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LENGTH-WEIGHT RELATIONSHIP AND CONDITION FACTOR OF CRAYFISH FROM SOUTH SORONG AND JAYAWIJAYA, PAPUA, INDONESIA

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ABSTRACT

The objectives of this study were to investigate the length-weight relationship and condition factor of crayfish living in the natural habitat of South Sorong and Jayawijaya Regencies, Papua, Indonesia. Three species of crayfish (*Cherax monticola, C. albertisii* and *C. communis*) were collected from Jayawijaya Regency and only one species of crayfish (*C. snowden*) was collected from South Sorong Regency. The growth coefficient (b) for each crayfish species ranged from 2.55 to 3.10. *C. monticola* from Jayawijaya Regency presented the highest b value (3.10), and *C. snowden* from South Sorong Regency showed the lowest b value (2.55). The condition factors (K) for each crayfish species ranged from 1.9 to 2.3. *C. monticola* and *C. albertissi* had the highest K value (2.3), whereas *C. swonden* demonstrated the lowest K value (1.9). The present study indicated that the values of b and K of crayfish living in Jayawijaya were higher than those from South Sorong probably because Jayawijaya habitat provides more suitable environment and better food supply for crayfish than South Sorong.

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INTRODUCTION

Freshwater crayfish of the family Parastacidae is one of the spectacular features of the fauna of Papua Indonesia. The distribution of Parastacidae is restricted to the southern hemisphere (Holthuis, 1982). The family Parastacidae has 15 genera, 11 of which are found in Oceania (Lukhaup and Herbert, 2008). Nine genera are found only in Australia and 1 genus is found only in New Zealand (Hopkins, 1970). Outside of Oceania, other Parastacidae were found in Madagascar (1 genus) (Hobbs, 1987) and South America (3 genera) (Riek, 1971; Crandall et al., 2000). All crayfish in Papua Indonesia and also in New Guinea belong to the genus *Cherax* (Holthuis, 1982).

Crayfish are known to be present in the river, river floodplain and lake of southern part of Papua Indonesia. They are collected and eaten by local people in all regions, particularly during the dry season when the water level is low. The crayfish of the island of Papua Indonesia and New Guinea were extensively studied by Holthuis (1949, 1956, 1958, 1982, 1986, 1996), Lukhaup and Pekny (2006, 2008), Lukhaup and Herbert (2008), Lukhaup (2015) and Lukhaup et al. (2015), and Patoka et al. (2015); however all previous studies were focused on the morphological description of

the new species of *Cherax*. Few studies have been conducted concerning the growth of crayfish in their natural habitat. Measuring individual body length and weight is a basic procedure in the scientific study of a species. The length-weight relationship (LWR) is a useful tool in environmental monitoring programs, especially for calculating weight at a certain length (and vice versa), as well as for the calculation of a condition factor in order to allow comparisons between populations from different regions (Lindqvist and Lahti, 1983; Milosevic and Talevski, 2016). The condition factor can be used to assess the degree of well-being of the organisms in their habitat (Mac Gregor, 1959). When condition factor value is higher, it means that the animal has attained a better condition. The condition factor of aquatic organism can be affected by a number of factors such as stress, availability of feeds, season and water quality of habitat (Khallaf et al., 2003).

LWR and condition factor are regarded as more suitable for assessing not only fish, but also crustaceans. LWR and condition factor values of some crayfish species in relation to habitat variables and aquaculture conditions have been demonstrated by some authors (Streissl and Hodl, 2002; Mazlum et al., 2007; Wang et al., 2011).

The growth pattern in crustaceans is a discontinuous process with successive moults interspersed by intermolts during which the animals increase in size (Renai et al., 2007). While the internal physiological growth is continuous, a rapid increase in length and weight occurs only at the moult (Kozak et al., 2009). Cesar et al. (2006) reported that the progressive shrinking of abdominal muscle occurred at premolt and swelling at postmolt. The abdominal muscle buildup occurs mostly during intermolt. Due to this reason, crayfishes in intermolt stage were used in this study. Because there had been no previous studies on growths and condition factors of crayfish inhabiting the natural habitat of South Sorong and Jayawijaya Regencies, Papua Indonesia, we undertook this investigation.

MATERIALS AND METHODS

Sample collection

Crayfish were collected from three districts (Yalengga, Wamena and Kurma) at Jayawijaya Regency and three districts (Sawiat, Tofot and Seremuk) at South Sorong Regency (Fig. 1) between November 2015 and January 2016. The animals were collected with the assistance of local people using cast net, *noken* (a knotted net or woven bag handmade from wood fiber or leaves by communities in Papua Indonesia), and hands to pick and dislodge them from their burrow. They were placed in clean polythene bags and

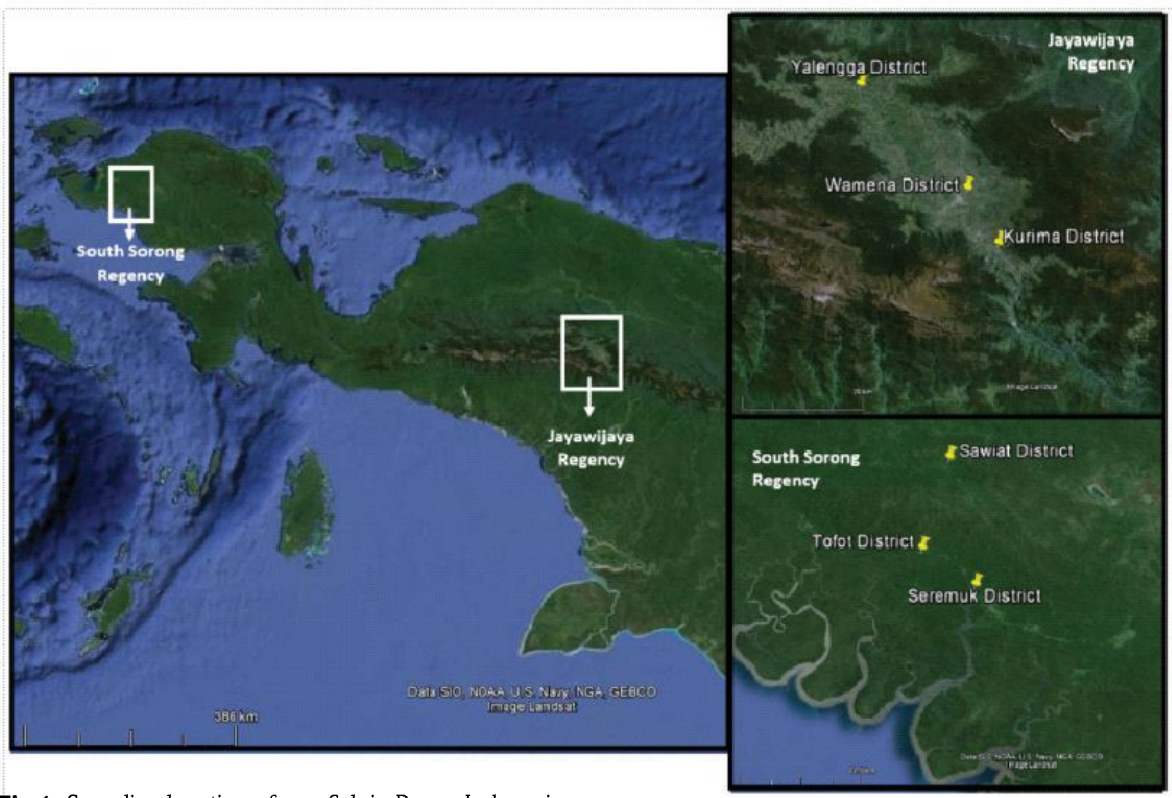

Fig 1. Sampling location of crayfish in Papua Indonesia

transported to the laboratory for analysis. Crayfishes were placed on filter paper for several minutes to remove excess water, then weighed to the nearest 0.1 g and measured to the nearest 0.1 cm in total length (from the tip of rostrum to the end of telson). Only crayfishes in intermolt stage were considered for the study. The animal's molt stage was determined by examining cuticular and setal development in the pleopods (Turnbull, 1989).

Data analysis

Isometric-allometric growth of crayfish was calculated from the LWR equation $W = aL^b$ (Cone, 1989), where W is the weight of crayfish in g, L is the total length of crayfish in cm, a is the intercept and b is the slope (isometric-allometric growth coefficient). The parameters a and b of LWR were estimated by linear regression analysis (least squares method) on log transformed data from the following equation: $\log W = \log a + b \log L$ (Cone, 1989). The coefficient of determination (r^2) was estimated to understand the quality of the linear regression analysis (Scherrer, 1984). The value of b gives information on the kind of crayfish growth: growth is isometric if $b = 3$ and growth is allometric if $b \neq 3$. The growth of crayfish is considered to be negatively allometric if $b < 3$ and positively allometric if $b > 3$ (Riedel et al., 2007). Isometric growth is attained when there is no change of body shape as an organism grows. Negative allometric growth is attained when the organism becomes more slender as it increases in weight, while positive allometric growth is reached when the organism becomes relatively stouter or deeper-bodied as it increases in length (Riedel et al., 2007).

The condition factor (K) was calculated from equation, $K = 100W/L^3$, where W is observed total body weight (g) and L (cm) is body length (Ricker, 1975). Differences in the condition factor were examined between species of crayfish with one-way analysis of variance. When significant differences were detected ($p < 0.05$), a Duncan's multiple range test was used to identify the condition factor value that differed at a significance level (α) of 0.05.

Water quality parameters of habitat such as temperature, pH, dissolved oxygen (DO) and turbidity were measured during the collection of crayfish at each sampling station (district). Temperature and DO were measured with portable DO meter Lutron DO 5510, pH with a pH indicator paper and turbidity with portable turbidity meter Hanna C102. The physico-chemical characteristics of these sites are outlined in Table 1.

Table 1. The physico-chemical characteristics of sampling sites

Location	River Width (m)	River Depth (m)	Temperature (°C)	pH	Turbidity (NTU)	DO (ppm)	Substrate Type
Jayawijaya Regency							
Yalengga District	20-25	1.6-6.4	17-18	7.0-7.5	35.0-39.2	7.32-7.84	Sandy clay
Wamena District	20-30	1.2-2.0	17-18	7.0-7.5	36.0-38.2	7.20-7.32	Sandy clay
Kurima District	25-35	1.3-1.8	17-18	7.0-7.5	37.0-38.8	7.40-7.53	Sandy clay
Overall range	20-35	1.2-6.4	17-18	7.0-7.5	35.0-39.2	7.20-7.84	
South Sorong Regency							
Sawiat District	4-7	0.5-0.7	26-27	7.0-7.5	0.53-0.57	6.23-7.15	Rocky and pebbly
Tofot District	5-8	0.4-0.7	26-28	7.0-7.5	1.19-1.66	7.37-7.71	Rocky and pebbly
Seremuk District	5-9	0.3-0.8	26-28	7.0-7.5	0.43-0.62	7.56-7.85	Rocky and pebbly
Overall range	4-9	0.3-0.8	26-28	7.0-7.5	0.43-1.66	6.23-7.85	

RESULTS

The environmental factors of habitat, particularly temperature, turbidity and substrate type of South Sorong, were substantially different than those of Jayawijaya (Table 1). The temperatures of habitat of South Sorong were higher than those of Jayawijaya, and the turbidities of South Sorong were lower than those of Jayawijaya. The type of substrate of South Sorong was rocky and pebbly, whereas the substrate of Jayawijaya was sandy clay. The river habitat of crayfish in Jayawijaya was also larger and deeper than the habitat in South Sorong.

Three species of crayfish were collected from Jayawijaya Regency and only one species of crayfish was collected from South Sorong Regency. *C. monticola*, *C. communis* and *C. albertissi* were caught at all districts of Jayawijaya Regency. During survey, only *C. snowden* was caught from South Sorong Regency (Table 2).

The b-value range for the studied species was from 2.55 to 3.10 (Table 3). The highest b value was found in *C. monticola* and the lowest b value was noted in *C. snowden*. The condition factors (K) for studied crayfish species ranged from 1.9 to 2.3 (Table 3). The highest K value was observed in *C. monticola* and *C. albertisii*, and the lowest K value was recorded in *C. snowden.* We noted that *C. monticola* and *C. communis* showed positive allometric growth, *C albertisii* demonstrated isometric growth and *C. snowden* showed negative allometric growth.

Table 2. Number of species, sample size (N), weight and total length of crayfish from Jayawijaya and South Sorong Regencies, Papua, Indonesia

Species of crayfish	N from District of Jayawijaya			N from District of South Sorong			Total N	Weight (g)	Total Length (cm)
	Yalengga	Wamena	Kurima	Sawiat	Tofot	Seremuk			
Cherax monticola	18	5	13	-	-	-	36	10.5-432.5	8.1-24.0
C. communis	13	15	16	-	-	-	44	8.3-83.6	7.3-15.8
C albertisii	2	11	4	-	-	-	17	9.5-88.3	7.4-15.4
C. snowden	-	-	-	30	30	27	87	3.0-95.0	5.0-15.5

Table 3. Weight–length regression analysis and condition factor (K) of crayfish from Papua Indonesia

Crayfish species	Log a	b	Growth type	r^2	K (Range)	K (Mean ± SD)
Cherax monticola	-1.77	3.10	+A	0.95	1.5 – 3.3	2.3 ± 0.4^a
C. communis	-1.76	3.05	+A	0.93	1.3 – 2.5	2.0 ± 0.3^b
C. albertisii	-1.63	3.00	I	0.93	1.6 – 3.0	2.3 ± 0.4^a
C. snowden	-1.35	2.55	-A	0.84	1.2 – 2.7	1.9 ± 0.4^b

Notes: Growth type: I = isometric growth, +A = positive allometric growth, -A = negative allometric growth Different letters indicate significant differences ($p < 0.05$; $a > b$)

DISCUSSION

The present study is the first report on length-weight relationship and condition factor of crayfish from South Sorong and Jayawijaya, Papua, Indonesia. Our results showed that the estimated b values varied among species. In Papua Indonesia, the population of crayfish *C. snowden* demonstrated negative allometric growth, *C. monticola* and *C. communis* showed positive allometric growth and *C. albertisii* presented isometric growth. According to the K values, *C. monticola* (2.3) and *C. albertisii* (2.3) seem to attain a better condition than *C. snowden* (1.9) and *C. communis* (2.0). Crayfishes living in Jayawijaya, which is characterized by a larger and deeper habitat, higher turbidity, lower water temperature and sandy-clay substrate, had higher values of b and K compared to crayfishes living in South Sorong. Jayawijaya habitat provides more suitable environment and better food supply for crayfish than South Sorong.

Table 4. A comparison of growth and condition factor (K) of crayfish from Papua Indonesia and other regions of the world

Species	b	Growth type	K	Location	Reference
Procambarus alleni	3.30	+A	-	Wetlands of Everglades National Park, USA	Acosta and Perry (2000)
Austropotamobius torrentium	3.25	+A	3.3	Danube river, Austria	Streissl and Hodl (2002)
Procambarus acutus	3.3	+A	1.6	Calhoun Field Station, Clemson University, Clemson, South Carolina	Mazlum et al. (2007)
Procambarus clarkii	3.47	+A	2.3	Zhougang Field Station, Nanjing Fisheries Research Institute, Jiangsu, China	Wang et al. (2011)
Orconectes rusticus	3.10	+A	1.5	Northern, central, and southeastern Indiana and the state of Wisconsin USA	Anderson and Simon (2015)
Orconectes virilis	5.44	+A	5.88	Laurentian Great Lakes and Ohio River, USA	Simon and Stewart (2014)
Astacus leptodactylus	3.04	I	2.6	Iznik lake, Bursa, Turkey	Aydin et al. (2015)
Procambarus clarkii	3.70	+A	-	Rharb region, Marocco	Qoraychy et al. (2015)
Procambarus alleni	2.85	-A	-	North America	Hobbs et al. (1989)
Procambarus fallax	3.03	I	-	North America	Hobbs et al. (1989)

Note: b = the slope (allometric growth coefficient) of the equation: log W = log a + b log L, Growth type: I = isometric growth, +A = positive allometric growth, -A = negative allometric growth

A comparison with data from other researchers (Table 4) showed that the growth types and condition factors of crayfish were highly varied among species and locations. Most crayfish species such as *Procambarus alleni* (Acosta and Perry, 2000), *Austropotamobius torrentium* (Streissl and Hodl, 2002), *P. acutus* (Mazlum et al., 2007), *P. clarkii* (Wang et al., 2011; Qoraychy et al., 2015), *Orconectes virilis* (Simon and Stewart, 2014), *O. rusticus* (Anderson and Simon, 2015) demonstrated positive allometric growth (Table 4). While *Astacus leptodactylus* from Iznik Lake, Turkey (Aydin et al., 2015), *P. fallax* from North America (Hobbs et al., 1989) showed isometric growth, and *P. alleni* from North America (Hobbs et al., 1989) presented negative allometric growth. Concerning the condition factor, most crayfish showed higher values of condition factor (>1); it means that the animal has attained a better condition (Table 4). The difference of growth types and condition factors of crayfish among species and locations may be a reflection of a number of factors, including population density, food abundance, photoperiod, water level fluctuations and water quality (Acosta and Perry, 2000). Lindqvist and Lahti (1983) reported that the variation of length–weight relationships among crayfish species was also affected by sex, sexual stage and ecological conditions. Aiken and Waddy (1987) reported that growth rates and patterns were highly variable among crayfish species, and within a species under different environmental conditions. Moreover, Acosta and Perry (2000) reported that growth of crayfish in the natural habitat with a high-protein diet was higher than those in habitat with low food supply. Davis et al. (1994) reported that the natural habitat provided food and shelter for crayfish, so they grew in optimal conditions.

CONCLUSIONS

The present study is the first report on the length-weight relationship and condition factor of crayfishes from Papua Indonesia. The growth coefficients (b) and condition factors (K) of crayfishes living in Jayawijaya were higher than those living in South Sorong. All data indicate that Jayawijaya habitat provides more suitable environment and better food supply for crayfish. This study provides baseline information on the isometric-allometric growths and Ks of crayfish, which will be beneficial for further reference especially for management and conservation of crayfish.

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Sažetak

DUŽINSKO-MASENI ODNOS I KONDICIJSKI FAKTOR RIJEČNIH RAKOVA JUŽNOG SORONGA I JAYAWIJAYA, PAPUA, INDONEZIJA

Ciljevi ovog rada bili su istražiti dužinsko-masene odnose i faktore kondicije riječnih rakova iz prirodnog staništa Južnog Soronga i Jayawijaya, Papua, Indonezija. Tri vrste riječnih rakova (*Cherax monticola, C. albertisii* i *C. communis)* prikupljene su u području Jayawijaya, a samo jedna vrsta *(C. snowden)* prikupljena je u Južnom Sorongu. Koeficijent rasta (b) za sve vrste imao je raspon od 2,55 do 3,10. Vrsta *C. monticola* iz područja Jayawijaya imala je najveću b vrijednost (3,10), a *C. snowden* iz Južnog Soronga najmanju b vrijednost (2,55). Faktor kondicije (K) za sve vrste imao je raspon od 1,9 do 2,3. Vrste *C. monticola* i *C. albertissi* imale su najveću K vrijednost (2,3) dok je vrsta *C. snowden* pokazala najmanju K vrijednost (1,9). Ovo istraživanje pokazalo je da su vrijednosti b i K za rakove koji žive u Jayawiaya području bile više od onih iz Južnog Soronga vjerojatno zbog toga što stanište Jayawijaya ima bolje uvjete okoliša i osigurava bolje uvjete za hranjenje rakova od staništa Južnog Soronga.

Ključne riječi: riječni rak, *Cherax*, rast, faktor kondicije

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