

Late Quaternary deep-sea ostracod taxonomy of the eastern North Atlantic Ocean

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ABSTRACT – Taxonomic revision and re-evaluation of the eastern North Atlantic deep-sea ostracods are conducted based on late Quaternary sediments from Ocean Drilling Program (ODP) Hole 982A, Rockall Plateau, eastern North Atlantic. Twenty-one genera and 51 species were examined and (re-)illustrated with high-resolution scanning electron microscopy images. Six new species are described: *Polycope lunaris*, *Argilloecia labri*, *Bythoceratina nuda*, *Cytheropteron colesoabyssorum*, *Cytheropteron colesopunctatum* and *Cytheropteron paramediotumidum*. Excellent fossil ostracod preservation in this sediment core enabled us to provide a robust taxonomic baseline of the eastern North Atlantic deep-sea ostracods for application to palaeoceanographical, palaeoecological and biogeographical studies.

KEYWORDS: deep-sea, Ostracoda, taxonomy, Quaternary, eastern North Atlantic, upper bathyal

INTRODUCTION

North Atlantic deep-sea ostracods have been well investigated (e.g. Brady, 1880; Whatley & Coles, 1987; Coles & Whatley, 1989; Dingle & Lord, 1990; Cronin & Raymo, 1997; Cronin *et al.*, 1999; Didié *et al.*, 2002; Yasuhara & Cronin, 2008; Yasuhara *et al.*, 2008, 2009a; Alvarez Zarikian, 2009; Yamaguchi & Norris, 2012). However, detailed taxonomic studies using the scanning electron microscope (SEM) are still limited and concentrated on the ostracod faunas from the lower bathyal and abyssal zones (i.e. >2000 m water depth) (Whatley & Coles, 1987; Coles & Whatley, 1989; Coles *et al.*, 1994; Alvarez Zarikian, 2009). Thus, little is known on the bathyal North Atlantic ostracod taxonomy, compared to well-investigated Mediterranean bathyal fauna (Bonaduce *et al.*, 1976; Colalongo & Pasini, 1980; Aiello *et al.*, 2000; Guernet, 2005; Aiello & Barra, 2010), even though bathyal faunas are usually much more diverse than abyssal faunas (e.g. Yasuhara *et al.*, 2012). Furthermore, there is some taxonomic confusion in North Atlantic ostracod taxonomy, faunal and palaeoceanographic studies in which a same species has often been called by several different names (see synonymy lists in the present study).

Recently, Yasuhara *et al.* (2009b) conducted a comprehensive taxonomic revision of western North Atlantic Quaternary deep-sea ostracods using a sediment core taken from the upper bathyal zone with high-resolution SEM images of 87 species and a detailed literature survey. However, a comparable in-depth taxonomic study has not been undertaken previously for the upper bathyal zone of the eastern North Atlantic.

Ocean Drilling Program (ODP) Hole 982A gave us an ideal opportunity to study eastern North Atlantic deep-sea ostracods from the upper bathyal zone in detail, because its sediments have an abundant, diverse and well-preserved ostracod fauna. Here we investigate late Quaternary ODP 982A ostracod taxonomy using high-resolution SEM images to reduce taxonomic confusion of North Atlantic bathyal ostracods. In addition, we briefly discuss similarity of bathyal ostracod faunas among the western and eastern North Atlantic, the Mediterranean, and the western North Pacific.

MATERIALS AND METHODS

A total of 47 samples of ODP Hole 982A (57°30.992'N, 15°52.001'W, 1135.3 m water depth; Rockall Plateau, eastern North Atlantic) covering the past 230 000 years and Marine Isotope Stages (MIS) 1–7 (Venz *et al.*, 1999) were examined for ostracod taxonomy. The full information for the samples and specimens used for the present study is shown in Tables 1 and 2. Uncoated specimens were digitally imaged with a Philips XL-30 environmental SEM. High-resolution figures of ostracod SEM images (Figs 2–16) are available at Dryad (<http://datadryad.org/>; <http://doi.org/10.5061/dryad.sc193>). We follow the higher classification scheme of the World Register of Marine Species (WoRMS: <http://www.marinespecies.org/>) with certain modifications.

Repository. Figured specimens are deposited in the National Museum of Natural History (Washington DC, catalogue numbers USNM 603625–USNM 603760).

Abbreviations. LV, left valve; RV, right valve; L, length (mm); H, height (mm).

SYSTEMATIC PALAEONTOLOGY

Class **Ostracoda** Latreille, 1802

Subclass **Myodocopa** Sars, 1866

Order **Halocyprida** Dana, 1853

Suborder **Cladocopina** Sars, 1866

Superfamily **Polycopidea** Sars, 1866

Family **Polycopidae** Sars, 1866

Genus *Polycope* Sars, 1866

Type species. *Polycope orbicularis* Sars, 1866

Remarks. We use the genus name *Polycope* in a broad sense following typical deep-sea ostracod taxonomy, but note that recent zoological studies, for example Karanovic & Brandão (2012), divide the genus into several separate genera based on soft parts, which are not preserved in fossil ostracods.

Polycope martinezi (Karanovic & Brandão, 2012)

(Fig. 2A)

2001 *Polycope* sp. cf. *P. arcys* Joy & Clark; Didié & Bauch: 104, pl. 1, fig. 28 (as erratum for Didié & Bauch, 2000).

Table 1. Detailed information of the specimens used for the present study.

USNM	No.	Species	T	V	Instar	Hole	Section	Figure
603625	ODP982154poly	<i>Polycope martinezi</i>		L	?	982A	1/3/2–4	2A
603626	ODP982161	<i>Polycope lunaris</i> sp. nov.	H	L?	A?	982A	1/3/42–44	2B
603627	ODP982162	<i>Polycope lunaris</i> sp. nov.	P	R?	A?	982A	1/3/42–44	2C
603628	ODP982155poly	<i>Polycope</i> cf. <i>bireticulata</i>		L	?	982A	1/3/32–34	2D
603629	ODP982156poly	<i>Polycope</i> cf. <i>bireticulata</i>		R	?	982A	1/3/32–34	2E
603630	ODP982157poly	<i>Polycope orbicularis</i> s.l.		R	?	982A	1/3/112–114	2F
603631	ODP982158poly	<i>Polycope orbicularis</i> s.l.		L	?	982A	1/3/112–114	2G
603632	ODP982159poly	<i>Polycope vasfiensis</i>		L	A?	982A	1/2/27–29	2H
603633	ODP982160poly	<i>Polycope vasfiensis</i>		R	A?	982A	1/2/27–29	2I
603634	ODP982163poly	<i>Polycope reticulata</i>		L	?	982A	1/3/32–34	2J
603635	ODP982164poly	<i>Polycope reticulata</i>		R	?	982A	1/3/32–34	2K
603636	ODP982075	<i>Cytherella robusta</i>		L	J	982A	1/2/107–109	3A
603637	ODP982076	<i>Cytherella robusta</i>		R	J	982A	1/2/107–109	3B
603638	ODP982066	<i>Bairdoppilata conformis</i>		L	A	982A	1/2/67–69	3C, D
603639	ODP982067	<i>Bairdoppilata conformis</i>		R	A	982A	1/3/82–84	3E, F
603640	ODP982124	<i>Macrocyprissa arcuata</i>		R	A	982A	1/1/97–99	3G
603641	ODP982126	<i>Macrocyprissa arcuata</i>		R	A	982A	1/3/102–104	3H
603642	ODP982125	<i>Macrocyprissa arcuata</i>		L	A	982A	1/3/102–104	3I
603643	ODP982062	<i>Argilloecia acuminata</i>		L	A	982A	1/1/60–62	4A
603644	ODP982063	<i>Argilloecia acuminata</i>		R	A	982A	1/1/60–62	4B
603645	ODP982064	<i>Argilloecia acuminata</i>		L	A	982A	1/1/50–52	4C
603646	ODP982065	<i>Argilloecia acuminata</i>		R	A	982A	1/1/50–52	4D
603647	ODP982052	<i>Argilloecia caju</i>		L	A	982A	1/2/17–19	4E
603648	ODP982053	<i>Argilloecia caju</i>		R	A	982A	1/2/17–19	4F
603649	ODP982058	<i>Argilloecia labri</i> sp. nov.	P	L	A	982A	1/3/102–104	4G
603650	ODP982059	<i>Argilloecia labri</i> sp. nov.	P	R	A	982A	1/3/102–104	4H
603651	ODP982060	<i>Argilloecia labri</i> sp. nov.	H	L	A	982A	1/1/50–52	4I
603652	ODP982061	<i>Argilloecia labri</i> sp. nov.	P	R	A	982A	1/3/82–84	4J
603653	ODP982054	<i>Argilloecia bensoni</i>		R	A	982A	1/1/97–99	4K
603654	ODP982057	<i>Argilloecia bensoni</i>		L	A	982A	1/1/142–144	4L
603655	ODP982056	<i>Argilloecia bensoni</i>		R	A	982A	1/3/112–114	4M
603656	ODP982055	<i>Argilloecia bensoni</i>		L	A	982A	1/1/107–109	4N
603657	ODP982165prop	<i>Propontocypris acuminata</i>		L	J?	982A	1/2/37–39	5A
603658	ODP982166prop	<i>Propontocypris</i> sp.		L	J?	982A	1/1/60–62	5B
603659	ODP982072	<i>Bythoceratina scaberrima</i>		L	A	982A	1/2/67–69	5C
603660	ODP982073	<i>Bythoceratina nuda</i> sp. nov.	H	L	A	982A	1/3/52–54	5D
603661	ODP982074	<i>Bythoceratina nuda</i> sp. nov.	P	R	A	982A	1/3/42–44	5E
603662	ODP982167pseu	<i>Pseudocythere caudata</i>		L	A?	982A	1/3/42–44	5F
603663	ODP982168pseu	<i>Pseudocythere caudata</i>		R	A?	982A	1/3/42–44	5G
603664	ODP982131	<i>Paijenborchella cymbula</i>		R	A	982A	1/1/97–99	5H
603665	ODP982132	<i>Paijenborchella cymbula</i>		L	A	982A	1/1/40–42	5I
603666	ODP982133	<i>Paijenborchella cymbula</i>		R	A	982A	1/1/40–42	5J
603667	ODP982134	<i>Paijenborchella cymbula</i>		L	A	982A	1/1/40–42	5K
603668	ODP982048	<i>Aversovalva hydrodynamica</i>		R	A	982A	1/1/107–109	6A
603669	ODP982049	<i>Aversovalva hydrodynamica</i>		L	A	982A	1/1/107–109	6B
603670	ODP982050	<i>Aversovalva hydrodynamica</i>		L	A	982A	1/1/107–109	6C
603671	ODP982051	<i>Aversovalva hydrodynamica</i>		R	A	982A	1/1/117–119	6D
603672	ODP982042	<i>Cytheropteron aielloi</i>		L	A	982A	1/3/42–44	6E
603673	ODP982043	<i>Cytheropteron aielloi</i>		R	A	982A	1/3/42–44	6F
603674	ODP982044	<i>Cytheropteron aielloi</i>		R	A	982A	1/3/42–44	6G
603675	ODP982084	<i>Cytheropteron alatum</i>		R	A	982A	1/3/112–114	6H
603676	ODP982077	<i>Cytheropteron colesoabyssorum</i> sp. nov.	H	R	A	982A	1/2/37–39	7A
603677	ODP982082	<i>Cytheropteron colesopunctatum</i> sp. nov.	H	R	A	982A	1/1/30–32	7B
603678	ODP982083	<i>Cytheropteron colesopunctatum</i> sp. nov.	P	L	A	982A	1/1/30–32	7C

(Continued)

Table 1. (Continued)

USNM	No.	Species	T	V	Instar	Hole	Section	Figure
603679	ODP982085	<i>Cytheropteron didieae</i>		R	A	982A	1/1/50–52	7D
603680	ODP982086	<i>Cytheropteron didieae</i>		R	A	982A	1/1/60–62	7E
603681	ODP982087	<i>Cytheropteron didieae</i>		R	A	982A	1/1/60–62	7F
603682	ODP982088	<i>Cytheropteron didieae</i>		L	A	982A	1/1/60–62	7G
603683	ODP982089	<i>Cytheropteron didieae</i>		L	A	982A	1/2/127–129	7H
603684	ODP982035	<i>Cytheropteron fugu</i>		L	A	982A	1/2/67–69	7I
603685	ODP982036	<i>Cytheropteron fugu</i>		L	A	982A	1/2/67–69	7J
603686	ODP982037	<i>Cytheropteron fugu</i>		R	A	982A	1/2/57–59	8A
603687	ODP982038	<i>Cytheropteron fugu</i>		R	A	982A	1/2/57–59	8B
603688	ODP982040	<i>Cytheropteron omega</i>		L	A	982A	1/4/12–14	8C
603689	ODP982039	<i>Cytheropteron omega</i>		R	A	982A	1/4/12–14	8D
603690	ODP982041	<i>Cytheropteron omega</i>		R	A	982A	1/3/132–134	8E
603691	ODP982045	<i>Cytheropteron omega</i>		L	A	982A	1/2/127–129	8F
603692	ODP982080	<i>Cytheropteron inornatum</i>		L	A	982A	1/1/97–99	8G
603693	ODP982079	<i>Cytheropteron inornatum</i>		R	A	982A	1/2/17–19	8H
603694	ODP982081	<i>Cytheropteron inornatum</i>		R	A	982A	1/1/97–99	8I
603695	ODP982078	<i>Cytheropteron inornatum</i>		L	A	982A	1/2/17–19	8J
603696	ODP982047	<i>Cytheropteron massoni</i>		L	A	982A	1/1/117–119	8K
603697	ODP982046	<i>Cytheropteron massoni</i>		R	A	982A	1/2/17–19	8L
603698	ODP982092	<i>Cytheropteron parameditumidum</i> sp. nov.	H	L	A	982A	1/2/107–109	9A
603699	ODP982093	<i>Cytheropteron parameditumidum</i> sp. nov.	P	R	A	982A	1/2/127–129	9B
603700	ODP982090	<i>Cytheropteron demenocali</i>		L	A	982A	1/1/137–139	9C
603701	ODP982091	<i>Cytheropteron demenocali</i>		R	A	982A	1/2/17–19	9D
603702	ODP982095	<i>Cytheropteron pararhombiformis</i>		L	A	982A	1/1/30–32	9E
603703	ODP982096	<i>Cytheropteron pararhombiformis</i>		R	A	982A	1/1/40–42	9F
603704	ODP982097	<i>Cytheropteron paucipunctatum</i>		L	A	982A	1/2/127–129	9G
603705	ODP982098	<i>Cytheropteron paucipunctatum</i>		R	A	982A	1/3/52–54	9H
603706	ODP982033	<i>Cytheropteron perlaria</i>		L	A	982A	1/2/17–19	10A
603707	ODP982034	<i>Cytheropteron perlaria</i>		R	A	982A	1/2/17–19	10B
603708	ODP982032	<i>Cytheropteron pherozigzag</i>		L	A	982A	1/1/142–144	10C
603709	ODP982031	<i>Cytheropteron pherozigzag</i>		R	A	982A	1/2/17–19	10D
603710	ODP982094	<i>Cytheropteron pseudoalatum</i>		L	A	982A	1/2/127–129	10E
603711	ODP982100	<i>Eucytherura calabra</i>		L	A	982A	1/1/70–72	10F
603712	ODP982101	<i>Eucytherura calabra</i>		L	A	982A	1/1/90–92	10G
603713	ODP982102	<i>Eucytherura calabra</i>		R	A	982A	1/1/107–109	10H
603714	ODP982004	<i>Eucytherura multituberculata</i>		R	A	982A	1/3/112–114	10I
603715	ODP982005	<i>Eucytherura multituberculata</i>		L	A	982A	1/3/92–94	10J
603716	ODP982001	<i>Eucytherura tetrapteron</i>		L	A	982A	1/3/112–114	11A
603717	ODP982002	<i>Eucytherura tetrapteron</i>		R	A	982A	1/3/112–114	11B
603718	ODP982003	<i>Eucytherura tetrapteron</i>		L	A	982A	1/3/112–114	11C
603719	ODP982104	<i>Kangarina abyssicola</i>		L	A	982A	1/1/137–139	11D
603720	ODP982103	<i>Kangarina abyssicola</i>		R	A	982A	1/1/70–72	11E
603721	ODP982136	<i>Pedicythere atroposopetasi</i>		L	A	982A	1/3/82–84	11F, G
603722	ODP982137	<i>Pedicythere atroposopetasi</i>		R	A	982A	1/3/82–84	11H, I
603723	ODP982138	<i>Pedicythere atroposopetasi</i>		R	A	982A	1/1/70–72	12A
603724	ODP982139	<i>Pedicythere atroposopetasi</i>		L	A	982A	1/3/92–94	12B
603725	ODP982146	<i>Pedicythere atroposopetasi</i>		R	A	982A	1/1/142–144	12C, D
603726	ODP982140	<i>Pedicythere lachesisopetasi</i>		R	A	982A	1/1/97–99	12E, F
603727	ODP982141	<i>Pedicythere lachesisopetasi</i>		L	A	982A	1/3/122–124	12G, H
603728	ODP982142	<i>Pedicythere lachesisopetasi</i>		R	A	982A	1/3/122–124	12I, J
603729	ODP982144	<i>Pedicythere lachesisopetasi</i>		R	A	982A	1/3/122–124	13A
603730	ODP982145	<i>Pedicythere lachesisopetasi</i>		L	A	982A	1/1/60–62	13B
603731	ODP982143	<i>Pedicythere lachesisopetasi</i>		L	A	982A	1/3/122–124	13C, D
603732	ODP982147	<i>Pedicythere kennettopetasi</i>		L	A	982A	1/3/72–74	13E, F

(Continued)

Table 1. (Continued)

USNM	No.	Species	T	V	Instar	Hole	Section	Figure
603733	ODP982148	<i>Pedicythere klothropetasi</i>		L	A	982A	1/1/80–82	13G
603734	ODP982149pedi	<i>Pedicythere klothropetasi</i>		R	A	982A	1/1/80–82	13H
603735	ODP982150	<i>Pedicythere klothropetasi</i>		R	A	982A	1/1/80–82	13I, J
603736	ODP982151	<i>Pedicythere klothropetasi</i>		R	A	982A	1/1/80–82	14A
603737	ODP982152	<i>Pedicythere klothropetasi</i>		L	A	982A	1/1/70–72	14B, C
603738	ODP982153	<i>Pedicythere klothropetasi</i>		R	A	982A	1/1/70–72	14D, E
603739	ODP982099	<i>Eucythere triangula</i>		L	A	982A	1/2/117–119	14F
603740	ODP982127-2	<i>Cluthia</i> sp.		L	A	982A	1/3/12–14	14G
603741	ODP982128	<i>Cluthia</i> sp.		R	A	982A	1/3/92–94	14H
603742	ODP982129-1	<i>Cluthia</i> sp.		L	A	982A	1/3/92–94	14I
603743	ODP982130	<i>Cluthia</i> sp.		R	A	982A	1/3/92–94	14J
603744	ODP982123	<i>Loxoconchidea minima</i>		L	A	982A	1/3/12–14	15A
603745	ODP982135	<i>Paracytherois bondi</i>		R	A	982A	1/1/80–82	15B, C
603746	ODP982169rock	<i>Arcacythere enigmatica</i>		L	A	982A	1/2/77–79	15D
603747	ODP982170rock	<i>Arcacythere enigmatica</i>		R	A	982A	1/2/77–79	15E
603748	ODP982171rock	<i>Arcacythere enigmatica</i>		L	A	982A	1/2/77–79	15F
603749	ODP982172rock	<i>Arcacythere enigmatica</i>		R	A	982A	1/2/77–79	15G
603750	ODP982173rock	<i>Arcacythere enigmatica</i>		R	A	982A	1/2/67–69	15H
603751	ODP982174rock	<i>Arcacythere enigmatica</i>		L	A	982A	1/3/92–94	15I
603752	ODP982027	<i>Echinocythereis echinata</i>		R	A	982A	1/1/142–144	16A
603753	ODP982028	<i>Echinocythereis echinata</i>		R	A	982A	1/1/142–144	16B
603754	ODP982029	<i>Echinocythereis echinata</i>		L	A	982A	1/3/72–74	16C
603755	ODP982030	<i>Echinocythereis echinata</i>		L	A	982A	1/3/72–74	16D
603756	ODP982022	<i>Henryhowella asperrima</i>		L	A	982A	1/1/137–139	16E
603757	ODP982023	<i>Henryhowella asperrima</i>		R	A	982A	1/1/137–139	16F
603758	ODP982026	<i>Henryhowella asperrima</i>		L	A	982A	1/1/0–2	16G
603759	ODP982024	<i>Henryhowella asperrima</i>		R	A	982A	1/1/142–144	16H, I
603760	ODP982025	<i>Henryhowella asperrima</i>		L	A	982A	1/1/107–109	16J, K

All specimens from late Quaternary sediments. Core samples are specified by standard ODP notation (core/section/interval). USNM, catalog number; No., M.Y.'s personal catalog number. T, type (P, paratype; H, holotype); V, valve (L, left; R, right); A, adult; J, juvenile.

2009b *Polycope arcys* Joy & Clark; Yasuhara *et al.*: 881, pl. 1, fig. 6.
2012 *Archypolycope martinezi* Karanovic & Brandão: 348, figs 20–24.

Remarks. *Polycope martinezi* is very similar to the Arctic species *Polycope arcys*, but distinguished by lacking obvious lateral spines and having finer reticulation. *P. martinezi* was originally reported from the equatorial Atlantic (Karanovic & Brandão, 2012) and is also known from the North Atlantic (Didié & Bauch, 2000, 2001; Yasuhara *et al.* 2009b).

Polycope lunaris sp. nov.
(Fig. 2B–C)

2001 *Polycope* sp. Didié & Bauch: 103, pl. 1, fig. 27 (as erratum for Didié & Bauch, 2000).

Derivation of name. From Latin *lunar* (adjective; nominative singular; gender, neutral)=lunar.

Diagnosis. A small, heavily calcified *Polycope* species with well-developed primary reticulation.

Holotype. LV, USNM 603626 (ODP982161) (Fig. 2B).

Paratype. RV, USNM 603627 (ODP982162).

Type locality and horizon. ODP 982A, 1/3/42–44.

Description. Carapace heavily calcified, small in size. Outline rounded in lateral view. Lateral surface ornamented with well-developed, rounded primary reticulation. Anteroventral ridge thick, well developed and bearing no reticulation. Internal features as for genus.

Dimensions. USNM 603626 (ODP982161) (Holotype), L=0.378, H=0.343; USNM 603627 (ODP982162) (Paratype), L=0.353, H=0.328.

Remarks. This species is distinctive from any other *Polycope* species by having a heavily calcified carapace with well-developed, rounded primary reticulation and thick anteroventral ridge.

Polycope cf. *bireticulata* Joy & Clark, 1977
(Fig. 2D–E)

2009b *Polycope* cf. *bireticulata* Joy & Clark; Yasuhara *et al.*: 881, pl. 1, figs 3 and 4.

Remarks. ODP 982A specimens have better developed reticulation compared to the specimens from the western North Atlantic (Yasuhara *et al.*, 2009b), considered here to be

Table 2. The list of ODP 982A samples used for the present study.

Core	Section	Interval (top: cm)	Interval (bottom: cm)	MCD (cm)	Age (ka BP)	N	S
1	1	0	2	0	0.0	87	10
1	1	10	12	10	1.0	119	15
1	1	20	22	20	2.2	107	14
1	1	30	32	30	3.4	204	19
1	1	40	42	40	5.2	276	26
1	1	50	52	50	7.2	221	35
1	1	60	62	60	10.0	231	40
1	1	70	72	70	14.9	184	39
1	1	80	82	80	19.9	141	25
1	1	90	92	90	24.9	140	31
1	1	97	99	97	28.3	237	42
1	1	107	109	107	33.3	234	30
1	1	117	119	117	38.3	241	25
1	1	127	129	127	43.2	312	29
1	1	137	139	137	48.2	259	28
1	1	142	144	142	50.7	354	34
1	2	7	9	157	58.1	264	40
1	2	17	19	167	63.1	283	34
1	2	27	29	177	68.0	268	37
1	2	37	39	187	73.0	228	34
1	2	47	49	197	77.9	227	35
1	2	57	59	207	82.9	214	28
1	2	67	69	217	87.9	195	32
1	2	77	79	227	92.8	155	32
1	2	87	89	237	97.8	264	29
1	2	97	99	247	102.8	123	25
1	2	107	109	257	107.7	320	25
1	2	117	119	267	112.7	201	21
1	2	127	129	277	117.6	237	28
1	2	137	139	287	122.6	148	24
1	3	2	4	302	130.0	220	30
1	3	12	14	312	136.3	169	25
1	3	22	24	322	146.5	161	27
1	3	32	34	332	156.8	139	28
1	3	42	44	342	165.0	195	27
1	3	52	54	352	172.5	152	28
1	3	62	64	362	179.6	228	26
1	3	72	74	372	184.9	128	25
1	3	82	84	382	190.2	229	28
1	3	92	94	392	195.3	164	31
1	3	102	104	402	200.4	294	43
1	3	112	114	412	205.6	198	34
1	3	122	124	422	210.7	367	39
1	3	132	134	432	215.8	131	27
1	3	142	144	442	220.9	164	27
1	4	2	4	452	226.0	202	29
1	4	12	14	462	231.1	161	29

N, number of ostracode specimens per sample; S, number of ostracode species per sample. Chronology from Venz *et al.* (1999)

intraspecific variation. This species is similar to *P. bireticulata*, but the latter has a more evenly rounded outline and different alignment of muri (Yasuhara *et al.* in press *b*).

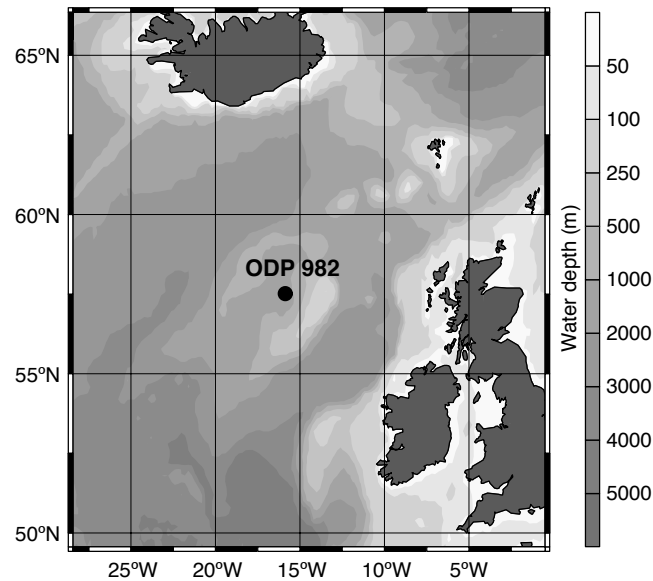


Fig. 1. Locality map of ODP Hole 982A.

Polycope orbicularis s.l. Sars, 1866
(Fig. 2F–G)

2009*b* *Polycope* cf. *orbicularis* Sars; Yasuhara *et al.*: 881, pl. 1, fig. 5.
2009*b* *Polycope orbicularis* s.l. Sars; Yasuhara *et al.*: 881.
2009 *Polycope orbicularis* Sars; Alvarez Zarikian: 3, pl. P1, fig. 7.

Remarks. *Polycope orbicularis* s.l. is discussed in Yasuhara *et al.* (2009*b*).

Polycope vasfiensis Sissingh, 1972
(Fig. 2H–I)

1972 *Polycope vasfiensis* Sissingh: 68, pl. 1, fig. 6.
1976 *Polycope vasfiensis* Sissingh; Bonaduce *et al.*: 18, pl. 1, figs 6–8, text-fig. 6.
2000 *Polycope vasfiensis* Sissingh; Aiello *et al.*: 85, pl. 1, fig. 1.
2009*b* *Polycope vasfiensis* Sissingh; Yasuhara *et al.*: 882, pl. 1, figs 1–2.

Polycope reticulata Müller, 1894
(Fig. 2J–K)

1894 *Polycope reticulata* Müller: 235, pl. 7, figs 44, 49–50; pl. 8, fig. 20.
non 1976 *Polycope reticulata* Müller; Bonaduce *et al.*: 14, pl. 2, figs 9 and 10.
2013 *Polycope reticulata* Müller; Cabral & Loureiro: 137, pl. 1, fig. 1.

Remarks. We consider that *Polycope reticulata* sensu Bonaduce *et al.* (1976) is not conspecific with *P. reticulata* Müller, 1894 because the original sketch by Müller (1894, pl. 8, fig. 20) lacks secondary reticulation and has a different primary reticulation pattern and more inflated carapace.

Subclass **Podocopa** Müller, 1894
Order **Platycopida** Sars, 1866
Suborder **Platycopina** Sars, 1866
Superfamily **Cytherelloidea** Sars, 1866

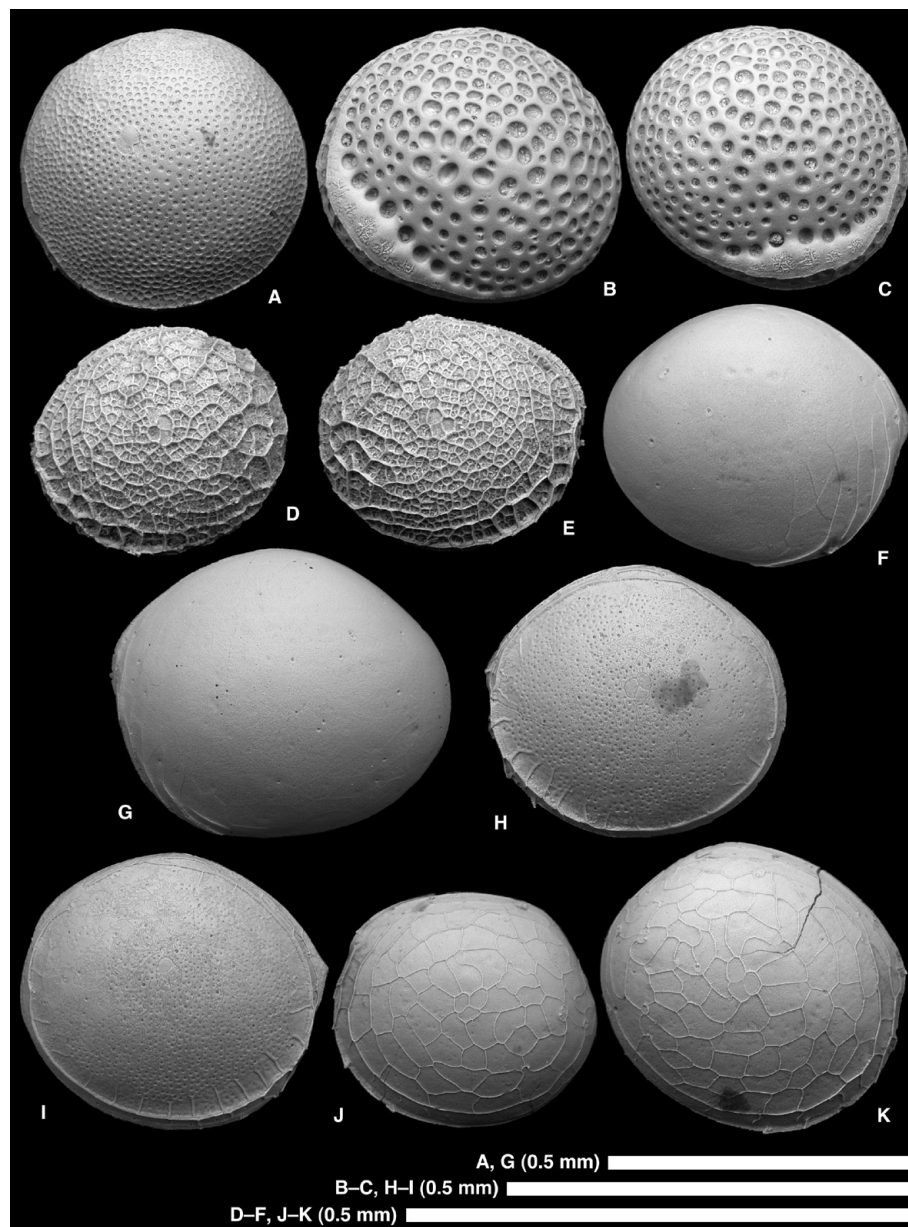


Fig. 2. Scanning electron microscope (SEM) images of *Polycope* species. **A**, *Polycope martinezi* (Karanovic & Brandão, 2012), USNM 603625 (ODP982154poly); LV from 1/3/2–4. **B–C**, *Polycope lunaris* sp. nov.: **B**, Holotype USNM 603626 (ODP982161); adult? LV? from 1/3/42–44; **C**, Paratype USNM 603627 (ODP982162); adult? RV? from 1/3/42–44. **D–E**, *Polycope* cf. *bireticulata* Joy & Clark, 1977: **D**, USNM 603628 (ODP982155poly); LV from 1/3/32–34; **E**, USNM 603629 (ODP982156poly); RV from 1/3/32–34. **F–G**, *Polycope orbicularis* s.l. Sars, 1866: **F**, USNM 603630 (ODP982157poly); RV from 1/3/112–114; **G**, USNM 603631 (ODP982158poly); LV from 1/3/112–114. **H–I**, *Polycope vasfiensis* Sissingh, 1972: **H**, USNM 603632 (ODP982159poly); adult? LV from 1/2/27–29; **I**, USNM 603633 (ODP982160poly); adult? RV from 1/2/27–29. **J–K**, *Polycope reticulata* Müller, 1894: **J**, USNM 603634 (ODP982163poly); LV from 1/3/32–34; **K**, USNM 603635 (ODP982164poly); RV from 1/3/32–34. All lateral views. All specimens from late Quaternary section of ODP Hole 982A, Rockall Plateau, eastern North Atlantic. Scale bars represent 0.5 mm.

Family **Cytherellidae** Sars, 1866

Genus *Cytherella* Jones, 1849

Type species. *Cytherina ovata* Roemer, 1841
(designated by Ulrich, 1894)

Cytherella robusta Colalongo & Pasini, 1980
(Fig. 3A–B)

1979 *Cytherella* sp. 11 Ducasse & Peypouquet: pl. 1, figs 3–4.

1980 *Cytherella robusta* Colalongo & Pasini: 78, pl. 6, figs 4–10.

1996b *Cytherella robusta* Colalongo & Pasini; Aiello *et al.*: 184, pl. 2, figs 4–5, 8–12.

2001 *Cytherella serratula* (Brady); Didié & Bauch: 104, pl. 1, fig. 5 (erratum for Didié & Bauch, 2000).

2001 *Cytherella* sp. 1 Didié & Bauch: 104, pl. 1, fig. 6 (erratum for Didié & Bauch, 2000).



Fig. 3. SEM images of *Cytherella robusta* Colalongo & Pasini, 1980, *Bairdoppilata conformis* (Terquem, 1878) and *Macrocyprissa arcuata* (Colalongo & Pasini, 1980). **A–B**, *Cytherella robusta* Colalongo & Pasini, 1980: **A**, USNM 603636 (ODP982075); juvenile LV from 1/2/107–109; **B**, USNM 603637 (ODP982076); juvenile RV from 1/2/107–109. **C–F**, *Bairdoppilata conformis* (Terquem, 1878): **C–D**, USNM 603638 (ODP982066); adult LV from 1/2/67–69; **E–F**, USNM 603639 (ODP982067); adult RV from 1/3/82–84. **G–I**, *Macrocyprissa arcuata* (Colalongo & Pasini, 1980): **G**, USNM 603640 (ODP982124); adult RV from 1/1/97–99; **H**, USNM 603641 (ODP982126); adult RV from 1/3/102–104; **I**, USNM 603642 (ODP982125); adult LV from 1/3/102–104. **A–C**, **E**, **G–I**, lateral views; **D**, **F**, internal views. All specimens from late Quaternary section of ODP Hole 982A, Rockall Plateau, eastern North Atlantic. Scale bars represent 1 mm.

2001 *Cytherella* sp. 2 Didié & Bauch: 104, pl. 1, fig. 7 (erratum for Didié & Bauch, 2000).

2009 *Cytherella* sp. Alvarez Zarikian: 7, pl. P10, fig. 5.

2009b *Cytherella robusta* s.l. Colalongo & Pasini; Yasuhara *et al.*: 882, pl. 1, figs 7–12.

2013 *Cytherella robusta* Colalongo & Pasini; Cabral & Loureiro: 137, pl. 1, fig. 3.

Remarks. Juvenile specimens of *Cytherella robusta* are shown here. As discussed in Yasuhara & Okahashi (in press), this species has certain intraspecific variation. A comprehensive

synonymy list in Aiello *et al.* (1996b), Yasuhara *et al.* (2009b) and Yasuhara & Okahashi (in press).

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

Remarks. We follow Maddocks' (1969) genus-level taxonomy for this family.

Genus *Bairdoppilata* Coryell, Sample & Jennings (1935)

Type species. *Bairdoppilata martyni* Coryell, Sample & Jennings (1935)

Bairdoppilata conformis (Terquem, 1878)

(Fig. 3C–F)

1878 *Bairdia subdeltoidea* var. *conformis* Terquem: 93, pl. 10, fig. 17a–c.

1962 *Bairdia conformis* Terquem; Ruggieri: 13.

1976 *Bairdia conformis* Terquem; Bonaduce *et al.*: 22, pl. 6, figs 5–10.

2000 *Bairdoppilata conformis* (Terquem); Aiello *et al.*: 85, pl. 1, fig. 2.

2003 *Bairdoppilata conformis* (Terquem); Sciuto: 182, fig. 2a.

2008 *Bairdoppilata conformis* (Terquem); Faranda *et al.*: 300, tab. 2.

2010 *Bairdoppilata conformis* (Terquem); Aiello & Barra: 406.

Remarks. A comprehensive synonymy list is in Aiello *et al.* (2000) and supplemented herein. Our specimens are identical to that shown in Aiello *et al.* (2000). Our specimens are also very similar to the specimens in Terquem (1878) and Bonaduce *et al.* (1976), but the latter specimens have a more heavily calcified carapace and slightly more upturned caudal process. Other authors have also reported this species, but with a slightly different outline (Sciuto, 2003) or without images (Faranda *et al.*, 2008; Aiello & Barra, 2010). We consider all of these differences as intraspecific variation and include them in *Bairdoppilata conformis*. Slight differences in outlines may be due to intraspecific variation in calcification. No SEM or microscopic image of type specimens has been published.

Suborder **Cypridocopina** Jones, 1901

Superfamily **Macrocypridoidea** Müller, 1912

Family **Macrocyprididae** Müller, 1912

Genus *Macrocyprissa* Triebel, 1960

Type species. *Bairdia cylindracea* Bornemann, 1855

Macrocyprissa arcuata (Colalongo & Pasini, 1980)

(Fig. 3G–I)

1980 *Paramacrocypris arcuata* Colalongo & Pasini: 106, pl. 25, figs 1–8.

1990 *Macrocyprissa arcuata* (Colalongo & Pasini); Maddocks: 85, figs 12.17–18, 13.17–18, 21.24, 23.24, 24.34, 28.29–30, 29.9, 35.19, 44.5, 47.6–7, 50.15–19, 51.9–13, 56.10, 24, 27, 57.11, 32, 58.18, 59.26, 33, 60.4, 63.3, 17, 64.23, 40, 51, 68.5, 72.1–3, 76.3, 78.9–10; pl. 30, figs 7–10, pl. 31, figs 7–11; pl. 67, figs 8–9; pl. 68, figs 6–14; pl. 69, fig. 1; pl. 70, figs 1–4; pl. 80, fig. 7; pl. 91, figs 10–14; pl. 104, figs 1–5; pl. 111, fig. 6.

1996 *Macrocyprissa arcuata* (Colalongo & Pasini); Coles *et al.*: 132, pl. 1, figs 10–11.

Remarks. A comprehensive synonymy list is given in Maddocks (1990).

Superfamily **Pontocypridoidea** Müller, 1894

Family **Pontocyprididae** Müller, 1894

Genus *Argilloecia* Sars, 1866

Type species. *Argilloecia cylindrica* Sars, 1866

Argilloecia acuminata Müller, 1894

(Fig. 4A–D)

1894 *Argilloecia acuminata* Müller: 261, pl. 12, figs 1–2, 12–22.

1975 *Argilloecia acuminata* Müller; Breman: 82, pl. 2, fig. 21, pl. 6, fig. 69.

1987 *Argilloecia* sp. 5 Whatley & Coles: 87, pl. 1, figs 19–20.

2004 *Argilloecia acuminata* Müller; Aiello & Szczechura: 16, pl. 1, fig. 2.

2009b *Argilloecia acuminata* Müller; Yasuhara *et al.*: 886, pl. 3, figs 1–2, 4–5.

2009 (part) *Argilloecia* sp. 2 Alvarez Zarikian: 7, pl. P8, fig. 4 (*non* 3).

Remarks. Comprehensive synonymy lists are given in Aiello & Szczechura (2004), Yasuhara *et al.* (2009b) and supplemented herein.

Argilloecia caju Yasuhara, Okahashi & Cronin 2009

(Fig. 4E–F)

2009b *Argilloecia caju* Yasuhara, Okahashi & Cronin: 886, pl. 3, figs 21–24.

Remarks. *Argilloecia caju* is similar to Pacific species *A. viriosa* Hao, 1988 (in Ruan & Hao, 1988), but distinguished by having a much more slender outline. *A. caju* was originally reported from the western North Atlantic (Yasuhara *et al.*, 2009b) and is here confirmed in the eastern North Atlantic.

Argilloecia labri sp. nov.

(Fig. 4G–J)

1987 *Argilloecia* sp. 4 Whatley & Coles: 86, pl. 1, figs 17–18.

2000 *Argilloecia* sp. 2 Didié & Bauch: 116, pl. 3, figs 3–4.

Derivation of name. From Latin *labri* (noun, genitive singular)=lip.

Diagnosis. A small, moderately calcified *Argilloecia* species with lip-shaped outline.

Holotype. LV, USNM 603651 (ODP982060) (Fig. 4I).

Paratypes. LV, USNM 603649 (ODP982058); RV, USNM 603650 (ODP982059); RV, USNM 603652 (ODP982061).

Type locality and horizon. ODP 982A, 1/1/50–52.

Description. Carapace moderately calcified, small, highest at mid-length. Outline trapezoidal in lateral view; anterior margin rounded and upturned; posterior margin acuminate and slightly upturned; dorsal margin arched; ventral margin slightly sinuous. Anterodorsal and posterodorsal margins obtuse-angular. RV strongly overlaps LV. Lateral surface smooth. Internal features as for genus.

Dimensions. USNM 603651 (ODP982060) (Holotype), L=0.461, H=0.202;

USNM 603650 (ODP982059) (Paratype), L=0.497, H=0.223.

Remarks. This species is similar to the Pacific species *Argilloecia spicata* Hao, 1988 (in Ruan & Hao, 1988), but distinguished by having a much more upturned posterior margin.

Argilloecia bensoni Barra, Aiello & Bonaduce, 1996

(Fig. 4K–N)

1996 *Argilloecia bensoni* Barra, Aiello & Bonaduce: 129, pl. 2, figs 3–4; pl. 3, figs 1–3.



Fig. 4. SEM images of *Argilloecia* species. **A–D**, *Argilloecia acuminata* Müller, 1894: **A**, USNM 603643 (ODP982062); adult LV from 1/1/60–62; **B**, USNM 603644 (ODP982063); adult RV from 1/1/60–62; **C**, USNM 603645 (ODP982064); adult LV from 1/1/50–52; **D**, USNM 603646 (ODP982065); adult RV from 1/1/50–52. **E–F**, *Argilloecia caju* Yasuhara, Okahashi & Cronin, 2009: **E**, USNM 603647 (ODP982052); adult LV from 1/2/17–19; **F**, USNM 603648 (ODP982053); adult RV from 1/2/17–19. **G–J**, *Argilloecia labri* sp. nov.: **G**, Paratype USNM 603649 (ODP982058); adult LV from 1/3/102–104; **H**, Paratype USNM 603650 (ODP982059); adult RV from 1/3/102–104; **I**, Holotype USNM 603651 (ODP982060); adult LV from 1/1/50–52; **J**, Paratype USNM 603652 (ODP982061); adult RV from 1/3/82–84. **K–N**, *Argilloecia bensoni* Barra, Aiello & Bonaduce, 1996: **K**, USNM 603653 (ODP982054); adult RV from 1/1/97–99; **L**, USNM 603654 (ODP982057); adult LV from 1/1/142–144; **M**, USNM 603655 (ODP982056); adult RV from 1/3/112–114; **N**, USNM 603656 (ODP982055); adult LV from 1/1/107–109. **C–F**, **I–J**, **M–N**, lateral views; **A–B**, **G–H**, **K–L**, internal views. All specimens from late Quaternary section of ODP Hole 982A, Rockall Plateau, eastern North Atlantic. Scale bar represents 1 mm.

Remarks. This species was originally reported from Mediterranean Plio-Pleistocene strata.

Genus *Propontocypris* Sylvester-Bradley, 1947

Type species. *Pontocypris trigonella*
Sars, 1866

Propontocypris acuminata (Müller, 1894)
(Fig. 5A)

1894 *Erythrocypris acuminata* Müller: 259, pl. 11, figs 5–6, 16–18, 40–42; pl. 28, figs 23, 30; pl. 38, figs 47–48.

1976 *Pontocypris acuminata* (Müller); Bonaduce *et al.*: 25, pl. 9, figs 1–2.

2000 *Pontocypris* sp. Didié & Bauch: 116, pl. 4, fig. 17.

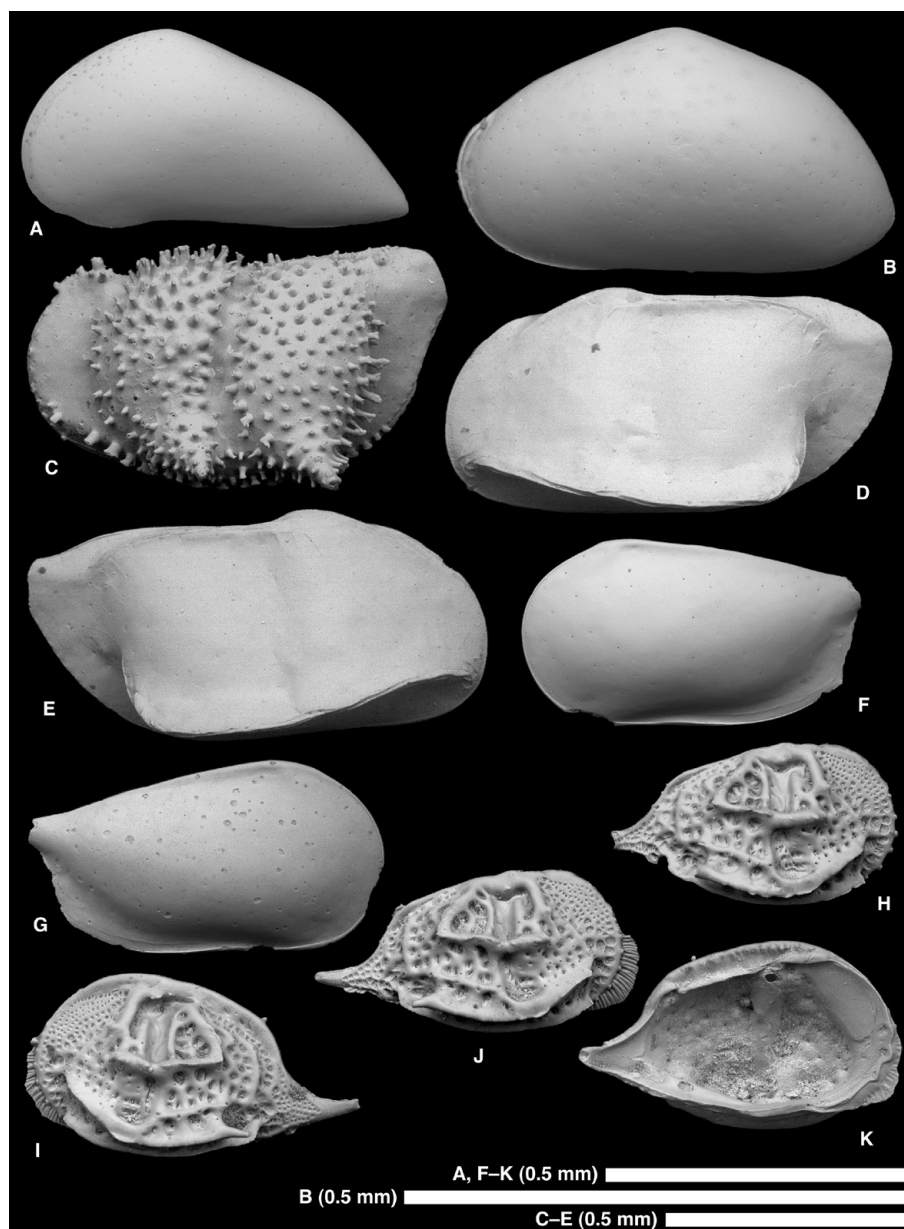


Fig. 5. SEM images of *Propontocypris*, *Bythoceratina*, *Pseudocythere* and *Paijenborchella* species. **A**, *Propontocypris acuminata* (Müller, 1894), USNM 603657 (ODP982165prop); juvenile? LV from 1/2/37–39. **B**, *Propontocypris* sp., USNM 603658 (ODP982166prop); juvenile? LV from 1/1/60–62. **C**, *Bythoceratina scaberrima* (Brady, 1886), USNM 603659 (ODP982072); adult LV from 1/2/67–69. **D–E**, *Bythoceratina nuda* sp. nov.: **D**, Holotype USNM 603660 (ODP982073); adult LV from 1/3/52–54; **E**, Paratype USNM 603661 (ODP982074); adult RV from 1/3/42–44. **F–G**, *Pseudocythere caudata* Sars, 1866: **F**, USNM 603662 (ODP982167pseu); adult? LV from 1/3/42–44; **G**, USNM 603663 (ODP982168pseu); adult? RV from 1/3/42–44. **H–K**, *Paijenborchella cymbula* Ruggieri, 1950: **H**, USNM 603664 (ODP982131); adult RV from 1/1/97–99; **I**, USNM 603665 (ODP982132); adult LV from 1/1/40–42; **J**, USNM 603666 (ODP982133); adult RV from 1/1/40–42; **K**, USNM 603667 (ODP982134); adult LV from 1/1/40–42. **A–J**, lateral views; **K**, internal view. All specimens from late Quaternary section of ODP Hole 982A, Rockall Plateau, eastern North Atlantic. Scale bars represent 0.5 mm.

Propontocypris sp.
(Fig. 5B)

?2009 *Propontocypris trigonella* Sars; Alvarez Zarikian: 7, pl. P8, fig. 10.

Suborder **Cytherocopina** Gründel, 1967
Superfamily **Cytheroidea** Baird, 1850

Family **Bythocytheridae** Sars, 1866
Genus *Bythoceratina* Hornibrook, 1952

Type species. *Bythoceratina mestayerae*, Hornibrook, 1952

Bythoceratina scaberrima (Brady, 1886)
(Fig. 5C)

1886 *Cytherura scaberrima* Brady: 198, pl. 14, figs 10–11.

- 1980 *Bythoceratina scaberrima mediterranea* Colalongo & Pasini: 72, pl. 1, fig. 9; pl. 4, figs 9–10.
2001 *Bythoceratina scaberrima* (Brady); Didié & Bauch: pl. 1, fig. 29 (erratum for Didié & Bauch, 2000).
2005 *Retibythere scaberrima* (Brady); Guernet: 109.

Remarks. Comprehensive synonymy list and detailed discussion in Guernet (2005) and Yasuhara *et al.* (in press b).

Bythoceratina nuda sp. nov.
(Fig. 5D–E)

Derivation of name. From Latin *nuda* (adjective, nominative singular, gender feminine or neuter)=stripped, with reference to its carapace without any spine or reticulation.

Diagnosis. A large, moderately calcified *Bythoceratina* species without spines or reticulation.

Holotype. LV, USNM 603660 (ODP982073) (Fig. 5D)

Paratype. RV, USNM 603661 (ODP982074).

Type locality and horizon. ODP 982A, 1/3/52–54.

Description. Carapace moderately calcified, large, highest at anterodorsal corner (=anterior cardinal angle). Outline parallelogram-like in lateral view; anterior margin rounded; caudal process upturned; dorsal margin sinuous; ventral margin slightly curved. Anterodorsal margin prominent; posterodorsal margin slightly angular. Lateral surface smooth. A ventrolateral ridge well developed, reaching to anterior margin; thin dorsolateral ridge present. A median sulcus present, but very shallow. Internal features as for genus.

Dimensions. USNM 603660 (ODP982073) (Holotype), L=0.920, H=0.462; USNM 603661 (ODP982074) (Paratype), L=0.948, H=0.471.

Remarks. This species is distinguished from any other *Bythoceratina* species by its lack of spines and reticulation.

Genus *Pseudocythere* Sars, 1866
Type species. *Pseudocythere caudata* Sars, 1866

Pseudocythere caudata Sars, 1866
(Fig. 5F–G)

- 1866 *Pseudocythere caudata* Sars: 88.
1926 *Pseudocythere caudata* Sars; Sars: 239, pl. 109, fig. 2a–k.
2009b *Pseudocythere caudata* Sars; Yasuhara *et al.*: 892, pl. 4, figs 7–12.

Remarks. We think that this species has considerable intraspecific variation. A comprehensive synonymy list and detailed discussion are given in Yasuhara *et al.* (in press b).

Family **Cytheridae** Baird, 1850
Genus *Paijenborchella* Kingma, 1948
Type species. *Paijenborchella iocosa* Kingma, 1948

Paijenborchella cymbula Ruggieri, 1950
(Fig. 5H–K)

- 1950 *Paijenborchella cymbula* Ruggieri: 60, 1 unnumbered fig. on p. 61.

- 1973 *Paijenborchella* (*Eopaijenborchella*) *malaiensis cymbula* Ruggieri; Doruk: 161, pls 1.30.162, 1.30.164.
2000 *Paijenborchella malaiensis cymbula* Ruggieri; Aiello *et al.*: 93, pl. 2, fig. 12.
2005 *Paijenborchella cymbula* Ruggieri; Guernet: 107.

Remarks. A comprehensive synonymy list can be found in Aiello *et al.* (2000) and Guernet (2005). To our knowledge, this is the first well-illustrated record (SEM images) of this species from the Atlantic. This species was recently reported from the Iberian Margin at IODP Site U1387 (Expedition 339 Scientists, 2013).

Family **Cytheruridae** Müller, 1894
Genus *Aversovalva* Hornibrook, 1952
Type species. *Cytheropteron*
(*Aversovalva*) *aureum* Hornibrook, 1952

Remarks. Several authors have considered *Aversovalva* Hornibrook, 1952 as a subgenus (Aiello *et al.*, 1996a) or junior synonym (Whatley & Masson, 1979; Horne & Whittaker, 1988) of *Cytheropteron* Sars, 1866. However, in our opinion, differences in hingement and outline including a straight median hinge element, highly developed smooth and rounded terminal teeth clearly distinct from the median hinge element, and parallelogram-like outline in *Aversovalva* (e.g. Figs 6C–D) are sufficient to separate *Aversovalva* from *Cytheropteron*. Most recent deep-sea ostracod papers have considered *Aversovalva* as an independent genus (e.g. see synonymy of *Aversovalva hydrodynamica* below), supporting our decision.

Aversovalva hydrodynamica Whatley & Coles, 1987
(Fig. 6A–D)

- 1987 *Aversovalva hydrodynamica* Whatley & Coles: 69, pl. 3, figs 10–11.
1996 *Aversovalva hydrodynamica* Whatley & Coles; Coles *et al.*: 150, pl. 3, fig. 17.
1988 (part) *Aversovalva* sp. 2 Whatley & Ayress: 742, pl. 2, fig. 1a (non 1b).
?2001 *Aversovalva* sp. cf. *A. hydrodynamica* Didié & Bauch: 103, pl. 1, fig. 12 (as erratum for Didié & Bauch, 2000).
2009 *Aversovalva hydrodynamica* Whatley & Coles; Alvarez Zarikian: 3, pl. P3, fig. 7.

Remarks. Very similar, but slightly different species are reported from the western North Atlantic as *Aversovalva* sp. 1 and *A. cf. hydrodynamica* (Yasuhara *et al.*, 2009b). A Pliocene Mediterranean species *Aversovalva denticulatum* (Aiello, Barra & Bonaduce, 1996) shows strong affinity to *A. hydrodynamica* Whatley & Coles, 1987, but the former has a more triangular outline. *A. hydrodynamica* is also similar to *A. consueta* (Dall'Antonia, 2003), but the latter has thicker and more downward-extended alae and weaker reticulation. Although Coles *et al.* (1990, 1996) suggested a global distribution for this species, reliable records with SEM images are restricted in the eastern North Atlantic.

Genus *Cytheropteron* Sars, 1866
Type species. *Cythere latissima* Norman, 1865 (designated by Brady & Norman, 1889; see Horne & Whittaker (1988) for details and lectotype).

Remarks. We agree with Horne & Whittaker (1988) and consider *Kobayashiina* Hanai, 1957b and *Lobosocytheropteron* Ishizaki & Gunther, 1974 as junior synonyms of *Cytheropteron*.

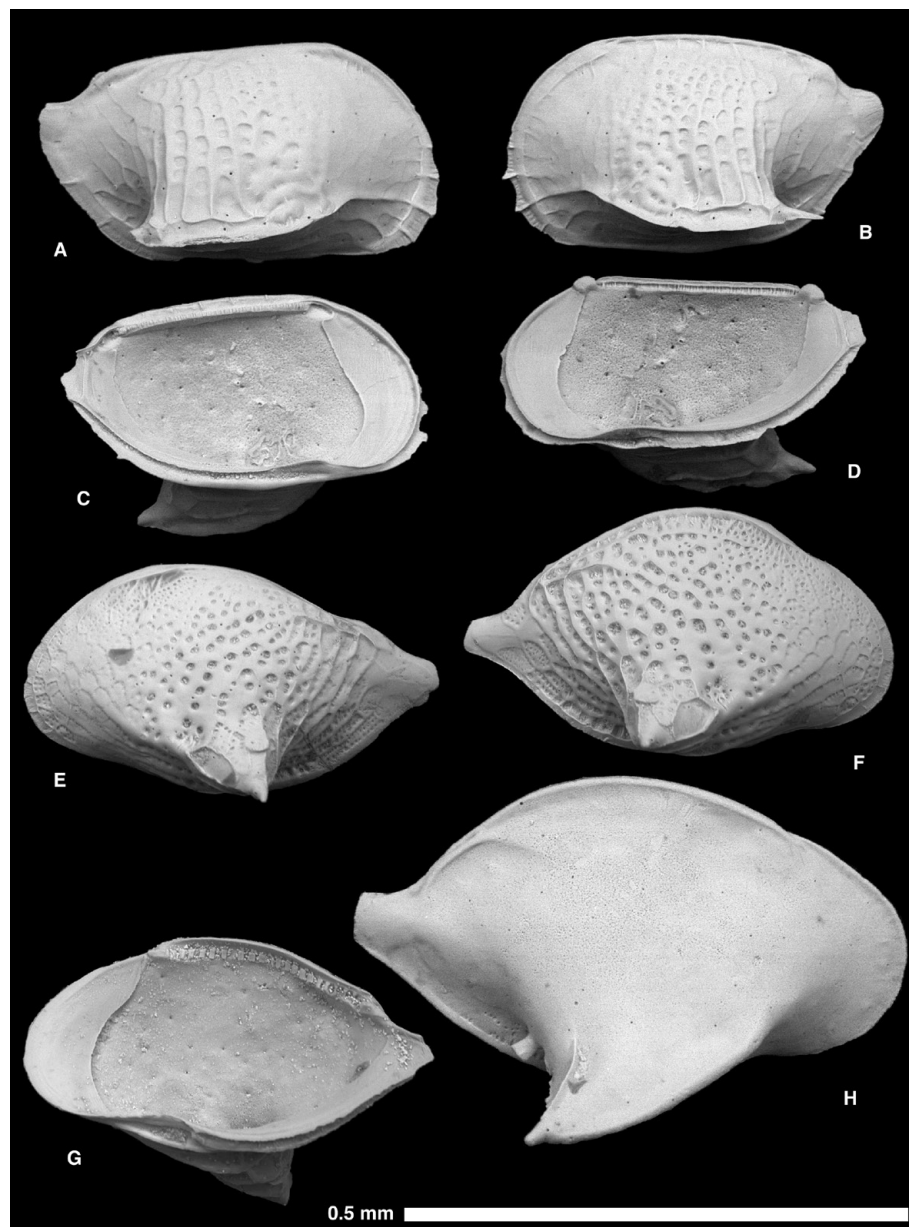


Fig. 6. SEM images of *Aversoalva* and *Cytheropteron* species. **A–D**, *Aversoalva hydrodynamica* Whatley & Coles, 1987: **A**, USNM 603668 (ODP982048); adult RV from 1/1/107–109; **B**, USNM 603669 (ODP982049); adult LV from 1/1/107–109; **C**, USNM 603670 (ODP982050); adult LV from 1/1/107–109; **D**, USNM 603671 (ODP982051); adult RV from 1/1/117–119. **E–G**, *Cytheropteron aielloi* Yasuhara, Okahashi & Cronin, 2009: **E**, USNM 603672 (ODP982042); adult LV from 1/3/42–44; **F**, USNM 603673 (ODP982043); adult RV from 1/3/42–44; **G**, USNM 603674 (ODP982044); adult RV from 1/3/42–44; **H**, *Cytheropteron alatum* Sars, 1866, USNM 603675 (ODP982084); adult RV from 1/3/112–114. **A–B**, **E–F**, **H**, lateral views; **C–D**, **G**, internal views. All specimens from late Quaternary section of ODP Hole 982A, Rockall Plateau, eastern North Atlantic. Scale bar represents 0.5 mm.

Cytheropteron aielloi Yasuhara, Okahashi & Cronin, 2009

(Fig. 6E–G)

1996 *Cytheropteron sedovi* Schneider; Whatley *et al.*: 19, pl. 2, figs 15–17.

1998 *Cytheropteron sedovi* Schneider; Whatley *et al.*: 21, pl. 2, figs 11–12.

2009 *Cytheropteron aielloi* Yasuhara, Okahashi & Cronin: 898, pl. 10, figs 3–6.

Remarks. This species is known not only from the North Atlantic proper but also from the Nordic seas.

Cytheropteron alatum Sars, 1866

(Fig. 6H)

1866 *Cytheropteron alatum* Sars: 81.

1926 *Cytheropteron alatum* Sars; Sars: 225, pl. 104, fig. 1.

1993 *Cytheropteron alatum* Sars; Penney: figs 4n–o.

1996 *Cytheropteron vespertilio* (Reuss); Coles *et al.*: 136, pl. 3, fig. 9.

1998 *Cytheropteron alatum* Sars; Freiwald & Mostafawi: 260, pl. 59, fig. 7.

2000 *Cytheropteron alatum* Sars; Didié & Bauch: pl. 2, fig. 6.

Remarks. Reliable occurrence records of this species with SEM image(s) or sketches are known only from the eastern North Atlantic as listed in the synonymy list above. Detailed discussion of this species can be found in Yasuhara *et al.* (in press b).

Cytheropteron colesoabyssorum sp. nov.
(Fig. 7A)

1996 *Cytheropteron* cf. *abyssorum* Brady; Coles *et al.*: 136, pl. 3, figs 12–13.

Derivation of name. In honour of Graham P. Coles for his contribution to deep-sea ostracod research; and with reference to its similarity to *Cytheropteron abyssorum* as indicated by him.

Diagnosis. A large, moderately calcified *Cytheropteron* species with finely punctate carapace, upturned caudal process, and relatively rounded outline.

Holotype. RV, USNM 603676 (ODP982077) (Fig. 7A).

Type locality and horizon. ODP 982A, 1/2/37–39.

Description. Carapace moderately calcified, large, highest at mid-length. Outline rhomboidal and rounded in lateral view; anterior margin evenly rounded; caudal process strongly upturned; dorsal margin arched; ventral margin slightly curved; alae well developed, almost reaching to anterior margin and slightly extended below ventral margin; median sulcus present on alae; thin dorso-lateral ridge present along dorsal margin. Anterodorsal and posterodorsal margins slightly angular. Lateral surface finely punctate. Internal features as for genus.

Dimensions. USNM 603676 (ODP982077) (Holotype), L=0.489, H=0.301.

Remarks. *Cytheropteron colesoabyssorum* sp. nov. is similar to *C. abyssorum* Brady, 1880 (see Passlow & Ayress, 1994) in certain aspects, such as presence of a median sulcus on alae and punctate carapace, but easily distinguished by having much finer punctation covering entire carapace, thinner and longer alae, and upturned caudal process and presence of dorsolateral ridge. *C. colesoabyssorum* sp. nov. is similar to *C. cf. tenuialatum* of Coles *et al.* (1996), but distinguished by having a dorsolateral ridge and more strongly upturned caudal process, and by the absence of primary reticulation on the caudal process.

Cytheropteron colesopunctatum sp. nov.
(Fig. 7B–C)

1996 (part) *Cytheropteron* gr. *punctatum* Brady; Coles *et al.*: 136, pl. 3, figs 7–8 (non 5–6).
in press a *Cytheropteron* sp. Yasuhara *et al.*: fig. 6.7–8.

Derivation of name. In honour of Graham P. Coles for his contribution to deep-sea ostracod research; and with reference to its similarity to *Cytheropteron punctatum* as indicated by him.

Diagnosis. A large, moderately calcified *Cytheropteron* species with coarsely punctate carapace and horizontally long, well-developed alae.

Holotype. RV, USNM 603677 (ODP982082) (Fig. 7B).

Paratype. LV, USNM 603678 (ODP982083).

Type locality and horizon. ODP 982A, 1/1/30–32.

Description. Carapace moderately calcified, large, highest at mid-length. Outline rhomboidal or almond-like in lateral view; anterior margin evenly rounded; caudal process prominent and upturned; dorsal margin arched and slightly sinuous; ventral margin curved; alae curved, horizontally long and well-developed, reaching to anterior margin and extending slightly below ventral margin, with a small spine at apex. Anterodorsal margin slightly angular; posterodorsal margin weakly angular. Lateral surface coarsely punctate; primary and secondary reticulation developed in posterior one third. Internal features as for genus.

Dimensions. USNM 603677 (ODP982082) (Holotype), L=0.514, H=0.306; USNM 603678 (ODP982083) (Paratype), L=0.545, H=0.338.

Remarks. *Cytheropteron colesopunctatum* sp. nov. is similar to *C. punctatum* Brady, 1868 in certain aspects, such as punctate carapace and general outline, but is distinguished by having smoothly curved and horizontally longer alae reaching to anterior margin and well-developed primary and secondary reticulation in posterior one-third. *C. punctatum* has sinuous and horizontally shorter alae and no or only poorly developed reticulation, according to the sketches and SEM images shown in Brady (1868), Sars (1928) and Whatley & Masson (1979). *C. colesopunctatum* sp. nov. is similar to *C. paracarolinae* Zhao *et al.*, 2000 (see Zhao *et al.*, 2000; Hou & Gou, 2007), but the latter is larger, lacks punctation in anterior one-third, and has more slender outline and stronger caudal process.

Cytheropteron didieae Yasuhara, Okahashi & Cronin 2009
(Fig. 7D–H)

2009 *Cytheropteron didieae* Yasuhara, Okahashi & Cronin: 900, pl. 6, figs 5–6, 8–9, 11–12.

Remarks. This is the first record of the species from the eastern North Atlantic.

Cytheropteron fugu Yasuhara, Okahashi & Cronin, 2009
(Figs. 7I–J, 8A–B)

2009 *Cytheropteron fugu* Yasuhara, Okahashi & Cronin: 902, pl. 7, figs 1–6.

Remarks. This is the first record of the species from the eastern North Atlantic.

Cytheropteron inornatum Brady & Robertson, 1872
(Fig. 8G–J)

1872 *Cytheropteron inornatum* Brady & Robertson: 61, pl. 2, figs 1–3.

1979 *Cytheropteron inornatum* Brady & Robertson; Whatley & Masson: 238, pl. 3, figs 1–3, 5–7.

1981 *Cytheropteron hanaii* Ishizaki: 55, pl. 11, figs 11–12; pl. 12, figs 1–4; pl. 13, figs 8–9; pl. 14, fig. 3.

1988 *Cytheropteron hanaii* Ishizaki; Wang *et al.*: 265, pl. 52, figs 17–18.

1989 *Cytheropteron inornatum* Brady & Robertson; Athersuch *et al.*: 226, fig. 95; pl. 8, fig. 4.

1992 *Cytheropteron hanaii* Ishizaki; Ikeya & Suzuki: 126, pl. 4, fig. 4.

1996 *Cytheropteron inornatum* Brady & Robertson; Coles *et al.*: 135, pl. 2, fig. 15.

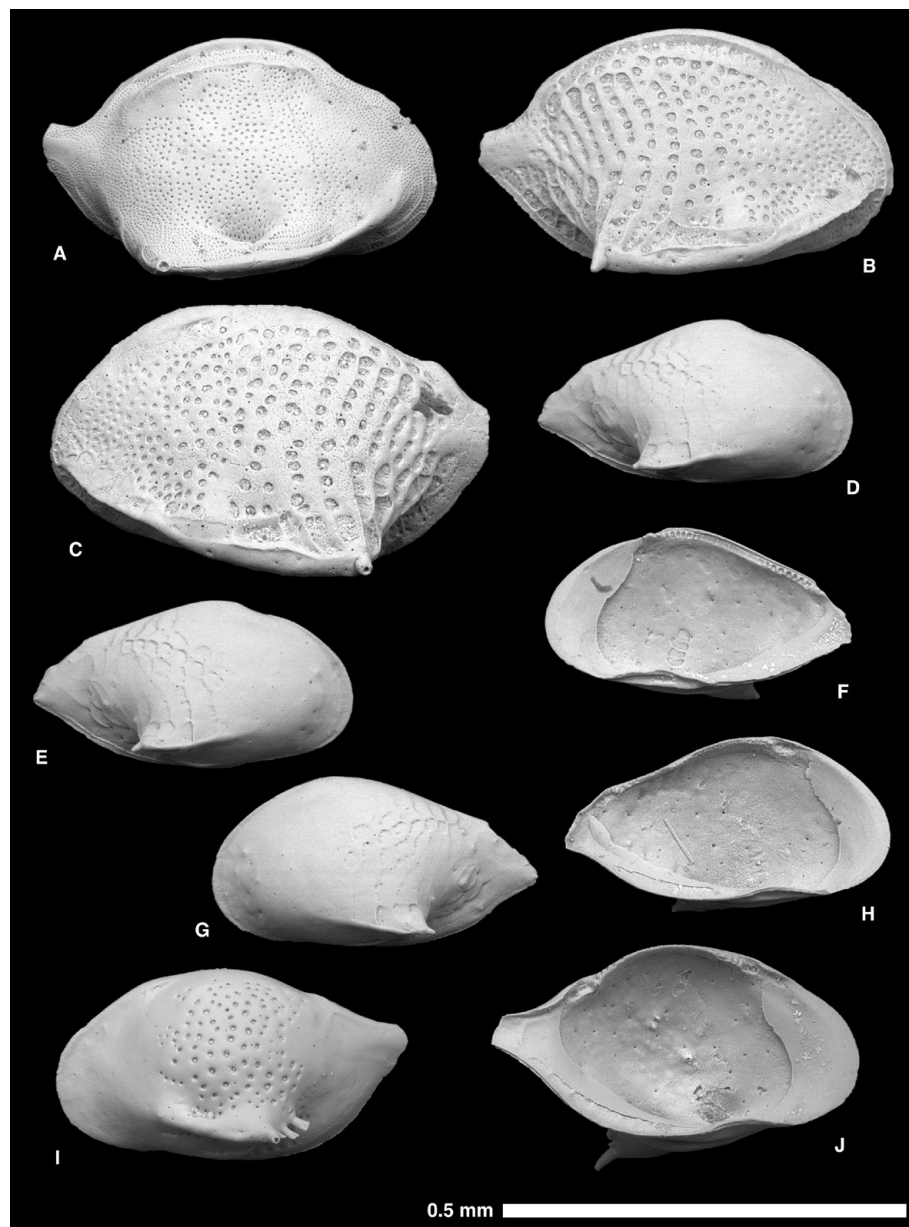


Fig. 7. SEM images of *Cytheropteron* species. **A**, *Cytheropteron colesoabyssorum* sp. nov., Holotype USNM 603676 (ODP982077); adult RV from 1/2/37–39. **B–C**, *Cytheropteron colesopunctatum* sp. nov.: **B**, Holotype USNM 603677 (ODP982082); adult RV from 1/1/30–32; **C**, Paratype USNM 603678 (ODP982083); adult LV from 1/1/30–32. **D–H**, *Cytheropteron didieae* Yasuhara, Okahashi & Cronin, 2009: **D**, USNM 603679 (ODP982085); adult RV from 1/1/50–52; **E**, USNM 603680 (ODP982086); adult RV from 1/1/60–62; **F**, USNM 603681 (ODP982087); adult RV from 1/1/60–62; **G**, USNM 603682 (ODP982088); adult LV from 1/1/60–62; **H**, USNM 603683 (ODP982089); adult LV from 1/2/127–129. **I–J**, *Cytheropteron fugu* Yasuhara, Okahashi & Cronin, 2009: **I**, USNM 603684 (ODP982035); adult LV from 1/2/67–69; **J**, USNM 603685 (ODP982036); adult LV from 1/2/67–69. **A–E**, **G**, **I**, lateral views; **F**, **H**, **J**, internal views. All specimens from late Quaternary section of ODP Hole 982A, Rockall Plateau, eastern North Atlantic. Scale bar represents 0.5 mm.

2000 *Cytheropteron hanaii* Ishizaki; Zhao *et al.*: 262, pl. 3, figs 8–9.

2007 *Cytheropteron hanaii* Ishizaki; Hou & Gou: 294, pl. 119, figs 14–15; pl. 122, figs 11–12.

2009 *Cytheropteron* sp. g Yasuhara, Okahashi & Cronin: 908, pl. 6, fig. 14.

2012 *Cytheropteron hanaii* Ishizaki; Tanaka *et al.*: 10, pl. 1, fig. 13.

Remarks. Detailed comparison with similar species such as *C. fraudulentum* Aiello, Barra & Bonaduce 1996 and *C. sulcatum* Bonaduce, Ciampo & Masoli, 1976 is found in Aiello *et al.* (1996a) and Athersuch *et al.* (1989). In our opinion, *C. hanaii* Ishizaki, 1981 (see Ishizaki, 1981; Zhao *et al.*, 2000; Hou & Gou, 2007) is a junior synonym of *C. inornatum* Brady & Robertson, 1872.

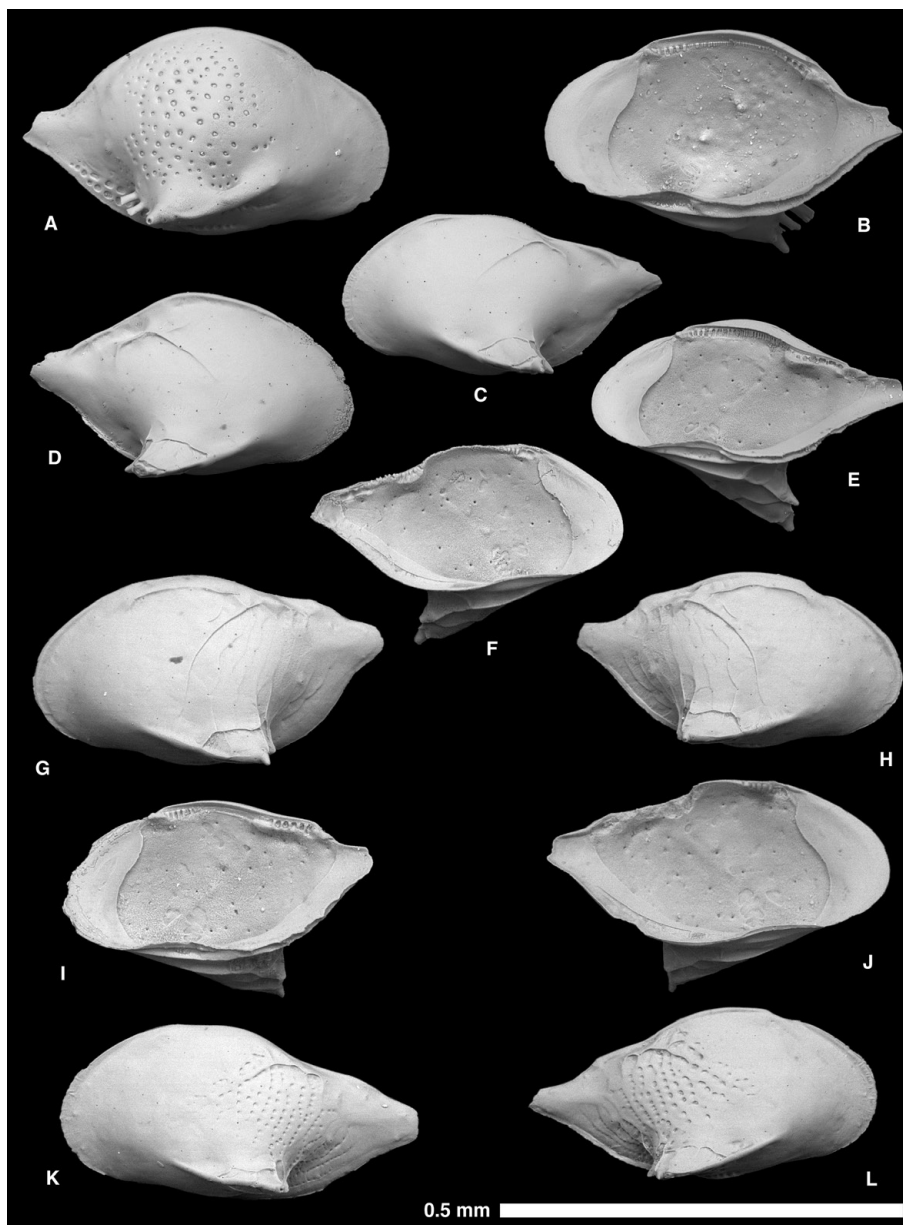


Fig. 8. SEM images of *Cytheropteron* species. **A–B**, *Cytheropteron fugu* Yasuhara, Okahashi & Cronin, 2009: **A**, USNM 603686 (ODP982037); adult RV from 1/2/57–59; **B**, USNM 603687 (ODP982038); adult RV from 1/2/57–59. **C–F**, *Cytheropteron omega* Aiello, Barra & Bonaduce, 1996: **C**, USNM 603688 (ODP982040); adult LV from 1/4/12–14; **D**, USNM 603689 (ODP982039); adult RV from 1/4/12–14; **E**, USNM 603690 (ODP982041); adult RV from 1/3/132–134; **F**, USNM 603691 (ODP982045); adult LV from 1/2/127–129. **G–J**, *Cytheropteron inornatum* Brady & Robertson, 1872: **G**, USNM 603692 (ODP982080); adult LV from 1/1/97–99; **H**, USNM 603693 (ODP982079); adult RV from 1/2/17–19; **I**, USNM 603694 (ODP982081); adult RV from 1/1/97–99; **J**, USNM 603695 (ODP982078); adult LV from 1/2/17–19. **K–L**, *Cytheropteron massoni* Whatley & Coles, 1987: **K**, USNM 603696 (ODP982047); adult LV from 1/1/117–119; **L**, USNM 603697 (ODP982046); adult RV from 1/2/17–19. **A**, **C–D**, **G–H**, **K–L**, lateral views; **B**, **E–F**, **I–J**, internal views. All specimens from late Quaternary section of ODP Hole 982A, Rockall Plateau, eastern North Atlantic. Scale bar represents 0.5 mm.

Cytheropteron massoni Whatley & Coles, 1987
(Fig. 8K–L)

1987 *Cytheropteron massoni* Whatley & Coles: 63, pl. 2, figs 15–17.

2000 *Cytheropteron massoni* Whatley & Coles; Didié & Bauch: 113, pl. 2, fig. 11.

2009b *Cytheropteron massoni* Whatley & Coles; Yasuhara *et al.*: 904, p. 6, figs 7, 10, 13.

Remarks. *C. massoni* Whatley & Coles, 1987 is known from both the eastern and western North Atlantic.

Cytheropteron omega Aiello, Barra & Bonaduce, 1996
(Fig. 8C–F)

1987 (part) *Cytheropteron syntomoalatum* Whatley & Coles: pl. 2, fig. 27 (*non* pl. 2, figs 25–26, 28–29).

1996 *Cytheropteron omega* Aiello, Barra & Bonaduce: 170, pl. 2, figs 7–9.

Remarks. Detailed comparison with similar species such as *C. garganicum* Bonaduce, Ciampo & Masoli, 1976 can be found in Aiello *et al.* (1996a). Our specimens have relatively weakly developed dorsal ridges compared to the type specimens and thus the ‘upside-down omega’ structure is unclear, but otherwise identical. We consider this difference as intraspecific variation. Well-preserved specimens shown here indicate that there are two spines at the apex of alae. A paratype specimen of *C. syntomoalatum* of Whatley & Coles (1987, pl. 2, fig. 27) is not conspecific with *C. syntomoalatum* Whatley & Coles, 1987 and is considered here and by Aiello *et al.* (1996a) as *C. omega* Aiello, Barra & Bonaduce, 1996, although this specimen has only one spine at the apex of the alae and a slightly more slender outline.

Cytheropteron paramediotumidum sp. nov.
(Fig. 9A–B)

1996 (part) *Cytheropteron* gr. *punctatum* Brady; Coles *et al.*: 136, pl. 3, figs 5–6 (*non* 7–8).

Derivation of name. With reference to its similarity to *Cytheropteron mediotumidum*.

Diagnosis. A large, moderately calcified *Cytheropteron* species with finely punctate carapace and straight-sided alae.

Holotype. LV, USNM 603698 (ODP982092) (Fig. 9A).

Paratype. RV, USNM 603699 (ODP982093).

Type locality and horizon. ODP 982A, 1/2/107–109.

Description. Carapace moderately calcified, large, highest at mid-length. Outline subrhomboidal in lateral view; anterior margin rounded; caudal process moderately prominent; dorsal margin arched; ventral margin slightly curved; alae straight, thin and horizontally long, almost reaching to anterior margin, and extending slightly below ventral margin; a small subcentral depression present on alae. Anterodorsal margin slightly angular; posterodorsal margin weakly prominent. Lateral surface finely punctate in posterior two-thirds; primary and secondary reticulation weakly developed in posterior one-third. Internal features as for genus.

Dimensions. USNM 603698 (ODP982092) (Holotype), L=0.638, H=0.389; USNM 603699 (ODP982093) (Paratype), L=0.671, H=0.431.

Remarks. *Cytheropteron paramediotumidum* sp. nov. is very similar to *C. mediotumidum* Zhao, Whatley & Zhou, 2000, but distinguished by having a less upturned caudal process, finer punctation, less distinct primary reticulation and straight-sided alae. *C. paramediotumidum* sp. nov. is also similar to *C. colesopunctatum* sp. nov., but the latter has more prominent caudal processes, coarser and more distinct punctation, and curved-sided alae.

Cytheropteron demenocali Yasuhara, Okahashi & Cronin, 2009
(Fig. 9C–D)

?2000 *Cytheropteron porterae* Whatley & Coles; Didié & Bauch: 113, pl. 2, fig. 20 (*non* figs 19 and 21).

2009 *Cytheropteron demenocali* Yasuhara, Okahashi & Cronin: 900, pl. 9, figs 1–10.

Remarks. Our specimens have two spines (instead of one) at the apex of alae and slightly more ventrally-extended alae, but are otherwise identical. We consider these differences as intraspecific variation, at least for now.

Cytheropteron pararhombiformis Zhao, Whatley & Zhou, 2000
(Fig. 9E–F)

1988 *Cytheropteron rhombiformis* Chen; Ruan & Hao: 283, pl. 47, figs 18–20.

1996 *Cytheropteron* sp. Coles *et al.*: 136, pl. 3, fig. 16.

2000 *Cytheropteron pararhombiformis* Zhao, Whatley & Zhou: 275, pl. 4, figs 5–8.

2007 *Cytheropteron pararhombiforme* Zhao, Whatley & Zhou; Hou & Gou: 301, pl. 123, figs 5–8.

Remarks. *Cytheropteron pararhombiformis* Zhao, Whatley & Zhou, 2000 is very similar to *C. zinzulusae* Bonaduce, Ciampo & Masoli, 1976, but distinguished by having irregular and coarser punctation and a less upturned caudal process. This species was originally reported from the western North Pacific.

Cytheropteron paucipunctatum Whatley & Coles, 1987
(Fig. 9G–H)

1987 *Cytheropteron paucipunctatum* Whatley & Coles: 63, pl. 2, figs 18–20.

1988 *Cytheropteron* sp. 1 Whatley & Ayress: 740, pl. 1, fig. 6a–b.

Remarks. Our specimens have weakly developed primary reticulation in the posterior one-third, but otherwise are identical to *C. paucipunctatum* Whatley & Coles, 1987. We consider this difference as intraspecific variation. This species is known only from the eastern North Atlantic.

Cytheropteron perlaria Hao, 1988 (in Ruan & Hao, 1988)
(Fig. 10A–B)

1988 *Cytheropteron perlaria* Hao (in Ruan & Hao, 1988): 280, pl. 47, figs 4–9.

1996 *Cytheropteron testudo* Sars; Coles *et al.*: 136, pl. 3, figs 10–11.

1999 *Cytheropteron perlaria* Hao; Swanson & Ayress: 155, pl. 1, figs 7–13; pl. 2, figs 1–3.

non 2004 *Cytheropteron perlaria* Hao; Ayress *et al.*: 29, pl. 3, figs 7–8.

2006 *Cytheropteron perlaria* Hao; Stepanova: S163, pl. 3, figs 8–10.

2007 *Cytheropteron testudo* Sars; Hou & Gou: 290, pl. 120, figs 9–10.

2009 *Cytheropteron perlaria* Hao; Alvarez Zarikian: 4, pl. P3, figs 1–2.

2009b *Cytheropteron perlaria* Hao; Yasuhara *et al.*: 904, pl. 7, figs 12–13.

2011 *Cytheropteron perlaria* Hao; Zhao *et al.*: 27, pl. 1, fig. 26.

Remarks. This species is known from the Atlantic, Arctic and Pacific oceans.

Cytheropteron pherozigzag Whatley, Ayress & Downing, 1986
(Fig. 10C–D)

1986 *Cytheropteron pherozigzag* Whatley, Ayress & Downing: 32, pl. 1, figs 6–20.

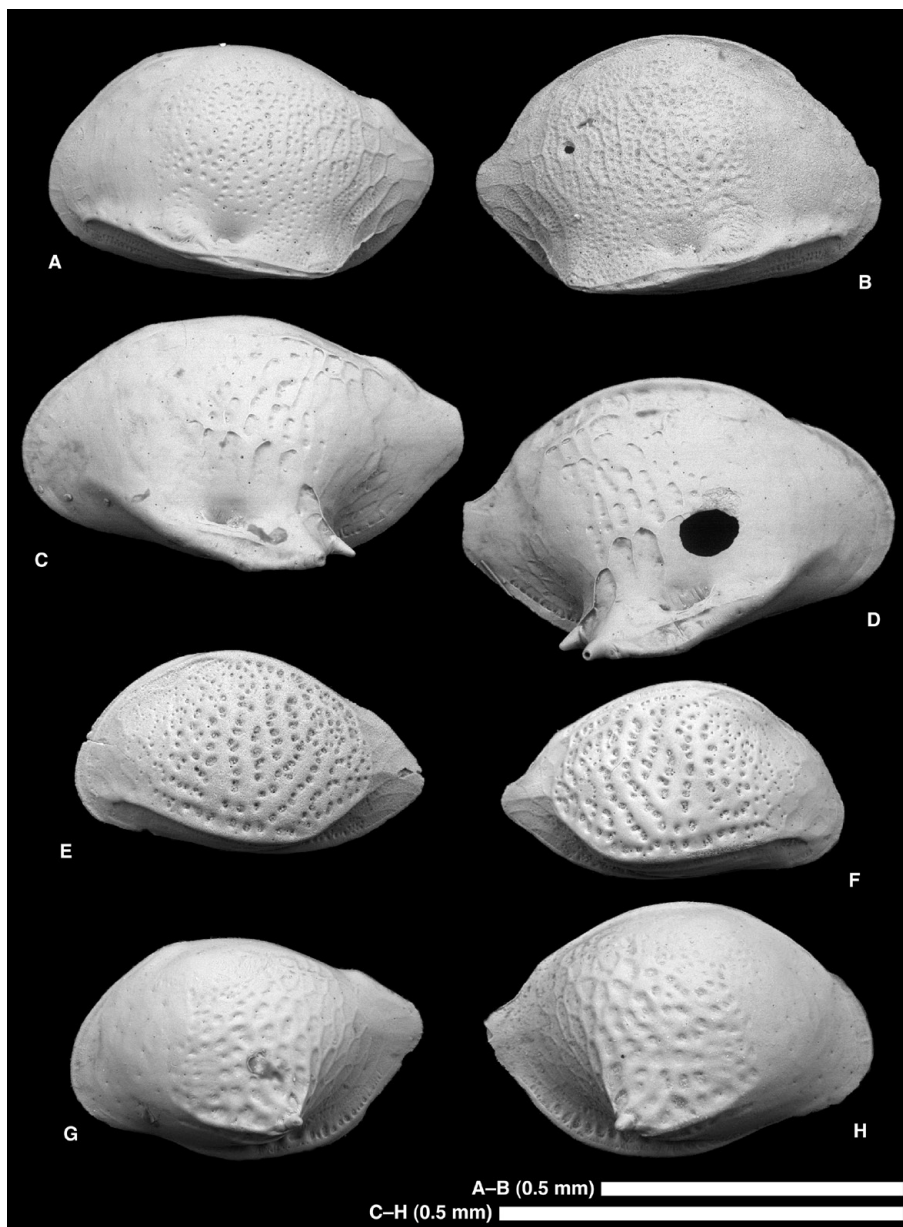


Fig. 9. SEM images of *Cytheropteron* species. **A–B**, *Cytheropteron paramediotumidum* sp. nov.: **A**, Holotype USNM 603698 (ODP982092); adult LV from 1/2/107–109; **B**, Paratype USNM 603699 (ODP982093); adult RV from 1/2/127–129. **C–D**, *Cytheropteron demenocali* Yasuhara, Okahashi & Cronin, 2009: **C**, USNM 603700 (ODP982090); adult LV from 1/1/137–139; **D**, USNM 603701 (ODP982091); adult RV from 1/2/17–19. **E–F**, *Cytheropteron pararhombiformis* Zhao, Whatley & Zhou, 2000: **E**, USNM 603702 (ODP982095); adult LV from 1/1/30–32; **F**, USNM 603703 (ODP982096); adult RV from 1/1/40–42. **G–H**, *Cytheropteron paucipunctatum* Whatley & Coles, 1987: **G**, USNM 603704 (ODP982097); adult LV from 1/2/127–129; **H**, USNM 603705 (ODP982098); adult RV from 1/3/52–54. All lateral views. All specimens from late Quaternary section of ODP Hole 982A, Rockall Plateau, eastern North Atlantic. Scale bars represent 0.5 mm.

1988 *Cytheropteron pherozigzag* Whatley, Ayress & Downing; Whatley & Ayress: pl. 2, fig. 3a–b.
 1996 *Cytheropteron pherozigzag* Whatley, Ayress & Downing; Zhao & Zheng: 72, pl. 2, fig. 3.
 2000 *Cytheropteron pherozigzag* Whatley, Ayress & Downing; Zhao *et al.*: 263, pl. 1, fig. 20.
 2005 *Cytheropteron pherozigzag* Whatley, Ayress & Downing; Zhao: 39, pl. 2, fig. 15.

2007 *Lobosocytheropteron pherozigzag* (Whatley, Ayress & Downing); Hou & Gou: 309, pl. 125, fig. 17.
 2009b *Cytheropteron pherozigzag* Whatley, Ayress & Downing; Yasuhara *et al.*: 906, pl. 5, figs 6–8, 10.

Remarks. This species is known from the eastern and western North Atlantic and northwestern Pacific oceans.

Cytheropteron pseudoalatum Colalongo & Pasini, 1980
(Fig. 10E)

- 1980 *Cytheropteron pseudoalatum* Colalongo & Pasini: 92, pl. 8, fig. 8; pl. 9, figs 1–5.
1996a *Cytheropteron pseudoalatum* Colalongo & Pasini; Aiello *et al.*: 171, pl. 2, figs 1–3; pl. 3, figs 1–2.

Remarks. This species was originally reported from the Mediterranean. This is the first record from the North Atlantic.

Genus *Eucytherura* Müller, 1894

Type species. *Cythere complexa* Brady, 1867 (designated by Alexander, 1936).

Remarks. We agree with Ayress *et al.* (1995) and consider *Typhlocythere* Bonaduce, Ciampo & Masoli, 1976, *Typhloeucytherura* Colalongo & Pasini, 1980 and *Parahemingwayella* Dingle, 1984 as junior synonyms of *Eucytherura* Müller, 1894.

Eucytherura calabra (Colalongo & Pasini, 1980)
(Fig. 10F–H)

- 1980 *Typhloeucytherura calabra* Colalongo & Pasini: 122, pl. 20, figs 1–8; pl. 21, figs 1–2.
1987 *Eucytherura calabra* (Colalongo & Pasini); Whatley & Coles: pl. 3, figs 14–16.
1988 *Eucytherura* sp. 1; Ruan & Hao: 291, pl. 49, fig. 18.
1988 *Eucytherura calabra* (Colalongo & Pasini); Whatley & Ayress: pl. 1, fig. 9a–b.
1995 *Eucytherura calabra* (Colalongo & Pasini); Ayress *et al.*: 211, fig. 3A–D.
1996 *Eucytherura calabra* (Colalongo & Pasini); Coles *et al.*: 136, pl. 3, fig. 18.
1996 *Eucytherura calabra* (Colalongo & Pasini); Zhao & Zheng: 72, pl. 2, fig. 36.
2001 *Eucytherura calabra* (Colalongo & Pasini); Didié & Bauch (as erratum of Didié & Bauch, 2000): 103, pl. 1, figs 9–10.

Remarks. *Eucytherura calabra* (Colalongo & Pasini, 1980) is similar to *E. spinicorona* Yasuhara, Okahashi & Cronin 2009, but the former has a curved dorsal margin and rectangular outline. *E. calabra* is known from the Atlantic, Mediterranean and Pacific.

Eucytherura multituberculata Ayress, Whatley,
Downing & Millson, 1995
(Fig. 10I–J)

- 1983 ?*Tuberculocthere* sp. Cronin: 107, pl. 6, fig. A.
1987 *Eucytherura* sp. 2 Whatley & Coles: 90, pl. 3, fig. 18.
1995 *Eucytherura multituberculata* Ayress, Whatley, Downing & Millson: 213, fig. 5A–E.

Remarks. This species is known both from the western and eastern North Atlantic.

Eucytherura tetrapteron (Bonaduce, Ciampo & Masoli, 1976)
(Fig. 11A–C)

- 1976 ?*Cytheropteron tetrapteron* Bonaduce, Ciampo & Masoli: 99, pl. 47, fig. 1–7.
1980 *Cytheropteron?* *tetrapteron* Bonaduce, Ciampo & Masoli; Ciampo: 19, pl. 3, fig. 5.
1980 *Tuberculocthere tetrapteron* (Bonaduce, Ciampo & Masoli); Colalongo & Pasini: 120, pl. 34 fig. 2.

- 1985 *Tuberculocthere tetrapteron* (Bonaduce, Ciampo & Masoli); Moncharmont-Zei *et al.*: 28, pl. 1, fig. 1.
1994 *Parahemingwayella tetrapteron* (Bonaduce, Ciampo & Masoli); Malz & Jellinek: 28, pl. 7, figs 37–40.
2000 *Parahemingwayella tetrapteron* (Bonaduce, Ciampo & Masoli); Aiello *et al.*: 94, pl. 3, fig. 9.
2001 *Eucytherura* sp. Didié & Bauch (as erratum of Didié & Bauch, 2000): 103, pl. 1, fig. 11.
2005 *Parahemingwayella tetrapteron* (Bonaduce, Ciampo & Masoli); Guernet: 108.

Remarks. *Eucytherura tetrapteron* (Bonaduce, Ciampo & Masoli, 1976) is very similar to *E. downingae* (Coles & Whatley, 1989), but the latter has more strongly developed primary and secondary reticulation and bears two spines on the anterodorsal margin (the former bears a continuous frill). Although these differences are subtle and may be a result of intraspecific variation in calcification, we consider these two as separate species at least for now. *E. tetrapteron* is known from the Mediterranean and the eastern North Atlantic.

Genus *Kangarina* Coryell & Fields, 1937

Type species. *Kangarina quellita* Coryell & Fields, 1937
Kangarina abyssicola (Müller, 1894)
(Fig. 11D–E)

- 1894 *Cytheropteron abyssiculum* Müller: 302, pl. 20, figs 5, 11; pl. 21, figs 6–9.
1952 *Cytheropteron* (*Kangarina*) *abyssiculum* Müller; Ruggieri: 77, pl. 6, fig. 9.
1953 *Kangarina abyssicola coarctata* Ruggieri: 53, figs 16, 16a.
1953 *Kangarina abyssicola* (Müller); Ruggieri: 53, figs 15, 15a.
1972 *Kangarina septentrionalis* Neale: 33, pl. 1, figs 1–8.
1976 *Kangarina abyssicola* (Müller); Bonaduce *et al.*: 84, pl. 17, fig. 16.
1980 *Kangarina abyssicola* (Müller); Colalongo & Pasini: 58, pl. 22, fig. 2.
1988 *Kangarina abyssicola* (Müller); Guernet & Fourcade: 145, pl. 4, fig. 12.
non 1993 *Kangarina abyssicola* (Müller); Witte: 43, pl. 9, figs 25–26.
1996 *Kangarina abyssicola* (Müller); Coles *et al.*: 135, pl. 2, figs 10–11.
2004 *Kangarina?* *abyssicola* (Müller); Aiello & Szczechura: 53, pl. 8, fig. 15.
2005 *Kangarina abyssicola* (Müller); Guernet: 103.
2005 *Kangarina coarctata* Ruggieri; Guernet: 103.
2009b *Kangarina* cf. *abyssicola* (Müller); Yasuhara *et al.*: 914, p. 14, fig. 13.
2010 *Kangarina abyssicola* (Müller); Aiello & Barra: 412.

Remarks. We consider *Kangarina coarctata* Ruggieri, 1953 and *K. septentrionalis* Neale, 1972 as junior synonyms of *K. abyssicola* (Müller, 1894). *K. abyssicola* is known from the Mediterranean and the eastern and western North Atlantic.

Genus *Pedicythere* Eagar, 1965

Type species. *Pedicythere tessae* Eagar, 1965

Remarks. We found four *Pedicythere* species in ODP 982A, all of which also occur in the western North Atlantic (Yasuhara *et al.*, 2009b).

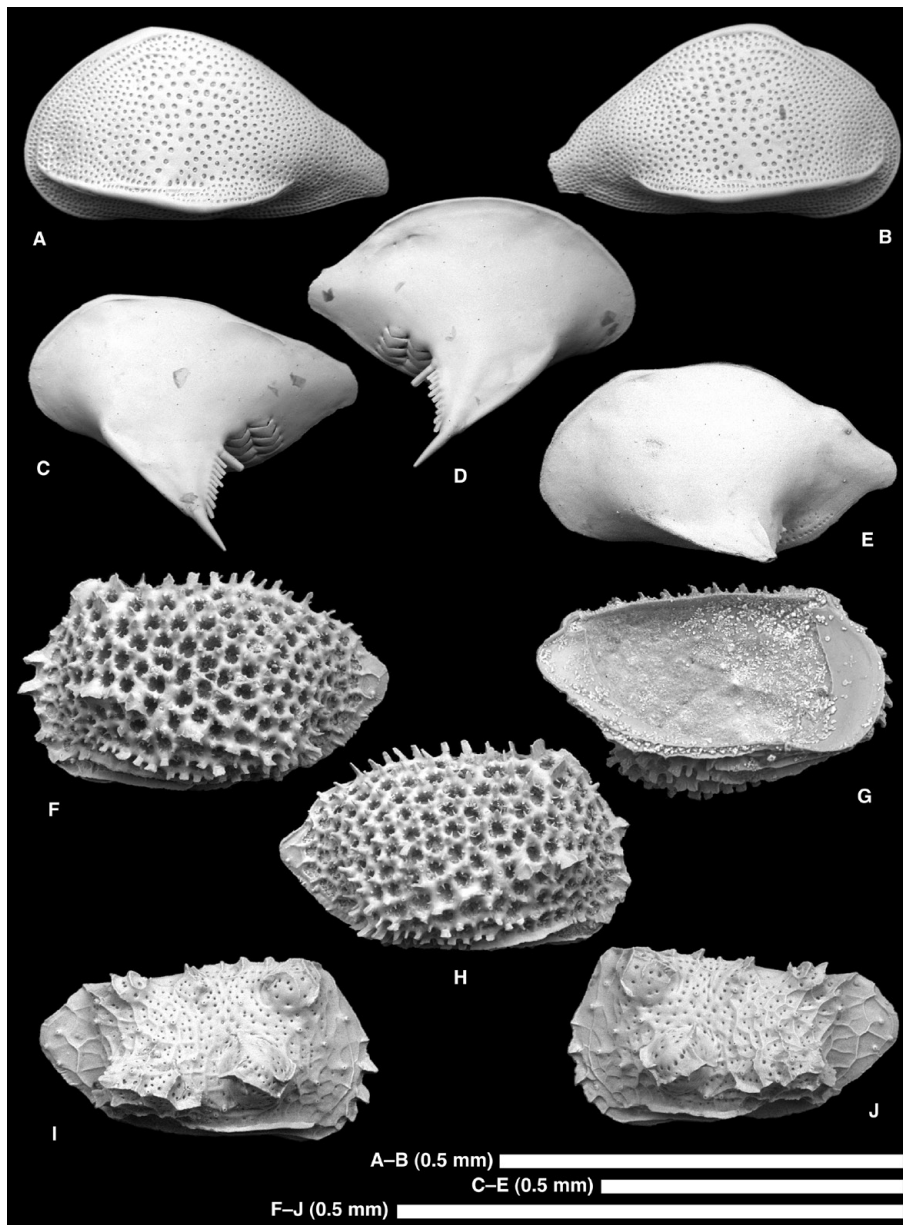


Fig. 10. SEM images of *Cytheropteron* and *Eucytherura* species. **A–B**, *Cytheropteron perlaria* Hao, 1988: **A**, USNM 603706 (ODP982033); adult LV from 1/2/17–19; **B**, USNM 603707 (ODP982034); adult RV from 1/2/17–19. **C–D**, *Cytheropteron pherozigzag* Whatley, Ayress & Downing, 1986: **C**, USNM 603708 (ODP982032); adult LV from 1/1/142–144; **D**, USNM 603709 (ODP982031); adult RV from 1/2/17–19. **E**, *Cytheropteron pseudoalatum* Colalongo & Pasini, 1980, USNM 603710 (ODP982094); adult LV from 1/2/127–129. **F–H**, *Eucytherura calabra* (Colalongo & Pasini, 1980): **F**, USNM 603711 (ODP982100); adult LV from 1/1/70–72; **G**, USNM 603712 (ODP982101); adult LV from 1/1/90–92; **H**, USNM 603713 (ODP982102); adult RV from 1/1/107–109. **I–J**, *Eucytherura multituberculata* Ayress, Whatley, Downing & Millson, 1995: **I**, USNM 603714 (ODP982004); adult RV from 1/3/112–114; **J**, USNM 603715 (ODP982005); adult LV from 1/3/92–94. **A–F**, **H–J**, lateral views; **G**, internal view. All specimens from late Quaternary section of ODP Hole 982A, Rockall Plateau, eastern North Atlantic. Scale bars represent 0.5 mm.

Pedicythere atroposopetasi Yasuhara, Okahashi & Cronin, 2009
(Figs 11F–I, 12A–D)
?2000 *Pedicythere* sp. B Guernet & Bellier: 270, pl. 5, fig. 3.
2009 *Pedicythere atroposopetasi* Yasuhara, Okahashi & Cronin:
914, pl. 15, figs 1–13.

Pedicythere kennettopetasi Yasuhara, Okahashi & Cronin, 2009
(Fig. 13E–F)

?2000 (part) *Pedicythere* sp. A Guernet & Bellier: 270, pl. 5, fig. 2
(non fig. 1).

2009 *Pedicythere kennettopetasi* Yasuhara, Okahashi & Cronin:
916, pl. 16, figs 1–10.

Pedicythere klothropetasi Yasuhara, Okahashi & Cronin, 2009
(Figs 13G–J, 14A–E)

2009 *Pedicythere klothropetasi* Yasuhara, Okahashi & Cronin:
916, pl. 15, figs 14–21.

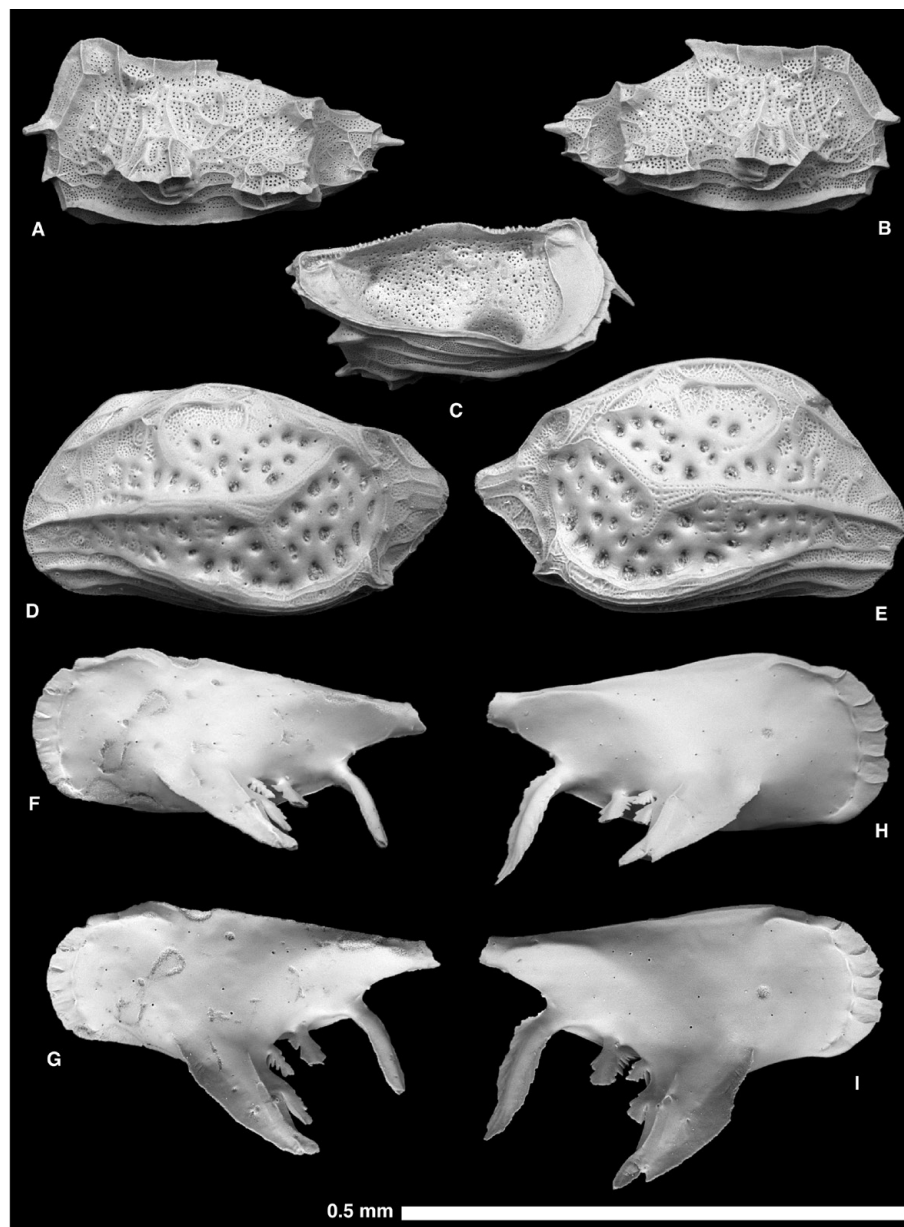


Fig. 11. SEM images of *Eucytherura*, *Kangarina* and *Pedicythere* species. **A–C**, *Eucytherura tetrapteron* (Bonaduce, Ciampo & Masoli, 1976): **A**, USNM 603716 (ODP982001); adult LV from 1/3/112–114; **B**, USNM 603717 (ODP982002); adult RV from 1/3/112–114; **C**, USNM 603718 (ODP982003); adult LV from 1/3/112–114. **D–E**, *Kangarina abyssicola* (Müller, 1894): **D**, USNM 603719 (ODP982104); adult LV from 1/1/137–139; **E**, USNM 603720 (ODP982103); adult RV from 1/1/70–72. **F–I**, *Pedicythere atroposopetasi* Yasuhara, Okahashi & Cronin, 2009: **F–G**, USNM 603721 (ODP982136); adult LV from 1/3/82–84; **H–I**, USNM 603722 (ODP982137); adult RV from 1/3/82–84. **A–B**, **D–F**, **H**, lateral views; **C**, internal view; **G**, **I**, oblique views. All specimens from late Quaternary section of ODP Hole 982A, Rockall Plateau, eastern North Atlantic. Scale bar represents 0.5 mm.

Pedicythere lachesisopetasi Yasuhara, Okahashi & Cronin, 2009
(Figs 12E–J, 13A–D)
1983 *Pedicythere* sp. A Cronin: 110, pl. 4H.
2008 *Pedicythere* sp. Bergue & Coimbra: 130, pl. 6, fig. 13.
2009 *Pedicythere lachesisopetasi* Yasuhara, Okahashi & Cronin:
918, pl. 16, figs 11–21.

Family **Eucytheridae** Puri, 1954
Genus *Eucythere* Brady, 1868

Type species. *Cythere declivis* Norman, 1867 (designated by Brady & Norman, 1889; see Horne & Whittaker (1985) for details and lectotype).

Eucythere triangula Whatley & Coles, 1987
(Fig. 14F)

1987 *Eucythere triangula* Whatley & Coles: 74, pl. 4, figs 16–18.
2000 *Eucythere triangula* Whatley & Coles; Didié & Bauch: 114,
pl. 3, fig. 21.

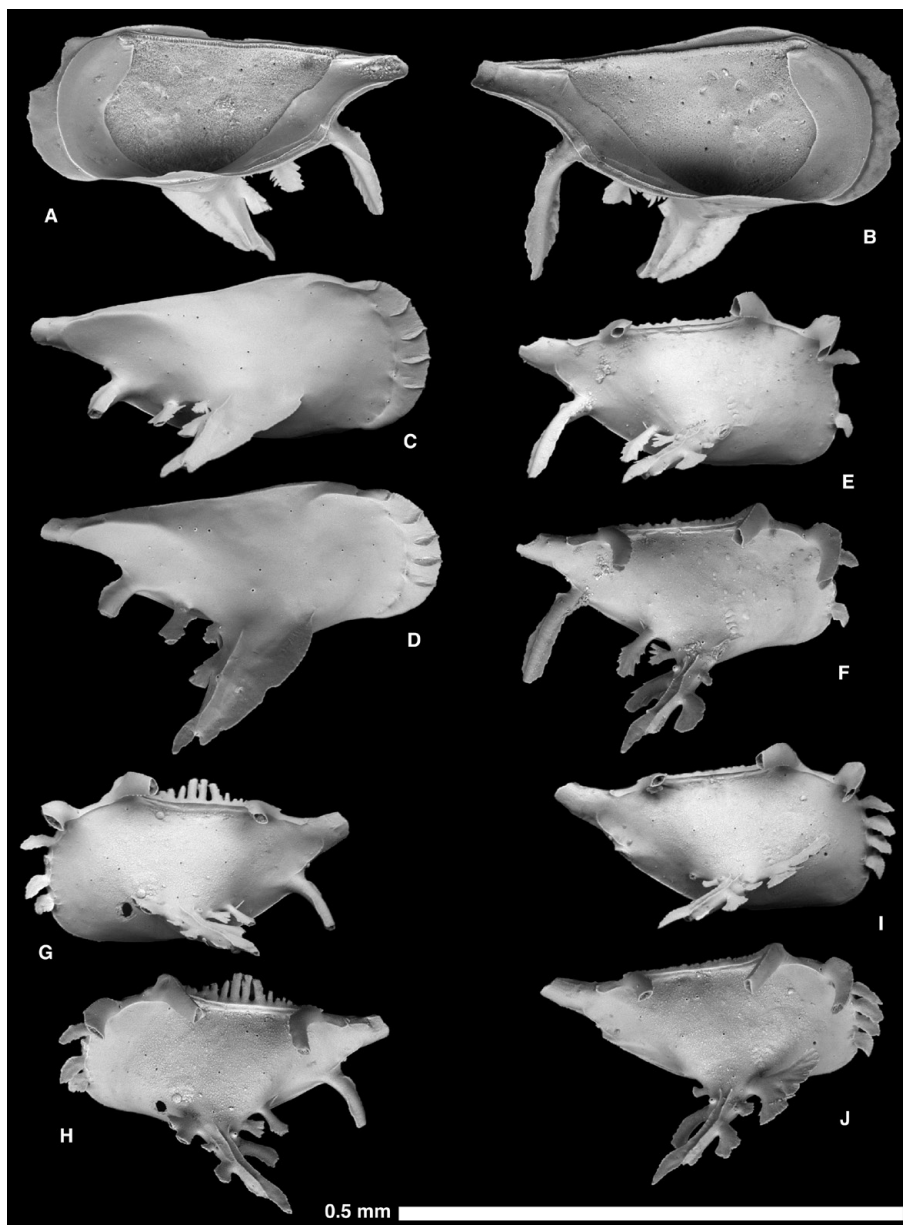


Fig. 12. SEM images of *Pedicythere* species. **A–D**, *Pedicythere atroposopetasi* Yasuhara, Okahashi & Cronin, 2009: **A**, USNM 603723 (ODP982138); adult RV from 1/1/70–72; **B**, USNM 603724 (ODP982139); adult LV from 1/3/92–94; **C–D**, USNM 603725 (ODP982146); adult RV from 1/1/142–144. **E–J**, *Pedicythere lachesisopetasi* Yasuhara, Okahashi & Cronin, 2009: **E–F**, USNM 603726 (ODP982140); adult RV from 1/1/97–99; **G–H**, USNM 603727 (ODP982141); adult LV from 1/3/122–124; **I–J**, USNM 603728 (ODP982142); adult RV from 1/3/122–124. **C, E, G, I**, lateral views; **A–B**, internal views; **D, F, H, J**, oblique views. All specimens from late Quaternary section of ODP Hole 982A, Rockall Plateau, eastern North Atlantic. Scale bar represents 0.5 mm.

2009 *Eucythere triangula* Whatley & Coles; Alvarez Zarikian: 4, pl. P6, fig. 4.

2009b *Eucythere triangula* Whatley & Coles; Yasuhara *et al.*: 920, pl. 17, figs 2–7.

Remarks. This species is known both from the eastern and western North Atlantic.

Family **Krithidae** Mandelstam, 1958 (in Bubikyan, 1958)

Genus *Krithe* Brady, Crosskey & Robertson, 1874

Type species. *Ilyobates praetexta* Sars, 1866

Remarks. *Krithe* is one of the most abundant genera in this core, representing on average 20% of the total fauna. We followed the taxonomy of Coles *et al.* (1994). *Krithe* in this core is mainly composed of *K. dolichodeira* van den Bold, 1946, *K. ayressi* Coles *et al.*, 1994 and *K. minima* Coles *et al.*, 1994.

Family **Leptocytheridae** Hanai, 1957

Genus *Cluthia* Neale, 1973

Type species. *Cythere cluthae* Brady, Crosskey & Robertson, 1874

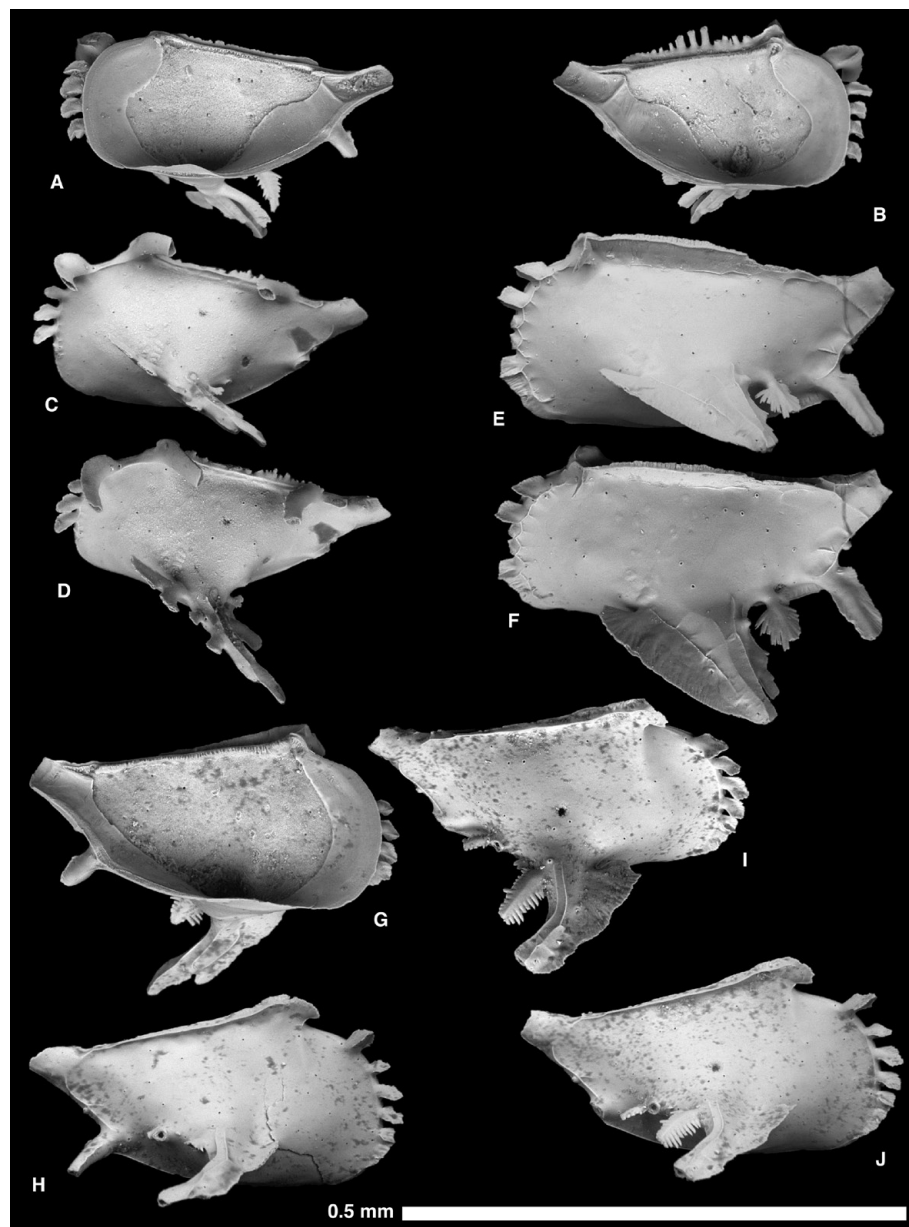


Fig. 13. SEM images of *Pedicythere* species. **A–D**, *Pedicythere lachesisopetasi* Yasuhara, Okahashi & Cronin, 2009: **A**, USNM 603729 (ODP982144); adult RV from 1/3/122–124; **B**, USNM 603730 (ODP982145); adult LV from 1/1/60–62; **C–D**, USNM 603731 (ODP982143); adult LV from 1/3/122–124. **E–F**, *Pedicythere kennettopetasi* Yasuhara, Okahashi & Cronin, 2009, USNM 603732 (ODP982147); adult LV from 1/3/72–74. **G–J**, *Pedicythere klothopetasi* Yasuhara, Okahashi & Cronin, 2009: **G**, USNM 603733 (ODP982148); adult LV from 1/1/80–82; **H**, USNM 603734 (ODP982149pedi); adult RV from 1/1/80–82; **I–J**, USNM 603735 (ODP982150); adult RV from 1/1/80–82. **C**, **E**, **H**, **J**, lateral views; **A–B**, **G**, internal views; **D**, **F**, **I**, oblique views. All specimens from late Quaternary section of ODP Hole 982A, Rockall Plateau, eastern North Atlantic. Scale bar represents 0.5 mm.

Cluthia sp.
(Fig. 14G–J)

1998 *Nannocythere* sp. Whatley, Eynon & Moguelevsky: 23, pl. 3, figs 9–10.

?2000 *Nannocythere* sp. Didié & Bauch: 111, pl. 4, fig. 25.

Remarks. This species is formally described as new in Yasuhara *et al.* (in press *b*).

Family **Loxoconchidae** Sars, 1926

Genus *Loxoconchidea* Bonaduce, Ciampo & Masoli, 1976

Type species. *Loxoconchidea minima* Bonaduce, Ciampo & Masoli, 1976

Loxoconchidea minima Bonaduce, Ciampo & Masoli, 1976
(Fig. 15A)

1976 *Loxoconchidea minima* Bonaduce, Ciampo & Masoli: 112, pl. 59, figs 1–7, text-fig. 43.

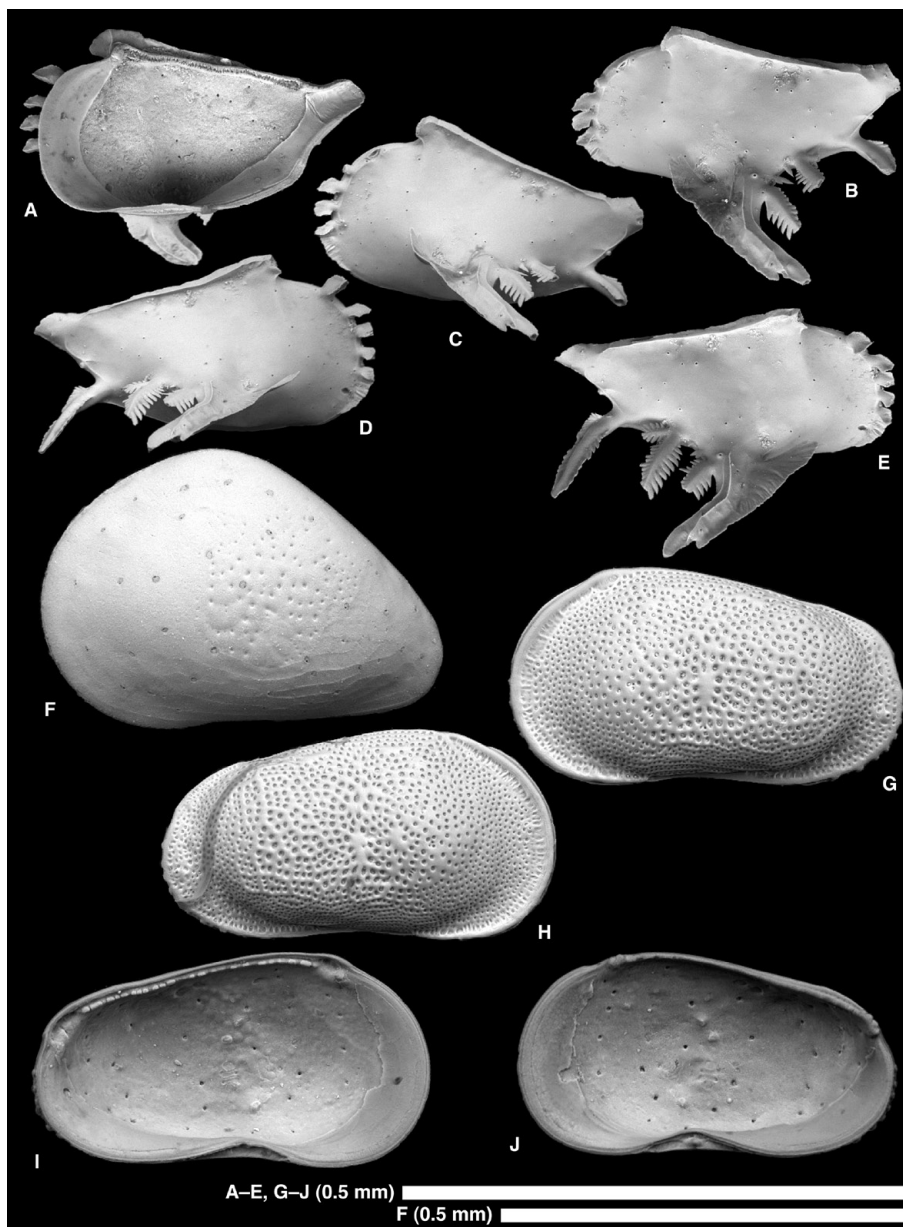


Fig. 14. SEM images of *Pedicythere*, *Eucythere* and *Cluthia* species. **A–E**, *Pedicythere klothopetasi* Yasuhara, Okahashi & Cronin, 2009: **A**, USNM 603736 (ODP982151); adult RV from 1/1/80–82; **B–C**, USNM 603737 (ODP982152); adult LV from 1/1/70–72; **D–E**, USNM 603738 (ODP982153); adult RV from 1/1/70–72. **F**, *Eucythere triangula* Whatley & Coles, 1987, USNM 603739 (ODP982099); adult LV from 1/2/117–119. **G–J**, *Cluthia* sp.: **G**, USNM 603740 (ODP982127-2); adult LV from 1/3/12–14; **H**, USNM 603741 (ODP982128); adult RV from 1/3/92–94; **I**, USNM 603742 (ODP982129-1); adult LV from 1/3/92–94; **J**, USNM 603743 (ODP982130); adult RV from 1/3/92–94. C–D, F–H, lateral views; A, I–J, internal views; B, E, oblique views. All specimens from late Quaternary section of ODP Hole 982A, Rockall Plateau, eastern North Atlantic. Scale bars represent 0.5 mm.

2000 *Loxoconchidea minima* Bonaduce, Ciampo & Masoli; Aiello *et al.*: 97, pl. 3, fig. 10.

2004 *Loxoconchidea minima* Bonaduce, Ciampo & Masoli; Aiello & Szczechura: 35, pl. 7, figs 1–3.

2006 *Loxoconchidea minima* Bonaduce, Ciampo & Masoli; Bergue *et al.*: 206, fig. 6E.

2008 *Loxoconchidea minima* Bonaduce, Ciampo & Masoli; Bergue & Coimbra: 115, pl. 1, fig. 16.

2009b *Loxoconchidea minima* Bonaduce, Ciampo & Masoli; Yasuhara *et al.*: 920, pl. 17, figs 8–11.

Remarks. A comprehensive synonymy list can be found in Aiello & Szczechura (2004) and Yasuhara *et al.* (2009b). This species is known from the Atlantic and Mediterranean regions.

Family **Paradoxostomatidae** Brady & Norman, 1889

Genus *Paracytheroïs* Müller, 1894

Type species. *Paracytheroïs striata* Müller, 1894 [designated by Howe, 1955 (he considered this species a junior synonym of *Paradoxostoma flexuosum* Brady (1868) (*sic*: correctly, *Bythocythere? flexuosa* Brady, (1867)); see Ellis & Messina Catalogue].

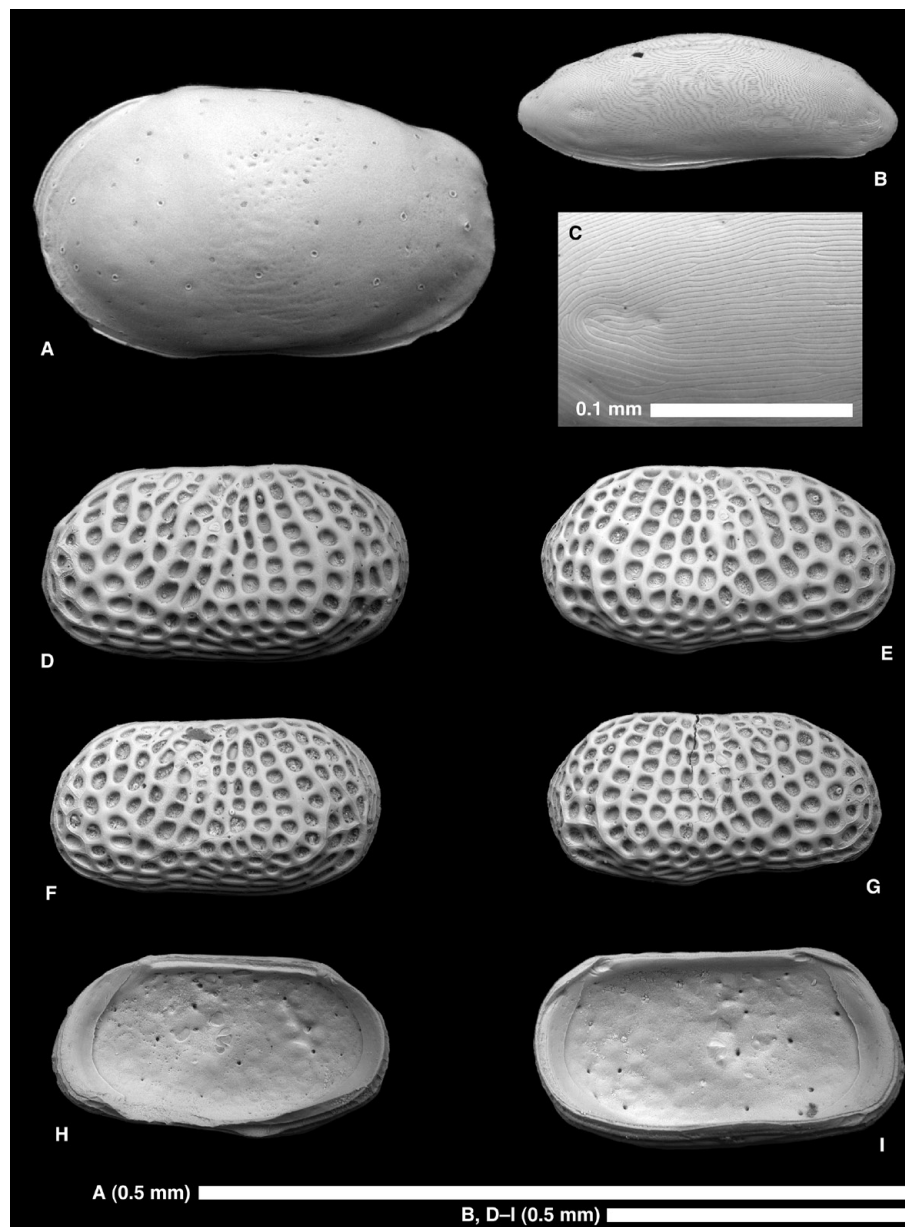


Fig. 15. SEM images of *Loxoconchidea*, *Paracytherois*, and *Arcacythere* species. **A**, *Loxoconchidea minima* Bonaduce, Ciampo & Masoli, 1976, USNM 603744 (ODP982123); adult LV from 1/3/12–14. **B–C**, *Paracytherois bondi* Yasuhara, Okahashi & Cronin, 2009: USNM 603745 (ODP982135); adult RV from 1/1/80–82. **D–I**, *Arcacythere enigmatica* (Whatley, Frame & Whittaker, 1978): **D**, USNM 603746 (ODP982169rock); adult LV from 1/2/77–79; **E**, USNM 603747 (ODP982170rock); adult RV from 1/2/77–79; **F**, USNM 603748 (ODP982171rock); adult LV from 1/2/77–79; **G**, USNM 603749 (ODP982172rock); adult RV from 1/2/77–79; **H**, USNM 603750 (ODP982173rock); adult RV from 1/2/67–69; **I**, USNM 603751 (ODP982174rock); adult LV from 1/3/92–94. **A–G**, lateral views; **H–I**, internal views. All specimens from late Quaternary section of ODP Hole 982A, Rockall Plateau, eastern North Atlantic. Scale bars represent 0.5 mm for **A–B**, **D–I** and 0.1 mm for **C**.

Paracytherois bondi Yasuhara, Okahashi & Cronin, 2009
(Fig. 15B–C)

2009b *Paracytherois bondi* Yasuhara, Okahashi & Cronin: 924,
pl. 19, figs 5–10, 15 (?12).

Remarks. This species was known only from the western North Atlantic, but this record confirms its presence in the eastern North Atlantic.

Family **Rockalliidae** Whatley, Uffenorde, Harlow, Downing & Kesler, 1982

Genus *Arcacythere* Hornibrook, 1952

Type species. *Arcacythere chapmani* Hornibrook, 1952

Remarks. We agree with Ayress (1991) in considering *Rockallia* Whatley, Frame & Whittaker, 1978 as a junior synonym of *Arcacythere* Hornibrook, 1952. See Yasuhara & Okahashi (in press) for detailed discussion.

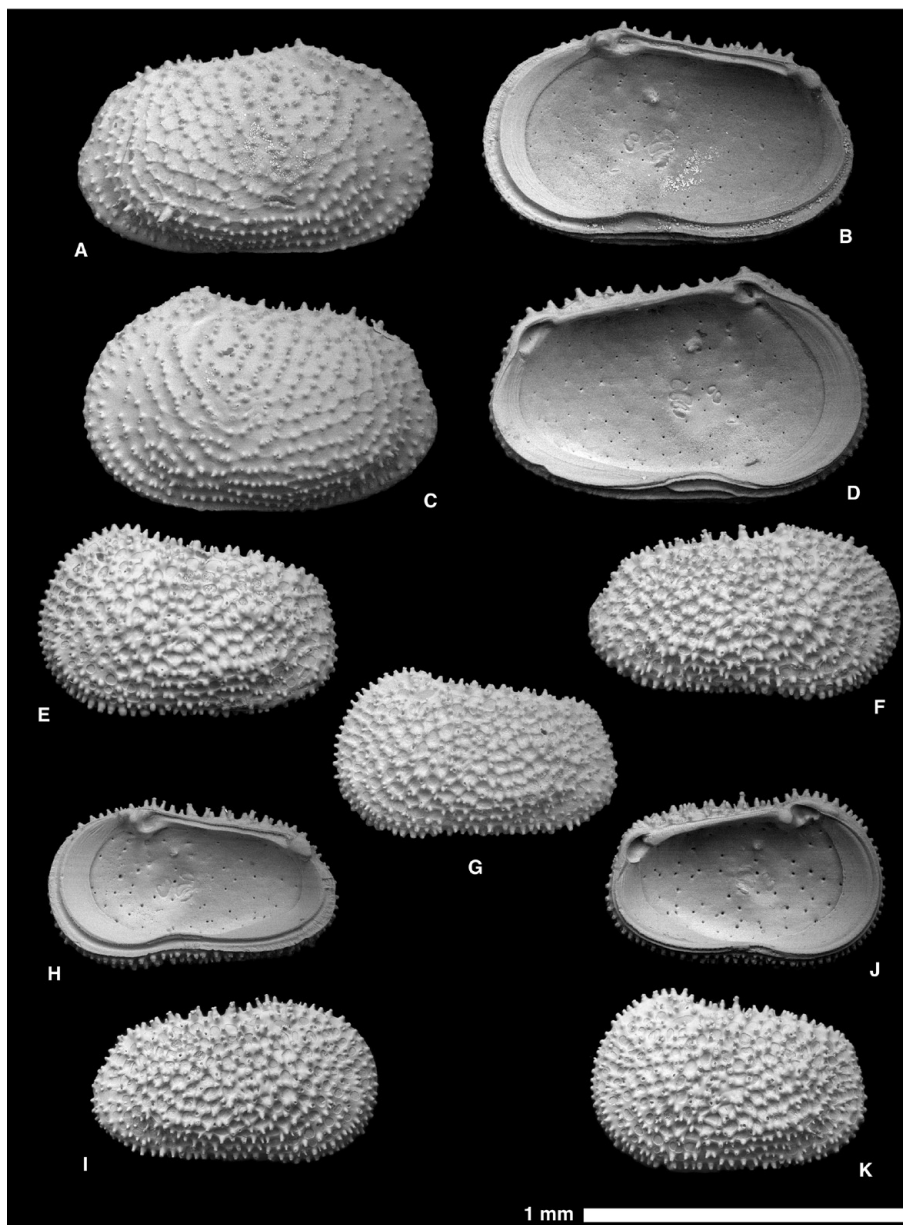


Fig. 16. SEM images of *Echinocythereis* and *Henryhowella* species. **A–D**, *Echinocythereis echinata* (Sars, 1866): **A**, USNM 603752 (ODP982027); adult RV from 1/1/142–144; **B**, USNM 603753 (ODP982028); adult RV from 1/1/142–144; **C**, USNM 603754 (ODP982029); adult LV from 1/3/72–74; **D**, USNM 603755 (ODP982030); adult LV from 1/3/72–74. **E–K**, *Henryhowella asperrima* (Reuss, 1850): **E**, USNM 603756 (ODP982022); adult LV from 1/1/137–139; **F**, USNM 603757 (ODP982023); adult RV from 1/1/137–139; **G**, USNM 603758 (ODP982026); adult LV from 1/1/0–2; **H–I**, USNM 603759 (ODP982024); adult RV from 1/1/142–144; **J–K**, USNM 603760 (ODP982025); adult LV from 1/1/107–109. **A, C, E–G, I, K**, lateral views; **B, D, H, J**, internal views. All specimens from late Quaternary section of ODP Hole 982A, Rockall Plateau, eastern North Atlantic. Scale bar represents 1 mm.

- Arcacythere enigmatica* (Whatley, Frame & Whittaker, 1978)
(Fig. 15D–I)
- 1978 *Rockallia enigmatica* Whatley, Frame & Whittaker: 137, pls 5–138, 5–140, 5–142, 5–144; text-fig. 1.
- 1979 Indet. Gen. 3 Ducasse & Peypouquet: pl. 5, fig. 9.
- 1982 *Rockallia enigmatica* Whatley, Frame & Whittaker; Whatley *et al.*: 3, pl. 1, figs 1, 4.
- 1987 *Rockallia enigmatica* Whatley, Frame & Whittaker; Whatley & Coles: 80, pl. 2, figs 3–4.
- 1987 *Rockallia* sp. Whatley & Coles: 89, pl. 2, fig. 5.
- 1988 *Rockallia enigmatica* Whatley, Frame & Whittaker; Ruan & Hao: 377, pl. 70, figs 2–4.
- 1988 *Rockallia inceptiocelata* Whatley, Uffenorde, Harlow, Downing & Kesler; Ruan & Hao: 377, pl. 70, figs 5–7.
- 1990 *Rockallia enigmatica* Whatley, Frame & Whittaker; Malz: 143, fig. 4.2.
- 2000 *Rockallia enigmatica* Whatley, Frame & Whittaker; Didić & Bauch: 116, pl. 3, figs 13–14.

- 2003 *Rockallia enigmatica* Whatley, Frame & Whittaker; Cronin & Dwyer: 263, pl. 2, fig. n.
 2005 *Rockallia enigmatica* Whatley, Frame & Whittaker; Mazzini: 86, figs 50P, 51B.
 2007 *Rockallia enigmatica* Whatley, Frame & Whittaker; Hou & Gou: 509, pl. 198, figs 1–4.
 2007 *Rockallia inceptiocelata* Whatley, Uffenorde, Harlow, Downing & Kesler; Hou & Gou: 509, pl. 198, figs 5, 8 (?6–7).
 2009 *Rockallia enigmatica* Whatley, Frame & Whittaker; Alvarez Zarikian: 5, pl. P9, fig. 5.

Remarks. This species is known from the eastern North Atlantic and northwestern Pacific oceans.

Family **Trachyleberididae** Sylvester-Bradley, 1948

Remarks. *Ambocythere*, *Buntonia* and *Pennyella* occur in this core, but we will discuss these genera elsewhere.

Genus *Echinocythereis* Puri, 1954

Type species. *Cythere margaritifera* Brady, 1870 [= *Cythereis garretti* Howe & McGuirt, 1935 (in Howe & graduate students, 1935); see Hazel (1967)].

Echinocythereis echinata (Sars, 1866)
 (Fig. 16A–D)

- 1866 *Cythereis echinata* Sars: 44.
 1880 *Cythere irpex* Brady: 107, pl. 17, fig. 2a–d.
 ?1967 *Echinocythereis echinata* (Sars); Hazel: 37, pl. 6, figs 10–11.
 1976 *Cythere irpex* Brady; Puri & Hulings: 278, pl. 11, figs 1–9.
 1990 *Echinocythereis whatleyi* Dingle, Lord & Boomer: 303, figs 35B–F, 36E–G, I–J.
 2000 *Echinocythereis echinata* (Sars); Barra & Bonaduce: 214, pl. 1, figs 1–10; text-fig. 1.
 2004 *Echinocythereis echinata* (Sars); Ayress *et al.*: 35, pl. 3, fig. 9.
 2009 *Echinocythereis echinata* (Sars); Alvarez Zarikian: 6, pl. P9, figs 3–4.
 2009b *Echinocythereis echinata* (Sars); Yasuhara *et al.*: 926, pl. 21, figs 6–9.

Remarks. A comprehensive synonymy and detailed discussion are found in Yasuhara *et al.* (2009b) and references therein. This species is known from the Atlantic and Southern Oceans.

Genus *Henryhowella* Puri, 1957

Type species. *Cythere evax* Ulrich & Bassler, 1904
Henryhowella asperrima (Reuss, 1850)
 (Fig. 16E–K)

- 1850 *Cypridina asperrima* Reuss: 74, pl. 10, fig. 5a–b.
 2005 *Henryhowella asperrima* (Reuss); Mazzini: 50, figs 26A–I, 27B.
 2009 *Henryhowella dasyderma* (Brady); Alvarez Zarikian: 6, pl. 9, figs 6–8.
 2009b *Henryhowella* cf. *asperrima* (Reuss); Yasuhara *et al.*: 926, pl. 20, fig. 7; pl. 21, figs 1–4.
 2010 *Henryhowella asperrima* (Reuss); Bergue & Govindan: 751, fig. 3.14.
 2011 *Henryhowella asperrima* (Reuss); Pirkenseer & Berger: 54, pl. 7, figs 6a–6c, 7a–7c; pl. 8, figs 1a–1c, 2a–2c, 3a–3c.

Remarks. To be discussed in detail elsewhere.

DISCUSSION

ODP 982A late Quaternary ostracod assemblages show a strong affinity to the western North Atlantic and Mediterranean bathyal faunas and, to a lesser extent, to the western North Pacific bathyal fauna. There are many common or closely related species among these regions, as shown in the Systematic Palaeontology section above. The strong affinity among the western North Atlantic, the eastern North Atlantic and the Mediterranean faunas is understandable, given their proximity and bathyal-depth connections (e.g. Strait of Gibraltar and Greenland–Iceland–Faeroe Ridge). However, an affinity between the North Atlantic and the North Pacific is more difficult to explain. Two possibilities are proposed: (1) many bathyal ostracod species are cosmopolitan; or (2) they were able to migrate through the Bering Strait despite its present-day shallow depth (<50 m). We will need further modern and palaeo-biogeographical studies to evaluate these hypotheses.

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