

Original Article

Some Reflections on the Beginning of the Oldest Corals Rugosa

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Abstract

Provides a conceptual theory of origin Rugosa. Discusses the possibility of the oldest single corals from the Cambrian forebears. With specific examples showing ways of their development and transmission of hereditary traits. Discusses the validity of the terms "Tetracorallia" and "Rugosa" and their bilaterally.

Keywords: Cambrian; Development; Origin; Rugosa

Materials and Methods

Material for work served as field observations and collection of fossils of the Paleozoic Rugosa authored in the North-East of Russia, the Siberian platform Podolia and the Baltic States from more than 500 diagrammatic fees and hundreds of coral communities. Morphologic characteristics and variability of several thousand paleontological slices corals at different stages of growth of corals were studied. Compiled and the results of their group and published works (see bibliography) on the morphology, systematic, evolution and variability Rugosa.

Conceptual Introduction in the Theory of the Origin of Rugosa

In the animal kingdom Precambrian undoubted dominance belonged skeleton less coelenterate - meduzoids, solitary and colonial polyps. They are the largest organisms, representing 67% of the 1500 samples of soft-bodied multicellular marine sediments collected in different areas of the Earth (Sokolov, Fedonkin, cite: ru-mo). Consequently, we cannot exclude the probability of single-band coral rugosa of Precambrian ancestors, single marine anemones that had all the features rugosa, but cannot produce solid skeleton [1,2]. The ability to

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form a calcareous skeleton could occur at the beginning of the Early Cambrian (skeletal evolution during the Cambrian explosion). And from that moment it began a rapid development rugosa and widespread dissemination. In the early Caradoc already known genera of 5-6 separate taxonomically and morphologically groups – streptelasma tin, Cystiphyllum and columnar in. On average, Caradoc number genera doubled and by the end of the Ordovician have risen to 30 with the dominance of single forms [3-5].

First rugosa had only simple septa and full bottom with single tabulae acquire the ability to very wide variation, and by the end of the Late Ordovician kaliko blastes basal surface polyp's single rugosa acquired the ability to secrete peripheral convex skeletal elements - septum (*Paliphyllum*). By the beginning of the Late Ordovician all types of microstructures - lamellar, fibrous, monakant, golokant, rabdakant, dimorfakant participated in the construction of the tabulae, septa, plate and akanthin septa. The ability to secrete lamellar sclerenchyma vertical and horizontal skeletal elements like thickening until their mutual fusion, was developed from the beginning rugosa stories and observed in many genera, or lesser greater extent until the end of their existence. A stereoplasmic growth layer (sclerenchyma cover) expanded also towards the remaining skeletal elements [1,5,6]. All such secondary thickenings were originally composed of crystalline fibrils and trabecular oriented parallel to the surface of a given skeletal element.

We can only speculate whether the evolution of life forms coral influenced change streptelasmatic internal structure or vice versa delivrance from primitive massive improved internal structure of the skeletal elements and development caused the growth of the species diversity of these rugosa that we find at the end of the single coral Late Llandovery. Even with the experimental data confirming this account with what some modern similar corals, we would not be able to transfer these results to streptelasmatic, since the nature of the appearance of single *scleractinian* metasept have in principle different from the method of laying new septum in single-band single fossil corals. But those elements evolution streptelasma tid that we can observe on the skeletal remains of these concrete rugosa remain undoubted facts allowing them uniquely interpret any professionals involved in the study of corals.

One way or another, but by the end of the Middle - Late Ordovician top single rugosa had an overwhelming number of morphological traits, vertical and horizontal skeletal elements, the microstructure of the entire arsenal of features that have occurred in the history of existence of the Middle Ordovician to the end of the Permian. Basic life forms were developed - a conical, cylindrical-conical, trochoid, turbidity. Vertical single skeletal elements deposited rugosa as plate and spiny, large and small septum. Partitions themselves since the beginning of the emergence possessed a high degree of variability in shape, curvature, length and width, as well as spatial orientation in the axial zone corallites. Various types of axial structures can form in the cup coral subtle and very prominent uplift. Oriented septum

bilaterally pinnately or subradial released with size major protosepta that could pitch in fossula recess.

Along with this happening deliverance from sclerenchymal thickening of the skeletal elements, the development of septal apparatus of thick rare septum in numerous thin septa. Increasing the number and size interseptal cameras, converting the axial structure of the solid with central sclerenchyma raising through fungus- porous structure of the entanglements septa and tabulae in the axial wave septum, and then the release of the central area of any coral formations axis. Transformation complete rare tabulae in numerous incomplete convex interseptal lamellas, sometimes to proto dissepiments (Figure 1). This single form of existence and throughout the history of bilateral streptelasmatid orientation corallites their bodies and that at the time of their greatest prosperity become pronounced.

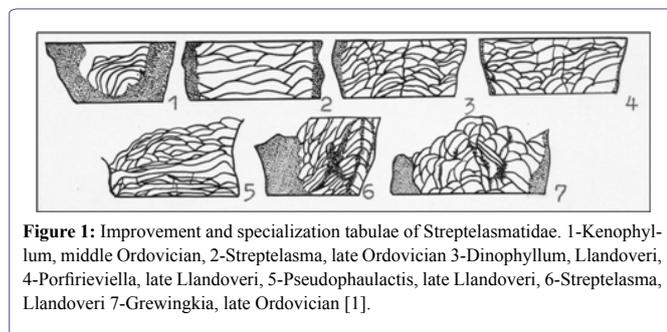


Figure 1: Improvement and specialization tabulae of Streptelasmatidae. 1-Kenophyllum, middle Ordovician, 2-Streptelasma, late Ordovician 3-Dinophyllum, Llandovery, 4-Porfirievella, late Llandovery, 5-Pseudophaulactis, late Llandovery, 6-Streptelasma, Llandovery 7-Grewingkia, late Ordovician [1].

From this perspective, it seems to me likely following scheme of single-band single rugosa (Figure 2).

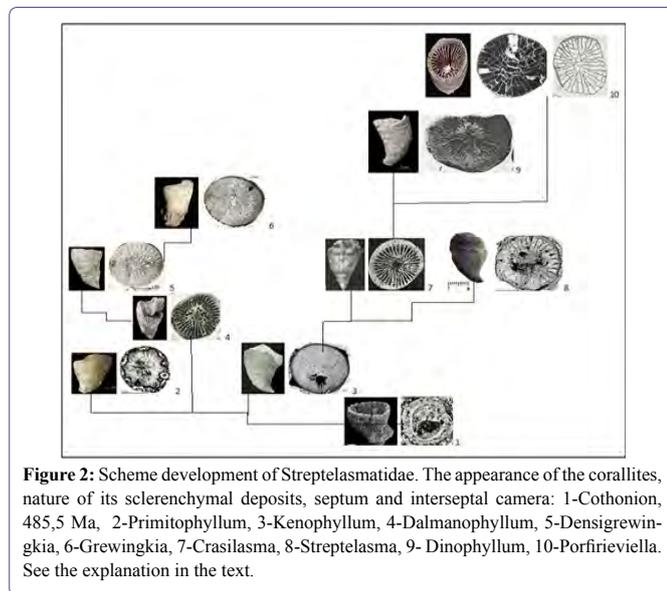


Figure 2: Scheme development of Streptelasmatidae. The appearance of the corallites, nature of its sclerenchymal deposits, septum and interseptal camera: 1-Cothonion, 485,5 Ma, 2-Primitophyllum, 3-Kenophyllum, 4-Dalmanophyllum, 5-Densigrewingkia, 6-Grewingkia, 7-Crasilasma, 8-Streptelasma, 9- Dinophyllum, 10-Porfirievella. See the explanation in the text.

Information and Discussion about the Origin of Rugosa

Streptelasmatidae ubiquitous in marine sediments from the Early and Middle Cambrian to Late Llandovery [5,7,8-10]. The most primitive solitary corals were probably genera *Cothonion*. Dzik, et al. made an attempt at the reconstruction of the earliest history of the Rugosa

[11]. He favored the early Middle Cambrian, as ancestral for all of the Rugosa. He based his conclusions only on the original description of on account of the similarity of its operculum to the Devonian *Calceolasandalina* [8,12]. There is no need and reliable data, how to write Fedorovski [13] to bind to *Cothonion* by *Calceola* using the presence of caps at the latest. As well as trying to find the similarities and differences between rugosa and scleractinian, as does the last author. This is a completely different animal organized. The characteristics and properties of these groups of coral only converged. And to refer to rugosa Cnidaria and even more so to Hexacorallia is very doubtful and wrong [14,15]. Especially because Rugosa name they received 16 years earlier [16]. No one knows whether they have stinging cells and exactly at rugosa laid protoseptum only four instead of six like *scleractinian*. As rugosa never been Tetracorallia [15,16].

Representatives *Cothonion* enough their features and characteristics, to consider them as credible ancestors rugosa and in particular the first of them, streptelasmatid. But more about that in the next paragraph.

Not everyone believes that rugosa, in the early stages of the evolution of cnidarians, connected its origin with coral genus *Cothonion* [3,17,18]. Nevertheless it facts and specific instances of these fossils rugosa remove existing doubts. Obviously, this was a small trochoid corals with characteristic rugosa deep cup, developed septa, fibrotic and trabecular microstructure corallites [8,10]. Corals possess bilateral symmetry and unique to rugosa to insert septal walls, which are clearly visible on the surviving corallites (Figure 3). They may be single thin plate shaped tabulae.

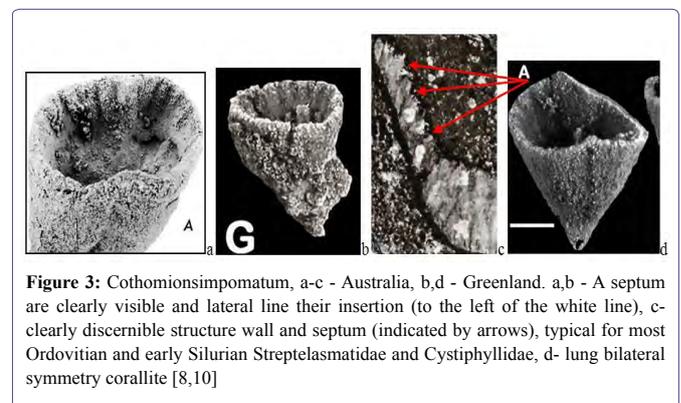


Figure 3: *Cothonionsimpomatum*, a-c - Australia, b,d - Greenland. a,b - A septum are clearly visible and lateral line their insertion (to the left of the white line), c- clearly discernible structure wall and septum (indicated by arrows), typical for most Ordovician and early Silurian Streptelasmatidae and Cystiphyllidae, d- lung bilateral symmetry corallite [8,10]

By the early Middle Ordovician in different seas and there rugosa *Primitophyllum*, *Kenophyllum*. If the first had a solid sclerenchymal thickening skeletal elements at all stages of growth, the presented *Kenophyllum* during ontogeny markedly rid of these deposits. Interseptal camera in the early and middle stages of growth can not be traced. With age, they developed a coral, but remain rare, short and narrow. Tabulae, complete and rare, were appearing only in the later phases of ephelic growth stage (Figure 4). By the end of the Middle and Late Ordovician both species ceased to exist. More similar to rugosa characteristics not known to early Ordovician none of fossil animals.

From the very beginning of history Streptelasmatidae their development has gone in two ways. On the one hand, it developed a group of coral formations with intense axial and continuing during ontogeny

gosa, with developed interseptal cameras already in the early stages of growth, heavily facilitated in ontogenesis all skeletal elements. The second line of development, a progressive, includes most Streptelasmatae.

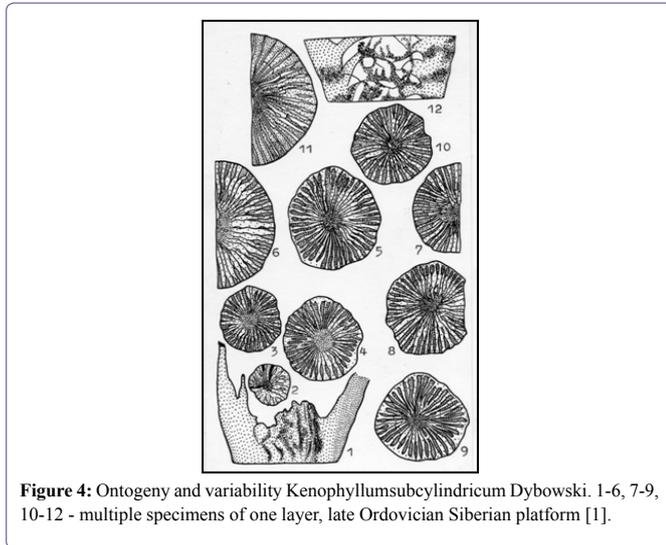


Figure 4: Ontogeny and variability *Kenophyllum subcylindricum* Dybowski. 1-6, 7-9, 10-12 - multiple specimens of one layer, late Ordovician Siberian platform [1].

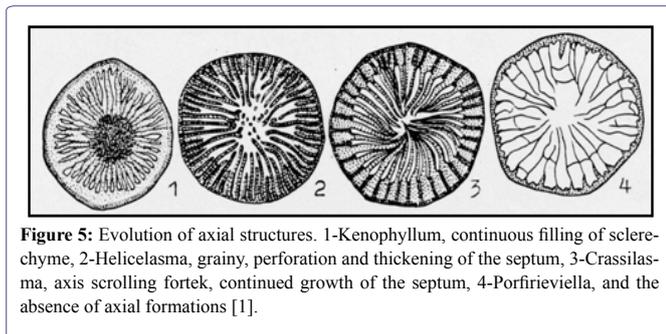


Figure 5: Evolution of axial structures. 1-Kenophyllum, continuous filling of sclerenchyma, 2-Helicelasma, grainy, perforation and thickening of the septum, 3-Crassilasma, axis scrolling fortetk, continued growth of the septum, 4-Porfirievella, and the absence of axial formations [1].

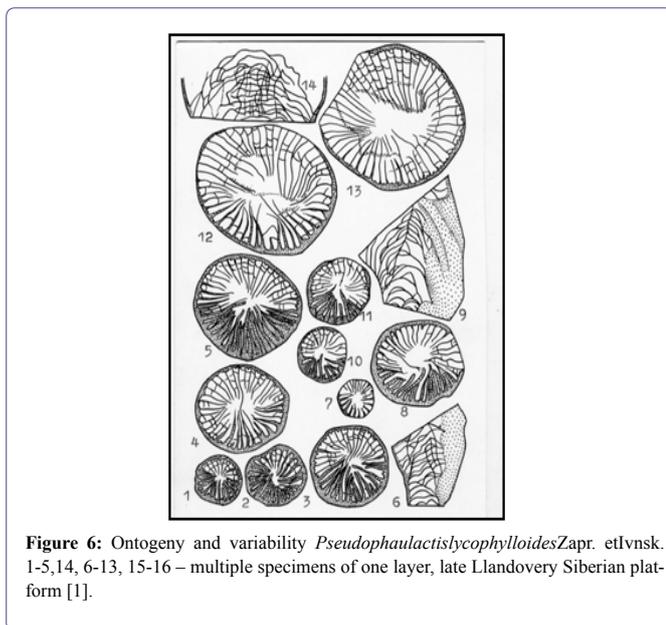


Figure 6: Ontogeny and variability *Pseudophaulactislycophylloides* Zapr. etlvnsk. 1-5,14, 6-13, 15-16 – multiple specimens of one layer, late Llandovery Siberian platform [1].

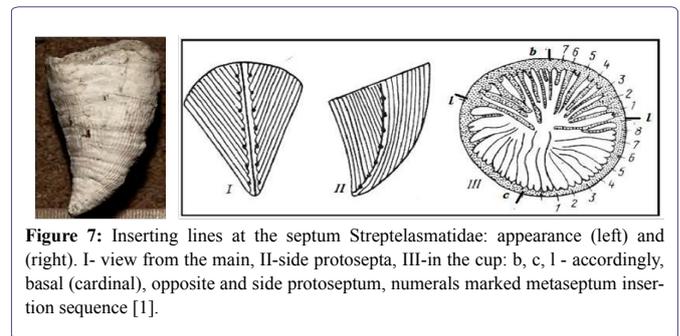


Figure 7: Inserting lines at the septum Streptelasmatae: appearance (left) and (right). I- view from the main, II-side protosepta, III-in the cup: b, c, l - accordingly, basal (cardinal), opposite and side protoseptum, numerals marked metaseptum insertion sequence [1].

Acceleration in ontogenesis sclerenchyma reduce some *Kenophyllum* by increasing the work and the number of platelets led to the end of the first half Late Ordovician rugosa genera *Dalmanophyllum*. These corals were more highly organized than their possible ancestors. Although they remained entirely with the early stages of merging septa without visible boundaries interseptal cameras and axis structure of sclerenchyma cover, but by the middle phase of neanic growth stage habitats most interseptal chambers partly exonerated from sclerenchyma deposits. At a later stage they were clearly distinguishable between each pair of baffles moderately incassation of sclerenchyma.

Derived from *Dalmanophyllum* can be considered *Densigrewingia* and *Grewingia* as a result of further development of the ability of coral faster during growth to facilitate significant part of corallites abundant sclerenchyma.

Streptelasmatae type *Densigrewingia* just as their ancestors had, since the early stages may be exempted from part of sclerenchyma, but this release has been much more intense. Almost all interseptal cameras they differed with neanic growth stage. Further evolution of the tabulae, increase the convexity of the plates and their number, and the acceleration of the process of getting rid of sclerenchyma in ontogenesis leads to rugosa of genera *Grewingia*. Majority *Grewingia* from the earliest stages freed from a significant number of sclerenchyma, thereby facilitating corals. Many of these early differed interseptal camera. *Densigrewingia* exist until the end of the Ordovician, *Grewingia* lived until middle Llandovery, *Dalmanophyllum* - until the end of Llandovery.

On the other hand, the development tendency streptelasmataid conversion axial structure, increasing the number and size of interseptal chambers thinning due to skeletal elements, large plates tabulae conversion into smaller convex, numerous, sometimes interseptal.

For corals with such an organization, first of all, are rugosagenera *Crassilasma*, which could occur from *Kenophyllum*, freeing up more skeletal elements and axial space coral formations on ample sclerenchyma. In the early stages of growth of these rugosa as well as that of their hypothetic ancestors were thick confluent septum without distinction interseptal cameras. The oldest *Crassilasma* keep a thickening neanic until the end, and even until middlebrepic growth stage. The majority of same *Crassilasma* ferns started to decline from the mid-to late neanic stage, revealing interseptal camera. But the final extinction, it is also like *Kenophyllum*, it did not occur even at the late stage of growth. All *Crassilasma* skeletal elements were thickened to a greater or sclerenchyma least coral throughout life, but in the axial space was not sclerenchyma solid. Septum, and filled if the axial zone, it is not in fuse structure. Reliable *Crassilasma* known since the

beginning of the Late Ordovician, but their level of organization inner structure in the Late Ordovician says that the roots of these streptelasmatid should go into the Middle Ordovician, close to the time of occurrence and spread of Kenophyllum.

Strengthening the process of reducing sclerenchyme with septal apparatus and zoom interseptal cameras some *Crassilasma* could cause streptelasmatid genera *Nelicelasma*. These corals only in the very early stages of growth were abundant deposits of sclerenchyma. But from the middle phase neanic stage it began to decrease rapidly, facilitating the skeleton and labeling short interseptal chamber, the number and size of which increased rapidly with age coral. The axial zone filled with curled or variously curved, sometimes interrupted ends septum composing the porous structure of the centerline. On epehebic stage growth thickened skeletal elements were only peripheral parts of septum. This is significant progress in the development of single-band single corals to facilitate and improve the skeleton. Most of the life of a polyp was large enough and numerous interseptal camera and a relatively thin skeletal elements. Deputy *Nelicelasma* arose, probably in the second half Middle Ordovician and lasted until the end of the Late Llandovery.

Even more intensively going reduction in sclerenchyma corallites and above all, in the axial zone of the genus *Streptelasma*. These rugosa the earliest stage growth clearly differed interseptal cameras that with age, as well as skeletal elements, almost entirely absolve from sclerenchyma. With an average phase neanic stage growth most of these rugosa axial zone has remained free from any axial formations. At a later stage of growth continued to thicken sclerenchyma exiguous of the peripheral parts of the septum. *Streptelasma* existed since the middle of the Middle Ordovician to Late Llandovery.

With the passage of time to become a characteristic streptelasmatid only moderate thickening of the skeletal elements by sclerenchyma and development interseptal cameras free of it at an early growth habitats. The nature of the deposits sclerenchyma new feature appears in the process of evolution. During ontogeny, it is now not only reduced, but distributed differently in different parts of the coral. Septal apparatus of single-band rugosa obtain increasingly clear bilateral orientation, and the tabulae of the plate became more numerous, but smaller and more convex and counter sectors tend interseptal (Figure 5).

One of the first streptelasmatid with the development of the skeleton steel corals genera *Dinophyllum*. These were the early rugosa stage growth has considerably lightened the skeleton with moderate deposits sclerenchyma and clearly distinguishable inter septal cameras. With the growth of coral skeleton thickening reduces or distributed on the periphery of the septa around the perimeter of the cup, or only in the main and opposite sextants. Septal apparatus the end of the neanic stage, as a rule, acquired a clear bilateral orientation. Representatives *Dinophyllum* emerged, most probably from the Late Ordovician *Crassilasma*, reached its peak in Llandovery and, most likely, in early Wenlock ceased to exist.

Acquiring the ability to differentiate sclerenchyma with the aftermost early stages of growth could give some Kenophyllum to education streptelasmatid genera *Pseudophaulactis*. This coral extinction occurred first on skeletal elements opposite the top side, and then with middle growth stage began intensive thinning of the skeleton in the main sectors of the lower reclining side. In the later stages of growth sclerenchyma it disappeared completely or very slightly thickens

peripheral ends of the septa, mostly cardinal directions (Figure 6) *Pseudophaulactis* known from the Late Ordovician to Late Llandovery.

Some Llandovery *Dinophyllum* were able in the early stages of growth is almost completely relieve skeletal elements of sclerenchyma deposits. Securing this ability could cause the appearance genera *Porfirieviella* of coral that had thin septa, clear interseptal camera and only minor sclerenchyma thickening at the earliest stages of growth. From the middle stage of these corals skeletal elements hardly carried any bulges. Tabulae in ontogenesis increased in number, but their records abridge sizes to transform into vesicular-interseptal on the periphery of the coral. *Porfirieviella* had known only Llandovery.

Some *Dinophyllum*, *Pseudophaulactis* and *Porfirieviella* on late stages of growth in many ways reminiscent of primitive pleonophorn rugosa multiple thin septa, sometimes two cycles, raised numerous interseptal plates tabulae, clearly visible in the cross sections, minor deposits sclerenchyma vice peripheral rim. This is especially true for the latter species of corals.

Observation on Symmetry Rugosa

Many, particularly the Russian-speaking publications, rugosa called 'four radial corals - Tetracoralla' rather than "Tetracorallia" as the primary source in Haeckel, et al. [15]. The author has shown that rugosa cannot be attributed to the four beam animals [16]. E. Haeckel in this term put a different meaning (1866). By Tetracorallia he took coelenterates animals with a four-beam symmetry (hence the name), and rugosa, followed by Edwards and Haime, et al. [19], he singled out in a separate unit based on them is clearly visible morphological characters of longitudinal and transverse wrinkles wall corallites (rugae - «wrinkle" in Latin).

There is a concept of the origin Bilateria from Vendian bilaterally symmetrical coelenterates with metameric arrangement of the pockets of the gastric cavity. Ancestors Cnidaria attached to the substrate aboral pole, resulting in a reduction of the aboral nerve ganglion. Bilateral symmetry coral is treated as a characteristic feature of primitive cnidarians [20].

The fixed on the outer surface throughout the entire life cycle of the device orientation septal many rugosa demonstrates that it was bilaterally symmetrical animals (through the body and its coral skeleton can be carried out only one plane of symmetry). Metasepta insertion mechanism also shows that was inherent only rugosa bilateral symmetry [5,19,21-23]. Of all the possible ways of inserting the next successive partitions are "selected" only one - each next metaseptum inserted only in the direction of the main protosepta (Figure 7).

It is believed that coelenterates cells phagocytoblast acquired epithelial location and developed [23,24], for the first time in the history of animals, a common digestive cavity connected with the environment a real mouth. With coelenterates and binds the first appearance of nerve cells and their tissues circa divided into the same as that in higher animals: epithelial, connective, muscular, nervous, and reproductive. All multicellular facing upstream of coelenterates, referred to as Bilateria, suggesting a new level of organization of the body plan of the main building. On the ways of evolution of living organisms is their development of formless protozoa (anaxial amoeba) to bilaterally symmetric vertebrates. We can assume that the body of the ancient coelenterates is in the initial stages of integration of tissue

transformed from monaxial form by further restructuring in bilaterally symmetrical. The first recorded find it at *Cothonionsimpomatum*, the beginning of the early Cambrian of Greenland (Figure 2d) - the first skeletal ancestors of rugosa, and at the last bilateral body symmetry existed continuously during the life cycle. And it was not already selected, and numerous corals, occupying a leading position in the formation of the then marine ecosystems and a large part of sedimentary rocks.

Bilateral symmetry is hypothetical rugosa and was fixed skeleton themselves, so it should be formed much earlier, then there are, in the Precambrian. The principal types of invertebrates became isolated in Vendian and bilateral symmetry, such as trilobites is not in doubt. Qualitative restructuring of symmetry coelenterates on a completely different level of organization may have occurred in one of the critical boundaries of natural systems [8,25] at the beginning of the last milliardoletic.

If we assume that coelenterates - the first multicellular animals in Earth's history, and we know that 63-70% of species of multicellular Precambrian accounted for coelenterates, then we are entitled to assume that the first bilateral symmetry manifested in this group of animals.

Conclusion

Streptelasmataidae most likely have monophyletic origin, and the above internal structure of the organization could be the ancestors of many branches of pleonophora rugosa. A coral with symptoms similar to rugosa of genera *Phaulactis*, *Pilophyllum*, *Neocystiphyllum*, *Miculiella* etc., would almost certainly have had ancestors Streptelasmataidae [8,9]. By the early Silurian, in some provinces of the late Ordovician, streptelasmataid achieve widespread distribution, its height and the internal structure of close pleonophora corals, widespread outbreak of the formation of the latter, attributable to the late Llandovery, most likely occurred precisely because many of them were the ancestors of many Steptelasmataidae.

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