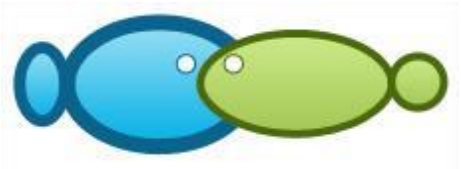

Carapace length-body weight relationship and condition factor of painted rock lobster *Panulirus versicolor* in Sorong waters, West Papua, Indonesia

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Abstract. Painted rock lobster (*Panulirus versicolor*) is a superior commodity with an important economic value, also being the most dominant species found in the waters of the Sorong region. Sampling was conducted from March to August 2020 in Tanjung Kasuari waters, Sorong City and Makbon waters, Sorong Regency. During the study, 365 lobster samples were captured from Tanjung Kasuari waters and 460 from Makbon waters. The results showed that in the waters of Tanjung Kasuari male lobsters had a hypoallometric growth pattern and female lobsters had an isometric growth pattern. The mean condition factors were 1.0049 for males and 0.9865 for females. On the other hand, both male and female lobsters in Makbon waters have a hypoallometric growth pattern with a mean condition factor of 0.9948 for males and 0.9875 for females.

Key Words: spiny lobster, growth pattern, hypoallometric.

Introduction. Lobster is a leading export commodity that has important economic value and has significantly contributed to the country's fishery sector and foreign exchange (Hasrun & Kasmawati 2018). Lobster is included in the genus *Panulirus* which has 21 species, 7 of which are found in Indonesian waters (Holthuis 1991; Chan 1998, 2010; Chang et al 2010; Ernawaty et al 2014; Wardiatno et al 2016; Wahyudin et al 2017a,b): *P. femoristriga* (Von Martens 1872), *P. homarus* (Linnaeus 1758), *P. longipes longipes* (Milne-Edwards 1868), *P. ornatus* (Fabricius 1798), *P. penicillatus* (Olivier 1791), *P. polyphagus* (Herbst 1793), and *P. versicolor* (Latreille 1804).

The Sorong region water has high potential for lobster resources due to its rocky waters characteristics, an ideal habitat for lobsters (Holthuis 1991). A total of 6 lobster species can be found in Sorong region waters (Sururi et al 2016), and *P. versicolor* is one of the fishing targets of local fishermen, due to its dominance.

By far, the majority of lobster production comes from fishing activities (Kusuma et al 2012). The high selling value of lobsters and the increasing market demand affect the level of the intensive fishing activity. Fishing pressure on the young specimens causes a decrease in the lobster population. This can be seen in several regions in Indonesia, such as Bali (Kembaren et al 2015), Yogyakarta (Larasati et al 2018) and Sukabumi (Rombe et al 2018). Fishing pressure risks causing the extinction of lobster resources (Kadafi et al 2006; Hargiyatno et al 2013).

Lobster fishing is suspected to have undergone overfishing with an indication that its size is getting smaller during the fishing season. Therefore, it is necessary to manage

existing lobster resources. Several aspects that need to be considered in sustainable fisheries management are related to the biological aspects, including carapace length-body weight relationship and condition factors (Adiputra et al 2018).

Information related to lobster research in Sorong waters is limited to the sustainable potential of the resource (Sururi et al 2016) and utilization status (Tirtadanu & Yusuf 2018). Based on our knowledge, there is no reported reference to the carapace length and body weight relationship and condition factors, especially regarding painted rock lobster, *Panulirus versicolor*, in Sorong region waters. Hence, in the present study we focused on the carapace length-body weight and condition factors as a basis for the sustainable management of *P. versicolor* resources.

Material and Method

Period and location. The research was conducted from March to August 2020. Lobster samples were obtained from fishermen's catch landed at several collectors in Sorong city. Two sampling station points were selected based on differences in the condition of coral reefs which were habitats for lobsters: Station 1, in Tanjung Kasuari waters, Sorong City, with a coral reef conditions in bad condition and Station 2, in Makbon waters, Sorong Regency, with a coral reef in good condition (Figure 1).

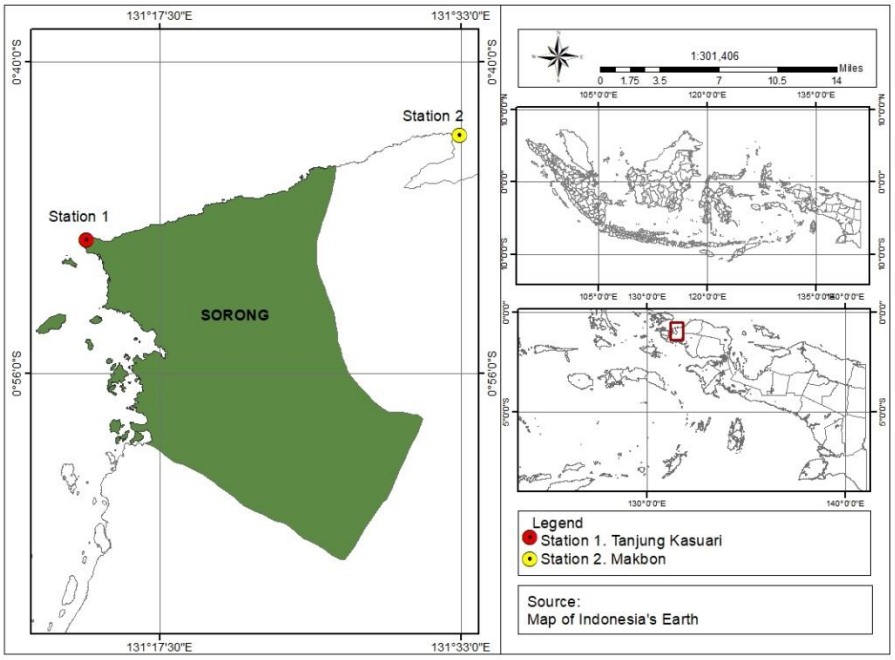

Figure 1. *Panulirus versicolor* sample collection sites in Tanjung Kasuari (Station 1) and Makbon (Station 2), in the Sorong region waters, West Papua Province, Indonesia.

Sampling and sample handling. Lobster samples were collected 6 times, once a month. The used sampling method was the purposive sampling. Carapace length measurements used calipers with a precision of 0.01 mm, while for weighing the body a digital scale with a precision of 0.01 g was used. The data were then processed using Microsoft Excel for Windows 2010 and differentiated by gender.

Data analysis. The relationship between the carapace length and the body weight of *P. versicolor* was analyzed based on sexes and research location using the formula (Le Cren 1951; Ricker 1975):

$$W = a L^b$$
$$\log W = \log a + b \log L$$

Where:
W - the body weight of the fish (g);
L - the total length of the fish (mm);
a - a constant (intercept);
b - the growth exponent (regression coefficient).

To determine whether the value of b obtained is equal or not to 3, a t-test is performed on the b value obtained from the previous formula (Zar 2014). Furthermore, to determine differences in the mean values of the regression coefficient b by sexes were also evaluated using a t-test with 95% confidence interval, as suggested by Fowler et al (1998).

The value of the condition factor was analyzed based on the gender and the sampling location, using the formula (King 2007):

$$CF = W / Wp$$

Where:
W - actual body weight;
Wp - estimated body weight (obtained from $Wp = a L^b$).

Results

Sample number and lobster size. A total number of 386 *P. versicolor* specimens were captured in the Tanjung Kasuari waters, consisting of 156 males and 230 females. In contrast, in the Makbon waters, the number of lobsters captured was 460, consisting of 219 males and 241 females. The range and average length of carapace and bodyweight of both male and female lobsters from the two sampling locations can be seen in Table 1.

Table 1

Carapace length and body weight of male and female *Panulirus versicolor* originating from Tanjung Kasuari and Makbon, in Sorong waters, West Papua Province, Indonesia

Site	*Sexes*	*N*	*Carapace length (mm)*		*Body weight (g)*	
			Range	*Mean±SE*	*Range*	*Mean±SE*
Tanjung Kasuari	Male	156	45.60-107.41	70.14±0.96	98-1.032	352.46±13.65
	Female	230	48.22-90.60	70.30±0.60	109-792	354.24±9.25
	All	386	45.60-107.41	70.23±0.53	98-1.032	353.52±7.79
Makbon	Male	219	48.26-120.50	81.16±0.92	101-1.471	525.06±17.02
	Female	241	54.22-120.90	78.92±0.78	149-1.500	506.48±14.51
	All	460	48.26-120.90	79.99±0.60	101-1.500	515.32±11.11

Carapace length-body weight relationship. Carapace length (L) to body weight (W) relationships in *P. versicolor* captured in the Tanjung Kasuari waters were $W = 0.0030 L^{2,7302}$ for males and $W = 0.0013 L^{2,9349}$ for females (Table 2). According to the t-test applied to b, male lobsters had a hypoallometric or negative allometric growth type (b<3), while female lobsters had an isometric growth type (b=3). Further statistical analysis of the regression coefficients between male and female lobsters showed no significant difference (p>0.05), which indicated that in general male and female lobsters have similarities in length and weight gained. Therefore, the data were combined and provided a regression equation $W = 0.0020 L^{2,8260}$, which indicates the type of hypoallometric growth. In the waters of Makbon, both male and female lobsters had hypoallometric growth types, with their respective equations, $W = 0.0015 L^{2,88884}$ and $W = 0.0018 L^{2,8617}$ (Table 2). Based on the results of statistical tests, the regression coefficients for male and female lobsters were not significantly different (p>0.05) so that the data were combined and produced a regression

equation W = 0.0017 $L^{2,8624}$ which shows the type of hypoallometric growth. Furthermore, Table 2 also showed the high correlation coefficient (r), ranging from 0.9695 to 0.9970 and a coefficient of determination (R^2) ranging from 0.9399 to 0.9941.

Table 2

Carapace length-body weight relationship of male and female *Panulirus versicolor* originating from Tanjung Kasuari and Makbon, in Sorong waters, West Papua Province

Sexes	*a*	*95% CL (a)*	*b*	*95% CL (b)*	*R²*	*r*	*Sig.*
Tanjung Kasuari							
Male	0.0030	0.0019-0.0048	2.7302	2.6204-2.8401	0.9399	0.9695	P<0.05
Female	0.0013	0.0009-0.0018	2.9349	2.8483-3.0215	0.9514	0.9754	P>0.05
All	0.0020	0.0015-0.0027	2.8260	2.7570-2.8951	0.9941	0.9970	P<0.05
Makbon							
Male	0.0015	0.0012-0.0019	2.8884	2.8356-2.9412	0.9817	0.9908	P<0.05
Female	0.0018	0.0012-0.0026	2.8617	2.7767-2.9468	0.9484	0.9739	P<0.05
All	0.0017	0.0014-0.0022	2.8624	2.8105-2.9144	0.9624	0.9810	P<0.05

Condition factor. The range and average condition of the *P. versicolor* in the waters of Tanjung Kasuari and Makbon can be seen in Table 3.

Table 3

The range value and mean condition factor of the male and female *Panulirus versicolor* from Tanjung Kasuari and Makbon, in Sorong waters, West Papua Province, Indonesia

Sexes	*Tanjung Kasuari*		*Makbon*	
	Range	*Mean±SE*	*Range*	*Mean±SE*
Male	0.7439-1.7460	1.0049±0.0111	0.8132-1.2430	0.9948±0.0045
Female	0.6484-1.2345	0.9865±0.0053	0.6407-1.8861	0.9875±1.8861
All	0.6725-1.7683	1.0127±0.0057	0.6760-1.9911	1.0144±0.0050

Discussion

Size distribution. Table 1 shows that both male and female *P. versicolor* lobster specimens caught in the Makbon water have a relatively larger size when compared to lobsters originating from Tanjung Kasuari, according to their range and average length. The average carapace length of female lobsters in Makbon waters is greater than that of male lobsters. In contrast, male lobsters in Tanjung Kasuari waters have longer carapaces than female lobsters. In addition, a higher number of lobster samples were obtained from the Makbon waters than from the Tanjung Kasuari waters. This is because the conditions of Makbon waters are a more appropriate habitat for lobsters. In general, the coral reefs' condition in Makbon waters is good (Loka PSPL Sorong 2019). In contrast, Tanjung Kasuari waters are not very supportive due to the bad conditions of the coral reefs (Loka PSPL Sorong 2012). Pratiwi (2018) added that *P. versicolor* prefers to live in coral reef waters, being protected by the coral rocks. Based on the carapace length range, male and female lobsters found in the Sorong region waters were relatively larger than those found in Kebumen and Palabuhan Ratu. Kadafi et al (2006) found that *P. versicolor* lobsters in Kebumen had a carapace length ranging from 35 to 83 mm, for the males, and from 34 to 73 mm, for the females. The graph of the carapace length relationship to the body weight in *P. versicolor* specimens from Tanjung Kasuari waters and Makbon waters can be seen in Figure 2.

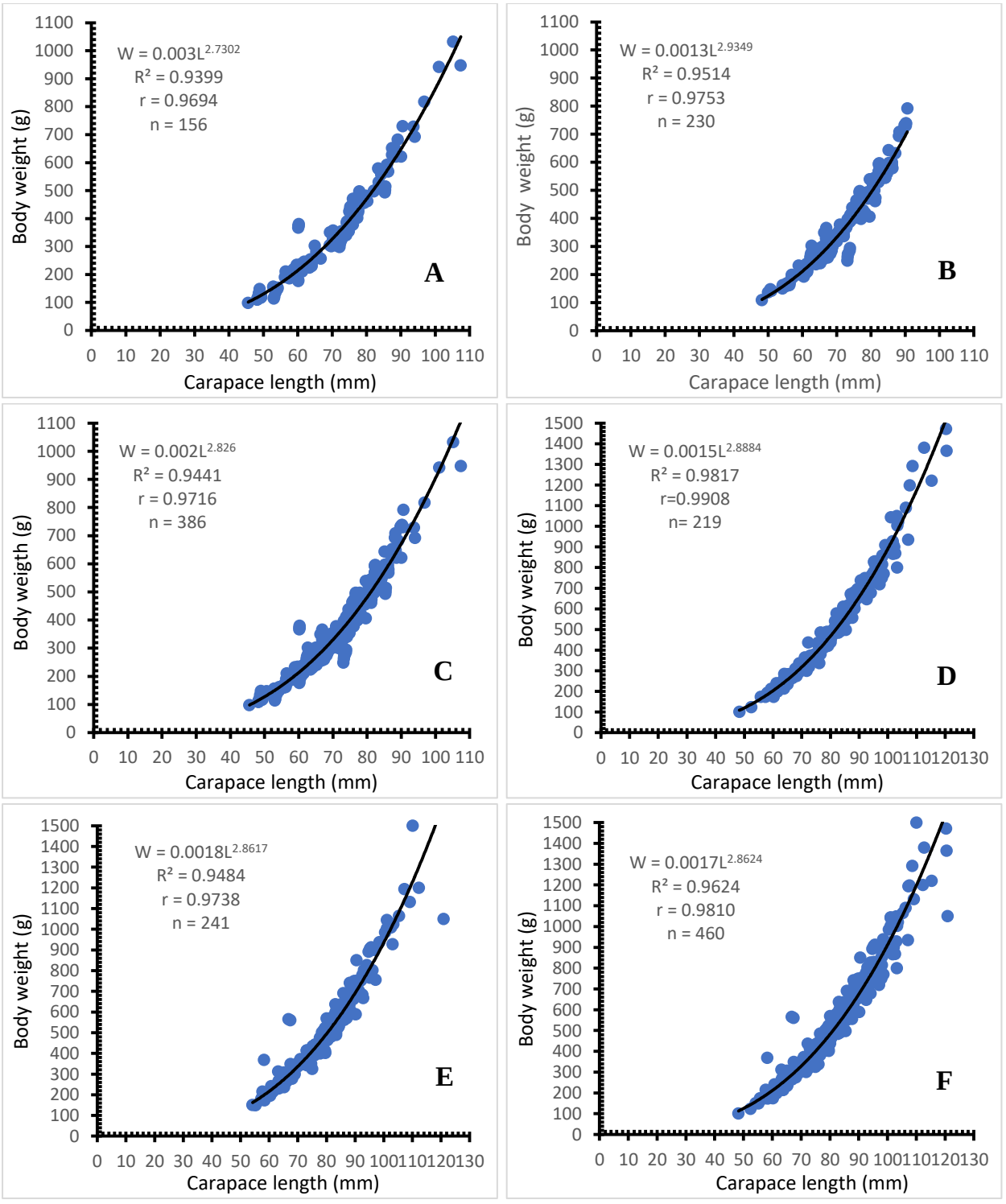

Figure 2. Carapace length-weight regression curves and equations for *Panulirus versicolor* in the waters of Sorong region. A. Male lobster from Tanjung Kasuari; B. Female lobster from Tanjung Kasuari; C. Combined male and female from Tanjung Kasuari; D. Male lobster from Makbon; E. Female lobster from Makbon; F. Combined male and female from Makbon.

In Palabuhan Ratu, Suherman (2017) obtained a range of carapace length of male and female lobsters of 40-95 mm and 45-90 mm, respectively. The result of the research conducted in the Sorong region waters indicated a smaller lobster size when compared to the results of Ongkers et al (2014) in Latulahat, Ambon, and of Triharyuni & Wiadnyana (2017) in Kupang. Lobsters' carapace lengths in Latulahat waters ranged from 63 to 141 mm for males and from 60 to 124 mm for females (Ongkers et al 2014), while in Kupang waters they ranged from 80 to 150.26 mm for males and from 80 to 127.68 mm for females (Triharyuni & Wiadnyana 2017).

Carapace length-body weight relationship*.* Information on the length and body weight relationship is needed in fisheries management in order to determine the condition of the organism (Andy 2015). Length-weight relationship can also indicate the growth properties of lobsters (Hargiyatno et al 2013) and it is very important in fisheries management practices and population dynamics studies (Senevirathna et al 2014).

The carapace length-body weight shows an exponential relationship, which, according to Froese et al (2011), are of three types, based on the value of b (regression coefficient), namely: isometric (b=3) if the increase rates in body weight and body length are the same, hypoallometric (b<3) if the increase in body weight is slower than the increase in length, and hyperallometric (b>3) if the weight gain is faster than the increase in fish body length.

The results of the analysis of the carapace length and body weight relationship of *P. versicolor* in Tanjung Kasuari waters based on gender showed differences in growth patterns. Male lobsters have a hypoallometric growth pattern, namely the carapace length growth is faster than the body weight, while female lobsters have an isometric growth pattern, namely the carapace length growth is as fast as the body weight growth. The *P. versicolor* in Makbon waters, both male and female, based on the results of the analysis of the carapace length-body weight relationship showed a hypoallometric growth pattern, namely the carapace length growth was faster than body weight.

Kadafi et al (2006) in the waters of Ayah (Kebumen) and Ongkers et al (2014) in the Latulahat waters (Ambon) also found hypoallometric growth patterns in male lobsters and isometric growth patterns in female lobsters. The results of other studies showing differences in growth patterns between male and female lobsters were found for the sand lobsters (*P. homarus*) in Sri Lanka waters (Senevirathna et al 2014), which shows isometric growth patterns in male lobsters and hypoallometric growth patterns in female lobsters. In general, *Panulirus* lobsters in various waters in Indonesia exhibit hypoallometric growth types, as listed in Table 4.

Based on the value of the b coefficient obtained during the study, the body weight growth of female *P. versicolor* lobsters is faster than that of male lobsters in Tanjung Kasuari. The opposite happened in Makbon, male lobsters grew faster in body weight than female lobsters. According to Wootton (1992, 1998), when fish grow bigger they will become slimmer if they have hypoallometric growth or fatter if they have hyperalometric growth. Hypoallometric growth patterns can also be due to overcatch, competition and trophic potential (Mashar 2016). Yusuf et al (2017) added that the hypoallometric growth pattern indicates a young developmental phase in the caught lobster population is in, where energy is still directed to the growth of body length instead of being used for spawning preparation (gonad growth). Briones-Fourzán & Lozano-Álvarez (2003) found that *P. gracilis* and *P. inflatus* lobsters grew faster than female lobsters. This is because the female lobster undergoes ovarian maturation so that growth is stunted (Hunt & Lyons 1986). Hunt & Lyons (1986) and Pollock (1986) also stated that male lobsters grow faster than female lobsters. In general, *Panulirus* lobster in various waters in Indonesia exhibit condition factors, as listed in Table 5.

Table 4

The coefficient of carapace length-body weight relationship and growth pattern of several *Panulirus* species from various locations in Indonesia

Species	*Region*	*Sexes*	*n*	*a*	*b*	*R²*	*Growth pattern*	*Sources*
P. homarus	Kebumen, Central Java	M	210	0.0079	2.4539	0.8234	Hypoallometric	Kadafi et al 2006
	Kebumen, Central Java	F	166	0.0021	2.8132	0.9641	Hypoallometric	Kadafi et al 2006
	Kebumen, Central Java	C	376	0.0044	2.6149	0.8811	Hypoallometric	Kadafi et al 2006
	Baron, Yogyakarta	C	161	0.630	2.788	0.95	Isometric	Aisyah & Triharyuni 2010
	Gunungkidul, Yogyakarta & Pacitan, East Java	M	320	0.0025	2.7542	0.9571	Hypoallometric	Hargiyatno et al 2013
	Gunungkidul, Yogyakarta & Pacitan, East Java	F	225	0.002	2.828	0.9498	Hypoallometric	Hargiyatno et al 2013
	Tabanan, Bali	M	1839	0.0021	2.769	0.888	Hypoallometric	Kembaren et al 2015
	Tabanan, Bali	F	1947	0.0016	2.841	0.926	Hypoallometric	Kembaren et al 2015
	Tabanan, Bali	C	3786	0.0018	2.811	0.910	Hypoallometric	Kembaren et al 2015
	Aceh Jaya, Aceh	C	140	0.001	2.661	0.906	Hypoallometric	Irfannur et al 2017
	Palabuhanratu, West Java	M	236	0.0338	2.0402	0.6542	Hypoallometric	Islamiati 2017
	Palabuhanratu, West Java	F	247	0.0326	2.0680	0.6281	Hypoallometric	Islamiati 2017
	Palabuhanratu, West Java	M	98	0.0026	2.0834	0.6804	Hypoallometric	Permana 2017
	Palabuhanratu, West Java	F	142	0.0027	2.0871	0.6585	Hypoallometric	Permana 2017
	Palabuhanratu, West Java	C	240	0.0025	2.1187	0.6850	Hypoallometric	Permana 2017
	Palabuhanratu, West Java	M	236	0.0338	2.0402	0.6542	Hypoallometric	Zairion et al 2017
	Palabuhanratu, West Java	F	247	0.0326	2.068	0.6281	Hypoallometric	Zairion et al 2017
	Gunungkidul, Yogyakarta	C	1067	0.002	2.762	0.926	Hypoallometric	Damora et al 2018
	Pangandaran, West Java	M	35	1.2298	2.8594	0.9514	Isometric	Rahman et al 2018
	Pangandaran, West Java	F	72	1.139	2.9305	0.9618	Isometric	Rahman et al 2018
	Bumbang, Lombok, West Nusa Tenggara	C	139	0.6468	2.0645	0.7925	Hypoallometric	Yonvitner et al 2019
	Labangka, Sumbawa, West Nusa Tenggara	C	20	5.0350	1.108	0.398	Hypoallometric	Asrial et al 2020
	Palabuhanratu, West Java	M	95	0.0054	2.5510	0.6649	Hypoallometric	Kintani et al 2020
	Palabuhanratu, West Java	F	68	0.0074	2.4926	0.8030	Hypoallometric	Kintani et al 2020
P. longipes	Kebumen, Central Java	M	35	0.0017	2.8669	0.9433	Isometric	Kadafi et al 2006
	Kebumen, Central Java	F	26	0.0013	2.9585	0.9750	Isometric	Kadafi et al 2006
	Kebumen, Central Java	C	61	0.0019	2.8427	0.9413	Isometric	Kadafi et al 2006

Species	*Region*	*Sexes*	*n*	*a*	*b*	*R²*	*Growth pattern*	*Sources*
	Baron, Yogyakarta	C	30	0.426	3.006	0.93	Isometric	Aisyah & Triharyuni 2010
	Aceh Jaya, Aceh	C	130	0.053	1.885	0.715	Hypoallometric	Irfannur et al 2017
	Spermonde Island, South Sulawesi	C	209	0.8438	2.8166	0.9106	Hypoallometric	Hasrun & Kasmawati 2018
P. ornatus	Kebumen, Central Java	M	137	0.0007	3.0708	0.9349	Isometric	Kadafi et al 2006
	Kebumen, Central Java	F	117	0.0013	2.9324	0.8998	Isometric	Kadafi et al 2006
	Kebumen, Central Java	C	254	0.0009	2.9972	0.9156	Isometric	Kadafi et al 2006
	Baron, Yogyakarta	C	18	0.377	2.996	0.98	Isometric	Aisyah & Triharyuni 2010
	Aceh Jaya, Aceh	C	30	0.008	2.310	0.911	Hypoallometric	Irfannur et al 2017
	Spermonde Island, South Sulawesi	C	334	0.926	2.7764	0.9574	Hypoallometric	Hasrun & Kasmawati 2018
	Sorong, West Papua	C	557	0.0075	2.5432	0.9282	Hypoallometric	Tirtadanu & Yusuf 2018
	Bumbang, Lombok, West Nusa Tenggara	C	142	1.0828	1.207	0.6707	Hypoallometric	Yonvitner et al 2019
P. penicillatus	Kebumen, Central Java	M	29	0.0038	2.6529	0.9775	Hypoallometric	Kadafi et al 2006
	Kebumen, Central Java	F	25	0.0021	2.7914	0.9301	Isometric	Kadafi et al 2006
	Kebumen, Central Java	C	54	0.0031	2.7037	0.9593	Hypoallometric	Kadafi et al 2006
	Baron, Yogyakarta	C	117	0.538	2.895	0.97	Isometric	Aisyah & Triharyuni 2010
	Gunungkidul, Yogyakarta & Pacitan, East Java	M	726	0.0022	2.7559	0.9418	Hypoallometric	Fauzi et al 2013
	Gunungkidul, Yogyakarta & Pacitan, East Java	F	551	0.0014	2.8884	0.9664	Hypoallometric	Fauzi et al 2013
	Gunungkidul, Yogyakarta & Pacitan, East Java	C	1277	0.0017	2.8287	0.9521	Hypoallometric	Fauzi et al 2013
	Aceh Jaya, Aceh	C	77	0.005	2.087	0.906	Hypoallometric	Irfannur et al 2017
	Simeulue, Aceh	C	72	0.0037	2.571	0.892	Hypoallometric	Karisma et al 2017
	Wonogiri, Central Java	M	216	0.0030	2.68		Hypoallometric	Zaenuddin & Putri 2017
	Wonogiri, Central Java	F	203	0.0041	2.59		Hypoallometric	Zaenuddin & Putri 2017
	Wonogiri, Central Java	C	419	0.0040	2.62		Hypoallometric	Zaenuddin & Putri 2017
	Palabuhanratu, West Java	M	37	0.006	2.5097	0.9450	Hypoallometric	Nurkholis 2018
	Palabuhanratu, West Java	F	41	0.025	2.1808	0.6690	Hypoallometric	Nurkholis 2018
	Palabuhanratu, West Java	M	410	0.0064	2.5134	0.9256	Hypoallometric	Wahyudin 2018
	Palabuhanratu, West Java	F	154	0.0086	2.4496	0.9618	Hypoallometric	Wahyudin 2018
	Wonogiri, Central Java	M	389	0.0087	2.3233	0.8861	Hypoallometric	Beni et al 2020
	Wonogiri, Central Java	F	288	0.0051	2.4262	0.8236	Hypoallometric	Beni et al 2020

Species	*Region*	*Sexes*	*n*	*a*	*b*	*R²*	*Growth pattern*	*Sources*
	Wonogiri, Central Java	C	677	0.0062	2.3931	0.8612	Hypoallometric	Beni et al 2020
	Simeulue, Aceh	M	705	0.0034	2.6431	0.8484	Hypoallometric	Yusuf et al 2019
	Simeulue, Aceh	F	677	0.0106	2.3754	0.7960	Hypoallometric	Yusuf et al 2019
	Labangka, Sumbawa, West Nusa Tenggara	C	293	0.00002	2.422	0.869	Hypoallometric	Asrial et al 2020
P. polyphagus	Kebumen, Central Java	M	7	0.0001	3.4621	0.9923	Hypoallometric	Kadafi et al 2006
	Kebumen, Central Java	F	8	0.0714	1.9050	0.8012	Hypoallometric	Kadafi et al 2006
	Kebumen, Central Java	C	15	0.0010	2.9363	0.9668	Isometric	Kadafi et al 2006
P. versicolor	Kebumen, Central Java	M	20	0.0027	2.7314	0.9664	Hypoallometric	Kadafi et al 2006
	Kebumen, Central Java	F	31	0.0018	2.8501	0.9554	Isometric	Kadafi et al 2006
	Kebumen, Central Java	C	51	0.0024	2.7747	0.9603	Hypoallometric	Kadafi et al 2006
	Baron, Yogyakarta	C	13	0.347	3.118	0.98	Isometric	Aisyah & Triharyuni 2010
	Sikka, East Nusa Tenggara	M	398	0.004	2.648	0.914	Hypoallometric	Ernawati et al 2014
	Sikka, East Nusa Tenggara	F	366	0.004	2.649	0.939	Hypoallometric	Ernawati et al 2014
	Latulahat, Ambon	M	31	4.1589	2.048	0.919	Hypoallometric	Ongkers et al 2014
	Latulahat, Ambon	F	25	0.5612	2.931	0.9289	Isometric	Ongkers et al 2014
	Latulahat, Ambon	C	56	1.4199	2.054	0.9158	Hypoallometric	Ongkers et al 2014
	Aceh Jaya, Aceh	C	73	0.0057	2.415	0891	Hypoallometric	Irfannur et al 2017
	Simeulue, Aceh	C	65	0.0033	2.609	0.869	Hypoallometric	Karisma et al 2017
	Nabire, Papua	C	111	0.0989	2.4912	0.7458	Hypoallometric	Pranata et al 2017
	Palabuharatu, West Java	M	91	0.0058	1.9285	0.8305	Hypoallometric	Suherman 2017
	Palabuharatu, West Java	F	55	0.0054	1.9479	0.8362	Hypoallometric	Suherman 2017
	Simeulue, Aceh	M	547	0.001	2.924	0.934	Hypoallometric	Yusuf et al 2017
	Simeulue, Aceh	F	826	0.001	2.925	0890	Hypoallometric	Yusuf et al 2017
	Spermonde Island, South Sulawesi	C	313	1.1105	2.6779	0.8959	Hypoallometric	Hasrun & Kasmawati 2018
	Tanjung Kasuari, West Papua	M	156	0.0030	2.7302	0.9399	Hypoallometric	Present study
	Tanjung Kasuari, West Papua	F	230	0.0013	2.9349	0.9514	Isometric	Present study
	Tanjung Kasuari, West Papua	C	386	0.0020	2.8260	0.9941	Hypoallometric	Present study
	Makbon, West Papua	M	219	0.0015	2.8884	0.9817	Hypoallometric	Present study
	Makbon, West Papua	F	241	0.0018	2.8617	0.9484	Hypoallometric	Present study
	Makbon, West Papua	C	460	0.0017	2.8624	0.9624	Hypoallometric	Present study

M – male; F - female; C - combined sexes (male and female).

Table 5

The value of the condition factor for several species of *Panulirus* from various locations in Indonesia

Species	*Region*	*Sexes*	*Condition factor*		*Sources*
			Range	*Mean±SE*	
P. homarus	Gunungkidul, Yogyakarta, & Pacitan, East Java	M	0.658-1.121	0.933±0.14	Hargiyatno et al 2013
	Gunungkidul, Yogyakarta, & Pacitan, East Java	F	0.804-1.074	1.003±0.09	Hargiyatno et al 2013
	Tabanan, Bali	M	0.966-1.107		Kembaren et al 2015
	Tabanan, Bali	F	0.937-1.179		Kembaren et al 2015
	Pananjung Pangandaran, West Java	M	0.82-1.19	0.98±0.09	Rahman et al 2018
	Pananjung Pangandaran, West Java	F	0.86-1.26	1.02±0.08	Rahman et al 2018
	Labangka, Sumbawa, NTB	C	0.032-0.110		Asrial et al 2020
	Pelabuhanratu Bay, Indonesia	M	0.0909-0.1436		Kintani et al 2020
	Pelabuhanratu Bay, Indonesia	F	0.0935-0.1241		Kintani et al 2020
P. penicillatus	Gunungkidul, Yogyakarta, & Pacitan, East Java	M	0.83-1.10	0.96	Fauzi et al 2013
	Gunungkidul, Yogyakarta, & Pacitan, East Java	F	0.92-1.14	1.02	Fauzi et al 2013
	Gunungkidul, Yogyakarta, & Pacitan, East Java	C	0.83-1.14	0.99	Fauzi et al 2013
	Simeulue, Indonesia	C	1.68-2.90 (Kn)	2.25±0.36	Karisma et al 2017
	Labangka, Sumbawa, NTB	C	0.034-0.127		Asrial et al 2020
P. versicolor	Latulahat, Ambon	M	1.06		Ongkers et al 2014
	Latulahat, Ambon	F	1.13		Ongkers et al 2014
	Simeulue, Aceh	C	1.68-2.91 (Kn)	2.15±0.42	Karisma et al 2017
	Cassowary Cape	M	0.7439-1.7460	1.0049±0.0111	Present study
	Cassowary Cape	F	0.6484-1.2345	0.9865±0.0053	Present study
	Cassowary Cape	C	0.6725-1.7683	1.0127±0.0057	Present study
	Makbon	M	0.8132-1.2430	0.9948±0.0045	Present study
	Makbon	F	0.6407-1.8861	0.9875±1.8861	Present study
	Makbon	C	0.6760-1.9911	1.0144±0.0050	Present study

() – mean; Kn - relative condition factor; M – male; F – female; C - combined sex (male and female).

The values of lobsters' allometric regression coefficients obtained during the research at Tanjung Kasuari ranged from 2.7302 to 2.9349, while in Makbon, it ranged from 2.8617-2.8884. Overall, lobsters in Makbon waters had a higher allometric regression coefficient value compared to lobsters in Tanjung Kasuari (Table 2). This shows that the lobsters found in Makbon have a better growth than those in Tanjung Kasuari. Beverton & Holt (1957) stated that the length and body weight relationship is cubed ($W=a\ L^3$), which indicates isometric growth. However, according to Le Cren (1951), the regression coefficient value b often varies and ranges from 2.5 to 4.5, while according to Froese (2006) and Karna et al (2020), the value of b must be in the range of 2.5 to 3.5.

The regression coefficient (coefficient b) in Table 4 shows that there are variations, both between species and between populations, in the same lobster species from the same waters. The growth rates of several *Panulirus* species varied widely between regions. The variation is affected by temperature, salinity (Jones 2009; Vidya & Joseph 2012), availability of food (Chittleborough 1976; Pollock 1991), lobster density with food supply (Newman & Pollock 1974; Edgar 1990) and gonads' maturity (Hunt & Lyons 1986; Briones-Fourzán & Lozano-Álvarez 2003). Even though the lobster *Panulirus* lives clustered, at very high densities growth may be suppressed (Pollock 1991; Subhan et al 2018). According to Forcucci et al (1994), lobster growth is strongly influenced by temperature, season, initial size, diet (abundance, availability and quality), and shelter. In addition to temperature, food availability, and density, Chittleborough (1975) and Brown & Caputi (1985) stated that photoperiodism also affects lobsters' growth. Briones-Fourzán & Lozano-Álvarez (2003) also stated that in general, the growth rate of *Panulirus* lobsters is related to temperature and photoperiod.

According to Senevirathna et al (2014), the length-weight relationship regression coefficients may vary seasonally, even daily, and differ between habitats, depending on: water environmental factors (temperature, salinity, habitat), differences in sample size, geographic location, season, ontogenetic differences, age differences, growth phases, gonad maturity levels, reproduction, species, sex, food (quantity, quality and size), stomach fullness, parasite pressure and preservation techniques (Senevirathna et al 2014; Azevedo et al 2017; Hanif et al 2020), fish health and condition (Moutopoulos & Stergiou 2002), food availability and sampling procedures (Jafari et al 2016; Shalloof & El-Far 2017; Olopade et al 2018; Mitu et al 2019). The range of measures used can also affect the value of the regression coefficient b (Nazir & Khan 2017; Blasinaa et al 2018). Therefore, Nazir & Khan (2017) recommend avoiding young or old fish samples in the length-weight regression calculations. The difference in the value of the regression coefficient can be due to a sole factor or to a combination of the factors mentioned above. Several factors mentioned above could not been observed when sampling was performed due to limited time and space. The difference in growth patterns between male and female lobsters, both in Tanjung Kasuari and in Makbon, is thought to be due to differences in sex and differences in habitat.

The correlation coefficient (r) values obtained during the study ranged from 0.9695-0.9970 and the coefficient of determination (R^2) ranged from 0.9399-0.9941 (Table 2). The high correlation coefficient and determination coefficient values indicate good predictive power and small data dispersion. Andy (2013) stated that if the r value ranges from 0.90-1.00 it indicates a very strong correlation between body length and weight. For ideal fish growth, Hanif et al (2020) stated that the R^2 coefficient is usually found to be between 0.9 and 1.0.

Condition factor. The condition factor is the morphometric index that can be used to evaluate the physiological status of the specimens, based on the principle that individuals of a certain length which have a greater weight compared to other individuals are in a better 'condition' (Froese 2006; Awasthi et al 2015; Falaye et al 2015; Azevedo et al 2017). Furthermore, Falaye et al (2015) stated that condition factors can be used to measure the health of individuals in a population or to determine whether a population is healthy relatively to other fish populations.

In Tanjung Kasuari waters, the value of the condition factor for male lobsters ranges from 0.7439-1.7460 with an average of 1.0049 and female lobsters ranged from 0.6484 to 1.2345 with a mean of 0.9865. In contrast, the value of the condition factor for male lobsters in Makbon waters ranges 0.8132-1.2430 with a mean of 0.9948 and in female lobsters it ranged from 0.6407 to 1.8861 with a mean of 0.9875 (Table 3). These results show that, in general, the range of condition factor values for male lobsters is higher than that of female lobsters. However, there was no significant difference between the two populations. Based on the literature search that has been carried out (Table 5), it appears that the condition factor value of *P. versicolor* found in Sorong waters is in the range of the condition factor values for several other *Panulirus* species, but is lower when compared to the condition factor values for lobsters originating from Simeulue waters, Aceh (Karisma et al 2017).

In the same waters, fish having a condition factor of more than 1.0 is said to be in better condition than fish whose condition factor value is less than 1 (Froese 2006; Awasthi et al 2015; Falaye et al 2015). Fish that are in optimal physiological conditions must grow and reproduce successfully to ensure the sustainability of the population (Olopade et al 2018). The sustainability of a population is a condition where there is a balance from the individual within a group that share the similar characteristics. Therefore, the sustainability is maintained without limited time. Bagenal & Tesch (1978) stated the condition factor values ranged from 2.9 to 4.8 as the ideal range for normal fish growth.

According to Zargar et al (2012) and Awasthi et al (2015), assessing the fish condition factor is influenced by many factors, including gender, season, environmental factors, stress, gonad development, availability of food, and feeding activity. Other factors that can also affect the value of the condition factor are age, climate, and water quality parameters (Anibeze 2000; Khallaf et al 2003; Falaye et al 2015; Olopade et al 2018). According to Araujo & Lira (2012), a lower condition factor value in female lobsters is associated with the occurrence of the spawning season, as a normal post-spawning condition.

Conclusions. Male and female *P. versicolor* in Makbon waters has a hypoallometric growth pattern, i.e. the increase of the carapace length is faster than the weight growth. On the other hand, male lobsters in Tanjung Kasuari waters have a hypoallometric growth pattern and female lobsters have an isometric growth pattern, i.e. carapace length growth is the same as body weight growth. In general, the condition factor for male lobsters is greater when compared to the condition factor for female lobsters at both locations.

Conflict of interests. None reported.

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