Journal of Sciences, Islamic Republic of Iran 24(2): 149-155 (2013) http://jsciences.ut.ac.ir
University of Tehran, ISSN 1016-1104

Echinoids of the Genus *Tetragramma* Agassiz (Phymosomatoida) from the Aptian Sediments of the Basab Region, Northwest of Kerman, Iran

M.R. Vaziri* and A.L. Arab

Department of Geology, Faculty of Sciences, Shahid Bahonar University, Kerman, Islamic Republic of Iran

Received: 13 August 2012 / Revised: 2 February 2013 / Accepted: 19 February 2013

Abstract

The echinoid fauna of Basab area (Aptian), northwest of Kerman, is fairly rich and diverse, represented by Pygaulidae, Acropeltidae, Emiratiidae, Toxasteridae, Holectypidae, Stomechinidae and Saleniidae. Four regular echinoid species, among which three are new, assigned to genus *Tetragramma* Agassiz, are described and illustrated in the present paper. The new species are *Tetragramma basabensis, T. depressum* and *T. tetratuberculatus*. The diagnostic features of the species are chiefly the number of interambulacral tubercles on ambital plates, the size of apical disc and peristome, and also horizontal and vertical outlines of the test. The *Tetragramma* specimens occur in association with a rich orbitolinid fauna and macro-invertebrates consisting of bivalves, brachiopods, corals and gastropods. Associated micro-macro fauna suggest an Aptian age for the sediments.

Keywords: Regular echinoids; Aptian; *Tetragramma*; Kerman; Iran

Introduction

Echinoids are among the most conspicuous of marine invertebrate faunal elements of the Cretaceous strata in Kerman province. However, very few studies have been published on this subject. Indeed most of the papers about fossil echinoids from the Kerman province concern the Middle Cretaceous echinoids from Ekhtiar abad and Baghin areas. Vaziri et al. [1] reported six species of the Late Albian-Early Cenomanian echinoids from Ekhtiar abad region, west of Kerman. Arab & Vaziri [2] described sexual dimorphism in a new species of cassiduloid echinoid, *Pygaulus baghinensis*, from the Aptian marls of the Baghin area. Vaziri & Arab [3] discussed morphological variations and paleoecology of a spatangoid echinoid, *Heteraster renngarteni* from the region. Similarly, they [4] identified two new species of arbacioid echinoids, genus *Goniopygus*, from the Cretaceous deposits of the region. The echinoid fauna of Basab area is fairly rich and diverse and represented by Pygaulidae, Acropeltidae, Emiratiidae, Toxasteridae, Holectypidae, Stomechinidae and Saleniidae (Table 1), among which the Toxasteridae and Acropeltidae are dominant groups of the assemblage. The echinoids generally confirm the Aptian age suggested by the other fossils, associated with these echinoids, such as foraminifers.

* Corresponding author, Tel.: +98(341)3222035, Fax: +98(341)3222035, E-mail: vazirimohammadreza@yahoo.com

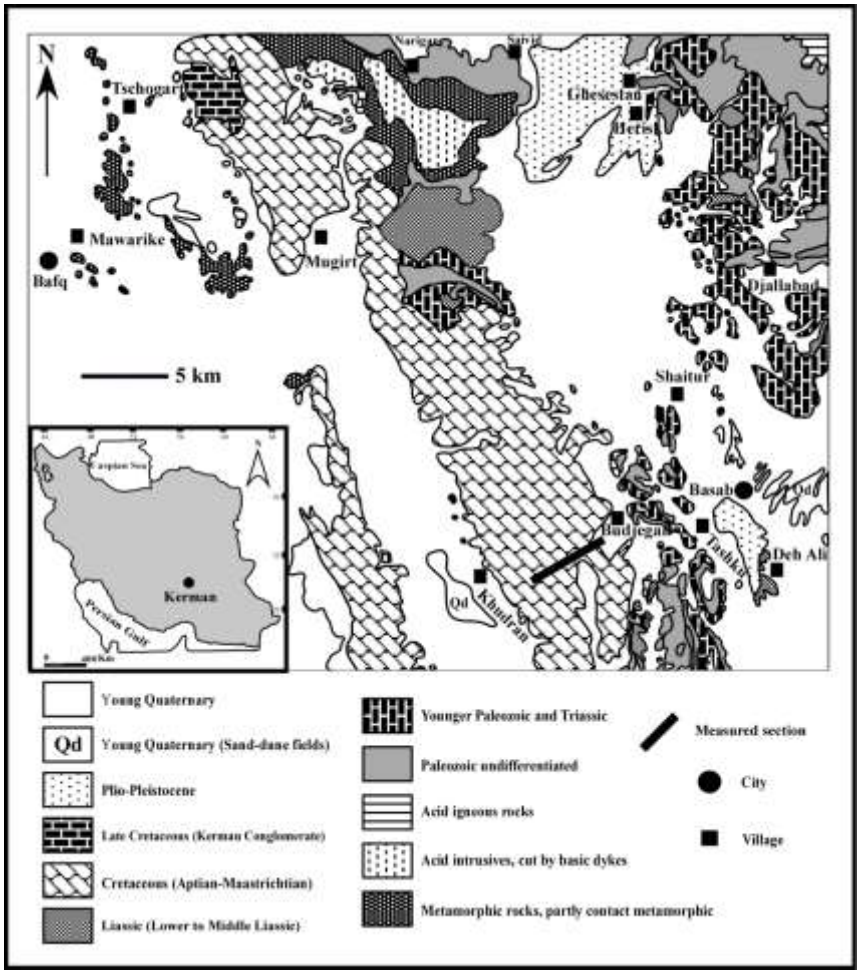

Figure 1. Simplified geological map of the Basab area.

Geological Setting and Stratigraphy

The echinoids described here have been collected from Aptian strata that crop out at Basab area, a district in Kuhbanan city, northwest of Kerman province, Iran (Fig. 1). The Cretaceous sedimentary rocks of Basab can be divided in two distinctive parts (Fig. 2). The lower part comprises monotonous rhythmic alternations of green marls with thin intercalations of yellowish shaly limestones. The green marls contain an abundant benthic fauna of *Orbitolina*, brachiopods, oysters, bivalves, gastropods and corals. The fossiliferous deposits pass continuously into the overlying thin-bedded limestone. This succession is similar to Aptian deposits of Baghin area, west of Kerman, which includes relatively the same micro and macro-invertebrate fauna. Thus, the first sedimentary cycle of Basab is equivalent to the Baghin section, described by Vaziri and Arab [3]. The upper part of the section is made essentially of green marls overlain by a massive-bedded limestone, relatively barren of macro-invertebrates. The Cretaceous succession of Basab thus consists of two clastic-carbonate cycles, each starts with marls or shaly marls, continues with a thin or massive-bedded limestone. A fairy divers microfauna is present throughout the section, however there are only minor differences between the foraminifer assemblages in both sedimentary cycles. Benthonic foraminifera include orbitolinids, *Marssonella turiss*, *Minoxia* sp., *Pseudocyclammina* sp., *Lenticulina rotula*, *Glomospira* sp., *Nezzazatinella picardi*, *Nautiloculina oolithica*, *Charentia cuvillieri*, *Pseudolituonella reicheli*, *Ophtalmidium* sp., *Pseudotextulariella* sp. and miliolids [5]. The boundary between two recognized cycles is regarded tentatively as the Aptian-Albian boundary. However, there is no evidence for a hiatus or an unconformity at the stage boundary level here.

Materials and Methods

To study the *Tetragramma* fauna of Basab area, several specimens of this regular echinoid has been collected from green marls of the lower part of the section. About two third of the specimens were crushed, distorted, imperfect, or weathered. Well preserved specimens were cleaned, using a mild detergent and whenever necessary by using an ultrasonic vibrator and a preparation needle. The materials used in this study are housed in the Paleontology Laboratory of Shahid Bahonar University of Kerman, Iran.

Systematic Paleontology

Four species of *Tetragramma* are here recognized in the Aptian series of Basab area. The most obvious differences between the species are the number of interambulacral tubercles on ambital plates, the size of apical disc and peristome, and also slight differences in horizontal and vertical outlines of the tests. However, the number of vertical rows of tubercles in the interambulacra of *Tetragramma* generally increases with the size of the individual. Small specimens commonly have only four; larger ones may have eight or more rows [6].

Tetragramma is easily distinguished from *Phymosoma* by its perforated tubercles, though the two genera are superficially very similar [7].

Subphylum: Echinozoa Haeckel in Zittel, 1895
Class: Echinoidea Laske, 1778
Subclass: Euechinoidea Bronn, 1860
Cohort: Regularia Letreille, 1825
Superorder: Stirodonta Jackson, 1912
Order: Phymosomatoida Mortensen, 1904
Family: Emiratiidae Ali, 1990
Subfamily: Diplopodiinae Smith & Wright, 1993
Genus: *Tetragramma* Agassiz, 1840

Tetragramma basabensis Vaziri & Arab sp. nov.
(Fig. 3: A-G & Fig. 7: a-c)

Material: Two specimens.
Etymology: Refers to its type region (Basab area).
Occurrence: The species occurs in the Aptian sequence of Basab area.
Description: Test highly inflated, weakly subpentagonal in outline and ranges in size from 38.5 to 39.3 mm in diameter and 15.1 to 16.2 mm in height. Upper surface flat, margin rounded, lower surface nearly flat. Primary tubercles are perforate and crenulate, two vertical rows in each ambulacrum. Ambulacra are straight and relatively narrow. They are 40% of the width of interambulacra. Interambulacra are broad, being 13% of the test diameter. There are three large equal primary tubercles on each ambital plate of the interambulacra, but only one on the last adapical small plates. The pore pairs are uniserial at ambitus and adorally, becoming biserial adapically. The ambitus lies at mid-height. The peristome is relatively large, circular in outline and very slightly sunken.
Remarks: In shape and decoration this species seems to be similar to *Tetragramma variolare* (Brongniart) from the Cenomanian of France, although its peristome is larger. Moreover, *T. variolare* has more uniform interambulacral tuberculation which is rather coarser than *T. basabensis* and in profile its ambitus lies well above mid-height.

Tetragramma depressum Vaziri & Arab sp. nov.
(Fig. 4: A-E & Fig. 7: d-f)

Material: One specimen.
Etymology: Refers to its sunken peristome.
Occurrence: The species occurs in the Aptian sequence of Basab area.
Description: Horizontal outline subcircular, disc-shaped, 40.2 mm in diameter and 12.9 mm in height. Upper surface low arched, margin rounded, lower surface concave around the peristome. Apical scar large. Primary tubercles perforate and crenulate. Ambulacra narrow, less than half as wide as the interambulacra. Each ambulacrum comprises two vertical rows of tubercles. There are three equal primary tubercles on each interambulacra plate at ambitus. In profile the ambitus lies well below mid-height. Poriferous zones uniserial at ambitus and adorally, whereas biserial adapically. Peristome nearly central, large and sunken.

Table 1. List of the echinoids recovered from the Basab area

Family	Species
Pygaulidae	*Plagiochasma olfersii* Agassiz, 1836 *Pygaulus baghinensis* Vaziri, 2010 *Pygaulus* sp.
Acropeltidae	*Goniopygus annularis* Vaziri & Arab, 2012 *Goniopygus triangularis* Vaziri & Arab, 2012
Emiratiidae	*Tetragramma basabensis* Vaziri & Arab sp. nov. *Tetragramma depressum* Vaziri & Arab sp. nov. *Tetragramma tetratuberculatus* Vaziri & Arab sp. nov. *Tetragramma* sp.
Toxasteridae	*Heteraster rengarteni* Poretzkaja, 1961 *Toxaster collegnoi* Sismonda, 1843
Holectypidae	*Conholectypus macropygus* Desor, 1842
Stomechinidae	*Codechinus rotundus* (Gras, 1848) *Stomechinus* sp.
Saleniidae	*Leptosalenia sergipensis* (White, 1887)

Remarks: *Tetragramma depressum* is similar to *Tetragramma basabensis* in having three primary tubercles on each interambulacra plate at ambitus, but adorally the number of secondary tubercles increases and reaches up to six around the peristome. *Tetragramma depressum* can be distinguished from *Tetragramma almerai* (Lambert, 1902) by its larger and sunken peristome.

Tetragramma tetratuberculatus Vaziri & Arab sp. nov.
(Fig. 5: A-D & Fig. 7: g-i)

Material: One specimen.

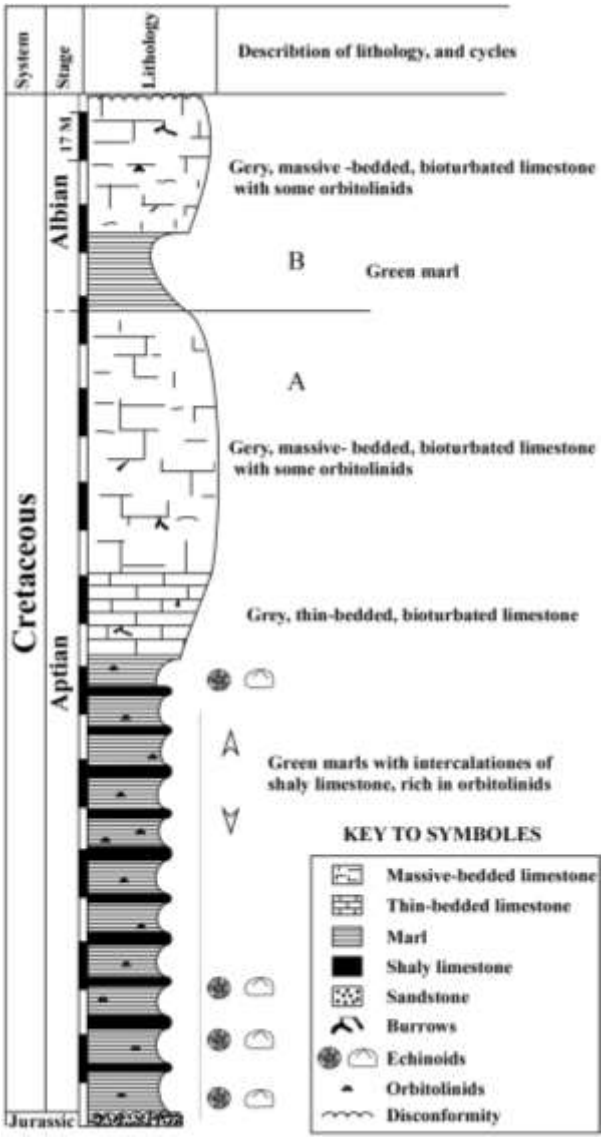

Figure 2. Schematic lithological succession of Cretaceous strata in Basab area. A and B represent the first and second sedimentary cycles.

Etymology: Refers to its four interambulacral tubercles on ambital plates.

Occurrence: The species occurs in the Aptian sequence of Basab area.

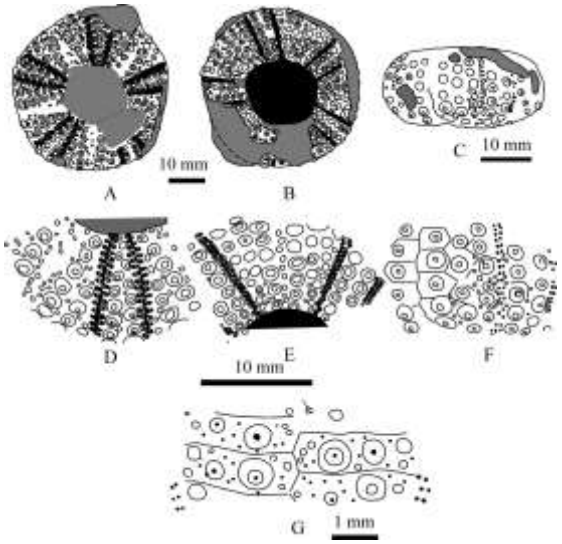

Figure 3. Camera lucida drawings of apical, oral and lateral views in *Tetragramma basabensis* sp. nov.; A: apical surface, showing ambulacra, interambulacra, tubercles and periproct; B: oral surface, showing ambulacra, interambulacra and peristome; C: lateral view, showing height of the test and 3 interambulacral tubercles on ambital plates; D-F: adapical, adoral and ambital tuberculation patterns; G: ambital interambulacral plates.

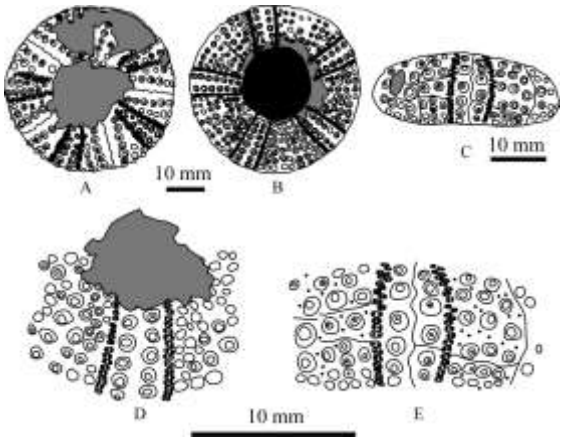

Figure 4. Camera lucida drawings of apical, oral and lateral views in *Tetragramma depressum* sp. nov.; A: apical surface, showing ambulacra, interambulacra, tubercles and periproct; B: oral surface, showing ambulacra, interambulacra and peristome; C: lateral view, showing height of the test and 3 interambulacral tubercles on ambital plates; D & E: adapical and ambital tuberculation patterns.

Description: Horizontal outline circular, 33.1 mm in diameter and 14.1 mm in height. Test relatively inflated in profile, upper surface low arched, margin rounded, lower surface nearly flat. The apical disc is known only by its scar. Primary tubercles perforate, crenulate, two vertical rows in each ambulacrum. At the ambitus, ambulacra are 7.5% of the test diameter. They are relatively narrow and straight. Interambulacral plates are long and narrow. There are four equal primary tubercles on each ambital and adoral plate of the interambulacra. The pore pairs are biserial on both adapical and adoral surface, whereas uniserial at the ambitus. In profile, the ambitus lies at mid-height. The peristome is large and circular in outline and occupies about one third of the test diameter.

Remark: *Tetragramma tetratuberculatus* differs from other Basab *Tetragramma* species by its long and narrow interambulacra plates, composed of four primary tubercles at ambitus. This species is easily distinguished from *T. malbosi* (Agassiz) by its more inflated shape, and also by its biserial arrangement of pore-pairs at adapical and adoral surface.

Tetragramma sp.
(Fig. 6: A-D & Fig. 7: j-l)

Material: One specimen.

Occurrence: The species occurs in the Aptian sequence of Basab area.

Description: The unique specimen is 33.1 mm in diameter and 13.2 mm in height. The test is depressed and circular in outline. Tubercles perforated, crenulated, set on relatively large bases, two rows on each ambulacrum. Ambulacra are relatively narrow and straight. Interambulacra are relatively broad with two equal sized tubercles, which occupy virtually the entire width of the plate, on ambital, adoral and adapical surface. Ambitus lies at mid-height. The pore pairs are uniserial on the ambital and adoral plates, whereas biserial on adapical surface. The peristome is large and occupies about 65% of the test diameter.

Remarks: This species shows many features of the Barremian *Tetragramma autissiodorense* (Cotteau, 1851), but appears to differ from it in its larger peristome and flatter test.

Results and Discussion

Echinoids live in a wide range of environments in and on the sediments. They may be generalist or specialist and employ different feeding mechanisms [8]. Most of the regular echinoids, in contrast to irregular ones, fall apart after death and may not be found as complete tests. According to Kier and Grant [9] the major factor influencing echinoid distribution is water depth/shore distance. Other factors (such as light penetration, wave agitation, current direction and food supply) are either functions of these or factors difficult to evaluate. However, Smith [10] concluded that nine factors affect the distribution patterns of echinoid species: nature of the substratum, hydrodynamic regime, predation, salinity, temperature, food availability, water depth, behavior and chance. Most of the regular echinoids are algivores. They are at their most diverse today in shallow shelf platform environments and decrease in abundance dramatically in water depth greater than about 50 m [11].

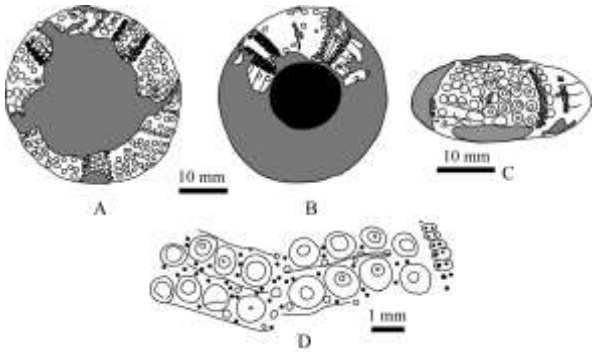

Figure 5. Camera lucida drawings of apical, oral and lateral views in *Tetragramma tetratuberculatus* sp. nov.; A: apical surface, showing ambulacra, interambulacra, tubercles and periproct; B: oral surface, showing ambulacra, interambulacra and peristome; C: lateral view, showing height of the test and 4 interambulacral tubercles on ambital plates; D: ambital interambulacral plates.

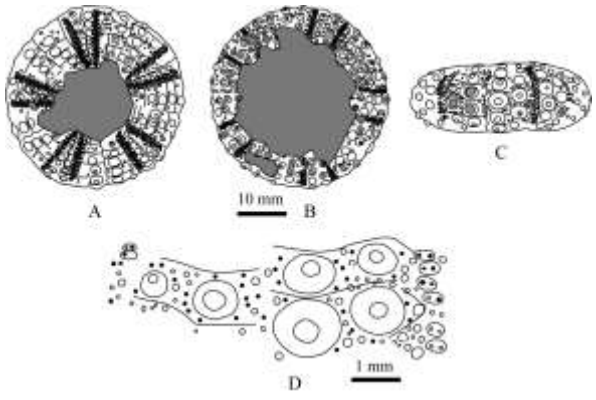

Figure 6. Camera lucida drawings of apical, oral and lateral views in *Tetragramma* sp.; A: apical surface, showing ambulacra, interambulacra, tubercles and periproct; B: oral surface, showing ambulacra, interambulacra and peristome; C: lateral view, showing height of the test and 2 interambulacral tubercles on ambital plates; D: ambital interambulacral plates.

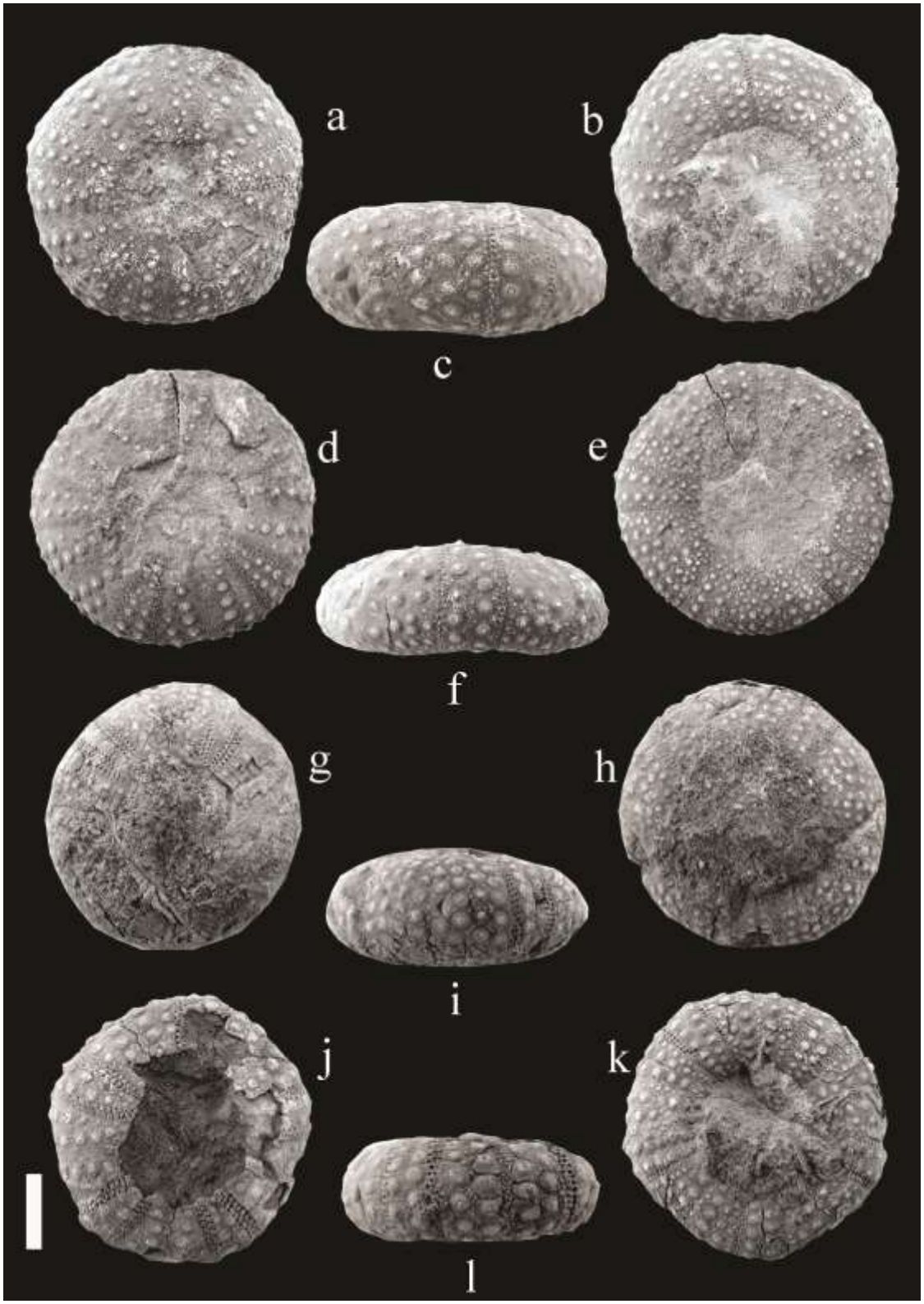

Figure 7. a-c, *Tetragramma basabensis* sp. nov., KUIC 1420; apical, oral and lateral views. d-f, *Tetragramma depressum* sp. nov., KUIC 1428; apical, oral and lateral views. g-i, *Tetragramma tetratuberculatus* sp. nov., KUIC 1432; apical, oral and lateral views. j-l, *Tetragramma* sp. KUIC 1438; apical, oral and lateral views. Scale bar represents 1 cm.

Although regular echinoids are relatively abundant today, the fossil records of these organisms are proportionally lacking [12]. Regular sea urchins of the genus *Tetragramma* are relatively common in Upper Jurassic (Oxfordian) to Upper Cretaceous (Turonian) sediments in Western Europe, Middle East, North Africa, North and South America and represents important member of benthic invertebrate communities. Smith et al. [13] considered *Tetragramma* as a taxon that expanded over the shelf during periods of low sea-level stand or regressive phases. The echinoid association from Basab indicates a relatively shallow platform environment. This is confirmed by the presence of epifaunal and infaunal foraminifers, which are found together in shallow environments [14] and also by the presence of algae, living in shallow, high light, and well aerated environments [15]. In Basab, all four species of the genus *Tetragramma* are rather flattened, short-spined, with large peristome and periproct, which show a strong tendency towards algivory.

Although the echinoid fauna recovered from Basab area is relatively diverse and abundant, it displays a high degree of endemism, comprising a high percentage of species unknown from other regions of the world. It suggests the existence of a discrete biogeographic entity, influenced from adjacent bioproviences, which is documented by an even proportion of shared species.

Acknowledgments

The authors express a deep sense of gratitude to prof. Loïc Villier, Université de Provence, France for his valuable comments on identification of echinoids. Special thanks to individuals who have helped to collect echinoids from Basab area, including J. Hassani and M. Rami.

References

1. Vaziri, M. R., Dasanpour, M., Mahanipour, A. and Arab, L. A. Mid-Cretaceous macrofossils assemblage from west of kerman. Tehran University, Journal of sciences, **35**(2): 105-113 (2006).
2. Arab, A. L. and Vaziri, M. R. Sexual dimorphism in a new species of cassidoluid echinoid, *Pygaulus baghinensis*, from the Aptian strata of Baghin area, west of Kerman, Iran. Journal of Sciences, Islamic Republic of Iran, **21**(1): 43-47 (2010).
3. Vaziri, M. R. and Arab, A. L. Morphological Variations, Patterns of Frontal Ambulacrum Pores and Paleoecology of *Heteraster renngarteni* Poretzkaja (Echinoidea: Spatangoida) from Aptian Sediments of Baghin area, Kerman, Iran. Pakistan Journal of Scientific and Industrial Research, Series B: Biological Science, **54**(1): 41-46 (2011).
4. Vaziri, M.R. and Arab, A.L. Two new species of arbacioid echinoids (genus *Goniopygus*) from the Aptian sediments of Baghin area (Kerman, Iran). Iranian Journal of Science and Technology (2012).
5. Rami, M., Vaziri, M.R., Taherpour, M., Hosseini, S. A., Ivana Carević, I. and Allameh, M. Microbiostratigraphy of the Lower Cretaceous strata from the Bararig Mountain, SE Iran. Revista Mexicana de Ciencias Geológicas, v. **29**: núm. 1, 63-75 (2012).
6. Cooke, C.W. Some Cretaceous echinoids from the Americas. United States Geological Survey, Professional Papers **264**-E: 87-112, pls. 18-29 (1955).
7. Cooke, C.W. Comanche Echinoids. Journal of Paleontology, **20**(3): 193-237 (1946).
8. Kroh, A. and Nebelsick, J. H. Echinoid assemblages as a tool for palaeoenvironmental reconstruction- an example from the Early Miocene of Egypt. Palaeogeography, Palaeoclimatology, Palaeoecology, **201**: 157-177 (2003).
9. Kier, P.M. and Grant, R.E. Echinoid Distribution and Habits, Key Largo Coral Reef Preserve, Florida. Smithsonian Miscellaneous Collections, **149**(6): 1-68 (1965).
10. Smith, A. B. Echinoid palaeobiology. Allen and Unwin, London (1984).
11. Smith, A. B. and Bengtson, P. Cretaceous echinoids from north-eastern Brazil. Fossils and Strata, no. 31, Oslo, Universitetsforlaget (1991).
12. Davis, C. Biostratinomy of regular and irregular echinoids from selected localities of San Salvador islands, Bahamas. 1st Keck Symposium Volume, Beloit College (1988).
13. Smith, A.B., Monks, N.E.A. and Gale, N.S. Echinoid distribution and sequence stratigraphy in the Cenomanian (Upper Cretaceous) of southern England. Proceedings of the Geologists' Association, **117**: 207-217 (2006).
14. Corliss, B.H. and Chen, Ch. Morphotype patterns of Norwegian Sea deep-sea benthic foraminifera and ecological implications: Geology, **16**: 716-719 (1988).
15. Flugel, E. Microfacies Analysis of Limestone, Berlin, Springer (1982).