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Research Article

Estimation of Length-weight Relationship and Condition Factor of Five Cultrinae Fish Species from Dianshan Lake, Shanghai, China

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Abstract: The main aim of this study was to carry out the estimation of Length-Weight Relationship (LWR) and condition factor of five cultrinae fish species collected from Dianshan Lake, Shanghai, China investigated using specimens obtained from fishers. The sampling duration was from January to December 2013 by using fishing gears such as trawls and gillnets. Fish specimens were selected, morphometrically identified and measured. Specimens collected were stored in coolers containing ice then transported to the laboratory for further analysis. Fork length and body weight were measured using standard methods; the mean lengths and weights of the species were used for data analysis. Linear regression analysis was executed for the study of length-weight relationship $W = aL_b$ and the respective exponential equations for LWR relationship are *Chanodichthys erythropterus* ($W_t = 0.0065(FL)^{3.2019}$); *Chanodichthys mongolicus* ($W_t = 0.0022(FL)^{3.562}$) ; *Hemiculter leucisculus* ($W_t = 0.1692(FL)^{1.7}$) *;* *Hemiculter bleekeri* ($W_t = 0.0059(FL)^{3.0521}$) and *Culter alburnus* ($W_t = 0.0014(FL)^{3.7429}$). In the present study, the results revealed that *Hemiculter bleekeri bleekeri* showed an isometric pattern of growth ($b \approx 3$); *Hemiculter leucisculus* showed a negative allometric growth pattern ($b = 1.7$); while *Chanodichthys erythropterus*, *Chanodichthys mongolicus* and *Culter alburnus* all exhibited positive allometric growth $b \approx 3.2, 3.6$ *and* 3.7 respectively. Studies on condition factor revealed that the fluctuations in K values can be attributed to the spawning cycle as well as feeding intensity. The condition factor ranged from 0.746 (*Hemiculter leucisculus*) to 2.566 (*Chanodichthys mongolicus*). New maximum lengths for two species: *Hemiculter leucisculus* (72.9 cm) and *Hemiculter bleekeri bleekeri* (19.9 cm) are also reported.

Keywords: Condition factor, Dianshan Lake freshwater fish, length, species and weight

INTRODUCTION

Cyprinidae (Cyprinid) is a family of soft-finned fish in the Order *Cypriniformes*, which is one of five orders contained in the Superorder Ostariophysi. Cyprinids are multifariously located worldwide across lakes and rivers but are largely concentrated in lakes. The Cultrinae (Sharp bellies and Breams) are one of at least 13 subfamilies of cyprinid fish, many of which are found in lakes and rivers of East Asia, notably China. It contains seven genera and 32 described species, but in our present study,we focused on five species from (3) genera, notably *Chanodichthys* [*Chanodichthys erythropterus* (Basilewsky, 1855), *Chanodichthys mongolicus* (*Basilewsky*, 1855)], *Culter* [*Culter alburnus* (*Basilewsky*, 1855)] and *Hemiculter* [*Hemiculter leucisculus* (*Basilewsky*, 1855), *Hemiculter bleekeri* (*Warpachowski*, 1888)].

The mathematical relationship between length and weight of fishes is a practical index suitable for understanding their survival, growth, maturity, reproduction and general well-being (Le Cren, 1951). Length-weight relationships are widely used for conversion of the growth-in-length equation to growth-in-weight for use in stock assessment models and estimation of biomass from length observations (Weatherley and Gill, 1987; Wootton, 1990; Moutopoulos and Stergiou, 2002) and also allowing for morphological comparisons among species or among populations of the same species from different habitats and/or regions (Moutopoulos and Stergiou, 2002). Length-weight relationship studies on fish are extensive.; notable among these are the reports from Khan and Sabah (2013), for five fish species in Kashmir valley, Dulčić and Kraljević (1996) for 40 species Eastern Adriatic(Croatia), Ye *et al*. (2007) for

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30 fish species in Niushan Lake, China, Mousavi-Sabet *et al*. (2013) studies on *Hemiculter leucisculus* (*Basilewsky*, 1855) Caspian Sea Basin from Iran, Garcia (2010) for fishes in the Candaba wetland on Luzon Island, Philippines and Li *et al*. (2016) LWR for nine fish species, Lake Dianshan, China.

The condition factor which shows the degree of the well-being of the fish in their habitat is expressed by 'coefficient of condition' also known as length- weight factor. This factor is a measure of various ecological and biological factors such as the degree of fitness, gonad development and the suitability of the environment with regard to the feeding condition (Le Cren, 1951). When condition factor value is higher it means that the fish has attained a better condition. The condition factor of fish can be affected by a number of factors such as stress, sex, season, availability of feeds and other water quality parameters. Fulton's condition factor (K) is widely used in fisheries and fish biology studies. This factor is calculated from the relationship between the weight of a fish and its length, with the intention of describing the condition of that individual fish (Fulton, 1904). Some condition factors reported for other fish species include; Mousavi-Sabet *et al*. (2013) studies on *Hemiculter leucisculus* (*Basilewsky*, 1855) Caspian Sea Basin from Iran and Mir *et al*. (2012), *Schizopyge curvifrons* (*Heckel*, 1838) from River Jhelum, Kashmir, India.

A large number of studies have been carried out on many species found in this lake as well as in different regions in China. Unfortunately, to the best of our knowledge, no work has been done on the length-weight relationship and condition factor of *Chanodichthys erythropterus* (Basilewsky, 1855), *Chanodichthys mongolicus* (*Basilewsky*, 1855), *Hemiculter leucisculus* (*Basilewsky*, 1855) and *Culter alburnus* (*Basilewsky*, *1855*) from the Dianshan Lake; the aim of this present study was to provide the LWRs and condition factor for these species in this lake. Therefore, this study provides additional information on the Cyprinidae family, specifically to these fish species of the subfamily cultrinae harvested from the Dianshan Lake. This additional information may serve as a tool for management and conservation practices.

MATERIALS AND METHODS

Description of study area: Geographically, the Dianshan Lake lies within the boundaries of Latitudes 31° 11'N and longitudes 120° 96' E (Fig. 1). It is the largest freshwater lake in Shanghai, with a total area of 63.7 km^2, an average depth of 2.5 m, with the deepest recorded depth to be 4.9 m. It is located in between Shanghai, Zhejiang and Kunshan of Jiangsu Province. Increased fishing pressure and urbanization caused the collapse of populations of many fish species in this Lake which in the past had abundant fisheries resources and was rich in aquatic bio-diversity. This Lake supports a lucrative fishery in Shanghai and fishermen involved in fishing bring in commercially important fish species now in reduced quantities (because high fishing pressure).

Length- weight relationship: Live specimens were randomly captured directly from the selected sampling

Fig. 1: Sampling site (Dianshan lake)

stations with the help of local fishermen by using gillnets and trawls. The sampling of landed catches was done once a month for a period of twelve months (from January to December 2013). The randomly captured samples were selected, morphometrically identified and measured. Specimens collected were stored in coolers containing ice then transported to the laboratory for further biological measurements. Fork length (FL)) was measured to the nearest 0.01 cm and the weight was taken on digital balance with 0.01 g accuracy for each individual. The relation between length and weight of fish was analyzed by measuring length and weight of fish specimens collected from the study area. The statistical relationship between these parameters of fish was established by using the parabolic equation by Froese (2006):

$$W = aFL^b \quad (1)$$

where,
W = Weight of fish (g)
FL = (Fork) length of fish (cm)
a = Constant (intercept)
b = An exponential expressing relation between length and weight (slope)

The relationship $W = aFL^b$, when converted into the logarithmic form, gives a straight line relationship graphically:

Log W = Log a + b Log FL (Beverton and Holt, 1957).

where,
b = The slope of the line
Log a = A constant

The coefficient of determination (r^2) was used as an indicator of the quality of the linear regression. The value of b provides information on the fish growth type.

Condition factor (K): The condition factor is used for comparing the condition, fatness, or wellbeing (Mir *et al*., 2012) of fish, based on the assumption that heavier fish of a given length are in better condition. The difference in the condition factor has been interpreted as a measure of histological events such as fat reservation, adaptation to the environment and gonadal development (Le Cren, 1951). The coefficient of the condition, K was calculated using (Fulton, 1904).

$$K = 100 * \frac{W}{L^3} \quad (2)$$

where,
W = Weight in grams
L = Length in cm and 100 is a factor to bring the value of K near unity (Froese, 2006).

RESULTS AND DISCUSSION

Results: A total of 1170 were captured and 1152 specimens of five species were measured. In the present study, the sample size varied with fish species. Table 1 presents the species, sample size (N), minimum, maximum and mean lengths; mean length's Standard Deviation (SD), the coefficient of determination (r^2), the constant a (intercept), slope regression (b), growth type and the condition factor (K).

Table 1: Length–weight relationship for the five fish species

		Length characteristics			
Fish species	N	Min.	Max.	Mean	S.D.
Chanodichthys erythropterus	706	4.7	24.7	11.668	±1.241
Hemiculter leucisculus*	217	7.3	72.9	11.179	±1.890
Culter alburnus	68	6.9	34.7	14.553	±3.345
Chanodichthys mongolicus	32	6.1	44.5	14.438	±6.832
Hemiculter bleekeri bleekeri*	129	9.1	19.9	12.264	±1.483

	Parameters of the relation				
Fish species	a	b	r^2	Growth type	Condition Factor K
Chanodichthys erythropterus	0.0065	3.2019	0.802	PA	1.116
Hemiculter leucisculus*	0.1692	1.7000	0.662	NA	0.746
Culter alburnus	0.0014	3.7429	0.730	PA	1.397
Chanodichthys mongolicus	0.0022	3.5620	0.903	PA	2.566
Hemiculter bleekeri bleekeri*	0.0059	3.0521	0.907	IS	0.988

N.: Sample size; Min. and Max.: minimum and maximum Fork lengths in cm; a and b.: The parameters of the length-weight relationship; S.D.: Standard deviation of length mean; r^2.: The coefficient of determination; IS.: Isometric; PA.: Positive allometric; NA.: Negative Allometric; *.: Representing new records of maximum length in Froese and Pauly (2016) FishBase

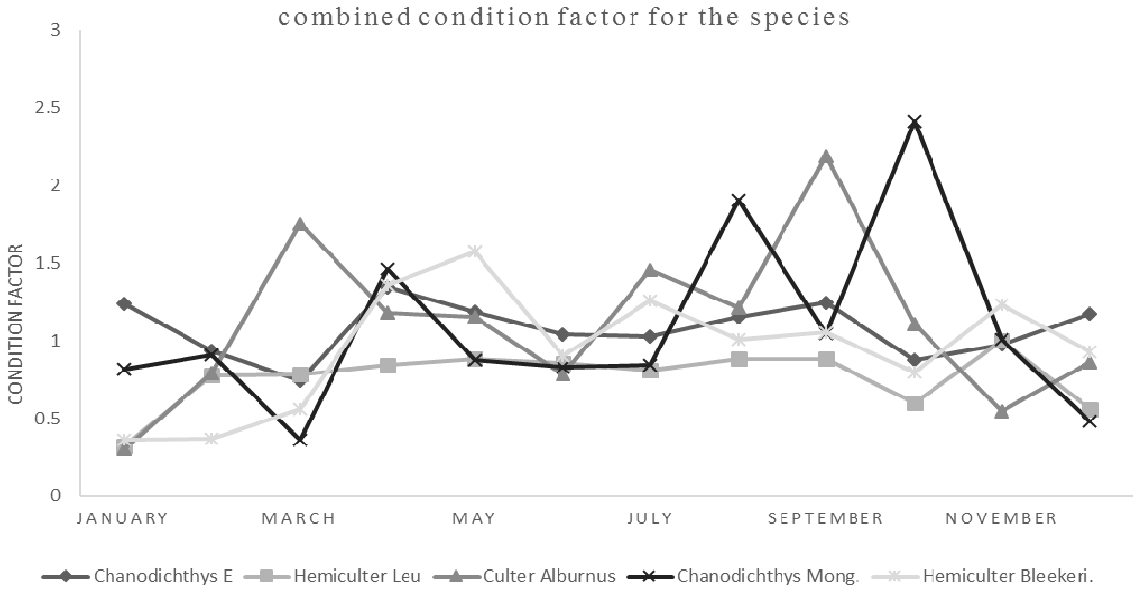

Fig. 2: Monthly condition factor for the species Jan-Dec 2013 (combined)

The respective exponential equations are: relationship are:

Chanodichthys erythropterus ($W_t = 0.0065(FL)^{3.2019}$), *Chanodichthys mongolicus* ($W_t = 0.0022(FL)^{3.562}$), *Hemiculter leucisculus* ($W_t = 0.1692(FL)^{1.7}$), *Hemiculter bleekeri* ($W_t = 0.0059(FL)^{3.0521}$) and *Culter alburnus* ($W_t = 0.0022(FL)^{3.7429}$).

Chanodichthys erythropterus, *Culter alburnus* and *Chanodichthys mongolicus* were positively allometric in their growth; *Hemiculter bleekeri bleekeri* was isometric in its growth while *Hemiculter leucisculus* was negatively allometric in its growth.

Graphical presentations of the condition factors of all species studied are shown in Fig. 2, while the monthly condition factor for each species is presented in Fig. 3 to 7. The condition factor ranged from 0.746 (*Hemiculter leucisculus*) to 2.566 (*Chanodichthys mongolicus*).

Discussion:

Length-weight relationship: Studies on the length-weight relation of fish constitute an important tool in fishery biology and help to understand whether variations from the expected weight for the known groups are the indicators of fatness, well-being and gonadal development in relation to the environment (Le Cren, 1951; Bagenal, 1978). Fisheries management and research often require the use of biometric relationships in order to transform data collecting in the field into appropriate indices. The length-weight relationship can be obtained from length and weight measurements of the same fish throughout their lives or from a sample of fish taken at a particular time (Wootton, 1990).

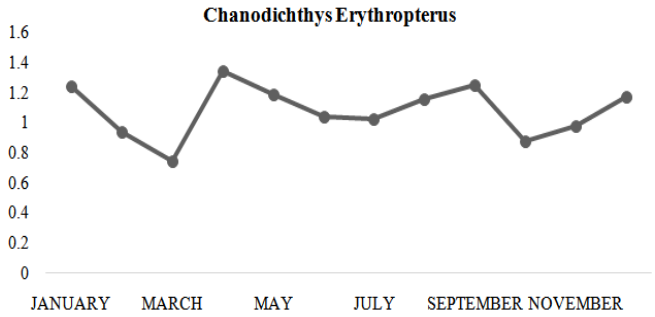

Fig. 3: Condition factor for *Chanodichthys erythropterus*

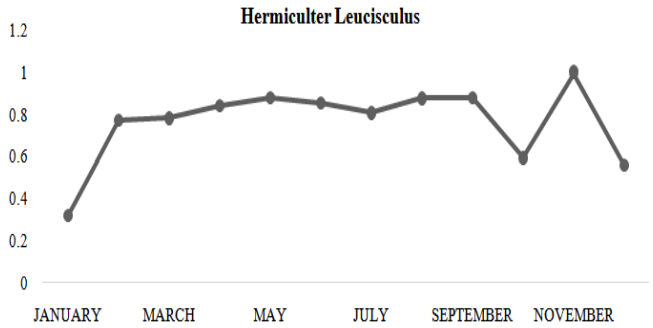

Fig. 4: Condition factor for *Hemiculter leucisculus*

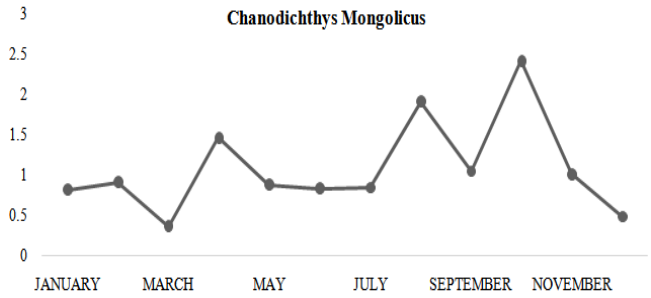

Fig. 5: Condition factor for *Chanodichthys mongolicus*

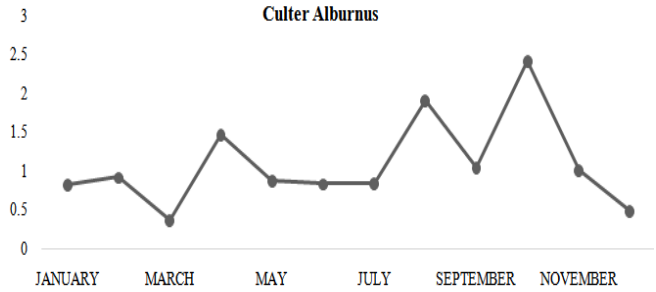

Fig. 6: Condition factor for *Culter alburnus*

From the length-weight relationship (Table 1), the values obtained for b showed variations of growth from the five species. Values of b equal to 3 indicate that the fish grows isometrically; values other than 3 indicate allometric growth (Tesch, 1971). In the present study, the results revealed that *Hemiculter bleekeri bleekeri* showed an isometric pattern of growth (b = 3) indicating that, the small specimens have the same form and probably the same condition as large specimens, *Hemiculter leucisculus* showed a negative allometric growth pattern (b<3) implying that, the increase in length is not in accordance with increase in weight while *Chanodichthys erythropterus*, *Chanodichthys mongolicus* and *Culter alburnus* all exhibited positive

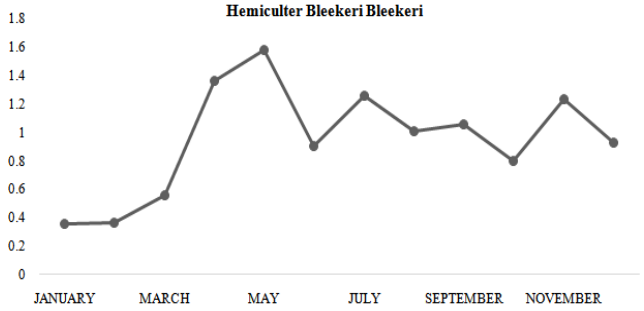

Fig. 7: Condition factor for *Hemiculter bleekeri bleekeri*

allometric growth (b>3) indicating that, these species gain weight at a faster rate to their length. The value of b usually remains constant at 3.0 for an ideal fish (Hile, 1936). All regressions were significant, with the coefficient of determination r^2 ranging from 0.662 (*Hemiculter leucisculus*) to 0.907 (*Hemiculter bleekeri bleekeri*).

In this study, we recorded a negative allometric growth pattern for *Hemiculter leucisculus* (*Basilewsky, 1855*); Ye *et al*. (2007) for Niushan Lake, China and Mousavi-Sabet *et al*. (2013) for Caspian Sea Basin from Iran both also reported a negative allometric growth for the same species. However, the reports for the same species from, Wang *et al*. (2012) for Tian-e-zhou Oxbow, China and Radkhah (2015) for Anzali Wetland of Iran are not in agreement with the report from this study; they both reported a positive allometric growth pattern. The variation (from FishBase) of the *b*-value in this study might be due to the inclusion of juveniles that might have affected the species-specific LWR. As for *Hemiculter bleekeri bleekeri*, Ye *et al*. (2007) also reported an isometric growth as reported in this study, while, Wang *et al*. (2012) and Li *et al*. (2016) both reported a positive isometric growth for the same species. As for the other species studied in this present work, Wang *et al*. (2012) and Ye *et al*. (2007) both reported positive allometric growth patterns for *Chanodichthys erythropterus*, *Chanodichthys mongolicus* and *Culter alburnus* as obtained in our present study. Ricker (1973) stated that the functional regression b value represents the body form and is directly related to the weight affected by ecological factors such as temperature, food supply, spawning conditions and other factors such as sex, age, fishing time and area.

Condition factor: Condition indices have been widely used as indicators of relative health (Brown and Murphy, 1991). The condition Factor (K) reflects, through its variations, information on the psychological state of the fish in relation to its wellbeing. In the present study, the condition factor varied from 0.746 (*Hemiculter leucisculus*) to 2.566 (*Chanodichthys mongolicus*) as shown above in Table 1. In addition to that, monthly variations of condition factor for all five species are also given in Fig. 2 to 7. Le Cren (1951) had reported that environmental factors, food supply and parasitism have great influence on the health of the fish. The differences in condition factors seasonally could be attributed to low feeding intensity and degeneration of ovaries during winter and high feeding intensity and full development of gonads during summer months. The present study to the best of our knowledge is the first attempt to provide information about the growth condition of *Chanodichthys erythropterus*, *Culter alburnus*, *Chanodichthys mongolicus*, *Hemiculter bleekeri bleekeri* and *Hemiculter leucisculus* in the Dianshan Lake. This study will enlighten biologists about the status and growth condition of these fish species in natural waters and will be useful for the fishery biologists and conservation agencies, for successful development. From a reproductive point of view, the highest K value is reached in some species, if the fish is fully mature and having higher reproductive potentiality (Angelescu *et al*., 1958). From a nutritional point of view, an increase in K value indicates the accumulation of fat and gonadal development (Le Cren, 1951). Figueiredo-Garuti and Garuti (1991) had stated that the lowest K value occurs at the beginning of the reproductive period and the highest at its end. K also gives information when comparing two populations living in certain feeding, density, climate and other conditions; when determining the period of gonad maturation and when the degree of feeding activity is followed up for a species to verify whether it is making good use of its feeding source (Bagenal and Tesch, 1978).

CONCLUSION

From the above assertions, we could say that the values obtained in this study showed that these five species reproduce between November to February since they recorded the lowest values of K at about this period and that all five species were in good condition ($K \geq 0.5$). Furthermore, in studies of population dynamics high condition factor values indicates favorable environmental conditions (such as: habitat and prey availability) and low values indicate less favorable environmental conditions (Blackwell *et al*.,

2000); we could say that, maybe the environmental conditions were not favorable for the species (*Hemiculter leucisculus*) since they recorded the lowest value of K and favorable environmental conditions for the rest of the species who recorded higher values of K. This study provides new records of maximum Fork length in FishBase (Froese and Pauly, 2016) for two species: *Hemiculter leucisculus* (72.9 cm) and *Hemiculter bleekeri bleekeri* (19.9 cm) and also provides basic data on the length-weight relationship and condition factor (K) that would be beneficial for fishery biologist's managers to impose suitable regulations for sustainable fishery management in the Dianshan Lake.

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