

Early Permian Tabulate Corals from the Jamal Formation, East-Central Iran

Shuji Niko¹, Mahdi Badpa², Abbas Ghaderi³ and Mohammad Reza Ataei³

¹Department of Environmental Studies, Faculty of Integrated Arts and Sciences, Hiroshima University,
1–7–1 Kagamiyama, Higashihiroshima 739–8521, Japan

²Department of Geology, Payame Noor University of Qom, Qom, Iran

³Department of Geology, Faculty of Science, Ferdowsi University of Mashhad, Mashhad, Iran

Abstract Seven species of tabulate corals, *Sutherlandia jamalensis* sp. nov., *Pseudofavosites exiguus* Flügel, 1972, *P. fusiforme* (Flügel, 1972), *Michelinia* sp. indet., *Gertholites?* *diversaporus* (Flügel, 1972), *G.* sp. indet., and *Thamnoptychia directa* (Flügel, 1972), are described from the Bagh-e Vang Member (late early Permian) of the Jamal Formation at the Tabas area, East-Central Iran. The discoveries of *Sutherlandia* and *Thamnoptychia* mark the first records of these genera in Iran. This assemblage inhabited on the southern shelves of the Paleotethys along northern margin of Gondwana.

Key words: late early Permian, Jamal Formation, Iran, Gondwana, Tabulata

Introduction

Permian tabulate corals are poorly known from Iran. Since the initial study by Flügel (1964), who described *Michelinia?* cf. *glomerata* M'Coy, 1849, *Protomichelinia abnormis* (Huang, 1932), *P. favositoides* (Girty, 1908), *P. laosensis* (Mansuy, 1914) and *Cystomichelinia biknia* Flügel, 1964 from the Ruteh Limestone, only 13 species of the subclass have been recorded by Flügel (1968, Nesen Formation; 1972, Jamal Formation; 1995, Jamal Formation; 1997, "Mittlere schiefrige Fazies der Yabeina-Zone Perm, Zagros Mountains"), Ezaki (1991, Surmaq, Adadeh, Hambast and Gnishik formations), Ataei *et al.* (2018, Jamal Formation), and Ghaderi *et al.* (in press, Khachik, Julfa and Ali-Bashi formations).

This contribution deals with new material collected from the Jamal Formation in two localities at the Tabas area of East-Central Iran. They are Shesh-Angosht (coordinates of N33°59'15" and E56°46'50") on the western flank of the Shesh-Angosht Mountain and Bagh-e Vang (coordinates of N33°58'27" and E56°47'33") on the southwestern flank of the Bagh-e Vang Mountain (Figs. 1, 2). The purposes are to revise the systematics of the known tabulate coral species by previous workers (Flügel, 1972, 1995; Ataei *et al.*, 2018) and add undescribed taxa for the fauna.

Repositories: Except for a specimen S72 that is kept in the National Museum of Nature and Science, Tokyo, Japan, all specimens are housed in the paleontological collections at Ferdowsi University of Mashhad, Mashhad, Iran.

Geologic setting

The Jamal Formation was introduced by Stöcklin *et al.* (1965) for the Permian rocks consisting mainly of limestone and dolomite in the Sotori and Shirgesht mountain ranges of the Tabas Block. Its thickness ranges from 293 to 473 m (Stöcklin *et al.*, 1965; Ruttner *et al.*, 1968; Leven and Vaziri Mohaddam, 2004). The succession rests unconformably upon eroded surface of sandstone belonging to the Carboniferous Sardar Formation and is conformably overlain by the Lower Triassic Sorkh Shale Formation (Partoazar *et al.*, 2014). The stratigraphic interval in which all examined tabulate corals occur represents the lowest ca. 60 m part (= Bagh-e Vang Member in Partoazar, 1995), where carbonate facies are sandy to marly and contain interlayers of sandstone, shale, and olistolith.

The lowest member was dated by various taxa. These results are as follows: Bolorian (=Kungurian; fusulinids; Leven and Vaziri Mohaddam, 2004), Yakhtashian (=Artinskian) to Bolorian (fusulinids; Arefifad, 2006), Artinskian to Kungu-

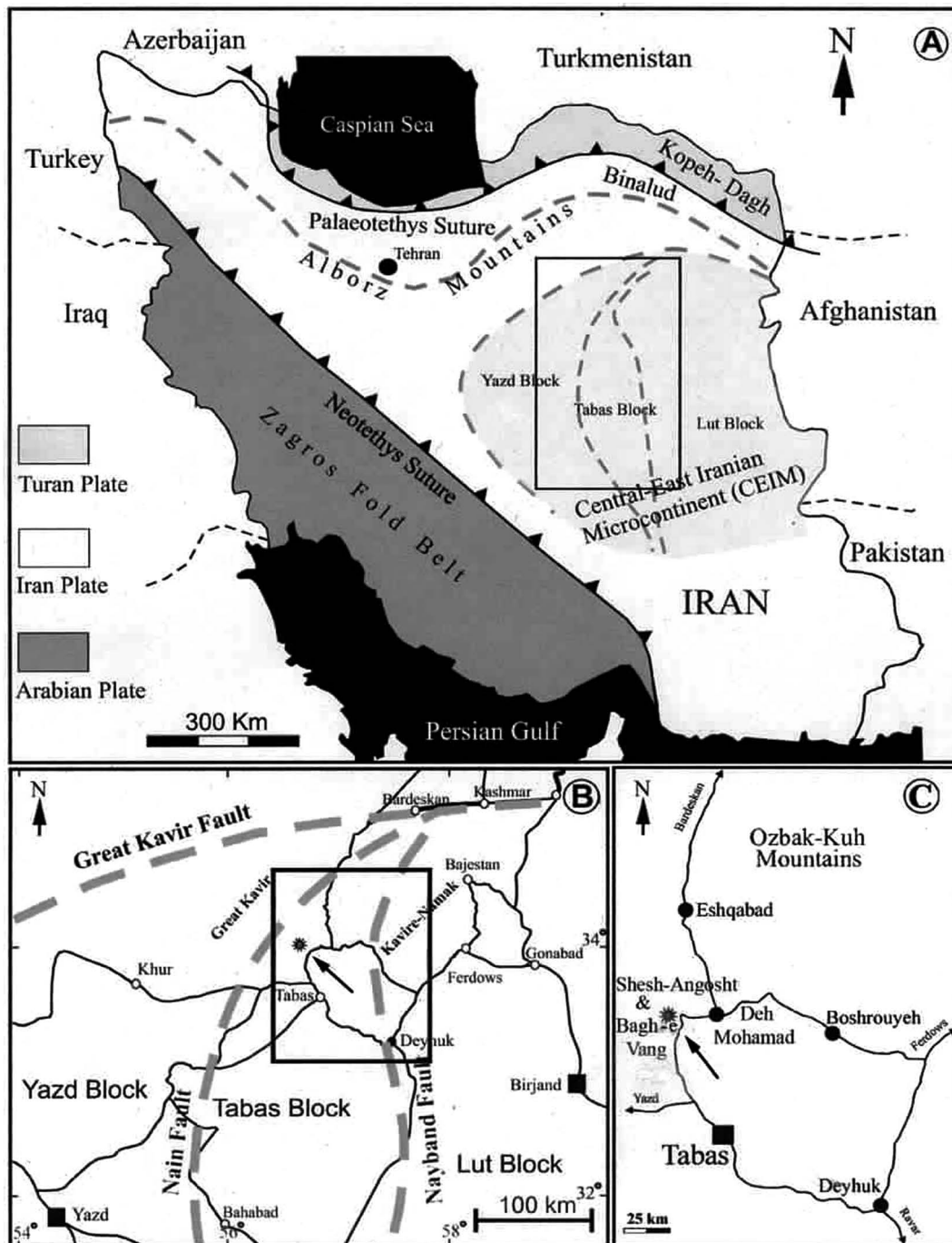


Fig. 1. Maps showing geologic setting and geographic position of tabulate coral localities (modified from Badpa *et al.*, 2016). **A**, tectonic map of Iran. **B**, close-up of rectangular area in Fig. 1A, note fossil localities (asterisk) belonging to the Tabas Block. **C**, close-up of rectangular area in Fig. 1B, showing detailed position of fossil localities (asterisk) in the Tabas area, East-Central Iran.

rian (bryozoans; Ernst *et al.*, 2006), Bolorian to early Kubergandian (= early Roadian; fusulinids; Leven and Gorgij, 2011), and Sakmarian to Kungurian (conodonts; Voulo, 2014). Taking these information into consideration, the age of tabulate corals examined herein is best constrained as late early Permian. The Tabas Block forms the Central-East Iranian Microcontinent with the Yazd and Lut blocks, whose paleogeographic position is inter-

preted to have been part of northern margin of Gondwana during early Permian time (e.g. Berberian and King, 1981; Scotese and Langford, 1995; Ruban *et al.*, 2007). It is concluded that, therefore, habitat of the Jamal tabulate coral assemblage was on the southern shelves of the Paleotethys.

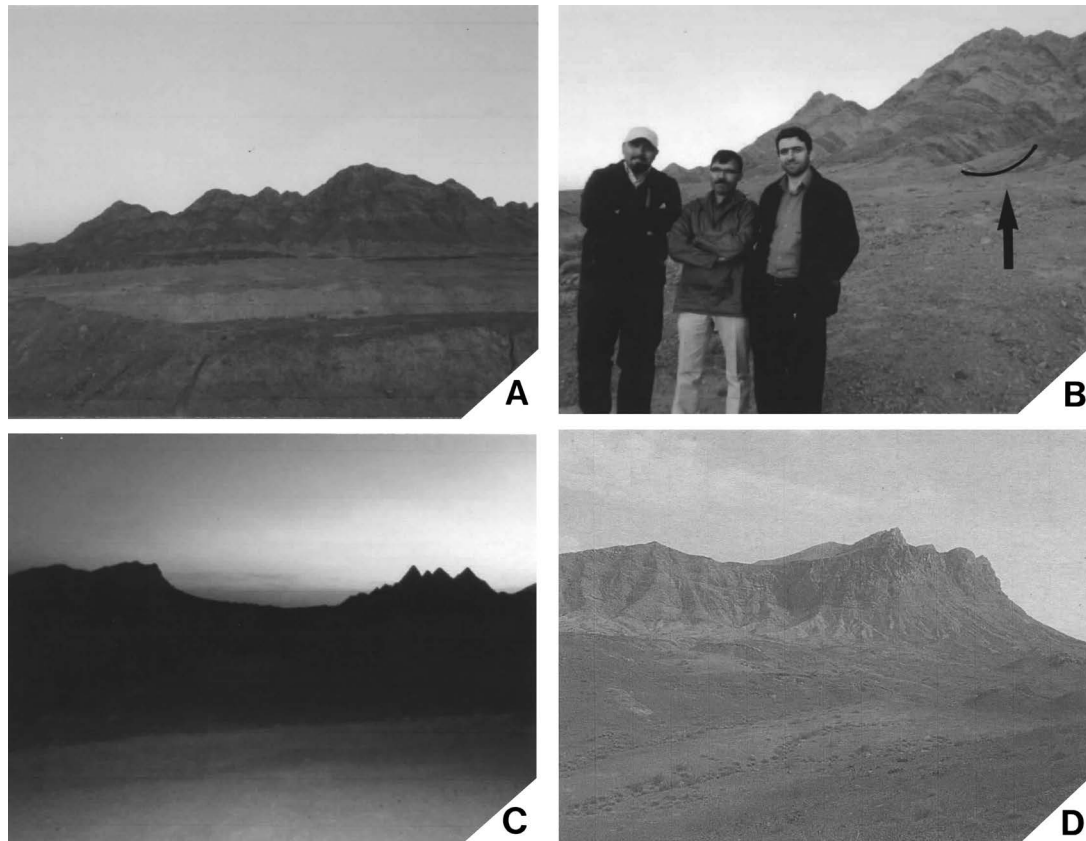


Fig. 2. Exposures of the Permian Jamal Formation and landscape of the Shirgesht Mountain Range in the Tabas area, East-Central Iran. **A**, the Shesh-Angosht Mountain. Flank of front is Shesh-Angosht locality. **B**, close-up of Shesh-Angosht locality, showing the Bagh-e Vang Member (arrow). The persons are the third author (A. G), the forth author (M. R. A.) and the second author (M. B.), from left to right. **C**, silhouette of the Bagh-e Vang Mountain (left) and the Shesh-Angosht Mountain (right). Distance between these mountains is about 1 km. **D**, the Bagh-e Vang Mountain. Bagh-e Vang locality is on other side of the mountain.

Systematic Paleontology

Subclass Tabulata Milne-Edwards and Haime, 1850

Order Favositida Wedekind, 1937

Suborder Favositina Wedekind, 1937

Superfamily Favositoidea Dana, 1846

Family Favositidae Dana, 1846

Subfamily Emmonsinae Lecompte, 1952

Genus *Sutherlandia* Cocke and Bowsher, 1968

Type species: Sutherlandia irregularis Cocke and Bowsher, 1968.

Sutherlandia jamalensis sp. nov.

(Figs. 3-1-8)

Pseudofavosites sp., Flügel, 1972, p. 93, 94, pl. 6, fig. 3; 1995, p. 39.

Material examined: Holotype, specimen S43, from which two thin sections were made. Paratype,

specimen S76.

Locality: Shesh-Angosht.

Diagnosis: Species of *Sutherlandia* with corallum diameter of 12–14 mm and prismatic to subcylindrical corallites; diameters of distal corallites approximately 1.7 mm; intercorallite walls thickened, 0.10–0.61 mm; squamulae relatively short for genus; conical to hemi-spherical septal spines developed at distal corallites; tabulae relatively rare, complete.

Description: Coralla cerioid, subspherical in growth form and consist of radially arranged corallites; diameters of coralla are small for the subfamily, but moderate for the genus, indicating 12–14 mm. Corallites prismatic to subcylindrical; transverse sections of proximal portions of corallites are 3–5 sided polygonal, then they shift to rounded polygonal to nearly circular in distal portions; diameters of corallites range from 0.4 to 2.2 mm with approximately 1.7 mm mean ($n = 7$) at distal corallites; lumina (tabularia) rounded polygonal to circu-

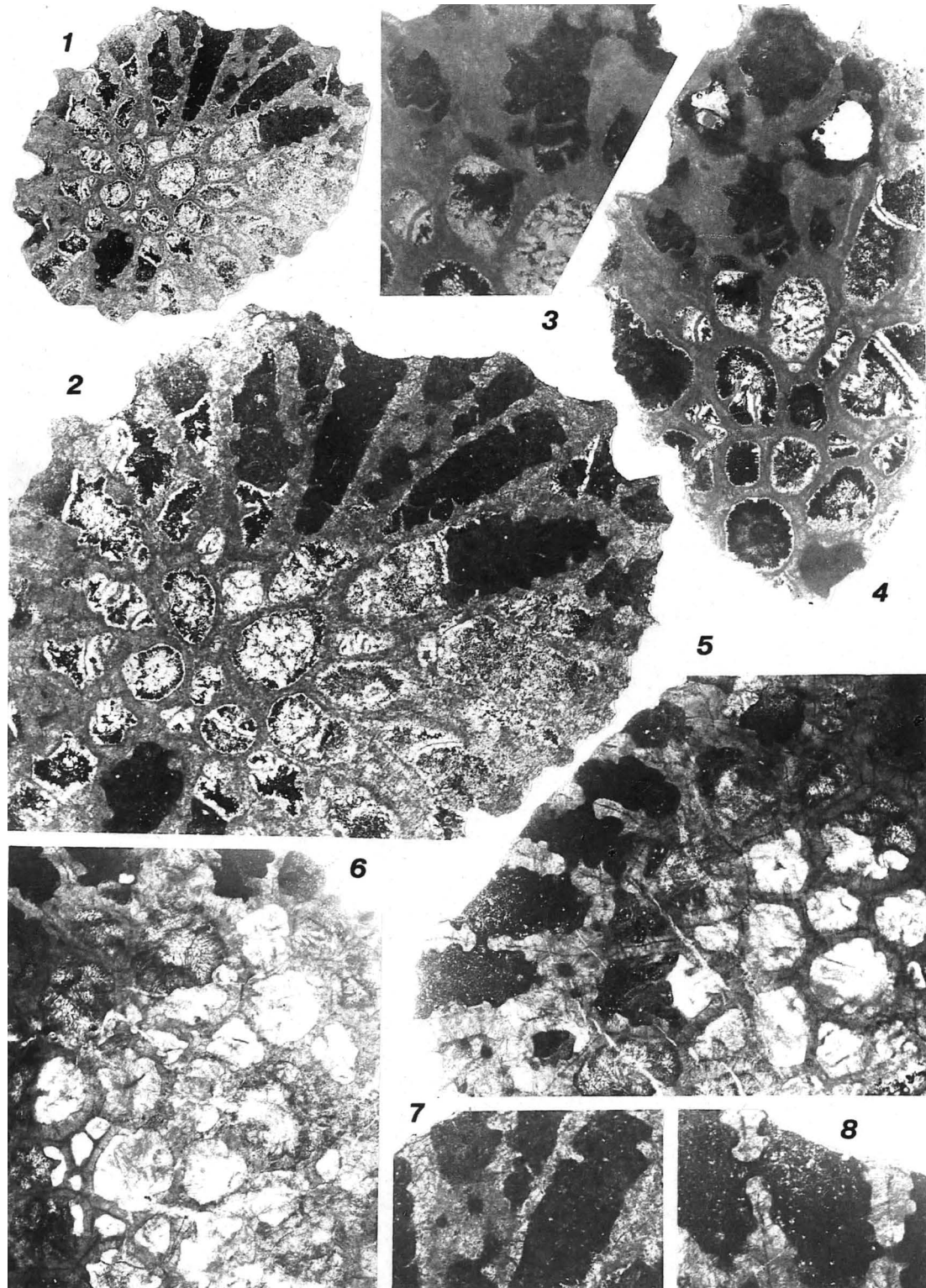


Fig. 3. *Sutherlandia jamalensis* sp. nov., thin sections. 1–4, 7, holotype, specimen S43. 1, transverse section (slightly off its center) of corallum, $\times 5$. 2, partial enlargement of Fig. 3-1, showing transverse to longitudinal sections of corallites, $\times 10$. 3, partial enlargement of Fig. 3-4, showing squamulae, septal spines and tabula, $\times 14$. 4, oblique section (off its center) of corallum, note complete tabulae, $\times 10$. 7, partial enlargement of Fig. 3-1, showing mural pores, squamulae and septal spines, $\times 14$. 5, 6, 8, paratype, specimen S76. 5, 6, transverse to oblique sections of corallites, $\times 10$. 8, partial enlargement of Fig. 3-5, showing mural pores and septal spines, $\times 14$.

lar in transverse section; calices deep to very deep and perpendicularly oriented to corallum surface; no calical modification recognized; increase of new

corallite is intermural(?). Intercorallite walls thickened, 0.10–0.61 mm, differentiated into median dark line and stereoplasm, the latter of which has rect-

radiate fibers in microstructure; mural pores occur on corallite faces, forming two rows, and circular to subcircular in profile; diameters of pores are 0.06–0.31 mm; squamulae commonly occur in proximal corallites and sporadic in distal ones, relatively short for the genus, 0.25–0.48 mm; approximate ratios of squamula length per lumen diameter are up to 0.6; thickness of squamula is thin to moderately thickened, attaining 0.13 mm; considerable squamulae replaced by conical to hemi-spherical septal spines at distal corallites; spine length 0.08–0.23 mm; tabulae relatively rare, complete, slightly concave to nearly transverse.

Etymology: The specific name is derived from the type stratum, named the Jamal Formation.

Discussion: Although Flügel (1972) placed this species in *Pseudofavosites*, we herein transfer it to *Sutherlandia* on the basis of the possessions of thickened intercorallite walls and complete tabulae. The present two specimens represent the first record of the genus from Iran.

Permian occurrences of *Sutherlandia* are very rare. As far as we know, only four species are previously documented from North China (Tchi, 1980; Lin, 1983; Ding *et al.*, 1984) and Japan (Senzai and Niko, 2005). Among them, the new species most resembles *S. finitimus minor* (Ding in Ding *et al.*, 1984, p. 85, pl. 16, figs. 1a, a', b, b', c, c', 2a–d, d'; Lin *et al.*, 1988, p. 419), which is reported from the middle Permian of Inner Mongolia. However, the presence of conical to hemi-spherical septal spines distinguishes it from the Chinese species.

Family Pseudofavositidae Sokolov, 1950

Genus *Pseudofavosites* Gerth, 1921

Type species: Pseudofavosites styliifer Gerth, 1921.

Pseudofavosites exiguus Flügel, 1972

(Figs. 4-1–3)

Pseudofavosites extraspinosus exiguus Flügel, 1972, p. 93, pl. 6, fig. 2; 1995, p. 39; Ataei *et al.*, 2018, figs. 4a, b.

Material examined: Specimen S35.

Locality: Shesh-Angosht.

Description: An incomplete corallum is available for study; it is cerioid and consists of radially arranged corallites; growth form of corallum is

probably sub-spherical with approximately 18 mm in maximum diameter. Corallites prismatic to sub-prismatic, whose diameters range from 0.5 to 1.8 mm; transverse sections of each corallite are quadrate in proximal portion, then become rounded polygonal in distal one; calices very deep. Intercorallite walls 0.04–0.21 mm in thickness; mural pores occur at corallite angles and faces; profiles of pores are longitudinally elliptical having diameters of 0.20×0.25 , 0.22×0.29 mm in typical ones; squamulae well developed though all growth stages of corallites and long, attaining 0.67 mm; tabula absent.

Discussion: In the original description by Flügel (1972), this species was established as a new subspecies of *Pseudofavosites extraspinosus* Sokolov (1955, p. 157, pl. 7, figs. 7, 8, text-figs. 30a, b), of which the types are known from the lower Permian of the Urals. However, *P. extraspinosus* lacks squamulae in proximal portion of corallites and has larger corallite diameters (1.5–2.5 mm) than those of the Iranian species. We think that these morphologic differences beyond intraspecific variations.

The distinctive characters between *Pseudofavosites exiguus* and an associated species in the Jamal Formation, *P. fusiforme*, are given in the discussion of the latter species.

Pseudofavosites fusiforme (Flügel, 1972)

(Figs. 4-4–6)

Favosites fusiforme Flügel, 1972, p. 92, pl. 6, fig. 1; 1995, p. 39.

Pseudofavosites extraspinosus exiguus Flügel; Ataei *et al.*, 2018, figs. 5a, b.

Material examined: Specimens S42, B163.

Localities: Shesh-Angosht (S42) and Bagh-e Vang (B183).

Description: Coralla cerioid formed by radially arranged corallites, sub-spherical in growth form and encircling crinoid stems; diameters of coralla are large for the genus, attaining to at least 32 mm. Corallites prismatic and measure 0.3–2.6 mm in diameter; except for the most proximal adhesive portions where transverse sections of corallite are triangular to quadrate, then they become rounded polygonal in distal one; calices very deep. Intercorallite walls 0.07–0.25 mm in thickness; mural pores occur at corallite angles and faces; profiles of pores

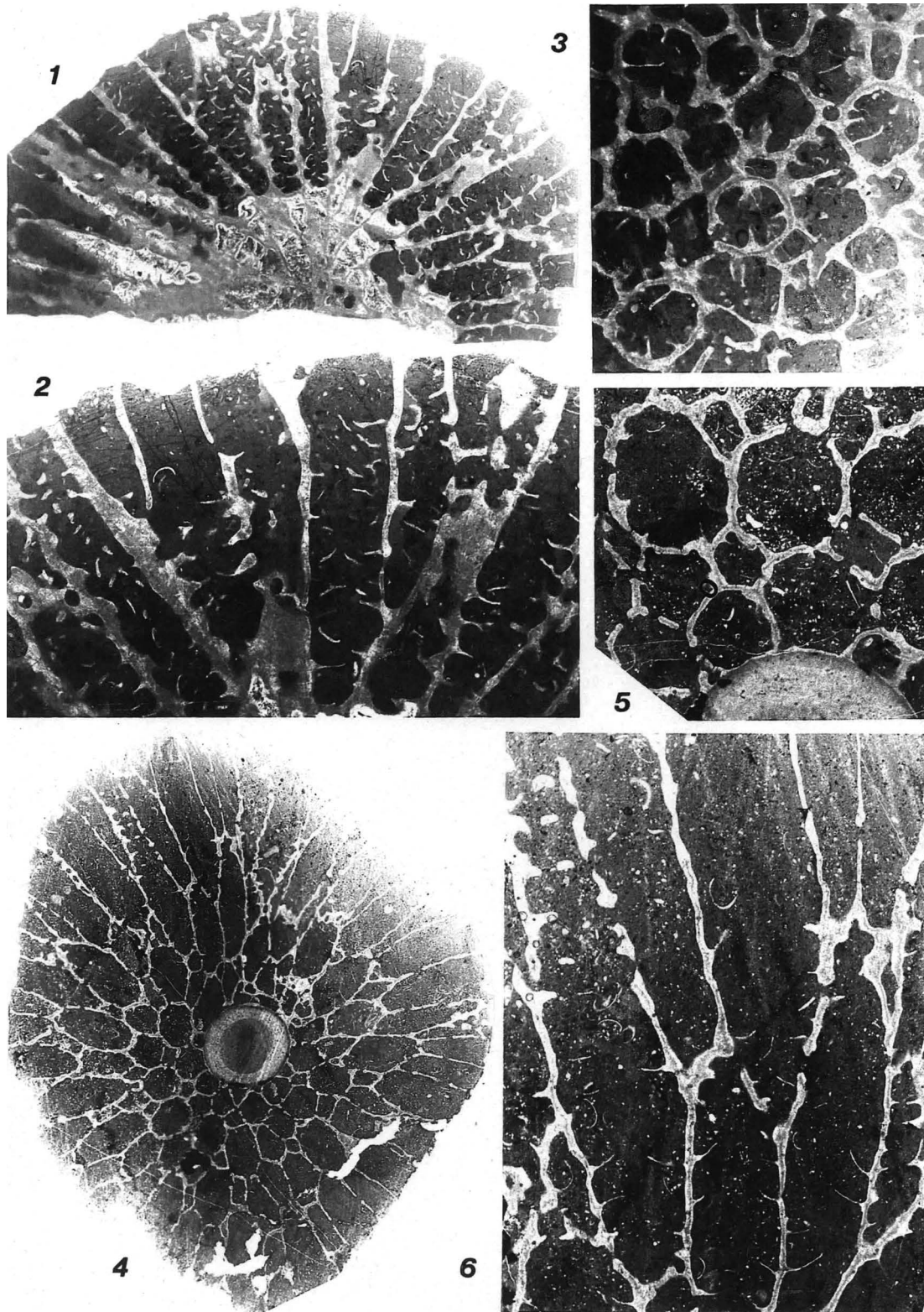


Fig. 4. 1–3, *Pseudofavosites exiguus* Flügel, 1972, specimen S35, thin sections. 1, transverse section of corallum, $\times 5$. 2, partial enlargement of Fig. 4-1, showing longitudinal sections of corallites, $\times 10$. 3, transverse sections of corallites, $\times 10$. 4–6, *Pseudofavosites fusiforme* (Flügel, 1972), specimen S42, thin sections. 4, transverse section of corallum, $\times 3$. 5, partial enlargement of Fig. 4-4, showing transverse sections of corallites, $\times 10$. 6, partial enlargement of Fig. 4-4, showing longitudinal sections of corallites, $\times 10$.

are longitudinally elliptical to circular having diameters of 0.20×0.27 , 0.13 mm in typical ones; squamulae common in proximal and almost absent in

distal portions of corallites; lengths of squamulae are long, attaining 0.88 mm; thickness of squamulae is mostly very thin; tabula absent.

Discussion: This species, originally introduced by Flügel (1972) as *Favosites fusiforme*, is herein transferred to *Pseudofavosites* on the basis of the preserved characters of newly collected specimens from the identical stratum with the holotype. Among them, the corallum encircling crinoid stem and the possession of squamulae warrant the generic assignment.

Pseudofavosites fusiforme differs from *P. exiguus* by having larger corallite diameters and fewer squamulae.

Family Micheliniidae Waagen and Wentzel, 1886

Subfamily Micheliniinae
Waagen and Wentzel, 1886

Genus *Michelinia* de Koninck, 1841

Type species: *Calamopora tenuiseptata* Phillips, 1836.

Michelinia sp. indet.

(Figs. 5-1, 2)

Material examined: Specimen S9.

Locality: Shesh-Angosht.

Description: A fragmentary corallum is available for study; it is cerioid and 13 mm in maximum diameter. Corallites prismatic with transverse sections of 4–8 sided polygonal; diameters of corallites are 1.6–4.3 mm. Intercorallite walls weakly thickened for the genus, 0.19–0.46 mm; mural pores circular in profile and occur on corallite faces and at angles; diameters of pores are 0.10–0.31 mm; septal spines well developed, low conical; tabulae numerous, in which incomplete tabulae are predominant, but complete ones not rare.

Discussion: This specimen is tentatively assigned to *Michelinia* rather than *Protomichelinia* because

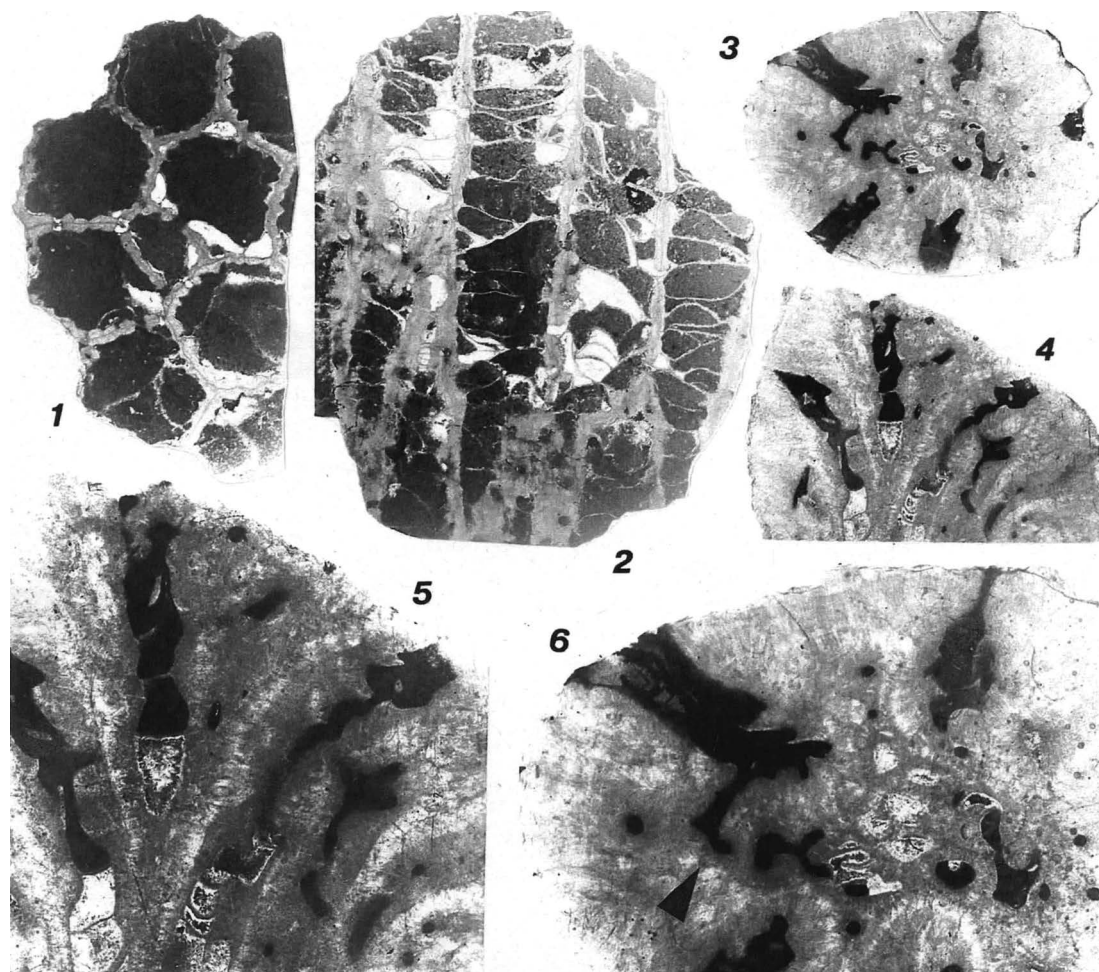


Fig. 5. 1, 2, *Michelinia* sp. indet., specimen S9, thin sections. 1, transverse sections of corallites, $\times 5$. 2, longitudinal sections of corallites, $\times 5$. 3–6, *Gertholites* sp. indet., specimen S58, thin sections. 3, transverse section of branch, $\times 5$. 4, longitudinal section of branch, $\times 5$. 5, partial enlargement of Fig. 5-4, showing longitudinal sections of corallites, $\times 10$. 6, partial enlargement of Fig. 5-3, showing transverse to longitudinal sections of corallites, arrow indicates vermiform tunnels, $\times 10$.

of being well-developed incomplete tabulae. However, it is too fragmentary to be identified confidently.

Superfamily Pachyporoidea Gerth, 1921

Family Pachyporidae Gerth, 1921

Genus *Gertholites* Sokolov, 1955

Type species: Pachypora curvata Waagen and Wentzel, 1886.

Gertholites? diversaporus (Flügel, 1972)

(Figs. 6-1-4)

Trachypora archilaeus[sic] *diversapora* Flügel, 1972, p. 94, 95, pl. 6, figs. 4, 5; 1995, p. 39.

Gertholites diversaporus (Flügel); Tourneur, 1988, p. 305.

Material examined: Specimen S66.

Locality: Shesh-Angosht.

Description: A fragment of cylindrical branch is available for study; it is cerioid and 9 mm in diameter. Corallites prismatic to subprismatic with transverse sections of indistinct 4–7 sided to rounded polygonal; diameters of corallites are 0.2–2.7 mm; each corallite consists of directly longitudinal proximal portion and outwardly curved distal one; proximal and distal portions respectively form axial and peripheral zones; calices deep, open upward with 55°–70° for branch surface. Intercorallite walls relatively thin in axial zone, 0.11–0.36 mm; then, their thickness abruptly increases attaining approximately 1.2 mm to form stereozone at peripheral zone; apparent mural pore is not observable in axial zone; mural tunnels in peripheral zone are circular profiles and 0.08–0.15 mm in diameter; septal spines rare, restrict in in calical pit, high conical, and 0.13–0.36 mm in length; septal ridges also developed in calical pit; tabulae sporadic, complete.

Discussion: This species was established by Flügel (1972) as a new subspecies of *Trachypora achilleos* Heritsch (1937, p. 206–209, figs. 1–10), whose the type series is known from the Upper Carboniferous of Chios, Greek. Subsequently, it was removed from the abolished genus (see Lecompte, 1939) and placed in *Gertholites* by Tourneur (1988). Among the known pachyporid genera, *Gertholites* seems the most apposite for the generic assignment. How-

ever, neither the holotype nor the present newly collected specimen indicate anastomosed mural tunnels that is the most diagnostic character of *Gertholites*. The possession of septal ridges in this Iranian species also beyond the diagnosis of the genus.

Gertholites sp. indet.

(Figs. 5-3–6)

Material examined: Specimen S58.

Locality: Shesh-Angosht.

Description: A fragment of cylindrical branch is available for study; it is cerioid and 10 mm in diameter. Corallites subprismatic with rounded polygonal transverse sections; each corallites gradually divergent; approximate diameters of corallites are 0.5–2.5 mm; calices mostly deep, open oblique upward. Intercorallite walls uniformly thickened in axial zone of branch, 0.15–0.44 mm; then, their thickness abruptly increases attaining approximately 1.8 mm to form peripheral stereozone; mural tunnels vermiform and anastomosed with circular profiles; diameters of tunnels are 0.12–0.27 mm; septal spines common, high conical with more or less curved tips, and 0.19–0.48 mm in length; tabulae rare, complete.

Discussion: This specimen is placed in *Gertholites* on the basis of the possessions of thickened intercorallite walls, vermiform and anastomosed mural tunnels, and high conical septal spines. It probably represents new species, but identification is uncertain because of insufficient material.

Genus *Thamnoptychia* Hall, 1876

Type species: Madrepora limbata Eaton, 1832.

Thamnoptychia directa (Flügel, 1972)

(Figs. 6-5–9)

Trachypora directus Flügel, 1972, p. 95, pl. 6, figs. 6, 7; 1995, p. 39.

Material examined: Specimens S72, S82, B165.

Localities: Shesh-Angosht (S72, S82) and Bagh-e Vang (B165).

Description: Coralla ramose consisting of cylindrical and cerioid branches; branching probably bifurcate; diameters of branches are 6–12 mm. Corallites prismatic to subprismatic with indistinct 4–9

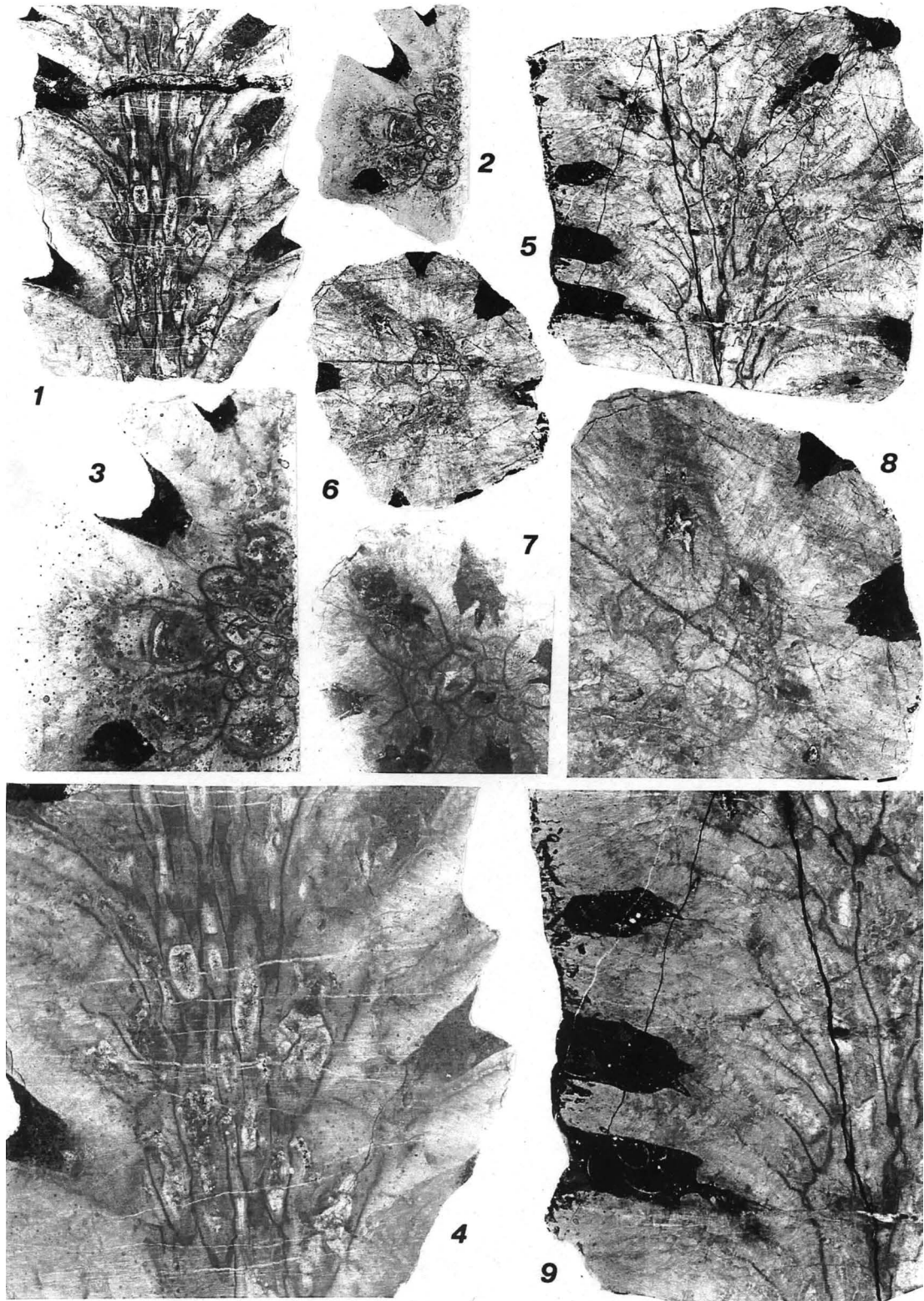


Fig. 6. 1–4, *Gertholites? diversaporus* (Flügel, 1972), specimen S66, thin sections. 1, longitudinal section of branch, $\times 5$. 2, transverse section of branch, $\times 5$. 3, partial enlargement of Fig. 6-2, showing transverse to oblique sections of corallites, $\times 10$. 4, partial enlargement of Fig. 6-1, longitudinal sections of corallites, $\times 10$. 5–9, *Thamnoptychia directa* (Flügel, 1972), thin sections. 5, 6, 8, 9, specimen B165. 5, longitudinal sections of branches, $\times 5$. 6, transverse section of branch, $\times 5$. 8, partial enlargement of Fig. 6-6, showing transverse to oblique sections of corallites, $\times 10$. 9, partial enlargement of Fig. 6-5, showing longitudinal sections of corallites, $\times 10$. 7, specimen S72, oblique to transverse sections of corallites, note well-developed septal ridges, $\times 10$.

sides, whose diameters 0.3–3.8 mm; each corallite consists of directly longitudinal proximal portion and outwardly curved distal one; proximal and distal portions of corallites respectively form axial and peripheral zones; calices open at nearly right angle to branch surface. Intercorallite walls uniformly thickened in axial zone, 0.17–0.75 mm; then, their thickness increases attaining approximately 1.5 mm to form wide stereozone; lumina (tabularia) almost closed by thickened walls; mural pores circular in profile and occur at corallite angles and faces, then they shift tunnels in peripheral zone; diameters of pores (tunnels) are 0.08–0.17 mm; septal spines well developed, conical, 0.13–0.23 mm in length; septal ridges also developed in calical pit; tabulae rare, complete.

Discussion: Because *Trachypora* is an obsolete genus name (Lecompte, 1939), we transfer this Iranian species described by Flügel (1972) to *Thamnoptychia* on the basis of its perpendicularly directed calices to the branch surface, wide stereozone, almost closed lumina (tabularia), and rare tabulae. *Thamnoptychia directa* described herein represents the first record of the genus from Iran.

Acknowledgements

We would like to dedicate this paper to the late Dr. Helmut W. Flügel. Without his pioneering works on Palaeozoic corals in Iran, the present study could not have been done. We are grateful to Dr. Tetsuo Sugiyama for his valuable comments which improved the manuscript.

References

- Arefifard, S. (2006) Microbiostratigraphy and microfacies of Permian strata in Shotori, Shirgesht and Kalmard areas. 252 pp. Ph. D. Thesis, Shahid Beheshti University, Tehran.
- Ataei, M. R., Ghaderi, A., Badpa, M. and Ashouri, A. R. (2018) Permian corals of the Bagh-e-Vang Member of the Jamal Formation in Shesh-Angosht Mountain of Tabas, Central Iran. The 36th National and the 3rd International Geosciences Congress, Teheran, Iran (Poster session).
- Badpa, M., Poty, E., Ashouri, A. and Khaksar, K. (2016) Fasciculate kleopatrinid corals from the Bashkirian (Late Carboniferous) of Sadar Formation (Ozbak-Kuh Mountains, East-Central Iran). *Revista Brasileira de Paleontologia*, **19**: 151–166.
- Berberian, M. and King, G. C. P. (1981) Toward a paleogeography and tectonic evolution of Iran. *Canadian Journal of Earth Sciences*, **18**: 210–265.
- Cocke, J. M. and Bowsher, A. L. (1968) New tabulate genus *Sutherlandia* (Coelenterata, Anthozoa) from Pennsylvanian of Oklahoma and Kansas. *The University of Kansas Paleontological Contributions*, **33**: 1–8.
- Dana, J. D. (1846) Structure and Classification of Zoophytes: United States Exploring Expedition. During the Years 1838, 1839, 1840, 1841, 1842. Under the Command of Charles Wilkes, U. S. N. Volume 7. 740 pp. 61 pls. Lea and Blanchard, Philadelphia.
- Ding, Y., Xia, G., Duan, C., Li, W., Liu, X. and Liang, Z. (1984) Study on the Early Permian stratigraphy and fauna in Zhesi district, Nei Mongol Ziziqu (Inner Mongolia). *Bulletin Tianjin Institute of Geology and Mineral Resources*, **10**: 1–244, pls. 1–58. (In Chinese with English abstract)
- Eaton, A. (1832) Geological Text-book, for Aiding the Study of North American Geology: Being Systematic Arrangement of Facts, Collected by the Author and His Pupils, Under the Patronage of the Hon. Stephen van Rensselaer. 132 pp. 59 pls. Webster and Skinners, G. and C. and H. Carvill, William S. Parker, New York, Troy.
- Ernst, A., Senowbari-Daryan, B. and Rashidi, K. (2006) Lower Permian Bryozoa of the Jamal Formation from Bagh-e Vang (Shotori Mountains, northeast Iran). *Facies*, **52**: 627–635.
- Ezaki, Y. (1991) Permian corals from Abadeh and Julfa, Iran, west Tethys. *Journal of the Faculty of Science, Hokkaido University. Series IV*, **23**: 53–146.
- Flügel, H. W. (1964) The Geology of the Upper Djadgerud and Lar Valleys (N-Iran). *Rivista Italiana di Paleontologia e di Stratigrafia*, **70**: 403–444, pls. 28–34.
- Flügel, H. W. (1968) Korallen aus der oberen Nesen-Formation (Dzhulfa-Stufe, Perm) des zentralen Elburz (Iran). *Neues Jahrbuch für Geologie und Paläontologie. Abhandlungen*, **130**: 275–304, pl. 25.
- Flügel, H. W. (1972) Die paläozoischen Korallenfaunen Ost-Irans. 2. Rugosa und Tabulata der Jamal-Formation (Darwasian?, Perm). *Jahrbuch der Geologischen Bundesanstalt*, **115**: 49–102, pls. 1–6.
- Flügel, H. W. (1995) Biostratigraphie und Korallenfaunen des Jungpaläozoikums Ost-Iran. *Geologische-paläontologische Mitteilungen Innsbruck*, **20**: 35–49.
- Flügel, H. W. (1997) Korallen aus dem Perm von S-Tunesien, W-Iran und NW-Thailand. *Sitzungsberichte. Abteilung I, Biologische Wissenschaften und Erdwissenschaften*, **204**: 79–109.
- Gerth, H. (1921) Die Anthozoön der Dyas von Timor. *Paläontologie von Timor*, **9**: 65–147, pls. 145–150.
- Ghaderi, A., Badpa, M. and Ashouri, A. R. (in press) Permian corals of Ali-Bashi Mountains, Julfa, Northwest of Iran. *Report. Geological Survey of Iran*. (In Persian with English abstract)
- Girty, G. H. (1908) Descriptions of new species of Upper Paleozoic fossils from China. *Proceedings of the United States National Museum*, **33**: 37–48.
- Hall, J. (1876) Illustrations of Devonian Fossils: Corals of the Upper Helderberg and Hamilton Groups. 7 pp. 43 pls. Geological Survey of the State of New York, Weed, Par-

- sons and Co., Albany.
- Heritsch, F. (1937) Karbonische Korallen von der Insel Chios. I. *Trachypora achilleos* nov. spec. *Praktikates Akademias Athenon*, **12**: 203–209.
- Huang, T. K. (1932) Permian corals of southern China. *Palaeontologia Sinica. Series B*, **8**: 1–163, pls. 1–16.
- de Koninck, L. (1841–1844) Description des animaux fossiles qui se trouvent dans le terrain carbonifère de Belgique. 650 pp. pls. A–H, H. Dessain, Liège.
- Lecompte, M. (1939) Les Tabulés du Dévonien moyen et supérieur du Bord sud du Bassin de Dinant. *Mémoires du Musée Royal d'Histoire Naturelle*, **90**: 1–229, pls. 1–23.
- Lecompte, M. (1952) Madréporaires paléozoïques. In: Piveteau, J. (Ed.), *Traité de Paléontologie*. Volume 1, Masson et Cie, Paris, pp. 419–538.
- Leven, E. Ja. and Gorgij, M. N. (2011) Fusulinids and stratigraphy of the Carboniferous and Permian in Iran. *Stratigraphy and Geological Correlation*, **19**: 687–776.
- Leven, E. Ja. and Vaziri Mohaddam, H. (2004) Carboniferous-Permian stratigraphy and fusulinids of eastern Iran. The Permian in the Bag-e-Vang section (Shirgesht area). *Rivista Italiana di Paleontologia e di Stratigrafia*, **110**: 441–465.
- Lin, B. (1983) Lower Permian stratigraphy and coral faunas from both flanks of Yarlung Zangbo River in central-southern Xizang (Tibet). *Contribution to the Geology of the Qinghai-Xizang (Tibet) Plateau*, **8**: 69–181, pls. 1–32. (In Chinese with English abstract)
- Lin, B., Tchi, Y., Jin, C., Li, Y. and Yan, Y. (1988) Monograph of Palaeozoic corals. Tabulatomorphic Corals. Volume 2, 493 pp. Geological Publishing House, Beijing. (In Chinese)
- Mansuy, H. (1914) Contribution à la Paléontologie du Laos. *Mémoires du Service Géologique de l'Indochine*, **3**: 37–34, pls. 2–4.
- M'Coy, F. (1849) On some new genera and species of Palaeozoic corals and foraminifera. *The Annals and Magazine of Natural History. Second Series*, **3**: 1–20, 119–136.
- Milne-Edwards, H. and Haime, J. (1850) A Monograph of the British Fossil Corals. First Part. Introduction; Corals from the Tertiary and Cretaceous Formations. 71 pp. 11 pls. Monographs of the Palaeontographical Society, London.
- Partoazr. H. (1995) Permian deposits in Iran. In: *Treaties on the Geology of Iran*, Volume 22. Geological Survey of Iran, Teheran, pp. 1–370. (In Persian with English abstract)
- Partoazar, H., Hamdi, B. and Aghanabati, S. A. (2014) New approach on biostratigraphy of Permian deposits of Jamal Formation in Bagh Vang section, Shirgesht area (Central Iran). *Geopersia*, **4**: 141–154.
- Phillips, J. (1836) Illustrations of the Geology of Yorkshire: or a Description of the Strata and Organic Remains: Accompanied by a Geological Map, Sections, and Diagrams, and Figures of the Fossils. Part II. The Mountain Limestone District. 253 pp. 25 pls. John Murray, London.
- Ruban, D. A., Al-Husseini, M. I. and Iwasaki, Y. (2007) Review of Middle East Paleozoic plate tectonics. *GeoArabia*, **12**: 35–56.
- Ruttner, A. W., Nabavi, M. H., Hajian, J. (1968) Geology of the Shirgesht area (Tabas area, East Iran). *Report. Geological Survey of Iran*, **4**: 1–133.
- Scotese, C. R. and Langford, R. P. (1995) Pangea and the paleogeography of the Permian. In: Scholle, P. A. et al. (Eds.), *The Permian of Northern Pangea*. Volume 1: Paleogeography, Paleoclimates, Stratigraphy. Springer-Verlag, Berlin, Heidelberg, pp. 3–19.
- Senzai Y. and S. Niko, S. (2005) An early Permian tabulate coral *Sutherlandia* from the Tamba Belt in the Oji area, Kameoka City, Kyoto Prefecture, Central Japan. *Chigakukennyu*, **54**: 3–7. (In Japanese with English abstract)
- Sokolov, B. S. (1950) Systematics and history of the development of the Paleozoic corals Anthozoa Tabulata. *Voprosy Paleontologii*, **1**: 134–210. (In Russian)
- Sokolov, B. S. (1955) Paleozoic Tabulata of the European parts of the USSR. Introduction to the general study of the systematics and development of the tabulates. *Trudy Vsesoyuznogo Neftyanogo Nauchno-Issledovatel'skogo Geologo-Razvedochnogo Instituta, Novaya Seriya*, **85**: 1–527. (In Russian)
- Stöcklin, J., Eftekhar-Nezhad, J. and Hushmand-Zadeh, A. (1965) Geology of the Shotori Range (Tabas area, East Iran). *Report. Geological Survey of Iran*, **3**: 1–69.
- Tchi, Y. (1980) Tabulata. In: Shenyang Institute of Geology and Mineral Resources (Ed.), *Paleontological Atlas of Northeast China*. (1), Paleozoic Volume. Geological Publishing House, Beijing, pp. 153–188, 646–649, pls. 67–87. (In Chinese)
- Tourneur, F. (1988) Mise au point sur le genre *Trachypora* Milne-Edwards & Haime 1851 (Tabulata, Devonien). *Annales de la Société Géologique de Belgique*, **110**: 297–308.
- Vuolo, I. (2014) Conodont biostratigraphy from Carboniferous and Permian successions of Pamir, Central Iran and Tunisia. 308 pp. Ph. D. Thesis, Università degli Studi di Milano, Milan.
- Waagen, W. H. and Wentzel, J. (1886) Salt Range fossils. Volume 1, *Productus* Limestone fossils; 6, Coelenterata. *Paleontologica Indica*, **13**: 835–924, pls. 97–116.
- Wedekind, R. (1937) Einführung in die Grundlagen der Historischen Geologie. II. Band. Mikrobiostratigraphie, Die Korallen- und Foraminiferenzeit. 136 pp. 16 pls. Ferdinand Enke, Stuttgart.