

GEA, FLORA ET FAUNA

The genus *Thordisa* Bergh, 1877 (Mollusca: Gastropoda: Heterobranchia) in the Iberian Peninsula

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Abstract

The family Discodorididae (Mollusca, Gastropoda, Nudibranchia) is one of the most numerous nudibranch families in terms of species and includes well-known genera in European waters such as *Discodoris* Bergh, 1877, *Geitodoris* Bergh, 1891, *Jorunna* Bergh, 1876, *Peltodoris* Bergh, 1880, *Platydoris* Bergh, 1877 and *Taringa* Er. Marcus, 1955. This family also includes the genus *Thordisa* Bergh, 1877, with about 25 species, known to live in all seas and oceans except the polar ones. Only 4 species of *Thordisa* have been recorded in European waters: *T. filix* Pruvot-Fol, 1951, *T. azmanii* Cervera & García-Gómez, 1989, *T. pallida* Bergh, 1884 and *T. aurea* Pruvot-Fol, 1951, however the last two are Mediterranean species that have not been collected again since their original description. Here we present new anatomical and biological information and distribution data of specimens collected in the Iberian Peninsula: *Thordisa filix* collected in the NE and specimens of *T. azmanii* collected in the NW. The validity of the other two European species is also discussed.

Key words: morphology, anatomy, habitat, distribution, *Thordisa*, Iberian Peninsula.

Resum

El gènere *Thordisa* Bergh, 1877 (Mollusca, Gastropoda, Heterobranchia) a la península Ibèrica

La família Discodorididae (Mollusca, Gastropoda, Nudibranchia) és una de les famílies de nudibrànquis més nombroses quant a espècies i inclou gèneres coneguts en aigües europees com *Discodoris* Bergh, 1877, *Geitodoris* Bergh, 1891, *Jorunna* Bergh, 1876, *Peltodoris* Bergh, 1880, *Platydoris* Bergh, 1877 i *Taringa* Er. Marcus, 1955. També dins d'aquesta família es troba el gènere *Thordisa* Bergh, 1877, amb unes 25 espècies conegudes que viuen a tots els mars i oceans excepte els polars. Només s'han registrat 4 espècies de *Thordisa* en aigües europees: *T. filix* Pruvot-Fol, 1951, *T. azmanii* Cervera & García-Gómez, 1989, *T. pallida* Bergh, 1884 i *T. aurea* Pruvot-Fol, 1951, però les dues últimes són espècies mediterrànies que no s'han tornat a col·lectar des de la seva descripció. Aquí presentem nova informació anatòmica i biològica i dades de distribució d'exemplars recollits a la Península Ibèrica: *Thordisa filix* col·lectada al NE i exemplars de *T. azmanii* col·lectats al NO. També es discuteix la validesa de les altres dues espècies europees.

Paraules clau: morfologia, anatomia, hàbitat, distribució, *Thordisa*, península Ibèrica.

Introduction

The nudibranch species of the *Thordisa* Bergh, 1877 genus are within the family Discodorididae, one of the families with the largest number of species within the Doridina. Dayrat (2010) carried out a complete and extensive review of the Discodorididae family based on morphological characters, redescribing the species and analyzing the taxonomic status of each one of them. This family includes almost thirty genera, some well-known in the Atlanto-Mediterranean area

such as *Discodoris* Bergh, 1880; *Geitodoris* Bergh, 1891; *Jorunna* Bergh, 1876; *Peltodoris* Bergh, 1880; *Platydoris* Bergh, 1877 and *Taringa* Er. Marcus, 1955 among others. It should be noted that more than half of the Discodorididae genera were erected by L. R. S. Bergh (Fig. 1), a Danish doctor who in the second half of the 19th century also devoted himself intensely to zoology and especially to the study of nudibranch molluscs. Much of Bergh's numerous publications were written in German and for this reason perhaps his work was not as well known to non-specialists in the group.



Figure 1. Drawing of Ludwig Rudolph Sophus Bergh by the Danish-Norwegian artist Peder Severin Kroyer in 1894.

About 25 accepted species belonging to the genus *Thordisa* Bergh, 1877 have been described worldwide (Chan & Gosliner, 2006, 2007; MolluscaBase, 2023). They usually live in temperate and warm waters, but only four of these species have been recorded in European coasts: *T. filix* Pruvot-Fol, 1951; *T. azmanii* Cervera & García-Gómez, 1989; *T.*

pallida Bergh, 1884 and *T. aurea* Pruvot-Fol, 1951. The last two are Mediterranean species that have not been collected again since their original description.

Here we present anatomical and biological information of specimens of *Thordisa* collected in the Iberian Peninsula: *Thordisa filix* collected in the NE and specimens of *T. azmanii* collected in the NW, and we discuss the validity of the other two European species.

Results

Thordisa filix Pruvot-Fol, 1951

Studied material

In 1986, 12 individuals of this species (between 8 and 17 mm in length) were collected at La Planassa fishing ground (Blanes, NE Spain) with a commercial trawl at about 100 meters depth. Two preserved specimens of 12 and 15 mm in length are deposited in the collections of the Animal Biodiversity Resource Center (CRBA) of the University of Barcelona with the codes CRBA-9644 and CRBA-9645 respectively; another 22 mm specimen was captured at Pollensa Bay (Mallorca, Balearic Islands, Spain) with a «bou de varas» trawl at 58 meters depth during the oceanographic research expedition Fauna III (June - July 1994).

Morphology and anatomy

Thordisa filix is easily identifiable from the other species of *Thordisa* by its yellow color, the presence of well separated and unequal digitiform tubercles on the notum, and by the four tripinnate gills (Fig. 2).

The outline of the animal is oval and relatively flat (Fig. 3a). The entire back is adorned with small, well-spaced conical tubercles, with 4-5 longer ones in the center of the back,

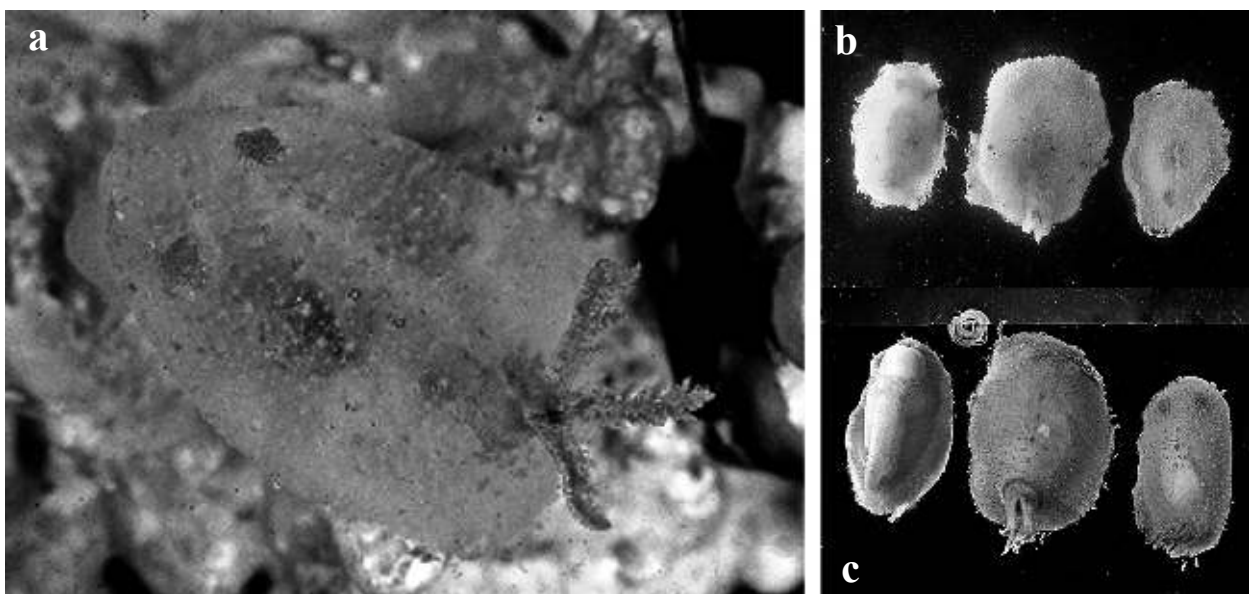


Figure 2. *Thordisa filix*. a) The living animal from Pollensa Bay with the gill and rhinophores extended (Picture by Diego Moreno/Fauna III). b) three specimens from Blanes collected by trawling. c) The same specimens preserved in alcohol, in the center there is the spiral-shaped vestibular gland of one of the specimens (Pictures B and C by Manuel Ballesteros).

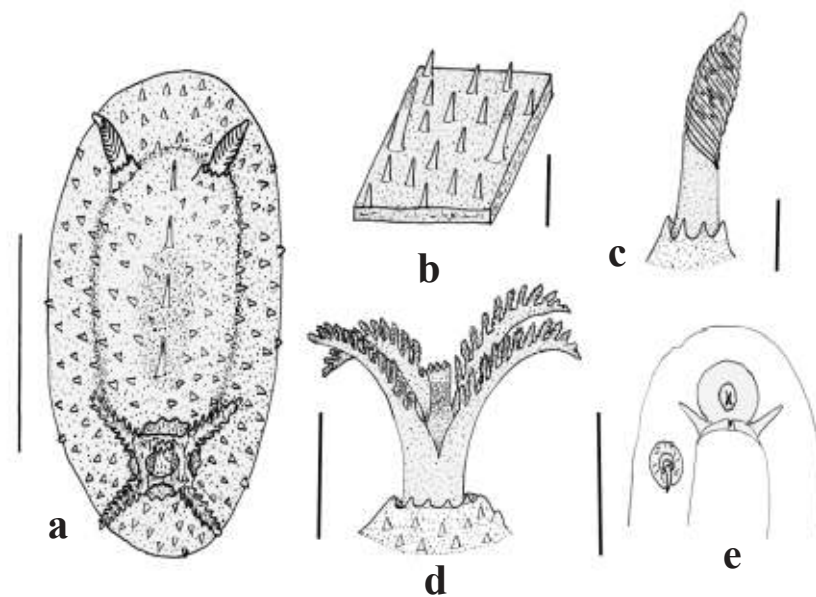


Figure 3. *Thordisa filix*. a) Drawing of the living animal, bar means 10 mm; b) detail of the dorsal tubercles, the longest ones in the middle on the back, bar means 1 mm; c) detail of the rhinophore and rhinophoral sheath, bar means 1 mm; d) structure of the gill leaves, gill sheath and anal papilla, bar means 5 mm; e) detail of the lower anterior part of the animal with the mouth and labial palps, the furrowed and cleaved anterior lip and the genital papilla, bar means 5 mm.

between the gill and the rhinophores, tipped with brown pigment (Fig. 3b). The back of the animal is very spiculous. The rhinophores have a yellowish base and the laminar part has about 20 lamellae colored light brown with white granulations, the apex is whitish; the rhinophoral sheath is somewhat elevated and with a tuberculate rim (Fig. 3c). The gill is made up of 4 narrow tripinnate leaves, of the same color as the rhinophores, that are held erect when the animal is at rest; the gill sheath is somewhat elevated and with a tuberculate upper rim. The brown anal papilla is located in the center of the branchial leaves, it is well elevated and with 6-8 lobes on the upper rim (Fig. 3d). The yellow foot is narrow and it is furrowed and cleaved anteriorly. The buccal bulb is prominent and has a pair of elongated labial palps. The genital papilla is visible on the underside of the mantle, on the right side of the body (Fig. 3e).

The general anatomy (Fig. 4a) shows a greenish blood gland, a wide esophagus that turns in a clear curve before entering the stomach, a spherical digestive caecum and a very developed vestibular gland. The buccal mass has three pairs of retractor muscles (Fig. 4b). The genital apparatus (Fig. 4c) has a characteristic vestibular gland (Fig. 4d) with the shape of duct coiled in a flat spiral that covers dorsally the genital apparatus and part of the other viscera when completely developed. Presumably, after mating the substances from the gland are transferred to the other animal and the coiled tube of the vestibular gland lose its consistence and gets the shape of an irregularly rolled tube (Pruvot-Fol, 1954). The spherical bursa copulatrix is brown and is enclosed by the prostatic gland. There is a short white ampulla and a small vaginal gland.

The radular formula of the 22 mm specimen was 45 x (10.32.0.32.10) (Fig. 5) while a 10 mm preserved specimen

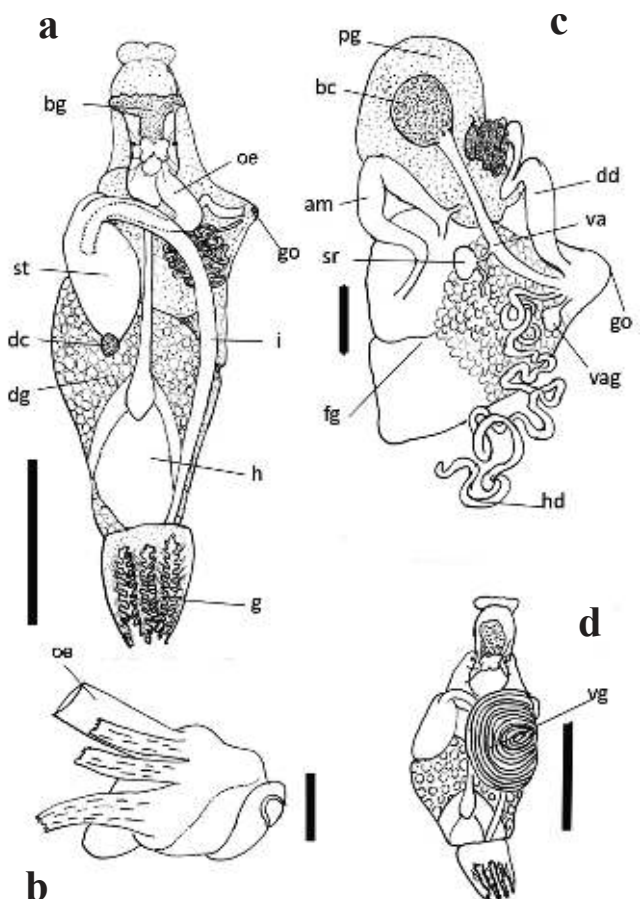


Figure 4. *Thordisa filix*. a) General view of the organs in dorsal view (vestibular spiral gland has been previously extracted), bar means 5 mm; b) buccal tube detail, with its muscles in right lateral view, bar means 3 mm; c) genital apparatus, bar means 1 mm; d) general anatomy with vestibular spiral gland, bar means 5 mm. [Abbreviations: am) ampulla; bc) bursa copulatrix; bg) blood gland; dc) digestive caecum; dd) deferent duct; dg) digestive gland; fg) female glands; go) genital orifice; h) heart; hd) hermaphroditic conduct; oe) esophagus; pg) prostate; sr) seminal receptacle; st) stomach; va) vagina; vag) vaginal gland; vg) vestibular gland].

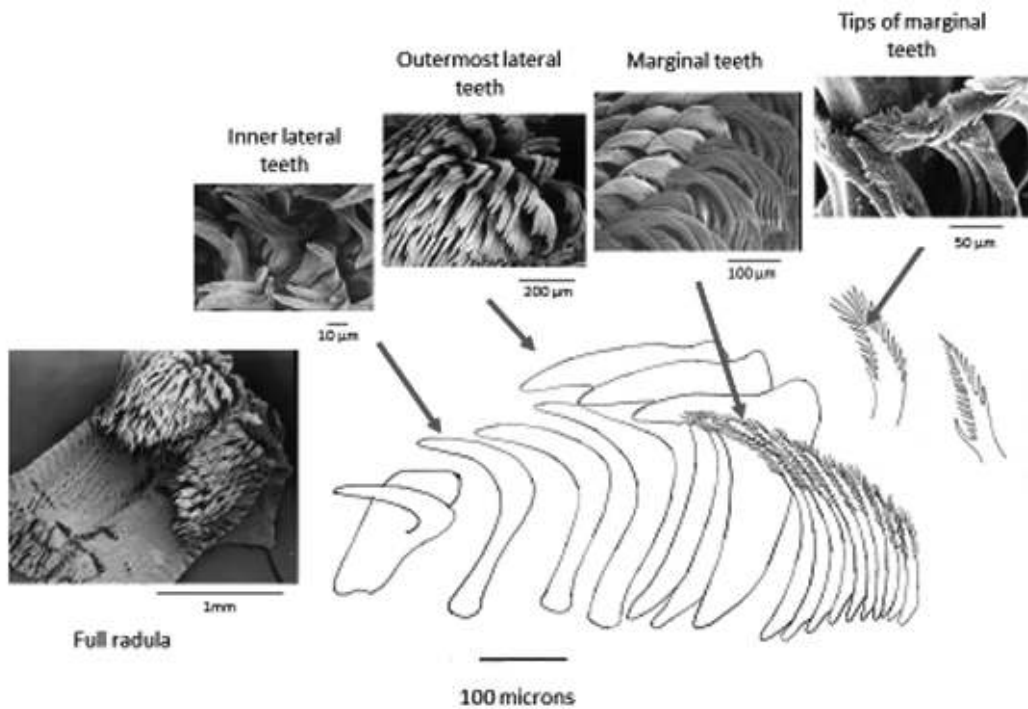


Figure 5. *Thordisa filix*. Structure of the radula.

had a radular formula of 28 x (10.30.0.30.10). The lateral teeth are hooked and clearly increase in length from the inner one to the 25th; there are 10 marginal pectinate teeth, being the 3-4 outer ones less developed. The lip cuticle is smooth, without rods.

Biology, habitat and distribution

Very little is known about the distribution and biology of *Thordisa filix*. Original description cited 40-50 mm long specimens collected in Banyuls sur Mer (France). Schmekel (1968) pointed out that the spawn is a spiral ribbon with yellow eggs

of about 120 microns. It is supposed to eat sponges, as other species of the genus (McDonald & Nybakken, 1997).

We have collected this species on maërl bottoms with seaweeds as *Osmundaria volubilis* (Linnaeus) R.E. Norris, 1991 and *Phyllophora* sp., and on muddy bottoms like La Planassa, a commercial trawling bottom off Blanes (Costa Brava, NE Spain) with an area of 70 km² and depths from 100 to 150 m with common reports of sponges (*Tethya aurantium* Pallas, 1766), cnidarians (*Eunicella cavolini* (Kock, 1887), *Adamsia palliata* (Fabricius, 1779), *Pennatula rubra* (Ellis, 1764), *Caryophyllia (Caryophyllia) smithii* Stokes & Broderip,



Figure 6. Location of *Thordisa filix* records. The numbers correspond to the locations indicated in the text.

1828), crustaceans (*Pagurus prideaux* Leach, 1815, *Calappa granulata* (Linnaeus, 1758), *Eurynome aspera* (Pennant, 1777), *Inachus phalangium*, (Fabricius, 1775)) and molluscs (*Nucula nucleus* (Linnaeus, 1758), *Venus casina* Linnaeus, 1758, *Pteria hirundo* (Linnaeus, 1758), *Anomia ephippium* Linnaeus, 1758). These data suggest that *Thordisa filix* lives from moderate to deep bottoms (Pruvot-Fol, 1951; Vicente, 1967; Schmekel, 1968) on the continental shelf.

This is an uncommon species that has been recorded mainly (Fig. 6) in the western Mediterranean basin as in Banyuls-sur-mer (1), France (Géry Parent, 1990; 1992), Gulf of Naples (2), Italy (Schmekel & Portmann, 1982), Cabo de Palos, Murcia (3), Spain (Templado *et al.*, 1988), Blanes, Barcelona (4), Spain (Ballesteros *et al.*, 2019), Algeciras Bay (5), Spain (García-Gómez, 2002), Mallorca (6), Spain (Dominguez *et al.*, 2013), San Isidoro, Nardò (7), Italy (Perrone, 1998), Bay of Piran (8), Slovenia (Lipej and Mavrič [in] Zenetos *et al.*, 2015) but there are also records in the Eastern Mediterranean basin from Greece (9) (Koukouras, 2000), Yassiada, Istanbul (10), Turkey (Yokeş, 2001), Haifa Bay (11), Israel (Barash & Danin, 1992), and also in the Atlantic Ocean, along the coasts of Arrábida (12), Portugal (Calado *et al.*, 1999) and Sagres, Algarve (13), Portugal (García-Gómez *et al.*, 1991), which would be the only ones outside the Mediterranean Sea. In the

Catalan coast it is a relatively common species in commercial fishing grounds.

***Thordisa azmanii* Cervera & García-Gómez, 1989**

Studied material

In April 1988, one living specimen of *T. azmanii* measuring 19 x 8 mm was collected on the southern side of the

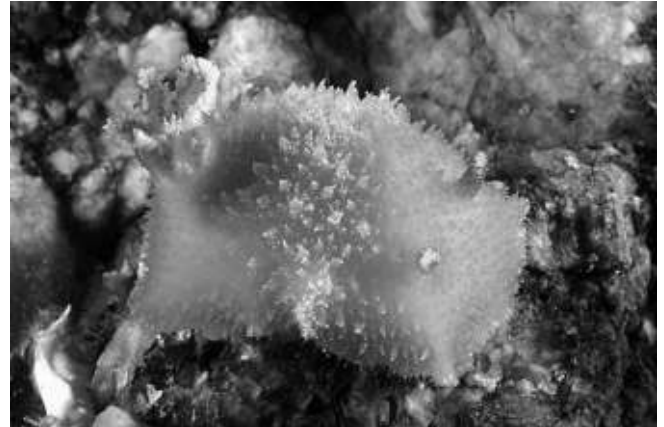


Figure 7. *Thordisa azmanii* from NW Spain on its habitat. Picture by J. Perez Dieste

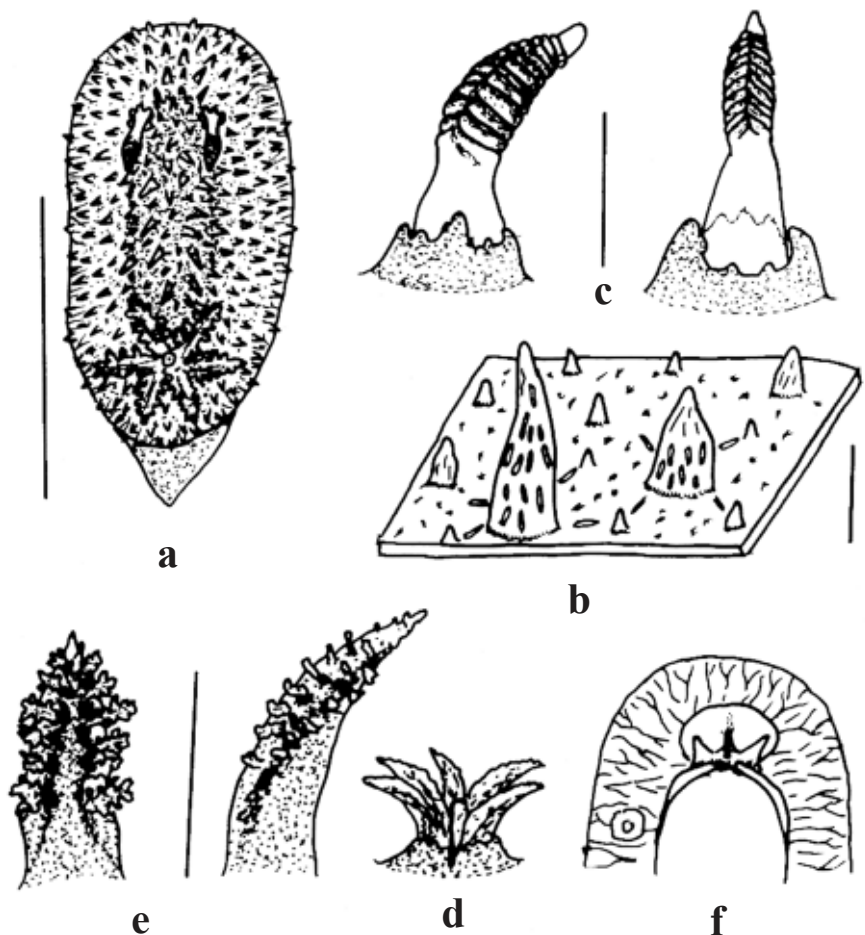


Figure 8. *Thordisa azmanii*. a) general morphology, bar means 10 mm; b) detail of dorsal tubercles, bar means 1 mm; c) rhinophore detail in lateral left view (left drawing) and anterior view (right drawing), bar means 2 mm; d) gills; e) gill leaves detail in dorsal view (left drawing) and lateral view (right drawing), bar means 2 mm.; f) underside view of the anterior part of the body, bar means 5 mm.

Magdalena Peninsula (Santander, Northern Spain) moving under stones in the intertidal zone, the preserved specimen is deposited in the collections of the Animal Biodiversity Resource Center (CRBA) with the code CRBA-105191; in April 1990, two living specimens (17 and 14 mm in length) were collected in the same area.

External morphology

General body color is yellowish or orange, with the center of the back colored brown due to the internal viscera (Fig. 7); the 14 mm specimen was brown with a darker mantle margin. These three specimens had the same morphological characteristics (Fig. 8a). Mantle covered with unequal, conical, yellowish tubercles with brown punctuations and elongated white granulations. Largest tubercles are surrounded by 4-5 smaller ones, with elongated radial-type white spots between the large and small ones (Fig. 8b). The large tubercles are in the center of the back. The underside of the mantle is yellow and bundles of spicules can be clearly seen, also from the upper side. The genital opening is located on the underside of the mantle on the right side of the body (Fig. 8f). Rhinophores are yellow and have 10-11 lamellae with brown punctuations (Fig. 8c) and a whitish apex. The basal part of the rhinophore has no lamellae and is greatly enlarged. Rhinophoral sheath is somewhat elevated and has a thick tubercle on each side, two smaller ones on the front side and 3-4 on the rear side. All tubercles on the rhinophoral sheath have a white tip. The large lateral tubercle on the right is somewhat anterior and the one on the left is somewhat posterior. There are 6 gill leaves, two directed forward, two directed to the sides, and two directed backwards (Figs. 8d, e). The gill leaves are tripinnate and have brown granulations on the basal 2/3 and cream-colored tips. Gill sheath is slightly raised and has whitish rounded tubercles placed in pairs on the rim. The foot is of the same color as the body and is furrowed and cleaved at the front. When the animal moves, the foot protrudes 2-3 mm behind the mantle showing a triangular outline. The mouth has a pair of small yellow buccal palps (Fig. 8f).

Internal anatomy

The preserved animals were in very poor condition and have not been dissected. Cervera & García-Gómez (1989)

provided data of the radular structure and the genital apparatus in the description of the species; these authors indicated a radular formula of 31 x (4.23.0.23.4) for a specimen of 13 mm in length. Chan & Gosliner (2007) provided a radular formula of 29 x (4.18.0.18.4) for a preserved 7 mm specimen from Azores.

Biology, habitat and distribution

The specimens from Galicia (Almón *et al.*, 2010) were found living on sponges of the genus *Raspailia* Nardo, 1833: specifically, *Raspailia (Clathriodendron) hispida* (Montagu, 1814), *R. (Raspailia) ramosa* (Montagu, 1814) and *R. (Raspailia) cf. viminalis* Schmidt, 1862 (Fig. 9) and they are supposed to feed on them, but this point has not been confirmed. The spawn consists of a light-yellow ribbon, wound in a spiral of one or two whorls attached by one of its sides to the substrate -generally on the sponge-, with eggs of 100 microns in diameter arranged transversely forming rows of 25 eggs in two overlapping layers (Ortea & Martínez, 1990 as *T. diuda*). Observed at a certain distance, the general appearance of this nudibranch is similar to the bryozoan *Cellepora pumicosa* (Pallas, 1766), which could be understood as a form of camouflage in which the animal adopts the appearance of a species unattractive to predators. The spiculous notum facilitates the retention of marine debris in the same way *Raspailia* sponges do, so they can pass unnoticed to predators.

This species has been reported on the Atlantic coasts of the Iberian Peninsula (Fig. 10): in Cádiz (1) (Cervera & García Gómez, 1989; Patiño *et al.*, 2022); in Portugal (2) (Calado & Urgorri, 1990; García Gómez *et al.*, 1991); in the Ría de Arousa (3), Galicia (Almón *et al.*, 2010); and in Cudillero (4), Asturias (Ortea & Martínez, 1990 as *T. diuda*). The specimens from Asturias, Santander (4, present work) and Cádiz (1) were living in the intertidal, while those from Galicia were living down to 20 meters, so its bathymetric distribution is not clear. Outside the Iberian Peninsula this species has also been found on the shores of St. Agnes, Cornwall (6), Great Britain (Picton, 1978 [in] Medslugs) and at Ouessant, Brittany (7), France (Roche, 2018), but these records should be confirmed because they lack the opaque white pigmentation of the original description. It has also been cited in the



Figure 9. On the left, a specimen of *T. azmanii* and two spawns on the sponge of the genus *Raspailia*. On the right, detail of a specimen of *T. azmanii* and its spawn on the same sponge. Pictures taken by J. Pérez Dieste on the Galician coast at a depth of about 25 m.

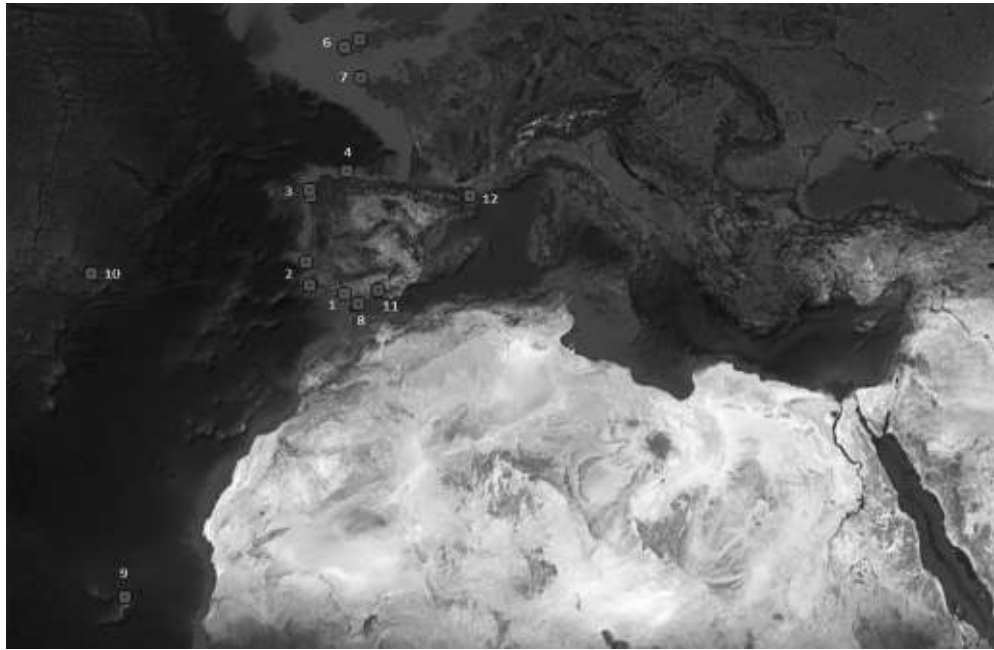


Figure 10. Location of *Thordisa azmanii* records. The numbers correspond to the locations indicated in the text.

coastal zone of Monte Hacho (8) in Ceuta (Northern Africa, Strait of Gibraltar) (Obimasa, 2018). There is a report from Cape Verde (9) (Ortea & Cabrera, 1999) as *T. diuda* that probably corresponds to *T. azmanii*, since the authors assimilate it to the findings from Northern Spain. Chan & Gosliner (2007) cited *T. azmanii* for the Azores (10).

There are very few reports for this species in the Mediterranean. There are pictures of the observation of a 10 mm specimen at a depth of 8 meters in Numana, on the Italian Adriatic coast (Betti, 2010), but we think that the specimen does not match with *T. azmanii* because the rounded and widely spaced tubercles on the back while in *T. azmanii* they are conical, of different sizes and are very close together, giving the animal's back a "villous" appearance. Another single 5 mm specimen was found at 5 m in depth at the Punta del Vapor, Granada (11) (Southern Spain) in 1998 (Sánchez Tocino, 2003), and Enric Madrenas (pers. comm.) reported a 6 mm specimen at 12 meters in depth at the Punta del Romani, L'Escala (12) (Costa Brava, Girona, NE Spain) in 2021.

General discussion

Cervera & García-Gómez (1989) provide a comparative table with the main morphological characteristics of the Atlantic and Mediterranean species of *Thordisa*. *Thordisa filix* is easily identifiable from the other species of *Thordisa* by its yellow color, the presence of well separated and unequal digitiform tubercles on the notum, and the four tripinnate gills (Figs. 2 and 11). Although this species can be confused by its external coloration with other doridacean species such as *Baptodoris cinnabarina* Bergh, 1884, dissecting the specimens solves any doubts as *T. filix* has a characteristic spirally coiled vestibular gland that covers dorsally part of the inter-

nal viscera. The radular structure matches with that indicated by Schmekel & Portmann (1982) for specimens of similar sizes to those studied in this work, while the number of rows and lateral teeth is slightly less than those indicated by Pruvot-Fol (1954) for larger specimens, 30-40 mm long.

Thordisa azmanii has external similarities to *T. filix*, but *T. azmanii* is darker in color and has many more mantle papillae. Based on specimens of *T. azmanii* from the coasts of Andalusia (SW Spain), Sanchez-Tocino (2011) indicates the coloration of this species as orange-brown or dark brown, and the gill leaves and the laminar part of the rhinophores dark brown, almost black. These data may indicate some chromatic variability within the species.

Ortea & Martínez (1990) and Ortea & Cabrera (1999) collected specimens of *Thordisa* on the Asturian coast (North Spain) and in the Cape Verde archipelago, respectively, which they identified as *T. diuda*, a species originary from the coasts of Brazil, also synonymizing *T. azmanii* as belonging to that species. The specimens we studied from the Magdalena Peninsula in Santander lack the fine white marking described in the original description of the species but coincide in their external morphology almost exactly with those described by Ortea & Martínez (1990) from the Asturian coast as *T. diuda*. Chan & Gosliner (2006) described a new species of *Thordisa* and carried out a phylogenetic analysis based on 23 morphological characters. The same authors subsequently described another five new species of this genus (Chan & Gosliner, 2007) and provided a new phylogeny based on 18 different anatomical and morphological characteristics of 13 species. In both phylogenetic studies from previous authors, the species *T. diuda* from the western Atlantic and *T. azmanii* from the eastern Atlantic were recovered separately in different clades. Alvim & Dias-Pimenta (2013), in their review of Discodorididae species from the Brazilian coasts, discuss the dif-

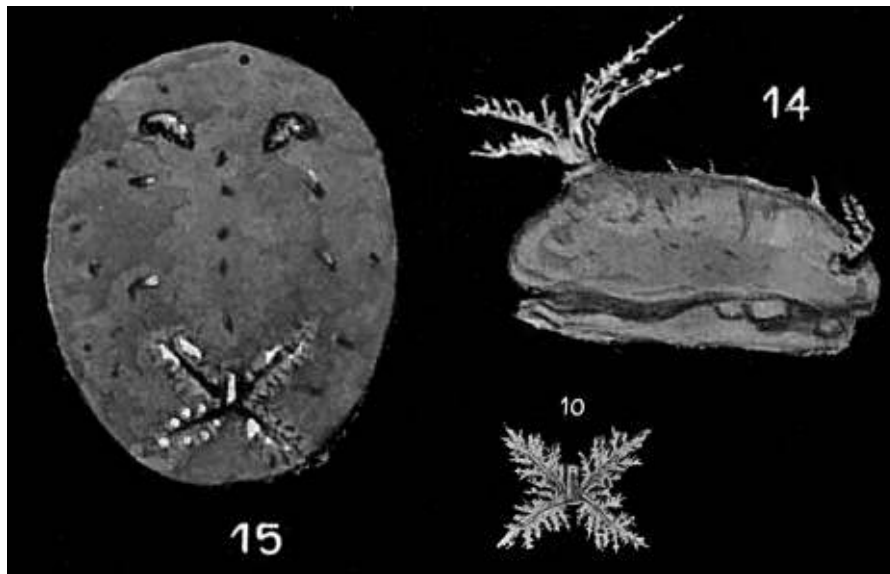


Figure 11. *Thordisa filix*, original illustration of the description of the species by Pruvot-Fol, 1951.

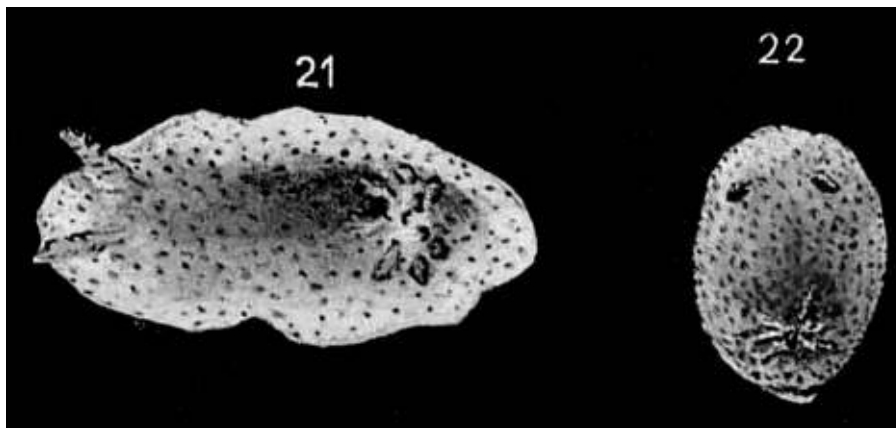


Figure 12. *Thordisa aurea*, original illustration of the description of the species by Pruvot-Fol, 1951.

ferences between *T. diuda* and *T. azmanii* and consider them to be different species, the first one distributed in the western Atlantic between the Bahamas and Brazil and the second in the eastern Atlantic off the Iberian coast to Cape Verde. Currently, both species are considered as valid (MolluscaBase, 2023). This opinion is the one we follow in the present work until molecular data of both species are known. However, given that there are locations where *T. azmanii* can be found in the intertidal (specimens from Cádiz and Santander, in this work) and other locations where it can be found in the sublittoral at a depth of about 20 meters (Galicia), we consider that it would be appropriate to carry out molecular analysis of specimens from these locations to confirm whether they are the same species, or perhaps different species with very similar morphological characteristics. It would also be interesting to compare the molecular data of Atlantic and Mediterranean specimens to rule out that they could be different cryptic species.

Regarding the other two *Thordisa* species recorded in European waters, Bergh (1884) cited *Thordisa pallida* for the

Italian coasts in Trieste (Adriatic Sea) and Naples but there are no other records of this species for the Mediterranean Sea nor any other marine areas. The history of the description of *T. pallida* is very curious. Bergh, when studying the species *Jorunna johnsoni* (Alder & Hancock, 1845) (now *J. tomentosa* (Cuvier, 1804)), requested specimens of this species from the museums of Naples and Trieste, and received two specimens preserved in alcohol labeled as *Doris tomentosa*. At first glance these specimens were very similar to *J. johnsoni* but when observing them under a magnifying glass, Bergh realized that they were of a different species and decided to describe the new species *T. pallida*. The preserved specimens studied by Bergh had about 35 mm in length, white and slightly yellowish body, with rounded nodules on the back, ten tripinnate gill leaves, the foot furrowed and cleaved in front, smooth labial cuticle and radulae with 28-31 rows and 45-49 hooked radular teeth in the posterior rows, of which the outermost 5-8 are smaller and finer and have a serrated inner edge. The same author was not even sure that the species *T. pallida* belonged to the genus *Thordisa* and in

his publication of 1890 he no longer lists *T. pallida* among the known species of *Thordisa* at that time. This species was also cited by Graeffe (1903) in his list of the fauna of the Gulf of Trieste living among seaweeds on the coast. Presumably this author was only repeating Bergh's record. Pruvot-Fol (1954) writes that Bergh's species could be *Jorunna tomentosa*, however, we believe that her assumption was not very accurate since *J. tomentosa* has caryophylliid tubercles on the back and the marginal teeth of the radula are not pectinated, as they are in the species of the genus *Thordisa*. For all the reasons mentioned above for *T. pallida* and not knowing where the holotype of the species is deposited, we propose that *T. pallida* should be considered as *nomen dubium*.

Only two specimens of *Thordisa aurea* were collected by Pruvot-Fol in 1951 in trawling grounds off Banyuls (French Southern Mediterranean coast) and in the original description there is a color drawing (Fig. 12): its color is yellow, it has six gills and lacks a spiral vestibular gland; this author says that they are very similar to *T. filix* "Mais les deux espèces diffèrent par l'aspect général, la couleur, les rhinophores, les branchies et ne peuvent être confondues". Pruvot-Fol did not dissect the genitalia because she considered the specimens were possibly immature. Until more specimens are collected and molecularly analyzed, we consider this species as valid.

Despite not having been observed again after its original descriptions, *T. pallida* and *T. aurea* are currently considered valid species according to WoRMS (2023).

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