

Review of Mio-Pliocene pectinids and ostracods from Minab region and Qeshm Island, Persian Gulf, southern Iran

Revisión de pectínidos y ostrácodos del Mio-Plioceno de la región de Minab e Isla Qeshm, Golfo Pérsico, sur de Irán

Fereshteh Mahdipour Haskouei¹, Ali Bahrami^{1,*}, Mehdi Yazdi¹, Francisco J. Vega²

¹ Department of Geology, Faculty of Sciences, University of Isfahan, POB. 81746-73441, Isfahan, Iran.

² Instituto de Geología, Universidad Nacional Autónoma de México, Ciudad Universitaria, Coyoacán, 04510, CDMX, México.

* Corresponding author:
(A. Bahrami) a.bahrami@sci.ui.ac.ir

How to cite this article:

Mahdipour Haskouei, F., Bahrami, A., Yazdi, M., Vega, F.J., 2025, Review of Mio-Pliocene pectinids and ostracods from Minab region and Qeshm Island, Persian Gulf, southern Iran: Boletín de la Sociedad Geológica Mexicana, 77(1), A251224. <http://dx.doi.org/10.18268/BSGM2025v77n1a251224>

Manuscript received: August 17, 2024
Corrected manuscript received: September 15, 2024
Manuscript accepted: September 19, 2024

Peer Reviewing under the responsibility of Universidad Nacional Autónoma de México.

This is an open access article under the CC BY-NC-SA license (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

ABSTRACT

The present study investigates the pectinid bivalve record characterizing the Mio-Pliocene of Mishan and Aghjari formations in Qeshm Island of the Persian Gulf and Minab region of Makran Basin (Hormozgan Province). Thick-bedded deposits of highly accumulated levels of epifaunal free-lying pectinids were investigated in terms of paleoecology and taphonomy. Eight species of the family Pectinidae (Bivalvia) and nine species of Ostracoda are reported from the Direstan rural area, Qeshm Island, Persian Gulf, Southern Iran. Most bivalve shells display extreme taphonomic features such as breakage, bioerosion, encrustation, disarticulation, and abrasion. Encrusting Cheilostomata bryozoans, as well as polychaeta worms, encrust pectinid valves; Langian (Middle Miocene) Cheilostomata are identified as *Microporella berningi*. The studied pectinids are represented by the following species: *Pecten* aff. *rotundatus*, *Pecten* cf. *subarcuatus*, *Flabellipecten piramidesensis*, *Argopecten gratus*, *Chlamys varia*, *Chlamys multistriata*, *C. actinodes*, and *Talochlamys articulata*. Ostracoda were also collected from two more outcrops in Qeshm Island (Kendaloo and Star Valley) and one outcrop of Minab region (Bemani section). The studied ostracods are: *Alocopocythere kendengensis*, *Actinocythereis iraqensis*, *Loxococoncha hamrinensis*, *Neomonoceratina iniqua*, *Bairdoppilata triangulata*, *Bairdia rafidainensis*, *Hermanites transversicostis*, *Costa tricostata*, and *Cytherelloidea hamrinensis*.

Keywords: taphonomic features, pectinids, ostracods, polychaete worms, Qeshm Island.

RESUMEN

El presente estudio investiga el registro de bivalvos pectínidos que caracteriza el Mio-Plioceno de las formaciones Mishan y Aghjari en la isla de Qeshm del Golfo Pérsico y la región de Minab de la cuenca de Makran (provincia de Hormozgan). Se investigaron depósitos de estratos gruesos de niveles altamente acumulados de pectínidos libres de epifauna en términos de paleoecología y tafonomía. Ocho especies de la familia Pectinidae (Bivalvia) y nueve especies de Ostracoda se reportan del área rural de Direstan, isla de Qeshm, Golfo Pérsico, sur de Irán. La mayoría de las conchas de los bivalvos muestran características tafonómicas extremas como rotura, bioerosión, incrustación, desarticulación y abrasión. Los briozoos incrustantes Cheilostomata, así como los gusanos poliquetas, incrustan valvas de pectínidos; los Cheilostomata del Langiano (Mioceno Medio) se identifican como *Microporella berningi*. Los pectínidos estudiados están representados por las siguientes especies: *Pecten* aff. *rotundatus*, *Pecten* cf. *subarcuatus*, *Flabellipecten piramidesensis*, *Argopecten gratus*, *Chlamys varia*, *Chlamys multistriata*, *C. actinodes* y *Talochlamys articulata*. También se recolectaron ostracoda de dos afloramientos más en la isla Qeshm (Kendaloo y Star Valley) y un afloramiento de la región de Minab (sección Bemani). Los ostrácodos estudiados son: *Alocopocythere kendengensis*, *Actinocythereis iraqensis*, *Loxococoncha hamrinensis*, *Neomonoceratina iniqua*, *Bairdoppilata triangulata*, *Bairdia rafidainensis*, *Hermanites transversicostis*, *Costa tricostata* y *Cytherelloidea hamrinensis*.

Palabras clave: características tafonómicas, pectínidos, ostrácodos, gusanos poliquetas, Isla de Qeshm.

1. Introduction

The Persian Gulf is an epicontinental margin basin surrounded by the Zagros Mountains, which form the active margin in the north and the Arabian stable foreland in the south (Falcon, 1969; Purser and Seibold, 1973; Haynes and McQuillan, 1974; Bordenave, 2002; Alavi, 2007; Jahani *et al.* 2009, 2017; Motamedi *et al.* 2011; Perotti *et al.*, 2011, 2016). Qeshm Island is composed of NW-SE, W-E, and N-S trending anticlines and synclines with very thick Fars Group deposits (Gachsaran, Mishan, Aghajari, and Bakhtiari Formations) and the presence of 118 salt plugs (Sajadi and Rashidi, 2019). According to the tectonic and sedimentology evidence, Qeshm Island in the Persian Gulf is considered part of the south of the Zagros Mountains. The geological similarities as well as the existing harmony between the anticlines in the Zagros Mountains and Qeshm Island are similar and therefore related geologically to one another. The oil-bearing Zagros Mountains are northwest-southeast-trending from northern Iraq to southeast Iran and have been interpreted as the active zone of the Arabia-Eurasia collision belt (Stöcklin, 1968, Alavi, 2004, Allen *et al.*, 2006). Qeshm is the largest island of the Persian Gulf and is located at the southern end of the folded Zagros Mountains (Figure 1).

The stratigraphic units of the Qeshm Island include the Hormoz series, Mishan Formation, Agha Jari Formation, and Quaternary deposits (Rezaee and Zarezadeh, 2014). Additional to the Late Proterozoic/Early Paleozoic salt complex of the Namakdan Group, the main prominent geological formations of the Qeshm Island are the extended outcrops of the Miocene-Pliocene-Early Pleistocene marly and sandy to silty deposits of the Mishan-Agha Jari and younger equivalent formations, with Quaternary calcareous marine terraces. The surface geology of Qeshm Island comprises gentle folds of Lower Miocene Mishan marls, Upper Miocene to Pliocene Agha Jari sandstones, and Lahbari marls, as well as Plio-Pleistocene Kharg limestones. This manuscript is the

first report of Pectinid bivalves from Guri Member of Mishan Formation, near Direstan village, and ostracods of Guri Member and Gushi marls (Makran Basin), southern Iran. All recorded biota of the Mishan Formation and Gushi marls in the studied areas remain unpublished. The Makran Basin extends from the Oman Sea coasts in the south to the Jazmurian depression in the north. Its western limit is the Minab fault that separates the Makran and Zagros basins. There are no formal lithostratigraphic divisions in the Makran Basin; thus, the Makran successions are informally divided into 14 different units (Ghaedi *et al.*, 2016). Gushi marl is the third unit composed of gypsumiferous and calcareous marls, with interbedded siltstone and sandstone (Peterson and Rudzinkas, 1982; Ghaedi *et al.*, 2016).

2. Geological settings

The pectinid specimens were collected from calcareous marls of the Mishan Formation, including patches of scleractinian corals, located south of Direstan Village (26°44'14" N; 55°56'07" E), Qeshm Island in the Persian Gulf. Ostracod specimens were collected from four sections: Direstan (south of Direstan village); Kendaloo (26°41'45.84" N; 55°55'25.67" E), near Kendaloo harbor, Star Valley section (26°52'9.99" N; 56°7'20.42" E); and Bemani (26°55'42" N; 57°07'25" E). The first three sections are the Mishan Formation (Zagros Basin), in Qeshm Island, and the fourth is part of the Makran units in the Minab region, Hormozgan Province, southern Iran (Figures 1 and 2). In Qeshm Island, the Mishan Formation contains about 943 m of green to grey marl and clay-limestone with a rich fossil content (Yazdi *et al.*, 2013). The Mishan Formation is overlaid by the Agha Jari Formation (Figure 3A).

Qeshm Island is part of the Hormozgan province, and like other parts of this province, Mishan Formation is composed of two members; a thick to massive, rock-forming, hard limestone that is called Guri Member, and a very thick unnamed

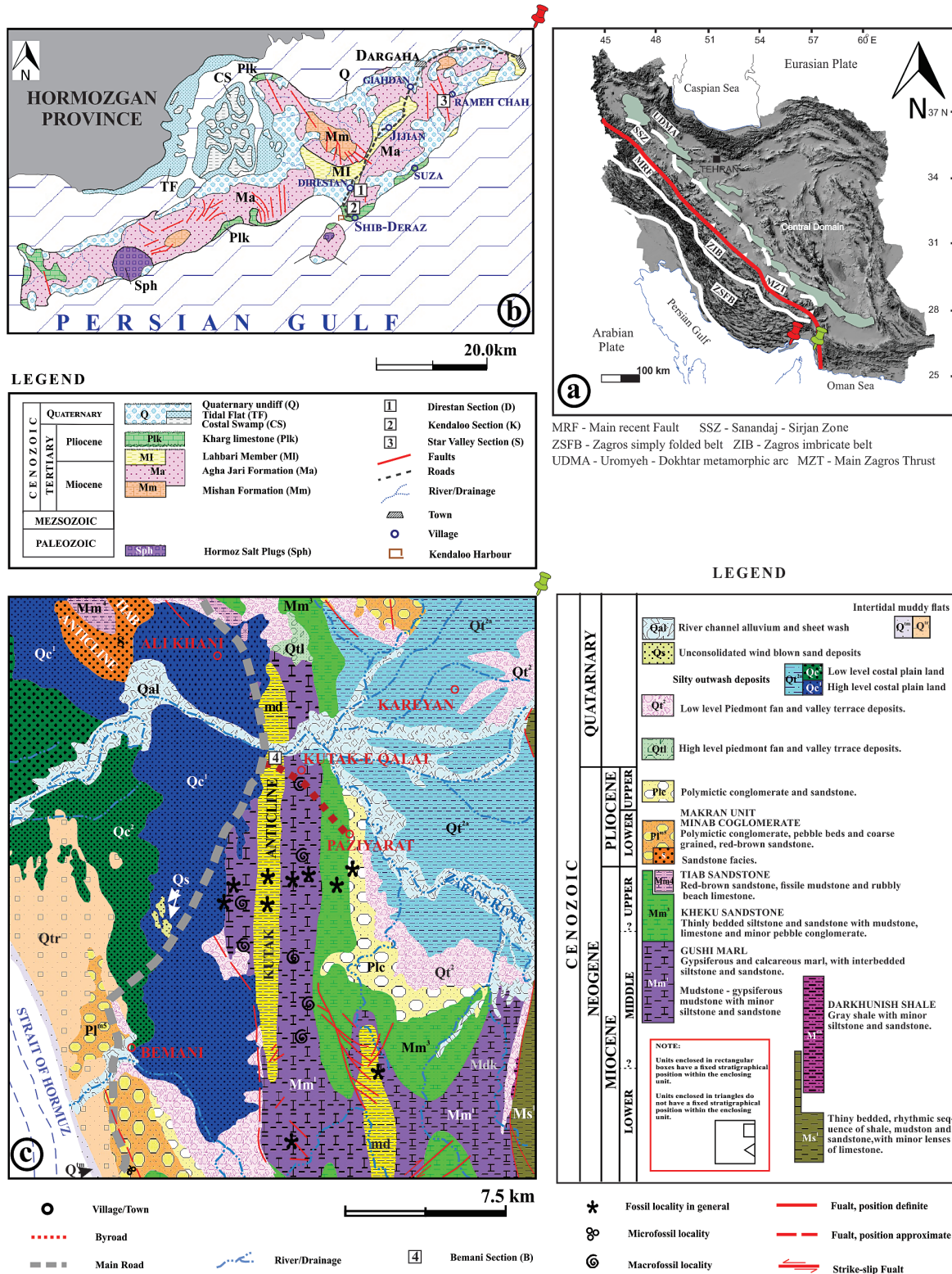


Figure 1 Geological map of the investigated areas; A. Terrain map of Iran; B. Geological map of Qeshm Island, Persian Gulf (after Huber, 1977), with three sampled localities; 1=Direstan outcrop near the village; 2= Kendaloo outcrop in NE of the Kendaloo harbour; 3= Stars Valley outcrop; C. Geological map of Minab region (after Peterson and Rudzinkas, 1982), 4= Bemani outcrop.

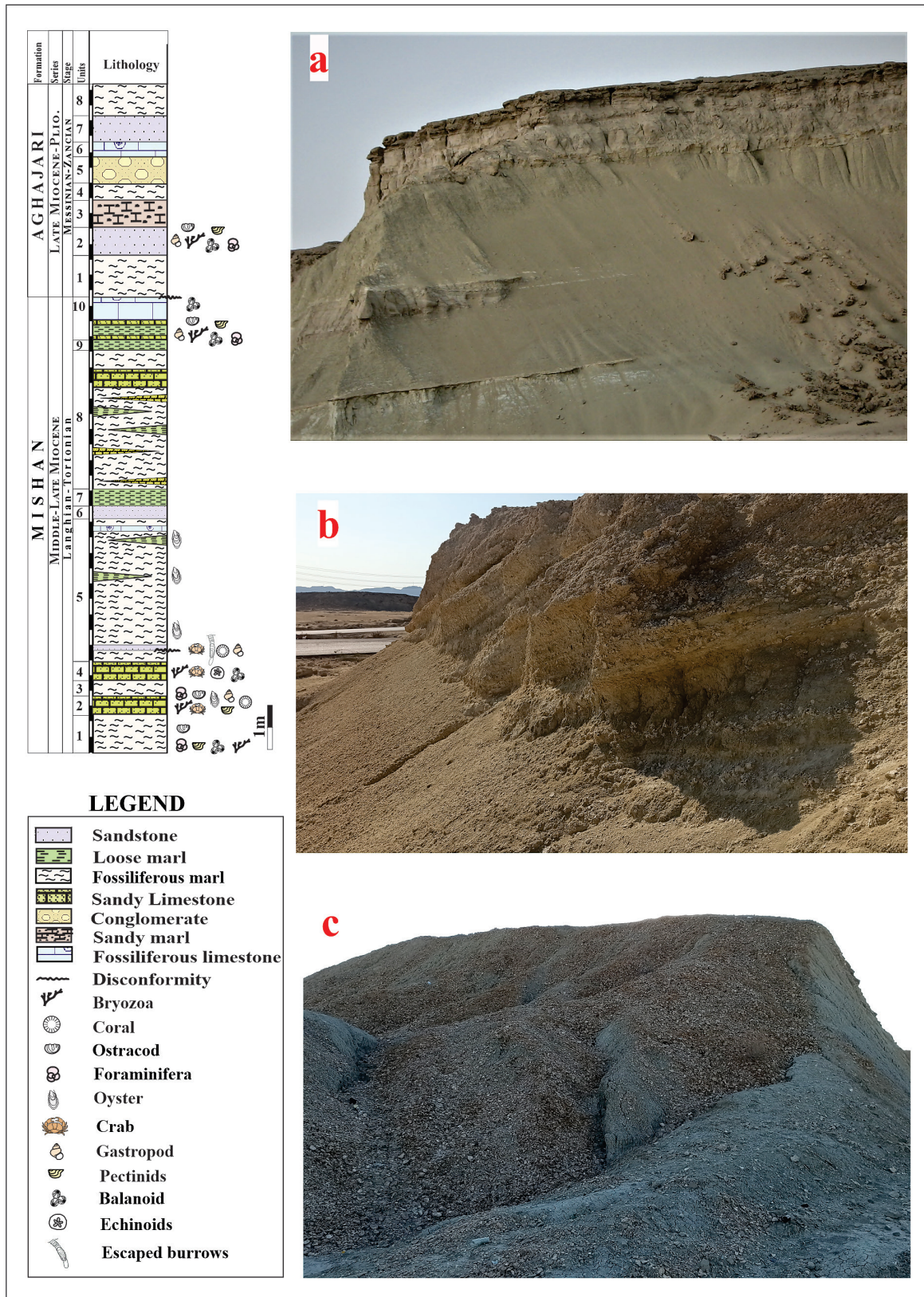


Figure 2 Stratigraphic column and profiles of studied areas; A. Stars Valley section (Qeshm Island, Zagros Basin), B. Kendaloo outcrop (Qeshm Island, Zagros Basin), C. and Bemani section (Makran Basin).

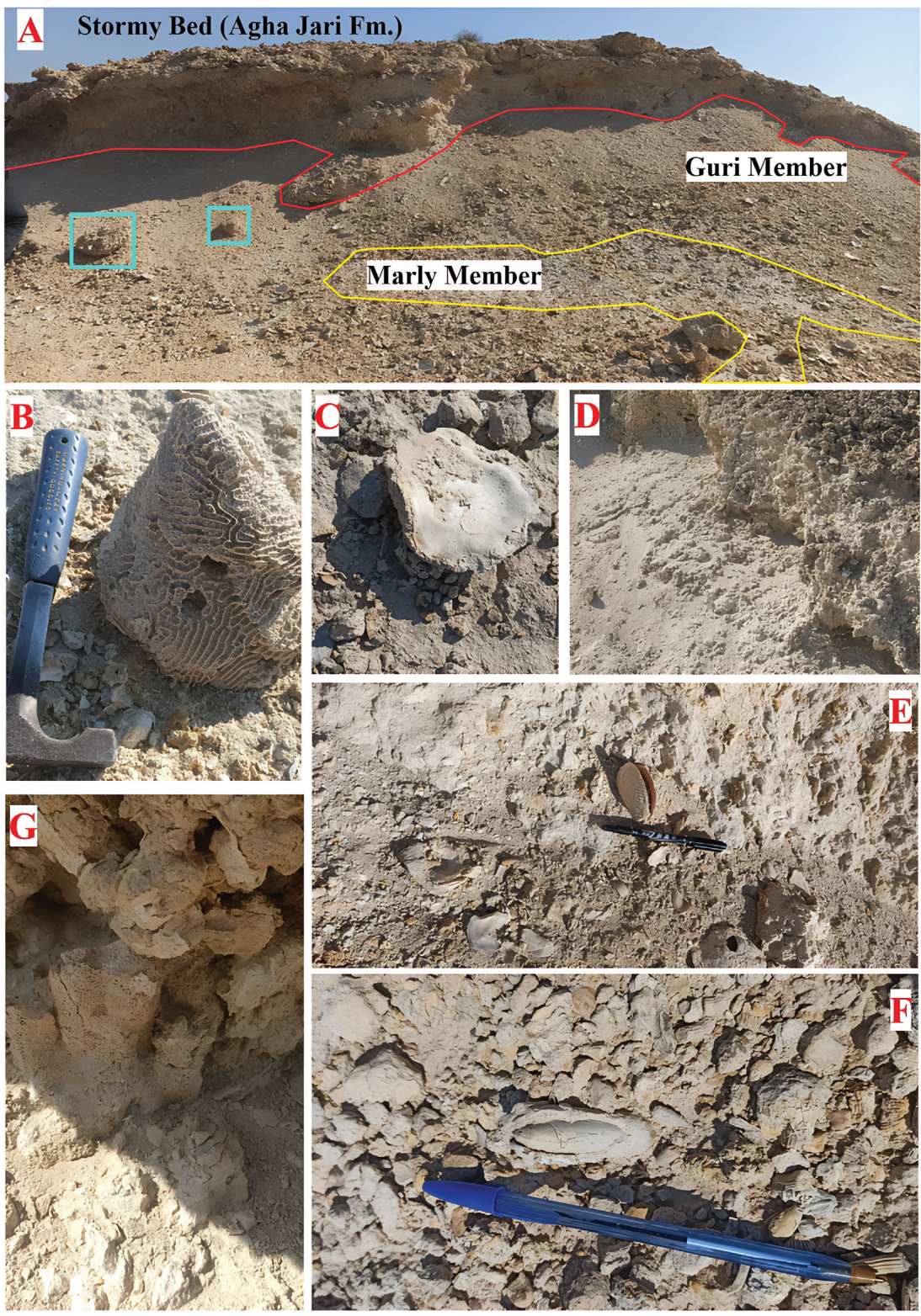


Figure 3 More details of Direstan outcrops; A. Layers from top, Stormy bed (Agha Jari Formation), Guri Member and Marly Member (Mishan Formation); B. Close-up of Figure A (see green line boxes), showing a colony of Scleractinian coral; C. Ostreid bivalve; D. Stormy bed and Guri Member Boundary; E. Guri Member and Marly Member boundary; F. Close-up of Stormy bed; G. Close-up of Guri Member, shows a colony of Scleractinian coral exactly under the Stormy bed.

green or grey marl with intercalated of thin to medium bedded limestone reported by Rashidi *et al.* (2023), as the Marly Member, an informal member at the north end of the Island. In Direstan, the boundary of Guri Member and Marly Member is distinctly recognizable (Figure 3E).

The Mishan Formation is the middle unit of the Fars Group that begins with the Gachsaran Formation sediments or its clastic equivalents (*i.e.*, Razak Formation) and continues with Mishan Formation sediments, finally forming Aghajari with red clastic sediments (Haghipour and Aghanabati, 2005; Motiei, 1993). The Mishan Formation is exposed and present in most parts of the Zagros basin (Motiei 1993) but is well developed in Hormozgan Province (Rashidi *et al.*, 2023) and Qeshm Island. In Qeshm Island, Guri Member organisms include bryozoans, echinoids, corals, gastropods, pectinid and oyster bivalves, crustaceans such as crabs and balanoids, and their shell fragments, while Gushi marls only bear ostreids (oyster bars) and balanoids (Figure 2C).

3. Materials and methods

Three well-exposed outcrops of the uppermost part of the Mishan Formation in the east (Star Valley, 26°52'9.99" N; 56°7'20.42" E) and central part (south Direstan, 26°44'19.06" N; 55°56'21.86" E and Kendaloo 26°41'45.84" N; 55°55'25.67" E) of the Qeshm Island and one profile (Bemani, 26°55'42"N; 57°07'25"E) in the Minab province (alongside the eastern margin of the Persian Gulf) were sampled to reveal the ostracod assemblages.

In Direstan only the Pectinidae assemblages were exposed. Forty-nine specimens of pectinids were collected from the studied area, all display extreme taphonomic features like breakage, bioerosion, encrustation, disarticulation, and abrasion. Most important taphonomic features, like bioerosion (ichnospecies) and activities of encrusting organisms like colonies of bryozoans or polychaetae tubes, are listed in Table 1. Overall, 34 ostracod carapaces and valves were studied,

5 specimens from Direstan; 8 specimens from Kendaloo; 9 specimens from Star Valley, and 12 specimens from the Minab province (Bemani section) were selected and are described herein. The material includes plentiful, well-preserved specimens that were cleaned using a mild detergent, and whenever necessary, an ultrasonic vibrator bath and a preparation needle. Finally, a light binocular microscope was used when necessary. Pectinid bivalves were washed in water and cleaned ultrasonically before taking pictures. To measure samples a pair of callipers were applied. All studied materials are housed within the Department of Geology, Faculty of Science, University of Isfahan, Iran, under the acronym of IUMC.

4. Systematic descriptions

Scallops represent a large and diverse group of molluscs living mostly as vagile epifauna in marine environments, except for some species which are attached or cemented to the bottom. Species living free on the bottom are capable of swimming. Pectinids are common in the fossil record due to their calcite shell with high preservation potential. They are also important as a biostratigraphic tool, and a paleoecological and paleomigrational indicator of the possible open marine corridors.

4.1. PECTINIDAE BIVALVES

The systematic arrangement of the described Pectinidae follows Del Río (1992) and Bieler *et al.*, 2010. Additionally, it takes into consideration the papers of Jimenez *et al.* (2009) and Fontannes (1880), Mandic (2004), Dijkstra and Maestrati (2008), Kroh *et al.* (2011), and Moore (1971).

Phylum Mollusca Linnaeus, 1758

Class Bivalvia Linnaeus, 1758

Subclass Autobranchia Grobben, 1894

Superorder Pteriomorpha Beurlen, 1944

Suborder Pteriina Newell, 1965

Superfamily Pectinacea Rafinesque, 1815

Family Pectinidae Rafinesque, 1815

Table 1. Measurements and taphonomic features (like encrusting organisms, ichnogenera or ichnospecies, etc) of identified species of family Pectinidae, collected from Direstan Outcrop, Qeshm Island, southern Iran. Note: Ex=external of the valve, In=internal of the valve, AL= Auricular Length.

Specimen number	AL (mm)	Height (mm)	Length (mm)	Ex/In of the Valve	Genus/specie	Figures	Taphonomic features	Figures	
0-CLD	45	67	67	Ex -	<i>Pecten</i> aff. <i>rotundatus</i>	7A	bryozoan colony	7B	
1-CLD	36	69	70	- left	<i>Chlamys varia</i>	-	abraded balanoid cluster	-	
3-CLD	broken	broken	35	- "	<i>Chlamys</i> aff. <i>multistriata</i>	-	ventral margin breakage	-	
4-CLD	17	41	36	- left	<i>Ch. multistriata</i>	6A-B	Encrusting organisms	-	
5-CLD	broken	44	35	Ex "	<i>Talochlamys articulata</i>	8D-E	<i>Gastrochaenolites</i> isp.	8F	
6-CLD	33	62	53	- "	<i>Chlamys varia</i>	-	-	-	
7-CLD	35	66	67	- right		6G-H	Polycheate worms	6H	
8-CLD	37	58	broken	both left	<i>Ch. varia</i>	6D-E	<i>Entobia</i> cf. <i>ovula</i>	6F	
9-CLD	31	54	48	Ex right	<i>Ch. varia</i>	-	-	-	
10-CLD	29	53	45	" right	<i>Ch. varia</i>	7G	calcareous tubes of polycheate worms	7G	
3-PCD	26	35	40	- "	<i>Flabellipecten piramidesensis</i>	7D-E	<i>Microponella beringi</i>	7F	
4-PCD	26	35	40	- "	<i>Flabel. piramidesensis</i>	8A-B	Encrusting bryozoan	8C	
5-PCD	28	41	47	- "	<i>Pecten</i> cf. <i>subarcuatus</i>	6C	Encrusting bryozoans	-	
D1-PC4	33	65	56	both	right	9A-B	<i>Rogerella</i> isp.	9C-D	
				Ex			<i>Gastrochaenolites</i> isp.		
				"			<i>Trypanites weisei</i>		
D1-PC8	30	72	60	Ex	"	10A-B	<i>Maeandropolydora sulcans</i>	9F	
				both			<i>Maeandropolydora</i> isp.		
				"			<i>Entobia cateniformis</i>		
D1-PC14	42	79	70	Ex	"	11A-B	<i>Rogerella</i> isp.	11D	
				In			<i>Trypanites weisei</i>		
				"			<i>Renichmus</i> aff. <i>arcuatus</i>		
				"			<i>M. sulcans</i>		
D1-CL16	37	69	59	both	left	4A-B	Encrusting bryozoans	11E-F	
				Ex			<i>Rogerella</i> isp.		
D1-CL17	38	66	57	both	left	5A-B	<i>Gastrochaenolites</i> isp.	4D	
							"		<i>Maeandropolydora</i> isp.
							"		<i>Rogerella</i> isp.
D1-CL18	26	57	49	"	right	4E	<i>Gastrochaenolites</i> isp.	5E-G	
							"		<i>Oichnus simplex</i>

Subfamily Chlamydinæ Von Teppner, 1922

Genus *Chlamys* Roding, 1798

Chlamys actinodes Sowerby, 1846

(Figures 4A-B, 4E, 5A-B)

1846 *Pecten actinodes* –Sowerby in Darwin, p. 376, Pl. 3, fig. 33.

1921 *Chlamys theresinae* –Roveretto, p. 27, fig. 27, fig. 12a.

1992 *Chlamys actinodes* –Del Río, p. 58, pl. 5, figs. 1-4.

2016 *Chlamys actinodes* –Del Río *et al.*, p. 650, fig. 3.

Studied material. 20 valves, all disarticulated, all affected by taphonomic features.

Description. Shell large, thick, and left-convex. The auricular dorsal margin is straight and short. Anterior auricle longer than posterior. Resilial insertions are deep, triangular, and higher than long. A pair of short and moderately impressed cardinal crura with a prominent denticle. Right

valve with anterior auricle ornamented with 5 to 10 fine riblets and with a rounded free margin. The byssal notch is deep, and wide, with the apex commonly rounded, exceptionally acute, and byssal fasciole broad. Posterior auricles sculptured with 15 to 20 riblets; free margin straight and forming a right-angle at junctures with the outer ligament. Ornamentation of disk is highly variable consisting of 40 to 50 low rounded plicae and shallow interspaces, both longitudinally sculptured with flat, narrow, and closely set secondary riblets. Other specimens are characterized by the presence of 60 to 70 very fine, low, sharp, or flat-topped primary ribs separated by wider and shallow interspaces with 5 to 7 riblets narrower than the primary ones (Del Río, 1992)

Remarks. Although the samples are affected by taphonomic features specially bioerosion, and valves are full of boreholes or fused to balanoid

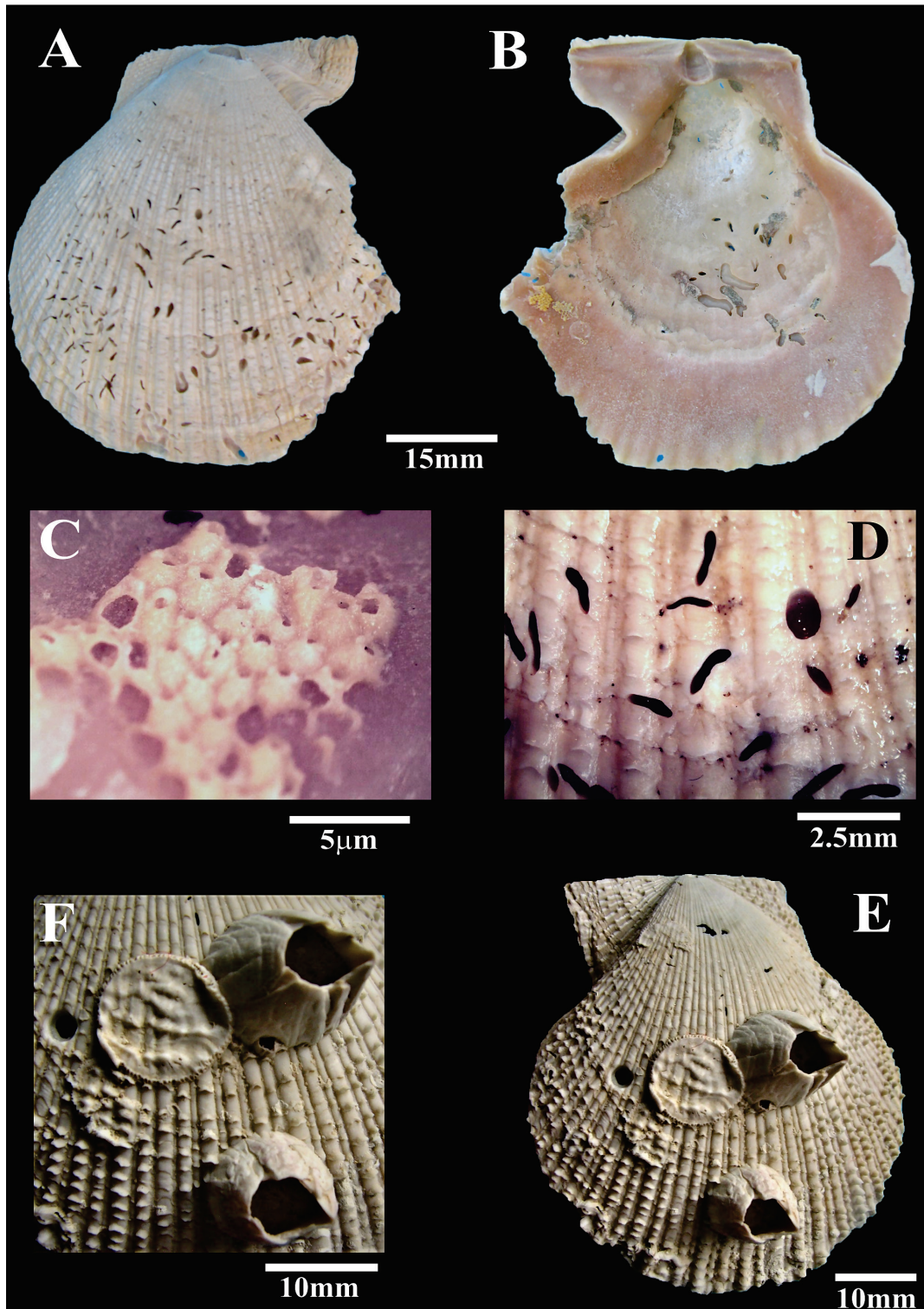


Figure 4 *Chalamys actinodes* (Sowerby, 1846); A. external view of the left valve, showing exterior of the shell that is perforated, and also bearing a marginal breakage; B. internal view of the left valve, bearing a colony of encrusting Cheilostomata bryozoan; C. Close-up view of Figure B, showing a colony of encrusting Cheilostomata bryozoan; D. Close-up view of Figure A, exhibiting ichnogenus *Rogerella* (Saint-Seine, 1951), and ichnogenus *Gastrochaenolites* (D1-CL16). E-F. *Chalamys actinodes* (Sowerby, 1846); E. external view of the right valve, bearing one eroded and two well-preserved shells of genus *Balanus*, welded to the surface of the valve; F. Close-up view of Figure E, represented by *Oichnus simplex* (Bromley, 1981) and apical view of two specimens of genus *Balanus* (D1-CL18).

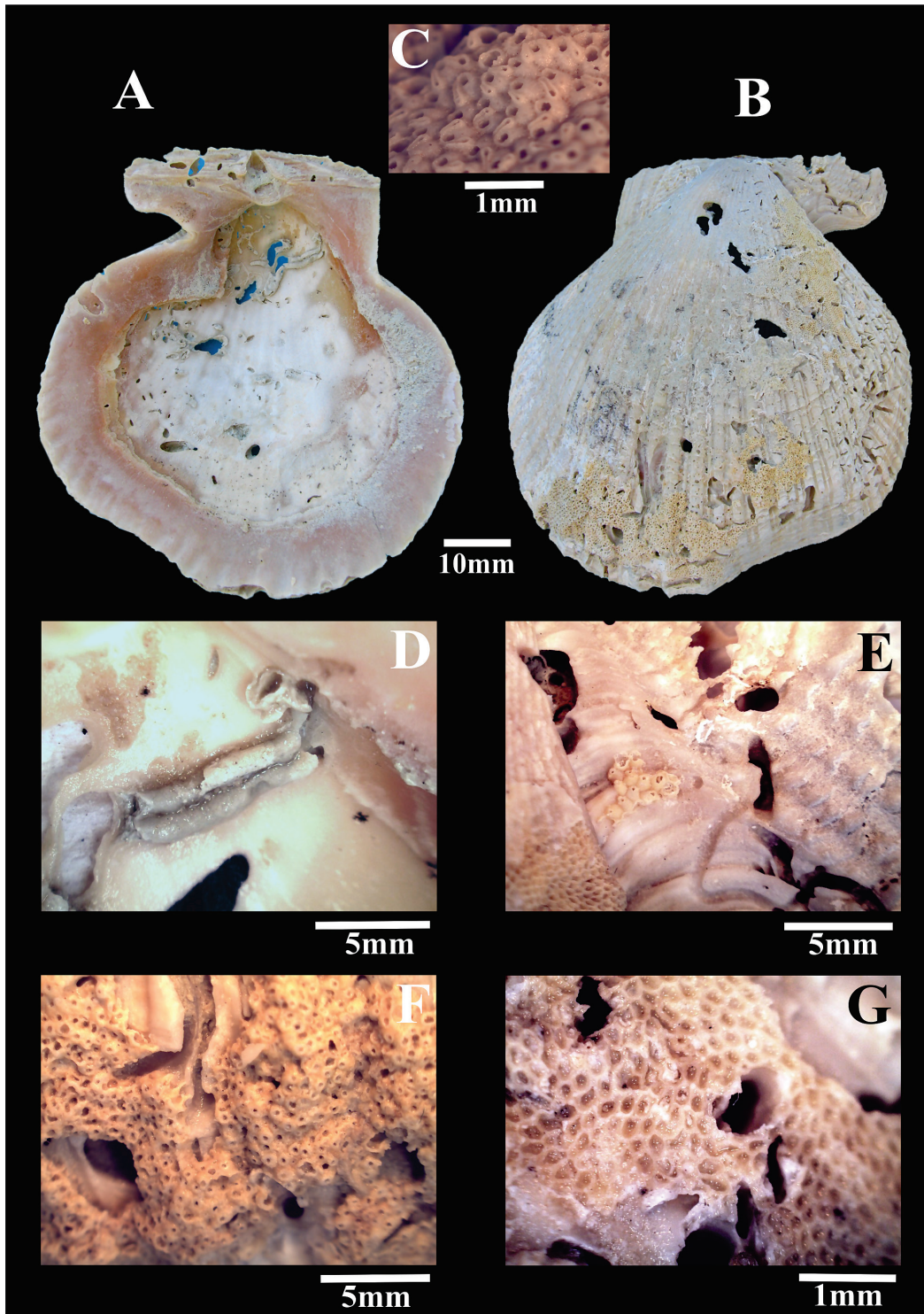


Figure 5 *Chalamys actinodes* (Sowerby, 1846); A. internal view of the left valve, showing interior of the shell is perforated, and bearing calcareous tubes of polychaete worms; B. external view of the left valve, bearing a colony of encrusting Cheilostomata Bryozoan, and also the shell is perforated; C. Close-up view of Figure B, showing a colony of encrusting Cheilostomata Bryozoan; D. Close-up view of Figure A, exhibiting a calcareous tube of polychaete worm; E. Close-up view of Figure B, ichnogenus *Gastrochaenolites*, two colonies of encrusting Cheilostomata Bryozoans, and *Maeandropolydora sulcans* (Bromley, 1981); F-G. Close-up view of Figure B, showing colonies of encrusting Cheilostomata Bryozoans perforated by activity of bioeroders produce ichnogenus *Gastrochaenolites*, *Rogerella* and *Maeandropolydora* (D1-CL17).

barnacles (see Figures 4F and 5E-G), they still show the most characteristic features of the species. Some specimens were perforated by bioeroders. Some specimens bear polychaeta worms indwelling deep in the byssal notch (see Figure 5D).

Distribution. Del Río *et al.* (2016) mentioned this species as widely distributed along lower shoreface to mid-shelf facies and for recent species, they inhabit gravel-substrate or firm-sandy bottoms of depths ranging between 70 and 185 m in open sea.

Chlamys multistriata Poli, 1795

(Figure 6A-B)

1887 *Pecten multistriatus* –Bucquoy *et al.*, p. 104. Gives extensive synonymy.

1939 *Chlamys multistriata* –Roger, p. 165. Gives extensive synonymy.

1972 *Chlamys multistriata* –Comaschi Caria, p. 69, pl. XXV, figs. 12-17.

1982 *Chlamys (Chlamys) multistriata* –Andres, p. 137, pl. 3, figs. 4-5.

1989 *Chlamys (Chlamys) pusio* –Lauriat Rage *et al.*, p. 125, pl. II, figs. 6-7.

1994 *Chlamys (Chlamys) multistriata* –Ben Moussa, p. 76, pl. 3, fig. 3.

2009 *Chlamys multistriata* –Jimenez *et al.*, p. 9, figs. 4c-d.

Studied material. One disarticulated left valve, a little fragmented.

Description. Shell of small size, oval in shape, larger in height than in length. The anterior lateral margin is a bit shorter than the posterior one, which is slightly concave. On the outer surface of the valve, there are 22 thin and rounded radial ribs close to the umbo. The ribs split as the individual grows, thus doubling the number of ribs in the ventral margin. Ribs and interspaces are similar in width (less than 1 mm). Secondary ornamentation consists of thin growth striae that intersect the radial ribs, giving way to imbricate scales with an arrangement similar to tiles on a roof. The cardinal margin is not straight, being higher in the anterior part of the shell. Auricles have 5 to 12 small costae diverging to the margins. (Jimenez *et al.*, 2009).

Remarks. *Chlamys multistriata* is similar to *C. varia*, but the latter is larger. Additionally, *C. multistriata* contains more radial ribs and they are irregularly divided to the ventral margin. Finally, *C. varia* has spines, which do not occur in *C. multistriata* (Jimenez *et al.*, 2009).

Distribution. Lower Miocene to present. Jimenez *et al.* (2009) mentioned that *Chlamys varia* and *C. multistriata* are quite common in fine- to medium-grained sands and silts of Pliocene strata of SE Spain.

Chlamys varia Linnaeus, 1758

(Figure 6D-H)

1758 *Ostrea varia* Linnaeus, p. 698.

1907 *Chlamys varia* –Cerulli Irelli, p. 89, pl. IV, figs. 46-48.

1939 *Chlamys varia* –Roger, p. 157, pl. XXII, figs. 21-23.

1974 *Chlamys (Chlamys) varia* –Malatesta, p. 44, pl. III, fig. 11.

1981 *Chlamys (Chlamys) varia* –Lauriat Rage, p. 42, pl. IV, fig. 8.

1990 *Chlamys varia* –Demarq and Schoepfer, p. 23, pl. II, fig. 3.

1994 *Chlamys (Chlamys) varia* –Ben Moussa, p. 77, pl. 3, figs. 4, 5, 10, 11.

Studied material. Six disarticulated specimens, four left and two right valves, two bear encruster organisms, and two affected by bioerosion.

Description. All three individuals are small. Not equilateral. Both the anterior and posterior margins are almost straight; the anterior one is slightly curved close to the end of the margin. The external surfaces of the valve have 26 radial ribs rounded in section and with the same width as the interspaces. One of the three valves shows growth striae parallel to the ventral margin as secondary ornamentation. Two specimens show tile-like scales at the intersection of striae and ribs. For more descriptions see Jimenez *et al.* (2009).

Distribution. Jimenez *et al.* (2009) mention that the species is one of the most abundant pectinids in Pliocene deposits. It mostly occurs in medium- to coarse-grained sands, calcarenites-calcirudites,

and occasionally in conglomerates.

Remarks. From six specimens, four valves are affected by taphonomic features. One of them is full of boreholes produced by boring *Entobia* sponges (Figure 6F), still showing the most characteristic features of the species. Overall, the two valves are well-preserved and show all characteristic features.

Genus *Pecten* Muller, 1776

Pecten cf. *subarcuatus* Hilber, 1879

(Figure 6C)

1879 *Pecten styriacus* Hilber, p. 455, pl. 6, figs. 13-15.

1928 *Pecten subarcuatus* Tournouer. var. *styriaca* Kautsky, pl. 7, figs. 9-10.

1947 *Pecten subarcuatus* Tourn. var. *styriaca* –Sieber, p. 158

2001 *Pecten subarcuatus styriacus* –Schultz, p. 271, pl. 42, figs. 2-3.

Studied material. A disarticulated right valve, moderately preserved, with a broken right auricle.

Description. Small size, equilateral shell, very short hinge line, both the anterior and posterior margins are slightly curved; the external surfaces of the valve have 33 radial ribs. Growth striae parallel to the ventral margin as secondary ornamentation (Mandic, 2004).

Remark. Mandic (2004) reports this species from the late Burdigalian of the Suez region in NE Egypt, and Reuter *et al.* (2009) report it from the Oligo-Miocene, Qum formation, Iran.

Pecten aff. *rotundatus*, Lamarck, 1819

(Figures 7A-C)

1918 *Pecten rotundatus* –Favre, pl. 5, fig. 14a-b, non fig. 15a-b.

1819 *Pecten rotundatus*– Natural history of animals without vertebrae, p. 179, pl. VI.

1880 *Pecten rotundatus* –Fontannes, p. 161, pl. V, fig. 1.

1897 *Pecten rotundatus* –Nicolas, p. 45.

1938 *Pecten rotundatus* –de Lapparent, p. 123, 125, 126, 128, 136.

2015 *Pecten rotundatus* var. *dromica* –Bongrain, pl. V, figs. 2 et 3

Studied material. An articulated specimen, moderately preserved, with a broken auricle.

Diagnosis. see (Fontannes, 1880).

Description. Equilateral, moderately large size shell, short hinge line, rib width almost 2 mm, interspace almost less than 1 mm, sinusoidal commissure, auricles broken.

Remark. Fontannes (1880) reported this species only once in his thesis from Burdigalin of Qum formation, Siyah kuh, Central Iran as *Pecten rotundatus* var. *dromica* and we never see it again in any reports from Iran or other parts of the world. He suggested that the species could have derived from any previous species, by having a more complete equilateral valve, the slightly wider apical angle, the less curved hinge near the ventral margin, and also the anterior auricle of the right valve less indented.

Genus *Flabellipecten* Sacco, 1897

Flabellipecten pyramidesensis Ihering, 1907

(Figures 7D-E, 8A-B)

1907 *Pecten oblongus pyramidesius* Ihering, 375

1992 *Flabellipecten pyramidesensis* Ihering–Del Río, p. 22, pl. 3, fig. 3, pl. 4, figs. 1- 4.

Studied material. Two left valves, both individually moderately well preserved, both specimens are disarticulated, external surfaces of both valves bear one or more colonies of Cheilostomata bryozoans as encrusting organisms.

Description. Shell small, attaining heights of 35 mm, thick, equilateral in outline and slightly shorter than high, left valve flat. The dorsal margin was straight. Anterior auricle covered with fine growth lines. Free margin sigmoidal in the plane of commissure. Byssal notch moderately deep. The posterior auricle sculptured with only fine growth lines and with free margin straight. The triangular resilial pit was very small and almost flattened. Left valve flat, concave near the umbonal area. Auricular margin straight. Disk sculptured with 23 to 26 equidistant, low, slightly rounded, wide plicae. Interspaces wider than plicae (Del Río, 1992).

Remarks. Del Río (1992) reported *Flabellipecten pyramidesensis* from Miocene deposits of the Puerto

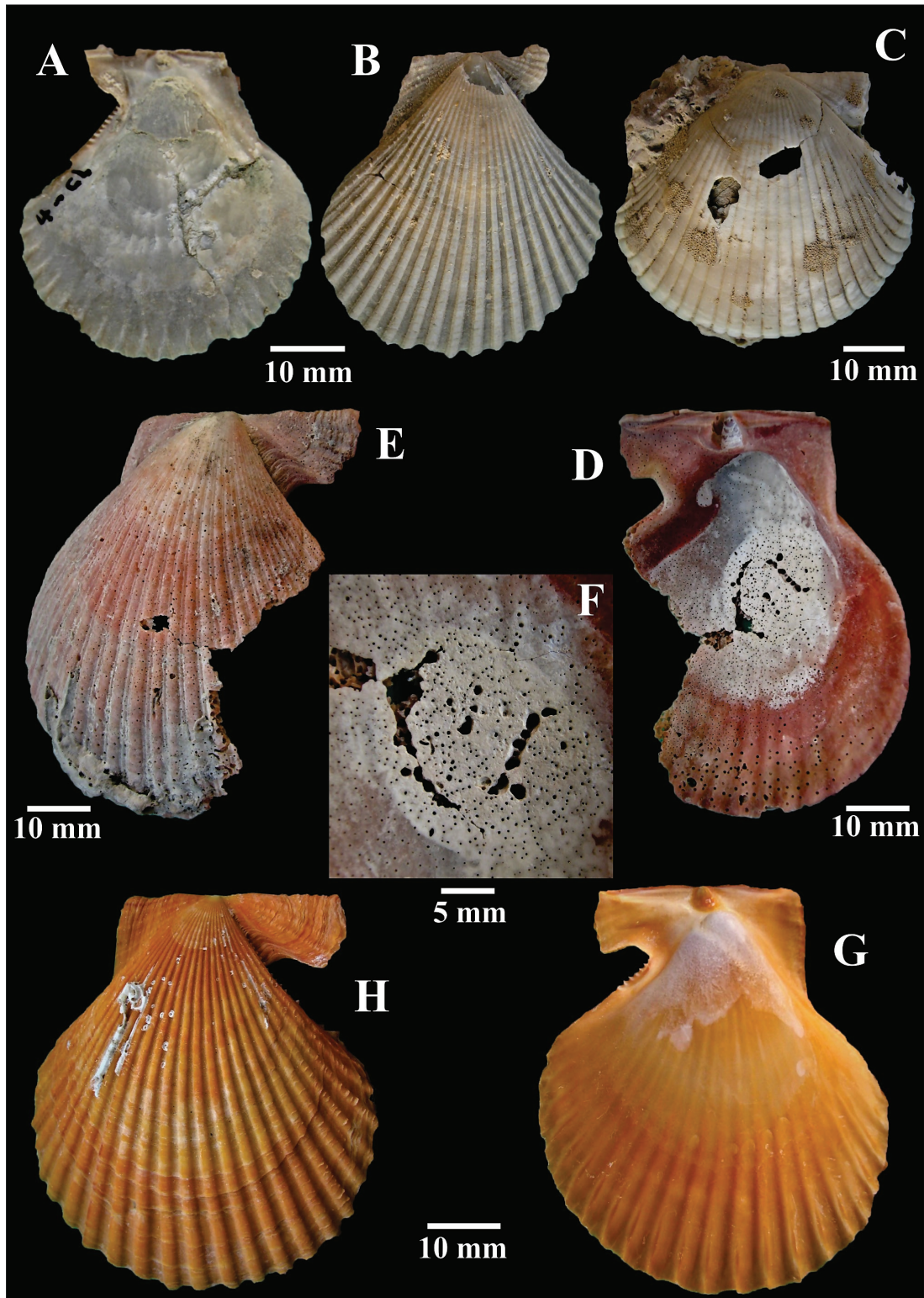


Figure 6 A-B. *Chlamys multistriata* (Poli, 1795); disarticulated, left valve; A. internal view; B. external view (4-CLD); C. *Pecten* cf. *subarcuatus* (Hilber, 1879), disarticulated, broken Auricular, right valve, external view (5-PCD); D-E. *Chlamys varia* (Linnaeus, 1758); disarticulated, left valve; D. internal view; E. internal view (8-CLD); F. Close-up view of Figure E, represent by ichnospecie *Entobia* cf. *ovula* (Bromley and D'Alessandro, 1984); G-H. *Chlamys varia* (Linnaeus, 1758); disarticulated, left valve; G. internal view, not affected by post-mortem processes; H. internal view, shows a calcareous tube of polychaetae worm (7-CLD).

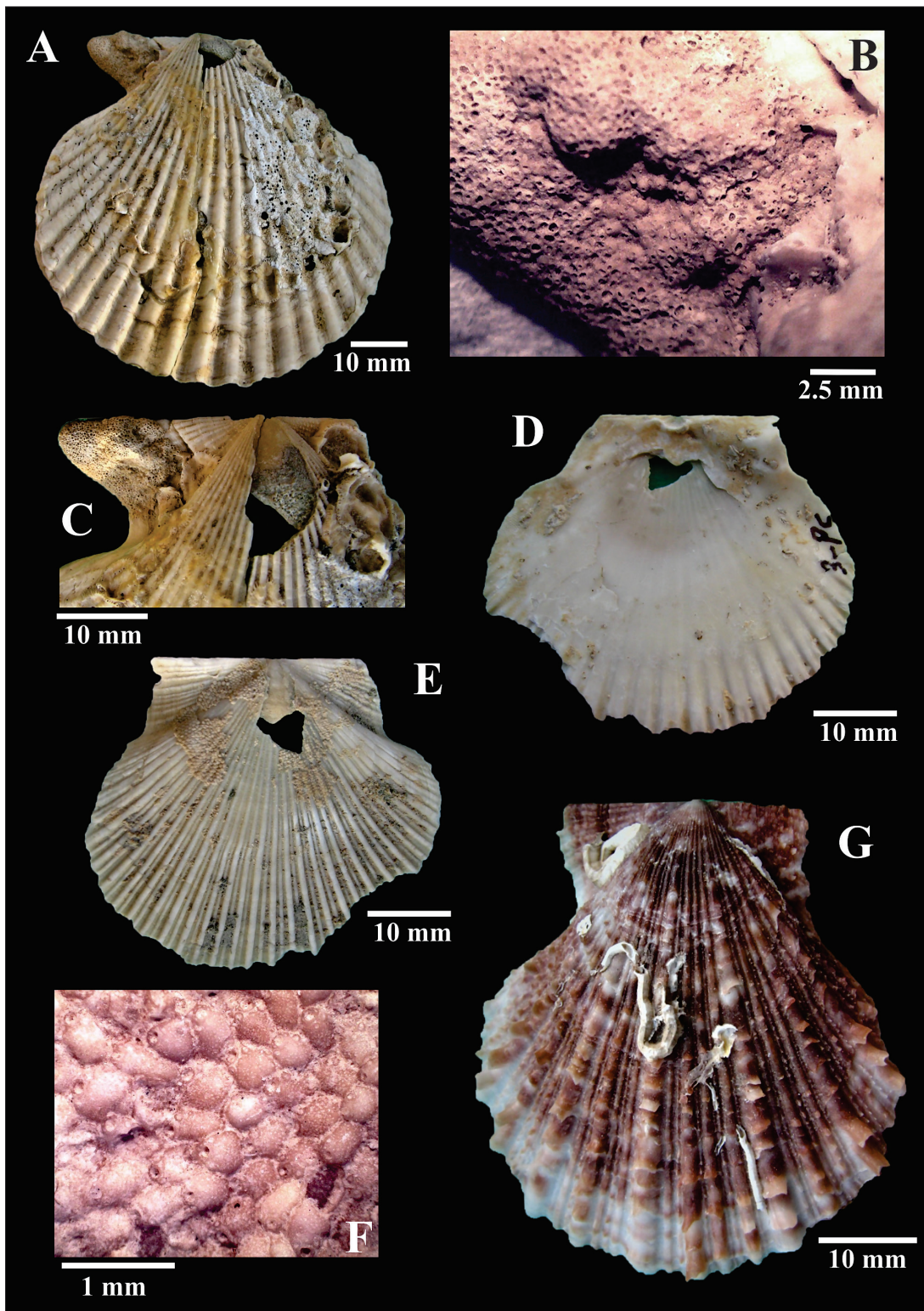


Figure 7 A-C. *Pecten* aff. *rotundatus* (Lamark, 1819); A. external view of undefined valve with broken auricular, B. Close-up view of Figure C, showing a colony of encrusting bryozoan (0-CLD); C. Close-up view of Figure A, showing anterior auricular is broken; D-E. *Flabelliptecten piramidesensis* (Ihering, 1907); disarticulated, left valve; D. internal view; E. external view (3-PCD); F. Close-up of Figure E, represent by an encrusting colony of Cheilostomata bryozoan, *Microporella berningi* (Zágoršek, 2010); G. *Chlamys varia* (Linnaeus, 1758); disarticulated; external view of the right valve (10-CLD).

Madryn Formation, Spain; and also, from Tertiary marine deposits of eastern Patagonia, Argentina (Del Río, 2004).

Genus *Talochlamys* Iredale, 1929
Talochlamys articulata Sowerby, 1840
 (Figures 8D-E)

- * 1840 *Pecten articulatus* Sowerby, pl. 25, fig. 15.
- * 1853 *Pecten articulatus* Sowerby –D’Archiac and Haime, p. 269–270, pl. 24, fig. 1.
- * 1901 *Pecten kokenianus* spec. nov., –Noetling, p. 117–121, pl. 4, figs. 2–6.
- 1916 *Pecten (Chlamys) senatorius* –Martin, p. 263.
- 1928 *Pecten (Chlamys) articulatus* –Vredenburg, p. 434.
- 1928 *Chlamys Senatoria* –Douglas, p. 2–4, pl. 8, figs. 3–5.
- 1950 *Chlamys senatoria* –Eames, p. 145.
- 2011 *Talochlamys articulata* Sowerby –Kroh *et al.*, p. 433–435, figs 11, 12.1–13.

Studied material. One specimen, disarticulated, left valve, with broken auricular.

Description. Shell of medium size, moderately thick-walled, rounded in outline, somewhat higher than long, with about 26 prominent ribs fixed. The commissural line is wavy, triangular resilium, disc outline is equilateral to slightly inequilateral. The beak does not project over the hinge line. The anterior auricle is broken. Rib width and interspace width reflect the internal of the valve (Kroh *et al.*, 2011).

Remark. This specimen is a sclerobiont of taphonomic features, like a borehole represented by *Oichnus simplex* (Bromley, 1981), see (Figure 8F), an undefined early-stage bivalve, fused on the external surface of the valve and an encrusting colony of bryozoans, indwelling internal side of the valve.

Genus *Argopecten* Monterosato, 1889
Argopecten gratus Del Río, 1992
 (Figures 9, 10, 11A-B)

- 1989 *Argopecten gratus* Del Río, p. 246, pl. 1, fig. 7.
- 1992 *Argopecten gratus* Del Río – Del Río; p. 60, pl. 2, fig. 5; p. 61, pl. 3, fig. 7.

Studied material. Altogether 13 specimens were studied, all are disarticulated right or left valves, moderately well to weakly preserved. Internal and external surface of the valves affected by taphonomic features.

Description. Shell of medium size, longer than high, lightly inflated right valves. Apical angle obtuse. The auricular margin and dorsal margin of the disk are straight. The margin and dorsal margin of the disk are straight. All three right valves show anterior auricle longer than posterior, covered with 7 wide and distinct riblets and growth. Byssal notch triangular. All three valves show sculptured posterior auricle with 11 or 12 fine riblets. The resilial pit is shallow, higher than long (Del Río, 1992).

Remarks. Almost all samples affected by taphonomic features, and valves are perforated by trace fossils like *Entobia cateniformis* (Bromley and D’Alessandro, 1984), *Trypanites weisei* (Magdefrau, 1932), *Rogerella* isp (Saint-Seine, 1951), *Renichnus* aff. *arcuatus* (Mayoral, 1987), *Gastrochaenolites clunifformis* (Kelly and Bromley, 1984), *Maeandropolydora sulcans* (Bromley, 1981), and overlaid by Cheilostomata bryozoans, undefined bivalves from early ontogenetic stages or polychaetae worms (Figures 9–11).

4.2. THE CRUSTACEANS OSTRACODA

The systematic arrangement of described Ostracoda follows Khalaf (1984; 1988) and the papers of Hawramy and Khalaf (2013), Gammudi and Keen (1993), Sciuto (2014), and Forel (2021).

Class Ostracoda Latreille, 1806

Order Podocopida Sars, 1866

Suborder Cytherocopina Grundel, 1967

Superfamily Cytheroidea Baird, 1850

Family Trachyleberididae Sylvester-Bradley, 1948

Subfamily Trachyleberidinae Sylvester-Bradley,
1948

Genus *Alocopocythere* Siddiqui, 1971

Alocopocythere kendengensis Kingma, 1948

(Figures 12A-E)

2021 *Alocopocythere kendengensis* Kingma – Forel, p.

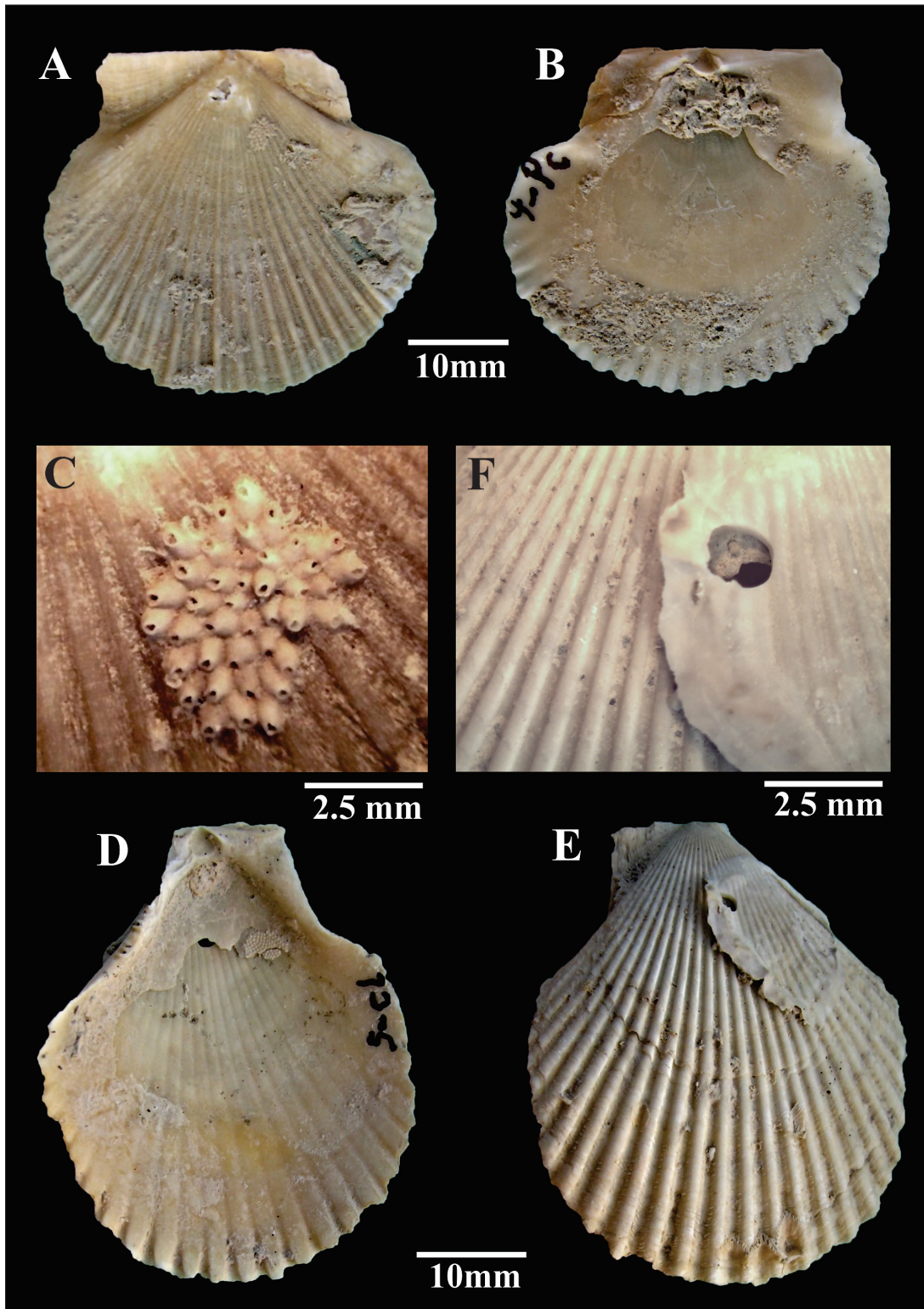


Figure 8 A-B. *Flabellipecten piramidesensis* (Ihering, 1907); disarticulated, left valve; A. external view; B. internal view (4-PCD); C. Close-up view of Figure A, represent by a colony of encrusting Cheilostomata bryozoan; D-F. *Talochlamys articulata* (Sowerby, 1840); disarticulated, broken Auricular, left valve; D. internal view; E. external view showing a fixed valve of an undefined bivalve from early ontogenetic stages, perforated by ichnospecies *Oichnus cf. simplex* (Bromley, 1981); F. Close-up view of Figure E, represent by *Oichnus cf. simplex* (5-CLD).

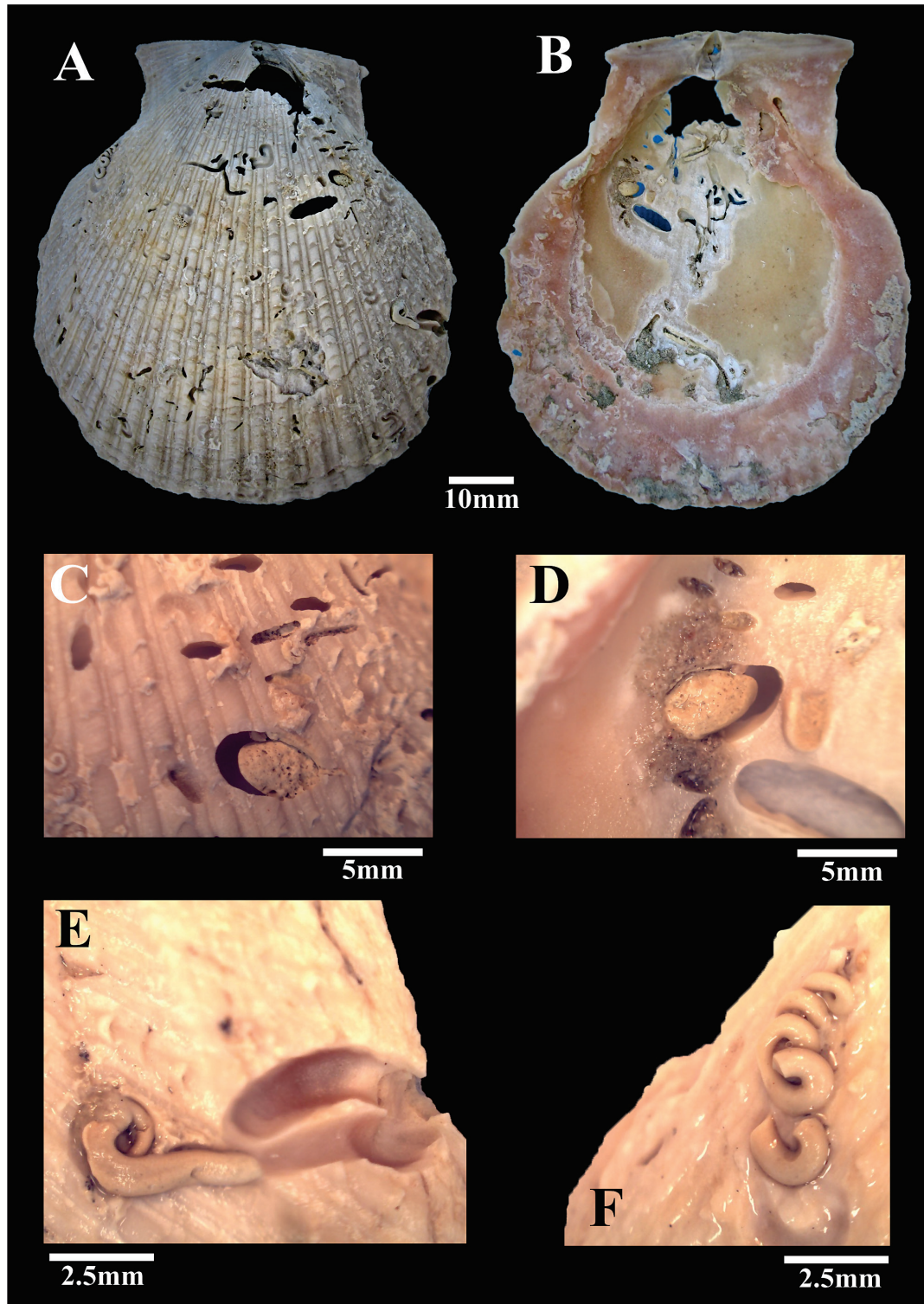


Figure 9 *Argopecten gratus* (Del Río, 1992); A. external view of the right valve, showing exterior of the shell is perforated by different type of bioerosion activities and a breakage around umbo. B. internal view of the right valve, bearing continued parts of bores, which are performed external of the valve or the whole thickness of the shell; C-D. Close-up view of Figures A and B, respectively, bearing a remain part of a Pholadid bivalve, producer of ichnogenus *Gastrochaenolites*, and Pouch-shaped bores refers to ichnogenus *Rogerella* (Saint-Seine, 1951), E-F. Close-up view of Figure A, exhibiting calcareous tubes of Polychaetae worm, *Glomerula?* sp. (Brünnich Nielsen, 1931), which are producers of ichnospecies *Trypanites weisei* and *Maeandropolydora sulcans*, respectively (D1-PC4).

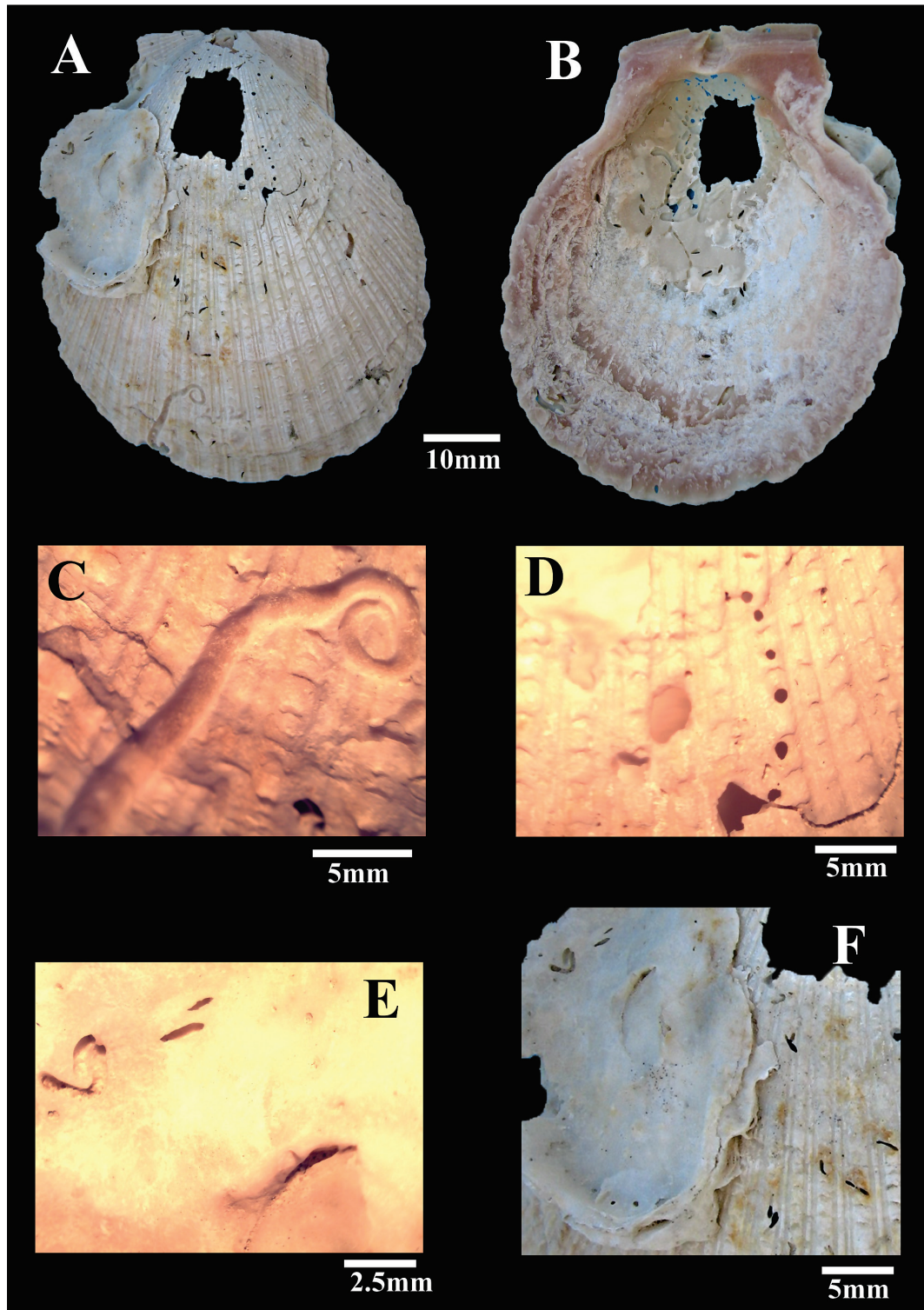


Figure 10 *Argopecten gratus* (Del Río, 1992); A. external view of the right valve, bearing fixed valve of an Ostreid from early ontogenetic stages and a breakage near it; B. internal view of the right valve, showing the breakage and other parts of boreholes through the entire thickness of the studied shell C. Close-up view of Figure A, showing ichnogenus *Maeandropolydora*; D. Close-up view of Figure A, exhibiting ichnogenus *Entobia cateniformis* (Bromley and D'Alessandro, 1984); E. Close-up view of Figure F, exhibiting ichnogenus *Trypanites weisei* (Magdefrau, 1932), and *Rogerella* isp., F. Close-up view of Figure A, showing the fixed valve of a juvenile Ostreid, which is attached to the shell of *Argopecten gratus* (D1-PC8).

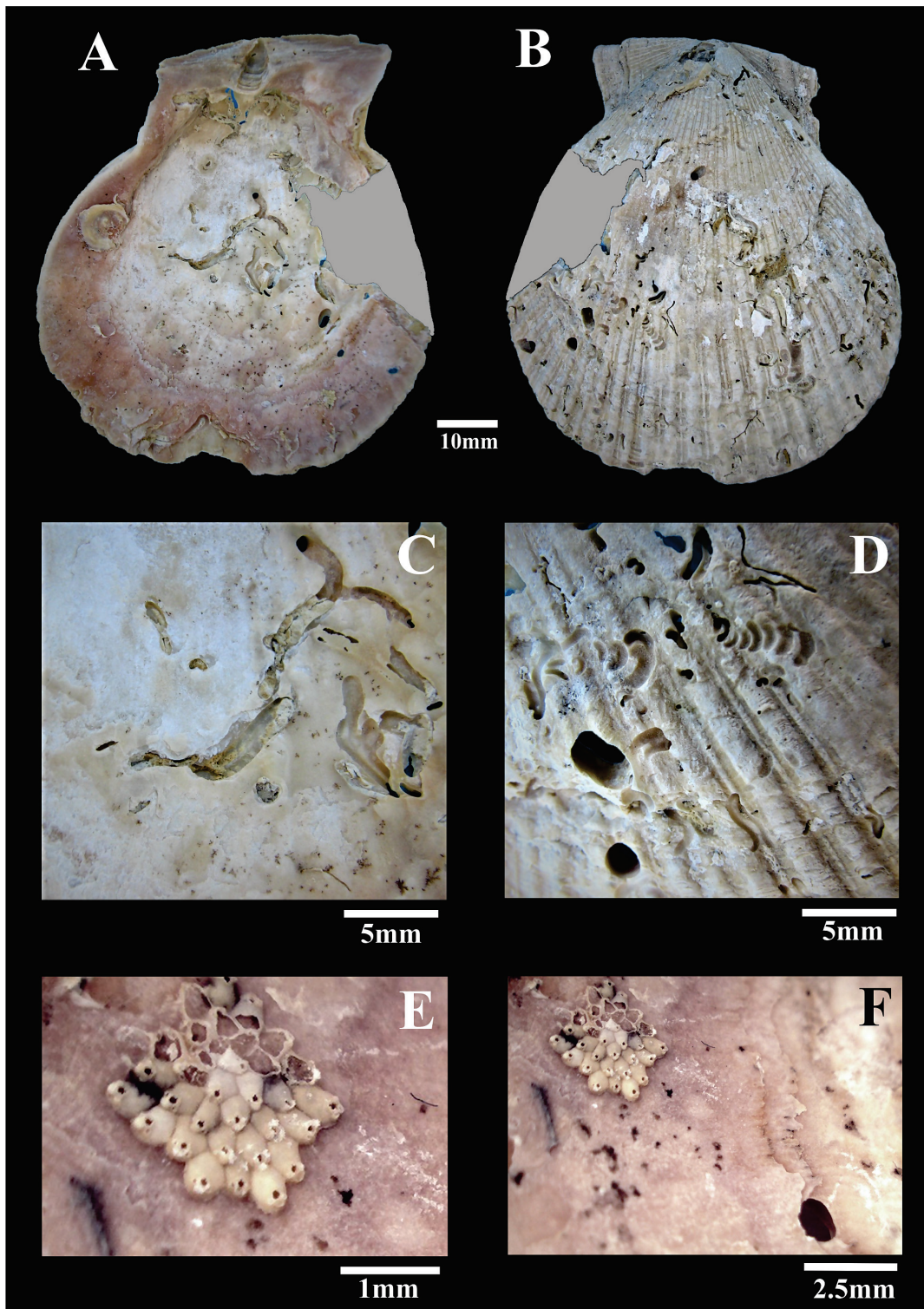


Figure 11 *Argopecten gratus* (Del Río, 1992); A. internal view of the right valve, showing the shell is broken, perforated, and also bears a fused undefined valve from early ontogenetic stages of bivalves; B. external view of the right valve, showing the studied valve is almost a heavily used shell; C. Close-up view of Figure A, showing a remain of calcareous tubes of worms produced by the ichnogenus *Maeandropolydora*; D. Close-up view of Figure B, exhibiting different ichnogenes such as *Gastrochaenolites cluniformis* (Kelly and Bromley, 1984), *Trypanites weisei*, *Renichnus* aff. *arcuatus* (Mayoral, 1987), and *Maeandropolydora sulcans*; E-F: Close-up views of Figure A, present by a Cheilostomata Bryozoan as an encruster fauna, with a rhomboidal colony (D1-PC14).

4, figs. 4 T, U, 5A.

Studied material. Five specimens were studied, 4 carapaces, and one valve. One carapace and one valve are from Kendaloo, and others are from Direstan, Star Valley, Bemani sections.

Diagnosis. see (Forel, 2021).

Distribution and Occurrence. Recent (Forel, 2021; Kingma, 1948; Dewi, 1993; Fauzielly *et al.*, 2013). Pliocene of China (Guan *et al.*, 1978), for more see (Forel, 2021). In the present study, Mid-late Miocene of Mishan Formation, Qeshm Island, Zagros Basin, and also, Mio-Pliocene of Minab region, Makran Basin, southern Iran.

Genus *Actinocythereis* Puri, 1953

Actinocythereis iraqensis Khalaf, 1982a

(Figures 12F-J)

1982a *Actinocythereis iraqensis* Khalaf, Stero-Atlas 9(9) 51-54.

2013 *Actinocythereis iraqensis* Khalaf–Hawramy and Khalaf, p. 71, pl. 2, figs. 1,2.

Studied material. Seven specimens were studied, one carapace and one valve from Star Valley; one carapace and one valve from Kendaloo, and also three carapaces were studied from the Bemani section.

Diagnosis. see (Khalaf, 1982a; Hawramy and Khalaf, 2013).

Distribution and Occurrence. According to Hawramy and Khalaf (2013), the species was found only in Mid-Late Miocene of Iraq, and now we found and collected this species from Mid-Late Miocene strata of Mishan formation in Qeshm Island, Zagros Basin, and also, from Mio-Pliocene strata of Minab region, Makran Basin, southern Iran.

Genus *Hermanites* Puri, 1955

Hermanites transversicostata Khalaf, 1982b

(Figure 13G-J)

1982b *Hermanites transversicostata* Khalaf–Stero-Atlas of Ostracoda Shells, 9(11), 59-62.

2013 *Hermanites transversicostata* Khalaf–Hawramy and Khalaf p. 71, pl. 2, figs. 15-18.

Studied material. Four specimens were stud-

ied, three are carapaces and one valve. The valve is from Kendaloo, one carapace Star Valley, one from Bemani and also, one from Direstan section. Diagnosis: see (Khalaf, 1982b; Hawramy and Khalaf, 2013).

Distribution and Occurrence. Mid-late Miocene of Qeshm Island and Mio-Pliocene of Minab region, southern Iran (present study). Mid-late Miocene of Iraq.

Genus *Costa* Neviani, 1928

Subgenus *Cuneocosta* Ruggieri, 1992

Costa (Cuneocosta) cf. *tricostata pliocenica* Ruggieri, 1992

(Figure 13K)

1992 *Costa (Cuneocosta) tricostata pliocenica* Ruggieri, p. 177-178, fig. 6;

2000 *Costa (Cuneocosta) tricostata pliocenica* Ruggieri–Aiello *et al.*, p. 102, pl. 5, fig. 2;

2003 *Costa tricostata pliocenica* Ruggieri–Sciuto, p. 181, pl. 1, fig. 2f.

Studied material. four carapaces, from the Bemani section.

Diagnosis. see (Sciuto, 2014).

Distribution and occurrence. According to Ruggieri (1992), *Costa (Cuneocosta) tricostata pliocenica* is referred to bathyal environments. The species is known from Early Pliocene (Ruggieri, 1992) to Early Pleistocene (Aiello *et al.*, 2000). Also, Sciuto (2014) reported the species from Upper Pliocene layers of Punta Mazza, Italy. From southern Iran, the species was found and recorded from Mio-Pliocene marly strata of Bemani section, Minab region, Makran Basin.

Family Loxoconchidae Sars, 1925

Subfamily Loxoconchinae Sars, 1825

Genus *Loxoconcha* Sars, 1866

Loxoconcha (Loxoconcha) hamrinensis Khalaf, 1998

(Figures 12K-M)

1998 *Loxoconcha (Loxoconcha) hamrinensis* Khalaf– p. 2, pl. 1, figs. 1,2,4,5.

2013 *Loxoconcha (Loxoconcha) hamrinensis* Khalaf–Hawramy and Khalaf, p. 71, pl. 2, figs. 22-24.

Studied material. Four specimens were studied,

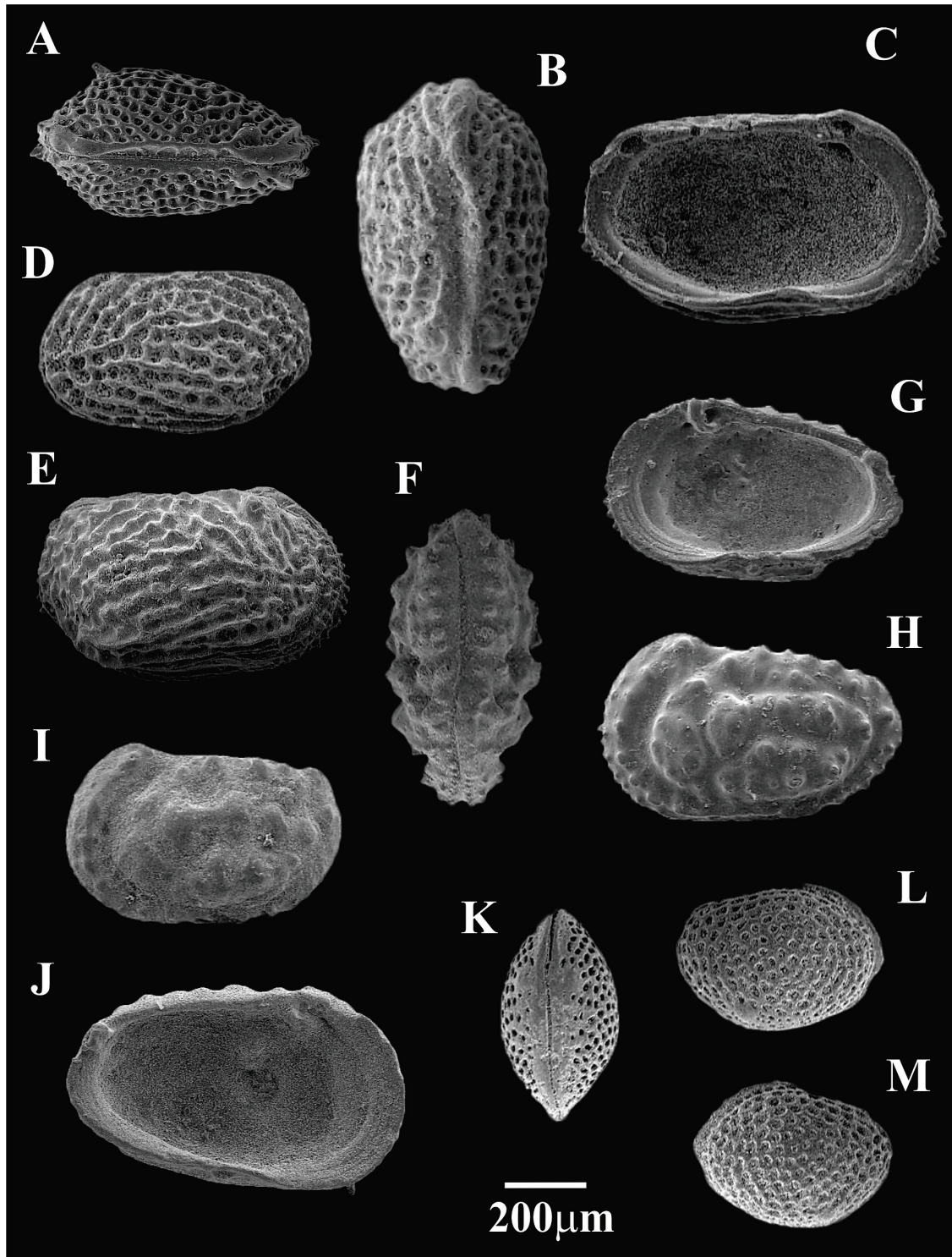


Figure 12 A-E. *Alococythere kendengensis* (Kingma, 1948); A-B. Dorsal views of two complete carapaces, from Star Valley section (S.Ost.Cc.Msh.Fm.1) and Kendaloo section (K.Ost.Cc.Msh.Fm.2), respectively; C. Internal view of a left valve (K.Ost.LV.Msh.Fm.3); D. Lateral view of a left valve (D.LV.Ost.Msh.Fm.4); E. Right lateral view of a complete carapace (B.Ost.Cc.Gsh.M.5); F-J. *Actinocythereis iraqensis* (Khalaf, 1982a); F. Dorsal view of the complete carapace (B.Ost.Cc.Gsh.M.6); G. Internal view of a right valve (S.Ost.RV.Msh.Fm.7); H. Lateral view of a left valve (S.Ost.LV.Msh.Fm.8); I. Lateral view of a left valve (K.Ost.LV.Msh.Fm.9); J. Internal view of a left valve (K.Ost.LV.Msh.Fm.10); K-M. *Loxoconcha (Loxoconcha) hamrinensis* (Khalaf, 1998); K. Dorsal view of a complete carapace (S.Ost.Cc.Msh.Fm.11); L. Left lateral view of a complete carapace (D.Cc.Ost.Msh.Fm.12); M. Right lateral view of a complete carapace (B.Ost.Cc.Gsh.M.13).

all carapaces, one from Kendaloo, one Star Valley, one Bemani, and one from Direstan section.

Diagnosis. see (Khalaf, 1998; Hawramy and Khalaf, 2013).

Distribution and Occurrence. According to Hawramy and Khalaf (2013), the species was reported only in Mid-Late Miocene of Iraq, and in this study, they were collected from Mid-Late Miocene strata of Mishan formation, Qeshm Island, Zagros Basin.

Family Schizocytheridae Howe in Moore, 1961

Subfamily Schizocytherinae Mandelstam, 1960

Genus *Neomonoceratina* Kingma, 1948

Neomonoceratina iniqua Brady, 1868a

(Figures 13A-C)

2021 *Neomonoceratina iniqua* Brady– Forel, p. 4, figs. 4D, E

Studied material. Four specimens were studied, all are carapaces, one from Kendaloo, one Star Valley, one Bemani, and one from Direstan section.

Diagnosis. see (Forel, 2021).

Distribution and Occurrence. Mid-late Miocene of Qeshm Island, southern Iran (present study); Recent (Forel, 2021); Holocene of Iraq (Al-Jumaily and Al-Sheikhly, 1999); Pliocene-Pleistocene of India (Guha, 1968); Persian Gulf (*e.g.*, Mostafawi *et al.*, 2010); Middle Miocene, Late Pliocene-Pleistocene of Japan (Nohara, 1987); for more see (Forel, 2021; Al-Jumaily and Al-Sheikhly, 1999).

Superfamily Bairdiacea Sars, 1888

Family Bairdiidae Sars, 1888

Genus *Bairdoppilata* Coryell, Sample and Jennings, 1935

Bairdoppilata triangulata Edwards, 1944

(Figures 13D-F)

1944 *Bairdoppilata triangulata* Edwards, p. 507, pl. 85, figs. 5, 6.

1954, *Bairdoppilata triangulata* Edwards – Puri, p. 223, pl. 1, figs. 3, 4; text figs. 1a, b.

1974 *Bairdoppilata triangulata* Edwards– Swain, p. 53, pl.1, figs. 2a, b; text figs 2, 3.

1993 *Bairdoppilata triangulata* Edwards– Gammudi and Keen, p. 123, pl. 1, fig. 1.

2011 *Bairdoppilata triangulata* Edwards – Ceolin *et al.*, p. 115, figs. 3q-p.

Studied material. Three specimens were studied, one carapace and one valve from Star Valley section and one carapace from Kendaloo section.

Diagnosis. see (Swain, 1974; Gammudi and Keen, 1993).

Distribution and Occurrence. Mid-Late Miocene of Qeshm Island, south of Iran (present study), Late Miocene of Atlantic Coast region (Pliocene, Swain, 1968; Hazel, 1971), mid-Late Miocene of Florida (Puri, 1954); Recent (Benson and Coleman, 1963; Swain, 1974).

Family Cytherelloidea Sars, 1866

Genus *Cytherelloidea* Alexander, 1929

Cytherelloidea hamrinensis Khalaf, 1993

(Figure 13L-N)

1993a *Cytherelloidea hamrinensis* Khalaf, Iraq. Geol. Jour. 26(3), pp. 184-186, pl. 3, figs. 1-4.

2013 *Cytherelloidea hamrinensis* Khalaf– Hawramy and Khalaf, p. 70, pl. 1, figs. 5,6.

Studied material. Three specimens, all are carapaces, one carapace from Star Valley, one from Bemani and one from Direstan section.

Diagnosis. see (Khalaf, 1993; Hawramy and Khalaf, 2013).

Distribution and Occurrence. Mid-Late Miocene of Qeshm Island and Mio-Pliocene of Minab region, southern Iran (present study). Mid-late Miocene of Iraq.

4.3. ENCRUSTER ORGANISMS

The systematics of described Cheilostomat bryozoans takes into consideration the books of Bassler (1953) and Zágoršek (2010).

Phylum Bryozoa Ehrenberg, 1831

Class Gymnolaemata Allman, 1896

Order Cheilostomata Busk, 1852

Suborder Ascophora Levinsen, 1909

Infraorder Acanthostega Levinden, 1902

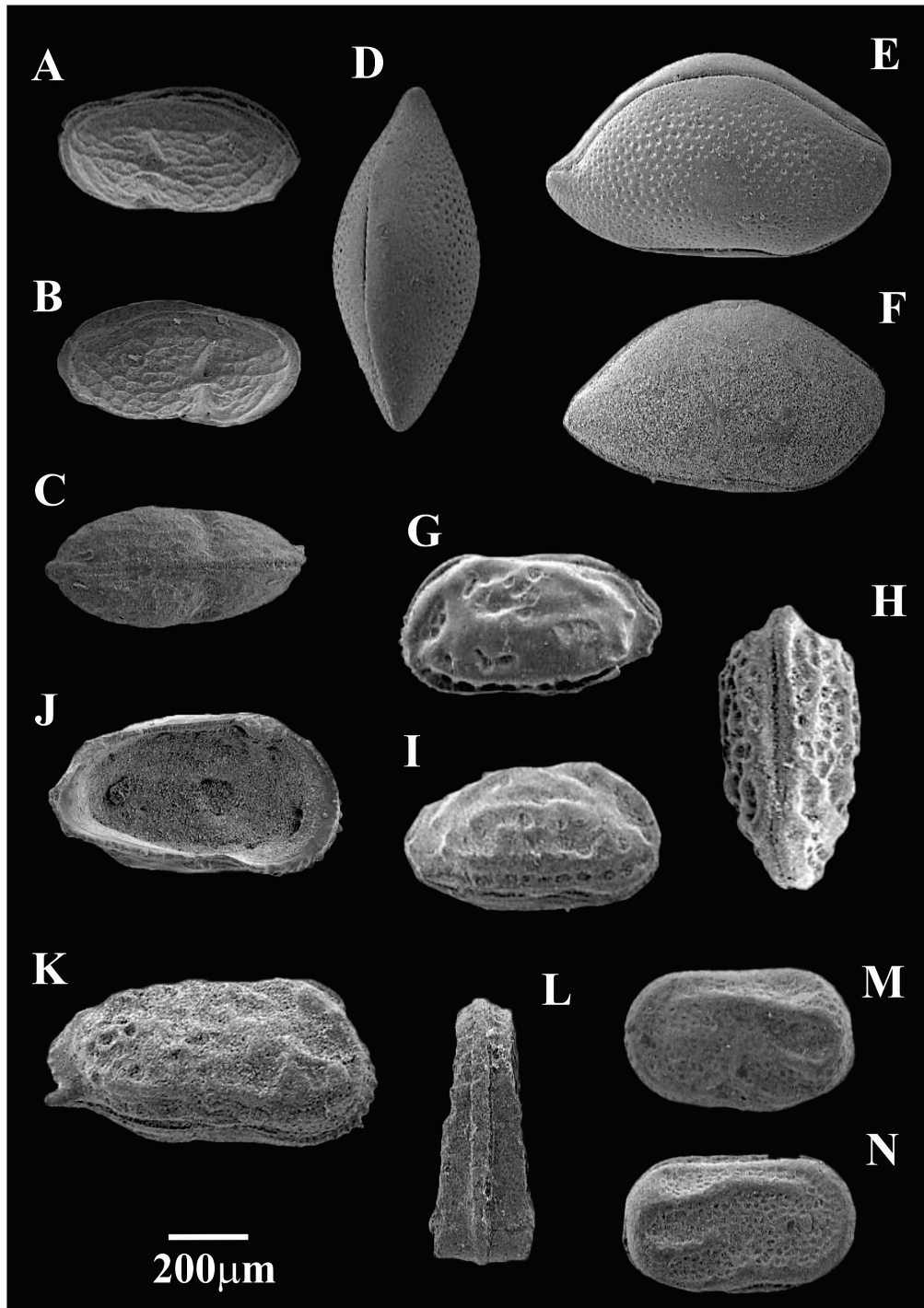


Figure 13 A-C. *Neomonoceratina iniqua* (Brady, 1868); A. Left lateral view of a complete carapace (B.Ost.Cc.Gsh.M.14); B. Right lateral view of a complete carapace (D.Ost.Cc.Msh.F. 15); C. Ventral view of a complete carapace (K.Ost.Cc.Msh.F.16); D-F. *Bairdoppilata triangulata* (Edwards, 1944); D. Dorsal view of a complete carapace (S.Ost.Cc.Msh.Fm.17); E. Right lateral view of a complete carapace (S.Ost.Cc.Msh. Fm.18); F. Right lateral view of a complete carapace (S.Ost.Cc.Msh.Fm.19); G-J. *Hermanites transversicostata* (Khalaf, 1982a); G. Left lateral view of a complete carapace (K.Ost.Cc.Msh.Fm.20); H. Dorsal view of a complete carapace (B.Ost.Cc.Gsh.M.21); I. Right lateral view of a complete carapace (S.Ost.Cc.Msh.Fm.22); J. Internal view of a left valve (D.Ost.LV.Msh.F.23); K. *Costa (Cuneocosta) cf. tricostata pliocenica* (Ruggieri, 1992); Right lateral view of a complete carapace (B.Ost.Cc.Gsh.M.24); L-N. *Cytherelloidea hamrinensis* (Khalaf, 1993); L. Dorsal view of a complete carapace (B.Ost.Cc.Gsh.M.25); M. Right lateral view of a complete carapace (D.Ost.LV.Msh.F.26); N. Left lateral view of a complete carapace (S.Ost.Cc.Msh.Fm. 27).

Family Microporellidae Hincks, 1879

Genus *Microporella* Hincks, 1877

Description. Encrusting colony. Aperture semi-lunar, ascopore very distinct at the top of a short umbo. Frontal wall porous. Oral spines present. Avicularia adventitious, with a pivotal bar. Ovicell prominent, slightly immersed, or recumbent.

Microporella berningi Zágorský, 2010

(Figure 7F)

Non 1999 *Microporella appendiculata* Heller – Hayward and Ryland, p. 294, figs. 134,135.

2006 *Microporella* aff. *appendiculata* Heller – Berning, p. 103, fig. 13.

2010 *Microporella berningi* Zágorský –Zágorský Pl. 116, figs. 1-5.

Studied material. One encrusting colony, indwelling on the external side of the left valve of a pectinid specie, *Flabelligerella piramidesensis* (Ihering, 1907), collected from Direstan outcrop, Mishan Formation, Qeshm Island, Persian Gulf, Southern Iran.

Diagnosis. See Zágorský (2010).

Remarks. The preserved colony is well-preserved and shows all characteristic features of the species.

Distribution and Occurrence. Mid-Late strata of Mishan Formation, Zagros Basin (present study); Langhian, Miocene of Czech Republic (Zágorský, 2010).

5. Conclusions

This study identified and described nine Ostracods species belonging to nine genera and five families from thirty-four Ostracoda specimens. Also, this study identified and described eight bivalve species belonging to the five genera of one family Pectinidae (overall forty-nine bivalve specimens). Only one encrusting bryozoan was identified and described, *Microporella berningi* (Zagorský, 2010), from the Langhian stage of Middle Miocene for carbonate strata of Mishan Formation, near Direstan village, Qeshm Island, southern Iran. Several ostracod species collected from four

outcrops were studied in this paper, reported as Mediterranean-Indopacific-Tethyan realm fauna of the Middle Miocene of the region.

Rögl (1997), suggested that in southern Iran including Qeshm Island and Minab region a Tethyan seaway basin existed during the Oligo-Miocene. Overall, some of the native ostracod species in this study were reported from the Fat'ha Formation of Iraq as Middle Miocene Ostracoda from Northern Iraq (Khalaf, 1984, 1988, 1993, 1998; Hawramy and Khalaf, 2013), before, which Hawramy and Khalaf (2013) believed they represented intermediate bioprovinces zone between Mediterranean and Indopacific. They concluded that the region paleoenvironmentally was a shallow basin similar to a Lagoonal environment with salinity fluctuations.

Hawramy and Khalaf (2013), reported the presence of the genus *Cytherelloidea* indicating that the Middle Miocene Sea of Iraq was a warm temperature environment. Additionally, Al-Shareefi *et al.* (2022), reported some ostracod species like *Actinocythereis iraqensis* (Khalaf, 1982a) and *Hermanites transversicostata* (Khalaf, 1982b) from the Fat'ha Formation of Iraq, vary from normal salinity to brackish and saline environments, with the shallow lagoonal environment and sometimes deep lagoonal environment that do not exceed the margin of shelf zone. Moreover, Mohammadi and Hassani (2021), reported *Bairdia rafidainensis* (Khalaf, 1984) from Rupelian of Qom Formation (Central Iran) and mentioned that this genus is adaptable to diverse environments with fine-grained sandstones, rich in nutrients, and maximum flourish usually occurs in medium depth.

Contributions of authors

FMH: fieldwork, basic stratigraphic data, writing part of the original manuscript; AB: conceptualization, writing of the original manuscript, figures design; MY: fieldwork, data interpretation, writing part of the original manuscript, edition of the manuscript; FJV: conceptualization, edition of the

manuscript, partial paleontological identification, and interpretation.

Financing

The Vice Chancellor for Research and Technology at the University of Isfahan is acknowledged for financing granted to the PhD project of the first author.

Acknowledgements

Hereby, we acknowledge the Vice Chancellor for Research and Technology of the University of Isfahan. As well, the authors appreciate the Department of Geology of University of Isfahan for the scientific and logistical support.

Conflicts of interest

The authors declare no potential of interest.

Handling editor

Torrey Nyborg

References

- Aiello, G., Barra, D., 2000, Systematics and biostratigraphy of the Ostracoda of the Plio-Pleistocene Monte S. Nicola section (Gela, Sicily), *Bollettino Della Società Paleontologica Italiana*, 38(1), 83-112.
- Al-Jumaily, W.A.K., Al-Sheikhly, S.S., 1999, Palaeozoogeography of Shallow Marine Ostracoda from Holocene Sediments-Southern Iraq: *Qatar University Science Journal*, 18, 215–230.
- Al-Shareefi, I., Al-Badrani, O., Kharofa, L., 2022, Nannobiostratigraphy and Paleoecology of Fat'ha Formation, Bashiqa Anticline, Northeastern Iraq: *Iraqi Journal of Science*, 63, 1574-1590. <https://doi.org/10.24996/ij.s.2022.63.4.18>
- Alavi, M., 2004, Regional Stratigraphy of the Zagros Fold-Thrust Belt of Iran and Its Proforeland Evolution: *American Journal of Science*, 304, 1–20. <https://doi.org/10.2475/ajs.304.1.1>
- Alavi, M., 2007, Structures of the Zagros fold-thrust belt in Iran: *American Journal of Science*, 307, 1064–1095. <https://doi.org/10.2475/09.2007.02>
- Alexander, C.I., 1929, Ostracoda of the Cretaceous of North Texas: *University of Texas Bulletin*, 2907, 1-137.
- Allen, M.B., Blanc, E.J.-P., Walker, R., Jackson, J., Talebian, M., Ghassemi, M.R., 2006, Contrasting styles of convergence in the Arabia-Eurasia collision: Why escape tectonics does not occur in Iran, in Dilek, Y., Pavlides, S., (eds.), *Postcollisional tectonics and magmatism in the Mediterranean region and Asia: Geological Society of America Special Paper*, 409, 579–589. [https://doi.org/10.1130/2006.2409\(26\)](https://doi.org/10.1130/2006.2409(26))
- Andrés I., 1982, Estudio Malacológico (Clase Bivalvia) del Plioceno marino de Bonares (Huelva): España, Universidad de Salamanca, tesis doctoral, 410 p.
- Baird, W., 1850, *The Natural History of the British Entomostraca*: London, Ray Society, 364 p.
- Bassler, R.S., 1953, *Treatise on Invertebrate Paleontology. Part G, Bryozoa*: Lawrence, Kansas, Geological Society of America and University of Kansas Press, 253 p. <https://doi.org/10.17161/dt.v0i0.5172>
- Ben Moussa, A., 1994, Les bivalves néogènes des secteurs occidental et oriental du Maroc septentrional. *Biostratigraphie, Paleobiogeographie et Paleoecologie*: France, Université Claude Bernard, tesis doctoral, 296 p.
- Benson, R.H., Coleman, G.L., 1963, Recent marine ostracods from the eastern Gulf of Mexico: *The University of Kansas Paleontological Contributions*, 2, 1-52.
- Beurlen, K., 1944, Beiträge zur Stammesgeschichte der Muscheln.

- Mathematisch-Naturwissenschaftlichen Abteilung der Bayerischen Akademie der Wissenschaften zu München, Sitzungsberichte, (1–2), 133–145.
- Bieler, R., Carter, J.G., Coan, E.V., 2010, Classification of Bivalve Families, Part 2, *Malacologia*, 52(2), 113–133.
- Bongrain, M., 2015, Révision de *Pecten rotundatus* Lamarck, 1819 (Mollusca : Bivalvia : Pectinidae) des gisements burdigaliens franco-italiens: *Revue de Paléobiologie*, 34(1), 123–150, pls. 1–5.
- Bordenave, M.L., 2002, Gas prospective areas in the Zagros domain of Iran and in the Gulf Iranian Waters, en AAPG Annual Meeting, March 10–13, Houston, Texas: AAPG, 1–10.
- Brady G.S., 1868, Description of Ostracoda, in Folin, L., Périer, L., (eds.), *Les Fonds de la Mer. Étude sur les Particularités nouvelles des Régions sous-marines*, Part 1: Paris, Savy-Librairie Editeur, 49–112. <https://doi.org/10.5962/bhl.title.13261>
- Bromley, R.G., 1981, Concepts in ichnotaxonomy illustrated by small round holes in shells: *Acta Geologica Hispanica*, 16(1–2), 55–64.
- Bromley, R.G., D’Alessandro, A., 1984, The ichnogenus *Entobia* from the Miocene, Pliocene and Pleistocene of southern Italy. *Rivista Italiana di Paleontologia e Stratigrafia*, 90, 227–296.
- Bucquoy, E., Dautzenberg, Ph., Dollfus, G., 1887, *Les Mollusques marins du Roussillon: 2. Pélécyfodes avec atlas de 99 planches en phototypie*: Paris, J.-B. Baillièrre & Fils, 2 vols, 884, 99 p.
- Busk, G., 1852, An account of the Polyzoa and sertularian zoophytes collected in the voyage of the “Rattlesnake” on the coast of Australia and the Louisiade Archipelago, in Macgillivray, J., *Narrative of the voyage of H.M.S. Rattlesnake commanded by the late Captain O. Stanley during the years 1846–1850*.
- Cerulli-Irelli, S., 1907, *Fauna malacologica mariana: Palaeontographia Italica*, 13, 65–140.
- Comaschi-Caria I., 1972, I Pettinidi del Miocene della Sardegna: Fossataro, Stabil. Tipogr. Ed., 82 p.
- Coryell, H.N., Sample, C.H., Jennings, P.H., 1935, *Bairdoppilata*, a new genus of Ostracoda, with two new species: *American Museum Novitates*, 777, 1–5.
- Del Río, C.J., 1992, Middle Miocene bivalves of the Puerto Madryn Formation, Valdes Peninsula, Chubut Province, Argentina (Nuculidae-Pectinidae) Part I: *Palaeontographica Abteilung A Band A225 Lieferung 1–3*, 1–58 p.
- Del Río, C.J., 2004, Tertiary marine molluscan assemblages of eastern Patagonia (Argentina): A biostratigraphic analysis: *Journal of Paleontology*, 78, 1097–1122. <https://doi.org/10.1017/s0022336000043912>
- Del Río, C.J., Santelli, M.B., Márquez F., 2016, Environmental control on shell-sculpture of the Miocene pectinid “*Chlamys*” *actinodes* (Sowerby, 1846) (Patagonia, Argentina): *Ameghiniana*, 53, 645–654. <https://doi.org/10.5710/AMGH.07.07.2019.2994>
- Demarq, G., Schoepfer, P., 1990, Les Pectinidés du Miocène de Suisse occidentale: données nouvelles de paléontologie dynamique: *Eclogae Geologicae Helvetiae*, 83(3), 751–791.
- Dewi, K.T., 1993, *Ostracoda from the Java Sea, West of Bawean Island, Indonesia*: Australia, University of Wollongong, master thesis, 165 p.
- Dijkstra H.H., Maestrati P., 2008, New species and new records of deep-water Pectinoidea (Bivalvia: Propeamussiidae, Entoliidae and Pectinidae) from the South Pacific, in Heros V., Cowie R.H., Bouchet P. (eds.), *Tropical Deep-Sea Benthos*: Paris, Publications Scientifiques du Muséum, *Mémoires du Muséum national d’Histoire naturelle*, 25, 77–113.
- Douglas, J.A., 1928, *Contributions to Persian Palaeontology III*: Oxford, The Holywell

- Press, 19 p., pls. 8-15.
- Eames, F.E., 1950, Notes on some Caenozoic Molluscan Species from the Far East: Proceedings of the Malacological Society of London, 28(4-5), 145-155.
- Edwards, R.A., 1944, Ostracoda from the Duplin marl (Upper Miocene) of North Carolina: Journal of Paleontology, 18, 505-528.
- Ehrenberg, C.G., 1831, Animalia evertebrata exclusis Insectis, Series prima, in Hemprich, F.G., Ehrenberg, C.G., Symbolae physicae, seu icones et descriptiones Mammalium, Avium, Insectorum et animalia evertebra, quae ex itinere per Africam borealem et Asiam occidentalem studio nova aut illustrata redierunt, 126 p.
- Falcon, N.L., 1969, Problem of the relationship between surface structures and deep displacements illustrated by the Zagros range: Geological Society of London Special Publication, 3, 9–21. <https://doi.org/10.1144/gsl.sp.1969.003.01.02>
- Fauzielly, L., Irizuki, T., Sampei, Y., 2013, Spatial distribution of recent ostracode assemblages and depositional environments in Jakarta Bay, Indonesia, with relation to environmental factors: Paleontological Research, 16, 267-281. <https://doi.org/10.2517/1342-8144-16.4.267>
- Favre, E., 1869, Description des mollusques fossiles de la Craie des environs de Lemberg en Galicie: Paris, H. Georg Libraire-Éditeur, 1-13.
- Fontannes, F., 1880, Études stratigraphiques et paléontologiques pour servir à l'histoire de la période tertiaire dans le bassin du Rhône, 6 Le Bassin de Crest: Lyon, H. Georg Libraire, 214 p. <https://doi.org/10.3406/mhnl.1872.936>
- Forel, M.B., 2021, Recent ostracods (Crustacea) from the southwestern coast of Peninsular Thailand (Satun Province), Andaman Sea Ostracodes (Crustacea) récents de la côte sud-ouest de la péninsule de Thaïlande (Province de Satun), Mer d'Andaman: Revue de Micropaléontologie, 72, 100526. <https://doi.org/10.1016/j.revmic.2021.100526>
- Gammudi, A., Keen, M.C., 1993, Ostracoda from the Miocene Marada Formation of Libya: Journal of Micropalaeontology, 12, 121-139. <https://doi.org/10.1144/jm.12.1.121>
- Ghaedi, M., Johnson, K., Yazdi, M., 2016, Paleoenvironmental conditions of Early Miocene corals, western Makran, Iran: Arabian Journal of Geosciences, 9, 686. <https://doi.org/10.1007/s12517-016-2712-3>
- Grobben, K., 1894, Zur Kenntnis der Morphologie, der Verwandtschaftsverhältnisse und des Systems der Mollusken: Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Mathematisch-Naturwissenschaftliche Classe, 103, 61–86.
- Guan, S.Z., Sun, Q.Y., Jiang, Y.W., Li, L.L., Zhao, B.Q., Zhang, X.Q., Yang, R.L., Feng, B.Y., 1978, Ostracoda, in Paleontological Atlas of Central and South China 4: Beijing, Geological Publishing House, 115-324.
- Guha, D.K. 1968, Young Cenozoic marine ostracoda from subcrops of South India: Memoirs of the Geological Society of India, 2, 208-217.
- Haghipour A, Aghanabati A., 2005, Geological Map of Qeshm Island: Tehran, Geological Survey of Iran-Pub.
- Hawramy, O.A., Khalaf, S.K., 2013, Ostracoda of Fat'ha Formation (Middle Miocene) from (Darbandikhan and Aghjalar) sections, Sulaimani-Kurdistan Region/Northeastern Iraq: Journal of Zankoy Sulaimani Part A, 15, 49–76. <https://doi.org/10.17656/jzs.10259>
- Haynes, S.J., McQuillan, H., 1974, Evolution of the Zagros suture zone, southern Iran: Geological Society of America Bulletin, 85, 739–744. [https://doi.org/10.1130/0016-7606\(1974\)85<739:co;2](https://doi.org/10.1130/0016-7606(1974)85<739:co;2)
- Hazel, J.E., 1971, Ostracode biostratigraphy of the Yorktown Formation (upper Miocene

- and lower Pliocene) of Virginia and North Carolina: U.S. Geological Survey Professional Paper, 704, 13 p.
- Hilber, V., 1879, Neue Conchylien aus den mittelsteierischen Mediterranschichten. Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften, mathematisch-naturwissenschaftliche Classe, 1: Abtheilung, 79(5), 416-461.
- Huber, H., 1977, Geological and tectonic maps and cross sections of Iran, 1: 500,000: Tehran, National Iranian Oil Company (NIOC), Iran.
- Ihering, H. von, 1907, Les Mollusques fossils du Tertiaire et du cretacé Supérieur de l'Argentine: Anales Museo Nacional de Historia Natural Serie, 3(7), 1-611.
- Iredale, T., 1929, Mollusca from the continental shelf of eastern Australia. No 2: Records of the Australian Museum, 17(4), 157-189.
- Jahani, S., Hassanpour, J., Mohammadi-Firouz, S., Letouzey, J., Frizon de Lamotte, D., Alavi, A., Soleimany, B., 2017, Salt tectonics and tear faulting in the central part of the Zagros Fold-Thrust Belt, Iran: Marine and Petroleum Geology, 86, 426-446. <https://doi.org/10.1016/j.marpetgeo.2017.06.003>
- Jahani, S., Callot, J.P., Letouzey, J., Frizon de Lamotte, D., 2009, The eastern termination of the Zagros Fold-and-Thrust Belt, Iran: Structures, evolution, and relationships between salt plugs, folding, and faulting: Tectonics, 28, TC6004, 1-22. <https://doi.org/10.1029/2008TC002418>
- Jiménez, A.P., Aguirre, J., Rivas, P., 2009, Taxonomic study of scallops (Pectinidae: Mollusca, Bivalvia) from Pliocene deposits (Almería, SE Spain): Revista Española de Paleontología, 24(1), 1-30.
- Kautsky, F. 1928. Die biostratigraphische Bedeutung der Pectiniden des niederösterreichischen Miozäns: Annales Historische Museum Wien, 42, 245-274.
- Kelly, S.R.A., Bromley, R.G., 1984, Ichnological nomenclature of clavate borings: Palaeontology, 27, 793-807.
- Khalaf, S.K., 1982a, On *Hermanites transversicostata* Khalaf sp. nov.: Stereo-Atlas of Ostracod Shells, 9, 59-62.
- Khalaf, S.K., 1982b, On *Actinocythereis iraqensis* Khalaf sp. nov.: Stereo-Atlas of Ostracoda Shells, 9, 51-54.
- Khalaf, S.K., 1984, Middle Miocene Ostracoda from Northern Iraq: England, Department of Geology, University of Hull, doctoral thesis, 493 p.
- Khalaf, S.K., 1988, Middle Miocene Ostracoda from Northern Iraq, in Developments in Paleontology and Stratigraphy, vol. 11, Evolutionary Biology of Ostracoda: Its Fundamentals and Applications, 1113-1124. [https://doi.org/10.1016/S0920-5446\(08\)70243-7](https://doi.org/10.1016/S0920-5446(08)70243-7)
- Khalaf, S.K., 1993, Some new Ostracoda species of the genera *Cytherella* and *Cytherelloidea* from the M. Miocene of North Iraq: Iraqi Geological Journal. 26, 175-195.
- Khalaf, S.K., 1998, The Ostracode family *Ixoconchidae* from the Middle Miocene of Northern Iraq: Iraqi Geology Journal, 31, 83-89.
- Kingma, J.T., 1948, Contributions to the knowledge of the young-Caenozoic Ostracoda from the Malayan region: Utrecht, University of Utrecht, 119 p.
- Kroh, A., Gholamalian, H., Mandic, O., Ćorić, S., Harzhauser, M., Reuter, M., Piller, W.E., 2011, Echinoids and pectinid bivalves from the Early Miocene Mishan Formation of Iran: Acta Geologica Polonica, 61, 419-439.
- Lamarck, J.B., 1819, Histoire naturelle des animaux sans vertèbres, présentant les caractères généraux et particulier de ces animaux, leur distribution, leur classes, leur familles, leurs genres, et la citation des principales espèces qui s'y rapportent: Paris, 343 p.
- Latreille, P.A., 1806, Genera crustaceorum et insectorum, Volumen 1: Paris et Argentorati, Amand Koenig, 303 p.
- Lauriat, A., 1981, Les Bivalves du Redonien

- (Pliocène atlantique de France), signification stratigraphique et paléobiogéographique, in Mémoires du Muséum National d'Histoire Naturelle, sér. C, Sciences de la Terre: Paris, 45, 212 p.
- Lauriat Rage, A., Brebion, Ph., Buge, E., Chaix, C. Chevalier, M., Margerel, J.P., Pajaud, D., Pouit, D., Roman, J., Viaud, J.M., 1989 Le gisement redonien (pliocène) de la Marnière (La Limouzinière, Loire-Atlantique). Biostratigraphie, paléoécologie, affinités paléobiogéographiques: Géologie de la France, 1-2, 117-152.
- Levinsen, G.M.R., 1909, Morphological and systematic studies on the cheilostomatous Bryozoa. Copenhagen, Nationale Forfatterers Forlag, 1-431 p.
- Linnaeus, C., 1758, Systema Naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. Editio decima, reformata [10th revised edition], vol. 1, 824 pp. Laurentius Salvius: Holmiae.
- Magdefrau, K., 1932, Ober einige bohrgänge aus dem unteren muschelkalk von Jena: Paliiontologische Zeitschrift, 14, 150-160.
- Mandic, O., 2004, Pectinid bivalves from the Grund formation (Lower Badenian, Middle Miocene, Alpine-Carpathian foredeep) Taxonomic revision and stratigraphic significance: Geologica Carpathica, 55, 129-146.
- Malatesta, A., 1974, Malacofauna Pliocenica Umbra. Memoria per servire alla descrizione della Carta Geologica d'Italia: Serv. Geol. Italia, 13, 498 p.
- Mayoral, E., 1987, Acción bioerosiva de Mollusca (Gastropoda, Bivalvia) en el Plioceno Inferior de la Cuenca del Bajo Guadalquivir: Revista Española de Paleontología 2, 49-58.
- Mohammadi, E., Hassani, M.J., 2021, Paleoecology of the Qom Formation ostracods in eastern Sirjan and southwestern Kashan (Sanandaj-Sirjan Fore-Arc Basin): Scientific Quarterly Journal of Geosciences, 31, 65-78. (in Persian). <https://doi.org/10.22071/gsj.2020.223762.1772>
- Monterosato, T.A.Di., 1889, Coquilles marines Marocaines: Journal de Conchyliologie, 37, 20-22.
- Moore, R.C., 1971, Treatise on Invertebrate Paleontology, Part N, volume 3, Mollusca 6 Bivalvia: Lawrence, Kansas, The University of Kansas. <https://doi.org/10.17161/dt.v0i0.5597>
- Mostafawi, N., Nabavi, S.M.B., Moghaddasi, B., 2010, Ostracods from the Strait of Hormuz and Gulf of Oman, Northern Arabian Sea: Revista Española de Micropaleontología, 42, 243-265.
- Motamedi, H., Sepehr, M., Sherhati, S., Pourkermani, M., 2011, Multi-phase Hormuz salt diapirism in the Southern Zagros, SW Iran: Journal of Petroleum Geology, 34(1), 29-43. <https://doi.org/10.1111/j.1747-5457.2011.00491.x>
- Motiei, H., 1993, Stratigraphy of Zagros: Treatise on the Geology of Iran: Geological Survey of Iran, 536 p.
- Müller, O.F., 1776, Zoologiae Danicae prodromus: seu Animalium Daniae et Norvegiae indigenarum characteres, nomina, et synonyma imprimis popularium. typis: Hallagerii, 32, 274.
- Neviani, A., 1928, Ostracodi fossili d'Italia I. Vallebiaja (Calabriano): Memorie de la Pontifice Accademia delle Scienze, Nuovi Lincei, 11, 1-120.
- Newell, N., 1965, Classification of the Bivalvia. American Museum Novitates, 2206, 25.
- Nicolas, H., 1897, Étude sur les terrains Tertiaires des environs d'Avignon. Le Miocène: Mémoires de l'Académie du Vaucluse, 16, 60-152.
- Noetling, F., 1901, Fauna of the Miocene beds of Burma, Memoirs of the Geological Survey of India: Palaeontologia Indica, new series, 1(3), 1-378, 25 pls.
- Perotti, C., Carruba, S., Rinaldi, M., Bertozzi, G., Feltre, L., Rahimi, M., 2011. The

- Qatar–South Fars Arch Development (Arabian Platform, Persian Gulf): insights from seismic interpretation and analogue modelling, in Schattner, U. (eds.), *New Frontiers in Tectonic Research – At the Midst of Plate Convergence*: InTech, 325–352. <https://doi.org/10.5772/20299>
- Perotti, C., Chiariotti, L., Bresciani, I., Cattaneo, L., Toscani, G., 2016, Evolution and timing of salt diapirism in the Iranian sector of the Persian Gulf: *Tectonophysics*, 679, 180–198. <https://doi.org/10.1016/j.tecto.2016.04.040>
- Peterson, L.W., Rudzinkas, K.K., 1982, *Cartography: explanatory text of the Taherui quadrangle map 1:250000*: Geological Survey of Iran, Tehran, 1 map.
- Poli, J.X., 1795, *Testacea utriusque Siciliae eorumque historia et anatome tabulis aeneis illustrata*: Parma, Regio Typographeio, Vol. 2, i-xlix, 1-2, 75-264.
- Puri, H.S., 1954, *Contributions to the study of the Miocene of the Florida Panhandle*: Florida Department Conservation Geological Bulletin, 36, 358 p.
- Rafinesque, C.S., 1815, *Analyse de la nature, ou tableau de l'univers et des corps organisés*: Palermo, Italy, Privately Published, 224 p.
- Rashidi, R.F., Ghafor I., Javadova A., 2023, Benthic foraminifera as a tool for indication of biostratigraphy, and paleoecology of the Guri Member (Mishan Formation), Bander Abbas, South Iran: *Readings of AI Bulatov-Materials of VII International scientific and practical conference (on March 31, 2023)*, Russia, vol. 1, 37-53.
- Rezaee, P., Zarezadeh, R., 2014, Carbonate Marine Terraces of Qeshm Island, a Symbol of Sea Level Changes of the Persian Gulf in the Quaternary: *Scientific Quarterly Journal of Geosciences*, 23, 67-74. <https://doi.org/10.22071/gsj.2014.43653>
- Reuter, M., Piller, W.E., Harzhauser, Mandic, O., Berning, B., Rögl, F., Kroh, A., Aubry, M.-P., Wielandt-Schuster, U., Hamedani, A., 2009, The Oligo-/Miocene Qom Formation (Iran): evidence for an early Burdigalian restriction of the Tethyan Seaway and closure of its Iranian gateways: *International Journal of Earth Sciences*, 98, 627–650. <https://doi.org/10.1007/s00531-007-0269-9>
- Rovereto, G., 1921, *Studi de geomorfologie argentina. La Península de Valdez*: *Bolletino della Società Geologica Italiana*, 40(5), 1-47.
- Roger, J., 1939, *Le genre Chlamys dans les formations Néogènes del'Europe. Conclusions générales sur la répartition géographique et stratigraphique des Pectinidés du Tertiaire récent*: *Mémoires de la Société Géologique de France*, 17(2-4), 294 p.
- Rögl, F., 1997, Palaeogeographic considerations for Mediterranean and Paratethys seaways (Oligocene to Miocene): *Annalen des Naturhistorischen Museums in Wien, Serie A Für Mineralogie Und Petrographie, Geologie Und Paläontologie, Anthropologie Und Prähistorie*, 99, 279–310.
- Ruggieri, G., 1992, *Considerazioni tassonomi-che su ostracodi neogenici e pleistocenici risultate dalla revisione di vecchi lavori dello scrivente*: *Bollettino della Società Paleontologica Italiana*, 31, 175-188.
- Sacco F., 1897, *I Molluschi dei terreni terziarii del Piemonte e della Liguria, Parte 24*: *Bollettino dei Musei di Zoologia ed Anatomia Comparata della R. Università di Torino*, 12(298), 101-102.
- Sajadi S.H., Rashidi, R.F., 2019, Paleocology and Sedimentary Environments of the Oligo-Miocene Deposits of the Asmari Formation (Qeshm Island, SE Persian Gulf), in Aiello, G. (ed.), *New Insights into the Stratigraphic Setting of Paleozoic to Miocene Deposits - Case Studies from the Persian Gulf: Peninsular Malaysia and South-Eastern Pyrenees*: IntechOpen <http://dx.doi.org/10.5772/intechopen.81402>
- Sars, G.O., 1866, *Oversigt af Norges marine ostracoder, Overview of Norway's marine*

- ostracods: Forhandlinger i Videnskabs-Selskabet i Christiania, 1865(1), 1-130.
- Sciuto F., 2014, Ostracods of the Upper Pliocene - Pleistocene Punta Mazza succession (NE Sicily) with special focus on the Family Trachyleberididae Sylvester-Bradley, 1948, and description of a new species: Carnets de Géologie, 14, 1-13. <https://doi.org/10.4267/2042/53172>
- Siddiqui, Q.A., 1971, Early Tertiary Ostracoda of the family Trachyleberididae from West Pakistan: Bulletin of the British Museum (Natural History) Geology Supplement, 9, 1-98.
- Schultz, O., 2001, Bivalvia neogenica (Nuculacea-Unionacea), in Catalogus Fossilium Austriae: Wien, Austria, Piller, W.E., Ed., Band 1/Teil 1, 1-379 p.
- Sowerby, J.C., 1840, Systematic list of organic remains, the plants determined by Mr. John Morris, and the remainder by Mr. James de Carl Sowerby: Transactions of the Geological Society of London, serie 2, 5, 327-329, pls 21-26.
- Sowerby, G.B.I., 1846, Description of the Tertiary fossils shells from South America, en Darwin C. (ed.), Geological Observations on the volcanics Islands and parts of South America visited during the voyage of H.M.S. "Beagle" (Appendix), Appleton, Londres, 548 p.
- Stocklin, J., 1968, Structural history and tectonics of Iran: A review: The American Association of Petroleum Geologists Bulletin, 52, 1229-1258. <https://doi.org/10.1306/5d25c4a5-16c1-11d7-8645000102c1865d>
- Swain, F.M., 1968, Ostracoda from the upper Tertiary Waccamaw Formation of North Carolina and South Carolina, in Contributions to paleontology, 1966: U.S. Geological Survey Professional Paper, 573-D, D1-D37 p.
- Swain, F.M., 1974, Some Upper Miocene and Pliocene (?) Ostracoda of Atlantic coastal region for use in hydrogeologic studies: Washington, Geological Survey Professional Paper, 821, 81 p.
- Sylvester-Bradley, P.C., 1948, The ostracod genus Cythereis: Journal of Paleontology, 22(6), 792-797.
- Purser, B.H., Seibold, E., 1973, The Principal Environmental Factors Influencing Holocene Sedimentation and Diagenesis in the Persian Gulf, in Purser, B.H., Seibold, E. (eds.), The Persian Gulf: New York, Springer-Verlag, 1-9. https://doi.org/10.1007/978-3-642-65545-6_1
- Vredenburg, E.W., 1928, Descriptions of Mollusca from the Post-Eocene Tertiary Formation of North-Western India, Gastropoda (in part) and Lamellibranchiata: Memoirs of the Geological Survey of India, 50(2), 351-462.
- Yazdi M., Bahrami A., Abbasi P., Sadeghi R., Vega F.J., 2013, Miocene brachyuran Crustacea from Konar-Takhteh and Ahram sections, southwestern Iran: Boletín de la Sociedad Geológica Mexicana, 65, 225-233. <http://dx.doi.org/10.18268/BSGM2013v65n2a4>
- Zágoršek, K., 2010, Bryozoa from the Langhian (Miocene) of the Czech Republic: Acta Musei Nationalis Pragae (B, Historia naturalis), 66, 1-255.