Southeast Asian Fisheries Development Center

United Nations Environment Programme

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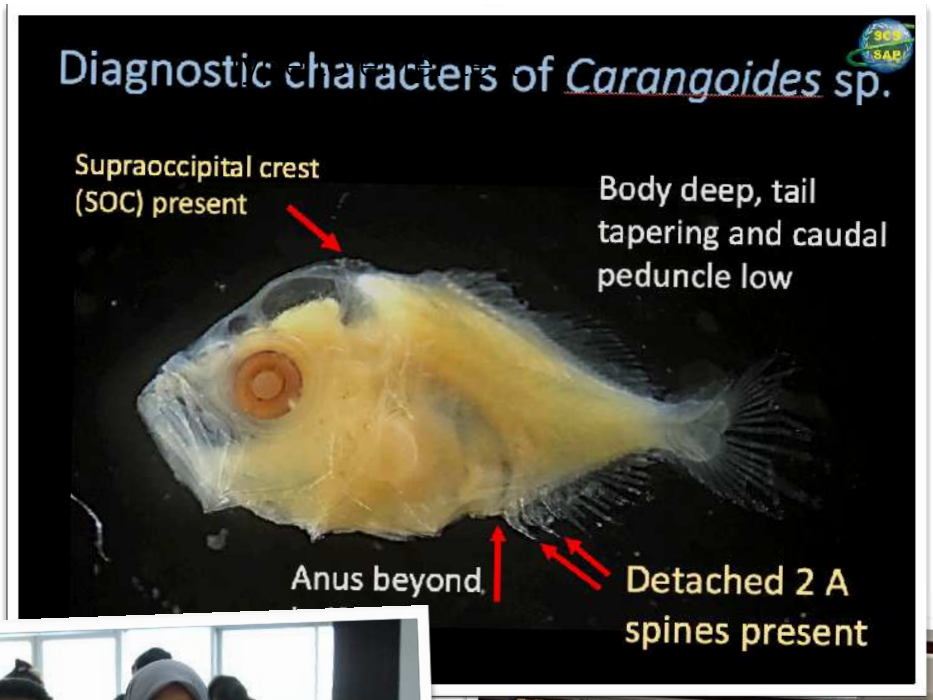
REGIONAL TRAINING COURSE ON LARVAL FISH IDENTIFICATION AND FISH EARLY LIFE HISTORY SCIENCE



DECEMBER 2022

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SEAFDEC/UNEP/GEF Project on Establishment and Operation of a Regional System of Fisheries *Refugia* in the South China Sea and the Gulf of Thailand

REPORT
REGIONAL TRAINING COURSE ON LARVAL FISH IDENTIFICATION AND FISH EARLY LIFE HISTORY SCIENCE

16–27 NOVEMBER 2022,
SEAFDEC/TRAINING DEPARTMENT, THAILAND

SEAFDEC/UNEP/GEF
FISHERIES *REFUGIA*
DECEMBER 2022

First published in Phrasamutchedi, Samut Prakan, Kingdom of Thailand in December 2022 by the SEAFDEC/UNEP/GEF Fisheries *Refugia* Project, Training Department of the Southeast Asian Fisheries Development Center.

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For citation purposes, this document may be cited as:

SEAFDEC, 2022. Establishment and Operation of a Regional System of Fisheries *Refugia* in the South China Sea and Gulf of Thailand, Report of the **Regional Training Course on Larval Fish Identification and Fish Early Life History Science**. Southeast Asian Fisheries Development Center, Training Department, Samutprakarn, Thailand. 162 p.

SEAFDEC/UNEP/GEF Project on Establishment and Operation of a Regional System of Fisheries *Refugia* in the South China Sea and Gulf of Thailand

Report
Regional Training Course on
Larval Fish Identification and Fish Early Life History Science

16–27 November 2022,
SEAFDEC Training Department, Samut Prakan, Thailand

I. EXECUTIVE SUMMARY

The SEAFDEC/UNEP/GEF Project on Establishment and Operation of a Regional System of Fisheries Refugia in the South China Sea and the Gulf of Thailand, in collaboration with the Research and Development Division of the SEAFDEC/Training Department, organized the Regional Training Course on Larval Fish Identification and Fish Early Life History Science from 16 to 27 November 2022. The training course, held at the Training Department in Samut Prakan/Thailand, aimed to improve fisheries biologists' knowledge and techniques to work on early life history science and identify larval fish species, considering that larval fish data are crucial in stock identification to indicate spawning locations and times and as an index of spawning stock biomass. Ichthyologists led by Dr. Yoshinobu Konishi, former scientist of the Seikai National Fisheries Research Institute, Japan, as well as other resource persons from the Department of Fisheries, Thailand; Kasetsart University, Thailand; University of the Ryukyus, Japan; and the University of Nottingham, Malaysia, joined as a team. In the end, twenty-six fisheries biologists from 8 ASEAN Member States (AMSs), including Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Philippines, Thailand, and Viet Nam, possess an improved understanding of fish early life history science and skill in larval fish identification for further application for managing the fish stock at national and sub-regional levels through strengthened regional cooperation on larval fish networking.

The training course was designed to review of morphological development of larval fish characters, lecture, and practices on identification methods of the larvae and juveniles targeting six families such as Scombridae, Carangidae, Engraulidae, Lutjanidae, Siganidae, and serranid Epinephelinae from the Southeast Asian region. The course also included the lessons learned from Dr. Keita KOEDA, Lecturer from the University of the Ryukyus Japan, on Early life history studies of the subtropical marine fishes in Okinawa, Japan. In addition, a lecture by Dr. Cecillia Chu, a Researcher from the University of Nottingham Malaysia, on utilizing DNA barcodes to identify tropical larval fishes in Klang Strait, Straits of Malacca, and DNA barcode collecting and preserving technique. By the end of the training course, trainees presented the results/findings of species identification and morphological descriptions of examined larvae and juveniles in the class, indicating their increased capability in these fields to become Ichthyologists in the near future. Photographs and illustrations of morphological characters of the marine fish larvae from the training are documented and shared online. In addition, to support and sharing of information about fish's early life history science study, all trainees are invited to the Fish Larvae Network.

II. BACKGROUND

Larvae of marine fishes termed ichthyoplankton usually are pelagic, drifting in the sea and interacting with pelagic predators and planktonic prey. Most fish larvae, even species that ultimately are herbivores as juveniles or adults, are primarily carnivorous during the larval stage, feeding smaller planktonic organisms. In turn, larval fishes prey on larger nektonic and planktonic organisms. Escape from the precarious larval stage is accomplished via growth and ontogeny. Only a few individuals from thousands of newly hatched larvae survive the ever-present threats of starvation and predation during planktonic life. Surveys at sea generally estimate distributions, abundance, diversity, and structure of 'ichthyoplankton' communities, including associations of larvae with their predators and prey. Such surveys sometimes are a component of stock assessments used in fisheries management. Furthermore, many developed countries have long used ichthyoplankton data in stock identification to indicate spawning locations and times and as an index of spawning stock biomass (Heath, 1993; Richardson et al., 2010).

In Southeast Asia, early life stages in stock identification studies have been regionally conducted in the South China Sea (SCS) and the Gulf of Thailand (GoT) by the Southeast Asian Fisheries Development Center (SEAFDEC) in collaboration with member countries since 1997 by M.V. SEAFDEC and since 2004 by M.V. SEAFDEC 2. At the Regional Training Program on larval fish identification held in 2007, 2008, and 2016 supported by the GEF/UNEP project on "Reversing Environment Degradation Trends in the SCS and GoT," some larval fish samples from the survey have been identified. Later a team of ichthyologists and fisheries biologists led by Dr. Yoshinobu Konishi reanalyzed the findings from training and published a Larval Fish Identification Guide for the South China Sea and the Gulf of Thailand in 2008 and Scombridae Larvae Identification Guide for Southeast Asian Countries in 2022.

The SEAFDEC/UNEP/GEF project entitled "Establishment and Operation of a Regional System of Fisheries Refugia in the South China Sea and the Gulf of Thailand" has been developed and implemented since 2016. The overall objective of the fisheries refugia (FR) initiative project is to improve the understanding and management of the links between fish stocks and critical fisheries habitats. The project focuses on sustainable use by implementing the fisheries refugia concept as "Spatially and geographically defined, marine or coastal areas in which specific management measures are applied to sustain important species during critical stages of their life-cycle." To achieve the project target objectives, identifying fisheries refugia sites, including the samplings and species identified for fish eggs and larvae, is one of the essential activities. In addition, the results from larval fish identification would further support the local knowledge to develop a critical science-based management policy for sustainable management of fisheries refugia.

Nevertheless, knowledge and human resources on ichthyoplankton studies, particularly larval fish identification, are limited in many countries implementing the FR project. Many fish eggs and larvae were identified at family and genus levels, not at the species level. Considering the long-term sustainable management of fisheries, capacity building on larval fish identification and early life history science is also critically needed. In association with the above circumstance, the Regional Scientific and Technical Committee, at its third meeting (RSTC3) held in Hai Phong, Viet Nam, in 2020, requested the Project Coordination Unit (PCU) to arrange another regional training course on larval fish identification. Accordingly, the PCU, with the support from the Research and Development Division (RDD) of the SEAFDEC Training Department, proposes conducting the Regional Training Course on Larval Identification and Fish Early Life History Science before the project's termination by the end of 2022. The training focuses on six (6) fish groups related to the fisheries refugia target species, namely Scombridae, Carangidae, Engraulidae,

Lutjanidae, Siganidae, and Serranidae. The training course includes sharing experience on a country plan/strategy for fisheries resources survey and fish stock identification, including scientific-based management to protect the critical stages of the fish life cycle.

III. OBJECTIVES

- To improve the knowledge and techniques of scientists or fisheries biologists to be able to work on fish early life history science and identify the larval fish of six (6) targeted groups at family, genus, and some species levels.
- To strengthen communication and networking among the scientists on fish early life history science.
- To compile the photographs and illustrations of morphological characters of the marine fish larvae from the training.

IV. ENVISAGED OUTCOMES

- Participants possess an improved understanding of fish early life history science and skill in larval fish identification for further application for managing the fish stock at national and sub-regional levels.
- Regional cooperation on fish stock identification and management strengthened through communication networking.
- Awareness of the importance of the early life history science study for fish stock identification and management is built for long-term sustainable fisheries management.

V. PARTICIPANTS

- The SEAFDEC/UNEP/GEF Fisheries Refugia Project supports two scientists, each from eight ASEAN Member States, namely Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Philippines, Thailand, and Viet Nam.
- Five lecturers and researcher(s) from academe and fisheries research institutions who are actively worked on larval fish identification within the Southeast Asia such as Chulalongkorn University Thailand, Burapha Chanthaburi University of Thailand, University of Nottingham Malaysia, Marine Fisheries Research Development and Management Department of Malaysia, and Training Department of SEAFDEC.
- List of participants is shown as **Annex 1**.

VI. RESOURCE PERSONS AND SPECIAL LECTURERS

Resource Persons	**Position/Institution**
1) Dr. Yoshinobu KONISHI	Former staff of the Seikai National Fisheries Research Institute, Japan
2) Mr. Rangsan CHAYAKUL	Former staff of the Department of Fisheries, Thailand
3) Dr. Teerapong DUANGDEE	Lecturer, Kasetsart University, Thailand
Special Lectures	**Position/Institution**

1) Dr. Keita KOEDA	Lecturer, University of the Ryukyus, Japan
2) Dr. Cecilia CHU	Researcher, University of Nottingham Malaysia

VII. AGENDA AND TIMETABLE

Date/Time	Training Activity/Topic	Responsibility
15 Nov. 22 – Tuesday		
	Participants arrive at SEAFDEC Training Department, Samut Prakan, Thailand	SEAFDEC Personnel
16 Nov. 22 – Wednesday		
0830–0900	Registration	All Participants
0900–0920	Opening ceremony & group photo	SEAFDEC/TD FR/PCU
0920–0940	Brief on schedule and anticipated outputs	SEAFDEC Personnel
0940–1000	Coffee break	SEAFDEC Personnel
1000–1200	Country report on the research plan for fisheries resources survey and study on fish stock identification (15 minutes for each country)	Country Representative (10 Countries)
1200–1330	Lunch break	SEAFDEC Personnel
1330–1430	Keynote Address: Early life history studies of the subtropical marine fishes in Okinawa, Japan (via Online)	Dr. Keita KOEDA
1430–1450	Coffee break	SEAFDEC Personnel
1450–1600	Lecture: Utilization of DNA barcodes for the identification of tropical larval fishes in Klang Strait, Straits of Malacca	Dr. Cecilia CHU
1600–1700	Practical: DNA barcode collecting and preserving technique	Dr. Cecilia CHU
17 Nov. 22 – Thursday		
0900–1000	Lecture: Review of morphological development of larval fish characters	Dr. Yoshinobu KONISHI
1000–1020	Coffee break	SEAFDEC Personnel
1020–1200	Lecture: Identification methods of the Scombridae larvae and juveniles in the Southeast Asian region	Dr. Yoshinobu KONISHI
1200–1330	Lunch break	SEAFDEC Personnel
1330–1500	Practice: Species identification and morphological description of the Scombridae larvae and juveniles (1)	Instructor Team Dr. Yoshinobu KONISHI, Mr. Rangsan CHAYAKUL Dr. Teerapong DUANGDEE
1500–1520	Coffee break	SEAFDEC Personnel
1520–1700	***Continued*** Practice: Species identification and morphological description of the Scombridae larvae and juveniles (1)	Instructor Team
18 Nov. 22 – Friday		

0900–1000	Practice: Species identification and morphological description of the Scombridae larvae and juveniles (2)	Instructor Team
1000–1020	Coffee break	SEAFDEC Personnel
1020–1200	***Continued*** Practice: Species identification and morphological description of the Scombridae larvae and juveniles (2)	Instructor Team
1200–1330	Lunch break	SEAFDEC Personnel
1330–1500	Practice: Species identification and morphological description of the Scombridae larvae and juveniles (3)	Instructor Team
1500–1520	Coffee break	SEAFDEC Personnel
1520–1700	***Continued*** Practice: Species identification and morphological description of the Scombridae larvae and juveniles (3)	Instructor Team
19 Nov. 22 – Saturday		
0900–1000	Lecture: Identification methods of the Carangidae larvae in the Southeast Asian region	Dr. Yoshinobu KONISHI
1000–1020	Coffee break	SEAFDEC Personnel
1020–1200	Practice: Species identification and morphological description of the Carangidae larvae (1)	Instructor Team
1200–1330	Lunch break	SEAFDEC Personnel
1330–1500	Practice: Species identification and morphological description of the Carangidae larvae (2)	Instructor Team
1500–1520	Coffee break	SEAFDEC Personnel
1520–1700	***Continued*** Practice: Species identification and morphological description of the Carangidae larvae (2)	Instructor Team
20 Nov. 22 – Sunday		
	Refreshment/Excursion	SEAFDEC Personnel
21 Nov. 22 – Monday		
0900–1000	Practice: Species identification and morphological description of the Carangidae larvae (3)	Instructor Team
1000–1020	Coffee break	SEAFDEC Personnel
1020–1200	***Continued*** Practice: Species identification and morphological description of the Carangidae larvae (3)	Instructor Team
1200–1330	Lunch break	SEAFDEC Personnel
1330–1430	Lecture: Identification methods of the Engraulidae larvae in the Southeast Asian region	Dr. Yoshinobu KONISHI
1430-1500	Practice: Species identification and morphological description of the Engraulidae larvae (1)	Instructor Team
1500–1520	Coffee break	SEAFDEC Personnel
1520–1700	***Continued*** Practice: Species identification and morphological description of the Engraulidae larvae (1)	Instructor Team
22 Nov. 22 – Tuesday		
0900–1000	Practice: Species identification and morphological description of the Engraulidae larvae (2)	Instructor Team

1000–1020	Coffee break	SEAFDEC Personnel
1020–1200	***Continued*** Practice: Species identification and morphological description of the Engraulidae larvae (2)	Instructor Team
1200–1330	Lunch break	SEAFDEC Personnel
1330–1500	Practice: Species identification and morphological description of the Engraulidae larvae (3)	Instructor Team
1500–1520	Coffee break	SEAFDEC Personnel
1520–1700	***Continued*** Practice: Species identification and morphological description of the Engraulidae larvae (3)	Instructor Team
23 Nov. 22 – Wednesday		
0900–1000	Presentation of case study on early life history science based on the references for planning of future working subjects in country	Country Representative (10 Countries)
1000–1020	Coffee break	SEAFDEC Personnel
1020–1200	***Continued*** Presentation of case study on early life history science based on the references for planning of future working subjects in country	Country Representative (10 Countries)
1200–1330	Lunch break	SEAFDEC Personnel
1330–1430	Lecture: Identification methods of the Lutjanidae, Siganidae and serranid Epinephelinae larvae in the Southeast Asian region	Dr. Yoshinobu KONISHI
1430–1500	Practice: Species identification and morphological description of the Lutjanidae, Siganidae and serranid Epinephelinae larvae (1)	Instructor Team
1500–1520	Coffee break	SEAFDEC Personnel
1520–1700	***Continued*** Practice: Species identification and morphological description of the Lutjanidae, Siganidae and serranid Epinephelinae larvae (1)	Instructor Team
24 Nov. 22 – Thursday		
0900–1000	Practice: Species identification and morphological description of the Lutjanidae, Siganidae and serranid Epinephelinae larvae (2)	Instructor Team
1000–1020	Coffee break	SEAFDEC Personnel
1020–1200	***Continued*** Practice: Species identification and morphological description of the Lutjanidae, Siganidae and serranid Epinephelinae larvae (2)	Instructor Team
1200–1330	Lunch break	SEAFDEC Personnel
1330–1500	Practice: Species identification and morphological description of the Lutjanidae, Siganidae and serranid Epinephelinae larvae (3)	Instructor Team
1500–1520	Coffee break	SEAFDEC Personnel
1520–1700	***Continued*** Practice: Species identification and morphological description of the Lutjanidae, Siganidae and serranid Epinephelinae larvae (3)	Instructor Team
25 Nov. 22 – Friday		
0900–1000	Practice: Species identification and morphological description of the Lutjanidae, Siganidae and serranid Epinephelinae larvae (4)	Instructor Team
1000–1020	Coffee break	SEAFDEC Personnel

1020–1200	***Continued*** Practice: Species identification and morphological description of the Lutjanidae, Siganidae and serranid Epinephelinae larvae (4)	Instructor Team
1200–1330	Lunch break	SEAFDEC Personnel
1330–1500	Preparation of presentation on species identification and morphological descriptions of examined larvae and juveniles, and on future working subjects to be planned	Country Representative (10 Countries)
1500–1520	Coffee break	SEAFDEC Personnel
1520–1700	***Continued*** Preparation of presentation on species identification and morphological descriptions of examined larvae and juveniles, and on future working subjects to be planned	Country Representative (10 Countries)
26 Nov. 22 – Saturday		
0900–1000	Presentation on results of species identification and morphological descriptions of examined larvae and juveniles, and on future working subjects to be planned	Country Representative (10 Countries)
1000–1020	Coffee break	SEAFDEC Personnel
1020–1200	***Continued*** Presentation on results of species identification and morphological descriptions of examined larvae and juveniles, and on future working subjects to be planned	Country Representative (10 Countries)
1200–1330	Lunch break	SEAFDEC Personnel
1330–1430	Training course evaluation	FR/PCU
1430–1500	Closing Ceremony for Phase I	FR/PCU SEAFDEC/TD
	Free	
1700–2200	Farewell Dinner	
27 Nov. 22 – Sunday		
	Refreshment/Excursion	SEAFDEC Personnel

VIII. ENHANCING KNOWLEADGES AND PRACTICES/SKILL

A. Utilization of DNA barcodes for the identification of tropical larval fishes

Dr Cecilia Chu, a researcher from the University of Nottingham Malaysia has presented an-hour lecture on the 'Utilization of DNA barcodes for the identification of tropical larval fishes in Klang Strait, Straits of Malacca' on the first day of the Larval Fish Identification and Fish Early Life History Regional Training Course (Phase I) held in SEAFDEC/TD, Samut Prakan, Thailand. Her lecture covers part of her PhD research on the use of molecular technique such as DNA barcoding, for species level identification of larval fishes in Malaysia. She briefed through the workflow for obtaining the species identification based on molecular characters. The workflow includes sample collection and preservation, extraction of DNA from larval samples and amplification of the DNA fragments using Polymerase Chain Reaction (PCR), outsourcing of PCR products to get DNA sequences, and finally, analyses of DNA sequences including the construction of phylogenetic tree. Based on her phylogenetic analyses, DNA barcodes can potentially differentiate between species of larval specimens through the matching of DNA sequences with reference sequences found in public database such as Genbank, and/or DNA sequences of the adult specimens collected from the vicinity areas. Furthermore, cost-effective method for routine sampling and identification of larval specimens using DNA barcode is also possible using Chelex resin for DNA extraction from ethanol-preserved larval samples. However, few limitations of the molecular techniques are

pointed out, such as the ambiguity of species identification from non-curated public sources, the general lack of reference sequences for speciose and non-commercial fish families, and the need to include more than one gene (other than the COI gene) further to investigate the relationship between cryptic species, or conspecifics. Nevertheless, she managed to identify at least 48 taxa, or possible species, from the 21 larval fish families collected, including two species that were not known to be distributed in the area, thus strengthening the use of the molecular technique as one of the tools for larval identification. Dr. Cecilia Chu presentation is enclosed as **Annex 2**.

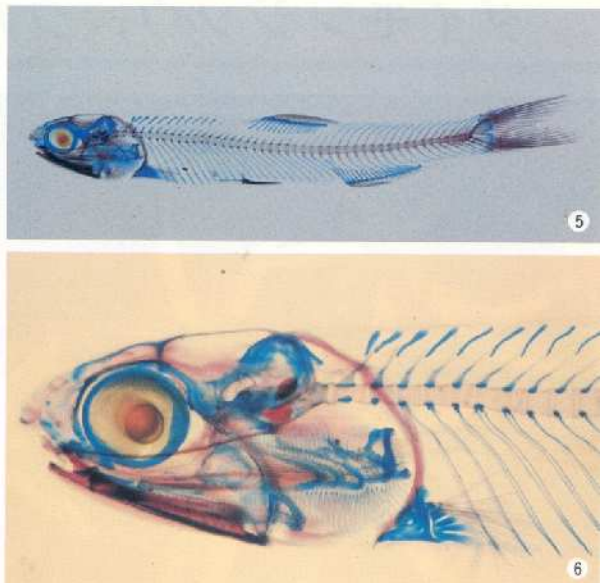
B. Review of morphological development of larval fish characters

Refers to **Annex 3**.

C. How to stain and illustrate fish larvae?

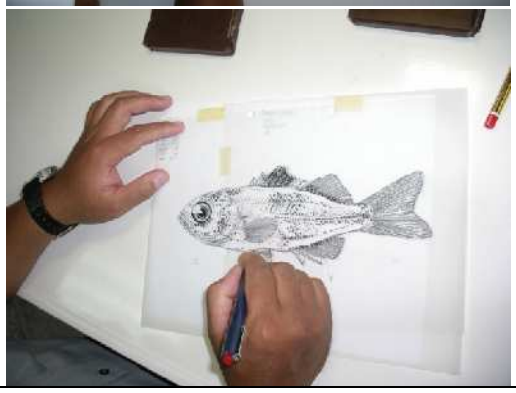
The procedure of clearing and staining fish larvae and juveniles, as described by Dingerkus and Uhler (1977) is summarized as follows:

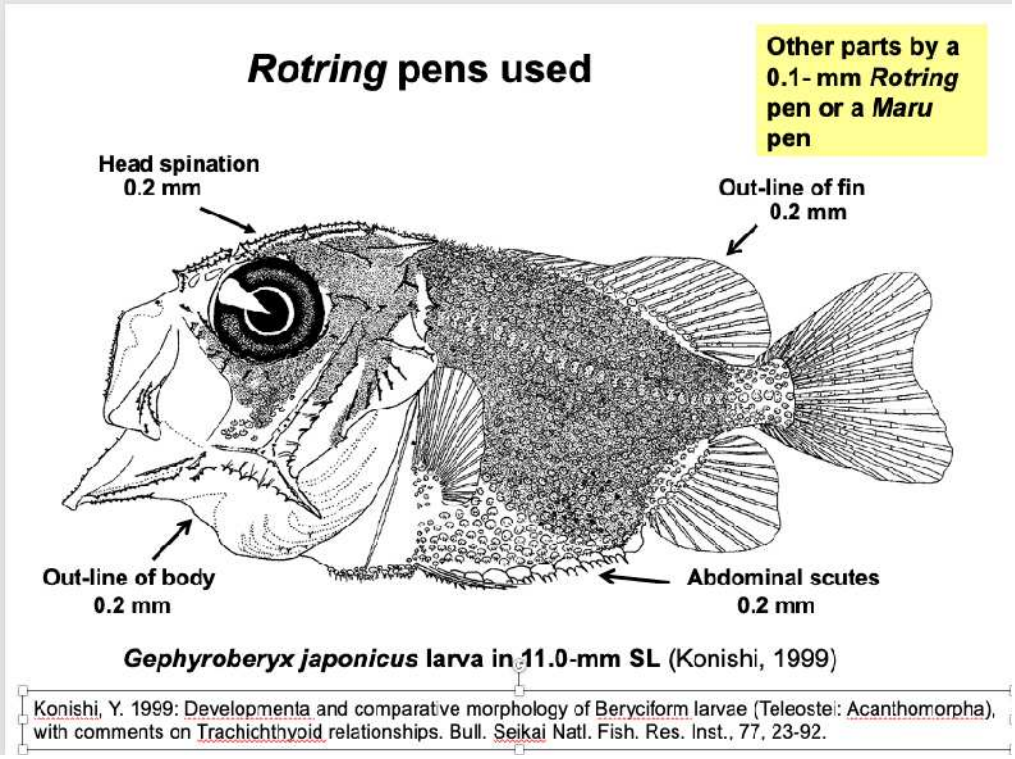
1) Fix fresh material in 10% formalin for 2-3 days.
2) Wash in several changes of distilled water 2-3 days.
3) Place directly into a mixture of 10 mg alcian blue 8GN, 80 ml 95% ethanol, and 20 ml glacial acetic acid, 24-48 hrs.
4) Transfer to 2 changes of 95% ethanol, 2-3 hours in each change.
5) Transfer through 75%, 40%, and 15% ethanol for 2-3 hours each, or until the specimen sinks.
6) Transfer to distilled water 2-3 hours or till the specimen sinks.
7) Place in an enzyme solution of 30 ml saturated aqueous sodium borate, 70 distilled water, and 1 g trypsin (4xpancreatin, Nutritional Biochemicals). Change solution every 2-3 days. Continue until bones and cartilage are clearly visible and flesh retains no blue color.
8) Transfer to 0.5% aqueous KOH, to which enough alizarin red S has been added to turn the solution deep purple. Leave 24 hours, or until bones are distinctly red.
9) Transfer through a 0.5% KOH-glycerine series (3:1, 1;1, 1:3) to pure glycerine. To the first two KOH-glycerine solutions, 3 or 4 drops of 3% H2O2 may be added per 100 ml solution to bleach pigments of dark specimens. Specimens may be left in the bleaching step for several days or until dark pigment are removed.
10) Store specimens in pure glycerine to which a few crystals of thymol have been added. The thymol inhabits growth of molds and bacteria.

	A A juvenile of Japanese anchovy (*Engraulis japonica*) cleared and stained. (from Sumikawa and Fujita, 1984)

	Equipment and tools needed: • Binocular • Camera lucida • Measuring apparatus (micrometer) • Optic and transmitted illuminations for binocular • Light for drawing pape • Pencils (black-2B, red, blue) • Kent paper • Tracing paper • Adhesive tape (or weight) • Eraser • Rotring pens • Maru-pen • Cards • Cut glass in small slip

The procedure of illustrating fish larvae are as follows:

1. Choosing specimens to be drawn If possible, 3 specimens of preflexion, flexion and postflexion stages of a species 2. Observing, measuring and counting • SL, HL, BD, ED, SnL, PAL, etc • DF, AF, P1F, P2F, PCR, Myomere • Pigmentation (by red or blue pencil) • Spination (location, arrangement and shape) (should be noted in a card with data of sampling date (time), position and gear) 3. Making a first sketch by pencil on a kent paper (Photo 1 and 2) • Zoom-up drawing (in full size of A4) for small-sized larva • Cut glasses are used to keep the specimen in a position and to make twisted body extend. 4. Tracing the first sketch covered by a tracing paper with rotring pens (Photo 3) If a size of the 1st illustration is larger than A4, reduce in an A4 size by photocopy machine.	  



D. Identification methods of the Scombridae fishes and their larvae in Southeast Asia.
Refers to **Annex 4**.

E. Identification methods of the Carangidae fishes and their larvae in Southeast Asia.
Refers to **Annex 5**.

F. Identification methods of the Engraulidae fishes and their larvae in Southeast Asia.
Refers to **Annex 6**.

G. Identification methods of the Lutjanidae, Siganidae and Epinephelini larvae in Southeast Asia.
Refers to **Annex 7.**

IX. CASE STUDY ON EARLY LIFE HISTORY SCIENCE BASED ON THE REFERENCES FOR PLANNING OF FUTURE WORKING SUBJECTS IN COUNTRY

NO.	Key Words	Title	Author(s)	Journal	Abstract
1	fish eggs, DNA barcode, morphology, *Decapterus*, spawning ground, northern South China Sea	Molecular and Morphological Identification and Seasonal Distribution of Eggs of Four *Decapterus* Fish Species in the Northern South China Sea: A Key to Conservation of Spawning Ground	Gang Hou, Jinrun Wang, Zuozhi Chen, Jinlong Zhou, Wangsu Huang and Hui Zhang	Frontiers in Marine Science ORIGINAL RESEARCH published: 12 November 2020 doi: 10.3389/fmars.2020.590564	Although species of Decapterus form important pelagic fisheries in the northern South China Sea, information on their spawning grounds is limited because identification of fish eggs based on their morphology is difficult. We identify eggs of four Decapterus species (D. macrosoma, D. maruadsi, D. macarellus, and D. tabl) with DNA barcodes from the fishery resources surveys in spring and autumn 2018 in Xisha islands, and spring and later summer–autumn 2019 along the continental shelf of the northern South China Sea, and describe egg morphology. Of 1405 fish eggs with obtained cytochrome c oxidase subunit I (COI) sequences, 81 were successfully attributed to four Decapterus species; eggs of each are spherical, have a smooth chorion and narrow perivitelline space, and can be partly differentiated by diameter, melanophore drops on the oil globule, and the notum of the embryo. Seasonal distributions of eggs reveal spawning grounds, with that of D. maruadsi located mainly off the Pearl River estuary in spring; eggs of D. maruadsi rarely co-occur with those of D. macrosoma. Spawning grounds of D. macrosoma are probably further south, where water temperature and salinity are higher. Spawning periods of these four Decapterus species overlap slightly. Spawning habitat of D. maruadsi has been lost, and the spawning season of D. macrosoma has extended.

NO.	Key Words	Title	Author(s)	Journal	Abstract
					Identification of Decapterus eggs using DNA barcodes can assist with the identification of eggs using traditional morphological approaches. Spatial and temporal information on the distributions of Decapterus eggs can be used for improved conservation of spawning grounds and fisheries management in the northern South China Sea.
2	Between-year difference · Food availability · Habitat temperature · Larval distribution ·Larval growth · PCR-RFLP analysis · Scomber australasicus · Scomber japonicus	Distribution and growth of *Scomber japonicus* and *S. australasicus* larvae in the southern East China Sea in response to oceanographic conditions	Chiyuki Sassa, Youichi Tsukamoto	Mar Ecol Prog Ser Vol. 419: 185–199, 2010	Chub mackerel Scomber japonicus and spotted mackerel S. australasicus are important fishery resources in the countries adjacent to the East China Sea (ECS). During February to March in 2004 and 2005, based on species identification using PCR-restriction fragment length polymorphism (PCR-RFLP) analysis of mtDNA, we examined the larval distribution, transport and growth of both species in the southern ECS, where extremely high abundances of Scomber spp. larvae are found. Distribution of S. australasicus was in a more southern area than was S. japonicus, with a higher and narrower range of habitat temperature (20 to 23°C versus 15 to 22°C), although there was some spatial overlap. In 2004, when an intrusion of the warm Kuroshio Branch Current north of Taiwan was evident, S. australasicus were transported northeastward, while they dispersed eastward along the Kuroshio front in 2005 when the intrusion was weak. Although S. japonicus showed a similar pattern of transport and dispersal to S. australasicus, it was more gradual, corresponding with the weaker flow in the northern part of the study area. The daily specific growth rates of S. japonicus and S. australasicus were 6.2 to 8.2%

NO.	Key Words	Title	Author(s)	Journal	Abstract
					and 7.7 to 9.3% of body length per day, respectively, and growth was significantly higher in 2004 than in 2005 for both species, with both habitat temperature and food availability being higher in 2004. Our study provides fundamental information on the spawning and recruitment of these 2 mackerel species on which to base predictive models, which are essential for protecting these shared stocks that migrate across the boundaries within the ECS.
3	East China Sea, Jack mackerel Kuroshio, Kuroshio branch current, Larval transport, Spawning ground	Spawning ground and larval transport processes of jack mackerel *Trachurus japonicus* in the shelf-break region of the southern East China Sea	Chiyuki Sassa, Youichi Tsukamoto, Kou Nishiuchi, Yoshinobu Konishi	Continental Shelf Research 28 (2008) 2574–2583	Horizontal distribution patterns of jack mackerel Trachurus japonicus larvae were investigated extensively in the East China Sea (ECS) along the shelf-break region between 261 and 301N during February–March based on fine-scale larval sampling in 2002 and 2003. A total of 2363 T. japonicus ranging from 1.2 to 12.4mm body length (BL) were collected at 310 bongo net sampling stations, of which larvae o10mm BL accounted for 99.1%. In both years, newly hatched larvae (o3mm BL) were concentrated in the shelf-break region mainly in the southern part of ECS between 261 and 271N in warmwater of 21–23 1C, suggesting that their primary spawning ground existed in and around this area. With growth, larvae were transported in two different directions, i.e., northward and northeastward, corresponding closely with the direction of the Kuroshio Branch Current north of Taiwan (KBCNT) and the Kuroshio, respectively. Replicate sampling cruises at 2 week intervals were conducted in 2003, and the larval distribution pattern changed significantly between the sampling cruises, suggesting that the transport

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					process fluctuates over relatively short periods in relation to oceanographic processes. The transport speed by the KBCNT was estimated to be 0.13–0.28 knots based on the larval distribution, which is one order of magnitude slower than that by the Kuroshio (1.5–3 knots). Habitat temperature gradually declined with growth in both the Kuroshio and KBCNT, but in the KBCNT it was 1–2 1C lower than in the Kuroshio. Our results suggest that the two different larval transport processes lead to a significant difference in the transport route, habitat conditions (such as temperature and food), and site where young fish recruit to the demersal habitat, which will result in different survival and recruitment processes.
4	interannual variations, Japanese jack mackerel, larval abundance, larval distribution, Southern East China Sea, spawning grounds.	Interannual variations in distribution and abundance of Japanese jack mackerel Trachurus japonicus larvae in the East China Sea	Chiyuki Sassa, Motomitsu Takahashi, Yoshinobu Konishi, and Youichi Tsukamoto	ICES Journal of Marine Science Advance Access published January 24, 2016	We examined the interannual variations in distribution and abundance of Japanese jack mackerel Trachurus japonicus larvae ,5 mm standard length (SL), based on sampling surveys over a broad area of the shelf break region of the East China Sea (ECS) during late winter and spring for 12 years from 2001 to 2012. Larval abundances in late winter were higher than those in spring. In late winter, ratios (expressed as %) of larval abundance in the southern ECS south of 288N to the whole study area were highest during the study period, with values ranging from 80.0 to 95.8%. In spring, the ratios in the southern ECS were still high (34.3–88.8%), although the values increased slightly in the northern and central ECS. Therewas no significant interannual variation in the centre of distribution of the larvae, suggesting that the

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					formation of spawning grounds would be related to topographic rather than hydrographic conditions. Habitat temperature of larvae in the central and southern ECSwas 3–58C higher than that in the northern ECS throughout the study period, indicating that larval growth and survival processes may differ between the two areas. In the southern ECS, larval abundances fluctuated largely from year-to-year, and the interannual variations were closely correlated with water temperature and chlorophyll a concentration. However, larval abundance did not correlate with an index of recruited juveniles (50–75 mm SL) in the ECS, suggesting that mortality during the late larval and early juvenile stages is responsible for recruitment success or failure.
5	interannual variations, larval distribution, *Seriola quinqueradiata*, shelf-break region of the East China Sea, southward expansion of spawning ground, spawning stock biomass	The rapid expansion of yellowtail (*Seriola quinqueradiata*) spawning ground in the East China Sea is linked to increasing recruitment and spawning stock biomass	Chiyuki Sassa, Motomitsu Takahashi, Yoshinobu Konishi, Aonuma Yoshimasa, and Youichi Tsukamoto	ICES Journal of Marine Science (2020), 77(2), 581–592. doi:10.1093/icesjms/fsz200	Biomass of the yellowtail Seriola quinqueradiata, an important fishery resource in Japan, has increased about threefold over the past 20 years to "300 thousand metric tons. We examined the interannual variations in distribution and abundance of S. quinqueradiata larvae [4.2–7.9 mm body length (BL), "7 to 18 days after hatching], based on sampling surveys over a broad area of the shelf-break region of the East China Sea (ECS) in April, the main spawning period, over 15 years (2001–2015). High abundances of larvae were found in the northern ECS off the southwestern coast of Kyushu Island throughout the survey period. After 2010, the larvae began to occur abundantly also in the southern ECS south of 29#300N, indicating a southward expansion of the

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					spawning ground. There has been a significant positive trend of larval abundance over the whole ECS during the 15 years, which was mainly due to the sharp increase in larval abundance in the southern ECS after 2010. Although interannual variation in larval abundance was not related to environmental conditions (temperature, salinity, and chlorophyll a concentration), it was closely correlated with the spawning stock biomass. This indicates that the increasing trend of larvae was related to the increase in egg production in the ECS. Also, the larval abundance showed a weak positive correlation with recruitment, suggesting that the increased larval abundance has, in part, contributed to high recruitment.
6	batch fecundity, *Benthosema pterotum*, daily egg production method, daily production of larvae, spawning biomass, spawning fraction.	Estimation of the spawning biomass of myctophids based on larval production and reproductive parameters: the case study of Benthosema pterotum in the East China Sea	Chiyuki Sassa	ICES Journal of Marine Science (2019), 76(3), 743–754. doi:10.1093/icesjms/fsy051	This study estimated the spawning biomass of a myctophid by applying the daily egg production method (DEPM) based on data of larval fish surveys and reproductive parameters. Benthosema pterotum in the central part of the East China Sea shelf was used as the model species, as ecological and reproductive data are available in the literature. This study used data of the larvae and adults sampled in late summer when the primary spawning occurs. Daily egg production was estimated by back-projection of the daily production of larvae at hatching by 10 h, assuming that the mortality rate during the egg stage is the same to that of the larval stage. This study determined the sex ratio, batch fecundity, and spawning fraction. As a result, spawning biomass of B. pterotum in the East China Sea shelf was estimated to

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					be 9036 tons. The study also assesses and discusses several sources of potential uncertainty. The relative sensitivity of estimates of spawning biomass to variations in each parameter showed a four fold difference between the lowest and highest estimates (4066–16 265 tons). Since this was comparable to the biomass estimated by a swept-area trawl survey, the approximate estimation of biomass would be possible by applying this method. Considering that larval fish surveys have been conducted in the world's oceans and myctophids have always dominated in the samples, application of the DEPM is a potential option for estimating the order of magnitude of the biomass of myctophids.
7	Pelagic juvenile reef fish . Mid-water baited remote underwater stereo-video . Demersal fish . Ningaloo Reef .Western Australia	Presettlement schooling behaviour of a priacanthid, the Purplespotted Bigeye Priacanthus tayenus (Priacanthidae: Teleostei)	Julia Santana-Garcon & Jeffrey M. Leis & Stephen J. Newman & Euan S. Harvey	Environ Biol Fish DOI 10.1007/s10641-013-0150-6	We report in situ behavioural observations of presettlement schooling in Priacanthus tayenus off Coral Bay, Western Australia collected using pelagic Baited Remote Underwater stereo-Video systems. Two groups of fish (8 and 9 individuals) were observed that aggregated into a single school. Mean total length was 24.1 mm (12.5–30.2 mm). The fish swam at a mean speed of 8.5 cm s−1 in a group spacing themselves more or less evenly at a distance of around one body length from the nearest neighbour within the school. P. tayenus appeared to be sometimes associated with juveniles of other species. The results presented here add to the limited, but growing body of literature on the schooling behaviour of the early pelagic stages of demersal fishes.

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8	PREDICTING SELF-RECRUITMENT	PREDICTING SELF-RECRUITMENT IN MARINE POPULATIONS: BIOPHYSICAL CORRELATES AND MECHANISMS	Su Sponaugle, Robert K. Cowen, Alan Shanks, Steven G. Morgan, Jeffrey M. Leis, Jesús Pineda, George W. Boehlert, Michael J. Kingsford, Kenyon C. Lindeman, Churchill Grimes and John L. Munro	BULLETIN OF MARINE SCIENCE, 70(1) SUPPL.: 341–375, 2002	Mounting evidence suggests that some populations of benthic marine organisms may be less demographically 'open' than previously thought. The degree to which a population receives recruits from local sources versus other populations has important ecological and management ramifications. For either of these reasons, it is often desirable to estimate the degree to which a population of interest is self-recruiting. Although methods for actual estimation of population self-recruitment are limited and often difficult to employ, the presence of several biological and physical conditions may improve our estimates of self-recruitment for particular populations. Biological traits of benthic adults (relative fecundity, spatial and temporal patterns of spawning and larval release, parental investment), as well as pelagic larvae (stage of development at hatching, pelagic larval duration, vertical migration behavior, horizontal swimming ability, and sensory capabilities) influence where and when larvae are released, where and how they are transported, their ability to move actively in the pelagic realm, and finally, spatial and temporal settlement patterns. Physical variables potentially influencing self-recruitment include site isolation, coastal complexity and flow variability. Within these physical variables we discuss explicit mechanisms by which larvae may be retained in proximity to their natal population. We provide examples from specific locations such as coral reefs, isolated islands and seamounts, and semi-enclosed embayments such as lagoons and estuaries, as well as characteristic

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					oceanographic features such as upwelling systems, fronts, moving convergences, eddies and counter currents.
9		Onshore-offshore distribution and abundance of tuna larvae (Pisces: Scombridae: Thunnini) in near-reef waters of the Coral Sea	Ashley M. Fowler (contact author)1, 2 Jeffrey M. Leis2 Iain M. Suthers1	Manuscript submitted 8 January 2008. Manuscript accepted 23 June 2008. Fish. Bull. 106:405–416 (2008).	The on-offshore distributions of tuna larvae in near-reef waters of the Coral Sea, near Lizard Island (14°30'S, 145°27'E), Australia, were investigated during four cruises from November 1984 to February 1985 to test the hypothesis that larvae of these oceanic f ishes are found in highest abundance near coral reefs. Oblique bongo net tows were made in five on-offshore blocks in the Coral Sea, ranging from 0–18.5 km offshore of the outer reefs of the Great Barrier Reef, as well as inside the Great Barrier Reef Lagoon. The smallest individuals (<3.2 mm SL) of the genus Thunnus could not be identified to species, and are referred to as Thunnus spp. We found species-specific distributional patterns. Thunnus spp. and T. alalunga (albacore) larvae were most abundant (up to 68 larvae/100 m2) in near-reef (0–5.5 km offshore) waters,whereas Katsuwonus pelamis (skipjack tuna) larvae increased in abundance in the offshore direction (up to 228 larvae/100 m2, 11.1–18.5 km offshore). Larvae of T. albacares (yellowfin tuna) and Euthynnus affinis (kawakawa) were relatively rare throughout the study region, and the patterns of their distributions were inconclusive. Few larvae of any tuna species were found in the lagoon. Size-frequency distributions revealed a greater proportion of small larvae inshore compared to offshore for K. pelamis and T. albacares. The absence of significant differences in size-frequency distributions for other

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					species and during the other cruises was most likely due to the low numbers of larvae. Larval distributions probably resulted from a combination of patterns of spawning and vertical distribution, combined with wind-driven onshore advection and downwelling on the seaward side of the outer reefs.
10	dispersal, demography, connectivity, larval-fish behaviour, recruitment, settlement	WHAT DOES LARVAL FISH BIOLOGY TELL US ABOUT THE DESIGN AND EFFICACY OF MARINE PROTECTED AREAS?	Jeffrey M. Leis University of Tasmania	J.P. Beumer, A. Grant and D.C. Smith (eds) 2003. Proceedings of the World Congress on Aquatic Protected Areas, Cairns, Australia, August 2002. Published by the Australian Society for Fish Biology.	Marine Protected Areas (MPAs) can theoretically achieve two Goals: protection of biodiversity, and replenishment of populations both inside and far outside the MPA boundary. The second is supposed to result primarily from larval export from the MPA. Although there is evidence that □no-take□ MPAs protect biodiversity and have higher stocks of larger, older, more fecund fishes, there is scant empirical evidence to support the notion that MPAs actually do replenish unprotected areas, or if they do, over what spatial scale. This notion of replenishment over large scales is largely based on theoretical considerations of larval dispersal and larval biology. Recent research shows that at least fish larvae do not conform to traditional theory: they may have much more control over where they disperse than previously thought. This has important implications for the design and implementation of MPAs, and what we can expect from them as conservation tools. This paper reviews recent advances in understanding larval fish biology and behavioural capabilities and how these impact on the efficacy and design of MPAs. If larvae are as good at resisting dispersal as their behavioural capabilities suggest, then replenishment in ecologically meaningful quantities probably takes place over much

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					smaller scales than previously thought, and MPAs will have to be designed accordingly. These scales, however, are likely to differ spatially, temporally and among species.
11	Japanese jack mackerel, Artificial fertilization, Formalin sample, Egg identification, Morphological description, Segmentation of yolk, DNA sequence, Rearing experiment	Revisiting morphological identification of Japanese jack mackerel Trachurus japonicus eggs preserved in formalin	Masato Nishiyama, Mami Saito, Yasuhiro Sanada, Shizumasa Onoue, Akinori Takasuka, Yoshioki Oozeki	Fish Sci (2014) 80:517–529 DOI 10.1007/s12562-014-0732-z	Since formalin-preserved eggs of Japanese jack mackerel Trachurus japonicus have been considered difficult to identify, egg abundance of this species has not been estimated, and subsequently information on their spawning habitat is limited. The present study provides a practical identification of Japanese jack mackerel eggs from formalin-preserved samples based on morphological characteristics with validations through DNA sequencing and a rearing experiment. Eggs obtained by artificial fertilization from mature adults were reared in the laboratory,and developmental changes of morphological characteristics in the formalin-preserved samples were examined. The morphological descriptions were detailed to identify jack mackerel eggs from field-captured egg samples preserved in formalin. Moreover, the identification was validated through DNA sequencing and a rearing experiment.Overall, the diagnostic characteristic for identification was the egg diameter and the segmentation of the yolk, which was maintained in formalin-preserved samples even long after fixation. The presented morphological description with its developmental changes for formalin-preserved eggs is anticipated to promote stock assessments and biological studies for jack mackerel based on the egg and larval surveys.

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12		Chapter 8: The Biology, Behavior, and Ecology of the Pelagic, Larval Stage of Coral Reef Fishes	Leis, J.M. and McCormic, M.I.	Sale, P.F. 2002. Coral Reef Fishes: Dynamics and Diversity in a Complex Ecosystem. Academic Press. San Diego. P:171-199.	Reef fish biologists are keenly aware that nearly all bony fishes on coral reefs have a pelagic larval phase that is potentially dispersive, and that this has major implications for reef fish populations not only at evolutionary (or biogeographic) scales, but also at ecological (or demographic, including management) scales. The literature is full of statements of how important this type of life history is for reef fishes, and for study and management of them. However, this realization has not been accompanied by a major shift in research effort to studying this pelagic phase, what one might refer to as “prerecruitment” studies. Neither has it led to a widespread view of the pelagic phase as much more than a “black box” that results in open populations and large fluctuations in recruitment. Even attempts to assess the population connectivity that presumably results from larval dispersal typically make simplifying assumptions, either explicitly or implicitly, that portray the larvae as little more than passive tracers of water movement that “go with the flow,” doing nothing much until they bump into a reef by chance and settle at once.
13	eggs and larvae, jack mackerel, numerical model, recruitment, transport.	Transport and survival processes of eggs and larvae of jack mackerel Trachurus japonicus in the East China Sea	Akihide KASAI, Kousei KOMATSU, Chiyuki SASSA, and Yoshinobu KONISHI	Fisheries Science, 74:8-18, 2008	Recent surveys showed substantial aggregation of larvae of jack mackerel in the southern East China Sea, indicating intensive spawning grounds near Taiwan. A numerical model was applied to investigate transport and survival processes of eggs and larvae of jack mackerel from the spawning area to the nurseries. The results show that: (i) the distributions of larvae simulated by the model agreed well with those obtained by field survey; (ii) the stock of jack mackerel

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					in the Sea of Japan is composed of both groups from north of Taiwan and from the western coast of Kyushu. It takes more than two months for the former to reach the Sea of Japan, while it is within 40 days for the latter; and (iii) large proportions of the eggs and larvae spawned off the north of Taiwan are transported rapidly to the Pacific side of Kyushu by the Kuroshio Current, and the rest slowly to the east or north-east along the continental slope in the East China Sea. In contrast to the larval flux, survivors are more abundant in the northern East China Sea than in the Pacific Ocean, indicating that survival in the northern East China Sea would determine the jack mackerel stock in Japan.
14	Juvenile grouper, *Epinephelus striatus*, seagrass, Strombus gigas, blowout	The Distribution of Early Juvenile Groupers Around South Caicos, Turks and Caicos Islands	Claydon, J.A.B. and Kroetz, A.M.	Proceedings of the 60th Gulf and Caribbean Fisheries Institute. 5-9 November 2007. Punta Cana. Dominican Republic. P:345-350, 2007	Groupers are important components of fisheries throughout tropical seas. However, little is known of their early life histories. This study aimed to investigate habitat use by early juvenile (< 12 cm TL) groupers around the south coast of South Caicos, Turks and Caicos Islands. From May to August 2007, a 530,000 m2 shallow (< 5m) area was systematically sampled on snorkel covering a range of habitats extending from a fringing reef crest into a harbour and sheltered bay. Species, size, GPS position, and habitat of all epinepheline groupers observed were recorded. Epinephelus striatus (n=209), E. guttatus (n = 15), E. adscensionis (n = 9), Cephalopholis fulva (n = 396), and C. cruentatus (n = 4) were found to have overlapping but substantially different distributions: 87% of E. striatus and 73% of E. guttatus were found in seagrass areas which covered < 30% of the study area; C. fulva

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					favoured rubble/rock areas (57%); and all E. adscensionis were found within 10m of land. E. striatus were found sheltering predominantly in two structures: discarded conch shells (44% of individuals) and ledges formed by the roots and rhizomes of seagrass in blowout walls (33% of individuals). Whilst previous studies have emphasized the importance of macroalgal beds in tidal creeks as early juvenile E. striatus habitat, around South Caicos, seagrass habitats cover large areas and may contribute more individuals to local populations than alternative habitats.
15	*Siganus canalicullatus*, south coast, traps, Fisher folk.	A review on Biology and aquaculture potential of rabbit fish in Tamilnadu (*Sigganus canaliculatus*)	M. Jaikumar	International Journal of Plant, Animal and Environmental Sciences. 2(2):57-64, 2012	Preliminary investigation on the culture of *Siganus canaliculatus* in floating cages in mandapam coastal water has revealed that the fish has high culture potential in the region. It is euryhaline, inhabiting areas where salinities range from 17 ppt to 37.0 ppt. The Juvenile are abundant in the area of reef and seaweed bed and collecting in traps near mandapam. Natural occurrence of juveniles of S. canaliculatus in large quantity was noticed during February through May in the Gulf of Mannar. The fish feeds mainly on seaweeds. It is reported that the fish can reach a marketable size of 20 cm fork length in 6 months. The rabbit fish is cultured in South East Asian countries. India has enormous potential for rabbit fish culture.
16	Lutjanidae . Settlement . Behaviour. Pelagic dispersal	Settlement behaviour of larvae of the Stripey Snapper, *Lutjanus carponotatus* (Teleostei: Lutjanidae)	Gaëlle Quéré and Jeffrey M. Leis	Environment and Biological of Fish. doi: 10.1007/s10641-010-9633-x	Larval behaviour is important to dispersal and settlement, but is seldom quantified. Behavioural capabilities of larval Lutjanus carponotatus in both offshore pelagic and reef environments at Lizard Island, Great Barrier Reef were observed in situ to

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	. Larva . Great Barrier Reef				determine if they were sufficient to influence dispersal. Offshore, larvae swam with higher directional precision and faster on the windward side of the island (28 cm.s−1) than on the leeward side (16 cm s−1). Most larvae swam directionally. Mean swimming directions were southerly in the windward area and northerly in the leeward area. Larvae avoided the surface and remained mostly between 3–15 m. Larvae released near reefs were 2–3 times faster swimming away from reefs (19 cm s−1) than swimming toward or over them (6–8 cm s−1). Speed swimming away was similar to that offshore. Of 41 larvae released near reefs, 73% reached the reef, 59% settled, and 13% of those reaching the reef were eaten. Larvae settled onto hard and soft coral (58%), topographic reef features (29%) and sand and rubble (13%). Settlement depth averaged 5.5 m (2–8 m). Before settling larvae spent up to 800 s over the reef (mean 231 s) and swam up to 53 m (mean 14 m). About half of the larvae interacted with reef residents including predatory attacks and aggressive approaches by residents and aggressive approaches by settling larvae. Settlement behaviour of L. carponotatus was more similar to a serranid than to pomacentrids. Settlementstage larvae of L. carponotatus are behaviourally capable, and have a complex settlement behaviour.
17		Egg and Larval development of laboratory-reared nassau grouper,	Allyn B. Powell and John W Tucker, Jr.	Bulletin of Marine Science, 50(1): 171-185, 1992	Egg and larval development of the Nassau grouper, Epinephelus striatus, is described from laboratory-reared specimens. Egg diameters averaged 0.92 mm (0.86-0.97 mm), and those of the single oil globule

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		Epinephelus striatus (Pisces, Serranidae)			averaged 0.24 mm (0.20-0.26 mm). No pigmentation was discernible on embryos. Newly hatched larvae measured 1.7-1.8 mm notochord length, and were inconspicuously pigmented. A characteristic pigment pattern that persists during larval development first appeared on late yolk-sac larvae-a mass of pigment on the ventral midline and lateral surface of the caudal peduncle, and on the dorsal and lateral surface of the gut. The enlarged, serrated, second first-dorsal-fin and pelvic spines that are characteristic of epinephelin larvae formed very early in the preflexion stage, but spinelets were not well developed until postflexion. The adult complement of dorsal-fin and anal-fin spines and rays was first observed on specimens approximately 6.8 mm standard length (SL) based on pterygiophores to obtain counts. But the appearance of bony stays, which signified completion of the dorsal and anal fins was not complete until 7.4 mm and 7.0 mm SL, respectively. Separation of preflexion and flexion E. striatus from all other epinephelin groupers does not appear possible until comparative studies of pigment patterns, second-dorsal-fin pterygiophore patterns, ceratobranchial gill raker counts, and spinelet development can be done. E. striatus postflexion larvae longer than 7.4 mm SL can be separated from all other epinephelin larvae except E. adscensionis on the basis of dorsal and anal fin ray counts, spinelet configuration, second first-dorsal-fin spine length relative to standard length, and capture location.

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18	swimming and settlement behaviour, coral-reef fish	In situ swimming and settlement behaviour of larvae of an Indo-Pacific coral-reef fish, the coral trout *Plectropomus leopardus* (Pisces: Serranidae)	J. M. Leis á B. M. Carson-Ewart	Marine Biology, 137:51-64, 1999	Late larvae of the serranid coral trout *Plectropomus leopardus* (LacepeÁde), captured in light traps, were released during the day both in open water and adjacent to two reefs, and their behaviour was observed by divers at Lizard Island, northern Great Barrier Reef. Coral trout larvae (n = 110) were present in light-trap catches from 18 November to 3 December 1997, including new moon (30 November). The swimming speed of larvae in open water or when swimming away from reefs was signi®cantly greater (mean 17.9 cm/s) than the speed of larvae swimming towards or over reefs (mean 7.2 cm/s). Near reefs, larvae swam at average depths of 2.7 to 4.2 m, avoiding 0 to 2 m. In open water, swimming depth varied with location: larvae >1 km east of Lizard Island swam steeply downward to >20 m in 2 to 4 min; larvae >1 km west oscillated between 2.6 and 13 m; larvae 100 to 200 m east of Lizard Island oscillated between 0.8 and 15 m. Nearly all larvae swam directionally in open water and near reefs. In open water, the average swimming direction of all larvae was towards the island, and 80% (4 of 5) swam directionally ($p < 0.05$, Rayleigh's test). Larvae swam directionally over the reef while looking for settlement sites. The frequency of behaviours by larvae diered between two reefs of dierent exposure and morphology. Depending on site, 26 to 32% of larvae released adjacent to reefs swam to open water: of these, some initially swam towards or over the reef before swimming oshore. In some cases, oshore-swimming seemed to be due to the presence of predators, but usually no obvious cause

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					was observed. Depending on the reef, 49 to 64% of the larvae settled. Non-predatory reef residents aggressively approached 19% of settlers. Between 5 and 17% of the larvae were eaten while approaching the reef or attempting to settle, primarily by lizardfishes but also by wrasses, groupers and snappers. A higher percentage of larvae settled in the second week of our study than in the first. Average time to settlement was short (138 s 33 SE), but some larvae took up to 15 min to settle. Average settlement depth was 7.5 to 9.9 m, and diered between locations. No settlement took place on reef¯ats or at depths <4.2 m. Larvae did not appear to be selective about settlement substrate, but settled most frequently on live and dead hard coral. Late-stage larvae of coral trout are capable swimmers with considerable control over speed, depth and direction. Habitat selection, avoidance of predators and settlement seem to rely on vision.
19	nursery habitat, *Epinephelus itajara*	Mangroves assessential nursery habitat for goliath grouper (*Epinephelus itajara*)	Christopher C. Koenig, Felicia C. Coleman, Anne-Marie Eklund, Jennifer Schull, and Jeffrey Ueland	Bulletin of Marine Science, 80(3): 597-586, 2007	We evaluated goliath grouper's [*Epinephelus itajara* (Lichtenstein, 1822)] use of mangroves as essential nursery habitat by estimating absolute abundance, density, survival, age structure, home range, mangrove habitat association, habitat quality, and recruitment to the adult population. Densities (numbers km–1 mangrove shoreline) were calculated using Jolly-Seber mark-recapture methods for mangrovelined rivers and mangrove islands of the Ten Thousand Islands (TTI) and Everglades National Park, which includes Florida Bay, Florida, USA. Juveniles had smaller home ranges around islands (170 m) than in

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					rivers (586 m), as determined from observations on telemetered fish. Goliath grouper remained in mangrove habitats for 5–6 yrs (validated ages from dorsal spine sections), then emigrated from mangroves at about 1.0 m total length. In the TTI, juvenile densities around mangrove islands were higher (mean = 25 km–1, SE = 6.2, CV = 0.5) and less variable than those in rivers (mean = 11 km–1, SE = 4.2, CV = 1.2). Density was negatively correlated with the frequency of dissolved oxygen and salinity minima. Mean growth rate of recaptured fish around mangrove islands (0.358 mm d–1, 95% CL = 0.317–0.398) was significantly higher than that in rivers (0.289 mm d–1, 95% CL = 0.269–0.308). The annual survival rate, as estimated by the Kaplan-Meier method on telemetered fish, was 0.947 (95% CL = 0.834–1.0). Very low densities in Florida Bay were probably related to other water quality variables in this human-altered system. The offshore abundance of adults was largely explained by abundance of mangrove, but not seagrass habitat. Mangrove habitat with suitable water conditions, which appears essential to the recovery and sustainability of goliath-grouper populations, should be protected and/or restored.
20	Grouper · Acoustic telemetry · Marine protected area ·	Spatial ecology of Nassau grouper at home reef sites: using acoustic telemetry to track a	Kayla M. Blincow, Phillippe G. Bush, Scott A. Heppell, Croy	Marine Ecology Progress Series, 655:199-217, 2020	Characterizing the behavior of coral reef fishes at home reef sites can provide insight into the mechanisms of spatial ecology and provide a framework for spatial resource management. In the Caribbean, populations of Nassau grouper

NO.	Key Words	Title	Author(s)	Journal	Abstract
	Movement · Ontogeny	large, long-lived epinephelid across multiple years (2005−2008)	M. McCoy, Bradley C. Johnson, Christy V. Pattengill-Semmens, Selina S. Heppell, Sierra J. Stevens-McGeever, Leslie Whaylen, Kirsten Luke, and Brice X. Semmens		Epinephelus striatus have declined due to fishing impacts on spawning aggregations. Despite local and regional efforts by fisheries managers to implement regulations protecting spawning aggregations, few Nassau grouper populations appear to be recovering. In order to improve management strategies for this critically endangered species, it is necessary to understand the spatial ecology of the species across seasons and years. In the Cayman Islands, we used a multi-year, presence/absence, depth-coded acoustic tagging dataset of Nassau grouper to characterize patterns in the species' behavior and vertical habitat use at home reef sites. Twenty acoustically tagged individuals (56−84 cm, 70.01 ± 7.40 cm; total length, mean ± SD) maintained consistent home reef sites, although some fish regularly shifted activity centers within the home site, often following a seasonal spawning migration. Seven fish with depth-coded tags showed a higher probability of vertical movement in the hours immediately following dawn and preceding dusk. We found evidence of a positive relationship between the fish condition factor and depth of home reef site. The finding of persistent home reef sites across years suggests that properly sized spatial reserves at home reef sites can be a useful complement to spawning aggregation protection when considering management strategies for Nassau grouper.

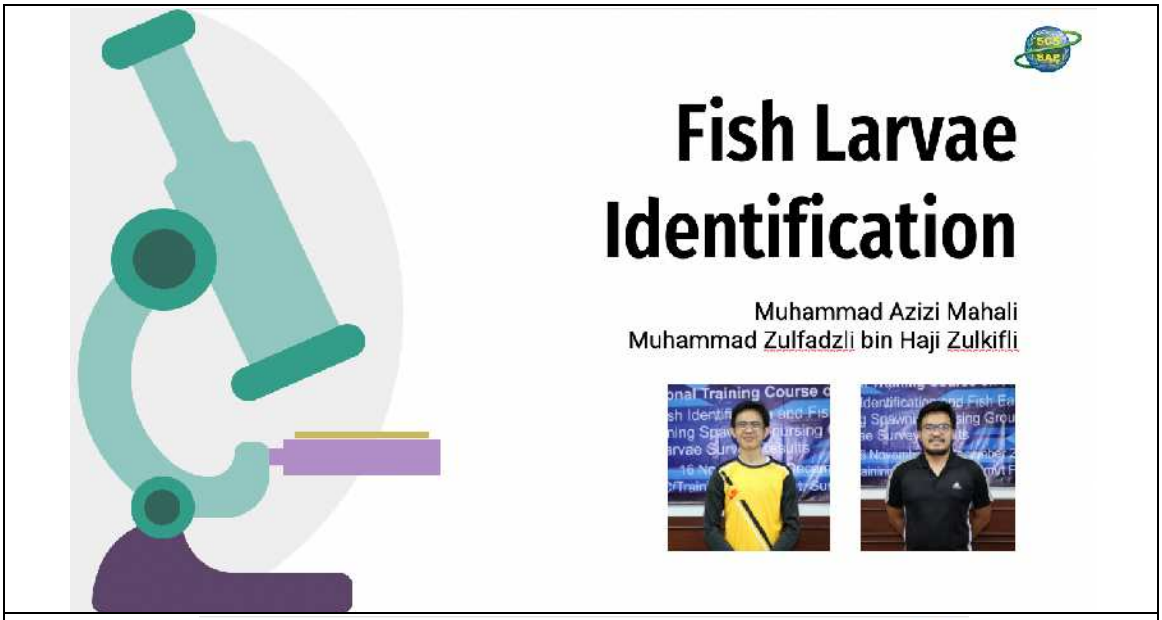
NO.	Key Words	Title	Author(s)	Journal	Abstract
21	Nassau grouper · Site fidelity · Swimming speed · Migration · Acoustic telemetry · Grouper conservation	Spatial dynamics of the Nassau grouper Epinephelus striatus in a Caribbean atoll	Richard M. Starr, Enric Sala, Enric Ballesteros, and Mikel Zabala	Marine Ecology Progress Series, 343:239-249, 2007	Worldwide, chronic overfishing has depleted populations of large predatory reef fishes and caused unexpected, top-down changes in coral reef ecosystems. Groupers are especially susceptible to overexploitation, because they aggregate to reproduce at specific locations and times. An understanding of the spatial dynamics of these fishes is critical for fisheries management and conservation. However, movements and migration dynamics of endangered reef fishes are poorly known. We show, using acoustic telemetry, that Nassau groupers Epinephelus striatus exhibit highly synchronised migration to spawning sites, despite their otherwise solitary habits. Reproductive adults leave their individual territories in shallow waters near the winter full moons, and migrate to the same spawning site up to 4 times yr–1. At the spawning site, a remarkable population-wide depth change occurs within an hour as individuals dive to a maximum depth of 255 m. Our results greatly expand the previously known migration frequency and depth range of this species, and reveal an unexpected yet predictable complexity of adult fish migration between habitats. Effective conservation of this threatened species requires that deeper reefs and the timing of migration events be incorporated into fisheries management plans.
22	Morphological Development, *Epinephelus fuscoguttatus*	Morphological Development of Larval and Juvenile	Hiroshi Kohno, Susanti Diani, and Ateng Supriatna	Japan. J. Ichthyol. 40(3):307-316, 1993	The morphological development of larval and juvenile grouper, *Epinephelus fuscoguttatus*, was examined in a hatchery-reared series. By about 4mm body length (BL), the larvae had developed pigment

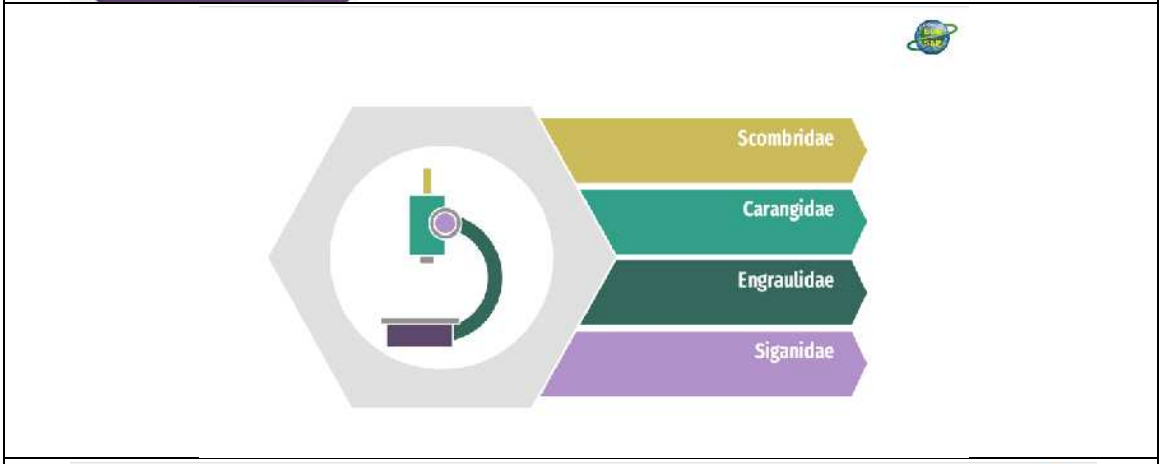
NO.	Key Words	Title	Author(s)	Journal	Abstract
		Grouper, *Epinephelus fuscoguttatus*			patterns peculiar to groupers, such as melanophores on the dorsal part of the gut, on the tip of the second dorsal and pelvic-fin spines, and in a cluster on the ventral side of the tail. The spines characteristic of groupers, such as spinelets on the second dorsal and pelvic-fin spines, the preopercular angle spine and the supraocular spine, started to develop by about 5mm BL. The notochord end was in the process of flexion in larvae of 5 to 6mm BL, by which time major spines and pigments had started to appear. The fin ray counts attained the adult complement at about 8mm BL. Major spines disappeared by 15-16mm BL, from which size, more or less densely-pigmented patches started to appear on the body. In juveniles larger than 20-22mm BL, the lengths of the second dorsal and pelvic-fin spines in relation to BL became stable .
23	Behavioral ontogeny, giant trevally (*Caranx ignobilis*)	Behavioral ontogeny in larvae and early juveniles of the giant trevally (*Caranx ignobilis*) (Pisces: Carangidae)	Leis, Jeffrey M.; Hay, Amanda C.; Clark, Domine L.; Chen, I-Shiung; Shao, Kwang-Tsao	Fishery Bulletin, 104(3):401-414, 2006	Behavior of young (8−18 mm SL) giant trevally (Caranx ignobilis), a large coral-reef–associated predator, was observed in the laboratory and the ocean. Size was a better predictor of swimming speed and endurance than was age. Critical speed increased with size from 12 to 40 cm/s at 2.7 cm/s for each mm increase in size. Mean scaled critical speed was 19 body lengths/s and was not size related. Swimming speed in the ocean was 4 to 20 cm/s (about half of critical speed) and varied among areas, but within each area, it increased at 2 cm/s for each mm increase in size. Swimming endurance in the laboratory increased from 5 to 40 km at 5 km for each mm increase in size. Vertical distribution

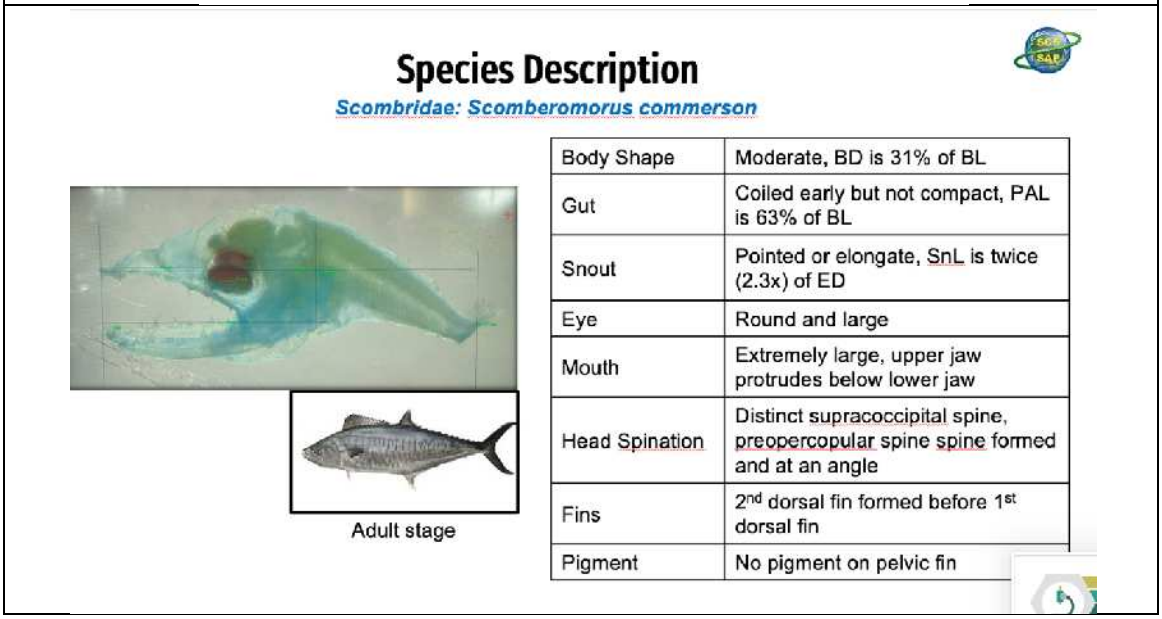
NO.	Key Words	Title	Author(s)	Journal	Abstract
					changed ontogenetically: larvae swam shallower, but more variably, and then deeper with growth. Two-thirds of individuals swam directionally with no ontogenetic increase in orientation precision. Larvae swam offshore off open coasts, but not in a bay. In situ observations of C. ignobilis feeding, interacting with pelagic animals, and reacting to reefs are reported.

X. RESULTS ON LARVAL FISH IDENTIFICATION

A. BRUNEI DARUSSALAM



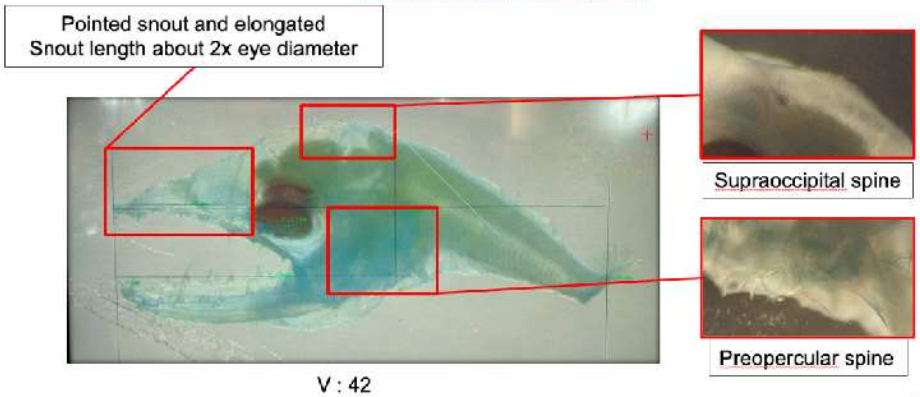




Body Shape	Moderate, BD is 31% of BL
Gut	Coiled early but not compact, PAL is 63% of BL
Snout	Pointed or elongate, SnL is twice (2.3x) of ED
Eye	Round and large
Mouth	Extremely large, upper jaw protrudes below lower jaw
Head Spination	Distinct supracoccipital spine, preopercopular spine spine formed and at an angle
Fins	2nd dorsal fin formed before 1st dorsal fin
Pigment	No pigment on pelvic fin

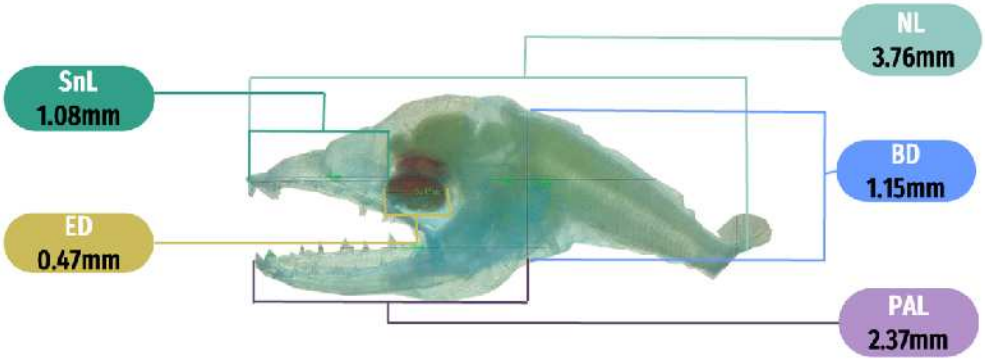
Morphological Characters

Scomberomorus commerson



V : 42

Morphological Measurement



Growth stage: Flexion

Species Description

Carangidae: Selar sp.

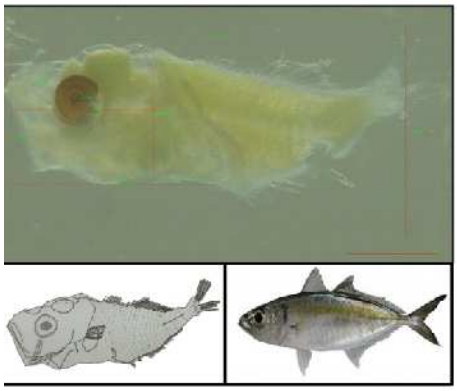
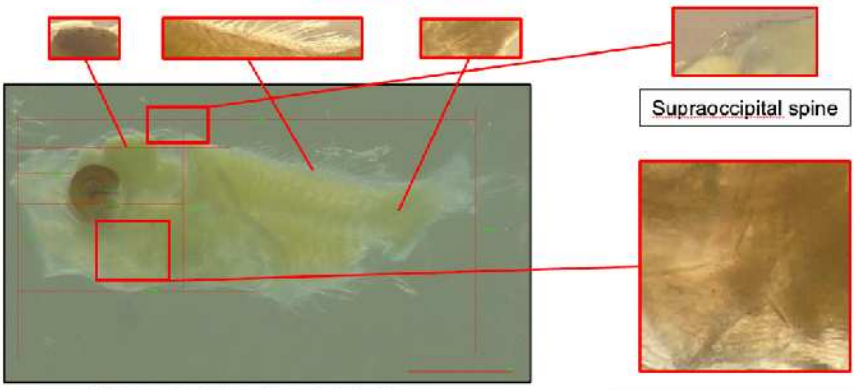


Illustration Adult stage

Body Shape	Moderate, BD is 34% of BL
Gut	Coiled early but not compact, PAL is more than ½ of BL (53% of BL)
Snout	Moderate and slightly concave. SnL is 33% of HL
Eye	Large and round, ED is 33% HL
Mouth	Large, oblique and terminal
Head Spination	SOC present, POC at an angle
Fins	-
Pigment	Head (sparse), along midline septum and dorsoventral.

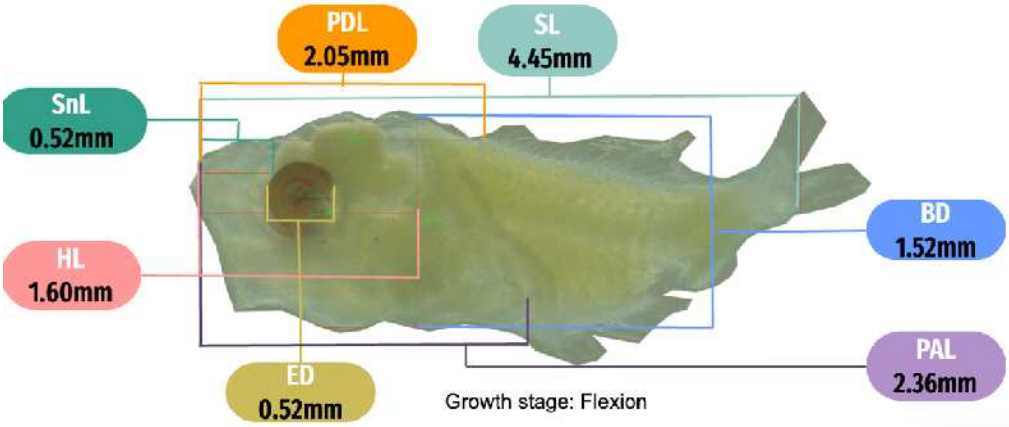
Morphological Characters

Carangidae: Selar sp.



V: 24 D: VIII-I, 23 A: II-I, 23

Morphological Measurement



Growth stage: Flexion

Species Description

Family: Engraulidae

Encrasicholina punctifer

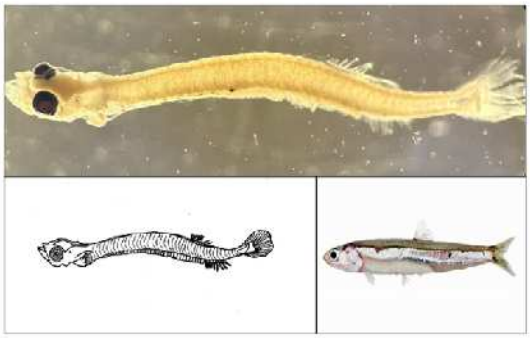
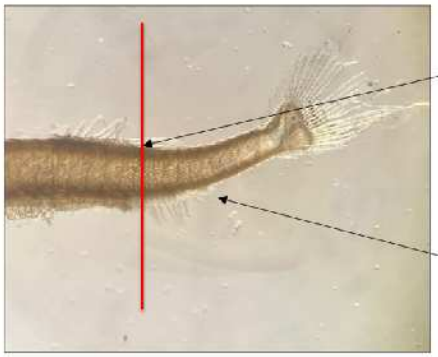


Illustration Adult Stage

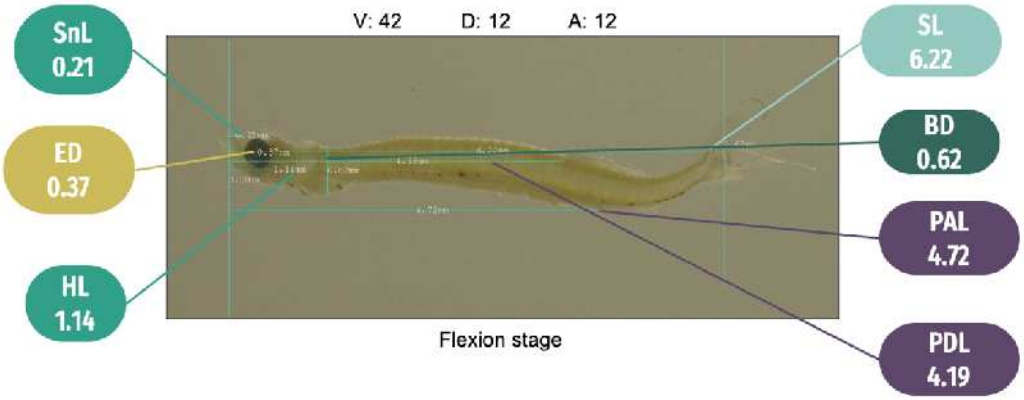
Body Shape	Very elongate, BD is 10% of SL
Gut	Very long, PAL is 76% of SL
Snout	Short and slightly concave, SnL is 18% of HL
Eye	Round and large
Mouth	Small and terminal
Head Spination	None
Fins	Origin of anal fin just under end of dorsal fin
Pigment	Gut, hindbrain, ventral s of tail

Morphological Characters

Encrasicolina punctifer



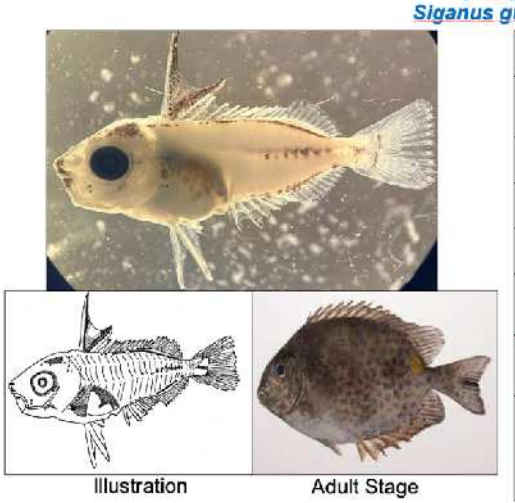
Morphological Measurement (mm)



Species Description

Family: Siganidae

Siganus guttatus



Body Shape	Moderate, BD is 34% of SL
Gut	Gut folds and compact, PAL is 53% of SL
Snout	Blunt, SnL is 35% of HL
Mouth	Small
Eye	Round and large
Head Spination	Serrate ridges form on preopercular
Fins	Second dorsal spine and first pelvic spine are subequal length
Pigment	Upper & lower jaw, Head, Hindgut, Notochord, dorsal fin & anal fin base, dorsal & anal fin membrane

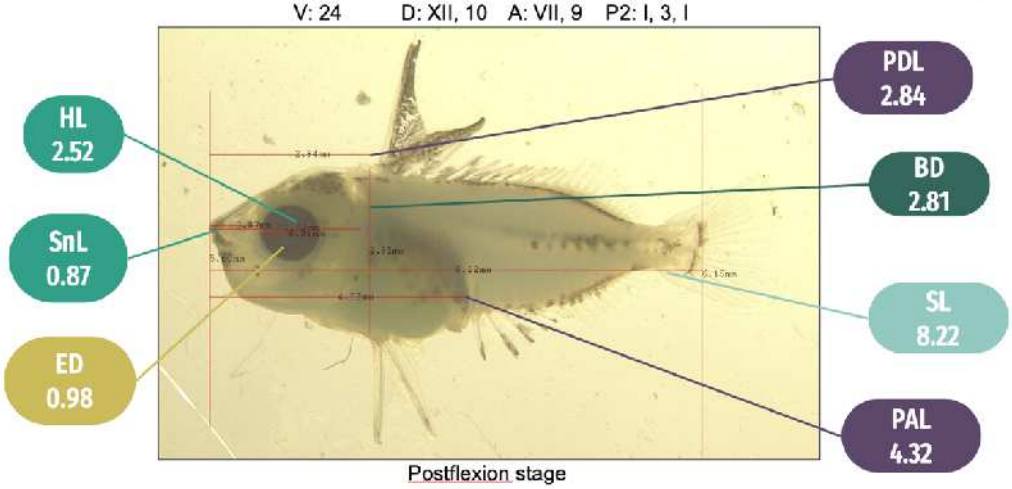
Morphological Characters

Siganus guttatus

Length of the second ridge of the dorsal fin and the outer spine of the pelvic fin to the total length are subequal length

Morphological Measurement (mm)

V: 24 D: XII, 10 A: VII, 9 P2: I, 3, I



Postflexion stage

B. CAMBODIA

Regional training workshop on fish larvae

Phase1: Larval Fish Identification and Early life History Science

Results of species identification and morphological description of examinate larvae and juvenile and future working subjects to be planned

Prepare by: Cambodia Participant on 26-Nov-2022

Mr :THACH Phanara

Mr :HOK Seiha

SEAFDEC/TD, Samunt Prakan, Thailand

Content

Introduction

fish larvae identification is essential for understanding spawning grounds and their abundance and also identification helps to confirm the morphological identification result.

This study's purpose is to confirm on fish larvae morphological identification result is possible following as :

❖Developmental stage of fish

- Egg development
- Newly Hatched (yolk-sack)
- Larvae (Characters of Pre flexion larvae and external Characters of Post flexion Larvae)

❖ Identification Method

- Description of body shape fish larvae
- Standard measurement

Genera of Scombridae

Family Scombridae
↘ **Genus** *Auxis*
↘ **Species** sp.
↘ **Scientific name** *Auxis* sp.

❑ **Standard Measurement (mm)**

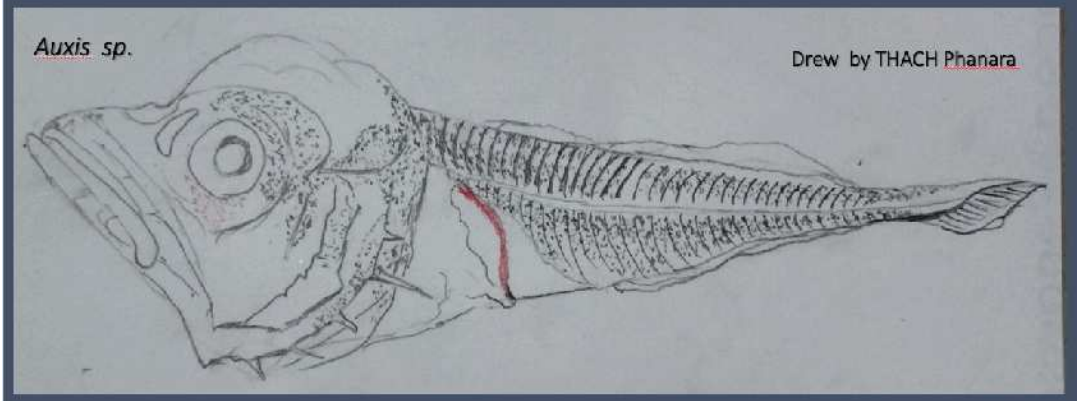
- Standard length :11.28mm
- Body depth :2.66mm
- Body length :12.28mm
- Snot Length :1.95mm
- Eye Diameter :1.34mm
- Head Length :6.43mm
- Pre-Anal length :6.15mm

Description of *Auxis* sp.

- **Body Shap** : Moderate (BD 30% of SL)
- **Head** : large Preopercular and well developed
- **Myomere** : Around TM 34-36
- **Gut** : Compact and anus position with growth
- **Snout** : Snout pointed
- **Mouth** : Low jaw tip usually pigment
- **Fin Information** : fin-tail are present
- **Pigment** : No pigment on anterior margin of the forebrain, dorsal line, and literal line .

Species *Auxis* sp.

Species *Auxis* sp.



Genera of Scombridae (cont)

Family Scombridae
Genus *Rastrelliger*
Species sp.
Scientific name *Rastrelliger* sp.

❑ **Standard Measurement (mm)**

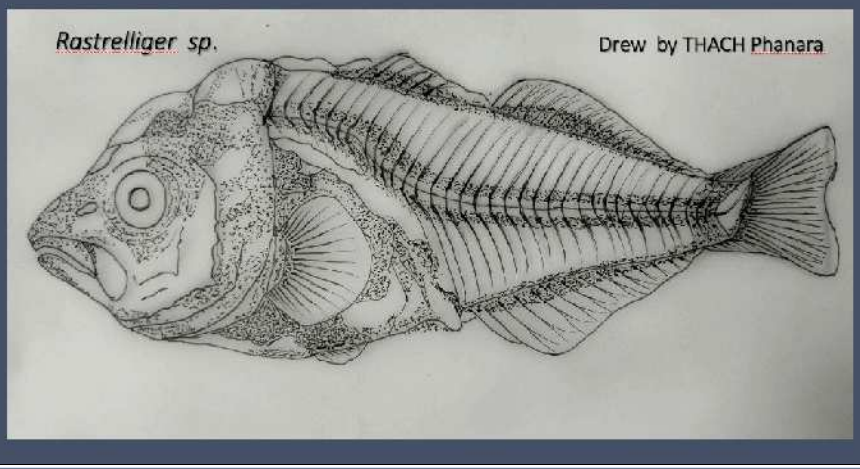
- Standard length :6.82mm
- Body depth :2.25mm
- Body length :6.82mm
- Snout Length :0.88mm
- Eye Diameter :0.80mm
- Head Length :2.50mm
- Pre-Anal length :2.67mm
- Pre-Dosal-fin length :0.50mm

Description of *Rastrelliger* sp.

- **Head** : Pigment over brain sparse at pre flexion to flexion stage
- **Myomere** : Around TM 29-31
- **Anus** : Anus and anal-fin origin spaced
- **Snout** : No point
- **Mouth** : Both jaw tips nearly join
- **Fin Information** : Dorsal-fin and Anal-fin develops are presented
- **Pigment** : No pigment on anterior margin of the forebrain, dorsal line, and literal line,

Species *Rastrelliger* sp.

Species *Rastrelliger* sp.



Genera of Carangidae

Family Carangidae
Genus *Decapterus*
Species spp.
Scientific name *Decapterus* spp.

❑ **Standard Measurement (mm)**

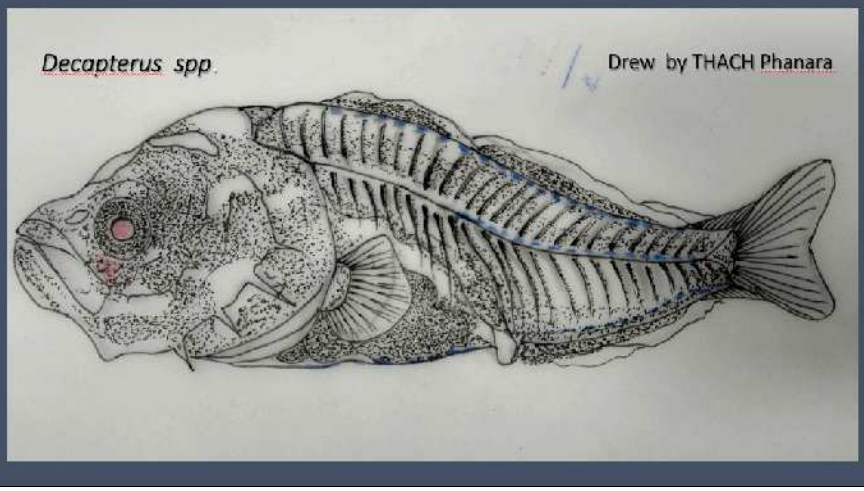
- Standard length :3.41mm
- Body depth :1.21mm
- Body length :3.88mm
- Snout Length :0.48mm
- Eye Diameter :0.43mm
- Head Length :1.13mm
- Pre-Anal length :2.06mm
- Pre-Dosal-fin length :1.44mm

Description of *Decapterus* spp.

- **Head** : Large and pigment present on head 3-5
- **Myomere** : Around TM 24-26
- **Vertebrae** : Around TV 10+16
- **Gut** : Compact and anus position with growth
- **Snout** : Snout pointed and around
- **Mouth** : Low jaw tip usually pigment
- **Fin Information** : 2 rows present melanophores appear long and dorsal fin base
- **Pigment** : pigment are present on anterior margin of the forebrain, dorsal line, and literal line .

Species *Decapterus* spp.

Species *Decapterus* spp.



Genera of Engraulidae

Family Engraulidae
Genus *Engraulis*
Species japonica.
Scientific name *Engrauli japonica*

❑ **Standard Measurement (mm)**

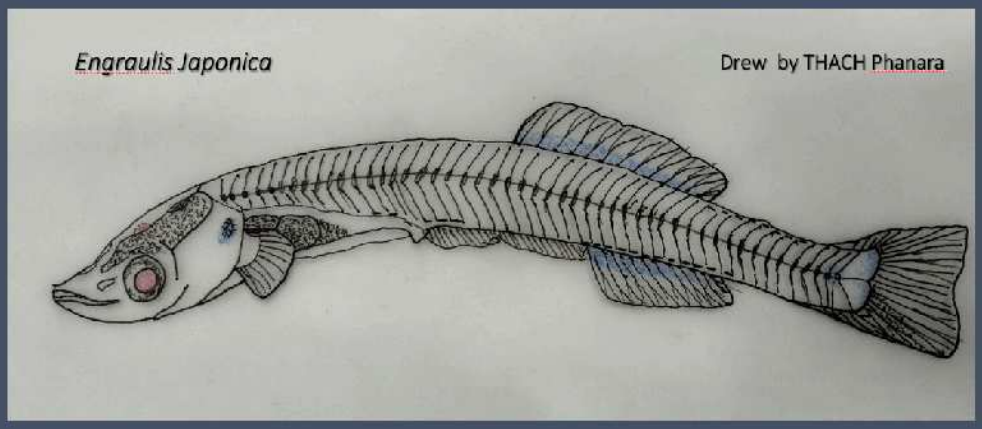
- Standard length :11.23mm
- Body depth :1.52mm
- Body length :11.88mm
- Snout Length :0.68mm
- Eye Diameter :0.52mm
- Head Length :2.68mm
- Pre-Anal length :5.31mm
- Pre-Dosal-fin length :7.81mm

Description of *Engraulis japonica*

- **Myomere** : Around TM 42-44
- **Gut** : Compact, gut relatively short and anus under or just posterior to dorsal fin
- **Snout** : Snout pointed and around
- **Mouth** : Low jaw tip usually pigment
- **Fin Information** : Origin of anal fin just under end of dorsal fin, anal fin base short (Dorsal fin 13-14 , Anal fin 14-16)
- **Pigment** : pigment present on the ventral midline
- **Remark** : Dorsal and the ventral midline of the caudal peduncle heavily pigment

Species *Engraulis japonica*

Species *Engraulis japonica*



Genera of Siganidae

Family Siganidae
Genus *Siganus*
Species *guttatus*
Scientific name *Siganus guttatus*

❑ **Standard Measurement (mm)**

- Standard length :6.15mm
- Body depth :2.32mm
- Body length :6.65mm
- Snout Length :0.63mm
- Eye Diameter :0.77mm
- Head Length :2.27mm
- Pre-Anal length :2.18mm
- Pre-Dosal-fin length :2.26mm
- VAFL :1.67mm

Description of *Siganus guttatus*

- **Head** : Large and pigment present on heavily
- **Myomre** : Can't Count
- **Vertebrae** : Can't Count
- **Gut** : Anus beyond the middle body
- **Mouth** : both jaws are present
- **Fin Information** : first dorsal spine is short, the dorsal fin is pigment, dorsal fin 13, dorsal fin ray 9, Anal fin spine 6, second anal fin ray 8
- **Pigment** : Caudal fin Dorsal fin Anus fin and body shape present on heavily
- **Remark** : second dorsal spine elongates and the second spine is present, Pelvic spine2 and soft spine ray elongate

Siganus guttatus

Siganus guttatus

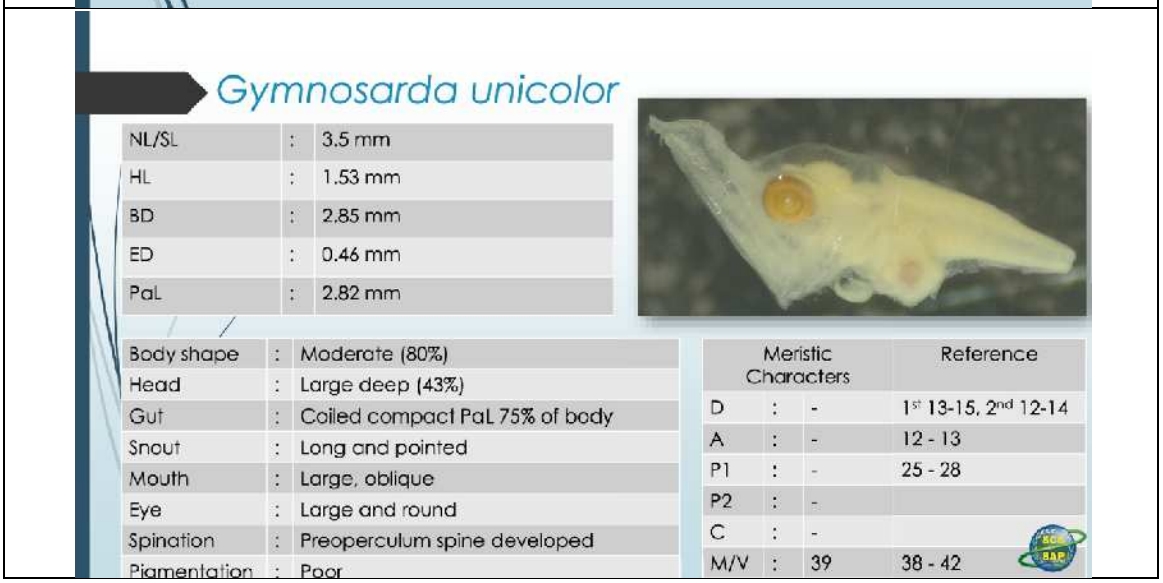
Planning Future Work

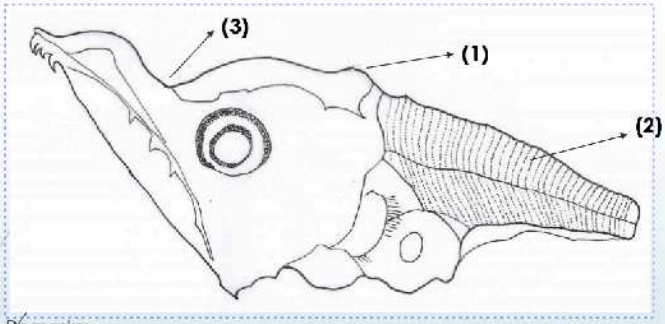
- To study larvae and juvenile fish abundance and diversity through two sampling locations – Mekong and Tonle Sap Rivers close to Phnom Penh
- To assess fish larvae quantity and density.
- To compare fish larvae abundance, quantity/density, and diversity amongst the left, middle and right monitoring sites of the river.
- To assess the likely fish spawning grounds.

C. INDONESIA


TRAINING COURSE ON FISH LARVAE: PHASE I
RESULT OF SPECIES IDENTIFICATION AND MORPHOLOGICAL DESCRIPTION OF EXAMINED LARVAE AND JUVENILE
Group 3 (Indonesia):
Masayu Rahmia Anwar Putri
Indriatmoko
16 – 26 November 2022
Samut Prakan, Thailand


FAMILY SCOMBRIDAE


Gymnosarda unicolor
NL/SL : 3.5 mm
HL : 1.53 mm
BD : 2.85 mm
ED : 0.46 mm
PaL : 2.82 mm
Body shape : Moderate (80%)
Head : Large deep (43%)
Gut : Coiled compact PaL 75% of body
Snout : Long and pointed
Mouth : Large, oblique
Eye : Large and round
Spination : Preoperculum spine developed
Pigmentation : Poor
Meristic Characters
Reference
D : - 1st 13-15, 2nd 12-14
A : - 12 - 13
P1 : - 25 - 28
P2 : -
C : -
M/V : 39 38 - 42



Remarks:

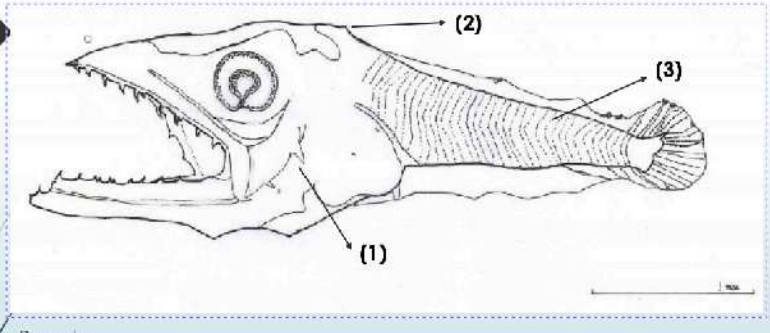
- This specimen show several characteristic typical for scombrids family by **large head and eyes**, and head spination. The myomere number of this family more than 31, different with some families Nemipterids, Sparids, Teraponlidae, and Ambassidae, which have lower number of myomere. This specimen is not Pingupedids because the head spination is not well developed.
- During the identification, the specimen characteristic resemble *Scomberomorus commerson* and *Gymnosarda unicolor*. But in several characteristic it closest to *Gymnosarda*, i.e. absent supraoccipital spine **(1)**, relatively small preoperculum, and the myomers was less than 42 **(2)** (*Scomberomorus commerson* myomer from 42-52). In addition, the curved head shape on the forebrain similar to 3.4 mm NL *Gymnosarda unicolor* illustration provided by Okiyama and Ueyanagi (1977) **(3)**

Scomberomorus commerson

NL/SL	:	5.1 mm
HL	:	2.33 mm
BD	:	1.48 mm
ED	:	0.57 mm
PaL	:	2.85 mm
SnL	:	1.31 mm
PdL	:	2.58 mm

Body shape	:	Moderate, BD 29% of BL
Head	:	Large, 45% of BL
Gut	:	Coiled not compact, PaL > ½ BL
Snout	:	Pointed and elongated
Mouth	:	Oblique and large
Eye	:	Large and round
Spination	:	Developed
Piamentation	:	Poor

Meristic Characters			Reference
D	:	-	1st 13-22, 2nd 15-25
A	:	-	16-29
P1	:	-	20-26
P2	:	-	
C	:	-	
M/V	:	46	41 – 56



Remarks:

- This specimen show several characteristic typical for scombrids family by large head and eyes, and head supination. The myomere number more than 31, different with some families Nemipterids, Sparids, teraponlidae, and Ambassidae, which have lower number of myomere. This specimen is not Pingupedids because the head spination is not well developed.
- Preopercular spine present **(1)**
- Supraoccipital spine present **(2)**
- The different with *Sarda* sp. observed from the vertebrae, 44-45 for *Sarda* and 42-46 for *S. commerson* **(3)**

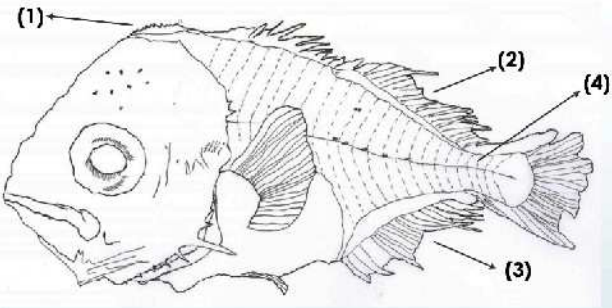
FAMILY CARANGIDAE

Carangoides chrysophrys

NL/SL	:	5,14 mm
HL	:	2,15 mm
BD	:	2,41 mm
ED	:	0,71 mm
PaL	:	3,08 mm
SnL	:	0,63 mm
PdL	:	2,25 mm

Body shape	:	Deep (BD 46% BL)
Head	:	Large, deep (HL 42% BL)
Gut	:	Coiled not compact
Snout	:	Moderate
Mouth	:	Large, terminal
Eye	:	Large and round
Spination	:	Well developed
Pigmentation	:	Poor, Pigment spots small on the body and midhead

Meristic Characters			Reference
D	:	VIII-1,19	VIII-1,18-20
A	:	II-I, 14	II-I, 14-17
P1	:	-	
P2	:	-	
C	:	-	
M/V	:	24	10 + 14



Remarks

- The main characters of Carangidae observed from the specimen are the present of SOC (not Lactaridae and Nomeidae), relatively long PAL (not Apogonidae), smaller gut than Chaetodontidae, the myomere less than 30 (not Citharidae).
- Supraoccipital crest **(1)** present and body shape deep as member of group I
- The first dorsal fin soft ray is not elongate (not *Alectis* sp.), no pigmentation observed on the abdominal finfold (not *Caranx* sp.), preoperculum spine not very elongate (not *Gnathanodon* sp.), and the dorsal fin rays less than 40 (not *Parastromateus* sp.). Thus the closest identity for this specimen is *Carangoides* sp.
- Among 15 *Carangoides* species, the closest characteristic similar to this specimen is *C. chrysophrys* because the dorsal fin rays is 19 (18-20) **(2)**, the anal fin rays is 14 (14-17) **(3)**, the scutes is not observable, and the vertebrae for most of Carangoides species is 24 **(4)**.

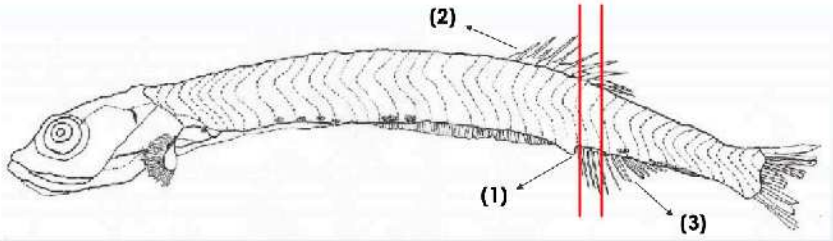
FAMILY ENGRAULIDAE

Enchrasicholina heteroloba

NL/SL	:	9,15 mm
HL	:	1,73 mm
BD	:	0,88 mm
ED	:	0,43 mm
PaL	:	6,82 mm
SnL	:	0,44 mm
PdL	:	6,04 mm

Body shape	:	Very elongate (BD 9% BL)
Head	:	Small (HL 18% BL)
Gut	:	Straight very long
Snout	:	Long and pointed
Mouth	:	Large and terminal
Eye	:	Large and round (ED 25% HL)
Spination	:	-
Pigmentation	:	Poor, small spots on the body

Meristic Characters			Reference
D	:	13	13 – 15
A	:	12	15 -19
P1	:	-	
P2	:	-	
C	:	-	
M/V	:	44	41 - 44



Remarks:

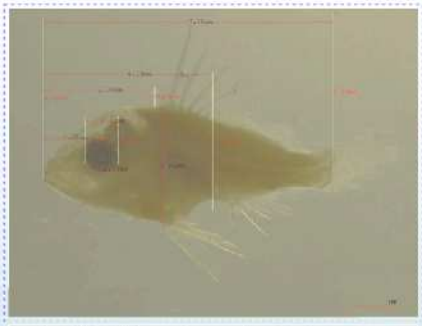
- The identification keys to the family are the elongate body shape and anus under or just posterior to dorsal fin.
- As a member of Engraulidae with the number of anal fin rays less than 30, this specimen has closest characteristic to *Stolephorus*, *Encrasicholina*, and *Engraulis*.
- The specimen is not *Engraulis* because the origin of anal fin just anterior to end of dorsal fin. The specimen also is not *Stolephorus* because of lower number of dorsal and anal rays. In *Stolephorus*, dorsal rays 14-18 and in anal rays 17-24, while for *Encrasicholina*, dorsal and anal rays, 12-16 and 14-21, respectively.
- The main characteristics in identifying this specimen as *E. heteroloba* was from the position origin of anal fin just anterior to end of dorsal fin **(1)**.
- The reference number of dorsal and anal rays for *E. heteroloba* is 13-15 and 15-19, respectively. The number of dorsal rays suitable with the reference (13 dorsal rays) **(2)**, but in this specimen the anal rays is 12 **(3)**, less then 15. This was due to in this specimen size (less than 10 mm) the rays is possibly not well-developed yet.

FAMILY LUTJANIDAE

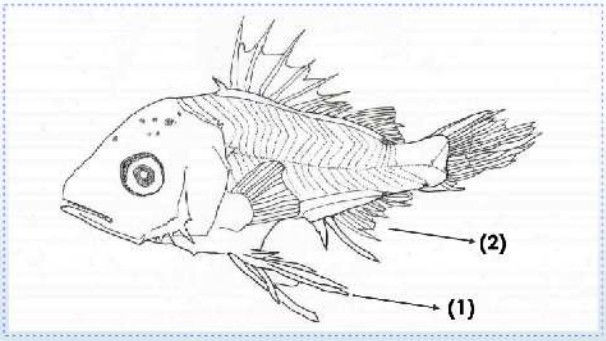
Lutjanus sp.

NL/SL	:	7,10 mm
HL	:	2,99 mm
BD	:	2,82 mm
ED	:	0,82 mm
PaL	:	4,15 mm
SnL	:	1,01 mm
PdL	:	2,75 mm

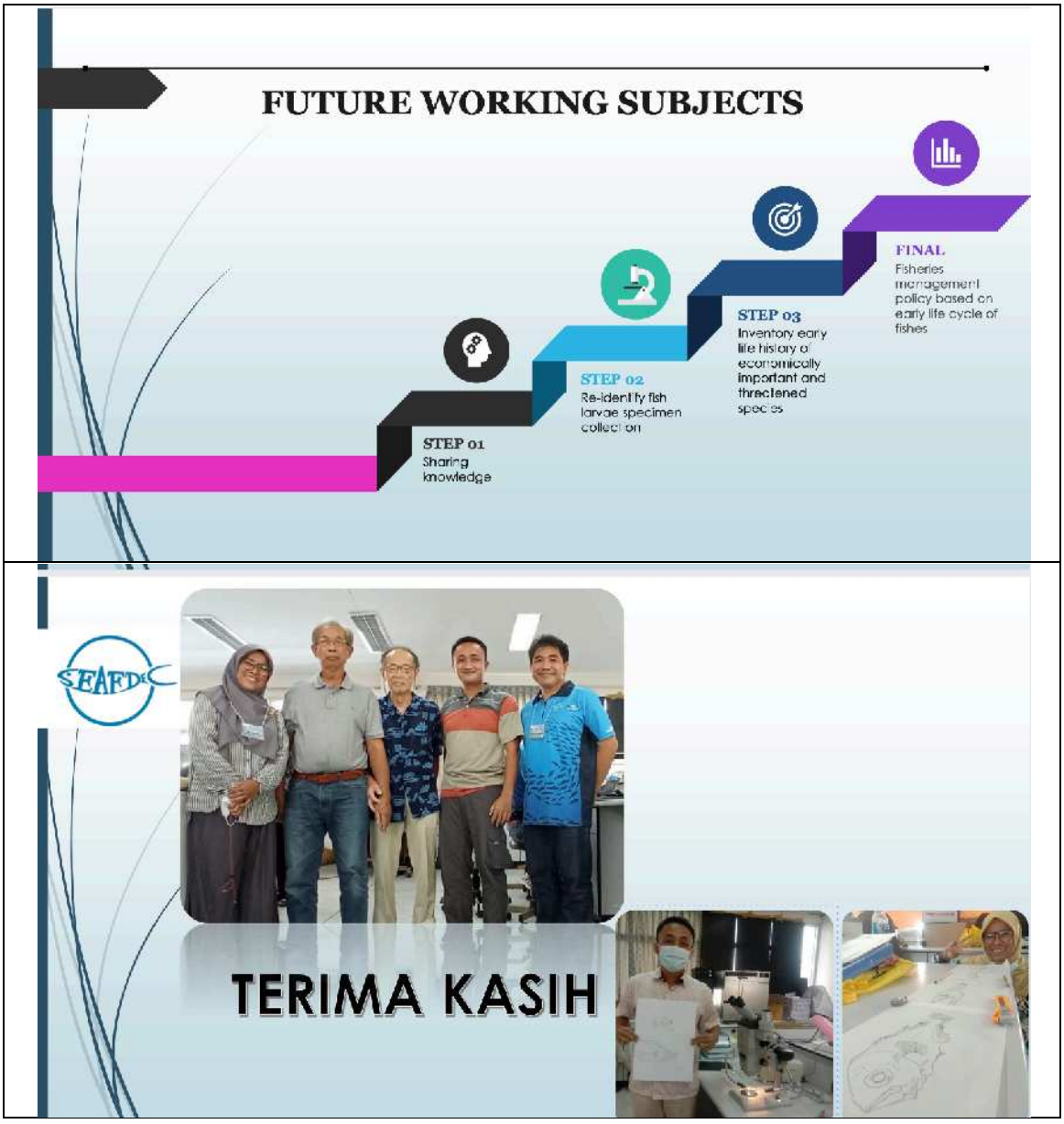
Body shape	:	Moderate (BD 39% BL)
Head	:	Moderate (HL 42% BL)
Gut	:	Coiled not compact
Snout	:	Moderate
Mouth	:	Small and terminal
Eye	:	Round
Spination	:	Well developed
Pigmentation	:	Some pigmentations on the head and posterior of the body



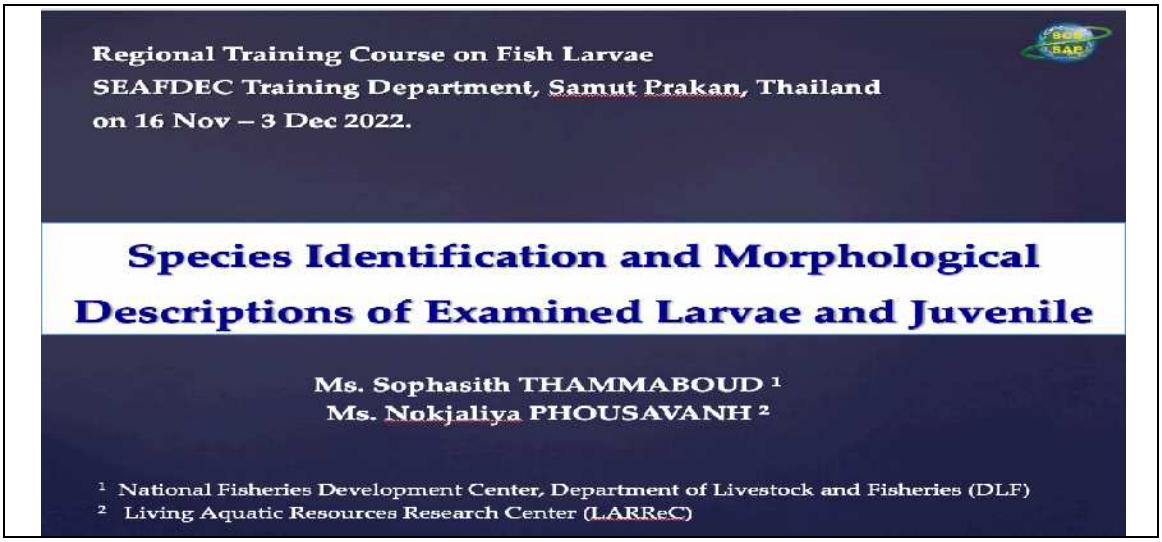
Meristic Characters			Reference
D	:	X, 13	X-XII, 12-16
A	:	III, 8	III, 7 – 11
P1	:	15	15 – 17
P2	:	I, 5	I, 5
C	:	17	
M/V	:	24	10 + 14



- The first characteristic on determining Lutjanidae identity from this specimen was from the dorsal spine formation. The round shape of caudal fin was also ensure that this specimen is a lutjanid and not caesonidae. The absent of serrate ridges on the forehead of this specimen was also ensure that this specimen is not siganidae.
- Its ray pelvic fin is a little longer than the pelvic spine **(1)**. From the anal rays number (8) **(2)**, this specimen was different from *Macolor sp.* which has 10-11 and *Caesio sp.* which has 10-13.


FUTURE WORKING SUBJECTS
STEP 01
Sharing knowledge
STEP 02
Re-identify fish larvae specimen collection
STEP 03
Inventory early life history of economically important and threatened species
FINAL
Fisheries management policy based on early life cycle of fishes
SEAFDEC
TERIMA KASIH

D. LAO PDR


Regional Training Course on Fish Larvae
SEAFDEC Training Department, Samut Prakan, Thailand
on 16 Nov – 3 Dec 2022.
Species Identification and Morphological Descriptions of Examined Larvae and Juvenile
Ms. Sophasith THAMMABOUD [1]
Ms. Nokjaliya PHOUSAVANH [2]
[1] National Fisheries Development Center, Department of Livestock and Fisheries (DLF)
[2] Living Aquatic Resources Research Center (LARReC)

1. Scombridae Larvae

Measurement (mm)

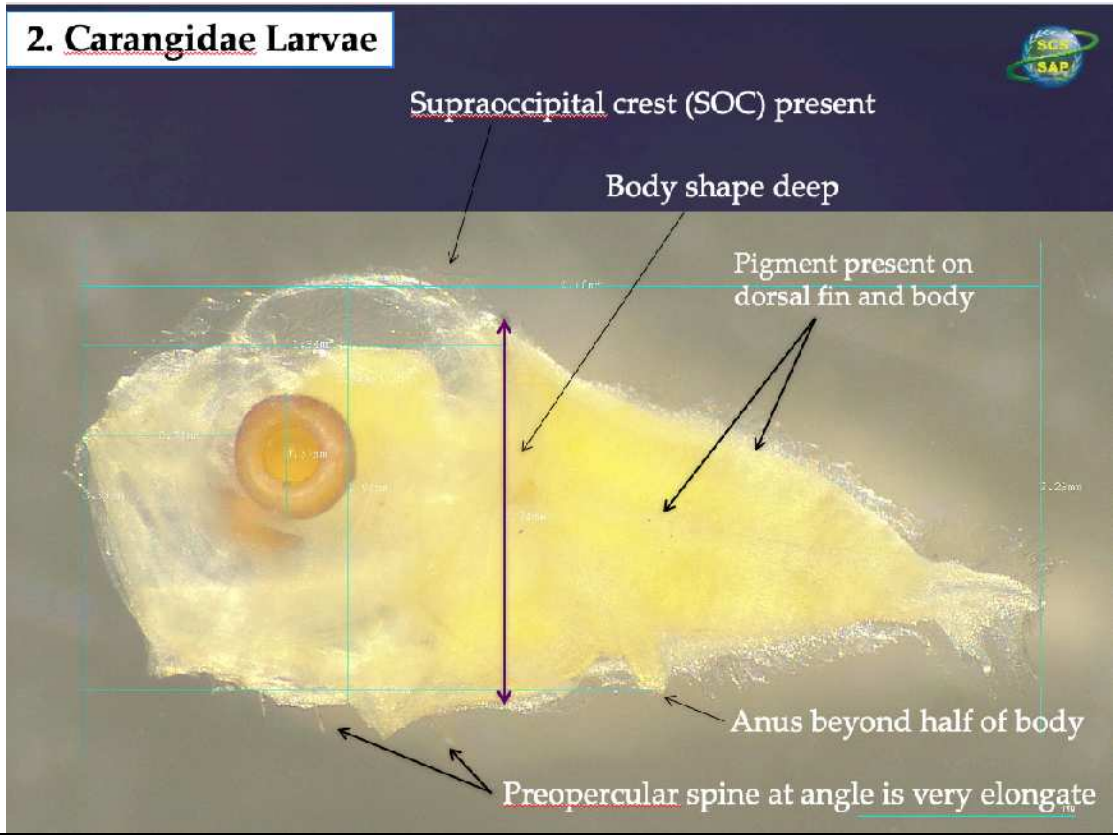
- Body length : 4.35 mm
- Body depth : 1.33 mm (30.5% BL)
  Body depth moderate
- Eye diameter : 0.54 mm
- Head length : 1.51 mm
- Pre-anal length: 2.12 mm
- Pre-dorsal length : 2.06 mm
- Snout length : 0.41 mm

Morphological Description

- Preopercular spine absent
- Pigment present sparsely over brain
- Spots on ventral gut and preanus
- Myomere ≈ 31

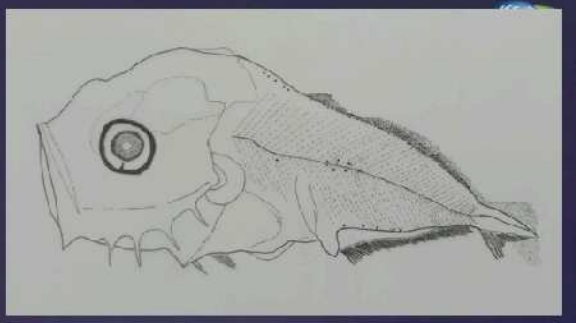
Family: Scombridae
Tribe: Scombrini
Genus: Rastrelliger
Specie: R……

2. Carangidae Larvae



Measurement (mm)

- Body length : 4.40 mm
- Body depth : 1.74 mm (39.5% BL)
  Body depth moderate
- Eye diameter : 0.57 mm
- Head length : 1.94 mm
- Pre-anal length: 2.62 mm
- Pre-dorsal length : 2.34 mm
- Snout length : 0.71 mm

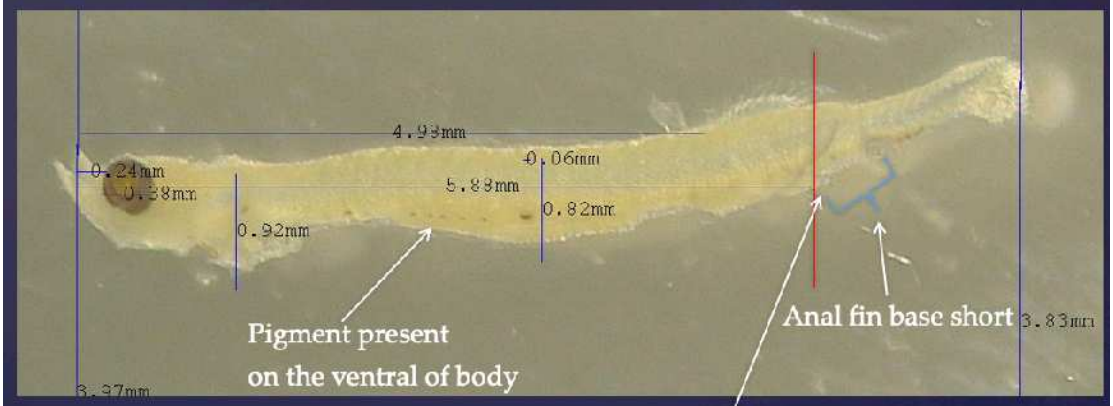


Morphological Description

- Supraoccipital crest (SOC) present
- Body shape deep
- Pigment present on dorsal fin and body
- Preopercular spine elongate
- Anus beyond half of body

Family: Carangidae
Tribe: Carangini
Genus: Gnathanodon
Specie: G. *speciosus*

3. Engraulidae Larvae



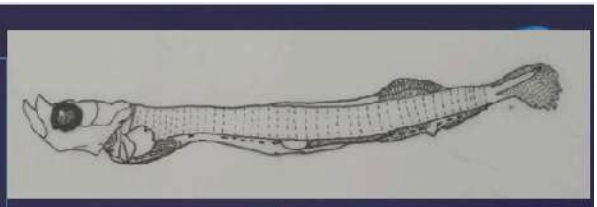
Origin of anal fin just
under end of dorsal fin

Measurement (mm)

- Body length : 7.56 mm
- Body depth : 0.82 mm (10.85%BL)

Body elongate

- Eye diameter : 0.38 mm
- Head length : 0.92 mm
- Pre-anal length: 5.88 mm
- Pre-dorsal length : 4.98 mm
- Snout length : 0.24 mm



Family: Engraulidae
Genus: Encrasicholina
Specie: E. *punctifer*

Morphological Description

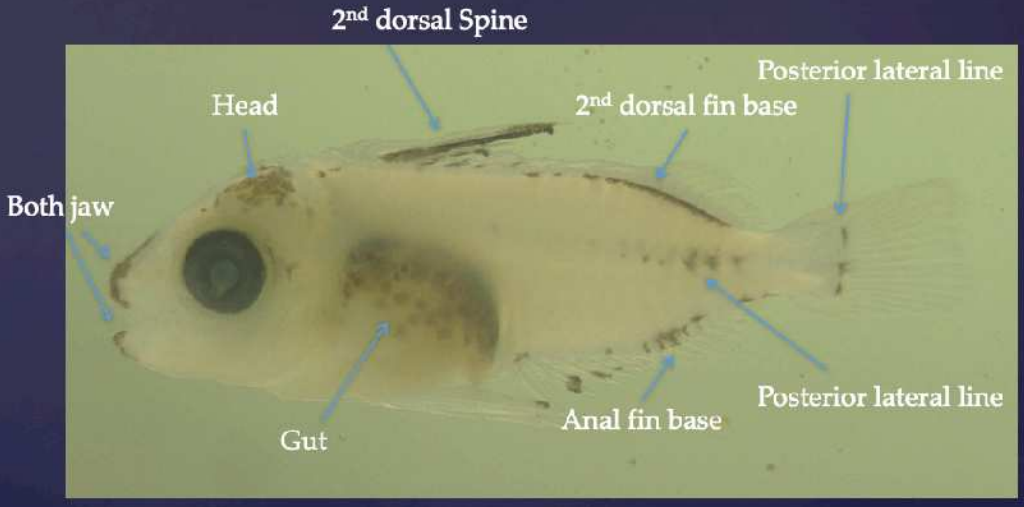
- Origin of anal fin just under end of dorsal fin
- Anal fin base short
- Pigment present on the ventral of body

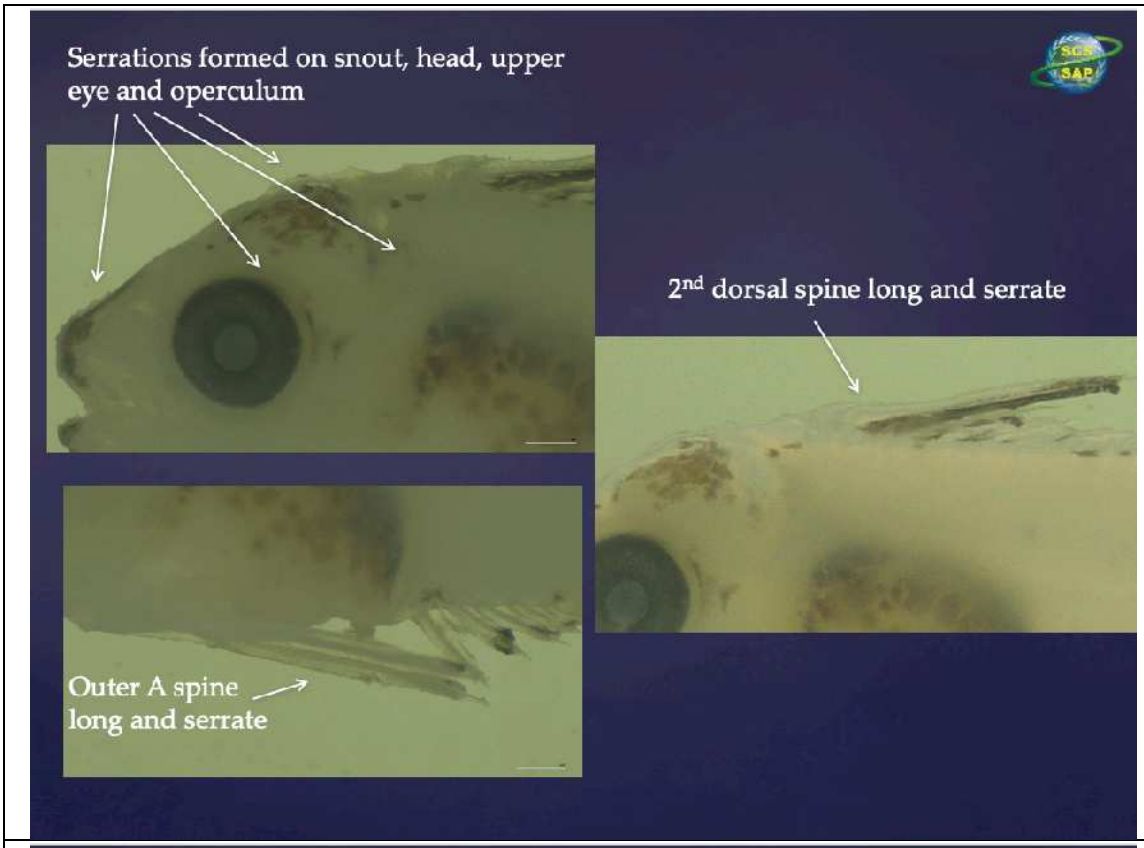
Counting

- M = 40-44
- D = 12-14

4. Siganidae Larvae

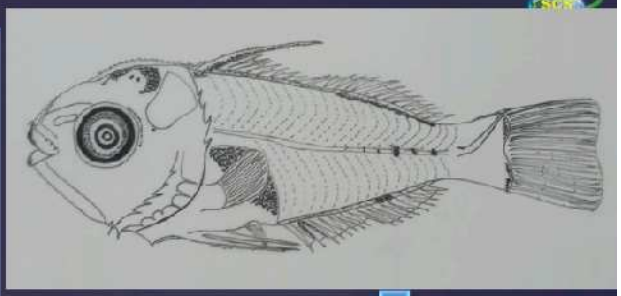
Pigment presented





Measurement (mm)

- Body length : 7.64 mm
- Body depth : 2.36 mm (30.8%BL)
  Body depth moderate
- Eye diameter : 0.87 mm
- Head length : 2.45 mm
- Pre-anal length: 3.99 mm
- Pre-dorsal length : 2.26 mm
- Snout length : 0.78 mm



Family: Siganidae
Genus: Siganus
Specie: S. *Guttatus*

Morphological Description

- 2nd dorsal spine long and serrate
- Outer A spine long and serrate
- Serrations formed on snout, head and eye
- Preopercular spines form
- Pigment develop

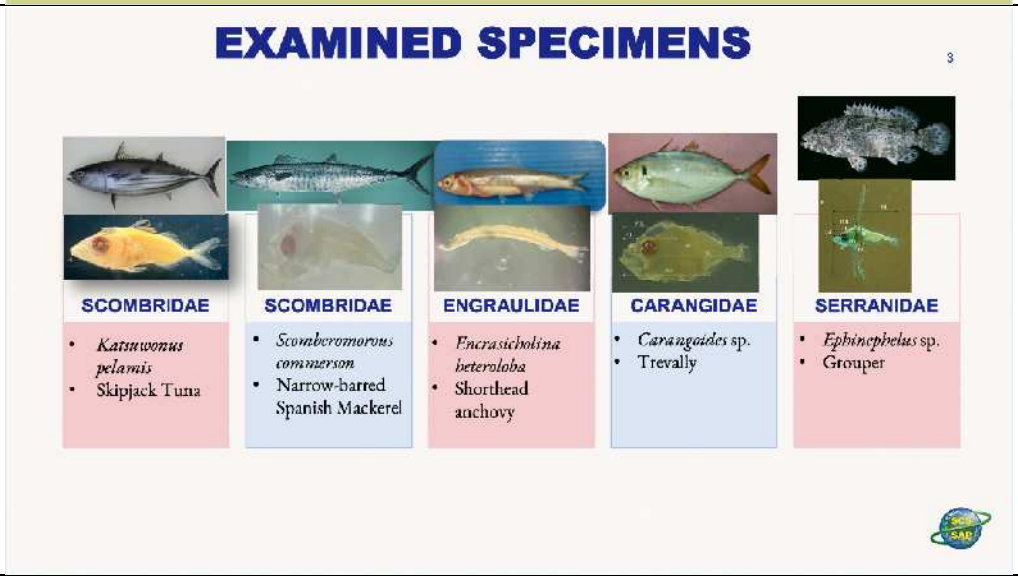
Counting

- D = 20
- A = 16-17

E. MALAYSIA


Regional Training Course on Fish Larvae
Phase I: Larval Fish Identification and Fish Early Life History Science
16-27 November 2022,
SEAFDEC Training Department, Samut Prakan, Thailand
Jabatan Perikanan Malaysia
TASK 3: SPECIES IDENTIFICATION AND MORPHOLOGICAL DESCRIPTIONS OF FISH LARVAE (FAMILY: SCOMBRIDAE, CARANGIDAE, ENGRAULIDAE & SERRANIDAE)
NUR HIDAYAH ASGNARI
PERCEVAL CONDER
CECILIA CHU
26 November 2022
MALAYSIA

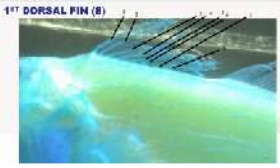

2
MEET OUR TEAM
NUR HIDAYAH ASGNARI
Research Officer
Department of Fisheries Malaysia
PERCEVAL CONDER
Research Officer
Department of Fisheries Malaysia
CECILIA CHU
Researcher
University of Nottingham Malaysia

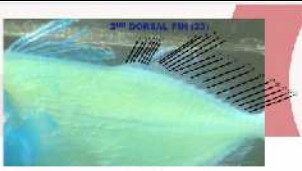

EXAMINED SPECIMENS
3
SCOMBRIDAE
Katsuwonus pelamis
Skipjack Tuna
SCOMBRIDAE
Scomberomorous commerson
Narrow-barred Spanish Mackerel
ENGRAULIDAE
Encrasicholina heteroloba
Shorthead anchovy
CARANGIDAE
Carangoides sp.
Trevally
SERRANIDAE
Ephinephelus sp.
Grouper

1

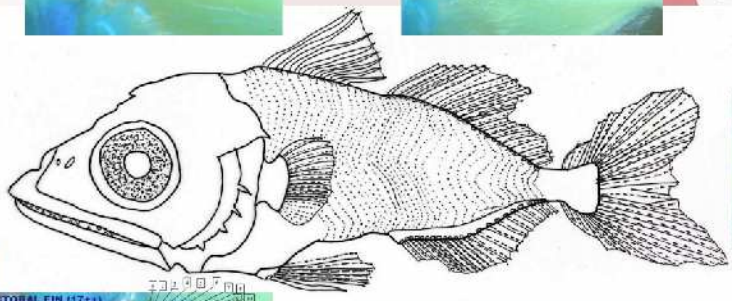
SCOMBRIDAE

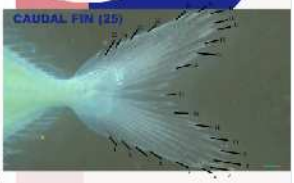
Katsuwonus pelamis

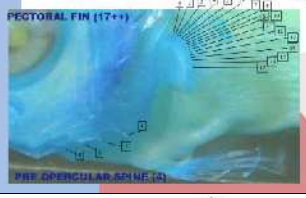


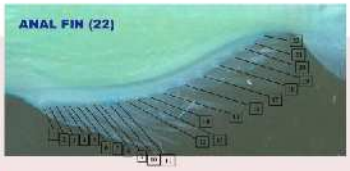


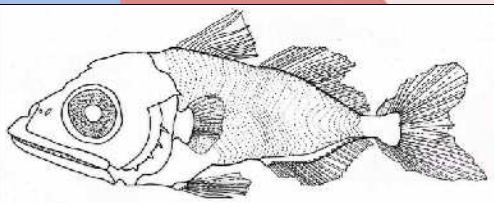
SCOMBRIDAE
Katsuwonus pelamis











KEYS TO IDENTIFY UNTIL SPECIES LEVEL:

1b. First dorsal fin develop prior second dorsal fin 3

3b. Snout pointed or elongated. Preopercular spines form elongate at angle. Vertebrae (myomere) >39..... 4

4b. Supraoccipita spine absent..... 6

6b. Body moderate and tail tapering. Gut compact and anus position anterior to or near half the body. Snout pointed or elongate. Mouth moderate or large. Myomere 38-41 7

7b. Snout pointed. Both jaw tips nearly ..... Or upper jaw tip slightly projecting at postflextion stage. Branchiostegal membrans and opercular area sparsely pigmented..... 8

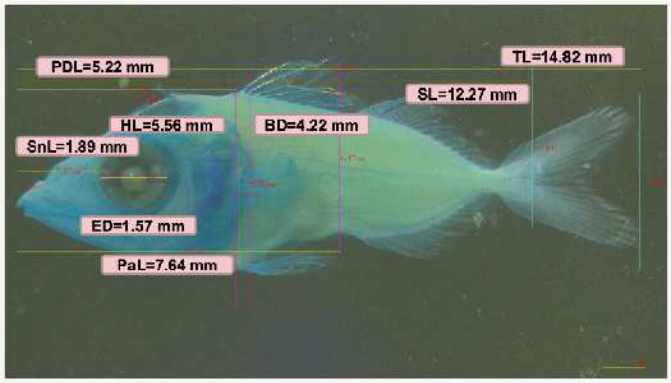
8a. Internal pigment present on anterior margin of forebrain..... 9

9b.Cleithial symphysis (ithsmus) and pre anus unpigmented. 10

10a. Pigment appears early on lower jaw tip at about 3.5 mm NL. First dorsal fin pigmented late at above 6mm SL. Pigment appear late on upper jaw. Myomere 41.....***Katsuwonus pelamis***

Measurement

7

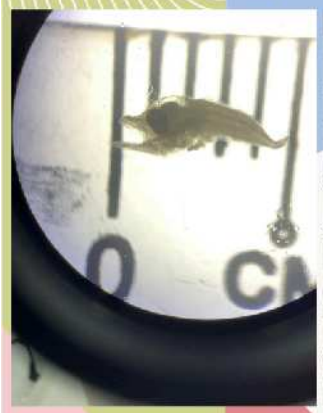


No	Part	Measurement (mm)	Notes
1	SL	12.27	
2	TL	14.82	
3	BD	4.22	
4	HL	5.56	
5	ED	1.57	
6	PAL	7.64	
7	SnL	1.89	
8	PDL	5.22	

*Notes:
SL = Standard Length
TL = Total Length
BD = Body Depth
HL = Head Length
ED = Eye Diameter
PAL = Pre Anal Length
SnL = Snout Length
PDL=Pre dorsal-fin length

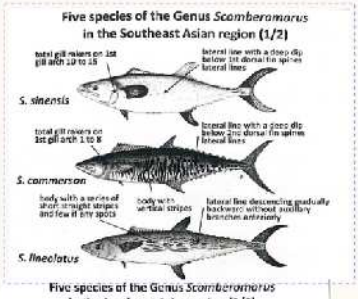
2 SCOMBRIDAE

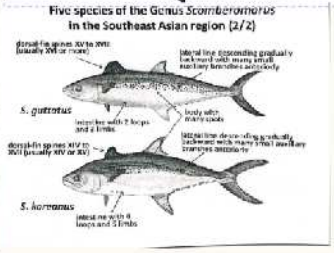
8



Scomberomorus commerson
Tenggiri batang

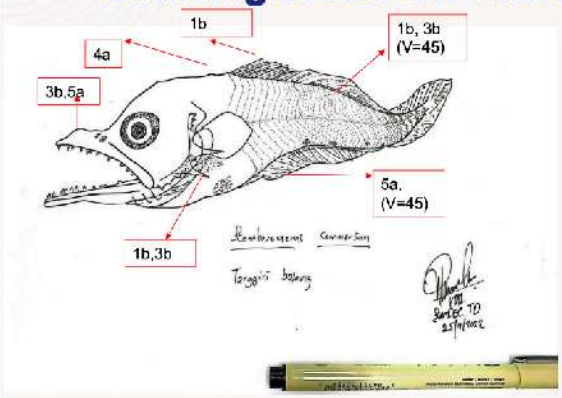
Genus identified= *Scomberomorus*





10

Drawing based on Microscope Observation



1b. First dorsal fin develop prior second dorsal fin. Preopercular spines present. Vertebrae (myomere) 31-64 3

3b. Snout pointed. Preopercular spines form usually well and elongate at angle. Vertebrae (myomere) >39..... 4

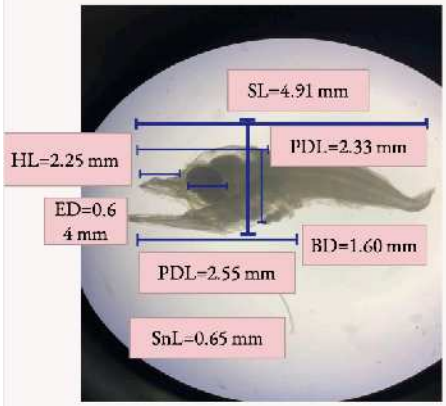
4a. Supraoccipital spine present..... 5

5a. Snout elongate and it length about 2x of eye diameter. Supraoccipital spine distinct. No pigment appears on pelvic fin. Vertebrae (myomere) 41-52 ....***Scomberomorus***

- Key identification for *Scomberomorus commerson*.

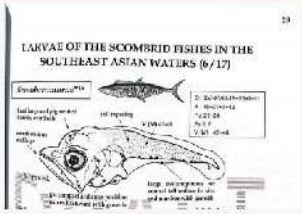
11

Measurement Information



No	Part	Measurement (mm)	Notes
1	SL	4.91	
2	HL	2.25	
3	ED	0.64	
4	SnL	0.65	
5	PAL	2.55	
6	PDL	2.33	
7	BD	1.60	

*Notes:
SL = Standard Length
TL = Total Length
BD = Body Depth
HL = Head Length
ED = Eye Diameter
PAL = Pre Anal Length
SnL = Snout Length



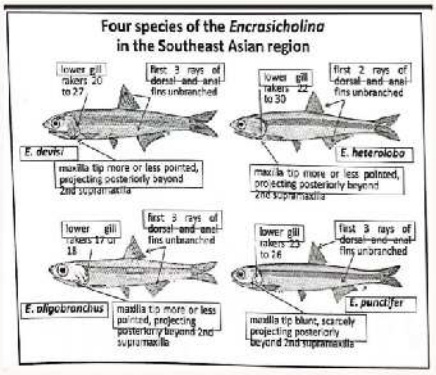
3

ENGRAULIDAE

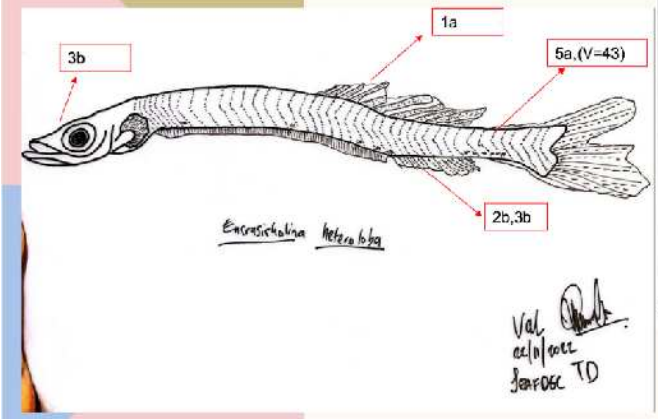
12

Encrasicholina heteroloba
(Short-head anchovy)
(Bilis Bunga Kepala Pendek

4 Species under Encrasicholina genus



Genus Identified



Key to genus of the Engraulidae larvae in the Southeast Asian region

1a Dorsal-fin base present at midpoint of body, and its end remarkably anterior to anus. Total myomeres more than 70. ····· *Cailla*

~~1b Dorsal-fin base present near midpoint of body or posterior to it, and its end over origin of anal fin or posterior to the origin. Total myomeres less than 70.~~ ····· 2

~~2a Anal-fin rays more than 30, and its base more than 1.5 times of dorsal-fin base.~~ ····· 3

2b Anal-fin rays less than 30, and its base less than 1.5 times of dorsal-fin base. ····· 4

~~3a Head depressed (until early postflexion stage). Anal-fin rays more than 47.~~ ····· *Setipinna*

3b Head not depressed. Anal-fin rays less than 49. ····· *Thryssa*

4a Origin of anal fin just under end of dorsal fin. ····· 5

4b Origin of anal fin distinctly anterior to end of dorsal fin. ····· *Stolephorus*

5a Total vertebrae 40-45 ····· *Encrasicholina* *

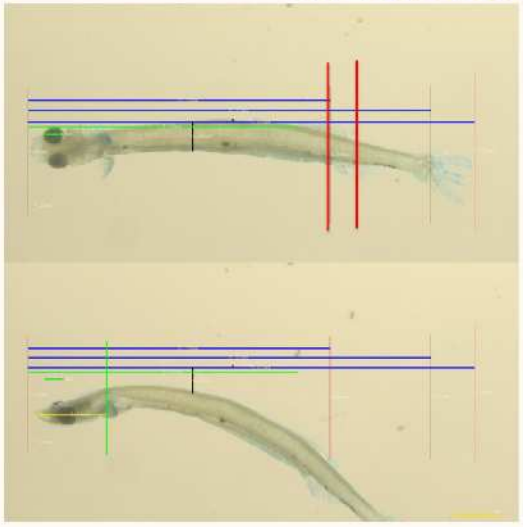
5b Total vertebrae 44-47 ····· *Engraulis*

* Some Encrasicholain larvae have the *Stolephorus*-type arrangement of dorsal and anal fins. Riverine and lacustrine species of Lycothrissa is excluded in the above key.

29

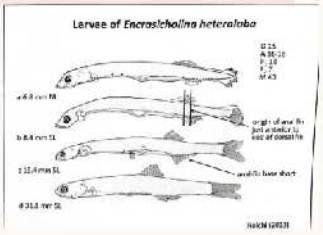
MEASUREMENT

14



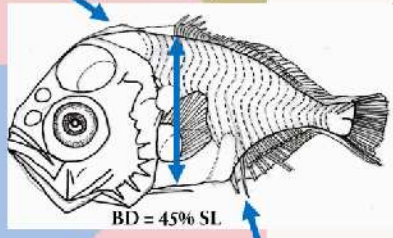
No	Part	Measurement (mm)	Notes
1	SL	8.47	
2	TL	9.42	
3	BD	0.60	
4	HL	1.50	
5	ED	0.40	
6	PAL	6.36	
7	SnL	0.52	
8	PDL	5.68	

*Notes:
SL = Standard Length
TL = Total Length
BD = Body Depth
HL = Head Length
ED = Eye Diameter
PAL = Pre Anal Length
SnL = Snout Length



4 CARANGIDAE *Carangoides* sp.

15

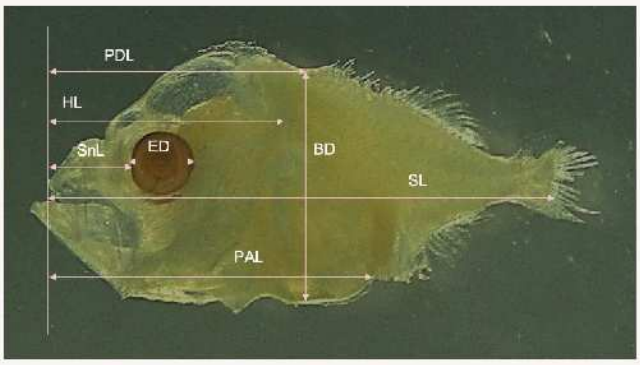


Group 1: supraoccipital crest (SOC) present; body shape deep

- No elongated fin rays → not an *Alectis* spp.
- No pigment on myomere and abdominal finfold → not a *Caranx sexfasciatus*
- No very elongated preopercular spine, and body not heavily pigmented → not a *Gnathanodon speciosus*
- Body not rhomboid → not a *Parastromateus niger*
- Pelvic fins and body not heavily pigmented → not an *Ulua* sp.

MEASUREMENTS AND COUNTS

16



Stage: Postflexion
D: VIII, 19
A: II, 14
TM: 25 (10+15)

No	Part	Measurement (mm)
1	SL	4.22
2	HL	1.65
3	ED	0.50
4	SnL	0.60
5	PAL	2.79
6	PDL	2.16
7	BD	1.89

Deep body
BD 45% BL

Large head
HL 52% BL

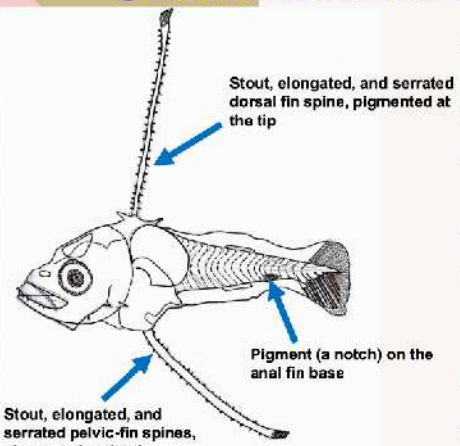
Small eye
ED 23% HL

Gut moderate
PAL 43% BL

5

SERRANIDAE *Epinephelus* sp.

17



Group 9: Body moderate, gut coiled and compact

↓

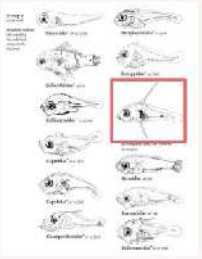
Body shape: Epinephelinae Serranidae

↓

No. of myomeres is 24, serrate dorsal- and pelvic-fin spines → not a *Niphon*

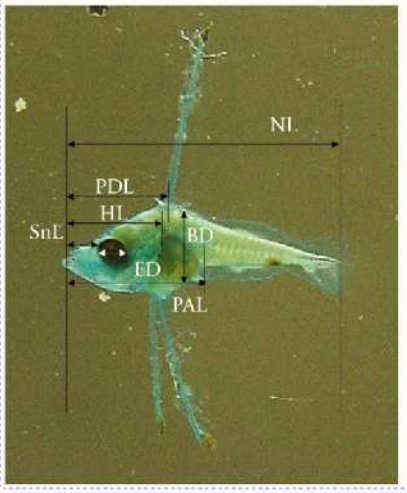
↓

Tribe: Epinephelini, genus *Epinephelus*



MEASUREMENTS AND COUNTS

18



Moderate body
BD 25% BL

Large head
HL 36% BL

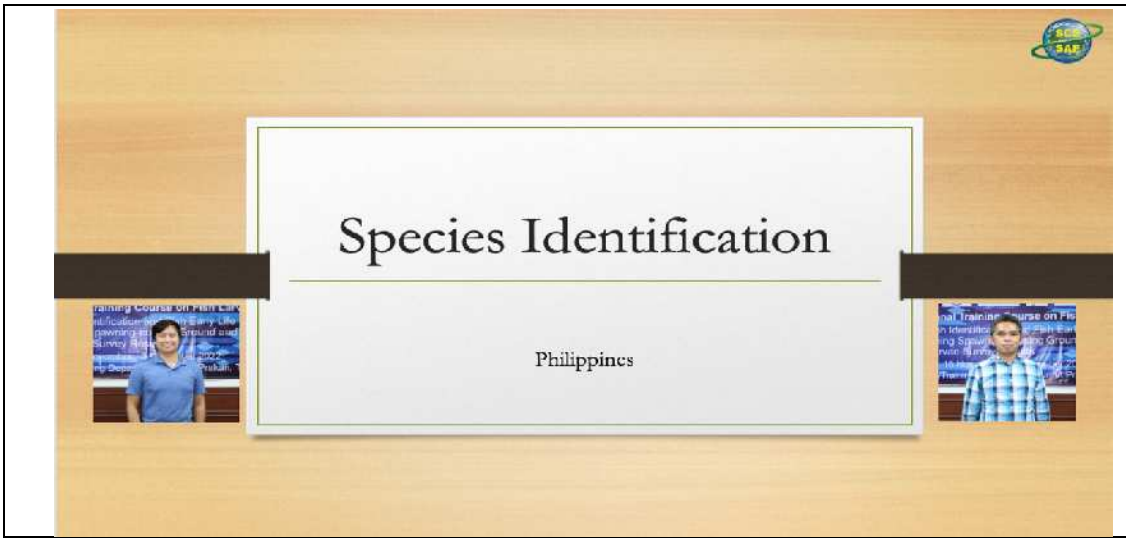
Moderate eye
ED 29% HL

Gut short
PAL 49% BL

Stage: Flexion
D: not developed
A: not developed
TM: 24 (5–19)

No	Part	Measurement (mm)
1	NL	4.56
2	HL	1.66
3	ED	0.48
4	SnL	0.44
5	PAL	2.25
6	PDL	1.70
7	BD	1.15

F. PHILIPPINES



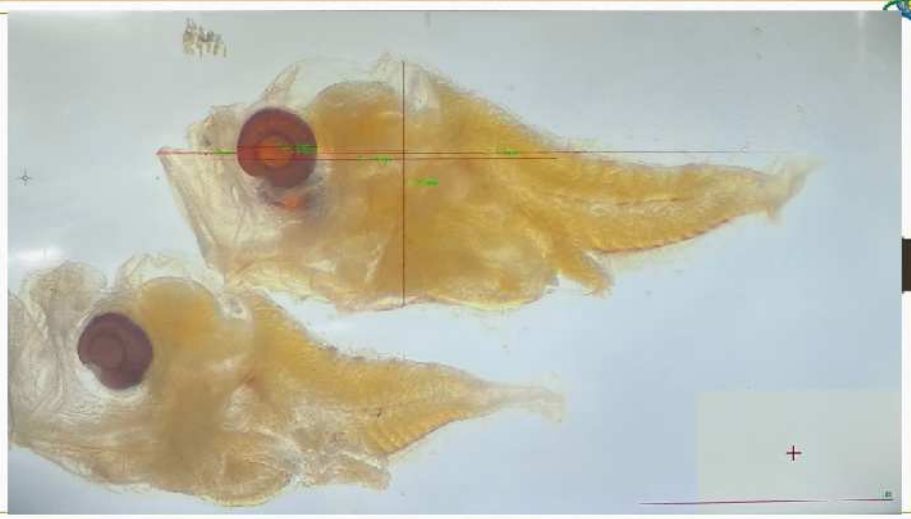
Sample 1: Carangidae

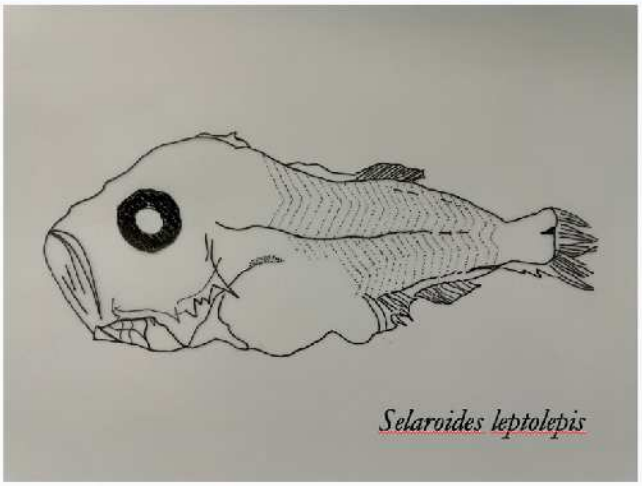
Click to add text

Morphological Descriptions

- Body depth: 1.77 mm
- Body length: 4.22 mm
- Eye diameter: 0.52 mm
- Head length: 1.65 mm
- PDL: mm
- SnL: 0.58 mm

- Dorsal:
- A:
- P_1:
- P_2:
- V:
- Description:
  - Body moderately elongate (Group II)
  - Supraoccipital crest (SOC) is present and has a pointed part at the middle
  - Notable melanophores on the ventral and midline
  - Presence of Preopercular spination





Sample 2: Engraulidae

Click to add text

Morphological Descriptions

- Body depth: 1.32 mm
- Body length: 14.55 mm
- Eye diameter: 0.61 mm
- Head length: 2.45 mm
- PDL: --- mm
- SnL: 0.64 mm
- Dorsal: 14
- A: 16
- P_1:
- P_2:
- M: 43
- Description:
  - Body very elongate
  - Start of anal is located at the mid posterior part of the dorsal fin
  - Series of melanophores on the ventral portion of the body (from below the operculum up to caudal fin base

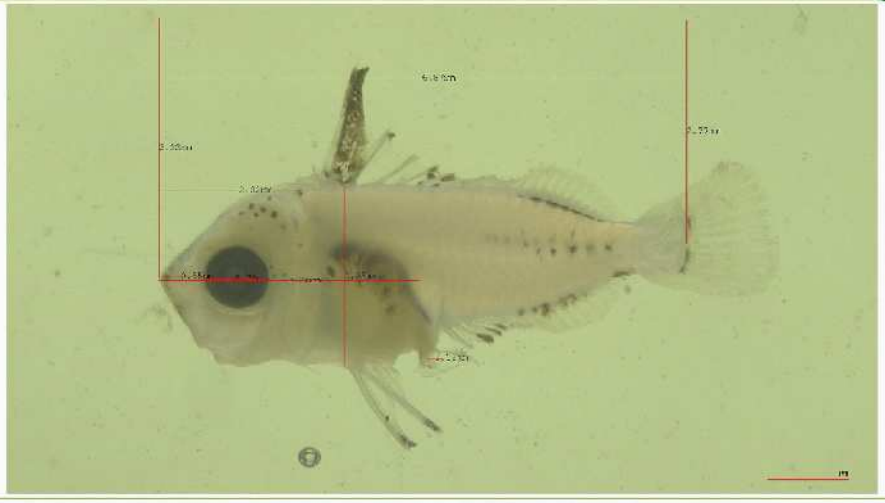
Sample 3: Siganidae

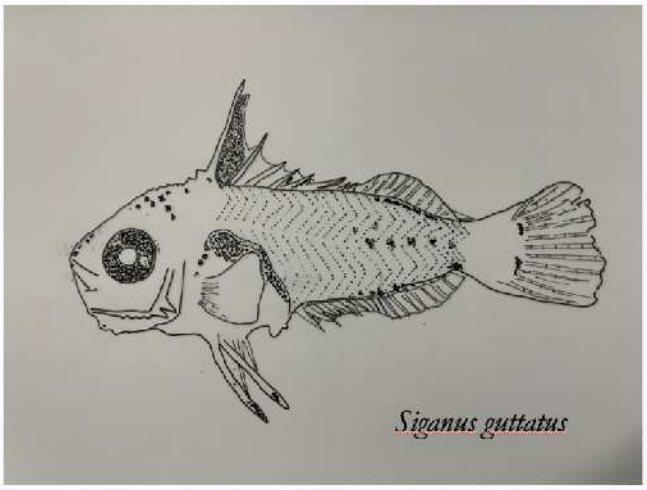
Click to add text

Morphological Descriptions

- Body depth: 2.23 mm
- Body length: 6.57 mm
- Eye diameter: 0.79 mm
- Head length: 2.02 mm
- PDL: ---- mm
- SnL: 0.55 mm

- Dorsal: XIII, 10
- A: VII, 9
- P_1: 17
- P_2: I, 3, I
- V: 23
- Description:
  - Serrated snout and frontal lobe
  - Heavy pigmentation on the 2nd dorsal spine
  - Series of melanophores at the base of 2nd dorsal fin and along the midline





Sample 4: Serranidae

Click to add text

Morphological Descriptions

- Body depth: 3.52 mm
- Body length: 10.14 mm
- Eye diameter: 1.05 mm
- Head length: 4.41 mm
- PDL: 4.78 mm
- SnL: 2.06 mm

- Dorsal: X- 16 – 17
- Anal: II- 8
- P_2: III
- Description:
  - Very long dorsal (2nd) and pelvic (1st)
  - Fine serration on the anterior margin of the spine
  - Large serration on the posterior margin of the spine
  - Fin membrane pigmented


Future Plan
Study the migration of C. ignobilis larvae from the seawater environment (Balayan Bay) to the freshwater environment (Taal Lake).
Apply the same study on:
Siganids
Abundance and Distribution of Ichthyoplankton in Northern Palawan focusing on Decaptus spp and other small pelagics

G. THAILAND


SEAFDEC
UN environment
gef
REGIONAL TRAINING COURSE ON FISH LARVAE
PHASE I: LARVAL FISH IDENTIFICATION AND FISH EARLY LIFE HISTORY SCIENCE


Trainees
Department of Fisheries
THAILAND
Mrs Piyawan Hussadee
Mr Wiwattanan Boonyoung
SRDEC

Characteristics

Description

1. Supraoccipital spine
2. 42 myomeres
3. Head pointed, snout large
4. Teeth

Scomberomorus commerson

Scombridae

Scombridae

Measurement (mm)

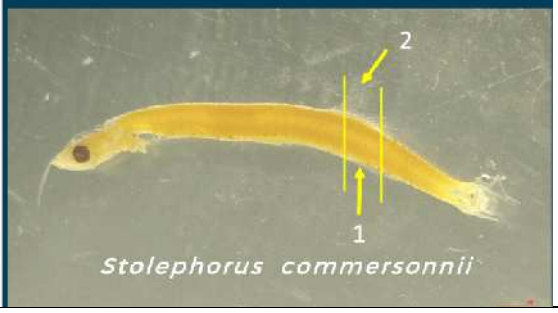
SL : 3.53
HL : 1.66
ED : 0.39
SnL : 0.80
BD : 1.25
PAL : 2.38
PDL : 1.66

Engraulidae

Characteristics

Description

1. Anal fin rays less than 30, and its base less than 1.5 times of dorsal fin base
2. Origin of anal fin distinctly anterior to end of dorsal fin



Stolephorus commersonnii

Engraulidae

Measurement (mm)

SL : 12.50
HL : 1.94
ED : 0.50
SnL : 0.66
BD : 1.07
PAL : 8.41
PDL : 7.88

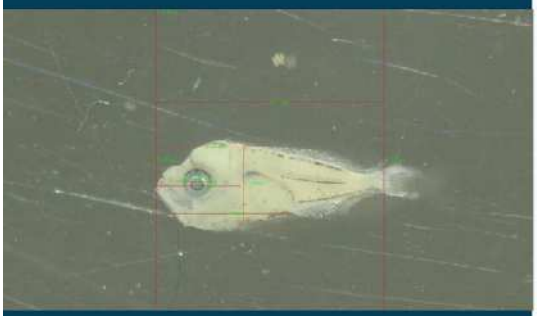
Carangidae

Description (Group 2)

1. SOC present (shape like mountain ; Ref. Chayakul, 2022)
2. Preopercular spine developed
3. Pigment present on lateral midline

Selaroides leptolepis

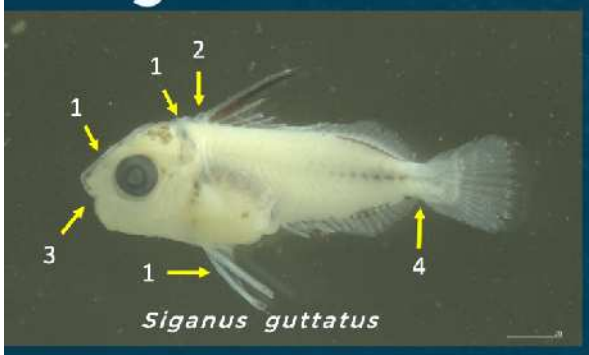
Carangidae



Measurement (mm)

SL : 4.61
HL : 1.72
ED : 0.54
SnL : 0.56
BD : 1.56
PAL : 2.74
PDL : 2.00

Siganidae



Description

1. Serrattions formed
2. Small spine extended forward
3. Small mouth
4. Caudle peduncle narrow

Siganidae

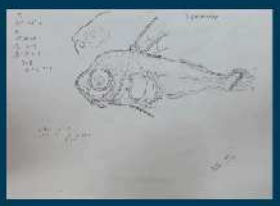
Measurement (mm)

SL : 6.94
HL : 2.15
ED : 0.79
SnL : 2.22
BD : 1.56
PAL : 3.55
PDL : 2.06

ILLUSTRATION

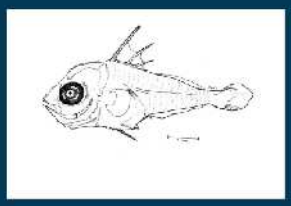
STEP 1: Choosing speciment

If possible, 3 speciments of 3 stages of a species



STEP 2: Making a first sketch by pencil

Observing, measuring and counting. Zoom-up in full size of A4



STEP 3: Tracing paper with rotring pens

Enlarge or reduce in an A4 size by photocopy machine

ILLUSTRATION

STEP 1: Choosing speciment

If possible, 3 speciments of 3 stages of a species

STEP 2: Making a first sketch by pencil

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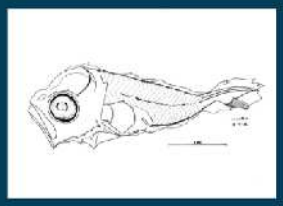

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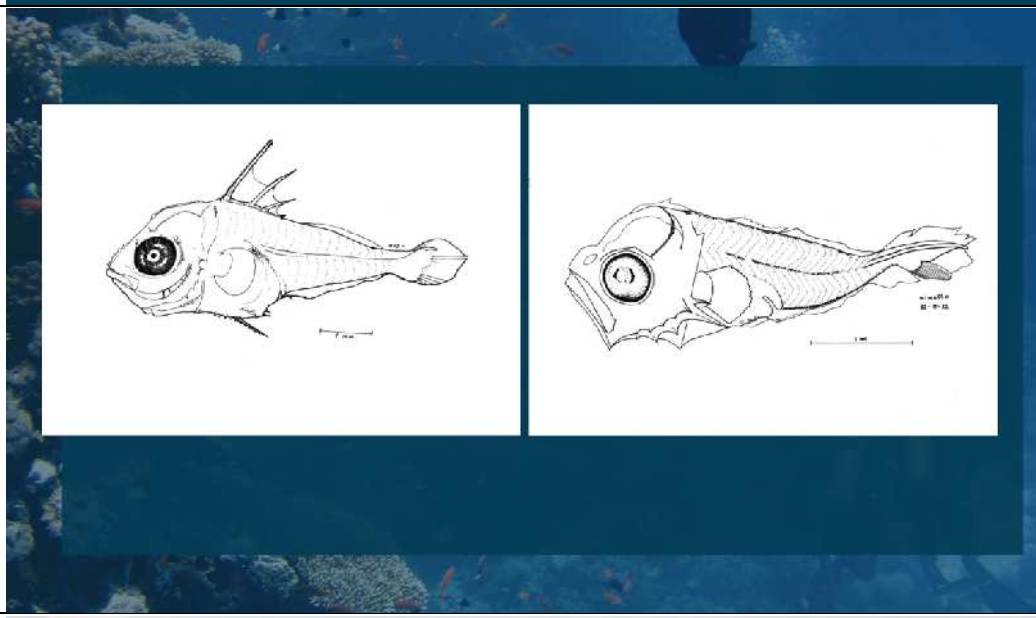


Thank you very much

H. VIET NAM

Larval Fish Identification and Fish Early Life History Science

Fish Larval Idetification Result

Prepared by
Mr. Tran Nhat Anh and Mr. Pham Xuan Thai
(Research institute for marine fisheries)

Fish Larval Idetification Result

Nemipteridae

Scombridae

Clupeidae

Carangidae (*Atule mate*)

Lutjaidae

Family: Nemipteridae

Description:

Body shape: Moderate and compressed (BD is 32.5% of SL)
Gut: Round and coiled reachs to mid body (PAL 54,5% SL)
Head: Moderate and rounded dorsally (HL 37% SL)
Snout: Short and steeply sloped (SnL 28% HL)
Head spination: None
Eyes: Large and round (ED 35,7% HL)
Pigment: Disappear on this specimen
Fin: Not completion

Scombridae (T 98)
Sampling ST: 72, Sampling date: 09/10/2018
Mesh size: 330 µm

Family: **Nemipteridae**
Genus:
Science name:

Measurements:

SL:	4.92 mm
HL:	1.82 mm
BD:	1.60 mm
SnL:	0.51 mm
ED:	0.65 mm
PAL:	2.68 mm
PDL:	2.03 mm
Myomere:	24

Family: Scombridae

Thunnus tonggol (T 102)
Sampling ST: 18
Mesh size: 500 µm

Family: **Scombridae**

Genus:

Science name:

Measurements:

SL: 4.42 mm
HL: 2.22 mm
BD: 1.49 mm
SnL: 0.90 mm
ED: 0.65 mm
PAL: 2.40 mm
PDL: 2.34 mm
Myomere: 39

Description:

Body shape: Moderate and tail tapering

Gut: Round and coiled reachs to mid body

Head: Large (HL is 50% of SL)

Snout: Pointed and elongate (SnL 40.5% HL)

Spination: Spines present on preopercular, supraoccipital spine absent

Pigment: None

Fin: Fins are not completed, first dorsal fin develops prior to second dorsal fin

Famisly: Carangidae

***Caragoides* sp.** (52)
Sampling ST: 44 (Gulf of Thailand)
Mesh size: 500 µm (Bongo net)

Family: **Carangidae**

Genus: *Atule*

Science name: *Atule mate*

Measurements:

SL: 12.95 mm
HL: 4.56 mm
BD: 4.90 mm
SnL: 1.57 mm
ED: 1.11 mm
PAL: 7.03 mm
PDL: 5.36 mm
Myomere:

Description:

Body shape: Moderate (BD is 37.8% of SL)

Gut: Round and coiled reachs to mid body (PAL 50.3% SL)

Head: Large (HL 35.2% SL). Eyes are round and moderate

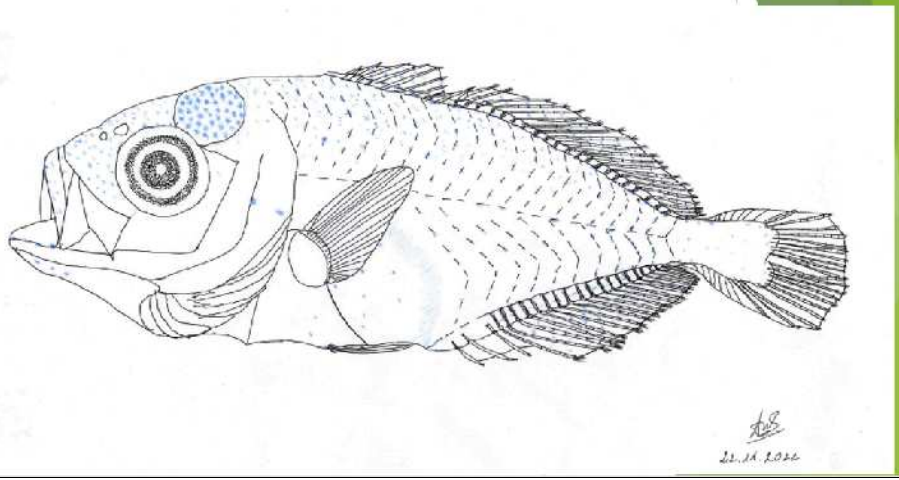
Snout: Triangular (SnL 34.4% HL)

Head spination: Disappear

Pigment: Pigment ditribution on body, on head, base dorsal and penvic fin, pigment present along myoseptum

Fin: Fins are fully completed. D VIII-I, 24; A II-I, 20; C 9+8

Atule mate



Family: Clupeidae

Clupeidae (52)
Sampling ST: 44, sampling date: 05/02/25 (Neuston net)

Family: **Clupeidae**

Genus:

Science name:

Measurements:

SL:	11.15 mm
HL:	1.70 mm
BD:	0.90 mm
SnL:	0.45 mm
ED:	0.40 mm
PAL:	9.19 mm
PDL:	6.99 mm

Myomere: 40

Description:

Body shape: Very elongate

Gut: Striated and elongate (PAL is 82.4% of SL)

Head: Moderate and compressed (HL 15.2% SL)

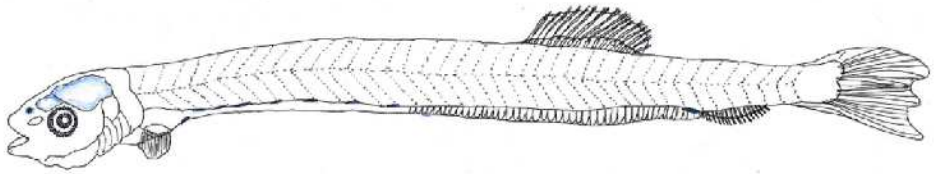
Snout: Moderate and pointed (SnL 26.5% HL)

Head spination: None

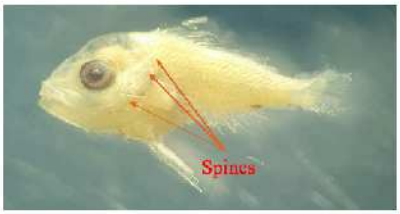
Pigment: **Linear pigment develops ventrolaterally**

Fin: Fin rays are present. D 16; A 16, C 9 | 8

Clupeidae



Family: Lutjanidae



(52)
05 B (0,3) 14 - 7

Family: **Lutjanidae**

Genus:

Science name:

Measurements:

SL:	4.75 mm
HL:	1.75 mm
BD:	2.03 mm
SnL:	0.50 mm
ED:	0.54 mm
PAL:	2.52 mm
PDL:	1.67 mm

Myomere: 24

Description

Body shape: Deep (BD is 42.7% of SL)

Gut: Coiled and triangular, extends to around mid body (PAL 53.1% SL)

Head: Large (HL 36.8% SL)

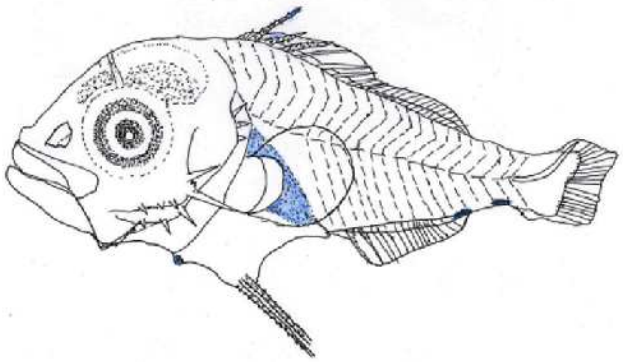
Snout: Moderate, concave in the dorsal profile and slightly pointed (SnL 28.6% HL)

Head spination: Spines form on the preopercular, opercular, supracleithral, spines on preopercle are large

Pigment: present on cleithral symphysis, ventral of tail

Fin: D X, 13; A III, 8

Lutjanidae



Some fish species in Vietnam waters

Scombridae (*Rastrelliger kanagurta*)

Engraulidae (*Stolephorus indicus*)

Carangidae (*Atule mate*)

Lutjanidae (*Lutjanus carponotatus*)

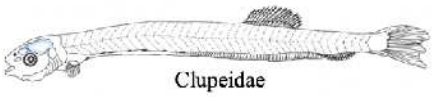
Serranidae (*Epinephelus awoara*)

Siganidae (*Siganus javus*)

THANK FOR YOUR ATTENTION!

Atule mate

Lutjanidae



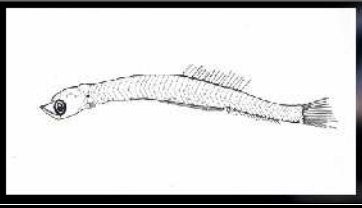
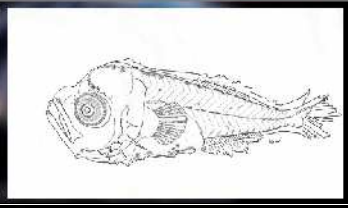
Clupeidae

I. UNIVERSITIES-THAILAND

Regional Training Course on Fish Larvae
Phase I: Larval Fish Identification and Fish Early Life History Science

Fish Larvae Identification:
Scombridae Carangidae Engraulidae and Siganidae

Presented by Asst. Prof. Penchan Laongmanee and Nathacha Changphetphol

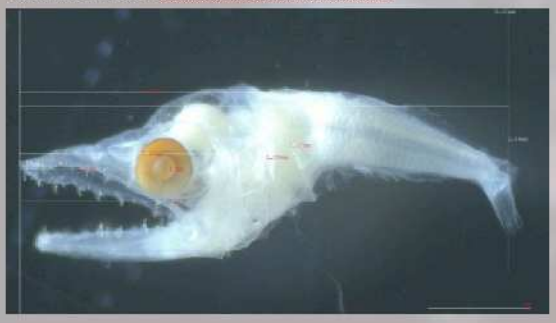
Regional Training Course on Fish Larvae
Phase I: Larval Fish Identification and Fish Early Life History Science

Family: Scombridae

Regional Training Course on Fish Larvae
Phase I: Larval Fish Identification and Fish Early Life History Science

Family: Scombridae

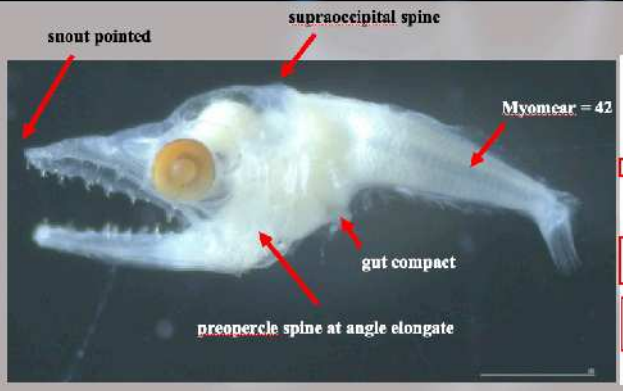
Scientific name : ***Scomberomorus commerson***



Morphology

Body shape: Moderate
Gut: compact
Snout: pointed
Mouth: Oblique
Teeth: Developed
Eye: Round and large
Head spination: supraoccipital spine present
Pigment: no pigment

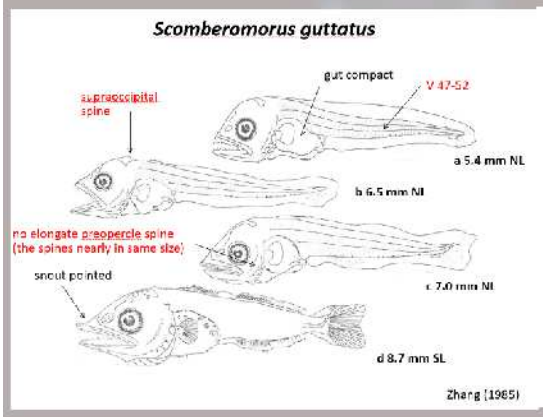
Regional Training Course on Fish Larvae
Phase I: Larval Fish Identification and Fish Early Life History Science

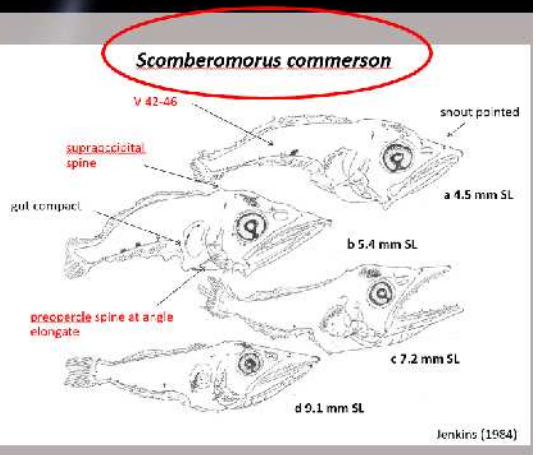


Key to species (genus) of the Scombridae larvae (ca 10 mm BL >) in the Southeast Asian region (1 /3)

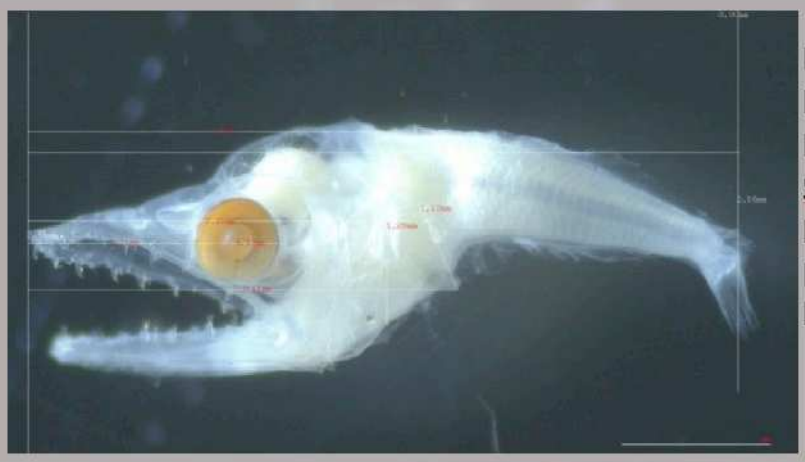
1 a No preopercular spines. Round head and mouth relatively small. Ventral margin of tail pigmented. V (TM) 31. ... *Scomber, Rastrelliger*
1 b Preopercular spines present. ... 2
2 a Snout and head round. Preopercular spines small and supraorbital ridge not distinct. Five to 6 large pigment patches present on dorsolateral body in flexion to juvenile stages. V (TM) 41. ... *Grammatorcynus bilineatus*
2 b Head, eyes and mouth relatively large. Spines on preopercle, post-temporal well-developed. V (TM) more than 32. ... 3
3 a A supraoccipital spine present. ... 4
3 b Supraoccipital spine absent. ... 5
4 a Snout large and its length about 2 times of eye diameter. Mouth large. Supraoccipital spine distinct. V (TM) more than 45. ... *Scomberomorus*
4b Snout moderately large and its length 1.5 times of eye diameter. Supraoccipital spine small. V (TM) 44-45. ... *Sarda orientalis*

Regional Training Course on Fish Larvae
Phase I: Larval Fish Identification and Fish Early Life History Science





Regional Training Course on Fish Larvae
Phase I: Larval Fish Identification and Fish Early Life History Science



BL 4.8	mm
HL 2.40	mm
ED 0.57	mm
SnL 1.11	mm
BD 1.29	mm
PAL 2.90	mm
PDL 2.41	mm

Regional Training Course on Fish Larvae
Phase I: Larval Fish Identification and Fish Early Life History Science

Distribution

- Indo-West Pacific: Red Sea and South Africa to Southeast Asia, north to China and Japan and south to southeast Australia, and to Fiji (Ref. 6390).
- Immigrant to the eastern Mediterranean Sea by way of the Suez Canal. Southeast Atlantic: St. Helena.

Ref. fishbase

Regional Training Course on Fish Larvae
Phase I: Larval Fish Identification and Fish Early Life History Science

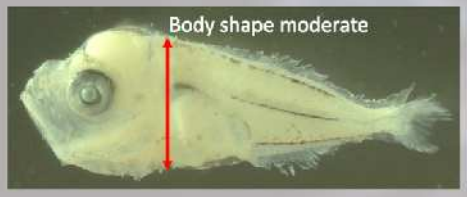
Family: Carangidae

Regional Training Course on Fish Larvae
Phase I: Larval Fish Identification and Fish Early Life History Science

Family: Carangidae

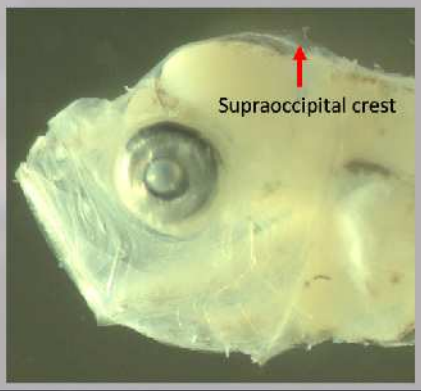
Scientific name : *Selaroides leptolepis*

Morphology



Group 2

From 4 groups of carangid larvae in the Southeast Asian Region



Genera and species with larval information available among carangid fishes in the Southeast Asian region – Group 2

Characters	Tribe	Genus	Species
Group 2: Supraoccipital crest (SOC) present; body shape moderate	Carangini	*Alepes*	*Alepes* sp.
		Decapterus	*D. macarellus*
			D. macrosoma
		Selar	*S. crumenophthalmus*
		Selaroides	*S. leptolepis*
	Naucratini	*Elagatis*	*E. bipinnulata*
	Scomberoidini	*Scomberoides*	*S. lysan*
			S. tol

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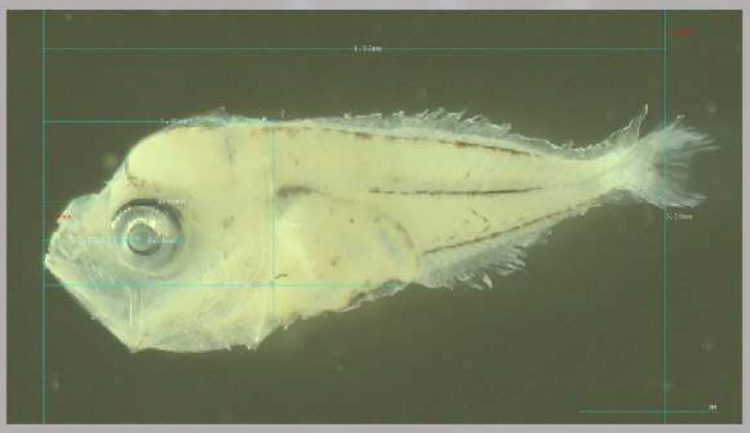

BL 4.5 mm
HL 1.66 mm
ED 0.54 mm
SnL 0.49 mm
BD 1.51 mm
PAL 2.62 mm
PDL 1.70 mm

Myomear = 10+14

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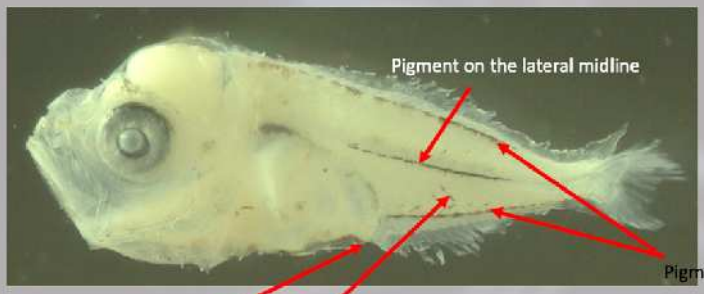
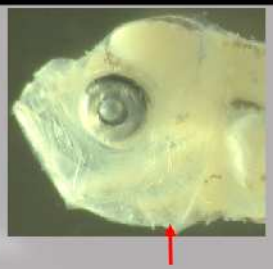
Phase I: Larval Fish Identification and Fish Early Life History Science

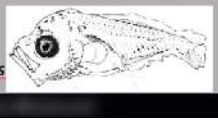
Morphological





3 preopercle spine development

* *Similar to Selar crumenophtamus*



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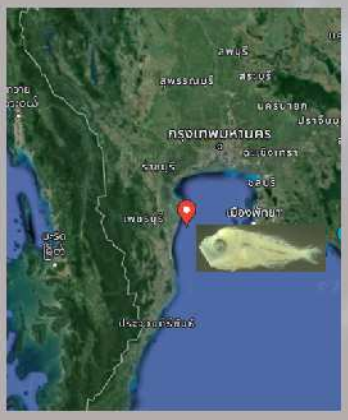
Selaroides leptolepis

Regional Training Course on Fish Larvae
Phase I: Larval Fish Identification and Fish Early Life History Science



From St. no. 5 of the regular fisheries resource survey in the Gulf of Thailand Of Department of Fisheries, Thailand

Thank to
Mr. Wiwattanan Boonyoung &
Mrs. Piyawan Hussadee

Regional Training Course on Fish Larvae
Phase I: Larval Fish Identification and Fish Early Life History Science

Distribution

- Indo-West Pacific: Persian Gulf to the Philippines, north to Japan, south to the Arafura Sea (Ref. 9819) and Australia (Ref. 3287).

Ref. fishbase

Family: Engraulidae

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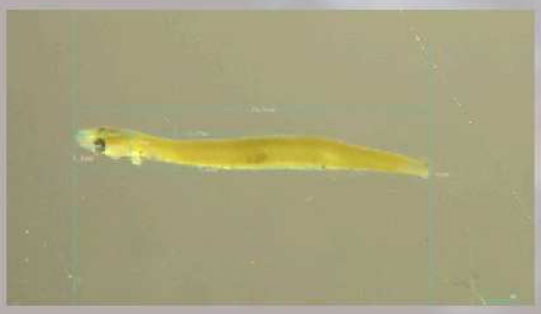
Family: Engraulidae

Scientific name : ***Stolephorus indicus***

Morphology



Body shape: Very elongate

Gut: Elongate, 75 % of SL

Snout: Short, 31 % of HL

Mouth: Small and terminal

Eye: Round and large to moderate

Head spination: None

Fins: anal-fin base short, dorsal fin ray overlap with the anus fin

Pigment: Isthmus, notochord, ventral midline gut

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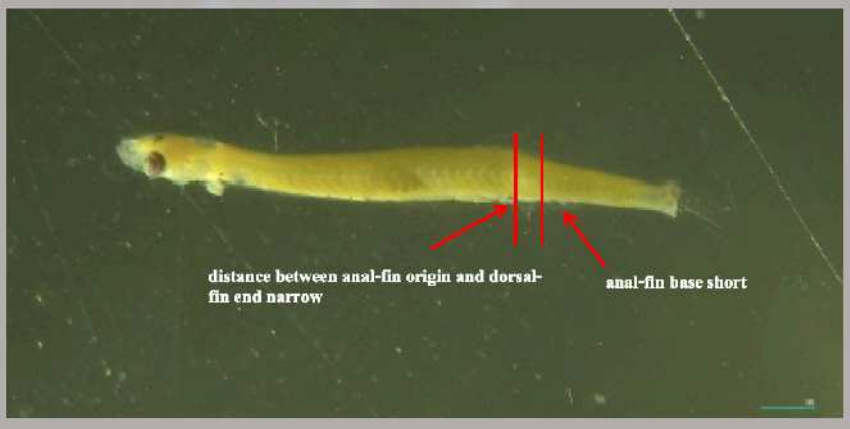

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BL 10.58 mm
HL 1.66 mm
ED 0.43 mm
SnL 0.48 mm
BD 0.79 mm
PAL 7.46 mm
PDL 6.87 mm

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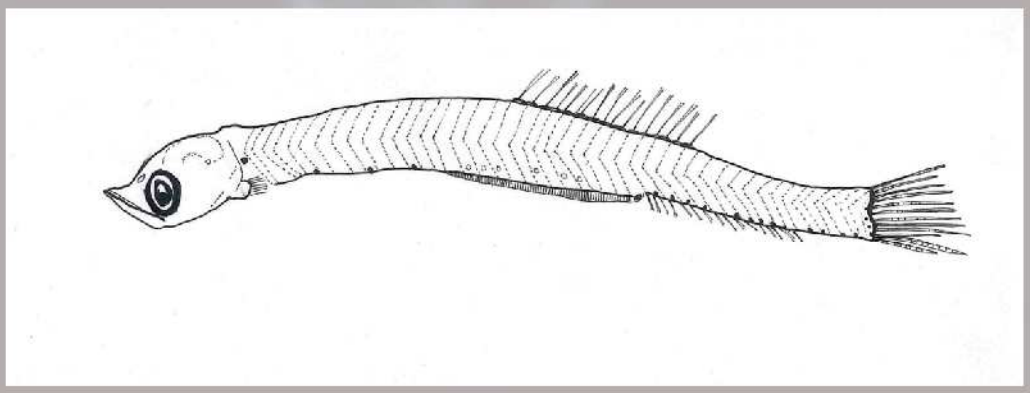

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Phase I: Larval Fish Identification and Fish Early Life History Science

Distribution

- Indo-Pacific: Red Sea and South Africa, including the Persian Gulf, Madagascar and Mauritius eastward to Hong Kong, the Arafura Sea (Ref. 9819), northern and eastern coasts of Australia and further east to Samoa and Tahiti.

Ref. fishbase

Family: Siganidae

Regional Training Course on Fish Larvae
Phase I: Larval Fish Identification and Fish Early Life History Science

Family: Siganidae

Morphology

Scientific name : ***Siganus guttatus***

Body shape: compressed

Gut: compact

Snout: Short

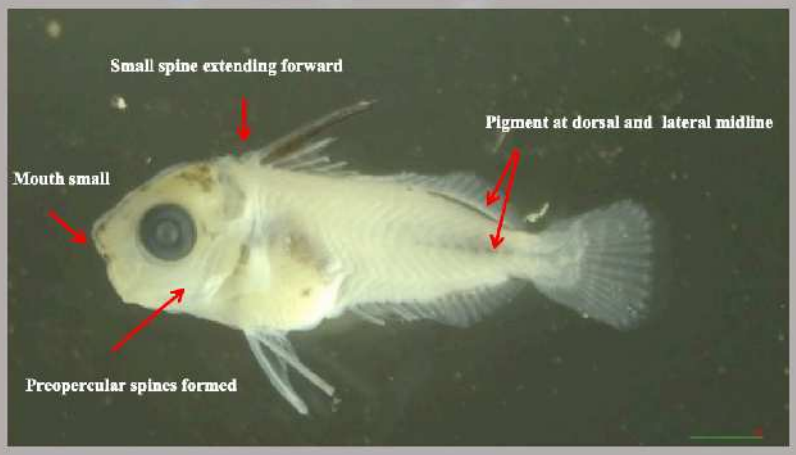
Mouth: very small

Eye: Round and large

Head spination: Preopercular spines formed

Pigment: snout, head, dorsal spaines membrain , dorsal and lateral midline

Regional Training Course on Fish Larvae
Phase I: Larval Fish Identification and Fish Early Life History Science



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BL 6.81 mm
HL 2.21 mm
ED 0.79 mm
SnL 0.64 mm
BD 2.2 mm
PAL 3.21 mm
PDL 2.01 mm

Regional Training Course on Fish Larvae
Phase I: Larval Fish Identification and Fish Early Life History Science

From Philippines

Thank to
Mr. Marvin Tobias &
Dr. Dennis D. Tanay

Regional Training Course on Fish Larvae
Phase I: Larval Fish Identification and Fish Early Life History Science

From Philippines

Thank to
Mr. Marvin Tobias &
Dr. Dennis D. Tanay

J. RESEARCH INSTITUTION-(MFRDMD + CHULA LONGKORN UNIVERSITY)

Family: Scombridae

- Sample: #79 ST.16 330 µm 19-12-62
- Genus: Rastrelliger
- Scientific name: *Rastrelliger kanagurta* (tentative)
- Larvae stage: Post-flexion

Body part	Adult Count	Larvae Count	Actual Count
D (Dorsal fin)	VIII~XI – 11~13 + 4~6	VIII~IX – 12 + 5	D2: 12 + 5 (17)
A (Anal fin)	10 ~ 13 + 5	12 + 5	12 + 5 (17)
P1 (Pectoral fin)	18 ~ 22	19~20	NA
P2 (Pelvic fin)	I, 5		NA
V(M) (Myomere)	31	31	31

Identification key:

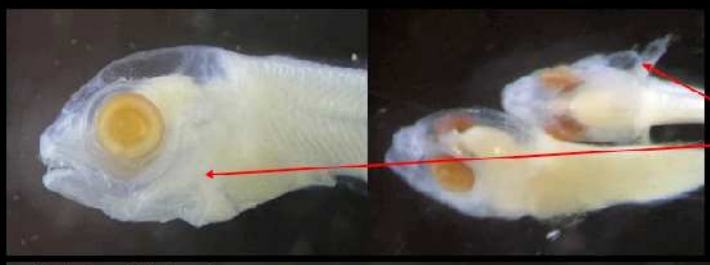
1. No preopercular spine, round head, mouth relatively small
2. 2nd dorsal fin develops prior to first dorsal fin
3. 2nd dorsal fin 17 (12 fin ray + 5 finlets)
4. Myomere count 31

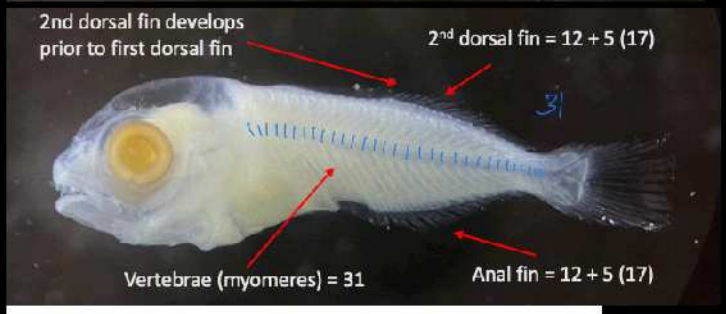
Description to *Rastrelliger sp.*

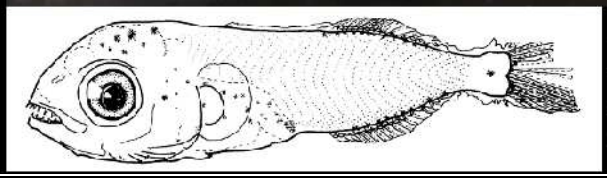
Body part	Features
Body shape	Slightly elongate (BD 10-20% BL)
Head	Large, round
Gut	Coiled and compact early (3 mm)
Snout	Round
Mouth	Oblique; relatively small
Eye	Round
Head Spination	No spination

Note: It is difficult to differentiate the species between Rastrelliger genus. The larvae morphology is very similar. Need a molecular (DNA) approach to confirm the species.

Distinct features of *Rastrelliger sp.*

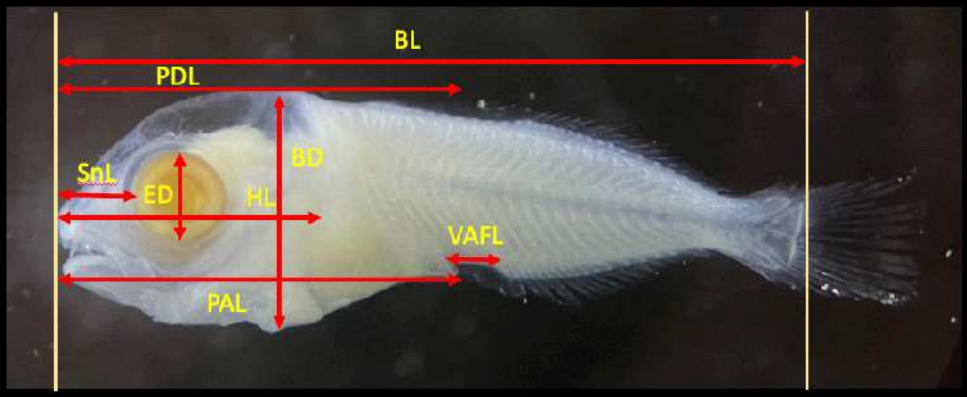






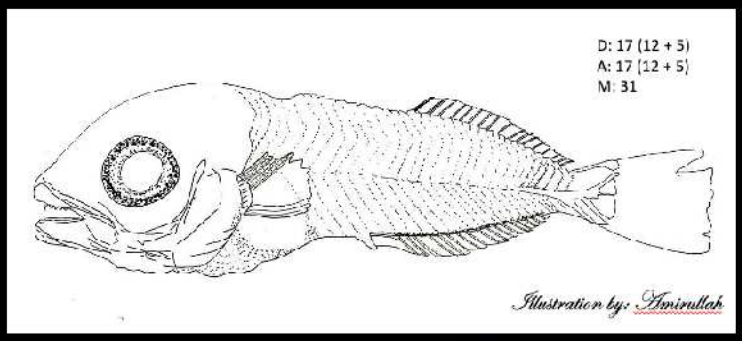
The dorsal and finlet form as part of the main body of the fin and do not separate from it until early juvenile stage.

Measurement of *Rastrelliger sp.*



Body part	Measurement (mm)	Body part ratio
BL (Standard length)	5.2	
HL (Head length)	1.94	HL 37.3% of SL
BD (Body depth)	1.54	BD 29.6% of SL
SnL (Snout length)	0.47	SnL 24.2% of HL
ED (Eye diameter)	0.65	ED 33.5% of HL
PAL (Pre-anal fin length)	2.79	PAL 53.7% of SL
PDL (Pre-dorsal fin length)	2.22	
VAFL (Vent to anal fin length)	0.35	

Specimen photo & Drawing *Rastrelliger sp.*



Family: Engraulidae

- **Sample:** #71 ST.11 500 µm 18-12-62
- **Genus:** Encrasicholina
- **Species name:** *Encrasicholina sp.*
- **Larvae stage:** Post-flexion

Body part	Larvae Count	Actual Count
D (Dorsal fin)	11~16	12-13
A (Anal fin)	14~21	12
P1 (Pectoral fin)	12~17	NA
P2 (Pelvic fin)	7	NA
V(M) (Myomere)	41~44	43

Identification key:

1. Dorsal fin base posterior to midpoint of body, myomere < 70
2. Anal fin ray less than 30
3. Origin of anal fin just under end of dorsal fin
4. Myomere count 40-45

Description to *Encrasicholina sp.*

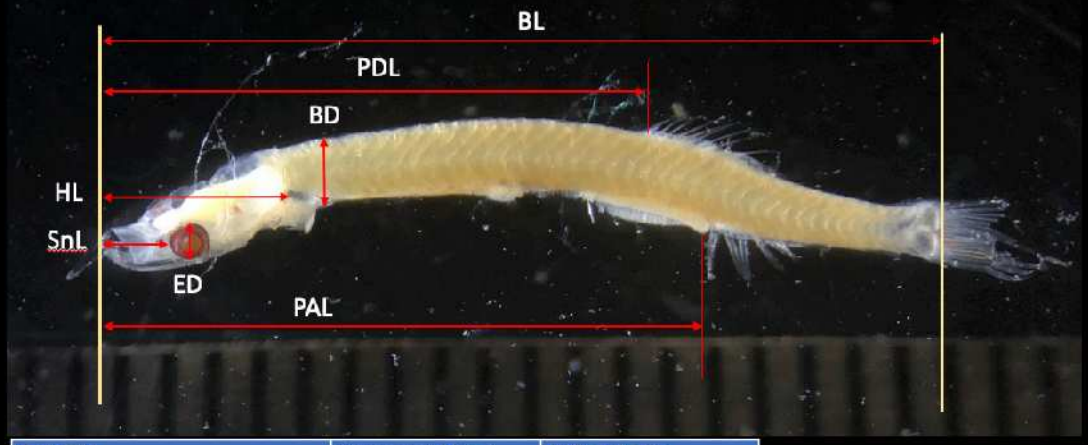
Body part	Features
Body shape	Very elongate (BD <10% BL)
Head	Round and small
Gut	Very long (PAL >70% BL)
Snout	Slightly concave
Mouth	Small and terminal; reaches to the anterior half of eye
Eye	Round; moderate
Head Spination	No spination
Origin of anal fin	Under the anterior end of dorsal fin

Note:

- In Engraulidae family, it is difficult to differentiate between *Encrasicholina sp.* and *Stolephorus sp.* larvae. (before, this two genus group together)
- The overlap of dorsal fin base and anal fin base is very important features to differentiate between the *Encrasicholina sp.* and *Stolephorus sp.*

Distinct features of *Encrasicholina* sp.

Measurement of *Encrasicholina* sp.



Body part	Measurement (mm)	Body part ratio
BL (Standard length)	9.86	
HL (Head length)	1.70	HL 17.2% of SL
BD (Body depth)	1.02	BD 10.3% of SL
SnL (Snout length)	0.56	SnL 32.9% of HL
ED (Eye diameter)	0.43	ED 25.3% of HL
PAL (Pre-anal fin length)	7.14	PAL 72.4% of SL
PDL (Pre-dorsal fin length)	6.24	

Family: Carangidae

- Sample: #54 ST.44
- Tribe: Carangini
- Scientific name: *Carangiodes* sp.
- Larvae stage: Post-flexion

Body part	Adult Count	Larvae Count	Actual Count
D (Dorsal fin)	VIII-I, 17 ~ 34	VIII-I, 17 ~ 34	VIII-I, 19
A (Anal fin)	II-I, 14 ~ 27	II-I, 14 ~ 27	II-I, 14
P1 (Pectoral fin)	18 ~ 24	18 ~ 24	NA
P2 (Pelvic fin)	I, 5	I, 5	NA
V(M) (Myomere)	10+14	10+14 ~ 15	10+14

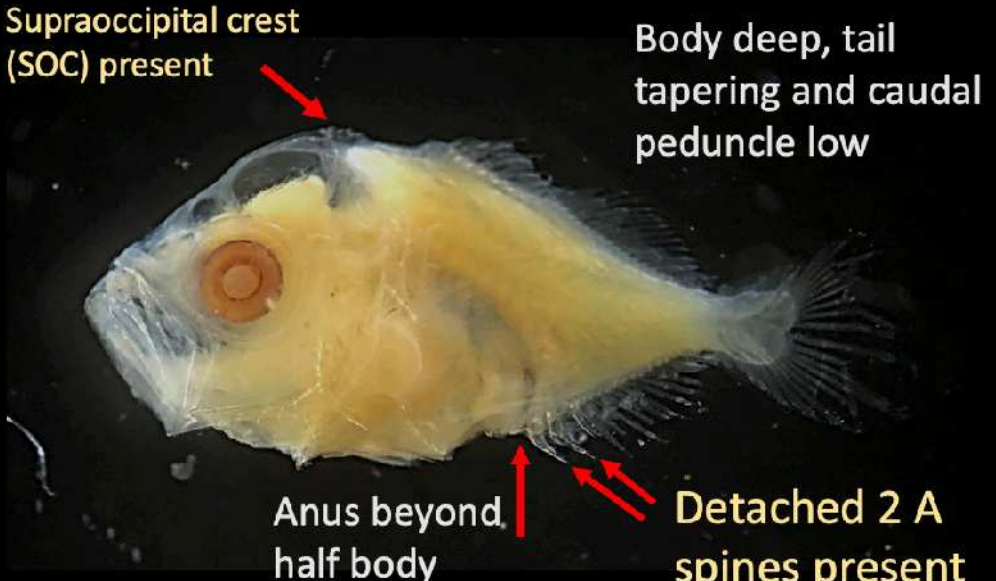
Identification key: Group 1 of carangid larvae

1. Supraoccipital crest (SOC) present
2. Body shape deep
3. Preopercular spines present

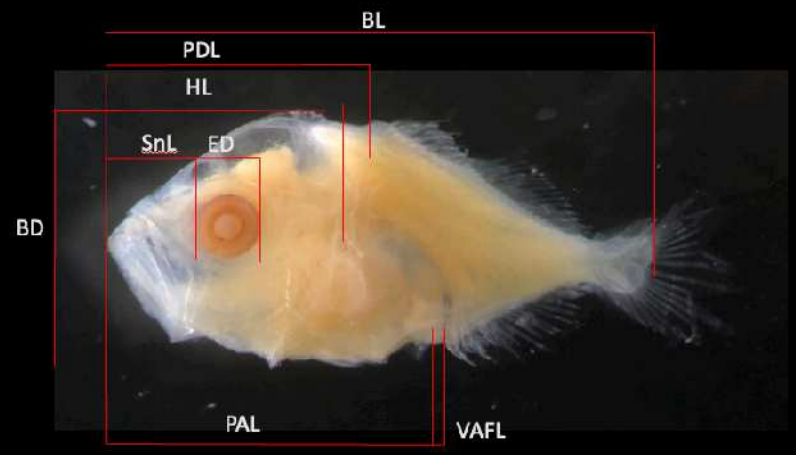
Description of *Carangiodes* sp.

- Body shape: deep to very deep (BD>40% BL)
- Head: moderate to large and moderately compressed, roundly triangular
- Gut: coiled, roundly triangular
- Snout: triangular, short
- Mouth: oblique
- Eye: large round
- Spination: two rows of smooth preopercular spines present, spine at angle longest
- Pigment: if present occur on dorsal and ventral midline, snout and brain
- Remark: pigments of our specimen is not clearly seen

Diagnostic characters of *Carangoides* sp.



Measurement of *Carangiodes* sp.



Body part	Measurement (mm)
BL (Standard length)	5.37
HL (Head length)	2.40; 44.6% BL
BD (Body depth)	2.49; 46.4% BL
SnL (Snout length)	0.80; 33.3% HL
ED (Eye diameter)	0.63; 26.3% HL

Body part	Measurement (mm)
PAL (Pre-anal fin length)	3.07; 57.1% BL
PDL (Pre-dorsal fin length)	2.69
VAFL (Vent to anal-fin length)	0.28

Family: Lutjanidae

Subfamily: Lutjaninae

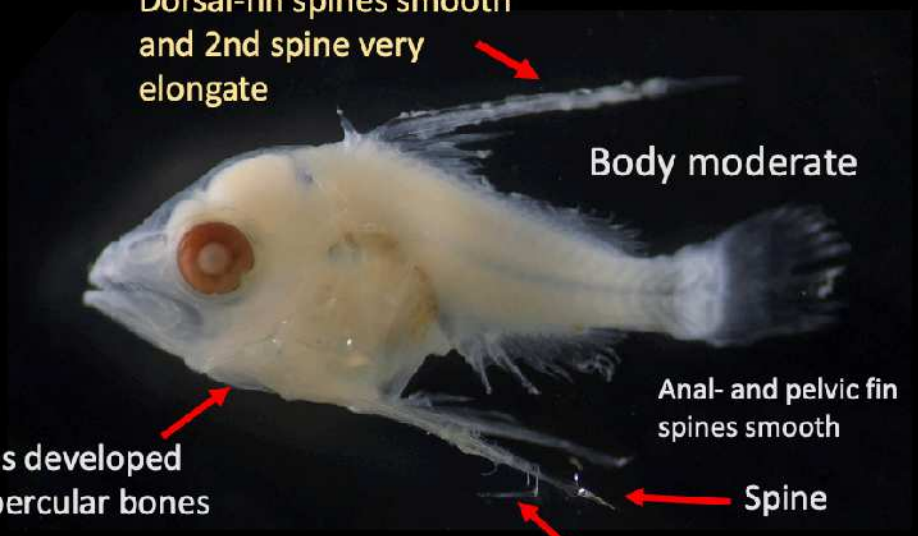
- Sample: Upper Gulf of Thailand from P' Mai (Piyawan-san)
- Scientific name: *Lutjanus* sp.
- Larvae stage: Post-flexion

Body part	Larvae Count	Actual Count
D (Dorsal fin)	X-XII, 12-16	X, 14
A (Anal fin)	III, 7-11	III, 9
P1 (Pectoral fin)	15 ~ 19	NA
P2 (Pelvic fin)	I, 5	NA
V(M) (Myomere)	10+14	10+14

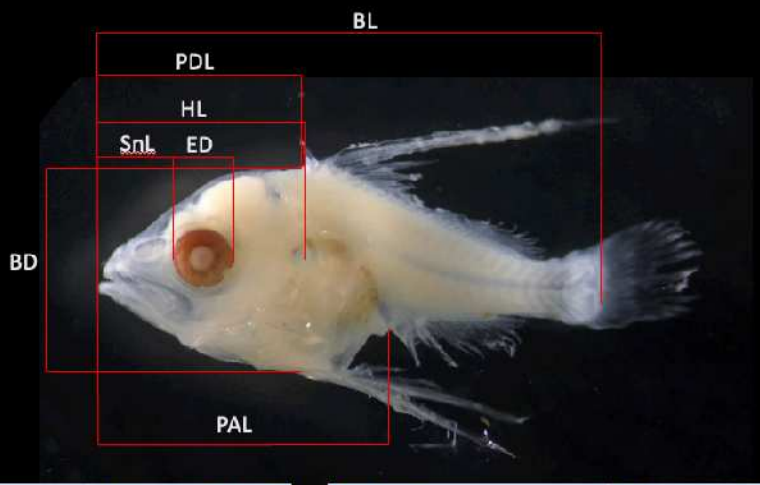
Description of Lutjanidae

- Body shape: deep to very deep (BD>40% BL)
- Head: compressed
- Gut: coiled, 40-67% BL
- Snout: slightly elongate
- Mouth: horizontal to oblique, prominent canine teeth
- Eye: round; moderate size
- Spination: smooth spines on preopercle, at the angle largest
- Pigment: dorsal surface of the gut and gas bladder (not see)
- Remark: pigments of our specimen is not clearly seen

Diagnostic characters of Lutjanidae



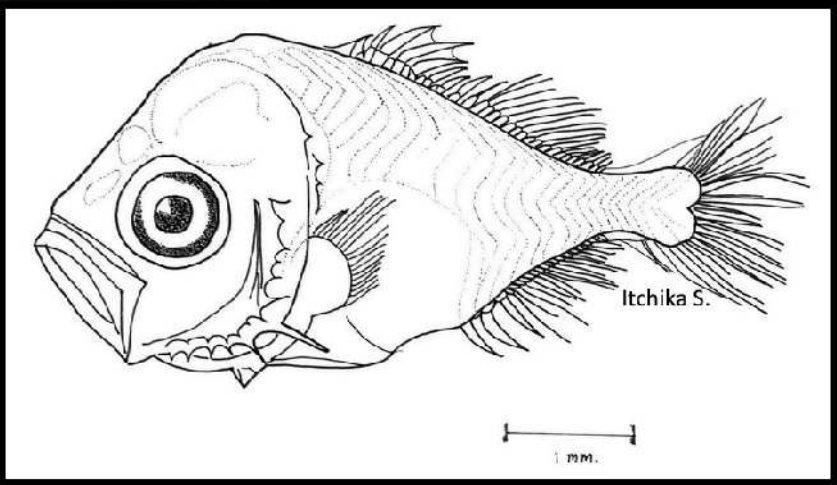
Measurement of *Lutjanus* sp.



Body part	Measurement (mm)
BL (Standard length)	5.88
HL (Head length)	2.40; 40.8% BL
BD (Body depth)	2.33; 39.6% BL
SnL (Snout length)	0.76; 31.7% HL
ED (Eye diameter)	0.72; 30.0% HL

Body part	Measurement (mm)
PAL (Pre-anal fin length)	3.42; 58.2%
PDL (Pre-dorsal fin length)	2.29
VAFL (Vent to anal-fin length)	NA

Drawing of *Carangiodes* sp.



Acknowledgement

- *Refugia* project
- SEAFDEC staffs
- All sensei: Konishi, Rungsan, Teerapong + P'Mai

Thank you !

Annex 1: List of all Participants

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Annex 2: Utilization of DNA barcodes for the identification of tropical larval fishes

Utilization of DNA barcodes for the identification of tropical larval fishes in Klang Strait, Straits of Malacca

By Cecilia Chu

16 November 2022

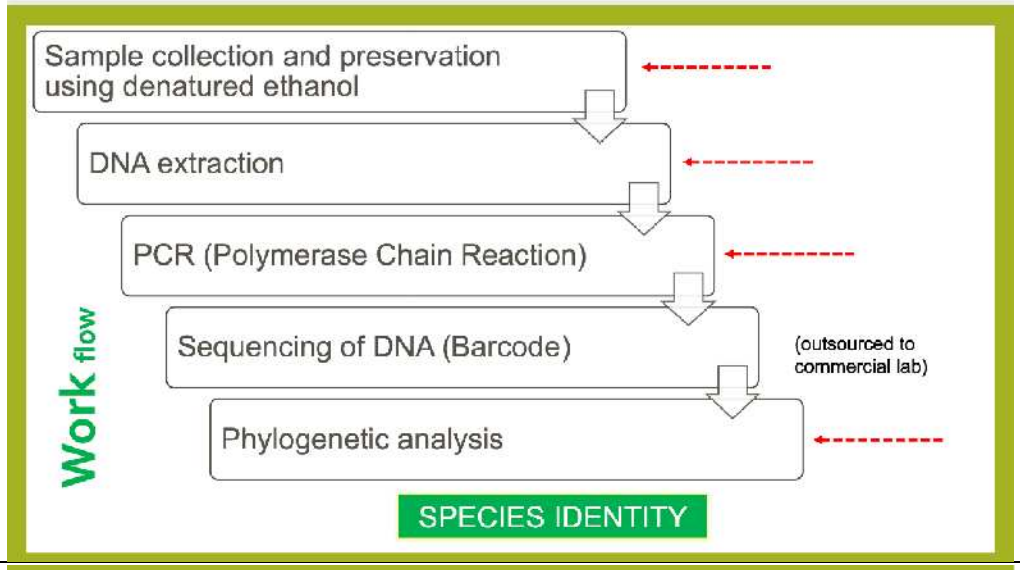
SEAFDEC/TD, Samut Prakan, Thailand

UNIVERSITY OF MALAYA INSTITUTE FOR ADVANCED STUDIES

IOES Institute of Ocean & Earth Sciences University of Malaya

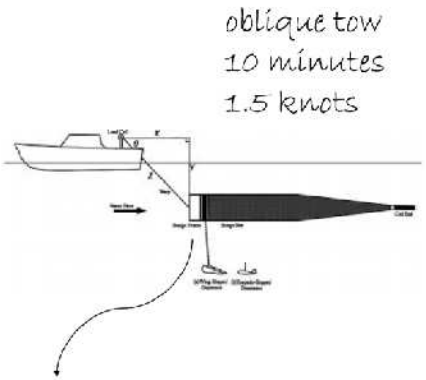
HIGH IMPACT RESEARCH

MINISTRY OF EDUCATION MALAYSIA



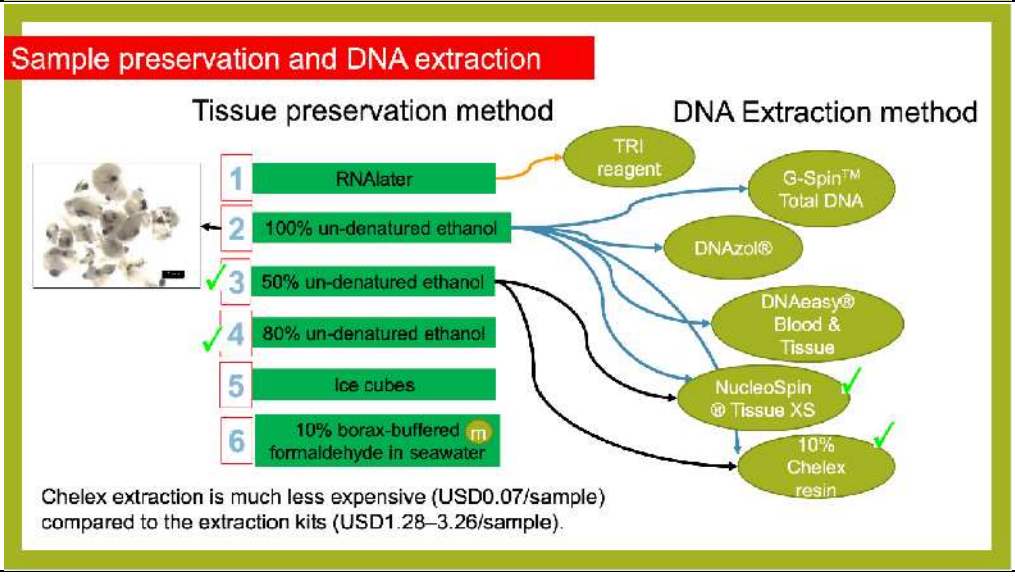
Sample collection

Image source: © 2020 Google




Left: Twin bongo nets (363 & 180 µm mesh)
Right: Plankton net


Sampling of adult to create a database for local fish species


Sample preservation and DNA extraction
Tissue preservation method
DNA Extraction method
1 RNAlater
2 100% un-denatured ethanol
3 50% un-denatured ethanol
4 80% un-denatured ethanol
5 Ice cubes
6 10% borax-buffered formaldehyde in seawater
TRI reagent
G-Spin™ Total DNA
DNAzol®
DNAeasy® Blood & Tissue
NucleoSpin® Tissue XS
10% Chelex resin
Chelex extraction is much less expensive (USD0.07/sample) compared to the extraction kits (USD1.28–3.26/sample).

Vol. 286: 269–277, 2005 | MARINE ECOLOGY PROGRESS SERIES Mar Ecol Prog Ser | Published February 2

Shipboard identification of fish eggs and larvae by multiplex PCR, and description of fertilized eggs of blue marlin, shortbill spearfish, and wahoo

J. R. Hyde[1,2,*], E. Lynn[2], R. Humphreys Jr.[3], M. Musyl[4], A. P. West[5], R. Vetter[2]

- ✓Cheap
- ✓Rapid
- ✓Easy
- ✓Whole body of larva can be kept for future reference

DNA extraction using 10% Chelex resin

1

5g Chelex resin + dH_2O

Place magnetic stirring bar inside the falcon tube and stir the solution

While mixing, aliquot 150µl 10% Chelex resin into 0.2ml centrifuge tube

Store at -20°C

2

No tissue (NT)

3

1. 60°C, 2 min
2. 103°C, 25 min
3. Leave at room temperature

4

Supernatant containing DNA

Chelex resin

Supernatant containing DNA → Keep at 20°C until PCR

PCR amplification

Barcoding primers (Ward et al., 2005)
F2 5' TCG ACT AAT CAT AA GAT ATC GGC AC 3'
R2 5' – ACT TCA GGG TGA CCG AAG AAT CAG AA – 3'

COI
(Cytochrome oxidase subunit I)

exTen 2x PCR master mix	12.5 µl
forward primer	0.5 µl
reverse primer	0.5 µl
DNA template	1.0 µl
dH_2O	10.5 µl
Total	25.0 µl

Initial denaturation	95°C	10 minutes	x 1
	94°C	1 minute	x 35
	55°C	1 minute	
	72°C	1.5 minutes	
Final extension	72°C	7 minutes	∞

~ 3 hours

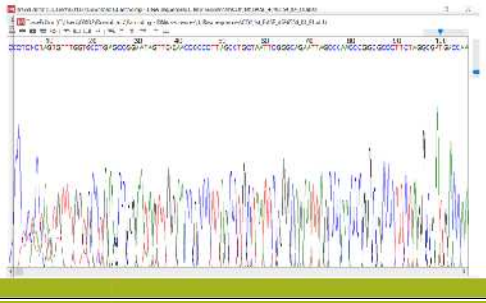
Thermal cycler

→ DNA sequencing (outsource)

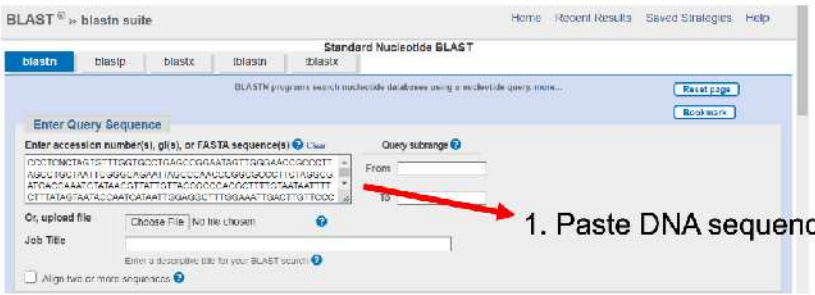
Data analysis

Sequence Scanner 2.0:
http://resource.thermofisher.com/page/WE28396_2/

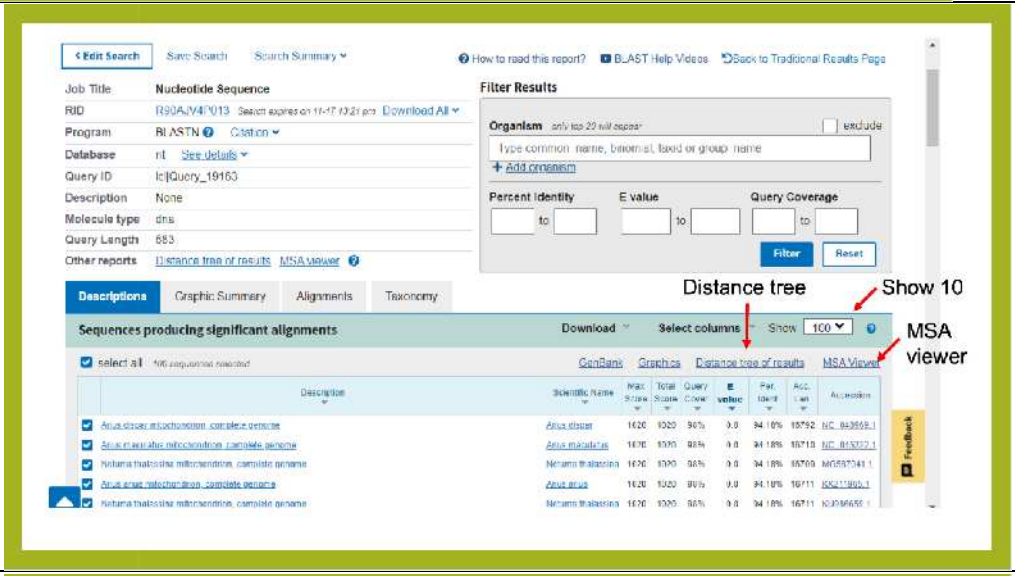
MEGA software:
https://www.megasoftware.net/

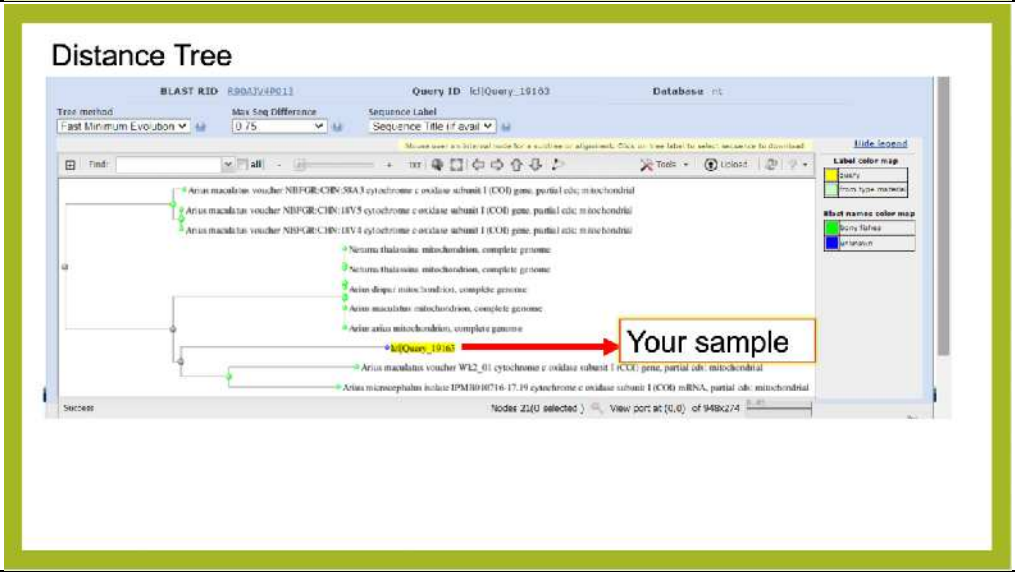


Website:
https://blast.ncbi.nlm.nih.gov/Blast.cgi?PROGRAM=blastn&PAGE_TYPE=BlastSearch&LINK_LOC=blasthome

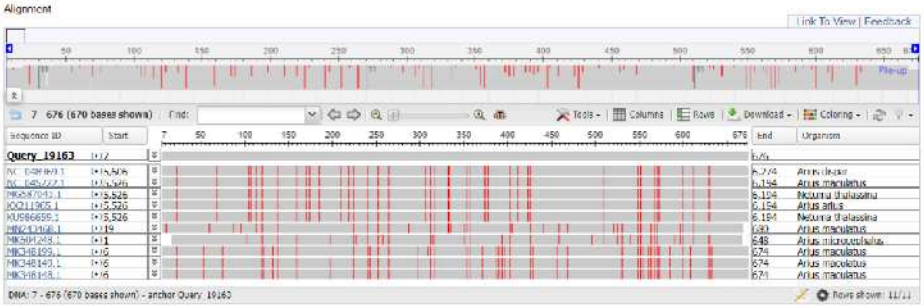



Choose Search Set
Database
Standard databases (nr etc.)
rRNA/ITS databases
Genomic + transcript databases
Betacoronavirus
Nucleotide collection (nr/nt)
2. Select nucleotide
Organism
Optional
Enter organism name or id--completions will be suggested
exclude
Add organism
Enter organism common name, binomial, or tax id. Only 20 top taxa will be shown
Exclude
Optional
Models (XM/XP)
Uncultured/environmental sample sequences
Limit to
Optional
Sequences from type material
Entrez Query
Optional
Create custom database
Enter an Entrez query to limit search
Program Selection
Optimize for
Highly similar sequences (megablast)
More dissimilar sequences (discontiguous megablast)
Somewhat similar sequences (blastn)
3. Select "Highly similar sequences"
Choose a BLAST algorithm
BLAST
Search database Nucleotide collection (nr/nt) using Megablast (Optimize for highly similar sequences)
Show results in a new window
4. Click on BLAST


Edit Search
Save Search
Search Summary
How to read this report?
BLAST Help Videos
Back to Traditional Results Page
Job Title
Nucleotide Sequence
RID
Program
BLASTN
Database
nt
Query ID
lcl|Query_19163
Description
None
Molecule type
dna
Query Length
683
Other reports
Distance tree of results
MSA viewer
Filter Results
Organism
exclude
Add organism
Percent Identity
E value
Query Coverage
Filter
Reset
Descriptions
Graphic Summary
Alignments
Taxonomy
Distance tree
Show 10
Sequences producing significant alignments
Download
Select columns
Show
MSA viewer
select all
GenBank
Graphics
Distance tree of results
MSA Viewer
Feedback

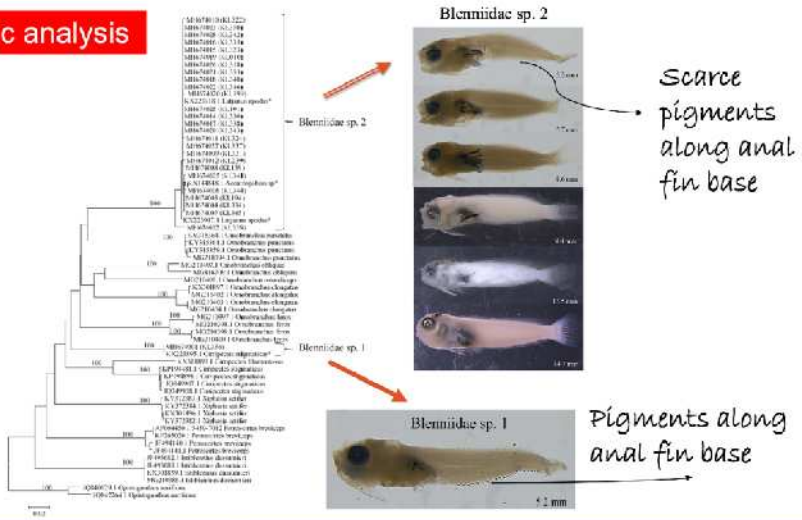

Distance Tree
BLAST RID
Query ID
Database
Tree method
Max Seq Difference
Sequence Label
Hide legend
Label color map
Your sample

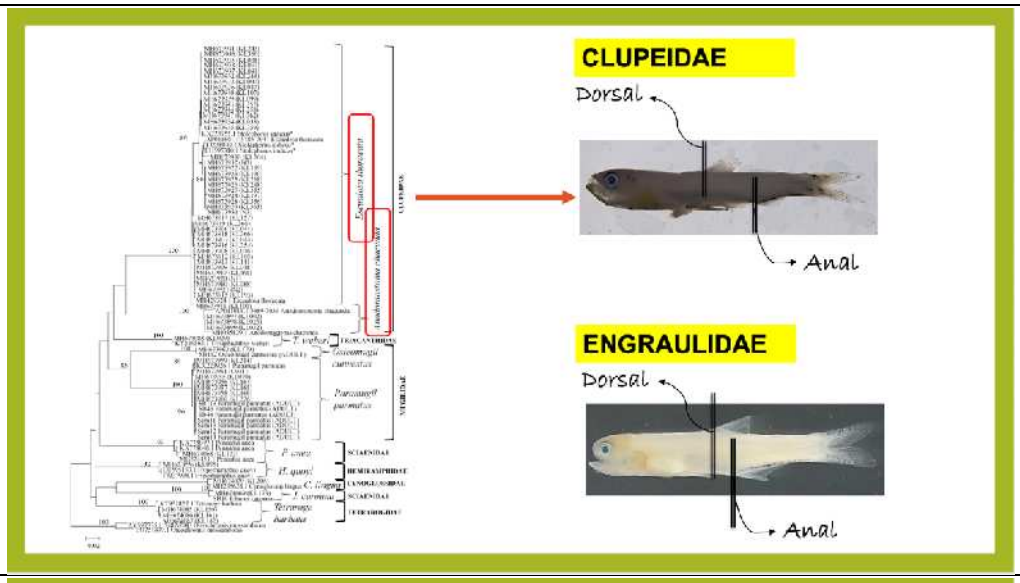
MSA viewer

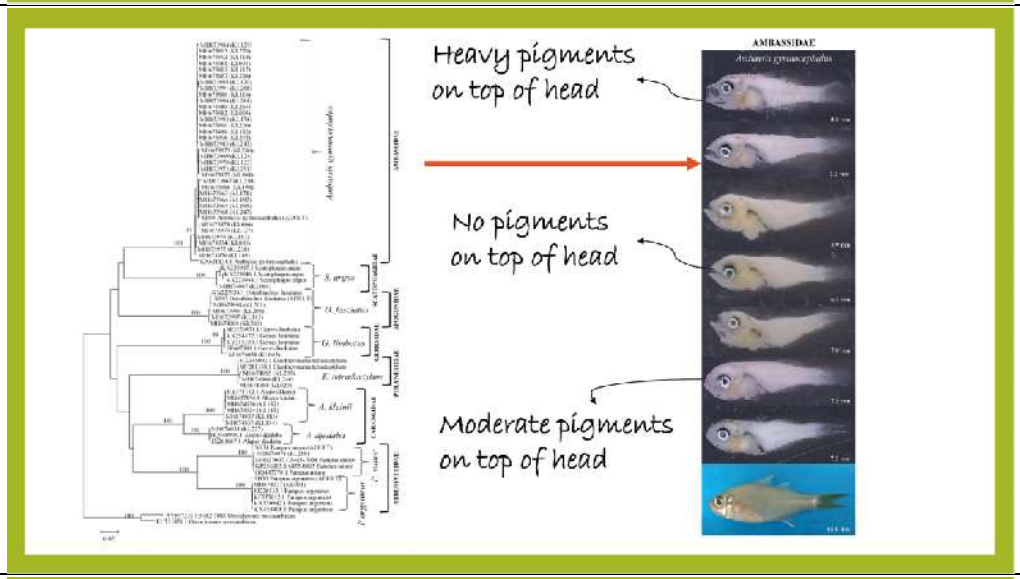


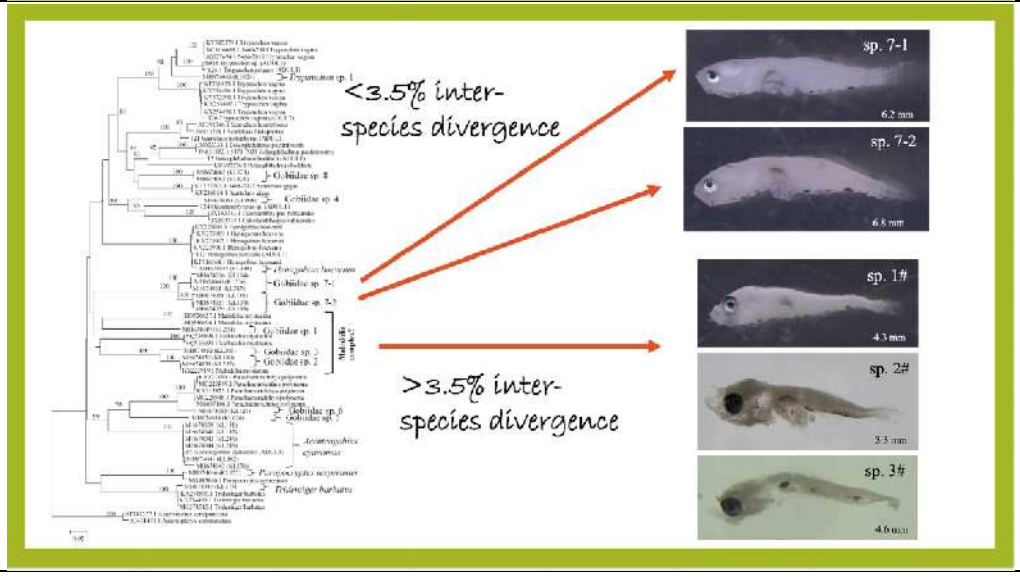
MEGA software

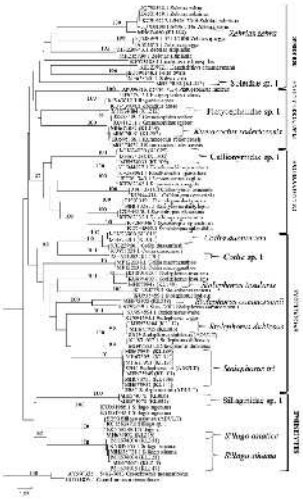
Phylogenetic analysis




CLUPEIDAE
Dorsal
Anal
ENGRAULIDAE
Dorsal
Anal


Heavy pigments on top of head
No pigments on top of head
Moderate pigments on top of head
AMBASSIDAE


<3.5% inter-species divergence
>3.5% inter-species divergence
sp. 7-1
6.2 mm
sp. 7-2
6.8 mm
sp. 1#
4.3 mm
sp. 2#
3.3 mm
sp. 3#
4.6 mm



Q: Can DNA barcode differentiate between the species of larvae and used for routine identification of the larval fishes?

A: Yes, for most species

But…

- Species assignment is not straightforward because of **ambiguous** matches and wrong identification
- General **lack of reference sequences** especially for speciose and non-commercial fish families such as Gobiidae, Blenniidae, and Callionymidae
- **Other gene markers** may be needed to elucidate the identity and phylogenetic relationships of cryptic species such as Ambassidae and Gobiidae

Species of larvae identified using DNA barcode

- 48 taxa from 21 families

Hemiramphidae (*Hyporhamphus quoyi*)
Clupeidae (*Anodontostoma chacunda*, *Escualosa thoracata*)
Engraulidae (*Coilia dussumieri*, *Coilia* sp. 1, *Stolephorus commersonii*, *Stolephorus dubiosus*, *Stolephorus insularis*, *Stolephorus tri*)
Mugilidae (*Paramugil parmatus* and *Osteomugil cunnesius*)
Ambassidae (*Ambassis gymnocephalus*)
Apogonidae (*Ostorhinchus fasciatus*)
Blenniidae (Sp. 1, Sp. 2)
Callionymidae (Sp. 1)
Carangidae (*Alepes djedaba* and *Alepes kleinii*)
Gerreidae (*Gerres limbatus*)
Gobiidae (*Acentrogobius cyanomos*, *Hemigobius hoevenii*, *Parapocryptes serperaster*, *Trypauchen* sp. 1, *Tridentiger barbatus*, Sp. 1, Sp. 2, Sp. 3, Sp. 4, Sp. 5, Sp. 6, Sp. 7, Sp. 8)
Polynemidae (*Eleutheronema tetradactylum*)
Scatophagidae (*Scatophagus argus*)
Sciaenidae (*Pennahia anea* and *Johnius carouna*)
Sillaginidae (*Sillago asiatica* and *Sillago sihama*, Sp. 1)
Stromateidae (*Pampus argenteus* and *Pampus minor*)
Cynoglossidae (*Cynoglossus lingua*)
Soleidae (*Zebrias zebra*, Sp. 1)
Platycephalidae (*Kumococius rodericensis*, Sp. 1)
Tetrarogidae (*Tetraroge barbatus*)
Triacanthidae (*Trixiphichthys weberi*)

Zoological Studies 58: 30 (2019)
doi:10.6620/ZS.2019.58-30

Zoological Studies

Open Access

Using DNA Barcodes to Aid the Identification of Larval Fishes in Tropical Estuarine Waters (Malacca Straits, Malaysia)

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Received 5 April 2019 / Accepted 18 August 2019 / Published 18 October 2019
Communicated by Benny K.K. Chan

New

Tetraroge barbata
TETRAROGIDAE

New

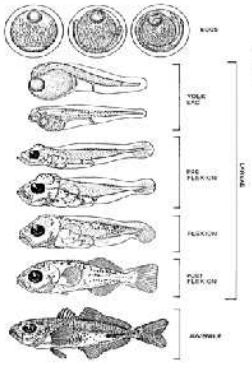
Tridentiger barbatus
GOBIIDAE

Morphological characters useful for larval fish identification

Yoshinobu KONISHI

Formerly, *Seikai* National Fisheries Research Institute
Nagasaki, JAPAN

Early life history stages of *Trachurus symmetricus*



from Kendall et al., 1984
(originally Ahlstrom and Ball, 1954)

Kendall, A. W. Jr., Ahlstrom, E. H. and Moser, H. G. 1984: Early life history stages of fishes and their characters. Pages 11-22 *in* Moser, H. G., Richards, W. J., Cohen, D. M., Fahay, M. P., Kendall, A. W. Jr. and Richardson, S. L. (eds.) Ontogeny and systematics of fishes. Am. Soc. Ichthyol. Herpetol. Spec. Publ. I.

Developmental stages of bony fish

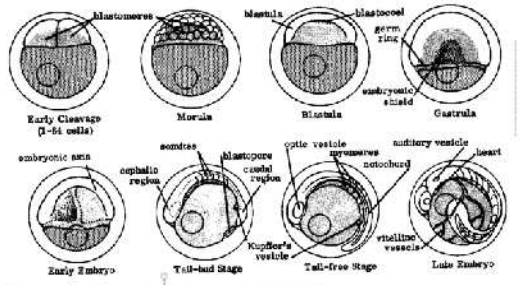
from Jones et al., 1978

- **Egg**
- **Yolk-sac larva**
  stage between hatching and absorption of yolk
- **Larva**
  stage between absorption of yolk and acquisition of minimum adult fin ray complement
- **Juvenile**
  stage between acquisition of minimum adult fin ray complement and sexual maturity with assumption of adult body form (*prejuvenile*: with assumption of incomplete adult body form)
- **Adult**
  sexually mature

Jones, P. W., Martin, F. D. and Hardy, J. D. Jr. 1978. Development of fishes of the Mid-Atlantic Bight. An atlas of egg, larval and juvenile stages. Volume I Acipenseridae through Ictaluridae. U. S. Dep. Interior, Fish Wildl. Serv., Biol. Serv. Prog. FWS/OBS-78/12. 366 pp.

Eggs and yolk-sac larvae

Developmental stages of fish eggs



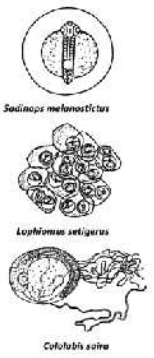
Early stage: spawning – blastpore closure
Middle stage: blastpore closure – tailbud free
Late stage: tailbud free - hatching

from Jones et al., 1978

Various types of fish eggs

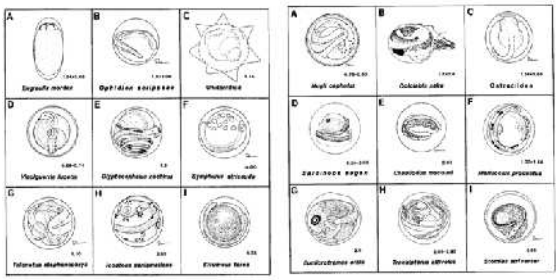
modified Mito (1979)

- **Pelagic eggs**
  - ✓ *Isolated eggs* (mostly)
    The spawned eggs are isolated, not forming any mass
  - ✓ Agglutinated eggs (Lophiidae)
    The spawned eggs are embedded in a gelatinous ribbon/balloon, or agglutinated to each other forming a mass
- **Demersal eggs**
  - ✓ Adhesive eggs (Exocoetidae, Gobiidae)
    The spawned eggs adhesive to substratum with adhesive egg membrane or filaments
  - ✓ Non-adhesive eggs (Salmonidae)



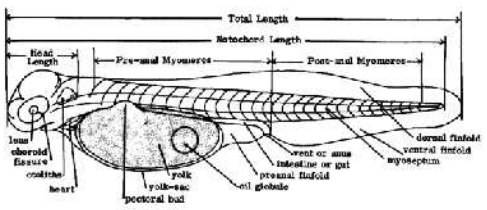
Various types of isolated pelagic fish eggs

from Kendall et al., 1984



Kendall, A. W. Jr. 1984: Identification of fish eggs. p. 27-31. in Ontogeny and systematics of fishes. Moser, H. G., Richards, W. J., Cohen, D. M., Fahay, M. P., Kendall, A. W. Jr. and Richardson, S. L. (eds.) Amer. Soc. Ich. and Herp. Spec. Pub., No. 1

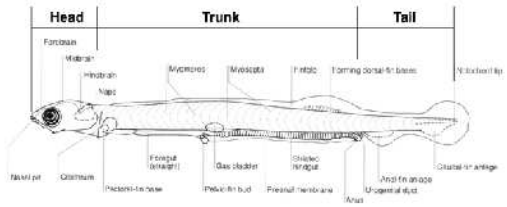
Structure and measuring method of yolk-sack (newly hatched) larva



from Jones et al., 1978

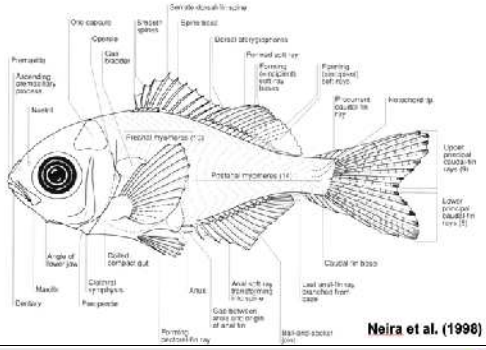
Larvae

External characters of Preflexion larva



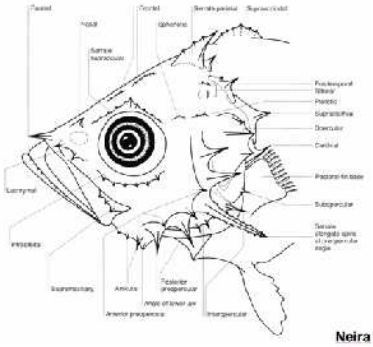
Neira et al. (1998)

External characters of Postflexion larva



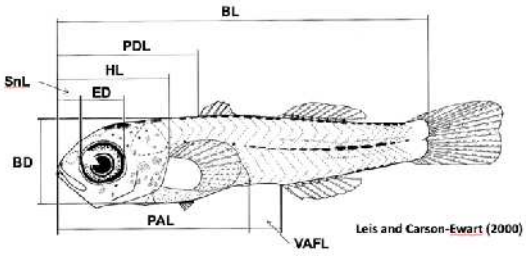
Neira et al. (1998)

Head spination



Neira et al. (1998)

Measurement



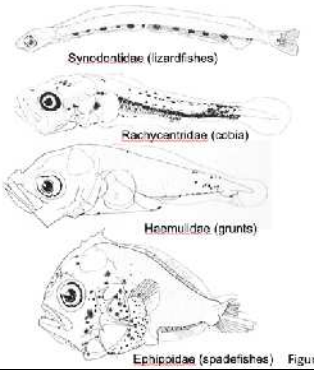
Leis and Carson-Ewart (2000)

BD: body depth; **BL:** body length; **ED:** eye diameter; **HL:** head length; **PAL:** preanal length; **PDL:** pre dorsal-fin length; **SnL:** snout length; **VAFL:** vent to anal-fin length.

General characters useful for the identification

1. Body shape
2. Myomeres
3. Gut
4. Head
5. Snout
6. Mouth
7. Eyes
8. Head spination
9. Fin formation
10. Pigment

1. Body shape (1/2)



Very elongate
BD < 10% BL

Elongate
BD 10-20% BL

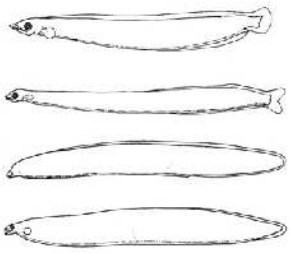
Moderate
BD 20-40% BL

Deep to very deep
BD > 40% BL

Figures from Leis and Carson-Ewart (2000)

1. Body shape (2/2)

Leptocephalus stage of the Anguilliformes : transparent, ribbon-like and usually have a small head and fang-like teeth



Elopidae (tenpounders)

Albulidae (bonefishes)

Muraenidae (moreys)

Congridae (conger eels)

Figures from Moser (1996)

2. Myomeres

Trichiuridae (cutlassfishes)

TM ca 100 - 200

Engraulidae (anchovies)

TM ca 40 - 80

Scombridae (mackerels, spanish mackerels, bonitos, tunas)

TM ca 30 - 60

Nemipteridae (thread-fin breams)

TM 24

Figures from Leis and Carson-Ewart (2000)

3. Gut

Chirocentridae (wolf herrings)

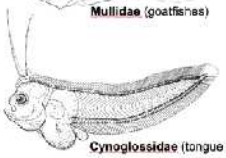
Straight
Very long

Carangidae (jacks)

Coiled
Not compact
(PAL ≧1/2 body)

Mullidae (goatfishes)

Coiled
Compact
(PAL ≦1/2 body)



Cynoglossidae (tongue soles)

Coiled
Ventrally protrudent

Figures from Leis and Carson-Ewart (2000)

4. Head

Drepaneidae (sicklefishes)

Large (deep)
HL > 33% BL

Terapontidae (grunters)

Moderate
HL 20 – 33% BL
(larger with growth in some species)

Sillaginidae (whitings)

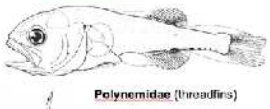
Small
HL < 20% BL
(larger with growth in some species)

Figures from Leis and Carson-Ewart (2000)

5. Snout

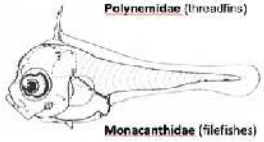
Sphyraenidae (barracudas)

Long and pointed



Polynemidae (threadfins)

Moderate and round

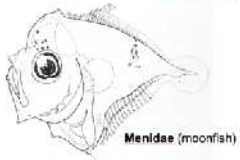


Monacanthidae (filefishes)

Short and
concave in
dorsal profile

Figures from Leis and Carson-Ewart (2000)

6. Mouth



Menidae (moonfish)

Large, oblique and terminal

Engraulidae (anchovies)

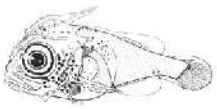
Large and inferior (at large postflexion and juvenile stages)

Balistidae (triggerfishes)

Small and terminal

Figures from Leis and Carson-Ewart (2000)

7. Eyes



Priacanthidae (bigeyes)

Large and round
(ED > 33% HL)

Sciaenidae (croakers)

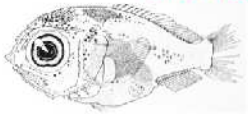
Small at postflexion stage
(ED < 25% HL) and round

Scaridae (parrotfishes)

Elliptical in some species

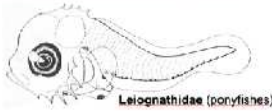
Figures from Leis and Carson-Ewart (2000)

8. Head spination



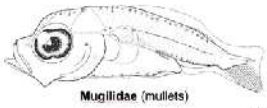
Malacanthidae (Branchiostegidae, tilefishes)

Well-developed



Leiognathidae (ponyfishes)

Developed



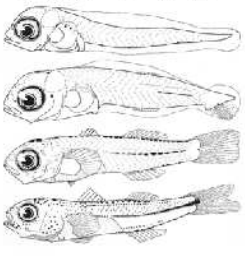
Mugilidae (mullets)

No spination

Figures from Leis and Carson-Ewart (2000)

9. Fin formation

Fin development sequence
C → 2D & A → 1D → P_1 → P_2



Mullid *Upeneus tragula* (goatfish)

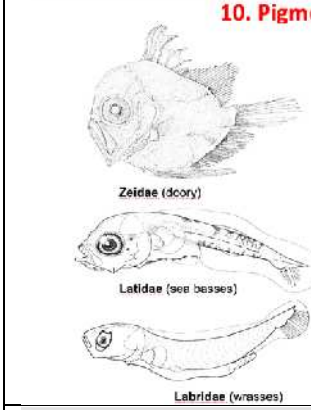
Elongate (early forming) rays
and enlarged fin

Serranid Epinephelinae
(groupers)

Scorpaenidae (scorpionfishes)

Figures from Leis and Carson-Ewart (2000)

10. Pigment



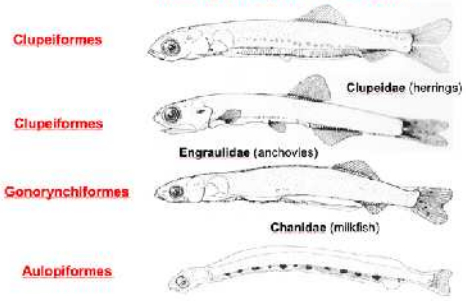
Figures from Leis and Carson-Ewart (2000)

Characters useful for identification in order 1 (1/6)

Characters	Clupeiformes	Gonorynchiformes	Aulopiformes
Type of fin elements	Rays	Rays	Rays
P_1 formation	Late	Late	Often early
P_2 fin formation	Late	Late	Early to late
P_2 fin position	Abdominal	Abdominal	Abdominal
P_2 fin formula	Usually 7-10	9-12	7-11
Dorsal fin (s)	1	1	1
Anal fin	0 spine	0 spine	0 spine
Adipose fin	No	No	Usually present
Principal Caudal rays	19	19	19
Dominant body shape	Elongate, slender	Elongate, slender	Various, often elongate
Preanal length (% BL)	48-90%	77-90%	ca 20-75%
Type of gut	Straight	Straight	Straight, variously types
Vertebrae	39-76	40-61	36-121
Head spination	None	None	Usually none
Early forming fin	No	No	Occasionally P_1 rays

Leis and Carson-Ewart (2000), hereafter same

1) Clupeiformes, 2) Gonorynchiformes and 3) Aulopiformes larvae

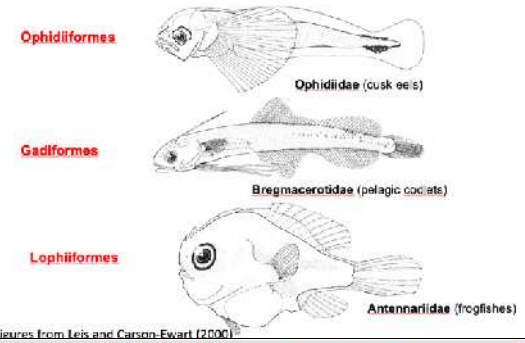


Figures from Leis and Carson-Ewart (2000)

Characters useful for identification in order 1 (2/6)

Characters	Ophidiiformes	Gadiformes	Lophiiformes
Type of fin elements	Rays	Rays	Spines and rays
P_1 formation	Sometimes early	Sometimes late	Sometimes early
P_2 fin formation	Late	Often early	Often absent, early to late
P_2 fin position	Jugular	Thoracic or jugular	Thoracic
P_2 fin formula	0-2	Various; 2-8	0 or I, 3-5
Dorsal fin (s)	1	1-3	2, anterior on head
Anal fin	0 spine	0 spine	0 spine
Adipose fin	No	No	No
Principal Caudal rays	0-14	Various numbers	8-10
Dominant body shape	Elongate	Various, elongate to deep-bodied	Globular
Preanal length (% BL)	33-55%	Usually < 50%	30-90%
Type of gut	Coiled	Usually coiled	Deep, coiled
Vertebrae	40-150	40-many	18-31
Head spination	Opercular spines	Usually none	None
Early forming fin	P_1 rays and vexillum in some	No	Varies, none to P_2 and anterior D

4) Ophidiiformes, 5) Gadiformes and 6) Lophiiformes larvae

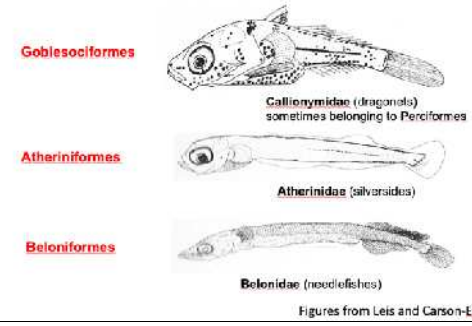


Figures from Leis and Carson-Ewart (2000)

Characters useful for identification in order 1 (3/6)

Characters	Gobiesociformes	Atheriniformes	Beloniformes
Type of fin elements	Spines, rays, or rays only	Spines and rays	Rays
P_1 formation	Late	Late	Late
P_2 fin formation	Late	Late	Late
P_2 fin position	Thoracic	Abdominal to thoracic	Abdominal
P_2 fin formula	I, 4-I, 5	I, 5	6
Dorsal fin (s)	1 or 2	2	1
Anal fin	0-1 spine	0-1 spine	0 spine
Adipose fin	No	No	No
Principal Caudal rays	8-14	17	15
Dominant body shape	Moderate to very stubbly	Elongate	Elongate
Preanal length (% BL)	50-85%	20-50%, increases ontogenetically	65-80%
Type of gut	Initially straight, later coiled	Coiled	Straight
Vertebrae	21-54	21-55	36-97
Head spination	No or 1 opercular spine	No	No
Early forming fin	No	No	C at hatching

7) Gobiesociformes, 8) Atheriniformes and 9) Beloniformes larvae

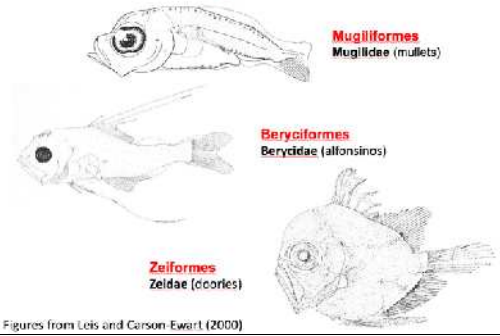


Figures from Leis and Carson-Ewart (2000)

Characters useful for identification in order 1 (4/6)

Characters	Mugiliformes	Berycifformes	Zeiformes
Type of fin elements	Spines, rays	Spines and rays	Spines and rays
P_1 formation	Late	Not late	Late
P_2 fin formation	Late	Often early	Various, early to late
P_2 fin position	Subabdominal	Thoracic or abdominal	Abdominal to thoracic
P_2 fin formula	I, 5	0-I, 2-13	0-I, 3-10
Dorsal fin (s)	2	1 or 2	1
Anal fin	2-3 spines	0-4 spines	0-3 spines
Adipose fin	No	No	No
Principal Caudal rays	14-15	18-19	9-13
Dominant body shape	Slender to moderate	Slender to stubbly	Deep, compressed
Preanal length (% BL)	57-78%	ca 30-79%	50-70%
Type of gut	Coiled, underslung	Coiled	Deep, coiled
Vertebrae	24-26	24-30	21-45
Head spination	None	None to markedly heavy	None to markedly heavy
Early forming fin	None	Often P_2 and anterior D	Various, none to P_2

10) Mugiliformes, 11) Beryciformes and 12) Zeiformes larvae

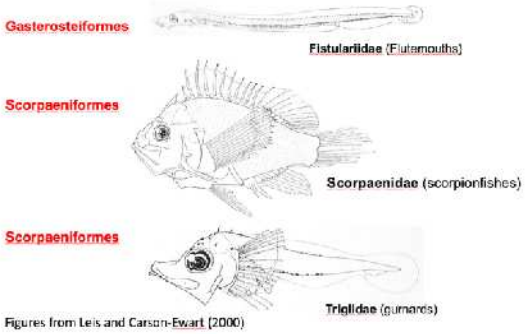


Figures from Leis and Carson-Ewart (2000)

Characters useful for identification in order 1 (5/6)

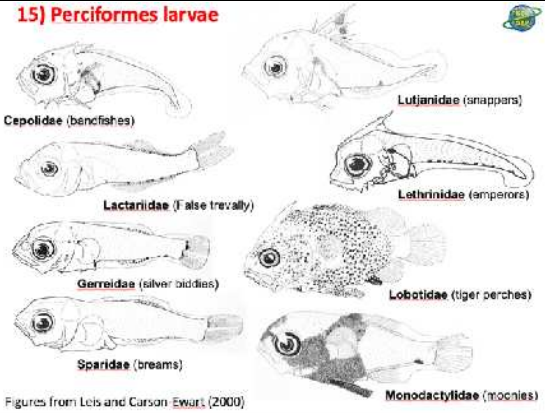
Characters	Gasterosteiformes	Scorpaeniformes	Perciformes
Type of fin elements	Spines, rays	Spines and rays	Spines and rays
P_1 formation	Late	Late	Various
P_2 fin formation	Often absent, late	Intermediate	Sometimes early
P_2 fin position	Abdominal	Thoracic	Various, usually thoracic
P_2 fin formula	0-6	I, 5 or fewer	I, 5 or fewer
Dorsal fin (s)	1 or 2	1 or 2	1 or 2
Anal fin	0-1 spine	0-3 spines	Usually 1-3 spines
Adipose fin	No	No	No
Principal Caudal rays	0-15	Variable, <18	Usually 17
Dominant body shape	Various, often elongate	Various, usually stubby	Various, usually stubby
Preanal length (% BL)	Various, 45-90%	ca 35-60%	Various, 20-80%
Type of gut	Usually straight	Coiled	Various, usually coiled
Vertebrae	19-87	ca 25-65	ca 20-100+, often 24-28
Head spination	None to heavy, often associated with body plates	Usually	None to markedly heavy
Early forming fin	None	P_2 can be large	Sometimes: D spine, P_2 spine and rays

13) Gasterosteiformes and 14) Scorpaeniformes larvae



Figures from Leis and Carson-Ewart (2000)

15) Perciformes larvae

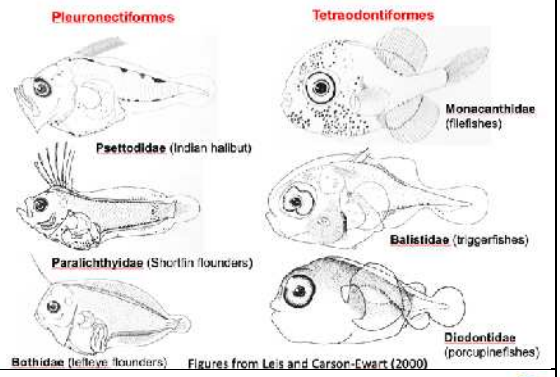


Figures from Leis and Carson-Ewart (2000)

Characters useful for identification in order 1 (6/6)

Characters	Pleuronectiformes	Tetraodontiformes
Type of fin elements	Rays except P_2 spine in some	Spines and rays or rays only
P_1 formation	Late	Sometimes early
P_2 fin formation	Sometimes early	Often absent
P_2 fin position	Thoracic to jugular	Thoracic
P_2 fin formula	I, 5 or 0, 2-6	0-I, 5
Dorsal fin (s)	1	1 or 2
Anal fin	0 spine	0 spine
Adipose fin	No	No
Principal Caudal rays	Variable	9-12
Dominant body shape	Various, markedly compressed	Various, usually moderate
Preanal length (% BL)	Usually < 40%	40-90%
Type of gut	Coiled	Coiled
Vertebrae	23-65	16-30
Head spination	None to heavy	Various
Early forming fin	Often, 1-12 anterior D rays, sometimes 2-3 P_2 rays	Sometimes P_2 rays

16) Pleuronectiformes and 17) Tetraodontiformes larvae



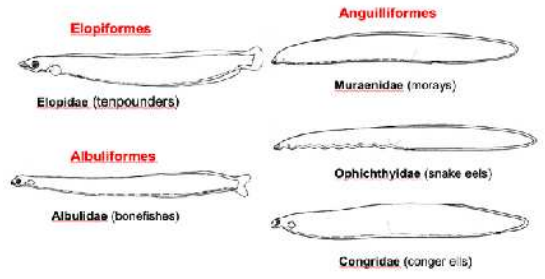
Figures from Leis and Carson-Ewart (2000)

Characters useful for identification in order 2 (1/3)

Characters	Elopiformes Albuliformes	Anguilliformes
Type of fin elements	Rays	Rays
P_1 formation	Late	Late
P_2 fin formation	Late	Absent
P_2 fin position	Abdominal	Absent
P_2 fin formula	10-16 (Elop.) 9-11 (Albu.)	Absent
Dorsal fin (s)	1	1
Anal fin	1	1
Adipose fin	No	No
Principal Caudal rays	19	Usually 5-11, absent in some
Dominant body shape	Leptocephalus, forked tail	Leptocephalus
Preanal length (% BL)	75-80 (Elop.), 90-95 (Albu.)	40-95
Type of gut	Straight	Straight, some with loop, rarely trailing
Vertebrae	51-82 (Elop.), 65-92 (Albu.)	97-400+ (most 100-250)
Head spination	No	No
Early forming fin	No	No

Moser (1996), hereafter same

18) Elopiformes, 19) Albuliformes and 20) Anguilliformes larvae

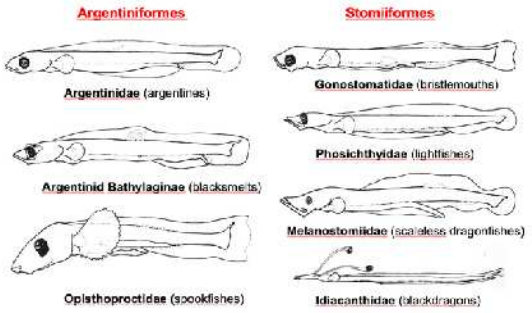


Figures from Moser (1996)

Characters useful for identification in order 2 (2/3)

Characters	Argentiniformes	Stomiiformes
Type of fin elements	Rays	Rays
P_2 formation	Late, elongate in some	Late in most, elongate in *Ichthyococcus*
P_2 fin formation	Usually late, elongate in some	Late
P_2 fin position	Abdominal	Abdominal
P_2 fin formula	Varied, usually 8-12	Varied, usually 5-8, up to 26 in *Bathophilus*
Dorsal fin (s)	1	1
Anal fin	1	1
Adipose fin	Usually present	Often present
Principal Caudal rays	19 (10+9)	19 (10+9)
Dominant body shape	Elongate, slender, some stout	Elongate, some compressed
Preanal length (% BL)	70-95	30-95
Type of gut	Straight, folded or saccular in some	Straight, trailing and ornamented in some
Vertebrae	40-85	30-100+
Head spination	None	None
Early forming fin	No	P_1 in *Ichthyococcus*

20) Argentiniformes and 21) Stomiiformes larvae

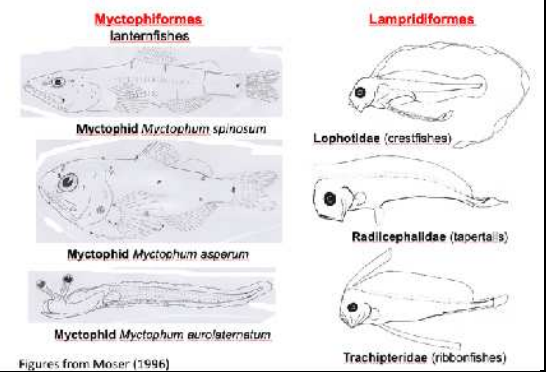


Figures from Moser (1996)

Characters useful for identification in order 2 (3/3)

Characters	Myctophiformes	Lampridiformes
Type of fin elements	Rays	Rays
P_2 formation	Various, early and elongate in some	Late
P_2 fin formation	Various, early and elongate in some	Usually early, 1 or more elongate, usually heavily ornamented
P_2 fin position	Abdominal	Abdominal to thoracic
P_2 fin formula	Varied, usually 8-10	0-17
Dorsal fin (s)	1 fin	1 fin, 1 or more anterior rays elongate and highly ornamented
Anal fin	1	0 or 1
Adipose fin	Usually present	No
Principal Caudal rays	19 (10+9)	3-32
Dominant body shape	Various, elongate to moderately stout	Usually elongate and compressed
Preanal length (% BL)	40-70	45-90
Type of gut	Straight, varied shapes, trailing in 1 species	Coiled
Vertebrae	28-45	33-200
Head spination	Usually none	No
Early forming fin	P_1 and P_2 in some	1 or more anterior D rays and P_2

22) Myctophiformes and 23) Lampridiformes larvae



Figures from Moser (1996)

Annex 4: Identification methods of the Scombridae fishes and their larvae in Southeast Asia

Identification methods of the Scombridae fishes and their larvae in the Southeast Asian region

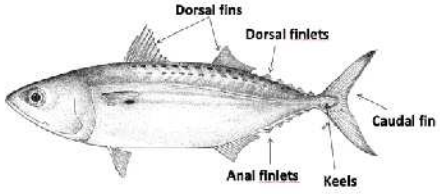
Yoshinobu KONISHI

Formerly, *Seikai* National Fisheries Research Institute
Nagasaki, JAPAN

Adults

Reference:
Collette, B. B. (2001). Scombridae. Pages 3721-3756 *in* Carpenter, K. E. and V. H. Niem eds. The living marine resources of the Western Central Pacific. FAO species identification guide for fishery purposes. FAO, Rome.

Diagnostic characters of the Scombridae fishes



- Two dorsal fins
- Five to ten dorsal and anal finlets
- Caudal fin deeply forked
- Two small keels on each side of caudal peduncle

Representative species of scombrid genera in the region

Genera and species of the Scombridae in the Southeast Asian region

No.	Tribe	Genus	Species
1	Scombrini	*Rastrelliger*	3
2		*Scomber*	2
3	Scombero-morini	*Acanthocybium*	1
4		*Grammatorcynus*	1
5		*Scomberomorus*	5
6	Sardini	*Gymnosarda*	1
7		*Sarda*	1
8	Thunnini	*Auxis*	2
9		*Euthynnus*	1
10		*Katsuwonus*	1
11		*Thunnus*	4

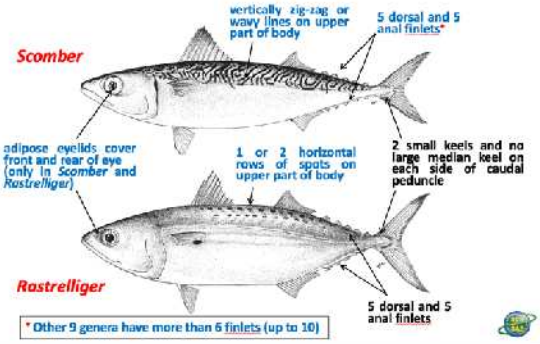
Total 22 species

Genera and species of the Scombridae in Myanmar, Thailand, Cambodia and Viet Nam

Genus	Myan	Thai	Camb	Viet
Acanthocybium	0	0	0	0
Auxis	2	2	2	2
Euthynnus	1	0	1	1
Grammatorcynus	1	0	0	0
Gymnosarda	0	0	0	0
Katsuwonus	1	0	0	1
Rastrelliger	3	3	3	2
Sarda	0	0	0	0
Scomber	0	0	0	0
Scomberomorus	4	3	3	4
Thunnus	1	0	0	4
Total	13	8	9	14

Myan : Myanmar ; Thai : Thailand (the Gulf of Thailand) ; Camb : Cambodia ; Viet : Viet Nam

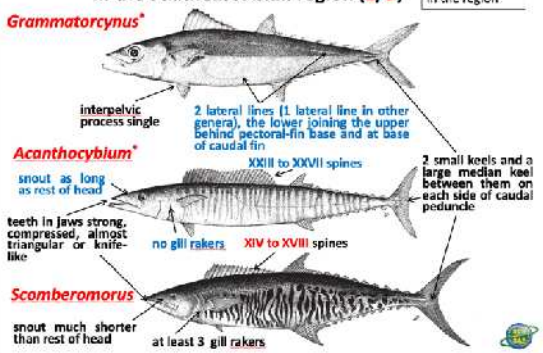
Eleven genera of the Scombridae in the Southeast Asian region (1/5)



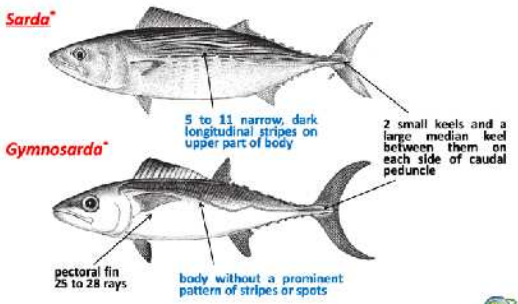
* Other 9 genera have more than 6 finlets (up to 10)

Eleven genera of the Scombridae in the Southeast Asian region (2/5)

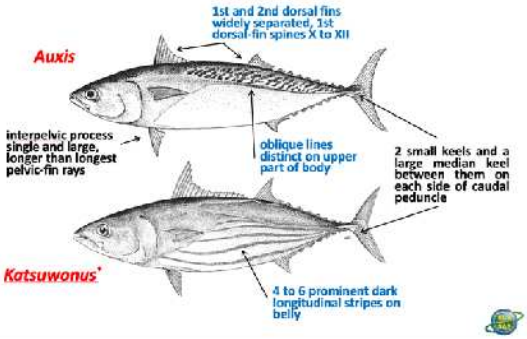
* Single species in the region



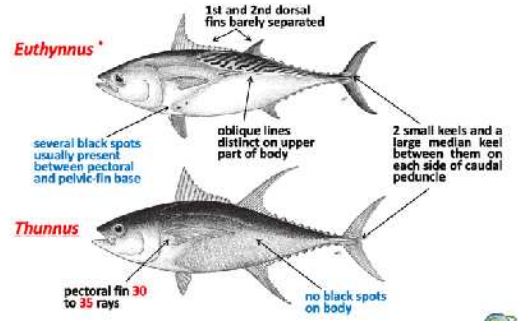
Eleven genera of the Scombridae in the Southeast Asian region (3/5)



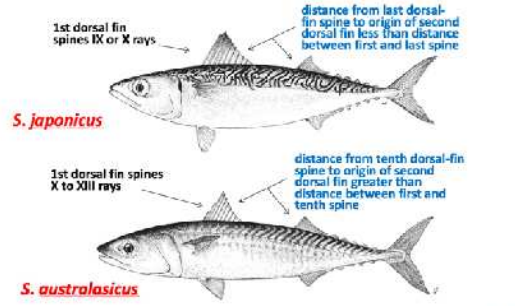
Eleven genera of the Scombridae in the Southeast Asian region (4/5)



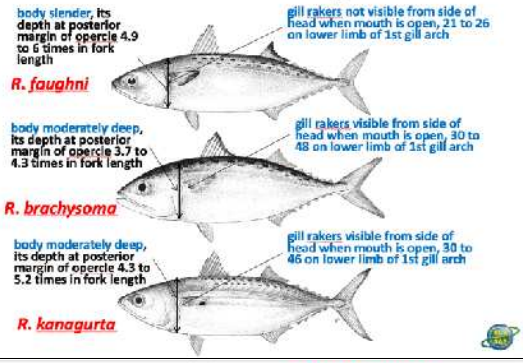
Eleven genera of the Scombridae in the Southeast Asian region (5/5)



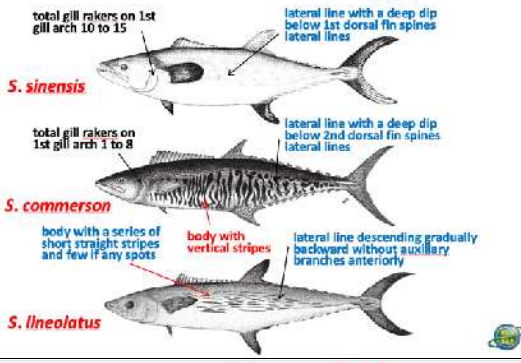
Two species of the Genus *Scomber* in the Southeast Asian region



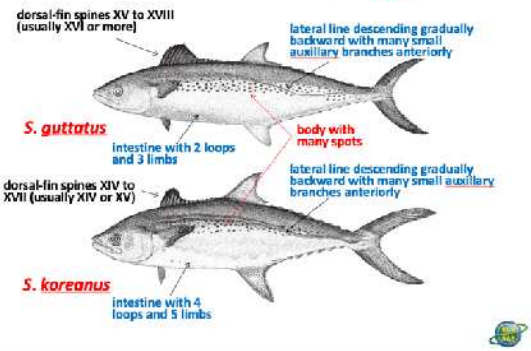
Three species of the Genus *Rastrelliger* in the Southeast Asian region



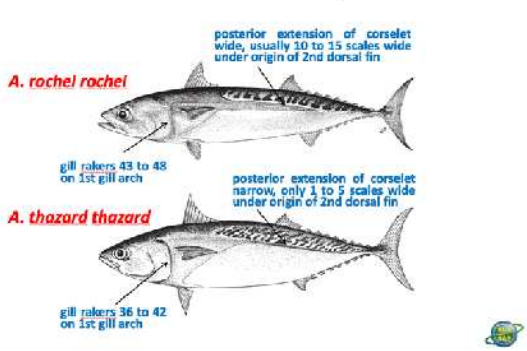
Five species of the Genus *Scomberomorus* in the Southeast Asian region (1/2)



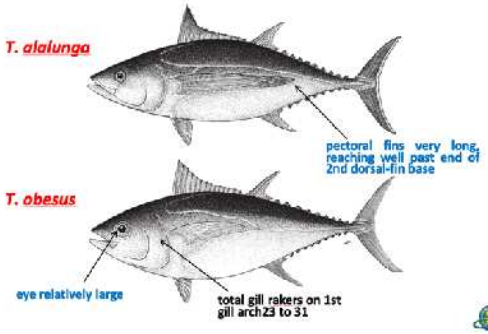
Five species of the Genus *Scomberomorus* in the Southeast Asian region (2/2)



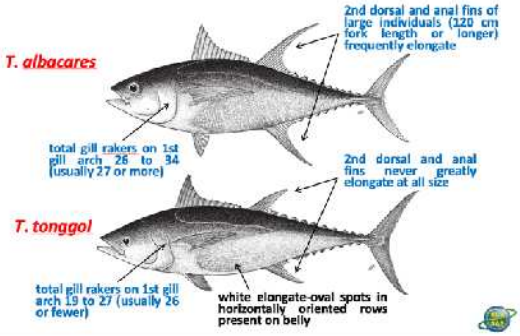
Two species of the Genus *Auxis* in the Southeast Asian region



Four species of the Genus *Thunnus* in the Southeast Asian region (1/2)



Four species of the Genus *Thunnus* in the Southeast Asian region (2/2)



Larvae

References:

Okiyama, M. ed. (2013). An atlas of early stage fishes in Japan. Second edition. Tokai University Press, Hatano, 1639pp. (in Japanese).

Richards, W. J. and G. P. Jenkins. (2000). Scombridae. Pages 693-700 *in* Leis, J. M. and B. M. Carson-Ewart eds. The larvae of Indo-Pacific coastal fishes. An identification guide to marine fish larvae. Brill, Leiden.

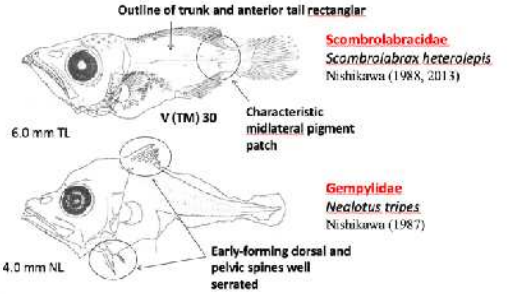
Meristic characters of Southeast Asian scombrid genera

	Genus	1st D	2nd D	D finlets	A	A finlets	P_2	V
1	*Scomber*	9-13	12	5	12	5	18-21	31
2	*Rastrelliger*	8-9	12	5	12	5	19-20	31
3	*Gymnosarda*	13-15	12-14	6-7	12-13	6	25-28	38
4	*Sarda*	17-19	13-18	7	14-17	6	23-27	44-46
5	*Acanthocybium*	23-27	12-16	8-9	12-14	9	22-26	62-64
6	*Grammatorcynus* *	9-13	10-12	6-8	11-13	5-7	21-25	31
7	*Scomberomorus* *	13-22	15-25	6-11	16-29	5-12	20-26	41-56
8	*Auxis*	10-12	10-12	8	11-14	7	23-25	39
9	*Euthynnus*	10-15	11-13	8-10	13-14	6-8	25-29	39
10	*Katsuwonus*	14-16	14-16	7-9	14-16	6-8	26-27	41
11	*Thunnus* *	11-14	12-16	7-10	11-16	7-10	30-36	39

1, 2 : Scombrini ; 3, 4 : Sardini ; 5-7 : Scomberomorini ; 8-11 : Thunnini
* including the Indo-Pacific species out of the Southeast Asian region.

modified Richards and Jenkins (2000)

Similar larvae to the Scombridae



Preflexion larvae (V 31) of *Rastrelliger* and *Scomber* are similar to those of Ambassidae (24), Nemipteridae (23-24), Sparidae (24), Terapontidae (25), Pinguipedidae (29-34) and some myctophids (no head spines and head compressed) .

Key to species (genus) of the Scombridae larvae (ca 10 mm BL >) in the Southeast Asian region (1 /3)

1 a No preopercular spines. Round head and mouth relatively small. Ventral margin of tail pigmented. V (TM) 31. ··· ***Scomber, Rastrelliger***
1 b Preopercular spines present. ····· 2
2 a Snout and head round. Preopercular spines small and supraorbital ridge not distinct. Five to 6 large pigment patches present on dorsolateral body in flexion to juvenile stages. V (TM) 31. ····· ***Grammatorcynus bilineatus***
2 b Head, eyes and mouth relatively large. Spines on preopercle, post-temporal well-developed. V (TM) more than 32. ····· 3
3 a A supraoccipital spine present. ····· 4
3 b Supraoccipital spine absent. ····· 5
4 a Snout large and its length about 2 times of eye diameter. Mouth large. Supraoccipital spine distinct. V (TM) more than 46. ····· ***Scomberamorus***
4b Snout moderately large and its length 1.5 times of eye diameter. Supraoccipital spine small. V (TM) 44-45. ····· ***Sarda orientalis***

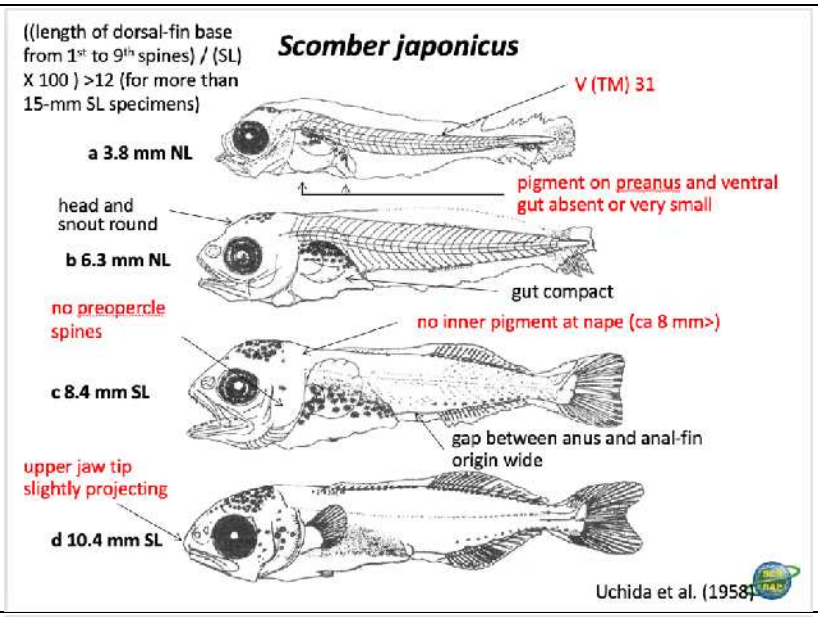
modified Nishikawa (2013)

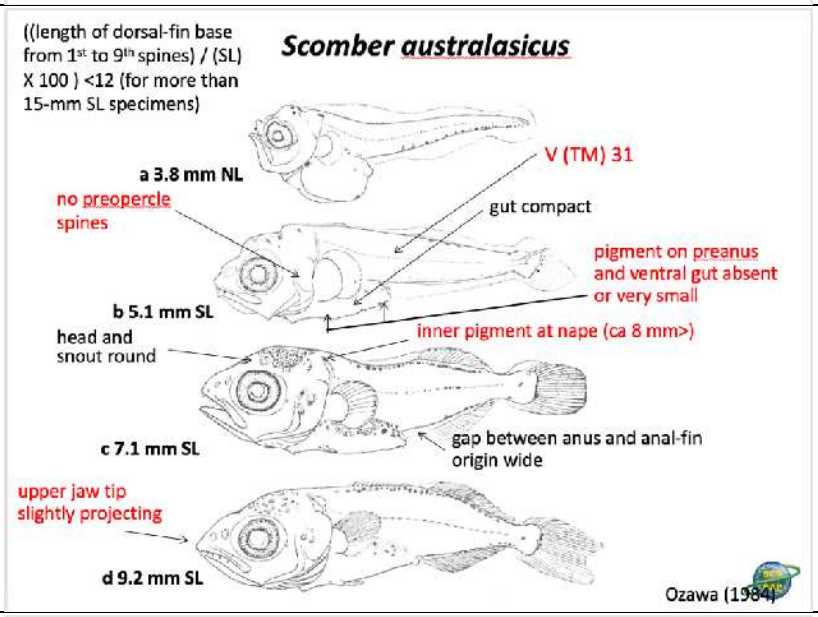
Key to species (genus) of the Scombridae larvae (ca 10 mm BL >) in the Southeast Asian region (2 /3)

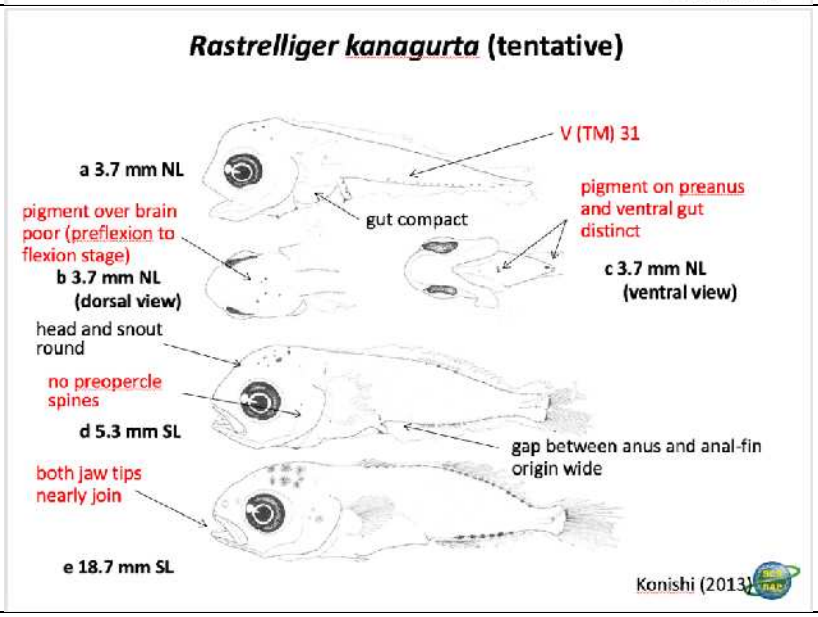
5 a Body elongate and anus position beyond half body. Snout very elongate and mouth large. V (TM) 62-64. ·· ***Acanthocybium solandri***
5 b Body moderate and tail tapering. Gut compact and anus anterior to half body. Snout and mouth varied (small to large). V (TM) 40-42. ····· 6
6 a Snout elongate. Tip of upper jaw well projecting. Pigment appears densely on branchiostegal membrane and opercular portion. No pigment appears on tail. ····· ***Gymnosarda unicolor***
6 b Snout not elongate. Pigment on body poor. ····· 7
7 a Inner pigment appears at anterior margin of forebrain. ····· 8
7 b No inner pigment appears at anterior margin of forebrain. ····· 10
8 a Pigment present on isthmus and preanus. Pigment spots appear on ventral midline of tail. ····· ***Euthynnus affinis***
8 b No pigment present on isthmus and preanus. ····· 9

Key to species (genus) of the Scombridae larvae (ca 10 mm BL >) in the Southeast Asian region (3 /3)

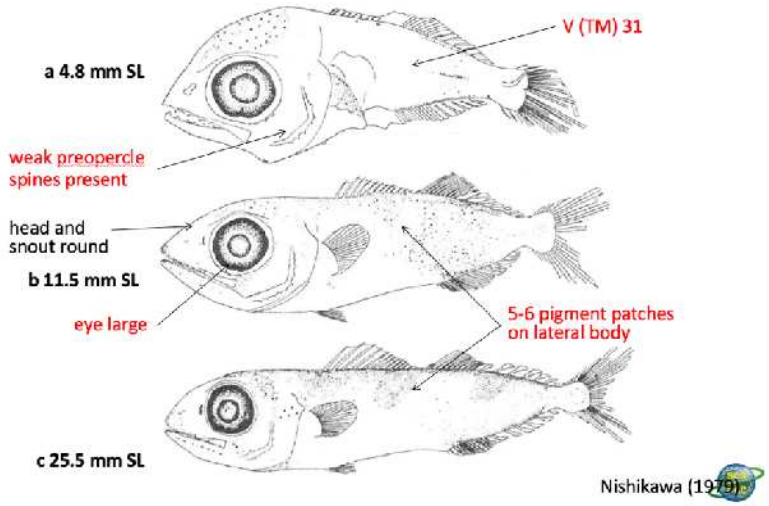
9 a Anterior tip of lower jaw pigmented (3 mm NL <). Pigment on spinous dorsal fin begin to appear in 8-mm BL. ····· ***Katsuwonus pelamis***
9 b Anterior tip of lower jaw unpigmented (at least ca 8 mm NL >). Pigment on spinous dorsal fin begin to appear in 5-mm BL. ·· ***Thunnus tonggol***
10 a Pigment present on isthmus and preanus. ····· ***Auxis***
10 b No pigment on isthmus and preanus. ····· 11
11 a One to two small melanophores present on ventral midline of caudal peduncle. ····· ***Thunnus obesus***
11 b No melanophores present on lateral body. ····· 13
12 a Lower jaw tip unpigmented (ca 8-mm BL >). ····· ***Thunnus alalunga***
12 b Lower jaw tip pigmented. ····· ***Thunnus albacares***


((length of dorsal-fin base from 1st to 9th spines) / (SL) X 100) >12 (for more than 15-mm SL specimens)
Scomber japonicus
V (TM) 31
a 3.8 mm NL
pigment on preanus and ventral gut absent or very small
head and snout round
b 6.3 mm NL
gut compact
no preopercle spines
no inner pigment at nape (ca 8 mm>)
c 8.4 mm SL
gap between anus and anal-fin origin wide
upper jaw tip slightly projecting
d 10.4 mm SL
Uchida et al. (1958)


((length of dorsal-fin base from 1st to 9th spines) / (SL) X 100) <12 (for more than 15-mm SL specimens)
Scomber australasicus
a 3.8 mm NL
V (TM) 31
no preopercle spines
gut compact
pigment on preanus and ventral gut absent or very small
b 5.1 mm SL
head and snout round
inner pigment at nape (ca 8 mm>)
c 7.1 mm SL
gap between anus and anal-fin origin wide
upper jaw tip slightly projecting
d 9.2 mm SL
Ozawa (1984)

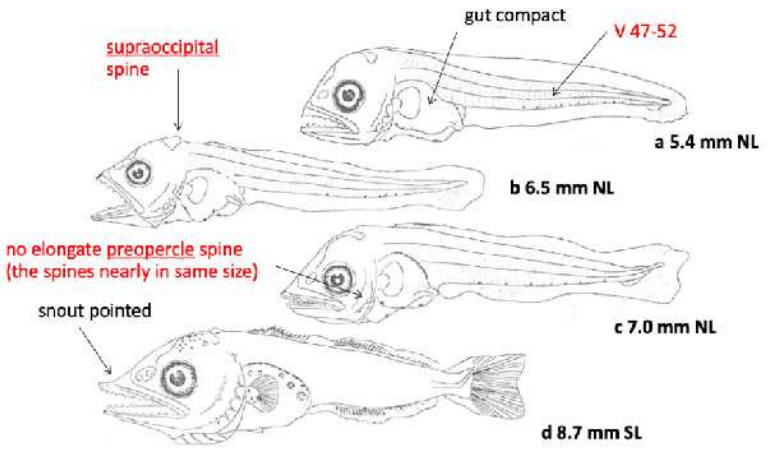

Rastrelliger kanagurta (tentative)
a 3.7 mm NL
V (TM) 31
pigment over brain poor (preflexion to flexion stage)
gut compact
pigment on preanus and ventral gut distinct
b 3.7 mm NL (dorsal view)
c 3.7 mm NL (ventral view)
head and snout round
no preopercle spines
d 5.3 mm SL
gap between anus and anal-fin origin wide
both jaw tips nearly join
e 18.7 mm SL
Konishi (2013)

Grammatorcynus bilineatus



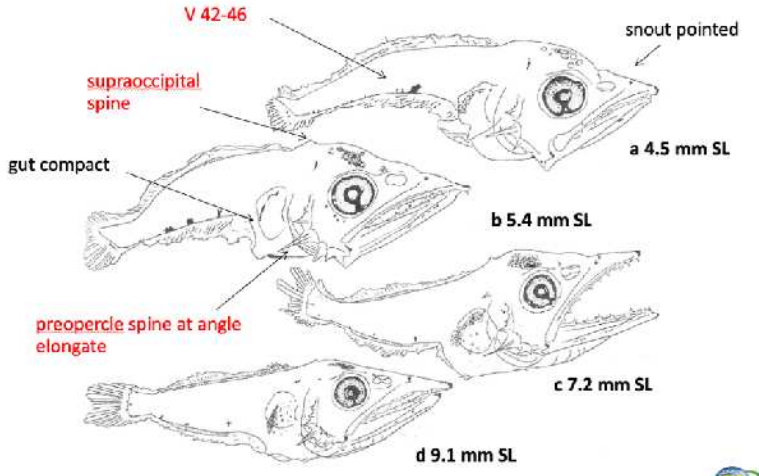
Nishikawa (1979)

Scomberomorus guttatus



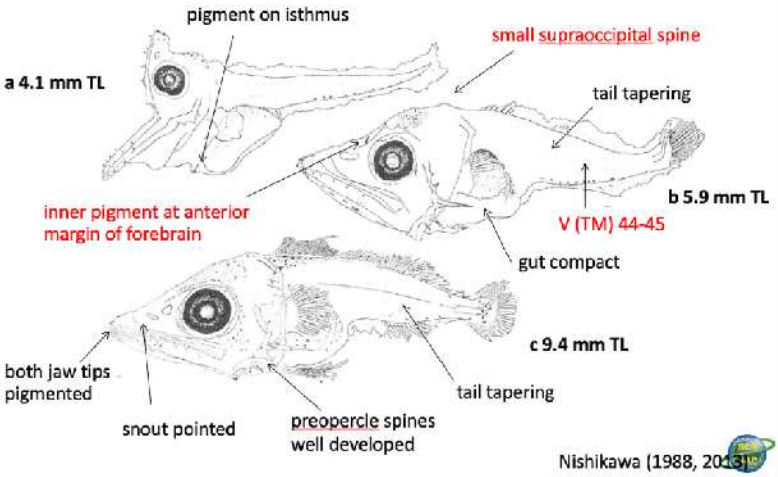
Zhang (1985)

Scomberomorus commerson



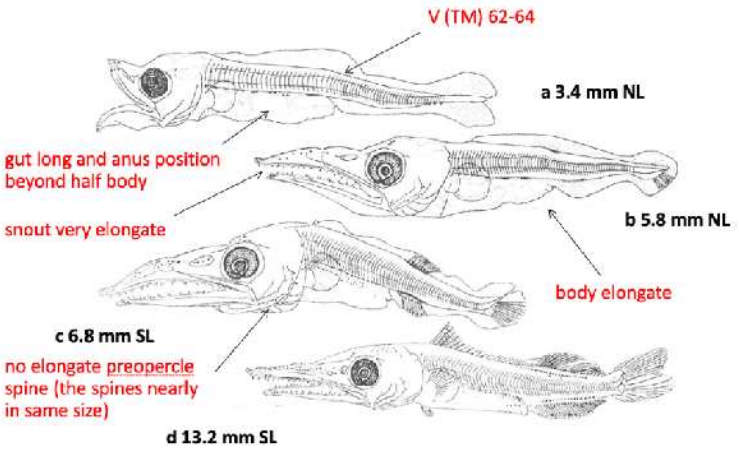
Jenkins (1984)

Sarda orientalis



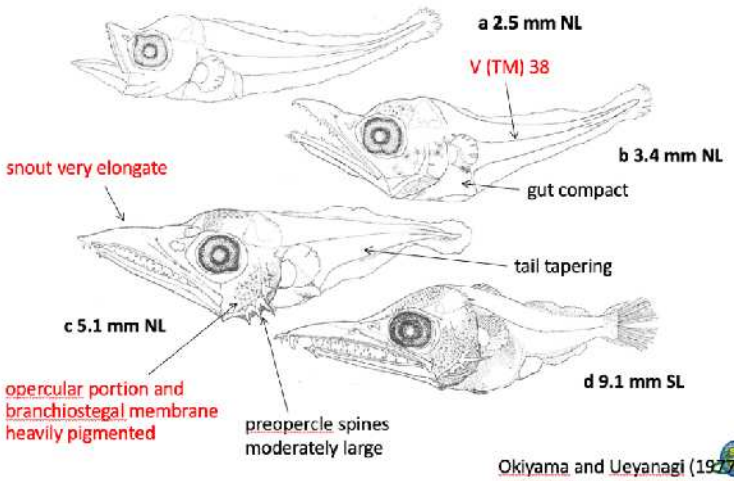
Nishikawa (1988, 201

Acanthocybium solandri

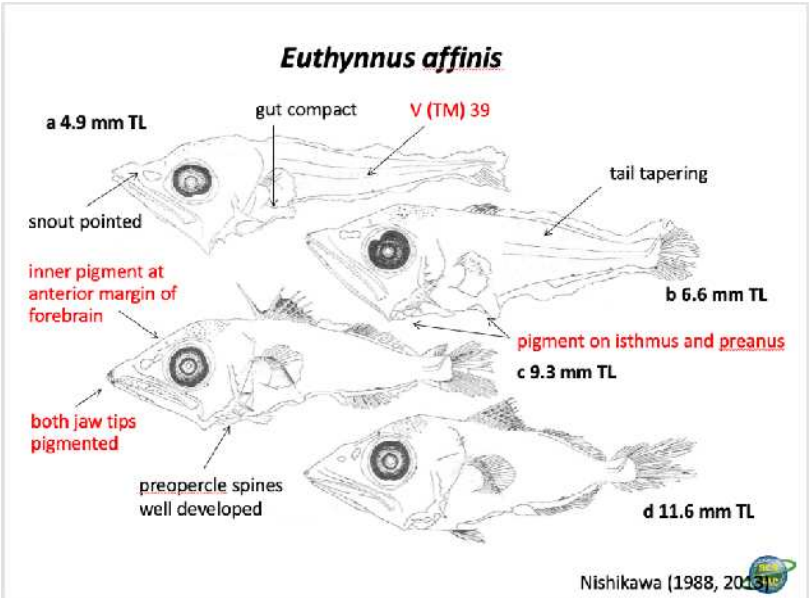


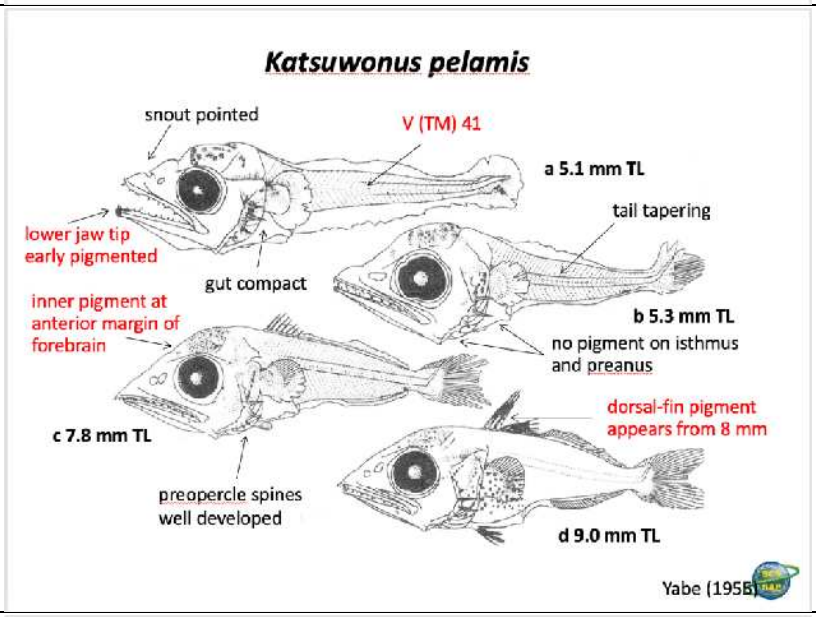
Matsumoto (19

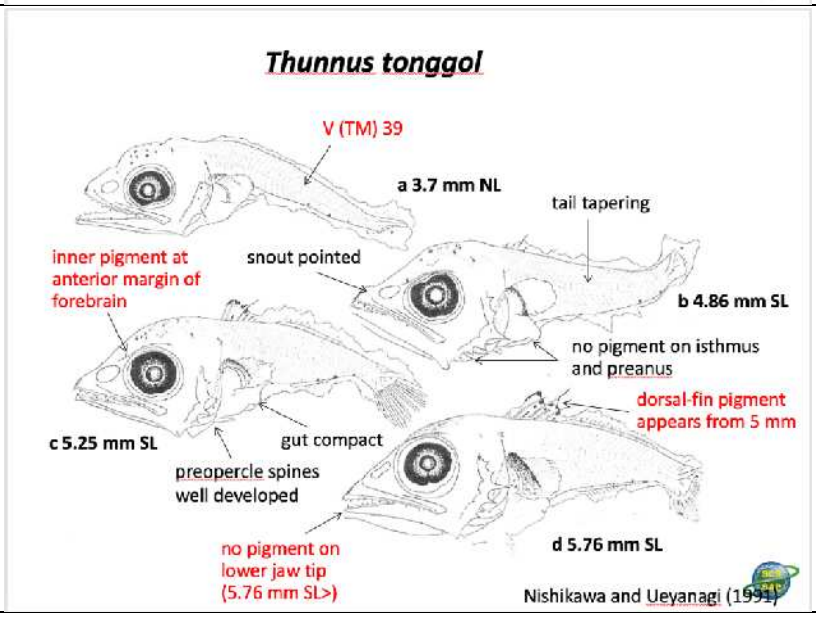
Gymnosarda unicolor

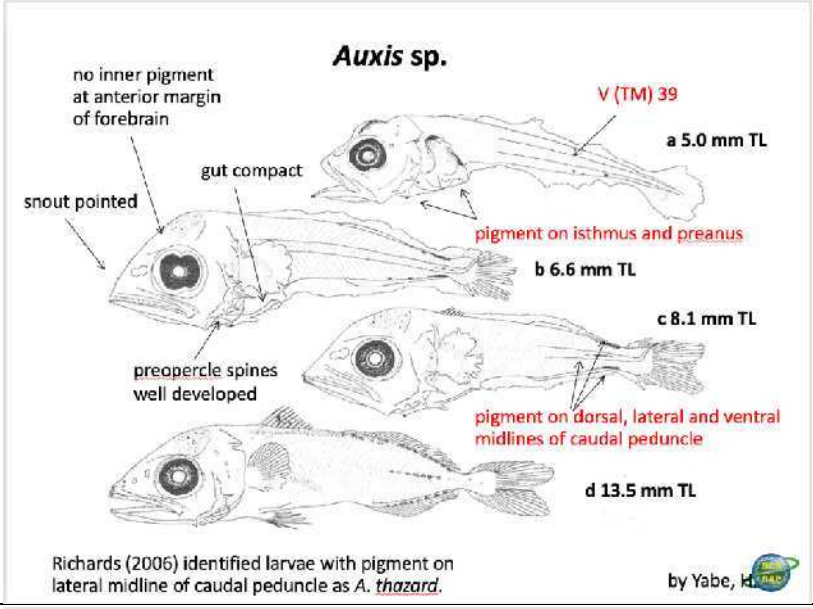


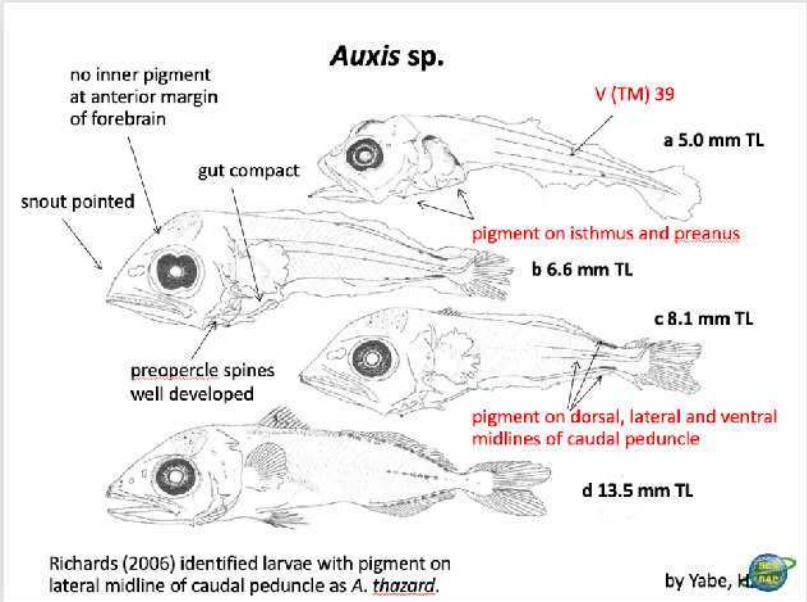
Okiyama and Ueyanagi (19

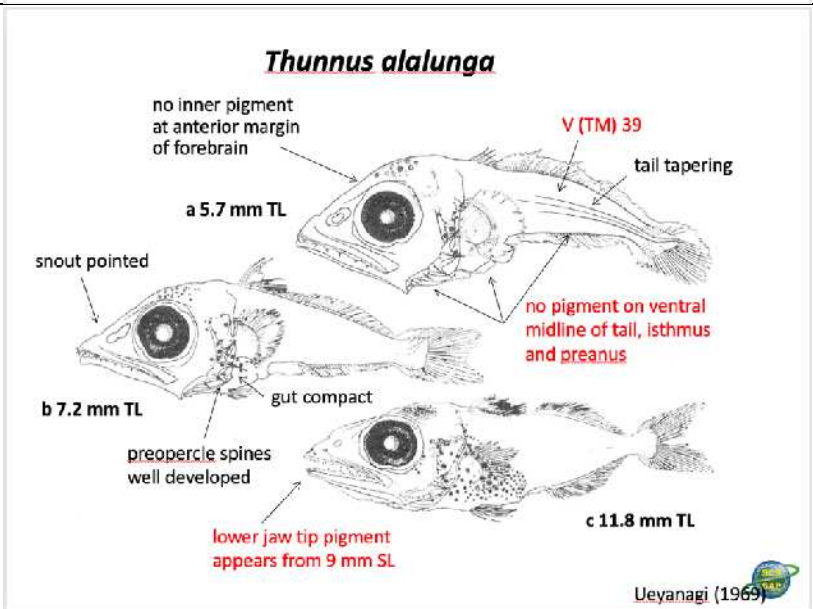

Euthynnus affinis
a 4.9 mm TL
gut compact
V (TM) 39
tail tapering
snout pointed
inner pigment at anterior margin of forebrain
b 6.6 mm TL
pigment on isthmus and preanus
c 9.3 mm TL
both jaw tips pigmented
preopercle spines well developed
d 11.6 mm TL
Nishikawa (1988, 2013)

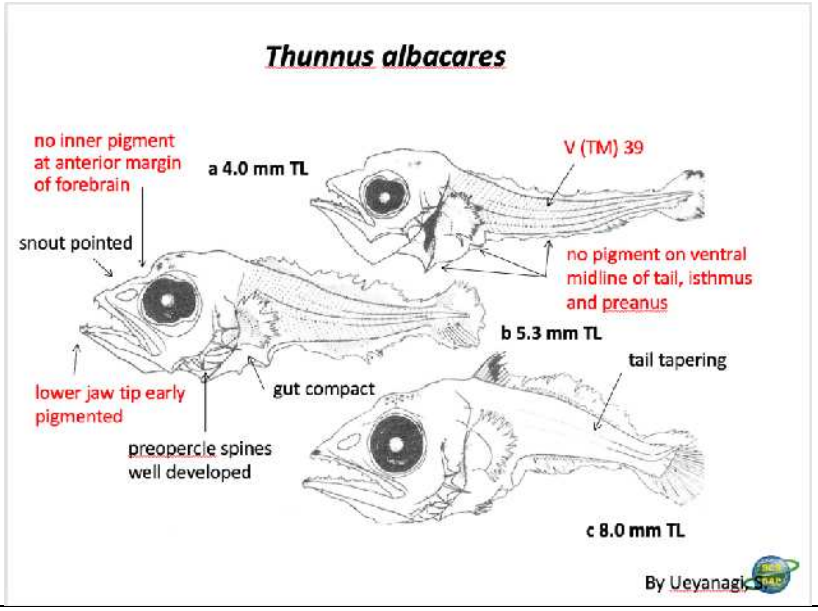

Katsuwonus pelamis
snout pointed
V (TM) 41
a 5.1 mm TL
tail tapering
lower jaw tip early pigmented
gut compact
inner pigment at anterior margin of forebrain
b 5.3 mm TL
no pigment on isthmus and preanus
dorsal-fin pigment appears from 8 mm
c 7.8 mm TL
preopercle spines well developed
d 9.0 mm TL
Yabe (1958)


Thunnus tonggol
V (TM) 39
a 3.7 mm NL
tail tapering
inner pigment at anterior margin of forebrain
snout pointed
b 4.86 mm SL
no pigment on isthmus and preanus
dorsal-fin pigment appears from 5 mm
c 5.25 mm SL
gut compact
preopercle spines well developed
no pigment on lower jaw tip (5.76 mm SL>)
d 5.76 mm SL
Nishikawa and Ueyanagi (1991)


Auxis sp.
no inner pigment
at anterior margin
of forebrain
V (TM) 39
a 5.0 mm TL
gut compact
snout pointed
pigment on isthmus and preanus
b 6.6 mm TL
c 8.1 mm TL
preopercle spines
well developed
pigment on dorsal, lateral and ventral
midlines of caudal peduncle
d 13.5 mm TL
Richards (2006) identified larvae with pigment on
lateral midline of caudal peduncle as A. thazard.
by Yabe,


Auxis sp.
no inner pigment
at anterior margin
of forebrain
V (TM) 39
a 5.0 mm TL
gut compact
snout pointed
pigment on isthmus and preanus
b 6.6 mm TL
c 8.1 mm TL
preopercle spines
well developed
pigment on dorsal, lateral and ventral
midlines of caudal peduncle
d 13.5 mm TL
Richards (2006) identified larvae with pigment on
lateral midline of caudal peduncle as A. thazard.
by Yabe,


Thunnus alalunga
no inner pigment
at anterior margin
of forebrain
V (TM) 39
tail tapering
a 5.7 mm TL
snout pointed
no pigment on ventral
midline of tail, isthmus
and preanus
b 7.2 mm TL
gut compact
preopercle spines
well developed
c 11.8 mm TL
lower jaw tip pigment
appears from 9 mm SL
Ueyanagi (1969)


Thunnus albacares
no inner pigment at anterior margin of forebrain
a 4.0 mm TL
V (TM) 39
snout pointed
no pigment on ventral midline of tail, isthmus and preanus
b 5.3 mm TL
tail tapering
lower jaw tip early pigmented
gut compact
preopercle spines well developed
c 8.0 mm TL
By Ueyanagi, SMAB

Annex 5: Identification methods of the Carangidae fishes and their larvae in Southeast Asia

Identification methods of the Carangidae fishes and their larvae in the Southeast Asian region

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Main References (Adults)

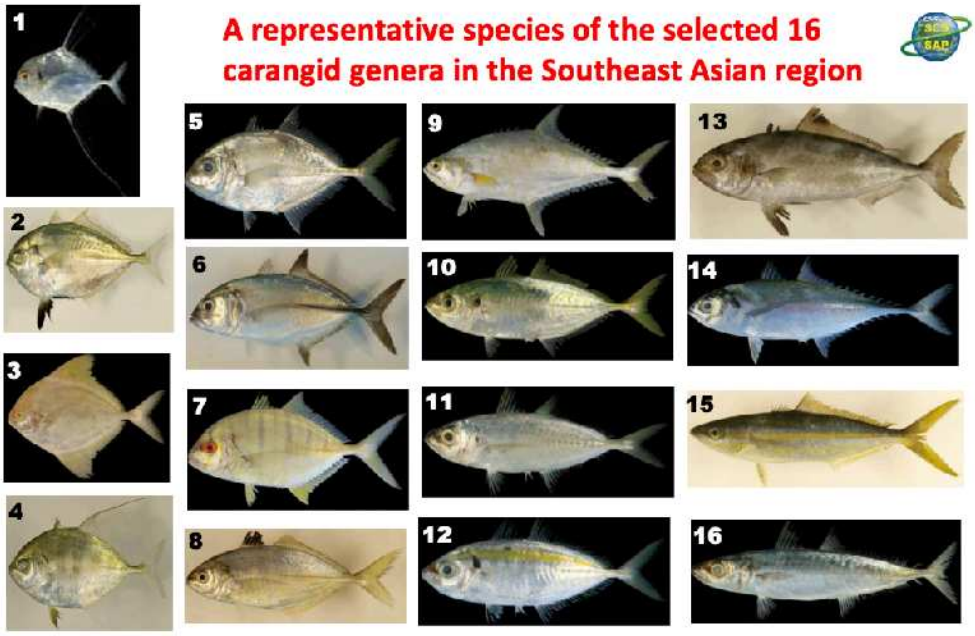
Smith-Vaniz, W. F. (1999). Carangidae. Pages 2659-2756. *In* Carpenter, K. E. and V. H. Niem (eds.). The living marine resources of the Western Central Pacific. FAO species identification guide for fishery purposes. FAO, Rome. [Accessed at]

Randall, J. E. and K. K. P., Lim (eds.) (2000). A checklist of the fishes of the South China Sea. Raffles Bull. Zool. Natl. Univ. Singapore., Supl. 8: 569-667. [Accessed at].

Kimura, S. (2011). Carangidae: Jacks (Scads, Trevallies). Pages 98-107. *In* Matsunuma, M., M. Motomura, K. Matsuura, N. A. M. Shazili and M. A. Ambak (eds.). Fishes of Terengganu–east coast of Malay Peninsula, Malaysia. National Museum of Nature and Science, Univ. Malaysia Terengganu and Kagoshima Univ. Museum, 251p.

Senoh, H. (2013). Carangidae. Pages 878-899, 1991-1995. *In* Nakabo (ed.). Fishes of Japan with pictorial keys to the species. Third edition. Tokai Univ. Press, Hadano.

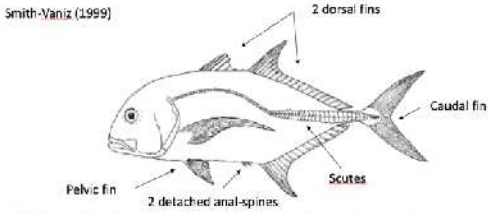
A representative species of the selected 16 carangid genera in the Southeast Asian region



1: *Alectis ciliaris*; 2: *Atropus atropos*; 3: *Parastromateus niger*; 4: *Ulua mentalis*; 5: *Carangoides malabaricus*; 6: *Caranx sexfasciatus*; 7: *Gnathanodon speciosus*; 8: *Alepes melanoptera*; 9: *Scomberoides commersonnianus*; 10: *Atule mate*; 11: *Selar crumenophthalmus*; 12: *Selaroides leptolepis*; 13: *Seriolina nigrofasciata*; 14: *Megalaspis cordyla*; 15: *Elagatis bipinnulata*; 16: *Decapterus macrosoma* Kimura (2011)

Carangid fishes

Smith-Vaniz (1999)



- Body ranging from elongate and fusiform to deep and strongly compressed.
- Two dorsal fins (D1: 4-8 spines; D 2: 1 spine and 18-44 soft rays).
- Two detached anal-fin spines (1 spine in *Elagatis* and *Seriolina*).
- Pelvic fin with 1 spine and 5 soft rays (absent in *Parastromateus*).
- Caudal fin forked.
- Scutes present on straight lateral line (prominent, reduced or absent).
- Single or multiple finlets present in 2nd dorsal and anal fins (only in *Decapterus* and *Megalaspis*).

Habitat, biology, and fisheries

Smith-Vaniz (1999)

- Mostly schooling species (but *Alectis* generally solitary).
- Some species have largely continental distributions and occur primarily in brackish environments (especially young).
- Others such as *Elagatis* and *Naucrates* are pelagic, usually found at or near the surface, mostly in oceanic waters, often far offshore.
- This is one of the most important families of commercial fishes, and all species are used for food.
- For 1995, FAO's Yearbook of Fishery Statistics reports a total catch of around 959 300 t of Carangidae from the Western Central Pacific.
- Caught commercially with trawls, also with purse seines, traps, and on line gear.
- The larger species of *Trachinotus*, *Seriola*, and *Caranx* are highly regarded as sportfish.

Tribes, genera and species of the Carangidae in the Southeast Asian region (1/2)

No	Tribe	Genus	Species
1	Carangini	*Alectis*	2
2	Carangini	*Alepes*	4
3	Carangini	*Atropus*	1
4	Carangini	*Atule*	1
5	Carangini	*Carangoides*	15
6	Carangini	*Caranx*	8
7	Carangini	*Decapterus*	6
8	Carangini	*Gnathanodon*	1
9	Carangini	*Megalaspis*	1
10	Carangini	*Parastromateus*	1
11	Carangini	*Selar*	2
12	Carangini	*Selaroides*	1
13	Carangini	*Ulua*	1
14	Carangini	*Uraspis*	1
Subtotal	1 tribe	14 genera	45 species

Tribes, genera and species of the Carangidae in the Southeast Asian region (2/2)

No	Tribe	Genus	Species
15	Naucratini	*Elagatis*	1
16	Naucratini	*Naucrates*	1
17	Naucratini	*Seriola*	2
18	Naucratini	*Seriolina*	1
19	Scomberoidini	*Scomberoides*	4
20	Trachinotini	*Trachinotus*	5
Subtotal	3 tribes	6 genera	14 species
Total	4 tribes	20 genera	59 species

Meristic data of the Carangidae genera in the South- east Asian region (1/2)

Tribe	Genus	Species	Dorsal fin	Anal fin	Scutes	Vertebrae
Carangini	*Alectis*	2	IV~VII-I, 18~20	(II)-I, 15~17	6~30	10 + 14
Carangini	*Alepes*	4	VII~VIII-I, 21~27	II-I, 18~23	35~69	10 + 14
Carangini	*Atropus*	1	VIII-I, 19~22	II-I, 17~18	31~37	10 + 14
Carangini	*Atule*	1	VIII-I, 22~25	II-I, 18~21	36~52	10 + 14
Carangini	*Carangoides*	15	VIII-I, 17~34	II-I, 14~27	11~45	10 + 14~15
Carangini	*Caranx*	8	VIII-I, 18~24	II-I, 14~20	26~42	10 + 14~15
Carangini	*Decapterus*	6	VIII-I, 27~38 + 1	II-I, 20~30 + 1	24~40	10 + 14
Carangini	*Gnathanodon*	1	VII~VIII-I, 18~21	II-I, 15~17	14~26	10 + 14
Carangini	*Megalaspis*	1	VIII-I, 9~11 + 7~10	II-I, 8~10 + 6~8	51~59	10 + 14
Carangini	*Parastromateus*	1	(V~VI)-I, 40~45	(II)-I, 35~39	8~19	10 + 14

Spines in parenthesis are not visible due to burying under the body.
Numerals with "+" are number of finlet(s).

Meristic data of the Carangidae genera in the South- east Asian region (2/2)

Tribe	Genus	Species	Dorsal fin	Anal fin	Scutes	Vertebrae
Carangini	*Selar*	2	VIII-I, 23~28	II-I, 19~23	29~46	10 + 14
Carangini	*Selaroides*	1	VIII-I, 24~26	II-I, 20~23	20~33	10 + 14
Carangini	*Ulua*	1	VIII-I, 20~22	II-I, 17~18	26~38	10 + 14
Carangini	*Uraspis*	1	VI~VIII-I, 24~30	(II)-I, 17~22	24~39	10 + 14
Naucratini	*Elagatis*	1	V~VI-I, 23~28 + 2	(I)-I, 15~20 + 2	0	10 + 14
Naucratini	*Naucrates*	1	IV~V-I, 25~29	II-I, 15~17	0	10 + 15
Naucratini	*Seriola*	2	VI~VII-I, 26~35	II-I, 18~22	0	10 + 14
Naucratini	*Seriolina*	1	V~VIII-I, 30~37	(I)-I, 15~18	0	11 + 13
Scomberoidini	*Scomberoides*	4	VI~VII-I, 19~21	II-I (II), 16~20	0	10 + 16
Trachinotini	*Trachinotus*	5	V~VI-I, 18~25	II-I, 16~24	0	10 + 14

Meristic data of the Carangidae species in the South-east Asian region (1/6) [Tribe Carangini]

Species	Dorsal fin	Anal fin	Scutes	Vertebrae
Alectis ciliaris	IV~VII-I, 18~20	(II)-I, 15~17	8~30	10 + 14
A. indica	V~VI-I, 18~20	(II)-I, 15~17	6~13	10 + 14
Alepes djedaba	VIII-I, 23~25	II-I, 18~21	39~51	10 + 14
A. kleinii	VIII-I, 21~26	II-I, 19~22	35~45	10 + 14
A. melanoptera	VII-I, 23~26	II-I, 18~21	49~69	10 + 14
A. vari	VIII-I, 23~27	II-I, 20~23	48~69	10 + 14
Atropus atropos	VIII-I, 19~22	II-I, 17~18	31~37	10 + 14
Atule mate	VIII-I, 22~25	II-I, 18~21	36~52	10 + 14
Carangoides armatus	VIII-I, 19~22	II-I, 16~18	11~24	10 + 14
C. bajad	VIII-I, 24~26	II-I, 21~24	20~30	10 + 14
C. coeruleopinnatus	VIII-I, 20~23	II-I, 16~20	16~38	10 + 14
C. chrysophrys	VIII-I, 18~20	II-I, 14~17	20~37	10 + 14

Meristic data of the Carangidae species in the South-east Asian region (2/6) [Tribe Carangini]

Species	Dorsal fin	Anal fin	Scutes	Vertebrae
Carangoides dinema	VIII-I, 17~19	II-I, 15~17	23-30	10 + 14
C. ferdau	VIII-I, 26~34	II-I, 21~27	21~37	10 + 14
C. fulvoguttatus	VIII-I, 25~30	II-I, 21~26	14~21	10 + 14
C. gymnostethus	VIII-I, 28~33	II-I, 24~27	15~31	10 + 14~15
C. hedlandensis	VIII-I, 19~22	II-I, 16~18	17~29	10 + 14
C. malabaricus	VIII-I, 20~23	II-I, 17~19	19~36	10 + 14
C. oblongus	VIII-I, 20~22	II-I, 18~19	37~45	10 + 14
C. orthogrammus	VIII-I, 28~33	II-I, 23~27	19~31	10 + 14
C. plagiotaenia	VIII-I, 22~24	II-I, 18~20	11~19	10 + 14
C. praeustus	VIII-I, 21~24	II-I, 18~20	23~34	10 + 14
C. talamparoides	VIII-I, 20~23	II-I, 17~19	20~32	10 + 14

Meristic data of the Carangidae species in the South-east Asian region (3/6) [Tribe Carangini]

Species	Dorsal fin	Anal fin	Scutes	Vertebrae
Caranx bucculentus	VIII-I, 18~19	II-I, 15~17	33~39	10 + 14
C. heberi	VIII-I, 19~21	II-I, 15~17	30~40	10 + 14
C. ignobilis	VIII-I, 18~21	II-I, 15~17	26~38	10 + 14
C. lugubris	VIII-I, 20~22	II-I, 16~19	26~33	10 + 14
C. melampygus	VIII-I, 21~24	II-I, 17~20	27~42	10 + 14
C. papuensis	VIII-I, 21~23	II-I, 16~19	31~39	10 + 14
C. sexfasciatus	VIII-I, 19~22	II-I, 14~17	27~36	10 + 15
C. tille	VIII-I, 20~22	II-I, 16~18	33~42	10 + 14
Decapterus akaadsi	VIII-I, 27~30 + 1	II-I, 20~24 + 1	32~35	10 + 14
D. kurroides	VIII-I, 28~29 + 1	II-I, 22~25 + 1	31~36	10 + 14
D. macarellus	VIII-I, 30~36 + 1	II-I, 26~30 + 1	24~40	10 + 14

Meristic data of the Carangidae species in the South-east Asian region (4/6) [Tribe Carangini]

Species	Dorsal fin	Anal fin	Scutes	Vertebrae
Decapterus macrosoma	VIII-I, 32~38 + 1	II-I, 26~30 + 1	24~40	10 + 14
D. russelli	VIII-I, 27~32 + 1	II-I, 24~28 + 1	30~40	10 + 14
D. tabl	VIII-I, 29~33 + 1	II-I, 23~26 + 1	30~40	10 + 14
Gnathanodon speciosus	VII~VIII-I, 18~21	II-I, 15~17	14~26	10 + 14
Megalaspis cordyla	VIII-I, 9~11 + 7~10	II-I, 8~10 + 6~8	51~59	10 + 14
Parastromateus niger	[V~VI]-I, 40~45	(II)-I, 35~39	8~19	10 + 14
Selar boops	VIII-I, 23~25	II-I, 19~21	37~46	10 + 14
S. crumenophthalmus	VIII-I, 23~28	II-I, 21~23	29~42	10 + 14
Selaroides leptolepis	VIII-I, 24~26	II-I, 20~23	20~33	10 + 14
Ulua mentalis	VIII-I, 20~22	II-I, 17~18	26~38	10 + 14
Uraspis uraspis	VI~VIII-I, 24~30	(II)-I, 17~22	24~39	10 + 14

Meristic data of the Carangidae species in the South-east Asian region (5/6) [Tribe Naucratini]

Species	Dorsal fin	Anal fin	Scutes	Vertebrae
Elagatis bipinnulata	V~V-I, 23~28 + 2	(I)-I, 15~20 + 2	0	10 + 14
Naucrates ductor	IV~V-I, 25~29	II-I, 15~17	0	10 + 15
Seriola dumerili	VI~VII-I, 29~35	II-I, 18~22	0	10 + 14
S. rivoliana	VII-I, 26~33	II-I, 18~22	0	10 + 14
Seriolina nigrofasciata	V~VIII-I, 30~37	(I)-I, 15~18	0	11 + 13

Meristic data of the Carangidae species in the Southeast Asian region (6/6) [Tribe Scomberoidini & Trachinotini]

Species	Dorsal fin	Anal fin	Scutes	Vertebrae
Scomberoides lysan	VI~VII-I, 19~21	II-I, 17~19	0	10+16
S. commersonnianus	VI~VII-I, 19~21	II-I, 16~19	0	10 + 16
S. taio	VI~VII-I, 19~21	II, 16~19	0	10+16
S. tol	VI~VII-I, 19~21	II-I, 17~20	0	10+16
Trachinotus africanus	VI-I, 21~23	II-I, 19~21	0	10+14
T. baillonii	V~VI-I, 21~25	II-I, 20~24	0	10+14
T. blochii	VI-I, 18~20	II-I, 16~18	0	10 + 14
T. botla	VI-I, 22~24	II-I, 19~21	0	10+14
T. mookalee	VI-I, 18~20	II-I, 16~18	0	10+14

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Key to the genera and subgenera of Carangidae occurring in the area Smith-Vaniz (1999)

1a. Posterior straight part of lateral line with hardened scutes; in adults, pectoral fins long and falcate, in most genera longer than head (Fig. 1) (about equal to head length in *Selar* and *Trachinotus*, and shorter than head length in some *Decapterus* spp.) . . . . . → 2

1b. No scutes in lateral line (only pored scales, not enlarged); pectoral fins relatively short, shorter than head (about 50 to 98% of head length) . . . . . → 19

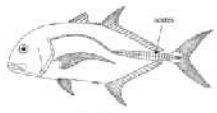

Fig. 1 *Caranx*

2a. Pored scales in curved lateral line scale-like, expanded dorsoventrally (Fig. 2) (caution: in large fish may be obscured by overgrowth of smaller scales); dorsal accessory lateral line normally extends posteriorly at least to below origin of second dorsal fin, usually farther posteriorly (Figs. 2 and 3) . . . . . *Trachurus*

2b. No enlarged scute-like scales in curved lateral line; dorsal accessory lateral line terminating before origin of spinous dorsal fin . . . . . → 3

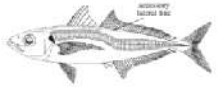

Fig. 2 *Trachurus*

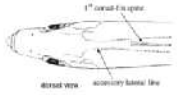

Fig. 3 *Trachinotus*

The target area of this key is the warm waters of the Indian and western Pacific Oceans. Therefore, it includes fishes outside of the Southeast Asian waters. The same applies to the following keys for each genus.

2/9

3a. Pelvic fins, if present (absent in specimens larger than about 10 cm fork length), positioned distinctly anterior to a vertical line through pectoral-fin base; soft anal-fin rays 35 to 39 . . . . . *Parastromateus*

3b. Pelvic fins (always present) not positioned distinctly anterior to a vertical through pectoral-fin base; soft anal-fin rays 15 to 31 . . . . . → 4

4a. Scales on body minute, inconspicuous and embedded giving the impression of naked skin; in smaller fish, anterior soft rays of dorsal and anal fins filamentous (Fig. 4) . . . . . *Alectis*

4b. Scales on body small but conspicuous, not embedded; in smaller fish, anterior soft rays of dorsal and anal fins not filamentous . . . . . → 5

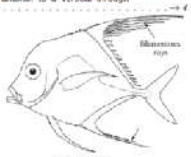

Fig. 4 *Alectis*

5a. Second dorsal and anal fins with 1 or more distinctly separate finlets . . . . . → 6

5b. Second dorsal and anal fins without finlets . . . . . → 7

6a. Single detached terminal 2-rayed finlet in dorsal and anal fins (Fig. 5); shoulder girdle (cleithrum) margin with 2 papillae, the lower papilla larger (Fig. 6); maximum scute height smaller than eye diameter . . . *Decapterus*

6b. Posterior soft dorsal- and anal-fin rays consisting of 0 to 10 detached finlets; shoulder girdle margin smooth; maximum scute height larger than eye diameter (Fig. 7) . . . *Megalaspis*

Fig. 5 *Decapterus*

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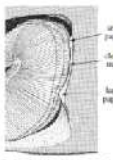

gill chamber after lifting operculum
Fig. 6 *Decapterus*

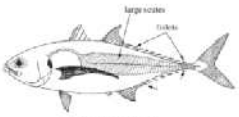

Fig. 7 *Megalaspis*

7a. Shoulder girdle (cleithrum) margin with a furrow ventrally, a large papilla immediately above it and a smaller papilla near upper edge (Fig. 8) . . . . . *Selar*

7b. Shoulder girdle margin smooth . . . . . → 8

8a. Upper jaw without teeth . . . . . → 9

8b. Upper jaw with 1 or 2 rows or a band of minute teeth (caution: teeth difficult to detect in some *Carangoides*) . . . . . → 10

gill chamber after lifting operculum
Fig. 8 *Selar*

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8a. Lower jaw with a series of minute teeth; a prominent black opercular spot encroaching on shoulder, adipose eyelid well developed posteriorly . . . . . *Selaroides*

8b. Lower jaw with a few feeble teeth in young (smaller than 10 cm fork length); absent in adults; no black opercular spot; adipose eyelid poorly developed . . . . . *Gnathanodon*


Fig. 9 *Uraspis*

10a. Tongue, roof and floor of mouth white, the rest dark (Fig. 9); anal-fin spines reabsorbed or reduced and immovable; no teeth on vomer or palatines . . . . . *Uraspis*

10b. Lining of mouth not distinctly black and white; anal-fin spines normal and movable; teeth present on vomer and palatines . . . . . → 11

11a. Fleshy adipose eyelid completely covering eye except for a vertical slit centred on pupil (Fig. 10a); terminal ray of dorsal and anal fins finlet-like, a little more separated from other rays but not detached, and about twice length of penultimate ray . . . . . *Atule*

11b. Fleshy adipose eyelid, if present, not well developed anteriorly, most of anterior half of pupil exposed; terminal ray of dorsal and anal fins not finlet-like (except terminal ray length 1.5 times the length of penultimate ray in large *Alepes djedaba*) . . . . . → 12

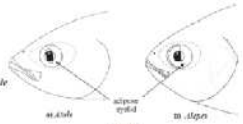

Fig. 10

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12a. Both jaws with a single row of numerous, comb-like teeth, adipose eyelid well developed on posterior half of eye only (Fig. 10b) . . . . . *Alepes*

12b. Dentition not as above; adipose eyelid, if present, variously developed . . . . . → 13

13a. Upper jaw anteriorly with 2 irregular rows of short conical teeth, posteriorly inner surface of jaw paved with blunt teeth (Fig. 11a); snout shorter than eye diameter . . . . . *"Alepes"*

13b. Dentition not as above; snout usually equal or larger than eye diameter . . . . . → 14

14a. Upper jaw with an outer series of moderate to strong canines and an inner band of fine teeth (Fig. 11b); lower jaw with a single row of teeth . . . . . → 15

14b. Dentition not as above . . . . . → 16

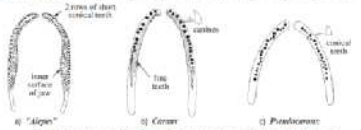

Fig. 11 Ventral view of teeth in upper jaw (teeth on roof of mouth not shown)

15a. Body generally deep, with dorsal profile more convex than ventral; total gill rakers 20 to 31 on first gil arch, segmented dorsal- and anal-fin rays never produced as filaments; 2 to 4 canines anteriorly in each jaw . . . . . *Caranx*

15b. Body shallow with dorsal and ventral profiles equally convex; total gill rakers 34 to 39 on first gill arch; segmented dorsal- and anal-fin rays produced as filaments in adult males; no canines anteriorly in either jaw . . . . . *Pseudocaranx*

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16a. Both jaws with single series of short, conical teeth (upper jaw sometimes with an inner row of conical teeth anteriorly) (Fig. 11c); breast completely scaly . . . . . *Pseudocaranx*

16b. Both jaws with a band of teeth, at least anteriorly; breast naked ventrally (most species) to completely scaly . . . . . → 17

17a. Belly with a deep median groove, accommodating pelvic fins, anus, and anal-fin spines (Fig. 12a); pelvic fins conspicuously long and black, tip of depressed fins extending almost to origin of anal fin; curved lateral line short, chord of curved part of lateral line contained 1.5 to 2 times in straight part (Fig. 12b) . . . . . *Atropus*

17b. Belly without median groove; pelvic fins not conspicuously long and black; curved lateral line moderate; in most species, with chord of curved part of lateral line contained less than 1.5 times in straight part . . . . . → 18

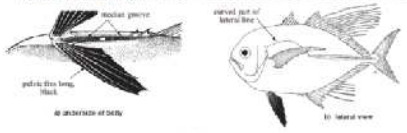
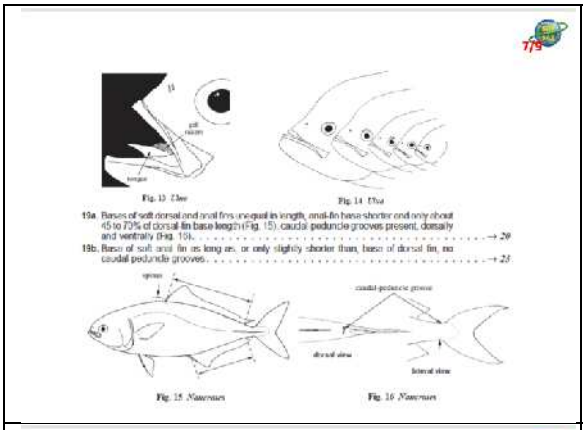


Fig. 12 *Atropus*

18a. Gill rakers long, feather like, and project into mouth along side of tongue (Fig. 13); total gill rakers 54 to 86 on first gill arch; lower jaw becoming prominent in large adults, with the angle of "chin" projecting beyond upper jaw (Fig. 14) . . . . . *Gnathanodon*

18b. Gill rakers of normal length and shape, total gill rakers 21 to 30 on first gil arch; shape of lower jaw not as above . . . . . *Carangoides*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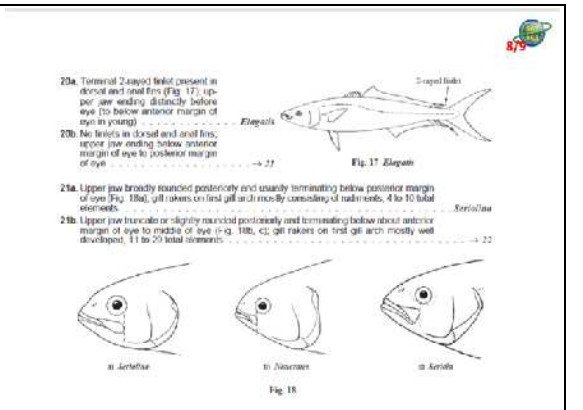
19a. Bases of soft dorsal and anal fins unequal in length, anal-fin base shorter and only about 45 to 70% of dorsal-fin base length (Fig. 15); caudal peduncle grooves present, dorsally and ventrally (Fig. 16b) . . . . . → 20
19b. Base of soft anal fin as long as, or only slightly shorter than, base of dorsal fin; no caudal peduncle grooves . . . . . → 23
Fig. 13 Uhe
Fig. 14 Uhe
Fig. 15 Nuncrates
Fig. 16 Nuncrates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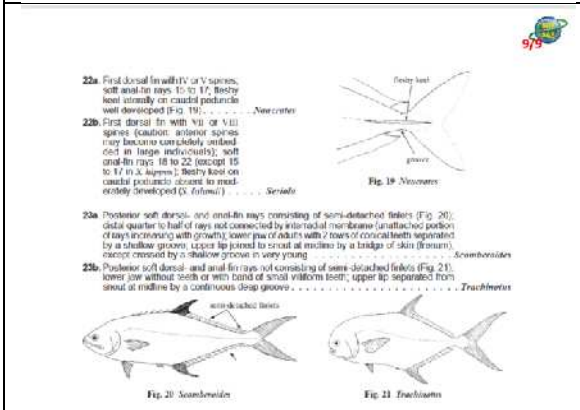
20a. Terminal 2-rayed finlet present in dorsal and anal fins (Fig. 17); upper jaw ending distinctly before eye (to below anterior margin of eye in young) . . . . . Elagatis
20b. No finlets in dorsal and anal fins; upper jaw ending below anterior margin of eye to posterior margin of eye . . . . . → 21
Fig. 17 Elagatis
21a. Upper jaw broadly rounded posteriorly and usually terminating below posterior margin of eye (Fig. 18a), gill rakers on first gill arch mostly consisting of rudiments, 4 to 10 total elements . . . . . Seriolina
21b. Upper jaw truncate or slightly rounded posteriorly and terminating below about anterior margin of eye to middle of eye (e.g. 18b, c); gill rakers on first gill arch mostly well developed, 11 to 29 total elements . . . . . → 22
Fig. 18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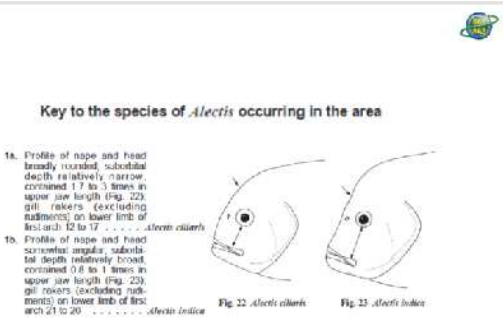
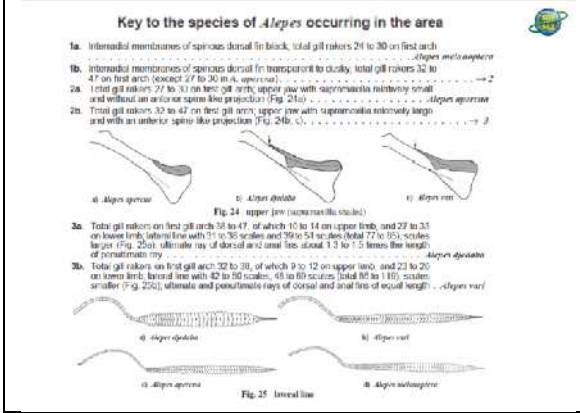
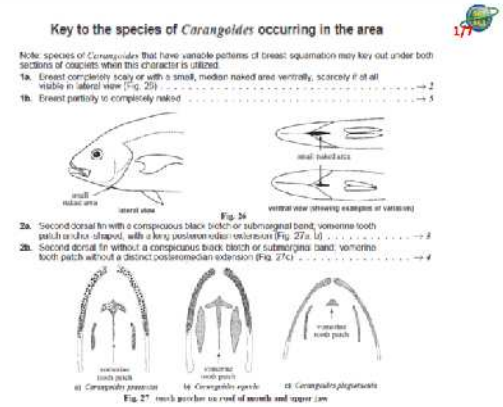
22a. First dorsal fin with IV or V spines, soft anal-fin rays 15 to 17, fleshy keel laterally on caudal peduncle well developed (Fig. 19) . . . . . Nauclerates
22b. First dorsal fin with VII or VIII spines (caution: anterior spines may become completely embedded in large individuals); soft anal-fin rays 18 to 22 (except 15 to 17 in X. lugens); fleshy keel on caudal peduncle absent to moderately developed (X. taiwanii) . . . . . Seriola
Fig. 19 Nauclerates
23a. Posterior soft dorsal- and anal-fin rays consisting of semi-detached finlets (Fig. 20); distal quarter to half of rays not connected by intermedial membrane (unattached portion of rays increasing with growth); lower jaw of adults with 2 rows of conical teeth separated by a shallow groove; upper lip joined to snout at midline by a bridge of skin (frenum), except crossed by a shallow groove in very young . . . . . Scomberoides
23b. Posterior soft dorsal- and anal-fin rays not consisting of semi-detached finlets (Fig. 21); lower jaw without teeth or with band of small villiform teeth; upper lip separated from snout at midline by a continuous deep groove . . . . . Trachinotus
Fig. 20 Scomberoides
Fig. 21 Trachinotus


Key to the species of Alectis occurring in the area
1a. Profile of nape and head broadly rounded, suborbital depth relatively narrow, contained 1.7 to 3 times in upper jaw length (Fig. 22); gill rakers (excluding rudiments) on lower limb of first arch 12 to 17 . . . . . Alectis ciliaris
1b. Profile of nape and head somewhat angular, suborbital depth relatively broad, contained 0.8 to 1 times in upper jaw length (Fig. 23); gill rakers (excluding rudiments) on lower limb of first arch 21 to 26 . . . . . Alectis indica
Fig. 22 Alectis ciliaris
Fig. 23 Alectis indica


Key to the species of Alepes occurring in the area
1a. Intermedial membranes of spinous dorsal fin black, total gill rakers 24 to 30 on first arch . . . . . Alepes melanoptera
1b. Intermedial membranes of spinous dorsal fin transparent to dusky, total gill rakers 32 to 47 on first arch (except 27 to 30 in A. apercna) . . . . . → 2
2a. Total gill rakers 27 to 30 on first gill arch; upper jaw with supramaxilla extremely small and without an anterior spine like projection (Fig. 24a) . . . . . Alepes apercna
2b. Total gill rakers 32 to 47 on first gill arch; upper jaw with supramaxilla relatively large and with an anterior spine like projection (Fig. 24b, c) . . . . . → 3
Fig. 24 upper jaw (supramaxilla shaded)
3a. Total gill rakers on first gill arch 38 to 47, of which 10 to 14 on upper limb, and 27 to 33 on lower limb; lateral line with 51 to 56 scales and 39 to 54 scales (total 77 to 95); scales larger (Fig. 25b); ultimate ray of dorsal and anal fins about 1.3 to 1.5 times the length of penultimate ray . . . . . Alepes djedaba
3b. Total gill rakers on first gill arch 32 to 38, of which 9 to 12 on upper limb, and 23 to 26 on lower limb; lateral line with 82 to 90 scales, 48 to 60 scales (total 86 to 116), scales smaller (Fig. 25a); ultimate and penultimate rays of dorsal and anal fins of equal length . . . Alepes vari
Fig. 25 lateral line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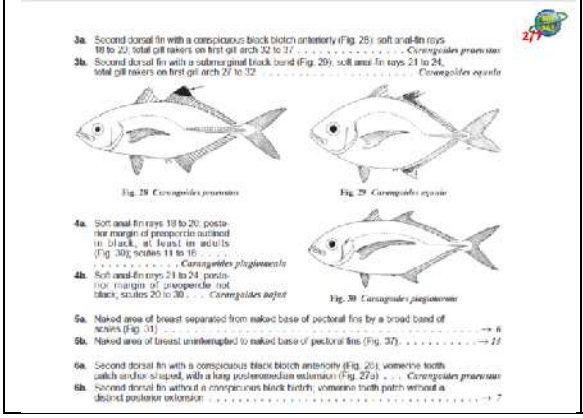
Key to the species of Carangoides occurring in the area
Note: species of Carangoides that have variable patterns of breast squamation may key out under both sections of couplets when this character is utilized.
1a. Breast completely scaly or with a small, median naked area ventrally, scarcely if at all visible in lateral view (Fig. 26) . . . . . → 2
1b. Breast partially to completely naked . . . . . → 5
Fig. 26
2a. Second dorsal fin with a conspicuous black blotch or submarginal band, vomerine tooth patch arcuate-shaped, with a long posteromedian extension (Fig. 27a, b) . . . . . → 3
2b. Second dorsal fin without a conspicuous black blotch or submarginal band; vomerine tooth patch without a distinct posteromedian extension (Fig. 27c) . . . . . → 4
Fig. 27 tooth patches on roof of mouth and upper jaw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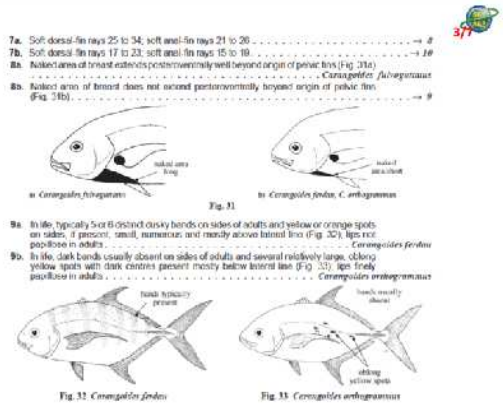
3a. Second dorsal fin with a conspicuous black blotch anteriorly (Fig. 28); soft anal-fin rays 18 to 23; total gill rakers on first gill arch 32 to 37 . . . . . Carangoides praetextus
3b. Second dorsal fin with a submarginal black band (Fig. 29); soft anal-fin rays 21 to 24; total gill rakers on first gill arch 29 to 32 . . . . . Carangoides equula
Fig. 28 Carangoides praetextus
Fig. 29 Carangoides equula
4a. Soft anal-fin rays 18 to 20; posterior margin of preopercle outlined in black, at least in adults (Fig. 30); scales 18 to 18 . . . . . Carangoides plagiotaenia
4b. Soft anal-fin rays 21 to 24; posterior margin of preopercle not black; scales 20 to 30 . . . . . Carangoides talami
Fig. 30 Carangoides plagiotaenia
5a. Naked area of breast separated from naked base of pectoral fins by a broad band of scales (Fig. 31) . . . . . → 6
5b. Naked area of breast uninterrupted to naked base of pectoral fins (Fig. 32) . . . . . → 11
6a. Second dorsal fin with a conspicuous black blotch anteriorly (Fig. 28); vomerine tooth patch arcuate-shaped, with a long posteromedian extension (Fig. 27a) . . . . Carangoides praetextus
6b. Second dorsal fin without a conspicuous black blotch; vomerine tooth patch without a distinct posterior extension . . . . . → 7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7a. Soft dorsal-fin rays 25 to 34; soft anal-fin rays 21 to 26 . . . . . → 8
7b. Soft dorsal-fin rays 17 to 23; soft anal-fin rays 15 to 19 . . . . . → 10
8a. Naked area of breast extends posteroventrally well beyond origin of pelvic fins (Fig. 31a) . . . . . Carangoides fulvoguttatus
8b. Naked area of breast does not extend posteroventrally beyond origin of pelvic fins (Fig. 31b) . . . . . → 9
Fig. 31
9a. In life, typically 5 or 6 distinct dusky bands on sides of adults and yellow or orange spots on sides, if present, small, numerous and mostly above lateral line (Fig. 32); lips not papillose in adults . . . . . Carangoides ferdau
9b. In life, dark bands usually absent on sides of adults and several relatively large, oblong yellow spots with dark centres present mostly below lateral line (Fig. 33); lips finely papillose in adults . . . . . Carangoides orthogrammus
Fig. 32 Carangoides ferdau
Fig. 33 Carangoides orthogrammus

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10a. Straight part of lateral line slightly longer than curved part (Fig. 34); scutes 37 to 45 . . . . . *Carangoides oblongus*

10b. Straight part of lateral line slightly shorter than curved part (Fig. 35); scutes 36 to 38 . . . . . → *11*

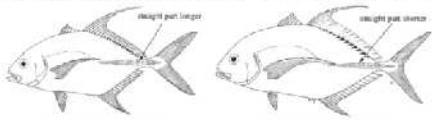

Fig. 34 *Carangoides oblongus* Fig. 35 *Carangoides dinema*

11a. No small dark blotches on dorsum between bases of dorsal-fin rays . . . . . *Carangoides caeruleopinnatus*

11b. Small dark blotches (becoming larger posteriorly) on dorsum between bases of dorsal-fin rays . . . . . → *12*

12a. Soft dorsal-fin rays 20 to 22 (rarely 19); large black spot usually present on shoulder; naked area of breast extends posteroventrally well beyond origin of pelvic fins (Fig. 36a) . . . . . *Carangoides humerosus*

12b. Soft dorsal-fin rays 17 to 19; no large black spot present on shoulder; naked area of breast typically does not extend posteroventrally beyond origin of pelvic fins (Fig. 36b) . . . . . *Carangoides dinema*

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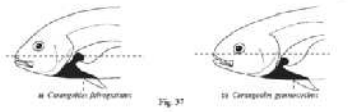
a) *Carangoides humerosus* Fig. 36 b) *Carangoides dinema*

13a. Soft dorsal-fin rays 25 to 32 (rarely 25) . . . . . → *14*

13b. Soft dorsal-fin rays 17 to 23 . . . . . → *15*

14a. Profile of snout angular and, in specimens larger than about 30 cm fork length, horizontal line from tip of snout distinctly below level of eye (Fig. 37a); soft anal-fin rays 21 to 29 (rarely 25 or 26); total gill rakers (including rudiments) on first gill arch 22 to 27, of which 6 to 8 on upper limb, and 17 to 21 on lower limb; vertebrae 10+14 . . . . *Carangoides fulvoguttatus*

14b. Profile of snout moderately rounded and, in specimens larger than about 30 cm fork length, horizontal line from tip of snout at or through level of eye (Fig. 37b); soft anal-fin rays 24 to 26 (usually 25); total gill rakers (including rudiments) on first gill arch 27 to 31, of which 7 to 9 on upper limb and 19 to 22 on lower limb; vertebrae 10+15 . . . . *Carangoides gymnostethus*



a) *Carangoides fulvoguttatus* Fig. 37 b) *Carangoides gymnostethus*

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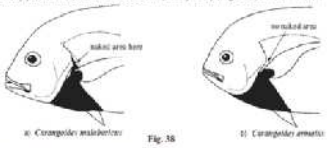
15a. Small area naked of scales anteriorly just above pectoral-fin base (Fig. 38a) . . . . . → *16*

15b. Area anteriorly just above pectoral fin base completely scaly (Fig. 38b) . . . . . → *17*



a) *Carangoides malabaricus* Fig. 38 b) *Carangoides armatus*

16a. Total gill rakers (including rudiments) on first gill arch 32 to 36, of which 8 to 12 on upper limb, and 21 to 27 on lower limb; in life, tongue greyish brown to brown . . . . *Carangoides malabaricus*

16b. Total gill rakers (including rudiments) on first gill arch 27 to 31, of which 6 to 9 on upper limb, and 19 to 22 on lower limb; in life, tongue white to pale grey . . . . *Carangoides talamparoides*

17a. Small dark blotches (becoming larger posteriorly) on back between bases of dorsal-fin rays; naked area of breast typically does not extend posteroventrally beyond origin of pelvic fins (Fig. 36b); soft dorsal-fin rays 17 to 19 . . . . . *Carangoides dinema*

17b. Colour pattern not as above; naked area of breast extends posteroventrally well beyond origin of pelvic fins (Fig. 36b); soft dorsal-fin rays 18 to 23 . . . . . → *18*

18a. Total gill rakers (including rudiments) on first gill arch 34 to 37 . . . . . *Carangoides armatus*

18b. Total gill rakers (including rudiments) on first gill arch 26 to 27 . . . . . → *19*

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19a. Adults with a steep dorsal head profile, and with a distinct break ("bump") in profile in the interorbital region (Fig. 39a); 3 to 6 (usually 5 to 6) of central soft rays of dorsal and anal fins elongated in mature males (about 17 cm fork length), eye diameter about equal to, or larger than snout length . . . . . *Carangoides bucculentus*

19b. Dorsal head profile not as steep in adults, and no distinct break ("bump") in profile in the interorbital region (Fig. 39b, c); central soft rays of dorsal and anal fins not elongated in mature males; eye diameter slightly to much smaller than snout length . . . . . → *20*

20a. Dorsal profile of snout gently sloped, then abruptly vertical just above mouth cleft (Fig. 39b); soft dorsal-fin rays 18 to 20; soft anal-fin rays 15 to 17 . . . . . *Carangoides chrysophrys*

20b. Dorsal profile of snout not as above (Fig. 39c); soft dorsal-fin rays 20 to 23 (usually 22 or 23); soft anal-fin rays 16 to 20 (usually 18 or 19) . . . . . *Carangoides caeruleopinnatus*

a) *Carangoides bucculentus* b) *Carangoides chrysophrys* c) *Carangoides caeruleopinnatus*

Fig. 39

1/3

Key to the species of *Caranx* occurring in the area

Note: species of *Caranx* that have variable patterns of breast squamation will key out under both sections of a couplet when this character is utilized.

1a. Breast completely scaly . . . . . → *2*

1b. Breast naked ventrally, frequently with small patch of prepelvic scales (Fig. 40) . . . . . → *6*

2a. In life, body coloration essentially uniform grey to brown; lobe of dorsal fin relatively long, contained 2.3 to 3.3 times in fork length; profile of head relatively steep and angular (Fig. 41) . . . . . *Caranx bucculentus*

2b. Body coloration not as above; lobe of dorsal fin contained 4.2 to 8.8 times in fork length; profile of head not noticeably steep and angular . . . . . → *3*

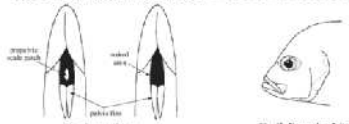


Fig. 40 ventral view Fig. 41 *Caranx bucculentus*

3a. Small black spots scattered on head and body (forming at about 16 to 22 cm fork length); snout length contained 9.2 to 12.7 times in fork length; total gill rakers (including rudiments) on first gill arch 25 to 29 (usually 28 or 27), and total soft dorsal- and anal-fin rays 39 to 44 . . . . . *Caranx melampygus*

3b. No small black spots scattered on head and body; snout length contained 13.1 to 18.4 times in fork length; total gill rakers (including rudiments) on first gill arch 22 to 25, except 24 to 27 in *C. heberi* which has 34 to 38 total soft dorsal- and anal-fin rays . . . . . → *4*

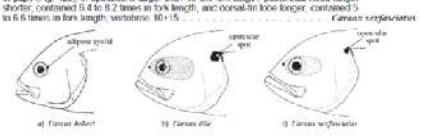
2/3

4a. No small black spot present on upper margin of opercle; upper lobe or caudal fin frequently with distal half noticeably dark or black, especially in juveniles; in adults, adipose eyelid only slightly developed (Fig. 42a) . . . . . *Caranx latus*

4b. A small, black spot present on upper margin of opercle; upper lobe of caudal fin usually uniformly pigmented; in adults, adipose eyelid well developed, especially posteriorly (Fig. 42b, c) . . . . . → *5*

5a. In adults, dorsal-fin lobe without white tip; dorsal profile of head strongly convex and a black spot on upper margin of opercle, in adults, at least 1/2 the diameter of pupil (Fig. 42b); in specimens larger than 15 cm fork length, postorbital head length longer, contained 5.7 to 7.2 times in fork length, and dorsal-fin lobe shorter, contained 5.7 to 9.8 times in fork length; vertebrae 10+14 . . . . . *Caranx tille*

5b. In adults, dorsal-fin lobe with white tip; dorsal profile of head moderately convex and black spot on upper margin of opercle, its size in adults no larger than twice the diameter of pupil (Fig. 42c); in specimens larger than 15 cm fork length, postorbital head length shorter, contained 8.4 to 8.7 times in fork length, and dorsal-fin lobe longer, contained 5 to 6.6 times in fork length; vertebrae 10+15 . . . . . *Caranx sexfasciatus*



a) *Caranx latus* b) *Caranx tille* c) *Caranx sexfasciatus*

Fig. 42

6a. Naked area of breast uninterrupted to naked base of pectoral fins (Fig. 43); curved part of lateral line short, chord of curved part contained 2.5 to 3.3 times in straight part; scutes larger (Fig. 44a) . . . . . *Caranx bucculentus*

6b. Naked area of breast separated from naked bases of pectoral fins by a broad band of scaled; curved part of lateral line moderate, with chord of curved part contained less than 1.5 times in straight part; scutes smaller (Fig. 44b) . . . . . → *7*

3/3

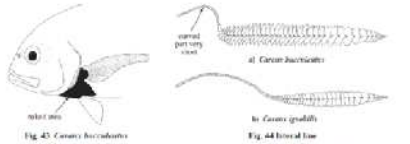


Fig. 43 *Caranx bucculentus* a) *Caranx bucculentus* Fig. 44 lateral line b) *Caranx gallus*

7a. Total gill rakers (including rudiments) 20 to 24 on first gill arch; general body colour silvery to black, in specimens larger than 15 cm fork length, body depth contained 2.2 to 3.2 times in fork length . . . . . *Caranx gallus*

7b. Total gill rakers (including rudiments) 23 to 30 (rarely 23) on first gill arch; general body colour bronze to yellow-green, in specimens larger than 15 cm fork length, body depth contained 2.7 to 3.8 times in fork length . . . . . → *8*

8a. Total soft dorsal- and anal-fin rays 34 to 38 (rarely 33); upper lobe of caudal fin frequently with distal half noticeably dark or black (especially in juveniles), and posterior margin of lower lobe without a narrow white border; no pale spot on shoulder just behind posterodorsal margin of opercle; adults without small black spots . . . . . *Caranx heberi*

8b. Total soft dorsal- and anal-fin rays 37 to 41 (rarely 34); upper lobe of caudal fin usually uniformly pigmented, and posterior margin of lower lobe with a narrow white border; in life a conspicuous pale spot, approximately the diameter of pupil, on shoulder just behind posterodorsal margin of opercle (Fig. 45); adults with small black spots on body above lateral line (forming at about 25 cm fork length) . . . . . *Caranx papuensis*

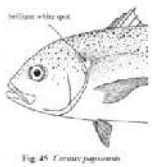


Fig. 45 *Caranx papuensis*

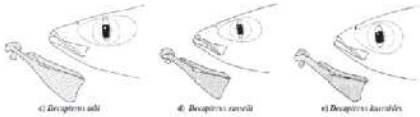
1/3

Key to the species of *Decapterus* occurring in the area

1a. Posterior end of upper jaw concave above, rounded and produced below (Fig. 46a); straight part of lateral line with 14 to 29 scales (Fig. 47a) . . . . . *Decapterus macrosoma*

1b. Posterior end of upper jaw straight above, straight to slightly concave below (Fig. 46b-e); straight part of lateral line with 0 to 15 scales (except 18 to 39 scales in *D. macarellus*) . . . . . → *2*

a) *Decapterus macrosoma* b) *Decapterus macarellus*



c) *Decapterus akaadsi* d) *Decapterus russelli* e) *Decapterus kurroides*

Fig. 46

2/3

2a. Posterior end of upper jaw noticeably slanted anteroventrally (Fig. 46b); straight part of lateral line with 15 to 26 scales and 24 to 40 scales = 52 to 57 total (Fig. 47b); pectoral fins usually shorter in adults, 56 to 72% head length; oral valve (membrane) at symphysis of upper jaw conspicuously white (Fig. 48) . . . . . *Decapterus macarellus*

2b. Posterior end of upper jaw not as noticeably slanted anteroventrally (Fig. 46c–e); straight part of lateral line with 0 to 10 scales and 30 to 40 scales = 38 to 49 total (except 5 to 15 scales and 32 to 42 scales = 41 to 50 total in *D. tabl*); pectoral fins usually longer in adults, 71 to 165% head length (except 52 to 63% in *D. tabl*); oral valve (membrane) at symphysis of upper jaw dusky or transparent (except white in *D. macarellus*) . . . . . → 3

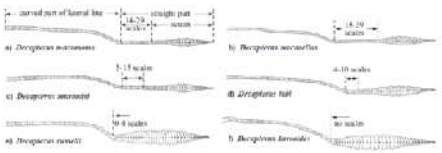


Fig. 47 lateral line

3/3

3a. In life, caudal fin with upper lobe greenish yellow and lower lobe grey; oral valve (membrane) at symphysis of upper jaw conspicuously white in adults (Fig. 48); gill rakers on lower limb of first gill arch 36 to 42 . . . . . *Decapterus muroadsi*

3b. In life, caudal fin with upper and lower lobes both hyaline, brownish or red; oral valve (membrane) at symphysis of upper jaw transparent or dusky; gill rakers on lower limb of first gill arch 26 to 33 (except 30 to 39 in *D. muroadsi*) . . . . . → 4

Fig. 48 ventral view of upper jaw and roof of mouth

4a. Scales relatively small (Fig. 47d); curved part of lateral line with 61 to 73 scales; straight part of lateral line with 4 to 10 anterior scales; total lateral-line scales and scales (excluding scales on caudal fin) 103 to 118; in life, caudal fin red; posteroocular margin of opercular membrane minutely serrated in large adults (Fig. 49) . . . . . *Decapterus tabl*

4b. Scales relatively large (Fig. 47e, f); curved part of lateral line with 42 to 62 scales; straight part of lateral line with 0 to 4 anterior scales; total lateral-line scales and scales (excluding scales on caudal fin) 77 to 102; in life, caudal fin dusky or red; posterodorsal margin of opercular membrane smooth in adults . . . . . → 5

Fig. 49 *Decapterus tabl*

5a. In life, caudal fin hyaline to dusky; gill rakers on lower limb of first gill arch usually 32 to 39; soft anal-fin rays (including finlets) 25 to 29 (rarely 25); eye usually smaller . . . *Decapterus russelli*

5b. In life, caudal fin red; gill rakers on lower limb of first gill arch usually 26 to 32; soft anal-fin rays (including finlets) 22 to 26 (rarely 26); eye usually larger . . . . . *Decapterus kurroides*

1/2

Key to the species of *Scomberoides* occurring in the area

1a. Total gill rakers 8 to 11 on first gill arch; scales on midbody below lateral line broadly oblong or bluntly lanceolate (Fig. 51a, b); lobe of dorsal fin uniformly pigmented (Figs 52 and 53) . . . . . → 2

1b. Total gill rakers 21 to 27 on first gill arch; scales on midbody below lateral line sharply lanceolate or needle-like (Fig. 51c, d); distal half of dorsal-fin lobe abruptly and heavily pigmented (Figs 55 and 56) . . . . . → 3

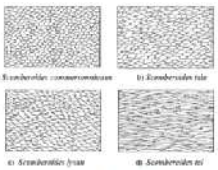


Fig. 51 scales on midbody below lateral line

2a. Upper jaw extends well beyond posterior margin of eye, especially in adults (Fig. 52); in adults, teeth of inner and outer rows in lower jaw subequal in size (Fig. 54a); in life, large oval blotches above or touching lateral line . . . *Scomberoides commersonianus*

2b. Upper jaw extends slightly beyond posterior margin of eye (Fig. 53); in adults, inner row of teeth in lower jaw distinctly larger than those in outer row (Fig. 54b); in life, vertically elongate blotches intersecting lateral line . . . . . *Scomberoides tala*

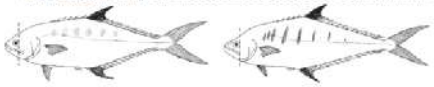


Fig. 52 *Scomberoides commersonianus* Fig. 53 *Scomberoides tala*

2/2

Fig. 54 teeth in lower jaw (teeth in inner row black)

3a. Scales on midbody below lateral line sharply lanceolate (Fig. 51c), in adults, upper jaw extends to or slightly beyond posterior margin of eye (Fig. 55); in life, a double series of 6 to 8 dusky, roundish blotches above and below lateral line, occasionally connected by narrow isthmus . . . . . *Scomberoides lysan*

3b. Scales on midbody below lateral line slender, needle like (Fig. 51d); in adults, upper jaw does not extend to posterior margin of eye (Fig. 56); in life, *mid or vertically oblong dark* blotches, the first 4 or 5 intersecting lateral line . . . . . *Scomberoides sol*

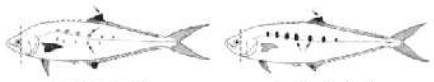


Fig. 55 *Scomberoides lysan* Fig. 56 *Scomberoides sol*

Key to the species of *Selar* occurring in the area

1a. Curved part of lateral line with 48 to 56 scales; curved part of lateral line moderate, with chord of curved part contained 3.7 to 4.2 times in straight part; scales smaller (Fig. 57a) . . . . . *Selar crumenophthalmus*

1b. Curved part of lateral line with 21 to 24 scales; curved part of lateral line short, chord of curved part contained 2.1 to 3 times in straight part; scales larger (Fig. 57b) . . . . . *Selar boops*

Fig. 57 lateral line

Key to the species of *Seriola* occurring in the area

1/2

1a. Soft dorsal- and anal-fin rays 22 to 25 and 15 to 17 (rarely 17), respectively, in specimens larger than about 20 cm fork length; total gill rakers (excluding rudiments) on first gill arch 10 to 12; in life, papillae surrounding broad band of teeth in both jaws engorged with blood giving teeth a red appearance . . . . . *Seriola hippos*

1b. Soft dorsal- and anal-fin rays 27 to 35 and 18 to 22, respectively, in specimens larger than about 20 cm fork length; total gill rakers (excluding rudiments) on first gill arch 11 to 29; in life, papillae surrounding broad band of teeth in both jaws not engorged with blood, appearance of teeth white . . . . . → 2

2a. Upper jaw moderately slender posteriorly, with slender supramaxilla (Fig. 58a); caudal fin yellowish, in adults, a moderate cutaneous keel laterally on caudal peduncle; vertebrae 11+14 . . . . . *Seriola lalandi*

2b. Upper jaw relatively broad posteriorly, with broad supramaxilla (Fig. 58b–d); caudal fin dark to dusky, sometimes with a lighter posterior margin; in adults, cutaneous keel on caudal peduncle absent to slightly developed; vertebrae 10+14 . . . . . → 3

2/2

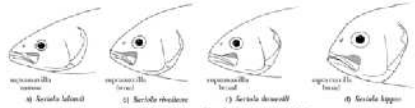


Fig. 58 lateral view of head (supramaxilla shaded)

3a. In adults, length of dorsal-fin lobe about 1.3 to 1.6 times longer than pectoral fins (Fig. 59a) and 18 to 22% of fork length; in specimens larger than about 20 cm fork length, total gill rakers (excluding rudiments) 22 to 25 on first gill arch; first pterygiophore of anal fin straight in specimens larger than about 10 cm fork length (Fig. 60a) . . . . . *Seriola rivoliana*

3b. In adults, length of dorsal-fin lobe about equal to, or slightly longer than pectoral fins (Fig. 59b) and 13 to 18% of fork length; in specimens larger than about 20 cm fork length, total gill rakers (excluding rudiments) 11 to 19 on first gill arch; first pterygiophore of anal fin moderately curved (Fig. 60b) . . . . . *Seriola dumerili*

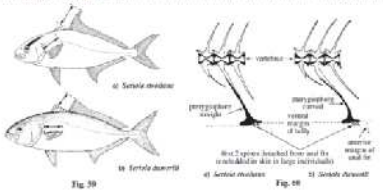


Fig. 59 Fig. 60

1/3

Key to the species of *Trachinotus* occurring in the area

1a. One to 7 spots in a longitudinal row on or near lateral line (spots absent on specimens smaller than about 10 to 13 cm fork length); soft dorsal fin rays 21 to 25 . . . . . → 2

1b. No spots in a longitudinal row on or near lateral line; soft dorsal fin rays 18 to 20 (except 21 to 23 in *T. africanus*) . . . . . → 4

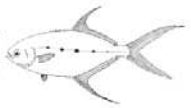


Fig. 61 *Trachinotus baillonii*

2a. In adults, all spots equal to, or smaller than eye diameter, and with about half of spot below lateral line (Fig. 61); gill rakers (including rudiments) on lower limb of first gill arch 15 to 19; vomerine and palatine teeth patches typically type "A" (Fig. 62b) . . . . . *Trachinotus baillonii*

2b. In adults, anterior 2 spots larger than eye diameter and at least two-thirds of spot above lateral line (Figs 63 and 64); gill rakers (including rudiments) on lower limb of first gill arch 11 to 15; vomerine and palatine tooth patches usually type "B" or "C" (Fig. 62b, c) . . . . . → 3

Fig. 62 tooth patches on roof of mouth and upper jaw

2/3

3a. Soft anal-fin rays 19 to 21; in adults only 1 dark spot above pectoral fins, and in large specimens spots oval-shaped (Fig. 63); dorsal-fin lobe usually longer than anal-fin lobe in specimens larger than about 25 cm fork length; pelvic fins long, their length contained 1.5 to 1.7 times in pectoral-fin length in specimens larger than about 25 cm fork length; vomerine tooth patch usually type "B" (Fig. 62b) . . . . . *Trachinotus falcatus*

3b. Soft anal-fin rays 22 to 24; in adults 2 dark spots above pectoral fins, and in large specimens spots more vertically elongate (Fig. 64); dorsal-fin lobe consistently shorter than anal-fin lobe in specimens larger than about 25 cm fork length; pelvic fins relatively short, their length contained 1.7 to 2.2 times in pectoral-fin length in specimens larger than about 25 cm fork length; vomerine tooth patch usually type "C" (Fig. 62c) . . . . . *Trachinotus goreensis*

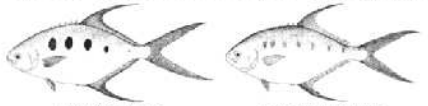


Fig. 63 *Trachinotus falcatus* Fig. 64 *Trachinotus goreensis*

4a. Soft dorsal- and anal-fin rays 21 to 23 and 19 to 21, respectively; body often with a black oval-shaped blotch in axillary base under pectoral fins . . . . . *Trachinotus africanus*

4b. Soft dorsal- and anal-fin rays 18 to 20 and 16 to 18, respectively; body uniformly pigmented in axillary base under pectoral fins . . . . . → 5

5a. First preciosus bone inserted treadmo- or oval-shaped (Fig. 65a), this character is easily observed by simple dissection along midline of nape); height of dorsal-fin lobe longer; 35 to 60% of fork length in specimens 10 to 40 cm fork length . . . . . *Trachinotus kuehlii*

5b. First preciosus bone shaped like an inverted "L" with the arm projecting anteriorly (Fig. 65b–c); anal-fin lobe yellow without a brownish anterior margin; height of dorsal-fin lobe moderate, 24 to 37% of fork length in specimens 10 to 40 cm fork length . . . . . → 6

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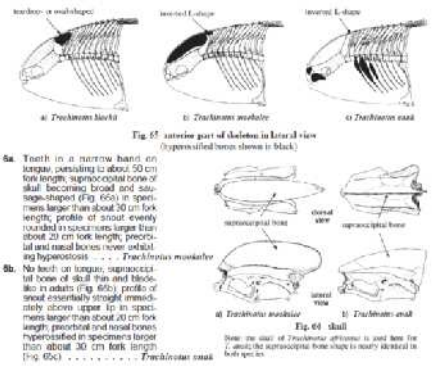


Fig. 65 anterior part of skeleton in lateral view (hyperossified bones shown in black)

5a. Teeth in a narrow band on tongue, persisting to about 50 cm fork length; supraoccipital bone of skull becoming broad and sabre-shaped (Fig. 66a) in specimens larger than about 30 cm fork length; profile of snout evenly rounded in specimens larger than about 20 cm fork length; preorbital and nasal bones never exhibiting hyperostosis . . . . *Trachinotus mookalee*

5b. No teeth on tongue; supraoccipital bone of skull thin and blade-like in adults (Fig. 66b); profile of snout essentially straight immediately above upper lip in specimens larger than about 20 cm fork length; preorbital and nasal bones hyperossified in specimens larger than about 30 cm fork length (Fig. 66c) . . . . . *Trachinotus smithi*

Fig. 66 skull

Key to the species of *Ulua* occurring in the area

1a. Total gill rakers on first gill arch 54 to 61, of which 16 to 21 on upper limb, and 37 to 41 on lower limb; tongue with central band of villiform teeth; in specimens smaller than about 15 cm fork length, first anal fin ray produced but not filamentous, not extending beyond caudal peduncle . . . . . *Ulua aurochs*

1b. Total gill rakers on first gill arch 74 to 86, of which 23 to 27 on upper limb, and 51 to 61 on lower limb; tongue without central band of villiform teeth; in specimens smaller than about 15 cm fork length, first anal fin ray filamentous, extending beyond caudal peduncle . . . . . *Ulua mentalis*

Key to the species of *Uraspis* occurring in the area

1a. Naked area of breast extends uninterrupted to naked base of pectoral fins (Fig. 69a); scales in curved part of lateral line 61 to 82 . . . . . *Uraspis uraspis*

1b. Naked area of breast separated from naked base of pectoral fins by a broad band of scales (Fig. 69b); scales in curved part of lateral line 48 to 60 . . . . . *Uraspis helvola* and *U. secunda* (no verified records from the area; adults of these 2 species are virtually impossible to distinguish)

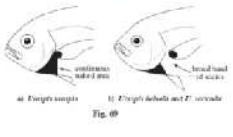


Fig. 69

Main References (Larvae) 1/2

Laroche, W. A., W. F. Smith-Vaniz and S. L. Richardson (1984). Carangidae: Development. Pages 510-522. In H. G. Moser, W. J. Richards, D. M. Cohen, M. P. Fahay, A. W. Kendall, Jr., S. L. Richardson (eds.). Ontogeny and systematics of fishes. American Society of ichthyologists and Herpetologists. Spec. Publ. 1.

Chayakul, R. (1996). The fish larvae in the Gulf of Thailand. Department of Fisheries (Thailand). 217pp.

Watson, W., S. R. Charter, H. G. Moser, D. A. Ambrose, and E. M. Sandknop (1996). Carangidae: jacks. Pages 914-953. *In* H. G. Moser (ed.). The early stages of fishes in the California Current region. California Cooperative Oceanic Fisheries Investigations Atlas 33.

Larval information of the carangid species distributing in the Southeast Asian region (1/2)

Tribe	Genera	Species 1*	Species 2**	Remarks
Carangini	*Alectis*	2	2	
Carangini	*Alepes*	4	(1)	as *Alepes* sp.
Carangini	*Atropus*	1	0	
Carangini	*Atule*	1	1	
Carangini	*Carangoides*	15	(2≤)	as *Carangoides* spp.
Carangini	*Caranx*	8	1	
Carangini	*Decapterus*	6	2	
Carangini	*Gnathanodon*	1	1	
Carangini	*Megalaspis*	1	0	
Carangini	*Parastromateus*	1	1	

*Species 1: consisting species of each genus.
**Species 2: number of species of which larvae are known. Numerals in parentheses are not included in a total.

Larval information of the carangid species distributing in the Southeast Asian region (2/2)

Tribe	Genera	Species 1	Species 2	Remarks
Carangini	*Selar*	2	1	
Carangini	*Selaroides*	1	1	
Carangini	*Ulua*	1	(1)	as *Ulua* sp.
Carangini	*Uraspis*	1	(1)	as *Uraspis secunda*
Naucratini	*Elagatis*	1	1	
Naucratini	*Naucrates*	1	1	
Naucratini	*Seriola*	2	2	
Naucratini	*Seriolina*	1	1	
Scomberoidini	*Scomberoides*	4	2	
Trachinotini	*Trachinotus*	5	2	
4 Tribes	20 Genera	50 species	[18 Genera]	[19 species]

Total numbers of genera and species with larval information are in "[ ]."

Three groups of the carangid larvae in the Southeast Asian region

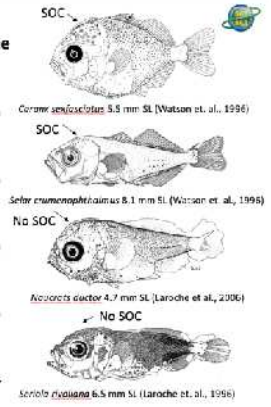
Group 1: supraoccipital crest (SOC) present; body shape deep.

Group 2: supraoccipital crest (SOC) present; body shape moderate.

Group 3: supraoccipital crest (SOC) absent; body shape deep.

Group 4: supraoccipital crest (SOC) absent; body shape moderate.

* SOC is reduced mostly at postflexion stage.



Genera and species with larval information available among carangid fishes in the Southeast Asian region – Group 1

Characters	Tribe	Genus	Species
Group 1: Supraoccipital crest (SOC) present; body shape deep	Carangini	*Alectis*	*A. ciliaris*
			A. indica
		Carangoides	*Carangoides* spp.
		Caranx	*C. sexfasciatus*
		Gnathanodon	*G. speciosus*
		Parastromateus	*P. niger*
		Ulua	*Ulua* sp.

Genera and species with larval information available among carangid fishes in the Southeast Asian region – Group 2

Characters	Tribe	Genus	Species
Group 2: Supraoccipital crest (SOC) present; body shape moderate	Carangini	*Alepes*	*Alepes* sp.
		Decapterus	*D. macarellus*
			D. macrosoma
		Selar	*S. crumenophthalmus*
		Selaroides	*S. leptolepis*
	Naucratini	*Elagatis*	*E. bipinnulata*
	Scomberoidini	*Scomberoides*	*S. lysan*
			S. tol

Genera and species with larval information available among carangid fishes in the Southeast Asian region – Group 3

Characters	Tribe	Genus	Species
Group 3: Supraoccipital crest (SOC) absent; body shape deep	Carangini	*Uraspis*	*U. secunda*"
	Naucratini	*Naucrates*	*N. ductor*
	Trachinotini	*Trachinotus*	*T. baillonii*
			T. blochii

- Presence of supraoccipital crest in carangini *Uraspis* larvae is obscure.
- Larvae of carangini *Atropus atropos* are unknown.

" Taiwan and Australia species (*U. uraspis* in the Southeast Asia region)

Genera and species with larval information available among carangid fishes in the Southeast Asian region – Group 4

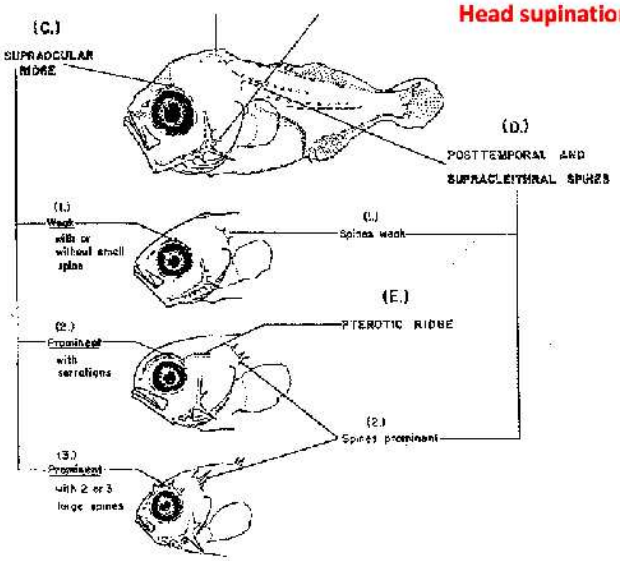
Characters	Tribe	Genus	Species
Group 4: Supraoccipital crest (SOC) absent; body shape moderate	Carangini	*Atule*	*A. mate*
	Naucratini	*Seriola*	*S. dumerili*
			S. rivoliana
		Seriolina	*S. nigrofasciata*

- Larvae of carangini *Megalaspis cordyla* are unknown.

Some characters used to identify carangid larvae

Laroche et al. (1996)

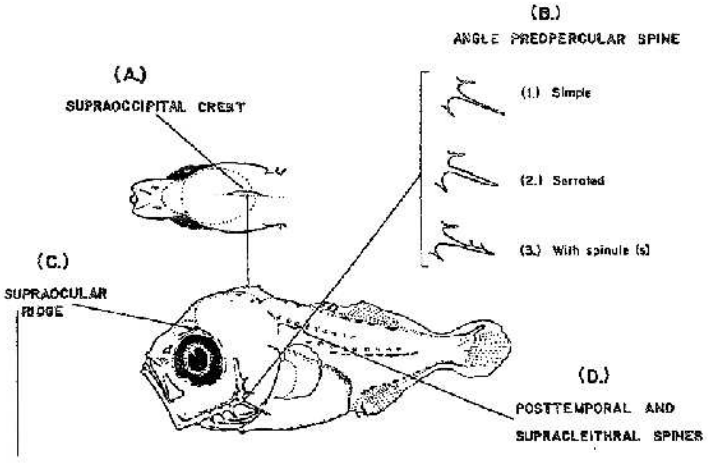
Head supination – 2/2



Some characters used to identify carangid larvae

Laroche et al. (1996)

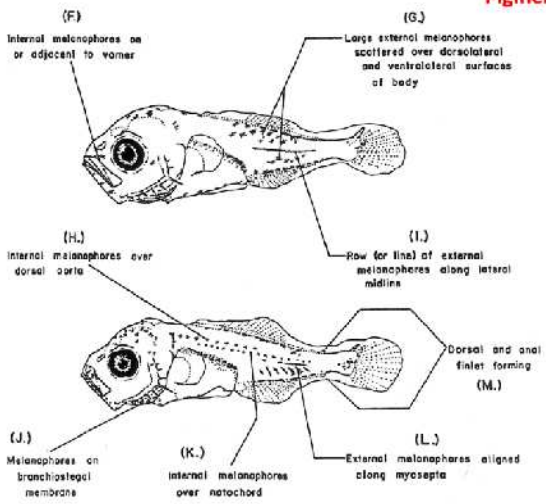
Head supination – 1/2



Some characters used to identify carangid larvae

Laroche et al. (1996)

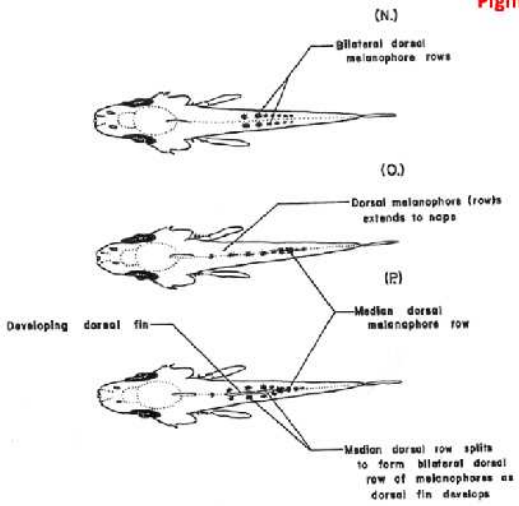
Pigment – 1/3



Some characters used to identify carangid larvae

Laroche et al. (1996)

Pigment – 2/3

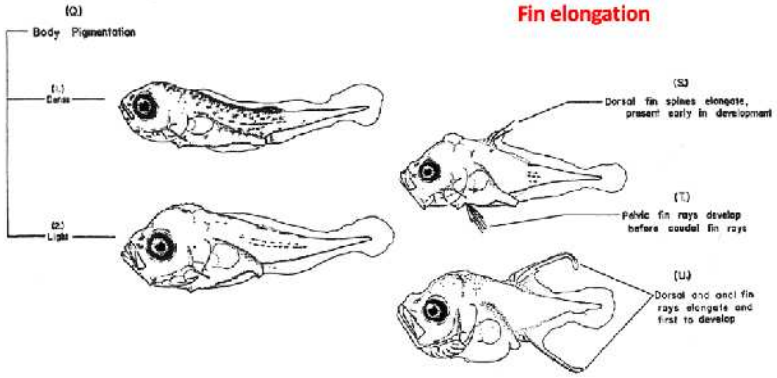


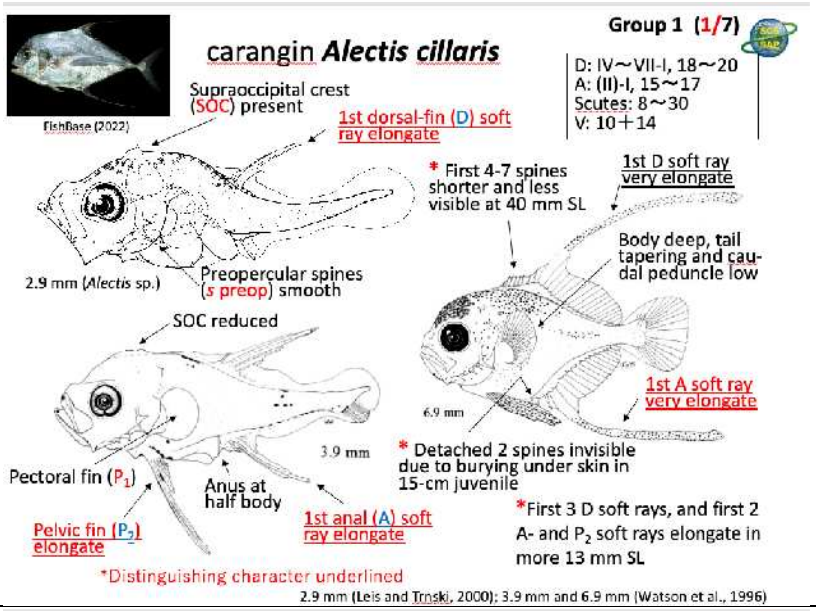
Some characters used to identify carangid larvae

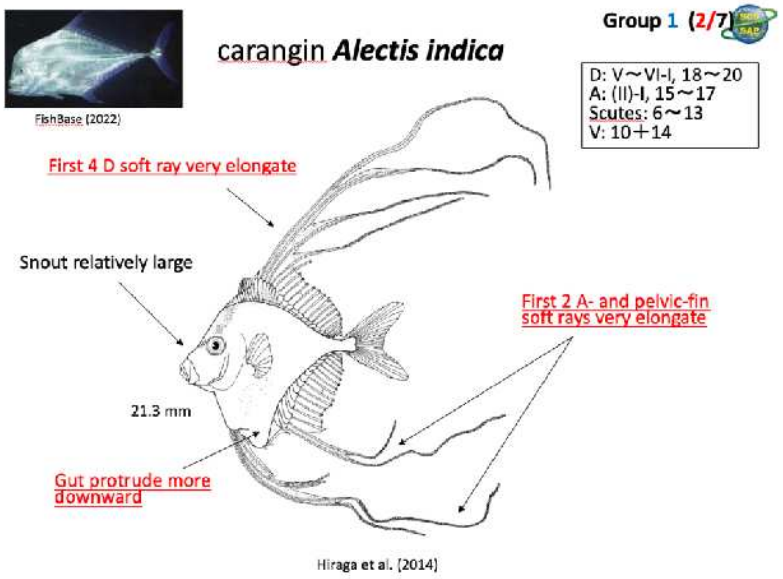
Laroche et al. (1996)

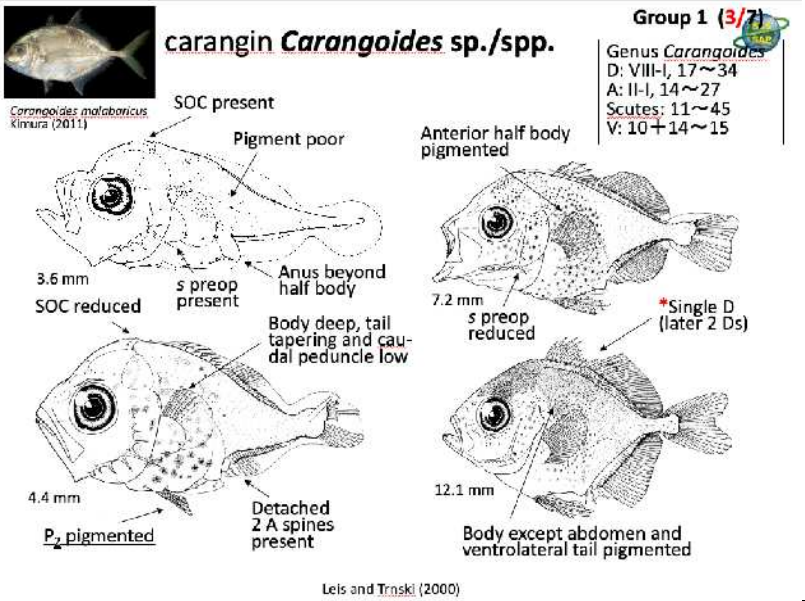
Pigment – 3/3

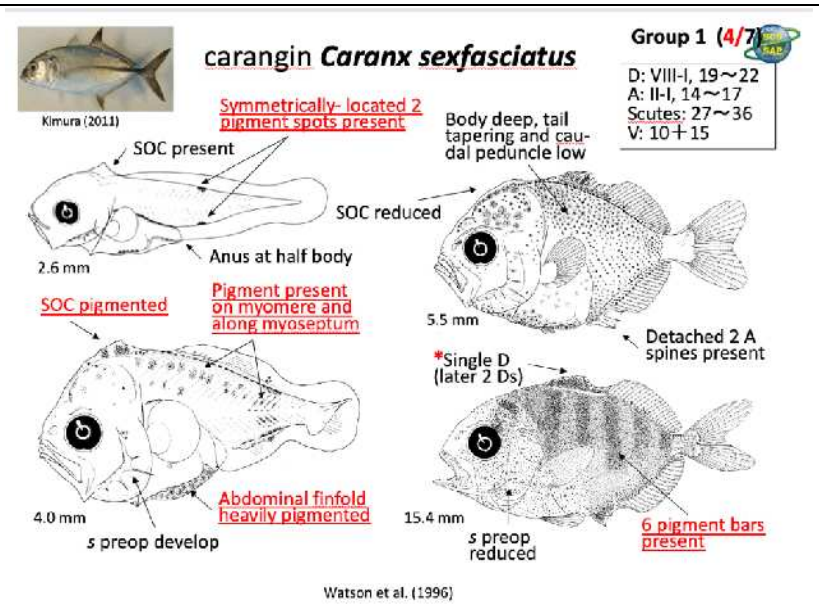
Fin elongation

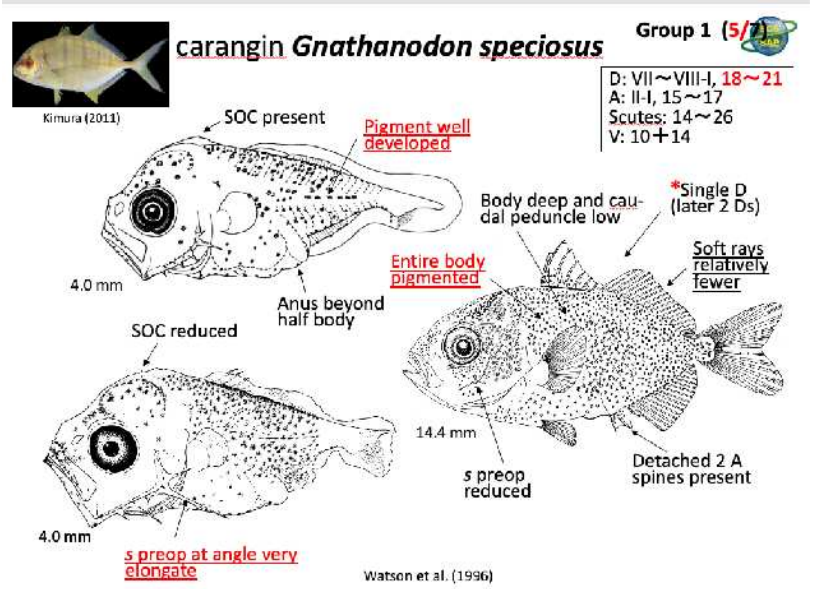


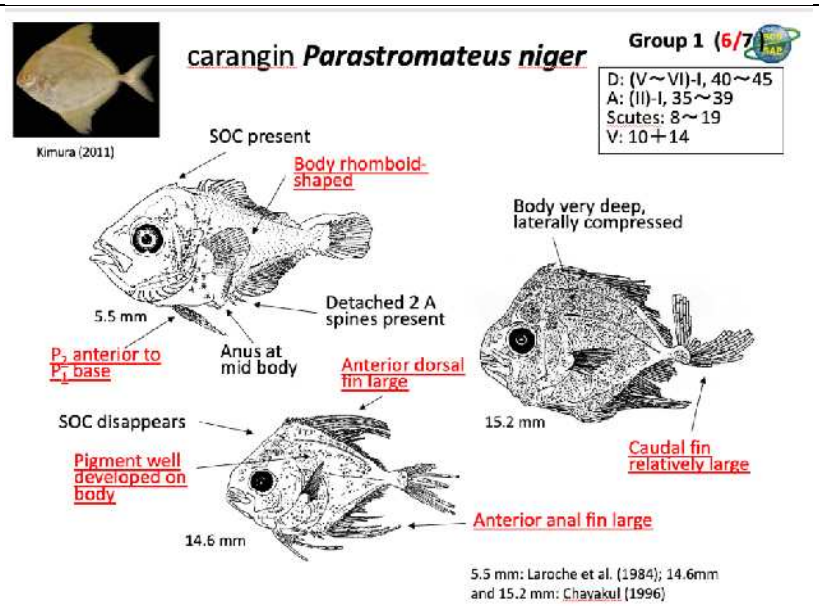

Group 1 (1/7)
carangin Alectis cillaris
FishBase (2022)
D: IV~VII-I, 18~20
A: (II)-I, 15~17
Scutes: 8~30
V: 10+14
Supraoccipital crest (SOC) present
1st dorsal-fin (D) soft ray elongate
* First 4-7 spines shorter and less visible at 40 mm SL
1st D soft ray very elongate
2.9 mm (Alectis sp.)
Preopercular spines (s preop) smooth
Body deep, tail tapering and caudal peduncle low
SOC reduced
6.9 mm
1st A soft ray very elongate
3.9 mm
* Detached 2 spines invisible due to burying under skin in 15-cm juvenile
Pectoral fin (P1)
Anus at half body
Pelvic fin (P2) elongate
1st anal (A) soft ray elongate
*First 3 D soft rays, and first 2 A- and P2 soft rays elongate in more 13 mm SL
*Distinguishing character underlined
2.9 mm (Leis and Trnski, 2000); 3.9 mm and 6.9 mm (Watson et al., 1996)


Group 1 (2/7)
carangin Alectis indica
FishBase (2022)
D: V~VI-I, 18~20
A: (II)-I, 15~17
Scutes: 6~13
V: 10+14
First 4 D soft ray very elongate
Snout relatively large
First 2 A- and pelvic-fin soft rays very elongate
21.3 mm
Gut protrude more downward
Hiraga et al. (2014)


Group 1 (3/7)
carangin Carangoides sp./spp.
Carangoides malabaricus Kimura (2011)
Genus Carangoides
D: VIII-I, 17~34
A: II-I, 14~27
Scutes: 11~45
V: 10+14~15
SOC present
Pigment poor
Anterior half body pigmented
3.6 mm
s preop present
Anus beyond half body
7.2 mm
s preop reduced
*Single D (later 2 Ds)
SOC reduced
Body deep, tail tapering and caudal peduncle low
4.4 mm
Detached 2 A spines present
P2 pigmented
12.1 mm
Body except abdomen and ventrolateral tail pigmented
Leis and Trnski (2000)


carangin Caranx sexfasciatus
Group 1 (4/7)
D: VIII-I, 19～22
A: II-I, 14～17
Scutes: 27～36
V: 10＋15
Kimura (2011)
Symmetrically- located 2 pigment spots present
SOC present
Body deep, tail tapering and caudal peduncle low
SOC reduced
Anus at half body
2.6 mm
5.5 mm
Detached 2 A spines present
SOC pigmented
Pigment present on myomere and along myoseptum
*Single D (later 2 Ds)
Abdominal finfold heavily pigmented
4.0 mm
s preop develop
15.4 mm
s preop reduced
6 pigment bars present
Watson et al. (1996)


carangin Gnathanodon speciosus
Group 1 (5/7)
D: VII～VIII-I, 18～21
A: II-I, 15～17
Scutes: 14～26
V: 10＋14
Kimura (2011)
SOC present
Pigment well developed
Body deep and caudal peduncle low
*Single D (later 2 Ds)
Soft rays relatively fewer
Entire body pigmented
4.0 mm
Anus beyond half body
SOC reduced
14.4 mm
Detached 2 A spines present
s preop reduced
4.0 mm
s preop at angle very elongate
Watson et al. (1996)

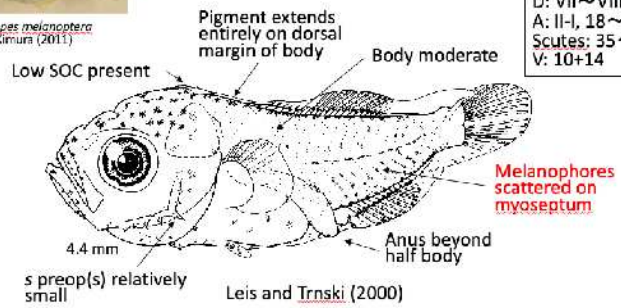

carangin Parastromateus niger
Group 1 (6/7)
D: (V～VI)-I, 40～45
A: (II)-I, 35～39
Scutes: 8～19
V: 10＋14
Kimura (2011)
SOC present
Body rhomboid-shaped
Body very deep, laterally compressed
Detached 2 A spines present
5.5 mm
P2 anterior to P1 base
Anus at mid body
Anterior dorsal fin large
15.2 mm
SOC disappears
Pigment well developed on body
Caudal fin relatively large
Anterior anal fin large
14.6 mm
5.5 mm: Laroche et al. (1984); 14.6mm and 15.2 mm: Chayakul (1996)

Alepes melanoptera
Kimura (2011)

carangin *Alepes* sp.

Group 2 (1/7)

Genus *Alepes*
D: VII～VIII-I, 21～27
A: II-I, 18～23
Scutes: 35～69
V: 10+14



Leis and Trnski (2000)

Selar crumenophthalmus 4.1 mm (Laroche et al., 2006) *Atule mate* 4.9 mm (Laroche et al., 1984)

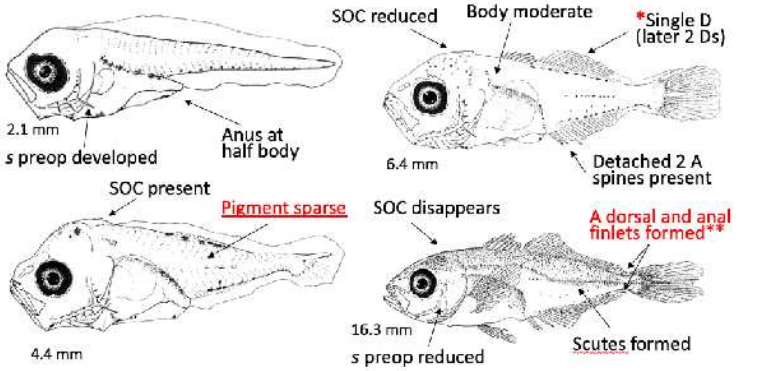
Characters of body shape and pigment patterns on myoseptum in the tail are shared by *Alepes*, *Selar* and *Atule* larvae in 4 mm. *Selar* in 4 mm have a slender body, longer preopercular spines, poor pigment and melanophores of dorsal body in tail are limited at the anterior tail. *Atule* larvae have no supraoccipital crest.

FishBase (2022)

carangin *Decapterus macarellus*

Group 2 (2/7)

D: VIII-I, 30～36+1
A: II-I, 26～30+1
Scutes: 24～40
V: 10+14



Laroche et al. (2006)

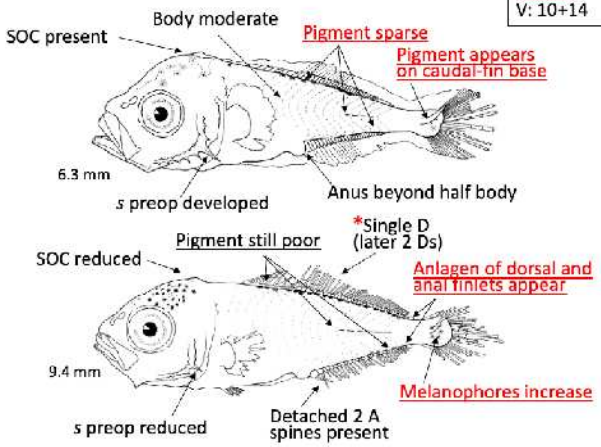
** In this size, finlets are continuous to 2nd dorsal and anal fins by fin membranes. Spaces between pterygiophores of last dorsal and anal soft rays and finlets are wider than those of each 2 soft rays. This feature indicates finlet formation.

Kimura (2011)

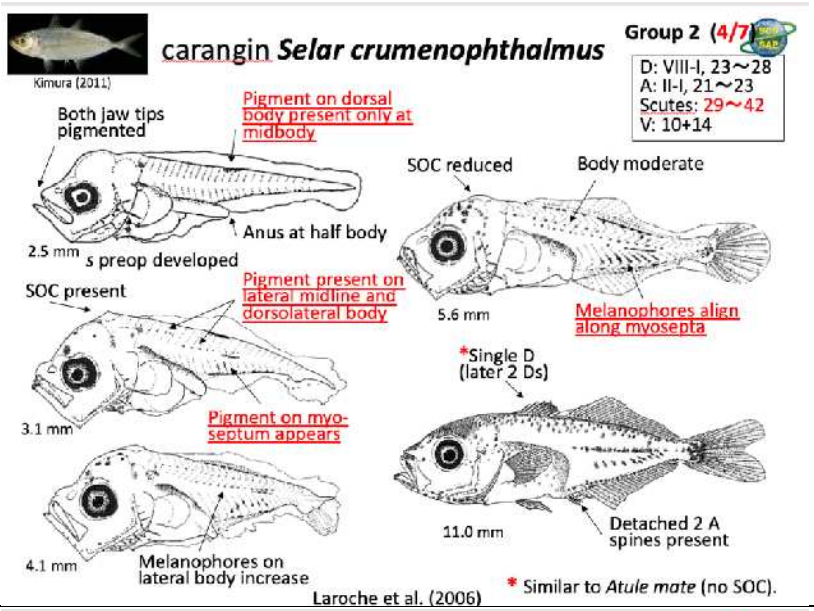
carangin *Decapterus macrosoma*

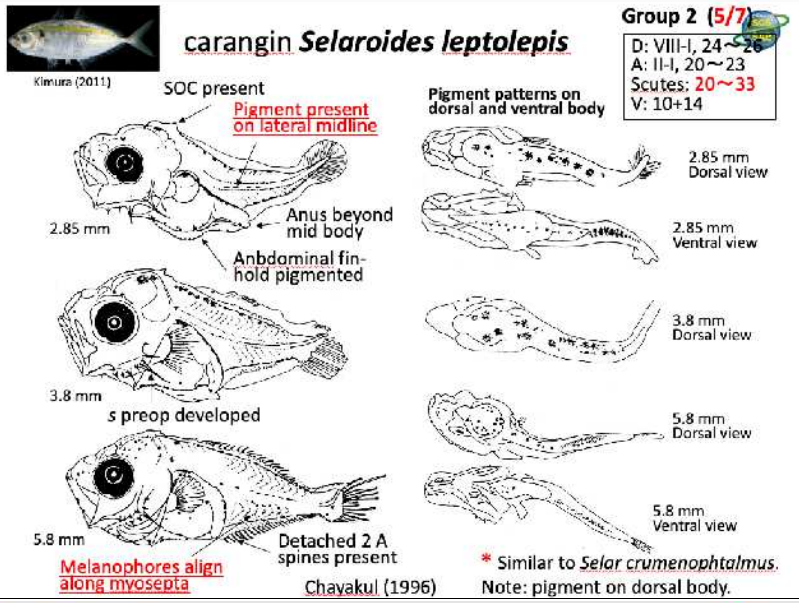
Group 2 (3/7)

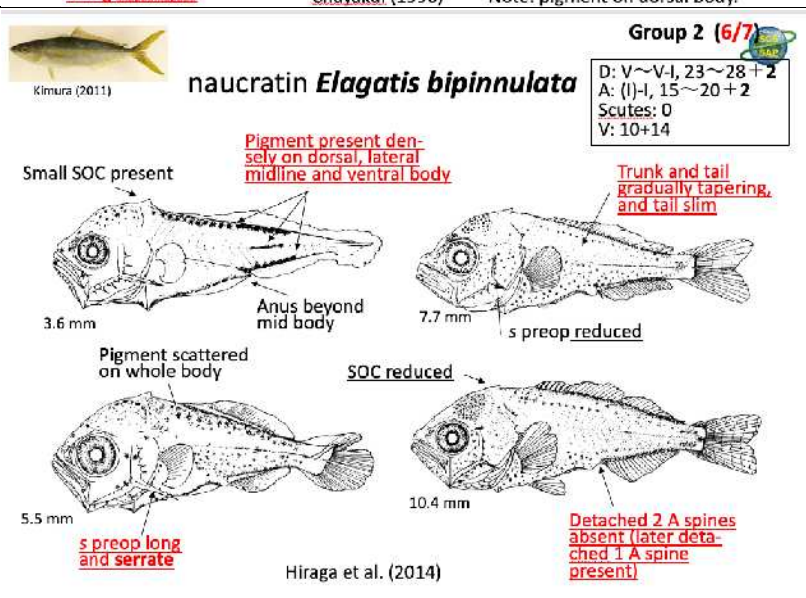
D: VIII-I, 32～38+1
A: II-I, 26～30+1
Scutes: 24～40
V: 10+14

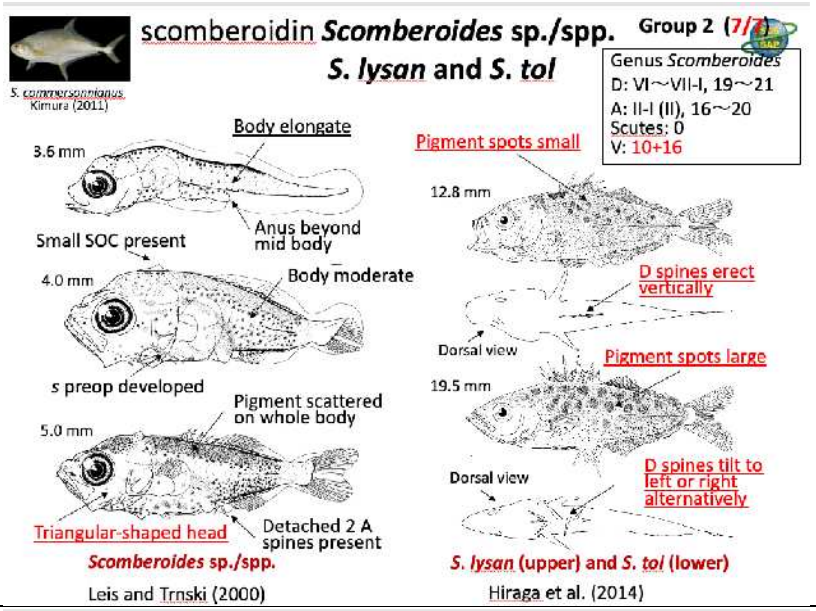


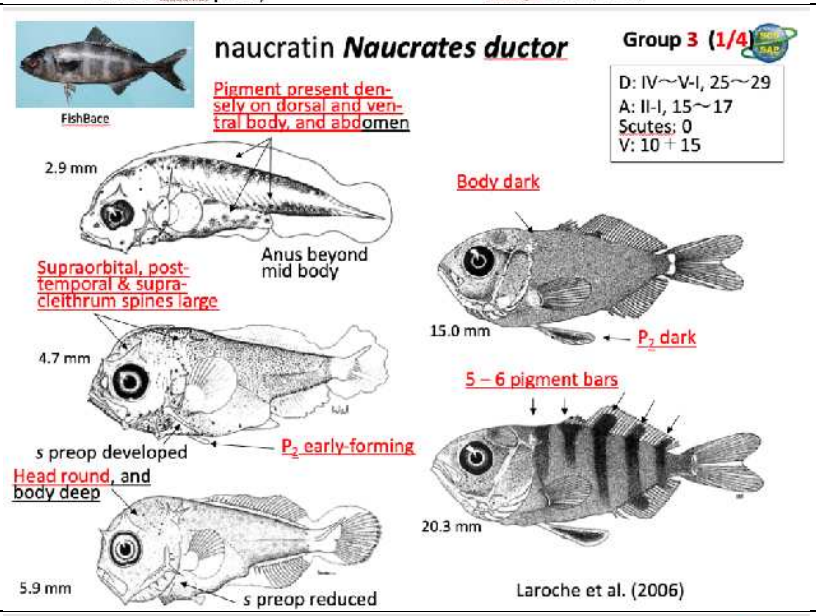
Hiraga et al. (2014)

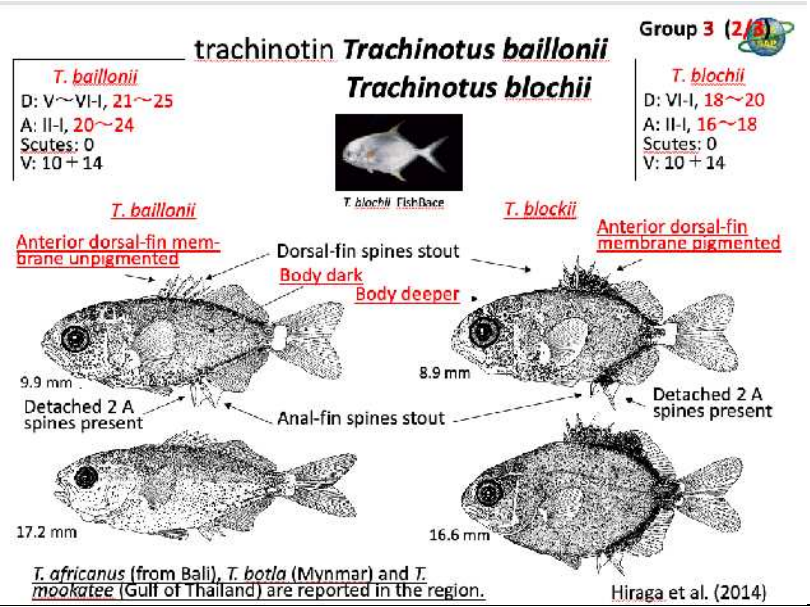

carangin Selar crumenophthalmus
Group 2 (4/7)
D: VIII-I, 23~28
A: II-I, 21~23
Scutes: 29~42
V: 10+14
Kimura (2011)
Both jaw tips pigmented
Pigment on dorsal body present only at midbody
Anus at half body
2.5 mm
s preop developed
SOC reduced
Body moderate
5.6 mm
Melanophores align along myosepta
SOC present
Pigment present on lateral midline and dorsolateral body
3.1 mm
Pigment on myo-septum appears
*Single D (later 2 Ds)
11.0 mm
Detached 2 A spines present
4.1 mm
Melanophores on lateral body increase
Laroche et al. (2006)
* Similar to Atule mate (no SOC).


carangin Selaroides leptolepis
Group 2 (5/7)
D: VIII-I, 24~26
A: II-I, 20~23
Scutes: 20~33
V: 10+14
Kimura (2011)
SOC present
Pigment present on lateral midline
Pigment patterns on dorsal and ventral body
2.85 mm
Anus beyond mid body
Anbdominal fin-fold pigmented
2.85 mm Dorsal view
2.85 mm Ventral view
3.8 mm
3.8 mm Dorsal view
s preop developed
5.8 mm Dorsal view
5.8 mm
Detached 2 A spines present
5.8 mm Ventral view
Melanophores align along myosepta
Chavakul (1996)
* Similar to Selar crumenophtalmus.
Note: pigment on dorsal body.


naucratin Elagatis bipinnulata
Group 2 (6/7)
D: V~V-I, 23~28+2
A: (I)-I, 15~20+2
Scutes: 0
V: 10+14
Kimura (2011)
Small SOC present
Pigment present densely on dorsal, lateral midline and ventral body
Trunk and tail gradually tapering, and tail slim
3.6 mm
Anus beyond mid body
7.7 mm
s preop reduced
Pigment scattered on whole body
SOC reduced
5.5 mm
10.4 mm
s preop long and serrate
Detached 2 A spines absent (later detached 1 A spine present)
Hiraga et al. (2014)


scomberoidin Scomberoides sp./spp.
S. lysan and S. tol
Group 2 (7/7)
Genus Scomberoides
D: VI~VII-I, 19~21
A: II-I (II), 16~20
Scutes: 0
V: 10+16
S. commersonnianus
Kimura (2011)
Body elongate
3.6 mm
Anus beyond mid body
Small SOC present
4.0 mm
Body moderate
s preop developed
Pigment scattered on whole body
5.0 mm
Triangular-shaped head
Detached 2 A spines present
Scomberoides sp./spp.
Leis and Trnski (2000)
Pigment spots small
12.8 mm
D spines erect vertically
Dorsal view
Pigment spots large
19.5 mm
Dorsal view
D spines tilt to left or right alternatively
S. lysan (upper) and S. tol (lower)
Hiraga et al. (2014)

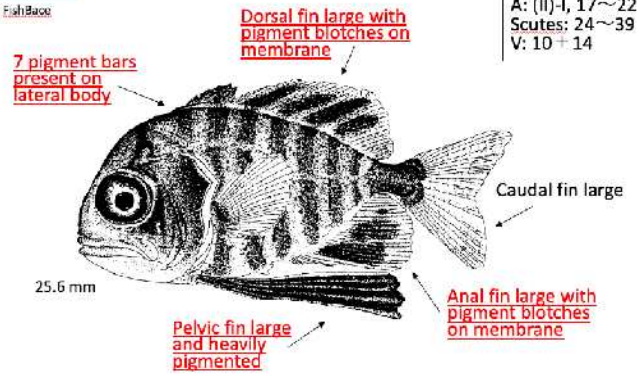

naucratin Naucrates ductor
Group 3 (1/4)
D: IV~V-I, 25~29
A: II-I, 15~17
Scutes: 0
V: 10+15
FishBase
Pigment present densely on dorsal and ventral body, and abdomen
2.9 mm
Anus beyond mid body
Supraorbital, post-temporal & supracleithrum spines large
4.7 mm
s preop developed
P2 early-forming
Head round, and body deep
5.9 mm
s preop reduced
Body dark
15.0 mm
P2 dark
5 – 6 pigment bars
20.3 mm
Laroche et al. (2006)


trachinotin Trachinotus baillonii
Trachinotus blochii
Group 3 (2/3)
T. baillonii
D: V~VI-I, 21~25
A: II-I, 20~24
Scutes: 0
V: 10+14
T. blochii
D: VI-I, 18~20
A: II-I, 16~18
Scutes: 0
V: 10+14
T. blochii FishBase
T. baillonii
Anterior dorsal-fin membrane unpigmented
Dorsal-fin spines stout
Body dark
Body deeper
9.9 mm
Detached 2 A spines present
Anal-fin spines stout
17.2 mm
T. blockii
Anterior dorsal-fin membrane pigmented
8.9 mm
Detached 2 A spines present
16.6 mm
T. africanus (from Bali), T. botla (Mynmar) and T. mookatee (Gulf of Thailand) are reported in the region.
Hiraga et al. (2014)

carangin *Ulaspis secunda*

Group 3 (3/3)

U. uraspis
D: VI~VIII-I, 24~30
A: (II)-I, 17~22
Scutes: 24~39
V: 10+14



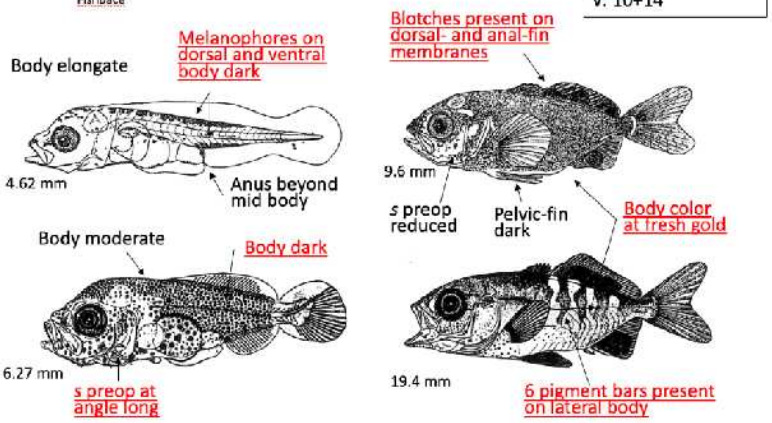
*Larvae of this species are not known.

Laroche et al. (1984)

naucratin *Seriola dumerili*

Group 4 (2/4)

D: VI~VII-I, 29~35
A: II-I, 18~22
Scutes: 0
V: 10+14



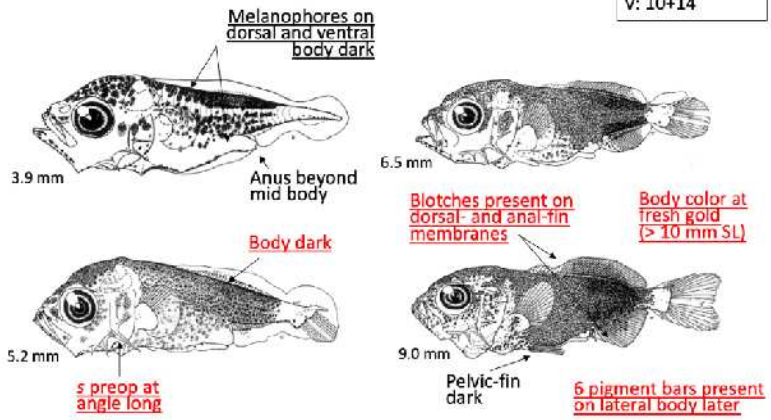
*Larave of *S. dumerili* and *S. rivolian* are quite similar. Pigment patterns on the D and A fin membranes may different.

Laroche et al. (2006)

naucratin *Seriola rivoliana*

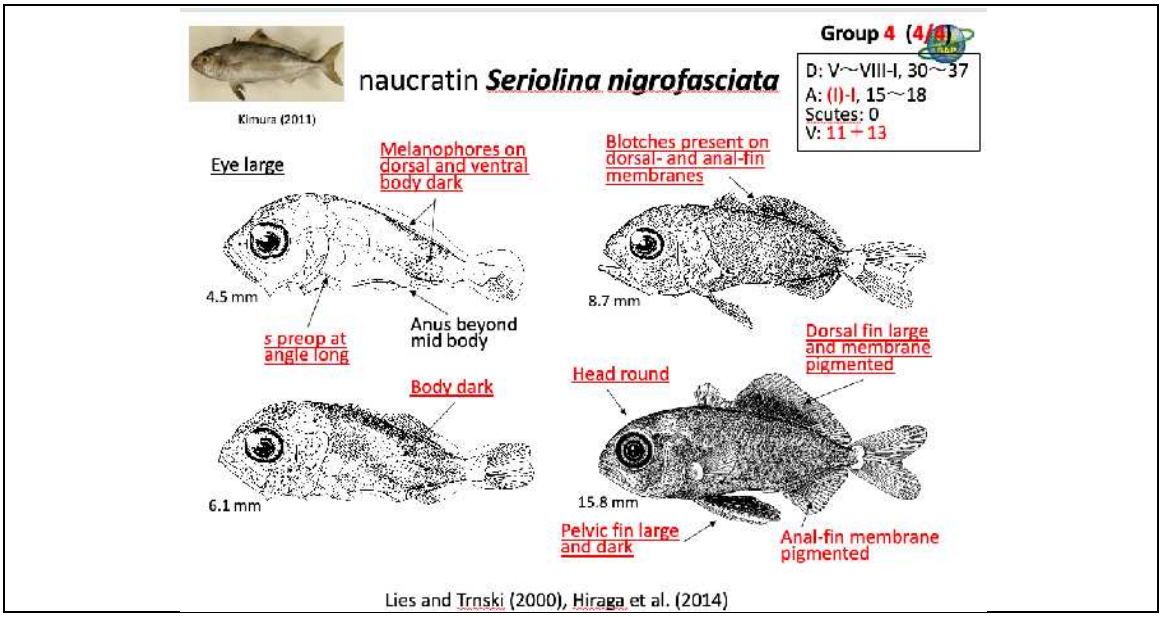
Group 4 (3/4)

D: VII-I, 26~33
A: II-I, 18~22
Scutes: 0
V: 10+14



*Larave of *S. rivolian* and *S. dumerili* are quite similar. Pigment patterns on the D and A fin membranes may different.

Laroche et al. (2006)


Group 4 (4/4)
naucratin Seriolina nigrofasciata
Kimura (2011)
D: V~VIII-I, 30~37
A: (I)-I, 15~18
Scutes: 0
V: 11 - 13
Eye large
Melanophores on dorsal and ventral body dark
Blotches present on dorsal- and anal-fin membranes
4.5 mm
8.7 mm
s preop at angle long
Anus beyond mid body
Dorsal fin large and membrane pigmented
Head round
Body dark
6.1 mm
15.8 mm
Pelvic fin large and dark
Anal-fin membrane pigmented
Lies and Trnski (2000), Hiraga et al. (2014)

Annex 6: Identification methods of the Engraulidae fishes and their larvae in Southeast Asia

Identification methods of the Engraulidae fishes and their larvae in the Southeast Asian region

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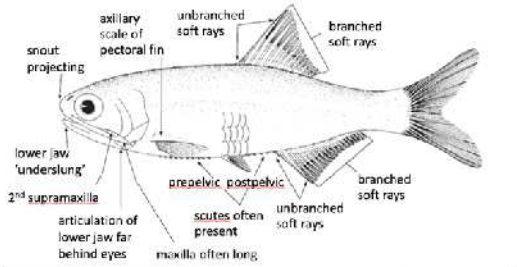
Formerly, *Seikai* National Fisheries Research Institute
Nagasaki, JAPAN

Adults

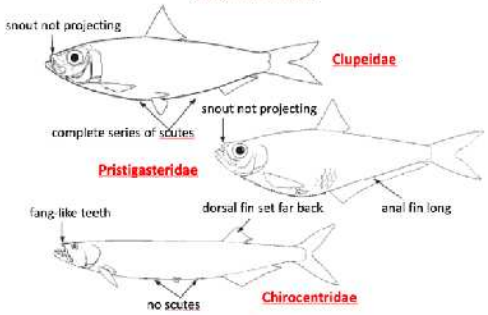
Reference:
Wongratana, T., T. A. Munroe and M. S. Nizinski (1998). Engraulidae. Pages 1698-1753 *in* Carpenter, K. E. and V. H. Niem eds. The living marine resources of the Western Central Pacific. FAO species identification guide for fishery purposes. FAO, Rome.

Diagnostic characters of the Engraulidae fishes

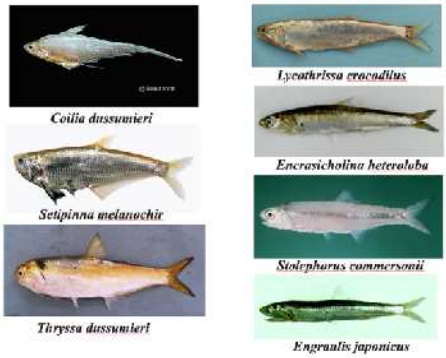


- Dorsal fin single, short, and usually near midpoint of body (far forward in *Coilia*).
- No adipose fin.
- Pectoral fins set low on body.
- Pelvic fins anterior to, equal with, or posterior to the vertical through dorsal-fin base.

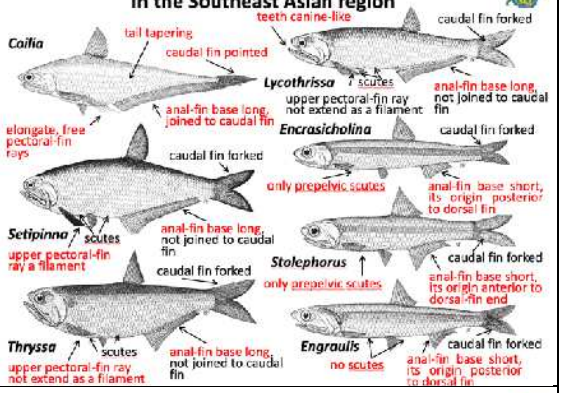
Similar families to the Engraulidae in the Southeast Asian region (Clupeiformes)



Representative species of engraulid genera in the region



Seven genera of the Engraulidae in the Southeast Asian region



Genera and species of the Engraulidae in the Southeast Asian region

No.	Genus	Species
1	*Coilia*	8
2	*Encrasicholina*	4
3	*Engraulis*	1
4	*Lycothrissa*	1
5	*Setipinna*	4
6	*Stolephorus*	10
7	*Thryssa*	8

Total
36 species

Genera and species of the Engraulidae in Myanmar, Malaysia, Thailand, Cambodia and Viet Nam

Genus	Mya	Mal 1	Mal 2	Thai	Cam	Vie
Coilia	2	2	2	2	1	3
Setipinna	2	1	2	2	1	0
Thryssa	6	5	5	5	5	3
Lycothrissa	1	1	1	1	1	1
Engraulis	0	0	0	0	0	0
Encrasicholina	3	3	3	3	3	3
Stolephorus	5	2	8	8	8	4
Total	19	14	21	21	19	14

Mya : Myanmar ; Mal 1 : west coast of Peninsula Malay ; Mal 2 : east coast of Peninsula Malay ; Thai : Thailand (the Gulf of Thailand) ; Cam : Cambodia ; Vie : Viet Nam

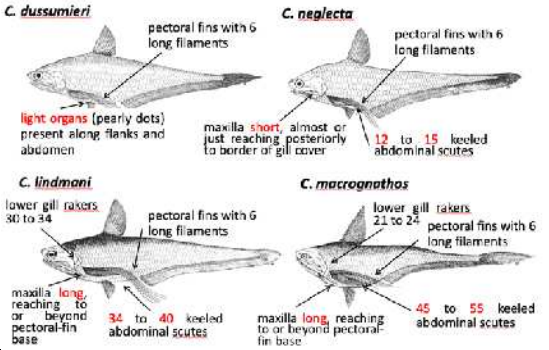
Species of the engraulid *Coilia** in Myanmar, Malaysia, Thailand, Cambodia and Viet Nam

Species	Mya	Mal 1	Mal 2	Thai	Cam	Vie
C. borneensis						
C. coomansi						
C. gravii						○
C. dussumieri	●	●	●	●		
C. lindmani			○	○	○	○
C. macrognathos						
C. neglecta	○	○				
C. rebentischii						○
Total	2	2	2	2	1	3

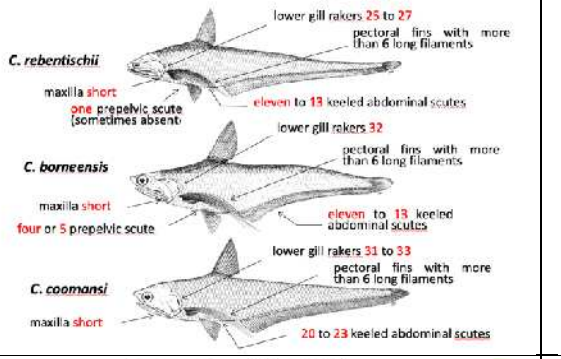
* Habitat in the low salinity area
● Marketed species
C. borneensis, *C. coomansi*: only in Indonesia; *C. rebentischii*: only in Borneo

Mya : Myanmar ; Mal 1: Malaysia (west coast of the Peninsula); Mal 2: Malaysia (east coast of the Peninsula); Thai : Thailand (the Gulf of Thailand) ; Camb : Cambodia ; Viet : Viet Nam

Seven species of the *Coilia* in the Southeast Asian region (1/2)



Seven species of the *Coilia* in the Southeast Asian region (2/2)



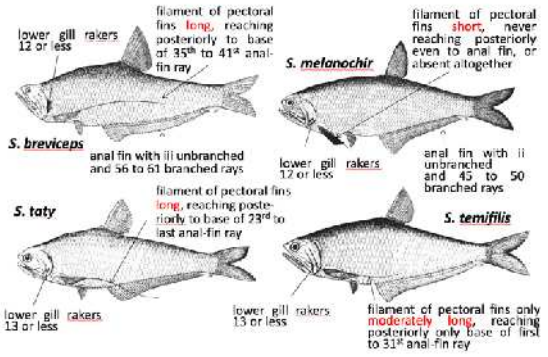
Species of the engraulid *Setipinna** in Myanmar, Malaysia, Thailand, Cambodia and Viet Nam

Species	Mya	Mal 1	Mal 2	Thai	Cam	Vie
S. breviceps	○	○				
S. melanochir			●	●		
S. taty	●		●	●	●	
S. tenuifilis						
Total	2	1	2	2	1	0

* Habitat in the low salinity area
● Marketed species
S. tenuifilis: only in Borneo, Philippine

Mya : Myanmar ; Mal 1: Malaysia (west coast of the Peninsula); Mal 2: Malaysia (east coast of the Peninsula); Thai : Thailand (the Gulf of Thailand) ; Camb : Cambodia ; Viet : Viet Nam

Four species of the *Setipinna* in the Southeast Asian region



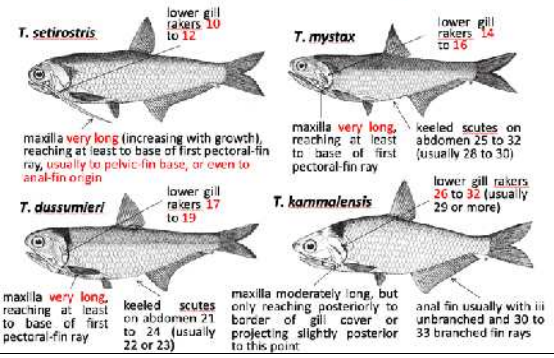
Species of the engraulid *Thryssa** in Myanmar, Malaysia, Thailand, Cambodia and Viet Nam

Species	Mya	Mal 1	Mal 2	Thai	Cam	Vie
T. baelama	●					
T. dussumieri	○		○	○	○	○
T. encrasicholoides						
T. hamiltonii	●	●	●	●	●	●
T. kammalensis		○	○	○	○	
T. mystax	●	●	●	●	●	
T. setirostris	●	●	●	●	●	●
T. spinidens	○	○				
Total	6	5	5	5	5	3

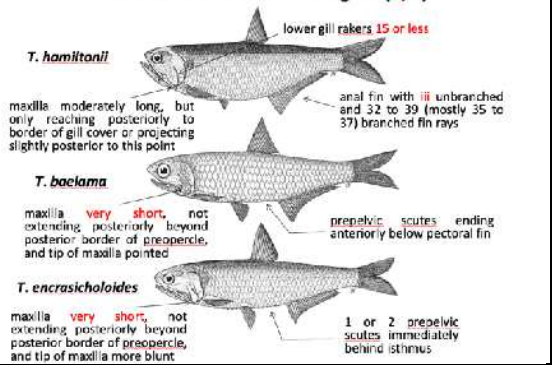
* Habitat in the low salinity area
● Marketed species
T. encrasicholoides: only in Indonesia, Philippine

Mya : Myanmar ; Mal 1: Malaysia (west coast of the Peninsula); Mal 2: Malaysia (east coast of the Peninsula); Thai : Thailand (the Gulf of Thailand) ; Camb : Cambodia ; Viet : Viet Nam

Seven species of the *Thryssa* in the Southeast Asian region (1/2)



Seven species of the *Thryssa* in the Southeast Asian region (2/2)



Species of the engraulid *Engraulis* and *Lycothrissa** in Myanmar, Malaysia, Thailand, Cambodia and Viet Nam

Species	Mya	Mal 1	Mal 2	Thai	Cam	Vie
E. japonicus						
*L. crocodilus**	○	○	○	○	○	○

* Habitat in the fresh water and low salinity area

E. japonicus: only in Philippine

Mya : Myanmar ; Mal 1: Malaysia (west coast of the Peninsula); Mal 2: Malaysia (east coast of the Peninsula); Thai : Thailand (the Gulf of Thailand) ; Camb : Cambodia ; Viet : Viet Nam

Species of the engraulid *Encrasicholina* in Myanmar, Malaysia, Thailand, Cambodia and Viet Nam

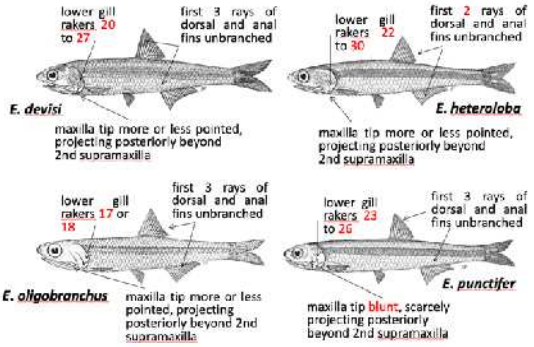
Species	Mya	Mal 1	Mal 2	Thai	Cam	Vie
E. devisi	●	●	●	●	●	●
E. heteroloba	●	●	●	●	●	●
E. oligobranchus						
E. punctifer	●	●	●	●	●	●
Total	3	3	3	3	3	3

● Marketed species

E. oligobranchus: only in Philippine

Mya : Myanmar ; Mal 1: Malaysia (west coast of the Peninsula); Mal 2: Malaysia (east coast of the Peninsula); Thai : Thailand (the Gulf of Thailand) ; Camb : Cambodia ; Viet : Viet Nam

Four species of the *Encrasicholina* in the Southeast Asian region



Species of the engraulid *Stolephorus* in Myanmar, Malaysia, Thailand, Cambodia and Viet Nam

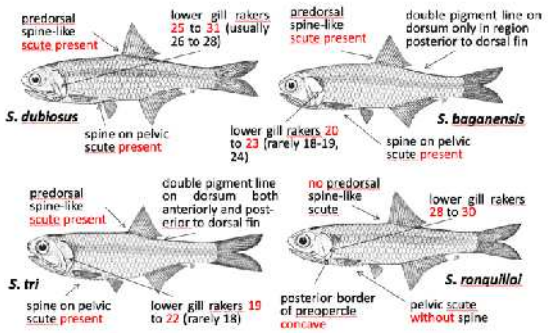
Species	Mya	Mal 1	Mal 2	Thai	Cam	Vie
S. andhraensis						
S. baganensis			○	○	○	
S. chinensis			○	○	○	○
S. commersonii	●	●	●	●	●	●
S. dubiosus	○		○	○	○	
S. indicus	●	●	●	●	●	●
S.insularis	○		○	○	○	○
S. ronquilloi						
S. tri			●	●	●	
S. waitei	●		●	●	●	
Total	5	2	8	8	8	4

● Marketed species

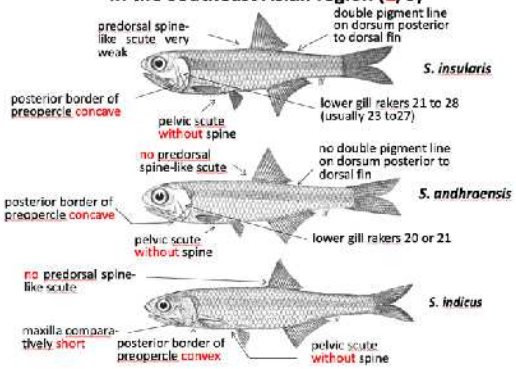
S. andhraensis: only in Borneo, Java; *S. ronquilloi*: only in Philippine

Mya : Myanmar ; Mal 1: Malaysia (west coast of the Peninsula); Mal 2: Malaysia (east coast of the Peninsula); Thai : Thailand (the Gulf of Thailand) ; Camb : Cambodia ; Viet : Viet Nam

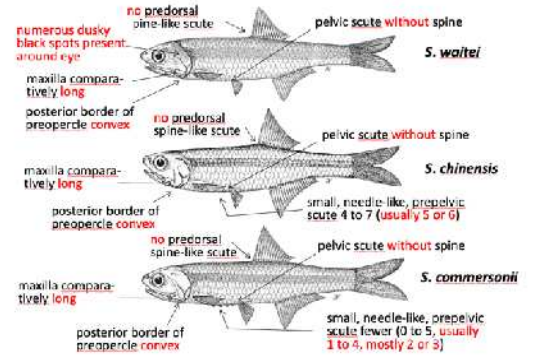
Ten species of the *Stolephorus* in the Southeast Asian region (1/3)



Ten species of the *Stolephorus* in the Southeast Asian region (2/3)



Ten species of the *Stolephorus* in the Southeast Asian region (3/3)



Larvae

References:

Okiyama, M. ed. (2013). An atlas of early stage fishes in Japan. Second edition. Tokai University Press, Hatano, 1639pp. (in Japanese).

Leis, J. M. and B. M. Carson-Ewart. eds. (2000) The larvae of Indo-Pacific coastal fishes. An identification guide to marine fish larvae. Brill, Leiden, 850pp.

McGowan, M. F. and F. H. Berry. (1984). Clupeiformes: development and relationships. Pages 108-126. *in* Moser, H. G., W. J. Richards, D. M. Cohen, M. P. Fahay, A. W. Kendall, Jr. and S. L. Richardson. eds. Ontogeny and systematics of fishes. Amer. Soc. Ichthyol. Herpetol., Sp. Publ., No. 1

Meristic characters of Indo-Pacific engraulid genera

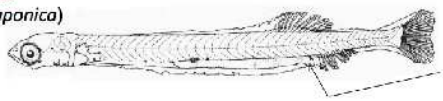
Genus	D	A	P_1	P_2	C	V
Coilinae						
1 *Coilia* *	13-17	62-117	11-29	6-10	19	14-21+46-61=60-76
2 *Setipinna* *	13-15	48-64	11-15	7	19	15-18+31-37=46-54
3 *Thrissa* *	11-17	26-49	10-14	7	19	12-21+22-28=39-46
4 *Lycothrissa* *	10-13	47-51		6-7		
Engraulinae						
5 *Encrasicholina*	11-16	14-21	12-17	7	19	21-25+17-21=41-44
6 *Engraulis*	13-17	14-22	15-18	7	19	43-47
7 *Stolephorus*	13-18	17-25	11-17	7	19	18-23+18-21=38-43

* low salinity species

modified Leis and Trnski (2000)

Similar larvae to the Engraulidae (1/3)

Engraulidae
(*Engraulis japonica*)
10.1 mm TL



A 14-117 ; V 38-76
gut relatively short and anus under or just posterior to dorsal fin (except *Coilia**)

Clupeidae
Herklotsichthys sp.
12.1 mm BL

cross-hatching pattern

A 9-28 ; V 40-57
gut long and anus posterior to dorsal fin

Pristigasteridae
Ilisha elongata
17.0 mm TL

body relatively deep

striated hindgut

A 34-93 ; V 41-62
gut moderately long and anus posterior to dorsal fin

Chirocentridae
Chirocentrus dorab
20.5 mm TL

body very elongate

A 29-37 ; V 69-75
gut long and anus under dorsal fin

* *Coilia* : dorsal fin anteriorly far from anus.
These four clupeiform family larvae share 1) cross-hatching pattern of muscle fibers (except clupeid *Spratelloides*) and 2) striated hindgut.

Similar larvae to the Engraulidae (2/3)

Chanidae
(*Chanos chanos*)
13.6 mm SL

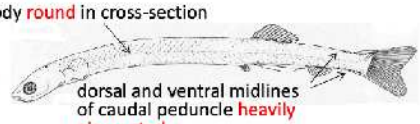
pigment present on dorsal midline of body

body relatively deep and compressed

pigment present on ventral midline of gut

A 8-11 ; V 40-46
no cross-hatching pattern and hindgut smooth

Gonorynichidae
(*Gonorynchus abbreviatus*)
18.3 mm TL

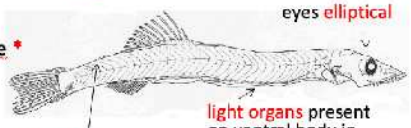


body round in cross-section

dorsal and ventral midlines of caudal peduncle heavily pigmented

A 7-9 ; V 54-56
no cross-hatching pattern and hindgut striated

Phosichthyidae *
(*Vinciguerria nimbaria*)
13.5 mm SL



eyes elliptical

adipose fin present

light organs present on ventral body in large larvae

A 12-15 ; V 38-44
no cross-hatching pattern and hindgut smooth

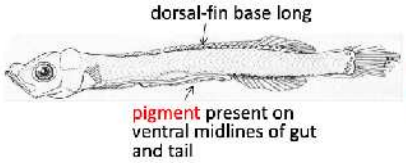
* Deep-sea fish

Similar larvae to the Engraulidae (3/3)

Notosudidae *
(*Scopelosaurus smithii*)
26.0 mm SL

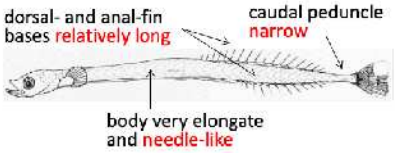
V around 55
no cross-hatching pattern and hindgut
smooth

Ammodytidae
(*Bleekeria viridiangguilla*)
9.9 mm BL



V 50-56
no cross-hatching pattern and hindgut
smooth

Schindleriidae
(*Schindleria praematura*)
11.2 mm BL



V 31-44
no cross-hatching pattern and hindgut
smooth

* Deep-sea fish

Key to genus of the Engraulidae larvae in the Southeast Asian region

1a Dorsal-fin base present at midpoint of body, and its end remarkably anterior to anus. Total myomeres more than 70. ····· ***Coilia***

1b Dorsal-fin base present near midpoint of body or posterior to it, and its end over origin of anal fin or posterior to the origin. Total myomeres less than 70. ····· **2**

2a Anal-fin rays more than 30, and its base more than 1.5 times of dorsal-fin base . ····· **3**

2b Anal-fin rays less than 30, and its base less than 1.5 times of dorsal-fin base . ····· **4**

3a Head depressed (until early postflexion stage). Anal-fin rays more than 47. ····· ***Setipinna***

3b Head not depressed. Anal-fin rays less than 49. ····· ***Thryssa***

4a Origin of anal fin just under end of dorsal fin. ····· **5**

4b Origin of anal fin distinctly anterior to end of dorsal fin. ····· ***Stolephorus***

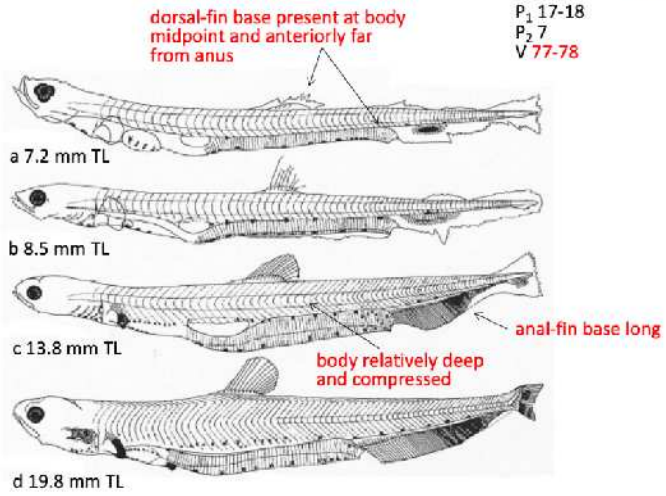
5a Total vertebrae 40-45 ····· ***Encrasicholina*** *

5b Total vertebrae 44-47 ····· ***Engraulis***

* Some *Encrasicholina* larvae have the *Stolephorus*-type arrangement of dorsal and anal fins. Riverine and lacustrine species of *Lycothrissa* is excluded in the above key.

Larvae of *Coilia nasus* *

D 13
A 81-97
P_1 17-18
P_2 7
V 77-78

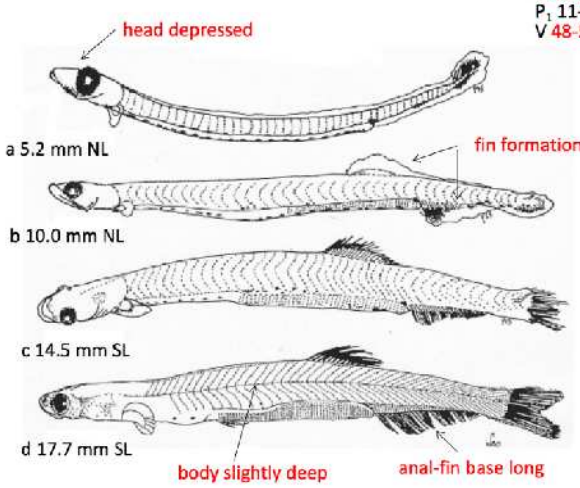


* Endemic species in Japan

Takita (1967)

Larvae of *Setipinna tenuifilis*

D 15
A 49-59
P_1 11-13
V 48-50

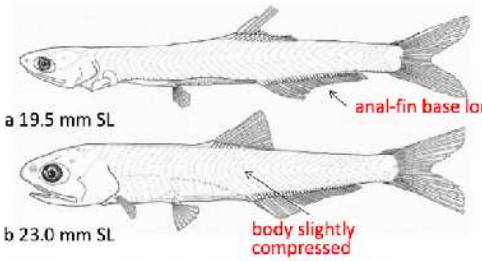


Young et. al. (1995)

Two species larvae of *Thryssa*

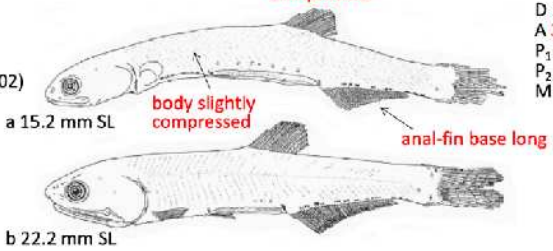
D 14-15
A 30-33
P_1 16
P_2 7
V

T. baelama
Noichi (2013)



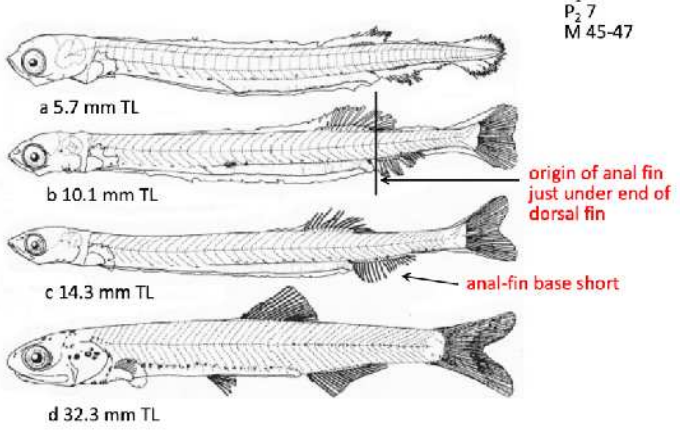
D 13-14
A 35-45
P_1 16
P_2 7
M 44-46

T. hamiltoni
Kanou et. al. (2002)



Larvae of *Engraulis japonica* *

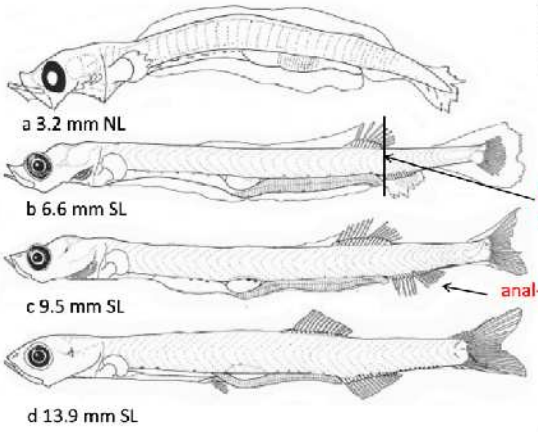
D 14-16
A 15-18
P_1 16-17
P_2 7
M 45-47



*Adults only in Philippine

by Tsumoto, K.

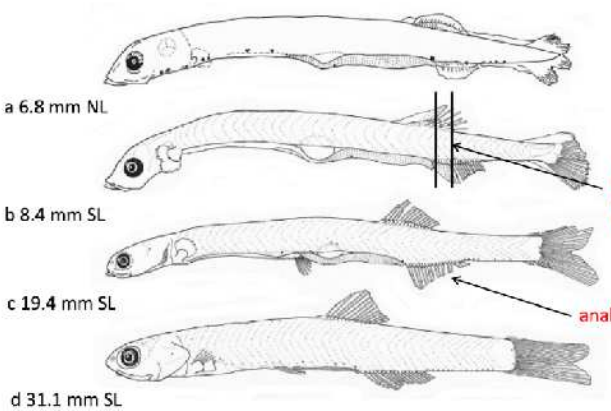
Larvae of *Encrasicholina punctifer*



D 12-14
A 12-15
P_1 16
P_2 7
M 44

Noichi (2013)

Larvae of *Encrasicholina heteroloba*

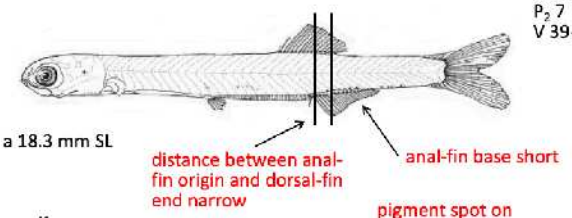


D 15
A 16-18
P_1 16
P_2 7
M 43

Noichi (2013)

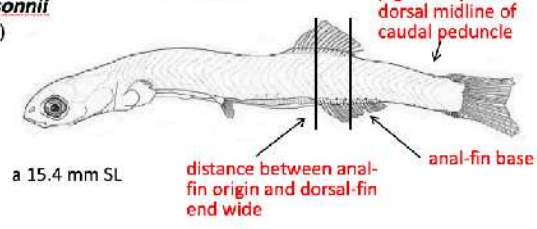
Two species larvae of *Stolephorus*

S. indicus
Fujitai and Kinoshita (2008)



D 16
A 18-21
P_2 7
V 39-44

S. commersonnii
Noichi (2013)



D 16
A 20-22
P_1 14
P_2 7
V 39

Dorsal- and anal-fin rays of *Encrasicholina* and *Stolephorus* in the Southeast Asian region

Species	D	A	Species	D	A
Encrasicholina	**12-16**	**14-21**	***Stolephorus***	**14-18**	**17-24**
E. devisi	13-16	17-21	*S. andhraensis*	15-17	19-23
E. heteroloba	13-15	15-19	*S. baganensis*	14-16	20-23
E. oligobranchus	14-16	18	*S. chinensis*	16-18	20-23
E. punctifer	12-16	14-17	*S. commersonii*	15-17	20-23
			S. dubiosus	14-16	19-24
			S. indicus	14-17	17-22
			S.insularis	14-17	19-23
			S. ronquilloi	15-17	19-22
			S. tri	14-15	19-22
			S. waitei	15-17	19-24

Species in red color : marketed species
McGowan and Berry (1984)

Annex 7: Identification methods of the Lutjanidae, Siganidae and Epinephelini larvae in Southeast Asia

Identification methods of the Lutjanidae, Siganidae and Epinephelini larvae in the Southeast Asian region

Yoshinobu KONISHI

Formerly, *Seikai* National Fisheries Research Institute
Nagasaki, JAPAN

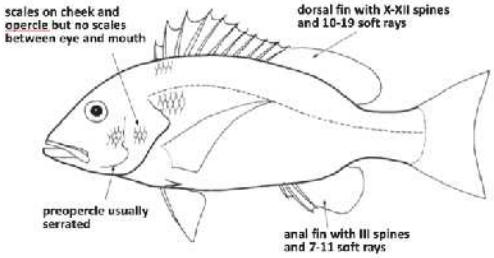
Lutjanidae (Snappers)

Adults

Reference:

Anderson, W. D. Jr. and G.R. Allen (2001). Lutjanidae. Pages 2840-2918 *in* Carpenter, K. E. and V. H. Niem eds. The living marine resources of the Western Central Pacific. FAO species identification guide for fishery purposes. FAO, Rome.

Diagnostic characters of the Lutjanidae fishes



- Opercular spines 2. Branchiostegal rays 7. Dorsal fin single. Caudal fin truncate to deeply forked.
- D X-XII, 10-19; A III, 7-11; PRC 17 (9+8); P_1 14-19; P_2 I, 5; Vertebrae (10+14).
- Colour: highly variable; mainly from red through yellow to blue; often with blotches, lines, or other patterns.

Anderson and Allen (2001)

Habitat, and biology

- Juveniles of several species of *Lutjanus* enter estuaries and the lower reaches of fresh-water streams; a few Indo-Pacific species of *Lutjanus* are inhabitants of fresh waters.
- Mostly bottom-associated fishes, occurring from shallow inshore areas to depths of about 500 m (mainly over reefs or rocky outcrops).
- Populations in continental waters have extended spawning throughout the summer, whereas those occurring around islands spawn throughout the year with peaks in spring and fall.
- Lutjanids are batch spawners, with individual females usually spawning several times in a reproductive season.
- Spawning is apparently at night, on some occasions coinciding with spring tides.
- Larvae avoid surface waters during the day, but display a more even vertical distribution at night.

Anderson and Allen (2001)

Representative species of lutjanid genera in the region


Lipocheilus carnolabrum


Etelis coruscans


Pinjalo pinjalo


Pristipomoides argyrogrammicus


Paracaesio xanthura


Symphorichthys spilurus


Aphareus furca


Lutjanus argentimaculatus


Symphorus nematophorus


Aprion virescens


Macolor niger

Photos: FishBase

Subfamilies, genera, and species of the Lutjanidae in the Southeast Asian region

Subfamily	Genus	D	A	P_2
Apsilinae	*Lipocheilus* (1)	X, 10	III, 8	15-16
	Paracaesio (4)	X, 9-10	III, 8-9	16-18
Etelinae	*Aphareus* (2)	X, 10-11	III, 8	15-16
	Aprion (1)	X, 11	III, 8	16-18
	Etelis (3)	X, 11	III, 8	15-17
	Pristipomoides (8)	X, 11	III, 8	15-17
Lutjaninae	*Lutjanus* (33)	X-XII, 12-16	III, 7-11	15-17
	Macolor (2)	IX-X, 13-15	III, 10-11	16-18
	Pinjalo (2)	XI-XII, 13-14	III, 9-10	17-19
Paradichthyinae	*Symphorichthys* (1)	X, 17-19	III, 11	16-17
	Symphorus (1)	X, 14-17	III, 9-10	16-17

- Numerals in parenthesis: number of species (11 genera with 56 species in the region).
- P_2: I, 5; C: 9+8; Vertebrae: 10+14 (all species of lutjanid fishes in the region).
- Meristic data: Indo-Pacific lutjanid fishes by Leis and Rennis (2000).

Key to the genera of Lutjanidae occurring in the area (1/4)

Notes: species names are given when a genus includes a single species. Counts of gill rakers include rudiments, if present.

Anderson and Allen (2001)

1a. Dorsal and anal fins without scales; dorsal fin with X spines and 10 or 11 soft rays *2*
1b. Soft dorsal and anal fins with scales or sheathed with scales basally; dorsal fin with X to XII spines and 11 to 19 softrays *10*
2a. Maxilla with scales *3*
2b. Maxilla without scales *5*
3a. Spinous portion of dorsal fin deeply incised at its junction with soft portion; dorsal fin with X spines and 11 (very infrequently 10) soft rays ..... *Etelis*
3b. Spinous portion of dorsal fin not deeply incised at its junction with soft portion; dorsal fin with X spines and 10 softrays *4*
4a. Last soft ray of both dorsal and anal fins shorter than next to last soft ray ..... *Paracaesio*
4b. Last soft ray of both dorsal and anal fins about equal to or slightly longer than next to last soft ray ..... *Parapristipomoides squamimaxillaris*

Key to the genera of Lutjanidae occurring in the area (2/4)

5a. Premaxillae essentially not protrusible, attached to snout at symphysis by a frenum *6*
5b. Premaxillae protrusible, not attached to snout by frenum *7*
6a. Vomer without teeth (small juveniles may have minute teeth on vomer); teeth in jaws very small, no caniniform teeth; pectoral fins somewhat shorter than head; lateral surface of maxilla smooth ..... *Aphareus*
6b. Vomer with teeth; jaws with some caniniform teeth; pectoral fins about 1/2 to 2/3 length of head; lateral surface of maxilla with a series of well-developed longitudinal ridg. ..... *Randallichthys filamentosus*
7a. Dorsal fin with X spines and 11 (rarely 10) soft rays; last soft ray of both dorsal and anal fins longer than next to last softray *8*
7b. Dorsal fin with X spines and 10 soft rays; last soft ray of both dorsal and anal fins shorter than next to last softray *9*
8a. Groove present on snout below nostrils (Fig. 1); pectoral fins less than 1/2 length of head. ..... *Aprion virescens*
8b. No groove on snout; pectoral fins a little shorter than head to somewhat longer than head ..... *Pristipomoides*

Key to the genera of Lutjanidae occurring in the area (3/4)

9a. Upper lip with a median fleshy protrusion, well developed in adults (Fig. 2); spines of dorsal and anal fins strong, very robust in large adults ..... *Lipocheilus carnolabrum*
9b. Upper lip without a median fleshy protrusion ..... *Paracaesio*
10a. Vomer without teeth; dorsal fin with X spines and 14 to 19 soft rays; 1 or more anterior soft dorsal-fin rays produced as filaments (at least in juveniles) *11*
10b. Vomer with teeth; dorsal fin with X to X II spines and 11 to 16 soft rays; none of anterior soft dorsal-fin rays produced as filaments *12*
11a. Anterior profile quite steep; dorsal fin with X spines and 17 to 19 soft rays; upper and lower pharyngeals enlarged and bearing large molariform teeth ..... *Symphorichthys spilurus*
11b. Anterior profile sloping more gently; dorsal fin with X spines and 14 to 17 soft rays; upper and lower pharyngeals not particularly enlarged, not bearing molariform teeth ..... *Symphorus nematophorus*

Key to the genera of Lutjanidae occurring in the area (4/4)

12a. First gill arch with 30 or more gill rakers on lower limb ..... *Macolor*
12b. First gill arch with 20 or fewer gill rakers on lower limb *13*
13a. Upper and lower profiles of head equally rounded; eye set toward middle of head; mouth rather small, somewhat upturned; no fang-like canines at anterior ends of jaws ..... *Pinjalo*
13b. Upper and lower profiles of head not equally rounded, upper profile evenly rounded to steeply sloped, and lower profile flattened; eye closer to upper profile of head than to lower; mouth larger, usually not upturned; some fang-like canines usually present at anterior ends of jaws ..... *Lutjanus*

Larvae (1/2)

References (Guide book):

Leis, J. M. and D. S. Rennis (2000). Lutjanidae (Snappers and Fusiliers. Pages 329-337. *in:* Leis, J. M. and B. M. Carson-Ewart. (eds.) The larvae of Indo-Pacific coastal fishes. An identification guide to marine fish larvae. Brill, Leiden.

Lindeman, K.C., Richards, W.J., Lyczkowski-Shultz, J., Drass, D.M., Paris, C.B., Leis, J.M., Lara, M. & Comyns, B.H. (2005) Lutjanidae: Snappers. pages. 1549–1586. *In:* Richards, W.J. (Ed): *Early Stages of Atlantic Fishes. An identifycation guide for the Western Central Atlantic.* Taylor and Francis: Boca Raton, Florida.

Okiyama, M. ed. (2014). Lutjanidae. Pages 819-835. *in* An atlas of early stage fishes in Japan. Second edition. Tokai University Press, Hatano.

Larvae

References (papers):

Leis, J.M. & Lee, K. (1994). Larval development in the lutjanid subfamily Etelinae (Pisces):the genera *Aphareus*, *Aprion*, *Etelis* and *Pristipomoides*. *Bulletin of Marine Science* 55, 46–125.

Leis, J.M. & Bray, D.J. (1995). Larval development in the lutjanid subfamily Paradicichthyinae (Pisces):the genera *Symphorus* and *Symphorichthys*. *Bulletin of Marine Science* 56, 418–433.

Leis, J.M., Bullock, S., Bray, D.J. & Lee, K. (1997). Larval development in the lutjanid subfamily Apsilinae (Pisces): the genus *Paracaesio*. *Bulletin of Marine Science* 61, 697–742.

Leis, J.M. (2005) A larva of the eteline lutjanid, *Randallichthys filamentosus* (Pisces: Perciformes), with comments on phylogenetic implications of larval morphology of basal lutjanids. *Zootaxa* 1008, 57–64.

Leis, J. M. (2007). Larval Development in the Lutjanid Subfamily Lutjaninae (Pisces): the Genus *Macolor*. Records of the Australian Museum. 59: 1-8.

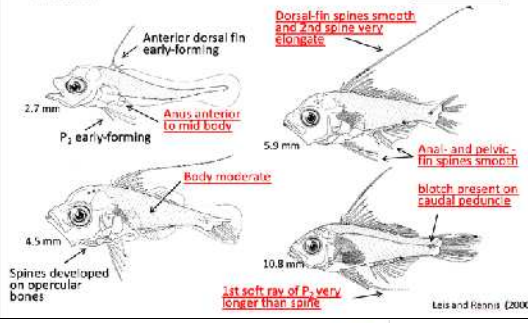
Leis, J. M. (2008). Larval development in the lutjanid subfamily Lutjaninae (Pisces): the Indo-Pacific genus *Pinjalo*, Zootaxa, 1760: 37-49.

Larvae of some lutjanid species (1/)

apsiline ***Paracaesio*** sp.

Paracaesio stonei
FishBase (2022)

Paracaesio
D: X, 9～10
A: III, 8～9
P_1: 16～18
P_2: I, 5
V: 10+14



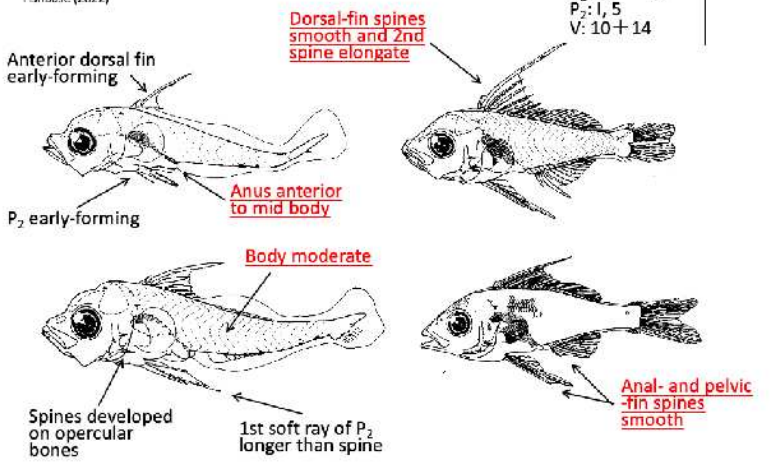
Leis and Rennis (2000)

Larvae of some lutjanid species (2/)

eteline ***Aprion virescens***

FishBase (2022)

D: X, 11
A: III, 8
P_1: 17～18
P_2: I, 5
V: 10+14



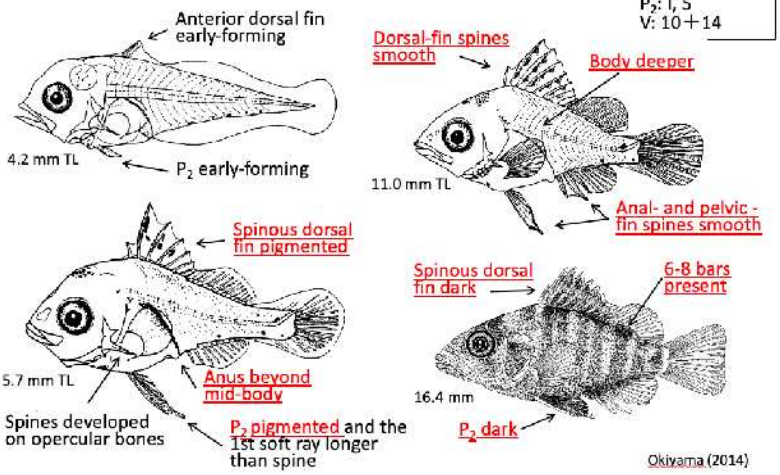
Leis and Rennis (2000)

Larvae of some lutjanid species (3/)

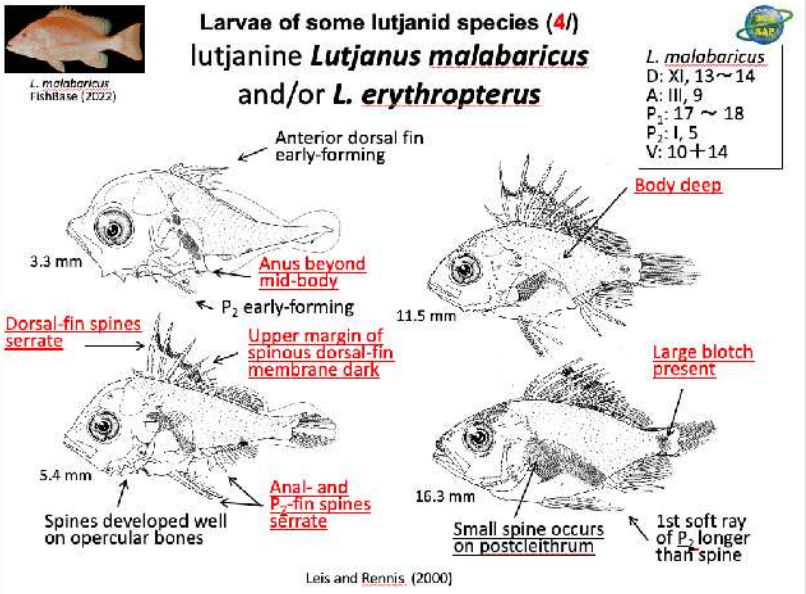
lutjanine ***Lutjanus argentimaculatus***

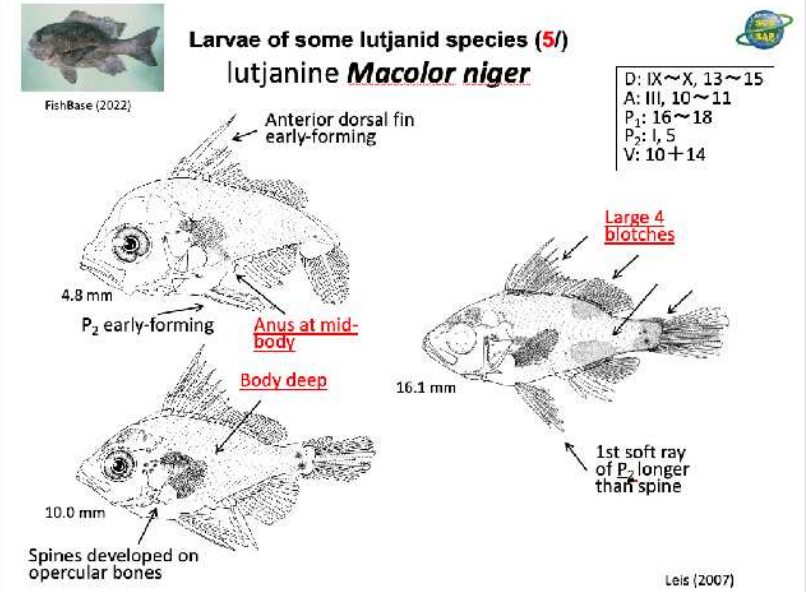
FishBase (2022)

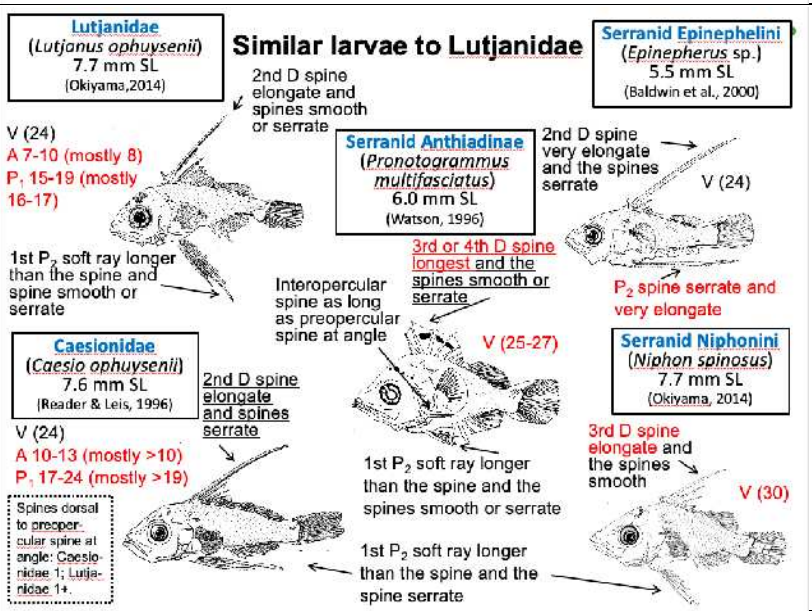
D: XIII, 13～14
A: III, 8
P_1: 17
P_2: I, 5
V: 10+14



Okiyama (2014)


L. malabaricus
FishBase (2022)
Larvae of some lutjanid species (4/)
lutjanine Lutjanus malabaricus
and/or L. erythropterus
L. malabaricus
D: XI, 13~14
A: III, 9
P1: 17 ~ 18
P2: I, 5
V: 10+14
Anterior dorsal fin early-forming
3.3 mm
Anus beyond mid-body
P2 early-forming
Dorsal-fin spines serrate
Upper margin of spinous dorsal-fin membrane dark
5.4 mm
Anal- and P2-fin spines serrate
Spines developed well on opercular bones
Body deep
11.5 mm
Large blotch present
16.3 mm
Small spine occurs on postcleithrum
1st soft ray of P2 longer than spine
Leis and Rennis (2000)


FishBase (2022)
Larvae of some lutjanid species (5/)
lutjanine Macolor niger
D: IX~X, 13~15
A: III, 10~11
P1: 16~18
P2: I, 5
V: 10+14
Anterior dorsal fin early-forming
4.8 mm
P2 early-forming
Anus at mid-body
Body deep
10.0 mm
Spines developed on opercular bones
Large 4 blotches
16.1 mm
1st soft ray of P2 longer than spine
Leis (2007)


Lutjanidae
(Lutjanus ophuysenii)
7.7 mm SL
(Okiyama,2014)
Similar larvae to Lutjanidae
Serranid Epinephelini
(Epinepherus sp.)
5.5 mm SL
(Baldwin et al., 2000)
2nd D spine elongate and spines smooth or serrate
V (24)
A 7-10 (mostly 8)
P1 15-19 (mostly 16-17)
1st P2 soft ray longer than the spine and spine smooth or serrate
Serranid Anthiadinae
(Pronotogrammus multifasciatus)
6.0 mm SL
(Watson, 1996)
2nd D spine very elongate and the spines serrate
V (24)
3rd or 4th D spine longest and the spines smooth or serrate
P2 spine serrate and very elongate
Interopercular spine as long as preopercular spine at angle
V (25-27)
Caesionidae
(Caesio ophuysenii)
7.6 mm SL
(Reader & Leis, 1996)
2nd D spine elongate and spines serrate
V (24)
A 10-13 (mostly >10)
P1 17-24 (mostly >19)
Spines dorsal to preopercular spine at angle: Caesionidae 1; Lutjanidae 1+.
1st P2 soft ray longer than the spine and the spines smooth or serrate
1st P2 soft ray longer than the spine and the spine serrate
Serranid Niphonini
(Niphon spinosus)
7.7 mm SL
(Okiyama, 2014)
3rd D spine elongate and the spines smooth
V (30)

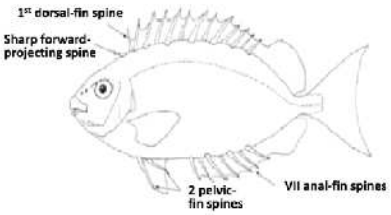
Siganidae (Rabbitfishes)

Adults

Reference:

Woodland, D.J. (2001). Siganidae. Pages 3627-3650. *In* Carpenter, K. E. and V. H. Niem eds. The living marine resources of the Western Central Pacific. FAO species identification guide for fishery purposes. FAO, Rome.

Diagnostic characters of the Siganidae fishes



- Body laterally compressed, oval, deep or slender.
- Mouth terminal, very small.
- D XIII, 10; A VII, 9; P2 II (1 strong inner and 1 outer spine), 3 (in between).
- Membrane extends from inner spines to belly and anus lines between these membranes.

Habitat, and biology

- About bottom in shallow coastal waters to a depth of 50 m.
- Some species live in pairs among corals, others in schools around rock and coral reefs, mangroves, estuaries, and brackish lagoons.
- Some move with tides to feed in flooding areas of rock and coral reefs.
- Spawning in schooling species is by pairing from massed congregations at certain phases of the moon.
- Eggs adhesive.

Dominant species of siganid *Siganus* in the region

Photos: FishBase


Siganus argenteus


Siganus fuscescens


Siganus spinus


Siganus canaliculatus


Siganus guttatus


Siganus virgatus


Siganus corallinus


Siganus javus


Siganus vulpinus

Distributions of 18 siganid *Siganus* species in the Southeast Asian region

Species	Distribution			Species	Distribution		
	SCS	AND	eIND		SCS	AND	eIND
Siganus argenteus	○	○	○	*Siganus puellus*	△		○
S. canaliculatus	○	○	○	*S. punctatissimus*	△		
S. corallinus	○	○	○	*S. punctatus*	○		○
S. doliatus			○	*S. spinus*	○	○	○
S. fuscescens	○	○	○	*S. stellatus*		○	
S. guttatus	○	○	○	*S. unimaculatus*	△		
S. javus	○	○	○	*S. vermiculatus*	○	○	○
S.labyrinthodes			○	*S. virgatus*	○	○	○
S. lineatus	△			*S. vulpinus*	○		○

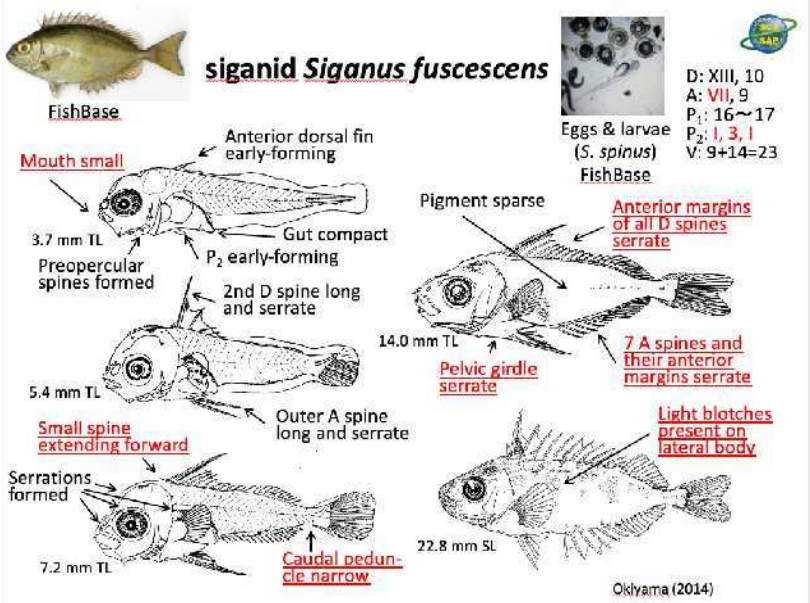
SCS: South China Sea (including Sulu Sea & Sulawesi Sea; AND: Andaman Sea; eIND: Eastern Indonesia.
△: only Sulu and/or Sulawesi Seas
All species have: D XIII, 10; A VII, 9; P_2 I, 3, I; C 9+8; V 23.

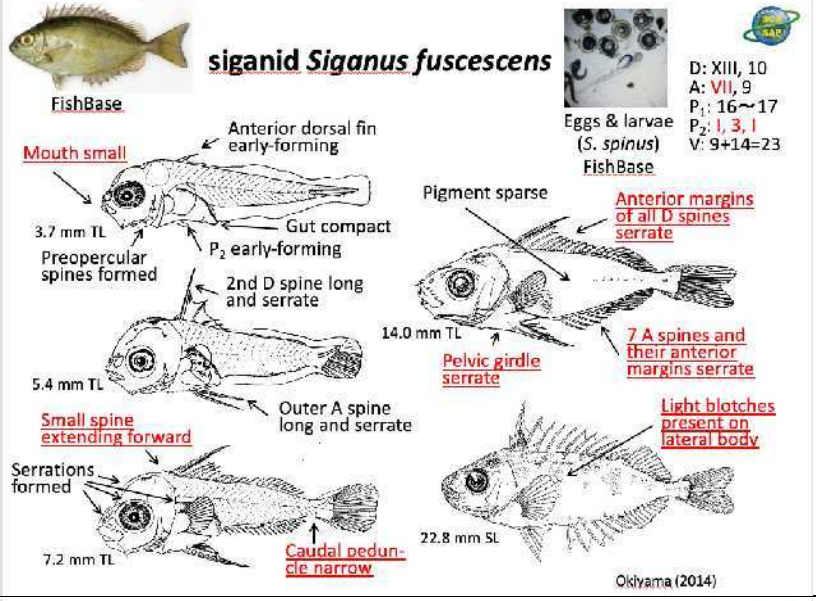
Larvae

References

Leis, J. M. and D. S. Rennis (2000). Siganidae (Rabbitfishes). Pages 671-675. *in:* Leis, J. M. and B. M. Carson-Ewart. (eds.) The larvae of Indo-Pacific coastal fishes. An identification guide to marine fish larvae. Brill, Leiden.

Okiyama, M. ed. (2014). Siganidae. Pages 1342-1345. *In* An atlas of early a stage fishes in Japan. Second edition. Tokai University Press, Hatano.





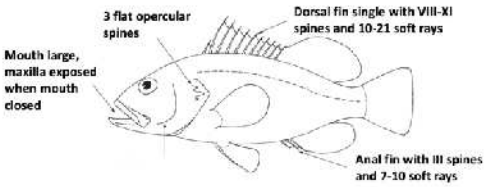
serranid
Epinephelini
(Groupers)

Adults

Reference:

Heemstra, P.C. and J.E. Randall. (1999). Serranidae. Pages 2442-2548. *In* Carpenter, K. E. and V. H. Niem eds. The living marine resources of the Western Central Pacific. FAO species identification guide for fishery purposes. FAO, Rome.

Diagnostic characters of the Epinephelini fishes



Habitat, and Biology

- Serranids are benthic or bottom-oriented fishes, usually found on coral reefs or rocky substrata.
- They first mature as females and, after spawning one or more times.
- They will then change sex, spawning thereafter as males.
- Some groupers form large aggregations at specific sites at the time of spawning.
- Except for occasional spawning aggregations, most groupers are solitary fishes.
- They are generally resident on a particular reef for a long time (often years).
- This site specificity and the relatively slow growth rate of groupers make them particularly vulnerable to over-fishing.

Life Cycles

Spawning Aggregations

Florida States University: https://marinelab.fsu.edu/labs/coleman/research/grouper-ecology/

Representative species of epinephelin genera in the region

Aethaloperca rogaa

Cromileptes altivelis

Plectropomus leopardus

Anyperodon leucogrammicus

Epinephelus malabaricus

Variola albimarginata

Cephalopholis argus

Gracila albomarginata

Photos: FishBase

Nice genera of Tribe Epinephenini in the Southeast Asian region

Genus	D	A	P_1	P_2	C	V
Aethaloperca (1)	IX, 16-18	III, 8-9	17-18	I, 5	9+8	10+14=24
Anyperodon (1)	XI, 14-16	III, 8-9	15-17	I, 5	9+8	10+14=24
Cephalopholis (15)	IX, 13-17	III, 7-10	15-20	I, 5	9+8	10+14=24
Cromileptes (1)	X, 17-19	III, 9-10	17-18	I, 5	9+8	10+14=24
Epinephelus (53)	XI, 12-19	III, 7-10	15-20	I, 5	9+8	10+14=24
Gracila (1)	VIII-IX, 14-16	III, 9-10	18-19	I, 5	9+8	10+14=24
Plectropomus (6)	VIII, 10-12	III, 8	14-18	I, 5	9+8	10+14=24
Triso (1)	XI, 18-21	III, 9-10	18-20	I, 5	9+8	10+14=24
Variola (2)	IX, 13-15	III, 8	16-19	I, 5	9+8	10+14=24

- Numerals in parenthesis: number of species (9 genera with 81 species in the region).
- Meristic data: Indo-Pacific lutjanid fishes by Leis and Rennis (2000).

Key to the genera of Epinephelini occurring in the area (9 genera and 81 species) * 1/5

12a. Dorsal-fin spines VII or VIII; lower edge of preopercle with 1 to 3 enlarged spines (usually hidden by skin, but these spines can be detected by running a finger or probe along preopercle edge) . . . . . → *13*

12b. Dorsal-fin spines IX to XI; lower edge of preopercle smooth (except for a few species of *Epinephelus* with 1 to 4 enlarged serrae) . . . . . → *14*

13a. Anal-fin spines strong, all 3 distinct; preorbital depth 1/2 or less of eye diameter; head length 2.5 to 2.6 times in standard length (Fig. 3) . . . . . *Saloptia powelli*

13b. Anal-fin spines weak, the first and second covered by skin; preorbital depth 0.7 to 2 times eye diameter; head length 2.8 to 3.1 times in standard length (Fig. 4) . . . . . *Plectropomus*

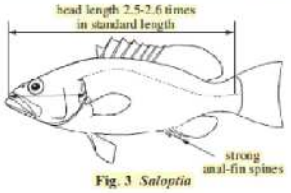


Fig. 3 *Saloptia*

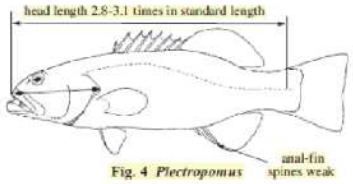


Fig. 4 *Plectropomus*

* *Aethaloperca* (1 species); *Anyperodon* (1); *Cephalopholis* (15); *Cromileptes* (1); *Epinephelus* (53); *Gracila* (1); *Plectropomus* (6); *Triso* (1); *Variola* (2)

Key to the genera of Epinephelini occurring in the area (9 genera and 81 species) 2/5

14a. Caudal fin deeply lunate or forked; dorsal-fin spines IX (Fig. 5) . . . . . *Variola*

14b. Caudal fin rounded, truncate, or concave; dorsal-fin spines IX to XI . . . . . → *15*

15a. No teeth on palatines; body and head elongate and markedly compressed, the greatest body width 11 to 15% of standard length and more than 3 times in head length (Fig. 6) . . . . . *Anyperodon leucogrammicus*

15b. Palatines with teeth; body compressed in some species, but its width only 1.8 to 3 times in head length . . . . . → *16*

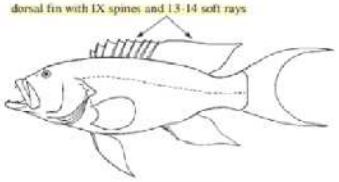


Fig. 5 *Variola*

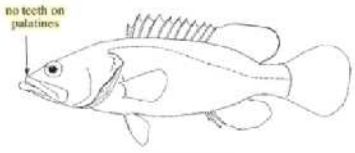


Fig. 6 *Anyperodon*

Key to the genera of Epinephelini occurring in the area
(9 genera and 81 species) 3/5

16a. Dorsal profile of head markedly concave; dorsal-fin spines X; rear nostrils of adults a long vertical slit (Fig. 7). . . . . *Cromileptes altivelis*

16b. Dorsal profile of head straight, convex or slightly concave; dorsal-fin spines IX or XI (rarely X); rear nostrils round or oblong . . . . . → *17*

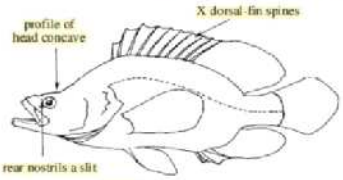


Fig. 7 *Cromileptes*

17a. Pectoral fins distinctly asymmetric, the fifth or sixth rays longest (Fig. 8a); dorsal fin with IX spines and 17 or 18 soft rays; caudal fin truncate (Fig. 9) . . . . . *Aethaloperca rogaa*

17b. Pectoral fins symmetric or nearly so, the middle rays longest (Fig. 8b); dorsal fin with IX to XI spines and 12 to 21 soft rays; caudal fin rounded, truncate, or emarginate . . . . . → *18*

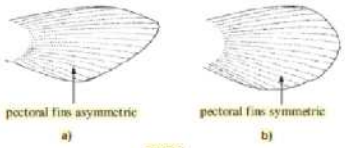


Fig. 8

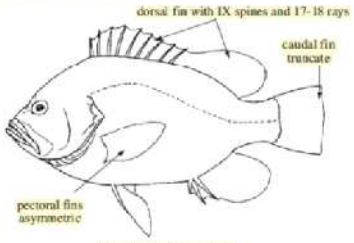


Fig. 9 *Aethaloperca*

18a. Dorsal-fin spines IX . . . . . → *19*

18b. Dorsal-fin spines XI . . . . . → *20*

Key to the genera of Epinephelini occurring in the area
(9 genera and 81 species) 4/5

19a. Caudal fin truncate; head small, 2.9 to 3.2 times in standard length; distal part of maxilla with step or hook-like process on lower edge (hidden by lip); dorsal-fin membranes not incised between spines (Fig. 10) . . . . . *Gracila albomarginata*

19b. Caudal fin rounded (truncate in *Cephalopholis polleni*); head length 2.2 to 3.1 times in standard length; adults with a knob at lower rear corner of maxilla (hidden by upper lip); dorsal-fin membranes distinctly incised between spines (Fig. 11). . . . . *Cephalopholis*

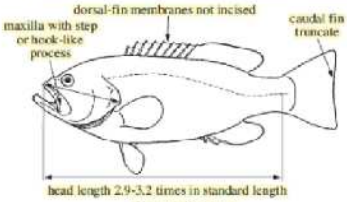


Fig. 10 *Gracila*

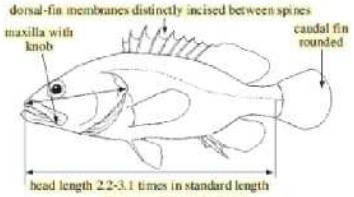


Fig. 11 *Cephalopholis*

Key to the genera of Epinephelini occurring in the area
(9 genera and 81 species) 5/5

20a. Body depth distinctly greater than head length and 2.4 to 2.7 times in standard length; dorsal fin with XI spines and 18 to 21 soft rays, the base of soft-rayed part longer than that of spinous part (Fig. 12) . . . . . *Triso dermopterus*

20b. Body depth 2.4 to 4.1 times in standard length, usually less than head length; dorsal fin with XI spines and 12 to 19 soft rays, the base of soft-rayed part shorter than or equal to that of spinous part (Fig. 13) . . . . . *Epinephelus*


Fig. 12 *Triso*

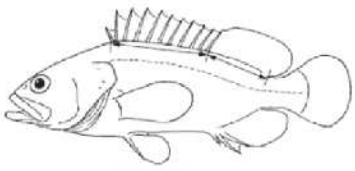
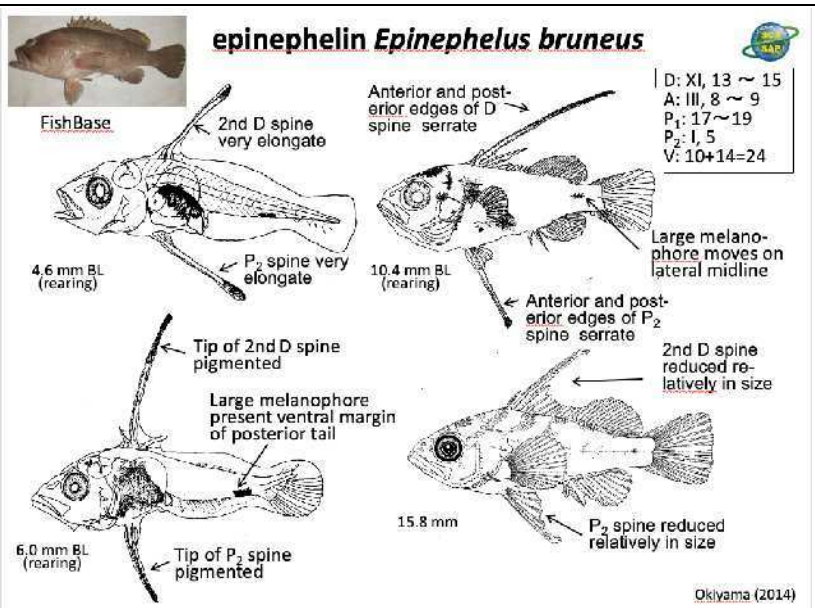
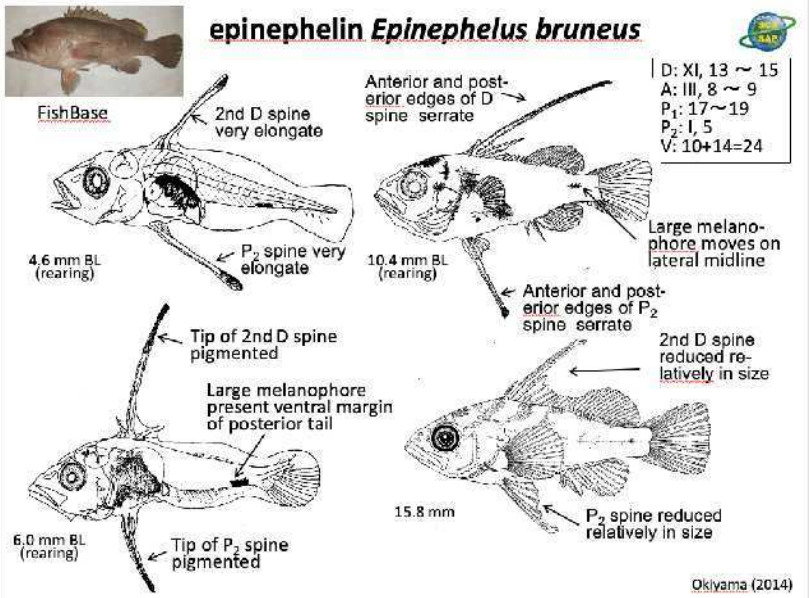
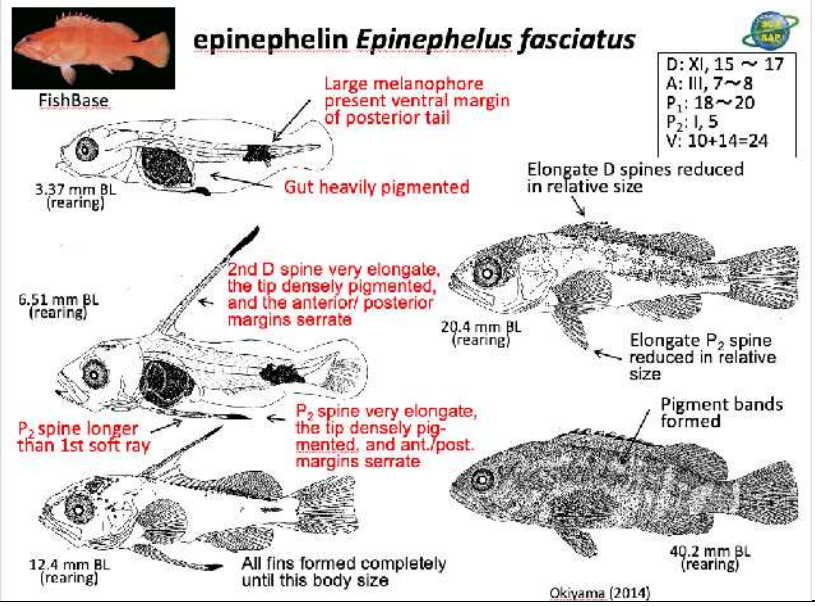
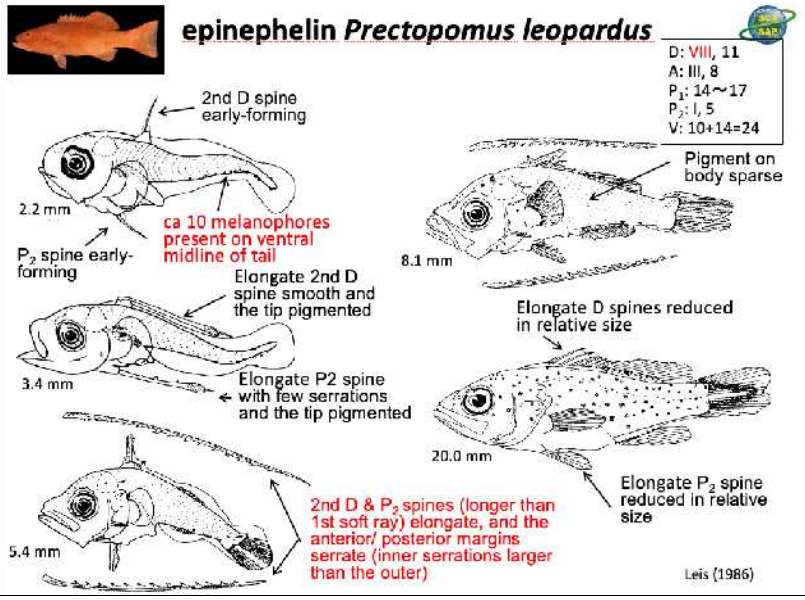


Fig. 13 *Epinephelus*


epinephelin Epinephelus bruneus
FishBase
2nd D spine very elongate
P2 spine very elongate
4.6 mm BL (rearing)
Anterior and post-erior edges of D spine serrate
Large melano-phore moves on lateral midline
10.4 mm BL (rearing)
Anterior and post-erior edges of P2 spine serrate
2nd D spine reduced re-latively in size
15.8 mm
P2 spine reduced relatively in size
Tip of 2nd D spine pigmented
Large melanophore present ventral margin of posterior tail
6.0 mm BL (rearing)
Tip of P2 spine pigmented
D: XI, 13 ~ 15
A: III, 8 ~ 9
P1: 17~19
P2: I, 5
V: 10+14=24
Okiyama (2014)


epinephelin Epinephelus bruneus
FishBase
2nd D spine very elongate
P2 spine very elongate
4.6 mm BL (rearing)
Anterior and post-erior edges of D spine serrate
Large melano-phore moves on lateral midline
10.4 mm BL (rearing)
Anterior and post-erior edges of P2 spine serrate
2nd D spine reduced re-latively in size
15.8 mm
P2 spine reduced relatively in size
Tip of 2nd D spine pigmented
Large melanophore present ventral margin of posterior tail
6.0 mm BL (rearing)
Tip of P2 spine pigmented
D: XI, 13 ~ 15
A: III, 8 ~ 9
P1: 17~19
P2: I, 5
V: 10+14=24
Okiyama (2014)


epinephelin Epinephelus fasciatus
FishBase
Large melanophore present ventral margin of posterior tail
3.37 mm BL (rearing)
Gut heavily pigmented
Elongate D spines reduced in relative size
2nd D spine very elongate, the tip densely pigmented, and the anterior/ posterior margins serrate
6.51 mm BL (rearing)
20.4 mm BL (rearing)
Elongate P2 spine reduced in relative size
P2 spine longer than 1st soft ray
P2 spine very elongate, the tip densely pig-mented, and ant./post. margins serrate
Pigment bands formed
12.4 mm BL (rearing)
All fins formed completely until this body size
40.2 mm BL (rearing)
D: XI, 15 ~ 17
A: III, 7~8
P1: 18~20
P2: I, 5
V: 10+14=24
Okiyama (2014)



NOTES:

As long as a large number of the lutjanid, siganid and epinepheline larvae are unknown, even if the examining larvae are morpho-logically similar to known species larvae, it is risky to identify them as the species.