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Fishes of Miyake-jima: History of Study and Zoogeographical Significance

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Abstract Miyake-jima, in the Izu Islands of Southern Japan, was overlooked as a region of ichthyological importance for many years, probably due to its geographic proximity to the Izu Peninsula and Sagami Bay, and the assumption that the fish fauna in the southern Izu Islands would be similar to nearby sites on the main island of Honshu. This, however, has not turned out to be the case. The Tatsuo Tanaka Memorial Biological Station was founded at Miyake-jima by the author in 1970 for the purpose of conducting detailed research on the shallow water reef fauna of the island. Between 1970 and 1988, when it was closed, the Station was visited by scientists from 12 nations and more than 90 research papers were published. Among such studies were descriptions of previously undescribed species and numerous geographical range extensions. The results of such research have clearly shown that the fish fauna of the southern Izu Islands is unique in many ways, differing both from the warm temperate fauna of the northern Izu Islands and the Izu Peninsula, and the more tropical fauna of the Ogasawara and Mariana Islands to the south and the Nansei Islands to the southwest. The influences of the Kuroshio Current, latitude, volcanism and plate tectonics on the evolution of unique Izu Island fauna are discussed.

Key words: Izu Islands, Kuroshio Current, plate tectonics, endemism, Micronesia, Nansei Islands, temperate, warm temperate, tropical.

Over the past twenty years, it has become more and more apparent that the Kuroshio-influenced waters from Mikura-jima to Hachijyo-jima, including Miyake-jima, provide habitats for unique and valuable flora and fauna, including many apparently endemic species. The islands of Aogashima and Torishima are undoubtedly a part of this unique marine zoogeographical region, but, as yet, we have little data, due to their relative isolation.

This distinctive southern Izu Island marine ecosystem includes both pelagic and reef habitats, linked together by a variety of ecological interactions involving both biotic and abiotic factors that are still not clearly understood. Of primary importance are the combined effects of the warm Kuroshio waters, a geographical setting between 32°N. Lat. and 34°N. Lat., and tectonic activities along the borders of the Pacific and Philippine Plates.

The importance of the Southern Izu Islands as a treasure chest of biological diversity of immense global value has only recently begun to be recognized by ornithologists (Bibby *et al.*, in press). That the marine environment is equally unique is suggested by the oceanographic, geological and geographic factors stated above, and borne out by the relatively limited research on marine organisms that has taken place thusfar. By far the most data available to science has been collected by ichthyologists, and, as is the situation with birds, most of the research up to now has taken place at Miyake-jima.

In this paper, I examine ichthyological research at Miyake-jima historically, and, then, I attempt to analyze the scientific significance of this research in terms of future attempts to conserve biodiversity of extreme global value. I follow the nomenclature of Nakabo (1993) with the exception of the family Callionymidae, where I prefer the classification system of Fricke (1983).

History of Ichthyological Research at Miyake-jima

Ichthyological research can be divided broadly into two eras; i.e., pre-Pacific War and

post-Pacific War. This division results primarily from the invention of SCUBA (self-contained underwater breathing apparatus) during the war years. Ichthyological research prior to the war involved analysis of collections of fishes taken by commercial fishermen and/or scientific collectors. Because specimens were usually dead or dying when first analysed by scientists, actual living colors were not always available. Specimens were usually not examined for sexual identity, and often males, females and juveniles of the same species were described, mainly on the basis of coloration, as representing two or, in some cases, three species. The taxonomic confusion that resulted is still being sorted out by specialists at museums throughout the world.

Ecological and behavioral works during the same era suffered from the same constraints. Scientists based their research on what could be observed from above water and from aquarium observations. Obviously, the availability of SCUBA opened a new era.

Although there were collections from Miyake-jima in the pre-war era, with specimens deposited at a variety of locations, no directed or concentrated studies of Miyake fishes were ever undertaken, to my knowledge. Serious scientific studies using SCUBA began in North America and Europe in the late 1950s. It was 1970, still in the pioneer days of underwater research, that the Tatsuo Tanaka Memorial Biological Station (TMBS) was established by the author at Miyake-jima. The choice of the station's name and other pertinent details on its origin have been published elsewhere (Moyer, 1993). Although scientists worked underwater independently in the two decades that followed, by far the bulk of ichthyological research that took place at Miyake used TMBS as a base of operations.

Over the years, more than 200 scientists visited TMBS from twelve different nations, publishing the results of their works, identified as contributions of the Tatsuo Tanaka Memorial Biological Station, in a variety of professional journals throughout the world. Such TMBS contributions currently number 91, with some materials still remaining unpublished.

Among the visiting scientists, some made major contributions to the development and continuity of TMBS between 1970–1988, when the station ceased to function, due to rapid construction-related environmental deterioration of study sites and from constraints placed upon visiting foreign scientists by the inflated value of the Japanese Yen. Dr. Teruya Uyeno (Natural History Institute, National Science Museum, Tokyo) and the late Dr. Yoshiaki Tominaga (University of Tokyo) visited the station on several occasions in the early 1970s, making numerous suggestions and providing the beginnings of a library. Dr. John E. Randall (Bishop Museum, Honolulu) and Dr. Gerald R. Allen (Western Australian Museum) were frequent visitors, both initiating a wide range of professional contacts that resulted in a growing library. Dr. Hitoshi Ida (Kitasato University) engaged in important studies resulting in several research papers (Ida and Moyer, 1974, 1975; Moyer and Ida, 1975, 1976; Randall, *et al.*, 1982). Dr. Akinobu Nakazono (Kyushu University) and Dr. Yutaka Yogo (then of Kyushu University) made major ecological contributions (Moyer and Nakazono, 1978a, 1978b; Moyer and Yogo 1982; Yogo, 1985). Ecological studies at Miyake-jima will be reported, as Fishes of Miyake-jima: Ecology and Behavior, at a later date.

In the later years of TMBS history, Dr. Keiichi Matsuura (Natural History Institute, National Science Museum, Tokyo) and Dr. Mitsuhiko Sano (University of Tokyo) made numerous visits to the station, resulting in some valuable publications (Sano and Moyer, 1985; Moyer and Sano, 1985, 1987). Dr. Ronald Fricke (Staatliches Museum of Natural History, Germany) made important research contributions between 1982–1985 (Fricke and Zaiser, 1982, 1983; Fricke and Zaiser-Brownell, 1993; Zaiser and Fricke, 1985).

TMBS was staffed by a permanent team of young workers, mostly former students of the author at the American School in Japan. These included John Shepard and the late Katherine Meyer, whose research on labrid fishes included several important publications (Shepard and Randall, 1976; Moyer and Shepard, 1975; Shepard and Meyer, 1978a, 1978b; Shepard and Okamoto, 1977, Meyer,

1977). They described one previously unknown species and gathered materials to describe six others, all taken for the first or only times in Miyake-jima waters. These remained undescribed, as a result of the tragic death of Katherine Meyer in 1985. Five were later described by Dr. Randall, one, *Cirrhilabrus katherinae*, in memory of Ms. Meyer's valuable contributions to science (Randall, 1992). The sixth remains undescribed to this day. Shepard also contributed to an understanding of Miyake-jima pomacentrids, pomacanthids and chaetodontids (Shepard and Moyer, 1980).

Martha Zaiser-Brownell specialized in callionymid fishes and discovered three undescribed species and additional important new data, later reported in collaboration with Dr. Fricke (cited above).

Major contribution were made in other marine biology disciplines. Dr. Susan Brawley (formerly from the University of California, Berkeley) investigated marine algae at Igaya Bay (Oofunatowan), Miyake-jima, in 1976–1977, collecting more than 150 species, the great majority of which were tropical in origin. Included in this collection were at least two undescribed species of *Codium*. Sadly, Dr. Brawley never published her results; however, her collection was deposited at the University Arboretum, University of California, Berkeley. Dr. Gordon Tribble (then of the University of Hawaii) investigated corals in the same bay in 1979, collaborating with Dr. Richard Randall (University of Guam). A total of 91 species of corals was collected, including 80 hermatypic species. At least one species of *Acropora* was apparently new to science (Tribble and Randall, 1986).

Analysis of Southern Izu Island Fish Fauna

For scientists who have worked in both the Nansei Islands and the Izu Peninsula, the first impressions underwater at Miyake-jima and Hachijyo-jima are that Southern Izu Island reefs are unique, unlike both the coral reef habitats south of Kagoshima and the algae habitats of Izu. The most strikingly obvious feature of Southern Izu Island reef habitats is the clearly visible competition for space between algae and corals, and the absence of the large, fleshy brown algae species so abundant along the Izu Peninsula.

Vast meadows of lush algae are dotted with outcroppings of corals, providing cover for a wide variety of labrid fishes. Nearby, volcanic cliffs, topped with broad patches of corals, provide habitat for immense aggregations of coral reef damselfishes, marine angelfishes and basslets. Usually, a relatively wide zone of mixed coral rubble and volcanic pebbles or sand divides cliffs from nearby algae beds, providing superb habitat for callionymids. This rich diversity in habitats is similar to what is found on reefs south of Nichinan, Miyazaki-ken; the Pacific coast of Kagoshima-ken; the Ashizuri Peninsula of Kochi-ken and the Kii Peninsula of Wakayama-ken. However, there are important differences in fish species composition.

Shepard and Meyer identified more than 70 species of labrid fishes at Miyake-jima, more than have been recorded, for example, at Guam in the Mariana Islands. Included were nine species of the genus *Cirrhilabrus* (specimens deposited at the Natural History Institute, National Science Museum, Tokyo, and the Bernice P. Bishop Museum, Honolulu). Of these, only four have been reported from similar habitats on the Izu Peninsula. Reproductively functional social groups of the common coral reef labrids *Thalassoma lunare*, *T. lutescens*, *T. amblycephalum*, *Coris aygula*, *Halichoeres melanochir*, *Pseudojuloides cerasinus* and *Pseudojuloides elongatis* are observed regularly at Miyake-jima, and spawning groups of *Halichoeres chrysus* and *Macropharyngodon negrosensis* are observed frequently after winters when water temperatures remain above 16°C.

Similarly, the rich callionymid fauna at Miyake-jima regularly includes four species that are only rarely seen on the nearby Izu Peninsula after periods of exceptionally warm currents (*Synchiropus kiyoe*, *S. moyeri*, *Callionymus persicus* and *C. curvispinis*) (Fricke and Zaiser-Brownell, 1993).

Damselfishes follow this pattern. A total of 33 species of damselfishes has been reported from Miyake-jima, including 12 species of the genus *Chromis* (Randall *et al.*, 1982). Large spawning aggregations of *Chromis flavomaculatus* and *Chromis chrysurus* are reminiscent of

the Nansei Islands, as is the presence in deep waters of *Chromis ovatiformis*, *Chromis atripes* and fairly large aggregations of *Chrysiptera starcki*. This is a different fauna than is present on the Izu Peninsula, only 64 kilometers to the northwest.

Looked at in another way, *Chromis fumeus* is abundant in adult spawning aggregations along the main islands of Japan from Izu to Kagoshima, but is found at Miyake-jima only as an occasional juvenile in mixed schools of small juveniles of *Chromis flavomaculatus*. Similarly, adults of *Cirrhitichthys aureus*, *Sebastes inermis*, *Chaetodontoplus septentrionalis* and many other common Izu species are never found at Miyake-jima. (Occasional juveniles of *Sebastes inermis* and one small juvenile of *Chaetodontoplus septentrionalis* were recorded during the especially cold waters of the winter of 1983–1984, after a major El Nino event in the tropical Pacific). It is not the purpose of this paper to specifically list the faunal differences of the Southern Izu Islands and neighboring regions. Based on the data available, such a list would be premature. The examples presented above, however, should suffice to show that the Southern Izu Islands are unique biogeographically. There are several possible explanations of why this should be so.

Certainly, the combination of a temperate latitude and warm Kuroshio waters is significant. Winter water temperatures at Miyake-jima rarely fall below 15°C for periods of more than a few days, and the lowest temperature recorded thusfar is 13°C. Drops in water temperature below 16°C for periods of several days result in extreme mortality in a wide range of Miyake-jima species. On the average, the waters of the Southern Izu Islands are warmer in winter than the waters of the Izu Peninsula. Secondly, the Izu, Kii and Ashizuri Peninsulas, Miyazaki and Kagoshima are all located at the eastern edge of the Continental Shelf, and thus, share Continental Shelf fauna. For example, the garden eel *Gorgasia taiwanensis*, occurring from western Izu to Taiwan, appears to be a Continental Shelf species. *Gorgasia japonica*, on the other hand, may be a Philippine Plate endemic, being known only from Miyake-jima, Hachijyo-jima and Taiwan. The geographical ranges of *Cirrhitichthys aureus*, *Chaetodontoplus septentrionalis* and other Izu Peninsula species, including *Bodianus izuensis* and *Bodianus masudai*, can be explained similarly.

The Continental Shelf-Izu Island division can also be examined from the standpoint of plate tectonics. Dr. Victor Springer (U.S. National Museum, Washington) has hypothesized that movements of crustal plates over geological time periods may have contributed to plate-specific fauna (Springer, 1982; see, also, Myers, 1989). Springer has recognized numerous Pacific Plate endemics, including some species that are also found on the Philippine Plate, *e.g. Synchiropus morrisoni*, which is not uncommon at Miyake-jima. Springer (1982) does not recognize a faunal difference between the Pacific and Philippine Plates. However, there are some species that appear to be confined to the Philippine Plate and its margins; *e.g.*, *Centropyge shepardi* from the Ogasawara-Mariana Arc and *Centropyge ferrugatus* from the Nansei Islands and Philippines. Both are found at Miyake-jima, and I consider them to be color morphs of the same species.

The Southern Izu Islands are located at the borders of the Philippine, Pacific and Eurasian Plates, whereas the main islands of Japan, including, of course, the Izu Peninsula, are on the Eurasian Plate. Springer's hypothesis, in combination with great fluctuation in water temperatures as a result of high latitudes, may help to explain the evolution of endemic Southern Izu Island marine fauna and other unique aspects of the region.

The Future

Coastal construction continues to alter the underwater landscape in Japan from Hokkaido to Iriomote-jima. The Southern Izu Islands are no exception, and much precious underwater habitat has already been destroyed; *e.g.*, much of the southern portion of Ofunato-wan (Igaya Bay), Miyake-jima. It is of utmost importance that careful, directed faunal surveys be carried out throughout the Izu Islands, focusing on the strong possibility that endemic and otherwise limited range species will be identified. Minute ecological data are also required. For example,

not only is it important to know that a species occurs in thick algae, but the identity of the algae, the depth and the presence or absence of tidal currents, etc., should also be noted.

Especially, we need data from Oshima to Kozu-shima. We know that there is a faunal break, a sort of zoogeographical boundary, between the Izu Peninsula and Miyake-jima, but we do not know where that boundary occurs. Oshima appears to be almost identical to the Izu Peninsula; *e.g., Cirrhitichthys aureus, Chaetodontoplus septentrionalis*, adult spawning populations of *Chromis fumeus*, etc. Once available, data must be interpreted with caution. For example, the waters of Nii-jima, Shikine-jima, and Kozu-shima have substrates consisting largely of eroded pumice, resulting in a fine sand, inappropriate habitat for many callionymid fishes that might otherwise be present, but possibly ideal for others.

As for Miyake-jima, research to date has focused only upon seven families: Apogonidae, Pomacentridae, Labridae, Chaetodontidae, Pomacanthidae, Scorpaenidae and Callionymidae. Other families of reef fishes should be systematically surveyed. Especially promising from the standpoint of potential endemism is the Tripterygiidae. This family should receive first priority.

Once biodiversity has been documented in terms of species composition, endemism and important ecological sites, attempts should be made to conserve selected sites before they are destroyed by so-called development. Obvious areas in need of protection at Miyake-jima, for example, are the rich reef at the edge of the cliff just north of the harbor at Igaya and Chotaro-ike at Tsubota. Other such areas must be identified throughout the Izu Islands as soon as possible, and efforts should be made to gain their protection.

Japan has recently signed an international treaty designed to protect dwindling biodiversity on a global scale. Terrestrial biologists have already recognized areas of global biological importance. Although more than 70% of the earth's surface consists of oceans, very little data is available to allow selection of similar sites underwater.

The Izu Islands have been identified by ornithologists as an area of globally important biodiversity above water. Based on limited data, I am convinced that the reefs of the Southern Izu Islands are of equal importance. Data are urgently needed, first, to identify specific sites of impressive marine biodiversity, including limited range species, and, second, to convince government agencies of the necessity for protecting such sites from deterioration, once identified.

The Miyake-jima Nature Center (Akakokkokan) provides a natural setting to take over from the now-defunct Tatsuo Tanaka Memorial Biological Station as a focal point for marine research in the Southern Izu Islands and as a possible data processing center for research concerning this vital area.

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三宅島の魚類：その研究史と生物地理的重要性

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伊豆諸島の一つである三宅島は，その魚類学上の重要性について，長い間，見逃されてきた．それは恐らく，この島が伊豆半島や相模湾と地理的に近く，その魚類相が，本州とあまり違わないと思われてきたことによる．しかし，それが正しくないということが，わかってきた．1970 年，三宅島に田中達男記念生物学研究所が創設された．その目的は，三宅島沿岸の動物相を詳細に研究することである．1970 年から，活動を停止した 1988 年まで，研究所には，延べ 12 カ国から多くの研究者が訪れた．その研究成果は，90 余りの論文として出版された．その研究の中には，多くの新種の記載や，分布初記録が含まれている．これらの研究成果は，三宅島の魚類相が明かに，ユニークであることを示している．つまりそれ

は，伊豆諸島北部の島々や，伊豆半島の温暖帯性の魚類相と異なり，また，小笠原諸島からマリアナ諸島以南，あるいは南西諸島からさらにその南西部の熱帯性の魚類相とも異なることが，明かである．黒潮の流れ，緯度，火山活動，プレートテクトニクスが，伊豆諸島の魚類相の進化に及ぼした影響について，議論した．