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Relative Abundance and Growth of Male and Female *Nemipterus furcosus* Population

(Kelimpahan Relatif dan Tumbesaran Jantan dan Betina Populasi *Nemipterus furcosus*)

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ABSTRACT

A study was conducted to understand the relative abundance and growth of male and female Nemipterus furcosus *population in the Pahang coastal water, Malaysia. The sampling was done monthly for a period of one year. A total of 1446 fish specimens were studied in this research. The results showed that male* N. furcosus *population was significantly more than female (*p*<0.01)* N. furcosus *population. The growth coefficient (b value) varied between 2.6808 and 3.2396 for male and 2.0926 and 3.2838 for female* N. furcosus. *The growth co-efficients of male* N. furcosus *were significantly different than the growth co-efficients of female* N. furcosus *in all months (*p*<0.05). They showed negative allometric growths in February- June and September. Female* N. furcosus *showed positive allometric growths in November-January and August. Isometric growths of female were observed only in October and July. As for male* N. furcosus, *negative allometric growths were observed in March-June, November and January. Male* N. furcosus *showed positive allometric growths in August, September, October, December and February. Male* N. furcosus *showed isometric growth only in July. The overall mean condition factor of male and female was statistically similar (*p*>0.05). The condition factor (K) ranged from 1.2559 to 1.3917 for male while 1.2503 to 1.3926 for female* N. furcosus. *Overall, higher mean condition factor was observed in smaller fish of both sexes. This study is useful for policy makers and fishery biologists for sustainable fishery management in the Pahang coastal water, Malaysia.*

Keywords: Condition factor; growth; Nemipterus furcosus*; Pahang Coastal water*; *relative abundance*

ABSTRAK

Suatu kajian telah dijalankan untuk memahami kelimpahan relatif dan pertumbuhan jantan dan betina populasi Nemipterus furcosus *di pesisir pantai Pahang, Malaysia. Persampelan dilakukan setiap bulan untuk tempoh satu tahun. Sebanyak 1446 spesimen ikan dikaji dalam kajian ini. Hasil kajian menunjukkan bahawa populasi jantan* N. furcosus *adalah jauh lebih banyak (*p*<0.01) daripada populasi betina* N. furcosus. *Pekali pertumbuhan (nilai b) adalah antara 26808 dan 32396 untuk jantan dan 20926 dan 32838 untuk betina* N. furcosus. *Pekali pertumbuhan jantan* N. furcosus *berbeza secara ketara daripada pekali pertumbuhan betina* N. furcosus *dalam semua bulan (*p*<0.05). Mereka menunjukkan pertumbuhan alometrik negatif dalam bulan Februari-Jun dan September.* N. furcosus *betina menunjukkan pertumbuhan alometrik positif pada bulan November-Januari dan Ogos. Pertumbuhan isometrik betina telah diperhatikan hanya pada bulan Oktober dan Julai. Bagi* N. furcosus *jantan, pertumbuhan alometrik negatif diperhatikan pada Mac-Jun, November dan Januari.* N. furcosus *lelaki menunjukkan pertumbuhan alometrik positif pada bulan Ogos, September, Oktober, Disember dan Februari.* N. furcosus *jantan menunjukkan pertumbuhan isometrik hanya pada bulan Julai. Min keseluruhan faktor keadaan jantan dan betina adalah sama secara statistik (*p*>0.05). Keadaan faktor (K) adalah antara 12559-13917 bagi jantan manakala 12503-13926 untuk* N. furcosus *betina. Secara keseluruhan, min faktor keadaan diperhatikan lebih tinggi pada ikan yang lebih kecil untuk kedua-dua jantina. Kajian ini berguna bagi pembuat dasar dan ahli biologi perikanan bagi pengurusan perikanan yang mapan di pesisir pantai Pahang, Malaysia.*

Kata kunci: Faktor keadaan; kelimpahan relatif; Nemipterus furcosus; *pertumbuhan; pesisir pantai Pahang*

INTRODUCTION

Nemipterus furcosus, commonly known as fork-tail threadfin bream is an economically important food fish in Malaysia. The total production of this fish in Malaysian water is decreasing day by day (FAO 2012) and this puts an increasing demand on the study and management of their population. A few studies have been conducted on the population of other economically important fish in Malaysia but the study on the *N. furcosus* population in the Malaysian water is still lacking. Adequate information about population parameters is prerequisite for the management of any wild fish stock (Hossain et al. 2009; Rahman & Hafzath 2012). According to Antony et al. (2014) and Gopalakrishnan et al. (2014), understanding basic information of any wild population particularly their abundance, growth and condition factor are prerequisite

before identifying proper management techniques on any wild fish stock.

Understanding the relative abundance of male and female fish is very important in population dynamics because it is related to spawning success, recruitment and longevity of a fish population (Adebiyi 2013; Ahmed et al. 2014). Growth is another important population parameter that is used to study the life history, development of fishery, resource management and culture of the species (Ahmed et al. 2015; Khatune-Jannat et al. 2012; Wu et al. 2015). It is also important in fisheries science for both applied and basic use to: Calculate production and biomass of a population; Compare the growth male and female fish in different localities; Determine the relative growth of small fish compared to large fish; and compare the population spatio-temporally (Gopalakrishnan et al. 2014; Rahman & Hafzath 2012). Although growth pattern is dependent on season and size (length-length relationship) are readily available for many fishes (Gopalakrishnan et al. 2014; Leunda et al. 2006; Miranda et al. 2006; Muhamad & Mohamad 2012; Oscoz et al. 2005; Rahman & Hafzath 2012), adequate local information is still scarce for most fish species especially for *N. furcosus*.

Condition factor is another important quantitative parameter that is related to maturity, gonadal development and general well-being of the fish. It determines the present and future population success by influencing growth, reproduction and survival (Ashraf et al. 2011; Kreiner et al. 2011; Wootton 1990). Since food availability is affected by the environment, the condition factor can also serve as an index to assess the status of the aquatic system in the fish habitat (Anene 2005; Ashraf et al. 2012; Rahman 2015a, 2015b). Unfortunately, there is no published information about the condition factor of *N. furcosus* especially in the Pahang coastal water. Thus, this research aimed to elucidate relative abundance of male and female and their growth and condition in the coastal water of Pahang, Malaysia.

Materials and Methods

A total of 1446 *N. furcosus* were sampled for this study. The samples were collected monthly for a period of 12 months from August 2012 to July 2013. All *N. furcosus* were collected from commercial fishing vessel at Kompleks Lembaga Kemajuan Ikan Malaysia (LKIM) Kuantan, Pahang, Malaysia. This landing center is used to collect the fish which were caught within 15 to 20 nautical miles distance from the Kuantan river estuary to the South China Sea. The required information like area of capture and method of capture were collected from the fishing vessel. Fishing vessel used trawl net to catch *N. furcosus*. All fish were collected from fishing vessel before sorting out in order to maintain random selection to get the best aggregate for the population. All sampled fish were transferred into ice box and then brought to the laboratory at Faculty (Kulliyyah) of Science, IIUM.

The male and female *N. furcosus* were separated upon arrival in the laboratory. Total length (TL) was measured on a board with a special meter ruler calibrated in cm. Body weight (BW) of two decimal points was measured after blot drying with paper towels. Weighing was done with a digital balance to the nearest gram. The growth coefficient was calculated from the mathematical relationship between length and weight (regression analysis). It was calculated using the equation, $W = aL^b$ (Pauly 1993) with W is the weight of fish (g), a is the intercept in the y-axis, b is an exponent (the regression coefficient) indicating growth pattern of fish and L is the total length of fish (cm). The value of b indicates isometric growth when close to 3, negative allometric growth when less than 3 and positive allometric growth when more than 3. The coefficient of determination (R^2) and the parameters a and b were estimated by linear regression analysis after logarithmic transformed equation, $Log\ W = Log\ a + b\ Log\ L$. The Fulton's condition factor (K) for each fish was calculated using the formula, with K is the condition factor, W is the weight of fish, L is the standard length of fish (cm).

The difference between male and female fish abundances in the monthly samples were analyzed through the chi-squared (χ^2 test). In order to confirm whether growth coefficient (b) obtained in the linear regressions were significantly different from isometric growth (b=3), we used a one-sample t-test expressed by the mathematical equation $t_s = (b-3)/s_b$ with t_s is the t-test value, b is the slope and s_b is the standard error of slope (b). The comparison between obtained t-test values and the respective tabled critical values allowed for the determination of the b values statistically significant and their inclusion in the isometric range or allometric range. Statistical equality of growth coefficient (b) and condition factors between male and female were analyzed through the analysis of covariance (ANCOVA), which was also used to test the statistical difference of growth coefficient (b) and condition factors among different sampling months. All continuous data (growth coefficient (b) and condition factor were checked for normally and homogeneity of variance before performing parametric test. All statistical analysises were considered significant at $p \leq 0.05$. The statistical software SPSS (version 22.0) was used for all statistical analyses.

Results

Out of 1446 *N. furcosus* collected from August 2012 to July 2013, 569 (39.35%) were females and 877 (60.65%) were males. The number of male and female *N. furcosus* were significantly different ($p<0.05$) in all sampling months except April ($\chi^2 = 0.08$; $p>0.05$), July ($\chi^2 = 0.605$; $p>0.05$) and October ($\chi^2 = 2.42$; $p>0.05$) (Table 1). Male outnumbered than female in January, February, March, August, September, November and December whereas female outnumbered than male in May and June. Overall sex ratio differ significantly ($\chi^2 = 121.68$; $p<0.01$). Overall male was significantly more than female but both of them were normally distributed (Figure 1).

Monthly regression lines and regression coefficients (b value, growth coefficient) and coefficient of determination

TABLE 1. Relative abundance of male and female of *N. furcosus* in different sampling months

Month	Sex	n	χ^2 value	Significance (p value)
Aug12	M	102	14.05	**
	F	49		
Sep12	M	111	25.92	**
	F	39		
Oct12	M	40	2.42	NS
	F	18		
Nov12	M	66	16.82	**
	F	8		
Dec12	M	83	9.25	**
	F	40		
Jan13	M	109	28.88	**
	F	33		
Feb13	M	83	7.22	**
	F	45		
Mar13	M	82	6.13	*
	F	47		
Apr13	M	42	0.08	NS
	F	46		
May13	M	47	7.22	**
	F	85		
Jun13	M	32	16.82	**
	F	90		
Jul13	M	80	0.61	NS
	F	69		
Overall	M	877	121.68	**
	F	569		

M, Male; F, Female; *, $p<0.05$; **, $p<0.01$; NS, not significant

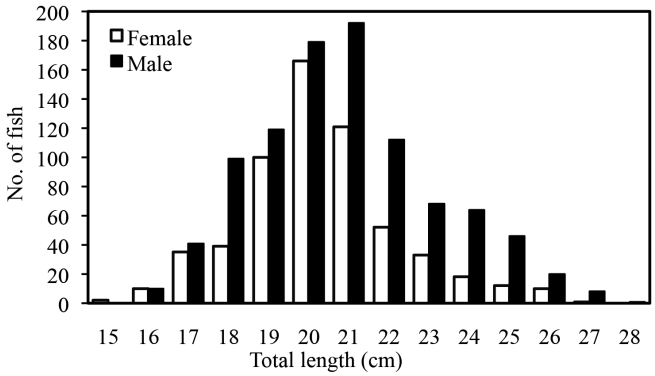

FIGURE 1. Lengthwise frequency distribution of male and female *N. furcosus* in Pahang coastal water, Malaysia

(R^2) of length-weight relationship in male and female *N. furcosus* are presented in Figure 2 and Table 2, respectively. All regression lines were linear with high coefficient of determination. Regression analysis showed that the growth coefficients vary between 2.0926 (September) and 3.2838 (December) for female while 2.6808 (May) and 3.2396 (August) for male *N. furcosus* (Table 2). The mathematical relationships between length and weight in both male and female in each month was significant ($p<0.05$). Female *N. furcosus* showed negative allometric growths in September, February, March, April, May and June (Table 2). Female *N. furcosus* showed positive allometric growths in August,

TABLE 2. Relative growth coefficient of male and female *N. furcosus* in different sampling months

			Regression parameters				
Month	Sex	n	a	b		R^2	Sig. (*p* value)
Aug12	M	102	0.0066	3.2396	+	0.9683	*
	F	49	0.0100	3.1050	+	0.9684	*
Sep12	M	111	0.0097	3.1080	+	0.8831	*
	F	39	0.2217	2.0926	-	0.5091	*
Oct12	M	40	0.0008	3.1663	+	0.9026	*
	F	18	0.0109	3.0514	iso	0.9483	*
Nov12	M	66	0.0158	2.9466	-	0.9200	*
	F	8	0.0065	3.2466	+	0.9756	*
Dec12	M	83	0.0084	3.1392	+	0.8900	*
	F	40	0.0056	3.2838	+	0.9138	*
Jan13	M	109	0.0221	2.8255	-	0.9578	*
	F	33	0.0081	3.1720	+	0.9779	*
Feb13	M	83	0.0084	3.1258	+	0.9576	*
	F	45	0.0191	2.8563	-	0.9486	*
Mar13	M	82	0.0165	2.9100	-	0.9116	*
	F	47	0.0158	2.9203	-	0.9012	*
Apr13	M	42	0.0215	2.8346	-	0.9184	*
	F	46	0.0231	2.8057	-	0.9193	*
May13	M	47	0.0336	2.6808	-	0.7799	*
	F	85	0.1216	2.2570	-	0.6886	*
Jun13	M	32	0.0314	2.7139	-	0.7810	*
	F	90	0.0464	2.5889	-	0.7795	*
Jul13	M	80	0.0104	3.0625	iso	0.9363	*
	F	69	0.0121	3.0221	iso	0.9189	*

M, Male; F, Female; n, number of fish sampled; a, intercept of regression line; b, regression coefficient; R^2, coefficient of determination; *, regression significant at 0.01 level ($p<0.01$); +, positive allometric growth; -, negative allometric growth; iso, isometric growth

November, December and January. Isometric growths of female were observed only in October and July. As for male *N. furcosus*, negative allometric growths were observed in November, January, March, April, May and June. Male *N. furcosus* showed positive allometric growths in August, September, October, December and February. Male *N. furcosus* showed isometric growth only in July. The growth co-efficients (b values) of male *N. furcosus* were significantly different than the growth co-efficients of female *N. furcosus* in all months (Figure 2).

The condition factor (K) ranged from 1.2559 to 1.3917 (Figure 3) for male while 1.2503 to 1.3926 (Figure 4) for female *N. furcosus*. The effects of sampling months, sex and their interaction on condition factor of *N. furcosus* are presented in Table 3. There was no significant difference ($p>0.05$) between condition factors of male and female *N. furcosus* (Table 3). Temporal effects was significant ($p>0.05$) on condition factors ($p<0.05$) of *N. furcosus*. The interaction effect of sampling month and sex was not significant on the condition factor of *N. furcosus*. The significantly ($p<0.05$) lowest K value was found in March, April, May and July for male *N. furcosus* (Figure 3) while female *N. furcosus* had lowest condition factor in March, April and October (Figure 4). Both male and female *N. furcosus* showed highest K value in August. The condition factor in relation to size class for both sexes is shown in Figure 5. Small and large fish showed almost similar K value.

DISCUSSION

In the present study, male fish was dominated over female by number in almost all sampling months. This indicated that male and female are not balanced in the *N. furcosus* population in the Pahang coastal water. In the present study, no sexual dimorphism was observed. However, *N. furcosus* showed size-related differences in sex ratio with male predominating at larger sizes. This might be related to different growth and longevity characteristics between the sexes (Wu et al. 2008). Male *N. furcosus* generally grows faster than female as the growth of female fish slows at the onset of sexual maturity in females (Haddy 2007). Many *Nemipterus* species show size-related differences in sex ratio, with large fish being mainly males (Young & Martin 1985). There is no published information comparing the sex ratio of *N. furcosus* in the Pahang coastal water. However, our result concurs with Young and Martin (1985), who observed sex ratio of *N. furcosus* in the North West Shelf with males predominating at larger sizes. Rahman and

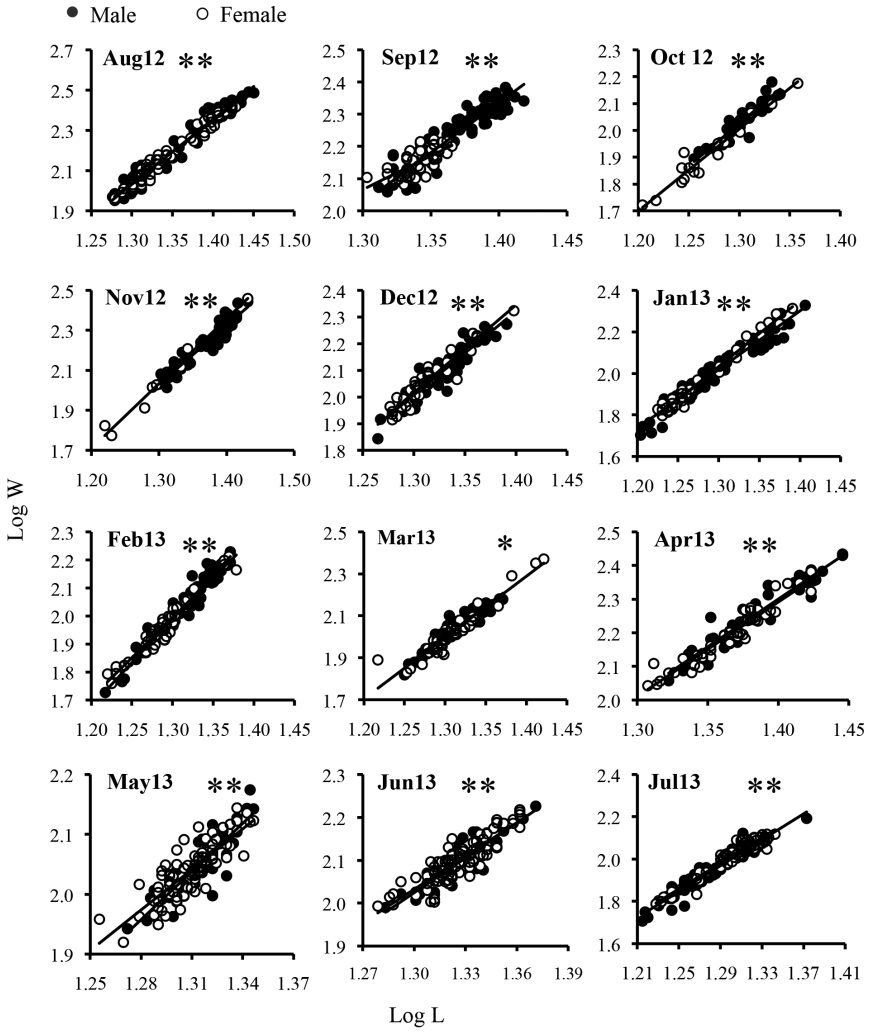

FIGURE 2. Comparison between male and female *N. furcosus* on regression line of length-weight relationship. Asterisk indicates significant difference between male and female (*, p<0.05; **, <0.01)

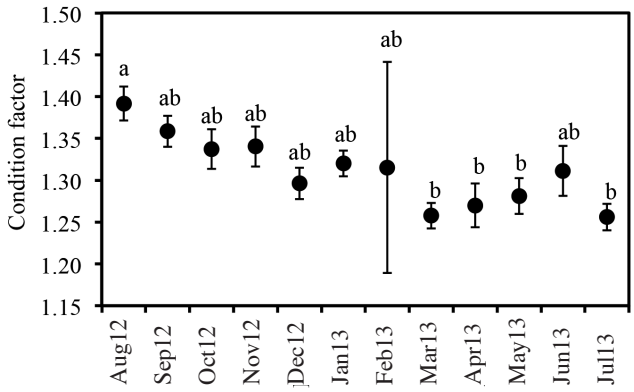

FIGURE 3. Temporal changes of condition factor (mean ± 95% confidence intervals) of male *N. furcosus*. Mean with no letter in common differ significantly (p<0.05)

Hafzath (2012) studied the sex ratio of another carangid fish *Rastrelliger kanagurta* in the coastal water of Pahang where male *R. kanagurta* was dominated over female *R. kanagurta*. Besides growth differences, sex ratio can be different due to catchability by gear. Location and time can also influence the sex ratio in carangids, probably because of segregation and differential movement with respect to sex or spawning condition (Wu et al. 2008).

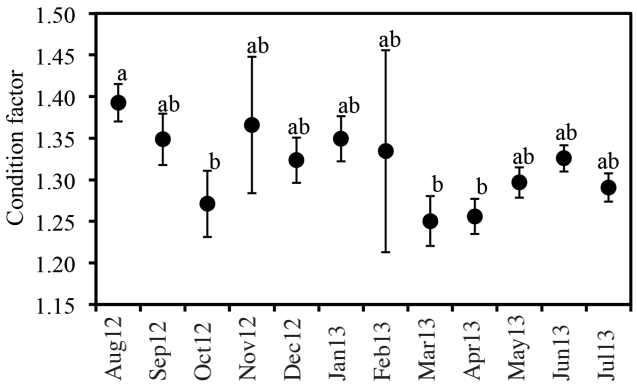

FIGURE 4. Temporal changes of condition factor (mean ± 95% confidence intervals) of female *N. furcosus*. Mean with no letter in common differ significantly ($p<0.05$)

TABLE 3. Effects of sampling month and sex and their effect on condition factor of male and female *N. furcosus* based on two-way ANOVA

Factor	Significance (P value)
Sampling month	*
Sex	NS
Sampling month × Sex	NS

*Indicates significantly different ($p<0.01$) and NS indicates not significantly different ($p>0.05$)

In this study, the observed growth of male and female *N. furcosus* were within the acceptable range. According to Bagenal and Tesch (1987), the fish growth coefficient (b value) varies between 2 and 4 and generally in the range of 2.5 to 3.5. To the best of my knowledge, there is no previous study regarding growth of *N. furcosus* in Malaysia including Pahang coastal water. However, a study conducted in the Jizan region in the Red Sea by Bakhsh (1994) who observed the growth coefficient of *N. japonicus* ranged from 2.428 to 3.087. Nursyazwani (2013) studied the growth coefficient of *N. nemurus* in the Pahang coastal water, Malaysia and observed the growth coefficient values ranged from 2.64 to 3.23. Joshi (2005) studied the biology of *N. mesoprion* in the Indian water and reported growth coefficient 2.93. In this study, female *N. furcosus* had a negative allometric growth in February, March, April, May and June. The reason of low growth coefficient in these months is unknown. However, many marine fish exibits lower growth coefficient value during the spawning months compare to other months as large number of mature individuals with higher rates of increase in body weight than in body length. Therefore, it can be speculated that female *N. furcosus* had low growth coefficient values in February, March, April, May and June due to spawning period. More research is needed on the relationship between growth coefficient and spawning period of *N. furcosus*. The differences in the water quality (especially temperature), habitat, diet, food availability, competition and pollution are also very well-known factors that influence the growth and behavior of fish (Rahman & Verdegem 2010; Rahman et al. 2016, 2008a, 2008b, 2008c). In this study however, environmental and habitat factors were not analyzed. Thus, more research is needed including analyzing environmental or habitat factors to understand the cause of low growth coefficient in February, March, April, May and June for female *N. furcosus* in Pahang coastal water.

The study of condition factor is very essential in understanding the life cycle including spawning season of fish and leads to adequate management for sustainable production. The condition factor varied from 1.2559 to 1.3917 for male and 1.2503 to 1.3926 for female *N. furcosus* represented a fair and acceptable condition of fish (Charles & Alan 2003). So far, there are no studies regarding condition factor of *N. furcosus* found in Malaysia or the world but a study conducted by Amal (2012) on the condition factor of *N. japonicus*, one of the closely related species to *N. furcosus*. However, the result of the present study concurs with Amal (2012), who observed the mean values of condition factor 0.9577 to 1.728 for males and 1.007 to 1.622 for female *N. japonicus* in the Gulf of Suez, Egypt. In the present study, the condition factor of male *N. furcosus* was the lowest in March, April, May and July, while in March, April and October for female *N. furcosus*. On the other hand, condition factor of male and female *N. furcosus* was highest in August. There are many factors that influence the condition factor of fish. The interaction between the fish and the environment influences the condition factor and well-being of the fish (Rahman & Mayer 2009; Rahman et al. 2010; Sun et al. 2015). The drop of condition factor values might be due to environmental conditions and food availability. According to Braga and Gennari (1990), condition factor vary according to season and is influenced by environmental conditions (Rahman & Verdegem 2010; Rahman et al. 2009; Rajkumar et al. 2013). Rainfall and productivity of ecosystem are also known to influence condition factor values (Rahman et al. 2010). More research is needed to understand the relationship between different environmental factors and condition factor of *N. furcosus* in the Pahang coastal water. In conclusion, the present study provides some important

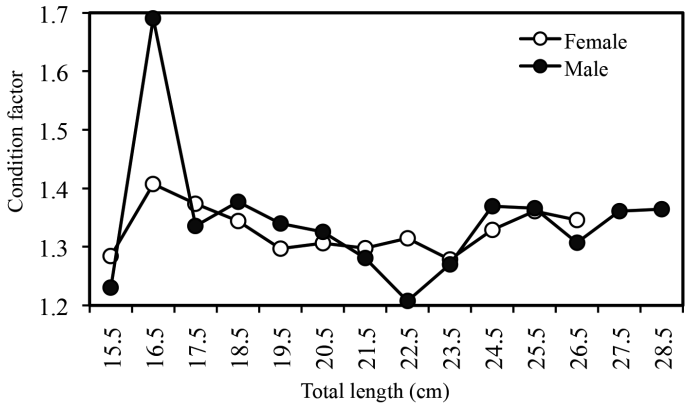

FIGURE 5. Condition factor of different sizes male and female *N. furcosus*

basic information on relative population abundance, growth and condition of male and female *N. furcosus*. The results of the present study may be useful for policy makers and fishery biologists to impose rules and regulations for sustainable fishery management in the Pahang coastal water, Malaysia.

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