First Record of a New Species of Amblypygus (Echinoidea) from the Middle Miocene of Mersa Matruh, Western Desert, Egypt

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First record of a new species of *Amblypygus* (Echinoidea) from the middle Miocene of Mersa Matruh, Western Desert, Egypt

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Abstract. The echinoid genus *Amblypygus* Agassiz is reported for the first time from the middle Miocene and is represented by a new species, *A. matruhensis* sp. nov., from the area west of Mersa Matruh, Western Desert, Egypt. This extends the range of *Amblypygus* from the lower Eocene to the middle Miocene. A morphological comparison between the two genera *Amblypygus* and *Echinoneus* shows that they differ in that *Amblypygus* has a semi-ethmolytic apical disc and crenulate, perforate tubercles whereas *Echinoneus* has an ethmophract apical disc and non-crenulate, non-perforate tubercles. The paleoecology and the paleogeography of the genus *Amblypygus* are discussed.

Key words: *Amblypygus matruhensis* sp. nov., Mediterranean region, paleoecology, paleogeography, Western Desert of Egypt

Introduction

Amblypygus Agassiz, 1840, is an echinoid genus which has, until now, been considered only to occur in the Eocene and Oligocene epochs (Wagner and Durham, 1966; Smith and Kroh, 2015). The genus is well known from the Caribbean, North America, West African, Mediterranean and Indo-West Pacific regions. It has not been reported from Australia or South America. According to Rose (1982), *Amblypygus* has a long history of taxonomic controversy. Many European authors (e.g. Roman and Gorodski, 1959; Sapoundjieva, 1964) have followed Mortensen (1948) in ascribing the genus to the order Cassiduloida, either to the family Echinobrissidae or to the family Echinolampadidae (Roman, 1965). Roman (1968) followed Duncan and Sladen (1884) in ascribing the genus to the order Holectypoida, usually placing it in the family Echinoeidae. Wagner and Durham (1966) ascribed *Amblypygus* to the order Holectypoida, suborder uncertain, family uncertain. Kroh and Smith (2010) and Smith and Kroh (2015) ascribed *Amblypygus* to the order Echinoneoida, family Echinoneidae.

Material

During stratigraphic studies carried out in several middle Miocene sections west of Mersa Matruh City, Western Desert of Egypt (Figure 1), six echinoid specimens belonging to the genus *Amblypygus* were collected. These specimens originate from the Marmarica Formation of three different localities, namely Wadi Um El Ashtan, Wadi El Habis and Wadi Agiba; two specimens from each section were collected from the White Limestone Fossiliferous Member (Figure 2). Five of these specimens are complete and are well preserved. The sixth specimen shows partially preserved ambulacra and a complete oral surface.

Geological setting and stratigraphy

The northern part of the Western Desert of Egypt is covered by thick deposits of Miocene rocks. Excellent outcrops of these rocks are observed along the Mediterranean Sea at Mersa Matruh (Figure 1). Following Said (1962), the Miocene beds of that area belong to two formations. The lower is the Moghra Formation of early Miocene (Burdigalian) age as indicated by the presence of the foraminiferal index fossil *Spiroclypeus orbitoideus* Douvillé. The upper is the Marmarica Formation and consists of

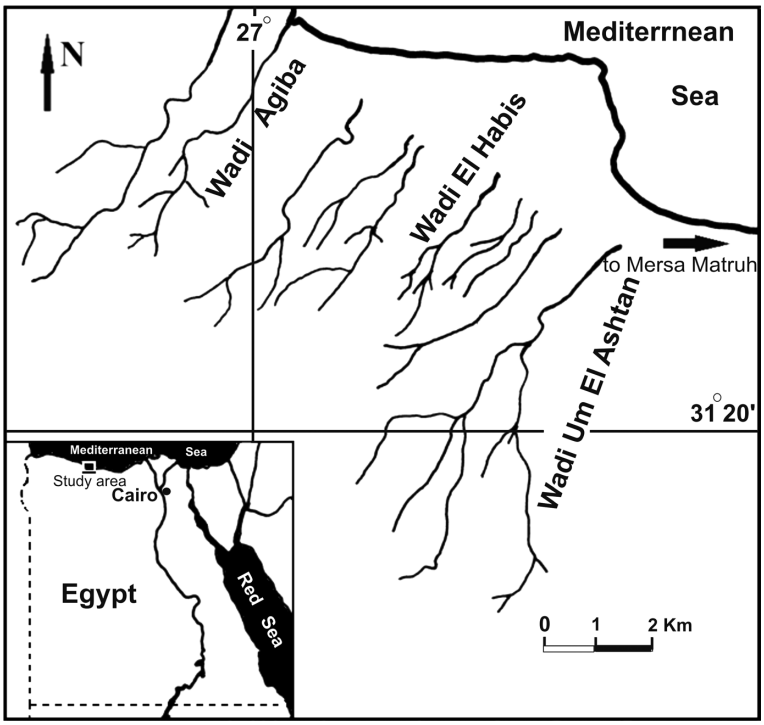


Figure 1. Location map of the studied sections (modified after Google Earth).

entirely marine deposits that contain the index fossil *Neoalveolina* (*Borelis*) *melo* (Fichtel and Moll). This indicates that this formation is of middle Miocene age (Langhian–Serravallian).

The middle Miocene Marmarica Formation is exposed widely in the northern Western Desert. It was first introduced into Egyptian lithostratigraphy by Said (1961) for the middle Miocene limestone intercalated with clay and marlstones with a number of oyster banks and reefal beds exposed north of Siwa Oasis. The Marmarica Formation consists of a lower member on the El Diffa plateau (El Diffa Plateau Member), which consists of alternating cross-bedded carbonates, fissile shales and marlstones (Said, 1990), a middle Snow White Chalk Member and an upper White Limestone Fossiliferous Member in which the echinoids are found (Figure 2).

The Wadi Um El Ashtan Section is located 16 km west of Mersa Matruh City (31°21'00"N, 27°03'99"E). The total thickness of these Miocene beds is 63.5 m. The section is composed mainly of limestones and marlstones of the White Limestone Member.

The Wadi El Habis Section is located 2.8 km west of the Wadi Um El Ashtan section (31°22'81"N, 27°03'54"E). The Miocene beds are about 44 m in thickness. The middle Miocene consists here mainly of limestones and marly limestones of the White Limestone Member.

The Wadi Agiba Section is located 23 km west of Mersa Matruh City, nearly 7 km west of Um El Ashtan section (31°25'78"N, 27°00'33"E). The total thickness of the Marmarica Formation beds here is about 35 m, and consists of limestones and marly limestones, also in the White Limestone Member.

Introduction to the genus *Amblypygus* Agassiz, 1840

The type species, *Amblypygus dilatatus* Agassiz and Desor (1847, p. 109; Cotteau, 1887, p. 488, pls. 130, 131) is from the Eocene of Europe. It was named by Agassiz (1840, p. 5) without description and was attributed to the Cretaceous of the Crimea, but Cotteau cited only localities in France, Switzerland, Italy and Spain. Agassiz (1840, p. 17) gave a brief diagnosis of *Amblypygus*: "Ambitus subcircularis vel subovatus. Testa depressa. Os transversum impressum; anus maximus, longitudinalis, inferus. Ambulacra poris supra sulco conjuncitis". Cotteau (1863) made some most important remarks on the generic diagnosis of *Amblypygus* which characterized that genus and added (p. 109) that "the ambulacral pores are oblong and conjugate, the tubercles are close and homogeneous, and no floscelle in the peristome". Characters of *A. dilatatus*, as figured by Cotteau, 1887, are long, straight, open petals extending to the margin, with circular inner pores and elongated outer pores; oblique distorted central peri-

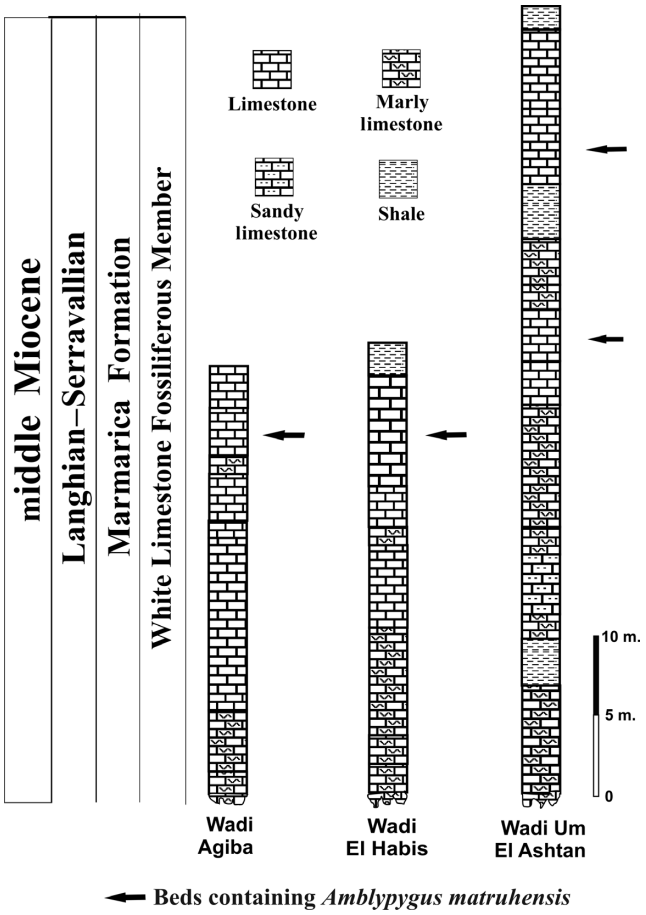


Figure 2. Lithology of the middle Miocene successions of the studied sections showing beds containing *Amblypygus matruhensis* sp. nov. (arrows).

stome; and a large, flush, bilunate periproct between the margin and the peristome. The circular shape and large, flush periproct of *Amblypygus* resembles that of *Holectypus*, but the circular, notched peristome of *Holectypus* is quite different. *Amblypygus* appears to be more closely related to *Echinoneus*, which has a similar peristome and periproct, but differs in that its ambulacra are less distinctly petaloid and the outer pores on its upper surface are not elongated.

Comparison among *Amblypygus*, *Echinoneus* and the collected specimens

Due to the close similarity between *Amblypygus* and *Echinoneus*, a comparison between the two genera has been made in order to explain the main differences between them and to find out to which genus the specimens of the present study belong (Figure 3). All the data of these two genera are obtained from the "Echinoid directory" (Smith and Kroh, 2015).

It is clear from this comparison that the specimens of the present study are very similar and more closely related to the genus *Amblypygus* than to *Echinoneus*, except for the presence of non-perforated tubercles. Srivastava (2009) described *Amblypygus pentagonalis* Duncan and Sladen, 1883, p. 47, with non-perforated tubercles. Thus, the specimens of the present study are closer to the genus *Amblypygus*.

Paleogeographic distribution of *Amblypygus*

Of 21 species formally ascribed to *Amblypygus* by different authors, only 15 species appear valid. Table 1 summarizes the global paleogeographic distribution of these species. India has the largest number of nominal *Amblypygus* species with 7 species recorded from the Eocene.

Amblypygus dilatatus Agassiz and Desor, 1847, is widely distributed in the Mediterranean region and West Africa, including Spain (Cotteau, 1889, p. 41, 1890, p. 51; Lambert, 1927–28, p. 74), France (Lambert, 1905, p.107; Roman and Gorodiski, 1959, p. 17; Roman, 1968, p. 260), Italy (Oppenheim, 1902, p. 197), Bulgaria, Greece, Romania, Hungary, Ukraine and Germany (Sapoundjieva, 1964, p. 13), Slovenia (Mikuz and Pavlovec, 2004, p. 16), Austria and Crimea (Collignon, 1930, p. 549), Switzerland (Loriol, 1875, p. 44), Mozambique, Congo, Angola and Madagascar (Dartevelle, 1953, p. 43), Senegal (Tessier, 1952, p. 295; Gorodiski, 1951, p. 322), Oman (Roman and Strougo, 1994, p. 32), and Egypt (Loriol, 1880, p. 84; 1881, p. 17; Fourtau, 1899, p. 646). The remaining species, however, have either been placed into other genera (e.g. *Amblypygus melitensis* Wright, 1864 and *A. lorioli* Simonelli, 1889 are ascribed to genus *Echinoneus*) or they have been determined to be synonyms of other species of *Amblypygus*. The subgenus *Paramblypygus* was defined by Roman (1973) to accommodate *A.* (*P.*) *houphoueti* Roman from the Paleocene to Eocene of the Ivory Coast, West Africa. This monospecific taxon is distinguished from *Amblypygus* s.s. by its anteriorly situated ethmophract apical system; anterior ambulacrum in depression on oral surface; and lack of demiplates in ambulacral plate structure.

Paleoecology of *Amblypygus*

Amblypygus is extinct, but it is possible to make inferences about its paleoecology from the associated echinoid fauna, such as *Clypeaster*, *Echinolampas* and *Agassizia*, which are extant. The living species of *Clypeaster* and *Echinolampas* are shallow burrowers (Kier, 1975), and are largely confined to moderate- to coarse-grained

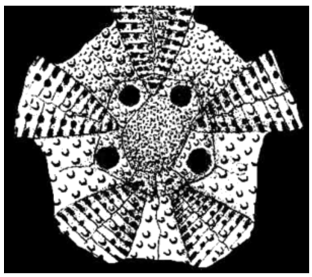
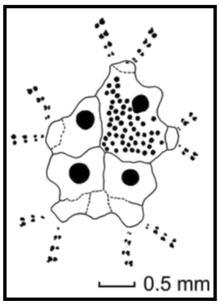
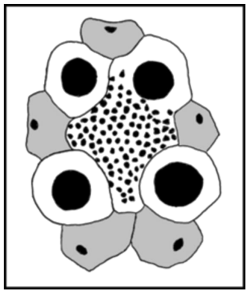
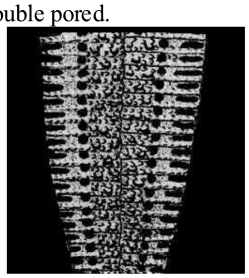
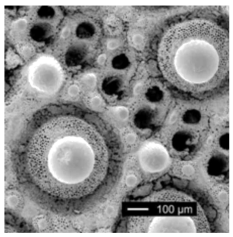
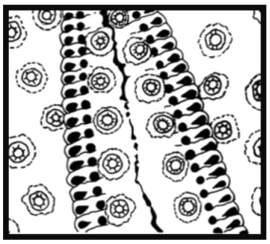
Amblypygus	*Echinoneus*	Present specimens
Test large, circular or ovoid in outline, aboral side low arched, subconical, margin broadly rounded, oral surface sunken towards the peristome.	**Test** of moderate size, ovoid, margin broadly rounded, oral surface sunken towards the peristome.	**Test** small, ovoid in outline, margin rounded, oral surface sunken around the peristome.
Apical disc: subcentral, tetrabasal with four genital pores, large madreporite.	**Apical disc:** central, tetrabasal with four genital pores.	**Apical disc:** central to subcentral, tetrabasal, with four genital pores, with large madreporite.
		
Apical disc:Semi-ethmolytic.	**Apical disc: Ethmophract.**	**Apical disc: Semi-ethmolytic.**
Ambulacra with long petals, extending almost to margin, open, poriferous zones, tapering distally, pores conjugate, outer series elongate transversely; all ambulacral plates double pored.	**Ambulacra** narrow, petals undeveloped, pores double throughout and arranged uniserially. Ambulacral plating trigeminate with every third element a tiny adradial demiplate..	**Ambulacra** petaloid, Petals long, extending to margin, open. Poriferous zones with conjugate pores, outer pores elongated transversely, inner pores round.
		
Periproct oral, very large, longitudinally elongate, midway between peristome and the posterior edge of the test	**Periproct** oral, very large, longitudinally elongate, close to the peristome.	**Periproct** oral, very large, longitudinally elongate, close to posterior margin.
Peristome large, subcentral, oblique, depressed	**Peristome** large, central or slightly anteriorly, oblique, depressed.	**Peristome** large, subcentral anteriorly, oblique, depressed.
Tubercles: crenulate, perforate.	**Tubercles:** noncrenulate, nonperforate.	**Tubercles:** crenulate, nonperforate.

Figure 3. Comparison among *Amblypygus*, *Echinoneus* and the material of the present study. All the data are derived from http://www.nhm.ac.uk/research-curation/research/projects/echinoid-directory.

sand in shallow water (McNamara and Kendrick, 1994). Mortensen (1948) reported extant *Echinolampas ovata* (Leske) in a depth of 9 m to 75 m while *E. crassa* (Bell) was found on coarse-grained sandy substrates between 18 m and 24 m in False Bay, South Africa. Mooi (1990) found the living Caribbean cassiduloid species *E. depressa* Gray

Table 1. Paleogeographic distribution of *Amblypygus* species.

Amblypygus species	Eocene			Oligocene
	early	middle	late	
A. altus Duncan and Sladen, 1883		India		
A. americanus Desor, 1858 = *A. merrilli* Clark and Twitchell, 1915 = *A. apheles* Agassiz, 1847		Jamaica, California	Florida, Georgia	
A. checchiai Socin, 1942				Somaliland
A. depressus Sánchez Roig, 1953		Cuba		
Amblypygus dilatatus Agassiz and Desor, 1847	Egypt, Slovenia, Spain	Egypt, Oman, France, Spain, Crimea, Switzerland, Bavarian Alps, Austria, Senegal	Bulgaria, France, Italy, Spain, Crimea, Switzerland	Bulgaria, Italy
A. dilatatus costulatus Fourtau, 1905		Egypt		
A. dilatatus mokattamensis Fourtau, 1913		Egypt		
A. douvillei Lambert in Sánchez Roig, 1949			Cuba	
A. latus Duncan and Sladen, 1884		India	India	
A. moriensis Srivastava and Singh, 2001		India		
A. patellaeformis Duncan and Sladen, 1884		India	India	
A. pellati Cotteau, 1887 = *A. arnoldi* Cotteau, 1863 (non Agassiz)			France, Italy	
A. pentagonalis Duncan and Sladen,1883		India		
A. subrotundus Duncan and Sladen,1884		India	India	
A. tumidus Duncan and Sladen, 1884		India	India	

at depths of 30 to 310+ m. *Echinolampas* lives in relatively coarse-grained carbonate sands that are composed largely of coralline and algal fragments (Mooi, 1990). The modern *Clypeaster subdepressus* (Gray) lives in sand and buried as deeply as 25 mm below the surface (Kier and Grant, 1965), or it moves along the top of the sand with sand and shell fragments held by its tube feet over the top of its test (Kier, 1997). *Agassizia* has two extant species: *A. scrobiculata* Valenciennes, known from the west coast of Central America; and *A. excentrica* Agassiz, from the Caribbean region and the Gulf of Mexico. Both of these species are restricted to tropical waters (Kier, 1980) and apparently live in sandy environments (Kier, 1997).

In summary, the paleoecology of *Amblypygus matruhensis* sp. nov. can be reconstructed as in or on coarse-grained carbonate sands of shallow water, well oxygenated environments. In addition, it lived in tropical or subtropical regions comparable to the Red Sea or Caribbean.

Systematic description

Remarks.—Type and illustrated specimens of taxa described herein are housed in the Geological Museum, Faculty of Science, Minia University (GMFMU). The classification of Kroh and Smith (2010) and Smith and Kroh (2015), is adopted.

Class Echinoidea Leske, 1778
Subclass Euechinoidea Bronn, 1860
Cohorte Irregularia Latreille, 1825
Order Echinoneoida Clark, 1925
Family Echinoneidae Agassiz and Desor, 1847
Genus ***Amblypygus*** Agassiz, 1840
Amblypygus matruhensis sp. nov**.**

Figures 4–8

Material.—Five well preserved specimens; a sixth specimen is partially preserved on aboral surface, while its oral surface is complete. Holotype: MUFGM 2015 E101; para-

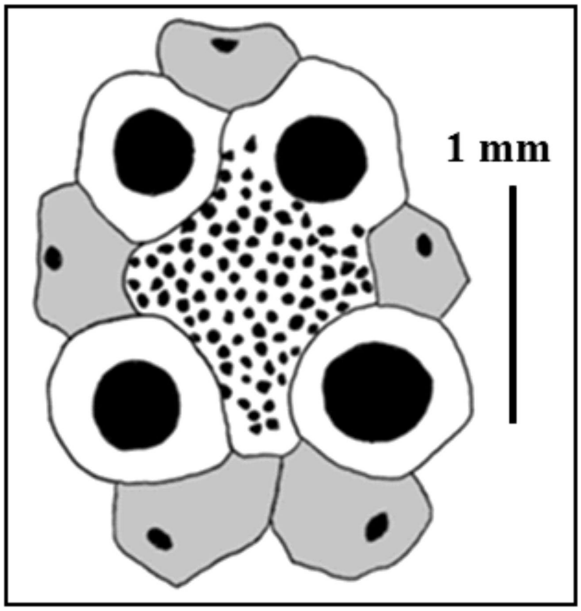


Figure 4. *Amblypygus matruhensis* sp. nov., camera lucida drawing of the semi-ethmolytic apical disc (holotype, MUFGM2015 E101).

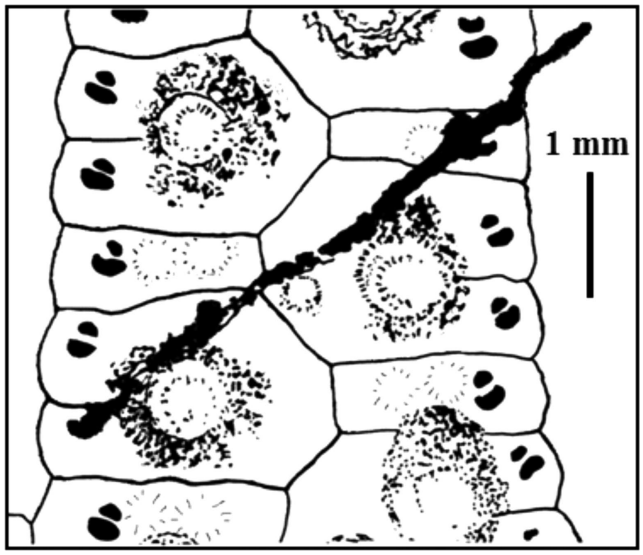


Figure 6. *Amblypygus matruhensis* sp. nov., camera lucida drawing of the demiplate arrangement at the oral surface (holotype, MUFGM2015 E101).

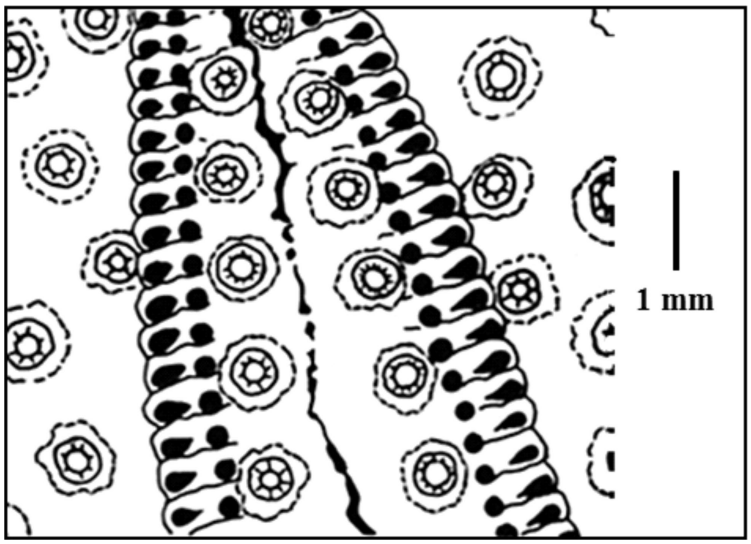


Figure 5. *Amblypygus matruhensis* sp. nov., camera lucida drawing of the shape of the pore pairs at the aboral surface (holotype, MUFGM2015 E101).

types: MUFGM 2015 E102–106.

Etymology.—The new species is named after Matruh City, Egypt.

Diagnosis.—Test small, depressed, ovate in outline; apical disc central to eccentric anteriorly, semi-ethmolytic; ambulacra straight; peristome relatively large, oval, oblique eccentric towards anterior margin; periproct lies on the oral surface, very large, longitudinally elongate, midway between peristome and the posterior edge of test.

Description

Test small, length ranging from about 28.5 mm to about 34 mm, slightly ovate longitudinally, longer than broad, width 83–87 percent of test length, depressed, height 38–49 percent of test length; margin slightly tumid and well rounded; aboral surface flattened dome-shaped; oral surface concave centrally, depressed around peristome. Apical disc small and compact, central to eccentric ante-

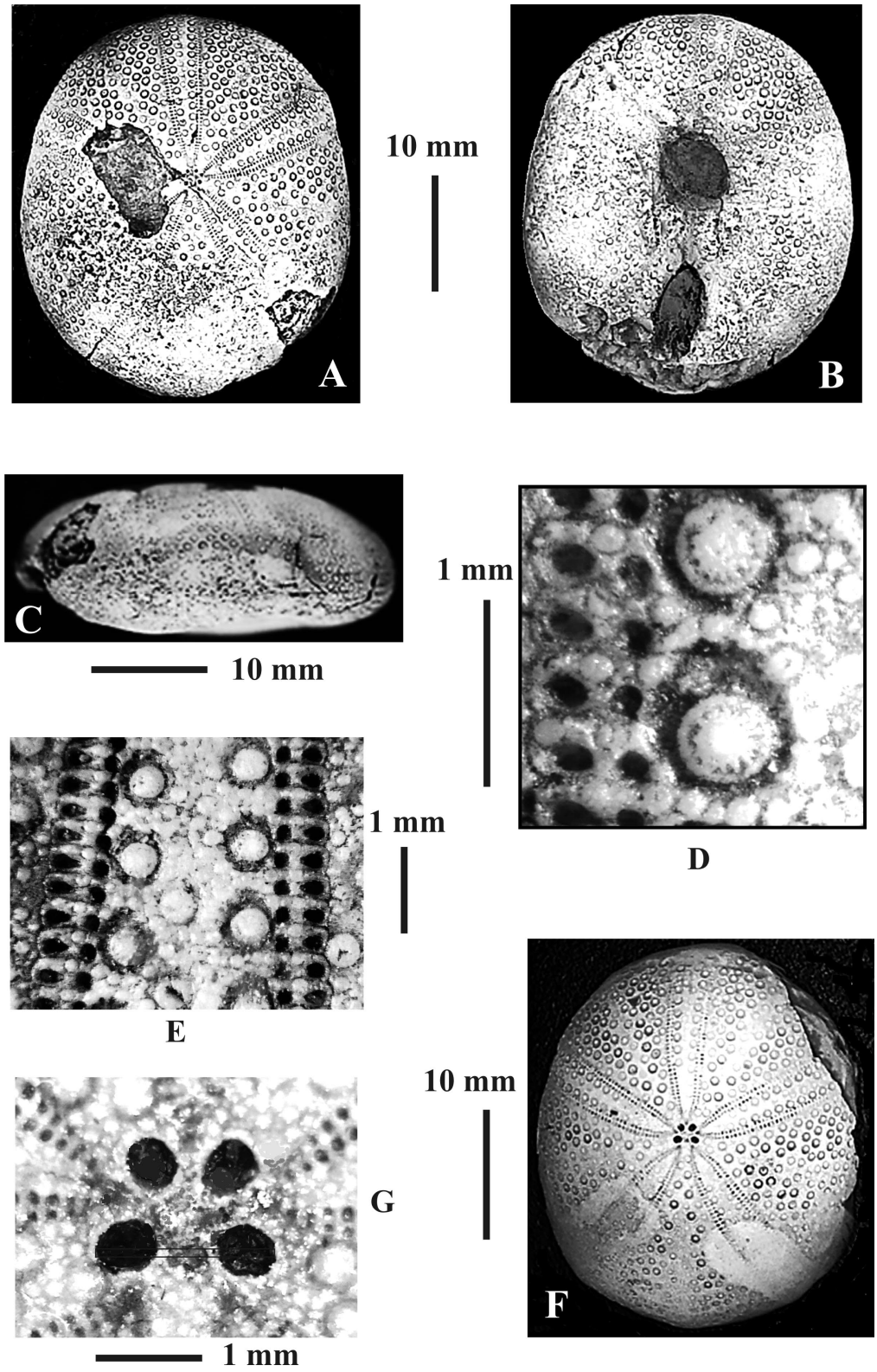


Figure 7. *Amblypygus matruhensis* sp. nov. **A–E,** holotype, MUFGM2015 E101; A, aboral surface; B, oral surface; C, side view; D, part of ambulacrum III showing the crenulated tubercles; E, part of ambulacrum I showing the shape of pore-pairs; **F, G,** paratype, MUFGM2015 E102; F, aboral surface; G, apical disk.

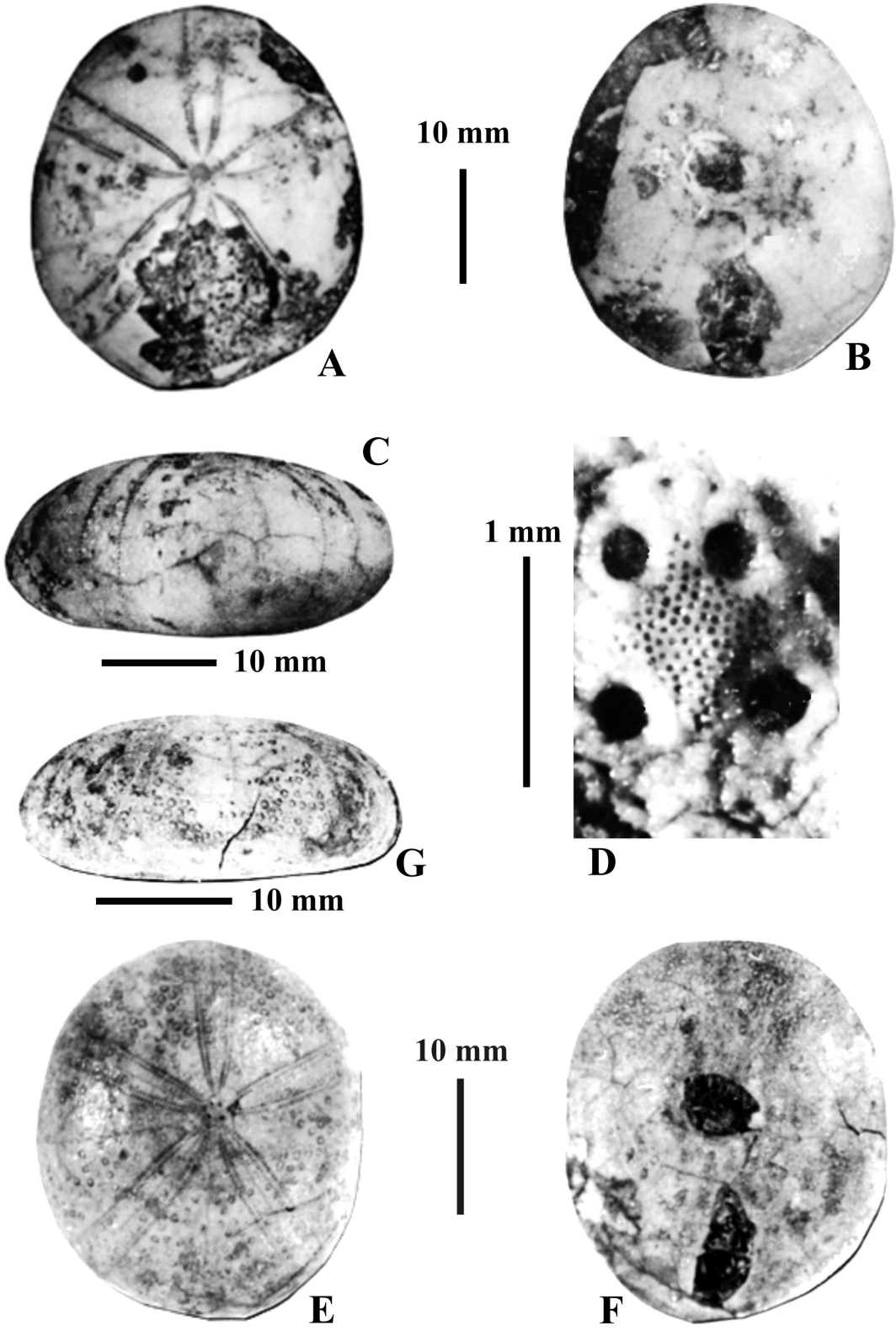


Figure 8. *Amblypygus matruhensis* sp. nov. **A–D,** paratype, MUFGM2015 E103; A, aboral surface; B, oral surface; C, side view; D, apical disc; **E–G,** paratype, MUFGM2015 E104; E, aboral surface; F, oral surface; G, side view.

riorly, located at 41–50 percent of test length, tetrabasal and semi-ethmolytic (Figure 4); with four relatively large rounded genital pores, anterior pair relatively slightly less in diameter than posterior pair; anterior genital pores being nearer together than posterior pair; madreporite extends posteriorly separating genital plates 1 and 4, and occupying most of apical disc; ocular plates small, subpentagonal in shape. Ambulacral area petaloid, widely open, reaching nearly to margin of test; more or less narrow, flush or slightly raised; petal III smallest and narrowest; petals I and V longest, 51–51.3 percent of test length, broadest 10–11.8 percent of test length. Interambulacral areas broad, covered with numerous crenulated, imperforate tubercles. Poriferous zones well developed and slightly increase in width from apical disc towards test margin, maximum width at middle and gradually close near ambitus, thence becoming very narrow and consisting of a straight series of small pairs; inner pores small, round and arranged in a straight linear series whereas outer ones are slightly elongate transversally (Figure 5). Pore pairs separated by a raised costa. Ambulacral plates at oral surface consist of demiplates with two pore pairs (Figures 6 , 7E). Interporiferous zones relatively broad, about six times as wide as one poriferous zone, maximum width near test margin. Tubercles of both ambulacral and interambulacral areas very small, crenulated, imperforate. Peristome large, placed in an oblique position, its longest diameter being about 40° to transverse axis of test, found in a well developed deep depression, widely open, slightly eccentric anteriorly, its center situated at about 40 per cent of test length from anterior margin; no floscelle. Periproct lies fully on the oral surface, large, slightly larger than peristome, length 24 percent of test length, width 12 percent of test length, situated near posterior margin, occupies more than half of area between peristome and test margin, oval or pyriform in outline, with major diameter in direction of longitudinal axis of test, slightly depressed.

Remarks.—On the one hand, *Amblypygus matruhensis* sp. nov. differs from all other known *Amblypygus* species in having a small test ranging in length between 28.5 and 34 mm, while in the other species the length ranges between 47 and 124 mm as in *A. americanus* Desor. On the other hand, the new species closely resembles *A. dilatatus* Agassiz and Desor, 1847, but differs chiefly in having a more elongate and oval test, which is of lesser height. The ambulacral petals and the poriferous zones are much narrower; the periproct is slightly larger and wide, placed at relatively a great distance from the peristome.

Occurrences.—Marmarica Formation, middle Miocene (Langhian–Serravallian), at Wadi Um El Ashtan, Wadi El Habis and Wadi Agiba, Mersa Matruh, Western Desert, Egypt.

Summary and conclusions

1) The echinoid *Amblypygus matruhensis* sp. nov. is described from the middle Miocene of northern Egypt.

2) This is the first record of *Amblypygus* from the middle Miocene (Langhian–Serravallian) of Egypt, extending the stratigraphic range of the genus from the lower Eocene to the middle Miocene.

3) *Amblypygus* is a widespread species in the Mediterranean region. It has not been recorded from South America and Australia.

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