

G. ZAMMIT-MAEMPEL (*)

OBSERVATIONS ON *ECHINOCARDIUM*
(ECHINODERMATA: ECHINOIDEA)
FROM MALTESE WATERS (CENTRAL MEDITERRANEAN)

Abstract — The discovery of *Echinocardium mediterraneum* (Forbes, 1844) in Maltese waters is recorded for the first time, on the basis of five specimens collected from three different sandy bays of the island of Malta. The specimens are described and intraspecific differences and variations are noted.

Riassunto — Osservazioni su *Echinocardium mediterraneum* (Echinodermata: Echinoidea) nel mare di Malta (Mediterraneo centrale). Sulla base di cinque campioni provenienti da tre diverse stazioni viene per la prima volta provata la presenza di *Echinocardium mediterraneum* (Forbes, 1844) a Malta. I reperti vengono descritti e ne viene valutata la variabilità infraspecifica.

Key words — *Echinocardium* / Malta.

HISTORICAL

There are no previous records of *Echinocardium* from the seas around Malta (MICALLEF, EVANS, 1968; SCHEMBRI, 1978). This is attributed partly to the burrowing habits of the animal (which make it so elusive) and partly to the great fragility of its test (which renders it very difficult to find unshattered once it has been unearthed from its burrow by the action of waves and currents). It should be noted, however, that in the list of «new additions» to the Echinoderm Reference Collections at the Natural History Section of the Valletta Museum at Auberge d'Italie, DESPOTT (1928: xvii) records the acquisition of «*Centrostephanus longispinus* Peters and *Echinocardium mediterraneum* Forbes». Thus, though it is quite possible that both

(*) 53, Main Street, Birkirkara (Malta).

specimens could have come from Maltese waters, Despott's listing cannot be accepted as a local record, for the Museum Reference Collections contained also «Mediterranean species but not locally obtained» (DESPOTT, 1928: xvii).

MALTESE MATERIAL AVAILABLE

Five specimens in Author's Collection (ZM/1-5) collected from the following sites (Fig. 1):

ZM/1. Mellieha Bay, N.E. Malta, February 1976. Denuded test found washed up on a sandy-muddy patch beneath Mellieha Bay Hotel (specimen accidentally shattered before completing detailed study);

ZM/2 and 3. Bahar ic-Caghaq, east Malta, May 1977. Empty, denuded test on sandy bottom c. 100 m offshore, depth 6 m.;

ZM/4 and 5. Wied il-Ghajj, SE Malta, June 1977. Test with greyish white spines directed backwards, alive. Unearthed accidentally after

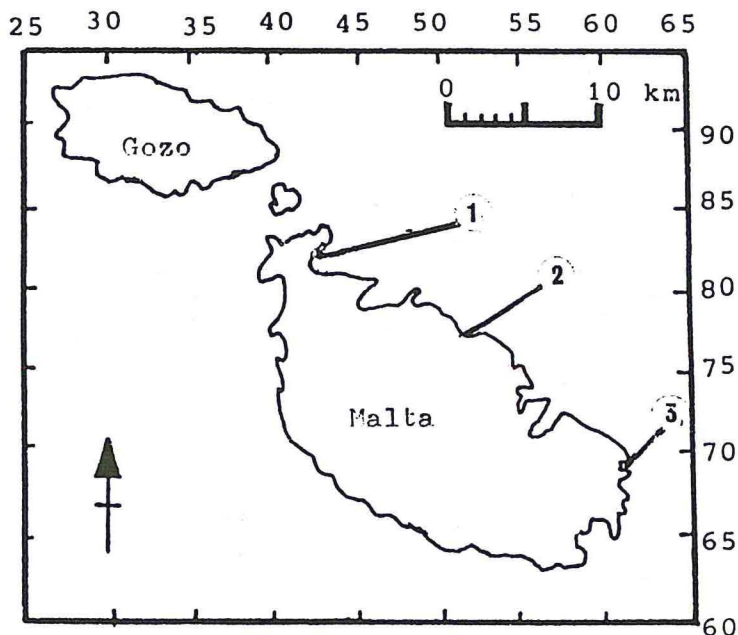


Fig. 1 - Location map showing collection sites of *Echinocardium mediterraneum* (Forbes). 1. Mellieha bay; 2. Bahar ic-Caghaq bay; 3. Wied il-Ghajj bay.

shallow scraping of sandy bottom 'close to shore' (ZM/5 has since been donated to the Echinoderm Section, British Museum (Nat. Hist.) and carries registration no. 1985. 11.7.1).

DIAGNOSIS

All available material is attributed to *Echinocardium mediterraneum* (FORBES, 1844) mainly on the basis of the heart-shaped test, presence of a bullet-shaped internal fasciole, an anal and a subanal fasciole, absence of any primary tubercles on the aboral surface above ambitus except within internal fasciole, and these without any deep areoles, presence of an anterior ambulacral sulcus or groove which does not reach apical systems, but which is more or less limited by anterior end of internal fasciole and a periproctal opening whose long axis is vertical.

SYSTEMATIC DESCRIPTION

Family: Loveniidae Lambert, 1905

Genus: *Echinocardium* Gray, 1925, p. 430

Species: *Echinocardium mediterraneum* (FORBES, 1844 a: 183; 1844 b: 518)

Synonymy:

Amphidetus mediterraneus: FORBES, 1844 a: 183; FORBES, 1844 b: 518

Amphidetus gibbosus: L. AGASSIZ-DESOR, 1847: 11

Echinocardium mediterraneum: HELLER, 1868: 65; A. AGASSIZ, 1874: 110, 580 pl. xxv fig. 29, pl. xxvi fig. 19; LUDWIG, 1879: 562; KOEHLER, 1899: 173-187; 1921: 135 fig. 94; 1927: 99-100, pl. xiv fig. 2 a-f, pl. xviii fig. 19; CHECCHIA-RISPOLI, 1906-94, pl. iv figs. 16-26; MORTENSEN, 1907, 4 (2): 150 pl. 17; 1951: 162; PEQUIGNAT, 1964: TORTONESE, 1965: 359, 365-366, fig. 179.

RANGE AND DISTRIBUTION

The genus *Echinocardium* ranges from Oligocene to Recent and is cosmopolitan in distribution. *E. mediterraneum* has been recorded fossil from the Pliocene of Sicily (TORTONESE, 1965: 366). Recent

specimens are known from the Mediterranean — being common in Italy (Livorno, Alassio, Naples), France (Bouches du Rhône, S. Raphael, Nice), — Sea of Marmara and NE Atlantic (from Gibraltar to Bay of Biscay), living in depths of 5-40 m on sandy beds (KOEHLER, 1927: 100; TORTONESE, 1965: 366). The British Museum (Nat. Hist.) collections incorporate only one dry specimen (1979.9.18, 22) from Antalya, Turkey and four other samples in alcohol, from Naples, Marseilles, Ibiza and Santander (N. Spain).

DESCRIPTION OF MALTESE SPECIMENS

Test high, thin-walled, fragile, cordiform outline, slightly longer than broad, width greater than height. All local specimens available have Ray 2 (Loven) slightly more prominent than Ray 3, but in ZM/4 the assymetry is much more pronounced.

Dorsal surface: flat with very prominent triangular bulge posteriorly in the region of 5th interr radial; a moderately-sunken, non-diverging, wide sulcus or groove on its truncated anterior border, reaching up to, or just beyond, the anterior edge of the bullet-shaped internal fasciole, but never reaching the apical system; all the large above-ambital tuberculation limited to within internal fasciole; absence of deep areoles.

Ventral surface: flat anteriorly as far as the moderately developed, raised labrum. The latter extends posteriorly as a keel-like prominence in the 5th interr radial. Posterior end of test is consequently much higher than anterior end, and as in all Maltese specimens posterior border slopes gently backwards, the posterior end is a very characteristic backward-pointed, triangular prominence on the ventral surface.

Measurements are given in Tab. 1.

Anterior ambulacrum

Non-petaloid, composed of two uniserial rows of alternating pore pairs extending from apical region to lower edge of anterior border. The finely granulated median region within the internal fasciole develops anteriorly into a wider anterior groove. This is smooth medially but has several rows of very minute granulations on either side peripherally.

TAB. 1 - *Maltese Echinocardium mediterraneum. Test*

Maltese specimen ZN/1-5	Location	Ventral Length mm L'	Dorsal Length* mm L''	Width mm.	Index L/W	Ant. Height H'	Index L/H'	Post. Height H''	Index L/H''
ZM/1	Mellieha	30.0	25.5	27.8	1.08	16.0	1.87	20.0	1.50
ZM/3	Bahar is-Caghaq	31.0	25.5	29.8	1.21	16.5	1.87	21.0	1.47
ZM/4	Wied il-Ghajn	38.4	28.5	35.0	1.26	19.0	1.95	22.1	1.67
ZM/5	Wied il-Ghajn	39.8	33.5	38.7	1.19	21.5	1.87	26.5	1.52
ZM/2	Bahar is-Caghaq	44.3	36.4	43.0	1.22	23.5	1.87	28.5	1.54

* dorsal length measured at upper level of periprectal opening

Pores

Two zig-zagging, uniserial rows of 17-19 pore pairs extend anteriorly from apical system to peristome. Each row has 9-11 very minute and sub-equal pores within internal fasciole, 4-6 markedly unequal pores (adoral or median pore much larger) within groove on anterior side, and 3 on oral surface. Within the fasciole the pores are round and closely set, along anterior surface, they are vertically oriented slits and on oral surface they are round. Only one pore per plate and its position varies in different plates.

Antero-lateral ambulacra

Petaloid, depressed, formed by two rows of non-conjugate pore pairs. Upper series (rows nearest Ray III): straight with 7-10 large round/oval, subequal pore pairs. There are 4-5 round to slit-like pores between petals and ambitus, but the series extends also to oral surface. Lower series (rows nearest Ray 1 and 4 respectively): curved, with 11-13 large oval (except first) pore pairs, outermost larger, placed at an angle to each other. ZM/1 has two extra petaloid pores on either side of the lower series at level of the eight oval pore pair (counted distally). Thus, at this level, the plate has four, instead of two, pore pairs. The two distal pores are much larger and are set at an angle to each other, whilst each of the proximal pair is set with its long axis horizontal. The adjacent or upper rows of pore pairs in Ray II and IV subtend an angle of about 165° .

Postero-lateral ambulacra

Petaloid, very slightly sunken (almost flush with first and fourth interradial), composed of two rows of non-conjugate pore pairs. Upper rows (nearest Ray 1 and 4 respectively) longer, slightly curved and almost meeting outer row of antero-lateral ambulacral pore pairs; 9-10 pore pairs in inner (lower) rows and 10-12 in outer (upper) rows. No evidence of extra-petaloid pore pairs as in antero-lateral ambulacra. Adjacent (inner) set of rows of pore pairs in Ray I and V subtend an angle of about 65° .

Interambulacra

The maximum number of horizontal rows of plates above ambitus is 6-7. Tuberculation is small and uniform both in size and density.

Apical system

Ethmolytic with madreporite extending backwards well beyond posterior pores and separating oculars I and V, four round genital pores with anterior pair smaller and more closely set than posterior pair.

Apical system excentric anteriorly at slightly more than one third distance from anterior border at level of coronal suture.

Fasciole

Internal (endopetalous, inner), anal and subanal. These are three bands of fine dense brownish tuberculation, equipped with small strongly ciliated and modified spines or clavulae, serve to generate currents into and out of vertical and horizontal tunnels to promote oxygenation of the animal (internal fasciole) and an adequate drainage of the products of digestion or respiration (anal and subanal fascioles).

Internal fasciole

Bullet-shaped, encloses all the larger tubercles above-ambitus; pointed posterior end extends to apex of triangular bulge on 5th interradiar, wider anterior end reaches anterior border, narrows in thickness, shallows and traverses anterior ambulacrum perpendicularly. Internal fasciole is the deepest of the three bands (except in ZM/5).

Index of fasciole (maximum height or length of fasciole/maximum width) in the Maltese specimens ranges from 1.77 to 1.84 (av. 1.80).

Anal fasciole

Widest of the three bands on test, very shallow, generally U-shaped with tips reaching level of most distal 1st and 2nd pore pairs in ambulacra I and V (in ZM/5, anal fasciole is horse-shoe shaped, tapers to a fine point which reaches most distal 2nd and 3rd pore pairs). It widens considerably at its base where it communicates with the underlying subanal fasciole through a short vertical fasciole junction at its middle.

Index Height/Width ranges from 1.2 to 1.3.

Subanal fasciole

Depressed, varying in shape from cordiform (ZM/1) to different forms of shield-shape in the others; apex directed downwards. All specimens have two overlying pore pairs — each of which is located in a small depression — on either side of and within fasciole. In ZM/5, right upper pair is missing but its depression is present. Subanal fasciole communicates with base of overlying anal fasciole at its midline through a short vertical neck. Communication most marked in ZM/5 (7-10 minute granules across its width).

Index Max. height/Max. width of fasciole is 0.80-0.95.

Tuberculation

On dorsal or adapical surface (above ambitus): scanty large tubercles, all lacking deep areoles, limited to within internal fasciole where they lie on either side of a densely and finely granulated linear median area. Dorsal interambulacral tuberculation is small, uniform in size and density. On ventral (adoral) surface: tubercles increase in size progressively from periphery inwards and they stand in the anterior part of each plate.

Spines

In specimens ZM/5 and 2 (length of test 39.8 mm and 44.3 mm resp.) spines range in size from less than 1 mm to over 15 mm, being longest on adoral surface in region of interradians 1 and 4 (sand moving spines) and stoutest over plastron (locomotor spines).

Several varieties of spines noted on test, most conspicuous being: Long greyish white spines having a sloping, eccentrically expanded base with a milled edge and a curved cylindrical stalk, which is set on a neck at an angle. Stalk tapers initially but widens more distally and terminates blade-like. It is faintly striated with striations becoming deeper at base of spine, giving rise to the milled edge. Such long spatulate spines are most evident adorally on interradians 1 and 4 (where they are somewhat open-S shaped) and over the plastron (where they are open-C shaped and end distally in a much angulated curved spatula). The latter feature suggests that, besides their normal locomotory function, plastron spines of the Maltese *Echinocardium mediterraneum* carry out also the additional one of shovelling sand. Similar but non-spatulate spines are found also above ambitus;

Much shorter, light brown or white, non-spatulate spines are found mainly in apical and periproctal region (within anal fasciole);

Very small brownish cilia-bearing spines (clavules) forming very clearly demarcated fascioles seen on test either as brownish bands or as bands of apparently bare areas, if in the midst of long spines;

Very fine hair-like spines, limited mainly to periproctal plates.

Posterior surface

Arched and rounded dorsally, pointed ventrally, surface sloping gently backwards with a marked indentation in the uppermost two thirds. In this hollow is located the periproctal opening surrounded by 3-5 radial ridges and flutings on either side of the opening. The area beneath the depression is occupied completely by the subanal fasciole.

Periproct

In a denuded test, the periproctal opening is a wide, vertical ovoid opening (average diam. 7 mm x 4 mm), located in a longitudinal depression in upper two thirds of posterior surface, having pronounced radial ridges and depressions (3-5 on either side), enclosed within the U- or horse-shoe-shaped anal fasciole. On account of its location on the sloping posterior surface, the vertical periproctal opening is depressed ventrally. In living specimens, the large opening is covered with a membrane having a horizontal ovoid opening (anus) in its upper region and a system of plates in its lower part. The latter system is composed of radially arranged, transparent, partially calcified plates having a small tubercle close to their-base, surrounded by rows of fully calcified plates each bearing a small tubercle (one plate bears 4 tubercles). The partially calcified plates are triangular and have their apex pointing medially, whilst the fully calcified ones are rectangular. Genital 5, which in *Echinocardium* becomes incorporated in the periproctal system of plates (MELVILLE, DURHAM, 1966), could not be identified (unless it is the plate with 4 tubercles).

Peristome

Labrum raised but not very prominent and does not cover the opening internally. This gap is closed by a half domed membrane to which are affixed irregularly shaped, white, calcareous plates lacking any tubercles.

DISCUSSION

Shape and size. In *E. mediterraneum* the length is only slightly greater than the width (Tab. 1 gives the various dimensions and indices of the local species). The Index Maximum length/Maximum width of test averages 1.19, whilst that of *E. cordatum* (Author's Collection, North Sea, Wilhelmshaven) averages 1.03.

Asymmetries and irregularities are very common in both fossil and Recent spatangoids (COTTREAU, 1913; BONNET, 1926; TORTONESE, 1965). In all *E. mediterraneum* specimens available, Ray 2 (Loven) is larger and more bulging than Ray 3, but in specimen ZM/5 this asymmetry is much more marked.

Posterior side/surface

KOEHLER (1927: 96) and TORTONESE (1965: 366) both describe the posterior side of *E. mediterraneum* as «vertical». In all Maltese specimens however, this is never the case. It slopes gently backwards towards the ventral side ending in a very prominent and posteriorly-directed, pointed protuberance (not seen in the available *E. cordatum*), so that the length of the ventral surface is 18.8 to 22% longer than that of the dorsal surface (measured at level of upper end of periproctal opening) (Tab. 1).

Anterior groove/sulcus

This feature has great systematic importance as its extension to the apical system characterises *E. cordatum*. In *E. mediterraneum*, anterior groove is recorded as ending abruptly at the anterior edge of the internal fasciole (TORTONESE, 1965: 366) and as being limited to the vertical anterior side of test (KOEHLER, 1927: 99).

In two of the Maltese specimens (esp. ZM/4), groove extends to just within internal fasciole, but does not reach apical system. This suggests that «not reaching apical system» or «terminating at or just within anterior edge of internal fasciole», rather than «limited by the anterior edge of internal fasciole» should be the terminology of choice to qualify the anterior groove in *Echinocardium mediterraneum*.

Internal fasciole

In local *E. mediterraneum*, this fasciole is longer and narrower than that of *E. cordatum* in author's collection. The Index maximum

length/height/maximum width of this fasciole in all Maltese specimens available is 1.8, whilst that for *E. cordatum* averages 1.5 (Tab. 2 and Tab. 4).

Periproctal fluting

The periproctal radial ridges and depressions on either side of the depressed area in which the periproctal opening is located, is apparently, a characteristic of the Maltese *E. mediterraneum*. It is prominent in all available Maltese specimens, but is not so pronounced in the Turkish specimen from Antalya (BMNH/1979.9.18.22).

Subanal fasciole

This band which surrounds a special tuft of spines and also the two groups of tube feet in the pore pairs that build the sanitary drain, provides the necessary current for removing respiratory and faecal waste from the area (NICHOLS, 1962: 107). NICHOLS (1962: 115) observed also that in all British *Echinocardium cordatum*, the cordiform subanal fasciole tends to get more circular with age and to be greatly affected by substrate. In the Maltese *E. mediterraneum*, this tendency could not be confirmed. On the contrary, it was found that the larger (older) specimens (e.g. ZM/5, 39.8 mm long) tended to have the more elongated shield-shaped subanal fasciole and that its shape varied even in specimens collected from same substrate a few centimeters apart (ZM/4 and ZM/5).

Pore pairs within subanal fasciole

KOEHLER (1927: 99) records 1-2 pore pairs on either side within subanal fasciole. TORTONESE (1965: 366), basing himself on 50 Mediterranean specimens (none from Maltese Islands), observed 3 on either side. The present study (limited to only five specimens from three different sites) revealed the presence of only two pore pairs on either side, with in one case (ZM/5), the right upper pore pair missing. Its location, however, is still marked by an unperforated «dimple» in the test.

DIFFERENTIAL DIAGNOSIS

Six nominal species of *Echinocardium* have been recorded from the Mediterranean region: *E. flavescens* (O.F. MULLER, 1776), *E. cor-*

TAB. 2 - *Maltese Echinocardium mediterraneum. Fascioles*

Maltese specimens	Internal fasciole			Anal fasciole			Subanal fasciole		
	Height* mm	Max. Width mm	Index H/W	Height mm	Width mm	Index H/W	Height mm	Width mm	Index H/W
ZM/1	16.0	9.0	1.77	?	?	?	?	?	?
ZM/3	16.1	9.0	1.79	13.3	11.0	1.21	7.2	7.6	0.95
ZM/4	16.5	9.0	1.83	13.0	10.0	1.30	7.8	9.7	0.80
ZM/5	19.5	11.0	1.77	17.0	13.0	1.31	9.0	10.0	0.90
ZM/2	20.5	11.0	1.84	18.0	15.0	1.20	15.0	0.80	
		average	1.80		average	1.25		average	0.9

* Height or Length of fasciole

TAB. 3 - *Maltese Echinocardium mediterraneum. Ambulacra*

Specimens	Minimum distance between ambulacral tips of:				Pore pairs per row (anti-clockwise) in Rays:				
	Rays II & IV		Rays V & I		I	II	III	IV	V
	inner rows	outer rows	inner rows	outer rows					
ZM/1	?	?	?	?	?	?	?	?	?
ZM/3	22.0	23.7 mm	11.0	13.4 mm	9.10	12.9	4.5	8.12	10.9
ZM/4	25.8	27.4 mm	11.9	14.4 mm	10.12	12.8	5.5	10.13	12.11
ZM/5	29.3	31.1 mm	13.3	16.1 mm	10.12	13.10	5.6	9.13	12.9
ZM/2	27.6	31.7 mm	14.8	18.9 mm	9.11	11.8	6.6	7.13	11.10

TAB. 4 - Echinocardium cordatum (Penn.), Wilhelmshaven, North Sea. Test and Fasciole measurements (in millimeters)

Specimen	Test				Anterior fasciole		
	L	W	Index L/W	H'	Index L/H'	H''	Index L/H''
ZM/I.	20.0	19.0	1.05	9.1	2.20	12.5	1.60
ZM/II.	20.7	19.5	1.06	9.7	2.13	13.5	1.53
ZM/III.	23.5	21.4	1.09	10.5	2.24	15.5	1.52
ZM/IV.	23.8	22.5	1.06	10.5	2.27	15.5	1.53
						14.0	1.48

L = maximum length, on ventral surface

H' = Anterior height, measured at level of anterior edge of Internal fasciole

H'' = Posterior height, measured at level of maximum height, over 5th interradiar

W = maximum width

datum (PENNANT, 1777), *E. mediterraneum* (FORBES, 1844), *E. pennatifidum* NORMAN, 1868, *E. mortenseni* THIERY, 1909 and *E. fenauxi* PEQUIGNAT, 1964 but *E. mortenseni* is considered by TORTONESE (1965) to be a synonym of *E. pennatifidum*.

Unlike Maltese specimens: *E. flavescens* and *E. pennatifidum* both have large tuberculations also outside the internal fasciole — *E. flavescens* on Rays 1, 2, 3, 4 and *E. pennatifidum* on Rays 2 and 3 only.

E. fenauxi has a transverse periproctal opening whilst *E. cordatum* has an anterior groove that is wider, deeper and extends to apical system.

Like *E. mediterraneum*, the Maltese specimens under review have the large supra-ambital tuberculation limited to the area within the internal fasciole, an anterior sulcus that does not reach apical system, stopping at or just beyond anterior edge of internal fasciole, and a vertical periproctal opening.

On this account, all the five Maltese specimens collected from three different sandy bays of the Island of Malta have been attributed to *Echinocardium mediterraneum* (FORBES). They show, however, some minor intraspecific differences, particularly in size and shape of subanal fasciole and in the number of pore pairs within it. Similar and other intraspecific differences between two populations of the heart urchin *Echinocardium cordatum* (PENNANT) from different localities in Britain were recorded by NICHOLS (1962).

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