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Particular Qualities of Identification and Taxonomy of Some Scleractinian (Scleractinia: Astrocoeniina) Family Acroporidae Verrill, 1903

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Abstract Brief history of taxonomy and identification of one of the diverse groups of the hermatypic coral family Acroporidae. Drawn attention to the difficulties and errors that have occurred in their taxonomy. Describes the terminology and morphological characteristics that can be successful identification and description of corals of the family.

Keywords Family Acroporidae; History Study; Systematics; Signs

1 Taxonomic Implication

Family Acroporidae consists of five genera – *Montipora*, *Acropora*, *Astreopora*, *Isopora* and *Anacropora*. The latter genus includes several species, which at the present are known mainly on the reefs of Australia and Philippines. One *Anacropora* species has been found on some reefs of the Spratly Archipelago and the Indian Ocean. Whereas corals of the first three genera, being only 3.79% of the generic structure of reef-building scleractinian, substantially determine their species diversity on practically all reefs of the Pacific and Indian Oceans, and compose 39.89% of more than 1500 nominal species of the Indo-Pacific area. *Acropora* and *Montipora* have the greatest taxonomic diversity of all scleractinian of the Indo-Pacific area: 364 and 211 nominal species, respectively (80-85 and 48-50 of valid species). Acroporids are able to have all the growth forms known for hermatypic corals. Branching and lamellar colonies of *Montipora* and *Acropora*, and particularly the latter ones, are able to constitute dense populations on reef flats and reef slopes, which can extend along reefs for many hundreds of square meters. Being distributed everywhere and having a leading part in reef-formation, at the same time acroporids are the most difficult for identification. The extremely variable growth form of the colonies – from massive encrusting to finely branching forms, small corallites, quite similar for all representatives of the family, the small number of "good" diagnostic features, permitting one to distinguish one species from another one, result in the fact that many species often have 5-10 synonymous names. The number of nominal species of *Acropora* and *Montipora* is 4-5 times greater than that of the number of valid species in those genera. The acroporids of the Great Barrier Reef (Australia), the Philippines, Japan, the Maldives, Vietnam and the Red Sea have been described and redecribed in the modern times, and species lists of the Seychelles Islands have been revised, but in many regions the species composition of acroporids, as well as that of the other scleractinian, still contains many synonyms, or, on the contrary, is far from being complete and contains only the main species. The ubiquity and the great diversity of acroporids corals on the Vietnamese reefs, more 25% of the total Acroporidae Indo-Pacific (Latypov, 2014), allow to consider particularities of their identification and taxonomy.

2 Taxonomic History

The genus *Montipora* was established by H. Blainville in 1830 (Blainville, 1830) though the description appeared in 1833 (Quoy and Gaimard, 1833). J. Dana (1846) discussed such corals under the name *Manopora*. He included 29 species in this genus, 16 of which were new ones. M. Edwards and J. Haime again revised *Montipora*, restored its status, and included species of other genera, especially that of *Porites* (Edwards and Haime, 1849, 1850). H. Bernard (1897), discussing the confusion with identification of *Montipora* type species, came to the conclusion that *Montipora obtusata* Quelch, 1866 can be identified as the type of the genus. He studied the *Montipora* collection of the British Museum (presumably 135 species), described it in detail, re-described and systematized it. Describing *Montipora* species, Bernard divided them into five main groups according to the morphology of their colonies: glabrous, glabro-foveolate, foveolate, papillae, and tuberculate. The latter three had further subdivisions. Bernard described and re-described 89 nominal *Montipora* species, which make up 75% of all species of this genus.

After Bernard, issues of nomenclature of some species and partially revision of the genus *Montipora* were dealt with by T. Vaughan (1918), C. Crossland (1952), J. Wells (1954, 1956), and F. Nemenzo (1967). Nevertheless, corals of this genus, which is the second most diverse genus, were described mainly based on a small number of specimens without the study of their variability in natural conditions. That is why the majority of them retained their unexplained problems of synonymy, problems of geographic and genetic variability in the given region.

J. Veron and C. Wallace (1984) re-considered the majority of type specimens (holotypes, syntypes) of *Montipora*. Based on the data they obtained, and investigating variability of these corals on the basis of facts of their own observations on the Great Barrier Reef, these researchers made a revision of most of the nominal species names. After Bernard, these authors subdivided morphologically all *Montipora* into five types. When describing *Montipora*, they used new terms – papillae and tuberculae – for the series of structures formed on cenosteume. Veron and Wallace described 36 species of *Montipora* from the Great Barrier Reef, two of which were new ones. Numerous other names were placed in synonymy with these 36 species

Anacropora was distinguished as an individual genus by S. Ridley in 1884 (Ridley, 1884). Nine nominal species are known, and four of them are synonymous by their type specimens with *Anacropora forbesi* Ridley, 1884 (Veron and Wallace, 1984). The rest of the species can be differentiated clearly enough systematically. Veron and Wallace, describing *Anacropora* of the Eastern Australia, briefly considered taxonomic problems of all known species of this genus, and showed synonymy of some species with respect to the others (Veron and Wallace. 1984).
Perhaps *Acropora* is one of the most important coral groups among scleractinian having the largest number of species and the greatest importance in reef-formation of the reefs of the Pacific and Indian Oceans. No, wonder that genus *Acropora* has the greatest number of taxonomic problems of any genus of corals. Due to their wide polymorphism, extraordinary diversity of variations of colony shapes (forms) even within the same biotope, not to mention geographical variability and variability due to environmental fluctuations, *Acropora* species are one of the most difficult to identify. Suffice it to say that the status of genus *Acropora* Oken, 1815 was restored by the International Committee on Zoological Nomenclature only in the second half of the XX century (Boschma, 1961; China, 1963). Though many researchers after A. Verrill (1902), who provided grounds for restoration of replacement of *Madrepora* by *Acropora*, applied the latter genus mane.

Early investigations of *Madrepora* corals were more descriptive than taxonomic. It was the process of accumulation of isolated data, and the first attempts to interpret and classify the materials. The first monographic investigation of *Madrepora* was conducted by G. Brook at the end of the XIX century (1893). He critically examined the schemes of the previous researchers (Dana, 1846; Edwards and Haime, 1850; Klunzinger, 1879), showing that they were based only on colony habitus, and many of their subdivisions of colony types overlapped in the distinguishing features. Taking into account distinctions in colony shape, skeletal peculiarities of corals, and analyzing their variability, Brook re-described all known species, and described 93 new species from the collection of the British Museum. Despite the fact that Brook did not investigate *Madrepora* in natural conditions and his descriptions were based on museum collections, taxonomists use many species identified by him today.

In the first half of the XX century *Acropora* were investigated in detail together with the other scleractinian by many researchers (Vaughan, 1918; Hoffmeister, 1925; Crossland, 1952; Wells, 1954); however there were no special works devoted to just *Acropora*.

C. Wallace was actually the first researcher who studied *Acropora* in situ and type material in museum collections (Wallace, 1978). She revised *Acropora* of the Great Barrier Reef of Australia, described 41 species and synonymized about 100 species. Wallace thought that the main features characterizing a genus are the form of colony branching due to lengthwise growth of axial polyps, and peculiarities of budding of radial polyps. She distinguished sice varieties of the main colony forms, and 14 forms of radial corallites and ways of their budding from the wall of the axial corallite, and used these features when identifying and describing species.

Genus *Astreopora* was introduced by H. Blainville in 1830 (Blainville, 1830), when isolating four species of this genus from the genus *Astrea* (Lamark). In the following years, the genus was enlarged by other species (Dana, 1846; Verrill, 1872; Gardiner, 1898; Hoffmeister, 1925; etc.). Minor revisions and re-identifications of species based on field investigations and investigations of type species were conducted in the first half of the XX century (Yabe and Sugiyama, 1941; Wells, 1954).

Yuri Latypov, studied *Acropora* in situ (more 1000 specimen) and photo type material in museum collections, describing Scleractinian Vietnam, considered a brief history of the taxonomy of this genus, terminology and morphological signs used when identifying and describing these corals. He described with an extensive synonymy 5 *Acropora* species, three of which are new to science (Latypov 1992, 2014).

Isopora name first appeared in 1878, the year when T. Stader described *Acropora-Madrepora (Isopora)* (Stader, 1878). These corals were identified and described as *palifera* and *Acropora (Acropora) cuneata*. In 1984 year Veron and Wallace (Veron, Wallace, 1984) offered their assigned to *Acropora* Subgenera *(Isopora)* with the model view *Astrea palifera* Lamarck, 1816.

One publication Latypov (Latypov, 1992), drew attention to the fact that these two species are very different from all other *Acropora*. Having full-scale observation and study on the material collections of coral from the Great Barrier Reef, Vietnam, Seychelles and Mauritius, he found that among the large variety of species of the genus *Acropora* species group is allocated with the following characteristics, detached them from other species in this genus:

1. Unlike in all the other *Acropora* species, transformation of the planula larva into the polyp in them takes place in the gastric cavity.
2. All corallites grow with an equal rate without subdivision into axial and radial corallites.
3. They never form branched colonies, have encrusting and encrusting-massive colonies with vertical columnar or palm-shaped branches.
4. Being distributed mainly in shallow waters of lagoons, inner reef-flat, backreef zone and the upper part of barrier reef slopes, they, as a rule, form vast monospecific colonies.

The main peculiarity of *Acropora* is the presence of axial corallites which, having larger sizes, are able to grow faster than the other corallites, and to form colony branches. Radial corallites, which is the other distinctive form of these corallites, bud from the top or lateral surface of axial corallites. The way of budding and shape of a corallite and its calice are noticeably different in every species. Growth and the relationship between axial and radial corallites provide the opportunity for *Acropora* species to form branched colonies especially well in this genus. Due to such properties, they stand apart from the other genera and occupy the key position among the other scleractinian of a reef ecosystem.

Thus, a group of species, having a pronounced morphological status (absence of axial and radial corallites, inability to form branched colonies), peculiarities of reproduction (bearing planula up to a polyp state) and occupying specific ecological niches, should be distinguished taxonomically as well. That is why it is better to consider corals of subgenus *Madrepora* (*Isopora*) Studer (1878), synonyms Brook (1893), *Acropora* (*Isopora*) Veron and Wallace (1984), and subgroup *Isopora* (Nemenzo, 1967) within the independent genus *Isopora* Studer, 1878 (Latypov, 1992, 2014).

Latypov also showed that constantly found two forms of *Isopora* – incrusting and massively branching distinctly separated and on other grounds. The first is the corallites are shallow, chaotic densely adjoin to each other (65-72 per unit area), covered by numerous spines. The second is the corallites are larger (23-36 per unit area), poorly oriented in rows and separated from each other. They were described as *Isopora cuneata* and (Figure 1). Below you will see that these are two genetically isolated species. K. Wallace pointed out that some questionable types of *Acropora* better consider comprising subgenus *Acropora (Isopora)* Studer, 1878, to elevate the status of the genus *Isopora* by T. Randall (Randall, 1981), but so far they have not come to a final decision (Wallace, 1997)

Later, Wallace and co-authors, having morphological and genetic studies of different corals *Acropora* and *Isopora* confirmed the statements of Latypov. They showed that the species *A. palifera*, *A. togianensis* and *A. cuneata* except bearing polyp inside known, instead of broadcast spawning external fertilization, (as all *Acropora*) differ from each other, and from other *Acropora* on mitochondrial knowledgebase b (cytb) and nucleic histones 2a and 2b (h2ab) group A. They formally proposed the species *Acropora (Acropora) togianensis A. (Isopora) palifera* and *(A) (Isopora) cuneata* classified as genus *Isopora* Studer , 1878 (Wallace et al., 2007).

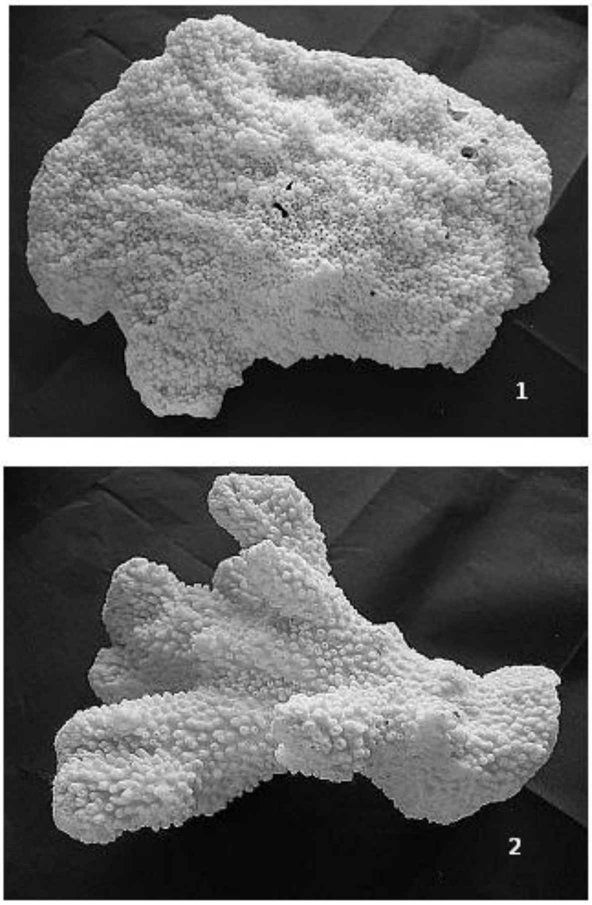

Figure 1 Form colonies of corals of the genus *Isopora*. 1- *I. cuneata*, 2- *I. palifera*, clearly visible differences in the sizes of the corallite and their location.

3 Terminology and Morphological-taxonomic Signs

Since acroporids are one of the most complicated coral groups, it is necessary to pay special attention to peculiarities of terminology and construction of skeletal elements, used in identification and systematization of corals of this family. Acroporids do not have or have rudiments of many skeleton elements, which are usually used in species identification and investigation of variability of most other corals: columella, dissepiments, and septal structures. That is why colony shape, modes of branching, features of coenosteum structure, construction of axial and radial corallites and their interrelations serve as the main characteristics for identification of genera and species.

The main distinctive feature of *Acropora* from *Anacropora*, as well as from all other scleractinian formation of two types of radial and axial corallites, which differ morphologically and functionally. Axial corallites are beginning to grow from the base of the colony and grow up with different speeds, diversely oriented in space according to the genetic abilities of each species in a particular environment Wednesday. Constantly increasing at branches in different directions, they form branching and branchy-plate of the colony and never form massive colonies. Radial corallites are forms from the lateral surface of the axial angles with varying density and have a different cup. Their growth in aggregate and generates the diversity of colonies, which is inherent in *Acropora*.

3.1 Form of Colonies

Most *Montipora* species have massive or massive-encrusting colony shapes. For some species, colony shape can vary from horizontally lamellar to digitate-branching and subarborescent even within the same biotope. In such cases colony shape as a distinguishing feature can be used together with the other characteristics, and primary among these are peculiarities of a corallite form (shape) together with cenosteume structure.

Coenosteum consists of a basal formation termed reticulum, as well as a series of combined cenosteume structures, distributed among corallites and termed papillae and tuberculae. Papillae protrude in a form of digitate branchlets on the surface of the reticulum, having a diameter equal or less than that of a corallite (Figure 2). Papillae may surround corallites (thecal papillae), or may be scattered independently of the corallite (reticular papillae). Both types of papillae can be simple or compound. Tubercle can be thought of, as large papillae with sizes can be several times the diameter of the corallite. Tubercle often merge in rows, ribs or can be thecal or reticular like papillae, i. e. they can surround corallites or be dispersed among them. The main shapes of *Acropora* colonies are termed arborescent, hispidose, corymbose, caespitose, digitate, and lamellate (Figure 3).

Figure 3 The appearance of colonies *Acropora*: 1-subarborescent, 2-tree, 3-corymbose, 4-5, subdigitate-cespitose, 6-digitate, 7-lamellar, 8-massively branching

3.2 Структура Кораллитов

Corallites of *Montipora* can be immersed or exert above the cenosteume (Figure 2). They can have or lack thecal papillae or tuberculae. Immersed corallites can be deeply embedded in reticulum in such a way that the latter forms the upper corallite wall, which is usually funnel-shaped. Such corallites are termed foveolate. Corals without any additional structures in reticulum are termed glabrous.

Anacropora also have the same construction featuresas *Montipora*, but they form arborescent and subarborescent colonies with regularly located corallites on the branch surface. The coenosteum of these corals has similar construction for all species and consists of thin tall spinules with complexly branching top ends, without the formation of tubercle. Despite good branching, *Anacropora* have no axial

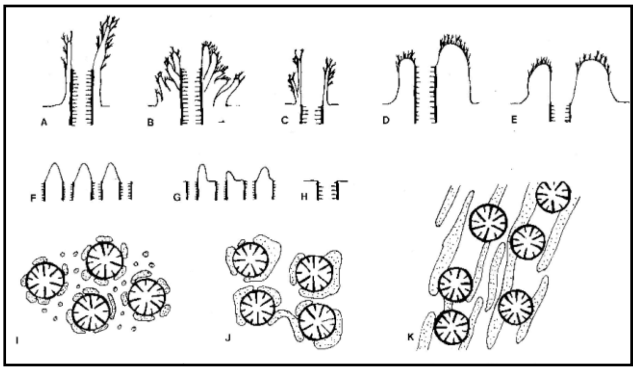

Figure 2 Diagrammatic transverse (A-H) and surface (I-K) views of *Montipora* corallites and associated coenostial structures. (A) simple papillae with exsert corallite, (B) compound papillae with exsert corallite, (C) simple papillae with immersed corallite, (D) tuberculae with exsert corallite, (E) tuberculae with immersed corallite, (FH) foveolate, tuberculate and glabrous corallites (respectively), (I) corallites with thecal and reticulum papillae, (J) corallites with thecal tuberculae, (K) corallites with reticulum tuberculae forming ridges(to Veron, Wallace, 1984).

or specialized radial corallites. Corallites of *Anacropora* are immersed or protrude slightly from undifferentiated coenosteum.

Axial corallites start growing from the base of a colony and grow upwards with different rates, diversely orienting in space according to the genetic ability of each species in certain environments. Growing fixed on branch ends in different directions; they form branched and branched -lamellar colonies, and never form massive colonies. Radial corallites bud from the lateral surface of axial corallites at different angles and with different spacings, and have different corallite shapes. Their growth taken together forms that diversity of colony shapes which is typical for *Acropora*. Various forms of corallites and their terminology are shown in the Figure 4, 5.

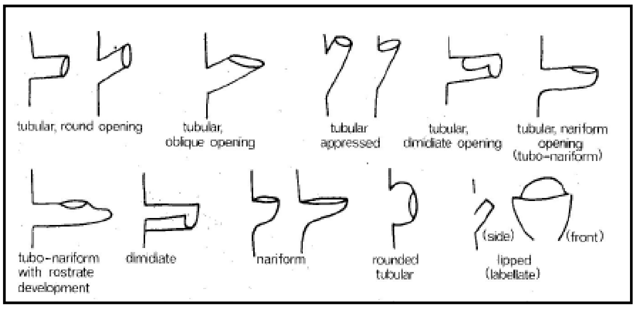

Figure 4 Radial corallite shapes of *Acropora* and their nomenclature (to Wallace, 1978).

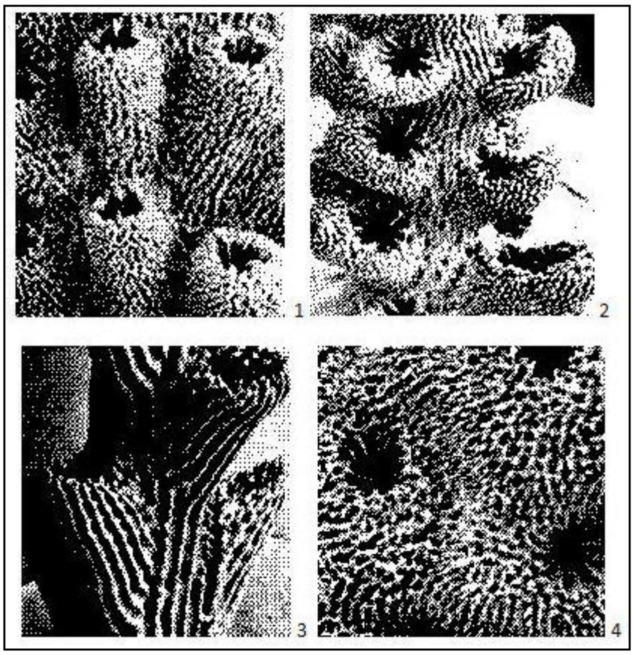

Figure 5 The appearance of corallites *Acropora*. 1-tubular, 2-nariform, 3-tube, pressed 4-loaded with simulate (spines) on cenosteume

4 Identification Signs

Acropora skeleton structure is much simpler compared to other genera. They have no columella orvarious septal reinforcements. A simple structure consisting of three septal cycles develops in the calices. Every element of these septal cycles is connected with trabecular lobes. Radial elements, passing through one or several concentric theca, form a row of trabecules, closely connected to synapticula. Three complete septal sets develop in a small number of corallites. Usually one or both directive septa and several metasepta, located symmetrically to the main ones, are well developed. Septa are developed better, as a rule, in axial corallites.

When describing and identification species, the following features are usually used: characteristics of axial corallites, corallite shapes, development of septal apparatus in calices, sizes of outer and inner diameters, wall thickness, morphology of main septa, septa of the first and second orders. That is why it is appropriate to provide a schematic illustration of axial and radial corallites with an indication of the main skeletal elements and the locations of measurements (Figure 6).

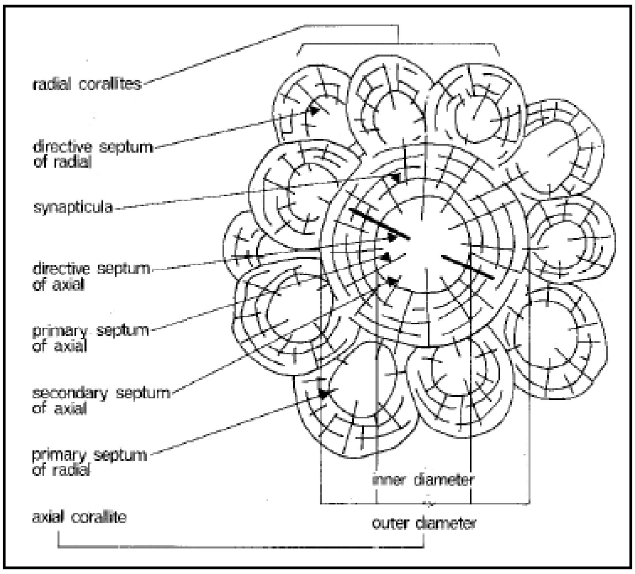

Figure 6. Diagrammatic representation cross section of corallite indicating features used in the description of species (to Wallace, 1978).

Morphologically *Astreopora* are distinguished among the other acroporids by the fact they are found mainly as massive colonies with large numerous corallites and reticular coenosteum having a spiky surface. When describing and identifying the species, the sizes and shapes of corallites, their number per colony surface unit; sizes and degree of thickness of primary septa, the character of metasepta development; and the simplicity or complexity of the coenosteum spines split are used.

The essence of doubt taxonomists studying CNIDARIAN, was not what the concept of type select with only phenotype as allegedly the sole and primary means of classification, and not a lack of opportunity to observe or verify the reproductive isolation of the species. The problem lies in the ability to make you refuse bias to any concept of species-zoological, paleontological or some other "specificity" of research. You must disengage from the concept of "species", target the natural biological research together, and not just some amount of samples; all the time, be influenced by the fact that the integrity of these aggregates is determined not to disparities, and isolation, are they not from the amount of independent individuals, and of populations. Define such a set of lighter and more adequately can be based on its relationship to other sets, rather than on the relationship between individuals within the same population. The identification of such aggregate, sufficiently detached, to describe her and name, pretending to be the formal taxonomic category. In the basis of the totality of the specimens lie bottom cells-settlement of the past and a population.

A clear and precise formulation of the objectives, clarifying methodological prerequisites, objectives, methods, and their mandatory constraint, along with an understanding of the biological meaning of results of research largely dictate the success of the work.

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