

Studies of the Catostomid Fishes of the Genus
Moxostoma, With Descriptions of
Two New Species

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Studies of the Catostomid Fishes of the Genus *Moxostoma*, with Descriptions of Two New Species¹

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The suckers of the genus *Moxostoma*, commonly referred to as "redhorse" or "jumprock", have remained one of the most perplexing groups of fishes encountered by the American ichthyologist. Despite the numerous species and the large size which many of them attain, very little information is available on the spawning habits, age, growth, and other features of their life histories. The gathering of such data has been hindered by the uncertain systematic position and inadequate diagnoses of the species, especially in the southeastern United States.

Several difficulties beset the student of *Moxostoma*. First, except for a brief spawning period, many of the species occur only in large bodies of water. They are therefore not easy to obtain by routine collecting techniques. Then, too, their large size presents difficult problems of preservation and storage. Thus the series of specimens available for detailed study are meager for all but a few species. In addition, meristic features, such as numbers of fin rays and scale rows, often so useful in studies of species in other genera, exhibit few interspecific differences. Pigmentation, the shape of the fins, the relative size and shape of body parts, and detailed structure of the lips have had to be relied upon. Also, the group presents nomenclatorial difficulties. Most of the names were proposed before 1900 and the diagnoses are inadequate. Cope (1869: 236; 1870: 467-479) proposed no fewer than thirteen new names. These were described from abundant material taken by commercial fishermen, but few specimens were preserved and some of these have since been lost. The difficulty in allocating Cope's named forms has discouraged research in the group. Since Cope, the main contributions

¹ Assistance from the Cornell University Faculty Research Grants Committee made possible many of the field trips that were necessary to obtain the fishes used in this study.

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have been by Jordan (1877, 1878a), Regan (1907), Fowler (1913, 1945), Hubbs (1930), Legendre (1942, 1943, 1952), Nelson (1948), and Trautman and Martin (1951).

The discovery of a remarkable new species in the Roanoke River stimulated the present writers to gather together available materials and to diagnose the species present in the streams of the Atlantic and Gulf coasts. Further study revealed an undescribed species in the Apalachicola River system of Georgia and Alabama. In investigating these two new forms, the authors have studied all species of *Moxostoma* known to exist in the United States and Canada, but have limited this paper mostly to a comparative description of the species of the subgenus *Scartomyzon*. Here, adequate material has been available to permit a study of *rupiscartes*, *cervinum*, and *robustum*, and to present a comparative description of these heretofore inadequately diagnosed forms. *M. austrinum* and *congestum* are poorly represented in collections and are treated only in comparison with the other species. Too few specimens of any form are available to make a definitive study of the infraspecific variations, although definite problems have been noted with *rupiscartes* and *cervinum*.

As far as possible, the synonymies include all publications of importance for the systematics and distribution of the forms but references which involve only species lists are generally omitted.

Methods

Dial calipers, calibrated to tenths of millimeters, were used in taking measurements. Counts and measurements, except those defined below, were made in accordance with the definitions of Hubbs and Lagler (1947: 8-15).

Head depth (1) is the depth of the head measured vertically through the center of the eye.

Head depth (2) is the depth of the head measured at the midpoint of the occipital line. A comparison of these two measurements of head depth will show differences in the slope of the dorsal surface of the head in several species.

Head width is measured at the cheek directly below the center of the eye.

Body depth and body width are measured at and under the origin of the dorsal fin. These measurements may not represent the greatest depth or width of the body but are used since they apparently vary little with the condition of the fish.

Occipital head length is the distance from the anterior tip of the snout to the midpoint of the occipital line.

Postorbital head length is the least distance from the margin of the eye to the posterior edge of the opercular flap.

The three figures in parentheses which follow the catalogue number in the listings of material examined represent the number of specimens and the standard length, in millimeters, of the largest and the smallest specimens

in the collection. Standard abbreviations are used for compass directions, and for brevity, the word "of" is omitted. Other abbreviations are: Co. = county, Cr. = creek, mi. = mile(s), R. = river, trib. = tributary (of), ANSP = Academy of Natural Sciences of Philadelphia, CM = Charleston Museum, CU = Cornell University, UMMZ = University of Michigan Museum of Zoology, USC = University of South Carolina, and USNM = United States National Museum.

Generic and Subgeneric Classification

Jordan (1878) gave an analysis of *Moxostoma*. Hubbs (1930: 9) reported a brief diagnosis of *Moxostoma* in key form and included it with *Placopharynx* (= *Moxostoma*) and *Lagochila* in the tribe Moxostomatini. The present writers agree with Nelson (1948, 1949), rather than Hubbs (1930, 1955), that *Thoburnia* and *Hypentelium* belong in the tribe Moxostomatini.

Subgenus Scartomyzon

The subgenus *Scartomyzon* was erected by Fowler (1914: 59) with "*Ptychostomus cervinus*" Cope as the type species. His diagnosis emphasized the low dorsal-ray count, which holds only on the average, and the streaked coloration which appears not only in members of this subgenus, but to a lesser extent, in the subgenus *Moxostoma* (*poecilurum* and *duquesnei*). *Scartomyzon* is probably the best defined of the three natural units which appear to be present in *Moxostoma*. The best character for separating *Scartomyzon* is the high caudal-peduncle scale count of 16 (7-2-7) which is found only in two species outside of this subgenus (*hubbsi* and *valenciennesi*). Other characters of *Scartomyzon* are: (1) a small pharyngeal arch, (2) a high lateral-line scale count (*cervinum* excepted), (3) a rounded or S-shaped dorsal fin with a low ray count, (4) rounded caudal-fin lobes, (5) an elongate, subterete body and a heavy caudal peduncle, (6) horizontal dark and light stripes on the body, and (7) more rounded pectoral fins; rays 4 and 5 rather than 2 and 3 are longest.

Subgenus Megapharynx

The writers assign two species, *hubbsi* and *valenciennesi*, to the subgenus *Megapharynx*. *M. valenciennesi* has not previously been closely associated with *hubbsi* in the literature even though their similarity led to early nomenclatorial confusion (Legendre, 1952). Legendre (1942: 229) based the genus *Megapharynx* on specimens of an undescribed species to which he mistakenly applied the name *M. valenciennesi*. This error was corrected by Legendre (1952) who gave the name *Moxostoma hubbsi* to the species. We note that *hubbsi* and not *valenciennesi* is the type species of *Megapharynx* (Copenhagen Decisions on Zoological Nomenclature, 1953, page 68, article 30, paragraph 128).

The subgenus *Megapharynx* is characterized by the convex margin of the

dorsal fin and high counts for lateral-line scales, circumferential scales and scales around the caudal peduncle, 16 (7-2-7). Both species have a black spot at the base of each scale and reddish fins, in which characters they converge with the *aureolum* group of the subgenus *Moxostoma*.

The heavy pharyngeal arch and teeth possessed by *hubbsi* and to a lesser extent by *carinatum* (subgenus *Moxostoma*) have been considered evidence of close relationship between the two species. We believe that a heavy pharyngeal arch has evolved independently in these two lines and is not of basic significance. Thus the tendency of authors to associate *hubbsi* and *carinatum* seems not to be in accord with their natural relationships.

Subgenus Moxostoma

The subgenus *Moxostoma*, the largest of the three natural groups, is characterized by a moderate pharyngeal arch, a falcate (even though slight) dorsal fin, a low or moderate lateral-line scale count (except for some populations of *duquesnei*), more pointed pectoral fins (rays 3-4 longest), and a low caudal-peduncle scale count, 12 (5-2-5) except for *duquesnei* which occasionally has 13 (6-2-5).

Hubbs (1955: 8) recognizes *Placopharynx* as a distinct subgenus with the one species *carinatum*. Many differences exist between other species of *Moxostoma* which seem of greater significance than the development of the pharyngeal arch and teeth of *carinatum*. The writers consider *Placopharynx* a subgeneric synonym of *Moxostoma*.

The subgenus *Scartomyzon* is considered the most primitive. It contains relict forms, such as *ariommum*, which possess a combination of primitive and specialized structures. It has a widespread but disjunct distribution which includes both the Atlantic and Pacific slopes of Mexico as well as the southeastern United States. Large gaps apparently exist between related species such as that between *congestum* in Texas and *robustum* in the Altamaha River, Georgia.

Scartomyzon is not now represented in the Mississippi River system or in the other large rivers of Mississippi and Alabama although it must have occurred there formerly. Perhaps competition with *poecilurum* along Gulf drainages and other species of the subgenus *Moxostoma* in the Mississippi valley has eliminated *Scartomyzon* from all but its peripheral refuges in the Southeast and Southwest. Here, for the most part, the species of *Scartomyzon* inhabit small streams or are specialized for riffle existence. Apparently they are able to compete successfully with species of the subgenus *Moxostoma* in these streams.

The subgenera *Moxostoma* and *Megapharynx* apparently do not compete except in post-Pleistocene lakes and large rivers. In many ways, but especially in the caudal-peduncle scale count, the species of *Megapharynx* seem to be closer to the species of the subgenus *Scartomyzon* than to those of *Moxostoma*.

Studies on the eastern species of the subgenus *Moxostoma* are progressing

slowly as specimens become available. Most are large and usually occur in big rivers or in the freshwater section of estuaries. Apparently the *aureolum* group, represented in the Mississippi valley and northward by three forms, *M. a. aureolum* (LeSueur), *M. aureolum pisolabrum* Trautman and Martin and *M. breviceps* (Cope), and in the East by *M. macrolepidotum* (LeSueur) and *M. coregonus* (Cope), is primitive and shares the characters of red fins and dark scale bases. *M. carinatum* (Cope), a large-headed western form thought to be primitive in the subgenus *Moxostoma*, is perhaps represented in the East as far north as the Roanoke River system by the specialized and widely distributed *M. pappillosum* (Cope). *M. anisurum* (Rafinesque) is widely distributed in rivers and lakes in northern and central North America. It is clearly represented on the Atlantic slope in big rivers, from the Roanoke River southward, by *M. collapsum* (Cope). *M. erythrurum* (Rafinesque), a stream species which is widespread in the Mississippi River system, is unusual in that breeding males possess tubercles on the snout. In the East it is represented by *M. lachrymale* (Cope), a form so similar to *erythrurum* that the two may best be regarded as subspecies although adequate material is not available to permit a definite decision. *M. duquesnei* (LeSueur), a widespread form in the Mississippi River and Gulf Coast regions, is perhaps more recently evolved and seems to have no eastern representative. It is a creek form and shows a trend toward an increase in caudal peduncle scale rows, a character which is remarkably constant in other species.

Thoburnia, like *Scartomyzon*, appears to represent a relict group of a former widespread upland fauna. There can be little doubt that the genera *Thoburnia* and *Moxostoma* are closely related. This relationship is best seen through species in the genus *Scartomyzon*, as is pointed out in more detail farther on.

Key to the Subgenera of *Moxostoma* and to the Species of *Scartomyzon* and *Megapharynx*

- 1a.—Scales around caudal peduncle 16 (7-2-7)..... 2
- 1b.—Scales around caudal peduncle 12 (5-2-5), rarely 13 (6-2-5) in *M. duquesnei*.
..... subgenus *Moxostoma* Rafinesque
- 2a.—Dorsal rays typically 13 or more. Margin of dorsal fin convex. Length of base of dorsal fin enters distance between its origin and the occipital line less than two times. subgenus *Megapharynx* Legendre 3
- 2b.—Dorsal rays typically 12 or less, rarely 13. Margin of dorsal fin falcate or S-shaped (only slightly in some). Length of base of dorsal fin enters distance between its origin and the occiput more than two times (except in *M. ariommum* and *M. robustum*). subgenus *Scartomyzon* Fowler 4
- 3a.—Pharyngeal arch enlarged, heavy; bases of 7 largest teeth more than half the length of arch. Middle of pupil less than halfway from snout tip to posterior edge of opercle. Nostril situated above posterior margin of upper lip. Scale rows above lateral line immediately before dorsal fin origin 15. Scale rows below lateral line immediately before pelvic fins 19. Range: St. Lawrence and Ottawa rivers from Lake St. Louis and Lake of the Two Mountains to Lake St. Peter.
..... Copper Redhorse, *Moxostoma hubbsi* Legendre

- 3b.—Pharyngeal arch not greatly enlarged; bases of 7 largest teeth much less than half the length of arch. Middle of pupil more than halfway from snout tip to posterior edge of opercle. Nostril situated slightly posterior to lower lip. Scale rows above lateral line immediately before pelvic fins 17. Range: Upper Mississippi River system in Minnesota, Wisconsin and Illinois through the basins of all the Great Lakes to Oneida Lake and Lake Champlain, New York and the St. Lawrence River to Montreal.
- 4a.—Lower lip flattened and flaring with many prominent and well separated papillae; upper lip flattened and folded in, inner surface with numerous papillae. Eye very large, greater than least postorbital head. Mouth extended posteriorly; anterior edge of eye lies above or only slightly behind the posterior edge of lower lip. Nostril lies far in front of a vertical through the hind margin of lower lip. Occipital line straight. Last dorsal ray long, less than 1½ times in dorsal base. Range: Roanoke River
Greater Redhorse, *Moxostoma valenciennesi* Jordan
- 4b.—Lips plicate or semipapillose; not modified as above. Eye smaller, less than least postorbital distance. Mouth not extended posteriorly; anterior edge of eye lies decidedly behind the lower lip. Nostril lies behind a vertical through the posterior edge of lower lip. Occipital line curved forward. Last dorsal ray shorter, more than 1½ times in dorsal base. 5
Bigeye Jumprock, *Moxostoma ariommum* Robins and Raney
- 5a.—Tip of anterior dorsal rays black; caudal lobes tipped with black except in very young. Scales large, usually 43 or fewer in lateral line. Lips plicate; gape a semi-circle. Eye length greater than two-thirds the outside width of mouth in adults. Range: James, Roanoke, Chowan, Tar and Neuse Rivers.
Black Jumprock, *Moxostoma cervinum* (Cope)
- 5b.—Black absent on lobes of dorsal and caudal fins, dorsal sometimes edged with dusky. Scales smaller; usually 44 or more in lateral line. Lips plicate or semipapillose; gape a broad arc. Eye length less than two-thirds the outside width of mouth in adults. 6
- 6a.—Head elongate; head depth at occiput enters predorsal distance 3 or more times. Mid-scales of lateral line smaller, much smaller than eye. Eye enters head length more than 5 times. Depth of body at origin of dorsal fin less than head length. 7
- 6b.—Head short and deep; head depth at occiput enters predorsal distance less than three times. Mid-scales of lateral line large, equal to or larger than eye. Eye enters head length less than 5 times. Depth of body at origin of dorsal fin greater (equal in young) than head length. 8
- 7a.—Head deeper than wide. Lips plicate. Lowermost caudal ray light colored. Dorsal rays modally 12. Range: Apalachicola River system
Greater Jumprock, *Moxostoma lachneri* Robins and Raney
- 7b.—Head wider than deep. Lips semipapillose or if plicate, the plicae are divided posteriorly. Lowermost caudal ray dusky. Dorsal rays modally 11 or 10. Santee, Savannah, Altamaha and Chattahoochee Rivers.
Striped Jumprock, *Moxostoma rupiscartes* Jordan and Jenkins
- 8a.—Ventral body contour to origin of anal fin, gently convex. Anterior base of pelvic fin nearer origin of anal fin than anterior base of pectoral fin. Preoperculomandibular canal connected to infraorbital canal on both sides. Total pectoral rays usually 34 or more. Membranes of anal fin light. Range: Cape Fear, PeeDee, Santee, Savannah, and Altamaha Rivers.
- 8b.—Ventral body contour to origin of anal fin, straight. Anterior base of pelvic fin nearer anterior base of pectoral fin than origin of anal fin. Preoperculomandibular canal not connected to the infraorbital canal on both sides of head; usually ends below the level of the eye. Total pectoral rays usually 33 or fewer. Membranes of anal fin dark. Range: Texas and northeastern Mexico.
Gray Redhorse, *Moxostoma congestum* (Baird and Girard)

The authors tentatively follow Knapp (1953: 44) and consider *Moxostoma congestum albidum* (Girard), which occurs in northeastern Mexico, as a subspecies. It usually has 11 dorsal rays whereas *Moxostoma congestum congestum* has 12.

The type of *Moxostoma austrinum* (Bean), USNM 23120, from the Rio de Santiago, Mexico, has 16 (7-2-7) caudal-peduncle scales which places it in the subgenus *Scartomyzon*. It seems to be related to *M. congestum*. Two specimens, 225-246 mm., UMMZ 161693, taken in Rio Mezquital (or trib.), approximately 3 mi. S. of Durango, Mexico, on February 16, 1951 by John Greenbank are identified as *M. austrinum*. Too few specimens are available to permit discussion of the characters of *austrinum* or to include it in the above key. Jordan and Evermann (1896: 189), Meek (1904: 34), and Regan (1906: 145) gave keys for its identification.

Moxostoma lachneri, sp. nov.

Greater Jumprock

Plates 1 and 4

This large species which seems to be limited to the Apalachicola River system apparently has not been noticed by ichthyologists. Jordan and Brayton (1878: 43) reported "*Myxostoma*" *cervinum* from Shallow Ford in the Chattahoochee basin but whether this record was based on specimens of *Moxostoma rupiscartes* or *lachneri* cannot be determined. Probably *lachneri* has been overlooked because of its striking, superficial resemblance to *poecilurum* (Jordan). The authors have dedicated this new sucker to their friend Ernest A. Lachner, Associate Curator of Fishes, U. S. National Museum, who has added much to the knowledge of catostomid fishes.

Material examined.—All 56 specimens are from the Apalachicola River system. The holotype, CU 15831, an adult female 152 mm. in standard length, was taken on June 12, 1949, in a trib. of Hatchechubbee Cr., 4 mi. SW of Seale, Russell Co., Alabama, by R. D. Suttkus, R. H. Gibbs, and C. F. Cole. Taken with the holotype was CU 28329, a specimen 97 mm. long, which is designated as a paratype.

The remaining specimens (designated as paratypes) were taken in Georgia. Habersham Co.: CU 11207 (1, 71), trib. Soque R., 3 mi. NE. Clarksville, April 9, 1947, Raney, Ross, Suttkus. White Co.: UMMZ 165616 (11, 60-204) Chattahoochee R., 4 mi. above Helen, Oct. 21, 1940, A. D. Holloway. Lumpkin Co.: CU 21414 (1, 119) Cane Cr., 1.5 mi. SW. Dahlonoga, US Hwy. 19, June 10, 1952, Gibbs, Caswell; CU 21449 (1, 139) Yahooola Cr., 1 mi. E. Dahlonoga, Ga. Hwy. 52, June 10, 1952, Gibbs, Caswell and at the same locality CU 19799 (1, 100) March 26, 1951, Raney, Robins; CU 25019 (2, 81-189) Chestatee R. at Walnut, 9 mi. NNE. Dahlonoga, US Hwy. 19, April 10, 1947, Raney, Ross, Suttkus; USNM 162416 (1, 115 and 16, 26-40) trib. Chestatee R., 1.3 mi. WSW. Dahlonoga, US Hwy. 19, Sept. 11, 1947, Lachner, P. S. Handwerk; UMMZ 157955 (4, 25-36) Cane Cr., 1.2 mi. WSW. Dahlonoga, Aug. 25, 1939, R. M. and M. K. Bailey; UMMZ 157964 (2, 24-29) Chestatee R. 9.5 mi. NW. Cleveland, Aug. 26, 1939, R. M. and M. K. Bailey; UMMZ 165539 (4, 140-167)

Bagg's Cr., 10 mi. W. Cleveland, Oct. 17, 1940, Holloway. Harris Co.: CU 17518 (3, 41-194) trib. Mulberry Cr., 7.7 mi. E. Hamilton, Ga. Hwy. 11B, March 29, 1950, Raney, Suttkus, Backus, Robins. Muscogee Co.: CU 15957 (1, 75) Randall Cr., trib. Upatoi Cr., 6.7 mi. W. Talbot-Muscogee Co. line, June 11, 1949, Suttkus, Gibbs, Cole. Stewart Co.: CU 17784 (2, 114-134) Hannahatchee Cr., 8.1 mi. N. Lumpkin, US Hwy. 27, March 28, 1950, Raney, Suttkus, Backus, Robins. Early Co.: CU 24133 (3, 206-327) trib. Chattahoochee R., 9.9 mi. W. Donalsonville, US Hwy. 84, Dec. 30, 1949, Suttkus, Wigley, Cole, Yerger. Lee Co.: ANSP (uncatalogued) (1, 375) Flint R. Abrams Landing, 11 mi. NE. Albany Power Dam, Sept. 16, 1952, H. E. Winn, R. R. Rosanio.

Diagnosis.—One of the largest species of the subgenus *Scartomyzon* (to 375 mm. in standard length). Caudal-peduncle scales 16 (7-2-7). Dorsal rays 12, rarely 11 or 13. Pharyngeal arch weak with narrow shelf. Lateral-line scale count high, 45 or 46, rarely 44 or 47. Free edges of pectoral and pelvic fins rounded. Free edge of dorsal S-shaped, falcate anteriorly. Body elongate, semiterete. Head long and narrow. Lips plicate; lower lips meet at an obtuse angle. Snout bluntish. Body with prominent dark and light stripes. Caudal fin bicolored; the white lower ray contrasts with the darker rays immediately above. Leading edge of dorsal and caudal fins black. Oblique dark bar on shoulder girdle moderately developed.

Description.—Many of the characters are illustrated in plates 1 and 4. Fin-ray counts, lateral-line scale counts and proportional measurements are given in tables 1 and 2. Additional characters are given in the section on relationships and in tables 3 and 4. The description which follows is based on the holotype and the numerous paratypes as listed above. The body is elongate, even, and somewhat compressed (plate 2). The dorsal body contour is rather evenly curved from the tip of the snout to the origin of the dorsal fin; the back is not greatly elevated in the occipital area. Beneath the dorsal-fin base the dorsum is straight and slopes gently downward, posteriorly. Behind the dorsal fin the slope is less pronounced; the contour is almost straight to the procurrent caudal rays which are well developed and form a rather pronounced ridge. The ventral contour is almost straight to a point just before the anus where it slopes upward, almost on a straight line, to the anterior procurrent caudal rays. The caudal peduncle is slender, more so than in other species of the subgenus. The lateral line lies in the fifth scale row above the base of the pectoral fin and is nearly straight to the mid-caudal base. In lateral view the head is subquadrate. The eye is moderate in size and is relatively larger in young specimens. The midpoint of the pupil lies well behind the center of the head. The greatest head width is less than the head depth at the occiput. The prominent snout is subconical to bluntish as viewed laterally and is blunt or only slightly curved when viewed from above.

The posterior edge of the lower lip reaches a vertical projected from the nostril. The mouth is moderate in size; viewed from below the gape is broadly arched rather than semicircular. The lips are plicate; the upper is thin throughout its length and is about one-half the width of the lower lip at its midpoint (plate 4). The lower lips are broadly joined and meet at an obtuse angle (about 125°) in both juveniles and adults.

The fins are relatively short. The origin of the dorsal fin lies considerably closer to the tip of the snout than to the caudal end of the hypural plate, whereas the anterior tip of the pelvic-fin base lies nearer the caudal end of the hypural plate. The dorsal-fin height exceeds the length of the dorsal base; the fin is S-shaped on the free edge, being falcate in front and convex behind. The tip of the pectoral fin is rounded and has rays 4 and 5 longest and subequal; the posterior edge is almost straight and meets the inner border of the fin at about a right angle. The pelvic fin has a rounded tip; the hind margin is almost straight and forms an acute angle with the projected inner border. In adults the anal fin is rounded at the tip but in young it is somewhat pointed. When the anal fin is depressed its posterior tip does not extend beyond the posterior edge of the hypural plate. Compared with other species of *Scartomyzon* the caudal fin is more deeply forked and the notch is angular rather than rounded. The caudal lobes are pointed with straight rather than rounded inner borders.

Fin-ray counts on the holotype are: dorsal 12, anal 7, pectoral 17-17, pelvic 9-9, and caudal 18. Variational data for these counts are given in table 1.

The scales are rounded apically, well imbricated, and fairly large. A scale from the mid-lateral line almost equals the area of the eye. Scale counts on the holotype are: lateral line 46; around the caudal peduncle 16 (7-2-7); above lateral line 6; below lateral line 5, the lowermost being small; rows before dorsal fin 15; and circumferential scales 30 (13-2-15); in the paratypes the scales above the lateral line were 13 or 14; those below were usually 17, but varied from 15 to 18. The total circumferential count for 10 specimens including the holotype is 30 (2), 32 (4), 33 (2), 34 (2).

The pseudobranchiae are well developed and exposed. There are 27 flattened gill rakers on the first arch of one paratype, the lower 5 of which are rudimentary. The upper and middle rakers are rather long and thin and each has two rows of 8 to 10 tubercles on the inner edge. It should be noted throughout the study that gill rakers were counted on only a few specimens. There is some indication from these preliminary data that good specific differences exist even though there is considerable intraspecific variation; *cerwinum* and *ariommmum* have low counts. The anterior fontanelle is closed. The posterior fontanelle is well developed and rectangular in shape.

The scythe-shaped pharyngeal arch is relatively weak and the lateral shelf is narrow. There are about 60 teeth on either side, arranged in a single graduated row; those near the base are somewhat longer than those near the middle of the arch and the uppermost teeth are the smallest. The basal

teeth are considerably thicker, wider at the tip, and slightly hooked on the anterior edge.

The Weberian apparatus was studied and the terminology used by Nelson (1948) is followed. These structures are described in considerable detail for *rupiscartes* and the other species are compared with it. In *lachneri* the tripus is very similar in over-all form to that of *rupiscartes* (plate 1). The ventral edge is straight, however, and the anterior process is better developed, extending farther dorsad than the base of the median fulcrum. Other differences are associated with the fulcrum itself and with the shelf on the central body. In lateral view the fulcrum projects directly dorsad, in contrast to the forward-sloping fulcrum of *rupiscartes*. Its dorsal edge widens laterally to form a fossa but this is not nearly so large as in *rupiscartes*. The shelf is very similar to that of *rupiscartes* although flatter and projecting laterally rather than dorsally. Because of this, the junction of the shelf and the base of the anterior process does not enclose a deeply U-shaped space but its outline is gently concave.

The pleural ribs, transverse plate, and esophageal supports are similar to those of *rupiscartes* in general aspect, although the entire structure is somewhat more vertical than in that species. The pleural ribs, however, are more sharply pointed. The concavity formed by the inner margin of the pleural ribs and the ventral edge of the transverse plate, excluding the projecting esophageal supports, is trapezoidal in outline. The space enclosed by the fusion of the second and fourth pleural ribs is large and opens laterally rather than anteriorly.

Coloration.—In preservative the pattern is rather sharply bicolored, dark above and light below, but in some series the dark gradually fades ventrally. The underparts of the head and body and the caudal fin are white. The body is lined with 8 pronounced light and dark lateral stripes. The lowermost dark stripe is faint anteriorly and is located on the second scale row below the lateral line. The lateral scales are faintly outlined in dark, and have lighter centers. The bases of the predorsal scales are black; large specimens have the scales on the upper side similarly marked. The head is dark above in contrast to the light color of the lower snout and cheek; the ventral extension of dark color is variable. A dark occipital bar extends obliquely downward on the shoulder girdle and continues onto the upper surface of the pectoral fin. The bar is best developed dorsally and is interrupted near the lateral line. The upper surface of the pectoral fin is dark except for the first ray and for a narrow light border on the posterior edge. The upper surface of the pelvic fin is light in juvenile specimens and is either light or dark in adults, except for the first ray and the posterior border which is always light. The anal fin is variably colored; it may be dark in the center but has a light-colored first ray and posterior border. The membranes of the caudal fin are variously dusky and the outer border of the fin is sometimes dark. The leading edge of the caudal fin is dark.

The light lower ray of the caudal fin always contrasts with the dusky rays above. The light-colored basal portion of the lower caudal ray is continuous with the light color of the lower side of the caudal peduncle. No bright fin colors were noted in the field. Posteriorly the peritoneum is silvery, but it is dark near the coil of the small intestine. The inner surface of the opercle is rather uniformly covered with melanophores.

Sexual dimorphism and nuptial tubercles.—In the male the innermost 4 pelvic rays are longer than the outer rays; in the female the reverse is true. No prominent urinogenital papilla was noted in either sex.

Males approaching breeding condition have a row of nuptial tubercles on each ray of the anal fin; these are best developed on the central third of the rays. Moderate-sized nuptial tubercles line the rays of the lower caudal lobe and a few are scattered on the upper lobe. The female has a few small tubercles on the anal fin. The most advanced male examined had one scale only on the anterior side, which was densely covered with small tubercles. Perhaps this indicates that tubercles develop rather generally on the scales at spawning time.

Relationships and comparisons.—*M. lachneri* is one of the few fishes restricted to the Apalachicola River system. Its distribution parallels that of another recently described form, *Notropis hypsilepis* Suttkus and Raney (1955). *M. lachneri* shares this system with three other species of *Moxostoma*—*erythrurum*, *duquesnei*, and *rupiscartes*. *M. erythrurum* and *duquesnei* are wide-ranging forms known from the neighboring Alabama River system and northward, west of the Appalachians. *M. rupiscartes* is primarily a species of the Atlantic slope which reaches the southwestern limit of its range in the Chattahoochee River system.

Morphologically, the closest relative of *lachneri* is *rupiscartes* although the two are clearly differentiated at the species level. The important characters which separate *lachneri* from *rupiscartes* are given in table 3. In addition, *lachneri* is known to attain a larger size (375 mm.); *rupiscartes* commonly reaches 200 mm. but no specimens exceed 230 mm. Despite the many differences, it seems clear that these two forms evolved from the same stock.

Superficially *lachneri* resembles *poecilurum* (see table 4, plates 2 and 3). The similarities, especially the coloration of the lower caudal lobe, are striking and are due to convergence since the two species belong to different phylogenetic lines. *M. poecilurum* has 12 (5-2-5) caudal-peduncle scales. The relationships of the latter are probably with *M. erythrurum* rather than with *M. aureolum* as suggested by Hubbs (1930:30). Some of the salient differences between *lachneri* and *poecilurum* are given in table 4. The two have similar dorsal-ray counts, although *poecilurum* averages slightly lower in the pectoral-ray count. The dark and light lateral stripes of the *poecilurum* reach more ventrad and are prominent anteriorly

on the second, third, and fourth scale rows below the lateral line; in *lachneri* the lower stripes are developed on the second and third scale rows below the lateral line.

M. lachneri resembles *M. robustum*, which is known from Atlantic coastal streams, but the relationship does not appear to be close and they are not geographical representatives of a single type. *M. lachneri* differs from *robustum* in the following respects: (1) body, head, and caudal peduncle are slender rather than deep; (2) body depth at dorsal origin is less than head length rather than greater; (3) caudal-peduncle depth enters the dorsal height two or more times rather than less than two times; (4) depth of head at occiput when stepped off from the tip of snout reaches a point in front of the preopercle rather than falling behind the preopercle; (5) circumferential scales usually number 34 or fewer, rather than 35 or more; (6) caudal fin much longer, the length of the longest ray much greater instead of much less than depth of body; (7) caudal fin bicolored rather than uniformly dusky; (8) caudal fin more deeply forked with black dorsal edge rather than less forked with a whitish dorsal edge; (9) anal fin short, when depressed does not reach the posterior end of the hypural, rather than long, reaching beyond the posterior tip of the hypural; (10) dorsal fin with the free edge falcate in front and convex behind rather than having the free edge straight or only slightly falcate; (11) the posterior half of scales found in front of the dorsal fin have a thin dark line along the margin rather than being generally dusky.

The occurrence of *duquesnei* in the Apalachicola River system is verified by five yearling specimens (CU 17128). However, the relationships of this species are not with *lachneri*. Each belongs to a different subgenus; *duquesnei* has 5-2-5 caudal-peduncle scales with an occasional count of 6-2-5 or 7-2-5, and generally is a relatively fine-scaled form. However, the higher number of lateral-line scales which serve to identify this species throughout much of its range does not obtain for southern samples. The Apalachicola River form of *duquesnei* does not conform, in meristic features, with other populations. The Alabama River form of *duquesnei*, which is well represented in collections, differs from *lachneri* in the following characters: The lower ray of the caudal is dark or mottled rather than white; the pectoral fin is pointed (rays 3 and 4 are equal in length) rather than round (rays 4 and 5 are longest); few or no dark lateral stripes are present, whereas *lachneri* is striped; and the body anterior to the dorsal fin is deeper and heavier.

M. erythrurum which also occurs in the Apalachicola River system (2 specimens available, CU 26578 and CU 26579) again differs from *lachneri* fundamentally in having 5-2-5 caudal-peduncle scales. It also has fewer lateral line scales (43 and 44) than *lachneri* (usually 45 or 46); the pectoral fin is long and pointed (rays 3 and 4 longest) while in *lachneri* the pectoral is round (rays 4 and 5 longest); and has a deeper, heavier body.

Distribution and ecology.—*M. lachneri* is found in the Chattahoochee River and its main tributary, the Flint River. It ranges widely throughout the system and is recorded from Early Co., Ga., near the Florida state line to near the headwaters in Habersham Co. Ecological data are available from nine relatively small wooded streams and one collection is from the main Chattahoochee River. The small streams were less than 60 feet wide, except for one which measured 150 feet. In all instances except one, the current was moderate or swift over rubble, gravel, or bedrock bottom. Sand was generally present in the pools, but in view of its general abundance in the area it is probably not as significant as in the presence of hard bottom.

Moxostoma rupiscartes Jordan and Jenkins

Striped Jumrock

Plates 2 and 4

Ptychostomus cervinus.—Cope, 1870: 478-79 (in part; misidentification of Catawba and Yadkin River material only).

Myxostoma cervinum.—Jordan and Brayton, 1878: 11, 26, 33, 38 (Misidentification; records from the Santee, Savannah, and Altamaha River systems). Jordan, 1878a: 129-30 (misidentification, in part; Catawba, Ocmulgee, Saluda, and possibly Chattahoochee River material referable to *rupiscartes*). Jordan, 1878b: 316 (misidentification, in part) Jordan, 1880: 316 (misidentification, in part; range and characters combined with those of *cervinum*).

Moxostoma cervinum.—Jordan and Gilbert, 1883: 142 (misidentification, in part; range includes that of *cervinum*; characters confused). Jordan, 1885: 20 and 1899: 48 (in part; misidentification, range includes that of *cervinum*). Fowler, 1914: 60 (misidentification, in part; Catawba River specimens, incorrectly synonymized with *cervinum*). Fowler, 1923: 17 (misidentification; Catawba specimens erroneously listed as types of *cervinum*). Fowler, 1935: 6, 10 (misidentification; records in part, confused with *robustum*). Fowler, 1945: 24, table 1 (misidentification, in part; Santee, Savannah, Altamaha, and Chattahoochee records only; compiled).

Moxostoma rupiscartes.—Jordan and Jenkins, in Jordan, 1889: 353-54, pl. 44, fig. 3 (original description; correctly separated from *cervinum*). Jordan, 1889: 137 (Santee River distribution). Jordan and Evermann, 1896a: 243 (range; compiled). Jordan and Evermann, 1896b: 196-97 (characters; range; synonymy; compiled.) Smith, 1907: 81-82, fig. 24 (characters; range; synonymy; compiled). Pratt, 1923: 60-61 (characters; range; compiled). Pickens, 1928: 29 (compiled).

Scartomyzon rupiscartes.—Jordan, 1929: 65 (description; range). Jordan,

Evermann and Clark, 1930: 111 (range; synonymy; compiled). Pratt, 1935: 59 (characters; range; compiled). Driver, 1942: 276 (in key only).

An examination of the type, USNM 39927, confirms the correctness of applying the name *M. rupiscartes* to the species discussed below. The type specimen was taken from the Catawba River at Marion, N. C., and judging from its size is apparently the one used in preparing the illustration shown in Jordan (1889, plate 44, fig. 3). Although it would seem that this is clearly the type, since it was so designated by number and collection in the original description (Jordan, 1889: 353), the authors designate it as lectotype since six other specimens of *rupiscartes* were at one time included in the same jar. These specimens (65-175 mm. S.L.) were removed and recatalogued as USNM 163139. The other types were examined also—USNM 40424 (4 specimens: 35, 56, 157, and 160 mm. long) and USNM 125212 (1 specimen, 121 mm. in S.L.) collected by Jordan at Spartansburg, S. C. Two other species of *Moxostoma* (*pappillosum* and an unidentified species with 10 pelvic rays) were included with USNM 40424.

Although *Ptychostomus pidiensis* Cope (1870: 471) seems to answer the description of *Moxostoma rupiscartes*, it is *Minytrema melanops* (Rafinesque), as Fowler (1913: 56) indicated; Cope (1870: 478) admits having difficulty in identifying *Minytrema melanops*. The writers have examined the cotypes of *P. pidiensis* at the Academy of Natural Sciences of Philadelphia, numbers 6968-70. It is clear from Cope's description that he had the largest (89 mm.) of three specimens before him at the time the description was drawn up. It has 12 dorsal rays, narrow and plicate lips, and a V-shaped lower lip; dissection reveals that the air bladder is two-chambered. The lateral line is completely lacking on the body. This specimen (ANSP 6968), which was noted by Fowler (1913: 56) as "type", is herein designated as the lectotype of *Ptychostomus pidiensis* Cope, and the species is referred to the synonymy of *Minytrema melanops*. Two specimens, ANSP 6969 and 6970, which were included with the type, are not *Minytrema melanops*. They are young specimens of a species of *Moxostoma* which has 10 pelvic rays, but which the authors have not as yet identified with any known species. They are not specimens of *rupiscartes* or *robustum*. Fowler (1913:56) was in error in stating that "they show the air-vessel in two compartments" since upon dissection the writers have found three distinct chambers. It is also interesting that in the numerous collections from the Yadkin River system, which is the type locality of *Ptychostomus pidiensis*, no specimen of *Moxostoma rupiscartes* has been taken. Indeed, Cope (1870: 479), who did not recognize *rupiscartes*, but confused it with *Ptychostomus* (= *Moxostoma*) *cervinus*, noted that "*cervinus*" (= *rupiscartes*) existed in great numbers in the Catawba River but that he did not meet with it in the Yadkin or elsewhere. Also, Fowler (1913, 1945) did not recognize the very distinct *rupiscartes*, but continued to confuse it with *cervinum*.

Material examined.—Santee River system, Catawba drainage, North Carolina, Avery Co.: CU 19349 (12, 24-52) Braggs Cr. near Roseboro; CU 28331 (26, 55-142) Lost Cove Cr. Caldwell Co.: CU 21349 (4, 67-101), trib. Catawba R., 1 mi. N. Caldwell Co. line on N.C. Hwy. 90; CU 21240 (3, 49-124) trib. Johns R., 2.5 mi. E. Collettsville on N.C. Hwy. 90; CU 25114 (1, 201) trib. Lower Cr., 6.8 mi. SW. Lenoir. McDowell Co.: CU 19243 (10, 26-38), CU 11672 (1, 52); CU 10911 (9, 39-209) Catawba R. at Old Fort; CU 25150 (3, 46-174) 4 mi. W. Marion; USNM 39927 lectotype (1, 227), USNM 67973 (1, 96), USNM 163139 (6, 65-175) at Marion; USNM 100662 (3, 57-96 Crooked Cr. 18 mi. N. Bat Cave. Burke Co.: CU 11261 (1, 29) Roses Cr. 1.5 mi. S. Smyrna on N.C. Hwy. 181. Alexander Co.: CU 19293 (5, 43-82) first stream N. Taylorsville on N.C. Hwy. 16; CU 19372 (1, 68) Lowes Cr. 7 mi. N. Taylorsville; CU 19299 (1, 72) trib. Ball Cr., Millersville; CU 21392 (4, 47-149) trib. Catawba R., 2 mi. E. Caldwell Co. line N.C. Hwy. 90. Catawba Co.: CU 18310 (2, 101-172) Lyle Cr. 2.5 mi. E. Claremont; CU 19296 (10, 20-28) Lyle Cr. 3 mi. N. Canover; USNM 162914 (2, 87-133) Maiden Cr. at Maiden; USNM 162915 (1, 48) trib. 5 mi. N. Newton; USNM 162913 (1, 44) trib. S. Fk. Catawba R., 3.4 mi. S. Newton. Lincoln Co.: CU 19550 (5, 43-166) trib. Catawba R., 9 mi. NW. Lowesville, Gaston Co.: USNM 162289 (8, 40-112) trib. S. Fk. Catawba R., 9 mi. S. Lincolnton. County unknown: USNM 92525 (1, 75) Catawba R. South Carolina, York Co.: CM 34.219.3 (3, 89-91) Steele Cr. 2 mi. N. Ft. Mills.

Broad Drainage, North Carolina, Henderson Co.: USNM 162259 (3, 74-133) trib. Broad R. near Bat Cave. Polk Co.: CU 19344 (6, 20-96) Pacolet R., Tryon. Cleveland Co.: CU 19356 (1, 97) Knob Cr. 2 mi. W. Toluca; CU 9777 (1, 162) Brushy Cr., 7 mi. E. Mooresboro. South Carolina, Spartansburg Co.: USNM 40424 (4, 36-162), USNM 125212 (1, 121) Pacolet R., Spartansburg. Union Co.: CU 17723 (31, 52-223) Cane Cr., 1.7 mi. SW. Carlisle. Greenville Co.: CU 11754 (2, 130-172) Enoree R., 3 mi. NE. Travellers Rest. Fairfield Co.: CU 19671 (1, 138) Little R., 10.3 mi. W. Winnsboro. Newberry Co.: CU 19713 (2, 55-60) Hellers Cr., 2.9 mi. E. Strother; CU 11934 (7, 53-164) Hunting Fk. Cr., 4.8 mi. S. Whitmire.

Saluda Drainage, South Carolina, Pickens Co.: USNM 162358 (1, 64) trib. Saluda R., 5 mi. W. Greenville. Greenville Co.: CU 11794 (2, 21-31), CM 31.331.13 (8, 38-53), CM 31.331.7 (2, 49-50) Middle Saluda R., Cleveland; CM 31.330.7 (7, 43-82) N. Saluda R., 10 mi. N. Travellers Rest; CM 31.204.9 (3, 26-75) headwaters N. Saluda R.; USNM 162357 (5, 69-165) N. Saluda R., 12.6 mi. S. Tuxedo, N. C. Anderson Co.: CM 34.275.3 (1, 71) Brushy Cr., 10 mi. SW. Greenville. Newberry Co.: CM 31.201.6 (2, 88-104) vic. Newberry. Lexington Co.: USC 513D54 (1, 163) trib. Lake Murray, 4 mi. SW. Chapin.

Savannah River system, South Carolina, Oconee Co.: CU 19751 (2, 41-60) Cane Cr., 3 mi. NW. Walhalla; CM 34.283.1 (3, 42-126) 7.5 mi.

NW. Walhalla; CM 34.285.2 (2, 83-93), ANSP 61178-82 (5, 61-129) 9.5 mi. NW. Walhalla; CU 19815 (1, 161) headwaters Chauga R., 1.8 mi. SE. Mountain Rest; CM 33.142.2 (1, 52), CM 33.286.4 (1, 160) Chattooga R., NW. Mountain Rest; CU 19088 (2, 69-97) East Village Cr., just S. Mountain Rest; CU 11449 (6, 86-155) trib. Coreross Cr., 5.3 mi. S. Seneca; CU 17364 (2, 48-113) trib. Tugaloo R., 4.7 mi. N. Fair Play. Pickens Co.: CU 19794 (15, 41-149) trib. Twelvemile Cr., 3 mi. NNW. Pickens. Anderson Co.: CU 19748 (2, 74-86) Eighteen Mile Cr., 1 mi. NW. Pendleton; USNM 162360 (1, 131) trib. Seneca R., 1 mi. NW. Pendleton; CM 34.276.4 (1, 135) just N. Anderson. Georgia, Stephens Co.: CU 17443 (10, 97-133) Toccoa Falls, 2.5 mi. from Toccoa; CU 11221 (2, 133-174) N. Fk. Broad R., 3.7 mi. W. Toccoa. Madison Co.: USNM 162460 (2, 84-117) trib. Broad R., 0.7 mi. SW. Danielsville; CU 26580 (2, 94-108) S. Fk. Broad R. at Anthony Shoals near Carleton; CU 22686 (1, 87) trib. S. Fk. 2.4 mi. NE. Madison Co. line on U.S. Hwy. 29. Franklin Co.: CU 19618 (8, 92-153) trib. Nail Cr., 0.7 mi. SW. Ashland.

Altamaha River system, Georgia, Hall Co.: CU 11201 (6, 79-146) headwaters Oconee R., 2 mi. NW. Gillsville; CU 17342 (1, 103) Mulberry Fk., 13.8 mi. S. Gainesville. Winnett Co.: USNM 163140 (3, 72-98) Haynes Cr., 5.5 mi. W. Logansville. Barrow Co.: USNM 162446 (8, 39-181) trib. Mulberry Fk., 2.5 mi. N. Winder. Oconee Co.: CU 26584 (3, 44-181) Barkers Cr. at Hope Mill, near Princeton. Henry Co.: CU 17525 (1, 155) Walnut Cr., 1.5 mi. N. McDonough.

Chattahoochee River system, Georgia, Hall Co.: CU 21420 (1, 135) trib. Chattahoochee R., 1.3 mi. N. Chattahoochee R. on U.S. Hwy. 129; CU 11004 (4, 126-149) trib. Chattahoochee R., 6 mi. N. Gainesville. County unknown: USNM 162415 (2, 28-62) trib. Chestatee R.

Comparative description.—A small species of *Scartomyzon* which reaches a standard length of 230 mm. The body is elongate and subterete (plate 2). The nape is flattened. The dorsal contour is only slightly elevated from the tip of the snout to the origin of the dorsal fin, and posteriorly it slopes gradually to the anterior procurent rays. The preanal ventral contour is almost straight but is slightly bulged midway; posterior to the origin of the anal fin it slopes sharply upward and then levels off on the under side of the caudal peduncle. The caudal peduncle is relatively deep. The body depth, measured at dorsal-fin origin, considerably exceeds the greatest body width.

The head is subquadrate in lateral view and is almost U-shaped when viewed from above; its width is greater than its depth. In lateral view the anterior snout is rather square. The occipital line is bowed toward the snout and is marked posteriorly by dark pigment which continues downward on the shoulder girdle as a bar of variable intensity. The relatively small eye is located supralaterally and the center of the pupil is distinctly behind the midpoint of the head.

Considerable variation exists between river systems in the structure of the lips, although different samples from a single system exhibit little variation. They are plicate in Altamaha and Chattahoochee specimens and semi-papillose in those from the Savannah, Santee, and PeeDee River systems (plate 4). The plicae may branch posteriorly in all populations. The lower lips are broadly joined and meet at an angle of about 140° in adults. In specimens of the related *robustum*, the lower lips are truncate behind. The posterior tip of the lower lip reaches a vertical projected from the anterior nostril. The upper lip is only slightly thicker in the center than laterally.

The dorsal-fin origin lies well in front of the point midway between the posterior end of the hypural and the snout tip, whereas the insertion of the pelvic-fin base lies behind this point. The pectoral fin is moderately pointed and rays 4 and 5 are longest. The pelvic fins are moderately rounded on the outer tip and the inner rays of the male are somewhat more elongate. The anterior tip of the dorsal fin is pointed; the free edge varies from slightly concave to almost straight. The caudal fin has a rounded notch; the inner edges of the fork are rounded or convex; the upper lobe is somewhat pointed, while the lower lobe is rounded. The procurent caudal rays are well developed.

Some fin-ray and scale counts are given in table 1. The dorsal-ray count varies somewhat in the several river systems, but modally is 11, except for the Altamaha River system where the mode is 10 (see table 1). Other fin-ray counts are: anal 7, pelvics 9-9, with rarely 8 or 10 on one side; caudal 18; pectoral variable (see table 1).

The lateral-line scale count varies in the several stream systems as shown in table 1. Other scale counts are as follows: around the caudal peduncle number 16 (7-2-7); above lateral line 6 or 7, the upper one is small; below lateral line 5 or 6, the lowermost one is small; predorsal dorsal rows 17-20; circumferential 32 to 37; normally 15 above the lateral line but occasionally 13; and 17 to 20 rows below the lateral line.

The pseudobranchiae are exposed and well developed. The gill rakers are variable in number; 23 to 30, including 5 or 6 rudiments, were counted in adults. The anterior fontanelle is closed; the posterior fontanelle is developed and rectangular.

The pharyngeal arch is weak, is strongly curved, and has a moderately developed shelf. Teeth number from 40 to 50, and each is hooked on the anterior tip; the hook is especially well developed on the smaller teeth.

The ventral edge of the tripus in *rupiscartes* (plate 1) is slightly concave under the basal half of the posterior process. Anteriorly it is convex, sloping gradually into the upturned anterior process. The posterior process is attenuated and but slightly upturned at its tip; the dorsal edge is straight, except near the tip, and slopes upward and forward to the base of the median fulcrum. The narrow anterior process which curves sharply dorsad is rather short and does not extend so far dorsad as the outer base of the

median fulcrum. The central body is compressed on its posterior half but bears a shelf anteriorly which is tilted at a steep angle, the more dorsad portion being on the lateral side of the tripus. The shelf does not project far laterally. Viewed laterally and excluding this shelf, the dorsal edges of the central body form the apex of a triangle, at which point the fulcrum projects anteriorly. In medial view the shelf slopes downward at a moderate angle through most of its length, but turns sharply downward to the central body of the tripus near the base of the anterior process; the deeply U-shaped notch which is formed between the dorsal edge of the anterior process and the shelf is diagnostic for the species. The median fulcrum is a transverse plate which crosses the axis of the tripus at a sharp angle. From base to tip the fulcrum slopes forward; this contrasts with the caudally sloping process of *M. aureolum* which is shown by Nelson (1948: pl. 3, fig. 13). Dorsally the fulcrum consists of a sharp ridge medially but widens laterally to form a large elliptical fossa. The lateral surfaces of the tripus are solid and smooth.

The large pleural ribs, the transverse plate, and the esophageal supports slope sharply caudad so that their anterior surface may be fully seen in ventral view. Compared with that of *M. aureolum* (Nelson, 1948: Pl. 3, fig. 13), the following differences may be noted: the ventral edge, excluding the projecting esophageal supports, is broadly U-shaped rather than trapezoidal. Because of the greater slope of the entire structure the pleural ribs project farther caudally and their tips are broadly rounded. The space enclosed by the fusion of the second and fourth pleural ribs opens anteriorly rather than laterally.

Coloration.—In preservative the prominent light and dark lateral streaks extend well onto the dorsum. The body is not bicolored. Young and small juveniles usually have 4 or 5 blotches along the side. These blotches are more or less interrupted on the upper side and continue over the back as complete or incomplete saddles. Adult specimens from the Santee River system are without blotches, while those from the Savannah, Altamaha, and Chattahoochee Rivers tend to retain the juvenile color as adults. The blotches extend somewhat lower on the side in Savannah River specimens. Scale coloration is treated below in the section on infraspecific variation. The underside of the head, the extreme lower sides, and the underparts are white, gradually changing on the sides; the dorsum is dark. The dark occiput contrasts with the light of the top of the head. A bar on the shoulder girdle may be well to poorly developed in the several river systems. A diffuse dark spot marks the middle of the opercle. The snout is uniformly dusky; it fades to light below in Santee specimens but is blotched in those from the Savannah, Altamaha, and Chattahoochee Rivers. The caudal-fin coloration is noted below under *Relationships*. The dorsal fin tends to have a faint narrow dark border; the leading edge is dusky, but on the pectoral and

pelvic fins it is light. The pectoral and anal fins are variably washed or mottled with dusky. Occasionally the anterior half of the pectoral fin is dark except for the leading edge. The peritoneum and undersurface of the opercle vary from dusky to light.

Breeding specimens seen in life were brownish with an indefinite yellow-brown band along the side. The lower fins were a dull brown, yellow, or dull orange. Other items on coloration are to be noted in the comparison of *cervinum* and *rupiscartes* in table 5.

Sexual dimorphism and nuptial tubercles.—The urogenital papilla is flat and U-shaped; in the male it is somewhat smaller and is serrulate on the posterior edge. The anal fin is usually longer in the male; when depressed it extends to the lower procurent caudal rays, while that of the female normally does not. The inner rays of the pelvic fins are much longer in the male. The length of the pelvic fin when projected posteriorly reaches just beyond the origin of the anal fin in the female but nearly meets the posterior anal base in the male.

The nuptial tubercles on adults are recorded from specimens in breeding condition taken in Cane Creek, Santee River system, S. C., CU 17723. The male has minute white tubercles scattered over the head, snout, and the anterior scales. Those on the predorsal scales are limited to a row near the edge of the scale. The pattern is similar in the female but fewer and smaller tubercles are present. Rows of small tubercles are present on the anterior part of the pectoral fin; they are also present on the pelvic fins but are not as limited in distribution. The tubercles on the anal-fin rays are most characteristic and best developed. In the male, they line the rays; as they extend outward from the fin base the tubercles become larger but they are absent on the outer quarter of the fin. In the female the tubercles are limited to the basal two-thirds of rays 2 to 5. Small tubercles are scattered on the rays of the caudal fin; those on the lower lobe are somewhat larger than on the upper, but are much smaller than those found on the anal fin. In the female the lowermost half of the lower lobe of the caudal fin bears a few minute pale-colored tubercles. In the male the scales of the caudal peduncle just anterior to the procurent caudal rays and adjacent to the anal fin are thickened and lack tubercles; the female had neither tubercles nor thickened scales in this region. This species does not approach the scarified and tuberculate condition found in both *cervinum* and *robustum*.

The males seem to reach sexual maturity at a smaller size, but there are some rather large breeding males in the large collection taken in Cane Creek. Perhaps there is not the disparity in maximum size noted for the sexes in *cervinum*.

Ripe males and females were taken in Cane Creek on March 23, 1950, when the water temperature was 56° F. The stream at this point was less than 10 feet wide, the bottom was of sand, and the current was moderate.

Intraspecific variation.—Considerable variation is noted in several characters when specimens from the Santee, Savannah, Altamaha, and Chattahoochee River systems are compared. There seems to be greater variation in this species than in the other *Moxostoma* studied by the authors. In view of the constancy of most characters exhibited by the other species of *Moxostoma* this occasions some surprise.

Some populations are well enough differentiated to be recognized as subspecies. For example, those from the Santee and Savannah Rivers have the lower lips semipapillose (plate 4) as compared with the strictly plicate lower lips found in specimens from the Altamaha and Chattahoochee Rivers. Although this break is sharp and equals those which have been used as a basis for recognizing subspecies by others who have studied the genus, the authors propose to point out the differences observed in these four populations as a guide for others who may study them in the future, when additional series are available.

Frequency distributions of the number of fin rays and lateral-line scales for the four populations are given in table 1. For lateral-line scale counts there is a clinal increase from south to north. However, a line drawn between 45 and 46 lateral-line scales gives a separation of 97 and 78 per cent of the specimens from the Santee and Savannah, respectively, from 89 and 66 per cent of the specimens from the Altamaha and the Chattahoochee. When the pectoral ray counts are considered, the break comes between the Santee, which has the higher counts, and the Savannah, Altamaha, and Chattahoochee to the south. When a line is drawn between 16 and 17 pectoral rays, 72 per cent of the Santee specimens are separated from 83, 80, and 78 per cent of those from the Savannah, Altamaha, and Chattahoochee, respectively. The Altamaha population has the lowest dorsal-ray count of the four. A line drawn between 10 and 11 dorsal rays permits a separation of 90, 63, and 87 per cent, respectively, of the Santee, Savannah, and Chattahoochee specimens from 59 per cent of those from the Altamaha system.

Adults from the Santee River system are not usually blotched along the side, while those from the Savannah, Altamaha, and Chattahoochee systems retain their juvenile coloration, which consists of four broken lateral blotches extending far down on the sides. Santee specimens also have a definite subterminal darkish band on the scale, which tends to interrupt the lateral stripes; those from the Savannah, Altamaha, and Chattahoochee have the light streaks uninterrupted.

The terminal dark band of the caudal fin in Santee specimens is lighter and is not expanded at the tips of the lobes. Savannah specimens have the terminal band expanded somewhat on the tip of the lower lobe, while in Altamaha specimens the band is very little developed except on the two lobes. In Chattahoochee specimens the lobes, especially the ventral one, are dark, and the terminal band is only slightly darker than the dusky caudal rays.

In Santee specimens the anterior third of the lowest caudal ray is light-colored, in contrast to the dark on the anterior half of the ray immediately above. Those from the Savannah are similar but the contrast is not as great. In Altamaha and Chattahoochee specimens the lower edge of the caudal is light almost to the tip and is definitely dusky on the ray immediately above.

Specimens from the Chattahoochee are somewhat darkened at the dorsal fin tip, more so than those from the other three river systems.

The snout in Santee specimens is uniformly dusky above and lighter below but is blotched in the other three populations. Savannah specimens have a wider mouth and a less robust snout as viewed from above, than those from the Santee, Altamaha, or Chattahoochee Rivers. As viewed from below, the head is attenuate in Santee specimens and more blunt in the other populations. The dorsal aspect of the pectoral fin is not blotched in Santee specimens, is sometimes blotched in those from the Savannah, and is normally blotched in those from the Altamaha and Chattahoochee Rivers.

Relationships and comparisons.—Within the subgenus, *rupiscartes* seems to be most closely related to *lachneri*. It appears from the evidence now available that *rupiscartes* evolved from an early invasion of *lachneri* or *lachneri* stock into the more easterly Altamaha River system. Since both species occur in small streams, headwater capture seems probable. A lowland invasion of *lachneri* stock into the Altamaha River system is another possibility since *lachneri* is also known to live in big waters.

After *rupiscartes* had evolved in the Altamaha River system it invaded the Apalachicola River system. Although both species occur in the Apalachicola River system they have not been taken together. In the plicate condition of the lips, a primitive condition, the populations of *rupiscartes* in the Altamaha and Apalachicola River systems are similar. *M. rupiscartes* also moved northeastward into the Savannah. It may have utilized the well-known stream capture (see Fenneman, 1938) which occurred when the headwaters of the Chattahoochee River were beheaded by the Savannah River. Other species which may have transferred at the time of this capture are *Hybopsis bellica* (Girard), *Hybopsis rubrifrons* (Jordan), *Notropis zonistius* (Jordan), *Notropis lutipinnis* (Jordan and Brayton), *Micropterus coosae* Hubbs and Bailey, *Hadropterus nigrofasciatus* Agassiz, and *Cottus bairdi* subsp. It is equally possible that *rupiscartes* invaded the Savannah River system directly from the Altamaha River system. The Savannah population of *rupiscartes* now differs in having semipapillose lips, a derived character. There are also fin-ray and scale character differences.

Compared with the remaining species of the genus, *rupiscartes* seems closest to *cervinum*, although the two differ trenchantly; and apparently they have long been separated geographically.

Moxostoma robustum occurs with *rupiscartes* in the Santee and Savannah River systems. It differs in having a shorter, deeper, head; the other differ-

ences are noted in table 6 and are discussed below under *M. robustum*. It is not closely related to *ariommum* and a comparison of the two does not seem necessary.

Of the subgenus *Moxostoma*, two species, *pappillosum* (Cope) and *collapsum* (Cope) occur commonly throughout much of the range of *rupiscartes* but are very different. They possess the following characters that will separate them from *rupiscartes*. (1) A deep V-shaped cleft at the symphysis of the lower lips; (2) 12 (5-2-5) caudal-peduncle scales; (3) a deeply forked caudal fin; (4) a greater number of dorsal rays, usually 14 or 15 in *collapsum*, and 12 to 15 in *pappillosum*; and (5) fewer lateral-line scales, 39 to 43 in *collapsum*, and usually 42 to 44 in *pappillosum*. At least two other species of the subgenus *Moxostoma* occur within the range of *rupiscartes* and each may easily be separated by the caudal-peduncle scale count.

Distribution and ecology.—*Moxostoma rupiscartes* is essentially a small-stream fish found in the Piedmont area and in the mountains. It is known from the Santee, Savannah, Altamaha, and Chattahoochee River systems. Apparently it is widespread and common in the upper regions of all, except at the extreme of its range in the headwaters of the Chattahoochee River. *M. rupiscartes* is not represented in the numerous collections from the Edisto and Combahee drainages which are essentially Coastal Plain systems. The writers have collected it many times, almost always in fairly fast water or riffles and over sand, gravel, and rubble.

Moxostoma cervinum (Cope)

Black Jump Rock

Plates 2 and 4

Catostomus duquesnii.—Gunther, 1868: 483 (misidentification of Roanoke R. specimen).

Teretulus cervinus.—Cope, 1869: 236, pl. 24 (description, figured in color; type locality "headwaters of the Roanoke and James Rivers, Va. preferring rapids"). Jordan and Copeland, 1876: 157 (name only).

Ptychostomus cervinus.—Cope, 1870: 478-79 (in part, Roanoke and James Rivers only; Catawba and Yadkin River material referable to *rupiscartes*; characters confused).

Myxostoma cervinum.—Jordan, 1878a: 129-30 (in part; James River to Neuse River only). Jordan, 1878b: 316 and 1880: 316 (in part; range and characters combined with those of *rupiscartes*).

Moxostoma cervinum.—Jordan, 1876: 296 (characters and range). Jordan and Gilbert, 1883: 142 (in part; range includes that of *rupiscartes*; characters compounded). Jordan, 1885: 808 (range includes that of *rupiscartes*). Jordan and Jenkins, in Jordan, 1889: 353-54 (comparison with *rupiscartes*; ranges clarified). Jordan, 1889: 122, 125 (Roanoke and Pamlico River systems). Jordan, 1899: 48 (range includes that of *rupiscartes*). Evermann and Cox, 1896: 305 (common in Neuse River basin). Jordan and Evermann, 1896a: 243 (Roanoke and James Rivers; compiled). Jordan and Evermann, 1896b: 197 (characters; range; synonymy; compiled). Smith, 1907: 82 (characters; range synonymy; compiled). Fowler, 1913: 60 (in part; Roanoke River material referable to *cervinum* and *Thoburnia hamiltoni*; James R. material referable to *T. rhothoeca* and Catawba R. specimens to *M. rupiscartes* and other species; type erroneously chosen). Pratt, 1923: 61 (in part, characters confused with those of *Thoburnia rhothoeca*; compiled). Hubbs, 1930: 43-44 (comparison with *Thoburnia rhothoeca*). Fowler, 1945: 24, table 1 (range incorrectly includes Santee, Savannah, Altamaha, and Chattahoochee Rivers; compiled). Raney and Lachner, 1946: 218-26 (comparison with *Thoburnia rhothoeca* and *T. hamiltoni*; nomenclature). Raney, 1950: 159 (status in James River).

Scartomyzon cervinus.—Jordan, 1929 (description; range; habitat). Jordan, Evermann and Clark, 1930: 111 (synonymy; range; compiled). Driver, 1942: 276 (in key only).

Scartomyzon cervinum.—Pratt, 1935: 60 (characters; range; habitat; compiled).

Fowler (1913:60) designated three series of Cope's specimens as cotypes of "*Ptychostomus cervinus*". One of these series, ANSP 6920-6925, was from the Catawba River, North Carolina. He further indicated that ANSP 6920 was the "(type)" of *cervinum*. Fowler erred in designating the specimens of this series as cotypes and in naming ANSP 6920 as type, since the collection was made after the appearance of the original description of *cervinum* (January, 1869). Cope's journey to the Catawba River occurred during the autumn of 1869. Obviously these specimens could not have been used in Cope's original description. Upon examination, ANSP 6920 proved to be a specimen of *rupiscartes*. It is interesting to note that the five other specimens labeled as cotypes from the Catawba River, N.C. (ANSP 6921-25) include *M. rupiscartes* (3), *M. pappillosum* (1), and a small species of *Moxostoma* unidentified by the present writers. In describing *Teretulus cervinus*, Cope (1869: 236) listed the species only from the headwaters of the Roanoke and James Rivers, Virginia, and only later (1870: 472) erroneously included the Catawba River in the range of the species. The original description confuses the characters of *Thoburnia* and *Moxostoma*

cervinum, as Raney and Lachner (1946: 219) have pointed out, but does not include the features of *rupiscartes*. For example, the lips were listed by Cope (1869: 236) as strongly plicate. Lips of specimens of *rupiscartes* from the Catawba River are semipapillose and could hardly be considered plicate. In 1870, when Cope included the Catawba River specimens (*rupiscartes*) in his treatment of *cervinum*, he modified his description to include characters of *rupiscartes*—which, incidentally, he never recognized as a species. Cope then stated that the plicae are more or less broken up. Thus the specimen designated by Fowler (1913: 60) as type is not one of the original series of cotypes, and since the original series of cotypes is still extant the authors believe Fowler's action to be improper.

Also they agree with Hubbs (1930: 43) that Cope's original figure (1869: pl. 24, fig. 3) surely represents the species now called *Moxostoma cervinum*. The wedge-shaped snout and the black tip on the dorsal and caudal lobes are definitely features of *cervinum*, and are never noted in *Moxostoma rupiscartes*.

A second series of Cope's specimens ANSP 6928-46, designated as cotypes by Fowler (1913: 60), need not be considered further here since only specimens of *Thoburnia routhoeca* (Thoburn) are included.

The third series designated as cotypes by Fowler (1913:60) actually are cotypes and consist of 15 specimens bearing the data (probably not the original label) "*Ptychostomus cervinus* Cope, Headwaters of the Roanoke R., Va., E. D. Cope". Of these, three specimens, 59, 65, and 66 mm. in standard length are *Thoburnia hamiltoni* Raney and Lachner. The remaining 12 specimens are *M. cervinum*. The largest adult, which measures 140 mm. in standard length, is herein designated as lectotype. Also examined was a cotype which bears the same data and is now deposited in the Museum of Comparative Zoology, No. 25162.

When it is remembered that Fowler (1913: 60) had 42 specimens comprising a mixture of six species representing two genera, all of which he thought were *M. cervinum*, it is little wonder that he felt with regard to *rupiscartes* that "all its alleged characters of differences are covered by the very full series of typical examples." The subgenus *Scartomyzon* was apparently diagnosed by Fowler (1913: 59) on the basis of the above assemblage, but nevertheless is recognizable.

Material examined.—The type material discussed above is not listed below.

James River system, Virginia, Craig Co.: CU 20351 (1, 155), CU 24858 (4, 82-157), CU 28330 (4, 105-134) Johns Cr., New Castle.

Chowan River system, Virginia, Dinwiddie Co.: CU 11884 (1, 50) Strong Cr., 1.2 mi. S. Dinwiddie.

Roanoke River system, Virginia, Montgomery Co.: N. Fk. Roanoke R., CU 24940 (2, 126-128) McDonalds Mills; CU 20329 (8, 116-140), USNM 104123 (3, 78-117) Bennetts Mill; CU 24744 (7, 90-142) mouth of Den

Branch Cr.; CU 20726 (8, 53-139), CU 20308 (17, 97-159) near Lafayette. S. Fk. Roanoke R., CU 20659 (1, 143), CU 10518 (13, 45-118), CU 20309 (7, 91-123), CU 24821 (1, 138) at or near Allegheny Springs; CU 20701 (10, 100-148), USNM 162011 (4, 94-132), USNM 162012 (3, 81-151) near Shawsville; CU 24731 (26, 24-144) Elliston. Roanoke Co.: Roanoke River CU 24705 (4, 66-164), CU 9414 (1, 111), CU 20783 (2, 90-151), CU 24773 (5, 22-138) at Glenvar; CU 8348 (4, 30-77), USNM 125257 (2, 104-114), USNM 40278 (6, 115-142) at or near Roanoke; CU 11547 (5, 48-55) 2 mi. W. Salem; CU 24800 (11, 24-151) 2.4 mi. S. Elliston; UMMZ 158984 (1, 60) Mason Cr., 2 mi. E. Salem; Bedford Co.: CU 10504 (1, 73), USNM 162010 (11, 88-137), USNM 162009 (6, 89-151), CU 20714 (2, 95-100) Otter R. and Little Otter R., near Bedford. Campbell Co.: CU 16825 (1, 55) trib. Otter R. near Evington; CU 25094 (2, 102-109) Little Falling Cr., 4 mi. W. Redhouse. Franklin Co.: CU 11641 (19, 52-126) Pigg R., near Rocky Mount. Patrick Co.: CU 25123 (1, 125) Dan R., 10 mi. WSW. Stuart; CU 11746 (2, 93-111) S. Mayo R. at Stuart. Henry Co.: UMMZ 95404 (1, 141) N. Mayo R.; CU 25414 (2, 81-86), CU 19468 (3, 48-98) Smith R.

Tar River system, North Carolina, Granville Co.: Tar R., UMMZ 147579 (3, 33-37) 7 mi. SSW. Oxford; CU 19445 (1, 134) 2 mi. W. Berea; CU 19503 (6, 90-160) 1 mi. SW. Providence, Nash? Co.: USNM 40212 (5, 38-139) Tar R. at Rocky Mount.

Neuse River system, North Carolina, Orange Co.: CU 25048 (2, 58-132) Eno R., 2 mi. E. Efland. Wake Co.: USNM 40358 (1, 142) Neuse R. near Raleigh.

Comparative description.—A small species of *Scartomyzon*. No specimen of the numerous ones at hand exceeds 163 mm. standard length. The body is elongate and semiterete. The dorsal contour is arched from the tip of the snout to the base of the dorsal fin and is only slightly curved downward from this point to the heavy caudal peduncle (plate 2). In front of the origin of the anal fin and in the region of the caudal peduncle, the ventral contour is almost straight, in contrast to the area of the anal-fin base where the contour slopes upward. The procurent rays of the caudal fin are somewhat developed.

The snout is rounded, the head is semiconical in shape. Head depth and width are about equal. The occipital line is not straight; it is concave when viewed from behind.

The supralateral eye is moderate in size and is placed posteriorly so that the center of the pupil is somewhat behind the middle of the head. The gape is semicircular and reaches far back on either side. The lips are strictly plicate, the ridges being undivided (plate 4). The lower lips are broadly joined and meet at an obtuse angle. The posterior edge of the lower lip does not reach a vertical with the anterior nostril.

The pelvic and pectoral fins are more pointed than in some other species

of *Scartomyzon*. The anterior tip of the dorsal fin is pointed; the free edge is definitely, although slightly, falcate in front and convex near the rear. The caudal fin is small with a rather shallow notch; the upper lobe is considerably more pointed than the lower lobe, which is definitely rounded.

Some fin-ray and scale counts are presented as frequency distributions in table 1. Fin-ray counts are: dorsal usually 11, rarely 10 or 12; anal 7; pectoral usually 15, sometimes 14 or 16 and occasionally 13, the lowest pectoral count found in *Moxostoma*; pelvics 9-9, rarely 8 on one side, not 10 as noted by Cope (1869: 236); caudal 18. Frequency distributions of these counts are given in table 1.

There are constantly 16 (7-2-7) scales around the caudal peduncle. The lateral-line scale count is the lowest found in the subgenus *Scartomyzon*; range 39 to 44, usually 42 to 44 in the Roanoke and James River systems, and usually 40 to 42 in the Tar and Neuse River systems.

The pseudobranchiae are exposed and well developed. There are 21 gill rakers, the lower 4 of which are rudimentary. The rakers are of the *Scartomyzon* type, as described above. The anterior fontanelle is closed and the posterior one is rectangular.

The pharyngeal arch is essentially the same as described for *ariommmum* except for a considerably narrower shelf; teeth approximately 50.

The tripus of *cervinum* (plate 1) is most like that of *M. robustum*; in general appearance of the structure, the two species are indistinguishable. The ventral edge is flat; the fulcrum is near the midpoint of the tripus; the anterior shelf is flattened or concave dorsally and is nearly horizontal; the lateral edge of the shelf is convex and strongly projecting, and the medial edge, which also projects laterally, is concave.

The morphology of the pleural ribs and transverse plate is strikingly similar to that of *M. rupiscartes*. It differs slightly in that the inner edges of the pleural ribs meet the ventral edge of the transverse plate at an angle. They thus enclose a space which is trapezoidal rather than rounded. The esophageal supports are short and weakly developed.

Coloration.—Prominent dark and light stripes line the body but are most noticeable in juveniles. The latter also have about 6 dark blotches on the side of the body which form saddles across the dorsum. The body is sharply bicolored in specimens from the Roanoke and James River systems but it is noted that those from the Tar River have the dark blotches extending considerably below the lowermost dark lateral stripes. The opercle is dark, usually the lower cheek is light, and the snout is mottled. In specimens from the Tar River the dark extends far down on both the snout and cheek. The blackish tips of the caudal-fin lobes are diagnostic for the species. The dorsal fin is also black-tipped, and in some specimens from the Tar River the anal fin has a black tip. The leading edge of the dorsal fin and the upper edge of the caudal fin are light except for a dusky base and jet black tips. The leading edge of the lower fins is light, and the edge of the lowermost

caudal ray is definitely white. A dark blotch is especially well developed above the pectoral base in specimens from the Tar River system and is present, although less obvious, in the Roanoke River material. The peritoneum is silvery.

In life, the breeding male is dark above and brassy on the lower side. The caudal fin is red-orange; the lobes are reddish. The posterior quarter of the anal fin and the base of the pectoral and pelvic fins are red-orange.

Sexual dimorphism and nuptial tubercles.—In the male the rounded anal fin barely reaches the posterior tip of the hypural, while in the female the fin is much longer and more pointed, and, when depressed, reaches far beyond the posterior tip of the hypural. The inner rays of the pelvic fins are longer in the male. In the female the distance from the insertion of the pelvic fin to the tip of the longest ray when projected posteriorly, reaches about the middle of the anal-fin base. In the male the same measurement extends far behind the posterior end of the anal base.

At spawning time the urinogenital papilla of the female is conical, while that of the male is flattened and somewhat serrate on the posterior margin. The male is apparently smaller than the female, although this disparity may be due to a greater longevity of females rather than a faster rate of growth.

Nuptial tubercles are well developed on specimens in spawning condition which were taken in the Roanoke River at Lafayette on June 9, 1951 (CU 20308). The male has minute light-colored tubercles scattered over the top and the side of the head. Very small tubercles also are present on the dorsum and the upper side of the body, where they seem to be limited mostly to the posterior scale margin. On each anal ray the male has a row of fairly large tubercles; these are more concentrated along the middle third of the fin. A few small tubercles line the dorsal surface of the anterior rays of the pelvic fin. Smaller tubercles are present on the upper surface of the pectoral fin and are better developed on the distal half of the ray. Moderate-sized tubercles are scattered over the caudal fin but are concentrated on the rays; they are somewhat better developed on the lower lobe. The upper procurrent caudal rays have moderate tubercles. The lower procurrent caudal rays and the adjacent scales of the caudal peduncle below the lateral line bear large tubercles.

In the female, no tubercles were observed on the head or on the scales except in the region which begins approximately two scale rows before the anal fin and includes the caudal peduncle below the lateral line. Here, scattered coarse tubercles are present and there is a pronounced thickening of the skin such as has not been observed by the authors in any other catostomid. A few minute tubercles line the central portion of anal rays 2, 3, 4, and often 5. On the caudal fin, tubercles are lacking or are present only at the base of the lowermost few rays; they are absent on the dorsal and pelvic fins. It is obvious that these large tubercles are placed in such a manner as to facilitate spawning in fast water. In the Roanoke River at Lafayette on

June 9, 1951, the writers observed spawning aggregations taken from moderately swift riffles where the river is about 50 feet wide. Turbid water and dusk prohibited actual observation of spawning but the eggs and milt were running freely at the time of capture. The water temperature was 68° F.

Intraspecific variation.—The few specimens available from the Tar (5) and the Neuse (3) are noted to differ from specimens taken in the Roanoke and James River systems. They have a lower average lateral-line scale count (see table 1) and are more boldly marked with dark. In adults the dark blotches along the sides extend below the lowermost dark band and the lower cheek and head in general are blotched and mottled with dark. Also, the tip of the anal fin is consistently black, a feature not noted in specimens from the Roanoke and James River systems. The single specimen available from the Chowan River system is similar to the Roanoke material. While other differences have not been noted, time was not available for a detailed study, and study of additional specimens may indicate a difference in the circumferential scale count. When a line of separation is drawn between 41 and 42 lateral line scales it permits an average separation of 82 per cent of the specimens taken in the Tar and Neuse from those captured in the Roanoke and James. However, the level of differentiation is interpreted here as no greater than that of a race, at least until further studies are made.

Relationships and comparisons.—*M. rupiscartes* appears to be the closest relative of *cervinum*. Although the ranges of the two species do not overlap, the two are so different that there can be no question as to their specific differentiation. The salient differences are given in table 5. Jordan and Evermann (1896a: 191) mentioned that *Moxostoma pidiense* (Cope) "resembles *M. cervinum*, but the mouth entirely different." As has been noted above, *M. pidiense* is a synonym of *Minytrema melanops* (Rafinesque). *M. cervinum* superficially resembles *Thoburnia rhothoeca* and has been compared with that form by Raney and Lachner (1946: 219). *M. cervinum* resembles *M. ariommum* only in a superficial way; the salient differences are noted in the account of *ariommum*. *M. robustum*, which does not share the range of *M. cervinum*, can easily be separated by the absence of pigmentation on the fins and by its generally heavier body and shorter, deeper head.

Distribution and ecology.—*Moxostoma cervinum* is now known from the James, Roanoke (including its large tributary, the Chowan River, where apparently it is rare), Tar, and Neuse River systems. It is abundant in the upper Piedmont and mountains of the Roanoke River system but does not seem to be especially common elsewhere within its range. Raney (1950: 159) indicated that *cervinum* was not to be found in the James River. This statement was based on lack of specimens, especially since Cope's specimens (designated as cotypes by Fowler) ANSP 6928-46, which were undoubtedly taken in the headwaters of the James River system, had proved on exami-

nation to be *Thoburnia rhothoeca*. Hubbs (1930: 43) also has noted that one of Jordan's specimens, now in the Museum of Comparative Zoology, which was recorded as *M. cervinum* from Buffalo Creek in the James River system near Lexington, Va., is a specimen of *Thoburnia rhothoeca*. However, three collections of *cervinum* have been made recently in the upper James River system in Johns Creek at Newcastle, Craig County, Virginia. The habitat here was a moderately swift riffle with cold water. Also of interest was the discovery of *Noturus gilberti* and *Hybopsis* sp. at the same locality. The presence of the former, which is known otherwise only from the upper Roanoke River system, indicates rather clearly that these three species have reached the headwaters of the James River through stream capture from tributaries of the Roanoke River. However, *Hybopsis* sp. may have reached the James River by local stream capture from the New River system.

Moxostoma robustum (Cope)

Robust Redhorse

Plates 3 and 4

Ptychostomus robustus.—Cope, 1870: 473-74 (description; comparisons; type locality, Yadkin River).

Myxostoma macrolepidota var. *macrolepidota*.—Jordan, 1878b: 313 (confused in part).

Myxostoma macrolepidota.—Jordan, 1880: 313-314 (confused in part).

Myxostoma macrolepidotum.—Jordan, 1878a: 120-24 (in part, misidentification; *robustum* erringly placed in synonymy of *macrolepidotum*; compiled).

Moxostoma macrolepidotum.—Jordan and Gilbert, 1883: 140. (misidentification, in part, wrongly included in synonymy of *macrolepidotum*).

Moxostoma robustum.—Evermann and Cox, 1896: 309 (erred in including Neuse River in range by reference to Cope, 1870), Jordan and Evermann, 1896a: 242 (Yadkin R; compiled), 1896b: 193 (characters; range; compiled). Smith, 1907: 80 (characters; range; compiled). Fowler, 1913: 57 (redescription of cotypes, counts partly in error). Fowler, 1923: 17 (Yadkin River, compiled). Schrenkeisen, 1938: 93 (name only). Fowler, 1945: 106, figs. 66-67 (type figured; Yadkin River compiled).

Moxostoma cervinum.—Fowler, 1935: 10, Figs. 9 and 10 (in part, misidentification; figures represent *robustum* with lateral line erroneously omitted, specimens reexamined).

This species apparently has been known and recorded only in reference to the type specimens. Two specimens (ANSP 6958 and 6959) from the Yadkin River, N.C., in the collection of the Philadelphia Academy of Natural Sciences are labeled as cotypes of *Ptychostomus robustus* Cope. The larger specimen, an adult 232 mm. standard length in fair condition, agrees well with the original description. The smaller specimen, an adult 222 mm. standard length, is in poor condition and while referable to *robustum* it is somewhat extreme in several of its meristic features. For these reasons, the larger specimen (ANSP 6958) is designated herein as lectotype of *M. robustum*. The following 64 specimens from the Cape Fear (15 spec.), PeeDee (15), Santee (24), Savannah (9), and Altamaha (1) River systems are here identified with this species.

Material examined.—Cape Fear River system, North Carolina, Orange Co.: CU 14079 (3, 64-137) Morgan's Cr., 1 mi. below Chapel Hill. Moore Co.: USNM 162298 (11, 44-59) Crane Cr., about 1.8 mi. NE. Vass on U.S. Hwy. 1. Lee Co.: CU 28347 (1, 57) Rocky R., 10.6 mi. N. Sanford on U.S. Hwy. 15.

PeeDee River system, North Carolina, Davidson Co.: CU 11982 (5, 233-274) trib. of Yadkin R., 10 mi. SE. Lexington; CU 9275 (2, 269-294) trib. Yadkin R., 11 mi. SE. Lexington. Wilkes Co.: CU 25198 (1, 59) Bugaboo Cr., 2 mi. W. Ronda on Hwy. 268; Cu 11492 (1, 50) trib. Yadkin R., 1.2 mi. W. Moravian Falls. Surry Co.: CU 11337 (2, 44-48), trib. Ararat R., 2.5 mi. SE. Mt. Airy. Randolph Co.: UMMZ 147534 (1, 132), Uharie R. at U.S. Hwy. 64, 11.4 mi. W. Ashboro. Cabarrus Co.: CU 19631 (1, 221), Coddle Cr., 4 mi. SW. Concord on Hwy. 29. South Carolina, Kershaw Co.: ANSP 61175-76 (2,107-139), Little Lynchies R., 5 mi. SE. Kershaw.

Santee River system, South Carolina: ANSP 61177 (1, 41), Beaver Dam Cr., 5 mi. from Newberry. Richland Co.: USNM 25610 (1, 72) Columbia, Kershaw Co.: USC 14FW54 (1, 38), Twenty-five Mile Cr., 4 mi. W. Camden; USC 18FW54 (2, 52-58) Grannys Cr., 7.5 mi. NNW. Camden. Grannys Cr. 1.5 mi. NE. Wateree Power Plant: USC 17FW54 (1, 54), USC 5FW54 (9, 49-77), USC 5FW54 (9, 49-77); Sawney's Cr., 1.5 mi. NW. Wateree Power Plant.

Savannah River system, South Carolina, Aiken Co.: USNM 162461 (1, 248) Savannah R., at Demiere's Landing. Pickens Co.: CU 28345 (8, 167-261) Lake Issaquena, N. Clemson.

Altamaha River system, Georgia, Oconee Co.: CU 26581 (1, 74) High Shoals, Apalachee R.

Comparative description.—In table 2, many measurements of *M. robustum* are given in table form and may be compared with *lachneri* and *ariomum*. It is a moderate to large species of *Scartomyzon*. Apparently the largest specimen in existence in collections is one 274 mm. in standard

length. Cope (1870: 473) noted in the original description that the species attained a large size. He examined one 6 pounds in weight in the Yadkin River, the only place where *robustum* was observed by him. The body is robust, as noted and emphasized in the original description by Cope. The dorsal contour is arched up to or almost to the origin of the dorsal fin (plate 3). Posterior to the dorsal origin the contour is either straight or slightly convex to the procurent caudal rays, which are not particularly well developed. The ventral contour is slightly convex between the pectoral and pelvic bases, straight or gently curved beneath the anal-fin base, and gently curved along the caudal peduncle to the lower procurent rays. In cross-section (in front of the dorsal origin) both the dorsal and ventral aspects are curved, while in *congestum* (plate 3), a related species, the ventral aspect is straight. The caudal peduncle is fairly heavy. The body depth when measured at the dorsal origin is much wider than the greatest body width.

The head is short and deep but, contrary to the description by Cope (1870: 473), it is conical rather than truncate in profile. The head is deeper than wide. Viewed from above the snout is bluntly V-shaped, an important characteristic of this species. The occipital line is bowed toward the snout. The head between and behind the eyes and the nape is strongly arched. The moderately large eye is laterally placed and the center of the pupil is located behind the middle of the head.

The lower lips are broadly joined (plate 4), especially in juvenile specimens. They meet in almost a straight line or at a very obtuse angle in adults. The plicae of the lower lips are considerably branched. Occasionally they are broken but they can scarcely be described as semipapillose. The upper lip is definitely wider at its center than at its lateral edges. The gape is a broad arc.

The dorsal-fin origin lies well in front of a point midway between the posterior end of the hypural and the tip of the snout, but the anterior pelvic base is slightly closer to the posterior tip of the hypural than the tip of the snout.

The tip of the pectoral fin is pointed, the fourth ray being longest. The free edge of the pectoral is straight for most of its distance. The pelvic fin is not markedly rounded at the tip, and the free edge is fairly straight or gently rounded. In males the inner rays reach beyond the tips of the outer rays when the fin is depressed; the reverse is true in females. Sexual dimorphism in this character has already been noted in several species of *Scartomyzon*. The anal fin is pointed, and extends to the posterior tip of the hypural plate in females and beyond in males. Rays 3 and 4 are longest. The dorsal fin is moderate in size, almost straight or only slightly concave on its free margin. The dorsal fin is smaller in the male; the first and second dorsal rays are less than or equal to the length of the dorsal base; in the female, their length exceeds that of the dorsal base. The caudal fin is shallowly forked and the notch rounded. The inner surface of the forks are variable, either somewhat rounded or almost straight. The upper caudal lobe is more pointed than the lower.

Frequency distributions of some fin-ray and scale counts are given in table 1. Fin-ray counts: dorsal rays number 12, rarely 11 or 13; anal rays 7; pelvic rays normally 9-9, with 8 or 10 appearing occasionally on one side; caudal rays 18; pectoral rays usually 17, occasionally 16 or 18 and rarely 15; total pectoral rays usually 34 or 35, although ranging from 31 to 36.

There are constantly 16 (7-2-7) scales around the caudal peduncle.

Circumferential scales number 34-36, usually 35, with 14 or 15 in the series above the lateral line and 18 or 19 below. The lateral-line scale count varies from 43 to 49 but is usually 44 to 46. There are 7 scales above the lateral line to the dorsal origin and 6, rarely 5, below the lateral line to the anal origin; the lowermost are small.

The pseudobranchiae which differ from other species of *Scartomyzon* are reduced in size, are in a straight line rather than an arc, and are limited to 5 or 6 short filaments. Gill rakers number 25; the lower 6 are rudimentary. The anterior fontanelle is closed, the posterior fontanelle is well developed and rectangular in shape.

The pharyngeal arch is strongly curved, with a weak lateral shelf, and bears about 60 teeth. The teeth gradually decrease in size from the larger basal teeth to the very small ones near the tip of the arch. The hook on the anterior tip of the teeth is best developed in the smaller teeth.

The tripus of *robustum* (plate 1) is most like that of *congestum*. A comparison of these two forms is given later. Of the other species the tripus of *robustum* most closely approaches that of *ariommmum*. As in *ariommmum*, the fulcrum is directed at a right angle to the axis of the tripus. The position of the fulcrum is slightly anterior to the center of the tripus, a condition intermediate between that of *ariommmum* and *rupiscartes*. The anterior shelf is flattened and projects to both sides. The inner edge is convex; the outer, slightly concave and falcate. The shelf, however, is much more horizontal than that of *ariommmum*. The dorsal surface of the tripus, between the fulcrum and the tip of the anterior process, is only shallowly concave; in *ariommmum* it is U-shaped. The dorsal surface of the anterior shelf is concave. The fulcrum projects directly dorsad as in *ariommmum*. The dorsal edge of the fulcrum is at right angles to the body of the tripus; the lateral two-thirds of the edge is widened to form a long fossa such as is seen in *rupiscartes* and *lachneri*. The dorsal edge is not divided into two processes as in *ariommmum*.

The pleural ribs and the transverse plate are much more vertical in *robustum* than in *rupiscartes*. These ribs are moderately rounded at their tips and bend only slightly caudad. When viewed from in front, the inner edges of the pleural ribs and the transverse plate are nearly at right angles to each other, although the junctions are rounded. The space between the second and fourth pleural ribs is the same as described above for *rupiscartes*.

The tripus of *congestum* is so similar to that of *robustum* that only the differences in details of configuration need be discussed. The anterior shelf reaches its extreme development in this form; it projects to either side and

is the conspicuous feature of the dorsal surface of the tripus. The inner edge is convex; the outer is convex posteriorly and concave anteriorly. In cross-section the shelf is deeply V-shaped, because of a central trough—a diagnostic feature. The vertically placed fulcrum differs from that of *robustum* only in the extent of its dorsal ridge. The dorsal edge of the fulcrum is developed only medially in *congestum*, whereas it is fully developed in *robustum*. The large fossa is lateral in position.

The shape and size of the pleural ribs of *congestum* are the same as those in *robustum*. More detailed study may reveal differences, but the similarity is so striking as to confirm the closeness of relationship between these two forms.

Surprisingly, the tripus of *M. austrinum* (UMMZ 161693) is different from that of *M. congestum*, and seems intermediate between the type of *robustum* and *congestum* on the one hand and of *M. rupiscartes* and *M. lachneri* on the other. The fulcrum is vertically placed on the body and is at right angles with the axis of the tripus. The anterior shelf has its dorsal surface flat or slightly convex, certainly not V-shaped as in *congestum*. The shelf slopes gently from the fulcrum to the base of the anterior process. Its surface is highest and projects most on its inner edge, while it is lowest and projects little on its outer edge.

The pleural ribs and transverse plate are similar to those of *robustum* and *congestum*. The specimen examined differs in having the second and fourth pleural ribs only weakly joined.

Coloration.—In preservation, the body of *robustum* has light and dark lateral streaks which are much more prominently developed in the juveniles than in adults. The body is not bicolored; the dark of the upper side fades to the light of the lower side near the second or third scale above the pectoral and pelvic base. In the adult, each scale on the sides of the body has a vertical dark bar at its base and a broad light apical border—both of these tend to break up the light horizontal streaks.

On the back, before the dorsal fin, the dark streaks remain prominent in large adults. The streaks are absent from the ventum of *robustum* but are present on the related *congestum*, a feature which readily serves to distinguish the two species. In the small juvenile specimens, the light streaks on the side are much wider than the dark stripes, but both are pronounced; in addition, these specimens have indications of four blotches along the mid-side and four saddles across the back. In general, the lips, the underside of the head, and the undersides of the lower fins and ventrum are white. The top of the head is lighter than the back immediately behind the head. The lower half of the cheek is white. The opercle is dark, although a central light area may be present on the lower part. The dark occipital bar is rather diffuse. Its extension on the shoulder girdle is variable; it is developed in some adults, but is never a prominent feature.

The dorsal-fin membranes are dark in contrast to the light rays. The

mid-caudal membranes are also distinctly dark; the other caudal membranes have some dark pigment at the extreme dorsal and ventral base of the fin, but appear light in contrast to the rays. The anal fin is light-colored. Melanophores are scattered on the rays of the anterior half of the pectoral and pelvic fins, although the latter may be almost white.

Specimens of both sexes taken on March 22 in the Yadkin River in life were brownish with a golden cast along the sides. With the exception of the dorsal, all fins were orange. The anal fin was somewhat less colored than the pectoral and pelvic fins, and the caudal fin more intensely colored on the lower lobe than in the center. Cope (1870: 473) noted that the dorsal, caudal, and anal fins were dark crimson and that the color in general was smoky or clouded above, mingled with golden reflections and yellowish below. Juvenile specimens from 49 to 58 mm. from the Santee River system observed in formalin shortly after they were collected had red orange upper lip, and orange caudal, dorsal, and pectoral fins. The peritoneum is silvery below and dusky above, and is darkish near the large coil of the intestine.

Sexual dimorphism and nuptial tubercles.—The description of sexual differences in the fins has been noted above. Males with nuptial tubercles were taken on March 22 and April 5 in the Yadkin River system. Minute tubercles are scattered over the top and upper sides of the head and on the scales of the nape. On the scales, before and immediately behind the dorsal fin, small tubercles are best developed on the posterior scale margin. Tubercles are scattered on the body scales from a point before the anal fin up to and including the sides of the caudal peduncle. The skin of the lower and under side of the caudal peduncle is thickened. On the under side of the caudal peduncle the tubercles are fairly large, are well developed, and are continuous with the fairly large tubercles which line the rays of the lower lobe of the caudal fin. A few somewhat smaller tubercles are scattered over the remainder of the caudal fin. Those on the rays of the anal fin are well developed; they begin near the base and extend to near the tip of at least some of the rays. Although the tubercles about two-thirds of the distance from the anal-fin base are best developed, there is no great disparity in size such as was noted for *rupiscartes*. On the pelvic fin, rows of tubercles are found on the second, third, and, to a lesser degree, on the fourth ray. Small tubercles are also found on the rays of the anterior two-thirds of the pectoral fin. None were observed on the dorsal fin. A large female taken in the Yadkin River system on March 22 had small but well developed breeding tubercles on the second, third, and fourth anal rays, but none were noted elsewhere.

Intraspecific variation.—Too few specimens are available to investigate intraspecific variation. It is noted that Savannah River specimens have the dark lateral streaks extending further downward on the lower side than do more northerly specimens.

Relationships and comparisons.—*M. robustum* is most closely related to the southwestern species *congestum*, although their ranges, on the basis of specimens now available, seem to be separated by a wide gap; *congestum* is not known east of Texas. These two species differ mostly in body shape and coloration. The most pertinent differences have been shown in the table of comparisons (table 7). While *robustum* may be separated from *congestum* by the different dorsal profile, this difference is hard to describe. *M. congestum* is deep and foreshortened before the dorsal fin; the dorsal contour of *robustum* is a gentle curve. Beneath the base of the dorsal fin, *congestum* is much deeper. The angle is pronounced in *congestum* and the contour from the dorsal origin to the upper procurent caudal ray is gently concave.

M. robustum, which shares part of the range of *rupiscartes*, differs in many characters, as shown in table 6. *M. papillosum* and *collapsum* occur through most, if not all, of the range of *robustum*. They are most easily separated from *robustum* by the deeply V-shaped cleft at the meeting of the lower lips; they also have 12 (5-2-5) caudal-peduncle scales.

M. duquesnei from the Alabama River system superficially resembles *robustum* and represents an example of convergence. *M. duquesnei* has light and dark streaks along the side and otherwise resembles *robustum* but differs fundamentally in having the caudal-peduncle scale count of the subgenus *Moxostoma*. However, there is some variation in this count in *duquesnei* which usually has 12 (5-2-5), rarely varying to 14. The deeply forked tail and the differently shaped pectoral also separate it from *robustum*.

Distribution and ecology.—Cope noted this species only in the Yadkin River but the authors have examined specimens from the Yadkin, Cape Fear, Santee, Savannah, and Altamaha River systems. Most of these specimens were taken in moderate-sized streams, but in the Savannah River system this species is known to occur in lakes of at least 100 acres in area. Cope (1870: 473) mentions that it was highly valued for the table by people living near the Yadkin River.

***Moxostoma ariommmum*, sp. nov.**

Bigeye Jumprock

Plate 5

Material examined.—All 19 specimens were taken in the Roanoke River, Virginia. The holotype, USNM 162007, an adult male 142 mm. in standard length, was collected on September 5, 1947, in the Roanoke River, 2.5 miles southwest of Shawsville, Montgomery Co., by Ernest A. Lachner and P. S. Handwerk. Paratypes: USNM 165593 (1, 61) taken with the holotype. Roanoke Co.: CU 22850 (an adult male, 139) and CU 24712 (one young, 24), Roanoke R. at Glenvar, June 25, 1952, Raney, Ross, and Woolcott. CU 22851 (one young, 29 and a subadult female, 84), Roanoke R., 2.4 mi. S. Elliston on U. S. Hwy. 11, July 9, 1952, Raney, Ross, and Woolcott. UMMZ

95335 (juvenile female, 81), Roanoke R., May 16, 1931, C. L. Hubbs and E. Creaser. Montgomery Co.: CU 20725 (adult male, 134), North Fork Roanoke R., 2.2 mi. W. Lafayette, June 9, 1951, Raney, Robins. CU 20341 (adult female, 125), North Fork Roanoke R. at Bennetts Mills, June 7, 1951, Raney, Robins. Patrick Co. line: CU 25413 (10 young, 39-50), South R. between Fairystone Park and Ferrum on Va. Hwy. 623, Aug. 14, 1951, R. G. Martin.

Diagnosis.—An extremely specialized species of subgenus *Scartomyzon*. Small in size; to 142 mm. Caudal-peduncle scale rows 16 (7-2-7). Dorsal rays 11, rarely 10 or 12. Pharyngeal arch weak, strongly curved, and with a well developed shelf. Basal teeth with a weak hook on anterior tip. Lateral-line scales 44 to 46, rarely 47. Pectoral and pelvic fins rounded on posterior edges. The only *Moxostoma* with a concavity between the eyes. Eye large and supralateral in position; larger than least postorbital distance. Anterior margin of eye reaches a vertical from hind margin of lip. Head wider than deep. Occipital line straight or convex as viewed from the rear (concave in other *Moxostoma*). Free edge of dorsal fin slightly concave to straight, the posterior rays of the dorsal very long. Body terete; the width of body nearly equals body depth. Dorsum from posterior head to dorsal-fin origin flattened. Snout rounded in side view. Head U-shaped as viewed from above. Lips papillose, each with an inner cartilaginous shelf. Body sharply bicolored. Caudal fin dusky; rays dark throughout, membranes dark distally. Prominent dark occipital bar but extension on shoulder girdle not developed to pectoral base.

Description.—Fin-ray counts and lateral-line scale counts are given in table 1 and proportional measurements in table 2. The description which follows is based on the holotype and the 18 paratypes as listed above. *M. ariommum* is an elongate subterete species with the body flattened in front and compressed behind. From the tip of the snout the dorsal contour rises only slightly to a point just behind the eyes where the dorsum becomes flattened and continues so almost to the origin of the dorsal fin (plate 5). There is only a slight slope downward under the dorsal-fin base. Posteriorly the dorsum is straight to the procurrent rays of the caudal fin which are moderately developed. The ventral outline is virtually straight and parallel to the dorsal outline, at least as far as the origin of the anal fin. Here it slopes upward rather steeply beneath the anal base and levels out again on the ventral side of the caudal peduncle to join the rather weakly developed procurrent rays. This species is most extreme among *Moxostoma* in having the dorsal and ventral contours virtually parallel, at least to the anal origin. From the dorsal origin to the occiput the body is very wide; posterior to this it forms a wedge. It is extreme among *Moxostoma* in having the body width only slightly less than the greatest body depth, which is approximately at the origin of the dorsal fin. Also unique among *Moxostoma* is the deep and

narrow caudal peduncle which is illustrated in plate 5. The lateral line is almost straight and lies anteriorly in the fourth row of scales above the pectoral base.

The head is subquadrate in shape and is wider than deep. The dark occipital line is straight, or, when viewed from the posterior aspect, slightly convex; in all other known species of the genus the line is concave or bowed toward the snout (plate 5). The center of the pupil of the eye is well behind the midpoint of the head. The eye is extremely large and located posteriorly on the head; this is the only species of *Moxostoma* in which the length of the eye exceeds the postorbital length of head. The eye is supralateral in position and is entirely visible from a dorsal view. The forward edge of the eye reaches a vertical from the posterior lower lip, a feature unique among *Scartomyzon*. The snout is rounded in side view and is almost U-shaped as seen from above. The head is subquadrate. It is the only species of *Moxostoma* with a concavity between the eyes. The head is flattened just posterior to the hind margin of the eye. The mouth when open is almost circular; when closed it is subtriangular in over-all view.

The lips are flattened and the upper lip is folded inward (plate 5). The outer surface of the upper lip is smooth with a fringed edge. The inner surface of upper lip when mouth is open is almost circular and looks much like that of a sea lamprey, *Petromyzon marinus*. The well defined papillae are ranged in circles and those immediately in front and behind the oral opening are somewhat coarser than the rest. When the mouth is open, one may observe immediately before and behind the central oral opening, a small flap of skin which represents the oral breathing valve. The lower lip is deeply split, and the two halves meet at a very obtuse angle. In the lip structure, this species is unique in the genus as well as among other known Catostomidae, and indeed, would seem almost worthy of generic recognition. The mouth and lip structure is only superficially similar to that of other members of the genus, such as *M. pappillosum*, which has papillae on the lower lip.

The lateral line on the head is much more easily observed in this species than in other *Moxostoma*. The pores seem to be somewhat larger and the canals are swollen and perhaps more superficial in position.

The origin of the dorsal fin lies far in front; the anterior base of the pelvic fin lies somewhat behind a point midway between the snout tip and posterior end of the hypural. The pectoral fin is relatively short and rounded, the fourth and fifth rays being about equal and longer than the other rays. The pelvic fin is rounded on the outer margin but is fairly sharp on the posterior margin; this feature is exaggerated in the males. Compared with other members of the genus the dorsal fin is small. However, the height of the dorsal is longer than the base. It is unique in having the posterior three or four rays of the dorsal quite elongate. The free edge of the dorsal is either straight or only slightly falcate. The anal fin in the male is pointed and the posterior end reaches far beyond the rear end of the hypural; the third and

fourth rays are longest. In the female the anal fin is similarly shaped but is somewhat shorter, not reaching the posterior end of the hypural. The caudal fin is relatively short and is not deeply forked; the upper lobe is somewhat pointed and is longer than the lower; the lower lobe is rounded. The inner surfaces of the fork are convex rather than straight and the notch is only moderately rounded.

Fin-ray counts of the holotype are as follows: dorsal 11, anal 7, pectorals 15-15, pelvics 9-9, caudal 18. Counts for the paratypes are given in table 1.

The scales are small, as in other *Scartomyzon*, and are well imbricated, with the free edge rounded. Scale counts on the holotype are: lateral-line scales 44, scales around caudal peduncle 16 (7-2-7), scales above lateral line to dorsal origin 7, the uppermost small; scales below lateral line to anal origin 5, the lowermost small; scale rows before dorsal fin 14; circumferential scales 33 (14-2-17). In paratypes the scales in the circumferential series above the lateral line are normally 14, while those below the lateral line vary from 16 to 18.

The pseudobranchiae are well developed and exposed. The gill rakers on the first arch number 19; the lower 6 are rudiments. The gill rakers are moderately long near the middle of the arch and each is lined with tubercles on its inner surface.

The anterior fontanelle is closed, the posterior fontanelle is developed and rectangular. The pharyngeal arch is weak, strongly curved, and has a well developed lateral shelf. There are approximately 50 teeth. The distal hooks on the anterior border of the basal teeth are well developed in this species, perhaps more so than in any other member of the subgenus.

The tripus of *M. ariommmum* is very different from that of *rupiscartes* or *lachneri* (plate 1). The entire structure is shortened and heavy. The posterior process is short although still slightly upturned at its tip. The median fulcrum is almost centrally located rather than far in advance of that point. The anterior process, while not so sharply upturned, does reach a level with the base of the fulcrum. The greatest and most basic difference between *ariommmum* and *rupiscartes* are seen in the structure of the fulcrum and the anterior shelf. The plane of the fulcrum is nearly at right angles to the longitudinal axis of the tripus. A blunt process projects dorsally from the median edge of the fulcrum. A second and wider process, which bears a fossa, projects dorsally from the middle of the fulcrum. The two dorsal projections are separated by a rounded notch. This type of fulcrum is not seen in any other *Scartomyzon*. The anterior shelf is almost vertical, flattened, and not tilted laterally. In dorsal view it is asymmetrical; the lateral edge is convex and the median edge is concave.

The pleural ribs are short but strongly developed and sharply pointed distally. They diverge greatly toward their tips. The inner edges of the pleural ribs and the ventral edge of the transverse plate are broadly rounded at their junction so that the entire lower surface, excluding the esophageal supports, is smoothly concave rather than trapezoidal. This condition is

somewhat similar to that in *rupiscartes*. The esophageal supports are short, strongly compressed, and truncate distally. The pleural ribs, when seen in lateral view, curve caudally toward their tip. The space enclosed by the united second and fourth pleural ribs is triangular, large, and opens laterally. The general appearance and small size of the pleural ribs and the transverse plate seem very similar to those of *Thoburnia rathoeca* examined by the authors. The central placement of the fulcrum and the configuration of the anterior shelf on the tripus of *ariommum* again strongly suggest *Thoburnia*. There is no suggestion in *Thoburnia*, however, of two processes on the fulcrum; these features apparently are unique to *M. ariommum*.

Coloration.—The coloration in preservative is sharply bicolored. The dark of the upper side extends only slightly below the first row of scales beneath the lateral line. The light and dark horizontal stripes on the upper side are better developed in fresh than in preserved specimens, but probably less so than in any other *Scartomyzon*. A young specimen, 24 mm. in standard length, has a definite dark stripe along the mid-side which is occasionally partly interrupted, while young specimens 39 to 50 mm. in length lack a definite dark lateral stripe and are blotched along the side instead. The scales are generally darkish with a faint light border on the extreme edge. The undersides of the head and body are light.

It was noted that adults of *ariommum* observed in life were sharply bicolored, with a greenish cast above and an iridescent greenish streak on the opercle, which extended posteriorly on the upper side. The horizontal stripes on the body were faint and the lower sides of the body were whitish. The pectoral fins were light red-orange. The pelvic, anal, and caudal fins are much lighter in color than the pectoral, but had some orange.

The top and upper side of the head is dusky but is definitely lighter than the body behind the occiput. The occiput is marked by a prominent dark bar, which reaches normally only to the upper edge of the opercle and is weak, if present at all, on the shoulder girdle. The lower cheek, opercle, and snout are light; sometimes the anterior snout is dusky.

The leading edges of all fins are white. The upper surface of the pectoral-fin rays is dusky, particularly on the outer four or five rays. The upper surface of the outer pelvic rays are outlined in black. The second, third, and fourth rays of the anal fin are dusky, giving the impression of an interrupted dark band on this fin. The caudal fin is dusky; the rays are dusky throughout their length and the membranes are light on the basal half only. The small dark dashes at the scaly base of the caudal fin are diagnostic. The basal two-thirds of the dorsal membranes are white; the rays are dusky; the most obvious feature is the darkened free edge of the fin, but it is less dark posteriorly. There is a well developed groove behind the dorsal fin into which the hindmost ray of the dorsal fits rather snugly. This groove is present in the smallest young available for these studies and does not seem to be dependent upon preservation; it should be investigated further on fresh

specimens. The peritoneum is silvery throughout and is marked occasionally with melanophores which become somewhat more abundant dorsally. The inner surface of the opercle has relatively few melanophores.

Sexual dimorphism and nuptial tubercles.—The urinogenital papilla is subconical in the female; in the male it is a short subcylindrical structure with a serrate posterior border. There does not seem to be any difference in the length of the anal fin in the sexes. However, the inner rays of the pelvic fin of the male are longer and form a sharper angle posteriorly.

Although none of the specimens available for these studies seems to be in or near breeding condition, the holotype, a male taken September 5, has small nuptial tubercles on the outer rays of the anal fin.

Relationships and comparisons.—The flat nape and occiput, the concavity between the eyes, the very large eye, and the remarkable structure of the lips, are all features diagnostic for *M. ariommum*. Each would suffice to distinguish it from all other species of *Moxostoma*. Together, they impart to the species a distinctiveness among the forms of Catostomidae.

M. papillosum, which occurs with *ariommum* in the Roanoke River, also has papillose lips, but the basic structure of the lips is much different (plate 5). The lips in *papillosum* are heavy and rounded while those of *ariommum* are much flattened with the upper lip folded inward. The two species are not closely related. *M. papillosum* has 12 (5-2-5) caudal-peduncle scales, as well as other features of the subgenus *Moxostoma*. *M. ariommum* shares the following features with other species of *Scartomyzon*: a caudal-peduncle scale count of 16 (7-2-7), a small dorsal fin, and a low dorsal-ray count (usually 11 rays).

Its relationships within the subgenus are not clear. Of the included species *cervinum* is geographically closest and occurs with *ariommum* in the Roanoke River. *M. rupiscartes* reaches its northern limit in the PeeDee River system while the range of *robustum* extends northward to the Cape Fear River system. The general physiognomy of *robustum* is entirely different from *ariommum*. Of the above-mentioned species, *rupiscartes* appears most similar to *M. ariommum* superficially. However, closeness of relationship is not suggested between either *rupiscartes* or *cervinum* and *ariommum* in those features listed in the description as unique for *ariommum*.

It is interesting to note the following features of *Thoburnia rathoeca* and *T. hamiltoni*: (1) the occiput is straight, (2) the caudal-peduncle scale count is 16 (7-2-7), (3) the caudal fin is small with a shallow fork and rounded lobes, (4) the posterior rays of the dorsal fin are relatively long, and (5) the dorsal fin is small, 10 or 11 rays. Of these, 1 and 4 are also features of *ariommum* while 2, 3, and 5 are generally characteristic of all *Scartomyzon*.

The well developed three-chambered air bladder of *ariommum* clearly places it in *Moxostoma*, however. It is concluded that *ariommum* represents a somewhat intermediate stage between the *Scartomyzon* section of *Moxo-*

stoma and *Thoburnia*. Apparently it is a long established species that has no very close relationship to other living *Scartomyzon*. The large eye, the specialized and peculiar lip, and the concavity between the eyes (the last perhaps effected by the enlargement of the eyes) may best be thought of as specialized features rather than primitive ones. The above evidence convinces us that *Moxostoma* and *Thoburnia* should be placed together in the tribe Moxostomini.

Distribution and ecology.—*M. ariommum* is apparently limited to the upper Roanoke River system including both main branches. Ecologically, it has been found only in rapids, and apparently is adapted to life in swift waters. It may be limited mostly to the main rivers since exhaustive collecting in the small headwater streams of the upper Roanoke River system over more than a 10-year period has failed to reveal a single specimen. A specimen of *M. ariommum* was taken in a riffle in the Roanoke River, two and a half miles south of Elliston, Roanoke County, Virginia, along with *Thoburnia hamiltoni*, *Moxostoma cervinum*, *Hypentelium roanokense*, and *H. nigricans*. Also collected within several hundred yards of the riffle in which the above were captured, were *Moxostoma pappilosum*, *M. erythrurum*, *M. collapsum*, and *Catostomus c. commersoni*, as well as 21 other species of freshwater fishes characteristic of the upper Roanoke River.

The discovery of *M. ariommum* adds yet another species to the Roanoke River fauna already known for its endemic or relict forms. It may be noted in this connection that *Hypentelium roanokense* and *Thoburnia hamiltoni* are small montane forms limited to the same river system.

The name is derived from two Greek words, *ari*, a strengthening prefix, *omma*, a noun meaning eye, and *-um*, the neuter form of the adjectival suffix.

Summary

Extensive collecting in the southeastern United States over the past 15 years and a study of museum material have permitted a reevaluation of the genus *Moxostoma*. Three subgenera, *Megapharynx* Legendre, *Scartomyzon* Fowler, and *Moxostoma* Rafinesque, are recognized.

The present paper considers only the species of *Scartomyzon*. Two new species, *M. ariommum* and *M. lachneri*, are described.

Three natural groupings of species are recognized within the subgenus. The first includes only *M. ariommum*, a striking form which exhibits a combination of primitive and specialized structures. It is confined to the Roanoke River system, but most likely represents a relict population of a type formerly more widespread. The genus *Thoburnia* shares many structures with *M. ariommum*, and it is with this species that the close relationship of *Thoburnia* and *Moxostoma* may best be seen. *Thoburnia* is assigned to tribe Moxostomini.

The second group includes *M. rupiscartes*, *lachneri*, and *cervinum*. Here *rupiscartes* and *lachneri* seem to have diverged most recently. *M. cervinum* probably has long since diverged from the *rupiscartes* type since the two forms are very different. A brief treatment of the infraspecific variation in *rupiscartes* is given. *Ptychostomus pidiensis* Cope is relegated to the synonymy of *Minytrema melanops* (Rafinesque).

The third group includes at least three very similar, but geographically widely separated, species. *M. robustum* occurs on the Atlantic slope from the Cape Fear to the Savannah River systems; *M. congestum* (including *M. albidum*) occurs in Texas and northeastern Mexico. *M. austrinum*, a little known species, occurs on the Pacific slope of Mexico. The *robustum* group morphologically represents the closest approach of *Scartomyzon* to *Moxostoma*.

Important taxonomic features are found in the detailed configuration of the Weberian apparatus, particularly in that of the tripus. These features confirm and strengthen the relationships suggested by the external morphology.

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Table 1. Distributions of fin-ray and lateral-line scale counts in five species of *Moxostoma*

Species		<i>ariommum</i>	<i>lachneri</i>	<i>robustum</i>	<i>rupiscartes</i>				<i>cervinum</i>	
River system..		Roanoke	Apalachi- cola	Cape Fear, Peedee, Santee, Savannah	Chatta- hoochee	Alta- maha	Savan- nah	Santee	Tar and Neuse	Roanoke and Chowan
Dorsal rays	10	2	..	..	1	13	23	14	..	4
	11	15	4	3	6	9	39	95	3	39
	12	2	28	33	..	..	..	5	..	5
	13	..	2	4	..	..	..	..	..	..
Pelvic rays	8	4	5	6	1	..	1	7	..	3
	9	29	33	65	13	36	25	44	6	21
	10	4	..	2	..	2	..	1	..	..
	13	..	..	..	..	..	..	..	..	2
Pectoral rays	14	..	..	..	..	..	..	..	..	13
	15	..	..	2	2	14	24	2	4	40
	16	1	5	10	9	15	45	26	2	10
	17	2	29	53	3	7	14	59	..	..
	18	13	5	15	..	..	..	12	..	..
	19	1	1	..	..	..	..	1	..	..
20	1	..	..	..	..	..	..	..	..
Lateral- line scales	39	..	..	..	..	..	..	..	2	..
	40	..	..	..	..	..	..	..	5	1
	41	..	..	..	..	..	..	..	3	3
	42	..	..	..	..	..	..	..	3	10
	43	..	..	3	1	2	..	..	..	10
	44	9	1	7	2	..	..	..	..	6
	45	5	10	12	1	4	10	1	..	..
	46	2	6	11	2	2	10	5	..	..
	47	1	1	3	..	..	15	9	..	..
	48	..	..	2	..	..	9	12	..	..
	49	..	..	1	..	..	1	5	..	..
50	..	..	..	..	..	..	2	..	..

Table 2. Measurements of *Moxostoma* in thousandths of standard length (Range is included within parentheses, followed by mean which includes holotype in new species)

Species.....	<i>lachneri</i>		<i>robustum</i>		<i>ariommum</i>	
	Holotype	Paratypes	Holotype	Paratypes	Holotype	Paratypes
No. of species.....		9		12		6
Standard length in mm.....	152	(97-194) 135	(107-294) 223		142	(61-142) 109
Head length.....	231	(225-245) 235	(223-245) 231		249	(231-249) 243
depth ⁽¹⁾ *.....	131	(127-146) 136	(137-157) 147		133	(119-135) 126
depth ⁽²⁾ *.....	158	(148-167) 159	(163-185) 172		155	(129-156) 146
width*.....	109	(106-125) 115	(111-134) 119		135	(117-138) 128
Body depth*.....	226	(201-227) 215	(225-260) 238		202	(184-210) 197
width*.....	163	(145-165) 156	(155-203) 171		178	(140-182) 160
Snout length.....	107	(99-115) 108	(102-117) 108		123	(106-123) 112
Occipital head length.....	196	(188-213) 199	(178-212) 201		213	(213-221) 216
Eye length.....	45	(39-54) 47	(36-56) 43		70	(63-70) 67
Postorbital head length*.....	68	(64-81) 71	(65-74) 71		49	(49-62) 55
Gape width.....	55	(51-71) 59	(52-65) 57		93	(73-98) 88
Caudal peduncle least depth...	97	(88-97) 93	(100-110) 104		111	(100-111) 107
Dorsal height.....	201	(185-208) 200	(163-220) 190		197	(197-234) 215
Anal height.....	209	(183-213) 197	(204-252) 219		255	(203-263) 231

* See explanation under *Methods* (p. 4); measurements not indicated by asterisks were made following Hubbs and Lagler (1947).

Table 3. Comparison of *Moxostoma lachneri* and *M. rupiscartes* from the Apalachicola River System
(Fin-ray count is modal count)

Character	<i>lachneri</i>	<i>rupiscartes</i>
Dorsal rays	12	11
Pectoral rays	17	16*
Eye into mouth width†	1.5 times	2+ times
Plicae of lower lip	Unbranched	Branched posteriorly
Dorsal-fin height	Greater than occipital head length	Less than occipital head length
Head: depth measured at occiput compared with greatest width	Deeper than wide	Wider than deep
Caudal-fin lobes	Pointed, with straight borders along notch	Rounded
Longest caudal ray	Longer than head	Shorter than head
Lowermost caudal ray	White	Dusky
Caudal-peduncle depth into height of dorsal fin	More than 2 times	Less than 2 times

* *M. rupiscartes* has 17 pectoral rays in the Santee River System.

† Greatest transverse distance between outer lips.

Table 4. Comparison of *Moxostoma lachneri* and *M. poecilurum*

Character	<i>lachneri</i>	<i>poecilurum</i>
Scales around caudal peduncle	16 (7-2-7)	12 (5-2-5)
Lateral-line scales	44-47, usually 45 or 46	40-43, usually 41 or 42
Coloration of caudal fin	Lowermost ray white, with scattered melanophores; rest of fin dusky, the upper and lower lobes colored alike	Lower 2 rays milky white; next 5 rays on lower lobe black; upper lobe light to dusky with dark at tip in adult
Dorsal edge of caudal fin	Black throughout	White except near base
Outer two-thirds of leading edge of dorsal fin	Black	White
Anal fin	Rounded	Pointed
Posterior tip of anal fin	Not reaching posterior edge of hypural	Extends beyond posterior edge of hypural
Pectoral	Rounded at tip, rays 4 and 5 are longest	Pointed, rays 2 and 3 longest
Dorsal-fin height into predorsal length	More than 2.5 times	Less than 2.5 times
Caudal-fin notch	Rounded, shallow	Angular, deep
Distance from posterior hypural to mid-caudal notch	Less than distance from notch to tip of longest caudal lobe	Greater than distance from notch to tip of longest lobe
Basal margin of predorsal scales	With large dark subtriangular marks	Lacks dark basally but has a narrow dark line present at apical edge of scale
Dark oblique bar on shoulder girdle	Interrupted at about level of the lateral line; not expanded above pectoral-fin base	Continuous and expanded to a dark blotch above pectoral-fin base

Table 5. Comparison of the characters of *Moxostoma cervinum* and *Moxostoma rupiscartes*, based upon specimens taken throughout the range of the former and from the Santee River System for the latter

Character	<i>cervinum</i>	<i>rupiscartes</i>
Lateral-line scales	39-44, usually 42 or fewer in the Neuse and Tar rivers	45-50, usually 46-49
Scales above lateral line (typically)	6	7
Scale rows below lateral line (typically)	4 or 5	6
Size of scale in middle of lateral line	Larger than eye	Smaller than eye
Pectoral rays	13-16, modally 15	15-19, usually 16-18
Total pectoral rays	27-32, usually 30	31-37, usually 34
Caudal-fin lobes	Tipped with black	No darker than rest of fin
Tip of dorsal fin	Black	Light, or, if dark, the entire edge of fin is dark
Color pattern on side of body	Sharply bicolored	Dark of dorsum and upper side blends gradually into the light of the lower side
Insertion of pelvic fin	Closer to posterior tip of hypural than to tip of snout	Closer to tip of snout than posterior hypural tip or midway between
Lower lip	Plicate, ridges large and seldom branched	Semipapillose, ridges smaller and divided several times posteriorly
Gape	Narrow, semicircular arc reaching far back laterally	A broad arc

Table 6. Comparison of *Moxostoma rupiscartes* and *M. robustum*

Character	<i>rupiscartes</i>	<i>robustum</i>
Dorsal rays	10 or 11, rarely 12	12, rarely 11 or 13
Body shape	Semi-terete, elongate	Robust
Dorsal profile	Low, only slightly arched before dorsal fin	High, arched before and behind dorsal fin
Preanal profile	Straight	Curved
Body depth:		
Into standard length	Less than head length	Greater than head length
Into standard length	More than 4.5 times	Less than 4.5 times
Head in adults	Long and less deep; wider than deep; subquadrate in shape	Short and deep, deeper than wide; conical in shape
Position of eye	Supralateral	Lateral
Head between eyes	Flattened or slightly convex	Strongly convex
Cross section of nape	Little arched above	Strongly arched above
Hind margin of lower lips	Form an obtuse angle	Straight (180°) in young; slightly emarginate in adults
Dorsal-fin color	Light basally	Dusky throughout; especially dark on membranes
Median interradial membranes of caudal fin	Light	Dark
Caudal fin: color of young in life	Yellow	Red
Lateral body stripes in young	Dark stripes wider	White stripes wider

Table 7. Comparison of *Moxostoma robustum* and *M. congestum*

Character	<i>robustum</i>	<i>congestum</i>
Lateral light and dark stripes on ventrum	Absent	Present
Light stripes on body	Interrupted by dark vertical bars at base of scales	Not interrupted
Lower half of opercle	Dark, at least in part; dark often encircles a light median area	Light
Anal fin, membranes	Light	Dark
Caudal fin, membranes	Dark centrally, contrasting with light directly above and below	Dark
Pelvic insertion	Nearer origin of anal fin than of the pectoral insertion	Nearer pectoral insertion than origin of anal fin
Preoperculomandibular canal	Connected to infraorbital canal on both sides of head	Not connected to infraorbital canal on both sides of head; usually ends below the level of the eye
Total pectoral rays	Usually 34 or more	Usually 33 or fewer
Ventral body contour	Gently convex to anal origin	Straight to anal fin origin

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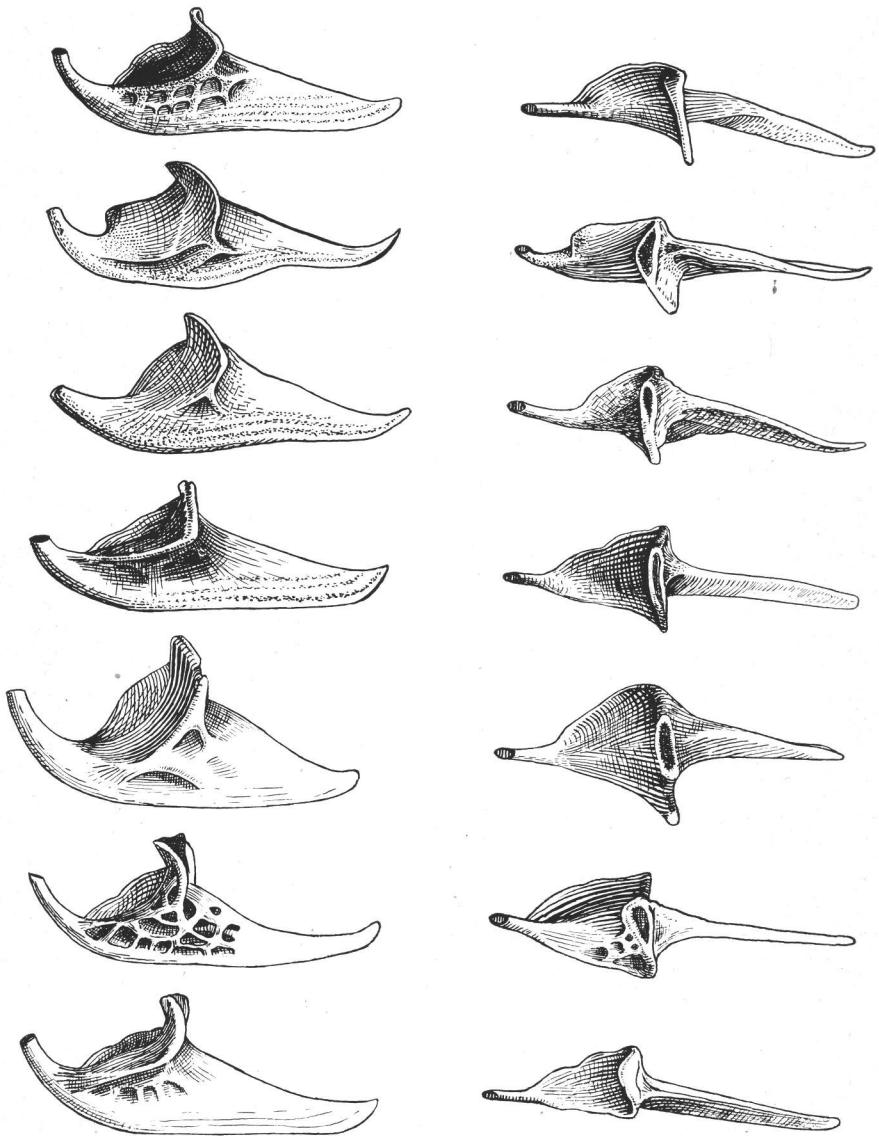


Plate I. Variation in shape of right tripus in 7 species of *Moxostoma*. Anterior end is to the left. Left column: lateral view; right column: dorsal view. Top to bottom (catalogue number and standard length in parentheses): *lachneri* (CU 25019, 189 mm.), *rupiscartes* (USNM 162937, 118 mm.), *cervinum* (CU 19503, 159 mm.), *robustum* (CU 14079, 137 mm.), *ariommum* (CU 22850, 139 mm.), *congestum* (CU 26585, 200 mm.), *austinum* (UMMZ 161693, 224 mm.). (Drawings by Rudolph J. Miller.)

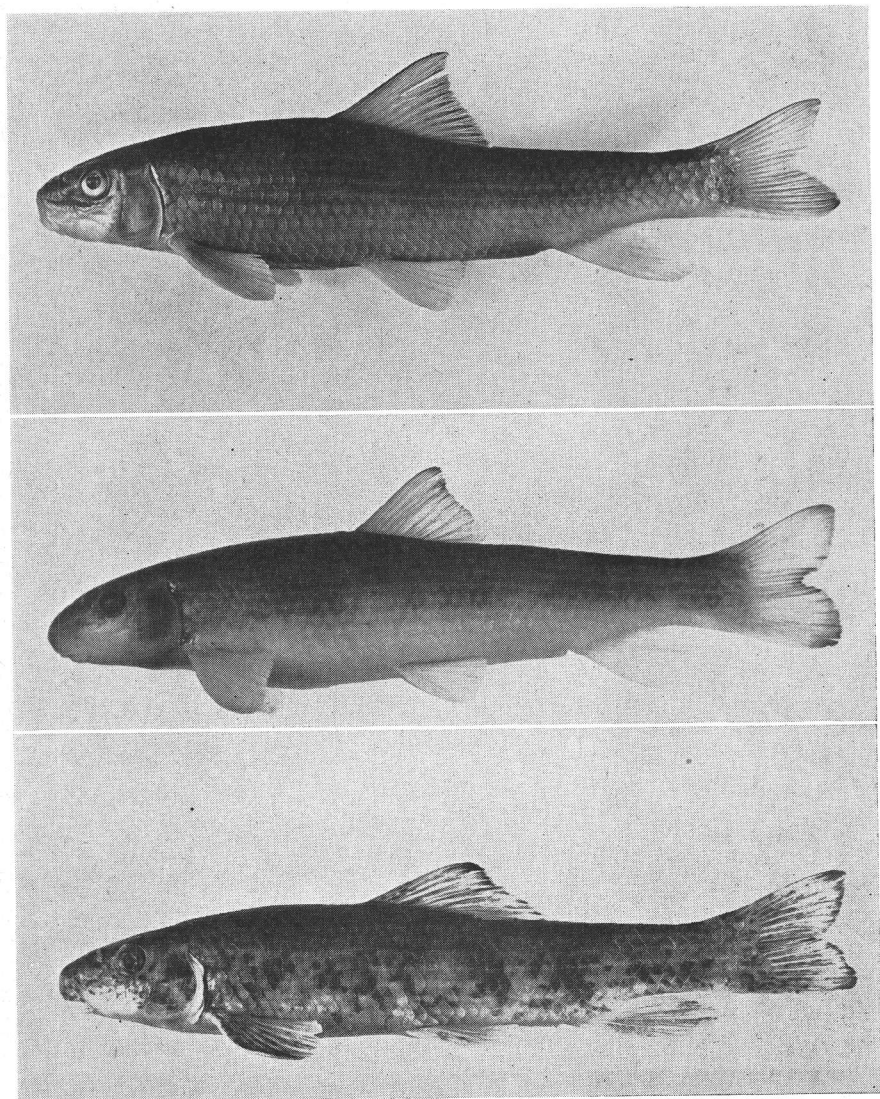


Plate 2. Upper: *Moxostoma lachneri*, side view of holotype, adult female, 152 mm. S.L., CU 15831, Apalachicola River system. Center: *Moxostoma rupiscartes*, side view of adult female, 162 mm. S.L., CU 17525, Altamaha River system. Lower: *Moxostoma cervinum*, side view of adult male, 120 mm. S.L., CU 11641, Roanoke River system. (All photographs by Douglass M. Payne, except those of *Moxostoma ariommum*, which were furnished by the U.S. National Museum.)

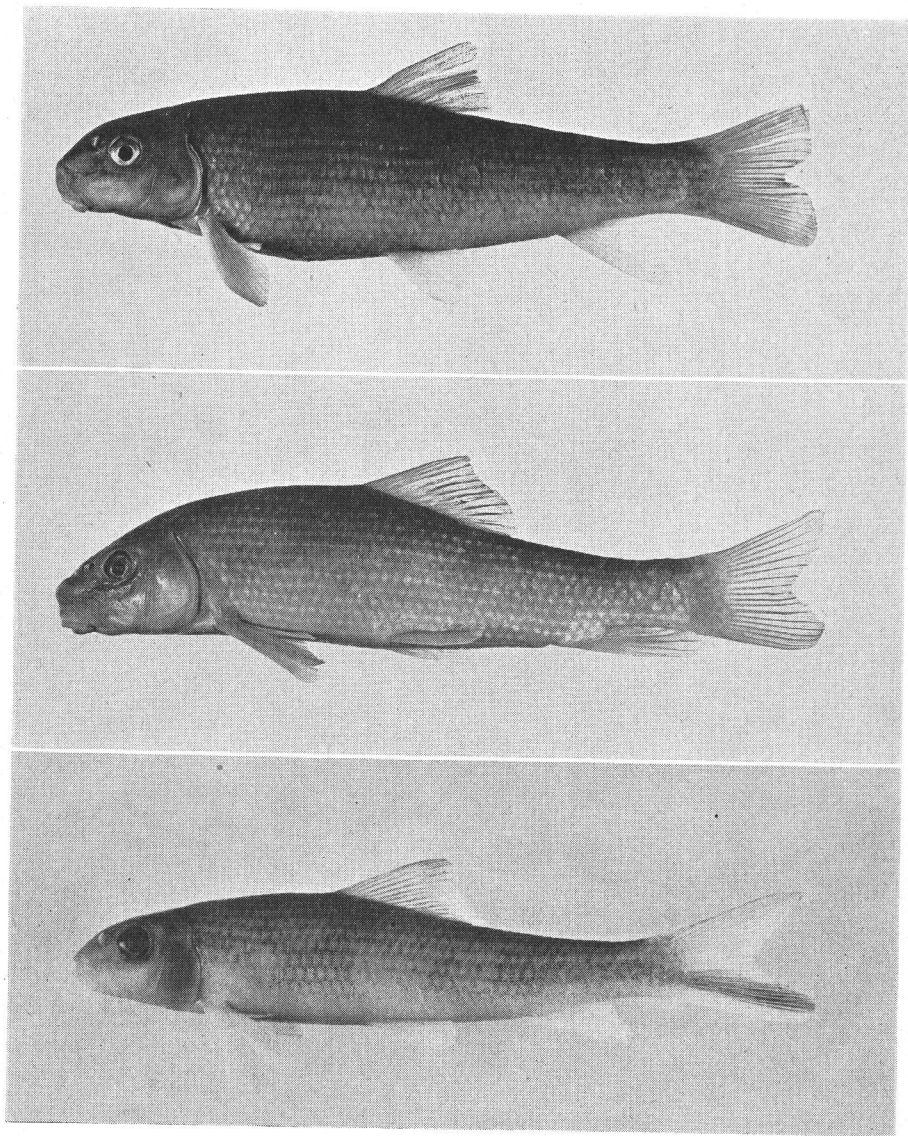


Plate 3. Upper: Moxostoma robustum, side view of juvenile, 137 mm. S.L., CU 14079, Cape Fear River system. *Center: Moxostoma congestum congestum*, side view of adult female, 201 mm. S.L., UMMZ 120295, Pinto Creek (trib. of Rio Grande R., Kinney Co., Texas). *Lower: Moxostoma poecilurum*, side view of juvenile, 69 mm. S.L., CU 13779, tributary of Black Warrior River at Cottondale, Tuscaloosa Co., Alabama.

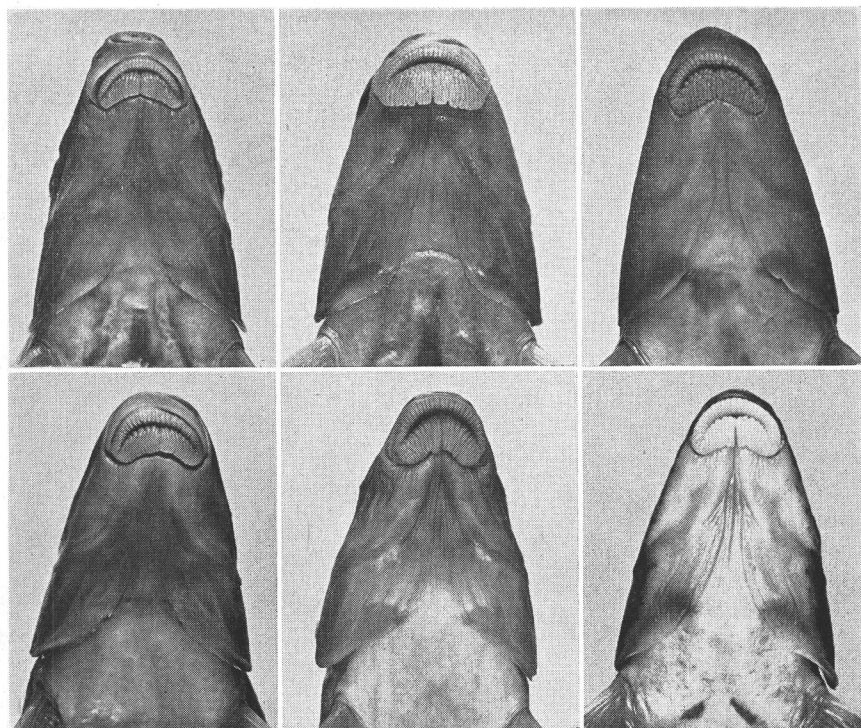


Plate 4. Ventral view of head. *Upper left: Moxostoma lachneri*, holotype, adult female, 152 mm. S.L., CU 15831. *Upper center: Moxostoma rupiscartes*, adult, 135 mm. S.L., CU 21420, Chattahoochee River system. *Upper right: Moxostoma rupiscartes*, adult, 209 mm. S.L., CU 10911, Santee River system. *Lower left: Moxostoma robustum*, adult, 261 mm. S.L., CU 11982, Pee Dee River system. *Lower center: Moxostoma congestum congestum*, adult female, 201 mm. S.L., UMMZ 120295, Pinto Creek (trib. Rio Grande R., Kinney Co., Texas). *Lower right: Moxostoma cervinum*, adult male, 120 mm. S.L., CU 11641, Roanoke River system.

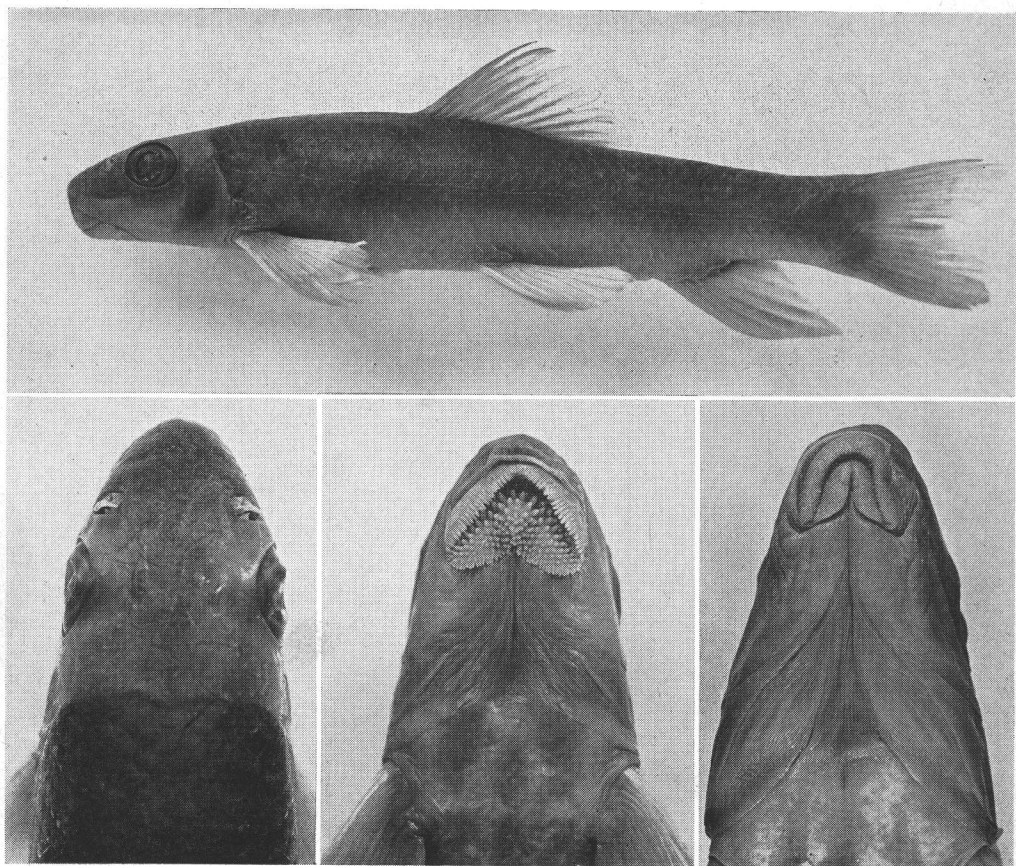


Plate 5. Upper: *Moxostoma ariommum*, side view of holotype, adult male, 142 mm. S.L., USNM 162007, Roanoke River system. Lower left: *Moxostoma ariommum*, dorsal view of head of holotype. Lower center: *Moxostoma ariommum*, ventral view of head of holotype. Lower right: *Moxostoma pappilosum*, ventral view of head of adult, 260 mm. S.L., CU 23877, Roanoke River, 2.4 miles south of Elliston, Roanoke Co., Virginia.