Imbs, A.B., 131-140
Tuyển tập Báo cáo Hội nghị Quốc gia "Biển Đông-2007", 12-14/9/2007, Nha Trang

TỔNG QUAN VỀ ĐẶC ĐIỂM HÓA SINH CỦA LIPIT SAN HÔ VỚI CÁC THÔNG TIN CẬP NHẬT CỦA MỘT NGHIÊN CỨU MỚI Ở VIỆT NAM

Andrey B. Imbs
Viện Sinh học biển Zhirmunsky, Phân viện Viễn Đông
Viện Hàn lâm Khoa học Nga

Tóm tắt Lipid tổng và các axít béo (FAs) của nó chiếm tới 40% sinh khối san hô khô. Lipit không chỉ là thành phần cấu tạo nên màng tế bào ở cả san hô và vi tảo sống cộng sinh với nó (zooxanthellae) mà chúng còn là nguồn năng lượng dự trữ lâu dài chính của san hô tạo rạn.

Lipit tham gia vào hầu hết các quá trình sinh lý và hóa sinh trong những động vật này, vì thế sự thay đổi trong thành phần lipit phản ánh sự thay đổi về sinh thái, dinh dưỡng và thể chất của san hô. San hô là nguồn cung cấp nhiều FAs có hoạt tính sinh học, như là các axit teracosapolyenoic có chuỗi rất dài (TPAs), và các chất dẫn xuất FA không no đa nối đôi - prostaglandins và oxylipins. Có những chứng cớ rõ ràng cho thấy san hô mềm là những đối tượng tuyệt vời để nghiên cứu quá trình tổng hợp sinh học các axit béo C_{22} mới phát hiện gần đây bằng cách oxy hóa β của TPAs. Không tìm thấy các TPAs chính trong san hô Hexacorallia, và sự vắng mặt của các axit này chính là sự khác biệt trong đặc điểm phân loại hóa sinh giữa san hô cứng và san hô mềm.

Thành phần các axít béo (FAs) là đặc điểm cơ bản chính của lipit, vì thế, những khía cạnh quan trọng đối với đời sống của san hô có liên quan đến lipit có thể được khảo sát thông qua việc phân tích các axít béo. FAs có thể được sử dụng làm chỉ thị cho loại tảo sống cộng sinh, và chúng thể hiện sự trao đổi lipit giữa sinh vật cộng sinh và vật chủ. FAs chứng tỏ rất rõ ràng sự có mặt của các nguồn thức ăn bên ngoài như là động thực vật phù du ở hình thức đa dưỡng của san hô.

Lipit san hô và các axít béo của nó chủ yếu được chuyển hóa từ carbon được cố định qua quá trình quang hợp của vi tảo sống cộng sinh. Sự khác nhau trong thành phần axit béo của san hô có tảo cộng sinh có thể là một trong số những nguyên nhân tạo ra sự khác biệt trong hàm lượng các axit béo của các họ san hô tạo rạn. Axit béo được sử dụng để phân loại hóa sinh các nhóm sinh vật biển. Chúng tôi đã chỉ ra rằng việc áp dụng các phương pháp thống kê là rất hữu ích cho những nghiên cứu phân loại hóa sinh của san hô tạo rạn và san hô mềm. Tóm lại, những số liệu mới về lipit thu được từ các nhóm san hô có và không có tảo cộng sinh có thể có ý nghĩa quan trọng đối với những nghiên cứu trong tương lai về các loài cộng sinh trên san hô, sự trao đổi lipit, chỉ thị dinh dưỡng và trong những nghiên cứu về phân loại hóa sinh san hô.

Imbs, A.B., 131-140
Proceedings of National Conference 'Bien Dong – 2007', Sept. 12-14, 2007, Nhatrang

REVIEW OF BIOCHEMISTRY OF CORAL LIPIDS WITH UPDATED INFORMATION OF A NEW STUDY IN VIETNAM

Andrey B. Imbs
A.V. Zhirmunsky Institute of Marine Biology, Far Eastern Branch
Russian Academy of Sciences

Abstract Total lipids and their fatty acids (FAs) form up to 40% of coral dry biomass. Lipids are not only the building blocks of cell membranes both in the host coral and their symbiotic dinoflagellates (zooxanthellae), but also they are the main long-term source of stored energy in corals.

Lipids are involved in a majority of biochemical and physiological processes in these animals, therefore changes in the lipid composition reflect changes in ecology, nutrition, and health of corals. Corals are sources of a number of biologically active FAs, such as very-long-chain teracosapolyenoic acids (TPAs), prostaglandins and oxylipins. The key TPAs have not been found in Hexacorallia, and the absence of these acids is the central chemotaxonomic distinction between stony and soft corals.

The composition of fatty acids (FAs) is the primary common characteristic of lipids; therefore important aspects of coral life, with lipids involved, can be investigated by the analysis of FAs. FAs can serve as markers for a type of zooxanthellae, and they indicate the lipid exchange between symbionts and their coral host. FA is most probably indicative of external food sources such as zoo- and phytoplankton in polytrophic feeding of corals.

Coral lipids and its FAs are mainly derived from carbon photosynthetically fixed by symbiotic microalgae. The difference in FA composition of the zooxanthellae may be one of the probable reasons for the difference in FA content of reef-building coral families. FAs have been used for the biochemical classification of several groups of marine biota. We have been shown that the application of statistical methods is useful for the chemotaxonomic FA studies of reef-building and soft corals. On the whole, the new data on lipids obtained for the numerous group of azooxanthellate and zooxanthellate corals, might be important for future investigations of coral symbionts, lipid metabolism, trophic markers, and in chemotaxonomic studies of corals.

Lipids are fatty acids (FAs) and their derivatives, and substances related biosynthetically or functionally of these compounds. Lipids are one of the main classes of biological substances together with proteins, carbohydrates, nucleic acids, etc. Total lipids form up to 40% of coral dry biomass. Lipids are the structural base of all cell membranes both in the host coral and their symbiotic

microalgae (zooxanthellae). Lipids are the main long-term source of stored energy in the corals.

The main lipid classes of Vietnamese corals were hydrocarbons (HC), triacylglycerols (TG), monoalkyldiacylglycerols (MDG), free fatty acids (FFAs), sterols (ST), and polar lipids (PL) (Fig. 1). The main PL identified were phosphatidylcholine (PC), phosphatidylethanolamine (PE), and phosphatidylserine (PS). Along with the widespread phospholipids (PC, PE, and PS), two types of less common phosphonolipids (ceramide aminoethylphosphonate (CAEP) and ceramide methylaminoethylphos-phonate) were identified. The total lipids of Vietnamese reef-building coral species contained a considerable proportion of neutral lipids, in particular HC and TG. The content of PL and MDG in Vietnamese soft coral species was higher than that in the reef-building species (Fig. 1) (Imbs, pers. comm.). Obtained difference in the proportions of the main lipid classes was statistically significant and essential for a separation of hard and soft coral species into two independent groups (Fig. 2).

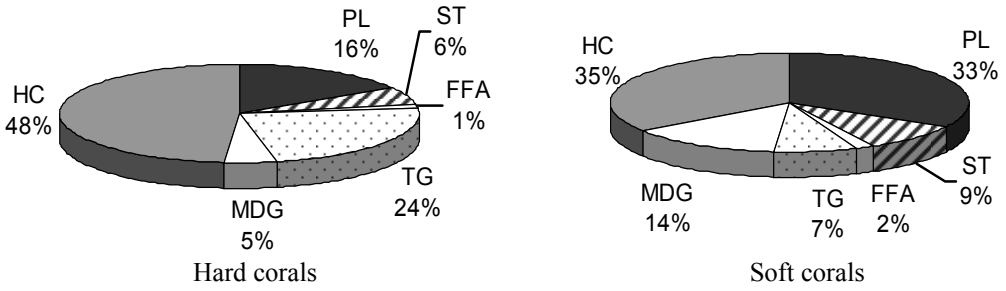

Fig. 1. Comparison of lipid composition (% of total lipids) of Vietnamese hard and soft corals (average contents for 60 species)

Corals are polytrophic organisms, i.e. they simultaneously or alternatively derive lipids through a variety of mechanisms from different trophic sources. The polytrophic nature of the corals varies greatly among species with respect to morphology, habitats and availability and diversity of food. Heterotrophy includes the uptake of particulate living and dead organic matter (POM) and the absorption of dissolved organic material (DOM). In zooxanthellate coral species, the phototrophic supply is delivered by endosymbiotic microalgae (zooxanthellae = dinoflagellates of the *Symbiodinium microadriaticum* group) living within gastrodermal host cells. The POM supply in a given habitat is highly diverse in quantity and quality and comprises all the different size classes of plankton and organic detritus. Thus partitioning of trophic resources may be necessary to coexist in the same habitat.

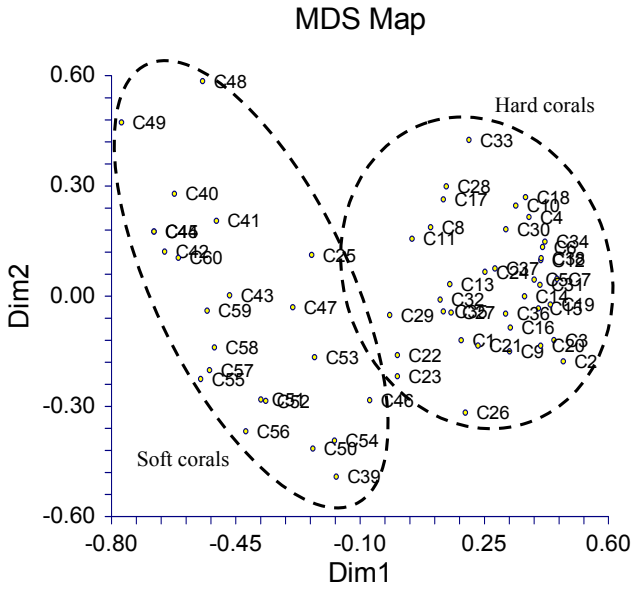

Fig. 2. Multidimensional scale analysis performed using the 6 variables (6 lipid class contents) measured in the 60 Vietnamese coral species

Lipid is an important part of the transport of total organic carbon in coral reef ecosystem. Lipids are involved in a majority of biochemical and physiological processes in corals, therefore changes in the lipid composition reflect changes in the ecology, nutrition, and health of corals. Coral bleaching are accompanied by significant variations in total lipid content and proportions of the main lipid classes in coral colonies (Michalek-Wagner *et al.*, 2001) (Fig. 3). The composition of coral lipids depends on the light regimes and varies during the annual cycle (Oku *et al.*, 2003) (Fig. 4). The lipid content of tumorous coral tissue is characterized by a reduced level of stored lipids (Yamashiro *et al.*, 2001) (Fig. 5). The lipid content of tumor was 10.6% of the dry tissue weight, and was much lower than that for normal tissues (32.2%).

The composition of FAs is the primary characteristic of lipids; therefore important aspects of coral life, with lipids involved, can be investigated by the analysis of FAs (Latyshev *et al.*, 1991). FAs can serve as markers for a type of zooxanthellae, and they indicate the lipid exchange between symbionts and their coral host (Zhukova *et al.*, 2003). The active transport of saturated and several unsaturated FAs from symbiotic dinoflagellates to the host is documented. In hermatypic corals, zooxanthellae have a specific FA composition, which differs from that of external food sources. Two Vietnamese soft coral groups such as azooxanthellate Dendrophylliidae and other zooxanthellate families have the most taxonomic and biological distinctions (Imbs *et al.*, 2007) (Fig. 6).

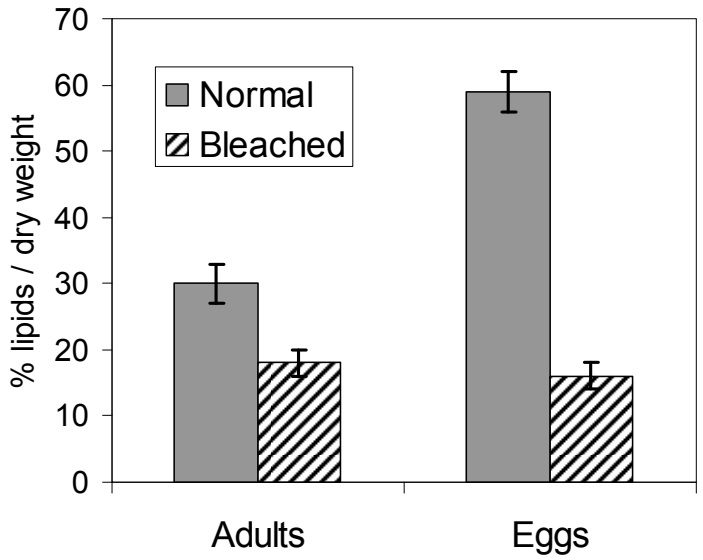

Fig. 3. Variations in total lipid content (% of lipids/dry weight) in normal and bleached soft coral *Lobophytum compactum* colonies (following Michalek-Wagner and Willis, 2001)

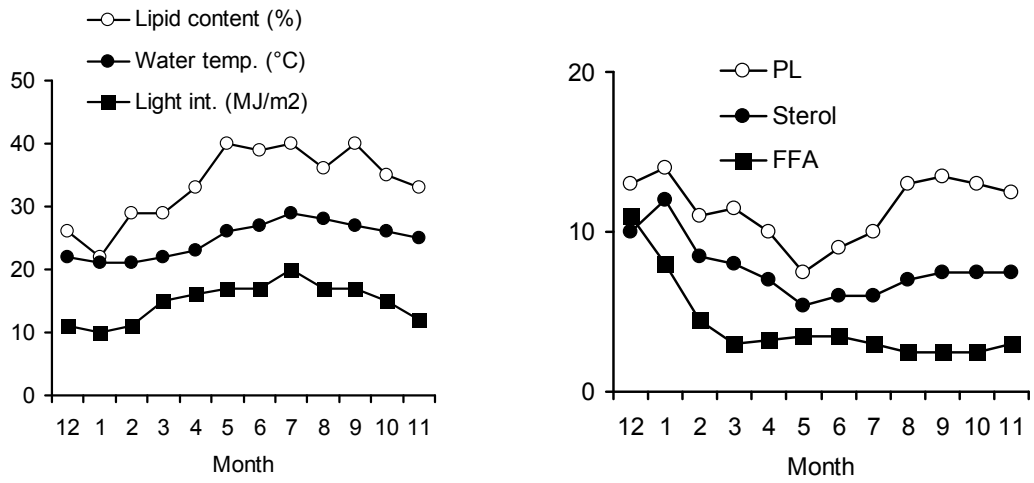

Fig. 4. Seasonal changes in total lipid and polar lipid contents of scleractinian coral *Goniastrea aspera*, sea surface temperature, and light intensity (Following Oku *et al.*, 2003)

Corals are sources of a number of biologically active FAs, such as very-long-chain teracosapolyenoic acids (TPAs), and polyunsaturated FA

derivatives – prostaglandins and oxylipins. There is strong evidence that soft corals are excellent objects for the study of newly discovered biosynthesis of C_{22} FAs via β-oxidation of TPAs. The key TPAs have not been found in Hexacorallia, and the absence of these acids is the central chemotaxonomic distinction between Hexacorallia (stony corals) and Octocorallia (soft corals).

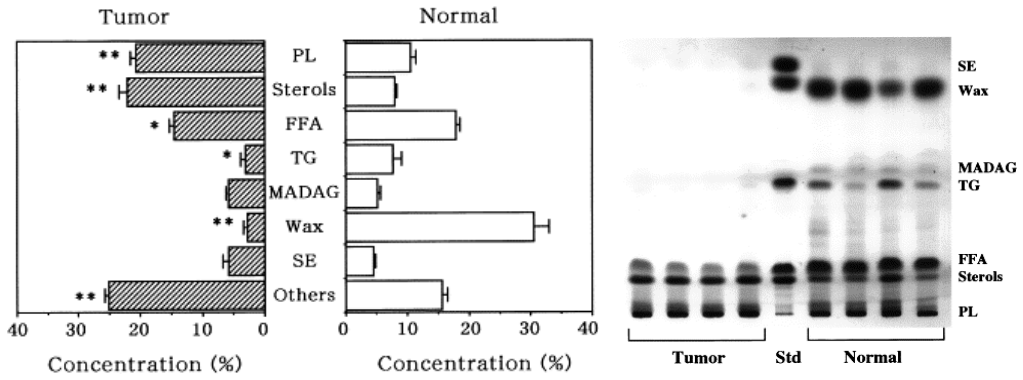

Fig. 5. Comparison of lipid composition of normal and tumorous tissues of reef-building coral *Montipora informis* (Following Yamashiro *et al.*, 2001)

FAs have been used for the biochemical classification of several groups of marine biota, such as bacteria, fungi, microalgae, plankton, macrophytic algae, and sea grasses. However, some investigators are inclined to conclude that FAs are not really useful for the biochemical classification of corals. We have been shown that the application of statistical methods (PCA, MSA) for the FA composition is useful for the chemotaxonomic studies of reef-building and soft corals. The difference in FA composition of the symbiotic dinoflagellates may be one of the probable reasons for the difference in FA content of reef-building coral families (Imbs and Dautova, 2008) (Fig. 7). The relation between a taxonomic position and lipid composition of octocorals from shallow-waters of Vietnam was investigated. Principal components analysis (PCA) of total fatty acid (FA) composition of 64 soft coral specimens showed that the total FAs were markers on the family level. The good distinction was obtained between antipatarians, gorgonians, and alcyonarians. Azooxanthellate corals of the genus *Dendronephthya* formed the separated group also (Imbs *et al.*, 2007) (Fig. 8A). The distinction between the genus of the alcyonarians (*Sinularia*, *Lobophytum*, and *Sarcophyton*) was only achieved on the base of the composition of selected polyunsaturated FAs (Fig. 8B). It was supposed that taxon-specific composition of FAs was determined by the differences in food sources, symbiont composition and FA synthesis enzyme activity of the octocorals.

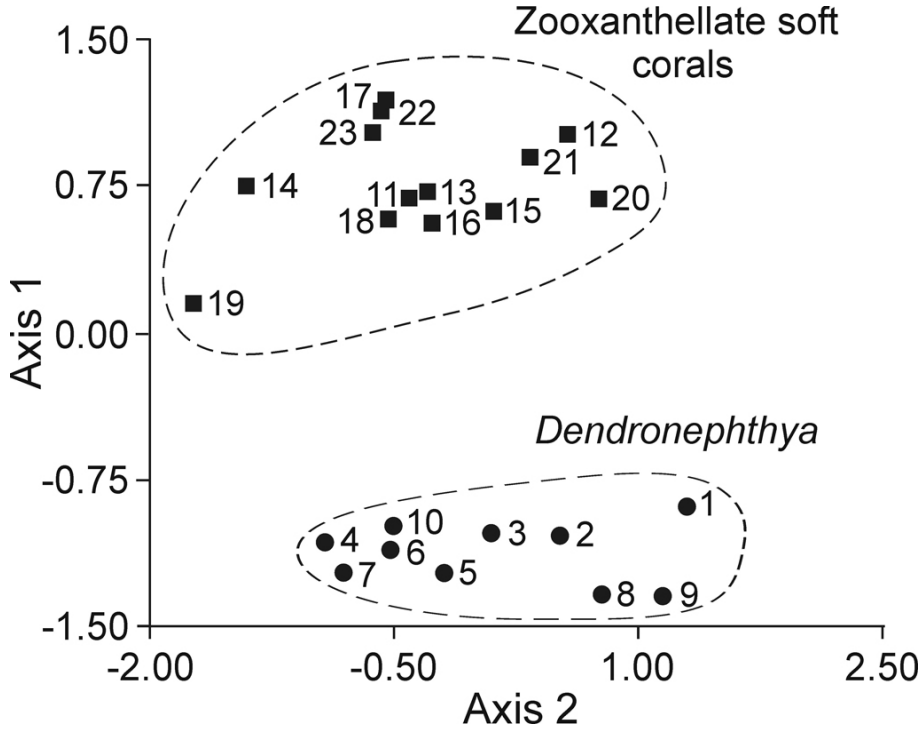

Fig. 6. Principal components analysis using the content of nine principal FA measured in all the 24 soft coral specimens (azooxanthellate Dendrophylliidae and other zooxanthellate families) from Vietnam

The lack of reliable information on the coral lipids and FAs limits our understanding of the biology and biochemistry of these anthozoans. Studies of lipids in reef-building corals have not so far been systematic. Current data available on FA composition of reef-building corals are very limited. Lipids and FAs of several wide-distributed species have been described but the FA profiles of the most genus are practically unknown. Data on FA composition of zooxanthellae from soft corals and FAs of azooxanthellate soft corals are not available until now. Comparison of lipid composition between tropical and boreal coral species has not been performed.

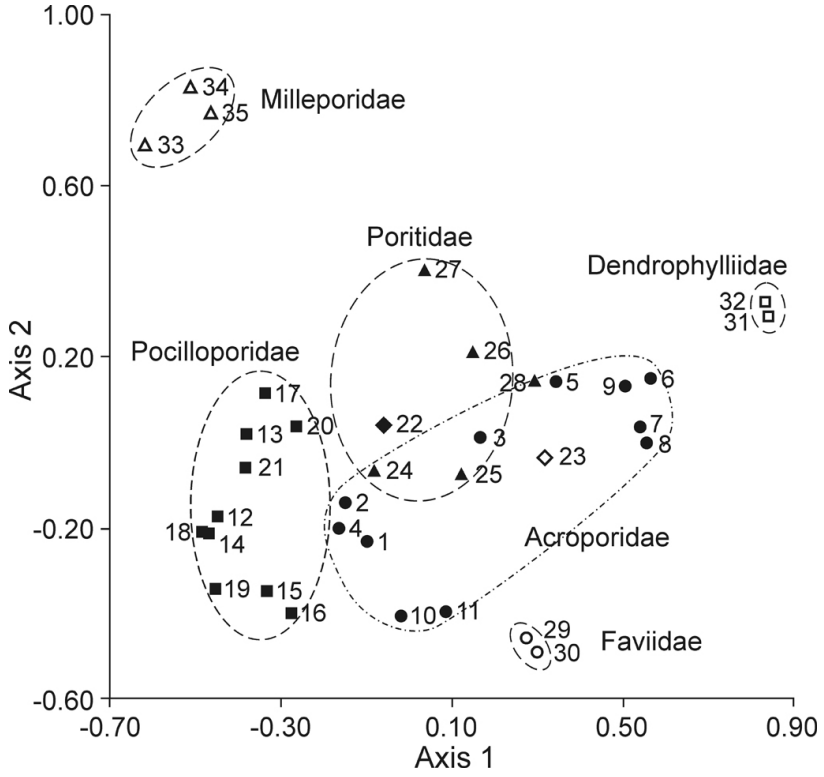

Fig.7. Multidimensional scale analysis performed using the 10 variables (square root of 10 PUFA contents) measured in all the 35 reef-building coral specimens from Vietnam

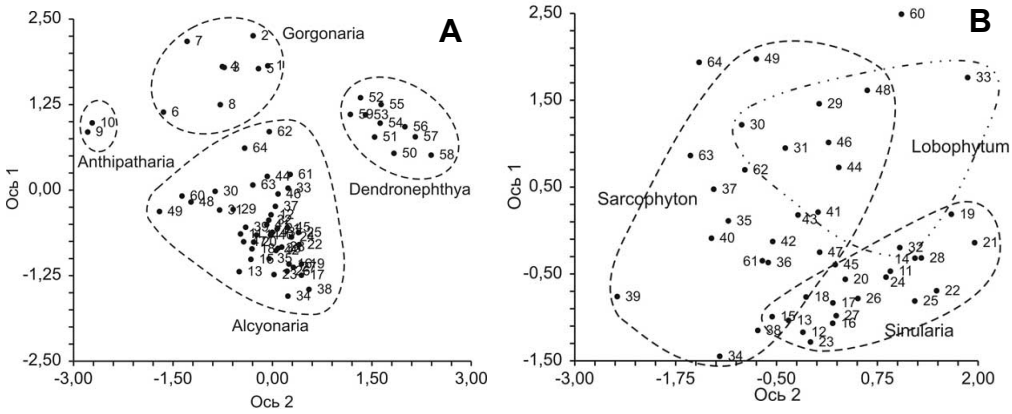

Fig. 8. Multidimensional scale analysis performed: (A) using the 33 variables (square root of total FA contents) measured in all the 64 soft coral specimens from Vietnam; (B) using the 10 variables (square root of 10 principal PUFA contents) measured in 42 soft coral specimens from Vietnam

It is recommended that a number of lipid studies as listed below could be considered in investigations of coral reefs.

- Determination of food chains in reef communities and food strategies of main reef consuments.

- Determination of the interaction between synbionts of soft corals and their functions

- Application of the data on fatty acid composition for the chemotaxonomy of corals.

- Screening of biological active fatty acids, lipids and oxylipins in the corals.

- Investigation of the role of active lipids in the regulation of vital activity of the corals.

ACKNOWLEDGEMENT

This work was supported by the project N21 “Chemical and biological studies of coral reefs of Vietnam and marine natural products” and the grant 07-03-90001-Viet of the Russian Foundation of Basic Research

REFERENCES

Imbs A.B., T.N. Dautova, 2008. Application of lipids for chemotaxonomy of octocorals (Cnidaria: Alcyonaria). Russian J. Mar. Biol., in press.

Imbs A.B., D.A. Demidkova, Y.Y. Latypov, L.Q. Pham, 2007. Application of fatty acids for chemotaxonomy of reef-building corals. Lipids, in press.

Imbs A.B., N.A. Latyshev, N.V. Zhukova, T.N. Dautova, 2007. Comparison of fatty acid compositions of azooxanthellate Dendronephthya and zooxanthellate soft coral species. Comp. Biochem. Physiol. part B, in press.

Latyshev N.A., N.V. Naumenko, V.I. Svetashev, Y.Y. Latypov, 1991. Fatty acids of reef-building corals. Mar. Ecol. Prog. Ser. 76: 295–301.

Michalek-Wagner K., B.L. Willis, 2001. Impacts of bleaching on the soft coral Lobophytum compactum. II. Biochemical changes in the adults and their eggs. Coral Reefs 19: 240-246.

Oku H., H. Yamashiro, K. Onaga, K. Sakai, H. Iwasaki, 2003. Seasonal changes in the content and composition of lipids in the coral Goniastrea aspera. Coral reefs 22: 83–85.

Yamashiro H., H. Oku, K. Onaga, H. Iwasaki, K. Takara, 2001. Coral tumors store reduced level of lipids. J. Exp. Mar. Biol. Ecol. 265: 171–179.

Zhukova N.V., E.A. Titlyanov, 2003. Fatty acid variations in symbiotic dinoflagellates from Okinawan corals. Phytochemistry 62: 191–195.