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NEWS AND NOTES

ANNUAL MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCES

MARTIN R. BRITTAN

The recent national meetings of the American Association for the Advancement of Sciences and its participating affiliated societies held much of interest for ichthyologists and others concerned with fishes. About 7,000 persons registered. Since the titles of papers dealing with fishes are scattered among a bewildering diversity of papers treating of other subjects, we have extracted them from the Association's 348 page general program, and list them below (AFS—American Fisheries Society; ASZ—American Society of Zoologists; ABS—Animal Behavior Society; SSZ—Society of Systematic Zoology; ESA—Ecological Society of America; WSN—Western Society of Naturalists):

Changes in Striped Bass Migrations in the Estuary. HAROLD K. CHADWICK, California Department of Fish and Game, Sacramento, Calif. (AFS)

Movements of Fish and Shrimp in the Salinity Gradient. DAVID GANSSLE, California Department of Fish and Game, Stockton, Calif. (AFS)

Analysis of Locomotory Response to Olfactory Stimulation—Shark and Fish. H. KLEEREKOPER, McMaster University. (ASZ)

Relationships between the Preoptic Olfactory System, Preoptic Nucleus, and Hypothalamic Neurosecretion in Fish. AUBREY GORBMAN, T. J. HARA, and A. JASINSKI, University of Washington (20 min.) (ASZ)

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Temperature Adaptation and the Nervous System of Fish. M. H. BARLOW, University of Hawaii, and EUGENE AGALIDES, General Dynamics Electric Corporation, Rochester, N. Y. (40 min.) (ASZ)

Formative Movements in Teleost Embryos. WILLIAM W. BALLARD, Dartmouth College. (15 min.) (ASZ)

Studies on Nerve Regrowth and Selective Nerve-Muscle Connections in Fishes. H. L. ARORA and R. W. SPERRY, California Institute of Technology. (15 min.) (ASZ)

The Effect of Radio-thyroidectomy on Growth Rates of Juvenile Steelhead Trout (*Salmo gairdneri*) and Chinook Salmon (*Oncorhynchus tshawytscha*). DAVID O. NORRIS, University of Washington. (Introduced by Aubrey Gorbman.) (15 min.) (ASZ)

Thermoacclimatory Variations in the Plasma Proteins of the Goldfish, *Carassius auratus*. ARTHUR H. HOUSTON and JAMES C. FENWICK, Marquette University. (15 min.) (ASZ)

The Effect of Temperature Acclimation on the Tissues of *Salmo Gairdneri* (Rainbow Trout). J. M. DEAN and J. D. BERLIN, Pacific North-Laboratory-Battelle Northwest, Richland, Wash. (15 min.) (ASZ)

Growth and Organization of the Scales in the Teleostei. HOWARD MCCULLY, University of North Dakota. (15 min.) (ASZ)

Gravid Female Shark (*Carcharhinus leucas*) in Fresh Water of Rio San Juan, Nicaragua. THOMAS B. THORSON, University of Nebraska. (10 min.) (ASZ)

Ecological Specificity in Two Sympatric Species of the Blennioid Genus *Hypsoblennius*. JOHN S. STEPHENS, JR., Occidental College, Los Angeles. (15 min.) (ASZ)

A Quantitative Laboratory Study of Behavioral Differences with Applications to the Ecology of Two Sympatric Species of *Hypsoblennius*. ROBERT K. JOHNSON, Occidental College, Los Angeles. (Introduced by John Stephens.) (15 min.) (ASZ)

Serological Comparison of Four Species of Fishes of the Genus *Poecilia*. PETER ABRAMOFF, REZNEAT M. DARNELL, and JOSEPH S. BALSANO, Marquette University. (15 min.) (ASZ)

Morphological Comparison of Three Species of the Genus *Poecilia*. REZNEAT M. DARNELL, BRUCE MENZEL, and PETER ABRAMOFF, Marquette University. (15 min.) (ASZ)

Sodium Metabolism in *Fundulus kansae* in Fresh Water and During Adaptation to Sea Water. JON G. STANLEY and W. R. FLEMING, University of Missouri (15 min.) (ASZ)

Effect of Hypophysectomy on Ammonia Excretion by *Fundulus kansae*. RICHARD L. SWALLOW and W. R. FLEMING, University of Missouri. (15 min.) ASZ)

Response of the Bowfin, *Amia calva* to Exposure to Air. RICHARD M. MATTER and W. R. FLEMING, University of Missouri. (15 min.) (ASZ)

Conditioned and Unconditioned Aggression in the Siamese Fighting Fish. TRAVIS THOMPSON, University of Minnesota Medical School. (Lantern, 30 min.) (ABS)

Shape Discrimination in the Siamese Fighting Fish *Betta splendens*. JAMES C. BRADDOCK and VERONICA A. CERNY, Michigan State University. (Lantern, 15 min.) (ABS)

Behavorial Differences between Wild and Domestic Strains of the Paradise Fish, *Macropodus opercularis*. RONALD W. WARD, Johns Hopkins University. (Lantern, 15 min.) (ABS)

Evolution of Male Courtship Behavior in Fishes of the American Genus *Cyprinodon*. ROBERT K. LIU, University of California, Los Angeles. (Lantern, 15 min.) (ABS)

Variations in the Reproductive Behavior of *Kiraglus maculata*. O. ANNE E. RASA, University of Hawaii. (Lantern, 15 min.) (ABS)

The Role of the Gonad in the Control of Sexual Behavior in the Female Guppy, *Poecilia reticulata* Peters. N. ROBIN LILEY, University of British Columbia. (Film, 15 min.) (ABS)

Observations on Acclimation Behavior in the Symbiosis of Anemone Fish and Sea Anemones. RICHARD N. MARISCAL, University of California, Berkeley. (Lantern, 15 min.) (ABS)

Olfaction and Orientation in Fishes. H. KLEEREKOPER, McMaster University, Ontario. (Lantern, 15 min.) (ABS)

Orientation of Homing White Bass. ARTHUR D. HASLER, H. F. HENDERSON, R. M. HORRALL, and E. S. GARDELLA, University of Wisconsin. (Lantern, 15 min.) (ABS)

Rhythmic Activity of Bluefish, *Pomatomus saltatrix*, in Relation to Light. BORI L. OLLA, Sandy Hook Marine Laboratory, New Jersey. (Lantern, 15 min.) (ABS)

Comments on the Geographical Distribution of Ophidioid Fishes from below 2000 Meters. DANIEL M. COHEN, U. S. Fish and Wildlife Service, Washington, D. C. (Lantern, 15 min.) (SSZ)

Quaternary Hydrography and Fish Life of the New Arid American West. ROBERT RUSH MILLER, University of Michigan. (ESA)

Controlled Fluctuating Salinity and Temperature Acclimation in Fish and Crabs. WALLACE G. HEATH, Western Washington State College, Bellingham. (ESA)

Fish Fauna of the Antarctic. JAY SAVAGE, Department of Biological Sciences, University of Southern California. (WSN)

Fish-grazing and Outer Reef Flat Primary Production at Eniwetok, Marshall Islands. GERALD J. BAKUS, Allan Hancock Foundation, University of Southern California. (WSN)

Merely a listing such as the one above gives some idea of the great breadth of research in ichthyology today.

ANTHIUM DIOXIDE, A NEW DISINFECTANT COMPOUND FOR AQUARIA

Warren Zeiller
Curator of Fishes,
Miami Seaquarium,
Miami, Florida

Twenty years have passed since the Gelfand Patent proved the value of the combination of copper sulfate and citric acid as an algicide and fungicide. Through 17 years of the duration of the patent, aquarists waited hungrily for its expiration so that they too might reap the rewards of its benefits. Now, only a year or two after the long wait ended, a new development may change the entire picture.

A revolutionary water additive soon will be available under the trade name Microcide. This liquid chemical compound is an anthium dioxide complex, the basis of which is chlorine. Chlorine in its many forms is fine in swimming pools and drinking water, but always has proved a deadly addition for all but mammalia in aquatic environments. The new product, fine also in swimming pools, etc., is, under controls no more difficult to maintain than those for copper compounds, harmless and even beneficial to aquatic vertebrates. Unfortunately, like copper compounds, it is not tolerated by most invertebrates.

Experiments with anthium dioxide have proved the following:

1. Control of Algae, Bacteria, and Fungi in Water Containing Aquatic Mammalia

The chemical was pumped directly into the water supply line of a 160,000-gallon semi-closed system pool (approximately 10%, daily water make-up) containing one and sometimes two or three bottle-nosed dolphins (*Tursiops truncatus*). Salt water for the system is filtered by three drum-type sand-gravel pressure filters. Within a week the water was quite colorless and crystal clear. The amount of residual chlorine in the system was tested with an inexpensive standard swimming pool test kit using orthotolodine (O.T.O.) as the reagent. Fishes have been found to tolerate 0.5 ppm residual chlorine for indefinite periods of time. This amount was set as the maximum for the porpoises as well, and probably allowed a high margin of safety. Readings during the test period varied from 0.3 ppm to 0.5 ppm and were maintained by daily additions of the chemical. The amount to be added will vary directly with the contamination in a system. As microorganisms are reduced, the chlorine residual will increase and the feed rate must be reduced to maintain the proper residual.

In addition to extreme water clarity, the divers who vacuum and scrub algae from the inside of the pool stated that the algae, though still present, took less effort to remove than when copper sulfate was used as an algicide. Bacteria counts were taken during the test period and were compared with those taken during the same time the previous year. The counts proved to be little more than half of what they had been. This provides a healthier environment for the porpoises and leaves enough bacteria to maintain efficient biological filtration. In all, this experiment was a total success and I foresee no reason why the product will not perform as well in pools containing sea lions, seals, and the like.

II. To Maintain a Healthy Environment for Fishes (Exclude Invertebrates)

A series of experiments were conducted involving dozens of marine and several freshwater species. Preliminary tests were run to determine fishes' tolerances, if any, for the product. One ppm of residual chlorine was found to be toxic after 1 or 2 weeks of immersion. Specimens seemed to lose equilibrium and swim in tight circles until they expired. If caught in time and placed in untreated water they survived. Finally, 0.5 ppm residual chlorine was found to be the point at which vertebrate species can live indefinitely and at which the strength of the chemical is adequate to perform its functions. At 0.5 ppm fishes can be introduced safely into or removed from the water with no ill effects.

All tests were conducted in 15- to 50-gallon aquaria. During these tests several interesting points came to light. When specimens were fed, excess portions of food were left intentionally on the bottom. Instead of decomposing in the usual manner (turning black and producing foul odors from hydrogen sulfide), waste portions of fish decomposed into a harmless, finely-divided, granular white mass, as did waste from the specimens themselves. Even sea anemones, whose death and decomposition often annihilate fish populations, did the same; the demise and decomposition of an anemone or other invertebrate did not result in the usual fish mortalities.

The chlorine product was then tested in six 50-gallon display aquaria containing numerous fine specimens too small or prized to be shown elsewhere. Laboratory tests had shown that the chemical, at the relatively low

concentration of 0.5 ppm residual chlorine, was not strong enough to destroy algae already established. Thus, all experiments here were conducted in aquaria which first had been thoroughly cleaned. A rule of thumb regarding the amount of chemical to be added was developed at this point. *Two drops per gallon of water* worked unfailingly as a safe method of introduction. The final quantity required to maintain the desired level of 0.5 ppm varied according to the number and size of specimens present in the aquarium. Daily testing with the standard OTO swimming pool test kit and further addition of the chemical when needed to reach 0.5 ppm was all that was required to maintain the aquarium. Once the optimum level was reached and held for a few days, daily testing was no longer necessary. Periodic checks and chemical addition when necessary were sufficient.

Normally, the six display aquaria are emptied of their contents and cleaned monthly. This, of course, is subject to many variables with which aquarists are familiar. When treated with anthium dioxide, cleaning time was extended to 6 weeks or more, and even then there was not as much algae and foreign matter present as there had been previously after only a month. Specimens retained their vivid natural colors, fed well, and remained fully active. Their whole state of well-being seemed greatly improved, although no other variations in normal care were introduced.

III. As A Quarantine for Sea Horses

Sea horses from local waters invariably arrive at Seaquarium bearing copepod parasites. Those visible to the naked eye always have been removed by hand and the sea horses then placed in their 300-gallon open system aquarium. Shortly thereafter, row upon row of tiny white specks appeared on the aquarium glass—the eggs of copepods, thriving at the expense of the sea horses.

In testing as many species as possible for tolerance of the chlorine product, sea horses soon entered the picture. After each test, the parasitic copepods were found not on the sea horses, but dead on the aquarium glass above the water line. Further work proved that sea horses quarantined in a concentration of only 0.2 ppm residual chlorine for 48 hours emerged parasite-free and in a state of health they seldom enjoy in their natural habitat. This finding prompted treatment of the entire 300-gallon display, including 10 golden-browed jawfish (*O. aurifrons*), which were heavily infested at the time. They lived in burrows and shells on the bottom of the sea horse aquarium, and large copepods were plainly visible in alarming numbers on their bodies. After 2 days at 0.2 ppm the copepods were no longer in evidence. The entire aquarium has been completely free of these parasites since the quarantine measure has been inaugurated and followed religiously. In addition, the longevity of the sea horses after treatment has increased gratifyingly, to what extent one cannot even guess. The end is truly not yet in sight.

Seaquarium is basically a marine exhibition, and the majority of this research was done in salt water. It must be noted that anthium dioxide is most efficient in the low pH range of fresh water; therefore it is a boon to all aquarists. Of particular interest is the fact that one freshwater *Belonesox belizanus* gave birth to two large groups of normal, healthy young in an established Microcide environment. A number of these were raised successfully to a length of 2 inches and then transferred to an open system untreated display aquarium without special precautions or difficulty. Regardless of the kind of water, the treatment is most effective and least expensive in completely closed (100% recirculation) aquarium systems.

In closing, I wish to acknowledge the assistance of Mr. Thomas Marooney for supplying Seaquarium with the materials for these experiments.

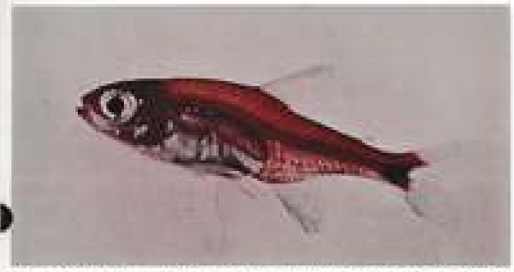

Fig. 1—*Axelrodia riesei* sp. nov. (one of the types. Photograph by Dr. Herbert R. Axelrod).

AXELRODIA RIESEI, A NEW CHARACOID FISH FROM UPPER RIO MÉTA IN COLOMBIA. (WITH REMARKS CONCERNING THE GENUS *AXELRODIA* AND DESCRIPTION OF A SIMILAR, SYMPATRIC, *HYPHESSOBRYCON*—SPECIES.)

Jacques Géry[1]

The present paper deals with a remarkable new species of the recently-erected cheirodontine—genus *Axelrodia* (Géry, 1965b). It was discovered by Dr. Herbert R. Axelrod and Mr. William Riese during their most successful T.F.H. Colombian Expedition (see H. R. Axelrod, Tropical Fish Hobbyist, March 1965), and I am most pleased to name it for Mr. Riese.

The genus **Axelrodia** *and its type-species.*

The small group to which *Axelrodia* apparently belongs, the Aphyoditeini, a sub-tribe of the Cheirodontidi, was briefly reviewed in my recent paper concerning *Brittanichthys* (Géry, 1965a). In this paper, as well as in a preceding one concerning Mr. Roberts' collecting around Iquitos (Géry, 1964c), I could not expressly name the genus: its formal description, with designation of a type-species, was still in press. It was thus given the code-letter P (following alphabetically "genus O," which I can now indicate stands for *Oxybrycon* (Géry, 1964b).[2]

[1] Contribution No. 48 to the study of characoid fishes.
[2] Citation of new names is subject to the law of priority if the taxon is recognizable; differences in publication speed amongst scientific journals obliged use of an initial to avoid publication of a name alone before its publication accompanied by the full description of the fish to which it is applied.

In the above-mentioned papers, reference was made to *Hyphessobrycon stigmatias* as the type of "genus P." I was not entirely satisfied with this identification. Lately I rechecked my material, which consists of very small examples strongly resembling *stigmatias*, and compared it, point to point, with the description of Fowler (1914). It was finally decided that the observed differences were too great; they did not allow the erection of a new genus on the basis of a dubiously identified species. It was thus preferable to make, for the specimens at hand, a new species, which was given the name *fowleri*, honoring the great American ichthyologist Henry W. Fowler. This was done on the proofs of the 1965b paper, too late to be included in the 1964c and 1965a article. During a research trip sponsored by the N.A.T.O. and supplemented by a grant from the T.F.H. Foundation, I had the opportunity to study the type of *H. stigmatias* in the Academy of Natural Sciences, Philadelphia. The observable characters, particularly the absence of a second row of premaxillary teeth and the number of anal rays (probably iii12 or 13) suggest that *A. fowleri* is a pure synonym of *A. stigmatias* (Fowler). The latter becomes the type-species of *Axelrodia*.

Now a remarkable coincidence takes place: at the same time that the case of *stigmatias* was reestimated in the above explained manner, the T.F.H. expedition was in Colombia. Its leaders, no doubt guided by the god of ichthyologists, were busy collecting not only a second colorful species of the new genus but, also, a fish which resembles closely the true *stigmatias* of Fowler! The record seems now complete, save for still more discoveries. It reveals an interesting little group of two genera, characterized (externally) by a short anal fin and a conspicuous, asymmetrically set, black spot on the caudal fin. Other (anatomical) convergencies and divergencies will be described below.

Axelrodia riesei *sp. nov.* (*fig.* 1 *and* 3, *middle*).

HOLOTYPE (in the U.S.N.M.): 16.4 mm in standard length (19.5 mm in total length), collected by Dr. H. R. Axelrod and W. Riese, Nov. 1964, in the upper Rio Méta basin, east of Villavicencio, Colombia.

PARATYPES: 17, about 14.0–16.7 mm in standard length, same data; orig. No. 0411.

DIAGNOSIS: *Cheirodon*-like; probably one of the smallest aquarium fishes (it is not known whether the largest specimens, not more than 20 mm in total length, are mature or not); certainly one of the most colorful: body almost entirely cherry or ruby-red, fins hyaline except at the base of dorsal and caudal, which is also red-colored; eye red and bluish; a black spot on the ventral part of the caudal peduncle; dorsal ii9 (last ray unbranched); anal iii14 or 15 (last ray double), distributed as follows: 14 br. rays, eleven specimens; 15 br. rays, seven specimens; pectoral i8 (last ray or rays simple, rather rudimentary); ventral i6 (last ray simple); caudal v or vi I 9,8 I vi or v; scales in longitudinal

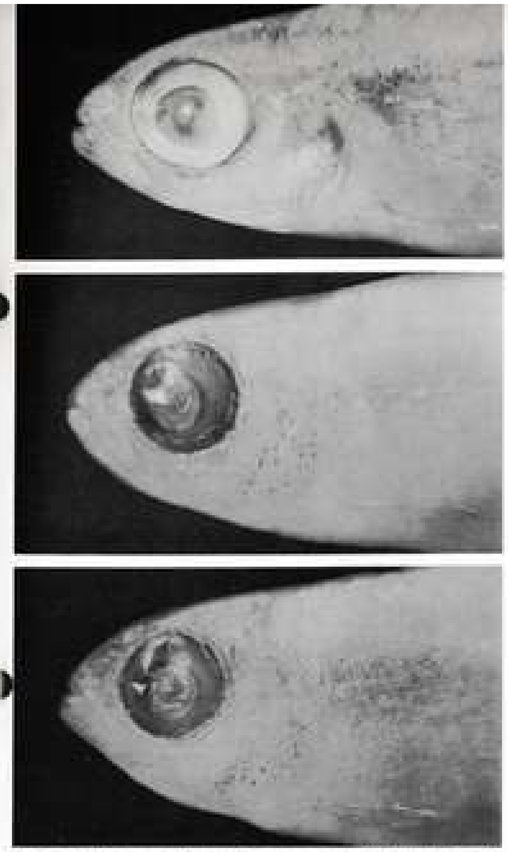

Fig. 3—Heads of (from top to bottom): *A. stigmatias*, type of *A. riesei* sp. nov., and cf. *Hyphessobrycon* sp. from upper Río Méta.

series 29 or 30, lateral line perforating only 5 or 6 scales; transverse scale rows 8 or 9 (generally 5/1/3 up to ventral), predorsal scales about 9 or 10, circumpeduncular scales 10 or 12; gill-rakers about 6/9; teeth conical, more or less regular on premaxillary (see description).

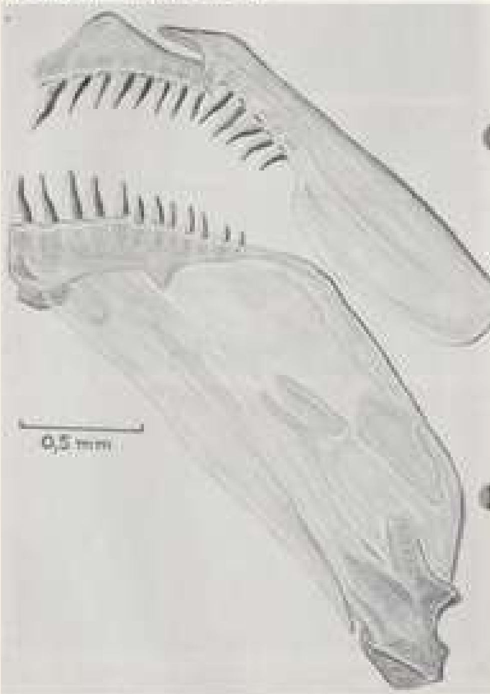

Fig. 3—Teeth of a paratype of *Axelrodia riesei* sp. nov.

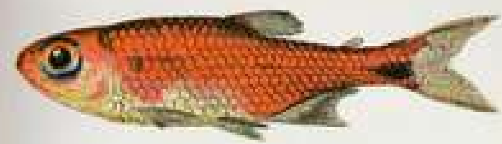

Fig. 4—Coloration of *Axelrodia riesei*, the "red-ruby tetra" (sketch made immediately after unpacking formalin preserved specimens).

DESCRIPTION: body moderately deep, its greatest depth before the ventrals, 3.16–3.52 in the standard length (all proportions from micrometric ocular measurements of the ten largest specimens); dorsal profile moderately arched, ventral profile almost straight; caudal peduncle rather elongate, its depth 1.7–2.2 in its length; dorsal fin clearly, if only slightly, *behind* the middle of the body, snout-to-dorsal 0.90–0.99 in dorsal-to-caudal; ventral fins originating in advance of dorsal, snout-to-ventral 1.04–1.15 in ventral-to-caudal; pectorals rather short, not quite reaching base of ventrals; tips of ventrals overlapping first rays of anal; anal fin short, its border falciform; adipose fin present; scales regular, predorsal and preventral regularly scaled and not modified (not keeled nor flattened); no scales on caudal lobes; a short sheath of scales on anal-base; no interhaemals; a narrow pseudotympanum, apparently present on all specimens.

Head (fig. 2, middle) rather short, its length (without membrane) 3.43–3.70 in the standard length; eye large, 2.25–2.34 in the length of head; interorbital about 2.8–3.0 in the same; posterior ("parietal") fontanel very broad, anterior (frontal) one narrower but elongate, reaching to level of front of pupil; snout rounded, short, about 4.5–5.5 in length of head; maxillary rather short, not quite reaching the level of the anterior border of the eye, its apparent length scarcely more than half the eye-diameter, about 4.0–4.5 in the length of head. Mouth small, the dentary very slightly in front of the premaxillary; latter very small, without ascending (mesial) process; it is armed with an irregular series of 7 or 8 tiny, conical teeth (fig. 3); in some specimens, the third or fourth tooth, the root of which is at the same level as the adjacent ones, may be directed forward: this cannot be considered as a second, external series as in the genus *Hyphessobrycon* (a similar irregularity is to be found in many genera of the Cheirodontidi; see Géry & Boutière, 1964); maxillary teeth 4 or 5, continuous with the premaxillary row; mandibular teeth about 12, similar; third suborbital narrow, leaving a rather broad naked area on cheek; apparently no postorbitals.

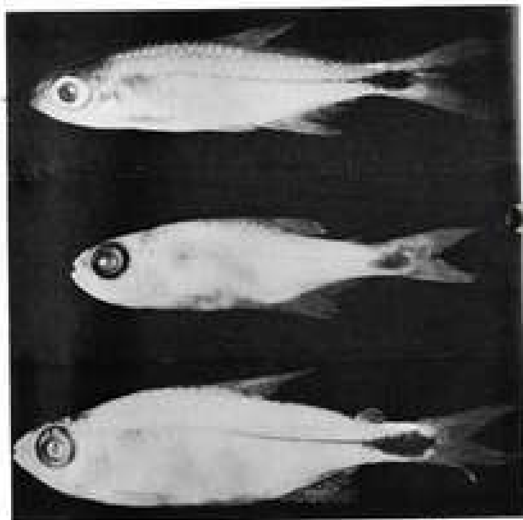

Fig. 5—From top to bottom: type of *A. fowleri* (=*A. stigmatias*), type of *A. riesei* sp. nov. (16.4 mm in standard length), and *Hyphessobrycon* from upper Rio Meta (the upper photograph is taken from Géry, 1965b, by courtesy of Senck. Biol.).

The coloration was noted on freshly preserved specimens (fig. 4); the fish is almost entirely of the same red color as that of the cardinal tetra, *Cheirodon axelrodi*; only the belly and the lower part of the head are plain; the cherry-red tint extends most conspicuously over the base of the caudal lobes, chiefly on the upper one, and slightly over the dorsal fin base; the black peduncular spot, although well delimited, is less intense than in most tetras (particularly *A. stigmatias*); it is horizontally oval and extends further onto the lower part of the end of the caudal peduncle, as in the above-mentioned forms; there is no humeral spot, save for a small, triangular gray area which is the pseudotympanum or "humeral hiatus"; the eye is ruby-red above, golden with bluish iridescence below; there is some gray on the first dorsal, ventral and caudal rays, as well as on the median part of the anal fin.

DISCUSSION: *Axelrodia riesei* sp. nov. clearly belongs to the genus *Axelrodia*,

as defined by the characters of its type-species, *stigmatias* (fig. 5, upper fish). This is best shown by a numerical comparison, using the matrix of generic characters which was proposed for the Aphyoditeini (Géry 1965a). The coefficient of association between *A. stigmatias* ("*H. stigmatias*" in the cited paper) and *A. riesei* is 93%, i.e., they have almost all characters in common. However, the third suborbital is not entire in *A. riesei*. This is likely to extend slightly the definition of *Axelrodia* from "third suborbital entire" to "third suborbital entire or not," but this does not significantly alter the entire matrix.

Specific differences are as follow:

	A. stigmatias	*A. riesei*
Largest size (sd. lgth.)	20.5	16.7
Sd. lgth./depth	4.07–5.0	3.16–3.52
Head/eye	2.6–3.0	2.25–2.54
Head/interorb.	3.47–3.72	2.8–3.0
Dors.-caud./snout-dors.	1.03–1.13	0.90–0.98
Scales longit.	32	29–30
Pmx. teeth	9–10	7–8
Dn. teeth	14–16	12

Another marked difference is to be seen in the coloration. Although the color *in vivo* of *A. stigmatias* is not known, it almost surely does not have the intense red tint of *A. riesei*. Judging from its aspect after preservation, it is likely to have a golden iridescence on peduncle as does *Hemigrammus hyanuary* (with which it was mixed in the Roberts sample from Iquitos). In the collection, *Axelrodia riesei* may be recognized at once by its much shorter body, position of the dorsal fin, larger eye, rounder snout, less numerous teeth, etc.

ASSOCIATED SPECIES AND BIOTOPE: particulars concerning the biotope are to be found in Dr. Axelrod's paper referred to at the beginning, as well as in the photographs that accompany the article (pp. 70–71).

Several characids were caught together with *A. riesei*, or at least were part of the same sample: they are *Tetragonopterus chalceus*, *Moenkhausia collettii*, *Hemigrammus barrigonae*, *Hyphessobrycon sticsus*, *H. saizi*, *H. minimus* (or close to it), *H. species* (see below), *Megalamphodus sweglesi*, *Cheirodon axelrodi*, *Creatochanes melanurus*, *Carnegiella strigata*, *Pyrrhulina brevis lugubris*, *Copella metae*, *Ctenotropus labyrinthicus*, and *Carinatopsis erolymae*.

The fish-fauna of the upper Rio Méta, a tributary of the Orinoco, at least the characoids, as known from old collections (see Eigenmann, 1922) as well as from recent ones (see Géry, 1963), is very rich. I have up to this writing

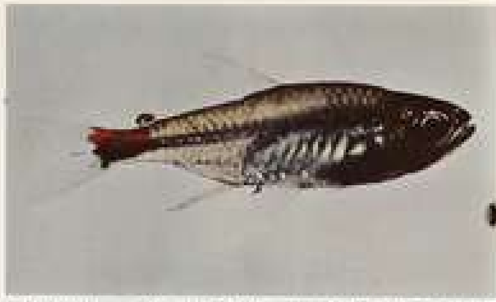

Fig. 6—*Hyphessobrycon* sp. from upper Rio Mêta. (Photograph by Dr. Herbert R. Axelrod).

recognized more than 60 characoid species, exclusive of large forms, and this is surely short of the mark. Most of this fauna would be qualified as "typical Guianean."[8] A passage from the Rio Negro via a northern tributary can also be suspected following the striking discovery of *Cheirodon axelrodi* (known only, so far, from the Rio Negro) in Colombia.

Cf. **Hyphessobrycon species** (*figs. 5 lower fish and 6*).

Nine ex., largest 21.3 mm in standard length, collected together with *Axelrodia riesei*; orig. No. 0414.

Depth about 3.33–3.5 in the standard length; depth of caudal peduncle 1.8–2.0 in its length; dorsal fin very slightly in advance of the middle of the body; pectoral and ventral not quite reaching next respective fin; anal short, iii12–14 (one with 15 branched rays), falciform; no interhaemals, no pseudotympanum; caudal not scaled; scales 5/29–30/3 or 3), six pores in the lateral line, 9 scales in predorsal series, 12 scale rows around peduncle.

Head (fig. 2, lower fish) about 3.8–4.2 in the standard length; eye 2.25–2.5, and maxillary and snout about 4.0–4.2 in the length of head; jaws and teeth (fig. 7) of the tetragonopterine-type (in the restricted sense), i.e., with two rows of teeth on the premaxillary, which has an ascending process, and at least some teeth with lateral cusps on both jaws; in the specimens here described, only the first three or four teeth in inner premaxillary series and in dentary (counting from the middle), as well as the first maxillary tooth, have

[8] The fauna of the Guianas is apparently more distinct from that of the middle Amazon than from that of upper Amazon. Certain zoogeographical hypotheses would explain this (Géry, 1964a).

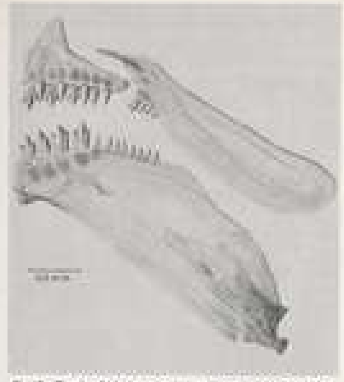

Fig. 7—Teeth of *Hyphessobrycon* sp. from upper Rio Mêta.

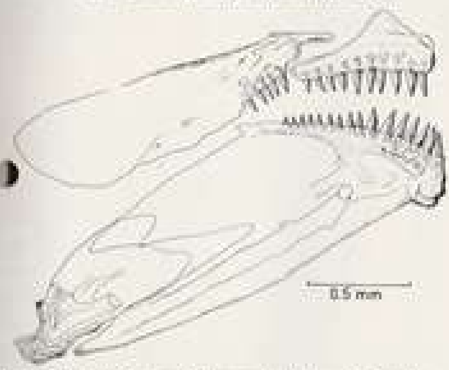

Fig. 8—Teeth of *Axelrodia fowleri* (=*A. stigmatias*) (taken from: Géry, 1965b, by courtesy of Senck. biol.).

two lateral cusps. The dentition is thus tricuspid in front, followed on sides by some conical teeth; posterior fontanel broad, anterior one about 2 times narrower, reaching to the level of middle of eye; third suborbital incomplete, postorbitals rudimentary, but present; gill-rakers about 7/11.

A conspicuous, elongate black spot on lower part of caudal peduncle, prolonged forwards by a black longitudinal line up to the level of dorsal fin; an iridescent, red or golden, peduncular area over it.

The comparison of *H. species* with *A. stigmatias* (see figs. 2 and 5, bottom and top) shows an interesting phenomenon, which is not unique amongst the small characids (for example, *Hemigrammus rhodostomus* versus *Petitella georgiae*, etc.). The general aspect of both fish is quite similar. *A. stigmatias* would only be slightly more elongate, with a larger eye. Such similarity could scarcely be coincidental, and to call them "convergencies" is not at all an explanation. It is difficult to see how the two species could have arrived at almost the same systematic characters (including the pattern, up to the peduncle iridescence, etc.), without being of the same, *recent*, phylogenetic line. This is why a formal description of *Hyphessobrycon sp.* from Upper Rio Méta must await a revision of the genus.

Yet the jaws and the teeth, as shown by comparison of fig. 7 with fig. 8, are strikingly different. I once suggested that the evolutionary rate of the teeth (adaptive characters for nutrition) and of the pattern (recognition signal amongst sexes and/or species) are different, and that (at least in small characoid fishes) *the pattern would be the most conservative*. Such an explanation still asks for experimental verification.

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A SMALL COLLECTION OF SHORE FISHES FROM THE WEST COAST OF COSTA RICA

MARTIN R. BRITTAN

On July 21, 1962, a collection of marine fishes was made by William Bussing, Warren Houck, Alex Obando, and myself at Estero Mata Limón on the Pacific Coast of Costa Rica. The location and general topography of the locality is shown on the map (fig. 1). All specimens were taken with minnow seine or dipnet following the use of commercial emulsified-rotenone poison.

The author wishes to thank the following for various courtesies: Dr. John D. Abate, Dr. Jay M. Savage, and Mr. William Bussing of the University of Costa Rica and the University of Southern California for laboratory facilities; Dr. David Caldwell and Mr. Robert Lavenberg for use of materials in the Los Angeles County Museum; Dr. Ernest Lachner, of the U.S. National Museum, for identifying species of *Bathygobius*; Dr. John C. Briggs, of the University of South Florida, for identifying the clingfishes; and Mr. John Huddleson for his painstaking curatorial work.

Collections were made at four stations at Mata Limón estuary (approximately 9°55' north latitude, 84°43' west longitude), on a low incoming tide.

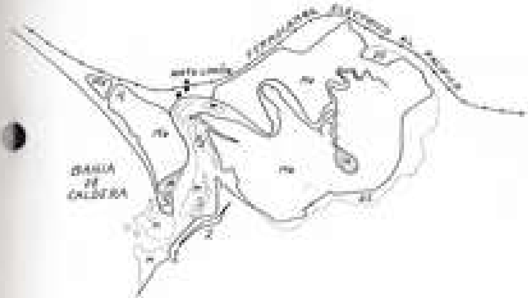


Fig. 1 - Map of Mata Limón estuary. This sketch map, traced from a Costa Rican government map, shows an area of mud-deposit off collecting station number one; at the period of collection, however, the mud-deposit had washed away under a high surf. M = mud-deposit, Ma = mangrove, DS = dry sand.

Mugil curema Cuv. & Val. 1836. SSC 21–9, 6, 35–61, LACM 7044, 56, 30–47mm.

Eucinostomus californiensis (Gill 1862). SSC 21–6, 2, 24–25mm.; LACM 7041, 21, 7–27mm.

Lutianus novemfasciatus (Gill 1862). SSC 21–10, 2, 59–65mm. (juvenile).

Dormitator maculatus (Bloch 1790). SSC 21–1, 5, 24–50; LACM 7036, 32, 15–47mm.

Erotelis armiger (Jordan 1895). SSC 21–2, 3, 33–94mm.; LACM 7037, 13, 16–69mm.

Bathygobius andrei (Sauvage 1880). SSC 21–5, 12, 48–55mm.; LACM 7040, 4, 36–50mm.; USNM 198119, 2, 42–47mm.

Evorthodus breviceps Gill 1862. SSC 21–8, 18, 13–23mm.; LACM 7043, 191, 11–25mm.

Gobionellus microdon (Gilbert 1891). SSC 21–3, 6, 51–73mm.; LACM 7030 12, 24–169mm.

Gobionellus sagittula (Günther 1861). SSC 21–4, 5, 23–54mm.; LACM 7039, 4, 36–60mm.

A completely different assemblage of fishes was found in the rocky pools as compared to areas where the substrate was mud, and especially when rocky tidepools are compared with mangrove swamp. The only fish found at all four stations were juvenile *Mugil curema*, which appear to be distributed everywhere inshore; these are, however, commonest in the barren mudbottomed or siltbottomed pools not heavily inhabited by many other species. The outer rocky tidepools are dominated by the sergeant-major (Pomacentridae) and the blenny, *Malacoctenus zonifer*. The mangrove swamp was dominated by the gobies *Evorthodus lyricus* and *Gobionellus sagittula*; the third commonest species was the eleotrid, *Dormitator maculatus*, all juveniles (the species reaches 200mm). Two other gobies, another eleotrid, a euryhyaline cyprinodont, and juvenile *Eucinostomus* were also prominent. Of particular interest is the fact that within the genus *Bathygobius*, *B. ramosus* of the rocky tidepools is replaced in the mangroves by *B. andrei*, with neither species present in the barren tidepools between.

NOTES ON THE SPECIES COLLECTED

(All names applied to the various species are, insofar as possible, listed. However, not all references are included. Along with the revisions by Ginsburg of *Bathygobius*, and Briggs of the clingfishes, the most generally useful works are Meek and Hildebrand 1925–1928, *Marine Fishes of Panama*; Jordan and Evermann 1896, *Fishes of North and Middle America*; Gilbert and Starks 1904, *Fishes of Panama Bay*; Jordan, Evermann and Clark 1930, *Checklist of the Fishes of North America North of the Isthmus of Tehuantepec*.)

ORDER CYPRINODONTES
FAMILY CYPRINODONTIDAE

Oxyzygonectes dovii (Günther)

Haplochilus dovii Günther 1866, Cat. Fishes Brit. Mus. 6, 316, Punta Arenas (Puntarenas), Costa Rica.

Fundulus dovii Jordan and Evermann 1896, Fishes of North and Middle America, Bull. U.S. Nat. Mus. 47 (1): 650 (description; coast of "Costa Rica").

Oxyzygonectes dovii, Fowler, 1916 Proc. Acad. Nat. Sci. Phila., 68:425 (new generic name; type *O. balboae*).

This dark brown top-minnow is about the size of *Fundulus heteroclitus* of the U.S. Atlantic Coast. It is probably generally distributed in mangrove-waters of Central America, in spite of the meager references to it in the literature, although reported so far only from Panama and Costa Rica. With its dark brown coloration, flattened anterior dorsum, and pointed snout (when viewed from above), it is a distinctive-appearing fish. It was among the slowest of the mangrove fishes to show the effect of our poison.

ORDER PERCOMORPHI
SUBORDER PERCOIDEA
FAMILY SERRANIDAE

Epinephalus sp. This juvenile specimen is too small for positive identification.

FAMILY LUTIANIDAE

Lutianus novemfasciatus (Gill)

Lutjanus novemfasciatus Gill, 1862, Proc. Acad. Nat. Sci., Phila., 14, 2.51 (Cape San Lucas, Baja California).

Mesoprion pacificus Bocourt 1868, Amm. Sci. Nat. Paris, 10:223 (Tanesco, Pacific Coast of Guatemala).

Lutjanus prieto Jordan and Gilbert, 1881, Proc. U.S. Nat. Mus. 4:353 (Mazatlan, Mexico).

Neomaenis novemfasciatus Jordan and Evermann, 1898, U.S. Nat. Mus. Bull. 47 (2):1254 (description).

Lutianus novemfasciatus Gilbert and Starks, 1904, Mem. Cal. Acad. Sci., 4:102 (Panama Bay).

This snapper is one of the commonest food fishes of the Central American Pacific coast, being found from the Galapagos Islands to Baja, California, and reaching a weight of 20 pounds. This may prove to be merely a race of the Atlantic *L. cyanopterus* (Cuvier and Valenciennes), or it may be its Pacific geminate species.

FAMILY GERRIDAE

Eucinostomus californiensis (Gill)

Diapterus californiensis Gill, 1862, Proc. Acad. Nat. Sci., Phila., 14:245 (Cape San Lucas, Baja, California).

Eucinostomus californiensis Meek and Hildebrand, 1925, Field Mus. Nat. Hist., Zool. Ser. 15:584, pl. 62 (Calif. to Ecuador, North Carolina to Brazil).

Juvenile specimens of this common "mojarra" school in estuaries and mud bottomed tidal pools. Meek and Hildebrand (1925 (2):584) consider that of the ten or so species described (as *Gerres*, *Diapterus*, or *Eucinostomus*), only *E. gula* and *E. californiensis* are valid members of this genus. Jordan, Evermann, and Clark (1930:340–1) recognize, in addition, *E. pseudogula* Poey, an Atlantic form, and *E. elongatus*, Meek and Hildebrand, the latter originally described (loc. cit.:586) as *E. californiensis elongatus*.

FAMILY SCIAENIDAE

Umbrina xanti Gill

Umbrina xanti Gill, 1862, Proc. Acad. Nat. Sci. Phila., 14:257 (Cape St. Lucas, Lower California); Meek and Hildebrand, 1925, Field Mus. Nat. Hist., Zool. Seri. 15(2):615 (Cape San Lucas to Equador).

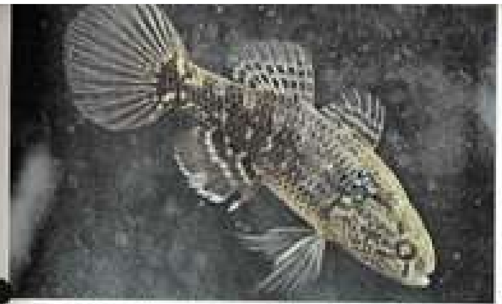
Umbrina analis Günther, 1868, Trans. Zool. Soc. London, 6:387, 426 (Panama).

Our single tiny juvenile specimen was taken with a mixed school of *Mugil curema* and *Eucinostomus californiensis*.

FAMILY POMACENTRIDAE

Abudefduf saxatilis (Linnaeus)

Abudefduf saxatilis, showing coloration. Photo by Dr. Herbert R. Axelrod.



Dormitator maculatus, showing coloration. Photo by Dr. Herbert R. Axelrod.

Chaetodon saxatilis Linnaeus, 1758, Systema Naturae, 10th ed.: 276 1758 (India).

Widely distributed throughout tropical American coasts, both Pacific and Atlantic, and throughout the Indo Pacific to South Africa. This strikingly barred damselfish is one of the commonest of tidepool and inshore fishes. It was the most numerous non-bottom species in the rocky tidepools at Mata Limón, and easily the most prominent. Jordan, Evermann, and Clark, 1930, Checklist of Fishes: 415, consider *saxatilis* to be an "Asiatic" species and apply the name *marginatus* Bloch, 1787 to the American form. Meek and Hildebrand (1925(2):700-701, pls. 70–71) give the characters which distinguish between *saxatilis* and its congener, *A. analogus* (Gill 1863).

FAMILY LABRIDAE

Pseudojulis notospilus Günther

Pseudojulis notospilus Günther, 1864, Proc. Zool. Soc. London, 1864: 26 (Panama); Meek and Hildebrand, 1928, 15(3):725 (Mazatlan to Panama).

Julidio notospilus Jordan and Evermann, 1898, Bull. U.S.N.M. 47: 1603 (Mazatlan to Panama).

This tiny little wrasse was extremely numerous in all rocky tidepools in the Mata Limón area. Both Meek and Hildebrand (1928) and Jordan and Evermann (1898) comment on its commonness.

SUBORDER GOBIOIDEA
FAMILY ELEOTRIDAE

Dormitator maculatus Bloch

Dormitator maculatus Bloch, 1790, Ausl. Fische, pl. 299, fig. 2 (West Indies).

This larger sleeper, or guavina, reaches a length of about 200mm., and is common everywhere in estuaries and the lower courses of rivers. There are extensive synonymys in Jordan and Evermann (1898 (3):2196-8), Regan (1906, Biol. Centrali-Americana: 8), and Jordan, Evermann, and Clark (1930:436). Regan gives a good description (ibid.: 8 and pl. 7, fig. 3, the latter of *D. latifrons* which Jordan, Evermann, and Clark list under the synonymy of *D. maculatus*), as does Jordan and Evermann (ibid.:2196, and Iv, pl. cccxxiv, fig. 782). The species ranges from South Carolina to Pará, Brazil, and from Cape San Lucas to Panama.

Erotelis armiger (Jordan)

Alcozarus armiger Jordan, 1895, Proc. Cal. Acad. Sci., 2nd ser., 5:511, pl. 48 (La Paz, Lower Calif.); Jordan and Evermann, 1898:2203, pl. 325, fig. 784.

Erotelis armiger Meek and Hildebrand, 1928: Field Mus. Nat. Hist. Zool. Ser. 15(3):864 (description, Lower California to Panama).

This long, slender, brownish eleotrid may not be specifically distinct from *E. smaragdus*, found from Florida to Brazil on the east coast, or it may be a geminate species; it ranges from Panama to Lower California. There is a broad, concealed, slightly-hooked spine on the opercle in this genus (*Erotelis* = *Alcozarus*). This species and *Dormitator maculatus*, along with *Oxyzygonectes dovii*, were more resistant to poison than most of the others in the mangroves.

FAMILY GOBIIDAE

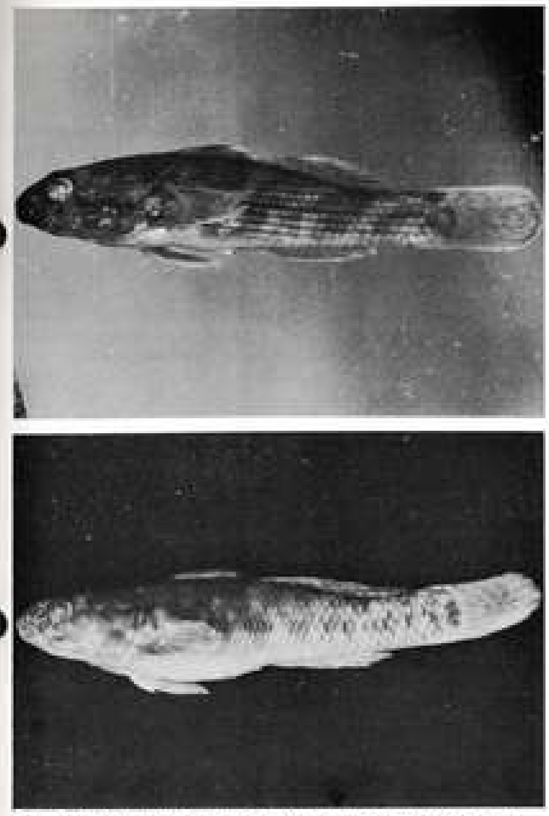
Bathygobius andrei (Sauvage)

Gobius andrei Sauvage, 1880, Bull. Soc. Philom., Paris (7) 4:44 (Rio Guayas, Ecuador).

Bathygobius andrei, Ginsburg, 1947, Journ. Wash. Acad. Sci. 37(8):282-284 (Costa Rica to Ecuador).

This species was found only on a mud bottom in the mangroves, where it was fairly common, although not nearly so as *Gobionellus* and *Evorthodus*. Its congener, *B. ramosus*, was found only in the rocky tidepools. The genus *Bathygobius* has been monographed by Ginsburg (1947, see above), but the systematics of the genus is in a state of confusion in the earlier literature (as is that of most gobiid genera at present); in most of the available literature, especially in the hands of those who have not worked extensively with gobies, both our forms would likely be identified as *B. soporator*, with which *andrei* has been synonymized in the past. In fact, Ginsburg (1947, which see) resurrects from the synonymy of *soporator* most of the forms listed by Meek and Hildebrand (1928:867-8). *Soporator* itself appears in reality to be an Atlantic species.

Bathygobius ramosus Ginsburg, 1947, Journ. Wash. Acad. Sci. 37(8):279-280 (Mexico to Peru on the Pacific coast).



Top - Bathygobius andrei. Bottom - Bathygobius ramosus. Both fishes 46.2 mm. sl.

At Mata Limón this form was restricted to rocky tidepools, where it was the commonest goby (however, all gobies were far less numerous on rocky as compared to muddy substrates). Ginsburg (1947:281) remarks that the populations on which his *ramosus* was based had previously been considered to be *soporator*.

Evorthodus lyricus (Girard)

Gobius lyricus Girard, 1858, Proc. Acad. Nat. Sci. Phila.: 169 (Brazos Santiago, Tex. male); 1859, U.S. and Mex. Boundary Survey (2):25, pl. 12, figs. 4, 5 (Texas); Jordan and Gilbert, 1882, Proc. U.S. Nat. Mus. 5:294 (Galveston, Male); Jordan and Eigenmann, 1886, Proc. U.S. Nat. Mus., 9:496; Ginsburg, 1936, Bull. U.S. Bur. Fisheries 47(5), 117–24, figs. 1–2. table 2 (revision and synonymy).

Gobius wurdemanni Girard, Proc. U.S.N.M., loc. cit. (Brazos Santiago, Tex.); 1859, U.S. and Mex. Boundary Surv., l.c. (Texas).

Evorthodus breviceps Gill, 1859, Proc. Acad. Nat. Sci. Phila.: 195 (Trinidad, female); Günther, 1861, Cat. Fish Brit. Mus., 3:85 (Surinam); Regan, Proc. Zool. Soc. London: 393; (Jordan and Richardson, 1908), Proc. U.S. Nat. Mus., 34:20, fig. 2 (Tampico, Mexico).

Smaragdus costalesi Poey, 1861, Mem. Hist. Nat. Cuba, 2:280 (1856–58) (Cuba, male).

Gobionellus costalesi Poey, 1868, Rep. Fis. Nat. Cuba, 2:394 (Cuba); 1876 Ann. Soc. Esp. Nat., 5:1868 (Cuba).

Euctenogobius lyricus Jordan and Gilbert, 1883 (1882), Bull. U.S. Nat. Mus., 16:633.

Gobius garmani Eigenmann & Eigenmann, 1888, Proc. Cal. Acad. Sci. (2nd ser.), 1:61 (Dominica, Fort de France, Martinique, St. Kitts; female).

Gobius stigmaticus Evermann and Bean, 1898 (1896), Bull. U.S. Fish Commission: 247 (Indian R. Inlet, Fla.).

Gobius parvus Meek, 1902, Publ. Field Mus. Nat. Hist. (Zool. Ser.), 3:121, p. 31 (Vera Cruz, Mex.).

Gobionellus lyricus Meek and Hildebrand, 1928, Publ. Field. Mus. Nat. Hist. (Zool. Ser.), 15:880 (Mindi, Panama).

Mugilostoma gobio Hildebrand and Schroeder, 1928, Fishes of Chesapeake Bay: 327 (Norfolk, Va., juvenile).

Evorthodus minutus Meek and Hildebrand, 1928, Pub. Field Mus. Nat. Hist. (Zool. Ser.), 15:1870, pl. 84 (Coronal, Panama).

Ginsburg (1931: 117–24) has untangled the difficult synonymy of this sexually dimorphic species, first described as *Gobius lyricus* from a male specimen and a year later as *Evorthodus breviceps* from a female specimen. Ginsburg remarks that the female has been named three times, the male independently twice, and the young once, evidences of both sexual di-

morphism and variability. His paper gives a detailed description and involved synonymy, since he had access to all the type material.

It was observed by Ginsburg that it is found typically in marshy, shallow mudbottomed lagoons. Our specimens, representing the nominal species *E. minutus*, are also from a mud substrate. We found this to be the commonest species in the mangroves, easily identified by the two dark spots on the base of the caudal fin, one above, one below, separated by a light area; the same marking identifies the Atlantic populations (*E. lyricus*).

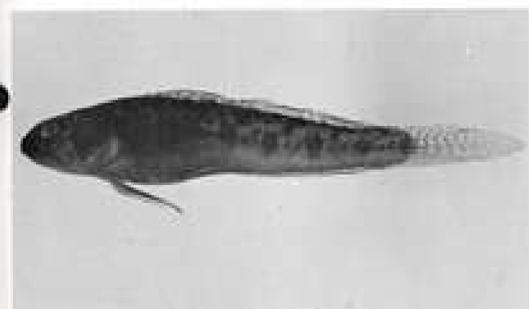
I have examined material from the Pacific coast of Costa Rica and Mexico (Nayarit), some of it identified as *E. breviceps* and some as *E. minutus*, and some of the examples fitting the descriptions of the former and some the latter, and I can only conclude that they are conspecific. Ginsburg (1931:124) while hesitating to synonymize *lyricus* and *minutus*, notes that there are no essential differences between the two.

Gobionellus microdon (Gilbert)

Gobius microdon Gilbert, 1891, Proc. U.S.N.M., XIV:554 (San Juan Lagoon, west coast of Mexico); Jordan and Evermann, 1898 (3):2227 (description, San Juan Lagoon, north of Rio Ahomé, Mex.).

Gobionellus microdon Gilbert and Starks, 1904, Fishes of Panama Bay, :171, pl. 28, fig. 51 (Miraflores, Panama). Jordan, Evermann and Clark, 1930:441 (San Juan Lagoon, west coast of Mex.).

Considerably larger than its congener, *G. sagittula*, this species was less common in the mangroves, and somewhat more resistant to our poison. It can easily be told from *sagittula* by the rounded rather than centrally-pointed tail.



Gobionellus microdon, 73.0 mm. st. l.

Gobionellus sagittula (Günther)

Euctenogobius sagittula Günther, 1861, Proc. Zool. Soc. London (3):371 (Pacific coast of Central America).

Gobius longicaudus Jenkins and Evermann, 1888, Proc. U.S. Nat. Mus. :146 (Guaymas, Mex.).

Gobius sagittula Jordan and Evermann, 1898, 3:2228 (Gulf of California to Panama; "very common in lagoons and mouths of rivers").

Smaller and slenderer than *G. microdon*, with a more pointed tail, this species was much more common.

Gerhardinus nudus Meek and Hildebrand

Gerhardinus nudus Meek and Hildebrand, 1928, Marine Fishes Panama, 15 (3):889, pl. 88 (Panama City).

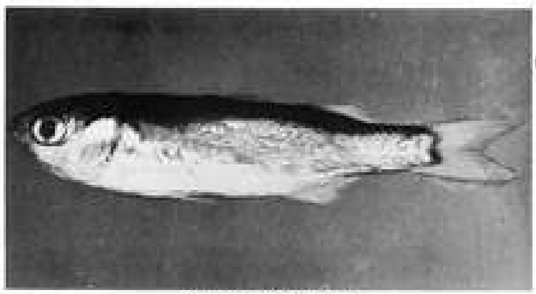
This secretive little goby fits well Meek and Hildebrand's written description, but is slenderer and has more-pronounced but more-irregular cross-bands than is shown in their illustration.

SUBORDER MUGILOIDEA
FAMILY MUGILIDAE

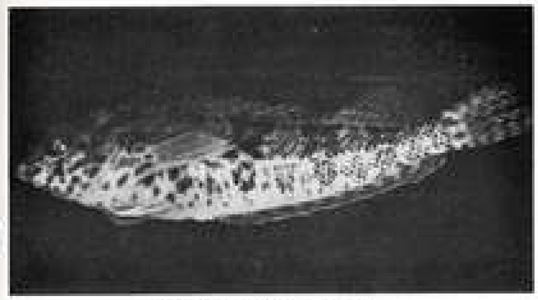
Mugil curema (Cuvier and Valenciennes)

Mugil curema Cuvier and Valenciennes, 1836, 77:64(87) (Brazil, Martinique, Cuba).

This species of mullet, sometimes placed with several others in the separate genus *Querimana* because the dorsal and anal are scaled basally, is said by Jordan, Evermann and Clark (1930: 253) to be found on "both coasts of America, Cape Cod to Brazil and Mazatlan to Chile." Young specimens are widely distributed inshore; we found them in all four of our collection localities.



Mugil curema, 31.5 mm. st. l.



Malacoctenus zonifer, 43.8 mm. st. l.

SUBORDER BLENNIOIDEA
FAMILY BLENNIDAE

Malacoctenus zonifer (Jordan and Gilbert)

Clinus zonifer Jordan and Gilbert, 1881, Proc. U.S.N.M. 4:361 (Mazatlan, Mexico).

About equal in number to *Abudefduf saxatilis* in the pools sampled, this small blenny was much less easily seen, as it possesses excellent protective coloration and lies on the bottom among tufts of calcareous algae. The bottom forms in general exhibited pronounced concealing coloration while the open water forms taken (*Abudefduf saxatilis* excepted), being the young of larger schooling forms, showed the typical blue-above, silvery-below coloration of these fishes. Jordan, Evermann and Clark (1930: 499) consider this form to be conspecific with *M. delalandi* (Cuv. and Val. 1836) (type locality Brazil).

ORDER XENOPTERYGII
FAMILY GOBIESOCIDAE

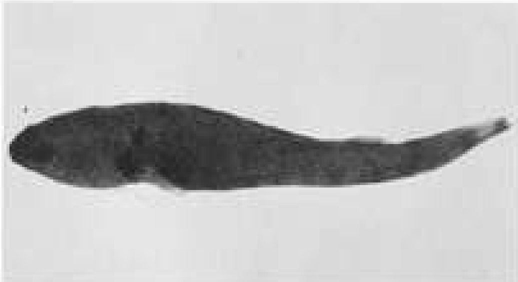
Gobiesox papillifer microspilus (Fowler)

Caularchus microspilus Fowler, 1916, Proc. Acad. Nat. Sci. Phila. 68:412, fig. 4 (Panama Bay).

Cotylis microspilus Briggs, 1951, Proc. Calif. Zool. Club 1(11):77 (San Francisco Bay to Panama City, Panama).

Gobiesox papillifer microspilus Briggs, 1955, Stanford Ichthyol. Bull. 6:124 (San Francisco Bay to Panama City, Panama).

Gobiesox papillifer Gilbert, 1890, Proc. U.S.N.M. 13 (797):96 (Magdalena Bay, Baja, Calif.).



Tomicodon petersi, 31.7 mm. st. l.

Our specimens were identified by Dr. John C. Briggs as *G. p. microspilus*, but he remarks (in lit.) that in some characters they stand intermediate between this subspecies and *G. p. papillifer* (Gilbert), and that subspecies differences may not hold because of clinal variation.

Tomicodon petersi (Garman)

Sicyases petersii Garman, 1875, Proc. Boston Soc. Nat. Hist., 18:203 (San José, San Miguel, and Siboga, all Pearl Islands, Panama Bay).

Sicyases pyrrhocinctus Cope, 1877, Proc. Amer. Philos. Soc. 17:27 (Peru).

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This *Polypterus senegalus* is 3 months old.

BEHAVIOR AND BREEDING IN THE AQUARIUM OF *POLYPTERUS SENEGALUS**

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In the last 50 years, breeding polypterids has been attempted many times. Actually most of the species are kept in public aquaria as well as in numerous laboratories, where it is hoped to breed them to augment the sparse facts so far known about their embryology, especially the first stages of development.

Polypterids are tough. They live perfectly well for several years in captivity. In spite of this, no egg-laying followed by hatching was observed until March 15, 1962. On this day I noticed eggs of *Polypterus senegalus* in one of our aquaria in the Ichthyology Laboratory of the Paris *Museum*. Preliminary observations regarding the biology and spawning of these fish were previously published (Arnoult, 1962). The main points will be recalled here.

Polypterus senegalus has the widest distribution of the polypterids. It is relatively common in the Upper Volta, occurring in rivers as well as lakes. The pair referred to above, which was part of our original laboratory stock, was taken from a lot of nine young ones caught with a hook and landing net in November, 1959, in the Upper Volta. Their pool, densely overgrown with aquatic vegetation (*Nymphaea lotus*, *Ceratophyllum demersum*), was

*Translated from the French from *Acta Zoologica*, March, 1964.

situated near Bobo-Dioulasso in a flooded plain. These young polypterids still had conspicuous external gills and did not exceed 4 inches in length when some days later I brought them back to France in a water-filled plastic bag.

In Paris, they were installed in a large aquarium (3 feet long, 3 feet wide, and 14 inches high), where the living conditions found in Upper Volta waters were duplicated. These conditions were as follows: Highest water temperature 72° F. (January) to 87° F. (May-June); lowest 67° F. (January) to 85° F. (June-July), except in very shallow pools where the temperature can rise to extreme values, so that *Clarias* (and *Polypterus*) are the only ones which can survive. The water is never clear; pH slightly above 6.0 in the dry season, changing abruptly to above 7.0 at the beginning of the rainy season, in the middle of June. Hardness is very low, due to the feeble solubility of the rocks. (DH never exceeded 5 in the dry season and was practically 0 in the rainy season.) The reserve alkaline total measured about 0.35 (up to 0.475 in the dry period).

The artificial living conditions (hardness 3-4 DH, temperature 76° F.) were maintained during the winter. The young *Polypterus* grew very slowly despite abundant nourishment with *Chironomus* larvae. (Other foods such as tubifex worms, daphnia, *Lumbricus*, and young guppies were ignored, which indicates that the polypterids are not the fierce predators they are depicted to be in literature about them.) They are even less voracious, and probably only occasionally ichthyophagous, in nature. They are shy of

An adult *Polypterus senegalus*. The species is native to the Niger and Congo Rivers.

light and spend most of the time on the bottom of the tank, resting on their pectoral fins or slowly moving by means of these pectorals or by undulations of the posterior part of the body. They do breathe atmospheric air, but occasionally their respiratory organs are accessory, not as in *Protopterus* where they are needed.

The regression of the external branchiae did not begin until September, 1960, and it was not completed until December. Then in February, 1961, I could notice some slight differences in their size and appearance and was able to isolate three pairs whose external sexual characteristics seemed very apparent. Besides a thicker and longer anal fin, the males have a turgid, laterally-deformed caudal peduncle, whereas females can be distinguished by their rounder bellies. The object was to try to breed the three pairs.

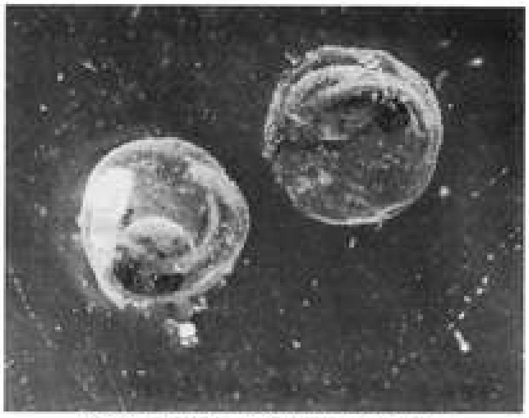
The water of the breeding tanks had been especially prepared; it was composed of three parts of artificially softened water and one part of water from a pond in the Sénart forest (pH 6.0, DH 3), which is rich in tannic acid from decayed oak leaves.

In their new surroundings (water pH 6.3, DH 4), the selected pairs rapidly acquired a new behavior. Instead of staying on the bottom, the pairs were swimming side by side in all directions, opening their mouths convulsively. The males preferred to take a position at the left of the females, attempting to bite them in the head region and curling themselves gently along their flanks. With their (the males') anal fins curved under the females' bellies, they simulated a spawning. Nevertheless there were no eggs laid, save for one pair which had been treated with chorionic gonatrope hormone; in this case no eggs developed.

At the beginning of 1962 the same experiments were performed again in approximately the same conditions. I simply added natural sea water in the proportion of 0.5 g. per liter; moreover, a sand filtration system replaced the simple aeration. There were no further hormone treatments, and, nevertheless, the pair which had produced infertile eggs the last year bred normally on March 15, 1962.

Most of the eggs, as well as 62 larvae at different developmental stages, were preserved. Twenty larvae were kept alive until their sexual maturity, which took place less than a year later, and as early as February, 1963, I was able to separate some mature pairs.

In March-April, 1963, all these pairs behaved like those described above, in the same environment. As early as April 25th, one of the young females laid fertile eggs which developed normally. Another spawning took place on May 24th. On the 26th of May another pair spawned. On the 30th and the 31st of May, there were new spawnings by two of the young pairs as well as another by the old pair that originally came from the Upper Volta.



Eggs containing embryos of *Polypterus senegalus* after 41 hours.

The second generation spawnings were of particular interest, because they proved that the spawning obtained in March 1962 was not a matter of luck and that the spawning of polypterids in the aquarium is a possibility if the proper biological and physical-chemical conditions are provided. I feel also that the addition of salt water is a particular benefit, because of the trace elements which are added with it to the fish's environment.

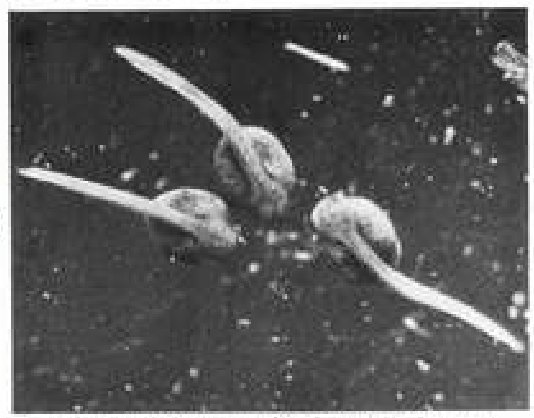
Spawning of *Polypterus senegalus* always takes place during the early morning hours. The male rubs along the female's side and fertilizes the eggs while they are being emitted. The spherical eggs, small in size, measure about 0.9 mm in diameter and are surrounded with a gelatinous mass. The clear animal nucleus is at the center of a zone rich in melanin, and the part opposed to the vegetative nucleus is speckled. The female lays her eggs singly on aquatic plants where they adhere feebly. I have also placed in the aquarium, to serve as a support for the eggs, some coconut fiber which had been boiled and rinsed, and in the last year, a bundle of nylon. This material is liked by the polypterids, which spawn frequently into it, and its white color makes the eggs easy to find.

It is very important to remove the eggs from the breeding aquarium as soon as possible, either by removing the supports upon which the eggs adhere, or with the use of a pipette. These eggs should be put into a glass

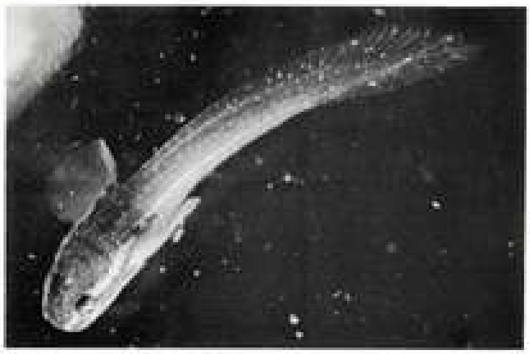
container or, better still, the small plastic containers used for filters. Their development at a temperature of 82° F. is very rapid; the stages of segmentation are completed in 60 hours, and the larva upon hatching has the general appearance of an amphibian larva. It lies on its side, but is capable of short spurts. Its respiration is accomplished, uniquely, by short external gills on each side of the head.

Twelve hours after hatching, the larva changes in appearance. The head and abdomen, instead of being globular, are extended into a tail; the external gills are comb-shaped; one can distinguish the outline of the eyes and the pectoral fins. The mouth is not fully formed, but one can see two adhesive organs, situated on the lower part of the head, below each eye.

Not until 8 days have gone by, when the mouth and eyes have become functional, is the larva capable of feeding. At this time, the larva measures about 4 mm in total length. This is a critical period, because the larva seems to be incapable of chasing its prey actively and contents itself with snapping at the bits of food that pass just below its mouth. My first attempts at feeding them resulted in a failure: all the larvae died of starvation rather than take the infusoria and microscopic algae which I offered them. Afterwards I used nothing but newly hatched brine shrimp, a considerable num-



Young larvae of *Polypterus senegalus* 54 hours after the eggs were laid.



A 20-day-old *Polypterus senegalus*.

ber of which the larvae were able to eat without any effort. The brine shrimp nauplii presented an advantage in that they did not foul the water in which they died, which is important because the polypterids are very fragile at this stage and cannot stand the slightest pollution.

After the fifteenth day the larvae had definitely lost their tadpole appearance and voraciously chased any brine shrimp which passed within their reach. They differed from the adults in that their dorsal fins were continuous, and their double bunches of external gills were still in evidence.

Growth proceeds rapidly if nourishment is abundant. The body color is elegant and is composed of longitudinal black stripes on a golden body color. The breaking up of the dorsal fin into pinnules takes place toward the end of the first month.

Raising the larvae in 1963 allowed me to get 116 specimens of all sizes and ages for embryological study. Twenty were not preserved, because I wanted to establish a record of their growth, and 17 of these were still alive in February, 1964.

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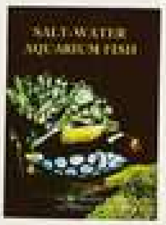

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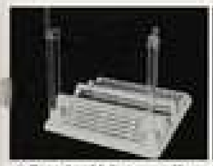

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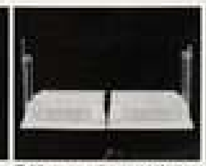

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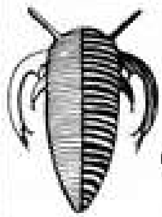

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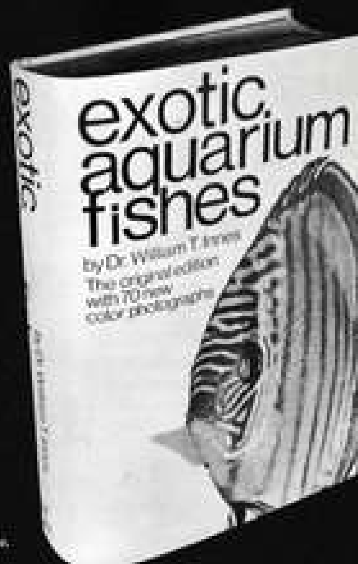

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