2.3	24.8 ± 1.7	16.7 ± 1.8	18.6 ± 1.7	14.0 ± 0.9	9.9 ± 0.7
16.0–18.8	4	84.1 ± 1.0	50.1 ± 0.5	19.9 ± 0.7	23.4 ± 1.3	23.2 ± 1.1	12.6 ± 0.9	16.6 ± 0.4	14.6 ± 1.1	10.0 ± 0.8
19.1–21.6	4	85.0 ± 0.7	50.4 ± 0.9	19.8 ± 0.3	23.3 ± 1.3	24.2 ± 1.3	13.0 ± 0.3	17.3 ± 0.8	14.6 ± 0.7	9.4 ± 0.9
22.2–26.1	5	86.1 ± 3.5	50.3 ± 0.9	20.6 ± 1.9	23.2 ± 2.3	24.3 ± 0.1	13.4 ± 0.8	16.4 ± 1.2	13.8 ± 1.0	9.5 ± 1.1

toral fins without incipient fin rays; yolk sac extremely large, spherical (ca. 42% TL); yolk amber, with a single anterior oil globule; vitelline vein forming a plexus on mid-ventral yolk sac; head not deflected over the yolk sac; jaws developed; eye diameter oval. Notochord flexion occurs 4.9–6.0 mm; first rays form in pectoral fin (5.0–5.6 mm); anal fin rays (5.3–5.9 mm); first caudal fin ray form (5.3–5.9 mm); soft dorsal rays form (5.4–6.2 mm); and spinous dorsal rays form (5.9–6.2 mm). Caudal fin round (5.8–6.2 mm); incipient dorsal and anal fin margins partially differentiate (7.1–8.0 mm); spinous dorsal fin origin situated over preanal myomere 4, soft dorsal origin over preanal myomere 15–16 (7.8 mm); predorsal length 36.3% SL (range: 33–39.7% SL); anal fin margin completely differentiate (7.9 mm); pelvic fin buds form anterior to dorsal fin origin prior to complete absorption of yolk sac (7.9–8.5 mm); yolk absorbed (7.8–8.0 mm). Entire finfold absorbed by 8.2 mm; first pelvic fin rays form (8.8–9.2 mm); no swim bladder forms, remains rudimentary (trace presence); gut straight; squamation initiated at 10.0 mm. Preoperculomandibular canals form (10.8–11.8); supraorbital, infraorbital, and lateral head canals form (11.0–12.6 mm); supraorbital completely form (11.7 mm); preoperculomandibular pores 10, completely form (12.6–13.8 mm); infraorbital canal form with 8 pores (10.8 mm), completely form with retrogression to interrupted condition of 4 pores anteriorly and 2 pores posteriorly (14.4–14.6 mm). Lateral line forms (14.0–14.2 mm); squamation complete (14.7 mm); scales absent on the nape, cheek, opercle, breast, and prepectoral areas.

Meristics.—Myomere number in *E. f. lineolatum* is constant posthatching, preanal myomeres 15, postanal myomeres 19–21 ($\bar{x}$ = 19.5; n = 155), with 34–36 total myomeres. Total vertebrae number 33–34 ($\bar{x}$ = 33.8, n = 5), including one urostylar element (from cleared and stained specimens from Spring Coulee Creek and the Root River). Scales in the lateral series ranged from 42–57 ($\bar{x}$ = 47.7; mode = 48; n = 13). Paired and median fin rays and length at appearance are summarized in Table 2.

Pigmentation.—Newly hatched larvae with scattered melanophores on a large yolk sac with greatest concentration laterally. Stellate

TABLE 2. Selected meristic values and size (mm total length) at the apparent onset of development for *Etheostoma flabellare lineolatum* and *E. percnurum*. Mean values are underscored. The number of secondary rays of the median fins are in lowercase Roman numerals.

Attribute/Event	*E. f. lineolatum*	*E. percnurum*
Dorsal fin spines/rays	VIII–IX/12–13–14	VI–VII–VIII/10–12–13
First rays formed	5.9/5.7	5.8/5.8
Adult complement formed	7.6/7.2	6.1/7.4
Pectoral fin rays	12–13	12–13–14
First rays formed	5.0–5.6	5.8
Adult complement formed	7.0	6.1–6.2
Anal fin spines/rays	II/9–10–11	II/7–8–9
First rays formed	5.3–5.9	5.8
Adult complement formed	7.0–7.2	7.4
Pelvic fin spines/rays	I/5	I/5
Bud formed	7.9–8.5	>8.1
First rays formed	8.8–9.2	9.3
Adult complement formed	8.8–9.2	9.3
Caudal fin rays	ix–xiv, 8 + 7, viii–xiv	xi–xvi, 8 + 8–9, xi–xv
First rays formed	5.3–5.5	5.8
Adult complement formed	7.0–7.5	7.5
Lateral series—scales	42–48–57	38–40–45–48
Myomeres/vertebrae	34–36/33–34	34–36/33–34–35
Preanal myomeres	15	15
Postanal myomeres	19–21	19–21

melanophores encircle optic lobe. Several melanophores laterally, rising obliquely near nape; lateral pigmentation with a midlateral stripe from the yolk sac posterior to base of caudal peduncle. Ventral melanophores present on gut and from posterior anus to approximately postanal myomere 9. Dorsal melanophores in 2 blotches located just anterior the anus, and initiating near posterior of ventral postanal melanophores. Majority of preanal myomeres without pigmentation (4.5–5.9 mm; Fig. 1). Postorbital bar formed, with additional horizontal pigment on operculum. Yolk sac with stellate melanophores on distal half. Dorsally, pigmentation on nape and at the base of soft dorsal. Laterally, melanophores outlining preanal myosepta posteriad of yolk sac, extending to middle of soft dorsal; a midlateral stripe formed from single melanophores at apex of preanal myomeres posterior of yolk sac. Ventrally, stellate melanophores present at almost every postanal myoseptum with several extending dorsally to midlateral; melanophores present at base of caudal fin (6.0–7.5 mm; Fig. 2A). Horizontal preorbital and postorbital bars with additional pigment present on operculum, and dorsally on nape; melanophores outline lateral myosepta of all myomeres just posteriad of soft dorsal. Melanophores extend onto rays of caudal, anal, and soft dorsal. Ventral pigmentation concentrated at midventral gut, and beneath operculum and branchiostegal rays (7.8–9.2 mm: Fig. 2B). Chevron shaped clusters present dorsal-anterioriad to orbit, and on the optic lobe. Dorsally 8 rectangular blotches extend from nape to base of caudal peduncle. Oval blotches become continuous anteriorly along the midlateral with scattered gut melanophores. Ventral pigmentation limited to 5 areas of concentration from just after anus to base of caudal peduncle. Spinous dorsal, pectoral, pelvic, and anal fins devoid of pigment (9.5–10.9 mm; Fig. 3A). An oblique bar extends towards nape laterally, posterior the orbit; cerebrum and optic lobe with clustered melanophores. Dorsally, 9–10 rectangular blotches with obliquely scattered melanophores connecting 12–13 midlateral blotches. Lateral epaxial scales outlined with scattered melanophores; pectoral girdle with a blotch near cleithrum. Lepidiotrichia of spinous and soft dorsal, anal, and base of caudal fins with melanophores. Mandible, maxilla, and interopercle with scattered melanophores; pectoral and pelvic fins devoid of pigment (11.0–13.9 mm). Juvenile pigmentation, cra-

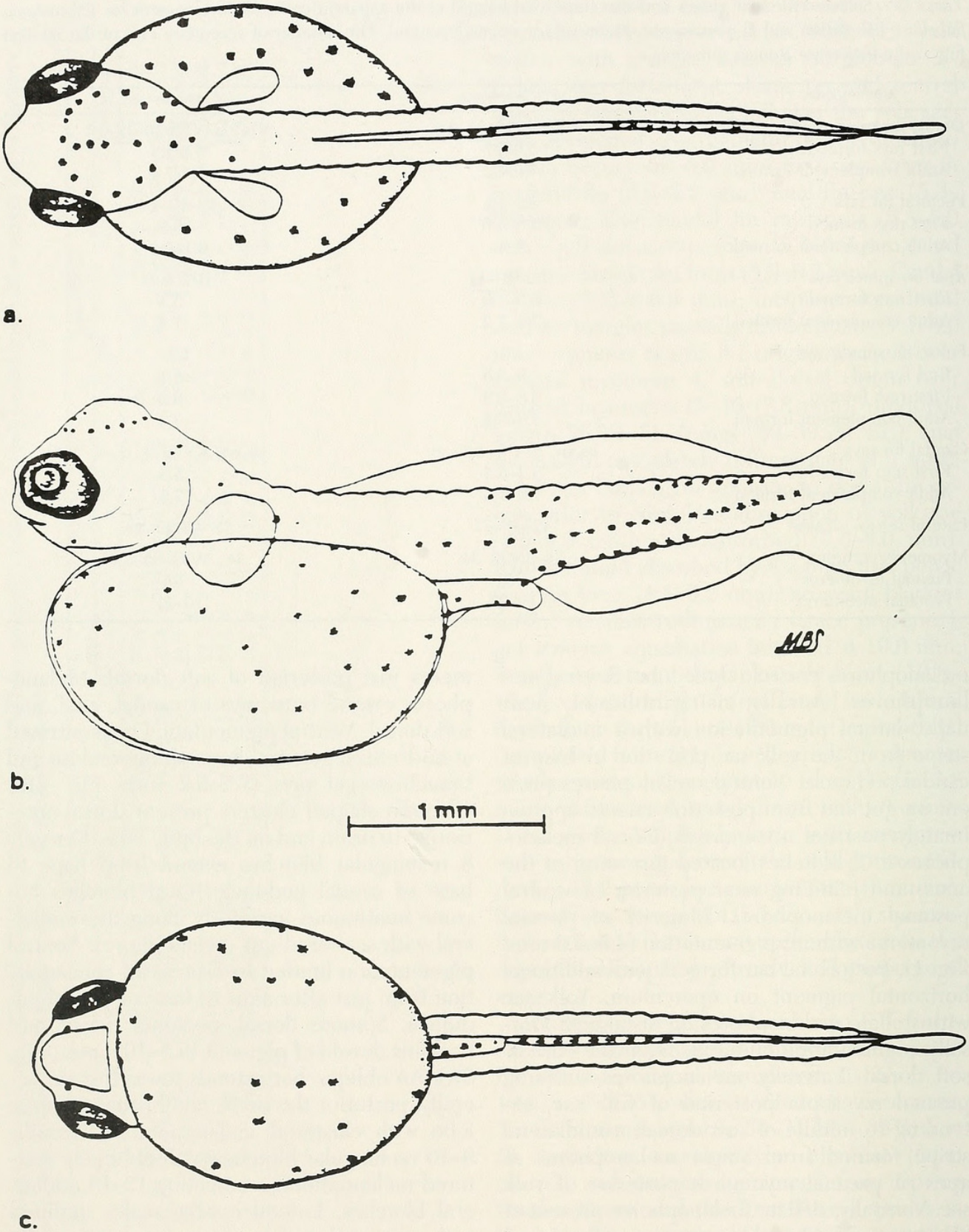

FIG. 1. *Etheostoma flabellare lineolatum*, striped fantail darter, newly hatched yolk sac larva, 4.8 mm TL, Coon Creek, Wisconsin. a. dorsal, b. lateral, c. ventral views.

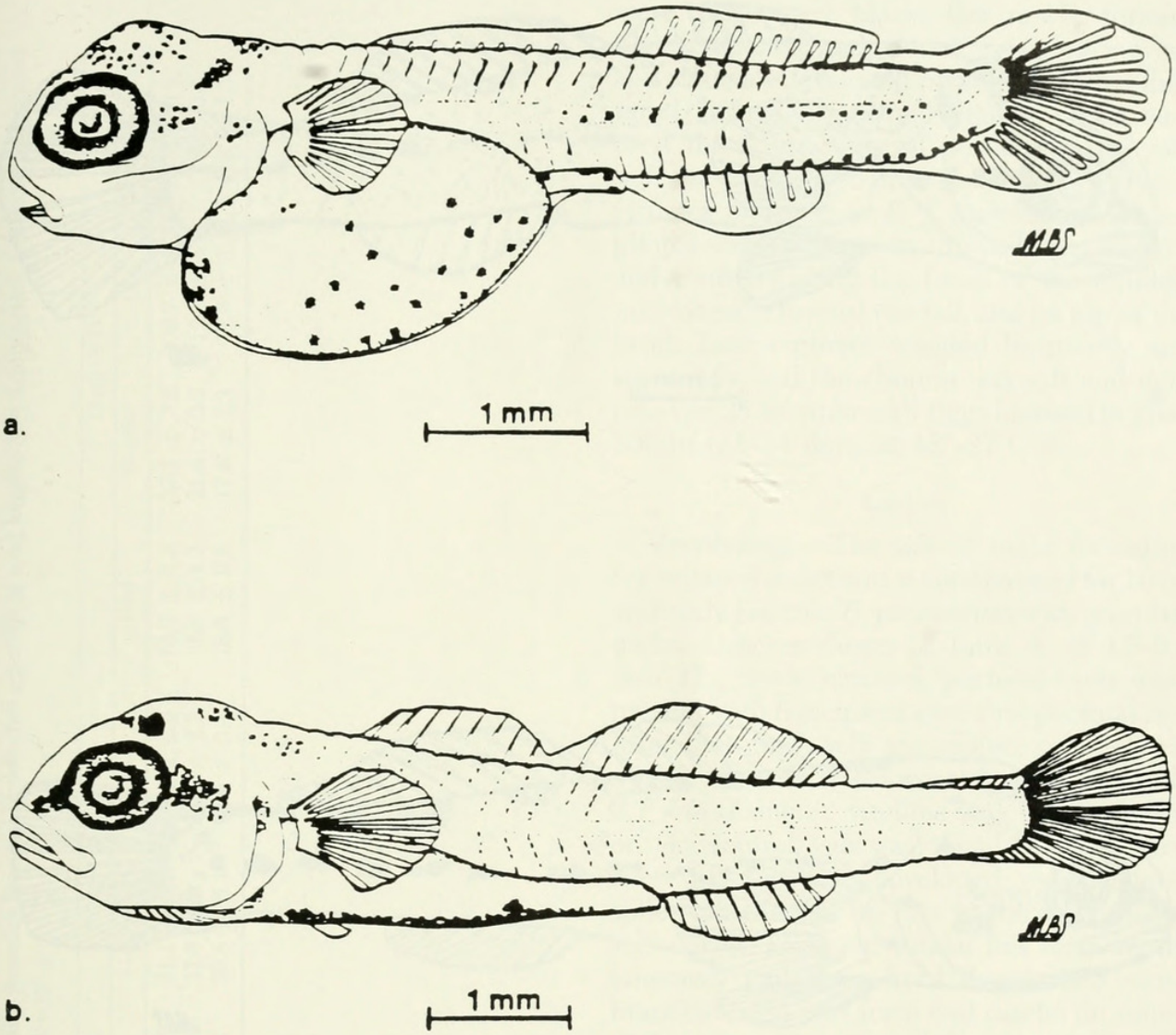

FIG. 2. *Etheostoma flabellare lineolatum*, striped fantail darter, Spring Coulee Creek, Wisconsin. a. 7.1 mm TL larva, lateral view, b. 8.2 mm TL larva, lateral view.

nium with concentrated melanophores over optic lobe and cerebrum; distinct preorbital and postorbital bars formed, no suborbital tear drop; a chevron shaped cluster of melanophores parallel to postorbital bar, scattered melanophores on cheek. Lateral pigmentation including 11–13 rectangular blotches connecting to 8 dorsal bands; the final lateral blotch may be divided to form 2 spots near midlateral caudal peduncle base. Horizontal lines of melanophores extend from the head to caudal peduncle, formed from individual melanophores on outer margins of scales; distinct humeral spot formed near posterior of opercular spine. Spinous dorsal, pectoral, and anal fins with scattered pigmentation on rays; 4–5 horizontal stripes on soft dorsal distributed on fin rays; caudal fin with 6–8 vertical stripes formed on interstitial membranes; pelvic fins without pigmentation (Fig. 3B).

Duskytail darter, *Etheostoma percnurum*

Eggs.—Nests of the duskytail darter in Little River consisted of single-layer clusters of 23 to 200 eggs (n = 22; $\bar{x}$ = 79; SD = 46) attached to the undersides of slab-shaped stones (4, 21). Fertilized eggs were translucent and spherical, and averaged 2.8 mm diameter from wild nests (range: 2.6–3.3 mm; n = 35; SD = 0.2 mm) and 2.9 mm from aquarium nests (range: 2.6–3.3 mm; n = 25; SD = 0.1 mm; 4). The chorion was clear, adhesive, and flattened at the point of attachment to the nest stone. The yolk was translucent, and a large translucent amber oil globule, surrounded by

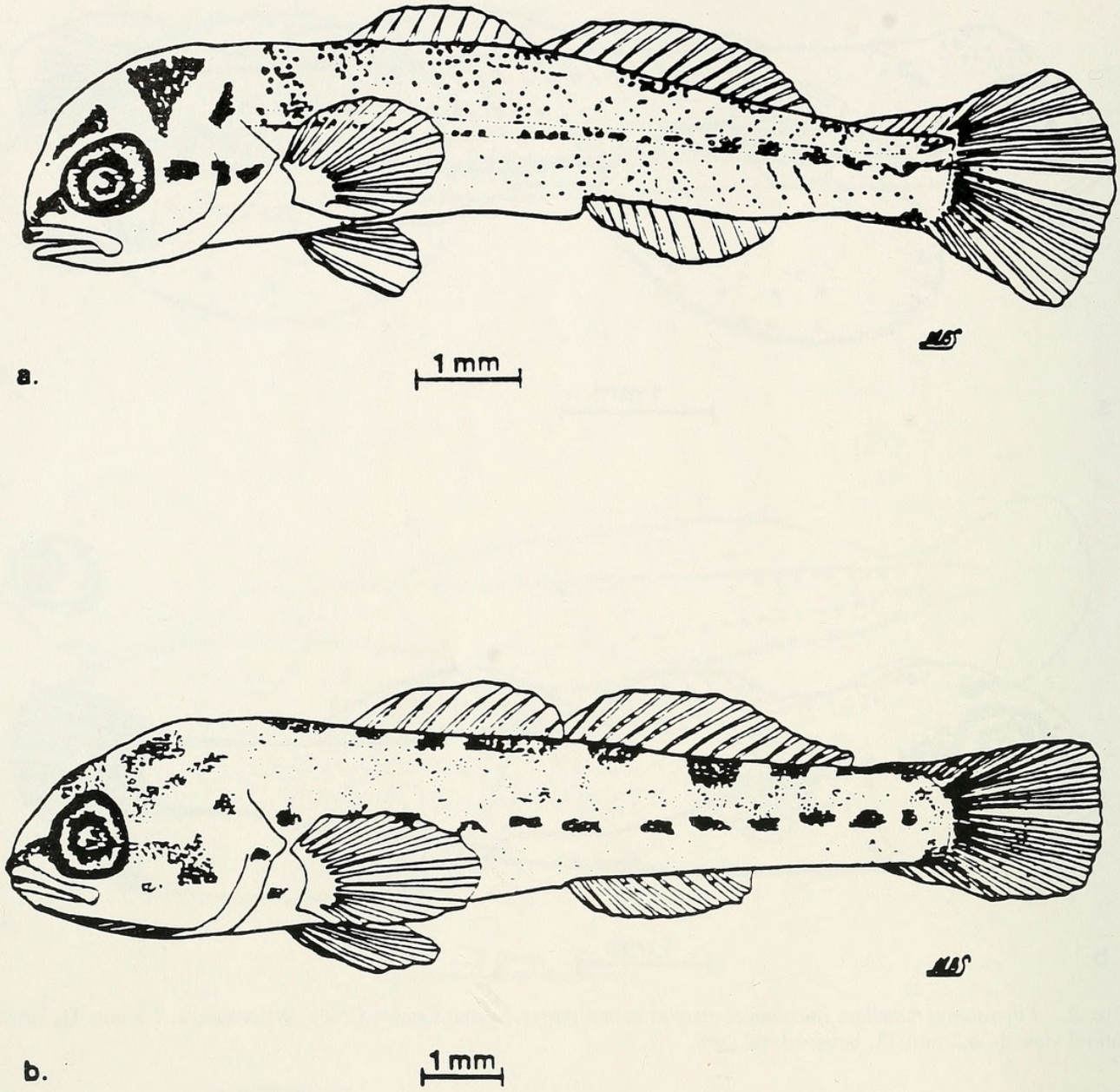

FIG. 3. *Etheostoma flabellare lineolatum*, striped fantail darter, Root River, Minnesota. a. 10.3 mm TL early juvenile, lateral view. b. 14.4 mm TL juvenile lateral view.

several much smaller ones, imparted an amber color to the egg.

Embryonic Development.—The morula was round and measured 0.8–0.9 mm in diameter; yolk was 2.2–2.3 mm in diameter, with a single large oil globule 0.6–0.7 mm in diameter; the perivitelline space ranged 0.1–0.4 mm (5 hr embryos). The blastoderm of the early embryo covered 67% of the yolk, the embryonic axis was forming, and the germ ring was visible (26 hr embryo). In the tail-bud stage, the optic vesicles were forming, and 9 somites were visible (ca. 28–47 hr embryos). In early tail-free embryos, dorsal and ventral finfolds were developing; auditory vesicles were visible; lenses were forming in the unpigmented eyes; and about 30 somites were discernible; the heart was clearly beating, and the embryo occasionally twitched. Melanophores were widely scattered over the yolk membrane and were most concentrated on the vent and body-yolk juncture (50 hr embryos). By the late tail-free stage, the head was highly elevated; the eyes were grayish-black; and the pectoral fin buds were present. Melanophores were more concentrated over the yolk membrane and had developed ventrally along the body to the tail (72–96 hr embryos). In late embryos, the eyes

TABLE 3. Morphometry of *Etheostoma percnurum* larvae and early juveniles grouped by selected intervals of total length (N = sample size). Characters expressed as percent total length or head length[a] with a single standard deviation.

Total length	N	Length (% TL)					Depth (% TL)			
		Standard	Preanal	Snout[a]	Eye[a]	Head	Head	Shoulder	Anus	Caudal peduncle
4.5–6.2	6	96.3 ± 0.4	56.8 ± 4.6	9.5 ± 1.5	41.1 ± 5.2	21.4 ± 2.0	18.9 ± 1.3	37.7 ± 7.0	9.7 ± 1.3	4.3 ± 0.9
7.4–11.8	16	86.3 ± 2.7	50.3 ± 1.7	15.0 ± 2.4	37.6 ± 4.1	23.2 ± 2.3	18.6 ± 1.3	21.4 ± 3.7	12.3 ± 1.0	7.0 ± 0.5
12.3–15.5	2	82.8 ± 0.9	52.4 ± 1.6	17.8 ± 0.1	30.8 ± 5.1	26.6 ± 0.1	16.8 ± 0.8	17.0 ± 1.1	11.6 ± 1.1	6.8 ± 1.3

were pigmented black; the newly formed mouth opened and closed; opercles moved; and the well-developed pectoral fin buds fluttered. A highly branched vitelline plexus covered the anterio-ventral portion of the yolk sac, very similar to that described by Paine (15) for embryos of *E. f. flabellare*. Melanophores were present on the yolk sac, dorsally and ventrally along the bases of the finfolds, mid-laterally toward the tail, and on top of the head. Late embryos wiggled frequently and vigorously, and the chorion was soft and delicate (>125 hr embryos). Eggs hatched in 264–336 hr (11–14 days) at 18°–27°C (5).

Larvae

Morphology.—The size of initial formation for selected structures is summarized for larval and early juvenile *E. percnurum* with morphometric features shown in Table 3. At 4.5–5.4 mm TL, newly hatched, pectoral buds were present with 6 incipient rays; first pectoral rays form (5.8 mm); yolk sac robust, spherical ca. 47.9% TL, yolk translucent, single oil globule 0.7 mm diameter; vitelline vein form a plexus on midventral yolk sac; head not deflected over yolk sac; jaws developed; eye diameter spherical. Median fin rays in the spinous and soft dorsal, anal, and caudal fins form simultaneously with notochord flexion (5.8 mm); branchiostegal rays form and caudal fin round (6.2 mm); incipient anal fin margin partially differentiated (7.4 mm); incipient dorsal fin margin partially differentiated (7.5 mm); spinous dorsal fin origin situated over preanal myomere 3–4, soft dorsal origin situated over postanal myomere 16 (7.5 mm); predorsal length 32.3% TL (range: 29.0–44.2% TL); 38.3% SL (range 31.2–53.3% SL; 7.5 mm); incipient anal fin margin completely differentiated (7.8 mm); pelvic buds form anterior to spinous dorsal fin origin (>8.1 mm); yolk completely absorbed and first pelvic fin rays form (9.3 mm); no swim bladder forms; gut straight; entire finfold absorbed (8.1 mm). Scale formation initiated in 15.5 mm juvenile at base of caudal peduncle. Squamation nearly complete by 18 mm SL. Scales absent from the cheeks, opercles, nape, breast, prepectoral area, and middle of abdomen.

Meristics.—Myomere number in *E. percnurum* constant posthatching, preanal myomeres 15, postanal 19–21 ($\bar{x}$ = 19.9, n = 20),

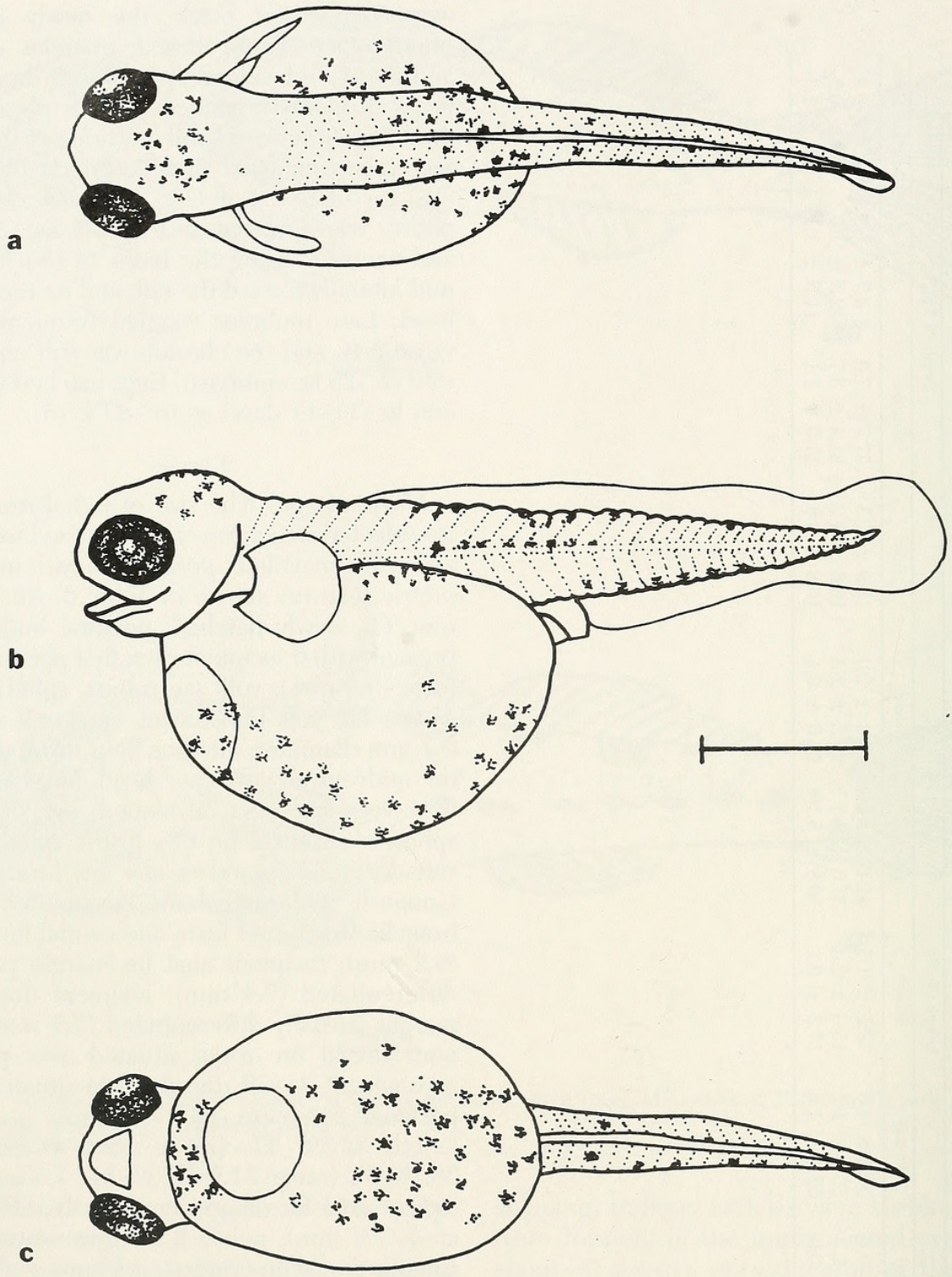

FIG. 4. *Etheostoma percnurum*, duskytail darter, newly hatched yolk sac larva, 5.1 mm TL, Little River, Tennessee. a. dorsal, b. lateral views, c. ventral views.

with 34–36 total myomeres ($\bar{x}$ = 34.8, n = 20). Total vertebrae number 33–35 ($\bar{x}$ = 34.0, n = 5), including one urostylar element (from cleared and stained specimens from Little River). Scales in the lateral series ranged from 38–48 ($\bar{x}$ = 43.3; mode = 45; n = 5). Paired and median fin ray values and lengths at appearance are presented in Table 2.

Pigmentation.—At 4.9–5.7 mm, newly hatched larvae: body translucent; amber oil globule flattened, located anteriorly in yolk sac; highly branched vitelline plexus (red in

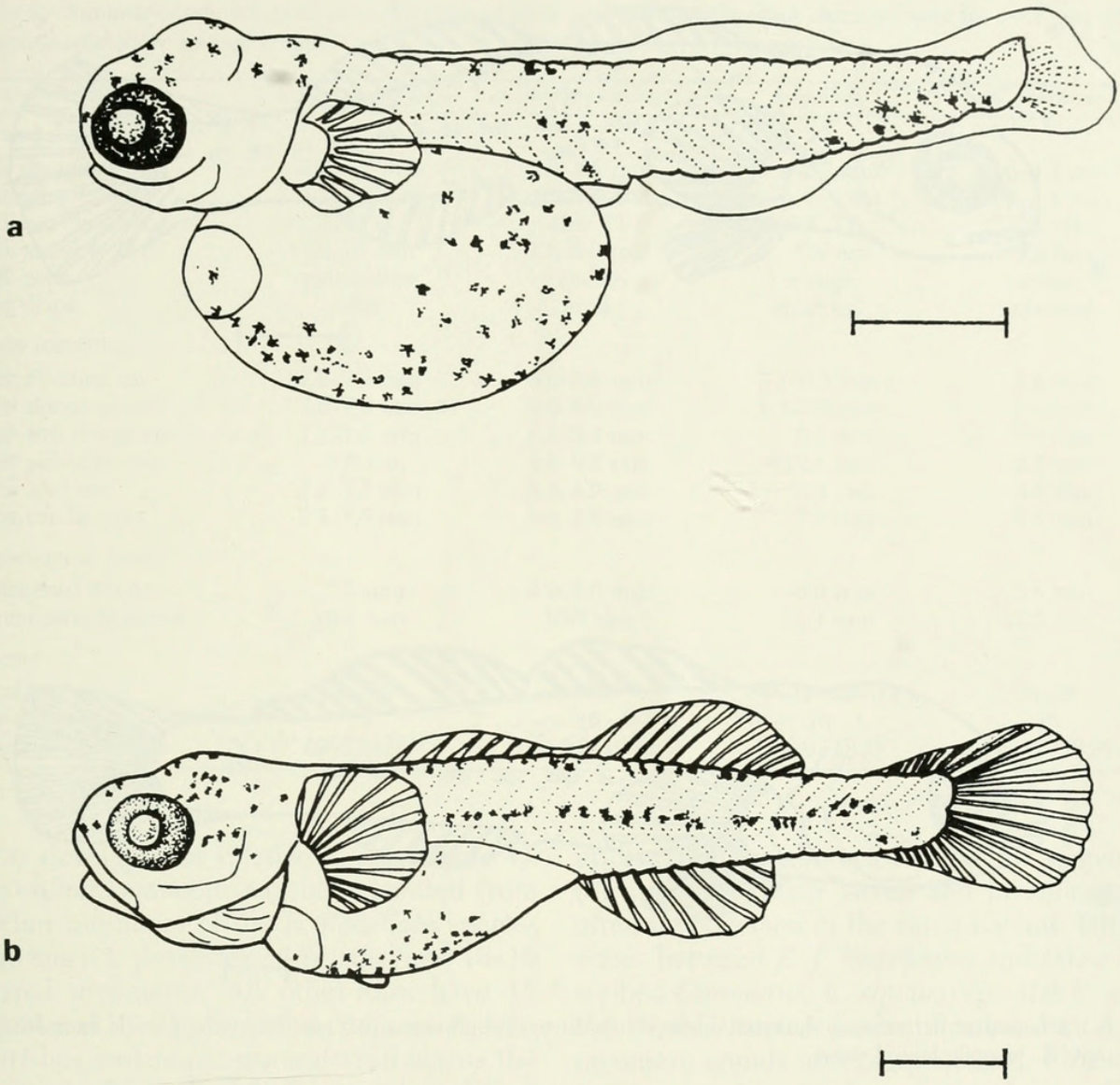

FIG. 5. *Etheostoma percnurum*, duskytail darter, Little River, Tennessee. a. 6.9 mm TL larva lateral view, b. 8.2 mm TL larva lateral view.

life) over oil globule and anterio-ventral portion of yolk sac; melanophores on yolk sac most concentrated ventrally, posterio-laterally, and at body-yolk juncture; prominent patch of melanophores on top of head; melanophores irregularly distributed along dorsum, mid-laterally along myosepta, and ventrally toward the tail (Fig. 4A, B). Melanophores developing anteriorly on top of head toward snout (6.1–6.2 mm; Fig. 4C). Body straw-colored, less translucent; dense patch of stellate melanophores on top of cranium; orbital bar of melanophores developing from opercle to snout; melanophores concentrated medially along dorsum and mid-laterally along horizontal septum; melanophores beginning to develop on soft dorsal, caudal, and anal fin rays; subcutaneous melanophores dorsally on gut (7.4–8.3 mm; Fig. 5). Pre- and post-orbital bars distinct; melanophores forming indistinct blotches dorsally (7–8) and mid-laterally; light scattering of melanophores on soft dorsal, caudal, and anal rays, and to lesser extent on spinous dorsal fin; subcutaneous melanophores on back of head and opercles; gold iridescent pigment in eyes (9.2–9.8 mm). Juveniles pigmentation, body opaque, straw-colored, heavily pigmented with melanophores; melanophores on top of head concentrated and confluent; dorsal and lateral blotches wider, diffuse, with indistinct dorso-lateral connections between them; soft dorsal, anal, and caudal fin rays lined with melanophores; few melanophores on pectoral and pelvic fin rays, spinous dorsal

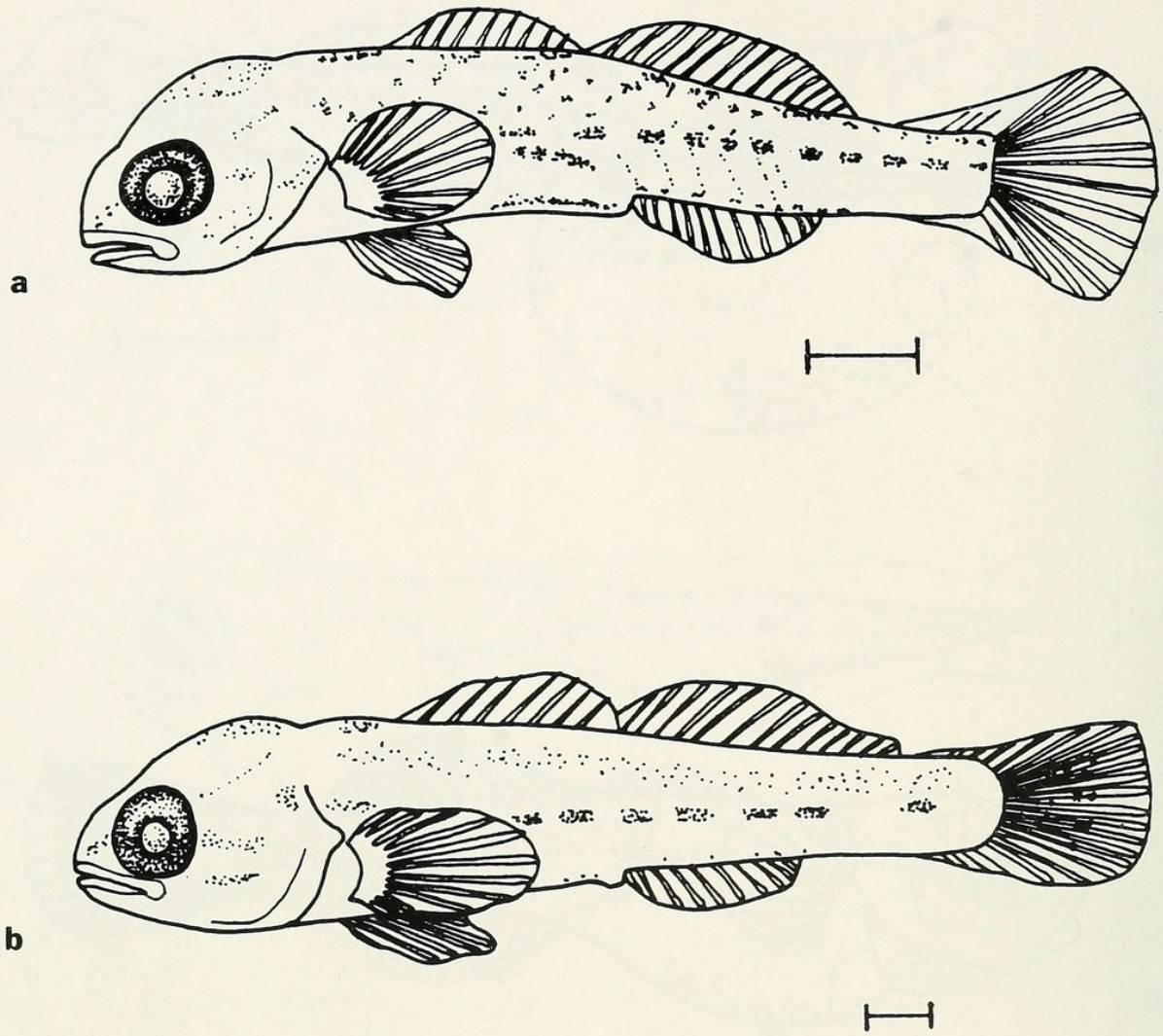

FIG. 6. *Etheostoma percnurum*, duskytail darter, Little River, Tennessee. a. 9.5 mm TL early juvenile lateral view, b. 15.5 mm TL juvenile lateral view.

fin, underside of head, breast, and belly; gold iridescence in eyes more pronounced (10.1–15.5 mm; Fig. 6). A wild juvenile at 18 mm SL: squamation nearly complete; pigmentation approaching that of adult: body straw-colored, 12 lateral vertical brown bars connected dorsolaterally to 6–7 irregular brown dorsal saddles, dark humeral spot, and cheeks speckled with melanophores.

DISCUSSION

Species of *Catonotus* are well known for their derived spawning habit of clustering eggs on the undersides of stones (8, 22). *Etheostoma flabellare* spawns beneath large stones in riffles, runs, or pools with slow to moderate current (12, 18). Spawning of *E. f. lineolatum* occurs in early April until May (23, 24, 25). In Wisconsin and Minnesota, spawning initiated in early May and continued until June at temperatures between 13°–17°C, but continued until mid-July when temperatures approached 25°C in Iowa and Illinois (17). The duskytail darter spawns in Little River from late April through June in pools and moderate runs beneath slab-shaped cobbles (5).

Etheostoma f. lineolatum and *E. percnurum* are sympatric, however, the former species is referred to as *E. f. flabellare* by McGeehan (2). Duskytail darter larvae are more precocious, developing incipient rays in the pectoral fins and complete rays in the median fins earlier than striped fantail darters; however, squamation begins later, at lengths >15 mm TL. These two taxa can be distinguished from other described members of the *E. flabellare* species group, *E. f. flabellare* and *E. kennicotti*, based on myomere number, pigmentation and

TABLE 4. Summary comparison of meristic, pigmentation, and ontogenetic event characteristics for four taxa of the *Etheostoma flabellare* species group.

Characteristic	*E. flabellare flabellare*	*E. flabellare lineolatum*	*E. kennicotti*	*E. percnurum*
Size and shape				
Egg diameter	2.2–2.7 mm	2.0–2.8 mm	1.9–2.5 mm	2.6–3.3 mm
Hatching length	4.7–6.2 mm	4.5–5.9 mm	4.1–4.7 mm	4.5–5.4 mm
Yolk sac diameter	31% TL	42% TL	32% TL	48% TL
Yolk sac absorbed	9–10 mm	7.8–8.0 mm	7.5 mm	9.3 mm
Yolk color	pale yellow	amber	orange	amber
Eye shape	oval	oval	spherical	spherical
Fin ray formation				
First pectoral ray	7.2–7.5 mm	5.0–5.6 mm	5.1–5.2 mm	5.8 mm
First dorsal spine	7.2–7.5 mm	5.9–6.2 mm	5.1–5.2 mm	5.8 mm
First soft dorsal ray	7.2–7.5 mm	5.3–5.9 mm	5.1 mm	5.8 mm
First pelvic fin ray	8.8 mm	8.8–9.2 mm	<12.1 mm	9.3 mm
First anal ray	7.2–7.5 mm	5.3–5.9 mm	6.9 mm	5.8 mm
First caudal ray	7.2–7.5 mm	5.3–5.9 mm	7.5 mm	5.8 mm
Morphological event				
Notochord flexion	7.2 mm	4.9–6.0 mm	6.9 mm	5.8 mm
Squamation initiated	13.0 mm	10.0 mm	13.1 mm	15.5 mm
Meristics				
Total myomeres	34–36	34–36	34–35	34–36
Preanal myomeres	15	15	16	15
Postanal myomeres	19–21 (21)	19–21 (19.5)	18–19 (18.5)	19–21 (19.9)

fin ray development relative to size (Table 4). *Etheostoma kennicotti* can be separated from all other members of the *E. flabellare* species group since it possesses 16 preanal and 18–19 postanal myomeres. All other taxa have 15 preanal and 19–21 postanal myomeres. *E. kennicotti* has melanophores scattered across the yolk-sac similar to *E. flabellare*, while it differs in possessing a dorsal and ventral cluster posterior to the anus. The other three taxa can be separated based on yolk-sac diameter, eye shape, and ontogenetic development of fin rays. The duskytail darter has a spherical eye shape while both subspecies of *E. flabellare* have an oval eye shape. Significant differences exist in the ontogenetic development of fin rays between *E. f. flabellare* and *E. f. lineolatum*. Development of fin rays is more precocious in *E. f. lineolatum*, occurring at smaller length intervals for all but the formation of the first pelvic fin ray. Yolk sac diameter is greatest in duskytail darter (48% TL), followed by *E. f. lineolatum* (42% TL), and *E. f. flabellare* (31% TL), while the yolk sac is absorbed at smaller length intervals in *E. f. lineolatum* and at similar sizes for *E. f. flabellare* and duskytail darter.

Sympatric species of *Catonotus* are likely to utilize similar slab rock habitat for spawning (3), and thus, their larvae and juveniles may often be collected in the same habitat. Differences between *E. f. lineolatum* and other described *Catonotus*, *E. squamiceps* and *E. smithi*, enable accurate identification based on myomere counts and pigmentation. *Etheostoma squamiceps* can be separated from *E. f. lineolatum* because the former possesses 16 preanal and 18–19 postanal myomeres (9). *Etheostoma smithi* has similar myomere counts to *E. f. lineolatum* but differs in yolk sac diameter, pigmentation, and formation of the rays (10). Yolk sac diameter is smaller (33.5%) than *E. f. lineolatum*; pigmentation is restricted to the nape, ventral yolk-sac, and mid-ventral postanal myosepta; and fin ray formation occurs later than in *E. f. lineolatum*.

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