The Middle Triassic scleractinia-like coral *Furcophyllia* from the Pamir Mountains

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Furcophyllia is an unusual coral with septa regularly splitting into branching sets called septal brooms. This pattern of septal apparatus is so alien to scleractinians, that, despite a trabecular microstructure of septa resembling that of the Scleractinia, the genus was originally ascribed to a rare group of corals informally referred to as sleractiniamorphs, previously known from the Ordovician and Permian. Genus *Furcophyllia* emerged together with corals of several groups, after the post-Permian crisis diversification of skeletonized anthozoans, some of them markedly differing in their skeletal features from typical Scleractinia. So far, the genus was represented by middle Carnian *Furcophyllia septafindens* from the Dolomites, in the Southern Alps. Here, we report *Furcophyllia shaitanica* sp. nov. from limestone boulders found in the volcano-clastic deposits of the upper Ladinian Šajtan suite of the South Eastern Pamirs. A new species of *Furcophyllia* signifies that the genus was a faunal element widely distributed in the Tethys.

Key words: Anthozoa, scleractinia-like corals, Triassic, Pamirs, Alps, Republic of Tajikistan, Italy.

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Introduction

The analysis of the skeletal morphology of *Furcophyllia* Stolarski, Roniewicz, and Grycuk, 2004, revealed the septal apparatus in this Triassic genus to be quite different from those in other Triassic corals. It is composed of septa that bifurcate several times during their growth towards the corallite center. A simple computer model simulating the growth of *Furcophyllia* septa at an adult stage of skeleton ontogeny provides a satisfactory approximation of the unique pattern of septal distribution realized in this genus (Stolarski et al. 2004). Although in the Scleractinia, secondary septa incepted on primary ones are known in Rhipidogyridae and Aulastraeoporidae, and diverse dichotomous branching of septal blades occurs in Micrabaciidae or as teratogenic bifurcation in some corals, the increase of their septal apparatuses follows different rules than that in *Furcophyllia*. In this genus, irregular branching of simple septa and succeeding branching of secondary septa results in pattern composed of densely arranged, uniformly distant and uniformly thick septa, incomparable to any septal pattern known in skeletonized Anthozoa.

The results of above morphological analysis based on so far single species, *Furcophyllia septafindens* (Volz, 1896) from the Carnian (*Trachyceras aonoides* + *Austrotrachyceras austriacum* ammonoid zones) of the Dolomites, Southern Alps, are herein confirmed by morphological observation of another species, *Furcophyllia shaitanica* sp. nov. from the upper Ladinian of the distant region of the Tethys, from the SE Pamirs. The two species are represented by only few specimens.

Institutional abbreviations.—GID, Institute of Geology, Akademy of Sciences of the Republic of Tajikistan, Dushanbe, Republic of Tajikistan; IPUM, Institute of Paleontology, University of Modena, Italy.

Other abbreviations.—CRA-CRA, distance between adjacent Centers of Rapid Accretion; d, diameter of corallum; f, length of calicular fossa; gd/mm, density of granulation, number of granulations per millimeter measured in transverse section; n:d, septal index, measured by total number of septa in relation to whole corallum diameter; s, number of septa; sd/mm, septal density, number of septa per millimeter measured directly at the corallum circumference; width of s, width of septa, measured in transverse section.

Material and geological setting

The new coral, herein described as *Furcophyllia shaitanica* sp. nov., was found by the late Victor Ivanovich Dronov during the geological expedition into the Pamirs organized in 1964 by the Geological Survey of the Republic of Tajikistan.

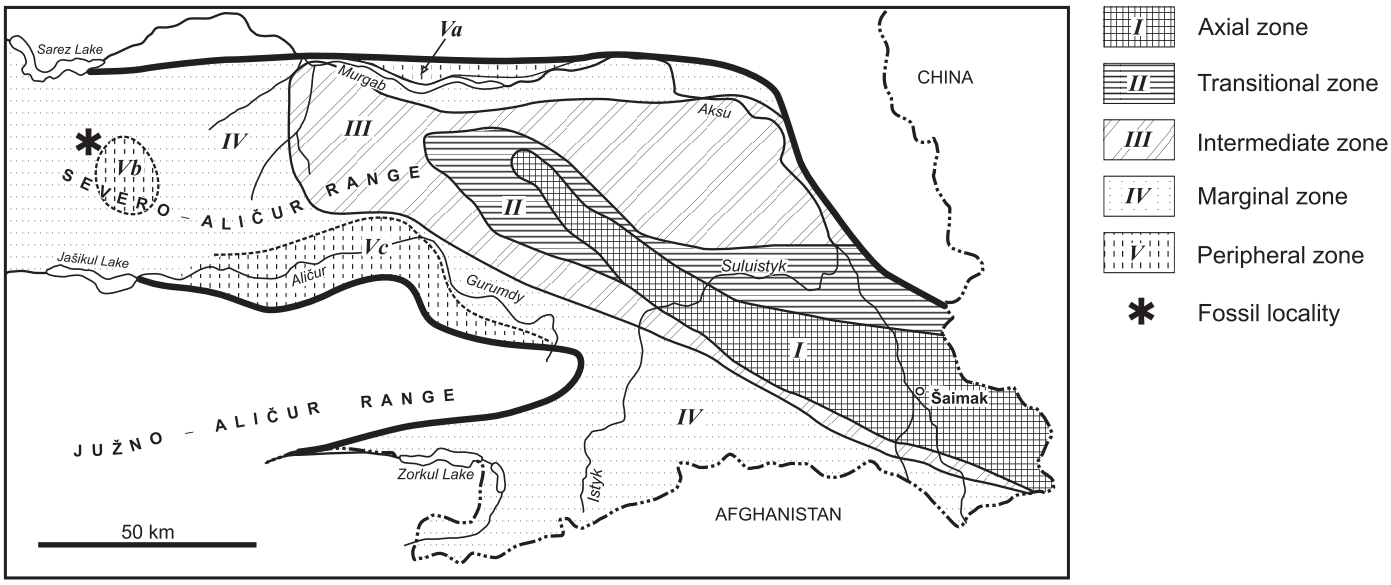

Fig. 1. Facies zonation of the Triassic in the South-Eastern Pamirs (after Dronov and Melnikova 1985, modified).

In the southeastern Pamirs, Triassic coralliferous deposits are known in two of five discriminated sedimentation zones (Fig. 1): in the Axial zone developed on an elongated submarine rise that is paralleled by adjacent basinal zones (Transitional, Intermediate, and Marginal zones) and in the outermost of all, called Peripheral zone (Dronov et al. 1982). The zones differ in water depth interpretations resulting in the following facies differentiation: in the Axial and Peripheral zones shallow-water facies developed, in Transitional and Intermediate zones there were neritic facies, and the deepest of all, in the Marginal zone. *Furcophyllia shaitanica* came from the Peripheral zone, from which the earliest Triassic corals of the region are known.

The Peripheral zone is composed of three discrete units of different sequences that represent three sedimentation subzones: Muzdubulak, Kattamardžanaj, and Tašdžilgin. In all of them, the basic parts contain volcanites; the first unit contains Induan and Ladinian deposits, while the second encompasses Ladinian and Carnian deposits yielding corals. The third contains probably Carnian and younger Triassic deposits composed of diverse volcanogenic and clastic sediments, partly metamorphosed (Dronov 2001).

ZONE	SUBZONE	SUITE	AGE
Peripheral	Kattamardžanaj	**Karadara**: ultrabasal volcanics	?early Carnian
		Kenkol: basal volcanics and bioherms	early Carnian
		Šajtan: basal volcanics and bioherms	late Ladinian

Fig. 2. Peripheral facies zone in the Triassic of the South-Eastern Pamirs: succession of upper Ladinian–middle Carnian deposits in the Kattamardžanaj facies subzone (after Dronov 2001).

The Kattamardžanaj sediments form the series composed of three superposing sequences (suits): Šajtan, Kenkol, and Karadarin (Fig. 2). The series outcrops in the basin of the Kattamardžanaj river, in the valleys of its tributaries, rivers Šajtan, Kenkol, and Akširiak.

The coral described herein origins from the Šajtan sequence. The sequence of 48 m in thickness is composed of green and green-brownish, massive and bedded lavas and volcanic breccias, tuffaceous breccias and other clastic deposits with embedded limestone fragments, boulders and bioherms containing late Ladinian fauna (Dronov 2001: 26) including: corals *Volzeia badiotica* (Volz, 1896), *Elysastrea*? *haueri* Laube, 1865 (see Melnikova 2001), and the flat clam *Daonella pichleri* Mojsisovics, 1874 (see Polubotko 2001). The fossils were found in sandstone composed of diverse, poorly sorted volcanogenic grains. The coral specimens are covered with heterogeneous layers up to 5 mm thick, some with irregular tube-like structural traces, other amorphous, probably representing microbial coatings.

Systematic paleontology

Genus *Furcophyllia* Stolarski, Roniewicz, and Grycuk, 2004

Type species: *Montlivaltia septafindens* Volz, 1896; middle Carnian, Forcella di Sett Sass, Italy.

Furcophyllia shaitanica sp. nov.

Figs. 3A–C, F; 4A.

Table 1. Comparison between *Furcophyllia shaitanica* sp. nov. and *Furcophyllia septafindens* (Volz, 1896).

Specimens	No.	d [mm]	f [mm]	s	sd/1mm	n:d	width of septa [μm]	g/1mm	CRA-CRA [μm]
Furcophyllia shaitanica sp. nov.	GID 20556/23	25 × 35	0	315	5–7	10.5	100–200	6–7	100–140
Furcophyllia septa findens (Volz, 1896)	holotype (lost) (Volz 1896: 44, pl. 3: 22–24)	larger diameters: 25–45	20	–	–				
	IPUM DOL/610	27 × 30	18	ca.300	4–5	ca.10.5	200	4–5	200

Type material: Holotype, two succeeding transverse thin sections GID 20556/23. Paratype, fragmentary transverse thin section GID 20556/6.

Type locality: Valley of Šajtan river tributary of Kattamardžanaj river, the Peripheral zone in the SE Pamirs.

Type horizon: Upper Ladinian volcanogenic and clastic deposits in the upper Ladinian Šajtan suite of the Kattamardžanaj series.

Diagnosis.—Solitary with approximately 320 septa at the calicular diameter of 25 × 35 mm, in the both parameters similar to *Furcophyllia septafindens* (Volz, 1896), but differing from the latter in a thin structure of septal apparatus, and in the central axial pit, not in the form of linear calicular fossa.

Material.—Holotype and paratype only.

Measurements.—See Table 1.

Description.—The calice is oval with a slightly wavy or lobate outline of the calicular rim and a small axial pit. The wall is very thin, septothecal, probably covered by a thin epitheca. The septa are thin, straight or arcuate and arranged radially toward the axial pit. The septa branch in the same way as those in *F. septafindens*, some remain non-branched, other intensively branch giving rise to new septa asymmetrically on both septal sides, and producing septal brooms (Fig. 3A, F). The septal brooms frequently are of a lense-like general shape. At the circumference, among septa producing septal brooms, there are quasi-systems composed of simple septa of the highest three or rarely four size orders well differentiated in length. The septal sides are densely covered with obtuse granulations that seem to be produced symmetrically on both septal sides and distributed in rows paralleling distal septal margin. The granulations reach far into the interseptal space, but the rows of adjacent septa rarely meet, suggesting their mutually alternating distribution. One of the sections shows a secondary calicular center in the vicinity of the axial pit of the adult corallum (Fig. 3A, B). This part of the corallum is re-crystallized, so the relationships between the two centers are not very clearly seen, but no septa are joining the centers. The new calice develops in the fan-like area limited by two septa of the adult calice. In the transverse section, the dissepiments are abundant, like those in *F. septafindens* and probably similarly extended (Fig. 3E).

Microstructure.—The septa are built of well delimited, rather isometric trabeculae that occupy the whole septal width (Fig. 4A). When observed in transverse section, each trabecula reveals a dark center corresponding to its Center of Rapid Accretion (CRA) and filled with diagenetically changed into opaque, calcitic deposit of the Center of Rapid Accretion (dCRA), surrounded by transparent sclerenchyme of its Thickening Deposit (TD); continuous accretion of dCRA results in formation of trabecular axis (terminology after Stolarski 2003). Lateral short offsets, provided each with a dark central axis, branch symmetrically from the main trabecula and form lateral septal granulations.

Remarks.—The differences between the species of *Furcophyllia* from the Dolomites and that from the Pamirs lie in the microstructural and morphological features. In *F. shaitanica* the trabeculae are thinner than in *F. septafindens*, the diameters being indicated by smaller distance between the centers CRA and smaller distances between lateral granulations (Fig. 4A, B). This results in smaller width of septal blades and higher septal density at the wall. But the structure of the axial part of the calice is by far more remarkably different, as the Pamirian species has a small, centered axial pit (Fig. 3C), while *F. septafindens* is characteristic for its long axial fossa (Fig. 3D). For the reason of radial distribution of septal apparatus, *F. shaitanica* corresponds more precisely to the models of furcated septal increase proposed in Stolarski et al. (2004), than in *F. septafindens,* having long fossa. *F. shaitanica* displays also a feature not presented by *F. septafindens* —the ability to form a secondary calicular center within the primary one. So, fixed polycentric conditions of corallum are not excluded in this species.

Discussion

Distribution.—In the Dolomites, *Furcophyllia septafindens* was found only in one locality, Forcella di Sett Sass, in the vicinity of Cortina d'Ampezzo. There, as in many sites in the region, the corals were collected not from the outcrops, but from the soil. Their position in the stratigraphic column is established at the middle Carnian in the interval involving the *Trachyceras aonoides* + *Austrotrachyceras austriacum* am-

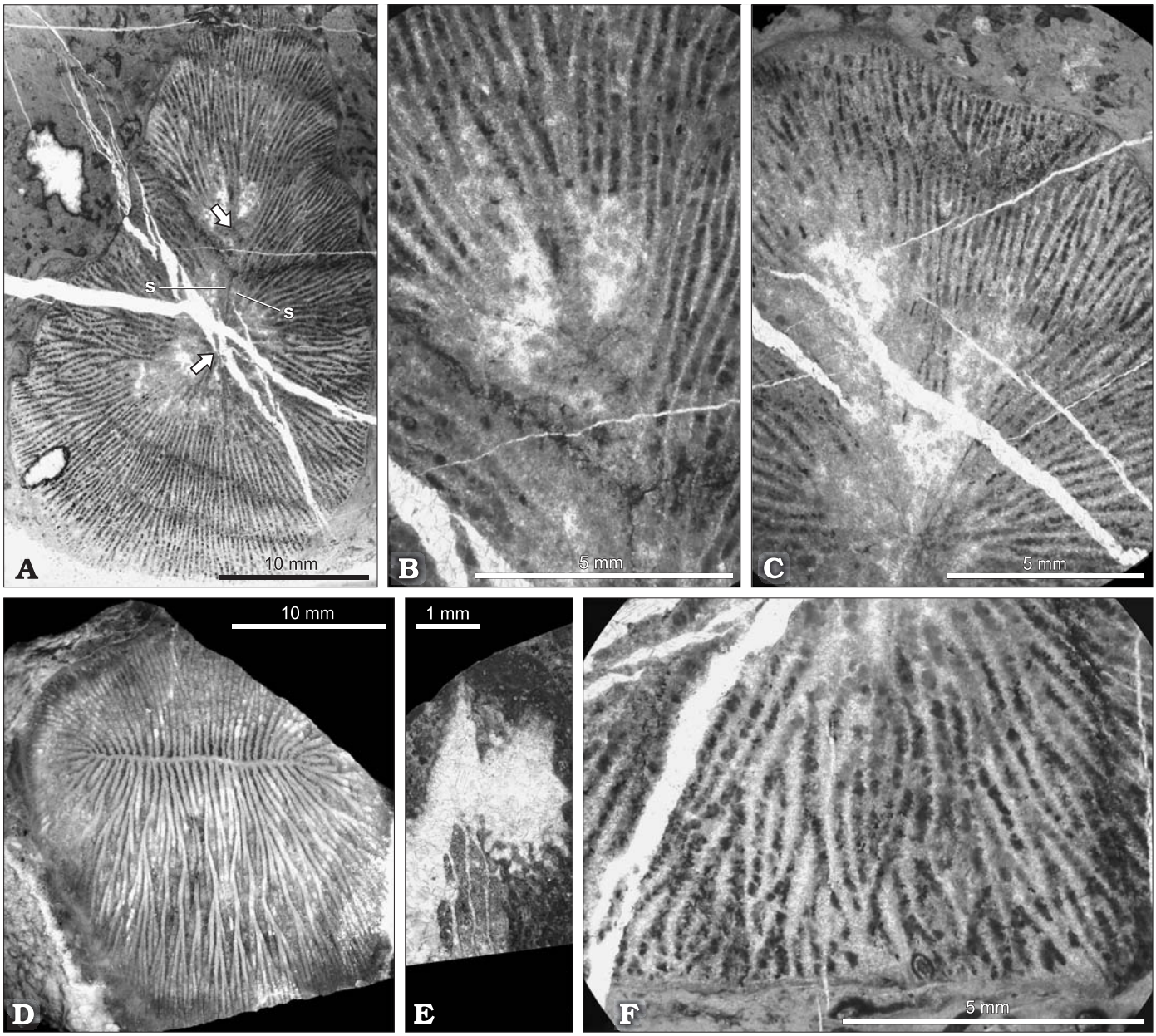

Fig. 3. Septal apparatus of *Furcophyllia* in transverse sections. **A–C**, **F**. *Furcophyllia shaitanica* sp. nov. Holotype, GID 20556/23, upper Ladinian of the SE Pamirs, Republic of Tajikistan. **A**. Corallum with two calicular pits: this of the adult calice and a secondary one of newly forming calice (arrows); two parallel septa (s) pass from the area of the axial pit of the adult towards the area occupied by the new pit, limiting this area from two sides. **B**. The secondary axial pit. **C**. The section situated more proximally in comparison with the previous one, cutting the middle calicular part; only primary axial pit is to be observed with its radial arrangement of septa, any rudiments of the secondary pit are lacking. **F**. Peripheral region of the corallum with well developed septal brooms. **D**, **E**. Morphology of *Furcophyllia septafindens* (Volz, 1896); IPUM DOL/610, middle Carnian, St. Cassian Beds, Forcella di Sett Sass, Dolomites, Italy. **D**. The section cutting obliquely the corallum at the level near by the calicular floor showing elongated calicular fossa. Compare the subparallel arrangement of septa in the central part of the calice with radial one in *F. shaitanica* sp. nov. **E**. Endotheca in longitudinal section: note steeply sloping down, very low and extended dissepiments.

monoid zones, above the volcanogenic sediments. The Pamirian *Furcophyllia shaitanica* origins from the volcanic and volcano-clastic sequence of the upper Ladinian Šajtan suite. So, recognition of the exact stratigraphic positions of the two species is rather vague. Thus the span of time separated the two species is uncertain.

Since *Furcophyllia* is a relatively large solitary coral with unusual septal apparatus, it can hardly be mistaken for any other coral. Two distinct species in geographically distant Pamirian and Alpine regions suggest that the taxon was already well established in the Tethys Ocean at least during Ladinian. Nevertheless, it remains among the rarest taxa. The

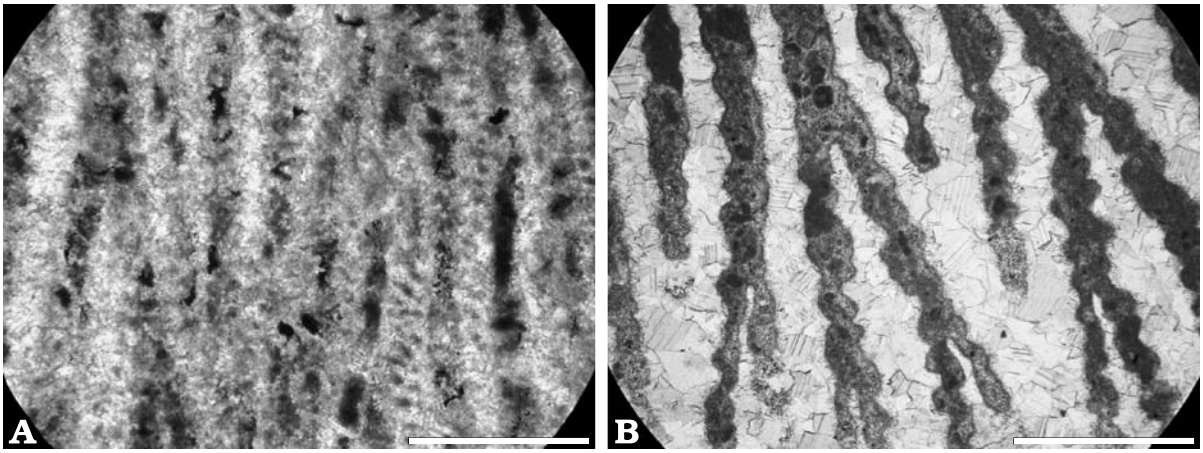

Fig. 4. Septal microarchitecture and traces of microstructure of *Furcophyllia* in transverse sections. **A**. *Furcophyllia shaitanica* sp. nov. Holotype, IGD 20556/23, upper Ladinian of the SE Pamirs, Republic of Tajikistan. Densely arranged septa with minute lateral granulations; centers of rapid accretion (CRA) are marked by dark dots. **B**. *Furcophyllia septafindens* (Volz, 1896), IPUM DOL/610, middle Carnian, St. Cassian Beds, Forcella di Sett Sass, Dolomites, Italy. Septa with relatively thick lateral granulations.

rare occurrence of the coral is probably biased by limited knowledge of Ladinian and Carnian strata in the former Tethys region.

Classification.—Transverse sections of *Furcophyllia shaitanica* sp. nov. disclose traces of isometric trabeculae resembling those in some Triassic corals described under the homonymous generic name of *Myriophyllia* Volz, 1896 (non d'Orbigny 1849), especially *Myriophyllia badiotica* (see Volz 1896: text-fig. 36) as well as those in the scleractinia-like coral, Ordovician *Sumsarophyllum* Lavrusevitch, 1971 and *Tjanshanophyllia* Erina and Kim, 1981 (e.g., *Tjanshanophyllia apekini*; Erina and Kim 1981: pl. 21: 1a–c). All these corals show, as well, densely arranged thin-bladed septa, but in Volz's *Myriophyllia* and in Ordovician *Sumsarophyllum* and *Tjanshanophyllia,* in opposite to *Furcophyllia*, the septa are simple. This difference in septal apparatuses as well as different microarchitecture (loosely arranged granulations in *Myriophyllia*, plate-like, continuous menianes in *Tjanshanophyllia*, and meniane-like structures made of granulations in *Furcophyllia*), allow to regard the similarities mentioned above as convergent features.

Systematic position of *Furcophyllia* remains debatable. Two possibilities exits: either it is a coral related to the rare Paleozoic group referred to as scleractinia-like corals or it represents an entirely new scleractinian group, most likely at the subordinal level. Distinct patterns of the septal apparatus support the first possibility. With the exception of a very general plan of coral structure, *Furcophyllia* does not show similarities with any other Triassic scleractinian. It must be stressed that the early skeletal ontogeny of this coral, as yet unavailable, may be decisive in understanding its classification. Its distribution during the Ladinian and Carnian time along the Tethys Ocean and taxonomic differentiation allow us to make a conjecture that it likely appeared early in the history of corals. Thus, Paleozoic roots among skeletonized or non-skeletonized anthozoans may not be ruled out, the problem having been recently discussed (Ezaki 1998; Stanley and Fautin 2001, 2003; Roniewicz et al. 2003) in relation to new paleontological discoveries (Wendt 1990; Scrutton and Clarkson 1991; Scrutton 1993; Ezaki 1997, 2000) and molecular phylogeny approach to the scleractinian early history (Romano and Palumbi 1996).

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