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RESEARCH ARTICLE

Some Aspects on the Taxonomy and Identification of Corals.

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Abstract

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A brief analysis of the taxonomy and the identification methods of corals are provided. The attention is drawn to difficulties and mistakes, which have occurred in their systematics, in the selection of type-species and their holotypes. Modern methods for morphometric, biochemical, and genetic researches are considered using examples in solving taxonomic problems and identifying corals. It is concluded that the taxonomy of corals came into the historical stage in the twenty-first century, when the previous nomenclature uncertainty began to be removed due to the availability of all data connecting taxonomic, phylogenetic, biogeographical, ecological, paleontological, and bibliographical, as well as environmental data.

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Introduction:-

The known property of the human reasoning to look for similarities and differences in observed facts and phenomena, certainly to categorize and give names makes us to find or just to note features or characteristics, by which we get to know about familiar or similar subjects and to perceive unfamiliar ones. When perceiving a thing, a phenomenon, we find, what differences from other things and phenomena they have, what similarities to them they bear, and give them certain names. People have identified the term "species" as taxonomic category for convenience of sorting organisms. And we can only guess, what was at first – "snakes", "animals", and "plants" (the highest categories) or "adder", "wolf", and "wheat" (the lowest categories). At first, there were probably the last ones, and then they were combined into animals, birds, etc. even before the appearance of the first conscious systematist on the Earth. Then species concepts were developed and, consequently, the species problem is as result of the struggle of adherents of various concepts.

The taxonomy of corals as inherently subjective science has gone through three historical stages: (1) researches of collections performed during their discovery in the early expeditions; (2) researches performed directly on reefs using autonomous diving equipment; (3) molecular and biochemical researches. These stages, each of which is associated with a different methodology and perception, have little in common, but they have a common goal, which is a classification of corals according to the concept of their natural order.
In 2013, a great article by Ch. Veron dedicated to almost all questions and problems of the taxonomy of reef-building corals was published. Its main conclusion is that taxonomists can no longer rest on any one publication, method or concept. They should be based on the open access to updating websites connecting the whole information, such as taxonomic, phylogenetic, biogeographical, ecological, paleontological, as well as

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environmental and bibliographical one. Such information sources allow systematists of any belief to see results of their efforts in the broad context, rather than just within their own subdisciplines (Veron, 2013).
Despite the appearance of hard calcareous skeletons of Scleractinia, they are very soft organisms and have some significant variations (30-40-fold changes of values of their features) of all their skeletal elements (Latypov, 1984). K. Gravier (1911) summarizing results of the previous researches (Pace, 1901; Wood-Jones, 1907) wrote: "Nothing really remains stable in these animals: neither the overall appearance of the colony, the coenenchyme nor even the theca". Consequently, the question of unusual intraspecies variability and establishment of its boundaries for each specific taxon or population concerning the problem of corals' species was extremely urgent (Latypov, 1984; Latypov, 2016a). "Healthy species theory" for corals was represented by T. Vaughan (1907) at the beginning of the last century, and it had almost no differences from the biological species concept appeared two years earlier. At the same time, it was emphasized that it was not about using different species concepts, but about a single biological approach when researching any corals. Only now, after more than two centuries, the coral taxonomists withdrawing from "peculiarities" of researching their material based on the biological species concept are adopting a population analysis and detection of variability limits along with using modern genetic and biochemical researches (Latypov, 1982, 1984; Veron, 1995; Latypov, 2014, 2016b).

Results:-

General provisions:-

The coral taxonomy came into the historical stage in the past century, when the nomenclature uncertainty began to grow rapidly. The main reason was a mandatory compliance with the species identification in historical classical monographs, which did not have necessary information on species at all, especially for the typical specimens if they have existed at all, or are often represented as their fragments out of all recognition. The historical problems including incorrect following redescription or synonymy of species have created uncertainty for many established species and genera, too.

The historical collections of corals with some exceptions were built *as separate specimens* representing new or unusual ones, rather than as representatives of the population or the taxonomic group. They were gathered in shallow lagoons and on reef flats, where the branching and placoid colonies usually developed in unusual forms of colonies. These collections representing biased samples and those devoid of taxonomic researches have led to the expansion of "type-species", which did not clearly represent the species destined for the identification.

Thus, the corals were gathered in quantities in museums throughout Europe and the United States more than 200 years ago. The collections are considered as critical contribution to the natural history, especially when they are described and published in monographs. In the historical perspective, these scientific publications were like works of art. These are books with excellent illustrations well-known among paleontologists and biologists (Müller,1775; Ellis &Solander, 1786; Stutchbury, 1830; de Blainville, 1834; Dana, 1846; Edwards &Haime, 1857; Haeckel, 1876; Agassiz, 1880), in which the authors tried to make the taxonomic characters of corals available to the broader scientific community. However, despite their high status among the best monographs of the time, they contain descriptions of the species, which cannot always be used, because they lack many details of morphology (especially variability and comparison with other species), a habit and even a location. For this reason, modern taxonomists should rely only on illustrations of the holotype, rather than on description to determine the described species.
The coral taxonomists of the one before last century did not have an opportunity to observe and gather corals on the reef under water. They did not understand how species (zooids, colonies) actually looked including their differences in form, color and abundance. If a received new specimen looked different, it was easily proclaimed a new species and given a new name. Inevitably, many of these specimens were lost, because they got a new mark and included in another collection, usually without specifying their original source (Veron, 2013). It is also probably that many typical specimens never existed, as they were no more than interesting specimens selected for illustration and description and then were returned to the general collection as soon as the description was completed.

Typical specimens and type-species:-

Today many historical typical specimens have a correct status, some of them deserve special mention, while the position of other ones is precarious. For Example, J. Dana (Dana, 1846), the most insightful coral taxonomist of the 19th century, was especially precise in selecting and describing typical specimens as distinct from A. Verrill, who has prescribed barely recognizable fragments, which he had deposited in various museums, to typical specimens following in the footsteps of Dana (Verrill, 1864). Some of Verrill's species now found in the Museums of Comparative Zoology of the Harvard University and the Smithsonian Institution were apparently taken from different colonies actually belonging to different species, for which the reference to Dana was not taken into account (Veron, 2013).

Many type-species, on which the genera are based, seem obvious. In practice, however, the use of type-species as basis for taxonomic solutions is not always effective, because they generally are a quintessence of historical problems described above among the first selections of type-species of genera. Coral taxonomists documentarily selecting an update of the typical species according to Vaughan and Wells (Vaughan & Wells, 1943; Wells, 1956) have found many surprises. For example, little is known about the type of the species of the *Leptoseris genus* – *Leptoserisfragilis* Milne Edwards &Haime, 1849. It was neither included nor redescribed in the edition of Denisen (Veron, (2000). The type-species called *Montastraea* is a fossil coral from the Miocene of France or Italy, *Astreaguettardi* de Blainville, 1830. It is considered to be extinct long ago and can not be identified. Such cases were ignored according to an old saying "Let sleeping dogs lie", but because of this the genus may be subject to integration (Veron, 2013). However, the stability of the generic names would be quite adequate without type-species and bundle, which is enclosed with them. Even the *Acropora* genus, the most famous one of all corals, was confirmed by the International Commission on Zoological Nomenclature (ICZN) only in 1963.

Species in situ:-

The taxonomic researches using undersea observations began in the early 1970-ies and immediately created various conflicts with almost all aspects of the traditional taxonomy. So, *Pocilloporadamicornis* described in more than 50 taxonomic publications has had a double number of non-taxonomic works prior to 1970, which have most frequently used this species in experimental researches. It was not clear: what the corals of the P. *damicornis* species are actually; how it can be reliably distinguished from other *Pocillopora* species; what the expansion of this species is. The original description of C. Linnaeus (Linnaeus, 1758, 20 words of the Latin language) cannot be used – the holotype is lost, its location is very undefined («O. Africano&Indico»). More importantly, when P. *damicornis* was researched in situ, it turned out, how many environmental variants were correlated with this species (fig. 1). The researches of corals in their natural environment using the undersea observation have become a reliable instrument for coral taxonomists (Veron, Pichon, 1976; Veron, 2013; Latypov, 1990, 2014).

Traditional and modern taxonomy:-

When working with corals having the extraordinary variability of almost all features and generally with polytypic species, the question is often if these differences between samples (populations) are great enough to consider them as different species. In most cases, we have isolated geographic or stratigraphical allopatric populations. Unfortunately, we cannot use an reproductive isolation criterion in pure form. And besides, to breed zooids of two or one prospective species on the experimental basis, first of all, we have to determine that these are zooids of one or two allied species, and this is our key problem. It remains to base on the probabilistic data on the fact that the reproductive isolation is correlated with a certain degree of a phenotypic, externally visible difference and is constant enough within a given taxonomic group. That is to act by contradiction: if groups with sufficiently clear morphological differences, with a distinct gap of values of qualitative or quantitative features are identified within this taxon, we may assume that these groups are good species.

So, three phenons of *Pocillopora* were revealed in the collection of Scleractinia from the South China Sea. They had differences in width of their branches, number of polyps per area unit, presence or absence of verruciformcorallites on major branches, but almost all these variations were partially overlapped. A sample of other corals of *Pocillopora* had different colonies with wide (from 30 mm to 50 mm thick) and long (up to 50-80 mm) branches. They had different distances between their branches. A more representative sample of all corals has discovered both the continuous variability of modal sizes of branches, the distance between them, and obvious gaps of various holotypes of the *Pocillopora* species.

The construction of different scattering diagrams induced more surely to divide these phenons, but left doubt on the final decision on their assignment to one or two species (fig. 2). Receiving the data on features of the individual growth and the fatty acid content of these corals (table, fig. 3) allowed to reveal distinct gaps in ontogenetic and biochemical characteristics and to divide these phenons in two species: *P.damicornis*and *P.verrucosa.* The same methods allowed to unite all samples of these corals under one species named *P.eyudouxi* in another case, as continuous variability of features, difference in ratio of the fatty acid content were not detected. The analysis of the fatty acid content ratio among colonies of various growth forms has confirmed their modification nature identifying differences only in percentage shares.

Meanwhile, many features were partially overlapped in two samples of *Pocillopora*
or had a very little gap except for one. The frequency of the shedding of the corals dissepiments of one sample was by more than 4-5 times in comparison with corals of the other one. The ratios of the content of some fatty acids of different samples of *Pocillopora* were different by 2-3 times, too. Two unfilled gaps (table, fig. 3) in morphometric, ontogenetic and biochemical features allowed to consider these *Pocillopora*'s samples as ones belonging to different species (Latypov, 1984, 2014). The cluster analysis has also confirmed the findings on the congeniality of ones and the isolability of other species (fig. 4).

Genetic systematic:-
Since the beginning of the current century, a considerable attention is given to the molecular and genetic researches of different groups of Scleractinia (Manchenko et all., 2000; Fukami, 2008; Huang et al., 2009; Arrigoni et al., 2012).

A wide range of taxonomic questions can be reliably answered by using the molecular and biochemical methods, and it is clear that the continuing dissemination of such researches will have a major impact on the most aspects of the taxonomy of corals. These methods produce especially demonstrable and convincing results in the cases, when it is necessary to classify objects, which are hard to distinguish. It should be noted that such cases can occur when working with sibling species or phenotypically similar species, as well as when working with groups, the taxonomic content of which is obscured as a result of the application of subjectively selected features. The genetic researches of zooids in natural populations require a labour-intensive work on breeding under controlled conditions. Such researches might be carried out in the laboratory with only a few organisms – those, which are easy to maintain and have a very short period of reproduction and development. The sympatric groups, or the morphs belonging to the similar species, are one and the same evolutionary unit. Therefore, they should have (taking into account the calculated error of the experiment) the same gene frequency for each gene locus. The zooids from different biotopes belonging to the same species must freely interbreed and differ only in their loci coding their morphological differences and, maybe, in some closest loci. Even if these morphs have been subjected to a rigorous selection, the gene frequencies for all other loci should remain the same ones through their recombination (Wright, 1978; Thorpe, Sole-Cava, 1994).

The actinias are a very diverse group of the marine invertebrates. Meanwhile, the features suitable for the taxonomy of these animals are very few, and the taxonomic problems in this group of the invertebrates often arise because of their relative structural simplicity. The analysis of genotypic differences between closely related species of the actinias is now actively used and often produces some interesting results. Generally, sympatric populations are subject to the analysis. In addition, sets of stinging cells of the actinias with an unclear taxonomic pattern are compared along with the electrophoresis of isozymes.

On the littoral of Skrebtsov Island (the South China Sea), settlements of the actinias of the *Anthopleura* species, which were presented by two color morphs, were examined. These actinias looked very alike. The variations in column coloration, mouth opening, tentacles have caused continuous series of the variability in this population. It was just observed that some actinias had a light grey-green oral disc, and the others had both a colorful and dark one. The actinias of the light morph raise higher above the sand surface. It turned out that the actinias differing in coloring of the oral disc are distinct both in the substrate nature, to which they are attached by the foot, and in the degree of their submergence in the sand. The combination of these features allowed to identify two morphs of the actinias in the population (Manchenko et all., 2000).

The analysis of genotypes of the sympatric morphs was performed by the electrophoresis of enzymes according to the standard method using original modifications (Manchenko, 1984). A 21 gene locus coding 19 enzymatic systems was examined. Eight of them have showed lack of common alleles in compared morphs. It clearly proves that the morphs gene pools are separate, and they do not exchange their genes between each other. Consequently, these morphs are separate species. They were morphologically identified as *Anthopleuraorientalis* (light morph) and *A*. sp. 1 (dark morph), respectively. The genetic differentiation between the species is very significant, what follows from the assessment of the genetic distance between them (D = 1,284). The average level of heterozygoty (H_e) for *A. orientalis* and *A*. sp. 1 amounts to 0,351 ± 0,054 and 0,250 ± 0,061, respectively (Manchenko et al., 2000).

Explanation and figures legend:-

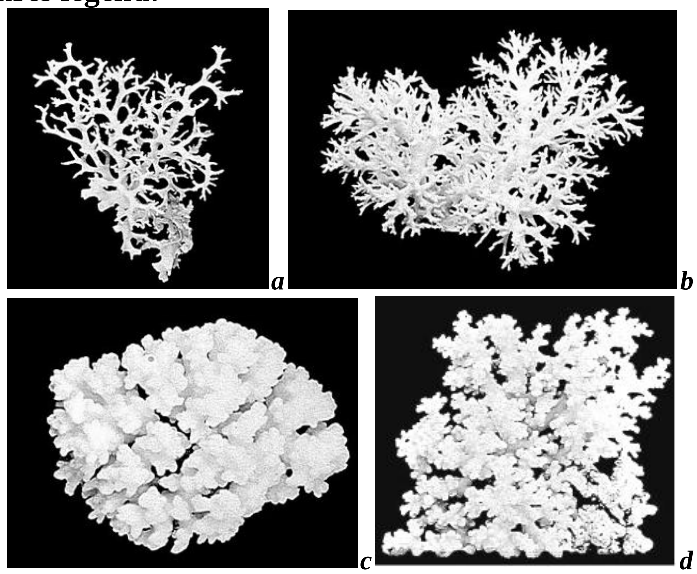

Figure 1.The dependence of *Pocilloporadamicornis* colonies from habitats. Shallow water mangrove (**a**), lagoon(**b**), reef flat (**c**), reef slope (**d**). (part by Veron, 2013)

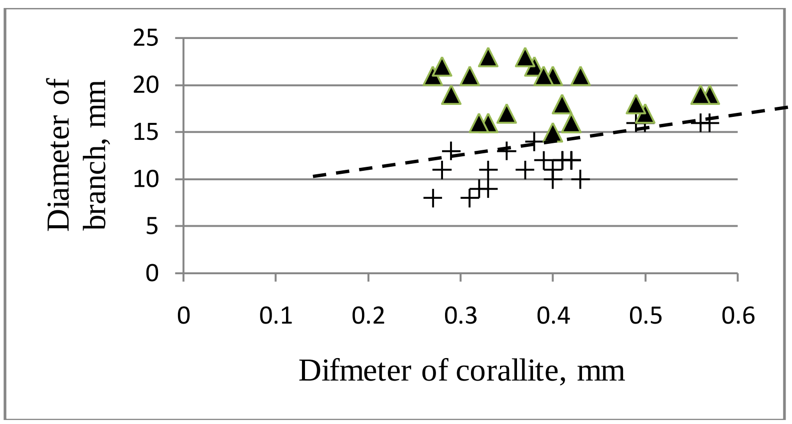

Figure 2. Separation of the two species *Pocillopora* depending on the diameter and number of corallites per unit area branch ▲ -*P. verrucosa*, + - *P. damicornis.*Dotted line the best separation.

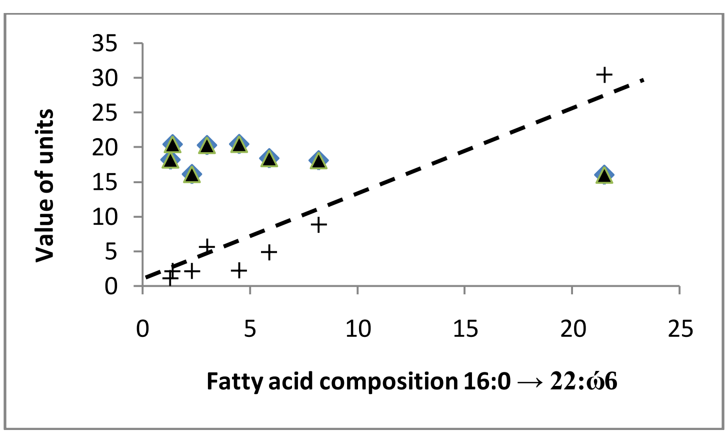

Figure 3.The separation of the two species *P. damicornis*-▲ *P. verrucosa*-+ on the composition of the fatty acids (see table). Dotted line the best separation

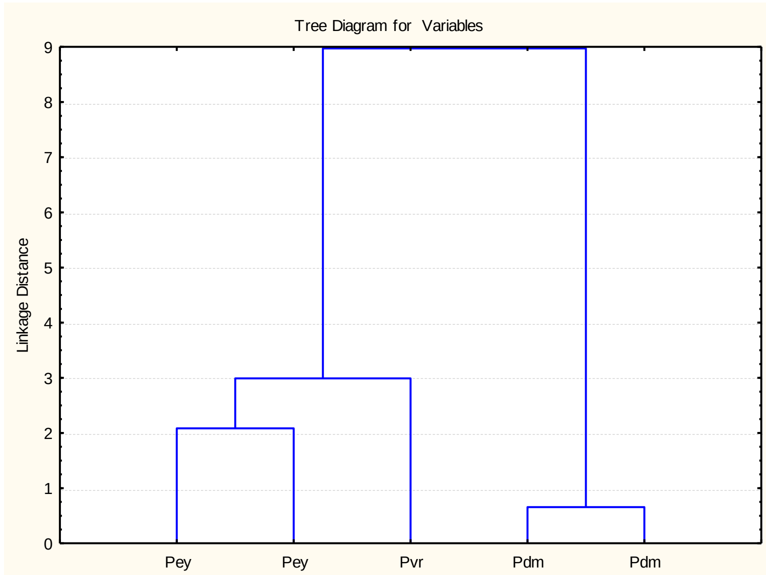

Figure 4. Clustered graph disunion and similarity different species *Pocillopora*. Pvr-*P.verrucosa*, Pdm-*P.damicornis*, Pey-*P.eydouxi*

Table. The ratio of fatty acid composition in various types of scleractinian

Fattty Acids	*Pocillopora damicornis*	*P. damicornis*	*P. verrucosa*	*P. eydouxi*	*P. eydouxi*
16:0	21,9	***21,5***	***30,4***	29,47	28,6
16:1	2,4	2,3	2,1	2,2	2,6
18:1	8,4	8,2	8,8	8,4	10,1
18:2ω6	1,1	1,3	1,1	0,7	0,5
18:4ω3	5,7	5,9	4,8	2,6	2,2
20:3ω6	3,1	***3,0***	***5,6***	5,7	6,1
20:4ω3	1,7	1,4	2,1	3,2	2,9
22:4ω6	4,3	***4,5***	***2,2***	0,9	1,2

Comment. Visible modifications the nature of qualitative and quantitative changes in the composition of the fatty acids from one species and significant discrete differences (in italics) up until the magnitude gap signs-different species

Conclusion:-

Thus, the problems arising when determining intra- and interspecific differences identified by morpho-physiological, ecological, and ethological means can be solved by using biochemical, cytogenetic, electrophoretic researches. But in any case, the original conclusion on similarities or differences between taxa is made based on absence or presence of the unfilled gap in certain sequences of features, identification and comparison of the specific characteristics of each taxon. Then it turns out, which biological reasons cause these differences and similarities of the features. And based on the facts of discretization of phenotypes identified between two feature complexes, a reproductive isolation of each separate species can be stated (Mayr, 1969; Latypov, 1984, 2014, 2015; Latypov et all., 1998).

More than two hundred years of experience of the coral taxonomy promise that coral systematists can avoid pitfalls if: 1 - the established names will be saved in the absence of any compelling reasons to replace them; 2 - the nomenclative priority should not be a reason to change the established names; 3 - the fossil names are not used for modern species (except in cases when the holotype is definitive); 4 - the names of the established genera cannot be changed due to the taxonomic problems of the type-species.

The taxonomy of corals came into the historical stage in the twenty-first century, when the previous nomenclature uncertainty began to be removed due to the availability of all data connecting taxonomic, phylogenetic, biogeographical, ecological, paleontological and bibliographical, as well as environmental data.

References:-

1. *Agassiz, L.* (1880): Report on the Florida reefs. Mem. Mus. Compar. Zool. Harvard College. 7: 1–61.
2. *Arrigoni, R., Stefani, F., Pichon, M., Galli, P., Benzoni, F.* (2012): Molecular phylogeny of the robust clade (Faviidae, Mussidae, Merulinidae, and Pectiniidae): an Indian Ocean perspective. Molec. Phylog. Evol. 65 (1):183-93.
3. *Dana, J.D.* (1846): Atlas of zoophytes. United States exploring expedition during the years 1838–1842. Philadelphia: Lea and Blanchard. 1–740 p. 61 pls.
4. *deBlainville, H.M.D.* (1834): Manuel d'actinologie, ou de zoophytologie. Planches. Paris: F.G. Levrault, 1–101 p.
5. *Ellis, J., and Solander, D.* (1786): The Natural History of many curious and uncommon Zoophytes collected from various parts of the globe. London. 1: 1–208. pl. 1–63.
6. *Fukami, H.* (2008): Short review: molecular phylogenetic analyses of reef corals *Galaxea.* Journal of Coral Reef Studies.10: 47-55.
7. ***Gravier, Ch.* (1911): Les recifs de corauxet les Madreporaires de la baie de Tadjourah (Golfed'Aden). Ann. Inst, oceanogr. 2(3): 1-99.**
8. *Haime, J. and, Milne Edwards H.* (1857): Histoire Naturelle des CoralliairesouPolypesproprementdits. Vol. 2. In Milne Edwards H, Haime J. Paris: Roret, 1–633.
9. *Haeckel, E.* (1876): ArabischeKorallen. EinAusflugnach der Korallenbänken des RothenMeeres und einBlick in das Leben der Korallenthiere. Berlin: Georg Reimer. 48.
10. *Huang, D., Meier, R., Todd, P.A. and, Chou, L.M.* (2009): More evidence for pervasive paraphyly in scleractinian corals: Systematic study of Southeast Asian Faviidae (Cnidaria; Scleractinia) based on molecular and morphological data. Molecular Phylogenetics and Evolution. 50 (1):102-116.
11. Latypov, Yu.Ya. (1984): Drevneishieodinochnyekorallyiprincypyihsystematiki. M.: Nauka. 92 p, (In Russian)
12. Latypov, Y.Y. (1990): KorallyskleraktiniiV'etnama. Tamnasteriidy, Astrotseniidy, Potsilloporidy, Dendrofilliidy [Scleractinian Corals of Vietnam. Thamnasteriidae, Astroceniidae, Pocilloporidae, Dendrophylliidae]. Nauka, Moscow, 80 p. (In Russian)
13. Latypov, Yuri.Ya. (2014): SCLERACTINIAN CORALS OF VIETNAM. Science Publishing Group, p. I-XXXIV, 1-481.
14. Latypov, Yu.Ya. (2015): Particular qualities of identification and taxonomy of some
15. Scleractinian. Species. 13(40): 29-41.
16. Latypov, Yu. Ya. (2016a): Particular Qualities of Identification and Taxonomy of Some ScleractinianFaviidae Gregory, 1900, (Scleractinia: Faviina). Intern. J. Mar. Scie. 6(11): 1-10.
17. Latypov, Yu.Ya. (2016b): Particular Qualities of Identification and Taxonomy of Some Scleractinian (Scleractinia: Astrocoeniina) Family AcroporidaeVerrill, 1903. Intern. J. Mar.Sci. 6(16): 1-8.
18. Latypov, Yu.,Ya., Dautova, T.,N., and Moshenko, A.,V,. (1998): The principles and
19. Methods of the CNIDARIA classification. Vladivostok, Dalnauka, 244.
20. Linnaeus, C. (1758): SystemaNaturae per regna trianaturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. Tomus I. Regnum Animale. Holmiae. EditioDecima. Reformata. 824 p.
21. Manchenko, G.P. (1984): Handbook of detection of enzymes on electrophoretic gels. CRC Press. Boca Raton..
22. Manchenko, G.,P., Dautova, T.,N., and Latypov, Yu.Ya.(2000): High level of genetic divergence between sympatric color morphs of the littoral sea anemone Anthopleuraoriennalis (Anthozoa: Actiniaria). Bioch. Syst. Ecol. 28: 737-750.
23. Mayr, E.W. (1969): Principles of Systematic Zoology. McGraw-Hill. 411 p.
24. Müller, P.L.S. (1775): Des Ritters Carl von LinnévollständigesNatursystemnach der zwölftenlateinischenAusgabe, und nachAnleitung des holländischenHouttuynischenWerks, miteinerausführlichenErklärung, ausgefertiget von Philipp Ludwig Statius.Nürnberg: Raspe. 6: 1–960. pl. 20–37.
25. Pace, S**.** (1830): On the corallum of Turbinaria. J. Linn. Soc. Lond. 28: 358-365.
26. Stutchbury, S. (1830): An account of the mode of growth of young corals of the genus Fungia. Trans. Linn. Soc.16: 493–498.

27. Thorpe, J.,P., and Sole-Cava, A.,M. 1994. The use of allozyme electrophoresis in invertebrate systematic. Zool. Scr. 23: 3-18.
28. Vaughan, T.,W. (1907): Recent Madreporaria of the Hawaiian Islands and Laysan. U. S. Natl. Mus. Bull. 59: 1-427.
29. Verrill, A.E. (1864): List of the polyps and corals sent by the Museum of Comparative Zoology to other institutions in exchange, with annotations. Bull. Mus. Comp. Zool. 1: 29-60.
30. Vaughan, T.,W., and Wells, J.W. (1943): Revision of the sub-orders, families and genera of the Scleractinia. Geol. Soc. Amer. Spec. Pap. 44: 1-363.
31. Veron, J.E.N. (1995): Corals in space and time. New York: Cornell University Press. 321 p.
32. Veron, J.E.N. (2000): Corals of the World. Volumes 1–3. Townsville. Darwin. Perth: Austral. Inst. Mar. Sci. 382 p.
33. Veron ,J.E.N. (2013): Overview of the taxonomy of zooxanthellateScleractinia. Zoological Journal of the Linnean Society. 24 p.
34. Veron, J.E.N., and Pichon, M. (1976): Scleractinia of Eastern Australia.I Families Thamnasteriidae, Astrocoeniidae, Pocilloporidae. Austr. Inst. Mar. Scie. Mon. Ser. 1:1–86.
35. Wells, J.W. (1956): The Scleractinia .Treatise on invertebrate paleontology. Pt I TheCoelenterata. Lawrence: Univ. Kans. Press. P. 328-444.
36. Wood-Jones, F. (1907): On the growth form and supposed species in corals. Proc. Zool. Soc. Lond. P. 318-585.
37. Wright, S. (1978): Evolution and the genetics of populations. Vol. 4. Variability within and among natural population. Chicago. University of Chicago Press. 590 p.