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DETERMINATION OF THE AGE OF *NOTOPTERUS NOTOPTERUS* (PALLAS, 1769) WITH REFERENCE TO THE STRUCTURAL CONFIGURATION IN SOME CALCIFIED STRUCTURES AND SCALES

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Abstract

The growth performance and age determination of *Notopterus notopterus* from Northern Part of Meiktila Lake were investigated during December 2019 to August 2020 by using back-calculated length at age and von Bertalanffy growth curve. The total length, standard length and weight of fishes were recorded. Five different calcified structures viz. scale, otolith, vertebrae, operculum and cleithrum of fishes were applied. Annuli in these calcified structures reading revealed 4 yrs, 5 yrs and 6 yrs in which operculum reading was more precise for age determination. The relevant combination of growth constants to estimating lengths from age interpretation to the nearest asymptotic length revealed $L_{\infty=}\,51.86,\ k = 0.13$ with the growth performance index $\emptyset' = 2.542$ in female and $L_{\infty=}\,56.36,\ k = 0.12$ with $\emptyset' = 2.581$ in male. The present results will provide the precise interpretation of aging structure of local fishes as well as to give the sense of their biological aspect in aquaculture.

Key words: bronze feather fish, ages, calcified structures, growth, length

Introduction

The "Bronze feather back fish", *Notopterus notopterus* is a common fresh water fish belongs to family Notopteridae, is widely distributed in Southeast Asia. It is known as Nga-pe in Myanmar. The years of life span are 9 - 12 years, breed in stagnant or running water and delay in growth performance (Froese and Pauly, 2019).

The age determination on specific species is relatively quite different even though under the same family. The age data of a stock indicates the healthy fish stock. Age can be determined by anatomical method as well as length-frequency analysis (Morales-Nin,1992). The mechanism of annulus formation for determination of fish age is supposed by a combination of factors including temperature, feeding habits, and the reproductive cycle (Huo *et al.*, 2012).

Meiktila is one of the tropical zones where dams, lake and ponds are the main source for aquaculture research as well as small economic income for rural life process. In which, the bronze feather back is one of the commercial small income fish and readily available from local fishermen.

The purpose of this research is whether to accept null hypothesis or not:

H_0: the precision of age-length increment in *N. notopterus* could be evaluated by using all calcified structures in northern part of meiktila lake and

H_1: the precision of age-length increment in *N. notopterus* could not be evaluated by using all calcified structures in northern part of meiktila lake.

Materials and Methods

Study site

Northern part of Meiktila Lake lies between geographical co-ordinates of 20˚53′ 55.87″ N Latitudes and 95˚51′ 32.02″ E Longitudes (Plate 1).

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Study period

The present study was commenced from December 2019 to August 2020.

Plate 1. Map of Northern part of Meiktila Lake. Source: Gogle 2020

Specimen collection

Fifty-three fresh samples of *Notopterus notopterus* were collected from Northern part of Meiktila Lake. These samples were weight in nearest 0.01 g (Digital Kitchen Scale) and measure their standard and total length in nearest 0.01 cm (Digital Caliper). They were divided into 10 cm equally in range according to their total length.

Identification of species

Identification of the species was followed those of Das *et al.,* (2012); Froese and Pauly (2019) and Muniya *et al*., (2019).

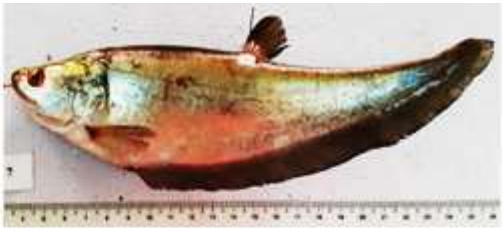


Plate 2. The bronze feather back *Notopoterus notopterus*

Age determination on calcified structures

Five calcified structures like scales, otoliths, opercula, cleithra and vertebrae were extracted from each fish. The anterior margin of the scale was checked under the light microscope (x40) and photographed to count the annuli. Left operculum and left cleithrum were photographed by hand lens (x12) to interpret the rings. Otoliths and the rings at the anterior part of the vertebrae were checked under the stereomicroscope (x40). The clear true annulus, widely spaced circuli, or one opaque and one transparent ring zone was assigned as one annulus.

Back-calculated length at age

A formula reflecting a scale- proportional hypothesis (SPH) credited to Hile (1941).

$$Li = -\left(a/_b\right) + \left[Lc + \left(a/_b\right)\right]\left(Si/_{Sc}\right)$$

Where Li = back-calculated body length at age,

Lc = fish body length at capture,

Sc = Mean scale total length,

Si = mean scale length at annulus i,

a = intercept from the regression of mean scale length on body length, and

b = slope from the regression of mean scale length on body length.

The von-Bertalanffy growth curve

The relationship between fish age and calcified structures was estimated by using von-Bertalanffy growth function (Ricker, 1975) to age-at-length data using

$$Lt = L_\infty \left\{1 - e^{[-K(t-t_0)]}\right\}$$

Where Lt = expected or mean length at time t,

L_∞ = maximum asymptotic mean length,

K = measure of the exponential rate at which curve approaches,

L_∞ or a constant equal to $\frac{1}{3}$ of catabolic coefficient,

e = base of the natural logarithm (exponential),

$t_0 =$ the theoretical age at which Lt would be zero and t = age of the fish.

Statistical analysis

The growth performance for length-at-age and von Bertalanffy's growth formula were generated with FISAT-II (version 1.2.2, FAO).

Results

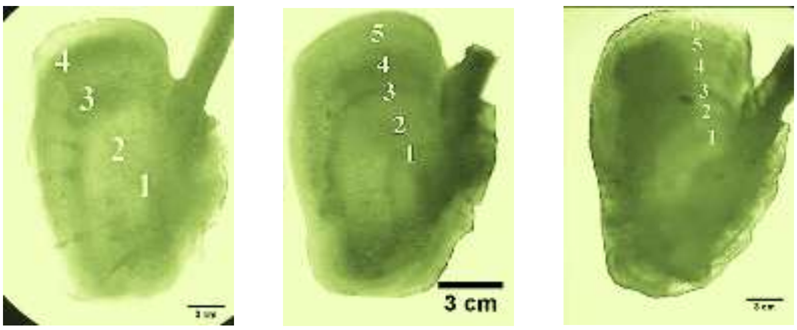
A sample of studies 53 *Notopterus notopterus* (Male = 26, Female = 27) from northern part of Meiktila Lake were taken into consideration during this research.

In female, the mean value of length and weight were 203.02 ± 28.11 mm with 54.15 ± 19.45 g at 4 yrs, 238.71 ± 23.80 mm with 101.11 ± 30.81 g at 5 yrs and 295.66 ± 34.62 mm with 204.20 ± 89.19 g at 6 yrs.

In male, the mean value of length and weight were 213.49 ± 35.57 mm with 82.39 ± 39.99 g at 4 yrs, 219.21 ± 30.40 mm with 84.22 ± 31.64 g at 5 yrs and 307.72 ± 0.00 mm with 233.30 ± 0.00 g at 6 yrs.

Age determination on calcified structures

Age for each growth mark of fish was determined by reading annulus on hard calcified structures. Annuli appeared as alternatively one broad opaque and one narrow translucent zone. The ring marks on scales were identified by the gap or broad ring between the growth annulus around the focus (Plate 3, 4, 5, 6 and 7).



A B C

Plate 3 Annuli marks in the otolith of *Notopterus notopterus* (A) Four years, (B) Five years and (C) Six years (x40)

A B C

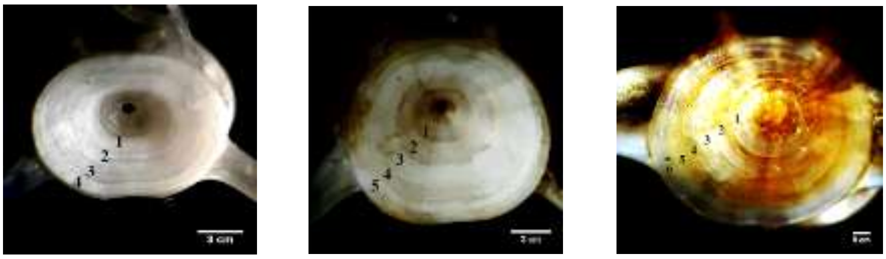
Plate 4 Annuli marks in the scale of *Notopterus notopterus* (A) Four years, (B) Five years and (C) Six years (x40)

A B C

Plate 5 Annuli marks in the cleithrum of *Notopterus notopterus* (A) Four years, (B) Five years and (C) Six years (x12)

A B C

Plate 6 Annuli marks in the operculum of *Notopterus notopterus* (A) Four years, (B) Five years and (C) Six years (x12)

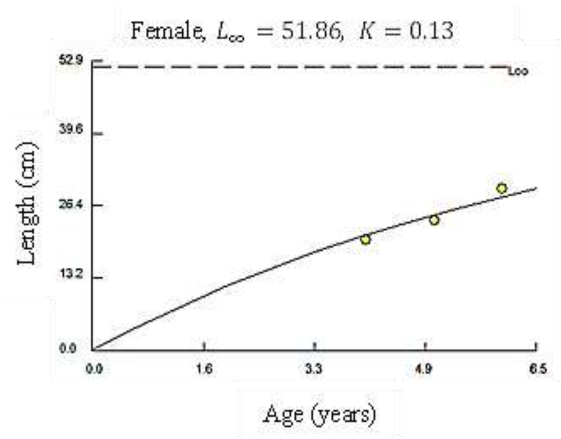


A B C

Plate 7 Annuli marks in vertebrae of *Notopterus notopterus*
(A) Four years (B) Five years and (C) Six years (x40)

Age-length relationship

Length-at-age on reading calcified structures were shown by von Bertalanffy Growth curve. The maximum asymptotic length of the feather back was $L_{\propto}$ = 51.86 cm with K = 0.13 in female and the male with at $L_{\propto}$ = 56.36 cm with K = 0.12 revealed by Ford-Wolford plot (Fig.1 and Fig. 2).



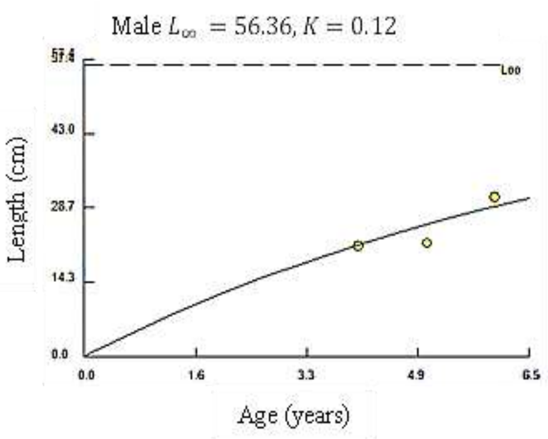


Figure.1. Age-length relationship of female male *N. notopterus*

Figure.2. Age-length relationship of *N. notopterus*

The increment of growth pattern of classified structures for aging interpretation were quite different in operculum and cleithrum in both sexes. Their growth pattern showed the exponentially increased in female than male with delay growth found at 5 yrs and then increased at 6 yrs. No largely different increment in the scale, vertebrae and otolith length observed in both female and male bronze fishes (Fig. 3).

Back-calculated length

The real growth development of male and female bronze fish was determined at each age by the back-calculated length compared with the observed total length (TL) (Table 1 and Fig.4).

Growth performance index ($\emptyset'$)

The average growth performance index of female bronze feather back was $\emptyset' = 2.542$ and male with $\emptyset' = 2.581$ revealed by Ford-Wolford plot. In female, the growth performance index for vertebrae reading $\emptyset' = 2.552$ was the highest value and the lowest $\emptyset' = 2.480$ in scale reading. In male, growth performance index $\emptyset' = 2.786$ was observed in otolith reading and the lowest $\emptyset' = 2.355$ in scale reading (Table 2).

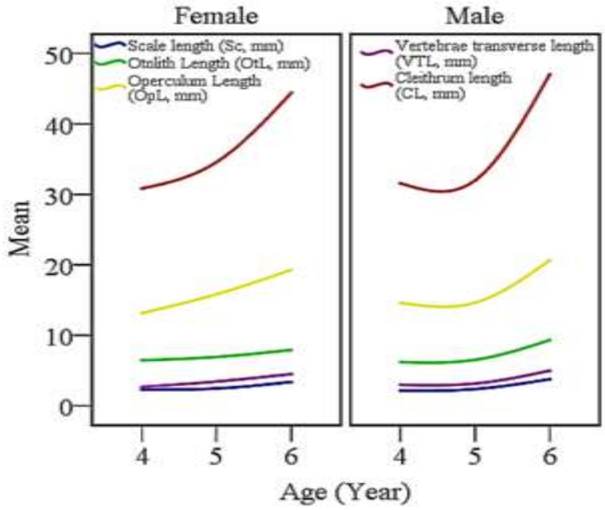


Figure. 3. Relationship of calcified structures with age of male and female *N. notopterus*

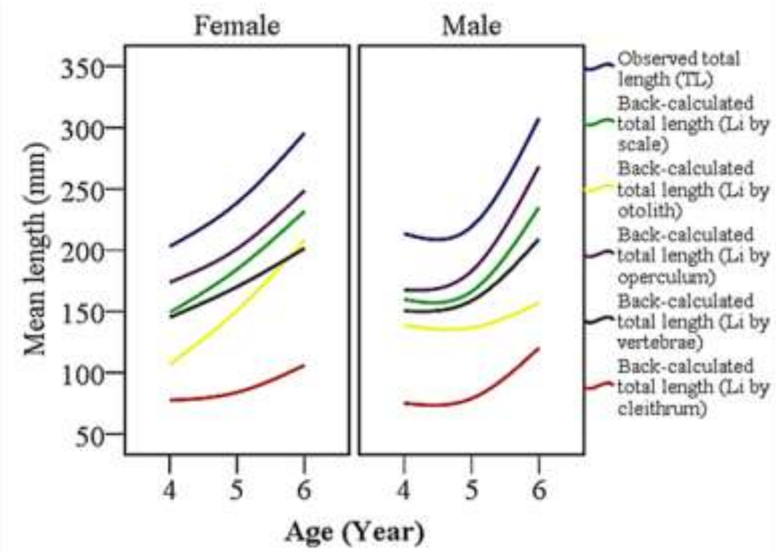


Figure. 4. Back-calculated length at age in male and female *N. notopterus*

Ford-Wolford plot of length at success at ages

The estimated parameters of the von Bertalanffy Growth formula by different calcified structures reading method in both males and females' fishes was shown in Table 2.

The growth increment of theoretical length (t_0) from both sexes revealed the negative t_0 predicted the similar growth pattern with their expected length (L_t) at each age (Table 3).

Table 1 Comparison of total length and back-calculated length of *N. notopterus* from Northern Part of Meiktila Lake. (n = number of specimens)

Items	Age (years)	Female	Age (years)	Male
Observed total length (TL, mm)	4 yrs (n = 2)	203.02 ± 28.11	4 yrs (n = 7)	213.49 ± 35.57
Back-calculated total length (Li, mm)		167.33 ± 22.16		152.47 ± 29.39
Combined Back-calculated total length (Com;Li, mm)		149.11 ± 23.82		159.73 ± 28.80
Observed total length (TL, mm)	5 yrs (n = 21)	238.71 ± 23.79	5 yrs (n = 18)	219.21 ± 30.39
Back-calculated total length (Li, mm)		199.55 ± 19.63		159.44 ± 22.75
Combined Back-calculated total length (Com;Li, mm)		184.52 ± 20.68		166.30 ± 22.53
Observed total length (TL, mm)	6 yrs (n = 4)	295.66 ± 34.62	6 yrs (n = 1)	307.72 ± 0.00
Back-calculated total length (Li, mm)		245.71 ± 31.75		228.67 ± 0.00
Combined Back-calculated total length (Com;Li, mm)		231.87 ± 33.18		235.00 ± 0.00

Table 2 Growth performance index ($\emptyset'$) of calcified structures in female and male *N. notopterus* from Northern Part of Meiktila Lake

Age characters	Female	Male
	$\emptyset' = Log\ K + 2\ Log\ L_\infty$	$\emptyset' = Log\ K + 2\ Log\ L_\infty$
Average	$\emptyset'$ = Log 0.13 + 2 Log 51.80 = 2.542	$\emptyset'$ = Log 0.12 + 2 Log 56.36 = 2.581
Scale	$\emptyset'$ = Log 0.38 + 2 Log 28.20 = 2.480	$\emptyset'$ = Log 0.26 + 2 Log 29.51 = 2.355
Otolith	$\emptyset'$ = Log 0.34 + 2 Log 30.32 = 2.495	$\emptyset'$ = Log 1.27 + 2 Log 21.93 = 2.786
Operculum	$\emptyset'$= Log 0.24 + 2 Log 35.69 = 2.485	$\emptyset'$= Log 0.17 + 2 Log 41.17 = 2.460
Cleithrum	$\emptyset'$ = Log 0.21 + 2 Log 39.11 = 2.507	$\emptyset'$ = Log 0.26 + 2 Log 32.75 = 2.445
Vertebrae	$\emptyset'$ = Log 0.41 + 2 Log 29.48 = 2.552	$\emptyset'$ = Log 1.19 + 2 Log 22.20 = 2.768

L_∞ = maximum asymptotic mean length and K = measure of the exponential rate at which curve approaches

Table 3 Growth increment of aging length at designated time point of *Notopterus notopterus* from Northern Part of Meiktila Lake

Age (Year)	Female		Age (Year)	Male	
	Theoretical length -t_0	Expected length -$L_{(t)}$		Theoretical length -t_0	Expected length -$L_{(t)}$
4 yrs (N = 2)	- 3.84	33.13	4 yrs (N = 7)	- 4.00	34.78
5 yrs (N = 21)	- 4.77	37.30	5 yrs (N = 18)	- 4.13	37.52
6 yrs (N = 4)	- 6.57	41.73	6 yrs (N = 1)	- 6.58	43.90

Discussion

Utilizing the alien freshwater fishes for age interpretation relation to their growth is the base line information in fisheries biology and resource management for tropical region. Accurate determination of fish age plays a main role in understanding of growth characteristics of specific species.

Comparison of age estimation from different calcified structures on bronze feather back *Notopterus notopterus* has been proved to assign the age of fish in northern part of Meiktila Lake. Exo-skeletal elements for scale, operculum and cleithrum, and endo-skeletal for vertebrae, and bony structure of otolith were used to determine the age of fish by reading a band or a ring pattern assigned a year of fish.

The characteristics of annulus pattern on various calcified structures revealed three groups of age composition such as 4 yrs, 5 yrs and 6 yrs. The dominant age was observed at 5 yrs in pooled fish. The ring formation on each structure expressed alternately opaque and translucent as assigned as one year.

Aging pattern on growth development of fish depends on their growth histories of fish through the investigation on back-calculated method. The back calculation is based on the assumption that the growth of fish proportional to the growth of its bony structures (Tarkan *et al.*, 2006).

In this study, the mean calculated total length was higher than the back-calculated length in both sexes. The interpretation of calcified structures has shown that the variation of growth increment patterns was observed in designated age of fish group. However, the expected length (L_t) of designated age of fish indicated that not largely different in growth increment as well as their negative growth increment of theoretical values (t_0) observed in both sexes based on the interpretation of von Bertalanffy growth function.

Furthermore, the value of growth performance index ($\emptyset'$) was nearly similar value of calcified structures in female, however, a little variation was observed in male fish. In reality, the recorded growth performance index ($\emptyset'$) has shown the negative allometric growth pattern due to the growth equation in length and for the equivalent in weight von Bertalanffy used the exponent b = 3 (Bertalanffy, 1957). The present finding of growth performance index ($\emptyset'$) of fish was consistent with Pauly and Munro (1984) reported that the value of ($\emptyset'$) represents and quantifies the energetics of a given habitat or niche because ($\emptyset'$) is directly related to growth performance and metabolism and food consumption.

Above all their aging development, the growth histories of feather back *Notopterus notopterus* from northern part of meiktila lake could be assigned to the nearest growth development pattern of length by operculum reading method. Therefore, to conclude the present research was confirmed that the precision of age-length increment *N. notopterus* could not be evaluated by using all calcified structures in northern part of meiktila lake.

Conclusion

Determination of age by operculum reading method was the more precise for aging structure of bronze feather back. Three composition of age groups such as 4 yrs, 5 yrs and 6 yrs were observed in the collected fishes. The maximum values of asymptotic fish length-at-age by von Bertalanffy Growth function were reliable to acceptance the age of fish length by operculum reading method. The back-calculation of fish length-at-age was largely concerned with the operculum reading method as well as the growth performance index ($\emptyset'$). The present research was confirmed that the acceptance of alternative hypothesis H_1: The precision of age-length increment *N. notopterus* could not be evaluated by using all calcified structures in northern part of meiktila lake, and rejected the null hypothesis H_0: The precision of age-length increment *N. notopterus* could be evaluated by using all calcified structures in northern part of meiktila lake.

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