

NEW SPECIES OF UMBILICATED *OXYCHILUS* (GASTROPODA: PULMONATA: OXYCHILIDAE) FROM SANTA MARIA, AÇORES

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ABSTRACT

Three species of umbilicated, colorful *Oxychilus* are described from Santa Maria Island, Açores. *Oxychilus andrei* n.sp., the largest, has a light-grey mantle with sparse light-yellow dots, dark blue neck becoming lighter toward the foot, ending in a fine black rim around the foot; it is conchologically characterized by a smooth, flattened spire, a rapidly expanding last whorl and umbilicus about 6% of shell diameter, sometimes obliterated; the base, of the central radular tooth is emarginated, the arms about half the length of the base the mesocone about four times longer than the ectocones; proximal portion and caecum of penis two thirds of total penis length, sac-like, internally with two prominent pilasters and a very large epiphalic pore extending for about half of total length of penis, with thick, finely and radially grooved lips. *Oxychilus melanooides* n.sp. has a blackish mantle variously dotted with white markings, neck very dark, clearing toward the foot which has a conspicuous black rim; shell conical, spire elevated, very finely grooved, last whorl contracted, aperture oblique, umbilicus 8% of shell diameter, deep; base of central radular tooth entire, the arms vestigial, mesocone about three times longer than ectocones; proximal portion and caecum of penis one third of total penis length, muscular, internally with several strong, transversely grooved folds and a small, almost apical epiphalic pore. *Oxychilus micromphalus* n.sp. has a light pink mantle marked with large white patches, neck bluish-gray becoming white toward the foot which has a dotted black rim in its posterior half; spire flat, finely grooved and with faint spiral cords, last whorl contracted, aperture semilunate, umbilicus 4% of shell diameter; base of central radular tooth slightly emarginated, the arms barely distinguishable, mesocone about twice longer than ectocones; proximal portion and caecum of penis one fourth of total penis length, muscular, internally with several strong, transversely grooved folds and a small, almost apical epiphalic pore. The distribution of the three species is restricted to the Pico Alto Complex, thus raising conservation concerns.

RESUMO

Descrevem-se três espécies de *Oxychilus* umbilicados, coloridos, da Ilha de Santa Maria, Açores. *Oxychilus andrei* n.sp., o maior dos três, possui manto cinzento-claro com manchas amarelo-claro dispersas, pescoço azul escuro tornando-se mais claro em direcção ao pé, terminando num fino debrum negro à volta do pé; concológicamente é caracterizado por espira lisa, achatada, última volta expandindo rapidamente e umbigo cerca de 6% do diâmetro da concha, por vezes obliterado; base do dente central da rádula emarginada, com braços cerca de metade do comprimento da base, mesocone cerca de 4 vezes mais longo que os ectocones; porção proximal e cego do pénis dois terços do comprimento total do pénis, com aparência de saco, internamente com duas pilastras proeminentes e poro do epifalo alongando-se por cerca de metade do comprimento total do pénis, com lábios espessos, finamente sulcados radialmente. *Oxychilus melanooides* n.sp. possui um manto negro, variadamente pontuado com manchas brancas, pescoço muito escuro, tornando-se mais claro em direcção ao pé que possui um conspícuo debrum negro; concha cónica, espira elevada, muito finamente sulcada, última volta contraída, abertura oblíqua, umbigo 8% do diâmetro da concha, profundo; base do dente central da rádula inteira, braços vestigiais, mesocone cerca de 3 vezes mais longo que os ectocones; porção proximal e cego

do pénis cerca de um terço do comprimento total do pénis, muscular, internamente com várias dobras sulcadas transversalmente e poro epifálico pequeno, quase apical. *Oxychilus micromphalus* n.sp. possui um manto rosa-claro marcado por várias grandes manchas brancas, pescoço cinzento azulado tornando-se branco em direção ao pé que na sua metade posterior possui um debrum ponteadado negro; espira achatada, finamente sulcada e com frascos cordões espirais; última volta contraída, abertura semilunada, umbigo 4% do diâmetro total da concha; base do dente central da rádula ligeiramente emarginada, braços apenas visíveis, mesocone cerca de duas vezes mais longo que os ectocones; porção proximal e cego do pénis um quarto do comprimento total do pénis, muscular, internamente com várias dobras sulcadas transversalmente e poro epifálico pequeno, quase apical.

A distribuição das três espécies está restringida ao Complexo do Pico Alto, levantando assim preocupação quanto à conservação.

INTRODUCTION

The genus *Oxychilus* Fitzinger, 1833, comprises the highest number of endemic species in the Azores (Martins, 2005, 2011; Martins *et al.*, 2013), presently contributing with 15 of the 49 species described for the Açorean land mollusks, ellobiids included; preliminary research has yielded evidence for an equal number of new species to be described (Martins, 2005, 2011). Santa Maria Island, the oldest of the Azorean archipelago (Féraud *et al.*, 1984; Serralheiro & Madeira, 1993), is also the richest in endemic species (Morelet, 1860; Backhuys, 1975; Martins *et al.*, 1991; Martins, 1999, 2002; 2011; Cunha *et al.*, 2010; Cameron *et al.*, 2012; Martins *et al.*, 2013). Following Riedel's (1964) fundamental anatomical work, research has focused mostly on the non-umbilicated endemic subgenus *Drouetia* Gude, 1911 (Martins, 1981, 1989, 2005, 2011; Harris *et al.*, 2013; Martins *et al.*, 2013), only sporadically addressing the also rich umbilicated *Oxychilus* (Martins, 1989; Martins & Ripken, 1991).

In the present work, three species from Santa Maria are described. The animals are richly colored, as those of the subgenera *Drouetia* and *Atlantoxychilus* Riedel, 1964, thus providing an interesting ground for interpretation of the relationships of the Azorean *Oxychilus* and of the origin of the endemic *Drouetia*.

Also, description of the still unknown biota from Santa Maria will confirm the island as a fundamental hotspot of

Azorean biodiversity, thus contributing to its conservation status.

MATERIALS AND METHODS

Materials

Specimens of the new species of *Oxychilus* were collected at the stations shown in Figure 1 and Table 1. In Table 1, station 1 relative to Pico Alto has been subdivided, so as to show the variety of habitats therein; however, due to the relatively small area, it has been considered as only one locality for the purpose of type series.

The type series are deposited at the Natural History Museum, London (NHMUK) and at the reference collection (terrestrial mollusks) of the Department of Biology of the University of the Açores (DB/UAç-MT).

Methods

Specimens were killed by drowning overnight and then preserved in 70% ethanol. The soft parts were prepared for SEM observation either by critical point drying with CO₂ or by running the dissection through pure ethanol, acetone/ethanol (1:1), pure acetone, and hexamethyldisilazane (15 minutes/step). SEM material was coated in a Denton DV-502 vacuum evaporator with two layers of gold/palladium (60:40) over a single layer of carbon, and observed in a JEOL 4500 SEM (UAç) or JEOL 5200LV (FCUL).

Representation of the internal morphology of the reproductive system was also prepared following the “almost SEM” technique, herein described: dissect on a transparent substrate (silicone), secure the structure with fine cactus spines; immerse the dissection in water, stain with a fine jet of methylene blue, wash, clean with an eye-lash glued to a needle; photograph under strong incident light on a white background; treat the image with Photoshop: select image/mode/gray tones, and then image/adjust/ invert.

Anatomical orientation of the reproductive system considers proximal those structures closest to the ovotestis.

SYSTEMATICS

Family Oxychilidae P. Hesse, 1927 (1879)
Genus *Oxychilus* Fitzinger, 1833

Oxychilus andrei n.sp.

Figures 2A-B, 3A-C, 4A-D, 5A-C, 6

Oxychilus sp. a, Martins 2011, Table 1.

Material. Holotype (Figures 2A; 4A, C-D; 5A-B): Sta 7, 15-06-2011, Natural History Museum, London (NHMUK 20170003) (ex-DB/UAç-MT 1934a). Paratypes: Sta 7, 15-06-2011, Natural History Museum, London (3 specimens NHMUK 20170004) (ex-DB/UAç-MT 1934); Department of Biology, University of the Açores, Portugal (DB/UAç-MT 1934). Other specimens: Sta 4: 24-06-1994 (DB/UAç-MT 1938); Sta 6: 13-06-1986 (DB/UAç-MT 1939), 30-03-1996 (DB/UAç-MT 1935); Sta 10: 22-06-1994 (DB/UAç-MT 1937), 29-03-1996 (DB/UAç-MT 1936) (see also Table 1).

Type locality. Miradouro das Fontinhas, Santa Maria, Açores (Figure 1 and Table 1, Sta 7).

Etymology. Named after my son André, for his kind appreciation of my taxonomic work.

Description. *Animal* (Figures 2A-B). Neck transversely grooved, blue to gray becoming gradually lighter toward the foot, the darkly pigmented posterior tentacle retractors visible by transparency running inside the outer edge of the upper tentacles; a pair of dorsal, light-blue grooves run forward from the border of the mantle on the neck ending just inside the base of the upper tentacles; anterior tentacles gray at the distal half, white posteriorly; dark-blue to black rim around the foot; sole of the foot longitudinally tripartite, gray. Border of the mantle interrupted near the pneumostome, black, lighter around the pneumostome. Mantle gray; a light-yellow rim inside and around the aperture of the shell followed by a large, transversal black patch continuing posteriorly near the suture; white to light-yellow patches, sometimes breaking into a fine mesh, dispersed along the mantle covering the visceral mass.

Shell (Figures 3A, 4A-B). Holotype 10.2 mm in diameter and 5.4 mm in height, somewhat solid, translucent, glossy, brown, with faint transversal reddish bands; spire very low, with 5 flattened, smooth whorls, last whorl rapidly expanding. Aperture slightly oblique, the columellar lip running almost parallel to the parietal lip; outer lip, sharp, columellar lip slightly reflected over the umbilical aperture; umbilicus 0.6 mm in diameter, sometimes obliterated. Protoconch well defined, ½ of a whorl, smooth.

Radula (Figure 4C-D) (10+2+1+2+10)×35. Central tooth shorter and narrower than laterals, tricuspid; mesocone long, about three quarters the length of the tooth, narrow, sharply pointed; ectocones very small, sharp; base narrowing towards the crown, base line emarginated, receding medially until at about the tip of the mesocone. First lateral tooth about three times longer than the

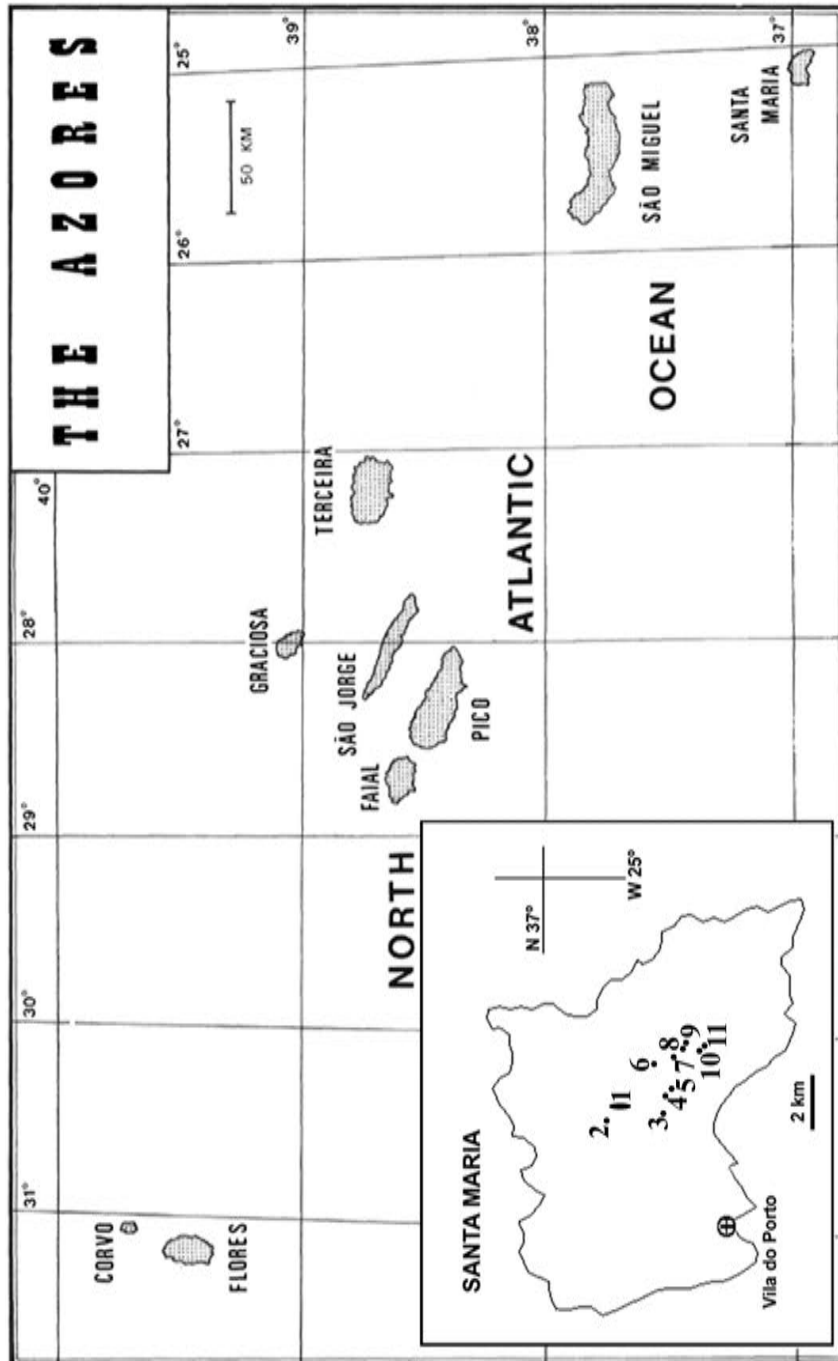


FIGURE 1. The Azores. Insert: location of the stations where specimens of *Oxychilus* n.spp. were collected. See Table 1 for explanation.

TABLE 1. List of stations where material of *Oxychilus* n.spp. was collected.

Sta #	Locality	Altitude (m)	Characterization	Date	Specimens				
					<i>O. andrei</i>		<i>O. melanooides</i>		<i>O. nitrocrumphiatus</i>
				Live	Shell	Live	Shell	Live	Shell
1a	Top of Pico Alto	480	Endemic vegetation, undergrowth of <i>Hedychium gardnerianum</i>	01-11-1974 09-10-1975 12-12-2008	- 22 -	- 37 1	- -	1 -	5 -
1b	W slope, Pico Alto	450	Forest of <i>Cryptomeria japonica</i> ; border of path, undergrowth of <i>Hedychium gardnerianum</i> and <i>Selaginella</i>	12-06-1986 12-06-1990 July, 1992 21-10-1993 21-06-1994 24-06-1994 16-06-2011	- 2 - - 14 2 -	- 2 - -	34 1 -	15 1 -	1 6 1 5 - 1 3
1c	S slope, Pico Alto	430	Forest of <i>Cryptomeria japonica</i> , undergrowth of <i>Hedychium gardnerianum</i>	30-03-1996	-	-	21	23	5
1d	E slope, Pico Alto	430	Forest of <i>Cryptomeria japonica</i> , undergrowth of <i>Hedychium gardnerianum</i>	13-06-1986	-	-	20	16	1
1e	N slope, Pico Alto	400	Forest of <i>Cryptomeria japonica</i> , undergrowth of <i>Hedychium gardnerianum</i>	21-10-1993 29-03-1996	- -	- -	5 2	7	2
2	Alto do Nascente, foot of Pico Alto	336	Old orchard; forest of <i>Pittosporum undulatum</i> and <i>Acacia melanoxylon</i> ; strewn stones	22-06-1994 13-12-2008 16-06-2011	- - -	- -	16 1 4	3 - 2	- - -
3	Ribeiro, Almagreira	250	Forest of <i>Cryptomeria japonica</i> , <i>Pittosporum undulatum</i> and <i>Acacia melanoxylon</i>	02-11-1974	-	-	10	1	-
4	Farropo, foot of Pico Alto	125	Forest of <i>Pittosporum undulatum</i> and <i>Acacia melanoxylon</i> ; no undergrowth	24-06-1994	2	3	4	-	-
5	S of Farropo, foot of Pico Alto	280	Forest of <i>Pittosporum undulatum</i> and <i>Eucalyptus globulus</i> ; no undergrowth	24-06-1994	-	-	12	1	-
6	Cruz dos Picos	400	Forest of <i>Cryptomeria japonica</i> and <i>Pittosporum undulatum</i> , undergrowth of <i>Hedychium gardnerianum</i>	13-06-1986 30-03-1996	- 15	2 5	1 4	2 2	- -
7	Miradouro das Fontinhas	400	Forest of <i>Cryptomeria japonica</i> and <i>Pittosporum undulatum</i> , undergrowth of <i>Hedychium gardnerianum</i> ; strewn stones	15-06-2011	18	2	-	-	-
8	Água dos Mouros, Fontinhas	400	Forest of <i>Cryptomeria japonica</i> , undergrowth of <i>Hedychium gardnerianum</i>	01-11-1974	-	-	4	21	-
9	Perímetro Florestal, Fontinhas	400	Forest of <i>Cryptomeria japonica</i> , undergrowth of <i>Hedychium gardnerianum</i>	10-10-1975	-	-	7	14	-
10	W slope of Cavacas	330	Forest of <i>Pittosporum undulatum</i> and <i>Myrica faya</i> ; no undergrowth	22-06-1994 29-03-1996	25 13	12 5	- 5	- -	- -
11	Road Malbusca/Pico das Cavacas	350	Secondary forest of <i>Pittosporum undulatum</i> ; sparse <i>Selaginella</i>	23-06-1994	-	-	7	1	2



FIGURE 2. Animals of *Oxychilus* from Santa Maria. **A-B**, *Oxychilus andrei* n.sp.; **A**, holotype (NHMUK 20170003), Sta 7; **B**, Sta 10, 22-06-1994 (DB/UAÇ-MT 1937). **C-E**, *Oxychilus melanoides* n.sp.; **C**, holotype (NHMUK 20170005), Sta 1b; **D**, paratype, Sta 1a, 12-12-2008 (DB/UAÇ-MT 1942); **E**, Sta 6, 30-03-1996 (DB/UAÇ-MT 1943); **F**, Sta 2, 16-06-2011 (DBUA-MT 1941). **G**, *Oxychilus micromphalus* n.sp., paratype Sta 1, July 1992 (DB/UAÇ-MT 1963). **H**, *Oxychilus (Drouetia) brincki* Riedel, 1964, Ribeira do Salto, Santa Maria, 16-06-2011.

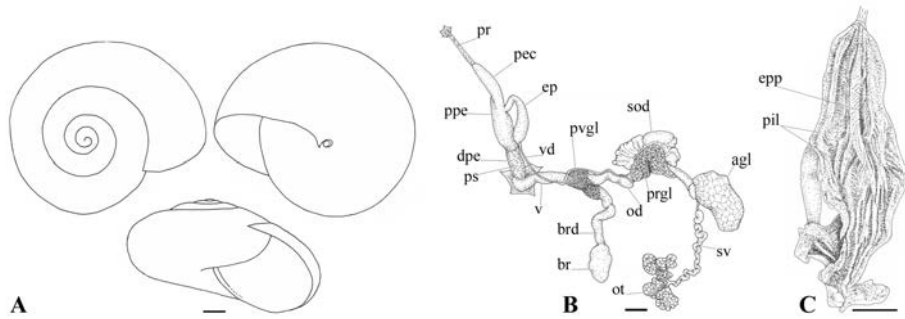


FIGURE 3. *Oxychilus andrei* n.sp. **A**, shell; **B**, reproductive system; **C**, internal morphology of the penis (DB/UAç-MT 1937 – Sta 10, 22-06-1994). agl, albumen gland; br, bursa; brd, bursa duct; dpe, distal penis; ep, epiphalum; epp, epiphalic pore; od, oviduct; pec, penial caecum; pil, pilasters; ppe, proximal penis; pr, penial retractor muscle; prgl, prostate gland; ps, penial sheath; pvgl, perivaginal gland; sod, spermoviduct; sv, seminal vesicle; v, vagina; vd, vas deferens. Scale bar = 1 mm.

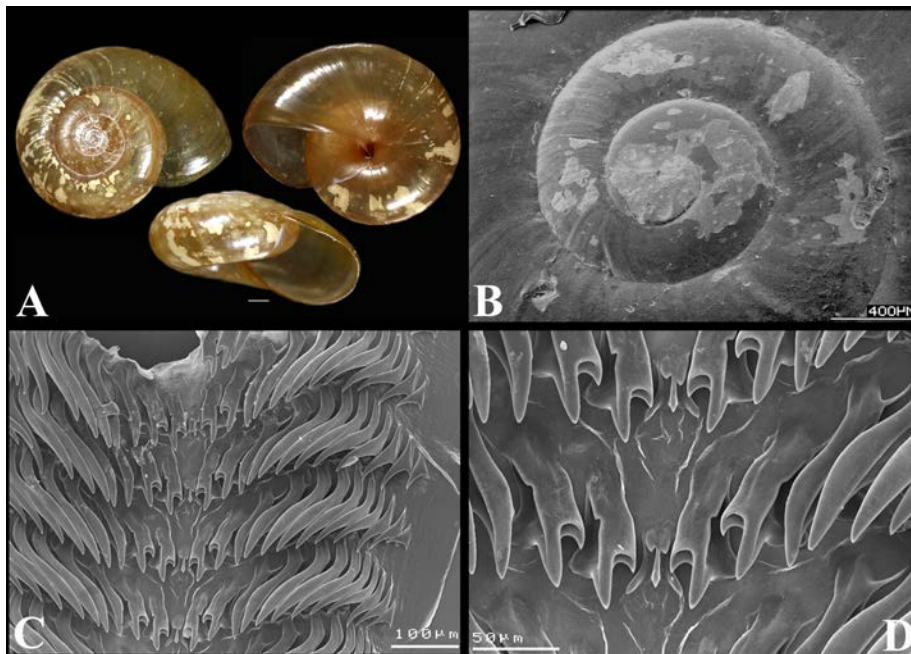


FIGURE 4. *Oxychilus andrei* n.sp. **A**, shell; **B**, Detail of the spire (SEM). **C**, radula (SEM), showing the left half-row of teeth; **D**, radula (SEM), showing the central, the two lateral and the first marginal teeth. **A**, **C**-**D**, holotype (NHMUK 20170003); **B**, Sta 10, 22-06-1994. Scale bar = 1 mm, except where stated otherwise.

central, tricuspid, endocone one third the total length of the tooth and merging medially into a basal tooth, receding laterally along with the base, with which it forms a pointed endocone, ectocone almost vestigial, located far back in the crown; second lateral tooth similar to the first, slightly larger; marginal teeth falciform, retaining only the mesocone which is long, curved and pointed; first marginal teeth larger but narrower than the laterals, decreasing in size towards the outer edge of the row.

Reproductive system (Figures 3B-C; 5A-C). Ovotestis acinose, five acini embedded in the last whorls of posterior lobe of digestive gland; hermaphroditic duct long, composed mainly of a median convoluted seminal vesicle; spermooviduct morphologically divided into three portions: a proximal whitish, globular

portion, a narrow, straight channel, and a wide, strongly convoluted and internally folded portion to which the massive prostate gland adheres; the prostate gland issues a duct, the vas deferens, which runs anteriorly, attaching to the border of the penial sheath before widening into the epiphalus; after the origin of the vas deferens, a free oviduct runs into the confluence with the bursa duct, both ducts opening into a vagina about as long as the oviduct, the confluence of the three ducts covered with a spongy, whitish perivaginal gland; the bursa duct is about as long as the penis, twisted, and ends in an oval-elongated, sharply demarcated bursa; internal walls of the oviduct, bursa duct and vagina strongly folded, the portion under the perivaginal gland reduced to one main fold going into the bursa duct; vagina opens into a short, internally smooth genital atrium. Penis divided in

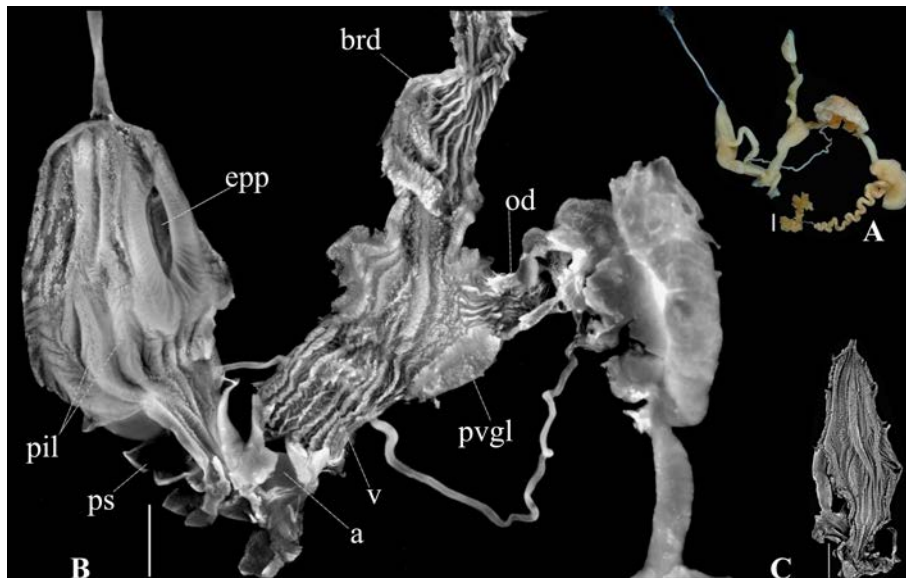


FIGURE 5. *Oxychilus andrei* n.sp. **A**, reproductive system; **B**, internal morphology of reproductive system (“almost SEM”); **C**, internal morphology of the penis (SEM). **A-B**, holotype (NHMUK 20170003); **C**, Sta 10, 22-06-1994. a, atrium; brd, bursa duct; epp, epiphalic pore; od, oviduct; pil, pilasters; ps, penial sheath; pvgl, perivaginal gland; v, vagina. Scale bar = 1 mm.

three portions: a conical, terminal caecum to which a long, thin penial retractor muscle attaches, a mid-portion into which the epiphallus opens, separated by a constriction from a short, muscular distal portion which is wrapped by a thick, glossy sheath; internally, the caecum and the mid-portion form a continuous chamber, with two conspicuous pilasters running longitudinally; the epiphallus – a thickening of the vas deferens where the spermatophore is produced – opens into the mid-portion of the chamber through a wide and elongated pore, its thick lips with fine, radiating grooves; the proximal chamber is separated from the narrower, muscular distal portion by a more or less pronounced constriction. The penial retractor muscle attaches to the middle of the floor of the lung.

Habitat. *Oxychilus andrei* n.sp. prefers the shade of forested areas, with undergrowth of *Hedychium gardnerianum*, seeking shelter under the broad dead leaves, often gathering under strewn rocks.

Distribution. The new species is restricted to the southern region of the Pico Alto Complex, from Fontinhas to Cavacas, on the island of Santa Maria. It has a patchy distribution, sometimes being locally abundant although difficult to find.

Morelet (1860), when referring to the two species of fossil land snails from Santa Maria earlier described, mentioned the presence, in the same fossil beds, of various other species, including oxychilids. Tucked inside the aperture of a type specimen of *Helix vetusta* Morelet & Drouët, 1857, in the Natural History Museum, London, was the specimen represented in Figure 6A, which is here identified as *Oxychilus andrei* n.sp. The recently rediscovered collection of Henri Drouët, Morelet's companion in the 1857 Azores Expedition (Morelet, 1860; Drouët, 1861), deposited at the Muséum d'Histoire naturelle de Dijon, France (Audibert *et al.*, 2013), includes a well preserved fossil specimen of *Oxychilus andrei* n.sp. (Figure 6B).

Oxychilus melanoides n.sp.
Figures 2C-F; 7A-C; 8A-D; 9A-C

Oxychilus sp. b, Martins 2011, Table 1.

Material. Holotype (Figures 2C; 8A, C-D; 9A-B): Sta 1b, 16-06-2011, Natural History Museum, London (NHMUK 20170005) (ex-DB/UAç-MT 1940a). Paratypes: Sta 1d, 13-06-1986, Natural History Museum, London (3 specimens NHMUK 20170006) (ex-DB/UAç-MT 1956); Department of Biology, University



FIGURE 6. *Oxychilus andrei* n.sp., fossil. A, specimen mixed with the types of *Helix vetusta* Morelet & Drouët, 1857, Museum of Natural History, London (BMNH 1893.2.4.347-9); B, specimen from the Drouët collection, Muséum d'Histoire naturelle de Dijon (MJS.D.2012.CO.20). Scale bar = 1 mm.

of the Açores, Portugal: Sta 1a: 01-11-1974 (DB/UAç-MT 1962), 09-10-1975 (DB/UAç-MT 1959), 12-12-2008 (DB/UAç-MT 1942); Sta 1b: 12-06-1986 (DB/UAç-MT 1957), 12-06-1990 (DB/UAç-MT 1954), 21-10-1993 (DB/UAç-MT 1953), 21-06-1964 (DB/UAç-MT 1951), 24-06-1994 (DB/UAç-MT 1946), 26-06-2011 (DB/UAç-MT 1940); Sta 1c: 30-03-1996 (DB/UAç-MT 1944); Sta 1d: 13-06-1986 (DB/UAç-MT 1956); Sta 1e: 21-10-1993 (DB/UAç-MT 1952), 29-03-1996 (DB/UAç-MT 1945). Other specimens (see Table 1): Sta 2: 22-06-1994 (DB/UAç-MT 1950), 13-12-2008 (DB/UAç-MT 1942), 16-06-2011 (DB/UAç-MT 1940); Sta 3: 02-11-1974 (DB/UAç-MT 1960); Sta 4: 24-06-1994 (DB/UAç-MT 1948); Sta 5: 26-06-1994 (DB/UAç-MT 1947); Sta 6: 13-06-1986 (DB/UAç-MT 1955), 30-03-1996 (DB/UAç-MT 1943); Sta 8: 01-11-1974 (DB/UAç-MT 1961); Sta 9: 10-10-1975 (DB/UAç-MT 1958); Sta 10: 29-03-1996 (DB/UAç-MT 1975); Sta 11: 23-06-1994 ((DB/UAç-MT 1949).

Type locality. Pico Alto, Santa Maria, Açores (Figure 1 and Table 1, Sta 1)

Etymology. Named after the pronounced dark color of the body.

Description. Animal (Figures 2C-F). Neck smooth, solid black to gray lined by the shallow groove that runs from the pneumostome to the lower tentacles, the darkly pigmented posterior tentacle retractors visible by transparency running inside the outer edge of the upper tentacles; anterior tentacles black to grayish; black rim around the foot. Border of the mantle black. Mantle dark brown; a large, transversal black patch over the pneumostome region; white to light-yellow patches dispersed across the mantle covering the visceral mass.

Shell (Figures 7A, 8A-B). Holotype 6.3 mm in diameter and 3.9 mm in height, thin, translucent, glossy, uniformly golden to straw-color; spire high, with 5.3 flattened whorls, covered with fine spiral cords transversely crossed by fine growth lines, last whorl contracted. Aperture oblique, columellar lip dark-red, reflected over the umbilical aperture; umbilicus 0.52 mm in diameter, deep. Protoconch barely distinguishable, 2/3 of a whorl, smooth.

Radula (Figure 8C-D) (22+2+1+2+22)x80. Central tooth shorter and narrower than laterals, tricuspid; mesocone short, not

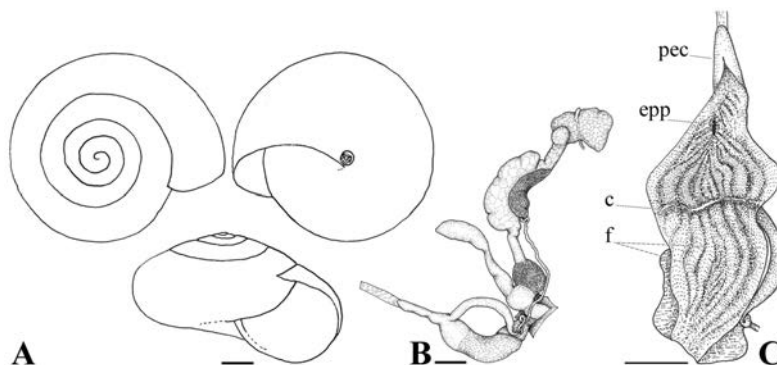


FIGURE 7. *Oxychilus melanoides* n.sp. **A**, shell; **B**, reproductive system; **C**, internal morphology of the penis (DB/UAç-MT 1944 – Sta 1c, 30-03-1996). Abbreviations: c, constriction, separating the distal portion of the penis from the proximal (penial caecum included) where the epiphalic pore lies; epp, epiphalic pore; f, folds; pec, penial caecum. Scale bar = 1 mm.

reaching the base line, about twice the length of the ectocones; base rectangular, base line straight. First lateral tooth about twice longer than the central, tricuspid, endocone about half the total length of the tooth and merging medially into a basal tooth, receding laterally along with the base, with which it forms a pointed endocone, ectocone well marked, located far back in the crown; second lateral tooth twice the size of the first; marginal teeth falciform, retaining only the mesocone which is long, curved and pointed; first marginal teeth somewhat larger than the second lateral, decreasing in size towards the outer edge of the row.

Reproductive system (Figures 7B-C; 9A-C). Basic layout as in *Oxychilus andrei* n.sp. Bursa duct shorter than penis, very

wide at base, ending in a small, elliptic, sharply demarcated bursa; perivaginal gland whitish, extending over the proximal portion of the bursa duct; internal walls of the oviduct, bursa duct and vagina strongly folded, the portion under the perivaginal gland irregularly grooved; vagina opens into a short, internally weakly folded genital atrium. Penis muscular; a short, terminal caecum to which a thick penial retractor muscle attaches; mid-portion short, globular, constriction well marked; muscular distal portion externally shiny, wrapped in its extremity by a glossy sheath; internally, the caecum and the mid-portion form a continuous chamber lined with 5 to 6 strong, compacted, convoluted folds; epiphalic pore small, roundish, lips deeply grooved. Penial retractor muscle attaches to the middle of the floor of the lung.

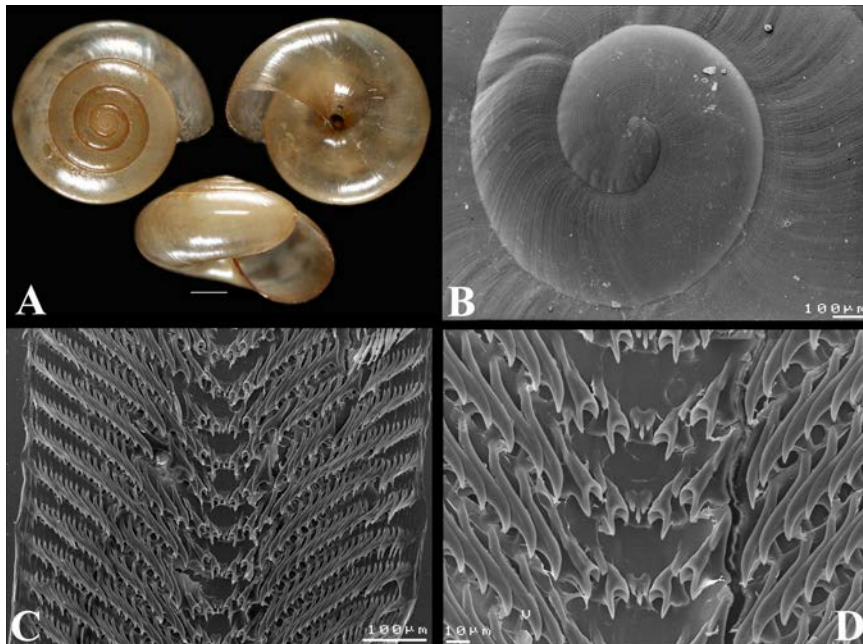


FIGURE 8. *Oxychilus melanoides* n.sp. A, shell. B, Detail of the spire (SEM). C, radula (SEM), showing the rows of teeth; D, radula (SEM), showing the central, the two lateral and the first marginal teeth. A, C-D: holotype (NHMUK 20170005); B, Sta 3, 02-11-1974. Scale bar = 1 mm, except where stated otherwise.

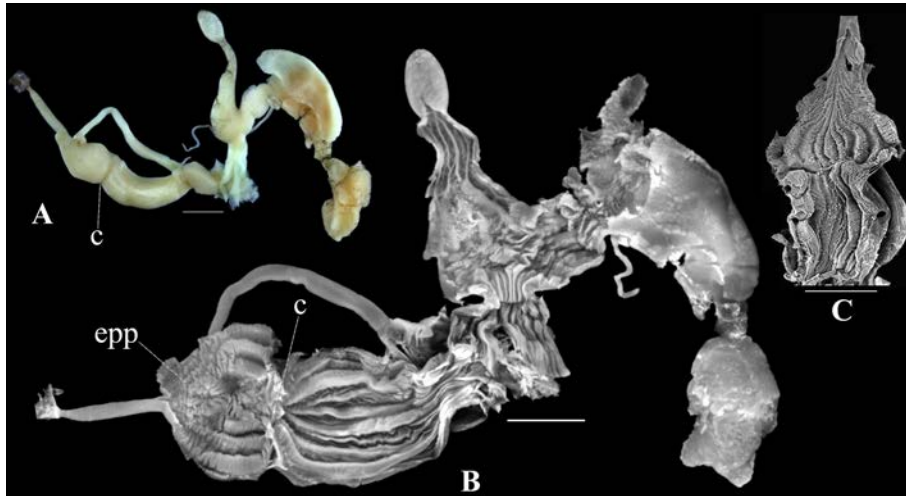


FIGURE 9. *Oxychilus melanoides* n.sp. **A**, reproductive system; **B**, internal morphology of reproductive system (“almost SEM”); **C**, internal morphology of the penis (SEM). **A-B**, holotype (NHMUK 20170005); **C**, Sta 1c, 30-03-1996. c, penial constriction; epp, epiphalic pore. Scale bar = 1 mm.

Habitat. *Oxychilus melanoides* n.sp., although not common, is well spread in forested areas, with undergrowth of *Hedychium gardneranum*, and under *Tradescantia* patches.

Distribution. The new species is restricted to the Pico Alto Complex, on the island of Santa Maria.

Oxychilus micromphalus n.sp.
Figures 2G, 10A-C, 11A-D, 12A-C

Oxychilus sp. c, Martins 2011, Table 1.

Material. Holotype (Figures 2G, 10A-B, 11A, C-D, 12A-B): Sta 1b, July 1992, Natural History Museum, London (NHMUK 20170007) (ex-DB/UAç-MT 1963a). Paratypes: Sta 1b, 12-06-1990, Natural History Museum, London (1 specimen NHMUK 20170008) (ex-DB/UAç-MT 1971); Department of Biology, University of the Azores, Portugal: Sta 1a: 01-11-1974 (DB/UA-MT 1974); Sta 1b: 12-06-1986 (DB/UAç-MT 1973), 12-06-1990

(DB/UAç-MT 1971), July 1992 (DB/UAç-MT 1963), 21-10-1993 (DB/UAç-MT 1979), 24-06-1994 (DB/UAç-MT 1967), 16-06-2011 (DB/UAç-MT 1964); Sta 1c: 30-03-1996 (DB/UAç-MT 1965); Sta 1d: 13-06-1986 (DB/UAç-MT 1972); Sta 1e: 29-03-1996 (DB/UAç-MT 1966). Other specimens (see Table 1) Sta 11: 23-06-1994 (DB/UAç-MT 1968).

Type locality. Pico Alto, Santa Maria, Açores (Figure 1 and Table 1, Sta 1).

Etymology. Named after the very small umbilicus.

Description. *Animal* (Figures 2G). Neck smooth, bluish-gray, lined by the shallow groove that runs from the pneumostome to the lower tentacles, posterior tentacles and anterior tentacles dark-gray; black rim around the foot a dashed line only on the posterior half. Border of the mantle black. Mantle light-brown; white to yellowish patches dispersed across the mantle covering the visceral mass.

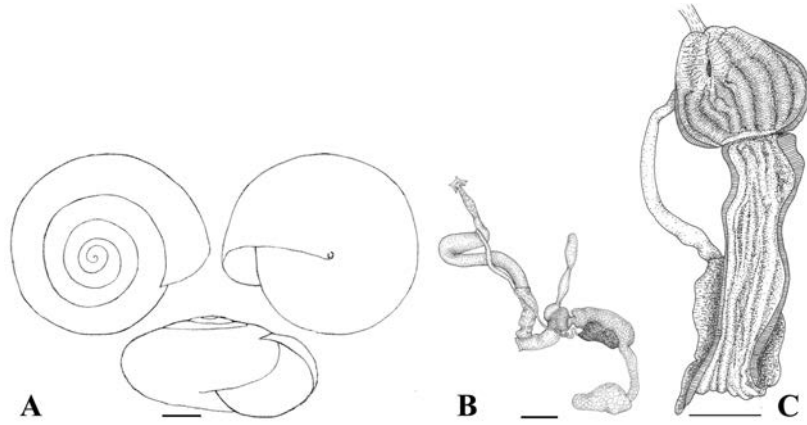


FIGURE 10. *Oxychilus micromphalus* n.sp. **A**, shell; **B**, reproductive system; **C**, internal morphology of the penis. **A-B**, holotype, Sta 1b (NHMUK 20170007); **C**, paratype, Sta 1b (DB/UAÇ-MT 1971). Scale bar = 1 mm.

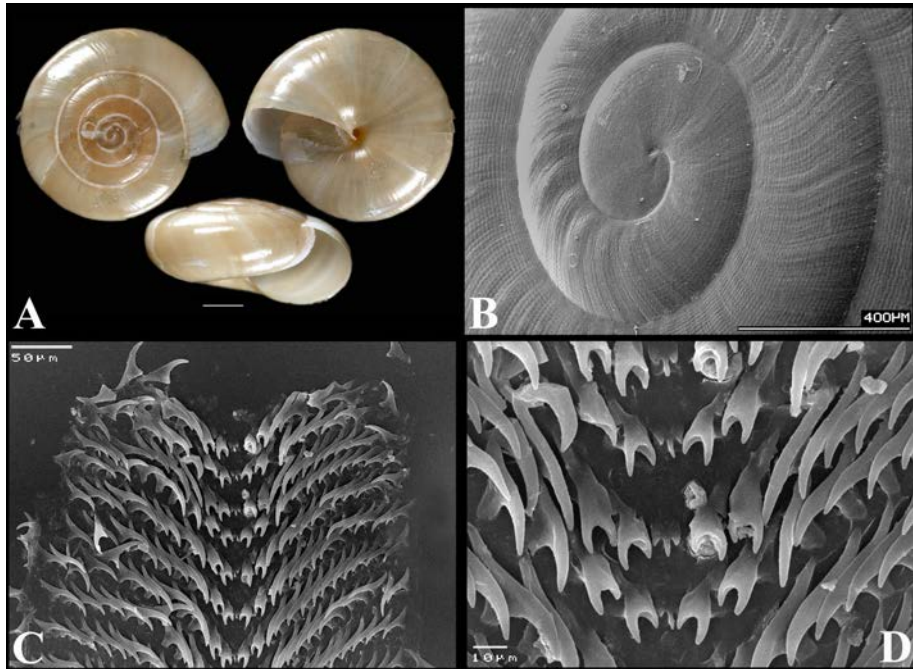


FIGURE 11. *Oxychilus micromphalus* n.sp. **A**, shell; **B**, Detail of the spire (SEM). **C**, radula (SEM), showing the rows of teeth; **D**, radula (SEM), showing the central, the two lateral and the first marginal teeth. **A**, **C-D**: holotype, Sta 1b (NHMUK 20170007); **B**, paratype, Sta 1b (DB/UAÇ-MT 1963). Scale bar = 1 mm, except where stated otherwise.

Shell (Figures 10A, 11A-B). Holotype 5.3 mm in diameter and 2.7 mm in height, thin, opaque to translucent, glossy, uniformly golden to straw-color; spire very low, with 5.1 flattened whorls, covered with fine spiral cords transversely crossed by fine growth lines, last whorl contracted. Aperture oblique, columellar lip yellowish, reflected over the umbilical aperture; umbilicus 0.21 mm in diameter. Protoconch readily distinguishable, 1.1 whorls, ornate with fine spiral cords.

Radula (Figure 11C-D) (12+2+1+2+12)×60. Central tooth shorter and narrower than laterals, tricuspid; mesocone short but surpassing the base line, about twice the length of the ectocones; base quadrate, base line slightly emarginated. First lateral tooth about twice longer than the central, tricuspid, endocone about half the total length of the tooth and merging medially into a basal tooth, receding laterally along with the base, with which it forms a pointed endocone almost as long as mesocone, ectocone well marked, located far back in the crown; second lateral tooth twice the size of the first; marginal teeth falciform, retaining only the mesocone which is long, curved and pointed; first marginal teeth about as

long as the second lateral, decreasing in size towards the outer edge of the row.

Reproductive system (Figures 10B-C; 12A-C). Basic layout as in *Oxychilus andreii* n.sp. Bursa duct one half the size of penis, wider at base, ending in an elongated, narrow and weakly demarcated bursa; perivaginal gland whitish, covering the confluence of bursa duct, oviduct and proximal vagina; internal walls of the proximal oviduct strongly folded. Penis long, narrow and muscular; short, terminal caecum to which a thick penial retractor muscle attaches; mid-portion short, globular, constriction not denounced but well marked inside; internally, the caecum and the mid-portion form a continuous chamber lined with 4 to 5 strong folds; epiphalic pore small, roundish, lips weakly grooved; folds of the distal portion not convoluted or transversely grooved. Penial retractor muscle attaches to the middle of the floor of the lung.

Habitat. *Oxychilus micromphalus* n.sp. was found alive only at the border of the path descending from Pico Alto toward Alto do Nascente. It was found living among the *Selaginella*.

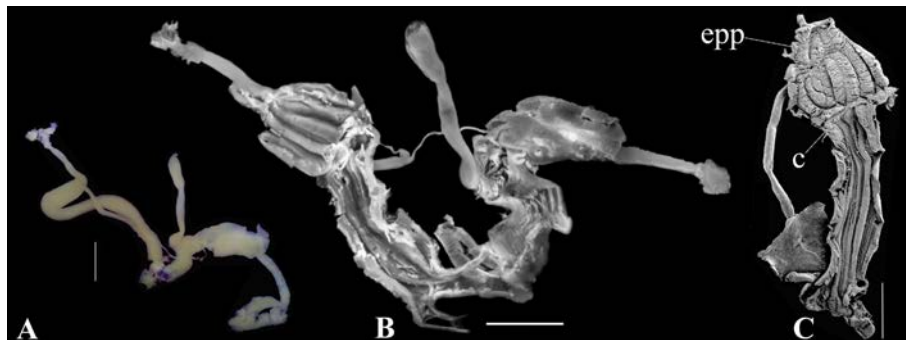


FIGURE 12. *Oxychilus micromphalus* n.sp. A, reproductive system; B, internal morphology of reproductive system ("almost SEM"); C, internal morphology of the penis (SEM). A-B, holotype Sta 1b (NHMUK 20170007); C, paratype Sta 1b (DB/UAç-MT 1971). c, penial constriction; epp, epiphalic pore. Scale bar = 1 mm.

Distribution. Although two specimens were found near Pico das Cavacas (Sta 11), the new species appears to be concentrated at Pico Alto (Sta 1b), on the island of Santa Maria. It is extremely rare.

REMARKS

Morelet (1860), in his seminal work on the Azorean terrestrial malacological fauna, mentioned 7 species as island endemics from Santa Maria, of which 2 were fossil. None of the oxychilids were considered island endemics but, from his remarks on the endemic species shared with other islands, it is possible to derive his recognition of the typical island variation associated with Santa Maria. It was only a century later that, due to Riedel's (1964) anatomical work on a collection from the Lund University Expedition seven years prior, the variety of the Azorean oxychilids started to be appreciated. Backhuys (1975: 150), who compiled the history of the research on the Azorean malacofauna, totally relied on Riedel's work for the oxychilids, relegating for future work any further details on the matter. As mentioned earlier, most work on the oxychilids was focused on the non-umbilicated species and only one umbilicated species from Santa Maria, *Oxychilus lineolatus* Martins & Ripken, 1991, was described. However, a great wealth of taxonomic novelty still remains to be dealt with in this area (Martins, 2011).

Oxychilus andrei n.sp., on account of its size, could be compared with the large *Oxychilus miguelinus* (Pfeiffer, 1856), endemic to São Miguel; however, the absence of the dark rim around the foot, the large umbilicus and the brick-red colored perivaginal gland of the latter set it apart (Martins, 1989; Martins & Ripken, 1991). The detail of the rim coloration around the foot, shared by the three new species, is also present in *Oxychilus (Atlantoxychilus)*

spectabilis (Milne-Edwards, 1885) and *Oxychilus (Atlantoxychilus) agostinhoi* Martins, 1981 – both from Santa Maria and both non-umbilicated – (Martins *et al.*, 2013) and, outside the island, only on a black-footed new species of *Drouetia* from Flores island (Martins, 2011). It appears, then, to be a peculiarity of the Santa Marian oxychilids, the meaning of which is not, by the moment, ascertained.

Were it not for the umbilicated shell, *Oxychilus melanoides* n.sp. could easily be mistaken with the sympatric, non-umbilicated *Oxychilus (Drouetia) brincki* (Figure 2H); however, the lack of the colored rim around the foot on the latter clearly sets them apart and their anatomies are completely different (Martins *et al.*, 2013). Two umbilicated species from Faial – *Oxychilus ornatus* Riedel, 1964 and *Oxychilus juvenostriatus* Riedel, 1964 – exhibit the patchy coloration on the visceral mass as seen in *O. melanoides*; they lack, however, the rim around the foot and their perivaginal gland is brick-red, in a clear association with *O. miguelinus* (Riedel, 1964; personal observation).

The rare and elusive *Oxychilus micromphalus* n.sp. has a peculiar coloration among the Azorean oxychilids. It is probably the rarest described molluscan species from the Azores and its conservation status should be considered critical.

The description of these three new species confirm Santa Maria as a hotspot of diversity within the Azorean archipelago. As seen above – and in accordance with a pattern observed, for example, with *Drouetia* (Martins 2005, Martins *et al.*, 2013) –, these species apparently do not have close relatives on the other islands, thus precluding Santa Maria, the oldest island, as the immediate origin of the remaining Azorean malacofauna.

Besides its rich living malacofauna, Santa Maria possesses an important fossil record, which Morelet (1860) started to explore; the presence, in the material he

then collected, of a specimen of one of the species herein described – *Oxychilus andrei* n.sp. (Figure 6) – confirms the importance of the natural legacy of that island. These findings constitute, then, a challenging invitation to continue the systematic research on the Azorean malacofauna.

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LITERATURE CITED

- AUDIBERT, C., M. PROST & A.M.F. MARTINS, 2013. Les types des Mollusques des Açores décrits par Morelet et Drouët, naturalistes-voyageurs. *Folia conchylologica*, 20: 5-20.
- BACKHUYS, W., 1975. *Zoogeography and Taxonomy of the Land and Freshwater Molluscs of the Azores*, XII + 350 pp., XXXII pls. Backhuys & Meesters, Amsterdam.
- CAMERON, R.A.D, B.M. POKRYSZKO & A.M.F. MARTINS, 2012. Land snail faunas on Santa Maria (Azores): local diversity in an old, isolated and disturbed island. *Journal of Molluscan Studies*, 78: 268–274.
- CUNHA, R., P. RODRIGUES & A.F. MARTINS, 2010. List of Molluscs. In: BORGES, P.A.V., A COSTA, R. CUNHA, R. GABRIEL, V. GONÇALVES, A.F. MARTINS, I. MELO, M. PARENTE, P. RAPOSEIRO, P. RODRIGUES, R.S. SANTOS, L. SILVA, P. VIEIRA & V. VIEIRA (Eds.), *A list of the terrestrial and marine biota from the Azores*, chapter X pp. 165–177. Principia, Cascais.
- DROUËT, H., 1861. *Éléments de la Faune Açoréenne*, 245 pp. J.-B. Baillière, Paris.
- FÉRAUD, G., H.U. SCHMINCKE, J. LIETZ, J. GOSTAUD, G. PRITCHARD & U. BLEIL, 1984. New K/Ar ages, chemical analyses and magnetic data of rocks from the islands of Santa Maria (Azores), Porto Santo and Madeira (Madeira Archipelago) and Gran Canaria (Canary Islands). *Arquipélago. Life and Marine Sciences*, 5: 213–140.
- HARRIS, J.D., A.F. FERREIRA & A.M.F. MARTINS, 2013. Implications from high levels of mitochondrial DNA diversity within the Azorean oxychilid land snails of the subgenus *Drouetia* (Gude, 1911) from São Miguel island. *Journal of Molluscan Studies*, 79: 177–182.
- MARTINS, A.M. de F., 1981. *Oxychilus (Drouetia) agostinhoi* new species (Stylommatophora: Zonitidae) from the Azores Islands, its anatomy and phylogenetic relationships. *Occasional Papers on Mollusks*, 4: 245–264.
- MARTINS, A.M. de F., 1989. Espécies novas do género *Oxychilus* (Gastropoda: Zonitidae) na Ilha Terceira. *Açoreana*, 7: 55–71.
- MARTINS, A.M. de F., 1991. Comparative anatomy of populations of *Oxychilus (Drouetia) atlanticus* (Morelet & Drouët, 1857) (Pulmonata: Zonitidae) from São Miguel Island, Azores. *Proceedings of the X International Malacological Congress, Tübingen, RFA, 1989*, 2: 571–575.
- MARTINS, A.M. de F., 1999. Evolution and distribution of the terrestrial molluscs of the Açores. *Bulletin of the Malacological Society of London*, 33: 5–6.
- MARTINS, A.M. de F., 2002. *Moreletina*, a new genus of Hygromiidae (Pulmonata: Stylommatophora) from Santa Maria, Açores. *Journal of Molluscan Studies*, 68: 205–215.
- MARTINS, A.M. de F., 2005. The shaping of a species: the Azorian *Drouetia* Gude (Pulmonata: Zonitidae: *Oxychilus*) as a model. *Records of the Western Australian Museum*, Supplement No. 68: 143–157.
- MARTINS, A.M. de F., 2011. When the Galápagos “finches” are Azorean snails. *Açoreana*, Suplemento 7: 209–228.
- MARTINS, A.M.F., C.P. BRITO & T. BACKELJAU, 2013. *Oxychilus (Drouetia) viridescens* (Gastropoda: Pulmonata), a new zonitid species from Santa Maria, Açores, and a review of the subgenus. *Zootaxa*, 3619(3): 343–368.
- MARTINS, A.M. de F., T. BACKELJAU, R.M.T. CUNHA & C.P. BRITO, 1991. Moluscos terrestres da ilha de Santa Maria. Lista

- preliminar. *Expedição Científica Santa Maria e Formigas/90. Relatórios e Comunicações do Departamento de Biologia*, 19: 53–59.
- MARTINS, A.M. de F., & T.E.J. RIPKEN, 1991. *Oxychilus (Ortizius) lineolatus* n.sp. (Gastropoda: Zonitidae) from Santa Maria Island, Azores. *Basteria*, 55: 45–53.
- MORELET, A., 1860. *Notice sur l'histoire naturelle des Açores suivie d'une description des mollusques terrestres de cet archipel*, 216 pp., 5 pls. J.-B. Baillièrre, Paris.
- MORELET, A., & H. DROUËT, 1857. Conchologiae Azoricae prodromus novarum specierum diagnoses sistens. *Journal de Conchyliologie*, 6: 148–153.
- RIEDEL, A., 1964. Zonitidae (Gastropoda) der Azoren. *Boletim do Museu Municipal do Funchal*, 18: 5–60.
- SERRALHEIRO, A., & J. MADEIRA, 1993. Stratigraphy and geochronology of Santa Maria Island (Azores). *Açoreana*, 7: 575–592.

