RECENT CAVE-DWELLING BRACHIOPODS FROM WESTERN PORTUGAL AND MADEIRA

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With 2 figures and 2 tables

ABSTRACT. A checklist of Recent brachiopod species collected by HELMUT ZIBROWIUS, LUIZ SALDANHA and colleagues from shallow caves in western Portugal near Sesimbra (Estremadura) in 1969 and at Sagres (Algarve) in 1986 is given. Comparisons are made with occurrences of these species from similar habitats in the Mediterranean and north-eastern Atlantic. A morphometric analysis of collections of *Megathiris detruncata* (Gmelin) from La Ciotat (France), Sagres (Portugal) and Madeira (Portugal) indicates there are significant differences in the width, thickness and, most importantly, the width-thickness index between the Mediterranean and north-eastern Atlantic occurrences which may represent a cline. Differences in thickness are accentuated by extreme abrasion of the umbones of both valves around the area of attachment of specimens from Sagres and Madeira.

RESUMO. No presente trabalho é apresentada uma lista de espécies recentes de braquiópodes, colhidas por HELMUT ZIBROWIUS, LUIZ SALDANHA e outros colegas, em grutas costeiras perto de Sesimbra (Estremadura) em 1969 e em Sagres (Algarve) em 1986. São efectuadas comparações com ocorrências destas espécies em habitats similares do Mediterrâneo e do Atlântico nordeste. Uma análise morfométrica de *Megathiris detruncata* (Gmelin) colhida em La Ciotat (França), Sagres e Madeira (Portugal) indica que existem diferenças significativas na largura, espessura e, acima de tudo, no índice largura/espessura, entre as ocorrências mediterrâneas e nordeste Atlânticas, o que pode significar uma clina. As diferenças na espessura são acentuadas pela extrema abrasão dos umbos de ambas as valvas, à volta da região de fixação, nas espécimes de Sagres e da Madeira.

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INTRODUCTION

Recent brachiopods are commonly found in shaded, light-poor environments and, in mid-latitudes, have been recorded from submarine caves from the Mediterranean (LOGAN, 1979; LOGAN & NOBLE, 1983; LOGAN & ZIBROWIUS, 1994; RUGGIERO, 1996), the west coast of Portugal (ZIBROWIUS & SALDANHA, 1976; LOGAN, 1979), the Canary Islands (LOGAN, 1988b) and the Madeira archipelago (LOGAN, 1979). These brachiopods, which can reach high densities, are part of an animal-dominated sessile community of scleractinian corals, bryozoans, serpulids, sponges and the foraminiferan *Homotrema rubrum*.

There are presently 12 species of brachiopods recorded from caves in the Mediterranean (LOGAN, 1979; LOGAN & ZIBROWIUS, 1994, but see BRUNTON, 1988), plus the recent discovery of *Gwynia capsula* from caves of Privlaka, Losinj Island, Croatia, by ERIC SIMON (*pers. comm.*) Eight of these 13 species occur in shallow coastal caves of the type described by LOGAN & ZIBROWIUS (1994). Five of these 8 species have so far been identified from shallow caves off the west coast of Portugal from specimens collected by HELMUT ZIBROWIUS and LUIZ SALDANHA. These caves occur: 1) between Sesimbra and Cape Espichel in the Estremadura region at a depth of 3-6 m, with specimens collected in August of 1969, and 2) at Sagres in the Algarve region at a depth of 3-17 m, with specimens collected in September of 1986. More information on their distribution in the Sagres caves has been given by BOURY-ESNAULT *et al,* 2001.

Brachiopods identified from Sesimbra and Sagres caves

Neocrania anomala (Müller)

This cementing inarticulate species is common on cave walls, particularly in the caves of Sagres. It is common throughout the Mediterranean, although BRUNTON (1988) believes that the eastern Mediterranean populations belong to a different species. It is presently known in the north-eastern Atlantic islands only by a single specimen from the Cape Verde islands (LOGAN, 1988b) but is otherwise relatively common (BRUNTON & CURRY, 1979; ANADÓN, 1994).

Argyrotheca cistellula (Searles-Wood)

This diminutive species occurs at both localities but is more common on the Sagres cave walls at depths between 2-10 m. It is often associated with *Gwynia capsula* (Jeffreys) in other areas (BRUNTON & CURRY, 1979; LOGAN *et al*., 1997) but the latter species has not yet been found in the Portuguese caves. *A. cistellula* is

distinguished from other species of Atlantic and Mediterranean *Argyrotheca* by its extremely small size (< 1.5 mm wide), smooth yellow-brown shell and distinctively transverse outline, as well as by marked internal differences (LOGAN, 1979).

Argyrotheca cuneata (Risso)

This species is represented by a total of 6 specimens collected from 2 caves at Sagres at 3-5 m depth. Only 2 of the 6 specimens show the distinctive pink stripes between the broad ribs but there is no doubt as to the identity of the others, since a colourless variety can occur (LOGAN, 1979). *A. cuneata* has been identified from the Canary and Cape Verde islands (LOGAN, 1983, 1988a) and from the Middle Miocene of south-eastern Poland by BITNER (1990).

Megerlia truncata (Linnaeus)

This species is normally a deeper water species in both the north-eastern Atlantic (COOPER, 1981; LOGAN, 1983, 1988a; ANADÓN, 1994) and the Mediterranean, but two examples were identified from the Grotte de Figuier, near Marseille, north-western Mediterranean, at a depth of 12m (LOGAN, 1979). J.-G. HARMELIN recently collected several individuals of this species from a cave in Menorca, Balearic Islands, at 8 m depth (H. ZIBROWIUS, *pers. comm.*). A total of 8 individuals of this species have been found in three caves at Sagres. They range in depth from 2-10 m and confirm the occasional occurrence of this otherwise bathyal zone species in shallow cryptic habitats. *M. truncata* has been described from the Middle Miocene of south-eastern Poland by BITNER (1990) and the Pleistocene of southern Italy by RUGGIERO (1985).

Megathiris detruncata (Gmelin) (Figs. 1 and 2)

This highly-variable species is relatively common at Sagres in the deepest recesses of caves at 3-15 m, while 13 specimens have been collected from Sesimbra caves. The species is common throughout the Mediterranean (LOGAN, 1979; LOGAN & NOBLE, 1983; TEMPLADO & LUQUE, 1986) and north-eastern Atlantic (BRUNTON & CURRY, 1979; LOGAN, 1983, 1988a; ANADÓN, 1994). Juveniles of this species are difficult to distinguish from colourless specimens of *Argyrotheca cuneata*, in which case the nature of the internal septa in the dorsal valve must be investigated. The differences between populations of *M. detruncata* from the north-western Mediterranean, southern Portuguese coast and Madeira are discussed below.

Morphometric analysis of *Megathiris detruncata*

JEFFREYS (1858) remarked on a variety of *Megathiris detruncata* from Guernsey and Madeira which is longitudinally oval and only faintly costate, unlike the typical form of this species, which is more transverse and costate. He goes on to say that these specimens may therefore belong to a distinct and undescribed species. LOGAN (1979, p. 56) reported that "an unusually large and robust form, with a highly convex pedicle valve, has been found around the coasts of Madeira and southern and south-eastern Portugal" and later (1983, p. 176) noted that "examples of an unusually large variety of this species, characterised by a highly convex pedicle valve and flat, very worn, almost catacline cardinal areas, were collected by the Zarco expedition in 1966 from very shallow water (30-50 m) around the Madeira Archipelago. Similar specimens have been obtained from the deepest recesses of caves at 3-15m depth from the Algarve and Estremadura regions of western Portugal by Saldanha, often attached to scleractinian corals (ZIBROWIUS & SALDANHA, 1976). The extreme wear in the beak region of both valves appears to be responsible for the catacline appearance of the cardinal areas and suggests that the morphological variation in this species may be phenotypically controlled, although why this should be most prevalent in cave-dwelling individuals is not yet understood.".

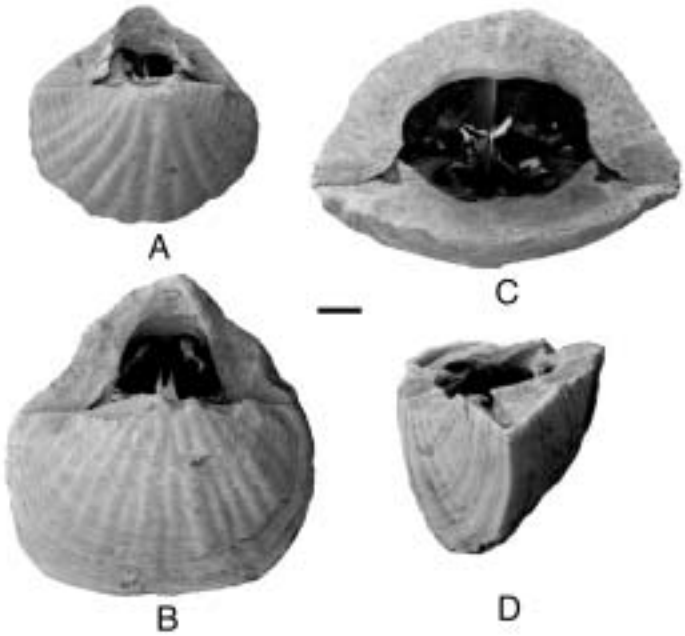

Fig. 1 - SEM's of *Megathiris detruncata* showing unworn specimens (A, B) and those with extreme abrasion of beak areas of both valves (C, D). A from La Ciotat, B from Sagres, C and D from Madeira. Pedicles missing. Scale bar is 1 mm.

The typical Mediterranean form of *M. detruncata* has 10-14 distinct costae, as DAVIDSON (1887) described, while the specimens from Sagres and Madeira have a similar number of fainter costae, similar to those described by JEFFREYS (*op. cit.*) from Guernsey and Madeira. Almost all specimens show some degree of wear in the beak regions of both valves, due to the extremely short pedicle and the rotational movement of the animals around their attachment point, the specimens from Sagres and Madeira being considerably more worn than their Mediterranean counterparts (Fig. 1C, D). On unworn specimens the length and width are approximately equal (Fig. 1A, B).

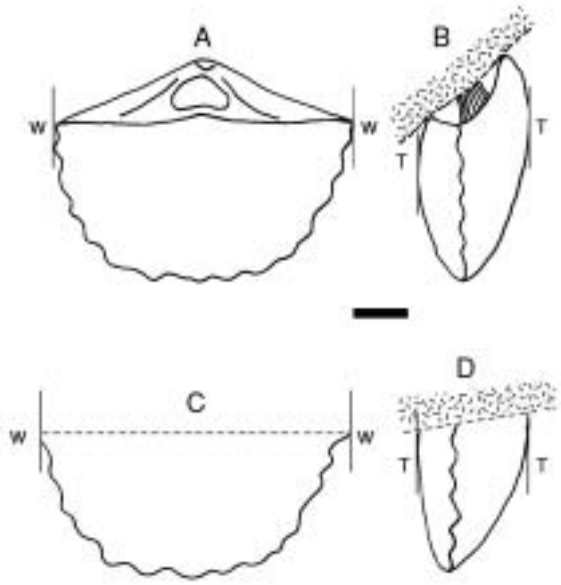

Fig. 2 - Diagrams to show how measurements W and T were made on *Megathiris detruncata* from La Ciotat, Sagres and Madeira. A and B show only slight abrasion of beak regions typical of La Ciotat examples, with pedicle in place. Pecked line on C and D indicates plane of abrasion typical of Sagres and Madeira examples, where the hinge area is closely adpressed to the substrate (shaded). Scale bar is 1 mm.

In an effort to quantify these real (or apparent) differences, samples from: 1) Gameau cave, near La Ciotat, France, in the north-western Mediterranean, collected by ZIBROWIUS & HARMELIN in 1992 from 6-8 m depth; 2) Sagres, southern Portugal, north-eastern Atlantic, cave with stalagtites ("grotte des cierges" in BOURY-ESNAULT *et al*., 2001), 4-5 m depth, collected by ZIBROWIUS in 1986; and 3) Ponta da Oliveira, Caniço de Baixo, Madeira, north-eastern Atlantic, lava cave at 12 m depth, collected by LOGAN & WIRTZ in 1993, were examined. The dimensions measured were maximum width (W) of the whole (bivalved) shell and maximum thickness (T) of the whole

(bivalved) shell, which usually occurs at or near the cardinal areas (Fig. 2). Because of the wear on the beak regions, width was regarded as a more accurate indicator of age than length. Since the samples were not randomly collected, the ratio of width:thickness (W/T index) was calculated for each locality and statistically compared. The summary statistics are shown in Table 1 and the results of the one-way ANOVA and Tukey's HSD tests in Table 2.

The mean width of specimens from La Ciotat was significantly less than those of the other two localities, which were not significantly different from each other. This, plus the reduced range of W at La Ciotat, indicates that the Mediterranean specimens are generally smaller than their eastern Atlantic counterparts. The mean thickness increases significantly from east to west (i. e. from La Ciotat to Sagres to Madeira). Since, as previously mentioned, the samples were non-randomly collected, the index W/T was used, as this is independent of growth stage where growth is essentially isometric (see LOGAN, 1979, Fig. 15 and this study). Statistical tests (Table 2) showed that there are significant differences in W/L among the three localities, the ratio decreasing westwards from the northern Mediterranean in the east to Madeira in the west. The fact that these differences are gradual suggests that they are varieties or morphs of a single highly variable species exhibiting a cline from the Mediterranean to the eastern Atlantic. The differences in thickness are accentuated by the amount of abrasion resulting from the closeness of attachment and perhaps the relative hardness of the substrate to which they are attached.

TABLE 1 - Summary statistics for *Megathiris detruncata* for W, T and W/T from La Ciotat, Sagres and Madeira (localities 1, 2 and 3, respectively). The data are normally distributed (normal probability plots) and variances are homogenous (Fmax test), hence no transformations are necessary. SD = standard deviation, Var. = variance. Number of individuals measured is 65 for each locality. All measurements in millimeters.

PARAMETER	W			T			W/T		
Locality	1	2	3	1	2	3	1	2	3
Mean	6.31	6.90	6.87	2.79	3.58	3.87	2.27	1.94	1.81
SD	0.79	0.67	0.87	0.36	0.50	0.71	0.19	0.16	0.23
Var.	0.63	0.45	0.73	0.13	0.25	0.50	0.04	0.02	0.05
Min.	4.63	5.16	4.96	1.98	2.81	2.32	1.80	1.56	1.39
Max.	7.82	8.37	8.26	3.60	5.28	5.92	2.75	2.30	2.39
Range	3.19	3.21	3.27	1.62	2.47	2.57	0.95	0.74	1.00

TABLE 2 - One-way ANOVA and Tukey HSD tests for W, T and W/T for *Megathiris detruncata* from La Ciotat, Sagres and Madeira (localities 1-3). ANOVAs tested the null hypotheses that there are no differences in the mean width, thickness and width/thickness index, respectively, among localities. Numbers in Tukey's HSD tests are p-values; an asterisk indicates a significant difference.

ONE-WAY ANOVA						TUKEY'S HSD TEST			
	SS	df	MS	F	P	1	2	3	Locality
W						-			1
Effect	14.230	2	7.115	11.782	0.000015	* 0.00007	-		2
Error	115.942	192	0.604	Null hypothesis rejected		* 0.00015	0.97037	-	3
T						-			1
Effect	40.687	2	20.343	68.938	0.000000	* 0.00002	-		2
Error	56.659	192	0.295	Null hypothesis rejected		* 0.00002	* 0.00827	-	3
W/T						-			1
Effect	7.477	2	3.739	99.960	0.000000	* 0.00002	-		2
Error	7.184	192	0.037	Null hypothesis rejected		* 0.00002	* 0.00023	-	3

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