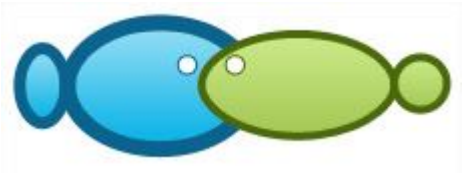

Biological aspects of genus *Thalamita* Latreille, 1829 (Decapoda: Portunidae) in Lasongko Bay, Southeast Sulawesi, Indonesia

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Abstract. The biological aspects of the genus *Thalamita* in Indonesia's waters have been rarely studied. This recent research aimed to study the diversity, size, carapace width-weight relationship, sex ratio, and spawning season of the genus *Thalamita* in Lasongko Bay, Southeast Sulawesi, Indonesia. Data collection was carried out each month starting from May 2013 to March 2014. The species samples of the genus were collected using gillnets. This research was successfully identified several species of the genus *Thalamita* in Lasongko Bay including *T. crenata, T. sima, T. spinimana,* and *T. prymna* with one exception of an unidentified *Thalamita* sp. The research also found that the carapace sizes of *T. crenata, T. sima,* and *T. spinimana* males were considerably bigger than that of the females. The relationship between carapace width-body weight and carapace length-body weight of the three *Thalamita* species were strongly and positively correlated and indicated a negative allometric growth type. One exception was the ratio of carapace width-body weight of *T. spinimana* which indicated an isometric growth. *T. crenata* and *T. spinimana* had unbalanced sex ratio whilst *T. sima* had a balanced sex ratio. The research had determined that the spawning season of *T. crenata, T. sima,* and *T. spinimana* occurred irregularly within a year period. This research has provided the first baseline information regarding the biological aspects of the genus *Thalamita* in Indonesia's waters.
Key Words: growth type, population characteristics, Portunid crabs, spawning season, sex ratio.

Introduction. The genus *Thalamita* is one of largest genera within the sub-family Portunidae and at least 66 species have been found in the Western Indo-Pacific (Wee & Ng 1995). *Thalamita* sp. is generally found in rocky and coral-covered seabeds (Moosa 1980; Wee & Ng 1995; Wahyudi 2008) as well as on sandy and muddy substrates (Moosa 1980; Wee & Ng 1995; Wahyudi 2008; Anggraeni et al 2015), mangrove vegetations (Moosa 1980; Cannicci et al 1996; Spiridonov 1999; Pratiwi & Widiyastuti 2013; Muhd-Farouk et al 2017) and seagrass areas (Moosa 1980; Moosa & Aswandy 1995; Pratiwi 2010, 2012; Anggraeni et al 2015). The vertical distribution of the genus *Thalamita* is from the intertidal area down to a depth of 100 m (Wee & Ng 1995; Spiridonov 1999; Wahyudi 2008; Anggorowati 2014).

The research regarding the biological aspects of the genus *Thalamita* is currently limited where the most available species information of the genus is *T. crenata.* The available limited information and research on the genus *Thalamita* ranged from taxonomy, phenetics, and ecology of the genus (Stephenson 1975; Wee & Ng 1995; Spiridonov 1999; Spiridonov & Neumann 2008; Wahyudi 2008; Spiridonov 2017) and of *T. cerasma* in particular (Naruse & Shokita 2003), population dynamics of *T. danae* (Yau 1992), food types of *T. danae* and *T. sima* (Williams 1981), biological reproduction of *T. sima* (Norman 1996), spawning behavior of *T. picta* (Norman et al 1999), the genetics of *T. danae, T. admete, T. savignyi,* and *T. sima* (Naz et al 2017; Zhong et al 2018), to

heavy metal accumulation on *T. prymna* (Mehdi et al 2013). Specific research on *T. crenata* dwelled in the biological aspect (Oyama 1968; Thomas 1984; Sigana 2002; Songrak et al 2010; Susanto & Irnawati 2014; Muhd-Farouk et al 2017), food and feeding habit (Williams 1981; Cannicci et al 1996), ecology (Kunsook et al 2010), behavior (Cannicci et al 2000); biochemistry (Thomas 1984; Kannupandi et al 1999), genetics (Naz et al 2017), and heavy metal accumulation in the body of the species (Chen et al 2005).

Database regarding the distribution of the genus *Thalamita* in Indonesia was primarily sourced from taxonomy and crustacean studies such as Stephenson (1975), Moosa (1980), Spiridonov (1999), Pratiwi (2010, 2012), Pratiwi & Widiyastuti (2013), Anggorowati (2014), Anggraeni et al (2015) and Hamid & Wardiatno (2018a). The first and only study to assess the biological aspects of *Thalamita* in Indonesia was conducted by Susanto & Irnawati (2014) focusing on the relationship between carapace width-length and body weight of *T. crenata*. Such data discrepancy has been the main drawbacks in the management of capture, culture, and conservation of the genus (Ikhwanuddin et al 2009; Kamrani et al 2010; Hamid et al 2016a; Muhd-Faruok et al 2017).

The genus *Thalamita* is included as an economically valued crab species despite its lower price in the market due to its relatively small size (Wee & Ng 1995; Ng 1998; Susanto & Irnawati 2014; Muhd-Farouk et al 2017; Santhanam 2018). In addition, the genus is generally considered as a bycatch in *Portunus pelagicus* capture industry in the Southeast Asia (Kunsook et al 2010; Songrak et al 2010) and in Lasongko Bay, Southeast Sulawesi, in particular, where its biological aspects are largely unknown. This research aimed to study the species types, sizes, carapace width and length relationships, sex ratios and spawning seasons of the genus *Thalamita* in Lasongko Bay, Southeast Sulawesi, Indonesia.

Material and Method

Study site. The research was conducted in Lasongko Bay, Central Buton Regency, Southeast Sulawesi Province. Lasongko Bay is situated between 05°15'-05°27'S and 122°27'-122°33'E. The sampling sites consisted of 6 sampling stations located within the bay and distributed randomly starting from the upstream to the center of the bay (Figure 1). The environmental characteristics of each station are listed in Table 1. The research lasted for 11 months starting from May 2013 to March 2014.

Table 1

The environmental characteristics of sampling stations where Thalamita was collected in Lasongko Bay, Southeast Sulawesi, Indonesia

Station	*Environmental characteristics*
1	It is located in the most inner part of the bay and narrow. The seabed is partly covered by seagrass and bare area with sand and sand clay substrate. Water depth ranged from 0.35 to 6.10 m. The seaggrass bed is less dense, and is dominated by *Enhalus acoroides*. It is also surrounded by mangrove tress.
2	It is located in the outermost of inner part of the bay. The seabed is some covered by seagrass and is some bare area. Water depth ranged from 0.35-6.60 m with sandy to rocky substrate. The dominant seagrass species is *Thalassia hemprichii* with low density, and there is thin mangrove area along the coastline.
3	It is located in the outer most of inner part of the bay and the position is the opposite of Station 2. The seabed in some area is covered moderately dense of *T. hemprichii*. The water depth ranged 0.62 to 8.85 m. The type of substrate varies from sandy to sandy clay.
4	It is located at the center of the bay. The seabed is partly dominated by moderately dense *T. hemprichii.* The water depth ranged from 0.40 to 13.02 m. There is variation of substrate type as in Station 3.
5	It is located in the center of the bay, and the environmental condition is similar to the Station 4, except the water depth which ranged from 0.35 to 9.50 m.
6	The position is in subtidal area with sandy to clay-loamy sand substrate. The water depth ranged from 3.65 to 9.55 m.

Source: adapted from Hamid (2015) and Hamid et al (2016b)

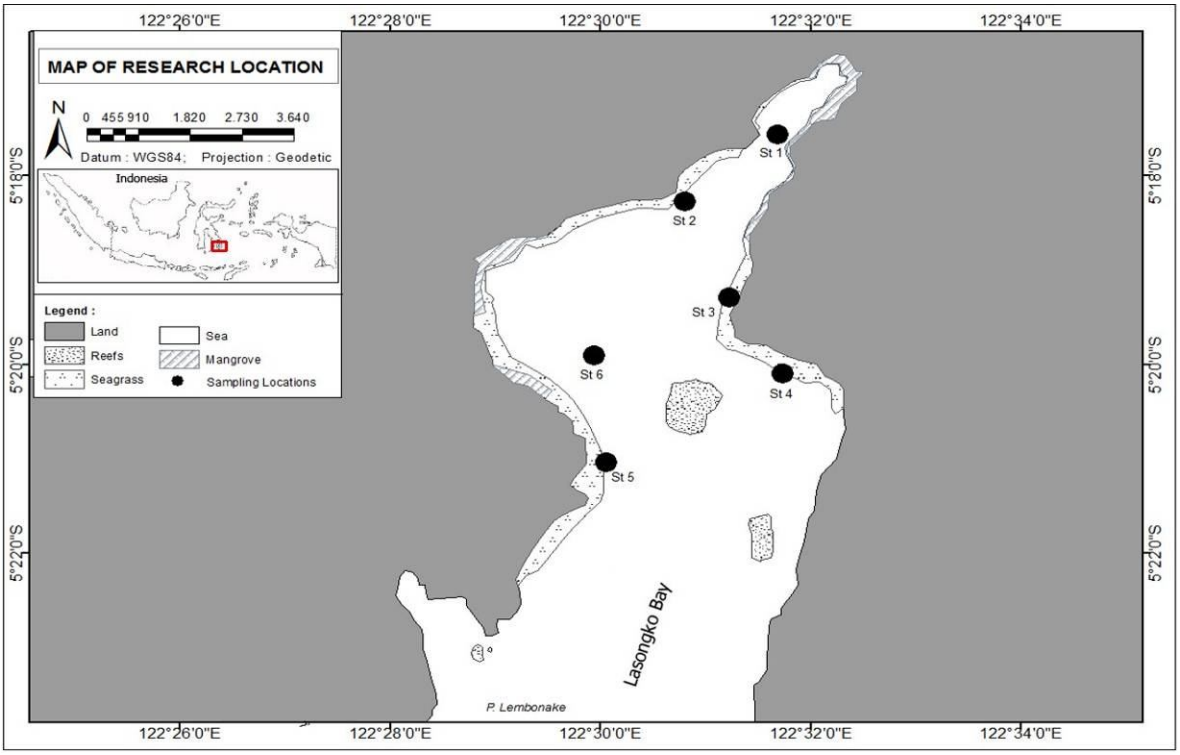

Figure 1. Study site and locations of sampling stations in Lasongko Bay (Map source were modified from Hamid 2015).

Data collection and measurement. Sample collection was carried out each month at each sampling station using bottom gillnets. The gillnets were placed on the seabed in the afternoon and left for 12 hours before lifted in the next morning. *Thalamita* caught in each gillnet were separated and counted based on species, sex type, and ovigerous/non-ovigerous females. The collected *Thalamita* were identified based on the method suggested by Wee & Ng (1995) and Ng (1998). The weight of each individual species was scaled using a digital scale (Xon Med Digital Scale) of 0.01 g accuracy, whilst the carapace width and length were measured using a Vernier Caliper with 0.05 mm measurement accuracy.

The relationship between carapace width-length and body weight of each *Thalamita* species was calculated using Power Equation (Hartnoll 1978; Josileen 2011; Hamid 2015) as follows:

$$BW = aCW^b \quad \text{..... (1)}$$

where: BW = body weight (g);
CW = carapace width (mm);
a = intercept;
b = *Thalamita* growth coefficient.

Equation 1 is log transformed (log_{10}) resulting in a linear equation as follows:

$$\text{Log BW} = \log a + b\text{Log CW} \quad \text{..... (2)}$$

The spawning season of each *Thalamita* species was estimated from the appearance of ovigerous females (Sukumaran 1995; Kamrani et al 2010; Hamid et al 2015; Ernawati et al 2017). The sex ratio of each species of *Thalamita* was defined as the ratio of the total number of females divided by the total number of males calculated using Hamid (2015) equation as follows:

$$\text{Sex ratio} = \frac{\sum \text{Female}}{\sum \text{Male}} \quad \text{..... (3)}$$

Data analysis. The data used to determine the relationship between carapace width-length and body weight of each *Thalamita* species was the total combination data of female and male of each species. The closeness relationship between carapace width-length and body weight was determined based on the value of the regression coefficient of each species (Steel & Torrie 1992). Growth type in relation to width-length and body weight relationship of each *Thalamita* species was determined based on the b value after being tested by t test with b = 3 at p = 0.05 (Steel & Torrie 1992). Growth type based on carapace width-length and body weight was determine based on Hartnoll (1978) and Josileen (2011) classification which is isometric if b = 3, negative allometric if b < 3, and positive allometric if b > 3. The sex ratio of each *Thalamita* species was tested on 1:1 sex ratio using chi-square test (χ^2) at p = 0.05 (Steel & Torrie 1992).

Results

Species and abundance. The study had found five species of the genus *Thalamita* in Lasongko Bay: *T. crenata, T. sima, T. spinimana, T. prymna,* and *Thalamita* sp. The total abundance of the genus *Thalamita* during the sampling collection was 264 individuals, consisting of 180 males and 84 females. and at each station it was found 12-110 individuals (Table 2). As many as 14-43 individuals were collected each month excluding the month of December where none was found (Table 2). None of *T. prymna* and *Thalamita* sp. females were found during the study period.

Table 2

Species and relative abundance of *Thalamita* at each sampling station and at each sampling period in Lasongko Bay, Southeast Sulawesi, Indonesia

Station)*	*Species relative abundance (ind.)*					*Total (ind.)*
	T. crenata	*T. sima*	*T. spinimana*	*T. prymna*	*Thalamita* sp.	
1	26	4	5	-	-	35
2	37	35	33	1	4	110
3	3	17	47	1	1	69
4	2	3	6	-	1	12
5	6	1	12	-	-	19
6	3	5	8	3	-	19
Month	*Species abundance (ind.)*					*Total (ind.)*
	T. crenata	*T. sima*	*T. spinimana*	*T. prymna*	*Thalamita* sp.	
May	4	4	19	1	1	29
June	6	4	14	-	1	25
July	1	12	2	-	4	19
August	9	7	14	1	-	31
September	9	-	6	2	-	17
October	10	-	9	-	-	19
November	19	-	17	-	-	36
December	-	-	-	-	-	-
January	2	2	10	-	-	14
February	6	24	13	-	-	43
March	11	12	7	1	-	31
Total	77	65	111	5	6	264

Note: * *Thalamita* data of each station was extracted from Hamid & Wardiatno (2018a); "-" = not found.

Carapace size. The size of the carapace of each *Thalamita* species found in Lasongko Bay is presented in Table 2. The carapace width of male and female *T. crenata* ranged between 3.02-7.32 cm and 2.51-6.13 cm respectively, and *T. sima* ranged between 2.57-6.01 cm and 3.01-6.22 cm respectively. The carapace width of male and female *T. spinimana* ranged between 2.57-7.89 cm and 3.35-6.41 cm respectively, and male *T. prymna* ranges from 4.66-7.68 cm and *Thalamita* sp. males range from 4.26-5.44 cm (Table 3).

Table 3

Male and female carapace sizes of genus *Thalamita* in Lasongko Bay, Southeast Sulawesi, Indonesia

Species	Male carapace width (cm)			Male carapace length (cm)		
	Min	Average± SD	Max	Min	Average± SD	Max
T. crenata	3.02	4.84±0.99	7.32	1.99	3.15±0.68	4.83
T. sima	2.57	4.62±0.74	6.01	1.92	2.90±0.42	3.75
T. spinimana	2.57	5.63±1.04	7.89	1.92	3.61±0.76	4.32
T. prymna	4.66	6.08±1.33	7.68	3.03	4.12±0.96	5.58
Thalamita sp.	4.26	4.88±0.40	5.44	2.75	3.03±0.18	3.15
Species	*Female carapace width (cm)*			*Female carapace length (cm)*		
T. crenata	2.51	4.23±1.02	6.13	1.61	2.86±0.71	4.19
T. sima	3.01	3.86±0.68	6.22	1.89	2.50±0.51	4.17
T. spinimana	3.35	5.00±0.70	6.41	2.13	3.26±0.48	4.05

The relationship between carapace width-length and body weight. The relationship between carapace width-length and body weight of the three *Thalamita* species is presented in Table 4 and Figure 2. There was a close and positive correlation between carapace width and length of the three *Thalamita* species indicated by correlation coefficients ranging between 0.913-0.963. The b values of *T. crenata* and *T. sima* were significantly different ($p < 0.05$) ($b = 3$) indicated a negative allometric growth whilst *T. spinimana* showed no significant difference ($p > 0.05$) with $b = 3$ and an isometric growth.

Table 4

The relationship between carapace width-length and body weight, coefficient correlation (r), t-test of b value and growth type of three *Thalamita* species in Lasongko Bay, Southeast Sulawesi, Indonesia

Species	Linear equation	r	t-test (b=3)	Growth type
	The relationship between carapace width and body weight			
T. crenata	Log BW = - 0.073 + 2.173 log CW	0.931	9.325*	Allometric negative
T. sima	Log BW = - 0.415 + 2.494 log CW	0.944	6.145*	Allometric negative
T. spinimana	Log BW = - 0.727 + 3.007 log CW	0.950	0.045^{ns}	Isometric
	The relationship between carapace length and body weight			
T. crenata	Log BW = 0.318 + 2.157 log CL	0.913	6.812*	Allometric negative
T. sima	Log BW = 0.078 + 2.342 log CL	0.922	6.115*	Allometric negative
T. spinimana	Log BW = -0.086 + 2.822 log CL	0.963	2.592*	Allometric negative

*significantly different ($p < 0.05$); ns = not significantly different ($p > 0.05$).

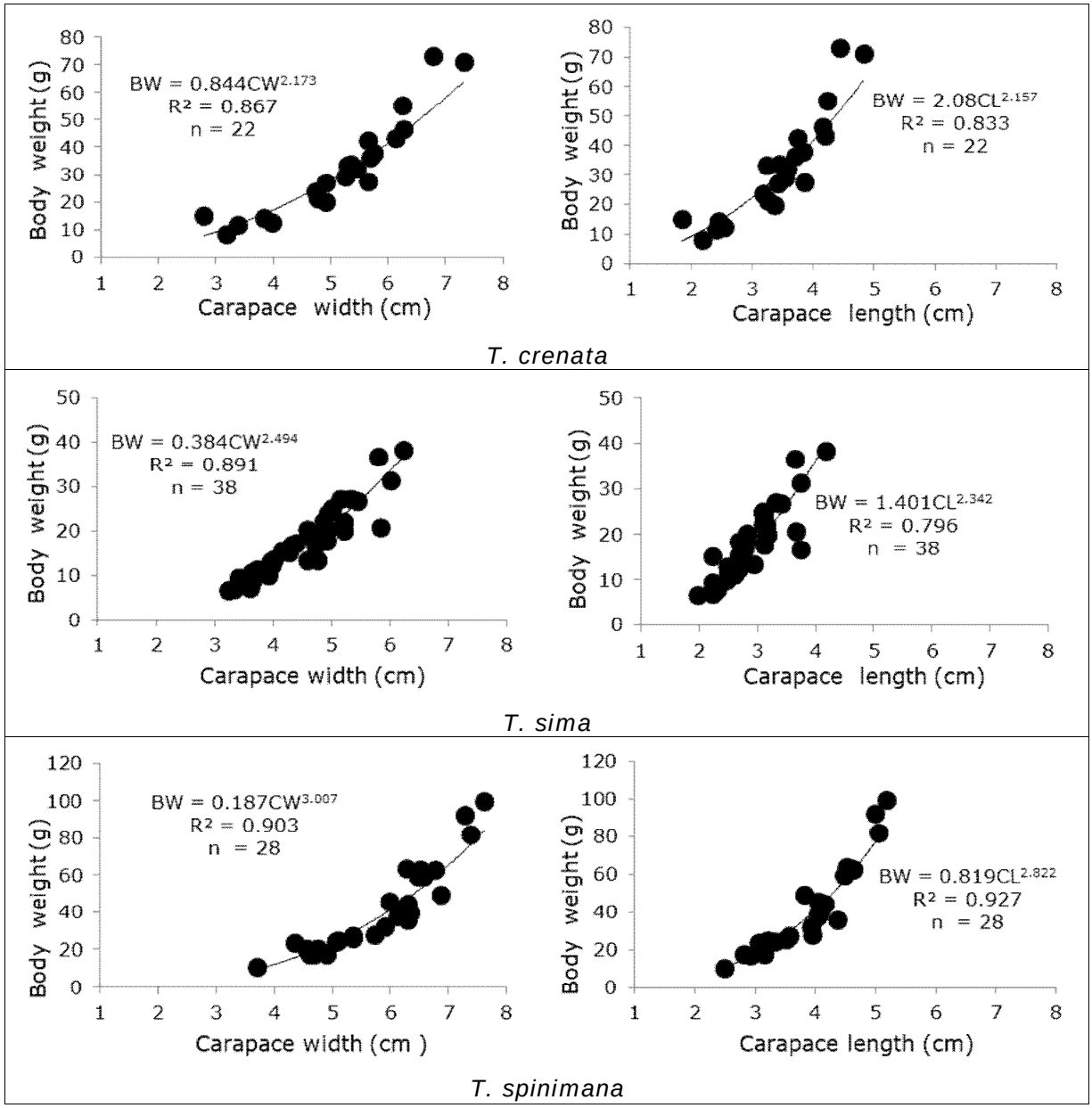

Figure 2. The relationship between carapace width-length and body weight of three *Thalamita* species in Lasongko Bay, Southeast Sulawesi, Indonesia, i.e. *Thalamita crenata, T. sima* and *T. spinimana*.

The carapace length and body weight of the three *Thalamita* species were also had a strong and positive correlation indicated by the range of coefficient correlation of 0.913-0.963 (Table 4). The growth coefficient (b) of the relationship between carapace length and body weight of the three species of *Thalamita* < 3, and t-test result of b values was significantly different ($p > 0.05$) with b = 3, and the growth type of the three species was negative allometric (Table 4).

Sex ratio. Number of *T. crenata* and *T. spinimana* males was twice more compared to the number of the female whereas *T. sima* had a relative balanced number of male and female (Table 5). The sex ratio of *T. crenata* was 1:0.40, *T. sima* was 1:1.03 and *T. spinimana* 1:0.36. The χ^2 test result revealed that *T. sima* was not significantly different ($p > 0.05$) with 1:1, whilst the other two *Thalamita* species were significantly different ($p < 0.05$) with a sex ratio of 1:1 (Table 5).

Table 5

Proportion and sex ratio of male and female of *Thalamita* in Lasongko Bay

Species	Number (ind.)		Proportion (%)		Sex ratio
	Male	Female	Male	Female	Male:female
T. crenata	55	22	71.43	28.57	1:0.40*
T. sima	32	33	49.23	50.77	1:1.03^{ns}
T. spinimana	81	29	73.87	26.13	1:0.37*

* Significant ($p < 0.05$); ns = not significant ($p > 0.05$).

Ovigerous female and spawning season. The proportion of ovigerous females of *T. sima* from the total female collected during the sampling campaign was the highest (96.97%), followed by *T. crenata* (90.91%), and the least was *T. spinimana* (31.03%) (Table 6). The largest number of the ovigerous females for *T. crenata* and *T. sima* was found at station 2 while *T. spinimana* ovigerous female was dominantly found at station 3 (Table 6). The carapace sizes of the ovigerous females of *T. crenata* and *T. sima* were relatively similar with the non-ovigerous (Table 3), whereas the carapace widths of *T. spinimana* ovigerous female ranged between 3.70 and 5.91 cm.

Table 6

Spatial-temporal collection record and proportion of ovigerous female (OF) of *Thalamita* in Lasongko Bay, Southeast Sulawesi, Indonesia

Station	T. crenata (ind.)		T. sima (ind.)		T. spinimana (ind.)	
	Female	OF	Female	OF	Female	OF
1	6	5	-	-	1	-
2	12	11	22	21	7	3
3	1	1	7	7	15	6
4	-	-	2	2	1	1
5	2	2	-	-	5	-
6	1	1	2	2	-	-
Sampling time	T. crenata (ind.)		T. sima (ind.)		T. spinimana (ind.)	
	Female	OF	Female	OF	Female	OF
May	-	-	3	3	6	1
June	1	1	-	-	2	-
July	1	1	10	10	1	1
August	-	-	7	7	1	1
September	2	2	-	-	2	-
October	1	-	-	-	4	-
November	8	8	-	-	4	-
December	-	-	-	-	-	-
January	2	2	-	-	4	2
February	3	2	9	8	4	4
March	4	4	4	4	1	-
Total (ind.)	22	20	33	32	29	9
OF proportion (%)		90.91		96.97		31.03

Note: - = not found.

The ovigerous females of *T. crenata, T. sima,* and *T. spinimana* were not found consistently in each month (Table 6) which indicated that the spawning season of the three species of *Thalamita* was not all year round. The peaks of spawning season of *T. crenata, T. sima* and *T. spinimana* in Lasongko Bay was estimated to occur in the month of November, July, and February, respectively.

Discussion

Number of species and body size. The most occurring species of *Thalamita* found in Lasongko Bay was *T. spinimana,* whilst *T. prymna* and *Thalamita* sp. were rarely found. The abundances of the genus *Thalamita* at Station 2 and 3 were higher compared to that of the other four stations (Table 2). The two stations have a rocky intertidal area which is a preferred habitat by the genus *Thalamita* (Wee & Ng 1995; Wahyudi 2008). The genus *Thalamita* in Lasongko Bay was dominantly found at the lower part of the intertidal area compared to the subtidal area. The lower intertidal area was covered by patchy seagrass vegetation with a sandy seabed. The subtidal area had no seagrass coverage and was dominated by muddy sand seabed (Hamid et al 2016b).

There were more species of *Thalamita* found in this research compared to that of found in Lampung Bay (Pratiwi 2010), Pulau Tikus, Seribu islands (Pratiwi 2012; Anggraeni et al 2015) and Matasiri (Pratiwi & Wijaya 2013). In total, there are 32 species of *Thalamita* that have been found and identified in Indonesia's waters where 21 species were reported by Moosa (1980), Spiridonov (1999), Pratiwi (2012), Pratiwi & Wijaya (2013), Anggorowati (2014), and Anggraeni et al (2015) in varying individuals among locations (Table 7). The expedition Snellius II in Indonesia's waters had found 21 spesies of *Thalamita* where 9 species among them were not included by the studies above. These species were *T. demani, T. gracilipes, T. koepangensis, T. parvidens, T. platypenis, T. poissonii, T. quadrilobata, T. spinimera,* and *T. woodmasoni* (Stephenson 1975). In waters of Sumatra peninsula, two species of Thalamita were found, *T. pelsarti* and *T. sexlobata* (Wee & Ng 1995). In Sunda strait, one new species of *Thalamita* was found, *T. williami* sp. n (Spiridonov 2017). The total number of *Thalamita* species found in Indonesia's waters is more than what has been found in Malaysia peninsula and Singapore which was only 17 species (Wee & Ng 1995).

Table 7

Thalamita species found in Indonesia

Location	*Species*	*Source*
Jakarta Bay	*T. crenata, T. spinimana, T. prymna, T. danae, T. foresti, T. holthuisi*	Moosa (1980)
Ambon	*T. crenata, T. admete, T. carinata, T.* cf. *chaptali, T. caeruleipes, T. cooperi, T. danae, T. granosimana, T.* cf. *mitsiensis, T. picta, T.* cf. *philippinensis philippinensis, T. prymna, T. sima, T. stephensoni*	Spiridonov (1999)
Lampung Bay	*T. crenata, T. danae*	Pratiwi (2010)
Tikus Island, Seribu Islands	*T. crenata, T. danae, T. stephensoni*	Pratiwi (2012)
Matasiri Islands	*T. danae, T. integra, T. mitsiensis*	Pratiwi & Wijaya (2013)
West Lombok, NTB	*T. sima, T. chaptali, T. dentatus, T. admete, T. danae, Thalamita* sp.	Anggorowati (2014)
Tikus Island, Seribu Islands	*T. crenata, T. admete, T. cooperi, T. integra*	Anggraeni et al (2015)
Lasongko Bay	*T. crenata, T. sima, T. spinimana, T. prymna, Thalamita* sp.	Hamid & Wardiatno (2018a); this research

The genus *Thalamita* is considered a small crab in size and currently traded locally. The body size of *T. prymna* found in this study was the largest, and *T. sima* was the smallest (Table 3). The carapace width of *T. prymna* found in this study was wider compared to that of the same species found in Malaysia peninsula which was 7.17 cm (Wee & Ng 1995). The maximum carapace width of *T. prymna* could reach 12 cm (Ng 1998). The male body sizes of *T. crenata, T. sima*, and *T. spinimana* found in Lasongko Bay were relatively larger compared to the female. This is similar to *T. crenata* found in Gazi Creek, Kenya (Sigana 2002) and Panjang island, Indonesia (Susanto & Irnawati 2014). In

contrast, the male body sizes of *T. crenata* found in Sikao Bay Thailand were smaller compared to the female (Songrak et al 2010). In addition, the body size of *T. crenata* found in this study was relatively smaller to that of found in Gazi Creek, Kenya (1.55-8.55 cm) (Sigana 2002), Sikao Bay Thailand (3.52-8.12 cm) (Songrak et al 2010), Panjang island, Indonesia (4.0-7.8 cm) (Susanto & Irnawati 2014) and in Setu-Trenggano, Malaysia (3.89-8.19 cm) (Muhd-Farouk et al 2017), but relatively larger compared to those found in Cochin, India (1.1-7.0 cm) (Thomas 1984) and Ambon, Indonesia (1.5-3.35 cm) (Spiridonov 1999). The carapace width of the largest male of *T. sima* found in this study was relatively the same with those found Tetayama-Ciba, Japan which were about 6.15 cm and smaller for females which were 5.44 cm (Norman 1996). The differences in body sizes of the genus *Thalamita* at different locations is suspected to be caused by the differences in habitat condition, food availability, and genetics.

The carapace width of *T. crenata* ovigerous females found in Lasongko Bay ranged between 2.51 and 6.13 cm, which was larger compared to that of found in Cochin, India (4.6-5.0 cm) (Thomas 1984) and in Gazi Creek, Kenya (4.05-5.05 cm) (Sigana 2002). The carapace width of *T. sima* ovigerous females found in Tetayama-Chiba, Japan ranged between 2.8 and 3.0 cm (Norman 1996) which was smaller compared those found in this study (3.01-6.22 cm) (Table 3). The carapace widths of *T. picta* ovigerous females found in Tetayama-Ciba, Japan and adult *T. danae* found in Hong Kong waters were 0.76 cm in average (Norman et al 1999) and 2.5-6.1 cm (Yau 1992), respectively.

The relationship between carapace width-length and body weight. The growth coefficient (b) of the relationship between carapace width-length and body weight of *T. spinimana* was the largest whilst the smallest was *T. crenata* (Table 4). This finding indicates that the growth of *T. spinimana* is faster compared to *T. sima* and *T. crenata*. The b values of the relationship between carapace width-length and body weight of *T. crenata* found in different locations waters (Table 8) are 2.173-2.873 and 2.157-3.0278. The b values of the relationship between carapace width-length and body weight of *T. crenata* in Lasongko Bay was smaller compared to that of found in Sikao Bay, Thailand (Songrak et al 2010) and Panjang Island, Indonesia (Susanto & Irnawati 2014) but greater compared to the b value of *Charybdis anidoson* females in the same location (Hamid & Wardiatno 2018b). The b value of *T. crenata* found in this study was smaller compared to that of found in Cochin, India (Thomas 1984) and Panjang Island, Indonesia (Susanto & Irnawati 2014). The b values of *T. sima* and *T. spinimana* were larger compared to the b value of *C. anidoson* females found in Lasongko Bay (Hamid & Wardiatno 2018b).

Table 8

Growth coefficient (b), regression coefficient (r) and growth type of *T. crenata* found in different waters

Location	*Relationship*	*b*	*r*	*Growth type*	*Source*
Cochin, India	CL-BW male	3.002	0.982	Isometric	Thomas (1984)
	CL-BW female	2.916	0.974	Isometric	
	CL-BW mix	2.969	0.978	Isometric	
Sikao Bay, Thailand	CW-BWmix	2.873	0.9077	Allometric Negative	Songrak et al (2010)
Panjang Island, Indonesia	CW-BW male	2.8247	0.9003	Allometric Negative	Susanto & Irnawati (2014)
	CW-BW female	2.7433	0.8382	Allometric Negative	
	CL-BW male	3.0278	0.9075	Isometric	
	CL-BW female	2.7433	0.8456	Allometric Negative	
Lasongko Bay, Indonesia	CW-BWmix	2.173	0.931	Allometric Negative	This research
	CL-BW mix	2.157	0.913	Allometric Negative	

Note: CW = carapace width; CL = carapace length; BW = body weight

The relationship between carapace width-length and body weight of *T. crenata, T. sima* and *T. spinimana* had a strong and positive correlation and was closely resembling with that of *T. crenata* in Cochin, India (Thomas 1984), Sikao Bay, Thailand (Songrak et al 2010), and Panjang island, Indonesia (Susanto & Irnawati 2014), as well as *C. anisodon* in Lasongko Bay, Indonesia (Hamid & Wardiatno 2018b). The growth type based on the relationship between carapace width-length and body weight of the three *Thalamita* species was generally a negative allometric with one exception of *T. spinimana* which was isometric (Table 4). The growth type carapace width-body weight of *T. crenata* in this study was similar to that of found in Sikao Bay, Thailand (Songrak et al 2010) and identically similar to that of found in Panjang island, Indonesia with one exception of the growth type for carapace length and body weight of *T. crenata* male which was isometric (Susanto & Irnawati 2014, Table 8) and similar to that of found in Cochin, India (Thomas 1984). Crabs with allometric growth type are considered as lean crabs because the growth of carapace width or length is faster than the growth of body weight (Sunarto et al 2010; Okon & Sikoki 2014).

Sex ratio and spawning season. The sex ratio of *T. sima* found in Lasongko Bay was considered balanced whilst *T. crenata* and *T. spinimana* were not. The sex ratios of *T. crenata* in Cochin, India (Thomas 1984) and Sikao Bay, Thailand (Songrak et al 2010) were balanced whilst in Panjang island, Indonesia (Susanto & Irnawati 2014) was identically similar to that of Lasongko Bay where the proportion of male was higher compared to female. The sex ratios of *T. crenata* found in Cochin, India (Thomas 1984) and in Gazi Creek, Kenya (Sigana 2002) were temporally balanced whilst based on the class size of the carapace, both populations were not balanced. Based on the sex ratio, *T. crenata* males could potentially fertilize more than one female whilst *T. spinimana* males could fertilize as many as three females during a mating season. The imbalanced proportion between male and female crabs could potentially reduce the success rate of spawning of this genus (Hamid et al 2016a).

The ovigerous females of *T. crenata, T. sima* and *T. spinimana* in Lasongko Bay were not found consistently each month during the one year period of the research. The ovigerous females of *T. crenata* were absent in the months of May, June, August, October, and December. The ovigerous females of *T. sima* were only caught in May, July, August, February, and March and *T. spinimana* females were only found in May, July, August, January and February (Table 6). This finding suggested that the spawning season of the three species in Lasongko Bay did not occur consistently throughout the year. The number of ovigerous females of the three species of *Thalamita* was relatively low. However, the proportion of ovigerous females for *T. crenata* and *T. sima* was considered high. This study suggests that subsequent detailed studies regarding the existence of ovigerous females and spawning season of each *Thalamita* species in Lasongko Bay need to be undertaken in Lasongko Bay by increasing sampling frequencies and covering larger areas.

The ovigerous females of *T. crenata* in Gazi Creek, Kenya were found throughout the year, in which, September and January were considered the peaks of the spawning season (Sigana 2002). Similar spawning consistency was also observed for the same species in Kun Kreng Bay, Thailand although peaked at different months which were in March and October (Kunsook et al 2010). The ovigerous females of *T. sima* found in Tateyama-Ciba, Japan were identified every month with the peak spawning seasons occurred between April and October (Norman 1996). In contrast, the ovigerous females of *T. danae* found in Hongkong were not found in each month throughout the year with the peak spawning seasons occurred between March-April, and July-September (Yau 1992). The ovigerous females of *C. anisodon* in Lasongko Bay were found every month throughout the year with the peak spawning seasons occurred in November and February (Hamid & Wardiatno 2018b).

Conclusions. The species of *Thalamita* found in Lasongko Bay were identified as *T. crenata, T. sima, T. spinimana, T. prymna,* and *Thalamita* sp. The body sizes of *T. crenata* males*, T. sima, and T. spinimana* were larger than that of the female. The

carapace width and the body weight and the carapace length and the body weight of *T. crenata, T. sima, T. spinimana* strongly and positively correlated. The growth type of all *Thalamita* species was classified as negative allometric with one exception for *T. spinimana* which was isometric. The sex ratio of *T. crenata* and *T. spinimana* was not balanced whilst *T. sima* was balanced. The spawning period of the three *Thalamita* species showed an inconsistency throughout the year based on the existence of ovigerous females. This study successfully provides a baseline information regarding several biological aspects of the genus *Thalamita* in Lasongko Bay and could be used in the management of the genus stock in Indonesia. However, future research to study the genus biological reproduction and population dynamics are needed in order to ensure a comprehensive management and conservation of the genus *Thalamita*.

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References

Anggorowati D. A., 2014 [Community structure of crustacean fauna at the intertidal zone of west Lombok]. Jurnal Zoologi Indonesia 23(2):92-100. [in Indonesian]

Anggraeni P., Elfidasari D., Pratiwi R., 2015 [Brachyuran crab distribution in Tikus Island, Pari Island group, Seribu Islands]. Prosiding Seminar Nasional Masyarakat Biodiversitas Indonesia 1(2):213-221. [in Indonesian]

Cannicci S., Dahdouh-Guebas F., Anyona D., Vannini M., 1996 Natural diet and feeding habits of *Thalamita crenata* (Decapoda: Portunidae). Journal of Crustacean Biology 16(4):678-683.

Cannicci S., Barelli C., Vannini M., 2000 Homing in the swimming crab *Thalamita crenata*: a mechanism based on underwater landmark memory. Animal Behaviour 60:203-210.

Chen M. H., Chen C. Y., Chou H. Y., Wen T. C., 2005 Gender and size effects of metal bioaccumulation on the rock crab, *Thalamita crenata*, in Dapeng Bay, southwestern Taiwan. Marine Pollution Bulletin 50:463-484.

Ernawati T., Sumiono B., Madduppa H., 2017 Reproductive ecology, spawning potential, and breeding season of blue swimming crab (Portunidae: *Portunus pelagicus*) in Java Sea, Indonesia. Biodiversitas 18(4):1705-1713.

Hamid A., 2015 [Habitat, reproductive biology and population dynamics of the blue swimming crab (*Portunus pelagicus* Linnaeus, 1758) as a basic of its management at Lasongko Bay, Southeast Sulawesi]. PhD Dissertation, Graduate School, Bogor Agricultural University, Bogor, 164 pp. [in Indonesian]

Hamid A., Wardiatno Y., 2018a Diversity of decapod crustaceans in Lasongko Bay, Southeast Sulawesi, Indonesia. Biodiversity Journal 9(3):303-311.

Hamid A., Wardiatno Y., 2018b Biological aspects of *Charybdis anisodon* (De Haan, 1850) in Lasongko Bay, Central Buton, Southeast Sulawesi, Indonesia. Biodiversitas 19(5):1755-1762.

Hamid A., Wardiatno Y., Lumban Batu D. T. F., Riani E., 2015 [Fecundity and gonad maturity stages of ovigerous female blue swimming crab (*Portunus pelagicus*) in Lasongko Bay, Southeast Sulawesi]. Bawal 7(1):43-50. [in Indonesian]

Hamid A., Lumban Batu D. T. F., Riani E., Wardiatno Y., 2016a Reproductive biology of blue swimming crab (*Portunus pelagicus* Linnaeus, 1758) in Lasongko Bay, Southeast Sulawesi-Indonesia. AACL Bioflux 9(5):1053-1066.

Hamid A., Wardiatno Y., Lumban Batu D. T. F., Riani E., 2016b Distribution, body size, and eggs of ovigerous swimming crab (*Portunus pelagicus* Linnaeus, 1758) at various habitats in Lasongko Bay, Central Buton, Indonesia. International Journal of Aquatic Biology 4(2):108-116.

Hartnoll R. G., 1978 The determination of relative growth in crustacea. Crustaceana 34(3):281-293.
Ikhwanuddin M., Shabdin M. L., Abol-Munafi A. B., 2009 Cath information of blue swimming crab (*Portunus pelagicus*) from Sarawak coastal water of South China Sea. Journal of Sustainability Science and Management 4(1):93-103.
Josileen J., 2011 Morphometrics and length-weight relationship in the blue swimmer crab, *Portunus pelagicus* (Linnaeus, 1758) (Decapoda, Brachyura) from the Mandapam Coast, India. Crustaceana 84(14):1665-1681.
Kamrani E., Sabili A. N., Yahyavi M., 2010 Stock assessment and reproductive biology of the blue swimming crab, *Portunus pelagicus* in Bandar Abbas coastal waters, northern Persian Gulf. Journal of the Persian Gulf (Marine Science) 1(2):11-22.
Kannupandi T., Krishnan T., Sound Arapandian P., Shanmugam A., 1999 Yolk utilization in an estuarine edible crab *Thalamita crenata* (Latreille). Indian Journal of Fisheries 46(3):289-294.
Kunsook C., Surawut S., Pakdee W., Dumrongrojwatthana P., 2010 Distribution and abundance of spiny rock crab *Thalamita crenata* Latreille, 1826 at Kung Krabaen Bay, Chanthaburi Province, Thailand. Poster, Department of Biology, Faculty of Science and Technology, Rambhai Barni Rajabhat University, Chanthaburi, Thailand.
Mehdi H., Bagher N. S. M., Ali M., Maryam S., 2013 Mercury levels in selected tissues of blue crab *Thalamita prymna* (Portunidae) from Musa Estuary, of the Persian Gulf. Journal of the Persian Gulf (Marine Science) 4(14):33-38.
Moosa M. K., 1980 [Some notes about the crabs from the Jakarta Bay and Seribu Islands]. In: Marine biological resources: overview on some research results of Pelita II. 1980. Burhanuddin, Moosa M. K., Razak H. (eds), National Institute of Oceanography, Indonesian Institute of Sciences, Jakarta, pp. 42-51. [in Indonesian]
Moosa M. K., Aswandy I., 1994 [Crustaceans of seagrass beds in the waters of South Lombok]. In: Biological community structure of seagrass on the southern coast of Lombok and environmental conditions. Kiswara W., Moosa M. K., Hutomo M. (eds), Research Center for Oceanography, Indonesian Institute of Sciences, Jakarta, pp. 42-51. [in Indonesian]
Muhd-Farouk H., Amin-Safwan A., Arif M. S., Ikhwanuddin M., 2017 Biological information and size at maturity of male crenate swimming crab, *Thalamita crenata* from Setiu Wetlands, Terengganu coastal waters. Journal of Sustainability Science and Management 12(2):119-127.
Naruse T., Shokita S., 2003 A record of rare swimming crab, *Thalamita cerasma cerasma* Wee and Ng, 1995 (Decapoda: Brachyura: Portunidae) from Okinawa Island, Ryukyu Islands, Japan. Biological Magazine, Okinawa 41:43-49.
Naz F., Saher N. U., Kamal M., 2017 Isozyme Variations in the Genus *Thalamita* of family Portunidae from the Coastal Waters of Pakistan. Journal of Aquaculture & Marine Biology 6(1):00147.
Ng P. K. L., 1998 Crabs. In: FAO specis identification guide for fishery purposes. The living marine resources of the Western Central Pacific. Volume 2. Carpenter K. E., Niem V. H. (eds), FAO, Rome, pp. 1046-1155.
Norman C. P., 1996 Reproductive biology and evidence for hard-female mating in the brachyuran crab *Thalamita sima* (Portunidae). Journal of Crustacean Biology 16(4):656-662.
Norman C. P., Nuka P., Miyazaki T., 1999 Mating behaviour in *Thalamita picta* (Brachyura: Portunidae) and comparisons with congeneric species. Crustacean Research 28:16-23.
Okon E. A., Sikoki F. D., 2014 Length-weight relationship and condition factor of the West African fiddler crab (*Uca tangeri*) in MboRiver, AkwaIbom State, Nigeria. Journal of Natural Sciences Research 4(14):33-41.
Oyama S. N., 1968 Neuroendocrine effect on ovarian development in the crab *Thalamita crenata* Latreille in vitro. PhD Disertation, University of Hawaii, Hawaii, 69 pp.
Pratiwi R., 2010 [Crustaceans association in seagrass ecosystems of Lampung Bay waters]. Ilmu Kelautan 15(2):66-76. [in Indonesian]

Pratiwi R., 2012 [The species and Distribution Patterns in Seagrass Beds at Tikus Island, Thousand Islands]. Oseanologi dan Limnologi di Indonesia 38(1):43-55. [in Indonesian]
Pratiwi R., Widyastuti E., 2013 [Distributional patterns and zonation of crustaceans mangrove in Lampung Bay]. Zoo Indonesia 22(1):11-21. [in Indonesian]
Santhanam R., 2018 Biology and culture of portunid crabs of world seas. Apple Academic Press Inc., Waretown, NJ. USA, 404 pp.
Sigana D. O., 2002 Breeding cycle of *Thalamita crenata* (Latreille, 1829) at Gazi Creek (Maftaha Bay), Kenya. Western Indian Ocean Journal Marine Science 1(2):145-153.
Songrak A., Koedprang W., Wangpittaya A., 2010 Fishery biology of spiny rock crab (*Thalamita crenata* Latreille, 1829) in Sikao Bay, Trang Province, Thailand. Journal of Fisheries Technology and Aquatic Resources 5(1):13-23.
Spiridonov V. A., 1999 Results of the Rumphius Biohistorical Expedition to Ambon (1990). Part 8. Swimming crabs of Ambon (Crustacea: Decapoda: Portunidae). Zoologische Mededelingen 73(4):63-97.
Spiridonov V. A., 2017 Two new species of *Thalamita* Latreille, 1829 (Decapoda, Portunidae). Crustaceana 90(7-10):1211-1233.
Spiridonov V. A., Neumann V., 2008 Coral-inhabiting swimming crabs (Crustacea, Decapoda, Portunidae) of the Sudanese Red Sea. Organisms Diversity and Evolution 8(3):170e1–170e19.
Steel R. G. D., Torire J. H., 1992 [Principles and procedure of statistic: biometric aproach]. Translated in Indonesian by Sumantri B. Gramedia Pustaka Utama, Jakarta, 748 pp. [in Indonesian]
Stephenson W., 1975 Biological results of the Snellius expeditio: XXVI. The Portunidae (Decapoda-Brachyura) of the Snellius expedition (part II). Zoologische Mededelingen 49(14):173-209.
Sukumaran K. K., 1995 Fishery, biology and population dynamics of the marine crabs, *Portunus (Portunus) sanguinolentus* (Herbst) and *Portunus (Portunus) pelagicus* (Linnaeus) along the Karnataka Coast. PhD Thesis, School of Ocean Sciences, Karnataka University, Karwar, India, 403 pp.
Sunarto, Soedharma D., Riani E., Martasuganda S., 2010 [Length-weight and width with body weight relationships and condition factor of population crab (*Portunus pelagicus*) of males and females in coastal waters of Brebes]. Jurnal Akuatika 1(1):83-92. [in Indonesian]
Susanto A., Irnawati R., 2014 Length-weight and width-weight relationship of spiny rock crab *Thalamita crenata* (Crustacea, Decapoda, Portunidae) in Panjang Island Banten Indonesia. AACL Bioflux 7(3):148-152.
Thomas M., 1984 Studies on portunid crabs [Crustacea, Decapoda, Brachyura]. PhD thesis, University of Cochin, Cochin,156 pp.
Wahyudi A. J., 2008 [Phenetic study on genus of *Thalamita* Latreille, 1829 (Crustacea: Decapoda: Brachyura: Portunoidea: Portunidae) based on morphological diagnosys in “Faune de Madagascar XVI”]. Jurnal Oseanologi 1(1):1-10. [in Indonesian]
Wee D. P. C., Ng P. K. L., 1995 Swimming crabs of the genera *Charybdis* De Haan, 1833, and *Thalamita* Latreille, 1829 (Crustacea: Decapoda: Brachyura: Portunidae) from peninsular Malaysia and Singapore. The Raffles Bulletin of Zoology 1:1-128.
Williams M. J., 1981 Methods for analysis of natural diet in portunid crabs (Crustacea:Decapoda: Portunidae). Journal of Experimental Marine Biology and Ecology 52(1):103-113.
Yau P. M., 1992 The population dynamics of *Parasesarma picta* (Decapoda: Grapsidae) and *Thalamita danae* (Decapoda: Portunidae) in Hongkong. Asian Marine Biology 9:167-180.
Yau P. M., 1992 The population dynamic of Parasersama picta (Decapoda: Grapsidae) and Thalamita danae (Decapoda: Portunidae) in Hongkong. Asian Marine Biology 9:167-180.
Zhong S., Zhao Y., Zhang Q., 2018 The complete mitochondrial genome of *Thalamita sima* (Decapoda: Portunidae). Mitochondrial DNA Part B 3(2):723-724.

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