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Sculpsitechinus iraniensis n. sp. (Clypeasteroida Astriclypeidae), from Chabahar Bay, southeast coast of Iran

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ABSTRACT In the past, the practice of giving more weight to the outer shape of echinoderms than the structural characters, has led to misinterpretations in the systematics within the family Astriclypeidae Stefanini, 1912 (Clypeasteroida). We do not know, often, what the previous researchers were referring to when they refer to *Echinodiscus*, since many of these, in fact, belong to the genus *Sculpsitechinus* (at present including two species: *S. auritus* and *S. tenuissimus*). Every sand dollar that had two posterior ambulacral slots opens on the rear edge, was always classified as "*E. auritus*" now accepted as *S. auritus*. In fact, this general form, common across the Indian Ocean and spread to Indonesian Archipelago, until the Western Pacific, showS, locally, strong differences that justify a change in the specific allocation. A new form of living *Sculpsitechinus* was found from the sediments at low tide of Chabahar Bay, located along the Iranian coast of the Gulf of Oman. The analysis of morphometric and structural data, allowed us to establish this form as a new species: *S. iraniensis* n. sp. This new species differs from the type species of *S. auritus* mainly by the considerable size of the petalodium, that reaches the mean of 55% of test length, in comparison to the mean of 40% of the type test length. Moreover, the studied population shows considerable variability in the plating scheme of the adoral face, which will give rise to future insights.

KEY WORDS *Sculpsitechinus iraniensis* n. sp.; Astriclypeidae; Iran; Chabahar Bay; Oman Gulf.

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INTRODUCTION

The intertidal benthic fauna of the Iranian coasts along the Gulf of Oman was studied as part of a research project covering coastal waters of Jask, Chabahar Bay and Gwatr Bay (Fig. 1). Identification and distribution of sand dollars in Chabahar Bay was part of this project. Astriclypeid echinoids are important members of the benthic fauna that lives in the soft sediments of the littoral to sublittoral zone (Stara & Sanciu, 2014), only rarely can they be found at up to 500 m depth (Tsaparas et al., 2007; Mihaljevic et al., 2011).

The family Astriclypeidae Stefanini, 1912 (Clypeasteroida) includes different genera characterized by posterior ambulacral lunules or notches. Two of these, *Echinodiscus* Leske, 1778 and *Sculpsitechinus* Stara et Sanciu, 2014 seem widespread from the east coast of Africa to the Indian Ocean, along the Malay Archipelago, including the China Seas, North Australia and the islands of the Western Pacific.

Figure 1. Map of sampling site, larger side of the search area (highlighted rectangle) 50 km.

Despite their widespread occurrence, data on their records are not always reliable.

Recently, Stara & Sanciu (2014) carried out a partial revision of some genera of this family, by establishing, among others, the genus *Sculpsitechinus* whose species were formerly included in the genus *Echinodiscus*. According to current knowledge, there are two nominal forms of *Sculpsitechinus*: *S. auritus* (Leske, 1778) and *S. tenuissimus* (L. Agassiz. in Agassiz & Desor, 1847). However it is likely, as appears from the study of Stara & Sanciu (2014), that more forms of this genus are present. Studies on the recent echinoderm fauna of the Iranian coasts are limited to Shakouri et al. (2009a, b), Attaran-Fariman et al. (2014), Pourvali et al. (2014) and Nateghi Shahrokni et al. (2016). Detailed studies on structural and morphometric characters have never been conducted on astriclypeids from the Gulf of Oman, along the Iranian coast.

Sculpsitechinus iraniensis n. sp. is a medium - large sized sand dollar (130 mm max in our sample) with a thin and flat test (10% of test length). It has two posterior ambulacral notches, small sub-central apical disc with four genital pores and varies in color from yellow to purple. The petalodium increases in size with the growth, as in *S. auritus* (see Stara & Fois, 2014) where it reaches, in the adult stage, the 40% of the test length. In *S. iraniensis* n. sp., in contrast, it becomes exceptionally large, reaching 60% of the test length.

MATERIAL AND METHODS

Samples of live and dead sand dollars were collected from sediments, preserved on ice, transferred to the laboratory, numbered from CESI224 to CESI239 and stored in the collection of the CMU-I (Chabahar Maritime University, Iran). The spines were removed from the samples after keeping them in deep freezer for 24 hours. The tests of specimens were photographed with a digital camera in three position (aboral, adoral and lateral view), and further studies and photography were done by using a stereo-microscope equipped with a camera model C-DS T4AL250 V. Subsequently, the specimens were identified based on the available literature (Durham, 1955; Price,1983; Sastry, 2007; Stara & Sanciu, 2014; Stara & Fois, 2014). Afterwards the samples were transferred in Ethanol 75% for long term preservation. The Holotype was X-rayed and another individual was dissected to compare the structural correspondence with the type species. We used a part of the morphometric data set (Fig. 2) used by Stara & Sanciu (2014).

ABBREVIATIONS. PL = petalodium length; TH = test height; TL = test length; TW = test width; L1 = notches length; L2 = notches width (approximate); L3 distance between the posterior paired petals tip and the notches; L4 = distance between apex and posterior margin; L5 = Length of the anterior odd petal; L6 = width of anterior odd petal; L7 = Length of the anterior paired petal; L8 = width of anterior paired petal; L9 = Length of the posterior paired petal; L10 = Width of the posterior paired petal; L11 = distance between periproct and posterior margin; L12 = distance between peristome and posterior margin; WA width of the interambulacrum 5 at the margin; ß = angle between notches. TL is reported in mm and other measures in % of TL. The TL was taken by a caliper rounding to the nearest millimeter; and all other measures in percentages were detected with Autodesk Graphic version 3.0.1, bringing to 100 the length of the test. In Table 1 the range and the mean of each measure was reported.

Numbering in plate drawings follows Lovén's (1874) system and interambulacra are shaded in grey as done by Durham (1955). The systematic classification follows Kroh (2015) and geographic coordinates are provided in WGS84. Thirteen specimens with whole complete test (n° CESI224 to CESI 236) and 3 fragments (n° CESI 237 to CESI 239) were stored in the CMU-I laboratory (Chabahar Maritime University, Iran). The specimens CESI 224/225/226/227/228/229/230/231/237/ 238/ 239 were collected from Chabahar coasts; the CESI 232/233/234/235/236, from the Tis coasts.

RESULTS

In addition to the significant petalodium, central hollow and of Aristotle's lanternsizes, the morphological study of this interesting population of *Sculpsitechinus* allowed us to observe a curious proliferation of abnormal plates with also numerous variations of theplating. Particularly interested is the plating of the oral face, in which varies greatly

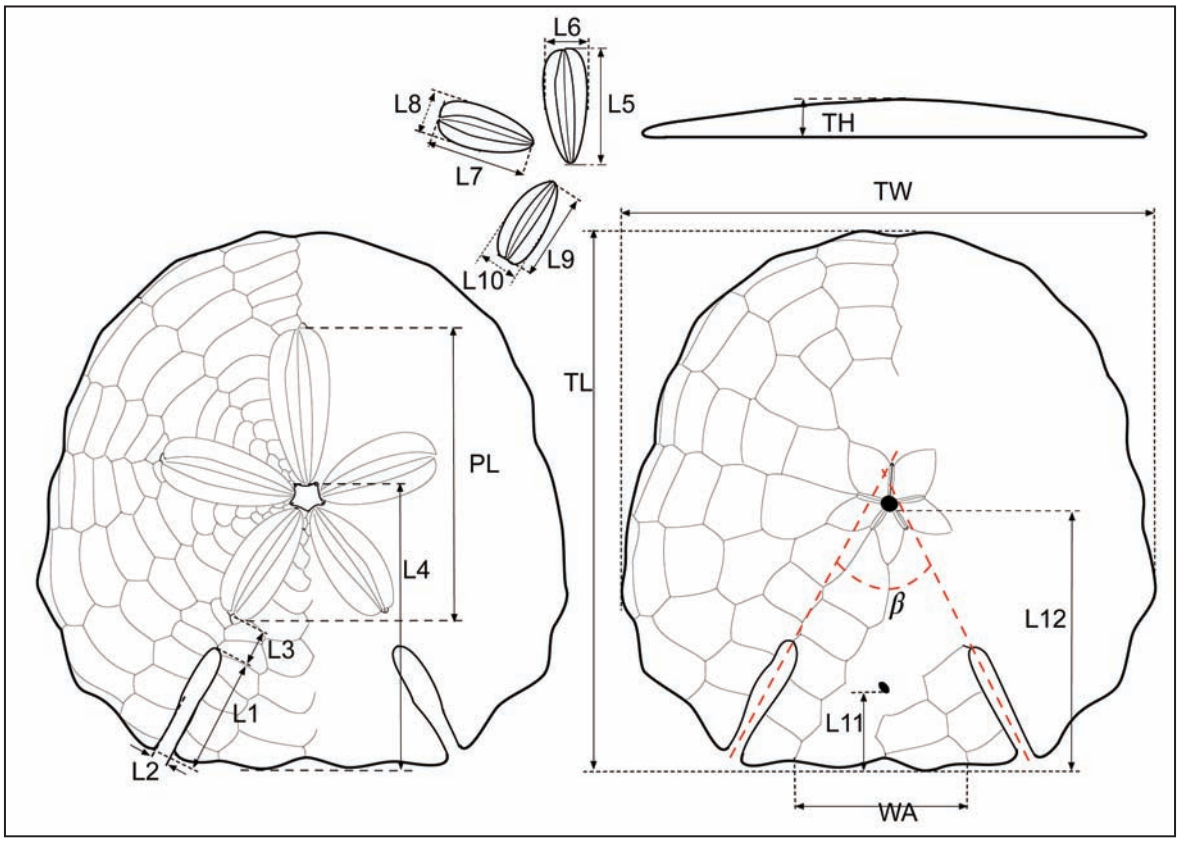


Figure 2. Location of measurements on the corona of the sand dollar.

the number of platesand the scheme of the relationship between ambulacral and adjacent interambulacral plates, as will be described in the systematic part. However, same x-rays photos, and the observation in section of the internal support system, did not show a relationship between duplication/modification of the plates and internal structure. So we've considered that these abnormalities result from external influences (ecological?) and do not involve specific differences.

SYSTEMATICS (following Kroh & Mooi, 2015)

Class ECHINOIDEA Leske, 1778
Order CLYPEASTEROIDA Agassiz, 1835
Suborder SCUTELLINA Haekel, 1896
Infraorder SCUTELLIFORMES Haekel, 1896
Superfamily SCUTELLIDEA Gray, 1825
Family ASTRICLYPEIDAE Stefanini, 1912
Genus *Sculpsitechinus* Stara et Sanciu, 2014

Sculpsitechinus iraniensis n. sp. (Figs. 3–5, 6, 10, 11)

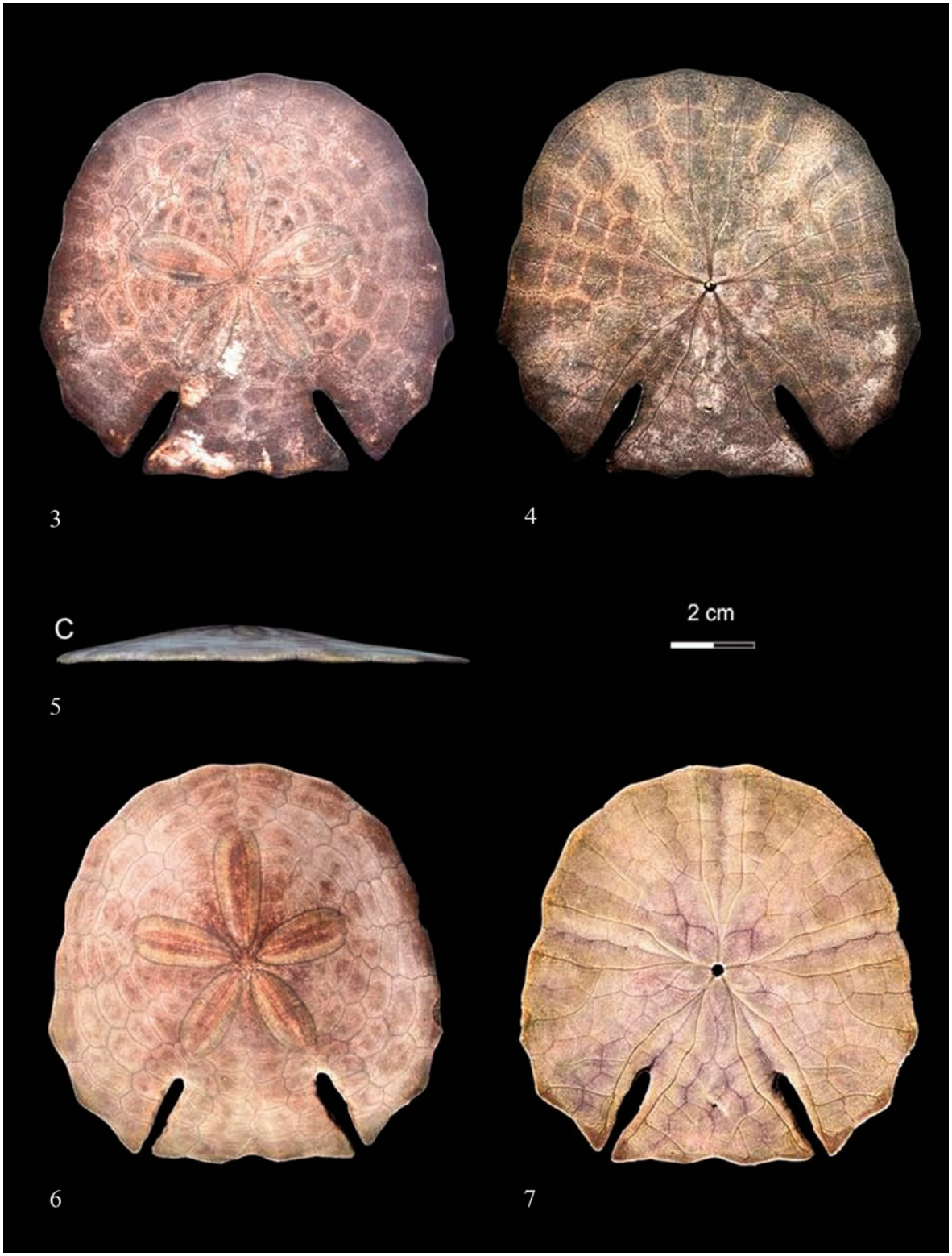
DIAGNOSYS. A species of *Sculpsitechinus*, with low side profile, open rear ambulacral notches, large petalodium (anteroposterior size about 60% TL) and large Aristotle's lantern (anteroposterior size=26% TL).

EXAMINED MATERIAL. Holotype: complete specimen CESI227 124 mm TL (Figs. 3–5, 6, 10, 11). Paratypes: complete specimen CESI228 (Table 1), 44.5 mm TL; and CESI234, TL=44.125 mm. Type locality (Fig. 1): Chabahar Bay (25° 16'N, 60° 40'), Sistan and Baluchestan Province, South East coast of Iran.

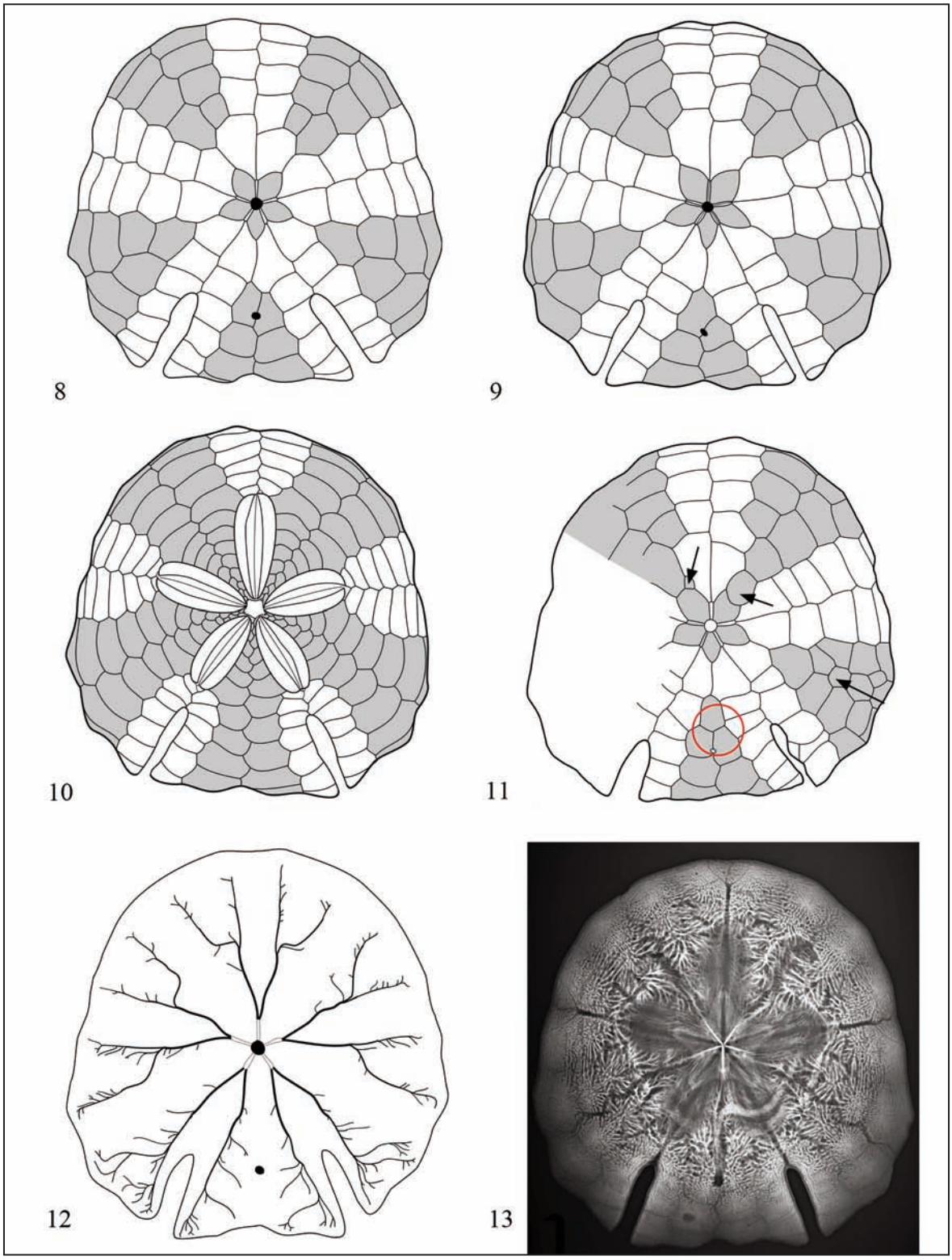
OTHER EXAMINED MATERIAL. Thirteen individuals with whole complete test (CESI224 to CESI236)

	CESI 224	CESI 225	CESI 226	CESI227 holotype	CESI 228	CESI229 paratype	CESI 230	CESI 231	CESI 232	CESI 233	CESI 234	CESI 235	CESI 236	CESI 237	CESI 238	CESI 239	mean	range
TL	111.5	118	122	124	44.5	123	124	72	130	-	125	129	126,5	-	40	-		40-130
TW	109	101	99	101	107	98	98	103	94	97	97	98	100	106	105	103	101	94-109
TH	11	10	8.4	10	8.8	9.8	10	11	10	-	11	10	8,3	-	-	-	10	8,3-11
PL	59	60	57	59	44	57	55	50	57	62	56	60	57	49	-	44	55	44 - 60
L1	13	20	17.5	22	18	20	20	17	21.5	21	20	21	19	21.5	11	18	18.8	11-22
L2	4	6	2	6	4	3	3	2	5	5	6	3	3	-	-	--	4	1-6
L3	8.2	5	7	6	12	6.8	9	8.6	7.8	6	9.4	6.8	11	13	-	12	8.6	5-13
L4	60	48	54	54.5	56	54	55	50	56	53	61	56	57	55	-	55	55	48-57
L5	34	34	31.5	31	22	31	30	27	29.5	34	29	31	29	25	-	24	29	22-34
L6	14	15	13	13.5	9	12	11	11	12.5	14	12	14	14	10	-	8.5	12	9-15
L9	29.5	27	25	25	20	24	24	22	25	25	26	27	28	23	-	19	25	19-29.5
L10	13	13	12	12.5	12	11	11	10	12.5	12	12	13	13	10	-	8.5	12	10-13
L11	17	17	14	18	19	14	14	15	18	17	17	16	19	13	17	-	17	13-19
L12	47	49	48	48	49	47	47	50	49	48	52	50	51	49	49	-	49	47-52
ß	42	54	50	62	62	56	62	59	48	43	45	43	48	-	-	-	52	42-62
st	4	4.4	3.8	3.1	4	3.4	3.2	3.7	3.8	3.5	3.4	3	-	-	4.6	-	3.7	3-4.6
pc	2	1.6	1.7	2	2.8	1.2	1.6	2	1.8	2	1.6	1.2	-	-	4	-	1.9	1.2-4
pos pc	2b/2a	2a/3b/3a	3b/2a	2b/2a	2b/2a	2b/2a	2b/2a+dop	3b/21	2b/2a	2b/2a	2b/2a	2b/2a	2b/2a	2b/2a	2b/2a	-		
apex	6	6	7	8	6	6.7	7	4.9	7.8	6	6.8	6.3	-	5.6	7.8	6.5	6.6	4.9/8
corcl basic	10	12.5	13	12	12	12.5	14.5	11	11	13	12	11.5	-	14	13.5	-	12	10/14.5
por/inter	4.5/6	3.8/5	4/5	-	2.6/4	3.6/4.8	4/3.5	3.4/3.9	-	-	3.2/5,2	4/5.6	-	2.8/4	-	-	-	2.6-4.5/3.9-6

Table 1. Morphometric data of *Sculpsitechinus iraniensis* n. sp. TL in mm, other measures in % TL.



Figures 3–7. *Sculpsitechinus iraniensis* n. sp. Figs. 3–5: *S. iraniensis* n. sp. holotype (CESI227) aboral, oral and lateral views respectively. Figs. 6, 7: aboral and oral views of a *S. iraniensis* n. sp. paratype (CESI229), showing a different oral plating pattern.



Figures 8–11. *Sculpsitechinus iraniensis* n. sp. plating schemes. Fig. 8: holotype (CESI227), oral face. Figs. 9, 10: paratype CESI229), with different oral plate pattern. Fig. 11: oral plate pattern in specimen (CESI226), showing doubling and numerous accessory plates in the oral test side. Figs. 12, 13. Holotype (CESI227) of *S. iraniensis* n. sp. Fig. 12: scheme of food grooves covering the whole oral face. Fig. 13: radiography showing the internal structures, the large Aristotle's lantern and the terminal part of the intestine.

and 3 fragments (CESI237 to CESI239) collected from Chabahar Bay housed in the CMU-I (Chabahar Maritime University, Iran). A specimen CESI229 was figured because of its different adoral plating pattern.

Description of Holotype. Medium large-sized species (maximum length observed in our sample = 130 mm), with low side profile (mean = 10% TL) and axially elongated notches in the posterior ambulacra. Ovoidal to polygonal ambital outline (mean TW= 101% TL); the posterior margin line, situated between the two notches (like a tail), is always irregular and often asymmetric (Figs. 3, 4 and 6, 7). The adoral face is flat or slightly planoconcave (Fig. 5). Internal structure (Fig. 13) with central hollow pentagonal; its length, from the rear wall to the front, equals ≈ 50% TL.A large cavity branch along the interambulacrum 2, containing the caecum; a second cavity, the shorter, extends along the interambulacrum 5, leading to the periproct. The internal ballast system is light but becomes very dense towards the margin. The Aristotle's lantern shown in the radiography (Fig. 12) and in sectioned specimens, is large and measures about 26% TL. The petalodium is large (PL range from 44 to 60%, mean 55% TL), with the anterior odd petal longer (mean L5 = 29% TL; L6 = 12% TL; L9 = 25% TL and L10 = 12% TL); the interporiferous zone is 1 to 1.5 large than the poriferous one. The apical disc is small and measures about 6% TL and is anteriorly eccentric (L4 = 55% TL). The peristome is pentagonal, with a mean diameter of 3.7% TL and centrally located (L12 = 49% TL). The periproct is small (mean diameter = 2 mm) and far from the posterior margin (L11 range from 13 to 19, mean 17% TL); it opens normally between plates 5.a.2 and 5.b.2 (Fig. 8) sometime posteriorly. The plate number in the interambulacrum 5 are variable: commonly are 3 in column "a" and 4 in column "b".

The posterior ambulacral notches (Figs. 8–11) are very variable in size (L1 range from 11 to 22% TL, mean 19% TL); L2 is difficult to measure because of the frequent deformations. On the aboral face, they are separated by 3–4 couples of plates per column(seldom 2 or 5) from the tip of the correspondent petals (L3= 8,6% TL). On the oral face, they are separated by 3–4 (seldom 2 or 5) plates per column from the basicoronal ambulacral plates. On the whole, in the interambulacrum 5 there are 14–15 (seldom 13–13 or 15–18) plates per column and in the ambulacra I and V there are 12–13 (seldom 11–12 or 14–15) plates per column. ß is approximately 55° and WA is on average 32% TL. The basicoronal interambulacral plates are normally disjointed. The tuberculation is dense, made up of medium sized tubercles, poorly differentiated and extended over the entire aboral surface. The tubercles are larger around the periproct and the smaller ones are found particularly along the main food grooves (Figs. 4, 7). On the aboral face the tuberculation is undifferentiated, thick and small, evenly distributed over the entire surface. The food grooves are strongly branched, covering the entire oral surface (Fig. 3).

The color ranges from purple to brown-yellowish. Spines are short and thin and covering whole of the oral and aboral surfaces.

Variability. Plating variability, based on a Paratype CESI229 and a part of the population. As we have said in the results, the plating of the oral face shows a large variability. In the oral face of the studied individuals, the normal number of plates is about 100; but in a case, for example, the number of extra plates is over 30 (total 130). The total number of plates in the interambulacrum 5 varies from a minimum of 13 (column a) and 13 (column b) to a maximum of 16 (column a) and 18 (column b); in the adjacent ambulacra I and V, the extra petals plates vary from 12 to 15 per column. On 15 individuals, the number of plates in column "a" and "b" respectively, on the oral interambulacrum 5, is so divided: 3–3 (8 specimens); 3–4 (4 specimens); 4–3 (2 specimens and 4–4 (1 specimen). In 16 individuals, between the petals tip and the notches the number of plates varies as follows: 3 plates (50%); 4 plates (20%); 2 plates (12%) and 5 plates (3%). The number of plates that separate the basicoronals from the notches is more constant: 3-3 plates per ambulacrum in the 90% of the cases), but there were also observed 2–2, 2–3, 3–4, 4–3 and 4–4 plates per ambulacrum. In the oral interambulacrum 5 there are 2–4 plates per column. The periproct opens normally between plates 2b-2a; in 2 out of 16 individuals it opens between plates 3b/2a. But the most interesting case of variability observed concerns the relationship between the first post-basicoronal interambulacral plates 5.a.2 and 5.b.2 with adjacent ambulacrals I.a.2 and V.b.2 (see plating schemes in figures 8, 9 and 11). In seven individuals including the holotype (Fig. 8)

plates 5.b.2 and 5.a.2, are paired and in meridoplacous contact with the first post basicoronal ambulacral plates I.b.2 and V.a.2. In other 6 individuals, the plate 5.b.2 shows amphiplacous contact with the relate post basicoronal ambulacral plates (Fig. 9) and in others 5 the scheme of interambulacrum 5 is completely abnormal (Fig. 11, highlighted by a circle). Furthermore, numerous accessory plates are visible in different points of the test (Fig. 11 the plates highlighted by arrows).

DISTRIBUTION. Recent, Chabahar Bay (Iranian Coast of the Gulf of Oman).

REMARKS. *Sculpsitechinus iraniensis* n. sp. differs from *S. auritus* in having a larger Aristotle's lantern, much larger petalodium and the periproct much closer to the posterior margin; *S. iraniensis* n. sp. differs from *S. tenuissimus* and from *Sculpsitechinus* sp. 2, by having notches rather than lunules and in having much larger petalodium; *S. iraniensis* n. sp. differs from *Sculpsitechinus* sp. 1, in having a larger Aristotle's lantern and greater petalodium. *Sculpsitechinus tenuissimus* (L. Agassiz, 1847) differs from *S. auritus* mainly because it has two ovoid lunules, elongated along the axis of the rear ambulacra, instead of the notches open to the posterior margin.

DISCUSSION

There are some reports of *Sculpsitechinus* "*auritus*" from sandy shores of Iran (Mortensen, 1940; Pourvali et al., 2014; Nateghi Shahrok et al., 2016). Although Duncan & Sladen (1886) doubtfully signaled the presence of fossils *S. auritus* in the Pliocene of Khark Island in the Northern Persian Gulf.

According to the revision carried out by Stara & Sanciu (2014), *S. tenuissimus* is living in regions bordering the Western Pacific; its spread does not extend to the Indian Ocean, where, instead, members of the genus *Echinodiscus* (such as *E. bisperforatus* Leske, 1778) are common.

Echinodiscus bisperforatus, has a distribution very similar to that of *S.* "*auritus*", ranging also from the Malay Archipelago to the China Seas and Japan (Stara & Sanciu, 2014). Both Stara & Sanciu (2014) and Jansen & Mooi (2011) suggested that several additional species morphologically similar to *S. auritus* exist.

According to Piller & Mansour (1990), *S.* cf. *auritus* lives on sandy shores with very low slopes. This form of *Sculpsitechinus* is well distributed along the south coast of the Persian Gulf and the Gulf of Oman (Nour El-Din, 2004). Now, according to this study, the distribution range of *S.* "*auritus*" in the Persian Gulf extends along the Iranian coast from north to the Gulf of Oman but, based on our observations, *S.* "*auritus*" is rarely seen in southeast coastal waters of Iran. This could be due to the higher substrate slopes and wave energy in the coastal waters of Iran compared to Saudi Arabia, Kuwait, Qatar, Bahrain and Oman (Reynolds, 1993; Kardavani, 1995; Faiz & Ebrahimi-salari, 2011; Etemad-Shahidi et al. , 2011).

In this study many specimens of the new species were collected at two stations of Chabahar Bay (Tis coast, 25° 20′N, 60° 35′E and Chabahar coast, 25° 16′N, 60° 40′E). Chabahar Bay is semiclosed with moderate slopped sandy shores, and has favorable conditions for the survival of sand dollars.

During our study *S. iraniensis* n. sp. was not found at Jask and Gwatar, probably due to sharp slope and extreme waves in the coast for the first one, and because of mangrove forests and muddy sediments for the latter. Besides having a really large petalodium in comparison to other members of the genus, probably due to a strong environmental pressure still unknown, the population studied appears really interesting because of its special plating patterns. In particular, the shape characterized by the plate 5.b.2 staggered with 5.a.2 and in meridoplacous contact with the two postbasicoronal ambulacrals I.a.2 and V.b.2 is characteristic for this genus.

To confirm the normality of the "regular" scheme showed in figure 10, we checked the normality of the scheme shown in figure 2, on specimens from Madagascar, Ethiopia, Red Sea (Egypt), Oman, Australia, Vietnam (Recent) (Dollfus & Roman, 1981; Jansen & Mooi, 2011; Stara & Sanciu, 2014; our collections) and from the Red Sea (Pliocene) (P. S. Collection). However, it must be said that in the specimens of the Philippines may be observed both patterns (Stara & Sanciu, 2014).

Furthermore, after this study, *Sculpsitechinus* differs from *Amphiope* also in reaching a large range of petalodium (30–60% against 45–60%) and by the different shape of the lunules. *Sculpsitechinus* differs from *Echinodiscus* by the smaller width

of interambulacrum 5 at the ambitus (30–38 against 35–54), by a lower number of adoral plates in interambulacum 5 and normally by the lower angle between the lunules (ß= 54°–70° against 70°–117°).

Finally, *Sculpsitechinus* differs from *Amphiope*, *Paraamphiope* and *Echinodiscus* by the food grooves, which are highly branched on the whole adoral surface (see Stara & Sanciu, 2014).

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