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Status of *Gobiosoma* (Teleostei: Gobiidae) from Brazil: description of a new species, redescription of *G. hemigymnum*, molecular phylogeny of the genus, and key to Atlantic species

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Abstract

It is unclear how many species of *Gobiosoma* occur in Brazil and what their geographic distributions are. Here we combine data from a comprehensive morphological survey and a molecular analysis to clarify this uncertain taxonomy and place Brazilian *Gobiosoma* within a phylogenetic framework. Recent collections in Brazil, from the states of Ceará to Santa Catarina, and in Uruguay yielded two allopatric species of *Gobiosoma* that are distinct in genetics, meristics, morphometrics, scale pattern and coloration. Comparisons were made with types and specimens of *Gobiosoma hemigymnum*, *Garmannia mediocricula*, *Gobiosoma spilotum* and *Gobiosoma parri* and all other known species of *Gobiosoma*. We place *G. parri* in synonomy with *G. hemigymnum* with a distribution of Rio de Janeiro to Uruguay and Argentina. The northern species, that extends from the states of Espírito Santo to Ceará, is described as a new species, *Gobiosoma alfiei*. A key to the Atlantic species of *Gobiosoma* is provided.

Key words: Gobiosomatini, New world, key to Atlantic *Gobiosoma*, molecular phylogeny, systematics

Resumo

A taxonomia do gênero *Gobiosoma* no Brasil é incerta, pois há dúvidas sobre o número de espécies e sua distribuição geográfica. Neste trabalho, associamos dados morfológicos e moleculares para esclarecer esta incerteza taxonômica e estabelecer as relações filogenéticas dentro do gênero. Coletas recentes realizadas no Brasil, do estado do Ceará até Santa Catarina, e no Uruguai permitiram a captura de duas espécies alopátricas. Estas espécies distinguem-se em relação às suas características genéticas, merísticas e morfológicas, no padrão de escamação e de coloração. Essas duas espécies foram comparadas com espécimes, incluindo material tipo, de *Gobiosoma hemigymnum, Garmannia mediocricula, Gobiosoma spilotum* e *Gobiosoma parri* e todas as outras espécies conhecidas de *Gobiosoma*. Como resultados, colocamos *G. parri* em sinonímia com *G. hemigymnum* com distribuição do estado do Rio de Janeiro até o Uruguai e a Argentina, e descrevemos a espécie *Gobiosoma alfiei* sp.n. que está distribuída do Ceará até o estado do Espírito Santo. Uma chave de identificação do gênero *Gobiosoma* para as espécies do oceano Atlântico é fornecida.

Resumen

La taxonomía del género *Gobiosoma* en Brasil es incierta y no está claro cuantas especies existen ni la distribución de las mismas. En este trabajo, hemos añadido datos morfológicos y moleculares para ayudar a aclarar esta taxonomía incierta y establecer las relaciones filogenéticas dentro del género. La investigación reciente en Brasil, de Ceará a Santa Catarina, y Uruguay, permitió la recolección de dos especies alopátricas. Estas especies difieren en relación a sus características genéticas, merísticas y morfológicas, en cuanto a su descamación y coloración. Estas dos especies se compararon con especímenes, incluyendo material tipo, de *Gobiosoma hemigymnum*, *Garmannia mediocricula*, *Gobiosoma spilotum* y *Gobiosoma parri*, así como de todas las otras especies conocidas de *Gobiosoma*. Como resultado, ponemos *G. parri* en sinonimia con *G. hemigymnum*, y su distribución de Río de Janeiro a Uruguay y Argentina, y describimos a la especie

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Gobiosoma alfiei sp.n., distribuida de Ceará a Espíritu Santo. También se proporciona una clave de identificación del género *Gobiosoma* para las especies del Océano Atlántico.

Introduction

While studying the gobioid fishes of Brazil we noted a number of problems associated with previous identifications of species within the genus *Gobiosoma*. Detailed descriptions and keys for those species are lacking leading to incorrect identifications. *Gobiosoma nudum* (Meek & Hildebrand 1928), which was previously documented from Brazil, was actually an undescribed species of *Barbulifer* (Joyeux *et al*. 2009), and it is unclear as to how many valid species of *Gobiosoma* occur in Brazil. Eighteen species of *Gobiosoma* were considered valid prior to this study (Tornabene & Van Tassell 2014), three of which were reported from the Brazilian Province *Gobiosoma hemigymnum* (Eigenmann & Eigenmann 1988), *Gobiosoma spilotum* (Ginsburg 1939), and *Gobiosoma parri* Ginsburg 1933. However, morphological diagnoses for these three species are lacking, and the validity of each and their occurrence in Brazil is questionable.

To resolve this problem, specimens of *Gobiosoma* were collected along the coast of Brazil from Pará, in the north, to Santa Catarina, in the south. We also incorporated specimens of *Gobiosoma parri* from Uruguay (4 km from the type locality). These data were compared with type material of *Gobius hemigymnus* Eigenmann & Eigenmann 1888, *Gobiosoma parri* Ginsburg 1933, *Garmannia spilota* Ginsburg 1939, *Garmannia mediocricula* Ginsburg 1942 (all species previously reported from Brazil); museum collections from Uruguay, Brazil and Panama; and all other valid species of *Gobiosoma*. Data from these specimens were used in a comprehensive morphological survey as well as a molecular phylogenetic analysis for specimens whose tissue samples were available. We also reviewed the major taxonomic literature on *Gobiosoma* from Brazil. Species descriptions were found to be inaccurate in meristic counts and locality data (*e.g. Gobius hemigymnus*); described without comparison to original type material, leading to incorrect conclusions (*e.g. Garmannia mediocricula*); described from juvenile specimens, when adults vary substantially but were not available (*e.g. Gobiosoma parri*), or based on a single specimen (*e.g. Garmannia spilota*).

Here we trace the historical development leading to the confusion regarding Brazilian *Gobiosoma* and incorporate new morphological, molecular and distributional data from re-examining museum collections and our own recent collections. Based on combined evidence from molecular data, the literature, type specimens and new material, we synonymize *Gobiosoma parri* and *Garmannia mediocricula* with *Gobiosoma hemigymnum* (redescribed here), describe a new species *Gobiosoma alfiei*, and present additional information on scale patterns, meristics, and distribution of *Gobiosoma spilotum*. Details justifying the synonymy are included in the discussion section below. Overall, our findings help clarify the status of *Gobiosoma* species in Brazil and highlight additional work required to resolve the status of *Gobiosoma* species in northern Brazil.

Methods

Meristics and morphometrics. Morphometric measurements: standard length—snout tip to posterior edge of hypural plate; head length—snout tip to upper attachment of opercular membrane; head width—distance across the head taken at the posterior preopercular margin; head depth—vertical distance taken at posterior preopercular margin; eye diameter—horizontal diameter of eye, including the sclera; pupil diameter—horizontal diameter of crystalline lens; postorbital distance—from posterior edge of orbit to dorsal most attachment of gill opening membrane; interorbital width—distance between orbits; body depth at dorsal-fin origin—the vertical distance from the origin of first dorsal fin to ventral surface (excluding pelvic fin); least depth of caudal peduncle—the vertical distance from dorsal to ventral surface at the lowest points of the caudal peduncle; upper jaw length—snout tip to posterior outer corner of mouth; pectoral fin length—from the attachment of the pectoral-fin base to the tip of the longest ray; pelvic fin length—from insertion of the spine to the tip of the longest ray; caudal fin length—length of longest ray, from the end of hypural plate to the ray tip; length of first dorsal spine—distance from the base to the tip; face barbel length—base to tip using ocular micrometer. Meristic counts: Spines and segmented rays are enumerated for each fin; first element of the second dorsal and anal fin is a flexible spine, the last element of each fin originates from a single interspinal element and is counted as one; lateral scale count—only scales along a

straight line are counted, scales not touching the line are omitted, basicaudal scales are not counted. Böhlke & Robins (1968) counted transverse scale rows which gives a slightly higher scale count. Measurements were taken with dial calipers of precision 0.05 or an ocular micrometer mounted on a dissecting scope for measurements of small specimens or distances. Length measurements (in mm) were rounded off to the first decimal place. Length of unsettled larvae is either the notochord length (preflexion and flexion individuals) or standard length (post-flexion individuals) measured under a dissecting scope. Proportions are expressed in percent of standard length (SL), head length (HL) or jaw length (JL). The description of the pores of the cephalic lateralis system of the head follows Akihito *et al.* (1984). Institutional abbreviations follow Sabaj Pérez (2014) except for IPK, Collection of Ichthyoplankton of Universidade Federal do Espírito Santo and GEA.ICT, Ichthyological Collection of Grupo de Ecologia Aquática, Universidade Federal do Pará.

Molecular phylogenetics. Specimens were stored in 95% ethanol at the time of capture. Total genomic DNA was extracted using the Qiagen ®DNAeasy Blood and Tissue Kit (Qiagen, Valencia, California). We sequenced four genes from 48 specimens across *Gobiosoma*. These loci included the nuclear genes protease III (Ptr) and Recombination Activating Gene I (Rag1), and the mitochondrial genes cytochrome-*b* (cyt-b) and cytochrome c oxidase I (COI). Primers used in PCR reactions are listed in Table 1. Amplification reactions used GoTaq® Hotstart Master Mix (Promega, Madison, Wisconsin) with the following thermal profile: 2 minutes at 95°C, followed by 35 cycles of 40 seconds at 95°C, 40 seconds at 50–55°C, and 90 seconds at 72°C, followed by a single extra extension period of 5 minutes at 72°C. Purification of PCR products and DNA sequencing were performed by Molecular Cloning Labs (MCLABS, San Francisco, California). Sequences were assembled and aligned using the program *Geneious ver. 6.0.6* (Biomatters, Ltd., Auckland).

TABLE 1. Primers used for molecular phylogenetic analysis.

Gene and direction	Primer name	Sequence (5' to 3')	References
Ptr - forward	PtrF2	TCGTTCATGGGATGTTTACAAAT	Yamada *et al.* 2009
Ptr - reverse	PtrR2	GGATGAGCCAGAAGTTCCCCAGAG	Yamada *et al.* 2009
Rag1 - forward	RAG1_2533F	CTGAGCTGCAGTCAGTACCATAAGATGT	Lopez *et al.* 2004
Rag1 - reverse	RAG1Ra	CGGGCRTAGTTCCCRTTCATCCTCAT	Tornabene & Pezold 2011
Cyt-b - forward	AJG15	CAAAAACCATCGTTGTAATTCAACT	Akihito *et al.* 2000
Cyt-b - reverse	H15531a	AGGGGYGGGAGTTAAAATCT	Tornabene & Pezold 2011
Cyt-b - forward	FishcytB-F	ACCACCGTTGTTATTCAACTACAAGAAC	Sevilla *et al.* 2007
Cyt-b - reverse	TruccytB-R	CCGACTTCCGGATTACAAGACCG	Sevilla *et al.* 2007
COI - forward	GOBYL6468	GCTCAGCCATTTTACCTGTG	Thacker 2003
COI - reverse	GOBYH7696	AGGCCTAGGAAGTGTTGAGGGAAG	Thacker 2003

The final alignments consisted of 52 specimens with 579 bp of Ptr, 1450 bp of Rag1, 1091 bp of cyt-b, and 1018 bp of COI, for a total of 4141 bp when concatenated. Some specimens had degraded DNA and failed to amplify for one or more genes, thus we only included samples that had high-quality sequences for at least one mitochondrial gene and one nuclear gene. The phylogeny was rooted with four species from the *Gobiosoma* group of Gobiosomatini: *Aboma etheostoma* Jordan & Starks 1895, *Barbulifer ceuthoecus* (Jordan & Gilbert 1884), *Ginsburgellus novemlineatus* (Fowler 1950) and *Tigrigobius macrodon* (Beebe & Tee-Van 1928).

Substitution models were chosen for each gene using the program *jModelTest ver.0.1.1* (Posada 2008) based on Akaike Information Criterion (AIC) scores. Phylogenetic analysis was done using Bayesian methods in the program *MrBayes ver.3.2* (Ronquist *et al*. 2012) partitioning by gene. Two parallel Metropolis Coupled Markov Chains were run for each analysis for 10,000,000 generations with a sampling frequency of 1000 generations. Stationarity and mixing of Markov Chains was assessed using the program *Tracer ver.1.5* (Rambaut & Drummand 2007) and the first 10% of trees from our posterior distribution were discarded as burn-in. A list of voucher specimens and GenBank accession numbers are included in Table 2.

TABLE 2. List of voucher specimens used in the molecular tree.

Genus	Species	Country	Locality	Voucher	Genbank COI	Genbank Rag1	Genbank cyt-b	Genbank Ptr
Gobiosoma	*aceras*	El Salvador	Isla Meanguera	AMNH 258323	KT278536		KT278585	KT278626
Gobiosoma	*alfiei*	Brazil	Espírito Santo	CIUFES 2007	KT278514	KT278646	KT278565	KT278603
Gobiosoma	*alfiei*	Brazil	Espírito Santo	CIUFES 2008	KT278520	KT278653	KT278572	KT278610
Gobiosoma	*alfiei*	Brazil	Bahia	GEA.ICT 01728	KT278522	KT278655	KT278574	KT278612
Gobiosoma	*alfiei*	Brazil	Espírito Santo	CIUFES 2245	KT278526	KT278659	KT278578	KT278616
Gobiosoma	*alfiei*	Brazil	Ceará	GEA.ICT 00307	KT278533	KT278666		KT278623
Gobiosoma	*alfiei*	Brazil	Rio Grande do Norte	GEA.ICT 00301	KT278544			KT278634
Gobiosoma	*alfiei*	Brazil	Rio Grande do Norte	GEA.ICT 00301	KT278545		KT278592	KT278635
Gobiosoma	*alfiei*	Brazil	Espírito Santo	CIUFES 2009	KT278550	KT278671		
Gobiosoma	*alfiei*	Brazil	Espírito Santo	CIUFES 2006	KT278551	KT278672		
Gobiosoma	*bosc*	USA	Florida	AMNH 263708	KT278516	KT278648	KT278567	KT278605
Gobiosoma	*bosc*	USA	Florida	AMNH 263709	KT278523	KT278656	KT278575	KT278613
Gobiosoma	*bosc*	USA	Texas	AMNH 254652	KT278535		KT278584	KT278625
Gobiosoma	*bosc*	Germany	Weser estuary	ZMH 25884	KT278549	KT278670		
Gobiosoma	*bosc*	USA	Texas	AMNH 243424	KT278552	KT278673		
Barbulifer	*ceuthoecus*	USA	Florida	AMNH 263710	KT278532	KT278665		KT278622
Aboma	*etheostoma*	Panama	Balboa	AMNH 254410	KT278543		KT278591	KT278633
Gobiosoma	*ginsburgi*	USA	New York	AMNH 263711	KT278506	KT278637	KT278556	KT278594
Gobiosoma	*grosvenori*	Venezuela	Isla de Cubagua	AMNH 238792	KT278546	KT278667		
Gobiosoma	*grosvenori*	USA	Florida	AMNH 263712	KT278509	KT278641	KT278560	KT278598
Gobiosoma	*grosvenori*	USA	Florida	AMNH 263713	KT278541		KT278589	KT278631
Gobiosoma	*grosvenori*	USA	Florida	AMNH 263713	KT278519	KT278651	KT278570	KT278608
Gobiosoma	*grosvenori*	Venezuela	Isla de Cubagua	AMNH 238792	KT278547	KT278668		
Gobiosoma	*grosvenori*	Venezuela	Isla de Cubagua	AMNH 238792	KT278505	KT278636	KT278555	KT278593
Gobiosoma	*hemigymnum*	Brazil	Santa Catarina	CIUFES 2596	KT278527	KT278660		KT278617
Gobiosoma	*hemigymnum*	Brazil	Santa Catarina	CIUFES 2599	KT278528	KT278661	KT278579	KT278618

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TABLE 2. (Continued)

Genus	Species	Country	Locality	Voucher	Genbank COI	Genbank Rag1	Genbank cyt-b	Genbank Ptr
Gobiosoma	*hemigymnum*	Brazil	Santa Catarina	CIUFES 2599	KT278529	KT278662	KT278580	KT278619
Gobiosoma	*hemigymnum*	Uruguay	Montevideo	CIUFES 2668	KT278530	KT278663	KT278581	KT278620
Gobiosoma	*hemigymnum*	Uruguay	Punta del Este	CIUFES 2669	KT278531	KT278664	KT278582	KT278621
Gobiosoma	*hildebrandi*	Panama	Miraflores	AMNH 256696	KT278538		KT278587	KT278628
Gobiosoma	*homochroma*	Panama	Miraflores	AMNH 233145	KT278517	KT278649	KT278568	KT278606
Gobiosoma	*longipala*	USA	Florida	AMNH 263714	KT278511	KT278643	KT278562	KT278600
Gobiosoma	*longipala*	USA	Florida	UF 237137	KT278524	KT278657	KT278576	KT278614
Tigrigobius	*macrodon*	USA	Florida	AMNH 263715	KT278540			KT278630
Ginsburgellus	*novemlineatus*	USA	Puerto Rico	AMNH 258515	KT278512	KT278644	KT278563	KT278601
Gobiosoma	*nudum*	El Salvador	Meanguera	AMNH 254710	KT278508	KT278639	KT278558	KT278596
Gobiosoma	*paradoxum*	Panama	Naos	AMNH 248555	KT278507	KT278638	KT278557	KT278595
Gobiosoma	*robustum*	USA	Texas	AMNH 258520	KT278515	KT278647	KT278566	KT278604
Gobiosoma	*robustum*	USA	Florida	AMNH 263716	KT278525	KT278658	KT278577	KT278615
Gobiosoma	*robustum*	USA	Florida	AMNH 263717	KT278542		KT278590	KT278632
Gobiosoma	*schultzi*	Venezuela	Lake Maracaibo	AMNH 241441	KT278513	KT278645	KT278564	KT278602
Gobiosoma	*schultzi*	Venezuela	Lake Maracaibo	AMNH 241460	KT278553	KT278674		
Gobiosoma	*seminudum*	El Salvador	El Union	AMNH 258423	KT278534		KT278583	KT278624
Gobiosoma	*seminudum*	El Salvador	El Union	AMNH 258423	KT278537		KT278586	KT278627
Gobiosoma	*seminudum*	El Salvador	Isla Meanguera	AMNH 258321	KT278539		KT278588	KT278629
Gobiosoma	*sp. nov.*	Mexico	Puerto Penasco	AMNH 263718		KT278640	KT278559	KT278597
Gobiosoma	*sp. nov.*	Mexico	Puerto Penasco	AMNH 263719	KT278510	KT278642	KT278561	KT278599
Gobiosoma	*spes*	Panama	Colon	AMNH 248362	KT278554	KT278675		
Gobiosoma	*spes*	Panama	Colon	AMNH 248362	KT278518	KT278650	KT278569	KT278607
Gobiosoma	*spilotum*	Panama	Colon	AMNH 233131		KT278652	KT278571	KT278609
Gobiosoma	*yucatanum*	Belize	Belize City	AMNH 263720	KT278521	KT278654	KT278573	KT278611
Gobiosoma	*yucatanum*	Belize	Belize City	AMNH 263720	KT278548	KT278669		

Redescription of *Gobiosoma hemigymnum*

***Gobiosoma hemigymnum* (Eigenmann & Eigenmann 1888)**
Common name: Half naked goby
Nome comum (Portuguese): Amboré zebra
Figs. 1–3

Gobius hemigymnus Eigenmann & Eigenmann, 1888: 66–67 (type locality: West Indies, exact location unknown). See discussion for additional information.

Garmannia hemigymna (Eigenmann & Eigenmann). Ginsburg, 1933: 57–58 (placed in subgenus *Risor*); Fowler, 1940: 791 (listed from Rio de Janeiro); Fowler, 1941: 177 (in checklist of fishes from Rio de Janeiro); Fowler, 1951: 30–31 (redescribed based on two specimens); Robins, 1960: 284 (removed from genus *Risor*, *Garmannia* synonymized with *Austrogobius*).

Garmannia mediocricula. Ginsburg, 1942: 365–366 (described based on same material as Fowler's references above); Robins, 1960: 284 (cited); Robins, 1964: 402 (compared to *G. grosvenori*).

Gobiosoma hemigymnum (Eigenmann & Eigenmann). Böhlke & Robins, 1968: 51–52, 59–60, 155 (key to genera, placed in subgenus *Austrogobius*, key to species, species account, comments on holotype, re-examination of holotype, synonymy with *G. mediocricula*, meristics); Lucena & Lucena, 1982: 43, 45 (coloration, B&W photograph); Menezes & Figueiredo, 1985: 60–61, 68–69, 105 (key to genera and species, species account, meristics, ink drawing of largest specimen [J.L. Figueiredo, pers. comm.]); Carvalho-Filho, 1999: 209–210 (species account, re-drawn from Menezes & Figueiredo, 1985 [A. Carvalho-Filho, pers. comm.]); Murdy & Hoese, 2002: 1782–1790, 1794 (key to species, listed); Moura *et al*., 2003: 99 (listed); Freire & Carvalho-Filho, 2009: 118 (listed, Portuguese common name); Van Tassell, 2011:154 (listed).

Gobiosoma hemigymnum (Jordan & Evermann, 1888). Moura *et al.*, 2005: 120 (error in authors' names, listed).

Gobiosoma parri. Ginsburg, 1933: 44–46 (type locality: Pocitos, Uruguay, description based on juveniles); Dawson, 1963: 585 (in subgenus *Dilepidion*, name only); Böhlke & Robins, 1968: 58, 155 (in subgenus *Austrogobius*, description, meristics, table); Cervigón & Bastida, 1974: 14–20 (drawing body and basicaudal scales, measurements for 11 specimens of 15 to 41 mm TL, comments on scale development); Menni *et al.*, 1984: 187, 322 (in subgenus *Austrogobius*, listed, drawing from Cervigón & Bastida, 1974); Weiss *et al.*, 1984: not paginated (larvae at the entrance of Patos Lagoon, state of Rio Grande do Sul); Menezes & Figueiredo, 1985: 69 (cited; authors note that "as described by Cervigón & Bastida (1974), [*G. parri*] should not be different from [*G. hemigymnum*]". Muelbert & Weiss, 1991: 48–50, 52–53 (larvae at the entrance of Patos Lagoon); Acha, 1994: 337–343 (larval development); Irigoyen & Galván, 2009: 38 (habitat, behaviour, color picture); Van Tassell, 2011:154 (listed).

Austrogobius parri. de Buen, 1950: 122 (synonymy, description of genus); 1951: 63–68 (made type for new genus, redescription, illustrated).

Garmannia parri. Robins, 1960: 284 (*Austrogobius* synonymized with *Garmannia*); Robins & Böhlke, 1964: 5 (retained in *Garmannia*).

Material examined: SANTA CATARINA, BRAZIL: MZUSP 46631, 1, MZUSP 46666, 1, A. Carvalho-Filho, January 1988, Porto Belo; MZUSP 55330, 4, R.L. Moura, A. Carvalho-Filho, C.H. Flesch & R. Francini-Filho, 15 December 1998, Ilha do Arvoredo, Florianópolis, 27° S 48° W, depth 3–9 m; MZUSP 55368, 1, R.L. Moura, A. Carvalho-Filho, C.H. Flesch & R. Francini-Filho, 16 December 1998, Ilha do Arvoredo, Florianópolis, 27°17'30" S 48°22'00" W, depth 8 m; MZUSP 55404, 1, R.L. Moura, A. Carvalho-Filho, C.H. Flesch & R. Francini-Filho, 17 December 1998, Ilha do Arvoredo, Florianópolis, depth 11 m; CIUFES 2596, 1, CIUFES 2600, 4, AMNH 262810, 25, J.-C. Joyeux, 23 May 2013, Lagoa da Conceição, Florianópolis; UF 187660, 11, CIUFES 2599, 9, J.-C. Joyeux, 21 May 2013, Lagoa da Conceição, Florianópolis; CIUFES 2628, 26, J.-C. Joyeux, 22 May 2013, Lagoa da Conceição, Florianópolis.

RIO GRANDE DO SUL, BRAZIL: MZUSP 65312, 3 (of 4), G.Q. Benvegnú, 18 August 1972, N.Oc. "Prof. W. Besnard", estação 1894, 32º58´ S 52º30´ W, depth 13m; MZUSP 65328, 2, G. Phonier, 01 August 1974, Barra de Tramandaí, Tramandaí.

URUGUAY: USNM 86677, 5 of 7, paratypes of *Gobiosoma parri*, Hugh M. Smith, 08 November 1922, tidepool, Pocitos; ANSP 80831, 3 of 4, Luis P. Barattini, February 1932, Puerto de Montevideo, radiograph; ANSP 121399, 1 Luis P. Barattini, February 1932, Puerto de Montevideo, c&s; CIUFES 2668, 1, A. Carvalho-Filho, 20 April 2013, Rio de la Plata estuary, tidepool at Malvin Beach, Montevideo; CIUFES 2669, 1, A. Carvalho-Filho; 22 April 2013, tidepool at Brava Beach, Punta del Este.

Diagnosis. A species of *Gobiosoma* distinguished from other members of the genus by the following characters: body scaled from caudal peduncle to base of pectoral fin, scales in a wedge shape to under posterior of first dorsal-fin base, wedge ending abruptly, then continuing forward in a narrow, straight row of 1–2 scales high

along midline; a naked area extending from mid- pectoral-fin base to (or past) posterior of second dorsal-fin base and from mid-pectoral-fin base to (or past) posterior end anal fin ray base; upper jaw 34.6 % in head length; lateral scales modally 31; pectoral fin 19 (17–21); maximum size to 44 mm SL.

General morphology. Meristic and morphometrics given in Table 3. Body cylindrical, elongate; head rounded in profile; eyes dorsolateral (mean followed by range in parentheses) 26.6% (21.8–34.8) in HL; maxilla generally extending posteriorly to a vertical under rear of pupil; upper jaw length 34.6% (28.3–53.5) in HL; anterior and posterior nares are tubes without flaps or tentacles; posterior naris 1/3 height of anterior naris (lower in juveniles); very small wart-like barbel in front of eye, near anterior naris; males with a triangular, wide, flattened urogenital papilla; female papilla, slightly tapering, not flattened, with large opening at end; juveniles with urogenital papilla similar to that of males but shorter, less flattened and rounder at tip.

FIGURE 1. (A) MCZ 27124, Holotype of *Gobiosoma hemigymnum*, photographed after fixation, 44.1 mm TL; (B) USNM 119876, *Gobiosoma hemigymnum* (Holotype of *Garmannia mediocricula*), photographed after fixation, 28 mm TL; (C) USNM 119899, *Gobiosoma hemigymnum* (Paratype of *Garmannia mediocricula*), photographed after fixation, 29 mm TL. Photograph (A) Museum of Comparative Zoology, Harvard University, © President and Fellows of Harvard College; photographs (B), (C) by Sandra Raredon USNM.

Fins: Counts for holotype followed by (range; mode). First dorsal VII (VII; VII), no elongate or filamentous spines; first dorsal connected to second dorsal by a low membrane; second dorsal fin falling short, or just reaching caudal fin when adpressed; second dorsal I,11 (I,10–I,11; I,11); anal I,9 (I,8–I,9; I,9), not reaching caudal when adpressed; pectoral counts for left fin followed by right, 17/18 (17–21/18–21; 19/19), fin ovate, reaching anterior of anal fin when adpressed; caudal segmented rays 17 (16–17; 17), branched rays, holotype unknown (13–15; 14); pelvic fin I,5 (I,5; I,5) rounded to ovate, not reaching anus when adpressed.

TABLE 3. Meristic and morphometric data for *Gobiosoma hemigymnum* based on re-examination of the holotypes of *G. hemigymnum* and *Garmannia mediocricula*, the paratype of *G. mediocricula* and recently collected material in Uruguay and southern Brazil. Morphometric data expressed as percent of standard length, of head length (†) or of jaw length (‡). n = number of individuals, including types.

Meristic characters	Holotype *G. hemigymnum*	Holotype *G. mediocricula*	Paratype *G. mediocricula*	n	Range	Mode
First dorsal fin	VII	VII	VII	33	VII–VII	VII
Second dorsal fin	I,11	I,11	I,11	36	I,10–I,11	I,11
Anal fin	I,9	I,9	I,9	36	I,8–I,9	I,9
Pectoral fin right	18	19		34	18–21	19
Pectoral fin left	17	19	19	32	17–21	19
Pelvic fin	I,5	I,5	I,5	40	I,5–I,5	I,5
Segmented rays in caudal fin	17	17	17	35	16–17	17
Branched rays in caudal fin				28	13–15	14
Scales in longitudinal series	31	30	32	35	3–35	31
Morphometric characters	Holotype *G. hemigymnum*	Holotype *G. mediocricula*	Paratype *G. mediocricula*	n	Range	Mean ± SD
Total length (mm)	44.1	26.0		36	17.3–44.1	26 ± 6.6
Standard length (mm)	36.0	21.5	23.4	38	14.0–36.0	21.1 ± 5.4
Standard length (% SL)	81.8	82.7		36	78.5–83.8	81.1 ± 1.2
Head length	26.3	32.4	32	38	26.3–32.4	29.8 ± 1.6
Head depth	18.8	18.5	16.6	38	15.5–21.5	18.3 ± 1.6
Head width	21.6	21.9	19.6	38	13.9–25.4	21.7 ± 2.3
Postorbital length	12.1	17.6	9.3	37	9.3–19.3	16.8 ± 1.8
Upper jaw length	14	12.9	13.7	38	8.3–14.0	10.3 ± 1.4
Interorbital width	3.1	2	2	38	1.2–5.3	2.5 ± 0.9
Eye diameter	6.3	8.9	7.5	37	6.0–10.0	7.9 ± 1.1
Pupil diameter	2.4			35	2.1–6.0	3.6 ± 0.9
Anterodorsal length				35	4.8–10.7	7.4 ± 1.4
First dorsal spine length				23	10.0–17.2	12.9 ± 2
Depth of body at D1 origin	18.9	19.9	19.8	37	12.7–21.4	18 ± 1.9
Pectoral-fin length - left				30	20.6–27.9	24.5 ± 1.6
Pectoral-fin length - right				31	20.8–28.4	24.4 ± 2.1
Pelvic-fin length				33	17.2–24.8	20.5 ± 1.6
Caudal peduncle depth	15.7	15.1	14.7	38	9.1–15.7	12.6 ± 1.4
Caudal fin length				34	19.2–28.3	23 ± 1.7
Postorbital length †	46.2	54.2	29.1	37	29.1–68.8	56.4 ± 6.4
Upper jaw length †	53.5	39.7	42.9	38	28.3–53.5	34.6 ± 5
Interorbital width †	11.6	6.2	6.4	38	4.0–17.8	8.4 ± 3.2
Eye diameter †	24.1	27.3	23.4	37	21.8–34.8	26.6 ± 3.5
Pupil diameter †	9			35	6.9–20.0	12.1 ± 3
Eye diameter ‡	45.1	68.8	54.5	37	45.1–114.3	78.7 ± 17.1

Scales: (Fig. 4A) Counts for holotype followed by (range; mode). Lateral scales rows 31 (3–35; 31), Böhlke and Robins 1968 counted "about 36" scales in the holotype, however we count 31; head, nape, abdomen, prepelvic region and belly without scales; scales ctenoid, with pigmented posterior edge; body scaled generally from caudal peduncle to base of pectoral fin, in a wedge shape, to under posterior of first dorsal-fin base, then continuing

anteriorly in a narrow, straight row of 1–2 scales along midline; a naked area extending diagonally from mid-pectoral-fin base to (or past) posterior of second-dorsal fin base (generally terminating posterior to fin base) and from mid-pectoral-fin base to (or past) base of posteriormost anal-fin ray (generally terminating posterior to fin base); four basicaudal scales extending on to caudal fin base, the dorsal and ventral-most with elongate ctenii (Fig. 4E); lateral scale pattern exhibiting some variation (see comparison section below).

Teeth: Upper jaw with 3–4 rows anteriorly tapering to a single row extending to near terminus of maxilla; outer row with larger teeth; all teeth in upper jaw conical, pointed with recurved tip; lower jaw with 3–4 rows anteriorly, tapering to a single row near terminus of dentary; outer and inner row of lower jaw with larger teeth, inner row consisting of only a few large teeth, well-spaced along the anterior third of the jaw, teeth in inner row larger in males then females.

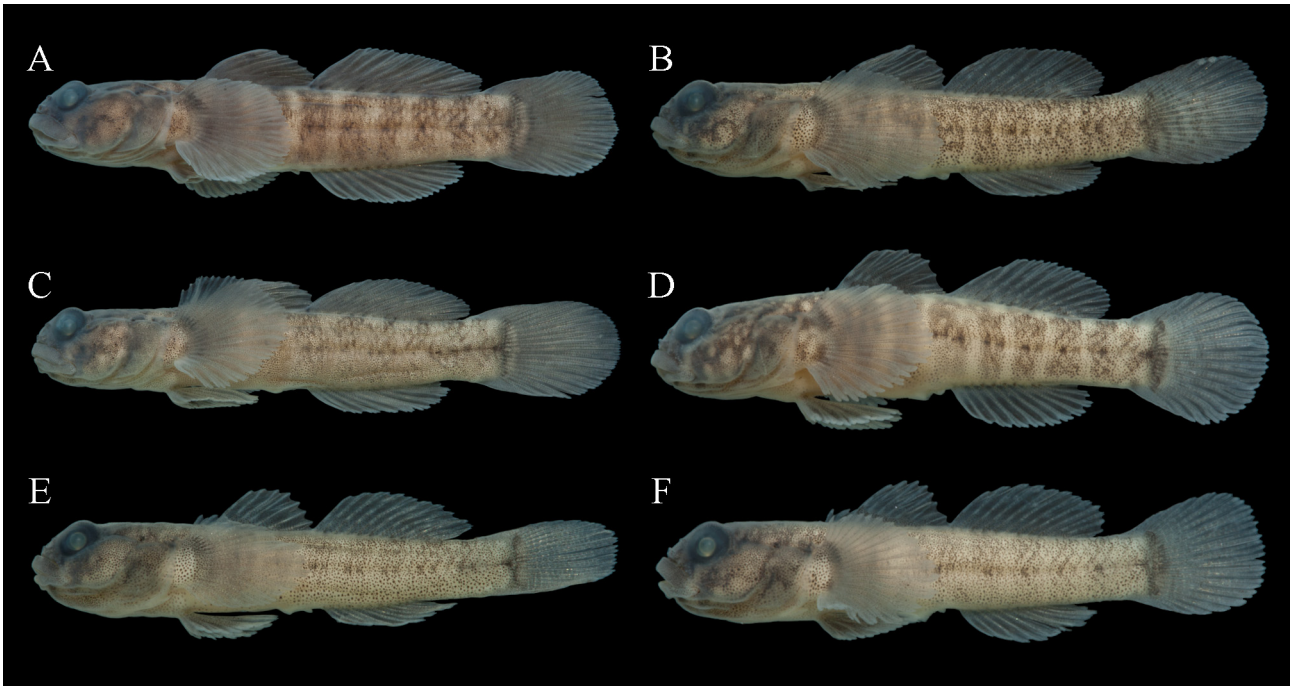

FIGURE 2. *Gobiosoma hemigymnum*, photographed after fixation in formalin 10% and preservation in ethyl alcohol 70%. (A) CIUFES 2628-1, 34.31 mm TL, adult male; (B) CIUFES 2628-2, 33.84 mm TL, adult male; (C) CIUFES 2628-3, 20.78 mm TL, male; (D) CIUFES 2628-A, 28.40 mm TL, adult female; (E) CIUFES 2628-B, 28.23 mm TL, adult female; (F) CIUFES 2628-C, 19.95 mm TL, female. Photographs by R.M. Macieira.

Lateral-line system (Fig. 3): Cephalic lateral line system with pores B', C(s), D(s), E, F, H' and posterior oculoscapular pores K', L'; preopercle canal with pores M', N and O'; supraorbital canals fused between the eyes with only single canal present.

Sensory papillae with transverse pattern; row 1 extending from orbit to row *d*; rows 2 and 3, extending almost to orbit; row 5*s* from orbit to anterior of *b*; row 6 not reaching row *b*; row 7 represented by 2 papillae; row *b* short; row *d* continuous; row 5*i* under *b* and extending below the level of *d* by 3–4 papillae; dorsal row *g* with 3–4 papillae; row *o* with 2 papillae; row *m* not observed; row *n* extending from level of pore F, medially to just posterior to pore E.

Color in recently preserved specimens (Fig. 2**).** Background color of head and body a pale brown; ventral surface from throat to anus, including chest and pelvic fin, uniformly pigmented, paler than sides of body. Body with series of eight dusky bars; first starting under anterior of first dorsal (D1); second starting under D1 spine 5; third just anterior to insertion of second dorsal (D2); fourth through 6th bar located under D2; seventh bar in middle of caudal peduncle; the eighth dusky bar, a thin, distinct vertical dusky line on the base of caudal fin rays; dusky bars not extending onto belly; barred pattern poorly developed in some individuals, when poorly developed, pattern more evident on dorsal part of body; dusky bars with slightly duskier outer edges; edges vertical, straight, never wavy. A series of dusky spots present on lateral midline in the center of each dusky bar, sometimes double; the last spot on caudal peduncle frequently a anteriorly directed triangle. Head with three dusky spots located between the

posterior of the eye and the upper pectoral fin base; first directly behind eye, second above preopercle, third above posterior edge of opercle; head pattern frequently with dusky bar extending forward and down from the anteroventral edge of eye to the mediolateral upper lip, often extending onto lip and chin; second bar on head from below the middle of the eye ventrally to below posterior corner of mouth; a thin line of pigment along most of the posterior of the preopercle, near but not at the edge; edge of posterior preopercle dusky; anterior edge of the opercle dusky. Dorsal fins with body bars slightly extending onto base of fin membranes, remainder of fins dusky with melanophores more concentrated in membranes than on elements, occasionally in a weak banding pattern. Anal fin dusky with melanophores concentrated on membrane between elements. Pectoral fin with two spots located on base of fin rays, on the upper and lower third of the fin, remainder of fin dusky. Pelvic fin dusky with melanophores concentrated along membrane between rays. Caudal fin transparent with several vertical lines of melanophores. No apparent sexual dichromatism.

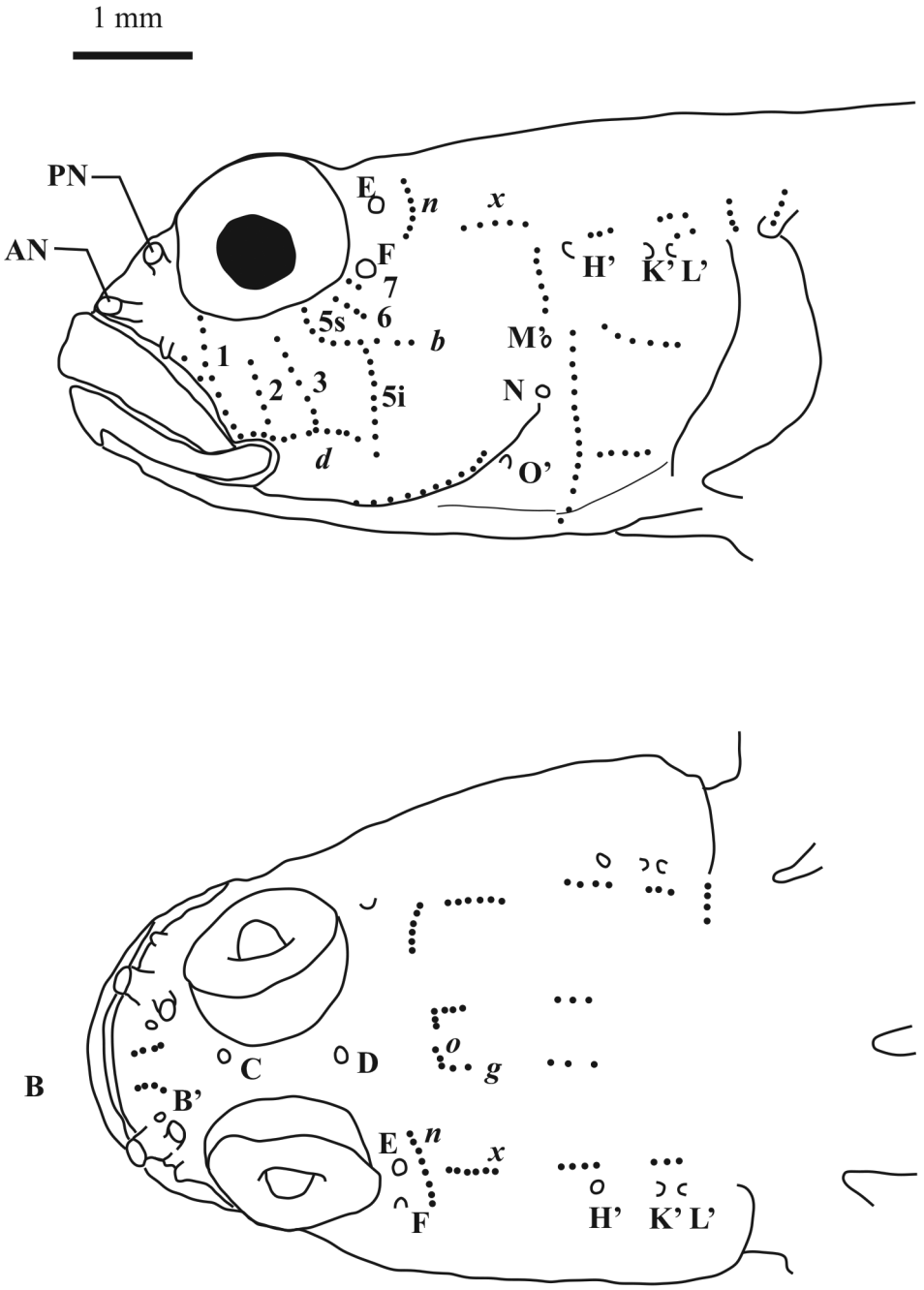

FIGURE 3. Sensory papillae and head canal pores of *Gobiosoma hemigymnum*.

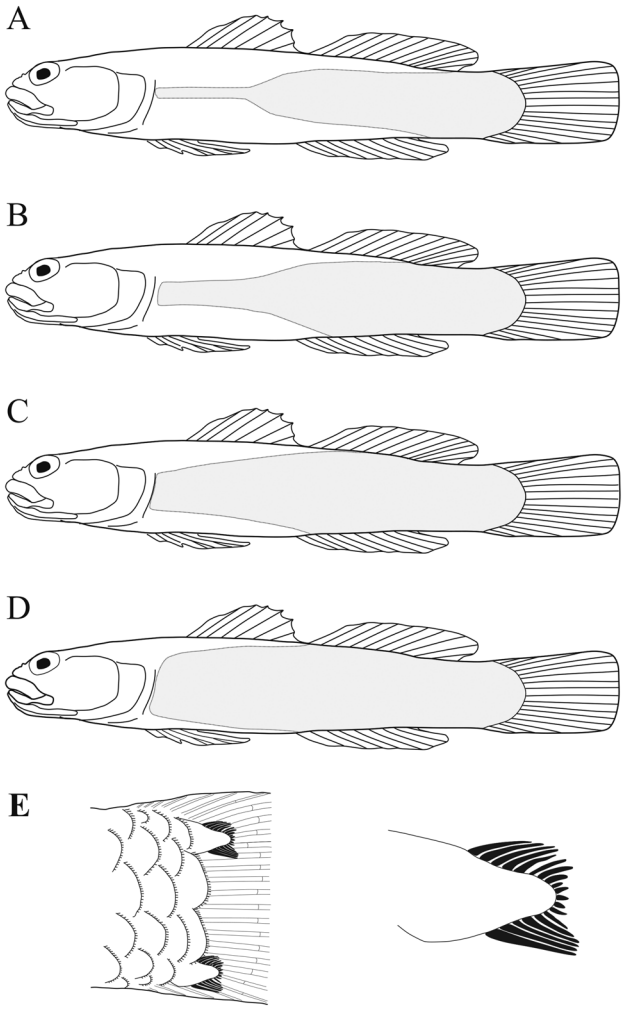

FIGURE 4. Scale patterns of A) *Gobiosoma hemigymnum*, B) *G. alfiei*, C) *G. spilotum*, D) *G. grosvenori*. Shaded areas in A-D indicate distribution of scales on body. E) Distribution of basicaudal scales, including modified basicaudal scales on dorsal and ventral caudal peduncle.

Osteology: Osteology based on one cleared and stained specimen (ANSP 121399), radiographs of types and ANSP 80831. Vertebrae 11 precaudal and 16 caudal (total 27); dorsal pterygiophore formula 3-221110; anal pterygiophores anterior to first haemal spine 2; hypurals 1/2 fused to hypurals 3/4 about ¼ to ½ the length.

Distribution, habitat and natural history (Fig. 5). *Gobiosoma hemigymnum* has been documented to occur, based on recent collections, in the southwestern Atlantic from Rio de Janeiro, Brazil, about 23° S, to Mar del Plata, Argentina, about 38° S. It may occur near Cabo Frio, about 22.8° S if the holotype was collected by the Hessler expedition in dredge 21 (See discussion for details). It inhabits estuarine, intertidal and shallow coastal areas; frequently found associated with epilithic organisms (2 centimeters or more in size) found at depths ranging from tidepools to 13 meters. Specimens from Lagoa da Conceição (state of Santa Catarina) were collected by one of us (JCJ) while snorkeling along the granitic shores in 1.5 to 2 meters of water in an area where the non-native *Styela plicata* (Lesueur 1823) occurs (Barros *et al.,* 2009). This solitary ascidian forms extensive aggregations in bands about 1 meter below the lower limit of the intertidal zone. Other species collected in the area included: the gobiid *Bathygobius soporator* (Valenciennes 1837), the native blenny *Hypleurochilus fissicornis* (Quoy & Gaimard 1824) and the invasive blenny *Omobranchus punctatus* (Valenciennes 1836), and the gobiesocid *Gobiesox barbatulus* Starks 1913. In Mar Chiquita lagoon (Buenos Aires Province, Argentina) the species has been recorded in high numbers associated with the reefs built by the invasive tubeworm *Ficopomatus enigmaticus* (Fauvel 1923; also known as *Mercierella enigmatica*) (Cervigón & Bastida, 1971). Nearby in Mar del Plata, the same authors indicate that *G. hemigymnum* inhabits the encrusting community in both the harbor and the mesolittoral zone of Cabo Corrientes. In the latter community, composed of the mussels *Brachidontes rodriguezii* (d'Orbigny 1842) and

Mytilus edulis platensis d'Orbigny 1842, *G. hemigymnum* is rare. In Uruguay, *G. hemigymnum* was found in tidepools 20 and 50 cm deep with clear water and sandy bottoms (A. Carvalho-Filho, pers. comm., 17 May 2013). Other fish species in the pools included: *H. fissicornis*, juveniles of *Mugil curema* Valenciennes 1836 and adults of *Jenynsia multidentata* (Jenyns 1842). Both *Barbulifer enigmaticus* and *G. hemigymnum* have been collected within the same tidepools in São Paulo (J.L. Figueiredo, pers. comm., 20 September 2010). The species has been documented at 8–13 meters in northern Argentina (Irigoyen & Galván, 2009) and southern Brazil (MZUSP catalogued specimens 55330, 55368, 55404, 65312). Medeiros (2013) reported that *G. hemigymnum* uses the empty shells of the cultured mussel *Perna perna* (Linnaeus 1758) for spawning and is an intermediary host of *Bucephalus margaritae* (Ozaki & Ishibashi 1934), a trematode worm parasitic on the mussel, in Santa Catarina.

FIGURE 5. Distribution of *Gobiosoma alfiei* (squares), *G. hemigymnum* (circles), and *G. spilotum* (triangle). Closed symbols are sites where samples were sequenced. Open symbols are sites with morphological samples only. The "?" represents possible locality for holotype of *G. hemigymnum*.

Gobiosoma alfiei sp. nov. Joyeux & Macieira

Alfie's goby
Common name: Alfie's goby
Nome comum (Portuguese): Amboré do Alfie
Figs. 6,7,8

Gobiosoma hemigymnum (Eingenmann & Eingenmann 1888) (misidentified; error in authors' names). Joyeux *et al*., 2009: 64–66 (cephalic head pores pattern, habitat); Macieira & Joyeux, 2011: 311 (listed).
Gobiosoma hemigymnum (Eigenmann & Eigenmann 1888) (misidentified). Macieira & Joyeux, 2011: 311 (listed).
Gobiosoma spilotum (Ginsburg 1939). (misidentified) Rocha *et al.*, 1998: 564 (listed).
Gobiosoma parri Ginsburg 1933. (misidentified) Gomes *et al.*, 2014:1001–1003 (larvae in a Bahian estuary).
Gobiosoma sp. Joyeux *et al*., 2004: 1281, 1283 (larvae in an Espírito Santo´s estuary)

Material examined: **Types**. Holotype: CIUFES 3114, 20.6 mm TL, male, J.-C. Joyeux, R.M. Macieira & C.R. Pimentel, 28 October 2007, tidepool at Praia dos Castelhanos, Anchieta, Espírito Santo, Brazil, 20°50'S 40°37'W.

Paratypes: PARAÍBA, BRAZIL: UFPB 4296, 1, P.B. Feitoza & L.A. Rocha, 08 April 1999, Taci Grande de Cadebelo, Praia Formosa, Cabedelo; UFPB 4882, 1, R.S. Rosa, 25 September 1992, Ponta Seixas, João Pessoa.

BAHIA, BRAZIL: CIUFES 0544, 2, A. Carvalho-Filho, 08 September 2007, tidepool at Praia do Forte, Mata de São João.

ESPÍRITO SANTO, BRAZIL: Collected from tidepools at Praia dos Castelhanos, Anchieta, 20°50'S, 40°37'W: AMNH 258026, 5, CIUFES 0103, 1, (c&s), CIUFES 0106, 1, c&s, R.M. Macieira & E.R.S. Almeida, 21 August 2005; CIUFES 0130, 1, c&s, CIUFES 0131, 2, c&s, R.M. Macieira, J.L. Gasparini & J.-C. Joyeux, 15 November 2005; UF 187658, 3, R.M. Macieira & J.-C. Joyeux, 24 August 2006; UF 187659, 3, R.M. Macieira, J.-C. Joyeux, J.L. Gasparini, C.R. Pimentel & P. Sant'Ana, 18 March 2007; AMNH 258025, 2, R.M. Macieira, J.-C. Joyeux, J.L. Gasparini, C.R. Pimentel & P. Sant'Ana, 18 March 2007; AMNH 258029, 1, CIUFES 0263, 1, R.M. Macieira, J.L.Gasparini, C.R. Pimentel & P. Sant'Ana, 17 June 2007; AMNH 258027, 1, R.M. Macieira & J.-C. Joyeux, 14 May 2006; CIUFES 0274, 4, R.M Macieira, J.-C. Joyeux, J.L. Gasparini, P. Sant'Ana & C.R. Pimentel, 15 February 2006; MZUSP 112485, 17, CIUFES 0525, 5, collected with holotype, J.-C. Joyeux, R.M. Macieira & C.R. Pimentel, 28 October 2007; ZUEC 9030, 6, A. Carvalho-Filho, R.M. Macieira & C.R. Pimentel, 30 August 2008.

ESPÍRITO SANTO, BRAZIL: Additional locations. CIUFES 0201, 4, J.-C. Joyeux & R.C. Smarzaro, 29 November 2005, tidepool at Praia Escondida, Aracruz; CIUFES 0646, 4, R.G. Santos, 28 November 2007, collected during algae sampling, Praia de Santa Helena, Vitória; CIUFES 1449, 2, J.L. Gasparini & S. Vogel, 03 November 1994, Santa Cruz, Aracruz; CIUFES 2006, 1, CIUFES 2007, 1, CIUFES 2008, 1, CIUFES 2009, 1, R.M. Macieira; J.L. Gasparini & J-C. Joyeux, 23 November 2010, tidepool at Barra do Riacho, Aracruz; CIUFES 2245, 1, R.M. Macieira, H.T. Pinheiro & L.B.C. Xavier, 27 September 2011, Manguinhos, Serra.

Non-type material: CEARÁ, BRAZIL: GEA.ICT 00307, 1, R.R.S. Oliveira & F.S. Machado, 08 May 2012, tidepool, Iparana, 03°41´08.4S, 38°38´04.9W.

RIO GRANDE DO NORTE, BRAZIL: GEA.ICT 00301, 2, R.R.S. Oliveira & F.S. Machado, 04 May 2012, tidepool, São Miguel do Gostoso, 05°06´05.9S, 35°41´57.5W.

PARAÍBA, BRAZIL: UFPB 4023, 7, P.B. Feitoza *et al.*, 04 November 1998, reefs at Praia do Poço, south of Areia Vermelha, Cabedelo; UFPB 4258, 1, P.B. Feitoza *et al*., 25 July 1998, tidepools north of Areia Vermelha, Cabedelo; UFPB 4610, 3, M.A. Guimarães *et al*., 18 July 1982, Ponta do Guajura.

PERNAMBUCO, BRAZIL: UF 141848, 1, T. Roberts, 31 March 1968, tidepool in front of LACIMAR (Laboratório de Ciências do Mar), Piedade; UF 141867, 6, T. Roberts, 03 May 1968, large open sandy tidepool beside old sewage canal at Paria (?), Recife.

ALAGOAS, BRAZIL: UF 19907, 3, N. Menezes, 12 December 1973, Ponta Verde, Maceió, 9.66408 S - 35.69463W.

BAHIA, BRAZIL: USNM 274857, 3, N.A. Menezes *et al.*, 21 March 1985, Coroa Vermelha reef, Prado, 17°06' S, 39°11' W, depth 0–2.5 feet; CIUFES 1385, 1, A. Carvalho-Filho, no date, Praia do Forte, Mata de São João; GEA.ICT 01728, 1, R.R.S. Oliveira & F.S. Machado, 19 April 2012, tidepool, Cabralia, 16°19´53.6 S, 39°00´02.3W.

ESPÍRITO SANTO, BRAZIL: Collected from tidepools at Praia dos Castelhanos, Anchieta, 20°50'S, 40°37'W; CIUFES 0039, 1, J.L. Van Tassell, J.-C. Joyeux & R.M. Macieira, 18 February 2004; CIUFES 0107, 1, R.M. Macieira & E.R.S. Almeida, 21 August 2005; CIUFES 0132, 1, CIUFES 0271, 1, R.M. Macieira, J.L. Gasparini & J.-C. Joyeux, 15 November 2005; CIUFES 0217, 1, R.M. Macieira, J.-C. Joyeux, J.L. Gasparini & P. SantAna, 04 November 2006; CIUFES 0265, 5, R.M. Macieira, J.L. Gasparini, C.R. Pimentel & P. SantAna, 17 June 2007; CIUFES 0272, 2, R.M. Macieira, J.-C. Joyeux, J.L. Gasparini, C.R. Pimentel & P. SantAna, 15 February 2006; AMNH 258024, 22, J.-C. Joyeux & R.M. Macieira, 28 October 2007; UF 184467, 23, J.-C. Joyeux & R.M. Macieira, 28 December 2007.

ESPÍRITO SANTO, BRAZIL: Additional locations. CIUFES 1118, 1, tidepool, Praia Escondida, Aracruz, J.-C. Joyeux & R.C. Smarzaro, 25 March 2005; CIUFES 2245, 1, tidepool, Praia de Manguinhos, Serra, R.M. Macieira, H.T. Pinheiro & L.B.C. Xavier, 27 September 2011; SIO 14–42, 8, R.M. Macieira & J.L. Gasparini, 02 June 2011, tidepool, Barra do Riacho, Aracruz; ZUEC 3179, 1, J.L. Gasparini & E.L.C. Dall'Orto Filho, 22 April 1987, between Ilha Galheta de Dentro and Ilha do Boi, Vitória; ZUEC 3178, 1, J.L. Gasparini & M.B. Collodetti,

06 February 1988, Ilha Galheta de Dentro, Vitória; CIUFES 130031, 1, CIUFES 130036, 14, E.C. Perrone, E.B. Santana, P.S.B. Barbosa & J.L. Helmer, 12 September 1983, tidepool, Praia de Capuba, Serra; CIUFES 130346, 1, C. Zamprogno, 15 September 1986, tidepool, Praia da Baleia, Serra;

Unsettled larvae from ichthyoplankton samples: IPK 0268, 7, IPK 0269, 6, IPK 0270, 3, J.-C. Joyeux & B.B. Pereira, 24 September 1999, Canal da Passagem, Vitória.

Diagnosis. A species of *Gobiosoma* distinguished from other members of the genus by the following characters: body scaled from caudal peduncle to base of pectoral fin, scales in a wedge shape to under posterior of first dorsal-fin base, then continuing anteriorly in a row of 3–4 scales, row slightly tapering anteriorly; a naked area extending from mid-pectoral-fin base to 4th—11th ray of second dorsal fin (rarely extending further) and from the mid-pectoral-fin base to 3rd—9th anal-fin ray (rarely extending further); upper jaw 21.5% in head length; lateral scales modally 29; individuals 15 mm SL or larger with 24+ scales; pectoral fin 18 (17–20); maximum size to 27.8 mm SL.

General morphology. Morphometrics and meristics of the holotype and paratypes are given in Table 4. Body cylindrical, elongate; head rounded in profile; eyes dorsolateral 6.7–9.6% in SL; maxilla generally extending posteriorly to a vertical ventral to mid-pupil; upper jaw length 4.0–9.6% in SL; anterior naris an elongate tube without a flap; posterior naris a raised rim to short tube; very small, wart-like barbel in front of eye, near anterior naris; males with a triangular, wide, flattened urogenital papilla; female papilla, slightly tapering, not flattened, with large opening at end; juveniles with urogenital papilla similar to that of males but shorter, less flattened and rounder at terminus.

Fins. Counts for holotype followed by (range; mode). First dorsal VII (VI–VII, single specimen with VI; VII), no elongate or filamentous spines; first dorsal connected to second dorsal by low membrane; second dorsal fin I,10 (I,8–I,11; I,11), not reaching caudal fin when adpressed; anal fin I,9 (I,5–I,9; I,9), not reaching caudal fin when adpressed; pectoral counts for left fin followed by right, 18/18 (17–20/17–20; 18/18), fin ovate, extending to anus when adpressed; caudal fin round, segmented rays 15 (14–17; 17), branched rays 14 (11–15; 14); pelvic fin I,5 (I,5; I,5), oblong to ovate, extending 3/4 distance to anus when adpressed.

FIGURE 6. (A) CIUFES 0525-2, Holotype of *Gobiosoma alfiei*, an adult breeding male photographed shortly after capture and fixation in formalin 10%, 20.55 mm TL; (B) CIUFES 0525-1, Paratype of *Gobiosoma alfiei*, an adult female photographed shortly after capture and fixation in formalin 10%, 21.27 mm TL. Photographs by R.M. Macieira.

TABLE 4. Meristic and morphometric data for 52 examined specimens of *Gobiosoma alfiei* spec. nov. Morphometric data expressed as percent of standard length, of head length (†) or of jaw length (‡). n = number of individuals, including types.

Meristic characters	Holotype	n	Range	Mode
First dorsal fin	VII	45	VI–VII	VII
Second dorsal fin	I,11	48	I,8–I,11	I,11
Anal fin	I,9	47	I,5-I,9	I,9
Pectoral fin - right	18	42	17–20	18
Pectoral fin - left	18	39	17–20	18
Pelvic fin rays	5	48	5–5	5
Segmented rays in caudal fin	15	47	14–17	17
Branched rays in caudal fin	14	41	11–15	14
Scales in longitudinal series	29	51	3–33	29
Morphometric characters	Holotype	n	Range	Mean ± SD
Total length (mm)	20.6	52	9.2–27.8	20.5 ± 4.1
Standard length (mm)	17.2	52	8.4–22.8	16.8 ± 3.3
Standard length (% TL)	83.6	52	79.2–91.3	82.2 ± 1.8
Head length	29.1	48	27.1–37.6	29.9 ± 1.7
Head depth	18.6	48	17.9–24.4	20.3 ± 1.5
Head width	20.4	48	19.0–27.2	23.0 ± 1.8
Postorbital length	17.5	48	14.7–19.3	17.2 ± 0.9
Upper jaw length	5.8	44	4.0–9.6	6.4 ± 1.3
Interorbital width	1.2	44	0.6–2.1	1.4 ± 0.4
Eye diameter	8.1	48	6.7–9.6	8.1 ± 0.7
Pupil diameter	2.9	39	2.9–4.6	3.7 ± 0.4
Anterodorsal length	8.1	48	6.0–14.8	8.6 ± 1.5
Face barbel length	1.7	25	0.3–2.3	1.2 ± 0.5
First dorsal spine length	12.2	33	8.5–15.0	12.1 ± 1.5
Depth of body at D1 origin	17.5	46	15.2–23.4	18.9 ± 1.7
Pectoral fin length - left	25.0	35	16.5–28.6	24.2 ± 2.4
Pectoral fin length - right	-	37	21.6–28.3	24.7 ± 1.7
Pelvic fin length	17.5	48	13.9–23.9	18.6 ± 1.8
Caudal peduncle depth	13.4	44	12.2–15.4	13.8 ± 0.8
Caudal fin length	22.7	48	16.7–27.0	23.5 ± 1.9
Postorbital length †	60.0	48	45.5–64.2	57.5 ± 3.5
Upper jaw length †	20.0	44	12.8–32.7	21.5 ± 4.6
Interorbital width †	4.0	44	1.9–7.1	4.8 ± 1.4
Eye diameter †	28.0	48	21.8–33.3	27.1 ± 2.3
Pupil diameter †	10.0	39	10.0–16.7	12.5 ± 1.4
Face barbel length †	6.0	25	1.0–7.7	4.2 ± 1.6
Eye diameter ‡	140.0	44	76.5–220.0	132.9 ± 31.5

Scales (Fig. 4B). Counts for holotype followed by (range; mode). Lateral scales rows 29 (3–33; 29); head, nape, abdomen, prepelvic region and belly without scales; scales ctenoid, with pigmented posterior edge; body scaled generally from caudal peduncle to base of pectoral fin, scales in a wedge shape to under posterior of first dorsal-fin base, then continuing forward in a row, reducing to 3–4 scales under pectoral-fin base; a naked area

extending diagonally from mid-pectoral-fin base to (or posterior to) the 4th ray of second dorsal fin (generally ending before posterior of D2 base) and from the mid-pectoral-fin base to (or past) the 3rd anal-fin ray (generally ending before end of anal fin base); four basicaudal scales extending on to caudal fin base, the dorsal and ventral-most with elongate ctenii (Fig. 4E). Juveniles show scale formation that progresses from posterior to anterior, adding scales at the anterior, dorsal and ventral edges of the wedge; basicaudal scales are present in settlement larvae (Fig. 9).

FIGURE 7. (A) CIUFES 0525-2, Holotype of *Gobiosoma alfiei*, an adult breeding male photographed after fixation in formalin 10% and preservation in ethyl alcohol 70%, 20.55 mm TL; (B) CIUFES 0525-1, Paratype of *Gobiosoma alfiei*, an adult female photographed after fixation in formalin 10% and preservation in ethyl alcohol 70%, 21.27 mm TL. Photographs by R.M. Macieira.

Teeth. Based on five cleared and stained specimens. **Females**: Upper jaw with 3–4 rows anteriorly, reduced to a single row posteriorly, extending nearly to end of premaxilla; all teeth conical pointed and recurved. Outer row of teeth large recurved, conical and evenly spaced; no canine teeth present; lower jaw with 3–4 rows anteriorly, reduced to 1 row posteriorly, outer and inner row slightly larger than central rows, teeth conical with recurved tip; no canine teeth present; teeth extending to terminus of dentary. **Males**: Upper jaw with 3–4 rows anteriorly reduced to a single row at posterior, extending nearly to terminus of premaxilla; all teeth conical, pointed and recurved; outer row with large recurved conical teeth, evenly spaced; no canine teeth present; lower jaw with 3–4 rows at anterior, outer row slightly larger, middle rows small, closely packed, inner row with 3–4 large recurved canine teeth along anterior third of jaw; teeth extending to terminus of dentary.

Lateral-line system (Fig. 8). Cephalic lateral line system with pores B', C(s), D(s), E, F, H' and posterior oculoscapular pores K', L'; preopercle canal with pores M', N and O'; supraorbital canals fused between the eyes with only single canal present; small individuals (< 17 mm TL) occasionally missing one or more of the following pores: K, L or M, N.

Sensory papillae in a transverse pattern (Fig. 8); row 1 extending from orbit to row *d*; rows 2 and 3, not reaching orbit; row 5*s* from orbit to near anterior of *b*, but not connecting to *b*; row 6 not reaching row *b*; row 7 represented by 1 papillae (rarely 2); row *b* short, ending anteriorly before row 5*s*; row *d* continuous; row 5*i* under *b* and extending below level of *d* by 2–3 papillae. Dorsal row *g* with 3–4 papillae; row *o* reduced to 1 papilla; row *m* not observed and row *n* extending from level of pore F, medially to just past pore E.

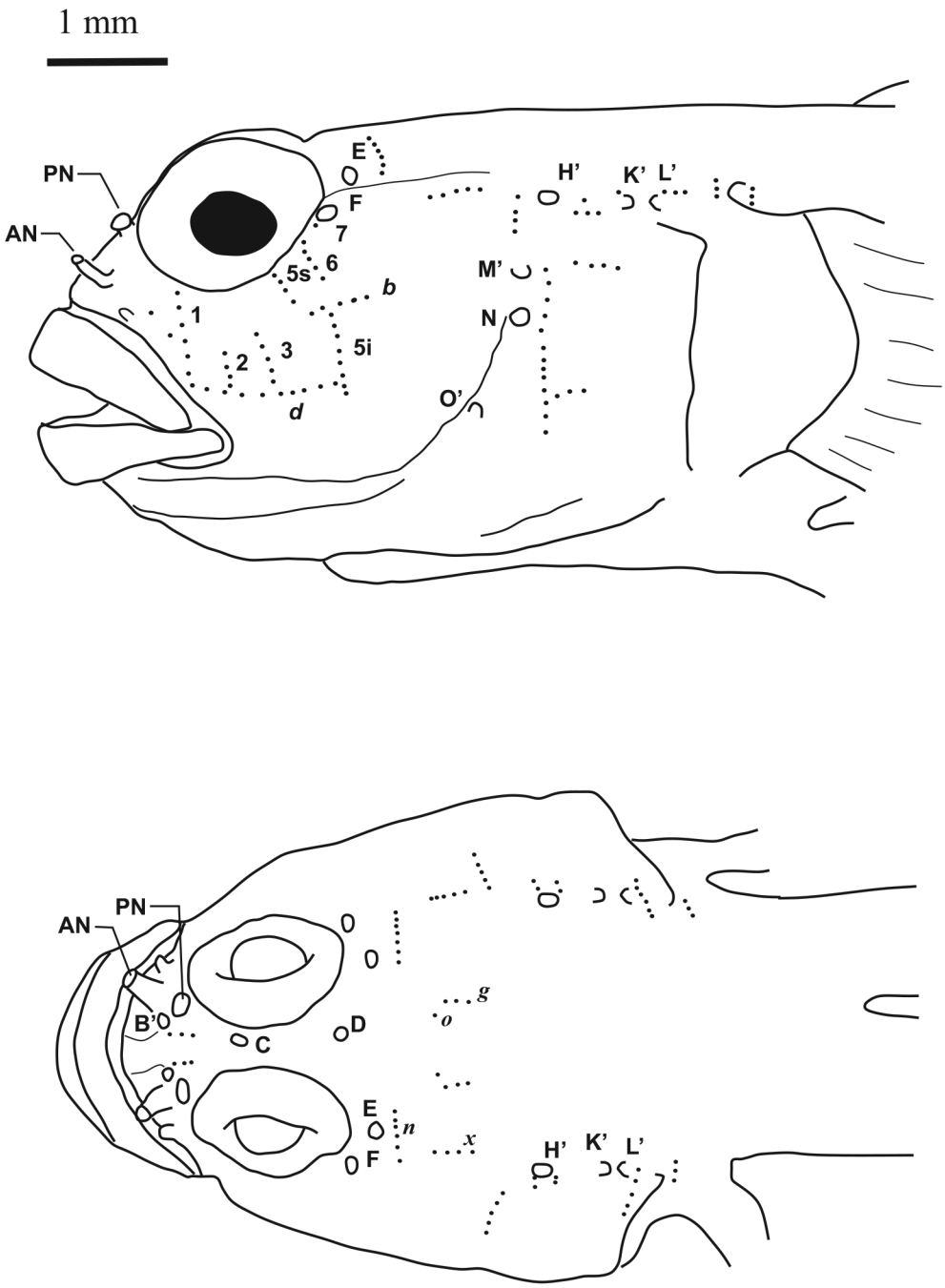

FIGURE 8. Sensory papillae and head canal pores of *Gobiosoma alfiei*, AMNH 258024.

Color in life (Fig. 6). Background color of head and body brownish to olive-green, occasionally with a golden tint. Body with eight bars along body from under anterior of first dorsal fin to caudal fin; each bar of mottled brown with a light (whitish) thin central area; edges of bars not well defined, with indistinct wavy edges; bars not extending onto the belly and often the bars are not evident in males. First bar located below the anterior of first dorsal fin (D1), second under posterior of D1, third between D1 and D2, 4th through 6th equally spaced under D2, 7th on caudal peduncle and the 8th, a thin bar, at the posterior of the caudal peduncle. A series of single dark spots along lateral midline (spots occasionally double) located in the middle of each bar; last dot, of 8th bar, often as a forward-pointing triangle. Head with three spots located in a line between the posterior of the eye and the posterior edge of the opercle; first located behind eye, second above posterior edge of preopercle and third above posterior edge of opercle. Side of head with two bars; first from the anteriorventral edge of the eye to the upper lip, extending over

the lip and occasionally onto the lower lip, bar not always distinct in appearance; a second more distinct bar from mid-ventral orbit, vertically to and past posterior of jaw, bar with a short posteriorly directed extension, below midpoint of bar. Posterior edge of preopercle dark, along most of its length. Opercle with dark anterior edge, not extending the full length. Dorsal fins with horizontal bands, continuous in males, pigment in females restricted to elements. First dorsal fin with three oblique dark bands, the lower two bands coalescing, at their posterior, with the first and second dark bars of the body; upper band located along dorsal edge of fin. Second dorsal fin with 4 oblique bands, first three coalescing, at their posterior ends, with bars of body; fourth band near dorsal margin of fin; bands poorly defined. Anal fin with two poorly defined horizontal bands along its dorsal and ventral edges. Pectoral fin with two diffuse dark spots (sometimes crescent shaped), on dorsal and ventral base of fin rays; remainder of the fin transparent. Pelvic fin dusky with melanophores concentrated between elements. Caudal fin transparent with a few scattered melanophores, forming light vertical bars in both sexes. The species is dimorphic in pigment pattern. In breeding males the head and the anterior part of the trunk is yellowish orange, body color darker and banding less obvious; in females the head coloration is similar to that of the body.

Preserved color (Fig. 7). Preserved specimens retain their distinct color pattern and dimorphism persists (7 years in alcohol 70%) despite fading; the brightest colors (reddish brown and golden yellow) vanish leaving only the underlying melanophores or unpigmented background.

Osteology. Osteology based on five cleared and stained specimens. Vertebrae 11 precaudal and 16 caudal (total 27)(5 specimens); dorsal pterygiophore formula 3-221110 (4) or 3-212110 (1); anal pterygiophores anterior to first haemal spine 2 (5); procurrent rays 6/ 6 (upper/lower) (2), 7/7 (2), 7/6 (1); segmented branched caudal rays 7/7 (2), 7/6 (3); segmented unbranched caudal rays 2/1 (2), 1/1 (2), ?/1 (1); epurals 1 (5); hypurals 1/2 fused to hypurals 3/ 4 halfway (5).

Etymology. The specific name honors Alfredo Carvalho-Filho ─Alfie, as he calls himself, a self-made ichthyologist in his spare time, for his contribution to the advancement in the diversity and taxonomy of Brazilian marine fishes and his friendship.

Distribution, habitat and natural history. *Gobiosoma alfiei* is currently known only from Brazil, from Anchieta, Espírito Santo to Iparana, Ceará. Most specimens from Espírito Santo were collected in shallow (< 0.5 m) tidepools within a flat reef. The tidepools are, generally, depressions in the calcareous material with a sand and gravel substrate, tidepool edges covered by algal turf, soft macro-algae, coralline algae and a few soft and hard corals. The reef surface is generally flat and pools frequently interconnect with each other through both overflows and an extensive system of dissolution holes and channels (see Joyeux *et al.* 2009 for illustration). Sympatric gobiid species, that share the same pools but not necessarily the same microhabitat, include *Bathygobius geminatus* Tornabene, Baldwin & Pezold 2010 (most abundant), *Bathygobius soporator* (Valenciennes 1837), *Barbulifer enigmaticus* (Joyeux, Van Tassell & Macieira 2009), *Coryphopterus glaucofraenum* Gill 1863 and *Ctenogobius saepepallens* (Gilbert & Randall 1968) (least abundant) (Joyeux *et al*. 2009; Macieira & Joyeux 2011). *Gobiosoma alfiei* is not limited to the intertidal zone. Underwater observations in the state of Alagoas (northeastern Brazil) at about three meters depth (low tide) by one of us (JCJ) showed several *G. alfiei* living on (and in) a rock outcrop located under a reef ledge. The outcrop was composed of encrusting coralline algae, interspersed with filamentous and turf-like algae. Mostly, isolated (single) *G. alfiei* were observed perched at the entrance of a small hole in the calcareous rock, occasionally biting at the substrate, and darting into the hole at the slightest disturbance. In one occasion, an individual was observed chasing another, both finally entering the same hole and not reappearing during the observation period. In the state of Paraíba (northeastern Brazil), the species was observed by one of us (JCJ) in subtidal areas (about three meters depth) under a small, flat, rounded stone lying on top of a flat clay substrate. Upon lifting the stone, the fish disappeared into a small round hole in the substrate. In a 15 cm deep tidepool in the state of Espírito Santo, one of us (JCJ) observed *G. alfiei* entering and exiting one of the numerous holes in the clay along the side of the pool. Swimming was limited to close contact with the bottom, in small (1–10 cm) darts, starting and ending in protected areas (*i.e.*, under stones, near holes, into cavities). Breeding males were observed perched near holes for extended periods, moving up to 30 cm away, before entering/exiting the hole.

Conservation. Least Concern (Assessment done by MMA/ICMBio; Ministério do Meio Ambiente/ Instituto Chico Mendes de Conservação da Biodiversidade). No known specific threat, but the anthropogenic modifications on coastal marine ecosystems could be a threat in the near future.

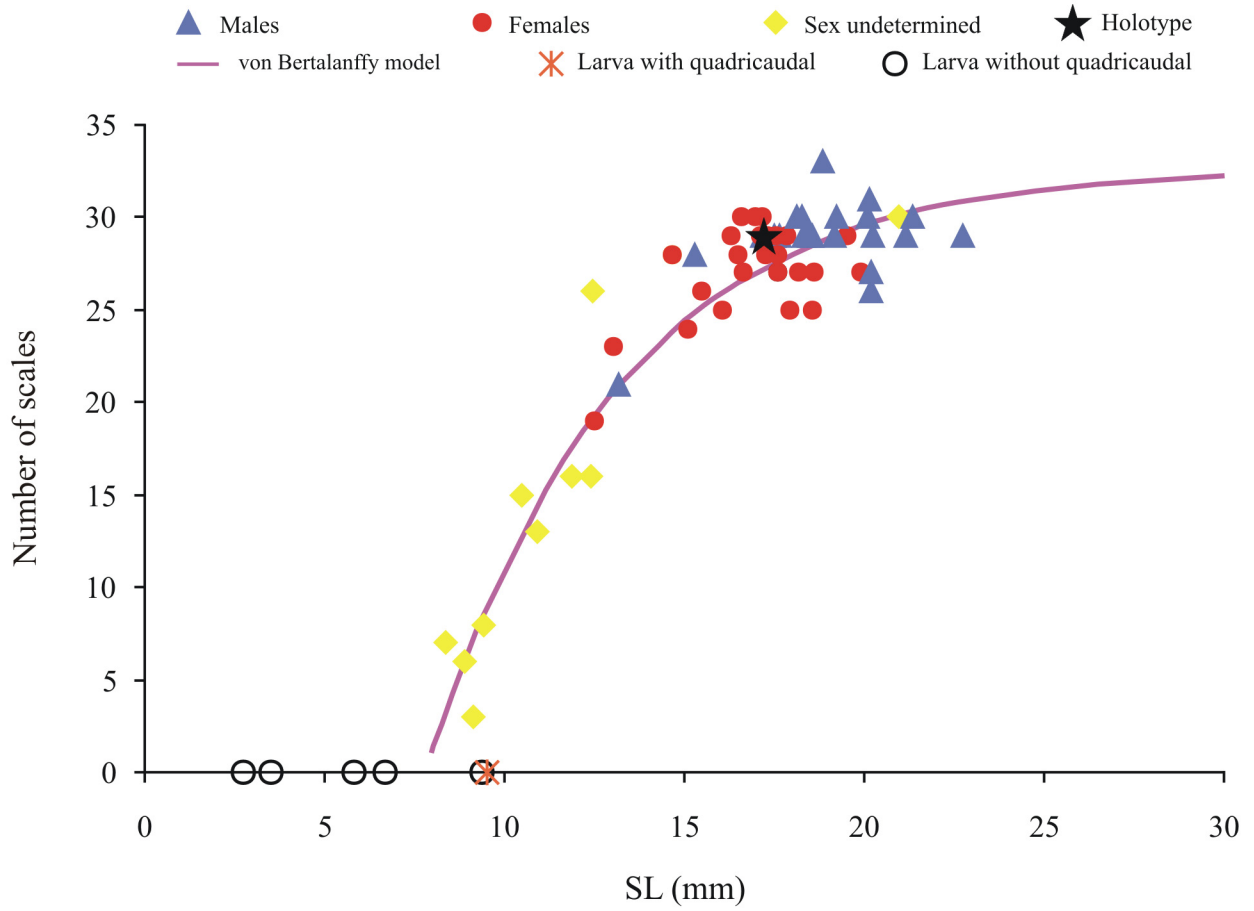

FIGURE 9. Number of scales longitudinal series as a function of standard length in *Gobiosoma alfiei* settled individuals of indeterminate sex (yellow diamonds), females (red circles) and males (blue triangles). The holotype, a male, is indicated by a black star. *Gobiosoma alfiei* planktonic larvae are indicated for individuals without external basicaudal scales (open circles) and with external basicaudal scales (crosses); length is notochord length or standard length depending upon the stage of the larva. The fitted von Bertalanffy curve relating scale count to standard length for settled individuals (see text) is overlaid; estimated values were extrapolated past lowest and highest SL for better visualization. The model explains 89 % of the variation in scale number according to standard length, as estimated by a Pearson correlation.

Redescription of *Gobiosoma spilotum*

Gobiosoma spilotum (Ginsburg 1939)

Figs. 10,11,12

Garmannia spilota Ginsburg 1939:62 (type locality: Colon, Panama, in tidepools)
Gobiosoma (*Austrogobius*) *spilotum* Böhlke & Robins 1968: 59 (assigned to *Gobiosoma*, subgenus *Austrogobius*).

Material examined. PANAMA (Atlantic): USNM 81828, holotype, Meek and Hildebrand, 12 March 1912, tidepools, Colon, Panama; AMNH 233131, 2 (1 female, 1 male photographed, male missing), J.L. Van Tassell, 09 April 2001, Panama Canal, near Fort Sherman; ANSP 108745, 6 of 7, Pillsbury sta. 321, 05 July 1966, W shore of Limon Bay, 1400 m S of Pulpit Point, Canal zone, Panama; ANSP 110681, 1, c&s, Pillsbury sta. 321, 05 July 1966, W shore of Limon Bay, 1400 m S of Pulpit Point, Canal zone, Panama; UF 222503, 5, R/V Pillsbury, 04 July1966, Canal zone, Caribbean Pulpit Point, Limon Bay; GCRL V72: 8698, 10 of 31, Dawson and Jones, 20 March 1972, Canal zone, Gatun Locks, Colon.

Comments on *Gobiosoma spilotum*. Böhlke and Robins (1968) adequately enhanced the description of *Gobiosoma spilotum* provided by Ginsburg (1939). We examined many of their specimens and additional collections made by Dawson & Jones (1972). Here we expand on the previous works to enable us to draw clear distinctions between *G. hemigymnum* and *G. alfiei*.

Diagnosis. A species of *Gobiosoma* distinguished from other members of the genus by the following characters: body scaled from caudal peduncle to base of pectoral fin, scales in a wedge shape to under anterior of second dorsal-fin base, then continuing anteriorly in a row of 4–5 scales, row slightly tapering anteriorly; a naked area extending from upper pectoral-fin base to 3rd of 4th ray of second dorsal fin (rarely extending further) and from the lower pectoral-fin base to 3rd or 4th anal-fin ray (rarely extending further); upper jaw 41.5% in head length; lateral scales modally 26; pectoral fin 19 (18–20); maximum size to 27 mm SL.

General morphology. Body is cylindrical, elongate; head rounded in profile; eyes dorsolateral 6.3–8.4% in SL; maxilla generally extending posteriorly to a vertical ventral to mid-eye; upper jaw length 10.6–12.3 % in SL; anterior naris an elongate narrow tube without a flap; posterior naris a raised rim. A very small, wart-like barbel in front of eye, near anterior naris. Males with a triangular, wide, flattened urogenital papilla; female papilla, slightly tapering, not flattened, with large opening at end; juveniles with urogenital papilla similar to that of males but shorter, less flattened and rounder at tip.

Fins. Counts for holotype followed by (range; mode). First dorsal fin VII, none filamentous or elongated; first dorsal connected to second dorsal by low membrane; second dorsal fin I,11 (I,10–I,11; I,11), the last element a single ray in 30% of specimens examined; anal I,9 (I,8–I,10; I,9); second dorsal and anal fins not reaching caudal fin when adpressed; pectoral counts for left fin followed by right, 19/19 (18–19/18–20; 19/19), fin ovate, extending to anus when adpressed; caudal segmented rays 16 (16–19; 17), and branched rays 15 (13–15; 14), fin round; pelvic fin I,5 (I,5; I,5), oblong to ovate, extending 3/4 distance to anus.

Scales (Fig. 4C). Lateral scale rows 28–29 (26–29); head, nape, abdomen, prepelvic region and belly without scales; body scales ctenoid, with posterior edge pigmented, scales in a wedge shape to under middle of first dorsal-fin base, than continuing forward, reducing in width ending under pectoral-fin base; one large cycloid scale, generally present under lower anterior third of pectoral fin; naked area extending from upper pectoral-fin base to 3rd element of second dorsal fin (never extending to end of fin base) and from lower pectoral-fin base to the 3rd element of anal-fin base (never extending to middle of fin base); four basicaudal scales extending on to caudal fin base, the dorsal and ventral-most with elongate ctenii (Fig. 4E).

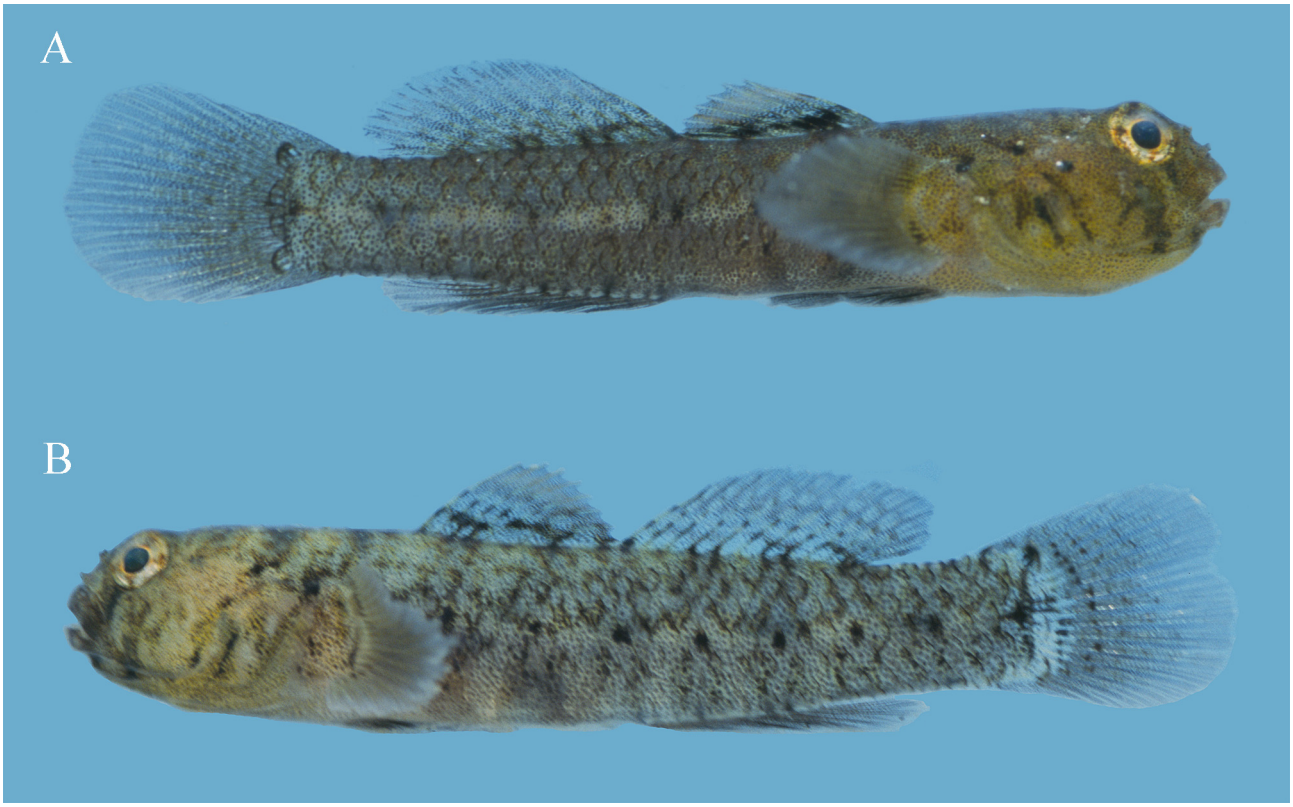

FIGURE 10. (A) JVT-01-105, *Gobiosoma spilotum*, an adult breeding male photographed shortly after capture, collected with AMNH 233131; (B) AMNH 233131, *Gobiosoma spilotum*, a female photographed shortly after capture. Photographs by J. L. Van Tassell.

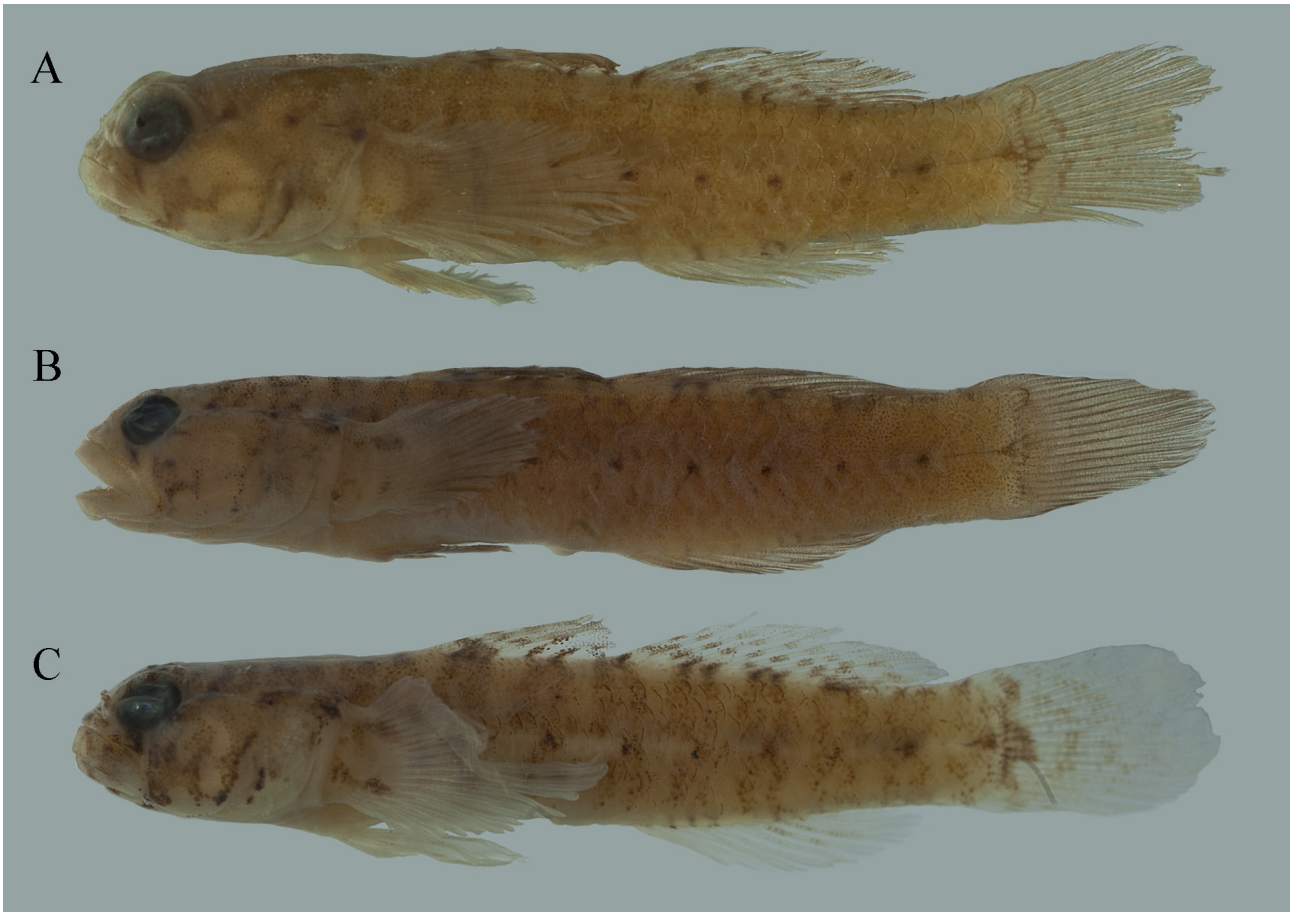

FIGURE 11. (A) ANSP 108745, *Gobiosoma spilotum*, a male photographed after fixation, 18.03mm TL; (B) GCRL V72 8698, *Gobiosoma spilotum*, a male photographed after fixation, 31.75 mm TL; (C) GCRL V72 8698, *Gobiosoma spilotum*, a female photographed after fixation, 23.29 mm TL. Photographs by J. L. Van Tassell.

Lateral-line system. Cephalic lateral line system (Fig. 12) with pores B', C(s), D(s), E, F, H' and posterior oculoscapular pores K', L'; preopercle canal with pores M', N and O'. The supraorbital canals are fused between the eyes with only a single canal present.

Sensory papillae in a transverse pattern (Fig. 12). Row 1 extending from orbit to row *d*; rows 2 and 3, not reaching orbit; row 5*s* from orbit to near anterior of *b*; row 6 not reaching row *b*; row 7 represented by 1 papilla (rarely 2). Row *b* short, ending anteriorly before row 5*s*; row *d* continuous; row 5*i* under *b* and extending below level of *d* by 2–3 papillae. Dorsal row *g* with 2 papillae; row *o* reduced to 1 papilla; row *m* not observed and row *n* extending from above pore F to beyond pore E (about 4 papillae medial to pore E).

Color in life. Based on photographs of two fresh specimens from AMNH 233131 (Fig. 10). Background color of body light grayish brown in males, somewhat lighter yellowish pale in females; body with eight bars faint in males, apparent in females; bars with light centers extending width of body, forming, in heavily pigmented specimens, a double bar. Anterior of first bar under second spine of D1, second bar under posterior of D1, third between D1 and D2, fourth, fifth, sixth under D2, seventh on mid-caudal peduncle, eight a thin bar on base of caudal fin. Sides of body, in both sexes, with a series of eight black spots along mid-line. In both, the first dot approximately below the 3rd spine of the first dorsal (D1) spine, the second spot below the origin of the 6th D1 spine, the third spot (may be doubled) below the origin of the second dorsal (D2) fin, the fourth spot below the 5th element of D2, the fifth spot (may be doubled) below the 7th element of D2; sixth spot under last element of D2, seventh on mid-caudal peduncle, and eighth spot, frequently a forward anteriorly directed triangle, on mid-caudal fin base; spots in males often separated by a narrow pale area along lateral midline. Posterior edge of scales pigmented, more heavily pigmented in females.

Background color of head yellowish brown, brighter yellow ventrally in males. Three dark spots located between the posterior of the eye and upper pectoral fin base; first directly behind eye, second above the preopercle,

third above posterior edge of opercle. Side of head with two dark bars below eye; anterior bar extending from anterior margin of eye ventrally across the jaw, continuing under the lower jaw, pigment on jaw much lighter in males than females. Posterior bar in both sexes, wider than anterior, nearly as wide as pupil diameter, originating below middle of eye, extending ventrally slightly below posterior margin of lower jaw. Two thin lines of pigment one near the posterior edge of the preopercle, the other along the anterior of the opercle.

First dorsal fin with dark lateral band near base of fin, dark band broken or mottled in females, dorsal half of fin pale or whitish. Second dorsal-fin base with dark marks continuous with bars on body; two bands formed by scattered melanophores, middle band lighter and narrower, upper band with light spotted pattern. Pectoral-fin base background yellowish with scattered melanophores; spot formed by larger melanophores on lower third of fin base, more distinct in males; base of fin rays with two pigmented areas on upper and lower thirds, each covering 5–6 rays; lower pigmented area extending on to fin base. Anal and pelvic fins with scattered melanophores, darkest at base, edges of fins with thin, light to whitish band. Caudal fin uniformly covered with melanophores on anterior half of in males, mottled or with broken vertical bars in females, posterior half of fin lightly pigmented to pale in both sexes.

Preserved color (Fig. 11). Preserved specimens body and head background color light brown only. Body and head markings as above; anal and pelvic fins tend to lose pigmentation.

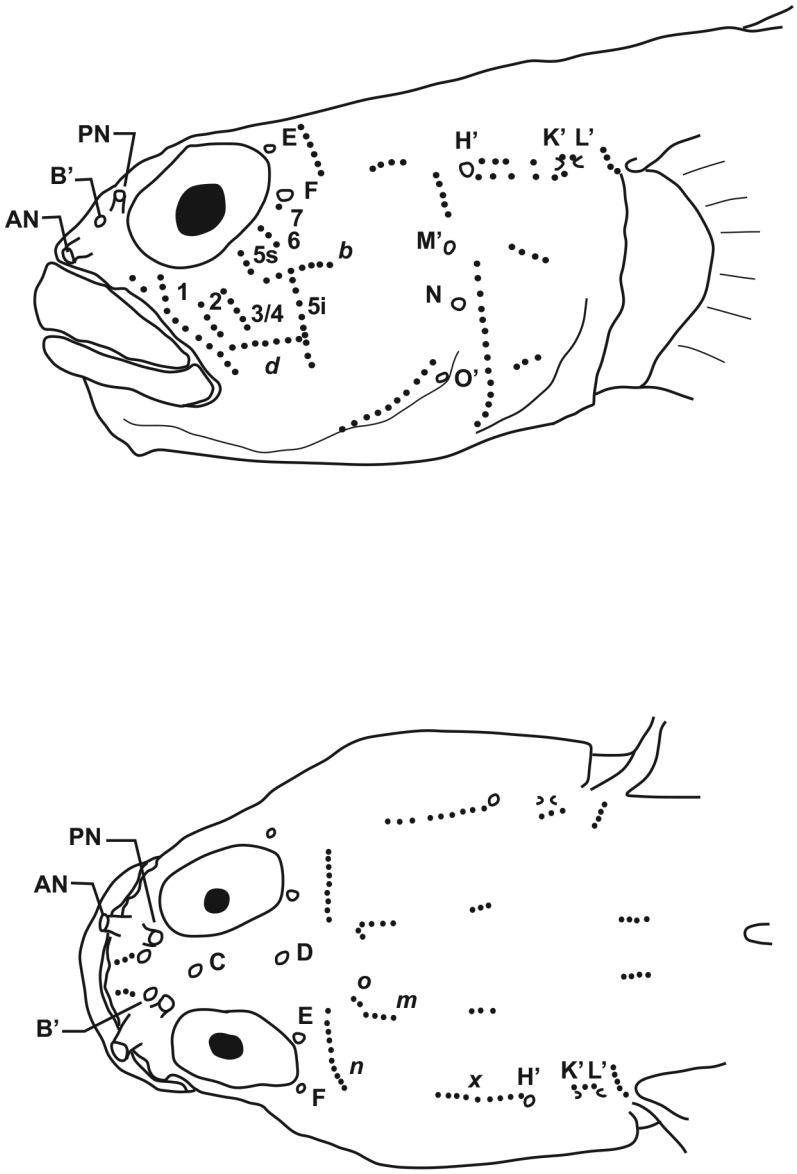

FIGURE 12. Sensory papillae patterns of *Gobiosoma spilotum*, from specimen GCRL V72 8698 #7.

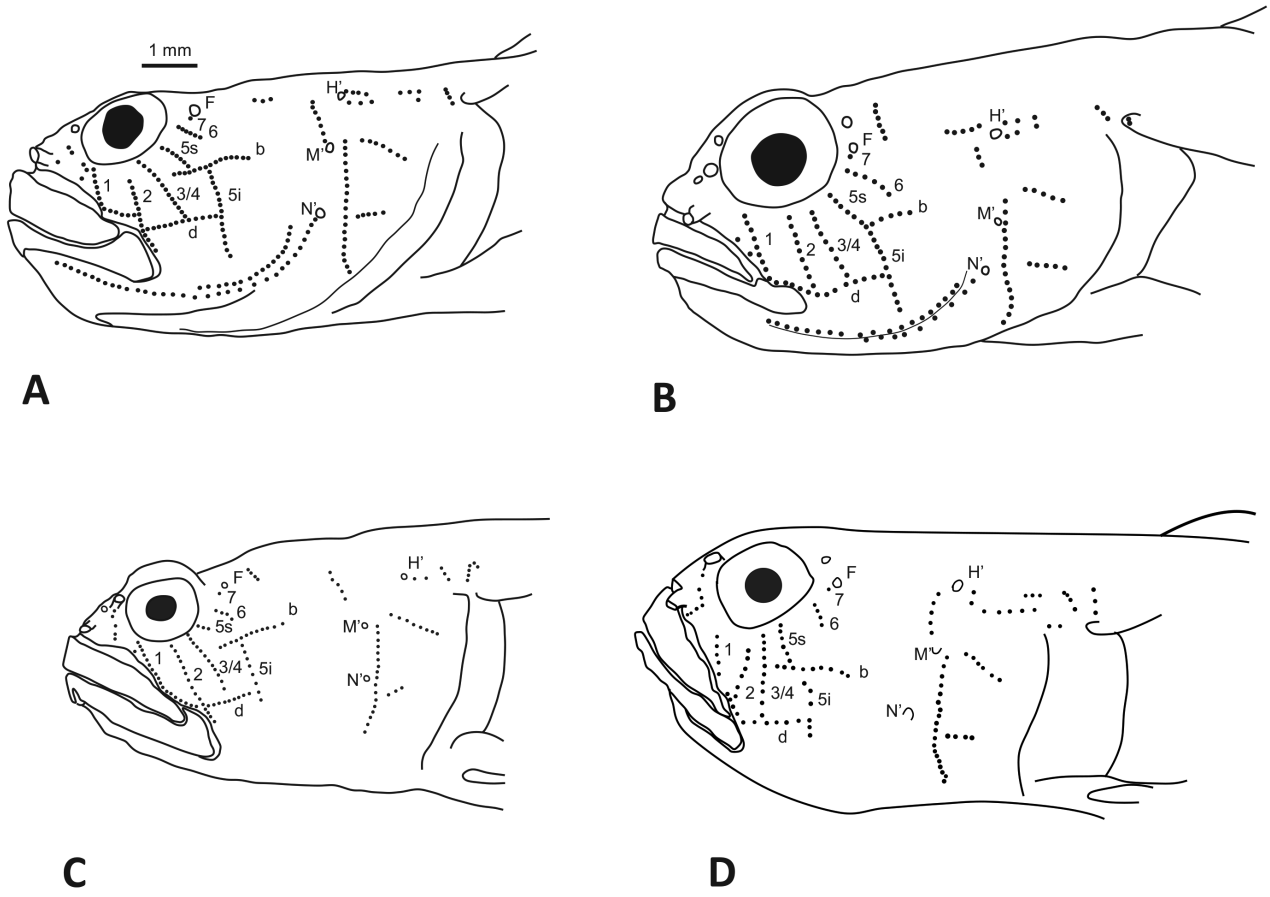

FIGURE 13. Lateral view of sensory papillae patterns for (A) *Gobiosoma spes*, (B) *G. hildebrandi*, (C) *G. yucatanum* and (D) *G. schultzi*.

Distribution and habitat. We can document this species only from the Panama Canal, Gatun locks and Limon Bay in the Atlantic. Three specimens from Columbia (INVEMAR PEC-1108) and one specimen from Costa Rica (UCR 276516), near the border with Panama exist but we have not yet been able to obtain these specimens in order to confirm the identification. The species is found in brackish coastal areas with a rock and algae substrate. *Gobiosoma spilotum* was collected in large numbers, 30–80 per lot by Dawson in 1972 and 1974, from the Gatun locks of the Panama Canal and Limon Bay, the Atlantic entrance to the canal. Recent collections in the same area, by one of us (JVT) in 2001, have yielded only two specimens AMNH 233131.

Conservation status. If the species only occurs in the Limon Bay and Gatun locks area, then it would be critically endangered. Construction of the new canal and pollution from shipping will impact the habitat. Specimens inhabiting Gatun Locks and the surrounding Gatun Lake are subject to predation by the introduced cichlid, *Cichla ocellaris* Bloch & Schneider 1801, which has eliminated seven of the eleven most common fish species within the lake (Zaret & Paine 1973).

Comparisons among species

Gobiosoma hemigymnum, *G. alfiei*, and *G. spilotum* appear very similar and have been incorrectly identified due to a number of reasons discussed below. While they are very similar there are a number of characters that can be used, in combination, to separate them in addition to their distribution patterns. To our knowledge, all three species have non-overlapping distributions with the possible exception being the northernmost limits of *G. hemigymnum* and the southernmost limits of *G. alfiei* (Fig. 5). These limits coincide with the region of transition between northern and southern faunas within the Brazilian biogeographical province (*e.g.*, Palacio 1982; Floeter *et al*. 2008). Freshwater and sediment input, upwelling regime, coast orientation and substrate differ between these zones, the latter factor

being crucial for benthic species (*e.g.*, Arakaki *et al*. 2014). From the south of Espírito Santo to Santa Catarina, substrate is essentially limited to Precambrian crystalline rock (granites and gneisses) that can support the sessile fauna associated with *G. hemigymnum* (*e.g.*, mussels, *Styela*). From southern Espírito Santo northward, cavity-rich carbonatic structures (limestone, biological reefs) and clay matrices of the Barreiras Formation dominate, the habitat in which *G. alfiei* is found.

Scale patterns are distinct between the species. They all possess an anteriorly directed wedge-shaped pattern that decreases to a reduced anteriorly directed extension, ending ventral to the pectoral fin. What differs is the dorsal and ventral naked areas and the width of the anterior extension of scales. In *Gobiosoma hemigymnum* (Fig. 4A) the dorsal naked area extends posteriorly to the end of the second-dorsal fin base or beyond with the forward extension being thin (width of 1–2 scales generally) and in a distinct straight line. In *Gobiosoma alfiei* (Fig. 4B) the dorsal naked area extends to or just past the 4th ray of the second dorsal or slightly beyond (never to the end of the second dorsal) and the anterior extension is not straight and narrow but, tapers anteriorly, with 4–5 scales reducing to 3–4 scales under the pectoral fin. *Gobiosoma spilotum* (Fig. 4C) is more heavily scaled, the dorsal naked area ends at or near the 3rd ray of the second dorsal and its dorsal extent remains close to the second dorsal-fin base; the anterior extension is much wider than the other species, the anterior end extending almost the width of the pectoral-fin base; there is frequently one or two large cycloid scales under the pectoral fin and the ventral edge of the scale pattern remains very low on the body.

Variations occur in number of scales in the lateral series particularly in *G. hemigymnum*. The number and extent of scales can be greatly reduced and is independent of size or sex, particularly in the southern-most populations. *Gobiosoma hemigymnum* is the southernmost member of the genus and is exposed to colder waters and seasonal changes in temperature caused by seasonal to extended periods of upwelling (Martos & Piccolo 1988; Guerrero *et al*., 1997). Hoese (1971) found that in Pacific *Gobiosoma*, size increased in cooler locations, extent of squamation varied with sex and locality, and specimens from areas of upwelling differ in meristics from those of more stable environments. Southern specimens of *G. hemigymnum* attain the largest size and exhibit the greatest variation on lateral scales, varying from only two basicaudal scales to a small patch on the caudal peduncle, up to the pattern described above.

The species differ in several other characters, which used in combination with scale patterns and distributions, can be used to differentiate them: A) Upper jaw length, *G. spilotum* has the largest upper jaw 41.5% in HL, followed by *G. hemigymnum* 34.6% in HL, and *G. alfiei* with a much smaller upper jaw of 21.5% in HL; B) Second dorsal terminal rays, in *G. spilotum* the last ray is not divided in about 30% of the specimens we examined, which has not been observed in the other species; C) Pectoral fin rays, *G. alfiei* has the lowest ray count with a mean of 18 with 52% of specimens have 18 or less compared to *G. hemigymnum* where only 13% have 18 rays, *G. hemigymnum* and *G. spilotum* both have a mean of 19 but *G. hemigymnum* has 21 rays in 30% of the specimens, none of the other species have 21; D) Color patterns, when present, the bars on the body have distinct differences. In *G. alfiei* the bars have wavy non-distinct outer edges and the central lighter region is not distinctly separate from the darker edges; the bars in *G. hemigymnum* have distinct straight outer edges, the central region is lighter but not distinct; *G. spilotum*, in heavily pigmented populations, has distinct bars with dark, thin, straight, outer edges and a wide distinct lighter central area, that extends the complete vertical distance of the body. In the other species the bars tend to extend only to the midline.

Key to the Atlantic species of *Gobiosoma*

The following identification key is based on data compiled from many specimens examined by us and others (Böhlke & Robins 1968; Dawson 1971; Ginsburg 1933, 1939, 1942, 1944; Joyeux, Van Tassell & Macieira 2009). These records and other distribution points from Robertson & Van Tassell (2012) served as initial estimates of species ranges. These distributions were then evaluated at three IUCN Red List assessment workshops (Global Marine Species Assessment workshops in Barbados 2011, Corpus Christi 2011 and 2014), where questionable distribution points were discussed, suspected mis-identifications removed or specimens examined and re-identified if required, resulting in the ranges listed for each species below. Given the overlap in several characters, identification of a single specimen without exact locality data may not be possible.

1a Body scales and modified basicaudal scales absent 2
1b Body scales and/or basicaudal scales present 3
2a Posterior oculoscapular pores K and L typically present; body with distinct dark and light bars, light bars thinner; series of small single spots along midline; D2 I,12 (I,11–I,13); anal fin I,10 (I,9–I,11); pectoral fin 18 (18–19); Massachusetts to Florida, (not Florida Keys), Everglade City, Florida along Gulf of Mexico coast to Veracruz, Mexico . . . . . *G. bosc*
2b Posterior oculoscapular pores K and L typically absent; body pattern with indistinct bars; series of small spots along midline, typically in pairs; D2 I,11(I,10–I,12); anal fin I,9 (I,8–I,10); pectoral fin 16–17 (15–18); Gulf of Mexico coast from southern Texas to Key West, Florida and along the Atlantic coast north to Miami and Cape Canaveral, Florida . . . . . *G. robustum*
3a Only two small modified basicaudal scales present 4
3b Body with scales, at least on caudal peduncle; modified basicaudal scales present or absent 5
4a Anal fin I,9 (I,8–I,10); pectoral fin 17 (15–18); Gulf of Mexico coast from Marco, Florida to Texas. . . . . *G. longipala*
4b Anal fin I,10 (I,9–I,11); pectoral fin 18–19 (17–20); Wareham River, Massachusetts to Jacksonville, Florida . . . . *G. ginsburgi*
5a Scales extending to posterior of caudal peduncle base; modified basicaudal scales present; head pores B', C(s), D(s), E, F, H' present, pores K' and L' present or absent; preopercle pores M', N, O' present 6
5b Scales not extending to posterior of caudal peduncle, ending before base of caudal fin rays; modified basicaudal scales lacking; head pores B', C(s), D(s), E, F, H' and preopercle pores M', and N' present 10
6a Head pores K' and L' absent; head and anterior of body with very distinct dark bars; first two D1 spines elongate in males, extending to middle of D2 when adpressed; sensory papillae transverse rows 1,2,3 extending from orbit to horizontal row *d*, row 5 continuous from orbit to below *d* and at anterior of row *b* (Fig 13B); Panama Canal, Atlantic coast of Panama from Bocas Del Toro, Laguna de Chiriqui to Maria Chiquita; migrant through canal into Panama Bay . . . . . *G. hildebrandi*
6b Head pores K' and L' present 7
7a Second dorsal fin I,10–I,11; anal fin typically I,9; pectoral fin rays 18–19; body scaled from caudal fin base to under pectoral fin base, scale pattern an anterior pointing wedge, a large naked area from pectoral fin base to second dorsal ray 3–10 and a large naked area from pectoral fin base to middle of anal fin base (Fig. 4A,B,C); very small, wart-like barbel in front of eye, near anterior naris 8
7b Second dorsal fin I,9; anal fin I,8; pectoral fin rays 17; body heavily scaled from posterior of caudal fin to pectoral fin base, a small narrow, naked area from upper end of pectoral fin base to origin of second dorsal fin and from the lower pectoral fin base to the anus, naked area narrow, scale edge remaining close to ventral surface (Fig. 4D); wart-like barbel in front of eye absent; distribution southeastern Florida, Jamaica, Bahamas, Mexico (Yucatan, Gulf of Mexico), Puerto Rico, Virgin Islands and Venezuela . . . . . *G. grosvenori*
8a Anterior and posterior nostrils tubes nares tubular, with posterior naris 1/3 or less the height of anterior naris; scale pattern as in Fig. 4A or 4C. 9
8b Anterior naris an elongate narrow tube, posterior naris only a raised rim; scale pattern as in Fig. 4B; distribution found in Brazil from Anchieta, Espírito Santo to Iparana, Ceará . . . . . *G. alfiei*
9a Scales on body in wedge shape, scale forward of anterior of wedge in a straight thin line of scales to base of pectoral fin (Fig. 4A); scales in lateral series typically 31; anterior and posterior nares tubular, posterior naris 1/3 height of anterior; distribution Rio de Janeiro, Brazil to Mar del Plata, Argentina . . . . . *G. hemigymnum*
9b Scales on body as in Fig. 4C, scales extending to upper and lower base of pectoral fin, not reducing in size; scales in lateral series 26–29; posterior naris a short tube, less than 1/3 height of anterior naris (Colon area of Panama) . . . . . *G. spilotum*
10a Adult males dark brown to almost black and first dorsal fin with 1st spine elongate; adults greater than 3 cm SL; papillae well defined, with row 2 extending below the level of *d* by more than 4 papillae (Fig. 13A); distribution Costa Rica, Panama and Venezuela . . . . . *G. spes*
10b Adult males mottled, similar to females; first dorsal fin with 1st spine not elongate; adult size less than 3 cm SL; papillae row 2 not extending below row *d* or if so by only 1-4 papillae. 11
11a Pectoral rays typically 17; anal fin typically I,9; posterior rows of scales 7–14; papillae row 2 not extending below row *d*; distribution Lake Maracaibo and vicinity, Venezuela . . . . . *G. schultzi*
11b Pectoral rays typically 16; anal fin typically I,8; posterior rows of scales 3–11; papillae row 2 extending below row *d* by 1-4 papillae; distribution Quintana Roo, Mexico south to Honduras . . . . . *G. yucatanum*

Results and discussion

Phylogenetic relationships of Brazilian *Gobiosoma* (Fig. 14). Specimens of *Gobiosoma* from Brazil were recovered in two reciprocally monophyletic clades, each with strong Bayesian posterior probability support values. One clade contains samples from the Brazilian states of Espírito Santo, Bahia, Rio Grande do Norte and Ceará. The second clade contains specimens from the southern states of Santa Catarina, Brazil and specimens from Rio de la Plata, Uruguay, near the type locality of *G. parri*. The northernmost Brazilian clade represents a new species described above, and the southernmost clades represent *G. hemigymnum*. The pair of Brazilian clades is sister to *G. spilotum* from the Panama Canal. These three lineages are more closely related to two Pacific species (*G. nudum* and an undescribed species) than they are to the other Western Atlantic species from South and Central America, *G. grosvenori*, *G. schultzi*, *G. spes* and *G. yucatanum*.

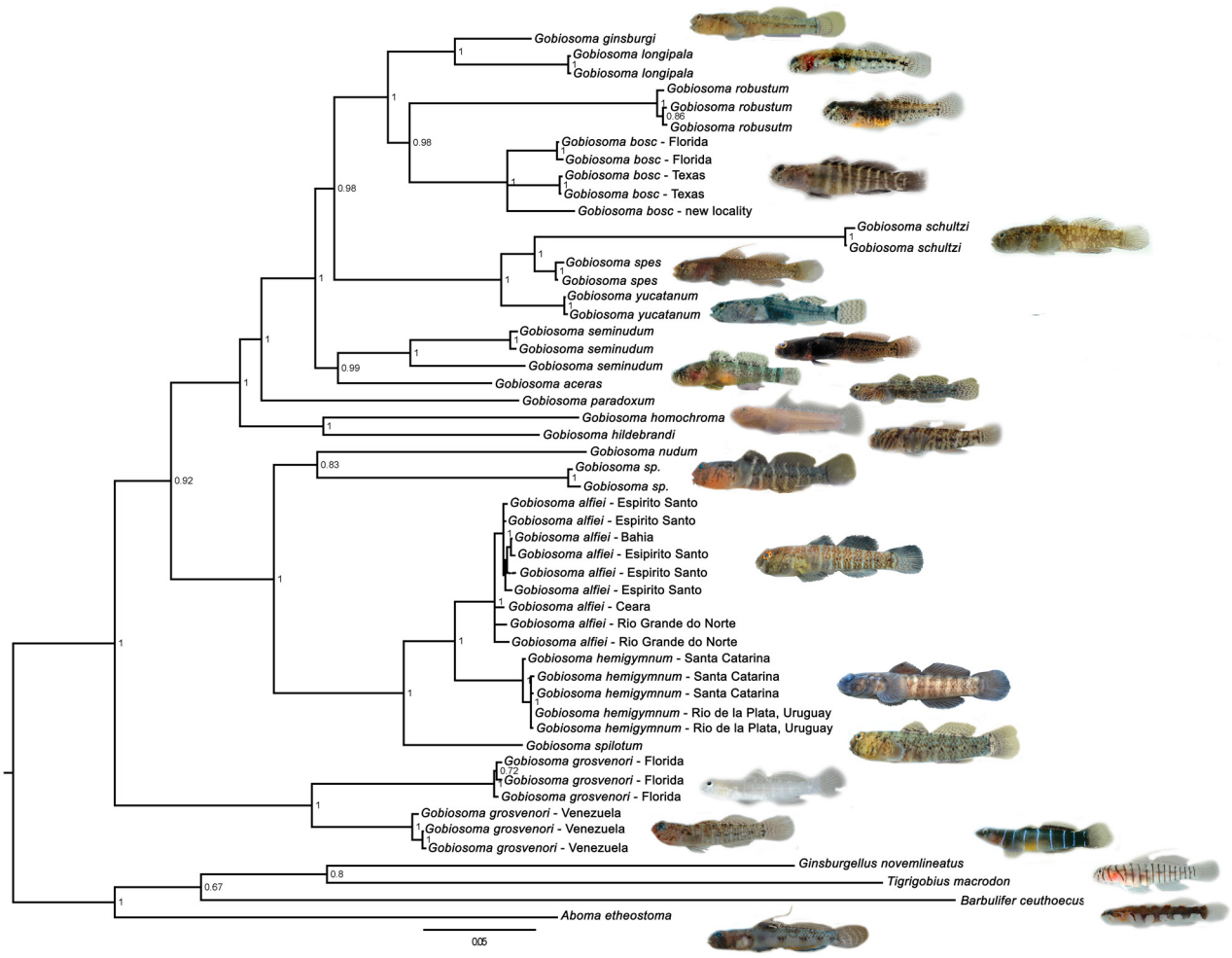

FIGURE 14. Molecular phylogenetic analysis of *Gobiosoma* based on combined nuclear and mitochondrial DNA. Support values at nodes are Bayesian posterior probabilities. Nodes with support less than 0.50 are collapsed.

Status of *Gobiosoma hemigymnum* (Eigenmann & Eigenmann 1888). In 1888 Eigenmann & Eigenmann described *Gobius hemigymnus* based on a single specimen from the West Indies, with exact location listed as unknown. The description of that species had inaccuracies including the dorsal fins recorded as first dorsal VI, second dorsal I,9 instead of VII and I,11 (Böhlke & Robins 1968 counted VII and I,12) and a lateral scale count of 17 instead of 36 (Böhlke & Robins 1968). Fowler (1940, 1941) placed the species in *Garmannia* and listed it as occurring in Rio de Janeiro, but gave no description of the two additional specimens on which the occurrence was based. Ginsburg (1942) used Fowler's two specimens to describe *Garmannia mediocricula*, stating that since Eigenmann & Eigenmann's (1888) description differed "so widely and in so many important particulars from the two specimens [...] described", the fish from Brazil could not be the species identified by Fowler as *Garmannia hemigymna*. Ginsburg concluded that Eigenmann & Eigenmann's (1888) *Gobius hemigymnus* was probably a species of *Risor*. Ginsburg admitted to never examining the type of *Gobius hemigymnus*, basing his comparison instead on the original inaccurate description. To add to the confusion, Fowler (1951) described *Garmannia hemigymna* (Eigenmann & Eigenmann) without reference to Ginsburg's previous work. Böhlke and Robins (1968) examined the types of *Garmannia mediocricula* and *Gobius hemigymnus* noting the inaccuracies in the original description of Eigenmann & Eigenmann (1888), and synonymized the two species as *Gobiosoma* (*Austrogobius*) *hemigymnum*.

Gobiosoma parri was described by Ginsburg (1933) based on 32 juvenile specimens from Uruguay, possessing only 2 basicaudal scales at most. Later, de Buen (1951) placed *G. parri* in *Austrogobius*, describing the species based on a single adult of 39 mm TL (commenting that a number of additional specimens were available but not included), noting that scales are present only on the caudal peduncle and the base of the caudal fin. Böhlke and

Robins (1968) placed de Buen's *Austrogobius* in a subgenus of *Gobiosoma*, noting that lateral scale counts of 8, 11 and 13 were found in three of the five specimens available to them (ANSP 80831). We examined the ANSP 80831 specimens and observed additional scales present under the pectoral fin in two individuals, indicating that original scale counts were higher than recorded by Böhlke and Robins (1968). Cervigón and Bastida (1974) examined 17 specimens from Argentina ranging in size from 15 to 51 mm TL noting that number of scales often varied with size and maturity from only basicaudal scales to 35 lateral scales, but there was no evidence of a direct correlation between size and scale count. They did not compare *Gobiosoma parri* to *Gobiosoma hemigymnum.*

We examined the types of *Garmannia mediocricula* Ginsburg (1942) and *Gobius hemigymnus* Eigenmann & Eigenmann (1888) and agree with Böhlke & Robins' (1968) synonymy. All the types share a unique scale pattern consisting of a triangular patch of scales whose apex faces forward; from under the origin of the second dorsal fin the scales extend forward in a narrow straight line, ending just short of the pectoral-fin base. This straight narrow line of scales also occurs in *Gobiosoma parri* in specimens we examined from Montevideo and Punta del Este, Uruguay and Santa Catarina, Brazil.

The presence of the unique straight narrow line of body scales in: a) the types of *Gobiosoma hemigymnum* from the West Indies; b) its junior synonym *Garmannia mediocricula* from Rio de Janeiro; and c) specimens of *Gobiosoma parri* from Uruguay and Argentina is perplexing. This scale pattern is not found in any other *Gobiosoma* species. Additionally, the types of *G. hemigymnum* are relatively large for highly scaled species of *Gobiosoma* (TL = 44) in the western Atlantic, and the only other species approximating this combination of size and scale pattern is *G. parri* (max TL = 51), which is only known from southern South America. This raises the question as to whether *G. parri* and *G. hemigymnum* (plus its synonym *Garmannia mediocricula*) are conspecific.

If *Gobiosoma parri*, *Gobiosoma hemigymnum* and *Garmannia mediocricula* are conspecific, then the species would have a broad distribution from Argentina to the West Indies—which is typically defined as the region within the Caribbean basin that includes the Antilles and the Bahamas. This distribution is highly unlikely. With the exception of the *G. hemigymnum* type, no specimens of *Gobiosoma* has ever been collected north of Rio de Janeiro that possess the combination of body size (> 50 mm TL) and the unique scale pattern. Therefore one must consider whether the locality of *Gobiosoma hemigymnum*, listed as "West Indies—exact location unknown", is truly within the Caribbean basin. While we cannot determine the exact locality beyond a doubt, it is entirely possible that the types of *G. hemigymnum* were in fact collected in Brazil. Of the three labels in the jar containing the type, one is a hand-written label by Carl Eigenmann that states "*Gobius hemigymnum* Eigenmann and Eigenmann Type", the second contains an MCZ catalog number and species name, presumably written by Borodin, and the third reads "Dredging no. 21" with no clues regarding location, date, vessel or collector (K. Hartel per. comm.). Karsten Hartel investigated MCZ collections obtained in Brazil prior to 1888 and found a dredge station no. 21 from the Hassler Expedition of 1872, US Coast Survey Steamer Hassler. The location of dredge 21 was off Cabo Frio, Brazil just north of Rio de Janerio, at a depth of 45 fathoms, with no range in depths given (Pierce & Patterson, 1879–1880). Blake's journal from that expedition (Blake, 1871–1872) notes that one fish was collected in that dredge, with no additional information provided. Thus, the designation of the West Indies as the origin of *G. hemigymnum* cannot be traced back in time to any point earlier than the description by Eigenmann & Eigenmann (1888). However, Eigenmann & Eigenmann (1888) seem to have included Rio de Janeiro, Brazil in their definition of West Indian fauna. For example, they list other species such as *Eleotris pisonis* (West Indian fauna: Florida to Rio de Janeiro) and *Gobius stigmaticus* (West Indian fauna; Southern United States to Rio de Janeiro) with ranges south to Rio de Janeiro. Thus, if their definition of West Indian fauna broadly includes all localities from Florida to Southern Brazil (*i.e.*, nearly all of tropical and subtropical western Atlantic) then it seems highly likely that Eigenmann & Eigenmann (1888) simply applied the label "West Indies—exact location unknown" when they encountered the unlabelled types to indicate that they likely came from the Western Atlantic, without any prior evidence that specimens were collected within the Caribbean Basin. Given the possibility that the holotype of *G. hemigymnum* could have been collected from virtually anywhere, the most parsimonious scenario is it was collected between Rio de Janeiro and Argentina (the range of *G. parri* plus *G. mediocricula*)—the only place where *Gobiosoma* were collected that are similar in size and scale pattern to the *G. hemigymnum* types. Given that the body scale distribution pattern is distinct for the holotype of *Gobius hemigymnus*, types of *Garmannia mediocricula*, and specimens of *Gobiosoma parri* examined by us, and the molecular tree shows strong support for a single species of *Gobiosoma* from southern Brazil and Uruguay, we place *Garmannia mediocricula* and *Gobiosoma parri* in synonymy with *Gobiosoma hemigymnum*.

Additional undescribed species in northern Brazil. Based on specimens forwarded to us by T. Giarrizzo (Universidade Federal do Pará), at least two other undescribed *Gobiosoma* species may occur in Brazil. One is found in estuaries in the states of Maranhão and Pará (north Brazil) and has been mis-identified as *G. hemigymnum* (*e.g.*, Barletta *et al*., 2000; Camargo & Isaac, 2001). Genetically (COI-wise; M.I.C. Sampaio, pers. comm.), this species appears closely related to *G. hemigymnum* and *G. alfiei*. A second, highly distinctive species is found in the mouth of the Amazon River and is of uncertain affinities. Collection of additional material is required to resolve its taxonomic status.

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