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Systematic Interpretation Of Silicified Specimens of Upper Cretaceous *Echinocorys* ex. gr. *scutata* (Leske, 1778), Farokhi Formation, Central Iran

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Abstract

Echinocorys ex. gr. *scutata* is one of the most important echinids in the Upper Cretaceous deposits. In this regard, a stratigraphic section of the Farokhi Formation in the Central Iran is sampled. This formation is less known and described in the geology of Iran. According to the macropaleontological investigations, 1 genus and 1 specious of completely silicified Echinocorythidae are determined and described. In these investigations, the samples are regarded also from the statistical point of view.

Keywords: Echinocorythidae, Statistics, Late Cretaceous, Farokhi Formation, Central Iran.

Introduction

Irregular echinoids first appeared during Early Jurassic and diversified markedly during the Cretaceous and Cenozoic, attaining a near-worldwide distribution. In the Turonian and Coniacian, the group was dominated by members of the orders Spatangoida and Holasteroida. The former is represented mainly by the genus *Micraster*, the latter by *Echinocorys* [11]. This study aims to present the results of the echinoids from the Farokhi Formation in the West of Central Iran sedimentary basin.

The Farokhi Formation is one of the informal Central Iran formations which is located in the NW Tabas township.

Cretaceous in Iran

The most complete Cretaceous sections in North Iran are found in the Kopet-Dagh Range on the border of Iran and Turkmenistan. The rocks consist of marine shales, marls, limestones and subordinate sandstones. The sequence reaches thickness of more than 3000 m and seems to represent all major stages of the Cretaceous system, including the Neocomian. The stratigraphic nomenclature for this region has been carried out by geologists of National Iranian Oil Company (NIOC) and is refered here to the Tirgan through Kalat formations ([11], with minor revision).

In the Alborz (=Elborz) mountains and farther south, Cretaceous rocks, mainly limestones and marls, are widely distributed, but the sections are less complete. In particular, the Neocomian seems to be missing nearly everywhere; possible exceptions to this are few limestone exposures close to the “Main Zagros Thrust”, and those few and limited areas of the western and eastern Alborz and south of Kerman, where Tithonian-?Lower Cretaceous *Calpionella* limestones have been observed. Elsewhere, unfossiliferous red clastic basal beds in the north of Ravar-Darband area initiate the Cretaceous sequence and are followed by limestones

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and marls of different ages. The oldest marine beds are *Orbitolina*-bearing limestones (here refered to the Tiz Kuh Formation), which are conventionally regarded as Aptian-Albian but may include stages as old as Barremian and as young as Cenomanian.

An unusual shale facies reaching great thickness and containing very rare cephalopods represents the (Barremian-) Albian in the Biabanak area of Central Iran (here refered to Biabanak Shales). Detrital limestones, reef limestones, marls and shales prevail. However, the sequences are frequently interrupted by conglomerates, red beds, sedimentary gaps and unconformities, and the sections vary in detail over short distances, reflecting the unstable sedimentary environment during the initial phases of the Alpine Orogeny.

Considerable disagreement between different authors regarding the stratigraphic significance of the faunas has so far made reliable correlation over any greater distance difficult, and a consistent stratigraphic subdivision of the Upper Cretaceous has yet to be drawn up. The Stratigraphic Terminological Committee has, therefore, recommended not to introduce formal stratigraphic names for the Upper Cretaceous of the Alborz, the Central and East Iran until more regional information becomes available to clarify the situation.

In Baluchestan and in several limited areas of central, northeastern and northwestern Iran, a peculiar chaotic association of pelagic limestones, radiolarites, ophiolites and various exotic blocks, has become known as the “Coloured Melange” and has been attributed by most authors to the Upper Cretaceous and, partly, to the

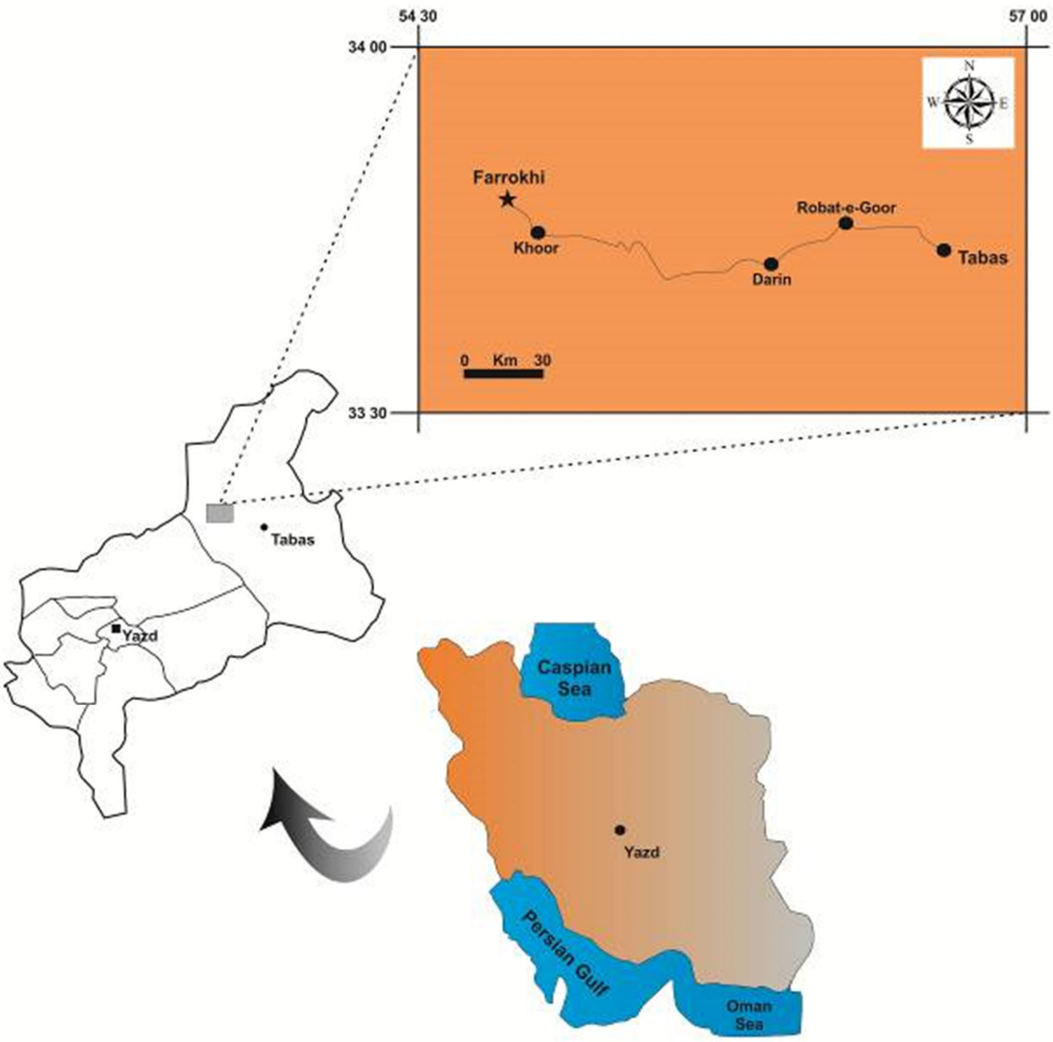


Figure 1. Location of the studied section in NE Iran

lowermost Tertiary ([11], with minor revision).

Geological setting

The Tabas area is a part of the Central Iran sedimentary basin which is located in the Yazd province. The Farokhi stratigraphic section is located 7 km northwest from Farokhi village (33 54’ 9’’N and 54 52’ 48’’E). The Bazyab, Debarso, Haftoman and Choopanan formations are well-exposed in the studied area (Fig. 2). In this study, the Farokhi Formation is investigated in the Farokhi stratigraphic section with regard to echinids (Fig. 1). The Farokhi Formation is mainly composed of thick-bedded limestones with Ammonoeids, thin-bedded limestone with silicified echinids and ichnofossils, marls with nodular cherts, spherical corals and bivalves.

Lithostratigraphy of the Farokhi Formation in the study area

The upper and lower boundaries of the Farokhi Formation in the studied stratigraphic section are not observable because of the wide-speading of formation in the area. From the lithological point of view, the Farokhi Formation in the studied area is mainly composed of the units as followed (Fig, 4):

- Thick-bedded, pinky limestone with fossil debris in some parts (50.50 m).
- Thin-bedded limestone with great amount of cherty echinids and ichnofossils (18.50 m).
- Marls with great amount of cherty echinids, nodular cherts, spherical corals and bivalves (22.50 m).
- Marls with reworked spherical corals (1.50 m).
- Marls with intercalations of shales and limestones with echinids, spherical corals, colonical corals and bivalves (5.50 m).
- Marls (44 m).
- Marls without macrofauna, with secondary oxide veins and small joints (11 m).
- Marls (29.50 m).
- Marly limestone and limy marls (7.50 m).
- Hardened marls with coatings of iron oxide and no macrofauna (6 m).
- Dark limestone without any macrofauna (4.50 m).
- Limestones with ichnofossils, ammonoids and spherical corals (9.50 m).
- Pale limestones with ichnofossils and echinids (5.50 m).
- Thin-bedded limestones with cherts and echinids (11 m).
- Thin-bedded limestones with ichnofossils (4 m).
- Limestones with echinids (9 m).
- Limestones with ichnofossils and partially compressed echinids (11 m).
- Limestones without any macrofauna (4 m).

Previous studies in the area

In the Central Iran sedimentary basin, no studies have been done on echinids in the Farokhi Formation. Wilmsen et al. (2012), have introduced *Porosphaera globularis* (Phillips, 1829) (Porifera, Calcarea) from the Maastrichtian Farokhi Formation.

Materials and Methods

Echinoderms are marine, solitary and usually benthic animals. They were diverse in shapes (in ambulacra, genital plates and etc.) in this phylum from the Early Paleozoic. Echinoderms are characterized by the presence of an ambulacral system. This organ helps the animal in food obtaining, the vascular system, the respiratory system, as well as organs for locomotion. The system starts at the surface with an opening known as the hydropore, or with a perforated calcareous madrepore plate.

<table>
<tr><th colspan="3">formations</th><th colspan="3">Thickness (m.)</th><th colspan="2">Lithology</th><th>Age</th></tr>
<tr><td colspan="3">Farokhi</td><td colspan="3">80 - 250</td><td colspan="2">Cherty limestone, Marl,Sandstone</td><td>Late Cenonian – Danian</td></tr>
<tr><td colspan="3">Haftoman</td><td colspan="3">220 - 950</td><td colspan="2">Rudist limestone, Sandstone, Conglomerate</td><td>Early Cenonion</td></tr>
<tr><td colspan="3">Debarsoo</td><td colspan="3">130 - 590</td><td colspan="2">Limestone, Marl, Conglomerate</td><td>Cenonion - Turonian</td></tr>
<tr><td rowspan="2">Bazyab</td><td colspan="2">Mirza</td><td rowspan="2">100 - 600</td><td colspan="2">>200</td><td>Shale, Limestone, Conglomerate</td><td rowspan="2">Marl, Limestone, Clay ston
Silt, Sandstone</td><td rowspan="2">Albian</td></tr>
<tr><td colspan="2" rowspan="2">Biabanak</td><td colspan="2"></td><td>Slate, Limestone, Sandstone</td></tr>
<tr><td>Shah Kooh</td><td colspan="2">10 - 460</td><td>2500 - 4400</td><td colspan="2">Orbitolina limestone, Argillaceous limestone</td><td>Aptian</td></tr>
<tr><td colspan="3">Mirza</td><td colspan="3">10 - 500</td><td colspan="2">Sandstone, Conglomerate, Limestone, Siltstone, Marl</td><td>Neocomian</td></tr>
</table>

Figure 2. Cretaceous formations in the Central Iran (Aghanabati, 2004)

Water which circulates through the ambulacral system not only provides the organism with oxygen, but also moves microscopic particles of food towards the mouth. Water penetrates food to the water vascular system, gradually passing into the radial canal in order to be taken into the every part of the body. Echinoderms developed an internal calcareous skeleton, the so-called theca, which consist of fixed plates or plates of $CaCO_3$ connected by joints. The name of this entire phylum is based on the fact that there are usually numerous spines sticking through the skin and covers the calcareous skeleton to appear on the surface. Living representatives of the echinoderms are subdivided into five classes and of these the subphyla Blastozoa, Crinozoa and Echinozoa are particularly important for paleontology [4].

The material comprises almost 150 specimens that have been analyzed biometrically (the used abbreviations are as follow: D (thickness), W (width), H (Height), a (longest ambulacrum), b (small ambulacrum) and c (distance between two small ambulacra)). Most of the specimens studied were collected by the author and are housed at the Department of Geology, Mashhad Branch, Islamic Azad University, Mashhad, Iran.

Systematic Descriptions

The following systematic describes diagnostic features and biometric calculations (the six linear parameters, which were measured on specimens to evaluate the morphological variations as well as finding any relations between variables, the results of these calculations are described in the biometric calculation part):The systematic is given following the latest concepts by Smith (1984), Smith & Wright (1999, 2000, 2003) and descriptive terminology by Durham & Wagner (1966) and Olszewska (2007).

Order Holasteroida Durham & Melville, 1957
Infraorder Meridosternata Loven, 1883
Family Echinocorythidae Wright, 1857
Genus *Echinocorys* Leske, 1778

The genus *Echinocorys*, similar to *Micraster* belongs to deposit feeders although it, similar to *Plesiocorys*, is epibenthonic (Ernst & Seibertz 1977; Jagt & Michels 1994), living on soft, chalky substrate. Several characters, such as shape and tuberculation of the test, large wide flattened base, the lack of the anterior groove on the ambulacral III, and of the fascioles, and the character of ambulacral pores (indicating respiratory function) on the adoral side (Smith 1980a, b, 1988; Jagt & Michles 1994), confirm its epibenthic mode of life. This interpretation is not commonly accepted, and Kongiel (1949), e. g. suggested a burrowing mode of life of the genus, although based on weakly evolved tubercles on the aboral side of the test, rare asymmetric tubercles, and the lack of fascioles in *Echinocorys*, Kongiel (1949) suggested it to be an ineffective, shallow burrower. The shape of the *Echinocorys* test is particularly sensitive for lithofacies. In the material from Germany, from pure limy lithotopes, the genus is larger and higher on average than its representatives from marly limestones, or silty to arenitic limy marls (Ernst 1970). Test height decreases with relative increase of clay or sand content in the substrate.

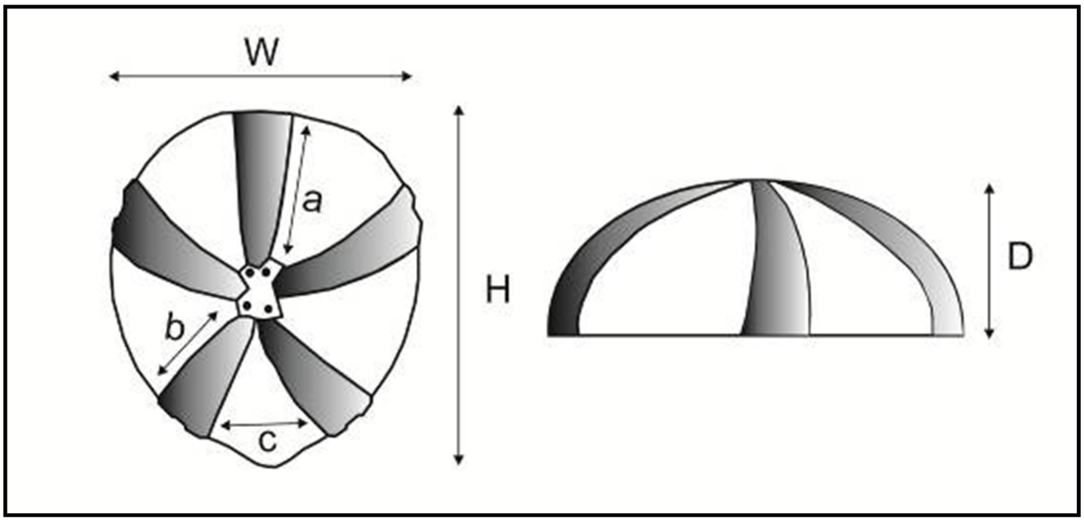


Figure 3. Measured elements on a schematic photo of *Echinocorys* ex. gr. *scutata* Leske, 1778

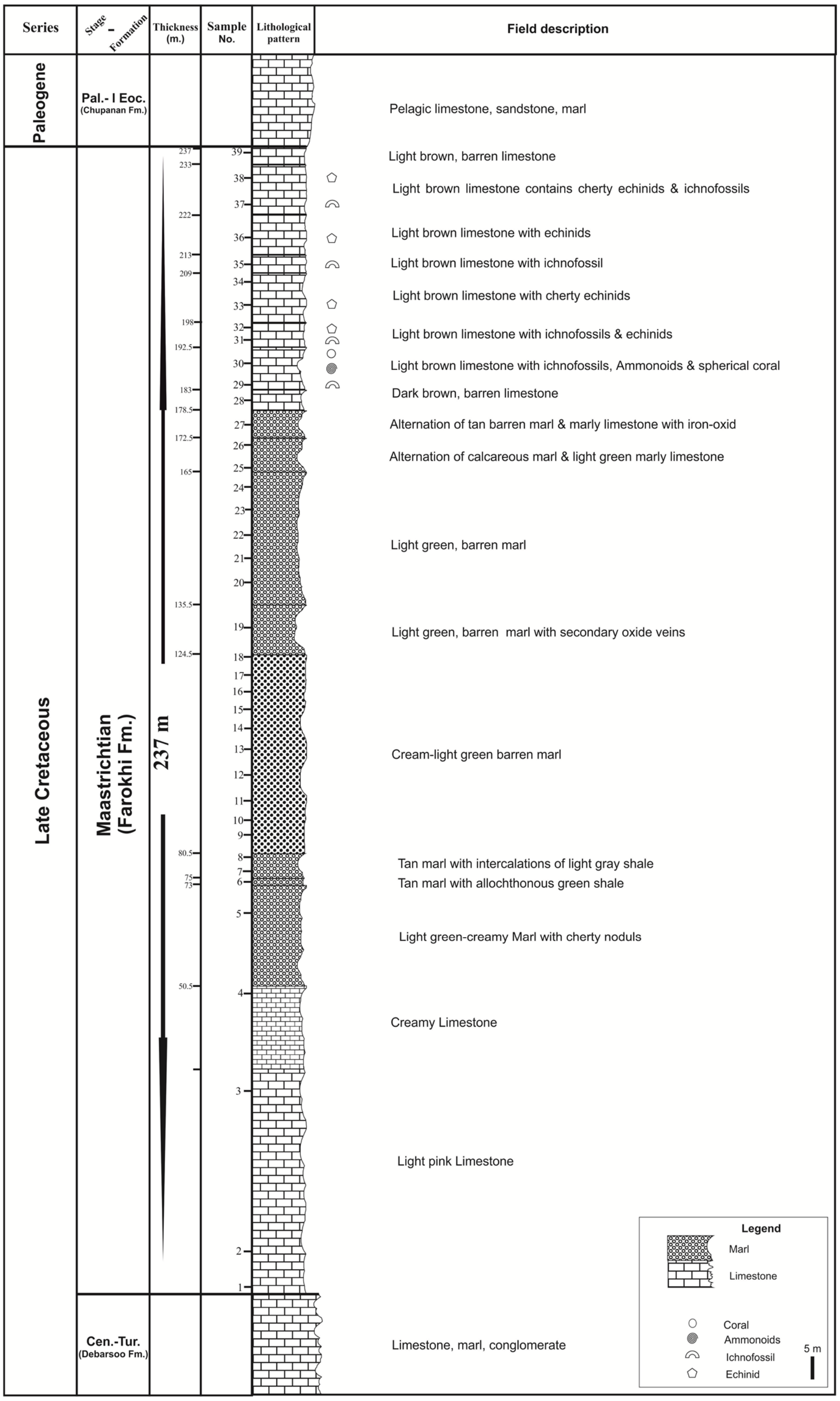
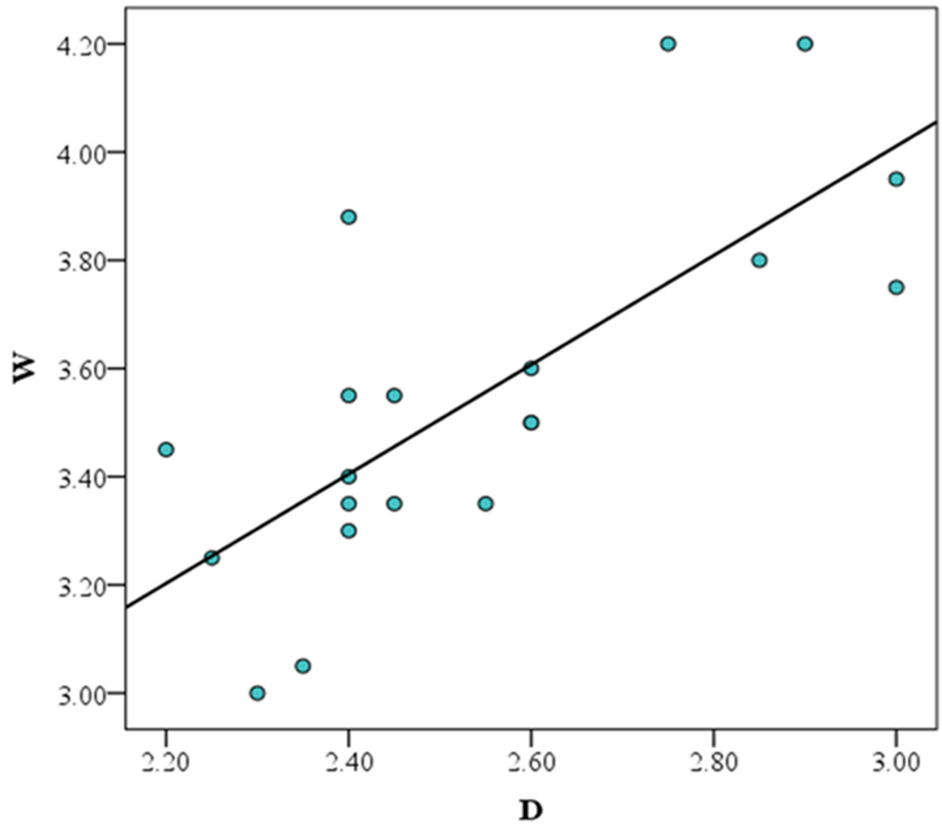


Figure 4. Stratigraphic column of the Farokhi Formation in the studied area

Echinicorys seems to have been much more sensitive to facies changes than infaunal *Micraster* (compare Ernst & Seibertz 1977).

***Diagnostic Features*:** Test ovate with flat base and domed upper surface; no anterior sulcus. Apical disc relatively large; with four gonopores. All ambulacra flush, with small circumflexed pore-pairs adapically.

Table 1. The linear relation and Pearson correlation coefficient between *W* and *D* variables



Correlations

		W
W	Pearson Correlation	1
	Sig. (2-tailed)	
	N	20
D	Pearson Correlation	.738**
	Sig. (2-tailed)	.000
	N	20

**. Correlation is significant at the 0.01 level (2-tailed).

Plastron meridosternous, with a single asymmetric sternal plate following the labrum. Subsequent plates biserial. Periproct inframarginal to oral. No enlarged primary tubercles aborally. No fascioles.

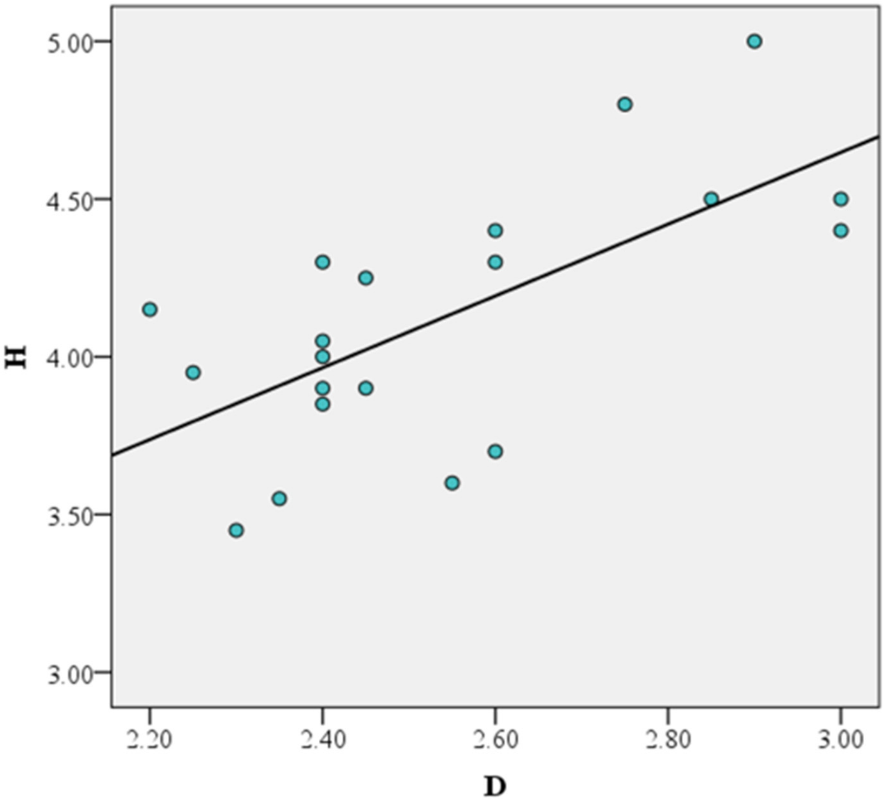
***Remarks*:** One of the best known Upper Cretaceous fossils of chalk deposits. An epifaunal deposit feeder. Closest to Pseudananchys, from which it differs in having small circumflexed pore-pairs aborally and an inframarginal periproct. Differs from Galeola only in having the periproct more adoral. The genus is rare in the Turonian. During the Coniacian- Maastrichtian the number of species and individuals considerably increased [6 & 14]. According to the opinion of several authors the genus *Echinocorys* represents a single large species complex in the Late Cretaceous of England.

***Occurrence*:** Middle Turonian to Late Paleocene, worldwide.

Echinocorys ex. gr. *scutata* (Leske, 1778)
(pl. 1-3)

1778 *Echinocorys scutatus* N.G. Leske, p. 111, pl. 15, figs. A, B.
1881 *Echinocorys vulgaris* Breynius, T. Wright

Table 2. The linear relation and Pearson correlation coefficient between *H* and *D* variables



Correlations

		H	D
H	Pearson Correlation	1	.670**
	Sig. (2-tailed)		.001
	N	20	20
D	Pearson Correlation	.670**	1
	Sig. (2-tailed)	.001	
	N	20	20

**. Correlation is significant at the 0.01 level (2-tailed).

(*partly*), p. 328, pl. 77, figs 1-11.

1903 *Echinocorys vulgaris* var. *scutatus* Leske; J. Lambert, p. 58.

1959 *Echinocorys gibbus* Lamarck; M.M. Moskvin, p. 256, text-fig. 56; pl. 6, fig. 1.

1959 *Echinocorys gravesi* Desor; M.M. Moskvin, p. 256, text-fig. 57; pl. 6, fig. 2.

1964 *Echinocorys gravesi* (Desor); G.N. Dzhabarov, p. 25, pl. 2, fig. 2.

1964 *Echinocorys gravesi* (Desor) var. *moskvini*; G.N. Dzhabarov, p. 26, pl. 2, fig. 3; pl. 3, fig. 1.

1966 *Echinocorys scutatus* Leske; C.D. Wagner & J.W. Durham, p. U528, fig. 416,*8*.

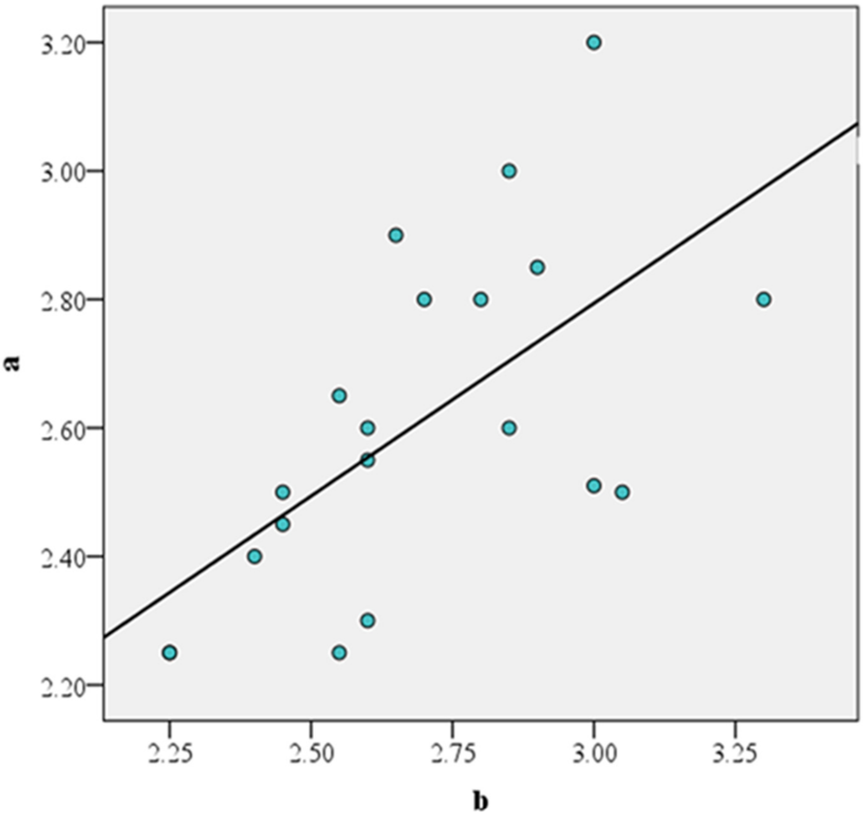
1967 *Echinocorys gravesi* (Desor); L. Cayeux & O. De Villoutreys, p. 36, pl. 3, fig. 9.

1968 *Echinocorys* cf. *conicus* Agassiz var. *minor* Lambert; S.I. Pasternak & *et al*., p. 212, text-fig. 42; pl. 44, figs 6, 7.

1970 *Echinocorys scutata* Leske; N.B. Peake & R.V. Melville, p. 57, pl. 2, figs A, B.

1974 *Echinocorys gravesi* Desor; O.V. Savchinskaya, p. 321, pl. 103, figs 12-16.

Table 3. The linear relation and Pearson correlation coefficient between *a* and *b* variables



Correlations

		a	b
a	Pearson Correlation	1	.624**
	Sig. (2-tailed)		.003
	N	20	20
b	Pearson Correlation	.624**	1
	Sig. (2-tailed)	.003	
	N	20	20

**. Correlation is significant at the 0.01 level (2-tailed).

1974 *Echinocorys* ex gr. *scutata* Leske; G. Ernst & M.G. Schulz, p. 36, text-figs 12, 13; pl. 4, figs 1-4.

2002 *Echinocorys scutata* Leske; A.B. Smith & C.W. Wright (pars), p. 287, text-fig. 13.1(A-D, I-J, K-L, O-P); pl. 59, figs 1, 2.

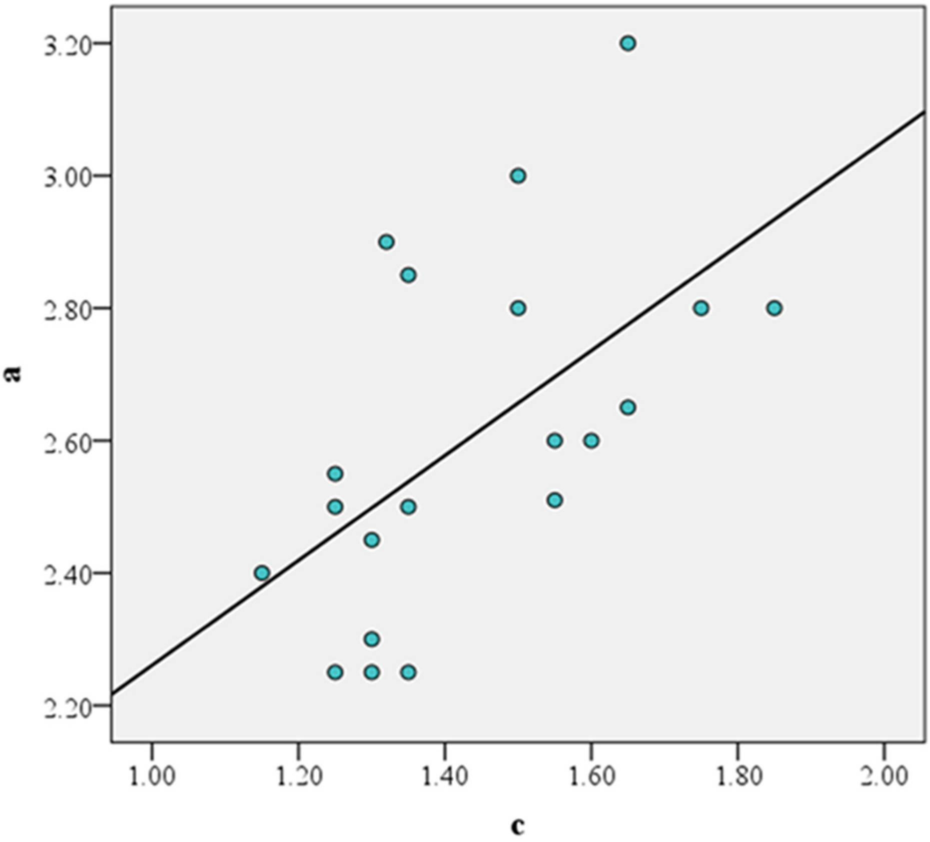
2003 *Echinocorys scutata* Leske; A.B. Smith & C.W. Wright (pars), p. 531, text-fig. 218; pl. 168, figs 1-4, pl. 169, fig. 5; pl. 170, figs 1-3, 8-9; pl. 171, figs ?1-?3, 4-9.

2007 *Echinocorys* ex gr. *scutata* Leske; D. Olszewska-Nejbert, Text-figs 18, 19; Pl. 8, Fig. 3; Pl. 9, Figs 1, 2; Pl. 10, Figs 1, 2.

***Material*:** From the total collected samples, 21 samples belong to this specimen which are well preserved and selected for detailed paleontological studies.

***Description*:** According to Noorbakhsh et al. 2013, The size of the test is various in samples. The shape is generally elliptical to sub elliptical and is completely rounded and concave in the anterior side but is less concave in the posterior side. Periproct is located in the ridge side and is generally rounded. Peristome is circular to elliptical in shape. In some samples, the

Table 4. The linear relation and Pearson correlation coefficient between *a* and *c* variables



Correlations

		a
a	Pearson Correlation	1
	Sig. (2-tailed)	
	N	20
c	Pearson Correlation	.571**
	Sig. (2-tailed)	.009
	N	20

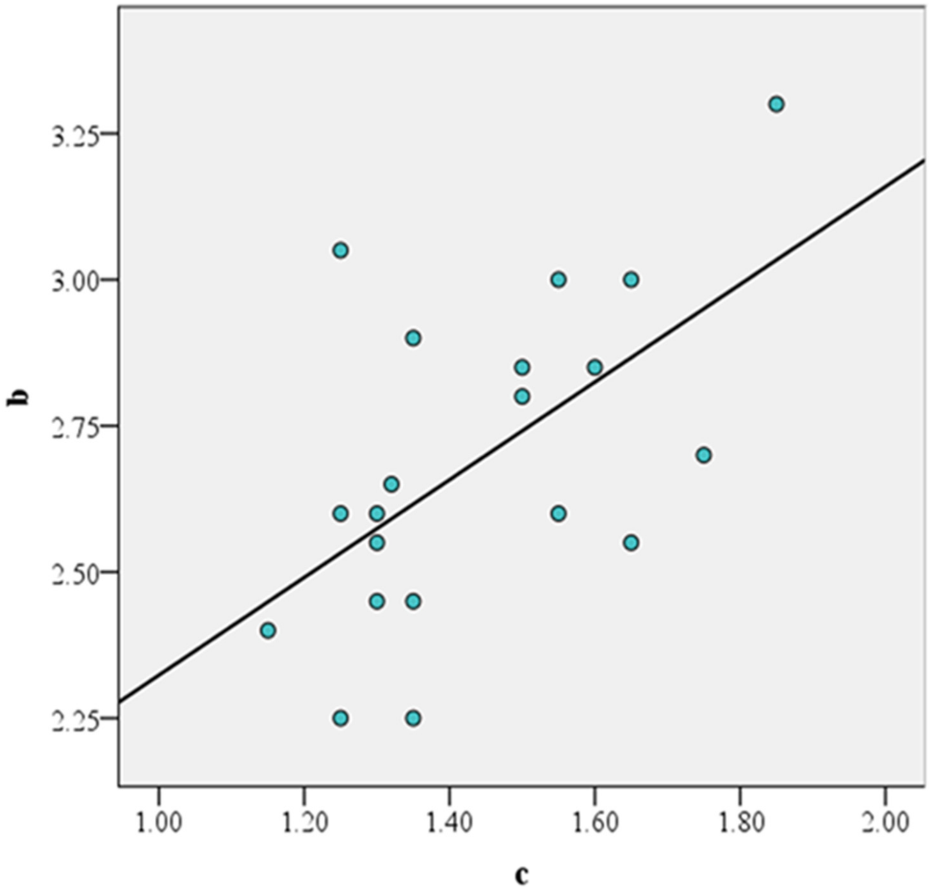
**. Correlation is significant at the 0.01 level (2-tailed).

regular tubercles are visible from the aperture to the ridge side. There are no tubercles on the aboral side or rarely are founded. The apical system is long. There is no labrum and fasciol. Ambitus is located higher than its normal place.

***Biometric calculations*:** The characters which are measured and abbreviations used for representatives of this family are shown in Figure 3 and tables 1-6. The used abbreviations are as follow: D (thickness), W (width), H (Height), a (longest ambulacrum), b (small ambulacrum) and c (distance between two small ambulacra).

***Occurrence*:** Early Coniacian (*Cremnoceramus* c. *crassus* Zone) at Shakh-Bogota, Middle and Late Coniacian at Sulu-Kapy, Shyrkala-Airakty and condensed Late Turonian-Coniacian of Azhirektoy and Besakty, plus Early Coniacian at Folwark. This species has also been reported from the Middle-Late Coniacian and Santonian of the North European Province (England, France, Belgium, Germany, western Ukraine,

Table 5. The linear relation and Pearson correlation coefficient between *b* and *c* variables



Correlations

		b	c
b	Pearson Correlation	1	.580**
	Sig. (2-tailed)		.007
	N	20	20
c	Pearson Correlation	.580**	1
	Sig. (2-tailed)	.007	
	N	20	20

**. Correlation is significant at the 0.01 level (2-tailed).

Donbass, ?northern Caucasus, Kopet-Dagh).

Ernst & Schulz (1974) described a very similar *Echinocorys* ex gr. *scutata* fauna from the Middle Coniacian to Middle Santonian from Lägerdorf, northern Germany, with an acme in the Late Coniacian and Early Santonian. At Lägerdorf, the morphotype “*striata*” succeeds the morphotype “*vulgaris*” during the Middle Santonian (Noorbakhsh Razmi, 2013).

Statistic relations analysis

We introduced two hypothesis as a pattern: Hypothesis “Zero”: the non-existence linear relation between two variats and hypotheis “One”: the existence linear relation between two variats.

According to the table 1 by increasing in *D* parameter, *W* parameter also increased. The value of the Pearson correlation coefficient between *W* and *D* parameters certified the positive linear relation between these two variables.

Table 6. Measured variants on *Echinocorys* ex. gr. *scutata* Leske, 1778 and calculated parameters

Variants Sample No.	a	b	c	W	H	D
1	2.50	2.45	1.35	3.45	4.15	2.20
2	2.25	2.25	1.35	3.25	3.95	2.25
3	2.40	2.40	1.15	3.00	3.45	2.30
4	2.25	2.25	1.25	3.05	3.55	2.35
5	2.55	2.60	1.25	3.55	3.90	2.40
6	2.55	2.60	1.25	3.55	3.90	2.40
7	2.50	3.05	1.25	3.35	4.00	2.40
8	2.65	2.55	1.65	3.88	4.30	2.40
9	2.30	2.60	1.30	3.40	4.05	2.40
10	2.60	2.85	1.60	3.55	4.25	2.45
11	2.45	2.45	1.30	3.35	3.90	2.45
12	2.25	2.55	1.30	3.35	3.60	2.55
13	3.00	2.85	1.50	3.50	4.40	2.60
14	2.60	2.60	1.55	3.50	3.70	2.60
15	2.90	2.65	1.32	3.60	4.30	2.60
16	2.51	3.00	1.55	4.20	4.80	2.75
17	3.25	3.00	1.65	3.80	4.50	2.85
18	2.80	3.30	1.85	4.20	5.00	2.90
19	2.85	2.90	1.35	3.75	4.40	3.00
20	2.80	2.70	1.75	3.95	4.50	3.00
Average ratio	2.62	2.69	1.44	3.55	4.13	2.54
Minimum value	3.20	3.30	1.85	4.20	5.00	3.00
Standard deviation	0.270	0.276	0.191	0.330	0.410	0.241
Median	2.58	2.63	1.35	3.50	4.10	2.45

According to table 2 by increasing in *D* parameter, *H* parameter also increased. The value of the Pearson correlation coefficient between *H* and *D* parameters certified the positive linear relation between these two variables.

According to the table 3 by increasing in *b* parameter, *a* parameter also increased. The value of the Pearson correlation coefficient between *a* and *b* parameters certified the positive linear relation between these two variables.

According to the table 4 by increasing in *c* parameter, *a* parameter also increased. The value of the Pearson correlation coefficient between *a* and *c* parameters certified the positive linear relation between these two variables.

According to the table 5 by increasing in *c* parameter, *b* parameter also increased. The value of the Pearson correlation coefficient between *c* and *b* parameters certified the positive linear relation between these two variables.

Results and Discusion

Detailed macropaleontological studies of the echinoids taxa from the Farokhi Formation, led to determination of 1 genus and 1 species. The recognized genus belongs to Echinocorythidae family and the only species is assigned to *Echinocorys* ex. gr. *scutata*.

Descriptions and standard biometric parameters are done and calculated accurately by the statistic relations and various parametric data following the related charts and diagrams. Some essential data such as average ratio, minimum and maximum value, median and standard deviation are reported. According to the determined taxa and its associations (Palynomorph elements and planktonic foraminifera such as *Contusotruncana contusa, Globotruncana linneiana, Pseudotextularia intermedia, Globotruncana arca, Globotruncanita stuarti*), the Maastrichtian age is suggested for the Farokhi Formation in the Central Iran sedimentary basin.

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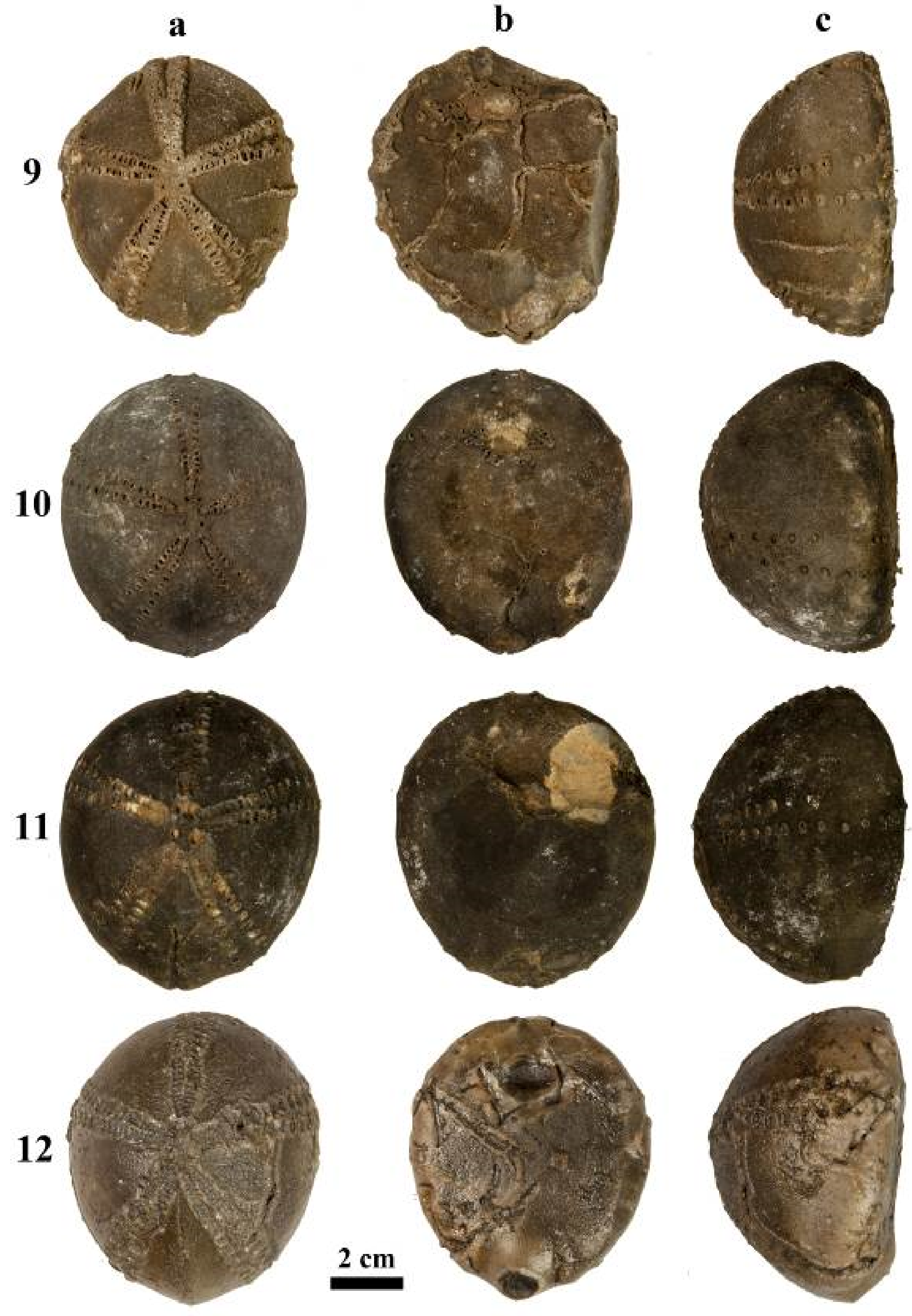
Echinocorys ex. gr. *scutata* (Leske, 1778)
1a-c: a (Aboral side), b (Oral side) and c (Lateral side)
2a-c: a (Aboral side), b (Oral side) and c (Lateral side)
3a-c: a (Aboral side), b (Oral side) and c (Lateral side)
4a-c: a (Aboral side), b (Oral side) and c (Lateral side)

5a-c: a (Aboral side), b (Oral side) and c (Lateral side)
6a-c: a (Aboral side), b (Oral side) and c (Lateral side)
7a-c: a (Aboral side), b (Oral side) and c (Lateral side)
8a-c: a (Aboral side), b (Oral side) and c (Lateral side)



9a-c: a (Aboral side), b (Oral side) and c (Lateral side)
10a-c: a (Aboral side), b (Oral side) and c (Lateral side)
11a-c: a (Aboral side), b (Oral side) and c (Lateral side)
12a-c: a (Aboral side), b (Oral side) and c (Lateral side)

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