

Taxonomy and Distribution
of the Stomioid Fish Genus
Eustomias (Melanostomiidae), II:
Biradiostomias, New Subgenus

JANET R. GOMON
and
ROBERT H. GIBBS, JR.

SERIES PUBLICATIONS OF THE SMITHSONIAN INSTITUTION

Emphasis upon publication as a means of "diffusing knowledge" was expressed by the first Secretary of the Smithsonian. In his formal plan for the Institution, Joseph Henry outlined a program that included the following statement: "It is proposed to publish a series of reports, giving an account of the new discoveries in science, and of the changes made from year to year in all branches of knowledge." This theme of basic research has been adhered to through the years by thousands of titles issued in series publications under the Smithsonian imprint, commencing with *Smithsonian Contributions to Knowledge* in 1848 and continuing with the following active series:

Smithsonian Contributions to Anthropology
Smithsonian Contributions to Astrophysics
Smithsonian Contributions to Botany
Smithsonian Contributions to the Earth Sciences
Smithsonian Contributions to the Marine Sciences
Smithsonian Contributions to Paleobiology
Smithsonian Contributions to Zoology
Smithsonian Folklife Studies
Smithsonian Studies in Air and Space
Smithsonian Studies in History and Technology

In these series, the Institution publishes small papers and full-scale monographs that report the research and collections of its various museums and bureaux or of professional colleagues in the world of science and scholarship. The publications are distributed by mailing lists to libraries, universities, and similar institutions throughout the world.

Papers or monographs submitted for series publication are received by the Smithsonian Institution Press, subject to its own review for format and style, only through departments of the various Smithsonian museums or bureaux, where the manuscripts are given substantive review. Press requirements for manuscript and art preparation are outlined on the inside back cover.

Robert McC. Adams
Secretary
Smithsonian Institution

SMITHSONIAN CONTRIBUTIONS TO ZOOLOGY • NUMBER 409

Taxonomy and Distribution
of the Stomioid Fish Genus
Eustomias (Melanostomiidae), II:
Biradiostomias, New Subgenus

Janet R. Gomon
and *Robert H. Gibbs, Jr.*



SMITHSONIAN INSTITUTION PRESS

City of Washington

1985

ABSTRACT

Gomon, Janet R. and Robert H. Gibbs, Jr. Taxonomy and Distribution of the Stomioid Fish Genus *Eustomias* (Melanostomiidae), II: *Biradiostomias*, New Subgenus. *Smithsonian Contributions to Zoology*, number 409, 58 pages, 21 figures, 5 tables, 1985.—A new subgenus *Biradiostomias* (*Eustomias brevibarbat* Parr, 1927, type-species) is described to include species of *Eustomias* with two long, free pectoral rays, a slender barbel stem without branches or external pigment spots, no ventral body groove behind the pectoral-fin base, and with photophore, vertebral, anal-ray, and tooth counts lower than in the subgenera *Eustomias* and *Nominostomias*, higher than in subgenus *Haploclonus*. Nineteen species of *Biradiostomias* are recognized, primarily on the basis of barbel structure. A key and table of diagnostic characters supplement descriptions, synonymies, graphs of barbel and postorbital-organ dimensions, and illustrations of barbels. Seven currently accepted species are recognized: *E. dubius*, *polyaster*, *macrophthalmus*, *brevibarbat*, *xenobolus*, *leptobolus*, and *ioani*. Three species are resurrected from synonymy: *E. pyrifer*, *variabilis*, and *schiffi*. Two names are considered nomina dubia: *E. micropterygius* and *globulifer*. Nine species are described as new: *E. contiguus*, *digitatus*, *dispar*, *hullei*, *hypopsilus*, *ignotus*, *quadrifilis*, *metamelas*, and *precarius*. *Eustomias ioani* occurs in the northern subtropical North Pacific. The 18 other species occur only in the Atlantic, and only one of them (*E. contiguus*) extends into the eastern Atlantic. Ten species occur primarily in the Gulf of Mexico, Caribbean Sea, and waters close to the Bahamas and Antilles; only one of these has been taken in the Northern Sargasso Sea, and another extends into and south of the Amazon influence. Five species have oceanic distributions, three in the Northern Sargasso Sea or adjacent Slope Water, two in the Southern Sargasso Sea. Three species are known from single records in the northwestern tropical, southwestern tropical, and southwestern subtropical Atlantic.

OFFICIAL PUBLICATION DATE is handstamped in a limited number of initial copies and is recorded in the Institution's annual report, *Smithsonian Year*. SERIES COVER DESIGN: The coral *Montastrea cavernosa* (Linnaeus).

Library of Congress Cataloging in Publication Data

Gomon, Janet R.

Taxonomy and distribution of the Stomioid fish genus *Eustomias* (Melanostomiidae), II: *Biradiostomias*, new subgenus.

(Smithsonian contributions to zoology ; no. 409)

Bibliography: p.

Supt. of Docs. no.: SI 1.21:409

1. *Eustomias*—Classification. 2. *Eustomias*—Geographical distribution. 3. Fishes—Classification. 4. Fishes—Geographical distribution. I. Gibbs, Robert H., Jr. II. Title. III. Title : *Biradiostomias*, new subgenus. IV. Series.

QL1.S54 no. 409 591 s [597'.55] 84-600383 [QL638.M3573]

Contents

| | <i>Page</i> |
|----------------------------------------------------------|-------------|
| Introduction | 1 |
| Abbreviations | 1 |
| Acknowledgments | 1 |
| <i>Biradiostomias</i> , New Subgenus | 2 |
| Key to the Species of <i>Biradiostomias</i> | 3 |
| Group I | 5 |
| <i>Eustomias brevibarbatatus</i> Parr | 5 |
| <i>Eustomias contiguus</i> , new species | 16 |
| <i>Eustomias dispar</i> , new species | 18 |
| <i>Eustomias hypopsilus</i> , new species | 19 |
| <i>Eustomias ignotus</i> , new species | 21 |
| <i>Eustomias metamelas</i> , new species | 22 |
| <i>Eustomias variabilis</i> Regan and Trewavas | 23 |
| Group II | 26 |
| <i>Eustomias digitatus</i> , new species | 26 |
| <i>Eustomias dubius</i> Parr | 32 |
| <i>Eustomias polyaster</i> Parr | 33 |
| <i>Eustomias schiffi</i> Beebe | 35 |
| Group III | 37 |
| <i>Eustomias hulleyi</i> , new species | 37 |
| <i>Eustomias ioani</i> Parin and Pokhilskaya | 40 |
| <i>Eustomias leptobolus</i> Regan and Trewavas | 44 |
| <i>Eustomias macrophthalmus</i> Parr | 45 |
| <i>Eustomias precarius</i> , new species | 47 |
| <i>Eustomias pyrifer</i> Regan and Trewavas | 48 |
| <i>Eustomias quadrifilis</i> , new species | 48 |
| <i>Eustomias xenobolus</i> Regan and Trewavas | 49 |
| Doubtful Species | 50 |
| <i>Eustomias globulifer</i> Regan and Trewavas | 50 |
| <i>Eustomias micropterygius</i> Parr | 52 |
| Geographic Distribution | 53 |
| Tables 3–5 | 55 |
| Literature Cited | 58 |

Taxonomy and Distribution of the Stomioid Fish Genus *Eustomias* (Melanostomiidae), II: *Biradiostomias*, New Subgenus

Janet R. Gomon
and Robert H. Gibbs, Jr.

Introduction

In this second installment of a revision of the genus *Eustomias*, we deal with the species that have two long, free pectoral rays. These were included in the subgenus *Nominostomias* by Regan and Trewavas (1930), but Gibbs, Clarke, and Gomon (1983) indicated that they should be in a separate subgenus and noted the characters that distinguish them from *Nominostomias* (Gibbs et al., 1983:8 and table 1). Herein we formally diagnose and name the new subgenus.

Parr (1927) described the first five nominal species that we include in the new subgenus: *dubius*, *polyaster*, *macrophthalmus*, *brevibarbatus*, and *micropterygius*. Regan and Trewavas (1930) suggested that *micropterygius* might be a synonym of *macrophthalmus*, recognized Parr's other four species, and described six additional species: *pyrifer*, *xenobolus*, *leptobolus*, *trituberatus*, *variabilis*, and *globulifer*. Beebe (1932) described *schiffi*, but Beebe and Crane (1939) considered it to be a synonym of *dubius*. Morrow and Gibbs (1964)

relegated *pyrifer* to the synonymy of *xenobolus* and *trituberatus* and *variabilis* to the synonymy of *brevibarbatus*. The only new species to be described since 1932 is *ioani* Parin and Pokhilskaya (1974). Thus, of 13 nominal species, only 8 have been considered valid in recent times.

In this study we recognize 10 of the 13 described species as valid, consider 2 others to be nomina dubia, and describe 9 new species.

We refer the reader to the first paper in this series (Gibbs, Clarke, and Gomon, 1983) for background and methods.

ABBREVIATIONS.—The abbreviations used to designate institutions and collections and those used in the descriptive and "Material Examined" sections are the same as in Gibbs et al. (1983:2–3), with three additions:

- OSUO Department of Oceanography, Oregon State University, Corvallis
USF University of South Florida, St. Petersburg
ZIL Zoological Institute, Akademia Nauk SSSR, Leningrad

ACKNOWLEDGMENTS.—We continue to be indebted and grateful to our many colleagues and their institutions for the loan and exchange of specimens, for providing information concerning

Janet R. Gomon and Robert H. Gibbs, Jr., Division of Fishes, Department of Vertebrate Zoology, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560.

specimens, for courtesies provided during visits to their collections, and for providing opportunities to participate in research cruises.

Figures 1a,b, 13a, and 13f were drawn by Gomon. All other barbel drawings were done by Penelope Kay Hollingsworth. Kenneth J. McCormick aided in preparation of computer-generated graphs and distribution maps. Frigga K. Gibbs typed all drafts of the manuscript using computer word processing.

We thank James E. Craddock, Robert Karl Johnson, and Stanley H. Weitzman for their critical comments on the manuscript.

This study has benefited from support at various times over the years from the National Science Foundation, Navy Undersea Systems Center, Smithsonian Research Foundation, and Fluid Research Fund, in addition to the continuous support of our home institution.

Biradiostomias, new subgenus

TYPE-SPECIES.—*Eustomias brevibarbatus* Parr, 1927.

DEFINITION.—Two well-developed, free pectoral rays. Seven pelvic rays. Barbel with slender stem having little or no external pigment (axis often pigmented), no row of dark spots, and no branches proximal to terminal bulbs. One to three, rarely four, relatively small terminal bulbs, with or without terminal filaments or projections. No wide ventral body groove posterior to pectoral-fin base. Photophores in ventral series (IC) 69–77 (mostly 71–75), in lateral series (OC) 64–71 (rarely more than 68, species modes mostly 66–68), VAV and VAL 13–19 (seldom more than 17, species modes 15–17 and 16–17, respectively). Usually 4–6 (rarely 7) VAV photophores located over anal-fin base. No paired photophores in lateral series. Vertebrae in continuous series 63–68 (seldom more than 66, species modes mostly 65–66). Anal rays 31–40, usually 33–38. Premaxillary teeth 7–15; mandibular teeth 9–18 (fewer of each in many specimens less than 100 mm SL).

Biradiostomias differs from all other subgenera

of *Eustomias* (see Gibbs et al., 1983) in the possession of two long, separate pectoral rays. *Dinematochirus*, when pectoral fins are present, also has two pectoral rays, but these are closely bound together in black membrane; furthermore, the species of *Dinematochirus* have a well-developed ventral body groove that extends beyond the pectoral-fin bases, and the barbel is short, usually with a pigmented stem, and usually with branches arising from the stem well before the terminal bulb.

Biradiostomias is most similar to the subgenera *Nominostomias*, *Haploclonus*, and *Eustomias* in possessing a relatively long, slender barbel that has little or no external pigment and in lacking a well-developed ventral groove behind the pectoral bases. These three subgenera have three long, separate pectoral rays. *Biradiostomias* generally is intermediate in photophore, vertebral, anal-ray, and tooth numbers between the higher counts in *Nominostomias* and *Eustomias* and the lower counts of *Haploclonus*. The subgenus *Eustomias* is unique in having paired photophores in the lateral series. Gibbs et al. (1983, table 1) compare counts of *Haploclonus*, *Biradiostomias* (as "2-pectoral-rays"), and *Nominostomias*.

ETYMOLOGY.—*Biradiostomias* is a masculine noun compounded of the Latin *bi-* (two), *radius* (rod or ray), and the Greek *stomias* (a kind of fish), in reference to the two separate pectoral rays that characterize the species in the group.

THE SPECIES AND CHARACTERS.—The following are the nominal species that we recognize as belonging to *Biradiostomias*. They are listed in order of the date of the original description, and their current names, if changed, are given in parentheses.

- Eustomias micropterygius* Parr, 1927 (nomen dubium)
- Eustomias dubius* Parr, 1927
- Eustomias macrophthalmus* Parr, 1927
- Eustomias brevibarbatus* Parr, 1927
- Eustomias polyaster* Parr, 1927
- Eustomias variabilis* Regan and Trewavas, 1930
- Eustomias trituberatus* Regan and Trewavas, 1930 (*variabilis*)
- Eustomias xenobolus* Regan and Trewavas, 1930
- Eustomias pyrifer* Regan and Trewavas, 1930

Eustomias globulifer Regan and Trewavas, 1930 (nomen dubium)
Eustomias macropthalmus Regan and Trewavas, 1930
Eustomias leptobolus Regan and Trewavas, 1930
Eustomias schiffi Beebe, 1932
Eustomias ioani Parin and Pokhilskaya, 1974
Eustomias contiguus, new species
Eustomias digitatus, new species
Eustomias dispar, new species
Eustomias hullei, new species
Eustomias hypopsilus, new species
Eustomias ignotus, new species
Eustomias metamelas, new species
Eustomias precarius, new species
Eustomias quadrifilis, new species

There is some question as to the inclusion of *ioani* in *Biradiostomias*. It is known only from the North Pacific and is the only species of *Biradiostomias* that occurs outside the Atlantic. The terminal bulb of its barbel bears filaments on its sides, not just from the distal end, and it is extreme for the subgenus in photophores and vertebral counts.

Counts and body proportions are of little use in distinguishing most of the species of *Biradiostomias*. Although there are modal differences in counts, there is always overlap in ranges (Tables 3–5). Similarly, while the data

for some species appear to indicate differences in relative growth, these differences appear to be sampling artifacts. The cloud of points for species with abundant measurements encompassed those with fewer measurements and indicated isometric growth after metamorphosis in every character except caudal-peduncle depth, which decreases relative to SL. Ranges of variations in morphometric characters are given in Table 2.

The species accounts that follow, therefore, make almost no mention of most meristic characters or of morphometric characters other than barbel or postorbital-organ measurements, which are virtually the only characters useful in distinguishing species.

For convenience in discussion and for mapping, we divide the species into three groups, which may or may not represent phylogenetic categories. Group I includes species with two or more terminal bulbs that are not bilobate. Group II includes species with a bilobate terminal bulb (some species occasionally have one additional bulb). Group III includes species with a single, non-bilobate bulb. These groupings are not reflected in the key to species.

Key to the Species of *Biradiostomias*

(Some species are keyed out in more than one couplet)

1. Barbel with 2 or more terminal bulbs2
 Barbel with a single terminal bulb10
2. Two contiguous barbel bulbs3
 Two to four well separated barbel bulbs4
3. Prominent branched filaments arising from distal bulb [Figure 1*d,e*]
 (subtropical North Atlantic) ***E. contiguus***
 Only a tiny projection at end of distal bulb [Figure 2*g*] (off southern
 Brazil) ***E. ignotus***
4. No filament arising from distal bulb (a tiny lateral projection sometimes
 present) [Figure 2*e,f*] (Gulf of Mexico; off Guianas) .. ***E. hypopsilus***
 One or more filaments arising from distal bulb5
5. Barbel length 54% SL or longer. A single unbranched filament without
 prominent bulblets arising from distal bulb6
 Barbel length 52% SL or shorter. One or more filaments, branched and/
 or with prominent bulblets, arising from distal bulb7

6. Barbel length 82% SL. Pigment on axis between terminal bulbs not much darker than on stem axis, not forming cap on base of distal bulb. Terminal filament 2.1% SL, only slightly longer than distal bulb [Figure 1*b*] (northwestern tropical Atlantic) *E. dispar*
 Barbel length 54–55% SL. Pigment on axis between terminal bulbs much darker than on stem axis, forming cap on base of distal bulb. Terminal filament 31% SL, about 20 times length of distal bulb [Figure 1*a*] (southwestern tropical Atlantic) *E. metamelas*
7. Prominent black cap covering proximal end of distal bulb [Figure 1*c*] (Gulf of Mexico, Caribbean Sea, western Atlantic from Florida to Rio de Janeiro) *E. brevibarbatus*
 No black cap on distal bulb 8
8. Distal bulb spheroidal or ovoid, not notched or bilobate [Figure 2*a–d*] (eastern Gulf of Mexico and Florida to Lesser Antilles and northwestern tropical Atlantic) *E. variabilis*
 Distal bulb notched or bilobate 9
9. Terminal filament 8% SL or longer, more than twice as long as distal bulb, with prominent, large bulblets [Figure 8] (Sargasso Sea and Gulf of Mexico to Caribbean Sea and Lesser Antilles) *E. polyaster*
 Terminal filament less than 6% SL, not more than twice as long as distal bulb, without prominent bulblets (tiny bulblets may be visible with magnification) [Figure 9*a,b*] (Northern Sargasso Sea) *E. schiffi*
10. Terminal bulb bilobate 11
 Terminal bulb not bilobate 13
11. Barbel 28% SL or shorter. Filament-bearing lobe of bulb long, tapering, 3–4 times length of other lobe. Terminal filaments simple, very short, 0.2% SL [Figure 9*e,f*] (off Leeward Islands) *E. digitatus*
 Barbel 37% SL or longer. Filament-bearing lobe of bulb shorter than to 1.7 times length of other lobe. Terminal filaments branched, longer, 0.4%–5.2% SL 12
12. Barbel length 58% SL or longer. Bulb 0.9%–1.3% SL. Notch between lobes of bulb 75% or more length of ovoid lobe. Terminal filaments 0.4%–1.4% SL [Figure 9*c,d*] (Bahamas to east of Lesser Antilles) *E. dubius*
 Barbel length 48% SL or shorter. Bulb 1.3%–2.3% SL. Notch between lobes of bulb about 50% length of ovoid lobe. Terminal filaments 2.1–5.2% SL [Figure 9*a,b*] (Northern Sargasso Sea) *E. schiffi*
13. Bulb about 5–6 times as long as wide, 2.6% SL or longer 14
 Bulb not more than about twice as long as wide, 1.5% SL or shorter . 16
14. Barbel length 76% SL or longer. Bulb length 4.3% SL or longer [Figure 14*a*] (Greater Antilles, southwestern Sargasso Sea) *E. macrophthalmus*
 Barbel length 49% SL or shorter. Bulb length (opaque part) 3.5% SL or shorter 15
15. Two pairs of terminal filaments, some with complex branching; bulb not

- constricted; IA photophores 56, IC 73 [Figure 14f] (northwestern Sargasso Sea or Slope Water) *E. quadrifilis*
- No more than 3 filaments, all simple; bulb constricted near distal end; IA photophores 57–59, IC 75–77 [Figure 14b,c] (eastern Gulf of Mexico, off Guianas) *E. leptobolus*
16. Bulb with filaments arising laterally as well as distally, each filament with a swollen bulblet at its tip. A prominent external patch of dark pigment on stem proximal to bulb, separated from bulb by unpigmented area [Figure 14e] (North Pacific) *E. ioani*
- Bulb without filaments or with distal filaments only, the filaments without swollen bulblets. External dark pigment present or absent proximal to bulb; if present, no unpigmented area separating pigment from bulb 17
17. Barbel length 75% SL or longer. Terminal filament absent or less than half bulb length [Figure 13a,b] (southwestern Sargasso Sea) *E. hulleyi*
- Barbel length 64% SL or shorter. Terminal filament half bulb length or longer 18
18. Barbel length 64% SL. Filament 2.6 times bulb length [Figure 13f] (off Puerto Rico) *E. precarius*
- Barbel length 57% SL or shorter. Filament 2.1 times bulb length or shorter 19
19. Bulb with slender proximal part almost separate from swollen distal part [Figure 13d,e] (western Gulf of Mexico; off Virgin Islands) *E. xenobolus*
- Bulb not distinctly slender proximally [Figure 13c] (off Virgin Islands) *E. pyrifer*

GROUP I

The species of this group have two or more terminal bulbs that may be contiguous or widely separated. The distalmost bulb is spherical to ovoid and is not bilobate. (A shallow notch is present in some *contiguus*.) A synopsis of the salient characters of the species is given in Table 1, and their barbel and postorbital-organ dimensions are plotted in Figures 3–7.

Eustomias brevibarbatus Parr, 1927

FIGURE 1c

Eustomias brevibarbatus Parr, 1927:68, figs. 36A, 40 [holotype and 1 paratype; type-locality 23°55'N, 77°09'W].—

Regan and Trewavas, 1930:92, figs. 17B, 74B,C [16 additional specimens, description].—Bertin, 1940:381 [specimen in MNHN].—Morrow and Gibbs, 1964:400–402, fig. 109C,D [in part; references to *E. brevibarbatus* only; no additional specimens].—Rass, 1971:511 [probably in part; listed for Gulf of Mexico and Caribbean Sea; may include *E. variabilis*].—Parin and Pokhilskaya, 1974:374 [in part; 4 specimens; not Kurchatov station 1255].—Bekker et al., 1975:305 [in part; specimen from station 1253 only].

DIAGNOSIS.—Two terminal bulbs separated by a short interspace, 0.1%–1.5% SL, about 0.3–2.5 times distal-bulb length. Proximal bulb small, 0.1%–0.7% SL. Distal bulb 0.4%–1.1% SL, 1–5 times proximal-bulb length, with distinctive black pigment cap on proximal end. Terminal filament short, 0.3%–2.5% SL, without prominent bul-

TABLE 1.—Synopsis of characters of species of *Biradiostomias* (SL is given (in mm) when characters are from only part of the size range).

| Species | Barbel length | | Proximal bulb | | Distal bulb | | Distal/proximal bulb | Interbulb distance | Interbulb distance/distal bulb | |
|-----------------------|---------------|-----|---------------|-----|-------------|-----|----------------------|--------------------|--------------------------------|-------|
| | (% SL) | SL | (% SL) | SL | (% SL) | SL | | | (% SL) | SL |
| GROUP I | | | | | | | | | | |
| <i>brevibarbatu</i> s | 13–33 | | 0.1–0.7 | | 0.4–1.1 | | 1.0–5.0 | 0.1–1.5 | 0.3–2.5 | |
| <i>contiguu</i> s | 15–49 | | 0.6–1.2 | | 0.6–1.2 | | 0.8–1.3 | 0 | — | |
| ? <i>contiguu</i> s | 86 | | 0.8 | | 0.6 | | 0.8 | 0 | — | |
| <i>dispar</i> | 82 | | 1.5 | | 1.8 | | 1.2 | 2.9 | 1.6 | |
| <i>hypopsil</i> u | 11–43 | <90 | 0.5–1.2 | | 0.5–1.5 | | 0.8–1.6 | 1.2–3.7 | 1.5–4.2 | |
| | 34–47 | >90 | | | | | | | | |
| <i>ignot</i> u | 44 | | 0.8 | | 0.7 | | 0.9 | 0.1 | 0.1 | |
| <i>metamel</i> as | 54–55 | | 1.3–1.6 | | 1.3–1.5 | | 0.9–1.0 | 3.1–4.4 | 2.1–3.3 | |
| <i>variabil</i> is | 18–41 | | 0.4–1.7 | | 0.6–2.1 | | 0.5–3.3 | 1.0–6.4 | 1.0–4.0 | 56–72 |
| | | | | | | | | 4.8–7.1 | 79–151 | |
| GROUP II | | | | | | | | | | |
| <i>digitat</i> u | 24–28 | | — | | 1.0–3.8 | | — | — | — | |
| <i>dubiu</i> s | 58–78 | | — | | 0.9–1.3 | | — | — | — | |
| <i>polyast</i> er | 7–37 | <77 | 0.3 | <77 | 0.6–0.8 | 65 | 1.3–3.0 | 0.8–2.6 | 0.4–1.4 | |
| | 37–52 | >77 | 0.7–1.3 | >77 | 1.3–2.5 | >77 | | | | |
| <i>schiff</i> i | 12 | 43 | none or | | 1.3–2.3 | | 0 or | 0 or | 0 or | |
| | 37–48 | >54 | 0.5–0.9 | | | | 2.6–3.5 | 0.5–1.1 | 0.3–0.6 | |
| GROUP III | | | | | | | | | | |
| <i>hulle</i> y | 75–87 | | — | | 0.8–1.4 | | — | — | — | |
| <i>ioani</i> west | 43–48 | | — | | 1.2–1.5 | | — | — | — | |
| east | 57–70 | | — | | | | — | — | — | |
| <i>leptobol</i> u | 46–49 | | — | | 3.3–3.5 | | — | — | — | |
| ? <i>leptobol</i> u | 35 | | — | | 2.7 | | — | — | — | |
| (106 mm) | | | | | | | | | | |
| <i>macrophthal</i> mu | 76–93 | | — | | 4.3–7.0 | | — | — | — | |
| <i>precari</i> u | 64 | | — | | 1.1 | | — | — | — | |
| <i>quadrifil</i> is | 36 | | — | | 2.6 | | — | — | — | |
| <i>pyrif</i> er | 25 | | — | | 0.6 | | — | — | — | |
| <i>xenobol</i> u | 22–57 | | — | | 0.5–1.4 | | — | — | — | |
| UNCLASSIFIED | | | | | | | | | | |
| <i>globulif</i> er | 5 | | — | | 0.6 | | | | | |
| <i>microptery</i> giu | 10 | | — | | ? | | | | | |

TABLE 1—Continued.

| Terminal filament(s) (% SL) | Filaments (no; structure) | Filament(s)/ distal bulb | Male postorbital | | Predorsal pairs of spots | Other characters* |
|-----------------------------|---------------------------------------|--------------------------|-------------------|------------------|--------------------------|-------------------|
| | | | (% SL) [SL] | (% fleshy orbit) | | |
| 0.3–2.5 | 1, bifurcate or trifurcate | 0.4–4.0 | 1.4–2.1 [125–152] | 56–82 | 8 | c,d |
| 1.5–3.8 | 5–9, some or all branched | 1.7–4.9 | 1.4–1.6 [122–127] | 47–53 | (7)8 | |
| 0.6 | 5, 1 branched | 1.0 | 1.6 [160] | 47 | 8 | h |
| 2.1 | 1, simple | 1.2 | — | — | 8 | |
| 0 | 0 | — | 1.6–1.9 [105–126] | 50–65 | (7)8 | a |
| 0.1 | 1, simple | 0.1 | — | — | 8 | |
| 31 | 1, simple | 20–24 | 2.2 [112] | 71 | 8 | c,d |
| 0.3–4.9 | 1–2, simple or branched | 0.3–4.4 | 1.5 [145] | 65 | 9(8) | b |
| 0.2 | 0–2, simple | 0.1 | — | — | 8 | g |
| 0.4–1.4 | 4–many, some branched | 0.4–1.4 | — | — | 8 | g |
| 8.0–19.1 | 1–4, main one with bulblets, branches | 2.6–10.2 | 1.6–2.0 [114–134] | 62–86 | 8 | g |
| 2.1–5.2 | 3–6, some branched | 0.9–2.1 | 1.7 [118] | 57 | 8 | g |
| 0.3–0.4 | 0–4, simple or branched | 0.3–0.4 | 1.7–2.2 [103–120] | 55–75 | 8 | e |
| 0.6–1.3 | 4–6, simple long bulblet | 0.5–1.1 | — | — | 9–10 | f |
| 0.1 | 1, simple | 0.1 | — | — | 8 | |
| 0.9 | 3, simple | 0.3 | — | — | | |
| 0.3–0.5 | 0–1, simple | 0–0.1 | 1.2–2.2 [97–111] | 34–67 | 8 | |
| 2.9+ | 1, branched | 2.6 | 2.6 [126] | 70 | 8 | |
| 2.2 | 4, branched | 0.9 | 0.9 [105] | 32 | ? | |
| ~0.6 | 1, bifurcate | ~1.0 | 1.9 [132] | 64 | 8 | |
| 0.2–3.3 | 1, branched or 3, simple | 0.4–2.1 | — | — | 8 | |

* Other characters: a, rarely a third terminal bulb; b, usually 3 or 4 terminal bulbs; c, black cap on base of distal bulb; d, axis darkest between bulbs; e, cylinder of dark pigment around axis near bulb; f, dark external pigment before bulb; g, bulb notched or bilobate; and h, a slight notch in distal bulb.

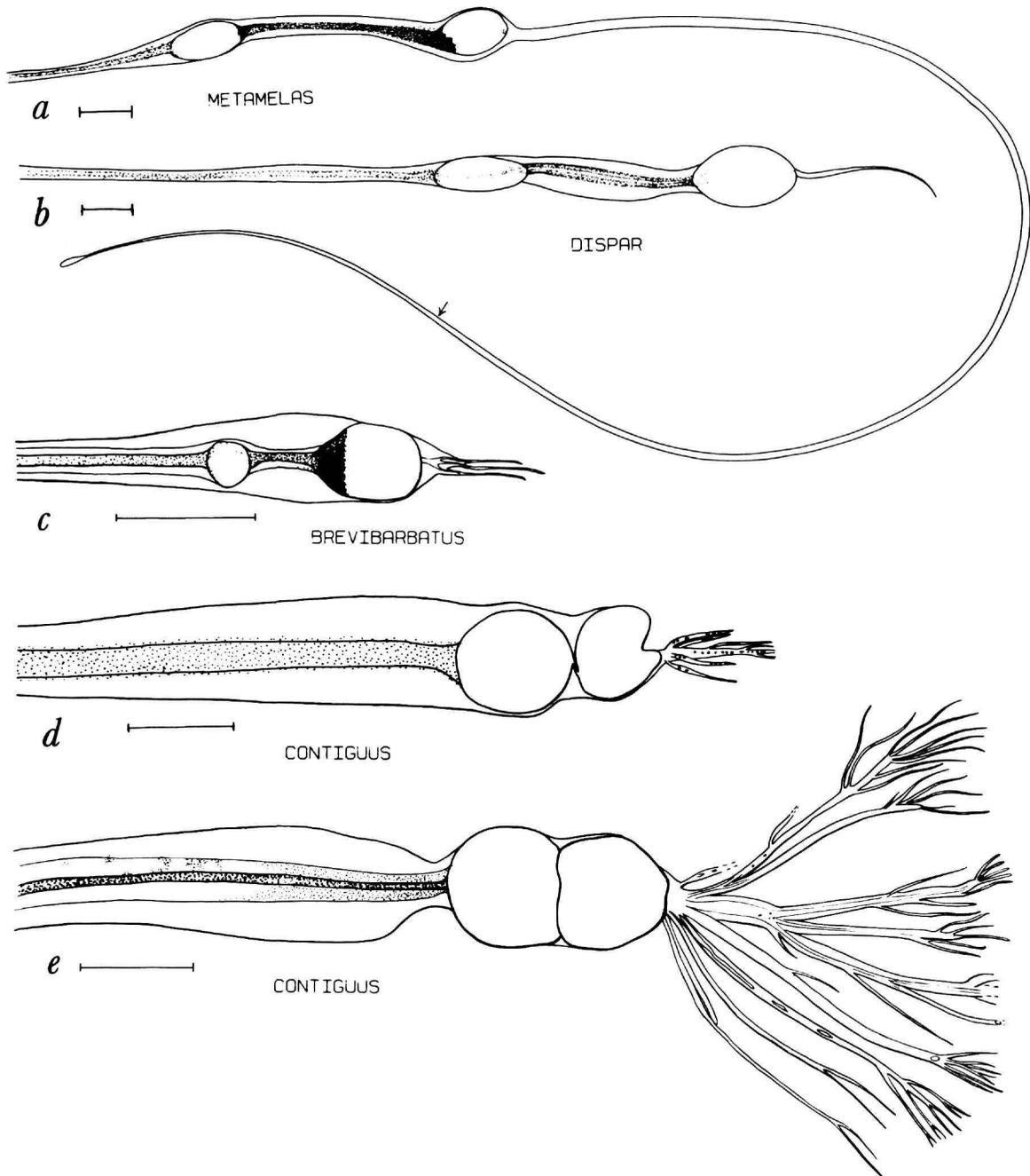


FIGURE 1.—Barbel ends of Group 1 species: *a*, *E. metamelas*, paratype, 91.5 mm, USNM 222184 (arrow indicates point where filament was broken); *b*, *E. dispar*, holotype, 116.5 mm SL, USNM 222183; *c*, *E. brevibarbatus*, 142.5 mm SL, UMML uncataloged (CI-221); *d,e*, *E. contiguus* (*d*, non-type, 160 mm SL, USNM 265197, with extremely long barbel; *e*, paratype, 131.4 mm SL, ISH 3303/79). (Bar = 1 mm.)

TABLE 2.—Range of variation of morphometric characters of all species of *Biradiostomias* combined (based on individual specimens and on species means where 4 or more specimens of a species were measured).

| Character | Range (% SL) | |
|----------------------------|--------------|---------------|
| | Individuals | Species means |
| Predorsal length | 80.1–87.4 | 82.9–84.8 |
| Preanal length | 67.2–77.6 | 72.9–75.0 |
| Prepelvic length | 54.5–65.1 | 58.7–61.3 |
| Head length | 9.6–15.1 | 11.8–13.3 |
| Snout length | 3.5–7.2 | 5.1–5.9 |
| Fleshy-orbit length | 1.8–4.7 | 2.6–3.3 |
| Lower-jaw length | 8.9–12.9 | 10.2–11.5 |
| Upper-jaw length | 8.1–12.0 | 9.3–10.7 |
| Depth behind head | 3.9–8.8 | 5.9–8.0 |
| Greatest depth | 3.8–11.3 | 5.6–8.4 |
| Caudal-peduncle depth | 1.2–2.7 | 1.5–2.0 |
| Pectoral-fin length | 2.7–26.4 | 9.7–13.0 |
| Pelvic-fin length | 4.7–18.4 | 12.9–16.2 |
| Dorsal-base length | 9.7–14.7 | 11.0–13.5 |
| Anal-base length | 18.7–26.2 | 20.9–23.8 |
| Longest premaxillary tooth | 0.5–2.3 | 1.4–1.9 |
| Longest mandibular tooth | 0.7–2.0 | 1.3–1.7 |

blets. Barbel length 13%–33% SL. Stem axis lightly to darkly pigmented. External chevron-shaped or roundish striated areas on stem unpigmented. Paired dorsal spots between occiput and dorsal-fin origin 8.

DESCRIPTION.—Barbel length is 13%–30% SL in specimens smaller than 65 mm, 15%–28% in those 65–90 mm, and 23%–33% in those larger than 90 mm. Apparently the increase in relative length occurs at different rates in small specimens, but no further change with growth occurs after about 90 mm SL. The axis of the stem varies from lightly to darkly peppered with melanophores, or streaked with dark pigment, the variation apparently not size related. The chevron-shaped or roundish striated areas on the stem are unpigmented. The axis between the bulbs is darkly peppered or streaked, especially distad where it extends onto the proximal quarter to third of the distal bulb as a black cap. The filament axis is without melanophores or with a few proximally.

Proximal and distal bulbs vary in shape from

spheroidal to ovoid. The proximal bulb is 0.1%–0.7% SL, distal bulb 0.4%–1.1% SL and 1–5 times proximal-bulb length, neither bulb changing size relative to SL with growth. Several specimens have non-opaque distal bulbs with a reticulate or dendritic network internally.

The distance between bulbs is 0.5%–1.5% SL in small specimens, decreasing in relative length to 0.1%–0.6% in the largest. The distance is 0.3–2.5 times as long as the distal bulb, with no relation to size of fish.

The terminal filament is short, 0.3%–2.5% SL, 0.4–4.0 times distal-bulb length, apparently not changing with growth. It bifurcates or trifurcates near its base, and occasionally branches again further distad. There are no bulblets in the filament.

The postorbital organs of 12 large males (125–152 mm SL) are 1.4%–2.1% SL, 56%–82% fleshy orbit length. A 134 mm male has a post-orbital organ only 1.0% SL, 45% fleshy orbit length, and one 105 mm has an organ 1.2% SL, 43% fleshy orbit length. In one female the organ is 0.9%; in all others it is 0.8% or less.

There are eight paired dorsal spots between occiput and dorsal-fin origin, one beneath the dorsal fin, and one variably present on the caudal peduncle.

In two freshly caught specimens the proximal bulb was yellow, the distal bulb blue.

SIMILAR SPECIES.—Of the species of *Biradiostomias* with two or more non-contiguous, non-bilobate terminal bulbs, *E. brevibarbatus* is unique in having a black pigment cap on the proximal $\frac{1}{4}$ – $\frac{1}{3}$ of the distal bulb. *Eustomias metamelas* also has pigment extending onto the distal bulb but the pigment does not extend as far or as evenly onto the bulb as in *brevibarbatus*, and the filament is longer (31% SL vs. 0.3%–2.5%). The barbels of both *metamelas* and *dispar* are longer (54%–82% SL vs. 13%–33% in *brevibarbatus*), the distance between bulbs is longer (2.9%–4.4% SL vs. 0.1%–1.5%), and both terminal bulbs are larger (proximal bulb 1.3%–1.6% SL vs. 0.1%–0.7%; distal bulb 1.3%–1.8% SL vs. 0.4%–1.1%). *Eustomias hypopsilus* and *E. variabilis* are similar to

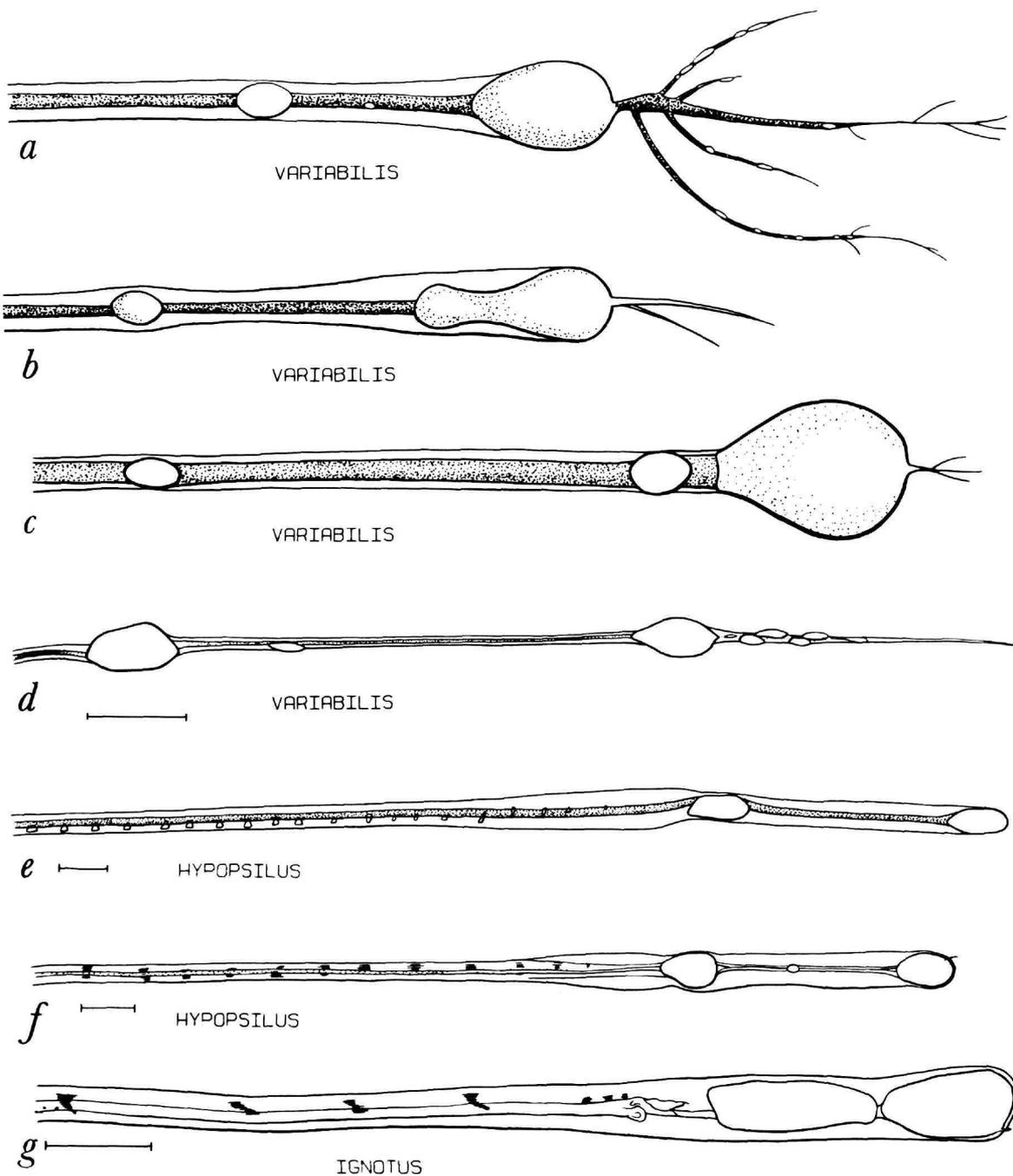


FIGURE 2.—Barbel ends of Group I species: *a-d*, *E. variabilis* (*a,b*, after Regan and Trewavas, 1930, figs. 720 and F, paralectotypes of *E. variabilis*; *c*, after Regan and Trewavas, 1930, fig. 74A, lectotype of *E. trituberosus*; *d*, 78.5 mm SL, UMML 23018); *e,f*, *E. hypopsilus* paratypes (*e*, 135.5 mm SL, USNM 224127; *f*, 125.8 mm SL, USNM 224126, with rare middle bulb and tiny filamentous projection); *g*, *E. ignotus*, holotype, 197 mm SL, ISH 907/66. (Bar = 1 mm.)

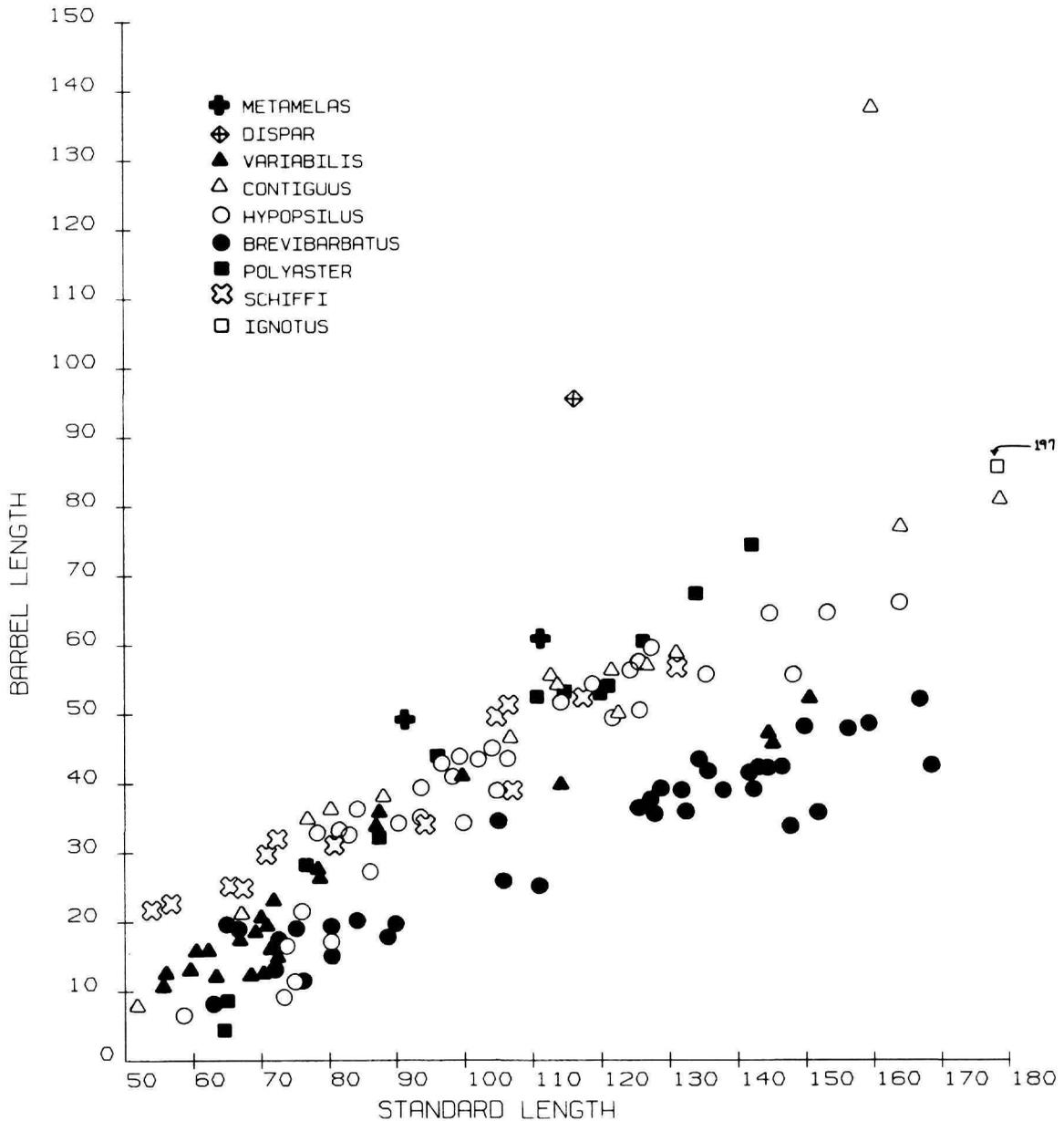


FIGURE 3.—Barbel length (mm) vs. SL (mm) in Group I species and *E. polyaster* and *schiffi* from Group II.

brevibarbatus in having short barbels and relatively small terminal bulbs, but differ in having a longer interspace between bulbs (1.2%–3.7% SL vs. 0.1%–1.5% SL in *brevibarbatus*). In addition,

hypopsilus lacks a terminal filament that is present in *brevibarbatus*, and the filament of *variabilis* usually has bulblets, which *brevibarbatus* lacks.

DISTRIBUTION.—Eastern Gulf of Mexico, Car-

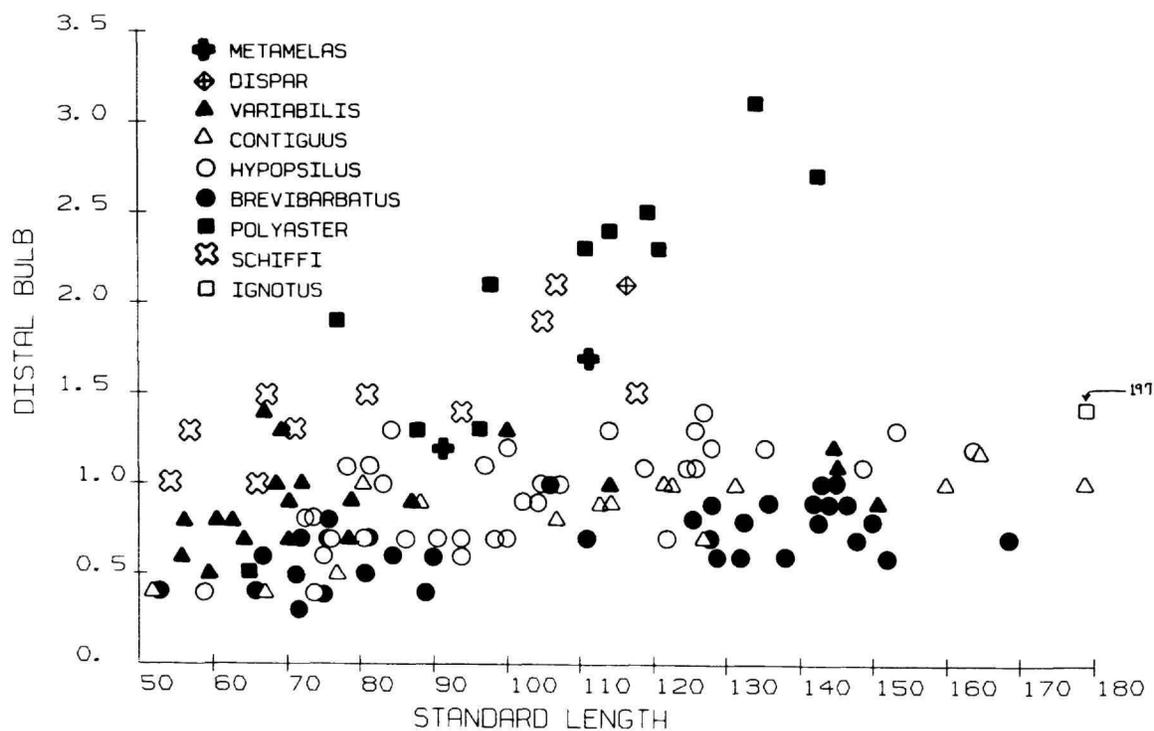
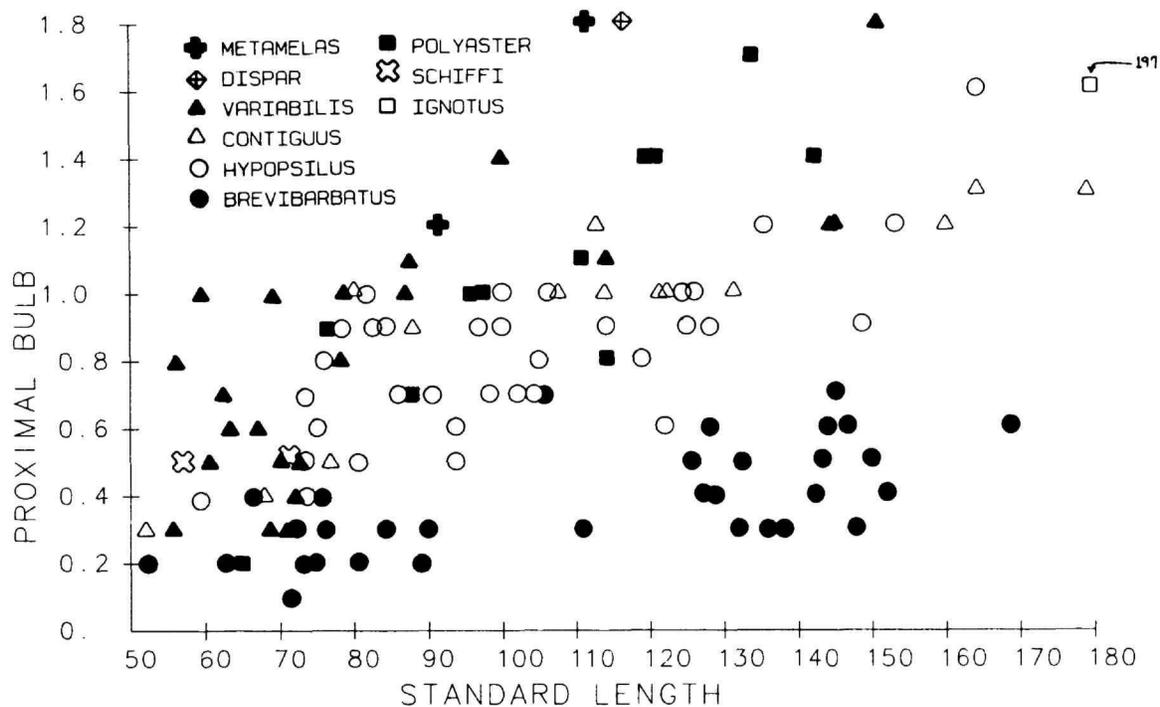


FIGURE 4.—Proximal-bulb (above) and distal-bulb (below) lengths (mm) vs. SL (mm) in Group I species and *E. polyaster* and *schiffi* from Group II.

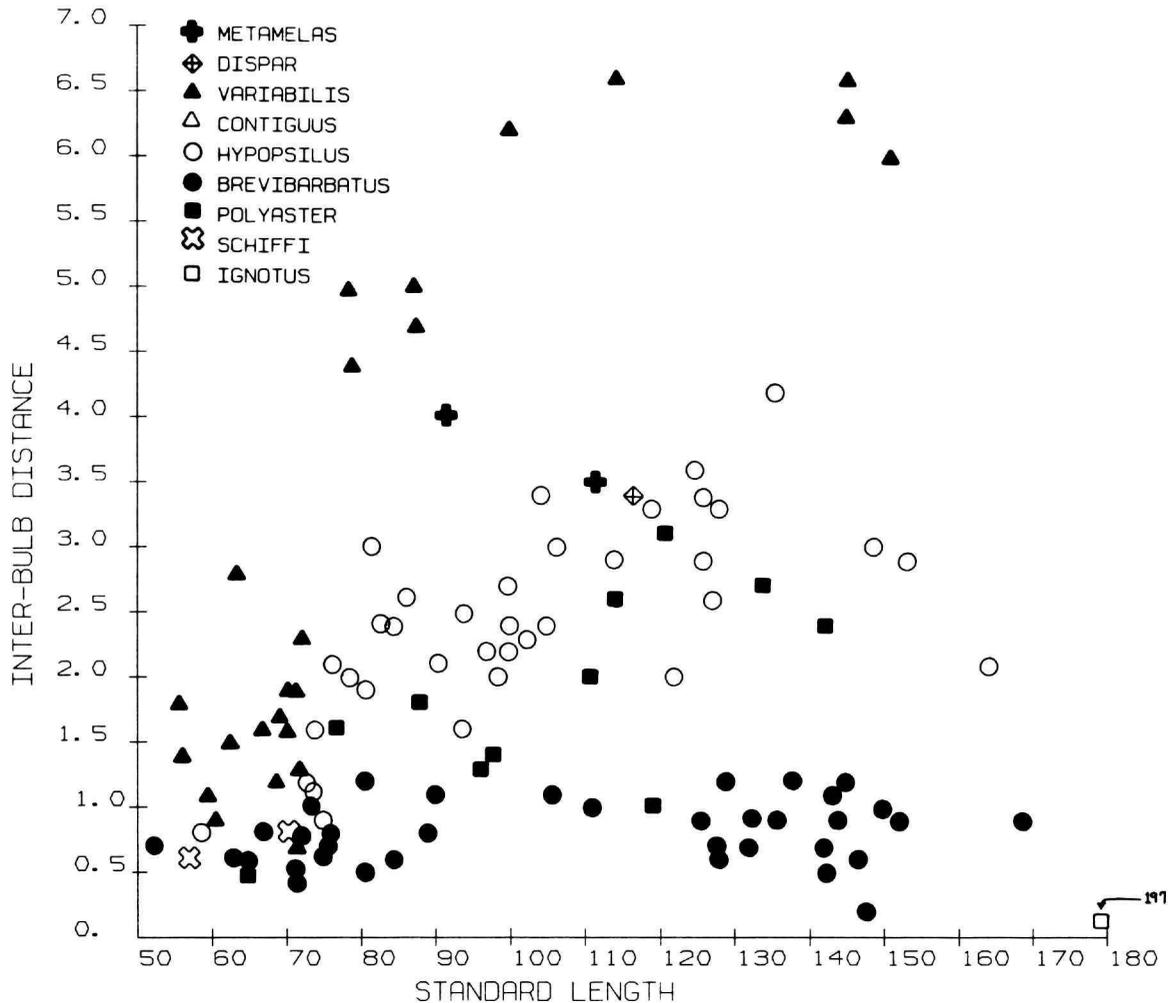


FIGURE 5.—Inter-bulb distance (mm) vs. SL (mm) in Group I species and two-bulbed *E. polyaster* and *schiffi* from Group II.

ibbean Sea, and from 29°N, 80°W (off northern Florida) through the Bahamas, Antilles, and offshore roughly parallel to the coast of South America to about 23°S, extending east to about 30°W off central Brazil (Figure 18).

MATERIAL EXAMINED (14♂, 13♀, 45 unsexed).—*Holotype*: BOC 2034 (? , 63.0), 23°55'N, 77°09'W, 0~1062 m (4000-7000 ft wire), 1 Mar 1927.

Paratype: BOC 2033 (? , 52.3), 24°00'N,

77°17'W, 0~910 m (6000 ft wire), 28 Feb 1927.

Non-types: BMNH 1929.7.6.119 (♀, 145.0), 10°24'N, 54°38'W, 0~150 m (300 mw), 1850, 19 Nov 1921. BMNH 1929.7.6.120 (♂, 132.5), 17°44'N, 64°57'W, 0~300 m (600 mw), 0320, 7 Dec 1921. BMNH 1929.7.6.121 (♂, 135.8), 17°44'N, 64°57'W, 0~300 m (600 mw), 0320, 7 Dec 1921. BMNH 1929.7.6.122 (♂, 125.5), 17°13'N, 64°58'W, 0~400 m (800 mw), 1800,

15 Mar 1922. BMNH 1929.7.6.123 (♀, 105.8), 5°35'N, 51°08'W, 0-~300 m (600 mw), 1900, 16 Nov 1921.

IOAN uncat. (? , 77.3), 23°13'N, 66°52'W, 0-600 m, 1155-1225, 28 Apr 1962. IOAN uncat. (? , 92.2), 1°26'S, 34°44'W, 0-140 m, 0438-0508, 24 Feb 1964. IOAN uncat. (? , 69.0), 19°10'N, 80°43'W, 0-1000 m, 0648-0904, 19 Mar 1973. IOAN uncat. (? , 71.6), 13°56'S,

32°55'W, 0-200 m, 2254-2315, 2 Feb 1964.

ISH 626/66 (♂, 146.6), 5°34'S, 26°58'W, 0-320 m, 2000-2315, 20 May 1966. ISH 670/66 (♂, 105; ♀, 156.4-167), 9°41'S, 27°39'W, 0-400 m, 2000-2250, 21 May 1966. ISH 753/66 (3♂, 144-152.0), 21°00'S, 30°00'W, 0-200 m, 2000-2200, 24 May 1966. ISH 940/68 (♀, 159.5), 4°43'S, 26°39'W, 0-2000 m, 1155-1215, 4 Feb 1968. ISH 1017/68 (♂, 143.2),

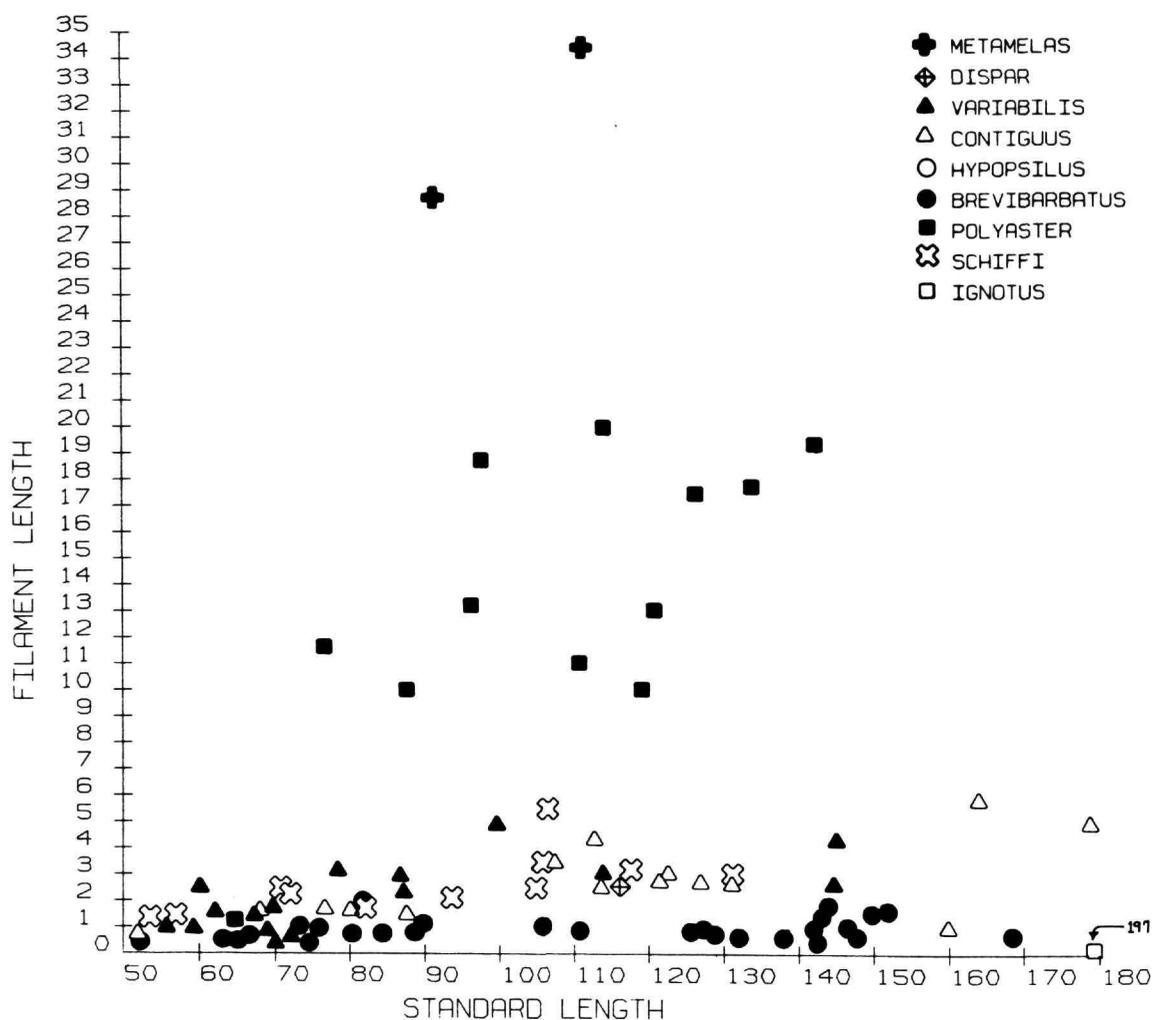


FIGURE 6.—Filament length (mm) vs. SL (mm) in Group I species and *E. polyaster* and *schiffi* from Group II.

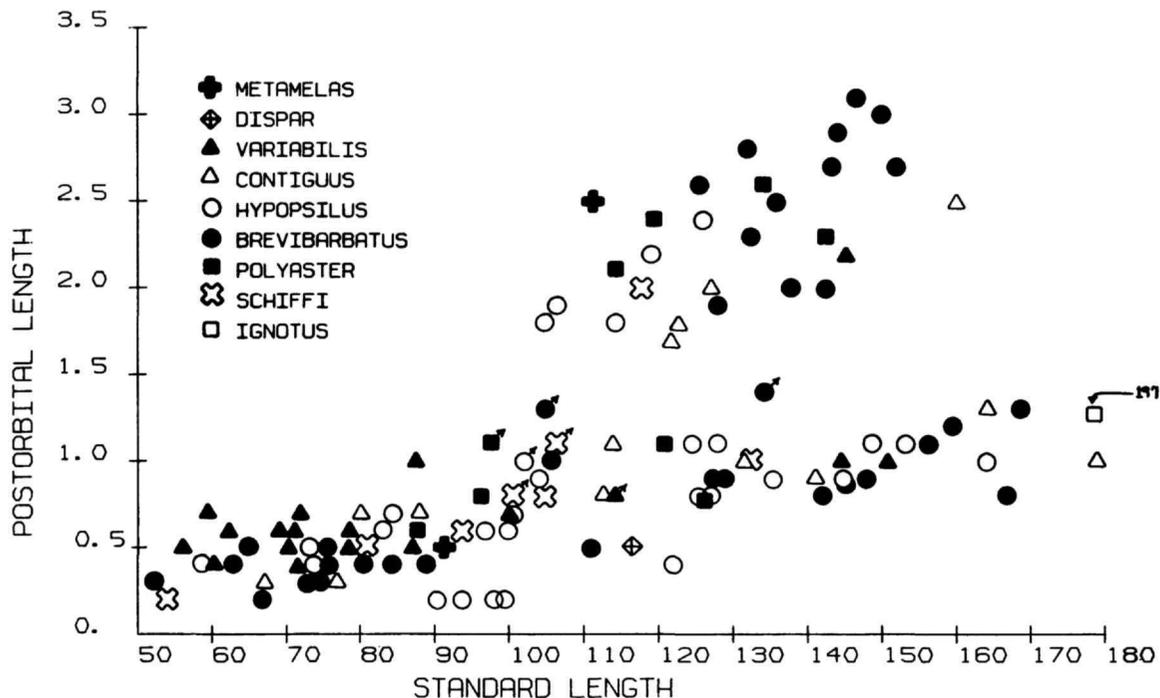


FIGURE 7.—Postorbital-organ length (mm) vs. SL (mm) in Group I species and *E. polyaster* and *schiffi* from Group II. All specimens with organs larger than 1.5 mm are males; unmarked specimens with smaller organs include both females and unknowns.

6°06'S, 27°00'W, 0–560 m, 2240–2310, 4 Feb 1968. ISH 647/74 (♂, 134.2), 2°27'N, 34°52'W, 0–350 m, 2118–2215, 24 Jul 1974.

MCZ 56601 (3♀, 75.5–81.4), 16°12'N, 78°00'W, 0–198 m, 0016–0430, 6 Jun 1966. MCZ 56602 (♀, 77.1), 12°38'N, 74°11'W, 0–225 m, 1702–2020, 29 May 1966. MCZ 56603 (♀, 83.0), 21°11'N, 85°12'W, 0–170 m, 2003–2327, 10 Jun 1966. MCZ 56685 (♀, 114), 0°13'N, 35°44'W, 0–25 m, 2025–2125, 15 Mar 1977. MCZ 56599 (♀, 71), 17°07'N, 79°32'W, 0–185 m, 0025–0412, 7 Jun 1966. MCZ uncat. (♀, 64.2), 16°38'N, 64°27'W, 0–133 m, 0038–0415, 25 May 1966. MCZ uncat. (♀, 72.3), 6°11'N, 37°01'W, 0–120 m, 0115–0315, 21 Mar 1977. MCZ uncat. (♀, 89), 23°08'S, 32°22'W, 0–110 m, 0355–0532, 9 Mar 1967. MCZ uncat. (♀, 79.6), 10°48'N, 52°17'W, 0–

120 m, 2330–0130, 26 Mar 1977.

MNHN 38-122 (♀, 100), 23°13'N, 82°21'W, 0–~25 m (50 mw), 0330, 4 Feb 1922. MNHN 1971-16 (♂, 128), 14°00'N, 61°40'W, 0–~1750 m (3500 mw), 0830, 25 Nov 1921.

TCWC 2651.10 (♀, 79.6), 24°01'N, 86°52'W, 0–300 m, 1730–1740, 8 Jul 1966.

UMML uncat. (♀, 71.2), 25°22'N, 79°28'W, 0–750 m, 1437–1733, 23 Feb 1974. UMML uncat. (♂, 142.5), 25°05'N, 79°23'W, 0–125 m, 2119–2252, 21 Feb 1974.

USNM 260274 (4♀, 76–101.1), 00°11'S, 34°47'W, 0–145 m, 0300–0515, 3 Jul 1971. USNM 260275 (♀, 130.2), 09°00'N, 40°53'W, 0–505 m, 0205–0405, 20 Sep 1973. USNM 260276 (♀, 142), 08°56'N, 46°36'W, 0–475 m, 0055–0257, 22 Nov 1973. USNM 260277 (3♀, 71.8–90.0), 00°53'N, 38°59'W, 0–200 m,

0000-0300, 14 Mar 1977. USNM 260278 (? , 75.7), 13°13'N, 54°49'W, 0-490 m, 2200-2400, 6 Oct 1973. USNM 260279 (? , 74.8), 00°01'N, 37°40'W, 0-130 m, 0045-0345, 15 Mar 1977. USNM 260280 (? , 73.1), 07°02'N, 39°29'W, 0-85 m, 2155-2355, 21 Mar 1977. USNM 260281 (? , 66.8), 11°12'N, 53°49'W, 0-100 m, 2330-0130, 27 Mar 1977. USNM 260282 (? , 65), 20°13'N, 84°12'W, 0-495 m, 0855-1225, 10 Jun 1966. USNM 260283 (? , 71.7), 27°01'N, 90°02'W, 0-95 m, 0000-0408, 22 Jun 1966. USNM 260284 (? , 80.6), 6°11'N, 37°01'W, 0-85 m, 2100-2300, 20 Mar 1977. USNM 260285 (♀, 111.0), 00°10'S, 34°43'W, 0-100 m, 0050-0250, 3 Jul 1971. USNM 260286 (♀, 89.0), 10°48'N, 52°17'W, 0-140 m, 0335-0530, 27 Mar 1977. USNM 260287 (? , 84.4), 07°43'N, 42°04'W, 0-85 m, 2235-0040, 22 Mar 1977. USNM 260288 (3?, 73.9-92.5), 10°03'N, 49°37'W, 0-120 m, 0250-0505, 26 Mar 1977. USNM 260289 (? , 80.5), 28°58'N, 88°18'W, 0-~992 m (545 fm), 27 Oct 1960. USNM 260290 (? , 76.2), 29°11'N, 79°50'W, 0-~364 m (200 fm), Mar-Apr 1962. USNM 260291 (♀, 168.7), 7°47'N, 53°53'W, 0-~695 m (382 fm), 16 Nov 1969. USNM 260300 (♀, 127.5), 19°56'N, 72°00'W, 0-~910 m (500 fm), 13 Oct 1963.

ZMUC P201829 (♂, 137.9), 14°00'N, 61°40'W, 0-~1750 m (3500 mw), 0830, 23 Nov 1921. ZMUC P201831 (♀, 147.8), 15°08'N, 61°31'W, 0-~500 m (1000 mw), 2215, 25 Nov 1921. ZMUC P201832 (♀, 128.9), 17°59'N, 64°41'W, 0-~50 m (100 mw), 2355, 8 Dec 1921. ZMUC P201833 (♂, 132.0), 16°03'N, 62°29'W, 0-~400 m (800 mw), 2000, 3 Apr 1922. ZMUC P202708 (? , 81.5), 10°24'N, 54°38'W, 0-~150 m (300 mw), 1850, 19 Nov 1921. ZMUC P202709 (? , 66.1), 17°59'N, 64°41'W, 0-~150 m (300 mw), 2350, 21 Dec 1921. ZMUC P202710 (? , 56.5), 17°43'N, 64°56'W, 0-~300 m (600 mw), 0020, 4 Jan 1922. ZMUC P202711 (? , 79.7), 17°13'N, 64°58'W, 0-~400 m (800 mw), 0040, 16 Mar 1922. ZMUC P202712 (? , 70), 17°43'N, 64°56'W, 0-~400 m (800 mw), 2315, 24 Mar 1922.

Eustomias contiguus, new species

FIGURE 1*d,e*

DIAGNOSIS.—Two contiguous terminal bulbs, spheroidal to ovoid in shape. Both bulbs 0.6%–1.2% SL; distal bulb 75% of to 1.3 times length of proximal bulb. Five to nine terminal filaments arising together from distal bulb or from a short stem, one usually thicker than others with one or more bifurcations, trifurcations, or side branches; most filaments with numerous side branches giving a bushy appearance. Longest filament 1.5%–3.8% SL, 1.7–4.9 times distal-bulb length. Barbel length 15%–49% SL. Stem axis darkly pigmented except in smallest specimens. External chevron-shaped or roundish striated areas on stem unpigmented. Paired mid-dorsal spots between occiput and dorsal-fin origin usually 8, occasionally 7.

DESCRIPTION.—Barbel length increases from 15%–32% SL in specimens 52–67 mm SL to 41%–49% in those 77–179 mm SL. In most specimens the axis of the stem is darkly peppered or streaked with melanophores, with additional pigment, patchy or uniform, external to the axis near the bulbs. The two smallest specimens (52 and 67 mm SL) have the axis lightly peppered with small melanophores. The external chevron-shaped or roundish striated areas are unpigmented. One specimen (114 mm SL) has a patch of pigment on the bulbs near where they touch. The axis of the filaments is without pigment in small specimens (52–88 mm SL), usually with a few melanophores proximally on the filaments in larger specimens. A 107 mm specimen has the thicker filament darkly streaked with pigment, and the largest specimen (179 mm) has both the thicker and an additional filament extensively peppered with melanophores.

The two terminal bulbs are contiguous and are spheroidal to ovoid in shape. The proximal bulb increases from 0.6%–0.7% SL at 52–77 mm SL to 1.0%–1.2% at 80–88 mm, after which its relative size decreases to 0.7%–0.8% at 127–179 mm. The distal bulb is 1.0%–1.2% SL in two specimens (80–88 mm), 0.6%–0.8% SL in all others, apparently not changing relative to SL

with growth.

The distal bulb in the smallest specimen (52 mm) is slightly larger than the proximal bulb; in all others the distal bulb is 75% of to equal to the proximal bulb.

There are 5–9 terminal filaments that are 1.7–4.9 times the distal-bulb length. Filament length increases slightly relative to SL from 1.5%–2.2% SL at less than 100 mm to 2.0%–3.8% at greater than 100 mm. The thickest filament bifurcates or trifurcates about one distal-bulb length or less from the distal bulb, each branch often bifurcating again. All filaments bear many side branches, and most filaments have abundant branches distally. There are no bulblets in the filaments or branches.

The postorbital organs of three males, 122–127 mm SL, are 1.7–2.0 mm long, 1.4%–1.6% SL, 47%–53% of fleshy orbit length. These organs may still be in the process of enlarging. The postorbital organs of four females, 131–179 mm SL, are 0.6%–0.8% SL, 22%–28% of fleshy orbit length.

In four freshly caught specimens (two males, one female, one undetermined) the proximal bulb was noted as being blue-green, the distal bulb as being green, grass-green, or a yellow-green. An additional male specimen, after having been in formalin for several hours, had pale green bulbs. (In preserved specimens the distal bulbs usually have iridescent flecks which are missing or not as prevalent in the proximal bulbs.) Male postorbital organs were pink, the single female's white.

DESCRIPTION OF HOLOTYPE.—Female, 164 mm SL. D 23. A 36. P₁ 2. P₂ 7. IP 7. PV 34. VAV 15. OV 33. VAL 16. AC 18. IA 56. IC 74. OA 49. OC 67. VAV photophores over anal-fin base 6. Branchiostegal photophores 10. Premaxillary teeth 12 left, 10 right: from anterior to posterior, a moderate fixed tooth (broken on left) followed by a long space, a fixed fang (broken on right) followed by a moderate space, a short depressible tooth, a long depressible tooth, a moderate to long series of 3 depressible teeth, and a short to moderate series of 3 teeth. Maxilla with about 24 short, slanted, serra-like teeth.

Mandibular teeth 16 left, 15 right: from anterior to posterior, a short fixed symphyseal tooth (broken on right) followed by a moderate space, a fixed fang (broken on left and right) followed by a long space, 2 groups of 1 long and 2 short depressible teeth, 2 moderate depressible teeth (1 on right), and 6 short depressible teeth. (Depressibility of the teeth doubtful because of apparent deossification.) Vertebrae 65.

Measurements (in mm): Predorsal length 140.0, preanal length 120.3, prepelvic length 97.4, head length 19.9, barbel length 77.3, proximal-bulb length 1.3, distal-bulb length 1.2, distance between bulbs 0, filament length ~5.8 (ends curled and tangled), snout length 7.2, fleshy orbit length ~4.6, postorbital-organ length 1.3, lower-jaw length 17.3, upper-jaw length 16.3, depth behind head (greatest depth) 12.6, caudal-peduncle depth 2.9, pectoral-fin length 22.1, pelvic-fin length 25.2, dorsal-base length 19.5, anal-base length 39.3, longest premaxillary tooth 2.5, longest mandibular tooth broken.

Proximal bulb ovoid, distal bulb oblate-spheroidal. Axis of barbel stem darkly streaked with pigment. Near the bulbs, patchy pigment external to the axis. A light scattering of pigment on a few filaments. Nine terminal filaments (one broken near base) all about the same thickness and highly branched. Some filaments stuck together and curled at tips.

SIMILAR SPECIES.—In *Eustomias ignotus*, the only other species of *Biradiostomias* with two terminal bulbs in close approximation, the bulbs are separated by a small space (0.1 mm) (touching in *contiguus*); the bulbs are irregular, elongate ovoids in shape vs. spheroidal to slightly ovoid; there is a single, minute, simple terminal filament vs. 5–9 highly branched filaments 1.7–5 times bulb length in *contiguus*; and the axis of the barbel stem is lightly pigmented, becoming unpigmented before the bulbs, vs. darkly pigmented in *contiguus* (at least in specimens 80 mm or greater) with additional pigment external to the axis near the bulbs. Furthermore, the two species are widely separated geographically.

DISTRIBUTION.—Most records are from the northern sector of the North Atlantic Subtropi-

cal Region (Backus et al., 1977); one taken near the Bahamas, two in the southwestern Sargasso Sea (Figure 18). This is the only species of *Biradiostomias* that extends its range to the eastern Atlantic.

REMARKS.—We have examined a mature male (160 mm) taken off the Bahamas which we tentatively identify as *E. contiguus* (Figure 1d). The specimen resembles *contiguus* in having two contiguous terminal bulbs of the same relative size as the other specimens examined, five filaments, one thicker than the others and the axis of the barbel stem relatively darkly peppered with melanophores, with some patches external to the axis near the bulbs. It differs from other *contiguus* in having a much longer barbel (86% SL vs. 41%–49%), a slightly notched distal bulb, and shorter filaments (0.6% vs. 1.5%–3.8%) with small beads or bulblets in them and no pigment. This specimen was collected at the westernmost edge of the range of *E. contiguus*. We did not include it in the diagnosis and description.

ETYMOLOGY.—The specific name, *contiguus*, is a Latin adjective meaning adjacent or bordering, in reference to the two juxtaposed terminal bulbs.

MATERIAL EXAMINED (5♂, 7♀, 5 unsexed).—*Holotype*: ISH 3304/79 (♀, 164.2), 34°21'N, 35°22'W, 0–320 m, 2120–2208, 28 Apr 1979.

Paratypes: IOAN uncat. (♀, 179.0), 32°07'N, 31°21'W, 0–570 m, 10 May 1980. ISH 161/68 (2♀, 80.3–88.0), 32°34'N, 16°53'W, 0–1000 m, 2225–2255, 20 Jan 1968. ISH 3298/79 (♂, 107.0) 23°55'N, 63°58'W, 0–1800 m, 0358–0803, 8 Apr 1979. ISH 3302/79 (♂, 122.7) 35°02'N, 39°33'W, 0–185 m, 1940–2027, 27 Apr 1979. ISH 3303/79 (2♀, 131.4, 141.1) 33°04'N, 39°29'W, 0–345 m, 2040–2125, 27 Apr 1979. USNM 265198 (♀, 114), 23°46'N, 75°47'W, 0–1835 m, 1250–1715, 11 Feb 1974. USNM 222568 (♀, 67.2), 32°22'N, 64°11'W, 222 m, 0312–0412, 8 Nov 1971. USNM 222569 (♀, 52), 33°44'N, 74°23'W, 0–200 m, 0126–0358, 15 Aug 1978. USNM 222570 (♂, 127.0), 31°44'N, 64°57'W, 0–50 m, 0300–0400, 6 Jun 1970. USNM 265169 (♀, 76.9) 30°10'N,

67°32'W, 0–217 m, 0440–0625, 28 Nov 1968. USNM 265172 (♂, 121.7) 31°53'N, 42°50'W, 0–190 m, 1950–2036, 26 Mar 1979. USNM 265173 (♀, 112.9), 25°08'N, 67°39'W, 0–1800 m, 0416–0820, 12 Apr 1979.

Non-type: USNM 265197 (♂, 160), 24°23'N, 77°25'W, 0–1525 m, 1035–1432, 7 Feb 1974.

Eustomias dispar, new species

FIGURE 1b

DIAGNOSIS.—Two terminal bulbs separated by an interspace 2.9% SL, 1.6 times distal-bulb length. Proximal bulb slender, 1.5% SL; distal bulb wide, 1.8% SL. Barbel long, 82% SL. Axis moderately darkly pigmented; axis between bulbs only slightly darker than stem axis. External chevron-shaped or roundish striated areas on stem unpigmented. Terminal filament short, 2% SL, without side branches or bulblets. Paired middorsal spots between occiput and dorsal-fin origin 8.

DESCRIPTION OF HOLOTYPE (only known specimen).—Female, 116.5 mm SL. D 23. A 36. P₁ 2, P₂ 7. IP 7. PV 35. VAV 16. OV 35. VAL 17. AC 17. IA 58. IC 75. OA 52. OC 69. VAV photophores over anal-fin base 6. Branchiostegal photophores 10. Premaxillary teeth 10 left, 12 right: from anterior to posterior, a long fixed tooth followed by a long space, a long depressible fang (fixed on right) followed by a moderate space, a short to long series of 1 fixed and 2 depressible teeth, another short to long series of 1 fixed and 2 depressible teeth, and 2 depressible teeth, the first short, the second moderate (4 depressible teeth on right, the first, third, and fourth short, second moderate). Maxilla with about 15 slanted, serra-like teeth. Mandibular teeth 15 left, 13 right: from anterior to posterior, a short symphyseal tooth with replacement tooth (left side, replacement tooth only), a long fixed fang with replacement tooth (fang broken on right) followed by a long space, a long depressible tooth (with replacement tooth on right) followed by a moderate space, a short fixed tooth (missing

on right), a short to long series of 3 depressible teeth (1 fixed, 2 depressible on right), a short to long series of 1 fixed tooth and 2 depressible teeth, a short, a moderate and 3 short depressible teeth (a short, a moderate, and 2 short depressible teeth on right). Vertebrae 67. Nine pairs of dorsal spots, the last under the dorsal fin.

Measurements (in mm): Predorsal length 98.0, preanal length 84.8, prepelvic length 67.0, head length 13.0, barbel length 95.7, proximal-bulb length 1.8, distal-bulb length 2.1, distance between bulbs 3.4, filament length 2.5, snout length 5.8, fleshy orbit length 2.6, postorbital-organ length 0.5, upper-jaw length 10.5, lower-jaw length 11.2, depth behind head (greatest depth) 7.2, caudal-peduncle depth 1.8, pectoral fin broken, pelvic-fin length 17.9, dorsal-fin base 13.9, anal-fin base 26.5, longest premaxillary tooth 1.6, longest mandibular tooth 1.4.

Proximal bulb slender, 3 times longer than wide, 1.5% SL; distal bulb 1.8% SL, 1.2 times length of proximal bulb. Axis of stem moderately peppered with melanophores; axis between bulbs lightly peppered but with additional melanophores external to axis, resulting in interspace appearing slightly darker than stem; axis of terminal filament with a few melanophores proximally; a few melanophores on bulbs. External chevron-shaped or roundish striated areas on stem unpigmented.

No color observations have been recorded.

SIMILAR SPECIES.—*Eustomias metamelas* is the only other species of *Biradiostomias* with two relatively large, non-bilobate, non-contiguous terminal bulbs separated by a long interspace and with a simple terminal filament. In *metamelas*, however, the axis between the bulbs is much darker than that of the stem, the terminal bulbs are of equal width, the barbel is shorter (54%–55% SL vs. 82%) and the terminal filament is longer (31% SL vs. 2%).

DISTRIBUTION.—The only known specimen was taken in the northwestern tropical Atlantic (Figure 18).

ETYMOLOGY.—The specific name, *dispar*, is a Latin noun in apposition, meaning different or

unequal pair, alluding to the contrasting shapes of the terminal bulbs.

MATERIAL EXAMINED.—*Holotype:* USNM 222183 (♀, 116.5), 8°57'N, 46°29'W, 0–485 m, 2240–0010, 21 Sep 1973.

Eustomias hypopsilus, new species

FIGURE 2*e,f*

DIAGNOSIS.—Two terminal bulbs separated by a short to long interspace, 1.2%–3.7% SL, 1.5–4.2 times distal-bulb length. (Small bulblet between proximal and distal bulb in 1 specimen.) Proximal bulb 0.5%–1.2% SL. Distal bulb 0.5%–1.5% SL, usually equal to or up to 1.6 times proximal-bulb length; proximal bulb occasionally up to 1.3 times longer than distal. Barbel 11%–47% SL, 35% or greater in specimens over 100 mm SL. Stem axis lightly to darkly pigmented. No filament arising from distal end of distal bulb, but a single short, hardly discernible, filamentous projection (rarely 2) arising laterally from distal bulb in most specimens. External chevron-shaped or roundish striated areas on stem unpigmented. Paired dorsal spots between occiput and dorsal-fin origin usually 8 (7 in 1 specimen).

DESCRIPTION.—Barbel length increases from 11% SL in the smallest specimen (59 mm) to 35%–47% SL in those longer than about 100 mm. The axis of the stem is lightly peppered with melanophores in small specimens, more densely peppered or streaked with pigment in larger specimens (many of the paratypes are badly faded with little pigment remaining). The axis between the bulbs has no pigment in small specimens, but becomes more darkly pigmented with growth; the largest specimen (164 mm) has the darkest axis. The external chevron-shaped or roundish striated areas on the stem are unpigmented.

Both proximal and distal bulbs vary in shape from ovoid to long ovoid, as much as three times longer than wide. In one specimen (126 mm), a minute ovoid bulblet about ¼ distal-bulb length is situated between the two terminal bulbs. The proximal bulb is 0.5%–1.2% SL, the distal bulb

0.5%–1.5% SL, and neither appears to change relative to SL with growth, although the relatively larger bulbs are in specimens ~80 mm SL. The distal bulb varies from 0.8 to 1.6 times as long as the proximal bulb, in most specimens being equal to or longer than the proximal bulb.

The distance between proximal and distal bulbs is 1.2%–3.7% SL, apparently not changing with growth, and is 1.5 to 4.2 times distal-bulb length.

There are no terminal filaments. One or two small, hair-like, filamentous projections (often difficult to see even under magnification) arise laterally from the distal bulb in some specimens, rarely from the proximal bulb. These projections never exceed bulb length.

The five largest males, 105–126 mm SL, have postorbital organs 1.6%–1.9% SL, 50%–65% of fleshy orbit length. There are eight paired dorsal spots (seven in one specimen) between occiput and dorsal-fin origin, one beneath dorsal fin, and one or two on caudal peduncle.

No color observations have been recorded.

DESCRIPTION OF HOLOTYPE.—Female, 128 mm SL. D 26. A 40. P₁ 2. P₂ 7. IP 7. PV 34. VAV 16. OV 34. VAL 16. AC 17. IA 57. IC 74. OA 50. OC 67. VAV photophores over anal-fin base 6 (almost 7). Branchiostegal photophores 10. Premaxillary teeth 9 left, 11 right: from anterior to posterior, a long fixed tooth followed by a long space, a fixed fang, a short fixed and a long depressible tooth, a short fixed and a moderate depressible tooth, and 2 short fixed teeth (4 on right). Maxilla with about 22 slanted, serrate-like teeth. Mandibular teeth 10 left and right: from anterior to posterior, a small fixed symphyseal tooth (missing on left) followed by a moderate space, a fixed fang followed by a longer space, a long depressible tooth, a short fixed tooth, a long depressible tooth, 2 short fixed teeth, 1 long and 3 short depressible teeth (2 on right). Vertebrae 65. Ten pairs of pigment spots along dorsum, 8 before dorsal-fin origin, 1 beneath dorsal fin, and 1 on caudal peduncle.

Measurements (in mm): Predorsal length 105.9, preanal length 96.0, prepelvic length

77.2, head length 13.5, barbel length 59.4, proximal-bulb length 0.9, distal-bulb length 1.2, distance between bulbs 3.3, snout length 4.5, fleshy orbit length 3.7, postorbital-organ length 1.1, upper-jaw length 12.2, lower-jaw length 13.2, depth behind head 7.4, greatest depth 8.8, caudal-peduncle depth 2.1, pectoral and pelvic fins broken, dorsal-fin base 16.8, anal-fin base 30.0, longest premaxillary tooth 1.9, longest mandibular tooth 1.9.

Axis of barbel stem and interbulb space moderately peppered with large melanophores. External chevron-shaped or roundish striated areas quite apparent, but unpigmented.

Proximal bulb ovoid, distal bulb an elongate ovoid and slightly wider than proximal bulb. Distance between bulbs 2.7 times length of distal bulb. No lateral filamentous projections from proximal or distal bulbs.

SIMILAR SPECIES.—Four species (*metamelas*, *dispar*, *brevibarbatus*, and *variabilis*) resemble *E. hypopsilus* in having two (or more) non-bilobate terminal bulbs separated by an interspace. *Eustomias hypopsilus* is unique among these species, however, in that it lacks a terminal filament (at most a hair-like projection laterally on the bulb), the remaining species having filaments varying from 0.3%–31% SL. In addition, *metamelas* and *dispar* have longer bulbs (1.3%–1.8% SL vs. 0.4%–1.1%) and longer barbels (54%–82% SL vs. 11%–47%); and *metamelas* has a contrasting darkly pigmented axis between the bulbs. *Eustomias brevibarbatus*, *variabilis*, and *hypopsilus* have similar short barbel lengths, but *brevibarbatus* differs in having a shorter interspace between the bulbs (0.1%–1.5% SL vs. 1.2%–3.7%) and a distinctive black cap of pigment on the proximal end of the distal bulb. *Eustomias variabilis* often has one or two smaller bulbs between the main terminal bulbs, and specimens larger than ~80 mm have a greater distance between proximal and distal bulbs (4.0%–6.4% SL vs. 1.2%–3.7%).

DISTRIBUTION.—This species has been taken in the northern Gulf of Mexico and the Straits of Florida; one specimen is known from off the Guianas (Figure 18).

ETYMOLOGY.—From the Greek *hypo-* (less than), plus *psilos*, (bald or naked), *hypopsilus* is an adjective referring to the absence, or virtual absence, of filaments on the bulbs of this species.

MATERIAL EXAMINED (6♂, 10♀, 21 unsexed).—*Holotype*: USNM 223639 (♀, 128.0), 27°00'N, 86°00'W, 0–200 m, 2046–2147, 15 Jun 1975.

Paratypes: MCZ 48940 (♂, 106.4; 4♀, 73.6–86.2), 29°58'N, 87°36'W, 0–~27 m (15 fm), 18 Jul 1960. MCZ 48889 (3♀, 58.8–73.8), 27°40'N, 90°50'W, 0–~228 m (125 fm), 24 Aug 1960. MCZ 56598 (♂, 102.1), 25°31'N, 79°46'W, 0–205 m, 2024–2310, 25 Jun 1966. USNM 224118 (♀, 164.1), 7°46'N, 54°06'W, 0–~582 m (320 fm), 25 Nov 1969. USNM 224119 (♀, ~76), 28°28'N, 88°56'W, 0–150 m, 1839–2117, 21 Aug 1973. USNM 224120 (3♀, 78.4–81.5), 27°00'N, 86°00'W, 0–150 m, 2033–2208, 5 Oct 1977. USNM 224121 (♀, 148.7), 29°06'N, 88°02'W, 0–~910 m (500 fm), 9 Feb 1961. USNM 224122 (♀, 83.0), 29°10'N, 88°21'W, 0–~955 m (525 fm), 26 Sep 1961. USNM 224123 (♂, 104.9), 25°05'N, 96°27'W, 0–~728 m (400 fm), 12 Apr 1964. USNM 224125 (2♀, 100.0–122; 8♀, 84.2–99.9), 28°58'N, 88°18'W, 0–~992 m (545 fm), 27 Oct 1960. USNM 224126 (2♂, 118.9–125.9; 1♀, 125.8; 1♀, 104.2), 29°00'N, 88°02'W, 0–600 fm, 27 Apr 1961. USNM 224127 (♂, 114.2; 4♀, 124.7–153.2), 29°04'N, 87°37'W, 0–~1456 m (800 fm) 28 Apr 1961.

Eustomias ignotus, new species

FIGURE 2g

DIAGNOSIS.—Two terminal bulbs separated by a minute interspace 0.1 mm long (bulbs appearing contiguous without magnification). Bulbs irregularly shaped; proximal bulb 0.8% SL, elongate, narrowing distally, about 3 times longer than wide; distal bulb 0.7% SL, somewhat ovoid, about 2 times longer than wide, widest distally. Terminal filament minute and simple, 0.1 mm long, arising acentrically from distal bulb. Barbel length 44% SL. Axis of stem unevenly, lightly

peppered with melanophores, becoming lighter distally, and unpigmented before bulbs. External chevron-shaped or roundish striated areas on stem unpigmented. Paired middorsal spots between occiput and dorsal-fin origin 8.

DESCRIPTION OF HOLOTYPE (only known specimen).—Female, 197 mm SL. D 24. A 36. P₁ 2. P₂ 7. IP 7. PV 34. VAV 16. OV 34. VAL 17. AC 17. IA 57. IC 74. OA 51. OC 68. VAV photophores over anal-fin base 5. Branchiostegal photophores 10. Premaxillary teeth 12 left, 9 right: from anterior to posterior, a long fixed tooth followed by a long space, a long depressible fang with small replacement, a short fixed tooth with replacement, a long depressible tooth with replacement, another short fixed tooth with replacement, a moderate depressible tooth, one short replacement tooth, 3 close-set short depressible teeth slanted posteriorly (2 on right), and 2 very small teeth, the first depressible and second fixed (both missing on right). Maxilla with about 20 slanted, serra-like teeth. Mandibular teeth 14 left and right: from anterior to posterior, a short fixed symphyseal tooth (with replacement on right) followed by a moderate space, a fixed fang followed by a moderate space, a long depressible tooth, a short fixed tooth, another long depressible tooth and a short fixed tooth, one moderate depressible tooth, 3 short depressible teeth (4 on right), and 4 very short depressible teeth. Vertebrae 66. Nine pairs of pigment spots along dorsum, the last pair under the dorsal fin.

Measurements (in mm): Predorsal length 172.0, preanal length 150.2, prepelvic length 119.5, head length 19.2, barbel length 85.9, proximal-bulb length 1.6, distal-bulb length 1.4, distance between bulbs 0.1, filament length 0.1, snout length 9.5, fleshy orbit length 5.1, postorbital-organ length 1.3, upper-jaw length 16.2, lower-jaw length 17.5, depth behind head (greatest depth) 9.9, caudal-peduncle depth 2.9, pectoral and pelvic fins broken, dorsal-fin base 21.8, anal-fin base 37.4, longest premaxillary tooth 3.2, longest mandibular tooth 2.7.

Barbel described in diagnosis.

Postorbital organ 0.7% SL, 25% of fleshy orbit length.

No color observations recorded.

SIMILAR SPECIES.—In *contiguus*, the only other species of *Biradiostomias* with two contiguous bulbs, the bulbs are spheroidal to slightly ovoid with no space between them (vs. irregular elongate ovoid bulbs with a minute interspace in *E. ignotus*); there are five to nine bushy filaments that are one to five times bulb length (vs. a minute, simple filament); and, in specimens greater than 80 mm the axis of the barbel stem is darkly pigmented (vs. lightly pigmented in *ignotus*).

Eustomias leptobolus also resembles *E. ignotus*, but has a single, long, constricted terminal bulb rather than two contiguous terminal bulbs. With growth, the elongate bulb of *E. leptobolus* could possibly divide in two, in which case it would be difficult to distinguish from *ignotus*.

DISTRIBUTION.—The holotype, and only known specimen, was taken in the South Atlantic off southern Brazil (Figure 18).

ETYMOLOGY.—The specific name, *ignotus*, is a Latin adjective meaning unknown or strange, alluding to the uncertain status of this new species.

MATERIAL EXAMINED.—*Holotype*: ISH 907/66 (♀, 197), 32°44'S, 48°43'W, 0–580 m, 2200–0045, 29 May 1966.

Eustomias metamelas, new species

FIGURE 1a

DIAGNOSIS.—Two terminal bulbs of approximately equal size and shape separated by a long interspace, 3.1%–4.4% SL, 2.1–3.3 times distal-bulb length. Proximal bulb 1.3%–1.6% SL; distal bulb 1.3%–1.5% SL. Barbel length 54%–55% SL. Axis lightly pigmented; between bulbs darkly pigmented, the pigment forming a small cap to proximal end of distal bulb. External chevron-shaped or roundish striated areas on stem unpigmented. Terminal filament very long, 31% SL or longer, without side branches, and ending in a single, small terminal bulblet. Paired middorsal

spots between occiput and dorsal-fin origin 8.

DESCRIPTION.—In the two known specimens, the barbel is 54%–55% SL. The axis of the stem is lightly pigmented, either peppered with melanophores, or streaked. Contrastingly, the axis between bulbs and to some extent the sheath external to the axis are very darkly pigmented, the pigment extending onto the proximal base of the distal bulb. The external chevron-shaped or roundish striated areas are unpigmented. The filament is without pigment.

The terminal bulbs are ovoid in shape, the proximal bulb 1.3%–1.6% SL, distal bulb 1.3%–1.5% SL. In the smaller paratype the bulbs are of equal length; in the holotype, the proximal bulb is slightly longer than the distal.

The distance between the bulbs is 4.4% SL in the smaller specimen (91.5 mm SL), 3.1% SL in the larger (111.5 mm SL) and is 2.1–3.3 times the distal-bulb length.

The filament of the smaller specimen (tip of filament broken off but saved) is 31% SL and ends in a single, small bulblet which causes a swelling at the filament tip. The filament tip of the holotype appears to be missing, but to the break the filament is also 31% SL.

The postorbital organ of the 111.5 mm male holotype is 2.5 mm long, 2.2% SL, about 70% of fleshy orbit (the orbit is damaged).

Eustomias metamelas appears to have the longest pectoral-fin length of any species of *Biradiostomias*, 26% SL in the holotype (broken in paratype).

Bulbs of the freshly caught type-specimens were recorded as soft pink in color.

DESCRIPTION OF HOLOTYPE.—Male, 111.5 mm SL. D 24. A 35. P₁ 2. P₂ 7. IP 7. PV 33. VAV 16. OV 34. VAL 17. AC 17. IA 56. IC 73. OA 51. OC 68. VAV photophores over anal-fin base 5. Branchiostegal photophores 9. Premaxillary teeth 10 left, 13 right: from anterior to posterior, a long fixed tooth near symphysis followed by a long space, a long depressible fang (with replacement tooth on right), a short to long series of 1 fixed and 2 depressible teeth (1 depressible tooth missing on left), 2 short to moderate fixed teeth (1 on left), 4 moderate and 2

short depressible teeth (2 moderate and 3 short on left). Maxilla with about 15 slanted, serra-like teeth. Mandibular teeth 14 left, 15 right: from anterior to posterior, a short symphyseal tooth followed by a moderate space, a long fixed fang (broken, with small replacement tooth on left) followed by a long space, a long depressible tooth followed by a long space, a short fixed tooth (broken on right, absent on left), a short to long series of 1 fixed and 2 depressible teeth, another short to long series of 1 fixed and 2 depressible teeth (second tooth missing on left), and 6 short depressible teeth (5 on right). Vertebrae 67. Nine pairs of spots along the dorsum, the last beneath the dorsal-fin base.

Measurements (in mm): Predorsal length 91.6, preanal length 81.8, prepelvic length 62.5, head length 11.6, barbel length 61.0, proximal-bulb length 1.8, distal-bulb length 1.7, distance between bulbs 3.5, filament length 34.4 to break, snout length 4.6, fleshy orbit length ~3.5, post-orbital-organ length 2.5, upper-jaw length 10.2, lower-jaw length 11.1, depth behind head (greatest depth) 6.5, caudal-peduncle depth 1.5, pectoral-fin length 29.4, pelvic-fin length 17.4, dorsal-fin base 27.0, anal-fin base 27.0, longest premaxillary tooth 1.5, longest mandibular tooth 1.3.

Axis of barbel stem very lightly streaked with pigment proximally, becoming peppered with slightly darker melanophores distally. Pigment between bulbs distinctly darker, very dark, forming a spot at distal end of proximal bulb and a small cap over base of distal bulb.

SIMILAR SPECIES.—In *E. dispar*, the most similar species, the axis between the bulbs is not notably darker than the stem axis as in *E. metamelas*; the terminal bulbs are of unequal size, the distal bulb longer and much wider than the proximal bulb; the barbel is longer, 82% SL (vs. 54%–55%); and the terminal filament is much shorter, 2% SL vs. 31%. Other two-bulbed species of *Biradiostomias* differ in various characters, but all have shorter filaments (maximum 19% SL) than *metamelas*. In overall barbel structure, *metamelas* is reminiscent of some species of *Nominostomias* (Gibbs et al., 1983), all of which have three

pectoral rays.

DISTRIBUTION.—Specimens have been taken in one sample in the southwestern tropical Atlantic Ocean (Figure 18).

ETYMOLOGY.—The specific name, *metamelas*, combines the Greek adjective *melas* (black) with the adverbial prefix *meta* (between), in reference to the darkly pigmented axis between the bulbs.

MATERIAL EXAMINED (1♂, 1♀).—*Holotype*: ISH 669/66 (♂, 111.5), 9°41'S, 27°39'W, 0–400 m, 2000–2250, 21 May 1966.

Paratype: USNM 222184 (♀, 91.5), same data as holotype.

Eustomias variabilis Regan and Trewavas, 1930

FIGURE 2a–d

Eustomias variabilis Regan and Trewavas, 1930:90–91 [barbels fig. 72, teeth fig. 73A; 17 syntypes, northwestern Atlantic].—Nielsen, 1974:19 [syntypes in ZMUC].

Eustomias trituberculatus Regan and Trewavas, 1930:91–92 [teeth fig. 73B, barbel fig. 74A; 3 syntypes, northwestern Atlantic].—Nielsen, 1974:19 [syntypes in ZMUC].

Eustomias brevibarbatulus.—Morrow and Gibbs, 1964:305 [part; references to *variabilis*, *trituberculatus*, and USNM 117876].—Rass, 1971:364 [listed in Gulf of Mexico, Caribbean Sea, probably includes *variabilis*].—Parin and Pokhilskaia, 1974:364 [part; Kurchatov 1255 only].—Bekker et al., 1975:305 [part; Kurchatov 1255 only].

DIAGNOSIS.—Two to four terminal bulbs, the proximal and distal separated by a long interspace in specimens larger than 75 mm, 4.0%–6.2% SL, 4.8–7.1 times distal-bulb length (in specimens smaller than 75 mm 1.0%–4.4% SL, 1.0–4.0 times distal-bulb length). Proximal bulb 0.3%–1.3% SL. Distal bulb 0.6%–2.1% SL, 0.5–3.3 times proximal-bulb length, without black cap on proximal end. Terminal filaments short to long, 0.3%–4.9% SL, 0.3–4.4 times distal-bulb length, sometimes simple, usually with prominent, swollen bulblets. Barbel length 18%–41% SL, 32% SL or more in specimens over 75 mm SL. Stem axis well pigmented. External chevron-shaped or roundish striated areas on stem unpigmented. Paired dorsal spots between occiput and dorsal-fin origin usually 9, sometimes 8.

DESCRIPTION.—Barbel length is 18%–32% SL

in specimens 56–72 mm SL, indicating rapid growth; specimens 79 mm and larger have barbels 32%–41% SL, and no further change with growth is apparent. The axis of the stem is darkly pigmented. The chevron-shaped or roundish striated areas are unpigmented. The axis between the bulbs also is darkly pigmented, but no cap is formed on the distalmost bulb.

Variation in structure of the end of the barbel is illustrated in Regan and Trewavas (1930, figs. 72, 73A), the same figures reprinted in Morrow and Gibbs (1964, fig. 109). There may be two to four terminal bulbs. The proximal bulb is spheroidal to long-ovoid in shape. The distal bulb is variably ovoid, sometimes narrowed at one end, sometimes constricted in the middle. One or two smaller additional bulbs are present between the proximal and distal in many specimens; these middle bulbs can be spheroidal or ovoid, but they are smaller than either of the other two. Specimens 55–72 mm have the full range of observed relative proximal-bulb lengths, 0.4%–1.7% SL, indicative of rapid change with growth; after this a decrease with growth is suggested, from 1.0%–1.4% at 79–100 mm to 0.8%–1.2% at 145–151 mm. The distal bulb apparently decreases from 0.8%–2.1% SL in specimens smaller than 70 mm SL to 0.6%–0.8% at 145–151 mm. The distal bulb is 0.5–3.3 times the length of the proximal bulb, with a general decrease with growth suggested by the fact that in most specimens 72 mm or smaller the ratio is 1.3–3.3, while in those 79–151 mm it is 0.9–1.2 in all except one specimen, in which the ratio is 2.0.

The distance between bulbs apparently increases rapidly in small specimens, being 1.0%–4.4% SL at 56–72 mm, 5.6%–6.4% at 79 mm, and then decreases to 4.0%–4.5% in the largest specimens. The distance is 1.0–4.0 times the length of the distal bulb in specimens 56–72 mm SL and 4.8–7.1 times in those 79–151 mm.

There are one or two terminal filaments that vary in length and complexity from short and simple to long, branched, and bearing several prominent bulblets of variable size. The differences do not appear to be a function of size.

When filaments are branched, the first branches often arise only a short distance from the bulb, which can lead to the interpretation that there are up to four or more filaments (as in Regan and Trewavas, 1930). We consider a filament to include all branches that arise from a stem, no matter how short the stem may be. Thus, we find only two specimens with a single, unbranched filament, the one illustrated here (Figure 2d) and one paralectotype of *trituberatus* (BMNH 1929.7.6.117). Few specimens lack bulblets in the filaments or their branches. Most specimens have filaments that are both complexly branched and have prominent bulblets in some or all branches. Filament length is 0.3%–4.9% SL and 0.3–4.3 times the length of the distal bulb.

In the only large male, 145 mm, the postorbital organ is 1.5% SL, 65% of fleshy orbit length.

No color observations have been recorded.

In four specimens there were nine pairs of dorsal spots before the dorsal-fin origin, the last of these close to the origin, and one beside the base of the fin; in two others there were eight predorsal pairs and two pairs under the base, the first near the origin, the last near the posterior end. Two specimens had eight predorsal pairs and only one beside the dorsal base, and one of these had the last pair fairly close to the dorsal origin. Thus, nine predorsal pairs or eight, with one just behind the dorsal origin, appears to be the norm.

LECTOTYPE DESIGNATION.—We select as lectotype of *Eustomias variabilis* ZMUC P201984, a female, 144.8 mm SL. D 24. A 34. P₁ 2. P₂ 7. IP 7. PV 33. VAV 17. OV 33. VAL 17. AC 18. IA 57. IC 75. OA 50. OC 68. VAV photophores over anal-fin base 5. Branchiostegal photophores 11. Premaxillary teeth 11. Mandibular teeth 12. Vertebrae 66.

Measurements (in mm): Predorsal length 120.4, preanal length 109.0, prepelvic length 84.2, head length 16.6, barbel length 47.5, proximal-bulb length 1.2, middle bulb 0.5, distance between proximal and distal bulbs 6.3, between proximal and middle bulbs 1.7, between middle and distal bulbs 4.1, filament length 2.6, snout

length 6.5, fleshy orbit length 3.5, postorbital-organ length 1.0, upper-jaw length 14.8, depth behind head 10.0, greatest depth 14.5 (full stomach), caudal-peduncle depth 2.6, pectoral-fin length 14.5, pelvic-fin length 22.5, dorsal-base length 19.5, anal-base length 35.2, longest premaxillary tooth 2.0, longest mandibular tooth 2.2.

Barbel as in Regan and Trewavas (1930, fig. 72L) and Morrow and Gibbs (1964, fig. 109S).

We select as lectotype of *Eustomias trituberatus* (which we consider a junior synonym of *E. variabilis*) ZMUC P201979, a female, 71.2 mm SL. D 24. A 35. P₁ 2 (a possible rudimentary ray also present), P₂ 7. IP 7. PV 34. VAV 16. OV 34. VAL 17. AC 17. IA 57. IC 74. OA 51. OC 68. VAV photophores over anal-fin base 6. Branchiostegal photophores 10. Premaxillary teeth 11. Mandibular teeth 13. Vertebrae 66.

Measurements (in mm): Predorsal length 59.5, preanal length 53.0, prepelvic length 41.0, head length 8.9, barbel length 12.9, proximal-bulb length 0.3, distal-bulb length 0.7, middle bulb 0.3, distance between proximal and distal bulbs 1.9, between proximal and middle bulbs 1.5, between middle and distal bulbs 0.1, filament length 0.2, snout length 3.2, fleshy orbit length 2.2, postorbital-organ length 0.6, upper-jaw length 8.0, depth behind head (greatest depth) 5.4, caudal-peduncle depth 1.5, pectoral-fin length ~7.0, pelvic-fin length ~11.0, dorsal-base length 9.6, anal-base length 15.5, longest premaxillary tooth 1.2, longest mandibular tooth 1.2.

Barbel as in Regan and Trewavas (1930, fig. 74A) and Morrow and Gibbs (1964, fig. 109E).

SYNONYMY.—In their key, Regan and Trewavas (1930) place *variabilis* and *trituberatus* in a triplet with *brevibarbatus* as species with two pectoral rays and a barbel with two to four separate bulbs, none bilobed. The characters given to differentiate these three species are ambiguous; for *trituberatus* they say, "Three bulbs, the middle very near the distal one, which is larger." These requirements are filled by the barbel of *variabilis* in their figure 72A. The only other

suspicious character is the terminal filament, which is short and lacks bulblets; this is apparently uncommon in *variabilis*, but such a condition is illustrated by Regan and Trewavas (1930, fig. 72F). We find no other character that differentiates *trituberatus*, and regard it as a junior synonym of *variabilis*.

SIMILAR SPECIES.—Four other species have two well-separated terminal bulbs, none of which is bilobate. None of these species has the one or two middle bulbs or the prominent bulblets in the terminal filament that many or most *variabilis* possess. Compared to *variabilis*, regardless of the number of terminal bulbs or the presence of bulblets in the filament, *dispar* and *metamelas* have longer barbels (82% and 54%–55% SL, respectively, vs. maximum 41% in *variabilis*), *brevibarbatus* has a smaller proximal bulb than *variabilis* 79 mm and larger (0.1%–0.7% SL vs. 0.8%–1.4%), all four species (*hypopsilus* and the three already mentioned) have the proximal and distal bulbs separated by a shorter distance than in *variabilis* 79 mm and larger (maximum of 4.0% SL reached by *hypopsilus* vs. 4.8%–7.1% in larger *variabilis*), *metamelas* has a longer terminal filament (31% SL vs. maximum 4.3%), and *hypopsilus* lacks a terminal filament; both *metamelas* and particularly *brevibarbatus* have a distinctive pigment cap over the proximal end of the distal bulb.

DISTRIBUTION.—Most specimens have been taken close to shore, off the Mississippi delta in the northern Gulf of Mexico, the Straits of Florida, Bahamas, south of Cuba in the Caribbean Sea, and mostly off the Antilles from Puerto Rico to Martinique (Figure 18). Two offshore records in the south extend the range to about 10°N, 41°W.

MATERIAL EXAMINED (5♀, 2♂, 22 unsexed).—*Lectotype* (*E. variabilis*): ZMUC P 201984 (♀, 144.8), 14°38'N, 61°16'W, 0–~150 m (300 mw), 0300, 6 Apr 1922.

Paralectotypes (*E. variabilis*): ZMUC 201980 (? , 63.5) 12°11'N, 57°12'W, 0–~300 m (600 mw), 2130–2330, 20 Nov 1921. ZMUC P201981 (♂, 114.3) 18°22'N, 78°38'W, 0–

~300 (600 mw), 0100, 29 Jan 1922. ZMUC P201982 (? 55.8) 17°13'N, 64°58'W, 0~300 m (600 mw), 0040-0240, 16 Mar 1922. ZMUC P201983 (? 72.0), 17°43'N, 64°56'W, 0~150 m (300mw), 2330-0130, 23 Mar 1922. ZMUC P201985 (? 70.2) 17°43'N, 64°56'W, 0~250 m (500 mw), 0400-0600, 15 Apr 1922. ZMUC P201986-P201987 (? 67.0, 68.7) 17°43'N, 64°56'W, 0~150 m (300 mw), 1930-2130, 15 Apr 1922. ZMUC P201988 (? 62.5) 17°43'N, 64°56'W, 0~150 m, 1940-2140, 17 Apr 1922. ZMUC P201989 (♀, 87.6) 17°43'N, 64°56'W, 0~150 m (300 mw), 1930-2130, 18 Apr 1922. BMNH 1929.7.6.112 (♂, 145.2) 14°00'N, 61°40'W, 0~2000 m (4000 mw), 0830-1200, 25 Nov 1921. BMNH 1929.7.6.113 (♀, 100.0) 17°44'N, 64°57'W, 0~150 m (300 mw), 0320-0520, 7 Dec 1921. BMNH 1929.7.6.114 (? 69.2), 17°43'N, 64°56'W, 0~150 m (300 mw), 1930-2130, 15 Apr 1922. BMNH 1929.7.6.115 (? 78.9), 17°58'N, 64°41'W, 0~1000 m (2000 mw), 1440-1940, 8 Dec 1921. BMNH 1929.7.6.116 (? 56.2), 17°13'N, 64°58'W, 0~1000 m (2000 mw) 1800-2100, 15 Mar 1922. BMNH 1929.7.6.118 (? 59.6), 17°43'N, 64°56'W, 0~300 m (600 mw), 1940-2140, 17 Apr 1922.

Lectotype (*E. trituberosus*): ZMUC P201979 (♀, 71.2) 17°43'N, 64°56'W, 0~50 m (100 mw), 1930-2130, 15 Apr 1922.

Paralectotypes (*E. trituberosus*): ZMUC P201978 (? 70.5) 17°43'N, 64°56'W, 0~150 m (300 mw), 2100-2300, 30 Mar 1922. BMNH 1929.7.6.117 (? 72.1), 17°43'N, 64°56'W, 0~50 m (100 mw), 2020-2220, 1 Apr 1922.

Non-types: IOAN uncat. (? 87.1), 19°21'N, 80°38'W, 0-1000 m, 1137-1237, 19 Mar 1973. MCZ 56600 (? 68.0), 25°46'N, 79°47'W, 0-71 m, 2355-0407, 25 Jun 1966. UMML 23018 (? 78.5), 12°39'N, 61°47'W, 0-900 m, 31 Jul 1966. USNM 265196 (? 71.6), 23°54'N, 77°06'W, 0~950 m (1900 mw), 2005-2355, 9 Mar 1976. USNM 117876 (? 60.5), 18°31'N, 66°02'W, 2 Feb 1933. USNM 265166 (? 92.6), 9°36'N, 40°37'W, 0-280 m, 0010-0345, 19 Apr 1966. USNM 265167 (? 91.8, 124.8), 14°29'N, 59°04'W, 0-275 m, 2200-0200, 30

May 1966. USNM 265168 (♀, 150.9), 16°38'N, 64°27'W, 0-133 m, 0038-0415, 5 May 1966. USNM 265162 (? no SL, cleared and stained), 28°58'N, 88°18'W, 0-545 m, 27 Oct 1960.

GROUP II

The species of this group have a single bulb or two well-separated bulbs. The distalmost bulb is bilobate, the two lobes separated by a notch that may be shallow (*polyaster*) to almost as long as the non-filament-bearing lobe. (The notch was not well developed in one specimen of *polyaster*, see Figure 8c.) A synopsis of the salient characters of the species is given in Table 1, and their barbel and postorbital-organ dimensions are plotted in Figures 10-12.

Eustomias digitatus, new species

FIGURE 9e,f

Eustomias dubius.—Regan and Trewavas, 1930:88 [in part; barbel fig. 68; description based on holotype of *dubius* and 3 additional specimens that are *digitatus*].—Beebe and Crane, 1939:222-224 [in part; also includes *E. schiffi* and *E. dubius*; no additional *digitatus*].—Morrow and Gibbs, 1964:404-406 [in part; also includes *E. schiffi* and *E. dubius*; barbel p. 394, fig. 110j; no additional *digitatus*]

DIAGNOSIS.—A single, bilobate terminal bulb, 1.1%–3.8% SL, 1 lobe short and ovoid, the other (in large specimens) extremely long, 3 to 4 times ovoid lobe, and tapering. Notch in bulb about 75% of ovoid lobe as measured from proximal end of bulb to distal tip of lobe. Two very short filaments (0.2% SL, 7% bulb length) arising from elongate, tapered lobe, or filaments absent. Barbel short, 24%–28% SL. Stem axis lightly to darkly pigmented. External chevron-shaped or roundish striated areas unpigmented. Paired dorsal spots between occiput and dorsal-fin origin 8.

DESCRIPTION.—The barbel of *E. digitatus* apparently increases slightly relative to SL, from 24% to 28% SL between 70 and 122 mm SL. The axis of the stem is darkly streaked with pigment in the two larger specimens, somewhat more lightly pigmented in the 70 mm specimen.

The external chevron-shaped or rounded striated areas on the stem are not pigmented.

The single bilobate bulb is rounded proximally; distally, one lobe is short and ovoid, the second lobe extremely elongate and tapered distally. The elongate lobe bears the filaments, when present. The notch between the lobes is relatively deep, about 75% the length of the

ovoid lobe (the lobe is measured from proximal end of bulb to distal tip of lobe). The bulb apparently increases rapidly from 1.0% to 2.3%–3.8% SL between 70 and 122 mm SL.

Two short, thick, opaque filaments, 0.2% SL, 7% of bulb length, arise from the tip of the elongate lobe of the bulb of the 119 mm specimen. The bulbs of the 70 mm and 122 mm

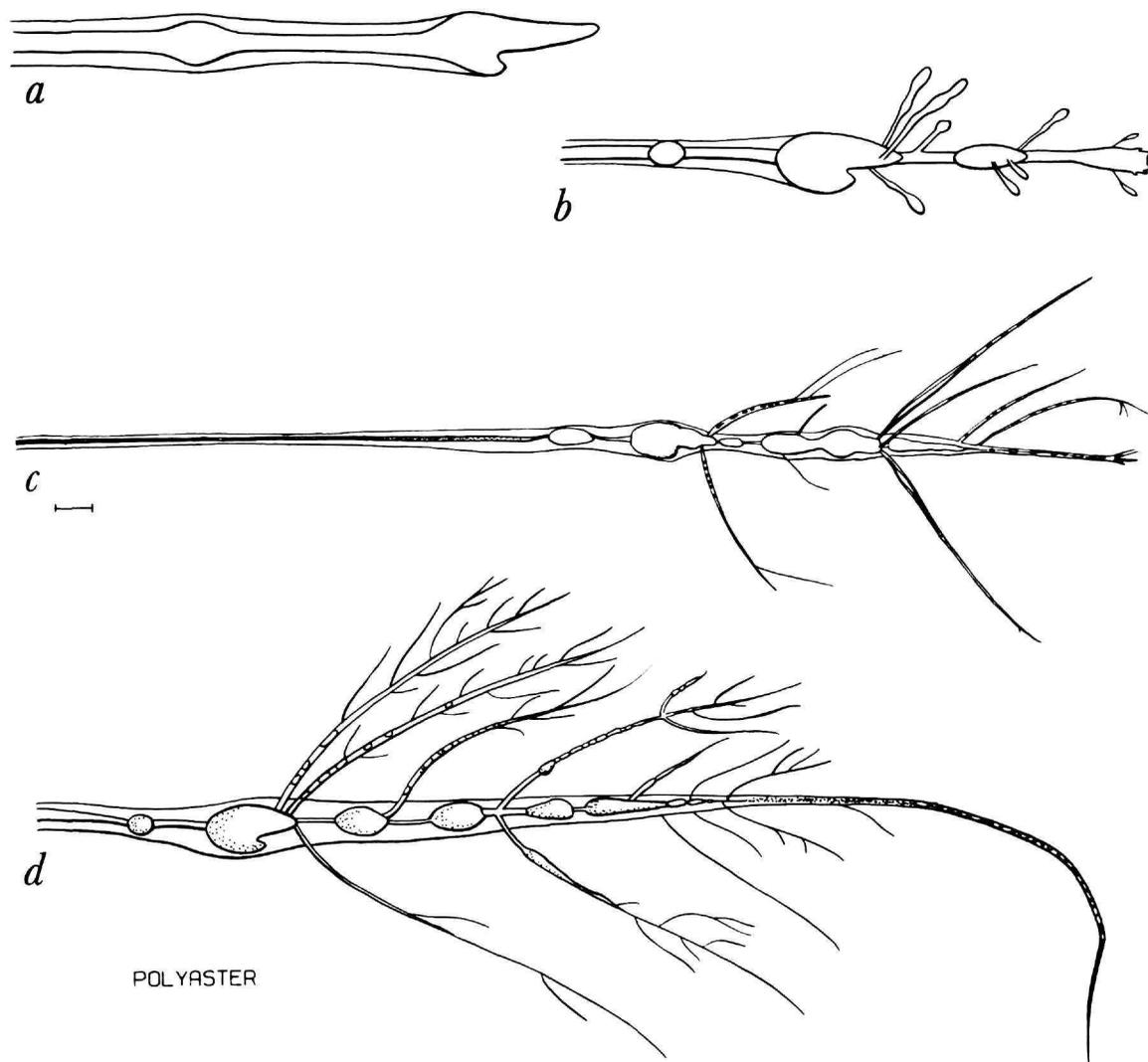


FIGURE 8.—Barbel ends of *E. polyaster*, a Group II species: *a*, *b*, both 65 mm SL, ZMUC P201877 and 201876, after Regan and Trewavas, 1930; *c*, 119.3 mm SL, USNM 222159, with least-developed notch in distal bulb; *d*, after Regan and Trewavas, 1930. (Bar = 1 mm.)

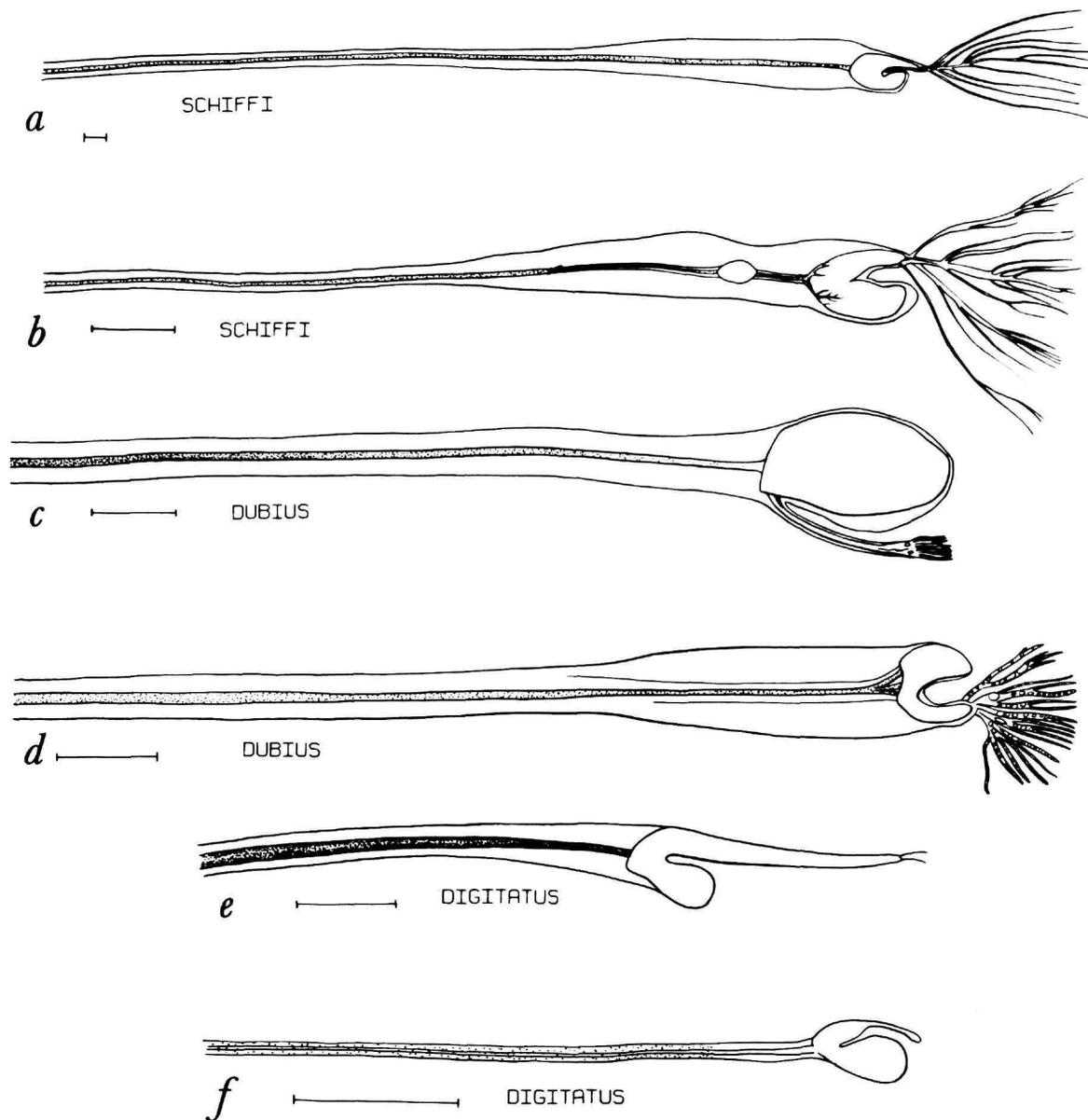


FIGURE 9.—Barbel ends of Group II species: *a,b*, *E. schiffi* (*a*, 117.8 mm SL, USNM 222181; *b*, 71.0 mm SL, USNM 222176, with proximal bulb); *c,d*, *E. dubius* (*c*, 185 mm SL, USNM 222161; *d*, holotype, 78.1 mm SL, BOC 2036); *e,f*, *E. digitatus* (*e*, holotype, 119.3 mm SL, ZMUC P201850 after Regan and Trewavas, 1930; *f*, non-type, 70.1 mm SL, ZMUC P201849). (Bar = 1 mm.)

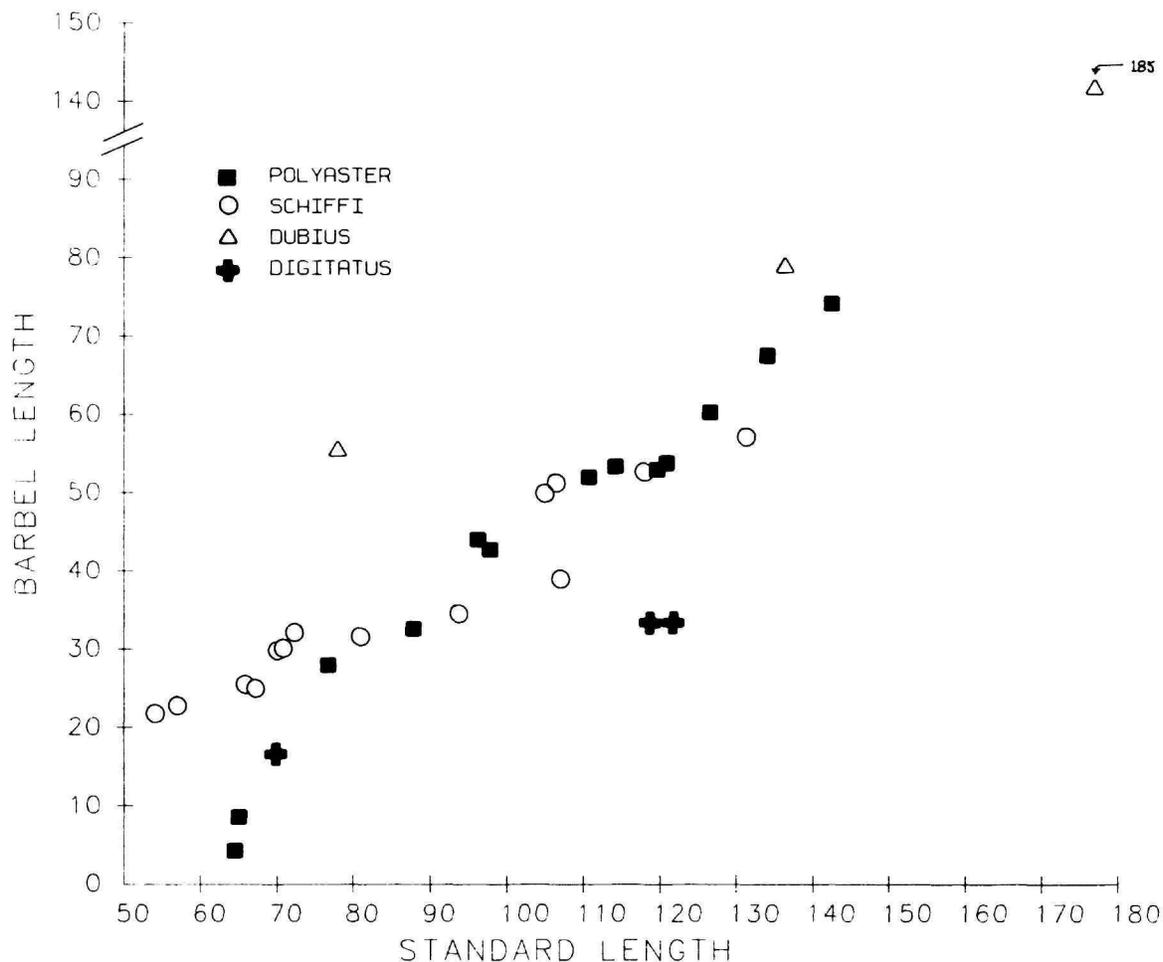


FIGURE 10.—Barbel length (mm) vs. SL (mm) in Group II species.

specimens have no filaments, although the tip of the elongate lobe of the larger specimen may be missing.

The two large specimens are females with post-orbital organs 0.5%–0.7% SL, 18.2%–30.8% of fleshy orbit. Thus the size of the male postorbital organ is unknown.

There are nine pairs of dorsal spots, the last under the dorsal fin.

No color observations have been recorded.

DESCRIPTION OF HOLOTYPE.—Female, 119.3

mm SL. D 22. A 37. P₁ 2. P₂ 7. IP 7. PV 35. VAV 13. OV 34. VAL 15. AC 18. IA 55. IC 73. OA 49. OC 67. VAV photophores over anal-fin base 4. Branchiostegal photophores 10. Premaxillary teeth 11 left, 9 right: from anterior to posterior, a moderate fixed tooth followed by a long space, a fixed fang followed by a moderate space, a small fixed tooth followed by 1 long depressible tooth, 2 small fixed teeth (1 on right), and 5 small to moderate depressible teeth (4 on right). Maxilla with about 10 small slanting,

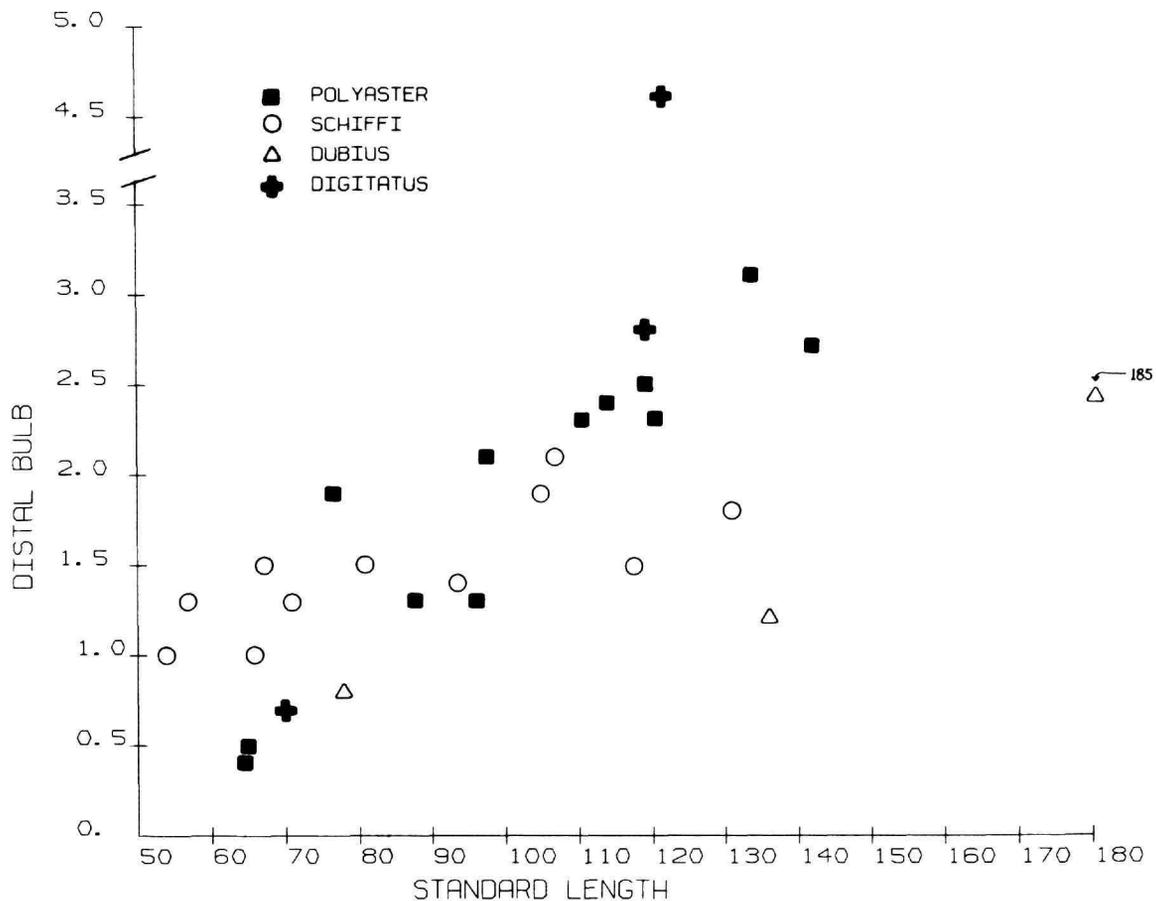


FIGURE 11.—Distal-bulb length (mm) vs. SL (mm) in Group II species. (The few proximal bulbs are plotted in Figure 4.)

serra-like teeth. Mandibular teeth 12 left, 11 right: from anterior to posterior, a short fixed symphyseal tooth (replacement tooth also well-developed on left) followed by a moderate space, a fixed fang followed by a moderate space, 1 long depressible tooth, 1 short fixed tooth, 2 long depressible teeth (1 on right), 1 short fixed tooth, and 5 short depressible teeth. Vertebrae 64.

Measurements (in mm): Predorsal length 100.6, preanal length 89.4, prepelvic length 72.2, head length 13.8, barbel length (measured to the ovoid lobe of bulb) 33.7, bulb length 2.8

(short lobe 0.9), filament length 0.2, fleshy orbit length 3.3, postorbital-organ length 0.6, lower-jaw length 13.3, upper-jaw length 11.9, depth behind head (greatest depth) 7.7, caudal-peduncle depth 1.9, pectoral and pelvic fins broken, dorsal-base length 14.5, anal-base length 28.2, longest premaxillary tooth 2.6, longest mandibular tooth 1.8.

The elongate lobe of the bulb of the holotype is now broken and the filaments are missing.

SIMILAR SPECIES.—In *E. schiffi* and *E. dubius*, the most similar species, the barbels are longer, 37%–78% SL in specimens 57 mm or longer vs.

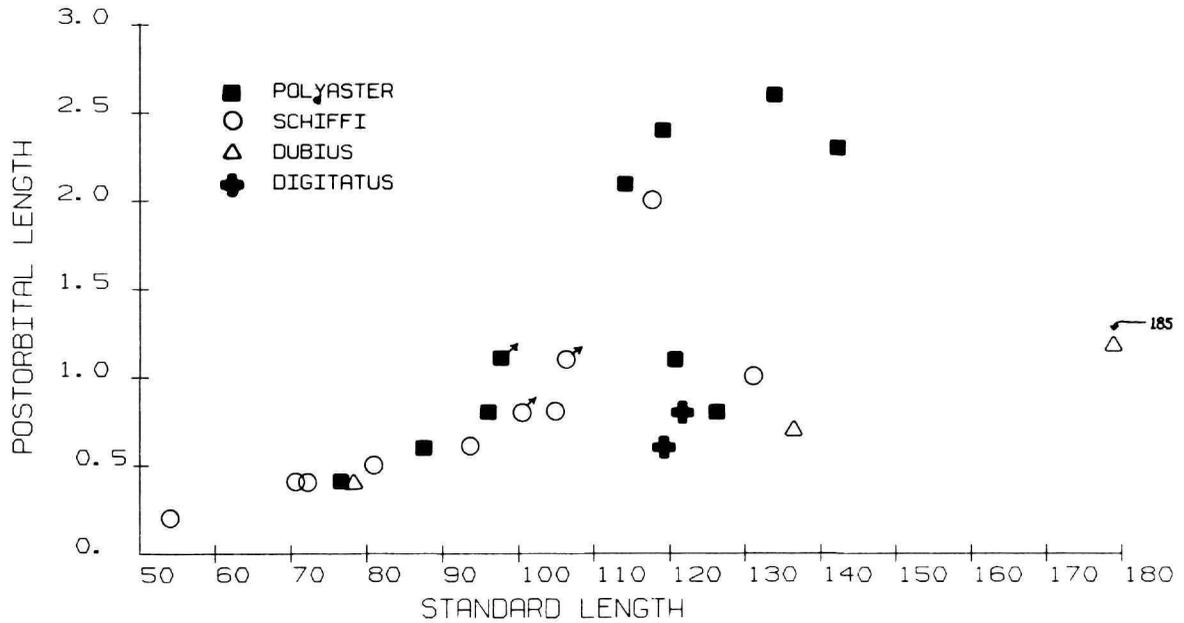
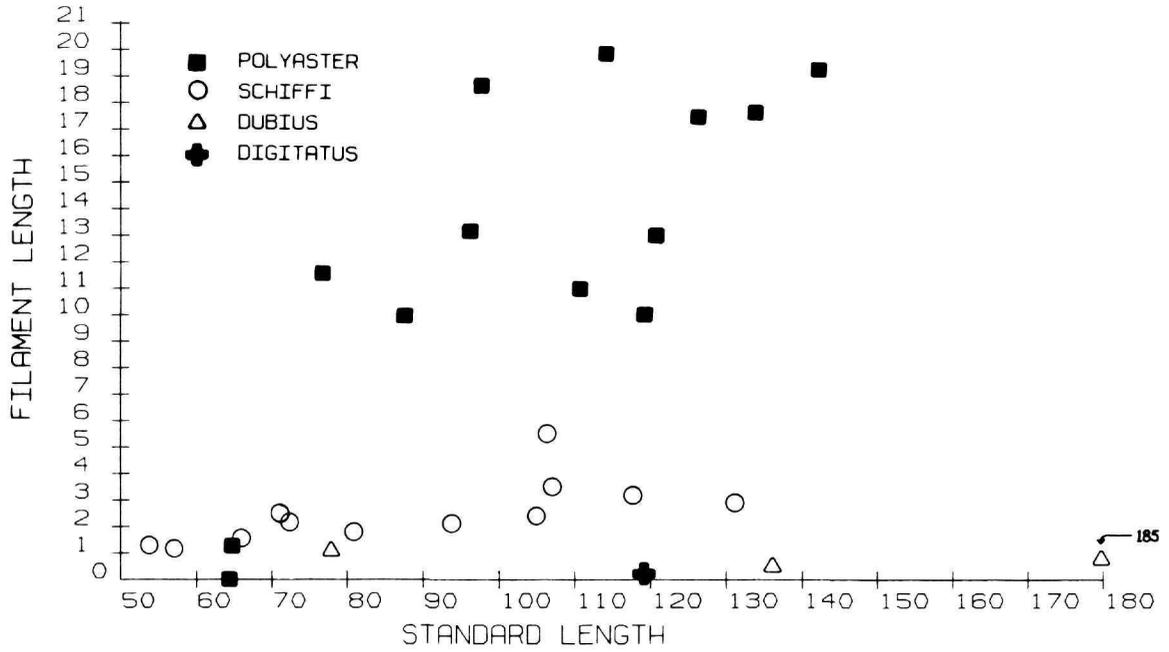


FIGURE 12.—Filament length (above) and postorbital-organ length (below) vs. SL (all in mm) in Group II species. All specimens with postorbital organs larger than 1.5 mm are males; unmarked specimens with smaller organs include both females and unknowns.

24%–28% SL in *digitatus*; the filaments are more numerous and longer (0.4%–5.2% SL, 38%–213% of bulb length, vs. 0.16% SL, 7% of bulb length in *digitatus*), and the filament-bearing lobe is shorter (about 0.9–1.7 times the length of the ovoid lobe vs. 3.1–4.4 times in *digitatus*). In addition, the notch in the terminal bulb of *E. schiffi* is shallower (about half the length of the ovoid lobe vs. about 75%). In large specimens of *E. dubius* the notch between the lobes is very deep, almost dividing the lobes completely in two.

DISTRIBUTION.—This species is known only from three specimens collected off the Leeward Islands (Figure 19).

REMARKS.—The 70.1 mm specimen of *E. digitatus* differs from the two larger type-specimens in having the slender, tapered lobe of the terminal bulb only slightly longer than the short, ovoid lobe, and therefore it is quite similar to *E. dubius*. In barbel length and bulb length this specimen could be either species, for it is at a size where rapid barbel and bulb growth normally occur. We consider the specimen to belong to *E. digitatus* because of the lack of terminal filaments (which are numerous and longer than bulb length in the 78.1 mm holotype of *dubius*), the slender lobe of the bulb being at least slightly longer than the ovoid lobe (equal to or shorter than the ovoid lobe in *dubius*), and because the barbel length is short, 24% SL (71% SL in the 78.1 mm *dubius*). Because of the slight possibility that it could be a specimen of *dubius*, however, we have chosen to exclude it from the type series.

ETYMOLOGY.—A Latin adjective meaning finger-bearing, *digitatus* refers to the long projection from the barbel bulb of this species.

MATERIAL EXAMINED (2♀, 1 unsexed).—*Holotype*: ZMUC P201850 (♀, 119.3), 17°43'N, 64°56'W, 0–~450 m (900 mw), 2315, 24 Mar 1922.

Paratype: BMNH 1929.7.6.109 (♀, 121.8), 17°43'N, 64°56'W, 0–~300 m (600 mw), 1930, 16 Apr 1922.

Non-type: ZMUC P201849 (? , 70.1), 17°41'N, 60°58'W, 0–~750 m (1500 mw), 0415, 27 Dec 1921.

Eustomias dubius Parr, 1927

FIGURE 9c,d

Eustomias dubius Parr, 1927:66–67 [holotype fig. 38, barbel p. 65 fig. 36D].—Regan and Trewavas, 1930:88 [barbel fig. 68; all 3 additional specimens are *digitatus*].—Beebe and Crane, 1939:212, 222–224 [in part; all 3 additional specimens are *schiffi*].—Morrow and Gibbs, 1964:404–406 [in part; barbels p. 394 fig. 110G;J; teeth fig. 117A; type re-examined; the 1 additional specimen is *schiffi*].—Rass, 1971:511 [listed, Caribbean Sea].

DIAGNOSIS.—A single, bilobate terminal bulb, 0.9–1.3% SL; 1 lobe thick and ovoid, the other slender, cylindrical, about equal in length to slightly shorter than ovoid lobe. Notch in bulb deep, about 75% length of ovoid lobe in the smallest specimen (lobe measured from proximal end of bulb to distal tip of lobe), in large specimens dividing the bulb almost completely. Numerous short filaments, 0.3%–1.4% SL, 0.4–1.4 times bulb length, arising from cylindrical lobe. Barbel length 58%–78% SL. Stem axis darkly pigmented. External chevron-shaped or roundish striated areas on stem unpigmented. Paired dorsal spots between occiput and dorsal-fin origin 8.

DESCRIPTION.—Barbel length is 58%–78% SL and does not appear to change with growth. The axis of the stem is darkly pigmented in the two larger specimens, one having streaky pigment, the other densely peppered with large melanophores that merge together. The axis of the small holotype is relatively densely peppered with faded melanophores until close to the bulb, where the density decreases. The external chevron-shaped or roundish striated areas on the stem are unpigmented.

The single bilobate bulb appears to increase slightly in relative size to SL, from 0.9%–1.3% SL. The thick ovoid lobe of the bulb is equal to or slightly longer than the slender, cylindrical, filament-bearing lobe. The notch between lobes is very deep, resulting in the bulbs of the two larger specimens being divided almost completely.

Numerous, short filaments (0.3%–1.4% SL) arise from the tip of the slender, cylindrical lobe

of the bulb. The smallest specimen (78.1 mm) has the relatively longest filaments, 1.4 times bulb length. The two larger specimens (136.4 mm and 185 mm) have filaments 33%–50% bulb length, stuck closely together, some having side branches. Under high magnification they appear to be filled with a granular material.

The two large specimens are females, and the sex of the smaller holotype is undetermined. Thus, the size of the male postorbital organ is unknown.

Nine pairs of subcutaneous spots along the dorsum, the last one under the dorsal fin, were counted in two specimens.

Parr (1927) described bulb color of the 78.1 mm holotype (sex undetermined) as having a "roseous" pear-shaped lobe and a "whitish" slender lobe.

SIMILAR SPECIES.—In *E. schiffi* and *E. digitatus*, the most similar species, the barbel is shorter (12%–48% SL vs. 58%–78%); the notch in the terminal bulb is shallower than in the large *dubius* (136 mm and 185 mm SL), approximately $\frac{1}{2}$ to $\frac{3}{4}$ the length of the ovoid lobe; and the filament-bearing lobe is thicker, tapering, and often elongate (vs. slender, of uniform thickness, and shorter in *dubius*). In addition, *E. schiffi* has longer terminal filaments (1.2–2.1 times terminal-bulb length, 2.1%–5.2% SL, except 92% of bulb length in a 57 mm SL specimen) and *E. digitatus* has shorter filaments (7% of bulb length, 0.2% SL, or none at all vs. 0.4–1.4 times bulb length, and 0.3%–1.4% SL in *dubius*).

Two other species, *polyaster* and *contiguus*, may have notched or bilobate terminal bulbs. A proximal bulb is always present in both species, touching the distal bulb in *contiguus*, well separated in *polyaster*, and in *polyaster* the terminal filament is much longer (8%–19% SL) than in *dubius* and has numerous prominent bulblets.

DISTRIBUTION.—The holotype is from the Bahamas; the other two known specimens are from north of Puerto Rico and the open Atlantic about 500 miles east of the Lesser Antilles (Figure 19).

MATERIAL EXAMINED (2♀, 1 unsexed).—*Holotype*: BOC 2036 (? , 78.1), 23°58'N, 77°26'W, 0–~1062 m (7000 ft wire), 2 Mar 1927.

Non-types: USNM 222160 (♀, 136.4), 13°29'N, 52°57'W, 0–450 m, 0034–0235, 8 Oct 1973. USNM 222161 (♀, 185), 20°11'N, 65°28'W, 0–380 m, 2220–2350, 11 Mar 1974.

Eustomias polyaster Parr, 1927

FIGURE 8

Eustomias polyaster Parr, 1927:74–75 [holotype p. 8, fig. 7; barbel fig. 42].—Regan and Trewavas, 1930:88–89 and 91 [young fig. 70, barbels figs. 69 and 71; 8 additional specimens].—Beebe and Crane, 1939:212 [holotype re-examined; no additional material].—Morrow and Gibbs, 1964:422–423 [barbels p. 392 fig. 108j,k; key p. 384, no additional material].—Rass, 1971:511 [listed, Caribbean Sea].

DIAGNOSIS.—Two non-contiguous terminal bulbs separated by a distance 0.8%–2.6% SL, 0.4–1.4 times distal-bulb length. Proximal bulb 0.7%–1.3% SL in specimens 77 mm or longer. Distal bulb 1.3%–2.5% SL, 1.3–3 times proximal bulb in specimens 77 mm or longer, bilobate or notched, the notch shallow (Figure 8), much less than half the length of the shorter, rounded lobe (the lobe measured from proximal end of bulb to distal tip of lobe). Terminal filament relatively long, 8%–19% SL, arising from the longer lobe of the distal bulb, with numerous prominent bulblets and side branches [absent or short in small (<~70 mm SL) specimens], with side branches also arising laterally from the bulb in some. Barbel length increasing from 37% to 52% SL in specimens 77 mm or greater. Stem axis variably lightly to darkly pigmented. External chevron-shaped or roundish striated areas on stem unpigmented. Paired dorsal spots between occiput and dorsal-fin origin 8.

DESCRIPTION.—The barbel of *E. polyaster* apparently increases rapidly in relative length from 7% to 37% SL in specimens 65–77 mm SL and then continues to increase less rapidly to 52% SL at 142 mm SL. The axis of the stem may be without pigment or range from lightly to darkly pigmented, the amount of pigmentation often lighter distally. It may be peppered with mela-

nophores or have streaky, diffuse pigment. We have not examined sufficient material to determine whether the amount of pigmentation is size related. Pigmentation is light or absent on the axis between the bulbs. The external chevron-shaped or roundish striated areas on the stem are unpigmented.

The proximal bulb is spheroidal to almond-shaped. The distal bulb is 1.3–3 times as long as the proximal and is rounded proximally, notched (Figure 8c) or bilobate distally; the longer lobe usually is finger-like; the shorter lobe is 60%–70% as long and may be rounded or thumb-like and pointing distally or abaxially. The notch between lobes is shallow. The proximal bulb increases in size relative to SL from 0.3% SL at 65 mm to 0.7%–1.3% at 77 mm and longer; there appears to be no relative change between 77 mm and 142 mm SL. Similarly, the distal bulb increases from 0.6% SL at 65 mm to 1.3%–2.5% SL at 77 mm, and no relative change is apparent between 77 mm and 142 mm SL.

The distance between bulbs varies widely in proportion, with no apparent relation to SL. It is 0.4–1.4 times the length of the distal bulb, 0.8%–2.6% SL. The single large female measured (121 mm) has the longest interbulb distance, suggesting possible sexual dimorphism in this character. No other sexually dimorphic barbel characters are apparent.

The main filament is 2% SL at 65 mm, increasing to 8%–19% in specimens 77 mm or greater, in which there is no indication of change in relative length with growth. Another small specimen (65 mm) with a developing barbel, tentatively identified as *polyaster*, has no terminal filament (see "Remarks"). In some specimens one to three shorter filaments arise directly from the finger-like lobe of the bilobate bulb. Numerous side branches arise from the main filament, and secondary branches arise from the side branches in all except the smallest specimen with a filament.

The sizes and shapes of the bulblets of the terminal filament and side branches are highly variable, ranging from small to fairly large and

from spheroidal and ovoid to extremely elongate with or without constrictions. Some bulblets cause swellings in the filament and side branches. Bulblet shape does not appear to be related to size of fish, although the number of bulblets increases as the relative length of the filament increases in specimens up to 77 mm SL. The axis of the filament is usually without pigment, or, at most, has a few melanophores immediately distal to the bilobate bulb.

The four largest males (114–134 mm SL) have postorbital organs 2.1–2.6 mm long. These are 1.6%–2.0% SL, 62%–86% of fleshy orbit.

Nine pairs of subcutaneous spots along the dorsum, the last under the dorsal-fin base, were counted in three specimens.

Bulbs of a freshly caught specimen (male, 148 mm) were greenish yellow, the bilobate bulb also with tinges of red. Almost all filaments were marked by red blood vessels. The postorbital organ was pinkish white.

SIMILAR SPECIES.—In *E. dubius*, *digitatus*, *schiffi*, and one questionable specimen of *contiguus*, which have bilobate distal bulbs, the terminal filaments are relatively much shorter (0.2%–5.2% SL vs. 8%–19%) and the filaments lack prominent, large bulblets. In the first three species, the notches in the terminal bulbs are deeper, at least one half the length of the ovoid lobe, and, except in some small *schiffi*, there is only one terminal bulb; *E. polyaster* always has two. In *contiguus* two bulbs are present, and the distal one has a shallow notch in one specimen, but the bulbs are contiguous.

DISTRIBUTION.—This species has been taken mostly near the Antilles, with one specimen each from the Gulf of Mexico, Caribbean Sea, Northern Sargasso Sea, and Southern Sargasso Sea (Figure 19).

REMARKS.—The smallest specimen examined (65 mm), which was illustrated by Regan and Trewavas (1930, fig. 71A) resembles small *E. schiffi* in having two terminal bulbs, the distal bulb notched or bilobate. We consider this specimen to be *E. polyaster* because of the shallowness of the notch in the terminal bulb and the short

relative barbel length of 6% SL. It appears that *E. schiffi* at the same SL has already developed its full relative barbel length of 37%–48%.

MATERIAL EXAMINED (2♀, 6♂, 6 unsexed).—*Holotype*: BOC 2042 (♂, 134.0), 22°31'N, 74°26'W, 0–~1500 m (10,000 ft wire), 30 Mar 1927.

Non-types: BMNH 1929.7.6.110 (♀, 120.8), 17°49'N, 64°54'W, 0–~300 m (600 mw), 1850, 14 Dec 1921. BMNH 1929.7.6.111 (♂, 97.8), 18°35'N, 66°00'W, 0–~400 m (800 mw), 1950, 8 Mar 1922. ISH 3311/79 (♂, 142.3), 25°02'N, 67°38'W, 0–1800 m, 1707–1955, 10 Apr 1979. UMML 28018 (♂, 110.8), 13°01'N, 71°55'W, 27 Jul 1966. USNM 222157 (? , 76.8), 37°15'N, 66°27'W, 0–150 m, 2030–2310, 13 Sep 1977. USNM 222158 (? , 87.8), 28°58'N, 88°18'W, 0–~300 m (545 fm), 27 Oct 1960. USNM 222159 (♂, 119.3), 15°00'N, 63°50'W, 0–302 m, 8 Jun 1974. ZMUC P201876 (? , 65.0), 13°03'N, 59°50'W, 0–~300 m (600 mw), 2220, 23 Nov 1921. ZMUC P201877 (? , 64.6), 17°59'N, 64°41'W, 0–~300 m (600 mw), 2350, 21 Dec 1921. ZMUC P201878 (? , 96.3), 17°43'N, 64°56'W, 0–~150 m (300 mw), 1920, 4 Mar 1922. ZMUC P201879 (? , 61), 17°13'N, 64°58'W, 0–~2250 m (4500 mw), 1800, 15 Mar 1922. ZMUC P201880 (♂, 114.2), 17°43'N, 64°56'W, 0–~500 m (1000 mw), 1940, 17 Mar 1922. ZMUC P201881 (♀, 126.4), 17°43'N, 64°56'W, 0–~300 m (600 mw), 1940, 17 Apr 1922.

Eustomias schiffi Beebe, 1932

FIGURE 9a,b

Eustomias schiffi Beebe, 1932:54–56 [off Nonsuch Island, Bermuda].—1937:200 [3 specimens listed].—Mead, 1958:132 [holotype in USNM].

Eustomias dubius.—Beebe and Crane, 1939:212, 222–224 [in part; barbel development fig. 72; 2 additional Bermuda specimens; *schiffi* in synonymy].—Morrow and Gibbs, 1964:404–406 [in part; barbels p. 394 fig. 110H,I p. 405 fig. 117D–F; teeth fig. 117B,C; types re-examined; 1 additional specimen].—Gibbs, 1971:239 [3 additional Bermuda specimens].

DIAGNOSIS.—Usually a single bilobate termi-

nal bulb 1.3%–2.3% SL, one lobe ovoid, the other 1 to 1¼ times length of ovoid lobe and tapered distally. Notch between lobes about half length of ovoid lobe (lobe measured from proximal end of bulb to distal tip of lobe). Sometimes a small proximal bulb (0.5%–0.9% SL) present, separated from distal bulb by 1.0–1.6 times proximal-bulb length, 0.5%–1.1% SL. Three to 6 filaments, 2.1%–5.2% SL, almost equal to about twice bulb length in specimens 54 mm or greater, arising from tapered lobe of bilobate bulb; 1 or 2 thicker than remainder, with side branches in some specimens. Barbel 37%–48% SL in specimens 54 mm SL or longer. Stem axis lightly to darkly pigmented. External chevron-shaped or roundish areas on stem unpigmented. Paired dorsal spots between occiput and dorsal-fin origin 8.

DESCRIPTION.—A relative barbel length of 37%–48% SL is reached at a small size (~54 mm), after which it does not appear to change with growth. The axis of the stem is lightly peppered with melanophores in small specimens, darkly peppered with melanophores or streaked with pigment in most larger specimens. A few large specimens have axes lightly peppered as in the smaller ones. The external chevron-shaped or rounded striated areas on the stem are not pigmented.

Three small specimens (43–71 mm) have two terminal bulbs. The proximal bulb of the 43 mm specimen is ill-defined; in the other two specimens (57 mm and 71 mm) it is spherical or ovoid and 0.5%–0.9% SL, 29%–39% of distal bulb length. The bilobate distal bulb appears to decrease in length relative to SL, from 1.9%–2.3% SL at 54–57 mm to 1.3%–1.4% at 118–131 mm. It is rounded proximally and has a broad, ovoid lobe separated from a more slender, filament-bearing lobe by a notch that is about half the length of the ovoid lobe (the lobe measured from proximal end of bulb to distal tip of lobe). The filament-bearing lobe usually tapers and may be from about equal to 1.75 times the length of the ovoid lobe.

The distance between terminal bulbs in the 57

mm and 71 mm specimens is 0.5–0.6 times the length of the distal bulb, 1.0–1.6 times the proximal bulb, 0.5%–1.1% SL.

Three to six filaments arise from the tapered lobe in specimens 54 mm to 131 mm SL. They are 2.1%–5.2% SL, 0.9–2.1 times distal-bulb length, apparently not changing in relative length with growth. Some filaments bear side branches. Bulblets may be present, but they are small, never causing external swellings. The smallest specimen examined (42.8 mm) has two or three very short, thick, opaque filaments. A 42.3 mm specimen illustrated by Beebe and Crane (1939) had no filaments. We found the barbel of this specimen broken, the distal bulb absent.

The postorbital organ of the largest male (118 mm) is 2.0 mm long, which is 1.7% SL, 57% of fleshy orbit. In the next largest male (107 mm) the organ is 1.0% SL and apparently is just beginning to enlarge. The relatively largest female organ in specimens up to 131 mm is 0.8% SL.

Nine pairs of subcutaneous spots along the dorsum, the last one under the dorsal fin, were counted in three specimens.

The bilobate bulbs of two freshly caught specimens, a 101 mm male and a female ~107 mm were deep bluish green fading to a pale bluish white in the longer, tapered lobe, pale yellowish white with a greenish blue distal end in the ovoid lobe. The filaments were colorless. These observations generally agree with those recorded by Beebe and Crane (1939) on the bulb color of the freshly caught 115 mm female holotype ("predominating colors peacock and turquoise blue"). They record the postorbital organ as being silvery-white. In Beebe (1932) the filaments (tentacles) are recorded as colorless and the bulblets (granules) as palest blue green.

SIMILAR SPECIES.—*E. dubius* and *E. digitatus* both resemble *E. schiffi* in having a bilobate terminal bulb with relatively short terminal filaments arising from one lobe. In *E. dubius* the barbel is proportionally longer (58%–78% SL vs. 37%–48% in *schiffi*); the notch between the lobes

of the terminal bulb is deeper (75% the length of the ovoid lobe or more vs. about half of the ovoid lobe); the filament-bearing lobe is slender, cylindrical, and equal to or shorter than the ovoid lobe (vs. tapering and from equal to 1.7 times the ovoid lobe); the terminal filaments are shorter (0.4%–1.4% SL vs. 2.1%–5.2%) and shorter than the bulb in large specimens (vs. longer than the bulb in *schiffi* ~70 mm and longer); and bulb color, according to Parr (1927), is roseous (vs. bluish green with pale blue or yellowish). In *E. digitatus* the barbel is proportionally shorter (24%–28% SL), the filament-bearing lobe is very long and tapering (3.1 to 4.3 times the length of the ovoid lobe vs. no more than 1.7 times in *schiffi*), there are only two terminal filaments, and they are very short (0.2% SL, 7% of bulb length) vs. three to six longer filaments in *E. schiffi*, 2.1%–5.2% SL and 92%–213% of bulb length). *E. dubius* and *E. digitatus* never have more than one terminal bulb; three small specimens of *E. schiffi* have two terminal bulbs.

The only other species with a notched or bilobate distal bulb, *contiguus* and *polyaster*, always have a proximal bulb, touching the distal bulb in *contiguus*, separate in *polyaster*. Further, in *polyaster* the terminal filament is much longer (8%–19% SL) than in *schiffi* and has numerous prominent bulblets.

DISTRIBUTION.—Specimens have been taken only in Slope Water and the Northern Sargasso Sea west of 50° W (Figure 19).

REMARKS.—We have examined one small (42.8 mm) specimen with an opaque, developing barbel. The barbel is only 12% SL. There appear to be two terminal bulbs, the proximal bulb very small and ill-defined, the distal bulb bilobate. Two or three very short, thick filaments arise from the tip of one lobe of the distal bulb. Another 42.3 mm specimen, illustrated by Beebe and Crane (1939), has a single, bilobate, terminal bulb bearing no filaments. These two specimens we consider as being *E. schiffi*, based on the presence of the two terminal bulbs in the one specimen and on the geographic location of both.

MATERIAL EXAMINED (3♂, 3♀, 15 unsexed).—*Holotype*: USNM 170935 (♀, 105.0), 32°N, 64°W, 0–330 m (0–600 fm), 29 May 1930.

Non-Types: USNM 222176 (♀, 71.0), 31°41'N, 63°47'W, 0–100 m, 0634–0640, 13 Jan 1970. USNM 222177 (♀, 72.3), 32°18'N, 64°20'W, 50–125 m, 0053–0123, 27 Oct 1967. USNM 222178 (♀, ~81), 39°30'N, 69°42'W, 0–1000 m, 1234–1705, 30 Apr 1977. USNM 222179 (♂, 100.6), 31°11'N, 63°27'W, 0–1700 m, 1430–1730, 19 Apr 1979. USNM 222180 (♂, ~106), 32°14'N, 64°13'W, 200 m, 0515–0615, 2 Jun 1970. USNM 222181 (♂, 117.8), 37°19'N, 66°23'W, 0–20 m, 2315–0050, 13 Sep 1977. USNM 222182 (♀, 42.8), 36°49'N, 65°58'W, 500–750 m, 1232–1646, 6 Nov 1977. USNM 265171 (♀, 93.8), 31°31'N, 67°31'W, 0–125 m, 1907–2137, 10 Dec 1968. ISH 3301/79 (♀, ~107), 30°27'N, 66°08'W, 0–1800 m, 0405–0813, 15 Apr 1979. MCZ 53248 (♀, 57), 33°03'N, 56°06'W, 0–1250 m, 1945–2330, 10 Oct 1972. MCZ 56703 (2♀, 67.3–70.7), 30°16'N, 67°34'W, 0–90 m, 0155–0405, 28 Nov 1968. MCZ 56704 (♀, ~66), 30°10'N, 67°32'W, 0–217 m, 0440–0625, 28 Nov 1968. BOC 4040 (♀, 131.3), 37°04'N, 50°57'W, 14 Aug 1931. AMNH 44214 (♀, 42.3), 32°12'N, 64°36'W, 0–330 m (600 fm), 28 Aug 1930. AMNH 44228 (♀, 54.0), 32°12'N, 64°36'W, 0–330 m (600 fm), 29 Oct 1931. WHOI uncat. (♀, 117), 36°53'N, 73°37'W, 0–1009 m, 0155–0408, 12 Aug 1982. WHOI uncat. (♀, 49), 37°05'N, 70°59'W, 0–1010 m, 0135–0240, 21 Aug 1982. WHOI uncat. (♀, 117), 39°11'N, 70°59'W, 0–1015 m, 1235–1400, 22 Aug 1982. WHOI uncat. (♀, 44), 39°05'N, 68°00'W, 599–800m, 0243–0311, 15 Oct 1982.

GROUP III

The species of this group have a single terminal bulb that is non-bilobate. (In *xenobolus* the bulb is swollen distally and has a much smaller proximal portion, not much wider than the stem axis, that appears almost to be a separate, contiguous body.) A synopsis of the salient characters

is given in Table 1, and their barbel and postorbital-organ dimensions are plotted in Figures 15–17.

Eustomia hulleyi, new species

FIGURE 13a,b

DIAGNOSIS.—A single terminal bulb 0.8%–1.4% SL, pear-shaped or ovoid, with zero to four short terminal filaments, less than one-half bulb length, arising acentrically from distal tip of bulb. Filaments without bulblets. Barbel long, 75%–87% SL. Axis of stem darkly pigmented; a second cylinder of pigment around axis proximal to bulb. External chevron-shaped or roundish striated areas pigmented in distal stem. Serial photophores: PV 32–34, OV 32–34. Vertebrae 63–65. Paired dorsal spots between occiput and dorsal-fin origin 8.

DESCRIPTION.—The barbel of *E. hulleyi* is 75%–87% SL and does not change with growth in the size range examined (86–123 mm). The stem axis is darkly pigmented, either peppered with melanophores or streaked with pigment. A cylinder of pigment around the axis makes the barbel stem appear darker near the bulb in most specimens. External chevron-shaped or roundish striated areas are pigmented toward distal end of the stem, but this may be obscured by pigment around the axis.

The terminal bulb is ovoid or pear-shaped, the wide end distad, with some specimens having a medial groove on the distal end of the bulb, causing it to resemble a derriere. The shape or presence of the groove does not appear size related. The bulb is 0.8%–1.0% SL in females and 1.0%–1.4% SL in males, apparently decreasing in size relative to SL in both sexes. No other sexually dimorphic barbel characters are apparent.

There are zero to four short terminal filaments. When present, they are less than one-half bulb length and always arise acentrically from the terminal-bulb end. In some specimens there is a single filament with one to three side

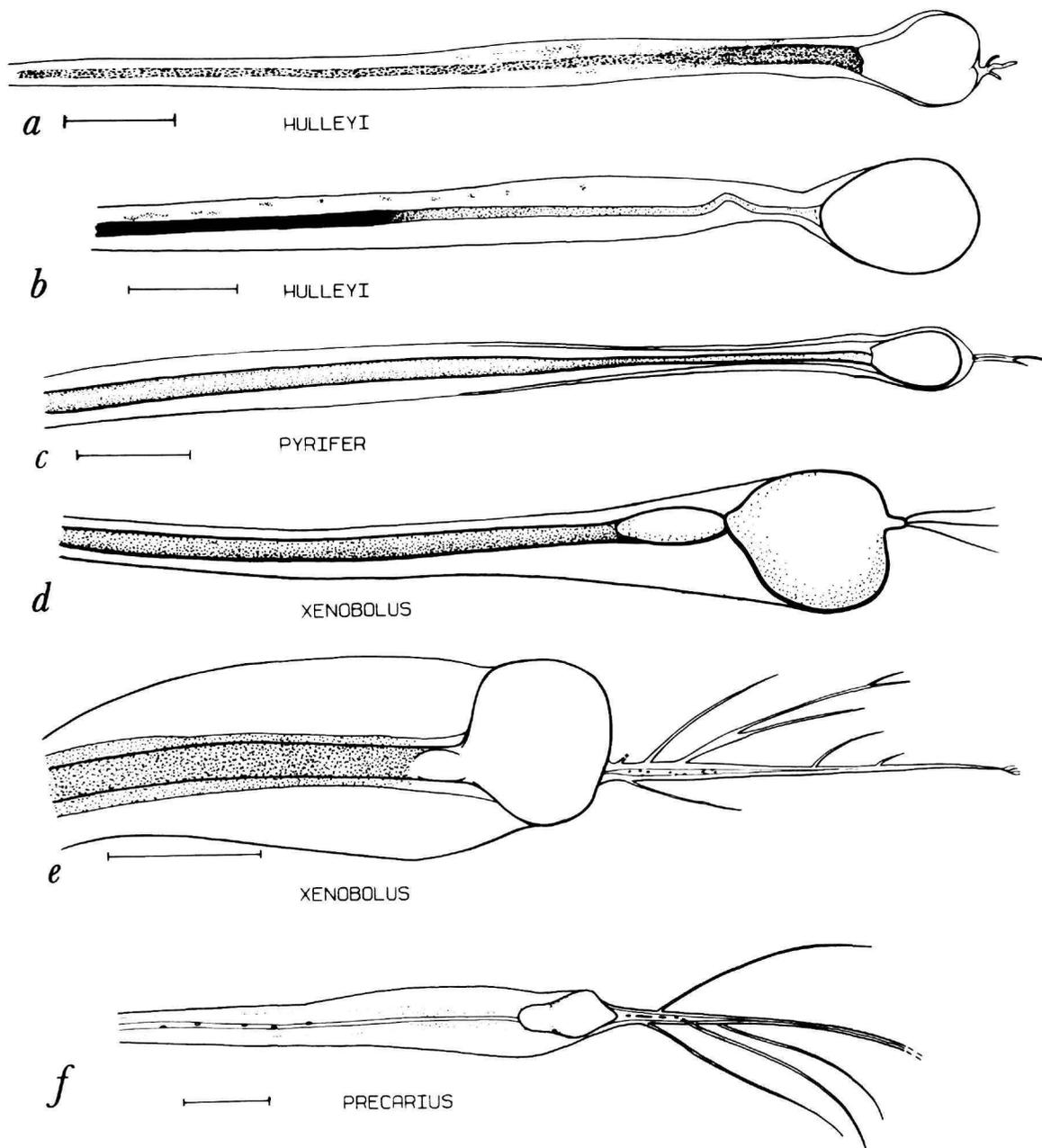


FIGURE 13.—Barbel ends of Group III species: *a, b*, *E. hulleyi* (*a*, paratype, 86.1 mm SL, USNM 258834; *b*, paratype, 109.4 mm SL, USNM 265170); *c*, *E. pyrifer*, holotype, 132.0 mm SL, ZMUC P201908; *d, e*, *E. xenobolus* (*d*, holotype, 171.0 mm SL, modified after Regan and Trewavas, 1930; *e*, 99.7 mm SL, MCZ 56608); *f*, *E. precarius*, holotype, 126.3 mm SL, USNM 259636. (Bar = 1 mm.)

branches; in others it is difficult to discern whether there is a single, branched filament or the filaments each arise from the bulb. Bulblets are not discernible in any of the filaments or side branches.

The postorbital organ of males 103–120 mm SL is 1.7%–2.2% SL, 55%–75% of fleshy orbit length.

There is some suggestion of sexual dimorphism in fleshy orbit and upper-jaw lengths. In four females, 86–123 mm SL, fleshy orbit lengths are 2.5%–3.0% SL; in five males, 103–120 mm SL, they are 2.8%–3.3% SL. Upper-jaw length is 9.8%–10.6% SL in the females, 10.2%–10.9% SL in the males.

Nine pairs of spots along the dorsum, the last one under the dorsal fin, were counted in two specimens.

Barbel bulbs of freshly caught specimens observed by us ranged in color from bright royal blue to greenish blue. The postorbital organs of males were white to pinkish.

DESCRIPTION OF HOLOTYPE.—Male, 105.4 mm SL. D 24. A 35. P₁ 2. P₂ 7. IP 7. PV 33. VAV 15. OV 33. VAL 15. AC 17. IA 55. IC 72. OA 48. OC 65. VAV photophores over anal-fin base 5. Branchiostegal photophores 9. Vertebrae 64. Premaxillary teeth 10 left, 9 right: from anterior to posterior, a moderate fixed tooth followed by a long space, a depressible fang followed by a moderate space, 1 short fixed tooth, 1 moderate depressible tooth, a short to long series of 1 fixed tooth and 2 depressible teeth (middle tooth missing on right), and 3 short depressible teeth. Maxilla with about 23 small, slanting, serra-like teeth. Mandibular teeth 12 left and right: from anterior to posterior, a short fixed symphyseal tooth followed by a moderate space, a fixed fang followed by a long space, 2 groups of 1 moderate depressible and 2 short fixed teeth, and 4 depressible teeth, the first moderate, the last 3 short.

Measurements (in mm): Predorsal length 88.8, preanal length 78.9, prepelvic length 65.4, head length 12.9, barbel length 86.4, bulb length

1.2, filament length 0.4, fleshy orbit length 3.0, postorbital-organ length 1.8, lower-jaw length 11.6, upper-jaw length 11.0, depth behind head (greatest depth) 6.4, caudal-peduncle depth 1.9, pectoral-fin length 13.2, pelvic-fin length 13.4, dorsal-base length 12.8, anal-base length 24.2, longest premaxillary tooth 1.9, longest mandibular tooth 1.3.

Barbel bulb pear-shaped with slight medial groove at distal end paralleling the stem. Three terminal filaments, the thicker, central filament bifurcate near tip.

SIMILAR SPECIES.—In the other species of *Biradiostomias* with single, short (3% SL or less), non-bilobate bulbs, the barbel is shorter, 22%–70% SL vs. 75%–87% in *hullei*. In *pyrifer*, *precaricus*, *ioani*, and one of two specimens of *xenobolus*, filament length is longer, approximately equal to or longer than bulb length vs. less than half bulb length. In *ioani* the filaments arise both distally and laterally from the bulb and contain bulblets; serial photophore and vertebral number also are higher. In *xenobolus* the bulb is in two distinct parts, the proximal part a slender swelling, the distal part globular and much wider.

The remaining species with single, non-bilobate terminal bulbs (*E. macrophthalmus*, *leptobolus*, and *quadrifilis*) have bulbs approximately five to six times longer than wide vs. less than two times.

DISTRIBUTION.—Southeastern Sargasso Sea between 40° and 60°W (Figure 20).

ETYMOLOGY.—Named for our colleague and shipmate, P. Alexander Hulley, Curator of Fishes at the South African Museum, who so appreciated the shapes and colors of *Eustomias* bulbs.

MATERIAL EXAMINED (4♂, 5♀).—*Holotype*: ISH 3295/79 (♂, 105.4), 23°46'N, 58°59'W, 0–1200 m, 1542–1742, 28 Mar 1979.

Paratypes: USNM 258834 (2♀, 86.1, 88.6), 23°09'N, 44°59'W, 0–500 m, 0215–0415, 15 Oct 1973. USNM 265170 (♀, 109.4), 27°02'N, 58°58'W, 0–600 m, 1910–2032, 26 Mar 1979. ISH 3300/79 (♀, 122.8), 23°46'N, 58°59'W, 0–1200 m, 1542–1742, 28 Mar 1979. ISH 3297/

79 (3♂, 102.5–119.8; ♀, 108.6), 23°31'N, 57°20'W, 0–1800 m, 0355–0810, 31 Mar 1979.

***Eustomias ioani* Parin and Pokhilskaya, 1974**

FIGURE 14e

Eustomias ioani Parin and Pokhilskaya, 1974:352–353 [holotype ZIL 41534, 108 mm, 24°25'N, 154°28'E, 0–800 m, 2130–2230, 11 Dec 1968; paratype examined by us; holotype, barbel and teeth, fig. 18].—Parin and Sokolovsky, 1976:248 [1 specimen from the Kuroshio Current area, not seen by us].

DIAGNOSIS.—A single terminal bulb 1.2%–1.5% SL, 2–3 times longer than wide, widest distally, with 4–6 short filaments, shorter than to about as long as bulb, arising laterally and distally from bulb, each with a single elongate bulblet. Barbel length 43%–48% SL. A dense, external black patch on stem approximately 1 bulb-length proximal to bulb. Axis of stem lightly pigmented or without pigment. External chevron-shaped or roundish striated areas unpigmented. Number of serial photophores and vertebrae high for *Biradiostomias*: PV 36, OV 36–37, vertebrae 67–68. Paired dorsal spots between occiput and dorsal-fin origin 9–10.

DESCRIPTION.—We have not examined the holotype, but its counts and measurements from Parin and Pokhilskaya (1974) are included here. Including the holotype, we have data for only six specimens (two of them with incomplete barbels) ranging from 83 to 113 mm.

Barbel length is 43%–48% SL and does not appear to change with growth in the size range examined. The axis of the stem is without melanophores in the smaller (83–110 mm) specimens. The two largest specimens (111 mm and 113 mm) have the axis lightly peppered with small melanophores, the pigment becoming sparse distally. (The holotype was not examined.) A dark, dense external patch of melanophores as long as or shorter than the bulb length is present approximately one bulb-length proximal to the bulb.

The terminal bulb is two to three times longer than wide and widest distally. It is 1.2%–1.5% SL, apparently not changing with growth.

There are four to six filaments on the sides and distal end of the bulb, all shorter than to about as long as bulb length (0.6%–1.3% SL, 0.5–1.1 times distal-bulb length), with no apparent change in relative length with growth. Each filament has a single elongate bulblet near its distal tip causing an external swelling. The filaments are without side branches.

Our specimens were either female or could not be sexed, and all had small postorbital organs (0.4%–0.6% SL, 14%–26% of fleshy orbit length). The size of the male postorbital organ is unknown.

Parin and Pokhilskaya (1974) counted 10–11 pairs of subcutaneous spots along the dorsum in the holotype and paratype, the last one located under the dorsal fin. In one additional specimen, we counted 10 pairs of dorsal spots.

No color observations have been recorded.

SIMILAR SPECIES.—Among the species of *Biradiostomias* with a single, non-bilobate, terminal bulb, *E. ioani* is unique in having filaments that arise both distally and laterally from bulb, and in each filament having a single, relatively large bulblet (*E. precarius* has a few small bulblets in the single terminal filament, which has several side branches). It is also unique in having a short, dense patch of melanophores external to the axis near the bulb; *E. hulleyi* and *E. xenobolus* have a longer darkened area proximal to the bulb, but this is due to a cylinder around the axis; both species have the axis more darkly pigmented than *ioani*.

DISTRIBUTION.—This species is known from the North Pacific between 20° and 35°N, from 150° to 175°E (the Kuroshio Zone of Parin and Sokolovsky (1976), who call *ioani* a peripheral-central species) and from 142° to 154°W (Figure 21).

REMARKS.—The only two specimens from the eastern part of the range have the ends of their barbels missing or damaged. They are assigned to *E. ioani*, primarily because no other species of *Biradiostomias* is known outside the Atlantic and because the capture locality is a logical extension of the otherwise known range of the species. In addition, one of these specimens has enough of

the barbel remaining to show the dense, external black patch on the stem, diagnostic of *E. ioani*, and both specimens have high vertebral counts (67 and 68). Both have barbels that, although

broken in one, are longer than in other known *ioani* specimens (57.4% and 69.8% SL). In one, the end of the barbel is transparent, and the bulb cannot be discerned, but several apparent fila-

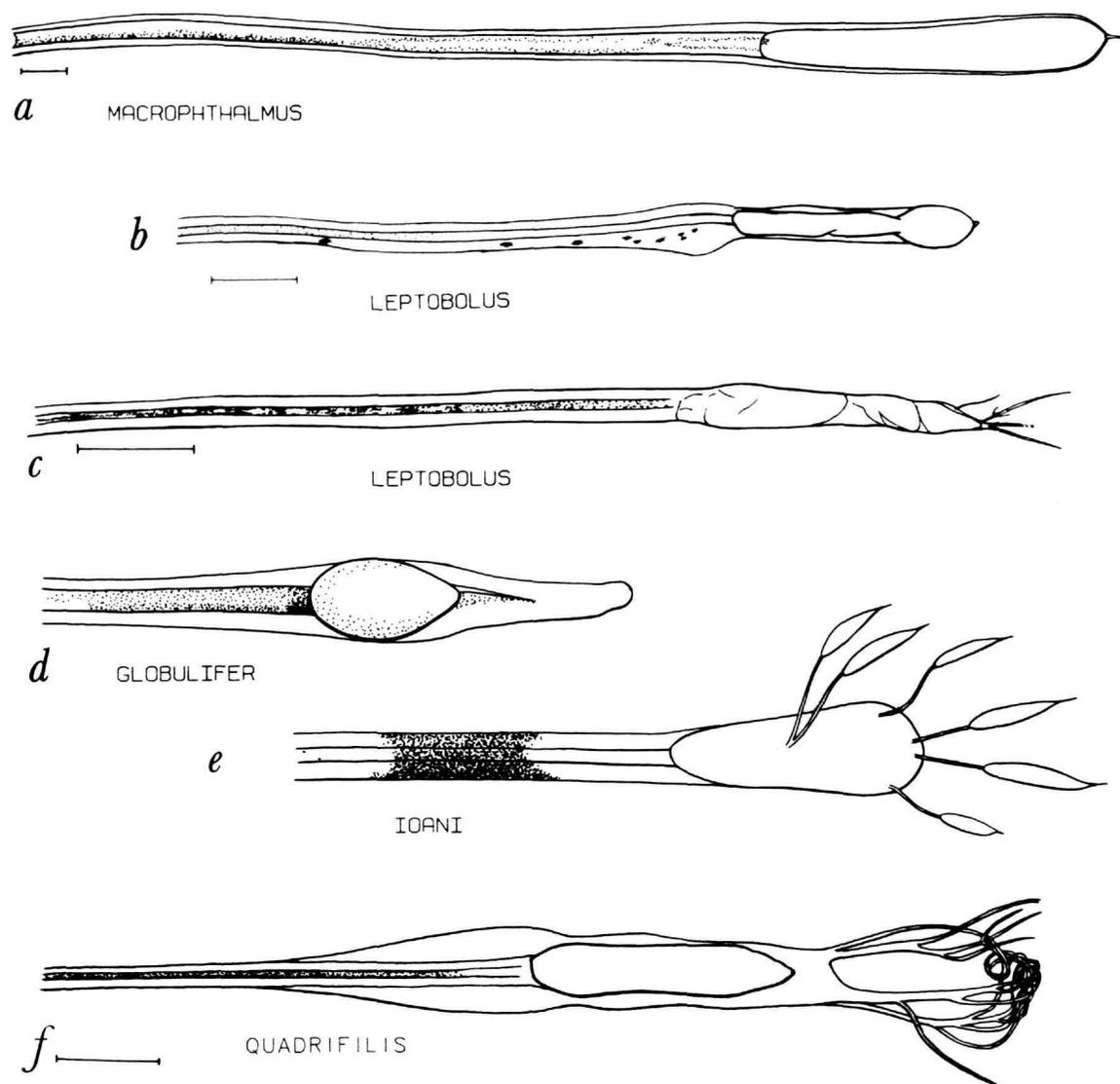


FIGURE 14.—Barbel ends of Group III species and *E. globulifer*, nomen dubium. *a*, *E. macrophthalmus*, 111.0 mm SL, UMML uncatalogued (GS 7301-67); *b, c*, *E. leptobolus* (*b*, 89.1 mm SL, USNM 222025; *c*, questionable specimen, 105.5 mm SL, USNM 222026); *d*, *E. globulifer*, after Regan and Trewavas, 1930; *e*, *E. ioani*, after Parin and Pokhilskaya, 1974; *f*, *E. quadrifilis*, holotype, 105.0 mm SL, USNM 266296. (Bar = 1 mm.)

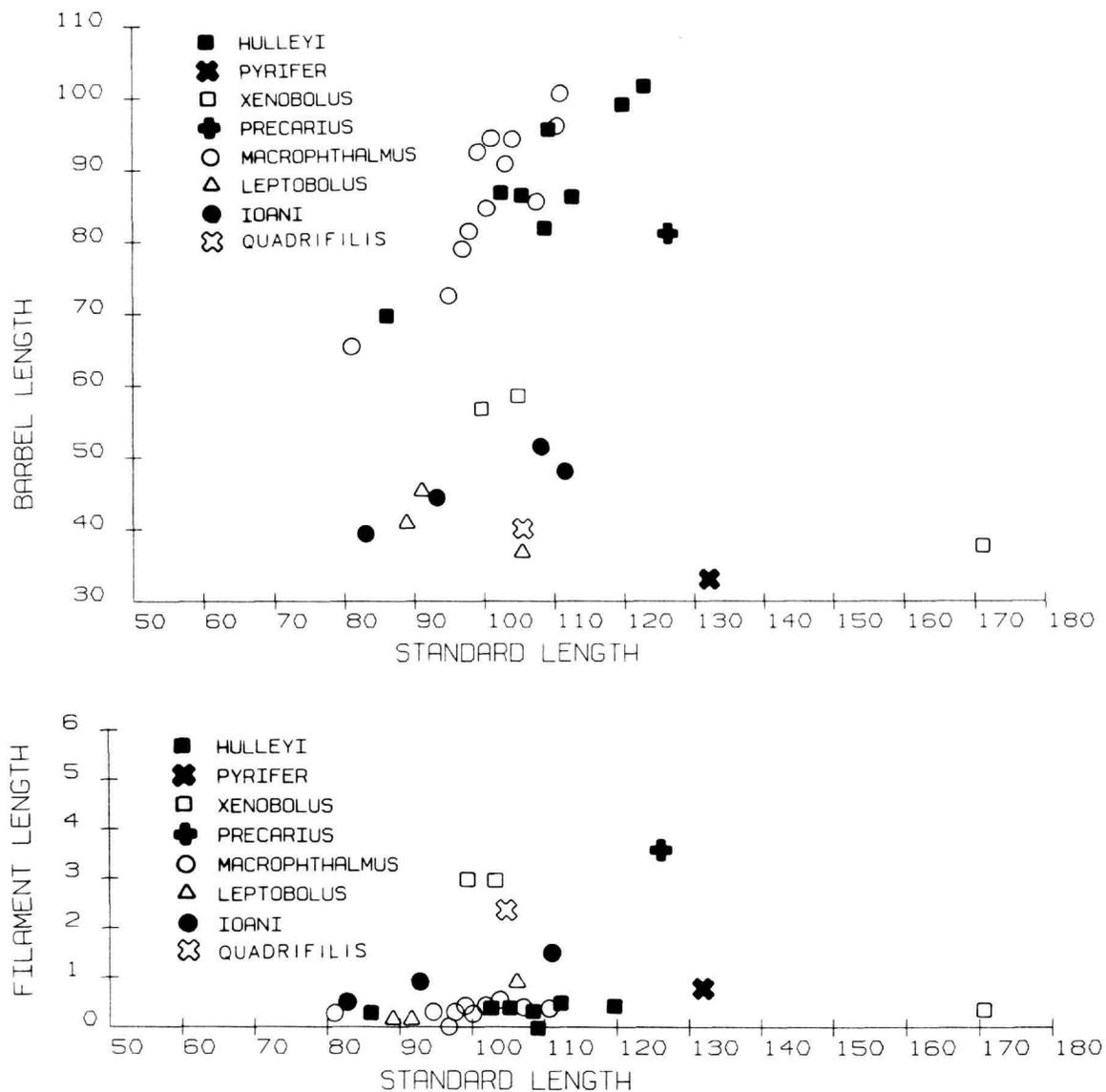


FIGURE 15.—Barbel length (above) and filament length (below) vs. SL (all in mm) in Group III species.

ments with no sign of bulblets are present. If these observations are not artifacts, our description of *ioani* will have to be modified.

MATERIAL EXAMINED (2♀, 4 unsexed).—*Paratype*: IOAN uncat., (? , 83), *Ekvator* sta. 22,

32°02'N, 173°10'E, 0–450 m, 2310–0010, 16 Jul 1968.

Non-types: USNM 265165, (? , 92.9), 34°56'N, 171°08'E, 0–100 m, 21 May 1970. IOAN uncat., (♀, 111.4), 32°40'N, 172°00'E, 0–100 m,

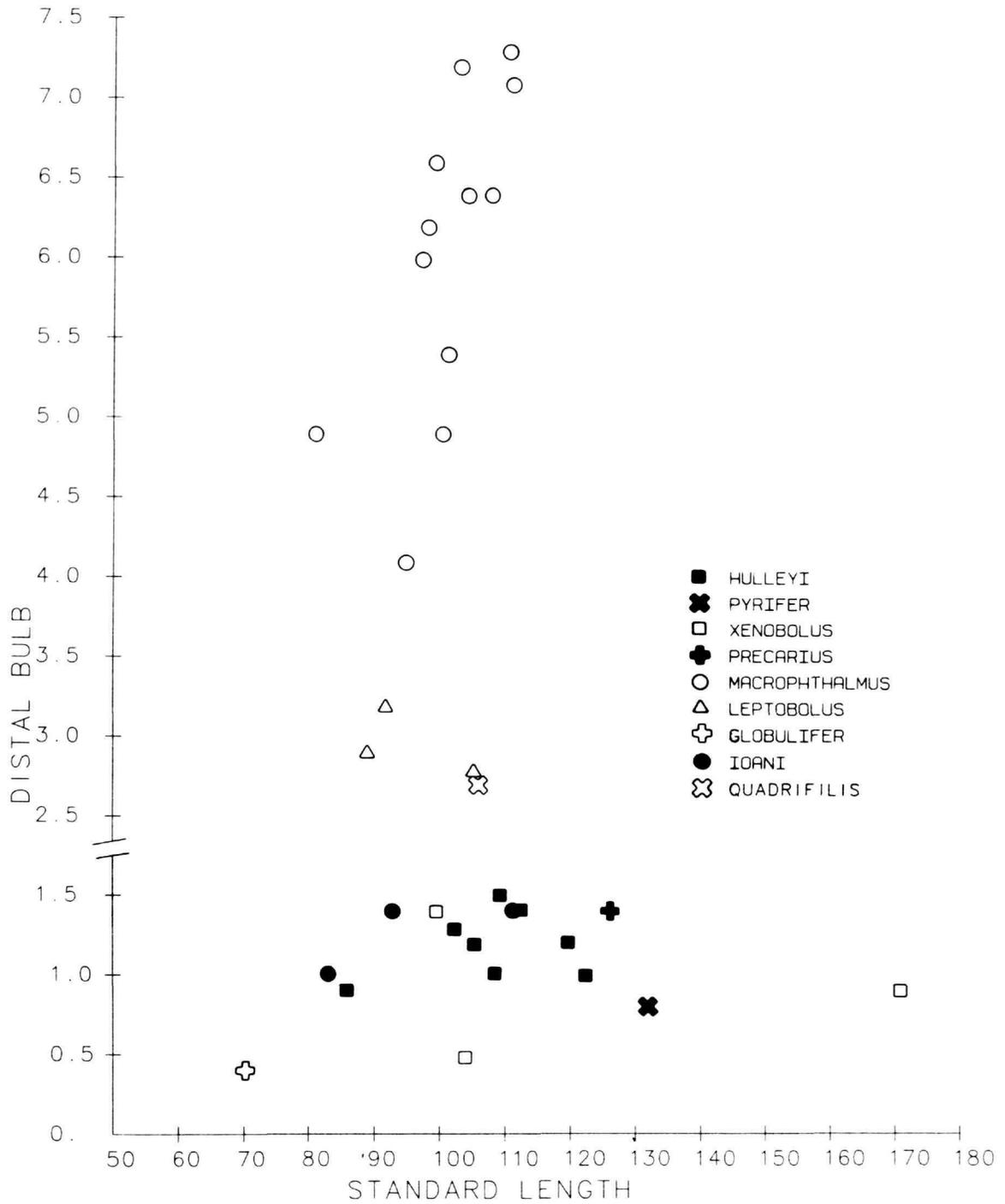


FIGURE 16.—Distal-bulb length (mm) vs. SL (mm) in Group III species.

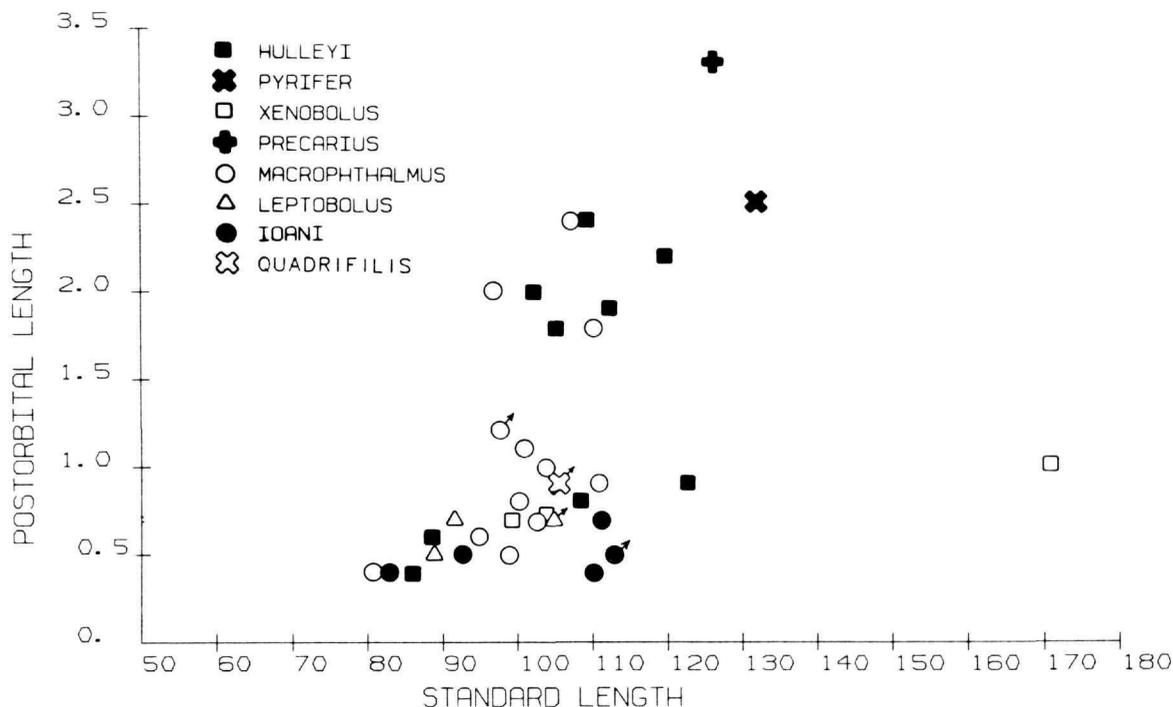


FIGURE 17.—Postorbital-organ length (mm) vs. SL (mm) in Group III species. All specimens with organs larger than 1.5 mm are males; unmarked specimens with smaller organs include both males and females.

13 May 1970. OSUO uncat., (♀, 110.2), 34°58'N, 142°57'W, 0–200 m, 2 Mar 1965. OSUO uncat., (? , 113.0), 30°02'N, 153°45'W, 0–250 m, 27 Jan 1980.

Eustomias leptobolus Regan and Trewavas, 1930

FIGURE 14b,c

Eustomias leptobolus Regan and Trewavas, 1930:94 [holotype barbel fig. 77A, not entirely accurate, see below].—Morrow and Gibbs, 1964:412 [no additional material; barbel fig. 110E].—Rass, 1971:511 [listed in Gulf of Mexico].—Nielsen, 1974:16 [holotype in ZMUC].

DIAGNOSIS.—A single large, elongate terminal bulb 3.3%–3.5% SL, approximately 6 times longer than wide, with constriction before tip. Proximal portion of bulb longer and somewhat

more slender than part distal to constriction. Terminal filament minute and simple. Barbel length 46%–49% SL. Stem axis darkly pigmented. External chevron-shaped roundish striated areas on stem not pigmented. Serial photophores: PV 33–34, OV 33, IA 57–59, IC 75–77. Vertebrae 65–67. Paired dorsal spots between occiput and dorsal-fin origin 8.

DESCRIPTION.—This section is based on two specimens, 89 and 92 mm SL. Proportions, bulb shape, and filament are as in diagnosis. The illustration of the bulb of the holotype (Regan and Trewavas, 1930; fig. 77A) shows the proximal part being about as wide as the distal part. We found the bulb of the holotype to be similar to our Figure 14b, with a more slender proximal part. The axis of the stem is darkly peppered with melanophores in the 92 mm holotype. The

second specimen has no stem pigment, but the body is also faded.

Both specimens are females with small postorbital organs, 0.6%–0.8% SL, 28%–29% of fleshy orbit length.

Nine pairs of subcutaneous spots along the dorsum, the last under the dorsal-fin base, were counted in one specimen.

The bulb of the 89 mm immature female, after being in preservative for some weeks, was an overall light purple.

SIMILAR SPECIES.—Two other species have long terminal bulbs. In *macrophthalmus*, the barbel is longer (76%–93% SL vs. 46%–49%); the terminal bulb has no constriction and is longer (4.3%–7.0% SL vs. 3.3%–3.5%); IA and IC photophore counts are lower (54–56 vs. 57–59 and 72–74 vs. 75–77); there are more mandibular teeth (11–18 vs. 9–10); and fleshy orbit diameter is larger (2.7%–3.6% SL vs. 1.9%–2.7%). The counts and the eye size differences may prove less trenchant when more is known about variation in *leptobolus*. The two pairs of relatively long terminal filaments easily distinguish *quadrifilis*, which also differs from *leptobolus* in having an unconstricted bulb, more mandibular teeth (13–17), and a larger fleshy orbit (2.7% SL).

The remaining species of *Biradiostomias* with a single, non-bilobate terminal bulb (*hullei*, *precarius*, *pyrifer*, *xenobolus*, and *ioani*) have relatively small bulbs, 0.5%–1.5% SL, that are less than three times longer than wide.

Eustomias ignotus also resembles *E. leptobolus*, but has two terminal bulbs in close approximation. If the two bulbs were joined, *ignotus* might be indistinguishable from *leptobolus*. The bulb of *leptobolus* appears less dense in its mid-portion than at its ends. Therefore, it is conceivable that with growth the elongate bulb of *leptobolus* could divide in two.

DISTRIBUTION.—The holotype was taken in the Straits of Florida, the second specimen from the northern Gulf of Mexico. A possible specimen from off the Guianas is discussed below.

REMARKS.—We have examined one badly damaged, immature male (105.5 mm) caught in

the Atlantic off the Guianas, which we tentatively identify as *E. leptobolus*. Its barbel is short, 35% SL; the bulb is elongate, approximately 2.7% SL; and the axis of the stem is darkly peppered with melanophores. These three characters are closest to those of *E. leptobolus*. It appears, however, that the terminal bulb is not constricted near its distal end and that there are three simple, terminal filaments rather than one (Figure 14c). We excluded this specimen from the diagnosis.

MATERIAL EXAMINED (1♂, 2♀).—*Holotype*: ZMUC P201900 (♀, 91.8), 23°13'N, 82°21'W, 0–~400 m (800 mw), 1900, 5 Feb 1922.

Non-types: USNM 222025 (♀, 89.1), 28°58'N, 88°18'W, 0–~300 m (545 fm), 27 Oct 1960. USNM 222026 (♂, 105.5), 7°46'N, 54°06'W, 0–~175 m (0–320 fm), 25 Nov 1969.

Eustomias macrophthalmus Parr, 1927

FIGURE 14a

Eustomias macrophthalmus Parr, 1927:67–68 [holotype fig. 39, barbel fig. 36c].—Regan and Trewavas, 1930:93 [barbel fig. 77b, 1 additional specimen; *E. micropterygius* a doubtful synonym].—Beebe and Crane, 1939:212–213 [type re-examined; no additional specimens].—Morrow and Gibbs, 1964:415–416 [no additional specimens; barbel, fig. 110d].—Rass, 1971:511 [listed in Caribbean Sea].—Parin and Pokhilskaya, 1974:364 [1 specimen from 22°42'N, 66°49'W].

DIAGNOSIS.—A single very large, elongate terminal bulb 4.3%–7.0% SL, approximately 6 times longer than wide, without any constriction. Terminal filament, when present, minute and simple. Barbel long, 76%–93% SL. Stem axis lightly pigmented. External chevron-shaped or roundish striated areas on stem not pigmented. Serial photophores: PV 31–34, OV 32–34, IA 54–56, IC 72–74. Vertebrae 63–66. Paired dorsal spots between occiput and dorsal-fin origin 8.

DESCRIPTION.—The barbel of *E. macrophthalmus* is long. Its relative length of 76%–93% SL is reached at least by 79 mm (the smallest specimen examined), after which it does not appear to change with growth in the size range examined (79–111 mm SL). There is some indication of

sexual dimorphism in barbel length, with six females (99–111 mm SL) having slightly longer barbels (84%–93% SL) than four males (97–111 mm SL with barbels 79%–87% SL). No other sexually dimorphic barbel characters are apparent. The stem axis is lightly peppered with melanophores or lightly streaked with pigment. One specimen (107.5 mm) has no axis pigment, but the body is also faded.

The single terminal bulb is very large, 4.3%–7.0% SL, and does not change with growth in the size range examined. It is approximately six times longer than wide, an elongate sausage-shaped ellipse. Two specimens (79–99 mm, MCZ 55318) have the distal portion of the bulb transparent with a thin dendritic network, rather than opaque. These bulbs may be still developing or regenerating their distal portions, or they may have been crushed.

A minute, simple terminal filament (less than 1% SL) is present in all except 1 specimen (79 mm). It usually is visible only under magnification.

Four males (97–111 mm) have postorbital organs 1.2–2.4 mm long, which are 1.2%–2.2% SL, 34%–67% of fleshy orbit. This development is reached at a short SL relative to other species of *Biradiostomias*.

In addition to barbel length and postorbital-organ size, the caudal-peduncle depth appears to be sexually dimorphic, with 4 males examined (97–111 mm) having depths of 1.9–2.1 mm and 5 females (99–111 mm) with depths of 1.6–1.9 mm.

Bulbs of three freshly caught males (97–111 mm), one female (100 mm) and one specimen of undetermined sex (95 mm) were deep purple distally, light purple or yellowish white proximally. The postorbital organs of the males were pink or pinkish white.

SIMILAR SPECIES.—Two other species have long terminal bulbs. In *E. leptobolus*, the most similar species, the barbel is shorter (46%–49% SL vs. 76%–93%), the terminal bulb has a constriction near its distal tip and is shorter (3.3%–3.5% SL vs. 4.3%–6.6%); it has more IA photop-

hores (57–59 vs. 54–56), and IC photophores (75–77 vs. 72–74) and fewer mandibular teeth (9–10 vs. 11–18); and its fleshy orbit diameter is smaller (1.9%–2.7% SL vs. 2.7%–3.6%). In *E. quadrifilis*, the bulb length, fleshy orbit diameter, and photophore counts resemble those of *macrophthalmus*, but it, like *leptobolus*, has a shorter barbel, and its two pairs of relatively long terminal filaments are distinctive. The differences in counts and orbit diameter could prove less trenchant when more is known about variation in *leptobolus*.

The remaining species of *Biradiostomias* with a single, non-bilobate, terminal bulb (*hullei*, *precaricus*, *pyrifer*, *xenobolus*, and *ioani*) have relatively small terminal bulbs, 0.5%–1.5% SL, with the bulb less than three times longer than wide.

Eustomias ignotus also resembles *macrophthalmus* but has two terminal bulbs in close approximation. If the two bulbs were joined, with no constriction, the bulb of *ignotus* could be indistinguishable from that of *macrophthalmus*. The barbel length of *E. ignotus*, however, is shorter, 43.6% SL vs. 76%–93%.

DISTRIBUTION.—Specimens have been taken in the Southern Sargasso Sea, the Straits of Florida, and in the West Indies from the Bahamas to the Virgin Islands (Figure 20).

MATERIAL EXAMINED (4♂, 6♀, 2 unsexed).—*Holotype*: BOC 2035 (♀, 104.1), 22°31'N, 74°26'W, 0–~1500 m (10,000 ft wire), 30 Mar 1927.

Non-types: ZMUC P201859 (♀, 101.2), 17°34'N, 64°56'W, 0–~150 m (300 mw), 18 Apr 1922. IOAN uncat. (♀, 102.9), 22°42'N, 66°49'W, 0–180 m, 28 Apr 1962. MCZ 55318 (♀, 99.3; ?, 81.1), 20°12'N, 65°19'W, 2000–2400, 25 Feb 1954. UMML uncat. (♀, 111.0), 24°29'N, 74°24'W, 0–400 m, 2220–2320, 25 Jan 1973. ISH 3299/79 (♂, 98.0), 25°08'N, 67°39'W, 0–1800 m, 0416–0820, 12 Apr 1979. ISH 2296/79 (♀, 100.4), 25°37'N, 61°56'W, 0–100 m, 2103–2200, 21 Mar 1979. USNM 259650 (? , 94.8), 23°46'N, 58°59'W, 0–1200 m, 1542–1742, 28 Mar 1979. USNM 259649 (♂, 110.5), 23°55'N, 63°58'W, 0–1800 m,

0358-0803, 8 Apr 1979. USNM 259647 (♂, 97.1), 26°42'N, 79°31'W, 400-750 m, 1320-1657, 7 Aug 1978. USNM 259648 (♂, 107.5), 19°56'N, 70°43'W, 0-220 m, 14 Oct 1963.

***Eustomias precarius*, new species**

FIGURE 13f

DIAGNOSIS.—A single terminal bulb 1.1% SL, modified pear-shaped (Figure 13f), with 1 terminal filament 2.9% SL, greater than 2.6 times bulb length (broken in only known specimen) bearing 4 side branches. Small bulblets near base of main filament. Barbel length 64% SL. Stem axis with little pigment, none distally. External chevron-shaped or roundish striated areas on stem unpigmented. Male postorbital organ large, 2.6% SL. PV photophores 32. Vertebrae 65. Paired dorsal spots between occiput and dorsal-fin origin 8.

DESCRIPTION OF HOLOTYPE.—Male, 126.3 mm SL. D 24. A 37. P₁ 2. P₂ 7. IP 7. PV 32. VAV 17. OV 32. VAL 17. AC 18. IA 54. IC 72. OA 49. OC 67. VAV photophores over anal-fin base 5. Branchiostegal photophores 10. Vertebrae 65. Premaxillary teeth 12 left and right: from anterior to posterior, a moderate fixed tooth followed by a long space, a long fixed fang followed by a moderate space, a short fixed tooth, 2 long depressible teeth (a space on right where the second should be), 2 moderate fixed teeth, 2 moderate depressible teeth (a space on right where the second should be) and 3 short depressible teeth. Maxilla with about 20 short, slanting, serra-like teeth. Mandibular teeth 18 left and right: from anterior to posterior, a short fixed symphyseal tooth (missing on right) followed by a moderate space, a long fixed fang and a short depressible tooth (the latter missing right) followed by a long space, a long depressible tooth followed by a moderate space, a short fixed tooth, a long and a moderate depressible tooth (missing right), a short fixed tooth, a short and 2 moderate depressible teeth (the first two missing on left), 2 small fixed teeth, and 5 small depressible teeth.

Measurements (in mm): Predorsal length 106.7, preanal length 95.5, prepelvic length 74.4, head length 15.8, barbel length 81.0, bulb length 1.4, filament length 3.6 to break, snout length 6.0, fleshy orbit length 4.7, postorbital-organ length 3.3, lower-jaw length 14.3, upper-jaw length 13.3, depth behind head (greatest depth) 9.5, caudal-peduncle depth 2.5, pectoral and pelvic fins broken, dorsal-base length 16.2, anal-base length 31.4, longest premaxillary tooth 2.4, longest mandibular tooth 1.6.

Axis of stem with intermittent streaky pigment proximally, without pigment distally near bulb and in terminal filament. External chevron-shaped or roundish striated areas on axis unpigmented.

Terminal bulb somewhat pear-shaped, widened distally but forming an acentric blunt point distally from which the terminal filament arises. Terminal filament with 4 side branches, staggered in their origin from the main filament, but all arising less than 1 bulb-length from terminal bulb. Two small bulblets in basal part of filament, none in side branches.

SIMILAR SPECIES.—Three species of *Biradiostomias* with single, non-bilobate terminal bulbs resemble *precarius* in one way or another: *hullei*, *pyrifer*, and *xenobolus*. The bulbs of *pyrifer*, and especially *hullei*, are somewhat similar in shape to that of *precarius*, but the bulb of *xenobolus*, with its small proximal and large, globular distal part, is very different. In one specimen and another questionable one of *xenobolus*, the filament is 2.1 times the bulb length, 3.0% SL; in all other specimens of the three species, the filament is 0.6% SL or shorter and equal to or shorter than bulb length (2.6 times bulb length, 2.9% SL in *precarius*). The barbel is longer in *hullei* (75%–87% SL) but shorter in *pyrifer* (25% SL) and *xenobolus* (22%–57%) than in *precarius* (64%). The stem is darkly pigmented in *hullei* and *xenobolus*, lightly pigmented in *pyrifer*. Very little pigment was discerned in the barbel of *precarius*, but this might be the result of extreme fading. The male postorbital organ of *precarius* (2.6% SL) is larger relative to SL than in any other

species of *Biradiostomias* (*hullei*, maximum 2.2% SL; *pyrifer* 1.9% SL).

DISTRIBUTION.—The holotype and only known specimen is from off Puerto Rico (Figure 20).

ETYMOLOGY.—From the Latin adjective *precarius*, (doubtful or uncertain), in allusion to the uncertainty involved in basing a new species on a single specimen.

MATERIAL EXAMINED.—*Holotype*: USNM 259636 (♂, 126.3) 19°21'N, 65°39'W, 3 Feb 1969.

Eustomias pyrifer Regan and Trewavas, 1930

FIGURE 13c

Eustomias pyrifer Regan and Trewavas, 1930:93 [barbel of holotype fig. 76B].—Nielsen, 1974:18 [holotype in ZMUC].

Eustomias xenobolus.—Morrow and Gibbs, 1964:428–429 [part; no additional specimens; *E. pyrifer* in synonymy].

DIAGNOSIS.—A single terminal bulb 0.6% SL, pear-shaped, slightly wider distad, with a single filament about equal to bulb length and bearing 1 side branch. Barbel very short, 25% SL. Axis of stem lightly pigmented with small melanophores. External chevron-shaped or roundish striated areas unpigmented. Serial photophores: PV 34, OV 34. Vertebrae 64. Paired dorsal spots between occiput and dorsal-fin origin 8.

DESCRIPTION.—Barbel, bulb, and filament as in diagnosis. Known only from the holotype, a 132 mm SL male with postorbital organ 2.5 mm long (1.9% SL, 64% of fleshy orbit length).

No color observations were recorded.

SIMILAR SPECIES.—Of the species of *Biradiostomias* with single, non-bilobate terminal bulbs, *E. pyrifer* is similar in barbel and bulb lengths to the larger specimen of *E. xenobolus* (barbel 25% SL vs. 22%; bulb 0.6% SL vs. 0.5%), but may be distinguished by bulb shape (pear shaped vs. in two distinct parts). Bulb shape and size are similar to those of *hullei* and *precarius*, but barbel length is significantly shorter in *pyrifer* (25% vs. 64%–87% SL). Both *xenobolus* and *hullei* have the

stem axis more darkly pigmented than in *pyrifer*, and both have a second cylinder of pigment around the axis proximal to the bulb. The lack of multiple filaments with single large bulblets easily distinguishes *pyrifer* from *ioani*. The remaining three single-bulb species, *macrophthalmus*, *leptobolus*, and *quadrifilis*, have much longer bulbs (2.6%–7.0% SL vs. 0.6% in *pyrifer*).

DISTRIBUTION.—The only specimen was taken in the Caribbean Sea off St. Croix, Virgin Islands (Figure 20).

MATERIAL EXAMINED.—*Holotype*: ZMUC P201908 (♂, 132), 17°59'N, 64°41'W, 0–50 m (100 mw), 0045, 1 Dec 1921.

Eustomias quadrifilis, new species

FIGURE 14f

DIAGNOSIS.—A single, elongate terminal bulb 2.6% SL, about 5 times longer than wide. Two pairs of complex terminal filaments about 2.2% SL arising separately from end of clear sheath of bulb. Barbel length 35.9% SL. Stem axis darkly pigmented. External chevron-shaped or roundish striated areas on stem not pigmented. Serial photophores: PV 33, OV 34, IA 56, IC 73. Vertebrae 64.

DESCRIPTION OF HOLOTYPE.—Male, 105.0 mm SL. D 22. A 34. P₁ 2. P₂ 7. IP 7. PV 33. VAV 16. OV 34 (first on left side paired, count could be 35). VAL 16. AC 17. IA 56. IC 73. OA 50. OC 67. VAV photophores over anal-fin base 5. Branchiostegal photophores 10. Vertebrae 64. Premaxillary teeth 11 left, 13 right: from anterior to posterior, a moderate fixed tooth followed by a long space, a fixed fang followed by a moderate space, a short fixed tooth, 5 moderate depressible teeth (only 2 right), 2 short fixed teeth (1 right), and a short depressible tooth (7 on right). Maxilla with about 20 small, slanting, serra-like teeth. Mandibular teeth 17 left, 13 right: from anterior to posterior, a short depressible symphyseal tooth with replacement followed by a moderate space, a fixed fang followed by a moderate space, 2 moderate depressible teeth (1

right) followed by a short space, 2 short depressible teeth followed by a short space (a short fixed, a moderate depressible, and another short fixed tooth on right), a long depressible tooth, 2 short depressible teeth (6 right), 5 moderate-to-short depressible teeth (none right), and 3 short fixed teeth (none right).

Measurements (in mm): Predorsal length 88.8, preanal length 77.2, prepelvic length 60.4, head length 11.7, barbel length 39.7, opaque-bulb length 2.7, filament length ~2.3 (distal ends tangled), fleshy orbit length 2.8, postorbital-organ length 0.9, lower-jaw length 11.3, upper-jaw length 10.5, depth behind head (greatest depth) 7.7, caudal-peduncle depth 2.0, pectoral-fin length 13.6, pelvic-fin length 14.5, dorsal-base length 13.2, anal-base length 25.3, longest premaxillary tooth 2.0, longest mandibular tooth 1.8.

Opaque barbel bulb elongate, about 5 times longer than wide, rounded proximally, narrowing almost to a point distally. Wide, clear sheath around bulb, with 2 well separated pairs of filaments arising from its distal end. One filament apparently simple; others branching and with several fine branches distally that are tangled together.

The darkness of the skin prevented counting of paired dorsal spots.

SIMILAR SPECIES.—The structure of the terminal filaments is unlike that of any other species of *Biradiostomias*. The elongate bulb of *quadrifilis* resembles those of *leptobolus* and *macrophthalmus*; its length is similar to that of *leptobolus*, shorter than in *macrophthalmus*. Barbel length is similar to *leptobolus*, shorter than in *macrophthalmus*. Photophore counts are within the range of *macrophthalmus* and lower than in *leptobolus*. Neither *leptobolus* (with one questionable exception) nor *macrophthalmus* has more than a short, simple filament (the three filaments of the exceptional *leptobolus* are less than half as long as those of *quadrifilis*).

DISTRIBUTION.—The only known specimen was taken in a warm-core eddy surrounded by Slope Water east of New Jersey, USA.

ETYMOLOGY.—The name *quadrifilis* is a Latin adjective meaning four-threaded, in allusion to the two pairs of terminal filaments.

MATERIAL EXAMINED.—*Holotype*: USNM 266296 (♀, 105.0), 38°58'N, 71°16'W, 250–500 m, 0307–0327, 22 Apr 1982.

***Eustomias xenobolus* Regan and Trewavas, 1930**

FIGURE 13d,e

Eustomias xenobolus Regan and Trewavas, 1930:92 [barbel of holotype fig. 75].—Morrow and Gibbs, 1964:428–429 [part; barbel fig. 110k; no additional material; *E. pyrifer* placed in synonymy].—Rass, 1971:512 [listed in Caribbean Sea].—Nielsen, 1974:19 [holotype in ZMUC].

DIAGNOSIS.—A single terminal bulb 0.5%–1.4% SL, in 2 distinct parts: proximal part a slender stalk about stem-axis width (almost a separate small bulb); distal part globular and much wider. One to 3 terminal filaments, simple or with side branches, 0.4–2.1 times bulb length. Filaments with few or no bulblets. Barbel length 22%–57% SL. Axis of stem darkly pigmented; a second cylinder of pigment around axis in swollen stem near bulb. External chevron-shaped or roundish striated areas pigmented in distal part of stem. Serial photophores: PV 34, OV 34. Vertebrae 65. Paired dorsal spots between occiput and dorsal-fin origin 8.

DESCRIPTION.—Of the two known specimens (100 and 171 mm SL) the smaller has a longer barbel (56.6 mm vs. 37.2 mm), larger bulb (1.4 mm vs. 0.9 mm), and longer terminal filament (~3.0 mm vs. ~0.5 mm). Thus, a decrease with growth is indicated for all three characters.

Stem pigmentation is described in the diagnosis.

The terminal bulb is in two distinct parts. A proximal, stalk-like part of the bulb could be interpreted as a separate small bulb, contiguous with the larger globoid distal part.

The smaller specimen has a single terminal filament 3.0% SL, 2.1 times bulb length bearing side branches. The larger specimen had three short terminal filaments arising from a single

point, the longest ~0.2% SL, ~40% of bulb length, but these are now missing.

Both specimens are females with well-developed ova (up to 0.6 mm diameter) and have small postorbital organs (0.7%–1.0% SL, 20%–22% of fleshy orbit length).

Both specimens have nine pairs of subcutaneous spots along the dorsum, the last one under the dorsal fin.

No color observations have been recorded.

SIMILAR SPECIES.—*Eustomias xenobolus* is unique among the species of *Biradiostomias* in having a single, non-bilobate terminal bulb with two distinct parts: a slender, stalk-like proximal swelling and a globular and much wider distal part. It resembles *E. hulleyi* in having a darkly pigmented stem axis and a second cylinder of pigment around the axis proximal to the bulb, but *hulleyi* differs in bulb shape and has a longer barbel (75%–87% SL vs. 22%–57%). Both *pyrifer* and *precarius*, like *hulleyi*, have single, relatively simple bulbs, but the stem axis of *pyrifer* is lightly pigmented, that of *precarius* has almost no pigment, and *precarius* has a longer barbel (64% SL) than *xenobolus*.

REMARKS.—A possible third specimen of *xenobolus* was taken at 27°N, 86°W, in the eastern Gulf of Mexico. This 104 mm immature female specimen has an apparently damaged barbel end, with a very small (0.4 mm) opaque bulb, distad of which is an obscure area that suggests that there might have been greater bulb development. The specimen resembles the smaller (100 mm) specimen in the description in having a 59.4 mm barbel with a ~3.0 mm terminal filament. The filament, probably broken, has a single branch at about one-third the distance from the bulb.

DISTRIBUTION.—The holotype was taken off St. Croix, Virgin Islands, the second specimen from the southwestern Gulf of Mexico, the questionable specimen from the northeastern Gulf (Figure 20).

MATERIAL EXAMINED (3♀).—*Holotype*: ZMUC P201913 (♀, 171), 17°43'N, 64°56'W, 0–~500 m (1000 mw), 2100, 30 Mar 1922.

Non-type: MCZ 56608 (♀, 99.7) 23°13'N, 94°50'W, 0–128 m, 2355–0413, 18–19 Jun 1966.

Questionable: USNM 266588 (♀, 104.3), 27°N, 86°W, 360–530 m, 0738–1058, 6 Jun 1972.

DOUBTFUL SPECIES

Two nominal species cannot be associated with any of the species that we recognize. Each is known only from its holotype, and both holotypes are young specimens that appear to have damaged barbels.

Eustomias globulifer Regan and Trewavas, 1930

FIGURE 14d

Eustomias globulifer Regan and Trewavas, 1930:93 [holotype only; barbel fig. 76A].—Morrow and Gibbs, 1964:411 [no additional specimens].—Rass, 1971:511 [listed in Caribbean Sea].—Nielsen, 1974:16 [holotype in ZMUC].

The holotype is 70.4 mm SL and is incompletely metamorphosed. Its two developed pectoral rays are preceded by a short projection that may be a rudimentary ray of the sort that is commonly seen in small *Eustomias* and later disappears. Its barbel is short, 9.5% SL, with a pigmented stem, a single ovoid terminal bulb, and a short, pigmented terminal projection (Figure 14d). The projection could be a portion of stem that has been broken off between two bulbs, so that barbel length may well have been longer. At 70 mm SL, the barbels of most *Biradiostomias* species for which developmental series are available are increasing rapidly in relative length, and the short barbel of *globulifer* could associate it with many or all the species that we recognize here. If the end of the barbel is not broken, the shape of the single bulb is vaguely reminiscent of *pyrifer*, *hulleyi*, or *precarius*, but the terminal appendage is unlike any of these. If the barbel is broken, its remaining bulb resembles the proximal bulb of *polyaster*, *dubius*, *variabilis*, *hypopsilus*, *metamelas*, or *dispar*. Of these six species, *meta-*

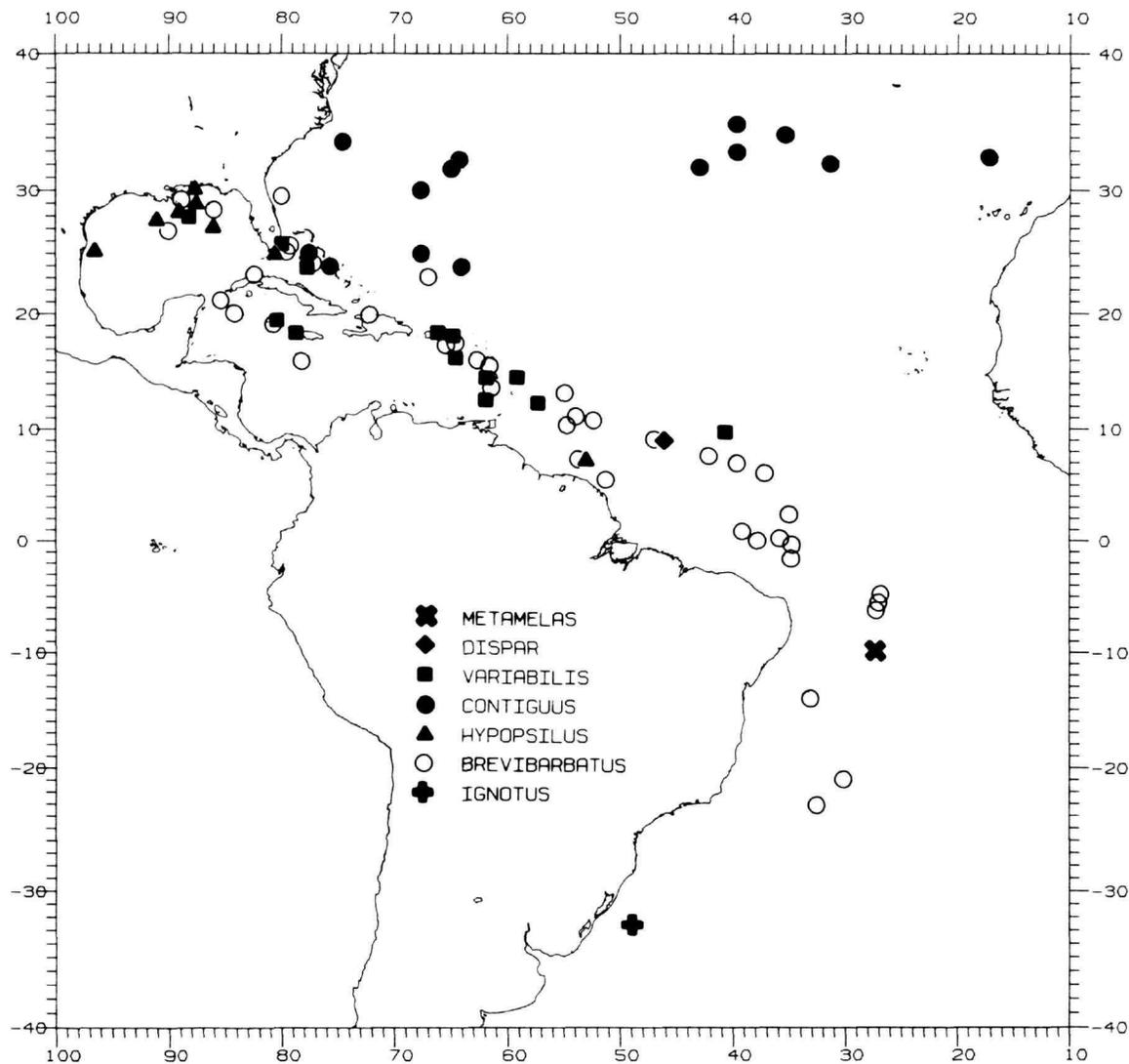


FIGURE 18.—Geographic distribution of Group I species.

melas and *dispar* are known only from south of 10°N; the other four have been taken in the Bahamas area, as was *globulifer*, and any of these might be conspecific with *globulifer*. At this time we cannot associate *globulifer* with any one of the known species of *Biradiostomias*.

DISTRIBUTION.—The holotype, and only known specimen, was taken east of Martinique in the Lesser Antilles.

MATERIAL EXAMINED.—*Holotype*: ZMUC P201899 (? 70.4), 14°38'N, 61°16'W, 0~300 m (600 mw), 0315, 7 Apr 1922.

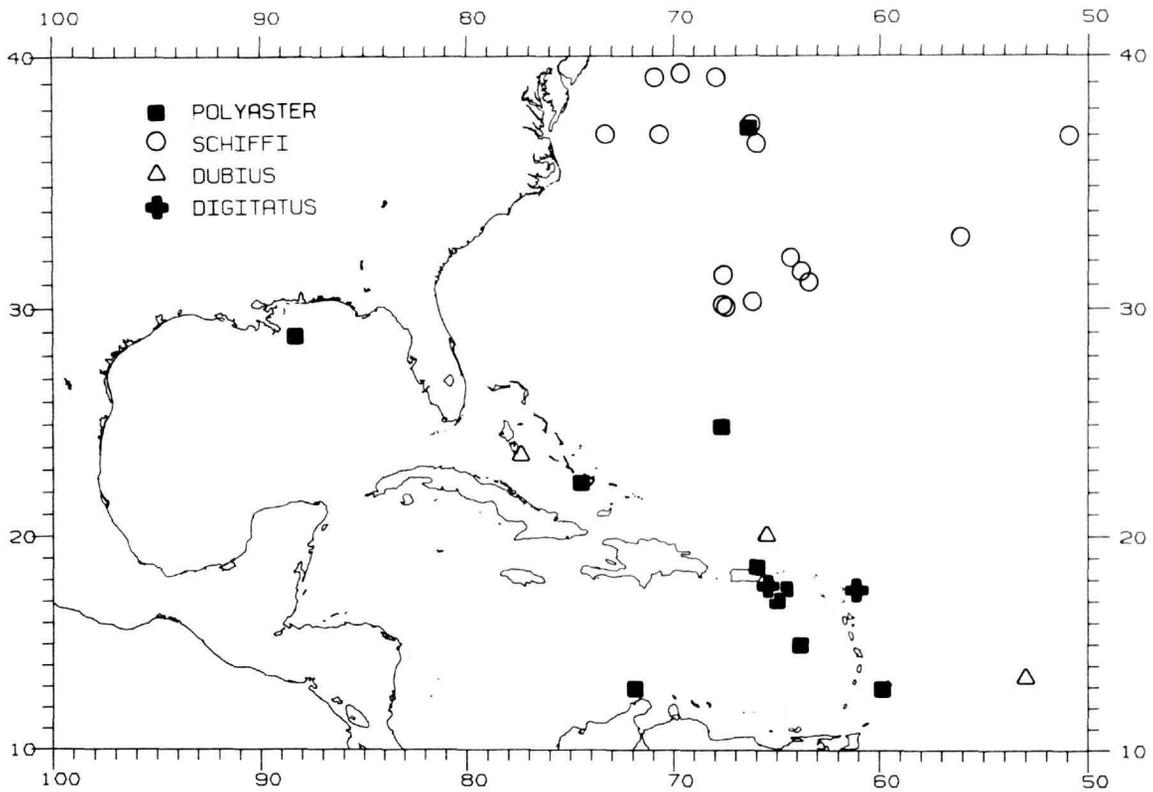


FIGURE 19.—Geographic distribution of Group II species.

***Eustomias micropterygius* Parr, 1927**

Eustomias micropterygius Parr, 1927:65–66 [holotype only; lateral view fig. 37].

The holotype (56.5 mm SL) is an incompletely metamorphosed specimen, even less developed than the other doubtful holotype, *E. globulifer*. The two pectoral rays are very short, and there is no suggestion of other, rudimentary rays. The barbel is short, only 5.3% SL, lacks pigment, and is greatly twisted and distorted. Parr's illustration appears to show a terminal bulb that is considerably longer than wide and has a slender distal projection. This is not at all certain on the specimen. It is equally possible that the end of the barbel has been broken off and the slight enlarge-

ment is not a bulb, or that the enlargement is a bulb, but the stem between it and a distal bulb has been severed.

Regan and Trewavas (1930) suggested that *micropterygius* might be a young *macrophthalmus* or an allied species, and Morrow and Gibbs (1964) concurred. Beebe and Crane (1939) thought it more likely to be a young *brevibarbatulus*. Although it is presumably a *Biradiostomias*, we cannot find grounds for associating it with any particular species.

DISTRIBUTION.—The holotype, the only known specimen, was taken in the Bahamas.

MATERIAL EXAMINED.—*Holotype*: BOC 2032 (?), 56.5), 23° 55' N, 77° 09' W, 0–~1062 m (7000 ft wire), 1 Mar 1927.

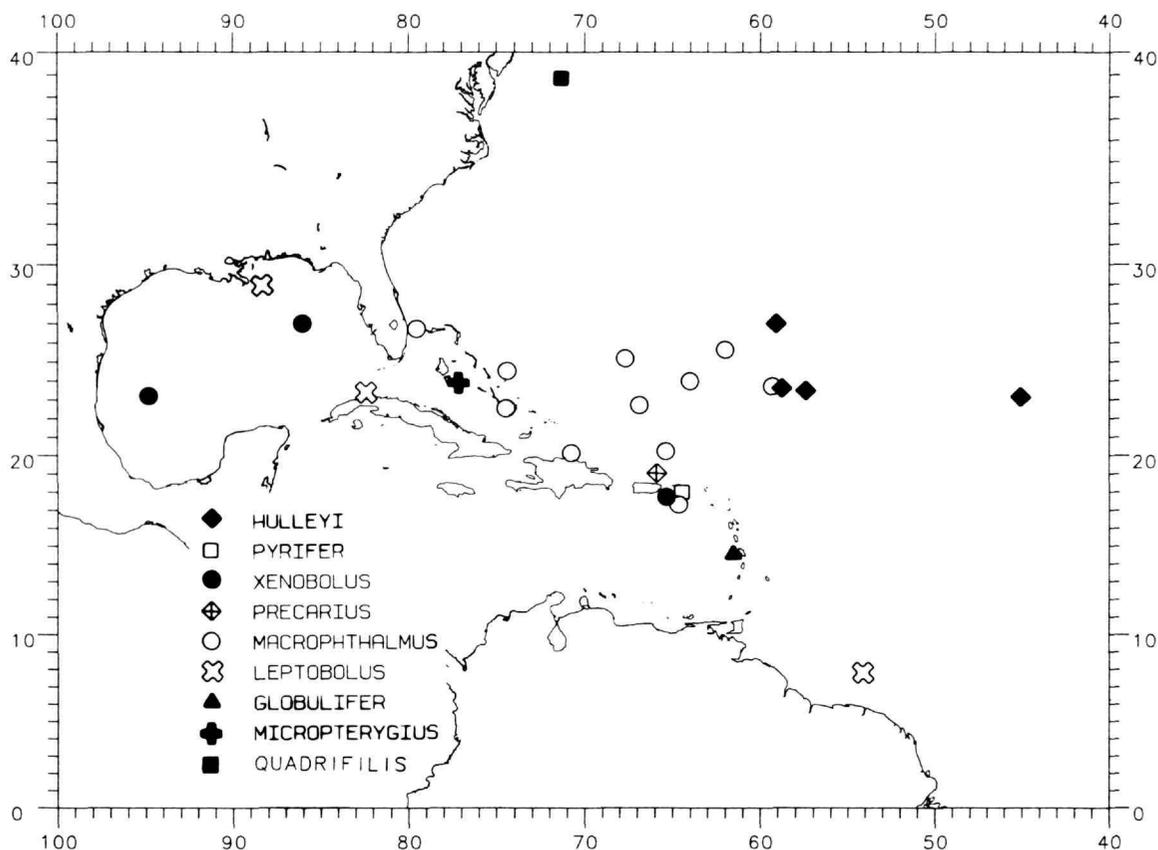


FIGURE 20.—Geographic distribution of Group III species except *ioani* and of nomina dubia *globulifer* and *micropterygius*.

Geographic Distribution

The distributions of the species of *Biradiostomias* (Figures 18–21) are remarkable in that 17 of the 18 species are found only in the Atlantic, and of those 17, all except 1 only in the western Atlantic.

Ten of the species occur mainly in the Gulf of Mexico, Caribbean Sea, and waters close to the Bahamas and Antilles. Four of the ten are known from only one or two specimens: *digitatus*, *pyrifer*, and *precarius* have been taken only in the area from north of Puerto Rico to the northern Lesser Antilles, between 18° and 20°N; *xenobolus* has been taken once in this same area and in the Gulf

of Mexico. The three specimens of *dubius*, all taken oceanward from the Antilles, indicate a range from the Bahamas to 14°N. Of the three specimens of *leptobolus*, two are from the Gulf of Mexico, the third from 9°N off Surinam. The remaining four species with Gulf-Antillean distributions are relatively well represented in collections. All four occur in the Gulf of Mexico and extend southward to various degrees, *polyaster* to 13°N, *variabilis* to 11°N, and *brevibarbatulus* to 23°S; *hypopsilus* would appear confined to the Gulf of Mexico but for a single specimen from off Surinam (possibly mislabeled?). Of these 10 Gulf-Antillean species, *polyaster* is the only one that appears to have been transported northward

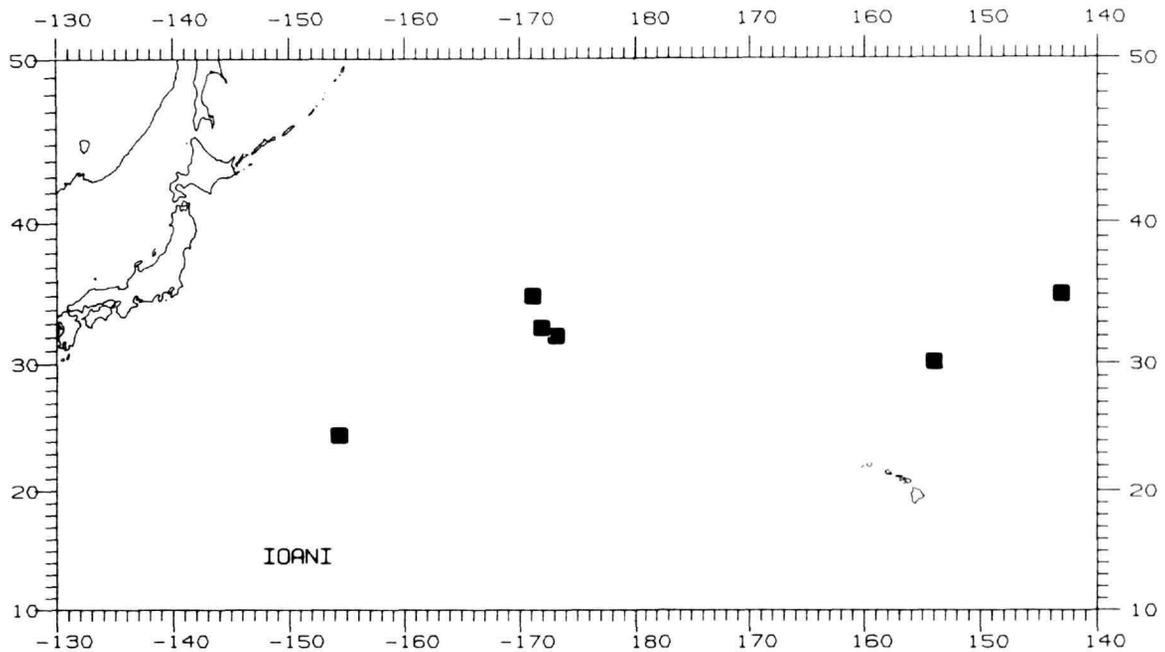


FIGURE 21.—Geographic distribution of *Eustomias ioani*.

by the Gulf Stream system far away from the Bahamas or Antilles, one specimen having been taken in the Northern Sargasso Sea. Both *polyaster* and *brevibarbatus* have been taken a short distance east of the Bahamas. On the other hand five of the species, *variabilis*, *hypopsilus*, *brevibarbatus*, *dubius*, and *leptobolus*, have been taken east and south of the southernmost Antilles at varying distances from the northeast coast of South America, in a direction opposite from the prevailing water movement. Of these, only *brevibarbatus* extends into and south of the Amazon influence.

Five species have open-ocean distributions in the North Atlantic. Three of these occur mainly between 30° and 40°N in the Northern Sargasso Sea or its eastern equivalent, *schiffi* between 50° and 70°W, *contiguus* between 18° and 75°W, and the single *quadrifilis* from a warm-core eddy

in Slope Water at 39°N, 71°W. The other two species occur mainly between 20° and 28°N in the Southern Sargasso Sea, *macrophthalmus* between 60° and 80°W, *hullei* between 45° and 60°W.

The remaining three Atlantic species are known from single collections of one or two specimens from localities that suggest open-ocean distributions in tropical or southern subtropical waters: *dispar* from 10°N (the southeastern limit of most Gulf-Antillean species), *metamelas* from 10°S, and *ignotus* from 32°S.

The only species of *Biradiostomias* in the Pacific is *ioani*, which occurs in the northern half of the northern subtropical region, and in which differences between the western and eastern individuals suggest that the two populations may be isolated to some degree.

TABLE 3.—Frequency distributions of numbers of dorsal and anal rays, VAV photophores above the anal-fin base, branchiostegal photophores, and vertebrae in species of *Biradiostomias*.

| Species | Dorsal Rays | | | | | | | | Anal Rays | | | | | | | | | |
|-----------------------|-------------|----|----|----|----|----|----|----|-----------|----|----|----|----|----|----|----|----|----|
| | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| <i>brevibarbatus</i> | 2 | 4 | 7 | 9 | 4 | | | | 1 | 1 | 4 | 3 | 12 | 3 | 1 | | | |
| <i>contiguus</i> | 1 | — | 4 | 5 | — | 3 | | | | | | | 2 | 7 | 3 | 2 | 1 | |
| <i>dispar</i> | | | 1 | | | | | | | | | | | 1 | | | | |
| <i>hypopsilus</i> | 1 | — | 5 | 8 | 10 | 1 | | | | | 2 | 4 | 2 | 4 | 9 | 1 | 1 | 1 |
| <i>ignotus</i> | | | | 1 | | | | | | | | | | 1 | | | | |
| <i>metamelas</i> | | | | 1 | 1 | | | | | | | | 1 | — | — | 1 | | |
| <i>variabilis</i> | | 3 | 8 | 7 | | | | | | | 1 | 7 | 6 | 3 | 1 | | | |
| <i>digitatus</i> | | 1 | — | — | 1 | | | | | | | | | | 1 | 1 | | |
| <i>dubius</i> | | | | | 2 | 1 | | | | | | | | | 1 | 2 | | |
| <i>polyaster</i> | | | 2 | 2 | 5 | 2 | | | | | 1 | 1 | 1 | 4 | 3 | 1 | | |
| <i>schiffi</i> | | 1 | 7 | 4 | | | | | | | | 1 | 7 | — | 3 | | | |
| <i>hullei</i> | | 1 | — | 6 | 2 | | | | | | | 1 | 4 | 1 | 2 | 1 | | |
| <i>ioani</i> | | | | 2 | 1 | 1 | | | | | | | 3 | — | 2 | | | |
| <i>leptobolus</i> | | | 1 | 1 | | | | | | | | | | 2 | 1 | | | |
| <i>macrophthalmus</i> | | | | 4 | 2 | 4 | — | 1 | | | | | 3 | 2 | 3 | 3 | 1 | |
| <i>precarius</i> | | | | 1 | | | | | | | | | | | 1 | | | |
| <i>pyrifer</i> | | | 1 | | | | | | | | | | 1 | | | | | |
| <i>quadrifilis</i> | | 1 | | | | | | | | | | 1 | | | | | | |
| <i>xenobolus</i> | | 1 | — | — | 2 | | | | | | | | | 2 | 1 | | | |
| <i>globulifer</i> | | | | | | | | | | | | | | | | | | |
| <i>micropterygius</i> | | | 1 | | | | | | | | | 1 | | | | | | |

| Species | Photophores | | | | | | | | | | | | | | | |
|-----------------------|-------------|----|----|---|----------------|----|----|----|----|----|----|----|-----------|----|----|--|
| | VAV above A | | | | Branchiostegal | | | | | | | | Vertebrae | | | |
| | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 63 | 64 | 65 | 66 | 67 | 68 | |
| <i>brevibarbatus</i> | 6 | 21 | 3 | | | 3 | 7 | 13 | 2 | 7 | 5 | 7 | 1 | | | |
| <i>contiguus</i> | | 3 | 9 | | 1 | 2 | 9 | 1 | | 1 | 8 | 1 | | | | |
| <i>dispar</i> | | | 1 | | | | 1 | | | | | | | 1 | | |
| <i>hypopsilus</i> | | 7 | 16 | | | 10 | 10 | 4 | | | 2 | 2 | 4 | | | |
| <i>ignotus</i> | | 1 | | | | | 1 | | | | | | 1 | | | |
| <i>metamelas</i> | | 2 | | | | 2 | | | | | | | 1 | 1 | | |
| <i>variabilis</i> | 1 | 13 | 6 | 1 | | 5 | 11 | 3 | | 2 | 2 | 4 | 2 | | | |
| <i>digitatus</i> | 1 | — | 1 | | | | 2 | | | | 1 | — | 1 | | | |
| <i>dubius</i> | | 1 | 1 | 1 | | | 1 | 1 | | | | | 2 | | | |
| <i>polyaster</i> | 1 | 3 | 8 | | | 2 | 6 | 2 | 1 | | | 2 | 3 | 2 | | |
| <i>schiffi</i> | | 4 | 6 | | 1 | 5 | 4 | 1 | | 1 | 3 | 5 | | | | |
| <i>hullei</i> | 1 | 6 | 2 | | | 4 | 5 | | | 1 | 1 | 2 | | | | |
| <i>ioani</i> | | 1 | 4 | | | 2 | 3 | | | | | | | 2 | 1 | |
| <i>leptobolus</i> | | | 2 | | | 2 | | | | | | 1 | 1 | 1 | | |
| <i>macrophthalmus</i> | | 1 | 4 | | | 3 | 5 | 2 | | 1 | 1 | — | 1 | | | |
| <i>precarius</i> | | 1 | | | | | | | | | | 1 | | | | |
| <i>pyrifer</i> | | 1 | | | | | | 1 | | | 1 | | | | | |
| <i>quadrifilis</i> | | 1 | | | | 1 | | | | | 1 | | | | | |
| <i>xenobolus</i> | | 1 | 1 | | | 1 | 1 | | | | | 2 | | | | |
| <i>globulifer</i> | | 1 | | | | 1 | | | | | | | | | | |
| <i>micropterygius</i> | | 1 | | | | | | 1 | | | | | | | | |

TABLE 4.—Frequency distributions of numbers of photophores in three sections of the ventral series (PV, VAV, and AC) and two sections of the lateral series (OV, VAL).

| Species | PV | | | | | | VAV | | | | | | AC | | | | | |
|-----------------------|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|----|----|
| | 31 | 32 | 33 | 34 | 35 | 36 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 15 | 16 | 17 | 18 | 19 |
| <i>brevibarbatus</i> | 1 | 1 | 9 | 11 | 3 | | | 6 | 13 | 6 | 1 | | | | 7 | 16 | 3 | |
| <i>contiguus</i> | | | 3 | 7 | 3 | | | 2 | 6 | 5 | 1 | | | 1 | 2 | 6 | 3 | |
| <i>dispar</i> | | | | | 1 | | | | | 1 | | | | | | 1 | | |
| <i>hypopsilus</i> | | 1 | 4 | 8 | 6 | 1 | | | 8 | 10 | 4 | 1 | 1 | | 5 | 11 | 9 | |
| <i>ignotus</i> | | | | 1 | | | | | | 1 | | | | | | 1 | | |
| <i>metamelas</i> | | | 1 | 1 | | | | | | 2 | | | | | | 2 | | |
| <i>variabilis</i> | 1 | 13 | 8 | 1 | | | | 1 | 7 | 11 | 5 | | | | 4 | 13 | 6 | |
| <i>digitatus</i> | | | | 1 | 1 | | 1 | — | — | 1 | | | | | | | 2 | |
| <i>dubius</i> | | | 2 | 1 | | | | | 1 | 2 | | | | | 1 | — | 1 | 1 |
| <i>polyaster</i> | | 1 | 6 | 2 | 2 | | | | 3 | 3 | 5 | | | | | 5 | 6 | |
| <i>schiffi</i> | | | 6 | 3 | 2 | | | | 5 | 5 | | | | 1 | 1 | 9 | 1 | |
| <i>hullei</i> | | 2 | 5 | 1 | | | | 1 | 3 | 2 | 2 | | | | 2 | 4 | 2 | 1 |
| <i>ioani</i> | | | | | | 2 | | | 4 | 1 | | | | | | | 4 | 1 |
| <i>leptobolus</i> | | | 1 | 1 | | | | | | 1 | — | 1 | | | | | 2 | |
| <i>macrophthalmus</i> | 2 | 4 | 2 | 1 | | | | | 4 | 3 | 2 | | | 1 | — | 2 | 5 | 2 |
| <i>precarius</i> | | 1 | | | | | | | | | 1 | | | | | | 1 | |
| <i>pyrifer</i> | | | | 1 | | | | | 1 | | | | | | | 1 | | |
| <i>quadrifilis</i> | | | 1 | | | | | | | 1 | | | | | | | 1 | |
| <i>xenobolus</i> | | | | 3 | | | | 1 | — | 2 | | | | | | 1 | 1 | |
| <i>globulifer</i> | | | 1 | | | | | | 1 | | | | | | | | | |
| <i>micropterygius</i> | 1 | | | | | | | | | 1 | | | | | | 1 | | |

| Species | OV | | | | | | | VAL | | | | | |
|-----------------------|----|----|----|----|----|----|----|-----|----|----|----|----|----|
| | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 13 | 14 | 15 | 16 | 17 | 18 |
| <i>brevibarbatus</i> | | 3 | 11 | 10 | 2 | | | | 1 | 9 | 14 | 2 | |
| <i>contiguus</i> | | 2 | 4 | 4 | 3 | | | | | 1 | 9 | 1 | 1 |
| <i>dispar</i> | | | | | 1 | | | | | | | 1 | |
| <i>hypopsilus</i> | 1 | 4 | 3 | 7 | 3 | 2 | | 1 | — | 1 | 9 | 11 | 2 |
| <i>ignotus</i> | | | | 1 | | | | | | | | 1 | |
| <i>metamelas</i> | | | | 1 | 1 | | | | | 1 | — | 1 | |
| <i>variabilis</i> | 3 | 10 | 8 | 3 | | | | | | | 7 | 14 | 2 |
| <i>digitatus</i> | | | | 1 | 1 | | | | | 1 | — | 1 | |
| <i>dubius</i> | | | | 3 | | | | | | | 1 | 2 | |
| <i>polyaster</i> | | 1 | 5 | 2 | 2 | | | | | | 1 | 6 | 3 |
| <i>schiffi</i> | | | 6 | 2 | | | | | | 1 | 7 | 2 | |
| <i>hullei</i> | | 3 | 5 | 1 | | | | | | 2 | 4 | 2 | |
| <i>ioani</i> | | | | | | 3 | 1 | | | | 2 | 2 | |
| <i>leptobolus</i> | | | 1 | | | | | | | | | 1 | |
| <i>macrophthalmus</i> | | 5 | 4 | 1 | | | | | | | 6 | 3 | |
| <i>precarius</i> | | 1 | | | | | | | | | | | 1 |
| <i>pyrifer</i> | | | | 1 | | | | | | | 1 | | |
| <i>quadrifilis</i> | | | | 1 | | | | | | | 1 | | |
| <i>xenobolus</i> | | | 1 | 1 | | | | | | | 1 | 1 | |
| <i>globulifer</i> | | 1 | | | | | | | | | | 1 | |
| <i>micropterygius</i> | | | 1 | | | | | | | | 1 | | |

TABLE 5.—Frequency distributions of numbers of photophores in the ventral series without AC (IA) and with AC (IC) and in the lateral series without (OA) and with (OC) AC.

| Species | IA | | | | | | | IC | | | | | | | | |
|-----------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 |
| <i>brevibarbatus</i> | | | 9 | 7 | 6 | 1 | | | | 2 | 9 | 4 | 5 | 2 | | |
| <i>contiguus</i> | | | 2 | 5 | 5 | 1 | | | | 2 | — | 4 | 4 | 1 | | |
| <i>dispar</i> | | | | | | 1 | | | | | | | | 1 | | |
| <i>hypopsilus</i> | | | 1 | 6 | 5 | 5 | 1 | | | | 1 | 4 | 8 | 2 | 3 | |
| <i>ignotus</i> | | | | | 1 | | | | | | | | 1 | | | |
| <i>metamelas</i> | | | | 1 | 1 | | | | | | | 1 | 1 | | | |
| <i>variabilis</i> | 1 | 2 | 12 | 6 | 2 | | | 1 | 1 | 3 | 5 | 9 | 2 | 1 | | |
| <i>digitatus</i> | | | 1 | — | 1 | | | | | | | 1 | — | 1 | | |
| <i>dubius</i> | | | | 2 | 1 | | | | | | | 1 | 1 | 1 | | |
| <i>polyaster</i> | | | 1 | — | 9 | 1 | | | | | | 1 | 5 | 4 | 1 | |
| <i>schiffi</i> | | | 2 | 5 | 2 | 1 | | | | 1 | 1 | 5 | 2 | 1 | | |
| <i>hulleyi</i> | | | 5 | 2 | 1 | | | | | 1 | 3 | 1 | 3 | | | |
| <i>ioani</i> | | | | | | 1 | | | | | | | | | 1 | |
| <i>leptobolus</i> | | | | | 1 | — | 1 | | | | | | | 1 | — | 1 |
| <i>macrophthalmus</i> | | 1 | 6 | 1 | | | | | | | 2 | 3 | 3 | | | |
| <i>precarius</i> | | | | 1 | | | | | | | | | 1 | | | |
| <i>pyrifer</i> | | | | 1 | | | | | | | | 1 | | | | |
| <i>quadrifilis</i> | | | | 1 | | | | | | | | 1 | | | | |
| <i>xenobolus</i> | | | | 1 | 2 | | | | | | | | 1 | 1 | | |
| <i>globulifer</i> | | | 1 | | | | | | | | | | | | | |
| <i>micropterygius</i> | | 1 | | | | | | | | 1 | | | | | | |

| Species | OA | | | | | | | OC | | | | | | | |
|-----------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 |
| <i>brevibarbatus</i> | 1 | 4 | 10 | 9 | | | | 3 | 4 | 8 | 7 | 1 | | | |
| <i>contiguus</i> | | 1 | 4 | 4 | 2 | | | | 3 | 1 | 5 | 2 | | | |
| <i>dispar</i> | | | | | | 1 | | | | | | | 1 | | |
| <i>hypopsilus</i> | 1 | — | 3 | 8 | 5 | 2 | 1 | | 1 | 5 | 3 | 8 | 1 | 2 | |
| <i>ignotus</i> | | | | | 1 | | | | | | | 1 | | | |
| <i>metamelas</i> | | | | 1 | 1 | | | | | | 1 | 1 | | | |
| <i>variabilis</i> | | 3 | 12 | 6 | 2 | | | 1 | 2 | 11 | 5 | 4 | | | |
| <i>digitatus</i> | | | 1 | 1 | | | | | | | 1 | 1 | | | |
| <i>dubius</i> | | | | 1 | 2 | | | | | | 1 | — | 2 | | |
| <i>polyaster</i> | | | | 4 | 5 | 1 | | | | | 1 | 7 | 1 | 1 | |
| <i>schiffi</i> | | | 6 | 2 | | | | 1 | — | 4 | 3 | | | | |
| <i>hulleyi</i> | | 3 | 4 | 1 | | | | 1 | 2 | 2 | 2 | 1 | | | |
| <i>ioani</i> | | | | | | 1 | 2 | | | | | | | 1 | 2 |
| <i>leptobolus</i> | | | | 1 | | | | | | | | 1 | | | |
| <i>macrophthalmus</i> | | 3 | 4 | 2 | | | | | | 3 | 4 | 2 | | | |
| <i>precarius</i> | | | | 1 | | | | | | | | 1 | | | |
| <i>pyrifer</i> | | | | 1 | | | | | | | 1 | | | | |
| <i>quadrifilis</i> | | | | 1 | | | | | | | 1 | | | | |
| <i>xenobolus</i> | | | 1 | — | 1 | | | | | | 1 | 1 | | | |
| <i>globulifer</i> | | | 1 | | | | | | | | | | | | |
| <i>micropterygius</i> | | | 1 | | | | | | | 1 | | | | | |

Literature Cited

- Backus, R.H., J.E. Craddock, R.L. Haedrich, and B.H. Robison
 1977. Atlantic Mesopelagic Zoogeography. In *Fishes of the Western North Atlantic. Memoirs of the Sears Foundation for Marine Research*, 1(7):266–287.
- Beebe, W.
 1932. Nineteen New Species and Four Post-larval Deep-Sea Fish. *Zoologica*, 13(4):47–107.
 1937. Preliminary List of Bermuda Deep-Sea Fish. *Zoologica*, 22(3):197–208.
- Beebe, W., and J. Crane
 1939. Deep-Sea Fishes of the Bermuda Oceanographic Expeditions: Family Melanostomiidae. *Zoologica*, 24(2):65–238.
- Bekker, V.E., Y.N. Shcherbachev, and V.M. Tchuvasov
 1975. [Deep-Sea Pelagic Fishes of the Caribbean Sea, Gulf of Mexico, and the Region of the Puerto-Rico Trench.] *Trudy Instituta Okeanologii im. P.P. Shirshova*, 100:289–336. [In Russian.]
- Bertin, L.
 1940. Revision des Stomiiformes Téléostéens Isospondyles du Muséum. *Bulletin du Muséum National d'Histoire Naturelle*, 2^e Série, 9(4):378–382.
- Gibbs, R.H., Jr.
 1971. Notes on Fishes of the Genus *Eustomias* (Stomiatoidei, Melanostomiidae) in Bermuda Waters, with the Description of a New Species. *Proceedings of the Biological Society of Washington*, 84(29):235–244.
- Gibbs, R.H., Jr., T.A. Clarke, and J.R. Gomon
 1983. Taxonomy and Distribution of the Stomioid Fish Genus *Eustomias* (Melanostomiidae), I: Subgenus *Nominostomias*. *Smithsonian Contributions to Zoology*, 380:i–iv, 1–139
- Mead, G.W.
 1958. A Catalog of the Type Specimens of Fishes Formerly in the Collections of the Department of Tropical Research, New York Zoological Society. *Zoologica*, 43(4):131–134.
- Morrow, J.E., Jr., and R.H. Gibbs, Jr.
 1964. Family Melanostomiidae. In *Fishes of the Western North Atlantic. Memoirs of the Sears Foundation for Marine Research*, 1(4):351–511.
- Nielsen, J.G.
 1974. *Fish Types in the Zoological Museum of Copenhagen*. 115 pages. Copenhagen: Zoological Museum, University of Copenhagen.
- Parin, N.V., and G.N. Pokhilskaya
 1974. [A Review of the Indo-Pacific Species of the Genus *Eustomias* (Melanostomiidae, Osteichthyes).] *Trudy Instituta Okeanologii im. P.P. Shirshova*, 96:316–368. [In Russian.]
- Parin, N.V., and A.S. Sokolovsky
 1976. [Species Composition of the Family Melanostomiidae in the Kuroshio Current Zone.] *Trudy Instituta Okeanologii im. P.P. Shirshova*, 104:237–249. [In Russian.]
- Parr, A.E.
 1927. The Stomioid Fishes of the Suborder Gymnophotodermi (Astronesthidae, Melanostomiidae, Idiacanthidae) with a Complete Review of the Species. *Bulletin of the Bingham Oceanographic Collection*, 3(2):1–123.
- Rass, T.S.
 1971. Deep-Sea Fish in the Caribbean Sea and the Gulf of Mexico (the American Mediterranean Region). In *Symposium on Investigations and Resources of the Caribbean Sea and Adjacent Regions* (Paris, UNESCO), pages 509–526.
- Regan, C.T., and E. Trewavas
 1930. The Fishes of the Families Stomiidae and Malacosteidae. In *Oceanographical Reports, Danish "Dana" Expeditions, 1920–1922*, 6:1–143.

REQUIREMENTS FOR SMITHSONIAN SERIES PUBLICATION

Manuscripts intended for series publication receive substantive review within their originating Smithsonian museums or offices and are submitted to the Smithsonian Institution Press with Form SI-36, which must show the approval of the appropriate authority designated by the sponsoring organizational unit. Requests for special treatment—use of color, foldouts, case-bound covers, etc.—require, on the same form, the added approval of the sponsoring authority.

Review of manuscripts and art by the Press for requirements of series format and style, completeness and clarity of copy, and arrangement of all material, as outlined below, will govern, within the judgment of the Press, acceptance or rejection of manuscripts and art.

Copy must be prepared on typewriter or word processor, double-spaced, on one side of standard white bond paper (not erasable), with 1¼" margins, submitted as ribbon copy (not carbon or xerox), in loose sheets (not stapled or bound), and accompanied by original art. Minimum acceptable length is 30 pages.

Front matter (preceding the text) should include: **title page** with only title and author and no other information; **abstract** page with author, title, series, etc., following the established format; table of **contents** with indents reflecting the hierarchy of heads in the paper; also, **foreword** and/or **preface**, if appropriate.

First page of text should carry the title and author at the top of the page; **second page** should have only the author's name and professional mailing address, to be used as an unnumbered footnote on the first page of printed text.

Center heads of whatever level should be typed with initial caps of major words, with extra space above and below the head, but with no other preparation (such as all caps or underline, except for the underline necessary for generic and specific epithets). Run-in paragraph heads should use period/dashes or colons as necessary.

Tabulations within text (lists of data, often in parallel columns) can be typed on the text page where they occur, but they should not contain rules or numbered table captions.

Formal tables (numbered, with captions, boxheads, stubs, rules) should be submitted as carefully typed, double-spaced copy separate from the text; they will be typeset unless otherwise requested. If camera-copy use is anticipated, do not draw rules on manuscript copy.

Taxonomic keys in natural history papers should use the aligned-couplet form for zoology and may use the multi-level indent form for botany. If cross referencing is required between key and text, do not include page references within the key, but number the keyed-out taxa, using the same numbers with their corresponding heads in the text.

Synonymy in zoology must use the short form (taxon, author, year:page), with full reference at the end of the paper under "Literature Cited." For botany, the long form (taxon, author, abbreviated journal or book title, volume, page, year, with no reference in "Literature Cited") is optional.

Text-reference system (author, year:page used within the text, with full citation in "Literature Cited" at the end of the text) must be used in place of bibliographic footnotes in all Contributions Series and is strongly recommended in the Studies Series: "(Jones, 1910:122)" or "... Jones (1910:122)." If bibliographic footnotes are required, use the short form (author,

brief title, page) with the full citation in the bibliography.

Footnotes, when few in number, whether annotative or bibliographic, should be typed on separate sheets and inserted immediately after the text pages on which the references occur. Extensive notes must be gathered together and placed at the end of the text in a notes section.

Bibliography, depending upon use, is termed "Literature Cited," "References," or "Bibliography." Spell out titles of books, articles, journals, and monographic series. For book and article titles use sentence-style capitalization according to the rules of the language employed (exception: capitalize all major words in English). For journal and series titles, capitalize the initial word and all subsequent words except articles, conjunctions, and prepositions. Transliterate languages that use a non-Roman alphabet according to the Library of Congress system. Underline (for italics) titles of journals and series and titles of books that are not part of a series. Use the parentheses/colon system for volume(number):page: "10(2):5-9." For alignment and arrangement of elements, follow the format of recent publications in the series for which the manuscript is intended. Guidelines for preparing bibliography may be secured from Series Section, SI Press.

Legends for illustrations must be submitted at the end of the manuscript, with as many legends typed, double-spaced, to a page as convenient.

Illustrations must be submitted as original art (not copies) accompanying, but separate from, the manuscript. Guidelines for preparing art may be secured from Series Section, SI Press. All types of illustrations (photographs, line drawings, maps, etc.) may be intermixed throughout the printed text. They should be termed **Figures** and should be numbered consecutively as they will appear in the monograph. If several illustrations are treated as components of a single composite figure, they should be designated by lowercase italic letters on the illustration; also, in the legend and in text references the italic letters (underlined in copy) should be used: "Figure 9b." Illustrations that are intended to follow the printed text may be termed **Plates**, and any components should be similarly lettered and referenced: "Plate 9b." Keys to any symbols within an illustration should appear on the art rather than in the legend.

Some points of style: Do not use periods after such abbreviations as "mm, ft, USNM, NNE." Spell out numbers "one" through "nine" in expository text, but use digits in all other cases if possible. Use of the metric system of measurement is preferable; where use of the English system is unavoidable, supply metric equivalents in parentheses. Use the decimal system for precise measurements and relationships, common fractions for approximations. Use day/month/year sequence for dates: "9 April 1976." For months in tabular listings or data sections, use three-letter abbreviations with no periods: "Jan, Mar, Jun," etc. Omit space between initials of a personal name: "J.B. Jones."

Arrange and paginate sequentially every sheet of manuscript in the following order: (1) title page, (2) abstract, (3) contents, (4) foreword and/or preface, (5) text, (6) appendixes, (7) notes section, (8) glossary, (9) bibliography, (10) legends, (11) tables. Index copy may be submitted at page proof stage, but plans for an index should be indicated when manuscript is submitted.

