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ZAMMIT-MAEMPEL G. *

LAGANUM DEPRESSUM AGASSIZ (ECHINOIDEA, LAGANIDAE),
A NEW RECORD FROM THE MALTESE TERTIARY

Summary — The genus *Laganum* is recorded for the first time from the Maltese Tertiary and from the whole Mediterranean region, on the basis of a single specimen of *Laganum depressum* AGASSIZ reputedly collected from the reef-bearing Upper Coralline Limestone (Upper Miocene, Tortonian) at Il-Karraba, N.W. Malta. It is now limited to Indo-Pacific waters and its record from the Maltese Tertiary not only confirms the presence of a former communication existing between European Tethys and the Indo-Pacific during Miocene times, but also increases still further the Indo-Pacific affinity of Maltese Tertiary faunas.

The Maltese *Laganum depressum* AGASSIZ is described and compared with similar *Laganum* material originating from distant geographical areas and now in the British Museum (Nat. Hist.) Collections. As the characteristic internal structure of *Laganum* is revealed by industrial radiography, the use of this important investigation is recommended whenever the identification of the genus is in doubt, particularly when it has to be differentiated from the apparently similar *Clypeaster*.

Riassunto — *Prima segnalazione di Laganum depressum AGASSIZ nel Terziario dell'isola di Malta.* Il rinvenimento di un esemplare di *Laganum depressum* AGASSIZ nella parte inferiore dell'Upper Coralline Limestone (Miocene Superiore, Tortoniano), della Karraba, a NW di Malta, permette di segnalare per la prima volta nel Miocene Superiore di Malta e di tutto il bacino mediterraneo il genere *Laganum*.

Questo genere è presentemente limitato alle acque calde e poco profonde della regione indo-pacifica, e la sua segnalazione nel Terziario di Malta serve non solo a confermare il collegamento della Tethys con quell'oceano durante il Miocene, ma anche ad aumentare le affinità pacifico-indiane della fauna terziaria di Malta.

Si descrive l'esemplare trovato a Malta e lo si compara con esemplari simili del Museo di Storia Naturale di Londra provenienti da località geograficamente molto distanti dall'isola mediterranea.

Siccome la caratteristica struttura interna del *Laganum* si rivela molto bene con la radiografia, si raccomanda questo tipo di indagine quando l'identificazione del genere è in dubbio, e specialmente per distinguerlo dall'apparentemente simile genere *Clypeaster*.

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The genus *Laganum* is new to the Maltese Islands, for when KLEIN (1734, p. 31) and LESKE (1778, p. 24 I 87) referred to the Maltese echinods figured by SCILLA in his *La vana speculazione* (1670, Tav. VIII, fig. I, III) as *Laganum scillae*, they had wrongly attributed to this genus the Maltese *Scutella subrotunda* (LESKE).

The Maltese upper Tertiary *Laganum* herein recorded was compared with extensive *Laganum* material in the British Museum (Nat. Hist.) collections. It was found to have great affinities with « *Laganum tumidum* DUNCAN & SLADEN » from the « Plio-Pleistocene » and from the « Post-Tertiary » of the Red Sea area, and to be particularly akin to *Laganum depressum* AGASSIZ from similar locations and geological horizons. These two species are now considered to be synonymous (BRIGHTON, 1931, p. 325). *Laganum depressum* AG. is a very variable species and variations, (particularly in size and shape of test), have been noted even in specimens collected from the same locality and geological horizons. The many variations shown by the Maltese *Laganum* fall within the very wide range of variability of the species, so that the specimen can be safely assigned to the species *Laganum depressum* AGASSIZ.

The *Laganum specimen* (Author's Coll. E. 1000) to be described, formed part of the personal collection of the late Chev. Dr J. G. BALDACCHINO, a one-time Curator and subsequently Director, of the National Museum of Malta. It formed part of a small collection of Maltese fossils collected by that gentleman and kindly donated by his heirs to the present writer. No document accompanied the small fossil collection, but Dr Baldacchino had marked the oral surface of the *Laganum* specimen with the words « U.C.L. » and « KARRABA » (fig. 1 b). These have been taken to refer respectively to the geological horizon, Upper Coralline Limestone, abbreviated as U.C.L. and the locality of the find, Il-Karraba (Grid ref. 401725) on the NW coast of Malta.

MALTA'S GEOLOGICAL SUCCESSION AND ITS AGE

With the exception of the lacustrine tufa leaf-beds and the few Quaternary deposits infilling fissures, caves and valley beds, all the rocks forming the geological succession of the Maltese Islands are of a marine sedimentary origin. They were deposited at various depths and distances from a continental mainland. In the

order of their deposition, the lithostratigraphic units that make up the Maltese geological sequence are: Lower Coralline Limestone, Globigerina Limestone, « Clays » (formerly often referred to as « Blue Clay », see ZAMMIT-MAEMPEL, 1977), Greensand and Upper Coralline Limestone.

The lowermost formation is now generally considered to be of Upper Oligocene (Chattian) age (see AMATO in GIANNELLI & SALVATORINI, 1972; FELIX, 1973), while the rest of the succession is attributed to various stages of the Miocene (FELIX, 1973; ROSE, 1975; PEDLEY, HOUSE & WAUGH, 1976; ZAMMIT-MAEMPEL, 1977). The uppermost formation is generally attributed to the Tortonian stage [Upper Miocene] (FELIX, 1973; PEDLEY, 1978), but GIANNELLI & SALVATORINI, 1972; FELIX, 1973) while the rest of the succession is granules in the « Clays » and in the Greensand, attributed a Messinian age to *some* of the Upper Coralline Limestone rocks. In 1975, the same authors attributed a similar age to this formation also on biostratigraphic grounds.

The *Laganum depressum* AG., herein recorded, is thought to have been collected from the lowermost division of the reef-bearing Upper Coralline Limestone. Though a Messinian age cannot be excluded, for *some* of the uppermost divisions, the lowermost beds are probably of Tortonian age (FELIX, 1973; PEDLEY, 1978).

At Il-Karraba, the Upper Coralline Limestone (U.C.L.) caps the « Clays » that form the promontory separating Ghajn Tuffieha bay from Gnejna bay. The U.C.L. in this region consists of two divisions: an upper compact, hard, light brownish limestone whose upper surface forms the characteristic Karraba plateau, and an underlying, much softer, creamy-yellowish (occasionally bluish) division made up entirely of originally horizontally aligned banks of the coralline algae *Lithothamnium* and *Lithophyllum*, with intercalated marly deposits that are highly fossiliferous. They abound in isolated chelae of various small crabs, *Argiope decollata* CHEMNITZ and small *Terebratulula* sp., oysters and echinoids chiefly *Brisus oblongus* WR., a Temnopleurid? *Arbacia*, *Schizaster parkinsoni* (DEFRANCE) and numerous isolated teeth of large echinoids.

As specimen GZM/E. 1000 described herein is relatively in a very good state of preservation and has no hard limestone attached to it, but merely some clay material in its peristomal opening, it is probable that it was recovered from the soft lower division of the Upper Coralline Limestone. Repeated search for further *Laga-*

num material in the easily accessible division at this locality has not been rewarding. On account of the dangers involved, the much harder upper division has not been properly investigated.

It is interesting to note that most of the « Tertiary » and « post-Tertiary » *Laganum depressum* material in the British Museum (Nat. Hist.) Collection was collected from analogous palaeoenvironmental conditions (« Reef Limestone » and the « Muddy Limestone » formations) of the Red Sea area thousands of miles away.

SYSTEMATIC PALAEONTOLOGY

Order CLYPEASTEROIDA A. AGASSIZ 1872

Suborder LAGANINA MORTENSEN 1948

Family LAGANIDAE A. AGASSIZ 1873

Genus *Laganum* LINK 1807

Laganum depressum L. AGASSIZ 1841

- 1841 - *Lagana depressa* (ex LESSON MS), L. AGASSIZ. *Monogr. Ech. viv. foss. Des Scutelles*, p. 110, pl. 23, figs. 1-7.
- 1867 - *Laganum depressum* var. *sinaticum* FRAAS. *Geol. aus d. Orient*, p. 333, pl. VI, fig. 15.
- 1873 - *Laganum depressum* A. AGASSIZ. *Rev. Echini*, p. 518, pl. XIII f, figs. 5-8.
- 1886 - *Laganum tumidum* DUNCAN & SLADEN. *Foss. Echin. Makram Ser.*, p. 379, pl. LVIII, figs. 6-10.
- 1894 - *Laganum fragile* MAZZETTI. *Cat. Echin. Mar Rosso e descr. sp. n.*, pp. 217-218, text fig. a-d (non BITTNER).
- 1894 - *Laganum delicatum* MAZZETTI. *Cat. Ech. Mar Rosso e descr. sp. n.*, p. 248, text figs. a-d.
- 1914 - *Laganum* sp. BAY et FOURTAU. *La Radiogr. et applic. Pal.*, pl. XII, fig. 1.
- 1922 - *Laganum depressum* KOEHLER. *Echin. Ind. Mus.*, pl. IX, figs. 1, 2, 7, 8; pl. XIII, fig. 3.
- 1925 - *Laganum depressum* CLARK, H. L. *Cat. Rec. Sea Urch Brit. Mus. (Nat. Hist.)*, p. 157.
- 1927 - *Laganum depressum* STOCKLEY. *Neog. Echin. Zanz. Protect.*, p. 115, pl. XXI, figs. 5 a, b.
- 1930 - *Laganum depressum* Ag. var. CURRIE. *Report IX Geol. Coll. coastl. Kenya Colony. Echin. Mc Kinn. Wood Coll.*, p. 175, pl. XVI, fig. 4.
- 1931 - *Laganum depressum* BRIGHTON. *The Geol. Farsan Is., Giz., Kam. Is., Red Sea*. pp. 324-326.
- 1971 - *Laganum depressum* CLARK A. M. & ROWE. *Shall. Wat. Indo-West Pac. Echin.*, pp. 114, 162.

NOMENCLATURE

Some authors like A. AGASSIZ, 1873; KOEHLER, 1922; CLARK, 1925, and CLARK & ROWE, 1971 have attributed the species *Laganum depressum* to LESSON, 1830. LESSON, however, never described or figured the species referred to. He had merely labelled some specimens in a collection as *Lagana depressa* (*nomen in collectione*). This is inferred from AGASSIZ, 1841, p. 111 wherein it is recorded that « Cette espèce (= *Laganum depressum*) provient de l'île Bourrou, d'où elle a été rapportée par MM. LESSON et GARNOT, qui l'ont déposée au Museum d'histoire naturelle de Paris sous le nom de *Lagana depressa* ». In view of the above L. AGASSIZ, 1841, who first published the name *Laganum depressum* and figured the species (pl. 23, figs. 1 - 7) should be its author, irrespective of the fact that out of politeness and courtesy, he himself had attributed the species to LESSON.

GEOGRAPHICAL AND GEOLOGICAL RANGE OF THE GENUS AND THE SPECIES

The genus *Laganum*, which has been recorded from the Eocene of Europe and from the Miocene to Recent of the Indo-Pacific region (WYATT DURHAM, 1966, p. 472), is herein recorded for the first time from the Upper Tertiary of the Maltese Islands and the Mediterranean region. This record extends still further the wide geographical range of the genus in Tertiary times, extending it from Java, East Africa, Red Sea and Suez to the Central Mediterranean region. The genus is now restricted to the shallow waters of the Indo-Pacific and its record from the Maltese Islands, not only confirms the presence of a former communication existing between European Tethys and the Indo-Pacific during Miocene times, but also furnishes another instance of the survival of Maltese Tertiary fauna in that region (ZAMMIT-MAEMPEL, 1979).

Positive records based on recent *Laganum* specimens in the British Museum (Nat. Hist.) collections indicate a depth range of 5 - 457 meters (CLARK & ROWE, 1971, Distribution Table, pp. 144-145); the species *Laganum depressum* AG., whose holotype was recorded from the East Indies from a depth of 10 m, is said to have a range of 5 m (East Africa and Madagascar) to 558 m (South Pacific).

British Museum (Nat. Hist.) collections reveal that in the fossil state *Laganum depressum* AG., has been encountered in the Miocene of Java (BM/E. 16535-79), Pliocene of the Red Sea Coast e.g. British Somaliland (BM/E. 18534-37), Saudi Arabia, Hassan Islands, Suez (BM/E. 11424-5), Plio-Pleistocene of the Red Sea, especially Farsan Islands (BM/E. 19523-94), Zanzibar, East Africa (described by STOCKLEY in 1927), and the Pleistocene of Kenya (BM/E. 18733-42).

MALTESE MATERIAL EXAMINED

Only one specimen, Author's Collection, registered as GZM/E. 1000. A medium-sized echinoid with a long pentagonal outline, rounded edges and uniformly inflated margins on the adapical surface; five genital pores, an elevated monobasal apical system with a sinuous groove for the madreporitic pores that are not individually distinct, and long petaloid areas exceeding two thirds of the diameter of test. Periproct close to the posterior margin. A double-layered interrupted, circular, internal canal system limited to the conspicuously inflated margins is revealed by industrial X-ray protography.

Shape. Test medium sized with long pentagonal outline, rounded edges, an elevated, low-conical, central region surmounted by apical system, and uniformly inflated margins adapically. The swelling is much more pronounced than in Red Sea and Zanzibar Tertiary and post-Tertiary specimens in the British Museum (Nat. Hist.) collections. Petaloid area gently convex. Tubercles on apical surface are slightly smaller than, but as densely packed as, those on adoral surface. Tuberculation on prominent surfaces, particularly petals, margins and edges, has been worn away and there is no evidence of the plate arrangement of the echinoid (This, however, is clearly evident in the Red Sea Plio-Pleistocene specimens BM/E. 19427 and 19593). Oral surface is gently concave from edge to central peristome. It was noted that the ratio of the maximum anterior diameter (at level of the antero-lateral ambulacral) to the maximum posterior diameter (at level of the postero-lateral ambulacral) in the Maltese specimen is always much less than that at the same level in specimens from the Plio-Pleistocene of the Reef Limestone of Khamran Islands, Red Sea.

Size. Test: Maximum antero-posterior diameter 29.85 mm;
Max. width at angles, just posterior to tips of antero-lateral petals 25.1 mm;
Max. width at angles just anterior to tips of postero-lateral petals 20.6 mm;
Max. height (apical system) 5.4 mm.

Margins: Width anterior 4.5 mm, posterior 5.5 mm;
Height (thickness) anterior and lateral 4.5 mm, posterior 4.0 mm.

Peristome: Anterior margin to anterior edge of peristome 14.0 mm;
Antero-posterior diameter 2.0 mm;
Width 1.8 mm;
Posterior edge of peristome to posterior margin 13.85 mm.

Periproctal opening: Antero-posterior diameter 1.65 mm;
Width 1.4 mm;
Posterior edge of periproct to posterior margin 3.4 mm.

Apical system. Central region of adapical surface is elevated and surmounted by the apical system, which is equidistant from both anterior and posterior borders. It is monobasal with a horizontal S-shaped sinuous groove anterior to genital pores 1 and 4, for housing the madreporitic pores that are not individually distinct. Gonopores five, with genital 1 and 4 wider apart than 2 and 3. It is probable that in the Red Sea area fossil *Laganum depressum* Ag. reached sexual maturity very early, for even small specimens have patent, narrow genital pores.

Ambulacra. Ambulacra are distinctly petaloid and slightly raised (convex), forming well developed, long, pointed petals that widen up in their proximal third and taper off almost to a closed end distally. In this feature they contrast with the petals of the Red Sea and Zanzibar fossil specimens seen in the British Museum (N.H.) collections, which are of a more uniform width throughout and which start tapering off almost to a closed end only in their distal third.

The Maltese *Laganum depressum* petals are narrower than those of similar specimens from the Miocene of Java (BM/E. 16563-79), and reach as far as the inner edge of the inflated margin of the test with the most distal 1-3 members in the series of their adradial (outer) pores extending also over it. Petals I, III, V are longer than II and IV. The former group (I, III, V) has petals 11.5 mm long, that is 0.74 of length of radius. The second group (II, IV), that is the antero-lateral petals, is 7.0 mm long or 0.53 of length of radius. Petals with unequal poriferous zones, external rows tending to be longer than internal and S-shaped; the outer member of each pore-pair (adradial) tending to be horizontally elongated. The number of pores in each row varies. In an anti-clockwise direction, starting from right postero-lateral petal (Ray I Loven), the count is as follows: (30, 29, 27, 27), (26, 26, 26, 27), (32, 32, 28, 31), (27, 26, 28, 28), (29, 28, 32, 33). Poriferous areas are abraded, but some petals still show the pores to have been conjugate. Marked allignment irregularity present in pores of Ray III.

Oral surface. This is slightly concave centrally, with simple, unbranched food grooves limited to this concavity and therefore not reaching margin.

Periproct. Subcircular (1.65 mm long and 1.4 mm wide), and closer to margin (3.8 mm away) than peristome (8.5 mm away). After examining the BM(NH) collections it was verified that the shape of periproct in *L. depressum* Ag. is very variable with considerable variations being noted even in specimens originating from the same location and geological horizon.

Tuberculation. Larger than that on adapical surface and apparently non-crenulate and non-perforate.

Peristome. Depressed, central, 14 mm away from either anterior or posterior margin and slightly longitudinal (2.4 mm high, 1.8 mm wide). No appreciable differences in shape of peristome was noted in the numerous *Laganum* material examined.

Bourrelets. Only very slightly developed.

RADIOGRAPHY AND INTERNAL STRUCTURE OF *Laganum*

There is a marked superficial resemblance between *Laganum* and *Clypeaster*, particularly *Laganum depressum* AG. and *Clypeaster scutiformis* LAMARCK. Various tests have been suggested to differentiate between the two genera (CLARK & ROWE, 1971, p. 159, fn. 5), but most of these cannot be carried out on fossil specimens. Recent or fossil specimens belonging to the two genera can, however, be very easily distinguished radiologically, for *Laganum* is characterised by a segmented and sacculated tube system (with inner sacculatation at a higher level) running within the inflated margin. This feature is completely lacking in *Clypeaster*, and can be detected even in fragments of *Laganum*. It is clearly visible to the naked eye in specimens with a chipped margin (GZM/E. 1000, BM/E. 19458).

The value of radiography to palaeontology was first noted in 1914 by BAY & FOURTAU. The genus *Laganum* seems to be particularly suited for X-ray investigation, as none of the hundreds of specimens examined in the British Museum (N.H.) collections had any hard solid matrix attached to its external surface or inside its internal cavity.

GZM/E. 1000 from the Upper Coralline Limestone [Upper Miocene] of Malta and BM/E. 19470 from the Plio-Pleistocene of the Red Sea Karaman Is. were X-rayed and their internal structure compared. The marginal tubular system of the two echinoids was found to be slightly different in arrangement. The Maltese specimen revealed the presence of five delicate supports radiating from the central region and alternating with five still more delicate and shorter rays. None of the radial structures reach the margin. No such features noted in the radiograph print of BM/E. 19470 from the Red Sea, which has a much filmsier test.

Chipped and broken *Laganum* specimens in the BM(NH) collections (BM/E. 19409, 19421, 19427, 19458, 19470, 19516, 73234) and GZM/E. 1000 give further valuable information on the internal structure of *Laganum*. They reveal a water vascular system in the form of a ring tube divided into five segments running inside the inflated margin. Each segment has at its middle a wide pore through which it communicates with the distal end of the nearest petal. Two sacculatation, one on either side of the wide pore, and directed

in opposite directions, protrude from the medial surface of each tube segment and run almost parallel to it and at a higher level, inside the inflated margin (see BM/E. 19458, BM/E. 19421, GZM/E. 1000 fig. 1 d, and BM/E. 19470 fig. 2). Irregularities in the number of sacculations is noted in the region of Ray 1 in GZM/1000 (fig. 1 d). There is no x-ray evidence of the adjacent tube segments communicating with each other. An isolated, irregular, tubular cavity with a narrow pore leading to the interambulacral area intervenes between each tube segment (see fig. 1 d and fig. 2).

Pillar supports flank the narrow pore in all the interambulacra except in ray 5, where the anus has lateral supports but none anterior to it. Similar pillar supports are lacking also around all wide pores encountered opposite the tip of each petaloid ambulacrum (see BM/E. 19516).

A number of radially arranged, perforated partitions or supports are noted peripherally bridging the adapical to the adoral surfaces. With age and increase in size, the tiny round pores in these vertical partitions become vertical slits of varying dimensions (see BM/E. 19409 and BM/E. 79427).

BM/E. 73234 from the Pliocene of El Waji, Saudi Arabia, Red Sea Coast, seems to have developed a special internal support system in the region of the antero-lateral ambulacra. The wide pores of the vascular system in this region are supported by « pleated curtains ». The anterior ambulacrum and the postero-lateral ambulacra, however, do not show such a development.

The arrangement of the internal support system in BM/E. 19427 and in BM/E. 19421 from the same locality (Plio-Pleistocene Reef Limestones, Zifzaz Is., Red Sea) is almost identical, but it differs markedly from that of the Maltese specimen GZM/E. 1000 or from that of other Plio-Pleistocene specimens from the Kamaran Is., Red Sea (BM/E. 19458, BM/E. 19470).

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PLATES

Fig. 1 a - d - *Laganum depressum* AGASSIZ. Upper Coralline Limestone (Upper Miocene), Il-Karraba, NW Malta. Author's Collection: GZM/E. 1000.

Fig. 1 a adapctical view, Fig. 1 b adoral view, Fig. 1 c right antero-lateral view. Chipping of inflated margin between ray I and II (Loven) exposing tubular water canal system.

Fig. 1 d Positive print of radiograph of Fig. 1 b.

Fig. 2 - *Laganum depressum* AGASSIZ. Plio-Pleistocene Reef Limestone, Kamanan Islands, Red Sea. British Museum (Natural History) Collection. Positive print or radiograph of BM/E. 19470 (adoral and adapical surfaces damaged).

