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A new middle Permian waagenophyllid rugose coral species, *Ipciphyllum dilatum* sp. nov. from the Shan Plateau, Myanmar

Aung Myo Zaw, Aye Ko Aung

Department of Geology, Dagon University, 11422 Minyekyawswa Road, East Dagon Myothit, Yangon, Myanmar
* Corresponding author email address: aungmyozaw009@gmail.com

Abstract: A new rugose coral, *Ipciphyllum dilatum* sp. nov. is described and illustrated from the Thitsipin Limestone of the Plateau Limestone Group of middle Permian (Roadian-Wordian) substages of the Shan Plateau, Myanmar. This new taxon is distinct from all other previously described species by having all septa in the tabularium being dilated, smaller corallite diameter, and lack of the medial plate in the axial column. It is palaeogeographically significant that it co-occurs with other middle Permian rugose coral species, *Yatsengia hangchowensis*, *Iranophyllum* sp. cf. *caracinophylloides*, *Ipciphyllum subelegans*, *Pavastehphyllum* sp., *Pavastehphyllum* (*Thomasiphyllum*) sp. in the Linwe area of the Shan Plateau region. This fossil assemblage is correlated with that of China, Thailand, Iran, and Malaysia. The similarities of middle Permian rugose corals between Myanmar and Malaysia clearly indicate that both were at a close paleogeographic position likely in the Cathaysian paleogeographic provinciality during the middle Permian. The new species demonstrates variability within five parameters: number of sides of corallite wall, nature of septa, number of septa, development of dissepiments, and variation of axial structure. From this work, it should be noted that, intraspecific variability is one of the basic criteria for identification of the rugose coral species.

Keywords: Middle Permian, rugose coral, new species, Myanmar

INTRODUCTION

The Permian limestone sequences of the Shan Plateau region, Shan State have yielded rich fossil coral, brachiopod, bryozoan, fusuline, and crinoid faunas that have significantly aided in the development of a biostratigraphic framework for the Shan Plateau. Initially, these faunas greatly assisted the geological mapping of the area. Stratigraphic correlations of the Permian strata throughout the region have been based on common stratigraphic position, lithology and totally identical fossil assemblages. Nevertheless, little has been published partly or wholly of the Permian coral faunas. Smith (1941) described seven species of rugose coral from five genera and three tabulate species collected by V. P. Sondhi from the "Plateau Limestone" of the southern Shan State. His coral faunas were obtained from five localities: Htam Sang, Pangtara (Pindaya), Poila (Pwehla), Alegyaung and Pon. Some unpublished reports on the Permian corals include, Myint Thein (1982) and in the frame of Master of Research and Master of Science studies on the corals which were carried out in the areas of the southern Shan State, Taung-ni (Soe Moe Lwin, 2003) and Thayetpya (Thandar Tun, 2010). The considerable numbers of coral specimens were collected by Aye Ko Aung, staff and students of Taunggyi and Dagon universities. He documented Permian rugose corals collected from 19 localities in southern Shan State: Thitsipin, Kyaukkupyin, Ye-U, Nwabangyi, Kazet, Linwe, Pegin, Kyauktaw, Hsinsapya, Kyauknget, Shwepahtoe, Konlon, Thayetpya, Yechanzin, Pwehla, Taungni, Hopong, Htamsang, and Banyin (Aye Ko Aung, 2011). Aung Myo Zaw (2014) first described five coral species belonging to four genera *Yatsengia hangchowensis*, *Iranophyllum* sp. cf. *caracinophylloides*, *Ipciphyllum subelegans*, *Pavastehphyllum* sp., and *Pavastehphyllum* (*Thomasiphyllum*) sp., from the Thitsipin Limestone of the Pegin-Linwe area, Ye-ngan Township, southern Shan State. The study area (Pegin-Linwe) is located about 13 km (8 miles) NE of Ye-U, Ye-ngan Township, southern Shan State (Figure 1). Documenting intragroup variation is necessary for differentiating fossil species especially for rugose corals because of the high variation well observed in, phylum Cnidaria, which includes Rugosa and Tabulata. Variation is noted in length and width, degree of curvature, number and relative position of dilated skeletal elements. It is necessary to consider the following criteria during identification; diagnostic characters of mature specimens,

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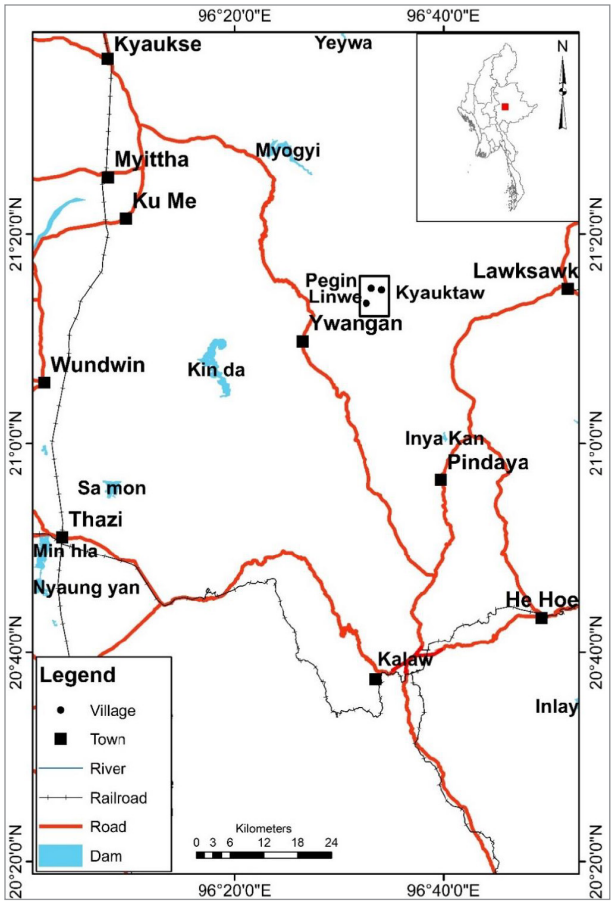

Figure 1: Locality map of the Pegin-Kyauktaw area.

ontogenetic development, and microstructure, which are morphological characteristics seen in the rugose corals are important in generic classifications. Intraspecific variability is a characteristic feature of many rugose corals but few examples have been well documented. The following papers on variation in rugose corals were submitted in the Fifth International Symposium on Fossil Cnidaria in 1988, Brisbane. Oliver (1989) described intraspecific variation in Pre-Carboniferous rugose corals. Fedorowski (1989) pointed out the intraspecific variation in Carboniferous and Permian rugose corals. Sutherland (1989) showed intraspecific variability in rugose coral *Stelechophyllum? mclareni* from the Carboniferous (Visean) of northeastern British Columbia. Sorauf & Mackey (1989) studied variation and biometrics in rugose corals.

Similarly, variation can be observed in other kinds of invertebrate fossils from Myanmar Permian strata, such as Bivalvia, Gastropoda, Trilobita, Cnidaria and Bryozoa. In the present work, the phylum Cnidaria is chosen by the authors for the study of intraspecific variation. The Permian corals are found in various localities in Myanmar, occurring at several horizons and are rather sporadically distributed in the Permian sequence of the southern Shan State. In this paper, we study the intraspecific variability in the rugose coral *Ipciphyllum dilatum* sp. nov. from the Permian Thitsipin Formation, near Phaya Cave, Pegin-Kyauktaw area, Ye-ngan Township, southern Shan State (Figure 1). This collection was made by the first author, a second year Honours student, Department of Geology, Dagon University in 2007.

Stratigraphic setting

The thick carbonate sequence of the Plateau Limestone Group (Brown & Sondhi, 1933) extensively outcrops in the southern Shan State. This paper follows the formation division described by Amos (1975) and Garson *et al*. (1976): the Thitsipin Limestone Formation (Permian), the Nwabangyi Dolomite Formation (late Permian-early Triassic), and the Natteik Limestone Formation (middle Triassic). The type section of the Thitsipin Limestone Formation is at the Thitsipin village, north of Ye-ngan Township and it is widely distributed northeast and southeast of Ye-ngan. It is also exposed in other regions: Taungni area, Taunggyi Township; Banyin, Naung Kha and Htam Sang, Hopong Township; Mong Pawn Township; Konlon Taung, Pindaya, Thayetpya, Yechanzin and Pwehla, Pindaya Township; and Nyaung-che-dauk, Heho Township. It consists of light to dark gray colored bedded to massive limestone and wackestone. Locally the limestone has been dolomitized, and it is extensively brecciated. Garson *et al.* (1976) divided the Thitsipin Limestone into three main facies: the massive limestone facies, massive cherty limestone facies, and the well-bedded calcarenite facies. The Thitsipin Limestone Formation contains fairly abundant fossils including corals, brachiopod, bryozoa, and fusulinids. The Thitsipin Limestone unconformably overlies the older Paleozoic rocks and it is conformally overlain by the Nwabangyi Dolomite Formation of late Permian to early Triassic age.

MATERIALS AND METHODS

Specimens were studied using light microscopy of the transverse and longitudinal thin-sections of the rugose corals. The rugose coral terminology and supergeneric classification follows that of Hill (1981). The abbreviations used are: N = number of septa; D = diameter of corallite in mm.

Repository

The coral fossil specimens are housed in the Dagon University Geology Museum and are prefixed by DUGM (Table 1).

Systematic palaeontology

Class ANTHOZOA Ehrenberg, 1834
Subclass RUGOSA Milne Edwards & Haime, 1850
Order METRIOPHYLLINA Spassky, 1965
Suborder PLEROPHYLLINA Sokolov, 1960

Family WAAGENOPHYLLIDAE Wang, 1950
Genus *Ipciphyllum* Hudson, 1958
Type species Ipciphyllum ipci Hudson, 1958

Diagnosis: Cerioid, axial column with thin, irregular persistent medial plate, radial lamellae and prominent conical axial tabellae, septa thin or somewhat thickened particularly in tabularium, and crestal in lonsdaleoid parts of wide dissepiment with normal concentric or anguloconcentric dissepiment tabularium occupies greater part of corallite, formed of wide outer zone of elongate almost vertical cytose clinotabullae and of narrow periaxial zone of horizontal tabulae (Hill, 1981).

Geological range and distribution: Upper Permian (*Parafusulina-Yabeina Z.*), Asia (Turkey, Iraq, Iran, Laos, Vietnam, China, Timor, Japan and Myanmar).

Ipciphyllum dilatum sp. nov. Figure (2 A&B)

Holotype: DUGM-(3005a-b) from middle Permian Thitsipin Limestone, Pegin-Kyauktaw area, Ye-ngan Township, southern Shan State, Myanmar.

Etymology: Composed of dilated septa.

Material studied: A single corallum (DUGM 3005), Middle part of the Permian Thitsipin Limestone, Plateau Limestone Group, Pegin-Kyauktaw area, Ye-ngan Township, southern Shan State, Myanmar.

Description: The corallum is compound, massive, and cerioid. In transverse section corallite are regularly polygonal, having five to seven sides, approximately 7 to 11.5 mm in diameter in the mature stages. They are circular to triangular in shape in the earlier stages. Corallite walls are thin and slightly undulating. Two orders of septa are radially arranged and are sometimes made discontinuous by the presence of small, lonsdaleoid dissepiments at the corallite corners. As many as 19 to 25 major septa, alternating with the same number of minor septa, are present in the mature corallites. Major septa nearly reach the axial column, but ordinarily do not touch; it even in the earlier stages. They are somewhat axially curved.

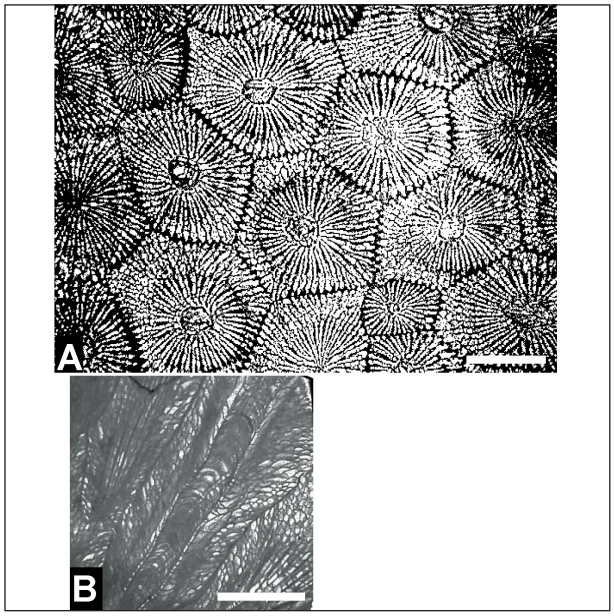

Figure 2: *I. subtimoricum dilatum* sp. nov. A) DUGM 3005, Holotype, transverse section of the cerioid corallum; B) DUGM 3005, Holotype, longitudinal section; from Phaya Cave, Pegin-Kyauktaw area, Ye-ngan Township, southern Shan State, showing general characters of the morphologic variation (scale bar = 2.5 mm).

Minor septa are a little shorter and thinner than major septa. Somewhat thickened septa in the tabularium coupled with slight dilation of the innermost series of dissepiment from a faint inner wall. The axial column is circular to sub elliptical in outline and ranges from 1.0 to 2.5 mm in diameter, occupying about one-fifth to one-fourth of the diameter of corallite. It is free from the axial ends of major septa and consists of radially disposed septal lamellae, sometimes showing a prominent medial plate; and several rows of axial tabellae. The tabularium is narrow and annular 0.6 to 1 mm in width. The dissepimentarium is wide and is filled with several rows of small dissepiments of concentric to angulo-concentric arrangement. At the corallite corners small and irregularly formed lonsdaleoid dissepiments are present. In longitudinal section, corallite walls are thin, tabulae are complate, 1 to 2 mm in width, the tabularium is composed of almost upwardly convex transverse tabulae, six to twelve transverse tabulae occur in a vertical distance of 5 mm; dissepimentarium is comparatively wide; dissepiments irregular in size and shape, three to eight rows of globose and steeply to gently inclined elongated dissepiments are present.

Comparison and remarks: The Myanmar specimen is compared with those of the previously described species, *Ipciphyllum subtimoricum* (Huang, 1932) from Nesan Formation, Abadeh, Iran (Ezaki, 1991). The present species is distinguished from the later by having highly dilated major septa, smaller corallite diameter, and greater number of septa. The axial column in Myanmar form is circular to sub-elliptical in outline. It has no prominent medial plate in the axial column like Iran form. The new species is closely allied to *Ipciphyllum stabilis* Zhao, described and illustrated by Ezaki, 1991, but it is distinguished from the latter in having a larger axial column and a wider tabularium. The new species falls in the group of *Ipciphyllum*, however, it is differing from other *Ipciphyllum* species by comparison of their morphological characters, such as: *I. subelegans* Minato & Kato, 1965 from Central Thailand (Fontaine *et al*., 1994); from Bukit Kepayang, Pahang State (Fontaine & Suteethorn, 1988); from Bukit Biwa, Terengganu state, Malaysia (Kato & Ezaki, 1986); from the Thitsipin Limestone, Pegin-Linwe area, Ye-ngan Township, southern Shan State, Myanmar (Aye Ko Aung, 1994; Aung Myo Zaw, 2014; 2024); from the Taungni area, Taunggyi Township, southern Shan State (Soe Moe Lwin, 2003); Thayetpya area, Pindaya Township, southern

Table 1: *Ipciphyllum dilatum* sp. nov.: Some dimensional characters of representative corallites (mm) housed in the Dagon University Geology Museum.

DUGM Cat. No	Dc	Dt	Dt/Dc	N	Preparation
3005	1.5	5.5	0.3	19	transverse section, longitudinal section
3006	4	2.5	0.6	32	transverse section
3007	5	3	0.6	32	transverse section
3008	4.5	3	0.67	30	transverse section
3009	6.5	5	0.77	34	transverse section
3010	6	4	0.67	38	transverse section
3011	7	6.5	1.0	25	transverse section

Dc = corallite diameter, Dt = tabularium diameter, N = number of septa

Shan State (Thandar Tun, 2010) (Table 2). At a glance, the present form appeared to the authors as representing a new subspecies of *Ipciphyllum subtimoricum dilatum* sub sp. nov. However, following the kind comments of the reviewer (1), we made taxonomic reinvestigation, and it suggests the taxon a new species.

ANALYSIS OF VARIABILITY

To show variation of specific characters within single a corallum, five serial transverse thin sections were prepared for this study. One transverse section contains 25 corallites; of these, 14 corallites are selected for the detailed study of variation. As the new subspecies is typical for previously studied Permian corals, morphological variability within this single corallum is high (Figure 2). The present species is varied in the following characteristics:

1. Number of sides of corallite wall
2. Nature of septa
3. Number of septa
4. Development of dissepiments
5. Variation of axial structure

Number of sides of corallite wall

This species has a corallite diameter that varies from 4 to 9.5 mm within an individual corallite. The number of corallites walls also varies in a mature specimen. Almost all corallites contain six to seven-sided walls but a few corallites composed of four (or) five sided (Figure 3).

Nature of septa

Figure 4 shows the septa from three areas: the dissepimentarium, the tabularium, and the axial area. In the dissepimentarium, most of the corallites comprises tapering septa (Figure 4A), some have sinuous septa (Figure 4B), and a few corallites show thickened septa (Figure 4C) in mature corallum. All septa in the middle part of tabularium area (Figure 4).

Number of septa

The numbers of septa are different between larger and smaller corallites within a single corallum. Larger

Table 2: Comparison of *Ipciphyllum dilatum* sp. nov. of the Pegin-Kyauktaw area, Ye-ngan Township, southern Shan State and *Ipciphyllum* species from other areas (mm).

	Dc	Dt	Dt/Dc	N	Ad
1	1.5-7	2.5-6.5	0.3-1	0.3-1	1.0-2.5
2	7-10.5	5.5-6.5	0.4-1.3	17-22	1.4-2.1
3	6.3-7.8	1.0-1.6	0.2-0.21	18- ?	1.2-1.6
4	6.0-8.5	-	-	16-20	1.2-1.8
5	10.5	0.7-1.2	0.06	15-17	1.4-2
6	6-7	2.5-3.5	0.4-0.5	20	1.5-1.6
7	5	3	0.6	32	2-1
8	4-6.5	2.5-5	0.5-0.77	32-44	16-20
9	5-6	3-3.5	0.6-0.58	52	-
10	5-7.5	3-5	0.5-0.77	32-44	16-20

1. *Ipciphyllum dilatum* sp. nov. Pegin-Kyauktaw area (Thitsipin Limestone), southern Shan state, Myanmar (This study).
2. *I. subtimoricum* (Huang, 1932) (Nesen Formation), Iran (Ezaki, 1991).
3. *I. huangi* Minato & Kato, 1965 (Surmaq Formation), Iran (Ezaki, 1991).
4. *I. subelegans* Minato & Kato, 1965 (Surmaq Formation), Iran (Ezaki, 1991).
5. *I. guangdongense* Xu, 1984, (Surmaq Formation), Iran (Ezaki, 1991).
6. *I. subelegans* Minato & Kato, 1965, Kampong Awah quarry, Pahang, Malaysia (Kato & Ezaki, 1986).
7. *I. subelegans* Minato & Kato, 1965, Taungni area, Taunggyi Township, southern shan State (Soe Moe Lwin, 2003).
8. *I. subelegans* Minato & Kato, 1965, Thayetpya area, Pindaya Township, southern Shan state (Thandar Tun, 2010).
9. *I. subelegans* Minato & Kato, 1965, Pegin-Linwe area, Ye-ngan Township, southern Shan state (Aung Myo Zaw, 2014).

Dc = corallite diameter, Dt = tabularium diameter, N = number of septa, Ad = axial diameter.

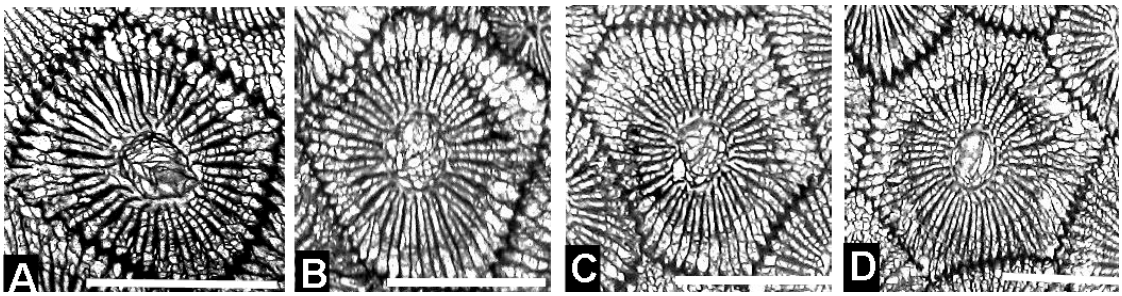

Figure 3 A-D: Variation in the number of corallite walls, A) refer to four sided, B) five sided, C) six sided, and D) seven sided (scale bar = 1.5 mm).

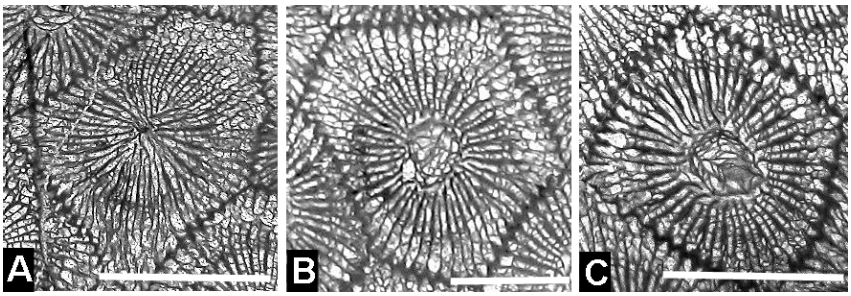

Figure 4 A-C: Variation in the nature of septa in single corallum (scale bar = 1.5 mm).

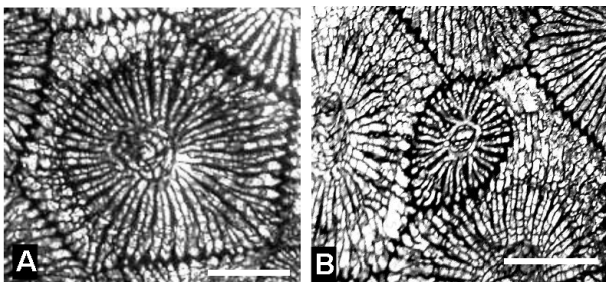

Figure 5 A, B: Variation in the number of septa (scale bar = 1.5 mm).

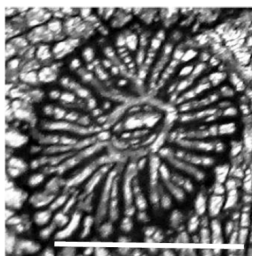

Figure 6: Smaller corallite showing poorly developed dissepiments (scale bar = 1.5 mm).

corallite (9 mm) contains 50-56 septa, while a smaller corallite may have 34 septa. The number of septa is directly proportional to corallite diameter (Figure 5).

Development of dissepiments

During growth of individual corallites, lateral dissepiments are well developed but some corallites have poor development of Lonsdaleoid dissepiments. No dissepiments developed in smaller corallite during mature stages (Figure 6).

Variation of axial structure

Axial structures varies in the corallum described. Three kinds of axial structure occur in this species, which are non-axial structure, simple axial structure and septal lamellae axial structure. Some corallites have a confluence of septa rather than the axial structure (Figure 7). Almost all corallites have a simple axial structure, but a few have septal lamellae in the axial area.

CONCLUSION

This paper has introduced a new waagenophyllid rugose coral species *Ipciphyllum dilatum* sp. nov., from the Thitsipin Limestone of the "Plateau Limestone Group". The occurrence of this coral genus is reported for the first time from the Linwe area, Ye-ngan Township, southern Shan State. The present fossil finding is significant because in the Linwe area, the genus co-occurs with other Middle Permian rugose corals; *Yatsengia hanchowensis* Huang, 1932, *Iranophyllum* sp. cf. *carcinophloides* Douglas, 1936, *Ipciphyllum subelegans* Minato & Kato, 1965, and *Pavastehphyllum* (*Thomasiphyllum*) Minato & Kato, 1965. Nowhere is found such an important paleogeographic clues on basis of the Permian rugose corals in one area. Some

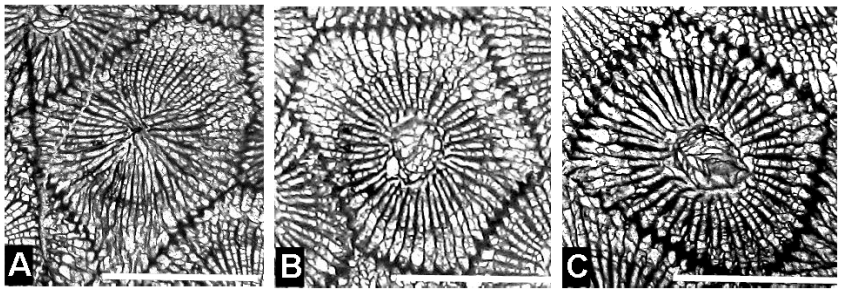

Figure 7 A-C: Variability of axial structure, A) lack of axial structure, B) subcircular axial structure, C) typical waagenophyllid axial structure (scale bar = 1.5 mm).

Middle Permian rugose corals from the Sibumasu Block in Myanmar *(Waagenophyllum yini* Fontaine *et al*., 1988; *Multimurinus fontaini* Kato & Ezaki, 1986 `*Ipciphyllum subelegans* Minato & Kato, 1965) also resemble those from Bukit Kapayang, Pahang State (Fontaine *et al*., 1988) and Bukit Biwah, Terengganu State (Kato & Ezaki, 1986), both are located in the East Peninsular Malaysia. The similarities between the Middle Permian rugose corals *Waagenophyllum yini* Fontaine, *Multimurinus fontainei* Kato & Ezaki and *Ipciphyllum subelegans* Minato & Kato from Sibumasu Block in Myanmar and that of the East Peninsular Malaysia Indochina Block suggest that both were at a close paleogeographic position likely in the Cathaysian paleogeographic provinciality during the Middle Permian.

The new species was first thought as a new subspecies, *Ipciphyllum subtimoricum dilatum*, closely similar to *Ipciphyllum subtimoricum* (Huang, 1932) in all aspects, however, it is characterized by the presence of dilated septa in the tabularium. Serial sectioning in *Ipciphyllum dilatum* sp. nov. shows that variation between corallites within most single thin sections reflects not changes in a specific direction. The main aspects are 1, different in number of sides of corallite wall, 2, variably dilated septa and their numbers in each corallite, 3, the dissepiments are well developed only when the corallites are large or matured, 4, the axial structures in individual corallites are varied possibly in all ontogenic stages.

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AUTHORS CONTRIBUTION

AMZ: Conceptualization, data curation, funding acquisition, investigation, methodology, writing original draft; AKA: Investigation, methodology, writing original draft, project administration, writing review and editing.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationship that could have appeared to influence the work reported in this paper.

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