Supplementary material to

„Late glacial and Holocene Ostracoda from the Melilla cold-water coral mound field“

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Systematic palaeontology

Class Ostracoda LATREILLE, 1802
Order Platycopida MUELLER, 1894
Family Cytherellidae SARS, 1866
Genus *Cytherella* JONES, 1849
Type species *Cytherina ovata* ROEMER, 1841

Cytherella robusta COLALONGO and PASINI, 1980
Figure 6a-c, 9 suppl.

* 1980 *Cytherella robusta,* Colalongo and Pasini, p. 78, pl. 6, fig. 4-10.
1984 *Cytherella robusta* Colalongo and Pasini; Peypouquet and Nachite, tab. 2, pl. 2, fig. 10.
1989 *Cytherella robusta,* Colalongo and Pasini 1980; Mostafawi, 124, pl. 1, fig. 4.
1996 *Cytherella robusta,* Colalongo and Pasini, 1980; Aiello et al., 184, pl. 2, fig. 4, 5, 8-12.
1998 *Cytherella robusta*; El Hmaidi et al., 623-626.
2005a *Cytherella robusta*; Hastrup and Thomsen, 169, 177, 179, fig. 9, appendix 1(1).
2005b *Cytherella robusta,* Colalongo and Pasini; Hastrup and Thomsen, 195, pl. 2, fig. 1-4.
? 2008 *Cytherella robusta,* Colalongo and Pasini, 1980; Faranda and Gliozzi, 221, pl. 1, fig. 4-5.
2008 *Cytherella robusta*; Maiorano et al., 322.
2010 *Cytherella robusta*; El Hmaidi et al., 22, tab. 1.
2010 *Cytherella robusta* Colalongo and Pasini, 1980; Nachite and Bekkali, 61, tab. 1, pl. 1, fig. 1.
2013 *Cytherella robusta* Colalongo and Pasini, 1980; Cabral and Loureiro, 137, pl. 1, fig. 3.

Material

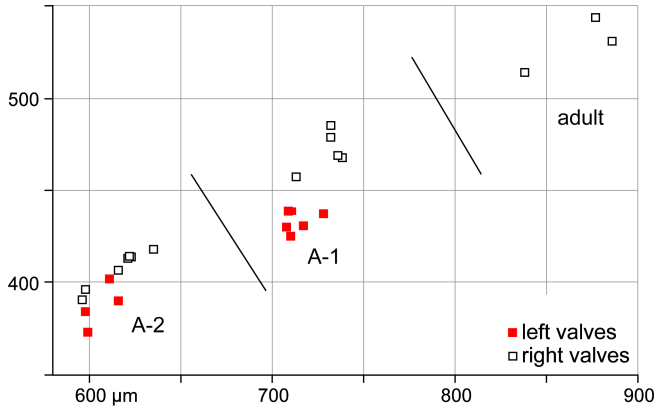
MHNF 32941, 32956, 32959, 32967, 32971-75, 32978

Table 1 (measures in µm)

Stage		length	Ø	height	Ø	l/h	Ø	No
adult	R	838-886	867	514-544	530	1.61-1.67	1.64	3
A-1	L	708-728	714	425-439	434	1.62-1.67	1.65	6
A-1	R	713-738	730	457-485	472	1.51-1.58	1.55	5
A-2	L	598-616	606	373-402	387	1.52-1.61	1.57	4
A-2	R	596-635	616	375-418	408	1.50-1.52	1.51	7

Remarks

Aiello et al. (1996) in their overview of Tortonian to Recent *Cytherella* deal with the past confusion of the relatively similar species *C. serratula*, *C. vulgata* and *C. robusta*. The differences between the latter two species are rather subtle (absence of anterior ornamentation in *C. vulgata*). According to them *C. robusta* is a primarily Plio-Pleistocene Mediterranean species, which has nonetheless occurrences in the Recent. Nachite and Bekkali (2010) extend the range to the late Tortonian. It



occurs also in the adjacent western Atlantic (Peypouquet and Nachite, 1984, Cabral and Loureiro, 2013). Values from our material are larger (838-886 µm vs. 730-770 µm) than those mentioned in Aiello et al. (1996). Plio-Pleistocene material from Rhodos Island (Hastrup and Thomsen 2005a,b) however, conforms in size (adult 885 µm, A-1 710 µm) to our specimens. The small specimens in Farranda and Gliozzi (2008) probably represent juveniles.

Fig. 9 suppl. Length/height diagram for *Cytherella robusta*.

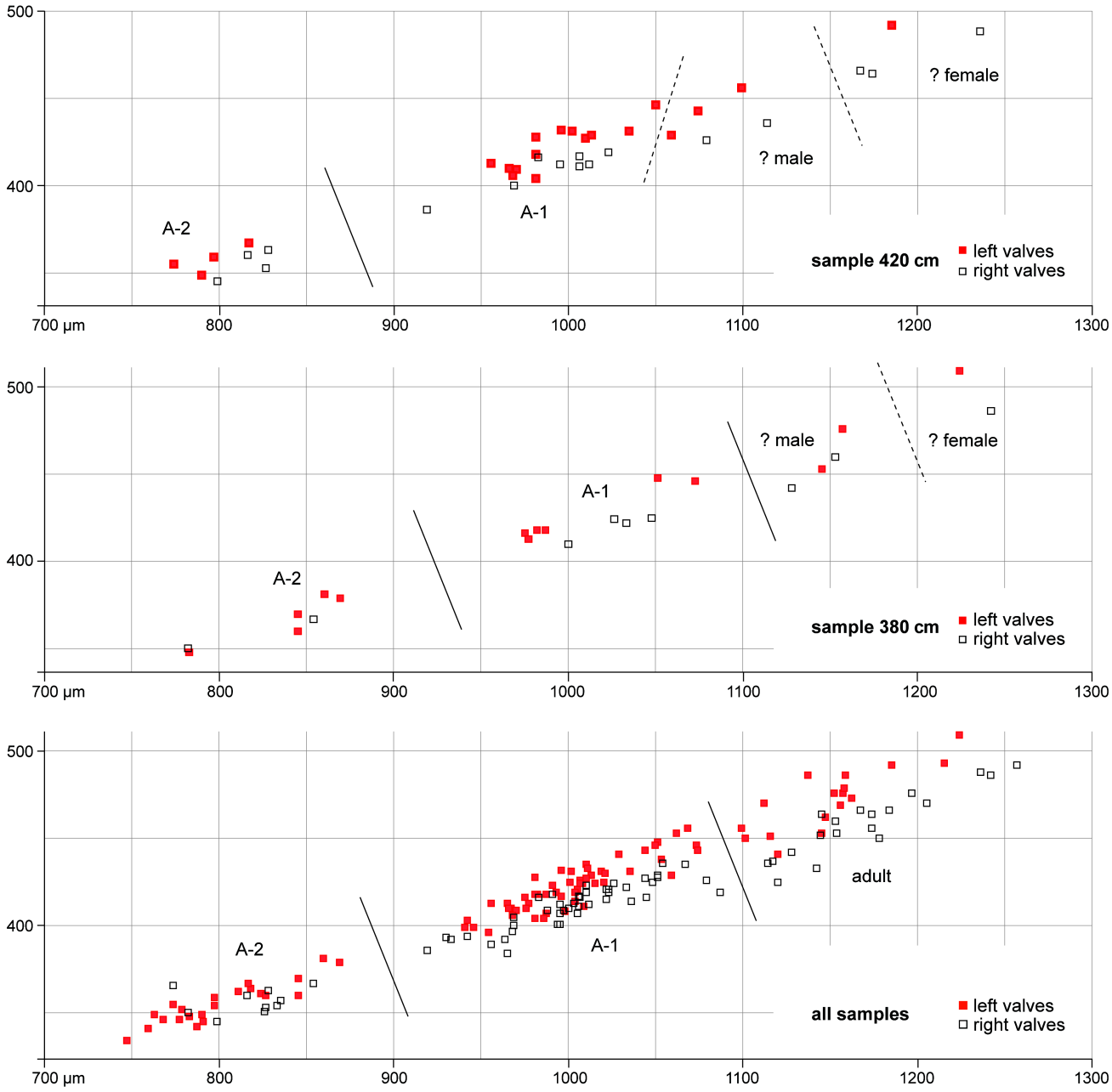


Figure 10 suppl. Length/height diagrams for *Paracypris polita*.

Order Podocopida SARS, 1866
Family Candonidae KAUFMANN, 1900
Genus *Paracypris* SARS, 1866
Type species *Paracypris polita* SARS, 1866

Paracypris polita SARS, 1866
Figure 3a-h, 10 suppl., 11a suppl.

* 1866 *Paracypris polita* Sars, p. 12.
1868 *Paracypris polita*, G.O. Sars; Brady, 378, pl. 27, figs. 1-4, pl. 38, fig. 2.
1923 *Paracypris polita* G.O. Sars; Sars, 70, pl. 31.
1988 *Paracypris polit*a Sars, 1866; Maddocks, 56, tab. 2.
2005b *Paracypris polita* Sars; Hastrup and Thomsen, p. 199, pl. 6, figs. 1-4.
2013 *Paracypris polita* Sars, 1866; Cabral and Loureiro, 151, pl. 9, fig. 21.

Material

MHNF 32931-32, 32934, 32945, 32947, 32956, 32961, 32964-65, 32967-32980

Table 2 (measures in µm)

Stage		length	Ø	height	Ø	l/h	Ø	No
adult	L	1099-1224	1150	441-509	472	2.34-2.54	2.44	17
adult	R	1114-1257	1170	425-492	459	2.47-2.64	2.55	19
A-1	L	941-1074	1003	396-456	423	2.29-2.47	2.37	54
A-1	R	919-1087	1007	384-436	412	2.36-2.59	2.44	45
A-2	L	747-869	801	334-381	356	2.18-2.35	2.25	22
A-2	R	774-854	817	345-367	357	2.11-2.35	2.29	10

Remarks

Separating *Paracypris* species based solely on external valve morphology remains difficult. This is further illustrated in the review of the genus in Maddocks (1988), stating that the drawings of *Paracypris polita* in Sars (1923) lack details, and hence morphological differences between species may be more pronounced than is actually the case. The closely related *Paracypris bensoni* from the western Atlantic has been separated from the eastern Atlantic *Paracypris polita* based on numerous differences in soft part anatomy (Maddocks, 1988). The only differing external parameters are the somewhat more angular dorsal margin and lower length/height-ratio (left valve 1.8 vs. 2.3) in *Paracypris polita*. Our material adheres rather to the external morphology of *Paracypris bensoni* than to *P. polita.* However since in the past Mediterranean species have always been attributed to *Paracypris polita*, we refrain from a specific reassignment until future analysis of soft parts of the Mediterranean population.

Our material illustrates the transition from simple straight radial pore channels in the last larval stage to irregularly branching radial and false radial pore channels in adults. However, in rare occasions adult valves also show simple radial pore channels. This feature and the possible overlap of sizes of the supposed last larval stage and smallest adults complicate the respective attribution to either development stage. This overlap is possibly due to an initial development of the size differences between larger females and smaller males (as reported for *Paracypris bensoni*; Maddocks, 1988) already in the last larval stage.

Right valves are on average slightly lower than left valves of the same length. The development of complex radial pore channels in our material starts above 1050 µm valve length, and without the aforementioned cases they are always present above 1100 µm.

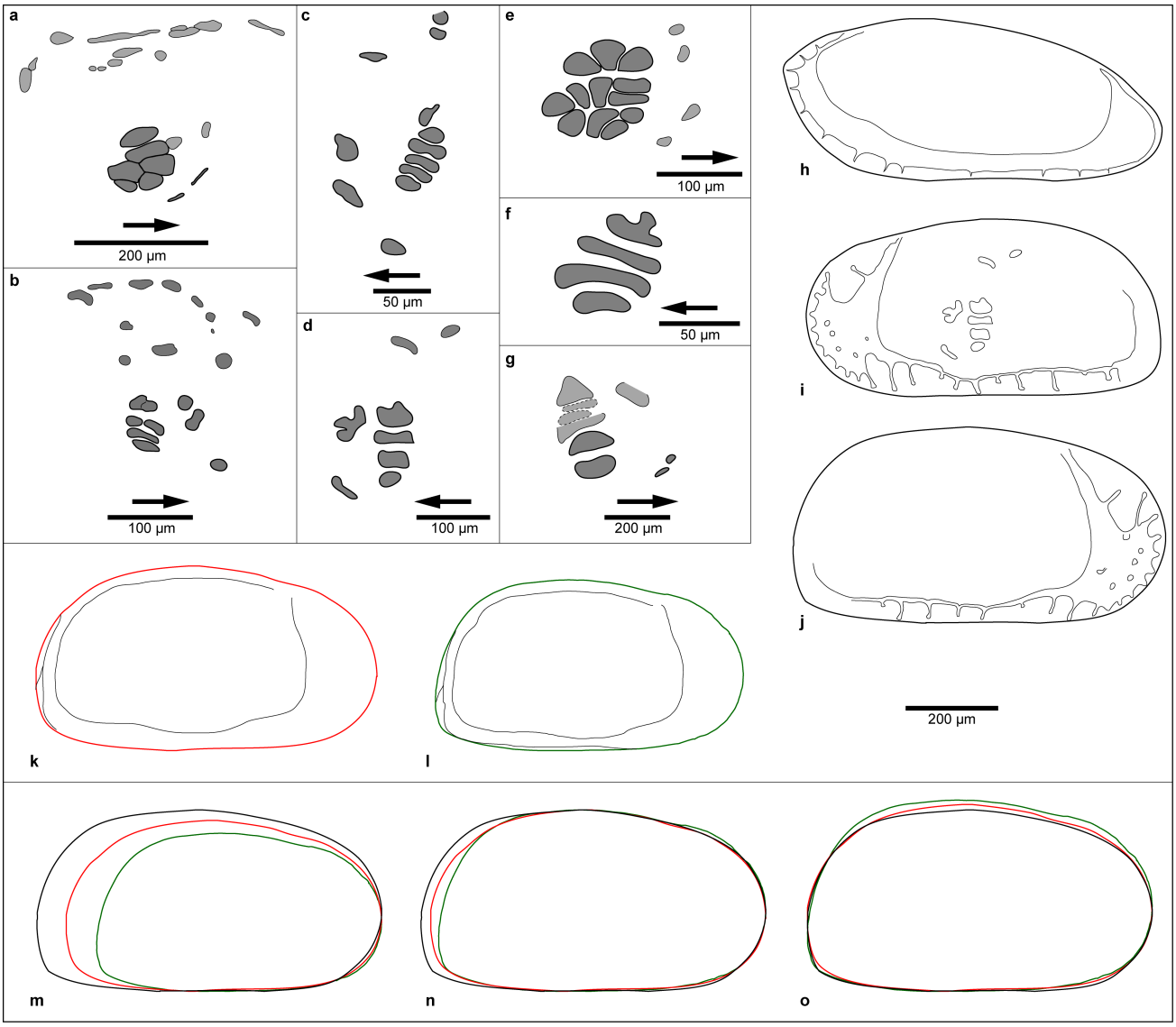


Figure 11 suppl. Muscle scars (internal view), marginal pore channels, vestibula and outlines of selected ostracod taxa. Arrows point in the direction of the anterior end. a) *Paracypris polita* / b) *Echinocythereis vidua* / c) *Bythocythere bradyi* / d) *Krithe praetexta* e) *Macromckenziea ligustica* / f) *Lanceostoma ensiforme* / g) *Cytheropteron* cf. *hadriaticum* / h) *Lanceostoma ensiforme* right valve / i-o) *Krithe praetexta* female left valves: Note the size difference between stressed (k = 540 cm, l = 100 cm) and unstressed (j = 300 cm) specimens. m) same scale / n) normalized to same height / o) normalized to same length. Stressed specimens are comparatively shorter /higher.

Family Trachyleberididae SYLVESTER-BRADLEY, 1948
Genus *Echinocythereis* PURI, 1953
Type species *Echinocythereis garetti* (HOWE and MCGUIRT, 1935)

Echinocythereis vidua BARRA and BONADUCE, 2000
Figure 5b-e, 11b suppl., 12 suppl.

* 2000 *Echinocythereis vidua,* Barra and Bonaduce, p. 218, pl. 2, fig. 6-11.
2007 *Echinocythereis vidua* Barra and Bonaduce, 2000; Faranda et al., p. 477, tab. 1.
2008 *Echinocythereis vidua,* Barra and Bonaduce; Faranda and Gliozzi, p. 221, pl. 6, fig. 13.
2015 *Echinocythereis vidua;* Stalder et al., p. 6, fig. 2.

Material
MHNF 32936, 32942-43, 32952, 32962, 32967-70, 32972-75

Table 3 (measures in µm)

Stage		length	Ø	height	Ø	l/h	Ø	No
adult	L	806-855	836	447-509	481	1.68-1.81	1.74	8
adult	R	850-872	861	453-455	454	1.88.1.92	1.90	2
A-1	L	638-712	691	378-416	402	1.65-1.77	1.72	14
A-1	R	698-737	715	382-415	402	1.74-1.86	1.78	7

Remarks

Material later assigned to *E. vidua* has initially been attributed to *E. laticarina* (e.g. Bonaduce et al. 1975). Barra and Bonaduce (2000) provide an outline of the main differences between both species and a discussion of synonymy. The main difference is a posteroventral carina that is absent in *E. vidua*. Costae are thicker in *E. laticarina* than in *E. vidua*, but this could be due to abrasive effects (our material is well preserved with a thin appearance of the costae). Guernet (2005) has hinted at a synonymy of *E. vidua* with *E. laticarina* (Brady, 1868), but does not provide further details supporting this claim. *Echinocythereis laticarina* has been widely reported in the Mediterranean and the eastern Atlantic (type area). The original description and figures in Brady (1868) are difficult to interpret.

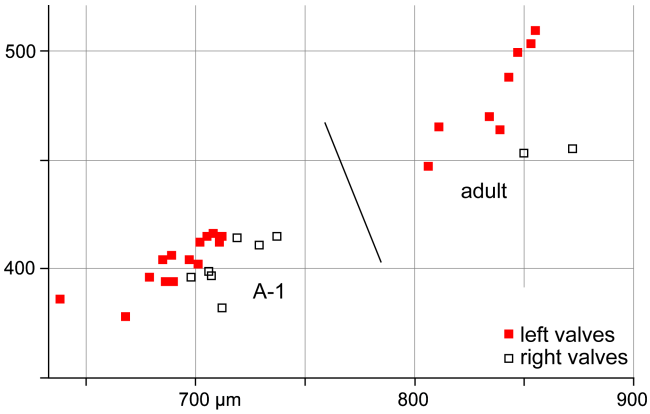


Figure 12 suppl. Length/height diagram for *Echinocythereis vidua*.

Family Paradoxostomatidae BRADY and NORMAN,1889
Genus *Lanceostoma* SCHORNIKOV and KEYSER, 2004
Type species *Lanceostoma tenerifense* SCHORNIKOV and KEYSER, 2004

Lanceostoma ensiforme (BRADY, 1868)
Figure 4e-f, 11f, h suppl.

* 1868 [partim] *Paradoxostoma ensiforme* n. sp.; Brady, p. 460, pl. 35, fig. 8-11.
? 1894 *Paradoxostoma triste* n. sp.; Müller, 317, pl. 23, fig. 1, 26, 29.
1985 *Paradoxostoma ensiforme* Brady, 1868; Horne and Whittaker, p. 149, fig. 9A-G, 10A-I, 38E-F.
2008 *Paradoxostoma ensiforme* Brady, 1868; Farranda and Gliozzi, p. 254, pl. 11, fig. 12.
2013 *Paradoxostoma ensiforme* Brady, 1868; Cabral and Loureiro, p. 147, pl. 7, fig. 15.
2015 *Paradoxostoma simile* Müller, 1894; Sciuto and Rosso: fig. 6.14.

Material

MHNF 32950, 32956, 32967, 32975

Table 4 (measures in µm)

Stage		length	Ø	height	Ø	l/h	Ø	No
adult	L	793-876	832	330-347	340	2.40-2.53	2.45	3
adult	R	836	-	355	-	2.36	-	1

Remarks

Following the definition of the genus *Lanceostoma* (lanceolate shell, narrowly rounded anterior and posterior margins, caudal process above mid-height) in Schornikov and Keyser (2004), the general external morphology of species resembling *Paradoxostoma ensiforme* necessitates

a reattribution to this new taxon. *Lanceostoma ensiforme* has been primarily recorded from the eastern Atlantic. *Lanceostoma angliorum* (Horne and Whittaker, 1985) differs in a somewhat broader fused zone, the form of the penis and is probably smaller. Based solely on shell material it is impossible to clearly delimit both species, since they share an identical external morphology, as has been indicated by the authors.

The illustration of the (smaller, 480-540 µm) type species of the genus *Lanceostoma* Schornikov and Keyser, 2004 (*L. tenerifense*) shows a discrepancy between the scanning electron microscope image and the drawings. The SEM image approaches *L. ensiforme* in external morphology, whereas the drawing deviates rather distinctly with more rounded posterior and anterior margins as well as the caudal process in a mid-height position.

Lanceostoma simplex Meireles, Keyser and Ávila, 2014 is somewhat smaller (670 µm) *than L. ensiforme*, and differs from *L. tenerifense* mainly by the form of the copulatory organ. The external valve morphology of the figured males is however very similar to *L. ensiforme*. *Lanceostoma triste* (Müller, 1894) from the Naples Bay resembles closely *L. ensiforme* in outline and size, and may represent a junior synonym of the latter.

Family Cytheruridae MÜLLER,1894
Genus *Cytheropteron* SARS, 1866
Type species *Cythere latissima* NORMAN, 1865

Cytheropteron cf. *hadriaticum* BONADUCE, CIAMPO and MASOLI, 1975
Figure 4a-b, 11g suppl.

Material

MHNF 32940, 32951

Table 5 (measures in µm)

Stage		length	height	l/h	No
adult	L	575	297	1.94	1
adult	R	580	322	1.80	1

Remarks

Our material compares in lateral fine ornamentation and outline well to the type material figured in Bonaduce et al. (1975) and Sciuto and Rosso (2015). It is however larger (580 µm vs. 460 µm) and shows a less pronounced, more rounded alar process in dorsal view. For a more thorough description supplementary material is needed.

Family Bythocytheridae SARS,1866
Genus *Bythocythere* SARS, 1866
Type species *Bythocythere turgida* SARS, 1866

Bythocythere bradyi SARS, 1926
Figure 5a-c, 11c suppl.

* 1926 *Bythocythere bradyi,* Sars, p. 236, pl. 108, fig. 2a-d.
1983 *Bythocythere bradyi,* Sars, 1926; Athersuch et al., p. 72, fig. 4u-w, 5a, pl. 2, fig. 9-11.
2002 *Bythocythere bradyi*; Horne et al., 20, fig. 12f-h.
? 2013 *Bythocythere bradyi,* Sars, 1926; Cabral and Loureiro, 138, pl. 1, fig. 7.

Material

MHNF 32946, 32975

Table 6 (measures in µm)

Stage		length	Ø	height	Ø	l/h	Ø	No
adult	R	618-649	634	340-350	345	1.82-1.85	1.84	2

Remarks

Sars (1926) indicates a length of 730 µm for a female specimen. Athersuch et al. (1983) give lengths ranging from 600 to 750 µm. For a brief discussion of the species see the latter reference. The type area lies in Norway, with additional records from British and Portuguese waters (Cabral and Loureiro, 2013), though the latter reference only seems to illustrate a juvenile specimen. Our material represents the first documented occurrence of the species in the Mediterranean, as all other records concern distinctly different taxa (e.g. Bonaduce et al., 1975, Sciuto, 2009, 2012).

Family Macrocyprididae MUeller, 1912
Genus *Macromckenziea* MADDOCKS, 1990
Type species *Macrocypris siliquosa* SARS, 1866

Macromckenziea ligustica (BONADUCE, MASOLI and PUGLIESE, 1977)
Figure 4c-d, 11e suppl.

* 1977 *Macrocypris ligustica,* Bonaduce, Masoli and Pugliese, p. 245, fig. 3, pl. 1, fig. 1-3.
? 1985 *Macrocypris ligustica*; Bonaduce and Sprovieri, fig. 1, pl. 2, fig. 7.
1990 *Macromckenziea ligustica* (Bonaduce, Masoli and Pugliese, 1977); Maddocks, p. 53, fig. 4.8, 5.7, 18.10, 24.21, 29.5, 32.1, 36-37.7, 46.26-28, 66.3, pl. 6.11-12, 7.11-12, 78.19-20.
2001 *Macromckenziea ligustica* (Bonaduce, Masoli and Pugliese); Dall'Antonia, Di Stefano and Foresi, p. 75, table 1.
Non 2008 *Macrocypris ligustica* Bonaduce, Masoli and Pugliese, 1977; Ertekin and Tunoğlu, p. 323, table 1-2, pl. 5, fig. 1-2.
2014 *Macromckenziea ligustica* (Bonaduce, Masoli and Pugliese, 1975); Sciuto, p. 125, tab. 1.
2015 *Macromckenziea ligustica* (Bonaduce et al. 1977); Aiello, Barra and Parisi, tab. 4-5, appendix 1.

Material

MHNF 32933, 32966, 32969-70, 32972, 32975

Table 7 (measure in µm)

Stage		length	Ø	height	Ø	l/h	Ø	No
adult	L	997-1187	1091	395-460	418	2.52-2.73	2.61	3
adult	R	1027-1035	1031	417-439	428	2.36-2.46	2.41	2

Remarks

Our material conforms in size and lateral shape to the material described in Bonaduce et al. (1977) and Maddocks (1990). The left valve figured in Bonaduce and Sprovieri (1985) represents a much stouter specimen (sexual dimorphism?). The much larger *M. siliquosa* differs in a less steep, more acute posterior end. The earliest record of *M. ligustica* dates from the Langhian of Sicily (Dall'Antonia, Di Stefano and Foresi, 2001). Pleistocene to Holocene material from offshore sediments in southern Turkey has been erroneously attributed to *M. ligustica* (Ertekin and Tunoğlu, 2008). The proposed synonymy of *M. ligustica* with the older *Macrocypris compressa* Seguenza, 1883 *sensu* Ruggieri (1984) has been refuted in Maddocks (1990).

Family Krithidae MANDELSTAM, 1958
Genus *Krithe* Brady, CROSSKEY and ROBERTSON, 1874
Type species *Cythere* (*Cytherideis*) *bartonensis* JONES, 1857

Krithe praetexta (SARS, 1866)
Figure 6d-i, 7a-g, 11d, i-o suppl., 13 suppl.

* 1865 *Ilyobates praetexta,* Sars, p. 60.
1989 *Krithe praetexta* (Sars, 1865) *praetexta* (Sars, 1865) McKenzie et al., 345, pl. 1, fig. 13, 15-16.
1989 *Krithe praetexta* (Sars 1866); Mostafawi, 139, pl. 6, fig. 117.
1993 *Krithe praetexta* (Sars, 1866); Penney, 244, 246-248, fig. 4i, append. 1.
1996 *Krithe praetexta*; Montenegro, Pugliese and Bonaduce, 96, 98, tab. 1.
2008 *Krithe praetexta*; Maiorano et al., 322, 327-28, fig. 10.
2014 *Krithe praetexta* (Sars, 1866); Sciuto, 123, tab. 1.
2015 *Krithe praetexta* (Sars 1866); Frezza and Di Bella, append. 1-2.
2015 *Krithe praetexta* (Sars, 1866); Sciuto et al., 137, tab. 2.

Material
MHNF 32937-39, 32944, 32948-49, 32953-58, 32960, 32963, 32967-70, 32972-76, 32980

Table 8 (measures in µm, "s" means environmentally stressed)

Stage		length	length Ø	height	height Ø	l/h Ø	No
Female	L	730-804	755	392-419	401	1.88	10
Female	R	750-775	761	373-385	379	2.01	8
Female (s)	L	693-706	700	376	-	1.86	2
Female (s)	R	688-712	701	343-350	347	2.02	3
Male	L	746-782	760	352-379	363	2.09	7
Male	R	764-768	766	336-348	342	2.24	2
Male (s)	L	707-711	709	327-332	330	2.14	3
A-1	L	603-635	619	330-353	346	1.79	13
A-1	R	596-612	606	333-340	337	1.80	5

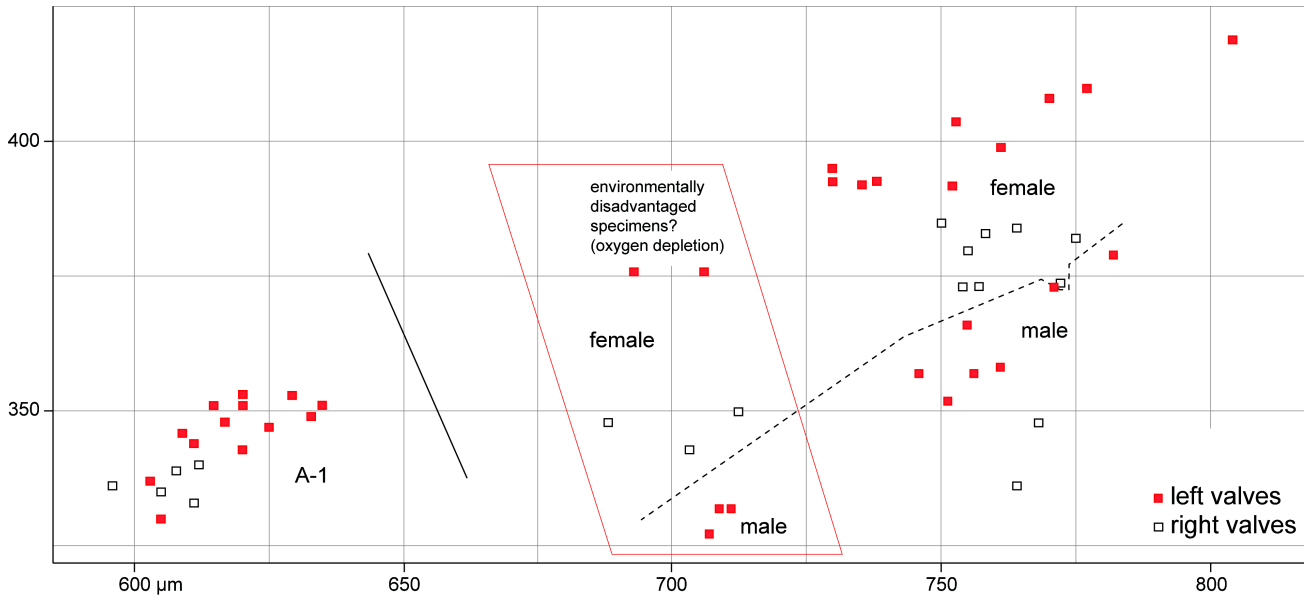


Figure 13 suppl. Length/height diagram for *Krithe praetexta*.

Remarks

The genus *Krithe* is in need of a revision of some of its species, especially considering the number of all the open (up to more than 20) or lumped-together species in the literature (e.g. Whatley and Coles 1987, Whatley and Coles 1991, Coles et al. 1994, Majoran and Dingle 2001). Neverthless, our material fits reasonably well within the general species concept of *Krithe praetexta* (*praetexta*) (e.g. McKenzie et al. 1989), an Atlantic species also occurring in the Mediterranean (see synonymy list).

The often-cited use of vestibulum size in *Krithe* to discern past water oxygenation (*sensu* Peypouquet 1975) is inconclusive (e.g. McKenzie et al. 1989, van Harten 1994, van Harten 1995, Do Carmo et al. 2009). Our material is distributed over four benthic foraminiferal assemblage zones (Stalder et al. 2015) that exhibit different environmental conditions, including unstable and dysoxic settings (see fig. 3). Specimens do not exhibit apparent aberrant variations of vestibulum size or shape related to environmentally challenged conditions, but rather a large difference in total size (extremes shown in Fig. 9m). The general shape of the specimens only shows small variations in lateral valve outline, with stressed specimens being comparatively less elongated (Fig. 9m-o). Hence we think that our material represents one species reacting to stressed environments with an overall size reduction.

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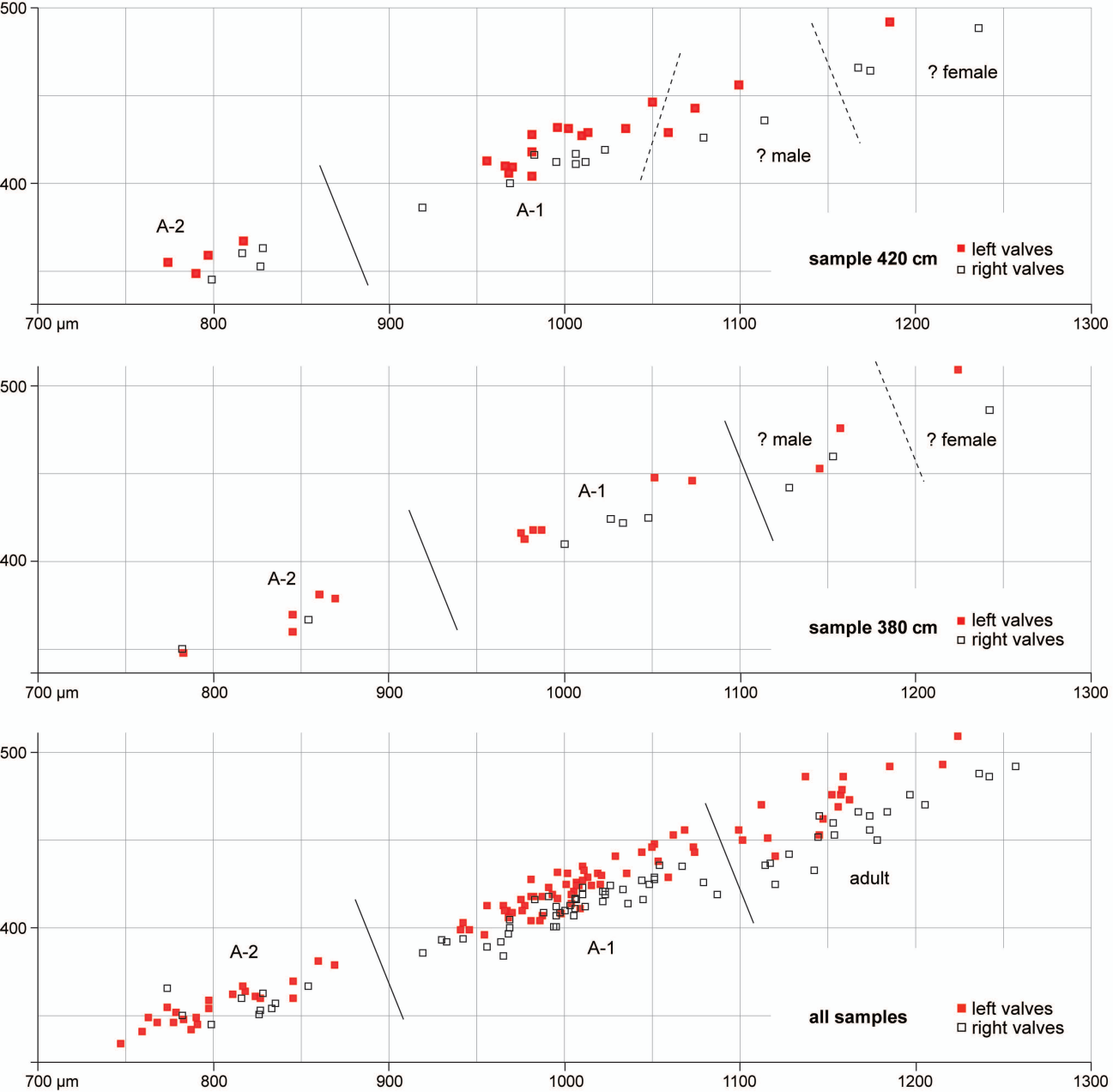
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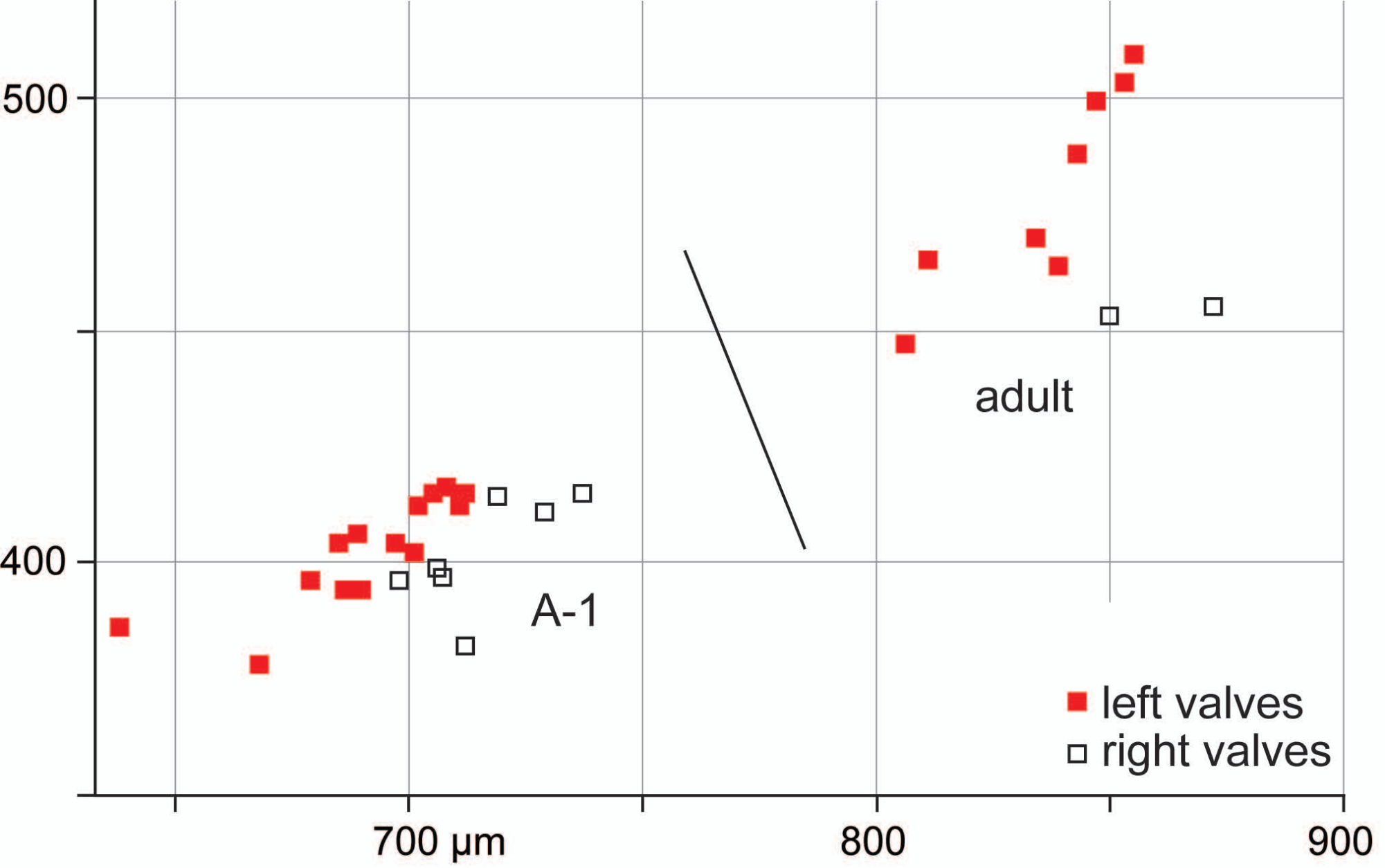
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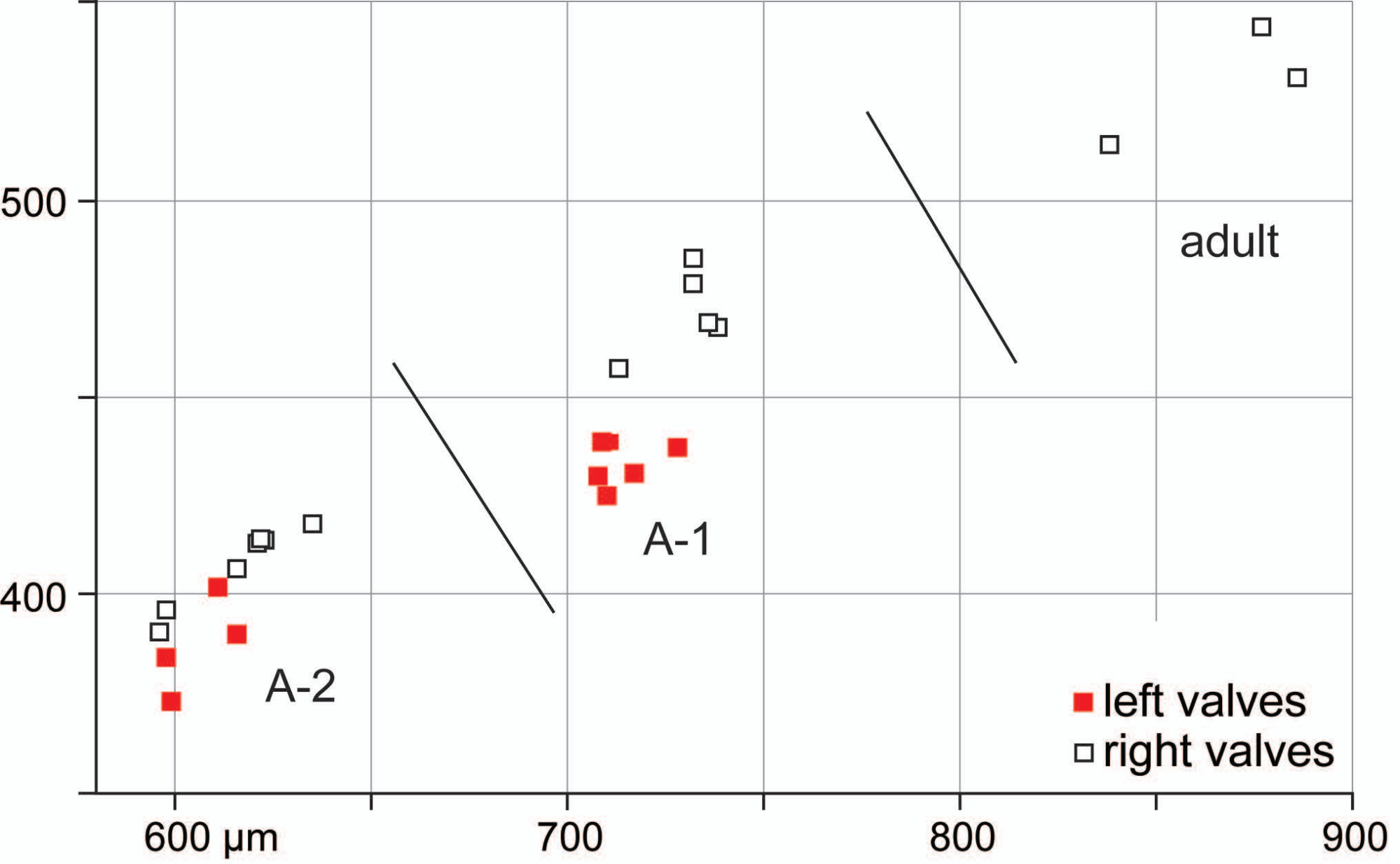
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adult
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A-2
left valves
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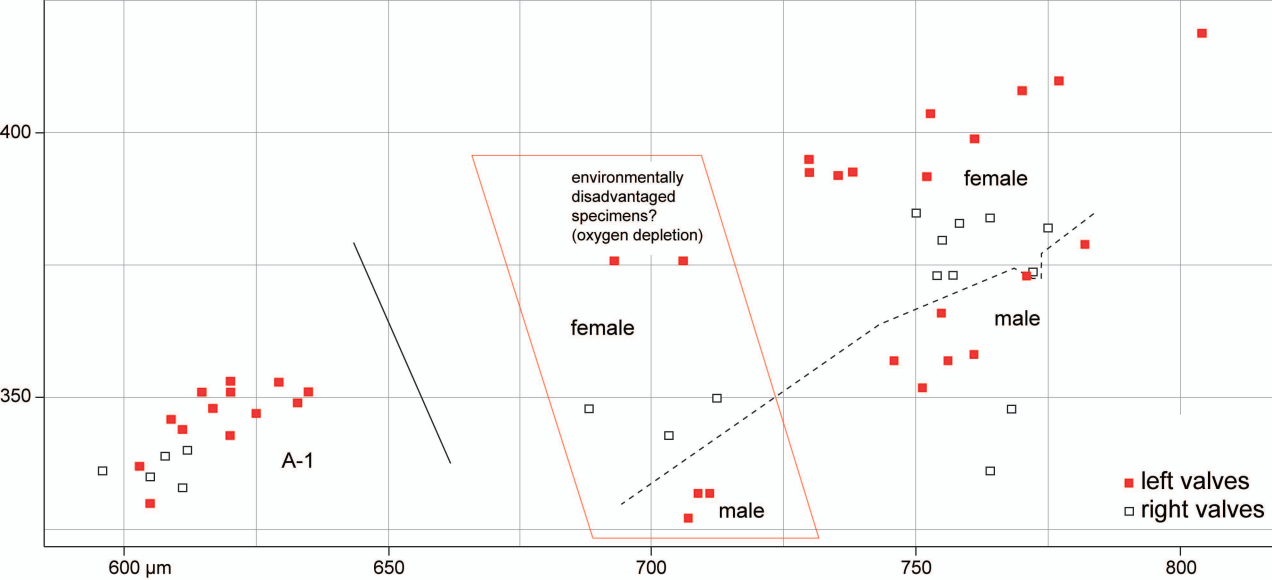
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environmentally
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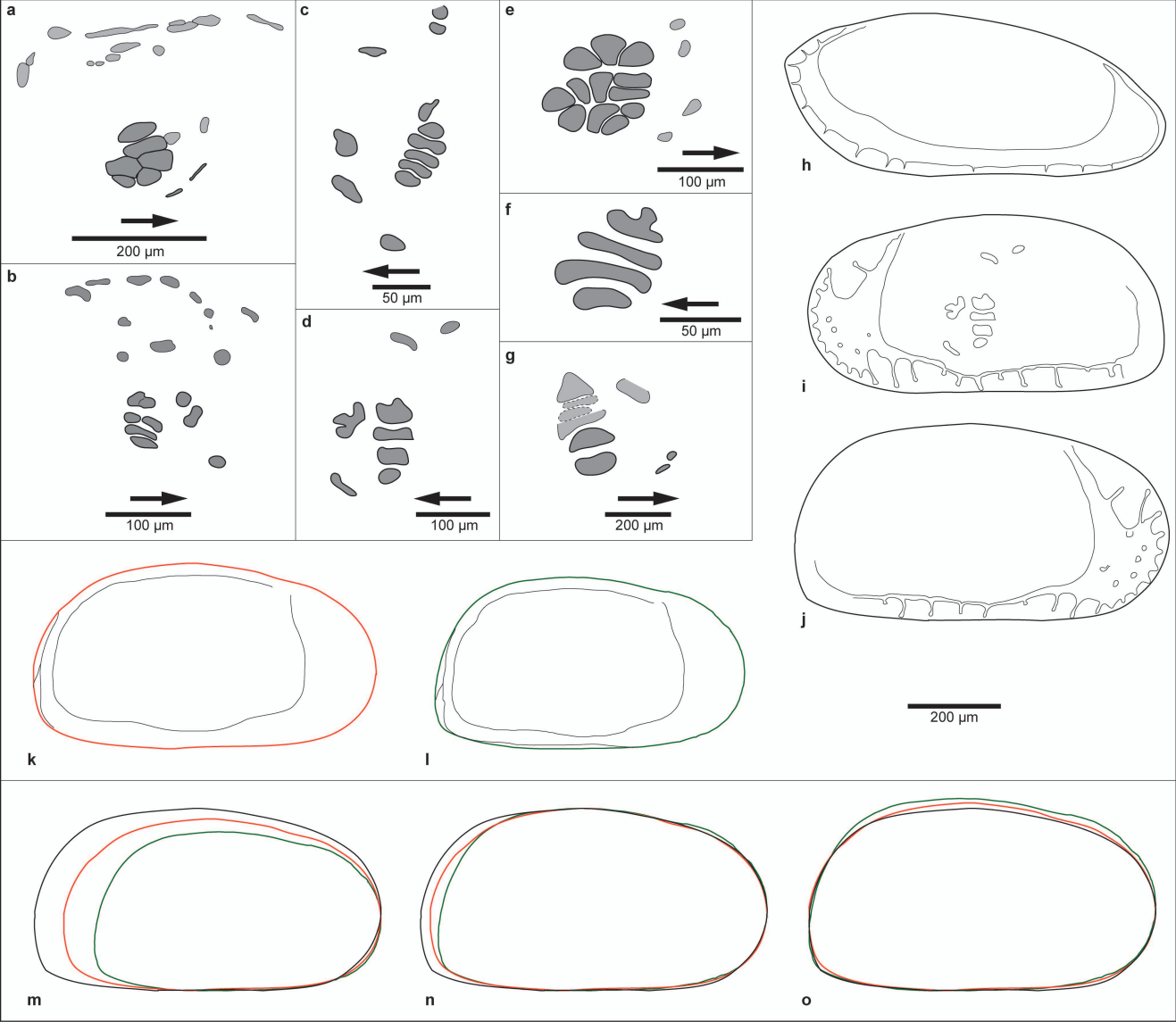
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