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Research Article

REPRODUCTIVE BIOLOGICAL ASPECTOF PANULIRUS PENICILLATUS IN SOUTHERN SUMBAWA ISLAND WATERS, INDONESIA

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ABSTRACT

Panulirus penicillatus reserve is quite abundant in Labangka waters, southern Sumbawa (Indonesia). Uropod is used to observe the lobster sex namely open uropod is female, and closed uropod (bud) is male. Measurement of female lobster to obtain data on carapace, body, gonad, and egg. The study aim is to determine the carapace length at first mature of gonad(CLm). The female Labangka spiny lobster CLmat 62.57 mm which was weight 217 grams. The egg diameter is 273 μm and fecundity 41,701 eggs, so that the gonad's maturity level (GML)was IV. Whereas, male lobster reaches GML IV at CLm 67.75 mm and body weight 273 grams. It can be estimated that each 1 mm of lobster carapace contains 666-667 eggs, or 192-193 eggs / gram of lobster body. The study results provide the benefits and ease of effective and efficient for lobster hatchery units to select prospective bloodstock lobster.

INTRODUCTION

Lobster *(Panulirus spp)* is classified as a fishery resource that is strategic for the Indonesian economy which is used as an export commodity of high economic value. Indonesian lobster production during the first Quarter of 2019 reached 384,181 kg, or decreased by 61.58% when compared to the production of lobster in the first Quarter of 2014 amounting to 1,000,074 kg. The Central Statistics Agency of Indonesian released, the largest Indonesian lobster export to countries in East Asia, then Southeast Asia, Australia and the United States (BPS, 2019). In the first quarter of 2019, lobster export volume was 99.86 tons. When compared with the First Quarter of 2014, prior to the issuance of Marine Affairs and Fisheries Minister Regulation No. 1 of 2015, the volume of lobster exports reached 97.05 tons (MAF RI, 2015).

Nusa Tenggara Barat Province (NTB), specifically the Ekas Bay, Central Lombok Regency, is one of the best lobster producing areas in Indonesia (https://food.detik.com/info-kuliner/d-4272541/5 *downloaded* 8 August 2019).In fact, most lobster production in NTB comes from the coastal waters of Sumbawa Island. Throughout 2016, Sumbawa Island lobster production was 28.0 tons, or 80% compared to NTB lobster production which reached 35.0 tons (MAF NTB, 2016). Sumbawa District contributed 10.0 tons, or 28.57%. All lobsters from NTB are sent to Bali and Jawa Timur, so there is no lobster export from NTB (BPS, 2019).

One of the lobster producing areas in Sumbawa District is Labangka Sub-district, specifically Jaya Makmur Village and Labangka Village. The species of lobster that are targeted by Labangka fishermen is *Panulirus penicillatus* (pronghorn spiny lobster) (Figure 1), being the most produced by fishermen.

Figure 1 Labangka pronghorn spiny lobster

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The Labangka coastline facing the Indian Ocean is known as the center of the production of pronghorn spiny lobster in NTB. Another species of lobster caught in Labangka waters is *P. homarus* (scalloped spiny lobster).

Research on the reproductive biological aspect of pronghorn spiny lobster carried out in Labangka is closely related to sustainable and responsible lobster fisheries resource management. The urgency is the availability of data, information, conditions, and status of *P. penicillatus* parent candidates in Labangka waters. While the aim is to determine the condition factor (K), fecundity, gonad (GML and GSI), and their sex ratio.

MATERIALS AND METHODS

Location and period of research

The study was conducted in the southern waters of Sumbawa, precisely in Labangka, Sumbawa District. The sample of pronghorn spiny lobster, which was captured in Labangka waters, was sourced from collectors who live in Jaya Makmur Village (Cemplung Beach) and Labangka Village, Labangka Sub-district, Sumbawa District (Figure2). The compilation of lobster samples comes from survey activities carried out during the period May 2019 to July 2019.

Figure 2 Map of research location in Labangka, southern Sumbawa, Indonesia

Sampling and data collection techniques

This study is part of the main research entitled "Implementation strategy of a responsible and sustainable lobster fisheries resource management" that applies the survey-dependent-descriptive method. A random sampling technique was used to collect 10 individuals of *P. penicillatus* (Figure 2) as lobster samples. Data about lobster (morphology, gonads, and eggs) were obtained by measuring, weighing, and observing techniques, as well as documentation of all samples. Interview techniques are used to collect data, including spawning and fishing season, and lobster production. Interviewees interviewed were fishermen on Cemplung beach, Jaya Makmur Village. The lobster traders reside in Jaya Makmur Village and Labangka Village.

The observations of body morphological characters, carapace length (LC) measurements and body weighing (WB) of lobster samples were carried out at the collector location. All lobster samples, in a state of life, were wrapped in paper individually and packaged in an airtight styrofoam box. Sand is sprinkled into the box, and ice bottles are added to maintain the temperature. Freezers are used to produce bottled ice made from fresh water which is put into plastic bottles. Next, the lobster sample box is transported to Mataram (Lombok) using a land transportation route.

Gonadal retrieval in the cephalothorax using a scalpel was carried out at the Basic Laboratory of the Faculty of Fisheries, University of 45 Mataram. Gonad obtained, put in a plastic bottle and preserved using 4% formaldehyde.

Gonadal and egg data collection using digital caliper, digital scales, and electronic microscopes through measurement and weighing of lobsers per individual. Carapace length (LC) data is obtained by measuring the tip of the horn until the end of the carapace is adjacent to the abdomen, using a digital caliper. Meanwhile, lobster weighing uses a digital scale to obtain body (WB) weight data.

Analysis of leading commodity

Leading commodity analysis uses the location quotient (LQ) approach of lobster production ratio (V_{LS}) and fisheries production (V_{PS}) of Sumbawa District. The results are compared to the ratio of lobster production (V_{LN}) and fisheries production (V_{PN}) of NTB. Here is the equation (Gili *et al.*, 2018):

$$LQ = (V_{LS}/V_{PS})/(V_{LN}/V_{PN})$$

If the value of LQ< 1.0 then the lobster commodity is not a leading commodity. However, if LQ> 1.0, the lobster is a leading commodity.

Growth pattern analysis

Growth speed of LC and WB lobster which were assessed together will get lobster growth patterns. The calculation uses the analysis of length and weight relationship (LWR) which statistically uses a parabolic shape (Freose, 2006).

Lobster samples come from waters that cannot be controlled (sea) then LC and WB data. Therefore, the data is transformed first into natural logarithmic data (ln) before LWR analysis is performed. The calculation follows the equation as follows:

$$\ln WB = a + b \ln LC$$

Condition factor analysis

Assessing the size of a lobster worth catching, fit for consumption, worth selling, and / or fit for process can be estimated by measuring the lobster's body plumpness. The feasibility was approached by the condition factor (K) which was calculated based on the ratio of body weight (WB = gram) and carapace length (LC = mm). The equation is (Effendie, 1979; Asrial *et al*., 2017):

$$K = 10^2 WB/LC^3.$$

According to Effendie (2002), K can be determined by food, age, sex, and gonad maturity. So, when K> 1, it's not necessarily plump lobster because it's fleshy, but it might be reaching GML IV.K values are an important part of lobster growth and can be used as a basis for population analysis(Effendie, 2002).

Gonad maturity level

The gonadal shape and capacity change phases that occur before and after fish spawning are called gonad maturity levels

/GML (Lagler *et al*., 1977). Thus, information about GML becomes very important for the management of fisheries resources related to its population. GML also functions to find out the size of the fish when the gonad is first matured and the condition of the fish has or has not spawned.

In this study, GML lobster is known from the observation process of morphology and egg diameter (Effendie, 2002). Whereas Silva and Cruz-Landim (2006) and Kizhakudan (2014) estimate the GML from the development of the testes and gonads, which are divided into five levels.

Gonad somatic index

Gonadsomatic index (GSI) is the development of the gonads resulting from the ratio of gonad weight (WG) to body weight (WB) expressed in percent. The equation is as follows:

$GSI = WG/WB\ x\ 100\%$.

As we know that what is meant by development / growth is a change that occurs not only in the dimensions of weight, but also in the dimensions of length and width. The same thing happened to the growth of lobster and gonads. This time, GSI is tried to be calculated based on length (GSI_L), which is gonad length (LG) divided by carapace length (LC), and width based (GSI_W), which is the ratio of gonad width (WiG) to carapace width (WiC).The two GSIs are also expressed in percent. So the equation becomes:$GSI_L = LG/LC\ x\ 100\%$and$GSI_W = WiG/WiC\ x\ 100\%$.

Egg and fecundity analysis

Fecundity is the number of eggs in a female gonad lobster before being released into the waters. Fecundity (size and shape) can vary in the same species as a result of adaptation to the habitat environment (Witthames *et al.*, 1995 *in* Murua *et al*., 2003), age, egg size, food, and season (Nikolsky, 1963; Kariyanti *et al*., 2014).

Data obtained by removing the gonad as a whole from the body of a lobster, then preserved in a bottle that was given 4% formalin solution. The data collection was carried out at the Basic Laboratory of Fishery Faculty, University of 45 Mataram. It starts by weighing the gonads, measuring the dimensions of the gonads, as well as measuring the diameter of the egg using an electronic microscope. The number of eggs is assumed by counting the number of eggs sampled from each gonad. Next, an analysis of the relationship between fecundity and egg diameter (fecundity and diameter relationship / FDR).

RESULT

Throughout 2016, Sumbawa District produced 9.99 tons of lobster, all of which are shipped outside the Sumbawa District area. In the same year, NTB lobster production reached 53.80 tons.Sumbawa and NTB fisheries production in 2016 were 51,554.08 tons and 170,166.16 tons, respectively. Based on all these data, the value of LQ = 0.613, or lobster commodity (*Panulirus* spp) is not classified as "leading commodity".In this classification, lobster production from Sumbawa District does not meet the consumption needs of the population of Sumbawa District. In fact, all lobsters are not consumed by residents of Sumbawa District because the lobster prices are unable to reach people's purchasing power.

The growth pattern of pronghorn spiny lobster was obtained from the analysis of the relationship between LC and WB (LWR) of 7 individual samples of prospective female lobster broodstock (Table 1). LC and WB data for LWR analysis are first converted to natural logarithms (ln) before being processed using the simple regression method. The results of the LWR analysis are mathematical models$ln\ WB = -0{,}08 + 2{,}95\ ln\ LC$. The equation is meaningful: each LC increases by 1 unit, the WB will increase by 2.95.

Through this equation, the condition factor (K) value represented by the LC coefficient value is b equal to 2.95. The status is hypo-allometric which is defined as the rate of growth of LC faster than the growth rate of WB. Thus, the prospective female pronghorn spiny lobster from Labangka has a slim body shape. This is in line with the condition factor which is worth less than one (K <1.0) precisely around 0.078-0.089 (Table 1).

Table 1 WB, LC, & Kof female P. *penicillatus*

WB (g)	LC (mm)	ln WB	ln LC	K
181	60.47	5.20	1.80	0.082
186	60.06	5.23	1.79	0.086
188	61.03	5.24	1.81	0.083
217	62.57	5.38	1.83	0.089
155	58.29	5.04	1.76	0.078
161	61.43	5.30	1.82	0.069
273	69.86	5.61	1.94	0.080

The pronghorn spiny lobster LC from Ekas Bay (Lombok) at the first time the gonad was matured (LCm) was 69.84 mm (Junaidi *et al*., 2010). Refer to Junaidi *et al*. (2010) and the results of sampling throughout July 2019 in Labangka, in the LC class frequency of 70.49-109.20 mm there were 19.32% LCm.

All pronghorn spiny lobster samples consisted of 7 females and 3 males (Table 2). Data collection was carried out one by one by weighing the body (WB) of the lobster, also measuring the length (LC) and width (WiC) of its carapace. While gonad data is collected through weighing (weight / GW) and measurements (length / GL and width / GWi) gonads.

Observation of sex is carried out according to the conditions agreed upon by the experts. The parts that are observed are the foot, gonophore, gonadophore, and pleopod (ovigerous setae) (Figure 3) (King, 2007; Yusnaini *et al*., 2009; Junaidi *et al*., 2010; Sukamto *et al*., 2017; Kintani, 2018). Observation of the sex of the Lobster is also carried out by testing the collecting trader traditions of who observe the uropod (Figure 4). Lobster received from fishermen is placed on a flat surface. If the uropods bloom (open) then the female sex. If the uropod is bud (closed), the sex is male. The observations of 97 lobster individuals on July 1st, 2019 using the traditions of Labangka lobster collecting traders resulted in an accuracy level of 97.94%. The authors call this method the term "Labangka Style".

Table 2 Carapace & gonad size of *P. penicillatus*

WB (g)	Carapace		Gonad			Sex
	LC (g)	WiC (mm)	GW (g)	GL (mm)	GWi (mm)	
181	60.47	47.32	0.87	47.00	8.00	Female
186	60.06	49.11	0.85	50.50	9.00	Female
188	61.03	47.96	0.81	42.50	9.00	Female
217	62.57	50.09	2.33	36.00	14.20	Female
155	58.29	47.80	0.28	20.50	4.09	Female
161	61.43	49.42	0.25	20.00	4.04	Female
273	69.86	54.63	1.62	33.50	11.06	Female
263	67.75	52.80	0.67	42.00	5.73	Male
271	72.20	56.06	0.75	24.00	6.78	Male
315	74.31	58.09	1.27	42.50	8.63	Male

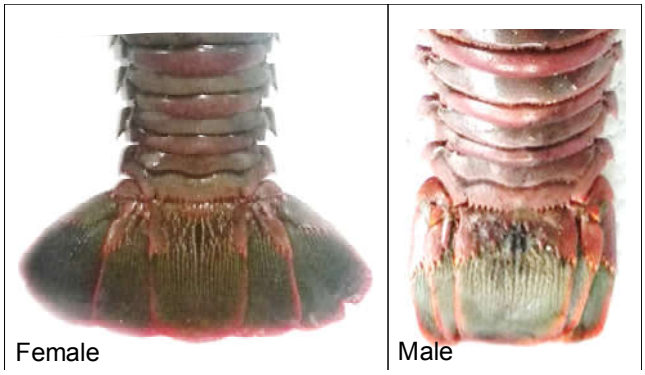

Figure 3 Female and male uropodof *P. penicillatus*

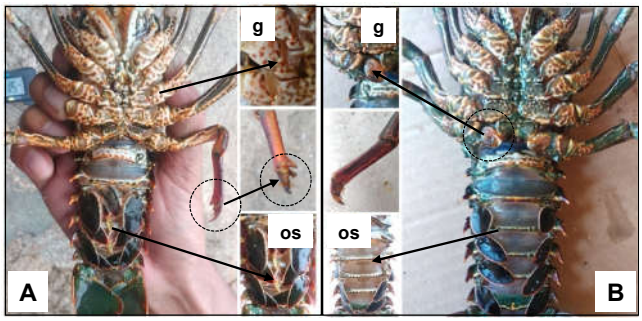

Figure 4 Secondary sexual characters of*P. penicillatus*: A = female, B = male, g = gonophore, os = ovigerous setae, ewl5 = end of walking legs 5th

Result of gonads and eggs identification were used to estimate the status of GML and GSI (Table 3). In female lobsters, GML II occurs at LC 58.29 mm. The LCm for GML III is 60.06 mm, and GML IV at LCm 62.57 mm. Whereas in male lobster, GML IV occurred at LCm 72.20 mm, and GML III at LCm 67.75 mm.

Table 3 GML and GSI of *P. penicillatus*

GML	Type of GSI (%)		
	GSI	GSI_L	GSI_{WI}
III	0.48	15.54	16.91
III	0.46	16.82	18.33
III	0.43	13.93	18.77
IV	1.07	11.59	28.35
II	0.18	7.15	8.56
II	0.15	6.54	8.17
IV	0.59	9.66	20.25
IV	0.25	12.47	10.85
V	0.28	6.68	12.09
V	0.40	11.57	14.86

Fecundity is the number of eggs obtained from a female lobster. Every individual in the same species of fish has different fecundity (Omar, 2005). Several factors that affect egg cell fecundity and diameter are genetic, seasonal, and environmental factors as well as age, length / weight of the individual, and species of fish.

The female *P. penicillatus* fecundity of Labangka ranges from 9,708 eggs to 46,545 eggs or an average of 25,137 eggs (Table 4). This amount is proportional to the fecundity of *P. penicillatus* in the waters of the Ekas Bay (Lombok), which ranges from 31,000 - 152,000 eggs (Junaidi *et al*., 2010).

Table 4 Egg and fecundity of *P. penicillatus*

Size	Egg Diameter (µm)	Fecundity (eggs/gonad)
Average	221.14	25,136.98
Most	276.00	46,545.00
Least	137.00	9.708.33

DISCUSSION

Spiny lobster seeds cultivated in Vietnam are mostly supplied from Indonesia. International trade in lobster seeds from Indonesia to Vietnam has the potential to disrupt the security, availability, and sustainability of lobster resource reserves in Indonesian waters. This concern is shown by the issuance of a regulation by the Minister of Marine Affairs and Fisheries of the Republic of Indonesia. The regulation consists of:(1) Regulation of the Minister of Marine Affairs and Fisheries Number 1 / PERMEN-KP / 2015 concerning Catching of Lobster (*Panulirus* spp.), Crab (*Scylla* spp.), and Small Crab (*Portunus* spp.), and (2) Regulation of the Minister of Marine Affairs and Fisheries Number: 56/PERMEN-KP/2016concerning Prohibition Catching and / or Shipping of Lobster (*Panulirus* spp.), Crab (*Scylla* spp.), and Small Crab (*Portunus* spp.) from the Republic of Indonesia.

Through these two regulations, the Government of the Republic of Indonesia has banned the activities of catching, trading and transporting spiny lobster seeds. The size of the spiny lobster that is legally caught, traded, and exported abroad is a consumption lobster that is LC more than 8.0 cm / individual or WB above 200 grams / individual. This measure is estimated to have reached the level of gonad maturity IV (GML IV) so it is safe to be caught by fishermen.

One species of spiny lobster that is commercialized and exported from Indonesia is pronghorn spiny lobster (*P.penicillatus*). This species is also called red spiny lobster by Hearn and Murillo (2008). While the people of Indonesia call it by the name "lobster batu".

The female red spiny lobster from Labangka reaches the first ripe gonad (LCm) at LC 62.57 mm. The LCm is the same as other red spiny lobster populations that live in coastal waters of Asia and Indonesia, which experience LCm at LC 56.46 - 69.84 mm. The contribution of female red spiny lobster in the LC 60-80 mm size class is 62.4% of the total egg production, the highest among all LC size classes (Chang *et al*., 2007). *P. penicillatus* from coastal waters of the Red Sea (Saudi Arabia) mature gonads at LC 40-50 mm (Hogarth and Barratt, 1996).While those from the waters of Ekas Bay (Lombok), LCm occurred at LC 69.84 mm (Junaidi *et al*., 2010). As for the southern coastal waters of Taiwan, the measure of

physiological maturity of 50% is LC 56.46 mm, and the size of functional maturity of 50% is 66.63 mm LC (Chang *et al*., 2007).LCm of the female red spiny lobster from Labangka is very relevant with similar lobsters from the coastal waters of Taiwan, Saudi Arabia, and Ekas Bay (Indonesia).

The female Taiwan red spiny lobsters big size (LC> 60 mm) tend to lay eggs in early spring, while smaller sizes (LC< 60 mm) lay eggs in summer (Chang *et al.*, 2007). Red spiny lobsters from the Ekas Bay water lay eggs in the period of June-November (Junaidi *et al*., 2010). Relevant to the research results of the two research groups, red spiny lobster caught in Labangka coastal waters in the summer (July 2019) is having a spawning season. The decision was shown by the level of gonad maturity which was dominated by GML III and GML IV.

Recruitment (addition of new individuals) red spiny lobster in Labangka waters occurs throughout the year in the May - September period (Figure 5). The peak of new individual additions took place in May (19.55%).

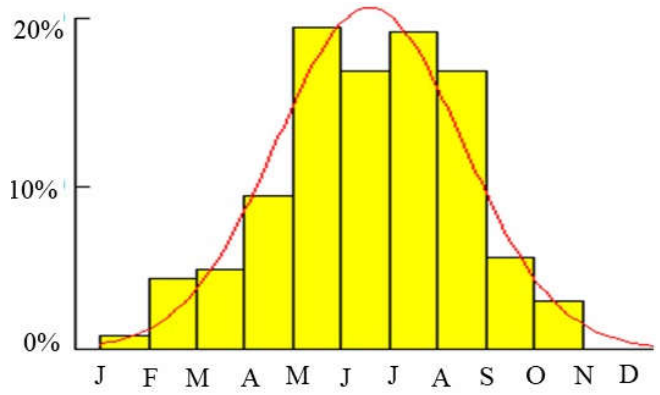

Figure 5 Labangka red spiny lobster annual recruitment pattern Based on the recruitment pattern, it is estimated / suspected lobster spawned throughout the year, and only one peak spawning season in a year. This is based on the recruitment peak pattern that occurs which means that in that month the lobster population is relatively abundant and exploited. This situation is relevant to Effendie's statement (2002) that recruitment is the addition of new individuals into the fishery resources stock caught by fishing gear. The addition of new individual fish resources in a waters area for each size class is very closely related to environmental conditions (Dodds, 2002)

CONCLUSION

Pronghorn spiny lobster from Labangka waters do spawning every month (January-December). The peak of spawning takes place in the dry season during May-August. Labangka pronghorn spiny lobster experiences gonad maturity level (GML) IV at CLm 62.57 mm and WB> 200 grams. When GML IV, the population in Labangka waters is estimated to reach around 28.57%. The eggs in GML IV have a diameter of 207-273 µm / egg and their fecundity is 41,701-46,545 eggs / gonad. It can be estimated that in each 1 cm of carapace length (LC) there are 6,663-6,665 eggs, or 171-192 eggs / gram of body weight. So the results of this study can be useful for lobster hatchery units around the world, especially those located in tropical waters. It is recommended to explore "Labangka Style" in observing the sex of lobsters for the enrichment of applied science scientifically. It is also recommended to conduct a study of the sustainable potential (MSY), gonad maturity, and fecundity of each species of spiny lobster to measure and evaluate the magnitude of the beneficial impact of the Indonesia Minister of Marine Affairs and Fishery's regulation regarding lobster capture after implemented and enforced since January 2015.

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