MISCELLANEOUS PUBLICATIONS
MUSEUM OF ZOOLOGY, UNIVERSITY OF MICHIGAN, NO. 66

REVISION OF *CERATICHTHYS*, A GENUS OF AMERICAN CYPRINID FISHES

BY
CARL L. HUBBS AND JOHN D. BLACK

ANN ARBOR
UNIVERSITY OF MICHIGAN PRESS
JANUARY 27, 1947

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REVISION OF *CERATICHTHYS*, A GENUS OF AMERICAN CYPRINID FISHES

INTRODUCTION

LIKE many other species of North American fresh-water fishes, those here referred to the genus *Ceratichthys* have been the subject of much systematic confusion—taxonomic as well as nomenclatorial. Recent discoveries, particularly those reported by Hubbs and Ortenburger (1929*a*: 35–38), have largely cleared up the status of the southwestern species, properly called *Ceratichthys vigilax* rather than *Cochlognathus ornatus,* but the widespread species long known as *Cliola vigilax* has been thrown into a nomenclatorial muddle. This form is here regarded as specifically but not as generically distinct, and its name is traced back to *Ceratichthys perspicuus* (Girard). A third species, *Ceratichthys tenellus* (Girard), from the Ozark Upland and adjacent regions, is now recognized for the first time since its original description in 1856. It is divided into *C. t. tenellus* (Girard) and *C. t. parviceps,* new subspecies. A fourth species, *Ceratichthys callarchus,* belonging to the *C. tenellus* group, is described as new from southeastern Missouri.

In the preparation of this paper we have closely examined all specimens of *Ceratichthys* in the University of Michigan Museum of Zoology, the United States National Museum, and the Chicago Natural History Museum (formerly Field Museum of Natural History). Before the rediscovery of *Ceratichthys tenellus,* the specimens in the Academy of Natural Sciences of Philadelphia and the Museum of Comparative Zoology had been studied. We are deeply grateful to the authorities of these museums for the privilege of making these investigations. We thank Dr. Leonard P. Schultz of the National Museum also for examining and sketching the pharyngeal arches and teeth of the types of *Hyborhynchus perspicuus* and of *H. tenellus.* Laura C. Hubbs gave assistance in the statistical calculations. Milton B. Trautman sent us his records for Ohio, along with information on the habitat preference displayed by *Ceratichthys perspicuus* in that state. Numerous specimens from Texas were made available by Kelshaw Bonham. George V. Harry collected and made ready for checking most of the material taken in Missouri. Reeve M. Bailey furnished records and other information for Iowa and Texas.

An appreciation of the status and relationships of *Ceratichthys* calls for a consideration of the group to which this genus is referred.

SUBFAMILY PIMEPHALINAE HUBBS

This subfamily was first organized on a formal basis and named by Hubbs (1926: 25–26 and 48). The group appears to be a specialized deriva-

tive of the Notropinae, which dominate the rich cyprinid fauna of the Atlantic and Gulf drainages of eastern North America.

The Pimephalinae agree with the Notropinae in most respects. They are all small; none attains a standard length of 100 mm. The pharyngeal teeth are reduced to 4 on each arch (and are uniserial). The dorsal and anal fins are few-rayed and spineless, and the dorsal is submedian in position.

The group of *Pimephales* and its allies differs from the *Notropis* complex in certain specialized structures. The nuptial tubercles of the head are confined to the muzzle and are much fewer though greatly enlarged. The body is wholly devoid of nuptial tubercles, and those on the pectoral rays are arranged in single unbranched rows (in *Ceratichthys perspicuus* and *C. vigilax* even these tubercles are obsolescent). The pectoral fin of the breeding male becomes broad, flat, and much thickened, particularly in long pads between the rays. In the much blackened breeding males the flattened nuchal region develops a thick rugose pad. This soft structure is used to wipe clean the eggs, which are deposited on the undersurfaces of flat objects. The second and third rays of the small dorsal fin are more distinctly separated than is usual by an interradial membrane. The first ray is minute or obsolescent. The second ray is somewhat more thickened than in most cyprinids. These features of the dorsal fin are conspicuous only in the breeding males, in which the thick and clavate but hardly "spinelike" second ray (usually the first obvious ray) is widely separated from the third ray. Above the base of the fin and near its front margin there is a blackish spot, which also is prominent only in breeding males. The anal fin is unusually small and rounded. The number of principal rays is typically 8 in the dorsal and only 7 in the anal fin, but is subject to variation. The scales are reduced in size in the anterodorsal region. The preponderance of nuptial features in the definition of this group confirms the taxonomic importance of sexual characters.

The distinctiveness and constancy of these specialized characters circumscribe the Pimephalinae as a very compact natural group of genera. It is, therefore, now difficult to appreciate why *Ceratichthys* (= *Cliola* = *Hypargyrus*) until recently was widely separated from *Pimephales*. The obvious error in taxonomic judgment was due to the unwarranted emphasis that was long placed on the length of the intestine as a primary character in the classification of the Cyprinidae and other families of fishes. Recent developments in systematic ichthyology indicate for the Cyprinidae as well as for several other groups that the true lines of relationship repeatedly cross divisions which were formerly based on differences in the length of the intestine, in associated structures, and in feeding habits (Hubbs and Brown, 1929: 29; Hubbs and Turner, 1939: 17). The directly adaptive structures related to nutrition are seemingly subject to repeated modification through convergent evolution (Hubbs, 1941: 188).

The close resemblance of *Ceratichthys* to *Pimephales* was observed and commented upon by almost all of the authorities who, nevertheless, persisted in widely separating the genera. The difficulty of distinguishing *"Cliola" vigilax* from *"Pimephales" notatus* was emphasized by some authors, either through misidentifications or through definite statements. For example, Forbes (1884: 78) indicated that *"Cliola vigilax"* closely resembles and has at times been confounded with *Pimephales notatus,* and Hay (1887: 246–47) even suggested that *vigilax* should probably be referred to *Pimephales.* Jordan and Evermann (1896: 251–52) wrote of *Cochlognathus* (= *Ceratichthys*):

> We place this genus and *Cliola* in the neighborhood of *Notropis,* on account of the shortness of the intestines, but it is likely that their true relations are with *Pimephales,* and that the reduction in the length of the alimentary canal is a character independently developed.

Despite such evidence, the genera were not formally associated in one group until 1926.

The view held by Jordan and previous workers that the short intestine of *Ceratichthys* is a modification of the primitive long-gutted condition no longer appears plausible. In the Cyprinidae as in other groups a short intestine and a carnivorous diet appear primitive—though subject to repeated change into the specialized condition of a long intestine fitted to digest plant material. The blackened peritoneum and the modifications of mouth and tooth structure associated with the herbivorous habit likewise appear to be specializations. The carnivorous North American cyprinids are much the more numerous and form a large group of generalized types, from different members of which the herbivorous genera are plausibly derivable along separate lines.

The short intestine and a silvery peritoneum are the chief characters by which *Ceratichthys* may be separated from the two other genera comprising the Pimephalinae (Hubbs, 1926: 48). The intestine shows the single, compressed S-shaped loop, without any kinks in the region of the anterior (second) bend. As was indicated by Hay (1887: 246–47) and Kendall (1903: 360), the length of the intestine is extremely variable in *Pimephales* (and *Hyborhynchus*), but in these genera there are always some additional kinks or coils, at least in the region of the anterior bend, and the peritoneum is invariably black.

ANALYSIS OF THE FORMS OF PIMEPHALINAE

The 3 genera, 6 species, and 8 forms which we recognize in the Pimephalinae may be separated by the use of the following key, supplemented, for the forms of *Ceratichthys,* by Tables IV to X.

1a.—Intestine not elongated, forming a simple compressed S-shaped loop without additional coils or kinks. Peritoneum silvery. Pharyngeal teeth rather strongly hooked. Nuptial tubercles on head 15 or fewer, typically 5 to 11, very rarely more than 13, with only 1 row intervening between nostril and preorbital edge. Scales of the mid-sides usually with a more shieldlike outline, and generally with radii in moderate number (Tables I–II) ..... Genus *Ceratichthys* (Tables IV–X)

1b.—Intestine more or less elongated, with extra coils or at least kinks about the second (anterior) bend of the S-shaped loop. Peritoneum black or nearly so. Pharyngeal teeth very weakly or not at all hooked. Nuptial tubercles on the head 15 or more (normally at least 16), with 2 rows intervening between nostril and preorbital edge. Scales of the mid-sides typically with a more vertically oval outline, and generally with more numerous radii (Table I).

2a.—Nuptial male without barbel-like expansion of the skin at end of maxillary. Nuptial tubercles usually more than 16 on head. Lateral line often incomplete. Head more rotund. Mouth more oblique. Caudal spot dusky. *Pimephales promelas*

3a.—Mouth strongly oblique. Nuptial tubercles developed on mandibles as well as on muzzle. Lateral line incomplete. Body usually deeper and more compressed ..... *P. p. promelas*

3b.—Mouth not strongly oblique. Nuptial tubercles lacking on mandibles. Lateral line almost to quite complete. Body usually more terete ..... *P. p. confertus*

2b.—Nuptial male with barbel-like expansion of the skin at end of maxillary. Nuptial tubercles normally 16 on head. Lateral line complete. Head less rotund. Mouth more nearly horizontal. Caudal spot black ..... *Hyborhynchus notatus*

The subspecies of *Pimephales promelas* (discussed by Hubbs and Ortenburger, 1929*a:* 38) intergrade irregularly over a wide area. There is also much local variation in each subspecies. Eventually more than the two forms will probably be named.

Despite its extensive range (Hubbs and Lagler, 1941: 61), *Hyborhynchus notatus* has not yet been divided into subspecies. Cursory examination, however, has indicated that a form, probably of subspecific rank, inhabits the lower Mississippi Valley and the streams of the Gulf coast east of the Mississippi River. Compared with typical *notatus* it seems to have coarser scales, particularly in the predorsal region, and a heavier build.

SCALE CHARACTERS

As indicated in the preceding key specimens of *Ceratichthys* can usually be distinguished from those of *Pimephales* and *Hyborhynchus* by an examination of the scales. Since the use of scale structure in fish taxonomy has been much neglected by most workers but has been greatly acclaimed by a few who have used limited material, a statistical study was undertaken to test the value of scale characters in the Pimephalinae. The number of radii was counted on more than 1,600 scales, as indicated in the subheading of Table I. The size and shape of the scale was not measured, since these features exhibit great variation and are very strongly correlated with the

number of radii. When the radii are few, considering the size of the fish, the scale usually assumes the outline of a shield, with the vertical dimension not very much greater than the horizontal, with a sharp angulation of the anterolateral margins and of the ridges on the anterolateral axes, often with the anterior margin concave above and below a median anterior convexity, and with the posterior margin very broadly rounded. When the radii are most numerous, the scale takes on a more or less vertically elongated oval outline. The correlation is evident in both individual and interspecific variation, and seems to be common among American Cyprinidae. For example the vertically oval scales of *Hybognathus hankinsoni* have more radii than the shield-shaped scales of *H. nuchalis* and *H. placitus* (Hubbs and Lagler, 1941: 50). As a rule the focus is close to the posterior margin in the shield-shaped scales with few radii and is less excentric in the multiradiate oval scales, but this correlation is subject to much fluctuation.

Since the number of radii and the shape of the scale are not perfectly correlated, the combination of the 2 features will usually suffice for a definite identification of any pimephaline minnow as a *Ceratichthys* or as a *Pimephales* or *Hyborhynchus*. There is a considerable overlap in the counts of radii for each size class of fish (Table I). *Ceratichthys vigilax* approaches *Pimephales* and *Hyborhynchus* more closely than do the other forms of *Ceratichthys*. This is much truer of certain populations than of others, for *C. vigilax* provides a partial, variable transition between *C. perspicuus* and either *Pimephales* or *Hyborhynchus,* in respect to scale form and number of radii (Table II). Some local variation, less strongly marked, was noted in other species.

In view of such raciation and particularly in view of the very wide individual variation in scale structure demonstrated in this study, it obviously behooves one to proceed thoroughly and cautiously in using scale characters for the separation of species of Cyprinidae. Valuable distinctions, however, do exist and should constantly be looked for.

PHYLOGENY OF THE PIMEPHALINAE

In accord with a phyletic principle that is becoming increasingly evident, the species and subspecies of the Pimephalinae show a mixture of primitive and specialized attributes. On the basis of the common denominator of presumably primitive features the ancestral pimephaline probably had the following characters, in addition to those cited above as definitive of the group as a whole:

A. Carnivorous habit, associated with a simple, S-shaped intestine, a silvery peritoneum, and strongly hooked teeth. These features are retained only in *Ceratichthys.*

B. A moderately compressed body form, less slender and less flattened

TABLE I

Number of Scale Radii in Forms of Pimephalinae

Counts were made of all radii, including rudiments, near the margin of 1 scale, occasionally 2–4 scales per fish, in the first to third row above the lateral line, approximately below the dorsal origin. For each 10-mm. size class the mean and the standard error are given; also the range of variation and, in parentheses, the number of scales studied. Trial counts show that *Pimephales p. promelas* agrees with *P. p. confertus*.

	10-Millimeter Size Classes					
	20–29 mm.	30–39 mm.	40–49 mm.	50–59 mm.	60–69 mm.	70–79 mm.
Pimephales promelas confertus	10.24 ± .25 7–14 (62)	18.48 ± .60 11–25 (44)	22.41 ± .62 13–29 (37)	27.66 ± .84 20–38 (35)	32.75 ± .80 23–45 (36)	43.29 ± 3.95 30–58 (7)
Hyborhynchus notatus	10.33 ± .30 8–14 (27)	14.72 ± .51 7–24 (61)	22.91 ± .36 14–34 (91)	30.07 ± .78 19–43 (46)	34.69 ± .65 25–47 (51)	39.54 ± .73 30–48 (37)
Ceratichthys perspicuus	7.19 ± .23 4–10 (43)	9.05 ± .27 6–14 (40)	12.63 ± .37 8–20 (60)	15.02 ± .44 8–24 (43)	18.75 ± .60 14–24 (24)	18.50 ? 18–19 (2)
Ceratichthys vigilax (total)	8.09 ± .15 4–14 (173)	12.24 ± .20 6–22 (284)	16.73 ± .25 9–27 (157)	21.54 ± .59 12–34 (56)	28.25 ± 1.32 23–34 (8)	.....
Ceratichthys t. tenellus	7.08 ± .27 3–11 (36)	9.42 ± .34 4–14 (45)	13.41 ± .41 8–21 (41)	15.31 ± .75 10–22 (16)	.....	.....
Ceratichthys t. parviceps	9.00 ? 7–11 (2)	8.50 ± .31 5–11 (24)	10.65 ± .50 7–17 (29)	14.00 ? 12–16 (2)	.....	.....
Ceratichthys callarchus	....	8.00 ? 8 (1)	.....	.....	.....	.....

TABLE II

NUMBER OF SCALE RADII IN *Ceratichthys vigilax* FROM DIFFERENT STREAM SYSTEMS

	10-Millimeter Size Classes				
	20–29 mm.	30–39 mm.	40–49 mm.	50–59 mm.	60–69 mm.
Stream system (north to south)					
Red River	10.00 ± .36 7–14 (27)	14.06 ± .43 7–22 (68)	17.92 ± .38 13–27 (61)	23.58 ± .53 19–34 (33)	28.25 ± 1.32 23–34 (8)
San Jacinto River	6.00 ? 6–6 (2)	9.50 ? 9–10 (2)	12.75 ? 12–13 (4)	16.25 ? 14–19 (4)	.....
Brazos River	6.88 ± .14 4–10 (75)	10.81 ± .31 6–19 (68)	14.70 ± .44 9–21 (33)	18.13 ± .93 12–24 (16)	.....
Colorado River	9.93 ± .37 8–13 (14)	13.91 ± .34 9–18 (34)	18.50 ? 17–20 (2)	26.00 ? 26 (1)	.....
Guadalupe and San Antonio rivers	8.35 ± .34 7–11 (17)	10.68 ± .30 6–19 (90)	15.72 ± .34 12–22 (43)	17.00 ? 17 (1)	.....
Nueces River	8.00 ? 5–13 (3)	16.33 ± .71 12–22 (15)	20.00 ± .91 17–25 (10)	30.00 ? 30 (1)	.....
Rio Grande	8.46 ± .23 6–11 (35)	12.43 ± 1.15 9–17 (7)	21.00 ? 20–22 (4)	.....	.....

in the nuchal region than in most species of the group. *Pimephales promelas promelas* is most primitive in this character; *Ceratichthys tenellus parviceps* and *C. callarchus* most extreme.

C. A complete lateral line. *Pimephales promelas promelas* is the only form with an incomplete line, but *P. p. confertus* often lacks some pores.

D. An oblique mouth.

E. Nuptial tubercles present on the mandible (in correlation with the obliquity of the mouth), and in 3 primary rows on the snout. In this feature, as in the obliquity of the mouth, *Pimephales promelas promelas* is most archaic, for it alone normally has chin tubercles. These are obsolete or very nearly so in typical *P. p. confertus,* though variably developed in the broad area in which *confertus* and *promelas* intergrade. Both subspecies of *P. promelas* at some localities commonly develop 1 to 3 extra rows of tubercles, usually of small size and of irregular disposition. *P. p. confertus,* as well as *Hyborhynchus notatus* and *Ceratichthys tenellus* and presumably also *C. callarchus,* regularly retain 3 rows of pearl organs across the snout, but in this series of species the tubercles become progressively fewer and more constant in number and arrangement. The same trend is continued in *Ceratichthys perspicuus* and is carried to an extreme in *C. vigilax.* The factual basis for these conclusions is presented in the following section.

F. Nuptial tubercles on rays of pectoral fin well developed, though limited to single unbranched files. These tubercles have become rudimentary, almost obsolete, in *C. perspicuus* and in *C. vigilax,* but in all other species, so far as is known, remain well developed.

G. Jaws of breeding males normal in structure, without exposed sharpened edges. *Ceratichthys perspicuus, C. tenellus,* and presumably *C. callarchus* are incipiently modified toward the extreme condition exhibited by the nuptial males of *C. vigilax,* which have jaws much like those of *Diodon.*

H. No barbel-like flap at the end of the maxillary in nuptial males. This specialized structure is developed by *Hyborhynchus* only.

I. Size moderate, as in *Ceratichthys perspicuus, C. vigilax,* and *Hyborhynchus notatus. Pimephales promelas* is ordinarily though not always a smaller fish. *Ceratichthys tenellus* is apparently a dwarfed species, and *C. callarchus* is assumed to be of similarly reduced size.

No living species combines all of these primitive characters, and none is specialized in every respect. The jumbled association of archaic and modified features in each species is illustrated by the data in Table III. For this table we quantified the primitiveness of each of the 8 pimephalines, for each of the characters (A to I) as listed above, by grading the forms on a point basis from 8 to 1, dividing the points for ties as is done in an athletic meet. Since 3 sets of characters are involved, the scores for item A are multiplied

by 3. By adding the figures for each character we obtained a rough index of primitiveness, which is given for each form in the last column of Table III. The similarity of the indices is further evidence of the admixture of primitive and specialized characters. *Ceratichthys perspicuus* ranks as the most archaic in the sum of the characters, but *Pimephales promelas promelas* is indicated as scarcely less archaic. *Hyborhynchus notatus* rates as most specialized. The other kinds show such close compensation in the combination of primitive and derived characters that their indices of primitiveness are of the same order of magnitude.

Obviously, no simple linear arrangement of the species is suggested by the data. Several sequences other than the one adopted in Table III would be about as logical. Each genus presumably arose independently from the root of the Pimephalinae, and there is a deep schism between the *Ceratichthys vigilax* and *C. tenellus* groups. The most probable direct-line sequences lie within these groups, respectively, from *C. perspicuus* to *C. vigilax* and from *Ceratichthys tenellus tenellus* to *C. t. parviceps* to *C. callarchus*.

SPECIALIZATION IN THE NUPTIAL TUBERCLES

In many respects the most interesting and significant of the specializations within the Pimephalinae pertain to the nuptial tubercles of the breeding males (characters E and F of the preceding discussion). These structures are greatly reduced in number and area in all pimephalines and exhibit a series along which the tubercles have become further reduced in number and more invariably fixed in both position and number. Such reduction and fixation is, no doubt, in the line of specialization, but there is no strong reason to believe that the entire sequence represents a single rectilinear trend in phylogeny. Reduction and fixation may well have proceeded to different degrees along 3 or more independent lines.

The most generalized tuberculation is exhibited by the males of *Pimephales p. promelas*. In this form there are hooks on the pectoral rays, in single unbranched files; a row or group of tubercles on each mandibular ramus, and 3 primary rows across the snout. *P. p. confertus* typically lacks the mandibular tubercles, but is otherwise similar.

Indicative of generalization in this respect the tubercles of the snout in *Pimephales promelas* exhibit much variation in number and arrangement. Those of the first row, running close to the anterior margin of the snout, vary from 6 to 14. Very often there is a median tubercle plus 3 on each side, as in *Hyborhynchus*. Frequently, there are 4 on each side, giving a count of 9 instead of 7. Only 1 male among many examined had the number reduced to 6. Further increases are generally due to the interpolation of small organs here or there, or to a longitudinal pairing of the outermost tubercle. The median tubercle also may be paired, either transversely or

TABLE III

EVALUATION OF DIFFERENTIAL PRIMITIVENESS OF KNOWN FORMS OF PIMEPHALINAE
The method of quantifying the primitiveness of each form is explained in the text.

	Evaluation of Primitiveness of Each Character, A to I									Index of Primitiveness
	A	B	C	D	E	F	G	H	I	
Pimephales p. promelas	6	8	1	8	8	5.5	7	5	4.5	53
Pimephales p. confertus	6	7	2	5	7	5.5	7	5	4.5	51
Hyborhynchus notatus	6	3.5	5.5	2	6	5.5	7	1	7	43.5
Ceratichthys perspicuus	18	5.5	5.5	6.5	2	1.5	3.5	5	7	54.5
Ceratichthys vigilax	18	5.5	5.5	6.5	1	1.5	1	5	7	51
Ceratichthys t. tenellus	18	3.5	5.5	4	4	5.5	3.5	5	2	51
Ceratichthys t. parviceps	18	1.5	5.5	2	4	5.5	3.5	5	2	47
Ceratichthys callarchus	18	1.5	5.5	2	4*	5.5*	3.5*	5*	2	47

* In assigning these values to *C. callarchus* it is assumed that in the characters of the nuptial males, as yet unknown, this species will be found to agree with *C. tenellus*.

longitudinally. The organs in the second row vary from 6 to 13, but are most commonly 7 or 9, with either 3 or 4 on each side of a median tubercle. The number is reduced to 6 in only 1 fish examined. This row runs close to the nostril and then curves around, so that the last tubercle ordinarily lies just below that orifice. The row, however, may end in front of the nostril or may extend behind it. Sometimes the last organ of either the second or first row, or of both rows, is doubled, so as to form a vertical series along the front edge of the orbit (perhaps reflecting an earlier pattern). In the second row there may be a median tubercle, or a pair of organs aligned either transversely or longitudinally. The third row almost invariably comprises 2 organs (rarely 1 or 3) between the nostrils. At some localities 1 or 2 additional rows of 1 to 3 tubercles each are occasionally (or even often) formed still farther back. Other supplementary rows of 1 to several tubercles, generally of small size, may occur in advance of the first row, particularly toward the sides, or between the first and second rows.

In *Hyborhynchus notatus* the nuptial tubercles are retained in the single files along the pectoral rays and in 3 rows across the muzzle, but those on the snout are fewer than is usual in *Pimephales* and are much more definitely fixed in number and position. The formula 7—7—2, often though not most frequently exhibited in *Pimephales promelas,* is standard for *Hyborhynchus.* There is almost no variation, except that the median tubercle of the second row is occasionally paired, either transversely or longitudinally or is accompanied by a small tubercle on either side. The first row consistently comprises a median tubercle plus 3 on each side. There are 2 rows between the nostril and the preorbital margin as in *Pimephales.* As in that genus the second row curves around the nostril so that the last organ lies between the nostril and the eye. The third row comprises 2 tubercles evenly aligned transversely between the nostrils.

In *Ceratichthys* the tubercles are further reduced and maintain very definite positions. The highest number of tubercles observed on the snout of any *Ceratichthys* is 15, and the highest usual number is 11, whereas in large series of *Pimephales* and *Hyborhynchus* examined the lowest number found is 15, and 16 is the lowest number of frequent occurrence.

In *Ceratichthys t. tenellus* the fundamental formula of tubercles on the muzzle is 5—4—2, at times increased to 5—5—2 by the interpolation of a second small tubercle below the nostril on either the left or the right side. In addition, 3 of the several tuberculate males examined have a median tubercle in the fold of the upper lip. One of these has also a rudiment before and to the right of the median tubercle of the first row and a small doubled organ behind and to the right of that tubercle. Since this fish also has an extra tubercle below 1 nostril its total complement is 15. The first row comprises a median tubercle, 1 on each side displaced backward to a

position about midway between the nostril and the suborbital edge (in the space where 2 rows occur in *Pimephales* and *Hyborhynchus*), and finally, beyond the preorbital incision on each side, a lateral organ near the suborbital margin. The second row lacks the median tubercle that is usually developed in *Pimephales* and *Hyborhynchus*. It consists of a well-separated pair of tubercles just in front of the nostril and of 1 (occasionally 2) on each side between the nostril and the eye. That these submedian and lateral structures are alignable into one row is concluded from the more complete seriation of these organs in *Pimephales* and *Hyborhynchus,* as described above. The pair of organs flanking the median one of the first row in *tenellus* might be counted rather as belonging to the second row, on which interpretation the basic formula would be given as 3—6—2 instead of 5—4—2. Two organs, regularly disposed transversely between the nostrils, make up the third row. Since these tubercles are smaller than those of the other 2 rows and break through the skin later during the nuptial development, they are often not evident in subnuptial males. The only tuberculate males of *C. t. parviceps* other than the holotype show only 5—4 tubercles, but they are in an early stage of sexual development; the third row is almost surely characteristic of this subspecies as well as of *C. t. tenellus*. The subnuptial holotype of *parviceps* is probably aberrant in the high number (15) of rostral tubercles, for the formula is 5—7—2, not including 1 on the mid-line of the upper lip. It has 3 supernumerary organs in the second row, 2 on one side and 1 on the other, located along the lower edge of the narial fossa. It is assumed that *C. callarchus* agrees with *C. tenellus* in having the nuptial tubercles in 3 rows.

Further reduction in the number of tubercles characterizes *Ceratichthys perspicuus* and *C. vigilax*. In these species only, so far as known, the hooks of the pectoral fin do not develop beyond an obsolescent condition. The organs on the muzzle of *C. perspicuus* are reduced to 2 rows, corresponding precisely to the first 2 rows of *C. tenellus*. The number (typically 5—4) and arrangement seldom vary. In 1 specimen among many examined a lateral organ of the second row, between the nostril and the eye, is lacking and 1 organ of the median pair is rudimentary. The median tubercle of the first row is doubled transversely in 1 specimen; in another it has 2 tips; in yet another it is markedly reduced in size.

In *Ceratichthys vigilax* the only tubercles anywhere on the head, body, or fins comprise a row of 5 that is exactly equivalent to the first or marginal row of *C. perspicuus*. As in the other species of *Ceratichthys* the median tubercle of each side is about halfway between the nostril and the suborbital edge. A few variants were found among many specimens examined. In 1 the median tubercle is doubled in an oblique line. In another it is paired transversely. In several it appears to be lacking (but may not

yet have broken through the skin). One variant has the middle tubercle on 1 side tripled. Another has 1 of the lateral organs doubled. In the most aberrant specimen, from Pin Oak Creek, Robertson County, Texas, the tubercles are abnormally increased to 13 and are so irregularly arranged as to form a narrow band medially and on 1 side. Two other specimens from the same locality have the normal number of 5 tubercles.

GENUS *CERATICHTHYS* BAIRD AND GIRARD

Ceratichthys.—Baird and Girard, 1853*a:* 391–92 (introduced only in the name *Ceratichthys vigilax,* new species, with generic name misspelled; hence *vigilax* is the haplotype). Jordan, 1916: 26; 1924: 72 (nomenclature; replaces *Cliola* according to Opinion 22 of International Commission on Zoological Nomenclature; not *Ceratichthys* Girard, 1856). Hubbs, 1926: 26 and 48 (characters; comparisons; member of Pimephalinae). Ortenburger and Hubbs, 1927: 133 (relationships). Hubbs and Ortenburger, 1929*a:* 36–37 (*Cochlognathus* a synonym; *Cliola* or *Ceratichthys* of most authors = *Hypargyrus*).

Cochlognathus.—Baird and Girard, 1854*b:* 158 (original description; haplotype, *C. ornatus*); 1859a*:* 46–47 (description). Cope, 1866: 380 (allied to *Hybopsis* but appearance like *Hyborhynchus*). Jordan and Gilbert, 1877*b:* 90 (type, *C. ornatus*). Jordan, 1877*c:* 56 (characters); 1878*d:* 787. Cope, 1880: 37–38 (more like *Alburnops* than *Pimephales*). Jordan and Gilbert, 1883: 161 (description). Jordan and Evermann, 1896: 203, 251–52 (description; relationships). Meek, 1904: 33, 57 (description). Cockerell, 1913: 129 (scales). Ortenburger and Hubbs, 1927: 133 (relationship). Jordan, Evermann, and Clark, 1930: 146.

Cliola.—Girard, 1856: 192 (original description; no type indicated; *C. vigilax, C. velox,* and *C. vivax* included); 1858: 256 (description; same species). Jordan, 1877*a:* 78, 1877*c:* 56, 58, 64, and 1878*d:* 787 (confused with *Minnilus* and *Episema*). Jordan and Gilbert, 1877*b:* 91 (type, *Ceratichthys vigilax*); 1883: 163–64 (description; type). Jordan, 1885*b:* 810 (= *Hypargyrus* Forbes; diagnosis; type restricted to *C. vigilax*). Hay, 1887: 246–47, 249 (closely related and possibly referable to *Pimephales*). Jordan and Evermann, 1896: 203, 252 (description; comparison; *Ceratichthys* first used for this group). Cockerell and Allison, 1909: 163, and Cockerell, 1913: 129 (in part; scale structure; relationship). Jordan, 1916: 26 (replaced by *Ceratichthys,* with same type species).

Hypargyrus.—Forbes, *in* Gilbert, 1884: 200 (name introduced in footnote as follows: "*Hypargyrus,* gen. nov. Forbes MSS., type *Hybopsis tuditanus* Cope"; the original *tuditanus* of Cope was *Hyborhynchus notatus,* but the *tuditanus* of Forbes and of Jordan and Gilbert was *Ceratichthys perspicuus*). Hubbs and Ortenburger, 1929*a:* 36–37 (to replace *Cliola* or *Ceratichthys* of authors; compared with *Ceratichthys* = *Cochlognathus*).

As indicated above in the annotated synonymy the name *Ceratichthys* Baird and Girard must be retained for the group that has most often been called *Cliola.* The name with this usage therefore takes precedence over *Ceratichthys* Baird (*in* Girard, 1856: 212–13), which is a synonym of *Nocomis* Girard (1856: 190). *Ceratichthys* was used in the same sense of Baird, for barbelled minnows, by Cope (1864: 277; 1866: 364–66), Günther (1868: 176), Jordan and Gilbert (1877*b:* 92), Jordan (1876: 270; 1877*a:*

80; 1877*b:* 328; 1878*a:* 108; 1878*d:* 785–87; 1880: 287, 290; 1882: 859–60), Jordan and Evermann (1896: 314), and by other authors, prior to the contrary action of the International Commission on Zoological Nomenclature, in Opinion 22 ("Opinions Rendered by the International Commission on Zoological Nomenclature, Opinions 1 to 25," published by the Smithsonian Institution, July, 1910).

The generic name was first spelled *Ceraticthys* by Baird and Girard, as was noted in Opinion 22 just cited. We interpret the first spelling as a misprint or *lapsus calami,* for the authors ordinarily spelled names correctly and subsequently wrote "*Ceratichthys*" without comment. The International Commission was ruling on the type species, not on the spelling.

Cliola, with the same type species (*vigilax*), is an objective synonym of *Ceratichthys.* As indicated by Hubbs and Ortenburger (1929*a:* 36–37), *Cochlognathus* (*ornatus*) was based on the nuptial males of the same species, *Ceratichthys vigilax. Hypargyrus* is of less certain application, as the intended type species, *Hypargyrus tuditanus* Forbes = *Ceratichthys perspicuus* (Girard) is not the same as the nominal type species, *Hybopsis tuditanus* Cope = *Hyborhynchus notatus.* On the unsettled proposition that the intended type species holds, *Hypargyrus* is available for the northern species, generally known as *Cliola vigilax* but herein called *Ceratichthys perspicuus.*

Whether *Hypargyrus* should be recognized as a genus distinct from *Ceratichthys* is a matter of opinion. Except for 2 characters exclusively shown by the nuptial males, the type species seem to be almost indistinguishable, and agree with one another in all respects by which either differs from the 2 other species, *C. tenellus* and *C. callarchus* (Table IV). Should *Hypargyrus* and *Ceratichthys* be generically separated, a new genus would apparently be needed for the *C. tenellus* group.

Since *C. perspicuus* (indirect type of *Hypargyrus*) and *C. vigilax* (type of *Ceratichthys*) are so much alike and have an allopatric distribution (Map 1), it is possible that they will be found to intergrade subspecifically. Should intergradation be demonstrated, even subgeneric and specific separation would be excluded.

As indicated above, and in Table IV, *Ceratichthys tenellus* and *C. callarchus* contrast with both *C. perspicuus* and *C. vigilax* in most characters. This table, together with Table V, showing the known differences between *C. perspicuus* and *C. vigilax,* and Table VI, which compares the 3 forms of the *C. tenellus* group, will serve in place of a key to the forms of the genus. Tables VII to IX summarize the counts and measurements which have proved of value in the separation of the 5 recognized forms of *Ceratichthys.* A comparison of the genus *Ceratichthys* with other pimephalines is given in the key on page 8.

TABLE IV

COMPARISON OF THE *perspicuus* AND *tenellus* GROUPS OF *Ceratichthys*

	Ceratichthys perspicuus Group: *C. perspicuus* and *C. vigilax* (See also Table V)	*Ceratichthys tenellus* Group: *C. tenellus* and *C. callarchus* (See also Table VI)
Body (Tables VIII–IX)	Generally deeper, but occasionally slender; more compressed (width about equal to distance from ridge of back to lateral line, or slightly greater)	Generally more attenuate (especially in *C. t. parviceps* and *C. callarchus*), and more terete (width nearly or quite one scale height greater than distance from ridge of back to lateral line)
Head: depth in length (Table IX)	1.4 to 1.7 (usually 1.5 or 1.6)	1.6 to 1.9 (usually 1.7 in *C. t. tenellus*, 1.7 or 1.8 in *C. t. parviceps*, 1.7 in type of *C. callarchus*)
Mouth	Moderately oblique; curved	About horizontal anteriorly; somewhat oblique posteriorly
Upper lip	Little expanded at mid-line	More expanded at mid-line
Scales above lateral line (Table VII)	6 to 8 (usually 7, seldom 6)	5 to 7 (usually 6, rarely 5 or 7, in *C. tenellus;* 7 in *C. callarchus*)
Lateral band	Less developed; in half-grown and adult scarcely developed on head; generally replaced on snout by a blackish spot below nostril, near preorbital edge	Better developed; in half-grown and adult slightly (*C. t. tenellus*) to rather strongly (*C. t. parviceps*) developed on head, even across snout (even stronger in *C. callarchus*)
Region about anus	Almost totally devoid of pigment	Conspicuously marked with black pigment
Stripe behind anal fin	Weaker, broader, more diffuse	Strong, narrow, definite
Spot on base of caudal	Nearly round	More or less elongate vertically
Cross hatching on scale pockets	Less conspicuous	More conspicuous
Dorsal fin	Blackened in crotch of rays (except in young)	Scarcely blackened in crotch of rays
Pectoral fin in nuptial males	Less blackened over main area, but with front edge black (except for a trace of light on extreme margin)	Mostly blackish, with conspicuous broad whitish front edge*
Pelvic fin in nuptial males	Black pigment lacking or confined to outer part of fin near axil; without definite light border	Mostly black, with whitish edge (outer edge bright)*

TABLE IV—(*Continued*)

	Ceratichthys perspicuus Group: *C. perspicuus* and *C. vigilax* (See also Table V)	*Ceratichthys tenellus* Group: *C. tenellus* and *C. callarchus* (See also Table VI)
Anal fin in nuptial male	Black pigment lacking or confined to a blotch near base anteriorly and a mark near posterior edge	Largely black, with clear anterior margin and light outer margin*
Light mark on caudal in nuptial males	In connected blotches, one at base of each lobe	In a vertical streak*
Light border on head along gill opening in nuptial males	Not very conspicuous: partly suffused with dusky	Bright and clear*
Nuptial tubercles of head (confined to snout)	In 1 or 2 rows (2 in *perspicuus*, 1 in *vigilax*)	In 3 primary rows*
Nuptial tubercles on pectoral rays	Obsolescent	Well developed, in 1 row*
Typical habitat	Turbid, sluggish, lowland rivers and oxbow lakes, generally with no vegetation	Clear, swift, mountain creeks and small rivers, generally in vegetation
Distribution (Maps 1–2)	Central Valley and Gulf tributaries	Ozarkian Upland and adjacent region to northwest

* Breeding males of *C. callarchus* are unknown.

ERRONEOUS IDENTIFICATIONS AND EXTRANEOUS RECORDS

Through errors in taxonomy and identification the ranges of *"Cliola"* and *"Cochlognathus"* have been unduly extended northward and westward. Since this revision aims to present an accurate picture of the distribution as well as the taxonomy of the species referred to *Ceratichthys,* an effort has been made to collate and correct those errors.

1. *Hybopsis tuditanus* COPE = *Hyborhynchus notatus*

After a re-examination of the types, Hubbs (1926: 48, footnote) and Hubbs and Ortenburger (1929*a:* 37) indicated that *Hybopsis tuditanus* Cope (1866: 381) was based on specimens of *Hyborhynchus notatus.* This corrected determination is in line with present knowledge of the characters and the ranges of *Ceratichthys perspicuus* and of *Hyborhynchus notatus.* Cope mentioned that the types of *tuditanus,* from the Detroit River, as well as the specimens from "the St. Josephs" (St. Joseph River, tributary to Lake Michigan), had a well-marked lateral band—which is a character of *Hyborhynchus notatus* as contrasted with *Ceratichthys perspicuus.* Cope's other specimens, from the Wabash River at Lafayette, Indiana, were obviously based on the *Ceratichthys,* for he describes them as not showing such

a band. That part of the literature on *tuditanus* which pertains to *Ceratichthys perspicuus* is included in the synonymy of that species.

Much confusion has arisen through the reference of *Hybopsis tuditanus* to *Hypargyrus, Cliola,* and *Ceratichthys.* Jordan and Gilbert (1883: 165–66) described the northern *Ceratichthys* as *Cliola tuditana,* and Gilbert (1884: 200–201) introduced Forbes' generic name *Hypargyrus* for this species, as thus misidentified (for subsequent references to *Hypargyrus,* refer to the synonymies of *Ceratichthys* and of *C. perspicuus*). Fowler (1918: 18–20, Pl. 7) gave a lengthy redescription and a figure of a cotype of *Hybopsis tuditanus* and reported other specimens from the Detroit River at Grosse Isle, under the erroneous heading of *Ceratichthys vigilax.* The figure clearly represents *Hyborhynchus notatus.* Some of Cope's Detroit

TABLE V

COMPARISON OF *Ceratichthys perspicuus* AND *C. vigilax*

	Ceratichthys perspicuus	*Ceratichthys vigilax*
Nuptial tubercles around snout	Consistently in 2 rows	Consistently in 1 row
Jawbones in breeding males	Less sharpened and barely exposed, but incipiently modified in same direction	Sharpened and exposed to form very strong biting jaws resembling those of *Diodon*
Distribution (Map 1)	Mississippi River system and other Gulf streams from the Alabama to the Trinity, excluding the upper Red River waters	Gulf of Mexico drainages from the San Jacinto to the Rio Grande; also the upper Red River system

River specimens in the Philadelphia Academy collections, labeled *Ceratichthys vigilax,* were found in 1924 to be poorly preserved, but apparently referable to *Hyborhynchus notatus* and *Notropis hudsonius.*

Unwarranted northward extensions of the range of *"Cliola vigilax"* (in the sense of *Ceratichthys perspicuus*) followed. "The St. Josephs" soon became "Lake Michigan" in the loose zoogeography of the last century, and on this basis Hoy (1883: 432) included *Hybopsis tudinatus* (*sic*) in his list of Wisconsin fishes. The Michigan records for *Hybopsis tuditanus* led to the inclusion of *Cliola vigilax* in the lists of fishes from the Great Lakes (Evermann, 1901: 95; and Bean, 1903: 740), Michigan (Michael, 1906: 14), Ontario (Nash, 1908: 39), and hence Canada (Halkett, 1913: 18).

2. *"Cliola vigilax"* FROM MISSOURI (IN PART) = *Hyborhynchus notatus*

Records of *Cliola vigilax* from Grand River at Clinton and Tabo Creek at Calhoun, in Missouri (Jordan and Meek, 1885: 16; and Evermann and

TABLE VI

COMPARISON OF THE SUBSPECIES OF *Ceratichthys tenellus* WITH EACH OTHER AND WITH *Ceratichthys callarchus*

	C. t. tenellus (Pl. I, Fig. 1; Pl. II, Fig. 1)	*C. t. parviceps* (Pl. I, Fig. 2; Pl. II, Fig. 2; Fig. 1 A)	*C. callarchus* (Pl. I, Fig. 3; Fig. 1 B)
Specific differences			
Scales above lateral line (Table VII)	5 to 7, usually 6	5 to 7, usually 6	7
Pigment about anus (Fig. 1)	Strong; without flanking row of melanophores	Strong; without flanking row of melanophores	Very strong; flanked by a row of large melanophores on each side; the two rows convergent backward
Row of spots on scale row below lateral line	Weak to moderate	Moderate to strong	Lacking
Subspecific differences			
Depth of body (Table VIII)	4.0 to 5.4, average 4.57	4.9 to 6.3, average 5.53	6.1
Caudal peduncle: depth into length (Table IX)	1.8 to 2.6, average 2.18	2.1 to 2.9 (2.6 to 2.9 in typical form)*	2.7
Head: depth in length (Table IX)	1.6 to 1.8, usually 1.7	1.7 to 1.9, usually 1.7 to 1.8	1.7
Length of head (Table VIII)	3.6 to 4.3, usually 3.7 to 4.1	3.8 to 4.6 (4.0 to 4.6 in typical form)*	4.2
Lips	Thick; upper lip not overhung by snout	Thin; upper lip definitely overhung by snout, as in *Hyborhynchus*	As in *C. t. parviceps*
Snout	Less gibbous	More gibbous (especially in typical form)	As in *C. t. parviceps*
Lateral band on snout	Weak	Stronger	Strongest
Distribution (Map 2)	Arkansas River system in southeastern Kansas, southwestern Missouri, eastern Oklahoma and extreme western Arkansas	Southward-draining streams of the Ozark Upland in southern Missouri and Arkansas from St. Francis River to Red River	Castor River, tributary to Mississippi River, southeastern Missouri

* See also Table X, p. 37.

TABLE VII

SCALE COUNTS IN *Ceratichthys*

	Scales above Lateral Line					
	5	6	7	8	No.	Ave.
C. perspicuus	.....	1	93	33	127	7.25
C. vigilax	.....	3	49	32	84	7.35
C. t. tenellus	4	47	1	.....	52	5.94
C. t. parviceps	1	17	1	.....	19	6.00
C. callarchus	.....	.....	1	.....	1	7.0?

	Scales along Lateral Line									
	37	38	39	40	41	42	43	44	No.	Ave.
C. perspicuus	1	3	2	12	9	8	.....	1	36	40.50
C. vigilax	1	4	2	3	5	3	3	.....	21	40.33
C. t. tenellus	2	10	13	11	8	1	.....	.....	45	39.36
C. t. parviceps	.....	2	6	6	3	1	.....	.....	18	39.72
C. callarchus	.....	.....	.....	.....	1	.....	.....	.....	1	41.0?

	Scales below Lateral Line				
	4	5	6	No.	Ave.
C. perspicuus	.....	34	2	36	5.06
C. vigilax	1	20	.....	21	4.95
C. t. tenellus	6	38	1	45	4.89
C. t. parviceps	.....	18	1	19	5.05
C. callarchus	.....	1	.....	1	5.0?

Cox, 1896: 362, 400), have recently been shown to have been based on misidentified specimens (U.S.N.M., No. 36228) of *Hyborhynchus notatus.*

3. *Cliola smithii* EVERMANN AND COX = *Pimephales promelas promelas*

The description of this nominal species led to erroneous northwestern records for the genus *Cliola* (= *Ceratichthys*) and to a supposed increase in the number of species of the genus. An examination of the types has led the senior writer to regard *Cliola smithii* as a synonym of *Pimephales promelas promelas.* The literature references are as follows:

Cliola smithii.—Evermann and Cox, 1896: 400–401, 424, 427 (original description; records, South Dakota). Jordan and Evermann, 1896: 253 (after Evermann and Cox). Cockerell and Callaway, 1909: 189; and Cockerell, 1913: 129 (scale structure and other characters; relations).

Ceratichthys smithi.—Jordan, Evermann, and Clark, 1930: 145. Churchill and Over, 1933: 43 (characters).

Ceratichthys smithii.—Schrenkeisen, 1938: 151 (characters).

Pimephales promelas.—Hubbs, 1933: 108 (*Ceratichthys smithi* a synonym).

TABLE VIII

DEPTH OF BODY AND LENGTH OF HEAD IN *Ceratichthys*

	Depth of Body*					Length of Head*				
	perspicuus	*vigilax*	*tenellus tenellus*	*tenellus parviceps*	*callarchus*	*perspicuus*	*vigilax*	*tenellus tenellus*	*tenellus parviceps*	*callarchus*
3.4	1	1	.....	.....	.....	.....	.....	.....	.....	.....
3.5	2	1	.....	.....	.....	.....	1	.....	.....	.....
3.6	1	2	.....	.....	.....	6	3	5	.....	.....
3.7	3	6	.....	.....	.....	22	24	9	.....	.....
3.8	8	5	.....	.....	.....	35	15	16	3	.....
3.9	1	1	.....	.....	.....	24	12	8	4	.....
4.0	7	12	1	.....	.....	19	10	9	6	.....
4.1	8	5	.....	.....	.....	8	4	7	2	.....
4.2	17	12	.....	.....	.....	4	4	3	3	1
4.3	19	9	12	.....	.....	1	2	1	5	.....
4.4	11	6	9	.....	.....	.....	.....	.....	8	.....
4.5	14	2	9	.....	.....	.....	.....	.....	2	.....
4.6	16	3	7	.....	.....	.....	.....	.....	1	.....
4.7	8	6	9	.....	.....	.....	.....	.....	.....	.....
4.8	2	2	3	.....	.....	.....	.....	.....	.....	.....
4.9	.....	.....	1	2	.....	.....	.....	.....	.....	.....
5.0	.....	.....	4	.....	.....	.....	.....	.....	.....	.....
5.1	.....	.....	1	1	.....	.....	.....	.....	.....	.....
5.2	.....	.....	1	6	.....	.....	.....	.....	.....	.....
5.3	.....	.....	.....	2	.....	.....	.....	.....	.....	.....
5.4	.....	.....	1	3	.....	.....	.....	.....	.....	.....
5.5	.....	1†	.....	2	.....	.....	.....	.....	.....	.....
5.6	.....	.....	.....	8	.....	.....	.....	.....	.....	.....
5.7	.....	.....	.....	6	.....	.....	.....	.....	.....	.....
5.8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
5.9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
6.0	.....	.....	.....	3	.....	.....	.....	.....	.....	.....
6.1	.....	.....	.....	.....	1	.....	.....	.....	.....	.....
6.2	.....	.....	.....	1	.....	.....	.....	.....	.....	.....
6.3	.....	.....	.....	1	.....	.....	.....	.....	.....	.....
No.	118	74	58	35	1	119	75	58	35	1
Ave.	4.28	4.18	4.57	5.53	6.1?	3.86	3.85	3.88	4.18	4.2?

* Measurement taken with dividers and stepped over curve of body into standard length.
† Measurement of a flabby type specimen of *Cochlognatus ornatus*.

4. *"Cochlognathus ornatus"* FROM COLORADO = *Notropis deliciosus missuriensis*

Fowler (1924: 404) recorded *Cochlognathus ornatus* from "Colorado," far west of any other record for *Ceratichthys*. As pointed out by Hubbs and Ortenburger (1929*a*: 36), this record was based on specimens of *Notropis deliciosus*.

5. *"Cliola vigilax"* FROM IOWA LAKES = *Pimephales promelas promelas?*

The records of *Cliola vigilax* from West Okoboji, East Okoboji, Spirit, Welch, and Center lakes, Iowa, given by Larrabee (1926: 12, 20, 21) and

TABLE IX

PROPORTIONAL MEASUREMENTS IN *Ceratichthys*

	Caudal Peduncle, Depth in Length					Head, Depth in Length				
	perspicuus	*vigilax*	*tenellus tenellus*	*tenellus parviceps*	*callarchus*	*perspicuus*	*vigilax*	*tenellus tenellus*	*tenellus parviceps*	*callarchus*
1.4	.....	.....	.....	.....	.....	9	5	.....	.....	.....
1.5	.....	.....	.....	.....	.....	52	41	.....	.....	.....
1.6	.....	.....	.....	.....	.....	48	25	11	.....	.....
1.7	7	8	.....	.....	.....	10	4	38	17	1
1.8	20	14	2	.....	.....	.....	.....	9	17	.....
1.9	23	13	2	.....	.....	.....	.....	.....	1	.....
2.0	42	25	15	.....	.....	.....	.....	.....	.....	.....
2.1	12	9	6	3	.....	.....	.....	.....	.....	.....
2.2	7	3	11	1	.....	.....	.....	.....	.....	.....
2.3	4	1	14	3	.....	.....	.....	.....	.....	.....
2.4	2	.....	2	2	.....	.....	.....	.....	.....	.....
2.5	.....	.....	5	4	.....	.....	.....	.....	.....	.....
2.6	.....	.....	1	9	.....	.....	.....	.....	.....	.....
2.7	.....	.....	.....	6	1	.....	.....	.....	.....	.....
2.8	.....	.....	.....	5	.....	.....	.....	.....	.....	.....
2.9	.....	.....	.....	2	.....	.....	.....	.....	.....	.....
No.	117	73	58	35	1	119	75	58	35	1
Ave.	1.97	1.94	2.18	2.56	2.7?	1.55	1.54	1.68	1.75	1.7?

repeated by Potter and Jones (1928: 349) are almost certainly erroneous. Those reports probably refer to *Pimephales promelas promelas* Rafinesque. Reeve M. Bailey, who has recently conducted an ichthyological survey of these glacial lakes of northern Iowa tells us that *Ceratichthys* is apparently entirely lacking there, whereas *Pimephales p. promelas,* not listed by Larrabee, abounds. Furthermore, the distinctive characters ascribed by that author to *C. vigilax* are those of *P. p. promelas.*

6. *"Ceratichthys perspicuus"* FROM LAKE SUPERIOR DRAINAGE = *Rhinichthys atratulus meleagris*

The recent extension of the range of *C. perspicuus* to the north shore tributaries of Lake Superior in Minnesota was based on a misidentification of specimens of *Rhinichthys atratulus meleagris* Agassiz (references given below, under *"Ceratichthys perspicuus"*).

BULLHEAD MINNOW

Ceratichthys perspicuus (Girard)

Hyborhynchus perspicuus.—Girard, 1856: 179 (original description; comparisons; Arkansas River near Fort Smith*); 1858: 231, Pl. 52, Figs. 16–20 (description; comparisons; same material;* generic name misprinted *Hyborhinchus*); 1859*b:* 53 (diagnosis; same material).

* The material designated in this synonymy by an asterisk (*) has been re-examined.

Hybognathus perspicuus.—Günther, 1868: 185 (description, after Girard*).

Ceratichthys perspicuus.—Hubbs and Lagler, 1941: 48, 61 (nomenclature and range, from manuscript of present paper; comparisons; habitat). Surber and Eddy, 1942: 36 (Minnesota). Eddy and Surber, 1943: 143, 148 (characters; range; distribution in Minnesota and Wisconsin—erroneously recorded from north shore streams in Lake Superior drainage of Minnesota*). Hubbs, 1945: 18–19 (status in brief; north shore records based on *Rhinichthys atratulus meleagris**). Gerking, 1945: 16, 68, Map 54 (distribution, ecology, and records in Indiana.)

Hybopsis tuditanus (misidentifications).—Cope, 1866: 381 (not the description; specimens from the Wabash River at Lafayette, Indiana, but not the types from Detroit River* nor the "others from the St. Josephs,"—as shown by Hubbs and Ortenburger, 1929*a:* 37). Jordan and Gilbert, 1877*a:* 2; and Klippart, 1878: 152 (Indiana part of range, "Indiana north").

Leuciscus tuditanus.—Günther, 1868: 259 (Wabash River record only).

Alburnops tuditanus.—Jordan, 1878*b:* 366 (Indiana part of range, "Indiana north").

Cliola tuditana.—Jordan and Gilbert, 1883: 165–66 (Indiana part of range, "Michigan to Indiana").

Hypargyrus tuditanus.—Gilbert, 1884: 200–201 (description; White River near Bedford, Indiana; Illinois).

Cochlognathus biguttatus.—"Cope MSS.," *in* Jordan, 1878*c:* 419 (*nomen nudum;* Texas). Jordan and Gilbert, 1883: 161, 884 (after Cope). Jordan, Evermann, and Clark, 1930: 146. Schrenkeisen, 1938: 154 (characters).

Cochlognathus biguttata.—Cope, 1880: 37–38 (original description; Trinity River, Fort Worth, Texas;* this name is regarded as pre-empted by *Ceratichthys biguttatus* (Kirtland) Girard, 1856: 213). Jordan and Evermann, 1896: 252 (after Cope).

Alburnops taurocephalus.—Hay, 1881: 503 (original description; Chickasawha River at Enterprise, Mississippi*); 1882: 69, 74 (distribution; Mississippi River in Arkansas opposite Memphis, Tennessee,* and in Louisiana or Mississippi near Vicksburg,* Mississippi; Pearl River system near Jackson* and Yalabasha River near Grenada,* Mississippi).

Cliola taurocephala.—Jordan and Gilbert, 1883: 166 (description).

Ceratichthys vigilax taurocephalus.—Hubbs and Lagler, 1939: 19 (Great Lakes basin; characters). Kuhne, 1939: 50 (Tennessee). Trautman, 1940: 19 (distribution in Ohio; characters).

Ceratichthys taurocephalus.—Breukelman, 1940: 381 (Neosho and Osage river systems, Kansas). Shoup, Peyton, and Gentry, 1941: 69 (records, Tennessee).

Cliola vigilax (misidentifications).—Forbes, 1884: 78 (small streams throughout Illinois; resembles and has been confounded with *Pimephales notatus*). Graham, 1885: 73 (in Kansas list, without records). Jordan and Meek, 1885: 3–4 (synonymy and characters, in part; Des Moines River at Ottumwa, Iowa*). Evermann and Bollman, 1886: 336 (Monongahela River* at Monongahela City and at Lock Nine; Pigeon Creek near Monongahela City). Jordan and Gilbert, 1886: 7, 15, 17 (Poteau River at Slate Ford, Oklahoma,* and Lees Creek near Van Buren,* Arkansas, both in part; Sabine River at Longview* and Trinity River at Dallas,* Texas). Gilbert, 1886: 209 (Neosho River, Oswego, Kansas—perhaps *C. tenellus*). Hay, 1887: 246–47, 249 (*taurocephalus* a synonym; characters; should probably be referred to *Pimephales*). Jenkins, 1887: 94 (Wabash River at Terre Haute, Indiana). Evermann and Jenkins, 1888*a:* 46, 53, 54; and 1888*b:* 112 (Wabash

River at Delphi, Indiana). Henshall, 1888: 78 (O'Bannon Creek, Hamilton County, Ohio). Garman, 1889: 18; and 1890: 143 (Long Lake and Willow and Wood sloughs, on Mississippi River bottoms near Quincy, Illinois). Jordan, 1890: 162 (Wabash River at Vincennes,* New Harmony,* and Mackey's Ferry,* Black Creek at New Harmony, and Big Creek 6.5 miles north of Mt. Vernon,* Indiana). Gilbert, 1891: 147, 152, 154, 157 (Spring Branch at Tuscumbia,* North River at Tuscaloosa,* and tributary of Coosa River at Attalla,* Alabama; Richland Creek, Pulaski, Tennessee*). Jordan, 1891: 17 (Arkansas River at Wichita, Kansas*). Meek, 1891: 109 (Cedar River basin at Palo and at Cedar Rapids,* Iowa); 1892*a:* 221, 223, 226, 228, 233, 239, 244 (mouth of Mud Creek near Muscatine,* Mississippi River at Davenport, Walnut Creek near Des Moines, Des Moines River at Des Moines and Estherville, Raccoon River at Perry, Beaver Creek near Des Moines, Middle River at Adel, Skunk River at Ames, Iowa River at Iowa City, Cedar River at Palo and at Cedar Rapids,* Wapsipinicon River at Wheatland, and Upper Iowa River at Chester and at Decorah, Iowa); 1892*b:* 12 (Iowa). Call, 1892: 43 (Middle River, Raccoon River at Des Moines, Perry, and Adel; Des Moines River at Des Moines; characters; ecology). Evermann, 1892: 76 (Neches River 14 miles east of Palestine, Trinity River at Magnolia Point,* and Long Lake near Magnolia Point, Texas). Woolman, 1892: 251, 262, 283, 287 (Rolling Fork of Salt River at Boothe, lower Cumberland River near Kuttawa, Blaine Creek near Catalpa, and Little Sandy River, Kentucky). Eigenmann and Beeson, 1894*a:* 86; and 1894*b:* 9 (Wabash River at Delphi, Terre Haute, Vincennes,* New Harmony,* and at Mackey's Ferry,* Raccoon Creek at Mecca, West Fork of White River at Gosport,* East Fork of White River near Bedford, Black Creek at New Harmony, and Big Creek in Posey County,* Indiana). Evermann and Kendall, 1894: 80, 83, 100 (Sabine River at Longview* and Trinity River at Dallas,* also Long Lake, Trinity River,* and Neches River near Palestine, all in Texas). Garman, 1894: 53 (Kentucky, Big Sandy, and Cumberland rivers, Kentucky). Hay, 1894: 204–5 (Posey,* Lawrence,* Carroll,* Owen,* and Vigo* counties, and Vincennes* and New Harmony,* Indiana; appears to prefer clear streams). Meek, 1894*a:* 240; and 1894*b:* 76, 84, 90, 92 (Fort Smith, in part;* White River,* Salado Creek, and Caney Creek, at Batesville; Black River at Black Rock; Arkansas River at Little Rock* and Mulberry; and East Fork of Chadron River at Conway,* all in Arkansas); 1895: 135 (Waterloo, Iowa); 1896: 342, 347 (rocky tributaries of the Poteau, Oklahoma; Arkansas and Poteau rivers at Fort Smith and St. Francis River at Big Bay, Arkansas, in part possibly *C. t. tenellus* and *C. t. parviceps*). Eigenmann, 1896: 254 (Indiana*). Evermann and Cox, 1896: 400, 427 (Floyd River at Sioux City, Iowa; Norfolk Creek at Norfolk Junction, and Elkhorn River at Norfolk Junction and at Ewing, Nebraska). Jordan and Evermann, 1896: 253 (description, range, and synonymy, in part). Moenkhaus, 1896: 160 (Patoka River near Huntingburg,* Indiana). Osburn and Williamson, 1898: 13, 19 (Big Walnut Creek, Franklin County, Ohio). Evermann, 1899: 307 (Angelina River at Michelli* and Neches River at Beaumont, Texas; characters). Jordan, 1899: 54–55 (description; range). Osburn, 1901: 50 (description; O'Bannon Creek in Hamilton County and Big Walnut Creek in Franklin County, Ohio). Large, 1902: 15 (characters; distribution in Illinois). Eigenmann and Beeson, 1905: 128 (reprint of 1894*b*). Meek, 1908*b:* 149 (Indiana*). Forbes, 1909: 386, 396, 402, 417, 428, 437, Map 32 (range; distribution and ecology in Illinois). Forbes and Richardson, 1909: 128–30, Fig. 28 and 2 col. figs. on pl. opp. p. 128, Map 32 (description; biology; Illinois records).

Hahn, 1909: 549 (outlet of Shawnee Cave near Mitchell, Indiana; perhaps *Hyborhynchus notatus*). Meek and Hildebrand, 1910: 266, Fig. 31 (description; range; included without records in list of fishes known to occur within 50 miles of Chicago). Forbes and Richardson, 1913: 521, 526 (Illinois River at Marseilles and mouth of Fox River, Illinois). Hankinson, 1913: 104, 106 (abundance; confined to large streams; Embarrass and Kaskaskia rivers near Charleston,* Illinois). Evermann and Hildebrand, 1916: 443 (Ball Creek near Tazewell* and Clinch River at Walkers Ford,* Tennessee; Chickamauga Creek at Lee and Gordon's Mill, Georgia*). Evermann, 1918: 321, 326, 341 (Clinch River near Clinton* and at Walkers Ford,* Ball Creek near Tazewell,* Stone River near Nashville,* and Richland Creek near Pulaski,* Tennessee; Spring Branch at Tuscumbia, Alabama;* Rolling Fork of Salt River near Boothe, Lower Cumberland River near Kuttawa, Blaine Creek near Catalpa, and Little Sandy River, Kentucky; Chickamauga Creek at Lee and Gordon's Mill, Georgia*). Forbes and Richardson, 1920 (reprint of 1909). Fowler, 1922: 22, 24 (records from Alabama; not mapped). Pratt, 1923: 74 (characters; range). Cahn, 1927: 37 (locally common in Menominee and Ashippun rivers, Waukesha County, Wisconsin;[1] food). Churchill, 1927: 6 (Choteau Creek and James, Vermillion, Big Sioux, Little Minnesota, and Whetstone rivers, South Dakota).[1] Potter and Jones, 1928: 349 (review of Iowa records—those of Larrabee in error). Thompson and Hunt, 1930: 23, 44, 64, Map 16 (characters; habits; records mapped for Sangamon River and East Branch of Salt Fork, Champaign County, Illinois).

Ceratichthys vigilax.—Fowler, 1908: 530 and 1919: 59 (Evermann and Bollman's Monongahela records*); 1924: 404 (characters; Miami [= Wabash] River at Lafayette, Ottumwa* and Amana, Iowa; Carthage, Missouri; Fort Smith, Arkansas). Hubbs, 1926: 26 (may occur in Great Lakes basin). Greene, 1927: 306 (Wisconsin*). Wiebe, 1928: 161 (St. Croix River at junction with Mississippi River, Wisconsin*). Jordan, 1929: 87 (description and range, in part). Jordan, Evermann, and Clark, 1930: 145 (synonymy and range, in part). Coker, 1930: 201 (Mississippi River and Sugar and Price creeks, near Keokuk). Churchill and Over, 1933: 42–43, Fig. 27 (characters; ecology (erroneous); South Dakota[1]). Fowler, 1933: 58 (Lake Charles, Clear Lake at Reeves, Sabine River at Merryville, and 21 miles south of Sulphur, Louisiana). O'Donnell, 1935: 483 (distribution and habits in Illinois). Pratt, 1935: 73 (characters; range). Blatchley, 1938: 56 (diagnosis; Walnut Creek and literature records from Hay, 1894, Indiana). Parks, 1938: 21 (Big Thicket area of east Texas, on basis of records in Evermann and Kendall, 1894*). Schrenkeisen, 1938: 151 (characters and range). Driver, 1942: 271 (characters and range, in part). Fowler, 1945: 233, 366 (records in Georgia—re-identification of *Lythrurus lirus* Fowler, 1935—and in Louisiana; published too late to be added to distribution map).

Pimephales notatus (misidentifications).—Jordan and Gilbert, 1883: 160 and Jordan, 1885: 121 (identification of *H. perspicuus*). Jordan and Gilbert, 1886: 11 (Saline River at Benton, Arkansas*). Evermann and Kendall, 1896: 218 (*H. perspicuus*, in synonymy).

Cochlognathus ornatus (misidenification).—Evermann and Kendall, 1894: 78, 83, 86, 89, 91, 100 (references to *C. biguttatus* only*). Fowler, 1924: 404 (note on types of *C. biguttatus;** description in part).

Hypargyrus velox (misidentifications).—Osburn, Wickliff, and Trautman, 1928: 174

[1] Some doubt is attached to these records (see p. 31).

(Ohio*). Hubbs and Ortenburger, 1929*a*: 36–37 and 1929*b*: 92–93 (*Ceratichthys biguttatus* Cope a synonym; characters; nomenclature; Arkansas River 5.5 miles southwest of Fort Smith*). Hubbs, 1930: 431 (nomenclature; Great Lakes drainage basin in Wisconsin and Lake St. Marys, Ohio).[2] Greene, 1935: 124, 221, Map 51 (Wisconsin records*). Aitken, 1936: 33 (Iowa). Parks, 1938: 21 (Big Thicket area of east Texas, on basis of records in Evermann and Kendall, 1894*). Raney, 1939: 275 (Ohio River drainage of Pennsylvania*).

Ceratichthys velox.—Fowler, 1945: 342–43 (records in Alabama; published too late to be added to distribution map).

Lythrurus lirus (misidentification).—Fowler, 1935: 72 (Armuchee, Georgia; re-identification by Fowler, 1945: 233).

Few of the common species of American cyprinids have had as varied a nomeclatorial history as has this species. Fortunately, we have now traced its nomenclature back to Girard's paper of 1856, almost surely to the first proposal of a specific name. Girard's description and figure of *Hyborhynchus perspicuus* very clearly represent this species, and this identification is confirmed by the type locality (Arkansas River near Fort Smith). The alcoholic type specimens appear to have been lost, but the pharyngeal arches and teeth are still preserved in the National Museum, where they were examined and sketched for us by Leonard P. Schultz in 1941. The formula is 4—4, and all of the teeth are strongly hooked, as in other specimens of *Ceratichthys*. Girard's name *perspicuus* passed unnoticed for more than half a century, after Jordan (1885: 121) synonymized it with *Pimephales notatus*. In this connection we may note that *Hyborhynchus puniceus* Girard (1856: 179; 1858: 232, Pl. 52, Figs. 1–5, 11–15) is obviously a synonym of *Dionda plumbea* Girard (1856: 178; 1858: 228–29, Pl. 52, Figs. 21–25) = *Campostoma anomalum plumbeum* (Girard).

The status of *Hybopsis tuditanus* is treated on pp. 20–21 and in the preceding synonymy. It is properly a synonym of *Hyborhynchus notatus*.

The type locality of Trinity River, Texas, fixes *Cochlognathus biguttata* Cope as a synonym of *Ceratichthys perspicuus*. Cope's types prove on re-examination to have been based on specimens which do not exhibit the nuptial characters, but only *perspicuus* is known from the Trinity River.

Alburnops taurocephalus Hay has properly been treated as a synonym of this species. Until we learned that the older name *perspicuus* applies to the bullhead minnow, we identified this species as *taurocephalus* (for references see synonymy).

That the name *vigilax* has been misapplied to the northern species was made clear by Hubbs and Ortenburger in 1929 and has been abundantly confirmed in the present study. Now it is clear that the name *velox* also belongs with the southern species.

The range of this species was defined by Hubbs and Lagler (1941: 61) on the basis of our Map 1 as follows:

[2] These records are discussed below.

MAP 1. Geographical distribution of *Ceratichthys vigilax* and *Ceratichthys perspicuus,* as indicated by record stations.

Literature reports as well as original records are included, all as solid dots. Nearly all the published records (see synonymies) have been verified by a re-examination of the specimens or have been confirmed by a study of new collections at the same or near-by localities. The status of a few far-northern records is discussed on page 31. The sharpness of the line between the ranges of the 2 species is treated on page 33. The records given by Fowler in 1922, 1935, and 1945 (see Literature Cited and the synonymy of *Ceratichthys perspicuus*) could not be entered on the map.

From the eastern borders of Nebraska and South Dakota and the southern parts of Minnesota and Wisconsin to the Ohio River and its affluents of Indiana, southern Ohio, western West Virginia and Pennsylvania (rare); southeast to the Alabama River system in Alabama and southwest to the Arkansas River system in Oklahoma and the Trinity River system in Texas (avoiding the upper part of the Red River system in Oklahoma and Texas). In the Great Lakes tributaries recorded only once from Lake St. Marys in Ohio and once from southeastern Wisconsin.

Some doubt is attached to the northwesternmost records (those of Churchill, 1927: 6, and of Churchill and Over, 1933: 42–43) for South Dakota. Cahn's record (1927: 37) for the Lake Michigan drainage of Wisconsin needs confirmation, but lies in an area of cross-overs and may well have been correct. The one other record from waters tributary to the Great Lakes, that of Hubbs (1930: 431) for Lake St. Marys, Ohio, is regarded as valid, for it was based on a specimen collected and identified by Milton B. Trautman. He suspects that it was an escaped bait minnow, for the local bait dealers habitually go southward for their supply and fishermen bring in bait from southern Ohio. The one known locality record for this species in the Osage River system of Kansas (Breukelman, 1940: 381), based on material in the Museum of Zoology collected by Breukelman in Jones Pond, Coffee County, no doubt represents an introduction from the Neosho River system.

The preferred habitat of *C. perspicuus* appears to be the sluggish muddy backwaters and bayous of large and medium-sized streams. We have found the species commonest in such habitats along the Mississippi River and Milton B. Trautman reports similar observations in Ohio. In testimony of its avoidance of the main current in the large rivers he wrote, on August 22, 1940, that he had taken only 1 specimen, obviously a stray, from the Ohio River proper.

The distinctive features of this species are brought out in Tables IV–V and VII–IX. In 118 specimens the eye is contained in the head 3.1 to 5.3 times (average, 3.83); the snout, 2.8 to 3.8 times (average, 3.31).

Some local variations, as in depth of body and size of eye, are rather striking, but no clear-cut evidence was found to justify a division of *C. perspicuus* into subspecies.

PARROT MINNOW

Ceratichthys vigilax Baird and Girard

Ceratichthys vigilax.—Baird and Girard, 1853*a:* 391–92 (original description; "Otter Creek, Arkansas" [= Otter Creek, southwestern Oklahoma, as indicated by Hubbs and Ortenburger, 1929*a:* 36 and 43]). Fowler, 1920: 404 (Wichita River, Texas). Ortenburger and Hubbs, 1927: 133 (tributary of Washita River near Dougherty, Murray County, Oklahoma*). Hubbs and Ortenburger, 1929*a:* 35–38 and 1929*b:* 93 (records, Red River system, Oklahoma;* type locality; *Cochlognathus ornatus* a synonym;* characters of *Cochlognathus* those of breeding males). Jordan,

* The material designated in this synonymy by an asterisk (*) has been re-examined.

1929: 87 (description and range, in part). Hubbs, 1930: 431 (nomenclature). Jordan, Evermann, and Clark, 1930: 145 (synonymy and range, in part). Ortenburger and Bird, 1934: 56, 58 (West Carter and East Carter salt plains, Oklahoma*). Driver, 1942: 271 (characters and range, in part).

Leuciscus vigilax.—Baird and Girard, 1853*b:* 248–49, Pl. 14, Figs. 1–4, and 1854*a:* 219–20, Pl. 14, Figs. 1–4 (description; same material).

Cliola vigilax.—Girard, 1856: 192 (references; same material); 1858: 257 (description; same material). Jordan and Copeland, 1876: 147. Jordan, 1878*c:* 423. Jordan and Gilbert, 1883: 169 (description, after Girard; synonymy). Jordan and Meek, 1885: 3–4 (synonymy and characters, in part). Jordan, 1885*a:* 122 (synonymy, including *velox* and *vivax*); 1885*b:* 810 (in part). Jordan and Gilbert, 1886: 19–20, 22–23 (Rio Lampasas at Belton,* Rio Colorado at Austin,* Rio San Marcos at San Marcos,* and Rio Comal at New Braunfels,* Texas). Evermann, 1892: 76 (San Marcos River at San Marcos* and Guadalupe River at New Braunfels,* also Hunter Creek, Big White Oak Bayou, and Buffalo Bayou, near Houston,* all in Texas). Evermann and Kendall, 1894: 67, 69, 73, 75, 80, 83, 86, 100 (references; Otter Creek, "Arkansas"; San Pedro Creek and Leon River* (tributaries of San Antonio River), Lampasas River at Belton,* Colorado River at Austin,* San Marcos River at San Marcos,* Comal Creek* and Guadalupe River* at New Braunfels, also Hunter Creek, Buffalo Bayou, and Big White Oak Bayou, near Houston,* all in Texas). Meek, 1894*a:* 240, and 1894*b:* 89, 92 (references to Girard); 1896: 342 (Flat Creek near Goodland, Oklahoma*). Jordan and Evermann, 1896: 253 (description, range, and synonymy, in part). Cockerell, 1913: 129 (scale structure, from Girard's figure).

Ceratichthys vigilax.—Lamb, 1941: 44 (records, San Jacinto River system, Texas).

Cochlognathus ornatus.—Baird and Girard, 1854*b:* 158 (original description; Brownsville, Texas*); 1859*a:* 46–47, Pl. 35, Figs. 12–17 (description; same material*). Jordan and Copeland, 1876: 147. Jordan, 1878*c:* 419. Cope, 1880: 38 (characters). Jordan and Gilbert, 1883: 161 (description). Jordan, 1885*a:* 121; 1885*b:* 810. Evermann and Kendall, 1894: 83, 86, 89, 91, 100 (references, except to *C. biguttatus;* notes on types of *C. ornatus*). Jordan and Evermann, 1896: 252 (description; Rio Grande). Meek 1904: xxxi, 58 (synonymy and description). Regan, 1908: 163. Fowler, 1924: 404 (note on type of *C. ornatus;* description in part). Jordan, Evermann, and Clark, 1930: 146. Schrenkeisen, 1938: 153–54 (characters). De Buen, 1940: 22 (Brownsville, Texas; "México, on Rio Grande?"). Driver, 1942: 271 (characters; Texas).

Cliola velox.—Girard, 1856: 192 (original diagnosis; San Pedro Creek, tributary of Rio San Antonio, Texas); 1858: 258 and 1859*a:* 51, Pl. 31, Figs. 21–24 (diagnosis; same material). Jordan and Copeland, 1876: 147. Jordan, 1878*c:* 423.

Cliola vivax.—Girard, 1856: 192 (original diagnosis; Leon River, tributary of Rio San Antonio, Texas*); 1858: 258, and 1859*b:* 55 (diagnoses; same material*). Jordan and Copeland, 1876: 147. Jordan, 1878*e:* 423.

Pimephales notatus (misidentifications).—Jordan and Gilbert, 1886: 20 (Rio Colorado at Austin, Texas).[3] Evermann and Kendall, 1894: 80, 83, 91, 100 (in part; Rio Colorado at Austin).[3] Meek, 1908*a:* 154 (Río Sabinas, at Sabinas, Coahuila*).

[3] Jordan and Gilbert recorded both *Pimephales notatus* and *Cliola vigilax* from the Colorado River at Austin, Texas, but there are no other records of *Hyborhynchus notatus* from Texas, and this species has not been included in extensive recent collections from that state. It is thought, therefore, that the Texas record of *P. notatus* was based on part of the material of *C. vigilax* collected at Austin.

The status of this species was elucidated by Hubbs and Ortenburger (1929 : 35–38), who showed that *Cochlognathus ornatus* was based on nuptial males of the true *Ceratichthys vigilax*. It has since become evident that the types of *Cliola velox* and *Cliola vivax* must also have been specimens of the southwestern species, since they came from well within the exclusive range of that form (Map 1). The northern form, therefore, cannot take either name, *vigilax* or *velox*. As indicated on p. 29 it is properly called *C. perspicuus*.

Ceratichthys vigilax and *C. perspicuus* are allopatric species, which differ trenchantly only in the characters of the nuptial males. Throughout the wide range of *perspicuus* the males develop 2 rows of tubercles around the snout, whereas *C. vigilax* has but 1 row of 5 tubercles (p. 16). Fortunately, it is possible to discern the tubercle pattern in unripe males and even in large females, by using strong magnification and bright illumination while a jet of compressed air is directed on the position of the nuptial organs. Geographically, the distinction is a very sharp one, for all tuberculate specimens from the Trinity River system have biserial tubercles, and are, therefore, *C. perspicuus,* whereas all from the immediately adjacent San Jacinto and Brazos systems, as well as from all streams thence southwestward to the Rio Grande system have only the 1 row of pearl organs. *C. vigilax* also occupies the entire Red River system within Texas and Oklahoma, and here again specimens from across the stream divides, in the Arkansas and Trinity systems, have 2 rows of tubercles.

This distributional pattern suggests that the parrot minnow formerly occupied the entire Red River system and all streams to the southwestward, but that the bullhead minnow, perhaps with floodwaters, extended its range, from the Mississippi River as far as the lower Red River and other waters to and including the Trinity River in Texas. As it became established in the new waters *C. perspicuus* probably extirpated *C. vigilax,* either through competition or through hybridization. It is not evident whether the 2 forms are capable of natural intergradation, for no intermediate or mixed populations are known. If intergradation occurs, it must be in the middle part of the Red River or near the mouth of the Trinity River. No critical material from the mouth of the Trinity is at hand, but from farther upstream all specimens showing tubercles are clearly *perspicuus.* All tuberculate fish from the upper Red River system, in Oklahoma and Texas, are *C. vigilax,* but the one critical specimen from the Red River in Arkansas (Map 1) is referable to *perspicuus.*

The further striking difference between breeding males of *perspicuus* and *vigilax,* in the structure of the jaws (Table V), makes one wonder whether the 2 forms will be found capable of intergrading. Since the known trenchant differences between the forms are confined to the nuptial males, intergradation may prove difficult to test.

The eye in *C. vigilax* averages slightly smaller than that of *C. perspicuus* in specimens of like size and sex, but contrary to the indication by Hubbs and Ortenburger (1929: 37), the difference does not provide a reliable criterion for identification. In 79 subadult to adult specimens of *C. vigilax* the length of the eye enters the head length 3.3 to 5.6 times (average, 4.04), whereas in 118 of *C. perspicuus* the proportion varies from 3.1 to 5.3 (average, 3.83). The eye becomes smaller with age, particularly in the larger males, and furthermore exhibits marked though irregular geographical variation. In other proportions the 2 species appear to agree. The snout length in 77 specimens of *C. vigilax* enters the head length from 2.8 to 3.7 times (average, 3.30).

On the average *vigilax* differs from *perspicuus* in the larger number of radii on the scales (Table I), but the number varies locally in *vigilax* (Table II). In the Brazos and San Jacinto systems, where the range of *vigilax* abuts that of *perspicuus,* the radii are not very much higher in *vigilax* than in *perspicuus,* and the frequencies overlap so widely as to render this character of very little value in the identification of single specimens. A gene flow may be indicated.

In the average number of scale radii there is a marked difference between the obviously long separated races of *C. vigilax* that respectively occupy the upper Red River system and the Brazos and San Jacinto drainage basins (Table II). By maximizing the differences in the frequencies for the counts of radii, within each 10-mm. size class, that is, by fixing lines so as to give the sharpest separation, it is indicated that 81 per cent of the Red River specimens are identifiable as of that form and that 77 per cent of those from the Brazos and San Jacinto waters are typical of that race. Since a percentage identifiablity of 75 for each form is conventionally regarded as the approximate lower limit for the separation of subspecies, we might distinguish these 2 races of *C. vigilax* subspecifically—if they were the only races known. We find, however, that intermediate races inhabit the stream systems south of the Brazos. Subspecies separation on the basis of scale characters therefore appears unwise, and no other characters seem more trenchant.

MOUNTAIN MINNOW

Ceratichthys tenellus (Girard)

We find that a second species group of *Ceratichthys* exists. In this group, which occurs in the region of the Ozark Upland, we recognize 2 species, *C. tenellus,* with 2 subspecies, and *C. callarchus.* Since the time of the publications on southwestern fishes by Girard (1856 to 1859) no one has recognized any of these forms. His accounts of *Hyborhynchus tenellus* seem to have been based on the form we call *C. t. tenellus,* and his types came

from within its range, "20 miles west of Choctaw Agency" (approximate location marked by the double circle on Map 2). The specimens are no longer extant, except for one of the pharyngeal arches. This was found by Dr. Leonard P. Schultz to bear 4 well-hooked teeth, indicating that Girard had a species of *Ceratichthys* rather than *Hyborhynchus notatus,* as Jordan thought in 1885. A study of Girard's description, which included a comparison with his *H. perspicuus,* indicates that his *tenellus* was the species with which we associate this name, rather than *C. perspicuus.* More significant features are: the smaller head, contained 5.5 rather than 5.0 times in the total length, "very much depressed, subpyramidal were the snout not rounded"; the depth of the body less than instead of nearly equal to the length of the head; the eye and mouth proportionately large; and the scales large.

The *tenellus* and *vigilax* groups are contrasted in Table IV. The 3 forms recognized in the *C. tenellus* species group are compared in Table VI. Comparative counts and measurements are given in Tables VII to IX.

In form and coloration the species of the *C. tenellus* groups closely resemble *Hyborhynchus notatus.* They may be distinguished from that species not only by the short intestine, silvery peritoneum, and hooked teeth, and by the fewer nuptial tubercles (p. 15) and the lack of a flap at the end of the maxillary in nuptial males, but also by the more shield-shaped (less oval) scales, with fewer radii (Table I) and by the expansion of the upper lip on the mid-line. The members of the *C. tenellus* group differ further from *Hyborhynchus* in the vertical elongation of the black spot at the base of the caudal fin, in the dark lines along the base of the main rays of each caudal lobe (forming with the spot an indistinct vertical bar), in the more distinct dark spot on the dorsal fin, and in the paler ground color, providing a stronger contrast with the dark lines bordering the scale pockets.

NEOSHO MOUNTAIN MINNOW

Ceratichthys tenellus tenellus (Girard)

(Pl. I, Fig. 1; Pl. II, Fig. 1)

Hyborhynchus tenellus.—Girard, 1856: 179 (original description; comparisons; 20 miles west of Choctaw Agency*); 1858: 231–32 (description; comparisons; same material*; 1859*b:* 53 (diagnosis; same material*).

Pimephales notatus (misidentifications).—Jordan, 1885: 121; Evermann and Kendall, 1894: 69, 72, 80, 83, 86, 91, 100; and Jordan and Evermann, 1896: 218 (identification of *H. tenellus*).

Cliola vigilax (misidentification).—Jordan and Gilbert, 1886: 7 (Lee's Creek near Van Buren, Arkansas, in part*). Meek, 1894*a:* 240, and 1894*b:* 90 (reference to Jordan and Gilbert's record*).

* Material designated by an asterisk has been re-examined.

Hypargyrus velox (misidentification).—Hubbs and Ortenburger, 1929*b*: 92–93 (Brazil Creek 3 miles north of Red Oak* and Elk River 7 miles north of Grove,* Oklahoma; 3 rows of tubercles).

The typical subspecies of *C. tenellus* is common in the waters of the Neosho and Verdigris river systems, in southeastern Kansas, southwestern Missouri, and northeastern Oklahoma. Most of the streams it inhabits drain the northwestern fringe of the Ozark Upland, and the hills west and north of the adjoining Cherokee Plains. The 1 record station for the Osage River system of Kansas doubtless represents an introduction from the Neosho system into an artificial pond, in which *C. perspicuus* also was taken out of range (p. 31). It occurs in other tributaries of the Arkansas, in northern and eastern Oklahoma and in extreme western Arkansas. It has frequently been collected with *C. perspicuus,* but in general appears to prefer the tributaries and headwaters, rather than the main streams, which *perspicuus* frequents.

Ceratichthys t. tenellus is obviously a small form. Among the 406 specimens in the Museum of Zoology the largest is 59 mm. long to caudal fin, and few are more than 50 mm. long. The high nuptial male illustrated on Plate II, Figure 1, is only 51 mm. in standard length. This is the 1 known nuptial male of the species. The nuptial characters outlined for *C. tenellus* in Table IV are taken from this specimen and from the subnuptial male holotype of *C. t. parviceps.*

Characters which *C. t. tenellus* shares with other forms of *Ceratichthys* are given in the generic diagnosis (p. 8). Certain features in coloration are described above (p. 35). The important generic and specific characters of the nuptial males have already been stressed, especially in Table IV. Other specific and subspecific differentiae are outlined in Tables I, IV, and VI–X. Counts and proportions other than those tabulated seem to be of little significance. Freshly preserved adults from Fall River, Kansas, showed considerable orange on the rays of all the fins. Within its circumscribed range *C. t. tenellus* is consistent in its characters.

Ceratichthys tenellus: parviceps × *tenellus*

Cliola vigilax (misidentifications).—Jordan and Gilbert, 1886: 7 (Poteau River at Slate Ford, Oklahoma,* in part). Meek, 1894*a*: 240, and 1894*b*: 90 (reference to Jordan and Gilbert's record*); 1896: 342, 347 (rocky tributaries of Poteau River at Poteau, Oklahoma, and Arkansas and Poteau rivers at Fort Smith, in part?).

Small series from the upper Poteau River in Arkansas and Oklahoma and from Horsehead Creek, a direct tributary of the Arkansas River in Johnson County, Arkansas (Map 2), appear intermediate between *Ceratichthys t. tenellus* and *C. t. parviceps* and are interpreted as intergrades. In

* Material designated by an asterisk has been re-examined.

proportional measurements (Table X) as well as in the other differentiating characters (as stated in Table VI) these specimens bridge over the gap between *C. t. tenellus* and the typical race of *C. t. parviceps*. Even greater overlap in proportions would result, had we been able to use fully adult specimens of *parviceps*.

Further intergradation in characters between *C. t. tenellus* and typical *C. t. parviceps* is exhibited by the atypical race of *parviceps* that inhabits the Black and St. Francis river systems in northeastern Arkansas and southeastern Missouri. This race occurs in an area that is rather distinct from the range of either of the extreme forms (Map 2), though still within the boundaries of the Ozarkian fish fauna. In fact the members of this atypical race might be regarded as nongeographic intergrades, on the basis of their intermediate characters. In proportions (Table X) they are approximately like the specimens we call intergrades, except that they rather closely

TABLE X

PROPORTIONAL MEASUREMENTS OF THE TWO SUBSPECIES OF *Ceratichthys tenellus* AND OF THE INTERMEDIATE RACES

	C. t. tenellus (58–61 specimens)	Intergrades (8 specimens)	Atypical *parviceps* (16)	Typical *C. t. parviceps* (16)
Depth of body	4.0–5.4 (4.57)	4.8–5.4 (5.01)	4.9–5.7 (5.38)	4.9–6.3 (5.67)
Caudal peduncle: depth into length	1.8–2.6 (2.18)	2.3–2.7 (2.50)	2.1–2.7 (2.41)	2.6–2.9 (2.72)
Head: depth in length	1.6–1.8 (1.68)	1.7–1.8 (1.74)	1.7–1.8 (1.74)	1.7–1.9 (1.76)
Length of head	3.6–4.3 (3.85)	4.0–4.4 (4.14)	3.8–4.4 (4.03)	4.0–4.6 (4.31)
Length of eye	3.4–5.0 (3.94)	3.5–4.5 (3.86)	3.5–4.0 (3.69)	3.6–4.1 (3.82)
Length of snout	3.0–4.0 (3.46)	3.4–3.8 (3.58)	3.3–3.9 (3.62)	3.1–4.0 (3.61)

approach typical *parviceps* in the especially important character of the slender body. They diverge from *parviceps* proper and approach or at times equal *C. t. tenellus* in the more definite thickening of the lips, in the more nearly to quite terminal position of the upper lip, and in the less gibbous snout.

The intermediacy of the geographically off-center populations of the Black and St. Francis, as compared with *C. t. tenellus* and typical *C. t. parviceps*, may well have an ecological rather than an historical basis. *C. t. tenellus* is a form of the northwestern margin of the Ozark Upland and the hills to the west of the Cherokee Plains, whereas typical *parviceps* is a mountain-stream form of the Ozarks. Since the streams of the Black and St. Francis lie at a lower elevation and have a lesser gradient, the habitat they offer is more comparable to that occupied by *C. t. tenellus*. The occurrence of *C. t. tenellus* in the lower waters of the Poteau River system and of intergrades in the upper waters provides another correlation between habi-

tat and subspecific characters. These interpretations confirm recently obtained indications that ecology often plays a more significant role than geography in the speciation of fresh-water fishes (Hubbs, 1940: 198–202; 1941: 185–87).

The St. Francis–Black race is represented in the University of Michigan Museum of Zoology by numerous specimens, ranging in standard length up to 52 mm., from the localities in Missouri spotted on Map 2. The record for northeastern Arkansas is for a specimen from Old River near Greenway, recorded by Meek and now in the Chicago Natural History Museum. The dot on the Fourche la Fave River, 11 miles south of Waldron, Arkansas, is for a young specimen recorded by Hubbs and Ortenburger, and now in the University of Oklahoma Museum of Zoology (for references see following synonymy).

SLENDER MOUNTAIN MINNOW

Ceratichthys tenellus parviceps, new subspecies

(Pl. I, Fig. 2; Pl. II, Fig. 2; Fig. 1A)

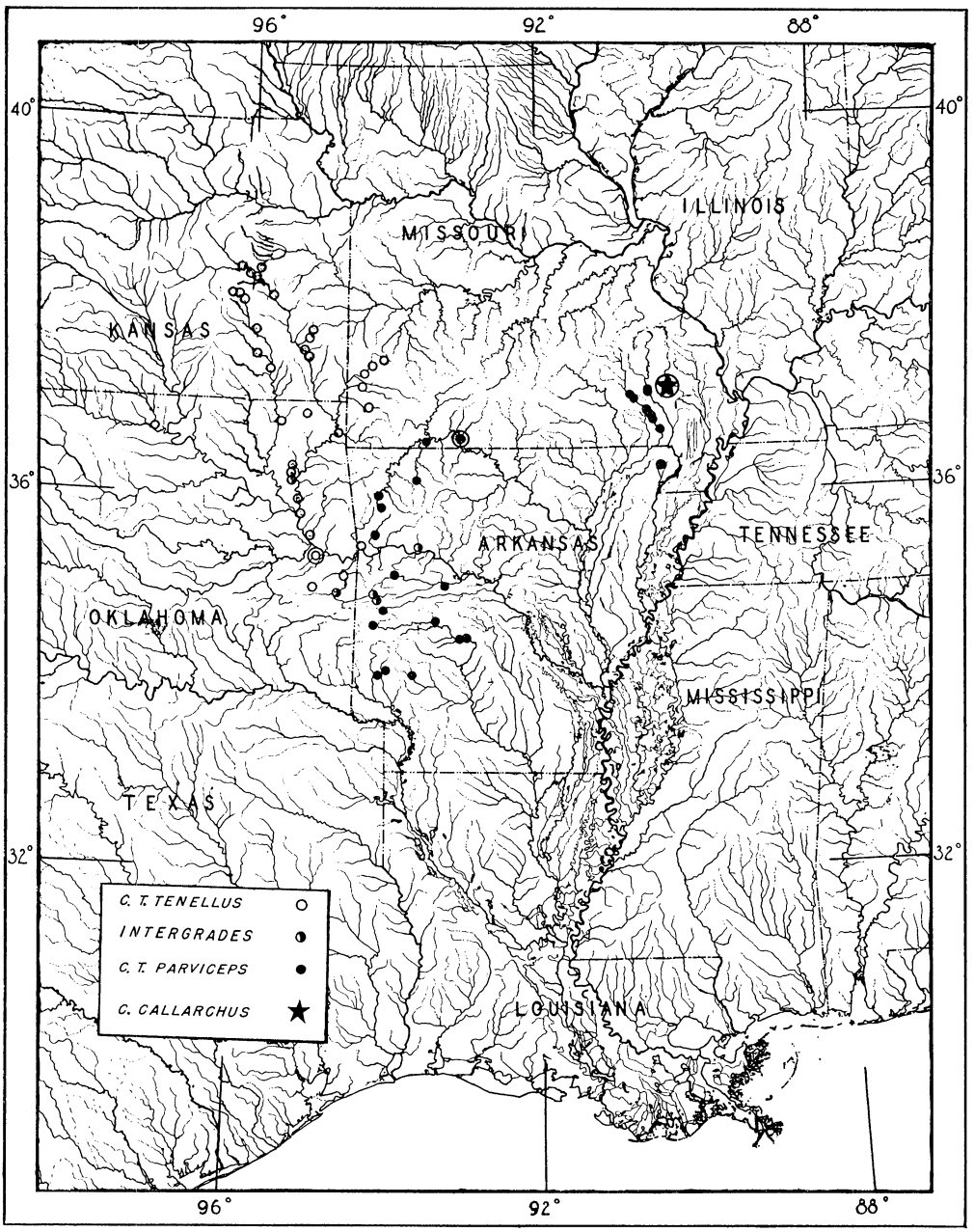
Cliola vigilax (misidentification).—Meek, 1896: 347 (Old River about 10 miles east of Greenway, Arkansas*).

Hypargyrus velox (misidentification).—Hubbs and Ortenburger, 1929*b*: 92–93 (tributary of Ouachita River, 6 miles north of Mena* and Fourche la Fave River 11 miles south of Waldron,* Arkansas; characters of young, like *Hyborhynchus*).

Typical populations of this subspecies inhabit Ozark streams in the upper White River system in Arkansas and extreme southern Missouri, and in headwaters of the Arkansas, Ouachita, and Red river systems in west-central Arkansas (Map 2). An aberrant race, approaching *C. t. tenellus,* occurs in the St. Francis and Black river systems. It is discussed above, along with the more conventional intergrades between the 2 subspecies. The typical habitats are provided by moderate-sized streams with a good gradient. Clean, cool water, gravel bottom and weed-beds appear to be preferred.

TYPE MATERIAL.—The holotype, University of Michigan Museum of Zoology No. 142073, is a subnuptial male 51.5 mm. long to the caudal fin. It was collected during the state fish survey by George V. Harry in White River 3 miles south of Kissee Mills, Taney County, Missouri, on August 4, 1940. Paratypes from the White River in Missouri comprise 2 specimens, University of Michigan Museum of Zoology No. 142074, collected with the holotype, and another (U.M.M.Z. No. 142009) which was seined by a survey party of the Missouri Conservation Department near Baxter, Stone County, on June 24, 1942. All other paratypes were obtained in Arkansas, and of these lots, all but 2 were seined by the junior author during his state fish

* Material designated by an asterisk has been re-examined.



MAP 2. Geographical distribution of the forms of the *Ceratichthys tenellus* group.

All records are based on specimens examined. The type localities are encircled.

survey in the summers of 1938 and 1939. Data follow for the Arkansas paratypes, with U.M.M.Z catalogue numbers and, in parentheses, the number of specimens: 81048 (1) Fourche la Fave River, 11 miles south of Waldron, Scott County, collected by University of Oklahoma Museum of Zoology expedition on July 3, 1927; 123004 (2), Booneville Creek near Booneville, Logan County; 123029 (6), pond at Ola, Yell County, near Petit Jean River; 123255 (1), Gulpha Creek at junction with Lake Hamilton, 10 miles east of Hot Springs, Garland County; 123371 (1), Prairie Creek near Murphreesboro, Pike County; 123394 (1), Kings River, 3 miles east of Alabam at Denny Cave, Madison County; 128077 (1), Hole Creek, 15 miles east of DeQueen, Sevier County; 128096 (2), Holly Creek, one-half mile southeast of Dierks, Howard County; 128128 (2), Prairie Creek at Murphreesboro, Pike County; 128404 (1), Frog Bayou, 1 mile south of Mountainburg, Crawford County; 128708 (3), West Fork of White River, 1 mile north of Brentwood, Washington County; 128040 (1, photographed) and 129705 (24), West Fork of White River at Baptist Ford, 1 mile south of Greenland, Washington County; 141984 (1), North Fork of Ouachita River, about 4 miles northwest of Blackville, Garland County, collected by Trut Holder, May 1, 1940. The localities for all of the type specimens are plotted as solid circles on Map 2, but the dots in the Black and St. Francis systems are for the atypical race.

Description of the Holotype.—The body, as shown in Plate II, Figure 2, is markedly elongated throughout, though the holotype is one of the most robust of all the specimens (its depth enters the standard length 4.9 times). The caudal peduncle is particularly long and attenuate; its depth measures 2.6 in its length. The body is proportionally wide; the greatest width enters the head length 1.5 times and equals the distance from the origin of the dorsal to the lower end of the first scale below the lateral line. The dorsal contour is somewhat more arched than the ventral; it is gently convex from the origin of the dorsal fin to the nostril and then descends more abruptly to the tip of the snout, which projects very slightly beyond the upper lip (it projects more conspicuously in half-grown and subadult specimens). As seen from below the approximately semicircular snout projects on all sides around the semioval mouth. In side view the mouth is very weakly oblique, and has a rather strong upward curvature; anteriorly, the gape slopes backward and slightly upward; posteriorly, it slopes backward and downward. The upper lip is very thin at the sides, but is rather markedly expanded near the mid-line, where its maximum width is about one-fourth its length. The width of the head is about one-tenth greater than its depth, which is contained 1.7 times in its length. The average subadult has the head about 0.1 narrower than deep. The length of the short head enters the standard length 4.3 times. Following are proportional measurements

of the head parts, stepped into the head length: eye length, 3.8; snout length, 3.1 (much longer than usual); fleshy interorbital width, 2.8 (about 3.1 in average subadult); length of upper jaw, 3.4 (about 4.4 in some less developed specimens). In the subnuptial male the jaws show only an incipient modification toward the extreme condition exhibited by *C. vigilax*. The internarial flap is conspicuous, as it is in other members of the genus. The width of the isthmus is contained 4.5 times in the head.

The thin scales number 6—40—5. Those in the dark predorsal strip are markedly reduced in size, numbering about 32 (maximum count) along the midline, although only 22 dorsolateral rows intervene between the shoulder girdle and a point below the origin of the dorsal fin. Around the narrowest part of the caudal peduncle there are 15 rows, 7 above and 6 below. The breast is scaleless.

Fin ray counts follow: dorsal, 8 principal, 9 total; anal, 7 principal, 9 total; caudal, 19 principal; pectoral, 14—14; pelvic, 8—8. The dorsal fin has its origin over the end (often over the middle) of the pelvic base, midway between the base of the caudal and the front of the nostril. The length of the depressed dorsal is contained 1.4 times in the distance forward to the occiput (about 1.6 times in less developed specimens). The anal, as usual in the subfamily, is a small squarish fin, the length of which, when depressed, is contained 1.4 times in the head (the anal of less advanced specimens is a rounded fin, with a depressed length that enters the head about 1.8 times). The upper caudal lobe is about one-tenth shorter than the head. The pectoral fin extends about two-thirds the distance to the pelvic insertion and enters the head 1.3 times. The length of the pelvic fin is contained 1.3 times in the distance from its insertion to the origin of the anal, and 1.8 times in the length of the head.

The narrow but rather conspicuous dark lateral band on the body follows the lateral line anteriorly, then runs immediately above the lateral line on the posterior part of the trunk, finally descending on the caudal peduncle to a position immediately below the axis. In the subnuptial male the band is somewhat reduced in conspicuousness, because the general body surface is also darkened. The band is somewhat dilated posteriorly and fades out in advance of the basicaudal spot. In other specimens the band ends abruptly at the light bar preceding the caudal spot. This spot lies on the base of the caudal rays and is somewhat expanded vertically. Together with the dusky color on the extreme bases of the caudal rays this spot forms a dark streak around the base of the caudal. In half-grown fish this basal streak is much weaker. The tail fin is also darkened on the interradial membranes, where the nuptial male is presumably black, but is clear of pigment on the upper and lower edges, including the anterior extensions. This color contrast is evident on close inspection in the half-grown, and

no doubt becomes sharper in fully nuptial males. In another approach toward the nuptial condition the holotype shows a light vertical bar just beyond the black basal spot. The dusky spot of the dorsal fin, near the front margin close to the base, is conspicuous and rather large in the subnuptial male holotype, and occurs on the membranes as well as along the rays, but in subadults is represented merely by streaks along the subbasal parts of the anterior rays. The front margin of the dorsal is clear of pigment. The extreme base is black posteriorly but clear anteriorly. A dusky blotch immediately precedes the dorsal fin and a very fine streak, requiring magnification to follow, runs from this spot to the occiput. The anal fin shows some blackening where the nuptial male is presumably black, but the front edge is clear of pigment and the outer edge light. The pectoral fin shows some blackish edging along the main rays, and in the subnuptial male the swollen interradial membranes are blackened, so that the darkened major part of the fin contrasts strongly with the broad whitish outer edge. No doubt this contrast becomes sharper in fully nuptial males, as it does in *C. t. tenellus*. In the subnuptial male the pelvic fin is blackish in a triangular area toward the base and toward the clear outer edges, but in less developed fish is clear throughout.

The general color of the body approaches the almost uniform black of the breeding male, as is seen in the one fully nuptial male of *C. t. tenellus* (Pl. II, Fig. 1). The body is dusky except on the lower surfaces of the head and trunk, and even in these inferior regions small melanophores are appearing. The sooty sides of the head, over the cheeks as well as the opercles, are separated sharply from the dusky body by a bright, melanophore-free crescent along the border of the gill opening. The dark color of the back merges into that of the sides. The dark margins of the scale pockets are conspicuous and are particularly broad on the back posteriorly. On each scale of the sides, at the apex of the border, the pigment is intensified to form a spot, and these spots are aligned into lengthwise streaks. The light areas bounded by the dark scale-pocket margins are dusted with melanophores, except posteroventrally. There is a nearly black band on the side of the snout, and some especially large melanophores on the upper part of the opercle, but otherwise the lateral band of the head is suffused into the general dark color.

Other specimens not showing nuptial male characters, are much lighter in general body color. The example shown in Plate I, Figure 2, may be described as follows: The back is dusky, becoming rather clear just above the lateral band. The dark margins of the scale pockets are rather broad on the back, about the very light scale centers. Just above the lateral line the scale borders are faint, but those of the lateral line row and the first row below on the trunk (except for the lower ends) are more conspicuous.

The lateral line pores on the trunk have blackened edges, which form rather conspicuous spots near the head. There is a parallel row of fainter spots along the middle of the scales of the row below the lateral line on the trunk. The lateral band is continued forward on the sides of the head as a cluster of large melanophores on the opercle, as a small patch of scattered specks behind the eye, and as a rather definite dusky bar across the side of the snout before the orbit. Below the band the head, including the lips, is clear, as are the lower surfaces of the trunk.

Conspicuous melanophores form a small blotch or streak on each side of the anus, and the base of the anal fin is markedly blackened (Fig. 1A), but the striking V-shaped mark of *C. callarchus* is lacking. The anal and caudal fins are connected by a very narrow stripe consisting chiefly of 2 rows of small melanophores.

The range of variation of this subspecies, as exhibited by the 16 specimens of the typical race that were counted and measured, is presented in Tables IV and VI to X. Variation in the number of scale radii is indicated in Table I. In these tabulations typical *parviceps* is compared with other species of the genus, with the aberrant race inhabiting the St. Francis and Black river systems and with intergrades between *C. t. parviceps* and *C. t. tenellus*.

The name *parviceps* is from *parvus*, "small," and *ceps*, "head."

CASTOR MINNOW

Ceratichthys callarchus, new species

(Pl. I, Fig. 3; Fig. 1B)

This species is known only from the holotype, U.M.M.Z., No. 139613, a subadult specimen 39 mm. long to caudal fin, collected on July 30, 1941, in Castor River, Bollinger County, Missouri, by Aden C. Bauman of the Missouri Department of Conservation. This stream enters a low, flat area, the Southeastern Lowland of Missouri, which is now drained by a large number of ditches, between the St. Francis and Mississippi rivers. It was formerly tributary to Little River, which drained sluggishly through Big Lake into the St. Francis River in Arkansas, with a direct outlet into the Mississippi in the "Bootheel" of Missouri. Now the waters of the Castor are led at normal water levels through the Headwater Diversion Ditch into the Mississippi just south of Cape Girardeau, Missouri. In great floods, however, the Mississippi flows across the lower Castor, occasionally as far westward as the St. Francis and Black rivers. A tongue of the lowlands, with cypress trees, extends up the Castor to beyond the point of collection, which was near the mouth of Bear Creek, south of Highway 34, in Section 20, Township 29 North, Range 8 East. These physiographic data were kindly imparted by Mr. Bauman.

It is presumed that this fish was a stray from some habitat in the hill section of Castor River. Reasons for so thinking are: (1) the species was not taken in very thorough seining in the river downstream, near the point of diversion, nor in any of the lowland channels and ditches which were successfully fished; (2) the minnows of the *C. tenellus* group are upland fishes; and (3) the Castor River has a distinctively Ozarkian fauna quite unlike that of the ditches of the Southeastern Lowland of Missouri. *C. callarchus* is undoubtedly closely related to *C. tenellus,* and is to be included among the Ozarkian elements in the Castor River fish fauna.

It is possible, however, that the changes in the streams of southeastern Missouri, resulting first from the great subsidence that accompanied the New Madrid earthquake of 1811–12 (Meek, 1896: 344) and subsequently from very thorough artificial drainage, may have brought *C. callarchus* close to extermination. It did not appear in three collections made farther up the river nor in a large collection from near the point of diversion, already mentioned, nor in a series from the old channel of Castor River still farther down.

The collector informs us that where the type specimen was seined the Castor River was a succession of swift riffles and of long pools as deep as 8 feet. There were dense marginal beds of *Dianthera* along the riffles. The bottom was of gravel and sand.

Ceratichthys callarchus differs from its close relative *C. tenellus* most strikingly in the V-shaped pattern of large melanophores whch diverges forward from the anal base, extending to opposite either side of the especially large and deep-black region about the anus (Fig. 1). The pigmentation of this region has proved to be a very constant and valuable character in the distinction of American Cyprinidae. Thus, the patch of black pigment about the anus is one of the surest means of distinguishing *Notropis volucellus volucellus* from *N. deliciosus stramineus* (Hubbs and Lagler, 1941: 52). *Ceratichthys perspicuus* and *C. vigilax* differ from all members of the *C. tenellus* group in the almost complete lack of melanophores near the anus.

Another probable difference between *C. callarchus* and all races of *C. tenellus* lies in the number of scales above the lateral line. In the type of *callarchus* 7 full-sized scales intervene on each side between the first dorsal ray and the lateral line scales. In *C. tenellus* the number is 5 to 7, usually 6. When, rarely, 7 rows are counted in *tenellus,* the scale nearest the origin of the dorsal is usually reduced in size. In other characters *C. callarchus* is most like typical *C. tenellus parviceps,* the slender, small-headed form of the Ozarks (Table VI).

Description of the Holotype.—As shown in Plate I, Figure 3, the body is very attenuate; the greatest depth enters the standard length 6.1 times,

and the least depth is contained 2.7 times in the length of the caudal peduncle. For its depth the trunk is disproportionately wide; the greatest width enters the head length 1.7 times and equals the distance from the

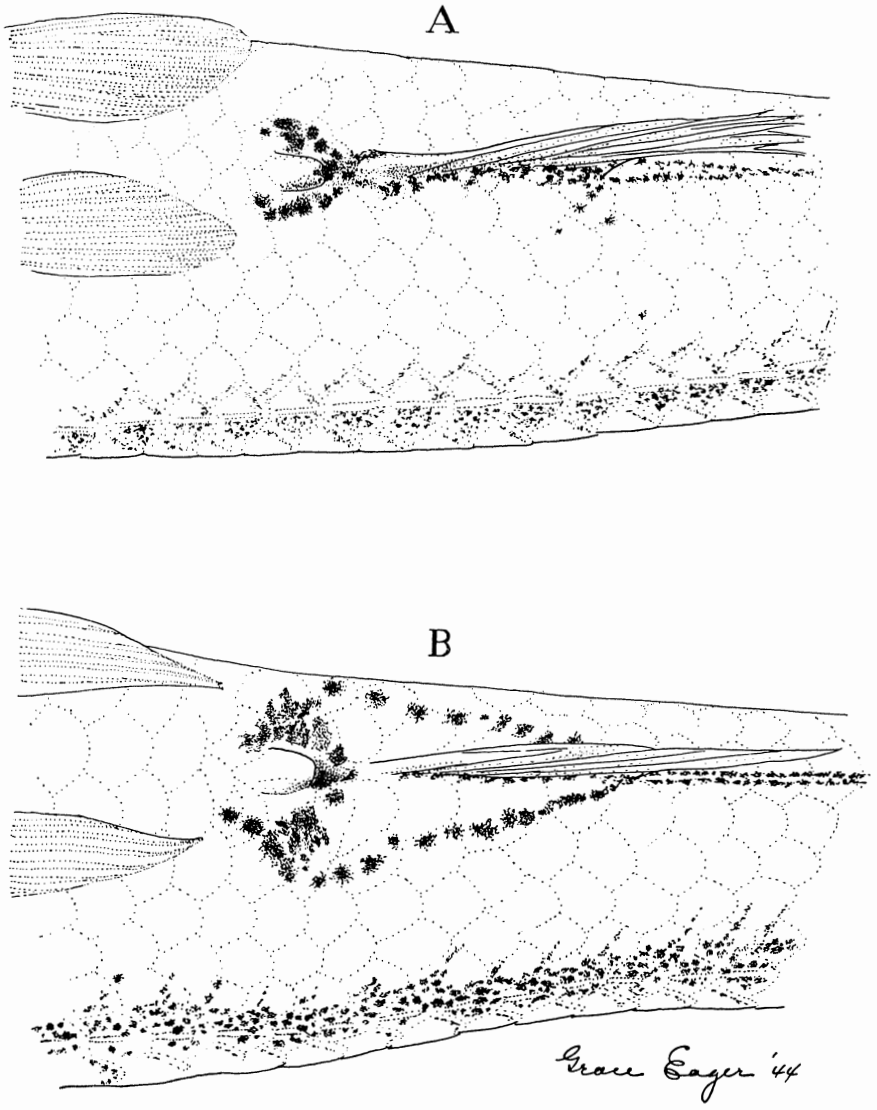


FIG. 1. Pigmentation about anus and anal fin in a subadult specimen of *Ceratichthys tenellus parviceps* (A) and in the holotype of *Ceratichthys callarchus* (B).

origin of the dorsal to the lower end of the second scale below the lateral line. The dorsal contour is weakly arched in the nuchal region, thence nearly straight from the occiput to above the anterior nostril, from which

it descends strongly to a rounded tip that projects slightly but distinctly beyond the upper lip. As seen from below, this snout protrudes more at the sides than it does around the front of the mouth. The mouth is semi-oval with the sides flattened toward the front, where the upper lip is expanded to a width of about one-fifth its length. In side view the gape is horizontal anteriorly and somewhat oblique posteriorly. The width of the head is about one-tenth less than its depth, which is contained 1.7 times in its length. The length of the head steps 4.2 times in the standard length. Following are measurements into the head length: eye length, 3.7; snout length, 3.4; fleshy interorbital width, 2.9; length of upper jaw, 4.3. The internarial flap is conspicuous. The width of the isthmus is contained 7.2 times in the head.

The thin scales number 7—41—5. Those in the dark predorsal strip are much reduced in size, numbering about 30 along the midline though only 20 dorsolateral rows intervene between the shoulder girdle and a point below the origin of the dorsal. Around the narrowest part of the caudal peduncle there are 14 rows, 6 above the lateral line and 6 below. The breast is scaleless. The scales of the mid-sides are somewhat shield-shaped, somewhat higher than long, with a narrow posterior field and a broadly rounded anterior field. The next scale above the lateral line below the dorsal origin has 8 radii (Table I).

Fin ray counts follow: dorsal, 8 principal, 9 total; anal, 7 principal, 9 total; caudal, 19 principal; pectoral, 14—13; pelvic, 8—8. The dorsal origin lies over the end of the pelvic base, midway between the base of the caudal and the internarial flap. The length of the depressed dorsal is contained 1.7 times in the distance to the occiput; that of the depressed anal, 1.7 times in the head; that of each caudal lobe, 1.05 times in the head; that of the pectoral 1.6 times in the interval between the pectoral and pelvic insertions and 1.4 times in the head; that of the pelvic, 1.25 times in the distance to the anal origin and 1.75 times in the head.

A blackish lateral band almost as wide as the pupil extends along the side of the body from the upper end of the gill-opening to just below the middle of the caudal base. The lateral line runs near the top of the band, but dips down toward its lower border near the middle of the trunk. On the urosome the band sends out streaks, running downward and backward along the myocommata. The band is separated by a clear interval from the irregularly shaped, almost jet-black caudal spot. Dusky pigment on the caudal fin near the edge of the body muscles forms a faint curved bar passing through this spot. There is some dark pigment along the edges of the caudal rays, except near the upper and lower margins of the fins. The spot on the dorsal fin is represented in the subadult type merely by dark margins on the subbasal part of the anterior rays. The extreme base of the dorsal is blackened posteriorly, but is clear near the front of the

fin. A diffuse dusky blotch immediately precedes the dorsal, and a very irregular file of melanophores connects this fin with the occiput. The back is dusky down to the broad and irregular light band that lies above the dark lateral band. On the back the scale centers are light (yellowish white in alcohol). On the upper sides the margins of the scale pockets are marked by fine dusky lines. On the anterior part of the trunk these lines extend partly around the first scales below the lateral line scales. The lateral line pores are bordered with blackish. There is no row of specks along the next scale series below the lateral band. The lower surfaces are whitish. The lateral band is continued across the side of the head, as a dense patch on the upper part of the opercle, a smaller and sparser group just behind the eye, and a blackish streak on the sides of the snout. Below this band the head, including both lips, is clear. Black pigment forms a conspicuous mark extending between the anus and the anal fin and in a triangular patch to either side of the peritroct. From near the tip of the triangle on each side a very conspicuous row of large melanophores runs backward to the posterior part of the anal base, the 2 forming a prominent V-shaped mark seemingly diagnostic of the species (Fig. 1B). The base of the anal fin is extensively blackened and a narrow blackish streak, consisting of 2 fine black lines and some intervening specks, runs between the anal and caudal fins.

The name *callarchus,* referring to the very conspicuous and distinctive pigmentation of the anal region, is derived from καλλός, "beautiful," and ἀρχός, "anus."

SUMMARY AND CONCLUSIONS

Ceratichthys, more commonly known as *Cliola,* is a genus of American cyprinid fishes referable to the subfamily Pimephalinae Hubbs, 1926. Although the close resemblance between *Ceratichthys* and *Pimephales* (now divided into *Pimephales* and *Hyborhynchus*) was noted by several ichthyologists, these genera with consistency were widely separated in previous classifications. This error in taxonomic judgment arose from the undue importance that was long placed by systematists on adaptive characters related to nutrition. As in other groups of Cyprinidae and in different families of fishes, the true lines of relationships cut across the divisions that were erected on the basis of such characters. Independent adaptations to an herbivorous diet have been frequent.

The Pimephalinae comprise a very compact natural group, circumscribed by the distinctiveness and the constancy of its specialized characters. This subfamily was probably derived from the Notropinae, from which it differs in a series of characters, exhibited most strikingly or solely by the breeding males. Within the Pimephalinae nuptial characters are also of prime

significance. The taxonomic importance of sexual characters is thus confirmed. *Ceratichthys vigilax* and *C. perspicuus* differ trenchantly only in the characters of the breeding males.

The correlated characters, shape of scale and number of radii, are of considerable importance in the classification of the Pimephalinae. A statistical study, however, demonstrates great individual and racial as well as specific variability in these respects and indicates a wide overlap between the forms. The number of radii increases as the scale grows.

In line with recent interpretations in phylogeny the 8 recognizable forms of the Pimephalinae exhibit different combinations of primitive and specialized features. The subspecies of *Pimephales,* although the most specialized pimephalines in some respects, are indicated as among the most archaic by the index of primitiveness, which is derived by summation from the quantified evaluation for each main character. *Ceratichthys perspicuus* is rated as most primitive by a scarcely significant margin. *Hyborhynchus notatus* ranks as the most specialized. The other kinds show such close compensation in the combination of primitive and specialized characters that their indexes of primitiveness are of the same order of magnitude. In agreement with a principle that is becoming increasingly obvious, all 3 genera of Pimephalinae and also the 2 species groups of *Ceratichthys* appear to have originated independently from near the ancestral base of the subfamily.

The nuptial tubercles are greatly reduced in number in all Pimephalinae, and within the group become fewer but increasingly constant in number and position. A single rectilinear trend, however, is probably not indicated. In the extreme species, *C. vigilax,* the nuptial tubercles are reduced to 5 large cones which develop in constant positions in a single series across the front of the snout. In this species the jaw bones become sharpened and break through the lips, to form biting edges like the teeth of *Diodon.*

Ceratichthys includes not only the previously recognized species, *C. vigilax* (*Cochlognathus ornatus*) and *C. perspicuus* (long known as *Cliola vigilax*), together comprising the much confused *C. vigilax* group, but also a group of three small forms of the Ozark Upland region. These members of the second or *C. tenellus* group are *C. tenellus tenellus,* with a name resurrected from Girard, *C. t. parviceps,* new subspecies, and *C. callarchus,* new species. The groups are differentiated by habitat preference as well as by numerous characters. Between the groups and within the *tenellus* division details of pigmentation are of outstanding significance. Within each group the forms are allopatric. The range of *C. vigilax* has become divided, probably by an incursion of *C. perspicuus.* Presumably in correlation with this isolation some differentiation has resulted. An off-center population of *C. tenellus* is intermediate in characters and in habitat but not in distribution between the 2 subspecies of *C. tenellus.* In the speciation

of this group ecology seems to have played a more significant role than geography—as it has in many Western fishes.

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PLATES

PLATE I

FIG. 1. Nonbreeding adult of *Ceratichthys tenellus tenellus,* 40 mm. in standard length, from Elk River, Delaware County, Oklahoma.

FIG. 2. Nonbreeding adult of *Ceratichthys tenellus parviceps,* 38.5 mm. long, from West Fork of White River, Washington County, Arkansas.

FIG. 3. Holotype of *Ceratichthys callarchus.* All photographs by F. W. Ouradnik.

PLATE I

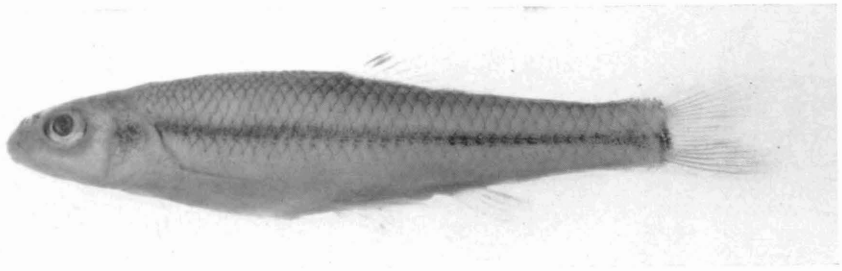

Fig. 1

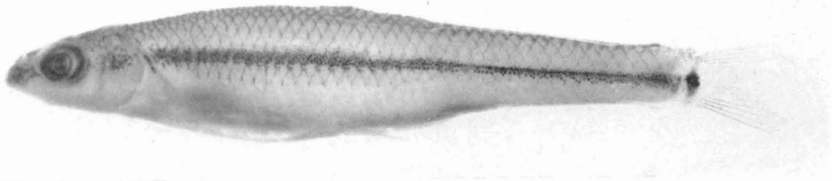

Fig. 2

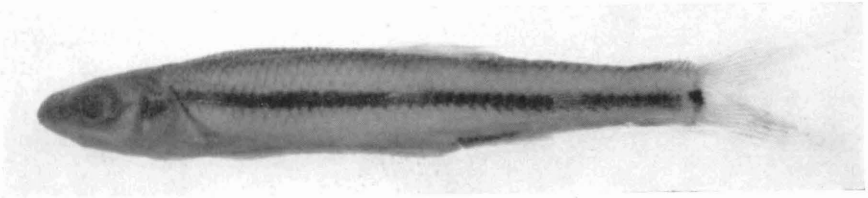

Fig. 3

PLATE II

FIG. 1. Breeding male of *Ceratichthys tenellus tenellus,* 51 mm. in standard length, from Chikaskia River, Kay County, Oklahoma, collected by George A. Moore on May 17, 1940.

FIG. 2. Subnuptial male holotype of *Ceratichthys tenellus parviceps.* Both photographs by F. W. Ouradnik.

PLATE II

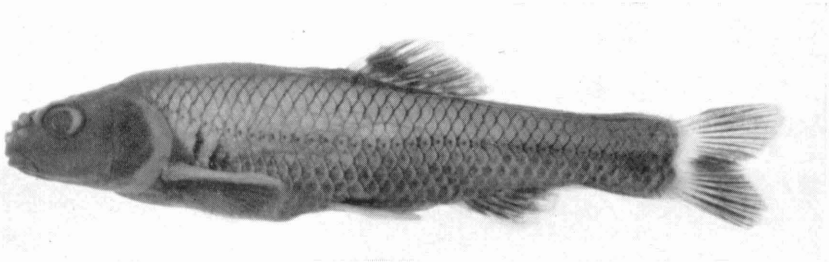

Fig. 1

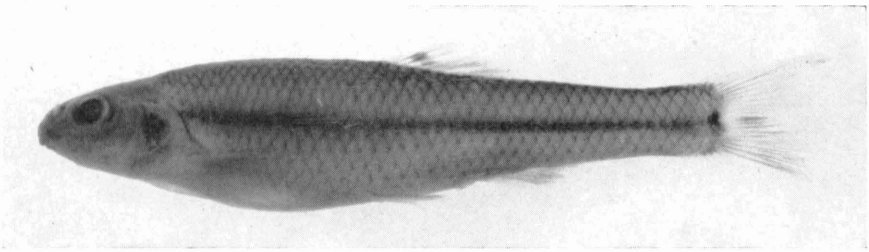

Fig. 2

(*Continued from inside front cover*)

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