

Sexual Dimorphism in a New Species of Cassiduloid Echinoid, *Pygaulus baghinensis*, from the Aptian Strata of Baghin Area, West of Kerman, Iran

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Abstract

A new species of cassiduloid echinoids, *Pygaulus baghinensis* is reported for the first time from Aptian sediments of Baghin area, west of Kerman, Iran. The diagnostic features of the species are centrally positioned of the apical disc and approximately low profile of the test. Variation in gonopore size in different individuals allows to conclude that *P. baghinensis* is sexually dimorphic. Specimens with large gonopores can be considered to be females, while other specimens whose gonopores diameter is small, can be considered to be males. One of the specimens has one large and three small gonopores on its apical disc. This difference may be due to hermaphroditic feature of the specimen.

Keywords: Sexual dimorphism; Gonopore; Cassiduloid echinoids; Cretaceous; Iran

Introduction

Sexual dimorphism is common in recent echinoids. Males and females are almost always separate from each other and seldom indicate pronounced sexual dimorphism [5]. Individuals with large gonopores can be considered to be females [4,8,14,16]. Usually rare hermaphroditic specimens, being reported as anomalies, are recognized as well [5].

Sexual dimorphism in fossil echinoids has been studied by some workers. Cottreau [3] has presented a detailed example of morphological dimorphism among fossil hemiasterids and thought that differences between two groups corresponded to a sexual dimorphism. Neraudeau [14] has studied sexual dimorphism in Cretaceous hemiasterid echinoids and concluded that it affects only on gonopore size and no other distinctive morphological differences allow the two sexes to be

distinguished. Sexual dimorphism among cassiduloids is exceptional. Saucedo and Neraudeau [15] have reported sexual dimorphism in a cassiduloid echinoid, *Nucleopygus (Jolyclypus) jolyi* in Cenomanian strata, based on gonopores size.

This paper deals with the first example of conspicuous sexual dimorphism among fossil pygaulid echinoids.

Geological Setting and Stratigraphy

The echinoids described here have been collected from Aptian strata that crop out at Baghin area, west of Kerman city (Fig. 1). The echinoid fauna of Baghin are fairly diverse and generally confirm the Aptian age suggested by the other fossil groups. The Aptian rocks of Baghin consists mainly of alternation of green marls and yellow shaly limestones (Fig. 2) with an abundant

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benthic fauna of *Orbitolina*, brachiopods, oysters, bivalves, gastropods and corals. Echinoids are common as well, predominantly by cidaroids, acropeltids, saleniids, toxasterids, stomechinids, phymosomatoids and a new species of pygaulids, *Pygaulus baghinensis*. The Aptian sediments overlies the gray, bioturbated, and thick-bedded limestones, relatively barren of macroinvertebrates.

Material and Methods

To examine the sexual dimorphism in *Pygaulus baghinensis*, eleven specimens of this cassiduloid echinoid have been subjected to biometric analysis. To measure the gonopore size, Neraudeau method [14] was used and the largest diameter of the right posterior genital pore was measured with an ocular micrometer.

The material used in this study is housed in paleontology laboratory of Shahid Bahonar University of Kerman.

Systematic Paleontology

- Phylum: Echinodermata Klein, 1754
- Class: Echinoidea Leske, 1778
- Cohort: Irregularia Letreille, 1825
- Order: Cassiduloida Claus, 1880
- Family: Pygaulidae Lambert, 1905
- Genus: *Pygaulus* L. Agassiz, 1840
- Type species: *Pygaulus baghinensis* Vaziri sp. nov.

Fig.3: A-J & Fig. 4: A-D

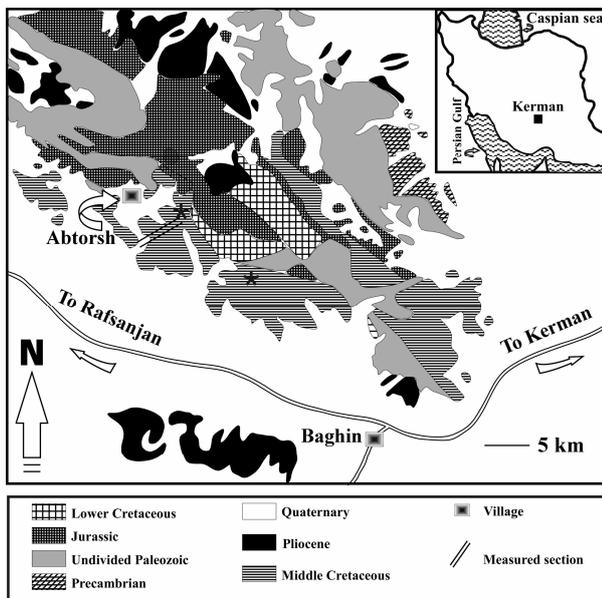


Figure 1. Simplified geological map of the Baghin area, showing localities (black stars) from where *Pygaulus baghinensis* has been collected.

Diagnosis

Pygaulus baghinensis resembles the species *Pygaulus desmoulinsii* Agassiz (1) in general shape, but can be distinguished from that species by the fact that its apical disc is approximately centrally positioned rather than near anterior of the test. In *P. desmoulinsii* the anterior petals are distinctly shorter than posterior ones, while in *P. baghinensis* all the petals are nearly equal. Furthermore, *P. baghinensis* is less inflated apical than *P. desmoulinsii*.

Material: 11 specimens.

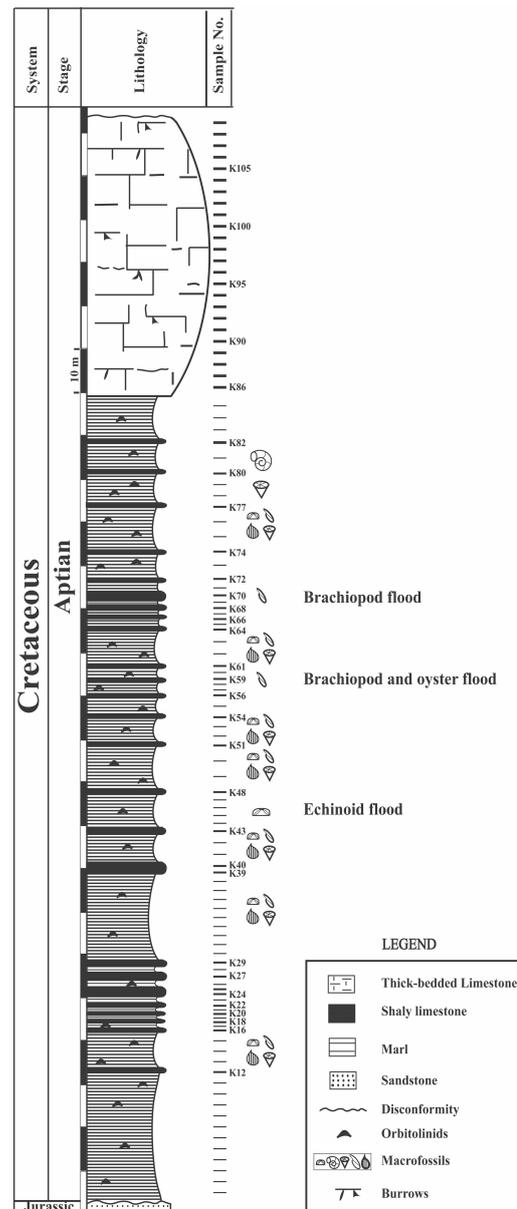


Figure 2. Schematic lithological succession of Aptian strata in Baghin area.

Description

Tests are 33-47 mm in length, 28-40 mm in width and 14-20 mm in height. They are ovate in outline with the widest part of the test towards the posterior (Fig. 3). Anterior and posterior margins rounded and maximum height lies at the apical system.

Adoral surface flattened and slightly concave.

Peristome large, oblique, positioned approximately central or slightly migrated towards anterior of the test.

Periproct inframarginal, completely visible from below, transversely elongate and subtriangular in outline.

Apical system positioned central, with four nearly rounded gonopores (Fig. 4), Madreporite fill almost the entire apical disc. Genital plates either greatly reduced or absent.

Ambulacra flush with the test, large and subequal in length. They are extremely board and open. On the apical surface, ambulacra are weakly flexed in width and consist of markedly anisoporous pore-pairs formed a mixture of elongate and circular ones. Ambulacra are about one third of interambulacra at the ambitus. On the oral surface the ambulacra are nearly well developed, nonpetaloid and straight. They become narrow slightly towards the peristome, and phyllodes extend from the peristome for about 1/3 of the radial length.

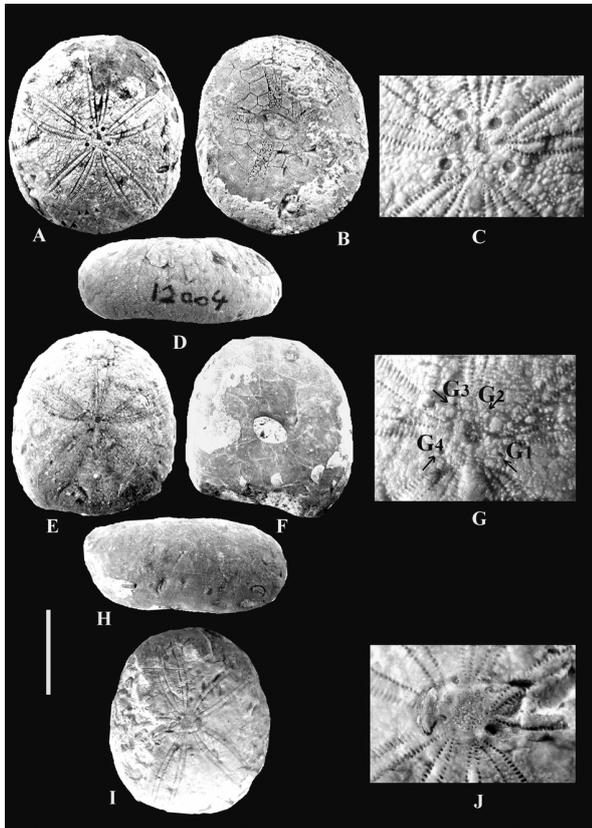


Figure 3. *Pygaulus baghinensis*. A-D: female; A, apical B, oral and D, lateral views C, apical system of the same specimen, showing the four wide gonopores. E-H: male, E, apical F, oral and H, lateral views G, apical system of the same specimen, showing the four small gonopores. I, apical view of hermaphrodite specimen J, apical system of the same specimen, showing the three small gonopores and one wide gonopore. G = gonopore. Scale bar represents 2 cm. Close up pictures (C, G and J) ×24.

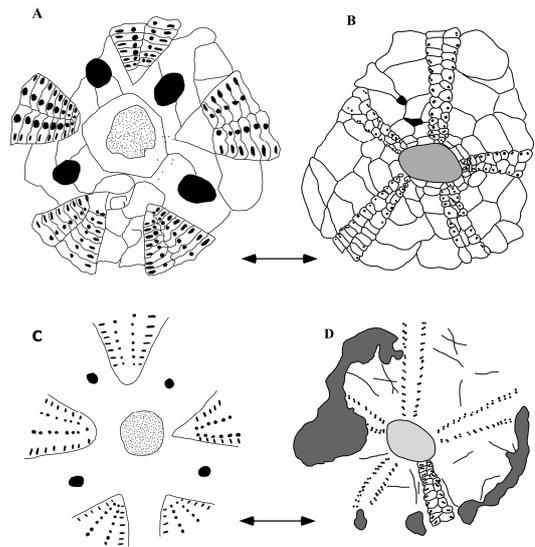


Figure 4. Camera lucida drawings of apical and oral surfaces in *Pygaulus baghinensis*. A, apical surface of a female, showing apical system; B, oral surface of a female, showing peristome and phyllodes; C, apical surface of a male, showing apical system; D, oral surface of a male, showing peristome and phyllodes.

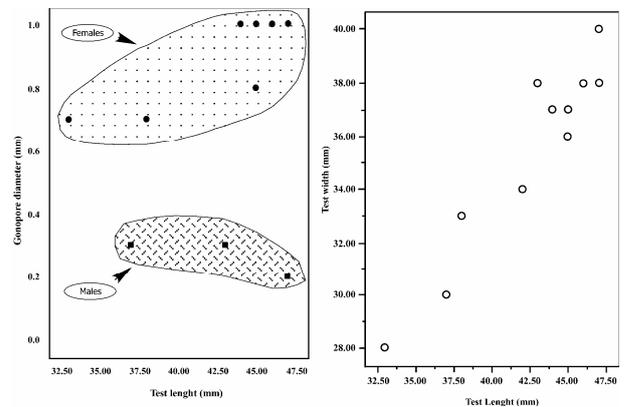


Figure 5. Scatter diagram showing the variation in gonopore diameter according to test size (left) and length size according to test width (right) in *Pygaulus baghinensis*.

The interambulacra are flush with the ambulacra and consist of large and wide plates, both in apical and oral sides.

Remarks

In Kier's [6], Pygaulidae is distinguished from all other cassiduloids by having an oblique peristome. The family ranges from Early Cretaceous (Valanginian) to Paleocene and contain following genera: *Pygopistes*, *Echinogalerus*, *Plagiochasma*, *Amblypygus*, *Pygorhynchus* and *Pygaulus*.

Although Lambert and Thiery [11] recognized some 13 species of *Pygaulus*, but there are little reviews within this genus. Some species of *Pygaulus* reported by Lambert and Thiery [11] are as below:

P. faasi, *P. macropygus*, *P. matheyi*, *P. morloti*, *P. ovatus*, *P. subaequalis*, *P. subinferus*, *P. jonatus*, *P. desmoulinssii*, *P. coquandi*.

Sexual Dimorphism in Adult *Pygaulus baghinensis*

Gonopore diameters were measured in eleven specimens, showing distinctive variation (Fig. 5). Seven specimens possess gonopores, with diameter ranging between 0.7-1 mm, larger than those of the three other specimens, ranging from 0.2-0.3 mm. In accordance with the recent sea-urchin dimorphism, specimens with large gonopores can be considered to be females and those with small gonopores to be males. The females are 37-47 in length, 34-38 mm in width and 15-19 mm in height. Their petals are conspicuous and flush with test surface. The males are 33-47 mm in length, 28-40 mm in width and 14-20 mm in height. They have petals that are slightly inconspicuous. In one specimen apical disc has 4 gonopores of which one (G1) is distinctively very larger, 3 mm, than the others, 1 mm. In this specimen the length, width and height are 45, 34 and 17 mm, respectively. The conspicuous variability in gonopores diameter allows concluding that this specimen is a hermaphrodite individual.

Results and Discussion

Sexual dimorphism in Cretaceous irregular echinoids is rare. Almost all dimorphic Cretaceous echinoids are regular species [9]. Some species such as *Hemiaster (Leymeriaster) similes* from the Upper Cenomanian of southwest France [14] and *Nucleopygus (Jolyclpus) jolyi* [15] represent the oldest example of secondary sexual dimorphism known in irregular echinoids. Neraudeau [14] has shown that immature juvenile hemiasterids have closed gonopores. During the

ontogeny, when the test reaches to a certain size, gonopores open, while the test has not achieved all the characteristics of the species morphology. This corresponds to the pre-adult stage. Finally genital pores open widely and the test acquires final adult morphology. At this stage, the echinoids are adults and sexually mature.

Variation in gonopore diameter found in *Pygaulus baghinensis* allows concluding that this species was sexually dimorphic. Open gonopores, besides the size of the tests show that all the specimens are adult and therefore sexually mature. The females have gonopores two to three times wider than those of the males. Moreover, they have larger size, more conspicuous petals and are more numerous than males in the *Pygaulus* population.

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