AQUATIC SCIENCE COLLOQIUM 2016

(AQUAColl2016)

Monograph

Experience Sharing in Aquatic Science Research 4

Malaysia Exclusive Economic Zone (EEZ) Cruise and Other Aquatic Science Research

Fisheries Research Institute, Bintawa, Sarawak,
Department of Fisheries Malaysia &
Department of Aquatic Science,
Faculty of Resource Science and Technology ,
Universiti Malaysia Sarawak.

UNIMAS
UNIVERSITI MALAYSIA SARAWAK

Jabatan Perikanan Malaysia

MONOGRAPH

AQUATIC SCIENCE COLLOQUIUM 2016 (AQUAColl 2016)

Experiences Sharing in Aquatic Science Research IV:

Malaysia Exclusive Economic Zone (EEZ) Cruise and other Aquatic Science Research

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Published in Malaysia by
Department of Aquatic Science,
Faculty of Resource Science and Technology,
UNIVERSITI MALAYSIA SARAWAK
94300 Kota Samarahan, Sarawak, Malaysia

Printed in Malaysia by
Lee Ming Press Sdn Bhd (541980-U)
No. 48, Jalan Ellis
93300, Kuching, Sarawak, Malaysia

Cover Designer: Samsur Mohamad

Perpustakaan Negara Malaysia Cataloguing-in-Publication Data

ISBN

Samsur, M., Shabdin, M.L., Nyanti, L., Khairul Adha, A.R., Hadil, R. and Mobilik, J.M. 2016. *Aquatic Science Colloquium 2016: Experiences Sharing in Aquatic Science Research IV: Malaysia Exclusive Economic Zone (EEZ) Cruise and other Aquatic Science Research.* Monograph, Department of Aquatic Science, Universiti Malaysia Sarawak, Kota Samarahan, Sarawak, Malaysia.

Message

THE DIRECTOR GENERAL, DEPARTMENT OF FISHERIES MALAYSIA

Assalamu'alaikum Warahmatullahi Wabarakatuh and Salam Sejahtera,

Firstly, I would like to extend my sincere appreciation to the organizing committee in organizing the Aquatic Science Colloquium 2016 (AQUAColl2016). The colloquium theme, "Exclusive Economic Zone (EEZ) Cruise and Other Aquatic Science Research" brings together scientists in the various fields from the Department of Aquatic Science, Faculty of Resource Science and Technology (FRST), University of Malaysia Sarawak (UNIMAS) and Fisheries Research Institute (FRI) Bintawa, Department of Fisheries Malaysia.

The Fisheries Research Institute (FRI) had been allocated a special fund (2014-2015) from the Economic Planning Unit, Prime Minister Office of Malaysia to carry out the National Fisheries Resource Survey in Malaysia waters utilizing the SEAFDEC research and training vessel MV SEAFDEC 2, and the Department Research Vessel, KL CERMIN.

The overall objective of the survey is to provide updated scientific findings on the status of fisheries resources and marine ecology in Malaysia waters.
The collaboration between UNIMAS and FRI Bintawa focused mainly the waters of Sarawak, Sabah and Federal Territory of Labuan. We hope the colloquium will enable participants to share their knowledge and strengthen their networking.

I sincerely hope that the colloquium will not only be the platform for researchers to present their findings but also to establish the resolution plan for the sustainable development of the fisheries resources in South China Sea.

Lastly, I also hope that the research outcomes can be a useful tools in providing informations to the public and industry.

Thank you.

(**DATUK HJ. ISMAIL BIN ABU HASSAN**)
Director-General of Fisheries Malaysia
Department of Fisheries Malaysia,
PUTRAJAYA

Message

DEAN, FACULTY OF RESOURCE SCIENCE AND TECHNOLOGY, UNIMAS

Assalamu'alaikum Warahmatullahi Wabarakatuh and Salam Sejahtera,

I would like to take this opportunity to congratulate the organising committees, FRI (Bintawa) as a co-organiser and all members of the Department of Aquatic Science for successfully organised the fourth series of Aquatic Science Colloquium 2016 (AQUAColl 2016).

I am very glad indeed to support such an important academic event where students, lecturers and researchers from other agencies can share their knowledge and research findings. The product of AQUAColl 2016 is the publication of approximately 17 selected research papers in the fourth monograph that focus specifically on the finding of the National Demersal Fish Resource Survey in the Malaysian Coastal and Exclusive Economic Zone (EEZ) waters of Sarawak, Sabah and Federal Territory of Labuan in 2014 and 2015 on board of M.V. SEAFDEC2. These scientific data may provide important information for future fisheries and oceanographic survey of these areas.

In line with our vision and mission, the faculty always supports any knowledge and research sharing activities as well as encouraging research collaboration with other researchers from both government and private agencies. We do believe that the consolidation of expertise in the field of aquatic science from all research institutions will enable us to explore and manage our natural aquatic resources more effectively.

I believed that the Colloquium was an excellent platform for our young and enthusiastic researchers to motivate, facilitate and develop themselves as a productive and quality researcher. To other participants, I hope the meeting provided a golden opportunity to enhance and strengthen research collaboration between the university and other agencies.

I would like to thank all AQUAColl 2016 participants for their contribution in making the meeting a success. My appreciation and thanks also goes to co-organiser who have funded, and to all researchers who have contributed research findings for the fourth monograph. I hope the monograph will be a major source of reference for future research activities in the Sarawak, Sabah and Federal Territory of Labuan.

(**ASSOCIATE PROF. DR OTHMAN BIN BOJO**)
Dean, Faculty of Resource Science and Technology,
Universiti Malaysia Sarawak, SARAWAK

Message

Coordinator, National Demersal Fish Resource Survey in the Malaysian Coastal and EEZ Waters of Sarawak, Sabah and Federal Territory of Labuan

Salam Sejahtera,

It gives me great pleasure to welcome all quests and participants to the **Aquatic Science Colloquium 2016 (AQUAColl 2016)** which is jointly organized by the Department of Aquatic Science, Faculty of Resource Science and Technology (FRST), University Malaysia Sarawak (UNIMAS) and Fisheries Research Institute (FRI) Bintawa, Sarawak, Department of Fisheries Malaysia.

The Department of Fisheries Malaysia through FRI Bintawa, had successfully conducted National Demersal Fish Resource Survey in the Malaysian coastal and Exclusive Economic Zone (EEZ) waters of Sarawak, Sabah and Federal Territory of Labuan in 2014 and 2015. FRI Bintawa is fortunate to have UNIMAS, University of Malaya (UM) and University Malaysia Sabah (UMS) as collaborators in implementing research in the field of aquatic science such as benthos, gastropods, bivalves, physicochemical characteristics, plankton and hydrocarbons during the survey. I indeed appreciate and thanks the scientists and researchers for their expertise in conducting the studies and finally produce scientific publications. The results of the studies is of great importance to FRI Bintawa because that will support and complement the findings on current status of the demersal fish resource stock in Sarawak, Sabah and FT Labuan waters obtained during the survey.

It is timely that this colloquium was held because it links aquatic parameters to the status of the demersal fish stock assessment in the waters of Sarawak, Sabah and FT Labuan. I hope that all participants of AQUAColl 2016 experience a productive and positive colloquium as it features about 20 technical papers oral presentation and 26 posters. It is also the best forum for researchers, academicians and students to exchange findings and to establish effective scientific networking among them.

I wish to congratulate and thanks AQUAColl 2016 organising committee for working tirelessly in gathering participants and excellent contribution to make this event a great success.

Thank you and best wishes to all participant.

(**RICHARD RUMPET**)
Fisheries Research Institute, Bintawa, Sarawak
Department of Fisheries Malaysia

Message

Chairperson, Aquatic Science Colloquium 2016 (AQUAColl 2016)

Assalamu'alaikum Warahmatullahi Wabarakatuh and Salam Sejahtera,

Aquatic Science Colloquium 2016 (*AQUAColl 2016*) is a biennial event, organised by the Department of Aquatic Science, FRST, and this is its 4th series. We are very honoured to have Fisheries Research Institute Bintawa (FRIB) as our co-organizer, in conjunction with the research activities carried out during the National Demersal Fish Resource Survey in the Malaysian Coastal and EEZ waters of Sarawak, Sabah and Federal Territory of Labuan in 2014 and 2015. This exercise had become a platform for human capacity building as training on board of MV SEAFDEC 2 had benefited staffs and students alike, as well as opportunity to collect samples used for various programmes (PhD, MSc and undergraduate). Approximately 35 staffs and graduate students from UNIMAS had worked on rotations to be on board and became land crews during leg 3 to leg 8 of the cruise (August to October 2015), thus this exercise fostered strong team work as well as blossomed volunteerism and philanthropy spirits.

After three long months of EEZ cruise, approximately twelve months of laboratory and data analysis work followed by six months of writing and answering irritating comments from reviewers, it is hoped that findings published in the *AQUAColl 2016* Monograph will help relevant agencies to make informed decisions on how to further manage and exploit EEZ areas and resources.

I wish to congratulate the organising committee for their excellent efforts in making *AQUAColl 2016* gathering fruitful and meaningful, not only for the researchers and managers but also the public. On behalf of the organizing committee, I would like to thank: (i) UNIMAS for logistics arrangement during this colloquium and small fund to kick start this colloquium and (ii) FRIB for generously sponsor the printing of *AQUAColl 2016* Monograph which will be distributed in December 2016.

Thank you.

(**ASSOCIATE PROF. DR RUHANA BINTI HASSAN**)
Chairperson, AQUAColl 2016

Contents

Research Notes on Incidental Sea Stars Catch during Malaysia EEZ off Sarawak Survey Cruise 2015

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Abstract

*This study was carried out to document starfish which had been collected as by-catch invertebrates during Malaysian EEZ off Sarawak survey cruise in September 2015. Sea star samples comprised three families namely F. Ophidiasteridae (*Linckia guildingi*), F. Oreasteridae (*Pentaceraster *sp.,* Halityle regularis*,* Anthenea *sp.,* Pentaceraster cumingi*,* Anthenea pentagonula*) and F. Zoroasteridae (*Zoroaster *sp.) were identified based on morphological characters. Stomach content analysis recorded the existence of benthic foraminiferans (the most common item found), fragments of crustaceans, sponges, corals, gastropods, bivalves, diatoms and sediments. Preliminary study on the gonad condition found that* L. guildingi, P. cumingi, H. regularis, Anthenea *sp. had filled gonad whereas the others were unfilled. This baseline data hopefully could encourage research related to tropical deep sea stars in the near future.*

Keywords: sea star, Malaysian Exclusive Economic Zone (EEZ), species

Introduction

Sea star, locally known as 'tapak sulaiman', belongs to Class Asteroidea, Phylum Echinodermata. Members of Family Asteroidea are characterized by radial symmetry in adults, bilateral in larvae, three germ layers, ciliated organ, and no segmentation in either adults or larvae (Storer *et al.*, 1979). The body surface has five symmetrical ambulacra, covered by epidermis over mesodermal endoskeleton of movable or fixed calcareous plates, usually with spines. There is no head and body arrangement in oral-aboral axis. Similarly, no excretory system could be found. In addition, the members also have large coelom lined with ciliated peritoneum and divided during development that give rise to water vascular system, with multipurpose podia and a complex hemal system. Respiration is by papulae extended from the coelom. Nervous system consist three rings at the center of mouth, branching along the arms. They have separate sexes, the external

morphology is similar, large gonads, bilateral larvae that are microscopic, ciliated, transparent and free-living with visible metamorphosis.

Echinoderms have been used as environmental indicator, for example the presence of ophiurids or echinoids can either indicate a healthy reef or a degraded environment, respectively (Maharavo, 2013). Asteroids are organisms of interest to organic chemists, biochemists and pharmacologists due to the presence of potential source of bioactive (Thao *et al.*, 2015). Several secondary metabolites had been found in starfish such steroids, steroidal glycosides, anthraquinones, alkaloids, phospholipids, peptides and fatty acids (Dong *et al.,* 2011). Starfish along with other marine invertebrates are targeted species for aquarium trade around the world and some are sold as souvenirs (Lunn and Moreau, 2004; Shuman *et al.*, 2005; Bos *et al.*, 2008).

Documentations on Asteroidea around reef areas are available from South China Sea (Wood and Aw, 2002), Archipelago of Beting Patinggi Ali to Pulau Layang-Layang, South China Sea (Kwang et al. 2008), Pulau Sipadan and Bodgaya (George and George, 1987), seagrass area of southern Peninsular Malaysia (Woo et al. 2014), while in Singapore by VangenSpiegel *et al.* (1998).

This paper aims to provide species lists, preliminary data on gut content analysis and gonad condition of the sea stars that were incidentally caught in the trawl nets during Malaysian EEZ off Sarawak resource survey cruise 2015.

Materials and Methods

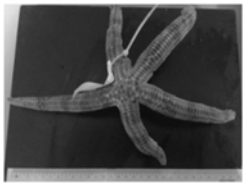
The sea star samples were collected from EEZ during Malaysian EEZ off Sarawak resource survey cruise 2015 (Leg 3 to Leg 8, from September to October 2015), labelled and stored in -20°C. Morphometric and meristic characters examinations were carried out in the Aquatic Science Department laboratories following Blake (1987) and Klenk (2015). Morphological features of the samples were observed by the naked eye (aboral and oral view) followed by inspection on abactinal (aboral), actinal (oral) and terminals (arm tips). Detail observations were done with aid of Olympus SZ 51 stereo microscope. Characters examined include general body appearance, encrusting ossicles, pedicellariae, madereporite, abactinals, terminals, marginals, intermarginals, actinals, oral frame, ambulacrals and adambulacrals, papulae, tube feet, digestive tract and its development. Photographs were captured using digital camera. Stomach contents were examined following Jangoux (1982). The status of gonad condition was examined following Moran *et al.* (2013) and Baeta *et al.* (2015).

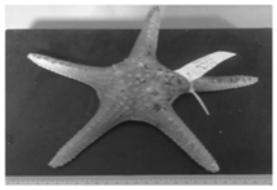
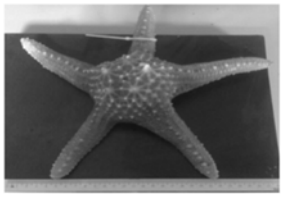
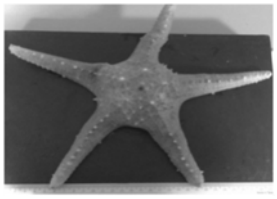
Results and Discussion

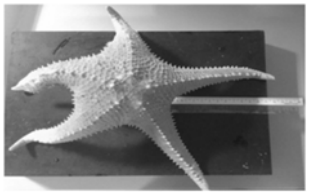
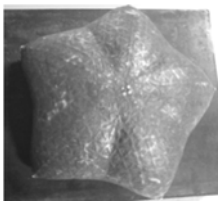
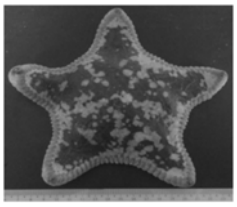
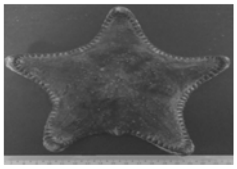
Table 1 shows the sea star samples that had been collected during this study which belonged to three families, namely Family Ophidiasteridae (*Linckia guildingi*), Family Zoroasteridae (*Zoroaster* sp.) and Family Oreasteridae (*Pentaceraster cumingi*, *Pentaceraster* spp., *Halityle regularis*, *Anthenea pentagonula*, *Anthenea*

sp.). Woo et al. (2014) reported five species of asteroids from four families and two orders were found in the Merambong Shoal seagrass bed, at the southern part of Peninsular Malaysia. For reef areas in the Archipelago of Beting Patinggi Ali to Pulau Layang-Layang, South China Sea, Kwang et al. (2008) had reported 6 families, 12 genera and 20 species of sea stars. The difference in number of taxa recorded is most likely due to striking differences in terms of location, depth and substratum as well as sample collections methods.

Table 1: Sea stars that were incidentally caught in the trawl net during Malaysian EEZ off Sarawak resource survey cruise 2015.

No.	Family / Species Name	Brief description	Location - Habitat
1.	Family Ophidiasteridae *Linckia guildingi*	 COLOUR: Light brown with dark banding R = 180mm, r = 32mm, R/r = 5.6/1	N 03°49'21" E 112°48'65" Depth: 47m Bottom type: mixture of sand and mud
2.	Family Zoroasteridae *Zoroaster* sp.	 COLOUR: Beige with cream coloured tubercles R = 159mm, r = 48mm, R/r = 3.3/1	N 03°42'86" E 112° 26'58" Depth: 48m Bottom type: information not available

3.	Family Oreasteridae *Pentaceraster cumingi*	 COLOUR: Pale brown with red tubercles and markings R = 178mm, r = 89mm, R/r = 2/1	N 03°57'50" E 112°15'53" Depth: 50 m Bottom type: information not available
	Pentaceraster sp.1	 COLOUR: Beige with cream tubercles R = 142mm, r = 61mm, R/r = 2.3/1	N 03°23'27" E 112°20'25" Depth: 51-54 m Bottom type: information not available
	Pentaceraster sp.2	 COLOUR: Dark green body with red lining and cream coloured tubercles R = 161mm, r = 67mm, R/r = 2.4/1	N 03°37'42" E 112°06'06" Depth : 38 m Bottom type: coral and sand
	Pentaceraster sp.3	 COLOUR: Light red with yellowish green coloured tubercles R= 159mm, r = 70mm, R/r = 2	N 03°37'42" E 112°06'06" Depth: 38 m Bottom type: coral and sand

	Pentaceraster sp.4	 COLOUR: Orange body with cream coloured tubercles R = 195mm, r = 73mm, R/r = 2.7/1	N 03°37’55” E 112°50’59” Depth: 38 m Bottom type: sand and mud
	Halityle regularis	 COLOUR: Dark red with light red marking on abactinal surface and pale red with purple-blue plates near oral frame R = 134mm, r = 115mm, R/r = 1.2/1	N 03°11’55” E 111°55’84” Depth: 38 - 41 m, Bottom type: muddy
	Anthenea pentagonula	 COLOUR: Reddish with cream coloured patches on abactinal surface and pale colour on actinal surface R = 91mm, r = 54mm, R/r= 1.7/1	N 03°37’42” E 112°06’06” Depth: 38 m Bottom type: coral and sand
	Anthenea sp.	 Dark green on abactinal surface and pale cream actinal surface R = 88mm, r = 57mm, R/r = 1.5/1	N 03°37’42” E 112°06’06” Depth: 38 m Bottom type: coral and sand sandy bottom

Due to limited samples, stomach content of only one individual per species was examined, thus findings reported here are regarded as preliminary data (Table 2). All stomachs examined contained corals and sponge fragments, suggesting bottom of the sea where they were found most likely support coral reef assemblages. Other than that, common items found include fragments of other benthic organisms including crustaceans, bivalves and gastropods. Seventy percent of the species contained traces of sediment, reflecting their feeding style as mud ingester (Jangoux, 1982) while *A. pentagonula*, *Anthenea* sp. and *L. guildingi* had no sediment in their guts. During this study, *L. guildingi* and *A. pentagonula* guts only contained sponge fragments and spicules as well as crustaceans fragments. Eight out of ten species showed the presence of benthic foraminifera in the guts, which also support the notion that they were mud ingesters. The presence of juvenile asteroid arms was observed in the stomachs of *H. regularis* and *Anthenea* sp. suggesting that these two are most likely scavengers or predators in the marine food web.

Forty percent of starfish examined during this study had filled gonad (Table 3). The gonad of *P. cumingi* collected by Moran *et al.* (2013) was recorded to be filled in August, while the gonad of *P. cumingi* in this study, was recorded to be filled when it was collected in September. Publication made by Hess (1978) did not record the spawning time of *L. guildingi,* thus comparison could not be made with *L. guildingi* found in this study, which the gonad was observed to be filled in September. Up until April 2016, no publications were made regarding the spawning season of *Anthenea* sp. and *H. regularis*.

The gonad for *Pentaceraster* sp. 1, *Pentaceraster* sp. 2, *Pentaceraster* sp. 3, *Pentaceraster* sp. 4, *A. pentagonula* and *Zoroaster* sp. was unfilled when it was found in September. However, study done by Villalobos (2005) reported that the gonad of *Zoroaster fulgens* was observed to be filled in September. There is no published documentation yet regarding spawning season for *Pentaceraster* sp. and *A. pentagonula*. As comparison, Baeta *et al.* (2015) reported that *Astropecten aranciacus* in the northwestern Mediterranean most likely start spawning in March until July, which coincide with spring phytoplankton bloom and the increase in sea water temperature. Since this study is just a snapshot of the whole reproduction cycle of starfish in Sarawak EEZ, future work is needed to understand the whole picture of starfish reproduction in the tropical oceans.

Conclusion

This short study had recorded ten star fish taxa inhabiting Malaysian EEZ off Sarawak. Since this study only involved by-catch samples during the survey, the findings reported here may underestimate the actual sea star composition in the area. Filled gonads of four taxa indicated healthy breeding sea star population in EEZ area, whereas those with unfilled gonads may have different breeding season. Preliminary findings of stomach content analyses revealed diverse feeding behaviour of star fish suggesting its important ecological role in deep sea area of

Malaysian EEZ, an indication of healthy ecosystem. Sustainable management of EEZ is important to ensure the survival of the ecosystem as well as those depend on its rich resources.

Table 2: Feeding styles and stomach content in sea stars collected during the Malaysian EEZ off Sarawak resource survey 2015.

Species	Proposed feeding type	Stomach content
VALVATIDA **Ophidiasteridae** *Linckia guildingi*	S/P, IP	Crustacean fragments Sponge fragments Sponge spicule (clump)
Oreasteridae *Pentaceraster* sp.4	MI, IP, S/P	Benthic foraminifera Sponge fragments Crustacean fragments Spine? Sediment traces Diatoms
Pentaceraster sp.2	MI, IP, S/P	Crustacean fragments Sediment traces Benthic foraminifera Coral sclerites Sponge spicules Diatoms
Pentaceraster sp.3	MI, IP, S/P	Barnacle plates Benthic foraminifera Bivalve shells Gastropod shells Sediment traces Diatoms Sponge spicules Coral sclerites Spindle-type coral sclerites
Pentaceraster sp.1	MI, IP, S/P	Sponge spicules Crustacean fragments Sediment traces Benthic foraminiferans
Pentaceraster cumingi	MI, IP, S/P	Crustacean fragments Gastropod Benthic foraminifera Coral sclerites Juvenile bivalve Sediment traces
Halityle regularis	MI, IP, S/P	Sediment traces Benthic foraminifera Bivalve shells Crustaceans fragments Diatoms Coral sclerite Gastropods Sponge fragments worm Juvenile starfish arm
Anthenea sp.	S/P, IP	Coral sclerites Juvenile starfish arm Sponge fragments
Anthenea pentagonula	S/P	Sponge fragments
FORCIPULATIDA **Zoroasteridae** *Zooraster* sp.	MI, S/P, IP	Crustaceans fragments Sediment traces Sponge fragments Sponge spicule (clump)

*MI = mud ingester, S/P= scavenger / predator, IP = infaunal predator

Table 3: Gonad condition of sea stars that were incidentally caught in the trawl nets during Malaysian EEZ off Sarawak resource survey cruise 2015.

No.	Gonad condition (September 2015)	Species
1.	Gonad filled	*Pentaceraster cumingi* *Linckia guildingi* *Halityle regularis* *Anthenea* sp.
2.	Gonad unfilled	*Pentaceraster* sp. 1 *Pentaceraster* sp. 2 *Pentaceraster* sp. 3 *Pentaceraster* sp. 4 *Anthenea pentagonula* *Zoroaster* sp.

Acknowledgement

Authors would like to thank UNIMAS for land transportation and laboratories equipment, chemicals and consumables. Thank you to all members of Malaysian EEZ off Sarawak research cruise 2015 for sample collections and trawl log sheet data.

References

Baeta, M.; Galimany, E. and Ramón, M. (2015). Growth and reproductive biology of the sea star Astropecten aranciacus (Echinodermata, Asteroidea) on the continental shelf of the Catalan Sea (northwestern Mediterranean). *Helgoland Marine Research* 453 [Open acess] DOI: 10.1186/s10152-016-0453-z

Blake, D. B. (1987). A classification and phylogeny of post-Palaeozoic sea stars (Asteroidea: Echinodermata). *Journal of Natural History, 21,* 481-528.

Bos, A. R.; Alipoyo, J. C. E.; Cardona, L. T.; Gumanao, G. S. and Salac, F. N. (2008). Population Structure of Common Indo-Pacific Sea Stars in the Davao Gulf, Philippines. *Journal of Natural Sciences, 13,* 11-24.

Dong, G.; Xu, T.; Yang, B.; Lin, X.; Zhou, X.; Yang, X. and Liu, Y. (2011). Chemical constituents and bioactivities of starfish. *Chemistry Biodiversity, 8* (5)*,* 91-740.

Klenk, T. (2015). *The Starfish*. Retrieved December 10 2015, from http://faculty.valenciacollege.edu/tklenk/mbstuff/labs/PDFLABS/MB%20Lab%2011%20Starfish%20Lab.pdf

Lunn, K. E. and Moreau, M. A. (2004). Unmonitored trade in marine ornamental fishes: the case of Indonesia's Banggai cardinalfish (*Pterapogon kauderni*). *Coral Reefs, 23,* 344-351.

Maharavo, J. (2013). Echinoderms from the North –East Coast of Madagascar. In: D. Obura, G.D. Carlo, A. Rabearisoa and T. Oliver (Eds.). *A Rapid Marine*

Biodiversity Assessment of the Coral Reefs of Northeast Madagascar. (pp. 40-43). Virginia, USA: Conservation International.

Moran, A. L.; McAlister, J. S. and Whitehill, E. A. G. (2013). Eggs as Energy: Revisiting the Scaling of Egg Size and Energetic Content Among Echinoderms. *Biological Bulletin, 224,* 184-191.

George, J. D. and George, J. (1987). The coral reefs of the Bodgaya Islands (Sabah: Malaysia) and Pulau Sipadan. *Malayan Nature Journal, 27,* 225 – 258.

Hess, S. C. (1978). Key to identification. In: G. Voss (Ed.). *Guide to the commoner shallow-water asteroids (starfish) of Florida, the Gulf of Mexico and the Caribbean Region* (pp. 10-34). Miami, FL: Library of Congress.

Jangoux, M. (1982). Digestive system: Asteroidea. In: M. Jangoux and J.M. Lawrence (Eds.). *Echinoderms nutrition*. (pp. 72-235). Rotterdam: A.A. Balkema Publishers.

Kwang, S.Y., Tan, A, S-H., and Yasin, Z. (2008). The Diversity and Abundance of the Sea Stars (Echinodermata: Asteroidea) from Coral Reefs of the Central South China Sea. The NAGISA WESTPAC Congress: 25-36

Shuman, C. S.; Hodgson, G. and Ambrose, R. F. (2005). Population impacts of collecting sea anemones and anemone fish for the marine aquarium trade in the Philippines. *Coral Reefs, 24,* 564-573.

Storer, T. I.; Usinger, R. L.; Stebbins, R. C. and Nybakken, J. W. (1979). *General Zoology* (6th ed.). USA: McGraw-Hill, Inc.

Thao, N. P.; Luyen, B. T. T.; Koo, J. E.; Kim. S.; Koh, Y. S.; Cuong, N. X.; Nam, N. H.; Kiem, P. V.; Kim, Y. H. and Minh, C. V. (2015). Anti-inflammatory components of the Vietnamese starfish *Protoreaster nodous. Biological Research, 48,* 12.

VangenSpiegel, D.; Lane, D. J. W.; Stampanato, S. and Jangoux, M. (1998). The asteroid fauna (Echinodermata) of Singapore, with a distribution table and an illustrated identification to the species. *The Raffles Bulletin of Zoology, 48* (2), 431-470.

Villalobos, F. B. (2005). *Reproduction and larval biology of North Atlantic asteroids related to the invasion of the deep sea*. PhD. University of Southampton. Unpublished.

Woo, S.P, Ng, P.F.A, Mohd Razalli, N., Nilamani,N., Teh, C.P., Yasin, Z., Tan,S.H., Fujita, T. (2014). New records of sea stars (Echinodermata Asteroidea) from Malaysia with notes on their association with seagrass beds. *Biodiversity Journal*, 5 (4): 453–458

Wood, E. and Aw, M. (2002). *Reef Fishes, corals and invertebrates of the South China Sea: including Thailand, Hong Kong, China, Malaysia, Taiwan, Singapore, Indonesia and the Philippines*. London: New Holland Publisher Ltd.

Composition of Ichthyoplankton in Malaysia Exclusive Economic Zone (EEZ) of Sarawak waters

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Abstract

Ichthyoplankton refers to fish eggs and larvae which usually can be found near the surface of water. A survey was carried out in Malaysia EEZ of South China Sea from 19th August until 10th September 2015 in order to determine the composition of ichthyoplankton at three different depth stratums (20-50m, 51-100m and 101-200m). At each of the 20 stations covered, a double oblique plankton tow with mesh-size of 330 µm and 500 µm was performed for about 20 minutes at a towing speed of 2 to 3 knots. In this study, a total of 2,329 fish eggs and 3,006 fish larvae ascribed to 16 orders with 52 families were obtained. Gobiidae, Engraulidae and Scombridae were the top three dominant among 26 families of fish larvae found. These 26 families (20 were commercial fish families) showed a wide larval dispersal because they were collected at all depth. Unidentified larvae comprise 38.7 % of whole specimens collected in this study. The highest mean density (38.37 ± 24.07 larvae/100 m^3) of fish larvae was recorded at depth 20-50m, followed by 34.91 ± 16.97 larvae/100 m^3at depth 51-100m and 29.25 ± 14.12 larvae/100 m^3at depth 101-200m. This paper provides some baseline data of fish larvae at some parts of Malaysia EEZ off Sarawak and thus can help in providing latest information about ichthyoplankton diversity in Sarawak waters.

Keywords: ichthyoplankton, composition, Malaysia EEZ

Introduction

Ichthyoplankton comprise fish eggs and larvae which usually can be found near the surface waters and distributed in or just below the photic zone, 150-200m depth (Ahlstrom and Moser, 1976). The eggs are passive and drift in the ocean along with the water currents while most of the fish larvae have almost no swimming ability initially but they will swim better as they go through several stages of development (Moser and Watson, 2006). Generally, ichthyoplankton thrives in the habitat that naturally provides high abundance of food, low predation

pressure and stable ocean condition for growth (Freitas and Muelbert, 2004) such as muddy, coral, shoal and sandy habitat.

Exclusive Economic Zone (EEZ) refers to the extending area of 200 nautical miles from a country's coastline within which this country has the right to manage and control marine affairs and resources, such as fishing, mineral extraction and oil drilling. However, anthropogenic threats resulted in degradation of the marine environment can caused the declined in commercial fish catches such as Sardines from Clupeidae family (MacDiarmid *et al.,* 2012). Ichthyoplankton diversity will also be reduced due to the harmful effect from disposal of organic pollutant, nutrient and organic matter (Hutching, 2001). Therefore, the study on ichthyoplankton is important as the presence of fish larvae can reflect the health of marine environment where fish spawned and recruited (Chamchang and Chayakul, 2000). Ichthyoplankton study can be used in generating fishery-independent stock assessment for the management of local fisheries (Moser and Smith, 1993).

The composition of ichthyoplankton had been studied in many seas and oceans all over the world. However, the study on ichthyoplankton in Malaysia is still limited. Previous studies in Malaysia by Blaber *et al.,* (1997), Ara *et al.,* (2011) and Muhammad and Rahim (2014) focused on fish larvae of Johor, Sarawak and Sabah inshore waters. Limited studies were carried out in offshore waters off Sarawak by Jivaluk (1999), others search for Matahari expedition by Universiti Putra Malaysia (1986) and South China Sea expedition by National Oceanography Directorate, MOSTI (2009). This study was carried out to document the composition of ichthyoplankton at different depth in Malaysia EEZ off Sarawak sampled from 19th August until 10th September 2015.

Materials and Methods

Ichthyoplankton comprising fish larvae and fish eggs were sampled using a double plankton net with mesh-size of 330 µm and 500 µm. Samplings were performed at 20 stations (Figure 1) onboard M. V. SEAFDEC 2 research vessel. Details of each station are shown in Table 1. Depending on the depth of the station, samplings were carried out at three strata: 20-50 m (seven stations), 51-100 m (eight stations) and 101-200 m (five stations).

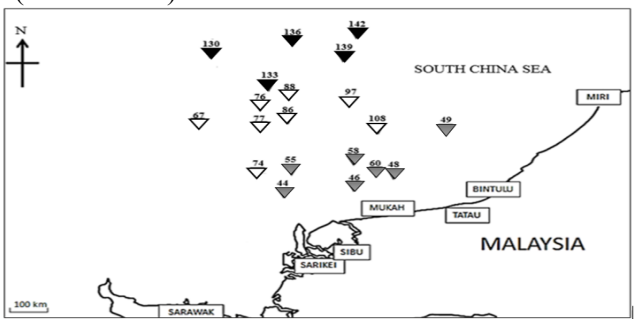

Figure 1. Location of 20 stations at Sarawak EEZ, South China Sea. (▽ = 20-50 m; ▽ = 51-100 m; ▼ = 101-200 m).

Table 1. Details of each station. Alphabets refer to the bottom descriptions. (M = Muddy; C = Coral; S = Sandy; Sh = Shoal; N/R = Not recorded).

Date (2015)	Coordinates	Station no.	Depth (m)	Max. towing depth (m)	Type of bottom
19 Aug	N 05° 37' 28" E 112° 07' 77"	142	175	90	M, S
20 Aug	N 05° 07' 51" E112° 02' 70"	139	113	80	C
21 Aug	N 04° 37' 54" E112° 07' 87"	97	84	58	M
22 Aug	N 04° 01' 95" E113° 02' 02"	49	45	35	S
22 Aug	N 04° 05' 43" E112° 36' 10"	108	59	35	M
23 Aug	N 03° 37' 28" E112° 50' 93"	48	34	30	S, M
26 Aug	N 03° 37' 62" E 112° 32' 45"	60	45	35	S, M
27 Aug	N 03° 57' 41" E 112° 11' 71"	58	50	35	N/R
28 Aug	N 04° 17' 28" E 111° 42' 78"	86	75	60	M, S, Sh
29 Aug	N 04° 47' 89" E 111° 40' 98"	88	95	80	M, S
30 Aug	N 05° 27' 54" E 111° 47' 83"	136	150	103	M, S
30 Aug	N 04° 57' 41" E 111° 22' 68"	133	105	80	M
1 Sep	N 03° 37' 62" E 111° 47' 90"	55	41	35	M, S
2 Sep	N 03° 15' 49" E 112° 12' 02"	46	27	20	M
6 Sep	N 05° 16' 29" E 110° 57' 37"	130	135	115	M, S
7 Sep	N 04° 12' 48" E 111° 12' 50''	76	92	80	M
8 Sep	N 04° 12' 48" E 110° 42' 80"	67	89	80	N/R
8 Sep	N 04° 09' 73" E 111° 16' 67"	77	69	65	N/R
9 Sep	N 03° 37' 11" E 111° 12' 34"	74	63	50	M, C
10 Sep	N 03° 08' 37" E 111° 38' 37"	44	30	20	M, Sh

At each station, the double plankton net was towed obliquely at a towing speed of 2-3 knots for about 20 minutes (10 minutes downward and 10 minutes upward). The 0.5 m diameter opening of each net was attached with a flow meter to measure the volume of water filtered during sampling. The samples obtained were immediately preserved in 10% buffered formalin diluted with seawater and brought back to laboratory for further identification processes.

The identification of the ichthyoplankton were done based on their morphological characteristics. Fish larvae and fish eggs were sorted according to their morphology and sizes using stereo microscope, *Motic SMZ-168*. The fish eggs were maintained in 10% buffered formalin while the larvae were put in 75% ethanol. The morphology of samples was documented using microscope digital camera (Moticam 352). Enumeration and identification of ichthyoplankton samples were performed up to family level based on the works of Jeyaseelan, 1998; Ré and Meneses, 2009. Larvae that could not be identified (including damaged specimens) were placed in unidentified category. The commercial families of fish larvae were checked using the guide book by Mansor *et al.,* 1998.

The density of ichthyoplankton samples were standardised and expressed as number of individual per 100 m^3 using the formula:

Density of ichthyoplankton (per 100 m^3):

$$\frac{\text{No. of individual x 100 } m^3}{\text{Volume of water filtered (100 } m^3)}$$

Results and Discussion

Composition of Ichthyoplankton

Figure 2 shows the percentage composition of ichthyoplankton sampled from 20 stations. In this study, Perciformes was the dominant order at 34.7 %, followed by Clupeiformes (7.9 %) while the other 14 orders were classified as others (18.4 %). However, the unidentified specimens comprised 38.7 % of whole specimens of fish larvae. The larvae under the order of Perciformes were usually from reef-associated fishes. According to Friedlander and Parrish (1998), habitat characteristics of a reef has a potential influence on fish assemblage structure because these fishes depend upon the coral reef for food and shelter (Sutton, 1985).

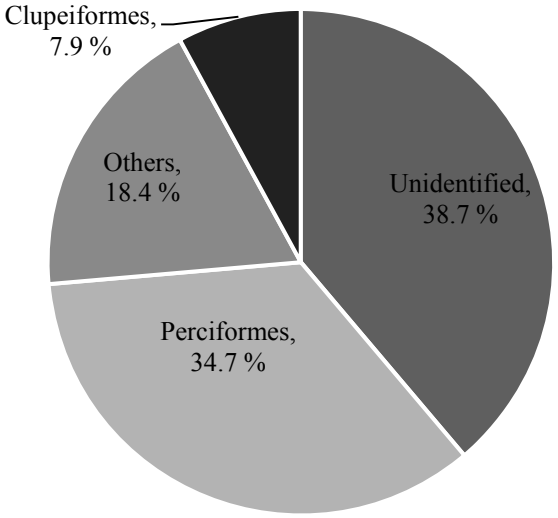

Figure 2. Percentage composition of ichthyoplankton (order) found at Malaysia EEZ off Sarawak, South China Sea 2015.

Fish larvae totalling 3,006 tails attributed to 52 families and 2,329 fish eggs were collected from 20 stations in Malaysia EEZ off Sarawak, South China Sea (Table 2). Most of the shape found for fish eggs was ellipsoidal and spherical shapes. A

total of 52 families were identified from the fish larvae specimens. The most abundant family was Gobiidae with 8.00 % of the total number of fish larvae followed by Engraulidae (6.3 %) and Scombridae (5.3 %). According to Okutsu (2011), Gobies usually spread all over the world in tropical and temperate near shore, brackish and freshwater environment. Scombrids known as pelagic (open-ocean) predators were found worldwide in tropical and cool temperate waters similarly, Engraulids were also widely distributed in tropical and sub-tropical waters (Mcgowan and Berry, 1983).

Previous study done by Chamchang and Chayakul (2000) in South China Sea, western Philippines identified 85 families which more than the fish larvae family found in this study. Myctophidae was the most abundant family, comprising 31.0% of the total number of larvae, followed by the Gonostomatidae (10.6%), Bregmacerotidae (7.4%) and Gobiidae (5.1%). The result showed that the dominant families found were different except for Gobiidae although both studies were carried out in open-ocean. The reason of this dissimilarity was probably due to different area and depth of sampling. The study by Chamchang and Chayakul only tow the net until 60 m while in this study, the samples were collected until 200m. According to Lanksbury *et al.,* (2005), depth affect the composition of fish larvae as well as the abundant of food source and prey-predation relationship. Thus, this showed that the depth may influence the composition of fish larvae found.

There were 20 commercial families namely Acanthuridae, Bothidae, Carangidae, Clupeidae, Engraulidae, Haemulidae, Holocentridae, Labridae, Leiognathidae, Lutjanidae, Monacanthidae, Mugilidae, Mullidae, Priacanthidae, Scaridae, Scombridae, Serranidae, Sphyraenidae, Synodontidae and Trichiuridae collected at the study sites (Table 2). The composition of the commercial fish usually changed over the time due to some factors such as increasing in the number of human populations, demands on marine protein sources, medicinal values of some marine animals and overfishing (Mansor *et al.,* 1998).

Table 2. List of fish larvae family collected at Malaysia EEZ off Sarawak, South China Sea 2015.

Order	Family	No. of fish larvae	Percentage (%)	Commercial family
Anguiliformes	Congridae	32	1.1	No
	Muraenidae	40	1.3	No
	Ophichtidae	6	0.2	No
Atheriniformes	Atherinidae	85	2.8	No
Aulopiformes	Synodontidae	77	2.6	Yes
Beloniformes	Hemiramphidae	9	0.3	No
Beryciformes	Berycidae	12	0.4	No
	Holocentridae	43	1.4	Yes
Clupeiformes	Clupeidae	49	1.6	Yes
	Engraulidae	189	6.3	Yes
Gadiformes	Bregmacerotidae	44	1.5	No
Lophiiformes	Antennariidae	1	0.0	No

Mugiliformes	Mugilidae	3	0.1	Yes
Myctophiformes	Myctophidae	13	0.4	No
Perciformes	Acanthuridae	16	0.5	Yes
	Blenniidae	16	0.5	No
	Callionymidae	40	1.3	No
	Carangidae	124	4.1	Yes
	Cepolidae	22	0.7	No
	Chaetodontidae	11	0.4	No
	Champsodontidae	4	0.1	No
	Cirrhitidae	2	0.1	No
	Coryphaenidae	7	0.2	No
	Gempylidae	4	0.1	No
	Gobiidae	241	8.0	No
	Haemulidae	69	2.3	Yes
	Kyphosidae	13	0.4	No
	Labridae	42	1.4	Yes
	Leiognathidae	63	2.1	Yes
	Lutjanidae	36	1.2	Yes
	Mullidae	27	0.9	Yes
	Plesiopidae	5	0.2	No
	Pomancentridae	3	0.1	No
	Priacanthidae	69	2.3	Yes
	Scaridae	26	0.9	Yes
	Scombridae	158	5.3	Yes
	Serranidae	2	0.1	Yes
	Sphyraenidae	1	0.0	Yes
	Trichiuridae	7	0.2	Yes
	Trichodontidae	40	1.3	No
Pleuronectiformes	Bothidae	19	0.6	Yes
	Cynoglossidae	6	0.2	No
	Soleidae	4	0.1	No
Scorpaeniformes	Platycephalidae	15	0.5	No
	Scorpaenidae	39	1.3	No
Stomiiformes	Malacosteidae	3	0.1	No
Syngnathiformes	Fistulariidae	13	0.4	No
	Centriscidae	2	0.1	No
Tetraodontiformes	Balistidae	26	0.9	No
	Monacanthidae	24	0.8	Yes
	Tetraodontidae	38	1.3	No
	Triancanthidae	1	0.0	No
Unidentified Samples	Unidentified	1,165	38.7	No
		3,006	**100**	

Density and Composition of Fish Larvae based on stratum

Table 3 shows the density of fish larvae according to tow station and depth stratum. The shallower depth stratum, 20-50m recorded a density range of 9.40 to 75.38 larvae/100m^3; 51-100m depth stratum (12.34-59.69 larvae/100m^3) and 101-200m depth stratum (9.60 to 41.49 larvae/100m^3). The mean density (Table 3 and Figure 3) of fish larvae was recorded at stratum 20-50m was highest at 38.37 ± 24.07 larvae/100 m^3 followed by stratum 51-100m (34.91 ± 19.97 larvae/100 m^3)