



A peculiar high-tidal molluscan assemblage from a Madeiran boulder beach

Una peculiar comunidad de moluscos del nivel superior de la marea en una playa de cantos rodados de Madeira

Emilio ROLÁN* and José TEMPLADO**

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ABSTRACT

The molluscs living at the higher intertidal level in a protected area of boulders in Madeira are described. Fourteen species of molluscs were found in this peculiar habitat, the gastropods *Littorina striata*, *Melaraphe neritoides*, *Assimineca cf. grayana*, *Paludinella littorina*, *Caecum armoricum*, *Caecum clarkii*, *Truncatella subcylindrica*, *Botryphallus epidauricus*, *Odostomia microeques* (parasitizing the former species), *Ovatella aequalis*, *Auriculinella bidentata*, *Pedipes pedipes*, *Pseudomelampus exiguus*, and the bivalve *Lasaea rubra*. Their abundance and distribution assemblages in this habitat are noted and they are compared with the molluscs found in similar habitats in other areas of the Northeastern Atlantic and Mediterranean.

RESUMEN

Se describen los moluscos hallados en el nivel superior de la marea en una zona de bloques y cantos rodados de la isla de Madeira. Se hallaron catorce especies de moluscos en este hábitat tan peculiar, los gasterópodos *Littorina striata*, *Melaraphe neritoides*, *Assimineca cf. grayana*, *Paludinella littorina*, *Caecum armoricum*, *Caecum clarkii*, *Truncatella subcylindrica*, *Botryphallus epidauricus*, *Odostomia microeques* (parasitando la especie anterior), *Ovatella aequalis*, *Auriculinella bidentata*, *Pedipes pedipes*, *Pseudomelampus exiguus* y el bivalvo *Lasaea rubra*. Se aportan datos sobre la abundancia de todas estas especies y su distribución dentro de este hábitat. Por último, se compara esta comunidad de moluscos con las halladas en hábitats similares en otras zonas del Atlántico nordeste y del Mediterráneo.

KEY WORDS: Madeira, boulder beach, high-tidal molluscan assemblage, Littorinidae, Assimineidae, Caecidae, Truncatellidae, Rissoidae, Pyramidellidae, Ellobiidae, Kelliidae.

PALABRAS CLAVE: Madeira, playa de cantos rodados, comunidad de moluscos supralitoral, Littorinidae, Assimineidae, Caecidae, Truncatellidae, Rossoidae, Pyramidellidae, Ellobiidae, Kelliidae.

INTRODUCTION

Faunas associated with boulder beaches were described by MORTON (1975) in New Zealand. He pointed out that the molluscs that lives at the high-

tidal level in such places form a distinctive ecological grouping. These molluscan communities are characterised by species of both marine and terrestrial

* Cánovas del Castillo 22, 36202 Vigo, Spain

** Museo Nacional de Ciencias Naturales (CSIC), José Gutiérrez Abascal 2, 28006 Madrid, Spain

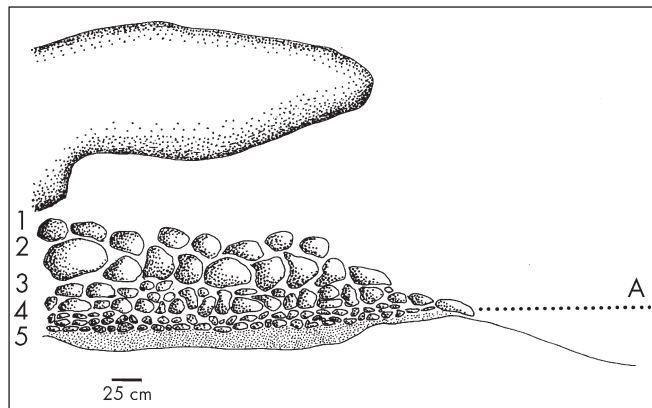


Figure 1. Schematic representation of the sampling site. 1: the upper level formed by cobbles of about 15-25 cm, occasionally receiving sunlight; 2: among and under them, there was another layer of scarcely smaller stones of about 9-15 cm, never exposed to sunlight; 3: other small stones without any contact with sand; 4: smaller ones mixed with some coarse sand formed a layer of about 6-8 cm thick; 5: bed of gravel and coarse sand mixed with very small stones; A: high tide level.

Figura 1. Esquema del lugar de muestreo. 1: nivel superior formado por cantos rodados de unos 15-25 cm, que reciben ocasionalmente la luz del sol; 2: entre ellos y por debajo hay otro nivel con piedras ligeramente más pequeñas (9-15 cm), que nunca están expuestas a la luz del sol; 3: otras piedras más pequeñas sin contacto alguno con arena; 4: otras piedras pequeñas mezcladas con arena compacta formando un estrato de unos 6-8 cm de espesor; 5: nivel de grava y arena compactada con pequeñas piedras; A: nivel de la marea alta.

groups, which form a mixed assemblage. According to this author especially common here are species of the caenogastropods families Assimineidae and Caecidae, and primitive pulmonates of the family Ellobiidae. PONDER (1990) studied a close related habitat in the Strait of Gibraltar, but in a somewhat lower level. He pointed out that "these habitats, long neglected by biologist, clearly deserve much closer attention".

During a short visit to Madeira Island in October of 1993 we had the opportunity to find a surprisingly diverse molluscan assemblage, quite similar to that described by MORTON (1975), in such seemingly inhospitable habitat. These molluscs and their abundance and distribution within this habitat are here described.

The small molluscs of Madeira were firstly studied by MANZONI (1868a, 1968b), WATSON (1873, 1891, 1898), and in more recent times by NORDSIECK AND

GARCÍA-TALAVERA (1979), VERDUIN (1984, 1988), MOOLENBEEK AND FABER (1987), PALAZZI (1988) and MOOLENBEEK AND HOENSELAAR (1989, 1998), among others. All these publications are mainly lists, inventories or description of new species, and most of them are based on dead material. In the other hand, the Ellobids from Madeira were studied firstly by WOLLASTON (1878) and in recent times by MARTINS (1995, 1996, 1999).

MATERIAL AND METHODS

The Madeiran coast is very steep, and exposed to an intense wave action. In most part of its coast only boulder beaches are found. In October of 1993 a small area of about 2 x 2 m was sampled in Funchal, near the Club Naval. The sampling site was located at the corner of a small bay, where wave-rounded boulders and large cobbles were over a

Table I. Species found in Madeira and their abundance and habitat where they predominated. 1: upper part of big boulders; 2: amongst and under boulders; 3: under cobbles without any contact with the sand layer. ; 4: amongst and under small stones in contact with the sand layer. ; 5: in the sand under cobbles; +: 1 - 10 specimens; ++: 11 - 50 specimens; +++: 51-150 specimens; ++++: more than 150 specimens.

Tabla I. Especies encontradas en Madeira, su abundancia y nivel en el que eran predominantes. 1: parte superior de bloques grandes; 2: entre y bajo bloques; 3: bajo guijarros sin ningún contacto con la capa de arena; 4: entre y bajo pequeñas piedras en contacto con la arena; 5: en la arena bajo guijarros; +: 1 - 10 especímenes; ++: 11 - 50 especímenes; +++: 51-150 especímenes; ++++: más de 150 especímenes.

Species	1	2	3	4	5
<i>L. striata</i>	+				
<i>M. neritoides</i>	+				
<i>A. cf. grayana</i>			+++	+	
<i>P. littorina</i>			+	+++	
<i>C. clarkii</i>					+
<i>C. armoricum</i>					++
<i>T. subcylindrica</i>				+	++
<i>B. epidauricus</i>				+	++++
<i>O. microeques</i>					++
<i>O. aequalis</i>		+	++++	+	
<i>A. bidentata</i>			+	++	
<i>P. pedipes</i>		+			
<i>P. exiguus</i>		+			
<i>L. rubra</i>				+	

coarse sand and gravel layer, among rocks (Fig. 1). It was a moderately stable, shady place, protected against the direct impact of the waves. The seawater was received slowly braked by its filtration through the gravel. Thus, the main ecological factors of the small area sampled were the high humidity, and permanently low levels of light and temperature. Some decaying algal wrack and plant debris can be found under stones, which constitute the food for most of the animals inhabiting there. No macroscopic seaweeds were observed in this habitat.

Material was collected in the high tide spring level by direct observation with frontal lens. Also, some cobbles were cleaned in a box with sea-water, and samples of the coarse sand and gravel placed under boulders and stones were taken in order to be studied later under magnification.

The samples obtained cannot be treated as a valid quantitative estimates. Therefore, the number of specimens given might be interpreted as a general picture of abundance and distribution of each species.

In order to make comparisons, a very similar habitat and level was sampled in other localities, two located in the Atlantic coast of NW Spain (Cies Islands, Ría de Vigo, June, 1997, and Ribadeo, Lugo, June, 1998), and another in the Mediterranean (Los Escullos, Almería, SE Spain, September 1996). Some specimens from the Muséum Nationale d'Histoire Naturelle of Paris (MNHN) (loaned by Serge Gofas), coming from Ceuta, Azores and Canary Islands were used for comparison. Voucher material of all the species recorded has been deposited in the Museo Nacional de Ciencias Naturales of Madrid.

Table II. Species found in similar habitat in Madeira and in several localities of the Spanish coasts (Ribadeo, Cies Islands, in NW Spain, and Los Escullos, SE Spain).

Tabla II. Especies presentes en hábitats similares en Madeira y varias localidades del litoral español (Ribadeo, Islas Cies, en el NO de España, y Los Escullos, SE de España).

Genera	Species in MADEIRA	Species in NW SPAIN	Species in SE SPAIN
<i>Littorina</i>	<i>L. striata</i>	<i>L. saxatilis</i>	
<i>Melaraphe</i>	<i>M. neritoides</i>		<i>M. neritoides</i>
<i>Assimineia</i>	<i>A. cf. grayana</i>		
<i>Paludinella</i>	<i>P. littorina</i>	<i>P. littorina</i>	<i>P. littorina</i>
<i>Caecum</i>	<i>C. armoricum</i>		<i>C. armoricum</i>
	<i>C. clarkii</i>		
<i>Cingula</i>		<i>C. trifasciata</i>	
<i>Truncatella</i>	<i>T. subcylindrica</i>	<i>T. subcylindrica</i>	<i>T. subcylindrica</i>
<i>Botryphalus</i>	<i>B. epidauricus</i>		<i>B. epidauricus</i>
<i>Odostomia</i>	<i>O. microeques</i>		
<i>Ovatella</i>	<i>O. aequalis</i>		
<i>Myosotella</i>		<i>M. myosotis</i>	<i>M. myosotis</i>
<i>Auriculinea</i>	<i>A. bidentata</i>	<i>A. bidentata</i>	<i>A. bidentata</i>
<i>Pedipes</i>	<i>P. pedipes</i>		
<i>Pseudomelampus</i>	<i>P. exiguus</i>	<i>P. exiguus</i>	<i>P. exiguus</i>
<i>Lasaea</i>	<i>L. rubra</i>	<i>L. rubra</i>	

RESULTS

Description of the habitat: We considered the following levels in the sampling site (Fig. 1), with independence of the big stones which were around the place:

1- the upper level was formed by cobbles of about 15-25 cm, occasionally receiving sunlight;

2- among and under them, there was another layer of scarcely smaller stones of about 9-15 cm, never exposed to sunlight; some algal debris were deposited here;

3- under these, other small stones without any contact with sand;

4- amongst and under small stones, smaller ones mixed with some coarse sand formed a layer of about 6-8 cm thick.

5- under this layer there was a bed of gravel and coarse sand mixed with very small stones.

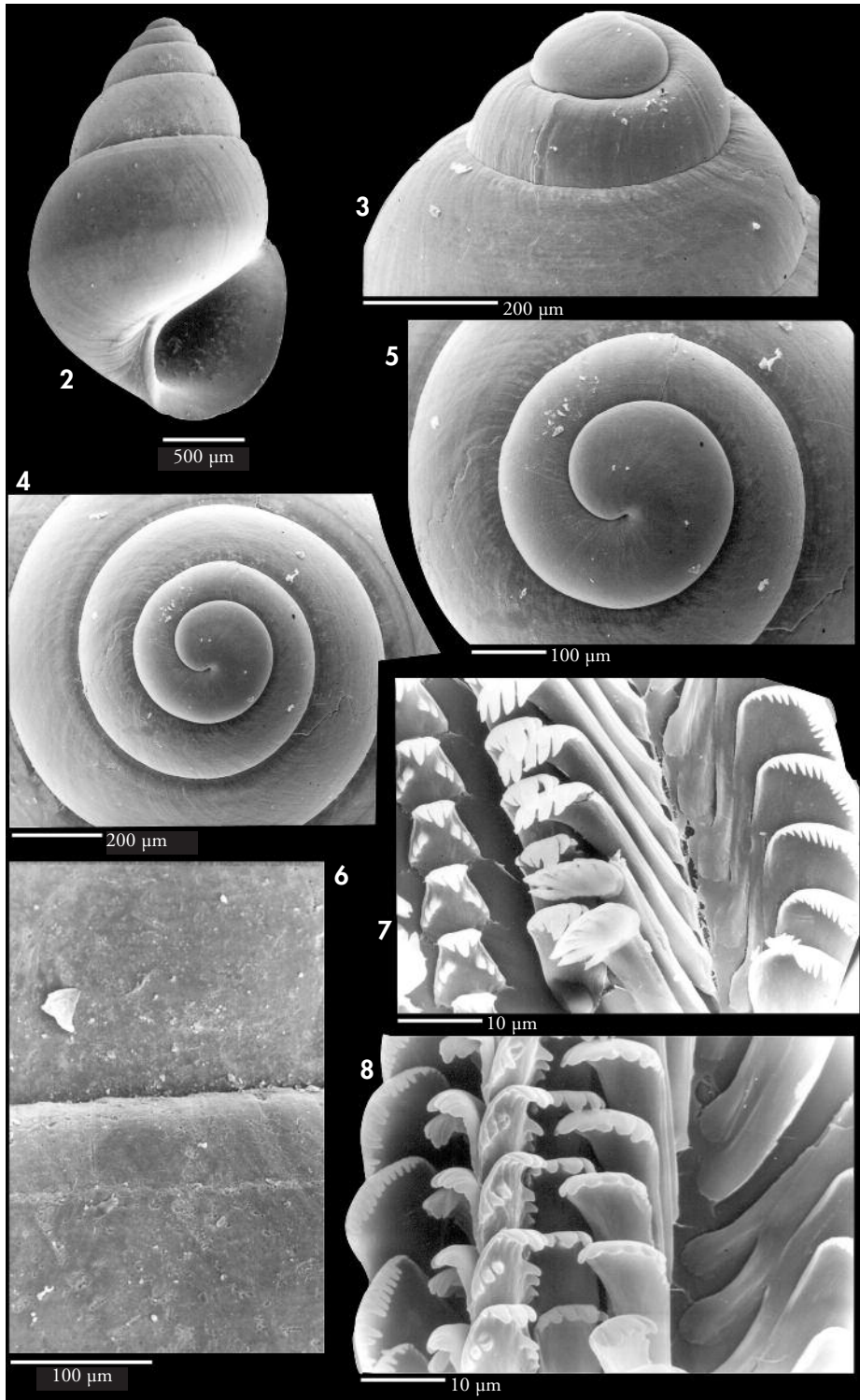
All these levels were at the higher intertidal level. Probably, the sea-water could reach the upper cobbles when the sea was strong, but normally the waves arrived to this place very attenuated. The cobbles and stones under boulders were always humid and they were not hardly heated by the sun.

The molluscan species found in this habitat lived very close one to another but occupied different levels or niches. Most of them were found very close because there were only about 25 cm from the higher to the lower level.

Species found: The species found in Madeira and its relative abundance and location within this habitat are shown in Table I. The Table II shows the species found in similar habitat in Madeira, NW Spain, and SE Spain.

(Right page) Figures 2-8. *Assimineia cf. grayana*, Madeira. 2: shell; 3-5: protoconch; 6: detail of the suture; 7-8: radula.

(Página derecha) Figuras 2-8. *Assimineia cf. grayana*, Madeira. 2: concha; 3-5: protoconcha; 6: detalle de la sutura; 7-8: rádula.



Family LITTORINIDAE Gray, 1840

Littorina striata King and Broderip, 1832

Material studied: 8 specimens from Madeira.

Habitat: Found in the upper level amongst big boulders.

Remarks: This species is known from Azores, Madeira, Canarias, Cabo Verde and São Tomé islands. Our specimens were found in the upper part of the studied area, on the rocks. Most of them were not adults. Some of them had tubercles in the upper part of the first

whorls, even in one specimen the tubercles reached the last whorl. This pattern is frequent in the same species in Cape Verde Islands. No other differences were appreciated between Madeiran and Canarian populations of this species. A detailed study on patterns of shell variation in this species along Macaronesia was done by DE WOLF ET AL. (1998).

Melaraphe neritoides (Linné, 1758)

Material studied: 7 specimens from Madeira, 20 specimens from Almería.

Habitat: Found in the upper level on the surface of big boulders.

Remarks: The species ranges from Scandinavia to the Mediterranean. The

shells from Madeira had the same characteristics that the ones found in the European mainland coasts populations.

Family ASSIMINEIDAE H. and A. Adams, 1856

Assimineia cf. grayana Fleming, 1828 (Figs. 2-8, 30)

Material studied: 104 specimens from Madeira.

Description: Shell (Fig. 2) small, solid, globose-conical, with spire scarcely pointed. Surface smooth, only with growth lines and a subsutural spiral groove (Fig. 6), not clearly appreciated in first whorls. Suture slowly depressed. Protoconch (Figs. 3-5) smooth, with somewhat more than one spiral whorl. Its nucleus measured 130 μm in diameter

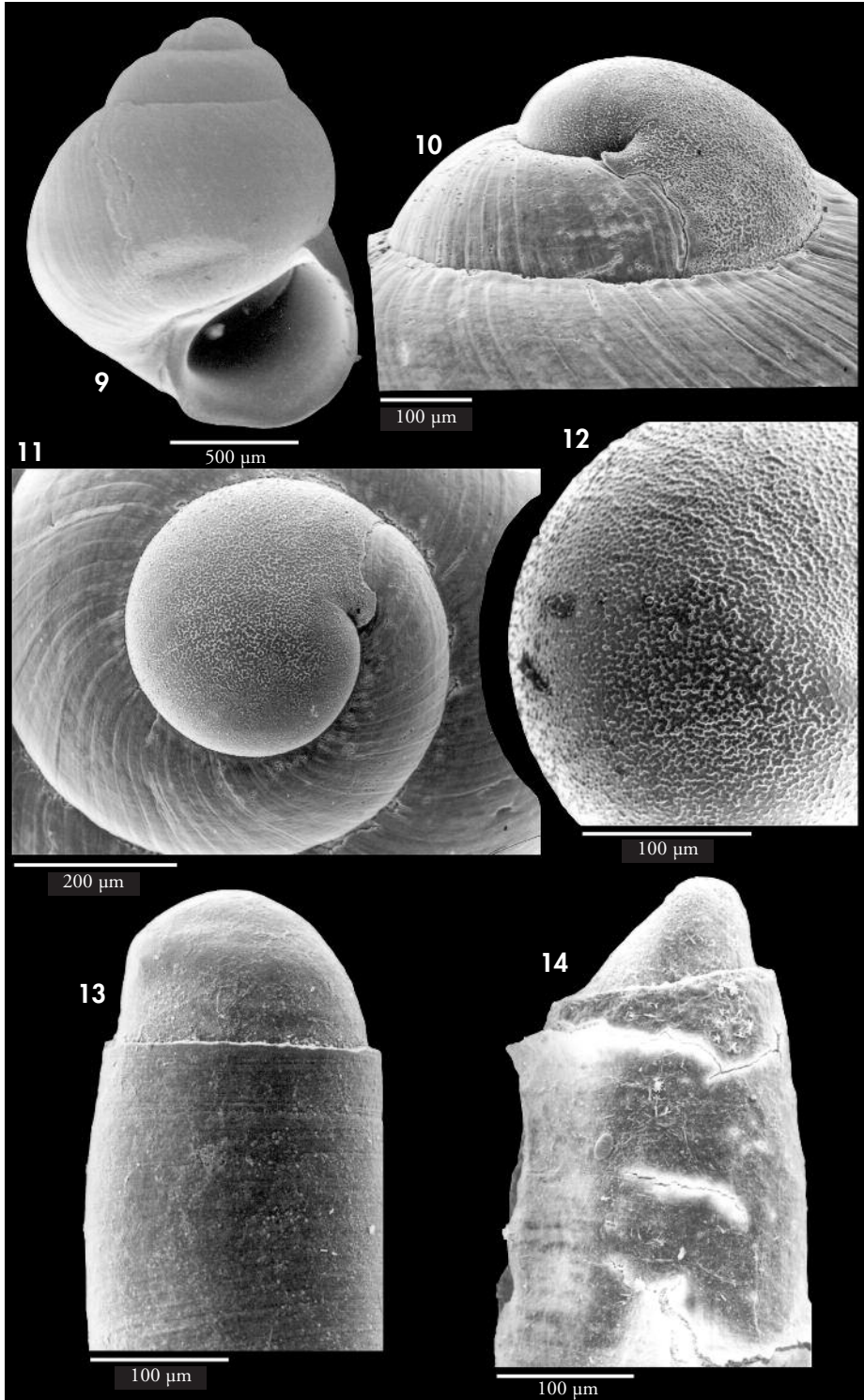
Animal white, with short and contractile cephalic tentacles, showing the eyes close to their tip. The anterior part of the foot is rounded and bilobulated

(Fig. 30). Black pigmentation was very constant in the external apical part of the tentacles. A black or grey spots in the head, between the tentacles, can be also present. In some specimens a quite dark first whorls can be observed by transparence.

Radula (Figs. 7-8) with a narrow and elongate rachidian tooth, which presents a prominent central cusp, with one or two at each side. There are also three small cusps near its base at each side, being less prominent the more basal. The lateral teeth have a spoon-like form,

(Right page) Figures 9-12. *Paludinella littorina*, Madeira. 9: shell; 10-11: protoconch; 12: microsculpture of the protoconch. Figure 13. *Caecum armoricum*, apex (Madeira). Figure 14. *Caecum clarki*, apex (Madeira).

(Página derecha) Figuras 9-12. *Paludinella littorina*, Madeira. 9: concha; 10-11: protoconcha; 12: microescultura de la protoconcha. Figura 13. *Caecum armoricum*, ápice (Madeira). Figura 14. *Caecum clarki*, ápice (Madeira).



with some cusps at their margin. The marginal internal are very similar to the lateral, being also spoon-like, somewhat wider, with smaller and more numerous cusps.

Habitat: Found living under boulders in humid parts, without contact with the sand, but very near to this layer.

Remarks: In a first glance we identified this species as *A. grayana* Fleming, 1828. But after a most detailed study we had some doubts because FRETTER AND GRAHAM (1978) noted spiral lines in the protoconch of this taxon, which are not present in our shells. They referred also a protoconch of two whorls, but our shells have only somewhat more than one (using the method of VERDUIN,

1984). We have tried to examine the protoconch of specimens of populations of this species recorded in the Ría de Arosa by CADÉE (1968) and ROLÁN (1987), but all the shells had the protoconch eroded.

A. grayana ranges from the Atlantic coast of Europe to the Mediterranean Sea. Other forms of the genus *Assiminea* has been observed in some areas of West Africa down to Angola. ÁVILA (1998, 2000) used the name *Assiminea eliae* Paladilhe, 1875 for the specimens of the Azores. Until a detailed review of all these forms is done, we prefer to keep the specimens from Madeira under the current name *A. grayana*, following the nomenclature proposed by the CLEMAN checklist.

Paludinella littorina (delle Chiaje, 1828) (Figs. 9-12, 29)

Material studied: 62 specimens from Madeira; 30 from Almería; 35 from Cies Islands; 15 from Ribadeo.

Description: Shell (Fig. 9) small, globose, glossy, semitransparent. Protoconch (Figs. 10-12) with a huge nucleus and one whorl and little more; its surface is covered by a fine microsculpture of irregular granulations. There is a distinct boundary with the teleoconch. Animal milky-white, with cephalic tentacles very short, flat, semitriangular, with subapical eyes (Fig. 29). A pinkish area can be observed by transparency between the tentacles.

Habitat: *P. littorina* was living under boulders near or in contact with the sand layer.

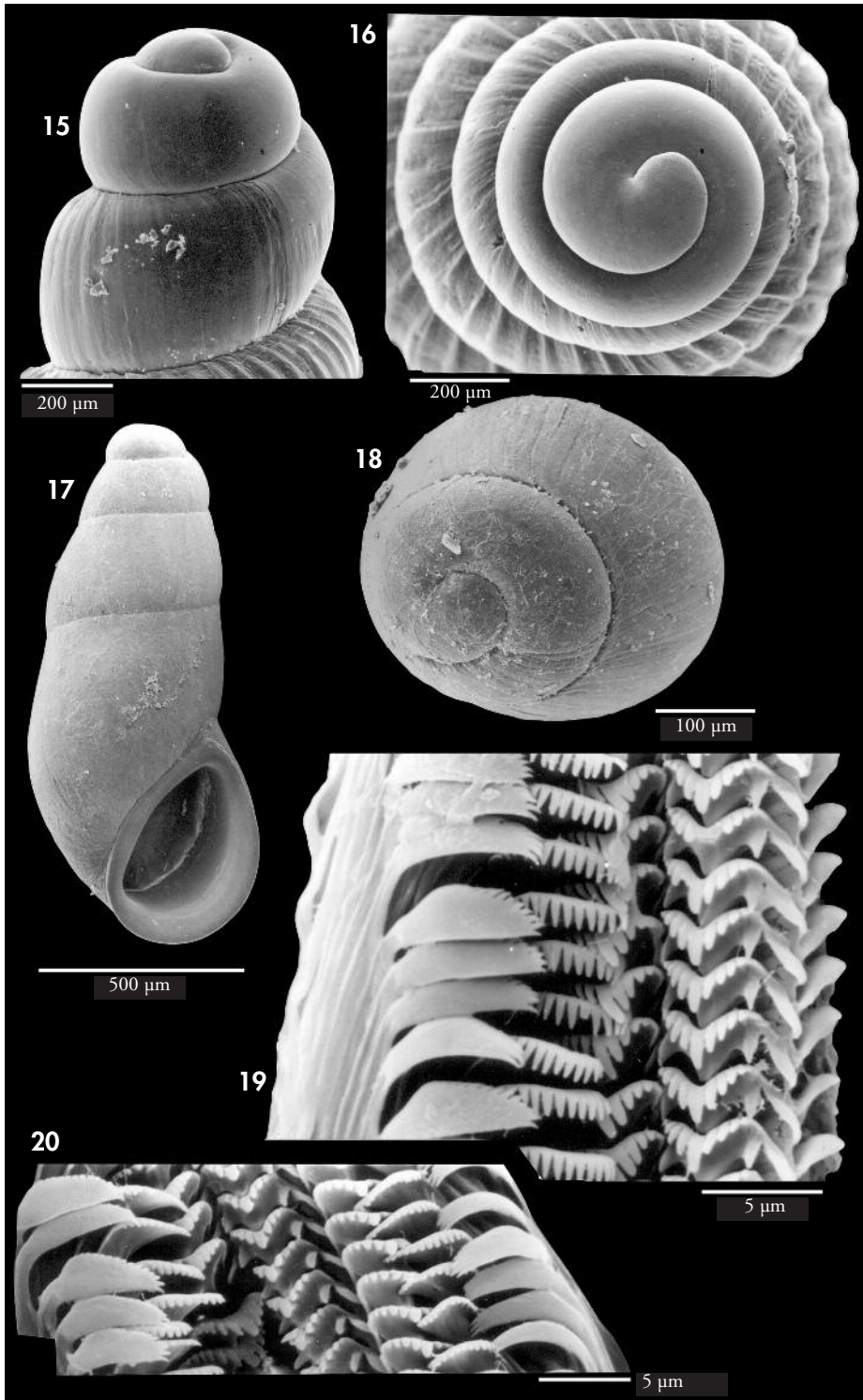
Remarks: FRETTER AND GRAHAM (1978) noted that *P. littorina* has a protoconch of 1 3/4 smooth whorls. The photograph presented by them (FRETTER AND GRAHAM, 1978, fig. 130) show a protoconch that seems to have less than one whorl. In fact, in our

material there is only a little more than 1/2 whorl after a wide nucleus (using the method of VERDUIN, 1984). The surface of the protoconch of our material is covered by irregular fine sculpture and was never smooth, as in the protoconch showed by FRETTER AND GRAHAM (1978, p. 149, fig. 130). Perhaps, the shells studied by these authors had eroded protoconchs or they were not studied at enough magnification. We have compared the Madeiran shells with those from SE Spain, and their microsculpture (Fig. 12) is similar in both populations. Thus we consider to be the same species both Madeiran and Mediterranean specimens.

This species occurs throughout the Mediterranean Sea and along the Eastern Atlantic coast, from Madeira to the southern coast of the British Isles.

(Right page) Figures 15-16. *Truncatella subcylindrica*, protoconch, Madeira. Figures 17-20. *Botryphallus epidauricus*., Madeira. 17: shell; 18: protoconch; 19-20: radula.

(Página derecha) Figuras 15-16. *Truncatella subcylindrica*, protoconcha, Madeira. Figuras 17-20. *Botryphallus epidauricus*., Madeira. 17: concha; 18: protoconcha; 19-20: rádula.



Family CAECIDAE Gray, 1850
Caecum armoricum de Folin, 1869 (Fig. 13)

Caecum incomptum (Monterosato, 1884).

Material studied: 22 specimens from Madeira; 9 specimens from Almería.

Description: A complete description of the shell of this species can be seen in the papers of VAN AARTSEN AND HOENSELAAR (1984) and HOEKSEMA AND SEGERS (1993). The specimens studied did not differ from these descriptions. Animal white.

Habitat: Found buried in the sand, under boulders and stones.

Remarks: PONDER (1990) pointed out that this species (as *C. incomptum*) is

very abundant in the intertidal gravel habitat in the Strait of Gibraltar. Our specimens are quite similar to those mentioned by this author. *Caecum armoricum* occurs throughout the Mediterranean Sea and along the Eastern Atlantic coast, from Canary Island to Azores and Northern France. Its distribution and systematic had been discussed by AARTSEN AND HOENSELAAR (1984) and HOEKSEMA AND SEGERS (1993).

Caecum clarkii Carpenter, 1858 (Fig. 14)

Material studied: 1 living specimen from Madeira.

Habitat: Buried in sand under cobbles.

Remarks: *C. clarkii* was originally described from Canary Islands and

widespread throughout the European Atlantic coasts and the Mediterranean Sea.

Family TRUNCATELLIDAE Gray, 1840

Truncatella subcylindrica (L., 1767) (Figs. 15-16, 28)

Material studied: 39 specimens from Madeira; 109 from Almería; 12 from Vigo; 45 from Ribadeo.

Description: Shells of Madeiran specimens were very similar to those from the Mediterranean populations, with numerous axial ribs, but some specimens were smooth. Protoconch smooth (Figs. 15-16). Animal white. Anterior end of the foot with two flat enlarge-

ments. Tentacles not very long, cylindrical with the eyes at their bases (Fig. 28).

Habitat: Amongst vegetal debris and cobbles.

Remarks: The characteristics of the habitat and shells are quite similar to those of the European populations.

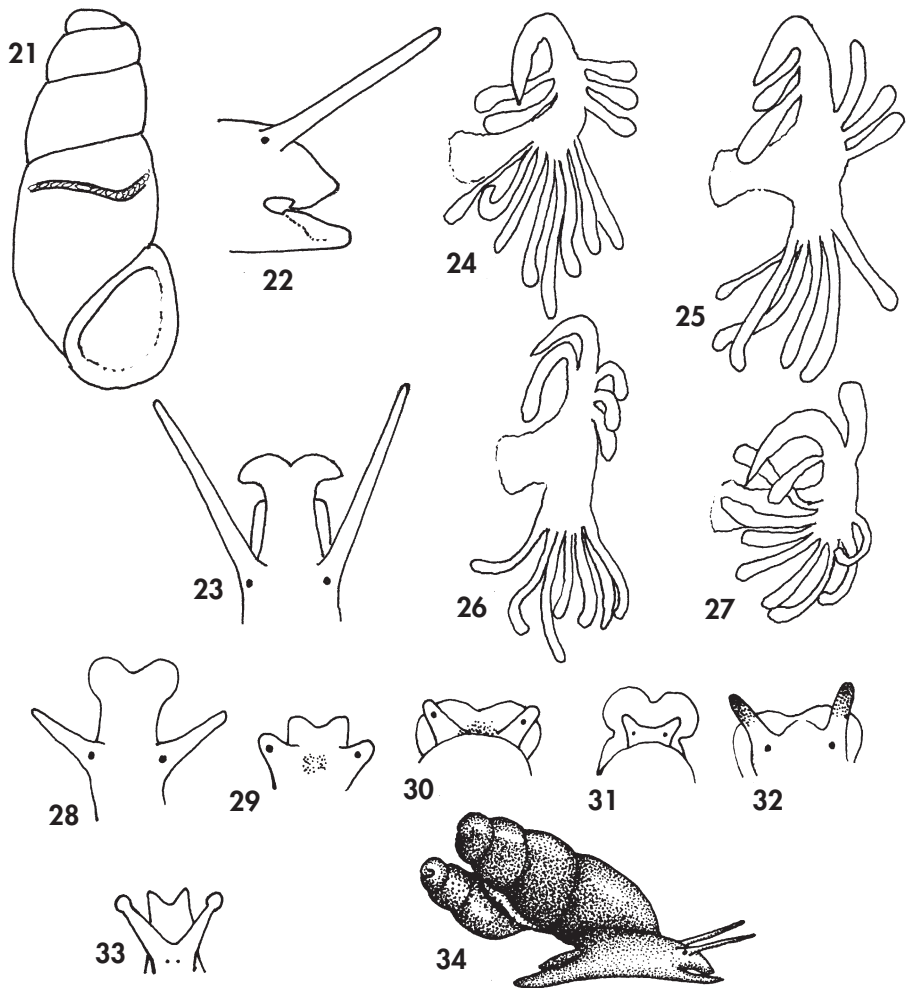
Family RISSOIDAE Gray, 1847

Botryphallus epidauricus (Brusina, 1866) (Figs. 17-27)

Material studied: 570 specimens from Madeira; 409 from Almería, more than 500 from Canary Islands (MNHN), and more than 500 from Ceuta (MNHN).

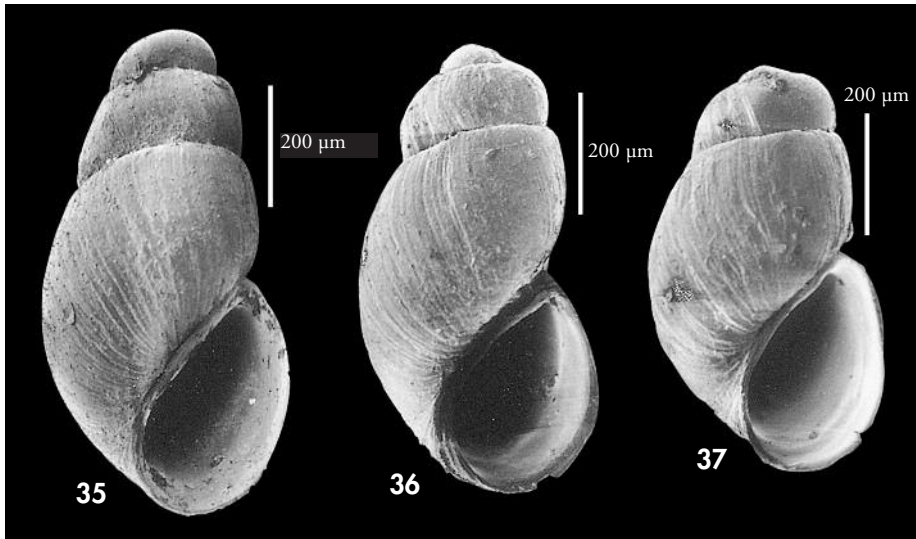
Description: Shell (Fig. 17) minute, tall-spined, almost cylindrical, smooth, whitish, with a dome-shaped apex. Aperture pyriform, slightly widening,

peristome continuous and outer lip smooth. Protoconch (Fig. 18) with about 1 smooth whorl. Teleoconch with about 3 whorls.



Figures 21-27. *Botryphallus epidauricus*, Madeira. 21: sketch of one specimen showing by transparency part of the intestinal tract; 22, 23: details of the head-foot; 24-27: penis of several males. Figure 28. Sketch of the head-foot of *Truncatella subcylindrica*, Madeira. Figure 29. Sketch of the head-foot of *Paludinella littorina*, Madeira. Figure 30. Sketch of the head-foot of *Assimineia cf. grayana*, Madeira. Figure 31. Sketch of the head-foot of *Pseudomelampus exiguus*, Madeira. Figure 32. Sketch of the head-foot of *Pedipes pedipes*, Madeira. Figure 33. Sketch of the head-foot of *Odostomia microeques*, Madeira. Figure 34. Live position of *Odostomia microeques* on its host, *Botryphallus epidauricus*, Madeira.

Figuras 21-27. Botryphallus epidauricus, Madeira. 21: esquema de un ejemplar mostrando por transparencia parte del tracto intestinal; 22, 23: detalles de la parte anterior del animal; 24-27: penes de algunos ejemplares. Figura 28. Esquema de la parte anterior del animal de Truncatella subcylindrica, Madeira. Figura 29. Esquema de la parte anterior del animal de Paludinella littorina, Madeira. Figura 30. Esquema de la parte anterior del animal de Assimineia cf. grayana, Madeira. Figura 31. Esquema de la parte anterior del animal de Pseudomelampus exiguus, Madeira. Figura 32. Esquema de la parte anterior del animal de Pedipes pedipes, Madeira. Figura 33. Esquema de la parte anterior del animal de Odostomia microeques, Madeira. Figura 34. Posición habitual de Odostomia microeques sobre su hospedador, Botryphallus epidauricus, Madeira.



Figures 35-37. Shells of *Odostomia microeques*, Madeira. 35: Holotype (MNCN); 36-37: paratypes (CER and MNHN).

Figuras 35-37. Conchas de Odostomia microeques, Madeira. 35: holotipo (MNCN); 36-37: paratipos (CER y MNHN).

Animal (Figs. 22, 23) translucent white, with cephalic tentacles thin and elongated. The eyes lie at their bases. Propodium with a conspicuous, triangular, and opaque-white pedal gland. Snout with two pronounced distal lobes. Intestine visible by transparence throughout the last whorl of the shell, with a slight curvature (Fig. 21). Males with a large and flower-like penis (Figs. 24-27), also visible by transparence, bearing several (from 11 to 16) digitiform appendages (apocrine glands, *sensu* Ponder, 1990). Operculum thin, translucent, paucispiral with an eccentric nucleus.

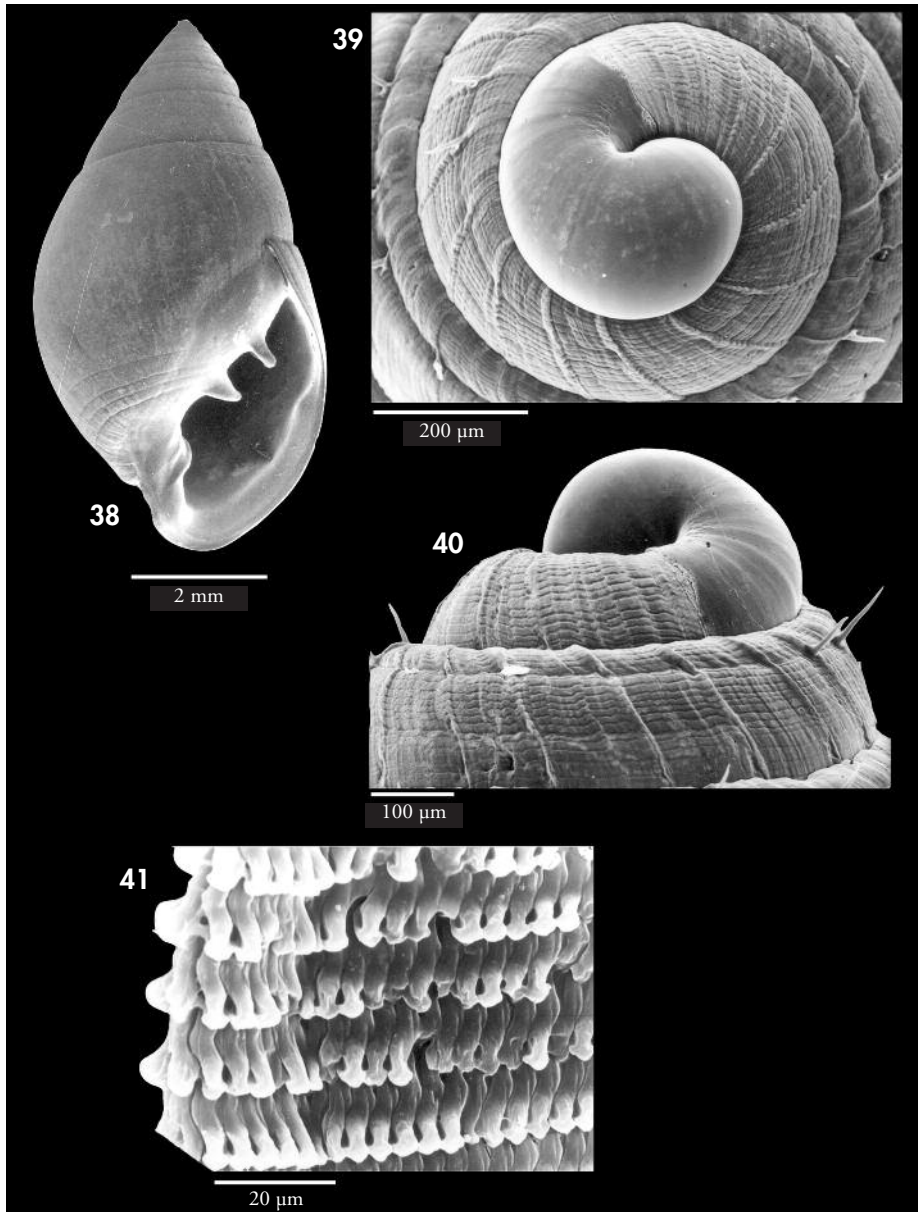
Radula (Figs. 19-20) taenioglossan, with a raquidian tooth having the cutting edge with 9 cusps (the central more elongated and the others smaller towards the periphery). Lateral teeth with 9 cusps also, one of the central more prominent and the others decreasing in size at both sides. Marginal teeth with many small cusps of the same size in their distal edge.

Habitat: Some specimens were found under cobbles and stones that were permanently humid and in contact with the

sand, but most of them were buried in the sand.

Remarks: At first we suspected that our specimens belonged to an undescribed species, due its short protoconch (meaning a direct development) and the long distance between Madeira and the Mediterranean Sea. Besides, the drawing of the penis of *B. epidauricus* showed by PONDER (1990, fig. 8C) upon material from the Strait of Gibraltar appeared to be rather different from our drawings. But later, we had the opportunity to study samples of a population of *B. epidauricus* from Los Escullos (Almería, SE Spain) and we found that the shell and the male genitalia in specimens of this population were identical to those from Madeira, and therefore belong to the same species. Perhaps the differences between our observations and the Ponder drawings are due to the fact that we have studied alcohol preserved material and he probably examined living specimens.

We have also studied two similar forms from the Canary Islands (MNHN)



Figures 38-41. *Ovatella aequalis*, Madeira. 38: shell; 39-40: protoconch; 41: radula.
Figuras 38-41. *Ovatella aequalis*, Madeira. 38: concha; 39-40: protoconcha; 41: rádula.

of different size, about 1.5 mm high the larger one, and about 1.0 the smaller. The bigger form is almost identical with the Madeiran specimens and probably is the species named by MANZONI (1868a)

Rissoa balteata, as VERDUIN (1988) and GOFAS (1990) suspected. The smaller form from the Canary Island, has a shell quite similar, but the males lack the characteristic penis of the genus *Botryp-*

hallus and it might be an undescribed species of the genus *Peringiella*.

Two similar species have been described in recent years: *B. ovummuscae* (Gofas, 1990) from Azores and *B. tuber* (Rolán, 1991) from Cape Verde islands,

both described under the genus *Peringiella*. According to the results of this study, the type species of this genus, *B. epidauricus*, occurs along the Mediterranean Sea, Atlantic coast of Spain and Portugal, and Madeira and Canary Islands.

Family PYRAMIDELLIDAE Gray, 1840

Odostomia microeques Rolán and Templado, 1999 (Figs. 33-37)

Material studied: 22 specimens from Madeira.

Description: Shell (Figs. 35-37) minute, oval-cylindrical, very fragile. Spire from 2 to 3 spiral whorls, slightly rounded, with suture impressed, and very evident prosoclines growth lines. Apex blunt, dome-shaped, with the protoconch of type C of 206 μm , emerging and showing less than one spiral whorl. Aperture oval and somewhat pyriform. Columella slightly curved. Peristoma continuous. Umbilicus absent. Columellar lip not showing any fold externaly, but a slight fold begin somewhat inner and continues internally well developed.

Animal translucent white, with short and divergent cephalic tentacles, slightly tapering distally but the distal end is expanded into a spheric tip (Fig. 33). Eyes small and placed very close behind the base of the tentacles. Operculum with a perpendicular line to the columella.

Habitat: Found just with its host, *Botryphallus epidauricus*, in the sand under stones.

Remarks: *O. microeques* is the smallest pyramidellid gastropod known. It was not observed during the first time in the collecting site due its very small size. Some samples of the sand taken under the cobbles was carried to the laboratory for examination under magnification. During this study the presence of some tiny shells, smaller than those of *Botryphallus epidauricus*, were observed, which was abundant in the sample. Curiously, it was observed that these specimens were placed on the shell of *B. epidauricus* (Fig. 34). Many times, we took off the specimens of *O. microeques* from the shells of *B. epidauricus*, but immediately, they looked for another specimen to go up it again. In oposition, they rejected the shells of other species that lived in the same habitat. This convinced us that *O. microeques* parasites *B. epidauricus*.

The closest species to *O. microeques* is *Odostomia megerlei* (Locard, 1886), but the latter is clearly bigger (see comments in PEÑAS AND ROLÁN, 1999).

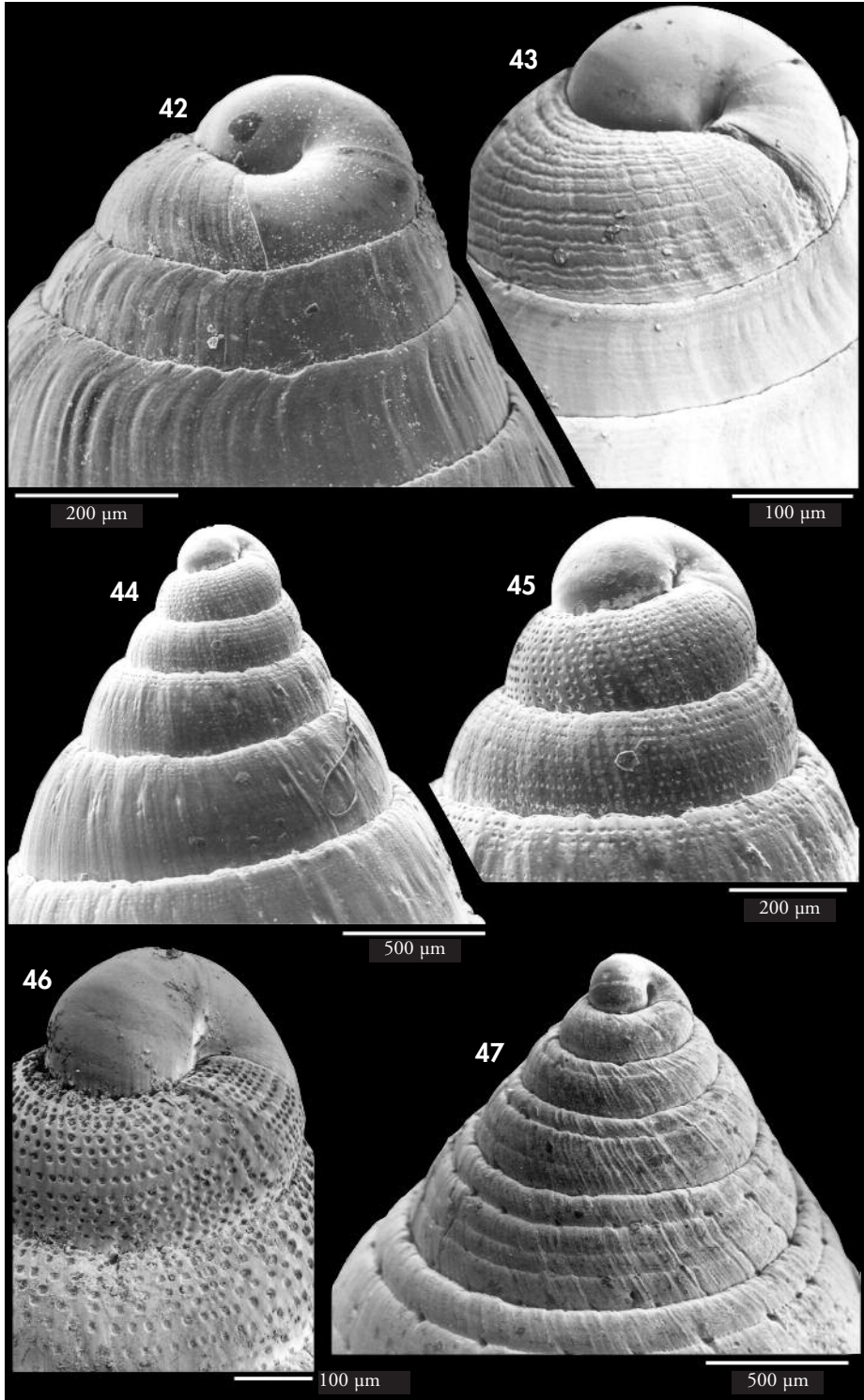
Family ELLOBIIDAE Pfeiffer, 1854

Ovatella aequalis (Lowe, 1832) (Figs. 38-41)

Material studied: 260 specimens from Madeira.

(Right page) Figures 42-47. Protoconchs of some European species of Ellobiidae. 42: *Auriculinea bidentata*, Cies Islands; 43: *A. bidentata*, Almería; 44-45: *Myosotella myosotis*, Cies Islands; 46: *M. myosotis*, Almería; 47: *Ovatella firminii*, Cies Islands.

(Página derecha) Figuras 42-47. Protoconchas de algunas especies europeas de Ellobiidae. 42: *Auriculinea bidentata*, Islas Cies; 43: *A. bidentata*, Almería; 44-45: *Myosotella myosotis*, Islas Cies; 46: *M. myosotis*, Almería; 47: *Ovatella firminii*, Islas Cies.



Description: Shell (Fig. 38) oval-conic, elongated, somewhat solid, brown. Protoconch (Figs. 39-40) smooth, with about one whorl. Teleoconch of about 6 whorls. Body whorl about 70% of the total height. First whorls with fine spiral striation and narrow and spaced prosocline axial ribs. There is a deep subsutural furrow in which sharp periostracal hairs inserted at each axial rib. Suture not depressed. Aperture oval-elongated with two columellar folds and two prominent parietal teeth. Animal whitish to pale-yellowish. Radula (Fig. 41) with many teeth, all quite similar, disposed in rows.

Habitat: Below and under cobbles of middle size, in humid places, not close to the sand layer.

Remarks: MARTINS (1995, 1999) has compared the Açorean *O. vulcani* (Morelet, 1860) with the Mediterranean *O. firminii* (Payraudeau, 1826) and the Madeiran *O. aequalis*, concluding for the recognition all of them as valid species, often previously considered as synonyms. According to this author, the sculpture of the protoconch and the first whorls of the teleoconch seems to be very important as specific characters in this group. To show the differences with other close European species we present the protoconchs of *Myosotella myosotis* (Draparnaud, 1801) (Figs. 44-46) from Cies Islands and Almería, and *Ovatella firminii* (Payraudeau, 1826) (Fig. 47) from the Cies islands.

Auriculinella bidentata (Montagu, 1808) (Figs. 42, 43, 48-50)

Material studied: 39 specimens from Madeira; 21 from Almería; 12 from Ribadeo; 15 from Cies Islands.

Description: Shell (Fig. 48) oval-conic elongated, smooth, whitish, with blunt apex, very similar to the European populations studied. Protoconch (Figs. 42, 43, 49, 50) smooth with about half whorl. The teleoconch begins with axial prosocline striation which cross fine spiral threads. This sculpture almost disappears in subsequent whorls. Aperture oval, elongated with a prominent parietal tooth and a curved columellar fold below.

Animal white, sometimes with small dark areas at the tip of the cephalic tentacles.

Habitat: Found amongst and under cobbles of middle size, in humid places.

Remarks: The specimens from Madeira are almost identical to the European populations examined, showing the specimens from Almería the typical sculpture of the first whorl of the teleoconch (Figs. 49-50), and being less evident in the shells of the Cies Islands (Fig. 42). This species widespread from the British Isles to the Mediterranean, Azores and Madeira.

Pedipes pedipes (Bruguière, 1789) (Figs. 32, 51-54)

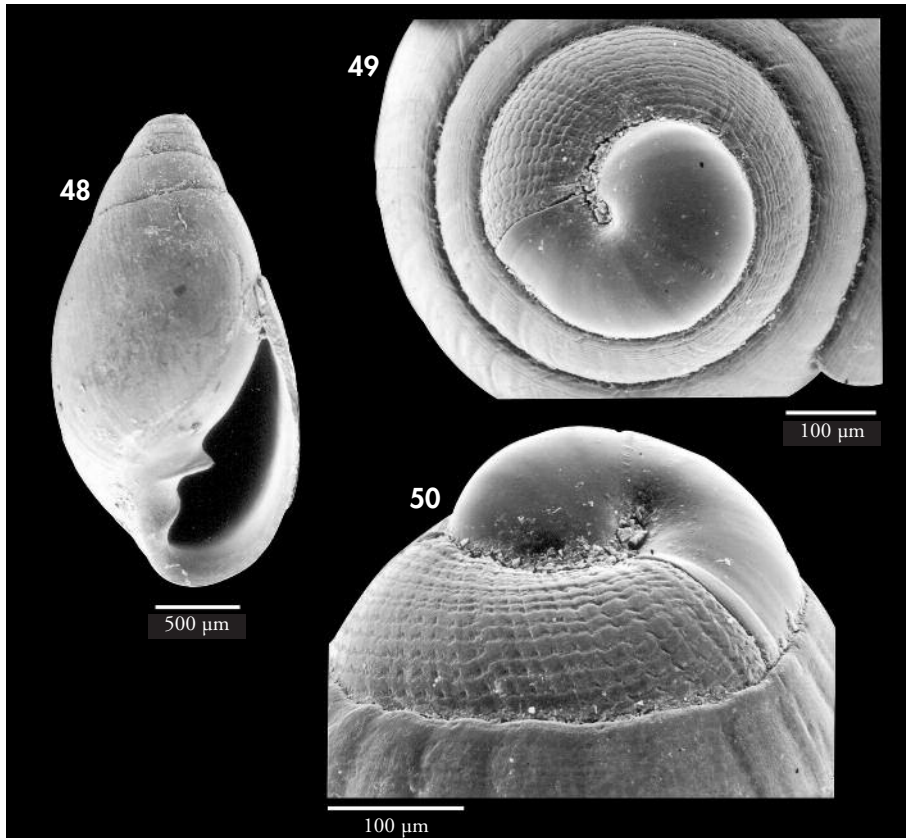
Pedipes afer (Gmelin, 1791)

Material studied: 5 specimens from Madeira.

Description: Shell (Fig. 51) globose, solid, brown, with low spire and very large body whorl, that averaging near the 90% of shell length. Protoconch (Figs. 52-54) very small, with less than one whorl. The teleoconch begins with spiral and prosocline axial sculpture, the later disappearing in the following whorls. Aperture

ovate, widely rounded at base, about 70% of the length of body whorl. There are two strong columellar teeth, and one strongest parietal tooth very elongated.

Animal (Fig. 32) white with grey pigmentation towards the tip of the cephalic tentacles. Anterior part of the foot bilobulated by a central incision. Snout



Figures 48-50: *Auriculinnella bidentata*, Madeira. 48: shell; 49-50: protoconch.
 Figuras 48-50: *Auriculinnella bidentata*, Madeira. 48: concha; 49-50: protoconcha.

short and cephalic tentacles contractile, somewhat elongated when extended.

Habitat: Found amongst boulders in the upper level of the collecting site.

Remarks: This species is known from Azores, Madeira, Canary, Cape Verde and São Tomé Islands (FERNANDES AND ROLÁN, 1993; ÁVILA, 2000).

Pseudomelampus exiguus (Lowe, 1832) (Figs. 31, 55-57)

Material studied: 2 specimens from Madeira; 12 from Almería; 20 from Ribadeo.

Description: Shell (Fig. 55) ovoid, solid, pinkish-brown, body whorl more than 90% of total shell height. Protoconch (Fig. 56) smooth, heterostrophic, with its spiral axis perpendicular to the axis of the shell, and partly covered with first whorl of teleoconch. Microsculpture of irregular spiral striae (Fig. 57). Aperture elongate with one columellar tooth and

two parietal theeth. Animal (Fig. 31) whitish, foot bilobulated anteriorly, cephalic tentacles short, somewhat flattened, with the eyes in the middle of their bases.

Habitat: Found amongst big stones in the upper part of the bottom.

Remarks: The lectotype of this species was figured by MARTINS (1996, fig. 180), being Madeira the type locality.

Family KELLIIDAE Forbes and Hanley, 1848

Lasaea rubra (Montagu, 1803)

Material studied: 2 specimens from Madeira; more than 200 specimens in Cies Islands.

Remarks: *L. rubra* is an extremely common species, frequently associated with some of the previously mentioned

species in other areas, sometimes in high number. In the studied community its presence was scarce.

DISCUSSION

The under-boulder molluscs assemblage studied in a protected place of the upper level of the tide and its distribution in different levels in Madeira has some resemblance with that described by MORTON (1975) in New Zealand (dominated by species of Ellobiidae, Assimineidae and Caecidae). Four of the fourteen species we found clearly dominated in this habitat in Madeira. *Botryphallus epidauricus* in the lowest level, on the sand under rocks, *Paludinella littorina* in a somewhat higher layer, amongst small stones in contact with sand. *Ovatella aequalis* and *Assimineea cf. grayana* dominated in an upper level, under boulders without contact with sand. Other species frequent in this habitat were *Caecum armoricum*, *Truncatella subcylindrica* and *Odostomia microeques* in the same layer that *B. epidauricus*, and *Auriculinea bidentata*, living together with *Paludinella littorina*. The other species found were scarce. The ellobids *Pedipes pedipes* and *Pseudomelampus exiguus*, and the littorinids *Littorina striata* and *Melaraphe neritoides* are typical supralittoral species, which sometimes can be found in the highest level of the habitat studied. *Lasaea rubra* is very common in tufts of coralline algae and lichens (*Lichina* sp.) high in the intertidal zone and only isolated specimens can be found in boulder beach (BULLOCK ET AL., 1990). Last,

Caecum clarkii prefer lower shore (mid-littoral or sublittoral) but is capable of penetrating the upper levels when conditions are favourable (PONDER, 1990).

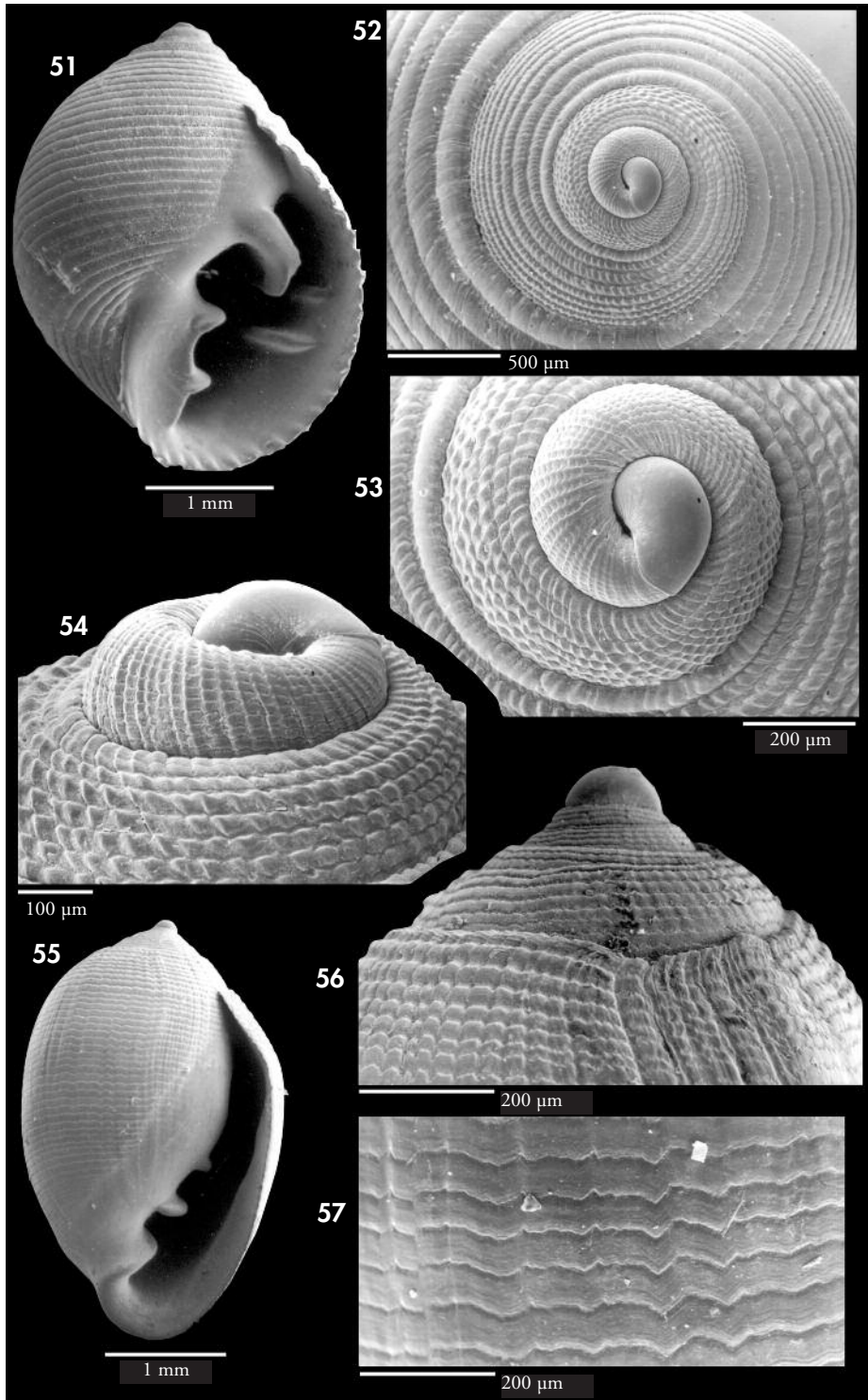
Only two of the species found are apparently endemic of Madeira: *Ovatella aequalis* and *Odostomia microeques*. The latter might be present in other areas where its host occurs, but it might be over looked due its minute size (smaller than 1 mm). *Ovatella aequalis* is replaced by its related species *Myosotella myosotis* (Draparnaud, 1801) in the European coasts and by *O. vulcani* (Morelet, 1860) in Azores. All the other species, but *Littorina striata* and *Pedipes pedipes*, are also present in the European mainland, both in the Atlantic and Mediterranean coasts. Ten of the species found in Madeira occurs also in Azores and eight in Canary Islands.

The most abundant species, *Botryphallus epidauricus*, widespread along the Atlantic and Mediterranean coasts of Europe and also in Canary Islands. It is replaced in Azores (northward) and in Cabo Verde Island (southward) by the related species *B. ovummuscae* and *B. tuber*, respectively.

PONDER (1990) studied a similar habitat in the Strait of Gibraltar, but in a somewhat lower level. He studied an intertidal gravel beach at Ceuta, and its upper level coincides with the lowest one studied by us. In both localities (Funchal

(Right page) Figures 51-54. *Pedipes pedipes*, Madeira. 51: shell; 52-54: protoconch. Figures 55-57: *Pseudomelampus exiguus*, Madeira. 55: shell; 56: protoconch; 57: microsculpture.

(Página derecha) Figuras 51-54. *Pedipes pedipes*, Madeira. 51: concha; 52-54: protoconcha. Figuras 55-57: *Pseudomelampus exiguus*, Madeira. 55: concha; 56: protoconcha; 57: microescultura.



in Madeira, and Ceuta in the Strait of Gibraltar) this level is dominated by the same species: *Botryphallus epidauricus*.

The small molluscs found in this peculiar habitat in Madeira seem to form a distinctive ecological grouping which have close parallels in European/North African mainland and in other Macaronesian Islands. Some species of this grouping are present in this habitat in all areas of the temperate NE Atlantic, and other are replaced by close related species according to the geographical area.

The species found in this habitat in Madeira and in some localities of the Spanish coasts (Ribadeo and Cies Islands, NW Spain, and Los Escullos, SE Spain) are included in Table II. Four species have been found in this habitat in all localities sampled: *P. littorina*, *T. subcylindrica*, *A. bidentata* and *P. exiguus*. In Madeira this molluscan assemblage is particularly diverse. Six of the species found here, including the two endemic of Madeira, were not found in the other localities sampled. Some of them are present in these localities, but they did not find in this habitat. The more remarkable peculiarity of this molluscan assemblage in Madeira is the presence of an parasitic pyramidellid gastropod (*O. microeques*). In contrast, only two of the species collected in this habitat in

the Spanish coasts were not found in Madeira: *Littorina saxatilis* (Olivier, 1792) and *Cingula trifasciata* (J. Adams, 1800). The former is not typical of this habitat but it can be found sometimes in the upper part of big boulders in the Atlantic European mainland. *C. trifasciata* is quite common beneath large boulders in shaded, stable places in other areas (PONDER, 1990), including Azores Islands (ÁVILA, 1998), but it was not present in the samples taken in Madeira.

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