

Length-Weight Relationship, Condition Factor, and Age Estimation of Commercially Important Trawl Species from Mersing Coastal Waters, Johor, Malaysia

(Hubungan Panjang Berat, Faktor Keadaan dan Penganggaran Umur Ikan Pukat Tunda Komersial Tempatan dari Muara Mersing, Johor, Malaysia)

SIMON KUMAR DAS*, TOU WEE XIANG, NOORASHIKIN MD NOOR, MOUMITA DE & ABDULLAH SAMAT

ABSTRACT

Trawl fishing contributes to majority of the total fishes' landings, supporting the choice of using age, growth determination, and condition factors (K) as part of the monitoring method for the fishes in Malaysia waters. This research specifically examines the use of age, length-weight relationship (LWR), and K to monitor the status of the commercially important fishes in Malaysia waters. LWR, K, and age of 10 commercially important trawl species (*Gerres erythrourus*, *Drepane punctata*, *Otolithes ruber*, *Anodontostoma chacunda*, *Drepane longimana*, *Dendrophysa russelii*, *Sillago parvisquamis*, *Cynoglossus bilineatus*, *Sardinella brachysoma*, and *Alepes kleinii*) from Mersing coastal waters, Johor, Malaysia, were studied. LWR ($W=aL^b$) indicated positive allometric growth ($b > 3$) for *G. erythrourus* and *D. punctata* but negative allometric growth ($b < 3$) for the other species. Results indicated that the species collected were in good conditions (average K, $K_n > 1$) in Mersing coastal waters, Johor, Malaysia. The daily growth rings of scale counts confirmed that the ages of the 10 species were typically less than 1 year (age range: 50-170 days; mean age: 95 days). The data obtained from this study will be useful for understanding the population growth pattern, age, and well-being of commercially important trawl species, which will facilitate better management techniques of these important fishery resources.

Keywords: Age; condition factor; estuary; growth; scale; trawling

ABSTRAK

Penangkapan ikan pukat menyumbang kepada sebahagian besar pendaratan ikan serta menyokong pilihan menggunakan usia, penentuan pertumbuhan dan faktor keadaan (K) sebagai kaedah pemantauan ikan di perairan Malaysia. Penyelidikan ini fokus menggunakan usia, penentuan pertumbuhan hubungan panjang berat badan (LWR) dan K sebagai sebahagian daripada langkah untuk memantau status ikan yang penting secara komersial di perairan Malaysia. LWR, K dan umur spesies ikat pukat tunda komersial yang penting (*Gerres erythrourus*, *Drepane punctata*, *Otolithes ruber*, *Anodontostoma chacunda*, *Drepane longimana*, *Dendrophysa russelii*, *Sillago parvisquamis*, *Cynoglossus bilineatus*, *Sardinella brachysoma* dan *Alepes kleinii*) dari perairan pantai Mersing, Johor, Malaysia telah dikaji. LWR menunjukkan pertumbuhan alometrik positif ($b > 3$) bagi *G. erythrourus* dan *D. punctata* manakala pertumbuhan alometrik negatif ($b < 3$) bagi spesies lain. Nilai K yang lebih tinggi daripada satu menunjukkan ikan berada dalam keadaan baik. Annulus pada sisik mengesahkan bahawa umur untuk sepuluh spesies ini adalah kurang daripada satu tahun (lingkungan umur: 50 - 170 hari; purata umur: 95 hari). Keputusan yang diperolehi akan menjadi berguna untuk memahami pertumbuhan, umur dan kesihatan spesies ikat pukat tunda yang akan memudahkan teknik pengurusan yang lebih baik.

Kata kunci: Faktor keadaan; muara; pertumbuhan; pukat tunda; sisik ikan; umur

INTRODUCTION

Several studies have been conducted on length-weight relationship (LWR) parameters of fish species to predict the average weight of fish for a given length group, fish condition, and morphometric comparisons of species and populations between different regions (Alavi-Yeganeh; Yilmaz & Polat 2011). In this study, the data were

collected from Mersing coastal waters, Johor, Malaysia. Our literature showed few reports on Malaysian waters by Simon et al. (2013, 2010, 2008) and Mazlan and Rohaya (2008). In addition, Simon et al. (2010) conducted a study related to fish distribution in the coastal waters of Johor; however, their data were limited to two species only. Many efforts on management, conservation, and regulations have

been established by the Malaysian government to monitor and protect fishery resources and their habitat, especially marine fisheries. However, those efforts are insufficient and will not function at their maximum effectiveness without information to show the real condition of the fish population and their environment. Thus, the age determinations, growth parameters, and condition factors were applied for these purposes. Age and growth determination, including LWR and condition factors, enable the calculation of other parameters, such as growth and mortality rate. Moreover, evaluations of population age structures, as an indicator of fish health and fitness, and their environmental food availability, provide us with a thorough understanding of the behaviors of fish species relative to their environment. Results obtained from this research can be utilized as an important reference to increase the effectiveness of fish farming methods and improve aquaculture productivity.

Studies on age and longevity provide important demographic parameters to analyze and assess the fish population (Maceina & Sammons 2006). However, accurate age information is crucial for a precise understanding of these metrics (Campana 2001). Age has been determined in tropical freshwater fish through annual increments in calcified structures, such as scales, spines, vertebrae, and otoliths. Scales are widely used for the determination of age, because their removal involves a non-lethal technique, and they are easy to collect and prepare (Chung & Woo 1999).

Thus, this research attempted to provide baseline information for the growth (LWR and condition factor) and age estimation of most abundant trawling fish species found in Mersing coastal water, Johor, Malaysia. These trawling fish species were priced at RM 8-12/kg based on the current market. The estimated growth and age in this study could provide valuable information for future research to conduct a comparison between years and locations. Moreover, this study could provide information about the well-being of fish species inhabiting Mersing coastal water, Johor, Malaysia.

MATERIALS AND METHODS

FIELD SAMPLING

Fish samples were collected from Mersing coastal water, Johor (01°24'53 N; 104°09'44 E), Malaysia, in April 2016. A total of 500 fishes (50 fishes for each species) were collected by using a three-layered trammel, cast, scoop nets, and traps. These gears were set up at random in appropriate places along the study areas. The mesh sizes of the trammel and cast nets were 4.2, 6.5, 7.5, and 2 cm. The mesh size of the scoop net was 1.5 cm. The lengths of the trammel net and cast net were 20 m and 250 cm, respectively. The diameter for the scoop net was 40 cm.

Specimens were identified in the field according to the description given by Nelson et al. (2016). For each species, the fish were then further analyzed for body measurement and age estimation.

LWR AND CONDITION FACTOR (*K*) ANALYSIS

Weight (*W*, g) of fish was determined to the nearest 0.01 g by using an electronic balance (Model: KD-300KC), and the total length (*L*, cm) of fish was measured by using a ruler board (Das et al. 2014; De et al. 2016). Fish growth was investigated via LWR analysis. LWR was calculated as follows: $W = aTL^b$ (Pauly 1984), where *a* is the intercept, and *b* is the slope. The values of the exponent *b* provide information on fish growth form (Beverton & Holt 1966). The relationship between weight and total length, aL^b , was converted into its logarithmic expression: $\ln W = \ln a + b \ln L$ (Zar 1984). The parameters *a* and *b* were calculated by least-squares regression, similar to the coefficient of determination (R^2). The *b* value for each species was tested by a t-test at the 0.05 significance level to verify if it was significantly different from 3. The *b* value indicated the growth type of the fish, which may be isometric ($b = 3$), positive allometric ($b > 3$), or negative allometric ($b < 3$). The computer software MINITAB 17 (StatSoft Inc., Tulsa, OK, USA) was used for statistical analyses. A statistical significance of 5% was adopted for all cases.

The condition factors (Fulton's condition factor = *K* and relative condition factor = *Kn*) were calculated from the relationship between the weight of a fish and its length by the following formula:

$$K = 100 * (W / L^3) \text{ (Fulton 1904)}$$

$$Kn = W / aL^b \text{ (Le Cren 1951)}$$

where *a* and *b* were obtained from LWR analysis.

AGE ESTIMATION

Individual scales from below the pectoral fin were extracted from the fish for interpretable age estimates, as the scales below the pectoral fin were larger than the scales from the other body parts (Campana 2001). For each specimen, about 10 scales were sampled and treated in 0.5% ammonia solution for at least 2 days, rinsed three times with distilled water, dried, and mounted between two microscope slides (Chung & Woo 1999). The mounted scales were labeled, observed, and photographed under a microscope (HITACHI Tabletop Scanning Microscope TM-1000) (Simon et al. 2008). The daily increments or rings of the scale were repeatedly counted using Adobe™ graphic software with slight modification of Mazlan and Rohaya (2008). Age of the fishes was estimated based on the number of daily increment or rings (age in days),

as well as the annulus (age in years) on the scale (Werder & Soares 1985).

RESULTS AND DISCUSSION

LWR AND CONDITION FACTOR

Table 1 shows the sample size, range and mean length (\pm S.E.), range weight measured, LWR parameters a and b , standard error of the slope, and coefficient of determination R^2 for each species. Information on the kind of growth (isometric or allometric) of each species is provided. A total of 10 commercially important trawl species (*Gerres erythrourus*, *Drepane punctata*, *Otolithes ruber*, *Anodontostoma chacunda*, *Drepane longimana*,

Dendrophysa russelii, *Sillago parvisquamis*, *Cynoglossus bilineatus*, *Sardinella brachysoma*, and *Alepes kleinii*) were identified and used in the present study. From the data obtained, the total length (TL) of the samples ranged from 7.0 to 28.5 cm, and the BWs of the samples ranged from 7.4 to 63.0 g (Table 1). All regressions were significant ($P < 0.05$). Half of the ten species showed R^2 values greater than 0.95. Two species showed $b > 3.0$ which were *G. erythrourus* and *D. punctata*. Thus, these two fish species grew faster in their BW than in their length, which indicated that the fish would become wider or deeper as they grew. Meanwhile, b was < 3.0 in other species, which suggested that these fish species had higher tendency on the increment of length compared with their body weight; such fish will become slender as their weight increases.

TABLE 1. Descriptive statistics and estimated parameters of length-weight relationships for ten species sampled from Mersing Coastal Waters, Johor, Malaysia

Species	TL characteristics		BW characteristics		Parameters of LWR				Growth type
	Range (cm)	Mean \pm SE (cm)	Range (g)	Mean \pm SE (g)	a	b	SE (b)	R^2	
<i>Gerres erythrourus</i>	9.50 – 20.30	14.51 \pm 0.42	25.10 – 60.36	15.25 \pm 8.94	0.021	3.137	0.073	0.977	Positive Allometric
<i>Drepane punctata</i>	9.70 – 26.60	18.20 \pm 0.66	20.57 – 70.41	16.96 \pm 38.92	0.022	3.261	0.177	0.990	Positive Allometric
<i>Otolithes ruber</i>	9.50 – 17.50	13.30 \pm 0.32	21.65 – 71.20	10.13 \pm 1.82	0.066	2.352	0.107	0.954	Negative Allometric
<i>Anodontostoma chacunda</i>	10.70 – 16.90	13.60 \pm 0.23	26.38 – 83.02	17.63 \pm 1.39	0.865	2.534	0.081	0.911	Negative Allometric
<i>Drepane longimana</i>	7.00 – 13.70	10.68 \pm 0.25	27.41 – 61.04	12.34 \pm 1.52	0.019	2.957	0.034	0.923	Negative Allometric
<i>Dendrophysa russelii</i>	7.00 – 13.20	10.68 \pm 0.25	22.11 – 61.04	12.34 \pm 1.52	0.019	2.941	0.07	0.969	Negative Allometric
<i>Sillago parvisquamis</i>	10.80 – 18.50	15.13 \pm 0.26	28.93 – 75.81	15.16 \pm 1.52	0.042	2.465	0.107	0.944	Negative Allometric
<i>Cynoglossus bilineatus</i>	15.00 – 28.50	22.84 \pm 0.55	20.07 – 78.54	15.57 \pm 4.93	0.016	2.719	0.088	0.954	Negative Allometric
<i>Sardinella brachysoma</i>	10.80 – 13.10	11.59 \pm 0.07	28.27 – 75.45	11.09 \pm 0.27	0.472	2.798	0.104	0.929	Negative Allometric
<i>Alepes kleinii</i>	9.50 – 12.00	10.71 \pm 0.07	22.95 – 86.39	12.19 \pm 0.43	0.035	2.835	0.134	0.932	Negative Allometric

TL: Total length, BW: Body weight, a : intercept, b : regression coefficient, R^2 : coefficient of determination

LWR analyses on the 10 trawl species in Malaysia or nearby waters are limited. However, some studies have examined the LWR of these species in different localities other than Malaysia. For all of the studied species in this study, the “b” values were not generally in agreement with previous results, except for *G. erythrourus*, *O. ruber*, and *D. longimana*. The functional regression “b” value represents the body form. It is directly related to the weight, which is influenced by some ecological factors such as temperature, food supply, spawning conditions, and other factors (e.g., sex, age, fishing time, fishing area, and

fishing vessels) (Hossain et al. 2006). The LWR in fishes is affected by few factors such as habitat, diet, growth phase, season, degree of stomach fullness, gonad maturity, sex, size range, health and general fish conditions, and preservation techniques (Mir et al. 2012).

The mean condition factors (K and K_n) are shown in Table 2. The condition factors were in the range of 2.004-2.910 and 1.002-1.288 for K and K_n , respectively. The high K and K_n values indicated that the general well-being and condition of the fish in this study were suitable.

TABLE 2. Descriptive statistics and estimated parameters of condition factors of ten species sampled from Mersing Coastal Waters, Johor, Malaysia

Species	Fulton's condition factor, K		Relative condition factor, K_n	
	Range	Mean \pm standard error (SE)	Range	Mean \pm standard error (SE)
<i>Gerres erythrourus</i>	2.128 – 2.755	3.014 \pm 0.053	1.052 – 1.223	1.098 \pm 0.016
<i>Drepane punctata</i>	2.774 – 2.910	4.788 \pm 0.099	1.085 – 1.260	1.128 \pm 0.019
<i>Otolithes ruber</i>	2.039 – 2.795	1.222 \pm 0.029	1.017 – 1.383	1.280 \pm 0.021
<i>Anodontostoma chacunda</i>	2.300 – 2.540	1.925 \pm 0.051	1.075 – 1.204	1.198 \pm 0.013
<i>Drepane longimana</i>	2.004 – 2.597	4.087 \pm 0.104	1.060 – 1.324	1.012 \pm 0.022
<i>Dendrophys russelii</i>	2.322 – 2.826	1.727 \pm 0.042	1.070 – 1.624	1.006 \pm 0.024
<i>Sillago parvisquamis</i>	2.171 – 2.773	1.007 \pm 0.025	1.030 – 1.581	1.016 \pm 0.018
<i>Cynoglossus bilineatus</i>	2.446 – 2.871	0.705 \pm 0.023	1.072 – 1.588	1.049 \pm 0.028
<i>Sardinella brachysoma</i>	2.113 – 2.637	1.358 \pm 0.015	1.005 – 1.120	1.002 \pm 0.009
<i>Alepes kleinii</i>	2.116 – 2.781	1.473 \pm 0.023	1.075 – 1.203	1.288 \pm 0.015

On the basis of the obtained results, all the 10 fish species in this study were living in good conditions throughout the study period of this experiment. The

condition of a fish may vary due to physiological, environmental, nutritional, and biological cycles. K is often used to understand the changes in weight for length,

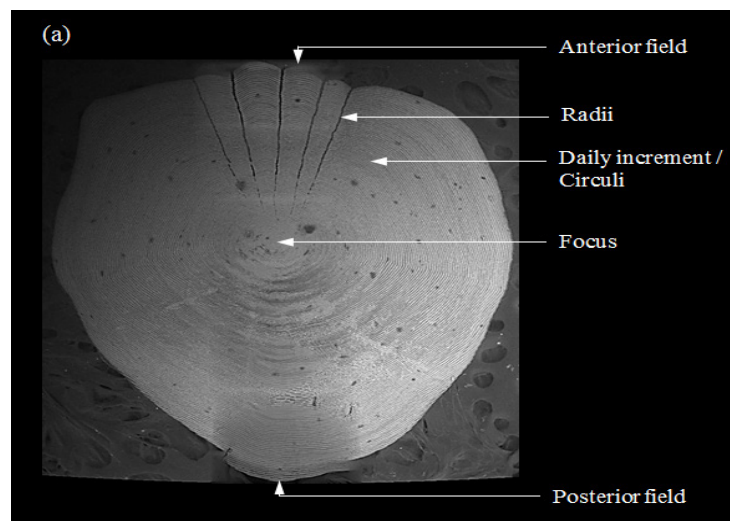
assuming that the LWR follows the cube law. Meanwhile, Kn compares the mean weight of fish in a sample with the predicted weight of fish from a generalized LWR to determine whether the fishes are in better or poorer condition than the standard one (Simon et al. 2013). The K and Kn values can be influenced by certain external factors, such as changes in temperature and photoperiod (De et al. 2016; Mazumder et al. 2016; Youson et al. 1993). Given that Malaysia has a steady temperature or has no variation in seasonal changes and photoperiod changes throughout the year, these two factors (temperature and photoperiod) might not be the major factors for the 10 trawl species in the study area.

AGE ESTIMATION

Table 3 presents the size range and estimated ages extracted from the scale (Figure 1). The age range for all species did not exceed 1 year where the maximum age observed was 170 days for *G. erythrourus*. This phenomenon might be why large fish escaped the net (Jørgensen et al. 2009). The relationships between the scale ages to the total length are also shown in Table 3. Linear correlations were noted between the scale ages and total length. For all the fish species, the regression line showed positive relationships for the age-length relationship. The correlation coefficient (r) was high between the increment of fish ages and their body length.

TABLE 3. Age, total length range and age-length relationship of the ten species sampled from Mersing Coastal Waters, Johor, Malaysia

Species	Age range (days)	Total length range (cm)	Age-length relationship	r
<i>Gerres erythrourus</i>	56 – 170	9.5 – 20.3	$y = 8.102x + 647.950$	0.961
<i>Drepane punctata</i>	80 – 159	9.7 – 26.6	$y = 9.388x + 905.560$	0.955
<i>Otolithes ruber</i>	94 – 123	9.5 – 17.5	$y = 0.157x - 0.306$	0.972
<i>Anodontostoma chacunda</i>	63 – 97	10.7 – 16.9	$y = 0.117x + 0.785$	0.960
<i>Drepane longimana</i>	50 – 80	15.0 – 28.5	$y = 0.939x - 51.207$	0.988
<i>Dendrophys russelii</i>	60 – 84	7.0 – 13.7	$y = 0.764x - 51.355$	0.960
<i>Sillago parvisquamis</i>	102 – 160	7.0 – 13.2	$y = 0.083x + 3.476$	0.967
<i>Cynoglossus bilineatus</i>	62 – 157	10.8 – 18.5	$y = 0.074x + 3.542$	0.954
<i>Sardinella brachysoma</i>	81 – 151	10.8 – 18.1	$y = 1.011x - 35.240$	0.970
<i>Alepes kleinii</i>	60 – 153	9.5 – 15.0	$y = 0.043x + 4.397$	0.965



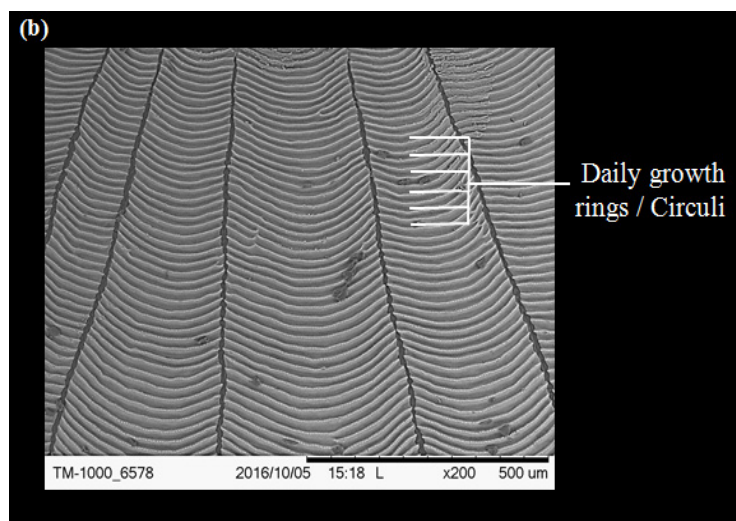


FIGURE 1. Scale from an age <1-year individual trawl fishes sampled; (a) scale (b) scanning electron micrograph showing daily increment/growth rings

A previous study suggested that the most suitable site of the scale selection for age determination was the area below the pectoral fin. Other than the area below the pectoral fin, the other sites for scale selection may lead to underestimation of fish age (Campana 2001). Ageing of fishes from tropical waters has been reported through annual increments in calcified structures, such as scales (Simon et al. 2010), dorsal and pectoral spines (McFarlane & Beamish 1987), vertebral centra (Brown & Gruber 1988), and otoliths (Newman et al. 2000). Scales are the easiest to collect and process among the abovementioned structures. Using scales as structures for ageing also avoids sacrificing the specimens like those in ageing methods employing otoliths.

However, using scales for fish ageing leads to some drawbacks, such as difficulties in reading. The annuli method has low precision, and scale ages may become inaccurate when growth becomes asymptotic (Lowerre-Barbieri et al. 1994). In this research, the reliability of scale readings was increased by sampling scales only from a fixed position, where the scales have large uniform size, good symmetry, and high legibility. However, as extremely senescent specimens were unavailable in this research, annuli readings have been relatively legible and reliable (Maccina & Sammons 2006).

CONCLUSION

In conclusion, LWR indicated positive allometric growth for *G. erythrourus* and *D. punctata*, which showed that the species became more spherical as they grew compared with the other species that showed negative allometric

growth. The condition factor K indicated that the 10 species were living in good conditions. Age estimation data showed that the populations in the study area comprised the juvenile age group (<1 year). These data are needed for fishery management as the population of these trawling fish species in Malaysian estuaries is dwindling over time due to fishing pressure and habitat destruction. Therefore, the growth properties (LWR and K) and the use of scales in age determination and life history study are pertinent for these commercially important trawling fish species.

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Simon Kumar Das*, Tou Wee Xiang, Noorashikin Md Noor, Mounita De & Abdullah Samat
Department of Earth Sciences and Environment
Faculty of Science and Technology
Universiti Kebangsaan Malaysia
43600 UKM Bangi, Selangor Darul Ehsan
Malaysia

Simon Kumar Das*
Marine Ecosystem Research Center
Faculty of Science and Technology
Universiti Kebangsaan Malaysia
43600 UKM Bangi, Selangor Darul Ehsan
Malaysia

*Corresponding author; email: simon@ukm.edu.my

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