

*Didogobius amicuscaridis* spec. nov. and *D. wirtzi* spec. nov.,  
two new species of symbiotic gobiid fish  
from São Tomé and Cape Verde islands

(Perciformes, Gobiidae)

Ulrich K. Schliewen & Marcelo Kovačić

Schliewen, U. K. & M. Kovačić (2008): *Didogobius amicuscaridis* and *D. wirtzi*, two new species of symbiotic gobiid fish from São Tomé and Cape Verde Islands (Perciformes, Gobiidae) – *Spixiana* 31/2: 247-261

Two new tropical eastern Atlantic gobies are described, which are obligatorily living in burrows of the axiid shrimp *Axiopsis serratifrons*. Both new species are placed in *Didogobius*, which is re-diagnosed. *Didogobius amicuscaridis* spec. nov. from São Tomé islands and *D. wirtzi* spec. nov. from the Cape Verde Islands, are similar to each other in overall appearance, but differ by a suite of morphometric characters, meristics and coloration. A comparison of key characters for all known species of the apparently closely related genera *Didogobius*, *Gammogobius* and *Chromogobius* is provided. Definitions for all used 41 morphometric distances including several new ones are represented to serve as a reference for gobioid morphometrics.

Ulrich K. Schliewen, Bavarian State Collection of Zoology, Department of Ichthyology, Münchhausenstr. 21, D-81247 München, Germany;  
e-mail: schliewen@zsm.mwn.de

Marcelo Kovačić, Prirodoslovni muzej Rijeka, Lorenzov prolaz 1, HR-51000 Rijeka, Croatia; e-mail: Marcelo.Kovacic@public.carnet.hr

### Introduction

Diversity of small benthic or cryptobenthic fishes in the Gulf of Guinea and Cape Verde islands is most likely drastically underestimated as only few targeted collections using the combination of SCUBA diving and the use of ichthyocides have been accomplished. Except for the SCUBA-based collections made by Lubbock off the coast of Ghana (Miller 1988) only few results of recent efforts have been published so far (Afonso et al. 1999). Forecasts of these results, which highlighted increased levels of endemism and diversity in the coastal waters of São Tomé islands, were supported by new observations in 2004 and targeted collection efforts in 2006, which lead to the discovery of dozens of previously unrecorded fish species around São Tomé as well as several new species including gobies (Wirtz et

al. 2007, Kovačić & Schliewen 2008). Most surprising among them was a goby that obligatorily lives in burrows of the axiid shrimp *Axiopsis serratifrons* (Wirtz 2005, Wirtz in prep.). Preliminary attempts to identify the goby were unsuccessful because only underwater photographs were available and no material was collected in 2004. Inspection of the single intact male and a second damaged female specimen, that were finally collected in 2006 confirmed that the goby represents a new species. The discovery of a shrimp associated goby in the Eastern Atlantic led to intensified searches by P. Wirtz for shrimp gobies in similar habitats around the Cape Verde Islands in 2007 although a recent publication on gobies from the Cape Verde Islands (Brito & Miller 2001) did not mention the presence of a shrimp associated goby. Two additional specimens were recovered, which however, differed in a suite of characters from the

two São Tomé specimens despite their overall similarity. In summary, altogether only two specimens of each of these ecologically and phenetically highly distinct gobies are now available for study, and additional targeted collections are not anticipated.

These ecologically and morphologically highly distinctive specimens share several presumably autoapomorphic characters with the cryptobenthic Eastern Atlantic and Mediterranean goby genus *Didogobius* Miller, 1966. However, they differ also in several characters from all known *Didogobius* specimens, as well as from the most recent re-diagnosis of the genus *Didogobius* by Van Tassell (1988). Miller's diagnosis was based on a single specimen of *Didogobius bentuvii*. *Didogobius schlieweni*, described later by Miller (1992), fitted well with the original generic diagnosis as well as with the one by Van Tassell (1988). With the inclusion of *D. splechnai* another species was described, that did not fit with both Miller's (1966) and Van Tassell's (1988) definition, especially with regard to scale types and squamation pattern. Obviously, too few *Didogobius* specimens of the few species in that genus were available to provide a lasting diagnosis of the genus based on the evaluation of intra- and interspecific variability within the genus. Based on this fact, the high number of mono- or oligotypic gobiid genera in the eastern Atlantic, as well as on the fact that no comprehensive phylogenetic analyses of the family Gobiidae are available, we place our new species in the phenetically most similar genus, i.e. *Didogobius*, for which we provide a re-diagnosis.

### Methods and abbreviations

Apart from the description of the sensory papillae pattern, the description is based on inspection of single intact specimen of the São Tomé species and only two specimens of the Cape Verde species. All material was preserved in 96% ethanol after collection. The second known specimen of the São Tomé species is a severely damaged specimen (without tail region and strongly distorted apart from the head region).

**Fin and scale abbreviations:** A, anal fin; C, caudal fin; D1, D2, first and second dorsal fins; P, pectoral fin; LL, longitudinal scale rows; TR, scales in transverse series; V, pelvic disc.

**Morphometry.** Morphometric methods represent a composite of Miller (1988) and Randall (2005) measurements, enriched with morphometric characters used in ratios for species diagnostic characters in Miller (2003). As the definitions were not provided for all morphometric measurements (Miller 1988, Randall 2005) or

they could be interpreted in different ways, we have repeatedly encountered difficulties with precise morphometric measurements. Therefore we provide a list of definitions for all measurements taken from the specimens of the two new species. Part of these definitions was already clarified by Kovačić & Schliewen (2008). We also tried to reduce to the minimum morphometric measurements that are not point to point measured and measurements without defined position. Distances with values in smaller specimens below 3 mm were measured with a stereomicroscope fitted with an ocular micrometer; larger distances were measured point to point with a digital calliper to an accuracy of 0.01 mm; all values are rounded to the nearest 0.1 mm. Distance abbreviations follow in brackets after the name of the distance. As the holotype was preserved directly in 96 % ethanol in the field measurements might have been influenced due to dehydration.

**Measurements:** **Ab**, anal fin base is measured at the insertion of the spine and the last ray with the body; **Ad**, body depth at the anal fin origin is measured at the level of the insertion of the first anal spine fin; **A1I**, 1<sup>st</sup> anal spine length is measured from the insertion of the first A spine with the body to the tip of the spine; **AULw**, anterior upper lip width is measured at the anterior end of the upper lip; **Aw**, body width at the anal fin origin is the maximum body width at the level of the insertion of the anal fin spine; **Bd** body depth, is the greatest body depth (can not be measured at homologous landmarks); **CHd**, cheek depth is the minimum margin of the eye to the most posterior fleshy point of the jaws angle and includes the scleral cartilage or ossicle ring framing the eyes; **Cl**, caudal fin length is the horizontal distance from the base of the fin, i.e. the posterior end of the hypural plate to the tip of the longest ray (no point-to-point measure); **CP**, caudal peduncle length is the horizontal distance from the fleshy insertion of last ray of A to the caudal fin base, i.e. the posterior end of the hypural plate; **CPd**, caudal peduncle depth is the least depth on caudal peduncle (can not be measured at homologous landmarks); **D1I**, 1<sup>st</sup> dorsal spine length is measured from the insertion of the spine I with the body to the tip of the spine; **D1II** 2<sup>nd</sup> dorsal spine length is measured from the insertion of the spine II with the body to the tip of the spine; **D1III**, 3<sup>rd</sup> dorsal spine length is measured from the insertion of the spine III with the body to the tip of the spine; **D1b**, first dorsal fin base is measured at the fleshy insertions of the first and last spines with the body; **D2b**, second dorsal fin base is measured at the fleshy insertions of the spine and the last ray with the body; **D2I**, 1<sup>st</sup> dorsal spine is measured from the insertion of the spine with the body to the tip of the spine; **E**, eye diameter is the horizontal orbit diameter excluding the ligamentous ring around the eye; **Hd**, head depth is the maximum depth in a vertical line at the mideye; **HI**, head length is measured from the most-anterior end of the upper lip to the posterior end of opercular membrane; **Hw**, head width is the maximum width adjusting for any excessive flaring of the opercula; **I**, interorbital width is the minimum

width including the scleral cartilage or ossicle ring framing the eye; **IDs**, interdorsal space is the distance between the insertion of the last spine of D1 and the first of D2; **LPd**, lateral preorbital depth is the minimum between upper lip and eye including the scleral cartilage or ossicle ring framing the eye (can not be measured at homologous landmarks); **MULw**, maximum lip width is the maximum width of the upper lip (can not be measured at homologous landmarks); **Pl**, pectoral fin length is measured from the vertical of the upper pectoral fin base connection with the flank insertion to the vertical at the end of the longest ray (no point-to-point measure); **PO**, postorbital length is measured from the most posterior margin of the eyeball to the posterior end of opercular membrane and includes the ligamentous ring; **Sl**, standard length is measured from the most-anterior end of the upper lip to the base of the caudal fin (posterior end of the hypural plate); **SN**, snout length is measured from the most-anterior end of the upper lip to the most anterior margin of the orbit including the ligamentous ring; **SN/A**, snout to A is the distance from the most-anterior end of the upper lip to insertion of the A spine; **SN/AN**, snout to anus is the distance from the most-anterior end of the upper lip to anterior anus origin; **SN/D1**, snout to D1 is the distance from most-anterior end of the upper lip to insertion of the first D1 spine; **SN/D2**, snout to D2 is the distance from most-anterior end of the upper lip to insertion of the D2 spine; **SN/V**, snout to V is the distance from most-anterior end of the upper lip to insertions of the V spines; **ULI**, upper lip length is taken from the lateral view from the front of the upper lip to the posterior end of the upper lip; **VSl**, pelvic spine length is measured from the insertion of the spine with the body to the tip of the spine; **V/AN**, pelvic to anus is the distance from the base of the pelvic spine to the anterior origin of the anus; **Vd**, body depth at the pelvic fin origin is measured at the level of the insertion of the pelvic spine; **VI**, pelvic fin length is measured from the base of the pelvic spine to the tip of the longest soft ray; **Vw**, body width at the pelvic fin origin is the maximum body width (including the pectoral fin base) at the level of the insertion of the pelvic spine.

**Meristics.** TR is made from the anterior origin of the anal fin obliquely upwards and rearwards to the base of D2; LL are counted from axially along lateral midline, including scales over the origin of C; in D2 and A counts the last bifid ray is counted as one; *vertebrae count* include the urostyle; *dorsal and anal fin pterygiophore insertion pattern* were determined from x-rays, and osteological terminology follows Birdsong et al. (1988).

**Lateral line system.** Terminology of papillae series and rows, and of head canal pores follows Miller (1986) based on Sanzo (1911). Papillae were found to be semi-destroyed in the holotype of *D. amicuscaridis* spec. nov. probably due to abrasion after preserving the specimen in 96 % ethanol for DNA-analysis purposes; therefore the lateral system is described from the paratype which was stained by dipping it for 20 s

into 2 % KMnO<sub>4</sub>-solution, and thereafter for 20 s into a 0.3 % H<sub>2</sub>SO<sub>4</sub>-solution, before rinsing it in ddH<sub>2</sub>O. The lateral line system of *Didogobius wirtzi* spec. nov. was checked and described on both specimens, holotype and paratype without staining.

**Collections.** Type specimens of the new species have been deposited at the Bavarian State Collection of Zoology, Munich, Germany (ZSM), the collection of the Universidade Federal do Espírito Santo, Vitória, Brazil (UFES) and of the Staatliches Museum für Naturkunde, Germany (SMNS).

## Results

**Generic identification and rediagnosis of *Didogobius* Miller, 1966.** To include the new species, we provide here a rediagnosis for *Didogobius* Miller 1966 based on the evaluation of characters presented in the species descriptions below: *Didogobius* are Gobiinae sensu Pezold (1993) with the following characters: (1) Head and predorsal area naked or with only a few small scales (only in *D. kochi*); (2) no mental barbels; (3) pelvic disc complete with fully developed anterior membrane (frenum); (4) anterior oculoscapular present, posterior oculoscapular canal absent, preopercular canals present or absent (absent only in *D. bentuvii*); (5) suborbital papillae without row *a*; (6) six suborbital transverse rows present, row 4 missing, last row 7 near pore  $\alpha$  represented by one or several papillae (several papillae only in *D. amicuscaridis* and *D. wirtzi*); (7) row 5 long, ending near row *d*; (8) interorbital papillae absent. *Didogobius* differs from highly similar and probably closely related members of the atlantico-mediterranean genera *Chromogobius* and *Gammogobius* by characters (6) and (7).

### *Didogobius amicuscaridis*, spec. nov.

(Fig. 1a,c, 2, 3a)

**Types.** Holotype: ZSM 34186, male, 31.5+7.5 mm, São Tomé, Diogo Vaz (00°19'N, 006°29'E), in 24 m depth over sand mixed with coral rubble, 14th February 2006, rotenone, collected Eduardo Ferreira. – Paratype: UFES 133, female, specimen without tail and partially distorted (length of specimen: 25.6 mm), São Tomé, Santana Islet (00°15'N, 006°46'E) in 18 m depth over coarse sand, 9th February 2006, handnet, collected by Eduardo Ferreira.

**Diagnosis.** *Didogobius amicuscaridis* spec. nov. differs from all other described *Didogobius*, i.e. *D. bentuvii* Miller, 1966; *D. kochi* Van Tassell, 1988; *D. schlieveni* Miller, 1992 and *D. splechnai* Ahnelt & Patzner, 1995 by (1) anterior nostril barely reaching, not overlap-

ping the upper lip, (2) posterior nostril slightly erected, not tubular, (3) row 1 below eye, (4) dorsal end of suborbital rows 2 and 3 distant from orbit, (5) suborbital row 7 consisting of more than one papilla, (6) suborbital row *b* anteriorly not extending to below eye, (7) anterior dorsal row *m* consisting of more than one papilla (Fig. 2), (8) body not elongated (Vd/Sl about 1/5). It differs from all other *Didogobius* species except *D. splechnai* and *D. wirtzi* spec. nov. (described below) by head not strongly depressed and P reaching vertical of D2. It differs from *D. splechnai* by D1 I not being the longest spine in D1 and by a flat predorsal profile. Together with *D. wirtzi* spec. nov., the new species differs most, among described *Didogobius* species, from *D. bentuvii* by: (1) preopercular canals present, (2) anterior oculoscapular canal with pores  $\sigma$ ,  $\lambda$ ,  $\kappa$ ,  $\omega$ ,  $\alpha$ ,  $\beta$ ,  $\rho$  present, (3) eyes normal, not reduced, (4) interorbit narrow, much narrower than eye diameter, (5) C rounded and not elongated, (6) anterior dorsal rows *o* connected, (7) anterior dorsal row *g* ends anteriorly in front row *o*. It differs from another similar, but yet undescribed, species of *Didogobius* (or a possibly a closely related new genus) from the Canary islands by possessing anterior oculoscapular and preopercular canals and pores (Van Tassell, pers. comm.). *D. amicuscaridis* differs from the similar Cape Verde shrimp goby *D. wirtzi* spec. nov. (described below) by (1) LL 37 vs. LL 48-51; (2) TR 12-14 vs. TR 15-16; (3) P 17 vs. P 18; (4) a longer head (31.7 % SL vs. 25.9-27.4 % SL); (5) much more compressed caudal part of flanc (body width at anal fin origin 8.6 % SL vs. 13.1-13.2 % SL); (6) D1 spines longer than in *D. wirtzi*: D1 I/Sl=16 %, D1 II/Sl=22 %, D1 III/Sl=19 % vs. D1 I/Sl=12-13 %, D1 II/Sl=14-16 %, D1 III/Sl=13-15%; (7) posterior flanc bars (3 to 6) straight vertical with pale bars in between uninterrupted from dorsal to lateral midline vs posterior flanc bars (3 to 6) in zigzag pattern, with pale area in between separated in upper and lower blotches; (8) in preserved specimens pectoral fin base pigmented, with dark dot in upper part vs. basal part of pectoral fin base and of pectoral fin membrane whitish.

## Description

**General morphology.** Body proportions and meristics of the holotype, the single known intact specimen, are given in Table I. For a general view see Fig 1a. Body moderately elongate and laterally compressed, head moderately depressed; interorbital space very narrow, dorsolaterally positioned eyes. Mouth strongly oblique, lower jaw slightly projecting, posterior angle of jaws below mideye. Snout shorter than eye and rounded in dorsal view.

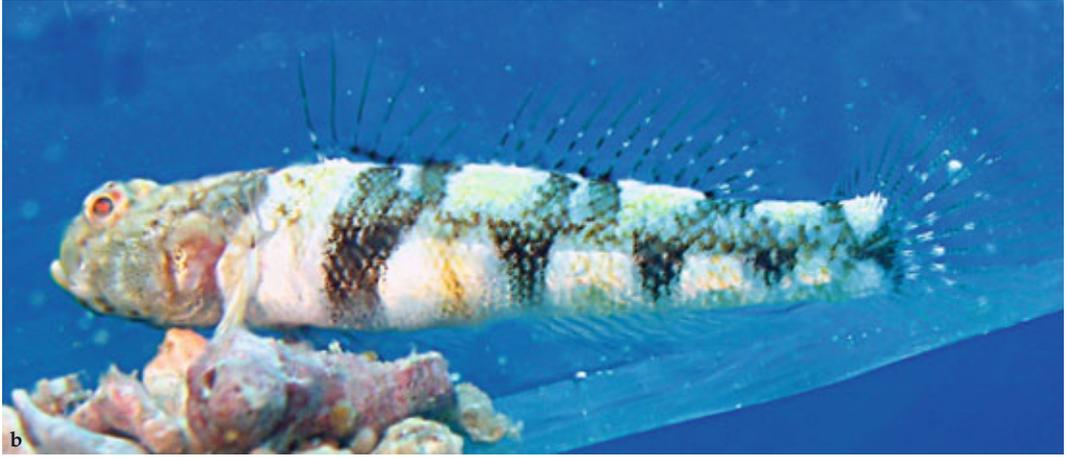
Anterior nostril tubular (longer than diameter), without process from rim, barely reaching but not overlapping the upper lip; posterior nostril slightly erected, but not tubular. Chin lacking barbels. Upper lips anteriorly slightly thinner than laterally. Branchiostegal membrane attached along entire lateral margin; gill opening approximately at the level of lower edge of pectoral fin base. Cranial roof covered by dorsal axial musculature. Pectoral girdle without dermal flaps on anterior edge. Tongue truncate.

**Fins.** D1 VI; D2 I/11 (last bifid); AI/10; P 17 (counted only on left side); V (left/right) I/5+5/1; C (branched/segmented rays) 14/17. Second D1 spine being significantly longer in both specimens (male and female) than all other spines in D1; interdorsal space narrow but no fin membrane connection between D1 and D2; longest D2 rays reaching base of uppermost caudal fin rays. A originates slightly posterior of vertical through D2 origin; C rounded; uppermost rays of P probably not free of membrane, but in both specimens P edges are damaged not allowing for an unambiguous statement; V complete and rounded with ray 4 as long as ray 5, and a fully developed anterior pelvic membrane (frenum).

**Scales.** Body covered anteriorly with cycloid and caudally with ctenoid scales; ctenoid scales start midlaterally from the vertical below base of the fifth spine of D1, dorsally and ventrally further caudally from approximately the vertical below the base of 2<sup>nd</sup> ray of D2 and third ray of A. Head and predorsal area naked, breast with few cycloid scales. Few small scales on the central part of caudal fin base. LL 37, TR 12-14 (scale appear difficult to count owing to irregular scale rows).

**Teeth.** Teeth in lower jaw in three rows. Outer row with three medium-sized teeth frontally, caniniform (pointing slightly backwards). Middle teeth conical, small, numerous, more or less in one row. Inner row with five teeth, caniniform, rearwards increasing in size, the three anterior teeth of medium size between enlarged posterior-lateral teeth. The latter greatly enlarged in holotype. Teeth in upper jaw in three rows. Outer row with eight teeth, medium sized, caniniform (pointing slightly backwards). Teeth in second row, conical, small, numerous, extending far posteriorly; inner row with two anterior teeth, medium sized, caniniform.

**Lateral line system.** Head with anterior oculoscapular and preopercular canals, with pores  $\sigma$ ,  $\lambda$ ,  $\kappa$ ,  $\omega$ ,  $\alpha$ ,  $\beta$ ,  $\rho$ , and  $\gamma$ ,  $\delta$ ,  $\epsilon$  respectively. Rows and number of sensory papillae as follows (Fig. 2): (I) *preorbital*: snout with four rows in median preorbital series. Row *r* (3) above pore  $\sigma$ . Upper row *s*<sup>1</sup> (3) near posterior nostril, lower *s*<sup>2</sup> (3) near anterior nostril, and *s*<sup>3</sup> above



**Fig.1.** Freshly collected and preserved holotypes of *Didogobius amicuscaridis* spec. nov. (A,C) and *D. wirtzi* sp. nov. (B,D).

upper lip (2). Lateral series *c* in four parts: superior *c*<sup>2</sup> between posterior and anterior nostrils (9) as one cluster and one row; middle transversal *c*<sup>1</sup> (5) below anterior nostril; inferior upper *c*<sub>2</sub> (7) and lower *c*<sub>1</sub> (3) as two rows between lips and row 1. (II) *suborbital*: six transverse and two longitudinal rows of sensory

papillae on cheek. Rows 1-5 before longitudinal row *b*; row 6 divided by *b* in superior (6*s*) and inferior sections (6*i*); row 7 near pore *α* (1: 12, 2: 6, 3/4: 8, 5: 18, 6*s*: 8, 6*i*: 15, 7: 4). Row 1 below eye orbit, rows 1, 5, and 6 begin near orbit; the beginning of rows 2 and 3/4 more distant from orbit. Row 6*i* ending

**Tab. 1.** Standard length and proportional measurements of the holotype of *Didogobius amicuscaridis* spec. nov. and *D. wirtzi* spec. nov.

		<i>D. amicuscaridis</i>		<i>D. wirtzi</i>	
		Holotype ZSM 34186 mm (%)	Holotype ZSM 36566 mm (%)	Paratype SMNS 26370 mm (%)	
	SL, standard length	31.5	30.5	26.6	
%SI	A1 I, 1st anal spine length	2.2 (7.0)	2.3 (7.5)	2.1 (7.9)	
	Ab, anal fin base	7.4 (23.5)	6.6 (21.6)	5.9 (22.2)	
	Ad, body depth at anal fin origin	6.2 (19.7)	5.7 (18.7)	5.1 (19.2)	
	Aw, body width at anal fin origin	2.7 (8.6)	4.0 (13.1)	3.5 (13.2)	
	Bd, body depth	6.9 (21.9)	6.1 (20.0)	5.7 (21.4)	
	Cl, caudal fin length	8.3 (26.3)	8.1 (26.6)	7.0 (26.3)	
	CP, caudal peduncle length	5.8 (18.4)	6.0 (19.6)	5.3 (19.9)	
	CPd, caudal peduncle depth	3.9 (12.4)	3.7 (12.1)	3.3 (12.4)	
	D1 I, 1st dorsal spine length	5.1 (16.1)	3.6 (11.8)	3.4 (12.8)	
	D1 II 2nd dorsal spine length	6.9 (21.9)	4.2 (13.8)	4.2 (15.8)	
	D1 III, 3rd dorsal spine length	6.0 (19.0)	3.9 (12.8)	4.0 (15.0)	
	D1b, first dorsal fin base	3.4 (10.8)	3.6 (11.8)	3.4 (12.8)	
	D2 I, 1st dorsal spine length	4.2 (13.3)	3.4 (11.1)	3.2 (12.0)	
	D2b, second dorsal fin base	8.5 (27.0)	8.2 (26.9)	7.2 (27.1)	
	Hl, head length	10.0 (31.7)	7.9 (25.9)	7.3 (27.4)	
	Hw, head width	6.0 (19.0)	6.0 (19.7)	5.6 (21.1)	
	IDs, interdorsal space	2.1 (6.7)	1.9 (6.2)	1.8 (7.8)	
	Pl, pectoral fin length	8.6 (27.3)	6.5 (21.3)	6.0 (22.6)	
	SN/A, snout to A	19.5 (61.9)	18.1 (59.3)	16.8 (63.2)	
	SN/AN, snout to anus	17.5 (55.6)	16.9 (55.4)	15.6 (58.5)	
	SN/D1, snout to D1	12.1 (38.4)	10.8 (35.4)	10.0 (37.6)	
	SN/D2, snout to D2	18.3 (58.1)	16.8 (55.1)	15.7 (59.0)	
	SN/V, snout to V	10.8 (34.3)	8.9 (29.2)	8.7 (32.7)	
	V/AN, pelvic to anus	7.9 (25.1)	8.2 (26.9)	7.8 (29.3)	
	Vd, body depth at pelvic fin origin	6.1 (19.4)	6.1 (20.0)	5.4 (20.3)	
	Vl, pelvic fin length	7.4 (23.5)	6.9 (22.6)	6.5 (24.4)	
	VSl, pelvic spine length	2.5 (7.9)	2.5 (8.2)	2.3 (8.6)	
	Vw, body width at pelvic fin origin	4.8 (15.2)	4.6 (15.1)	4.4 (16.5)	
%CP	CPd, caudal peduncle depth	3.9 (67.2)	3.7 (61.7)	3.3 (62.3)	
%HI	AULw, anterior upper lip width	0.6 (6.0)	0.7 (8.9)	0.6 (8.2)	
	CHd, cheek depth	2.7 (27.0)	2.0 (25.3)	1.7 (23.3)	
	E, eye diameter	2.1 (21.0)	2.2 (27.8)	2.1 (28.8)	
	Hd, head depth	5.0 (50.0)	4.6 (58.2)	3.8 (52.1)	
	Hw, head width	5.9 (59.0)	5.9 (74.7)	5.4 (74.0)	
	LPd, lateral preorbital depth	0.9 (9.0)	0.8 (10.1)	0.6 (8.2)	
	MULw, maximum lip width	0.7 (7.0)	0.8 (10.1)	0.7 (9.6)	
	PO, postorbital length	6.3 (63.0)	4.8 (60.8)	4.4 (60.3)	
	SN, snout length	1.7 (17.0)	1.4 (17.7)	1.3 (17.8)	
	ULL, upper lip length	2.8 (28.0)	2.6 (32.9)	2.5 (34.2)	
%E	I, interorbital width	0.4 (19.0)	0.8 (36.4)	0.7 (33.3)	

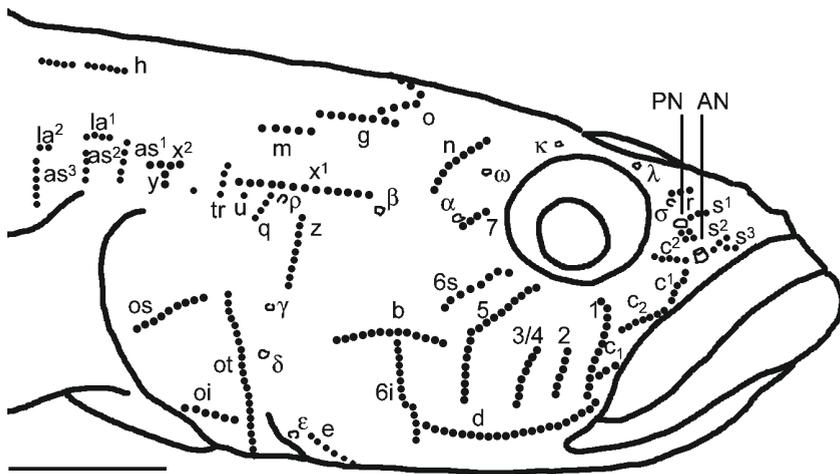


Fig 2. Sensory papillae pattern of *Didogobius amicuscaridis* spec. nov. (paratype). The pattern of the two specimens of *D. wirtzi* spec. nov. is identical.

ventrally below level of row *d*. Longitudinal row *b* (13) ending anteriorly behind rear border of eye. Longitudinal row *d* (21) continuous. (III) *preoperculo-mandibular*: external row *e* and internal row *i* divided into anterior (*e*: 22, *i*: 10), and posterior sections (*e*: 21, *i*: 7); row *f* longitudinal (8). (IV) *oculoscapular*: anterior longitudinal row *x*<sup>1</sup> (13) from behind pore  $\beta$  to near transversal row *tr*; posterior longitudinal row *x*<sup>2</sup> (4) above transversal row *y* (2); transversal row *z* (9) with lower end above pore  $\gamma$ ; transversal row *q* (4) beginning behind pore  $\rho$ ; *u* as single papilla between rows *q* and *tr* (4); one additional papilla present between rows *tr* and *y*; transversal axillary rows *as*<sup>1</sup> (5), *as*<sup>2</sup> (4), *as*<sup>3</sup> (6) and longitudinal rows *la*<sup>1</sup> (4) and *la*<sup>2</sup> (2) present. (V) *opercular*: transverse row *ot* (23); superior longitudinal row *os* (9); and inferior longitudinal row *oi* (6). (VI) *anterior dorsal*: transversal row *n* behind pore  $\omega$  (9); transversal rows *o* (4) connected; longitudinal row *g* (8) ends anteriorly in front row *o*, longitudinal row *m* (5) behind and below of row *g*; longitudinal row *h* (11) divided into two sections.

**Coloration.** In life (based on holotype shortly after capture and additional underwater photographs reproduced in Fig 1a, 3b). Six broad dark reddish-brown vertical bands on flanks, the first from the predorsal area in front of D1 over the ventral edge of the operculum, the second extending from approximately midbase of the D1 to behind D1, the third from base of 1<sup>st</sup> to 4<sup>th</sup> ray of D2, the fourth from 6<sup>th</sup> to 7<sup>th</sup> ray of D2 and the fifth from the base of the last three rays of D2. Bands 2 to 6 reach from the dorsum to the ventral line, and are enclosed below the lateral midline by two thin white bands.

The sixth band extending from behind D2 to the dorsal origin of C to the central caudal peduncle forming a blotch. All six bands appear in the dorsal view as dark saddles. Body coloration varies from white, over grey to light brown. If brown, small white dots on the flank scales may result in a reticulate pattern. If white, a brown midlateral stripe may extend from after the second band to the last partial band. Snout, chin, cheek and opercula dark brown to black with interspersed white dots on the operculum; caudal edge of operculum with 4 white narrow patches. Area below preoperculum, between junction of operculum, preoperculum and lower jaw with a white stripe; a prominent white narrow band extending from the suborbital area over the posterior lips, light brown with small white dots at anterior edge. Pectoral fin base white with brown bands, a prominent dark brown blotch on dorsal part of fin base extending on the base of fin rays; otherwise pectorals hyaline with small white dots in two to three narrow white bands. D1, D2 and C with hyaline fin membranes, predominantly brown spines and rays interrupted by two to three (D1, D2) or up to five narrow white bands. V, A, breast and isthmus grey. A specimen photographed lurking out of an axiid burrow shows a snowwhite dorsal band extending from the anterior lower lip over the snout and eyes and predorsal area in front of the first vertical band. Coloration of eyes is not uniform but split into a white frontal part and black posterior part; the pectoral fin base and the area behind the first lateral band are white, too, but the extent of the white coloration cannot be recognized, because the fish was partially hidden in the burrow.

In alcohol (based on the holotype, Fig. 1c). Very similar to coloration of freshly collected holotype (Fig. 1a). Six dark bands with white margins as in alive specimen, but with bands four to six less pronounced in dorsal area. Body coloration grey-brown with white flank scale centers in posterior flank behind the second band, and with several small black dots along the lateral midline not visible when alive. Snout, chin, cheek and opercula dark brown to black with interspersed white dots on the operculum; caudal edge of operculum with 4 white narrow patches. Area below preoperculum, between junction of operculum, preoperculum and lower jaw with a white stripe; a prominent white narrow band extending from the suborbital area over the posterior part of lips, to meet on the chin between the lower jaws; lips and frontal part of chin light brown with small white dots, central part of chin black. Pectoral fin base white with black dots and a prominent dark brown blotch at dorsal part of fin base extending onto the rays; lower part of pectoral fin base with an anterior narrow white bar followed by a narrow dark brown bar. Otherwise, pectorals greyish-hyaline with small white dots. D1, D2 and C with hyaline fin membranes, predominantly brown spines and rays interrupted by two to three (D1, D2) or up to five narrow white bands. V, A, breast and isthmus grey. Anterior parts of branchiostegal membranes white.

**Vertebral column and pterygiophore insertion pattern.** 10 precaudal and 17 caudal vertebrae (including urostyle); total count: 27. One epural; pty 3-22110; two prehemal pterygiophores.

**Etymology.** Named *amicuscaridis* as derived from the latin noun *amicus* for friend and latin *caris, caridis* for shrimp, in reference to the obligatory association of the new species with shrimp burrows.

**Ecological and geographical distribution.** *Didogobius amicuscaridis* spec. nov. is only known from São Tomé, where it was observed and/or collected from two locations on São Tomé Island, i.e. Diogo Vaz (00°19'N, 006°29'E) and Santana Islet (00°15'N, 06°46'E), and at one location at the north coast of Príncipe island (01°41'N, 07° 24'E). At all locations, only single specimens were observed at the entrance of burrows of the axiid shrimp *Axiopsis serratifrons*. It was observed in depths from 7 m to 25 m (all ecological information P.Wirtz, pers. comm.). It is not known, whether this species sometimes lives in pairs in the burrows. A detailed description of field observations of this species is currently being prepared by P. Wirtz. Gut contents visible on the radiograph of the holotype show at least six snails of different families: One specimen of *Sinozona* sp.

(Scissurellidae), and several specimens most likely belonging to Rissoidae and Limacinidae (Schwabe, pers. comm.).

***Didogobius wirtzi*, spec. nov.**

(Fig. 1b,d, 2, 3a)

**Types.** Holotype. ZSM 36566, male, 30.5+8.1 mm; Cape Verde Islands, Bay of Tarrafal (15° 17,14'N, W 23° 45,5'W), in 16 m depth over sand mixed with coral rubble, 22th August 2007, quinaldine, collected by Peter Wirtz. – Paratype. SMNS 26370, male, 26.6+7.0 mm; same data as holotype.

**Diagnosis.** *Didogobius wirtzi* spec. nov. differs from all other described *Didogobius*, i.e. *D. bentuvii* Miller, 1966; *D. kochi* Van Tassell, 1988; *D. schlieveni* Miller, 1992 and *D. splechnai* Ahnelt & Patzner, 1995 by (1) anterior nostril barely reaching, not overlapping the upper lip, (2) posterior nostril slightly erected, not tubular, (3) row 1 below eye, (4) dorsal end of suborbital rows 2 and 3 distant from orbit, (5) sub-orbital row 7 consisting of more than one papilla, (6) suborbital row *b* anteriorly not extending to below eye, (7) anterior dorsal row *m* consisting of more than one papilla (Fig. 2), (8) body not elongated (Vd/Sl about 1/5). It differs from all other *Didogobius* species except *D. splechnai* and *D. amicuscaridis* spec. nov. (described above) by head not strongly depressed and P reaching vertical of D2. It differs from *D. splechnai* by D1 I not being the longest spine in D1 and by a flat predorsal profile. Together with *D. amicuscaridis* spec. nov. it differs most, among described *Didogobius* species, from *D. bentuvii* by: (1) preopercular canals present, (2) anterior oculoscapular canal with pores  $\sigma$ ,  $\lambda$ ,  $\kappa$ ,  $\omega$ ,  $\alpha$ ,  $\beta$ ,  $\rho$  present, (3) eyes normal, not reduced, (4) interorbit narrow, much narrower than eye diameter, (5) C rounded and not elongated, (6) anterior dorsal rows *o* connected, (7) anterior dorsal row *g* ends anteriorly in front row *o*. It differs from another similar, but yet undescribed, species of *Didogobius* (or a possibly a closely related new genus) from the Canary islands by possessing anterior oculoscapular and preopercular canals and pores (Van Tassell, pers. comm.). It differs from *D. amicuscaridis* spec. nov. by (1) LL 48-51 vs. LL 37; (2) TR 15-16 vs. TR 12-14; (3) P18 vs. P 17; (4) a shorter head (25.9-27.4 % SL vs. 31.7 % SL); (5) much less compressed caudal part of flanc (body width at anal fin origin 13.1-13.2 % SL vs. 8.6 % SL); (6) D1 spines shorter than in *D. amicuscaridis*: D1 I/Sl= 12-13 %, D1 II/Sl= 14-16 %, D1 III/Sl= 13-15 % vs. D1 I/Sl= 16 %, D1 II/Sl= 22 %, D1 III/Sl= 19 %; (7) posterior flanc bars (3 to 6) in zigzag pattern, with pale area in between separated in upper and lower blotches vs. posterior flanc bars



**Fig. 3.** *Didogobius wirtzi* spec. nov. (A), and *D. amicuscaridis* spec. nov. (B) resting at the entrance of the axiid shrimp burrow (shrimp visible in B). Note the white dorsal head band and porcelain colored pectoral fin bases.

(3 to 6) straight vertical with pale bars in between uninterrupted from dorsal to lateral midline; (8) in preserved specimens basal part of pectoral fin base and of pectoral fin membrane whitish vs. pectoral fin base pigmented, with dark dot in upper part.

### Description

**General morphology.** Body proportions and meristics of the holotype and paratype are given in Table I. For a general view see Fig 1b, 3a. Body moderately elongate and laterally compressed, head depressed. Interorbital space narrow, dorsolaterally positioned eyes. Mouth strongly oblique, lower jaw slightly projecting, posterior angle of jaws below mideye.

Snout shorter than eye and rounded in dorsal view. Anterior nostril tubular (longer than diameter), without process from rim, barely reaching but not overlapping the upper lip; posterior nostril slightly erected, but not tubular. Chin lacking barbels. Upper lips anteriorly slightly thinner than laterally. Branchiostegal membrane attached along entire lateral margin; gill opening approximately at the level of lower edge of pectoral fin base. Cranial roof covered by dorsal axial musculature. Pectoral girdle without dermal flaps on anterior edge. Tongue truncate.

**Fins.** D1 VI; D2 I/10-I/11 (last bifid); A I/9-I/10; P 18 (counted in both specimens just on undamaged side); V (left/right) I/5+5/I; C (branched/segmented rays) 14/17. Second D1 spine being significantly longer in both specimens than all other spines in D1; interdorsal space narrow but no fin membrane connection between D1 and D2; longest D2 rays almost reaching base of uppermost caudal fin rays. A originates slightly posterior of vertical through D2 origin; C rounded; uppermost rays of P not free of membrane; V complete and rounded with ray 4 almost as long as ray 5, and a fully developed anterior pelvic membrane (frenum).

**Scales.** Body covered anteriorly with cycloid and caudally with ctenoid scales; ctenoid scales start mid-laterally from the vertical below base of the fourth spine of D1, dorsally and ventrally farther caudally from approximately just behind the last ray of D2 and A. Head and predorsal area naked, breast with few cycloid scales. Few scales on the central part of caudal fin base. LL 48-51, TR 15-16 (scales appear difficult to count owing to irregular scale rows).

**Teeth.** Teeth in lower jaw in three rows. Outer row with three medium-sized teeth anteriorly, caniniform (pointing slightly backwards). Middle teeth conical, small, numerous, more or less in one row, extending far posteriorly. Inner row with five teeth, caniniform, increasing in size posteriorly, the three anterior teeth of medium size, the two posterior-lateral teeth, especially the second one is greatly enlarged as a fang. Teeth in upper jaw in three rows. Outer row with eight teeth, medium sized, caniniform (pointing slightly backwards). Teeth in second row conical, small, numerous, extending far posteriorly; inner row with two anterior teeth, medium sized, caniniform.

**Lateral line system.** Head with anterior oculoscapular and preopercular canals, with pores  $\sigma$ ,  $\lambda$ ,  $\kappa$ ,  $\omega$ ,  $\alpha$ ,  $\beta$ ,  $\rho$ , and  $\gamma$ ,  $\delta$ ,  $\epsilon$  respectively. Rows and number of sensory papillae as follows (the pattern of sensory papillae rows in this species match very well with the pattern and distribution of rows in *D. amicuscaridis* spec. nov. presented in Fig. 2): (I) *preorbital*: snout

with four rows in median preorbital series. Row  $r$  (3) above pore  $\sigma$ . Upper row  $s^1$  (2-3) near posterior nostril, lower  $s^2$  (2-3) near anterior nostril, and  $s^3$  above upper lip (2-3). Lateral series  $c$  in four parts: superior  $c^2$  between posterior and anterior nostrils (7) as two rows; middle transversal  $c^1$  (4) below anterior nostril; inferior upper  $c_2$  (4-5) and lower  $c_1$  (2-3) as two rows between lips and row 1. (II) *suborbital*: six transverse and two longitudinal rows of sensory papillae on cheek. Rows 1-5 before longitudinal row  $b$ ; row 6 divided by  $b$  in superior ( $6s$ ) and inferior sections ( $6i$ ); row 7 near pore  $\alpha$  (1: 8-9, 2: 6-7, 3/4: 7-9, 5: 12-13,  $6s$ : 4,  $6i$ : 9-10, 7: 3). Row 1 below eye orbit, rows 1, 5, and 6 begin near orbit; dorsal end of rows 2 and 3/4 more distant from orbit. Row  $6i$  ending ventrally below level of row  $d$ . Longitudinal row  $b$  (10-11) ending anteriorly behind rear border of eye. Longitudinal row  $d$  (19-22) continuous. (III) *preoperculo-mandibular*: external row  $e$  and internal row  $i$  divided into anterior ( $e$ : 22-24,  $i$ : 8), and posterior sections ( $e$ : 17-20,  $i$ : 7); row  $f$  longitudinal, not clearly visible to correctly count. (IV) *oculoscapular*: anterior longitudinal row  $x^1$  (13-14) from behind pore  $\beta$  to near transversal row  $tr$ ; posterior longitudinal row  $x^2$  (3-5) above transversal row  $y$  (2-3); transversal row  $z$  (6-9) with lower end above pore  $\gamma$ ; transversal row  $q$  (3-4) beginning behind pore  $\rho$ ;  $u$  as single papilla between rows  $q$  and  $tr$  (3-4); one additional papilla present between rows  $tr$  and  $y$ ; transversal axillary rows  $as^1$  (7-8),  $as^2$  (4-5),  $as^3$  (4-5) and longitudinal rows  $la^1$  (2-3) and  $la^2$  (2-3) present. (V) *opercular*: transverse row  $ot$  (16-17); superior longitudinal row  $os$  (7-8); and inferior longitudinal row  $oi$  (5-6). (VI) *anterior dorsal*: transversal row  $n$  behind pore  $\omega$  (8-9); transversal rows  $o$  (4) connected; longitudinal row  $g$  (6) ends anteriorly in front row  $o$ , longitudinal row  $m$  (3) behind and below of row  $g$ ; longitudinal row  $h$  not completely visible and therefore difficult to count.

**Coloration.** In life (based on both specimens shortly after capture and additional underwater photographs in Fig. 1b, 3a). Six broad reddish-brown to almost black vertical bars on flanks, the first from the predorsal area in front of D1 over the ventral edge of the operculum the second extending from approximately midbase of the D1 to behind D1, the third from base of 4<sup>th</sup> to 6<sup>th</sup> ray of D2, the fourth from last ray of D2 to slightly behind D2 and the fifth from the base of the last three rays of D2; bar 6 is more triangular on the caudal fin base than a bar. Bar 2 is a bar ventrally to midline and is split dorsally to form a Y-shaped pattern. Bars 3 to 5 are split dorsally into oblique subbars that only reach midline; below midline these form bars, that become ventrally narrow and are connected each to two

upper subbars, i.e. upper and lower bars form a zigzag-band on the caudal flank and terminate in the triangle on the caudal fin base. Bars 2 to 6 are connected by a faint narrow midlateral stripe. Dorsal and caudal interspaces between bars except on the ventral interspace behind pectorals are white with yellow central areas. All bars except for the caudal triangle appear in the dorsal view as dark saddles; the first bar covers the entire area between D1 and the eyes including a large yellow-white blotch enframed by the band. Body coloration varies from white to whitish-grey. Cheek and opercula dark brown with interspersed white small areas and numerous melanophores; preorbital brown stripe separates white to yellowish snout area extending from the anterior lower lip over the snout and eyes and predorsal area in front of the first vertical band; coloration of eyes is not uniform but vertically split into a white anterior part and black posterior part; the upper rear section of the iris contains a red blotch, the iris reflection is reddish. The entire snout area is snowwhite in specimens photographed appearing out of an axiid burrow. Caudal edge of operculum, pectoral fin base and basal part of pectoral fin membranes porcellane white. A conspicuous black dot on inner pectoral fin bases; otherwise pectorals hyaline. D1, D2 and C with hyaline fin membranes, predominantly brown spines and rays (distal parts dark yellow) interrupted in D2 and C by one, two or rarely more white dots. V, A, breast and white or grey. Pupilla red.

In alcohol (based on the holotype, Fig. 1d). Very similar to coloration of freshly collected material (Fig. 1b). Differences are: Only 5 vertical bands on flanks corresponding closely with bands two to six of living specimens, but a predorsal first band not distinguishable from overall grey predorsal and head area. Dorsal and caudal interspaces between bands except on the ventral interspace behind pectorals are white without yellow central areas. Body coloration white. Cheeks, opercula and pre-ventral breast area light grey with numerous melanophores; a white stripe extending from below eyes over chin; iris black; snout area white, D1 and D2 hyaline with a thin black at base. C with white elements at finbase.

**Vertebral column and pterygiophore insertion pattern.** 10 precaudal and 17 caudal vertebrae (including urostyle); total count: 27. One epural; pty 3-22110; two prehemal pterygiophores.

**Etymology.** The new species is named in honor of Peter Wirtz, Madeira, who collected all specimens of both new *Didogobius* species described herein as well as numerous additional gobies from the tropical and temperate eastern Atlantic Ocean now housed in ZSM and SMNS.

**Ecological and geographical distribution.** *Didogobius wirtzi* is only known from the Cape Verde Islands. Only single specimens were observed at the entrance of burrows of the axiid shrimp, *Axiopsis serratifrons*. They were collected in 16m depth on coarse sand from Tarrafal Bay on Santiago Island at a diving location named "Chinese Wall" (15° 17.14'N, 23°45.5'W), where the photographs in their original habitat were taken. It was also common at the south of Sal Island in 15 to 25 m depth (pers. comm. P. Wirtz; no photographs or specimens available).

## Discussion

### **Relationships of *D. amicuscaridis* and *D. wirtzi*.**

The lack of any comprehensive phylogenetic analyses for Atlantico-Mediterranean Gobiidae based either on morphological or molecular characters renders the phylogenetic placement of the new species difficult. However, based on the oculoscapular canal structure, the new species are members of the gobioid subfamily Gobiinae (sensu Pezold 1993). They are further characterized by the combination of the following characters: (1) pterygiophore formula 3-22110, (2) 27 vertebrae, (3) a fully developed anterior pelvic membrane (frenum), (4) suborbital transverse rows present and (5) suborbital papillae without row *a*, (6) no mental barbels, and (7) predorsal area naked. According to overview data compiled from Akihito (1984), Birdsong et al (1988), Goren (1996), Larson & Murdy (2001), Miller (1986, 1988, 1992), Pezold (1993), Scsepka & Ahnelt (1999), Scsepka et al. (1999), Van Tassell (2001, pers. comm.), this combination of characters is shared not only by members of *Didogobius*, but by members of the eastern atlantic, mediterranean and indo-pacific genera *Heteroleotris*, *Caffrogobius*, *Corcyrogobius*, *Chromogobius*, *Gammogobius*, *Millerigobius*, *Zebrus* and *Gobius* (in part). Given how little is known about phylogenetic relationships and character evolution within Gobiinae, it appears premature to firmly postulate that *Didogobius* is monophyletic. Therefore we provide as a basis for future discussion a compilation of selected character states of all 10 more or less elongate and cryptobenthic atlantico-mediterranean gobies currently placed in *Gammogobius*, *Chromogobius* and *Didogobius*, as well as for one undescribed species currently analysed by Van Tassell (pers. comm.).

Based on this compilation of external morphological characters, all described *Didogobius* species appear to form four distinguishable groups: (1) *D. kochi* and *D. schlieveni*, (2) *D. amicuscaridis* and *D. wirtzi*, (3) *D. splechnai*, (4) *D. bentuvii*. The most distinct species appears to be *D. bentuvii*, showing a

**Tab. 2.** Comparative data of selected characters. Values of morphometric distances are given in the accuracy as presented in the respective citation.

	<i>Gammogobius steinitzi</i>	<i>Chromogobius quadrivittatus</i>	<i>Chromogobius zebratus</i>	<i>Chromogobius britoi</i>
data from	Scsepka et al. 1999	Miller 1971	Miller 1971	Van Tassell 2001, Beldade et al. 2006
based on number of specimens	n=17	n=9	n=10	n=16
<b>LL Characters</b>				
suborbital transversals	6+1	6+1	6+1	6+1
row 1 below eye	no	no	no	no
rows 2 and 3	close to orbit	close to orbit	close to orbit	close to orbit
row 4	present	present	present	present
row 5	short	short	short	short
row 6	ending below d	ending below d	ending below d	ending below d
row 7	single papilla	single to several (4)	single to several (4)	single papilla
row b reaching below eye	yes	yes	yes	no
row g to o	g passing beyond o	g passing beyond o	g passing beyond o	g reaching o
rows o	connected	not connected	not connected	not connected
row m	2-4 papillae	3 to 8 papillae	1-3 papillae	0-1 papilla
anterior oculoscapular canal	present, $\sigma, \lambda, \kappa, \omega, \alpha, \beta, \rho$	present, $\sigma, \lambda, \kappa, \omega, \alpha, \beta, \rho$	present, $\sigma, \lambda, \kappa, \omega, \alpha, \beta, \rho$	present, $\sigma, \lambda, \kappa, \omega, \alpha, \beta, \rho$
posterior oculoscapular canal	absent	absent	absent	absent
preopercular canal	absent	present	present	present
<b>Fin Characters</b>				
D1 reaching D2 when depressed	no	no	no	no
D1 shape	D1 I longest	D1 I not the longest	D1 I not the longest	D1 I not the longest
D2 reaching C	no	no	no	no
D2 branched rays	8-9	8-11	10-11	9-11
A branched rays	8	7-9	9-10	8-9
P	15-17	16-18	15-16	14-17
P length	ending below D1	ending below D1	ending below D1	ending below D1
C	rounded	rounded	rounded	rounded
<b>Scale Characters</b>				
pd scales	few small	few small	naked	naked
ll scales	31-37	56-66	41-52	30-36
scale type	combined	cycloid	combined	ctenoid
<b>Morphometric Characters</b>				
H of SL	30.2-33.7	26.0-29.1	25.3-28.6	27.4-31.6
Vd of SL	17.3-19.9	13.9-16.3	13.2-15.7	11.9-16.2
Ad of SL	15.2-17.9	13.6-15.5	12.6-14.5	11.5-15.8
CPd of SL	8.9-10.2	11.1-12.2	9.9-11.7	no data
CHd of H	17.4-20.1	16.4-28.9	21.2-25.0	8.8-23.7
I of E	9.1-15.9	20.7-39.1	24.0-57.8	17.3-29.1
<b>Others</b>				
head strongly depressed	no	yes	yes	no
eye reduced	no	no	no	no
anterior nostril overlapping the upper lip	no	yes	yes	yes
predorsal profile	curved	almost straight	almost straight	curved
posterior nostril shape	tubular	tubular	tubular	tubular
porcelain white pectoral fin base	no	no	no	no
white dorsal band on head (see text)	no	no	no	no
shrimp-burrow associated	no	no	no	no

<i>Didogobius bentuvii</i>	<i>Didogobius kochi</i>	<i>Didogobius schlieveni</i>	<i>Didogobius splechnai</i>	new genus?, "canary goby"	<i>Didogobius amicuscaridis</i>	<i>Didogobius wirtzi</i>
Miller 1966 n=1	Van Tassell 1988 n=3	Miller 1992 n=1	Scepka et al. 1999 n=5	Van Tassell, pers. comm. n=1	this paper n=1 (2)	this paper n=2
5+1 no close to orbit missing long ending below d single papilla	5+1 no close to orbit missing long ending below d single papilla	5+1 no close to orbit missing long ending below d single papilla	5+1 no close to orbit missing long ending below d single papilla	6+1 no close to orbit missing long ending below d single papilla	6 yes distant to orbit missing long ending below d several papillae (5)	6 yes distant to orbit missing long ending below d several papillae (3)
yes g reaching o not connected missing ? present, $\sigma, \kappa, \alpha, \rho$ absent absent	yes g passing beyond o connected a single papilla present, $\sigma, \lambda, \kappa, \omega, \alpha, \beta, \rho$ absent present	yes g passing beyond o connected a single papilla present, $\sigma, \lambda, \kappa, \omega, \alpha, \beta, \rho$ absent present	yes g passing beyond o connected a single papilla present, $\sigma, \lambda, \kappa, \omega, \alpha, \beta, \rho$ absent present	yes g not reaching o connected 1-2 papillae absent absent absent	no g passing beyond o connected 5 papillae present, $\sigma, \lambda, \kappa, \omega, \alpha, \beta, \rho$ absent present	no g passing beyond o connected 3 papillae present, $\sigma, \lambda, \kappa, \omega, \alpha, \beta, \rho$ absent present
no D1 I not the longest yes 14 12 19 ending below D1 long, lanceolate	no D1 I not the longest no 12 11 18-19 ending below D1 rounded	no D1 I not the longest no 12-14 11-12 17 ending below D1 rounded	yes D1 I longest no 9-10 9 15-16 reaching D2 rounded	yes D1 I longest yes 11 9-10 no data reaching D2 rounded	yes D1 II longest yes 11 10 17 reaching D2 rounded	yes D1 II longest no 10-11 9-10 18 reaching D2 rounded
naked 65-70 cycloid or	partially scaled 33-37 cycloid	naked 55-56 cycloid	naked 28-30 combined	no data 31 combined	naked 37 combined	naked 48-51 combined
25.3 no data no data no data 27.0 181.1	25-28 12 10-11 8-9 no data no data	27 15 14 10 21.2 54.5	30-34 15-18 15-18 10-12 12.1-21.6 21.1-35.5	no data no data no data no data no data no data	32 19 20 12 27 19	26-27 20 19 12 23-25 33-36
yes yes yes almost straight tubular no data no data no data	yes no yes almost straight tubular no no no	yes no yes almost straight tubular no no no	no no yes curved tubular no no no	no no yes curved tubular no no no	no no no flat not tubular yes yes yes	no no no flat not tubular yes yes yes

number of external morphological characters being different from all other *Didogobius*, i.e. (1) preopercular canals and pores  $\lambda$ ,  $\omega$ ,  $\beta$  in anterior oculoscapular canal absent, (2) reduced eyes and broad interorbit, (3) long, lanceolate C. Its putatively derived morphology could reflect a highly derived ecology and/or an independent phylogenetic origin suggesting generic distinctiveness. Apart from overall similarity, *D. kochi* and *D. schlieveni* are difficult to group based on shared characters among the remaining species, but their flattened shape appears to be more specialised than in other *Didogobius* species for living in narrow cryptic spaces among stones. Finally, the shrimp burrow associated *D. amicuscaridis* and *D. wirtzi* are most likely sister species and are clearly distinct from *D. splechnai*. Based on data compiled in Table 2, both species share three putatively derived character states that may turn out to be true synapomorphies, i.e. qualifying for generic recognition after testing for alternative phylogenetic hypotheses: (1) Obligatory association with burrows of axiid shrimp *Axiops serratifrons*; (2) temporarily visible snow-white dorsal band extending from the anterior lower lip over the snout and eyes and predorsal area in front of the first vertical band white (see Fig. 3); (3) porcelain white pectoral fin bases (coloration is not known for *D. bentuvii*). However, the table leads also to the conclusion, that phylogenetic relationships among *Didogobius* species and species from related genera remain to be critically evaluated using additional morphological but also DNA-based characters. This study is currently underway (Rüber et al. in preparation)

**Descriptions based on limited number of specimens.** The present description of two new *Didogobius* species, as well as the recent description of *Gorogobius stevcici* (Kovačić & Schlieven 2008) and the gobiesocid *Apletodon wirtzi* (Fricke 2007) from the same remote region are the result of the use of targeted collections using SCUBA in combination with anaesthetics. SCUBA has enabled the discovery of these new species, in contrast to other collecting techniques, which cannot target cryptobenthic gobiid species and result in limited numbers of these specimens available for study. Nevertheless, (1) each of the new species is diagnosable by multiple characters, (2) both new species are morphologically and ecologically highly distinct from all closely related species currently placed in gobiid genera *Didogobius*, *Chromogobius* and *Gammogobius*, (3) additional specimens were observed but not collected, and (4) it is unlikely that additional specimens will be available in the near future, we chose to describe them on the basis of only 2 specimens each. We hope that the careful taxonomically valid description of those locally

endemic species will trigger future gobioid research in the Gulf of Guinea as well as the recognition of the marine conservation potential of both the Cape Verde Islands and São Tomé. To render our results falsifiable and because we had repeatedly encountered problems in applying comparative morphometric measurements of atlantic-mediterranean gobies, we chose to provide a comprehensive list of precise definitions of all measurements used in describing these four specimens.

**Comparative Material examined.** *D. schlieveni*: PMR 756, 1, 29.9+9.7 mm, the island of Krk, Croatia, 21<sup>st</sup> April 2000; PMR 785, 1, 39.1+11.1 mm, the island of Šolta, Croatia, 27<sup>th</sup> May 2000, leg. M. Kovačić. *D. splechnai*: PMR 1713, 1, 24.2+6.0 mm, the island of Susak, Croatia, 20<sup>th</sup> June 2007, leg. M. Kovačić. Comparative material is part of the collection of Prirodoslovni muzej Rijeka (PMR), Croatia.

### Acknowledgements

We wish to thank P. Wirtz, Madeira, Portugal, making available and donating the type material of the new species and for commenting on the manuscript, J.-C. Joyeux at UFES for loan of specimens. We are grateful to J. Van Tassell for providing us with unpublished morphological information on a new and undescribed goby species from Lanzarote, Canary islands. We thank P. Bartsch (ZMB), C. Lamour (ZMB) and M. Geiger (ZSM) for radiographing most specimens. E. Schwabe kindly identified mollusc gut contents based on the radiograph of the holotype of *D. amicuscaridis*. We thank P. Wirtz and L. Rocha for permitting us to use their photographs.

### References

- Afonso, P., Porteiro, F. M., Santos, R. S., Barreiros, J. P., Worms, J. & Wirtz, P. 1999. Coastal marine fishes of São Tome Island (Gulf of Guinea). *Arquipelago. Life and Marine Sciences* 17, 65-92.
- Ahnelt, H. & Patzner, R. A. 1995. A new species of *Didogobius* (Teleostei: Gobiidae) from the western Mediterranean. *Cybiurn* 19 (1), 95-102.
- Akihito, Emperor, 1984. Suborder Gobioidae. In: Masuda, H., Amaoka, K., Araga, C., Uyeno, T. & Yoshino, T. (eds). *The fishes of the Japanese archipelago*, p. 236-289. Tokyo (Tokai University Press).
- Beldade, R., Van Tassell, J. L. & Goncalves, E. J. 2006. First record of *Chromogobius britoi* (Teleostei: Gobiidae) on the mainland European coast. *Journal of Fish Biology* 68, 608-612.
- Birdsong, R. S., Murdy, E. O. & Pezold, F. L. 1988. A study of the vertebral column and median fin osteology in gobioid fishes with comments on gobioid classification. *Bulletin of Marine Science* 42(2), 174-214.

- Brito, A. & Miller, P. J. 2001. Gobiid fishes from the Cape Verde Islands, including two new species of *Gobius* (Teleostei: Gobioidae). *Journal of Natural History* 35, 235-277.
- Fricke, R. 2007. A new species of the clingfish genus *Apletodon* (Teleostei: Gobiidae) from São Tomé and Príncipe, eastern Central Atlantic. *Ichthyological Research* 54, 68-73.
- Goren, M. 1996. A review of the southern African gobiid fish genus *Caffrogobius* Smitt, 1900. J.L.B. Smith Institute of Ichthyology Special Publication 1996, 1-28.
- Kovačić, M. & Schliewen, U. K. 2008. A new species of *Gorogobius* (Perciformes: Gobiidae) from São Tomé Islands. *Zootaxa* 1686, 29-36.
- Larson, H. K. & Murdy, E. O. 2001. Families Eleotridae Gobioidae. In: *FAO Species Identification Guide*, Vol. 6 (Carpenter, K. E. & Niem, V. H., eds). p. 3574-3603. Rome (FAO).
- Miller, P. J. 1966. A new genus and species of gobiid fish from the eastern Mediterranean. *Annals and Magazine of Natural History* (Ser. 13) 8, 161-172.
- 1971. A revision of the Mediterranean gobiid genus *Chromogobius* (Teleostei-Perciformes). *Journal of Zoology* (London) 164, 305-334.
- 1986. Gobiidae. In: Whitehead, P. J. P., Bauchot, M.-L., Hureau, J.-C., Nielsen, J. & Tortonese, E. (eds). *Fishes of the North-eastern Atlantic and the Mediterranean* 3, pp. 1019-1085. Paris (UNESCO).
- 1988. New species of *Corcyrogobius*, *Thorogobius* and *Wheelerigobius* from West Africa (Teleostei: Gobiidae). *Journal of Natural History* 22, 1245-1262.
- 1992. A new species of *Didogobius* (Teleostei: Gobiidae) from the Adriatic Sea. *Journal of Natural History* 26, 1413-1419.
- (ed.), 2003. *The freshwater fishes of Europe*. V. 8/I. Mugilidae, Atherinidae, Atherinopsidae, Blenniidae, Odontobutidae, Gobiidae 1. Wiebelsheim, 404 p., (AULA-Verlag).
- Pezold, F. 1993. Evidence for a monophyletic Gobiinae. *Copeia* 1993, 634-643.
- Randall, J. E., 2005. *Pascua caudilinea*, a new genus and species of gobiid fish (Perciformes: Gobiidae) from Easter Island. *Zoological Studies* 44(1), 19-25.
- Sanzo, L., 1911. Distribuzione delle papille cutanee (organi ciatiformi) e suo valore sistematico nei gobi. *Mitteilungen der Zoologischen Station Neapel* 20, 249-328.
- Scepka, S. & Ahnelt, H. 1999. Wiederbeschreibung von *Gammogobius steinitzi* Bath, 1971 sowie ein Erstnachweis von *Corcyrogobius liechtensteini* (Kolombatovic 1891) für Frankreich (Pisces, Gobiidae). *Senckenbergiana biologica* 79, 71-81.
- Scepka, S., Ahnelt, H., Herler, J. & Hilgers, H. 1999. Morphology of two rare Mediterranean gobiid fishes (Teleostei: Gobiidae). *Cybio* 23, 169-187.
- Van Tassell, J. L. 1988. A new species of *Didogobius* (Perciformes: Gobiidae) from the Canary Islands. *American Museum Novitates* 2906, 1-8.
- 2001. *Chromogobius* (Teleostei: Gobiidae): a new species from the eastern Atlantic. *Copeia* 2001, 1073-1080.
- Wirtz, P. 2005. Eine neue Grundel-Krebs-Symbiose im Ostatlantik. *Die Aquarien- und Terrarienzeitschrift (DATZ)* 56, 66-68. (English translation in <http://explorebiodiversity.com/Hawaii/Shrimp-goby/general/Grundel-Krebs.htm>)
- Wirtz, P., Ferreira, C. E. L., Floeter, S., Fricke, R. Gasparini, J. L., Iwamoto, T., Rocha, L., Sampaio, C. L. S. & Schliewen, U. K. 2007. Coastal Fishes of São Tomé and Príncipe – an update. *Zootaxa* 1523, 1-48.