

A NEW SPECIES OF THE GENUS *DIODORA* GRAY, 1821 (GASTROPODA, FISSURELLIDAE) FROM THE CABO VERDE ISLANDS

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Abstract A new species is described, *Diodora terezae*, from off Boavista Island (Cabo Verde Archipelago) collected during the CCLME–FAO ecosystemic survey CAPVERT-1106 at a depth of 92–98m. This new species is characterised by the presence of 70 flattened primary axial ribs, absence of secondary riblets in the interspaces, and numerous, evenly spaced, undulated concentric cords. The main differences between *Diodora terezae* n. sp., and those species previously reported from the Cabo Verde Islands or elsewhere are discussed. A table summarising the main morphological features, geographical distribution, depth range, and main references for all the species discussed in this paper is also provided.

Key words Gastropoda, Fissurellidae, *Diodora*, new species, Cabo Verde Islands, Northwest Africa

INTRODUCTION

The status of the genus *Diodora* Gray, 1821 in the Cabo Verde Islands is unclear, and there is much debate on the total number of species reported from this area. Salvat (1967) and Christiaens (1982) reported *Diodora candida* (Sowerby, 1833), *Diodora gibberula* (Lamarck, 1822), *Diodora graeca* (Linnaeus, 1758) — as *Diodora reticulata* (Récluz, 1843) — *Diodora menkeana* (Dunker, 1846), and *Diodora philippiana* (Dunker, 1846) in the Cabo Verde Islands. Later, Rolán (2005) reported *Diodora dorsata* (Monterosato, 1878) for the first time in Cabo Verde Islands and considered the presence of *D. mankeana* doubtful; in addition, one species was identified only to the generic level. After Rolán (2005), seven *Diodora* species have been identified in the Cabo Verde Islands. However, recently, Cunha *et al.* (2017) performed a molecular study of the genera *Diodora* and *Fissurella* from almost the entire Cabo Verde Archipelago, that focused on species distribution patterns and connectivity, and found only *D. philippiana* in Boavista, which was considered endemic.

In recent years, the number of *Diodora* species known from West Africa has increased with the description of two new species: *Diodora canariensis* Verstraeten & Nolf, 2007 from the Canary Islands and *Diodora sculptilis* Rolán & Gori, 2011

from São Tomé Island. With the description of this new species, we elevate the number of *Diodora* species recently discovered in the area to three.

This study was developed in the framework of the Canary Current Large Marine Ecosystem (CCLME) project and Ecosystem Approach to Fisheries (EAF-Nansen Program) of the FAO, in partnership with the West African Regional Fisheries Project (WARFP-CV), Direção Geral das Pescas (DGP) of Cabo Verde Islands, Norwegian Institute of Marine Research (IMR), Spanish Institute of Oceanography (IEO), and the University of Vigo.

MATERIALS AND METHODS

The material studied here was obtained during the CCLME ecosystemic survey conducted in Cabo Verde Islands in June 2011 on board the Norwegian R/V *Dr Fridtjof Nansen*. During the survey, 25 stations were sampled at depths between 30 and 960m with a commercial bottom trawl (*Gisund* type) (Krakstad *et al.*, 2011). The invertebrates collected in each haul were sorted on board to morpho-species level, counted, and weighed; the gastropods were fixed and preserved in 70% ethanol for further research.

The only collected specimen of *Diodora* was identified at the Laboratory of Marine Zoology of the University of Vigo. The shell morphology was studied with a motorised Nikon SMZ25

stereomicroscope equipped with Nikon DS-Fi2 digital camera. The photographs were obtained using the NIS-Elements Microscope Imaging Software.

The holotype of *Diodora terezae* n. sp., has been deposited in the Museo Nacional de Ciencias Naturales (MNCN) of Madrid.

SYSTEMATIC

Family Fissurellidae Fleming, 1822

Subfamily Diodorinae Odhner, 1932

Genus *Diodora* Gray, 1821

Diodora terezae new species
(Figs 1–3)

Zoobank number urn:lsid:zoobank.org:act:F03A974A-C5BF-467D-A23F 39AE73718F98

Holotype One mature female; Off the northwest coast of Boavista Island, Cabo Verde Archipelago, Stn. CV25 (16°11'14"N–23°03'37"W), 92–98m depth, 13 vi 2011, MNCN15.05/200022

Measurements Length 21.95mm; width 13.10mm; height 6.17mm.

Type locality Off the northwest coast of Boavista Island, Cabo Verde Archipelago.

Description of holotype Shell limpet-shaped, solid, moderately large, conical, profile gently elevated, anterior and posterior slopes almost straight, with the anterior one more steeply inclined. Base oblong, slightly narrower anteriorly, elongated antero-posteriorly and slightly raised at the center. Anal aperture located in the anterior half at 9.07mm and 13.45mm from anterior and posterior shell margins, respectively (distance from anterior margin 67% of the distance from posterior margin). The aperture is elongated, 2.76mm long, rounded in both extremes, a little wider in the middle, and tilted towards the anterior margin. Radial sculpture integrated by about 70 depressed axial ribs, wider and uniform in size in the lateral areas of the shell, but subequal and slightly alternating in size in the anterior and posterior areas. No secondary axial riblets present. Intervals much narrower than rib width. Fine concentric cords, ranging from about

30 in the lateral areas to about 50 in the posterior area, cross the axial ribs and perform very regular axial undulations throughout the entire shell surface, giving a squamous appearance. The edge of the shell is crenulated where the ribs meet. Outer shell surface greenish (pale-cream when preserved) with four brown bands (one anterior, one posterior, and two laterals) radiating from the apex; inner background white with the apical area and ventral edge grey.

Etymology This species is named in memory of Tereza Gertrudes de Sousa, the first author's beloved grandmother, who passed away in January 2017.

Distribution Only known from the type locality.

Habitat This species was collected on hard substrate with high abundance of the echinoid *Centrostephanus longispinus* (Philippi, 1845) together with a suspension feeder community dominated by acorn barnacles, antipatharians, alcyonarians and sponges. In addition, the abundance of *C. longispinus* and a rich community of suspension feeding invertebrates was linked to the existence of bottom currents in the area (Rowe, 1971; Templado & Moreno, 1996; Ramos *et al.*, 2017). The known depth range for this species is 92–98m.

DISCUSSION

Diodora terezae n. sp. is characterised by its numerous depressed axial ribs and undulated concentric cords crossing the ribs, resulting in a very regular sculpture. These features make it to easily distinguishable from all seven *Diodora* species reported from the Cabo Verde Islands and also from other related species within this genus. In the table 1 we summarise the main morphological features, geographical distribution, depth range, and main references for all the species discussed in this paper. *Diodora graeca* has only 18–20 radial ribs and the number of radial ribs ranges from ca. 40 in *D. candida*, *D. dorsata*, and *D. philippiana* to 52 in *D. gibberula*. In addition, *D. dorsata*, *D. gibberula*, *D. graeca*, and *D. philippiana* have secondary riblets. In *D. candida*, the concentric cords are numerous but without elevations in the intersections with the radial ribs. *Diodora mankeana* has numerous axial ribs, but the

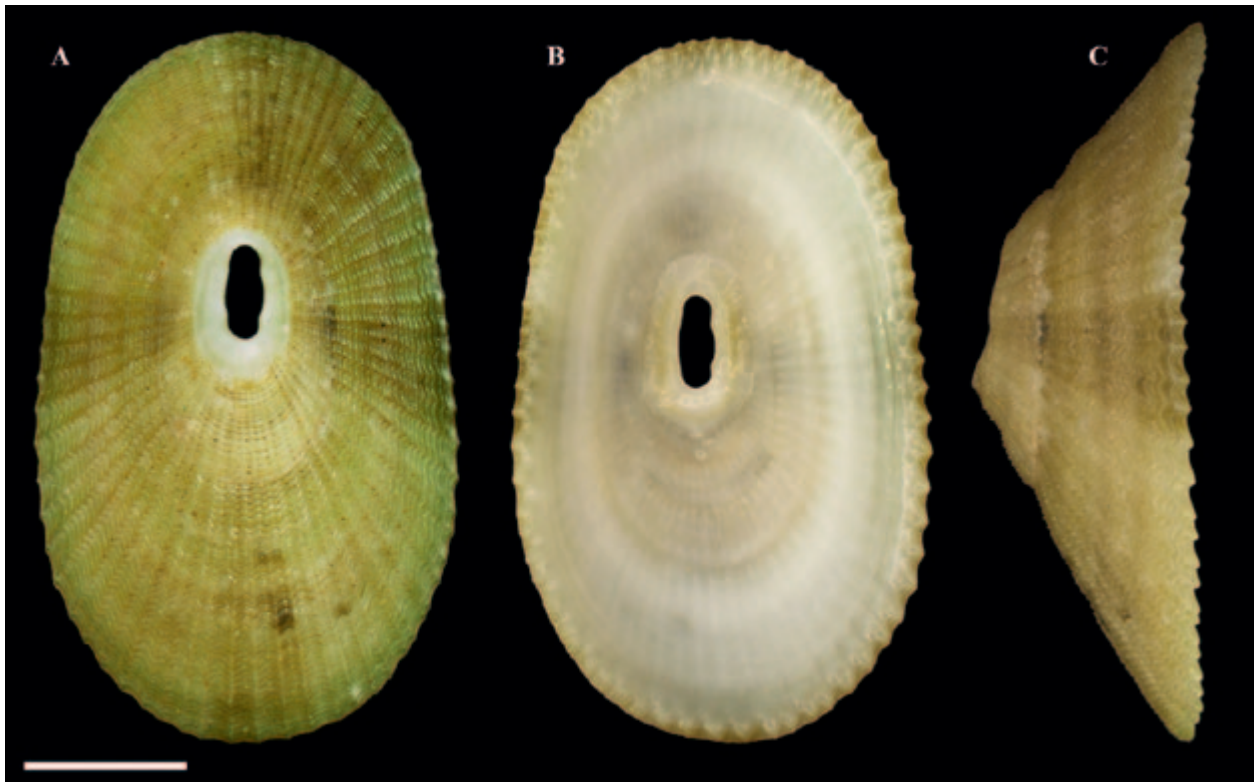


Figure 1 *Diodora terezae* n. sp. holotype. A, External view; B, Inner view; C, Profile view. Scale bar=5mm.

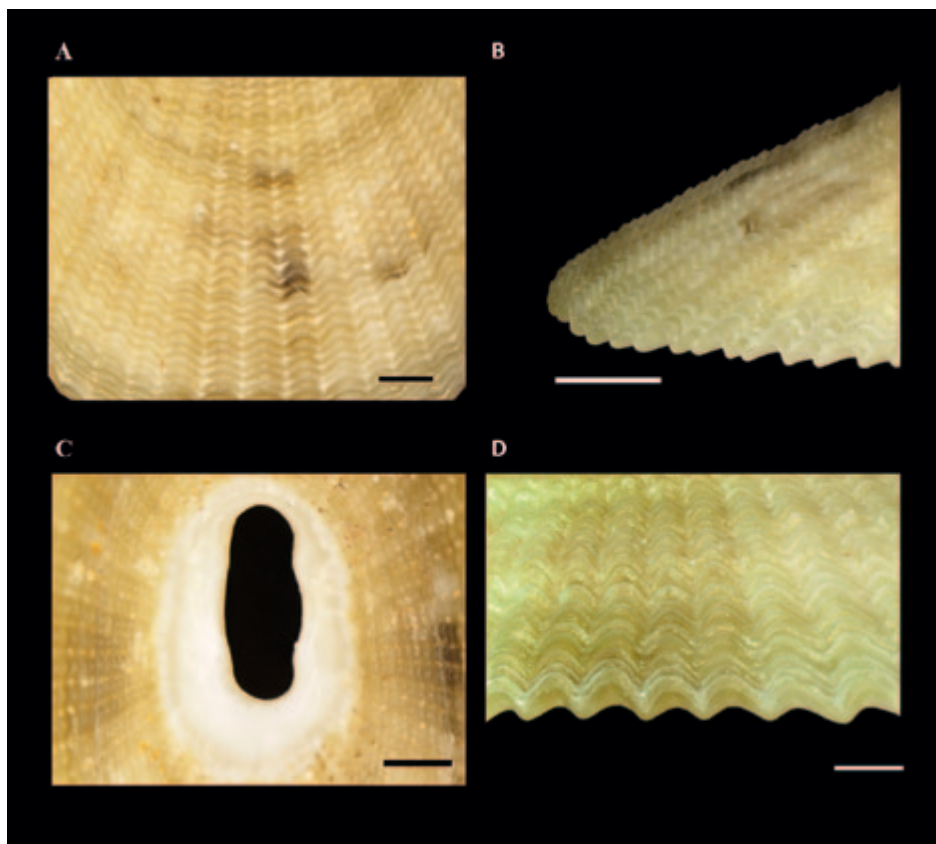


Figure 2 *Diodora terezae* n. sp. holotype. A, Sculpture of the posterior part of the shell; B, Profile view of the sculpture of the posterior part of the shell showing disposition of the concentric cords; C, Anal aperture; D, Sculpture of the lateral part of the shell. Scale bar=1mm.

Table 1 Summary of characters of *Diodora* species that occur in Cabo Verde Islands and of other related species

| | <i>D. dorsata</i> | <i>D. gibberula</i> | <i>D. graeca</i> |
|--------------------|--|--|--|
| Measurements | Length up to 14.5mm, usually smaller than 10 mm | Length up to 20 mm | Length up to 25 mm |
| Profile | Elevated, peristome not adherent to the plane | Elevated, peristome not adherent to the plane | Elevated, peristome not adherent to the plane |
| Anal pore shape | Variable | Variable | Elongated |
| Sculpture | 42 axial ribs. Overall sculpture as that of <i>D. gibberula</i> | 46–52 ribs; 0 to 3 secondary riblets. Concentric cords forming nodules at the intersection with the ribs | 18–20 radial ribs; 3 secondary riblets. Concentric cords forming a regular reticulation with intersected ribs |
| Color | Light grey with greenish radial bands, or red alternating with white or green | White-yellow with dark radial bands | Grey with darker to greenish radial bands |
| Distribution range | Mediterranean Sea and Cabo Verde Islands | Mediterranean Sea, European Atlantic, West Africa, Canary Islands, Madeira and Cabo Verde Islands | Mediterranean Sea, European Atlantic, Northwest Africa, Canary Islands and Cabo Verde Islands |
| Depth range | Common below 20–30m in Cabo Verde Islands | Found in Cabo Verde Islands from 0–28 to 40 m | Low intertidal to 250 m |
| Main references | Rolán (2005); Aissaoui <i>et al.</i> (2017) | Salvat (1967); Poppe & Goto (1991); Rolán (2005); Aissaoui <i>et al.</i> (2017) | Poppe & Goto (1991); Hayward & Ryland (1995); Aissaoui <i>et al.</i> (2017) |
| | <i>D. candida</i> | <i>D. mankeana</i> | <i>D. philippiana</i> |
| Measurements | Length up to 11 mm | Usually smaller than 7mm in length | Length up to 32mm, usually less than 20 mm |
| Profile | ? | Elevated, peristome not adherent to the plane | Elevated, peristome not adherent to the plane |
| Anal pore shape | Sub-circular, wider in the middle | Elongated | Elongated, wider in the middle ? |
| Sculpture | About 40 radial ribs. Numerous concentric cords, without elevation in the intersection | Numerous ribs and no prominent concentric cords | About 40 ribs with secondary riblets. Concentric cords forming prominent nodules at the intersection with the radial ribs |
| Color | White | Usually cream or white | 36 elevated radial ribs with smaller intercalated ribs. Concentric cords hardly visible. Squamous elevation in the intersection with the ribs With pink hues or olive-green |

| | <i>D. candida</i> | <i>D. mankeana</i> | <i>D. philippiana</i> | <i>Diodora</i> sp |
|--------------------|---|--|--|--|
| Distribution range | Cabo Verde Islands | Mauritania to Angola, Canary Islands, São Tomé and (?)Cabo Verde Islands | Cabo Verde Islands and São Tomé and Príncipe | Cabo Verde Islands |
| Depth range | ? | Found in Cabo Verde from 25–30 to 50–65m | Shallow water to 10 m | 30 m |
| Main references | Christiaens (1982); Rolán (2005) | Dunker (1845,1846); Nicklès (1950); Salvat (1967) | Dunker (1845;1846); Rolán (2005) | Rolán (2005) |
| <hr/> | | | | |
| | <i>D. demartiniorium</i> | <i>D. giannispadai</i> | <i>D. italica</i> | <i>Diodora terezae</i> n. sp. |
| Measurements | Length 35mm, width 21mm, height 7.5mm (average) | Length 45.5mm, width 21.5mm, height 13.5mm (average) | Length 39mm, width 21.5mm, height 8mm (average) | Length 21.95mm, width 13.1mm, height 6.17 mm |
| Profile | Low, peristome adherent to the plane | Low, peristome adherent to the plane | Elevated, peristome convex | Relatively elevated, peristome slightly convex |
| Anal pore shape | Rounded-elongated, angled in the central area | Elongated, broad | Oval | Elongated, a little wider in the middle |
| Sculpture | 75–78 primary radial ribs; 2 secondary riblets. Concentric cords fine and evenly spaced | 70 unequal primary radial ribs; 3 secondary riblets. Concentric cords coarse and unevenly spaced | 28–36 unequal primary radial ribs; 1 to 3 secondary riblets. Concentric cords coarse and unevenly spaced | 70 primary axial ribs; no secondary axial riblets. Concentric cords numerous, evenly spaced, and undulated |
| Color | Dark grey with greenish radial bands | Cream with darker, greenish to brownish radial bands | Cream with darker radial bands | Greenish (pale-cream when preserved) with 4 brown radial bands |
| Distribution range | Gulf of Gabes (Tunisia), Mediterranean Sea | Limnos Island (Greece), Aegean Sea | Throughout the Mediterranean Sea | Off the northwest coast of Boavista Island, Cabo Verde Archipelago |
| Depth range | 0–2 m | Shallow subtidal | Shallow water | 92–98 m |
| Main references | Buzzurro & Russo (2005); Aissaoui <i>et al.</i> (2017) | Aissaoui <i>et al.</i> (2017) | Poppe & Goto (1991); Aissaoui <i>et al.</i> (2017) | Present study |



Figure 3 *Diodora terezae* n. sp. holotype. Living specimen.

number has not been reported in the available literature. Nevertheless, this species has no prominent concentric cords; the shell sculpture is quite different; the anal aperture is closer to the anterior margin; and it is a small species, usually up to 7mm in length. The Cabo Verde material described as *Diodora* sp. by Rolán (2005) has only 36 radial ribs with smaller intercalated ribs, and the concentric cords are poorly developed.

The new species shows more affinities with *Diodora demartiniorum*, *Diodora giannispadai*, and *Diodora italica*; however, there are also clear differences that make them easily distinguishable. *Diodora terezae* n. sp. differs from *D. demartiniorum* in the formation of the axial ribs, which are fewer in number and without secondary riblets; the concentric cords are more numerous, becoming very regular axial undulations; the adult size is smaller and oblong, with its profile proportionally more elevated and the peristome slightly convex. *Diodora demartiniorum* is bigger, oval-shaped, the anal aperture has two sharp-angled profiles in the central area, the axial ribs form a ^-shaped sequential structure, and the peristome is flat and adherent to the plane. *Diodora giannispadai* resembles the new species by the presence of 70 unequal primary radial ribs but differs by the presence of three secondary riblets per interspace and a coarse and unevenly spaced concentric sculpture. In addition, adults reach a considerably larger size, up to 45.5mm; the anal aperture is wider and not enlarged in the

middle; its profile is low; and the peristome is adherent to the plane. *Diodora italica* can be distinguished from *Diodora terezae* n. sp. mainly by having fewer primary axial ribs (28–36), presence of secondary riblets, and the irregular shape of the concentric cords, which become increasingly rough and wavy. Moreover, *D. italica* adults are larger, markedly narrower towards the anterior part, have a more convex peristome, and the anal aperture is wider and not enlarged in the middle.

Despite Salvat (1967), Christiaens (1982) and Rolán (2005) having reported seven species of *Diodora* from the Cabo Verde Archipelago, recently, Cunha *et al.* (2017), in a molecular study of the genera *Diodora* and *Fissurella* from Cabo Verde only found *D. philippiana* at Boavista Island. Based on their study and considering the degree of plasticity exhibited by gastropod shells, Cunha *et al.* (2017) assumed that *D. philippiana* could be the only species of this genus present in the archipelago with its distribution restricted to Boavista Island. However, this scenario seems to be unlikely because several *Diodora* species have been reported from different islands and while the accurate identification at specific level may be difficult due to the already mentioned plasticity of the shells, the presence of representatives of this genus in other Cabo Verde Islands cannot be ignored. Thus, *Diodora candida* was collected from Sal (Christiaens, 1982; Rolán, 2005), *D. graeca* from Santiago (Salvat, 1967) and other islands (Rolán, 2005); *D. gibberula* from Sal, Boavista, Santiago, Fogo and Brava (Salvat, 1967; Christiaens, 1982; Rolán, 2005) and *D. philippiana* along the entire archipelago (Rolán 2005). Moreover, Rolán (2005) reported *D. dorsata* for the first time in Cabo Verde. All these species are well known, and in our opinion, there are no objective reasons to consider all these records as being erroneous.

Cunha *et al.* (2017) didn't specify the sampling sites nor the sampling depth, but the most characteristic habitat for *D. philippiana* and the species of *Fissurella* identified by these authors from Cabo Verde, are the intertidal zones and adjacent shallow waters (Salvat, 1967; Rolán, 2005). The other species of *Diodora* recorded from the archipelago seems to occur in deeper waters: *Diodora gibberula* was collected from 0–28 to 40m (Salvat, 1967), *D. graeca* from 30–50 (Rolán, 2005) to 55–60m (Salvat, 1967) and *D. dorsata* is considered a common species below 20–30m (Rolán,

2005). Moreover, a *Diodora* sp. was described by Rolán (2005) from 30m depth in Maio Island and *D. menkeana* was reported from 25–30 and 50–65m by Salvat (1967) but its presence in Cabo Verde is considered doubtful by Rolán (2005).

This suggests that the sampling program carried out by Cunha *et al.* (2017) was focused mainly on shallow coastal areas, which could explain the differences observed in the number and distribution of species of *Diodora* reported from Cabo Verde Islands by previous authors and particularly by Rolán (2005).

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