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First record of *Gitolampas subrotundus* (Cotteau, 1856) (Echinoidea) from the Late Paleocene of Iran

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Key words:
Echinoidea, Gitolampas, Coccolithophores, Paleocene, Kopet-Dagh area, Iran.

Abstract. In this paper we present the first record of well preserved specimens of *Gitolampas subrotundus* (Cotteau, 1856) from the Late Paleocene of Iran (Jorasán Razaví county, northeast Iran). The detailed biostratigraphic and calcareous nannofossils investigations were carried out on a stratigraphic section in Chehel Formation. This study extends the palaeogeographical distribution of Late Paleocene echinids along the northern Tethyan margins. The investigated fossiliferous section is compared with coeval strata from other European regions.

Кључне речи:
Ехиниди, Gitolampas, коколитофориде, палеоцен, област Kopet-Dagh, Иран.

Апстракт. У овом раду је приказан први налазак добро очуваних примерака врсте *Gitolampas subrotundus* (Cotteau, 1856) из горњег палеоцена Ирана (округ Jorasán Razaví, североисточни Иран). На стратиграфском профилу у Chehel формацији су извршена детаљна биостратиграфска истраживања и истраживања карбонатних нанофосила. Овај рад проширује палеогеографску дистрибуцију каснопалеоценских ехинида дуж северног обода Тетиса. Истраживани фосилоносни профил је поређен са сличним слојевима других европских региона.

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.Introduction

The Kopet-Dagh (or Koppeh Dagh, Kopeh Dagh) Mountain Range represents a NE-trending, approximately 650 km long and 200 km wide, active fold belt at the border between Iran and Turkmenistan, east of the Caspian Sea. This sedimentary basin is located in the northeast of Iran and south of Turkmenistan as an intracontinental basin. It was formed on the Hercynian metamorphosed basement at the SW margin of the Turan Platform and is composed of approximately 10 km of mostly conformably Mesozoic and Tertiary sediments dominated by carbonates (Taherpour-Khalil-Abad et al., 2013). These sediments were deposited in a marginal sea of the northern Tethys.

Ocean, one of the so-called Peri-Tethyan basins, which became closed with the suturing of NE Iran to the Eurasian Turan Platform resulting from the convergence between the Arabian and Eurasian plates (Taherpour-Khalil-Abad, 2017; Taherpour-Khalil-Abad et al., 2013).

Geological Survey of Iran and Geosciences Research Center, NE Territory, Geoscience Museum of Mashhad (Maryam Ahmadi Kooshki collection) with prefix GMM (Geoscience Museum of Mashhad).

Stratigraphy

The studied samples originated from the Paleogene Chehel Kaman Formation referring to the Chehel Kaman Valley in the eastern Kopet-Dagh (NE Iran, Fig. 1). The name, introduced by Afshar-Harb (1969), applies to the lithostratigraphic unit of bedded limestone and dolomite with inter-bedded marl and shale occurring throughout the Kopet-Dagh mountain range. The study area is located in the Khorasan-e-Razavi province, northeast Iran (Fig. 1), an area where several outcrops of the Upper Cretaceous Abderaz, Abtalkh, Neyzar and Kalat formations as well as the Paleogene Pestehligh, Chehel Kaman and Khangiran formations are presented. The locality from which the samples containing echinoid were collected is named Bazangan-lake stratigraphic section (Fig. 2), located about 20 km southeast of Bazangan lake. At the Bazangan-lake stratigraphic section, the Chehel Kaman Formation is about 101.2 m thick and is overlain by the Khangi-

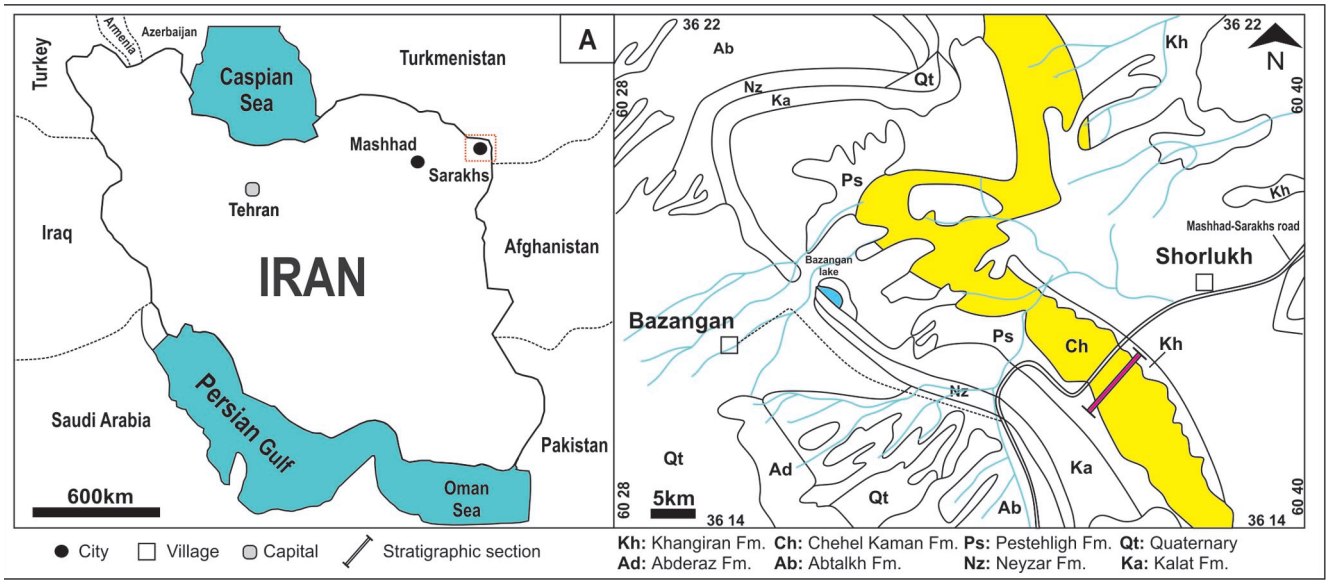

Fig. 1. *The location map of the studied area.*

The palaeontological fauna of the Echinoidea from Iran has scarcely been studied especially the one belonging to the Eocene. A significant amount of *Gitolampas subrotundus* specimens which are well preserved are housed in the repository system of the

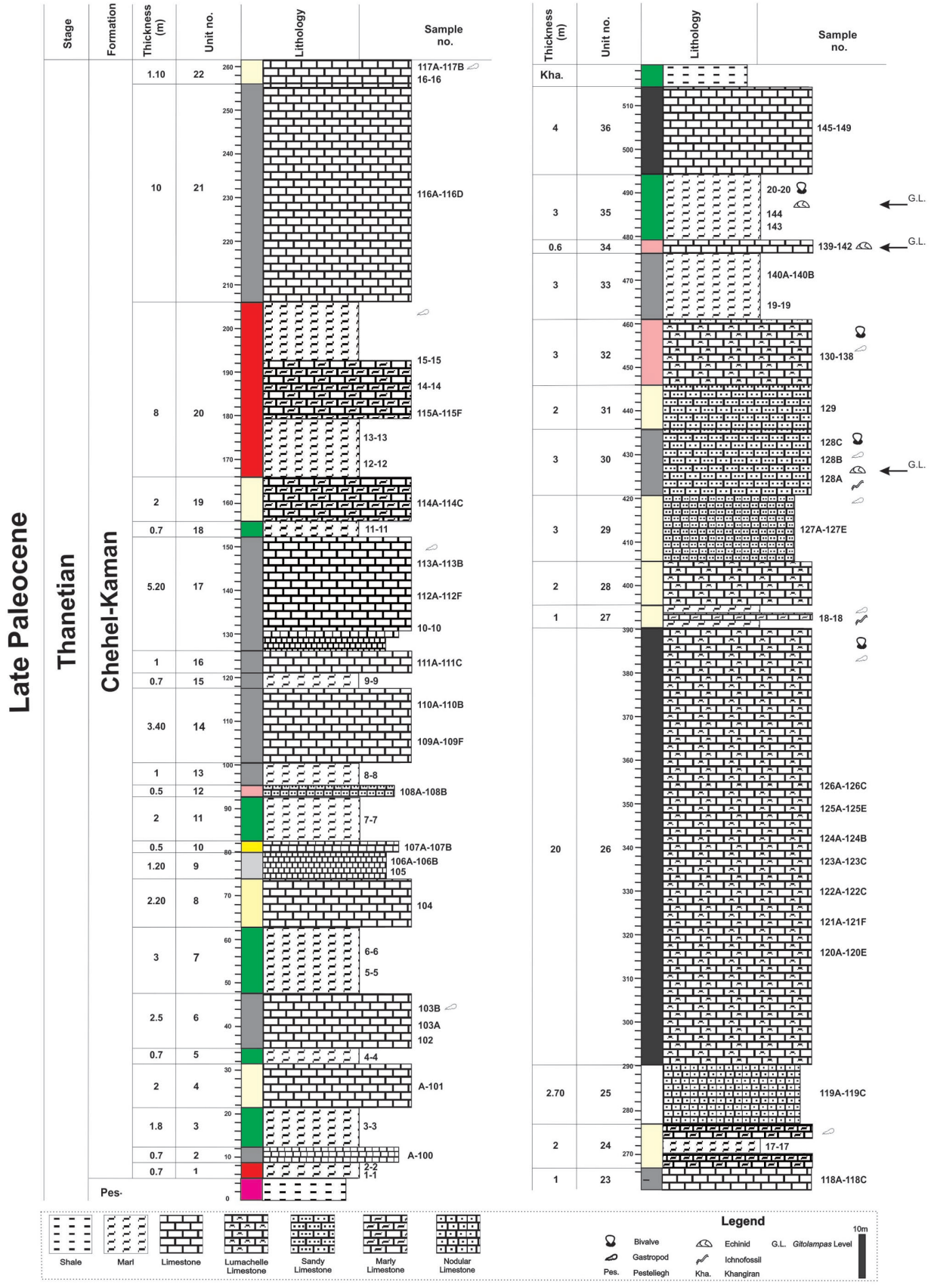

Fig. 2. *Stratigraphic column and the occurrence levels of Gitolampas subrotundus samples in the studied stratigraphic section.*

ran Formation and conformably underlain by the Pestehligh Formation.

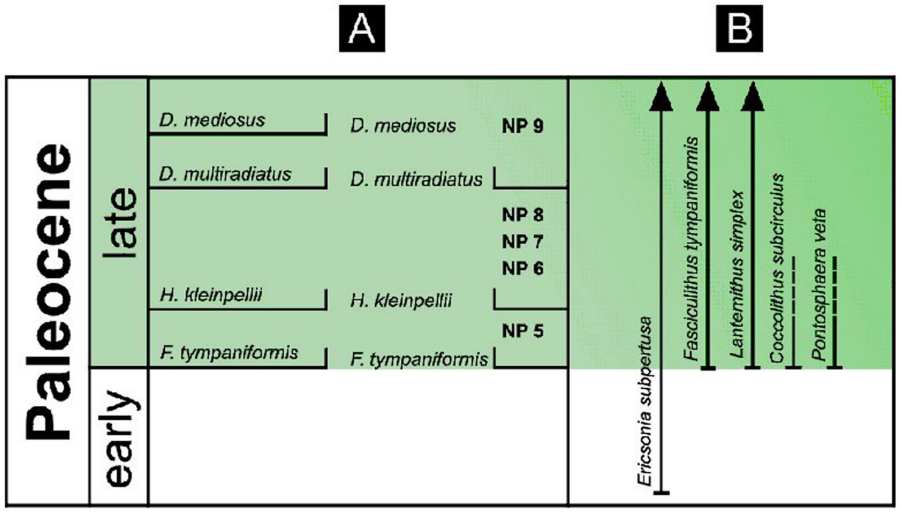

Fig 3. A, *Nannofossil zonation of Paleocene (after* Martini, *1971);* ***B,*** *Index nannofossil occurence in the studied successions.*

The Chehel Kaman Formation is represented by a light grey sandy limestone rich in bivalve overlain by medium to thick-bedded fossiliferous limestone and white to grey thick-bedded sandy limestone. Micropaleontological investigations of echinoid rich levels led to the identification of the following Late Paleocene foraminifera assemblages: *Cribrobulimina carniolicu, Discorbis* sp.*, Elphidium* sp.*, Lockhartia* sp.*, Miscellanea* sp.*, Nodosaria* sp.*, Ornatorotalia granum, Pararotalia* sp.*, Quinqueloculina* sp.*, Ranikothalia nuttalli, Rotalia trochidiformid, Smoutima* sp., *Spiroloculina* sp.

Coccolithophores represents an important component of the phytoplanktonic community, characterized by the minute calcareous plates they secrete, called coccoliths. Today nannofossils are one of the best correlation tools in marine sediments that contain pelagic constituents. Precise age determinations and correlations can be made in Cretaceous and Cenozoic strata for which numerous reference sections have been studied. This is the first study of calcareous nannofossils from the Chehel Kaman Formation in Bazangan stratigraphic section. Nannofossils in the studied samples (samples no. 18-18, 19-19 and 20-20) were common to abundant and well preserved without apparent diagenetic changes (dissolution and recrystallization). Samples were cut and rinsed to remove the weathered surface and to prevent contamination. Standard preparation techniques of Bramlette & Sullivan (1961) have been followed; smear slides were examined with a light microscope using transmitted and cross-polarized light at 1250× magnification. Five genera and five species of the calcareous nannofossils are identified from these samples (Fig. 3B): *Lanternithus simplex, Coccolithus subcirculus, Pontosphaera veta, Fasciculithus tympaniformis* and *Ericsonia subpertusa* indicating Late Paleocene which is equivalent to the nannofossil zone NP5 introduced by Martini (1971).

Systematic palaeontology

Superorder: Neognathostomata Smith, 1981
Order: Cassiduloida L. Agassiz & Desor, 1847
Family: Gitolampids

Discussion. Kier (1962) included *Gitolampas* in Pliolampadidae Kier, 1962 family and Smith et al. (1999) in Echinolampadidae Gray, 1851 family. However in this work we share the opinion of Smith & Kroh from the Echinoid Directory (2011) to include *Gitolampas* in Gitolampids, a paraphyletic taxon provisional. These autors point out that *"Gitolampids are close to Cassidulidae and Echinolampadidae in phyllode and "bourrelet" structure but differing from both in periproct position and from Echinolampadidae in having a longitudinal rather than transverse periproct"*.

Genus: *Gitolampas* Gauthier, 1889

The synonymy proposed by Smith & Kroh in the Echinoid Directory (2011) is complemented by the data provided by Kier (1962):

1899 *Bothriolampas* Gauthier *in* Fourtau. p. 652. Figuras originales en Thomas & Gauthier 1889, p. 97, pl. VI, figs. 7–9
1902 ?*Phaleropygus* de Loriol. p. 15, pl. 3, fig. 7a, b, c, d
1921 *Gitolampopsis* Checchia-Rispoli, p. 18, pl. I, figs. 5–8
1942 *Echanthus* Cooke, p. 37. Type species by original designation *Echinanthus georgiensis* Twitchel 1915, pl. 26, figs. 14–16
1959 *Santeelampas* Cooke, p. 61, pl. 26, figs. 1–8
1962 *Gitolampas* Gauthier; Kier, p. 206, pl. 42, figs. 1–6; text figure 175
1966 *Gitolampas* Gauthier; Kier, p. U518 (with synonymy)
1970 *Echinanthus* Breynius; Roman & Villatte *in* Reguant et al., p. 903 (pars).
1978 *Gitolampas* Gauthier; Kier & Lawson, p. 87

Type species. *Pliolampas tunetana* Gauthier, 1889, by original designation, housed in the Museum National d'Histoire Naturelle, Paris, no. MNHN.F.R62287. This specimen has been figured by Cotteau (1891, p. 184, pl. 245, figs. 6–9; pl. 246, figs. 1–6) and it is in the Lambert Collection at the Sorbonne, Paris (Kier, 1962).

Remarks. There is a great confusion in the scientific literature between different species of *Gitolampas* Gauthier, 1889 and *Echinanthus* Leske, 1778. It is recommended the reading of Kier (1962) to clarify this issue. In this paper it is prefered *Gitolampas* rather than *Echinanthus*. Although *Echinanthus* was poorly described and figured it should have in mind that *Echinanthus* has the periproct above ambitus without cutting it. In many cases it is a subtle character, for that reason Kier (1962) affirmed the following: "*Most of the species that have been referred by other authors to Echinanthus are herein referred to Gitolampas".* For the specimens presented in this study the taxonomic criteria of Kier (1962) are accepted and the diagnosis is transcribed below.

Diagnosis. Kier (1962): *"Medium size, elongate, often with pointed posterior extremity, greatest width posterior to center, rounded margin; apical system monobasal, anterior, four genital pores; petals well developed, broad, closing distally, with broad interporiferous zones, poriferous zones of same petal of same length, pores conjugate, outer pore elongate but not slitlike, ambulacral plates beyond petals single pored; periproct marginal, slightly visible from above or below, longitudinal; peristome transverse, anterior, large, subpentagonal; bourrclets well developed, vertical walled; phyllodes broad, single pored, with two or sometimes three series of pores in each half-ambulacrum; bucal pores present".*

Remarks to the diagnosis. It is also worth noting the following observation by Kier (1962) about *Gitolampas tunetana*: *"The figure by Cotteau (1890, pl. 246, fig. 6) of the floscelle is in error in showing double pores in the phyllodes".*

Occurrence. Upper Cretaceous (Senonian) to Miocene of Europe, North Africa, Cuba, Japan, Oman, Tibet, Pakistan, United Arab Emirates, Madagascar, India, and the USA. The present study extends the paleogreographic distribution of *Gitolampas* to NE of Iran.

Gitolampas subrotundus (Desor, 1857)
(Plate 1, Figs. 1–3)

Here is accepted the synonymy proposed by Smith et al. (1999) with the integration of new data:

1856 *Pygorhynchus subrotundus* Cotteau in Leymerie & Cotteau, p. 334
1857 *Echinanthus subrotundus* n. sp.; Desor, p. 293
1863 *Echinanthus subrotundus* Desor; Cotteau, p. 91, pl. III, figs. 6–9
1888 *Echinanthus sub-rotundus* Desor; Cotteau, p. 586, pl. 173, figs. 1–4, pl. 174, figs. 1–3, pl. 175, figs. 1–3.
1908 *Echinanthus subrotundus* Cotteau (Pygorhynchus); Lambert, p. 365
1908 *Echinanthus arizensis* Cotteau; Lambert, p. 366
1908 *Echinanthus Heberti* Cotteau; Lambert, p. 367
1908 *Echinanthus Cotteaui* Hébert; Lambert, p. 368
1908 *Echinanthus Gourdoni* Cotteau; Lambert, p. 368
1911 *Echinanthus subrotundus* (*Pygorhynchus*) Cotteau; Lambert, p. 179
1964 *Echinanthus subrotundus* (Cotteau); Sapoundjeva, p. 15, pl. IV, figs. 5 a–d
1975 *Echinanthus arizensis* Lambert; Plaziat et al., p. 631, pl. 2, figs. 1–3
1999 *Gitolampas subrotundus* (Cotteau, 1856); Smith et al., p. 101, pl. 3, figs. 12–14

Type material. Specimen briefly outlined by Desor (p. 293, 1857) and later figured and amply described by Cotteau (1863, p. 91, pl. III, figs. 6–9). Current the type-material is whereabouts unknown.

Locus typicus. Fabas (Ariège Departament, S France) and Martres (Haute-Garonne Departament, S. France).

Age. Thanetian (see **Ocurrence** part).

Remarks. In the scientific literature on *Gitolampas* species a great taxonomic confusion has been found due to the wrong method for establishing species from shape test parameters, nevertheless studies of echinoid biology (e.g. Dafni, 1986) show that the test shape of different populations in irregular echinoids within the same species correspond to an adaptation to the granulometry of the sediment. It is recommended the reading of taxonomic remarks about *Gitolampas subrotundus* in Smith & Jeffery (2000) to help throw light on this taxonomic problem and understand the synonymy proposed by these authors and accepted in the present work.

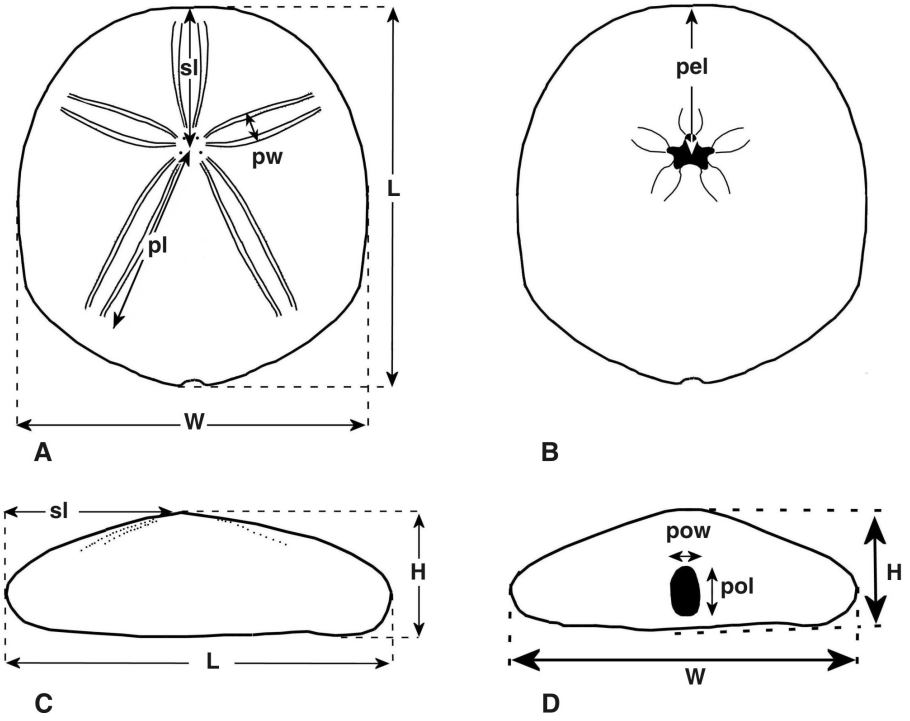

*Fig. 4. Schematic drawings from GMM97EF12 specimen of the aboral area (**A**), adoral area (**B**), lateral area (**C**) and posterior area (**D**), showing the morphometric parameters listed in Table 1.*

Material and Morphometry. It is studied 11 specimens from Chehel-Kaman Fm in Kopet Dagh Basin of northern Iran. In order to facilitate the interpretation of the data from Table I is helpful to consult the Figures 4 and 5.

Description. ***Test shape*** - Subcircular to circular outline, width 95–100% of length; low test, height *ca.* 20–30%; slight conical profile; lower surface sunken towards the peristome; rounded margins.

Apical system – Monobasal and it lies subcentrally, *ca.* 40% test length from de anterior border in plan view; the madreporite plate occupies most of apical system; apical system with four genital pores.

Ambulacra - Petals with poriferus zones a little bowed in greatest width of each petal and tendency to close distally; petals relatively narrow: the maximum width is *ca.* 20% of length. Poriferous zone inner and outer more or less the equal width. Posterior petals pair *ca.* 15–20% longer than anterior petals pair. The anterior petal is slightly shorter than the anterior petals pair and the zone poriferous and right porifera zone is a little longer than the left one. Posterior and anterior petals pair extending 85% the distance to the ambitus in plan view. Interporiferous zones tree times width of poriferous zones. Pores conjugate, outer pore elongated transversely, inner pore rounded.

Tuberculation - Perforate and crenulate primary tubercles in sunken areoles. On aboral zone the tubercles are crowded and little ones than of the adoral zone that are larger, more or less double size of tubercles of aboral zone and more scattered. The diameter of an adoral tubercle is about1 mm, the mamelon is 1/3 of diameter of tubercle and the perforation has a diameter about 50–60 μm in plan view. This perforation is so minute and shallow, for that reason it is very difficult to observe the perforation, possibly because it is easily erodable.

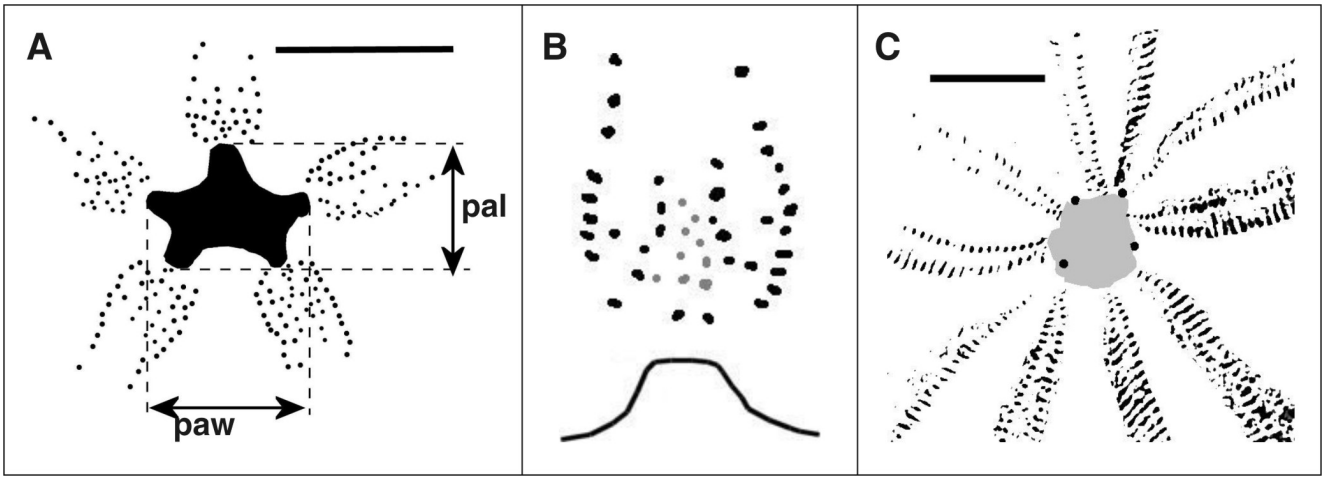

Fig. 5. A. *Phloscelle and peristome from GMM97EF8 specimen; pal = length and paw = width of peristome;* ***B.*** *Phyllode IV from GMM 97FE7;* ***C.*** *Apical system from GMM97EF7. Scale bar: A = 0,5 cm, C = 1 cm.*

Table 1. Morphometric data on **test: L,** length; **W,** width;**H,** height. On **petals: pw,** width; **pl,** length. On **peristome: paw,** width; **pal,** length. On **periproct: pol,** length; **pow,** width. Length to the anterior part of the contour of the apical system (**sl**) and the peristome (**pel**). Measurements in mm.

						Petals													
No	**Test**					**I**		**II**		**III**		**IV**		**V**		**Peristome**		**Periproct**	
	L	**W**	**H**	**sl**	**pel**	**pw**	**pl**	**pw**	**pl**	**pw**	**pl**	**pw**	**pl**	**pw**	**pl**	**paw**	**pal**	**pol**	**pow**
GMM97FE5	56,0	55,0	17,0	25,0	25,0	6,0	27,5	6,0	23,5	–	–	–	–	6,0	28,0	6,0	8,0	–	–
GMM97FE6	39,0	38,5	12,7	15,0	16,0	–	–	3,5	13,0	–	–	–	–	–	–	–	–	–	–
GMM97FE7	44,0	42,0	9,7	18,0	19,0	5,0	19,0	4,5	14,5	4,0	14,5	4,5	12,0	5,0	19,0	3,5	5,0	6,0	3,5
GMM97FE8	47,0	46,0	10,0	19,5	19,5	–	21,5	–	–	3,5	19,0	4,0	20,0	4,0	23,0	3,6	4,5	–	–
GMM97FE9	–	–	17,0	–	–	4	–	–	–	4	–	–	–	4	–	–	–	–	–
GMM97FE10	52,0	52,0	13,0	24,0	21,0	–	21,0	–	–	–	–	–	–	–	–	–	–	6	5
GMM97FE11	47,0	45,0	12,0	19,0	19,0	4,0	21,5	4,0	18,5	3,5	16,0	4,0	18,5	4,0	21,5	–	–	–	–
GMM97FE12	49,0	46,0	15,9	21,0	21,0	4,0	22,0	3,5	21,0	4,0	20,0	3,5	21,0	4,0	22,0	–	–	5,0	3,5
GMM97FE13	46,0	44,5	14,0	–	20,0	–	–	–	–	–	–	–	–	–	–	–	–	–	–
GMM97FE14	50,5	48,8	14,0	20,0	20,0	–	–	3,0	22,0	–	–	3,5	18,5	–	–	–	–	–	4
GMM97FE15	49,5	48,0	12,0	20,0	20,0	–	21,0	–	17,0	–	17,0	–	17	–	22	5,0	7,0	–	–

Peristome – Pentagonal and transverse; length 75% the width; anterior position: 40% test length from the anterior ambitus in plan view. Bourrelets well developed with vertical walled. Phyllodes slightly broadened with two or three series of crowed distribution of single pores in each half-ambulacrum. Bucal pores present at outer margin of entrance to peristome.

Periproct – Oval, longitudinal, width 70% the length, and lies at the center of posterior margin; length *ca.* 10% test length.

Differential diagnosis. This species is distinguished from others by the subcircular or circular outline, conical profile, low test (height is <40 % of test length), strongly transverse peristome and straight and long narrow petals.

Remarks. Smith & Jeffery (2000) propose a practical dichotomous key to identify the differents Maastrictian-Palaeocene species, however when trying to use the key, the species *G. subrotundus* would placed in the group "with a high test", specifically the height of the test is >75% per cent. of test length. Nevertheless the figures of this authors show the height of test is 35% of test length. Furthermore, the type-species was described like as "déprimé" test in Cotteau *in* Leymerie & Cotteau (p. 334, 1856) and in Desor (p. 293, 1857). Later Cotteau (p. 91, pl. III, figs. 6–9, 1863) does not affirm anything about the relative height of the test but in the figures 6 and 7 it can calculate 40% of the length of test. The material studied in this work, shows a relative low test with a height *ca.* 30% of test length and has a profile test (conical profile and relative height) very similar to the material described and figured by Sapoundjeva (1964) from specimens found in lower Ypresian of Bulgaria, also similar with the material figured in Smith et al. (1999) from Thanetian of the Santander (province of Cantabria, N Spain). This last material was also reproduced later in Smith & Kroh (2011) in the Echinoid Directory of Natural History Museum of London as *Gitolampas subrotundus* (Desor, 1857). *Vide supra* in the remarks the taxonomic relative significance of the test shape in Irregularia.

On the other hand, the possession of 2 series of single pores in each half-ambulacrum in the phylodies is common in the species of *Gitolampas*, but in the forms studied in this work some specimens present phylodies with 2 series, others 3 series of simple pores, and others with a crowed distribution. It has not been considered opportune to give a great taxonomic importance to this character until a profound revision of the genus take place in the future.

Occurrence. The french records in 19th century of this species were assigned to the middle Lutetian in localities from the northern Pyrenees in the Haute-Garonne and Ariège departments (S of France). The modern stratigraphy accepts that in the department of Haute Garonne (Midi-Pyrénées region) the fauna of *Echinanthus* with the presence of *Echinanthus subrotundus* and *Echinanthus pouechi* is assigned to "lower" Thanetian age (Cavaillé & Paris, 1974). In the same zone but at the Department of Ariège *Echinanthus* sp. is assigned to Lower Thanetian as also *Echinanthus arizensis* (often confused with *Gitolampas subrotundus*, *vide supra* synonymy), *Echinanthus pyrenaicus* to the upper Thanetian (Souquet et al., 1979). Plaziat et al. (1975) points out that in Spain, *G. subrotundus* appears to be quite common in the Thanetian limestones with *Coskinolina liburnica* and *Alveolina primaeva* in the Villarcayo basin (Burgos province, N of Spain). Plaziat (1984) concludes that this species characterizes the late Thanetian–early Ipresian range from the findings of this species in the South of France and the North of Spain. On the other hand Sapoundjeva (1964) found *G. subrotundus* in Ypresian beds of NE Bulgaria.

In summary, *Gitolampas subrotundus* has been found in beds from Upper Thanetian of Santander and Burgos provinces (N of Spain), in Lower Thanetian to Lower Ypresian in localities from French and Spanish Pyrenees zone, and Ypresian from Bulgaria. This paper extends the palaeogeographic distribution to late Paleocene of Northeastern Iran.

Conclusions

This work increases the knowledge of the morphology of *Gitolampas subrotundus* and also the variety in profile-test within this species is confirmed. Consequently, the discriminatory criteria that separate *G. subrotundus* from other species are increased. Moreover it has been found variety of forms of the phylodes inside *G. subrotundus* with 2 series or 3 series of simple pores, and others with a crowed distribution, therefore the type of phyllode points out a very variable intraspecific character. On the other hand this research yielded the first record of *Gitolampas subrotundus* in Iran. Up to now this species has been found in the Upper Paleocene–Lower Eocene strata in Europe (N of Spain, S of France and NE of Bulgaria). This work extends the species distribution to the Late Paleocene of NE Iran, in other words this finding increases the faunal affinities between the western and eastern region of the Tethys in the upper Paleocene.

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ous nannofossils, and the journal reviewers for their pertinent comments on the paper.

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Резиме

Први налазак *Gitolampas subrotundus* (Cotteau, 1856) (Echinoidea) у горњем палеоцену Ирана

У раду су приказана биостратиграфска истраживања палеогене Chehel Kaman формације у источном Копет-Даг басену. Планински венац Копет–Даг, 650 km дуг и 200 km широк, представља велики седиментациони басен који се простире на североистоку Ирана и југу Туркменистана, источно од Каспијског мора.

У циљу добијања нових података извршена су истраживања фосилоносне седиментне сукцесије са ехинидима на локалитету који се налази 20 km југоисточно од језера Базанган. Истраживана сукцесија Chehel Kaman формације дебљине 101,2 m је изграђена од светло сивих песковитих кречњака са бивалвијама преко којих належу слојевити кречњаци са ехинидима.

На основу микропалеонтолошких истраживања нивоа који садрже богату асоцијацију ехинида утврђена је горњопалеоценска асоцијација фораминифера:

Cribrobulimina carniolicu, Discorbis sp.*, Elphidium* sp.*, Lockhartia* sp.*, Miscellanea* sp.*, Nodosaria* sp.*, Ornatorotalia granum, Pararotalia* sp.*, Quinqueloculina* sp.*, Ranikothalia nuttalli, Rotalia trochidiformid, Smoutima* sp. и *Spiroloculina* sp. Међу кречњачким нанофосилима утврђено је пет родова и пет врста: *Lanternithus simplex, Coccolithus subcirculus, Pontosphaera veta, Fasciculithus tympaniformis* и *Ericsonia subpertusa* који такође указују на горњопалеоценску старост сукцесије и одговарају нанофосилној зони NP5 Martini (1971).

Од ехинида су пронађени добро очувани примерци врсте *Gitolampas subrotundus* која је до сада, била позната само из горњопалеоценских-доњоеоценских слојева Европе (јужни део Шпаније, јужни део Француске и североисточна Бугарска).

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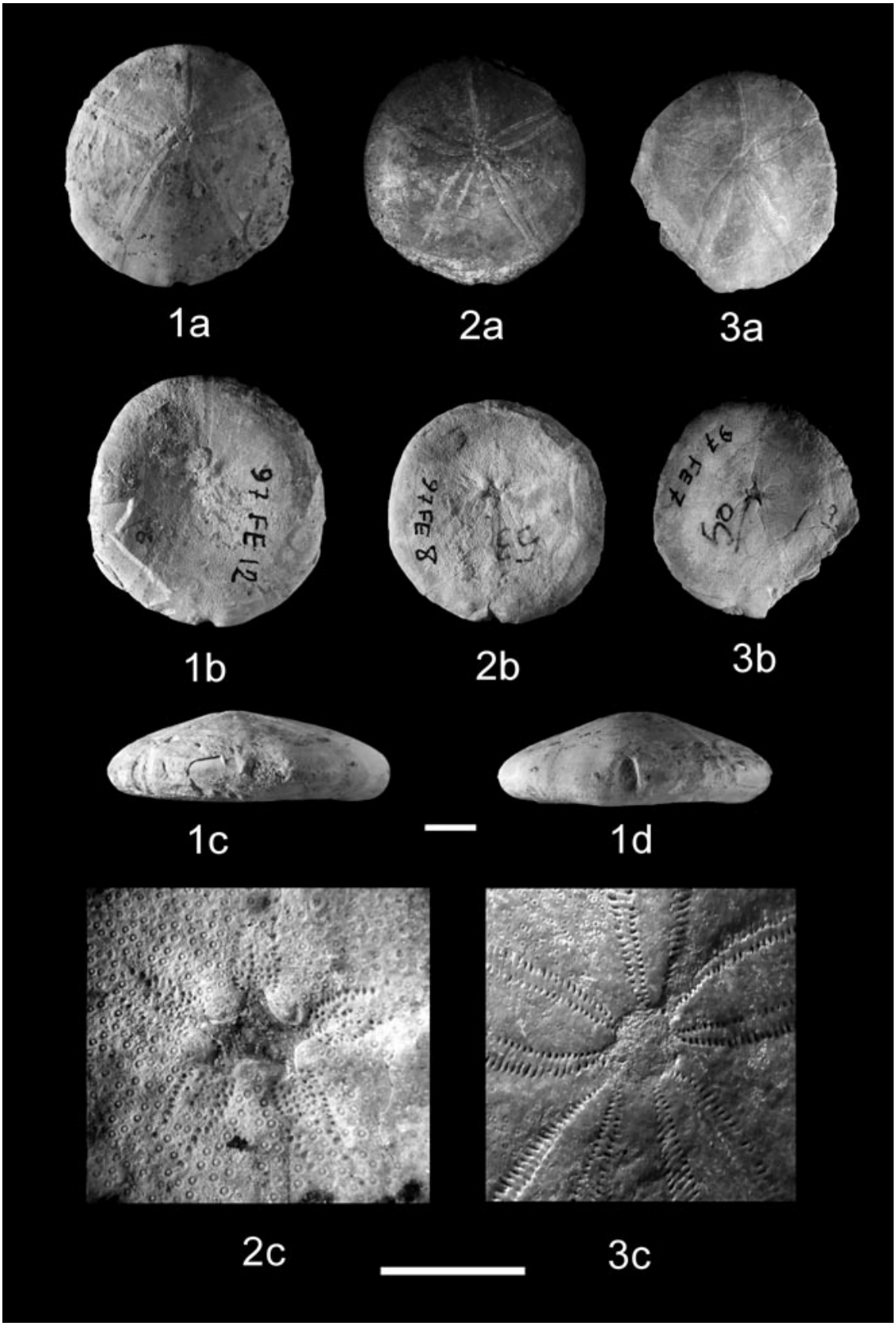

Plate 1. *Gitolampas subrotundus* from GMM97EF12 specimen, 1a: Aboral view; 1b: adoral view; 1c: left lateral view; 1d: posterior view. From GMM97EF8, 2a: Aboral view; 2b: adoral view and 2c: peristome and floscelle. From GMM97EF7 specimen, 3a: Aboral view; 3b: adoral view and 3c: apical system. Scale bar = 1 cm.