Ostracods of the Upper Toarcian (Jurassic) of Boca da Mata, Alvaiázere, Portugal: taxonomy and evolution

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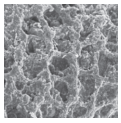

Upper Toarcian ostracod assemblages from Boca da Mata, Alvaiázere, Central Portugal, are described to complement earlier work on the ostracods of the Toarcian GSSP at Peniche, western Portugal. A total of 44 species are recorded and the following new taxa described: *Cytheropterina ainsworthi* sp. nov., *Eucytherura alvaiazerensis* sp. nov., *Otocythere iberobritannica* sp. nov., *Ophektycythere* gen. nov. with *O. herrrigi* sp. nov., *O. mataensis* sp. nov. and *O.*? *sicoensis* sp. nov. The assemblages reflect oxygenated fully marine, sublittoral shallow water conditions in a proximal margin of the Lusitanian Basin. The species spectrum has most in common with material described from Western Europe especially the Fastnet Basin, offshore Ireland. Lowermost Aalenian assemblages contain some Toarcian species but also new taxa not studied in detail. • Key words: Toarcian–Aalenian, ostracods, new species, palaeobiogeography, Lusitanian Basin, Portugal.

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The purpose of this paper is to enhance the documentation of Toarcian ostracod assemblages from Portugal initiated by Cabral *et al.* (2020) in their study of the ostracods across the Global Boundary Stratotype Section and Point (GSSP) for the base of the Toarcian stage at Peniche, western Portugal (Rocha *et al.* 2016); stratigraphically it is essentially a continuation of Cabral *et al.* (2020). The present study developed from partial data in the MSc study of the third author (S. Pinto) significantly completed. It improves knowledge of taxonomy, biodiversity and palaeogeographical distribution of Toarcian ostracods in Western Europe.

Since 2020 the description and discussion of global palaeoenvironmental patterns and events across the Pliensbachian–Toarcian boundary and through the Lower Toarcian (Toarcian Oceanic Anoxic Event/Jenkyns Event, Reolid *et al*. 2021) of the Lusitanian Basin (LB) have continued with undiminished intensity. This has included different approaches involving sedimentology, geochemistry and palaeontology (*e.g.* Müller *et al.* 2020, Rodrigues *et al*. 2020, Ullmann *et al*. 2020, Correia *et al*. 2021, De Baets *et al*. 2021, Font *et al*. 2022). These developments are due to the Toarcian Oceanic Anoxic Event being particularly well recorded in the LB and have led to an increase in the work carried out (see references above and also Duarte *et al*. 2017). In contrast, the Middle and Upper Toarcian of the basin have not been studied in similar detail, but rather have only been the subject of very sporadic analysis (*e.g.* Duarte *et al*. 2001; Reolid & Duarte 2014; Ferreira *et al*. 2015, 2019; Andrade *et al*. 2016; Correia *et al*. 2018).

The Upper Toarcian section at Boca da Mata, Alvaiázere

The studied section (39° 48′ 24.46″ N; 8° 23′ 54.19″ W) is located inland in western Portugal, 150 km to the NNE of Lisbon and 100 km NE of the coastal section at Peniche (Fig. 1A, B), in the area of Alvaiázere (Duarte 1995, 1997; Andrade *et al*. 2010). The locality is approximately 30 km south of Rabaçal which features in some ostracod

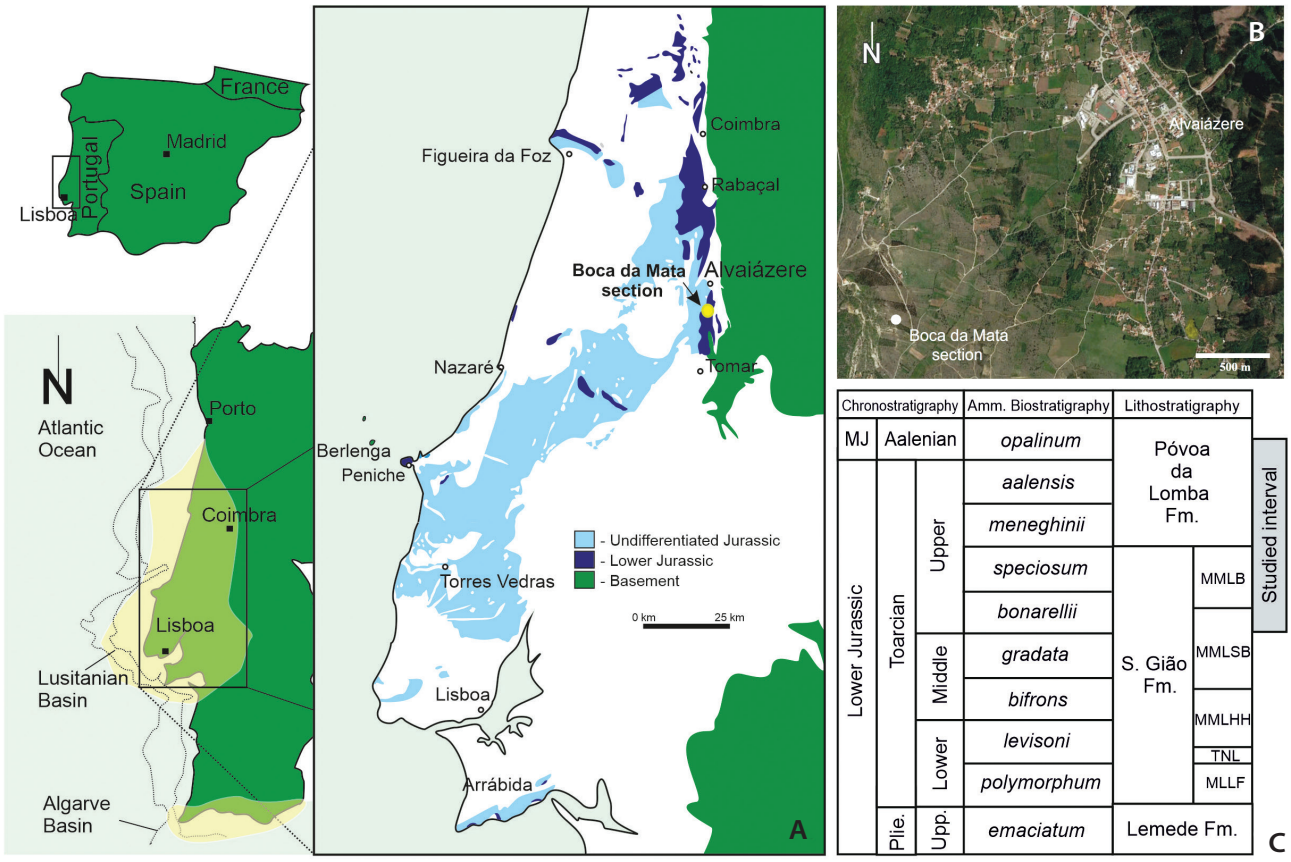


Figure 1. A – general map of the Jurassic in the onshore area of the Lusitanian Basin, showing the location of the studied Boca da Mata section and other Toarcian reference sections of the basin, such as Peniche and Rabaçal (adapted from Duarte *et al*. 2010). • B – aerial view of the Alvaiázere region and detailed location of the Boca da Mata section (from Google Earth). • C – chronostratigraphic, biostratigraphic (ammonite) and lithostratigraphic framework of the studied interval (based on Duarte & Soares 2002). Abbreviations: MLLF – Marly Limestones with "Leptaena" Facies; TNL – Thin Nodular Limestone; MMLHH – Marls and Marly Limestones with *Hildaites* and *Hildoceras*; MMLSB – Marls and Marly Limestones with Sponge Bioconstructions; MMLB – Marls and Marly Limestones with Brachiopods.

literature as the Zambujal locality (Exton 1979, Exton & Gradstein 1984, Boomer *et al.* 1998). These Jurassic successions are part of the sedimentary infilling of the LB. This Mesozoic western Iberian basin developed within the geodynamic framework leading to the North Atlantic Ocean opening, having been also under the influence of the Western Tethys Sea. The Lower and Middle Jurassic record of the LB corresponds to a post-Triassic rifting stage, characterized by increasingly marine deposition over the basin, represented by deep- to shallow-marine limestones and marls, dolostones and organic-rich shales, developed on a carbonate ramp depositional system (*e.g.* Duarte *et al*. 2001, 2010; Azerêdo *et al*. 2003, 2014; and references therein).

The studied section displays a 42 m thick marl–limestone succession (Fig. 2) that belongs to the upper part of the São Gião Formation (originally described as S. Gião Formation, a term that will be used in this text and figures) and the lower part of the Póvoa da Lomba Formation (Fm), the ages of which are well constrained by ammonite biostratigraphy (Mouterde & Ruget 1967, Elmi *et al*. 1989, Duarte & Soares 2002, Duarte 2007), (Fig. 1C). The studied interval of the S. Gião Fm includes the two upper members of this unit (Duarte *et al*. 2001, Duarte & Soares 2002): the upper part of the Marls and Marly Limestones with Sponge Bioconstructions (MMLSB) Member, assigned to the *bonarellii* Biozone, a unit that is characterized by the occurrence of siliceous sponge bioherms; the Marls and Marly Limestones with Brachiopods (MMLB) Member, a marly dominated unit with very rare marly limestone beds, corresponding to the *bonarellii* and *speciosum* ammonite biozones interval. The studied interval of the Póvoa da Lomba Fm, dominated by limestones in a marl-limestone succession, with siliceous sponge bioherms, involves the *meneghinii* to the *opalinum* ammonite biozones, the latter corresponding to the Aalenian (Middle Jurassic). Thus, the top of the studied section extends into the Aalenian, but this was not studied in detail because it was out of the scope of the present work. Both formations are rich in marine macrofossils, besides

ammonites, namely brachiopods, bivalves, crinoids and siliceous sponges; a range of ichnofossils, such as *Zoophycos*, *Chondrites*, *Thalassinoides* and *Planolites*, are also common (Duarte 1997, Duarte *et al*. 2001, Reolid & Duarte 2014). The succession loses its prominent marly nature towards the top, where limestone beds become dominant, characterizing the Póvoa da Lomba Fm (Fig. 2).

The Late Toarcian succession in the LB represents a regressive trend (relative sea level fall), with this transition marked by a discontinuity differently developed over the basin, and by sedimentological and palaeontological features (Duarte 1997, Duarte *et al*. 2001, Azerêdo *et al*. 2003). The upward increase in thicker bioclastic limestones exhibited in the studied Boca da Mata section is one of these expressions. The sponge-mound facies, which only occurs in the eastern region of the basin (inner part of the ramp depositional system), is likely related to lowered argillaceous sedimentation rate when compared with more distal areas (Duarte *et al*. 2001, Reolid & Duarte 2014). In the earliest Aalenian a transgressive trend is recorded (Duarte 1997, Duarte *et al*. 2001, Azerêdo *et al*. 2014).

In summary, the deposits studied for ostracods correspond to the *bonarellii*, *speciosum*, *meneghinii* and *aalensis* Toarcian ammonite biozones, and only secondarily to the base of the *opalinum* Aalenian ammonite biozone. For the equivalent stratigraphic interval at the reference section of Rabaçal and other distal sections, the ammonite biostratigraphy is complemented with data on calcareous nannofossils and dinoflagellates (Perilli & Duarte 2006, Correia *et al*. 2018, Ferreira *et al*. 2019), but for the studied Boca da Mata section there are no other biostratigraphic data, or geochemical/isotopic information.

Material and methods

Twenty-one samples from the Upper Toarcian of the studied section (Fig. 2) were collected in 2005. Sampling along the section was focused on marl beds, however, these became fewer up-section in the Póvoa da Lomba Fm. As the Boca da Mata section extends into the Lower Aalenian four additional samples in this interval (Fig. 2) were analysed, but not in detail, in order to recognise any changes in the ostracod assemblages across the stage boundary.

The *gradata* ammonite biozone was not studied either at Peniche (by Cabral *et al*. 2020) or in the present work

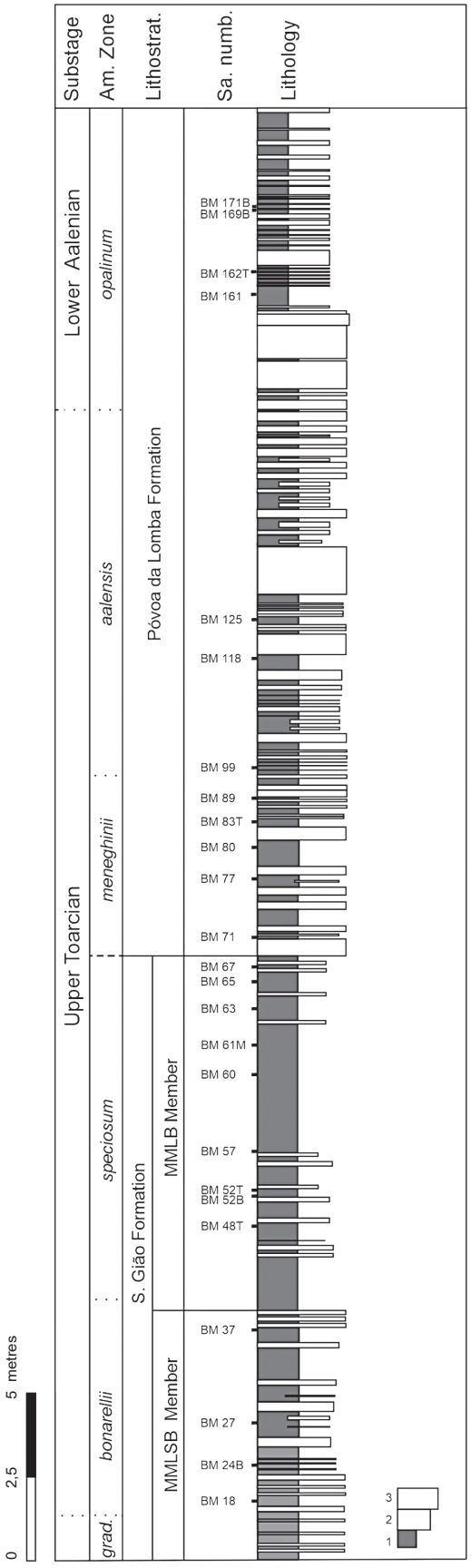


Figure 2. Boca da Mata section – lithostratigraphic field column (based on Duarte 1995), with studied samples. Legend: 1 – marl and calcareous marl; 2 – marly limestone; 3 – micritic limestone; Am. Zone – ammonite Zone; Lithostrat. – lithostratigraphy; Sa. numb. – sample number.

at Boca da Mata, in the case of Peniche for facies reasons (see Duarte 1997, Duarte & Soares 2002) and at Boca da Mata for lack of exposure.

The collected samples were analysed using standard micropalaeontological techniques. Approximately 300 g of each sample were dried for 24 hours and then treated with kerosene, and when disaggregated the sample was washed on 150 and 63 µm sieves. The 150 µm fraction was completely picked and identifiable species counted. The 150-63 µm residue was inspected for small adult species. Ostracod material from inland Lower Jurassic sections is better preserved than from the coastal section at Peniche (see comments in Cabral *et al*. 2020, p. 245). In the systematic palaeontology below the term Material refers to the number of specimens studied from Boca da Mata (only Upper Toarcian material) and Occurrence to the ammonite biozonal range at this locality, other records are cited in Discussion. For counts we considered one specimen equal to one valve or one carapace.

Type and figured specimens are deposited in the Senckenberg Museum, Frankfurt-am-Main.

Abbreviations: C = carapace(s); V = valve(s); LV = left valve; RV = right valve; l = maximum length in mm; h = maximum height in mm; w = maximum width in mm.

Very small C (l < 0.40 mm); small C (l = 0.40–0.50 mm); medium C (l = 0.51–0.70 mm); large C (l = 0.71–0.90 mm).

Systematic Palaeontology – ostracods

Ostracods of Early Jurassic age are reasonably well-known from Northern and Western Europe (see for example Arias 2006 for a list of species and literature) and from Portugal assemblages of late Toarcian age have been described from Rabaçal (Exton 1979, Exton & Gradstein 1984, Boomer *et al.* 1998, Loureiro *et al*. 2010); some unpublished occurrences in Rabaçal referred in the text correspond to personal data of M.C. Cabral.

All the species recorded are figured (Figs 3–10) and their biostratigraphical distribution shown in Fig. 11.

In the section below, we primarily focus on taxa that are new or of importance for biostratigraphical and palaeobiogeographical reasons. Synonymy lists are usually limited to the first naming of the species and key references in Iberia (only when the species are figured).

Class Ostracoda Latreille, 1802
Subclass Myodocopa Sars, 1866
Order Halocyprida Dana, 1852
Suborder Cladocopina Sars, 1866
Superfamily Cladocopoidea Sars, 1866
Family Polycopidae Sars, 1866

Genus *Polycope* Sars, 1866

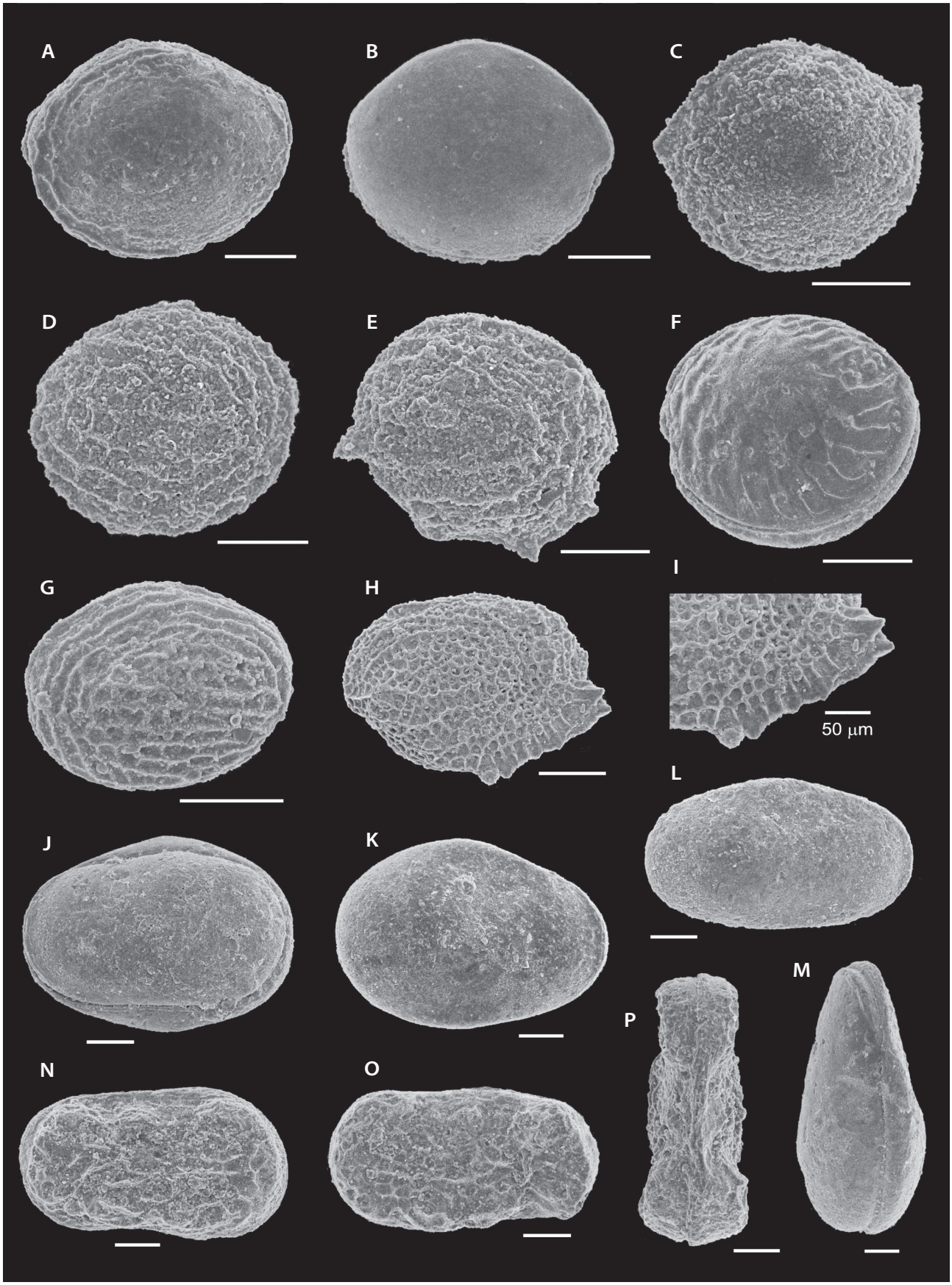
Type species. – *Polycope orbicularis* Sars, 1866.

Remarks. – In Boca da Mata *Polycope* occurs very abundantly in all the samples of the studied biozones (*bonarellii*, *speciosum*, *meneghinii* and *aalensis*), particularly in the two upper levels. Most are adult C but are too poorly preserved to identify at species level or are figured in the literature under open nomenclature and are referred here to *Polycope* spp. (Fig. 3A–C). We were able to identify *Polycope cincinnata* Apostolescu, 1959 (Fig. 3D), *Polycope* aff. *cincinnata* Apostolescu, 1959 (Fig. 3E), *P*. cf. *pelta* Fischer, 1961 (Fig. 3F) and *P*. *transversicostata* Ainsworth, 1986 (Fig. 3G).

Polycope cincinnata was described from the Pliensbachian of the Paris Basin, France, and also occurs in the Lower Jurassic of several other European countries (*e.g.* Denmark, Michelsen 1975; Germany, Herrig 1981a; Spain, Arias & Lord 1999a); in Portugal it was found in the Upper Pliensbachian and Lower Toarcian of Peniche (Cabral *et al.* 2020, fig. 3b) and in the Toarcian of Rabaçal (Exton 1979, pl. 16, fig. 8; M.C. Cabral data). We also figure a single specimen of *Polycope* aff. *cincinnata* very similar to *P. cincinnata*, with the same ornamentation, but having a different outline, with a clear flange (Fig. 3E).

Polycope pelta was described from the Upper Toarcian (Lias ζ) of SW Germany, however, the holotype was poorly illustrated. Fortunately, Franz *et al*. (2018, pl. 1, fig. 4a–c) have refigured the holotype and it is clear that the Boca da Mata material is not *P*. *pelta*. Our *Polycope*

Figure 3. Ostracods from the Upper Toarcian of Boca da Mata section, Portugal. • A–C – *Polycope* spp.; A – carapace, left view, SMF Xe 24004, l = 0.40, h = 0.32, *meneghinii* Biozone, sample BM71; B – carapace, right view, SMF Xe 24005, l = 0.35, h = 0.32, *speciosum* Biozone, sample BM52T; C – carapace, left view, SMF Xe 24006, l = 0.30, h = 0.27, *bonarellii* Biozone, sample BM27. • D – *Polycope cincinnata* Apostolescu, 1959, LV, external view, SMF Xe 24007, l = 0.30, h = 0.29, *aalensis* Biozone, sample BM118. • E – *Polycope* aff. *cincinnata* Apostolescu, 1959, carapace, left view, SMF Xe 24008, l = 0.33, h = 0.28, *speciosum* Biozone, sample BM125. • F – *Polycope* cf. *pelta* Fischer, 1961, carapace, left view, SMF Xe 24009, l = 0.44, h = 0.40, *speciosum* Biozone, sample BM52B. • G – *Polycope transversicostata* Ainsworth, 1986, carapace, right view, SMF Xe 24010, l = 0.33, h = 0.25, *meneghinii* Biozone, sample BM71. • H, I – *Polycope* sp. A, *speciosum* Biozone, sample BM52B; H – carapace, left view, SMF Xe 24011, l = 0.40, h = 0.30; I – detail of H. • J–M – *Cytherella* cf. *toarcensis* Bizon, 1960, *speciosum* Biozone, sample BM52B; J – female carapace, left view, SMF Xe 24012, l = 0.60, h = 0.43; K – female RV, external view, SMF Xe 24013, l = 0.62, h = 0.45; L – male carapace, right view, SMF Xe 24014, l = 0.58, h = 0.34; M – female carapace, dorsal view, SMF Xe 24015, l = 0.60, h = 0.44. • N–P – *Cytherelloidea* sp. A; N – male RV, external view, SMF Xe 24016, l = 0.60, h = 0.35, *speciosum* Biozone, sample BM63; O – female LV, external view, specimen lost, *aalensis* Biozone, sample BM99; P – female carapace, dorsal view, SMF Xe 24017, l = 0.58, h = 0.32, *aalensis* Biozone, sample BM99. Dimensions in mm. Scale bars = 100 µm, except when indicated.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cf. *pelta* is figured in the literature from Portugal (Exton 1979, pl. 11, fig. 4, Toarcian; Exton & Gradstein 1984, pl. 2, fig. 13, Toarcian), offshore SW Ireland (Ainsworth 1986, pl. 1, fig. 1, Toarcian–Aalenian), Spain (Arias & Lord 1999a, pl. 1, fig. 4, Toarcian; Arias *et al*. 2009, pl. 1, fig. 2, Upper Toarcian), Scotland, U.K. (Whatley 1970, pl. 1, figs1–4, Upper Callovian and Lower Oxfordian), NW, SW and S Germany (Plumhoff 1963, pl. 1, figs 1, 2, Aalenian–Lower Bajocian; Franz *et al.* 2018, pl. 1, fig. 5, Aalenian; Franz *et al*. 2014, fig. 13o, Bathonian) and differs from true *P*. *pelta* in possession of coarser curved ribs only around the valve periphery and a smooth centre.

Polycope transversicostata was described from the Upper Toarcian and Aalenian of the Fastnet Basin, offshore SW Ireland, and can be distinguished from *P*. *discus* Fischer, 1961 by shape of the dorsal margin and ornamental detail of the ribbing as described by Ainsworth (1986, pp. 289, 290); our specimens are very similar to Ainsworth's figured material but also show similarities to *P*. *discus*; it was also found in the Middle and Upper Toarcian of Rabaçal (M.C. Cabral data).

We figure *Polycope* sp. A (Fig. 3H, I), which has a distinctive flange located in a presumed posteroventral position, somewhat similar with the one found in *P*. aff. *cincinnata* referred to above (Fig. 3E, this work). *Polycope* cf. *cincinnata* Apostolescu, 1959 from the Upper Sinemurian to Upper Pliensbachian of Denmark, figured in Michelsen (1975, pl. 40, fig. 566), is closely related to *P*. sp. A; both species have similar ornamentation and distinctive flange, but clearly differ from *P. cincinnata* in having more numerous and less coarse ribs.

Subclass Podocopa Sars, 1866
Order Platycopida Sars, 1866
Suborder Platycopina Sars, 1866
Superfamily Cytherelloidea Sars, 1866
Family Cytherellidae Sars, 1866

Genus *Cytherella* Jones, 1849

Type species. – *Cytherina ovata* Roemer, 1841.

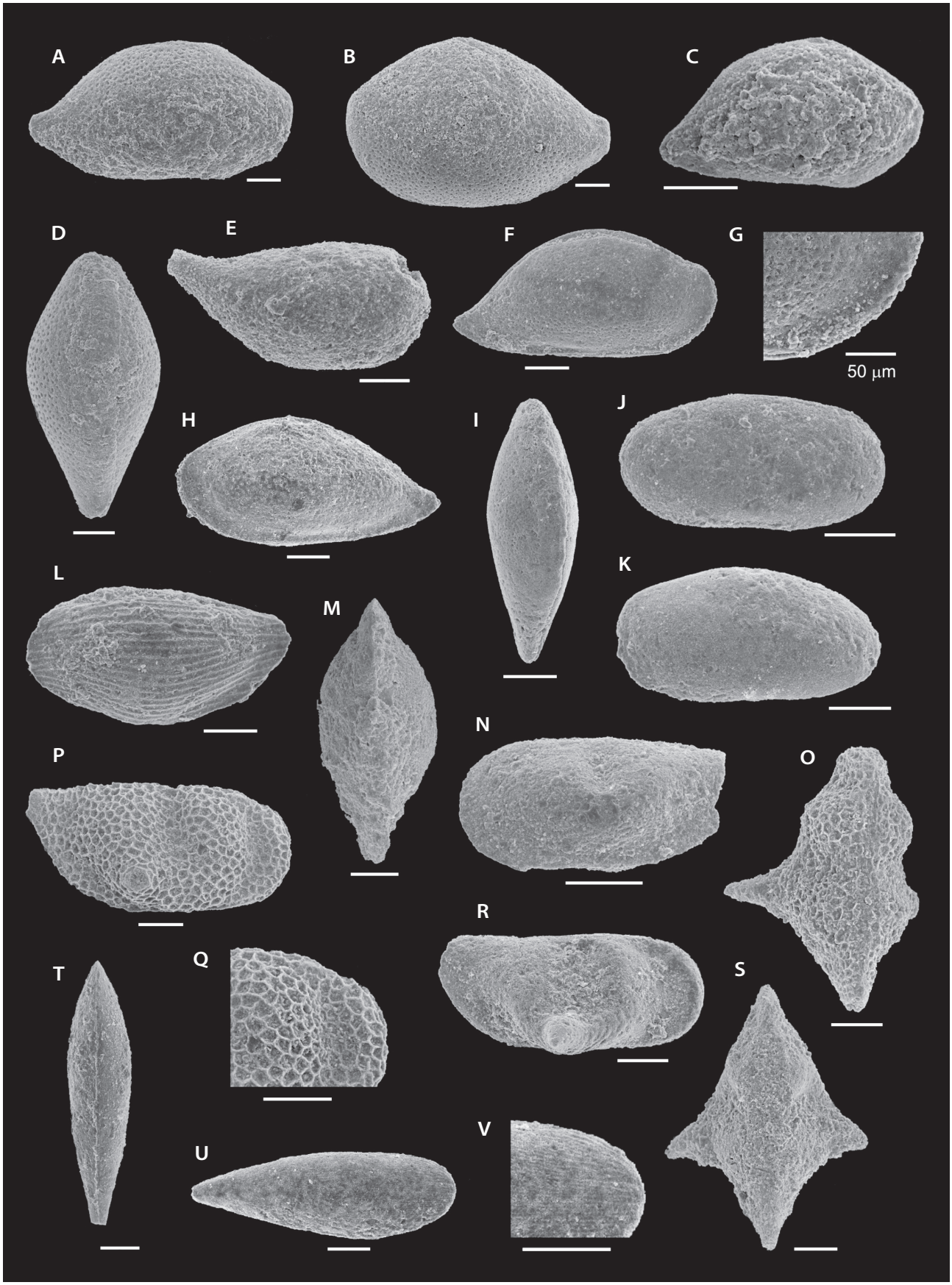
***Cytherella* cf. *toarcensis* Bizon, 1960**
Figure 3J–M

cf. 1960 *Cytherella toarcensis* sp. nov.; Bizon, p. 203, pl. 1, fig. 4a–c, pl. 2, fig. 2a–c.
1979 *Cytherella toarcensis* Bizon. – Exton, p. 64, pl. 11, figs 8, 9.
2009 *Cytherella toarcensis* Bizon. – Arias *et al*., pp. 214, 216, pl. 1, figs 3–5.
cf. 2020 *Cytherella toarcensis* Bizon. – Cabral *et al*., p. 246, fig. 3l–p.

Material. – More than 1000 V and C, adults and juveniles in the Toarcian.

Remarks. – *Cytherella toarcensis* Bizon, 1960 from the Toarcian of the Paris Basin is characterized by its oval outline and a depression corresponding to the adductor muscle scars. The Early Toarcian age material from Peniche (Cabral *et al*. 2020) is very similar to specimens from the type area and elsewhere in France. However, Late Toarcian material from Boca da Mata and other localities of the same age in Portugal (Rabaçal, Exton 1979, M.C. Cabral data), Great Britain (Boomer & Ainsworth 2009, pl. 3, fig. 2, Mochras Borehole), Germany (Knitter & Riegraf 1984, pl. 4, fig. 4) and Spain (Arias *et al*. 2009) differ in having a less rounded outline, a more angular dorsal margin, a depression bordering the anterior margin, and a more strongly defined mid-dorsal to mid-valve depression. These morphological and distributional differences probably represent a new species. *Cytherella* cf. *toarcensis* is abundant in the Boca da Mata samples, totalling more than all other species combined (Fig. 11).

Figure 4. Ostracods from the Upper Toarcian of Boca da Mata section, Portugal. • A–D – *Bairdia ohmerti* Knitter, 1984, *bonarellii* Biozone, sample BM27; A – male RV, external view, SMF Xe 24018, l = 0.77, h = 0.42; B – female LV, external view, SMF Xe 24019, l = 0.80, h = 0.51; C – juvenile RV (A-3?), external view, SMF Xe 24020, l = 0.35, h = 0.20; D – juvenile carapace (A-1), dorsal view, SMF Xe 24021, l = 0.65, h = 0.41. • E – *Bairdia* aff. gr. *rostrata* Issler, 1908, RV, external view, SMF Xe 24022, l = 0.65, h = 0.30, *speciosum* Biozone, sample BM57. • F–I – *Bairdia* sp. A; F – carapace, right view, SMF Xe 24023, l = 0.61, h = 0.33, *meneghinii* Biozone, sample BM89; G – detail of F (antero-ventral zone); H – carapace, left view, SMF Xe 24024, l = 0.62, h = 0.31, *aalensis* Biozone, sample BM125; I – juvenile carapace (A-1), dorsal view, SMF Xe 24025, l = 0.51, h = 0.27, *aalensis* Biozone, sample BM118. • J, K – *Bairdiacypris rectangularis* Ainsworth, 1986; J – juvenile carapace (A-1?), right view, SMF Xe 24026, l = 0.39, h = 0.21, *bonarellii* Biozone, sample BM37; K – carapace, left view, SMF Xe 24027, l = 0.45, h = 0.24, *aalensis* Biozone, sample BM118. • L – *Patellacythere striata* (Triebel & Bartenstein, 1938), carapace, left view, SMF Xe 24028, l = 0.56, h = 0.32, *meneghinii* Biozone, sample BM80. • M, N – *Patellacythere ungulina* (Triebel & Bartenstein, 1938); M – carapace, dorsal view, SMF Xe 24029, l = 0.54, h = 0.30, *bonarellii* Biozone, sample BM18; N – broken juvenile carapace, left view, SMF Xe 24030, l = 0.36, h = 0.20, *bonarellii* Biozone, sample BM27. • O–Q – *Praebythoceratina scrobiculata* (Triebel & Bartenstein, 1938); O – carapace, dorsal view, SMF Xe 24031, l = 0.55, h = 0.30, *aalensis* Biozone, sample BM118; P – RV, external view, SMF Xe 24032, l = 0.62, h = 0.32, *speciosum* Biozone, sample BM61M; Q – detail of P, antero-dorsal zone. • R, S – *Praebythoceratina stimulea* (Schwager, 1866), *speciosum* Biozone, sample BM60; R – RV, external view, SMF Xe 24033, l = 0.55, h = 0.31; S – carapace, dorsal view, SMF Xe 24034, l = 0.63, h = 0.30. • T–V – *Tanycythere posteroelongata* Cabral, Lord, Boomer & Malz, 2014; T – carapace, dorsal view, SMF Xe 24035, l = 0.70, h = 0.24, *aalensis* Biozone, sample BM118; U – carapace, right view, SMF Xe 24036, l = 0.60, h = 0.20, *meneghinii* Biozone, sample BM80; V – detail of U, antero-dorsal zone. Dimensions in mm. Scale bars = 100 μm, except when indicated.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Occurrence. – Toarcian, *bonarellii*, *speciosum*, *meneghinii* and *aalensis* biozones to Aalenian, *opalinum* Biozone.

Genus *Cytherelloidea* Alexander, 1929

Type species. – *Cytherella williamsoniana* Jones, 1849.

***Cytherelloidea* sp. A**
Figure 3N–P

2009 *Cytherelloidea reticuloornata* Knitter, 1983. – Arias *et al*., pp. 216, 217, pl. 1, fig. 10.

Material. – 17 V and 1 C, adults and juveniles.

Remarks. – *Cytherelloidea* sp. A is an undescribed species with a central pattern of short, thin and irregular ribs, partly reticulate, however, our material comprises mostly valves, of adults and juveniles, many broken and poorly preserved. The species rarely occurs in the Upper Toarcian of Rabaçal (M.C. Cabral data), but with better preserved specimens, where the reticulation seems to occupy all the lateral surface. The species also occurs in the Late Toarcian of Cordillera Ibérica, Spain, identified as *C. reticuloornata*, but the Spanish specimens are less long than the Portuguese ones.

Occurrence. – Toarcian, *speciosum*, *meneghinii* and *aalensis* biozones.

Order Podocopida Sars, 1866
Suborder Bairdiocopina Gründel, 1967
Superfamily Bairdioidea Sars, 1887
Family Bairdiidae Sars, 1887

Genus *Bairdia* M'Coy, 1844

Type species. – *Bairdia curta* M'Coy, 1844.

Remarks. – Maddocks (1969) sensibly argues that *Bairdia* sensu stricto refers to Palaeozoic taxa, however, with early Mesozoic material for convenience we use the name *Bairdia* sensu lato.

***Bairdia ohmerti* Knitter, 1984**
Figure 4A–D

1979 *Bairdia* sp. 3. – Exton, p. 54, pl. 11, figs 1, 2.
1983 *Bairdia inflata* sp. nov.; Knitter, p. 217, pl. 35, figs 1, 2.
1984 *Bairdia ohmerti* sp. nov.; Knitter, p. 50 pl. 1, fig. 1.

Material. – *Ca.* 90 adult and juvenile V and C.

Remarks. – Our material is identical in three-dimensional shape and ornament to specimens figured by Knitter (1983) from the Upper Toarcian (Lias ζ) of SW Germany, including male and female dimorphs; the species also occurs in the Upper Toarcian of Rabaçal (Loureiro *et al*. 2010, M.C. Cabral data).

Occurrence. – Toarcian, *bonarellii*, *speciosum* and *meneghinii* biozones.

***Bairdia* aff. gr. *rostrata* Issler, 1908**
Figure 4E

aff. 1908 *Bairdia rostrata* sp. nov.; Issler, p. 95, pl. 7, fig. 345.
2007 *Bairdia* aff. *rostrata*. – Pinto *et al*., pl. 1, fig. 2.
2016 *Bairdia* aff. *rostrata*. – Rocha *et al*., figs 4, 8.10.
2020 *Bairdia* cf. *B. rostrata*. – Cabral *et al*., p. 255, fig. 6n.

Material. – 2 adult V.

Remarks. – *Bairdia rostrata* was described from the Upper Pliensbachian (Lias δ) of SW Germany. Our material differs from the type figure of Issler in a less rounded dorsal margin and in the higher and shorter posterior margin, and from the Peniche carapace in greater length, lower height and a straighter dorsal margin, that is, the Peniche specimen is closer to Issler's figure.

Occurrence. – Toarcian, *speciosum* Biozone.

***Bairdia* sp. A**
Figure 4F–I

Material. – *Ca*. 120 C, mostly juveniles.

Remarks. – An elongate subtrapezoidal species with straight ventral margin leading to a short pointed posterior extremity located ventrally at ¾ h. Anterior margin evenly rounded with greatest extremity at mid-h. Weak anterior and posterior marginal depressions, as described by Apostolescu (1959) for *Bairdia molesta* Apostolescu. In dorsal view elongate with position of greatest w located slightly anterior of mid-l. Surface completely punctate. Interior unknown. The species also occurs in the Upper Toarcian of Rabaçal (M.C. Cabral data).

Bairdia sp. A differs from *B. ohmerti* in smaller presumed adult dimensions and relative carapace elongation.

Occurrence. – Toarcian, *meneghinii* and *aalensis* biozones.

Genus *Bairdiacypris* Bradfield, 1935

Type species. – *Bairdiacypris deloi* Bradfield, 1935.

***Bairdiacypris rectangularis* Ainsworth, 1986**
Figure 4J–K

1979 *Bairdiacypris* sp. – Exton, p. 55, pl. 11, fig. 11.
1986 *Bairdiacypris rectangularis* sp. nov.; Ainsworth, pp. 295, 296, pl. 3, figs 1, 2, 7.
2013 *Bairdiacypris rectangularis* Ainsworth. – Cabral *et al*., p. 68, estampa 1–18.
2020 *Bairdiacypris rectangularis* Ainsworth. – Cabral *et al*., p. 256, fig. 7a–c.

Material. – 35 C, adults and juveniles.

Remarks. – *Bairdiacypris rectangularis* ranges from the Lower Toarcian of Peniche where it occurs abundantly after the Carbon Isotope Excursion, however, in the Upper Toarcian of Boca da Mata it is relatively uncommon. It also occurs through all the Toarcian of Rabaçal, except *polymorphum* Biozone (Loureiro *et al*. 2010).

Occurrence. – Toarcian, *bonarellii*, *speciosum* and *aalensis* biozones.

Suborder Cytherocopina Baird, 1850
Superfamily Cytheroidea Baird, 1850
Family Bythocytheridae Sars, 1926

Genus *Patellacythere* Gründel & Kozur, 1972

Type species. – *Monoceratina williamsi* Stephenson, 1946.

Remarks. – Jurassic species formerly placed in *Monoceratina* Roth, 1928 have been revised, see discussion in Pais *et al*. (2016, p. 213).

***Patellacythere striata* (Triebel & Bartenstein, 1938)**
Figure 4L

1938 *Monoceratina striata* sp. nov.; Triebel & Bartenstein, pp. 514, 516, figs 14, 15.
1999a *Monoceratina striata* Triebel & Bartenstein. – Arias & Lord, p. 92, pl. 4, fig. 4.

Material. – 4 C.

Remarks. – *Patellacythere striata* is reported widely from the Toarcian of Western Europe although it is rarely common; it also occurs sporadically through all the Toarcian of Rabaçal (Loureiro *et al*. 2010, M.C. Cabral data).

Occurrence. – Toarcian, *bonarellii* and *meneghinii* biozones; Aalenian, *opalinum* Biozone.

***Patellacythere ungulina* (Triebel & Bartenstein, 1938)**
Figure 4M–N

1938 *Monoceratina ungulina* sp. nov.; Triebel & Bartenstein, pp. 506, 508, figs 3, 4.
1979 *Monoceratina ungulina* Triebel & Bartenstein. – Exton, p. 57, pl. 11, fig. 7.
1999a *Monoceratina ungulina* Triebel & Bartenstein. – Arias & Lord, p. 92, pl. 4, fig. 6.
2009 *Monoceratina ungulina* Triebel & Bartenstein. – Arias *et al*., p. 218, pl. 2, fig. 3.
2020 *Patellacythere ungulina* (Triebel & Bartenstein). – Cabral *et al*., p. 258, fig. 7o, p.

Material. – 9 C and V, mostly juveniles.

Remarks. – *Patellacythere ungulina*, described originally from the Upper Toarcian (Lias ζ) of SW Germany, occurs rarely in Boca da Mata, poorly preserved, as in Rabaçal (Lower to Upper Toarcian, Loureiro *et al.* 2010) and Peniche (Middle Toarcian).

Occurrence. – Toarcian, *bonarellii* Biozone.

Genus *Praebythoceratina* Gründel & Kozur, 1972

Type species. – *Bythoceratina progacilis* Kozur, 1972.

***Praebythoceratina scrobiculata* (Triebel & Bartenstein, 1938)**
Figure 4O–Q

1938 *Monoceratina scrobiculata* sp. nov.; Triebel & Bartenstein, pp. 508, 509, figs 5, 6.
1979 *Monoceratina scrobiculata* Triebel & Bartenstein. – Exton, p. 56, pl. 11, fig. 6.
2009 *Monoceratina scrobiculata* Triebel & Bartenstein. – Arias *et al*., p. 217, pl. 1, figs 13–15.

Material. – *Ca*. 500 V, adults and juveniles, 4 C.

Remarks. – Abundant in Boca da Mata, often broken. Common in the Toarcian of Western Europe, it also occurs in the Middle and Upper Toarcian of Rabaçal (Loureiro *et al*. 2010). A number of citations of *P. scrobiculata* in the literature are incorrect, see discussion in Pais *et al*. (2016, p. 214).

Occurrence. – Toarcian, *bonarellii*, *speciosum*, *meneghinii* and *aalensis* biozones to Aalenian, *opalinum* Biozone.

***Praebythoceratina stimulea* (Schwager, 1866)**
Figure 4R–S

1866 *Cythereis stimulea* sp. nov.; Schwager *in* Oppel & Waagen, p. 276, fig.1.
1938 *Monoceratina stimulea* (Schwager, 1866). – Triebel & Bartenstein, pp. 505, 506, figs 1, 2.
2009 *Monoceratina stimulea* (Schwager). – Arias *et al*., pp. 217, 218, pl. 2, figs 1, 2.

Material. – *Ca*. 50 V and C.

Remarks. – Characterised by a prominent lateral spine that is frequently broken. The species appears to range from the Toarcian to the Upper Jurassic. It also occurs in the Middle and Upper Toarcian of Rabaçal (Loureiro *et al*. 2010, M.C. Cabral data).

Occurrence. – Toarcian, *bonarellii*, *speciosum* and *aalensis* biozones.

Genus *Tanycythere* Cabral, Lord, Boomer & Malz, 2014

Type species. – *Tanycythere caudata* Cabral, Lord, Boomer & Malz, 2014.

***Tanycythere posteroelongata* Cabral, Lord, Boomer & Malz, 2014**
Figure 4T–V

2014 *Tanycythere posteroelongata* sp. nov.; Cabral, Lord, Boomer & Malz, p. 523, figs 2, 14–26.

Material. – 5 adult C, 1 adult V.

Remarks. – The description of *Tanycythere posteroelongata* includes figured material from Boca da Mata. A rare species in Boca da Mata and Rabaçal.

Occurrence. – Toarcian, *meneghinii* and *aalensis* biozones.

Family Cytheruridae G.W. Müller, 1894

Genus *Cytheropterina* Mandelstam, 1956

Type species. – *Cytheropterina vegranda* Mandelstam, 1956.

***Cytheropterina ainsworthi* Cabral, Lord & Pinto sp. nov.**
Figure 5A–K

LSID. – urn:lsid:zoobank.org:act:5C766176-77DB-484E-9C9B-69189715EED2

Types. – Holotype: one male LV, SMF Xe 24037; l = 0.56, h = 0.34, sample BM125 (Fig. 5A–C).

Paratypes: one female LV, SMF Xe 24038, l = 0.52, h = 0.33, sample BM125 (Fig. 5D); one female LV, SMF Xe 24039, l = 0.54, h = 0.35, sample BM125 (Fig. 5E); one male RV, SMF Xe 24040, l = 0.55, h = 0.27, sample BM125 (Fig. 5F); one ?female LV, SMF Xe 24041, l = 0.49, h = 0.33, sample BM125 (Fig. 5G); one female RV, SMF Xe 24042, l = 0.53, h = 0.28, sample BM125 (Fig. 5H); one juvenile C, SMF Xe 24043, l = 0.37, h = 0.22, sample BM125 (Fig. 5I, J); one female carapace, SMF Xe 24044, l = 0.50, h = 0.30, sample BM125 (Fig. 5K).

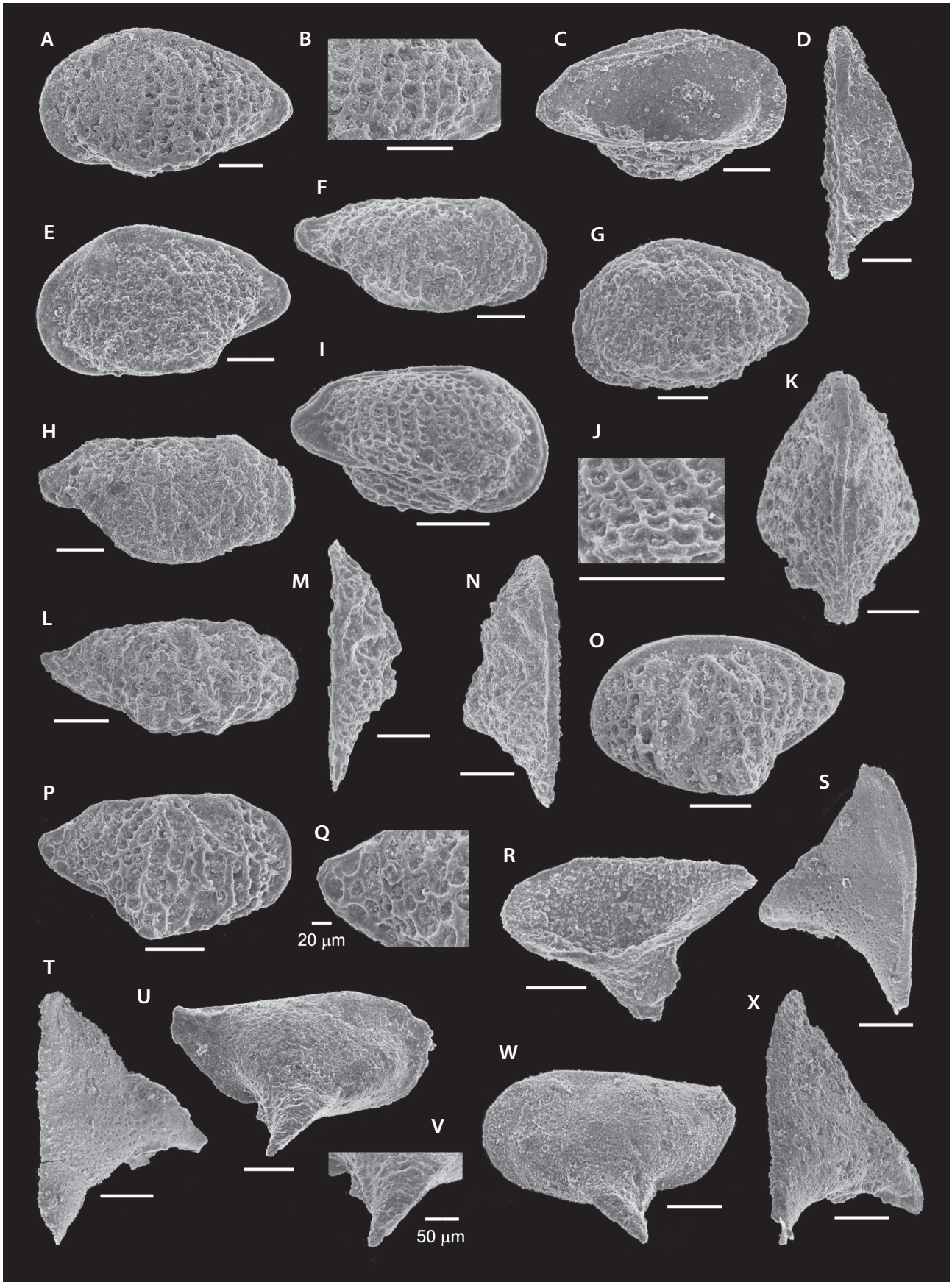
Type horizon and locality. – Type-level sample BM125, Toarcian, *aalensis* Biozone, Póvoa da Lomba Formation; Boca da Mata, Portugal.

Material. – *Ca*. 30 adult and juvenile V and rare C.

Etymology. – In honour of Dr. Nigel Ainsworth in recognition of his important contributions to knowledge of Mesozoic ostracods and their biostratigraphy from offshore Ireland, especially as based on borehole cuttings samples.

Diagnosis. – A species of the genus *Cytheropterina*, with a medium size carapace; reticulate ornamentation with polygonal cells, mostly quadrate, with primary ribs

Figure 5. Ostracods from the Upper Toarcian of Boca da Mata section, Portugal. • A–K – *Cytheropterina ainsworthi* Cabral, Lord, Pinto sp. nov., *aalensis* Biozone, sample BM125; A – male LV, external view, holotype, SMF Xe 24037, l = 0.56, h = 0.34; B – detail of A (ornamentation); C – male LV, internal view, holotype, same specimen as A; D – female LV, ventral view, paratype, SMF Xe 24038, l = 0.52, h = 0.33; E – female LV, external view, paratype, SMF Xe 24039, l = 0.54, h = 0.35; F – male RV, external view, paratype, SMF Xe 24040, l = 0.55, h = 0.27; G – female? LV, external view, paratype, SMF Xe 24041, l = 0.49, h = 0.33; H – female RV, external view, paratype, SMF Xe 24042, l = 0.53, h = 0.28; I – juvenile carapace (A-3?), right view, paratype, SMF Xe 24043, l = 0.37, h = 0.22; J – detail of I, ornamentation; K – female carapace, dorsal view, paratype, SMF Xe 24044, l = 0.50, h = 0.30. • L–Q – *Cytheropterina cribra* (Fischer, 1962). L–M – *meneghinii* Biozone, sample BM89; L – male RV, external view, SMF Xe 24045, l = 0.47, h = 0.22; M – male RV, dorsal view, same specimen as L. N – female LV, dorsal view, SMF Xe 24046, l = 0.45, h = 0.28, *speciosum* Biozone, sample BM67. O–Q – *bonarellii* Biozone, sample BM27; O – female LV, external view, SMF Xe 24047, l = 0.42, h = 0.27; P – female RV, external view, SMF Xe 24048, l = 0.43, h = 0.26; Q – detail of P, ornamentation. • R–X – *Cytheropteron alafastigatum* Fischer, 1962. R – juvenile RV (A-2?), internal view, SMF Xe 24049, l = 0.43, h = 0.28, *speciosum* Biozone, sample BM52B. S–V, *aalensis* Biozone, sample BM118; S – female? LV, dorsal view, SMF Xe 24050, l = 0.48, h = 0.35; T – female? RV, dorsal view, SMF Xe 24051, l = 0.48, h = 0.33; U – male? RV, external view, SMF Xe 24052, l = 0.52, h = 0.37; V – detail of U, ventral alar expansion. W, X – *bonarellii* Biozone, sample BM27; W – male? LV, external view, SMF Xe 24053, l = 0.51, h = 0.37; X – male? RV, dorsal view, SMF Xe 24054, l = 0.52, h = 0.40. Dimensions in mm. Scale bars = 100 µm, except when indicated.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vertical; ventral alar expansion highlighted by a curved rib along its margin.

Description. – Carapace medium size, with sub-quadrate to sub-oval outline tapering posteriorly; LV > RV. Greatest l above mid-h, coincident with the extremity of the caudal process; in LV, greatest h at anterior cardinal angle, more than half of l; in RV, greatest h at mid-length, less (♂) or equal (♀) than half of l; greatest w slightly posteriorly to 3/5 length, more than 3/5 of l in females. Presence of a round to elongate ocular tubercle and a round, well-developed ventral alar expansion. In dorsal (Fig. 5K) and ventral (Fig. 5D) view, the carapace is sagittate, with anterior pointed and the posterior margin extending beyond the two ventro-alar expansions. Sexual dimorphism present with males slightly longer and less high and less wide than females; juveniles (Fig. 5I, J) have a less oval outline, clear straight dorsal margin in both V and a concave ventral margin, and show well developed ornament.

Dorsal margin straight with clear cardinal angles, long in RV, shorter in LV. Ventral margin straight to slightly concave tapering towards the posterior, in external lateral view covered in the middle zone by the ventral alar expansion. Anterior margin rounded, infracurvate. Posterior margin with a flat caudal process, directed horizontally. Lateral surface reticulated with polygonal mesh, mostly quadrate (Fig. 5B). The reticulum is mainly formed by strong vertical primary ribs, slightly curved, ending in a horizontal curved rib that runs along the margin of the ventral alar expansion. In LV presence of anterior, posterior and dorsal marginal rims; in RV presence only of anterior and posterior marginal rims. Ventral surface reticulate (Fig. 5D). Simple normal pore canals can be seen on the lateral surface, on the muri of the reticulum or adjacent to them.

Hinge in the LV (Fig. 5C) with large terminal locellate sockets, separated by a median crenulate bar; presence of a large accommodation groove; narrow marginal zones, which seem without vestibule; other internal features not seen.

Dimensions: ♀ l = 0.49–0.54, h = 0.28–0.35; ♂ l = 0.55–0.56, h = 0.27–0.34.

Remarks. – *Cytheropterina ainsworthi* Cabral, Lord & Pinto sp. nov. is very similar to *C. cribra* (Fischer, 1962), from the Upper Toarcian (Lias ζ) of Germany and found abundantly through the Boca da Mata section, but the first species differs in having larger dimensions, absence of dorso-median vertical sulcus, a more regular reticulation pattern and ventral alar expansion rounded, not inclined postero-ventrally.

Cytheropterina alacostata Franz, Ebert & Stulpinaite, 2018, from the Middle Aalenian of SW Germany, is much smaller than the Portuguese species, has a more pronounced ventral alar expansion and in its reticulation pattern the primary vertical ribs are not so prominent.

Occurrence. – Until now only known in Portugal, in the Lower Jurassic, Upper Toarcian (*meneghinii* and *aalensis* biozones) at Boca da Mata (Póvoa da Lomba Formation).

***Cytheropterina cribra* (Fischer, 1962)**
Figure 5L–Q

1962 *Cytheropteron* (*Cytheropteron*) *bispinosum cribrum* sp. nov.; Fischer, p. 339, pl. 20, figs 8–11.
2009 *Cytheropteron cribrum* (Fischer). – Arias *et al*., p. 220, pl. 2, figs 5, 6.

Material. – *Ca*. 200 adult and juvenile V, 1 juvenile C.

Remarks. – From published figures some variation is evident in the strength of development of the ventral alar extension and of vertical and horizontal elements of the surface ornament. The Boca da Mata material is very close to the species figured by Bodergat & Donze (1988, pl. 1, fig. 18) from the Upper Toarcian of the Paris Basin and similar to material of Ainsworth (1986, pl. 4, fig. 6) from the Toarcian and Aalenian of Fastnet Basin, offshore SW Ireland which has a stronger median horizontal rib, as do other specimens from Western Europe figured in literature (Germany, Herrig 1981b, Franz *et al*. 2009; Switzerland, Tesakova 2017). Sexual dimorphism evident in l:h ratio with more elongate males.

Occurrence. – Toarcian, *bonarellii*, *speciosum*, *meneghinii* and *aalensis* biozones to Aalenian, *opalinum* Biozone.

Genus *Cytheropteron* Sars, 1866

Type species. – *Cythere latissima* Norman, 1865.

***Cytheropteron alafastigatum* Fischer, 1962**
Figure 5R–X

1962 *Cytheropteron alafastigatum* sp. nov.; Fischer, pp. 336–338, pl. 20, figs 1–6.
1979 *Cytheropteron alafastigatum* Fischer. – Exton, p. 57, pl. 11, fig. 5.
1999b *Cytheropteron byfieldensis* Boomer & Bodergat, 1992. – Arias & Lord, p. 220, pl. 1, figs 1, 2.

Material. – *Ca*. 500 V and rare C.

Remarks. – Originally described from the Upper Toarcian of SW Germany, occurs commonly in the Toarcian of Western Europe, including Rabaçal (Exton 1979). The

development of the alar ventral extension varies in strength and occasionally bears a rib (Fig. 5U, V) or a flangelike structure (Fig. 5R–T, X). The Boca da Mata specimens show a weak punctate ornamentation. The ventral extension is frequently more strongly developed and more posteriorly located than in the type-material especially in dorsal view. *Cytheropteron byfieldense* Boomer & Bodergat, 1992, from the Middle Toarcian of Byfield, U.K. has a more robust carapace with coarsely developed fossae and a rounded alar ventral extension.

Occurrence. – Toarcian, *bonarellii*, *speciosum*, *meneghinii* and *aalensis* biozones.

Genus *Eucytherura* G.W. Müller, 1894

Type species (by subsequent designation). – Eucytherura complexa (Brady, 1867).

Remarks. – Whatley & Boomer (1990) made a welcome revision of early Mesozoic cytherurids, however, we believe that placing many previously described fossil taxa into a single genus is probably an oversimplification of the systematics, especially as the genus selected is *Eucytherura*, a living genus. For reasons of practicality, we follow Whatley & Boomer (*op. cit.*). Danielopol *et al.* (2023) discuss aspects of *Eucytherura* species including pore conuli, loophole pore canals, the caudal process, and exterior marginal zone structures which we follow in description of the new species below.

***Eucytherura alvaiazerensis* Cabral, Lord & Pinto sp. nov.**
Figure 6A–J

1985 *Trachycythere* sp. – Dépêche, p. 136, pl. 31, fig. 20.
1990 *Vesticytherura* sp. – Brand, pp. 174, 175, pl. 6, figs 12, 13.
2018 *Tethysia* sp.1 Tesakova. – Franz *et al*., p. 71, pl. 3, fig. 12.
2021 *Eucytherura* cf. *yunga* Ballent & Whatley. – Franz, *in* Wannenmacher *et al*., p. 15, fig. 9.5.

LSID. – urn:lsid:zoobank.org:act:20202A10-E20F-4862-BE06-8B06BC2C2016

Types. – Holotype: one female carapace, SMF Xe 24055; l = 0.32, h = 0.17, sample BM77 (Fig. 6A).

Paratypes: one female carapace, SMF Xe 24056, l = 0.33, h = 0.18, sample BM61M (Fig. 6B, G); one male carapace, SMF Xe 24057, l = 0.36, h = 0.17, sample BM57 (Fig. 6C, F); one female RV, SMF Xe 24058, l = 0.34, h = 0.17, sample BM27 (Fig. 6D, E); one female carapace, SMF Xe 24059, l = 0.33, h = 0.17, sample BM57 (Fig. 6H); one female LV, SMF Xe 24060, l = 0.34, h = 0.17, sample B77 (Fig. 6I); one male RV, SMF Xe 24061, l = 0.37, h = 0.17, sample BM118 (Fig. 6J).

Type horizon and locality. – Type-level sample BM77, Toarcian, *meneghinii* Biozone, Póvoa da Lomba Formation; Boca da Mata, Portugal.

Material. – 22 C, 5V mostly adults.

Etymology. – A reference to the type-area of Alvaiázere, where the Boca da Mata section is located.

Diagnosis. – A species of *Eucytherura* with a very small elongate carapace; lateral surface with two main longitudinal ribs each one ending in a posterior node, and eight tubercles, four above and four below the mid rib.

Description. – Carapace very small, elongate, with subrectangular outline tapering posteriorly; valves of almost the same size. Greatest l below mid-h; greatest h at anterior cardinal angle, *ca*. half of l; greatest w posteriorly at $^{2}/_{3}$ length, less than $^{1}/_{3}$ of l. Presence of a round and prominent ocular tubercle and a curved, weak ventral expansion. In dorsal view (Fig. 6F, G) the carapace has almost parallel margins in the anterior and middle zones to slightly diverging ones posteriorly; the posterior end is pointed. In ventral view (Fig. 6H) it has a sagittate outline, with anterior pointed but slightly round, and the posterior margin pointed after extending beyond the two postero-ventro-lateral expansions; ventral surface with several fine longitudinal ribs. Sexual dimorphism present with males slightly longer and proportionally less high and wide than females.

Dorsal margin straight, partially covered by a prominent ridge which develops as an upstanding flange. Ventral margin straight tapering towards the posterior, partially covered by the weak ventro-lateral expansion. Anterior margin rounded, slightly infracurvate. In rare specimens the peripheral part of the anterior marginal zone (*sensu* Danielopol *et al*. 2023) displays 3–4 small radial strips (Fig. 6A and I). Posterior margin flattened and pointed, with extremity close to or below mid-h; absence of a caudal process (*sensu* Danielopol *et al*. 2023).

In rare better-preserved specimens (Fig. 6B, D, E) the lateral surface seems completely punctate; the flattened posterior zone is reticulated with a polygonal mesh (Fig. 6A, D). Starting in the ocular tubercle, a rib descends parallel to the anterior margin, bends upwards in the anteroventral region and then downwards in the medioventral region, ending posteriorly in a prominent node; below this sinuous ventral rib, several thin, longitudinal and curved ribs follow the margin of the weak ventral expansion. Starting from the anteromedian area,

a mid-rib, slightly sinuous, runs obliquely upwards, also ending posteriorly in a clear node which has several minor vertical ribs (Fig. 6A, D). Eight small tubercles are visible on the lateral surface, above and below the mid rib: above the mid rib and below the upstanding dorsal flange, four tubercles of different size occur, three located in the anterior half, one in the posterior; below the mid rib and above the ventral rib, four tubercles of similar size, one located anteriorly, three posteriorly, following the orientation of the mid rib. Normal pore canals of conuli type can be seen on the lateral surface, three of them very clearly, located in the posterior part, aligned vertically in a kind of curved rib (Fig. 6D, E).

Hinge in the right valve (Fig. 6J) with prominent terminal teeth, the anterior round, the posterior more elongated, separated by a long median groove, however, poor preservation prevented recognition of smooth or locellate median structure; marginal zones broad without vestibule; other internal features not seen.

Dimensions: ♀ l = 0.32–0.34, h = 0.17–0.18; ♂ l = 0.36–0.37, h = 0.17.

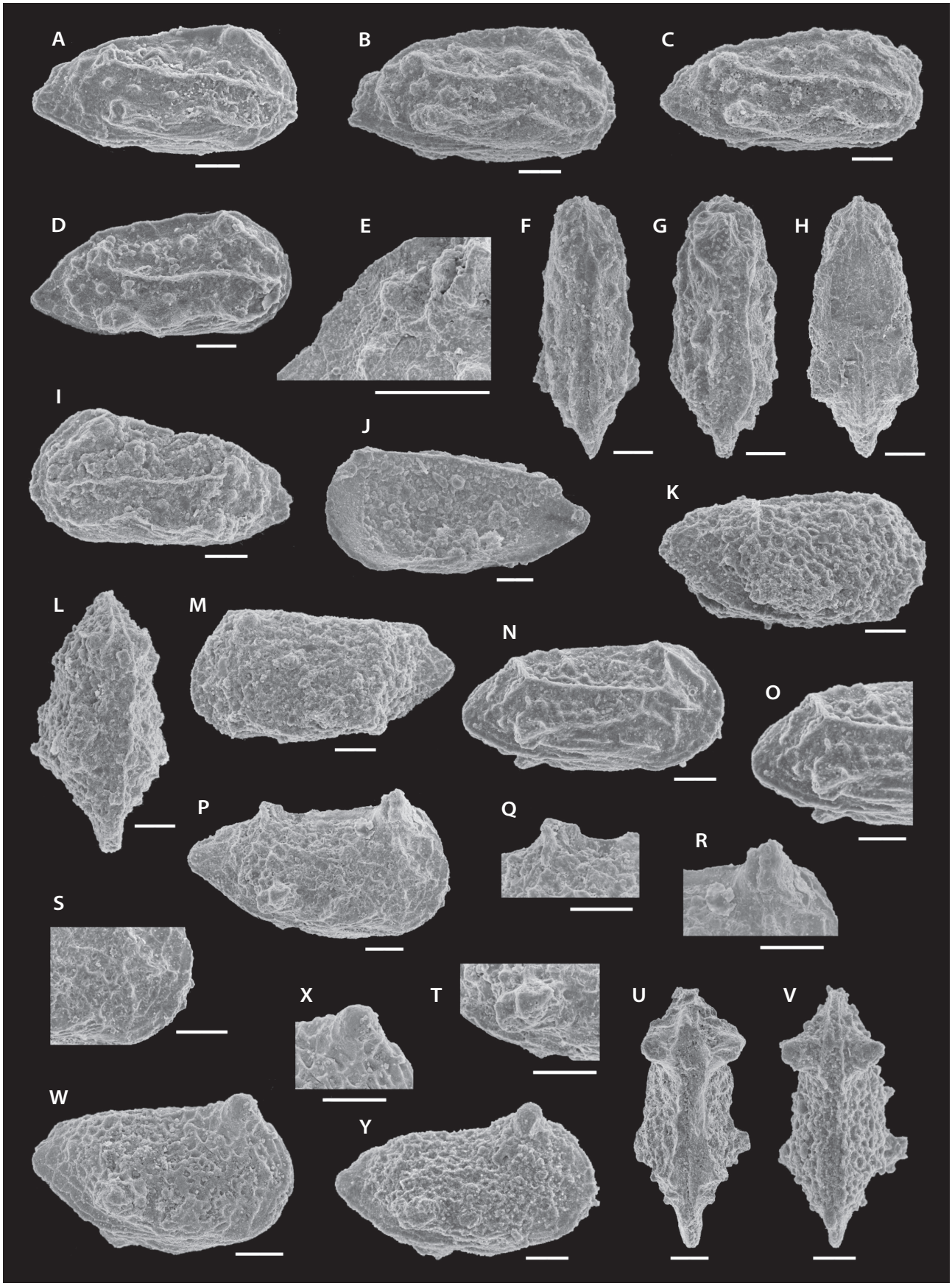
Remarks. – *Eucytherura alvaiazerensis* Cabral, Lord & Pinto sp. nov. is present in several levels at Boca da Mata, in all the Upper Toarcian biozones, but always with rare specimens. This rarity and its very small dimensions probably explain the absence of its description in the literature. In addition to Portugal, it was also found in Germany, in several localities of different ages attributed to different genera. It is figured by (1) Brand (1990) as *Vesticytherura* sp., found in the upper Bathonian (*discus* zone) in NW Germany; (2) Franz *et al*. (2018) as *Tethysia* sp.1 Tesakova, found in the Lower and Upper Aalenian of SW Germany; (3) Franz *in* Wannenmacher *et al*. (2021) as *Eucytherura* cf. *yunga* Ballent & Whatley, found in the Aalenian of SW Germany. The specimen of *Trachycythere* sp. figured in Dépêche (1985), from the Middle Bathonian of Normandy, France, though badly preserved, very probably also belongs to *E. alvaiazerensis*. According to these known occurrences, *E. alvaiazerensis* Cabral, Lord & Pinto sp. nov. ranges in age from the Early Jurassic (Upper Toarcian) to the Middle Jurassic (Bathonian), with the oldest form being the Portuguese one, the most southerly located.

Rutlandella striata Knitter, 1983, from the Lias ζ, SW Germany, is very similar to *E. alvaiazerensis* Cabral, Lord & Pinto sp. nov., but is proportionally more elongate, with a more projecting posterior margin, presence of secondary ribs running parallel to the stronger primary ones, protruding radial strips in the anterior marginal zone and absence of lateral tubercles. *Tethysia* sp. 1 Tesakova, 2017, from the Middle Jurassic of N Switzerland has a very weak ocular tubercle, less sinuous primary ribs (mid and ventral) with different posterior ends, and fine striate secondary ribs. *Rutlandella transversiplicata* Bate & Coleman, 1975, from the Lower and Middle Toarcian of U.K. has a more sub-ovate outline, a more developed ventral expansion and a reticulate ornamentation. These four species, from Portugal, Germany, Switzerland and U.K., are clearly closely related but not identical.

Eucytherura alvaiazerensis Cabral, Lord & Pinto sp. nov. is also very similar to our *E*. aff. *transversiplicata* (Fig. 6N, O), also found by Knitter (1983) and by Tesakova (2017) – see discussion below. This species differs from *E. alvaiazerensis* sp. nov. in having a less pronounced ocular tubercle and a different rib pattern: an independent and less sinuous ventral rib, not ending in a node; a straight mid rib, posteriorly bifurcated, without a final node; two short ribs starting at the ocular tubercle, one oblique and anterior, the other vertical, ending in the mid rib; a very short vertical rib joining the main mid and ventral ribs.

Occurrence. – In Portugal known from the Lower Jurassic, Upper Toarcian (*bonarellii*, *speciosum*, *meneghinii* and *aalensis* biozones) and Middle Jurassic, Aalenian

Figure 6. Ostracods from the Upper Toarcian of Boca da Mata section, Portugal. • A–J – *Eucytherura alvaiazerensis* Cabral, Lord, Pinto sp. nov.; A – female carapace, right view, holotype, SMF Xe 24055, l = 0.32, h = 0.17, *meneghinii* Biozone, sample BM77; B – female carapace, right view, paratype, SMF Xe 24056, l = 0.33, h = 0.18, *speciosum* Biozone, sample BM61M; C – male carapace, right view, paratype, SMF Xe 24057, l = 0.36, h = 0.17, *speciosum* Biozone, sample BM57; D – female RV, external view, paratype, SMF Xe 24058, l = 0.34, h = 0.17, *bonarellii* Biozone, sample B27; E – detail of D (ornamentation and pore conuli); F – male carapace, dorsal view, paratype, same specimen as C; G – female carapace, dorsal view, paratype, same specimen as B; H – female carapace, ventral view, paratype, SMF Xe 24059, l = 0.33, h = 0.17, *speciosum* Biozone, sample B57; I – female LV, external view, paratype, SMF Xe 24060, l = 0.34, h = 0.17, *meneghinii* Biozone, sample B77; J – male RV, internal view, paratype, SMF Xe 24061, l = 0.37, h = 0.17, *aalensis* Biozone, sample B118. • K–M – *Eucytherura* aff. *ornata* (Ainsworth, 1986); K – carapace, right view, SMF Xe 24062, l = 0.34, h = 0.19, *speciosum* Biozone, sample BM61M; L – carapace, dorsal view, same specimen as K; M – LV, external view, specimen lost, *speciosum* Biozone, sample BM60. • N, O – *Eucytherura* aff. *transversiplicata* (Bate & Coleman, 1975) *sensu* Knitter (1983); N – carapace, right view, SMF Xe 24063, l = 0.34, h = 0.17, *meneghinii* Biozone, sample BM89; O – detail of N, ornamentation, posterior zone. • P–U – *Eucytherura trituberosa* (Brand, 1990), *meneghinii* Biozone, sample BM89; P – carapace, right view, SMF Xe 24064, l = 0.35, h = 0.19; Q – detail of P, postero-dorsal tubercle; R – detail of P, ocular tubercle; S – detail of P, ornamentation and pore conuli, antero-ventral zone; T – detail of P, postero-ventral tubercle; U – carapace, dorsal view, same specimen as P. • V–Y– *Eucytherura* sp. A; V – female? carapace, dorsal view, SMF Xe 24065, l = 0.30, h = 0.17, *speciosum* Biozone, sample BM52B; W – female? carapace, right view, same specimen as V; X – detail of W, ocular tubercle; Y – male? carapace, right view, SMF Xe 24066, l = 0.32, h = 0.19, *aalensis* Biozone, sample BM125. Dimensions in mm. Scale bars = 50 μm.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(*opalinum* Biozone) at Boca da Mata (S. Gião and Póvoa da Lomba formations); also known in Germany and France, from the Middle Jurassic, Aalenian (SW Germany) and Bathonian (NW Germany and NW France).

***Eucytherura* aff. *ornata* (Ainsworth, 1986)**
Figure 6K–M

aff. 1986 *Wellandia ornata* sp. nov.; Ainsworth, pp. 308–10, pl. 5, figs 16, 19–21.

Material. – 2C, 2V.

Remarks. – Similar to *Wellandia ornata* Ainsworth, from the late Toarcian and Aalenian of Fastnet Basin, offshore SW Ireland, in external lateral shape and surface ornament. However, the Portuguese specimens are rare, very poorly preserved and we have no valves with good internal preservation to compare with the type figures, and there is no dorsal view of type material.

Occurrence. – Toarcian, *speciosum* Biozone.

***Eucytherura* aff. *transversiplicata* (Bate & Coleman, 1975) *sensu* Knitter (1983)**
Figure 6N, O

aff. 1975 *Rutlandella transversiplicata* sp. nov.; Bate & Coleman, pl. 10, figs 37–43, pl. 1.
1979 *Rutlandella transversiplicata* Bate & Coleman. – Exton, p. 58, pl. 14, fig. 6.

Material. – 5 C.

Remarks. – Our material differs from *Rutlandella transversiplicata* Bate & Coleman, 1975, from the Lower Toarcian of U.K. in ornamental detail, more quadrate lateral outline and shape when viewed dorsally. The Boca da Mata specimens are identical with Knitter's figures from the Upper Toarcian (Lias ζ), SW Germany, and Tesakova's figure from the Middle Jurassic of Switzerland. The species also occurs in the Upper Toarcian of Rabaçal (Exton 1979). The Portuguese, German and Swiss material is clearly closely related to *R. transversiplicata* but not identical, representing a new species.

Occurrence. – Toarcian, *speciosum*, *meneghinii* and *aalensis* biozones.

***Eucytherura trituberosa* (Brand, 1990)**
Figure 6P–U

1990 *Wellandia trituberosa* sp. nov.; Brand, p. 176, 177, pl. 6, figs 14–17.

Material. – 1 C.

Remarks. – One very small carapace identical with *Wellandia trituberosa* from the *discus* Biozone, Upper Bathonian, NW Germany. In both specimens from Portugal and the figured material from Germany the dorsal tubercles (ocular tubercle and postero-dorsal tubercle) are vertical and show single vertical grooves (Fig. 6P–R); the postero-ventral tubercle is longitudinal and presents a rounded top (Fig. 6P, T); in dorsal view (Fig. 6U) the width of dorsal margin between the two sets of tubercles is very narrow; the delicate anterior denticulation (Fig. 6S) is also common to both Portuguese and German material. The German specimens differ only slightly in having a longer posterior margin. In the Portuguese specimen it was possible to see normal pore canals of conuli type (Fig. 6S).

Occurrence. – Toarcian *meneghinii* Biozone.

***Eucytherura* sp. A**
Figure 6V–Y

Material. – 5 C.

Remarks. – Five very small carapaces at Boca da Mata are very close to *E. trituberosa* (Brand), with similar lateral outline, ornamentation (reticulation, ribs) and dorsal surface very narrow in dorsal view. The Portuguese specimens differ by the absence of the postero-dorsal tubercle, the presence of a more robust reticulation (thicker muri) and a round ocular tubercle (Fig. 6X). This rare species is very characteristic due to the strong prominent ocular tubercle, visible in lateral and dorsal views. Sexual dimorphism seems present with presumed males more elongate than females (Fig. 6W, Y). *Eucytherura* sp. A does not represent juveniles or sexual dimorphs of *E. trituberosa.*

Occurrence. – Toarcian, *bonarellii*, *speciosum*, *meneghinii* and *aalensis* biozones.

***Eucytherura* sp. B**
Figure 7A, B

Material. – 3 C.

Remarks. – Rare Boca da Mata specimens with very small dimensions, which differ from *Eucytherura liassica* Bate & Coleman, 1975 in lateral outline which taper posteriorly, strong posteroventral swelling and especially in lack of caudal process, much weaker ocular tubercle, and in ornamental detail. There is some similarity with *Tethysia bathonica* Sheppard (*in* Brand 1990) which has

a strong anterodorsal rib running from the weak ocular tubercle and a strong diagonal primary rib, and less pronounced posteroventral margin.

Occurrence. – Toarcian, *bonarellii* Biozone.

Genus *Microceratina* Swanson, 1980

Type species. – *Microceratina quadrata* Swanson, 1980.

***Microceratina andreui* Cabral & Lord, 2023 *in* Danielopol *et al*. (2023)**
Figure 7C, D

2023 *Microceratina andreui* sp. nov.; Cabral & Lord *in* Danielopol *et al*., pp. 325, 327, fig. 14a–v.

Material. – 3 C.

Remarks. – Very small to small carapaces, rare in the Toarcian, more abundant in the Aalenian. The type material is the three carapaces from the Toarcian of Boca da Mata.

Occurrence. – Toarcian, *speciosum* Biozone to Aalenian, *opalinum* Biozone.

Genus *Orthonotacythere* Alexander, 1933

Type species. – *Cytheridea*? *hanai* Israelsky, 1929.

***Orthonotacythere*? sp. 1**
Figure 7E, F

Material. – 2 C (one C is an internal cast of limited comparative use).

Remarks. – The carapace is relatively elongate with straight dorsal margin, convex ventral margin, rounded anterior margin and pointed posterior, with three prominent swellings ventrally, the third, most posterior of the three, seemingly a truncated spine base, and a fourth swelling adjacent to the anterior cardinal angle. Valve surfaces covered with reticulate ornamentation. Marginal spines present on the anterior and postero-ventral margins. We compare the figured carapace with *Orthonotacythere nodosa* Plumhoff, 1963 from the Upper Aalenian of NW Germany. The two species differ markedly in the arrangement of their prominent surface swellings but possibly belong together as two species of the same genus. Our specimen is probably related to the genus *Pariceratina* Gründel & Kozur, 1972, presenting the typical ventral row of three large nodes (sometimes thorn-like) with somewhat similar development, and anterior and posterior marginal spines, but it lacks the dorsal marginal spines and the anterior rib of that genus; unfortunately, the carapaces do not allow observation of the hinge.

Occurrence. – Toarcian, *speciosum* Biozone.

Genus *Otocythere* Triebel & Klingler, 1959

Type species. – *Otocythere callosa* Triebel & Klingler, 1959.

***Otocythere iberobritannica* Cabral & Lord sp. nov.**
Figure 7G–R

1978 *Otocythere callosa* Triebel & Klingler, 1959. – Lord, pp. 196, 200, 207, pl. 2, fig. 11.
1986 *Otocythere callosa* Triebel & Klingler, 1959. – Ainsworth, p. 302, pl. 4, fig. 7.

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Types. – Holotype: one female RV, SMF Xe 24070; l = 0.36, h = 0.20, sample BM77 (Fig. 7M).

Paratypes: one female carapace, SMF Xe 24071, l = 0.35, h = 0.22, sample BM77 (Fig. 7G); one male carapace, SMF Xe 24072, l = 0.41, h = 0.21, sample BM77 (Fig. 7H); one female LV, SMF Xe 24073, l = 0.38, h = 0.23, sample BM77 (Fig. 7I); one female carapace, SMF Xe 24074, l = 0.38, h = 0.22, sample BM77 (Fig. 7J); one male LV, SMF Xe 24075, l = 0.43, h = 0.23, sample BM77 (Fig. 7K, L); one male RV, SMF Xe 24076, l = 0.39, h = 0.20, sample BM77 (Fig. 7N); one female RV, SMF Xe 24077, l = 0.37, h = 0.21, sample BM77 (Fig. 7P, Q).

Type horizon and locality. – Type-level sample BM77, Toarcian, *meneghinii* Biozone, Póvoa da Lomba Formation; Boca da Mata, Portugal.

Material. – *Ca*. 360 V, *ca*. 30 C, adults and juveniles.

Etymology. – A reference to the geographical zones of known occurrence, Iberia (Portugal), British Islands (England, Wales and offshore SW Ireland).

Diagnosis. – A species of *Otocythere* with a small carapace; reticulate ornamentation with irregular round mesh and vertical primary ribs; two vertical sulci, a dorso-ventral median one and a short dorso-anterior one; short ventral alar expansion.

Description. – Carapace of small size, with sub-oval outline tapering posteriorly; LV > RV. Greatest l above

mid-h, coincident with the extremity of the caudal process; greatest h in the middle, coincident with the median sulcus, more than half of l, except in male RV; greatest w in the posterior third, more than ½ of l in females, less in males. Presence of a round ventral alar expansion, and of an ocular swelling in adults. In dorsal (Fig. 7G, H) and ventral (Fig. 7J) views, the carapace is ovate, with posterior pointed; in dorsal view, the overlap of the left valve on the right and the medium sulcus are clearly observed; ventral surface slightly depressed in the middle part, with 3–4 longitudinal ribs in each valve, separated by a row of pits in each interspace (Fig. 7J). Sexual dimorphism present with males longer and less high than females; juveniles similar to females.

Dorsal margin straight to slightly convex in LV, irregular in RV, with clear cardinal angles in RV. Ventral margin convex tapering towards the posterior, covered in external lateral view, in the middle zone by the ventral alar expansion. Anterior margin rounded, infra to equicurvate. Posterior margin with a caudal process (*sensu* Danielopol *et al*. 2023) pointing dorsally. Lateral surface reticulated with irregular round mesh; the reticulum is mainly formed by vertical primary ribs, slightly curved. Two vertical sulci start on the dorsal margin, close to each other; 1) a median one deeper, wider and longer, which finishes near the ventral margin after being interrupted by a short rib in the central zone (Fig. 7K, N, R); 2) an anterior one, oblique, also finishing near ventral margin, but deep in the dorsal part, very subtle below mid-h. Simple normal pore canals can be seen on the lateral surface, on the muri of the reticulum (Fig. 7L).

Hinge antimerodont (Fig. 7O–Q), the RV with two elongate terminal tooth plates bearing 6–8 teeth, separated by a short median locellate groove; LV with the corresponding terminal loculate sockets and a denticulate median bar above which is a long and narrow accommodation groove; narrow marginal zones without vestibule; other internal features not seen.

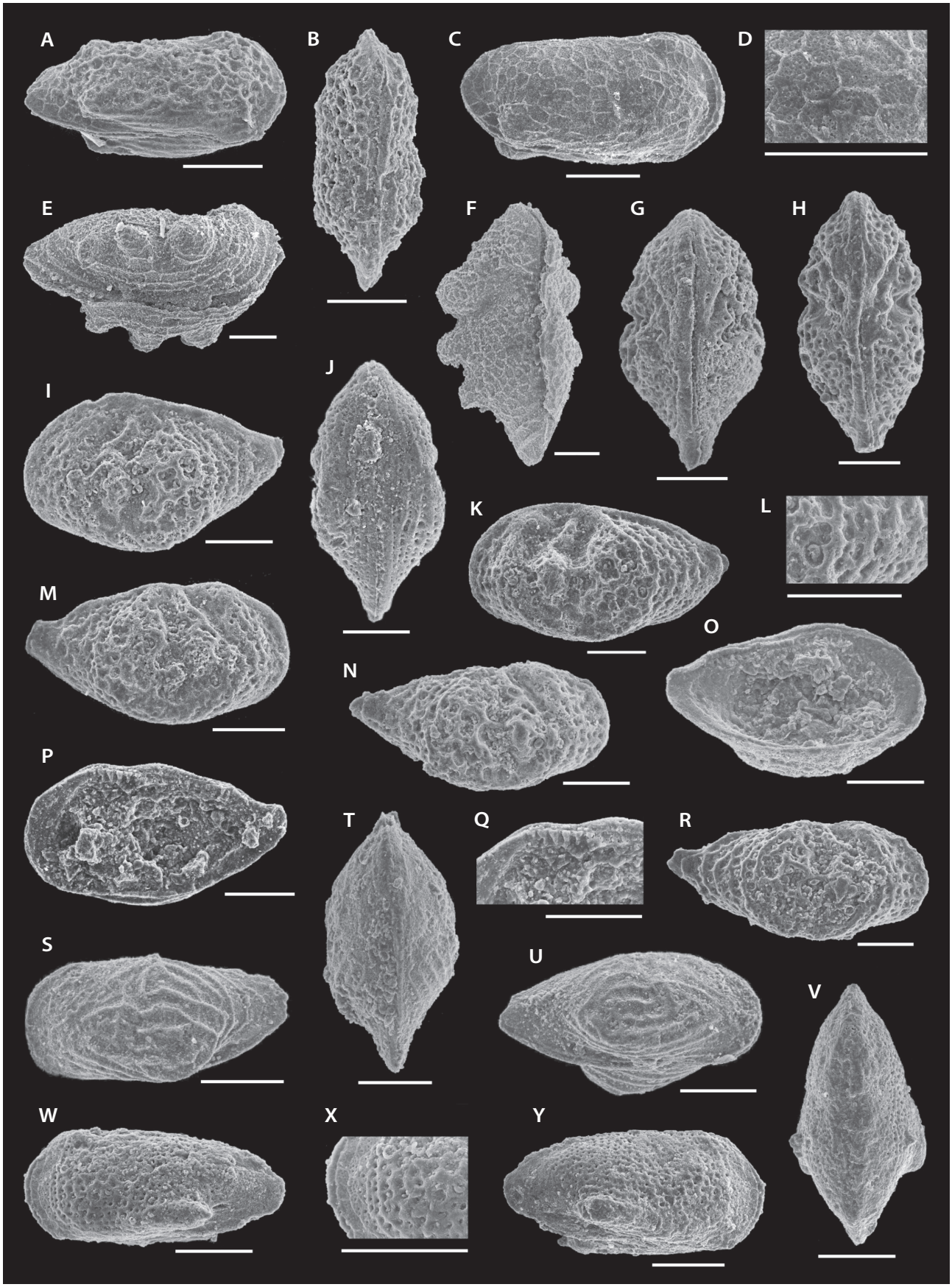
Dimensions: ♀ l = 0.35–0.38, h = 0.20–0.23; ♂ l = 0.39–0.43, h = 0.20–0.23.

Remarks. – *Otocythere iberobritannica* Cabral & Lord sp. nov. was found at Boca da Mata section, in almost all samples of the *speciosum*, *meneghinii* and *aalensis* biozones; the specimens from the *aalensis* Biozone are generally larger than those from the earlier biozones (Fig. 7R).

Otocythere iberobritannica sp. nov. is very similar to *O. callosa* Triebel & Klingler, 1959, from the Upper Toarcian and Aalenian of NW Germany, the only known species of the genus until now, with which it has been confused. *Otocythere callosa* is widely distributed in Western Europe, including Spain (Arias *et al*. 2009), and is characterised by a wrinkled mid-valve area with deeply excavated grooves and tubercles; the specimens of *O. iberobritannica* have less deep central depressions and stronger reticulate surface ornamentation; moreover, the Portuguese specimens are significantly smaller, both males and females, with small variation of l and h in each dimorph. The Portuguese material from Boca da Mata and Rabaçal (M.C. Cabral data) is identical to the figured specimens of Lord (1978) from the Upper Toarcian of Dorset coast, England, U.K., and of Ainsworth (1986) from the Toarcian and Aalenian of Fastnet Basin, offshore SW Ireland, representing a new species of *Otocythere* with a different palaeobiogeographical distribution of that of *O. callosa*.

Occurrence. – In Portugal known from the Lower Jurassic, Upper Toarcian, S. Gião and Póvoa da Lomba formations, at Boca da Mata (*bonarellii*, *speciosum*, *meneghinii* and *aalensis* biozones) and at Rabaçal (*speciosum* and *meneghinii* biozones); also known in the Upper Toarcian of England and Wales (Mochras Borehole data from P.F. Sherrington, pers. comm., in Lord 1978), and in the Toarcian and Aalenian offshore SW Ireland.

Figure 7. Ostracods from the Upper Toarcian of Boca da Mata section, Portugal. • A, B – *Eucytherura* sp. B, *bonarellii* Biozone, sample BM37; A – carapace, right oblique view, SMF Xe 24067, l = 0.35, h = 0.18; B – carapace, dorsal view, SMF Xe 24068, l = 0.35, h = 0.18. • C, D – *Microceratina andreui* Cabral & Lord, 2023 *in* Danielopol *et al.* (2023), *speciosum* Biozone, sample BM52B; C – carapace, right view, paratype, SMF Xe 23991, l = 0.39, h = 0.19; D – detail of C, ornamentation. • E, F –*Orthonotacythere*? sp. 1, *speciosum* Biozone, sample BM52B; E – carapace, right oblique view, SMF Xe 24069, l = 0.60, h = 0.30; F – carapace, dorsal oblique view, same specimen as E. • G–R – *Otocythere iberobritannica* Cabral & Lord sp. nov. G–Q – *meneghinii* Biozone, sample BM77; G – female carapace, dorsal view, paratype, SMF Xe 24071, l = 0.35, h = 0.22; H – male carapace, dorsal view, paratype, SMF Xe 24072, l = 0.41, h = 0.21; I – female LV, external view, paratype, SMF Xe 24073, l = 0.38, h = 0.23; J – female carapace, ventral view, paratype, SMF Xe 24074, l = 0.38, h = 0.22; K – male LV, external view, paratype, SMF Xe 24075, l = 0.43, h = 0.23; L – detail of K, ornamentation, posterior zone; M – female RV, external view, holotype, SMF Xe 24070, l = 0.36, h = 0.20; N – male RV, external view, paratype, SMF Xe 24076, l = 0.39, h = 0.20; O – female LV, internal oblique view, specimen lost, l = 0.34, h = 0.20; P – female RV, internal view, paratype, SMF Xe 24077, l = 0.37, h = 0.21; Q – detail of P, hinge, anterior zone. R – male RV, external view, SMF Xe 24078, l = 0.45, h = 0.21, *aalensis* Biozone, sample BM118. • S–U – *Procytherura supraliassicum* (Herrig, 1981). S – LV, external view, SMF Xe 24079, l = 0.33, h = 0.20, *speciosum* Biozone, sample BM61M. T, U – *aalensis* Biozone, sample BM118; T – carapace, dorsal view, SMF Xe 24080, l = 0.37, h = 0.19; U – carapace, right oblique view, SMF Xe 24081, l = 0.37, h = 0.18. • V–Y – *Procytherura*? sp. A, *aalensis* Biozone; V – carapace, dorsal view, SMF Xe 24082, l = 0.35, h = 0.15, sample BM99; W – carapace, left view, SMF Xe 24083, l = 0.36, h = 0.18, sample BM125; X – detail of W, ornamentation, anterior zone; Y – carapace, right view, same specimen as W. Dimensions in mm. Scale bars = 100 µm.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Genus *Procytherura* Whatley, 1970

Type species. – *Procytherura tenuicostata*, Whatley, 1970.

***Procytherura supraliassicum* (Herrig, 1981)**
Figure 7S–U

1981b *Procytheropteron supraliassicum* sp. nov.; Herrig, pp. 1018, 1019, pl. 1, fig. 4.

Material. – 1 V, 3 C.

Remarks. – Originally described from the Upper Toarcian and Aalenian of Central Germany; the Boca da Mata material is similar in size (very small to small), in lateral outline and ornamentation to the type-material and specimens from the Upper Toarcian (Lias ζ) of SW Germany figured by Knitter (1983, pl. 37, figs 3, 4), but has a more elongate and horizontal posterior extremity.

Occurrence. – Toarcian, *speciosum* and *aalensis* biozones.

***Procytherura*? sp. A**
Figure 7V–Y

Material. – 2 C.

Remarks. – Small, sub-elongate outline in lateral view with weakly convex dorsal and ventral margins, small postero-ventral swelling, and weak dorso-median sulcus; surface covered with strongly punctate ornamentation with fine ribs subparallel to anterior margin. In one specimen, the anterior margin has two very small tubercles in its mid zone (Fig. 7X). Simple normal pore canals visible on the anterior ribs. Probably a new species but rare, also present in the lower Aalenian of Boca da Mata.

Occurrence. – Toarcian, *aalensis* Biozone to Aalenian, *opalinum* Biozone.

Family Protocytheridae Ljubimova, 1955

Genus *Ektyphocythere* Bate, 1963

Type species. – *Procytheridea triangula* Brand, 1961 *in* Brand & Malz (1961).

***Ektyphocythere mediodepressa* Boomer, Ainsworth & Exton, 1998**
Figure 8A–C

1979 *Ektyphocythere* sp. 2. – Exton, p. 59, pl. 13, figs 1, 2.
1998 *Ektyphocythere mediodepressa* sp. nov.; Boomer, Ainsworth & Exton, p. 11, fig. 8, 1–8.

Material. – *Ca*.1000 V and *ca*. 70 C, adults and juveniles.

Remarks. – Originally described from the Toarcian at Rabaçal, it is very abundant in Boca da Mata in all biozones.

Occurrence. – Toarcian, *bonarellii*, *speciosum*, *meneghinii* and *aalensis* biozones.

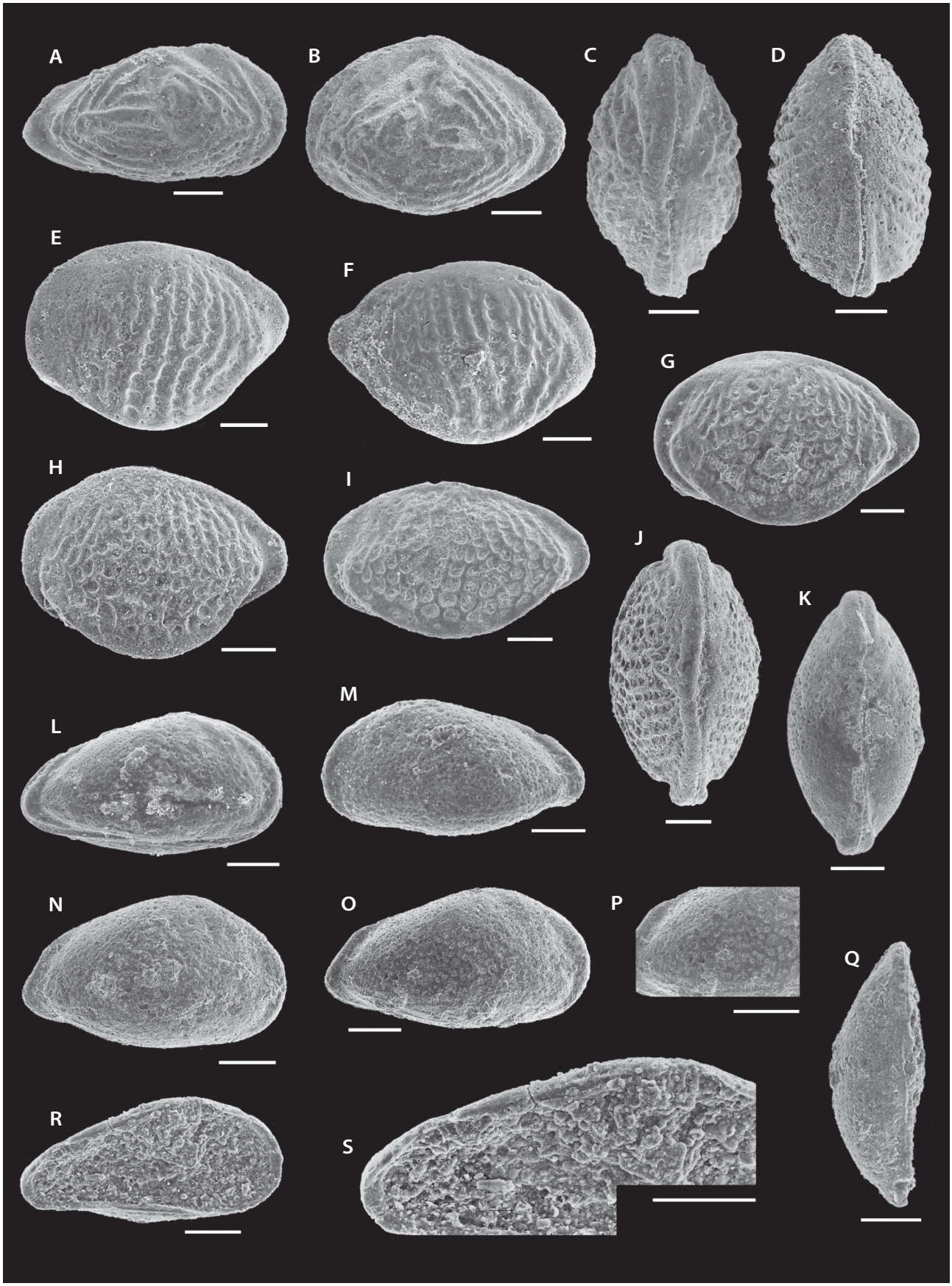
Genus *Kinkelinella* Martin, 1960

Type species. – *Kinkelinella tenuicostati* Martin, 1960.

***Kinkelinella costata* Knitter, 1983**
Figure 8D–F

1979 *Kinkelinella* sp. I (Apostolescu). – Exton, p. 60, pl. 13, figs 6–12.
1983 *Kinkelinella* (*Kinkelinella*) *costata* sp. nov.; Knitter, p. 224, pl. 39, figs 7–10.
2009 *Kinkelinella costata* Knitter. – Arias *et al*., pp. 221, 222, pl. 2, figs 11, 12.
2020 *Kinkelinella costata* Knitter. – Cabral *et al*., pp. 262, 263, fig. 8l–o.

Figure 8. Ostracods from the Upper Toarcian of Boca da Mata section, Portugal. • A–C – *Ektyphocythere mediodepressa* Boomer, Ainsworth & Exton, 1998, *speciosum* Biozone; A – male RV, external view, SMF Xe 24084, l = 0.57, h = 0.32, sample BM52T; B – female LV, external view, SMF Xe 24085, l = 0.53, h = 0.37, sample BM52B; C – female carapace, dorsal view, SMF Xe 24086, l = 0.53, h = 0.35, sample BM52B. • D–F – *Kinkelinella costata* Knitter, 1983, *bonarellii* Biozone, sample BM27; D – carapace, dorsal view, SMF Xe 24087, l = 0.59, h = 0.40; E – LV, external view, SMF Xe 24088, l = 0.57, h = 0.41; F – RV, external view, SMF Xe 24089, l = 0.55, h = 0.38. • G–J – *Kinkelinella sermoisensis* (Apostolescu, 1959). G, H – *bonarellii* Biozone; G – female LV, external view, SMF Xe 24090, l = 0.60, h = 0.42, sample BM18; H – female LV, external view, SMF Xe 24091, l = 0.53, h = 0.40, sample BM27. I, J – *speciosum* Biozone, sample BM48T; I – male LV, external view, SMF Xe 24092, l = 0.62, h = 0.41; J – female carapace, dorsal view, SMF Xe 24093, l = 0.60, h = 0.42. • K–S – *Ophektycythere herrigi* Cabral & Lord sp. nov., *speciosum* Biozone, sample BM57; K – male carapace, dorsal view, paratype, SMF Xe 24095, l = 0.49, h = 0.28; L – male carapace, right view, same specimen as K; M – male LV, external view, paratype, SMF Xe 24096, l = 0.47, h = 0.25; N – female RV, external view, paratype, SMF Xe 24097, l = 0.46, h = 0.27; O – male RV, external view, holotype, SMF Xe 24094, l = 0.51, h = 0.27; P – detail of O, ornamentation, postero-dorsal zone; Q – female RV, ventral view, paratype, SMF Xe 24098, l = 0.45, h = 0.25; R – male LV, internal view, paratype, same specimen as M; S – detail of R, hinge. Dimensions in mm. Scale bars = 100 μm.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Material. – *Ca*. 800 V and 14 C, adults and juveniles.

Remarks. – *Kinkelinella costata,* originally described from the Toarcian of SW Germany is common in Western Europe, also occurs in the Toarcian at Peniche and Rabaçal. The surface ornament of *K. costata* is characterized by strong vertical ribs and a ventral alar wing both slightly varying in thickness and extension. Rare in the *meneghinii* Biozone at Boca da Mata.

Occurrence. – Toarcian, *bonarellii*, *speciosum*, *meneghinii* and *aalensis* biozones.

***Kinkelinella sermoisensis* (Apostolescu, 1959)**
Figure 8G–J

1959 *Procytheridea sermoisensis* n. sp.; Apostolescu, p. 812, pl. 3, figs 37, 38.
1979 *Kinkelinella sermoisensis* (Apostolescu). – Exton, p. 59, pl. 12, figs 1–4.
1984 *Kinkelinella sermoisensis* (Apostolescu). – Exton & Gradstein, pl. 2, fig. 8.
1999b *Kinkelinella sermoisensis* (Apostolescu). – Arias & Lord, pp. 232, 233, pl. 3, fig. 6.
2009 *Kinkelinella sermoisensis* (Apostolescu). – Arias *et al*., pp. 222, 224, pl. 2, fig. 13.
2013 *Kinkelinella sermoisensis* (Apostolescu). – Cabral *et al*., p. 68, pl. 1, fig. 17.
2020 *Kinkelinella sermoisensis* (Apostolescu). – Cabral *et al.*, p. 263, fig. 8p–u.

Material. – *Ca*. 400 V, 9 C, adults and juveniles.

Remarks. – *Kinkelinella sermoisensis* occurs in the Toarcian at Peniche and Rabaçal and is very common throughout Western Europe. It is characterised by some variation in lateral outline, development of the alar extension and of surface ornamentation. Rare in the *meneghinii* Biozone at Boca da Mata.

Occurrence. – Toarcian, *bonarellii*, *speciosum*, *meneghinii* and *aalensis* biozones.

Genus *Ophektycythere* Cabral & Lord gen. nov.

LSID. – urn:lsid:zoobank.org:act:796397BE-6B59-4948-A1ED-BDD68C4A2350

Type species. – *Ophektycythere herrigi* Cabral & Lord sp. nov.

Etymology. – 'ophekty' an anagram of the letters 'ektypho' from the carapace similarity to *Ektyphocythere* Bate, 1963 + *cythere*.

Diagnosis. – A genus of the Protocytheridae with a small to medium size subtriangular carapace with weak ventrolateral expansion obscuring the ventral margin, posterior extremity located close to the lower third of h, and anterior and posterior marginal rims; dimorphic, males elongated. Ornamentation punctate or reticulate, arranged in a triangular pattern; LV > RV. Hinge hemimerodont with accommodation groove in LV.

Remarks. – In general outline *Ophektycythere* gen. nov. resembles *Ektyphocythere* Bate, 1963 but differs in being more elongate, with the posterior extremity located more ventrally; moreover, the ornament, with a much more subtle triangular arrangement as in *Ektyphocythere*, is punctate or reticulate, lacking the characteristic strong ribs of *Ektyphocythere*. *Kinkelinella* Martin, 1960, also resembles *Ophektycythere* gen. nov., but has a more oval outline, a strongly developed ventral alar expansion, the posterior extremity located more dorsally, and a more strongly convex carapace in dorsal view.

Two species of *Ophektycythere* gen. nov. are recognised here: *O. herrigi* Cabral & Lord sp. nov. and *O. mataensis* Cabral & Lord sp. nov. One other species is questionably assigned to *Ophektycythere* (*O.*? *sicoensis* Cabral & Lord sp. nov.) because of a difference in hinge type, although all other morphological features match the type species. *Ophektycythere*? *sicoensis* has antimerodont hingement (loculate/dentate median hinge elements) whereas *O. herrigi* and *O. mataensis* have hemimerodont hingement (smooth median hinge element). The three species differ in surface ornamental detail, but this is regarded as a species-level feature.

Other species. – Both in Peniche and Rabaçal, Portugal, there are other species which probably belong to *Ophektycythere*, but the small number of specimens and their preservation do not allow their description. Indet. gen. sp. A Bate & Coleman (1975, pl. 3, fig. 9) from Lower Toarcian, U.K., is very likely a juvenile specimen of a species belonging to this genus.

"*Asciocythere*" sp. (= *Asciocythere* "*mystron*" nom. nud. Dilger, 1963) from the Aalenian (*opalinum* Biozone) of SW Germany, figured in Franz *et al*. 2018 (pl. 4, figs 17, 18) and doubtfully assigned to the genus *Asciocythere* by these authors, possibly belongs to *Ophektycythere*; the two figured specimens have similar morphological characteristics, as the triangular outline with posterior extremity located *ca*. $^1/_3$ of h, anterior marginal rim, punctate ornamentation.

Occurrence. – Toarcian and Aalenian of Portugal and U.K.

***Ophektycythere herrigi* Cabral & Lord sp. nov.**
Figure 8K–S

2020 Gen. unknown spp. – Cabral *et al.*, p. 264, fig. 9k, m.

LSID. – urn:lsid:zoobank.org:act:B3AA000E-879B-49FA-B655-D2B08C53BB03

Types. – Holotype: one male RV, SMF Xe 24094; l = 0.51, h = 0.27, sample BM57 (Fig. 8O, P).

Paratypes: one male carapace, SMF Xe 24095, l = 0.49, h = 0.28, sample BM57 (Fig. 8K, L); one male LV, SMF Xe 24096, l = 0.47, h = 0.25, sample BM57 (Fig. 8M, R-S); one female RV, SMF Xe 24097, l = 0.46, h = 0.27, sample BM57 (Fig. 8N); one female RV, SMF Xe 24098, l = 0.45, h = 0.25, sample BM57 (Fig. 8Q).

Type horizon and locality. – Type-level sample BM57, Toarcian, *speciosum* Biozone, S. Gião Formation; Boca da Mata, Portugal.

Material. – 10 V and 1 C, adults and juveniles; more material in Peniche (Cabral *et al*. 2020) and Rabaçal (M.C. Cabral collection).

Etymology. – Dedicated to Ekkehard Herrig in recognition of his contributions to knowledge of post-Palaeozoic ostracods.

Diagnosis. – A species of *Ophektycythere* with a small to medium size subtriangular carapace in lateral view; lateral surface punctate, with very subtle primary ribs subvertical and divergent in the dorsal zone (Fig. 8L, O, P), sub-horizontal in the ventral zone, forming a general triangular pattern; moderately developed anterior and posterior marginal rims.

Description. – Carapace small to medium size, with sub-triangular outline tapering slightly posteriorly; LV > RV. Greatest l below mid-height, in the lower third of h, coincident with the posterior extremity; greatest h at anterior cardinal angle, more than half of length in females, *ca*. half of l in males; greatest w at mid-l, in both males and females, *ca*. half of length in males, more than half of length in females. Presence of a slight ocular swelling below the anterior cardinal angle and a curved, ventral expansion. In dorsal (Fig. 8K) and ventral (Fig. 8Q) views the carapace is convex, almost symmetrical, with the anterior and posterior marginal rims slightly prominent, especially in dorsal view; in carapace dorsal view the overlap of the left valve can be clearly observed; ventral surface with several very subtle longitudinal ribs in each valve. Sexual dimorphism present with males longer and proportionally less high than females.

Dorsal margin straight with anterior cardinal angle larger in males. Ventral margin slightly concave partially covered by the ventro-lateral expansion. Anterior margin rounded, infracurvate. Posterior margin pointed, with extremity below the lower third of h.

Lateral surface completely covered with punctate ornament, with the punctae arranged in a subtle triangular pattern (diagonal lines antero-dorsally and postero-dorsally, converging ventrally). Normal pore canals not seen.

Hinge hemimerodont (Fig. 8R, S), the LV with two terminal loculate elongate sockets (6–8 locules) of almost the same size, separated by a median smooth bar, above which is a narrow accommodation groove; marginal zones seem narrow without vestibule; other internal features not seen.

Dimensions: ♀ l = 0.45–0.46, h = 0.25–0.28; ♂ l = 0.47– 0.51, h = 0.25–0.28.

Remarks. – *Ophektycythere herrigi* Cabral & Lord sp. nov. is very similar to *O. mataensis* Cabral & Lord sp. nov., both species occurring at Boca da Mata, but in different biozones, *O. herrigi* in the lower part of the Upper Toarcian (*bonarellii* and base of *speciosum* biozones), *O. mataensis* in the upper part of the Upper Toarcian (top of *speciosum* Biozone to top of *aalensis* Biozone); *O. mataensis* appears just after the disappearance of *O. herrigi*, suggesting a direct evolutionary lineage. *Ophektycythere mataensis* differs from *O. herrigi* in having the punctate ornament arranged more randomly, a weak anterior marginal rim only, and a more rounded convex ventral margin.

The juvenile specimen from the Lower Toarcian of E England, figured in Bate & Coleman (1975, pl. 3, fig. 9), identified as Indet. gen. & sp. A, is similar to *O. herrigi*, with same ornamentation and presence of anterior and posterior marginal rims, however, it is a single juvenile specimen, very small and difficult to compare; in Loureiro *et al*. (2010) it was considered a synonym of *O. herrigi*.

Occurrence. – Until now only certainly known in Portugal, in the Lower Jurassic, Upper Toarcian (*bonarellii* and *speciosum* biozones) at Boca da Mata (S. Gião Formation), Middle Toarcian (*bifrons* Biozone) at Peniche, and Middle and Upper Toarcian at Rabaçal (Loureiro *et al*. 2010, identified as Gen. ind. sp. A Bate & Coleman, 1975; M.C. Cabral data).

***Ophektycythere mataensis* Cabral & Lord sp. nov.**
Figure 9A–H

LSID. – urn:lsid:zoobank.org:act:446A4574-8620-4A1F-8E8D-66CA9BD7C728

Types. – Holotype: one male RV, SMF Xe 24099; l = 0.52, h = 0.28, sample BM125 (Fig. 9A, B).

Paratypes: one female LV, SMF Xe 24100, l = 0.45, h = 0.28, sample BM125 (Fig. 9C); one male LV, SMF Xe 24101, l = 0.51, h = 0.29, sample BM125 (Fig. 9D); one female LV, SMF Xe 24102, l = 0.45, h = 0.29, sample BM125 (Fig. 9E); one female LV, SMF Xe 24103, l = 0.46, h = 0.29, sample BM125 (Fig. 9F).

Type horizon and locality. – Type-level sample BM125, Toarcian, *aalensis* Biozone, Póvoa da Lomba Formation; Boca da Mata, Portugal.

Material. – 22 V, 3 C, adults and juveniles.

Etymology. – From the name of the type-section, Boca da Mata.

Diagnosis. – A species of *Ophektycythere* with a small to medium size subtriangular carapace in lateral view; lateral surface punctate, punctae arranged in a very subtle triangular pattern (diagonal lines antero-dorsally and postero-dorsally, converging ventrally and defining a circle in the central zone); weak anterior marginal rim only.

Description. – Carapace small to medium size, with subtriangular outline tapering slightly posteriorly; LV > RV. Greatest l below mid-height, coincident with posterior extremity; greatest h at anterior cardinal angle, more than half of length; greatest w posterior of mid-l, more than half of length. Presence of a very subtle ocular sulcus below the anterior cardinal angle and a rounded ventral expansion. In dorsal (Fig. 9D) and ventral (Fig. 9E) views the carapace is convex with the anterior and posterior margins pointed but not protruding; ventral surface punctate with punctae longitudinally aligned. Sexual dimorphism present with female dimorphs distinguished from males by l/h ratio which is greater in males.

Dorsal margin straight with clear cardinal angles in both valves. Ventral margin straight to slightly concave partially covered by the ventro-lateral expansion. Anterior margin rounded, infracurvate. Posterior margin pointed, with extremity close to the lower third of h.

Lateral surface completely punctate, with the punctae arranged in a triangular pattern (diagonal lines antero-dorsally and postero-dorsally, converging ventrally and defining a circle in the central zone). Normal pore canals not seen.

Hinge hemimerodont (Fig. 9F, G), the LV with two terminal elongate sockets, the anterior larger, separated by a median smooth bar, above which is a narrow accommodation groove; marginal zones seem narrow without vestibule; other internal features not seen.

Dimensions: ♀ l = 0.45–0.46, h = 0.28–0.29; ♂ l = 0.51–0.52, h = 0.28–0.29.

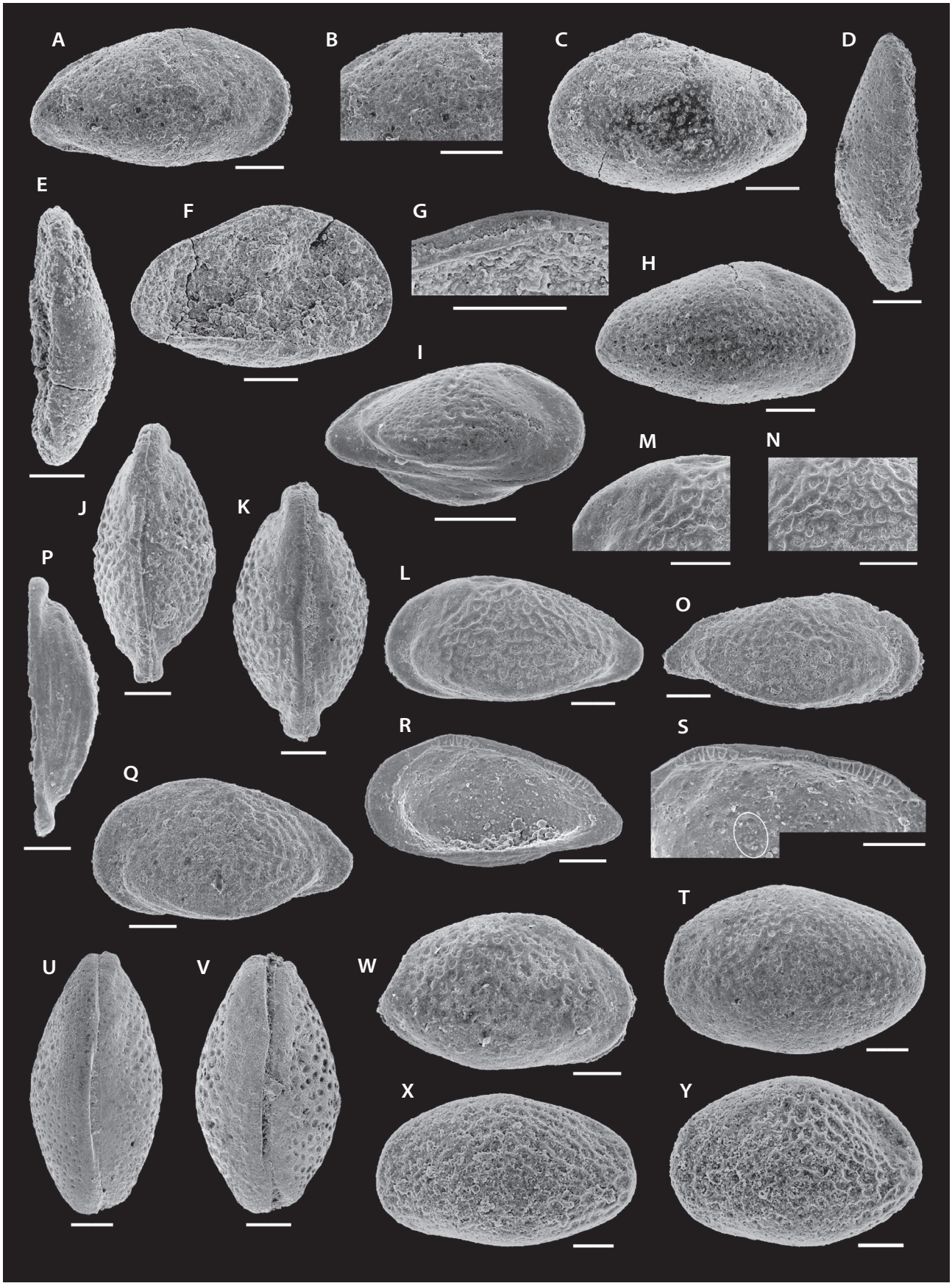
Remarks. – *Ophektycythere mataensis* Cabral & Lord sp. nov. differs from the two other described species of the genus, one questionable, in having a different shape in dorsal view, not symmetrical and with the extremities not protruding.

Occurrence. – Until now only known in Portugal, in the Lower Jurassic, Upper Toarcian (*speciosum*, *meneghinii* and *aalensis* biozones) and Middle Jurassic, Aalenian (*opalinum* Biozone) at Boca da Mata (S. Gião and Póvoa da Lomba formations), and Upper Toarcian at Rabaçal (*speciosum*, *meneghinii* and *aalensis* Biozone, M.C. Cabral data).

***Ophektycythere*? *sicoensis* Cabral & Lord sp. nov.**
Figure 9I–S

LSID. – urn:lsid:zoobank.org:act:018D2C26-7ED9-4081-8B7F-B4D714C3A846

Figure 9. Ostracods from the Upper Toarcian of Boca da Mata section, Portugal. • A–H – *Ophektycythere mataensis* Cabral & Lord sp. nov. A–F – *aalensis* Biozone, sample BM125; A – male RV, external view, holotype, SMF Xe 24099, l = 0.52, h = 0.28; B – detail of A, ornamentation, postero-dorsal zone; C – female LV, external view, paratype, SMF Xe 24100, l = 0.45, h = 028; D – male LV, dorsal view, paratype, SMF Xe 24101, l = 0.51, h = 0.29; E – female LV, ventral view, paratype, SMF Xe 24102, l = 0.45, h = 0.29; F – female LV, internal view, paratype, SMF Xe 24103, l = 0.46, h = 0.29. G, H – *meneghinii* Biozone, sample BM80; G – fragment of a male LV, internal view, SMF Xe 24104, detail of hinge; H – male RV, external view, SMF Xe 24105, l = 0.52, h = 0.29. • I–S – *Ophektycythere*? *sicoensis* Cabral & Lord sp. nov. I – juvenile carapace (A-3?), right oblique view, SMF Xe 24111, l = 0.34, h = 0.20, *speciosum* Biozone, sample BM52T. J – male carapace, dorsal view, SMF Xe 24112, l = 0.59, h = 0.28, *meneghinii* Biozone, sample BM71. K–Q – *speciosum* Biozone, sample BM60; K – female carapace, dorsal view, paratype, SMF Xe 24107, l = 0.56, h = 0.31; L – male LV, external view, holotype, SMF Xe 24106, l = 0.57, h = 0.30; M – detail of L, ornamentation, antero-dorsal zone; N – detail of L, ornamentation, median zone; O – male RV, external view, paratype, SMF Xe 24108, l = 0.58, h = 0.25; P – female LV, ventral view, paratype, SMF Xe 24109, l = 0.54, h = 0.32; Q – female LV, external view, paratype, SMF Xe 24110, l = 0.55, h = 0.31. R – female RV, internal view, SMF Xe 24113, l = 0.54, h = 0.31, *meneghinii* Biozone, sample BM71; S – detail of R, hinge and adductor muscle scars (white ellipsoidal line). • T–W – *Praeschuleridea foveolata* Ainsworth, 1986. T, U – *speciosum* Biozone, sample BM60; T – male LV, external view, SMF Xe 24114, l = 0.60, h = 0.40; U – male carapace, dorsal view, SMF Xe 24115, l = 0.60, h = 0.39. V, W – *aalensis* Biozone, sample BM125; V – female carapace, dorsal view, SMF Xe 24116, l = 0.57, h = 0.39; W – female RV, external view, SMF Xe 24117, l = 0.53, h = 0.32. • X, Y – *Praeschuleridea* cf. *whatleyi* Ainsworth, 1986, *bonarellii* Biozone, sample BM27; X– male LV, external view, SMF Xe 24118, l = 0.62, h = 0.37; Y – female LV, external view, SMF Xe 24119, l = 0.58, h = 0.38. Dimensions in mm. Scale bars = 100 μm.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Types. – Holotype: one male LV, SMF Xe 24106; l = 0.57, h = 0.30, sample BM60 (Fig. 9L-N).

Paratypes: one female carapace, SMF Xe 24107, l = 0.56, h = 0.31, sample BM60 (Fig. 9K); one male RV, SMF Xe 24108, l = 0.58, h = 0.25, sample BM60 (Fig. 90); one female LV, SMF Xe 24109, l = 0.54, h = 0.32, sample BM60 (Fig. 9P); one female LV, SMF Xe 24110, l = 0.55, h = 0.31, sample BM60 (Fig. 9Q).

Type horizon and locality. – Type-level sample BM60, Toarcian, *speciosum* Biozone, S. Gião Formation; Boca da Mata, Portugal.

Material. – *Ca*. 130 V and C, adults and juveniles.

Etymology. – From Sicó limestone Massif, which includes the Boca da Mata and Rabaçal regions.

Diagnosis. – A species questionably belonging to *Ophektycythere* with a medium size subtriangular elongate carapace in lateral view; lateral surface reticulate, with primary ribs subvertical and divergent in the dorsal zone, sub-horizontal in the ventral zone, forming a triangular pattern; strongly developed smooth anterior and posterior marginal rims.

Description. – Carapace medium size, elongate, with lateral sub-triangular outline tapering slightly posteriorly; LV > RV. Greatest l just below mid-height; greatest h at anterior cardinal angle, more than half of length in females, less in males; greatest w at mid-l in both males and females, more than $^1/_2$ of length in females, less in males. Presence of a slight ocular swelling below the anterior cardinal angle. In lateral view a weak ventro-lateral expansion obscures the ventral margin. In dorsal (Fig. 9J, K) and ventral (Fig. 9P) views the carapace is convex, almost symmetrical, with the anterior and posterior marginal rims prominent; in carapace dorsal view the overlap of the left valve can be clearly observed; ventral surface with three thick longitudinal ribs in each valve. Sexual dimorphism present, with males longer and less high and wide than females; juveniles with a less strong ornamentation but showing the triangular pattern (Fig. 9I).

Dorsal margin convex in LV, straight in RV. Ventral margin almost straight, partially covered by the weak ventro-lateral expansion. Anterior margin rounded, infracurvate; in rare specimens several antero-ventral marginal denticles (Fig. 9O) can be seen in the anterior margin. Posterior margin pointed, asymmetrically rounded (dorsally concave, ventrally convex), with extremity below mid-h.

Lateral surface reticulated with an irregular mesh, except in the anterior and posterior zones where strongly developed smooth marginal rims are present. The reticulation is formed by a triangular pattern of coarse ridges, dorsally sub-vertical and divergent from a central point in the middle of the dorsal margin, ventrally sub-horizontal, parallel to the border of the ventral expansion, with the line where the dorsal ridges join the ventral ones located approximately at mid-h. Simple normal pore canals can be seen on the lateral surface, on the muri of the reticulum (Fig. 9M, N).

Hinge antimerodont (Fig. 9R, S), the RV with two elongate terminal tooth plates bearing 6 to 8 denticles, the posterior larger, separated by a median locellate groove; LV with the corresponding terminal loculate sockets and a denticulate median bar above which is an accommodation groove. Marginal zones quite broad without vestibule; marginal pore canals straight and few, widely spaced. It was only possible to see four adductor muscle scars, arranged in a subvertical row (Fig. 9S, ellipsoidal line).

Dimensions: ♀ l = 0.54–0.56, h = 0.31–0.32; ♂ l = 0.57–0.59, h = 0.25–0.30.

Remarks. – The species *sicoensis* Cabral & Lord sp. nov. is questionably assigned to *Ophektycythere* for having an antimerodont hinge; it differs from the other described species of the genus in having larger dimensions, a reticulate ornamentation, and strongly developed smooth anterior and posterior marginal rims; in both *O. herrigi* Cabral & Lord sp. nov and *O. mataensis* Cabral & Lord sp. nov. the ornamentation is punctate (though with the triangular arrangement) and the marginal rims are less developed (particularly in *O. mataensis*) and not smooth, but punctate.

The presence of an antimerodont hinge in *O.*? *sicoensis* links the species to *Ekthyphocythere* and *Kinkelinella* genera, both with antimerodont hingement, but in the other morphological features it resembles *Ophektycythere* more closely than it does *Ekthyphocythere* and *Kinkelinella.*

Occurrence. – Until now only known in Portugal, in the Lower Jurassic, Upper Toarcian (*bonarellii*, *speciosum*, *meneghinii* and *aalensis* biozones) at Boca da Mata (S. Gião and Póvoa da Lomba formations), and Upper Toarcian at Rabaçal (*speciosum* Biozone, M.C. Cabral data).

Family Schulerideidae Mandelstam, 1959

Genus *Praeschuleridea* Bate, 1963

Type species. – *Cytheridea subtrigona* Jones & Sherborn, 1888.

***Praeschuleridea foveolata* Ainsworth, 1986**
Figure 9T–W

1979 *Praeschuleridea* sp. 2. – Exton, p. 61, pl. 14, figs 1–3.
1984 *Praeschuleridea* sp. 2 Exton. – Exton & Gradstein, pl. 2, fig. 11.
1986 *Praeschuleridea foveolata* n. sp.; Ainsworth, p. 321, pl. 10, figs 5–12.

Material. – *Ca*. 75 specimens, V and C, adults and juveniles.

Remarks. – Our material is very close in outline and ornamentation to late Toarcian–Aalenian specimens figured by Ainsworth; females are similar in lateral and dorsal views; however, males have their position of greatest h just anterior of mid-l and a more convex dorsal margin. The species also occurs in the Upper Toarcian of Rabaçal.

Occurrence. – Toarcian, *speciosum*, *meneghinii* and *aalensis* biozones.

***Praeschuleridea* cf. *whatleyi* Ainsworth, 1986**
Figures 9X, Y; 10A, B

1979 *Praeschuleridea* sp. 1. – Exton, p. 61, pl. 14, figs 4, 5.
cf. 1986 *Praeschuleridea whatleyi* sp. nov.; Ainsworth, p. 322, pl. 10, figs 13–20.
? 2009 *Praeschuleridea punctulata* (Plumhoff, 1963). – Arias *et al*., pp. 224, 225, pl. 3, fig. 4.

Material. – *Ca.* 115 V and C, adults and juveniles.

Remarks. – Our material is similar in dorsal view but differs in being more triangular in lateral outline with position of greatest h at mid l. Male valves have a dorsal margin which is weakly triangular at mid l compared to the types which have straight dorsal margins. Our material has a flattened area adjacent to the posterior cardinal angle lacking in the type figures. Ornamentation is the same as in *P. whatleyi*. The species also occurs in the Upper Toarcian of Rabaçal. The specimen figured by Arias *et al*. (2009) as *P. punctulata* possibly belongs here.

Occurrence. – Toarcian, *bonarellii* and *speciosum* biozones.

***Praeschuleridea* cf. sp. A *in* Ainsworth (1986)**
Figure 10C–G

cf. 1986 *Praeschuleridea* sp. A. – Ainsworth, p. 323, pl. 11, figs 8–15.

Material. – *Ca*. 60 V and C, adults and juveniles.

Remarks. – Our material has similarities to but differs from both *Praeschuleridea* sp. A of Ainsworth and from *Praeschuleridea* cf. *pseudokinkelinella* Bate & Coleman, 1975 *sensu* Ainsworth (1986, pl. 11, figs 1–8). Our *P*. cf. sp. A material, females and males, in lateral view is more triangular with a slightly less convex ventral margin and more convex dorsal margin and a less coarsely pitted reticulation compared to the figures of Ainsworth. *P*. cf. *pseudokinkelinella* figured by Ainsworth is relatively more elongate, both males and females, but ornamentation is closer to our material with irregular pitting increasing in size towards the valve centre. Our specimens are more symmetrically rounded in dorsal view than both *Praeschuleridea* sp. A of Ainsworth and *Praeschuleridea* cf. *pseudokinkelinella* of Ainsworth.

Occurrence. – Toarcian, *speciosum* Biozone.

Suborder Cypridocopina Baird, 1845
Superfamily Cypridoidea Baird, 1845
Family Candonidae Kaufmann, 1900

Genus *Paracypris* Sars, 1866

Type species. – *Paracypris polita* Sars, 1866.

***Paracypris* spp.**
Figure 10H–M

Material. – *Ca*. 140 C, adults and juveniles and rare valves.

Remarks. – Amongst numerous specimens of *Paracypris* we recognise differences in: (1) relative l-h-w dimensions, (2) strength of cardinal angles, (3) degree and position of overlap of larger LV in relation to smaller RV, (4) degree of extension of posterior margin, (5) position of greatest w in dorsal view, indicating the presence of a number of species of which we figure four morphotypes. However, as the genus has limited biostratigraphical or palaeoenvironmental utility we have not analysed them in detail.

Occurrence. – Toarcian, *bonarellii*, *speciosum*, *meneghinii* and *aalensis* biozones to Aalenian, *opalinum* Biozone.

Superfamily Pontocypridoidea G.W. Müller, 1894
Family Pontocyprididae G.W. Müller, 1894

Genus *Liasina* Gramann, 1963

Type species. – *Liasina vestibulifera* Gramann, 1963.

***Liasina*? *cylindrica* Ainsworth, 1986**
Figure 10N–P

1986 *Liasina*? *cylindrica* sp. nov.; Ainsworth, pp. 298, 299, pl. 4, figs 1, 2, 5.
1999a *Liasina* aff. *Liasina vestibulifera* Gramann, 1963. – Arias & Lord, p. 90, pl. 3, fig. 6.
2007 *Isobythocypris* cf. *tatei* (Coryell, 1963). – Pinto *et al*., pl. 1, figs 7, 8.
2013 *Isobythocypris tatei* (Coryell). – Cabral *et al*., p. 68, pl. 1, fig. 14.
2016 *Isobythocypris tatei*. – Rocha *et al*., fig. 4.
2020 ?*Liasina cylindrica* Ainsworth. – Cabral *et al*., p. 268, figs 10d–g.

Material. – 25 C, adults and juveniles.

Remarks. – *Liasina*? *cylindrica* was recovered in Boca da Mata in several samples but in small numbers. It is an important species in the *polymorphum* Biozone at Peniche and is also present in the Toarcian of Rabaçal (M.C. Cabral data). The morphological characteristics presented in the Boca da Mata material are coincident with the description of the type-material from the Toarcian and Aalenian of Fastnet Basin, offshore SW Ireland. It is also reported with other names in the Jurassic, for example, in the Toarcian of Spain (Arias & Lord 1999a, pl. 2, fig. 7), in the Toarcian to Aalenian of SW Germany (Franz *in* Wannenmacher *et al*. 2021, fig. 10.2) and in the Middle Jurassic of N Switzerland (Tesakova 2017, pl. 4, fig.15). Ainsworth and subsequent authors who figured the species *cylindrica* have not been able to demonstrate the generic placement in *Liasina*.

Occurrence. – Toarcian, *bonarellii*, *speciosum*, *meneghinii* and *aalensis* biozones to Aalenian, *opalinum* Biozone.

Suborder Sigilliocopina Mandelstam, 1960
Superfamily Sigillioidea Mandelstam, 1960
Family Saipanettidae McKenzie, 1968

Genus *Cardobairdia* Van den Bold, 1960

Type species. – *Cardobairdia ovata* Van den Bold, 1960.

***Cardobairdia* aff. *posteroprolata* Ainsworth, 1987**
Figure 10Q–S

aff. 1987 *Cardobairdia posteroprolata* sp. nov.; Ainsworth, p. 54, pl. 2, figs 7, 8, 14.
2020 *Cardobairdia* aff. *C. posteroprolata* Ainsworth. – Cabral *et al*., p. 268, fig. 10p, q.

Material. – *Ca*. 15 C, juveniles and ?adults.

Remarks. – *Cardobairdia posteroprolata* was described from the Pliensbachian of Fastnet Basin, offshore SW Ireland. Our material differs in its smaller size, a more rounded posterior margin of the RV and a less arched dorsal margin, and are probably juveniles. The species also rarely occurs in the Middle Toarcian (*bifrons* Biozone) of Peniche and in the Middle and Upper Toarcian of Rabaçal (Loureiro *et al*. 2010, M.C. Cabral data), with larger specimens with dimensions closer to the type-material.

Occurrence. – Toarcian, *bonarellii*, *speciosum*, *meneghinii* and *aalensis* biozones.

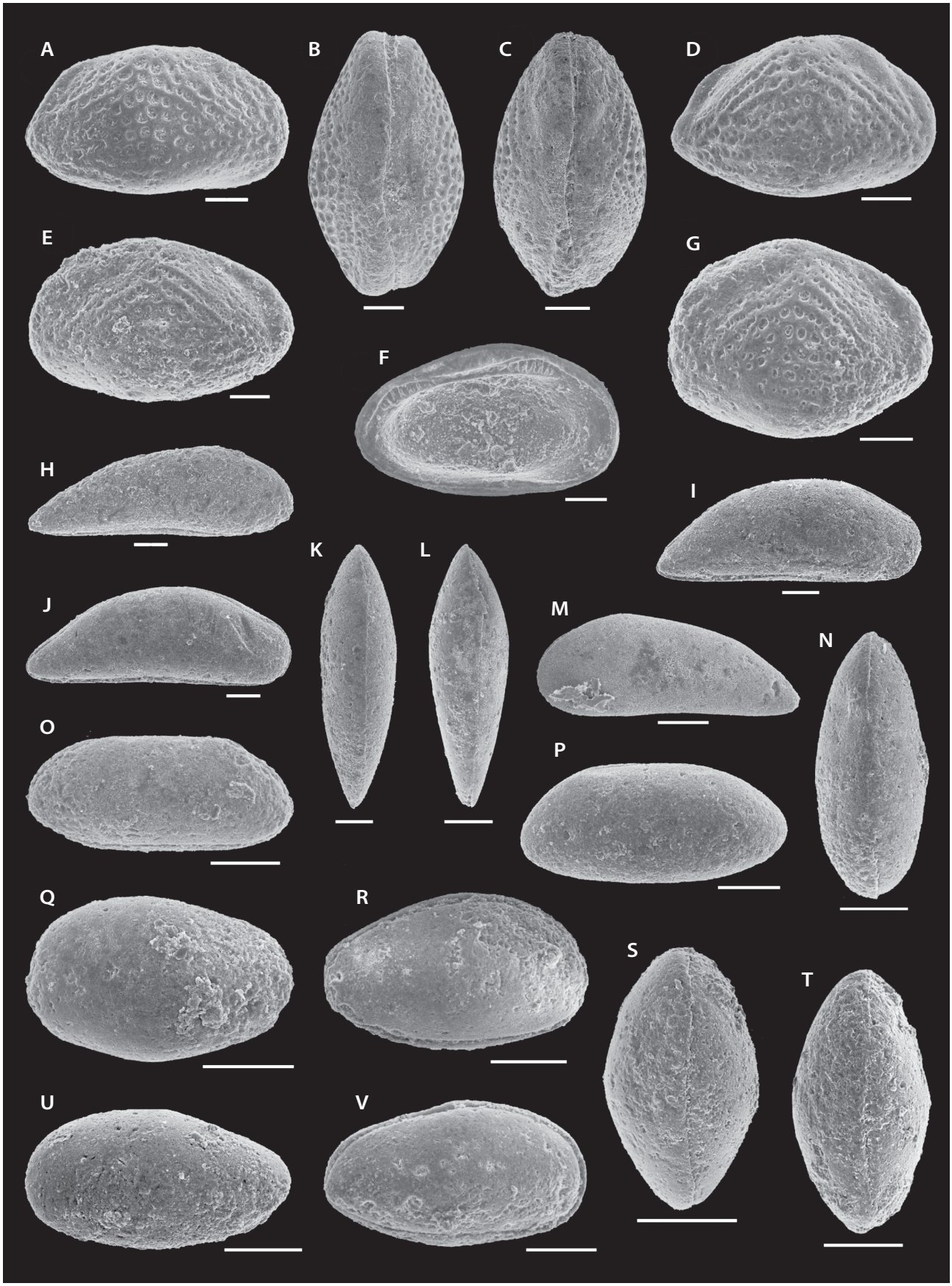
***Cardobairdia toarcensis* Ainsworth, 1986**
Figure 10T–V

1986 *Cardobairdia toarcensis* sp. nov.; Ainsworth, p. 300, pl. 3, figs 16, 21, 22.

Material. – *Ca*. 40 C, adults and juveniles.

Remarks. – *Cardobairdia toarcensis,* originally described from the Toarcian–Aalenian of Fastnet Basin, offshore SW

Figure 10. Ostracods from the Upper Toarcian of Boca da Mata section, Portugal. • A, B – *Praeschuleridea* cf. *whatleyi* Ainsworth, 1986, *speciosum* Biozone; A – male RV, external view, SMF Xe 24120, l = 0.61, h = 0.35, sample BM60; B – male carapace, dorsal view, SMF Xe 24121, l = 0.64, h = 0.41, sample BM48T. • C–G – *Praeschuleridea* cf. sp. A Ainsworth, 1986, *speciosum* Biozone, sample BM57; C – male carapace, dorsal view, SMF Xe 24122, l = 0.60, h = 0.35; D – female RV, external view, SMF Xe 24123, l = 0.52, h = 0.33; E – male LV, external view, SMF Xe 24124, l = 0.65, h = 0.40; F – male LV, internal view, SMF Xe 24125, l = 0.64, h = 0.38; G – female LV, external view, SMF Xe 24126, l = 0.50, h = 0.38. • H–M – *Paracypris* spp. H – carapace, right view, SMF Xe 24127, l = 0.75, h = 0.28, *meneghinii* Biozone, sample BM77. I–K – *bonarellii* Biozone, sample BM37; I – carapace, right view, SMF Xe 24128, l = 0.70, h = 0.28; J – carapace, right view, SMF Xe 24129, l = 0.81, h = 0.30; K – carapace, dorsal view, same specimen as J. L, M – *meneghinii* Biozone, sample BM80; L – carapace, dorsal view, SMF Xe 24130, l = 0.54, h = 0.22; M – carapace, left view, SMF Xe 24131, l = 0.52, h = 0.21. • N–P – *Liasina*? *cylindrica* Ainsworth, 1986. N, O – *speciosum* Biozone; N – carapace, dorsal view, SMF Xe 24132, l = 0.40, h = 0.16, sample BM60; O – carapace, right view, SMF Xe 24133, l = 0.37, h = 0.16, sample BM65. P – carapace, left view, SMF Xe 24134, l = 0.42, h = 0.19, *meneghinii* Biozone, sample BM80. • Q–S – *Cardobairdia* aff. *posteroprolata* Ainsworth, 1987, *speciosum* Biozone. Q, R – sample BM60; Q – carapace, left view, SMF Xe 24135, l = 0.29, h = 0.18; R – carapace, right view, SMF Xe 24136, l = 0.35, h = 0.20. S – carapace, dorsal view, SMF Xe 24137, l = 0.27, h = 0.17, sample BM61M. • T–V – *Cardobairdia toarcensis* Ainsworth, 1986, *speciosum* Biozone, sample BM60; T – carapace, dorsal view, SMF Xe 24138, l = 0.33, h = 0.18; U – carapace, left view, SMF Xe 24139, l = 0.33, h = 0.19; V – carapace, right view, SMF Xe 24140, l = 0.38, h = 0.20. Dimensions in mm. Scale bars = 100 µm.


A
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V

Ireland, where it is very abundant, also occurs in the Upper Toarcian at Boca da Mata and in the Middle and Upper Toarcian at Rabaçal (Loureiro *et al*. 2010, M.C. Cabral data). It is easily identified due to the dorsal margin of LV strongly arched, with highest peak at mid-length, as in the type-material.

Occurrence. – Toarcian, *bonarellii*, *speciosum*, *meneghinii* and *aalensis* biozones.

Results and discussion

Boca da Mata ostracod assemblages

Upper Toarcian

Upper Toarcian ostracods are abundant with in excess of 17,000 carapaces and valves representing over 44 species placed in 22 genera recovered from 21 samples. The most numerous taxa are distributed through the sampled section, whereas less common species show a more sporadic distribution with new appearances through the section (Fig. 11). A number of species (10: *Polycope cincinnata*, *Bairdia rostrata* group, *Bairdiacypris rectangularis*, *Patellacythere ungulina*, *Cytheropteron alafastigatum*, *Kinkelinella costata*, *K. sermoisensis*, *Ophekticythere herrigi* (as "genus unknown spp." of Cabral *et al*. 2020), *Liasina*? *cylindrica*, *Cardobairdia* aff. *posteroprolata*, plus numerous *Polycope* spp.) range up from the Lower and Middle Toarcian assemblages of Peniche reported by Cabral *et al.* (2020), and others are known to cross the Toarcian–Aalenian boundary (Fig. 12) (9: *Cytherella* cf. *toarcensis*, *Patellacythere striata*, *Praebytheroceratina scrobiculata*, *Cytheropterina cribra*, *Eucytherura alvaiazerensis*, *Liasina*? *cylindrica*, *Microceratina andreui*, *Ophektycythere mataensis*, *Procytherura*? sp. A, plus numerous *Polycope* spp. and *Paracypris* spp.); the Boca da Mata section continues into the Aalenian although that stage has not been studied in detail. The Boca da Mata assemblages are almost identical in species composition to Toarcian material from the nearby Rabaçal section (Exton 1979, Boomer *et al.* 1998, Loureiro *et al*. 2010 and M.C. Cabral, data) (Fig. 13).

The assemblages are fully marine and represent oxygenated epicontinental shelf conditions in a proximal location on the margin of the Lusitanian Basin. Reference to Fig. 11 shows that the most important taxa in the whole section are: *Polycope* spp., *Cytherella* cf. *toarcensis*, *Praebytheroceratina scrobiculata* and *Cytheropteron alafastigatum* which occur in all studied samples. *Ektyphocythere mediodepressa*, *Ophekticythere*? *sicoensis* and *Paracypris* spp. occur in most samples through the section. *Kinkelinella costata* and *K. sermoisensis* are well represented in the *bonarellii* and *speciosum* ammonite biozones and again in the *aalensis* Biozone but rare in the intervening *meneghinii* Biozone. Very small to small smooth species, *e.g. Liasina*? *cylindrica*, *Cardobairdia* spp., are also present through most of the sequence but not continuously. *Otocythere iberobritannica* occurs from the base of the section (*speciosum* Biozone) with increasing abundance especially in the *meneghinii* and *aalensis* biozones. Many of the species listed above have medium size, robust and well-calcified carapaces (e.g. *Cytherella* cf. *toarcensis*, the most abundant taxon), and frequently with strong surface ornament (*Ektyphocythere*, *Kinkelinella*, *Ophektycythere* species) reflecting carbonate-rich waters. The presence of *P. scrobiculata* and *C. alafastigatum* with well-developed lateral and ventral surface projections may reflect quiet bottom water conditions below wave base. The genus *Praeschuleridea* is represented by three species, all medium size, robust and well-ornamented but with a clearly defined stratigraphical distribution. *Praeschuleridea* cf. *whatleyi* ranges through the *bonarellii* to the top of the *speciosum* biozone, *P*. cf. sp. A is restricted to the *speciosum* biozone (samples BM52B, BM57) and is replaced by *P. foveolata* (samples BM60 to BM125) at a faunal change point in the mid *speciosum* biozone. There is a similar pattern with *Ophektycythere* species: *O. herrigi* is restricted to the *bonarellii* and lower *speciosum* biozones disappearing at the mid *speciosum* faunal change, while *O. mataensis* appears in the upper *speciosum* biozone and ranges to the Aalenian; *O.*? *sicoensis* is present in all Upper Toarcian biozones. It is clear from Fig. 11 that there is a faunal variation between samples BM57 and BM60, however, it should be noted that there is a gap in sampling at this interval (Fig. 12). In the assemblages above sample BM57 newly appearing species are generally very small to small (length = 0.3–0.5 mm), ornamented forms and this pattern continues up-section into the *aalensis* biozone. The mid *speciosum* faunal change event falls in the MMLB Member, in the thickest argillaceous unit in the entire sequence (Fig. 12). Thus, the faunal change may be related to sedimentation rate or to a secondarily related factor that we cannot identify. The overlying Póvoa da Lomba Fm becomes increasingly carbonate-rich up section, and the base of the unit coincides with a reduction in ostracod diversity (samples BM71, BM 77) followed by a faunal recovery.

Figure 11. Upper Toarcian ostracod distribution chart for the studied Boca da Mata section. Biozone divisions are not to scale.


Upper Toarcian
Stage
bonarellii
speciosum
meneghinii
aalensis
Ammonite Biozone
BM18
BM24B
BM27
BM37
BM48T
BM52B
BM52T
BM57
BM60
BM61M
BM63
BM65
BM67
BM71
BM77
BM80
BM83T
BM89
BM99
BM118
BM125
Samples
1 – 5
6 – 30
31 – 100
101 – 250
> 250
Polycope sp.
Polycope cincinnata Apostolescu, 1959
Polycope cf. pelta Fischer, 1961
Polycope transversicostata Ainsworth, 1986
Cytherella cf. toarcensis Bizon, 1960
Bairdia ohmerti Knitter, 1984
Bairdiacypris rectangularis Ainsworth, 1986
Patellacythere ungulina (Triebel & Bartenstein, 1938)
Praebythoceratina scrobiculata (Triebel & Bartenstein, 1938)
Praebythoceratina stimulea (Schwager, 1866)
Cytheropterina cribra (Fischer, 1962)
Cytheropteron alafastigatum Fischer, 1962
Eucytherura sp. A
Otocythere iberobritannica Cabral & Lord sp. nov.
Ektyphocythere mediodepressa Boomer, Ainsworth & Exton, 1998
Kinkelinella costata Knitter, 1983
Kinkelinella sermoisensis (Apostolescu, 1959)
Ophektycythere herrigi Cabral & Lord sp. nov.
Ophektycythere? sicoensis Cabral & Lord sp. nov.
Paracypris spp.
Patellacythere striata (Triebel & Bartenstein, 1938)
Eucytherura alvaiazerensis Cabral, Lord & Pinto sp. nov.
Eucytherura sp. B
Praeschuleridea cf. whatleyi Ainsworth, 1986
Liasina? cylindrica Ainsworth, 1986
Cardobairdia aff. posteroprolata Ainsworth, 1987
Cardobairdia toarcensis Ainsworth, 1986
Polycope sp. A
Microceratina andreui Cabral & Lord, 2023 in Danielopol et al. (2023)
Orthonotacythere? sp. 1
Praeschuleridea cf. sp. A in Ainsworth (1986)
Bairdia aff. gr. rostrata Issler, 1908
Eucytherura aff. transversiplicata (Bate & Coleman, 1975) sensu Knitter (1983)
Praeschuleridea foveolata Ainsworth, 1986
Eucytherura aff. ornata (Ainsworth, 1986)
Ophektycythere mataensis Cabral & Lord sp. nov.
Cytherelloidea sp. A
Procytherura supraliassicum (Herrig, 1981)
Tanycythere posteroelongata Cabral, Lord, Boomer & Malz, 2014
Bairdia sp. A
Cytheropterina ainsworthi Cabral, Lord & Pinto sp. nov.
Eucytherura trituberosa (Brand, 1990)
Procytherura? sp. A
Polycope aff. cincinnata Apostolescu, 1959
Number of species
20 14 20 18 15 19 17 20 22 20 19 17 19 13 12 18 18 21 19 21 19

Lower Aalenian

For reasons of more calcareous facies it was not possible to sample the uppermost Toarcian or lowermost Aalenian close to the stage boundary. Figure 12 shows the taxa from the Toarcian that range across the stage boundary into the Lower Aalenian: 9 species plus *Polycope* spp. and *Paracypris* spp. The Aalenian material has not been analysed in detail. The figure suggests faunal continuity across the boundary but in fact the Aalenian samples contain a number of new, small species especially members of the Bythocytheridae which may reflect an increase in water depth associated with the transgressive phase commencing in the earliest Aalenian; in contrast, medium to large species with robust carapaces, belonging to genera such as *Ektyphocythere*, *Kinkelinella* and *Bairdia* disappear locally. Also present are new *Praeschuleridea* species, and "*Monoceratina*?" sp. 1 Cabral *et al*., 2015 a taxon known in Portugal also from the Sinemurian (Cabral *et al.* 2015) and Lower and Middle Toarcian (Cabral *et al.* 2020).

Palaeobiogeography

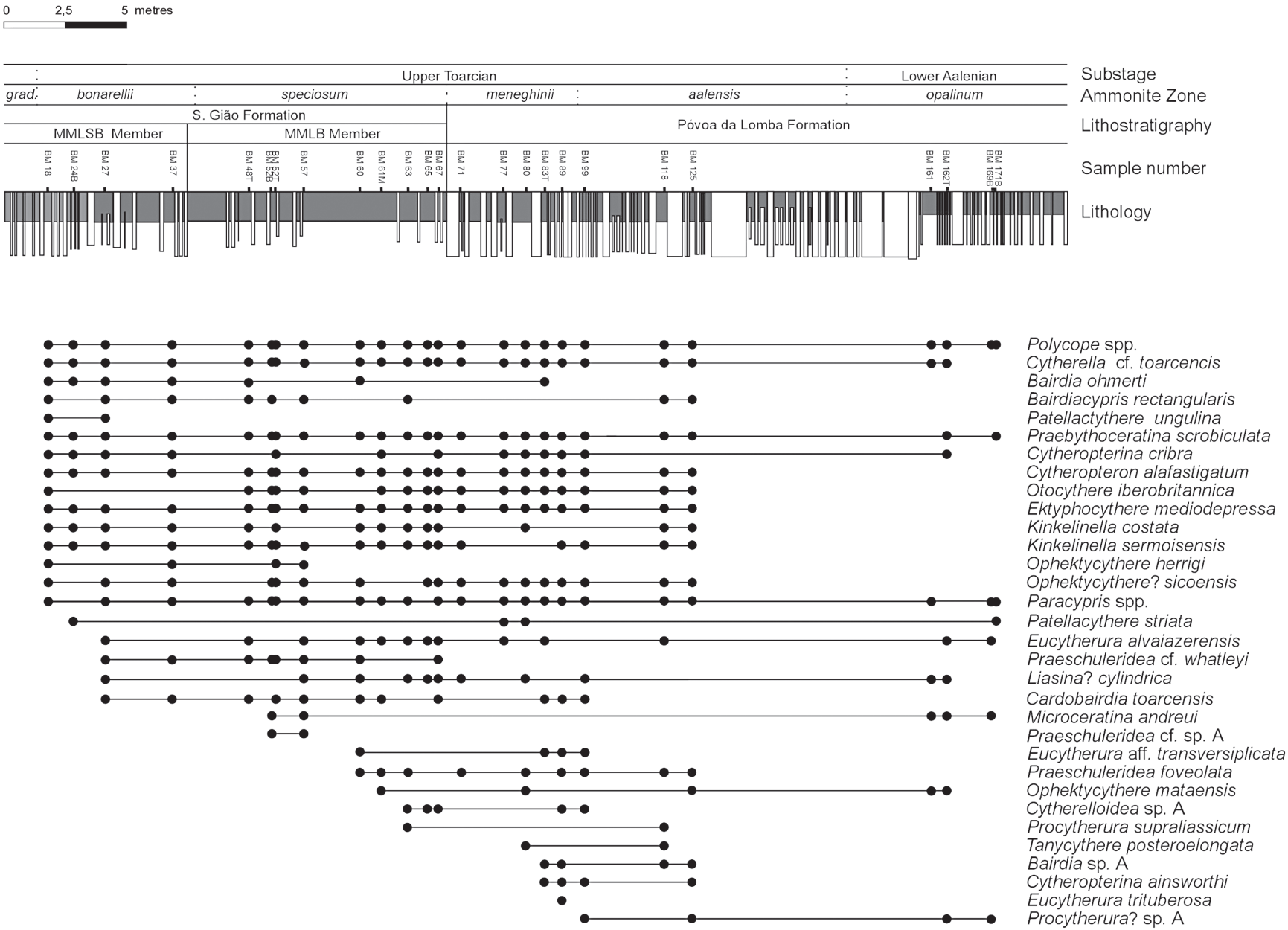
The science of biogeography aims to understand the distribution patterns and interrelationships of living animals and plants and ecosystems in the context of changing environmental parameters. Palaeobiogeographical analysis of fossil assemblages is clearly complicated by virtue of a range of preservational factors, with well-preserved lagerstätte being the exception rather than the rule. The assemblages studied here represent time-averaged groupings by the nature of the field sampling. The presence of suites of juveniles with adult ostracods (*e.g.* Boomer *et al*. 2003; Boomer *in* Lord *et al*. 2012, fig. 3.1) can be a helpful indicator of relative autochthoneity of a species in favourable conditions but juveniles are easily destroyed and if present not always easily linked taxonomically to adults. Thus, reconstructing groups of species that lived together in the deep past is problematic.

A common approach is to use the literature to compile a list of species region-by-region and this was done by Arias & Whatley (2005) for the Pliensbachian and Toarcian stages. The lists for the two stages were subjected, separately, to statistical analysis (Simpson, Dice and Jaccard indices) to identify the distribution of faunal similarity or dissimilarity. The results indicated faunal similarity between Western European basins and, more surprisingly, little difference between Boreal and Western Tethyan areas. Arias & Whatley state (2005, p. 699) that "a taxonomic evaluation of published literature was compiled and a faunal list of 270 marine ostracod species was elaborated by combining this data with that added by unpublished information obtained from various authors". Given the publications time range and the varying quality of published figured material, assuming that all species were illustrated by the various authors, the distribution patterns are at best unreliable, as are the conclusions drawn from the statistical analyses.

Over some years we (MCC, ARL) and colleagues have been investigating Jurassic ostracod assemblages and via several publications (Cabral *et al*. 2014, 2015, 2020; Pais *et al*. 2016; Lord *et al*. 2020; Danielopol *et al*. 2023) have been forced to the conclusion that the material is not as well-known taxonomically as previously supposed. We have therefore taken a different approach to Arias & Whatley (2005), based on a critical assessment of only the Boca da Mata taxa. We tabulate the occurrence pattern of the species described and figured in this work, time constrained by ammonite biostratigraphy, limited to records of figured material from Western Europe that we consider comparable (list below). As an example, see discussion of *Cytherella toarcensis* Bizon above, a species very widely reported, although not always figured, that in our opinion probably represents two species of which only the Lower Toarcian records represent *C. toarcensis* sensu stricto and our *C.* cf. *toarcensis* is a different new species. We note the absence of two important genera described from the Aalenian of NW Germany: 1. *Camptocythere* Triebel, 1950, recorded from Lower Toarcian of England (Bate & Coleman 1975) and the U. Toarcian–L. Aalenian of the Fastnet Basin, Ireland (Ainsworth 1986); 2. *Aphelocythere* Triebel & Klingler, 1959, recorded from the L. Toarcian–L. Aalenian of the Fastnet Basin, Ireland (Ainsworth, 1986). The species in the list below show a fourfold distribution pattern of: 1. taxa with a wide distribution in Western Europe; 2. taxa potentially limited to Iberia; 3. taxa characterising Western Iberia, SW Ireland and western England; and 4. taxa that at present may be indigenous to Western Iberia. However, the presence of *Eucytherura trituberosa* Brand described from the Upper Bathonian of NW Germany was a surprise.

Tabulated below and in Fig. 13 are the palaeobiogeographical distributions of Boca da Mata Upper Toarcian species recognised in this work, omitting minor taxa known only from Boca da Mata (*e.g. Polycope* sp. A) and amalgamated groups (*e.g. Polycope* spp.). L. = Lower, M. = Middle, U. = Upper, Wn = Western, N = North, NE = North East, NW = North West, S = South, SW = South West.

Figure 12. Stratigraphical distribution of selected ostracod species (black dots) through the *bonarellii*, *speciosum*, *meneghinii*, *aalensis* and base of *opalinum* ammonite biozones in Boca da Mata section; there are no data in the interval BM125-BM161. Lithological symbols and References as in Fig. 2.


0 2,5 5 metres
Upper Toarcian
Lower Aalenian
Substage
grad.
bonarellii
speciosum
meneghinii
aalensis
opalinum
Ammonite Zone
S. Gião Formation
MMLSB Member
MMLB Member
Póvoa da Lomba Formation
Lithostratigraphy
BM 18
BM 24B
BM 27
BM 37
BM 48T
BM 52T
BM 52B
BM 57
BM 60
BM 61M
BM 63
BM 65
BM 67
BM 71
BM 77
BM 80
BM 83T
BM 89
BM 99
BM 118
BM 125
BM 161
BM 162T
BM 171B
BM 169B
Sample number
Lithology
Polycope spp.
Cytherella cf. toarcencis
Bairdia ohmerti
Bairdiacypris rectangularis
Patellactythere ungulina
Praebythoceratina scrobiculata
Cytheropterina cribra
Cytheropteron alafastigatum
Otocythere iberobritannica
Ektyphocythere mediodepressa
Kinkelinella costata
Kinkelinella sermoisensis
Ophektycythere herrigi
Ophektycythere? sicoensis
Paracypris spp.
Patellacythere striata
Eucytherura alvaiazerensis
Praeschuleridea cf. whatleyi
Liasina? cylindrica
Cardobairdia toarcensis
Microceratina andreui
Praeschuleridea cf. sp. A
Eucytherura aff. transversiplicata
Praeschuleridea foveolata
Ophektycythere mataensis
Cytherelloidea sp. A
Procytherura supraliassicum
Tanycythere posteroelongata
Bairdia sp. A
Cytheropterina ainsworthi
Eucytherura trituberosa
Procytherura? sp. A

***Polycope cincinnata* Apostolescu, 1959.** Described: Pliensbachian, Paris Basin. Recorded: U. Pliensbachian–L. Toarcian, Peniche, Portugal (Cabral *et al*. 2020); Toarcian, Rabaçal, Portugal (Exton 1979); L. Toarcian, NE Spain (Arias & Lord 1999a); U. Bathonian, NW Germany (Brand 1990); U. Sinemurian–L. Pliensbachian, NE Germany (Herrig 1981a); U. Sinemurian–U. Pliensbachian, Denmark (Michelsen 1975).

***Polycope* cf. *pelta* Fischer, 1961.** See discussion in Systematic Palaeontology. Lower and Middle Jurassic, Wn Europe.

***Polycope transversicostata* Ainsworth, 1986.** Described: U. Toarcian–Aalenian, Fastnet Basin, Ireland. See discussion in Systematic Palaeontology. Recorded: M. and U. Toarcian, Rabaçal, Portugal (M.C. Cabral data).

***Cytherella* cf. *toarcensis* Bizon, 1960.** See discussion in Systematic Palaeontology. Recorded: M. and U. Toarcian, Rabaçal, Portugal (Exton 1979, M.C. Cabral data); U. Toarcian, Spain (Arias *et al*. 2009); U. Toarcian, Great Britain, Mochras Borehole (Boomer & Ainsworth 2009); Upper Toarcian, SW Germany (Knitter & Riegraf 1984).

***Cytherelloidea* sp. A.** See discussion in Systematic Palaeontology. Recorded: U. Toarcian, Rabaçal, Portugal (M.C. Cabral data); U. Toarcian, Spain (Arias *et al*. 2009).

***Bairdia ohmerti* Knitter, 1984.** Described: U. Toarcian, SW Germany. Recorded: U. Toarcian, Rabaçal, Portugal (Exton 1979, M.C. Cabral data); Toarcian–Aalenian, Fastnet Basin, Ireland (Ainsworth 1986); U. Toarcian, S. England (Boomer 1992); Toarcian, SW Germany (Knitter 1983, Riegraf 1985).

***Bairdiacypris rectangularis* Ainsworth, 1986.** Described: U. Toarcian–Aalenian, Fastnet Basin, Ireland. Recorded: L. and M. Toarcian, Peniche, Portugal (Cabral *et al*. 2020); Toarcian, Rabaçal, Portugal (Exton 1979, M.C. Cabral data).

***Patellacythere striata* (Triebel & Bartenstein, 1938).** Described: U. Toarcian, SW Germany. Recorded: Toarcian, Rabaçal, Portugal (M.C. Cabral data); Toarcian, NE Spain (Arias & Lord 1999a); Toarcian–Aalenian, Fastnet Basin, Ireland (Ainsworth 1986); L. Toarcian, S England (Bate & Coleman 1975); Toarcian, SW France (Andreu *et al*. 1995); Bathonian, NW France (Dépêche 1985); Aalenian–Bajocian, NW Germany (Plumhoff 1963).

***Patellacythere ungulina* (Triebel & Bartenstein, 1938).** Described: U. Toarcian, SW Germany. Recorded: M. Toarcian, Peniche, Portugal (Cabral *et al*. 2020); Toarcian, Rabaçal, Portugal (Exton 1979, M.C. Cabral data); L. Toarcian, NE Spain (Arias & Lord 1999a); U. Toarcian, NE Spain (Arias *et al*. 2009); U. Toarcian–L. Aalenian, SW Germany (Knitter 1983); Aalenian, SW Germany (Franz *et al*. 2018); U. Aalenian, NW Germany (Plumhoff 1963); M. Jurassic, N Switzerland (Tesakova 2017).

***Praebythoceratina scrobiculata* (Triebel & Bartenstein, 1938).** Described: Aalenian, SW Germany. Recorded: M. and U. Toarcian, Rabaçal, Portugal (Exton 1979, M.C. Cabral data); U. Toarcian–L. Aalenian, NE Spain (Arias *et al*. 2009); U. Toarcian–L. Aalenian, SW Germany (Knitter 1983); Aalenian, SW Germany (Franz *et al*. 2018); U. Bathonian, NW Germany (Brand 1990); Toarcian, Wn Europe.

***Praebythoceratina stimulea* (Schwager, 1866).** Described: Oxfordian, Wn France. Recorded: M. and U. Toarcian, Rabaçal, Portugal (M.C. Cabral data); U. Toarcian–L. Aalenian, NE Spain (Arias *et al*. 2009); Oxfordian, NW Scotland (Whatley 1970); U. Toarcian, SW Germany (Fischer 1962); U. Toarcian–L. Aalenian, SW Germany (Knitter 1983).

***Tanycythere posteroelongata* Cabral, Lord, Boomer & Malz, 2014.** Described: L. Aalenian, SW Germany. Recorded: U. Toarcian, Rabaçal, Portugal (Cabral *et al*. 2014).

***Cytheropterina ainsworthi* Cabral, Lord & Pinto sp. nov.** Described herein, at present known only from U. Toarcian, Portugal.

***Cytheropterina cribra* (Fischer, 1962).** Described: U. Toarcian, SW Germany. Recorded: U. Toarcian, Rabaçal, Portugal (M.C. Cabral data); U. Toarcian–L. Aalenian, NE Spain (Arias *et al*. 2009); Toarcian–Aalenian, Fastnet Basin, Ireland (Ainsworth 1986); U. Toarcian, Paris Basin, France (Bodergat & Donze 1988); U. Aalenian–L. Bajocian, NW Germany (Plumhoff 1963); Toarcian–?Aalenian, Central Germany (Herrig 1981b); Toarcian–Bajocian, SW Germany (Knitter 1983, Franz *et al*. 2009); M. Jurassic, N Switzerland (Tesakova 2017).

***Cytheropteron alafastigatum* Fischer, 1962.** Described: U. Toarcian, SW Germany. Recorded: cf. M. Toarcian, Peniche, Portugal (Cabral *et al*. 2020); M. and U. Toarcian, Rabaçal, Portugal (Exton 1979, Loureiro *et al*. 2010); U. Toarcian, NE Spain (Arias *et al*. 2009); M. Toarcian, NE Spain (Arias & Lord 1999b); L. Toarcian, S England (Bate & Coleman 1975); M. and U. Toarcian, S England

(Boomer 1992); Toarcian, Paris Basin, France (Bodergat & Donze 1988); Toarcian–?Aalenian, Central Germany (Herrig 1981b); Toarcian–Aalenian, SW Germany (Knitter 1983).

***Eucytherura alvaiazerensis* Cabral, Lord & Pinto sp. nov.** Described herein, see discussion in Systematic Palaeontology. Recorded: M. Bathonian, NW France (Dépêche 1985); L. Aalenian, SW Germany (Franz *et al*. 2018); U. Aalenian, SW Germany (Franz *in* Wannenmacher *et al*. 2021); U. Bathonian, NW Germany (Brand 1990).

***Eucytherura* aff. *ornata* (Ainsworth, 1986).** Described: aff. *ornata* from U. Toarcian–L. Aalenian, Fastnet Basin, Ireland.

***Eucytherura* aff. *transversiplicata* (Bate & Coleman, 1975) *sensu* Knitter (1983).** Described: aff. *transversiplicata* from Toarcian, England, as identified from U. Toarcian, SW Germany (Knitter 1983). Recorded: U. Toarcian, Rabaçal, Portugal (Exton 1979); M. Jurassic, N Switzerland (Tesakova 2017).

***Eucytherura trituberosa* (Brand, 1990).** Described: U. Bathonian, NW Germany.

***Microceratina andreui* Cabral & Lord, 2023.** Described: U. Toarcian, Boca da Mata Portugal. Remark: oldest representative of the living genus (Danielopol *et al*. 2023).

***Otocythere iberobritannica* Cabral & Lord sp. nov.** Described herein, see discussion in Systematic Palaeontology. Recorded: Toarcian–Aalenian, Fastnet Basin, Ireland (Ainsworth 1986); U. Toarcian, S England (Lord 1978).

***Procytherura supraliassicum* (Herrig, 1981).** Described: U. Toarcian, Central Germany. Recorded: U. Toarcian, SW Germany (Knitter 1983).

***Ektyphocythere mediodepressa* Boomer, Ainsworth & Exton, 1998.** Described: U. Toarcian, Rabaçal, Portugal.

***Kinkelinella costata* Knitter, 1983.** Described: U. Toarcian, SW Germany. Recorded: M. Toarcian, Peniche, Portugal (Cabral *et al*. 2020); M. and U. Toarcian, Rabaçal, Portugal (Exton 1979, Loureiro *et al*. 2010); Toarcian–Aalenian, Fastnet Basin, Ireland (Ainsworth 1986); L. Toarcian, S England (Lord 1974); M. and U. Toarcian, Paris Basin, France (Apostolescu 1959); Toarcian–Aalenian SW Germany (Franz *et al*. 2009).

***Kinkelinella sermoisensis* Apostolescu, 1959.** Described: Toarcian, Paris Basin, France. Recorded: L. and M. Toarcian, Peniche, Portugal (Cabral *et al*. 2020); Toarcian, Rabaçal, Portugal (Exton 1979, Exton & Gradstein 1984); Toarcian, NE Spain (Arias & Lord 1999b, Arias *et al*. 2009); Toarcian–Aalenian, Fastnet Basin, Ireland (Ainsworth 1986); L. Toarcian, S England (Bate & Coleman 1975); L. Toarcian, S England (Lord 1974); Toarcian, W France (Dépêche 1985); Toarcian, SW France (Andreu *et al*. 1995); L. Toarcian–L. Bajocian, SW Germany (Franz *et al*. 2009); U. Toarcian–L. Aalenian, SW Germany (Knitter 1983).

***Ophektycythere herrigi* Cabral & Lord sp. nov.** Described herein, see discussion in Systematic Palaeontology. Recorded: as "Gen. unknown spp.", M. Toarcian, Peniche, Portugal (Cabral *et al*. 2020); ?L. Toarcian, S England (Bate & Coleman 1975).

***Ophektycythere mataensis* Cabral & Lord sp. nov.** Described herein, at present known only from U. Toarcian–L. Aalenian, Portugal.

***Ophektycythere*? *sicoensis* Cabral & Lord sp. nov.** Described herein, at present known only from U. Toarcian, Portugal.

***Preaschuleridea foveolata* Ainsworth, 1986.** Described: U. Toarcian–Aalenian, Fastnet Basin, Ireland. Recorded: Toarcian, Rabaçal, Portugal (Exton 1979, Exton & Gradstein 1984).

***Praeschuleridea* cf. *whatleyi* Ainsworth, 1986.** Described: cf. *whatleyi* U. Toarcian–Aalenian, Fastnet Basin, Ireland. Recorded: Toarcian, Rabaçal, Portugal (Exton 1979); U. Toarcian, NE Spain (Arias *et al*. 2009).

***Praeschuleridea* cf. sp. A Ainsworth, 1986.** Described: cf. sp. A, U. Toarcian–Aalenian, Fastnet Basin, Ireland.

***Liasina*? *cylindrica* Ainsworth, 1986.** Described: U. Toarcian–Aalenian, Fastnet Basin, Ireland. Recorded: U. Pliensbachian–M. Toarcian, Peniche, Portugal (Pinto *et al*. 2007, Rocha *et al*. 2016, Cabral *et al*. 2020); L. Toarcian, NE Spain (Arias & Lord 1999a); Toarcian–Aalenian, SW Germany (Franz *in* Wannenmacher 2021); M. Jurassic, N Switzerland (Tesakova 2017).

***Cardobairdia toarcensis* Ainsworth, 1986.** Described: U. Toarcian–Aalenian, Fastnet Basin, Ireland. Recorded: M. and U. Toarcian, Rabaçal, Portugal (Loureiro *et al*. 2010, M.C. Cabral data).

***Cardobairdia* aff. *posteroprolata* Ainsworth, 1987.** Described: aff. *posteroprolata*, U. Pliensbachian, Fastnet Basin, Ireland. Recorded: M. Toarcian, Peniche, Portugal (Cabral *et al*. 2020); M. and U. Toarcian, Rabaçal, Portugal (M.C. Cabral data).

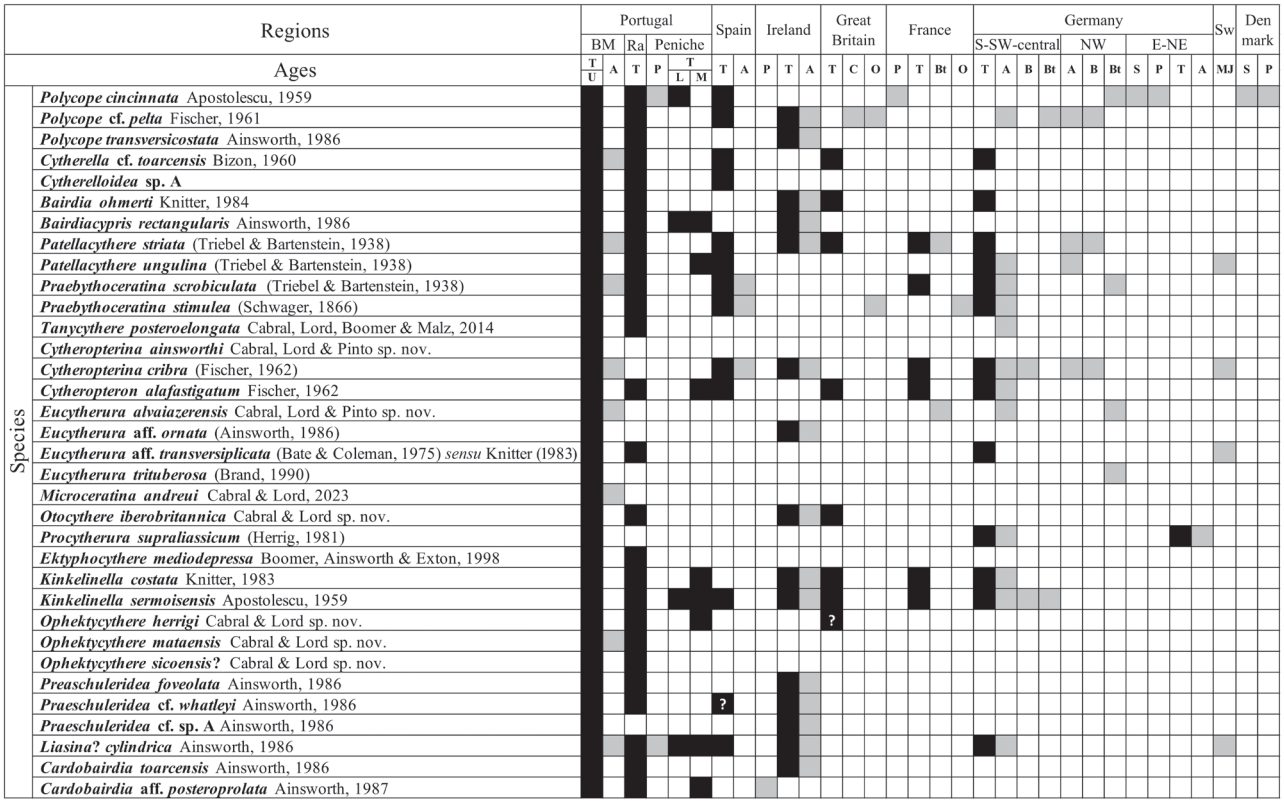


Figure 13. Palaeobiogeographical and stratigraphical distribution of the main Boca da Mata Toarcian species compared to data on the same species from most relevant European regions. Abbreviations: BM – Boca da Mata; Ra – Rabaçal; Sw – Switzerland; S – Sinemurian; P – Pliensbachian; T – Toarcian; A – Aalenian; B – Bajocian; Bt – Bathonian; C – Callovian; O – Oxfordian; MJ – Middle Jurassic; L – Lower; M – Middle; U – Upper. Black squares = Toarcian occurrences.

From the distributional records above, a clear pattern emerges of species restricted to Iberia, totaling 7 of 34 species, with 9 of 34 species occurring in both Iberia and Fastnet Basin, compared with 18 of 34 species which have a wider general Western European occurrence. It may be that the first group is endemic to Iberia but future investigations will test this idea. It is noteworthy that classic Toarcian–Aalenian taxa like *Camptocythere* and *Aphelocythere* described from NW Germany are present in the Fastnet Basin but apparently absent in Portugal and also NE Spain.

Aalenian ostracod assemblages

Compared to other Jurassic stages, the ostracods of the Aalenian are relatively poorly known with most information from NW and SW Germany. A study of Upper Aalenian–Lower Bajocian material from NW Germany was made by Plumhoff (1963) including species of characteristic Aalenian genera *Camptocythere* Triebel, 1950 and *Aphelocythere* Triebel & Klingler, 1959 together with 15 species assigned to "*Procytheridea*" which would now be placed in *Praeschuleridea* (Toarcian–Callovian) or *Kinkelinella* (Toarcian–Bathonian). Plumhoff (1967) made a fuller study of *Aphelocythere* and its evolution, recognising its presence in the Paris Basin. From SW Germany Knitter (1983) recorded *Aphelocythere*, *Praeschuleridea*, *Kinkelinella* and *Cytheropterina* ranging up from the Upper Toarcian into the Aalenian, a finding confirmed by Boomer (1994) with Aalenian borehole material from the same region, and who also reported small cytherurid species especially of *Eucytherura*. Ohmert [*in* Ohmert (ed.) 1996] provided a species range chart across the Toarcian and Aalenian boundary, and more recently Franz *et al.* (2018) and Franz *in* Wannenmacher *et al*. (2021) have given well-illustrated accounts of similar SW German Aalenian assemblages including *Camptocythere* and cytherurids.

Of closer palaeobiogeographical relevance to the Boca da Mata assemblages is Toarcian–Aalenian material described and figured from offshore SW Ireland by Ainsworth (1986), where eight industrial boreholes have yielded "Late Toarcian–Aalenian" material but the downhole biostratigraphy does not permit recognition of the stage boundary. The ostracod species range through the presumed stage boundary interval, although it should be noted that

most of the samples are drill cuttings and the ranges are plotted top-down. While many species are described as new to the area, and discussed under Palaeobiogeography above, they belong to familiar genera *Praeschuleridea*, *Kinkelinella*, *Aphelocythere*, *Camptocythere*, and small cytherurids such as *Cytheropterina* and *Eucytherura*.

Ostracods have been reported from the Toarcian–Aalenian of the Aalenian Global Boundary Stratotype Section and Point (GSSP) at Fuentelsaz, Iberian Range, NE Spain [Arias *et al*. *in* Ohmert (ed.) 1996, Arias *in* Cresta *et al.* 2001, Arias *et al.* 2009]. The assemblages of the Aalenian GSSP are described and figured by Arias *et al*. (2009) and are of moderate diversity (20 species) and from the figures are not very well preserved. Of the 20 species, 16 are identified with taxa described from Germany, three from the Paris Basin and one from offshore Denmark, belonging to the genera *Polycope* (2 spp.), *Cytherella* (1), *Cytherelloidea* (2), *Bairdiacypris* (1), *Monoceratina* (3), *Kinkelinella* (3), *Ektyphocythere* (1), *Praeschuleridea* (3), *Otocythere* (1), *Acrocythere* (1) and *Cytheropterina* (2). Faunal change is gradual, there is no event at the stage boundary, which is comparable to other cases where a range chart is provided [*e.g*. Ohmert *in* Ohmert (ed.) 1996, fig. 30] and to the results of the present work.

The Aalenian assemblages are essentially transitional between those of the Early Jurassic (Toarcian) and of the Middle Jurassic (Bajocian–Bathonian) with faunal change rather than dramatic extinctions/appearances. Authors refer to the Mesozoic Marine Revolution in the Bajocian (Fantasia *et al.* 2022, *cf*. Rojas *et al.* 2021), but from the perspective of ostracod macroevolution the most dramatic event was the extinction of the Suborder Metacopina in the early Toarcian *polymorphum* Biozone, before the Toarcian Oceanic Anoxic Event (Cabral *et al.* 2020). The disappearance of this long-ranging group (Ordovician to Lower Jurassic; survivors of the end-Permian extinction and end-Triassic events) at the Metacopina Extinction Event of Boomer *et al*. (2008) gave ostracod faunas a modern aspect, in the sense of cytherocope dominance as in extant marine faunas. Undoubtedly habitats and other resources became available following the disappearance of the metacopes and facilitated the dramatic diversification of the cytherocopes in the Toarcian and especially in the Middle Jurassic. From global data the Western European epicontinental sea (Laurasian Seaway) was a focus of evolutionary diversification of global importance.

Conclusions

1) Ostracod assemblages from the Upper Toarcian of Boca da Mata were studied in systematic detail and represent both a taxonomic and a biostratigraphical continuation of material described from the Lower and Middle Toarcian of Peniche by Cabral *et al.* (2020) (GSSP for base Toarcian). The assemblages are essentially identical to those of the Upper Toarcian of the nearby Rabaçal section (Zambujal of literature).

2) In excess of 17,000 specimens were studied, representing over 44 species (including species groups and open nomenclature taxa) in 22 genera, and reflecting fully marine and oxygenated epicontinental shelf conditions.

3) A new genus is described, *Ophektycythere* Cabral & Lord gen. nov., and the following species are recognised as new: *Cytheropterina ainsworthi* Cabral, Lord & Pinto sp. nov., *Eucytherura alvaiazerensis* Cabral, Lord & Pinto sp. nov., *Otocythere iberobritannica* Cabral & Lord sp. nov., *Ophektycythere herrigi* Cabral & Lord sp. nov., *Ophektycythere mataensis* Cabral & Lord sp. nov., *Ophektycythere*? *sicoensis* Cabral & Lord sp. nov.

4) In terms of their palaeobiogeography, the Boca da Mata assemblages have elements in common with offshore SW Ireland, approximately 50% of analysed species (16 of 34) from Iberia and the Fastnet Basin, compared with 18 of 34 with a broader Western European distribution. The surprise but convincing discovery of *Eucytherura trituberosa* (Brand), originally described from the Upper Bathonian of NW Germany, and the occurrence pattern of *Eucytherura alvaiazerensis* and *Tanycythere posteroelongata* Cabral *et al.* suggest an important background biodiversity of small, less common species.

5) Material of Early Aalenian age was not studied in detail, however, it is clear that a number of important Toarcian taxa range across the stage boundary representing gradual faunal turnover, comparable to the pattern described from the Aalenian GSSP section in northern Spain.

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