

## Late Triassic scleractinian corals from Nayband Formation, southwest Ardestan, Central Iran

*Corales escleractínidos del Triásico tardío de la Formación Nayband, suroeste de Ardestán, Irán central*

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## ABSTRACT

Late Triassic coral fauna from the Nayband Formation, southwest of Ardestan town (Central Iran), is represented by solitary, phaceloid and colonial (cerioid, meandroid, thamnasterioid, and plocoid) growth forms, attributed to 14 genera and 24 species. They occur in biostromal bioconstructions, in Bidestan and Howz-e-Khan Members of Nayband Formation. Sponges and corals are the main reef-building organisms in these biostromes, and occur together with hydrozoan *Heterastridium* spp., bivalves, and other reef dwellers (e.g., echinoderms, gastropods, and brachiopods). The corals of the studied area bear taxonomic resemblance to the Late Triassic corals from Northern Calcareous Alps and Pamirs, Central Asia.

**Keywords: Scleractinian corals, Late Triassic, Nayband Formation, Ardestan, Iran.**

## RESUMEN

La fauna coralina del Triásico tardío de la Formación Nayband en el suroeste de Ardestan (Irán Central) está representada por formas de crecimiento solitario, faceloide y colonial (cerioides, meandroides, thamnasterioides y plocoides), atribuidas a 14 géneros y 24 especies. Dichos corales se encuentran en bioconstrucciones de biostromas, en los miembros Bidestan y Howz-e-Khan de la Formación Nayband. Esponjas y corales representan los principales organismos constructores de estos biostromas, y se encuentran asociados al hidrozoo *Heterastridium* spp., bivalvos y otros habitantes del arrecife (e.g., echinodermos, gasterópodos y braquiópodos). Los corales del área de estudio tienen similitud taxonómica con corales del Triásico tardío de los Alpes Calcáreos del Norte y Pamir, Asia Central.

**Palabras clave: Corales escleractinios, Triásico tardío, Formación Nayband, Ardestan, Irán.**

## 1. Introduction

Upper Triassic sediments are widely exposed in central and northern Iran. Particularly abundant and taxonomically diverse Triassic marine invertebrate fauna is known from the Late Triassic Nayband Formation (name taken from the Nayband Mountain, 3008 m.a.s.l.), east of the small village of Naybandan (south of Tabas). The pioneering study on Nayband Formation strata was carried out by Douglas (1929), who subdivided the Nayband Formation into three members: (i) Howz-e-Sheikh, (ii) Nayband, and (iii) Howz-e-Khan. Sedimentology, biostratigraphy, and paleontology of this lithostratigraphic unit have been outlined by Brönnimann *et al.* (1971), Seyed-Emami (1971, 2003), Zahedi (1976), Kluyver *et al.* (1983), Fürsich *et al.* (2005), and Hautmann (2001). Several authors published studies on sponges, gastropod, and bivalve mollusks from the Nayband Formation (*e.g.*, Douglas, 1929; Fallahi *et al.*, 1983; Nützel and Senowbari-Daryan, 1999; Repine, 1996; Hautmann, 2001; Nützel *et al.*, 2003, 2010).

To date, only Shepherd *et al.* (2012) described Norian to Rhaetian scleractinian corals from the Nayband Formation (14 taxa), which were collected from the Ferdows patch reef in the Bidestan and Howz-e-Khan members. Remarkably, nine species of the scleractinian corals of the Ferdows area were also described in 40 Km of the southwest of Ardestan town. Many of these taxa were also reported from Tajikistan (Melnikova, 2001). This distribution indicates paleobiogeographic relationships with other parts of the Tethys Ocean in the Late Triassic. The purpose of this study is to provide more extensive description of Late Triassic (Norian to Rhaetian) scleractinian coral fauna from Nayband Formation recognized in two sections located in Bagher Abad and Dizlu in the southwest of Ardestan town.

## 2. Geological setting

The corals described (Table 1) were collected from the Nayband Formation, in 40 km southwest of

the town of Ardestan, from the outcrops 5 km east of Dizlu village (33°04'10"N, 52°01'40"E) (Figure 1C), and in the locality situated 15 km northeast of Bagher Abad village (33°05'28"N, 52°03'27"E) (Figure 1B).

The Nayband Formation is subdivided into the following (from bottom to top): Gelkan (shales and sandstones), Bidestan (oolithic limestones, sandstones, and reefal limestones with numerous algae, calcareous sponges, and corals), Howz-e-Sheikh (shales and sandstones), and Howz-e-Khan members (reefal limestones with algae, calcareous sponges, and corals). In addition, upper part of Nayband formation is Qadir member that overlay the Howz-e-Khan member. (Brönnimann *et al.*, 1971; Kluyver *et al.*, 1983; Fürsich *et al.*, 2005).

In the Dizlu area, the Nayband Formation has five members (Figure 2A). Lowermost part of Nayband formation is Gelkan Member (up to 400 m thick), which deposits on the Shotori formation (Middle Triassic) (Figure 2B). The Bidestan Member (Biostrome 1) lying conformably on the Gelkan member, the Bidestan member is about 11 m thick, with oolitic limestone at the base member, and biostromal bioconstructions (Figure 2C and 2D). In the biostromes, sponges and corals are the main reef-building organisms; hydrozoan *Heterastridium* spp. and bivalves are also relatively abundant. A list of corals is presented in Table 2. This assemblage indicates the late Norian–Rhaetian age of fauna (Figure 4). The Bidestan Member is overlain by the Howz-e-Sheikh member, which reaches a thickness of 44 m and consists mainly of light brown unfossiliferous sandstones (Figure 2E). The Howz-e-Khan Member, which is up to 15 m thick, rests on the Howz-e-Sheikh Member and starts with a thick limestone bed (Figure 2F).

The member contains abundant reef organisms, including sponges, corals, and reef dwellers (*e.g.*, echinoderms, bivalves, gastropods, and brachiopods) (Figure 4). The corals (Table 2) indicate the Rhaetian age of the Howz-e-Khan member. The uppermost Qadir Member, up to 200 m thick, comprises brown sandstones and marls. Two key horizons in the Qadir member contain bivalves

(*Indopecten glabra*) and flora (*Clathropteris* spp.), which indicate a Rhaetian age (Figures 2G and 2H). The Nayband Formation is overlain with an angular unconformity by Early Cretaceous deposits.

In the Bagher Abad area, the Nayband Formation starts with the Howz-e-Khan Member. The Qadir Member is overlain by Early Cretaceous beds (Figures 3A). The Howz-e-Khan Member, up to 25 m thick, is formed by cream to light-gray reefal limestone (Figures 3B and 3C), and contains abundant reef organisms, including: sponges, corals, and reef dwellers (e.g., echinoderms, bivalves, gastropods, and brachiopods) (Figure 5). The corals

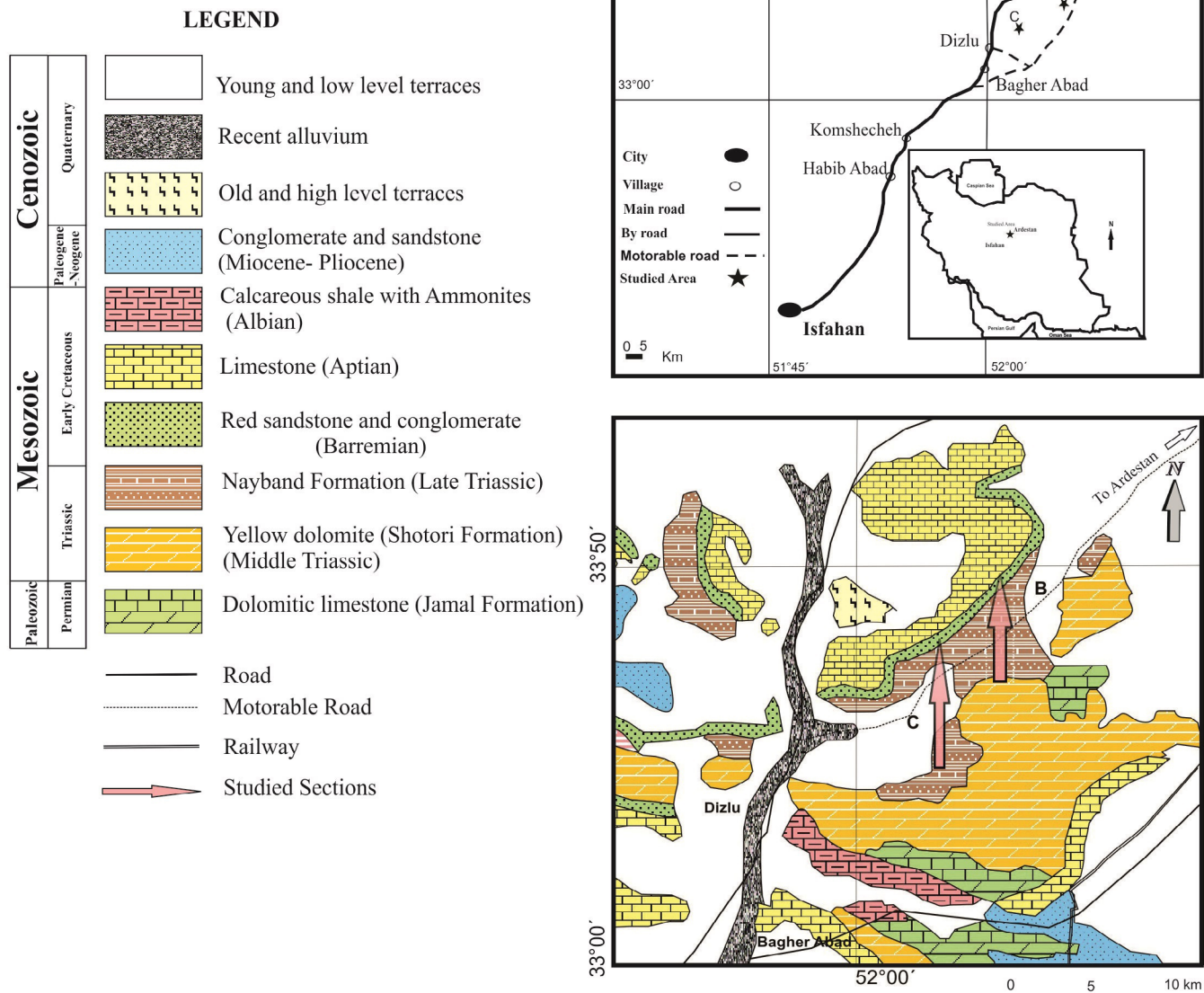
(Table 2) indicate a Rhaetian age for the Howz-e-Khan Member. The Qadir Member, up to 125 m thick, contains brown sandstones and marls. One of the key beds in the Qadir Member, the Nayband formation, is overlain with an angular unconformity by Early Cretaceous deposits.

### 3. Materials

The material examined consists of 88 specimens, represented by eight scleractinian families. Several coralla were sectioned to check preservation of

Table 1. Scleractinian corals from the Upper Triassic of Nayband Formation in the southwest of Ardestan.

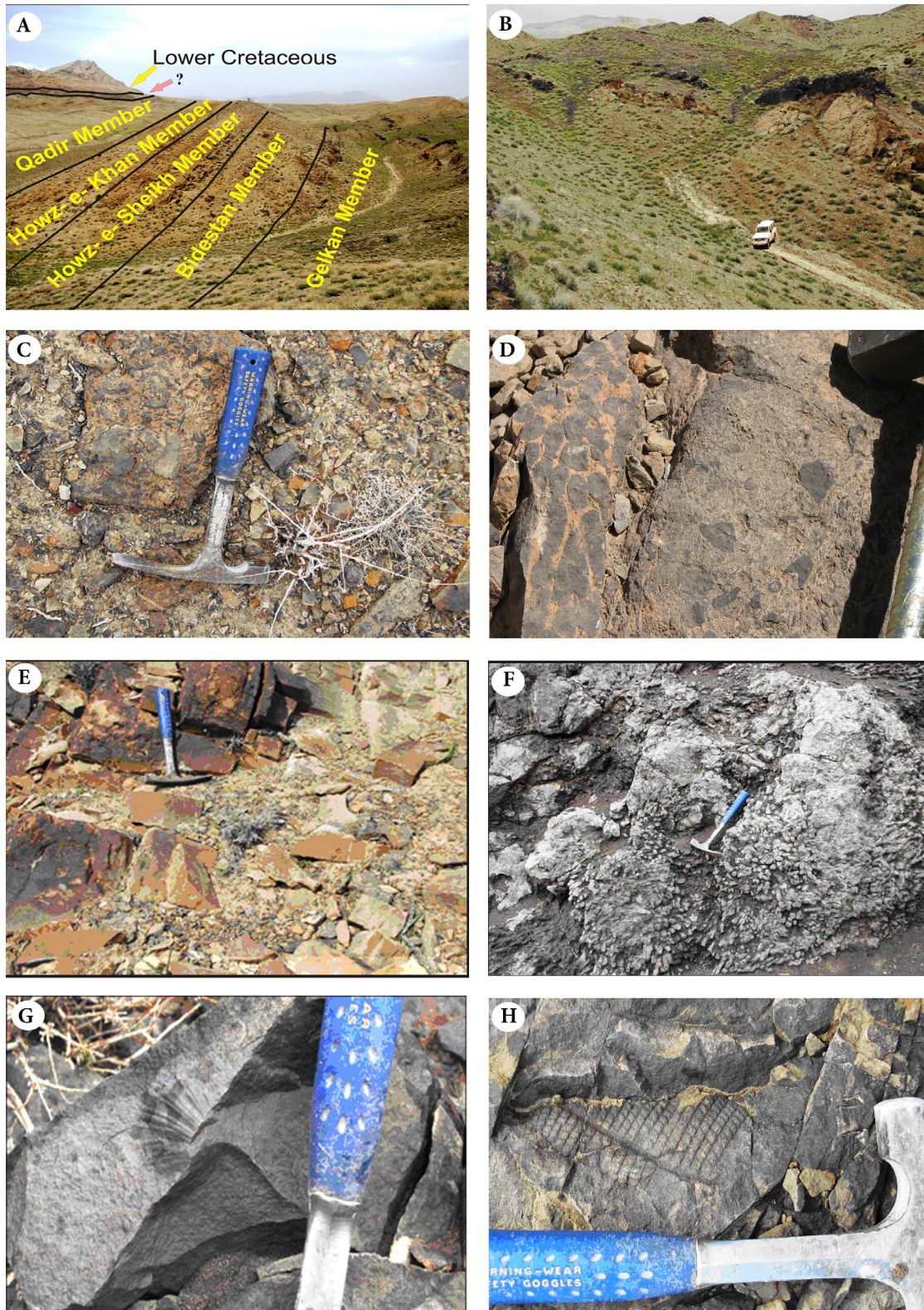
Family	Genus and species
Coryphyllidae Beauvais, 1981	<i>Cuifia columnaris</i> (RONIEWICZ, 1996)
	<i>Cuifia gigantella</i> (MELNIKOVA, 1975)
	<i>Cuifia elliptica</i> (MELNIKOVA, 1975)
Reimaniphyllidae MELNIKOVA, 1975	<i>Distichophyllia</i> cf. <i>norica</i> (FRECH, 1890)
	<i>Retiophyllia norica</i> (FRECH, 1890)
	<i>Retiophyllia clathrata</i> (EMMRICH, 1853)
	<i>Oedalmia norica</i> (FRECH, 1890)
Margarophylliidae VOLZ, 1890	<i>Margarophyllia</i> cf. <i>capitata</i> (MÜNSTER, 1841)
	<i>Margarophyllia</i> cf. <i>crenata</i> (MÜNSTER, 1841)
	<i>Margarophyllia</i> sp.
	<i>Distichomeandra austriaca</i> (FRECH, 1890)
Cyclophyllidae RONIEWICZ, 1989	<i>Kompsasteria oligocystis</i> (FRECH, 1890)
Procycolitidae VAUGHAN and WELLS, 1943	<i>Procycolites triadicus</i> (FRECH, 1890)
Astraeomorphaeidae FRECH, 1890	<i>Astraeomorpha crassisepta</i> (REUSS, 1854)
	<i>Astraeomorpha confusa</i> (WINKLER, 1861)
Actinastraeidae ALLOITEAU, 1952	<i>Chondrocoenia schafhaeutli</i> (WINKLER, 1861)
Pamiroseriidae MELNIKOVA, 1984	<i>Pamiroseris meriani</i> (STOPPANI 1858-1860)
	<i>Pamiroseris rectilamellosa</i> (WINKLER, 1861)
	<i>Pamiroseris multiseptata</i> (MELNIKOVA)
	<i>Crassistella juvavica</i> (FRECH, 1890)
Stylophyllidae FRECH, 1890	<i>Stylophyllopsis polyactis</i> (FRECH, 1890)
	<i>Stylophyllopsis rudis</i> (EMMRICH, 1853)
	<i>Stylophyllopsis lindstroemi</i> (FRECH, 1890)
	<i>Pamirophyllum iranicum</i> (MELNIKOVA, 1972)



**Figure 1** Geological map and location of the studied sections in the southwest of Ardestan, B. Bagher Abad, and C. Dizlu section.

the original structure. Coralla are typically completely recrystallized with blocky calcite crystals composing the skeletal structures. A few samples were also examined by cathodoluminescence microscopy (at the Institute of Paleobiology, Polish Academy of Sciences) in order to assess diagenetic patterns. Macroscopically, coralla are generally well preserved and major diagnostic features are recognizable, *i.e.*, septa, axial structures, walls.

Some traces of micromorphological features are sometimes visible (*e.g.*, septal granulations). The repository location is housed at the University of Payame-Noor, under the symbol “SH-PNUICO” (Shahin shahr Payame Noor University Iran Coral) (8378–8467). (8378–8467) are shown: The code number of museum samples in Shahin shahr Payame Noor University.



**Figure 2** Exposures of Late Triassic deposits of the Nayband Formation, Dizlu area, southwest of Ardestan town. (A) Field view of the rocks assigned to the Nayband Formation. (B) Alternated brown sandstone and marl, Gelkan Member. (C) Reefal limestone, Bidestan Member. (D) Scleractinian corals in limestone, Bidestan Member. (E) Alternated brown sandstones and marls, Howz-e-Sheikh Member. (F) Reefal limestone, Howz-e-Khan Member. (G) Bivalve key bed, Qadir Member. (H) Flora key horizon, Qadir Member.

Table 2. Distribution of Corals in the Norian to Rhaetian of the southwest of Ardestan.

Taxon	Dizlu Area Section C		Bagher Abad area Section B
	biostromes		biostrome
	1	2	2
<i>Cuifia columnaris</i>		■	
<i>Cuifia gigantella</i>		■	
<i>Cuifia elliptica</i>		■	
<i>Distichophyllia cf. norica</i>	■	■	
<i>Retiophyllia norica</i>		■	■
<i>Retiophyllia clathrata</i>	■		
<i>Oedalmia norica</i>		■	
<i>Margarophyllia cf. capitata</i>	■	■	
<i>Margarophyllia cf. crenata</i>	■		
<i>Margarophyllia sp.</i>	■		
<i>Distichomeandra austriaca</i>		■	
<i>Kompsasteria oligocystis</i>		■	
<i>Procycolites triadicus</i>	■		
<i>Astraeomorpha crassisepta</i>	■		
<i>Astraeomorpha confusa</i>		■	
<i>Chondrocoenia schafhaeutli</i>		■	■
<i>Pamiroseris meriani</i>		■	■
<i>Pamiroseris rectilamellosa</i>		■	■
<i>Pamiroseris multiseptata</i>		■	■
<i>Crassistella juvavica</i>	■	■	■
<i>Stylophylloopsis polyactis</i>		■	■
<i>Stylophylloopsis rudis</i>	■	■	■
<i>Stylophylloopsis cf. lindstroemi</i>		■	
<i>Pamirophyllum iranikum</i>	■		

Abbreviations used in the text include the following:

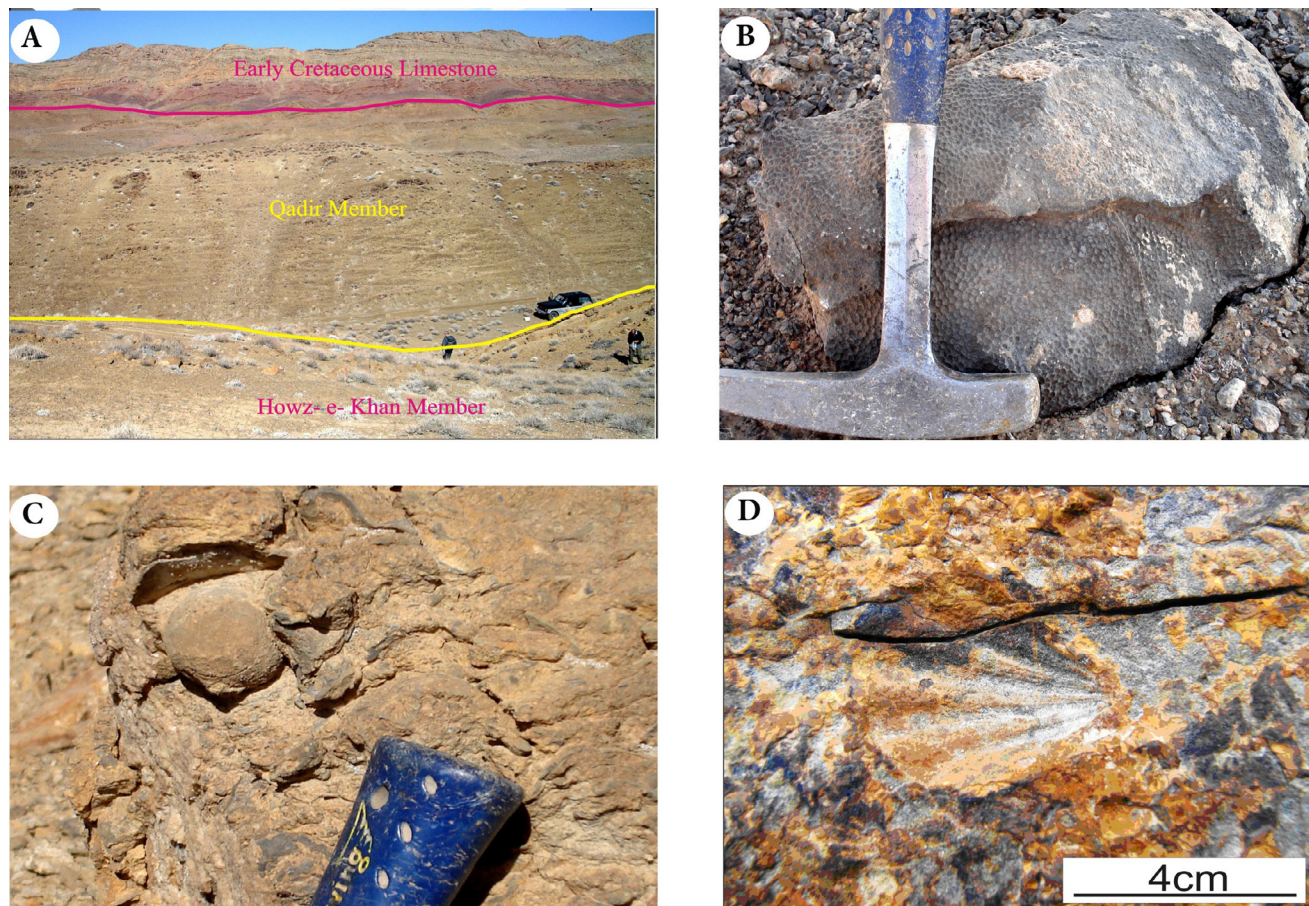
- c-c*: distance between the calicular axes,
- d*: diameter of juvenile corallite,
- D*: diameter of adult corallite,
- GCD*: greater calicular diameter,
- LCD*: smaller calicular diameter,
- H*: height of the solitary coral or colony,
- S*: number of septa; *S1*, *S2* ...etc.,
- S/mm*: septal density measured at the calicular wall.

#### 4. Systematic paleontology

Order Scleractina BOURNE, 1900  
 Family Coryphylliidae BEAUVAIS, 1981  
 Genus *Cuifia* MELNIKOVA, 1975  
 Type species: *Cuifia gigantella* Melnikova, 1975

*Cuifia columnaris* RONIEWICZ, 1996  
 Figures 7A and 7B

1996 *Cuifia columnaris*: RONIEWICZ,



**Figure 3** Exposures of Late Triassic deposits of the Nayband Formation, Bagher Abad area, southwest of Ardestan. (A) Field view of Nayband Formation rock exposures. (B) Scleractinian coral colony in reefal limestone, Howz-e-Khan member. (C) Hydrozoan *Heterastridium* sp. in limestone of Howz-e-Khan member. (D) Bivalve key bed, Qadir member.

p. 21, pl. 3, figs. 1-3; pl. 4, figs. 1, 4, 5  
 2001 *Cuifia columnaris* RONIEWICZ:  
 MELNIKOVA, p. 43, pl. 11, fig. 1

**Material:** One specimen (SH-PNUICO8408) from Biostrome 2, Section C, Dizlu area. Measurements (in mm):

Number	D	H	S	S/5mm
SH-PNUICO8408	65×67	135	110	5

**Description:** The coral is characterized by solitary corallum of sub-cylindrical shape, circular and deep calice of a considerable diameter, thick septa and granulation on septal faces. Radial elements are numerous, differentiated into more than 3 size orders. Endotheca is formed

by vesicular dissepiments. Wall thick, epithcal surface is destroyed. The corallum shows superposed growth stages with smaller or larger calicular diameters, which resulted from development in succeeding changes of paleoenvironmental conditions.

**Occurrence:** Late Triassic, Rhaetian, Howz-e-Khan Member, Dizlu, southwest of Ardestan, Central Iran.

The species is known from the upper Norian and Rhaetian of the European and Asian parts of the Tethys.

*Cuifia gigantella* MELNIKOVA, 1975  
 Figures 7G and 7H

1975 *Cuifia gigantella*: MELNIKOVA, p. 83,  
 pl. 14, figs. 1, 2

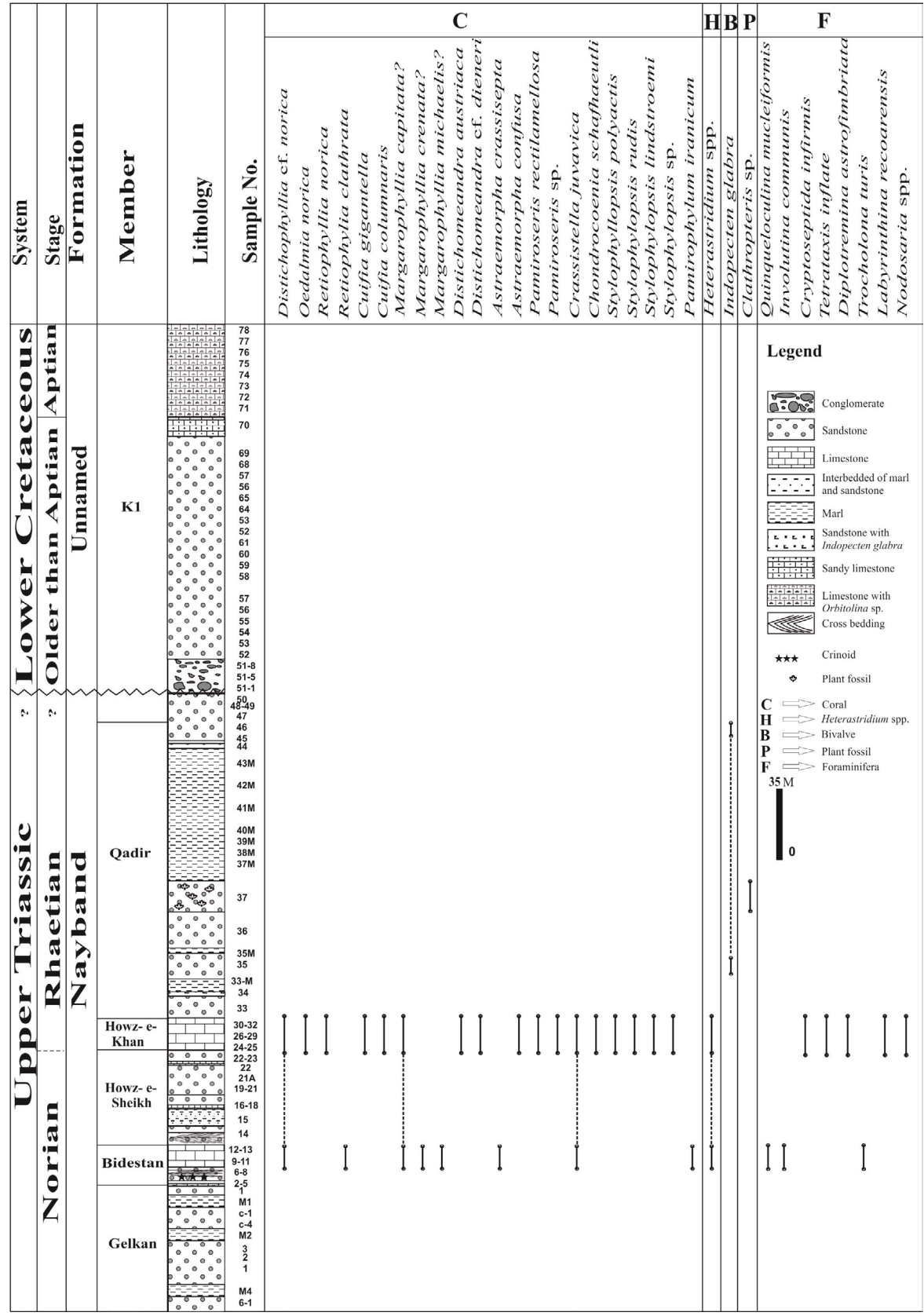


Figure 4 Biostratigraphic range chart of Late Triassic fauna from the Nayband Formation, Dizlu area, southwest of Ardestan.



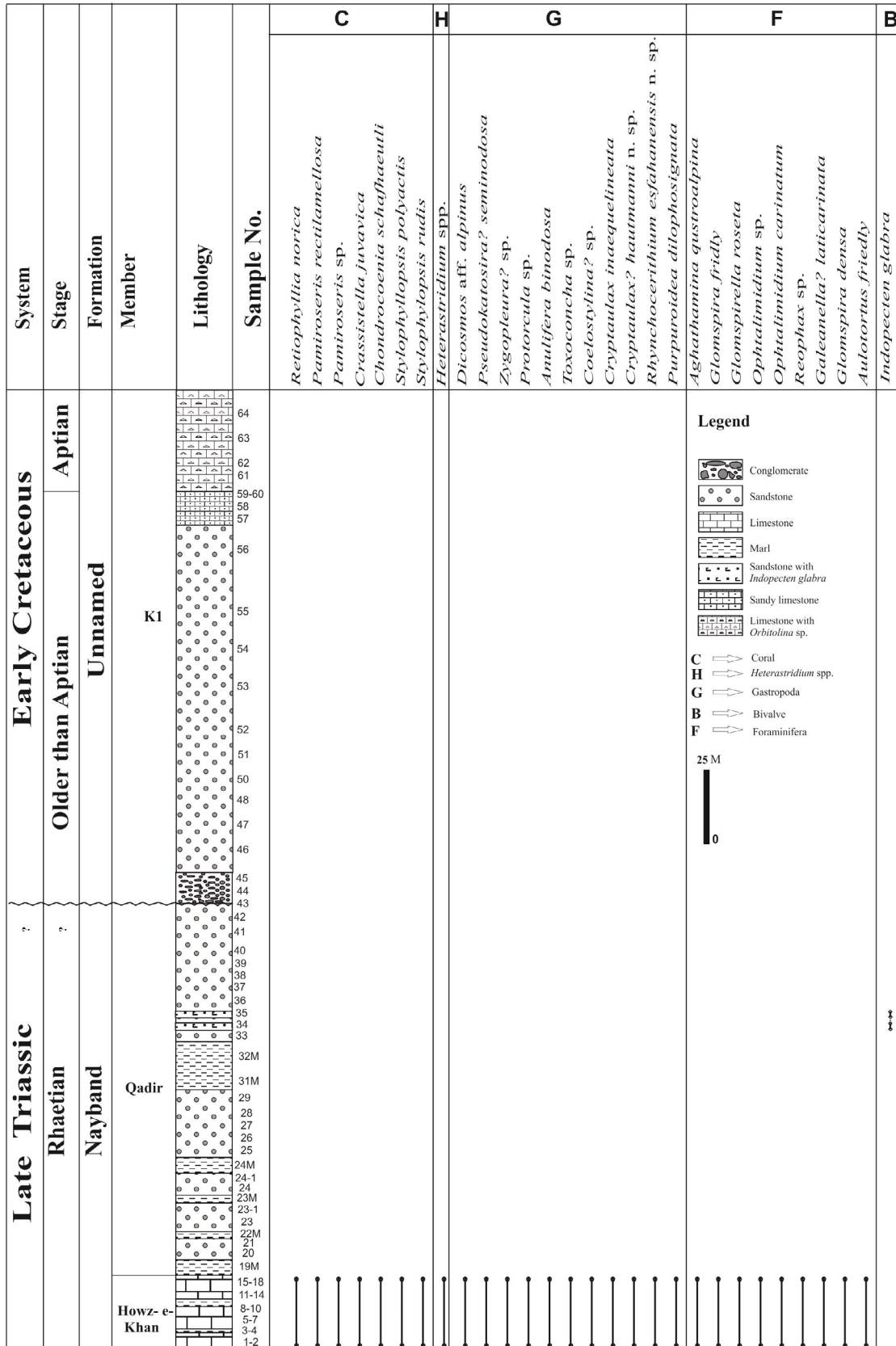
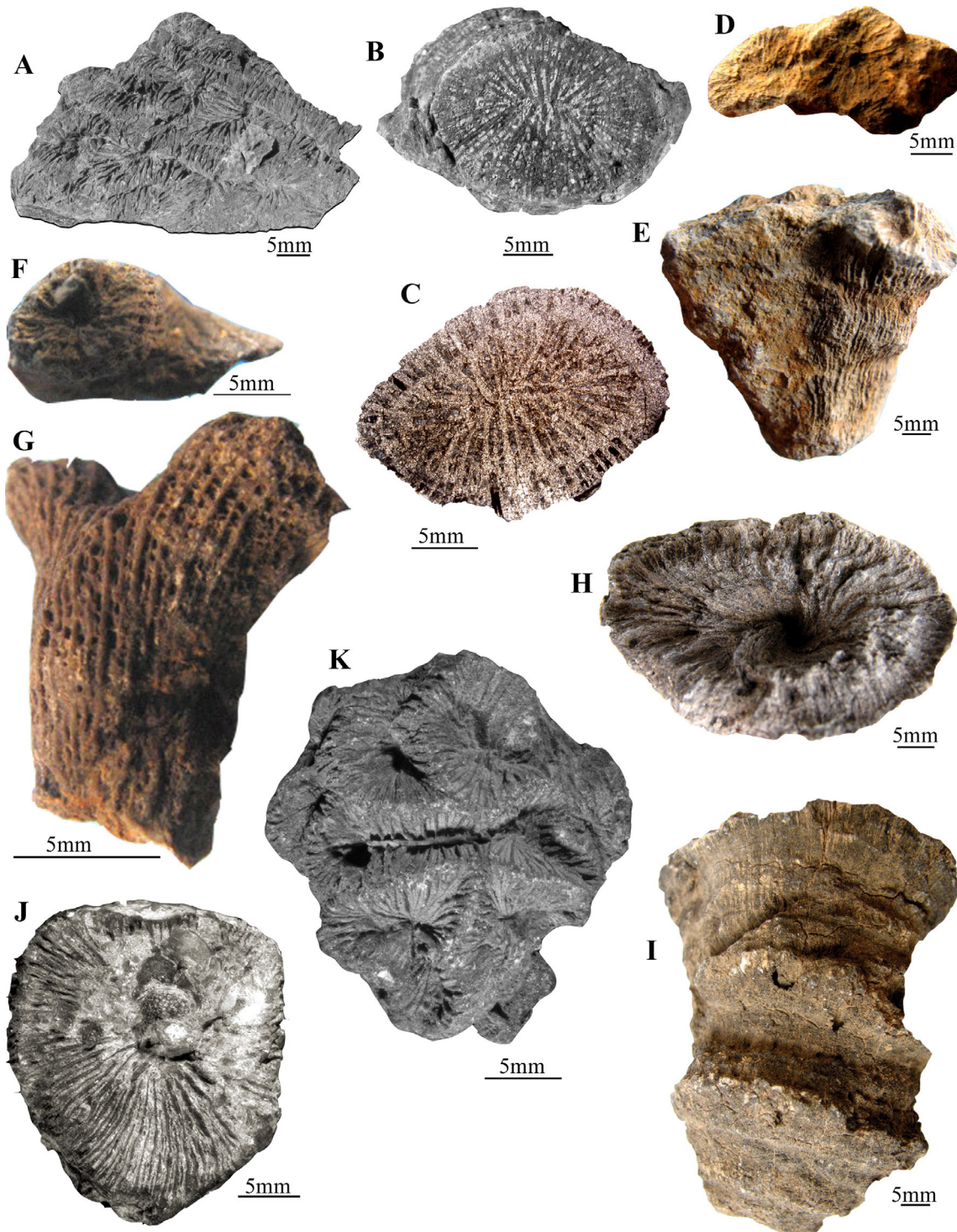


Figure 5 Biostratigraphic range of Late Triassic fauna from the Nayband Formation, Bagher Abad area, southwest of Ardestan.



**Figure 6** Scleractinian corals from the Nayband Formation, southwest of Ardestan, Iran. (A) *Oedalmia norica* (Frech, 1890) SH-PNUIC08424, Biostrome 2, Section C, Dizlu area. Colony in calicular view. (B-E) *Retiophyllia norica* (Frech, 1890). (B, C) SH-PNUIC08466, Biostrome 2, Section C, Dizlu area. (B) Colony in calicular view. (C) Colony in transverse section. (D, E) SH-PNUIC08428, Biostrome 2, Section B, Bagher Abad area. (D) Colony in calicular view. (E) Colony in side view. (F, G) *Retiophyllia clathrata* (Emmrich, 1853). SH-PNUIC08429, Biostrome 1, Section C, Dizlu area. (F) Colony in calicular view. (G) Colony in side view. (H, I) *Distichophyllia* cf. *norica* (Frech, 1890) SH-PNUIC08426, Biostrome 1, Section C, Dizlu area. (H) Corallum in calicular view. (I) Corallum in side view. (J) *Procycolites triadicus* (Frech, 1890). SH-PNUIC08401, Biostrome 1, Section C, Dizlu area. Corallum in calicular view. (K) *Distichomeandra* cf. *austriaca* (Frech, 1890). SH-PNUIC08432, Biostrome 2, Section C, Dizlu area. Colony in calicular view.

2001 *Cuifia gigantella* MELNIKOVA, p. 42, pl. 10, figs. 1, 2

**Material:** One specimen (SH-PNUICO8406) from Biostrome 2, Section C, Dizlu area. Measurements (in mm):

Number	D	H	S	S/5mm
SH-PNUICO8406	34×45	28	168(14+14+28+112)	6

**Description:** Corallum solitary, low-conical in shape, calice circular, slightly deepened, septa of the first size order thick and high, granulation on septal faces. Septa arranged into 4 size orders: the septal blades of the S1 septa continue to axial cavity, septal blades of the S2 septa are half of the S1 septa in thickness, the S3 septa are thinner and shorter than the S2 septa, and septal blades of the S4 septa are thin and the shortest of all. Wall epithelial, thick, partly destroyed.

**Occurrence:** Late Triassic, Rhaetian, Howze-Khan Member, Dizlu, southwest of Ardestan, Central Iran.

The species is known from the Norian–Rhaetian of the Pamir Mountains.

*Cuifia elliptica* MELNIKOVA, 1975

Figures 7C to 7F

1975 *Cuifia elliptica*: MELNIKOVA, p. 84, pl. 14, figs. 3–5

1989 *Coryphyllia elliptica* (Melnikova): RONIEWICZ, p. 65, pl. 15, figs. 1, 2, 7

2001 *Cuifia elliptica* MELNIKOVA: MELNIKOVA, p. 43, pl. 11, figs. 2–4

**Material:** Two specimens (SH-PNUICO8405, 8407) from Biostrome 2, Section C, Dizlu area. Measurements (in mm):

Number	D	H	S	S/5mm
SH-PNUICO8405 (adult)	21×24	47	92	9
juvenile	12×16	3.5		11-12
SH-PNUICO8407	35×43	41	96	7

**Description:** The specimen SH-PNUICO8405 is characterized by size and form, typical of *C. elliptica*. The longest septa of two size orders reach to the center: the S1 septa continue to the axial fossa, septal blades of the S2 septa are slightly shorter and thinner than the S1 septa; other septa are shorter depending on the order. Epitheca is destroyed. This corallum developed in variable environmental conditions, which resulted in formation of superposed stages of rejuvenation. At the rejuvenated stage, the wall is very thick.

**Occurrence:** Late Triassic, Rhaetian, Howze-Khan Member, Dizlu, southwest of Ardestan, Central Iran.

The species is known from the Norian–Rhaetian of the Pamir Mountains.

Family Reimaniphyllidae MELNIKOVA, 1975

Genus *Distichophyllia* CUIF, 1974

Type species: *Montlivaltia norica* FRECH, 1890

*Distichophyllia* cf. *norica* (FRECH, 1890)

Figures 6H and 6I

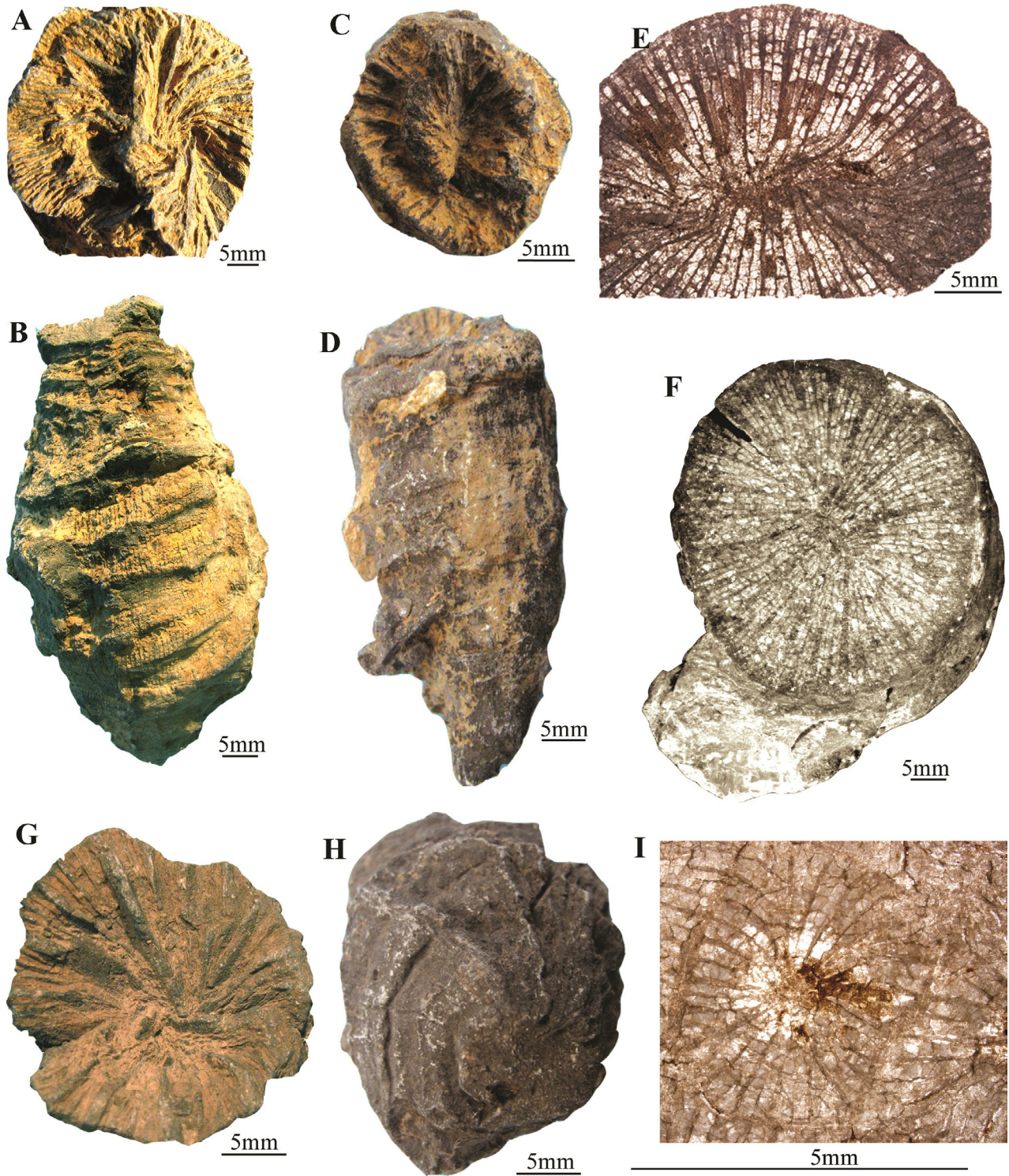
**Material:** Two specimens (SH-PNUICO8426, 8427) from Biostrome 1, Section C, Dizlu area. Measurements (in mm):

Number	GCD	LCD	H	S	S/5mm
SH-PNUICO8426	51	29	59	156	7-8
SH-PNUICO8427	48	40	45	156	7-8

**Description:** The coral is similar in general features to *Distichophyllia norica* (Frech, 1890), but its state of preservation does not allow for detailed examination of specific features of the skeleton. Septa may reach to the axial cavity. Radial elements are differentiated into at least 3 size orders, from which the septa S1 reach to the calicular fossa, Endotheca is vesicular. Epitheca is destroyed.

**Occurrence:** Late Triassic, Norian–Rhaetian, Bidestan Member, Dizlu, southwest of Ardestan, Central Iran.

Frech (1890) described *Montlivaltia norica* from Grosser Zlambachgraben (holotype), Hallstätter



**Figure 7** Scleractinian corals from the Nayband Formation, southwest of Ardestan, Central Iran, Iran. (A, B) *Cuifia columnaris* (Roniewicz, 1996). SH-PNUICO8408, Biostrome 2, Section C, Dizlu area. (A) Corallum in calicular view. (B) Corallum in side view. (C–F) *Cuifia elliptica* (Melnikova, 1975). (C–E) SH-PNUICO8405, Biostrome 2, Section C, Dizlu area. (C) Corallum in calicular view. (D) Corallum in side view. (E) Corallum in transverse section. (F) SH-PNUICO8407, Biostrome 2, Section C, Dizlu area. Corallum in calicular view. (G, H) *Cuifia gigantella* (Melnikova, 1975). SH-PNUICO 8406, Biostrome 2, Section C, Dizlu area. (G) Corallum in calicular view. (H) Corallum in proximal view. (I) *Kompsasteria oligocystis* (Frech, 1890). SH-PNUICO8433, Biostrome 2, Section C, Dizlu area. Colony in transverse section.

Salzberg and Scharitzkehlalp. According to Roniewicz (1989) the species is present in the Rhaetian of the Northern Calcareous Alps: in the Zlambach Beds of Fischerwise, Kesselwand-Rohrmoos, and Schneckengraben. Species common in the European and Asiatic parts of Tethys, and according to Stanley (1986), present in the Norian of North America.

Genus *Retiophyllia* CUIF, 1966

Type species: *Retiophyllia frechi* Roniewicz, 1989

*Retiophyllia norica* (FRECH, 1890)

Figures 6 B to 6E

1890 *Thecosmilia norica*:FRECH, p. 9, pl. 1, figs. 14–24 (non pl. 10, fig 6)

1989 *Retiophyllia norica* (FRECH): RONIEWICZ, p. 52, pl. 8, figs. 5–8; pl. 9, fig. 2; pl. 14, figs. 1, 2

**Material:** Two specimens (SH-PNUICO8466, SH-PNUICO8467) from Biostrome 2, Section C, Dizlu area and one specimen (SH-PNUICO8428) from Biostrome 2, Section B, Bagher Abad area. Measurements (in mm):

Number	D	H	d	S	S/3mm	Observations
SH-PNUICO8466	13.5×21	51	14×13	105(19+16+40+30)	8	before bifurcation
				78(15+12+16+34)	7	juvenile
SH-PNUICO8467	13×37.8	43.3	12.7×17	90	7	before bifurcation
				84	6-7	juvenile
SH-PNUICO8428	15×33	35.7	12×15	79	7-8	before bifurcation
				68		juvenile

**Description:** Corallum phaceloid. The specimen SH-PNUICO8426 shows corallites bifurcating with obtuse angle. Septa fusiform, differentiated into 3–4 orders. Septal blades of S1 septa continue to the center, the remaining septa are shorter in the order.

**Occurrence:** Late Triassic, Rhaetian, Howz-e-Khan Member, Dizlu and Bagher Abad, southwest of Ardestan, Central Iran.

The species is known from the Rhaetian of the Northern Calcareous Alps: Zlambach Beds of

Fischerwise and Zlambachgraben (Frech, 1890; Roniewicz, 1989). Stanley (1986) mentioned this species in the Norian of North America.

*Retiophyllia clathrata* (EMMRICH, 1853)

Figures 6F to 6G

1853 *Lithodendron clathratum*: EMMRICH, p. 78  
1890 *Thecosmilia clathrata* EMMRICH: FRECH, p. 15, pl. 4, figs. 1–5, 7–11

1974 *Retiophyllia clathrata* (Emmrich): RONIEWICZ, p. 108, pl. 4, fig. 1, pl.5, figs. 3, 7

**Material:** Two specimens (SH-PNUICO8429 and SH-PNUICO8430) from Biostrome 1, Section C, Dizlu area. Measurements (in mm):

Number	D	H	d	S	S/3mm
SH-PNUICO8429	7.4×9.6	18.4	5.4×8	30	8
SH-PNUICO8430	7.4×12.4	21.5	6.4×6.4	70	14

**Description:** The specimen SH-PNUICO8430 is characterized by phaceloid corallum, corallites bifurcating or trifurcating. The species shows a simple division of septal apparatus. Ornamentation is granular. Septa are differentiated into 2–3 size orders. Dissepiments are vesicular.

**Occurrence:** Late Triassic, Norian–Rhaetian, Bidestan Member, Dizlu, southwest of Ardestan, Central Iran.

The species is characteristic for the Rhaetian of the Alps and Carpathians. Similar corals under different specific names were described from the Norian of North America (*Calamophyllia suttonensis* in Clapp & Shimer, 1911; *Thecosmilia fenestrata* (Reuss) in Smith, 1927, and from South America (*Thecosmilia* sp. indet in Maeda *et al.*, 1974).

Genus *Oedalmia* CUIF, 1976

Type species: *Thamnastraea norica* FRECH, 1890

*Oedalmia norica* (FRECH, 1890)

Figure 6A

1890 *Thamnastraea norica* nov. sp.: FRECH, p. 63, pl. 17, figs. 1–6

1989 *Oedalmia norica* (FRECH, 1890): RONIEWICZ, p. 62, pl. 15, figs. 3–6

**Material:** One specimen (SH-PNUICO8424) from Biostrome 2, Section C, Dizlu area. Measurements (in mm):

Number	D of colony	H of colony	d	c-c	S	S/2mm
SH-PNUICO8424	34×54	9	9×11.6	6-7	38(10+10+18)	5

**Description:** The specimen represents a laminar colony, with simple calicular series paralleling the colony margin. There is mixing of thamnasteroid and meandroid form. In the series, calices are linked by simple bisepal blades. In the calice, axial cavity is fissure-like. The septa are arranged into 3 size orders: septal blades of the S1 septa continue to axial cavity, the S2 septa are thinner and slightly shorter than S1 septa, septal blades of the S3 septa are short and thin.

**Occurrence:** Late Triassic, Rhaetian, Howze-Khan Member, Dizlu, Southwest of Ardestan, Central Iran.

The species is known from the Rhaetian of the Northern Calcareous Alps: Zlambach Beds of Fischerwise, Kesselwand-Rohrmoos (Frech, 1890; Roniewicz, 1989).

Family Margarophylliidae CUIF, 1977

Genus *Margarophyllia* VOLZ, 1896

Type species: *Montivaltia capitata* Münster, 1841

**Remarks:** Three taxa have been here attributed with a reserve to the genus *Margarophyllia* known up to now from the late Carnian.

*Margarophyllia* cf. *capitata* (MÜNSTER, 1841)

Figures 8H and 8I

**Material:** Four specimens (SH-PNUICO8411, 8415, 8417, 8420) from Biostrome 1, and 2 specimens (SH-PNUICO8421 and 8422) from

Biostrome 2, Section C, Dizlu area. Measurements (in mm):

Number	GCD	LCD	H	S	S/5 mm
SH-PNUICO8411	16	10	28	96	11
SH-PNUICO8415	12	12	18	84	13-14
SH-PNUICO8417	13.7	12	21	96	9
SH-PNUICO8420	10	6	15	84	15
SH-PNUICO8421	18	17	19	108	10
SH-PNUICO8422	15	13	16	116	14

**Description:** Corallum solitary, conical, slightly curved proximally, subcircular in section, with short calicular fossa. Calice ellipsoid and deep. Septa spindle-like, differentiated into several size orders. The S1 septa are the thickest, reach to the calicular fossa with their axial margins, which dissociate into fragments. Septal blades of the S2 septa are shorter and slightly thinner than the S1 septa, the septa S3 are longer than half the length of the S1 septa. Other septal features: lateral flat granulation and denticulation on distal edge can be observed. Endotheca vesicular, built of small dissepiments. Epithelial wall pellicular and fragile, the best preserved proximally.

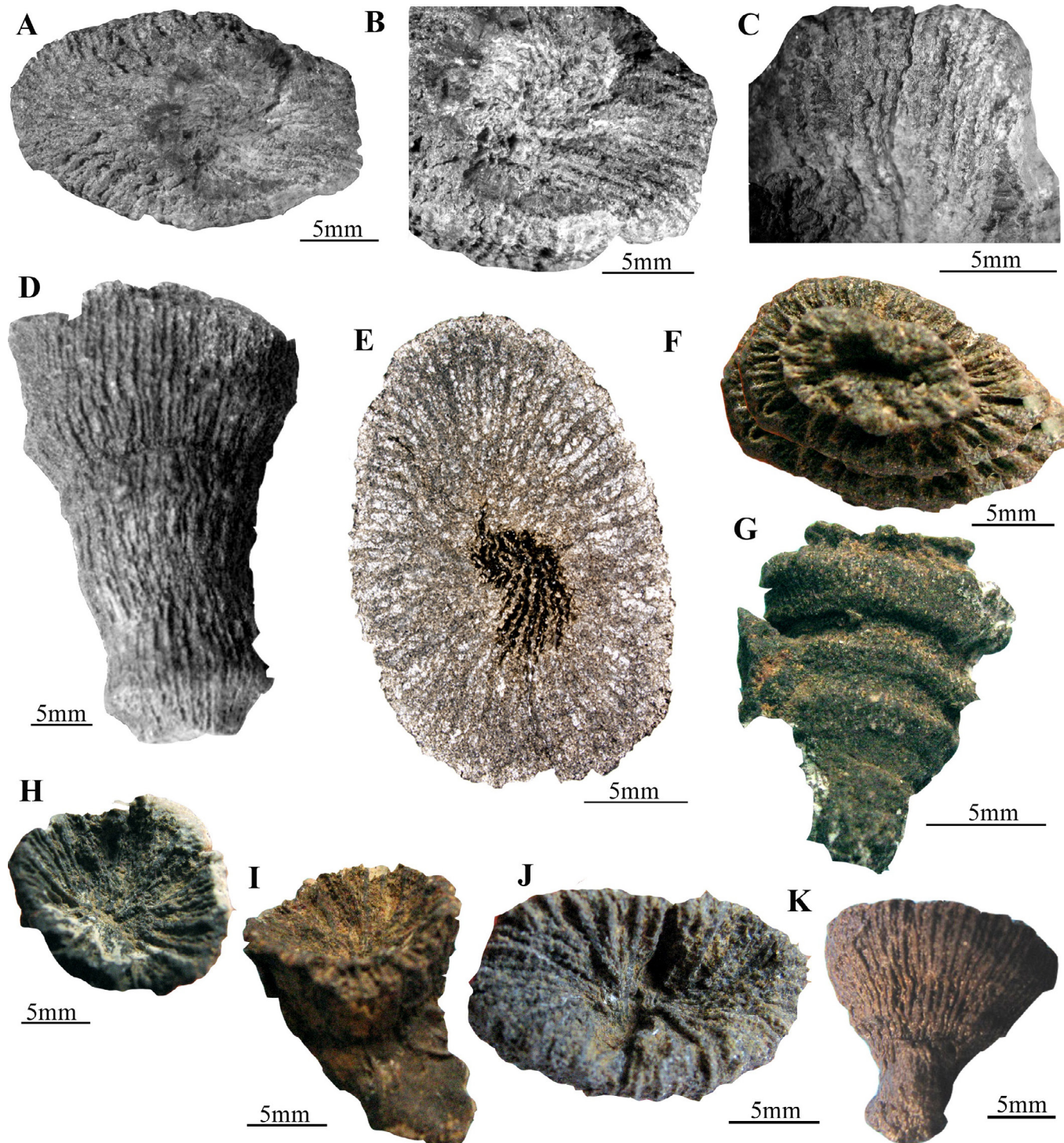
**Occurrence:** Late Triassic, Norian–Rhaetian, Bidestan Member and Howze-Khan Member, Dizlu, southwest of Ardestan, Central Iran.

*Margarophyllia* cf. *crenata* (MÜNSTER, 1841)

Figures 8A to 8G

Number	GCD	LCD	H	S	S/5 mm
SH-PNUICO8409	12	11	8	200	22
SH-PNUICO8410	18	11	18	132	13
SH-PNUICO8414	19	13	28	120	11
SH-PNUICO8418	26	21	24	120	12
SH-PNUICO8412	12	7	18	144	17
SH-PNUICO8419	9	7.6	14	144	30

**Description:** Corallum solitary, conical in shape slightly curved proximally. Calice circular to ellipsoid, from slightly deepened to shallow, with short calicular fossa. Septa thin, spindle-like,



**Figure 8** Scleractinian corals from the Nayband Formation, southwest of Ardestan, Central Iran, Iran. (A-G) *Margarophyllia* cf. *crenata* (Münster, 1841). SH-PNUICO8414, Biostrome 1, Section C, Dizlu area. (A) Corallum in calicular view. (B) Corallum in microstructure view. (C) Corallum in microstructure view. (D) Corallum in side view. (E) Corallum in transverse section. (F, G) SH-PNUICO8412, Biostrome 1, Section C, Dizlu area. (F) Corallum in calicular view. (G) Corallum in side view. (H, I) *Margarophyllia* cf. *capitata* (Münster, 1841) SH-PNUICO 8415, Biostrome 1, Section C, Dizlu area. (H) Corallum in calicular view. (I) Corallum in side view. (J, K) *Margarophyllia* sp. SH-PNUICO8416, Biostrome 1, Section C, Dizlu Area. (J) Corallum in calicular view. (K) Corallum in side view.

differentiated into 3 size orders. The S1 septa continue to the calicular fossa and their axial margins dissociate into fragments; the S2 septa are shorter; the S3 septa are longer than half the length of S2 septa. Granulation on septal faces and denticulation of distal septal margin can be observed. Endotheca vesicular, made of small dissepiments. Epitheca thin, generally preserved proximally, frequently destroyed.

**Occurrence:** Late Triassic, Norian–Rhaetian, Bidestan Member, Dizlu, southwest of Ardestan, Central Iran.

*Margarophyllia* sp.  
Figures 8J to 8K

**Material:** One specimen (SH-PNUICO8416) from Biostrome 1, Section C, Dizlu area. Measurements (in mm):

Number	GCD	LCD	H	S	S/5 mm
SH-PNUICO8416	16	9	16	72(36+36)	12

**Description:** Corallum solitary, conical in shape, calice ellipsoid, deep. Septa thick, with denticulation on the distal edge. Septal blade of the S1 septa reaching to axial cavity, septal blades of the S2 are shorter at about a half and thinner from the S1 septa. Septa of other orders are hardly identifiable. Endotheca made of small dissepiments. Lower part of the corallum is covered with epitheca but in the upper part of corallum, epitheca is destroyed.

**Occurrence:** Late Triassic, Norian–Rhaetian, Bidestan Member, Dizlu, southwest of Ardestan, Central Iran.

Genus *Distichomeandra* CUIF, 1976  
Type species: *Distichomeandra spinosa* Cuif, 1976  
*Distichomeandra austriaca* (FRECH, 1890)  
Figure 6K

**Material:** Two specimens (SH-PNUICO8431, 8432) from Biostrome 2, Section C, Dizlu area. Measurements (in mm):

Number	GCD of colony	LCD of colony	H of colony	d	e-c	S	S/3 mm
SH-PNUICO8431	60	40	50	18×12.5	9.5	58(14+14+30)	7
SH-PNUICO8432	25	20	14	8×9	5	60(15+15+30)	7

**Description:** The specimen SH-PNUICO8432 is characterized by polygonal, shallow and monocentric calices and some parts of colony with short calicular series. A new corallite appears as a new center in the extended portion of the adult. Septa thin, arranged into 3 size orders. Septal blades of the S1 septa are thick and continue to axial cavity, septal blades of the S2 septa are shorter and thinner than the S1 septa; the S3 septa are half of the S1 septa in length. Granules are present on the septal faces, they are round or elongate. Endotheca vesicular, concave.

**Remarks:** The coral resembles *D. austriaca* in the form of colony, mode of budding, and thick septa, but differs from it in larger diameters of corallites. Occurrence: Late Triassic, Rhaetian, Howz-e-Khan Member, Dizlu, southwest of Ardestan, Central Iran.

The species is known in the Rhaetian of the Northern Calcareous Alps, in the Zlambach Beds of the Gosaukamm region, and in Fischerwise (Roniewicz, 1989).

Family Cyclophyllidae RONIEWICZ, 1989  
Genus *Kompsasteria* RONIEWICZ, 1989

*Kompsasteria oligocystis* (FRECH, 1890)  
Figure 7I

1890 *Isastraea oligocystis*: FRECH, p. 24, pl. 5, figs. 8, 8 A, 8 b, 8 B  
1989 *Kompsasteria oligocystis* (FRECH, 1890): RONIEWICZ, p. 30, pl. 2, figs. 2, 3, pl. 3, figs. 1–5

**Material:** One sample from Biostrome 2 (SH-PNUICO8433), Dizlu area. Measurements (in mm):

Number	d	e-c	S	S/3
SH-PNUICO8433	13.5×20	11	76 (16+20+40)	8



**Description:** The specimen SH-PNUICO8433 is characterized by shallow, polygonal, monocentric calices and short, monoliner calicular series. A new corallite appear as a new center in the extended portion of the adult.

Septa thin, arranged into 3 size orders. Septal blades of S1 septa continue to axial cavity, septal blades of S2 septa are shorter and thinner than S1 septa, S3 septa are half of the S1 septa in length. Granules are present on the septal faces, they are round or elongate. Endotheca vesicular, endothecal surface is concave.

**Remarks:** With its very thin wall and septa, and large corallites, the coral answers to descriptions of *K. oligocystis*.

**Occurrence:** Late Triassic, Rhaetian, Howze-Khan Member, Dizlu, southwest of Ardestan, Central Iran.

The species is known from the Zlambach Beds of Schnecken graben and Kesselwand-Rohrmoos in the Northern Calcareous Alps (Roniewicz, 1989).

Family Procycolitidae Vaughan, and Wells, 1943

Genus *Procycolites* FRECH, 1890

Type species: *Procycolites triadicus* FRECH, 1890

*Procycolites triadicus* FRECH, 1890

Figure 6J

1890 *Procycolites triadicus*: FRECH, p. 64, pl. 18, figs. 1–16, text-fig. p. 65

1989 *Procycolites triadicus* FRECH: RONIEWICZ, p. 85, pl. 23, figs. 1–3, pl. 24, figs 1, 2

**Material:** One specimen (SH- PNUICO 8401) from Biostrome 1, Section C, Dizlu area.

Measurements (in mm):

Number	GCD	LCD	H	S	S/3mm
SH-PNUICO8401	26	21	36	144	10

**Description:** Calice slightly concave. Radial elements thin, numerous, equal in thickness. Lateral faces covered by menianes.

**Occurrence:** Late Triassic, Norian–Rhaetian, Bidestan Member, Dizlu, southwest of Ardestan, Central Iran.

The species is known in the Rhaetian of the Northern Calcareous Alps: in the Zlambach Beds of Fischerwise and Kesselwand-Rohrmoos (Roniewicz, 1989); reported from Halstatter Salzberg and Zlambachgraben (Frech, 1890).

Family *Astraeomorpha* FRECH, 1890

Genus *Astraeomorpha* REUSS, 1854

Type species: *Astraeomorpha crassisepta* REUSS, 1854

*Astraeomorpha crassisepta* REUSS, 1854

Figures 10A and 10B

1854 *Astraeomorpha crassisepta*: REUSS, p. 127, pl. 16, figs. 4–7

1890 *Astraeomorpha crassisepta* REUSS: FRECH, p. 66, text-fig. on p. 70, pl. 19, figs. 14–18

1980 *Astraeomorpha crassisepta* REUSS: SENOW-BARI-DARIAN, p. 38, pl. 2, fig. 3

1986 *Astraeomorpha crassisepta* REUSS:

MELNIKOVA, p. 56, pl. 20, figs. 1–3, pl. 21, fig. 2

1989 *Astraeomorpha crassisepta* REUSS: RONIEWICZ, p. 94, pl. 28, figs. 3–5

**Material:** One specimen (SH-PNUICO8425) from Biostrome 1, Section C, Dizlu area.

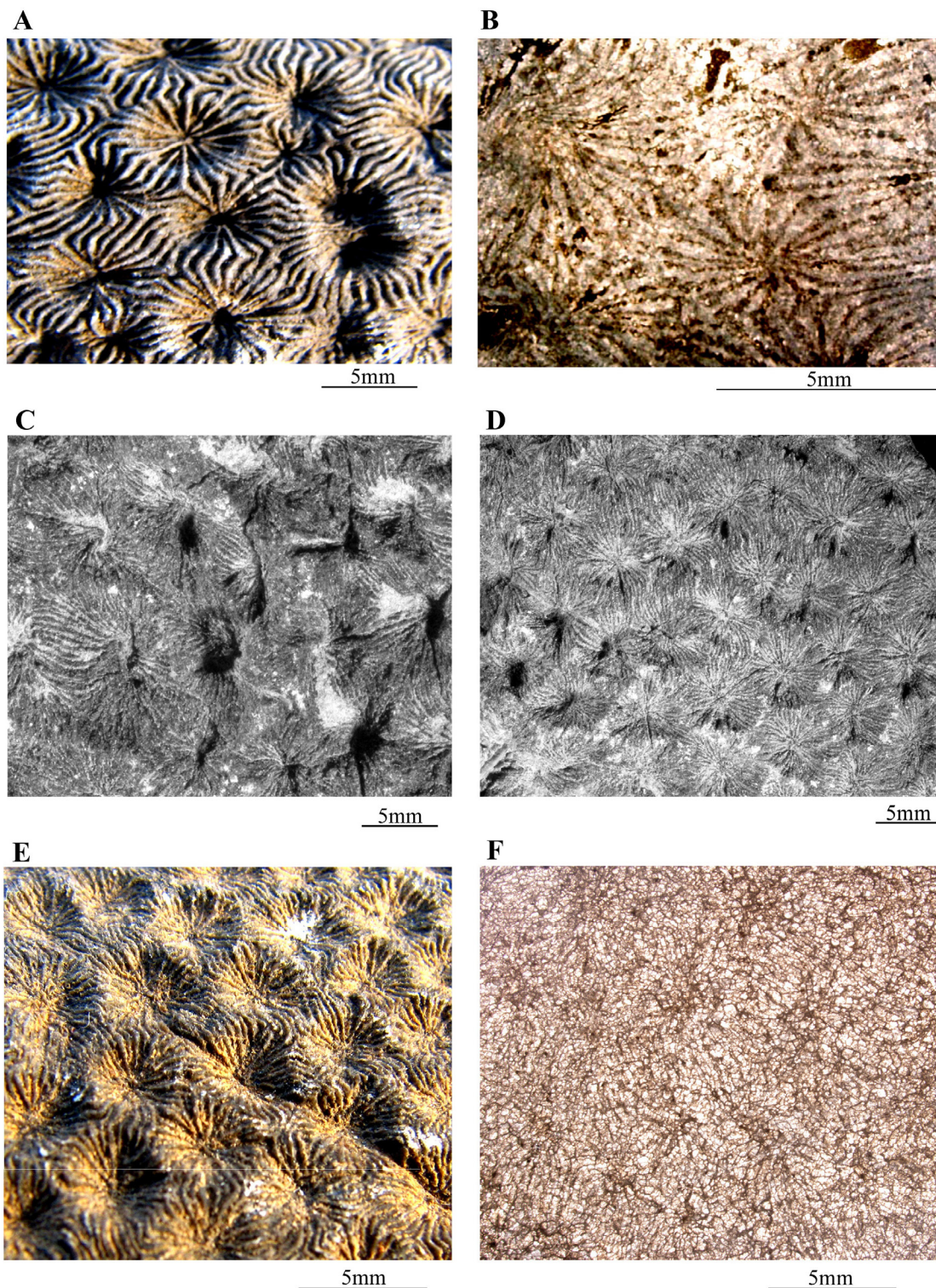
Measurements (in mm):

Number	D of colony	H of colony	d	e-c	S	S/1mm
SH-PNUICO8425	15×25	28	1.5×2	1.6-2	10	3-4

**Description:** Colony thamnasteroid, columnar in shape, septa not abundant, septal density low, endotheca formed by thin and vesicular dissepiments.

**Occurrence:** Late Triassic, Norian–Rhaetian, Bidestan Member, Dizlu, Southwest of Ardestan, Central Iran.

The species is present in the Norian and Rhaetian of the Northern Calcareous Alps: Zlambach Beds of Fischerwise, vicinity of Gosaukamm,



**Figure 9** Scleractinian corals from the Nayband Formation, southwest of Ardestan, Central Iran, Iran. (A, B) *Pamiroseris rectilamellosa* (Winkler, 1861). (A) SH-PNUICO8449, Biostrome 2, Section B, Bagher Abad area. Colony in calicular view. (B) SH-PNUICO8450, Biostrome 2, Section B, Bagher Abad area. Colony in transverse section. (C, D) *Pamiroseris multiseptata* (Melnikova, 1975). (C) SH-PNUICO8457, Biostrome 2, Section B, Bagher Abad area. Colony in calicular view. (D) SH-PNUICO8458, Biostrome 2, Section C, Dizlu area. Colony in calicular view. (E, F) *Pamiroseris meriani* (Stoppani, 1858-1860). SH-PNUICO8462, Biostrome 2, Section C, Dizlu area. (E) Colony in calicular view. (F) Colony in transverse section.

Zlambachgraben, Hallstätter Salzberg and Scharitzkehralp; Rhaetian limestones of Tyrol; Rhaetian of the Southern Alps (Lombardy); Norian–Rhaetian of the Caucasus, Central Asia; Timor and NE Asia (Roniewicz, 1989). According to Stanley (1986), it is present in the Norian of North America.

*Astraeomorpha confusa* (WINKLER, 1861)  
Figures 10C and 10D

1861 *Thamnastraea confusa*: WINKLER, p. 488, pl. 8, fig. 10

1890 *Astraeomorpha confusa* WINKLER: FRECH, p. 67, pl. 19, figs. 2, 3, 5, 6, 8, 10, 13

1979 *Astraeomorpha confusa* (WINKLER): SCHÄFER, p. 46, pl. 10, fig. 3

1980 *Astraeomorpha confusa* (WINKLER): KRISTIAN-TOLLMANN, TOLLMANN and HAMEDANI, p. 171, pl. 4, fig. 3

1986 *Astraeomorpha confusa* (WINKLER): MELNIKOVA, p. 57, pl. 20, fig. 4, pl. 21, fig. 1  
1989 *Astraeomorpha confusa* WINKLER: RONIEWICZ, p. 96, pl. 28, figs. 1, 2; pl. 29, figs. 1–3

**Material:** One specimen (SH-PNUICO8445) from Biostrome 2, Section C, Dizlu area. Measurements (in mm):

Number	D of colony	H of colony	d	e-c	S	S/1 mm
SH-PNUICO8445	20×22	15	1.8×2.2	1.5-2	18	4-5

**Description:** Thamnasterioid, fungiform; calices arranged in several series. In the intercalicular zone, septa are subparallel. Columella present, synapicalae numerous, dissepiments thin.

**Occurrence:** Late Triassic, Rhaetian, Howz-e-Khan Member, Dizlu, southwest of Ardestan, Central Iran.

The species is common in the Norian and Rhaetian of the Alps, Caucasus, Central Asia, and Timor (Roniewicz, 1989). Kristian-Tollmann *et al.* (1980) reported it from the Rhaetian of Iran. According to Stanley (1986) it is present in the Norian of North America.

Genus *Chondrocoenia* RONIEWICZ, 1989  
Type species: *Prionastraea schafhaeutli* WINKLER, 1861

*Chondrocoenia schafhaeutli* (WINKLER, 1861)  
Figures 10E to 10G

1861 *Prionastraea? Schafhaeutli*: WINKLER, p. 488, pl. 8, fig. 11

1890 *Stephanocoenia schafhäutli* WINKLER: FRECH, p. 37, text-fig. on p. 36 (A, B) and two text-figs. on p. 37

1980 *Stephanocoenia schafhaeutli* FRECH: SENOW-BARI-DARYAN, p. 41, pl. 5, fig. 1

1980 *Astrocoenia schafhaeutli* (WINKLER): KRISTIAN-TOLLMANN, TOLLMANN and HAMEDANI, p. 169, pl. 1, figs. 1–4

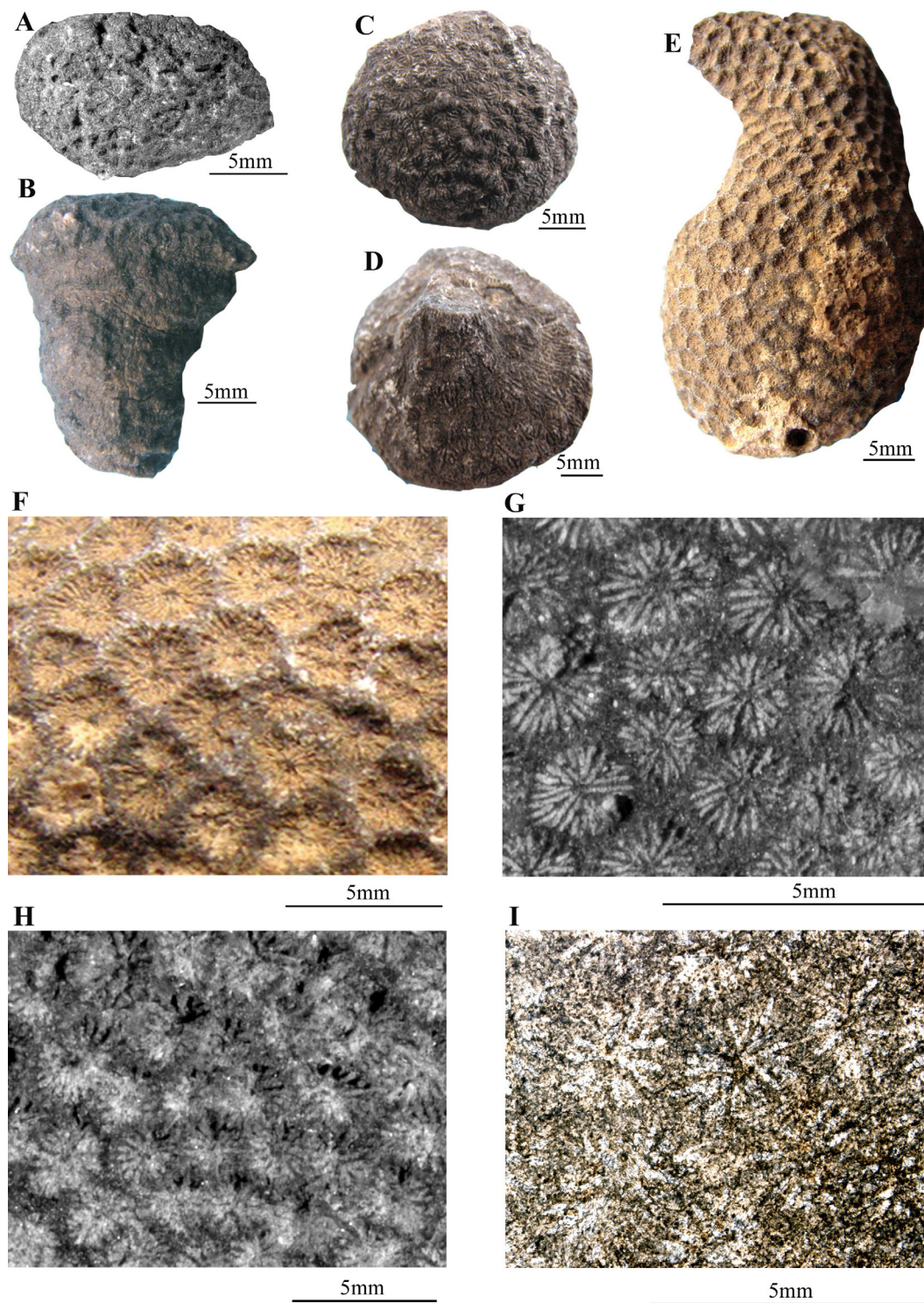
1989 *Chondrocoenia schafhaeutli* (WINKLER): RONIEWICZ, p. 104, pl. 33, figs. 1–3, 5

**Material:** Tree specimens (SH-PNUICO8442, 8443, 8445) from Biostrome 2, Section B, Bagher Abad area, and two specimens (SH-PNUICO8444, 8446) from Biostrome 2, Section C, Dizlu area. Measurements (in mm):

Number	GCD of colony	LCD of colony	H of colony	d	e-c	S	S/1mm
SH-PNUICO8442	20	16	21	2.5×2	2.5	24-25	5
SH-PNUICO8443	38	21	31	2.3×2.5	2.2	25	5-6
SH-PNUICO8445	36	32	20	2×1.7	2	24	7
SH-PNUICO8446	52	45	16	2.1×2.2	2.1	24-25	6

**Description:** Colonies of plocoid type, lamellate or hemispherical in shape. Lamellate colonies may be large but hemispherical colonies are about 30 mm in diameters. Calices are shallow, polygonal or rounded, columella thin, styliiform and oval in form. Septa do not continue to the columella. New corallites appear between adult corallites. Ornamentation of the septal faces granular. Septa arranged into 2 size orders. The S1 septa approach near to the collumela; the S2 septa are shorter than the S1. Endotheca dissepimental, wall thin.

**Occurrence:** Late Triassic, Rhaetian, Howz-e-Khan Member, Dizlu and Howz-e-Khan



**Figure 10** Scleractinian corals from the Nayband Formation, southwest of Ardestan, Central Iran, Iran. (A, B) *Astraeomorpha crassisepta* (Reuss, 1854). SH-PNUICO8425, Biostrome 1, Section C, Dizlu area. (A) Colony in calicular view. (B) Colony in side view. (C, D) *Astraeomorpha confusa* (Winkler, 1861). SH-PNUICO8445, Biostrome 2, Section C, Dizlu area. (C) Colony in calicular view. (D) Colony in proximal view. (E-G) *Chondrocoenia schafhaeutli* (WINKLER, 1861). E, F. SH-PNUICO8444, Biostrome 2, Section C, Dizlu area. (E) Colony in calicular view. (F) Detail of colony in calicular view. (G) SH-PNUICO8446, Biostrome 2, Section C, Dizlu area. Colony in calicular view. (H, I) *Crassistella juvavica* (Frech, 1890). (H) SH-PNUICO8436, Biostrome 1, Section C, Dizlu area. Colony in calicular view. (I) SH-PNUICO8438, Biostrome 2, Section C, Dizlu area. Colony in transverse section.

Member, Bagher Abad, southwest of Ardestan, Central Iran.

According to Roniewicz (1989), the species is present in the Rhaetian of the Northern Calcareous Alps: Zlambach Beds of Fischerwise and Kesselwand-Rohrmoos, Kössen Beds of Kothalpe and Voralpe near to Altenmarkt; Rhaetian of the Southern Alps (Lombardy); Rhaetian of the Carpathians; Norian–Rhaetian of the Pamirs and Afghanistan.

The species was described from the Rhaetian of Iran by Kristian-Tollmann et al. (1980). According to Stanley (1986), it is known from the Norian of North America.

Family Pamiroseriidae MELNIKOVA, 1984

Genus *Pamiroseris* MELNIKOVA, 1971

Type species: *Thamnastraea meriani* STOPPANI, 1860

*Pamiroseris meriani* (STOPPANI, 1860)  
Figures 9E and 9F

1858-1860 *Thamnastraea meriani*: STOPPANI, p. 108, pl. 26, figs. 3–6

1971 *Pamiroseris meriani* (STOPPANI):  
MELNIKOVA, p. 34, pl. 2, fig. 2

2001 *Pamiroseris meriani* (STOPPANI):  
MELNIKOVA, p. 74, pl. 19, figs. 2–4, pl. 24, fig. 4

**Material:** Five specimens (SH- PNUICO 8459, 8460, 8461, 8463, 8464) from Biostrome 2, Section B, Bagher Abad area. Two specimens (SH-PNUICO8462, 8465) from Biostrome 2, Section C, Dizlu area. Measurements (in mm):

Number	GCD of colony	LCD of colony	H of colony	d	e-c	S	S/1 mm
SH- PNUICO8459	49	40	19	4.8×4.5	4-5	44-46	4
SH- PNUICO8460	22.3	20	13	4.4×5	3.5-4	40	5
SH- PNUICO8461	69	60	21	3×4	3.5-4.5	31	5-6
SH- PNUICO8462	60	50	16	4.5×3.5	2.5-3.8	42-44	4-5
SH- PNUICO8463	36	32	30	3×3.6	3.5-4.5	40	4-5
SH- PNUICO8464	33	2	16	5.5×6.6	4.5	48	4
SH- PNUICO 8465							
adult	26	20	19	5×4.5	6.3	55	5
juvenile					4.2	40	4

**Description:** Thamnasterioid colonies, flat or fungi-form with a small trunk, shallow calices, thick wall, granulation on septal faces, denticulation on distal edge of septa. Columella well developed.

**Occurrence:** Late Triassic, Rhaetian, Howz-e-Khan Member, Dizlu and Howz-e-Khan Member, Bagher Abad, southwest of Ardestan, Central Iran. This species was described from the Rhaetian of the Alps and Pamirs (Roniewicz, 1989).

*Pamiroseris rectilamellosa* (WINKLER, 1861)  
Figures 9A, 9B and Figures 14A to 14F

1861 *Thamnastraea rectilamellosa*: WINKLER, p. 487, pl. 8, fig. 7

1890 *Thamnastraea rectilamellosa* WINKLER:  
FRECH, p. 60, text-fig. on p. 61, pl. 16, figs. 1–15

1979 *Thamnasteria rectilamellosa* WINKLER:  
SCHÄFER, p. 46, pl. 1, fig. 3

1980 *Thamnasteria rectilamellosa* (WINKLER):  
KRISTAN-TOLMANN, TOLLMANN and  
HAMEDANI, p. 169, pl. 2, figs. 1–3

1986 *Pamiroseris rectilamellosa* (WINKLER):  
MELNIKOVA, p. 63, pl. 25, figs. 1, 2, pl. 26, fig. 1

1989 *Pamiroseris rectilamellosa* (WINKLER):  
RONIEWICZ, p. 111, pl. 34, figs. 3–5

**Material:** Four specimens (SH- PNUICO 8446-8449) from Biostrome 2, Section B, Bagher Abad area. Six specimens (SH-PNUICO8450-8455) from Biostrome 2, Section C, Dizlu area. Measurements (in mm):

Number	GCD of colony	LCD of colony	H of colony	d	e-c	S	S/1 mm
SH-PNUICO8446	44	43	30	7×6.7	6	28	4
SH-PNUICO8447	28	26	17	4.8×5	4.2	27	3
SH-PNUICO8448	36	36	27	3.8×5.3	3.5	28-30	3
SH-PNUICO8449	38	31	19	4.5×4.3	4.8	28	3
SH-PNUICO8450	48	43	25	4.5×5	5.4	21	3
SH-PNUICO8451	42	33	28	3.9×4.5	5.2	30-37	5
SH-PNUICO8452	50	38	40	5×4.5	5-6	28	4-5
SH-PNUICO8453	19	15	1	3.5×3.3	4.8	22-26	3
SH-PNUICO8454	36	28	20	4×3.4	3.8	18-23	3
SH-PNUICO8455	63	63	33	8×9	5.6	32-44	3

**Description:** Thamnasteroid colonies, septa are sigmoid or straight in form. On the internal edge, trabecular denticles are present. Septa arranged into 2–3 orders. The S1 septa are long and thick, the S2 septa are short. Septal faces are covered by circular and flat granules. At the margin of colonies, corallites are arranged in series but at the center of colonies, the corallite arrangement is homogeneous. New centers appear between calices and then septal apparatuses of new corallites are organized. In the periaxial ring, endotheca is depressed while at the center of corallite it is convex. No distinct features of primary microstructure (calcification centers/fibers) are recognizable in the skeleton. However, in cathodoluminescence, the septal regions are much darker in comparison to interseptal deposits (strong red luminescence). Although septal structure is clearly diagenetically altered, secondary, Mn-enriched deposits (showing strong red-luminescence) were formed in interseptal spaces (Figures 14A to 14F).

**Occurrence:** Late Triassic, Rhaetian, Howz-e-Khan Member, Dizlu and Howz-e-Khan Member, Bagher Abad, southwest of Ardestan, Central Iran.

The species is common in the Rhaetian of the Northern Calcareous Alps: in Hallstätter Salzberg, Oedalm, Zlambachgraben (Frech, 1890), in Zlambach Beds of Fischerwise, Dachsteinkalk of the Donnerkogels, Dachsteinkalk and the Hochfelten, Rhaetian of the Voralpe near Altenmarkt, Kothalpe; in the Rhaetian of the Tatra Mountains, and in the Norian–Rhaetian of the Caucasus and Pamirs (Roniewicz, 1989). The species is known from the Rhaetian of Iran by Kristian-Tollmann *et al.* (1980).

*Pamiroseris multiseptata* (MELNIKOVA, 1967)  
Figures 9C and 9D

1967 *Fungiastraea multiseptata*: Melnikova, p. 24,  
pl. 2, fig. 3

1975 *Pamiroseris multiseptatum* Melnikova:  
MELNIKOVA, p. 131, pl. 30, figs. 1, 2

2001 *Pamiroseris multiseptata* Melnikova:

MELNIKOVA, p. 75, pl. 19, fig. 5, pl. 22,  
fig. 3, pl. 24, fig. 3

**Material:** One specimen (SH-PNUICO8457) from Biostrome 2, Section B, Bagher Abad area. Two specimens (SH-PNUICO8456, 8458) from Biostrome 2, Section C, Dizlu area. Measurements (in mm):

Number	GCD of colony	LCD of colony	H of colony	d	c-e	S	S/1 mm
SH-PNUICO8456	28	24	15	6×5	5.5	54	5
juvenile					4.2	50	
SH-PNUICO 8457	62	32	28	3.8×5.5	5.5	60	5
juvenile					3.5	50	
SH-PNUICO8458	63	50	22	4.6×5.7	5	49	4-5

**Description:** Thamnasteroid colonies, flat or fungi-form with a small trunk, shallow calices, and thick wall. Corallites have many septa of sigmoid or straight form, and they are larger than corallites in *Pamiroseris rectilamellosa*.

**Occurrence:** Late Triassic, Rhaetian, Howz-e-Khan Member, Dizlu and Bagher Abad, southwest of Ardestan, Central Iran.

The species is known from the Rhaetian of the Pamirs (Roniewicz, 1989).

Genus *Crassistella* RONIEWICZ, 1989

Type species: *Stephanocoenia juvavica* FRECH, 1890

*Crassistella juvavica* (FRECH, 1890)

Figures 10H and 10I

1890 *Stephanocoenia juvavica*: FRECH, p. 38, the left text-fig. on p. 38

1980 *Actinastraea juvavica* (FRECH): SENOW-BARI-DARYAN, p. 42, pl. 5, fig. 3

1989 *Crassistella juvavica* FRECH: RONIEWICZ, p. 113, pl. 34, figs. 1, 2, pl. 35, figs. 1, 2

**Material:** Four specimens (SH-PNUICO8434–8437) from Biostrome 1 and two specimens (SH-PNUICO8438, 8439) from Biostrome 2, Section C, Dizlu area. Two specimens (SH-PNUICO 8440, 8441) from Biostrome 2, Section B, Bagher Abad area. Measurements (in mm):

Number	GCD of colony	LCD of colony	H of colony	d	c-c	S	S/1 mm
SH-PNUICO8434	39	38	18	2.2×1.6	1.9	22	6-7
SH-PNUICO8435	38	31	12	1.6×1.9	1.3	22	6
SH-PNUICO8436	36	24	22	1.7×2	1.9	24-25	6
SH-PNUICO8437	30	22	12	2.3×2	2.1	24	6-7
SH-PNUICO8438	36	25	5	2.1×2.6	1.4	22	6-7
SH-PNUICO8439	35	33	22	1.7×2.6	1.7	25	7-8
SH-PNUICO8440	37	28	8	1.9×1.7	1.4	22	6-7
SH-PNUICO8441	31	23	12	1.9×2	1.6	30	7-8

**Description:** The species is characterized by flat and lamellate or massive and mamillate colonies. Mamillae grow up like columns. Calices are deep, columella small and wall is thick. Corallites increased by division into two juvenile corallites. Septal faces are ornamented with round granules. Septa are wedge-like, differentiated into 2–3 size orders, septal blades of the S1 septa and the S2 septa are subequal, they continue to columella. The S3 septa are half of the length of the S1 septa. Endotheca is formed of abundant, thin-walled vesicles, sub-horizontal or convex in the center of the corallite.

**Occurrence:** Late Triassic, Norian–Rhaetian, Bidestan and Howz-e-Khan Members, Dizlu and Rhaetian, Howz-e-Khan Member, Bagher Abad, southwest of Ardestan, Central Iran.

The species is known in the Rhaetian of the Northern Calcareous Alps: in the Zlambach Beds of Schneckengraben and Kesselwand-Rohrmoos; the Gruber Reef; dubious in Fischerwise; Norian–Rhaetian of the Pamirs and NE Asia (Roniewicz, 1989).

Family Stylophyllidae FRECH, 1890

Genus *Stylophyllopsis* FRECH, 1890

Type species: *Stylophyllopsis polyactis* FRECH, 1890 (designated by DIENER, 1921).

*Stylophyllopsis polyactis* FRECH, 1890

Figures 11A to 11I and 12A to 12F

1890 *Stylophyllopsis polyactis*: FRECH, p. 48, text-fig. on p. 49, pl. 12, fig. 3, pl. 15, figs. 17–23

1972 *Stylophyllopsis polyactis* FRECH: CUIF, p. 239, text-fig. 14 a–c

1989 *Stylophyllopsis polyactis* FRECH: RONIEWICZ, p. 124, pl. 36, figs. 6, 7, pl. 37, fig. 1, pl. 38, figs. 8, 9

**Material:** Eight specimens (SH-PNUICO8383, 8385, 8389, 8391, 8393, 8394, 8398, 8400) from Biostrome 2, Section C, Dizlu area and two specimens (SH-PNUICO8388, 8395) from Biostrome 2, Section B, Bagher Abad area. Measurements (in mm):

Number	GCD	LCD	H	S	S/5
SH-PNUICO8383	21	23	19	96	8
SH-PNUICO8385	16	15	9	72	12
SH-PNUICO8391	38	38	23	161	8
SH-PNUICO8395	24	18	31	176	8
SH-PNUICO8398	25	22	12	96	9
SH-PNUICO8394	27	24	3-4	124	7
SH-PNUICO8389	26	21	7	111	9
SH-PNUICO8388	24	20	19	168	9
SH-PNUICO8393	38	38	13	188	6
SH-PNUICO8400	16	14	21	160	10-11

**Description:** Corallum solitary, sub-cylindrical to conical in shape, with circular and shallow calice. Axial cavity filled with septal spines. Septa thin, arranged into 3–4 size orders. Septal blades of the S1 and S2 septa continue to the axial cavity. The S4 septa are the shortest of all. Wall thick.

**Occurrence:** Late Triassic, Rhaetian, Howz-e-Khan Member, Dizlu and Howz-e-Khan Bagher Abad, southwest of Ardestan, Central Iran.

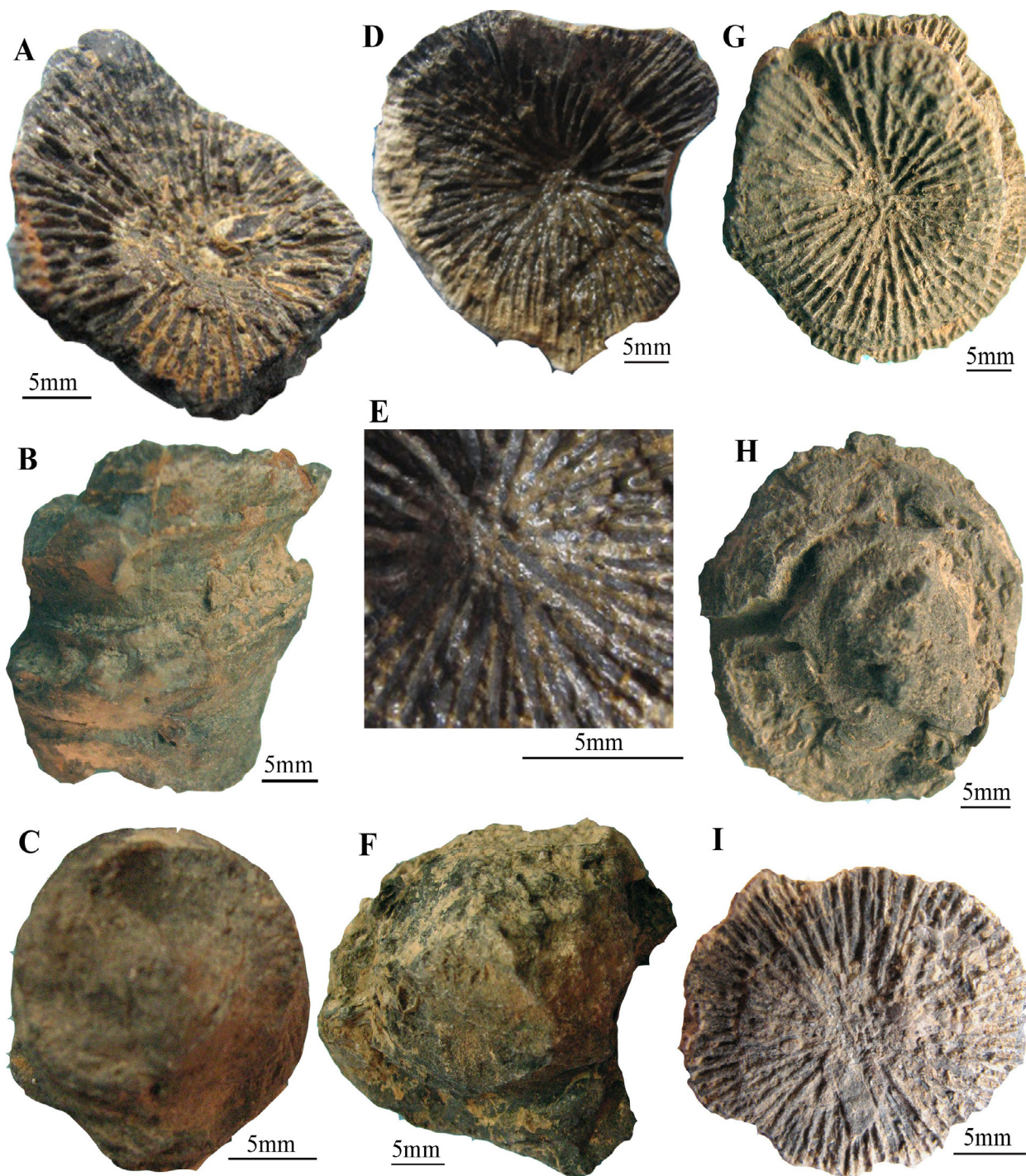
The species is common in the Rhaetian of the Northern Calcareous Alps: in the Zlambach Beds of Fischerwise, Kesselwand–Rohrmoos, Schneckengraben and HallstätterSalzberg (Roniewicz, 1989).

*Stylophyllopsis rudis* (EMMRICH, 1853)

Figures 13A to 13G and 15A to 15F

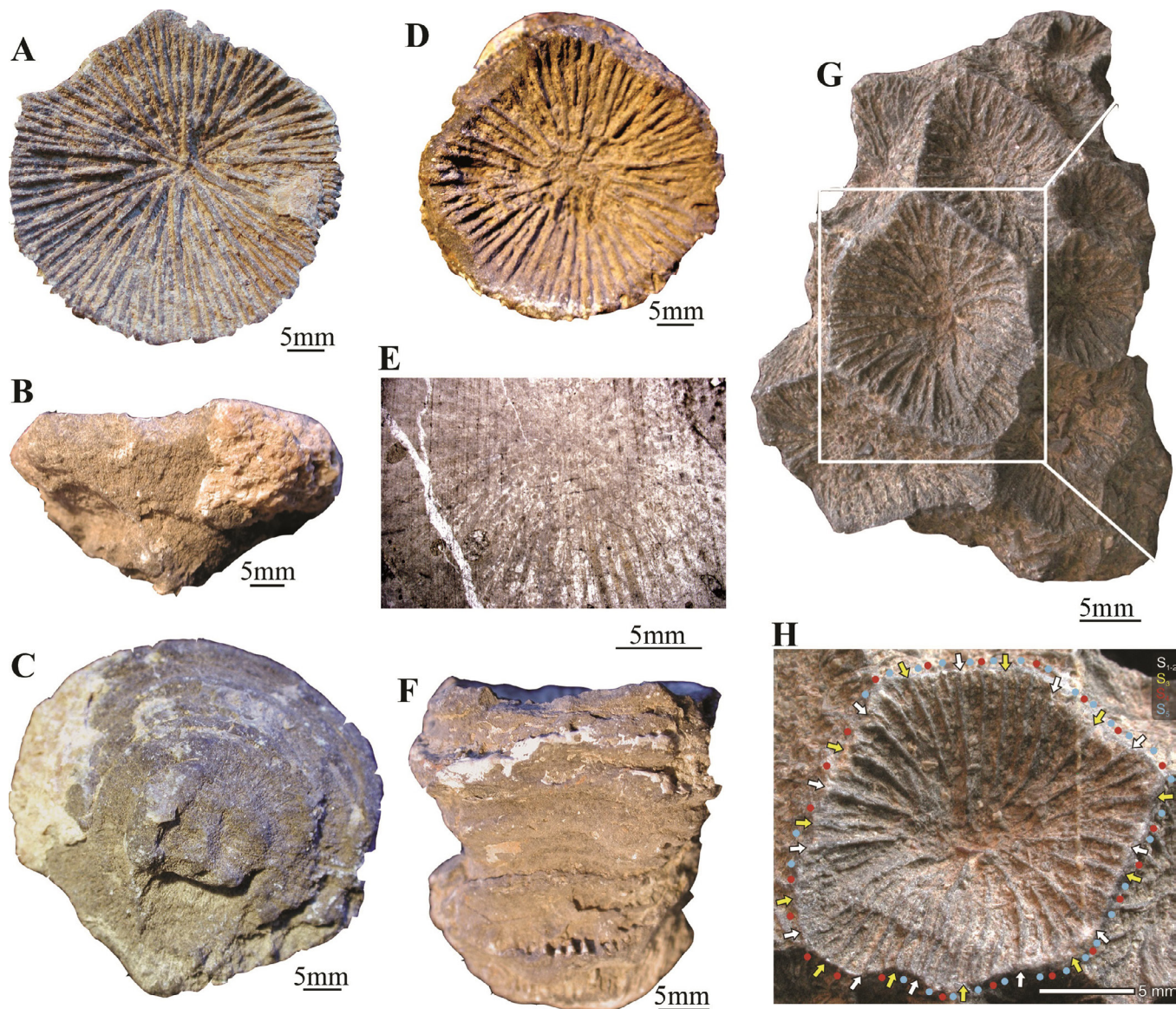
1853 *Fungia rudis*-EMMRICH, p. 378

1890 *Stylophyllopsis rudis* EMMRICH: FRECH, p. 50, pl. 12, figs. 1, 4-14



**Figure 11** Scleractinian corals from the Nayband Formation, southwest of Ardestan, Central Iran, Iran. (A–I) *Stylophylloopsis polyactis* (French, 1890). (A–C) SH-PNUICO8383, Biostrome 2, Section C, Dizlu area. (A) Corallum in calicular view. (B) Corallum in side view. (C) Corallum in proximal view, septa subequal in thickness, thin. (D–F) SH-PNUICO8391, Biostrome 2, Section C, Dizlu area. (D) Corallum in calicular view. (E) Septal spines in corallum. (F) Corallum in proximal view. (G, H) SH-PNUICO8398, Biostrome 2, Section C, Dizlu area. (G) Corallum in calicular view. (H) Corallum in proximal view. (I) SH-PNUICO8389, Biostrome 2, Section C, Dizlu area.





**Figure 12** Scleractinian corals from Nayband Formation, southwest of Ardestan, Central Iran, Iran. (A-F) *Stylophylloopsis polyactis* (French, 1890). (A-C) SH-PNUICO8393, Biostrome 2, Section C, Dizlu area. (A) Corallum in calicular view. (B) Corallum in side view. (C) Corallum in proximal view. (D-F) SH-PNUICO8394, Biostrome 2, Section C, Dizlu area. (D) Corallum in calicular view. (E) Corallum in transverse section. (F) Corallum in side view. (G, H) *Pamirophyllum iranicum* (Melnikova, 1972) SH-PNUICO8423, Biostrome 1, Section C, Dizlu area. (G, H) Colony in calicular view. (H) septa of four size orders marked with dots in the following colors: S1 white, S2 yellow, S3 red, S4 blue.

1980 *Stylophylloopsis mojsvari* FRECH: KRISTAN TOLLMANN, TOLLMANN and HAMEDANI, p. 173, pl. 5, fig. 3

1989 *Stylophylloopsis rudis* EMMRICH: RONIEWICZ, p. 126, pl. 39, figs. 2–6, pl. 40, figs. 1, 2, pl. 42, fig. 7

**Material:** One specimen (SH-PNUICO8378) from Biostrome 1, seven specimens (SH-PNUICO8379, 8380, 8384, 8390, 8392, 8396, 8397) from Biostrome 2, Section C, from Dizlu area, and three specimens (SH-PNUICO8387, 8399 and 8382) from Biostrome 2, Section B, Bagher Abad area. Measurements (in mm):

Number	GCD	LCD	H	S	S/5 mm
SH-PNUICO8384	17	15	11	72	9
SH-PNUICO8379	17	15	45	72	11
SH-PNUICO8380	20	13	42	72	10
SH-PNUICO8392	13	10	10	72	8
SH-PNUICO8387	27	15	32	80	8
SH-PNUICO8390	20	18	14	56	8
SH-PNUICO8396	16	14	27	87	10
SH-PNUICO8397	17	15	36	96	8-9
SH-PNUICO8399	14	13	11	96	15
SH-PNUICO8382	21	18	40	96	10
SH-PNUICO8378	21	17	12	96	9

**Description:** Corallum solitary, conical to horn-like in form, calice subcircular and shallow, septal spines in the axial cavity. This species has thin-septal morphotype (SH-PNUICO8387) and thick-septal morphotype (SH-PNUICO8392). Radial elements arranged into 4 size orders: the S1 septa continuing near to the axial cavity; the S2 septa shorter and slightly thinner than the S1 septa; the septa of the last order are very short, wall thick. Coralla are entirely recrystallized (no signs of original microstructure) that is also confirmed by their strong red-luminescence (Figures 15A to 15F).

**Occurrence:** Late Triassic, Norian–Rhaetian, Bidestan and Howz-e-Khan Members, Dizlu and

Howz-e-Khan Bagher Abad, southwest of Ardestan, Central Iran.

The species is known in the Rhaetian of the Northern Calcareous Alps, Iran, and the Pamirs. In the Alps, it is common in the Zlambach Beds of Fischerwise, Kesselwand-Rohrmoos, and in the Kössen Beds from Kothalp (Roniewicz, 1989). The species was described from the Rhaetian of Iran (Kristian-Tollmann *et al.*, 1980).

*Stylophylloopsis cf. lindstroemi* FRECH, 1890

Figures 13H to 13L

**Material:** Two well preserved specimens (SH-PNUICO8386 and 8381) from Biostrome 2, Dizlu area. Measurements (in mm):

Number	GCD	LCD	H	S	S/5 mm
SH-PNUICO8386	18	17	29	S1-S3: 144	13
SH-PNUICO8381	27	15	32	S1-S2: 72	8

**Description:** Corallum solitary, sub-cylindrical in shape, calice circular, slightly deepened. Septal spines extend to the axial cavity. Septa very thin, arranged into 3–4 size orders. Septal spines of the septa S1 continue to the center, the S2 septa are shorter than the S1 septa, the S3 septa are about a half of the length of the septa S1, the septa S4 are short and very thin. Wall thick.

The specimen SH-PNUICO8381 shows a deformed, flattened calice.

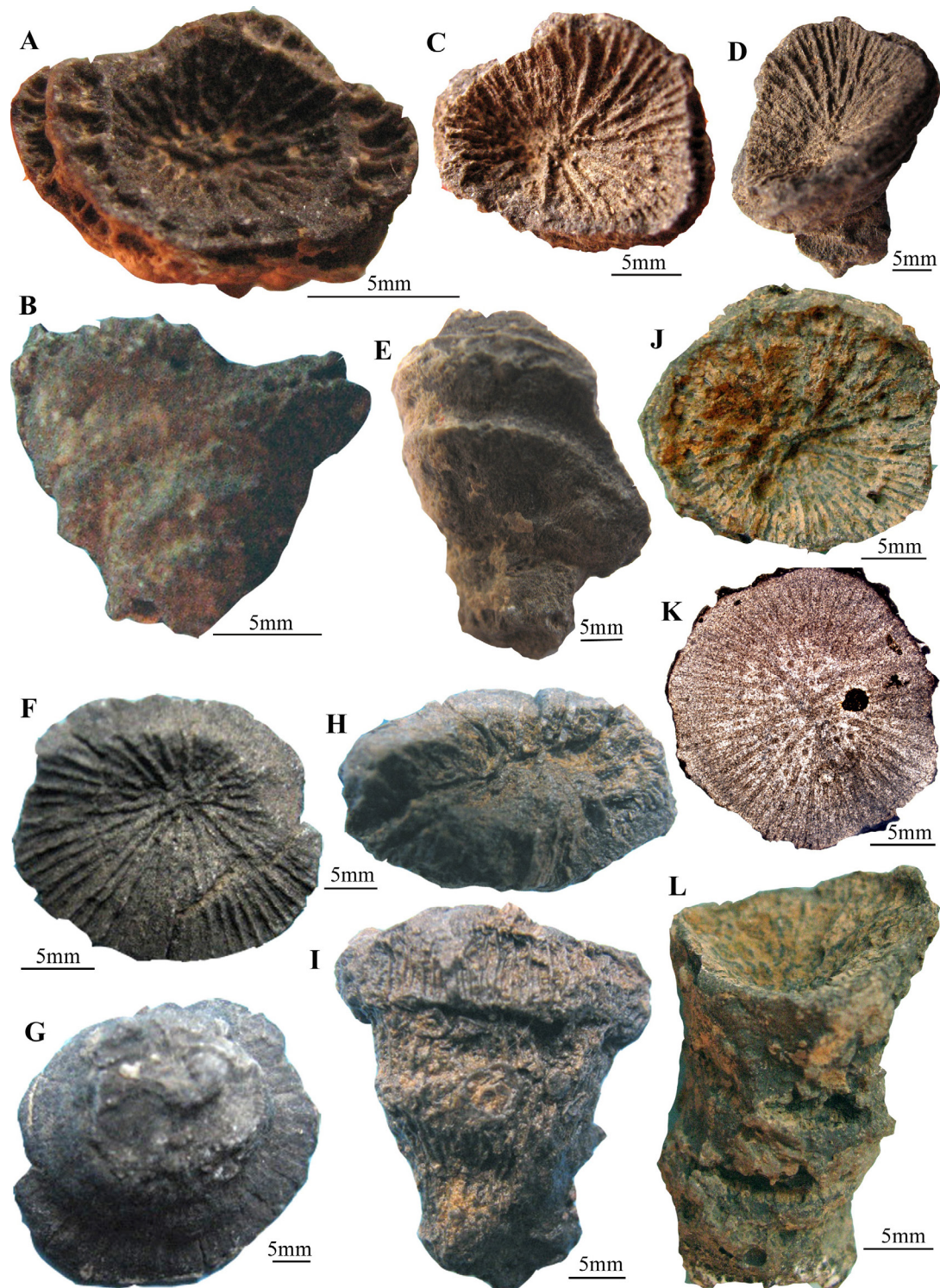
**Remarks:** The coral, having thin septal spines in which it resembles Rhaetian *S. lindstroemi*, shows large calices and septa much exceeding in number the septa of the latter species.

**Occurrence:** Late Triassic, Rhaetian, Howz-e-Khan Member, Dizlu, southwest of Ardestan, Central Iran.

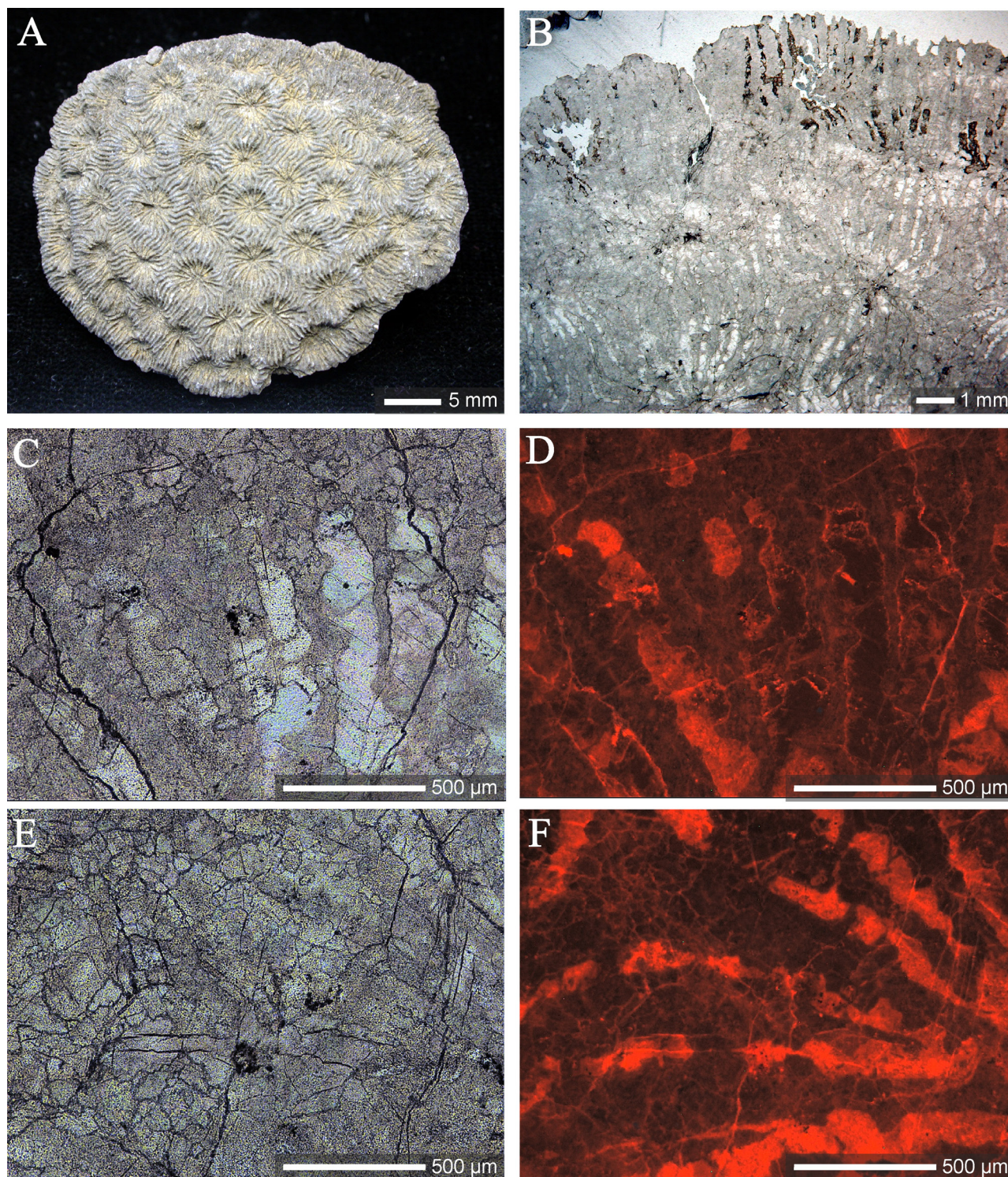
Genus *Pamirophyllum* Melnikova and Roniewicz, 1990

*Pamirophyllum iranikum* MELNIKOVA, 1972

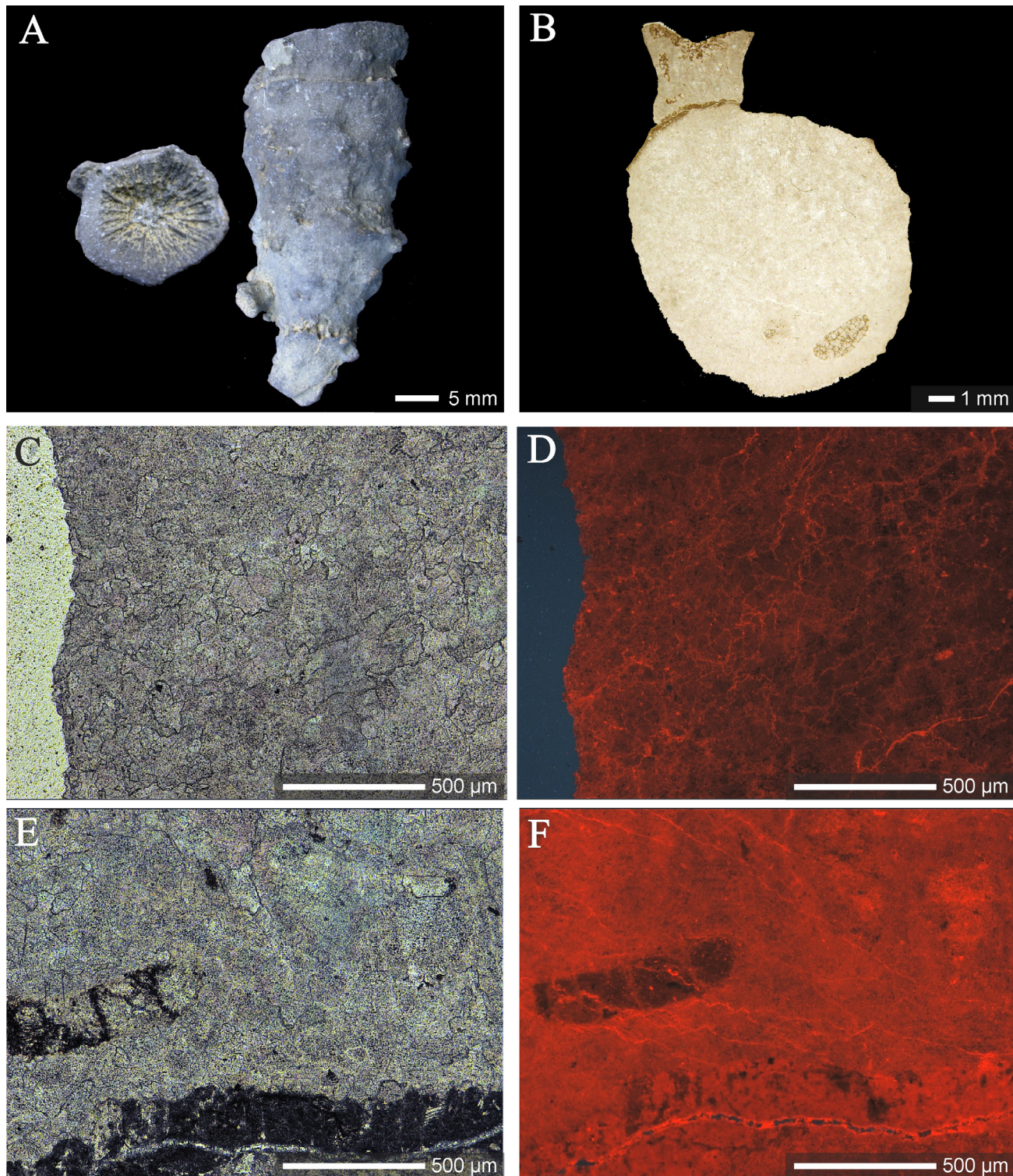
Figures 12G and 12H



**Figure 13** Scleractinian corals from the Nayband Formation, southwest of Ardestan, Central Iran, Iran. (A–G) *Stylophylloopsis rudis* FRECH, 1890. (A, B) SH-PNUICO8392, Biostrome 2, Section C, Dizlu area. (A) Corallum in calicular view. (B) Corallum in side view, thick-septal morphotype. (C–E) SH-PNUICO8387, Biostrome 2, Section B, Bagher Abad area. (C) Corallum in calicular view. (D) Corallum in calicular and side views. (E) Corallum in side view, thin-septal morphotype. (F, G) SH-PNUICO8378, Biostrome 1, Section C, Dizlu area. (F) Corallum in calicular view. (G) Corallum in proximal view. (H–L) *Stylophylloopsis* cf. *lindstroemi* Frech, 1890. (H, I) SH-PNUICO8381, Biostrome 2, Section C, Dizlu area. (H) Corallum in calicular view. (I) Corallum in side view, septa are very thin. (J–L) SH-PNUICO8386, Biostrome 2, Section C, Dizlu area. (J) Corallum in calicular view. (K) Corallum in transverse section. (L) Corallum in side view.



**Figure 14** Scleractinian corals from the Nayband Formation, southwest of Ardestan, Central Iran, Iran. (A-F) *Pamiroseris rectilamellosa* (Winkler, 1861), SH-PNUICO8449, Biostrome 2, Section. B, Bagher Abad area. (A) Colony in calicular view. (B) Thin-sectioned corallum in optical microscope. (C-F) Enlargements of thin-sectioned coralla. (C, E) Enlargements of thin-sectioned coralla in optical microscope view. (D, F) Enlargements of thin-sectioned coralla in cathodoluminescence microscope view. No distinct features of primary microstructure (calcification centers/fibers) are recognizable in the skeleton. However, in cathodoluminescence, the septal regions are much darker in comparison to interseptal deposits (strong red luminescence). Although septal structure is clearly diagenetically altered, secondary, Mn-enriched deposits (showing strong red-luminescence) were formed in interseptal spaces.



**Figure 15** Scleractinian corals from the Nayband Formation, southwest of Ardestan, Central Iran, Iran. (A-F) *Solitary Stylophylloopsis rudis* (Emmrich, 1853), SH-PNUICO8379, Biostrome 2, Section C, Dizlu area. (A) Corallum in calicular (left) and lateral (right) views. (B) Transversely thin-sectioned corallum (juvenile specimen attached to the adult corallum (upper part of the picture) sectioned longitudinally). (C-F) Enlargements of thin-sectioned coralla. (C, E) Enlargements of thin-sectioned coralla in optical view. (D, F) Enlargements of thin-sectioned coralla in cathodoluminescence microscope view. Coralla are entirely recrystallized (no signs of original microstructure), which is also confirmed by their strong red-luminescence.

1972 *Stylophyllum iranicum*: MELNIKOVA, p. 59, pl. 10, fig. 3

1975 *Stylophyllum iranicum* MELNIKOVA: MELNIKOVA, p. 77, pl. 9: 2, pl. 10: 1

1990 *Pamirophyllum iranicum* MELNIKOVA: MELNIKOVA and RONIEWICZ, p. 5, pl. 21, fig. 1

**Material:** One specimen (SH-PNUICO8423) from Biostrome 1, Dizlu area. Measurements (in mm):

Number	D of colony	H of colony	d	c-c	S	S/2 mm
SH-PNUICO8423 adult	30×51	19	19×23	12	96(24+24+48)	5
SH-PNUICO8423 juvenile			11×11	7	72(18+18+36)	5

**Description:** SH-PNUICO8423: colony cerioid, calices polygonal and deep with high and sharp edges; septal faces with small granulations. Axial cavity filled with papillary columella. Septa arranged into 3 size orders. Septal blades of the S1 septa continue to the axial cavity, septa of higher orders are thinner than the S1 septa and shorter in the order. Dissepiments are small. Corallum surface is covered by thin, epithelial wall.

**Occurrence:** Late Triassic, Norian–Rhaetian, Bidestan Member, Dizlu, southwest of Ardestan, Central Iran.

**Remarks:** Melnikova (1972) described this species from the upper Norian of the Shurabe-Nagi, Nayband region, Central Iran.

## 5. Conclusions

The Nayband Formation in the southwest of Ardestan includes five members: Gelkan, Bidestan, Howz-e-Sheikh, Howz-e-Khan, and Qadir. The Bidestan and Howz-e-Khan members form reefal limestone. Fourteen genera and 24 species of scleractinian corals were recognized in these members, which characterize the Norian–Rhaetian stage. Skeletons of all collected corals are diagenetically altered (no original microstructure is preserved) although some specimens show weaker (Figures

14) and some stronger (Figures 15) alteration that is expressed by different intensity of Mn-induced luminescence in cathodoluminescence microscopy. Scleractinian coral fauna from the Nayband Formation bears resemblance to corals from the Northern Calcareous Alps and Pamirs.

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