VI. THE SCALES OF THE SOUTH AMERICAN CHARACINID FISHES.

By T. D. A. Cockerell.

(Plates XXIII-XXVIII.)

In the Smithsonian Miscellaneous Collections, Vol. 56, No. 1 (1910) I reported on the scales of the African Characinidae. It has been a great pleasure, for which I am indebted to Dr. Eigenmann, the Curator of Ichthyology in the Carnegie Museum, to now examine the scales of the South American species, or at least a considerable number of them. The investigation emphasizes the well-known fact that the American Characinids are not only much more numerous, but also very much more diverse than those of Africa. It further indicates, that

1. The strongly ctenoid Dist’chodontine type of scale is represented only by Ctenobrycon in America. The nearest other approach known to me is found in Luciocharax, which seems to be a sort of connecting link with the Alestines. I know the Luciocharax scale only from a figure.

2. The Hemigrammus type of scale, so abundantly represented in America, is totally wanting in Africa.

3. The African and American series come together in the Alestines, particularly in such types as Chalceus macrolepidotus and Alestes macrolepidotus.

4. The Erythrinines, so far as squamation goes, connect up with the Old World Cyprinids.

5. If Hiodon (which has completely transverse apical circuli) has any relationship with the Characinids, it must be with the Curimatines, although the Serrasalmonine scale is not without resemblances, the system of circuli being about the same. Hiodon tergidus has the fine pustular markings seen in Curimatus spilurus. I figure (Plate XXV, fig. 3) Hiodon tergidus from Wisconsin (Polk County, Graenicher).

6. I cannot at present connect the Catostomids with the Characinids through the scales. Moxostoma aureolum has a very Erythrinine-looking scale, but the apical circuli are entirely transverse.

With regard to the history of the Characinids, the obvious indica-
tions are that the neotropical region is their original home. Africa appears to have been supplied with only a few types, perhaps three or four, at long intervals of time. Whether one or two may have gone by a southern route in very early times, it is now impossible to say; but I do not see why the ancestors of the Hydrocyoninæ might not have arrived via Asia, during the Tertiary, at some period when the northern climate was warm and America and Asia were continuous. The period of immigration into North America and Asia (probably two or three genera only) might have been relatively short, and the chances of finding any fossil remains might therefore be very remote. The close resemblance of the Erythrinine scale to that of Old World rather than New World Cyprinids must surely be significant.

Anodinæ.

Scales not seen.

Curimatinae.

Curimatella alburnus (Müller and Troschel). Scales broad, semi-circular in form, the base strongly pleated and wavy; two more or less imperfect apical radii, far apart; circuli moderately densely transverse in the apical field. This is a quite ordinary Curimatine type; the apical margin is not at all dentate. 

Psectrogaster and Curimatus are figured (cf. Plates XXIII–XXV). The scales in this group are broad, the base approximately straight except for the strong crenulations. There are often two forms of scales on the sides of the same fish, one with the circuli dense, the other with them much less so. The apical radii are variable, but there are often a pair of strong ones (Aphyocharax type), and others weak, or rudimentary. The margin in the scales seen by me is not properly ctenoid, but merely inclined to be toothed between the weak radii. Curimatus, Curimatopsis, and Psectrogaster do not essentially differ in the scales. The weaker type of scale, as in some (immature?) specimens of Psectrogaster, is like the African Citharinus. Citharinus has only the weak system of radii. Gill describes Psectrogaster auratus Gill, from Bolivia, as having the scales all deeply pectinate. The figure of the scales of P. ciliatus (M. & T.) now given shows only wavy irregular teeth, but the specimen is probably immature. The teeth, even if well-developed, would have no resemblance to those of Distichodus, etc., but may be compared with those of Citharidium.

The following species have been studied:
Psectrogaster ciliatus (Müller & Troschel). The character of the scales is sufficiently shown in Plate XXIII.

Psectrogaster curviventris Eigenmann & Kennedy. Scales broad, 3 mm. in diameter or rather more, strongly emarginate or biplicate basally; nucleus slightly below the centre, a broad granular nuclear area in some scales, in others it is circulate practically to the middle; circuli very strong and regular; basal circuli minutely beaded; radii apical only, confined to a couple of parallel rather faint lines (comet-orbit style); upper half of apical field free from circuli, lower half with transverse, not-angled circuli; apical margin very coarsely dentate, the teeth sharp, broad at base. Faint lines show that the marginal teeth have the same origin and character as those of Citharid'ium. One scale shows a parasite.

The principal differences between these scales and those of P. ciliatus, already described, seem to be due to the immaturity of the latter.

Curimatopsis macrolepis Steindachner. The scales have distinct laterobasal angles, and in general closely resemble those of Curimatus spilurus. The dermal pigment-spots are as in C. spilurus. The scales are not ctenoid.

Curimatus spilurus Günther. The characters are well shown in Plate XXV, figures 2 and 4. The scale of this younger specimen is from Rockstone.

Curimatus microcephalus Eigenmann & Eigenmann. A lateral line scale is shown in Plate XXV, fig. 5.

Curimatus moravchannæ Eigenmann. Scales like those of C. spilurus.

Curimatus schomburgkii Günther. Scales of the Curimatine type, the circuli rather coarse. The laterobasal angles are evanescent, broadly rounded much as in P. ciliatus, not evident and produced as in C. spilurus, etc. The apical margin also has a few broad wave-like teeth, as in P. ciliatus. C. schomburgkii, when compared with C. spilurus, microcephalus, etc., is a different-looking fish, with proportionately much smaller scales, which are brilliantly silvery, with hardly any radii. In C. spilurus and microcephalus the radii are very distinct. A young C. spilurus (Plate XXV, fig. 2) has shining scales which closely resemble those of C. microcephalus, while an older one (Plate XXV, fig. 4), though having the characteristic caudal spot, has duller scales with more radii. The older fish is altogether more heavily pigmented, with a strongly dusky caudal fin.
Boulenger has referred *Curimatus* to the Citharininae. I give a figure (Plate XXV, fig. 6) of the scale of the African *Citharinus congicus* Boulenger. It lacks the laterobasal angles of *Curimatus* spilurus, etc.

**Parodontinae.**

*Parodon paraguayensis* Eigenmann (cotype). Scales about 3 mm. broad and high, the apex broadly rounded, the laterobasal angles evident, the basal middle very deeply acutely emarginate; radii very strong, usually four apical and three or four basal, the apical more spreading, the radii are attached to a transverse median bar, which may be very short, or one-third of width of scale, in the latter case becoming zigzag; apical margin with an obscure microscopic very low denticulation; apical field (space between the apical radii) with a very minute vermiform sculpture, its circuli coarse, about twice as widely spaced as the basal, longitudinal, but in the middle becoming oblique, meeting in the middle line at a very acute angle; other circuli (lateral and basal) fine, normal, except that in some scales the circuli in the upper part of the basal area are modified into a fine vermiform or labyrinthine pattern.

*Parodon piracicaba* Eigenmann. Scales larger and broader, but entirely of the same type. The apical circuli meet at a larger angle. These scales are of course of the Alestiform type (cf. Proc. Biol. Soc. Wash., XXIII, p. 146.)

**Hemiodinae.**

*Hemiodus quadrimaculatus* Pellegrin (from Tumatumari) has been examined. The scales are of a Curimatine type with simple base, usually four strong apical radii, no weak radii, no sign of apical teeth. The laterobasal angles are moderately distinct. The basal margin is not crenate. The dermal pigment-spots are relatively large.

*Anisitsia notata* (Schomburgk). The brilliantly silvery scales are considerably larger in the ventral region than in the dorsal, but the sculpture is the same. Latero-basal angles obtuse; nucleus a little basad of middle; circuli fine, transverse in apical field, but usually failing toward the margin; about four to six fine apical radii; basal margin gently convex. All this is practically as in *Hemiodus*.

*Anostomus anostomus* (Linnaeus). Scales shaped as in *Leporinus megalépis* and *L. nigrotaniatus*, with the same strong midbasal
notch, laterobasal angles, etc. Radial system strong, but variable; always a transverse (lateral) radius on each side, directed a little upwards; a pair of apical radii not far apart, or sometimes only one; sometimes two basal radii; polygonal areas sometimes slightly developed. Apical circuli longitudinal, but failing apically. This is not far from the type of *Leporinus megalepis*. It is also strongly suggestive of the African *Petersius*, although the fishes are very dissimilar. Superficially the fish *Anostomus* looks like the African *Neoborus*, which has totally different (ctenoid) scales.

**Prochilodine.**

*Prochilodus rubrotinctus* Schomburgk (Plate XXIV). Large scales, about nine and one-half mm. long and ten mm. broad, the laterobasal angles rounded, the basal middle emarginate, with or without a radius running to nucleus; one to three pairs of lateral radii, more or less joined, U-like at base, and a single apical radius or none, nucleus a little apicad of middle, more or less multiple; apical margin finely irregularly dentate; apical field (bounded by the uppermost lateral radii) with coarse vertical (oblique toward middle) circuli basally, but beyond this the circuli are entirely broken up to form a dense labyrinthine pattern; lateral and basal circuli fine and regular. A remarkable type of scale, representing an early stage in the development of the ctenoid character, combined with an Alestiform radial pattern. So far as the scales go, it must be considered a stem-form.

**Chilodine.**

*Chilodus punctatus* Müller & Troschel (Plate XXVI, fig. 1) was actually referred to *Citharinus* by Cuvier and Valenciennes, but Boulenger places the related *Canotropus* in the Hemiodinæ (Hemiodontinae). The scale is very distinctive. It has indeed the Curi-matoid shape, but a strong transverse line (part of alestiform pattern), and the apical circuli longitudinal, but not reaching the apex, and hence the scale is not ctenoid. This doubtless illustrates the beginning of the development which culminates in such specialized ctenoid scales as those of the African *Xenocharax*. The fact that in this and other genera South America supplies types connecting the extremely different African groups typified by *Distichodus* and *Alestes*, may be taken as an indication that the Characinidæ originated in the Neotropical rather than the Ethiopian region.
Tylobranchia maculosa Eigenmann (cotype). Plate XXVI, fig. 2. The figure shows the form of the scale, which is about six and one-half mm. broad. The radial system is reduced to a single very strong line crossing the scale, as in Bryconamericanus. Base crenate; basal and lateral circuli fine, the latter longitudinal (herein quite different from Bryconamericanus); nuclear field very broadly pustulose; apical field without circuli; apical margin with low teeth. This may also be compared with Tetragonopterus, but the direction of the lateral circuli is entirely different. The closest resemblance is evidently to Chilodus, which must surely be a close relative. In the shape of the scale and the direction of the lateral circuli, there is a curious resemblance to Tilapia nilotica, but the latter has a regular system of fan-like basal radii or grooves.

Gymnocharacininæ.

The single species is unknown to me. It has no scales.

Anostomatínæ.

The scales of Leporinus are of the Curimatoid shape, but usually narrower, with a strong tendency to polygonal areas in the discal region, and a deep median basal notch. The radii are usually distinct, but not numerous. The circuli resemble those of Alestes sadleri, with a consequent slight tendency to apical teeth, as in some Alestes. The relationship with the Alestoids seems evident, in spite of the different habits and important adaptive modifications. The following have been examined:

Leporinus friderici Bloch. Scale shown in Plate XXVI, fig. 3. The photograph is unfortunately too dark to show the polygonal discal areas, with distinct apical and imperfect basal radii leaving them. The apical circuli slope obliquely toward the centre. There is in all this a very strong resemblance to the radial system of the Asiatic cyprinid Barbus pleurotaenia.

Leporinus megalepis Günther. Scales similar to those of L. friderici, but the polygonal areas are less developed, and there are few but strong basal radii.

Leporinus fasciatus (Bloch). Scales rather long, the basal radii imperfect, the apical ones numerous, and the oblique apical radii strong. Thus the scale comes to quite closely resemble that of the Asiatic Cyprinid Cirrhina jullieni.
Leporinus nigrotaniatus (Schomburgk). Scales similar to those of L. fasciatus, but the coarse apical circuli become transverse, forming low broad arches over the large granular nuclear field, but evanescent apically.

**Leporellinæ.**

The single species is unknown to me.

**Nannostomatæ.**

Boulenger places these with the Anostomatinae. The scales of Pacilobrycon and Nannostomus are like those of Leporinus, but with a strong radial system of the type well shown in the figure (Plate XXVI, fig. 4) of *Pacilobrycon ocellatus*. The apical circuli are sub-longitudinal (somewhat oblique), but fail toward the margin. Characidium is entirely different. The following have been studied:

Nannostomus marginatus Eigenmann (cotype). A minute fish, about 20 mm. long. The scales agree with those of *P. ocellatus* (Plate XXVI, fig. 4), except that they are rather broader.

Pacilobryon ocellatus Eigenmann (Plate XXVI, fig. 9). The figure of a specimen from Rockstone, shows the characters well.

Characidium vintoni Eigenmann. A very striking type of scale, quadrate in form, the base gently arched, not crenate or notched, the nuclear area very near the base, about twenty-four long, parallel (somewhat divergent at sides) apical radii, the laterobasal angles approximately at right angles, the relatively coarse circuli running up the sides of the scale, but not invading the field of the radii. With wear, the scales fray out at the apex, and appear dentate. There is, in all, a strong resemblance to the scales of the Gobioniform Cyprinidae, particularly to the genus *Pseudogobio*. The basal radii are variably indicated by extremely fine lines.

Characidium blennoides Eigenmann (cotype). The scales are in general similar to those of *C. vintoni*, but are distinctly triangular, the three sides about equal, the lateral margins convex, the apex very obtuse. The circuli seen in the broad laterobasal fields, are very widely spaced; the apical radii are greatly reduced in number, being only about eight. In some scales the field of the apical radii is very finely longitudinally striate, a sculpture very much finer than the circuli, and apparently having nothing to do with them. In many ways the scales of *C. blennoides* are curiously like those of *Gobio fluviatilis*; among the Characins they show a certain general approach to *Aphyocharax*. 
Pyrrhulina filamentosa Cuvier & Valenciennes has been examined. The form of the scales (with strong laterobasal angles) and their strong and characteristic radial sculpture, are entirely those of the Pacilobrycon-Nannostomus group. The apical circuli are longitudinal, and the apical margin has low and inconspicuous but genuine crenulations. With a high power it is noted that the dense transverse basal circuli in Pacilobrycon ocellatus are moniliform, broken into innumerable short pieces, averaging perhaps twice as long as wide. In Nannostomus marginatus and the Pyrrhulina these circuli are broken here and there, but are essentially entire. Thus, going on the scales alone, we should reach a different classification from that current, as follows:

1. Characidium.
2. Pacilobrycon.
3. Nannostomus.
4. Pyrrhulina.

Aphyocharacinae.

Aphyocharax erythrurus Eigenmann (cotype) is shown in Plate XXVI, fig. 5. The shape resembles that of Pacilobrycon, Pyrrhulina, etc., but the strong radial system is wanting, the radii being really reduced to a long U-shaped figure pointing apically, as the figure well shows. The figure does not show that the base of this U is finely reticulated, and that the field between its arms has a fine longitudinal striation, like that in the interradial field of Characidium blennoides. The widely spaced apical circuli, wholly longitudinal, simulate radii. All this could well be a modification of the Characidium type.

Cheirodon insignis Steindachner was figured in Smiths. Misc. Coll., vol. 56, No. 1, p. 3. It is a much weaker form of scale, with the sculpture evanescent apically.

Crenuchinae.

The two known species have been examined.

Crenuchus spilurus Günther. Scale broad, with the nucleus far basad; apical circuli longitudinal, widely spaced; apical radii about six.

Pacilocharax bowallii Eigenmann. Scale of the same character, but not so broad. Compared with Aphyocharax erythrurus, these scales differ conspicuously by the gently convex base, without the notch.
or bilobation. The nucleus also is more basad, and the radial system is not reduced to a U, though there is a certain tendency for two of the radii to connect and form this figure. The abundant longitudinal circuli in the interradial region distinguish Crenuchine scales from those of *Characidium blennoides*. So far as the scales go, the Crenuchines seem more primitive, or less specialized, than the fishes with which I have compared them.

**Iguanodectinæ.**

The only species is *Iguanodectes tenuis* Cope. The scales are transversely oval, with the broad nuclear area approximately central; circuli basal and lateral only, the latter widely spaced; no radii. This is evidently not far from the condition found in *Cheirodon insignis*. The fish itself is superficially just like some *Menidia*.

**Bryoninæ.**

*Brycon falcatus* Müller and Troschel (Plate XXVI, fig. 6). The large subquadrate scales are about ten mm. long and twelve mm. broad, the exposed part strongly silvery, the rest dull. The silvery part (about the apical third, or a trifle less) is ornamented with numerous (about thirty) radii, which are more or less curved, as the figure shows. This radial field is variably crossed by irregular growth-ridges, which are interrupted at the radii. The other part of the scale is densely covered with the finest possible circuli, except in the broad nuclear field, where the circuli are broken up and form a minutely labyrinthine pattern. The nuclear and adjacent regions present fine irregular cracks, which do not seem to represent degenerate radii. The basal circuli are entirely transverse. This is a very distinct scale.

*Holobrycon pesu* (Müller and Troschel). As in *B. falcatus*, the exposed part (about one-third) is silvery, the rest dull. The scales are about as broad as long (about five mm.), and have evident laterobasal angles. The apical field has a very variable number of radii (six to twelve or more), which extend over about half the length of the scale. The radial field has very distinct though widely-spaced circuli, which converge mesad, but are not far from longitudinal. The other part of the scale has very fine circuli in the manner of *B. falcatus*, but the nuclear modified area is small and rather different, the broken circuli being reduced more nearly to minute spots. This is evidently close to *B. falcatus*, the latter being the more specialized of the two.
Tetragonopterinæ.

A very large subfamily, of which numerous species have been studied.

*Phenacogaster megalostictus* Eigenmann. Very broad scales, about three and one-half mm. broad and only two and one-fourth mm. long. They have basal and lateral circuli, the latter widely spaced; apical field with rather strong growth-ridges, but no circuli; a few (2 to 4 or 5) widely spaced, weak radii. This scale has no resemblance to that of the Bryconinae (*Brycon* and *Holobrycon*), but is like that of *Cheirodon*.

*Deuterodon pinnatus* Eigenmann. Small scales of entirely the same type as the last, but only moderately broad, length about 1.5, breadth 2 mm. or a fraction over. The radii vary from about 4 to 7. The nuclear field, which is subbasal, is microscopically reticulate, this pattern being derived from modified circuli. Exactly the same reticulation may be seen in the scales of *Phenacogaster megalostictus*, but it is not always very distinct.

*Astyanax* Baird & Girard is a very large genus, divisible into *Astyanax* proper and *Pacilurichthys* Gill. The species examined are placed under these headings.

1. *Pacilurichthys*.

*Astyanax polylepis* (Günther). Small scales, broader than long, with rounded outlines, and evident, though broadly rounded, laterobasal angles; circuli basal and lateral, the latter widely spaced; nuclear area broad, with microscopic reticulations as in *Deuterodon*; apical field with six or seven widely spaced radii, and no regular circuli, but the compound microscope shows numerous broken rudiments, slanting toward the middle line. This is certainly close to *Deuterodon*.

*Astyanax abramoides* Eigenmann. Scales not unlike those of *A. polylepis*, but the circuli are more dense and regular, the radii are about four, and the apical field is fully covered with circuli, which meet at a very broad angle in the middle line. The nuclear reticulation is very irregular, and quite distinctive.

*Astyanax bimaculatus* (Linnaeus) (Plate XXVI, fig. 7). Scales large and thick, about six mm. long and seven and one-half mm. broad; nucleus very little below the middle, with a minute labyrinthine sculpture, derived from the circuli; circuli extremely fine and dense,
covering the whole scale, meeting at approximately right angles in the middle of the apical field; apical margin very faintly inclined to be crenulate; basal folds quite strong; radii apical, very strong, very variable, about 4 to 10, the arrangement fan-like, the outer ones often curved. A very distinct type of scale, much less like that of *A. polylepis* than the latter is like *Deuterodon*.

*Astyanax potaroensis* Eigenmann. Small transversely suboval scales with the nucleus subbasal and the radii few; the nucleus is reticulate as in *A. polylepis*, and the radial area is covered with widely spaced, largely broken circuli, which meet in the middle line at less than a right angle. This is of the general type of *A. polylepis* and *abramoides*.

*Astyanax mucronatus* Eigenmann. Small broad scales, with nearly the outline of a half circle; obtuse laterobasal angles; basal and lateral circuli, the latter widely spaced; nuclear area minutely squamose; radii usually reduced to two, which are distinct; no circuli in apical field, and the last of the lateral circuli strongly oblique (directed to the margin). This is strikingly different from the other species of *Pacilurichthys*, and approaches the condition of *Cheirodon* quite closely. (Superficially, the fish is much like *Cheirodon*.)

2. *Astyanax* s. str.

*Astyanax mutator* Eigenmann. Small scales, quite of the *A. polylepis* type, the radii about six, the radial field wholly without circuli; lateral circuli widely spaced, the innermost longitudinal, or some even bending over mesad; nuclear region simple, not reticulate.

*Astyanax guianensis* Eigenmann. Scales thin, much broader than long, exactly as in *A. mucronatus*, except that the two especially strong radii are usually more divergent, so that if continued basally to the nucleus they would form a V. The nuclear area has a sort of honeycomb-like reticulation. The fishes *mucronatus* and *guianensis* are much alike.

*Astyanax essequibensis* Eigenmann. Broad thin scales, inclined to be triangular; characters in general as in *mucronatus*, but radii weaker and more irregular. The widely spaced lateral circuli are oblique, directed toward the margin; there are no circuli in the radial or apical field; nuclear area not reticulated, all that is left of the reticulation being a few irregular markings.

According to the scales, the species of *Astyanax* would be classified thus:
1. *bimaculatus*.

2. 

\[ \begin{align*}
(a) \text{polylepis, abramoides, potaroënsis and mutator.} \\
(b) \text{macronatus, guianensis and essequibensis.}
\end{align*} \]

* Bryconamericus *hyphessus* Eigenmann. Small, thin, more or less semi-circular scales, with a very distinct pattern, as well shown in Plate XXVI, fig. 8. A strong curved line goes across the scale; below it are widely spaced circuli, above it no sculpture whatever. The condition strongly recalls certain scales of Clupeids, but there is little resemblance in detail.

*Creatochanes* Günther.

The scales of *Creatochanes* have a characteristic form, well shown in Plate XXVI, fig. 9, and Plate XXVII, fig. 1. The outline is much like that of *Leporinus*. At first sight there seems little or no resemblance to *Bryconamericus*, but closer inspection shows that, as in *B. hyphessus*, the apical area is free from circuli, and the circuli end abruptly at a line passing from the nucleus to the margin. The bounding line, however, is very broadly V-shaped instead of gently curved, and is not marked by anything more than the terminations of the circuli. Another difference is found in the presence of apical radii in *Creatochanes*. According to these characters, *Bryconamericus* could be derived from *Creatochanes*, but hardly the reverse.

*Creatochanes melanurus* (Bloch) (Plate XXVII, fig. 1). The scales have a diameter of about 2½ mm.; there are two strong apical radii forming a sort of U (compare *Aphyocharax*), and occasionally one or two additional.

*Creatochanes affinis* Günther (Plate XXVI, fig. 9). Similar, but the radii evanescent, sometimes wholly absent. In both species the nuclear area is reticulate, with the reticulations more or less broken down, becoming labyrinthiform.

*Creatochanes caudomaculatus* Günther. Scales about four mm. broad, of the same general type, the circuli fine, and the strong radii two to eight, arranged in a fan-like manner. When only two radii are present they usually form a V rather than a U. The nuclear area is broadly ornamented with a minute vermiciform sculpture, consisting of irregular bent and curved short strands, and intermingled dots, with dots also scattered over the basal half of the radial field. All this nuclear sculpture is derived from broken-up circuli; compare the structures in the Cyprinids *Barbichthys* and *Osteochilus*, as figured in Zool. Anzeiger, Sept. 27, 1910, pp. 252–253.
Ctenobrycon spilurus (Cuvier & Valenciennes). Scales transversely long-oval or oblong, about one and one-third mm. long and two mm. broad; nucleus a short distance basad of the middle; radii two, in the form of a V, or one, or none; the whole scale covered with circuli, which are widely spaced except basally, the apical ones practically transverse, but forming a very open angle where they meet in the middle line. A very distinct type of scale, wholly unlike those of Creatochanes, etc.

Ctenobrycon hauxwellianus (Cope). Collected by William James at Ica (Thayer Expedition). Scales thin, transverse, about two mm. long and two and one-half mm. broad, with rounded laterobasal corners; basal and lateral circuli ordinary, but quite widely spaced; apical circuli transverse, but more or less broken, and in the submarginal area thrown into waves, which become strong on the margin, producing an irregular series of short marginal teeth (of the general type of those in Citharidium, but less developed) a few feeble, irregularly placed apical radii. This, the type of Ctenobrycon, has scales which differ considerably from those of C. spilurus; the latter should probably be separated generically or subgenerically, in which case it falls into the subgenus Pacilurichthys.

Hemigrammus Gill.

The small thin scales of this genus are very uniform, and are of the form shown in Plate XXVII, fig. 2, representing H. orthus Durbin, from a drawing by Miss Evelyn Moore. It will be seen at once that this is the Cheirodon type of scale, and has no resemblance to Ctenobrycon, and not very much to Creatochanes, although agreeing in the absence of circuli in the apical field.

Hemigrammus rodwayi Durbin. Scales three mm. broad; apical radii strong, very variable, from three to twelve; nuclear area pustulose in appearance.

Hemigrammus analis Durbin. Scales about one and one-third mm. broad; radii about two to four; nuclear sculpture as in H. rodwayi.

Hemigrammus orthus Durbin (Plate XXVII, fig. 2). Scales about or hardly one mm. broad; radii two, rarely four; nuclear sculpture as in H. analis, but less distinct.

Hemigrammus cylindricus Durbin. Scales about one and two-thirds mm. broad, much rounder than in the other species; radii usually two, sometimes four; nuclear sculpture distinct. The form of the
scales accords with the shape of the fish, which is not nearly so deep-bodied as is usual in the genus.

*Hemigrammus unilineatus* Gill. Scales about one and two-thirds broad; radii usually four; nuclear sculpture as usual; radial area longitudinally striatulate.

*Hemigrammus ocellifer* Steindachner. Scales about one and two-thirds mm. broad, very broad for their length; radii about four to six; nuclear sculpture distinct.

*Hyphessobrycon* Durbin.

The scales are entirely of the *Hemigrammus* type.

*Hyphessobrycon gracilis* (Reinhartd). Scales about one mm. broad; radii usually four; only about three circuli basad of the nucleus, the circuli failing in the middle of the base, instead of becoming crowded as in most scales.

*Hyphessobrycon rosaceus* Durbin (cotype). Scales hardly one mm. broad, but very much broader in proportion to their length than those of *H. gracilis*; circuli very few and widely spaced; radii two, rarely four.

*Hyphessobrycon eos* Durbin (cotype). Scales one and one-half to one and two-thirds mm. broad, shape as in *H. gracilis*; radii six to nine.

*Hyphessobrycon stictus* Durbin (cotype). Scales about one mm. broad, shape nearly as in *H. gracilis*; radii usually two, sometimes more. In all these fishes, the deepening of the body is accompanied by a widening of the scales, rather than an increase in the number of rows.

*Pristella* Eigenmann.

Scales also of the *Hemigrammus-Cheirodon* type.

*Pristella riddlei* (Meek). Scales very broad for their length; breadth about one and three-fourths mm.; radii usually four; nuclear sculpture weak.

*Pristella aubynae* Eigenmann. Scales not nearly so broad in proportion to length; radii usually five; nuclear area broadly reticulated, but the network more or less broken.

*Moenkhausia* Eigenmann.

In this genus the circuli appear to be basal and lateral only, as in the *Hemigrammus* series, but the radial field is always minutely longi-
tudinally striate. As in other scales, this striation seems not to be connected with the circuli, but in *M. oligolepis* it is clearly seen to be connected with and derived from the minutely labyrinthine pattern of the broad nuclear area, and this latter certainly results from modified circuli.

The genus may be divided into groups as follows:

(a) Group of *M. oligolepis*.

*Moenkhausia oligolepis* Günther (Plate XXVII, fig. 3). Large scales about six mm. long and seven mm. broad; base strongly bilobate in middle (compare *Leporinus*, etc.); circuli fine; radii very strong, variable, about 5 to 10 apical, and one or two basal; nuclear area broad, little below middle, with a minute labyrinthine or nodulose pattern; laterobasal angles strong.

(b) Group of *M. lepidulius*.

Scales much smaller, the largest (*M. chrysargyrea*) about three and two-thirds mm. broad; pattern quite *Hemigrammus*-like, but with the well-defined apical striation; radii about four to six, arranged fan-wise; nucleus with well-defined pustuloid pattern. The species are so much alike that no separate descriptions seem necessary.

*Moenkhausia chrysargyrea* ( Günther).
*Moenkhausia lepidulius* ( Kner).
*Moenkhausia colletti* ( Steindachner).
*Moenkhausia copei* ( Steindachner).
*Moenkhausia cotinho* Eigenmann.
*Moenkhausia browni* Eigenmann.

(c) Group of *M. dichrourus*.

*Moenkhausia dichrourus* (Kner). Scales agreeing with the *lepidulius* group, except that the radii (4 to 8) are arranged like straight branches of a tree, leaving the main axis (the middle line) at angles of about 45°, only there is no actual median structure from which they arise.

*Moenkhausia grandisquamus* (Müller and Trochel). Scales of the same type as *M. dichrourus*, but even more extreme, most of the divergent radii becoming actually horizontal, transverse to the antero-posterior axis of the scale, the upper ones are more oblique, and all curve at the base, the whole pattern resembling closely an English peach tree trained against a wall. The transverse bars thus formed
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number about three to six on each side. Thus the longitudinal lines in *M. cotinho*, etc., are wholly homologous with the transverse lines in *M. grandisquamis*. *M. grandisquamis* and *dichrous* surely should be separated, at least subgenerically, from the other species examined.

*Tetragonopterus* Cuvier.

*Tetragonopterus chalece* Agassiz (Plate XXVII, fig. 4). Broad scales, the outline well shown in the figure; breadth about four and one-fourth mm. As in *Bryconameripus*, there is a strong line or band across the middle of the scale, and the apical (exposed) field is without any distinct sculpture. The much finer circuli, however, do not stop at the line, but go a short distance above it, especially at the sides. The base of the scale is wavy. The transverse line belongs of course to the radial system, but otherwise there are no radii. The lateral circuli are directed very obliquely toward the margin.

Reviewing the Tetragonopterine scales, it must be said that *Ctenobrycon* stands quite apart. *Tetragonopterus* and *Bryconameripus* may be grouped together, though not very closely related; *Creatochanes*, still more different, may yet be placed in the same vicinity. *Astyanax bimaculatus* may be a stem-form leading toward the more usual *Astyanax* type, which connects with the *Hemigrammus* series, but the latter could not properly include such a form as *A. bimaculatus*. *Hemigrammus*, *Hyphessobrycon*, *Pristella*, *Phenacogaster*, *Deuterodon*, part of *Astyanax*, and *Moenkhausia* may be grouped together. In all about four distinct tribes are apparently indicated, or perhaps the subfamily should be divided.

**Diapomini.**

Unknown to me.

**Stevardiini.**

Not examined.

**Piabucini.**

*Chaleceus macrolepidotus* Cuvier. A fish having the most amazing resemblance to *Alestes macrolepidotus* (Cuvier & Valenciennes) of the River Nile, though on closer inspection important differences are apparent in the structure of the head. The resemblance extends even to the general light straw-color, and the iridescent lilac borders
of the scales. The detailed structure of the scales is also remarkably similar, both having the same coarse longitudinal circuli in the region apicad of the nucleus, while the radial system is little different, except for the well-developed polygonal areas in the *Alestes*. Plate XXVII, fig. 5 shows the scale of *Chalceus macrolepidotus* so well that further description is hardly necessary. With regard to the polygonal discal areas of *Alestes macrolepidotus*, it must be said that they are not wholly distinctive, for the discal region shows some polygonal areas in the *Chalceus*; it is therefore only a matter of degree. As the figure shows, the basal and lateral circuli are extremely fine. Boulenger places *Chalceus* in the Hydrocyoninæ along with *Alestes*.

**Lebiasinæ.**

*Lebiasina bimaculata* Cuvier & Valenciennes (W. Ecuador). Large reddish scales, about six mm. long and broad, the apical field minutely dotted with dark reddish pigment-spots, stellate in form; laterobasal angles strong; basal middle strongly bilobed, emarginate between the lobes; nucleus very slightly apicad of the middle, from it radiate about ten very strong thick radii, normally three apical, three basal, and two on each side widely spreading, forming a V; apical margin not toothed; lateral and basal circuli twice as fine as apical, the latter coarse, vertical, oblique toward the middle, joining at an acute angle. This is not far from *Alestes* in scale-characters; among the neotropical types it is essentially as in the Erythrininæ.

**Gasteropelecinæ.**

*Gasteropelecus sternicla* (Linnaeus). Transversely oval scales, with the exposed part shining silvery-green; nucleus central; radii strong but few, one or two apical, and one on each side (or only on one side) lateral, all meeting in the middle; circuli very dense, but wanting on the exposed part of scale; nucleus with fine labyrinthiform sculpture. Peculiar scales, with a certain resemblance to *Crateochanes*. *Carnegiella strigata* (Gunther). Small scales, formed essentially as in *Gasteropelecus*, but the radii very weak and irregular, and sometimes as many as nine, while the nuclear area is very broadly minutely irregularly reticulated. *Chalcinus rotundatus* (Schomburghk) (Plate XXVII, fig. 6). Quite large scales (about eight mm. broad). The shape well shown in
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the figure, the base strongly bilobed, much as in *Leporinus*. The exposed part is shining silvery-green, and is without distinct sculpture, except for a single median radius, with perhaps rudiments of others. This radius is joined in the centre by others, namely one which continues in the same straight line to the basal notch, and one on each side, which soon branches, giving rise to a lateral V, the lower fork of which usually branches again. The circuli, covering all except the exposed part, are exceedingly dense, and are very largely moniliform, or broken into minute bead-like elements, as in *Scleropages*. The broad area just apicad of where the radii meet is covered with labyrinthine markings. In the region of the nucleus there are numerous scattered translucent spots.

*Chalcinus elongatus* Günther. Smaller, proportionately broader scales, without angles: length about four mm., width slightly over five mm.; structure quite as in *Gasteropelecus*, with the same sort of radii, but often with a fine basal radius. The region apicad of the nucleus, narrowing on each side, so far as the sculpturing goes, is densely covered with labyrinthiform markings, the inner basal circuli become largely moniliform. This is intermediate between *C. rotundatus* and *Gasteropelecus*.

**Stethaprioninæ.**

*Fowlerina orbicularis* (Cuvier & Valenciennes). The scales are entirely of the character and pattern of the *lepidurus*-section of *Moenkhausia*. Apical radii usually three or four, arranged in a fan-like manner.

**Agoniatinæ.**

*Piabucus dentatus* Kohlreuter (British Guiana). Small, transversely oval scales; no radii; nucleus about twice as far from apex as from base; basal circuli fine, close together; apical circuli widely spaced, continuous with basal, meeting in the middle line at about a right angle just above the nucleus, the angle becoming wider and wider apicad, until near the margin it is virtually absent. A characteristic little scale.

**Stichanodontinæ.**

*Stichanodon insignis* Steindachner. (Specific identity not quite certain.) (Collected by William James at Manacapouru, Thayer Expedition.) Scale agrees with that of *Moenkhausia dichrurus*. 
SERRASALMONINÆ.

Pygopristis denticulatus (Cuvier). Scales oblong, not very far from circular, the nucleus a short distance below the middle; the whole scale covered with practically uniform circuli, forming complete circles; no radii. The nucleus is very small, not sculptured. Some of the scales differ by having a very broad, strongly reticulated nuclear field, and the circuli (13 or 14 in all) widely spaced. Intermediate forms also occur. These scales are very closely related in structure to those of Clenobrycon.

Pygocentrus piraya (Cuvier). Small scales with precisely the same characters as those of Pygopristis, and the same variation, except that when the nuclear field is broad and sculptured, the sculpturing is labyrinthine.

Serrasalmo gymnogenys Günther. Again the same type as Pygopristis.

Serrasalmo rhombeus (Linnaeus) (Plate XXVII, figs. 7 and 7a). Again the same, with two forms, as shown in the figures. These scales closely resemble those of Argyrosomus, in the Salmonidae.

MYLÆ.

Myleus rubripinnis Müller & Troschel. Scales exactly like those of the Serrasalmoninae. The circuli very fine and dense in the normal form. Plate XXVII, fig. 8, shows a double scale, a monstrosity.

CYNODONTINÆ.

Hydrolycus scomberoides (Cuvier) (Rockstone, British Guiana, collected by Max Ellis). Scale agrees with that of Myleus rubripinnis, but is larger, and the lateral line scale has a curious system of basal grooves, with four broad Y-like prongs pointing basad, the most lateral reaching the prominent laterobasal angles. The ordinary scales are rounded, without angles. The grooves of the lateral line scales are curiously suggestive of the extinct Chirocentrid genus Cladocyclus.

CHARACINÆ.

Charax gibbosa (Linnaeus) (Plate XXVIII, fig. 1). Very broad scales without angles, as the figure well shows. The structure is like that of the Serrasalmoninae, with however the important difference that the apical region is sharply differentiated, without true circuli, but with fine growth-lines simulating them. Along the transition line, especially mesad, is a fine reticulation. There are no radii. Al-
though the circuli are much less dense, and there are no radii, there is quite a close resemblance to *Chalcinus elongatus*. We seem to get a hint here of how a Serrasalmonine type of scale may be modified into one more characteristic of the S. American Characinidae in general.

*Acanthocharax micropelis* Eigenmann. Scales extremely broad, length about one and one-third mm., breadth about two and one third mm.; sculpture as in *Cheirodon insignis* or *Hemigrammus orthus*, except that the circuli are more numerous, and there are no radii whatever.

**Hydrocynine.**

*Hydrocynus cuvieri* (Agassiz). Small round scales resembling those of the Serrasalmoninæ, but the strong circuli are only moderately dense, and in the apical field are irregular and much wider apart; there are also a few strong radii, more or less in the form of a cross or an X, usually two being basal. The nucleus is central, or nearly so. A distinct type.

The scale of *Luciocharax* was figured by Bean in Proc. U. S. Nat. Mus., 1908. It is entirely different from that of *Hydrocynus*, but is extraordinarily like that of the African *Phractolemus ansorgii* Boulenger. The fishes *Luciocharax* and *Phractolemus* are of course totally different. In the scale of *Luciocharax* we have something wanting in the African Characinid fauna—a connecting link between the Alestiform and Distichodontine types of scale.

**Acestrorhamphinæ.**

*Acestrorhynchus microlepis* (Schomburgk) and *A. falcatus* (Bloch) have small round scales, much like those of the Serrasalmonines, but with the larger nucleus subbasal, and the circuli failing apically, the innermost meeting at a wide angle. Plate XXV, fig. 7 shows *A. microlepis*, drawn by Miss Evelyn Moore.

**Erythrinine.**

These all have a purplish pigment on the exposed part of the scale (very strong and dense in *Hoplias macrophthalmus*); the same sort of thing is seen in *Leporinus* and *Characidium*.

Erythrinine scales are quite large, about as broad as long (broader in *Hoplererythrinus*), the laterobasal angles approximately right angles, the basal margin usually wavy or crenate, the median notch often
deep; nucleus nearly central; apical margin rounded, without teeth; radial system very strong, both basal and apical, the radii meeting at the nucleus; large discal polygonal areas developed in some scales of Hoplerythrinus; lateral and basal circuli fine (much coarser in Hoplerythrinus; finest in Hoplias); apical circuli differentiated, longitudinal, slightly oblique near the middle line.

Hoplias malabaricus (Bloch). Apical radii five or six, counting the sublateral ones; basal about six, the outermost, when complete, arched at upper end.

Hoplias macrophthalmus (Pellegrin) (Plate XXVIII, fig. 2). Large scales, over ten mm. across; apical radii, counting sublateral, about sixteen to eighteen, basal about eight to eleven; outer apical and basal both arched near base when complete. The figure sufficiently shows the arrangement.

Hoplerythrinus unitcaleratus (Spix) (Plate XXVIII, fig. 4). Scales about five mm. long and six broad; about four to eight apical radii, about the same basal, and usually some lateral; large pentagonal areas developed in some scales; apical circuli very widely spaced.

Erythrinus erythrinus (Bloch & Schneider). Scales about three and one-fourth to three and one-half mm. long and broad; sculpture and pattern as in Hoplerythrinus, but fewer radii.

I give a figure (Plate XXVIII, fig. 3) of the scale of the Asiatic Barbus chola, a Cyprinid type which shows in its squamation a strong resemblance to Erythrinus. Here, so far as the scales go, the Characinids and Cyprinids meet, and it is at least significant that this occurs in the Erythrine group on the one hand, and the Barbus-group on the other.

Appendix.

Bryconathiops microstoma Günther (Plate XXVIII, fig. 5). Ksibi River (Bates). British Museum. This African genus was omitted from my paper on the Characinidæ of that continent. The scale is about five and one-half mm. broad with weak sculpture, the broad nuclear region finely pustulose, and the apical field with nothing to represent the circuli, except a sparser pustulose ornamentation, even this failing toward the margin. The radial system is represented by a few irregular polygonal areas, from which arise imperfect and very asymmetrical radii. This is a weak type related to Alestes.

Hydrocyon forskalii Cuvier. (Plate XXVIII, fig. 6.) I give a figure
Prochilodus rubrolacustris.
of this Characinid from the Nile, as it has never been figured, and is the type of Hydrocyoninae, to which Boulenger refers many American genera.

*Sarcoedes odoe* (Bloch). (Plate XXVIII, fig. 7). This African genus is also figured for the first time. It is the only member of a distinct tribe.
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