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LENGTH-WEIGHT RELATIONSHIPS AND CONDITION FACTORS OF THE THREE DOMINANT SPECIES OF MARINE FISHES CAUGHT BY TRADITIONAL BEACH TRAWL IN ULELHEE BAY, BANDA ACEH CITY, INDONESIA

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ABSTRACT

The objective of the present study was to examine the length-weight relationships and condition factors of snapper *Lutjanus russellii*, ponyfish *Aurigequula fasciata* and white-spotted spinefoot *Siganus canaliculatus* harvested from Ulelhee Bay, Banda Aceh City, Indonesia. These species are the predominant fishes caught by traditional beach trawl in Ulelhee Bay, Banda Aceh City, Indonesia. The sampling was conducted for three months from April to June 2015 at one-week interval. A total of 900 fish samples (300 individuals for each species) were measured for the total length and body weight. The length-weight relationships were calculated using Linear Allometric Model (LAM), while the relative weights (Wr) and Fulton's condition (K) factors were calculated to assess the condition of the fish samples. The results showed that the *b* value of 3.04 in snapper indicates isometric growth pattern, while ponyfish and white-spotted spinefoot fish had the b values of 1.41 and 1.75, respectively, and these species display an allometric growth pattern. The average Fulton's condition factor (K) of snapper was 3.01 for male and 2.49 for female; female ponyfish has the K value of 2.92 and 2.92 for male. In addition, the average K value of white-spotted spinefoot was 2.61 and 2.59 for female and male, respectively. The relative weight condition factor ranges from 58.73 to 166.09 for snapper, from 70.55 to 129.65 for ponyfish, and from 71.63 to 133.53 for white-spotted spinefoot. In general, the relative weight condition factors tendedto be 100. It is concluded that snapper has isometric growth pattern, while ponyfish and white-spotted spinefoot display the negative allometric growth pattern. The condition factors are in excellent condition and indicate a balance of prey and predator.

How to Cite

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INTRODUCTION

Snapper *Lutjanus russellii* (Bleeker, 1849), ponyfish *Aurigequula fasciata* (Lacepčde, 1803) and white-spotted spinefoot *Siganus canaliculatus* (Park, 1797) are predominant and important species for artisanal fisheries in Aceh Region, Indonesia. These species are mostly caught using beach trawl operated in waters with a flat and sandy bottom and coral reef free. There is very little information on the biology of these three species from this coastal region. On the other hand, the intensive exploitation of this small pelagic fish significantly increases over the years (personal communication with local fisheries officer). Presently, no precise record of the annual production is available. However, local fishermen claim that the catch volume has been decreasing over the last decade.

The studies of length-weight relationships (LWRs) of snapper and ponyfish from New Caledonia, Pacific Ocean have been reported by Letourneur et al. (1998) and Isa et al. (2012) and Deyrestani et al. (2015) from Merbok Estuary, Malaysia, and Persian Gulf, respectively, while studies on LWRs of spinefoot have been reported by several researchers, for example, from Thailand waters (Yanagawa, 1994), Banda Islands, Indonesia (Munira et al., 2010), Selayar Islands, Indonesia (Masyahoro, 2011), Mananr Gulf, India (Anand and Reddy, 2012), and Ratnagiri Coast, India (Metar et al., 2017). However, there was no LWRs study on these species from Aceh Waters, Indonesia. Information of length-weight relationship is crucial for fishery biology (Dar et al., 2012) and it is an important tool used in fishery management (Ndiaye et al., 2015). Consequently, this topic is extensively studied in recent years. In general, the study of the length-weight relationship of fish aims to determine the variation of weight and length of fish in individuals or groups of fish as an indicator of obesity, health, productivity and physiological conditions including gonadal development (Blackweel et al., 2000; Saygin et al., 2016). The LWR analysis can also estimate the condition factor of fish population (Everhart and Youngs, 1981). This information is important in relation to planning a better management strategy of fisheries resources, for example, to determine the selectivity of fishing gears (Merta, 1993). Studies of LWRs in fishes from Indonesian waters have been reported by several researchers, for example, flying fish *Decapterus russellii* in Likupang Bay, North Sulawesi (Manik, 2009), groupers in Berau Waters, East Kalimantan and Padang City (Nuraini, 2007; Bulanin et al., 2017), mullet *Liza subviridis* (Wahyudewantoro and Haryono, 2013) and striped snakehead *Channa striata* (Muthmainnah, 2013).

The current knowledge on LWRs in fishes from Aceh Waters is limited to five freshwater species, namely, *Rasbora tawarensis, Poropuntius* tawarensis (Muchlisin et al., 2011; Muchlisin et al., 2010), keureling fish *Tor tambra* (Muchlisin et al., 2015), marble goby *Oxyeleotris marmorata* (Nasir et al., 2016), viviparous halfbeaks, Dermogenys sp. (Zuliani et al., 2016), and four marine fishes, namely, halfbeak *Zenarchopterus dispar* (Fadhil et al., 2016), mullet *Mugil cephalus,* seriding *Ambassis koopsii* and ponyfish *Leiognathus fasciatus* (Mulfizar et al., 2012). However, the LWRs study on other fish species, in particular marine fishes, was of very limited availability. Hence, this reported study is focused on the LWRs and condition factors of three marine species snapper, ponyfish and spinefoot harvested from Ulelhee Bay, Banda Aceh City, Indonesia. These species are the predominant fishes caught by traditional beach trawl in these coastal waters.

MATERIALS AND METHODS

Sampling site and sampling procedure

The sampling was conducted at Ujung Pancu Village, Ulelhee Bay, Banda Aceh City, Indonesia (coordinate 5°33'46,714"N and 95°14'12,472"E (Fig. 1)) from March to June 2015.

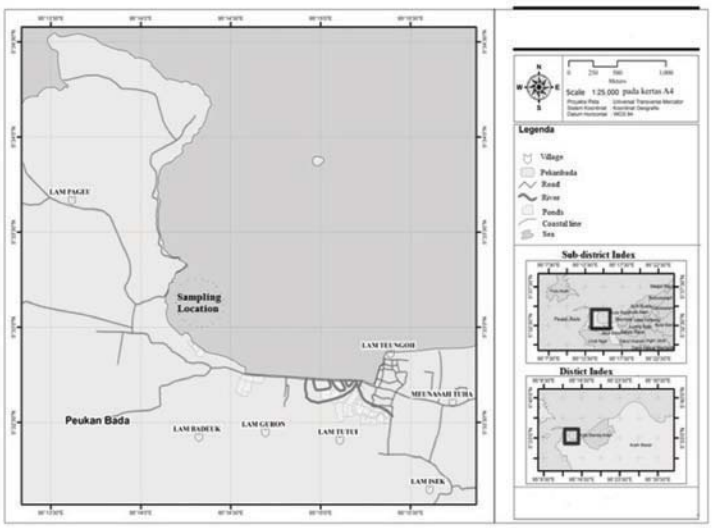

Fig 1. Map of Ulelhee Bay, Banda Aceh City, Indonesia with sampling locations

The target fish species examined in this study are the dominant species caught by traditional beach trawl in this region, that is, snapper, ponyfish and white-spotted spinefoot. The fish samples were captured using a traditional beach trawl, approximately 500 m from the shoreline (Fig. 1). The sampling was conducted at one-week interval for three months from April to June 2015. Collected fishes were counted and cleaned, and living fishes were anesthetized with overdose of MS.222, kept on crushed ice (4°C) and then transported to the Laboratory of Ichthyology Syiah Kuala University, Banda Aceh, Indonesia for further analysis. The measurement of total length and total body weight was

conducted on the same day of sampling time. The total length was measured to the nearest mm (0.1 mm errors) using a pair of digital calipers and weighed using a digital balance to the nearest gram (0.1 g errors).

Analysis of length-weight relationships and condition factor

The Linear Allometric Model (LAM) was used to estimate parameters *a* and *b* by log-transformed weight and length measurements. A correction for bias attributable to the back-transformation of mean weights from logarithmic units was performed when predicting weight at length from parameters fitted to the allometric equation following De-Robertis et al. (2008) as follows: $W = e^{0.56}aL^b$, where W is weight (g), L is total length (mm), *a* is the regression intercept, *b* is the regression coefficient and e is the variance of the residuals from the LAM regression. 0.56 is the correction factor of the datasets.

Fulton's condition factor (K) was calculated based on Muchlisin et al. (2010) as follows: $K_{TL} = WL^{-3} \times 100$, where K_{TL} is Fulton's condition factor, W is weight (g), L is length (mm) and -3 is length coefficient to ensure that the K value tends toward one. The relative weight condition factor (Wr) was examined based on Rypel and Richter (2008) as follows: Wr = (W/Ws) x 100, where Wr is relative weight condition factor, W is weight of fish sample and Ws is predicted weight of respective fish calculated as follows: $Ws = a \times L^b$.

RESULTS

Length weight relationships

A total of 900 fish samples were measured during the study consisting of 300 snapper (153 male: 147 female), 300 ponyfish (162 male: 138 female) and 300 white-spotted spinefoot (157 male: 143 female). The total length and body weight of snapper ranged from 87 mm to 177 mm and from 12 g to 69 g, respectively, while the dominant fish has total length between 106 mm and 150 mm (Fig. 1). Ponyfish has 85–185 mm total length and 15–52 g weight, while the dominant total length of this species was 96-135 mm (Fig. 2). In addition, the total length and weight of white-spotted spinefoot ranged from 70 mm to 117 mm and 8 g to 21 g, respectively, with the dominant fish samples having total length between 81 mm and 100 mm (Fig. 2).

The length-weight analysis revealed the *b* value of 1.43 in female ponyfish with a coefficient of determination (r^2) and coefficient of correlation (r) of 0.87 and 0.94, respectively, and the *b* value of male ponyfish was 1.41 with r^2 and r coefficients of 0.83 and 0.91, respectively (Fig. 3a; Fig. 3b). In addition, the observed growth was in agreement with predicted growth as shown in Fig. 3c and Fig. 3d. The *b* value of snapper was 3.028 for female and 3.039 for male with a coefficient r^2 and coefficient r of 0.862 and 0.928 for female, and 0.830 and 0.91 for male (Fig. 4a and fig. 4b). Figure 3c and figure 3d show that the predicted growth pattern was concordant to actual growth rate. In addition, the *b* values of white-spotted spinefoot fish were 1.7249 and 1.7193 for female and male, respectively, with the coefficient determination and correlation of 0.8015 and 0.7556 where both sexes display allometric growth pattern (Fig. 5).

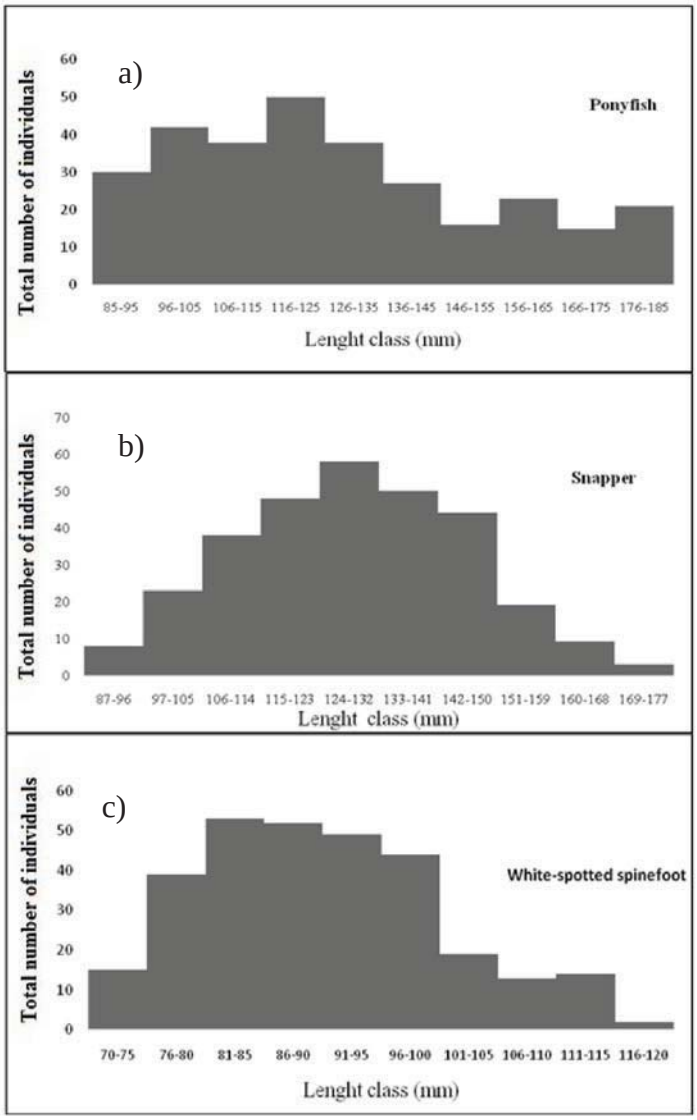

Fig 2. The total number of fish samples according to length classes: (a) snapper (n=300), (b) ponyfish (n=300) and (c) white-spotted spinefoot (n=300)

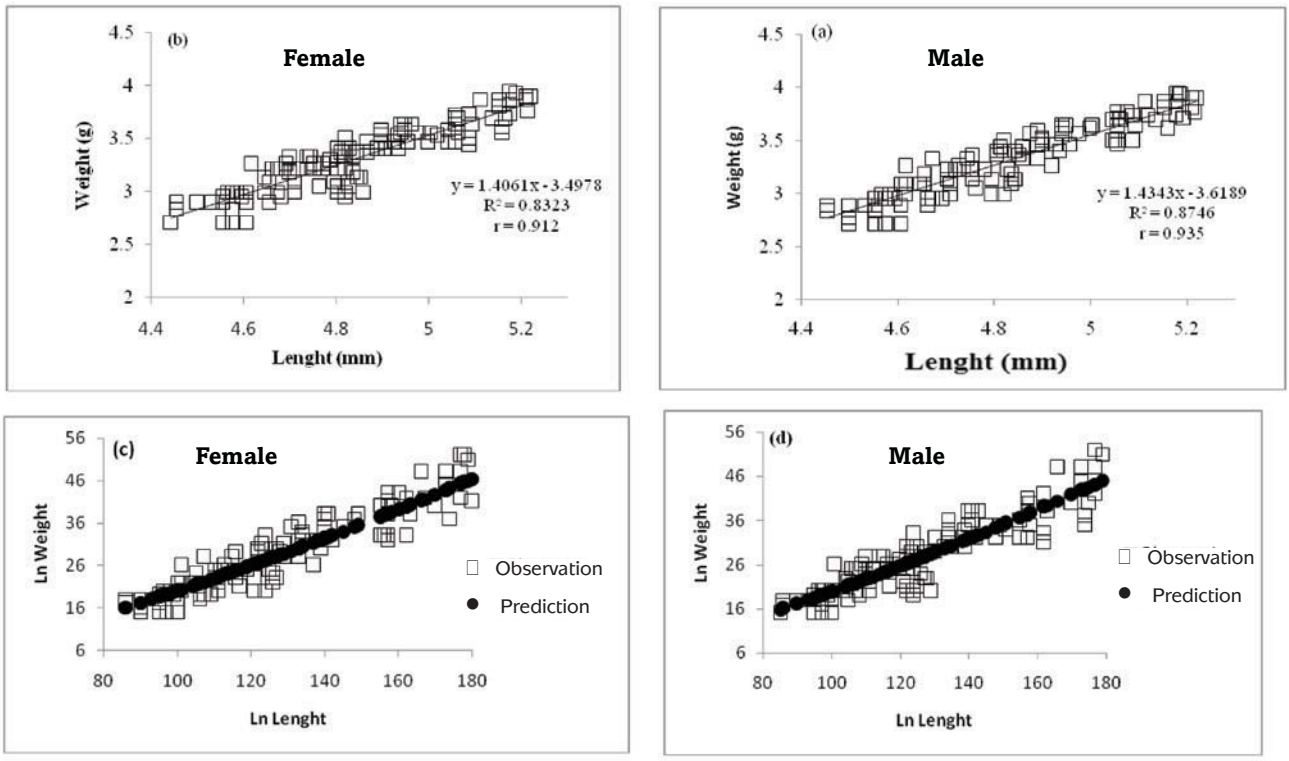

Fig 3. Length-weight relationships of ponyfish: (a) female (n=138) and (b) male (n=162)

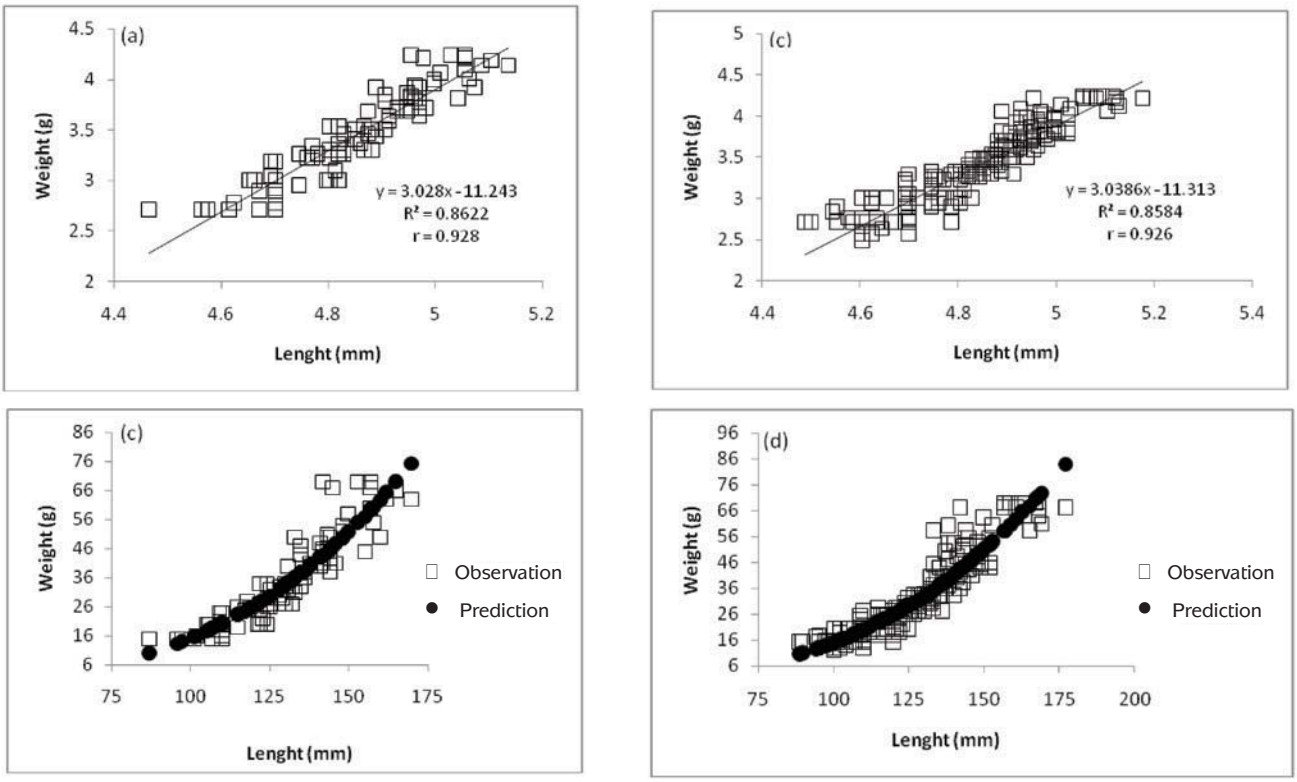

Fig 4. Length-weight relationships model of snapper showing the b value for (a) female (n=147) and (b) male (n=153)

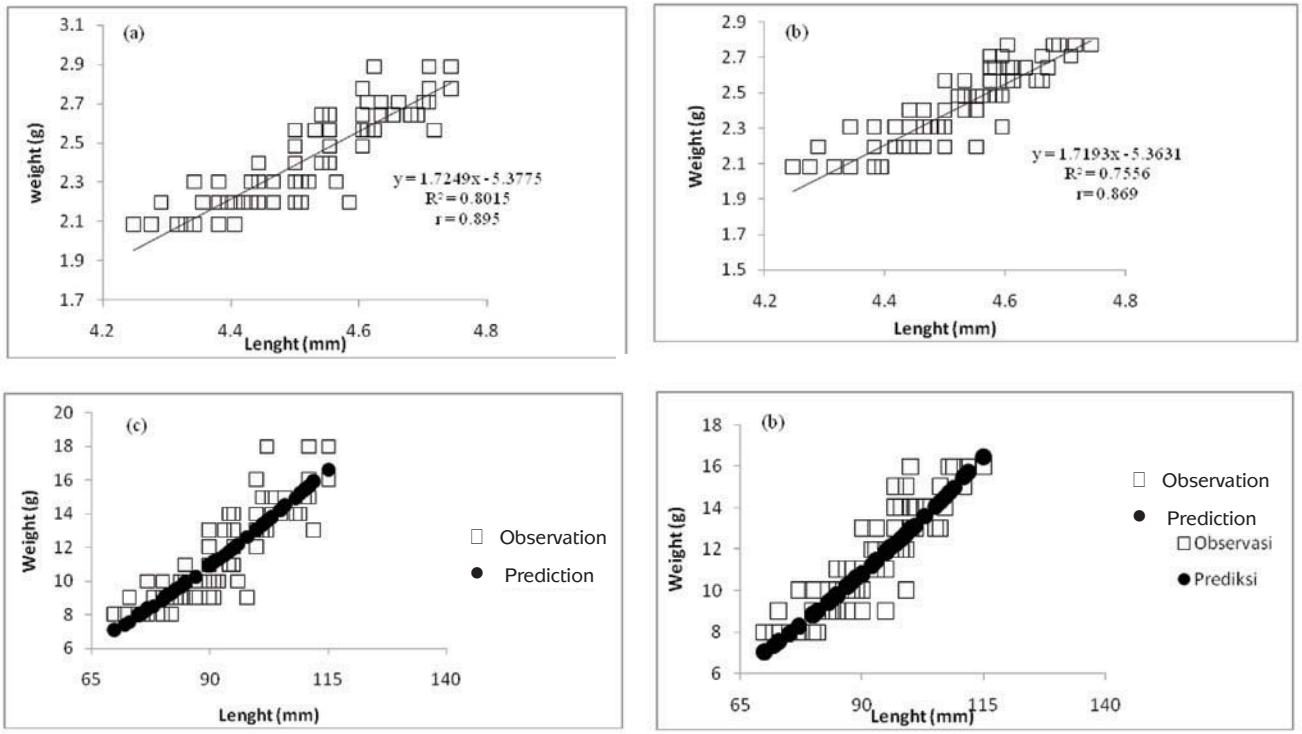

Fig 5. Length-weight relationship of white-spotted spinefoot: (a) female (n=143) and (b) male (n=157)

Condition factors

Two types of condition factors were measured in this study, that is, Fulton's condition (K) factor and the relative weight condition factor (Wr). Fulton's condition (K) factor of snapper fish ranged from 1.70 to 3.48 (average: 3.01) for male and 1.46 to 3.48 (average: 2.49) for female. The average relative weight condition factor of this fish was 101.38 for female and 101.57 for male. The K condition factor of ponyfish fish ranged from 2.62 to 3.31 (average: 2.92 ± 0.15) for female and 2.58 to 3.31 for male in average of 2.92 ± 0.16. Therefore, in general K values ranged from 2.49 to 3.01 for all three species and there was no significant difference in K values between male and female for ponyfish and white-spotted spinefoot fish. However, there was a significant difference in K values of female and male snapper fish where a higher K value was reported in female snapper.

The average relative weight condition factor was 100.68 for female and 100.81 for male. In addition, the K factor of white-spotted spinefoot fish ranged from 2.27 to 2.92 (average: 2.61 ± 0.11) for female and from 2.31 to 2.83 (average: 2.59 ± 0.11) for male. The average relative weight condition factor was 100.53 for female and 100.50 for male (Table 1). In general, the relative weight condition factors for all fish samples tended to be 100.

DISCUSSION

The results showed that the *b* values were not significantly different between the sexes in all three examined species. However, snapper has higher *b* values compared to ponyfish and spinefoot, whereas Ponyfish and spinefoot have negative allometric growth pattern while snapper displays an isometric growth pattern. This finding is supported by Fulton's condition factors that snapper has higher condition factor compared to the other two species. Coefficient determination (r^2) was higher than 0.75 for all examined species, indicating that 75% variance can be explained by this model. This also means that 75% of weight gain was attributed to length. Thus, there is a strong relationship between the weight gain and length gain of the fish, as the coefficient of correlation (r) was higher than 0.90 for all examined species. In contrast, Mulfizar et al. (2012) and Deyrestani et al. (2015) found that Ponyfish in Kuala Gigieng Water, Aceh Province, Indonesia and in the Persian Gulf, respectively, displayed a positive allometric growth pattern. However, Djaja and Saadah (2001) reported that ponyfish in Labuan Bay, Banten, Indonesia display isometric growth pattern. In addition, Isa et al. (2012) reported that Snapper in the Merbok Estuary, Malaysia had a negative growth pattern.

Table 1. The measured parameters of length-weight relationships and condition factor of snapper fish, ponyfish fish and barong fish harvested during April–June 2015

Parameter	Snapper		Ponyfish		White-spotted spinefoot	
	Female (n=147)	Male (n=153)	Female (n=138)	Male (n=162)	Female (n=143)	Male (n= 157)
Total length, TL (mm) (mean±SD)	87.0 – 170.0 (130.65±17.35)	89.1 – 179.0 (133.27±19.96)	86.1 – 185.1 (129.93±28.07)	85.0 – 185.0 (127.34±26.43)	70.2 – 115.1 91.32±10.88)	70.2 – 117.0 89.75±9.14)
Body weight, W (g) (average±SD)	15.0 – 69.3 (35.13±14.21)	12.1 – 69.2 (32.78±15.30)	15.1 – 52.1 (29.44 ± 9.63)	15.2 – 52.1 (28.14 ± 9.00)	8.3 – 18.1 11.28 ± 2.65)	8 .2– 16.1 10.80 ± 2.23)
Predicted body weight, Ws (g)	35.27±13,74	32.23±13.81	29.25±9.07	27.92±8.20	11.22±2.31	10.75±1.88
Relative body weight, W_r (average±SD)	16.93-160.13 (101.38 ± 16.93)	59.08 – 167.13 (101.57 ± 18.22)	74.14-129.37 (100.68±11.52)	71.18-130.54 (100.81±12.50)	71.61 – 133.67 (100.53±10.21)	76.40 – 124.36 (100.50±11.11)
Fulton's condition factor, K (average±SD)	0.17-3.48 (3.01 ± 0.17)	1.46-3.48 (2.49 ± 0.53)	2.62-3.31 (2.92±0.15)	2.58-3.31 (2.92±0.16)	2.27 – 2.92 (2.61 ± 0.11)	2.32 – 2.83 (2.59 ± 011)
Coefficient determination, R^2	0.86	0.87	0.88	0.83	0.80	0.76
Coefficient correlation (r)	0.93	0.93	0.94	0.91	0.90	0.90
b value	3.02	3.03	1.43	1.40	1.72	1.71
Growth pattern	Isometric		Negative allometric		Negative allometric	

Therefore, growth patterns depend on environment and not necessarily only on the particular species. However, no comparative data for Spinefoot is available. Those results indicate that Ulelhee Bay waters provided more favorable environment for snapper.

According to Jennings and Kaiser et al. (2001), population *b* values are dependent on physiological condition of fishes, for example, gonad development stage and food availability. Besides the biological and environmental conditions, geographical, temporal and sampling techniques also affect the observed growth pattern of the fish (Bagenal and Braum, 1978). In addition, Muchlisin et al. (2010) stated that *b* value is also affected by fish behavior; for example, active swimming fish may show lower *b* values compared to passive swimming fish. This is probably related to the energy allocation for movement and growth. This opinion was supported by Shukor et al. (2008) who argued that fast flowing stream environment could lower *b* value (and vice versa), as recorded in *R. sumatrana* from Peninsular Malaysia.

The relative weight condition factor (Wr) of all three species tended to be 100, indicating that there was a balanced presence between prey and predator in the community. This is an agreement with Anderson and Newman (1996) who stated that values of Wr < 100 for an individual or population suggest problems such as low prey availability or high predator density, whereas values above 100 indicate prey surplus or low predator density. A similar finding was reported in *Rasbora tawarensis* and *Poropuntius tawarensis* in Lake Laut Tawar, Indonesia, where the Wr of both species tends to be 100 (Muchlisin et al., 2010).

The condition factors show the health of the fish in general, productivity and physiological condition of the fish population (Blackweel et al., 2000; Richter, 2007). It reflects the condition of morphological characteristics of the fish, lipid content and growth rates (Bister et al., 2000; Froese, 2006; Stevenson and Woods, 2006). It is affected by the biotic and abiotic factors (Blackweel et al., 2000), for example, water quality and the density of prey (feed) and predator. Besides, the fisheries management strategy applied also influenced the condition factor (Murphy et al., 1991); for example, good management strategy will have a positive impact on the condition factor of the fish population. Presently, there are no baseline criteria for K value of all three species examined in this study and therefore we used the proposed criteria by Barnham and Baxter (1998) for salmonid fish where

the K value above 1.60 indicates excellent condition, which suggests that all examined species are in excellent condition. Further intensive study is needed to evaluate ranges of K value for snapper, ponyfish and spinefoot as a guideline to monitor the health condition of these species in the future.
In conclusion, snapper has isometric growth pattern, while ponyfish and white-spotted spinefoot display negative allometric growth pattern. Fulton's condition factor ranged from 2.49 to 3.01 for all fish samples, indicating an excellent condition. In addition, the relative weight condition factor tended to be 100, suggesting a balance of prey and predator. Hence, in general Ulelhee Bay waters are still in good condition and support the healthy fish growth.

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Sažetak

DUŽINSKO MASENI ODNOS TE KONDICIJSKO STANJE TRIJU DOMINANTNIH VRSTA MORSKIH RIBA UHVAĆENIH TRADICIONALNIM ULOVOM MREŽOM U ULELHEE ZALJEVU, BANDA ACEH, INDONEZIJA

Cilj studije bio je proučiti dužinsko maseni odnos te kondicijske faktore *Lutjanus russellii*, *Aurigequula fasciata* i *Siganus canaliculatus* ulovljenih u Ulehlee zaljevu, u gradu Banda Aceh, u Indoneziji. To su prevladavajuće riblje vrste, ulovljene tradicionalnim koćarenjem s kopna u Ulehlee zaljevu, u gradu Banda Aceh, u Indoneziji. Uzorkovanje je provođeno kroz period od tri mjeseca, od travnja do lipnja 2015. godine u intervalima od tjedan dana. Izmjerene su totalna dužina i masa na ukupno 900 uzoraka riba (300 individua iz svake navedene vrste). Dužinsko maseni odnos izračunat je pomoću linearnog alometrijskog modela (LAM), dok su relativna težina (W_r) i Fultonov koeficijent (K) izračunati kako bi se ocjenilo stanje uzoraka riba. Rezultati su pokazali da *b* vrijednost (3.04) kod *Lutjanus russellii* ukazuje na izometričan rast, dok je vrijednost *b* za *Aurigequula fasciata* i *Siganus canaliculatus* iznosila 1.41 i 1.75 te su vrste pokazale alometrijski rast. Prosječan Fultonov koeficijent (K) *Lutjanus russellii* iznosio je 3.01 kod mužjaka i 2.49 kod ženki. Kod oba spola *Aurigequula fasciata* K je iznosio 2.92. Uz to, prosječna vrijednost K *Siganus canaliculatus* iznosila je 2.61 kod ženki i 2.59 kod mužjaka. Općenito, faktori stanja relativne težine obično iznose 100. Zaključeno je da *Lutjanus russellii* ima izometričan obrazac rasta, dok *Aurigequula fasciata* i *Siganus canaliculatus* pokazuju negativan alometrijski uzorak rasta. Kondicijski faktori su u izvrsnom stanju te ukazuju na ravnotežu plijena i predatora.

Ključne riječi: obalni ribolov, faktor stanja relativne težine, Fultonov koeficijent, morske ribe

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