

Review of the western Atlantic species of *Bollmannia* (Teleostei: Gobiidae: Gobiosomatini) with the description of a new allied genus and species

James L. Van Tassell^{1*}, Luke Tornabene², Patrick L. Colin³

1) American Museum of Natural History, Central Park West at 79th Street, New York, NY 10024-5192, U.S.A. *Corresponding author: jvantassell@gobiidae.com

2) Texas A&M University – Corpus Christi, 6300 Ocean Drive, Corpus Christi, TX 78412, U.S.A.

3) Coral Reef Research Foundation P.O. Box 1765 Koror, Palau 96940

Received: 20 May 2011 – Accepted: 30 September 2011

Abstract

Bollmannia Jordan is a poorly studied group of American seven-spined gobies with representatives in the tropical and subtropical western Atlantic and tropical eastern Pacific oceans. We review the taxonomy of the western Atlantic species and provide redescrptions for the four valid species: *B. boqueronensis*, *B. communis*, *B. eigenmanni* and *B. litura*. *Bollmannia jeannae* is considered to be a junior synonym of *B. boqueronensis*. We also describe a new genus and species of deep-water goby and discuss its affinities to *Bollmannia* and other genera of the *Microgobius* group of the Gobiosomatini. An identification key is provided for all western Atlantic members of the *Microgobius* group. Results of this study highlight the need for a combined morphological and molecular phylogenetic analysis to resolve the relationships among the genera of the *Microgobius* group.

Zusammenfassung

Bollmannia Jordan ist eine kaum erforschte Gruppe amerikanischer Grundeln mit sieben Stacheln mit Vertretern im tropischen und subtropischen Westatlantik und im tropischen Ostpazifik. Wir überprüfen hier die Systematik der westatlantischen Arten und geben Neubeschreibungen der vier gültigen Arten: *B. boqueronensis*, *B. communis*, *B. eigenmanni* und *B. litura*. *Bollmannia jeannae* wird als jüngeres Synonym zu *B. boqueronensis* aufgefasst. Wir beschreiben außerdem eine neue Gattung und Art der Tiefwasser-Grundeln und diskutieren ihre verwandtschaftlichen Bezüge zu *Bollmannia* und anderen Gattungen der *Microgobius*-Gruppe der Gobiosomatini. Schließlich wird ein Bestimmungsschlüssel für alle westatlantischen Angehörigen der *Microgobius*-Gruppe wiedergegeben. Das Ergebnis der vorliegenden Untersuchung unterstreicht die Notwendigkeit einer kombinierten morphologischen und molekularbiologischen phylogenetischen Analyse, um die Verwandtschaftsbeziehungen zwischen den Gattungen der *Microgobius*-Gruppe zu klären.

Résumé

Bollmannia Jordan est un groupe peu étudié de gobies américains à sept épines avec des représentants dans l'Atlantique ouest tropical et subtropical et dans le Pacifique est tropical. Nous faisons une révision de espèces de l'Atlantique ouest et donnons la redescription des quatre espèces reconnues : *B. boqueronensis*, *B. communis*, *B. eigenmanni* et *B. litura*. *Bollmannia jeannae* est considéré comme un synonyme plus récent de *B. boqueronensis*. Nous décrivons aussi un nouveau genre et une nouvelle espèce de gobie des eaux profondes et en discutons les affinités avec *Bollmannia* et d'autres genres du groupe des *Microgobius* appartenant aux Gobiosomatini. Une clé de détermination est fournie pour tous les membres de l'Atlantique ouest du groupe des *Microgobius*. Les résultats de cette étude mettent en évidence la nécessité d'une analyse phylogénétique combinée, à la fois morphologique et moléculaire, pour tirer au clair les relations à l'intérieur des genres du groupe *Microgobius*.

Sommario

Il genere *Bollmannia* Jordan comprende un gruppo di ghiozzi a sette spine poco studiati che abitano le aree tropicali e subtropicali dell'Atlantico occidentale e quelle tropicali del Pacifico orientale. Si presenta una revisione della tassonomia delle specie atlantiche accompagnata da una nuova descrizione di quattro specie valide: *B. boqueronensis*, *B. communis*, *B. eigenmanni* e *B. litura*. *Bollmannia jeannae* è da considerarsi sinonimo di *B. boqueronensis*. Inoltre, viene descritto un nuovo genere e una nuova specie di ghiozzo di acque profonde discutendone le affinità con *Bollmannia* e altri generi del gruppo *Microgobius* della tribù Gobiosomatini. Per tutti i membri del gruppo *Microgobius* dell'Atlantico occidentale è fornita una chiave dicotomica. I risultati di questo studio sottolineano la necessità di un'analisi filogenetica combinata con dati morfologici e molecolari per risolvere le relazioni di parentela tra i generi del gruppo *Microgobius*.

INTRODUCTION

Bollmannia Jordan, 1890, is one of five genera that make up the *Microgobius* group of the tribe Gobiosomatini (Birdsong et al. 1988; Van Tassell & Baldwin 2004). The Gobiosomatini is a monophyletic group within the subfamily Gobiinae (sensu Pezold 1993; Thacker 2003; Thacker & Hardman 2005) and the tribe is often referred to as the American seven-spined gobies. *Bollmannia* currently comprises 14 nominal species, five of which were described from the Atlantic Ocean: *Bollmannia eigenmanni* (Garman, 1896), *B. boqueronensis* Evermann & Marsh, 1899, *B. jeannae* Fowler, 1941, *B. communis* Ginsburg, 1942, and *B. litura* Ginsburg, 1935. While attempting to identify specimens of *Bollmannia* collected from Panama in 2004, several problems were noted in the descriptions of the Atlantic species. The characters described for each of the species are not uniform across each of the descriptions. Several of the characters described as diagnostic are of little value as these characters are commonly destroyed when *Bollmannia* are trawled or dredged from considerable depths. In most cases the descriptions are based on a small number of specimens and do not adequately summarize the intraspecific variation seen among populations. Furthermore, there is a discrepancy between the description of *B. litura* and the corresponding holotype. As a result of these issues, the validity of several species is questioned. *Bollmannia jeannae* is not listed by Nelson et al. (2004), McEachern & Feckhelm (2005) or Murdy & Hoese (2002). Both *B. jeannae* and *B. eigenmanni* are omitted by Smith (1997). Eschmeyer (2011) lists all five nominal species as valid. This paper attempts to clarify these discrepancies and resolve the status of the Atlantic members of the genus.

No formal review of western Atlantic *Bollmannia* has been published to this point. In an unpublished master's thesis, Bedenbough (1988) reviewed the Pacific members of the genus. Ginsburg addressed the genus in two incomplete, unpublished manuscripts, the drafts and notes of which have been found at the Smithsonian Institution's National Museum of Natural History. Work on these manuscripts likely began between 1939 and 1942, as some of his notes included the eastern Pacific *Bollmannia* species described in Ginsburg (1939) but not *B. communis*, which he described in 1942. Subsequent drafts by Ginsburg contained *B. communis* and additional specimens of each of the species discussed in prior drafts. In

his unpublished works Ginsburg described and illustrated sensory papillae and head pore patterns for several species of *Bollmannia*. We describe these characters for each of the valid species in the western Atlantic.

In addition to the five nominal species of western Atlantic *Bollmannia*, we also address a previously undescribed deepwater goby from the Caribbean. This species was originally documented as the "filamentous goby" by Colin (1974) and subsequently referenced by Dennis et al. (2004), where it was referred to as the "sabre goby". The molecular phylogenies of Rüber et al. (2003) and Rüber & Van Tassell (unpublished, presented in 2006) suggested that this species belongs within the monophyletic *Microgobius* group of the tribe Gobiosomatini, specifically as the sister group to a monophyletic clade containing four species of *Bollmannia*. Despite the apparent close relationship between this species and *Bollmannia*, there are several prominent differences between the two in terms of morphology and habitat. Therefore, we describe this species and place it in a new genus, *Antilligobius*, within the *Microgobius* group of the Gobiosomatini. The affinities between *Antilligobius* n. gen. and the allied genera *Bollmannia*, *Akko*, *Parrella*, *Palatogobius* and *Microgobius* are discussed. Identification keys are provided for the Atlantic species of the *Microgobius* group of the Gobiosomatini.

METHODS

Methods for counts and measurements follow Böhlke & Robins (1968) in most regards. The last two elements in the second dorsal and anal fin stem from a single pterygiophore and are counted as a single ray. The upper and lower segmented caudal rays are frequently short with only one or two striae but are stouter than adjacent procurrent rays and are included in the counts of segmented caudal rays. Counts of branched caudal rays include rays with only slight terminal branching. Lateral scale counts are the number of diagonal rows beginning with the scale above and behind the posterodorsal corner of the operculum and ending at the posterior edge of the hypural plate. Transverse scale counts are the number of horizontal scale rows counted from the origin of the second dorsal fin diagonally to the origin of the anal fin. Caudal peduncle scales are counted beginning at the first full sized scale on top of the caudal peduncle immediately in front of the caudal fin, and following the scale rows down and forward to

the ventral edge of the peduncle, then around and back to the original scale. Gill raker counts are total counts for the outer edge of the first gill arch.

The following measurements are straight-line point to point measurements taken with digital calipers: standard length, snout tip to posterior edge of hypural plate; head length, snout tip to posterior edge of operculum, not including fleshy membrane; predorsal length, distance from the insertion point of the first dorsal spine to the tip of the snout; snout length, snout tip to the anterior rim of eye; upper jaw length, anterior tip of upper jaw to posterior margin of maxillary; eye diameter, horizontal diameter of orbit; pupil diameter, horizontal diameter of pupil; postorbital length, posterior rim of eye to posterior edge of operculum, not including fleshy membrane; body depth at first dorsal fin origin, vertical distance from origin of spinous dorsal fin to ventral profile, not including pelvic fin; least caudal peduncle depth, vertical distance at shallowest point between base of last anal ray to posterior edge of hypural plate; and caudal fin length, distance from origin of ray on hypural plate to tip of longest ray.

Dorsal pterygiophore formula is that of Birdsong et al. (1988), patterns of sensory papillae are described according to Sanzo (1911) and cephalic canal pore terminology follows Akihito et al. (1988). In some cases papillae and pore patterns were more easily observed by staining with cyanine blue (Saruwatari et al. 2006). Osteological observations were made from radiographs and specimens cleared with trypsin and counter stained for cartilage and bone (Dingerkus & Uhler 1977). Institutional acronyms follow Sabaj Pérez (2010).

In many cases scale counts of *Bollmannia* were determined by counting scale pockets or remnants thereof, as scales in this genus are highly deciduous and specimens are typically in poor condition as a result of collection via trawl or dredge. In many other specimens, including some holotypes, scale pockets were missing entirely. For this reason, the scale count ranges presented here are trends from a composite of specimens and should be regarded as approximations. Similarly, the fins are heavily damaged on most specimens of *Bollmannia*. The relative lengths of rays and spines described here should also be regarded as approximations. Papillae and pore patterns shown here are composite drawings from several specimens. In nearly every specimen of *Bollmannia*, portions of the lateralis canals are destroyed and in many cases entire rows of

papillae are missing as a result of damage or poor preservation. In particular, the predorsal region, the posterior half of the preoperculum and the operculum are typically more heavily damaged than other regions. Thus the absence of extensive papillae or cephalic canals in these regions (specifically the canal between K' and L') on our illustrations may be subject to correction if specimens are examined in which papillae and canals are more perfectly preserved. Despite these issues there is some taxonomic value in the aforementioned characters. However, this value, and consequently the ability to confidently identify specimens of *Bollmannia*, is largely determined by the overall physical condition of the specimen.

SYSTEMATICS

Antilligobius n. gen.

Van Tassell & Tornabene

Diagnosis: *Antilligobius* can be distinguished from other Gobiosomatini by the following combination of characters, not listed in order of taxonomic importance: first dorsal fin very elongate in both sexes, extending posteriorly at least to base of last anal fin ray when depressed, sometimes reaching middle of caudal fin; caudal fin elongate but with upper rays 3,4,5 shorter than corresponding lower rays, forming notch in upper margin of fin; pelvic fins united to form disk with well-developed frenum, frenum with smooth posterior margin, not supported with collagenous thickenings; trunk scales ctenoid, lateral scale rows 21-28; predorsal region, cheek, pectoral fin base and breast with cycloid scales; predorsal scales 8-10; first caudal vertebra with expanded haemal arch and tiny haemal spine; haemal arch with elongate parapophyses, "rib-like" in appearance in lateral view; abdominal cavity elongated and extending through first haemal arch.

Description: Body slightly elongate and laterally compressed; first dorsal spines VII; pterygiophore formula of first dorsal fin 3(221110); second dorsal fin I,11-12; first and second dorsal fins separate from each other and from caudal fin; pectoral rays 18-21; anal fin I,11-13, first two anal pterygiophores inserted anterior to first haemal spine, remaining pterygiophores in approximately 1:1 ratio with caudal vertebrae; total vertebrae 27, 11 precaudal and 16 caudal; pelvic fins with one spine and five rays; vomerine teeth absent; mouth large, 10.0-11.2% SL and inclined 30° from horizontal;

eye large, diameter 10.2-12.0% SL; gill opening extending from upper edge of pectoral fin to ventral body midline; gill rakers on lower limb of first arch thin and elongate, rakers on upper arm short, stubby; urogenital papilla thin and conical in males, thick and bulbous in females; cephalic lateralis canal and pore system on head well-developed; sensory papillae in transverse pattern; ventral post-cleithrum present; no obvious sexual dimorphism, except for urogenital papilla.

Comparison: *Antilligobius* has a number of characters not present in other American seven-spined genera that warrant its placement in a new genus. These include: a very narrow, splinter-like metapterygoid; short slender gill rakers on the lower limb of the first arch; a short papillae row *b*, never extending to posterior of the pupil; a modified first haemal arch; the caudal fin elongate but with the upper rays 3,4,5 shorter than the corresponding rays on the ventral half of the fin, forming a notch in the upper margin of the fin.

Antilligobius is most similar morphologically to *Bollmannia* and *Parrella*, sharing with those genera the presence of scales on the breast, belly, pectoral fin base and predominately ctenoid scales on the trunk. *Bollmannia* and *Antilligobius* also both possess scales on the cheek and a spatulate basihyal. The bright yellow stripe and blue colors of *Antilligobius* easily distinguish it from *Bollmannia* and *Parrella* which are drab brown with darker brown markings.

Etymology: The generic epithet *Antilligobius* is formed from the Dutch “Antillen,” which refers to the region now known as the Antilles or Caribbean Sea, and the Latin *gobius* meaning small fish or gudgeon. To be treated as masculine. The name is given in reference to its distribution within the ancient “Sea of the Antilles”.

***Antilligobius nikkiae*, n. sp.**

Van Tassell & Colin

Sabre goby (Figs 1-2, 4-11)



Fig. 1A-B. A. *Antilligobius nikkiae*, holotype, 30.2 mm SL, female, Curaçao, AMNH 253403, preserved; B. *Antilligobius nikkiae*, paratype, 23.19 mm SL, male, Curaçao, AMNH 233129. Photos by J. Van Tassell. Image editing by L. Tornabene.

Table I. Morphometrics for type specimens of *Antilligobius nikkiae* (excluding cleared and stained specimen). Measurements other than SL are in % SL.

	AMNH 253403 (holotype)	AMNH 233129 (paratype)	AMNH 253404 (paratype)	AMNH 253404 (paratype)	AMNH 253404 (paratype)	ANSP 150387 (paratype)	ANSP 150387 (paratype)	USNM 402717 (paratype)
Sex	female	female	male	male	female	male	female	female
SL (mm)	30.2	23.0	26.7	25.8	26.7	21.7	25.7	31.6
Eye diameter	10.6	10.6	10.7	10.2	12.0	10.6	10.5	10.4
Upper jaw length	10.6	10.0	11.2	10.8	11.2	10.1	10.5	10.7
Head length	24.5	25.7	27.3	25.9	33.3	30.0	26.8	30.3
Postorbital length	11.9	10.9	12.0	11.2	14.6	13.4	13.6	14.8
Depth at DI origin	19.5	18.3	21.0	21.5	18.4	17.1	17.9	18.3
Least caudal peduncle depth	10.7	10.2	11.2	11.2	10.5	10.6	10.1	11.7
Snout length	6.3	5.7	6.0	6.2	6.7	5.5	4.7	5.3

Holotype: AMNH 253403, 30.2 mm SL, female, Curaçao Sea Aquarium slope, Curaçao, 12.08715°N, 68.896576°W, quinaldine collection, collected by Adriaan “Dutch” Schrier, July 2004, depth 90 m, loose rock slope (Fig. 3).

Paratypes: AMNH 253404, 2 males, 25.8-26.7 mm SL, 1 female, 26.7 mm SL, collected with holotype; ANSP 147645, 29.7 mm SL, female, cleared and stained specimen, shelf edge of reef at La Parguera, Puerto Rico, 28 August 1979, Pat Colin; ANSP 150387, 1 male 21.7 mm SL, 1 female 25.7 mm SL, shelf edge of reef at La Paruera, 17.949005°N, 67.045345°W, 87-90 m, 45° slope, collected among small indentations in rocky structure of slope face, Puerto Rico, 22 November 1978, Pat Colin; AMNH 233129, 1 male, 23.19 mm SL, 90 m, JVT-01-012, Genbank AF491066, Curaçao Sea Aquarium slope, 12.08715°N, 68.896576°W, Curaçao, January 2001, Adriaan “Dutch” Schrier; USNM 402717, 1 female, 31.6 mm SL, 168-198 m, west coast of Isla de la Juventud, 21.78405°N, 83.23625°W, Cuba, 27 December 1997, R. Grant Gilmore.

Description: Morphometric data given in Table I. Counts of the holotype (Fig. 1) indicated by an asterisk, followed by number of specimens with each count in parentheses.

Median and paired fins: first dorsal VII*(9); first four dorsal spines very elongate, extending to base of last anal ray when depressed, extending to middle of caudal fin in some specimens; second dorsal I,11(4), I,12*(5); anal fin I,11(1), I,12*(1), I,13(7); pectoral rays 18(2), 20*(6), 21(1); pectoral fin elongate, reaching vertical through anterior end of anus; caudal fin elongate but with upper rays 3,4,5 shorter than corresponding lower rays, forming notch in upper margin of fin; segmented caudal rays 16(3), 17*(6), branched rays 14*(6), 15(3); pelvic fin I,5*(9); pelvic fins united to form disk, disk extending 2/3 to 3/4 distance from insertion of spine to anterior of anus; anterior margin of frenum extending halfway along pelvic spine, posterior margin of frenum smooth, without fimbriae and lacking collagenous thickenings.

Scales: body completely covered with ctenoid



Fig. 2. *Antilligobius nikkiae* in natural habitat, south-west Puerto Rico, approximately 90 m. Photos by P. Colin.

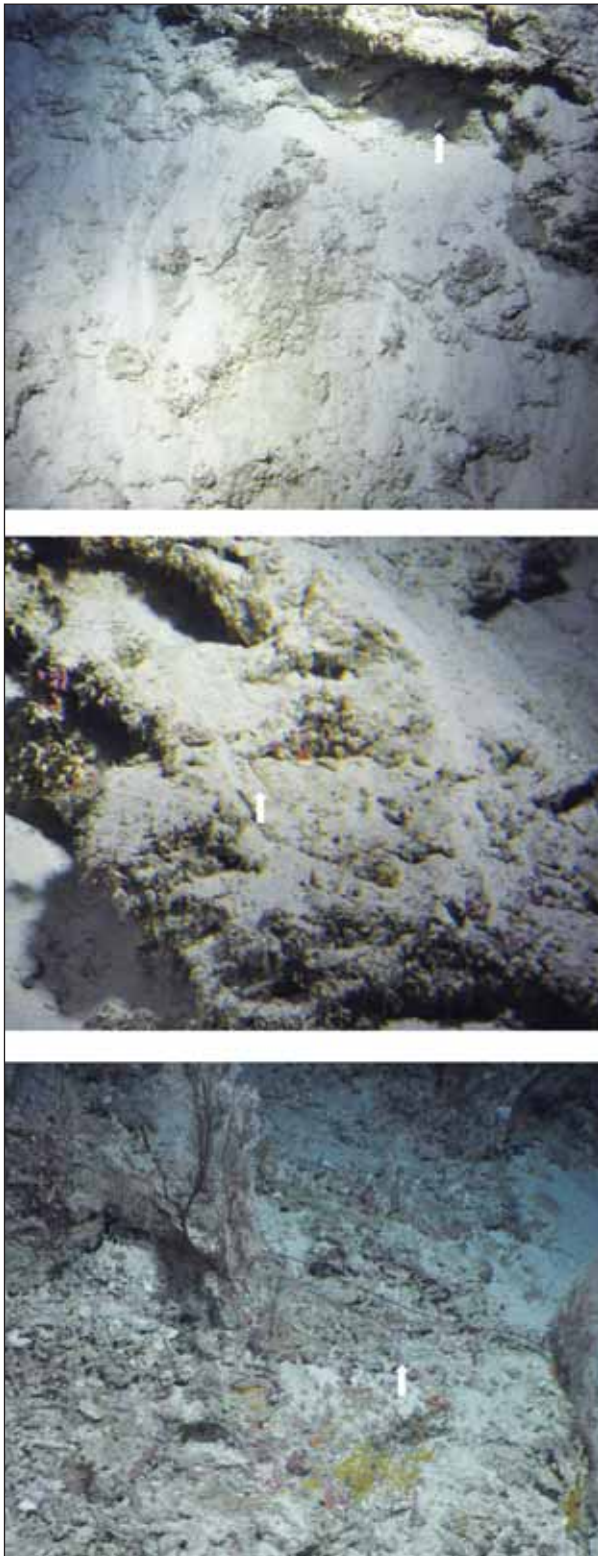


Fig. 3. Habitat at the type locality of *Antilligobius nikkiae*, Curaçao Sea Aquarium slope, approximately 90 m. Arrows indicate individual gobies. Photos by A. Schrier and C. Baldwin.

scales, ctenii becoming larger posteriorly; predorsal region, cheek, operculum, pectoral fin base and pelvic fin base with cycloid scales; lateral scale rows 21(1), 25(4), 26*(2), 28(1); transverse scale rows 6(2), 7*(4); predorsal scales 7(1), 8(4), 9(1), 10*(2), scales extending anteriorly to behind eye; caudal peduncle scales 9(1), 10(3), 11*(2), 12(1); scales on cheek 3(4), 4*(2), 5(2); operculum scales 0*(4), 3(4); no modified basicaudal scales present.

Head: head length 24.5-33.3% SL; mouth angled upwards 30° from horizontal, reaching posteriorly to vertical through pupil; upper jaw length 10-11.2% SL; teeth in upper jaw in 2-3 rows anteriorly, becoming two rows about midway along premaxilla, ending in single row at posterior end of premaxilla; all teeth conical with slightly recurved tips; teeth in outer row longest; teeth in lower jaw in two rows anteriorly, becoming single row about half way along dentary; teeth conical with slightly recurved tips; single recurved canine located at mid-dentary; tongue slightly emarginate; eye large, 10.2-12.0% SL; interorbital width approximately equal to pupil diameter; snout short, 4.7-6.7% SL;

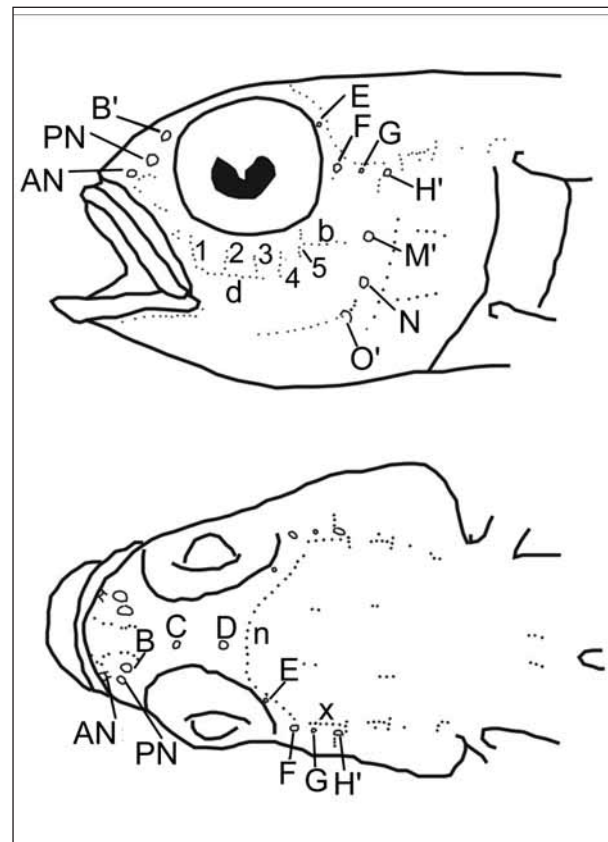


Fig. 4. Sensory papillae and head canal pores of *Antilligobius nikkiae*. Drawing by J. Van Tassell.

gill opening extending from upper edge of pectoral fin to ventral midline; gill rakers on lower arm of first arch 12-13, upper arm 5; gill rakers on lower arm of first arch thin and elongate, rakers on subsequent arches shorter and thicker; epibranchials present; anterior nostril a short erect tube; posterior nostril with raised rim along anterior edge; no barbels present.

Genitalia: papilla elongate and conical in males, with distinct line of melanophores along dorsal edge present in one specimen, all others with no pigment; papilla short, bulbous, and without melanophores in females.

Sensory papillae and head pores (Fig. 4): oculoscapular pores B', C(s), D(s), E, F, G, H' present; posterior canal (typically between pores K' and L') absent; preopercular pores M', N, O' present; single interorbital canal; papillae in transverse pattern, with 5 short vertical rows below eye, none extending below level of row *d*; row *d* long, beginning below anterior margin of eye, ending before transverse row 4; row *b* short, beginning below eye and posterior to 5th transverse row, ending well short of posterior margin of preopercle; row *n* continuous across dorsal midline; rows *g* and *m* reduced, each represented by 2-3 papillae on each side of dorsal midline.

Pigment: body translucent pearly in life, tan in preservation; body with bright yellow stripe (white after preservation) along lateral midline beginning at eye and extending onto caudal fin; width of stripe about $\frac{3}{4}$ of eye diameter at widest

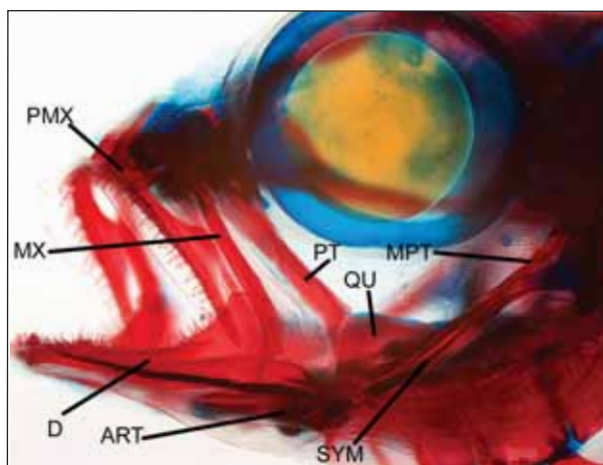


Fig. 5. Suspensorium and jaw osteology of *Antilligobius nikkiae*. Abbreviations - ART, anguloarticular; D, dentary; MPT, metapterygoid; MX, maxilla; PMX, premaxilla; PT, ectopterygoid; QU, quadrate; SYM, symplectic; Photo by J. Van Tassell, editing by L. Tornabene.

point, becoming thinner on caudal fin, ending at or near tip of caudal fin; thin iridescent blue stripe along ventral surface of yellow stripe anteriorly, absent in preservation; dorsal midline of body with narrow iridescent blue stripe, absent in preservation; abdomen and gular regions more or less pale; lateral edge of upper and lower jaw reddish-orange; iris of eye iridescent blue along dorsal and ventral margins, with iridescent patches of yellow at the anterior and posterior margins, iris uniformly dark in preservative; first dorsal fin translucent and tinged with yellow on interspinal membranes, uniformly clear in preservation; membranes between spines 4-6 of first dorsal fin with diffuse dark streak, streak more prominent in preservation; second dorsal fin yellow at base, translucent distally, uniformly clear with dusky distal margin in preservation; anal fin translucent with scattered

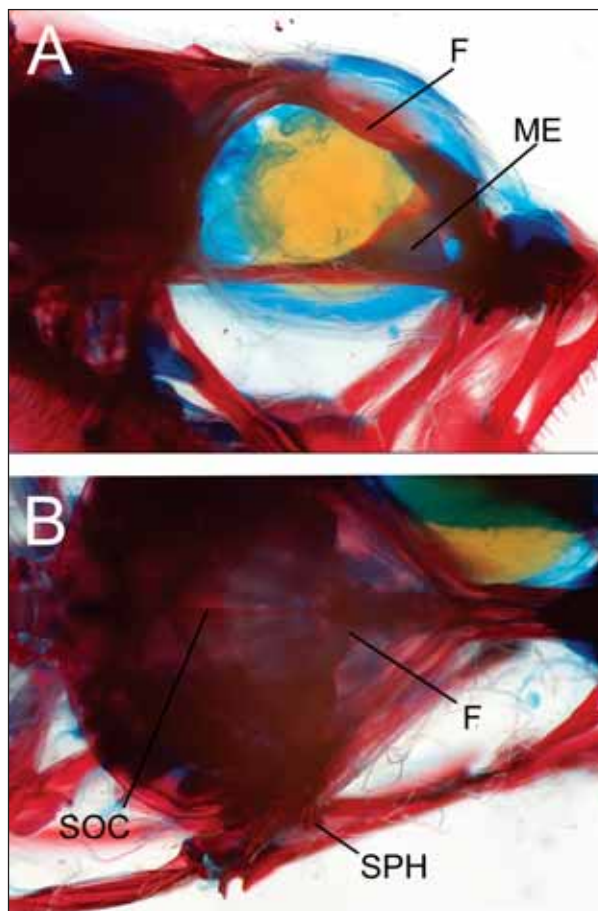


Fig. 6A-B. A. Cranial osteology (orbit) of *Antilligobius nikkiae*, lateral view; B. Cranial osteology (roof) of *Antilligobius nikkiae*, dorsal view. Abbreviations - F, frontal; ME, median ethmoid; SOC, supraoccipital; SPH, sphenotic. Photos by J. Van Tassell, editing by L. Tornabene.

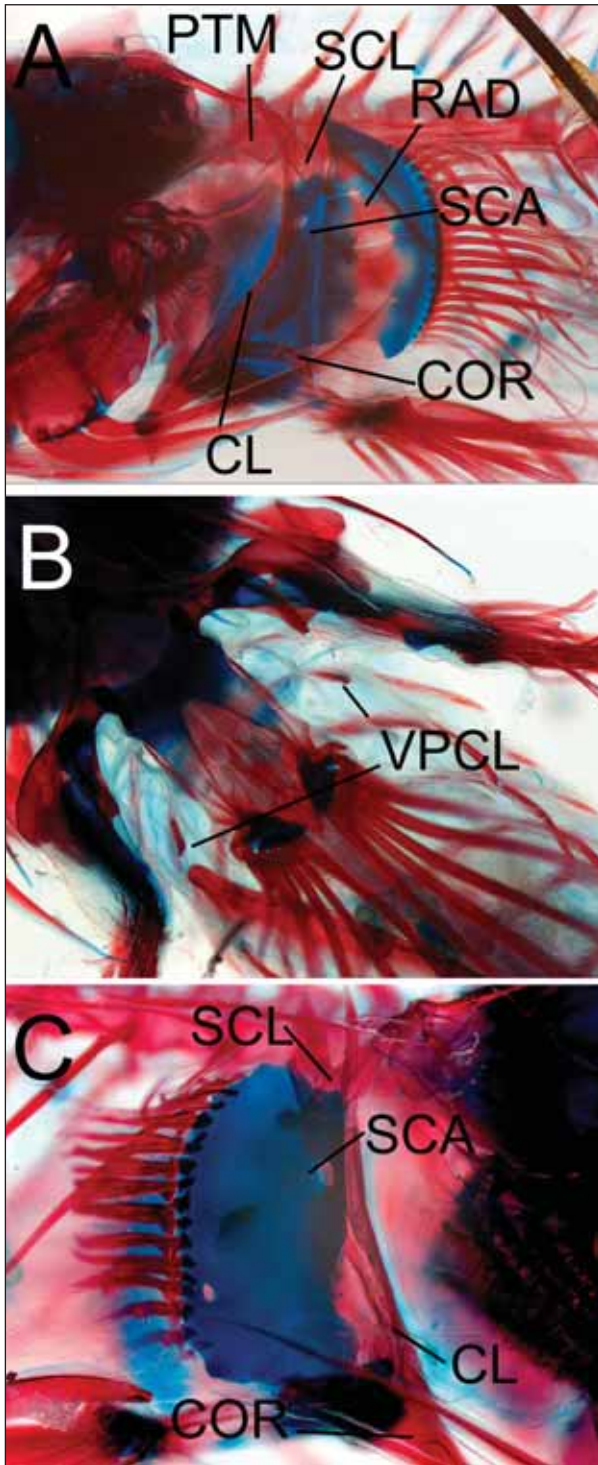


Fig. 7. A. *Antilligobius nikkiae* left pectoral fin osteology; B. *Antilligobius nikkiae* pectoral girdle, ventral view; C. *Antilligobius nikkiae* right pectoral fin girdle, with reduced ossification. Abbreviations – CL, cleithrum; COR, coracoid; PTM, posttemporal; RAD, radial; SCA, scapula; SCL, supracleithrum; VPCL, ventral postcleithrum. Photos by J. Van Tassell, editing by L. Tornabene.

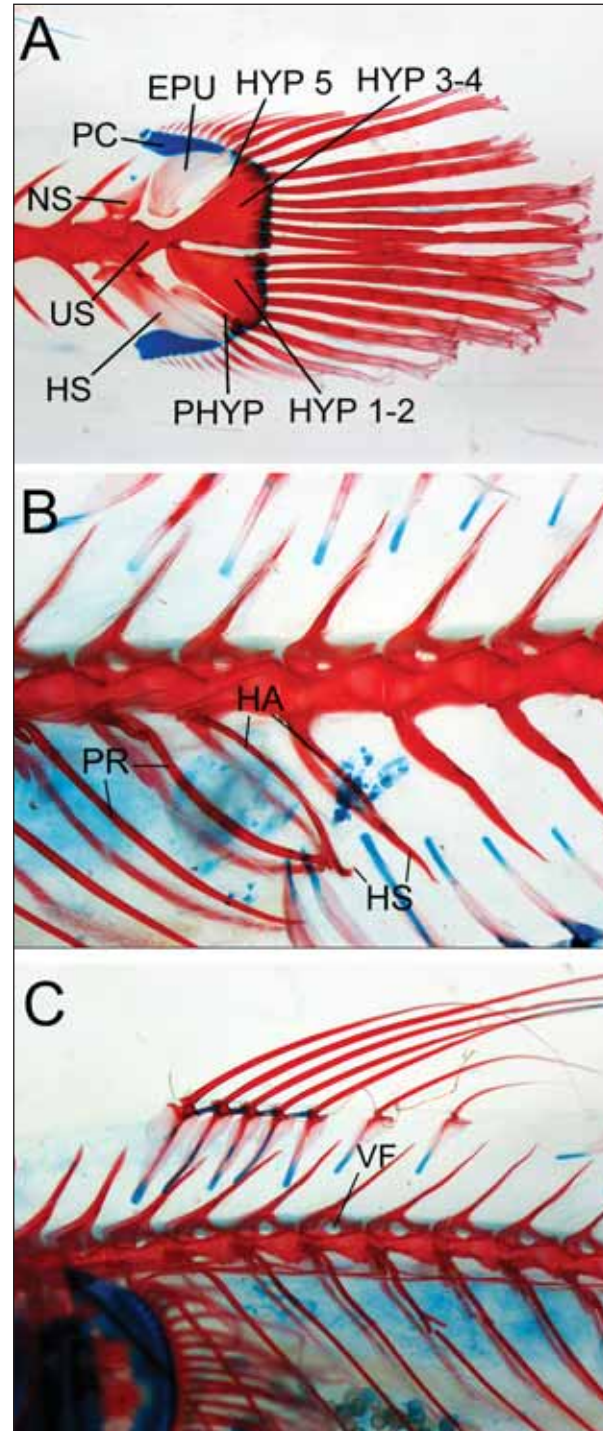


Fig. 8A-C. A. hypural plate of *Antilligobius nikkiae*; B. Ribs and haemal arch of *Antilligobius nikkiae*; C. pre-caudal vertebrae of *Antilligobius nikkiae*, note the large vertebral foramina. Abbreviations – EPU, epural; HYP, hypural; HA, haemal arch; HS, haemal spine; NS, neural spine; PC, procurrent cartilage; PHYP, parahypural; PR, pleural rib; US, urostyle; VF, vertebral foramen. Photos by J. Van Tassell, editing by L. Tornabene.

melanophores along dorsal and ventral edges and with horizontal yellow stripe along midline of fin in life, stripe pale in preservation; pelvic fin translucent with yellow dorsal margin in life, pale in preservation; caudal fin translucent with yellow stripes in life, dusky in preservation; two caudal fin stripes continuations of midlateral yellow body stripe and yellow stripe along base of anal fin; two additional yellow stripes on caudal fin, one thin one along dorsal fin margin and another along ventral margin; stripes pale in preservation; upper half of pectoral fin base yellow (white in preservation), lower half unpigmented; pectoral rays translucent.

Osteology: based on ANSP 147645, female, cleared and stained specimen.

Suspensorium and jaws (Fig. 5): anterior arm of suspensorium consisting of palatine, relatively broad dorsally, tapering to point about midway along ectopterygoid; ectopterygoid articulating with quadrate along its anterodorsal edge; metapterygoid very thin, "needle-like", not articulating with quadrate or its small cartilaginous posterior edge; no symplectic process on preopercle; ascending process of premaxilla extending dorsally to anterodorsal edge of rostral cartilage; maxilla narrow, lacking process along shaft, with ventral tip curved anteriorly; dentary reduced, lacking large pocket typically receiving anguloarticular; anguloarticular articulating with dentary along ventral groove in dentary and in small anterior pocket near symphysis of dentary.

Cranial (Fig. 6): median ethmoid forming septum between eyes, anterior and posterior edges ossified; anterior of frontals overlapping median ethmoid; sagittal crest present along dorsal midline where left and right frontal bones fuse; sagittal crest confluent with supraoccipital crest; anterolateral edge of frontals possessing well-developed transverse process; this process forming open tube supporting cephalic sensory canal; sphenotic short, lacking well-developed anterior process.

Pectoral girdle (Fig. 7): left side of specimen with four partly ossified radials and cartilaginous scapula; radials on right side not ossified, appearing fused into single cartilaginous plate along with scapula; posttemporal possessing single reduced lateral shelf; ventral postcleithrum present.

Vertebral column and caudal skeleton (Fig. 8): precaudal vertebrae 11; caudal vertebrae (including terminal element) 16; vertebrae 3-11 with pleural rib articulating with respective parapophyses; twelve pairs of epineurals, articulating with vertebrae as follows: epineurals 1, 2 with corresponding

parapophyses, 3-10 with corresponding pleural ribs, epineural 11 reduced and not articulating with pleural rib and 12 highly reduced and embedded in tissue; first caudal vertebra with expanded haemal arch and tiny haemal spine; haemal arch comprising elongate parapophyses, "rib-like" in appearance in lateral view; where parapophyses join ventrally to form haemal arch, a nubbin of bone (haemal spine) projecting posteriorly (Fig. 8B); "rib-like" lateral side of haemal arch easily confused with pleural ribs on radiographs; dorsal fin pterygiophore formula 3(221110); 2 pterygiophores of anal fin preceding first haemal arch; hypurals 1-2 not fused with hypurals 3-4; foramen on neural arches 6-22 singular and very large; neural arches 1, 24 through 27 with no foramen; neural arches 2, 3, and 4 with single small foramen; neural arch 5 with two foramina.

Hyoid series (Fig. 9): branchiostegals 5, first branchiostegal small, thin, and attached to ventral surface of narrow portion of ceratohyal, following three branchiostegals blade-like in appearance and attached to ventrolateral surface of broad portion of ceratohyal; posteriormost branchiostegal broadest, articulating with ventral surface of epihyal;



Fig. 9. Basihyal (BH) of *Antilligobius nikkiae*, spatulate in shape with only posterior one-third ossified. Photo by J. Van Tassell, editing L. Tornabene.

basihyal broad, spatulate, slightly emarginate, with only posterior third ossified (Fig. 9); ventral hypohyals, dorsal hypohyals and urohyal ossified; urohyal extremely thin; basibranchials 2, 3 ossified; basibranchial 4 either absent, unstained or too small to discern; hyobranchials 1, 2, and 3 cartilaginous; ceratobranchials 1, 2, 3, 4 cartilaginous at

tips; ceratobranchial 5 completely cartilaginous and fused with lower pharyngeal plate; lower pharyngeal plate ossified, possessing large conical teeth with slightly recurved tips.

Myology (Fig. 10): superficial jaw musculature composed of adductor mandibulae 1, adductor mandibulae 1 and adductor mandibulae 2; adduc-

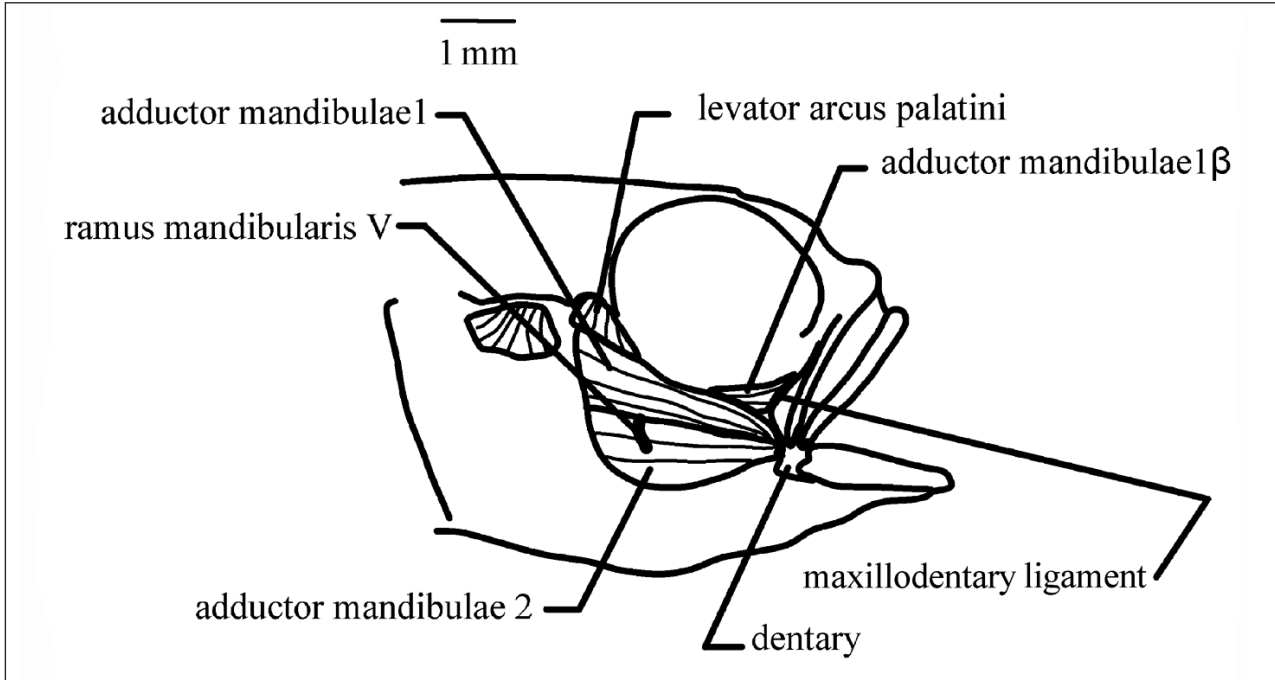


Fig. 10. Cheek myology of *Antilligobius nikkiae*. Drawing by J. Van Tassell.



Fig. 11. Illustration of *Antilligobius nikkiae* from Cayos los Indios, off the west coast of the Isla de Juventud, Cuba. Illustration by R. G. Gilmore.

tor mandibulae 1 and 1 combined along most of their length and originating on pterotic and ventrally along anterior edge of preopercle; adductor mandibulae 1 separated anteriorly from adductor mandibulae 1 and inserting on primordial ligament near its anterior attachment to maxilla, then running ventrally along primordial ligament and combining with fibers of adductor mandibulae 1; adductor mandibulae 1 with two insertions, along ventral section of primordial ligament and separately by tendon attached to coronoid process; adductor mandibulae 1 and 2 differentiated by presence of ramus mandibularis V, visible between muscle masses; adductor mandibulae 2 originating along preopercle, ventral to adductor mandibulae 1 and continuing ventrally to end of preopercle; adductor mandibulae 2 inserting via tendon onto coronoid process of dentary, joining with tendon of adductor mandibulae 1 before inserting on coronoid process.

Habitat: *Antilligobius nikkiae* is known from collections or observations from Curaçao, Bahamas, Cuba, Belize, Chinchorro Bank off eastern Yucatan (Quintana Roo) and Puerto Rico. It is a calcareous wall associate most often found in large numbers on the glacial sea level plateau at around 100 m (Grant Gilmore pers. comm.). Records of the habitat and behavior of this species are described below.

Belize: Colin (1974) recorded what is probably *A. nikkiae*, which he listed as “filamentous goby.” His observations were made from a submersible on deep

reef escarpments at Tobacco Reef and Glovers Reef, Belize, between 90 and 170 m (Colin 1974). The fish occurred in schools of hundreds of individuals and may have been the most common fish observed between 120 and 150 m in these areas. The gobies were reported as being slender, about 5 cm in length, with a silver body and blue eyes (consistent with the appearance of *A. nikkiae* in the field) and the first dorsal fin was extremely long and held erect. No specimens were collected or photographed in Belize.

Bahamas: The first series was collected by SCUBA diving at Acklins Island at 73 m in 1973 by one of us (PC). Small groups were found hovering along a steep drop-off in small indentations in the reef face. Specimens were returned to the surface alive, and some were maintained for several months in aquaria. Dennis et al. (2004) reported the species to be common at 90-150 m off Lee Stocking Island, Exuma chain, Bahamas.

Cuba: *Antilligobius nikkiae* (Fig. 11) was captured using crystalline rotenone in DMSO from the *Johnson-Sea-Link II* submarine, Dive 3,069 on 27 December 1997 at a depth of 169 to 198 m. It was collected at Cayos los Indios, 21.78405°N, 83.23625°W, off the west coast of the Isla de Juventud and Golfo de Batabano (Grant Gilmore pers. comm.). Gilmore observed *A. nikkiae* in small schools typically on vertical calcareous walls, hovering amidst the gorgonians and sponges, hanging along the wall margin. He has also observed them



Fig. 12. Pelvic frenum of *Bollmannia*, with collagenous supports and scalloped posterior margin. Photo by L. Tornabene.

quite often over the sandy terrace that marks the last glacial sea level beach, typically at a depth of around 100 m. He and his colleagues have observed this species in San Salvador, Abaco, New Providence, Grand Bahama and Cat Island in the Bahama Islands; Chinchorro Bank off eastern Yucatan (Quintana Roo); and Terneffe, Glovers and Lighthouse reefs off Belize. Observations in Cuba were limited to the southern shore west of Cayo Largo to Cabo San Antonio. The *Johnson-Sea-Link II* observations were made from 1978 to 1997.

Curaçao: *Antilligobius nikkiae* has been observed by technical divers, on talus slopes, starting at depths of 90 m and was quite common at 100 m (Fig. 3). They hovered a few inches to a foot above the substrate in small groups of 3-4, or in larger groups exceeding 24 individuals where they appeared to hunt for copepods or other zooplankton (Forrest Young, pers. comm.).

Puerto Rico: Specimens of *A. nikkiae* were collected on two occasions at 87-90 m depth on the shelf edge reef at La Parguera, Puerto Rico (Fig. 2). Two fish were taken on 22 November 1978 (ANSP 150387) while four specimens were collected on 28 August 1979 and later lost in the mail. Collection dates for these two fish from November 1978 are incorrectly listed in Dennis et al. (2004) as May 1978. Field notes record one deep dive on May 1978, but no fish were collected on that dive. Additional fish were seen on 21 August 1979 at another area along the shelf edge reef with similar geomorphology. Dennis et al. (2004) recorded the species from south-western Puerto Rico at 91 m. The gobies were found to hover slightly above the bottom, remaining close to one another and often facing in the same direction. The reef slope where the gobies were captured was steep, with an overall slope of about 45° from 45 to 90 m depth, then becoming near vertical below 90 m. The gobies were found among small indentations in the rocky structure of the reef face where the slope transitions between steep and vertical. They were found with other fish species typical of the deep vertical reef environment, including *Ptereleotris helenae*, *Chromis enchrysur*, *Chromis scotti*, *Centropyge argi*, *Chromis insolata*, *Liopropoma mowbrayi*, *Liopropoma carmabi*, *Gramma linki* and juvenile *Lutjanus buccanella*. The sabre gobies collected from Puerto Rico were captured alive using quinaldine-alcohol solution and returned directly to the surface with the SCUBA divers, where they were maintained in aquaria.

Distribution: Known from Belize, Bahamas,

Puerto Rico, Cuba, Mexico and Curaçao. The distribution is most likely widespread throughout the Caribbean wherever the glacial sea level plateau occurs.

Etymology: The specific epithet *nikkiae* is for Nicole Laura Schrier, the daughter of Adriaan “Dutch” Schrier, owner of the Sea Aquarium in Curaçao, who collected many of the type specimens. The species is given the common name Sabre goby in reference to its long, filamentous first dorsal fin that resembles a sabre (a long sword with a curved blade).

***Bollmannia* Jordan, 1890**

Bollmannia Jordan, in Jordan & Bollman, 1890: 164 (type species *Bollmannia chlamydes* Jordan by monotypy).

Diagnosis: *Bollmannia* can be distinguished from other Gobiosomatini genera by the following combination of characters, not listed in order of taxonomic importance: first dorsal of most species with black spot or blotch on posterior portion of fin; second dorsal I,11-15; anal I,10-15; pelvic fins with well-developed frenum supported with collagenous thickenings, frenum with scalloped posterior margin; caudal fin lanceolate; trunk scales ctenoid; predorsal region, cheek, pectoral fin base and breast with cycloid scales; predorsal scales 7-10.

Description: Body slightly elongate and laterally compressed; first dorsal VII; pterygiophore formula of first dorsal fin 3(221110); spines of dorsal fin frequently elongate in both sexes; second dorsal I,11-15; first and second dorsal fins separate from each other and from caudal fin; pectoral rays 19-26; anal I,10-15; trunk scales ctenoid; lateral scale rows 24-31; predorsal region, cheek, pectoral fin base and breast with cycloid scales; predorsal scales 6-10; scales highly deciduous; first pterygiophore of second dorsal fin inserted behind ninth neural spine, remaining pterygiophores arranged in 1:1 ratio with underlying vertebrae; first two anal pterygiophores inserted anterior to first haemal spine, remaining pterygiophores in 1:1 ratio with caudal vertebrae; total vertebrae 27, 11 precaudal, 16 caudal; caudal fin long, 30-50% SL, and lanceolate; pelvic fin with one spine and five rays, fins united, forming disk with well-developed frenum, frenum with thickened collagenous supports and scalloped margin (Fig. 12); teeth in both jaws arranged in multiple rows, teeth in inner and outer rows typically enlarged, evenly spaced, and more

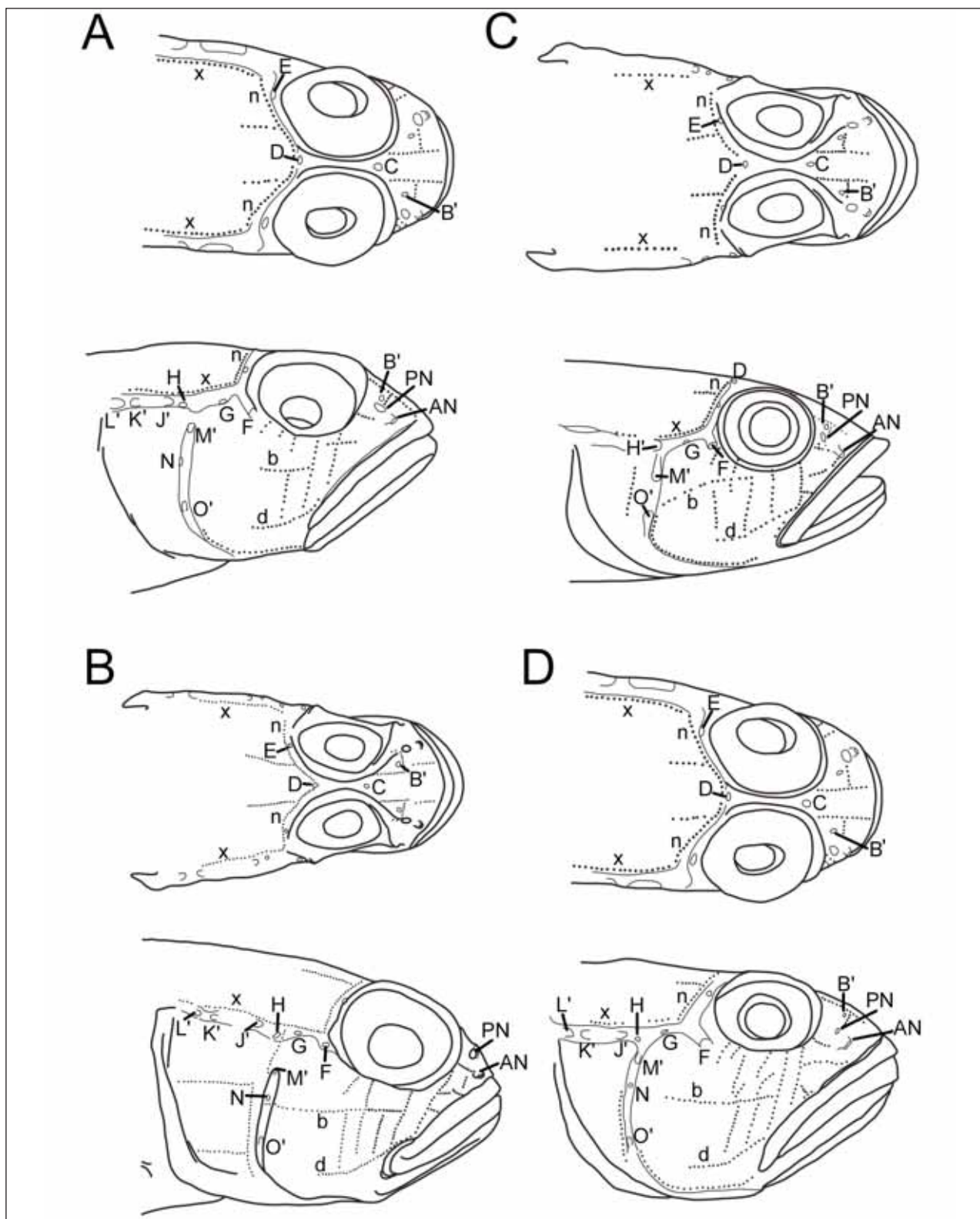


Fig. 13A-D. Sensory papillae and head canal pores of **A.** *Bollmannia litura*, **B.** *B. boqueronensis*, **C.** *B. eigenmanni* and **D.** *B. communis*. Abbreviations – AN, anterior naris; PN, posterior naris. Drawings by L. Tornabene (A, D), or modified from Ginsburg (unpublished manuscript) by L. Tornabene (B, C).

caninoid; teeth in middle rows smaller and more irregularly spaced; vomerine teeth absent; mouth large, 12-17% SL and inclined vertically; eye large, diameter 7.5-11% SL; gill opening extending entire length of pectoral fin base; gill rakers on lower arm of first arch elongate, rakers on upper arm short, stubby and poorly ossified; urogenital papilla thin and conical in males, thick and bulbous in females; cephalic lateralis canal and pore system on head well-developed (Fig. 13); sensory papillae pattern in transverse pattern (Fig. 13); ventral post-cleithrum present; nearly all species with dark conspicuous spot on posterior portion of first dorsal fin and sometimes on caudal peduncle; sexual dimorphism generally absent, with the exception of slightly larger dorsal fins in males of *B. boqueronensis*, and subtle pigmentation differences in *B. communis*.

***Bollmannia boqueronensis* Evermann & Marsh, 1899**

White-eye goby (Figs 13B, 14)

Bollmannia boqueronensis Evermann & Marsh, in Evermann & Marsh 1899: 356 (type locality Puerto Real, Puerto Rico).

Bollmannia jeannae Fowler, in Fowler 1941: 95, Figs 7-9 (type locality Key West, Florida).

Material examined: USNM 49366, holotype of *B. boqueronensis*, 15.5 m, Puerto Real, Puerto Rico; USNM 204311, paratype, 3, 15.5 m, Puerto Real, Puerto Rico; UF 172806, 2, 55-64 m, Cordoba, Colombia, 12 July 1966; AMNH 253405, 2 plus 1 cleared and stained, 29-32.2 mm SL, 8.4 m, JVT-04-306, Bocas del Toro, Laguna de Chiriqui, Panama, 9 June 2004, Robertson et al.; AMNH 253406, 4, 20-42.5 mm SL, 14.3 m, JVT-04-317,

Bocas del Toro, 09.422°N, 81.910°W, Panama, 12 June 2004, Robertson et al.; UF 223444, 12, 36 m, Golfo de Morrosquillo, Colombia, 13 July 1966; UF 223664, 5, 29-42 m, Caribbean Sea, N of Cabo Tiburon, Panama, 18 July 1966; USNM 116363, 1, 14.17 m, Key West, Florida, 13 February 1902; USNM 290282, 2, 37 m, Gulf of Mexico, Silver Bay Station 54, 28.150°N, 83.830°W, Florida, 16 July 1957; USNM 116366, 1, 49 m, Gulf of Mexico, 26.5583°N, 83.2583°W, Florida, 18 March 1885; USNM 118088, 2, Tortugas Islands, Florida, 24 July 1924; USNM 186228, 3, 73 m, Gulf of Venezuela, 12.2417°N, 70.33°W, Venezuela, 10 November 1958; AMNH 239100, 1, 47.7 mm SL, 1521 m, Spaanse Water, 12.069°N, 68.8519°W, Curaçao, 11 February 2005, Robertson et al.; AMNH 239103, 1, 49.4 mm SL, 15-21 m, Spaanse Water, 12.0697°N, 68.8519°W, Curaçao, 11 February 2005, Robertson et al.; AMNH 239083, 1, 45.22 mm SL, 15 m, Spaanse Water, 12.0697°N, 68.8519°W, Curaçao, 10 February 2005, Robertson et al.; ANSP 69718, *Bollmannia jeannae* holotype, 58.8 mm SL, 34.7 m, Key West, Florida, 12 April 1940; ANSP 69719, *B. jeannae* paratype, 52.7 mm SL, 34.7 m, Key West, Florida, 12 April 1940; UPRM 3392, 1, 45.8 mm SL, 18 m, east end of Laurel Reef, Puerto Rico, 7 September 1975; UPRM 3788, 3, 37.3-44.0 mm SL, no collection data (possibly collected with UPRM 3790); UPRM 3791, 1, 51.8 mm SL, no collection data (possibly collected with UPRM 3790); UPRM 3790, 49.0-57.0 mm SL, 18 m, Laurel Reef, La Parguera, Puerto Rico; UF 226784, 3, 29.8-32.8 mm SL, Golfo de Morrosquillo, 09.521667°N, 76.256667°W, Colombia, 13 July 1966; UF 231124, 24.5-27.5 m, field stations PLC-J19,



Fig. 14. *Bollmannia boqueronensis*, 41.5 mm SL, Bocas del Toro, Panama, AMNH 253406 Photo by J. Van Tassell, editing by L. Tornabene.

Caribbean Sea, Jamaica, 13 February 1971, P. L. Colin and N. Copland.

Diagnosis: Second dorsal fin typically I,12; anal fin typically I,12; eye diameter 7.7-10% SL; spines of first dorsal fin not distinctly elongate; first and second dorsal fins with 3-5 brown or tan horizontal stripes; upper lip lightly pigmented to pale, no dark stripe above upper lip; pelvic disk lightly pigmented to pale; body with 4-5 dark brown blotches along lateral midline; blotches often connected by slightly lighter horizontal band of pigment along lateral midline; longitudinal papillae row *b* originating at vertical through anterior margin of pupil.

Description: Body somewhat laterally compressed; depth at origin of first dorsal fin 17.5-21.8% SL; least depth of caudal peduncle 9.9-10.5% SL; size to 100 mm TL (Robins & Ray 1986).

Median and paired fins: first dorsal VII, spines not notably elongate; second dorsal I,11(8), I,12*(35), I,13(2); anal I,11*(7), I,12 (36), I,13(2); pectoral rays 19(3), 20(2), 21*(7), 22(5), 23(1), longest rays reaching posteriorly to vertical through anus; pelvic I,5*(10), fifth ray longest, reaching posteriorly to or just falling short of anus; pelvic fin with well-developed frenum; pelvic frenum supported with collagenous rays (Fig. 12); caudal fin lanceolate, segmented rays 16(1), 17(7), 19*(1), branched rays 14(6), 15(1).

Scales: trunk completely covered with ctenoid scales, ctenii becoming larger posteriorly; predorsal region, cheek, operculum, pectoral fin base and pelvic fin base with scattered cycloid scales; lateral scale rows 27-31; transverse scale rows 7; predorsal scales 9-10, scales extending anteriorly to vertical behind eye; caudal peduncle scales 11-13; no modified basicaudal scales present.

Head: head length 27.0-31.0% SL; mouth large, angled upwards approximately 20-30 degrees from horizontal; mouth reaching posteriorly to vertical through pupil; upper jaw length 11.0-13.0% SL; teeth in both jaws arranged in three rows; teeth in inner and outer rows enlarged, regularly spaced and caninoid; teeth in middle row smaller and irregularly spaced; eye diameter 7.7-10.0% SL; interorbital narrow, width less than diameter of pupil; snout short, 4.8-5.5% SL; postorbital length 12.8-16.5% SL; gill rakers on lower arm of first arch 10, upper arm 3; gill rakers on lower limb thin and elongate, rakers on subsequent arches shorter and thicker.

Genitalia: papilla elongate and conical in males, no melanophores present; papilla short and bulbous in females.

Sensory papillae and head pores (Fig. 13B): oculoscapular pores B', C(s), D(s), E, F, G, H', K' and L' present; in approximately half of specimens examined, anterior canal terminating with pore H', other half of specimens with anterior canal terminating with pore posterior to H, herein termed J', which may not be homologous with J sensu Akihito (1984); preopercular pores M', N, O' present; papillae in transverse pattern with 4-5 rows present below eye; first transverse row beginning approximately below anterior margin of eye; last transverse row beginning below posterior margin of pupil; transverse rows often extending below longitudinal row *b*; row *b* beginning at vertical through anterior margin of pupil; row *d* beginning slightly posteroventral of first transverse papillae row, at vertical through anterior one-third of eye and continuing posteriorly to below posterior margin of eye, sometimes slightly further posteriorly; row *n* not continuous across dorsal midline, stopping slightly before pore D; row *x* beginning at ventral termination of row *n* and continuing posteriorly to just before posterior margin of operculum; two horizontal rows of papillae on operculum, one beginning slightly above and behind pore N, the other slightly below and behind pore O'.

Pigmentation: following description based on recently collected specimens or preserved specimens with well-preserved pigmentation. Overall body background color pale; body with 4-5 dark brown blotches along lateral midline; blotches typically connected by slightly lighter horizontal stripe of pigment along lateral midline; thin, light brown or tan horizontal stripe of pigment below dorsal midline and above lateral midline, beginning behind eye and continuing to base of caudal fin; this stripe often broken or incomplete and becoming less distinct posteriorly; abdomen and gular regions pale; in life, head often with bright iridescent orange vertical markings on preoperculum and operculum and orange stripes on upper and lower jaws; dorsal fins with 3-5 brown or tan horizontal stripes separated by pale or translucent stripes; posterior portion of first dorsal fin with distinct black spot ranging in size from as small as pupil to as large as eye; anal fin completely pale or lightly pigmented at base; pelvic fin lightly pigmented to pale; upper half of caudal fin often with 2-3 horizontal or slightly diagonal brown or tan

Table II. Comparison of *Bollmannia litura* holotype and original description. Measurements other than SL are in % SL.

	<i>B. litura</i> holotype USNM 93737	Description of <i>B. litura</i> (Ginsburg 1935)
Sex	male	male
SL	38.4 mm	39 mm
Eye diameter	9.1	12
Postorbital length	15.5	16
Head length	30.7	31
Maximum body depth (base of first dorsal fin)	18.1	25
Least depth of caudal peduncle	10.0	13
Head depth behind eye	16.0	20
Head width behind eye	15.4	17
Predorsal distance	34.0	36
Caudal fin length	broken	49
Second dorsal fin elements	I,13	I,11
Anal fin elements	I,13	I,11
Pectoral fin rays	22	20

stripes similar to those on dorsal fins; midline of caudal fin often with brown horizontal stripe continuing from stripe on lateral midline of body; lower half of caudal fin pale; pectoral fin base and rays pale.

Habitat: Specimens in this study were collected over sand and sandy-mud bottoms and flat areas with fine sediment adjacent to coral reefs at depths from 8.4-73.0 meters.

Distribution: Specimens examined in this study were collected from the eastern Gulf of Mexico, Florida Keys, Tortugas, Puerto Rico, Jamaica, Colombia, Panama, Curaçao and Venezuela. Additional museum lots exist, but have not been examined, from Guatemala (UF 15661), Honduras (UF 288135-288136), Martinique (ANSP 108832), and Bahia, Brazil (MNHN 1989-0786). Moreno-Mendoza et al. (2011) also report *B. boqueronensis* from Alacranes Reef Marine Park, Mexico.

Remarks: Fowler's description of *B. jeannae* stated that *B. jeannae* differs from *B. boqueronensis* in coloration, pectoral fin length and cheek scale size (Fowler 1941). Ginsburg (1942) stated that the differences do not hold up when *B. jeannae* is compared to actual specimens of *B. boqueronensis* and that the illustrations of *B. boqueronensis* that accompany Evermann & Marsh's (1899) descrip-

tion are inaccurate. Ginsburg concluded that *B. jeannae*, which is known from only the holotype and one paratype, is almost certainly a synonym of *B. boqueronensis*. He offered no formal synonymy of the two species. *Bollmannia jeannae* falls within the range of *B. boqueronensis* in all measurements taken here. The coloration differences between the two species as described by Fowler (1941) do not hold when live or freshly preserved specimens of *B. boqueronensis* are compared, nor do the differences in scale size. The *B. jeannae* types differ from the *B. boqueronensis* holotype in second dorsal and anal fin ray counts. Both type specimens of *B. jeannae* have I,11 in the second dorsal fin and I,12 in the anal fin, whereas *B. boqueronensis* was described as having I,12 in the second dorsal and I,13 in the anal fin. Based on our analysis, both I,11 and I,12 are counts that have been observed in both fins of *B. boqueronensis*. For these reasons, we agree with Ginsburg (1942) and consider *B. jeannae* to be a synonym of *B. boqueronensis*.

Evermann & Marsh (1899) used the presence of a series of 3-5 large scales on the lower margin of the cheek as a unique and distinguishing characteristic for *B. boqueronensis*. Although this row of scales is rare or nonexistent in other species of *Bollmannia*, the deciduous nature of the scales on all species of *Bollmannia* diminishes the diagnostic utility of this character. Some specimens of *B. boqueronensis* examined in this study were missing some or all of these scales. Because scale pockets on the face are also frequently destroyed, it is difficult to determine if cheek scales were present at some point and lost during collection, or if scales were absent and thus this character is somewhat variable.

Robins & Ray (1986), Humann & Deloach (2002) and McEachran & Fechhelm (2005) report *B. boqueronensis* as sometimes having orange and yellow spots on the dorsal fins, but these observations were almost certainly based on misidentified specimens of *B. litura* (which has been collected with *B. boqueronensis*), or *B. communis*.

Ginsburg (unpublished manuscript) described *B. boqueronensis* as having an anterior oculoscapular lateralis canal ending with pore H' (missing pore J'). Ginsburg used the absence of this character to divide *Bollmannia* into two distinct groups (proposed subgenera), with *B. litura* and *B. communis* both possessing pore J'. Our study shows this char-

acter to be highly variable in *B. boqueronensis*, as approximately half of the specimens examined have pore J'. The variation in this character does not appear to be correlated with geographic distribution, sexual dimorphism or size.

Two specimens of *Bollmannia* from Alacranes Reef, Mexico were identified as *B. boqueronensis* by Moreno-Mendoza et al. (2011) despite possessing one spine and 13 rays in the anal and second dorsal fins. This combination of counts is more typical of *B. communis*, which is commonly reported from the western Gulf of Mexico; however, we agree with the identification of Moreno-Mendoza et al. (2011). Their specimens possess all of the diagnostic pigmentation features of *B. boqueronensis* described here and were also collected from sandy-mud sediment at the base of a coral reef, which is a common habitat for *B. boqueronensis*. *Bollmannia communis* is common over thick mud and is not typically associated with reef habitats.

Comparisons: *Bollmannia boqueronensis* can be distinguished from *B. communis* in usually having fewer anal and second dorsal elements (typically I,12 in *B. boqueronensis* vs. typically I,13 in *B. communis*). It differs from *B. litura* and *B. communis* in having a lightly pigmented pelvic fin (vs. a dark pelvic fin), in having tan or brown stripes on the dorsal fin (vs. having yellow or orange stripes or spots) and in having dark spots and a stripe of pigment along the lateral midline (vs. dark spots that are rarely connected by a stripe). *Bollmannia boqueronensis* can be distinguished from *B. eigenmanni* in lacking a distinct dark stripe of pigment on or above the upper lip, having a slightly deeper caudal peduncle (9.9-10.5% SL in *B. boqueronensis* vs. less than 10% SL in *B. eigenmanni*), having

three pores in the preopercular series (vs. two pores in the opercular series) and in having longitudinal papillae row *b* originating at a vertical through the anterior margin of pupil (vs. originating more posterior in *B. eigenmanni*).

***Bollmannia communis* Ginsburg, 1942**

Ragged goby (Figs 13D, 15)

Bollmannia communis Ginsburg, in Ginsburg 1942: 634 (type locality Gulf of Mexico, Louisiana).

Materials examined: USNM 119873, holotype, 1 male, 52.5 mm SL, 18 m, Gulf of Mexico, NW of Southwest Pass entrance, of Mississippi Delta, 28.983333°N, 89.483333°W, Louisiana, 7 September 2006; USNM 119879, paratype, 40 m, Gulf of Mexico, 28.4667°N, 91.2250°W, Louisiana, 30 January 1939; USNM 119880, paratype, 27 m, Gulf of Mexico, NW of Southwest Pass entrance, off Mississippi River Delta, 28.970°N, 89.475°W, Louisiana, 10 November 1938; USNM 119881, paratype, 68 m, Gulf of Mexico, 27.7333°N, 96.2917°W, Louisiana, 23 January 1939; USNM 119882, paratype, 55 m, Gulf of Mexico, 28.800°N, 89.850°W, Louisiana, 13 May 1938; USNM 119883, paratypes, 7, 77 m, Gulf of Mexico, 27.6667°N, 96.5667°W, Texas, 22 March 1938; USNM 119884, paratype, 46 m, Gulf of Mexico, 26.7167°N, 96.8500°W, Texas, 4 February 1939; USNM 119885, paratypes, 6, 64 m, Gulf of Mexico, 27.083333°N, 96.825°W, Texas, 31 January 1939; USNM 119886, paratypes, 3, 64 m, Gulf of Mexico, 28.825°N, 89.750°W, Louisiana, 13 May 1938; USNM



Fig. 15. *Bollmannia communis*, Gulf of Mexico. Photo by Brandi Noble, NOAA Photo Library.

119887, paratypes, 5, 64 m, Gulf of Mexico, east of Mustang Island, 27.7083°N, 96.3583°W, Texas, 23 January 1939; USNM 119888, paratype, 31 m, Gulf of Mexico, east of Mustang Island, 27.725°N, 96.730°W, Texas, 22 April 1938; USNM 119890, paratype, 82 m, Gulf of Mexico, 26.5667°N, 96.5333°W, Texas, 4 February 1939; USNM 119892, paratypes, 7, 46.4-68.5 mm SL, 60 m, Gulf of Mexico, 27.2167°N, 29.7833°W, Texas, 30 January 1939; USNM 119893, paratypes, 50.3 m, Gulf of Mexico, east of Mustang Island, 27.6667°N, 96.5667°W, Texas, 22 April 1938; USNM 197731, 20, Gulf of Mexico, 26.2700°N, 82.0500°W, Florida, 21 March 1962; USNM 337773, 6, 44 m, Gulf of Mexico, Campeche Bank, 110 Miles of (SW) Campeche, Yucatan, 19.600°N, 91.7917°W, Mexico, 19 August 1951; USNM 364236, 11 of 12, 64 m, 6.90000°N, 53.96667°W, French Guiana, 30 June 1972; TCWC 6829.10, 5, 29.3-54.0 mm SL, 47.5 m, Gulf of Mexico, Mississippi/Alabama, 12 March 1988; AMNH 253407, 16, Gulf of Mexico, NOAA Station 022, Texas, October 2006; AMNH 253408, 12, Gulf of Mexico, Texas, NOAA Station 032, October 2006; AMNH 253409, 12, Gulf of Mexico, Texas, NOAA Station 045, October 2006; UPRM 2196, 1, 40 mm SL, off Anasco, Puerto Rico, 7 August 1964, J. Randall; UPRM 3788, 2, 45-48 mm SL, off Rio Anasco, Puerto Rico, 11 August 1987, B. Yoshioka; UPRM 1551, 42 mm SL, Anasco, Puerto Rico, 29 March 1963, Randall et al.; GCRL 17540, 58, 41.0-49.0 mm SL, Gulf of Mexico, 28.952167°N, 89.683833°W, Louisiana, 26 August 1978; GCRL 28344, 2, 64.2-71.5 mm SL, 35 m, Gulf of Mexico, 29.300333°N, 88.902833°W, Louisiana, 9 November 1997, W. E. Aguirre.

Diagnosis: Second dorsal fin typically I,13; anal fin typically I,13; eye diameter 8.1-10% SL; middle spines of first dorsal slightly elongate; first and second dorsal fins with dark circles or ellipses with orange or yellow centers (centers pale in preservation); upper lip lightly pigmented to pale, no dark stripe above upper lip; pelvic fin heavily pigmented, black or nearly so; body with 4-5 dark brown blotches along lateral midline; blotches typically not connected by slightly lighter horizontal stripe of pigment along lateral midline; longitudinal papillae row *b* originating at vertical through anterior margin of pupil.

Description: Body somewhat laterally compressed, depth at origin of first dorsal fin 19.2-

21.1% SL; least depth of caudal peduncle 9.4-11.6% SL; size to 100 mm SL (Robins & Ray 1986).

Median and paired fins: first dorsal VII, middle spines slightly elongate in some specimens; in males, fourth spine reaching posteriorly to base of fourth to sixth ray of second dorsal fin when depressed; spines slightly shorter in females; second dorsal I,12(23), 1,13*(82), I,14(3); anal I,11(1), I,12(15), I,13*(84), I,14(8); pectoral rays 19(3), 20(4), 21(4), 22(8), 23*(4), longest rays extending posteriorly to vertical through anus; pelvic I,5*(10), fifth ray longest, extending to anus or falling just short of anus; pelvic fin with well-developed frenum; pelvic frenum supported with collagenous rays (Fig. 12); caudal fin lanceolate, segmented rays 16(1), 17*(5), branched rays 14*(6).

Scales: trunk completely covered with ctenoid scales, ctenii becoming larger posteriorly; predorsal region, cheek, operculum, pectoral fin base and pelvic fin base with scattered cycloid scales; scales in lateral series 24-29; transverse scale rows 6-7; predorsal scales 8-9, scales extending anteriorly to vertical behind eye; caudal peduncle scales 10-13; no modified basicaudal scales present.

Head: head length 31.0-33.5% SL; mouth large, angled upwards approximately 20-30 degrees from horizontal; mouth reaching posteriorly to vertical through pupil; upper jaw length 12.7-14.5% SL; teeth in both jaws arranged in three rows; teeth in inner and outer rows enlarged, regularly spaced and caninoid; teeth in middle row smaller and irregularly spaced; eye diameter 8.1-10.0% SL; interorbital narrow, width less than diameter of pupil; snout short, 5.8-7.3% SL; postorbital length 14.2-16.5% SL; gill rakers on lower arm of first arch 10, upper arm 3; gill rakers on lower limb thin and elongate, rakers on subsequent arches shorter and thicker.

Genitalia: papilla elongate and conical in males, occasionally with melanophores on lateral edges; papillae short and bulbous in females.

Sensory papillae and head pores (Fig. 13D): oculoscapular pores B', C(s), D(s), E, F, G, H, J' and K', L' present; anterior canal terminating in pore J'; preopercular pores M', N, O' present; papillae in transverse pattern, with 4-5 transverse rows present below eye; first transverse row beginning approximately below anterior margin of eye; last transverse row beginning below posterior margin of pupil or slightly more posterior; middle transverse rows highly variable, frequently disjunct, sometimes

extending below longitudinal row *b*; transverse rows on opposite sides of head often varying in a single individual; row *b* originating at vertical through anterior margin of pupil and continuing posteriorly to below posterior margin of eye, sometimes extending slightly further posteriorly; row *d* beginning slightly posteroventral of bottom of first transverse row, at vertical through anterior margin of pupil and continuing posteriorly to below posterior margin of eye, sometimes extending slightly further posteriorly; row *n* continuous across dorsal midline; row *x* beginning at ventral termination of row *n* and continuing posteriorly to above pore L'.

Pigmentation: following description based largely on recently preserved specimens. Comments on coloration in life based on color photographs of *B. communis* specimens from Gulf of Mexico (Fig. 15) which we have not examined. Overall body background color pale; body with 4-5 faint brown blotches along lateral midline; blotches rarely connected by slightly lighter horizontal stripe of pigment along lateral midline; abdomen and gular regions pale; top of head, snout, interorbital and area above jaw uniformly pigmented with scattered small dark melanophores; occasionally faint elongate patches of pigment present on preoperculum directly beneath and behind eye; base of first dorsal fin with two yellowish orange stripes in life (pale in preservation), stripes becoming broken distally and forming distinct ellipses with dark margins and bright yellow or orange centers in life; yellow and orange pigment on fins fading to pale in preservation; posterior portion of first dorsal fin with distinct black spot ranging in size from as small as pupil to as large as eye; distal margin of first dorsal fin with black stripe in males; second dorsal fin pigmented with ellipses similar to those of first dorsal fin; anal fin nearly pale at base, becoming more heavily pigmented distally; pelvic fin heavily pigmented, black or nearly so; upper half of caudal fin pigmented with ellipses similar to dorsal fins; lower half of caudal fin with two faint yellowish-orange diagonal stripes in life, fading in preservation; pectoral fin base pale; pectoral rays dusky to pale.

Habitat: Specimens in this study were collected from mud bottoms at depths of 18-77 m.

Distribution. Known primarily from the Gulf of Mexico, with one confirmed record from French Guiana. Several lots of *Bollmannia* from Puerto Rico, (UPRM 1551, UPRM 2196, ANSP 147645) were tentatively listed as *B. communis* by Dennis et

al. (2004); however, these specimens are in very poor condition and it is unclear as to whether these specimens are *B. communis* or *B. litura*.

Comparisons: *Bollmannia communis* and *B. litura* are the most similar of all western Atlantic *Bollmannia* species. The two species both have similar sensory papillae and sensory pore/canal patterns, nearly identical median fin pigmentation and lack a black band on the upper lip. *Bollmannia communis* can be distinguished from *B. litura* in having a smaller eye (typically less than 10% SL in *B. communis* vs. typically more than 10% SL in *B. litura*) and from *B. litura* and all other species in having higher modal counts in the second dorsal and anal fins (typically I,13 in *B. communis* vs. typically I,10-12 in other western Atlantic *Bollmannia* species). Male *B. communis* have dark distal margins on the first dorsal fin whereas male *B. litura* do not. *Bollmannia communis* can be further distinguished from *B. boqueronensis* by pigmentation, as *B. boqueronensis* has tan or brown stripes on the dorsal fins, a pale pelvic disk and usually a brown stripe of pigment on the lateral midline and *B. communis* typically has yellow or orange (pale in preservation) stripes and ellipses on the dorsal fins, a dark pelvic disk and no stripe of pigment on the lateral portion of the body. *Bollmannia communis* can be distinguished from *B. eigenmanni* in having three pores on the preoperculum (M', N, O') vs. having two (M', O'), having a dark pelvic fin (vs. a pale pelvic fin), lacking a distinct black stripe on or above the upper jaw (black stripe present in *B. eigenmanni*) and in having longitudinal papillae row *b* originating at a vertical through anterior margin of the pupil (vs. originating more posterior to this point in *B. eigenmanni*).

***Bollmannia eigenmanni* (Garman, 1896)**

Shelf Goby (Figs 13C, 16)

Gobius eigenmanni Garman, in Garman 1896:88, Pl. 3 (type locality Key West, Florida).

Materials examined: USNM 231318, holotype, 1 male, 26.12 mm SL, 110 m, Key West, Florida, 1893; USNM 116368, 1, 37.6 mm SL, 55-110 m, Gulf of Mexico, 28.74167°N, 85.1500°W, Florida, 15 March 1885; UF 210982, 1, 23.3 mm SL, 36.5-40 m, Gulf of Mexico, South of Cailou Bay, 28.441667°N, 91.008333°W, Louisiana, 12 September 1962; UF 228128, 1, 57-68 m, north of Isla de Margarita, 11.48333°N, 63.85000°W,

Table III. Comparison of morphological characters across the *Microgobius*-group genera

	Antilligobius	Bollmannia	Parrella	Microgobius	Akko	Palatogobius
Type species	<i>Antilligobius nikkiae</i> Van Tassel & Colin	<i>Bollmannia chlamydes</i> Jordan, 1890	<i>Parrella maxillaris</i> Ginsburg, 1938	<i>Microgobius signatus</i> Poey, 1876	<i>Akko dionaea</i> Birdsong & Robins, 1995	<i>Palatogobius paradoxus</i> Gilbert, 1971
Precaudal vertebrae	11	11	11	11	11	11
Caudal vertebrae	16	16	16	16-17	16-17	16
Hypurals 1-2 fused to 3-4 and to urostyle	No	No	No	No	No	No
DI	7	7	7	7	7	7
DI pterygiophores	3(221110)	3(221110)	3(221110)	3(221110)	3(221110)	3(221110)
DI elongate	Yes, both sexes	Yes, both sexes of some species	Yes, females of some species	Yes, males	No	No
DII	I,11-12	I,11-15	I,11-12	I,14-19	I,14-15	I,17-20
DII position	Post 9th neural spine	Post 9th neural spine	Post 9th neural spine	Post 9th neural spine	Post 9th neural spine	Post 9th neural spine
A	I,11-13	I,10-15	I,10-12	I,14-20	I,14-15	I,19-21
Anal fin position	First two elements anterior to haemal spine on 12th vertebrae	First two elements anterior to haemal spine on 12th vertebrae	First two elements anterior to haemal spine on 12th vertebrae	First two elements anterior to haemal spine on 12th vertebrae	First two elements anterior to haemal spine on 12th vertebrae	First two elements anterior to haemal spine on 12th vertebrae
C segmented	17	16-18 (Atlantic species only)	17	17	16-17	17
C branched	15	14-16 (Atlantic species only)	16	15	15-16	14
C shape	Lanceolate	Lanceolate	Lanceolate	Lanceolate	Lanceolate	Lanceolate
P	20	19-26	19-20	20-23	17-21	18-21
V	I,5	I,5	I,5	I,5	I,5	I,5
V shape	Ovate	Ovate	Rounded	Ovate	Ovate	Ovate
Pelvic frenum	Well developed, smooth margin	Well developed, scalloped margin	Well developed, scalloped margin	Well developed, smooth margin	Well developed, smooth margin	Absent
Cephalic lateral-line canal pores	B' C(s) D(s) E F H' (sometimes G)	B' C(s) D(s) E F G H' (or H', J') K' L' (K'L' absent in <i>B. eigenmanni</i>)	B' D(s) E H', or B' D(s) F G H', or B' C(s) G H', sometimes K' L'	B' D F G H'	B' G'	B' C(s) D(s) E F'
Opercular canal pores	M' N' O'	M' N' O' or M' O'	Absent or M', N'	M' N' O' or M' N'	Absent	Absent
Scale type	Mainly ctenoid, some cycloid	Mainly ctenoid, some cycloid	Ctenoid with reduced ctenii	Cycloid + ctenoid	Cycloid	Cycloid
Predorsal scales	6	6-10	18	0	Some	0
Scales cheek	2-3 scales	Few large scales	Absent	Absent	Absent	Absent
Scales opercular	Absent	Present	Absent	Absent	Absent	Absent
Scales breast	Present	Present	Present	Absent	Absent	Absent
Scales belly	Present	Present	Present	Absent	Absent	Absent
Scales pectoral fin base	Present	Present	Present	Absent	Absent	Absent
Scales transverse scale rows	6-8	6-8	8	20	19-20	None
Lateral scale rows	21-28	24-29	32	35-90	53-115	12-17
Modified basicaudal scales	Absent	Absent	Absent	Absent	Absent	Absent
Vomerine teeth	Absent	Absent	Absent	Absent	Absent	Present
Angle of mouth	30 deg	30 deg	35 deg	Highly variable between species	50 deg	35 deg

and over

	Upper pectoral fin base to ventral surface of body	Upper pectoral fin base to ventral surface of body	Upper pectoral fin base to ventral surface of body	Length of pectoral base and sex	Base of 4th pectoral ray to pelvic fin base	Upper margin of orbit to just below lower margin of orbit
Extent of gill openings	Upper pectoral fin base to ventral surface of body	Upper pectoral fin base to ventral surface of body	Upper pectoral fin base to ventral surface of body	Length of pectoral base and sex	Base of 4th pectoral ray to pelvic fin base	Upper margin of orbit to just below lower margin of orbit
Gill rakers shape	Short slender	Moderately long, slender	Short stout	Long slender	Papiloid	Moderately long, slender
Gill rakers upper+lower	5+12	3-4+9-12	4+8	3-5+10-18	6+6	4-5+12-13
Posterior nostrils	Raised rim	Slight raised rim	No rim	No rim	No rim	Raised rim
Anterior nostrils	Short tube	Short tube	Short tube	Short tube	Short tube	Short tube
Fleshy nape crest	Absent	Absent	Absent	Present - some species	Absent	Absent
Male papillae	Conical	Conical	Conical	Conical	Conical	Short, bluntly pointed
Female papillae	Bulbous	Bulbous	Bulbous	Bulbous	Short, rounded	Short blunt conical
Color sexually dimorphic	No	Only <i>B. communitis</i>	No	Some species	No	No
Head sexually dimorphic	No	No	Mouth and eye larger in males	Some species	No	No
Gas bladder	Well developed	Well developed	Absent	Well developed	Small - thickened	Absent
Bony support of supraorbital sensory canal	Canal supported by open trough	Portions of canal enclosed in bony tube	Canal supported by open trough	Canal supported by open trough	Canal supported by open trough	Canal supported by open trough
Sagittal crest on frontal bone	Present	Present	Absent	Present	Absent	Absent
Basihyal shape	Spatulate	Spatulate	Bifid	Bifid	Minute, reduced	Narrow
Process on metapterygoid overlapping quadrate	Absent	Absent	Absent	Absent	Absent	Absent
Metapterygoid shape	Very narrow, splinter like	Broad, 2-3 times width of symplectic (male)	Very broad, at least 3 times width of symplectic	Slightly broadened, less than 2 times width of symplectic (sexually dimorphic)	Very broad, at least 3 times width of symplectic	Very narrow
Symplectic process on preopercle	Absent	Slightly developed to absent	Absent	Slightly developed to absent	Absent	Present
Lateral shelf on posttemporal (number of shelves)	Present (1 reduced)	Present (2)	Present (1)	Absent	Present (1)	Absent
Sphenotic length	Moderate	Short	Short	Short	Long, extending to vertical through posterior margin of jaw	Short
Ventral postcleithrum	Present	Present	Absent	Absent	Absent	Present
Shape of braincase in dorsal view	Circular	Circular	Circular	Circular	Elongate	Circular
Sensory papillae row b	Short, not forward of last transverse row but <i>B. eigenmanni</i>	Medium to long, extending to anterior of eye in all but <i>B. eigenmanni</i>	Very long extending almost to 1st row	Short, anterior of pupil to posterior of eye or longer	Very long extending almost to posterior of pupil	Long extending forward to under middle of eye
Sensory papillae row n	Long, continuous across dorsal midline	Long, continuous across dorsal midline or nearly so	Short, not continuous across dorsal midline	Long, continuous across dorsal midline	Long, continuous across dorsal midline	Long, nearly continuous across dorsal midline
Sensory papillae row x ¹	Not continuous	Almost continuous	Almost continuous	Continuous	Continuous	Almost continuous
Sensory papillae row d	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous
Sensory papillae transverse rows extending below d	None	None	None	None	Last transverse row	None

Venezuela, 20 July 1968; AMNH 83384, 1, 20.1 mm SL, Gulf of Mexico, 29.805°N, 86.691667°W, Florida, 29 August 1976; UF 153662, 1, 36.2 mm SL, 41 m, Gulf of Mexico, 29.75°N, 86.00°W, United States, 5 June 1974; UF 228129, 1, 23.8 mm SL, 43-46 m, Golfo Triste, N of Puerto Cabello, 10.755°N, 68.138333°W, Venezuela, 26 July 1968; UF 230139, 1, 27.8 mm SL, 150-170 m, W of Cartagena, 10.365°N, 75.788333°W, Colombia, 1 August 1968; AMNH 85997, 1, 24.75 mm SL, Gulf of Mexico, 29.5000°N, 86.418667°W, United States, 7 February 1978; AMNH 83254, 1, Gulf of Mexico, 29.90500°N, 87.11667°W, United States, 28 August 1976; YPM 3987, 1, 84 m, Gulf of Mexico, 29.117°N, 88.717°W, Louisiana, 10 April 1937, R/V *Atlantis*; YPM 3986, 4, 51 m, Gulf of Mexico, 28.317°N, 90.983°W, Louisiana, 25 March 1937, R/V *Atlantis*; YPM 3983, 4, 79 m, Gulf of Mexico, 29.117°N, 88.717°W, Louisiana, 10 April 1937, R/V *Atlantis*; YPM 3921, 3, 79 m, 29.117°N, 88.717°W, Louisiana, 10 April 1937; TCWC 6829.32, 3, 24.7-30.1 mm SL, 47.5 m, Gulf of Mexico, 29.454722°N, 88.595000°W, Mississippi and Alabama, 12 March 1988; TCWC 6829.33, 1 cleared and stained, 28.3 mm SL, 47.5 m, Gulf of Mexico, 29.454722°N, 88.595000°W, Mississippi and Alabama, 12 March 1988; GCRL V69:3460, 1, 34 mm SL, 15.41667°N, 61.20000°W, Dominica, 5 March 1966, M/V *Oregon*. GCRL V81:17057, 1, 27.6 mm SL, 68.5 m, off Port O'Conner, Gulf of Mexico, 27.83333°N, 95.66667°W, Texas, 8 September 1980, R. Mulcahy.

Diagnosis: Second dorsal fin typically I,11; anal fin I,10-12; anterior spines of first dorsal fin elongate; eye diameter 6.9-10.0% SL; upper lip with distinct dark stripe of pigment on or directly above lip; pelvic disk lightly pigmented to pale; side of

body with no distinct markings; longitudinal papillae row *b* originating at vertical through posterior margin of pupil.

Description: Body somewhat laterally compressed, depth at origin of first dorsal fin 16.0-20.0% SL; body depth at caudal peduncle typically 7.8-10% SL (two specimens reaching 10.5% SL); size to 37 cm SL.

Median and paired fins: first dorsal VII, first three spines elongate, third spine longest, sometimes reaching origin of eighth second dorsal ray when placed flat against back; second dorsal I,10(1), I,11*(12); anal I,10(6), I,11(3), I,12*(4); pectoral rays 19(2), 20(3), 21*(4), rays extending posteriorly to vertical through anus; pelvic I,5, fifth ray longest, reaching posteriorly to or just falling short of anus; pelvic fin with well-developed frenum; pelvic frenum supported with collagenous rays (Fig. 12); caudal fin lanceolate, segmented rays 16(1), 17(7), 18(1), branched rays 14(4).

Scales: trunk completely covered with ctenoid scales, ctenii becoming larger posteriorly; predorsal region, cheek, operculum, pectoral fin base and pelvic fin base with scattered cycloid scales; lateral scales 27-29; transverse scale rows 7; predorsal scales 7-9, extending anteriorly to behind eye; caudal peduncle scales 10-11; no modified basicaudal scales present.

Head: head length 25.5-32.5% SL; mouth large, angled upward approximately 20-30 degrees from horizontal; mouth reaching posteriorly to vertical through pupil; upper jaw length 12.0-14.0% SL; teeth in both jaws arranged in three rows; teeth in inner and outer rows enlarged, regularly spaced and caninoid; middle row of teeth smaller and irregularly spaced; eye diameter 7.0-10.0% SL; interorbital narrow, width less than diameter of pupil; snout short, 5.2-6.0% SL; postorbital length



Fig. 16. *Bollmannia eigenmanni*, 30.1 mm SL, Gulf of Mexico, preserved, TCWC 6829.32. Photo by L. Tornabene.

13.7-17.1% SL; gill rakers in upper arm 3-4, lower arm 9-10; gill rakers on lower limb thin and elongate, rakers on subsequent arches shorter and thicker.

Genitalia: papilla elongate and conical in males, no melanophores present; papilla short and bulbous in females.

Sensory papillae and head pores (Fig. 13C): oculoscapular pores B', C(s), D(s), E, F, G, H' present; no enclosed posterior canal present over operculum; preopercular pores M', O' present; papillae in transverse pattern, with 4-5 rows present below eye; first transverse row beginning at vertical just anterior to anterior margin of pupil; last transverse row beginning below posterior margin of eye; middle transverse rows somewhat variable, with anterior rows sometimes extending ventrally to row *d*; row *b* beginning at vertical through posterior margin of pupil and continuing posteriorly to posterior margin of preopercle; row *d* beginning slightly posteroventral of first transverse row, at vertical through anterior one-third of eye and continuing posteriorly to vertical through posterior margin of eye and sometimes slightly further posteriorly; row *n* nearly continuous across dorsal midline, stopping before pore D; row *x* sometimes broken into two segments, beginning over pore F and ultimately terminating over operculum.

Pigmentation: no fresh or recently preserved specimens of *B. eigenmanni* were available for description. The museum specimens used in this study had no prominent pigmentation on the body and fins. For the most part the general color on the body and fins of these specimens is pale or dark brown, depending on the method and quality of preservation. The only pigmentation that is apparent after prolonged preservation is the distinct dark band of pigment on or directly above the upper jaw (diagnostic for this species) and a dark spot on the posterior portion of the first dorsal fin, and, in some specimens, a small patch of melanophores at the base of the caudal fin.

Habitat: Some specimens in this study were taken over muddy bottoms. It has been collected at depths of 36.5-170.0 m.

Distribution: *Bollmannia eigenmanni* is fairly uncommon in collections and is primarily known from the Florida Keys (type locality) and throughout the Gulf of Mexico, where it has been collected in trawls with *B. communis*. Records also exist from Venezuela. A single specimen from Dominica was previously identified as *B. eigenmanni* by C. E.

Dawson, however, this record is questionable (see Remarks below).

Remarks: When describing *B. litura*, Ginsburg (1935) noted that specimens of *B. eigenmanni* were not available for comparison, thus he was forced to rely on the original description of *B. eigenmanni* for comparison of the two species. In an unpublished manuscript, Ginsburg later noted that the type of *B. eigenmanni* had been lost. The *Gobius eigenmanni* holotype (USNM 231318) has since been found at USNM.

A single specimen from Dominica (GCRL 69:3460) was identified by C. E. Dawson as *B. eigenmanni*, likely due to the second dorsal and anal fin counts (I,11 and I,12 respectively), elongate first dorsal spines and a faint area of pigment above the upper jaw, which is restricted to the very tip of the snout on this specimen. There is no pigment on the remainder of the upper jaw. When compared with other *B. eigenmanni* this specimen has more pectoral rays (22) and gill rakers on the lower arm of the first arch (12) and also has a slightly shorter jaw, larger eye and shorter postorbital length. In addition, there are 3 pores in the preopercular canal series, whereas all other *B. eigenmanni* have two. For these reasons we do not consider this specimen to be *B. eigenmanni*. The identity of this specimen remains unclear and additional specimens are needed to clarify what species occurs in Dominica.

Comparisons: *Bollmannia eigenmanni* is the most distinctive species of western Atlantic *Bollmannia*. It differs from all other genera in having 2 pores in the preopercular series (M', O') versus having 3 (M', N, O'), a trait that Ginsburg (unpublished manuscript) used to separate *B. eigenmanni* into its own subgenus. Longitudinal papilla row *b* originates at a vertical through the posterior margin of the pupil in *B. eigenmanni*, whereas row *b* originates more anteriorly in the other Atlantic species. *Bollmannia eigenmanni* can also be distinguished from its Atlantic congeners by possessing a distinct dark stripe of pigment on or directly above the upper jaw and in having a shallower caudal peduncle (typically 7.8-10% SL in *B. eigenmanni*, with two specimens reaching 10.5% SL, vs. typically >10% SL in other species). It further differs from *B. communis* in averaging fewer rays in the second dorsal and anal fins (I,10-12, in *B. eigenmanni* vs. I,12-14 in *B. communis*) and from *B. boqueronensis* in having prolonged first dorsal spines.

***Bollmannia litura* Ginsburg, 1935**

Citrine goby (Figs 13A, 17)

Bollmannia litura Ginsburg, in Ginsburg 1939: 1, Pl. 1 (type locality Samaná Bay, Dominican Republic).

Materials examined: USNM 93797, holotype, 1 male, 38.4 mm SL, 33-35 m, Caroline station 59, Samana Bay, 19.175°, -69.509°, Dominican Republic, 16 February 1933; USNM 116365, 2 females, 35.9-38.5 mm SL, 31 m, Caroline station 59, Samana Bay, 19.170°N, 69.451°W, Dominican Republic, 16 February 1933; UF 141435, 4 of 14, 40.4-55.8 mm SL, 33-35 m, Gulf of Venezuela, Venezuela, 27 July 1968; AMNH 248373, 1, Portobello, 09.68319°N, 79.61935°W, Panama, 1 June 2007, Robertson et al.; AMNH 253410, 6 females, 2 males, 31.3-43.4 mm SL, 31.5 m, JVT-04-283, Bocas del Toro, 09.005367°N, 81.97682°W, Panama, 6 June 2004, Robertson et al.; AMNH 253411, 3 females, 7 males plus 1 male cleared and stained, 33.4-44.0 mm SL, 34.2 m, JVT-04-284, Bocas del Toro, 09.005367°N, 81.97682°W, Panama, 6 June 2004, Robertson et al.; UF 172809, 1, 53-54 m, Caribbean Sea, Colombia, 11 July 1966; USNM 338585, 1 female, field number IU 8849, St. Lucia; UF 141435, 15 of 16, 33-35 m, Golfo de Venezuela, PIL 762, Venezuela, 27 July 1968; UF141434, 10, 55-64 m, Cordoba, PIL 362, Colombia, 12 July 1966; UF 228131, 75, 19.3-41.5 mm SL, 12.8 m, NE of Cabo Res Puntas, 16.02500°N, 88.70833°W, Guatemala, 19 March 1968; UF 226730, 4 (labeled as 5), 25.0-49.3 mm SL, 18 m, Golfo de Morrosquillo, 09.59500°N, 75.62666°W, Colombia, 13 January 1966; UF 230660, 31 (labeled as 30), 26.5-57.4 mm SL, 35 m, Caribbean Sea, 1186667°N, 70.366667°W,

Venezuela, 27 July 1968; AMNH 253412, 1, 32.6 mm SL, 25.2 m, JVT-04-280, Bocas del Toro, Panama, 2004, Robertson et al.; UF 223880, 2, 22.2-35.3 mm SL, 36 m, Golfo de Morrosquillo, 09.52000°N, 75.68500°W, Colombia, 13 July 1966; UF 230134, 1, 41.3 mm SL, 60-66 m, off Cartagene, 10.34500°N, 75.65167°W, Colombia, 1 August 1968; UF 223967, 8 of 14 (2 cleared and stained removed under same number), 28.5-48.3 mm SL, 60-71 m, Caribbean Sea, station PIL 723, Venezuela, 21 July 1968; AMNH 253413, JVT-04-282, 1, 35.5 mm SL, 20.7 m, JVT-04-282, Bocas del Toro, Laguna de Chiriquí, 8.9755°N, 81.94413°W, Panama, 6 June 2004, Robertson et al.

Diagnosis: Second dorsal fin typically I,11 or I,12; anal fin typically I,11 or I,12; eye diameter 10.0-12.2% SL (9.5% in two specimens); middle spines of first dorsal fin elongate in some specimens; first and second dorsal fins with dark circles or ellipses with orange or yellow centers (centers pale in preservation); upper lip lightly pigmented to pale, no dark stripe above upper lip; pelvic disk heavily pigmented to black; body with 4-5 dark brown blotches along lateral midline; blotches very rarely connected to one another by narrow stripe of lighter pigment; longitudinal papilla row *b* beginning at vertical through anterior margin of pupil.

Description: Body and head somewhat laterally compressed, depth at origin of first dorsal fin 21.8-23.4% SL; least depth of caudal peduncle 10.0-12.0% SL; size to 57.4 mm SL.

Median and paired fins: first dorsal VII, middle spines slightly elongate in some specimens, fourth spine reaching posteriorly to base of fifth to seventh ray of second dorsal fin with placed flat along back, fifth and sixth spines somewhat shorter, typically not reaching beyond base of fourth ray of second dorsal fin when placed flat along back;



Fig. 17. *Bollmannia litura*, 35.5 mm SL, Bocas del Toro, Panama, AMNH 253413. Photo by J. Van Tassell, editing by L. Tornabene.

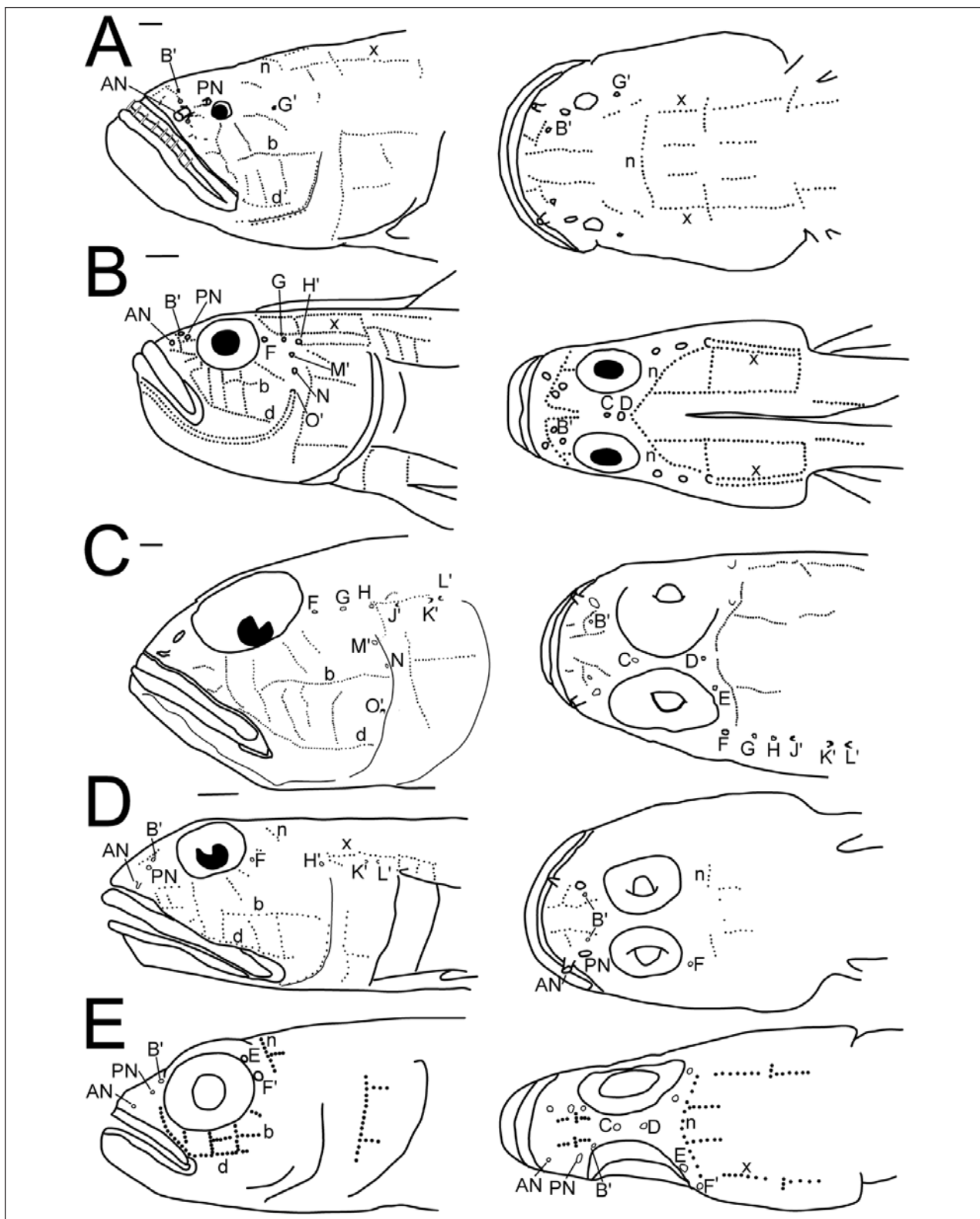


Fig. 18A-E. Sensory papillae and head canal pores patterns for type species of *Microgobius* group genera; A. *Akko brevis*; B. *Microgobius signatus*; C. *Bollmannia chlamydes*; D. *Parrella maxillaris*; E. *Palatogobius paradoxus*. Abbreviations – AN, anterior naris; PN, posterior naris. Drawings A,C-E by J. Van Tassell, B modified from Birdsong (1981).

second dorsal I,11(17), I,12(36), I,13*(1); anal I,10(1), I,11(13), I,12(41), I,13*(1); pectoral rays 18(1), 19(1), 20(5), 21(4), 22*(2), 23(2), reaching posteriorly to vertical through anus; pelvic I,5*(10), fifth ray longest, extending posteriorly to or just falling short of anus; pelvic fin with well-developed frenum; pelvic frenum supported with collagenous rays (Fig. 12); caudal fin lanceolate, segmented rays 16(3),17*(10), branched rays 13*(3), 14(10).

Scales: trunk completely covered with ctenoid scales, ctenii becoming larger posteriorly; predorsal region, cheek, operculum, pectoral fin base and pelvic fin base with scattered cycloid scales; lateral scale rows 24-28; transverse scale rows 6-7; predorsal scales 7-9, scales extending anteriorly to vertical behind eye; caudal peduncle scales 11-12; and no modified basicaudal scales present.

Head: head length 31.0-33.5% SL; mouth large, angled upward approximately 20-30 degrees from horizontal; mouth extending posteriorly to vertical through pupil; upper jaw length 13.0-15.0% SL; teeth in both jaws arranged in three rows; inner and outer rows of teeth enlarged and caninoid; middle row of teeth smaller than other rows and irregularly spaced; eye large, 10.0-12.2 (9.5 in two specimens) % SL; interorbital narrow, width less than diameter of pupil; snout length 5.5-7.8% SL; postorbital length 12.6-16.0% SL; gill rakers on lower arm 10*(5), upper arm 3*(5); gill rakers on lower first arch thin and elongate, rakers on subsequent arches shorter and thicker.

Genitalia: papilla elongate and conical in males, occasionally with melanophores on lateral edges; papilla short and bulbous in females.

Sensory papillae and head pores (Fig. 13A): oculoscapular pores B', C(s), D(s), E, F, G, H, J' and K', L' present; anterior canal terminating posterior to H in a pore herein termed J', which may not be homologous with J *sensu* Akihito (1984); preopercular pores M', N, O' present; papillae in transverse pattern, with 4-5 transverse rows present below eye; first transverse row beginning below anterior margin of eye; last transverse row beginning below and slightly behind posterior margin of pupil; middle transverse rows highly variable, often differing on each side of head of a single individual, frequently broken and sometimes extending below longitudinal row *b*; row *b* beginning at vertical through anterior margin of pupil, continuing posteriorly to vertical through posterior margin of eye, sometimes slightly further; row *d* beginning

slightly posteroventral of termination of first transverse row, at vertical through anterior one-third of eye and continuing posteriorly to below posterior margin of eye, sometimes slightly further; row *n* continuous across dorsal midline; row *x* beginning at ventral termination of row *n* and continuing posteriorly to above pore L'.

Pigmentation: following description based on recently collected specimens or preserved specimens with well-preserved pigmentation. Overall body background color pale; body with 4-5 faint brown blotches along lateral midline, most conspicuous at base of caudal fin; blotches never connected by slightly lighter horizontal stripe of pigment along lateral midline; abdomen and gular regions pale; in life, head often with bright orange markings vertically on preoperculum and operculum and horizontal orange stripes on upper and lower jaws; dorsal fins with distinct circles or ellipses with dark margins and bright yellow or orange centers in life, with yellow and orange becoming pale in preservation; posterior portion of first dorsal fin with distinct black spot ranging in size from as small as pupil to as large as eye; anal fin nearly pale, in life with 1-2 yellowish orange stripes continuing onto lower half of caudal fin; pelvic fin heavily pigmented, considerably darker than other fins; upper half of caudal fin pigmented with ellipses similar to dorsal fins; lower half of caudal fin with two yellowish orange diagonal stripes in life, stripes fading in preservation; pectoral fin base pale; pectoral rays lightly pigmented, appearing dusky to pale.

Habitat: Occurs at depths of 12.8-71.0 m. Specimens in this study from Panama were collected over mud, mixed mud, shell and leaf litter bottoms.

Distribution: This species has been recorded from Dominican Republic, Venezuela, Panama, Colombia, Guatemala, St. Lucia and also may occur off Puerto Rico (see Remarks on *B. communis* above).

Remarks: The description of *B. litura* (Ginsburg 1935) states that *B. litura* differs from western Atlantic congeners primarily in numbers of second dorsal and anal fin elements. The species is described as having one spine and 11 rays in the second dorsal and anal fins, however, the specimen cataloged as the holotype (USNM 93797) has one spine and 13 rays in both fins. In addition to the differences in dorsal and anal fin elements, there are also discrepancies between the holotype and the description in eye diameter, body depth at the caudal peduncle, maximum body depth, least depth of

caudal peduncle, depth and width of head at the posterior margin of the eye and in the length of the caudal fin, which, along with nearly every other fin, was in poor condition in the holotype when we examined it. The number of pectoral rays is also higher in the holotype than in the description (22 vs. 20), although the fins are heavily damaged and it was difficult to count the rays in the dorsalmost and ventralmost parts of the fin. The standard length, head length, predorsal distance and postorbital length were similar in the description and the holotype. Only one specimen of *B. litura* was known at the time of description; however, a second pair of *Bollmannia litura* (USNM 116365) was collected during the same expedition in which the holotype was collected, less than 5 miles from the type locality (Samana Bay, Dominican Republic) at similar depths (~20-30 m). These specimens were later identified as *B. litura* by Ginsburg and were included in notes from one of Ginsburg's unpublished manuscripts, making a total of three *B. litura* specimens analyzed by Ginsburg. One specimen (38.5 mm SL female) from USNM 116365 has counts of I,11 in both the second dorsal and anal fin and the second specimen (35.9 mm SL female) has counts of I,12 in both fins. Similar discrepancies in morphometrics were noted in the two USNM 116365 specimens, as the standard lengths, head lengths, and post orbital lengths measured in this study were similar to those recorded in Ginsburg's notes, but other features measured in this study were smaller than those recorded in Ginsburg's notes.

The differences in eye, depth and width measurements between Ginsburg's observations and ours may be due to specimen shrinkage over time, mainly in width and depth relative to length. But shrinkage cannot account for the discrepancies in counts of anal fin and second dorsal fin elements, the most notable inconsistency between the original description and the holotype. Ginsburg may have miscounted the fin and recorded the incorrect counts in the description as well as in his unpublished records. Alternatively, it is possible that at some point the holotype was switched with another specimen, with the original holotype now being lost. One reason for the former option being unlikely is Ginsburg's reputation of being meticulous and highly repetitive in his meristic counts. As noted by Myers (1976), "Ginsburg excelled in the meticulous measuring and counting of meristic characters...he demanded of himself the utmost accuracy. I have seen him spend

the morning measuring and counting the same small sample two or three times over, and then return after lunch to repeat the process on the same specimens once or twice again".

A second line of evidence supporting the scenario that the type was switched is that the description of *B. litura*, although inaccurate in its account of what now is catalogued as the holotype, is altogether quite accurate in its description of a morphologically distinctive species of *Bollmannia*. We have observed the species from multiple localities and note that several of its distinctive morphological characters were described by Ginsburg himself. We consider *B. litura* a valid species. If the holotype was indeed switched with another specimen, it is unlikely that it was one of the specimens from USNM 116365, as these specimens are female, and the holotype was described as being male. The identification of the specimen currently cataloged as the *B. litura* holotype remains unclear. Counts and measurements from the cataloged holotype (USNM 93797) and the original description are compared in Table II.

Comparisons: *Bollmannia litura* is most similar to *B. communis* but can be distinguished from that species in having a larger eye (typically greater than 10% SL in *B. litura* vs. less than 10% SL in *B. communis*) and in having lower modal counts in the second dorsal and anal fins (I,11-12 for *B. litura* vs. typically I,13 for *B. communis*). It can be distinguished from *B. boqueronensis* by lacking tan or brown stripes on the dorsal fins and brown blotches along the lateral midline. *Bollmannia litura* also typically has yellow or orange (pale in preservation) stripes and ellipses on the dorsal that are lacking in *B. boqueronensis*, and it has a much darker pelvic fin than *B. boqueronensis*. *Bollmannia litura* differs from *B. eigenmanni* in having three pores on the preoperculum (M', N, O') vs. having two (M', O'), having a dark pelvic fin (vs. a pale pelvic fin), lacking a distinct black stripe on or above the upper jaw (stripe present in *B. eigenmanni*), having longitudinal papillae row *b* originating at a vertical through the anterior margin of the eye (originating more posteriorly in *B. eigenmanni*) and in having a deeper caudal peduncle (10.0-12.0% SL vs. 7.8-10.0% SL).

Etymology: The common name of "citrine goby" is given in reference to the bright yellowish-orange spots on the dorsal and caudal fins of this species, which are reminiscent of the yellow-orange colored gemstone citrine.

Key to genera and species of the *Microgobius* group of the Gobiomatini (Atlantic species only)

Below is an artificial identification key to the Atlantic species of the genera *Akko*, *Bollmannia*, *Antilligobius*, *Microgobius*, *Palatogobius* and *Parrella*. The characters used in the generic key do not necessarily apply to eastern Pacific members of the genus. The key to western Atlantic *Microgobius* is modified from Birdsong (1981) and the characters used in the key to *Palatogobius* are from Greenfield (2002).

- 1a) Second dorsal fin and anal fin confluent with caudal fin..... *Akko* (*A. dionea*)
- 1b) Second dorsal fin and anal fin distinctly separate from caudal fin..... 2
- 2a) Vomerine teeth present; pelvic fin narrow, lacking a well-developed frenum; preopercular canal pores absent..... *Palatogobius*
- 2b) Vomerine teeth absent; pelvic fin rounded or oval, with a well-developed frenum; preopercular canal pores present or absent 3
- 3a) Top of head naked; second dorsal typically I,14-17..... *Microgobius*
- 3b) Top of head scaled; second dorsal typically I,11-13, rarely I,14..... 4
- 4a) Preopercular canal pores absent, head dorsoventrally depressed, pelvic fin round..... *Parrella* (*P. macropteryx*)
- 4b) Preopercular canal pores present, head laterally compressed, pelvic fin oval..... 5
- 5a) Dorsal spines 1-4 greatly elongate, longest spine reaching to or extending beyond posterior margin of second dorsal fin when depressed; body with distinct broad yellow band along lateral midline (white in preservation); pelvic frenum with smooth posterior margin, frenum lacking thickened collagenous supports..... *Antilligobius* (*A. nikkiae*)
- 5b) Dorsal spines 1-4 may or may not be elongate, but never extending to posterior margin of anal fin when depressed; body not pigmented as stated above; pelvic frenum with scalloped margin, frenum supported with collagenous thickenings (Fig. 12)..... *Bollmannia*

Key to Atlantic species of *Palatogobius* (characters from Greenfield 2002)

- 1a) Eye 9.7-11.3% SL; interorbital 1.6-1.9% SL; snout 3.1-3.9% SL; pectoral rays 21 *P. grandoculus*

- 1b) Eye 7.4-8.7% SL; interorbital 3.2-4.6% SL; snout 5.8-7.8% SL; pectoral rays typically 19 (sometimes 18 or 20)..... *P. paradoxus*

Key to Atlantic species of *Microgobius* (modified from Birdsong 1981)

- 1a. Three pores in preopercular sensory canal; second dorsal fin elements typically I,17 or more; anal fin elements typically I,18 or more; great than 65 lateral scale rows 2
- 1b. Two pores in preopercular sensory canal; second dorsal fin elements typically I,16 or less; anal fin elements I,17 or less; fewer than 65 lateral scale rows..... 3
- 2a. Soft dorsal-fin elements I,19-20; anal fin elements I,20 (occasionally I,19); lateral scale rows about 77-90; scales mostly cycloid; females with pale bar edged in black on body above pectoral fin..... *M. signatus*
- 2b. Soft dorsal fin elements I,17-18; anal fin elements I,18 (occasionally I,19); lateral scale rows 68-78; scales mostly ctenoid; no dark markings on body in either sex *M. microlepis*
- 3a. A fleshy median crest present on nape; a prominent dark spot on body below spinous dorsal fin origin; caudal fin usually greater than 40% of SL..... *M. meeki*
- 3b. Fleshy median crest absent or poorly developed on nape; body with no dark spot below spinous dorsal origin or with many dark spots; caudal fin usually less than 40% of SL..... 4
- 4a. Scales mostly ctenoid; about 4 enlarged caninoid teeth in outer row of each dentary; interorbital width broad (about 4% SL); a broad yellow stripe on side with 2 narrow yellow stripes above..... *M. carri*
- 4b. Scales mostly cycloid; about 8 enlarged caninoid teeth in outer row of each dentary; interorbital width narrow (less than 3% SL); no yellow stripe on body..... 5
- 5a. Three pores in lateral cephalic sensory canal; body with numerous dark blotches; mouth of males greatly enlarged (greater than 15% SL in males larger than 25 mm) *M. gulosus*
- 5b. Two pores in lateral cephalic sensory canal; body without dark spots; mouth of males little enlarged (less than 15% SL in males) *M. thalassinus*

Key to the Atlantic species of *Bollmannia*

- 1a) Upper jaw with distinct black stripe of pigment on or above upper lip; sensory lateralis canal on posterior margin of preopercle with 2 pores (M', O' – Fig. 13C); longitudinal papillae row *b* originating at vertical through posterior margin of pupil..... *B. eigenmanni*
- 1b) Upper jaw dusky or lacking pigment completely; sensory lateralis canal on posterior margin of preopercle with 3 pores (M', N, O' – Fig. 13A, B, D); longitudinal papillae row *b* originating at vertical through anterior margin of pupil..... 2
- 2a) Pelvic fin lightly pigmented to pale; dorsal fins with 3-4 light brown to tan longitudinal stripes often continuing onto caudal fin; lateral midline of body with 4-5 brown blotches often connected with a slightly lighter horizontal stripe of pigment..... *B. boqueronensis*
- 2b) Pelvic fin heavily pigmented to black; dorsal fins and upper half of caudal fin with dark ellipses with bright orange or yellow centers in life, center of ellipses pale in preservation; lateral midline of body with 4-5 faint brown blotches that are rarely connected by horizontal stripe of pigment..... 3
- 3a) Eye diameter greater than 10% SL; second dorsal and anal fin elements typically I,11-12 (rarely I,13) *B. litura*
- 3b) Eye diameter less than 10% SL; second dorsal and anal fin elements typically I,13 (occasionally I,12 or I,14 in either the second dorsal or anal, but rarely in both) *B. communis*

Comments on the tribe Gobiosomatini

(Materials examined listed in Appendix I)

Birdsong (1975) first proposed the tribe Gobiosomatini (see Smith & Baldwin (1999)) for discussion on spelling of tribe name) as a monophyletic assemblage to include 19 genera of New World gobiids based on the presence of the following characters: (1) vertebral count of 11 precaudal, 16-17 caudal; (2) first dorsal pterygiophore pattern of 3(221110); (3) scapula unossified; and (4) first 2 anal pterygiophores inserted anterior to the first haemal arch. Several of the sponge-dwelling genera do not possess those characters but were included based on previously suggested relationships (Böhlke & Robins 1969; Böhlke 1969) and the presence of hypural fusion in those genera and most genera within the Gobiosomatini – a character rarely found in other genera of Gobiiformes. The

tribe was later separated into the *Gobiosoma* and *Microgobius* groups (Birdsong et al. 1988). The *Gobiosoma* group is united based on: (1) fusion of hypurals 1-2 with 3-4 and the terminal vertebral element; (2) dorsal pterygiophore pattern of 3(221110); (3) vertebral counts of 11 precaudal and 16-17 caudal vertebrae; (4) one epural; and (5) two anal pterygiophores anterior to the first haemal arch. The *Microgobius* group lacks hypural fusion and possesses the remainder of characters uniting the Gobiosoma group. The genera *Robinsichthys* Birdsong, 1988, *Akko* Birdsong & Robins, 1995 and *Ophiogobius* Gill, 1863, were later added to the tribe.

Genera currently in the *Gobiosoma* group include *Aboma*, *Aruma*, *Barbulifer*, *Elacatinus*, *Chriolepis*, *Eleotrica*, *Evermannichthys*, *Ginsburgellus*, *Gobiosoma*, *Gobulus*, *Gymneleotris*, *Nes*, *Ophiogobius*, *Pariah*, *Psilotris*, *Pycnomma*, *Risor*, *Robinsichthys*, *Tigrigobius* and *Varicus*. *Aboma*, *Elacatinus* and *Tigrigobius* were included in Birdsong's genus *Gobiosoma* based on their subgeneric status as defined by either Böhlke & Robins (1969) for *Elacatinus* and *Tigrigobius* or Hoese (1971) for *Aboma*. The *Microgobius* group includes *Akko*, *Bollmannia*, *Microgobius*, *Palatogobius* and *Parrella*.

The outgroup to the Gobiosomatini is currently unknown and may be composed of more than one species (Rüber et al. 2003). Several eastern Atlantic and Mediterranean genera, namely *Odondebuena*, *Corcyrogobius*, *Vanneaugobius* and *Gorogobius* have been proposed as possible outgroups (Miller & Tortonese 1969; Miller 1972, 1978; Van Tassell et al. 1988) along with *Egglestonichthys* and *Callogobius* from the Indo-west Pacific (Miller & Wongrat 1979) based primarily on sensory papillae patterns. The presence of modified basicaudal scales in many of the Gobiosomatini along with similar pterygiophore insertion patterns suggest an eastern Atlantic/ Mediterranean origin for the outgroup (Van Tassell et al. 1988; Birdsong 1988; Birdsong et al. 1988).

Molecular studies of the tribe have added additional support for the monophyly and proposed relationships of the tribe to eastern Atlantic and Mediterranean genera (Rüber et al. 2003; Rüber & Van Tassell, unpublished, presented in 2006). They indicate additional subgroups within the *Gobiosoma* group and areas in need of further investigation. Four subgroups can be recognized: *Barbulifer* group (*Aruma*, *Barbulifer*, *Elacatinus*, *Enypnia*, *Evermannichthys*, *Ginsburgellus*, *Gobiosoma*, *Risor*,

Tigrigobius); *Nes* group (*Nes*, *Psilotris*, *Gobulus*, *Gymneleotris*, *Pycnomma*, *Chriolepis*, *Varicus*); *Aboma*; and *Robinsichthys*. *Aboma* is sister to the *Barbulifer* Group and lacks fusion of hypural 1-2 with 3-4, adductor mandibulae 1 gamma and adductor mandibulae 2 gamma, characters present in the *Barbulifer* group (Van Tassell 1998). Most genera within the *Nes* group examined to date (*Nes*, *Psilotris*, *Gobulus*, *Gymneleotris*, *Pycnomma*, *Chriolepis*, *Varicus*) have pelvic fins that are separate to at least some extent (never with complete disks), lack adductor mandibulae 1, possess no head pores or canals, but have hypural fusion. *Aboma* and *Robinsichthys* lack hypural fusion, but this was unknown when the *Gobiosoma* Group was first proposed and their relationship to the remaining genera requires further investigation. These subgroups are used to facilitate comparisons among genera in the *Microgobius* group below.

Comments on the *Microgobius* group

The *Microgobius* group proposed by Birdsong et al. (1988) consisted of *Microgobius*, *Bollmannia*, *Parrella* and *Palatogobius*. This group was phenetically associated with the *Gobiosoma* group on the basis of a dorsal pterygiophore pattern of 3(221110), vertebral count of 11+16, one epural and two anal pterygiophores anterior to the first haemal arch. The *Microgobius* group was distinguished from the *Gobiosoma* group by lacking fusion of hypural 1-2 with 3-4 and the terminal caudal element (Birdsong et al. 1988). Birdsong & Robins (1995) added *Akko* to the Gobiosomatini, but did not comment further on relationships due to the large number of autapomorphies it possesses. Additional studies of mtDNA (Rüber et al. 2003) and morphological characters (Van Tassell & Baldwin 2004) placed *Akko* in the *Microgobius* group. Additional characters that unite the group include dorsal papillae row *n* elongate, uniting across dorsum or nearly so, a feature present in all genera except *Parrella*; caudal fin lanceolate; body laterally compressed; metapterygoid process not overlapping the quadrate; and modified basicaudal scales absent.

We place *Antilligobius nikkiae* within the *Microgobius* group of the Gobiosomatini based on the presence of the following characters: vertebrae 11+16; dorsal pterygiophore formula 3(221110); anal pterygiophores anterior to the first haemal arch 2; hypurals 1-2 and 3-4 not fused; dorsal papillae row *n* elongate, uniting across dorsum; caudal fin

lanceolate; body laterally compressed; metapterygoid process not overlapping the quadrate; and modified basicaudal scales absent. A total of 57 morphological characters, including papillae and head pore patterns (Fig. 18), are summarized for the 6 genera of the *Microgobius* group in Table III.

DISCUSSION

Antilligobius nikkiae has a number of characters not present in other genera of the *Microgobius* group that warrant its placement in a new genus. These include a very narrow, splinter-like metapterygoid; short slender gill rakers on the lower limb of the first arch; a short papillae row *b*, never extending posterior of the pupil, and the modified first haemal arch. The modified haemal arch and its elongate parapophyses, "rib-like" in appearance in lateral view, where parapophyses join ventrally to form the haemal arch, is easily confused with pleural ribs in radiographs.

The modified first haemal arch and anterior curvature of the ventral tip of the premaxilla warrant further investigation. A similar modified haemal arch occurs in several species of *Trimma*, the expanded area being utilized by the swim bladder (Winterbottom 1984, 2007). The swim bladder of *A. nikkiae* also occupies this expanded area in the specimen examined. The anterior curvature of the ventral tip of the premaxilla occurs in *Antilligobius* and several species of *Microgobius*. Birdsong (1975) observed sexually dimorphic differences in the curvature of the ventral tip of the premaxilla, with the tip curving anteriorly in females of several species of *Microgobius*. Differences were also observed between small and large-mouthed species of *Microgobius*, regardless of sex (Birdsong 1975). The significance and distribution of these characters within the Gobiosomatini and Gobiiformes awaits further studies.

Within the *Microgobius* group *Antilligobius* is most similar morphologically to *Bollmannia* and *Parrella*. *Antilligobius* shares with those genera I,11-15 elements in the second dorsal fin (I,14-20 in *Microgobius*, *Akko*, *Palatogobius*); I,10-15 elements in the anal fin (I,14-21 in *Microgobius*, *Akko*, *Palatogobius*); mostly ctenoid scales on the trunk (few ctenoid scales present in *Microgobius*, and cycloid scales present in *Palatogobius* and *Akko*); scales present on the breast, belly and pectoral fin base (no scales in *Microgobius*, *Akko*, *Palatogobius*); 21-29 scales in the lateral series (35-115 in *Microgobius* and *Akko*, 12-17 in *Palatogo-*

bius); and 6-8 transverse scale rows (19-20 in *Microgobius*, *Akko* and none in *Palatogobius*). *Antilligobius* and *Bollmannia* both possess scales on the cheek and a spatulate basihyal, features not present in the other genera. In *Parrella* sensory papillae row *n* is not continuous across the nape, whereas it is continuous or almost so in the other genera. The foramen on each anterior vertebrae of *Antilligobius* (Fig. 8C) is much larger than that in *B. litura*, *B. communis* and *B. boqueronensis*, but is similar in size to that of *B. eigenmanni*. *Parrella maxillaris* vertebrae are unlike those of *Antilligobius* and *Bollmannia* in that there are numerous small foramina on the anterior vertebrae. *Antilligobius* also lacks the collagenous supports on the pelvic frenum that are present in *Bollmannia* (Fig. 12), which may be homologous with the extensive fimbriae found on the posterior margin of the pelvic frenum of *Parrella*. *Antilligobius* also differs from *Parrella* and *Bollmannia* ecologically, as it inhabits rock-reef talus slopes while both *Bollmannia* and *Parrella* are burrow dwellers in soft mud-sand substrate.

Elongate first dorsal filaments are found in nearly all species of *Bollmannia*, variable within *Microgobius* and *Parrella* and absent in *Palatogobius*. In *Antilligobius* the first four dorsal spines are all very elongate, giving the fin a sabre-like appearance. *Microgobius*, *Bollmannia* and *Antilligobius* all possess 2-3 pores in the preopercular canal (pores absent in *Parrella maxillaris*, *Akko*, *Palatogobius*) and have a sagittal crest on the frontal bone (absent in *Parrella*, *Akko*, *Palatogobius*). The sagittal crest was considered a specialized character within the *Microgobius* group by Birdsong (1975). *Antilligobius* shares the presence of a ventral postcleithrum with *Bollmannia* and *Palatogobius*. The very narrow metapterygoid in *Antilligobius*, somewhat similar but wider in *Palatogobius*, is broad in the remaining genera.

Molecular phylogenies by Rüber et al. (2003) and Rüber & Van Tassell (unpublished, presented in 2006) suggest a sister relationship between *Antilligobius* and *Bollmannia*. Rüber et al. (2003) recovered a strongly supported clade comprising *Antilligobius* + a monophyletic group of four *Bollmannia* species. That clade is sister to a clade containing eight species of *Microgobius* and *Akko*. *Parrella* and *Palatogobius* were not included in their study. With additional species of *Microgobius* and *Parrella lucretia* incorporated in the tree, the phylogeny reconstructed by Rüber & Van Tassell (unpublished, presented in 2006) showed an identical relationship between *Bollmannia* and *Antilligobius*

(labeled as New Genus in the tree), but *Parrella lucretia* and *Akko* now formed a distinct clade sister to *Microgobius*.

While several key morphological characters support a close relationship between *Antilligobius*, *Bollmannia* and *Parrella*, the existence of other characters shared between *Antilligobius* and other *Microgobius* group genera cloud this relationship. The large number of autapomorphic specializations and losses within the group coupled with the absence of DNA sequence data for many species in the *Microgobius* group adds to the ambiguity regarding the relationships among species. A robust phylogenetic analysis of all *Microgobius* group species using morphological and molecular data will help clarify the relationships between *Antilligobius* and allied species.

Appendix I

Gobiosomatini material examined:

Akko dionaea – USNM 32524, holotype, 1, male, 78.1 mm SL, east of Isla de Maraca, Mapa Province, Brazil, 25 May 1976, Oregon II.

Akko brevis – EL-01-017 (JVT collection), 2 cleared and stained, 20.0 m, shrimp trawler, 13.159°N, 087.805°W to 13.140333°N, 087.8°W, El Salvador, J.L. Van Tassell.

Aruma histrio – CAS 79602, 1, Guaymas, 2-3 miles north of Bahia San Carlos, Mexico, 25 May 1954, C. Limbaugh.

Barbulifer pantherinus – SU 49929, 52, Ensenada San Francisco, flat reef 0.3 miles north-west of - tip of Punta de las Cuevas, Puerto San Carlos, Mexico, 6 April 1955, Dickinson et al.

Barbulifer ceuthoecus – ANSP 110660, 7, shore at International Airport, Key West, Florida, 21 March 1958, Cohen et al.

Bollmannia chlamydes – CAS 42777, 11, off Balenas Bay, Gulf of Nicoya, 9.686111°N, 84.850833°W, Costa Rica, 25 February 1938, New York Zoological Society Eastern Pacific Expedition.

Chriolepis minutillus – LACM 20148, 4, Gulf of California, Angel de la Guarda Island, Puerto Refugio, Mexico, 27 January 1940, R/V *Velero*; UF 72110, 3 plus 1 cleared and stained, Gulf of Mexico, Florida, 3 October 1970, R/V *Tursiops*.

Chriolepis vespa – UF 72110, 1 cleared and stained, Gulf of Mexico, Florida, 3 October 1970, R/V *Tursiops*.

Elacatinus horsti – UF 26237, 4, Isla de Providencia, Colombia, 29 August 1971, Gilbert and Anderson. *Elacatinus oceanops* – UF 16169, 23,

Hawk Channel, Florida Keys, Florida, 6 August 1967, Gilbert and Starck. *Elacatinus xanthiprora* – UF 24797, 2, Isla de Providencia, Colombia, western Atlantic, 30 August 1971, P. Colin.

Eleotrica cableae – USNM 278977, 47, Indefatigable Island, Galapagos Islands, 0.7647°S, 90.3414°W, 18 May 1966, H. A. Fehlmann.

Eynpnias seminudus – USNM 123641, 2 cleared and stained, Miraflores Locks, Panama Canal, Panama, 28 April 1937, S.F. Hildebrand; FMNH 8457, 1, tidepools, Panama, 24 March 1912, Meek and Hildebrand.

Evermannichthys spongicola – AMNH 82393, 3 cleared and stained, Gulf of Mexico, 25 July 1975, S. Bortone.

Ginsburgellus novemlineatus – UF 201602, 8, Bethel Channel, Andros Islands, Bahama Islands, June 1951, E.C. Jones.

Gobiosoma chiquita – SU 66911, 1 cleared and stained, 1.5 m, Outer San Carlos Bay, shore of island, Gulf of California, Mexico, 2 June 1950, Wilimovsky et al.

Gobiosoma homochroma – USNM 293555, 9, Rio Pirre above tidal zone, Darien Prov., Panama, 17 February 1985, B. Chernoff et al.

Gobiosoma longipala – GCRL 815, 26, station 896, Gulf of Mexico, Mississippi, 3 November 1960.

Gobiosoma nudum – GCRL V73:11523, 11, station 1607, Venado Beach, Pacific Panama, 4 April 1973, Dawson et al.

Gobulus hancocki – SIO61-265, 4, 18.5-25.0 mm SL, Espiritu Santo Islands, El Cardonal Cove, 24.61°N, 110.38833°W, Mexico, 23 June 1961, R/V *Orca*, B. Walker et al.

Gymneleotris seminudus – MCZ 44759, 2, Rey Island, Perlas Islands, Panama, 27 September 1964, I. Rubinoff. *Microgobius miraflorensis* – FMNH 8489, 2, Rio Culebra, Culebra, Panama, 19 March 1911, Meek and Hildebrand.

Microgobius signatus – USNM 35164, 1 of 12, Havana, Cuba; MCZ 30602, 3, Havana, Cuba, 1913, T. Barbour.

Nes longus – ANSP 133224, 2 cleared and stained, Castle Harbor, Bermuda, 10 August 1975, W. F. Smith-Vaniz.

Ophiogobius jenynsi – USNM 176505, 1, Ancud, Golo de Quatalmaue, Pullingua, Chile, 7 February 1945, M. J. Lobell.

Palatogobius grandoculus – USNM 367311, holotype, 1, male, 33.0 mm SL, off Cozumel, 20.4475°N, 87.2553°W, Mexico, 11 April 1976, Marine Biomedical Institute.

Palatogobius paradoxus – ANSP 109182, holotype, female, 25.5 mm SL, St. John, Virgin Islands, 30 June 1961, J.E. Randall; UF 163509, 2, Gulf of Mexico, 29.833333°N, 86.108333°W, Florida, 20 July 1975, SA Bortone and Nester; UF 148027, 7, Gulf of Mexico, 29.933°N, 86.1°W, USA, 3 June 1974, R/V *Mafla*.

Pariah scotius – AMNH 26096, 3, Conception Island, Bahamas, 6 March 1966, C.L. Smith.

Parrella macropteryx – UF 167272, cleared and stained, PIL751 Field number, Caribbean Sea, Venezuela, 26 July 1968; UF 223879, 1, 36 m, Caribbean Sea, 9.52°N, 75.685°W, Colombia, 13 July 1966, R/V *Pilsbury*.

Parrella maxillaris – USNM 119901, Paratype, 1, La Paz Bay, Gulf of California, Mexico, 21 February 1936, Hancock Expedition; USNM 322735, 82, Punta San Ignacio, Sonora, 25° 35' N, 110°, 25°W, Mexico, 19 June 1990, G. Allen and D. Robertson; UF 167275, 22.9mm SL, 1 female, cleared and stained, 22-25 m, 7 miles north of Manta, bearing 270 deg, along 20 fm curve, 0.716667°S, 80.683333°W, Ecuador, 1 October 1961, R/V *Argosy*.

Robinsichthys arrowsmithensis – UF 234392, paratype, 1 female, cleared and stained, 23.5 mm SL, 242-320 m, Quintana Roo, station 893, 21.166667°N 86.35°N, Mexico, 10 Sept 1967, R/V *Gerda*.

Tigrigobius dilepis – UF 14032, 2, Exuma Sound, Exuma Cays, Bahama Islands, 29 August 1966, C.R. Gilbert. *Tigrigobius gemmatum* – AMNH 26076, 6, cleared and stained, Hog Cay, Ragged Islands, Bahamas, 9 July 1965, C. L. Smith & H. Tischler.

Tigrigobius janssi – LACM 32524-45, 1, Bahia Herradura, at tip of outer reef on N side of bay, Costa Rica, 9 March 1972, Bussing et al.

Tigrigobius macrodon – ANSP 147847, 36, 11.9-21.5 mm, Baileys Bay, Bermuda, 23 July 1981, W. F. Smith-Vaniz et al.

ACKNOWLEDGEMENTS

Thanks to D. Ross Robertson, Ben Victor, and Ernesto A. Peña E. along with the crew of the RV *Urraca* (Smithsonian Tropical Research Institute) for their aid in obtaining the *Bollmannia litura* specimens. Frank Pezold provided valuable comments throughout this study. Funding for collections in Panama was provided by Smithsonian Tropical Research Institute to D. Ross Robertson. B. Brown and R. Arrindell at AMNH, M. S. Pérez

at ANSP, S. LeCroy at GCRL, K. Conway and H. Prestridge at Texas A&M University – College Station, R. Robins at UF, M. Craig at UPRM, J. Williams, D. Pitassy and S. Raredon at USNM, and D. Skelly at YPM provided assistance with museum specimens. G. D. Johnson provided assistance with digital photography of cleared and stained specimen and helpful discussions on osteology. D. Smith provided assistance with unpublished Ginsburg material at USNM. C. Baldwin provided photographs of *Antilligobius* habitat. F. Young provided habitat information for *Antilligobius* specimens in Curaçao. A. Schrier provided critical comments, photographs and specimens of *Antilligobius*. R. G. Gilmore provided the specimen from Cuba, illustrations and detailed records of *Antilligobius* from Cuba and other localities.

REFERENCES

- AKIHITO, P., HAYASHI, M. & YOSHINO, T. 1984. Suborder Gobioidae. In: *The Fishes of the Japanese Archipelago*. (Ed. K. Masuda, C. Amaoka, C. Araga, Y. Uyeno and T. Yoshino.): 236-289. Tokai University Press, Tokyo.
- BIRDSONG, R. S. 1975. The osteology of *Microgobius signatus* Poey (Pisces: Gobiidae), with comments on other gobiid fishes. *Bulletin of the Florida State Museum, Biological Sciences* **19**: 135-187.
- BIRDSONG, R. S. 1981. A review of the gobiid fish genus *Microgobius* Poey. *Bulletin of Marine Science* **31**: 267-306.
- BIRDSONG, R. S. 1988. *Robinsichthys arrowsmithensis*, a new genus and species of deep-dwelling gobiid fish from the western Caribbean. *Proceedings of the Biological Society of Washington* **101**: 438-443.
- BIRDSONG, R. S., MURDY, E. O. & PEZOLD, F. L. 1988. A study of the vertebral column and median fin osteology in gobioid fishes with comments on gobioid relationships. *Bulletin of Marine Science* **42**: 174-214.
- BIRDSONG, R. S. & ROBINS, C. R. 1995. New genus and species of seven-spined goby (Gobiidae: Gobiomini) from the offing of the Amazona River, Brazil. *Copeia* **1995**: 676-683.
- BEDENBOURGH, R. L. 1988. A review of the Pacific members of the gobiid fish genus *Bollmannia* Jordan. Unpublished MS thesis, Old Dominion University. 56 pp.
- BÖHLKE, J. 1969. *Pariah scotius*, a new sponge-dwelling gobiid fish from the Bahamas. *Notulae Naturae* **421**: 1-7.
- BÖHLKE, J. E. & ROBINS, C. R. 1968. Western Atlantic seven-spined gobies, with descriptions of ten new species and a new genus, and comments on Pacific relatives. *Proceedings of the Academy of Natural Sciences of Philadelphia* **120**: 45-174.
- BÖHLKE, J. E. & ROBINS, C. R. 1969. Western Atlantic sponge-dwelling gobies of the genus *Evermannichthys*: their taxonomy, habits and relationships. *Proceedings of the Academy of Natural Sciences of Philadelphia* **121**: 1-24.
- COLIN, P. L. 1974. Observations and collection of deep-reef fishes off the coasts of Jamaica and British Honduras (Belize). *Marine Biology* **24**: 29-38.
- DENNIS, G., HENSLEY, D., COLIN, P. L. & KIMMEL, J. 2004. New records of marine fishes from the Puerto Rican Plateau. *Caribbean Journal of Science* **40**: 70-87.
- DINGERKUS, G. & UHLER, L. 1977. Enzyme clearing of alcian blue stained whole small vertebrates for demonstration of cartilage. *Stain Technology* **52**: 229-232.
- ESCHMEYER, W. 2011. Catalog of Fishes, electronic version (5 January 2011). <http://research.calacademy.org/ichthyology/catalog/fishcatmain.asp>.
- EVERMANN, B. & MARSH, M. 1899. Descriptions of new genera and species of fishes from Puerto Rico. *Report of the United States Fish Commission* **25**: 351-362.
- FOWLER, H. 1941. Notes on Florida fishes with descriptions of seven new species. *Proceedings of the Academy of Natural Sciences of Philadelphia* **93**: 81-106.
- GARMAN, S. 1896. Report on the fishes collected by the Bahama Expedition, of the State University of Iowa, under Professor C. C. Nutting, in 1893. *Bulletin of the Laboratory of Natural Science University of Iowa* **4**: 76-93.
- GINSBURG, I. 1935. *Bollmannia litura*, a new species of goby. *Smithsonian Miscellaneous Collections* **91**: 1-3.
- GINSBURG, I. 1939. Twenty one new American gobies. *Journal of the Washington Academy of Sciences* **29**: 51-63.
- GINSBURG, I. 1942. Seven new American fishes. *Journal of the Washington Academy of Sciences* **32**: 364-370.
- GREENFIELD, D. W. 2002. *Palatogobius grandoculus*: a new deep-water western Caribbean goby (Teleostei: Gobiidae). *Copeia* **2002**: 716-718.
- HOESE, D. F. 1971. A revision of the eastern Pacific species of the gobiid genus *Gobiosoma*, with a discussion of the relationships of the genus. Unpublished PhD Thesis, University of California, San Diego. 213 pp.
- HUMANN, P. & DELOACH, N. 2002. *Reef Fish Identification: Florida, Caribbean, Bahamas*. New World Publications, Jacksonville, 267.
- JORDAN, D. & BOLLMAN, C. 1890. Descriptions of new species of fishes collected at the Galapagos Islands and along the coast of the United States of Colombia, 1887-88. *Proceedings of the United States National Museum* **12**: 149-183.
- MCEACHRAN, J. & FECHHELM, J. 2005. *Fishes of the Gulf of Mexico. Volume 2: Scorpaeniformes to Tetraodontiformes*. University of Texas Press, Austin, 1004.
- MILLER, P. J. 1972. Generic status and redescription of the Mediterranean fish *Gobius liechtensteini* Kolombatovic, 1891 (Teleostei: Gobiidae), and its affinities with certain American and Indo-Pacific gobies. *Journal of Natural History* **6**: 395-407.
- MILLER, P. J. 1978. The status of the West African fish *Gobius nigrincinctus* with reference to New World autochthones and an Old World colour-analogue. *Zoological Journal of the Linnean Society* **64**: 27-39.
- MILLER, P. J. & TORTONESE, E. 1969. Distribution and systematics of the gobiid fish *Odondebuena balearica* (Pellegrin Frage). *Annali del Museo civico di storia natural Giacomo Doria* **77**: 342-359.

- MILLER, P. J. & WONGRAT, P. 1979. A new goby (Teleostei: Gobiidae) from the South China Sea and its significance for gobioid classification. *Zoological Journal of the Linnean Society* **67**: 239-257.
- MORENO-MENDOZA, R., GONZALEZ-SALAS, C., AGUILAR-PERERA, A., GALLARDO-TORRES, A. & SIMOES, N. 2011. First record of the white-eye goby, *Bollmannia boqueronensis* (Teleostei: Perciformes: Gobiidae) along the coast of the Yucatan Peninsula (Gulf of Mexico). *Marine Biodiversity Records* **4**: 1-4.
- MURDY, E. & HOESE, D. 2003. Gobiidae. In: *The living marine resources of the Western Central Atlantic. Bony fishes part 2 (Opistognathida to Molidae). FAO species identification guide for fishery purposes and American Society of Ichthyologists and Herpetologists Special Publication No. 5*. (Ed. K. Carpenter.): 1781-1796. FAO, Rome.
- MYERS, G. S. 1976. Isaac Ginsburg. *Copeia* **1796**: 217-219.
- NELSON, J., CROSSMAN, E., ESPINOSA-PÉREZ, H., FINDLEY, L., GILBERT, C., LEA, R. & WILLIAMS, J. 2004. *Common and Scientific Names of Fishes from the United States, Canada, and Mexico*. American Fisheries Society, Special Publication 29, Bethesda, 386.
- PEZOLD, F. 1993. Evidence for a monophyletic Gobiinae. *Copeia* **3**: 634-643.
- ROBINS, C. & RAY, G. 1986. *A Field Guide to Atlantic Coast Fishes of North America*. Houghton Mifflin Company, Boston, 368 pp.
- RÜBER, L. & VAN TASSELL, J. L. 2006. Small fish in a big clade: a molecular perspective on gobioid phylogeny. *Presented at Joint Meeting of Ichthyologists and Herpetologists*, July, 2006, New Orleans.
- RÜBER, L., VAN TASSELL, J. L. & ZARDOYA, R. 2003. Rapid speciation and ecological divergence in the American seven spined gobies (Gobiidae: Gobiosomatini) inferred from a molecular phylogeny. *Evolution* **57**: 1584-1598.
- SABAJ PÉREZ, M. 2010. Standard symbolic codes for institutional resource collections in herpetology and ichthyology: an Online Reference. Version 1.5 (4 October 2010). Electronically accessible at <http://www.asih.org/>. American Society of Ichthyologists and Herpetologists, Washington D.C.
- SANZO, L. 1911. Distribuzione delle papille cutanee (organi ciatiformi) e suo valore sistematico nei Gobi. *Mitteilungen aus der Zoologischen Station zu Neapel* **20**: 249-328.
- SARUWATARI, T., LOPEZ, J. A. & PIETSCH, T. W. 1997. Cyanine blue: a versatile and harmless stain for specimen observations. *Copeia* **1997**: 840-841.
- SMITH, C. L. 1997. *National Audubon Society Field Guide to Tropical Marine Fishes: Caribbean, Gulf of Mexico, Florida, Bahamas, Bermuda*. Alfred A. Knopf, New York. 720 pp.
- SMITH, D. G. & BALDWIN, C. C. 1999. *Psilotris amblyrhynchus*, a new seven-spined goby (Teleostei: Gobiidae) from Belize, with notes on settlement-stage larvae. *Proceedings of the Biological Society of Washington* **112**: 433-442.
- THACKER, C. E. 2003. Molecular phylogeny of the gobioid fishes (Teleostei: Perciformes: Gobioidei). *Molecular Phylogenetics and Evolution* **26**: 354-368.
- THACKER, C. E. & HARDMAN, M. 2005. Molecular phylogeny of basal gobioid fishes: Rhyacichthyidae, Odontobutidae, Xenisthmidae, Eleotridae (Teleostei: Perciformes: Gobioidei). *Molecular Phylogenetics and Evolution* **37**: 858-871.
- VAN TASSELL, J. L. 1998. Phylogenetic relationships of species within the gobiid genus *Gobiosoma* sensu Böhlke and Robins (1968) with comments on their relationships to other genera in the tribe Gobiosomini. PhD Dissertation, City University of New York Graduate Center, 283 pp.
- VAN TASSELL, J. L. & BALDWIN, C. C. 2004. A review of the gobiid genus *Akko* (Teleostei: Gobiidae) with description of a new species. *Zootaxa* **462**: 1-15.
- VAN TASSELL, J. L., MILLER, P. J. & BRITO, A. 1988. A revision of *Vanneaugobius* (Teleostei: Gobiidae), with description of a new species. *Journal of Natural History* **22**: 545-567.
- WINTERBOTTOM, R. 1984. A review of the gobiid fish genus *Trimma* from the Chagos Archipelago, central Indian Ocean, with description of seven new species. *Canadian Journal of Zoology* **62**: 695-715.
- WINTERBOTTOM, R. 2007. Three new species of genus *Trimma* from Palau, western Pacific (Percomorpha: Gobiidae). *International Journal of Ichthyology* **13** (1): 1-25.