

Fish Collection and Ichthyology at Kyoto University

For more than half-century, Maizuru Fisheries Research Station have obtained and kept enormous specimens.

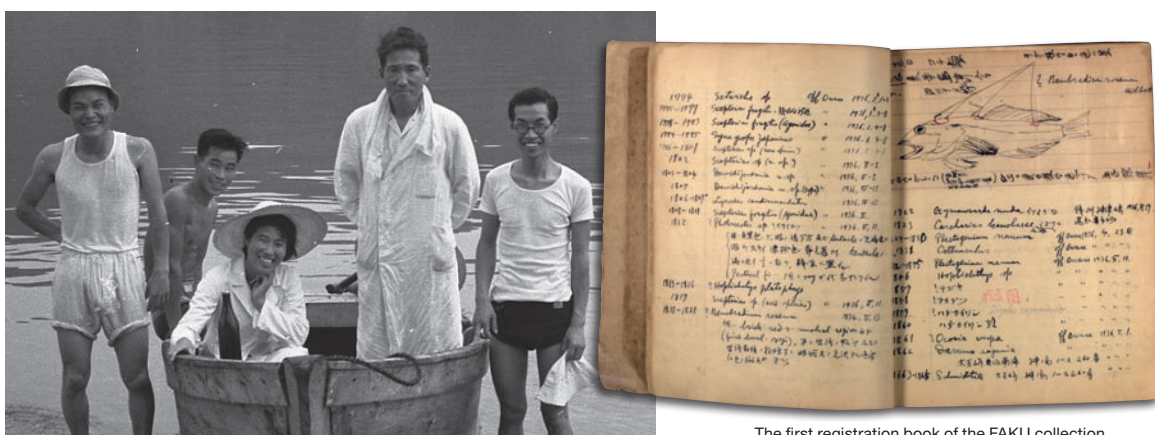


Fig.1 Dr. Kiyomatsu Matsubara (second right) and his students.

The Scientific collections of museums are important resources for the study of natural history, including taxonomy and phylogenetics. Kyoto University holds more than 300,000 fish specimens, the second largest fish collection in Japan. The collection is housed at both the Maizuru Fisheries Research Station (13), Field Science Education and Research Center (FSERC) and the Kyoto University Museum and has significantly contributed to the study of the world's fishes (ichthyology). Because of the high quality and quantity of the fish collection of Kyoto University, many research biologists come from various countries to examine the specimens. During the last decade, for example, we hosted biologists from Australia, China, France, Korea, Russia, Thailand, and the USA, as well as from Japan. We also lend many specimens to interested biologists for taxonomic and phylogenetic study. There are currently over 1,000 specimens on loan. Over twenty scientific papers are published every year on the basis of Kyoto University's fish collection.

The collection can be traced back to 1947, when Professor Kiyomatsu Matsubara (1906-1968: Fig. 1) was posted to Kyoto University. Matsubara was a pioneer in phylogenetic studies of the fishes. In his doctoral thesis "Studies on the scorpaenoid fishes of Japan. Anatomy, phylogeny and taxonomy," Matsubara presented a

phylogenetic tree on the basis of an extremely thorough analysis of skeletal and other characteristics. The work is acknowledged as pioneering model of systematic analysis. Although it was published in 1943, it is still referred to in many recent systematic studies of scorpaenoid fishes (scorpionfishes or rockfishes). Throughout his career, Matsubara studied not only scorpaenoid fish, but also various other kinds of fish. His remarkably broad knowledge of ichthyology was comprehensively summarized in "Fish Morphology and Hierarchy" published in 1955, covering most of



Fig.2 The first coelacanth specimen scale what donated by Dr. James L. B. Smith.



Fig.3 The main building of the Department of Fisheries, formerly utilized by the Imperial Japanese Navy. Photograph taken in 1957. The building was demolished in 2003.

the Japanese fishes known at that time. He provided keys to the identification of families, genera, and species, and comparative morphology and phylogeny of representative families. The book contains over 1,600 pages and 530 figures, and is the work of Matsubara alone. The work established him as legend in the field of ichthyology.

Matsubara started his professional career in 1929 in Imperial Fisheries Institute (now, Tokyo University of Marine Science and Technology). In that year, a famous world-leading ichthyologist, Carl L. Hubbs (University of Michigan), visited Japan to collect fishes, and Matsubara was chosen by the Institute to serve as his assistant. The field trip collecting fishes with Hubbs was a significant development in Matsubara's career in ichthyology. Despite the advent of World War II from 1939 to 1945, the relationship between the two scientists lasted until Matsubara passed away in 1968. Although Matsubara's doctoral thesis was published during WWII, it was written in English, and it was sent to Hubbs on 8 October 1946, soon after the war ended. In Matsubara's obituary, Hubbs wrote, "I have always regarded him as one of my outstanding students, and he has publicly acknowledged me as his teacher."

Matsubara had good relationships with several ichthyologists around the world before and after WWII. Albert W. C. T. Herre, a professor at the University of Washington, and Hubbs always supported Matsubara in obtaining literature about fishes from all over the

world. In the study of taxonomy, literature, including descriptions of new species, is very important, but the bulk of such works were published in Europe and the USA in the 18th to early 19th centuries, and were difficult to obtain in Japan at that time. During WWII, Matsubara put his collection of academic literature in wooden boxes and buried them in his garden in order to protect them from fire bombs. After WWII, James L. B. Smith, a famous South African ichthyologist who discovered the coelacanth species, also donated literature to Matsubara. Those works have been very valuable to Japanese ichthyologists. They are currently held by the library of the Faculty of Agriculture (see the column, p.17), to the supporting the taxonomic study of fishes at Kyoto University. Together with the academic literature, Smith gave Matsubara a scale from the first coelacanth specimen found off the east coast of South Africa in 1938 (Fig. 2). The scale is now preserved at the Maizuru Fisheries Research Station.

In July 1947, when Matsubara was transferred to Kyoto University's Faculty of Agriculture, he took his fish collection with him and started to expand it under the acronym FAKU (Faculty of Agriculture, Kyoto University). The Faculty of Agriculture, established the Department of Fisheries in 1947, in order to contribute to overcoming the post-war food shortage. The Department of Fisheries was established in Maizuru, 60km northwest of central Kyoto City, in buildings that were formerly used by the Imperial Japanese Navy

Kiyomatsu Matsubara (1907–1968): Graduated from the Imperial Fisheries Institute in 1929. Dr. Matsubara was the first professor of the Department of Fisheries of Kyoto University, and served as a professor of the Faculty of Agriculture for twenty years. He made distinguished contributions to the early stages of ichthyology, and was elected an honorary member of the American Society of Ichthyologists and Herpetologists.





Fig. 4 Aquatic Natural History Museum at the Maizuru Fisheries Research Station (left) and the Collection room (right)

(Fig. 3). Although the research situation at that time was not favorable, Matsubara and his students took part in many trips throughout Japan, collecting fish and expanding the university's fish collection.

It is said that Matsubara's enthusiasm for study was astonishing. He always brought two lunchboxes in order to work until late at night, always dashed down the hall to increase efficiency by saving time, and would not notice a phone ringing when he was busy preparing a manuscript. He was also known as a great educator. He inspired many students in their studies of ichthyology, and his academic traditions were carried to Hokkaido University, Kinki University, Kochi University, Miyazaki University, and the University of the Ryukyus (collection now transferred to the Okinawa Churashima Foundation): to this day, each of those institutions contains an excellent collection of fishes under the acronyms, HUMZ, KUN, BSKU, MUFs, and URM, respectively. A second generation of students, taught by Matsubara's students, have also carried on his tradition in various universities and public museums, and many of the major streams of ichthyology in Japan can be traced back to Matsubara.

One student of Matsubara, Dr. Izumi Nakamura, was succeeded as curator of the FAKU. Because he was a specialist in the taxonomy and phylogenetics of tuna and billfish, Nakamura participated in numerous research surveys by Japanese vessels chartered by the Fisheries Agency of Japan. Thanks to Nakamura, specimens collected in distant countries, including Argentina, Chile, New Zealand, and South Africa, were added to the collection. Some of the specimens were taken from waters in which trawling by foreign research vessels is no longer allowed due to sea conservation laws, and they are therefore very valuable. In 1972, the Department of Fisheries was moved to the main campus of Kyoto University and the Maizuru Campus became the Maizuru Fisheries Research Station, a

research facility of the Faculty of Agriculture. In 1984, a new building, containing two large collection rooms, was built in the Maizuru Fisheries Research Station (Aquatic Natural History Museum: left of Fig. 4). The fish specimens were then sorted by species, put into bottles, and arranged systematically on shelves, making the access to specimens easy (right of Fig. 4).

When Nakamura retired as curator of the FAKU and was replaced by the author in 2004, the faculty had begun collecting tissue for genetic analysis. Because the majority of the specimens at Kyoto University have been kept in formalin for a long time, they are not suitable for DNA analysis using current techniques. The tissue collection is a library of small tissue samples taken from fish before the fixation in formalin. The tissues are stored in alcohol and used for population genetic study, molecular phylogenetics, and "DNA barcoding." DNA barcoding is a taxonomic method that uses a short genetic marker in order to identify it as belonging to a particular species. Now, many DNA barcodes of fishes developed using the FAKU collection have been



Fig. 5 Main building of the Misaki Marine Biological Institute. Photograph taken in 1958.



Fig. 6 A rockfish, *Sebastes kiyomatsui* (Kai and Nakabo, 2004) (left) and its closely related species, *Sebastes scythropus* (Jordan and Snyder, 1900) (right). The former was named after Dr. Kiyomatsu Matsubara by the author and Dr. Tetsuji Nakabo, both inheriting Matsubara's tradition. The two species were considered to be color variations within a single species by Dr. Matsubara, but our research team found clear distinctions by genetic and morphological analyses.

deposited at the DNA Data Bank of Japan (DDBJ), GenBank of USA, and European Molecular Biology Laboratory (EMBL).

In 1997, the Kyoto University Museum was newly established on the main campus of Kyoto University. The museum holds historical materials relating to natural, cultural, and technological history. Since the Department of Fisheries was moved to the main building of the Faculty of Agriculture in 1972, the fish collection has also been established there under the same acronym, FAKU, as the Maizuru Fisheries Research Station. The fish collection in the Faculty of Agriculture was moved to the Kyoto University Museum in 2001, when the new museum building was constructed. The fish collection in the Kyoto University Museum was managed by Prof. Tetsuji Nakabo until his retirement in March 2015. The museum has an excellent collection of fishes of the East China Sea. Now, specimens catalogued as FAKU 60000-100000 and FAKU 200000 or later, and FAKU P series are deposited in the Kyoto University Museum, and other

specimens are in the Maizuru Fisheries Research Station.

Small, but important fish collections are also housed in Kyoto University. Seto Marine Biological Laboratory (31), which is located in Shirahama, Wakayama, was a research facility of the Faculty of Science, which is now merged into the Field Science Education and Research Center. The laboratory had a fish collection under the acronym "SMBL." The collection of SMBL was developed by Assistant Prof. Chuichi Araga, and mainly contained specimens collected from southern Japan. Now the most of the fish specimens of SMBL have been transferred to FAKU. Otsu Hydrobiological Station (OHS) of the the Faculty of Science (now, re-established as the Center for Ecological Research (21)) also holds a small collection of freshwater fishes, mostly collected from all over Japan, Korea, Taiwan, and mainland China. A large part of this collection was built by Drs. Denzaburo Miyadi and Tamezo Mori before WWII, making it the oldest fish collection in Kyoto University. The oldest specimens were collected



A postdoctoral research biologist at FAKU investigating an oarfish, *Regalecus russellii*. The oarfish is a very rare species, but FAKU has one of the largest collections of oarfish in the world, containing over twenty specimens. Accordingly, many biologists come from various countries to examine the oarfish specimens.



Prince Akishinonomiya Fumihito and Princess Akishinonomiya Kiko visited the Maizuru Fisheries Research Station on 24 July 2014. At the research station, they viewed the aquaculture building (photo) and the collection room of FAKU, particularly the goby specimens. Prince Fumihito's father, Emperor Akihito, is a famous goby taxonomist. In a recent research project, the Prince and the Emperor collaborated on a paper, titled "Evolution of the Pacific and the Sea of Japan populations of the two gobiid species, *Pterogobius elapoides* and *Pterogobius zonoleucus*, based on morphological and molecular analyses," published in *Gene* **427**(2008):7-18, doi:10.1016/j.gene.2008.09.026.

in 1910, but are still preserved in good condition. This collection was also transferred to the Kyoto University Museum in 2001, when its new building was constructed. Misaki Marine Biological Institute (note: as distinct from Misaki Marine Biological Station of the University of Tokyo) was established on 20 March 1958 under the sponsorship of the Nankai Electric Railway (Fig. 5). The institute was located in Misaki-Koen, in southern Osaka, and housed a small fish collection under the acronym MIKU. Although no detailed records or documents concerning the MIKU fish collection exist, it contained the specimens collected during the Amami (Kagoshima) Expedition undertaken in 1958 by Matsubara and his colleagues. After the death of Matsubara in 1968, the institute seems to have closed around 1970. Due to student activism at that time, the transfer of specimens was difficult. Unfortunately, most of the MIKU specimens have been lost, but some were transferred to FAKU by Prof. Tamotsu Iwai, who later became the director of the Faculty of Agriculture.

These scientific collections serve as important sources of "raw" biological data for biologists and

educators. In particular, voucher specimens in museums are the basis for zoological nomenclature, and provide the foundation for assigning new scientific names. Furthermore, the utility and value of collections to the scientific community has increased owing to the recent development of bioinformatics and new technologies, such as stable isotope analyses, massive parallel sequencing, and CT-scan tomography. Bioinformatics at the global level educates the potential value of scientific collections for future research in fields such as biodiversity, extinction, invasive species, and climate change. Next Generation DNA Sequencers (NGS) will enable to determine the sequences of historical specimens, which are not suitable for traditional sequencing because of the fragmentation of their DNA (Fig. 6). The fish collection of Kyoto University and its associated data have diverse histories and benefit a wide variety of scientific studies. They often serve as the basis for the successful management and conservation of populations, species, and ecosystems, and are expected to do so well into the future.

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WEB www.maizuru.marine.kais.kyoto-u.ac.jp/en/



Matsubara's Collection

Special collection of academic literature.

Academic works collected by Dr. Matsubara for his research on ichthyology taxonomy, including literatures given by Dr. J. L. B. Smith, are currently stored in the library of the Faculty of Agriculture. Please access the following library website if you would like to know more details.

WEB www.agril.kais.kyoto-u.ac.jp/guide/index-e.html#search

