



## The genus *Pradoxa* Fernandes & Rolán, 1993 (Gastropoda: Muricidae) in São Tomé, Príncipe and Annobón

### El género *Pradoxa* Fernandes & Rolán, 1993 (Gastropoda: Muricidae) en São Tomé, Príncipe y Annobón

Roland HOUART\* and Emilio ROLÁN\*\*

Recibido el 15-VI-2011. Aceptado el 6-X-2011

#### ABSTRACT

The genus *Pradoxa* is revised and all the species are described, compared and illustrated. Two new species are described from São Tomé, *Pradoxa gorii* spec. nov. and *P. urdambideli* spec. nov. The radula is illustrated for *P. confirmata* (Fernandes & Rolán, 1990), *P. thomensis* (Fernandes & Rolán, 1990) and *P. gorii* spec. nov. The subfamilial classification is discussed and a comparative table is added in the appendix.

#### RESUMEN

El género *Pradoxa* es revisado, con todas las especies descritas, ilustradas y comparadas. Se describen dos nuevas especies de São Tomé, *Pradoxa gorii* spec. nov. y *P. urdambideli* spec. nov. Se ilustra la rádula para *P. confirmata* (Fernandes y Rolán, 1990), *P. thomensis* (Fernandes y Rolán, 1990) y *P. gorii* spec. nov. La clasificación a nivel de subfamilia se discute y un cuadro comparativo se aporta en un apéndice.

#### INTRODUCTION

The genus *Pradoxa* was created to include two strange species, *P. confirmata* and *P. thomensis*, originally described in Buccinidae from São Tomé Island by FERNANDES & ROLÁN (1990). However, the radula morphology (Figs. 4J-L, 5A-E) is typical for Muricidae with a rachidian tooth bearing seven cusps and denticles and with a sickle-shaped lateral tooth on each side. Both species have now been reported from Príncipe and Annobón, two other islands of the Gulf of Guinea.

*Pradoxa* was included by HOUART (1996: 116) in the subfamily Muricopsi-

nae, together with *Muricopsis*, *Favartia*, *Murexiella* and *Subpterynotus*, because of their almost similar radula characters. In any case, the shell morphology presents some peculiar characteristics which clearly distinguishes it from any other muricid genera and which are commented upon in the present work.

The protoconch of the genus *Pradoxa* is unusual for the family Muricidae and differs completely from any other similar genus, showing some very strong and high spiral cords separated by deep interspaces (Figs. 2E-F, 3A-H). This character is very similar in the four

\* Research Associate, Institut royal des Sciences naturelles de Belgique, Rue Vautier, 29, B-1000 Bruxelles, Belgium. roland.houart@skynet.be

\*\* Museo de Historia Natural, Campus Universitario Sur, 15782 Santiago de Compostela, emiliorolan@gmail.com

Table I. Terminology used to describe the spiral cords and the internal denticles of the outer lip (based on MERLE 1999 and 2001) (Figs 2A-D).

*Tabla I. Terminología usada para describir los cordones espirales y los denticulos internos del labio exterior (basada en MERLE 1999 y 2001) (Figs 2A-D).*

SP:	Subsutural cord
P1 :	Shoulder cord
P2-P6 :	Primary cords of the convex part of the teleoconch whorl
ADP :	adapical primary cord on the siphonal canal
MP :	median primary cord on the siphonal canal
ABP:	abapical primary cord on the siphonal canal
APERTURE	
ID:	Infrasutural denticle
D1 to D5:	Abapical denticles

species included in the genus (Table II). In some species of *Muricopsis*, one or two shallow spiral cords forming a shoulder may be present but never four to six cords with deep interspaces. The presence of a very small nucleus, with a diameter of 120-200  $\mu\text{m}$  is another additional unusual character.

#### Abbreviations

IRSNB: Institut royal des Sciences naturelles de Belgique, Bruxelles, Belgium.

MHNS: Museo de Historia Natural of the University of Santiago de Compostela, Spain.

MNCN: Museo Nacional de Ciencias Naturales, Madrid, Spain.

MNHN: Muséum national d'Histoire naturelle, Paris, France.

JCD: Collection Jean-Claude Deleamarre.

PR: Collection Peter Ryall.

RH: Collection Roland Houart.

SG: Collection Sandro Gori.

lv: Collected alive.

dd: Empty shell.

See Table I for additional terminology.

## SYSTEMATICS

### Genus *Pradoxa* Fernandes & Rolán, 1993

*Paradoxa* Fernandes & Rolán, 1990: 342 (junior homonym of *Paradoxa* Marshall, 1894).

*Paradoxon* Fernandes & Rolán, 1990: 67 (replacement name for *Paradoxa* Fernandes & Rolán, 1990 non Marshall, 1894, but junior homonym of *Paradoxon* Fleutiaux, 1903).

*Pradoxa* Fernandes & Rolán, 1993: 61 (replacement name for *Paradoxon* Fernandes & Rolán, 1990 non *Paradoxon* Fleutiaux, 1903).

Type species by original designation: *Paradoxa confirmata* Fernandes & Rolán, 1993, Recent, São Tomé.

**Description:** Shell very small, up to 5 mm in height at maturity, narrow, spire very high. Protoconch large with a small nucleus and 1.5-2.2 rounded whorls sculptured by 4-6 narrow, rounded, high spiral cords with a deep interspace between each pair of cords. Teleoconch of 3.5-4.2 whorls. Spiral sculpture of teleoconch whorls consisting of primary

spiral cords, very rarely with additional secondary cords. Axial sculpture of numerous narrow ribs. Aperture small, width 600-900  $\mu\text{m}$   $\times$  height 500-700  $\mu\text{m}$ , with 4 or 5 narrow, elongate denticles within the outer lip. Operculum broadly ovate with subapical nucleus and weak inner curve on abapical left. Siphonal canal broadly open, very short, 7-10% of

total shell height. Radula rachiglossate with a three-dimensional rachidian bearing a central cusp with a single

lateral denticle, a single marginal cusp on each side and a very small marginal cusp.

*Pradoxa confirmata* (Fernandes & Rolán, 1990) (Figs. 1A-D, 2A, E-F, 4A, C, G, J)

*Pradoxa confirmata* Fernandes & Rolán, 1990: 343, text fig. 1B, figs 4-7.

**Type material examined:** Holotype MNCN 15.05/1041 and several paratypes (see Rolán & Fernandes, 1990)

**Other material examined:** São Tomé: Lagoa Azul, 4 m, MHNS, 6 lv (4 coated for SEM); Lagoa Azul, 0.5-3 m, under stones, RH, 5 lv & dd; Esprainha, 1-5 m, MHNS, 7 lv & dd; Esprainha, 2-3 m, RH, 8 dd; Minerio, 10 m, MHNS, 12 lv & dd; 30 m, MHNS, 5 dd; São Tomé Town, 1-3 m, MHNS, 21 lv & dd, RH, 2 lv; Sant'Ana, 0.2-3 m, brush of algae, RH, 4 lv; P. Mutamba, 6 m, MHNS, 73 dd (mostly fragments and protoconchs). Príncipe: Baía de Santo Antonio, 5 m, MHNS, 17 dd. Annobón: San Antonio de Palé, 1-8 m, MHNS, 97 dd (mainly fragments).

**Type locality:** São Tomé, Praia Mutamba.

*Description:* Shell small, up to 5 mm in height at maturity. Height / width ratio 2.6-2.7. Slender, narrowly ovate, heavy, nodose. Subsutural ramp broad, strongly sloping, weakly concave. Entirely brown, chestnut-brown or blackish brown. Inside of aperture weakly lighter coloured.

Spire very high with 2-2.1 protoconch whorls and teleoconch of up to 4-4.2 weakly convex, narrow, weakly shouldered, nodose whorls. Suture weakly adpressed. Protoconch large, broadly cylindrical, width  $900\text{ }\mu\text{m}$   $\times$  height  $800\text{ }\mu\text{m}$ . Whorls with 4 high, narrow, rounded spiral cords with a deep channel between each pair of cords. Each cord giving rise to a nodose spiral cord on first teleoconch whorl. Terminal lip not present.

Axial sculpture of teleoconch whorls consisting of high, narrow, rounded, nodose ribs. First whorl with 15-17 ribs, second with 17 or 18, third with 20, fourth with 20-22 ribs. Four or five last ribs of last teleoconch whorl fused, giving rise to a broad, high apertural lip. Spiral sculpture of high, strong, narrow, nodose, primary cords. First to third teleoconch whorls with SP, P1-P3, P3 occasionally partially or completely covered by next teleoconch whorl; last whorl with SP, P1-P6, ADP, (MP). SP broad, P1 and P2 of approximately similar strength and height, P3 weakly narrower and lower, P4 lowest cord, occasionally obsolete, P5 and P6 broadest and highest, similar in size, ADP narrow, MP very low

and narrow or obsolete. Presence of high rounded nodes at intersection of spiral cords with axial ribs, giving a nodose appearance to the whole shell.

Aperture small,  $800\text{-}900\text{ }\mu\text{m}$  high  $\times$   $500\text{ }\mu\text{m}$  wide, ovate. Columellar lip narrow, smooth, occasionally with weak knob abapically. Rim completely adherent. Anal notch shallow, broad. Outer lip smooth, with 5 weak, elongate denticles within: ID, D1-D4, D4 broadest and strongest, probably D4-D5 fused. Siphonal canal very short, 7 or 8% of total shell height, narrow, straight, broadly open.

Operculum light brown, ovate, with subapical nucleus and weak curve on abapical left. Radula rachiglossate with a three-dimensional rachidian tooth bearing a short, broad central cusp, a narrow, long lateral denticle, a broad, long lateral cusp and a very small marginal cusp. Lateral teeth sickle-shaped with broad base.

*Distribution:* São Tomé, Príncipe and Annobón, living in 0.5-10 m.

*Remarks:* *Pradoxa confirmata* is the largest species of *Pradoxa* with specimens reaching 5 mm in height. It is easily distinguished from the other species in having a strongly nodose shell and a very high spire, a narrow shell with very weakly convex teleoconch whorls and a very low or obsolete P4 on the last teleoconch whorl. The protoconch is also different in having 4 broad spiral cords *vs* 5 or 6 in the other species.



Figure 1. A-D: *Pradoxa confirmata* Fernandes & Rolán, 1990; A, B: São Tomé, Lagoa Azul, 2-3 m, 4.9 mm (MHNS); C: Lagoa Azul, 4 m, 4.1 mm (MHNS); D: San Antonio de Palé, Annobon, 3.2 mm (MHNS). E-G: *Pradoxa thomensis* Fernandes & Rolán, 1990; E, F: São Tomé, Esprainha, 1-5 m, 3.3 mm (MHNS); G: São Tomé, Lagoa Azul, 2-3 m, 2.7 mm (MHNS). H-L: *Pradoxa gorii* spec. nov. São Tomé, Minerio, 37-43 m; H, I, holotype MNHN 24260,3 mm; J, K: paratype MHNS 100559, 2.9 mm; L: paratype MHNS 100559, 2.9 mm. M-Q: *Pradoxa urdambideli* spec. nov. São Tomé, Minerio, 41 m; M, N: paratype SG, 3.6 mm; O, P: holotype MNHN 24264, 3.3 mm; Q: paratype RH, 3.7 mm.

Figura 1. A-D: *Pradoxa confirmata* Fernandes & Rolán, 1990; A, B: São Tomé, Lagoa Azul, 2-3 m, 4.9 mm (MHNS); C: Lagoa Azul, 4 m, 4.1 mm (MHNS); D: San Antonio de Palé, Annobon, 3.2 mm (MHNS). E-G: *Pradoxa thomensis* Fernandes & Rolán, 1990; E, F: São Tomé, Esprainha, 1-5 m, 3.3 mm (MHNS); G: São Tomé, Lagoa Azul, 2-3 m, 2.7 mm (MHNS). H-L: *Pradoxa gorii* spec. nov. São Tomé, Minerio, 37-43 m; H, I, holotype MNHN 24260,3 mm; J, K: paratype MHNS 100559, 2.9 mm; L: paratype MHNS 100559, 2.9 mm. M-Q: *Pradoxa urdambideli* spec. nov. São Tomé, Minerio, 41 m; M, N: paratype SG, 3.6 mm; O, P: holotype MNHN 24264, 3.3 mm; Q: paratype RH, 3.7 mm.

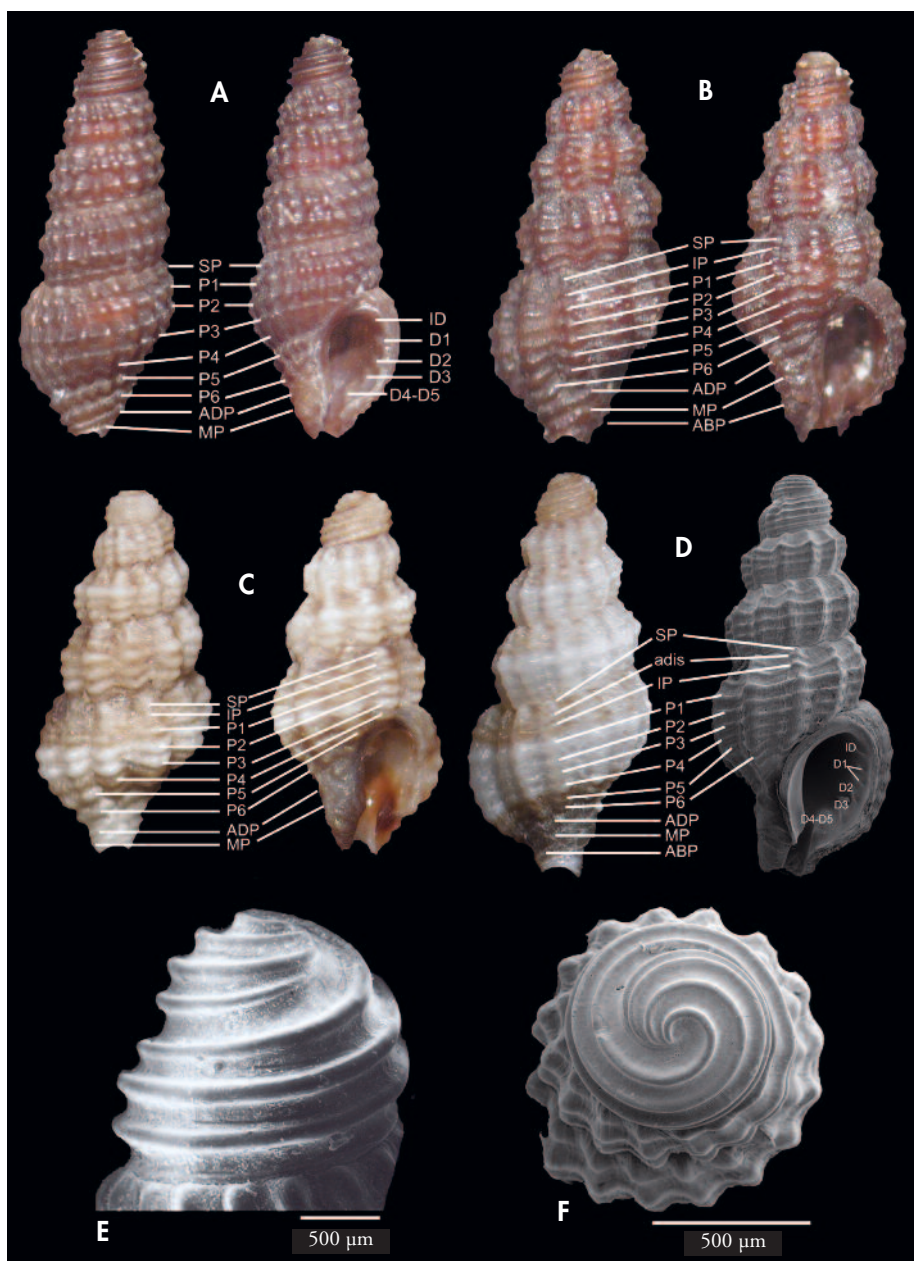


Figure 2. A-D: morphology of the spiral structure and of the apertural denticles. A: *Pradoxa confirmata* Fernandes & Rolán, 1990, São Tomé; B: *Pradoxa thomensis* Fernandes & Rolán, 1990, São Tomé; C: *Pradoxa gorii* spec. nov. São Tomé (holotype); D: *Pradoxa urdambideli* spec. nov. São Tomé. E, F: protoconch of *Pradoxa confirmata* Fernandes & Rolán, 1990.

Figura 2. A-D: morfología de la estructura espiral y denticulos de la abertura. A: *Pradoxa confirmata* Fernandes & Rolán, 1990, São Tomé; B: *Pradoxa thomensis* Fernandes & Rolán, 1990, São Tomé; C: *Pradoxa gorii* spec. nov. São Tomé (holotype); D: *Pradoxa urdambideli* spec. nov. São Tomé. E, F: protoconcha of *Pradoxa confirmata* Fernandes & Rolán, 1990.

*Pradoxa thomensis* (Fernandes & Rolán, 1990) (Figs. 1E-F, 2B, 3A-C, 4B, D, H, K-L)

*Pradoxa thomensis* Fernandes & Rolán, 1990: 345, figs 1-3.

**Type material examined:** Holotype MNCN 15.05/1042 and several paratypes (see Rolán & Fernandes, 1990)

**Other material examined:** São Tomé: Lagoa Azul, MHNS, 2 lv; Esprainha, 1-5 m, MHNS, 6 lv & dd, RH, 2 lv. Príncipe: Baía de Santo Antonio, 5 m, MHNS, 1 dd (juvenile).

**Type locality:** São Tomé.

*Description:* Shell small, up to 3.6 mm in height at maturity. Height/width ratio 2.1-2.4. Slender, lanceolate, narrowly convex, lightly built, tuberculate. Subsutural ramp narrow, weakly sloping on first teleoconch whorl, more strongly sloping on adapical whorls, weakly concave. Entirely brown or blackish brown. Inside of aperture similarly coloured.

Spire very high with 1.5-1.75 protoconch whorls and teleoconch of up to 4 broad, convex, weakly shouldered, nodose whorls. Suture weakly adpressed. Protoconch large, broad, width 600  $\mu$ m  $\times$  height 500  $\mu$ m. Whorls rounded with 4 or 5 high, narrow, rounded spiral cords with a more or less deep channel between each pair of cords. Fifth cord usually covered or partially covered by first teleoconch whorl. Each cord giving rise to a narrow, weakly nodose spiral cord on first teleoconch whorl. Terminal lip not present.

Axial sculpture of teleoconch whorls consisting of moderately high, broad, rounded, weakly nodose ribs. First and second whorls with 10 or 11 ribs, third with 9-11, fourth with 11 ribs. Apertural rib of last teleoconch whorl 2 or 3 times broader than other ribs. Spiral sculpture of low, rounded, narrow, smooth primary cords. First and second teleoconch whorls with SP, P1-P4, P4 usually partially or completely covered by next teleoconch whorl; third whorl with SP, IP, P1-P4; last whorl with SP, IP, P1-P6, ADP, MP, (ABP). IP, P1-P4 narrow, of approximately similar size, P5 and P6 weakly

broader, ADP and MP broadest; ABP when present, low and shallow. Spiral cords weakly broader and higher at intersection of spiral and axial sculpture.

Aperture small, 700-900  $\mu$ m high  $\times$  500  $\mu$ m wide, ovate. Columellar lip narrow, smooth, occasionally with weak, broad knob abapically. Rim completely adherent. Anal notch shallow, broad. Outer lip smooth, with 5 weak, elongate denticles within: ID, D1-D4, D4 broadest and strongest, probably D4-D5 fused. Siphonal canal very short, 6 or 7 % of total shell length, narrow, straight, broadly open.

Operculum light brown, ovate, with subapical nucleus and weak curve on abapical left. Radula rachiglossate with a three-dimensional rachidian tooth bearing a long broad central cusp, a narrow, long lateral denticle, a broad, long lateral cusp and a very small marginal cusp. Lateral teeth sickle-shaped with broad base.

*Distribution:* São Tomé and Príncipe, living at 1-5 m.

*Remarks:* *Pradoxa thomensis* differs from *P. confirmata* in being comparatively smaller and broader with more strongly convex teleoconch whorls. In having a comparatively more rounded and broader protoconch with narrow, lower spiral cords, in having less numerous axial ribs on the teleoconch whorls (9-11 vs 15-22), in having a different spiral sculpture morphology (Table II) and less obvious nodes at the intersection of spiral and axial sculpture, and in having a longer siphonal canal relative to its shell height.

*Pradoxa gorii* spec. nov. (Figs. 1H-L, 2C, 3D-F, 4E, I, 5A-E)

**Type material:** Holotype MNHN 24260. Paratypes: São Tomé, Minerio, 37-43 m - 1 IRSNB IG.31 896/ MT2540; 2 MHNS 100559; 1 MNCN (catalogue number pending). Lagoa Azul, 30-35 m - 1 JCD. Lagoa Azul, 37 m - 2 RH; 5 SG; 10 PR.

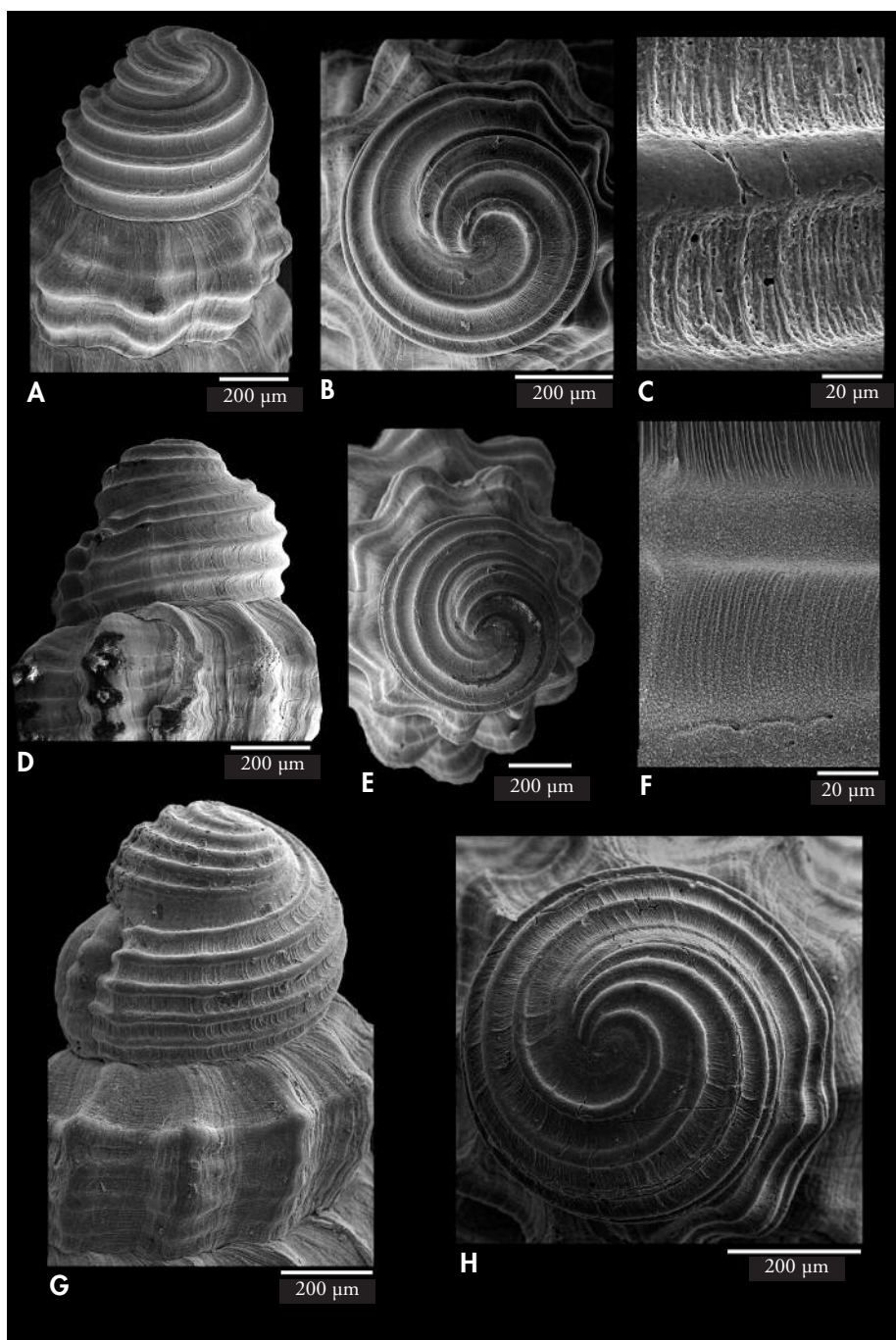


Figure 3. Protoconchs. A-C: *Pradoxa thomensis* Fernandes & Rolán, 1990, São Tomé; D-F: *Pradoxa gorii* spec. nov. São Tomé; G, H: *Pradoxa urdambideli* spec. nov. São Tomé.

Figura 3. Protoconchas. A-C: *Pradoxa thomensis* Fernandes & Rolán, 1990, São Tomé; D-F: *Pradoxa gorii* spec. nov. São Tomé; G, H: *Pradoxa urdambideli* spec. nov. São Tomé.

**Other material examined:** São Tomé: Lagoa Azul, 37 m, 41 lv, SG; Lagoa Azul, 30-35 m, 13 dd, RH; 9 lv & dd, MHNS; Minerio, 41 m, 9 lv, SG; Minerio, 37-43 m. 9 lv & dd, RH; 7 dd (fragments), MHNS.

**Etymology:** We are very pleased to name this new species in honour of our mutual friend Sandro Gori (Livorno, Italy), who provided us with the material studied herein.

**Type locality:** São Tomé, Minerio, 37-43 m.

**Description:** Shell small, up to 3.5 mm in height at maturity. Height/width ratio 1.9-2.2. Lanceolate, narrowly convex, tuberculate. Subsutural ramp broad, strongly sloping, almost straight or weakly convex. Creamy white or light tan with darker coloured band on subsutural ramp, on abapical part of last teleoconch whorl and on tip of siphonal canal, P2 and P3 creamy white. Protoconch occasionally slightly darker, Aperture creamy white or light tan with brown band adapically and abapically on columellar lip and inside of aperture. D4 darker brown.

Spire high with 1.5-1.75 protoconch whorls and teleoconch of up to 3.5 broad, convex, weakly shouldered, nodose whorls. Suture weakly adpressed. Protoconch large, broad, width 600  $\mu\text{m}$   $\times$  height 400-500  $\mu\text{m}$ . Whorls rounded with 5 high, narrow, rounded spiral cords with a more or less deep channel between each pair of cords. Last adapical cord narrower. Each cord giving rise to a narrow, nodose spiral cord on first teleoconch whorl. Terminal lip not apparent.

Axial sculpture of teleoconch whorls consisting of high, broad, rounded, no-

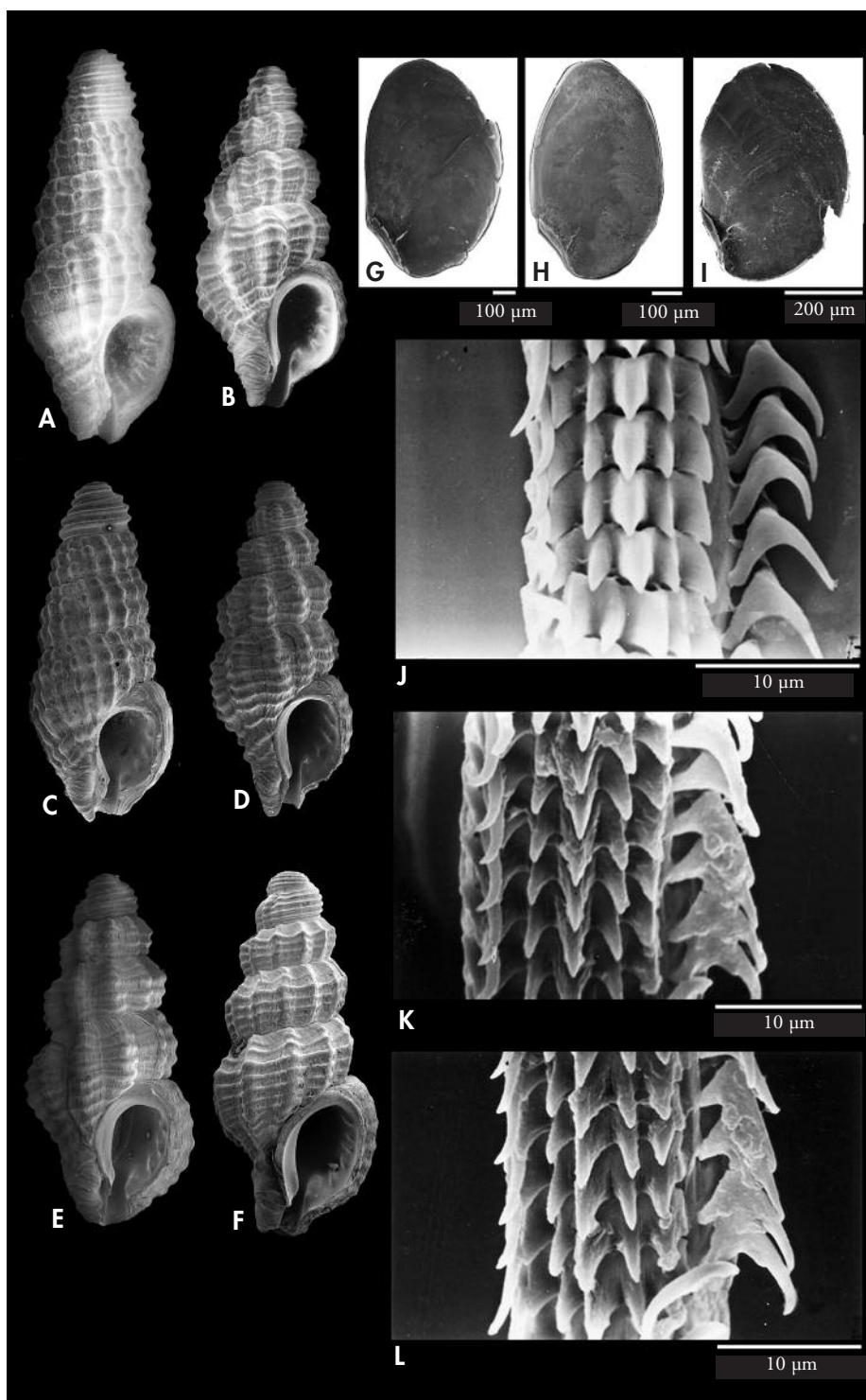
dose ribs. First whorl with 10-12 ribs, second with 9-11 ribs, last whorl with 10 or 11 ribs. Apertural rib of last teleoconch whorl twice as broad as other ribs. Spiral sculpture of high, rounded, strong, broad, smooth, primary cords. First and second teleoconch whorls with SP, IP, P1-P3; third and last whorls with SP, IP, P1-P6, ADP, MP, (ABP). IP, P1 narrow, P2 and P3 broadest cords, P4, P5, P6, ADP broad, of similar size, MP and ABP narrow when present. Spiral cords weakly broader and higher at intersection of spiral and axial sculpture.

Aperture small, 600-700  $\mu\text{m}$  high  $\times$  500  $\mu\text{m}$  wide, broadly ovate. Columellar lip narrow, smooth, with single, strong, broad knob abapically. Rim completely adherent. Anal notch shallow, broad. Outer lip smooth, with 4 weak, elongate denticles within: D1-D4, D4 broadest and strongest, probably D4-D5 fused. Siphonal canal very short, 7-10 % of total shell height, narrow, straight, broadly open.

Operculum colourless, translucent, ovate, with subapical nucleus and weak curve on abapical left. Radula rachiglossate with a three-dimensional rachidian

(Right page) Figure 4. A: *Pradoxa confirmata* Fernandes & Rolán, 1990, São Tomé, holotype MNCN 15.05/1041, 4.3 mm. B: *Pradoxa thomensis* Fernandes & Rolán, 1990, São Tomé, holotype MNCN 15.05/1042, 3.4 mm. C-F: Coated SEM; C: *Pradoxa confirmata* Fernandes & Rolán, 1990, São Tomé, 3.5 mm; D: *Pradoxa thomensis* Fernandes & Rolán, 1990, 2.9 mm; E: *Pradoxa gorii* spec. nov. São Tomé, 3.1 mm; F: *Pradoxa urdambideli* spec. nov. São Tomé, 3.4 mm. G-I: opercula; G: *Pradoxa confirmata* Fernandes & Rolán, 1990 (SEM A. Warén); H: *Pradoxa thomensis* Fernandes & Rolán, 1990 (SEM A. Warén); I: *Pradoxa gorii* spec. nov. J-L: radulae; J: *Pradoxa confirmata* Fernandes & Rolán, 1990 (SEM A. Warén); K-L: *Pradoxa thomensis* Fernandes & Rolán, 1990 (SEM A. Warén).

(Página derecha) Figure 4. A: *Pradoxa confirmata* Fernandes & Rolán, 1990, São Tomé, holotype MNCN 15.05/1041, 4.3 mm. B: *Pradoxa thomensis* Fernandes & Rolán, 1990, São Tomé, holotype MNCN 15.05/1042, 3.4 mm. C-F: Coated SEM; C: *Pradoxa confirmata* Fernandes & Rolán, 1990, São Tomé, 3.5 mm; D: *Pradoxa thomensis* Fernandes & Rolán, 1990, 2.9 mm; E: *Pradoxa gorii* spec. nov. São Tomé, 3.1 mm; F: *Pradoxa urdambideli* spec. nov. São Tomé, 3.4 mm. G-I: opercula; G: *Pradoxa confirmata* Fernandes & Rolán, 1990 (SEM A. Warén); H: *Pradoxa thomensis* Fernandes & Rolán, 1990 (SEM A. Warén); I: *Pradoxa gorii* spec. nov. J-L: radulae; J: *Pradoxa confirmata* Fernandes & Rolán, 1990 (SEM A. Warén); K-L: *Pradoxa thomensis* Fernandes & Rolán, 1990 (SEM A. Warén).



tooth bearing a long broad central cusp, a narrow, long lateral denticle, a broad, long lateral cusp and a very small marginal cusp. Lateral teeth sickle-shaped with broad base.

*Distribution:* São Tomé, living at 30-47 m.

*Remarks:* *Pradoxa gorii* spec. nov. differs in many ways from *P. confirmata* (Figs. 1A-D) and does not need to be compared here with this species.

*Pradoxa gorii* spec. nov. differs from *P. thomensis* (Figs. 1E-G) in having a more strongly shouldered shell with lower teleoconch whorls, a broader,

weakly convex and less sloping subsutural ramp, comparatively broader axial ribs, broader and more closely set spiral cords with a different morphology, a more obvious apertural D4, and a different microsculpture of the protoconch (Fig. 3) In all the populations there is an axial striation between the spiral cords of the protoconch; this is more irregular in *P. thomensis* (Fig. 3C) and more regular in *P. gorii* spec. nov. (Fig. 3F).

*Pradoxa gorii* spec. nov. also has a different shell colour, the shell of *P. thomensis* being uniformly dark brown (see also Table II).

***Pradoxa urdambideli* spec. nov. (Figs. 1M-Q, 2D, 3G-H, 4F)**

**Type material:** Holotype MNHN 24264. Paratypes: São Tomé, Minerio, 41 m - 2 MHNS 100560; 2 RH; 1 SG; 1 PR (lv & dd).

**Etymology:** The species is named after Carlos Urdambidelus, physitian and recognized researcher in genealogy, friend and family of the junior author.

**Type locality:** São Tomé, Minerio, 41 m.

*Description:* Shell small, up to 3.8 mm in height at maturity. Height/width ratio 2.0-2.2. Lanceolate, narrowly convex. Subsutural ramp broad, weakly sloping, weakly convex. White or light creamy white with a light tan or light brown band on abapical part of last teleoconch whorl, covering P5, P6, ADP, MP and ABP, and an occasional additional very lightly coloured spiral band on subsutural area. Aperture white within, apertural denticle D4, columellar lip and occasionally inside of outer lip dark brown.

Spire very high with 1.5-1.75 protoconch whorls and teleoconch of up to 4 broad, convex, weakly or strongly shouldered, lightly nodose whorls. Suture weakly adpressed. Protoconch large, broad, width 600-700  $\mu\text{m}$   $\times$  height 500-600  $\mu\text{m}$ . Whorls rounded with 6 narrow, rounded, moderately high spiral cords with a moderately deep channel between each pair of cords. Sixth cord (adapical) occasionally covered by first teleoconch whorl. Each cord giving rise to a narrow nodose spiral cord on first teleoconch whorl. Terminal lip not apparent.

Axial sculpture of teleoconch whorls consisting of moderately high, broad, rounded ribs. First whorl with 10-12 ribs, second with 10 or 11 ribs, third with 10-12 ribs, last whorl with 11 ribs. Apertural rib of last teleoconch whorl two or three times broader and quite higher than other ribs. Spiral sculpture of low, rounded, narrow, smooth, primary and secondary cords. First and second teleoconch whorls with SP, IP, P1-P4, P4 occasionally covered by next whorl; third whorl with SP, (adis), IP, P1-P4 or P1-P5, last whorl with SP, adis, IP, P1-P6, ADP, MP, (ABP). Primary cords of similar size, P1 occasionally weakly broader and higher. Spiral cords very weakly broader and higher at intersection of spiral and axial sculpture.

Aperture small, 800-900  $\mu\text{m}$  high  $\times$  600-700  $\mu\text{m}$  wide, broadly ovate. Columellar lip narrow, smooth, with occasional, single, weak knob abapically. Rim partially weakly erect abapically, adherent adapically. Anal notch shallow, broad. Outer lip smooth, with 5 weak, elongate denticles within: ID, D1-D4, D4 broadest and strongest, probably D4-D5 fused, D1 rarely split. Siphonal canal

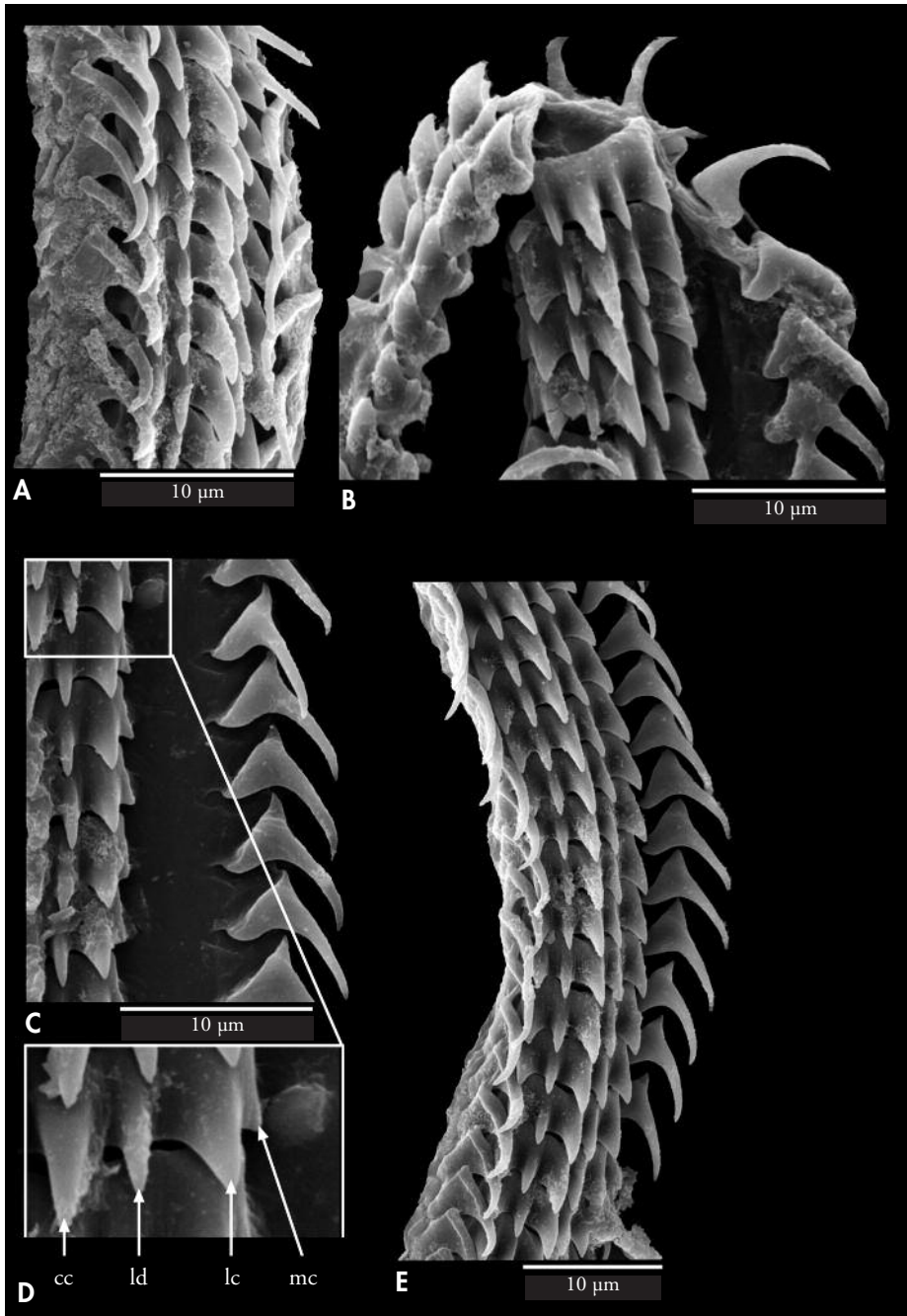


Figure 5. A-E: radular morphology of *Pradoxa gorii* spec. nov. Radula characters (rachidian tooth): cc= central cusp, ld= lateral denticle, lc= lateral cusp, mc= marginal cusp (Figure 5D).

Figura 5. A-E: morfología radular de *Pradoxa gorii* spec. nov. Caracteres de la rádula (diente raquídeo): cc= cúspide central, ld= denticulo lateral, lc= cúspide lateral, mc= cúspide marginal (Figura 5D).

Table II. Comparison of the shell morphology in the *Pradoxa* species.  
 Tabla II. Comparación de la morfología de la concha de las especies de *Pradoxa*.

Character	<i>Pradoxa confirmata</i>	<i>Pradoxa thomensis</i>	<i>Pradoxa gorii</i> spec. nov.	<i>Pradoxa urdambideli</i> spec. nov.
Maximum height	5 mm	3.6 mm	3.5 mm	3.8 mm
Height/width ratio	2.6-2.7	2.1-2.4	1.9-2.2	2.0-2.2
Width and height of protoconch	900 × 800 µm	600 × 500 µm	600 × 400-500 µm	600-700 × 500-600 µm
Sculpture of protoconch	4 high, narrow, rounded spiral cords	4 or 5 high, narrow, rounded spiral cords	5 high, narrow, rounded spiral cords	6 narrow, rounded, moderately high spiral cords
Number of axial ribs on last teleoconch whorl	20-22	11	10 or 11	11
Spiral cords on last teleoconch whorl	SP, P1-P6, ADP, (MP)	SP, P1-P6, ADP, MP, (ABP)	SP, IP, P1-P6, ADP, MP, (ABP)	SP, adis, IP, P1-P6, ADP, MP, (ABP)
Morphology of spiral cords	SP broad, P1 and P2 of approximately similar strength and height, P3 weakly narrower and lower, P4 lowest cord, occasionally obsolete, P5 and P6 broadest and highest, similar in size, ADP narrow, MP very low and narrow or obsolete	IP, P1-P4 narrow, of approximately similar size, P5 and P6 weakly broader, ADP and MP broadest; ABP when present, low and shallow	IP, P1 narrow, P2 and P3 broadest cords, P4, P5, P6, ADP broad, of similar size, MP and ABP narrow when present	Primary cords of similar size, P1 occasionally weakly broader and higher
Aperture height and width	800-900 × 500 µm	700-900 × 500 µm	600-700 × 500 µm	800-900 × 600-700 µm
Length of the siphonal canal	7 or 8% of total shell length	6 or 7 % of total shell length	7-10 % of total shell length	8-9% of total shell length
Colour	Entirely brown, chestnut-brown or blackish brown. Inside of aperture slightly lighter	Entirely brown or blackish brown. Inside of aperture similarly coloured	Creamy white or light tan with darker band on subsutural ramp, on abapical part of last teleoconch whorl and on tip of siphonal canal, P2 and P3 creamy white. Protoconch occasionally slightly darker, Aperture creamy white or light tan with brown band adapically and abapically on columellar lip and inside of aperture. D4 darker brown	White or light creamy white with a light tan or light brown band on abapical part of last teleoconch whorl covering P5, P6, ADP, MP and ABP, and an occasional additional very lightly coloured spiral band on subsutural area. Aperture white within, apertural denticle D4 and occasionally inside of outer lip dark brown

very short, 8-9 % of total shell height, narrow, straight, broadly open.

Operculum and radula unknown.

*Distribution*: Only known from the type locality.

*Remarks*: *Pradoxa urdambideli* spec. nov. differs from *P. gorii* spec. nov. (Figs. 1H-L) in having a larger shell with the same number of teleoconch whorls, in having a comparatively broader and larger aperture, weakly higher and less shouldered teleoconch whorls, especially the last whorl, and in having comparatively narrower spiral cords, more widely spaced from each other and of approximately similar size *vs* more variable in *P. gorii* spec. nov. (see Table II), in the presence of adis, not observed in *P. gorii* spec. nov. (Fig. 2D) and in having a

protoconch with 5 or 6 spiral cords, instead of 4, rarely 5 in *P. gorii* spec. nov. (Figs. 3D-H)

*Pradoxa urdambideli* spec. nov. differs from *P. thomensis* (Figs. 1E-G) in having more strongly shouldered teleoconch whorls, a comparatively broader protoconch, a broader aperture, narrower axial ribs, a protoconch with 5 or 6 narrow spiral cords on the last whorl instead of 4 in *P. thomensis*, in the presence of the secondary cord adis on penultimate and last teleoconch whorls and, as in *P. gorii*, in having a different shell colour. Apparently, *P. urdambideli* is also the only species with a lightly abapically erect columellar lip while completely adherent in the three other species. See also Table II.

## DISCUSSION

There are still strong doubts about the correct subfamilial placement of this genus.

We consider that the following differences are very important and significant characters which differentiate *Pradoxa* from the other genera in Muricopsinae and from other subfamilies as well:

- an almost cylindrical, very small shell with a very high spire;
- a very short siphonal canal and a very small aperture *vs* a very large and broad protoconch;
- an operculum with a weak curve on abapical left (Figs. 4G-I);
- the form, the peculiar sculpture and the large size of the protoconch.

Unfortunately the DNA study of *Pradoxa* did not give any information to date. Further attempts will be made with new material soon. We will follow the next steps very closely and will

publish the results of these investigations and their conclusions.

## ACKNOWLEDGEMENTS

Photographs with the scanning electron microscope (SEM) were made by Jesus Méndez and Inés Pazos in the Centro de Apoyo Científico y Tecnológico a la Investigación (CACTI) of the University of Vigo and by Anders Warén (Natural History Museum, Stockholm, Sweden). Some optical photographs were made in the Servicio de Xenética (XB2) of the same University. The authors also thanks Sandro Gori, Livorno, Italy, for the loan and gift of the material collected during some trips to the islands, and John Wolff, Lancaster, Pennsylvania, USA, for checking the English text and for his useful comments.

## BIBLIOGRAPHY

FERNANDES F. & ROLÁN E. 1989. Nuevo genero y nuevas especies de la familia Buccinidae Rafinesque, 1815 (Mollusca, Neogastropoda) de la Isla de São Tomé. *Bollettino Malacologico*, 25 (9-12): 341-348.

FERNANDES F. & ROLÁN E. 1990. *Paradoxon* nomen novum pro *Paradoxa* Fernandes & Rolán, 1989 (Mollusca, Neogastropoda). *Bollettino Malacologico*, 22 (1-4): 67.

- FERNANDES F. & ROLÁN E. 1993. *Pradoxa* nomen novum pro *Paradoxon* Fernandes y Rolán, 1990. *Iberus*, 11 (1): 61.
- HOUART R. 1996. Les Muricidae d'Afrique Occidentale. I. Muricinae & Muricopsinae. *Apex*, 11 (3-4): 95-161.
- MERLE D. 1999. *La radiation des Muricidae (Gastropoda : Neogastropoda) au Paléogène: approche phylogénétique et évolutive*. Paris. Thèse de doctorat du Muséum National d'Histoire Naturelle: i-vi, 1-499.
- MERLE D. 2001. The spiral cords and the internal denticles of the outer lip in the Muricidae: terminology and methodological comments. *Novapex*, 2 (3): 69-91.