

OLIGOCENE ECHINOIDS FROM WADI AL GHADAF, JORDAN

LOUIS G. ZACHOS¹, AHMAD SMADI² & FAYEZ AHMAD³

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Abstract. A small collection of echinoids from the Eastern Desert of Jordan includes the species *Clypeaster biarritzensis*, *Amphiope?* sp., *Echinolampas cherichirensis*, and *Eupatagus meslei*. This fauna closely resembles faunas of early Oligocene age from North Africa. The presence of the associated foraminifera *Nummulites intermedius* and *N. fichteli* dates the upper portion of the Wadi Shallala Formation exposed in the area of Wadi Al Ghadaf as early Oligocene (Rupelian), younger than the generally accepted middle (Bartonian) to late Eocene (Priabonian) age of this formation. The presence of rocks of this age in Jordan along what was probably the southern margin of the Tethyan Seaway is evidence that communication between the eastern and western provinces of the Western Tethys Region still existed in this area at this time.

Riassunto. Una piccola collezione di Echinoidi proveniente dal Deserto Orientale della Giordania include le specie *Clypeaster biarritzensis*, *Amphiope?* sp., *Echinolampas cherichirensis*, e *Eupatagus meslei*. Questa fauna è molto simile a faune dell'Oligocene inferiore del Nord Africa. I foraminiferi associati come *Nummulites intermedius* e *N. fichteli* consentono di datare all'Oligocene inferiore (Rupeliano) la porzione superiore della Formazione Wadi Shallala, affiorante nell'area di Wadi Al Ghadaf. Questa età è più recente di quella generalmente attribuita a questa formazione (Bartoniano - Priaboniano). La presenza di rocce di questa età in Giordania, lungo quello che fu probabilmente il margine meridionale della Tetide, prova che le comunicazioni tra le province occidentali ed orientali della Tetide Occidentale erano ancora aperte in questa area durante l'Oligocene inferiore.

Introduction

The Cenozoic echinoid faunas of the Middle East, and particularly Jordan, are not well known. This is the first report of a small but interesting fauna collected

from lower Oligocene rocks in the Wadi Al Ghadaf area of eastern Jordan. The combined presence of the species *Clypeaster biarritzensis*, *Amphiope?* sp., *Echinolampas cherichirensis*, and *Eupatagus meslei* suggests an early Oligocene age for the fauna. Foraminifera from the section belong to the *Nummulites fabianii* group and are probably conspecific with *Nummulites intermedius* and *N. fichteli*, which are considered to be index fossils for the early Oligocene (personal communication, Prof. Dr. Mohamed Boukhary, Ain Shams University, Egypt). The species of *Nummulites* present and the apparent lack of lepidocyclinid foraminifera indicate the Jordanian fauna corresponds to the shallow benthic foraminiferal biozone SB 21 (Cahuzac & Poignant 1997) and a lower to middle Rupelian age.

Study Area, Stratigraphy and Age

The study area (centered at 31° 27' 23" N, 36° 36' 42" E, 693 m above sea level) is in the Wadi Al Bisseh, located in the southwest portion of the Wadi Al Ghadaf area, south of Azraq, in the Al Azraq – Wadi as Sirhan Basin (Bender 1975) of Jordan (Fig. 1A). The geologic section (Fig. 1B,C) is composed of the upper part of the Wadi Shallala Formation. The base of the Wadi Shallala Formation section is made up of white to light grey chalky sheet-like, fractured limestone, overlain by white, hard fossiliferous limestone containing bivalves. This bed is in turn overlain by white to creamy, hard, lenticular nummulitic limestone, containing echinoids, bivalves, gastropods and corals. Above this is a medium

1 Department of Geological Sciences, Jackson School of Geosciences, The University of Texas at Austin, 1 University Station C1100, Austin, Texas 78712-0254, USA. E-mail: zachos@mail.utexas.edu

2 Dead Sea Museum, 16384 Madaba, Jordan. E-mail: drsmadi@yahoo.com

3 Faculty of Natural Resources and Environment, Department of Earth and Environmental Sciences, The Hashemite University, P.O. Box 330127, Zarqa 13133, Jordan. E-mail: fayeza@hu.edu.jo

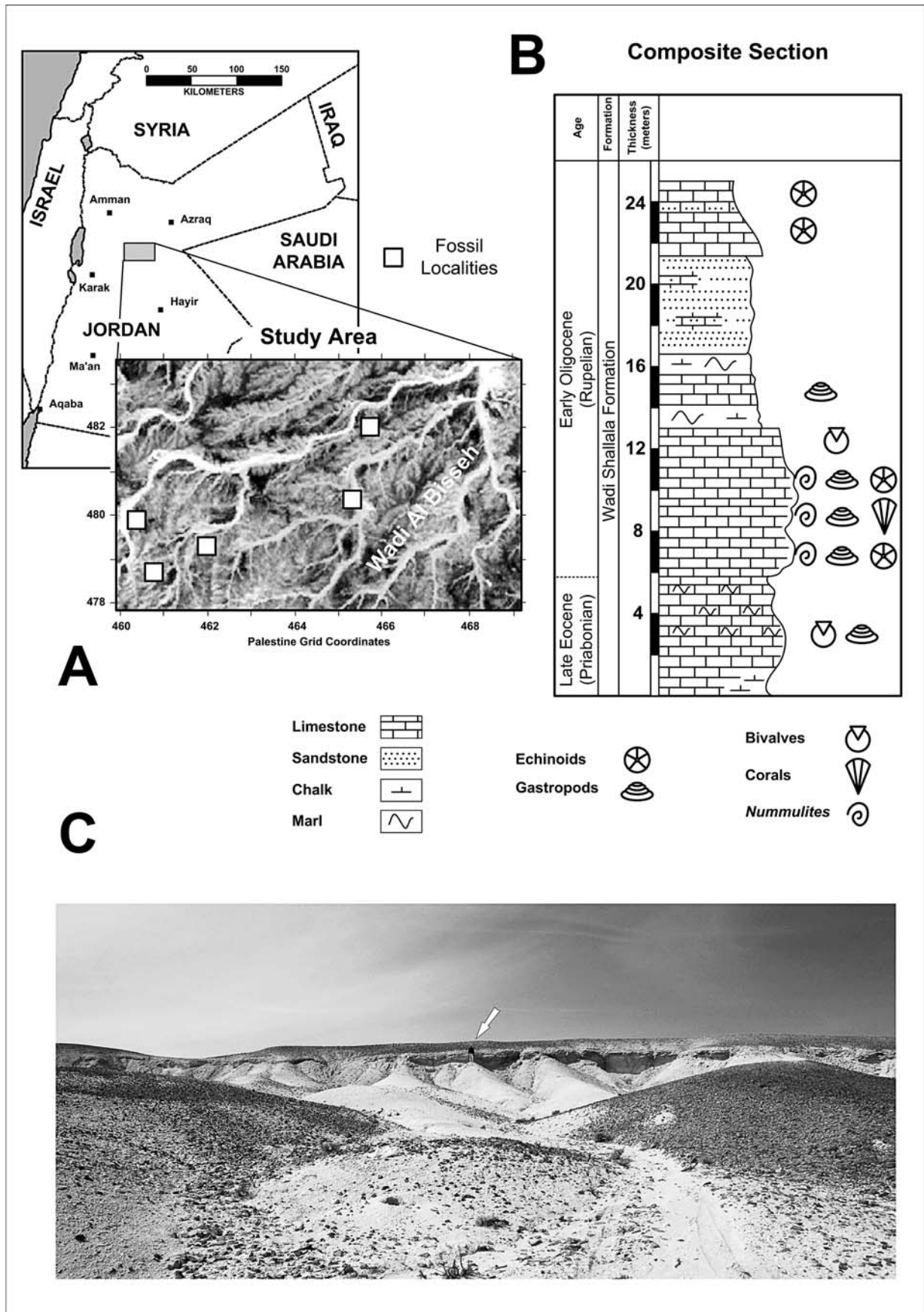


Fig. 1 - A) Location of study area. Inset background Landsat 7 image downloaded from worldwind.arc.nasa.gov, March, 2007. B) Composite geologic section of outcrop exposures in Wadi al Ghadaf. Exact chronostratigraphic boundary between Eocene/Oligocene not known. C) View of typical outcrop exposure, Wadi al Ghadaf. Person for scale (arrow).

hard, off-white to white chalky, marly limestone containing gastropods. The overlying section is composed of grey to cream-colored, medium hard sandy limestone capped by alternating limestone and sandstone beds, also containing echinoids.

There is a continuous series of carbonate sediments ranging from Late Cretaceous to Paleogene in age, included in the Belqa Group (Burdon 1959) by the Natural Resources Authority, Jordan. The early geological studies of Jordan (Bender 1968, 1974, 1975) divided the Paleogene section into several unnamed groups: the Paleocene chalk-marl member, the Upper Paleocene through Middle Eocene chert-limestone member, and the Upper Eocene calcareous-marly member. These sections have now been formalized as the Muwaqqar Formation, the Umm Rijam Formation, and the Wadi Shallala Formation, respectively (Moh'd 2000). Recent biostratigraphic studies by Smadi (2002, 2003) and Smadi et al. (2003) have confirmed the Paleogene age of these formations. The Wadi Shallala Formation is considered to be Bartonian to Priabonian (middle to late Eocene) in age, but is shown by its fauna at Wadi Al Ghadaf to be Rupelian (early Oligocene) at least in the uppermost part.

Weismann & Abdullatif (1963) briefly noted another interesting echinoid fauna, consisting of *Echinolampas* sp. and *Clypeaster* sp., from the Yarmouk Valley in northern Jordan. The echinoids were collected from their Tertiary Unit B, a hard, dense, partly dolomitic limestone, to which they assigned an Oligocene-Miocene age based on the megafauna. The two Tertiary Units A & B they considered to overly the upper chalk-marl section (= Wadi Shallala Formation). Bender (1968, 1974) also described this section, giving it a questionable Oligocene age. He included a photograph (Bender 1968) of the exposed glauconitic limestone in Esh Shuna on the east side of the Northern Jordan Rift Valley, but, unfortunately, no figures of the echinoids. Bender (1968, 1974) indicated that equivalent Oligocene-Miocene sediments occurred at Wagf as Suwwan and Dahikiyah in eastern Jordan and in his geologic map of Jordan (Bender 1975) indicated outliers of Oligocene-Miocene in the Wadi as Sirhan Basin. Moh'd (2000) stated that the Tertiary Unit B of Weismann & Abdullatif (1963) correlated to his Tayba Limestone Formation, in the Jordan Valley Group, Oligocene.

Zalmout et al. (2000) described a section similar to that at Wadi Al Ghadaf from Qa' Faydat ad Dahikiya in the Eastern Desert of Jordan. Their section consisted of a lower bituminous marl dated, in the upper part, as early Priabonian, overlain by glauconitic, phosphatic calcarenite, and an uppermost section of marl and marly limestone which they considered to be of questionable

Oligocene age. They included the entire section in the Wadi Shallala Formation. Although the echinoid- and foraminifera-bearing units at Wadi Al Ghadaf are characteristic of an early Oligocene (Rupelian) age, there is no information regarding the age of the lowermost limestone and marly limestone units. These are here considered to be late Eocene (Priabonian), with a conformable contact placed at the top of the marly limestone beds (Fig. 1B).

The species found in this Jordanian echinoid fauna are identical to those from the early Oligocene faunas of the northern coast of Africa. Two of the echinoid species recorded from Jordan, *Clypeaster biarritzensis* and *Echinolampas cherichirensis*, have also been reported from as far east as Iran, and all of the genera are known from northwestern India. These relationships imply free communication throughout the Western Tethys Region (Harzhuser et al. 2002) still existed during the early Oligocene. Roman (1977) proposed that the primary direction for propagation of the genus *Echinolampas* was from east to west (from India to France) during the Oligocene. However, the genus was well-established throughout the region by the late Eocene, and there is little evidence on which to base the actual direction of dispersal. Ali (1983) discussed the distribution of *Clypeaster* and noted that the Oligocene was a period of expanded dispersal of the genus, although it generally was rare in the eastern Tethys. Ali (1983) noted that the genus appears to have originated in the western Mediterranean region in the middle Eocene, implying west to east dispersal at some period between the middle Eocene and early Oligocene. Harzhuser et al. (2002) distinguished the Mediterranean-Iranian and the Western Indian-Eastern African Provinces within their Western Tethys Region. These provinces overlapped in the Middle East area and communication was facilitated by a west to east current along the northern shore during the Oligocene. The Jordanian echinoid occurrence described here is evidence that similar west to east dispersal may have characterized the southern shore as well.

Systematic Paleontology

The Wadi Al Ghadaf material studied includes 108 specimens of echinoids, most poorly preserved and fragmentary, and some additional steinkerns of bivalves and gastropods, a few oyster fragments, and nummulitid foraminifera. The specimens were collected as loose material on the outcrop. All the material has been deposited in the collections of the Nonvertebrate Paleontology Laboratory (NPL), Texas Natural Science Center, Austin, Texas (TNSC).

Class Echinoidea Leske, 1778

Order Clypeasteroidea A. Agassiz, 1872

Suborder Clypeasterina A. Agassiz, 1872

Family Clypeasteridae L. Agassiz, 1836

Clypeaster biarrizensis Cotteau, 1873

Pl. 1, figs. 1-3

1873 *Clypeaster biarrizensis* Cotteau, in Bouille, p. 101899 *Clypeaster taramellii* Airaghi, p. 153, pl. vi, fig. 31901 *Clypeaster pentagonalis* (non Michelotti) Airaghi, p. 179, pl. XX, figs. 1-21901 *Clypeaster laganoides* (non Agassiz) Airaghi, p. 181, pl. XX, fig. 41911 *Clypeaster biarrizensis* var. *trotteri* Gregory, p. 662-664, pl. XLVII, figs. 1a-b1914 *Clypeaster (Laganidea) biarrizensis* Lambert & Thiery, p. 300**Material examined.** Two specimens (TNSC NPL 4116-1,2).

Description. Medium size test, outline pentagonal, relatively flat with thin, rounded margin. Aboral surface steepest near apical system, relatively flat in band approximately 50% from margin towards margin. Length of TNSC NPL 4116.1 68.5 mm, width 64.5 mm, maximum height 19 mm, margin thickness 8 mm. Length of TNSC NPL 4116.2 86.5 mm, width 80 mm, maximum height 15.5 mm, margin thickness 5 mm. Petals very slightly inflated. Oral surface flat, with only slight concavity around peristome. Five narrow ambulacral furrows. Peristome central, pentagonal; periproct oval, wider than long, margin to periproct distance 19-20% the distance from margin to peristome.

Discussion. This species is widespread in rocks of early Oligocene age. Castex & Lambert (1919) listed a number of localities in France, the type region. Stefanini (1921) reported it from Tunisia and Libya (Cyrenaica).

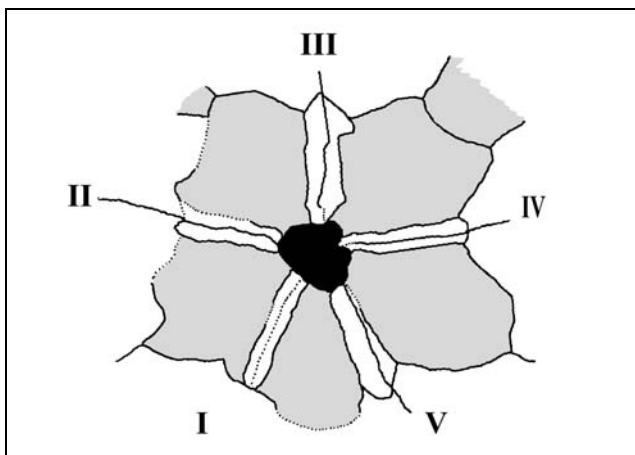


Fig. 2 - Drawing of basicoronial plate pattern, *Amphiope?* sp. (TNSC NPL 4117.1). Interambulacral plates shaded, peristome black, sutures dotted where uncertain.

Durham (1983) compared *C. biarrizensis* with a number of related species (some considered here to be synonyms, following Stefanini 1921) from the circum-Mediterranean region, Hungary, Bulgaria, Iran, and Somalia. He compared its geographic range (approximately 5,000 km along the Tethyan seaway) to that of several modern forms with ranges exceeding 10,000 km.

Suborder Scutellina Haeckel, 1896

Family Astrictlypeidae Stefanini, 1911

Amphiope? sp.

Pl. 1, figs 4,5

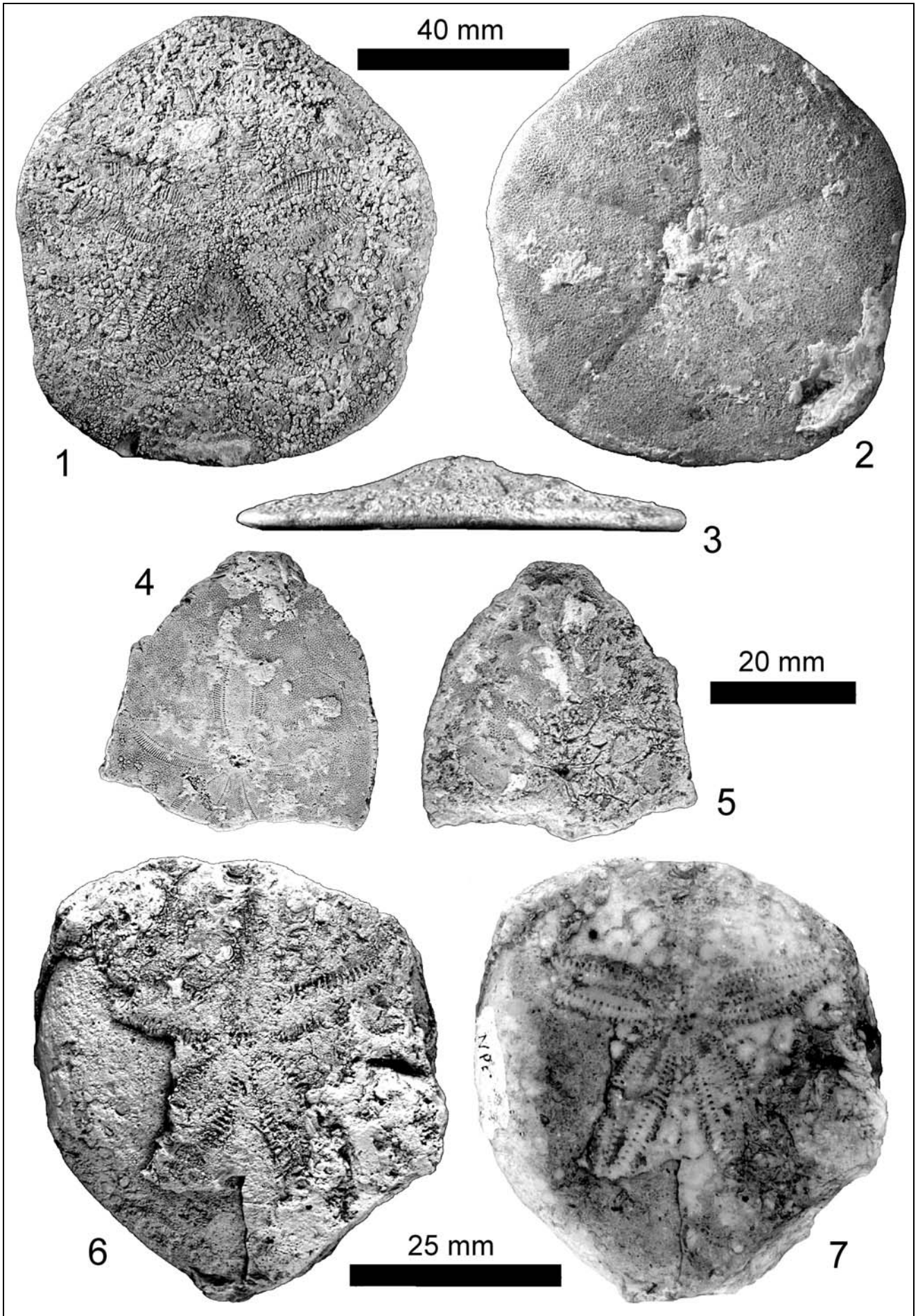
Material examined. One fragment of the central portion of the test and anterior margin (TNSC NPL 4117.1) and 1 fragmentary specimen encased in matrix (TNSC NPL 4117.2).

Description. Relatively large, flat test with thin margin. Length of largest fragment (TNSC NPL 4117.1) 37 mm, width 36 mm, complete length exceeds 50 mm. Five petals, closed distally, one or two trailing podia in antero-lateral petals (region not preserved in posterior petals); pores conjugate, outer pore elongate, simple. Anterior petals extend about 60% of distance to margin, other petals indeterminate due to margin damage but probably the same; petals all apparently the same length. Periproct position unknown but posterior of first post-basicoronial plate. Apical system damaged but shows many scattered hydropores; 4 genital pores. Interambulacra biserial to apex. Interambulacral basicoronial plates larger than paired ambulacral plates, basicoronial circle pentastellate, interambulacral plates much larger than ambulacral plates, posterior interambulacra (1, 4, & 5) disjunct (Fig. 2). Food grooves not preserved.

Discussion. Neither of the two specimens preserves the posterior portion of the test, and thus the presence of the paired lunules, diagnostic for this genus, cannot be confirmed. The pentastellate pattern of basicoronial plates around the peristome (Fig. 2) more closely resembles the pattern seen in *Amphiope* than in other scutellines.

PLATE 1

- Figs 1-3 - *Clypeaster biarrizensis*, TNSC NPL 4116.2; Fig.1 - aboral; Fig. 2 - oral; Fig. 3 - lateral (anterior to right).
 Figs 4, 5 - *Amphiope?* sp., TNSC NPL 4117.1; Fig. 4 - aboral; Fig. 5 - oral.
 Figs 6, 7 - *Eupatagus meslei*, TNSC NPL 4115; Figs 6, 7 - aboral.
 Figs 1-6 - specimens coated with ammonium chloride (NH₄Cl), Fig. 7: specimen immersed in dimethyl sulfoxide (DMSO).



Order Cassiduloidea Claus, 1880

Family Echinolampadidae Gray, 1851

Echinolampas cherichirensis Gauthier, 1889

Pl. 2, figs 1-7

1889 *Echinolampas cherichirensis* Gauthier, in Fourtau, p. 732.1890 *Echinolampas perrieri* (non Loriol) Cotteau, p. 126, pl. CCXLI, CCXLII, figs. 1-2.1900 *Echinolampas blainvillei* Oppenheim, p. 102, p. IX, figs. 1-1b.1900 *Echinolampas zignoi* Oppenheim, p. 103, pl. IX, figs. 3-3b.1900 *Echinolampas hydrocephalus* Oppenheim, pl. 103, pl. XVII, figs. 5-5b.1911 *Echinolampas chericherensis* Gregory, p. 669-671, pl. XLVIII, figs. 1-2, pl. XLIX, figs. 1-3.1921 *Echinolampas (Miolampas) cherichirensis* Lambert & Thiery, p. 383

Material examined. 92 relatively whole specimens (TNSC NPL 4118.1 - NPL 4118.77, NPL 4118.89 - NPL 4118.104) and 11 fragments (TNSC NPL 4118.78 - NPL 4118.88).

Description. Large, relatively low, robust test with nearly circular outline. Complete specimens range in length from 50 mm to 69 mm, width ranges from 90% to 100% of length (average 94%), height ranges from 30% to 50% of length (average 39%). Apical system slightly eccentric anteriorly, monobasal, 4 genital pores, posterior pair larger than anterior pair. Five petals, broad and long, converging but flaring distally, posterior pair longest, pores conjugate, outer pores elongate, inner pores round. Paired anterior petals distinctive, anterior poriferous zone (IIb and IVa) as much as 20% shorter than posterior, differing in length by about 12 pore pairs in larger specimens. The unequal lengths of the remaining petals minor, although anterior petal (III) often asymmetrical. Phyllodes widen distally, biserial, 24 to 28 pores in outer series, 8 to 10 in inner series; 2 buccal pores, 2 rows of ill-defined sphaeridia, 6 to 8 per ambulacrum, first 1 or 2 pairs share pit. Periproct oval, marginal to inframarginal.

Discussion. This species was described in Fourtau (1899) from a number of locations in Egypt and was reportedly found in association with *Nummulites fichteli*. Roman (1965) reported the species from Morocco, Algeria, Tunisia, Egypt, Libya (Cyrenaica), Northern Italy, Bulgaria, and Iran and Gregory (1911) also reported the species from northern Italy. Roman (1977, p. 342) stated that *E. cherichirensis* "...présente un remarquable potentiel de dispersion..."

The biserial series of pores in the phyllode and pattern of sphaeridia are suggestive of a Middle to Upper Eocene age (Roman 1965), although it clearly does not rule out a younger age. There is a wide but continuous range in test dimensions, more notable in relative height, and also in relative petal dimensions.

The continuous nature of this variability and the conservation of the phyllode character are strong evidence that there is a single species present, although it evidently has a variable phenotype; Gregory (1911) listed 5 distinct morphologic variations. The unequal poriferous zones in the paired anterior petals, although characteristic of *Echinolampas*, are strongly expressed in several Oligocene Indian species described by Srivastava & Singh (1999): *E. tandoni*, *E. gwarensis*, and *E. cookei*. *Echinolampas tandoni* can be distinguished by a triple series of phyllode pores; *E. gwarensis* by a more circular outline, longer petals, and more transversely elongate periproct and peristome; and *E. cookei* by wider interporiferous zones in the petals. The Jordanian specimens also resemble a group of species, *E. damesi*, *E. feddeni*, *E. haimei*, and *E. insignis*, described by Duncan & Sladen (1883) from the Nummulitic beds of Kachchh, India. These species are now considered to be Oligocene in age (Srivastava & Singh 1999). *Echinolampas feddeni* can be distinguished by shorter, unflared petals and a more deeply embedded floscelle, although the details of the phyllode pores are similar; *E. damesi* has a triple series of phyllode pores; the two species, *E. insignis* and *E. haimei* resemble *E. cherichirensis* in size and dimensions as well as the biserial rows of pores in the phyllode, but differ in having a triangular shaped periproct and relatively wider petals.

Order Spatangoida Claus, 1876

Family Brissidae Gray, 1855

Eupatagus meslei (Gauthier, 1893)

Pl. 1, figs 6, 7

1893 *Euspatangus meslei* Gauthier p. 653, pl. 358.1924 *Brissoides meslei* Lambert & Thiery, p. 451.

Material examined. One specimen (TNSC NPL 4115).

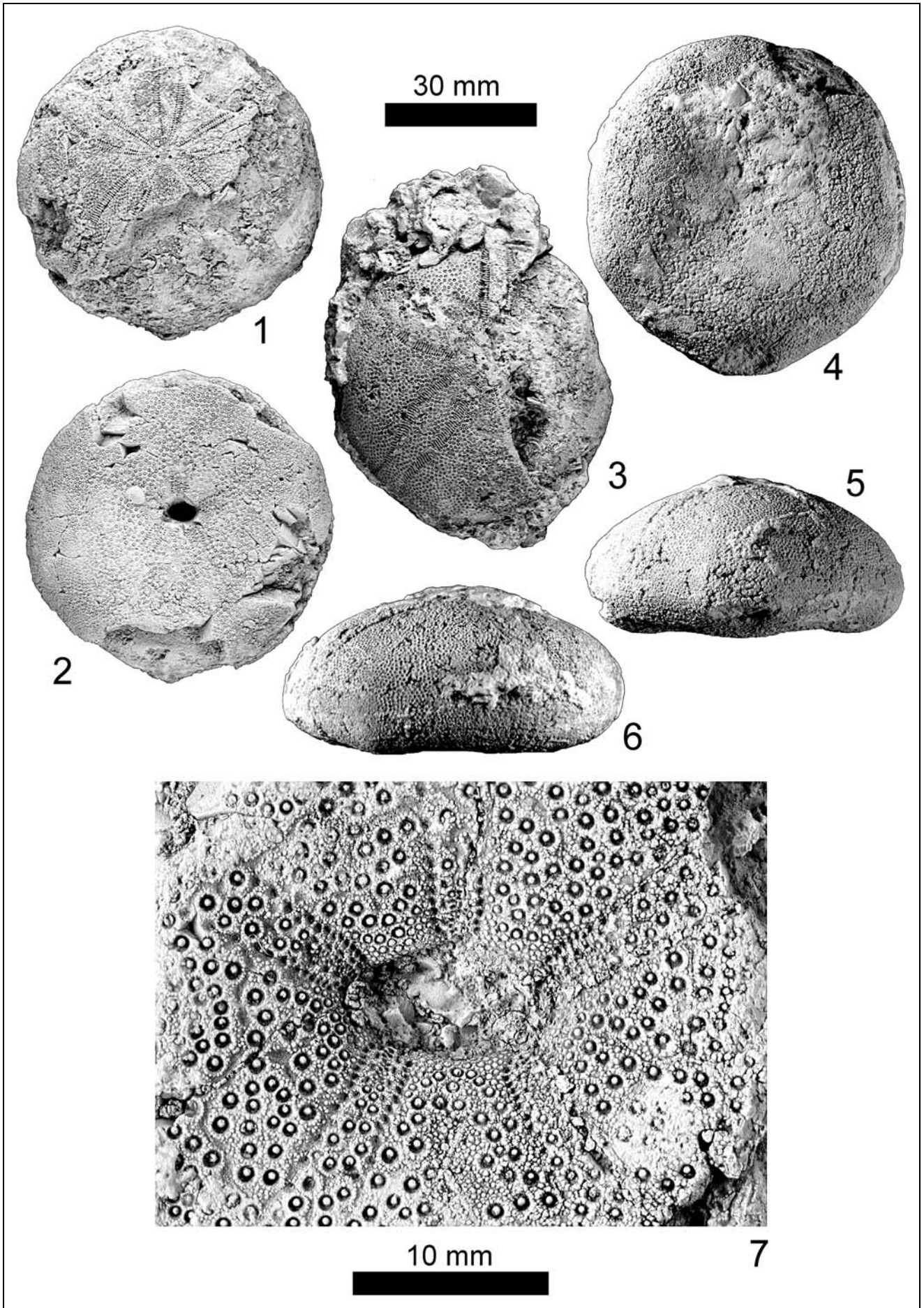
Description. Medium size, relatively wide test. Length 57 mm (anterior damaged, estimated total length

PLATE 2

Echinolampas cherichirensis.

- Figs 1, 2 - TNSC NPL 4118.38; Fig. 1 - aboral; Fig. 2 - oral.
 Fig. 3 - TNSC NPL 4118.4, aboral.
 Figs 4-6 - TNSC NPL 4118.91; Fig. 4 - oral; Fig. 5 - posterior; Fig. 6 - lateral (anterior to right).
 Fig. 7 - TNSC NPL 4118.50, detail of peristome and phyllodes.

All specimens coated with ammonium chloride (NH₄Cl).



~62 mm), width 52 mm, height at apical system 22 mm, keel extends 3 mm below oral plane. Aboral surface encrusted with sparry calcite. Apical system slightly eccentric anteriorly, ethmolytic, 4 genital pores. Four petals, broad and long, flush, slightly open distally; poriferous zones equal to ½ interporiferous zone, but anterior poriferous zones of antero-lateral petals (IIb and IVa) sinuous distally. Petal II 20 mm length, 22-23 pore pairs in each poriferous zone of II; petal V 25 mm length, 24-25 pore pairs. Anterior ambulacrum non-petaloid, nearly flush. Peristome semicircular, twice as wide as tall, eccentric anteriorly, center located 40 mm from posterior margin; labrum 7 mm length; sternum narrow, 20 mm length. Periproct terminal, apparently elongate vertically. Only faint remnants of subanal fasciole preserved in interambulacrum 5, no peripetalous fasciole preserved.

Discussion. As is the case with all examples of this fauna, the preservation of the single specimen is poor, but it agrees in the character of size, shape and relative length of petals, and pattern of primary tuberculation with a reference specimen in the TNSC collection of *E. meslei* from the Oligocene at Djebel Batene, Tunisia. Castany (1951) reported that the species occurred with *Echinolampas cherichirensis* and *Clypeaster biarritzensis* at Djebel Batene. Study of the characters was aided by submerging the specimen in dimethyl sulf-

oxide (DMSO) with a refractive index of 1.48, very close to that of calcite (1.486). This helped reveal some characters obscured by calcite overgrowths (Pl. 1, Fig. 7).

The Jordanian specimen resembles *E. rostratus* (d'Archaic) from the Oligocene of India in the length and form of the petals, but *E. meslei* completely lacks any anterior sinus, and the primary tubercles do not have sunken aeriotes. *Eupatagus rostratus* was reported by Duncan & Sladen (1883) from the Nummulitic beds of Kachchh, India. Srivastava (1981) reported the species from the *Nummulites fichteli* zone at Guvar, India, ranging into the Miocene, and later (Srivastava 2004) from the Middle Oligocene of Sind. *Eupatagus minutus* (Laube) from the lower Oligocene (Tongrian) of north-western Italy is also characterized by long (relative to posterior) anterior petals, although the specimens reported by Airaghi (1901) are significantly smaller than the Jordanian specimen.

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