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Book Review
Accurate Taxonomical Identification of Fish Eggs and Larvae in Taiwan Waters

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Reviewed work: Shao, K. T., Chiu, Y. J., Huang, S. K., & Chen, Y. F. (2024).
Eggs and Larvae of 500 Taiwan Fishes.
A Pictorial Guide. National Academy of Marine Research. Kaohsiung, Taiwan.
Two Volumes. Vol. 1. 415 pp. Vol. 2. 399 pp.
ISBN 978-626-7522-26-4. NT$ 1,600.

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Traditionally, the classification of fish is mainly based on the body color, appearance and shape of adult fish individuals, such as the number of hard and soft spines on the dorsal fin, pectoral fin, pelvic fin, caudal fin, and many skeletal characteristics as the basis for classification. However, for fertilized eggs, i.e., embryos, larvae and juveniles, the above-mentioned identification methods based on morphological and qualitative characteristics are invalid, because fish eggs, larvae and juveniles have to go through a process of metamorphosis, and their morphological and qualitative characteristics will change accordingly and therefore its morphology features are quite different from those of adult fish. Therefore, how to identify the species of fish eggs, larvae, and juveniles is a very tricky task. Even so, researchers have long tried to use various methods to provide useful criteria for identifying fish eggs, larvae, and juvenile fish species.

Figure 1. Covers of volume 1 and 2 of illustrated books of *Egg and larave of 500 Taiwan fishes.*

The United States of America National Marine Fisheries Service held a conference "Ontogeny of Fishes and Systematics of Fishes" in La Jolla, California, from August 15 to 18, 1983 and a total of 86 papers were presented. After the meeting, the American Society of Ichthyologists and Herpetologists issued a Special Publication Number 1 entitled "Ontogeny and Systematics of Fishes" in 1984 (Moser, 1984) with papers presented in the conference. A total of 44 orders and 19 species of fish eggs, larvae and juveniles were discussed. There are 12 papers in the second part of this special book, which discuss how to identify fish eggs, larvae and juveniles, how to draw line drawings, methods of fish body transparency and bone staining, X-ray bone photography methods, and tissue sections methods, scanning electron microscopy methods, developmental osteology, otolith identification methods, specimen preservation and curation method. This was the best and most comprehensive reference book for identifying fish eggs, larvae and juveniles in the academic world as of 1984.

Subsequently, many researchers have worked hard to compile illustrations of ontogenetic development of larval and juvenile fish for identification use (e.g., Leis & Rennis, 1984; Chiu, 1999; Leis & Carson-Ewart, 2000). However, the main method deployed was comparing the morphological and morphometric counts of larvae and juvenile fish with those of adult fish. Therefore, just like previous work, it was very difficult to identify them down to the genus level.

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In the 21st century, the use of DNA barcoding technology has made new progresses on the classification of fish eggs, larvae and juveniles. In 2002, a team led by a Research Fellow of Academia Sinica, Kwang Tsao Shao, used mtDNA sequencing to identify the names of fish eggs from eight fish species (Shao et al., 2002). This was the first initiative in the world. Subsequent DNA barcoding has been widely used to determine the genetic relationship of species (Hebert et al., 2002, 2003). In order to clarify the practical value of DNA barcoding in species identification, Professor Shao's team sent 100 larval fish specimens to five research institutions in Taiwan for identification based on morphological characteristics down to family, genus, and species levels. After the specimens were returned, those specimens were sequenced by DNA barcoding method to compare the accuracy of morphological identification. The results showed that the accuracy of morphological identification was 71.3-87.9% (average 80.1%) at the family level and 2.9-34.1% (average 41.1%) at the genus level, while the accuracy rate at the species level was only 2.9-34.1% (average 13.5%). This novel study confirmed the practicality of the DNA barcoding method in identifying larval fish species (Ko et al., 2013).

After more than 20 years of endeavors, Professor Shao's team in 2024 used a trove of DNA barcode data and photos of eggs, larvae, and juveniles of 505 species of fish from 29 orders, 121 families, and the relevant data compiled a two-volume pictorial book entitled "Eighteen Changes in Fish: Eggs and larvae of 500 Taiwan Fishes" which was published by the National Academy of Marine Research as a service to academic community in Taiwan (Shao et al., 2024).

This set of illustration consists of two volumes. Volume 1 has five chapters which offers the guidance on how to use this set of illustrations. The Chapter 1 is the introduction, which briefly explains the rationales for the compilation this book. Although the English title of the book is 500 Taiwan Fishes, in fact, this set of books contain taxonomical information on 505 species of fish eggs and larvae.

These fish species were selected for inclusion in the illustrated books based on four major criteria: (1) They must be identifiable by DNA barcodes down to the species level; (2) Photos of eggs or larvae have the best resolution; (3) Photos of larvae are better than photos of eggs only; (4) Encompassing as many different high-level taxa as possible, starting from the order, family, and genus are better than different species of the same family or genus, so that readers can better understand the different forms of fish eggs or larvae, as well as the early life history forms of different groups of fish that are the most diverse existing in Taiwan waters.

The Chapter 2 briefly analyzes the early life history of fish from the egg morphology and the four stages of development of larvae after hatching: yolk sac stage, preflexion stage, notochord flexion stage, and late notochord bending, postflexion, stage and juvenile stage are defined.

The Chapter 3 describes the investigation and collection methods of fish eggs and larvae deployed by Prof. Shao's team. There are four major steps involved. (1) Field collection methods often need to be adapted to local conditions. (2) Fixation, transportation and removal of fish eggs and larvae samples after collection. (3) Processing procedures for pelagic fish specimens after they were brought back to the laboratory. (4) Preservation and classification of samples of fish eggs and larvae.

The Chapter 4 provides readers with the steps used in this illustrated guide to identify fish eggs and larvae. (1) Morphological identification method of fish eggs. (2) Morphological identification methods of larvae and juvenile fish. (3) Usage of molecular methods to identify fish eggs and larvae. Although this part is only a short three pages long, in fact, it is the most important basis used for determining the fish species in these illustrated books.

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The Chapter 5 briefly explains the basics and research applications of fish eggs and larvae. In this chapter, the authors offer three main considerations when conducting surveys of eggs and larvae: (1) Using the distribution and abundance of pelagic eggs for a single target species to estimate the biomass of the adult spawning group; (2) Study the larvae of the target species to estimate the reproductive success rate of the year resulting from spawning, and to understand the potential factors for its population changes; (3) The data could be used to evaluate fish stocks in general, due to the recruitment of larvae and juveniles and to gauge the current status or resilience of fishery resources.

For each species identified in these books, it begins with a one-page overview of each family of fish which including family name, brief introduction (distribution waters, several genera and species native to Taiwan), line drawings of larvae or juveniles, and morphological characteristics of larvae and juveniles (Figure 2). The introduction to the fish species includes the order name, family name, scientific name, photos of the adult fish, morphological characteristics of the larvae, and QR code (after scanning the code, one can directly link it to the Environmental DNA Search Platform of the National Academy of Sciences to obtain detailed information about the fish species and DNA sequence data), photos of larvae and juveniles, egg diameter, body length of larvae and juveniles, month of collections and collection sites (Figure 3).

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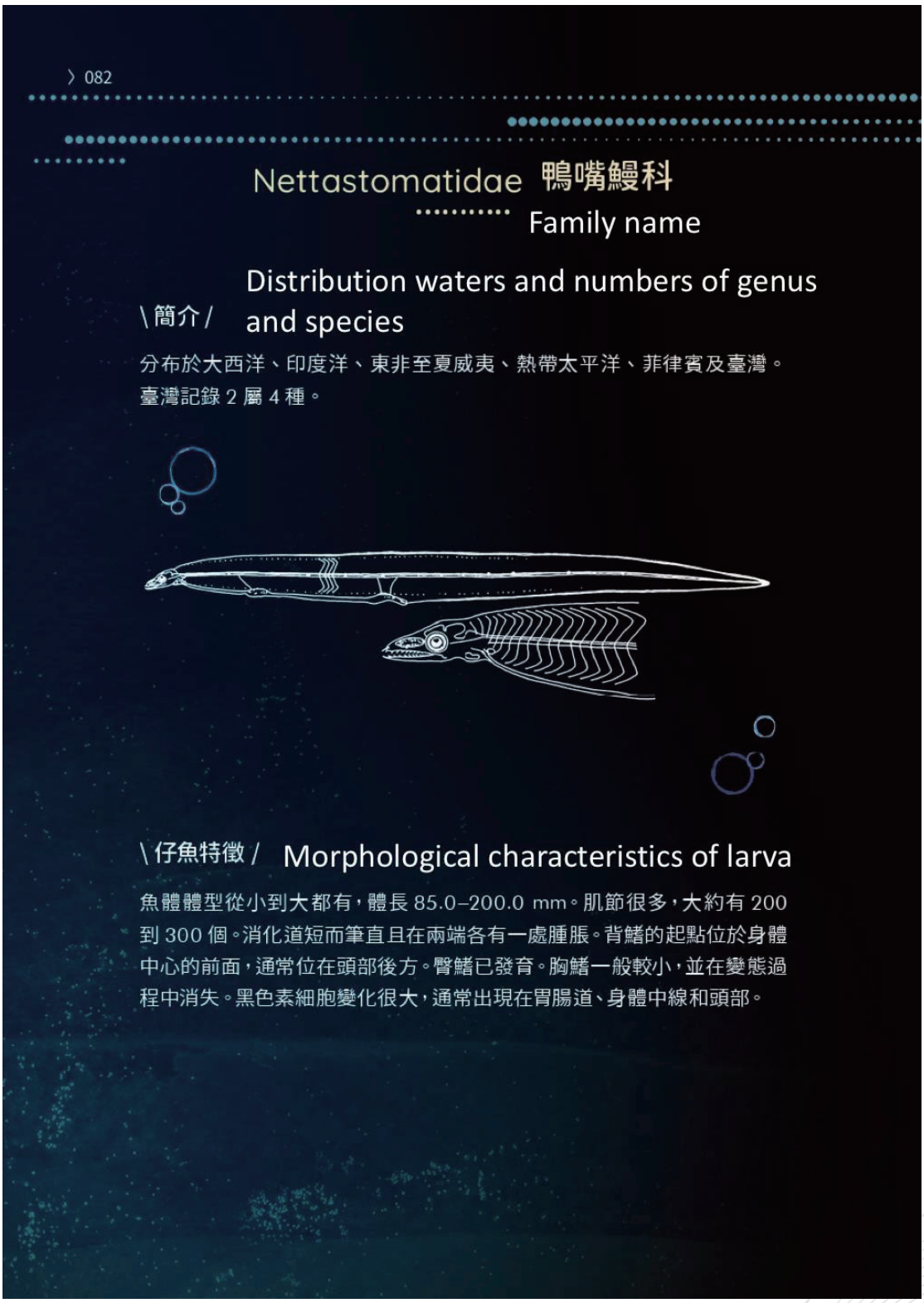

Figure 2. Sample page (p. 82) of illustrated book at family level.

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Figure 3. Sample page (p. 83) of illustrated book at species level.

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The rich contents of this set of illustrations clearly demonstrate the efforts of Prof. Shao's team has spent over the past two decades and their unwavering dedication deserves special acknowledgement. The willingness of National Academy of Marine Research to allocate resources to publish this set of illustrations is very far-sighted and the agency deserves the kudos. This set of books is also the first of its kind in the world of ichthyology. It fully demonstrates the strength of Taiwanese research and should not be underestimated.

This set of two illustrated books offer very useful resources for researchers who can read Chinese. However, I would like to make two suggestions to the National Academy of Marine Research, the publisher: (1) An English version should be published in the future so that researchers in other countries, in particular, the Pacific rims, can make the best use of vast information presented in these two books. Furthermore, the web pages linked after scanning the QR codes are only in Chinese as of now. It is hoped that when the English version of these illustrated books is released, the web pages can also have English texts provided. This will be beneficial for use by international scholars and will also showcase the prowess of Taiwan's basic research foundation. (2) From the perspective of promoting domestic education and learning, it is hoped that the contents of these two books can also be posted on the website of the National Academy of Marine Research for the general public use. There is one example to highlight the necessity of listing this set of books on the web. A book entitled "A guide book of common economic aquatic animals and plants in Taiwan" (Shao, 2015) was published by the Fishery Agency of Ministry of Agriculture of Taiwan government and its contents have been listed on the website of Taiwan Fishery Agency (https://www.fa.gov.tw/book/fishlibrary/files/assets/basic-html/page-I.html#) for public free use which attracts visits to the website more than 1,000+ time a month. This outcome underscore the importance of knowledge sharing that can be achieved by making information public on the Internet.

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