# *Notropis mekistocholas*, a New Herbivorous Cyprinid Fish Endemic to the Cape Fear River Basin, North Carolina

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**Notropis mekistocholas is described as a new species. It is unusual within the genus in exhibiting herbivorous adaptations—an elongate, convoluted intestine and black peritoneum. It is compared with N. alborus and N. procne, two sympatric relatives that differ in lacking herbivorous modifications, in having seven rather than eight anal rays, and in numerous other features.**

**N. mekistocholas is the first known endemic species from the Cape Fear drainage in North Carolina. It has a very restricted distribution in the east-central Piedmont province, being known from only four streams in Chatham and Harnett counties.**

**Intestinal modifications suggestive of an herbivorous diet are reported for N. anogenus and some species of the subgenus Luxilus. There is no evidence to suggest that N. mekistocholas should be aligned with the southwestern genus Dionda, which contains herbivorous species superifically similar to Notropis species. Closest relatives of N. mekistocholas appear to be N. procne and N. stramineus.**

## Introduction

The genus *Notropis* usually has been characterized as having a short, S-shaped alimentary tract, distinguishing it from closely related groups containing herbivorous forms with elongate intestines. Discovery of a unique new species of *Notropis*, closely related to *N. procne* (Cope), with an elongate gut tends to obscure further the already-vague limits of certain North American cyprinid genera.

This new minnow was first discovered in 1962 in a poorly collected region of the Cape Fear River drainage in east-central North Carolina. Subsequent collecting has revealed that it is endemic to a very restricted area within that system. Although its situation at present is not precarious, its limited distribution and the constant threat of habitat alteration suggest that this new form should be added to the growing list of endangered species.

## Methods

Counting and measuring procedures followed Hubbs and Lagler (1958:19–26) except as noted. Expression of meristic data in the form (8)9–11 (13) indicates that extreme values for this character were 8 and 13, and that 85–95% of the observed counts were between 9 and 11.

The number of predorsal scale rows includes all oblique scale rows crossing an imaginary line between the anterior insertion of the dorsal fin and the cleithrum. The first row counted was the one including the first predorsal scale; the last row counted was the one including the first (anterior-most) lateral line scale. Single scales interposed between two otherwise regular rows were not counted. However, two or more scales in a regular oblique series were considered a row even if that series terminated before crossing the dorsal midline or the lateral line.

The breast was defined as that triangular-shaped area forward of an imaginary line joining the most posterior point of the bases of the pectoral fins. Extent of breast scalation was estimated to the nearest 5%. Height and width of the exposed portion of the third lateral line scale behind the head were determined under a dissecting microscope equipped with an ocular micrometer; the results were expressed in a height-to-width ratio. Gill rakers on the lower limb of the first branchial arch were enumerated on the right side for ease of handling. Any raker that straddled the angle of the arch was included in the count. Vertebral numbers were determined from radiographs. The Weberian apparatus was included as four and the hypural as one.

The opercular membrane was excluded

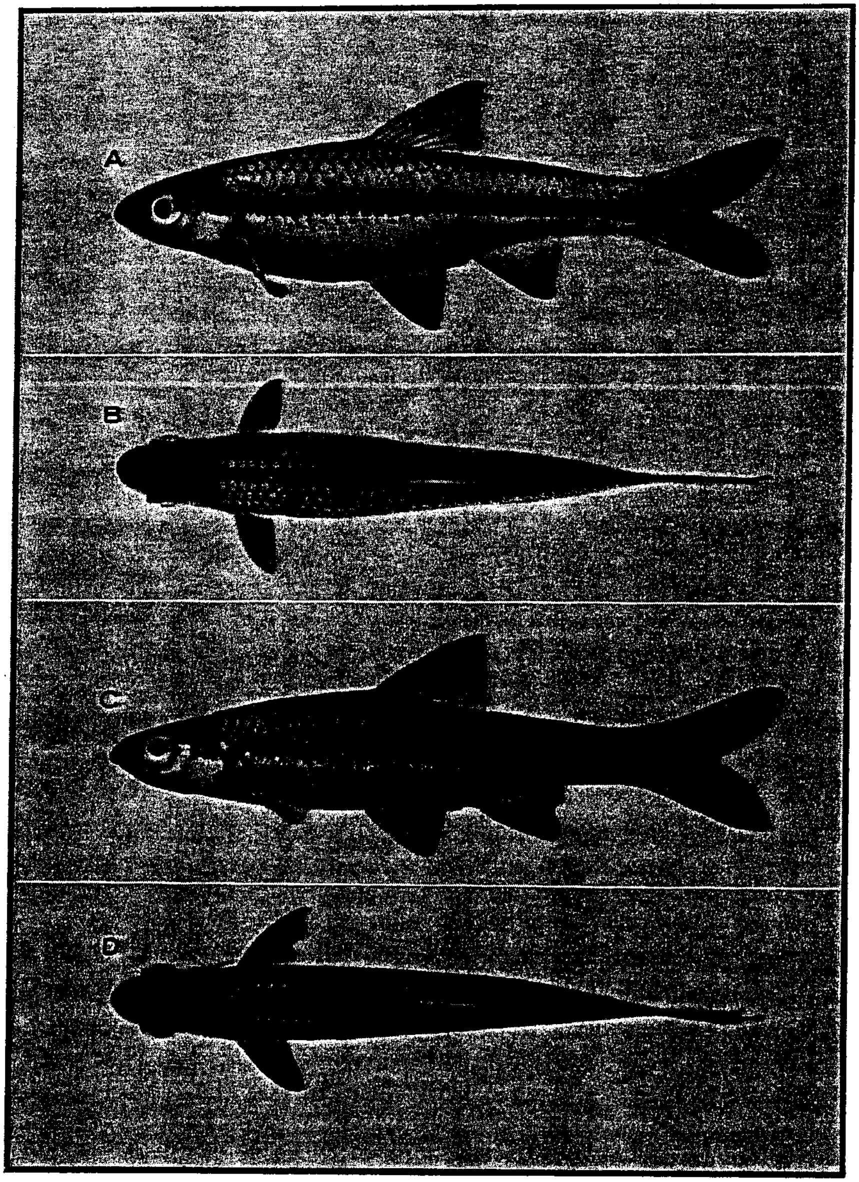


Fig. 1. A and B. Lateral and dorsal views of *Notropis mekistocholas*, gravid adult female 45.4 mm SL, NCSM 3105. C and D. Lateral and dorsal views of *Notropis procne*, tuberculate adult male 47.2 mm SL, NCSM 2974. (The slightly deeper body of the *N. mekistocholas* specimen is due to enlarged ovaries.)

from head length and postorbital head length measurements. Fleshy orbit length was the greatest transverse distance between the fleshy margins of the orbit, excluding any marginal skin that grew inward to cover the cornea. Distance from the dorsal fin origin to the lateral line was measured in a vertical plane. Body width was the maximum dimension, measured between the pectoral and pelvic fin bases. Distance between the dorsal fin origin and the occiput was measured along the dorsal midline. Postdorsal length was taken from the origin of the dorsal fin to the caudal base. Prepelvic and

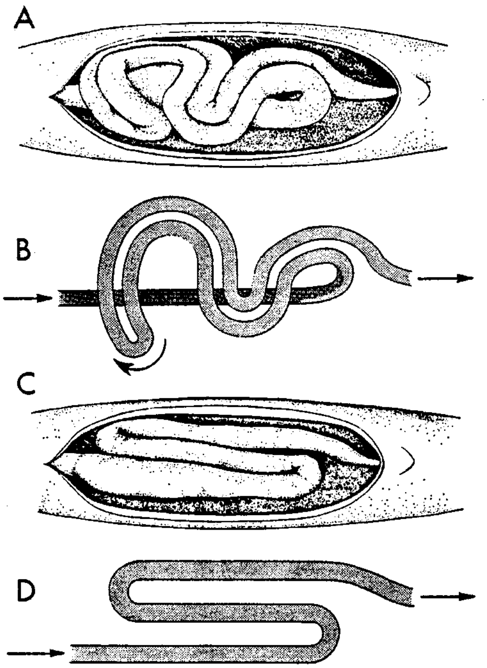


Fig. 2. A. Ventral view of the alimentary tract of *Notropis mekistocholas* with ventral body wall, viscera, and mesentaries removed. B. Alimentary tract of *N. mekistocholas*, diagrammatic. C. Ventral view of the alimentary tract of *Notropis procne* with ventral body wall, viscera, and mesentaries removed. D. Alimentary tract of *N. procne*, diagrammatic. Anterior to the left.

peranal measurements were taken from the insertion of the first ray of those fins to the tip of the upper lip. The distance between the anal fin origin and caudal fin base is self-explanatory.

In determining the length of the alimentary tract, the gut was severed immediately behind the transverse septum and at the anus; and all the viscera were removed. Connective tissue and organs were dissected away; and the alimentary tract was straightened, without stretching, along a steel millimeter rule.

Terminology, abbreviations, and counting procedures for the cephalic lateral line follow Illick (1956) with these exceptions:

1) The broad separation of the supratemporal canal at the dorsal midline is indicated by a comma; otherwise, interruptions along the length of a canal are indicated by a plus (+) sign. 2) A common pore at the junction of the supratemporal canal and postocular commissure was not included in the pore count of either canal. Unlike some recent authors (*e.g.* Reno, 1969), I follow Illick (1956) and include in the infraorbital canal those pores in the postocular commissure in addition to those in the infraorbital *sensu stricto*.

### *Notropis* ***mekistocholas*** n. sp.
Cape Fear Shiner
Figs. 1A, B; 2A, B

Apparently there are no references to this species in the literature. All of the material that Jordan (1889) recorded as *N. procne* from the Cape Fear has been reexamined by Hubbs and Raney (1947) and myself and found to represent either *N. alborus* or *N. procne*.

*Holotype.*—U. S. National Museum (USNM) 205299 (formerly NCSM 4928); a tuberculate adult male 55.7 mm SL; Cape Fear (Deep) dr., N. C., Chatham Co., Rocky R., N. C. Hwy. 902 bridge, 7.0 air miles SW center Pittsboro; 2 June 1968; Franklin F. Snelson, Jr. and William M. Palmer (FFS-68–31).

*Paratypes.*—Thirty-six specimens collected with the holotype are distributed as follows: Cornell University (CU) 64397 (7 specimens); Tulane University (TU) 63272 (7); University of Florida (UF) 17303 (7); University of Michigan Museum of Zoology (UMMZ) 197680 (7); USNM 205300 (8).

*Other material.*—None of the following are designated as type material: All were collected in the Cape Fear drainage in North Carolina and are deposited in the North Carolina State Natural History Museum. NCSM 2078 (6 specimens); Harnett Co., Neal's Cr., Co. Hwy. 1441 bridge, 2.5 miles W Angier. NCSM 2770 (4), 2976 (30), 3105 (13), 4842 (13); Chatham Co., Robeson Cr., Co. Hwy. 1939 bridge, 4.5 air miles ESE center Pittsboro. NCSM 3278 (16); Harnett Co., Parker's Cr., Co. Hwy. 1450 bridge, 7.5 air miles WSW Fuquay-Varina. NCSM 3463 (17), 3707 (5); Chatham Co., Rocky R., Co. Hwy. 1010 bridge, 5.5 miles SW center Pittsboro. NCSM 3883 (15); Chatham Co., Rocky R., U. S. Hwy. 15–501 bridge, 6.75 miles S Pittsboro. NCSM 4126 (29), 5281 (32); Chatham Co., Rocky R., N. C. Hwy. 902 bridge, 5.5 air miles SW center Pittsboro.

A total of 276 specimens of the new species has been examined.

*Diagnosis.*—Distinguished from all members of the genus in having an elongate alimentary tract with two accessory convo-

TABLE 1. FREQUENCY DISTRIBUTIONS FOR SCALE COUNTS AND BREAST SQUAMATION INDEX IN *Notropis mekistocholas*, *N. procne*, AND *N. alborus* FROM THE CAPE FEAR DRAINAGE. VALUES FOR THE HOLOTYPE OF *N. mekistocholas* ARE UNDERLINED.

| Species and System | Lateral Line Scales | | | | | | | | | Predorsal Scale Rows | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 31 | 32 | 33 | 34 | 35 | 36 | 37 | N | $\bar{x}$ | 12 | 13 | 14 | 15 | 16 | N | $\bar{x}$ |
| *N. mekistocholas* | | | | 6 | 59 | 56 | 3 | 124 | 35.5 | | 9 | 53 | 85 | 3 | 150 | 14.5 |
| *N. procne* | | 4 | 22 | 37 | 22 | 1 | | 86 | 33.9 | | 6 | 38 | 40 | 6 | 90 | 14.5 |
| *N. alborus* | 1 | 10 | 29 | 11 | | | | 51 | 33.0 | 13 | 44 | 4 | | | 61 | 12.9 |

| | Predorsal Scales | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | N | $\bar{x}$ |
| *N. mekistocholas* | 6 | 36 | 33 | 37 | 21 | 8 | 2 | 3 | | | 146 | 14.5 |
| *N. procne* | 4 | 11 | 14 | 28 | 18 | 10 | 3 | – | – | 1 | 89 | 15.1 |
| *N. alborus* | | 4 | 9 | 10 | 14 | 14 | 2 | 2 | 2 | 1 | 58 | 15.9 |

| | % of Breast Scaled | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1–10 | 11–20 | 21–30 | 31–40 | 41–50 | 51–60 | 61–70 | 71–80 | 81–90 | 91–100 | N |
| *N. mekistocholas* | | | | | | | | | | | | |
| Rocky R. | | | | | | | | | 4 | 19 | 53 | 76 |
| Robeson Cr. | | | 1 | 2 | 1 | 1 | 2 | 6 | 10 | 18 | 14 | 55 |
| Cape Fear tribs. | | | | | | | | 1 | 1 | 6 | 9 | 17 |
| *N. procne* | 29 | 54 | 6 | – | 2 | – | 1 | | | | | 92 |
| *N. alborus* | | | 2 | – | 1 | 2 | 2 | 10 | 13 | 18 | 5 | 53 |

TABLE 2. FREQUENCY DISTRIBUTIONS FOR SOME MERISTIC CHARACTERS OF *Notropis mekistocholas*, *N. procne*, AND *N. alborus* FROM THE CAPE FEAR DRAINAGE. VALUES FOR THE HOLOTYPE OF *N. mekistocholas* ARE UNDERLINED.

| Species | Gill Rakers | | | | | | | | Vertebrae | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | N | x̄ | 34 | 35 | 36 | 37 | N | x̄ |
| *N. mekistocholas* | | | 7 | 29 | 17 | | 53 | 6.2 | | | 10 | 4 | 14 | 36.3 |
| *N. procne* | | | 6 | 20 | 27 | 4 | 57 | 6.5 | 4 | 8 | 3 | | 15 | 34.9 |
| *N. alborus* | 8 | 27 | 22 | 3 | | | 60 | 4.3 | 3 | 11 | 1 | | 15 | 34.9 |

| | Left Pectoral Rays | | | | | | | Anal Rays | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 12 | 13 | 14 | 15 | 16 | N | x̄ | 7 | 8 | 9 | N | x̄ |
| *N. mekistocholas* | 1 | 1 | 42 | 58 | 14 | 116 | 14.8 | 1 | 156 | 1 | 158 | 8.0 |
| *N. procne* | | 3 | 29 | 38 | 4 | 74 | 14.6 | 81 | 1 | | 82 | 7.0 |
| *N. alborus* | | 4 | 26 | 17 | 2 | 49 | 14.3 | 58 | | | 58 | 7.0 |

lutions crossing the intestinal bulb, and distinguished from most members of the genus in having a black peritoneum. Further differentiated from its closest relatives on the basis of eight anal rays, a well-scaled breast, black lips, and numerous other features.

*Description.*—Measurements and certain counts are presented in Tables 1–5. Dorsal rays number 8 (in 147 specimens). Caudal rays usually 19 (126), rarely 18 (5) or 20 (1). Pelvic rays usually 8 (130), rarely 7 (4) or 9 (5).

Frequencies of body circumference scale counts are 22 (in 1 specimen), 23 (16), 24 (112), 25 (14), and 26 (2); x̄ = 24.0. Disposition of body circumference scale rows is 10 (19), 11 (135), and 12 (1) above lateral line; and 9 (1), 10 (7), 11 (122), 12 (13), and 13 (2) below. Frequencies for caudal peduncle scale counts are 11 (1), 12 (139), 13 (4), and 14 (1); x̄ = 12.0. Caudal peduncle scales disposed 5 (141) and 6 (4) above lateral line; and 4 (1), 5 (142), and 6 (2) below.

Pharyngeal teeth 0,4–4,0 in 19 specimens, 0,4–3,0 in one; teeth with small yet distinctive terminal hooks and moderately developed grinding surfaces. Gill rakers short, blunt, and not close set; those near middle of lower limb of first gill arch usually not reaching base of first raker below when depressed. Gill raker counts are given in Table 2. Peritoneum dusky black. Gut elongate, with convolutions crossing midline at two points (Fig. 2A). In 10 adult specimens, gut length ranged from 136–236% of standard length (x̄ = 175).

Scales rather large, moderately imbricate, and not crowded before dorsal fin. Exposed portion of third lateral line scale about 2.3 times higher than wide (Table 4). Nape fully scaled. Breast usually fully scaled or nearly so (Table 1).

Lateral line complete, dipping slightly from head to below dorsal fin. Cephalic lateral line system well developed, with small pores. Supratemporal canal narrowly interrupted at dorsal midline. Supraorbital canal incomplete (not joining postocular commissure) but without interruptions along its length. Infraorbital and preoperculomandibular canals uninterrupted. Frequency distributions for pore counts are given in Table 3.

General physiognomy is shown in Figs. 1A, B. Adult size usually 45–60 mm SL; largest specimen examined was a 64.5 mm female. Body moderately stocky, subterete, and somewhat compressed. Snout moderately acute and rounded, always overhanging upper lip. Mouth inferior, rather small, and C-shaped when viewed from below. Cleft of jaws only slightly oblique, rising anteriorly to level of lower border of pupil. Jaws short, not extending posteriorly to a vertical through front margin of eye. Eye moderate in size, round, and positioned laterally on head.

All fins somewhat pointed, dorsal most conspicuously so. In depressed dorsal fin, anterior rays exceed length of posterior rays,

TABLE 3. FREQUENCY DISTRIBUTIONS OF PORE COUNTS IN THE CEPHALIC LATERAL LINE OF *Notropis mekistocholas*, *N. procne*, AND *N. alborus* FROM THE CAPE FEAR DRAINAGE. THE INTERRUPTION RATIO (IR) IS THE NUMBER OF SPECIMENS HAVING AN INTERRUPTED (INCOMPLETE) CANAL WRITTEN OVER THE TOTAL NUMBER OF SPECIMENS EXAMINED. VALUES FOR THE HOLOTYPE OF *N. mekistocholas* ARE UNDERLINED.

| Species | Preoperculomandibular Pores | | | | | | | | | | | | | | Supraorbital Pores | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 4+5 | 5+4 | 5+5 | 5+6 | 6+7 | IR | 7 | 8 | 9 | 10 | 11 | IR |
| *N. mekistocholas* | | | 7 | 27 | 16 | 2 | 1 | | | | | | | 0/53 | 3 | 20 | 25 | 3 | 1 | 0/52 |
| *N. procne* | 1 | 11 | 31 | 24 | 3 | | | | | | | | | 5/75* | 1 | 41 | 12 | 1 | | 0/55 |
| *N. alborus* | | | | | | | | | 4 | 5 | 25 | 10 | 1 | 45/45 | | 11 | 19 | 6 | 1 | 10/47* |

| | Supratemporal Pores | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1,1 | 1,2 | 2,1 | 2,2 | 2,3 | 3,2 | 3,3 | 3,4 | 3,5 | 4,3 | 4,4 | IR |
| *N. mekistocholas* | | | | 2 | 4 | 2 | 35 | 5 | 1 | 2 | 1 | 53/53* |
| *N. procne* | | 2 | 2 | 47 | 5 | 3 | 3 | 1 | | | | 64/64* |
| *N. alborus* | 4 | 2 | 1 | 26 | 3 | 1 | | | | | | 46/46* |

| | Infraorbital Pores | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 12 | 13 | 14 | 15 | 16 | 17 | 11+1 | 11+2 | 11+3 | 12+2 | 12+3 | 12+4 | 13+2 | 13+3 | 13+4 | IR |
| *N. mekistocholas* | 1 | 8 | 34 | 5 | | | | | | | | | | | | 3/51* |
| *N. procne* | | 3 | 8 | 30 | 7 | 2 | | | | | | | | | | 7/57* |
| *N. alborus* | | 1 | 2 | – | – | – | 1 | 3 | 2 | 7 | 15 | 1 | 2 | 5 | 1 | 44/47* |

* All specimens examined are not represented in the frequency distribution. Pore counts were not recorded from specimens in which pore formation, bone formation, or canal position were anomalous.

TABLE 4. COMPARISON OF *Notropis mekistocholas*, *N. procne*, *N. alborus*, AND *N. volucellus* IN THE RATIO OF HEIGHT TO WIDTH OF THE EXPOSED PORTION OF THE THIRD LATERAL LINE SCALE BEHIND THE HEAD.

| Species and Drainage | N | Ht/Width Ratio Range | $\bar{x}$ |
|---|---|---|---|
| *N. mekistocholas* | | | |
| Cape Fear | 16 | 1.8–2.8 | 2.34 |
| *N. procne* | | | |
| Cape Fear | 16 | 1.6–3.2 | 2.37 |
| *N. alborus* | | | |
| Cape Fear | 16 | 1.7–2.9 | 2.35 |
| *N. volucellus* | | | |
| Roanoke, Tar, Neuse | 25 | 2.3–4.7 | 3.49 |

and second principal ray the longest. Dorsal fin origin over or slightly anterior to pelvic fin origin and slightly nearer snout tip than caudal base. Anal fin slightly falcate along posterior border. Lower lobe of caudal fin consistently shorter and more bluntly rounded than upper lobe.

Snout tip lightly and uniformly pigmented. Upper lip black from tip posteriorly to near rictus. Outer edge of lower lip bearing a thin, black line, best developed anteriorly, fading out posteriorly near rictus. Black lips contrasting sharply with more lightly pigmented snout. Bar or crescent-shaped concentration of pigment often present at posteromesial corner of each nostril. Area between posteroventral border of nostril and anterodorsal border of eye conspicuously depigmented. Deep-lying pigment in meninges of brain usually forming dark, heart-shaped spot posteriorly on top of head and occasionally forming a pair of dark bars between eyes. The following areas are without pigment: mandibular rami, gular area, suborbital area, lower two-thirds of postorbital and opercular areas, and remainder of underside of head.

Narrow, dusky middorsal stripe best developed predorsally and not surrounding dorsal fin base; this stripe slightly broader and more intense immediately before and at origin of dorsal fin. Concentrations of pigment at bases of dorsal rays three through seven or eight forming inconspicuous dusky bar on body along base of fin. Upper procurrent caudal rays pigmented.

Predorsal and anterior dorsolateral scales unpigmented or sparsely pigmented basally, dusky on posterior half, and outlined with narrow black borders. Laterad to dorsal fin and on dorsal and dorsolateral areas of caudal peduncle, scale pockets more uniformly pigmented, and black borders broader and darker. No concentration of pigment over cleithrum.

Black band, rather uniform in width (about one scale row wide, slightly broader at midbody) and intensity, extending along sides of body from caudal base to head. Upper margin of band lying along midlateral horizontal myoseptum. Band continuous across upper third of opercle but broken between anterior margin of opercle and posterior edge of eye. Band continuous through eye, represented by lightly pigmented spots on anterior and posterior parts of iris; band not continuous around snout but represented by dark preorbital blotch over lachrymal bone. Rectangular or wedge-shaped caudal spot, about half the size of pupil, lying over hypural base and usually disconnected from, but occasionally narrowly joined to, lateral band. Anteriorly, lateral line running along ventral margin of dark lateral band; on caudal peduncle, lateral line centered in lateral band. Each lateral line pore marked above and below by a dark, triangular spot.

Partially depigmented band, about 1½ scale rows wide, lying above dark lateral band. Within light band, pockets and borders of scales weakly pigmented; but small, dusky blotch usually present at apex of some scales, especially along caudal peduncle where a row of spots may be formed. Less commonly, such spots present anteriorly in depigmented area or even on sides of body immediately below lateral line.

No concentration of pigment about anus. Deep-lying pigment weakly developed along base of anal fin, and pigment very weak or absent along lower edge of caudal peduncle. Pigment normally extending no farther down sides of body than lateral line scale row.

Fin interradial membranes immaculate. Faint lines of melanophores bordering all dorsal, caudal, and anal fin rays. Pigment borders variously developed on first four to eight pectoral rays. Pelvic rays with or without faint black margins.

*Life colors.*—In breeding males, belly, breast, and underside of head white, dorsum

TABLE 5. PROPORTIONAL MEASUREMENTS (EXPRESSED IN THOUSANDTHS OF STANDARD LENGTH) FOR *Notropis mekistocholas* AND *N. procne* FROM THE CAPE FEAR DRAINAGE.

| Character | *N. mekistocholas* | | | | | *N. procne* | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Holotype | 15 Males | | 13 Females | | 15 Males | | 12 Females | |
| | | $\bar{x}$ | Range | $\bar{x}$ | Range | $\bar{x}$ | Range | $\bar{x}$ | Range |
| Standard length (mm) | 55.7 | 49.2 | 45.6–54.7 | 48.7 | 44.3–51.4 | 47.7 | 44.3–52.9 | 47.9 | 44.1–51.7 |
| Head length | 232 | 231 | 223–238 | 231 | 225–236 | 231 | 220–240 | 232 | 225–239 |
| Head depth | 153 | 154 | 148–162 | 161 | 152–172 | 154 | 144–163 | 161 | 156–171 |
| Head width | 140 | 140 | 134–147 | 143 | 133–152 | 145 | 139–153 | 150 | 142–157 |
| Postorbital head length | 96 | 98 | 94–102 | 97 | 92– 99 | 98 | 95–105 | 101 | 96–104 |
| Fleshy interorbital width | 89 | 88 | 84– 93 | 91 | 84– 97 | 82 | 77– 89 | 85 | 74– 89 |
| Fleshy orbit length | 72 | 71 | 65– 75 | 71 | 64– 75 | 74 | 67– 80 | 73 | 69– 77 |
| Snout length | 68 | 68 | 62– 72 | 69 | 65– 72 | 69 | 64– 76 | 70 | 67– 74 |
| Upper jaw length | 60 | 61 | 57– 65 | 61 | 56– 65 | 60[1] | 56– 64 | 61 | 56– 64 |
| Gape width | 56 | 53 | 47– 56 | 54 | 49– 60 | 54[1] | 48– 64 | 54 | 47– 60 |
| Body depth | 230 | 233 | 217–260 | 249 | 232–280 | 225[1] | 214–240 | 248 | 228–269 |
| Dorsal fin origin to lateral line | 145 | 148 | 139–160 | 149 | 138–167 | 140[1] | 128–156 | 145 | 134–157 |
| Body width | 146 | 142 | 124–153 | 155 | 143–169 | 144[1] | 132–164 | 169 | 154–193 |
| Predorsal length | 489 | 493 | 483–507 | 498 | 489–504 | 501 | 481–519 | 507 | 493–522 |
| Dorsal fin origin to occiput | 296 | 301 | 291–315 | 309 | 297–313 | 305 | 282–318 | 313 | 300–330 |
| Postdorsal length | 539 | 537 | 513–542 | 536 | 527–545 | 530 | 515–547 | 533 | 514–543 |
| Prepelvic length | 503 | 493 | 480–508 | 501 | 491–513 | 480 | 468–492 | 488 | 477–505 |
| Preanal length | 693 | 683 | 669–695 | 689 | 677–703 | 671 | 647–684 | 678 | 666–698 |
| Anal fin origin to caudal base | 318 | 332 | 322–349 | 325 | 318–331 | 340 | 326–359 | 332 | 320–342 |
| Caudal peduncle length | 224 | 229 | 217–241 | 226 | 218–232 | 246 | 236–264 | 242 | 228–254 |
| Caudal peduncle depth | 104 | 106 | 98–112 | 105 | 101–111 | 102 | 97–108 | 102 | 98–107 |
| Dorsal fin height | 225 | 235 | 225–252 | 232 | 221–246 | 220 | 206–229 | 217[2] | 204–228 |
| Anal fin height | 170 | 167 | 155–179 | 165 | 154–169 | 163 | 153–173 | 159 | 152–167 |
| Pectoral fin length | 187 | 188 | 181–197 | 181 | 172–189 | 170[3] | 163–181 | 168[1] | 158–181 |
| Pelvic fin length | 158 | 160 | 152–170 | 160 | 148–169 | 152[1] | 143–160 | 150[1] | 143–164 |

[1] Mean and range based on one less specimen than given in column heading.
[2] Based on two less specimens.
[3] Based on three less specimens.

olive. Entire lateral and dorsolateral area of body flushed with pale silvery yellow. Iris and postorbital and suborbital areas of head also faintly yellowish. All fins yellow, the pigment restricted primarily to rays and best developed proximally. Black lateral band and lips conspicuous in life. Breeding females colored like males but yellow pigment more subdued.

*Tuberculation.*—A few weak tubercles are occasionally developed in breeding females on some areas of the head or body. Tubercles are consistently well developed in breeding males, which form the basis of the following description.

Moderately small tubercles sparsely scattered in no consistent pattern over posterior half of head dorsum. No enlarged row or concentration of tubercles over orbits. Tubercles few between orbits and none extending anterior to nares onto snout. Lips nontuberculate. Tubercles absent in prenasal and subnasal areas. Only three of twenty tuberculate males examined had a few tubercles scattered over lachrymal bone. Temporal, postorbital, and suborbital areas bearing scattered tubercles about the same size as those on head dorsum but somewhat more densely arranged. Suborbital tubercles becoming fewer and smaller anteriorly, usually terminating below lachrymal bone. Suborbital and opercular tubercles wane ventrally; branchiostegals, lower arm of preopercle, and gular area nontuberculate.

Mandibular rami usually lacking tubercles but rarely bearing a weak row along outer margin bordering lip. Opercular membrane nontuberculate.

Minute tubercles sparsely scattered along middorsal line from occiput to dorsal fin, best developed anteriorly, and distributed primarily along posterior borders of predorsal scales. Posterior margins of breast scales lined with a few small tubercles. Five to nine minute tubercles were present along posterior margins of some scales on anterior dorsolateral part of body in a few of the largest males examined. Otherwise, body tubercles extremely reduced or absent.

Anal, pelvic, and caudal fins nontuberculate. Dorsal fin usually nontuberculate but rarely a few weak tubercles present along splint (rudimentary ray) and first two primary rays. Tubercles present dorsally on first six to nine rays of pectoral fin. Those on first ray few and weak, scattered over distal portion of ray, and only rarely dense enough to form a shagreen. Rays two through four most strongly tuberculate, being covered from near base to slightly distal to branching point with a shagreen of small, densely set tubercles. No hiatus present in the shagreen at points of ray segmentation. Posterior to ray four, the tubercle pattern is similar but progressively more degenerate.

First pectoral ray ranging from straight to slightly bowed outward and downward. Rays two through five varying from straight to moderately bowed upward.

*Variation.*—Ontogenetic variation in development of the gut was not examined in detail. The smallest specimen dissected was 32.5 mm SL; its gut was patterned like that of adults.

As would be predicted from its restricted distribution, the populations of *N. mekistocholas* are relatively homogeneous in meristic and morphometric characters. The only noteworthy geographic variation is in breast squamation of the Robeson Creek samples (Table 1).

*Etymology.*—The name *mekistocholas* is to be treated as a noun in apposition to the generic name. It is a compound of the Greek *mekistos* (meaning longest) and *cholas* (intestine).

## Comparisons

Major differences between *N. mekistocholas* and sympatric populations of *N. procne* and *N. alborus* are summarized in Table 6. Other distinctions, which are either more cryptic or less consistently developed, are as follows.

(1) Head shape: The head of *mekistocholas* and *procne* is subtriangular in lateral view; that of *alborus* is subrectangular.

(2) Eye shape and placement: The eye of *alborus* and *procne* is slightly enlongate in shape and positioned somewhat supralaterally on the head; that of *mekistocholas* is more nearly round and laterally positioned.

(3) Lips: The upper lip of *alborus* is usually slightly expanded at the symphysis and both lips are relatively thick and fleshy; usually there is no symphyseal expansion in *procne* and *mekistocholas* and the lips are thinner.

(4) Pigmentation of area between posterior border of nostril and eye: In *mekistocholas* and *alborus* this area is usually unpigmented, whereas in *procne* it is usually lightly to moderately pigmented.

(5) Lateral band immediately behind eye: It is better developed in *alborus* than in the other two species.

(6) Concentrations of pigment around dorsal fin base: In *alborus* the predorsal stripe is absent, and there is no intensification of pigment at the origin or along the base of the dorsal fin. In *procne* there is a discrete intensification of the predorsal stripe at the dorsal origin, and concentrations of pigment at the bases of dorsal rays three through eight form a dark bar along the posterior base of the fin. In *mekistocholas* both the predorsal intensification and the basidorsal bar are present but are never as well developed as in *procne*.

(7) Caudal spot: In *mekistocholas* the basicaudal spot ranges from subrectangular to wedge-shaped and is separate from (usually) or weakly conjoined with the lateral band. In *procne* the spot is approximately wedge-shaped and is separate from the lateral band. In *alborus* the spot is usually subrectangular and conjoined with the lateral band.

(8) Tuberculation: Breeding males of all three species agree in having specialized pectoral fin tuberculation. The tubercles are small and form a shagreen over the rays, and ray one is bowed downward and outward while rays two through five are arched upward (Hubbs and Raney, 1947:12). In this character, *mekistocholas* seems to be the

TABLE 6. A COMPARISON OF *Notropis mekistocholas*, *N. procne*, AND *N. alborus* FROM THE CAPE FEAR DRAINAGE.

| Character | *N. mekistocholas* | *N. procne* | *N. alborus* |
|---|---|---|---|
| Anal rays | 8 | 7 | 7 |
| Lateral line scales | (34) 35–36 (37); $\bar{x} = 35.5$ | (32) 33–35 (36); $\bar{x} = 33.9$ | (31) 32–34; $\bar{x} = 33.0$ |
| Predorsal scale rows | (13) 14–15 (16); $\bar{x} = 14.5$ | (13) 14–15 (16); $\bar{x} = 14.5$ | 12–13 (14); $\bar{x} = 12.9$ |
| Gill rakers on lower limb of first arch | (5) 6–7; $\bar{x} = 6.2$ | (5) 6–7 (8); $\bar{x} = 6.5$ | 3–5 (6); $\bar{x} = 4.3$ |
| Peritoneum | Black | Silvery, with few scattered melanophores | Silvery,with few scattered melanophores |
| Gut | Elongate, with two accessory loops (Fig. 2A, B) | Short, "S"-shaped (Fig. 2C, D) | Short, "S"-shaped |
| Cephalic lateral line | | | |
| IO | Usually 70–100 | Usually 0–10 | Usually 50–100 |
| % of breast scaled | Usually complete; pores (12) 13–15 | Usually complete; pores (13) 14–16 (17) | Usually incomplete; pores usually 12+2, 12+3, or 13+3 |
| POM | Complete; pores 9–11 (13) | Usually complete; pores (7) 8–10 (11) | Incomplete; pores usually 5+4, 5+5, or 5+6 |
| ST | Pores usually 3,3 | Pores usually 2,2 | Pores usually 2,2 |
| Fins | Moderate | Moderately short | Long and falcate |
| D height* | 22.1–25.2% SL; $\bar{x} = 23.3$ | 20.4–22.9% SL; $\bar{x} = 21.8$ | 23.9–27.2% SL; $\bar{x} = 25.8$ |
| A height* | 15.4–17.9% SL; $\bar{x} = 16.6$ | 15.2–17.3% SL; $\bar{x} = 16.1$ | 18.9–21.5% SL; $\bar{x} = 20.0$ |
| $P_1$ length* | 17.2–19.7% SL; $\bar{x} = 18.4$ | 15.8–18.1% SL; $\bar{x} = 16.9$ | 16.3–19.6% SL; $\bar{x} = 18.3$ |
| $P_2$ length* | 14.8–17.0% SL; $\bar{x} = 16.0$ | 14.3–16.4% SL; $\bar{x} = 15.1$ | 16.2–18.3% SL; $\bar{x} = 17.7$ |
| Snout pigment | Dark blotch limited to preorbital area, not surrounding snout; snout evenly pigmented | Dark blotch limited to preorbital area, not surrounding snout; snout evenly pigmented | Dark band surrounding snout above upper lip; a crescent-shaped depigmented area on snout above band |
| Lip pigment | Dark, contrasting sharply with lightly pigmented snout tip | Light, not contrasting with lightly pigmented snout tip | Typically absent |
| Upper | Exposed area heavily pigmented | Exposed area lightly pigmented | Exposed area usually unpigmented; a few melanophores in concealed area about symphysis |
| Lower | Thin black marginal band always present | Usually unpigmented; occasionally a few, scattered melanophores | Unpigmented |
| Predorsal stripe | Present | Present | Absent |
| Upper procurrent caudal rays | Pigmented | Unpigmented | Pigmented |
| Snout tubercles of breeding male | Usually absent | Numerous and well developed | ?; material not adequate |

* Sexes combined.

least modified, occasionally having all the pectoral rays straight. Adequate material for the description of head tuberculation in *alborus* was not available; it appears to have a very few, minute tubercles scattered over the head. Head tubercles of *procne* are slightly smaller and more numerous than those of *mekistocholas*, but, except as noted in Table 6, their general distribution is similar. (Certain elements of the tuberculation of *N. procne* appear to exhibit conspicuous geographic variation. Apparently Raney (1947) confused sensory papillae and tubercles in his description of the tuberculation of Rappahannock drainage *procne*.)

(9) Sensory structures on head: The head of *mekistocholas* has very few sensory structures of any type visible on gross inspection; the lips are rather smooth. The head of *procne* bears many scattered, papilla-like sensory structures; these are specially numerous ventrally—on the jaw rami, gular area, lower parts of the preopercle, branchiostegal rays, opercular membrane, and breast. The lips are rugose. The most prominent sensory structures on the head of *alborus* are pit-like depressions with slightly raised centers. On the head dorsum a few pits may be scattered in the temporal area, but otherwise they are restricted to a V-shaped patch that originates over each eye and converges anteriorly to form an apex between the nares. Sensory pits are well developed in the suborbital and subnasal areas. Ventral surfaces of the head, especially the jaw rami, gular area, and branchiostegal rays, are provided with sensory papillae. The lips are rugose.

(10) Life colors: The yellow sheen on the body and the black lips are convenient field characters for distinguishing *mekistocholas* from both *procne* and *alborus*.

The only other sympatric species with which *N. mekistocholas* could be confused is *N. hudsonius* (Clinton). They are superficially similiar in pigmentation and physiognomy and both have eight anal rays. However, *N. hudsonius* differs trenchantly yet cryptically in having a short, S-shaped intestine and silvery peritoneum. It also attains a substantially larger size and usually has a minor pharyngeal tooth row on one or both sides.

*N. volucellus* (Cope) has not been collected in the Cape Fear drainage, but does occur northward on the Atlantic slope from the Neuse to the James drainages. It agrees with *N. mekistocholas* in having eight anal rays and 0,4–4,0 pharyngeal teeth but otherwise differs trenchantly. The following are among the more conspicuous features differentiating *N. volucellus*: (1) body circumference scales (17) 18–21 (23), usually 9–2–9 = 20; (2) anterior lateral line scales more elevated (Table 4); (3) gut short and S-shaped, peritoneum silvery with few scattered melanophores; (4) upper lip lightly pigmented; (5) predorsal streak weak or obsolescent; (6) lateral band poorly developed; (7) pigment heavier along lower edge of caudal peduncle.

*N. heterolepis* Eigenmann and Eigenmann, an allopatric species of the northcentral and northeastern United States and adjacent southern Canada, is similar to *N. mekistocholas* in physiognomy, pigmentation, and meristics (especially in having eight anal rays and 0,4–4,0 pharyngeal teeth). In addition to having the typical S-shaped gut and silvery peritoneum, *N. heterolepis* differs in having (1) the dorsal fin inserted more posteriorly, slightly behind the pelvic fin insertion; (2) a more oblique gape; (3) weakly pigmented lips; and (4) a reduced lateral line on the head and body.

The only other species of *Notropis* in the Mississippi Valley bearing noteworthy resemblance to *N. mekistocholas* are *N. stramineus* (Cope) and a closely related, undescribed species from the Cumberland and Tennessee drainages (R. E. Jenkins, pers. comm.). Both of these forms show strong affinities with *N. procne* and may be distinguished from *N. mekistocholas* on the same basis (Table 6 and above).

## Distribution and Ecology

*N. mekistocholas* is the first endemic fish known from the Cape Fear drainage in North Carolina and probably has a more restricted distribution than any other described species of *Notropis*. It is limited to a small drainage area just above the Fall Line where the Deep and Haw rivers join to form the Cape Fear. It is known from only two counties (Chatham and Harnett) and four streams. Neal's and Parker's creeks are tributaries to the Cape Fear River just below the confluence of the Deep and Haw. Robeson Creek enters the Haw River from the west a few miles above the Deep-Haw confluence. Rocky River is the most downstream major tributary of the Deep River. More intensive collecting in the upper Cape Fear basin may show *N. mekistocholas* to be more widely distributed, but a search of museum collections has failed to prove this.

The streams inhabited by *N. mekistocholas* lie within the Carolina Slate Belt, an area of Ordovician volcanic activity (Stuckey, 1965). Robeson Creek and Rocky River are moderately large streams (25–80 ft wide) characterized by moderate gradients and riffles alternating with long, deep pools. The water is unstained but easily roiled by heavy runoff. The bottom is a mixture of sand-gravel, rubble, and boulders; in some areas boulders predominate and literally pave the stream bed. Water willow, *Justicia*, is a common emergent plant in many shoal areas and the rubble and boulders are carpeted with periphyton and some macrophytes. *N. mekistocholas* was most commonly collected in eddies, slow runs, and pools just below areas of fast, shallow water.

*N. mekistocholas* was collected in Neal's and Parker's creeks in 1962 but subsequent collecting attempts have been unsuccessful. These two streams differ from Robeson Creek and Rocky River in being smaller (to 30 ft wide) and in having predominantly sand beds, with little rubble or boulder material.

A study of the ecology of sympatric populations of *N. mekistocholas*, *N. procne*, and *N. alborus* should be most interesting. The black peritoneum and elongate intestine of *N. mekistocholas* presumably are adaptations to "herbivorous" feeding habits (probably mostly bottom detritus, diatoms, and other periphytes), whereas the short gut and silvery peritoneum of *N. procne* are associated with carnivorous habits. Perhaps through character displacement, *N. mekistocholas* evolved trophic modifications that permit it to coexist with *N. procne* with a minimum of competition. The two species may often be seen swimming in mixed schools.

Numerically, *N. alborus* is much less common than its two relatives and it is taken with them only infrequently. Perhaps its success has been limited by its inability to avoid competition with *N. procne*. However, it seemingly occupies a slightly different microhabitat than its relatives; and its somewhat fleshier lips, fewer and blunter gill rakers, and different sensory structures suggest that its feeding niche has diverged somewhat from that of *N. procne*.

## Discussion

The genus *Dionda* is currently maintained separate from *Notropis* primarily on the basis of its elongate intestine and black peritoneum. However, Swift (1970) had allied *Dionda nubila* (Forbes) with *Notropis chrosomus* (Jordan) and *N. leuciodus* (Cope) under the subgenus *Hydrophlox* of *Notropis*. The possibility that *N. mekistocholas* is related to species of *Dionda* (including for the moment *nubila*) was considered but rejected. Although they agree in having black peritonea and elongate alimentary tracts, the pattern of gut coiling is relatively uniform within the genus *Dionda* and is quite different from that of *N. mekistocholas*. *Dionda* species also differ from *N. mekistocholas* in breeding tuberculation, in exhibiting red breeding colors, in pigment pattern, and in several other respects. Furthermore, the alignment of the new species from the central Atlantic slope with the southwestern genus *Dionda* would present complex zoogeographic problems.

Inclusion of *mekistocholas* in the genus *Notropis* follows the recent trend toward minimizing the importance of trophic modifications at the generic level. For example, as presently constituted the genus *Pimephales* includes forms with short intestines and silvery peritonea as well as those with elongate intestines and black peritonea. That genus was previously split into three—*Ceratichthys*, *Hyborhynchus*, and *Pimephales*—primarily on the basis of trophic adaptations. Many authors now include the genus *Pfrille* within *Chrosomus* (or *Phoxinus*), thus rendering both "carnivorous" and "herbivorous" forms congeneric. Furthermore, it has recently been discovered that several genera previously thought to be composed of species with simple alimentary tracts contain forms in which the intestine is long and convoluted. Within *Nocomis*, *N. leptocephalus* (Girard) usually has a whorled intestine; and *N. micropogon* (Cope) and relatives occasionally have accessory intestinal loops (Lachner and Jenkins, 1967:564). Within *Hybopsis*, *H. x-punctata* Hubbs and Crowe occasionally has an elongate, convoluted gut (R. E. Jenkins, pers. comm.).

Recent studies have revealed heretofore unexpected intestinal modifications within the genus *Notropis* (not considering the recent transfer of the species *nubila* from *Dionda* to *Notropis* [see Swift, 1970]). Miller (1963) pointed out that *N. cornutus* (Mitchill) possesses a supplementary "semi-loop" at the point (near the spleen) where the ascending loop and terminal descending loop join. I have found this accessory loop to be characterstic of most forms of the subgenus *Luxilus*. The rare minnow *N. anogenus* Forbes also has an elongate intestine.

I am continuing investigations into the systematic significance of intestinal patterns in North American Cyprinidae. Conclusions are not yet in order, but it is clear that gut elongation and the assumption of herbivorous habits have occurred independently in several groups (Hubbs and Black, 1947:6–7). However, it does appear that in some cases patterns of gut coiling may be of use in defining lineages. *N. mekistocholas* does not appear to be one of these cases. Its coiling pattern is relatively easily derived from the primitive S-shaped pattern characteristic of most *Notropis*. Moreover, the pattern of coiling in *N. mekistocholas* is duplicated among the herbivorous cyprinids of eastern North America only by *Pimephales notatus* (Rafinesque), a similarity that surely is due to convergence.

All available evidence suggests that *N. mekistocholas* is most closely related to those species with which it bears strong resemblance—*N. procne* and *N. stramineus*. I interpret *N. procne* as being an Atlantic coast derivative of *N. stramineus*. *N. mekistocholas* may have been derived from a population of *N. procne* during a period when the range of the latter was disjunct and perhaps less extensive than at present. Alternatively, *N. mekistocholas* may represent the derivative of a separate invasion of a *stramineus*-like stock across the Appalachians. This question cannot be answered until a detailed analysis of *N. procne* and *N. stramineus* is undertaken. For example, the subspecies of *N. procne* as currently recognized (Raney, 1947) are of dubious status. *N. alborus*, despite its superficial resemblance to *N. mekistocholas*, shows stronger affinities with *N. heterolepis* and probably should be considered an Atlantic coast derivative of it.

For the present it seems expedient to leave the *procne* species group—tentatively including *N. alborus*, *N. heterolepis*, *N. mekistocholas*, *N. procne*, *N. stramineus*, *N. uranoscopus* Suttkus, and the undescribed *stramineus*-like form from the Cumberland and Tennessee drainages—unclassified as to subgenus. The subgenus *Alburnops* has acted as a "catch-all" group to which some of these species have been assigned. However, I can see no convincing evidence for such treatment; and little value would be derived from arbitrarily assigning this species group to *Alburnops* or any other currently recognized subgenus. I tentatively favor the restriction of *Alburnops* to the *blennius*, *bairdi*, *longirostris*, and *texanus* species groups as outlined by Swift (1970).

## Comparative Material

The following materials were used in gathering the data presented in the foregoing tables. Many other collections were examined for comparative and variational purposes but are not listed below.

*Notropis alborus*. All from Cape Fear drainage in North Carolina. Chatham Co.: CU 25900, 51957, NCSM 3701, 3876, 4119, 4924, 5058. Guilford Co.: UMMZ (old Indiana University collection) 7953. Orange Co.: CU 14073, 34624. Randolph Co.: CU 10074.

*Notropis procne*. All from Cape Fear drainage in North Carolina. Chatham Co.: NCSM 2974, 3705, 3881, 4122, 4840. Orange Co.: CU 14072, 34623.

*Notropis volucellus*. Roanoke drainage. Virginia, Roanoke Co.: CU 24779. North Carolina, Granville Co.: UMMZ 177032. Tar drainage. All from North Carolina. Franklin-Vance Co.: NCSM 3076. Granville Co.: CU 19526. Neuse drainage. North Carolina, Person Co.: CU 9667.

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