



Early Jurassic (Sinemurian) gastropods from the Lusitanian Basin (west of Portugal)

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Vitón, Í., Comas-Rengifo, M.J. & Paredes, R. 2020. Early Jurassic (Sinemurian) gastropods from the Lusitanian Basin (west of Portugal). [Gasterópodos del Jurásico Inferior (Sinemuriense) de la Cuenca Lusitánica (oeste de Portugal)]. *Spanish Journal of Palaeontology*, 35 (2), 147-166.

Manuscript received 17 December 2019

<https://doi.org/10.7203/sjp.35.2.18478>

Manuscript accepted 7 March 2020

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ABSTRACT

The Sinemurian gastropod specimens herein studied come from two sources: from museum collections and from samplings in field. The study of the Sinemurian gastropod specimens housed in the collections of the Museu Geológico (Laboratório Nacional de Energia e Geologia), Museu Nacional de História Natural e da Ciência (University of Lisbon), Museu da Ciência (University of Coimbra) and of the Museu de História Natural e da Ciência (University of Porto), has allowed the systematic and taxonomical update of this material. These specimens come mostly from Sinemurian outcrops in S. Pedro de Moel area and Coimbra region, and were collected by Paul Choffat and collaborators in the geological field works in relation to the cartography of the Portuguese Geological Map in 1887 and 1903. The review of these collections permitted to recognise original material that was used to describe several characteristic species of the Lusitanian Basin, namely *Scurriopsis (Scurriopsis) schmidti*, *Cryptaenia* sp., *Nerinella ficalhoi*, and *Boehmiola exilis*.

The study of the specimens sampled in field has allowed confirming the origin and stratigraphic position of those specimens collected by Choffat. This sampling was carried out in materials of Coimbra and Água de Madeiros formations

RESUMEN

Los ejemplares de gasterópodos del Sinemuriense aquí estudiados proceden, por una parte de colecciones de museo, y por otra del muestreo en campo. El estudio de los ejemplares albergados en las colecciones del Museu Geológico (Laboratório Nacional de Energia e Geologia), Museu Nacional de História Natural e da Ciência (Universidade de Lisboa), Museu da Ciência (Universidade de Coimbra) y del Museu de História Natural e da Ciência (Universidade de Oporto), ha permitido la actualización sistemática y taxonómica de este material. Estos ejemplares proceden principalmente de los afloramientos del Sinemuriense del área de S. Pedro de Moel y de la región de Coimbra, y fueron recolectados por Paul Choffat y sus colaboradores en 1887 y 1903 como parte de los trabajos de campo para la cartografía del Mapa Geológico Portugués. En la revisión de estas colecciones, se ha encontrado el material original que fue usado para la descripción de varias especies características de la Cuenca Lusitánica, *Scurriopsis (Scurriopsis) schmidti*, *Cryptaenia* sp., *Nerinella ficalhoi* y *Boehmiola exilis*.

El estudio de los ejemplares procedentes del muestreo en campo, ha permitido confirmar el origen y la posición estratigráfica de estos ejemplares recolectados por Choffat.

(*Obtusum* and *Oxynotum* chronozones) cropping out in S. Pedro de Moel, Praia Polvoeira, and Praia Pedra do Ouro.

A total of 386 specimens have been studied, 266 have been assigned to 14 taxa of 14 families, 13 genera and 8 species. Most of these taxa belong to the subclass Caenogastropoda (61.31% of the specimens), to the order Allogastropoda (30.66%), and the superfamilies Campaniloidea (28.83%) and Nerinoidea (20.8%). The most common species are endemic of the Lusitanian Basin, namely *Pseudomelania costae* Pictet & Campiche, 1862 and *Oonia casta* Böhm, 1901. Other species are known in Germany, Luxembourg and Austria basins.

Keywords: Systematics, S. Pedro de Moel, Coimbra, *Obtusum*, *Oxynotum*.

Este muestreo fue realizado en los materiales de las formaciones Coimbra y Água de Madeiros (cronozonas *Obtusum* y *Oxynotum*), que afloran en S. Pedro de Moel, Praia Polvoeira y Praia Pedra do Ouro.

Se han estudiado un total de 386 ejemplares, de los cuales 266 han sido asignados a 14 taxones de 14 familias, 13 géneros y 8 especies. La mayoría de estos taxones pertenecen a la subclase Caenogastropoda (61,31% de los ejemplares), al orden Allogastropoda (30,66%), y a las superfamilias Campaniloidea (28,83 %) y Nerinoidea (20,8%). Los taxones más frecuentes son endémicos de la Cuenca Lusitánica, como *Pseudomelania costae* Pictet y Campiche, 1862 y *Oonia casta* Böhm, 1901. Otros taxones determinados se han reconocido también en cuencas de Alemania, Luxemburgo y Austria.

Palabras clave: Sistemática, S. Pedro de Moel, Coimbra, *Obtusum*, *Oxynotum*.

1. INTRODUCTION

Portuguese Sinemurian gastropods, and Lower Jurassic ones in general, were studied mainly in the early 20th century as part of regional geological publications (Sharpe, 1850a; Choffat, 1903; Hallam, 1971) or fossil atlases (Böhm, 1901; Mouterde & Rocha, 1981). Hallam (1971, p. 255) wrote: “the few [gastropod] species that occur in Portugal are widely distributed forms that call for no special comment, but *Nerinea*”. Few recent studies of the Lusitanian Basin gastropods have been conducted, and none based upon a detailed stratigraphic analysis, although new species are described in Sharpe (1850a), Böhm (1901) and Choffat (1903), and some of them, such as *Boehmiola exilis*, have been used as guide fossils (Choffat, 1903).

In the last few years, gastropod faunas from other Lower Jurassic European basins have been published, mainly in Germany (Gründel, 2003, 2007a, 2007b, 2010; Nützel & Gründel, 2015; Schubert *et al.*, 2008), Austria-Hungary (Szabó, 2008a, 2016), England (Gründel *et al.*, 2011; Todd & Munt, 2010) and Italy (Conti *et al.*, 2004; Fischer *et al.*, 2002; Gatto & Monari, 2010; Szabo *et al.*, 2019). Researches about faunas from France (Gatto *et al.*, 2015), Luxembourg (Monari *et al.*, 2011) and Turkey (Okan & Hosgör, 2007), and other non-European countries, such as Argentina (Damborenea & Ferrari, 2008; Ferrari, 2009, 2013, 2014; Ferrari *et al.*, 2014) have also been published. This work aims to provide taxonomical update of the Sinemurian gastropods of the Lusitanian Basin.

2. GEOLOGICAL AND GEOGRAPHICAL CONTEXTS

The Sinemurian in the Lusitanian Basin (LB, W Portugal) crops out in three main geographical areas: S. Pedro de Moel, the outskirts of Coimbra and Peniche (Fig. 1). Due to anthropic changes in the landscape, the outcrops on the outskirts of Coimbra are no longer accessible as they were 100 years ago and the specimens in museum collections are therefore the most available source of palaeontological and geological information for this area.

Most of the gastropods studied were collected from the central-coastal region of the basin (Fig. 1). S. Pedro de Moel (Leiria district, Extremadura province) is the nearest reference location, in which two areas can be distinguished and summarised as North and South. The most complete and representative Sinemurian successions of the LB (Comas-Rengifo *et al.*, 2013) crop out in these areas. In the North, Penedo do Cabo (SPM) section, between Praia Velha (PV) and Praia da Concha, 600 m north of Penedo da Saudade lighthouse, shows the lower part of the Coimbra Formation (Fm.), *Obtusum* chronozone (Fig. 2), which is represented as unit D in Azêredo *et al.* (2010; fig. 3). In the south, 3.5 km from S. Pedro de Moel, lies Praia Pedra do Ouro (OU) and Praia da Polvoeira (PO) sections; they both show the upper part of *Obtusum* chronozone and lower part of *Oxynotum* chronozone (Fig. 2).

A continuous carbonate succession crops out from PV to PO, which represents three second-order transgressive-regressive subcycles (Azerêdo *et al.*, 2010, 2014; Comas-Rengifo *et al.*, 2013; Duarte *et al.*, 2008; Paredes *et al.*, 2016). The materials containing gastropods are in a transgressive subcycle with a maximum flood event in the Água de Madeiros Fm.

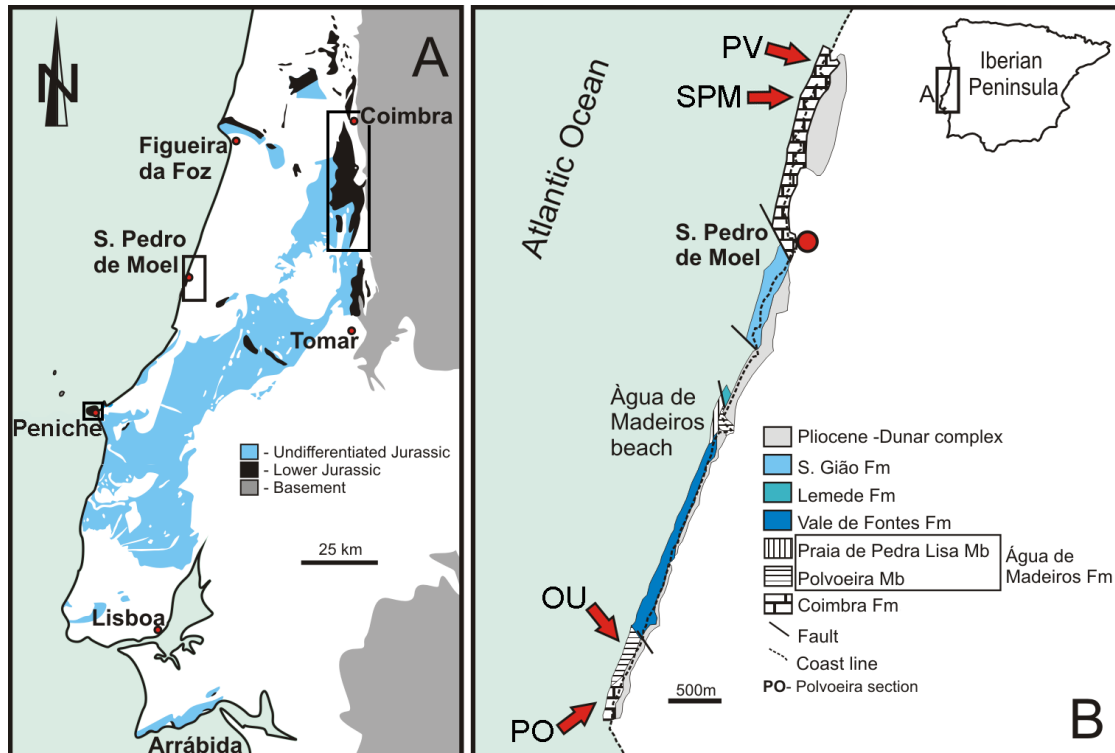


Figure 1. a) Geographical situation of the Jurassic outcrops studied in S. Pedro de Moel, Coimbra and Peniche. b) Detail of the S. Pedro de Moel area within a geological context. Modified from Duarte *et al.* (2008).

Azêredo *et al.* (2010, 2014) subdivided the Penedo do Cabo sedimentary succession into several lithological units. Five big limestone samples named SPM and PV were studied (Figs 2-3), coming from the lower part of unit D (Azêredo *et al.*, 2010, 2014), where bivalves are rare and small, and gastropods are common. Unit D is characterised by 25 m of limestones and marl-limestones alternating in layers of variable thickness, with marl interbeds that become increasingly thicker towards the top. The materials are highly bioturbated and the most frequent macrofossils are gastropods, bivalves and echinoderms. The gastropods and bivalves do not show a prevalent orientation, nor a homogeneous distribution, and show a medium level of fragmentation, with some specimens almost complete and others very fragmented. Fossils are concentrated in the lower part of almost every layer. The material studied comes from between layers 311 and 323 of Azêredo *et al.* (2010, 2014), which Dommergues *et al.* (2010) dated as upper Sinemurian, *Obtusum* chronozone. Layer 322 is the richest in fossils.

Two taphofacies (*sensu* Fernández-López, 2000) can be described in unit D (Fig. 4). Taphofacies type 1 is characterised by mudstone with evidence of rapid burial and a high sedimentation rate, where the gastropod specimens are found partially infilled with sediment and recrystallized. Taphofacies type 2 is characterised by a wackestone-packstone, associated with slow burial and a

low sedimentation rate. Gastropods are usually found as inner moulds, although complete shells are also present in some layers showing few traces of re-sedimentation, with the presence of articulated skeletons of echinoderms.

The sediments of the upper part of the Coimbra Fm. (around 25 m) and the lower part of the Água de Madeiros Fm. (Polvoeira Mb.) crop out to the south of S. Pedro de Moel, between PO and OU (Figs 1, 5). They were studied by Duarte *et al.* (2010), Paredes (2012), and Paredes *et al.* (2013, 2016) in relation to benthic associations. The gastropods studied herein were collected bed by bed. The lower part of the section is represented by limestones, sometimes bioclastic, marl-limestones and marlstones with some layers of black shales (high level of organic matter). As from the layer PO122, and all along the Água de Madeiros Fm., an increase in marl and black layers can be observed which, according to Paredes *et al.* (2016), coincides with the beginning of a transgressive cycle. This also coincides with an increase in the diversity of brachiopods, bivalves and gastropods (Fig. 5).

The Coimbra Fm. outcrops from the northern area of the LB, where some specimens of the Portuguese Geological Services come from, is often represented by dolomitic series; thus the gastropods are badly preserved. At present, these outcrops are not always visible because covered by vegetation and new buildings.

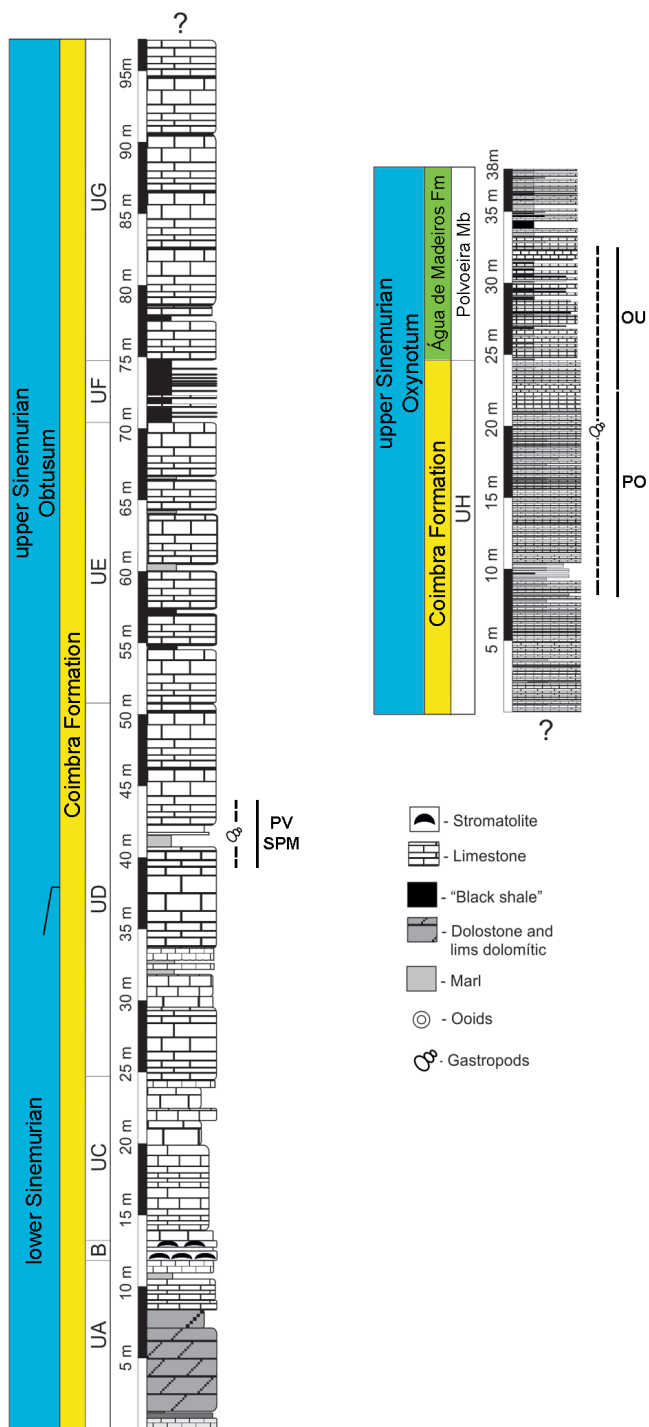


Figure 2. Composite stratigraphic log of the S. Pedro de Moel (SPM) region outcrops of Coimbra Fm. and Polvoeira Mb. (Água de Madeiros Fm). Lower Jurassic outcrops, between Praia Velha (PV) and Praia da Polvoeira (PO). Modified from Duarte *et al.* (2012). UA–UH: stratigraphic units defined by Azerêdo *et al.* (2010).

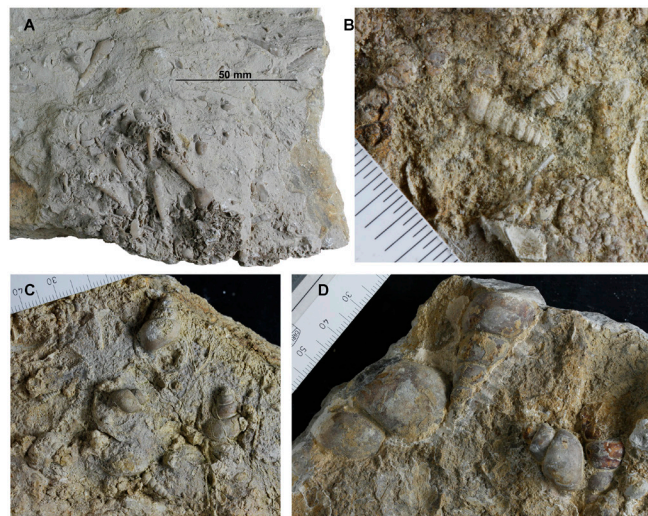


Figure 3. Examples of the diversity of Sinemurian gastropods from the S. Pedro de Moel area. **a)** SPM, Penedo do Cabo. **b-d)** PV, Praia Velha: **(b)** PV322b_1; **(c)** PV322b_2; **(d)** PV322mt. Photos: C. Alonso.



Figure 4. Examples of taphofacies recognised in Praia Velha (PV) outcrop. **a)** Levels 311 to 378, the hammer is on bed 322. **b)** Taphofacies type 1. **c)** Taphofacies type 2, inner mould. **d)** Taphofacies type 2, shell preserved. Scale in **(b-d)** is in centimetres. Photos: R. Paredes.

3. MATERIAL AND METHODS

Five museum collections were accessed for the present paper: the Museu Geológico de Portugal (SGP), the Museu Nacional de História Natural e da Ciência (MUHNAC), the LNEG Archive (Alfragide), the Museu da Ciência – Universidade de Coimbra (MCUC.MIN), and the Museu de História Natural e da Ciência – Universidade do Porto (UP).

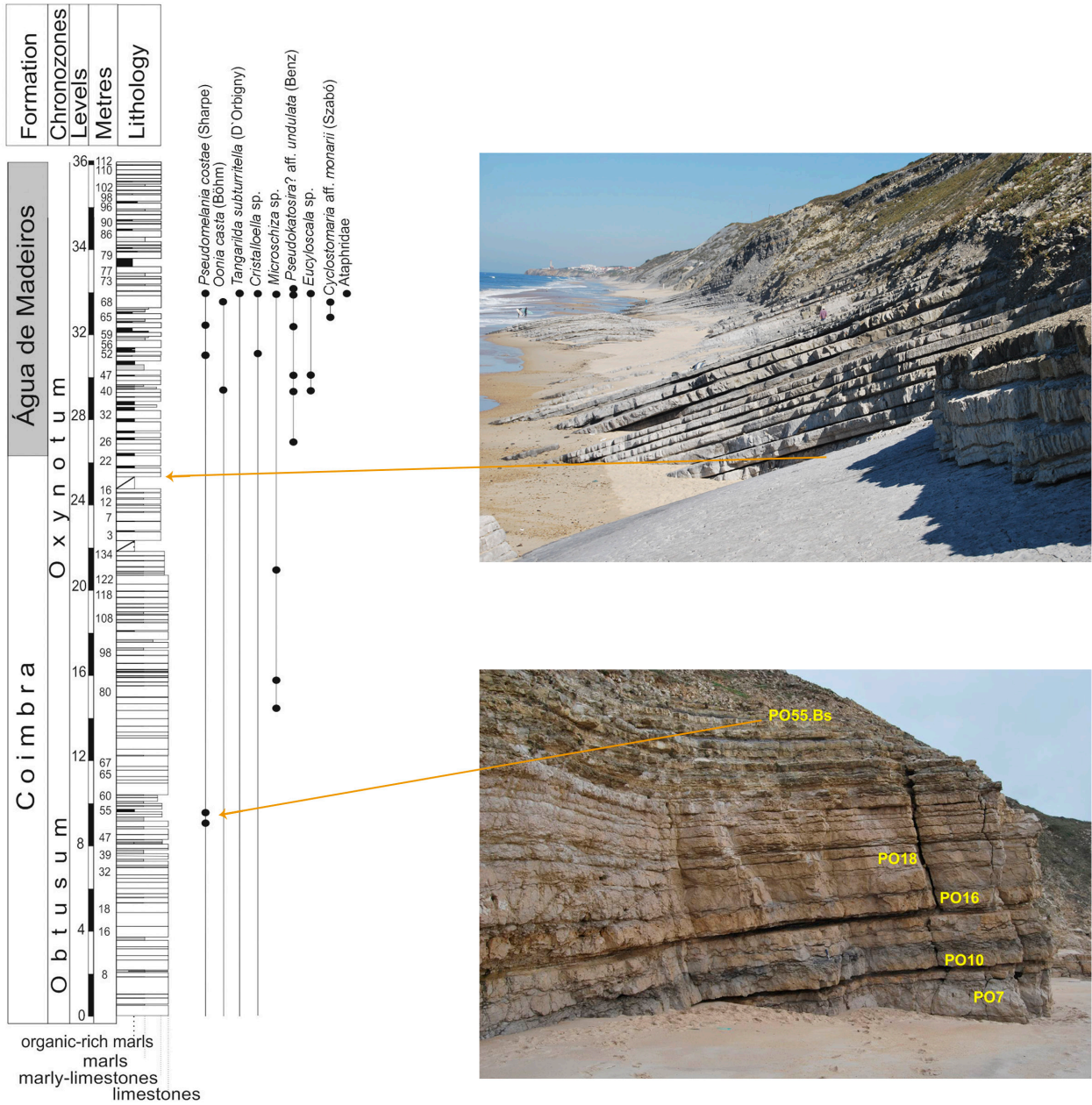


Figure 5. Stratigraphic log of the Praia Polvoeira beach (PO) and Praia Pedra do Ouro beach (OU) sections with the stratigraphic gastropod distribution. Modified from Duarte *et al.* (2012). Photos: R. Paredes.

MHNFCP). In addition, a detailed bed by bed sampling in S. Pedro de Moel was performed in the Penedo do Cabo outcrop (SPM and PV), at Praia Pedra do Ouro (OU) and at Praia Polvoeira (PO). The museum collection specimens come from the S. Pedro de Moel region and from the outskirts of Coimbra; furthermore, one specimen come from Peniche (Table 1; [Supplementary Information](#)).

In the SGP collection, the original catalogue numbers of the specimens have been kept. In addition, new official numbers (from SGP31700 to SGP31889) have been introduced for the other specimens collected in 19th–20th century lacking a catalogue number. At the

MUHNAC, the numbers are provisional, because the specimens studied have not yet been catalogued. The alphanumeric abbreviation refers to the drawer row and the following number refers to the drawer number in the storage organization of the collection. Choffat and his collectors also collected the specimens with the acronym MCUC.MIN and UP.MHNFCP thereafter referred. That material was originally housed in the SGP collection. Afterwards, some duplicates were sent in 20th century to Lisbon, Coimbra (in 1925) and Porto Universities, for Palaeontology teaching purposes where geology and palaeontology were introduced as new disciplines.

Table 1. Relation of fossil localities and number of identified specimens in the museum collections.

| Area | Locality | SGP | MCUC | UP.MHNFCP | MUHNAC |
|------------------|--------------------------------|------------|-----------|-----------|----------|
| S. Pedro de Moel | Polvoeira (S Água de Madeiros) | 22 | 5 | | |
| | Ninho do Corvo (N do farol) | 8 | 20 | | |
| | Penedo do Cabo (N Pedrianes) | 53 | 28 | | |
| | Praia S. Pedro de Moel | | 6 | | |
| | Undefined | | | 2 | |
| | Coimbra | | 1 | | |
| | Palheira | | 2 | | |
| Coimbra | Monte de Vera | 8 | | | |
| | Volta do Monte | 10 | | | |
| | Alcouce | 1 | | | |
| | Almaroz (Almalaguês) | 11 | | | |
| | Villa Secca / Almaroz | 9 | | | |
| | Miranda do Corvo | 8 | | | |
| Peniche | Peniche | 1 | | | |
| Unknown | | 13 | 3 | | 5 |
| Total | | 147 | 62 | 2 | 5 |

In the present paper we employ the measurements proposed by Gatto & Monari (2010) (Fig. 6), following the terminology used by Cox (1960). The linear measurements were taken with the use of a calliper (Vogel Germany-Electronic Digital Calliper) when possible, and when not, on digital images using the software Adobe Photoshop to 0.1 mm accuracy. The angular measurements were taken with Adobe Photoshop CS6 version 13.0.1. In the Systematic chapter, all the measurements are given in millimetres. Numbers in italics mean that measurement is approximate (*circa*) due to fragmentation or state of preservation. The measurements of taxa are those that better represent the average of all the material studied.

The photos were taken with different cameras (Canon 7D, Nikon D60 and Olympus) and a microscope (Leica MZ16A associated with the software LAS - Leica Application Suite - v3.8). The best-preserved specimens

were coated with magnesium oxide in order to enhance sculpture for photography.

The non-museum collection specimens referred hereafter are housed at the Departamento de Geodinámica, Estratigrafía y Paleontología, Facultad de Ciencias Geológicas, Universidad Complutense de Madrid. The identifying numbers make reference to the levels represent in Figure 5.

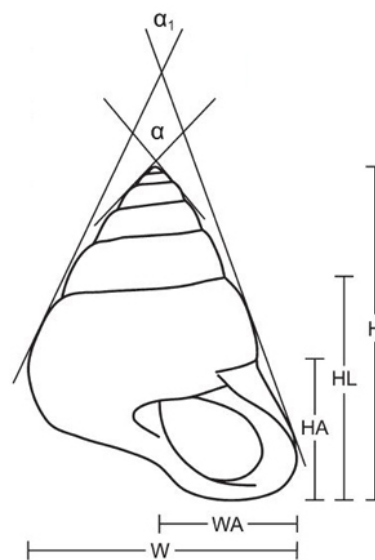


Figure 6. Measured parameters. H: Height of the shell; HL: Height of the last whorl; HA: Height of the aperture; W: Width of the shell; WA: Width of the aperture; α : Apical angle; α_1 : Pleural angle. Modified from Gatto & Monari (2010).

4. SYSTEMATIC PALAEOLOGY

The systematic is based on Bouchet *et al.* (2017), who modified significantly the hierarchical order made by previous authors, hence they “purposely abstained to attribute an author and date to names above superfamily”. Therefore, we will follow their criteria. For some specific issues, Gründel (2001, 2008, 2010) and Conti *et al.* (2004) have been taken into account.

Class GASTROPODA Cuvier, 1795

Subclass PATELOGASTROPODA

Order PATELLIDA

Superfamily **Lottioidea** Gray, 1840

Family **Acmaeidae** Forbes, 1850

Genus *Scurriopsis* Gemmellaro, 1879

Subgenus *Scurriopsis* Gemmellaro, 1879

Scurriopsis (Scurriopsis) schmidti (Dunker, 1844)
(Fig. 7a)

1846 *Patella schmidtii*; Dunker, p. 187.

1855 *Patella schmidtii* Dunker; Terquem, p. 281, Pl. 18, figs. 4 (4, 4a, 4b).

v 1901 *Patella delgadoi* sp. nov.; Böhm, p. 213, Pl. 8, figs. 1-2, Text-fig. 1.

1988 *Scurriopsis schmidtii*; Meier & Meiers, p. 25, Pl. 2, figs. 4a-b.

This species is cited in the Hettangian of Luxembourg, France and Germany.

Subclass VETIGASTROPODA

Order PLEUROTOMARIIDA

Superfamily **Eotomarioidea** Wenz, 1938

Family **Gosseletinidae** Wenz, 1938

Genus *Cyclostomaria* Szabó, 1980

Cyclostomaria aff. *monarii* Szabó, 2008b
(Fig. 12.1)

aff. 2008b *Cyclostomaria monarii* sp. nov.; Szabó, p.174, figs. 4.1-4.7.

Material. 4 specimens: SGP31714, SGP31821?, OU.65, OU.68.11, upper Sinemurian, Oxynotum chronozone.

Description. All of the specimens are cross-sections of a low-spired shell. Last whorl well convex, rounded. Specimen OU68.11 preserves a fragment of shell displaying a moderately wide selenizone that runs slightly above the periphery, and shell ornamented with spiral threads and collabral riblets. The number of threads and riblets cannot be counted because there are not completed whorls. Collabral riblets, irregularly sized and distributed, dominate in the adapical area of the whorl, whereas spiral ones dominate in the abapical region.

Remarks. The morphological characters of these specimens are similar to those described by Szabó (2008b) for *Cyclostomaria monarii* from the Pliensbachian, Margaritatus chronozone of the Bakony Mountains (Hungary). Specimens herein described and *Cyclostomaria monarii* differ in the position of the selenizone, whereas in *C. monarii* it is in a central position, near the mid-line of the whorl surface between the periphery and the adapical suture, in the specimens herein described, the selenizone runs just above the periphery.

Superfamily **Ptychomphaloidea** Wenz, 1939

Family **Ptychomphalidae** Wenz, 1938

Remarks. Some authors, as Gründel (2001), argue that Ptychomphalidae should be in superfamily Eotomarioidea instead of Ptychomphaloidea. Bandel (2009) consider the position in superfamily Ptychomphaloidea because of temporal divergence between the type species of *Eotomaria* (Ordovician) and *Ptychomphalus* (Jurassic), although admitting close similarities between both genera. Bouchet *et al.* (2017) compiled Bandel's position.

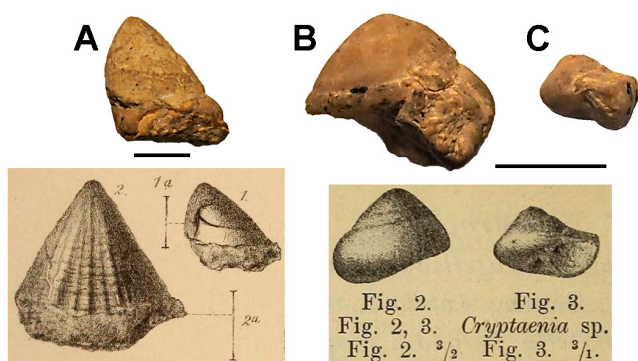


Figure 7. In the lower part of the figure are the original drawings by Böhm (1901) of *Scurriopsis (Scurriopsis) schmidti* (= *Patella delgadoi* in Böhm, 1901) (left) and *Cryptaenia* sp. (right). **a)** *Scurriopsis (Scurriopsis) schmidti*, SGP1283. **b-c)** *Cryptaenia* sp. (**b**) SGP1284(1); (**c**) SGP1284(2). Scale bars = 5 mm. Photos: R. Paredes.

2010 *Scurriopsis (Scurriopsis) schmidti* (Dunker); Gründel, p. 4, Pl. 1, figs. 1-2.

2011 *Scurriopsis (Scurriopsis) schmidti*; Monari *et al.*, p. 352, Fig. 5A-C.

Material. 1 specimen: SGP1283, Sinemurian.

Description. Shell limpet-shaped. The apex is placed anteriorly in relation with the medium axis of the shell length. In lateral view, posterior outline slightly convex and anterior outline straight. Aperture and ornamentation not visible.

Remarks. According to Monari *et al.* (2011), *Patella delgadoi* differs from the material of Luxembourg ascribed by them to *S. (S.) schmidti* only in having a higher shell. Since the other differences could be explained merely by intraspecific variation, these authors let open the possibility that *P. delgadoi* is synonymous of Dunker's species.

Genus *Cryptaenia* Deslongchamps, 1864

Cryptaenia sp.
(Figs 7b-7c)

v. 1901 *Cryptaenia* sp.; Böhm, p. 213, Text-figs. 2-3.

Material. 1 specimen: SGP1284, Sinemurian.

Description. Shell cyrtoconoidal and sublenticular with low spire. Four whorls flat with flush sutures. The last whorls are not complete and the aperture is missing. Ornamentation is not preserved or is lacking. The presence of the selenizone cannot be assessed.

Remarks. According to Böhm (1901) these two specimens could represent two different species. Ferrari (2014) pointed out that *Cryptaenia* is very similar to *Ptychomphalus*. Many species traditionally assigned to the former are currently included in the latter. The specimen described and figured by Böhm (1901), here re-illustrated (Figs 10a-10b), has not been reviewed in any recent publication; thus, further material is required in order to perform an in-depth analysis and to clarify its specific taxonomic position.

The genus *Cryptaenia* has also been cited in the Lower Jurassic (Hettangian-Pliensbachian) of Europe and South America (Ferrari, 2014).

Order SEGUENZIIDA

Superfamily **Seguenzioidea** Verrill, 1884

Family **Eucyclidae** Koken, 1896

Remarks. The systematics of the family Eucyclidae is controversial. Some authors, such as Okan & Hosgör (2007), Szabó (2008a), Monari *et al.* (2011), and Szabó *et al.* (2019) include it in the superfamily Eucycloidea. Others, such as Gründel (2007a), consider that it belongs to the superfamily Trochoidea. Todd & Munt (2010), Ferrari *et al.* (2014), and Ferrari & Kaim (2019) place it in the superfamily Seguenzioidea.

Following Bouchet & Rocroi (2005) and Bouchet *et al.* (2017), the Eucyclidae family is included in the superfamily Seguenzioidea. As Monari *et al.* (2011) and Szabó *et al.* (2019) pointed out, this classification is based upon molecular analysis (Kano, 2008), although there are substantial morphological and anatomical differences between eucyclids and seguenzioids that justify as well its assignation to superfamily Eucycloidea.

Subfamily **Eucycloscalinae** Gründel, 2007a

Genus *Eucycloscala* Cossmann, 1895

Eucycloscala sp.
(Figs 12.2-12.3)

cf. 2007a *Eucycloscala* sp. cf. *brunhuberi* (Schnittmann); Gründel, p. 7, pl. 2, fig. 3.

Material. 15 specimens: SGP (31700, 31708–31713, 31716?), Sinemurian; OU (40.7, 40.8, 40.42, 47.12, 69.2, 69.7, 69.9), upper Sinemurian, Oxynotum chronozone.

Measurements.

| Label | H | HL | HA | W | WA |
|----------|------|------|-----|------|-----|
| SGP31713 | 16.5 | 11.4 | 6.3 | 13.1 | 5.5 |

Description. The specimens partially preserve the shell. The spire is conoidal. The state of preservation does not allow the surface or the outline of the teleoconch to be observed. The peristome is subcircular. A spiral keel, thickened by small nodules, can be observed in the lower part of each whorl at periphery. In the first whorls (the intermediate whorls are not visible in any of the specimens), spiral and collabral ribs intersect, giving to the ornament a mesh-like appearance. On the base both types of ribs are also visible, although the collabrals are thinner.

Remarks. Gründel (2007a) gives a description of *Eucycloscala* cf. *brunhuberi* based on juvenile specimens, from Sinemurian, Obtusum chronozone, of SW Germany. The specimens here described could be similar to this species, but it cannot be assured that they are the same because of the state of preservation.

The SGP specimens are labelled as coming from Polvoeira (Table 1). As Pedra do Ouro is very near, perhaps in the original labels Pedra do Ouro and Polvoeira were considered as one single location and these specimens might also come from the OU40–OU69 layers.

Order TROCHIDA

Superfamily **Trochoidea** Rafinesque, 1815

Family **Ataphridae** Cossmann, 1915

Remarks. Kaim *et al.* (2014) considered *Ataphrus* Gabb, 1869 as *nomen dubium*, because as they pointed out, and Bouchet *et al.* (2017) compiled, the holotype of the type species *Ataphrus crassus* Gabb, 1869 is poorly preserved and both its type locality and age are uncertain. For this reason, they substituted the family name Ataphridae with Collonidae. However, Monari *et al.* (2018) maintained that this view is not justified. According to these authors, although the holotype is imperfectly preserved, it shows all the characters indicated in the original diagnosis and the uncertainty about its origin does

not affect the availability of the taxon. The priority of the family name Ataphridae against Colloniidae is discussed in Conti *et al.* (2004) and Gründel (2008).

Ataphridae indet.
(Fig. 12.4)

Material. 1 specimen: OU.69.10, upper Sinemurian, Oxynotum chronozone.

Measurements.

| Label | H | HL | HA | W | WA | α | α_1 |
|----------|-----|-----|----|-----|----|----------|------------|
| OU.69.10 | 5.6 | 3.7 | – | 5.9 | – | – | 55.7 |

Description. Recrystallized shell. Shell turbiniform with low spire. Four well convex whorls with well impressed suture. The last whorl is not complete and the aperture is missing. Ornamentation is not preserved or is lacked.

Remarks. Due to the scarcity of the material and the poor state of preservation of OU.69.10, we cannot give a more precise taxonomical assignation.

Subclass CAENOGASTROPODA

Family **Pseudomelaniidae** Hoernes, 1884

Genus *Pseudomelania* Pictet & Campiche, 1862

Remarks. According to Kaim (2004), this genus is in doubt due to the fact that the original material of the type species, *Pseudomelania gresslyi* Pictet & Campiche, 1862, is an indeterminable inner mould. Species generally included in this genus have shells with a high, slender spire, not umbilicate, oval-shaped aperture and without ornamentation.

Pseudomelania costae (Sharpe, 1850a)
(Figs 8, 12.5-12.7)

1850a *Rostellaria costae* sp. nov.; Sharpe, p. 193, Pl. 20, fig.1.

v. 1981 *Pseudomelania costae*; Mouterde & Rocha, p. 59, Pl. 2, fig. 4.

Material. 48 specimens: MCUC.MIN (2999–3001, 3032, 3033, 3035, 3066, 3067, 3078–3082), SGP (1016, 1017, 31715, 31727–31731, 31763?, 31774?, 31777, 31778?, 31779–31785, 31787, 31791, 31792, 31841, 31881, 31888), MUHNAC.G2.21.1.1, UP.MHNFCP.154782, UP.MHNFCP.154821, Sinemurian; PO (51, 54.1, 54.2), upper Sinemurian, Obtusum chronozone; OU (52.21, 62.19-5, 69.42-1, 69.56), upper Sinemurian, Oxynotum chronozone.

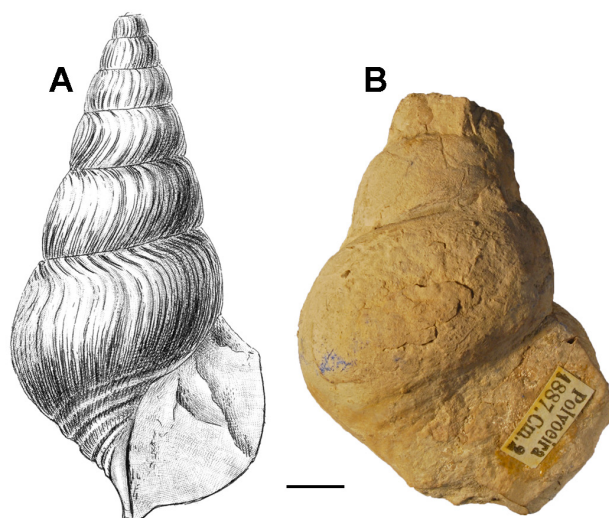


Figure 8. *Pseudomelania costae* specimens. a) Original drawing by Sharpe (1850a). b) Specimen SGP31715 (Polvoeira). Scale bar = 10 mm. Photo: R. Paredes.

Measurements.

| Label | H | HL | HA | W | WA | α | α_1 |
|----------|------|------|------|------|----|----------|------------|
| MIN.2999 | 77.4 | 40.1 | 18.7 | 33.7 | – | 34.3 | 30.2 |
| PO.54.2 | 90.0 | 56.0 | – | 47.0 | – | – | 40.1 |

Description. Inner moulds with variable preservation. Shell moderately high-spined, fusiform. The protoconch is not preserved. The teleoconch displays up to nine whorls, last whorl large. Whorl sides variable from convex initially, to almost flat on later whorls. Suture slightly oblique, impressed. Base round and convex. The aperture is not complete, probably elliptical, higher than wide, but a columellar fold (plait) can be frequently observed. Two-three thick marked spiral cords on base. Opisthocline growth lines and spiral cords on the base.

Remarks. According to Sharpe (1850a) the type material comes from “subcretaceous series at San Pedro de Muriel, near Meirinha Grande”. Afterwards, Mouterde & Rocha (1981) described one specimen from “lower Lotharingian” of S. Pedro de Moel. San Pedro de Muriel is currently named S. Pedro de Moel, and the subcretaceous series must refer to the Lower Jurassic (likely Obtusum chronozone, Sinemurian, as it is inferred from the denomination “lower Lotharingian” by Mouterde & Rocha (1981)) outcrops herein described (Fig. 1).

Superfamily **Pseudozygopleuroidea** Knight, 1930

Family **Zygopleuridae** Wenz, 1938

Subfamily **Zygopleurinae** Wenz, 1938

Genus *Pseudokatosira* Nützel & Gründel, 2007

Pseudokatosira? aff. *undulata* Benz, 1832
(Fig. 12.8)

1832 *Turritella undulata* sp. nov. Benz in Zieten, S. 43, af. 32, fig. 2.

1861 *Chemnitzia undulata* Benz; Stoliczka, p. 163, Pl. 1, fig. 1.

2007 *Pseudokatosira undulata* (Benz, 1830); Nützel & Gründel, p. 62, Pl. 1, figs. 1-6.

2008a *Pseudokatosira?* aff. *undulata*; Szabó, p. 91, figs. 84A-B, J-K.

2010 *Pseudokatosira undulata* (Benz); Todd & Munt, p.162, Pl. 24, fig. 2.

2015 *Pseudokatosira undulata* (Benz, 1832 in Zieten); Nützel and Gründel, p. 16, Pl. 8, figs. A-E.

Material. 31 specimens: SGP (31701–31707, 31824, 31835, 31887), Sinemurian; OU (26.21, 26.40, 40.1, 40.2, 40.4, 40.10, 47.1, 47.2, 47.4, 62.1, 62.2, 62.3, 62.4, 62.5, 62.6-1, 62.6-2, 62.19-3, 69.3, 69.4, 69.35, 71), upper Sinemurian, Oxynotum chronozone.

Measurements.

| Label | H | HL | HA | W | WA | α | α_1 |
|---------|------|-----|-----|-----|----|----------|------------|
| OU.40.1 | 18.5 | 5.5 | 2.2 | 5.1 | – | 30.5 | 15.6 |
| OU.62.1 | 16.4 | 5.7 | 3.2 | 5.5 | – | 40.3 | 17.6 |

Description. Some specimens preserve the shell. The protoconch is not preserved. The teleoconch has ten whorls, with slightly convex flanks and a slightly impressed suture. The base is round. The peristome is continuous and elliptical, with an angular adapical border. Collabral ornamentation is represented in every whorl by opisthocyrt continuous and closely set ribs. The number of ribs cannot be established because the specimens are embedded in the matrix. Specimens OU40.1 and OU40.10 possess up to 11 ribs, which enables an estimation of between 13 and 18 ribs per whorl.

Remarks. Hallam (1971) quoted the presence of the genus *Katosira* in S. Pedro de Moel, Oxynotum chronozone, although neither description nor figure is available; however, he is likely referring to this species. Szabó (2008a) cited this species in the upper Sinemurian, Oxynotum chronozone of the Austrian Alps.

The specimens SGP31701-31706 preserve the original labels, which indicate that these specimens come from Polvoeira locality. As Pedra do Ouro is very near, perhaps in the original labels Pedra do Ouro and Polvoeira were considered as one single location and the specimens

SGP31701-31706 might also come from the OU26 to OU71 layers. The original location of specimen SGP31835 is Palheira, an inner outcrop nearby Coimbra.

Superfamily **Campaniloidea** Douvillé, 1904

Family **Ampullinidae** Cossmann, 1919

Genus *Oonia* Gemmellaro, 1878

Remarks. The genus is assigned to family Ampullinidae following Bouchet *et al.* (2017) and Gründel (2001), although this family is under review (Gründel & Kaim, 2006; Kaim, pers. comm. 2018).

Oonia casta Böhm, 1901
(Figs 12.9-12.12)

1901 *Oonia casta* sp. nov.; Böhm, p. 221, Pl. 8, figs. 7-8.

Material. 79 specimens: MCUC.MIN (3003, 3005–3010, 3012–3015, 3017, 3018, 3021–3025), SGP (31722, 31723, 31736, 31742, 31745, 31746, 31750–31753, 31757, 31760–31762, 31764, 31765, 31788–31791, 31793?, 31794–31797, 31799–31803, 31825–31829, 31832, 31848–31857, 31869–31878), MUHNAC.G2.21.1.2, MUHNAC.G2.21.1.3, MUHNAC.G2.21.2, Sinemurian; OU (40.41, 68), upper Sinemurian, Oxynotum chronozone.

Measurements.

| Label | H | HL | HA | W | WA | α | α_1 |
|----------|------|-----|-----|-----|-----|----------|------------|
| MIN.3012 | 12.5 | 8.6 | 5.3 | 7.7 | 4.4 | – | 46.5 |
| MIN.3018 | 9.5 | 6.7 | – | 5.8 | – | 72.1 | 55.4 |

Description. The shell is preserved in some specimens. Shell moderately high turbiniform. The teleoconch has seven whorls with convex sides. Suture well-marked, almost straight. Base round and convex. Peristome is usually incomplete, but the aperture shape can be defined as oval. No ornamentation is observed. Prosocline growth lines.

Remarks. The morphological characters and dimensions are very similar to those described by Fischer *et al.* (2002) as *Pseudomelania* (*Oonia*) *turgidula* (Gemmellaro, 1878) from the lower Sinemurian of Monte Cucco (Italy). However, *P. turgidula* has much less convex whorls with less impressed suture, and the whorls, especially the last one, are higher than *O. casta*. Moreover, Gemmellaro (1878, p. 156) notes in the original diagnosis that the columellar lip is covered by a thin callus. This feature cannot be observed in the specimens described herein.

As both *P. costae* and *O. casta* are species with a significant number of specimens, we have considered the

elaboration of morphometric comparisons between both species. As it was expected, both species are represented as two different groups in PCA analysis (Fig. 9), mainly explained by H and HL measurements.

Order NEOGASTROPODA

Family **Purpurinidae** Zittel, 1895

Remarks. Gründel (2003) assigned this family to superfamily Purpurinoidea. Nevertheless, Bouchet *et al.* (2017) did not recognise this superfamily.

Genus *Microschiza* Gemmellaro, 1878

Microschiza sp.
(Figs 12.13-12.14)

cf. 1855 *Littorina clathrata* Deshayes; Terquem, p. 250, Pl. 14, fig. 4.

cf. 1909 *Littorina semiornata* Münster; Brösamlen, p. 252, Pl. 19, figs. 47-48.

cf. 1988 *Microschiza clathrata* Deshayes; Meier & Meiers, p. 42, 47, Pl. 8, fig. 28 a-b, Text-Fig. 7.

cf. 2003 *Microschiza semiornata* (Münster); Gründel, p. 28, Pl. 7, figs. 2-3.

Material. 10 specimens: MCUC.MIN.3011, SGP (31719, 31734, 31737, 31820?, 31842), Sinemurian; PO (77.1, 84), upper Sinemurian, Obtusum chronozone; PO.128.12, OU.69.6, upper Sinemurian, Oxynotum chronozone.

Measurements.

| Label | H | HL | HA | W | WA |
|----------|------|------|-----|------|-----|
| SGP31719 | 19.9 | 13.4 | 7.6 | 12.7 | 6.5 |

Description. Teleoconch with five whorls. Whorls with straight flanks, slightly convex adapically. A well-marked

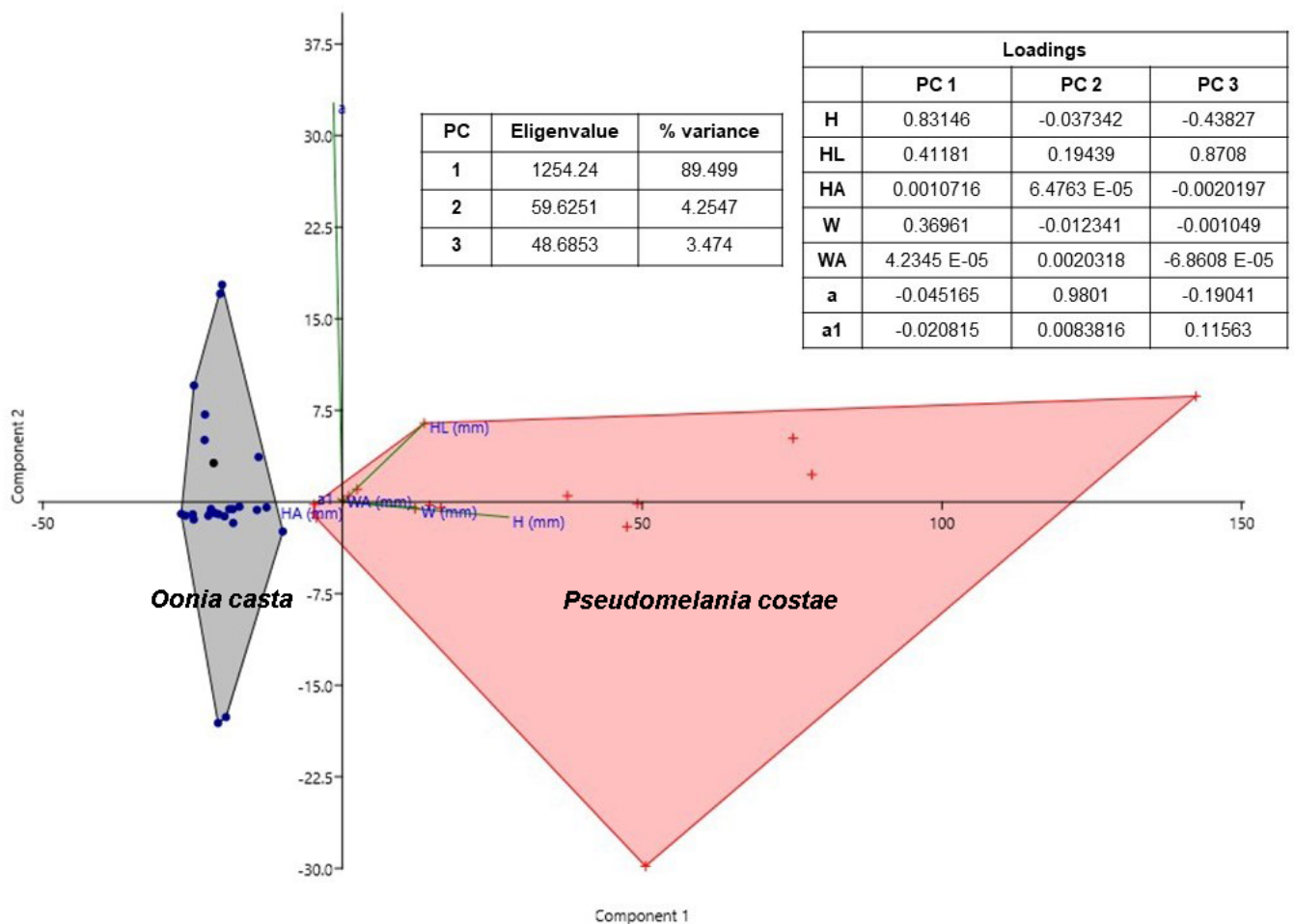


Figure 9. PCA analysis showing the morphological differentiation of the specimens, mainly explained by the H and HL measurements in the first component. Two species groups are clearly differentiated. Blue dots are the specimens assigned as *Oonia casta*, and red crosses are *Pseudomelania costae* specimens.

sutural shelf, with a 90° shoulder, gives to the shell a stair-like appearance. Aperture elliptical. The adapical margin of the whorls bears a row of tubercles. Growth lines are not preserved.

Remarks. According to Gründel (2003), *Microschiza semiornata* (Münster) (= *Littorina clathrata* Deshayes) has a high degree of intraspecific variability. The species is described from the upper Hettangian, Angulata chronozone, of S Germany and Luxembourg.

The specimen SGP31719 is labelled as coming from Praia da Polvoeira (Table 1). As Pedra do Ouro is very near, perhaps in the original labels Pedra do Ouro and Polvoeira were considered as one single location and SGP31719 might also come from the OU69 layer. The specimen SGP91842 is labelled as coming from Monte de Vera, an inland location at the south of Coimbra.

Subclass HETEROBRANCHIA

Order ALLOGASTROPODA

Remarks. Bouchet *et al.* (2017) do not recognise Allogastropoda. However, considering Gründel (2010), we keep this Order.

Superfamily **Nerinoidea** Zittel, 1873

Family **Ceritellidae** Wenz, 1938

Genus *Boehmiola* Strand, 1928

Remarks. Gründel *et al.* (2011) and Gründel & Nützel (2012) maintained that *Consobrinella* is most probably junior synonym of *Boehmiola* (= *Ephyra* Böhm 1901, non Péron & Lesueur, 1810). However, since the protoconch of *Boehmiola* is unknown, these relationships remain still uncertain.

Boehmiola exilis (Böhm, 1901)
(Fig. 10)

1901 *Ephyra exilis* sp. nov.; Böhm, p. 223, Pl. 8, figs. 5-6, Text-figs. 7-9.

v 1981 *Boehmiola exilis*; Mouterde & Rocha, p. 56, Pl. 1, figs. 6-7.

Material. 15 specimens: SGP (31808–31817, 31863?, 31878, 31886, 31889), lower Sinemurian. OU.69.47?, upper Sinemurian, Oxynotum chronozone.

Description. Shell turriculated. The apical part of the shell and aperture are not preserved in any of the specimens. Surface of whorls slightly convex, with a narrow and pronounced sutural ramp. Collabral ribs

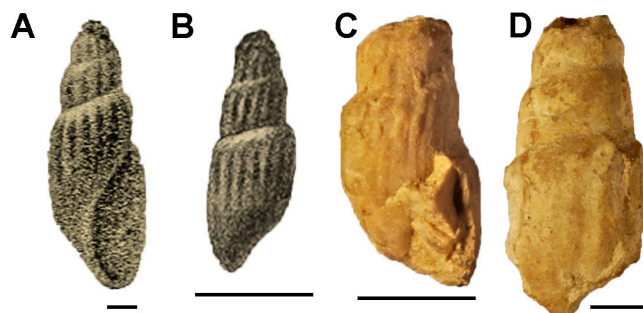


Figure 10. *Boehmiola exilis*. **a-b)** Original drawings by Böhm (1901); **(a)** Text-Fig. 8; **(b)** Pl. 8, Fig. 6. **c)** SGP31817. **d)** SGP31812. Scale bars = 5 mm. Photo: R. Paredes.

regularly repeating, slightly opisthocline, straight to slightly prosocyrct on most of the whorl surface and becoming strongly prosocyrct in the upper part of the whorl and on the sutural shelf.

Family **Nerinellidae** Pchelintsev, 1960

Genus *Nerinella* Sharpe, 1850b

Nerinella ficalhoi Choffat, 1903
(Figs 11, 12.15–12.19)

v 1903 *Nerinella ficalhoi* sp. nov.; Choffat, p. 107, figs. 12–15.

v 1981 *Nerinella ficalhoi*; Mouterde & Rocha, p. 59, Pl. 1, fig.13; Pl. 2, fig. 8.

Material. 42 specimens: MCUC.MIN (3002, 3036, 3037, 3039, 3040, 3050–3054, 3056–3058, 3060, 3061, 3068–3076, 3085, 3086, 3088, 3089), SGP (1153, 1154, 1156, 31732, 31738, 31744, 31768, 31769, 31771, 31773, 31776, 31824, 31861?, 31862?), Sinemurian.

Measurements.

| Label | H | HL | HA | W | WA |
|----------|------|------|-----|-----|-----|
| MIN.3068 | 29.1 | 6.1 | 3.7 | 6.3 | 2.5 |
| SGP1154 | 29.6 | 11.4 | 6.1 | 6.3 | 2.2 |

Description. The protoconch and first teleoconch whorls are missing in all the specimens. Shell turriculated with high spire. The most complete specimen (MCUC.MIN.3085) preserves seven whorls. Side of whorls straight with rounded shoulders and narrow sutural ramp. Suture slightly oblique. Aperture elliptical, becoming narrow adapically. Its height is more than half the height of the last whorl. Growth lines mostly prosocyrct but closer to sigmoidal shape. The shell has a labial fold, visible in

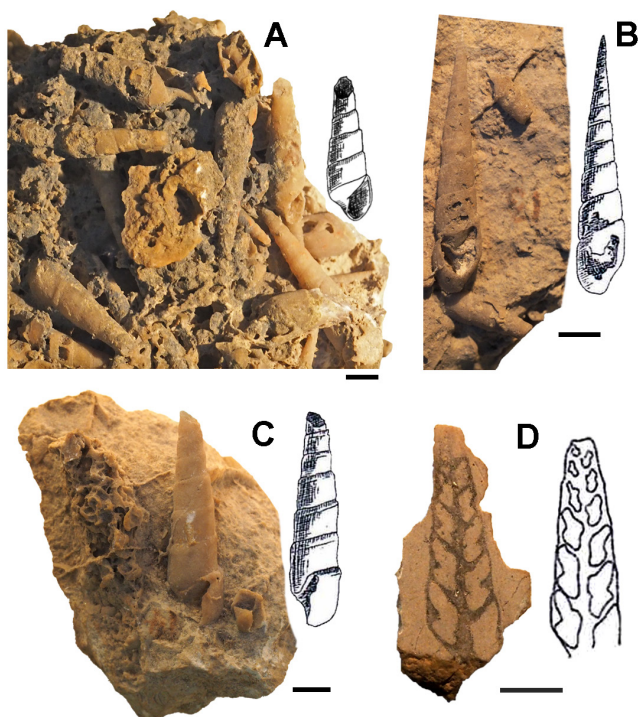


Figure 11. Original drawings by Choffat (1903) and actual photos of *Nerinella ficalthoi* figured specimens types. **a)** SGP1153(1), original of figure 12. **b)** SGP1153(2), original of figure 13. **c)** SGP1153(3), original of figure 14. **d)** SGP1153(4), original of figure 15. Scale bars = 5 mm. Photos: R. Paredes.

cross-section (Fig. 11d) and in the inner moulds (Figs. 12.15, 12.16), and a strong columellar fold, visible in the specimen of Figure 12.17. Collabral ribs are stronger in first whorls, and tend to disappear during growth.

Remarks. Choffat (1903) and Mouterde & Rocha (1981) indicated that this species is common in S. Pedro de Moel in the Obtusum chronozone and in the lower part of the Oxynotum chronozone.

Superfamily **Mathildoidea** Dall, 1889

Family **Mathildidae** Dall, 1889

Genus *Tangarilda* Gründel, 2010

Remarks. *Tangarilda* is a genus described as new by Gründel (2010), the type is *Melania turritella* Dunker, 1846 (= *Cerithium subturritella* d'Orbigny, 1850 nom. nov.). Gründel (2010) pointed out the presence of three spiral ribs and distinctly asymmetrical, opisthocyrt growth lines as diagnosis for this genus. *Tangarilda* is also described in Gründel & Nützel (2013), where they reviewed the genera of family Mathildidae.

Tangarilda subturritella (d'Orbigny, 1850)
(Figs 12.20-12.21)

1846 *Melania turritella* sp. nov.; Dunker, p.169.

1847 *Melania turritella*; Dunker, p.109, Pl. 13, figs. 5-7.

1850 *Cerithium subturritella*; d'Orbigny, p.255.

1901 *Promathildia turritella*; Böhm, p. 216, Pl. 8, figs. 15, 17.

1981 *Promathildia (Teretrina) turritella*; Mouterde & Rocha, p. 54, Pl. 1, figs. 3a-b.

1988 *Promathildia turritella*; Meier & Meiers, p. 36, Pl. 9, fig. 20.

2010 *Tangarilda subturritella* (d'Orbigny); Gründel, p. 10, Pl. 3, figs. 3-7; Pl. 4, fig. 1.

Material. 15 specimens: MCUC.MIN.3049, SGP (1155, 31733, 31786, 31864–31866, 31883–31885), MUHNAC.G2.21.2, MUHNAC.G2.21.3, Sinemurian; OU (69.46, 69.48, 69.50), upper Sinemurian, Oxynotum chronozone.

Measurements.

| Label | H | HL | HA | W | WA | α | α_1 |
|----------|-----|-----|----|-----|----|----------|------------|
| OU.69.48 | 7.1 | 2.1 | – | 3.3 | – | 44.1 | 21.5 |

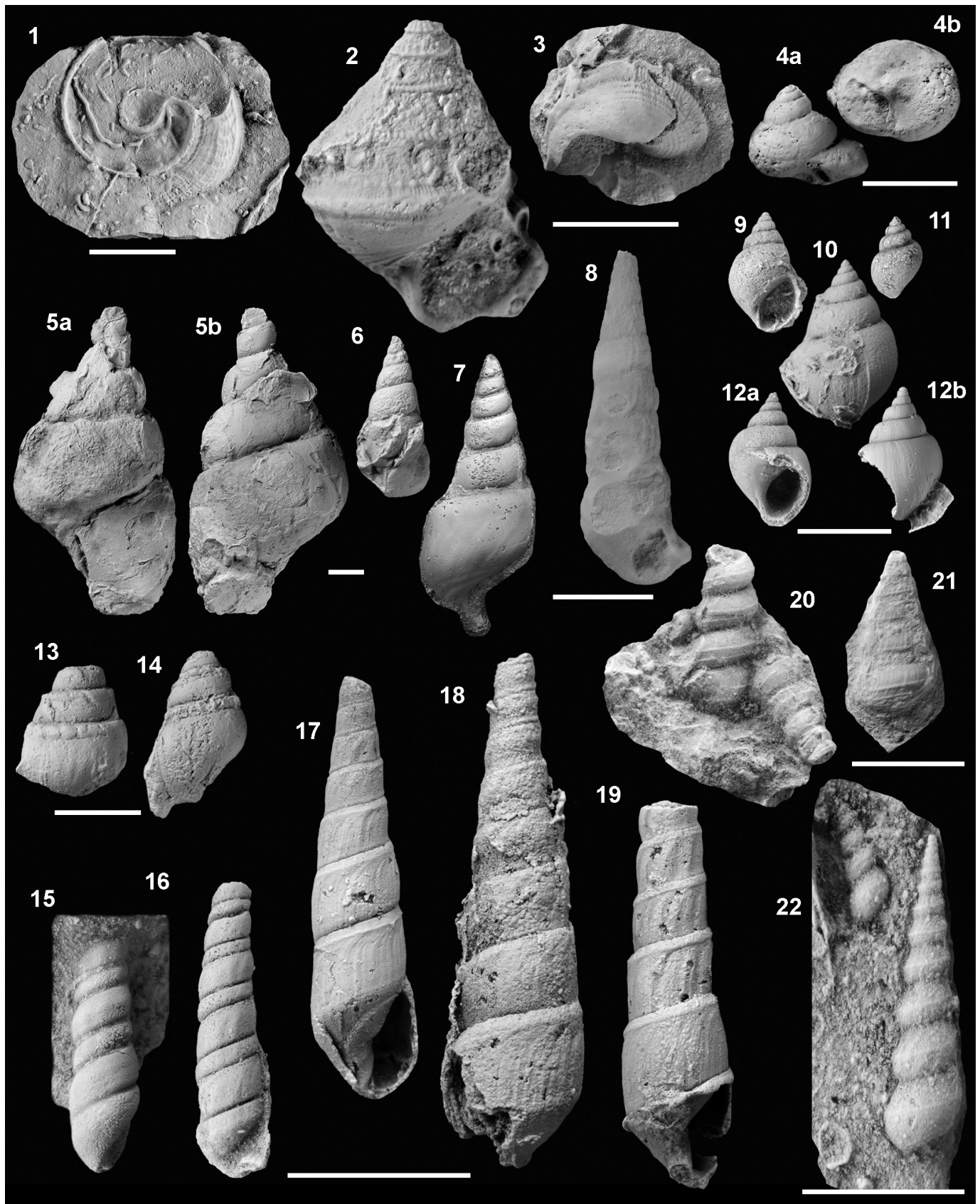
Description. Shell turriculated. Whorls convex with well-marked suture. In the middle part of each whorl, there are two spiral threads of the same width. The surface of the whorl between the two spiral threads is concave. A third thread weaker than the other two can be observed adapically in the last whorl of OU.69.48. Opisthocyrtic growth lines can be observed in the specimen OU.69.48. They match with the genus diagnosis by Gründel (2010), as they are asymmetrical “with the backmost point between the adapical and the middle spiral rib”.

Remarks. Gründel (2010) cited this species in lower Hettangian of Germany. Meier & Meiers (1988) describe it as an uncommon species in the Angulata chronozone, upper Hettangian of Luxembourg. Choffat (1903) and Mouterde & Rocha (1981) cite this species in upper Hettangian of Portugal, although this stratigraphic position should be revised.

Superfamily **Cimoidea** Warén, 1993

Family **Cimidae** Warén, 1993

Remarks. Gründel & Nützel (2013) used the name Tofanellidae for this family. However, Bouchet *et al.* (2017) considered Tofanellidae as synonym of Cimidae.



Genus *Cristalloella* Bandel, 1995

Cristalloella sp.
(Fig. 12.22)

Material. 4 specimens: MCUC.MIN.3062, SGP31772? Sinemurian; OU (52.20, 69.42-2), upper Sinemurian, Oxynotum chronozone.

Measurements.

| Label | H | HL | HA | W | WA | α | α_1 |
|----------|-----|-----|----|-----|----|----------|------------|
| MIN.3062 | 9.8 | 2.2 | – | 3.1 | – | – | – |
| OU.52.20 | 8.0 | 3.9 | – | 4.3 | – | 43.2 | 25.4 |

Description. Shell conspiral turruculated. The protoconch is not preserved. Up to twelve whorls, convex surface well-marked suture. A strong spiral keel is visible at the middle of each whorl. Growth lines are visible.

Remarks. Gründel & Nützel (2013; p. 815) described two subgenera, *Cristalloella* (*Cristalloella*) and *Cristalloella* (*Wonwalica*). In contrast, Kaim (2004) maintained that the *Cristalloella* species couldn't be differentiated from the *Wonwalica* species at the genus level. Gründel & Nützel (2013) indicate that *Wonwalica* possesses fewer whorls and is broader than the typical subgenus. In the material studied, OU.52.20 and OU.69.42 have fewer whorls, four to six, and are broader than MIN.3062 and SGP31772. Following Gründel & Nützel (2013), OU.52.20 and OU.69.42 could belong *Cristalloella* (*Wonwalica*) sp., and MIN.3062 and SGP31772 could be *Cristalloella* (*Cristalloella*). However, due to the state of preservation and the shortage of material we cannot assure these taxonomical assignments.

Gründel & Nützel (2013) confer to the genus a stratigraphic distribution between the Upper Triassic and the Middle Jurassic (Callovian) of Germany, France, New Zealand and North Italy.

Superfamily **Acteonoidea** D'Orbigny, 1843

Family **Cylindrobullinidae** Wenz, 1938

Remarks. Gründel & Kaim (2006) include this family in the superfamily Acteonoidea. Kaim (2004) includes the family Cylindrobullinidae in the superfamily Cephalaspidea. On the other hand, Gründel & Nützel (2012) follow the assignation to superfamily Acteonoidea but include this in Order Architectibranchia. In the present paper, we follow the classification of Bouchet & Rocroi (2005) and Bouchet *et al.* (2017).

Genus *Cylindrobullina* v. Ammon, 1878

Cylindrobullina sp.

Material. 8 specimens: SGP (31786, 31791, 31803–31806, 31844), MUHNAC.G2.21.2, Sinemurian.

Description. Shell conspiral shell. Low spire with three or four whorls. Convex margins with an overlapping suture. The first whorls are very tight and the last whorl measures almost the total shell height. The aperture is long, with a rounded base that becomes narrow apically; its height is almost equal to that of the last whorl. No ornamentation or growth lines are visible.

Remarks. It has been no possible to figure this species because of the preservation state and because as all the

Figure 12. 1) *Cyclostomaria* aff. *monarii* Oxynotum chronozone, Praia Pedra do Ouro beach, Água de Madeiros Fm. Cross section, with part of the shell preserved. OU.68.11. 2-3) *Eucycloscala* sp. Oxynotum chronozone, Praia da Pedra do Ouro beach, Água de Madeiros Fm. Apertural views showing detail of the selenizone and the spiral rib with nodules; (2) OU.47.12; (3) OU.40.7. 4) Ataphridae indet. Oxynotum chronozone, Praia Pedra do Ouro beach, Água de Madeiros Fm. Lateral and basal views. OU.69.10. 5-7) *Pseudomelania costae*, (5) Oxynotum chronozone, Praia da Polvoeira, Água de Madeiros Fm.; apertural (5a) and dorsal (5b) views. PO.54.2; (6-7) Obtusum chronozone, S. Pedro de Moel, Coimbra Fm.; (6) apertural view, MCUC.MIN.3078; (7) dorsal view, MCUC.MIN.2999. 8) *Pseudokatosira*? aff. *undulata*, Oxynotum chronozone, Praia da Pedra do Ouro beach, Água de Madeiros Fm. Lateral view. OU.40.1. 9-12) *Oonia casta*, Obtusum chronozone, Praia da Concha, Coimbra Fm.; (9) apertural view. MCUC.MIN.3012; (10) dorsal view showing the pattern of growth lines. MCUC.MIN.3009; (11) apertural view. MCUC.MIN.3018; apertural (12a) and dorsal (12b) views showing the pattern of growth lines. MCUC.MIN.3013. 13-14) *Microschiza* sp., Oxynotum chronozone, Praia da Polvoeira, Água de Madeiros Fm. Dorsal views showing a row of tubercles. 15-19) *Nerinella ficahoi*, Obtusum chronozone, Coimbra Fm.; (15, 16) Penedo da Saudade (S. Pedro de Moel). Inner moulds, lateral and apertural views; (15) MCUC.MIN.3037; (16) MCUC.MIN.3052; (17-19) Penedo do Cabo, apertural and dorsal views showing detail of the whorl surface; (17) MCUC.MIN.3085; (18) MCUC.MIN.3086; (19) MCUC.MIN.3088. 20-21) *Tangarilda subturritella*. Dorsal views; (20) Obtusum chronozone, Penedo da Saudade (SPM), Coimbra Fm., MCUC.MIN.3049; (21) Oxynotum chronozone, Praia da Pedra do Ouro beach, Água de Madeiros Fm., OU.69.48. 22) *Cristalloella* sp., Obtusum chronozone, Penedo da Saudade (SPM), Coimbra Fm. Dorsal views showing detail of the whorl surface. MCUC.MIN.3062. Scale bars in Figures (1-3, 5-7, 9-19) = 10 mm; Scale bars in Figures (4, 8, 20-22) = 5 mm.

specimens are embedded in rock, it was not possible to take high-quality photos. Nevertheless regarding the preserved features these specimens match with those described and figure by Böhm (1901; p. 266, pl. 8, fig. 19), and it has been considered interesting to leave proof of the presence of this taxa.

5. DISCUSSION AND CONCLUSIONS

A total of 386 Sinemurian gastropod specimens were studied. Of these, 96 were newly collected in the S. Pedro de Moel area and 290 were from museum collections. Among the new collected material, 77 specimens came from Pedro do Ouro (OU) and 19 from Polvoeira (PO) sections. From the main museum collections (the Museu Geológico de Portugal and Museu da Ciência - University of Coimbra), 283 Sinemurian gastropods were studied: 198 from SGP and 85 from MCUC. Moreover, other 5 specimens from MUHNAC and 2 from UP.MHNFCP are catalogued as Sinemurian.

Among these 386 specimens, 266 have been taxonomically identified (Table 1; [Supplementary Information](#)); the other 120 specimens were simply recognized as Gastropoda. 147 specimens from SGP, 62 from MCUC, and all the specimens from MUHNAC and UP.MHNFCP have been identified (Table 1). Moreover, 44 from OU and 6 from PO have been determined at some taxonomical level.

Adding to these 386 specimens, 5 bed samples from SPM (Figs 2, 3a) and PV (Figs 2, 3b-3d), that include numerous gastropod specimens, were studied. These specimens were not removed from the sediment in order to study in detail the distribution of the gastropod shells and their state of preservation. All of them were regarded taphonomically as autochthonous assemblages (Fernández-López, 2000), giving valuable information about the type of preservation and palaeocommunities approaches.

The following taxa have been identified in these samples: a) SPM (Fig. 3a). This is a monospecific sample of *Nerinella ficalhoi*; b) PV322b_1 (Fig. 3b). 56 specimens have been counted: 50 of them represent *Tangarilda subturritella*, with heights between 4.7 and 12.3 mm, 2 specimens belong to *Pseudomelania* indet., and 2 specimens to *Cylindrobullina* sp.; c) PV322b_2 (Fig. 3c). 17 specimens have been counted: 13 represent *T. subturritella*, with height between 8.1 and 10.3 mm, 3 specimens belong to *Oonia casta*, one is fragmented and the others show heights of 15.4 and 18.6 mm, and one specimen represents *Pseudomelania costae*, which has a height of 24.6 mm; d) PV322mt (Fig. 3d). From PV322 there are two sample assemblages in which *P. costae* and *T. subturritella* dominate. In the first one, 11 specimens

have been counted: 7 of *P. costae* and 4 of *T. subturritella*. One specimen of *P. costae* preserves three whorls, with a total height of 52.1 mm, another almost complete one has a height of 42.8 mm. There are other smaller ones, and the lowest height is 17.7 mm. The *T. subturritella* specimens present homogeneous heights of 5.7 mm. The second sample has 18 specimens, 14 of *T. subturritella*, with heights between 3.3 and 8.6 mm. The other 4 specimens belong to *P. costae*; two are incomplete, the larger one preserves three whorls with a height of 18.6 mm, the third one is almost complete, with a height of 15.2 mm and the fourth is the smallest, with a height of 3.8 mm. Other 3 specimens can be observed in axial cross-section.

In summary, in the layer 322, the most frequent species are *T. subturritella* and *P. costae*. Moreover, *O. casta* and *Cylindrobullina* sp. can be found albeit less frequently. To date, *Nerinella ficalhoi* has only been found in the stratigraphically lowest level, that one cited by Choffat as bed 4 ("Cam.4") of Penedo do Cabo. It is located most probably below the bed 315 of Azerêdo *et al.* (2010; fig. 3) log. Future research should specify the precise position of these records. The most continuous and best-exposed upper Sinemurian *p.p.* outcrops are located in the vicinity of S. Pedro de Moel, including OU and PO sections, where 300 of the 386 specimens (77.72%) come from. The outcrops of Coimbra Fm. located inland are badly exposed or inaccessible, but 59 specimens (15.28%) could be studied in the SGP collection, the only one that keep gastropods from these outcrops.

The specimens of *P. costae* and *O. casta*, labelled as coming from Penedo do Cabo, Penedo da Saudade and S. Pedro de Moel, likely belong to levels close to those of the Obtusum chronozone sampled at the Praia Velha and Praia da Concha. The specimens labelled in SGP as coming from Polvoeira belong to species also identified in Praia Pedro do Ouro (OU) and Praia da Polvoeira (PO) sections, which most probably indicates that they precisely come from the same outcrops studied recently in this area. In relation with the stratigraphic distribution of the taxa studied, it is remarkable that *Pseudomelania costae* and *Oonia casta* are the most frequent and widely distributed species, being found in the Obtusum and Oxynotum chronozones.

Nerinella ficalhoi and *Cylindrobullina* sp. have been only found in the Obtusum chronozone. *Microschiza* sp., *Pseudokatosira?* aff. *undulata*, *Eucycloscala* sp., and *Cyclostomaria* aff. *monarii* have only been recorded in the Oxynotum chronozone.

Tangarilda subturritella, which is common in the Obtusum chronozone, has also been identified in the bed OU69 of the Oxynotum chronozone.

Cryptaenia sp., *Boehmiola exilis*, and *Scurriopsis* (*Scurriopsis*) *schmidti* have only been identified in the SGP collection; they were labelled as coming from the Almaroz site. This is the only locality where this association has been recognised.

Microschiza sp., *T. subturritella*, and *S. (S.) schmidti* have been cited in the upper Hettangian of Luxembourg and SW Germany. Different species of *Nerinella* have been identified in N Europe, in older stratigraphic levels than those of S Europe (Sharpe, 1850b). These data open up an interesting path of research into possible north-southern migration way. In agreement with this hypothesis, similar forms to ones described here as *Pseudokatosira*? aff. *undulata* and *Eucycloscala* sp. have been found in lower Sinemurian levels of German and Austrian outcrops. In contrast, forms similar to *Cyclostomaria* aff. *monarii* and *B. exilis* have been described in the Pliensbachian of the Bakony Mountains (Hungary) and of Dorset (England), respectively.

To date, *N. ficalhoi* has only been cited in LB; thus, it might constitute an endemic species. This could also be the case of *P. costae* and *O. casta*.

ACKNOWLEDGEMENTS

Acknowledgments are due to Dr Roberto Gatto for the detailed revision of the manuscript; to both reviewers, Dr Stefano Monari and Dr Mariel Ferrari, for providing valuable comments on the manuscript; to Dr Luís Vítor Duarte (Marine and Environment Research Centre, Faculdade de Ciências e Tecnologia, Universidade de Coimbra) for the cession of Figure 2; to Dr Miguel Ramalho and his collaborators (Museu Geológico de Portugal), João Muchagata (MHNC-UP), Susana Machado (LNEG-Alfragide), Liliana Póvoas and João Paulo Lopes (MUHNAC) for their attention in their institutions, to Museu da Ciência (University of Coimbra) management, for lending the Sinemurian gastropod collection; to Cormac De Brun for the English review of the manuscript. We emphasise with special thanks the photographic work and collaboration edition of images received from Carlos Alonso (UCM). This paper benefited from the use of the Portuguese Infrastructure of Scientific Collections (PRISC.pt). This work is a contribution to the Portuguese E-Infrastructure for Information and Research on Biodiversity (PORBIOTA) and to the project CGL2015-66604-R (MINECO, Spain) and to the UCM group 910431 “Procesos Bióticos Mesozoicos”.

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