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Distribution and density of mackerel larvae (*Rastrelliger* spp.) in the waters off the northwest coast of peninsular Malaysia

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Abstract
This study was conducted to determine the density and distribution of *Rastrelliger* spp. larvae in northern part of West Coast of Peninsular Malaysia. Sampling was conducted thrice at the sampling site (August 2018, September 2018 and October 2019). Larvae were sampled using a larvae net with 500 µm mesh size. Oblique towing of larva net was carried out in study location which was between south of Langkawi Island to south of Kedah waters. Fish larvae samples were observed under stereomicroscopy and identified to family, genus or species level. Larvae were then preserved in 4% formalin. The result showed that the distribution of larvae was occurred more spawning in September compared to August and October. The average size of larvae was 3.1±0.7 mm (n=151). The highest density of *Rastrelliger* spp. larvae was recorded in September with 38 larvae/1000 m^3 where the sampling station was located near fish aggregation device site in Yan. Biological information in this study can be used for fishery resources management in order to ensure the sustainability of fisheries resources.

Keywords: *Rastrelliger* spp., larvae, density, distribution and spawning area

1. Introduction
Mackerel, *Rastrelliger* spp. are commercial fish as food source for human consumption in Malaysia. This is due to low market price, its abundance and highly demand among Malaysian [1]. *Rastrelliger* spp. are belong to family of Scombridae which locally known as "Kembung" that comprised of three main species such as *Rastrelliger kanagurta* (Indian Mackerel), *R. brachysoma* (Indo Pacific Mackerel) and *R. faughni* (Island Mackerel). *Rastrelliger* spp. are pelagic fish that commonly caught using purse seine, drift net and trawlers in West Coast of Peninsular Malaysia. *R. brachysoma* is distributed near-shore coastal areas and its habitat in shallow waters meanwhile *R. kanagurta* and *R. faughni* are in oceanic areas [2]. It undergoes external fertilization by which the eggs fertilize outside of the fish body [1] and both eggs and larvae are pelagic [3].
Apart from that, *Rastrelliger* spp. are also shared stock with neighboring country which are Indonesia, Thailand and Myanmar [4]. The landing of mackerel apparently declines from year 2014 to 2017. In Kedah, a total of 24, 064 metrics tonnes (MT) were landed in 2014 and decline to 5, 575 MT in 2017. Meanwhile, in 2017, it showed the highest landing of mackerel in Perak, Perlis and Kedah. In year 2017 the highest landing of mackerel recorded on May, September and October in West Coast of Peninsular Malaysia which were 2294 MT, 1981 MT and 1940 MT respectively [5]. The increasing in landing were related to the spawning season starting in April [6]. The spawning season for *R. brachysoma* is in April-May and October-December, meanwhile for *R. kanagurta* is in January-March and July-September [7].
Study on fish larvae and its identification is fundamental in order to know the morphology of the targeted species especially for economical fish. Basic characteristics on the morphology of larvae were very useful to identify the fish species. Generally, there are great variation among Scombridae larvae with the different shape of snout and jaws that ranging from rounded to blunt [8]. Furthermore, the main characteristic of the morphology of *Rastrelliger* spp. larvae is the present of black pigment spot on the head [8]. The other characteristics of *Rastrelliger* spp. larvae are elongate to moderate in depth, compressed and deeper in head and gut than in tail. The gut is compact, coiled and triangular in shape. The gap between anus and anal fin

origin is wide. The mouth on both jaw tips is nearly join and there is no preopercle spines on the operculum. The eye is round and moderate to large. There are pigments on along the anal fin to caudal peduncle.

Besides, the distribution of fish larvae and its abundance are very important for recruitment pattern of fish that lead to an efficient management of fish stock [9, 10]. Therefore, it is crucial to determine the spawning area of targeted species, so that the fisheries management could implement to close the area (close area) during spawning season (close season) in the waters. This initiative is to ensure the sustainability of reliable fisheries resources of mackerel in the area. Kedah waters were chosen as the sampling location based on the highest landing of Indo Pacific Mackerel recorded for past four years from 2017 to 2020 by which there is abundance of mackerel in the market from the landing in Kuala Kedah [11, 12, 13, 14]. Thus, this study was carried to determine the distribution and density of *Rastrelliger* spp. larvae in Kedah waters.

2. Materials and methods

Sampling was conducted thrice which were in August 2018, September 2018 and October 2019 as these three months were considered as spawning season [7]. The locations of the sampling area as shown in Figure 1. Larvae were sampled by using a larvae net with 500 µm in mesh size. Oblique towing of larva net was carried out with the speed of fishermen vessel at 2 knots from sea bottom to sea surface in study location which was between south of Langkawi Island to south of Kedah waters. A flow meter was attached to the mouth of net in order to determine the volume of seawater that passing through the larva net.

The samples were added with formalin to make the sample preserved at 10% formalin. Fish larvae samples were observed under stereomicroscopy and identified to family, genus or species level. Larvae was identified follow keys of Russell (1976), Okiyama (1988) Leis and Carson-Ewart (2000) and Ghaffar *et al.* (2010). Larvae of *Rastrelliger* spp. were measured and then preserved in 4% of formalin. Density of larvae were calculated by using the number of *Rastrelliger* spp. larvae and volume of water filtered. Density was standardized to 1000m^3 and the distribution was mapped using Surfer® 8. Formula for calculation of larvae density are as follows:

$$\text{Density per } 1000\ \text{m}^3 = \left(\frac{1000}{volume\ of\ water\ filtered}\right) \times total\ number\ of\ larvae$$

Where,

volume of water filtered is R X 0.3 m/rpm X area of larvae net's mouth,

R is the differences between the flowmeter reading.

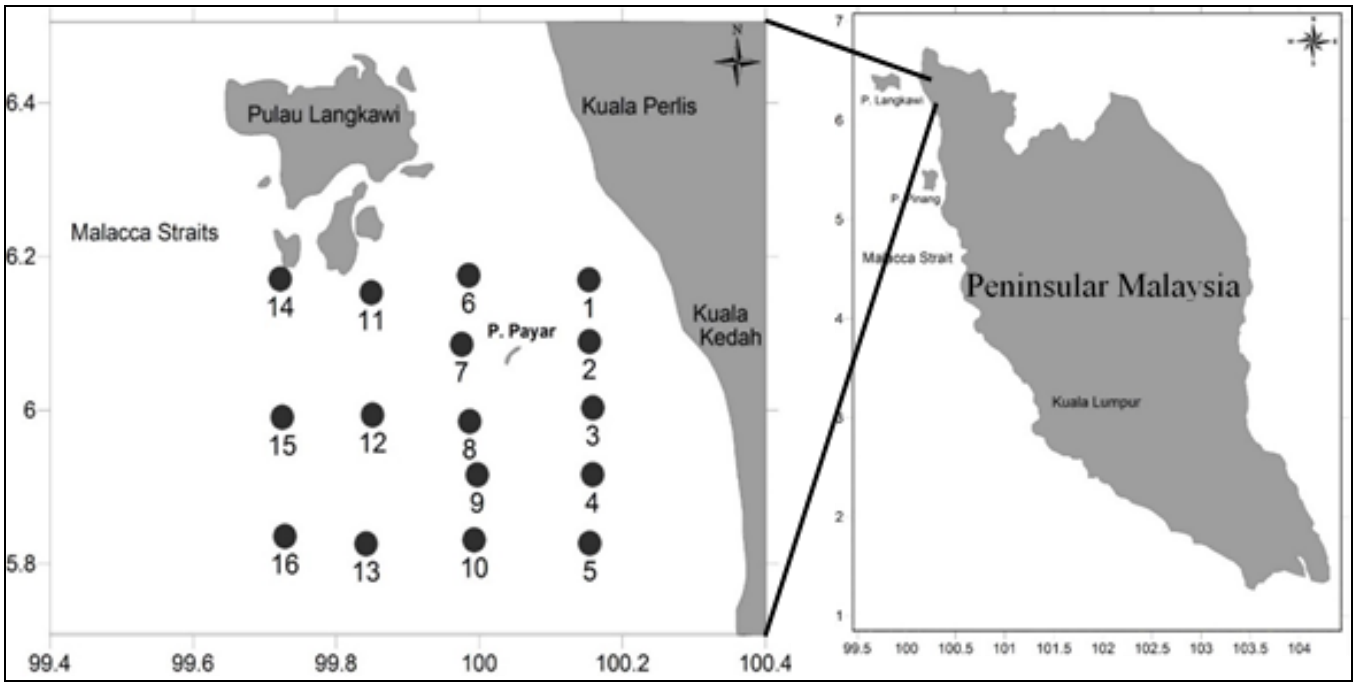


Fig 1: Location of sampling area in August 2018, September 2018 and October 2019

3. Results and discussions

Percentages of Species Composition of family of Scombridae larvae

A total of three species of Scombridae larvae were identified which were *Rastrelliger* spp., *Scomberomorus commerson and S. guttatus.* Figure 2 demonstrate the species composition of family of Scombridae larvae in August 2018 with the highest was *Scomberomorus commerson* (0.5%). Figure 3 illustrate the species composition of family of Scombridae larvae in September 2018 with the highest was *Rastrelliger* spp. (17.1%). Meanwhile in Figure 4 show the species composition of family of Scombridae larvae in October 2019 with only one species was identified which was *Rastrelliger* spp. (0.5%).

There were three species of family of Scombridae larvae were identified in this study with the highest percentage was *Rastrelliger* spp., followed by *S. commerson* and *S. guttatus.* These three species are widely distributed in the Southeast Asia with the total number of species of Scombridae is 54 species from 15 genera worldwide [18]. In this study, *S. commerson* was found in the waters off the Northwest Coast of Peninsular Malaysia as this species is known as an

epipelagic fish that inhabit the water from the sea surface and can be found throughout the coastal tropical waters of the indo-Pacific from South Africa to Southeast Asia [19, 20]. Scombridae is also among the top five most dominant family of fish larvae in Northwest of Peninsular Malaysia waters [21].

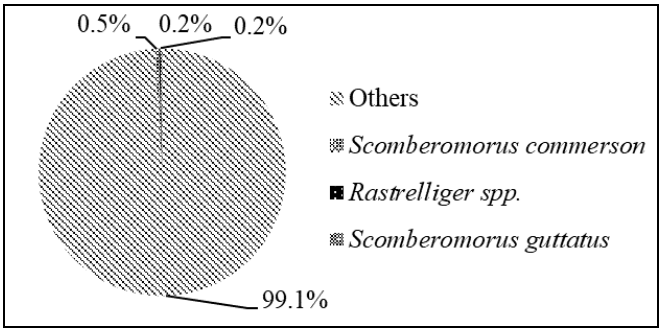


Fig 2: Species composition of family of Scombridae larvae in August 2018 in Kedah waters

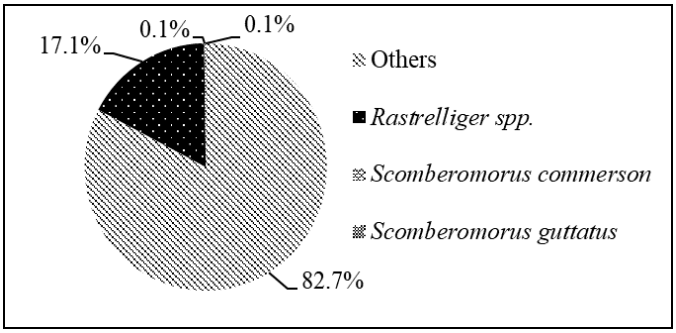


Fig 3: Species composition of family of Scombridae larvae in September 2018 in Kedah water

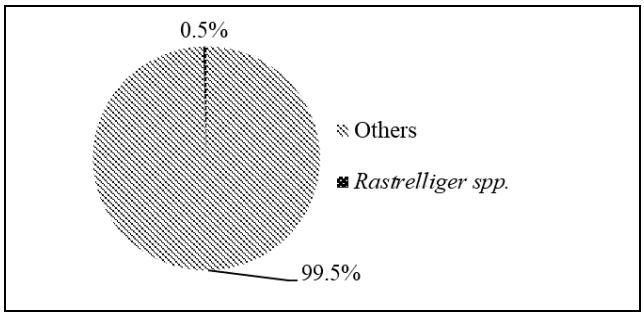


Fig 4: Species composition of family of Scombridae larvae in October 2019 in Kedah waters

Size and morphology of Rastrelliger spp. larvae

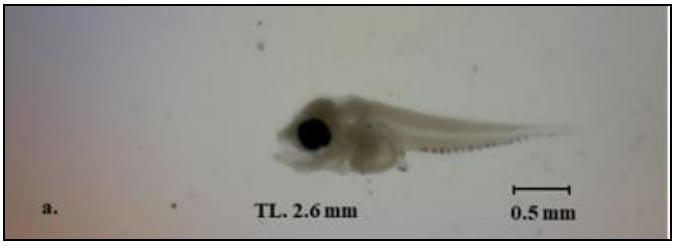
Table 1 show the length measurements of *Rastrelliger* spp. larvae for 151 individuals out of 164 specimens. The size of the larvae did not varied much at each of the stations. The average size of *Rastrelliger* spp. larvae recorded was 3.1±0.7 mm with the maximum total length was 5.2 mm at station 13 and the minimum was 1.3 mm at station 9.

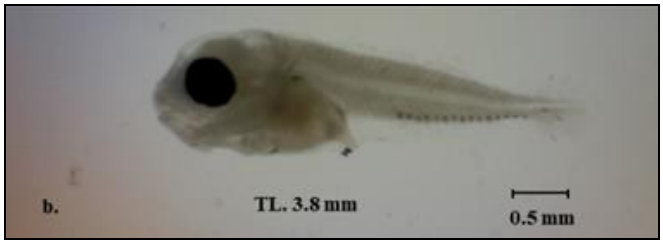
Table 1: Size of *Rastrelliger* spp. larvae recorded at different stations in Kedah waters (TL).

Station	Total number of larvae	Average Total Length (mm)	Minimum Total Length (mm)	Maximum Total Length (mm)
1	21	2.6 ± 0.6	2	3.5
2	5	2.7 ± 0.7	2.1	3.7
4	9	2.9 ± 0.6	2.1	3.6
5	61	3.4 ± 0.7	1.6	5.2
7	3	2.7 ± 0.6	2.3	3.4
9	25	3.3 ± 0.7	1.3	4.1
10	11	2.6 ± 0.4	2.1	3.3
12	14	2.9 ± 0.5	2.2	3.8
15	2	2.0 ± 0.1	1.9	2
Total	151			

*13 out of the 164 specimens were damaged and cannot be measured.

In this study, the size of *Rastrelliger* spp. larvae were between 1.3 mm to 5.2 mm (TL) which did not much varies with the size of *R. kanagurta* in the study conducted by Silas [22] where the most of larvae were between 2.5 to 6.0 mm (TL). Meanwhile, the size larva for the other genus of *Scomberomorus* form the same family showed a slightly larger size compared to *Rastrelliger* which for *S. guttatus* with the size of larvae was between 2.5 to 75 mm (TL) and *S. lineolatus* were 9.5 to 18.3 mm (TL) [23].





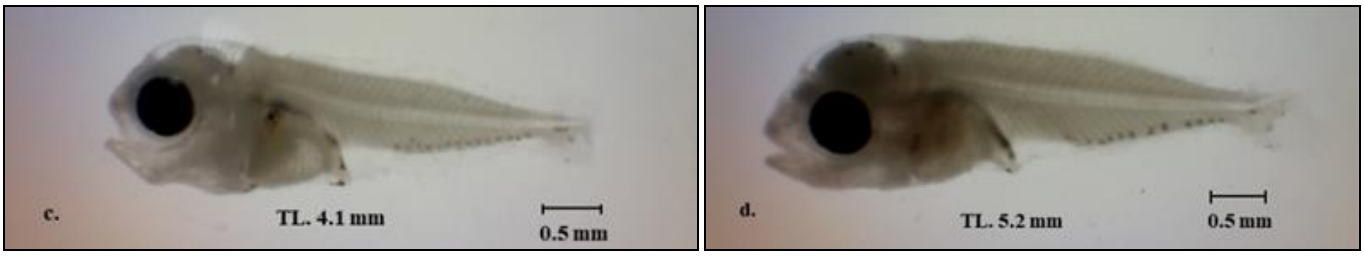


Fig 5: Morphology and difference sizes of *Rastrelliger* spp. larvae that were caught in Kedah waters: a. 2.6 mm, b. 3.8 mm, c. 4.1 mm and d. 5.2 mm in Total Length (TL)

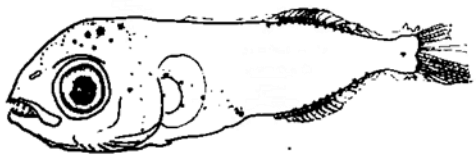


Fig 6: General morphology of *Rastrelliger* spp. larvae (adopted from Leis and Carson-Ewart) [8]

The morphology of larvae in this study showed the characteristics of *Rastrelliger* spp. that are elongate to moderate in depth, compressed and deeper in head and gut than in tail (Figure 5). The gut is compact, coiled and triangular in shape. The gap between anus and anal fin origin is wide. The head is large, snout round in shape and black pigment spot present on the head. The clear black pigment spot on the head as in Figure 6 which adopted from Leis and Carson-Ewart [8]. The mouth on both jaw tips is nearly join and there is no preopercle spines on the operculum. The eye is round and moderate to large. There are pigments on along the anal fin to caudal peduncle. The caudal fin is not fully developed.

In this study, the larvae were difficult to identify until species level due to similar characteristics on the morphology that were overlap between *R. kanagurta* and *R. brachysoma*. The species of larvae in this study is might be *R. brachysoma* due to the location where it was found [2] the distribution of *R. brachysoma* is near-shore coastal areas. Hence, a conformation study by using genetic approach should be advice to validate the result.

Distribution and Density of Rastrelliger spp. Larvae

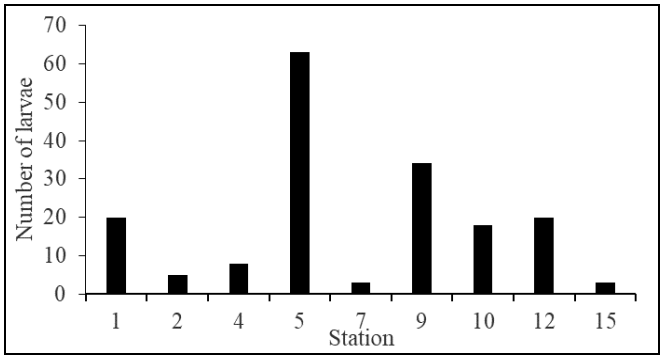


Fig 7: Number of *Rastrelliger* spp. larvae found at different stations

Figure 7 show the number of *Rastrelliger* spp. larvae found at different stations during three samplings duration; August 2018, September 2018 and October 2019. A total of 164 *Rastrelliger* spp. larva were found in the study (Figure 6 and Table 1). Only one larva was found in August 2018 which at station 5 (from the total of 16 stations). Meanwhile, in September 2018, *Rastrelliger* spp. larvae were found at 7 stations out of 16 stations with a total of 155 *Rastrelliger* spp. larvae (station 1, 4, 5, 9, 10, 12 and 15). Station 5 recorded the highest number of *Rastrelliger* spp. larvae which was 62 larvae whereas station 15 showed the lowest number which was 3 larvae. In October 2019, *Rastrelliger* spp. larvae were found in two stations which were in station 7 (3 individual) and station 2 (5 individual).

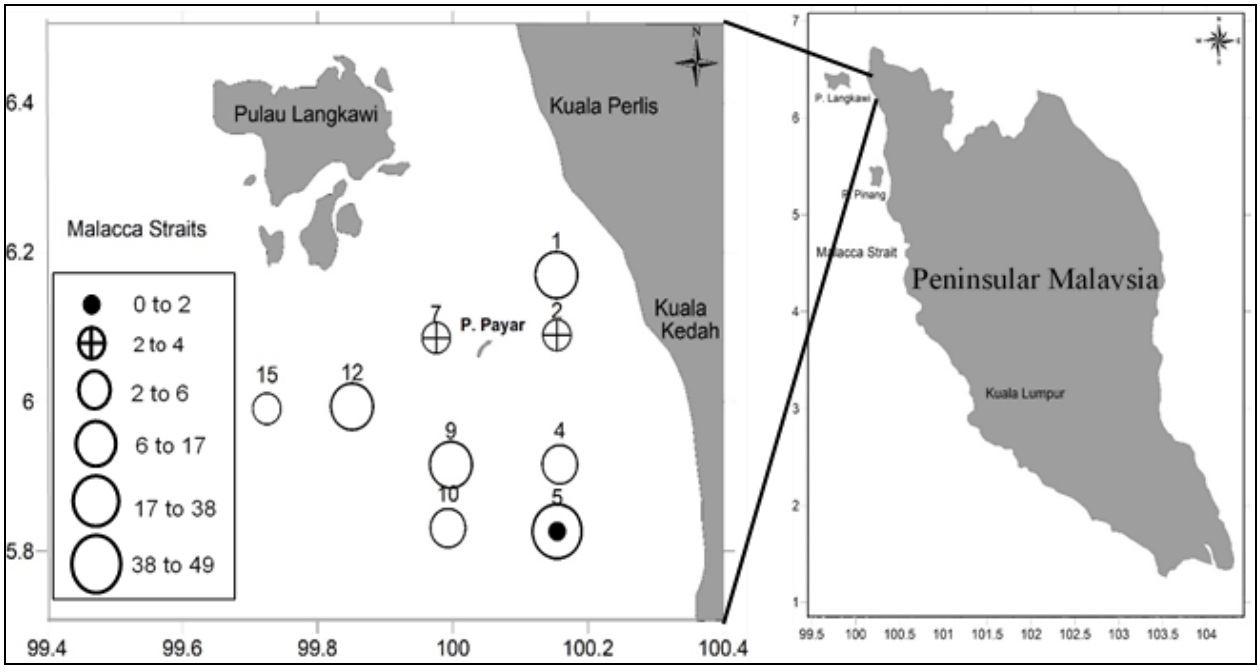


Fig 8: Distribution and density (larvae/1000 m^3) of *Rastrelliger* spp. larvae in Kedah waters during samplings in August 2018 (marked as ●), September 2018 (marked as O) and October 2019 (marked as)

Figure 8 illustrate the location of *Rastrelliger* spp. larvae found at nine stations which were at station 1, 2, 4, 5, 7, 9, 10, 12 and 15. During sampling in August 2018, only one station that positive mackerel larvae which was station 13 (0.5 larvae/1000 m^3) meanwhile, on September 2018 station 13 showed the highest density of *Rastrelliger* spp. was 38 larvae/1000 m^3, followed by station 17, 18 and 19 which all this three stations recorded same density of 17 larvae/1000 m^3. The density for other stations were less than 8 larvae/1000 m^3. During sampling in October 2019, station 20 recorded the highest density which was 3 larvae/1000 m^3 meanwhile the density of mackerel larvae at station 17 was 2 larvae/1000 m^3. Station 11, 13, 18 and 21 are along south of Kedah waters and near Yan.

The highest density of *Rastrelliger* spp. larvae that were found at station 13,18 and 19 which were located along south of Kedah waters and near Yan. Station 13 showed the highest density of *Rastrelliger* spp. larvae which located near the location of fish aggregation device that known as *tuas* or *unjam*. *Tuas* or *unjam* are marked area at the sea with thorn bamboo which made of leaf or tree branch and concrete. Its function like artificial reef for fish spawning and nursery ground. *Rastrelliger* spp. larvae are pelagic and it is migrating [24] where as in Figure 2 demonstrated that the distributions of *Rastrelliger* spp. larvae found along the Kedah waters where the fish aggregating device located.

Among these three months, the highest density of *Rastrelliger* spp. larvae were recorded in September compared to August and October due to the spawning season for *R. brachysoma* is in April-May and October-December, whereas for *R. kanagurta* is in January-March and July-September [7]. This will lead to the abundance of fish stock and landing of mackerel start on April which relate to the spawning season that takes around eight months to mature [6]. This pattern also was shown for past four years from 2017 to 2020 by which there is abundance of mackerel in the market from the landing in Kuala Kedah [11, 12, 13, 14].

The distribution of fish larvae and its abundance are very important for recruitment pattern of fish that lead to an efficient management of fish stock [9, 10]. A further study should be done for at least five years to clarify the spawning season of the *Rastreliger* spp. larvae. Further detailed studies on identification of *Rastreliger* spp. larvae for both molecular method and morphological variation are needed to form more accurate identification. Therefore, some areas that have been determine as a primary result for spawning area in this study which are along Pulau Payar to Yan can be consider as a baseline for the fisheries resources management to close the area (close area) during spawning season (close season) in the Kedah waters. This can ensure the sustainability of reliable source of mackerel in the area for the future.

4. Conclusion

The highest density of *Rastrelliger* spp. larvae found in September where the sampling station was located near unjam site in Yan. This study also found that the more spawning occurred in September compared to August and October. Biological information in this study can be used for fishery resources management in order to ensure the sustainability of fisheries resources.

5. Acknowledgements

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