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

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

Department of Geology, Faculty of Sciences, Shahid Bahonar University, Kerman, Iran
E-mail: Vazirimohammadreza@yahoo.com

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 periperoc is triangular in shape with three small, sunken tubercles, located alternatively adjacent to the periperoc, while *Goniopygus annularis* sp. nov. is characterized by having a circular periperoc 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

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, Holectypidae, 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, Holectypidae, 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
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 periperoct.
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 periperoct 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 periperoct.
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 periperoct outline of G. triangularis is triangular, having three sunken tubercles located alternatively adjacent to three genital plates. In G. annularis the periperoct 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 periperoct 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 periperoct. The periperoct 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 preperoect.

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 preperoect. 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 Gonioptus 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 bioproviences, 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, Holecystidae, 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 royoi 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 royoi 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, Holecystidae, 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 endemicity 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. Gonioptyus triangularis sp. nov., KUIC 12034; adapical, adoral and lateral views. D, E, F, Gonioptyus annularis sp. nov., KUIC 12039; adapical, adoral and lateral views, from Aptian of Baghin area. Scale bar represents 1 cm

References


