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## Two new species of Arbacioid echinoids (genus *Goniopygus*) from the Aptian sediments of Baghin area (Kerman, Iran)

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### Abstract

Two new species of an Arbacioid echinoid, genus *Goniopygus*, are reported for the first time from Aptian sediments of Baghin area, Kerman, Iran. The main features of the species lie in apical disc and peristome diameter. In *Goniopygus triangularis* sp. nov., the periproct is triangular in shape with three small, sunken tubercles, located alternatively adjacent to the periproct, while *Goniopygus annularis* sp. nov. is characterized by having a circular periproct without any sunken tubercle. Also, *Goniopygus triangularis* has a wider peristome than *Goniopygus annularis*. In both species sexual dimorphism is not conspicuous. They lived in restricted to low - moderate energy environments.

**Keywords:** Echinoids; *Goniopygus*; Cretaceous; Kerman; Iran

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### 1. Introduction

Although echinoids are among the most conspicuous and diverse constituents of marine invertebrate faunal elements of the Aptian sediments in Baghin area, very few studies have been published on this subject [1, 2]. The echinoid fauna of Baghin comprises Stomechinidae, Emiratiidae, Pygaulidae, Holoctypidae, Saleniidae, Cidaridae, Hemiasteridae, Toxasteridae and Acropeltidae. The family Acropeltidae is a Stirodont arbacioid echinoid which has a fossil record extending back to the Jurassic and is distinguished from other arbacioids by its perianal tubercles [3]. The genus *Goniopygus* is a member of this family, ranging from Upper Jurassic to Eocene and a well documented distribution in America, Europe and Asia [3-5]. Description of Iranian material will improve current knowledge about the genus and help compare it with specimens reported from other parts of the world.

### 2. Geological setting and stratigraphy

The two new species, *Goniopygus triangularis* and *Goniopygus annularis*, described here, have been collected from Aptian strata that crop out of the Baghin area, west of Kerman city (Fig. 1). The Aptian sediments of Baghin consist mainly of an alternation of green marls and thin layers of yellow

shaly limestone (Fig. 2) with an abundant benthic foraminifera (*Orbitolina*), brachiopods, oysters, bivalves, gastropods and corals, most of which confirm an Aptian age for the sediments. Echinoids are also among the most conspicuous and diverse constituents of the Aptian fauna of Baghin area, represented by Stomechinidae, Emiratiidae, Pygaulidae, Holoctypidae, Saleniidae, Cidaridae, Hemiasteridae, Toxasteridae and Acropeltidae, among which the two latter are dominant groups of the assemblage. The marls are covered by a gray, bioturbated, and thick-bedded limestone, relatively barren of macroinvertebrates.

### 3. Materials and methods

To study *Goniopygus triangularis* and *Goniopygus annularis*, eighteen specimens have been collected from green marls of Baghin area. The material includes some crushed, distorted, imperfect, or weathered individuals. Well-preserved specimens were cleaned, using a mild detergent and whenever necessary by using an ultrasonic vibrator and a preparation needle. In order to study apical disc, a light binocular microscope was used.

The material used in this study is housed in the Paleontology Laboratory of Shahid Bahonar University of Kerman, Iran.

### *Systematic paleontology*

Class: Echinoidea Leske, 1778  
Cohort: Regularia Letreille, 1825

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Order: Arbacioida Gregory, 1900  
 Family: Acropeltidae Lambert & Thiery, 1924  
 Genus: *Goniopygus* L. Agassiz, 1838  
 Type Species: *Goniopygus triangularis* Vaziri & Arab sp. nov. (Fig. 3)  
*Etymology*: (Latin *triangularis*) refers to the triangular shape of the periproct.  
*Material*: Three well- preserved specimens.  
*Occurrence*: The species occurs in the Aptian sequence of Baghin area.

**Diagnosis**: Test is dome-shaped, 16 to 20 mm in diameter and nearly 11 to 11.5 mm in height, flattened below and subconical adapically. Nine or ten primary tubercles in each interambulacrum column, arranged in regular series throughout. The peristome is very large and circular in outline, approximately 63-72.5 % of the test diameter, and has moderately sharp notches. The greatest ambulacrum width is 20% of the test diameter. Ambulacral plates are compound, trigeminate adapically and adorally, but quadrigeminate at the ambitus. Pore pairs are uniserial and two pores are separated from each other by a raised interporal knob. The periproct is triangular in shape and is 2 to 2.7 mm in diameter, corresponding to 12.5-14.5% of the test diameter. Apical disc dicyclic, thick and forming a raised platform. The genital plates pentagonal, together form a five-pointed star, and the gonopores are at the outer points. Three of the genital plates are represented as having a tubercle on the inner edge adjacent to the periproct. Ocular plates are smaller and projecting. Tubercles imperforate and non-crenulate. Interambulacral plates a little wider than tall, with a large primary tubercle on each. Peristome is rounded in outline and very slightly sunken.

Type Species: *Goniopygus annularis* Vaziri & Arab sp. nov. (Fig. 3)

*Etymology*: (Latin *annularis*) referring to the circular shape of the periproct.

*Material*: Four well- preserved specimens.

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

#### Diagnosis

This species differs from *G. triangularis* in the following counts. In *G. annularis* peristome is relatively small, 54-56.5% of the test diameter, while in *G. triangularis* the peristome is very large, 63-72.5% of the test diameter. Secondly, the periproct outline of *G. triangularis* is triangular, having three sunken tubercles located alternatively adjacent to three genital plates. In *G. annularis* the periproct is circular and there are no sunken tubercles. Thirdly, in *G. annularis* the test is

hemispherical in profile, whereas in *G. triangularis* the profile of the test is rather domed.

Camera lucida drawings and biometric data on *G. triangularis* and *Goniopygus annularis* are shown in Figs. 3 and 4.

#### 4. Results and discussion

##### a) Comparative remarks

The number and location of the tubercles on the genital plates have been regarded as generic features in the family of Acropeltidae [3]. For example, *Acropeltis aequituberculata*, which is a genotype of *Acropeltis* has one large tubercle near the center of each genital plate, while in many species of genus *Goniopygus* the tubercles lie at the edge of the genital plates. *Goniopygus annularis* shows many features in common with other species of the genus *Goniopygus*, except that none of its genital plates has sunken tubercles. The absence of sunken tubercles in *Goniopygus annularis* is a new character that is reported for the first time from the genus, and implies that restriction of *Goniopygus* to species having sunken tubercles on genital plates should be revised. The shape of the periproct is also a main character in distinguishing the different species of the genus *Goniopygus*. The most conspicuous difference between *G. annularis* and the other species of the genus lies in the shape of the periproct. The periproct outline in *G. annularis* is circular, while those of the other species are triangular, subcircular, quadrangular or subpentagonal. This difference suggests that *Goniopygus annularis* is a new species of the genus. *Goniopygus annularis* is nearly similar to *G. peltatus*, but differs from it in having no sunken tubercles in the margin of the periproct, and also by having a circular instead of subpentagonal preperoct.

*Goniopygus triangularis* is very similar to *G. zetteli* Clark. In both species, three genital plates have a sunken tubercle at their inner edge, adjacent to the preperoct. In *G. zetteli* the tubercles are located next to each other, whereas in *G. triangularis* there are small but well developed sunken perianal tubercles on genital plates 1, 3 and 5.

This condition distinguishes these two species from each other. It differs from *G. menardi* (Desmarest, 1825) by having wider peristome and a subconical test instead of subspherical profile. It comes closest to *G. whitneyi* from the early Albian [6]. *G. triangularis* is distinguished, however, by having a wider peristome.

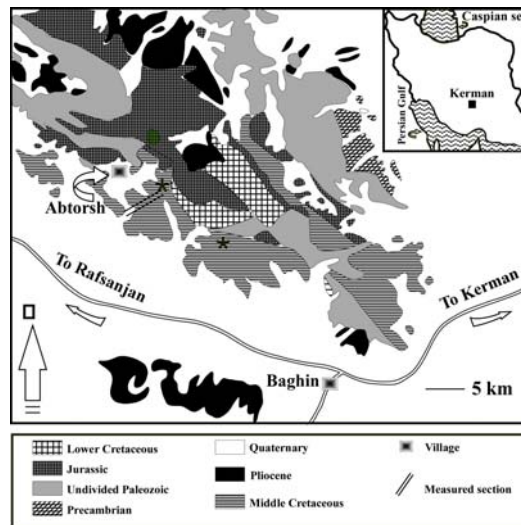


Fig. 1. Simplified geological map of the Baghin area. Black stars show localities, from where *Goniopygus triangularis* and *Goniopygus annularis* have been collected

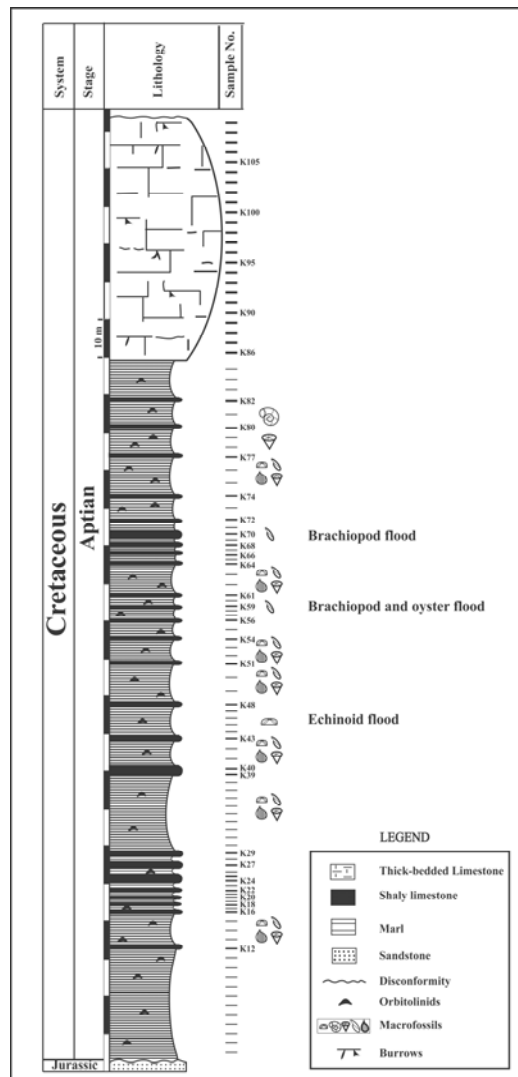
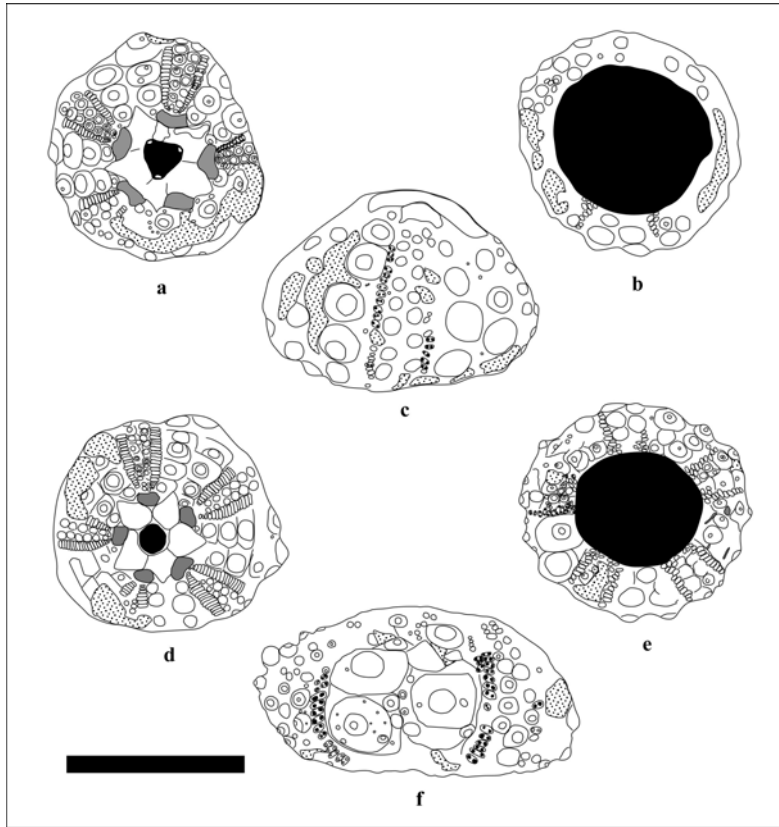
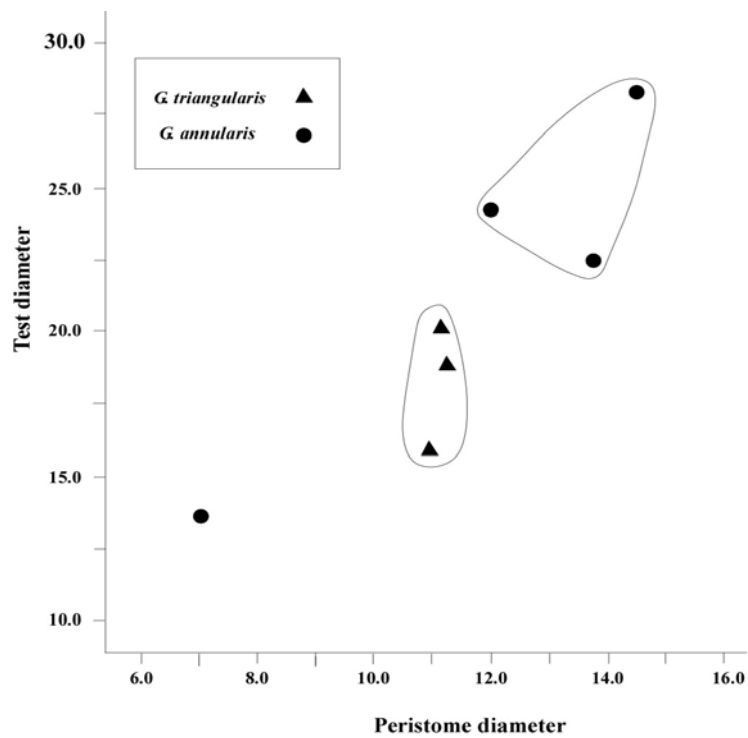


Fig. 2. Schematic lithological succession of Aptian strata in Baghin area



**Fig. 3.** Camera lucida drawings of *Goniopygus triangularis* sp. nov. and *G. annularis* sp. nov. from Aptian sediments of Baghin area; a-c, *G. triangularis*: a, adapical b, adoral and c, lateral views; d-f, *G. annularis*: d, adapical e, adoral and f, lateral views. Scale bar represents 1 cm



**Fig. 4.** Graphic plot of test diameter versus peristome diameter for seven specimens of *G. triangularis* and *G. annularis* from Aptian sediments of Baghin area

### b) Paleogeography

Iranian plate is a part of Tethyan region. In other words, its geology, tectonic style and connection with other areas is directly influenced by the development and history of the region. According to Stocklin [7] and Berberian and King [8] the following major structural zones can be distinguished throughout the Iranian plate: Folded Zagros, High Zagros, Sanandaj-Sirjan Ranges, Central Iran, Alborz Mountains, Kopet Dagh, Lut Block, and East Iran/Markran Ranges. The Baghin area is located at the Central Iranian zone. Although the echinoid fauna recovered from the Baghin area is relatively diverse and abundant, it displays a high degree of endemism, comprising a high percentage of species unknown from other regions. It suggests the existence of a discrete biogeographic entity, influenced from adjacent bioprovinces, which is documented by an even proportion of shared species. The paleogeographic map of central Iran through Barremian to Albian is shown in Fig. 5 [9].

### c) Paleoecology

The echinoid community of Baghin area is composed of Stomechinidae, Emiratiidae, Pygaulidae, Holoctypidae, Cidaridae, Hemiasteridae, Toxasteridae and Acropeltidae (Fig. 6), among which the latest is represented by two new species; *Goniopygus annularis* and *G. triangularis*.

In contrast to some species of the genus, such as *Goniopygus heberti* and *G. minor*, which possess strong oral phyllodes and live within the uppermost few meters of water column [10], both *Goniopygus annularis* and *G. triangularis* lack phyllodes, thus being restricted to low to moderate energy environments and an omnivorous lifestyle [11]. Both forms presumably feed on algae, bryozoans and other small invertebrates. Such animals usually prefer stable sedimentary bottoms [12].

### d) Sexual dimorphism

*Goniopygus annularis* and *G. triangularis* have been examined from the viewpoint of sexual dimorphism as well. This is important because sexual dimorphism has been reported in two Cretaceous arbacioid echinoids, *Goniopygus royoii* Lambert and *G. minor* Sorignet. According to Kier [13] three types of sexual dimorphism have been recognized in fossil echinoids: 1. presence of marsupial, 2. larger genital pores in females, and 3. larger and differently shaped genital plates in specimens considered to be females. Although

*Goniopygus royoii* and *G. minor* show a deep depression in the interambulacra at the edge of the genital plate, which seems to be a marsupium (Lambert, 1928), the studied specimens lack this depression (Fig. 7). This fact, along with the equal size of genital pores and also similarity in the shape of the genital plates, all suggest that sexual dimorphism is not conspicuous in *Goniopygus annularis* and *G. triangularis*.

## 5. Conclusions

a) A rich and diverse echinoid fauna, consisting of Stomechinidae, Emiratiidae, Pygaulidae, Holoctypidae, Saleniidae, Cidaridae, Hemiasteridae Toxasteridae and Acropeltidae is present in the Aptian sediments of the Baghin area, west of Kerman.

b) Two new arbacioid echinoids, *Goniopygus triangularis* and *G. annularis* are reported from this region for the first time.

c) The high endemism ratio of the fauna suggests the existence of a discrete biogeographic entity during the deposition of the strata in Baghin area.

d) Paleontological investigations indicate that both *Goniopygus triangularis* and *G. annularis* were relatively deep water organisms, living in low to moderate energy environments. They were omnivores and fed on algae, bryozoans, and small invertebrates.

e) The equal size of the gonopores and identical shape of the genital plates in different individuals allows us to conclude that *Goniopygus triangularis* and *G. annularis* were not sexually dimorphic.

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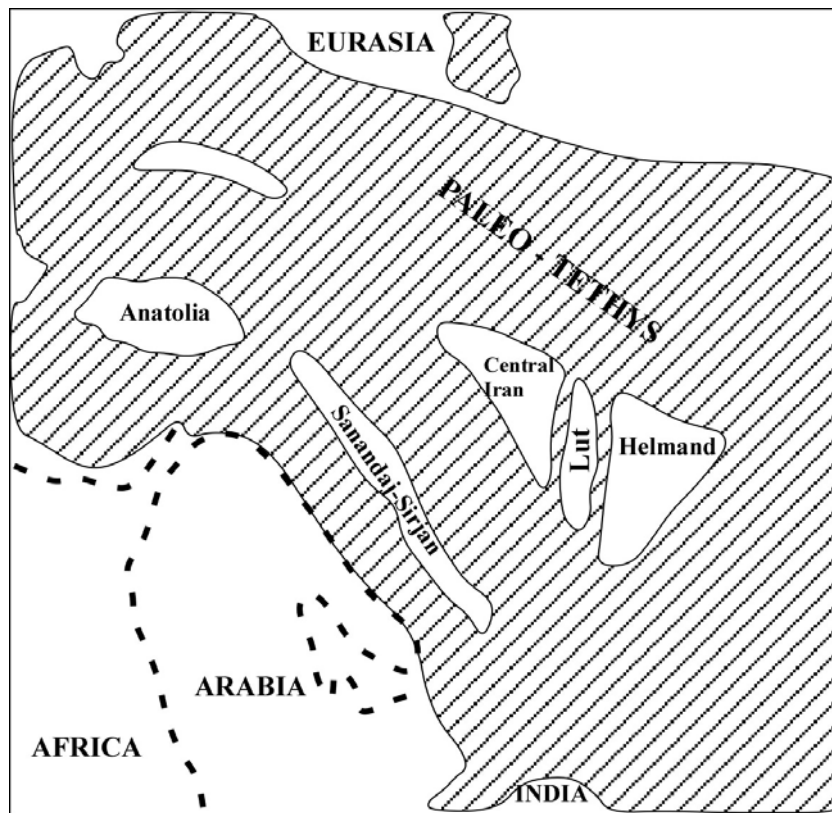


Fig. 5. Paleogeographic map of the world in Barremian-Aptian and location of Central Iran at the margin of Eurasia, Modified from Glennie (9)

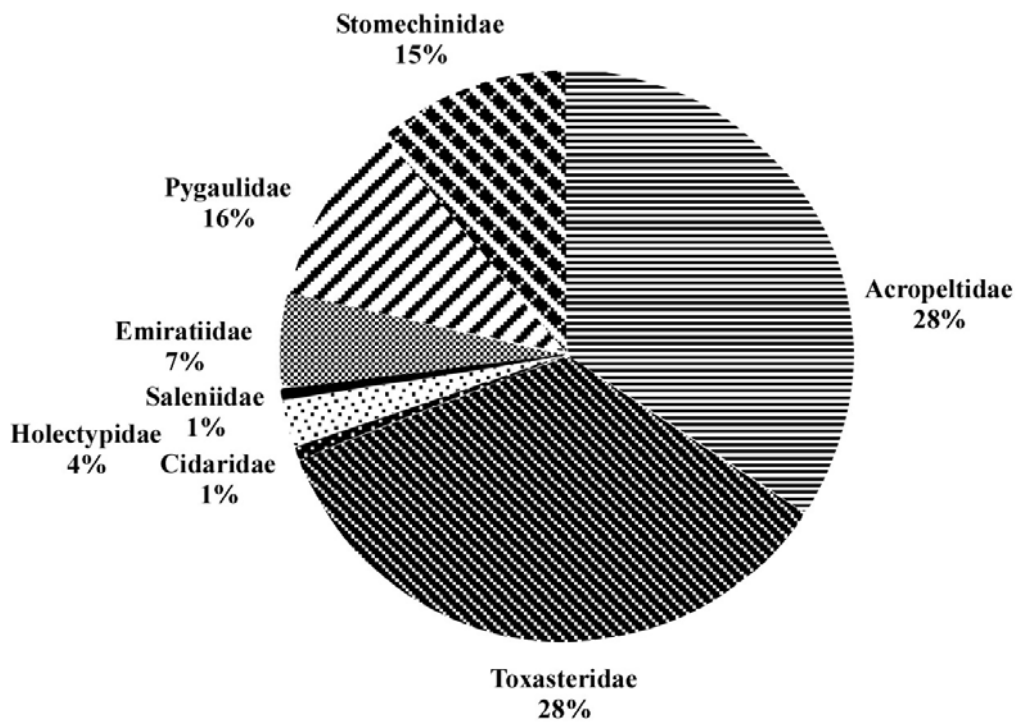
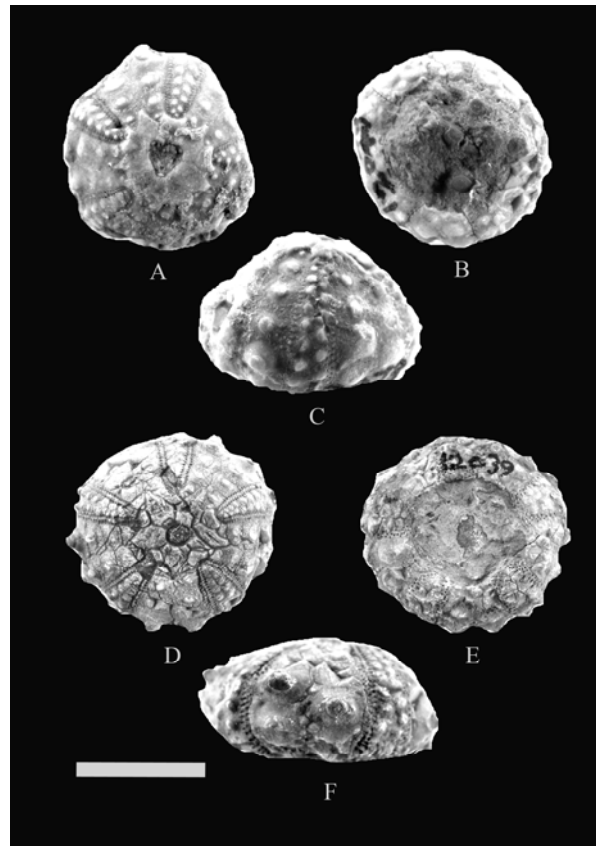


Fig. 6. Relative abundance of the echinoids of the Baghin area



**Fig. 7.** A, B, C, *Goniopygus triangularis* sp. nov., KUIC 12034; adapical, adoral and lateral views. D, E, F, *Goniopygus annularis* sp. nov., KUIC 12039; adapical, adoral and lateral views, from Aptian of Baghin area. Scale bar represents 1 cm

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