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A Review of the 35-Year History of the Taiwan Fish Database

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ABSTRACT

The "Taiwan Fish Database" (http://fishdb.sinica.edu.tw) is arguably the earliest and most popular biodiversity database in Taiwan. Established around 1990 by the Fish Ecology and Evolution Laboratory of the Institute of Zoology at Academia Sinica, it has a history spanning more than 35 years. The database originally began by collecting and organizing the most recent species names and geographic distribution of fish in Taiwan, and later expanded to include specimen collections, species descriptions, bibliographies, and other academic content. In 1998, with support from the "Taiwan Research Networking Project" at Academia Sinica, it began to take on a more public outreach focus. Starting in 2001, it received project support from the National Science Council's National Digital Archives Program, allowing for rapid improvements in content and information technology and making it a key partner of the global FishBase. Due to its comprehensive, authoritative, and fully open-access content, it has been highly valued and recognized by both domestic and international academia. In 2011, it became a Regular Member of the World Data System (WDS). However, due to security issues and aging systems, the database was taken over in 2016 by the Academia Sinica Center for Digital Cultures (ASCDC) for continued management and updates. The original database was split into two sub-websites: "Taiwan Fish Database" (focused on academic research) and "Fish Knowledge+" (aimed at public education). After the 2024 update, a new version was launched with an expanded species list of nearly 3,500 species. The old version of the site remains available for users who are accustomed to it, but it is no longer updated. This article provides an overview of the database's origins, its development into an international resource, the importance of open-access data, and future directions for continued progress.

Keywords: biodiversity database, fish knowledge, ichthyology, Taiwanese fishes, database history.

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1 THE FOUNDING AND DEVELOPMENT OF THE TAIWAN FISH DATABASE

The founder of the database, Kwang-Tsao Shao, returned to Taiwan from the United States in 1984 and began participating in the "Taiwan Fish Fauna Studies" project, led by Professor Shih-Chieh Shen at National Taiwan University. In this project, he worked with colleagues including Sin-Che Lee, Hin-Kiu Mok, Che-Tsung Chen, Chun-Hui Chen, and Chyng-Shyan Tzeng. The team conducted annual field surveys to resolve identification errors and discrepancies caused by lack of expertise. They also removed many fish species from earlier records that lacked specimens, literature references, or were determined to be synonyms. By 1993, the "Fauna of Taiwan Fishes" was published, recording 237 families and 2,028 species of fish (Shen et al., 1993). Although this number was fewer than the 2,252 species listed in Chen and Yu's 1986 work, many dubious species were removed, and hundreds of new species records for Taiwan were added.

Between 1989 and 1995, Kwang-Tsao Shao received support from the National Science Council for a five-year project titled "Research on the Spatio-temporal Distribution of Fish Assemblages in Taiwan and the Establishment of a Fish Database." This led to the establishment of the Taiwan Fish Database, including surveys of fish species in various regions of Taiwan—north, east, west, south, and the Penghu Islands. The Taiwan Fish Database was established in the 1990s, and in 1994 it began collaborating with FishBase. Shao became one of the earlier contributors, ranking 41st among 2,539 collaborators globally. The database officially opened to the public in 1997.

Between 1999 and 2002, the project received support from the "Taiwan Research Networking Project" at Academia Sinica, which allowed for the hiring of full-time assistants dedicated to database management. Later, between 2002 and 2006, it was supported by the "National Digital Archives Program" (NDAP), and from 2007 to 2012, by the "Taiwan e-Learning & Digital Archives Program" (TELDAP). These programs provided 11 years of long-term funding, which significantly enriched the database content. During this period, software engineer Yung-Chang Lin was tasked to build the information system and website, while assistants Pei-Li Lin, Sin-Hua Lin, and Han Lee made significant contributions to enriching the content.

By 2012, the database included descriptions and images for 295 families and around 3,000 species of Taiwanese fish, along with over a thousand references related to Taiwanese fish taxonomy and ecology. Specimen data were successfully integrated from nine domestic institutions—including Academia Sinica, National Taiwan University, the National Museum of Marine Biology and Aquarium, and the National Taiwan Museum, as well as from 25 overseas institutions. Users could view specimen data and geographic distribution maps of species collected across different institutions, both in Taiwan and abroad.

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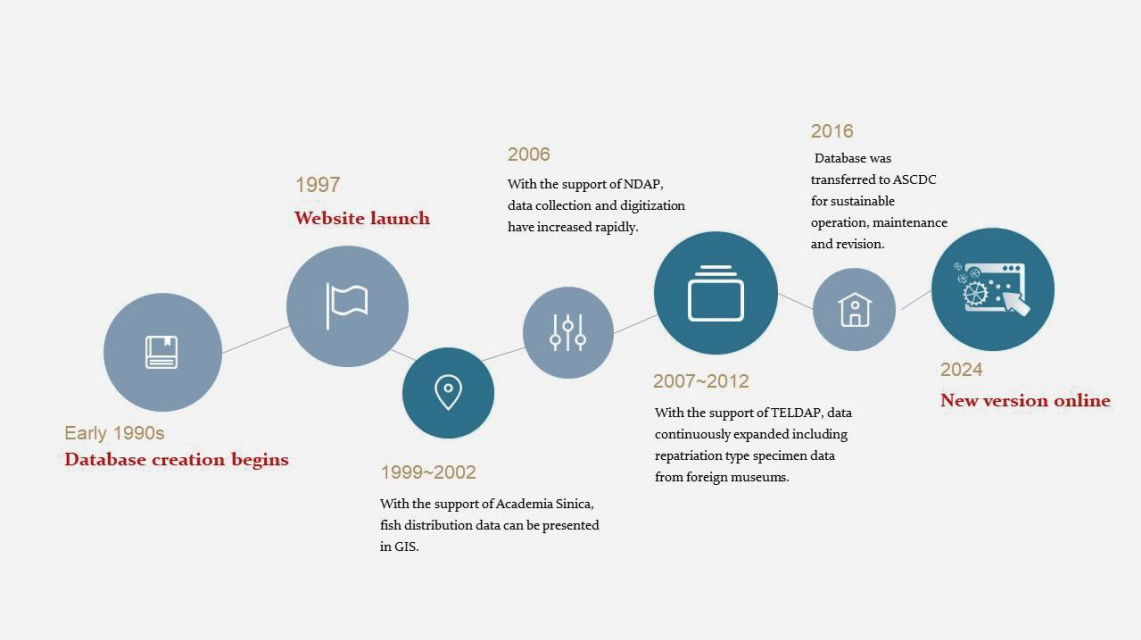

Figure 1. The development and history of the Taiwan Fish Database.

Due to its rich, comprehensive, and diverse content, the database attracted the attention of many researchers, educators, traders, and social groups both domestically and internationally. At its peak, users from over 150 countries visited the site, with more than 500,000 visits per month. It contributed significantly to education, research, conservation, and the sustainable use of Taiwanese fish. In 2010, it won the Best Website Award from Academia Sinica. However, sustaining the database has always been a challenge. After the retirement of the project leader in 2016, and in the absence of ongoing research plans and funding, the database's updates slowed significantly. Fortunately, the ASCDC agreed to take over its management, under the leadership of Cheng-Hsin Hsu, Chien-Ho Hsu, and Hui-Yi Chang, who also handled system updates and website revisions. Shih-Pin Huang, along with curators at the Biodiversity Research Museum at Biodiversity Research Center of Academia Sinica (BRCAS), and Hsuan-Ching Ho at National Kaohsiung Science and Technology University, continue to update the contents and make corrections for freshwater and marine fish, respectively. (Figure 1).

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2 THE PURPOSE AND IMPORTANCE OF THE TAIWAN FISH DATABASE

The initial goal of creating the database was to standardize both the Latin scientific names and Chinese names of fish species and to integrate information on their temporal and spatial distribution in Taiwan. This was intended to provide the most up-to-date, complete, and authoritative taxonomic information on Taiwan's native fish species (Chiu & Shao, 1991). However, progress was initially slow due to a lack of manpower and resources. The construction of any biodiversity database typically begins with the creation of an electronic species catalog, as every organism is identified by its species name. Only one Latin scientific name for each species is globally recognized as valid, while others are considered synonyms or invalid. Therefore, valid names can serve as primary keys to link various fish databases, allowing access to species descriptions, geographic or temporal distribution data, specimen collections, and relevant literature from both domestic and international sources. However, determining whether a species name is valid or identifying new records or species depends on the contributions of taxonomists, making the creation of a species catalog an essential responsibility for them.

When the Taiwan Fish Database was first developed, the primary challenge was selecting standardized Chinese names for fish species. Earlier publications on Taiwanese fish, such as "*Vertebrates of Taiwan*" (Chen & Yu, 1986), "*Fishes of Taiwan*" (Shen et al., 1993), and "*Taiwan Fish Illustrated Guide*" (Shen & Wu, 2011), often used different Chinese names for the same species. The issue became even more complicated when comparing with fish catalogs published in mainland China, such as "*Latin-Chinese-English Fish Names*" (Cheng & Zheng, 1992, p.296) and "*Species Catalog of Marine Organisms in China*" (Liu, 2008).

While standardizing Chinese names is less critical than standardizing Latin names, inconsistencies in Chinese nomenclature have caused communication challenges in teaching, research, trade, catch statistics, popular science, resource management, and ecological conservation. This has not only led to confusion but has also caused legal disputes. As Chinese names are considered common or vernacular, and can vary based on different interpretations, enforcing a single standard is difficult. However, by establishing a fish database with a standardized list of Chinese names that is publicly accessible online, it is hoped that, over time, the naming of Taiwan's fish species will become unified. Standardizing Chinese names across Taiwan and China is especially difficult due to more than 70 years of political separation, which has led to significant differences in Chinese nomenclature usage. To address this, comparative methods have been adopted, such as in the "*Latin-Chinese Fish Systematic Dictionary*" (Wu et al., 2012) or "*Marine Fishes of China and Its Adjacent Waters*" (Liu et al., 2024), which list both mainland China's and Taiwan's Chinese names. Some Chinese publications include Taiwan's Chinese names as alternate names, and when a species is found only in Taiwan, they often adopt the Taiwanese name. For example, the "*Chinese Species Catalog – Fishes*" (Zhang et al., 2021) includes Taiwanese names in its listings.

Fish species are a significant economic resource in Taiwan and are closely intertwined with human culture, economy, society, and nature. However, overfishing, pollution, habitat destruction, and other human activities have drastically reduced the populations of many species, placing some at risk of extinction. As a result, fish biodiversity conservation and the restoration of fish stocks have become global objectives. Achieving these goals requires access to reliable databases covering fish taxonomy, ecology, biology, and long-term changes in fisheries resources. Such data are essential for analyzing the impacts of both natural factors (e.g., climate change, El Niño) and human-induced pressures (e.g., overfishing, pollution, habitat destruction, invasive species). This database helps develop appropriate fisheries management policies. Additionally, ecological impact assessments, ecological tourism information (e.g., diving, fishing, tropical fish breeding), and scientific research using fish as material all require access to basic fish data. Therefore, the construction and continuous updating of a comprehensive Taiwan Fish Database is crucial.

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3 STRUCTURE AND CONTENT OF THE TAIWAN FISH DATABASE

The *Taiwan Fish Database* is centered around fish taxonomy and cataloging (Shao et al., 2005; Shao, 2009; Wu et al., 2012), using scientific names to integrate fish images, photos, literature, specimens, sounds, terminology, and distribution data. Users can query the database using various methods, such as by fish names, catalogs, photos, family outlines, or keyword strings. The structure and content of the database include: (1) basic species database, (2) distribution database, (3) literature database, (4) specimen database, (5) fish ecology gallery, and (6) other related data, such as global species names, Chinese name dictionaries, pronunciation guides, fish terminology, new fish knowledge, and corrections to the book of "*Fishes of Taiwan*" (Shen et al. 1993). The database consists of over 100 dynamic and static webpages (see Figure 2 and Appendix).

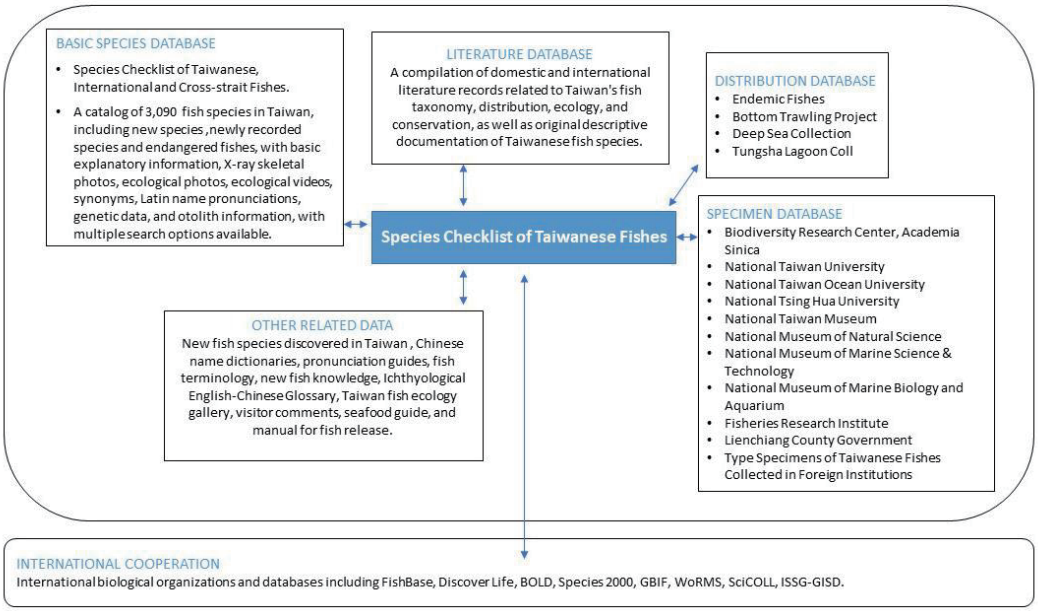

Figure 2. Structure of the Taiwan Fish Database. (from Shao et al., 2012b)

3.1 Taxonomy Data

By the end of the 2012 digital archiving project, the database had recorded 31,715 fish species worldwide, 4,984 species from both sides of the Taiwan Strait, and 3,090 species from Taiwan (Wu et al., 2012). The database includes a classification system, 15,810 synonym entries, and species descriptions for 3,090 species from Taiwan, and 39 species listed as endangered by the IUCN or the Taiwan Council of Agriculture. It also offers various multimedia resources, such as 1,002 ecological videos, 3,768 photos, 1,814 X-ray images, 951 DNA barcode (CO1) entries, and 393 otolith images. Various query methods, including keywords, species names, photos, and family outlines, are available. In 2012, a catalog of fossil fish species was also added.

Regarding the classification system, the Taiwan Fish Database follows the high-level taxonomy framework outlined in *Fishes of the World* (Nelson, 1994, 2006). For cartilaginous fish, revisions proposed by Compagno et al. (2005) may be incorporated in the future. For bony fish, the high-level system has undergone significant changes by Wiley and Johnson (2010). Additionally, recent molecular phylogenetic studies based on DNA sequencing may lead to further revisions to the classification system. Scientific names are primarily based on the *Catalog of Fishes* by William N. Eschmeyer (1998) and are updated using its website (http://research.calacademy.org). However, differences in interpretation among different scholars can lead to difficulties in confirming species names.

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3.2 Distribution Data

This section presents the results of various fish species investigation research projects conducted over the years, presented using different geographic information systems (GIS). Currently, the database includes information on endemic freshwater fish species, Taiwan's bottom trawl fishery resources, deep-sea biodiversity, and basic survey research on the Dongsha ecological resources. In total, there are about 230,000 data entries. These data can be integrated and displayed on maps through GIS programs and linked to specimen records, allowing for detailed information retrieval on individual entries. In the future, the aim is to gradually expand this integration to include data from long-term environmental impact or monitoring projects, such as fish population structure and the temporal-spatial distribution of species in projects like the two Northern Nuclear Power Plants, the Southern Nuclear Power Plant, the Bali Sewage Outfall Pipe, and offshore wind farms (including adult fish, eggs, and larvae).

In response to the global initiative by the Global Biodiversity Information Facility (GBIF) to promote the use of the Integrated Publishing Toolkit (IPT) for data sharing, Taiwan established its IPT data publishing station in September 2011 (http://ipt.fishbase.tw). As an example of its use, Taiwan published bottom trawl fish distribution data (1998–2003), resulting in the country's first data paper (Shao et al., 2012a). In 2014, long-term survey data from Taiwan's deep-sea fish survey project (2003–2012), supported by the National Science Council, was published in the *ZooKeys* journal (Shao et al., 2014).

3.3 Specimen Data

Before 2001, there were few digitized specimens of Taiwan's fish species, and each institution managed its collections separately. Fortunately, with strong support from the National Digital Archives Program (NDAP) and the Taiwan e-Learning and Digital Archives Program (TELDAP), over 41,000 records from ten fish specimen archives across Taiwan were integrated by 2012. These include 17,547 records from the Research Museum BRCAS, 8,629 from the National Taiwan University's Animal Museum, 1,470 from the National Taiwan Museum (NTM), 1,230 from the National Museum of Marine Science and Technology (NMMST), 6,298 from the National Museum of Marine Biology and Aquarium (NMMBA), 1,680 from the National Museum of Natural Science (NMNS), 2,970 from the Fisheries Research Institute (FRI), 495 from National Tsing Hua University (NTHU), 485 from the National Taiwan Ocean University (NTOU), and 200 from the Lienchiang County Government in Matsu. Currently, most of these specimens have been digitized, and their metadata has been integrated into an online database for public access (Lai et al., 2012). The Taiwan Fish Database also incorporates Google Earth and Google Maps to visualize specimen collection sites, providing a comprehensive map that links to specimen search interfaces and fish species descriptions.

Additionally, supported by the Forestry Bureau of the Council of Agriculture (now the Forestry and Nature Conservation Agency, Ministry of Agriculture), Taiwan has established a collection of cryobank genetic tissue specimens and a barcode of life database. By 2024, this collection included about 1,127 species, with 3,762 liquid nitrogen specimens and 3,664 alcohol-preserved specimens. Backup specimens are stored in the Animal Genetic Resource Center in Tainan. These specimen records can be accessed through the TaiBOL website (https://taibol.biodiv.tw/), which also provides access rules and sampling procedures. The liquid nitrogen and alcohol-preserved specimens are mainly intended for future molecular identification or molecular evolution studies. The COI barcode data are actively being integrated into the international Fish-BOL project. By 2024, barcode data had been completed for about 951 species of Taiwanese fish (2,162 sequences), including 350 species of commonly targeted economic fish. These efforts are very useful for species identification from tissues, eggs, larvae, stomach contents, as well as for phylogenetic studies of geographic relationships.

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In addition to domestic collections of Taiwan's fish specimens, many type specimens are housed in museums abroad. While repatriating these specimens is difficult, it is globally recognized as an important goal. Therefore, information on specimen collection and specimen label data, including digital images of specimen characteristics, should be collected and brought back to Taiwan to complete the documentation of Taiwan's biodiversity. Future researchers would then not need to visit overseas museums to examine specimens or consult records. Taiwan's fish type specimens are mainly dispersed across eight countries and about 34 institutions, including the Smithsonian National Museum of Natural History in Washington, D.C., the American Museum of Natural History in New York, the Field Museum of Natural History in Chicago, the National Museum of Natural History in France, the British Museum, and the Museum of Comparative Zoology at Harvard University. With support from the second phase of the Digital Archive Program, Dr. Hsuang-Ching Ho integrated data from 25 overseas institutions regarding Taiwan's fish specimens (4,879 records). These data are available on the same webpage, where users can find information about fish species specimens and their GIS-based geographic distribution or collection point maps, including data for 323 type specimens. The remaining 44 type specimen records are scattered across 11 countries, but due to limited manpower and funding in the project, they will need to be collected during future international trips by younger generations of Taiwanese fish taxonomists.

3.4 Literature Data

This section primarily contains about 1,870 records of domestic and international literature related to the taxonomy, distribution, ecology, and conservation of Taiwan's fish species. These records are available for academic research and include the original descriptions of Taiwan's fish species. Original taxonomic descriptions are crucial for species identification and comparison, serving as an essential verification step before publishing new species. Due to a lack of taxonomic literature reports published before 1950, taxonomic work is often challenging, and much of this literature must be obtained from abroad. Reports published before the 1900s are particularly difficult to access, as they are often too fragile to be loaned. Therefore, scanning and archiving foreign reports of Taiwan's fish species descriptions has become an important part of the second phase of the project. Initially, about 1,600 missing original descriptions of 3,000 native fish species were identified. By 2012, the Taiwan Fish Database had already included over 1,050 of these original descriptions. The literature interface is also integrated withing the species description interface.

The Biodiversity Heritage Library (BHL), the world's largest digital library for biodiversity, aims to digitize and make publicly accessible biological taxonomy and ecological literature from the 18th to early 20th centuries. Since Taiwan published few fish-related articles before the 1980s and faced intellectual property issues afterward, it has not joined the BHL or contributed to the collection of related literature. Although a significant amount of taxonomic and ecological literature has been published in Taiwan since 2012, the database has not been expanded due to limited resources. However, by using search engines like Google or Bing, one can often locate the sources and contents of these papers by entering the article title, or access global research reports on a species by searching its scientific name.

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3.5 Other Fish-Related -Information

This section contains knowledge related to Taiwan's fish species, including newly discovered species, fish-related phonetic terms, online resources, and a bilingual Chinese-English glossary of ichthyological terms. The online electronic book collection includes eight volumes, consisting of searchable electronic books such as the Council of Agriculture Fisheries Agency's "Wildlife and Aquatic Species Importation Guide," the bilingual "Taiwan Marine Fish Egg Guide," the corrected edition of the "Taiwan Fish Species Checklist," and the "Latin-Chinese World Fish Systematic Nomenclature Dictionary," as well as flat-format electronic books such as "Common Fish and Shellfish in Taiwan (Vol. 2 - Fish)," "Kenting National Park Marine Fish Guide (Revised Edition 2010)," "Common Fish and Shellfish Guide (2011)," and "Correct Seedling Release Manual (2011)." The Taiwan Fish Database also provides a classification hierarchy for fish species in Taiwan, China, and across the Taiwan Strait, based on data from the "Latin-Chinese World Fish Systematic Nomenclature Dictionary," facilitating quick queries for users (Wu et al., 2012).

In addition to providing academic knowledge on Taiwan's fish species, the Taiwan Fish Database also offers interactive channels for users to ask questions or exchange opinions through the "Guest comments or Q & A" section. Underwater photographers can also contribute vivid ecological fish photography through the "Ecological Art Gallery."

4 INTERNATIONAL COOPERATION

At the beginning of the first phase of the Taiwan Fish Database project, Taiwan joined the **Global Biodiversity Information Facility (GBIF)** as an Economy entity. In 2003, GBIF established an integrated platform for specimen and species catalog data using the **Darwin Core** as the standard format. Consequently, when Taiwan developed its GBIF portal (**TaiBIF**, http://taibif.org.tw) and the **Taiwan Biodiversity Information Network (TaiBNET, now TaiCOL**; http://taibnet.sinica.edu.tw), it adhered to GBIF's international standards. As a result, Taiwan's integrated biodiversity data, including fish and other flora and fauna records (catalogs and specimens), contributed significantly to GBIF, making Taiwan one of the earliest successful collaborators in global biodiversity data integration.

Additionally, Taiwan has established a long-term and stable partnership with **FishBase**, serving as a model for biodiversity databases transitioning from local to international platforms. The Taiwan Fish Database regularly provides FishBase with fish specimen data, distribution records, and literature. Both websites are interlinked at the species level, allowing for cross-referencing. Through this collaboration, global databases, such as **Species 2000**, the Integrated Taxonomic Information System (ITIS), GBIF, and various national biodiversity portals, can access Taiwan's latest fish species catalog, distribution data, specimens, common names, photos, regional studies, and literature (Shao et al., 2007a; 2007b).

On the technical side, the Taiwan Fish Database has assisted FishBase in localizing its website for Chinese users and maintains FishBase Taiwan as a mirror site. Among the eight global FishBase mirror sites, those in Taiwan and Germany are recognized as the most efficient and comprehensive. Taiwan has also provided technical support in taxonomy system development, character encoding conversion, scientific and common name search tools, domain name and website statistics software updates, and performance enhancements for the AquaMap mapping tools. Notably, in 2011, six of FishBase's seven global mirror sites were hacked and rendered inoperable, while the Taiwan mirror site remained unaffected. Taiwan further assisted FishBase headquarters in the Philippines by providing three solutions to resolve the issue, which were later shared with other mirror sites.

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In terms of international collaborations, the Taiwan Fish Database actively participates in international organizations and cooperative projects, sharing data with various partners:

- Species catalog data are provided to the Taiwan Species Checklist Database (TaiCOL) and integrated with Species 2000, ITIS, and the World Register of Marine Species (WoRMS).
- Fish specimen and DNA barcode data are exchanged between Taiwan's Frozen Genetic Material and Life Barcode Database (TaiBOL) and the international Barcode of Life (BOL) project.
- English species descriptions and common names are shared with the Taiwan Encyclopedia of Life (TaiEOL), cooperating with the Encyclopedia of Life (EOL).
- Geographical and ecological data are exchanged between the Taiwan Biodiversity Information Facility (TaiBIF) and the Ocean Biogeographic Information System (OBIS).
- Invasive fish species data are shared with the Taiwan Global Invasive Species Database (TaiGISD/TISD), which is linked to the IUCN Invasive Species Specialist Group (ISSG) and its Global Invasive Species Database (GISD).
- From 2010 to 2013, Taiwan collaborated with the European Union's Fish4Knowledge project, providing underwater footage from Kenting for the development of AI-based fish species recognition and analysis systems.
- In September 2011, the Taiwan Fish Database successfully joined the International Council for Science World Data System (WDS) as a regular member.

5 CROSS-STRAIT AND REGIONAL COLLABORATION

Between **2008 and 2012**, the Taiwan Fish Database attempted to collaborate with institutions in China, such as the **Institute of Zoology of the Chinese Academy of Sciences**, the **Institute of Hydrobiology**, and the **Fisheries Information Research Center**. However, as these institutions were still in the early stages of development, progress was limited.

In June 2012, Taiwan worked with Professor Han-Lin Wu of Shanghai Ocean University and Dr. Di-Hua Zhuang, president of the Hong Kong Ichthyological Society, to compile and publish the "Latin-Chinese World Fish Systematic Nomenclature Dictionary", which is now publicly accessible in the database (Wu et al., 2012). That same year, Taiwan also participated in a trilateral cooperation roundtable meeting with EOL, TaiEOL, and EOL China, contributing data for integration.

In 2013, China officially launched the China Biological Species Catalog. Fish species documentation was led by Dr. Chun-Guang Zhang's team at the Institute of Zoology, Chinese Academy of Sciences, who focused on freshwater fish, while Prof. Han-Lin Wu and Dr. Kwang-Tsao Shao were responsible for marine fish. After years of effort, the catalog was completed in 2019, listing 5,032 species (including subspecies) of native fish from China and Taiwan (Zhang et al., 2021).

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6 VALUE-ADDED APPLICATIONS AND OUTREACH

Since its launch in 2001, the Taiwan Fish Database has experienced significant growth in user engagement. As of 2012, total webpage views had exceeded 68 million, with over 8 million users (Figure 3). In 2024 alone, the site recorded over 4.3 million page views and 1.48 million users, with an average of 350,000 page views and 120,000 users per month (Figure 4). The top six user countries are Taiwan, China, Hong Kong, the United States, Japan, and Malaysia. The database receives over 10 inquiries annually regarding content usage authorization and now operates under a Creative Commons (CC) license, permitting non-commercial use with proper attribution.

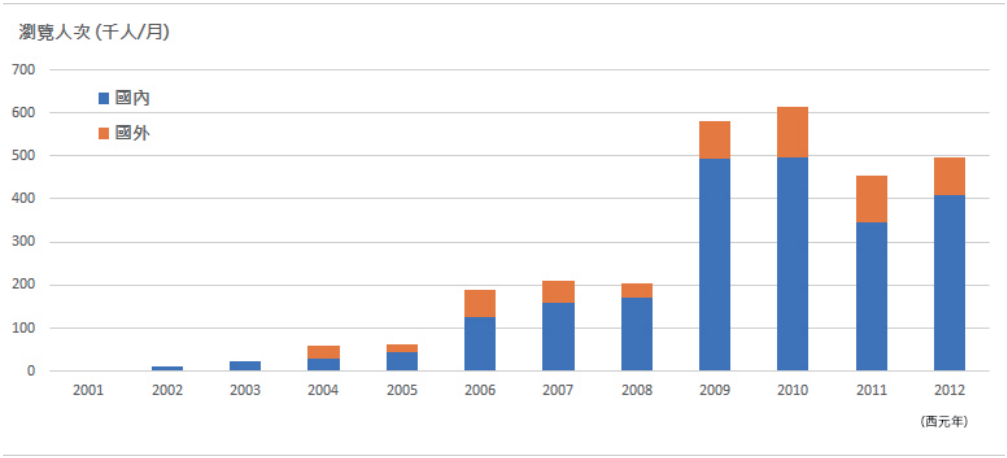

Figure 3. Average monthly Internet visits to the Taiwan Fish Database, both domestic and international (including search engine indexing traffic), from 2001 to August 2012. (Quoted in Shao et al., 2012b)

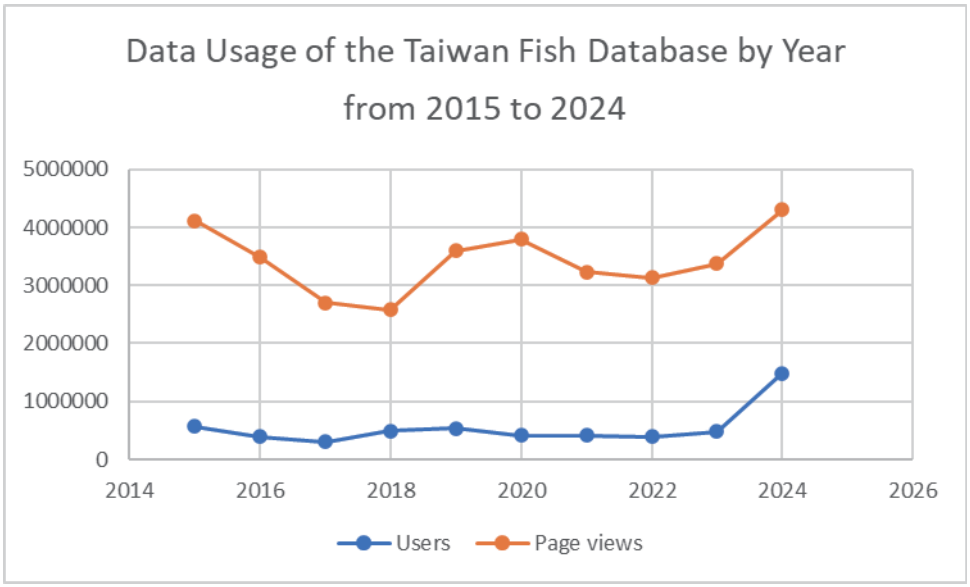

Figure 4. Annual statistics of users and page views for the Taiwan Fish Database from 2015 to 2024.

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Beyond academic services, the Taiwan Fish Database also contributes to sustainability and conservation efforts. Recognizing the impacts of overfishing, habitat destruction, pollution, invasive species, and climate change, the database launched the Seafood Choice Guide in 2010, encouraging consumers to support sustainable seafood. The guide promotes "green seafood" options and sustainable eating habits, reinforcing marine conservation education.

In 2012, with support from the Forestry Bureau, Taiwan published the Red Book of Freshwater Fish in Taiwan, covering 268 freshwater species (excluding 37 invasive species) (Chen et al., 2012). While data on 52 endangered species require authorization for access, information on all other species is publicly available at (http://sff.biodiv.tw).

The Taiwan Fish Database has also contributed to public science and educational initiatives, such as:

- The Taiwan Fish Atlas System and Taiwan Natural and Cultural Knowledge Base (developed under the National Digital Archives Program).
- Smart restaurant systems, 3D digital fish tanks, AR interactive knowledge cards, Web 2.0 marine education platforms, and e-books/e-journals (developed in collaboration with private enterprises through the Ministry of Economic Affairs' digital content subsidies).
- Integration with the Digital Archive Value-Added Platform, the TELDAP project, and industry commercialization initiatives, expanding its reach in both academia and the commercial sector.

From December 7, 2011, to April 30, 2012, the Taiwan Fish Database co-hosted the "Fish Fun e-Generation" exhibition at Academia Sinica, showcasing its achievements alongside private-sector innovations.

Ultimately, the Taiwan Fish Database serves as both a professional research resource and a public science education platform, providing information on fish species, seafood guide, fish culture, and marine conservation zones, helping to bridge the gap between academic research and public understanding.

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7 THE NEW VERSIONS OF THE TAIWAN FISH DATABASE AND ITS DIFFERENCES FROM THE PREVIOUS ONE

In 2017, considering that the existing Taiwan Fish Database system had been in operation for over 15 years, the Academia Sinica Digital Culture Center (ASCDC) took over its maintenance and began planning a system upgrade. The goal was to address cybersecurity challenges and ensure long-term sustainability. By then, the database had accumulated over 20 years of content. Besides its fundamental functions (see Appendix), more than 80 additional features had been identified, making the upgrade a massive undertaking.

The maintenance team decided to restructure the database by dividing its content into two sub-websites, each catering to a different target audience: one focused on academic research, which retained the name "Taiwan Fish Database," and another dedicated to public education, named "Fish Knowledge+" (Figure 5).

Starting in 2018, the team reconstructed and rebuilt the "Fish Knowledge+" website. Then, in 2020, using the "Open Museum" digital platform developed by ASCDC as a foundation, they began planning and implementing the upgraded "Taiwan Fish Database" system. By 2024, both sub-websites were largely completed and made publicly accessible (see Figure 5). With the assistance of Dr. Hsuan-Ching Ho and contributions from international scholars, newly recorded species and synonyms were revised, bringing the total number of species in the database to 3,489. The previous version of the website remains available for users accustomed to it, though its contents are no longer updated.

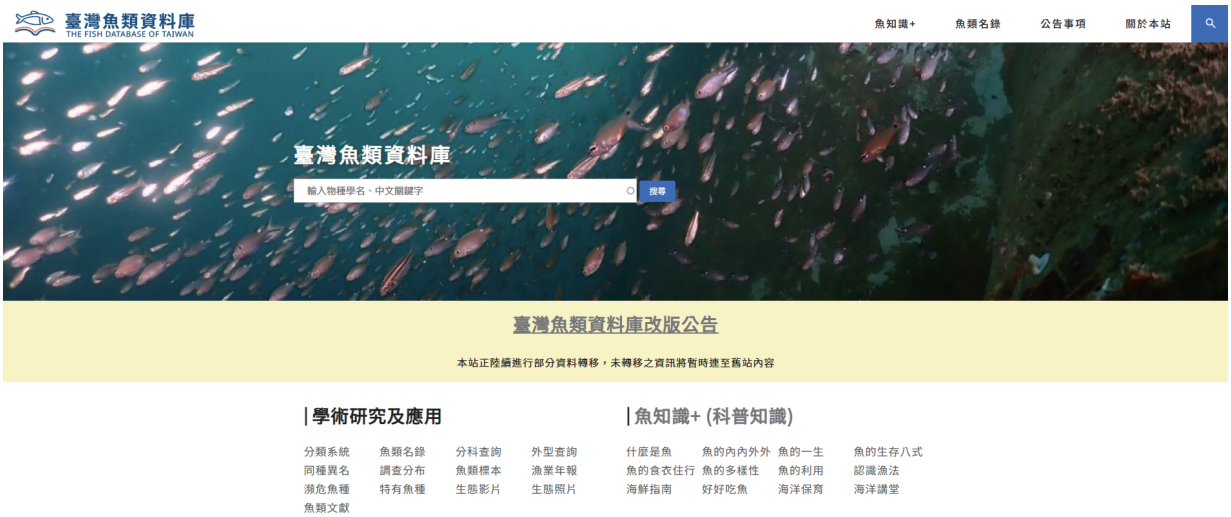

Figure 5. The revised Taiwan Fish Database, now divided into the academically focused "Taiwan Fish Database" and the public-oriented "Fish Knowledge+". (http://fishdb.sinica.edu.tw)

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7.1 The Academic "Taiwan Fish Database"

Since 2020, the maintenance team has gradually reorganized the various datasets within the Taiwan Fish Database, starting with the most frequently used fish species list and species descriptions. During this process, data gaps were identified, and specialists were invited to update and supplement the information (Figure 6).

With the help of experts over the past few years, the database now contains nearly 3,500 valid fish species names in Taiwan, along with over 3,500 taxonomic descriptions at both the species and family levels (Figure 6). In addition, since 2022, ASCDC has assisted in reconstructing the Academia Sinica Zoological Specimen Database (ASIZ). Since ASIZ also uses the "Open Museum" framework, its fish specimen collection is now seamlessly integrated into the Taiwan Fish Database, allowing for real-time cross-referencing.

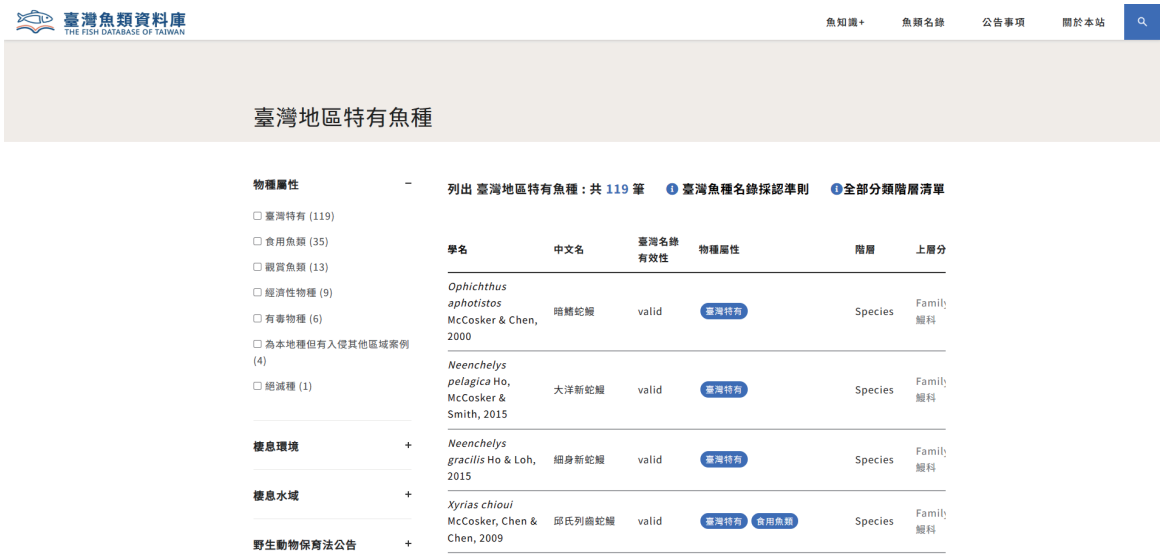

Figure 6. The species list serves as the backbone of the database. Users can filter species based on attributes. The image illustrates a search for endemic fish species in Taiwan. (http://fishdb.sinica.edu.tw)

Besides natural history collections, another crucial dataset comprises 230,000 species occurrence records compiled over the years from research projects led by Kwang-Tsao Shao. After reorganization, this dataset was relaunched in 2024 and is now available via the Taiwan Biodiversity Database's common query system (https://tbiadata.tw/) to serve a broader audience.

Regarding multimedia content, the new system integrates existing videos and images while also incorporating open multimedia data from the "Taiwan Encyclopedia of Life" and "iNaturalist Taiwan" in real time. As more datasets are integrated into the Open Museum framework, the multimedia content within the Taiwan Fish Database will continue to expand.

Several datasets are still being updated and reorganized, with efforts underway to collaborate with different parties to facilitate updates. To ensure long-term adaptability to evolving data presentation technologies, the maintenance team has adopted a "storage and retrieval separation" architecture. Initially, the focus is on the comprehensive storage of various data types, ensuring a stable digital repository. Meanwhile, data retrieval methods remain flexible, utilizing the most suitable front-end technologies. This approach allows the website to evolve while maintaining stable backend data storage and management.

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7.2 The Public-Oriented "Fish Knowledge+"

The "Fish Knowledge+" sub-website primarily targets high school and junior high school students, with general ocean and fish enthusiasts as a secondary audience. It aims to foster a deeper and broader understanding of the ocean and fish through organized knowledge and interactive displays. The website consists of four main sections:

Section 1: "Fundamentals of Ichthyology"

Drawing on an extensive collection of ecological and specimen images from the Taiwan Fish Database, this section introduces fundamental fish knowledge, including:

- Basic understanding of fish
- Fish anatomy (Figure 7)
- Fish habitats
- Special records related to fish

Figure 7. The "Fish Knowledge+" website provides explanations of various fish body parts when users search for fish anatomy. (http://fishdb.sinica.edu.tw)

Section 2: "The Relationship Between Humans and Fish"

This section explores the interactions between humans and fish, covering:

- Human consumption and use of fish
- Traditional Taiwanese fishing techniques
- Taiwanese seafood culture

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Section 3: "Living in Harmony with the Ocean"

This section focuses on marine conservation education, including:

- Video lectures from Kwang-Tsao Shao's 2017–2018 marine science seminars
- Conservation articles discussing marine protected areas, international agreements, and policies

Section 4: "Taiwan's Fish from a Local Perspective"

This section highlights the unique fish species found in Taiwan's waters, showcasing:

- Habitats of endemic fish species
- Distinct ecological features of local fish
- Exhibits illustrating Taiwan's marine biodiversity

The key feature of "Fish Knowledge+" is its ability to transform specialized fish knowledge into accessible educational content, making it easier for students and the general public to understand marine ecology. Through diverse forms of content presentation, the website aims to raise awareness about marine conservation.

8 FUTURE PROSPECTS AND SUSTAINABLE DEVELOPMENT

Over the years, the Taiwan Fish Database has achieved significant milestones with support from national digital archives programs and ASCDC initiatives. However, following the retirement of its original leader, the project no longer receives the same level of funding for data updates. Despite this, the Taiwan Fish Database remains a crucial resource for academic, governmental, and industry stakeholders in Taiwan.

Moving forward, the database will evolve from being managed by a single team to a collaborative effort involving multiple institutions. By partnering with research organizations, government agencies, and non-governmental groups, the database will ensure continued data updates and maintenance. Its primary role will remain the integration of key fish-related information in Taiwan, leveraging collective efforts to maintain its authority while adapting to the rapidly evolving field of biodiversity research.

In recent years, open data and integration efforts have gained traction in Taiwan, particularly with the establishment of the Taiwan Biodiversity Information Alliance (TBIA) in 2021 (http://tbiadata.tw). Cross-agency biodiversity data integration has become a priority for government institutions. The aggregation of "species occurrence records" and "natural history collections" is a core task of this alliance. Since 2023, ASCDC has been a member of TBIA, and the Taiwan Fish Database has contributed its species occurrence data as part of this open data initiative.

As TBIA continues to facilitate collaborations, more organizations are expected to open their biodiversity datasets. This will allow the Taiwan Fish Database to integrate a greater wealth of fish-related information, providing enhanced resources for researchers, policymakers, and educators while supporting the advancement of fish research and conservation in Taiwan.

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Appendix

Summary of Data Types in the Taiwan Fish Database (as of December 2024).

Data Type	Subcategory	Count
Taxonomy	World Fish Species	31,715
	Cross-Strait Fish Species	4,984
	Taiwan Fish Species	3,487
Detailed Descriptions	Taiwan Fish Species	3,246
Images	Ecological Photos	4,184
	Ecological Videos	1,024
	Otolith Photos	393
	X-ray Photos	1,924
Genetics	Barcode Sequences	951 species
Distribution	---	230,000 records
Specimen Collection	Academia Sinica	25,211
	NTU Specimens	8,629
	National Taiwan Museum	1,470
	National Museum of Marine Science & Technology	1,230
	National Museum of Marine Biology & Aquarium	6,298
	National Museum of Natural Science	1,680
	Fisheries Research Institute	2,970
	National Tsing Hua University	495
	National Taiwan Ocean University	485
	Matsu Lienchiang County Government	200
Overseas Collection	Type Specimens	323
	Others	4,879
Taiwan Fish Literature	Original Descriptions	1,050
	Other References	820
Others	Bilingual Terminology	6,032
	Illustrated Terms	860
	E-books	8
	Pronunciation of Fish-related Characters	952
	(Total)	13,245 words

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