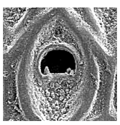
First report of Miocene Bryozoan fauna of the Mishan Formation from the Qeshm Island and Minab Province, southern Iran

Fereshteh Mahdipour Haskouei, Kamil Zágoršek, Ali Bahrami & Mehdi Yazdi



The Persian Gulf is the remains of an ancient seaway that connected the Indo–Pacific Region to the Mediterranean–Atlantic Region and the Paratethys Ocean. The Mishan Formation in Zagros Basin, Qeshm Island (Persian Gulf), and the Miocene strata of Minab Province in the Makran Basin, southern Iran, have yielded a rich fauna of bryozoans. A total of 22 species are here identified from four sections of in the Qeshm and Minab areas, including 13 species belonging to the order Cyclostomata, and 9 species belonging to the order Cheilostomata. The distribution and occurrences of the bryozoan fauna show the studied intervals were deposited during Early to Middle Miocene while the Iranian Seaways was connected to the Indo–Pacific Region from southeast, and to Mediterranean–Atlantic Region from northwest. Also, the most similar occurrences of the species described are with bryozoan faunas of the Paratethys Ocean. • Key words: Bryozoa, Miocene, Iran, taxonomy.

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Bryozoa represent an important part of the marine ecosystem. Their complicated morphology and taxonomy, however, often produce a rather low scientific interest; but can give significant palaeoecological, palaeoceanographical and palaeogeographical data as well as information about the evolution of fossil ecosystems (Zágoršek 2015). Miocene Bryozoans of Iran, especially cyclostomes, which occur in high quantity, have, however, not been studied in detail apart from an analysis of species growing on larger foraminifera (Berning *et al.* 2009). Zágoršek *et al.* (2017) described cyclostomatous bryozoans where 11 species have been recognized and Pedramara *et al.* (2019) recognized 30 bryozoan taxa, including one new species *Gigantopora vartonensis*, both from the Miocene of Qom Formation in Central Iran. Key *et al.* (2017) also reported bryozoan epibiosis on fossil crabs of Miocene Mishan Formation in the Zagros Basin of southwestern Iran. Here, we investigate the bryozoan assemblages of the uppermost part of the Mishan Formation in Qeshm Island and Minab Province along the Persian Gulf coast in order to describe the species distributions to provide new significant information for the biostratigraphy and intercontinental correlation of the Middle Miocene bryozoans of southern Zagros Basin and a better understanding of their evolutionary trends.

The Strait of Hormuz and Persian Gulf are the remains of an ancient seaway that once connected the Indo-Pacific Region to the Mediterranean–Atlantic Region and Paratethys Ocean (Fig. 1). 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 (Fig. 2; Falcon 1969, Purser & Seibold 1973, Haynes & McQuillan 1974, Alavi, 2007). According to tectonic and sedimentological evidence, Qeshm Island in the Persian Gulf is considered as part of the south of Zagros Range (Haghipour 2005). Geological similarities as well as congruence between anticlines on Qeshm Island and the Zagros Range are some of the evidence confirming the idea. The oil-bearing rocks of the 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).

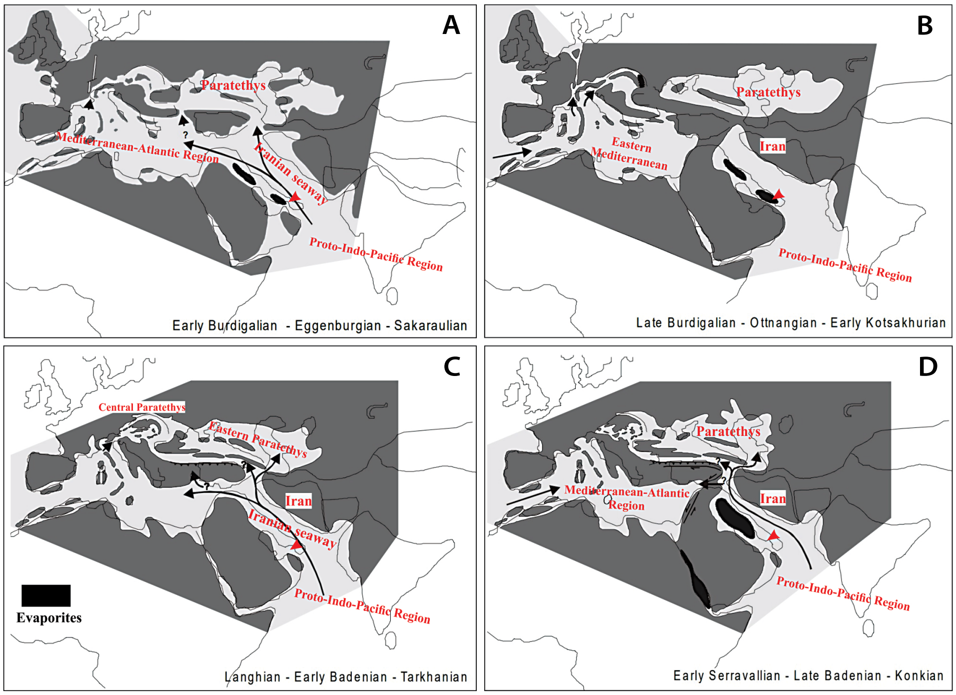


Figure 1. Open and closed connections between the Indo–Pacific Region, Mediterranean–Atlantic Region and Paratethys Ocean. Modified after Rögl (1999). Note: reddish arrowheads point right at the Strait of Hormuz where Qeshm Island and Minab Province are located.

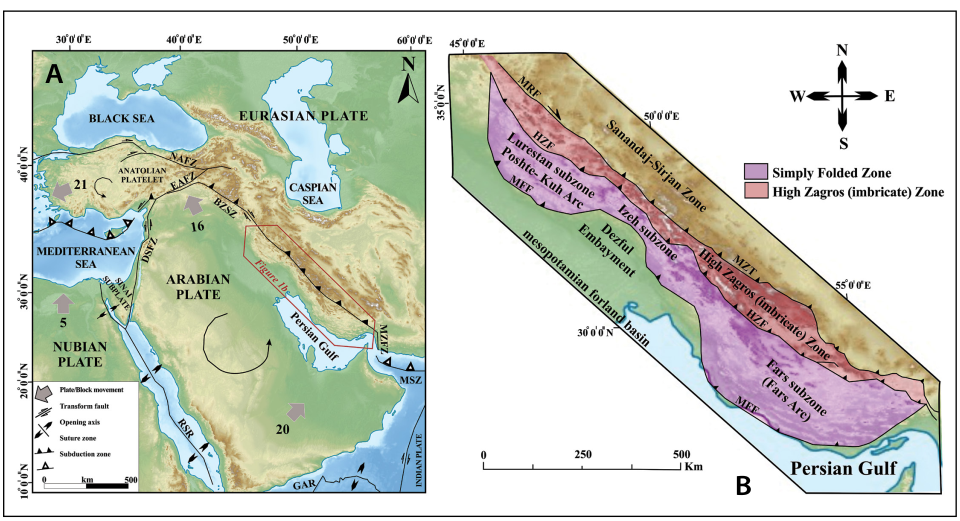


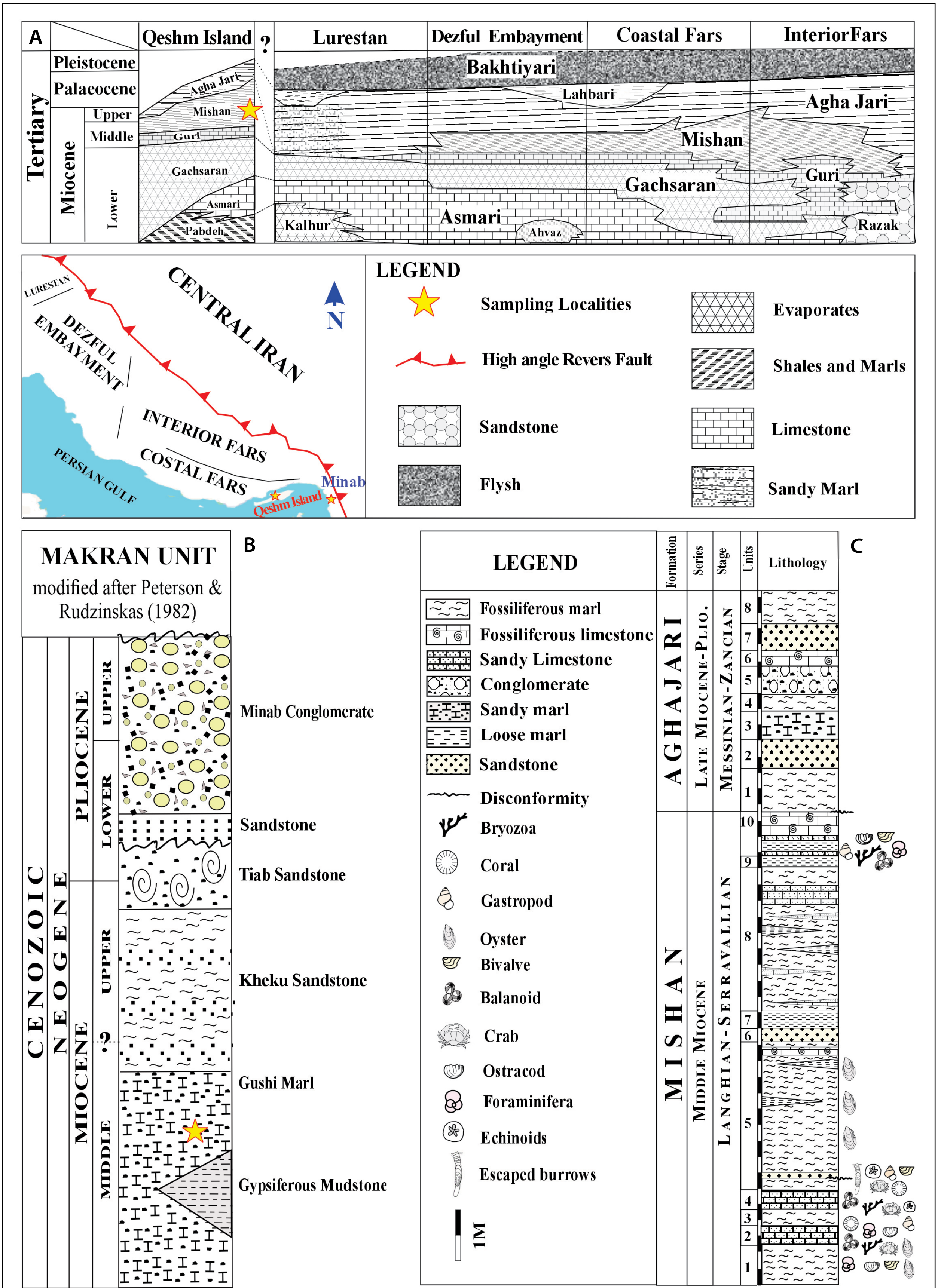
Figure 2. A – main neotectonic features of the eastern Mediterranean and Middle East regions. Global positioning satellite data relative to stable Eurasia. Modified after Reilinger *et al.* (2006) and Le Pichon & Kreemer (2010). • B – physiographic image of the Zagros Orogen with tectono-stratigraphic zones and the position of the studied localities. Abbreviations: HZF – High Zagros Fault; MFF – Mountain Front Fault; MRF – Main Recent Fault; MSZ – Makran Subduction Zone; MZFZ – Minabe Zendan Fault Zone; MZT – Main Zagros Thrust. Modified after Amante & Eakins (2009) and Gürbüz & Farzipour Saein (2019).

The Fars Group (Fig. 3A) includes sedimentary rocks that were deposited in supratidal and sabkha environments at the base (Gachsaran Formation), marine carbonate and marl (Mishan Formation), sedimentary rocks of the coastal plain and meandering rivers (Aghajari Formation) and, finally, conglomerate formed in a braided river environment (Bakhtyari Formation).

The north of Persian Gulf includes a part of the southeast of Zagros structural zone which has been deformed and folded as the result of the last phase of Alpine Orogeny in the Pliocene–Pleistocene. The geological formations of this belt may belong to the Late Precambrian to Cambrian and include diapirs called the Hormoz Series, which has been active until now with a trend toward the upper formations (Fig. 4A).

This region has been active since the late Tertiary as the tectonic zone in the south part of the deformed forehead or the convergent belt (Persian Gulf region), along

Figure 3. A – stratigraphy chart of Palaeogene–Neogene formations of the Persian Gulf and adjacent areas. Modified after James & Wynd (1965), Motiei (1993), Whybrow *et al.* (1999), Alavi (2004) and Jassim & Buday (2006). • B – stratigraphic column of Makran Unit, including Gushi marl. Modified after Peterson & Rudzinskas (1982). • C – stratigraphic column of studied areas. Including Direstan outcrop (Qeshm Island, Zagros Basin), Kendaloo outcrop (Qeshm Island, Zagros Basin), and Bemani outcrop (Minab Province, Makran Basin).


A
Qeshm Island
Lurestan
Dezful Embayment
Coastal Fars
InteriorFars
Tertiary
Pleistocene
Palaeocene
Miocene
Upper
Middle
Lower
Agha Jari
Mishan
Guri
Gachsaran
Asmari
Pabdeh
Bakhtiyari
Lahbari
Kalhur
Ahvaz
Razak
CENTRAL IRAN
LURESTAN
DEZFUL EMBAYMENT
INTERIOR FARS
COSTAL FARS
PERSIAN GULF
Minab
Qeshm Island
N
LEGEND
Sampling Localities
High angle Revers Fault
Sandstone
Flysh
Evaporates
Shales and Marls
Limestone
Sandy Marl
B
MAKRAN UNIT
modified after Peterson & Rudzinskas (1982)
CENOZOIC
NEOGENE
PLIOCENE
MIOCENE
UPPER
LOWER
MIDDLE
Minab Conglomerate
Sandstone
Tiab Sandstone
Kheku Sandstone
Gushi Marl
Gypsiferous Mudstone
C
LEGEND
Fossiliferous marl
Fossiliferous limestone
Sandy Limestone
Conglomerate
Sandy marl
Loose marl
Sandstone
Disconformity
Bryozoa
Coral
Gastropod
Oyster
Bivalve
Balanoid
Crab
Ostracod
Foraminifera
Echinoids
Escaped burrows
1M
Formation
Series
Stage
Units
Lithology
AGHAJARI
LATE MIOCENE-PLIO.
MESSINIAN-ZANCIAN
MISHAN
MIDDLE MIOCENE
LANGHIAN-SERRAVALLIAN

with the margins of the compression and collision plates of Iranian–Arabic continent.

Geological setting

Qeshm Island is the biggest island in the Persian Gulf, located between 26° 57′ 54.88″ N, 56° 16′ 15.32″ E and 26° 36′ 58.10″ N, 55° 14′ 13.27″ E with an area of about 1,600 km. The length of the island is 130 km, its average width and maximum-width 10 to 30 kilometres (Fig. 4A, B). This island includes a series of geological, biological, historical, cultural and natural attractions which are included in the first Middle East Geopark.

The Mishan Formation (Middle Miocene) can be identified at the core of some of Qeshm Island's anticlines and its thickness has been estimated to be 300 m including alternation of green marl with fossiliferous thin-bedded limestone (Mohammadkhani *et al.* 2022). The Aghajari Formation (Late Miocene–Pliocene) includes sandstone and marl interbeds that are the major outcrops of the tectonic structures in the Qeshm Island (Abbassi & Dashtban 2021).

Stars valley is a tourist attraction located at the southwest of Qeshm city, in the southeastern corner of the island. The incompletely lithified deposits of the Stars valley are composed of marl and marly limestone that accumulated during the Middle Miocene to Pliocene, and could be considered as the upper part of the Mishan and basal part of the Aghajari Formation. Palaeoecological data from foraminifera and ostracod communities suggested an agitated, saline environment during deposition of these sediments in the area (Hassani *et al.* 2014).

Mishan Formation

After the Burdigalian (Early Miocene) lake depositional system of the Gachsaran Formation, marine environments expanded and the Gachsaran Formation was covered by the transgressive and shallow marine sequence of the Mishan Formation. From a lithological point of view, it is differentiated into two parts: the lower part, which comprises the Guri Member is conformably overlain by co-called "Marly member"; grey or green marls in the upper part.

Guri Member. – This rock unit was called Guri Formation or *Operculina* limestone heretofore, but today, it is the lower part of the Mishan formation that contains cream fossiliferous limestone with green marl intercalations (Heydari *et al*. 2012). This Member includes macrofossils such as crabs, gastropods and bivalves, ichnofossils, annelids of the Ditrupa, algae and foraminifera such as *Triloculina tricarinata* (d'Orbigny), *Triloculina trigonula* (Lamarck), *Borelis melocurdica* (Reichel), *Meandropsina anahensis* (Henson), *Meandropsina iranica* (Henson), *Archaias hensoni* (Smout & Eames), *Archaias kirkukensis* (Henson), *Sphaerogypsina globules* (Reuss), *Amphistegina lessonii* (d'Orbigny *in* Deshayes), *Neorotalia viennotti* (Greig), *Ammonia beccari* (Linnaeus), *Ammonia stachi* (Huang), *Elphidium* sp., *Miogypsina* sp., *Operculina complanate* (Defrance *in* Blainville), *Orbulina universa* (d'Orbigny), *Globigerinoides* sp., *Globigerina* sp. and *Globorotalia* sp. which indicates the lower Miocene (Aquitanian–Burdigalian) age to this limestone member (Fanati Rashidi *et al*. 2014b).

"*Marly member*". – Marl deposits are underlied by the Guri Member limestones. Generally, green and grey marls intercalated with thin to medium-bedded limestone and marly limestone or calcareous marl contain macrofossils such as bryozoans, echinoids, crabs, gastropods, *Ostrea* Linnaeus and *Pecten* Müller, ichnofossil and foraminifera such as *Neorotalia viennotti* (Greig), *Ammonia beccari* (Linnaeus), *Ammonia stachi* (Huang), *Operculina complanate* (Defrance *in* Blainville), *Bigenerina* sp., *Textularia* sp., *Orbulina* sp., *Globigerinoides* sp., *Globigerina* sp., *Globogerina bulloides* (d'Orbigny), *Globogerinoides trilobus* (Reuss) and *Globogerinoides sicanus* (De Stefani), which indicate the Middle Miocene (Langhian–Serravallian) for the marl portion of the Mishan Formation (Fanati Rashidi *et al*. 2014a, Abbassi & Dashtban 2021).

Because of the similar lithology and fossil contents between all the studied sections, the detailed measured sequence and lithologic features (top to base) of the uppermost interval of the Mishan Formation at the Qeshm Island and Minab Province as it follows (Fig. 3C): Top – alternation of fine-grained micro-conglomerate, grey marl, sandstone, sandy limestone, anhydrite and halite with bituminous shales, (Aghajari Formation), 500 m; Unit 10 – fossiliferous limestone, 0.8 m; Unit 9 – green loos marl with thin sandstone layers, sandy limestone intercalations and thin bedded gypsum layers, 1 m; Unit 8 – olive to greenish marl with yellow to grey sandy limestone layers rich in gastropods, bivalves and crustaceans, 4.5 m; Unit 7 – olive to greenish loose marl with gypsum layers, 0.6 m; Unit 6 – fine-grained thin bedded siltstone–sandstone, 0.5 m; Unit 5 – platy green marl and sandy brown limestone with loose marl, 4.8 m; Unit 4 – grey to white thin bedded sandy limestone, 0.8 m; Unit 3 – olive to green marl with thin bituminous shale layers, 0.7 m; Unit 2 – sandy limestone, 0.8 m; Unit 1– green to grey fossiliferous marls, 1.2 m.

The bryozoan assemblages collected from the three localities in the Qeshm Island and one locality in the Minab Province are the objectives of this paper.

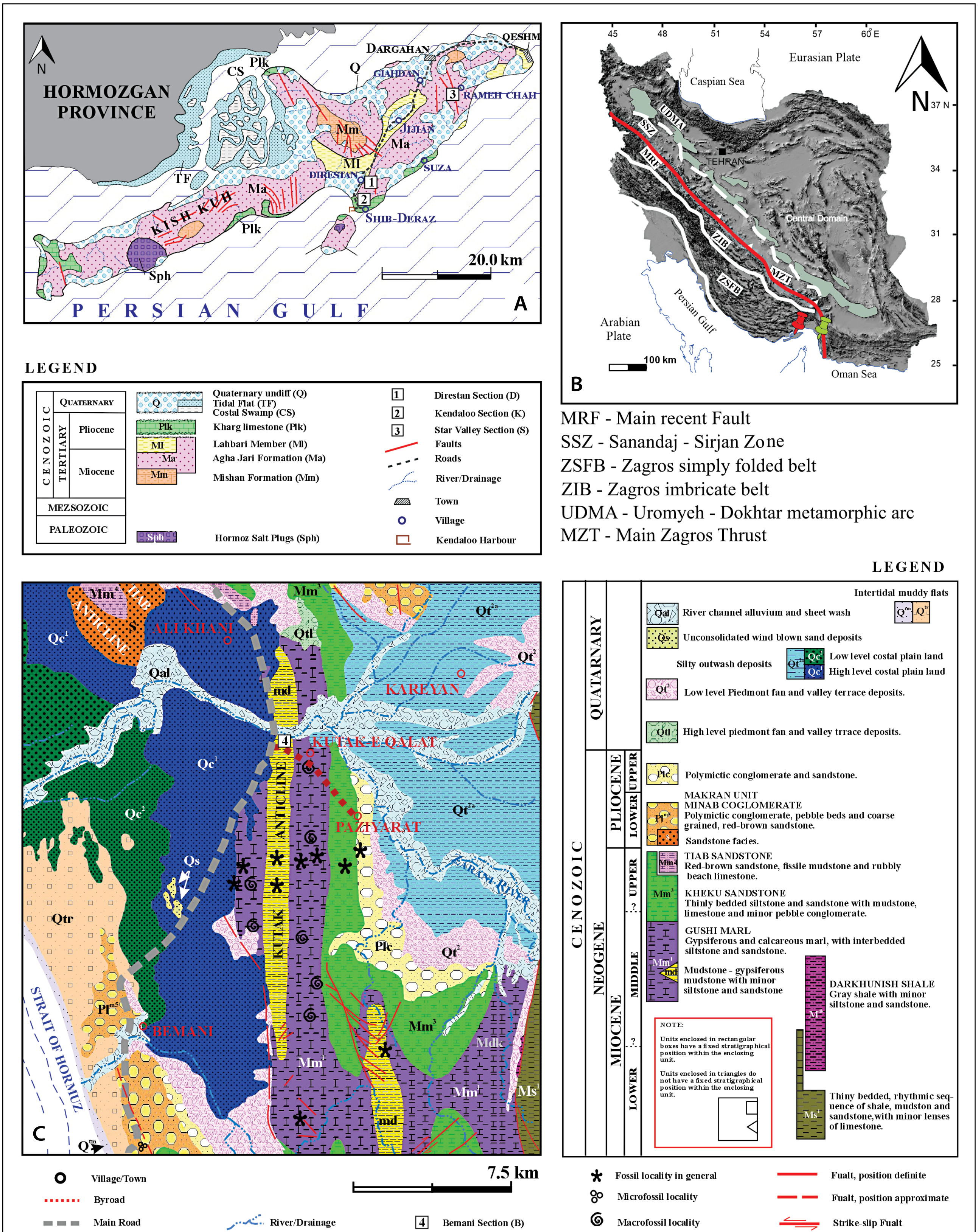


Figure 4. Geological map of the investigated areas. • A – terrain map of Iran. • B – geological map of Qeshm Island, Persian Gulf. Modified after Huber (1977). • C – geological map of Minab Province. Modified after Peterson & Rudzinskas (1982). Four sampled localities: 1 – Direstan outcrop near the village; 2 – Kendaloo outcrop in NE of the Kendaloo harbor; 3 – Stars Valley outcrop; and 4 – Bemani outcrop.

Makran Basin

Based on the sedimentary sequences, metamorphism, magmatism, intensity of deformations, and structural setting, the Iranian Plateau has been subdivided into eight continental fragments, including Zagros, Urumieh–Dokhtar, Sanandaj–Syrjan, Central Iran, Kopeh–Dagh, Alborz, Lut, and Makran (Heydari *et al.* 2003). Makran zone is one of the unique mountain ranges of the world that formed during the especial geological processes. Part of the Makran's mountain ranges positioned in Iran and the other part continued in Pakistan with an east–west trend. Western borders of the Makran's mountains limited to Minab Fault in Iran and the eastern borders restricted by Ornach–Nal Fault, that it is extended about 900 km from west (Iran) to east Pakistan (Moridi Farimani 2011).

The Makran coast extends east from the Strait of Hormuz in Iran to the mouth of the Indus River in Pakistan (Page *et al*. 1979). There is no formal lithostratigraphic division in the Makran Basin, thus, the Makran successions are informally divided into different units. The Gushi marl (Figs 3B, 4C) is the third unit of Lithological subdivisions of the Makran Miocene successions, composed by gypsiferous and calcareous marl, with interbedded siltstone and sandstone, tabled by Ghaedi *et al*. (2016, 2022), based on Taherui and Minab maps modified by Peterson & Rudzinskas (1982).

Methods and material

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 in order to reveal the bryozoan assemblages. The material includes plentiful, well-preserved specimens were cleaned by means of a mild detergent, and whenever necessary, an ultrasonic vibrator bath and a preparation needle. Finally, a light binocular microscope was used, where it was necessary. In total of 35 samples were collected from the studied profile in Qeshm Island and from the deposits of the Mishan formation at Bemani section, 17 rock samples and about 100 individual fossils (bryozoans, echinoids, crustaceans, bivalves, corals, Polychaete tube-worms and gastropods) with highly preserved structures collected and prepared for the further studies. 15 bryozoan specimens from the Direstan; 14 specimens from the Kendaloo; 29 specimens from the Stars Valley and 11 specimens from the Minab Province (Bemani section) were selected and described here. All specimens are housed in the Department of Geology, Faculty of Science, University of Isfahan, Iran, under acronym of IUMC.

Systematic palaeontology

The systematics of described cheilostomate bryozoans is based on Bassler (1953), Hayward & McKinney (2002), Zágoršek (2003, 2010, 2017), Zágoršek *et al.* (2017), Ziko & El-Sorogy (1995) and Banta & Carson (1977).

Abbreviations. – St – Stars Valley outcrop; K – Kendaloo outcrop; D – Direstan outcrop; Q – Qeshm Island; B – Bemani outcrop; M – Minab.

Phylum Bryozoa Ehrenberg, 1831
Class Stenolaemata Borg, 1926
Order Cyclostomata Busk, 1852
Suborder Articulata Busk, 1859
Family Crisiidae Johnston, 1838

Genus *Crisia* Lamourox, 1812

Type species. – Sertularia eburnea Linnaeus, 1758.

***Crisia* cf. *elongata* (Milne-Edwards, 1838)**
Figure 5A–F

1838 *Crisia elongata* sp. n.; Milne-Edwards, p. 203, pl. 7, fig. 2.
v. 1848 *Crisia edwardsii* m. – Reuss, p. 53, pl. 7, fig. 20.
1920 *Crisia edwardsii.* – Canu & Bassler, p. 705, pl. 141, figs 5–7. [cum. syn.]
v. 1958 *Crisia elongata* (Milne-Edwards). – Bobies, p. 158, pl. 13, fig. 4; pl. 15, figs 22, 23. [cum. syn.]
1995 *Crisia elongata* (Milne-Edwards). – Ziko & El-Sorogy, p. 88, pl. 3, figs 1, 2.
v. 2001 *Crisia elongata* (Milne-Edwards). – Zágoršek & Kázmér, p. 23, pl. 1, figs 4, 5. [cum. syn.]

Figure 5. Family Crisiidae (Johnston, 1838) • A–F– *Crisia* cf. *elongata* (Milne-Edwards, 1838). A, B – general view and a piece of the internode, KQ-Br-1. C, D – whole internode of a colony and part of the internode illustrated in different modes, StQ-Br-1. E, F – general view of the whole internode of a colony with a well preserved gonozooecium illustrated in different modes, StQ-Br-2. • G, H – *Crisia* cf. *haueri* (Reuss, 1848), detail showing a fragment of a colony in different modes, StQ-Br-7. Length of scale bar = 200 μm.


A
B
C
D
E
F
G
H

v. 2003 *Crisia elongata* (Milne-Edwards). – Zágoršek, p. 108, pl. 1, fig. 1. [cum. syn.]
2010a *Crisia elongata* (Milne-Edwards). – Zágoršek, p. 90, pl. 24, figs 1–6.

Material. – Altogether 11 specimens were collected and studied, four from the Mishan Formation of the Direstan outcrop, one from the Kendaloo outcrop, four from the Stars Valley outcrop, Qeshm Island, and two specimens collected from the Bemani outcrop, Minab Province, southern Iran.

Diagnosis. – For the revised diagnosis of the species see Zágoršek (2003, 2010a), and also Ziko & El-Sorogy (1995).

Remarks. – Studied material shows shorter distances between autozooecia (only 90–100 μm), while the other specimens of this species show more than 120 μm). Also, the gonozooecium in studied specimens are not identical; it's more rounded and has about 340–350 μm in diameter. Therefore, more material is needed to evaluate the species determination. The specimens from the Bemani outcrop are eroded and poorly preserved, while those from Stars Valley, Kendaloo and Direstan are well-preserved or moderately preserved with broken autozooecial apertures. Only one specimen bearing the gonozooecia.

Occurrence. – Miocene–Pliocene, Qeshm Island, Zagros Basin and Middle Miocene, Gushi marls, Makran Basin, southern Iran (present study). Pleistocene of Egypt (Ziko & El-Sorogy 1995), Eocene of France, North America. Oligocene of Germany, France, Italy. Miocene of Mersa Matruh (Egypt), France, Italy, Hungary, Poland, Czech Republic, Austria. Pliocene of Italy (Vávra 1977, Zikoiat *et al*. 1992), Eocene of Waschberg Zone, Austria (Zágoršek 2003), Miocene, Paratethys, Czech Republic, (Zágoršek 2010a).

***Crisia* cf. *haueri* (Reuss, 1848)**
Figure 5G, H

v. 1848 *Crisia haueri* m.; Reuss, p. 54, pl. 7, figs 22–24.
v. 1958 *Crisia haueri* (Reuss). – Bobies, p. 150, pl. 15, figs 17–21.
1977 *Crisia haueri* (Reuss). – Vávra, p. 13.
v. 2001 *Crisia haueri* (Reuss). – Zágoršek & Kázmér, p. 23, pl. 1, fig. 2. [cum. syn.]
2010a *Crisia haueri* (Reuss). – Zágoršek, p. 92, pl. 26, figs 1, 2.

Material. – Only one specimen was collected and studied from the Stars Valley outcrop, Qeshm Island, southern Iran, which, however, does not preserve gonozooecia.

Diagnosis. – For the revised diagnosis of the species see Zágoršek (2003).

Remarks. – Like other specimens collected from the Stars Valley section, the specimen is well preserved, and shows almost all characteristic features of the species, except for the gonozooecia. While this important feature is missing, species determination remains uncertain.

Occurrence. – Miocene–Pliocene, Qeshm Island, Zagros Basin, southern Iran (present study). Eocene of the Western of Carpathians, Slovakia (Zágoršek 1997), Miocene, Paratethys, Czeh Republic (Zágoršek 2010a?).

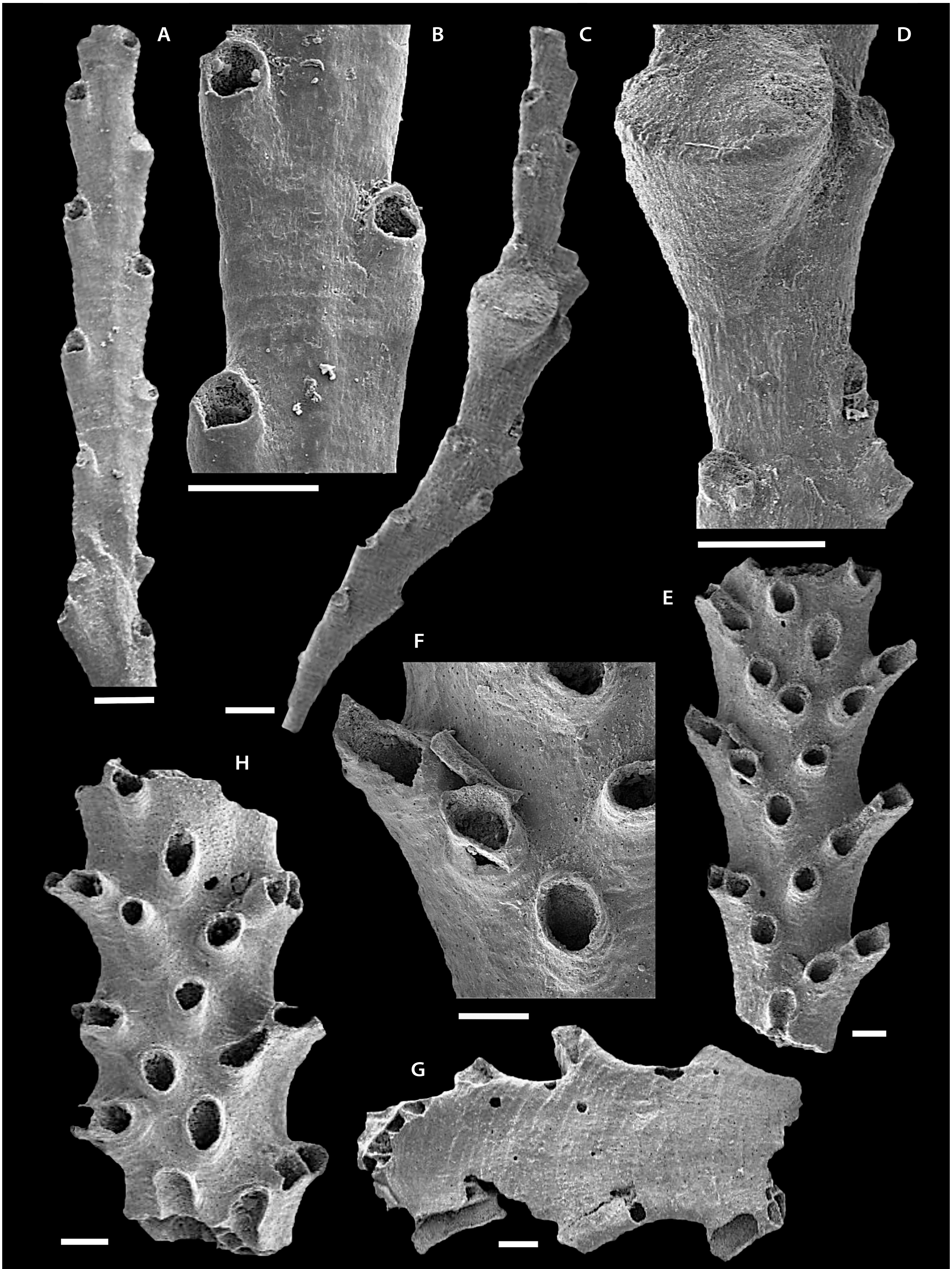
***Crisia eburnea* (Linnaeus, 1758)**
Figure 6A–D

1958 *Crisia eburnea* (Linnaeus). – Bobies, p. 151, pl. 12, figs 2, 3.
1977 *Crisia eburnea* (Linnaeus). – Vávra, p. 11. [cum. syn.]
? 1985 *Crisia eburnea* (Linnaeus). – Hayward & Ryland, p. 49, fig. 13.
v. 2003 *Crisia eburnea* (Linnaeus). – Zágoršek, p. 109, pl. 1, fig. 3. [cum. syn.]
2010a *Crisia* cf. *eburnea* (Linnaeus). – Zágoršek, p. 89, pl. 23, figs 1–5.

Material. – Altogether 7 specimens were studied, two collected from Mishan formation of Direstan outcrop, two from Kendaloo outcrop, two from Stars Valley outcrop, Qeshm Island, and also, one specimen collected from Bemani outcrop, Minab Province, southern Iran. One specimen bearing gonozooecia.

Diagnosis. – For the revised diagnosis of the species see Zágoršek (2003). Studied material has very narrow colony branches (internodes). The maximum width of the colony (270–290 μm) corresponds to the width of two, maximal three autozooecial tubes. The autozooecial wall is slightly ribbed or smooth, nonporous and a little convex. The gonozooecium is large and globular 170–180 μm wide, 220–240 μm long, the frontal wall is flattened.

Figure 6. Family Crisiidae and Family Terviidae • A–D– *Crisia eburnea* (Linnaeus, 1758). A, B – characteristic arrangement of autozooecial, StQ-Br-5. C, D – general view of the colony with a preserved gonozooecium, DQ-Br-5. • E–H– *Tervia irregularis* (Meneghini, 1845). E, F – details of a colony in different modes of the frontal side, StQ-Br-24. G, H – showing a specimen in two angles; G – dorsal side; H – frontal side, StQ-Br-23. Length of scale bar = 200 μm.


A
B
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H

Remarks. – Studied specimens show very similar morphology than the previously described material, especially the gonozooecium is almost identical. Like other specimens collected from these four outcrops, the best-preserved specimens are from Stars Valley and weak-preserved of them are from Bemani outcrop.

Occurrence. – Miocene–Pliocene, Qeshm Island, Zagros Basin and Middle Miocene, Gushi marls, Makran Basin, southern Iran (present study). Eocene of Waschberg Zone, Austria (Zágoršek 2003); Miocene, Paratethys, Czech Republic (Zágoršek 2010a). Common in the Recent cold waters of Europe and America and the western Atlantic, Mediterranean Sea and West Africa (Ziko *et al*. 2012).

Suborder Tubuliporina Milne-Edwards, 1838
Family Terviidae Canu & Bassler, 1920

Genus *Tervia* Jullien, 1882

Type species. – Tervia solida Jullien, 1882.

***Tervia irregularis* (Meneghini, 1845)**
Figure 6E–H

1920 *Tervia irregularis* (Meneghini). – Canu & Bassler, p. 789, fig. 254a–f.
1977 *Tervia irregularis* (Meneghini). – Vávra, p. 35. [cum syn.]
1985 *Tervia irregularis* (Meneghini). – Hayward & Ryland, p. 106, fig. 37.
2008 *Tervia irregularis* (Meneghini). – Zágoršek *et al*., p. 839, fig. 6.3–6.7.
2010a *Tervia irregularis* (Meneghini). – Zágoršek, p. 82, pl. 16, figs 1–7.

Material. – Three vinculariiform colonies were found and studied, one from the Miocene–Pliocene strata of Kendaloo, and two from Stars Valley outcrops, Qeshm Island, Zagros Basin, southern Iran, none of them bearing gonozooecia.

Diagnosis. – For revised diagnosis see Zágoršek (2010a). Studied colonies have rows composed of pairs or triple fascicles of peristomes on each side of the colony axis and with a median peristome, slightly irregularly placed from the fascicles. Peristomes curving laterally from the colony axis. Frontal wall with pseudopores. The gonozooecium is not observed.

Remarks. – The vinculariiform colony from Kendaloo is broken and eroded, while the Stars Valley specimens show multiserial autozooids. Even though gonozooecia are not preserved, the other features are very specific and the similarity with the *Tervia irregularis* is very large.

Occurrence. – Miocene–Pliocene, Qeshm Island, Zagros Basin, southern Iran (present study). Middle Miocene (Early Badenian) of Kralice nad Oslavou, Central Paratethys, Czech Republic (Zágoršek 2010a).

Family Plagioeciidae Canu, 1918

Genus *Ybselosoecia* Canu & Lecointre, 1933

Type species. – Pustulopora palmata Busk, 1859.

***Ybselosoecia typica* Manzoni, 1878**
Figure 7A, B

1878 *Filisparsa typica* sp. n.; Manzoni, p. 10, pl. 8, fig. 30.
v. 1977 *Ybselosoecia typica* (Manzoni). – Vávra, p. 48. [cum syn.]
1997 *Ybselosoecia typica* (Manzoni). – Pouyet, p. 26, pl. 1, figs 1–4.
2003 *Ybselosoecia typica* (Manzoni). – Zágoršek, p. 119, pl. 4, figs 5, 6. [cum syn.]
2010a *Ybselosoecia typica* (Manzoni). – Zágoršek, p. 81, pl. 15, figs 1–5.
2017 *Ybselosoecia typica* (Manzoni). – Zágoršek *et al*., p. 112, fig. 2j.

Material. – Vinculariiform colonies collected from Direstan outcrop, Qeshm Island, Zagros Basin, southern Iran bearing a gonozooecium.

Diagnosis. – See Zágoršek (2010a). Studied specimens showing erect colonies with semilunar cross section. Apertures with long peristomes (15–19 µm) and slightly perforated frontal wall. Dorsal side concave, smooth sometimes slightly concentrically ribbed. Gonozooecium

Figure 7. A, B – *Ybselosoecia typica* (Manzoni, 1878). A – general view of the colony, B – detail of a gonozooecium, KQ-Br-12. • C, D – *Exidmonea* cf. *giebeli* (Stoliczka, 1862). C – frontal side of the general view of the colony with chaotic growth of the autozooecia. D – chaotic growth of the autozooecial in larger mode, StQ-Br-27. • E, F – *Mecynoecia* cf. *proboscidea* (Milne-Edwards, 1838), fragmented colony with poradic growth of the autozooecial tubes separated by a large space in two different modes, StQ-Br-15. • G, H – *Nevianipora*? cf. *arcuata* (Winston, Vieira & Woollacott, 2014). G – details of the frontal side of the colony showing rows of the broken zooids. H – general view of the colony with tubular zooids and remains of calcified pillars, StQ-Br-9. Length of scale bar = 500 µm.


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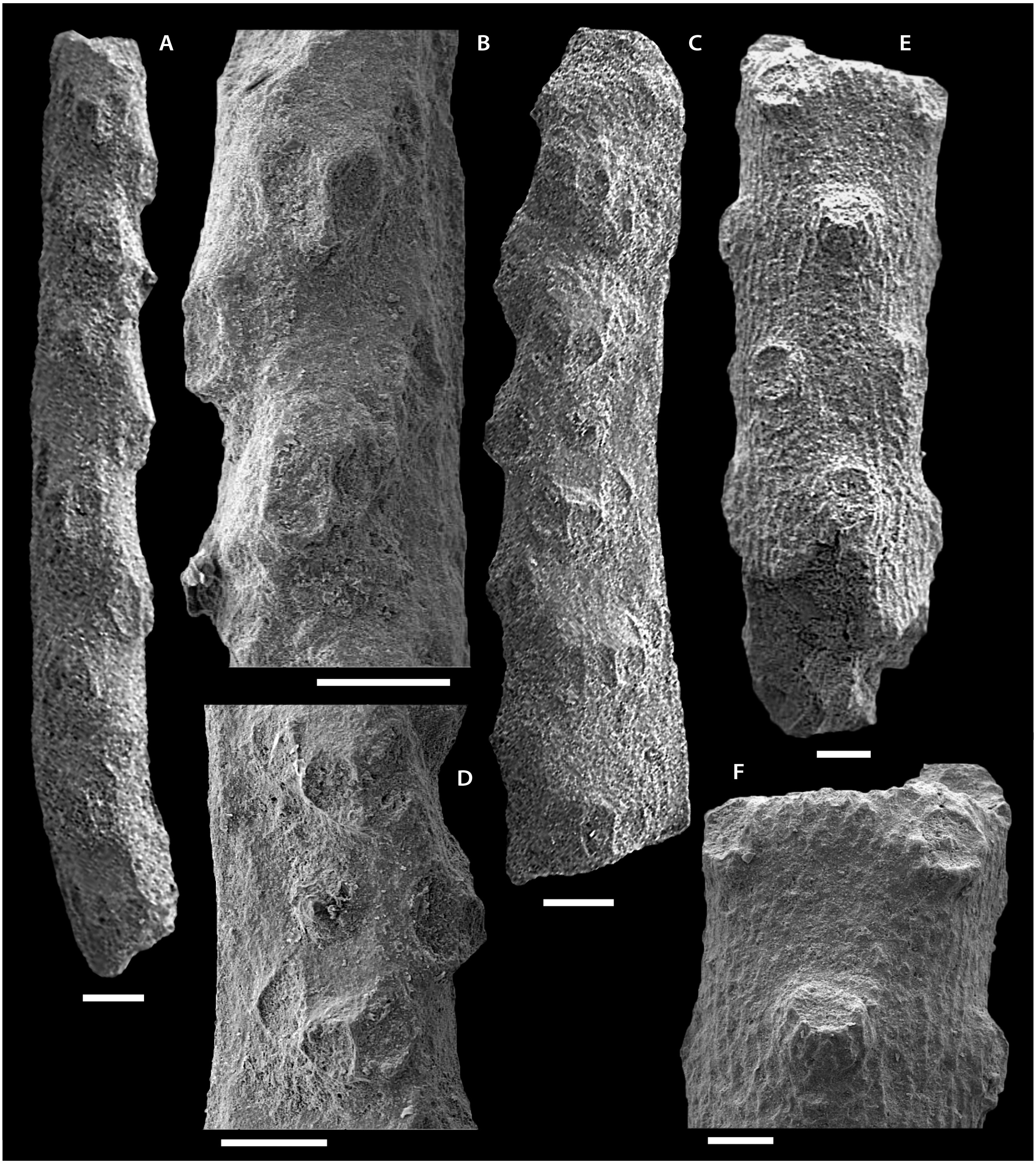


Figure 8. A–D – *Nevianipora*? cf. *isfahani* (Zágoršek, Yazdi & Bahrami, 2017). A, C – general view of the two colonies. B, D – detail of the gonozooecium showing weakly preserved apertures, BM-Br-9, BM-Br-10. • E, F – *Margaretta* cf. *cereoides* (Ellis & Solander, 1786). E – part of an erect colony with alternating growth patterns of autozooecia. F – detail of the poorly preserved the circular ascopore and the autozooecial peristomes, BM-Br-5. Length of scale bar = 200 µm.

large (extended almost 2 mm in length), irregularly oval, perforated by 5 autozooecia with a very flat frontal wall. The oeciopore is small (diameter 14 µm), situated very close to autozooecial aperture.

Remarks. – The moderately preserved colony shows some characteristic features of this species. Especially the gonozooecium and its ooeciopore are adequately preserved and identical with the previously described material.

Occurrence. – Mishan Formation, Qeshm Island, Zagros Basin, southern Iran (present study). Eocene of Waschberg Zone, Austria (Zágoršek 2003). Miocene, Paratethys, Czech Republic (Zágoršek 2010a). The NE of the Tethyan Ocean (Rupelian–Aquitanian) of Central Iran (Zágoršek *et al*. 2017).

Family Tubuliporidae Johnston, 1838

Genus *Eximonea* David, Mongereau & Pouyet, 1972

Type species. – Exidmonea atlantica David, Mongereau & Pouyet, 1972.

***Exidmonea* cf. *giebeli* (Stoliczka, 1862)**
Figure 7C, D

v. 1862 *Idmonea giebeli* sp. n.; Stoliczka, p. 81, pl. 1, fig. 6.
1969 *Exidmonea giebeli* (Stoliczka). – Mongereau, p. 232, pl. 20, figs 1–3, 9, 11.
v. 2001 *Exidmonea giebeli* (Stoliczka). – Zágoršek & Kázmér, p. 24, pl. 1, figs 10, 11. [cum syn.]
v. 2003 *Exidmonea giebeli* (Stoliczka). – Zágoršek, p. 110, pl. 2, figs 4, 5. [cum syn.]
2010a *Exidmonea giebeli* (Stoliczka). – Zágoršek, p. 72, pl. 6, figs 1–3.

Material. – Only four Vinculariiform colonies were studied, two from Kendaloo, and two from Stars Valley, Qeshm Island, Zagros Basin, southern Iran.

Diagnosis. – See Zágoršek (2010a). Studied specimens have colonies with flattened transverse section with 3 to 4 autozooecia in each fascicular row. An additional aperture is present between the pairs of fascicles, situated close to the median area of the frontal side of the colony. Gonozooecium unknown.

Remarks. – Colonies collected from Kendaloo are moderately preserved, and affected by abrasion, while almost all colonies from Stars Valley are well-preserved and show most of the characteristic features of this species. While gonozooecia are unknown (Zágoršek 2010a), the specific features are arrangement of the apertures and growth form of the colony. Arrangement of apertures are identical with the holotype; however, the cross section of the holotype colony is more triangular, with the angle between the frontal sides is about 100 degrees. The studied colonies have angle between the frontal sides is about 140 degrees. Therefore, the species attribution of this specimens remains uncertain.

Occurrence. – Miocene–Pliocene, Qeshm Island, Zagros Basin, southern Iran (present study). Eocene of Waschberg Zone, Austria (Zágoršek 2003), the NE of the Tethyan Ocean (Rupelian–Aquitanian) of Central Iran (Zágoršek *et al*. 2017), Miocene, Paratethys, Czech Republic (Zágoršek 2010a).

Family Entalophoridae Reuss, 1869

Genus *Mecynoecia* Canu, 1918

Type species. – Pustulopora proboscidea Milne-Edwards, 1838.

***Mecynoecia* cf. *proboscidea* (Milne-Edwards, 1838)**
Figure 7E, F

1838 *Pustulopora proboscidea sp.n.*; Milne-Edwards, p. 219, pl. 12, fig. 2.
v. 1977 *Mecynoecia proboscidea* (Milne-Edwards). – Vávra, p. 41. [cum syn.]
v. 2003 *Mecynoecia proboscidea* (Milne-Edwards). – Zágoršek, p. 115, pl. 2, fig. 7. [cum syn.]
2010a *Mecynoecia proboscidea* (Milne-Edwards). – Zágoršek, p. 84, pl. 18, figs 1–5.
2014 *Mecynoecia* cf. *proboscidea* (Milne-Edwards). – Zágoršek & Gordon, p. 545, fig. 1f.

Material. – Only two vinculariiform colonies were collected and studied, from Miocene–Pliocene strata of Kendaloo and Stars Valley outcrops, Qeshm Island, Zagros Basin, southern Iran. None of them developed gonozooecia.

Diagnosis. – See Zágoršek (2010a). Studied specimens have colonies with 3 to 4 autozooecial tubes arranged around the colonial axis with a circular to oval aperture situated on long peristomes. Frontal walls are very long, convex, slightly porous. Gonozooecium not observed.

Remarks. – All found colonies are abraded, however showing the arrangement of the autozooecial tubes characteristic for the genus *Mecynoecia*. While gonozooecia were not observed, the species attribution remains uncertain.

Occurrence. – Miocene–Pliocene, Qeshm Island, Zagros Basin, southern Iran (present study). Zágoršek (2003) reported *Mecynoecia proboscidea* from Eocene of Waschberg Zone, Austria, and also, from Miocene, Paratethys, Czech Republic (Zágoršek 2010a).

Family Diaperoeciidae Canu, 1918

Genus *Nevianipora* Borg, 1944

Type species. – Idmonea milneana d'Orbigny, 1842.

***Nevianipora*? cf. *arcuata* (Winston, Vieira & Woollacott, 2014)**
Figure 7G, H

1979 *Nevianipora rugosa*. – Buge, p. 231, pl. 6, figs 1–4.
2008 *Nevianipora rugosa* (Buge). – Vieira *et al*., p. 34.
2014 *Nevianipora arcuate*; Winston Vieira & Woollacott, p. 112, fig. 59.

Material. – Altogether five vinculariiform colonies were collected and studied, none with gonozooids, from the Gushi marls of the Bemani outcrop, Minab Province, Makran Basin, southern Iran.

Diagnosis. – See Zágoršek *et al*. (2017). Studied specimens have erect colonies with zooecia arranged in indistinct rows. Calcified pillars narrow, longer than branching tubes. No gonozooid observed. Dorsal side of the colony smooth and convex.

Remarks. – The vinculariiform colonies are abraded, but general arrangement of the zooecia and presence of calcified pillars indicate *Nevianipora* species. While no gonozooecium is observed, species as well as genus attribution remain uncertain.

***Nevianipora*? cf. *isfahani* Zágoršek, Yazdi & Bahrami, 2017**
Figure 8A–D

2017 *Nevianipora isfahani*; Zágoršek, Yazdi & Bahrami, p. 112, fig. 2e–g.

Material. – Only two vinculariiform colonies collected and studied from Gushi marls in Bemani outcrop, Minab Province, southern Iran.

Diagnosis. – See Zágoršek *et al*. (2017).

Remarks. – The preservation of the studied specimens does not allow the precise species determination. The vinculariiform colonies are abraded, and hardly show characteristic features of the species, but it is apparent that apertures are arranged chaotically in pairs and traces of calcified pillars resemble this species. While no gonozooecium is observed, species as well as genus attribution remain uncertain.

Occurrence. – Middle Miocene, Gushi marls, Makran Basin, southern Iran (present study), also, Zágoršek *et al*. (2017) reported *Nevianipora isfahani* from the Eocene of Waschberg Zone, Austria.

Class Gymnolaemata Allman, 1896
Order Cheilostomata Busk, 1852
Suborder Ascophora Levinsen, 1909
Infraorder Lepraliomorpha Gordon, 1989
Superfamily Schizoporelloidea Jullien, 1883
Family Margarettidae Harmer, 1957

Genus *Margaretta* Gray, 1843

Type species. – *Cellaria barbata* Lamarck, 1816.

***Margaretta* cf. *cereoides* (Ellis & Solander, 1786)**
Figure 8E, F

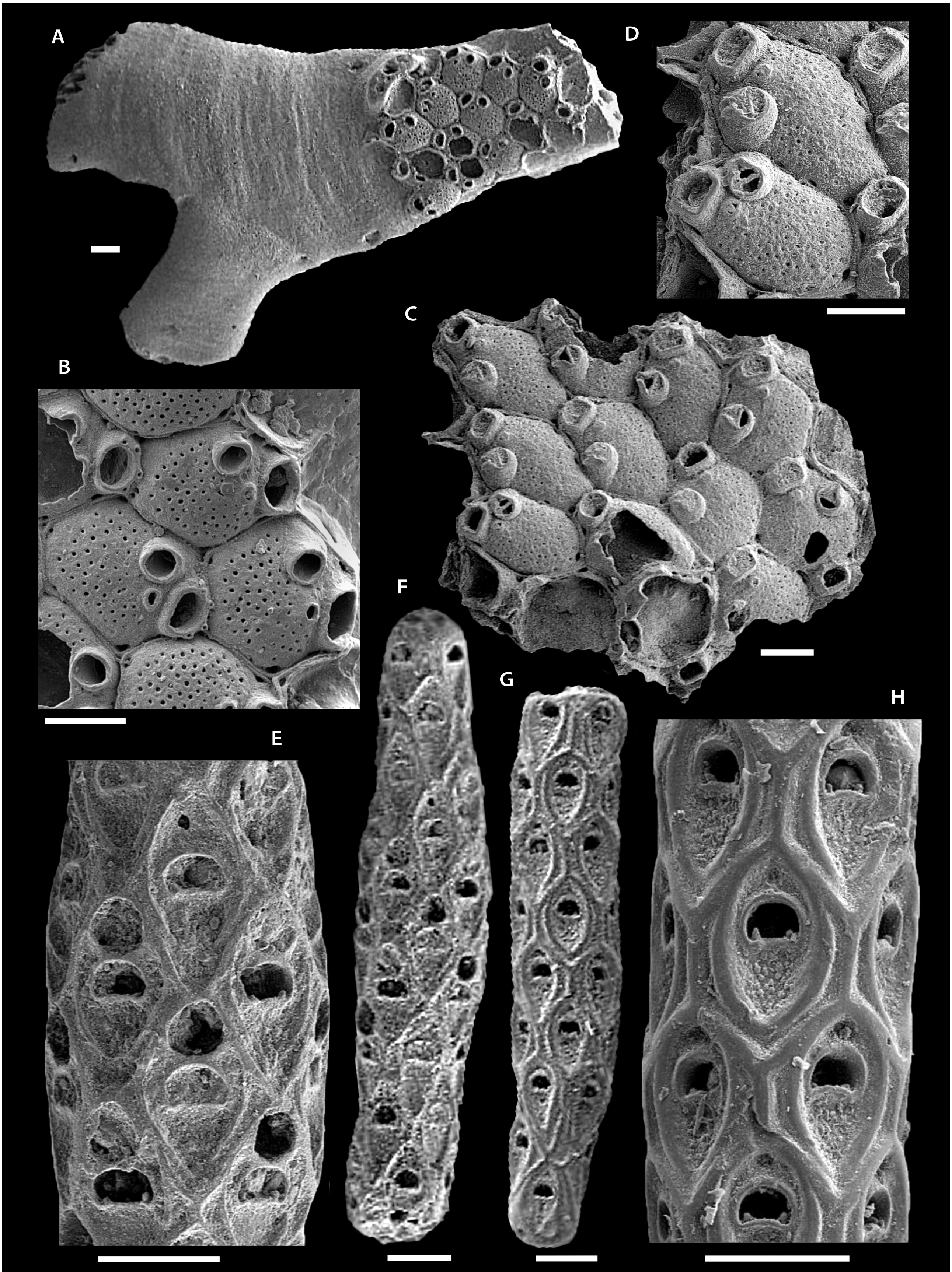
v. 1974 *Margaretta cereoides* (Ellis & Solander). – David & Pouyet, p. 196, pl. 10, fig. 7.
v. 1977 *Margaretta cereoides* (Ellis & Solander). – Vávra, p. 143. [cum syn.]
1989 *Margaretta cereoides* (Ellis & Solander). – Schmid, p. 52, pl. 15, figs 4, 5, 7, 8. [cum syn.]
v. 2010b *Margaretta cereoides* (Ellis & Solander). – Zágoršek, p. 154, pl. 109, figs 1–4. [cum syn.]
2019 *Margaretta cereoides* (Ellis & Solander). – Pedramara *et al*., p. 239, fig. 4d.

Material. – Altogether three Vinculariiform colonies collected and studied from Gushi marls in Bemani outcrop, Minab Province, southern Iran.

Diagnosis. – See Zágoršek (2010b). Studied material have columnar colony with a circular cross-section. Autozooecia are arranged in 4 to 8 longitudinal rows, separated by shallow grooves, elongated oval with a strongly porous, little convex frontal wall. Aperture slightly abraded, circular to oval and placed on a short peristome. Ascopore hardly observable due to the abrasion, circular, small, slightly larger than the regular pores on the frontal wall. Ovicell has not been observed.

Remarks. – The colonies are totally abraded, and show hardly characteristic features of the species, but it is apparent that apertures are circular to oval and situated

Figure 9. Family Microporellidae and Family Cellariidae • A–D – *Microporella* cf. *crenilabris* (Reuss, 1848). A – general view of a piece of encrusting colony overgrowing dorsal side of a colony of *Nevianipora*, StQ-Br-14. B – detail of an autozooecium with clearly visible avicularium and oral spines, StQ-Br-26. C, D – another colony from the same section, StQ-Br-25. • E, F – *Cellaria* cf. *fistulosa* (Linnaeus, 1758). E – complete colony segment (internode). F – detail of the colony showing the regular growth of autozooecial, StQ-Br-18. • G, H – *Cellaria* cf. *salicornioides* (Lamouroux, 1816). G– complete colony segment. H– detail of the colony showing the shape of the autozooecia and a large avicularium in the zone of bifurcation, StQ-Br-17. Length of scale bar = 200 μm.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on a short peristome, with small ascopore, which is very characteristic of *Margaretta*.

Occurrence. – Middle Miocene, Gushi marls, Makran Basin, southern Iran (present study). Eocene of Waschberg Zone, Austria (Zágoršek 2003), Paratethys, Miocene (Zágoršek 2010b?), and as Neogene Canary Islands fauna (Sendino & Taylor 2014), and Indo–Pacific bryozoan of the Badenian of Hungary (Moissette *et al*. 2006).

Family Microporellidae Hincks, 1879

Genus *Microporella* Hincks, 1877

Type species. – *Eschara ciliata* Pallas, 1766.

***Microporella* cf. *crenilabris* (Reuss, 1848)**
Figure 9A–D

v. *1848 *Cellepora crenilabris* m.; Reuss, p. 88, pl. 10, fig. 22.
? 1848 *Cellepora pleuropora* m.; Reuss, p. 88, pl. 10, fig. 21.
v. 1874 *Cellepora pleuropora* (Reuss). – Reuss, p. 153, pl. 4, fig. 12.
1974 *Microporella ciliata* (Pallas). – David & Pouyet, p. 182, pl. 7, fig. 5 [cum syn.].
v. 1989 *Microporella ciliata* (Pallas). – Schmid, p. 49, pl. 14, fig. 4.7 [cum syn.].
? 1999 *Microporella ciliata* (Pallas). – Hayward & Ryland, p. 296, figs 134c, d; 136.
? 2006 *Microporella* aff. *ciliata* (Pallas). – Berning, p. 105, figs 128–130.
2010b *Microporella crenilabris* (Reuss). – Zágoršek, p. 227, pl. 115, figs 1–5.

Material. – Altogether 2 specimens were studied, both are collected from Stars Valley outcrop, Qeshm Island, Zagros Basin, southern Iran.

Diagnosis. – See Zágoršek (2003). Studied specimens showing hexagonal to oval autozooecia, with a convex, porous frontal wall, clearly separated from each other. Aperture oval, slightly semilunar with 4 oral spines. Ascopore large, situated on the top of a small umbo. Avicularia single, lateral. Ovicell not observed.

Remarks. – Studied specimens from Stars Valley outcrop, exhibits different level of abrasion, which can considerably change the present morphology. However, all specimens have same arrangement of the avicularia, same number of oral spines, and same position of ascopore, which indicate same species. As mentioned by Di Martino & Rosso (2021) without ovicells, the exact determination is impossible and therefore we leave these species in open nomenclature.

Occurrence. – Miocene–Pliocene, Qeshm Island, Zagros Basin, southern Iran (present study). Eocene of Waschberg Zone, Austria (Zágoršek 2003). Miocene, Paratethys, Czech Republic (Zágoršek 2010b).

Suborder Flustrina Smitt, 1868
Superfamily Cellarioidea Fleming, 1828
Family Cellariidae Fleming, 1828

Genus *Cellaria* Ellis & Solander, 1786

Type species. – *Farcimia sinuosa* Hassall, 1840.

***Cellaria* cf. *fistulosa* (Linnaeus, 1758)**
Figure 9E, F

1758 *Eschara fistulosa*; Linnaeus, p. 804.
v. 1989 *Cellaria fistulosa* (Linnaeus). – Schmid, p. 20, pl. 4, figs 1–2. [cum. syn.]
? 1998 *Cellaria fistulosa* (Linnaeus). – Hayward & Ryland, p. 306, figs 104b; 106b, c; 107.
? 2002 *Cellaria fistulosa* (Linnaeus). – Hayward & McKinney, p. 34, fig. 15a–e.
2010a *Cellaria* cf. *fistulosa* (Linnaeus). – Zágoršek, pl. 68, figs 1–7.

Material. – Two vinculariiform colonies from Miocene–Pliocene strata of Kendaloo and the Stars Valley, Zagris Basin, Qeshm Island, southern Iran.

Diagnosis. – See Zágoršek (2010a) and Hayward & McKinney (2002).

Remarks. – Both specimens are erect colonies, with elongated rhomboidal to diamond-shaped autozooecia. As usual the specimen from the Stars Valley is well preserved and shows almost all characteristic features. Because no ovicells are observed, precise determination is impossible. Although beyond the scope of this study, the wide distribution of this "species" suggests the need for a thorough revision of all taxa in the genus *Cellaria*.

Occurrence. – Miocene–Pliocene, Qeshm Island, Zagros Basin, southern Iran (present study). Miocene, Paratethys, Czech Republic (Zágoršek 2010a), and also, Hayward & McKinney (2002) reported it from the vicinity of Rovinj, Croatia, and mentioned that it is a rather inconspicuous species, widely distributed throughout the Mediterranean, and has been reported from temperate and tropical seas worldwide.

***Cellaria* cf. *salicornioides* (Lamouroux, 1816)**
Figure 9G, H

1816 *Cellaria salicornioides*; Lamouroux, p. 127.

v. 1989 *Cellaria salicornioides* (Lamouroux). – Schmid, p. 19, pl. 4, figs 3–6. [cum. syn.]
? 1998 *Cellaria salicornioides* (Lamouroux). – Hayward & Ryland, p. 308, figs 104a, 105d, 108.
? 2002 *Cellaria salicornioides* (Lamouroux). – Hayward & McKinney, p. 36, fig. 15f–k.
2010a *Cellaria* cf. *salicornioides* (Lamouroux). – Zágoršek, pl. 69, figs 1–3.

Material. – Only one vinculariiform colony from Miocene–Pliocene strata of Stars Valley outcrop, Zagros Basin, Qeshm Island, southern Iran.

Diagnosis. – See Zágoršek (2010a) and Hayward & McKinney (2002).

Remarks. – Unlike other specimens collected from the Stars Valley, this one is moderately preserved and abraded on the edge of peristome columnar colony, but shows almost all of characteristic features. While no ovicells are observed, the precise determination is impossible.

Occurrence. – Miocene–Pliocene strata of Zagros Basin in Qeshm Island, southern Iran (present study). Miocene, Paratethys, Czech Republic (Zágoršek 2010a). Hayward & McKinney (2002) reported it from the vicinity of Rovinj, Croatia, and mentioned that the species lives in shallow coastal waters; and is widespread throughout the Mediterranean, ranging northwards along the western coasts of Britain and Ireland, to Shetland.

Superfamily Microporoidea Gray, 1847
Family Microporidae Gray, 1847

Genus *Calpensia* Jullien, 1888

Type species. – *Membranipora calpensis* Busk, 1854 (= *Cellepora nobilis* Esper, 1796).

***Calpensia gracilis* (Münster, 1826)**
Figure 10A, B

v. 1848 *Membranipora gracilis* (Münster). – Reuss, p. 93, pl. 11, fig. 12.
1974 *Calpensia gracilis* (Münster). – David & Pouyet, p. 121, pl. 3, fig. 7.
v. 1977 *Calpensia gracilis* (Münster). – Vávra, p. 92.
non v. 1989 *Calpensia gracilis* (Münster). – Schmid, p.17, pl. 2, figs 4–7.
2010a *Calpensia gracilis* (Münster). – Zágoršek, p. 121, pl. 55, figs 1–4.

Material. – Altogether 3 specimens were collected and studied from the Mishan Formation of Direstan (2 specimens), and Miocene–Pliocene strata of Kendaloo (only one specimen), Zagros Basin, Qeshm Island, southern Iran.

Diagnosis. – See Zágoršek (2010a).

Remarks. – Like other studied specimens from the Direstan outcrop, the specimens are eroded, but those from Kendaloo show all details characteristic features of the species. New molecular phylogenetic analysis suggested close relation between *Steginoporella* and *Calpensia* (Orr *et al*. 2020). While these results have not yet been supported by morphological analysis, *Calpensia* is here still listed among Microporidae.

Occurrence. – Miocene–Pliocene strata of southern Iran and Also, Mishan Formation, Qeshm Island, Zagros Basin, southern Iran (present study). Eocene of Waschberg Zone, Austria (Zágoršek 2003). Miocene, Paratethys, Czech Republic (Zágoršek 2010a).

Superfamily Buguloidea Gray, 1847
Family Candidae d'Orbigny, 1851

Genus *Scrupocellaria* Van Beneden, 1845

Type species. – *Sertularia scruposa* Linnaeus, 1758.

***Scrupocellaria elliptica* (Reuss, 1848)**
Figure 10C

v. 1848 *Bactridium ellipticum* m.; Reuss, p. 56, pl. 9, fig. 8.
1989 *Scrupocellaria elliptica* (Reuss). – Schmid, p. 23, pl. 5, figs 1–7. [cum syn.]
1995 *Scrupocellaria elliptica* (Reuss). – Ziko & El-Sorogy, p. 87, pl. 4, figs 3–5.
2010a *Scrupocellaria elliptica* (Reuss). – Zágoršek, p. 118, pl. 52, figs 1–6.

Material. – Altogether 3 specimens were studied, one collected from the Mishan Formation of the Direstan outcrop and one collected from the Kendaloo outcrop, Qeshm Island, Zagros Basin, southern Iran. In addition, one came from the Gushi marls in Bemani outcrop, Minab Province, Makran Basin, southern Iran.

Diagnosis. – See Zágoršek (2010a), and also, Ziko & El-Sorogy (1995).

Remarks. – The very well-preserved colony from Kendaloo shows all details of characteristic features of the specie. The pores in the walls of the colony collected from Direstan outcrop are covered by calcareous sediments.

Occurrence. – Mid–Late Miocene to Pliocene of Zagros Basin, Qeshm Island and also, Middle Miocene Gushi marls, Minab region, Makran Basin, southern Iran (present study). Eocene of Waschberg Zone, Austria (Zágoršek 2003). Miocene, Paratethys, Czech Republic (Zágoršek 2010a). As the Eastern Atlantic–Mediterranean bryozoan species from the Badenian of Hungary (Moissette *et al*. 2006, 2007). Pleistocene and Miocene of Egypt (Ziko & El-Sorogy 1995). Oligocene of France, Italy. Miocene of France, Austria, Poland, Portugal, Algeria. Pliocene of Portugal (Moissette & Pouyet 1987, Zikoiat *et al*. 1992).

Family Onychocellidae Jullien, 1882

Genus *Onychocella* Jullien, 1882

Type species. – *Cellepora angulosa* Reuss, 1848.

***Onychocella* sp.**
Figure 10D

? 2010a *Onychocella angulosa* (Reuss). – Zágoršek, p. pl. 62, figs 1–6.

Material. – Only two specimens were found from Bemani (Makran Basin) and Direstan outcrops (Zagros Basin), southern Iran.

Diagnosis. – See Zágoršek (2010a).

Remarks. – The specimens are poorly preserved and only show polygonal or hexagonal autozooids very similar to the genus *Onychocella*. Both specimens are erect, which also support the determination as Miocene *Onychocella*.

Occurrence. – Miocene–Pliocene strata of Makran Basin and Also, Mishan Formation, Qeshm Island, Zagros Basin, southern Iran (present study). Berning *et al*. (2009) reported *Onychocella* sp. from Late Oligocene, Tethyan Seaway, Iran, and Berning (2006) tabulated *Onychocella* spp. as tropical to subtropical Recent bryozoans, present in the Niebla, Spain.

Superfamily Calloporoidea Norman, 1903
Family Quadricellariidae Gordon, 1984

Genus *Nellia* Busk, 1852

Type species. – *Nellia oculata* Busk, 1852 (= *Cellaria tenella* Lamarck 1816).

***Nellia oculata* (Busk, 1852)**
Figure 10E, F

1852 *Nellia oculate*; Busk, p. 18, pl. 54, fig. 6, pl. 65, fig. 4.
1920 *Nellia oculata* (Busk). – Canu & Bassler, p. 195, pl. 82, figs 6–10.
1923 *Nellia oculata* (Busk). – Canu & Bassler, p. 55, pl. 2, figs 5–7.
1929 *Nellia oculata* (Busk). – Canu & Bassler, p. 185, pl. 5, figs 12, 13.
1949 *Nellia oculata* (Busk). – Vigneaux, p. 32, pl. figs 10–12.
1974 *Nellia oculata* (Busk). – Debourle, p. 154, pl. 16, fig. 11.
1995 *Nellia oculata* (Busk). – Ziko & El-Sorogy, p. 88, pl. 5, fig. 4.
2014 *Nellia oculata* (Busk). – Winston *et al*., p. 161, fig. 14.
2015 *Nellia oculata* (Busk). – Taylor & Tan, p. 14, fig. 7b–e.

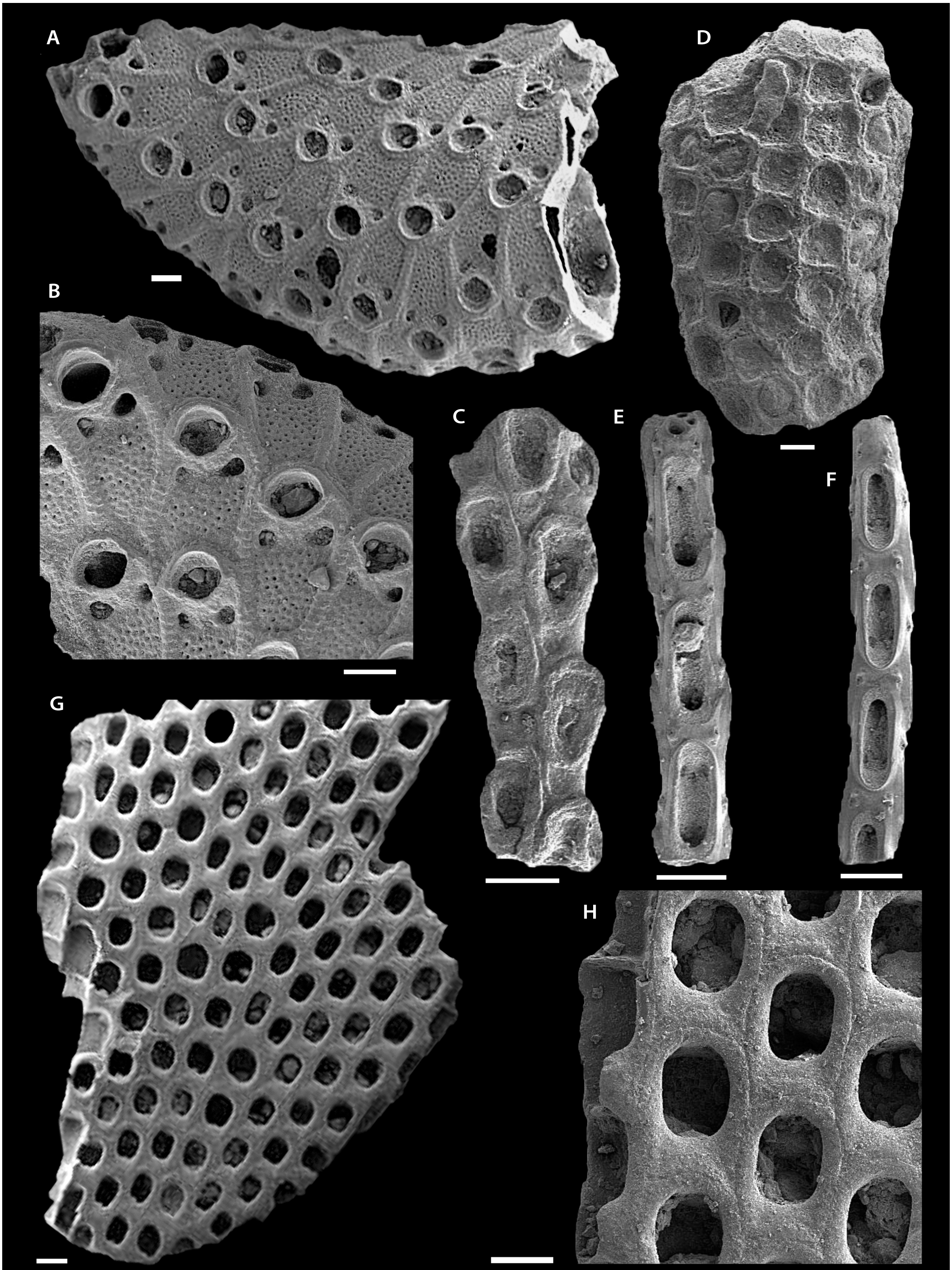
Material. – Altogether four cellariiform colonies were collected and studied from Direstan, Kendaloo and the Stars Valley outcrops, Qeshm Island, Zagros Basin, and also, from Bemani outcrop, Minab Province, Makran Basin, southern Iran.

Diagnosis. – See Ziko & El-Sorogy (1995), and also Taylor & Tan (2015).

Remarks. – The very well-preserved specimens of Kendaloo and the Stars Valley show all details of characteristic features of the species.

Occurrence. – Mid–Late Miocene to Pliocene, Zagros Basin, Qeshm Island, southern Iran (present study). Pleistocene of Egypt (Ziko & El-Sorogy 1995). Miocene of Brazil (Ramalho *et al*. 2019). Eocene and Miocene of Europe, Africa, North America, and Pliocene, Pleistocene of Asia and North America (Vávra 1977, Ziko & El-Sorogy 1995). Badenian of Hungary (Moissette *et al*. 2006). Widespread in Recent warm waters of Brazil (Winston *et al*. 2014). Tilbrook (2006) discussed thoroughly the distribution of this species. He mentioned, that occurrence in the western Pacific should be confirmed by the re-examination of the original material. Anyway,

Figure 10. A, B – *Calpensia gracilis* (Münster, 1826). A – general view of the colony showing growing rows of the autozooecial. B – details showing curved rows of autozooecial, opesiules and shape of the aperture, KQ-Br-14. • C– *Scrupocellaria elliptica* (Reuss, 1848), frontal side of the colony showing two rows of the pore chambers, KQ-Br-8. • D – *Onychocella* sp., general view of fragment of an abraded, poorly preserved colony, DQ-Br-7. • E, F – *Nellia oculata* (Busk, 1852), two complete internodes from two different outcrops, both nicely preserved, DQ-Br-11, StQ-Br-28. • G, H – *Biflustra savartii* (Audouin, 1826). G – fragment of an encrusting nicely preserved colony. H – detail of very regular arrangement of autozooecia, StQ-Br-19. Length of scale bar = 200 µm.


A
B
C
D
E
F
G
H

during Miocene, this species is widely distributed in Paratethys as well as the western part of Tethys (Vávra 1977, Ziko & El-Sorogy 1995).

Suborder Malacostegina Levinsen, 1902
Superfamily Membraniporoidea Busk, 1852
Family Membraniporidae Busk, 1852

Genus *Biflustra* d'Orbigny, 1852

Type species. – *Flustra ramosa* d'Orbigny, 1852.

***Biflustra savartii* (Audouin, 1826)**
Figure 10G, H

1974 *Biflustra savartii*. – David & Pouyet, p. 99.
1988 *Biflustra savartii* (Audouin). – Moissette, pl. 11, fig. 6.
2010a *Biflustra savartii* (Audouin). – Zágoršek, p. 108, pl. 42, figs 1–5.

Material. – Altogether 4 specimens were studied, two collected from Mishan Formation of Direstan outcrop, two from Miocene–Pliocene strata of Stars Valley and Kendaloo outcrops, Qeshm Island, Zagros Basin, southern Iran, respectively.

Diagnosis. – See Zágoršek (2010a).

Remarks. – Well-preserved colony of Stars valley outcrop shows all characteristic features of this specie, but the moderately well-preserved colonies of Kendaloo and Direstan outcrops show the most characteristic features of the species.

Occurrence. – Miocene–Pliocene strata of southern Iran and also, Mishan Formation, Qeshm Island, Zagros Basin, southern Iran (present study). Eocene of Waschberg Zone, Austria (Zágoršek 2003). Miocene, Paratethys, Czech Republic (Zágoršek 2010a) and the Badenian of Hungary (Moissette *et al*. 2007).

Discussion and conclusions

During the Middle Miocene, the Zagros foreland Basin was part of eastern Neotethys, representing a seaway connecting the Indian Ocean to the proto-Mediterranean Sea (western Tethys) (Rögl, 1999, Sepehr & Cosgrove, 2004, Harzhauser *et al.* 2007). At the same time, due to E–Antarctica ice sheet expansion, the climate changed from the warmest condition of the MMCO (Middle Miocene Climate Optimum) to colder conditions. This relative long-term climate transition was characterized by shorter climate variations, including high amplitude sea-level fluctuations (Flower & Kennett 1994, De Boer *et al.* 2010). The Middle Miocene climate transition led to the progressive closure of seaways in the Tethys Realm (Harzhauser *et al.* 2007) punctuated by short-term sea level changes testified by high-frequency cyclicity in the sedimentary record. So, the Mishan Formation yields two facies in a clastic and a carbonate one. The carbonate facies (Guri Member) preserve open lagoon shallow subtidal environments with diverse macrofauna and restricted lagoon microfossils (Kalantari 1992). The clastic facies ("Marly member") mainly consist of green and grey marls frequently intercalated with thin to medium bedded limestone, marly limestone, or calcareous marl.

These interbedded limestones and marly limestones sometimes contain aeolian quartz grains reflecting the extreme weathering and active tectonics in the Zagros region during deposition of the Mishan Formation. The marls also contain exogenetic quartz grains as sand and silt transported from land. The clastic microfacies are highly diverse in large benthic, e.g. *Neorotalia viennoti*, *Ammonia beccarii*, *A. stachi*, and pelagic foraminifera, *e.g. Globigerinoides* sp., *G. trilobus*, and *G. sicanus* as well as *Globigerina* sp. and *G. bulloides*, crustaceans, bryozoans, osterids, echinids and gastropods. Based on lithological microfacies analysis, and palaeontological evidence, it is clear that the clastic "Marly member" was deposited in a deeper setting than the carbonate Guri Member (Fanati Rashidi *et al*. 2014a, b, 2015; Pirouz *et al*. 2017).

A total of 22 species of Bryozoa have been found and identified from four sections, including 13 species belonging to the order Cyclostomata, and 9 species belonging to the order Cheilostomata. The bryozoans are generally poorly preserved, showing much fewer characters are visible than in Bryozoans from the similar sections in Iran, like Bagh and Dizlu (Zágoršek *et al.* 2017).

Cyclostomatous bryozoans, except for two species of *Crisia* and one colony of *Ybselosoecia*, do not developed gonozooecia, so closer determination is not possible. It can with high probability be assumed that most of the species are identical with those occurring in the Bagh and Dizlu sections (Zágoršek *et al*. 2017) and Qom formation (Pedramara *et al.* 2019). The only two additional species found in this study probably belong to the genus *Nevianipora*; both of which are poorly preserved and can only be informally identified.

The cheilostomatous bryozoans from the Bagh and Dizlu sections and Qom Formation are quite different compared with the bryozoans originating from the sections of this study. In the Bagh and Dizlu sections, the most common taxa (except for huge celleporids) are Cribrilaria and massive erect colonies (unpublished data), while in the investigated assemblage, encrusting species and *Cellaria* are dominant.

As shown by Zágoršek (2010a, b) and McKinney & Jackson (1989), the dominance of encrusting species (represented in the studied assemblage by genera *Microporella*, *Onychocella*, *Biflustra* and *Calpensia*) indicate shallow marine conditions. Erect flexible colonies in the studied association (such as *Margaretta* and *Cellaria*) usually live in higher energy water, mainly below the wave base. Therefore, the suggested environment seems warm, shallow marine with high-energy water, above the wave base.

Outside Iran, the most similar occurrences of the species are with the Paratethyan Miocene (Zágoršek 2010a, b), and also with the Eocene of the Waschberg Zone, Austria (Zágoršek 2003). The Paratethys was an epicontinental sea that developed as a relic of the ancient Tethys Ocean and existed between the end of the Eocene and the Middle Miocene. It consisted of a series of basins, which were intermittently connected to the Mediterranean and the Indo–Pacific (Rögl & Steininger 1983; Rögl 1998, 1999; Meulenkamp & Sissingh 2003; Moissette *et al*. 2007). Based on Hassani *et al*. (2014), Stars Valley strata show correlated with Rögl (1999) maps of evaporates parts of the Iranian Seaway which has mentioned as Indo–Pacific–Mediterranean Ocean during early Burdigalian to Langhian to early Serravallian, and based on Zágoršek *et al*. (2017), the species of Qom Formation and Bemani outcrop show biostratigraphic correlation, and may refer to open connection of Paratethys and the Indo–Pacific Region by the Iranian Seaway.

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