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Length-Weight Relationships, Condition Factor and Growth Parameters of *Periophthalmus chrysospilos* (Bleeker, 1852) (Gobiiformes: Gobiidae) in Bayan Bay, Penang, Malaysia

(Hubungan Panjang-Berat, Faktor Keadaan and Parameter Tumbesaran *Periophthalmus chrysospilos* (Bleeker, 1852) (Gobiiformes: Gobiidae) di Teluk Bayan, Pulau Pinang, Malaysia)

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ABSTRACT

This study reports the length-weight relationships (LWR), body condition factor (K_n) and growth parameters of Periophthalmus chrysospilos *in Bayan Bay of Penang, Malaysia. The values of exponent* b *for all categories of fish were higher than 3 indicating a positive allometric growth. The mean condition factor (K_n) for all categories of fish also higher than 1 which reflect the well beings of fish in the study area. The* b *values of LWR and condition factors for male was similar to female fish, but the* b *values of LWR and condition factors were significantly higher in rainy months compared to the dry months. The parameters of population dynamic show the asymptotic length ($L\infty$) of 13.20 cm, growth coefficient* (K) *of 0.68 year^{-1}, growth performance index (Ø') of 2.074, total mortality* (Z) *of 2.47 year^{-1}, and fishing mortality* (F) *of 0.70 year^{-1}. The exploitation level (E) was 0.28 year^{-1} indicating of low exploitation and estimation of length at first capture was 7.69 cm. The annual recruitment pattern of* P. chrysospilos *was recruited in two peaks per year.*

Keywords: Allometric growth; asymptotic length; mudskipper; recruitment pattern

ABSTRAK

Kajian ini melaporkan hubungan panjang-berat (LWR), faktor keadaan (K_n) dan parameter pertumbuhan Periophthalmus chrysospilos *di Teluk Bayan, Pulau Pinang, Malaysia. Nilai eksponen* b *bagi kesemua kategori ikan adalah lebih tinggi daripada 3 yang menunjukkan pertumbuhan secara positif alometrik. Faktor keadaan bagi kesemua kategori ikan juga lebih tinggi daripada 1 yang menunjukkan keadaan baik ikan di kawasan kajian. Nilai* b *hubungan panjang-berat dan faktor keadaan bagi ikan jantan adalah sama dengan ikan betina, walau bagaimana pun nilai* b *bagi hubungan panjang-berat dan faktor keadaan adalah lebih tinggi secara signifikan semasa musim hujan berbanding dengan musim kering. Parameter populasi dinamik menunjukkan panjang asimptot ($L\infty$) adalah 13.20 cm, pekali pertumbuhan (K) adalah 0.68 tahun^{-1}, indeks kemajuan pertumbuhan (Ø›) adalah 2.074, kadar kematian keseluruhan (Z) adalah 2.47 tahun^{-1}, kematian semasa tangkapan (F) adalah 0.70 tahun^{-1}. Aras eksplotasi (E) ikan adalah 0.28 tahun^{-1} menunjukkan ekploitasi yang rendah dan anggaran panjang pada tangkapan yang pertama adalah 7.69 cm. Corak rekrut tahunan* P. chrysospilos *adalah dua puncak setahun.*

Kata kunci: Corak rekrut; ikan belacak; panjang asimptot; tumbesaran alometrik

INTRODUCTION

The orange spotted mudskipper, *Periophthalmus chrysospilos* is a common mangrove and mudflat inhabitant in Peninsular Malaysia (Berry 1963; Polunin 1972; Murdy 1989; Takita & Ali 1999). They are abundantly found on the soft and sandy mud substrates of mudflat, riverine, and on the *Avicennia*, *Sonneratia,* and *Rhizophora* forest floor areas (Khaironizam & Norma-Rashid 2005). They also reported living in proximity to human settlements (Takita & Ali 1999). They can tolerate 30-34% of salinity, 29-34^{o}C air temperature, and 70-85% of air relative humidity (Chew & Ip 1990; Khaironizam 2004). In some areas of Langkawi and Selangor, this species has been claimed to have ethnomedicinal importance where the mixture of this fish flesh together with local herbal remedies and coconut oil were processed to become massage oil and were used in muscle pain, headache and migraine treatments (Khaironizam & Norma-Rashid 2000). Their raw flesh was also claimed to have aphrodisiac properties (Clayton 1993). For some indigenous people like Mah Meri in Morib, Selangor, this species had also been consumed as special meals in the family ceremony (Khaironizam 2004).

The information on growth patterns of *P. chrysospilos* is few and scarcely reported. The only available information of Malaysian *P. chrysospilos* was reported in the length-weight relationships from the Klang Strait, Selangor by Khaironizam and Norma-Rashid (2002). Knowledge on the length-weight relationships is essential as it will provide a useful data for estimating the average weight of fish at a given length, body condition, growth rates and age structures of the dynamism of fish populations (Abowei 2009; Froese 2006; Le Cren 1951; Samat et al. 2008). Froese (2006) reported that fish body condition factor might be influenced by both biotic factor (physiology, gonad maturity & feeding) and abiotic factor (water temperature, salinity, rainfall & seasonal change). In Malaysia, the information on the effects of seasonal changes (rainy and dry months) on the length-weight relationships and the body condition factor of this species are scarce and almost unavailable.

Study on fish growth is essential to understanding the population dynamics of fish. In sustainable fishery management, it allowed estimation of the stock population, the potential yield of productivity, mortality and recruitment pattern. However, information on growth, mortality and recruitment pattern of mudskippers are limited to several species like *Periophthalmus barbarus* (Chukwu & Deekae 2010; Etim et al. 2002, 1996; Turay et al. 2006), *Periophthalmus waltoni* (Sarafraz et al. 2011), *Periophthalmus novemradiatus* (Rahman et al. 2015), *Scartelaos gigas* (Kim et al. 2011; Park et al. 2008), *Scartelaos tenuis* (Salarpouri et al. 2013), *Periophthalmodon schlosseri* (Mazlan & Rohaya 2008) and *Boleophthalmus pectinirostris* (Nanami & Takegaki 2005). Currently, the documented knowledge on population parameters of *P. chrysospilos* is scarcely reported. Thus, this study would be the first comprehensive study of growth parameters, mortality, and recruitment pattern of *P. chrysospilos* in the northern region of Peninsular Malaysia.

Materials and Methods

Samples of *P. chrysospilos* were collected monthly during the low tides on the mudflat area of Bayan Bay, Penang (5⁰20'53.56'' N 100⁰18'47.68'' E), from July 2013 to July 2014 using hand net blockade techniques (Clayton 1993; Khaironizam 2004). The rainfall data were obtained from the Meteorological Department of Malaysia in Bayan Lepas. Bayan Bay areas experience two periods of heavy rainfall. The first period from July to November 2013 (mean rainfall of 301.4 mm) and the second one from April to May 2014 (mean rainfall of 206.1 mm). The dry months in the study area were recorded from December 2013 to March 2014 (mean rainfall of 46.7 mm) and from June 2014 to July 2014 (mean rainfall of 115.4 mm). Thus, we classified the study period into rainy months (from July to November 2013 and from April to May 2014), and the rest of the study period as are dry months. There are significant differences in the mean rainfalls between dry and wet months in Bayan Bay areas ($t = -4.02$, $p < 0.05$). All fish caught were sexed based on their external characteristics as suggested by Murdy (1989). The total length (L) of the fish was measured to the nearest centimeter by using the measuring board and the body weight measured by using electronic weight to the nearest 0.1 g. The specimens were euthanized in ice and were fixed in the 10% formalin solution. After a week in the formalin solution, the specimens were soaked in water and were preserved in the 70% alcohol.

The length-weight relationships were estimated by the parabolic equation, $W = aL^b$ (Le Cren 1951). This parabolic equation was then transformed to logarithmic form to gives a linear equation, $\text{Log } W = \text{Log } a + b \text{ Log } L$; where W is the weight in grams; L is the total length in centimeters; a is the intercept; and b is the regression coefficient. To confirm whether the b values significantly different from isometric values $b = 3$, T-test (H_o, $b = 3$) based on equation $T_s = (b\text{-}3)/S_b$ (Sokal & Rohlf 1987) was used, where T_s is the test value; b is the slope; and S_b is the standard error of the slope. The b value of different sex and season derived from the linear regression was subjected to ANCOVA analysis.

The fish body condition was estimated based on the Fulton condition factor (K_n) according to the equation $K_n = 100\ W/L^3$, where W is the weight in gram; L is the total length in centimeter. Significant differences in condition factor between different sex and season were subjected to Independent T-test analysis. All the statistical analyses used SPSS software version 20 (SPSS Inc., Chicago, IL, USA).

The length-frequency data of total *P. chrysospilos* was generated based on the 0.5 cm class interval for analysis of growth parameters using the FAO-ICLARM stock assessment tool (FISAT II) software. Separate growth cohorts of *P. chrysospilos* was determined using Bhattacharya's Method (Bhattacharya 1967). This method works by removing normal distributions for each cohort available within the total distribution in a one-year period.

Estimation of growth performance index is based on the equation $Ø' = \log_{10} K + 2 \log_{10} L\infty$ (Pauly & Munro 1984). The values of K and $L\infty$ were obtained from the von Bertalanffy Growth Function (VBGF). Estimation of length infinity ($L\infty$) and total mortality, (Z) in the form of Z/K where (Z) is total mortality and K is growth constant is based on Powell-Weatherall Plot. ELEFAN 1 was used to analyze the growth parameters through sequential length-frequency data to obtain the theoretical value of the highest total length fish could achieve, ($L\infty$) and growth coefficient (K). Estimation of mortality namely total mortality (Z), natural mortality (M) and fishing mortality (F) was estimated using the equation $Z = F + M$. This was analyzed by length-converted catch curve with the assumption that sampling is represented a steady - state population (Vakily & Cham 2003). Length converted catch curve normally used to estimate total mortality when age data from otolith and scale reading are difficult to obtain (Gayanilo & Pauly 1997).

Estimation of natural mortality (M) based on Pauly equation (Pauly 1984) given by $\text{Log}_{10}M = -0.0066 - 0.279\ \text{Log}_{10}L\infty + 0.6543\ \text{Log}_{10}K + 0.4634\ \text{Log}_{10}T$. T is the mean of surface water temperature (°C) where fish lives. Fishing mortality *(F)* estimated by subtracting M from Z, $F = Z\text{-}M$ where F is fishing mortality, (Z) is total mortality and (M) is natural mortality. This allowed estimation of the rate of exploitation using formula $E = F/Z = F/(F + M)$ (Gulland 1971). The length at first capture (L_c) was estimated using catch curve analysis (Pauly 1984). The probability of capture is estimated using running average and the value of L_{25}, L_{50} and L_{75} are established. The recruitment pattern is determined based on two assumptions which are all fish must be within the data set adhere to a single set of growth parameters and there is always one month out of twelve months where there is no any recruitment (Gayanilo & Pauly 1997).

RESULTS

A total of 714 individuals of *P. chrysospilos,* where 415 male and 299 female fish were collected in this study. Of this number, 343 and 371 individuals were caught in the dry and rainy months, respectively. The length-weight relationship (LWR) parameters of all individuals, males, and females caught in dry and rainy months are shown in Table 1. The T-Test analysis on the *b* values for all collected fish individuals was significantly higher ($t = 13.3$, $p < 0.05$) than the cubic value ($b = 3$) (Froese 2006; Le Cren 1951; Ricker 1973; Sokal & Rohlf 1987). The total length (L) and weight (W) for males and females *P. chrysospilos* were about similar ($t_L = -0.602$, $p > 0.05$; $t_W = -2.62$, $p > 0.05$; respectively - Table 1). The *b* value of LWR for males and females fish obtained from this study were not significantly different (ANCOVA = 3.221, $p > 0.05$; Table 1). However, the fish caught in the rainy months have a higher value of *b* compared to fish in dry months (ANCOVA = 19.453, $p < 0.05$), indicating that the fish in rainy months have better growth pattern compared to dry months. The body condition factor (K_n) for all individuals of *P. chrysospilos,* was ranged from 0.679 to 1.307 (Table 1). The body condition of male and female fish was about similar ($t = -1.86$, $p > 0.05$). However, the body condition of fish caught rainy months was significantly higher than those caught in a dry month ($t = -4.724$, $p < 0.05$).

Based on Bhattacharya's plot, *P. chrysospilos* population during July 2013 to July 2014 consisting of two distinctive cohorts at modal length (TL) 5.30 ± 0.83 cm and 8.33 ± 1.340 cm, respectively (Figure 1).

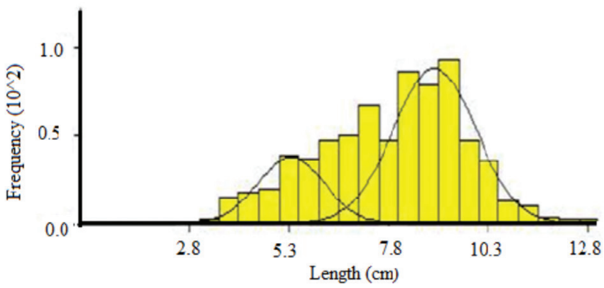

FIGURE 1. Bhattacharya's plot for *P. chrysospilos* in Bayan Bay, Penang from July 2013 to July 2014

Powell-Wetherall plot analysis estimated the preliminary value of $L\infty = 13.16$ and $Z/K = 1.421$ and general equation, $Y = 5.43 + (-0.413)*X$ (Figure 2). Whereas using ELEFAN 1 (K-scan, response surface and automatic search), the values of ($L\infty$) and (K) are 13.20 and 0.67 yr^{-1}, respectively. Based on these values, the von Bertalanffy Growth Function (VBGF) extracted (Figure 3).

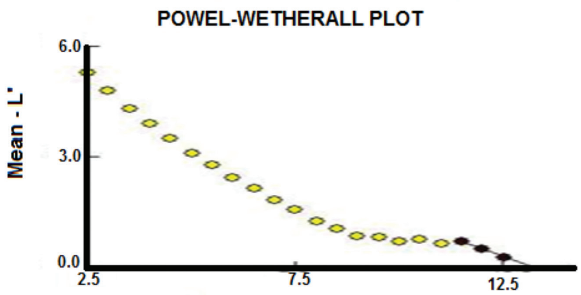

FIGURE 2. Estimation of $L\infty = 13.16$ cm and $Z/K = 1.421$ yr^{-1}, $R^2 = 0.995$ of *P. chrysospilos* using Powell-Wetherall plot

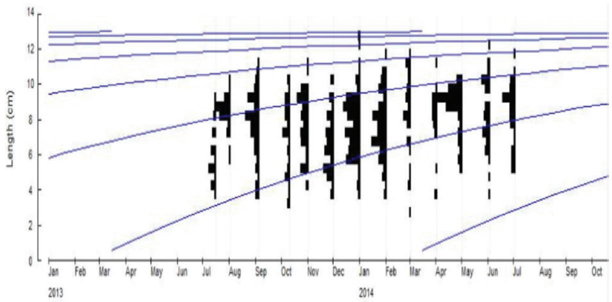

FIGURE 3. Shows the seasonal variation in VBGF of *P. chrysospilos* from Bayan Bay in Penang

This study established the L_{max} of *P. chrysospilos* was 12.84 cm with 13.20 cm of asymptotic length ($L\infty$). The asymptotic length ($L\infty$) of fish is the maximum theoretical average length that a fish species could reach in its habitat. The length at first capture (L_c) (Figure 4) indicates the length at which 50% of *P. chrysospilos* become vulnerable to the fishing gear when it reaches 7.69 cm of the total length. This study established the growth constant (K) value of *P. chrysospilos* is 0.67 yr^{-1}. The total mortality coefficient (Z), natural mortality (M) fishing mortality (F) and exploitation rate (E) of *P. chrysospilos* were 2.47 year$^{-1,}$ 1.77 year^{-1}, 0.70 year^{-1} and 0.28, respectively (Figure 5). The growth performance index (Ø') of *P. chrysospilos* based on the equation $Ø' = \log_{10} K + 2 \log_{10} L\infty$ was 2.07.

DISCUSSION

The results of length-weight relationships show that *P. crysospilos* in Bayan Bay of Penang have positive allometric growth. However, this result is contradicted to Khaironizam and Norma-Rashid (2002) as they found *P. chrysospilos* from Klang Straits of Selangor had negative allometric growth. The deviation from the cubic value ($b = 3$) are typical in fishes (Froese 2006) as they do not retain their same size and shape throughout their lifespan, and their specific gravity of body tissue may also change

TABLE 1. Length-weight relationships and condition factor of *P. chrysospilos* from Bayan Bay of Penang

Categories	N	Weight (g)		Length (cm)		Length-weight relationships (LWR) parameters					Condition factor (K_n)		
		Min	Max	Min	Max	*a*	95% C.I of *a*	*b*	95% C.I of *b*	r^2	Min	Max	Mean±SD
All individuals	714	0.23	18.00	2.82	12.84	0.0065	0.0061 – 0.0069	3.213	3.208 – 3.228	0.983	0.68	1.31	0.998±0.121
Males	415	0.23	13.80	2.82	11.54	0.0063	0.0058-0.0068	3.221	3.208-3.234	0.984	0.70	1.25	0.991±0.138
Females	299	0.30	18.00	3.10	12.84	0.0148	0.0118-0.0178	3.216	3.198-3.233	0.983	0.68	1.31	1.008±0.138
Dry months	343	0.23	18.00	2.82	12.84	0.0067	0.0060-0.0074	3.186	3.16-3.212	0.981	0.68	1.29	0.998±0.123
Rainy months	371	0.30	15.10	3.10	12.00	0.0062	0.0056-0.0068	3.240	3.226-3.254	0.986	0.70	1.31	1.018±0.115

Note: N = number of individuals, *a* = constant of proportionality, *b* = exponential value, C.I = confidence interval, r^2 = coefficient of determination, SD = standard deviation

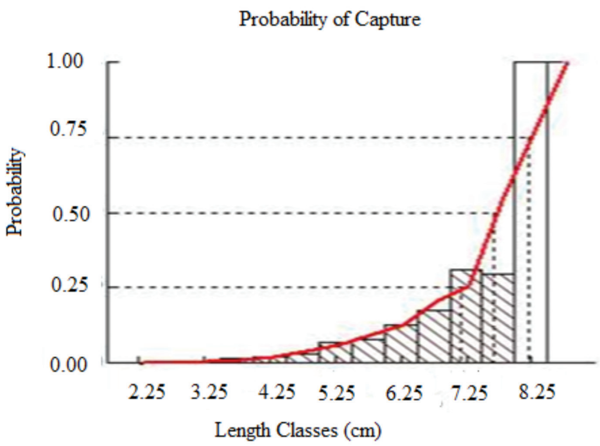

FIGURE 4. The probability of capture of *P. chrysospilos* at $L_{0.25}$ = 7.17cm, $L_{0.50}$ = 7.69 cm and $L_{0.75}$ = 8.22 cm

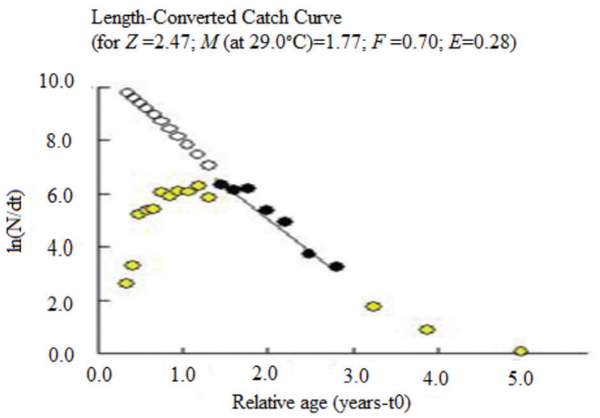

FIGURE 5. Length-converted catch curves with a regression coefficient (R^2)

as body size increase (Datta et al. 2013). Furthermore, the differences of *b* value in a fish species might be affected by several factors such as sexes, stomach fullness, gonadal maturity, physiology, sample size, habitats, physico-chemical parameters, seasonal changes and preservation techniques (Das et al. 2014; Froese 2006; Ghanbarifardi et al. 2014; Tesh 1971).

This study also shows *P. chrysospilos* in Bayan Bay having a better body condition in rainy months compared to dry months. However, this finding was different to *Periophthalmus barbarus* condition factor (Chukwu & Deekae 2011; King & Udo 1998) where the body condition factor was similar in both dry and wet seasons. Fish body condition index could fluctuate and influence by various factors such as seasonal changes, maturity, availability of food resources and reproductive behaviors (Baeck & Park 2015; Froese 2006; Le Cren 1951). The flushing process may cause the higher value of condition factor during rainy months during heavy rainfall (Ikongbeh et al. 2013). The influx of nutrient into the water body, which later dumped on the mangrove forest floor and mudflat areas may promote the growth of plankton and algae that leads to an abundance of food sources to the fish in the habitats. For most tropical fishes, gonad activities and gonad maturity also increase during wet seasons (Lizama & Ambrosio 2002). The increase of gonad maturity may also increase the fish body weight (King & Udo 1998) which then may influence the condition factor of the fish. This might explain the result in this study where high body condition factor was recorded during the rainy month compared to dry months. Reproductive behaviors (i.e. mating, egg producing and guarding) also known to effect the body condition of gobies species. Baeck and Park (2015) reported that condition factor of two mudskipper species *Periophthalmus modestus* and *Periophthalmus magnuspinnatus* show a high condition factor during the post spawning period compared to before and during spawning season. They attribute this to the energy constrains associated with reproductive behaviors. Furthermore, during spawning season, gonad development will limit the abdominal cavity thus affecting feeding activities of the fish.

The ($L\infty$) obtained in this study is within the range of ($L\infty$) found in the *Periophthalmus* genera. The lowest ($L\infty$) is represented by *P. novemradiatus* di Bakhali River of Bangladesh (Rahman et al. 2015) with $L\infty$ of 7.35 cm whereas the highest value of $L\infty$ is 21.6 cm represented by *P. barbarus* in Imo River of Nigeria (Etim et al. 2002). The different of the theoretical maximum size attainable by fish are influenced by various factors such as individual species and location specific (Abowei 2010). Nevertheless, the value of ($L\infty$) obtained in this present study is ideally within the range of *Periophthalmus* genera.

According to Sparre and Venema (1998), growth pattern classification, (K) = 1.0 yr^{-1} is fast growth, (K) = 0.5 yr^{-1} is medium growth and (K) = 0.2 yr^{-1} is slow growth. Thus, this showed that *P. chrysospilos* as medium growth rate fish. The (K) value of *P. chrysospilos* is nearly similar to the study of *P. barbarus,* from Calabar River, Nigeria where (K) = 0.65 yr^{-1}, (Chukwu & Deekae 2010). However, Turay et al. (2006) recorded a higher value of (K) = 0.89 yr^{-1} on *P. barbarus* from Sierra Leone. Nevertheless, this shows an agreement to the fact, that tropical fish usually has a fast growth rate (Sparre & Venema 1998). The variation of ($L\infty$) and (K) within the fish species was due to several factors such as the variation of water parameters, the rate of metabolism, food resources, and pollution (Abowei 2010; Etim et al. 2002; Sparre & Venema 1998).

According to Etim et al. (2002), direct comparison ($L\infty$) and (K) does not make a much biological contribution since one species or stock has different growth rate during their life stages. Therefore, growth performance index (Ø') is a more comprehensive method to be used in fishery sciences to compare the growth performance of a different population of fish species (Pauly & Munro 1984). Since there was no information available on growth performance index (Ø') of *P. chrysospilos*, the comparison was made with other mudskippers species (Table 2). Chukwu et al. (2010), Etim et al. (2002) and King (1996) reported that the growth performance of *P. barbarus* is 2.18, 2.28

TABLE 2. Comparative growth parameters ($L\infty$, K) and growth performance index (Ø') of *P. chrysospilos* and other species of mudskippers

Species	Region	$L\infty$ (cm)	K (year^{-1})	*Ø'*	Source
Periophthalmus barbarus	Calabar, Nigeria	19.39	0.51	-	Etim et al. (1996)
	Cross river, Nigeria	17.8	0.36	2.06	King & Udo (1998)
	Imo river, Nigeria	21.6	0.55	2.28	Etim et al. (2002)
	Freetown, Sierra Leone	17.00	0.89	-	Turay et al. (2006)
	Calabar, Nigeria	15.28	0.65	2.18	Chukwu & Deekae (2010)
	Imo river, Nigeria	19.9	1.00	2.59	Udoh et al. (2013)
Periophthalmus waltoni	Bandar-Pol, Iran	14.15	0.46	-	Sarafraz et al. (2011)
	Qeshm, Iran	16.69	0.42	-	Sarafraz et al. (2011)
Periophthalmus novemradiatus	Bakkhali river, Bangladesh	7.35	1.50	-	Rahman et al. (2015)
Periophthalmodon schlosseri	Selangor, Malaysia	29.00	1.40	3.1	Mazlan & Rohaya (2008)
Boleophthalmus pectinirostris	Kyushu, Japan	11.63	0.799	-	Nanami & Takegaki (2005)
Scartelaos gigas	Jeung-do Island, Korea	17.93	0.78	-	Park et al. (2008)
Scartelaos tenuis	Hormuzgan, Iran	19.43	0.64	-	Salarpouri et al. (2013)
Periophthalmus chrysospilos	Penang, Malaysia	13.2	0.67	2.07	Present study

and 2.06, respectively. This concluded that the growth performance index of *P. chrysospilos* in this present study to be moderate growth. A high-value performance index is attributed to the fish survival strategies adaptation in avoiding predator by rapidly increasing its size and reducing its risk of becoming prey (Abowei 2010). According to Kon et al. (2009), predation considered the significant factor that influenced the behavioral and adaptation of animal in the coastal marine environment. This is associated with the vast exposed of mudflat where mudskippers live and being at risk of predation from both aerial and water.

The value of (L_c) in this present study coincided with the (L_c) of *P. barbarus* in the Imo River (Udoh et al. 2013). However, lower value of (L_c = 4.15 cm) was also recorded in *P. novemradiatus* (Rahman et al. 2015) and *P. papilio* (now is = *P. barbarus*) as 7.60 cm (Etim et al. 1996). The mortality rate in this study is considered low compared to another mudskipper such as *P. barbarus* in New Calabar River, Nigeria (Chukwu & Deekae 2010). However, the study of *P. papilio* (now is = *P. barbarus*) by Etim et al. (1996) in Cross River of Nigeria are much higher (2.208 year^{-1}, 1.341 year^{-1}, 0.867 year^{-1} and 0.393 year^{-1}). The different result in mortalities rate is attributed to a different environment where the fish lives. Thus, it is subjected to a different level of predation, competition, food resource, and disease (Sparre & Venema 1998). Nevertheless, the natural mortality of *P. chrysospilos* in this study is lower than fishing mortality (F), suggesting that fishing activities do not affect the fish population in that area.

The estimation of exploitation rate (E) of *P. chrysospilos* showed that this fish is not overexploited. This is based on the optimum value of E (E_{opt}) = 0.5 when fishing mortality is equal to natural mortality $F = M$ (Gulland 1971). The estimation of exploitation rate of *P. chrysospilos* in Bayan Bay, Penang is 0.28. This is probably due to minimum fishing activities as this species has no commercial nor nutrition value in this country. Low value of (E) is also observed in several mudskippers species such as *P. novemradiatus* (E = 0.38) in Bakkhali River, Bangladesh (Rahman et al. 2015), *P. barbarus* (E = 0.17) in Calabar River, Nigeria (Chukwu & Deekae 2010) and *P. papilio* (now is = *P. barbarus*) (E = 0.35) in Cross River, Nigeria (Etim et al. 1996) as most of these mudskippers species is lightly exploited as a fishing bait. The value of $L_c/L\infty$ in this study was 0.58 with exploitation rate of 0.28. According to the relative isopleths diagram by Pauly and Soriano (1986). *P. chrysospilos* considered within the (A) quadrant. Meaning that this fish is under fishing where large fish are caught at a low effort level.

This present study established that *P. chrysospilos* had two peaks of recruitment per year with different magnitude and separated by five months interval between the first and second peaks. The overlapping of these peaks reflects that this mudskipper species is a continuous breeder. This finding is comparable to various studies on several mudskipper species such as *P. papilio* (now is = *P. barbarus*) (Etim et al. 1996) and *P. barbarus* (Chukwu & Deekae 2010). Furthermore, according to Pauly (1982), tropical fish species posed two recruitment pattern per year.

However, a single recruitment pattern does exist in mudskipper species. Etim et al. (2002), reported that *P. barbarus* had one pulse of recruitment peak and further confirmed by gonado-somatic index (GSI) analysis. This fact is coincided with the finding by Rahman et al. (2015) where they reported that *P. novemradiatus* also had one pulse of recruitment peak. Other genera within the family of Oxudercidae that show single recruitment pattern are *Boleophthalmus dussumeri* and *Boleophthalmus dendatus* (now is *Oxuderces dendatus*) (Mutsaddi & Bal 1969; Soni & Benson 1986). Different recruitment pattern within the same genera or species probably attributed to the biological characteristic and locality (Amin et al. 2014).

CONCLUSION

In conclusion, *P. chrysospilos* in Penang shows a positive allometric growth. The condition factor among male and female *P. chrysospilos* is found to be not significantly different. However, the value of condition factor is significantly higher during the wet season compared to the dry season. *P. chrysospilos* shows two cohorts per year, supported by two peaks of annual recruitment pattern. Growth parameters of this fish show that the asymptotic length 13.20 cm, growth coefficient 0.68, growth performance index of 2.074. Based on the value of exploitation rate (E) it shows that this is fish is under fishing, where natural mortality is higher than fishing mortality. The current exploitation rate is relatively small and should be increased with sustainable measured. Information provided by this study will be valuable for conservation and management effort of this fascinating fish, due to the rapid reclamation of mangrove and mudflat area in this state.

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