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Maturity Stages of Indian Mackerel *Rastrelliger kanagurta* (Cuvier, 1817) In Mayalibit Bay, Raja Ampat, West Papua

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Abstract: Maturity stages of 3,485 individuals of the Indian mackerel *Rastrelliger kanagurta* (Cuvier, 1817) were measured from a population occurring in Mayalibit bay in Radja Ampat Regency of West Papua during the period of March 2011 through February 2012. Approximately 200-600 individuals were collected each month from the Warsambin and Lopintol villages, respectively, closed to the mouth of Mayalibit Bay. One thousand seven hundred and thirty four out of the 3485 individuals gonads (49.76%) were males and 1751 (50.24%) were females. The estimated length at first maturity values or L_{m50} of male and female were at 19.55 cm and 20.71 cm, respectively, this significantly larger than populations examined in the Malacca Strait and Java Sea. In both sexes, individuals in all 5 maturity stages were recorded each month, with the highest cumulative percentage being stage IV (ripe gonads) for both males (50.4%) and females (38.8%). Weights of individual male testes ranged from 0.9 to 20.4 g, while female ovary weights ranged from 3.1 to 28.9 g. The result represents the heaviest ovaries that have not been recorded, yet for an individual of *R. kanagurta*. Two of the individuals examined showed hermaphroditic development. Forty among female ovaries specimens were at translucent stages which indicated the spawning periods of the species. This finding, along with the overall high percentage of individuals specimens at stage IV and V maturity, contribute a strong support to fisher knowledge and local fisheries office report that Mayalibit Bay may taken into considered as a spawning aggregation area for *R. kanagurta*.

Key Words: *Rastrelliger kanagurta*, maturity stages

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Introduction

Recent findings reported that there were 1638 fish species occurred in the Bird head of Papua and 1437 fish species in Raja Ampat. This was suggested that Raja Ampat were the highest biodiversity of fish in the world (Allen and Erdman, 2012). The diversity of marine life is also contributed to the livelihood of local communities. Preliminary study indicated that the main target species of fishers consisted of a group of small pelagic fish, large pelagic and reef fish. Raja Ampat islands are surrounded by Pacific Ocean in the western part where Mayalibit bay is located. People living in the coast area are mostly depends on several edible biotas, such as oyster, crab, shrimp, sea cucumbers, and a group of either demersal or pelagic fishes. Fishing activities in Mayalibit mainly catch the Indian mackerel or "ikan banyar" by the local method called as "balobe lema". This method is usually used by the people living in the Warsambin and Lopintol villages which near the outlet part of the gulf. The fish species that mostly catch by Mayalibit fishers was *Rastrelliger kanagurta* (Cuvier, 1817). This assumed that Mayalibit Bay is one of the fishing areas of *R. kanagurta* in Indonesia. According to the estimated landing data, approximately of 3,000 individual fish were catch per night on the dark period (21 days of fishing). Several biology aspects (morphology, growth, and reproduction) of *R. kanagurta* in the western part of Indonesia have been studied by several researchers, such as Sudjastani (1974), Atmaja *et al*. (2003), and Nurhakim (2003). Biological aspects of *R. kanagurta* in eastern part of Indonesian has been studied in Waigeo (Boely *et al*., 1986), and Makassar Strait (Amarumollo and Farid, 2002). The exploitation of small pelagic fish resources in the tropics tend to heavily exploited and leads to study in more depth (Garcia *et al*. 2003). Venkataraman (1970) reported the biology reproduction of Indian mackerel, *R. kanagurta* in India. Indian Mackerel *R. kanagurta* is one of the main target species for fisheries. Therefore, this species should be studied in order to understand their status and related to their management issues. Maturity stages of *R. kanagurta* is one of the important biological aspect in maintaing this species in Raja Ampat. Maturity stages of each individual specimen was determined by the gonads maturity indices. However, reproduction aspects (gonad maturity) of *R. kanagurta* in Mayalibit Bay are still limited. Therefore, study on gonad maturity might be help in understanding the monthly development of this fish. The benefit of this study was to support the traditional knowledge in relation to sustainable development approaches.

Materials and Methods

Period and Location

Field study was carried out from March 2011 up to February 2012, in the Mayalibit Bay as part of semi-enclosed marine waters of Waigeo islands of Raja Ampat, West Papua Province. Two out of ten coastal area villages have been selected as the sampling location. Those are Warsambin and Lopintol (Fig. 1). Both are located in the mouth of the Mayalibit Bay with geographically position of 00 ° 19.068 S, 130 ° 55.168' East of Warsambin and 00 ° 18.897 'S; 130 ° 53.475' E of Lopintol (Fig. 1). The semi-enclose marine area of Mayalibit Bay approximately has an area of 34,000 ha, administratively divided into two districts i.e. Mayalibit and Tiplol. The gulf surrounded by mountain with the highest of 636 meters above sea level, and the water depth range between 2-25 m (Dishidros 1996) with an average of 10 m (Blue *et al*. 2008). The mouth is relatively narrow at around 700 m (Goram 2009). Lopintol and Warsambin villages are located in western part of Mayalibit Bay. Both villages are the major fish producer because they are close to the fishing areas of Indian mackerel.

Fish Sampling

"Balobe lema" is a traditional fishing method allowed of catching mackerel in the Mayalibit Bay. Sampling was conducted every month during the fishing period which usually took place for 3 weeks each month. A total of 200 mature specimens with size of larger than 20 cm were observed with some exception of limited specimens of smaller size were also measured. Fish samples were collected at night and were kept in a cool box filled with ice, and then were identified in the morning

Parameters examined

Parameter examined were body fork length in centimeters (cm), body and gonad weight in grams (g). Length frequency measurements were carried out using measuring board. Body and gonad weight were carried out by digital scales.

Gonad observation

The abdominal part of fish were dissected, and the gonads were removed to observe the individual sex. The maturity for each sex determined following oocyte development pattern, fecundity type and spawning pattern with five criteria as stated by Holded and Raitt (1974). Translucent gonad were also recorded.

Data Analysis

The size of maturity was analysed using the equation of:

$$P = 1 / (1 + \exp[-r (L-Lm)])$$

Which:

P = probability (%)

r = slope of the curve

L = length of the fish

Lm = length of fish at specific gonad maturity

Estimated size of first maturity was determined by the number of fish collected at stages of IV and V at 0.5 probability or 50% of mature sample. Analysis of the Maturity stages specifically was determined on a sample size of fish of more than 20 cm. All of data have been processed and analyzed descriptively in the form of graphs, tables, and images, respectively.

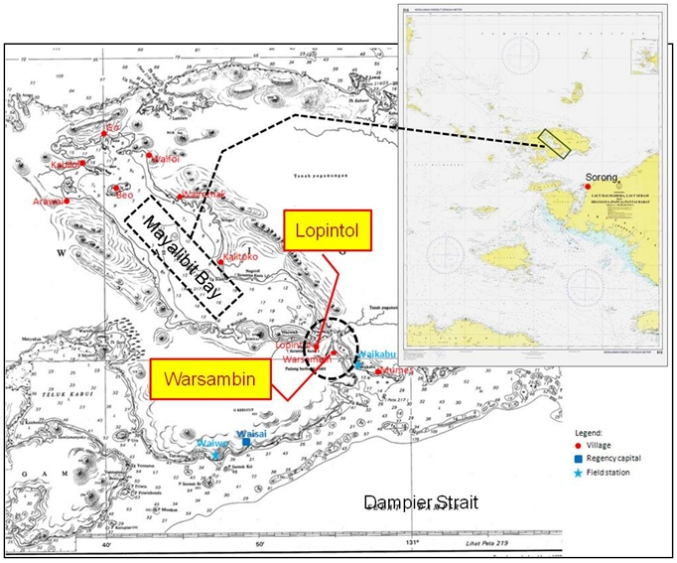

Fig. 1: Research location.

Results

Morphometry

Number of fish measured were 3,881 specimens and belong to *R. kanagurta*, with the size ranged between 6.3 and 26.0 cm. Number of mature fish were 3,485 specimens (Table 1).

The Estimated Length at the First Maturity (Lm)

Maturity stages of IV and V were used to determine the estimation on length at first maturity. The IV and V stages category were selected following the previous microscopic observations at stage IV which had already to spawn (mature ova or translucent appeared in gonads) (Fig. 2) and stage V had just spent. The male or female specimens were firstly matured at 19.55 cm or 20.71 cm, respectively.

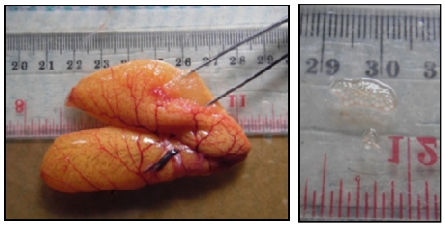

Fig. 2: Translucent gonad of *R. kanagurta* and its granule.

Tab. 1: Physical profile of *R. kanagurta*.

No.	Month	FL (cm)	Body Weight (g)	Maturity Stage		Gonad Weight (g)	
				Male	Female	Male	Female
Mar-11	No.	195	173	63	48	38	36
	Mean±S.D	17.30±5.15	100.36±65.53	4.21±0.68	3.81±0.96	4.52±2.57	3.38±2.55
	Max/Min	23.10/9.10	185/8.80	5/1	5/2	12/1	9.30/0.30
Apr-11	No.	210	210	71	79	57	80
	Mean±S.D	19.68±3.68	126.27±61.16	3.32±1.23	3.91±0.98	3.16±1.9	2.56±1.99
	Max/Min	26.00/8.70	273.70/6	5/1	5/2	8.50/0.03	10/0.11
May-11	No.	600	600	289	275	284	283
	Mean±S.D	21.88±1.7	160.32±31.79	3.46±1.4	3.75±1.23	2.62±2.15	2.64±2
	Max/Min	25.80/10.20	261.50/11.70	5/1	5/1	9.30/0.03	9.70/0.04
Jun-11	No.	255	255	132	117	126	114
	Mean±S.D	21.62±1.83	155.34±30.95	3.51±1.03	3.4±0.97	3.85±2.21	3.33±2.07
	Max/Min	24.20/12	208.30/21.80	5/1	5/1	9.80/0.12	9.80/0.07
Jul-11	No.	373	373	157	180	158	180
	Mean±S.D	20.76±3.78	150.17±49.23	3.68±0.9	3.04±0.95	4.16±2.85	3.54±2.81
	Max/Min	26.90/7.20	347.40/3.20	5/1	5/1	15/0.09	14.10/0.50
Aug-11	No.	213	213	81	129	80	128
	Mean±S.D	21.64±1.22	141.57±19.87	3.02±1.06	2.71±0.95	2.76±1.88	2.32±1.56
	Max/Min	24/11.10	210/16.28	5/1	5/1	9.23/0.11	8.25/0.46
Sep-11	No.	220	220	116	104	116	104
	Mean±S.D	22.23±0.45	168.74±12.47	3.36±0.91	2.92±0.82	3.97±2.35	3.22±2.29
	Max/Min	23.80/21.10	231.20/137.90	5/1	5/1	13.60/0.40	16.30/0.30
Oct-11	No.	244	244	120	124	120	124
	Mean±S.D	22.35±0.49	174.63±16.07	3.28±0.94	3.32±0.81	4.77±3.26	5.68±3.91
	Max/Min	23.70/21.00	231.30/138.10	5/1	5/1	14.40/0.05	22.10/0.40
Nov-11	No.	235	235	115	120	115	89
	Mean±S.D	22.55±0.51	183.05±15.62	3.68±0.97	3.45±0.82	6.43±3.93	6.54±4.77
	Max/Min	24.50/21.30	225.40/147.90	5/1	5/2	14.60/0.04	28.90/1.50
Dec-11	No.	303	303	134	166	116	159
	Mean±S.D	21.01±3.18	149.01±47.32	3.04±1.35	3.17±1.15	4.81±3.47	4.38±3.3
	Max/Min	24/9.10	223.60/6.50	5/1	5/1	14.90/0.04	25.50/0.05
Jan-12	No.	537	537	262	275	212	252
	Mean±S.D	19.68±3.21	126.25±42.71	2.98±1.29	3.16±1.06	3.26±1.81	3.49±1.94
	Max/Min	23/6.30	186.10/2.30	5/1	5/1	9.90/0.03	11.70/0.04
Feb-12	No.	496	496	194	134	176	120
	Mean±S.D	17.41±5.79	108.06±79.97	3.44±1.05	3.23±1.24	8.38±4.95	5.66±3.66
	Max/Min	23.90/6.30	225.20/1.50	5/1	5/1	20.40/0.20	16.70/0.03
Total No. (individuals)		**3,881**	**3,859**	**1,756**	**1,751**	**1,598**	**1,669**

Maturity Stages

Eighty persen of 3,338 samples were larger than 20 cm. The maturity varied from stage I to stage V. The highest proportion of maturity were at stage IV for male (50.4%) and female (38.8%), respectively, and the lowest were at stage I (<5%) (Fig. 3).

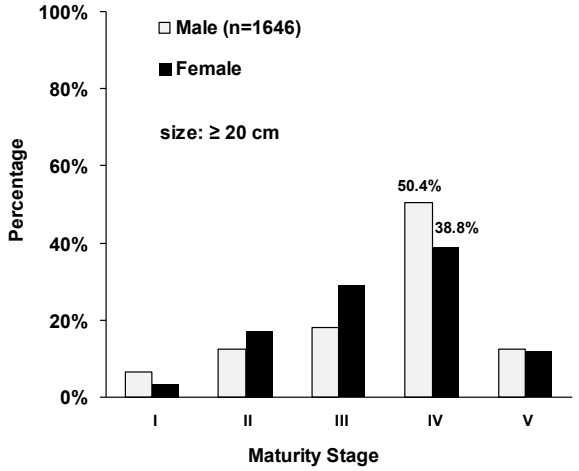

Fig. 3: The percentage of maturity stages for each sex of *R. kanagurta* with size ≥ 20 cm.

Sex Ratio

The monthly sex ratio on mature specimens (≥20 cm) indicated that the females were higher from April, July, August, October, November 2011 and January 2012. The dominance of male occurred on March, Mei, June, September, December 2011 and February 2012 (Fig. 4). The specimen caught mostly consisted of stage IV on both sex. This indicated that the ratios were different with variance within months. The highest ratio of female was found on April 2011 and January 2012. Overall ratios between male and female were 1: 0.7.

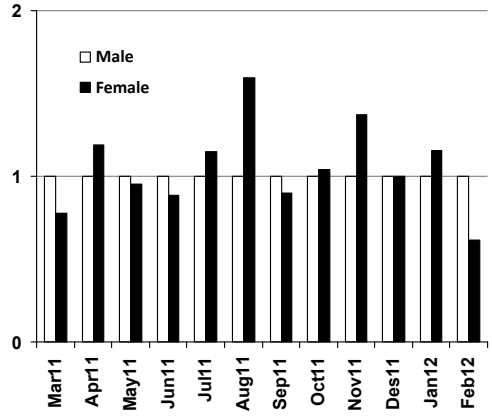

Fig. 4: Sex ratio for all maturity stages.

Hermaphroditic

During field observations, two samples of gonads were found hermaphroditic, those gonads which the right consisted of ova and testes (ovotestes) and the left was testes. Those anomalies specimens were found in May 2011 and February 2012. The maturity stages of male were fluctuated every month, but at the stage IV was shown the highest percentage. Male gonad weight of *R. kanagurta* at stage IV varied from 0.9 to 20.40 grams. The heaviest gonads obtained during the study were 20.40 grams with fork length of 22.4 cm and body weight of 199.7 grams. The minimum weight of male gonads on the at stage IV were found at 0.9 grams with fork length of 22.8 cm and 170.1 grams of body weight. The heaviest female gonads (28.9 grams) were found in November 2011 with fork length of 22.1 cm and body weight of 199.6 grams (Table 1). The

second heaviest weight in female gonads was found in December 2011 with the fork length of 25.5 grams and the third heaviest was found in October 2011 with the fork length of 22.1 grams. The three gonad samples were the hardest gonad at stage IV on translucent condition. The minimum translucent gonad weight of 3.1 g was found in January 2012 with the fork length of 22.0 cm and the body weight of 150.4 g. The total of translucent ovaries at stage IV were 40. Those translucent ovaries were obtained on May 2011 up to February 2012 with (Fig. 5).

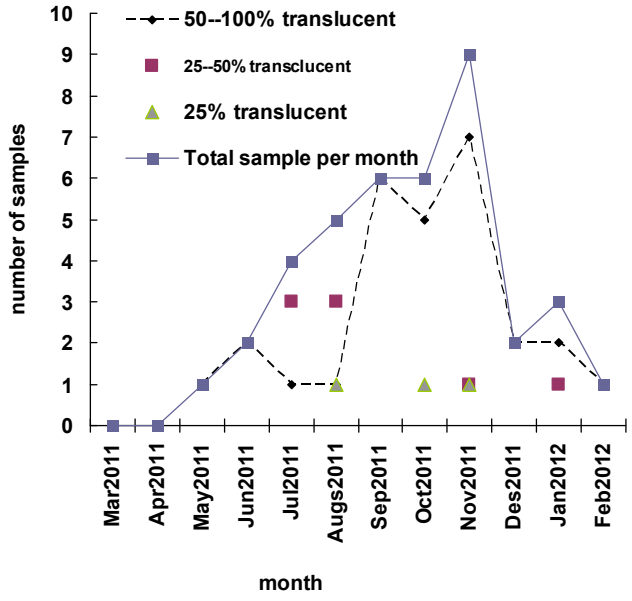

Fig. 5: Translucent ovary

Discussion

The sex ratio of male and female of the total sample of *R. kanagurta* was 1: 1. This ratio was obtained from the ratio number of specimen between 1734 males (49.76%) and 1751 females (50.24%). This result was different with the previous finding by Hariati *et al*. (2005) in Malacca straits which shown that male was higher (54%) than females (46%). Accordingly, sex reatios was influenced either by the stock status or the exploitation levels. The estimated length at the first maturity was showed that the males were smaller (19.55 cm) than females (20.71 cm). FAO (2001) was reported that the size of the first maturity of *R. kanagurta* was 20 cm, whereas in the Malacca strait was 17 cm (Hariati *et al*. 2005), while in the Java Sea was 18.25 cm (Atmadja *et al*. 1991). The immature fish was catch predominantly. Those findings suggested that the length at first maturity either in Malacca street or in Java Sea was smaller than Mayalibit Bay. Another area such as Indian waters also can be indicated already heavily explicated. The minimum length mature gonads *R. kanagurta* obtained regardless of sex is 16.8 cm. This figure is greater than indicated by the Gangga (2010) that the minimum length of the first maturity of *R. kanagurta* 14.7 cm.

Higher ratio of female occurred during six months, i.e. April, July, August, October, November 2011 and January 2012. Another six months the ratio of males is higher. Monthly ratio ranged from 0.88 and 1 and the accumulated of the ratio at stage IV is 1 and 0.7 with a ratio of males larger than females. The results suggested that the spawning process of *R. kanagurta* should be supported by 4 males to fertilize 3 females. The aggregation

ratio of male and female behavior associated with spawning, feeding, and migration (Bal and Rao 1984 *in* Hariati *et al*. 2005).

Several publications stated that the smaller ratio of females indicated there was related to their physiology of reproduction. The condition mature female body cavity filled with eggs, causing stomach distress could reduce their feeding habits. The nature of photo taxis positive of *R. kanagurta* associated to food sources such as plankton which becomes their main food habits. The "balobe lema" that rely on light do not affect on photo taxis positive behavior of mature females on stage IV.

However, two samples of gonad ovotestes were proved that there were abnormalities in sexual organs or the hermaphroditic. Findings hermaphroditic gonads in *R. kanagurta* been written by Phrabu and Raja (1958), Rao (1962) with the condition of the morphology and origin of the samples varied in between (see also Raja and Bande, 1972). The state of an organism to have heterosexual reproductive organs ovotestes naturally is true of almost all species although the chances are very small.

Each maturity stage of male and female fluctuates by month, but always as stage IV is the highest. The situation indicated that *R. kanagurta* being captured by fishers in Gulf of Mayalibit are in mature stage and ready to spawn.

Female at stage IV has a value lower percentage in June, July, August, September and November 2011 and these possibly due to spawn somewhere or being influenced by their physiological processes of reproduction that has been discussed previously. The dynamic of mature female confirmed that in general *R. kanagurta* might spawn throughout the year although the phenomenon was also obtained from the peak spawning season. The highest translucent specimens found in September, October and November indicated that the peak spawning season probably occurred in these months.

The findings of the gonad with translucent egg to 100% visually illustrates that the gonads are similar characteristics to total spawner gonads. Holden and Raitt (1974) defines the total spawner is the kind of fish that gonad maturation process begins, all the eggs or sperm will be spawned in one spawning season by each individual that developed simultaneously. Translucent gonad could be an additional evident that most of *R. kanagurta* Mayalibit into the Gulf in a state ready to spawn and this phenomenon strongly suggested that the Gulf Mayalibit as the spawning areas for *R. kanagurta.*

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