

***Duke of Edinburgh Prize to:***

Moritaka NISHIHIRA  
 Councilor, Ocean Exposition Commemorative  
 Park Management Foundation  
 Professor Emeritus, Tohoku University  
 Professor Emeritus, Meio University



“Research on Structuring and Conservation of  
 Coral Reef Communities in Japan, Especially  
 in Okinawa”

***Outline of the work:*****Summary of Research and Practice**

Dr. Moritaka Nishihira, in his detailed studies of life histories of epiphytic hydroids associated with marine algal thalli, found that algal selection of settling larvae and fine seasonal coincidence between the life cycles of hydroids and algae permitted stable association between them. In a project for IBP (International Biological Program), he studied animal communities in several major mountains at various locations in Japan, and also the blood-sucking tick population of sika deer in an island ecosystem. Based on comprehensive studies of concrete relationships among constituent species in the island ecosystem, he has played an instrumental role in advancing pioneer work in community conservation programs. Since the 1970s, he has carried out extensive field studies of coastal benthic communities and environmental conditions at many locations on major islands across Okinawa Prefecture. Based on his detailed descriptions and analyses, he concluded that for conservation activities to be effective it is necessary to treat both marine and terrestrial components and systems as an indivisible overall entity. Furthermore, he has published illustrated books of Japanese hermatypic corals, based on his own extensive diving studies with co-researchers at selected localities scattered widely from the Ryukyu Islands to the central part of mainland Japan. These studies contributed greatly to the elucidation of Japanese coral fauna and established an important foundation for advancing coral and coral reef research. Dr. Nishihira’s research is consistently field-oriented, which is basic but also unique given the current trend toward increasingly laboratory-oriented biology.

The two major contributions of Dr. Nishihira’s research, conducted based on the earlier studies mentioned above and summarized below, are appraised as being most worthy of the Duke of Edinburgh Prize from the Japan Academy.

**1. Devising the new concept of “Inhabitation chain” and its extension**

Based on his energetic, intensive and extensive field work on coral reef communities in Japan and overseas, Dr. Nishihira proposed hypotheses regarding “inhabitation coexistence” and “inhabitation chain”. In nature, organisms form various habitat structures by their existence and/or activities via three, and only three, habitat structuring processes—namely, provision, creation and conditioning—and those organisms that inhabit such a newly formed habitat also form habitat structures via similar processes. The reiteration of this formation of habitat and inhabitation is the “inhabitation chain”, which promotes multi-species coexistence. He showed that the great species diversity in a coral reef ecosystem results from this habitat formation by organisms and progression of the inhabitation chain; that is species diversity is promoted by a coexistent relationship among various organisms. Furthermore, based in part on past classical evidence, he pointed out that this inhabitation coexistence chain is not limited to coral reef ecosystems, but is widely found in terrestrial ecosystems as well. Studies of species diversity established by alteration of habitat structure carried out by

other researchers are now increasing with a focus mainly on forest communities.

This viewpoint of Dr. Nishihira stands in sharp contrast to community organisation concepts focused on predator-prey relationships and competition, as it explains community structuring based on coexistence relationships among species. As such, it has the potential to restructure the current dominant paradigm of ecological science. Although this concept has not yet become widely known among researchers of other countries, who are better acquainted with competition-oriented theories, it appears to be gradually spreading in part due to its close relationship with the concept of ecosystem engineering. It can be expected that Dr. Nishihira's inhabitation chain hypothesis will, on the basis of critical tests and applications, contribute to the future development and direction of ecological science.

## **2. Practical studies and activities for conservation, restoration and creation of coral reef communities**

In the Ryukyu Islands, outbreaks of crown-of-thorns starfish and elevated surface sea water temperature cause mass mortality of corals and thus severely damage coral reefs. In such cases, habitat structures largely collapse and inhabitants and species diversity greatly decrease. As a result, species richness and biological production decrease, underwater seascapes lose their beauty, and decreased larval production delays coral recovery in devastated areas.

Employing the inhabitation chain hypothesis as a basic theoretical instrument, Dr. Nishihira has attempted to restore whole coral reef communities (including corals and inhabitants), namely by transplanting of coral fragments. His ongoing activities to organize community-based working systems have included involving the local people, developing transplantation techniques, and assisting in social studies and conservation activities. He established a cheap yet effective transplantation technique, which can be used both easily and safely. The new technique uses two concrete nails and elastic material such as a spring or a rubber band (hence, it is called the "spring method"). It overcomes the disadvantages of earlier methods and can be applied to horizontal or steeply inclined surfaces, even to vertical surfaces and overhangs. Along with the growth of the transplanted coral fragments, which are laid horizontally on the rock surface and set so that the tissue is in direct contact with the surface, the coral cover greatly increases and fish and other animals return to inhabit the area. In time, both species richness and abundance increase. He demonstrated that, through the inhabitation chain, a whole community steadily recovers, thus restoring the beautiful underwater scenery. This comprehensive restoration technique was applied to large-scale restoration project in Bali, Indonesia, after making a slight modification to the method of fixing coral fragment. Dr. Nishihira visited Bali several times to provide ecological and technical advice to the Bali Beach Conservation Project, before, during and after implementing the transplantation. The results were technically, biologically and aesthetically satisfactory. They were received favourably by the local people, and left the researchers and technical staff as well as the local people highly motivated to participate in future coral restoration activities.

This method and system cannot at present be applied to Okinawan coral reefs, because of fisheries regulations. Along with transplantation experiments, however, technical improvements are being consistently explored. Dr. Nishihira has conducted workshops, open classes, technical training and symposia on the conservation of coral reef communities. He facilitates, promotes and supports self-development among local people whom he encourages to take an active part in restoration and management activities so as to raise public awareness in the utility of importance of conservation and restoration techniques, to help them learn how to apply such techniques, and to ultimately use what they have learned to wisely and rationally restore and establish coral communities so that they can enjoy both the tangible and intangible gifts that these underwater communities impact. The time and energy he invests in such activities are devoted to mainly to conservation of coral reef ecosystems and the diversity of their species and ecosystems, while, at the same time, they are fundamentally intended to provide a new basis for conservation and restoration of environments and landscapes, while contributing to the future extension of these concepts and techniques into wider fields. Dr. Nishihira's work is well known among many people in Okinawa, and is highly appraised by specialists engaged in nature conservation.

As mentioned above, Dr. Nishihira's discovery of the inhabitation chain and its extension is being actively applied and assessed within the ecological field. He has been deeply involved in conservation, restoration and creation activities in coral communities, using the inhabitation chain as a theoretical instrument and framework. Optimizing his experience in and knowledge of marine and terrestrial ecosystems, his practical research approach has yielded originality-rich field studies, proposals and activities that are well-recognized as major contributions to the fields of species protection and nature conservation. He was past president of the Japanese Coral Reef Society, and is currently president of the Okinawa Prefectural Coral Reef Conservation Conference.

#### **List of selected scientific papers and books (selected 25 articles)**

##### ***Scientific papers***

- Nishihira, M. 1968. Brief experiments on the effect of algal extracts in promoting the settlement of the larvae of *Coryne uchidai* Stechow (Hydrozoa). Bull. Mar. Biol. Stn. Asamushi, Tohoku University, 13: 91–101.
- Nishihira, M. 1968. Dynamics of natural populations of epiphytic Hydrozoa with especial reference to *Sertularella miurensis* Stechow. Bull. Mar. Biol. Stn. Asamushi, Tohoku University, 13: 103–124
- Tsuchiya, M. & Nishihira, M. 1986. Islands of *Mytilus edulis* as a habitat for small intertidal animals: effect of *Mytilus* age structure on the species composition of the associated fauna and community organization. Mar. Ecol. Prog. Ser., 31: 171–178.
- Nishihira, M. 1987. Natural and human interference with the coral reef and coastal environments in Okinawa. Galaxea, 6: 311–321.
- Nishihira, M. 1993. Habitat structure and biodiversity in the coral reef areas: Ecological process in habitat creation and community development on microatolls of the massive coral *Porites*. in "Symbiosphere: Ecological complexity for promoting biodiversity". Biology International (eds. Kawanabe, H., Ohgushi, T. and Higashi, M.), 29: 26–29.
- Nishi, E. & Nishihira, M. 1994. Colony formation via sexual and asexual reproduction in *Salmacina dysteri* Huxley (Polychaeta, Serpulidae). Zool. Sci., 11: 589–595.
- Yamashiro, H. & Nishihira, M. 1998. Experimental study of growth and asexual reproduction in *Diaseris distorta* (Michelin, 1843), a free-living fungiid coral. J. Exp. Mar. Biol. Ecol., 225: 253–267.
- Isomura, N. & Nishihira, M. 2001. Size variation of planulae and its effect on the life time of planulae in three pocilloporid corals. Coral Reefs, 20: 309–315.
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- Nanami, A. & Nishihira, M. 2004. Microhabitat association and temporal stability in reef fish assemblages on massive *Porites* microatolls. Ichthyol. Res., 51: 165–171.
- Nishihira, M. 2006. New methods for transplanting coral pieces using elastic materials. Bulletin of Research Institute, Meio University, 9: 71–75. (In Japanese)
- Nishihira, M. 2007. Survival and growth of transplanted coral pieces in a moat along the Gushichan-hama coast, Okinawa island. Bulletin of Research Institute, Meio University, (11): 37–46. (In Japanese)
- Onaka, S., Endo, S., Nishihira, M. & Yoshii, I. 2008. Implementation of large-scale coral transplantation in Indonesia. Coastal Annual Journal of Civil Engineering in the Ocean, 33: 825–830. (In Japanese)

##### ***Books and Reports***

- Nishihira, M. 1974. Intertidal zone–1974: Research Report of Present Status of Intertidal Zone of Okinawa Island.

- Marine Conservation Study Group. 262 pp. (In Japanese)
- Nishihira, M., Ito, T. & Kato, M. 1975. The Kinkasan Island. In: Numata, M. et al. (eds). Studies in Conservation of Natural Terrestrial Ecosystems in Japan (JIBP Synthesis 9). pp. 33–39.
- Nishihira, M. 1980. Intertidal zone of Iriomote Island–1978: Research Report of Present Status of Intertidal Zone of Iriomote Island. Nature Conservation Division, Okinawa Prefecture. 158 pp. (In Japanese)
- Nishihira, M., Yabiku, S. & Fujita, T. 1988. Studies of coral community restoration method by application of fragments of coral colony made via asexual reproduction: The first report of study group of conservation of coral reef area. Okinawa Environmental Research & Technology Center. pp. 184–254. (In Japanese)
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- Nishihira, M. 1992. Biotic formation of habitat and multi-species coexistence. In: Higashi, M. & Abe, T. (eds). What is the Earth Symbiotic System? Heibon-sha, Tokyo. pp. 86–100. (In Japanese)
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- Nishihira, M. 1998. Mechanism of multi-species coexistence on coral reefs. In: Inoue, T. & Wada, E. (eds). Biodiversity and its Conservation. Iwanami-shoten, Tokyo. pp. 161–195.