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A new species of *Decimoconularia* (Cnidaria, Medusozoa) from the Lower Cambrian of South China

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Hexangulaconulariids, a family of biradially symmetrical medusozoan cnidarians, have been widely reported from the Lower Cambrian of South China. The four currently recognized genera of hexangulaconulariids differ from each other mainly in the number of faces in the abapical region of the periderm. However, previously published illustrations of the monospecific type genus, *Hexangulaconularia*, clearly show two distinct morphotypes, one with six faces and the other with 10. Specimens with 10 faces are herein reassigned to the genus *Decimoconularia*. In addition, the new species *D. anisfacialis* is described from the Kuanchuanpu Formation (Cambrian Fortunian Stage) in the Kuanchuanpu and Shizhonggou sections in Ningqiang County, southern Shaanxi Province, China. Also described are additional specimens of *H. formosa* from the same formation in the Zhangjiagou section in Xixiang County, southern Shaanxi Province, and from Member 2 of the Yanjiahe Formation (Cambrian Fortunian Stage) in western Hubei Province. The discovery of *D. anisfacialis* extends the known stratigraphical range of *Decimoconularia*, now composed of two species, downward from Cambrian Stage 2 into the Fortunian Stage. Additionally, certain specimens previously assigned to *H. formosa* are reassigned to *D. anisfacialis*. The diagnoses of *Hexangulaconularia*, *Decimoconularia*, and Hexangulaconulariidae are emended accordingly. In accordance with the rule of time priority, the previously designated type genus and species, *Hexaconularia* He and Yang, 1986 and *Hexaconularia sichuanensis* He and Yang, 1986, are replaced herein by *Hexangulaconularia* He, in Xing et al., 1983.

KEYWORDS

small shelly fossils, Medusozoa, Hexangulaconulariids, Lower Cambrian, South China

1 Introduction

Small shelly fossils (SSFs), the dominant faunal element of the initial stages of the Cambrian Explosion, preserve a wealth of information concerning the early diversification of the metazoan phyla (e.g., Qian, 1989; Bengtson et al., 1990; Li et al., 2007; Shu, 2008; Shu et al., 2014; Zhu et al., 2019; Guo et al., 2020b). SSFs have been studied intensively for several decades and additional material continues to emerge, permitting in some cases the erection of new species and the revision of existing supraspecific taxa (e.g., Guo et al., 2020a; 2021a). One such taxon, the Family Hexangulaconulariidae (He, 1987), is thought to be an extinct group of polypoid medusozoan cnidarians with a biradially symmetrical, bipartite periderm having a variable number of faces in the periderm's fan-shaped abapical region. In specimens where the faces are clearly delineated, these features are corrugated planes forming obtuse and/or acute interior angles. In addition to the variable number of faces, hexangulaconulariids also exhibit variation in the relative widths of the faces, the anatomy of the boundaries between them, the rate of adaperatural expansion of the adapical region, and the degree of differentiation of this region from the apical region. The family currently comprises four genera: *Arthrochites* Chen, 1982 and *Hexangulaconularia* He in Xing et al., 1983, previously described from the Cambrian Fortunian Stage (Xing et al., 1983; Qian, 1989; Conway Morris and Chen 1992), and *Decimoconularia* (Guo et al., 2021; Guo et al., 2021a) and *Septuconularia* (Guo et al., 2020; Guo et al., 2020a; Song et al., 2022), previously described from Cambrian Stage 2. All four currently known genera are from South China.

Decimoconularia differs from other hexangulaconulariids in having a total of 10 faces in the abapical region (Guo et al., 2021a). In the type species, *D. isofacialis*, the 10 faces are essentially equal in width (Guo et al., 2021a). The present report describes new *Decimoconularia* specimens from the Fortunian Kuanchuanpu Formation in southern Shaanxi Province. Also described are additional *Hexaconularia* specimens from the same rock unit and locality and from Member 2 of the Yanjiahe Formation (Cambrian Fortunian Stage). The new *Decimoconularia* specimens differ from *D. isofacialis* in several characteristics, including the relative widths of the faces. We believe that these differences necessitate the erection of a new species, *D. anisfacialis*, to increase the total number of species in *Decimoconularia* to two and extend the stratigraphical range of this genus downward into the Fortunian Stage. Additionally, specimens placed by previous authors (He and Yang, 1986; Conway Morris and Chen, 1992; Van Iten et al., 2010; Zheng, 2012; Steiner et al., 2014; Duan et al., 2017; Xian et al., 2018; Zhang et al., 2018; Han et al., 2020) in *Hexangulaconularia* are reassigned to *D. anisfacialis*. We also emend the diagnoses

of both *Hexangulaconularia* and *Decimoconularia*, as well as the diagnosis of the family Hexangulaconulariidae.

2 Material and methods

Thirteen *Decimoconularia anisfacialis* n. sp. specimens were extracted from phosphatic limestone samples collected from the 1) Kuanchuanpu Formation (Cambrian Fortunian Stage) in the Shizhonggou section (SN021-K29-14, SN023-K30-189, SN047-K30-76, SN096-K44-131, SN096-K44-295, SN114-K32-79, and SN116-K52-53) and Kuanchuanpu section (KP-45-1, KP-45-2, KP-45-3, KP-45-4, and KP-45-5) (Ningqiang County, southern Shaanxi Province) and the 2) Kuanchuanpu Formation in the Zhangjiagou section (XX-99-284) in Xixiang County (Steiner et al., 2007, Figure 1). Nine *Hexangulaconularia formosa* specimens were collected from the Kuanchuanpu Formation in the Zhangjiagou section (XX33-52, XX62-238, XX72-47, XX78-452, XX79-65, XX91-610, XX94-79, and XX96-250) in Xixiang County, southern Shaanxi Province, and from Member 2 of the Yanjiahe Formation (Cambrian Fortunian Stage) in the Gunziao section (CUBar66-2) in Yichang city, western Hubei Province (Guo et al., 2020a, Figures 1.1–1.4).

All 22 fossil specimens were hand-picked under a binocular microscope from insoluble residues produced by the digestion of the rock samples in 10% acetic acid. Gold-coated specimens were imaged using an FEI Quanta 400 FEG scanning electron microscope (SEM). Sixteen specimens (SN, XX) are deposited in the Early Life Institute (ELI), Northwest University, Xi'an, China; the other six specimens (KP, CU) are housed at Chang'an University, Xi'an, China.

3 Systematic paleontology

Terminology—The anatomical terminology used herein mostly follows the precedents in Conway Morris and Chen (1992), Van Iten et al. (2010), Han et al. (2018), and Guo et al. (2020a, 2021a).

Phylum Cnidaria Verrill, 1865.

Subphylum Medusozoa Petersen, 1979.

Subclass ?Conulata Moore and Harrington, 1956.

Family Hexangulaconulariidae He, 1987.

Type genus—*Hexangulaconularia* He, in Xing et al., 1983 from the Hongcunping Formation (Cambrian Fortunian Stage) in the Maidiping section, Emei County, Sichuan Province, China.

Emended diagnosis—Laterally compressed, adapically tapered, biradially symmetrical periderm with variably differentiated apical and abapical regions (portions). The abapical region comprises six to 14 more or less well-defined, adapically narrowing faces with transverse ribbing and bounded by shallow narrow furrows and/or ridges. The wide oral end of

the periderm is open, with the apical end originally being rounded. The relatively small apical region is weakly to strongly differentiated from the rest of the periderm, with or without somewhat irregular, transverse fine wrinkles. The interspaces between the transverse ribs of the abapical region may be crossed by closely spaced, irregular wrinkles.

Remarks—The emended diagnosis above is consistent with that of [Guo et al. \(2021a\)](#), differing mainly in explicitly noting the presence of more or less distinct, apical and adapical regions.

| Genus *Hexangulaconularia* He, in [Xing et al., 1983](#), emend.

- 1983 ?*Conulariella* (nomen nudum) Yang et al., p. 108
- 1983 *Hexaconularia* (nomen nudum) Yang et al., p. 108
- 1983 *Hexangulaconularia* He, in Xing et al., p.171
- 1986 *Hexaconularia* He and Yang, p. 35
- 1987 *Hexangulaconularia* He; He, p. 11
- 1987 *Hexaconularia* He and Yang; He, p. 12
- 1987 *Hexaconularia* He and Yang; Braier and Singh, p. 337
- 1989 *Hexangulaconularia* He; Qian, p. 160
- 1992 *Hexaconularia* He and Yang; Conway Morris and Chen, pp. 400–401.

Type species—*Hexangulaconularia formosa* He, in [Xing et al., 1983](#) from the Hongcunping Formation (Cambrian Fortunian Stage) in the Maidiping section, Emei County, Sichuan Province, China.

Emended diagnosis—The periderm consists of clearly differentiated apical and adapical regions, with a total of six faces in the adapical region, three on each of the two major sides of the periderm.

Stratigraphical range—Cambrian Fortunian Stage.

Remarks—The genera *Hexangulaconularia* and *Hexaconularia* were formally established in 1983 ([Xing et al., 1983](#)) and 1986 ([He and Yang, 1986](#)), respectively. Thus, according to the rule of time priority in the International Code of Zoological Nomenclature (ICZN, 23) regulations, the genus *Hexaconularia* is invalid. While the genus *Hexangulaconularia* is currently monotypic, this may change. The emended diagnosis herein presented is based on characteristics appropriate to distinguish among hexangulaconulariid genera, with other previously included characteristics ([Van Iten et al., 2010](#)) best serving to distinguish among species.

| *Hexangulaconularia formosa* He, in [Xing et al., 1983](#).

- 1983 ?*Conulariella quadratas* (nomen nudum) Yang et al., p. 108, pl. III, **Figure 9**
- 1983 *Hexaconularia multicosmata* (nomen nudum) Yang et al., p. 108, pl. III, **Figures 6, 12**
- 1983 *Hexaconularia nanjiangensis* (nomen nudum) Yang et al., p. 108, pl. III, **Figure 8**

1983 *Hexaconularia* sp. (nomen nudum) Yang et al., p. 108, pl. III, **Figure 7**

1983 *Hexaconularia sichuanensis* (nomen nudum) Yang et al., p. 108, pl. III, **Figure 10**

1983 *Hexaconularia xinliensis* (nomen nudum) Yang et al., p. 108, pl. III, **Figure 11**

1983 *Hexangulaconularia formosa* He, in Xing et al., p. 172, pl. 15, **Figures 1–3**

1986 ?*Conulariella quadratas* He and Yang, p. 38–39, pl. IV, **Figure 1**

1986 *Hexaconularia breviculus* He and Yang, p. 36, pl. IV, **Figures 7–9**

1986 *Hexaconularia sichuanensis* He and Yang, pp. 35–36, pl. IV, **Figures 5, 6**

1986 *Hexaconularia xinliensis* He and Yang, pp. 36–37, pl. IV, **Figures 3, 4**

1986 *Hexaconularia xinliensis compressiformis* He and Yang, p. 37, pl. V, **Figure 1**

1986 *Hexaconularia xinliensis crassiformis* He and Yang, p. 37, pl. V, **Figures 3, 4**

1986 *Hexaconularia bellalus* He and Yang, p. 37, pl. V, **Figures 8–10**

1986 *Hexaconularia bellalus compressiformis* He and Yang, p. 37, pl. V, **Figure 2**

1986 *Hexaconularia multicosmata* He and Yang, p. 38, pl. V, **Figures 5, 6**

1986 *Hexaconularia longelus* He and Yang, p. 38, pl. V, **Figures 11–12**

1987 ?*Barbitositheca ansata* [Brasier and Singh](#), pp. 335, 337, **Figure 7.3**

1987 *Hexaconularia* cf. *formosa* [Brasier and Singh](#), p. 337, **Figure 7.4–7.6**

1987 *Hexaconularia xinliensis* He and Yang; He, p. 12, pl. I, **Figure 8**

1987 *Hexangulaconularia formosa* He; He, p. 12, pl. I, **Figures 9–10**

1989 *Hexangulaconularia formosa* He; Qian, pp.161–162, pl. 28, **Figures 7–9**

1989 *Hexangulaconularia xinliensis* He and Yang; Qian, pp. 162–163, pl. 10, figs. 12–13, pl. 28, **Figure 6**

1992 *Hexaconularia sichuanensis* He and Yang; Conway Morris and Chen, pp. 400–401, **Figures 12.8, 12.11–12.14**

2004 *Hexaconularia sichuanensis* He and Yang; Steiner et al., p. 270, **Figures 8.1–8.2**

2010 *Hexaconularia sichuanensis* He and Yang; Van Iten et al., p. 193, 195, **Text-Figures 1–2**

2012 *Hexaconularia sichuanensis* He and Yang; Zheng, pp. 70–72, **Figures 4.17A–F**

2014 *Hexaconularia sichuanensis* He and Yang; Steiner et al., p. 104, **Figures 7.19–7.20**

2014 *Hexaconularia sichuanensis* He and Yang; [Yang et al.](#), p. 39, **Figure 12N**

TABLE 1 Measurements of eight well-preserved *Hexaconularia sichuanensis* and 10 well-preserved *Decimoconularia anisfacialis* sp. nov. specimens.

Specimens	Length of periderm (mm)	Maximum width of abapical region (mm)	Apical angles of the periderm (degree)	Apical angles of the central face (degree)	Average width between adjacent transverse ridges (mm)	Type
CUBar66-2	1.450	×	×	54.82	0.049	<i>H. sichuanensis</i>
XX-33-52	×	1.805	68.85	44.96	0.076	
XX-62-238	×	×	81.78	56.22	0.041	
XX-78-452	1.524	1.548	52.33	27.16	0.081	
XX-86-8	1.198	×	45.80	31.18	0.042	
XX-79-65	1.357	×	52.26	39.99	0.051	
NIGP150159	1.144	1.382	80.27	48.22	0.045	
NIGP150163	×	1.752	56.14	35.92	0.057	
KYuan42	1.319	1.346	60.67	33.86	0.069	<i>D. anisfacialis</i> sp. nov.
NIGP160430	1.895	1.981	64.24	29.51	0.077	
SN047-k30-76	×	×	69.89	35.64	0.055	
SN096-k44-131	1.401	×	65.28	38.87	0.065	
SN114-k32-79	×	2.391	87.49	38.08	0.069	
XX-99-284	×	×	71.11	29.18	0.062	
KP-45-1	1.025	1.229	62.35	31.66	0.046	
KP-45-3	×	×	83.12	26.56	0.068	
KP-45-4	×	×	70.03	34.33	×	
KP-45-5	×	1.940	80.71	41.55	0.066	

KYuan42 cited from Steiner et al., 2014, Figure 7.16; NIGP160430 cited from Xian et al., 2018, Figure 3A; SN096-k44-131 cited from Han et al., 2020, Figure 2C; NIGP150159 and NIGP 150163 cited from Van Iten et al., 2010, Figures 1A, 3E.

2016 *Hexaconularia sichuanensis* He and Yang; Liu et al., p. 1045, Figures 1.9

2017 *Pseudoooides prima* Qian; Duan et al., pp. 7–9, Figures 5A–G, 5J–5K

2017 *Hexaconularia sichuanensis* He and Yang; Zhang et al., pp. 271–272, Figures 1, 2

2018 *Hexaconularia sichuanensis* He and Yang; Shao et al., p. 7, Figures 5.4–5.5

Holotype—10134 from the Maidiping section in Emei County. *Paratypes*—10135 from the same stratigraphic level and locality as the holotype.

New material—Nine specimens from the Kuanchuanpu Formation (Cambrian Fortunian Stage) in the Zhangjiagou section in Xixiang County, southern Shaanxi Province (XX33-52, XX62-238, XX72-47, XX78-452, XX79-65, XX91-610, XX94-79, XX96-250) and from Bed 2 of the Yanjiahe Formation (Cambrian Fortunian Stage) in the Gunziao section near the city of Yichang, western Hubei Province (CUBar66-2), China.

Description—Incomplete (broken) specimens ranging from 1.1 to 1.5 mm in length along the apical-abapical axis and from 1.4 to 1.8 mm in maximum width (Table 1). The apical region is missing or very poorly preserved. The original apertural margin was not preserved. The periderm is very thin and apparently non-

laminar. The angle of apertural expansion of the abapical region (abr) ranges from approximately 46° to 82° (Table 1) in the plane of its greatest width, with the two major sides of the abapical region meeting along a pair of marginal longitudinal ridges (mlr) (Figure 1D). The apertural margin was not preserved. Each of the two major sides of the abapical region consists of three well-defined, apically tapering faces. The boundaries between the broad central face and the two relatively narrow faces bordering it are marked by more or less well-defined, shallow narrow furrows along which the transverse ribs terminate (Figure 1). The transverse ribs on the four narrow faces are straight to gently arched abapically and variably spaced (0.04–0.08 mm) (Table 1) in most specimens, more closely so near the apical end of the faces. The transverse ribs on the broad central face are variable in course; they are rectilinear in some cases but with a sharp bend near the interfacial boundaries (Figures 1G,H,I). In other cases, they are slightly undulatory, with or without a sharp bend near the interfacial boundaries.

Remarks—The genera *Hexangulaconularia* and *Hexaconularia* were both first reported in 1983 (Xing et al., 1983; Yang et al., 1983). However, Yang et al. (1983) did not provide a description (only illustrations), and it was not until 1986 that *Hexaconularia*, with type species *Hexaconularia*

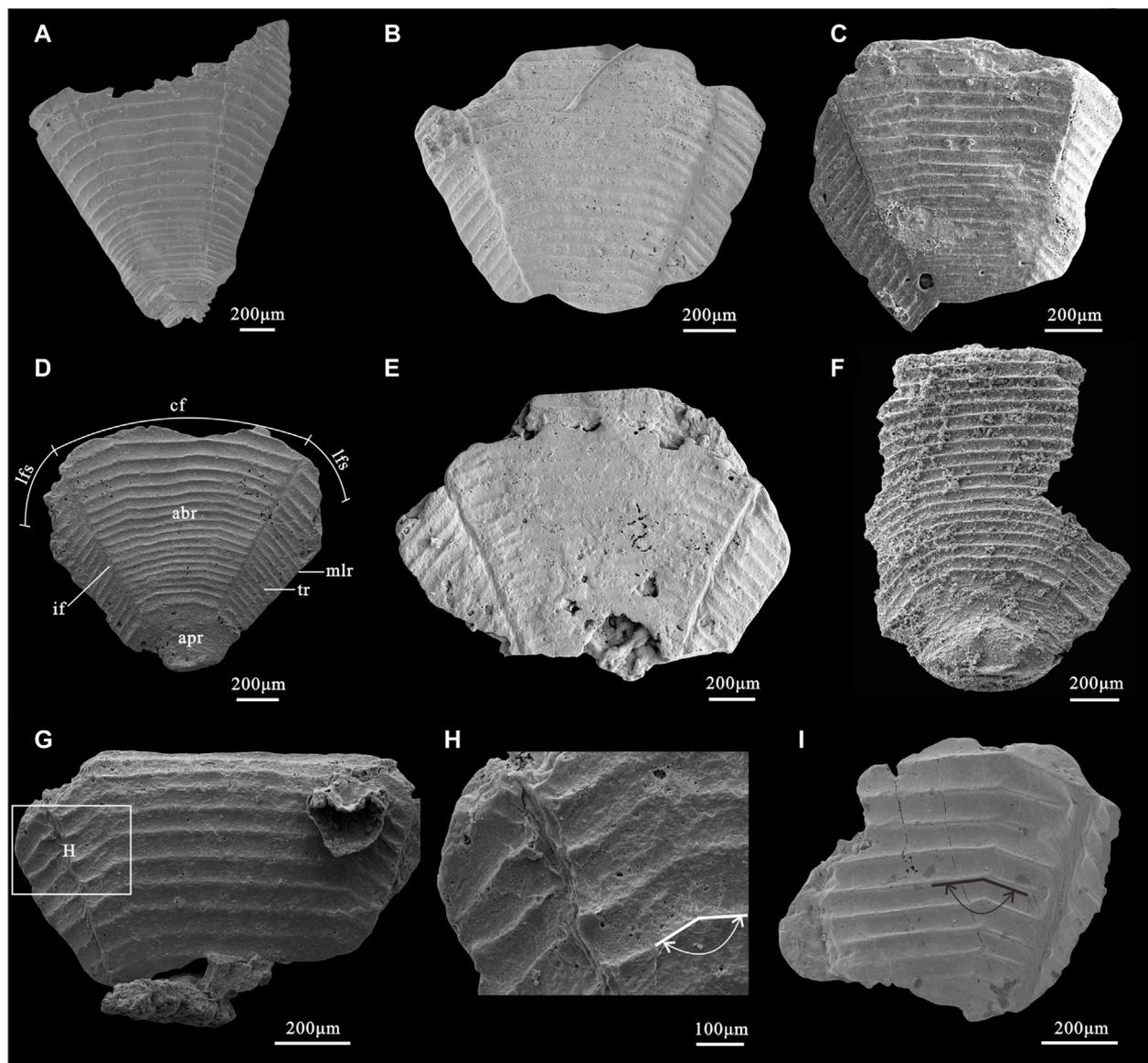


FIGURE 1

Hexangulaconularia formosa from the Kuanchuanpu Formation (Cambrian Fortunian Stage) of southern Shaanxi Province and Bed 2 of the Yanjiahe Formation (Cambrian Fortunian Stage) of western Hubei Province, China. (A–G,I) XX78-452, XX79-65, XX91-610, XX62-238, XX33-52, CUBar66-2, XX94-79, and XX96-250, respectively. (H) Magnified view of an interfacial (longitudinal) furrow and transverse ribs (G) showing sharp, abapical bending of the transverse ribs near the interfacial furrow and the absence of such a furrow along the locus of the points of inflection of the transverse ribs. Abbreviations: abr=abapical region; apr=apical region; cf=central face; if=interfacial (longitudinal) furrow; lfs=lateral faces; mlr=marginal longitudinal ridge; tr=transverse rib.

sichuanensis, was officially established (He and Yang, 1986). Hence, *Hexaconularia* and *Hexaconularia sichuanensis* are nomen nuda and are replaced herein by *Hexangulaconularia* and *H. formosa*, respectively. The Kuanchuanpu and Yanjiahe formation specimens described above are similar to each other and to specimens of *Hexangulaconularia formosa* previously described from the Kuanchuanpu Formation (e.g., Van Iten

et al., 2010). The course of the transverse ribs on the broad central face is variable, with some ribs consisting of three distinct, rectilinear segments (namely, a long central segment and two shorter lateral segments, each deflected toward the apical end of the periderm) and others being slightly undulatory but lacking well-defined bending near their two ends. The geometry of the transverse ribs and the angle of expansion (apical angle) of the central faces of

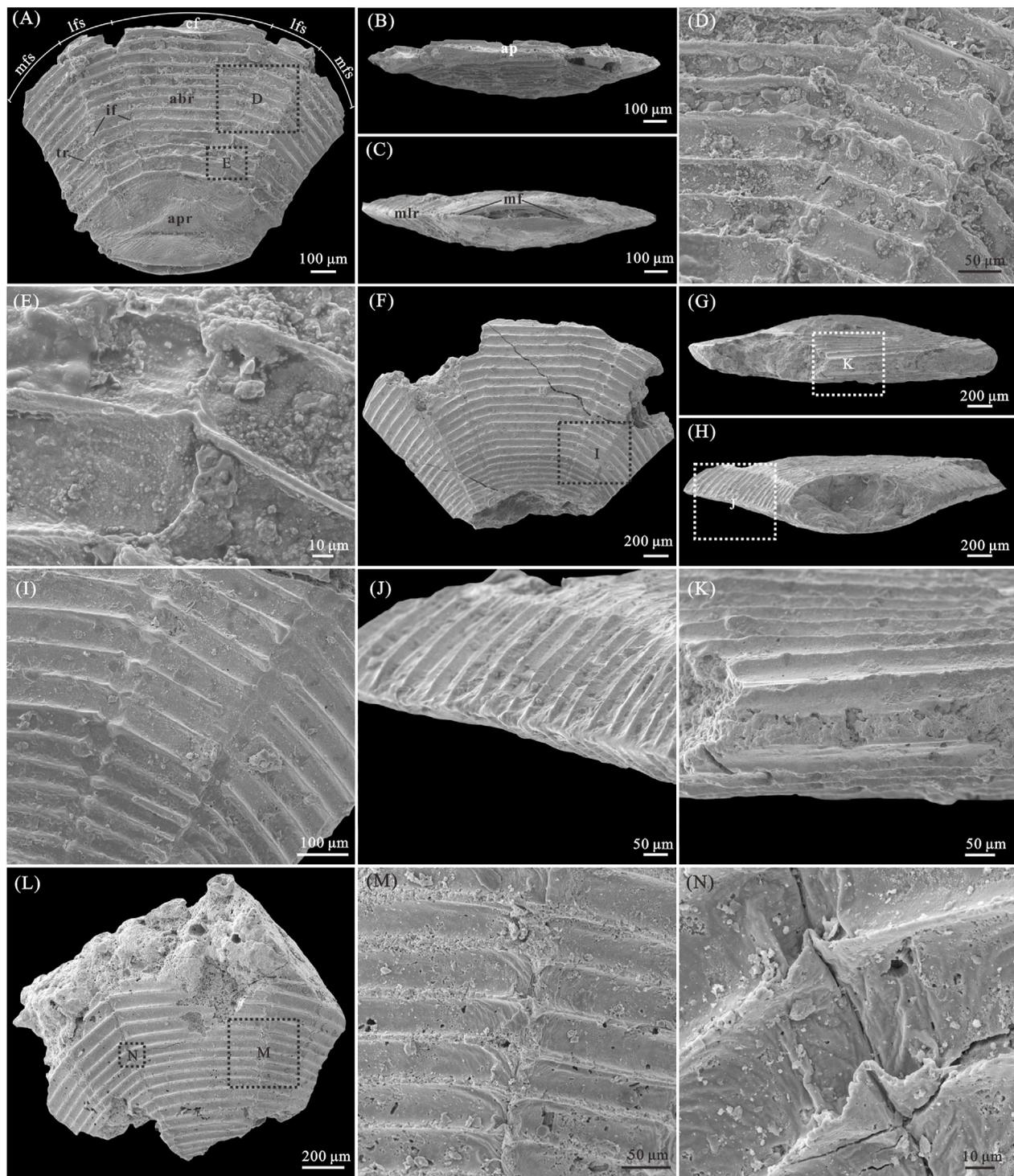


FIGURE 2

Decimoconularia anisfacialis n. sp. from the Kuanchuanpu Formation (Cambrian Fortunian Stage) of southern Shaanxi Province, China. (A,F,L) KP-45-1, SN114-k32-79, and SN047-K30-76, respectively. (B–C,G–H) Apertural and apical views of (A,F), respectively. (D,E) Magnified views of (A), showing the trochoidal transverse ribs, adjacent faces separated by interfacial (longitudinal) furrows, and transverse ribs puckered along the interfacial (longitudinal) furrow. (I,J,K) Magnified views of (F,G,H) respectively, showing adjacent faces separated by interfacial (longitudinal) furrows, two sides separated by marginal longitudinal ridges, and the very narrow aperture. (M,N) Magnified views of (L), showing the concave interspace between adjacent transverse ribs, fine irregular wrinkles within the interfacial (longitudinal) furrow, and puckering of the transverse ribs within and along the interfacial (longitudinal) furrow. Abbreviations: abr=abapical region; ap=aperture; apr=apical region; cf=central face; if=interfacial (longitudinal) furrow; lfs=lateral faces; mf=marginal furrow; mfs=marginal faces; mlr=marginal longitudinal ridge; tr=transverse rib.

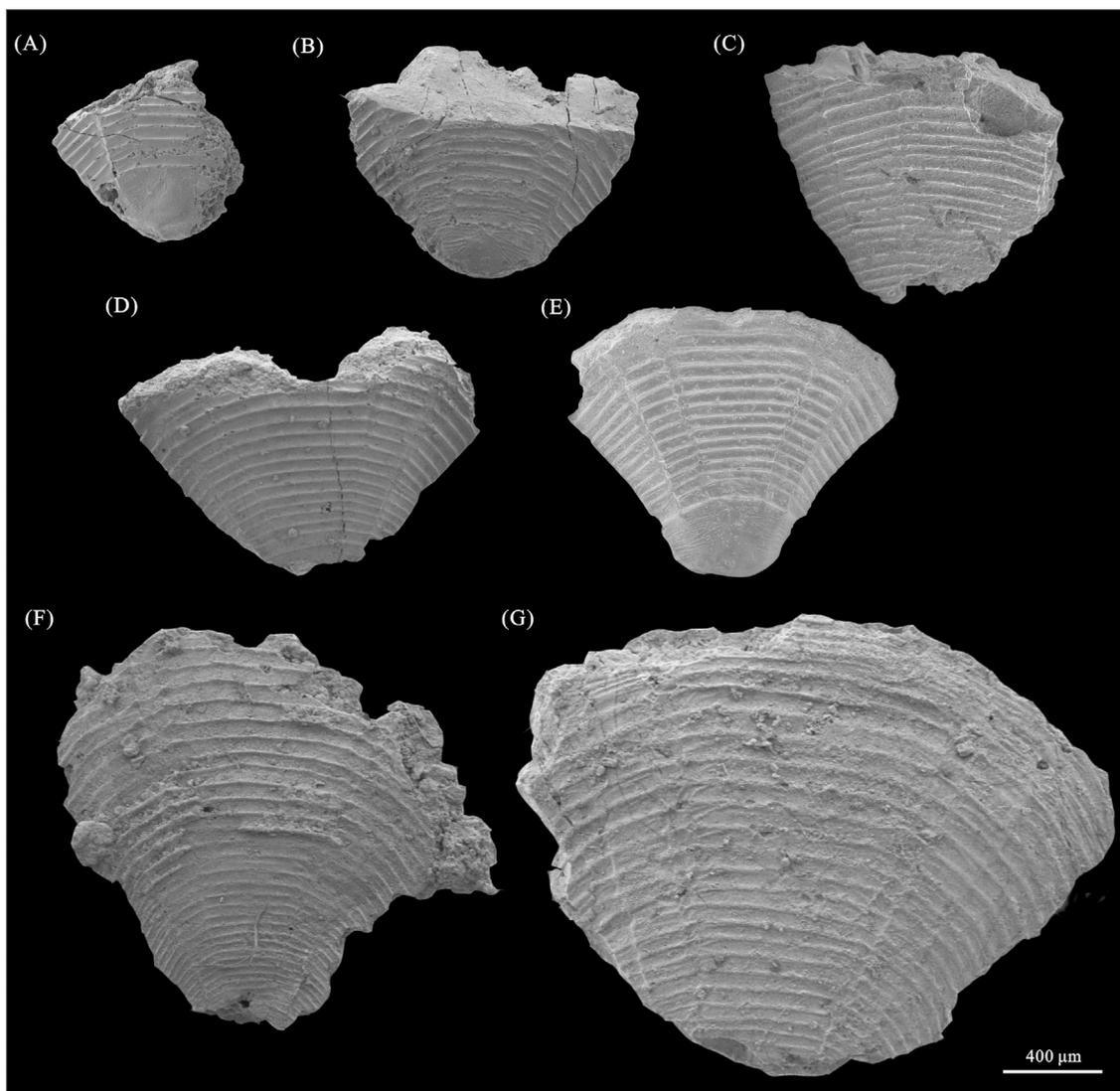


FIGURE 3

Possible growth series of *Decimoconularia anisfacialis* n. sp. from the Kuanchuanpu Formation (Cambrian Fortunian Stage) of southern Shaanxi Province, China. (A–G) SN096-K44-295, KP-45-3, SN023-K30-131, KP-45-5, SN096-k44-131 (taken from Han et al., 2020, Figure 2C), KP-45-4, and KP-45-2.

Hexangulaconularia are similar to the two broad faces of the conulariid *Conulariella* Bouček, 1939 (Ordovician, western Europe and South China; Van Iten et al., 2013); thus, it is not surprising that some authors (Yang et al., 1983; He and Yang, 1986) (provisionally) assigned *Hexaconularia* specimens to *Conulariella*.

| *Stratigraphical range*—Cambrian Fortunian Stage.

Genus *Decimoconularia* (Guo et al., 2021), emend.

Type species—*Decimoconularia isofacialis* (Guo et al., 2021) from the *Watsonella crosbyi* Assemblage Zone of the Yanjiahe

Formation (Member 5, Cambrian Stage 2) in the Yanjiahe section near the city of Yichang, Hubei Province, China (Guo et al., 2021b).

Emended diagnosis—The apical region of the periderm is weakly to strongly differentiated. The adapical region has a total of 10 faces, with five on each of the two major sides.

Remarks—As in the case of the emended diagnosis of *Hexangulaconularia*, the diagnosis of *Decimoconularia* herein omits those characteristics which do or may potentially differentiate species within the genus.

| *Decimoconularia anisfacialis* new species.

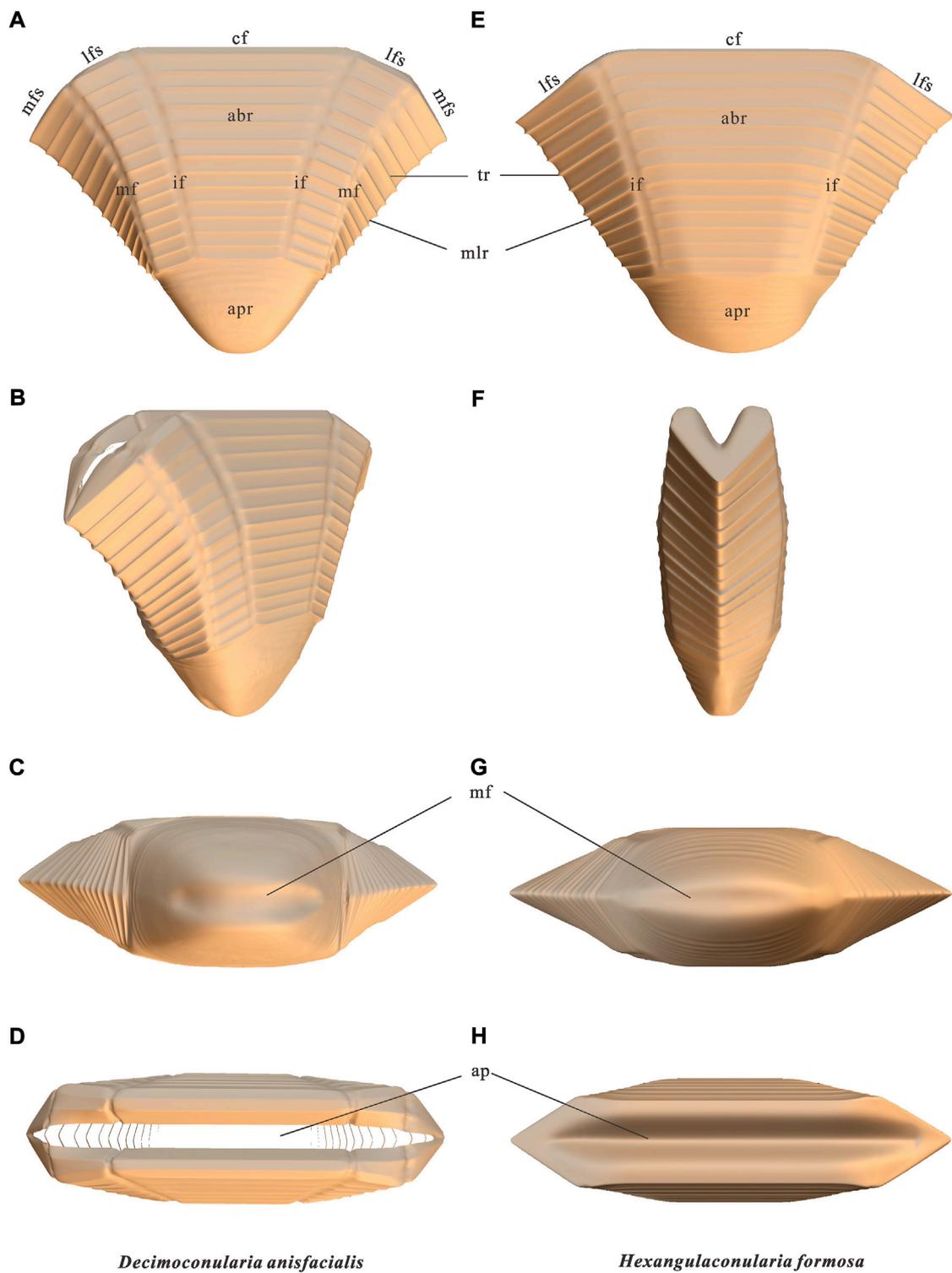


FIGURE 4
 Three-dimensional reconstructions of *Decimoconularia anisfacialis* n. sp. and *Hexangulaconularia formosa*. (A,E,B,F,C,G,D,H) Side, oblique lateral, apical, and apertural views, respectively. The color of the reconstructions does not represent the actual color of the animals. Abbreviations: abr=abapical region; ap=aperture; apr=apical region; cf=central face; if=interfacial (longitudinal) furrow; lfs=lateral faces; mf=marginal furrow; mfs=marginal faces; mlr=marginal longitudinal ridge; tr=transverse rib.

TABLE 2 Principal morphological differences among *Hexangulaconularia formosa*, *Decimoconularia anisfacialis*, and *Decimoconularia isofacialis*.

	<i>Hexangulaconularia formosa</i>	<i>Decimoconularia anisfacialis</i> sp. nov.	<i>Decimoconularia isofacialis</i>
Number of faces	6 (unequal)	10 (unequal)	10 (equal)
Cross section of apertural region	Laterally compressed lenticular	Laterally compressed lenticular	Laterally compressed lenticular
Cross section of apical region	Laterally compressed lenticular	Laterally compressed lenticular	Nearly round
Longitudinal structure between faces	Shallow narrow furrows	Shallow narrow furrows	Collinear longitudinal ridge and furrow

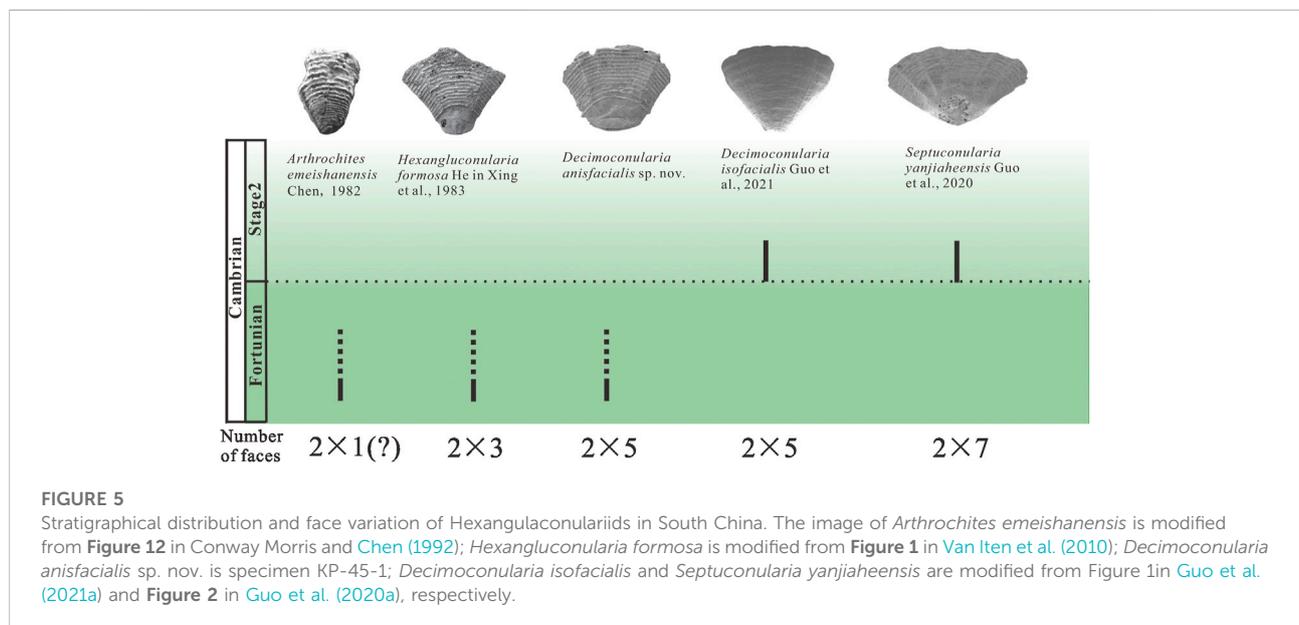


FIGURE 5

Stratigraphical distribution and face variation of Hexangulaconulariids in South China. The image of *Arthrochites emeishanensis* is modified from Figure 12 in Conway Morris and Chen (1992); *Hexangulaconularia formosa* is modified from Figure 1 in Van Iten et al. (2010); *Decimoconularia anisfacialis* sp. nov. is specimen KP-45-1; *Decimoconularia isofacialis* and *Septuconularia yanjiaheensis* are modified from Figure 1 in Guo et al. (2021a) and Figure 2 in Guo et al. (2020a), respectively.

1986 *Hexaconularia nanjiangensis* He and Yang, p. 36, pl. IV, **Figure 2**

1986 *Hexaconularia multicostata* He and Yang, p. 38, pl. V, **Figure 7**

1992 *Hexaconularia sichuanensis* He and Yang; Conway Morris and Chen, pp. 400–401, **Figures 12.9, 12.10?**

2012 *Hexaconularia ningqiangensis* Zheng, pp. 70–72, **Figures 4.17 G–K**

2014 *Hexaconularia sichuanensis* He and Yang; Steiner et al., p. 104, **Figures 7.13–7.16**

2017 *?Pseudoooides prima* Qian; Duan et al., pp. 7–9, **Figures 5H–I**

2018 *Hexaconularia sichuanensis* He and Yang; Xian et al., p. 228, **Figure 3A**

2018 *Hexaconularia sichuanensis* He and Yang; Zhang et al., p. 16, **Figure 2.9**

2020 *Hexaconularia sichuanensis* He and Yang; Han et al., p. 70, **Figure 2C**.

Holotype—KP-45-1 from the Kuanchuanpu Formation (Lower Cambrian, Fortunian Stage) in the Kuanchuanpu section in Ningqiang County, southern Shaanxi Province.

Paratypes—Eleven nearly complete and two partial specimens from the Kuanchuanpu Formation (Lower Cambrian, Fortunian Stage) in the Shizhonggou and Kuanchuanpu sections in Ningqiang County (SN021-K29-14, SN023-K30-189, SN047-K30-76, SN096-K44-131, SN096-K44-295, SN114-K32-79, SN116-K52-53, KP-45-1, KP-45-2, KP-45-3, KP-45-4, and KP-45-5) and the Zhangjiagou section in Xixiang County (XX99-284).

Diagnosis—Periderm with distinct apical and abapical regions. The abapical region has 10 faces, with five on each of the two major sides.

Occurrence—Cambrian Fortunian Stage; Kuanchuanpu Formation, northern Sichuan and southern Shaanxi provinces, China.

Description—Incomplete (broken) specimens ranging from 1.0 to 1.9 mm in length along the apical-abapical axis and from 1.2 to 2.0 mm in maximum width. The periderm is very thin and apparently non-laminar. The angle of adaperatural expansion of the abapical region (abr) ranges from approximately 60° to 87° in the plane of its greatest width, with the two major sides of the abapical region meeting along a pair of marginal longitudinal ridges (mlr). The transverse cross-section of the aperture (ap) is

narrowly lenticular (Figure 2B). The original apertural margin was not preserved.

Each major side of the abapical region (abr) has one central face (cf), two lateral faces (lfs), and two marginal faces (mfs). The central face is approximately 2–3 times wider than the other four faces (Figure 2A, Figure 4), with the lateral faces being slightly wider than the marginal faces and the angle of adapertural expansion of the central face ranging from approximately 27° to 42° (Table 1). Shallow interfacial (longitudinal) furrows (if) separate the faces. All faces exhibit coarse, trochoidal (long.), nearly evenly spaced transverse ribs (tr) that terminate along the interfacial boundaries and the boundaries between the two major sides. The crests of the transverse ribs are sharp, smooth, and spaced 0.4–0.8 mm apart. The transverse ribs of the lateral and marginal faces are straight, while the transverse ribs of the central face are straight or bent slightly adapicalward near the interfacial furrows. The ends of the transverse ribs on a given face abut or are very slightly offset from those of the neighboring faces and puckered along the two interfacial (longitudinal) furrows between the central face and the two lateral faces. The concave interspace between adjacent transverse ribs is smooth or gently wrinkled.

The apical region (apr) is strongly compressed, with a deep terminal concavity and divided by a partly marginal furrow (mf). The external ornament of the apical region consists of irregular, fine transverse ribs or wrinkles, in some cases showing bifurcation.

Internal transverse septa were not observed, and there is no evidence of relic soft tissue.

Etymology—From the Latin roots *anis* (unequal) and *facialis* (faces), highlighting the characteristic differences in width between the faces of the adapical region of the periderm.

Comparisons—Unlike *D. isofacialis*, the 10 faces of which are essentially equal in width, each major side of *D. anisfacialis* n. sp. exhibits a broad central face flanked by two pairs of narrower, lateral and marginal faces (Figures 2A,F,L, 3, 4). Additionally, whereas the interfacial boundaries of *D. isofacialis* consist of a furrow (groove) in approximately the apertural half of the abapical region and a collinear ridge in approximately the apical half (Guo et al., 2021a), those of *D. anisfacialis* consist entirely of a furrow (Figures 2D,I,M). The transverse ribs of *D. anisfacialis* are mostly straight (Figures 2A,F,L), while those of *D. isofacialis* arch gently toward the aperture. The average distance between adjacent transverse ribs is also greater in *D. anisfacialis* than in *D. isofacialis* (Figures 2D,I,M). In both species, the apical angle of the major faces is approximately 75°; however, the apical angle of the central face is 19° in *D. isofacialis* and 34° in *D. anisfacialis*. The apical region of *D. isofacialis* is incomplete (Guo et al., 2021a); thus, it is not yet possible to make detailed comparisons of this portion of the periderm with that of *D. anisfacialis*.

Additional remarks—Some specimens previously identified as *Hexangulaconularia formosa* exhibit 10 distinct, mutually inclined, unequal faces and are similar to *D. anisfacialis* in all other characteristics described above (Table 2). These specimens, assigned herein to *D. anisfacialis*, are listed above in the synonymy.

4 Discussion

The new *Hexangulaconularia formosa* and *Decimoconularia anisfacialis* sp. nov. material expands the known diversity and disparity of hexangulaconulariids and extends the stratigraphical range of *Decimoconularia* downward from Cambrian Stage 2 into the Fortunian Stage. Although beyond the scope of the present investigation, analysis of the phylogenetic relationships among the known species of hexangulaconulariids will be crucial in addressing the problem of the evolutionary origins of genera having six, 10, or 14 total faces (Figure 5). Finally, the functional morphology of hexangulaconulariids is poorly understood, owing in large part to the absence of soft tissue preservation. The slit-like narrow aperture of *Septuconularia yanjiaheensis* may have reduced the risk of sediment grains entering the gastrovascular cavity and spaces between the soft polyp and the inner surface of the periderm (Guo et al., 2020a; Song et al., 2022). Additionally, the puckering and wrinkling observed in *Decimoconularia anisfacialis* sp. nov. suggests that the periderm of this species may have been somewhat flexible.

5 Conclusions

Decimoconularia anisfacialis exhibits 10 faces rather than six. Thus, *Decimoconularia* can be interpreted as a minor but relatively long-ranging clade within the medusozoan family Hexangulaconulariidae. Moreover, following the ICZN, *Hexangulaconularia* He in Xing et al., 1983 has time priority over *Hexaconularia* in He and Yang 1986; consequently, the type genus of family Hexangulaconulariidae is changed herein from *Hexaconularia* to *Hexangulaconularia*, and the species name *Hexaconularia sichuanensis* is replaced by *Hexangulaconularia formosa*.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material; further inquiries can be directed to the corresponding authors.

Author contributions

Conceptualization: JG, JH, and ZS; writing-original draft: ZS; writing-review and editing: HV, JG, JH, and ZZ; sample collection: YQ, JP, JS, YZ, and XH.

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