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Redescription of *Coryphopterus tortugae* (Jordan) and a new allied species *Coryphopterus bol* (Perciformes: Gobiidae: Gobiinae) from the tropical western Atlantic Ocean.

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Abstract

A re-examination of the holotype and mtDNA barcoding confirms Garzon-Ferreira and Acero's separation of *Coryphopterus tortugae* from *C. glaucofraenum*. However, specimens matching the markings of their Santa Marta variant of *C. tortugae* comprise a distinct clade about 10% sequence divergent from true *C. tortugae* and *C. glaucofraenum*. The variant is described here as a new species, the sand-canyon goby *Coryphopterus bol*, from specimens collected in Puerto Rico, the US Virgin Islands, and the Atlantic coast of Panama. The new species is abundant and widespread in the region and has not been recognized as distinct from the bridled goby, *C. glaucofraenum*. *C. bol* can be distinguished from *C. tortugae* by markings: a dark oval spot on the lower third of the pectoral-fin base, a chain-link pattern of melanophores on the top of the head, and a thick C-shaped basicaudal mark and scale-edges outlined in lines of tiny melanophores on well-marked individuals. Putative bridled gobies from three different reef types were sampled: a wide and clearly-zoned shelf in the Greater Antilles (off La Parguera, Puerto Rico), a narrower mixed-zone island of the Lesser Antilles (St. Thomas, US Virgin Islands), and narrow fringing continental reefs in the Southern Caribbean (the Atlantic coast of Panama near Portobelo). In all three locations, *C. bol* was found in deeper and more offshore reef areas with strong currents, i.e. in the channels of the buttress-canyon zone just inshore of the drop-off in Puerto Rico, around exposed rocky points in St. Thomas, and on wave-swept reefs just offshore of the sediment-influenced coastline in Panama.

Key words. Gobiidae, Goby, New Species, BARCODE, BOLD, Fish, Identification, DNA, Caribbean, Western Atlantic, taxonomy and informatics.

Introduction

The bridled goby is one of the more common reef fishes of the tropical Atlantic, abundant in any sandy habitat adjacent to coral, rock, rubble or mangroves and found from the shoreline to deep offshore reefs (Bohlke and Chaplin 1993, Randall 1996). This goby shows extreme variation in markings, from almost completely pallid on white sand in clear water to dark with prominent stripes and spots in other habitats.

As a result, it has been alternately split into separate species or combined into one. The prevailing view has been to unite the marking variations into the single species *Coryphopterus glaucofraenum* (Gill) (Bohlke and Robins 1960, Murdy and Hoese 2002).

More recently, Garzon-Ferreira and Acero (1990) redescribed the well-known "pallid" variant as *Coryphopterus tortugae* (Jordan) and separated it from *C. glaucofraenum*. They demonstrated that *C. glaucofraenum* has a squared-off two-pointed head-stripe marking and a basicaudal mark consisting of two colon-like spots, while *C. tortugae* have a simple triangular head-stripe marking, a basicaudal mark made up of a bar, and a lesser body depth. Their putative *C. tortugae* included both heavily-marked and pale forms, shallow and deep collections, and samples from an isolated offshore island (Isla Providencia) as well as the continental coast (Santa Marta, Colombia). Their separation has not been generally accepted, but Greenfield and Johnson (1999) did distinguish between the two species in their habitat study in Belize. In the course of my collaboration with the Barcode of Life project, Fish-BOL (Ratnasingham and Hebert 2007), in which we used mtDNA sequences to link larvae to adults of *Coryphopterus spp.* gobies, I confirmed Garzon-Ferreira and Acero's separation. However, I found that not only are the specimens fitting the description of *C. tortugae* according to Garzon-Ferreira and Acero (1990) clearly sequence divergent from classic *C. glaucofraenum*, but, furthermore, that putative *C. tortugae* divided into two clearly-separated clades, mostly segregated by habitat in my collections.

Materials and Methods

Counts, measurements, and techniques follow Randall (2001). All fish lengths are standard length (SL). SIO is the institutional abbreviation for the Marine Vertebrate Collection of the Scripps Institution of Oceanography. AMNH is the American Museum of Natural History, SU is the Stanford University collection at the California Academy of Sciences, PMNH is the Peabody Museum of Natural History at Yale University, and SMF represents the Senckenberg Museum Frankfurt. The mitochondrial DNA sequences were obtained, processed, and archived following the BOLD procedure outlined in Ratnasingham and Hebert (2007). The phylogenetic tree was generated by 2-parameter distance metrics for sequence comparisons (Kimura) and genetic distances were calculated using the bold Management and Analysis System (www.barcodinglife.org).

***Coryphopterus bol*, new species**

Fig. 1

Coryphopterus tortugae (not of Jordan, in part), Garzon-Ferreira and Acero 1990: 107, Fig. 1A (Santa Marta region).

Holotype. SIO-08-69, 26.8 mm SL, female, Puerto Rico, La Parguera, Bosque near UPR-MIML dropoff-mooring (17.887, -67.018), 18 m depth, sand canyon, dipnet, B. Victor and C. Caldow, Aug. 5, 2007.

Paratypes. SIO-08-70, 1: 24.5 mm SL, United States Virgin Islands, St. Thomas, Outer Brass Island (18.401, -64.976), B. Victor, June 29, 2006; SIO-08-71, 9: 18.5-31.0 mm SL. Panama, Colon District, Salmedina Reef (9.569, -79.697), D.R. Robertson, B. Victor, and J. Van Tassell, May 30, 2007; SIO-08-72, 13: 15.3-31.0 mm SL. Panama, Colon District, Islas de las Dos Hermanas (9.597, -79.667), D.R. Robertson and J. Van Tassell, June 2, 2007; SIO-08-73, 5: 23.7-28.2 mm SL. Puerto Rico, La Parguera, Bosque near UPR-MIML dropoff-mooring (17.887, -67.018), B. Victor and C. Caldow, Aug. 5, 2007; SIO-08-74, 1: 32.1 mm SL. La Parguera, Medialuna Reef, seaward slope, (17.939, -64.047), B. Victor, Aug. 9, 2007.

FIGURE 1. (top to bottom) Holotype of *Coryphopterus bol,* 26.8 mm SL, female, Puerto Rico, La Parguera, near dropoff (deep); paratype 29.0 mm SL, Panama, Salmedina Reef (deep); paratype 24.5 mm SL, U.S. Virgin Islands, St. Thomas, Outer Brass Island, shallow and rocky; paratype 32.1 mm SL, Puerto Rico, La Parguera, Medialuna Reef (shallow).

Non-type materials. AMNH 33576, 92: 10.0-40.0 SL, U.S. Virgin Islands, St. John, Lameshur Bay, Tektite site, C. L. Smith and J. C. Tyler, Sep. 10, 1973 (labeled "*C. glaucofraenum*"); AMNH 239836, 5: 23.5-32.0 SL, Curacao, Saba Tugboat (12.0808, -68.8885), D.R. Robertson, J.S. Sparks and S. Piontek, Feb. 11, 2005 (labeled "*C. eidolon*"); AMNH 239847, 14: 25.6-39.9 SL, Curacao, Saba Tugboat (12.0808, -68.8885), D.R. Robertson, J.S. Sparks and S. Piontek, Feb. 11, 2005 (labeled "*C. glaucofraenum*"); AMNH 239861, 2: 30.8-34.9 SL, Curacao, Klein Curacao (11.9852, -68.6456), D.R. Robertson, J.S. Sparks and P. Hoetjes, Feb. 12, 2005 (labeled "*C. glaucofraenum*").

Diagnosis. A species of *Coryphopterus* with modal dorsal elements VI, I,9; anal fin elements I,9; pectoral fin rays 19; longitudinal scale series 26-27; pelvic fins fully joined medially by membrane, innermost rays branched and about equal in length to the next ray and a distinct frenum between the two pelvic fin spines; a prominent, dark, upward-pointed triangle-marking on the stripe behind the eye, no bar of melanophores from the eyeball at 8 o'clock to the mid-maxillary, a discrete oval, rectangular, or rounded collection of small melanophores on the lower third of the pectoral fin base and, on more darkly-marked specimens, a chain-link pattern of lines on the top of the head with a complete upper-eye stripe, the exposed scale-edges on the upper body outlined with tiny melanophores, and a basicaudal marking that is a thick C-shape.

Description. Dorsal elements VI, I,9; anal elements I,9; all dorsal and anal soft rays branched, the last to base; pectoral rays 19 (18-20), the upper and lowermost unbranched; pelvic elements I,5 with the rays all branched, united as a disk with a rounded edge, the innermost ray about equal to the next, a distinct frenum; branched caudal rays 12, upper unbranched caudal rays 9, posterior 3 segmented; lower unbranched caudal rays 8, posterior 2 segmented; longitudinal scale series 26-27; transverse scale series 7; circumpeduncular scales 12; gill rakers 2+6; branchiostegal rays 5; vertebrae 9+17; spinous dorsal-fin pterygiophore formula 3-22110.

Morphology varies with depth in this genus, specimens from deeper waters with stronger current flows are slimmer with more pointed snouts and have more prominent midline nuchal crests (or ridges) on the head. Measurement ranges listed here include the holotype, a typical pallid deeper-water specimen (in parentheses), along with three paratypes including one from shallower waters (Medialuna Reef at La Parguera, Puerto Rico). The latter specimen was captured along with numerous *C. tortugae* and the morphology of the two species from the same location was remarkably similar (fig. 2). Body elongate,

FIGURE 2. *Coryphopterus tortugae,* 36.8 mm SL, Puerto Rico, La Parguera, Medialuna Reef (shallow).

depth 4.26-4.74 (4.27) in SL, and compressed, width at pectoral fin base (side-to-side) 1.26-1.4 (1.4) in depth; ventral part of head and chest broad and nearly flat; head triangular when viewed from above, its length 3.17-3.71 (3.17) in SL, midline head ridge usually prominent; snout pointed, its length 4.1 to 5.14 (4.45) in head; orbit diameter 2.85-3.3 (3.3) in head, the eye extending above dorsal profile of head; interorbital space extremely narrow, 35.3-37 (36.5) in head; caudal-peduncle depth 2.03-2.54 (2.54) in head; caudal-peduncle long, its length 1.2-1.39 (1.38) in head. Mouth large, the maxilla ending below anterior 1/3 of pupil, the upper-jaw length 2.1-3.0 (2.89) in head; lower jaw projecting; mouth oblique; upper jaw and lower jaws with multiple rows of well-spaced-apart slender curved conical teeth. Tongue truncate with rounded corners.

Gill opening extending forward to below middle of opercle. Gill rakers on the first arch 2+8 in a paratype. Head naked except for scales on side of nape extending forward nearly to eye; no scales on fins except a few on base of caudal fin that are smaller than largest scales on body. Scales ctenoid except those on side of nape, thorax, prepectoral area, and a few just above base of pelvic fins that are cycloid. Anterior nostril a short membranous tube at level of middle of eye. Head pores prominent, as follows: a nasal pore, an anterior and a posterior interorbital pore, a postorbital pore, an infraorbital pore below the postorbital, a pore at each end of a lateral sensory canal; a short posterior lateral canal with a pore at each end, and 3 preopercular pores (i.e. Birdsong's B', C, D, E, F, G, H', K', L', M', N, O'). Head papillae in rows vertically along the lower opercle and along the lower rim of the preopercle extending forward along the line of the lower jaw.

Origin of dorsal fin behind upper base of pectoral fin, predorsal distance 2.76-3.18 (2.79) in SL; spines of fins slender and flexible; 1st dorsal fin lower than 2nd; 1st dorsal spine 1.5-1.74 (1.74) in head, sixth spine much shorter; spine of 2nd dorsal fin about 1.8 in head; 1st dorsal soft ray longest, about1.7 in head; origin of anal fin below base of 1st soft ray of 2nd dorsal fin, preanal distance 1.6-1.77 (1.77) in SL; anal spine about 3.1 in head; caudal fin moderately rounded, 3.42-3.94 (3.94) in SL; pectoral fins pointed, the middle rays longest, 3.4-3.7 (3.67) in SL; origin of pelvic fins directly beneath base of pectoral fins, prepelvic distance 3.1-3.58 (3.07) in SL; pelvic fins fully joined by membrane; pelvic frenum present; pelvic spine about 4.2 in head; 5th pelvic soft ray longest, nearly reaching origin of anal fin, its length 1.0-1.37 (1.37) in head; 4th pelvic soft ray about 95% length of 5th ray.

Markings vary substantially with habitat (fig. 1): those individuals on white sand bottoms in clear deep water on Caribbean islands are very pale with few dark markings. In shallower sand habitats at the same locations, individuals show more dark markings and, on rocky bottoms, individuals can be quite heavily-marked. On continental coasts, where water clarity is usually lower, even the individuals on white sand bottoms have distinct markings on the upper half of the body. Pallid individuals found on pure white sand have few melanophores, primarily in a major dark stripe rearward from the mid-level of the eye swelling into an upward-pointing triangle usually prominent above the operculum (sometimes followed by an additional smaller triangle). At the very end of the stripe, there is a large rounded spot of melanophores on the upper body below the origin of the dorsal fin, about the size of the pupil. Below that stripe is an under-eye dark stripe overlying a broad iridescent stripe along the cheek which comprises the "bridle" of the bridled gobies. The under-eye stripe extends back to the upper third of the pectoral fin base. Above the major mid-level stripe there is a dark upper-eye stripe. Notably, in this species, this stripe often develops even on lightly-marked individuals and is usually complete (i.e. not broken into short segments) extending back to the level of the origin of the dorsal fin. On pallid individuals the pattern of melanophores on top of the head is quite variable; sometimes none, but most often short lines of melanophores just alongside the midline in two locations: just forward of the dorsal fin origin and then midway to the interorbital

FIGURE 3. *Coryphopterus bol,* Bonaire, photograph courtesy Les Wilk, ReefNet.

(typically not isolated rounded collections of small melanophores). The short lines often bracket a distinctly unpigmented midline. As pigmentation advances, lyre-like lines of melanophores extend laterally from these two points to begin to form the chain-link pattern of melanophores on the top of the head. Additional melanophores on the head comprise small patches of melanophores on the operculum, at the corner of the jaw, and on the snout forward of the eyes.

There is typically a line or patch of melanophores across the upper third of the pectoral fin base, above an iridescent stripe occupying the center of the pectoral fin base and below an iridescent saddle at the top edge of the pectoral fin base (line can be absent on the most pallid individuals). There is a matching line of melanophores on the inward-facing axillary surface of the fin. On virtually all individuals over about 25 mm SL there is a discrete patch of melanophores on the lower third of the pectoral fin base. The patch is most often a distinctly oval or rectangular spot typically somewhat concave-facing dorsad, but, in some individuals, the patch can be rounded. On the most pallid individuals with very few melanophores (and typically with none on top of the head), the lower-third patch can be absent or reduced to just three or four centrally-placed small melanophores. On the dorsal midline of the body there are six dark spots evenly-spaced along the base of the dorsal fins, ending with several thin saddle lines of melanophores spaced along the top of the caudal peduncle. A row of short bars of melanophores runs along the lateral body just below the midline. On lightly-marked specimens the basicaudal bar of melanophores can be a simple bar, but often there are some tiny melanophores trailing onto the caudal fin base to form a C-shape. Rarely, the bar is split at the midline, but not into two distinctly-rounded spots. On many lightly-marked specimens some upper-body scales have lines of tiny melanophores outlining the exposed scale-edges.

Well-marked individuals develop additional melanophores: on the head, patches of melanophores extend along the anterior and mid-maxillary and the patch at the corner of the jaw extends up to meet the under-eye dark stripe (but note there is no discrete dark bar extending from 8 o'clock on the iris to the mid-maxillary, as is found on *C. eidolon* and often on *C. thrix*). The patch at the corner of the jaw extends back as an additional dark stripe across the lower cheek and curves up to meet the under-eye stripe at the edge of the operculum. On the pectoral fin base, there is often a collection of melanophores within the central iridescent stripe, in addition to the standard upper-base stripe and the characteristic lower-base spot. On the body there is an additional lateral row of short bars of melanophores above the lateral midline.

FIGURE 4. *Coryphopterus bol,* Bonaire, photograph courtesy Keri Wilk, ReefNet.

The bars and caudal peduncle spots often develop into irregular X shapes. In the darkest individuals, most scales on the body have thin lines of tiny melanophores outlining their exposed edges. A dark line underlies the mid-portion of the anal fin and three more dark lines are spaced along the ventral midline of the caudal peduncle. In most darker individuals the basicaudal bar is a distinct thick C-shape with marked extensions of melanophores extending onto the caudal fin. Breeding adults develop a uniform scattering of small melanophores over the branchiostegal rays, on the chest around the pelvic fin origin, and concentrated on the pelvic fin membranes.

Color in life. Live individuals are mostly translucent with colors limited to shades of orange and iridescent blue (figs. 3 and 4). In addition to the melanophore patterns described above, live individuals have iridescent white markings in stripes from the eye to the tip of the jaw and between the dark stripes below the eye (the bridle) and across the cheek. The white bridle stripe extends across the middle of the pectoral fin base and onto the central fin rays and the white stripe above the bridle extends onto the shoulder of the pectoral fin base. Rounded iridescent spots sit above the main dark eye-stripe behind the eye, bracketing the black triangle extensions from the stripe. Iridescent round spots speckle the side of the body and patches of white spots are present between the black spots along the dorsal midline. Orange pigment surrounds and fills in the black spots and stripes. On the side of the body below the lateral midline, rounded orange spots are bracketed by the bars and Xs of fine melanophores.

Particularly prominent in live specimens from deeper waters are large black spots on the iris in a clock-face pattern, usually placed at 12, 1:30, 3, 9 and 11 o'clock (figs. 5 and 6). Some individuals have an additional spot at 7 o'clock. Notably, the paratypes from shallower reefs (Medialuna in Puerto Rico and Outer Brass Island in St. Thomas) have less prominent clock-face spots since the entire surface of the iris has a dark underlying shading (likely an adaptation to protect the iris from sunlight)(fig. 7). The pupil is often ringed by a bright orange-yellow circle. On the interorbital side of the eyeball there are two or three oblique thick black bars over the eyeball membrane. Internal body markings include a central dark strip, often tinged with orange, along with an iridescent band running above the brain-case and spinal column, usually breaking into dark patches: below the first dorsal fin, the front of the soft dorsal fin, the mid-fin,

FIGURE 5. *Coryphopterus bol* paratype, 29.0 mm SL, Panama, Salmedina Reef (deep).

and then below the end of the fin. A dark band covers the anterior dorsal peritoneal lining and an opaque white layer lines the abdominal wall. The medial fin membranes are tinged orange with bluish stripes and edging.

Barcode sequence. A 651-nucleotide sequence of the section of COI gene used for barcoding by the BOLD informatics database (Ratnasingham and Hebert 2007) was obtained for the holotype (Genbank accession number EU567148). Following the database management recommendation of the BOLD the sequence of the holotype is presented here as well:

CCTTTATTTAGTTTTTGGTGCCTGAGCCGGAATAGTAGGGACTGCATTAAGCCTTCTTATCCGGCTGA
ACTTAGTCAACCGGGGGCCCTCCTCGGAGATGACCAAATTTACAATGTTATTGTAACTGCCCCGCAT
TTGTTATAATTTTCTTTATAGTAATACCGATTATGATTGGGGGATTTGGAAATTGACTTATCCCACTAAT
GATCGGGGCCCCTGATATAGCTTTCCCCCGAATAAACAACATAAGCTTTTGACTCCTTCCTCCATCGT
TCCTACTTCTTTTAGCATCGTCAGGCGTAGAAGCTGGTGCCGGGACTGGCTGAACCGTGTACCCCCC
CCTTGCCGGCAATTTAGCCCATGCAGGAGCATCAGTAGACTTGACCATTTTCTCCTTCATTTGGCTGG
TGTCTCTTCAATTCTAGGGGCAATCAACTTCATTACTACAATTTTAAACATGAAACCTCCTGCCACC

Distribution. Individuals that are mtDNA-sequence confirmed were collected from Puerto Rico, the US Virgin Islands, and the Atlantic coast of Panama. Fish matching the physical description of the new species are present throughout the region from Florida to the southern Caribbean.

Etymology. The new species is named for the Barcode of Life project which was instrumental in distinguishing the species and in recognition of the efforts of the FishBol team under Robert Hanner. Since BOL is an acronym and neither Latin nor latinized, it is treated as indeclinable and retains the original spelling (ICZN Article 31.2.3, 2007).

Common Name. The common name of sand-canyon goby is suggested to distinguish the species by its predilection for the buttress-and-canyon sand habitat (note that spur-and-groove is a misnomer *fide* T.J. Goreau). Most markings are shared among closely-related species and names such as bridled and pallid do not discriminate between species.

Comparisons. There are ten Caribbean species in the group of sand-perching gobies of the genus *Coryphopterus*. There is some small variation in fin-ray counts and pelvic fin morphology that helps distinguish a few species. Nevertheless, marking patterns are required to separate the several species within the clade that share 10 second dorsal fin elements and 10 anal fin elements.

The new species *Coryphopterus bol* is separated from its congeners by the following features (those listed not shared by *C. bol*):

Coryphopterus lipernes (Bohlke and Robins) is a colorful coral-dwelling blue-striped peppermint goby; it has divided pelvic fins and fewer pectoral fin rays (16-18).

Coryphopterus personatus (Jordan and Thompson) and *Coryphopterus hyalinus* (Bohlke and Robins) are hovering, not benthic, species with divided and unmarked pelvic fins, dark masks from the snout through the eye and black rings around the anus (Bohlke and Robins 1960, 1962; Randall 1996).

Coryphopterus kuna (Victor) has 9 second dorsal and anal fin elements and only 15 pectoral fin rays and does not have the black stripes on the head characteristic of the 10/10 fin-element group. In addition, it has two rows of small black spots across the upper iris and top of the eyeball (Victor 2007).

Coryphopterus alloides (Bohlke and Robins) has 9 anal fin elements, divided pelvic fins, and fewer pectoral fin rays (16-17).

Coryphopterus dicrus (Bohlke and Robins) has no pelvic fin frenum (as large juveniles and adults) and the innermost pelvic fin rays are distinctly shorter than the next ray, forming a notched pelvic fin outline, as well as colon-like spots on the pectoral fin base (notably the upper spot is also distinctly rounded).

Coryphopterus thrix (Bohlke and Robins) has a characteristic large black spot fully-covering the upper half of the pectoral fin base, often an extended second spine on the first dorsal fin, often a bar or a few melanophores running from the eye at 8 o'clock to the mid-maxillary, and, most distinctive, small reticulated black spots on the upper surface of the eyeball (pers. obs.).

Coryphopterus punctipectophorus (Springer) has 11 second dorsal fin elements and a long linear streak of melanophores along the midline of the head behind the interorbital (pers. obs.).

Coryphopterus glaucofraenum (Gill) has a basicaudal mark consisting of colon-like spots (or a barbell shape with rounded tips) and the triangular mark above the operculum is two-pointed at the apex and squared-off (Garzon-Ferreira and Acero 1990).

Coryphopterus venezuelae (Cervigon) resembles *C. glaucofraenum* and has 11 (on my count it is often 12) second dorsal and anal fin elements (Springer 1960, Cervigon 1966, 1994).

Coryphopterus eidolon (Bohlke and Robins) can appear quite similar to *C. bol* but has shortened innermost pelvic fin rays and a notched pelvic fin outline. Both pallid (traditionally illustrated in books and guides and listed in museum collections) and well-marked specimens (usually labeled as *C. glaucofraenum*) have a distinctive discrete bar of melanophores extending from the eye at 8 o'clock to the mid-maxillary and most have an upturned short line of melanophores behind the corner of the jaw (pers. obs.).

Coryphopterus tortugae (Jordan) is closest in appearance to *C. bol*, but differs by having no discrete spot of melanophores on the lower third of the pectoral fin base. In addition, they have prominent spots along the dorsal midline of the head that are isolated and discrete collections of fine melanophores (typically rounded and centered on the midline vs. linear and to the side of the midline and with connecting loops of melanophores in a chain-link pattern in *C. bol*). The upper-eye stripe (above the major stripe extending behind the mid-level of the eye) is usually incomplete, often broken into short segments (or absent) while in *C. bol* the upper-eye stripe is usually complete without a break to the level of the dorsal fin origin, even before the central region develops many markings (fig. 7).

Many shallow-water *C. tortugae* have short snouts, shorter than those exhibited by *C. bol* (fig. 7), often with a snout length from 5.5 to 7 times into the head length (snout length measured from the dorsal aspect from the tip of the upper jaw back to the level of the front of the eyeballs and head length from the tip of the upper jaw to the level of the posterior edge of the operculum). Nonetheless, some populations of *C. tortugae* have longer snouts that completely overlap with measurements from *C. bol* (e.g. 4.0-4.9 snouts in head on Medialuna Reef). Thus far, all of the *C. bol* I have examined have longer snouts (all are between 4.0 and 5.2 snouts in head), but, given the variability in morphology exhibited within these gobies, this may not be a rule.

Extremely pallid specimens of *C. bol* lacking melanophores on top of the head and on the pectoral fin base can be impossible to distinguish from the most lightly-marked *C. tortugae*. Similarly, larvae and juveniles of *Coryphopterus spp.* that are pallid with incomplete markings can overlap completely in appearance.

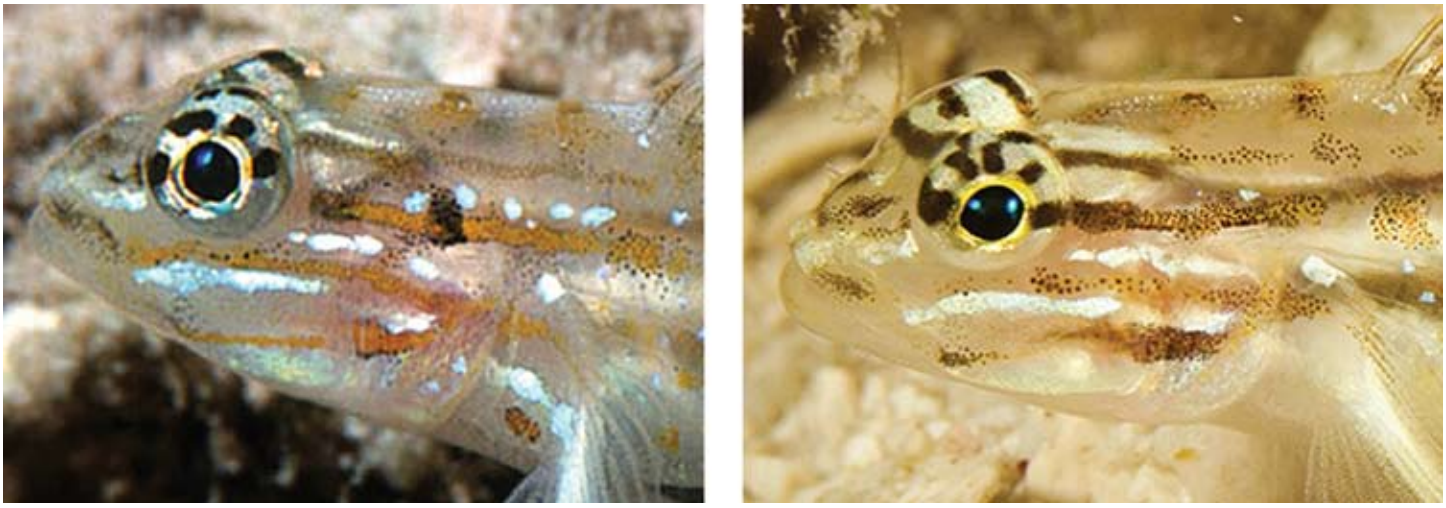

FIGURE 6. Comparison of *Coryphopterus bol* (left) and *Coryphopterus tortugae* (right).

FIGURE 7. Head markings of *Coryphopterus bol* (left) and *Coryphopterus tortugae* (right).

Coryphopterus tortugae (Jordan)

Figs. 8 and 9

Ctenogobius tortugae Jordan, Bull. U.S. Fish Comm. 1904, vol. 22 for 1902, 541-542, pl. 1 (Garden Key, Dry Tortugas, Florida). Longley and Hildebrand (1941):232; Bohlke and Robins (1960):107, synonymized with *Coryphopterus glaucofraenum* (Gill); Garzon-Ferreira and Acero (1990):105-112 (in part)(Isla de Providencia, Colombia).
Coryphopterus glaucofraenum (not of Gill, in part), Longley and Hildebrand (1941) 232-233; Bohlke and Robins (1960):106-112, pl. 1; Bohlke and Chaplin (1968):595; Randall (1983):249-250; Robins, Ray, and Douglass (1986): 244.
Ctenogobius transparentus Klausewitz 1958, Senckenbergiana Biol. 39:78-80 (Bonaire).

Holotype. SU 8363 (=SU 8568), 41.0 mm SL, female, Florida, Dry Tortugas, Garden Key, J.C. Thompson.

Diagnosis. A species of *Coryphopterus* with modal dorsal elements VI, I,9; anal fin elements I,9; pectoral fin rays 19; longitudinal scale series 26-27; pelvic fins fully joined medially by membrane, innermost rays branched and about equal in length to the next ray and a distinct frenum between the two pelvic fin spines; a prominent, dark, upward-pointed triangle-marking on the stripe behind the eye, no collection of small melanophores on the lower third of the pectoral fin base, no bar of melanophores from the eyeball at 8 o'clock to the mid-maxillary, two or three discrete spots along the dorsal midline on the top of the head between the interorbital and dorsal fin, usually an incomplete upper eye-stripe, and a basicaudal marking that is typically a simple vertical bar.

Description. Meristics and morphology follow Bohlke and Robins (1960) and Garzon-Ferreira and Acero (1990) and broadly overlaps *C. bol* described above, and therefore are not repeated here. Markings are distinctive. Specimens in alcohol vary from pallid with scant markings to well-marked.

Pallid individuals have few melanophores, primarily in a major dark stripe rearward from the mid-level of the eye swelling into an upward-pointing triangle usually prominent above the operculum (sometimes followed by an additional smaller triangle). At the very end of the stripe, there is a large rounded spot of melanophores on the upper body below the origin of the dorsal fin, about the size of the pupil. Below that stripe is an under-eye dark stripe overlying a broad iridescent stripe along the cheek which comprises the "bridle" of the bridled gobies. The under-eye stripe extends back to the upper third of the pectoral fin base. Above the major mid-level stripe there is a dark upper-eye stripe. Notably, in pallid individuals of this species, this upper-eye stripe is typically incomplete, often broken into short segments (or sometimes absent). On these pallid individuals, the pattern of melanophores on top of the head can vary; sometimes none, but usually two or three obvious isolated spots along the midline forward of the dorsal fin origin. The one closest to the dorsal fin is often rounded or a short transverse bar while the central one is typically a clearly rounded collection of small melanophores. Often there is a third spot forward, nearer the interorbital. Additional melanophores on the head comprise small patches of melanophores on the operculum, at the corner of the jaw, and on the snout forward of the eyes. There is typically a line or patch of melanophores across the upper third of the pectoral fin base, below an iridescent saddle at the top edge of the pectoral fin base and above an iridescent stripe occupying the center of the pectoral fin base. There is a matching line of melanophores on the inward-facing axillary surface of the fin. There are typically no melanophores on the lower third of the pectoral fin base. On the dorsal midline of the body there are six dark spots evenly-spaced along the base of the dorsal fins, ending with several thin saddle lines of melanophores spaced along the top of the caudal peduncle. A row of short bars of melanophores runs

along the lateral body just below the midline. A tenuous and quite variable basicaudal bar of melanophores is present, occasionally split at the midline (but not into two distinctly-rounded spots).

Well-marked individuals develop additional melanophores: on the head, patches of melanophores occur along the mid-maxillary, the patch at the corner of the jaw extends up to meet the under-eye dark stripe and extends back as an additional dark stripe across the lower cheek then curves up to meet the under-eye stripe at the edge of the operculum. On the pectoral fin base, there is often a collection of melanophores within the central iridescent stripe in addition to the standard upper base stripe, but there is distinctly no discrete collection of melanophores on the lower third of the pectoral fin base. Breeding adults with fully-speckled undersides can have some extension of the light uniform speckling onto the lower third of the pectoral fin base, but not in a discrete collection. On the body, there is an additional lateral row of short bars of melanophores above the lateral midline. The bars and caudal peduncle spots often develop into irregular X shapes.

Holotype. The holotype of *Coryphopterus tortugae* is a somewhat pallid adult female with typical markings. She has faded markings, but small melanophores are quite distinct and even the fine ventral speckling over the branchiostegals, chest, and pelvic fins is clearly visible (generally found in mature adult sand gobies). Notably for species identification, there are no melanophores on the lower third of the pectoral fin base, there is an obvious discrete rounded collection of small melanophores at the dorsal midline of the head (and no chain-link reticulations adjacent to the midline), and the upper-eye stripe above the main stripe behind the eye is clearly broken into short segments (fig. 9). The holotype has a short snout (5.3 snouts in head), out of the range of the *C. bol* I have examined. The engraving illustrating this holotype in Jordan (1904) shows only a few large spots and no fine detail and, furthermore, the measurements of snout and head lengths from the illustration are nowhere near the measurements from the specimen (a caution against using morphometrics from drawings). The holotype is from a collection of small shallow-water reef species collected long before any diving technology was available and thus the collection of *C. tortugae* instead of the deeper-water *C. bol* is to be expected.

FIGURE 8. *Coryphopterus tortugae*, Belize, photograph courtesy Paddy Ryan.

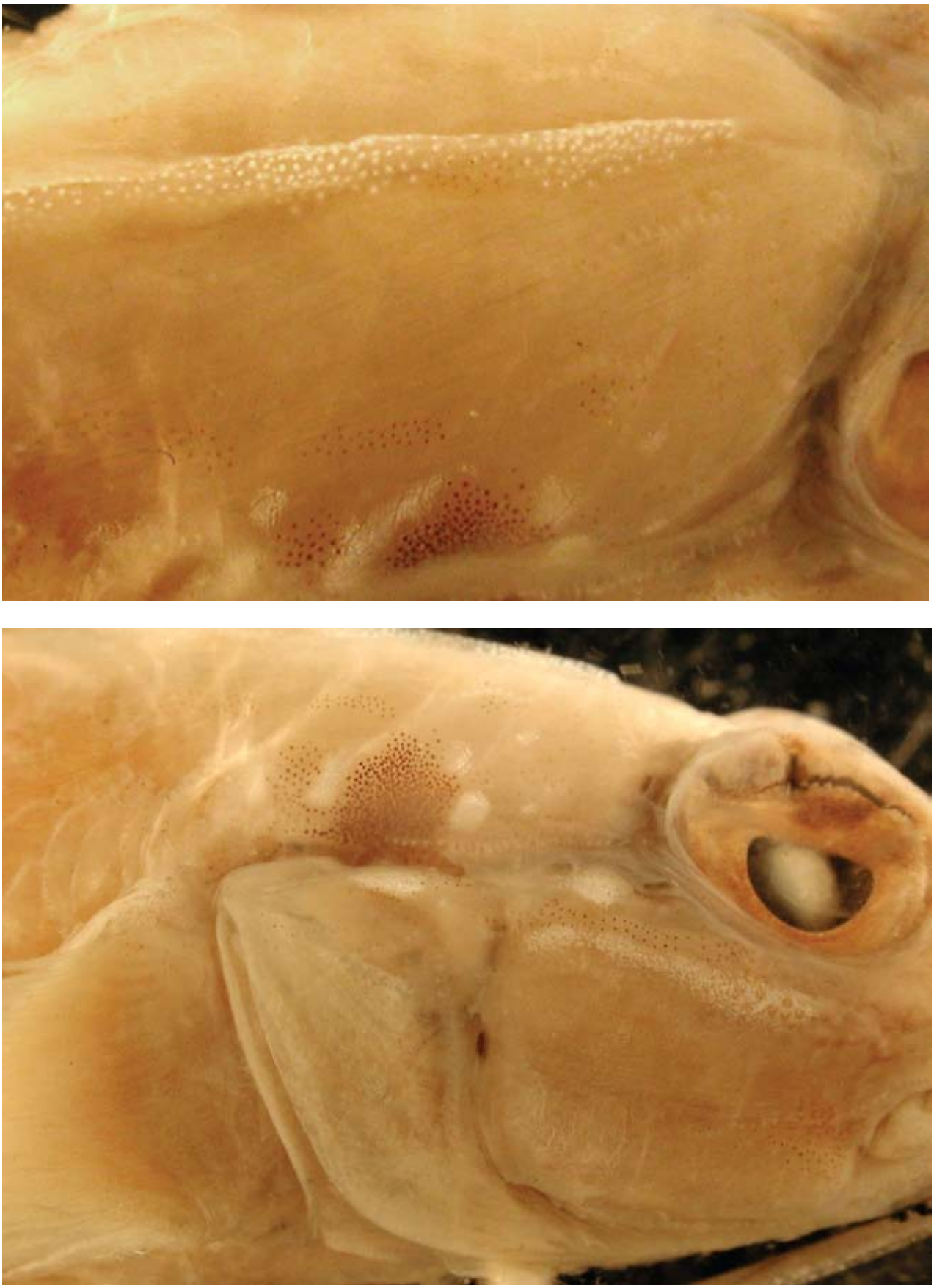

FIGURE 9. Holotype of *Coryphopterus tortugae*, 41 mm SL, female, Florida, SU 8363.

Color in life. Live individuals are mostly translucent with colors limited to shades of orange and iridescent blue. In addition to the melanophore patterns described above, live individuals have iridescent white markings in stripes from the eye to the tip of the jaw and between the dark stripes below the eye (the bridle) and across the cheek. The bridle stripe extends across the middle of the pectoral fin base and onto the central fin rays and the stripe above the bridle extends onto the upper edge of the pectoral fin base. Rounded iridescent spots sit above the main dark eye-stripe behind the eye, bracketing the black triangle extensions from the line. Iridescent round spots speckle the side of the body and patches of white spots are present between the black spots along the dorsal midline. Orange pigment surrounds and fills in the black spots and stripes. On the side of the body below the lateral midline, rounded orange spots are bracketed by the bars and Xs of fine melanophores.

Specimens from deeper clear water have large black spots on the iris in a prominent clock-face pattern, usually placed at 12, 1:30, 3, 9 and 11 o'clock (fig. 6). Occasional individuals have an additional spot at 7 o'clock. *C. tortugae* found in relatively shallow waters have the iris spots subdued by a background dark-shading of the surface of the eyeball (likely an adaptation to protect the eyeball from sunlight)(figs. 2 and 7). The pupil is often ringed by a bright orange-yellow circle. On the interorbital side of the eyeball there are two or three oblique black bars over the eyeball membrane. Internal markings include a central dark strip, often tinged with orange, along with an iridescent band running above the brain-case and spinal column, usually breaking into dark patches: below the first dorsal fin, the front of the soft dorsal fin, the mid-fin, and then below the end of the fin. A dark band covers the anterior dorsal peritoneal lining and an opaque white layer lines the abdominal wall. The medial fin membranes are tinged orange with bluish stripes and edging.

Junior synonyms. The holotype of *Ctenogobius transparentus* Klausewitz (SMF 4155) has three spots along the dorsal midline, no lines or chain-links of melanophores connecting the spots, and no upper eye-stripe. This marking pattern is typical of *C. tortugae.* There is a scattering of melanophores covering the branchiostegal membranes, the pelvic fin membranes, and the chest which does extend onto the lower pectoral fin base, but not in a discrete spot or collection. This pattern of ventral speckling spreading marginally onto the pectoral fin base is characteristic of breeding adults of *C. tortugae.* In addition, the holotype has a short snout (5.5 snouts in head), out of the range of the *C. bol* I have examined.

The holotype of *Lophogobius pallidus* Parr, a junior synonym of *C. glaucofraenum*, (Bingham Oceanographic Collection ICH 2534, PMNH Yale University) was photographed by Gregory Watkins-Colwell and he kindly provided the photograph which confirms the identification as *C. glaucofraenum*. The identification is further confirmed by the collection site within a mangrove channel at Crooked Island, Bahamas. The bridled gobies that live in mangrove channels are almost invariably *C. glaucofraenum*.

Common Name. The common name of patch-reef goby is suggested to distinguish the species by its predilection for shallow clear water-reefs. Most markings are shared among closely-related species and names such as bridled and pallid do not discriminate between species.

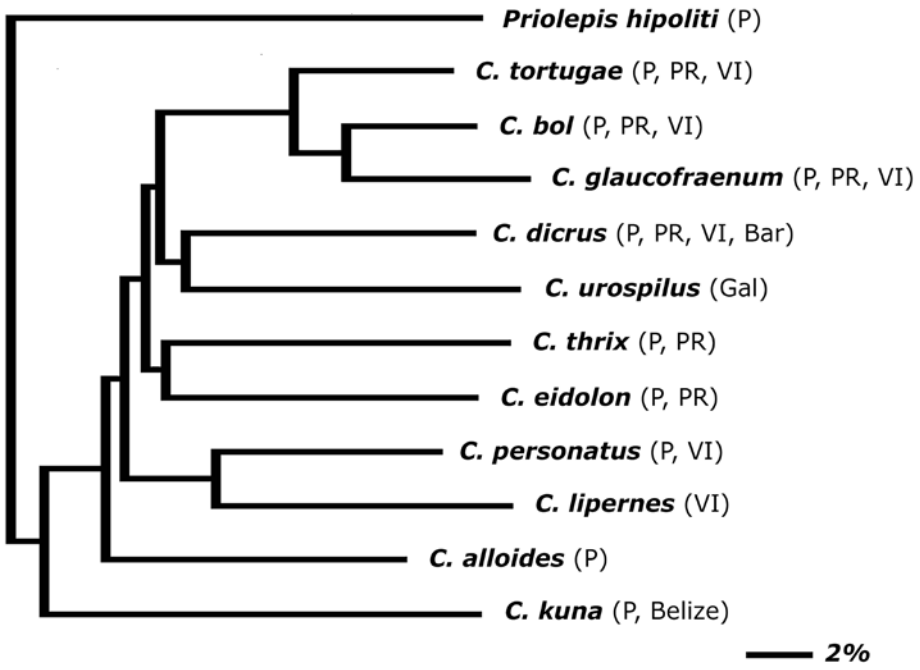

FIGURE 10. Molecular phylogeny of *Coryphopterus spp*. gobies; neighbor-joining tree for the 650 bp mitochondrial barcode sequence COI. Outgroup is *Priolepis hipoliti.* Locations of collections abbreviated as P for Panama, PR for Puerto Rico, VI for U.S. Virgin Islands, Bar for Barbados, Gal for Galapagos Islands, and Belize.

DNA Sequences. The phylogenetic tree generated from mtDNA barcode COI sequences for *Coryphopterus spp.* (with *Priolepis hipoliti* as the outgroup) reveals that *C. bol*, *C. tortugae*, and *C. glaucofraenum* form a clade within the genus, with each of the three species about 10% divergent from the others (fig. 10). Within-species variation in the Caribbean was very low: among 35 specimens of *C. bol* and 45 of *C. tortugae* there was less than 1% intra-specific sequence variation and the majority of individuals had identical sequences of 652 bp. Geographic variation in sequences was not apparent, most specimens shared identical sequences with conspecifics from opposite sides of the Caribbean (Panama and Puerto Rico/USVI).

Habitat. An interesting zoning pattern was detected among the bridled gobies of the region. Putative bridled gobies from three different reef types were identified by barcode sequencing. The sites examined constituted a wide and clearly-zoned shelf in the Greater Antilles (off La Parguera, Puerto Rico), a narrower mixed-zone island of the Lesser Antilles (St. Thomas, US Virgin Islands), and narrow fringing continental reefs in the Southern Caribbean (the Atlantic coast of Panama near Portobelo). Bridled gobies collected in far inshore locations, in mangrove areas or silty shallows, were almost exclusively *C. glaucofraenum*. In shallow sandy bays with clear water and some coral growth, both *C. glaucofraenum* and *C. tortugae* were present. In areas of shallow patch reefs, clear water, and low currents the vast majority of bridled gobies comprised *C. tortugae*. In all three locations, *C. bol* was found in deeper and more offshore reef areas with strong currents: in the channels of the buttress-canyon zone just inshore of the drop-off in Puerto Rico, around exposed rocky points in St. Thomas, and on wave-swept reefs just offshore of the sediment-influenced coastline in Panama.

The morphology of sand gobies varies greatly and matches the habitat type. As can be seen in the examples in figs. 1 and 7, shallower calm-water populations have deeper and wider bodies, broader and shorter snouts, and perhaps less development of the nuchal crest. As a result, the three species of bridled gobies would differ on average in morphology, however this difference is mostly environmentally-determined and should not be used *a priori* as a species character. Indeed, the conclusion by Garzon-Ferreira and Acero (1990) that *C. glaucofraenum* has a deeper body than both forms of *C. tortugae*, could reflect the collection sites of the species. Typical collections of *C. bol* from more offshore and higher-current locations would be slimmer and longer specimens with more pointed snouts. Similarly, the prominence of the large black upper-eye spots on the iris varies with depth (less apparent on shallower specimens with extensive background shading on the eyeball), and thus the more typical *C. bol* found in museum collections show prominent eye spots, although those individuals captured in shallow water have the same eyeball shading as typical inshore *C. tortugae* and *C. glaucofraenum*.

Evaluating prior studies of the habitat distribution of the sand gobies in the region is difficult, since the three species are lumped as *C. glaucofraenum*. Interestingly, in the one large habitat utilization study that recognized *C. tortugae*, by Greenfield and Johnson (1999) in Belize, there were two peaks of abundance of putative *C. tortugae*: one in relatively shallow patch reef environments and the other in the more offshore buttress-canyon channels. It is likely that the latter group represents *C. bol* and further studies documenting habitat separation in the sand gobies should elucidate the generality of these patterns.

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