Estimating Age and Growth of the Mekong Tiger Perch, *Datnioides undecimradiatus* (Roberts and Kottelat, 1994) by Using Hard Structures

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ABSTRACT

This work is a comparative study on age readings and growth of the Mekong tiger perch, *Datnioides undecimradiatus* (Roberts and Kottelat, 1994) from different hard structures *viz*., the foremost spine of the dorsal-, ventral- and anal-fins as well as otolith. The fish samples were collected from two stocks, i.e. the Mekong and Mun Rivers, which ranged between 8 and 24 cm of total length. The formation of the daily rings was confirmed by the otolith of the 3, 5, 7, 15 and 30 days old *D. undecimradiatus* larvae. The age reading was conducted by 3 readers and coefficients of variation in all hard structures were around 25%. There was no statistical difference in the asymptotic lengths (L_∞) and growth rates (K) between each pair of the hard structures (*P-value* > 0.05). The modified von Bertalanffy's growth function was $L_t = L_0 + (L_\infty - L_0)(1 - e^{-Kt})$, where L_0 is the size at birth, for *D. undecimradiatus* were $L_t = 0.15 + (24.87 - 0.15)(1 - e^{-0.47t})$ and $L_t = 0.15 + (26.05 - 0.15)(1 - e^{-0.44t})$, in the Mekong and Mun stocks, respectively.

Keywords: *Datnioides undecimradiatus*, hard structures, modified von Bertalanffy's growth function, likelihood ratio test

INTRODUCTION

Understanding age and growth of fish is among the fundamental aspects that is needed for both aquaculture and fisheries management. In aquaculture, where the age of fish is known, growth of the cultured species is important in particular to investigate the efficiency of feed and/ or assess the production. Meanwhile, for fisheries management, knowing the age and growth of the captured species can provide valuable insight into its life history event, which can be further used to investigate the optimum fishing event for sustaining the fisheries (Isley and Grabowski, 2007). The common methods for study on age and growth of fish are (a) tagging experiment, (b) length frequency analysis, and (c) hard structure analysis, which is the most robust method since the resultant age estimates are more accurate and precise than those derived from the first two methods (Morales-Nin, 1989; Kishore and Ramsundar, 2007).

Fluctuation in intra-annual environment, in particular water temperature, produces annual rings in the hard parts of the fish due

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to differences in daily deposit increment rate of the hard parts and then bring out the contrast between the opaque- and hyaline-rings on the hard structures, which can be counted to determine their annual periodicity (Morales- Nin, 1992; Isley and Grabowski, 2007). Estimation of age and growth of tropical fishes has been recognized since 1970s, when a number of evidences that tropical fish can generate annual rings in their hard parts under a wide range of conditions (Morales- Nin, 1989) were observed. In addition, using the weight of the hard part is also an option for fish age determination (Lou *et al*., 2007; Britton and Blackburn, 2014). The otolith, or ear bone, is the most common hard part used for age and growth estimation. However, the fish sample has to be sacrificed for the study. Therefore, other hard structures such as scales, opercular bone, fin rays and fin spines can be used as alternatives for age and growth estimation since they are non-destructive for commercially valuable or at-risk fish species (Khan and Khan 2009; Kopf *et a*l., 2010).

The Mekong tiger perch *Datnioides undecimradiatus* (Roberts and Kottelat, 1994) is widely distributed in the Lower Mekong Basin (LMB) and is now in vulnerable status, according to the IUCN red list (IUCN, 2015). This is due to the high demand of this fish in the ornamental fish business, in which the price of a 2-3 cm total length, i.e. cm TL, for sub-adult *D. undecimradiatus* can be as high as 250 – 300 Thai Baht or US$ 7-9 (Thabthipwan, 2009). This high demand consequently resulted in heavy exploitation of *D. undecimradiatus* in natural habitats. *D. undecimradiatus* can grow up to 40 cm TL (Baird *et al.*, 1999). There is still a need for understanding the growth of this fish, which can be further used to indicate the status of utilization of the stocks of *D. undecimradiatus* around LMB as well as provide effective management strategies. The main objective of this study was, therefore, to provide the information on age and growth of *D. undecimradiatus* from two stocks in LMB *viz*., the Mun River in Ubon Ratchathani province, and the Mekong River, in Mukdaharn and Nakhon Phanom provinces, Thailand. The study was based on the analysis of the four hard structures *viz*., otolith, dorsal-, ventral- and anal- spines. The study was also aimed to provide recommendations on the feasibility of using the spines instead of otolith, in which the fish must be killed, for further studies on age and growth of the other stocks of this fish in LMB.

MATERIALS AND METHODS

Field sampling

Fish samples were collected from the Mekong River (off Muang District, Nakhon Phanom and Muang District, Mukdaharn) and the Mun River (at Warin Chamrab, Pibun Mungsaharn and Khong Jiam Districts, Ubon Ratchathani) in 2012-2013. The collected fish samples were anaesthetized by clove oil (400 mg / liter of water) and died by euthanasia *in situ*. Each sample was labeled, measured for length (nearest 0.1 cm TL) and weighed (nearest 0.1 g). The largest pair of otoliths (i.e. sagittae) from each individual sample was removed as well as the foremost spines of the dorsal, ventral and anal fins which were cut at about 2 cm from the fish body, then washed and kept dried in vials. A water temperature logger (HOBO Data Loggers UA-002-08) was installed at 20 cm depth from the water surface at the mouth of the Mun River (to the Mekong) to obtain information on the annual fluctuation of water temperature.

Laboratory work

Laboratory work was conducted at the Faculty of Agriculture, Ubon Ratchathani University. Firstly, the deposit increment of the otoliths was determined by counting the daily rings on the otoliths of *D. undecimradiatus* larvae from artificial propagation, at ages 3, 5, 7, 15 and 30 days. Meanwhile, the deposit increment of the spines had been endorsed by the larger spine of the larger sized fish compared to those smaller-sized samples.

Only the sagitta, hereafter referred to as the otolith, from left ear was used for determining the age of the individual fish. The hard structures were embedded in resin and sectioned by the low speed diamond saw (South Bay Technology Inc., model: 650). After cutting, they were polished by sand paper (grit size ranging from 600 to 1500) until the core of the structure appeared, then further polished by a diamond polishing compound, i.e. diamond-pate, to make it more transparent and for clearer visibility. The number of annual rings in each sample was counted under the light microscope on high power (1000x), by three researchers who had no information on the size of the sample fish. The relative precision of age estimates obtained by the three researchers was tested by coefficient of variation (CV), expressed as the ratio of the standard deviation over the mean (Equation 1; Campana, 2001):

$$CV_j = 100\% \text{ x} \frac{\sqrt{\sum_{i=1}^{R} \frac{\left(x_{ij} - x_j\right)^2}{R-1}}}{x_j} \quad ....(1)$$

Where, CV_j is the age precision estimate for the j^{th} fish; x_{ij} is the i^{th} age determination of the j^{th} fish, x_j is the mean age estimate of the j^{th} fish; and R is the number of times the age of each fish was determined.

Data analysis

The modified von Bertalanffy's growth function (modified VBGF; Fabens, 1965), fitted with the length-at-age data to ensure that the curve passed through the known size at birth (Neer *et al*., 2005), was applied by using observed age-length data (Equation 2).

$$L_t = L_0 + (L_\infty - L_0)(1 - e^{-Kt}) \quad ....(2)$$

Where, L_0 is the size at birth, which is equal to 0.15 cm TL (Thaksin and Chokekeeree, 1984), L_t is the length at time t, L_∞ is the asymptotic length, and K is the growth coefficient. The modified VBGF curves of a pair of hard structures, were compared through the likelihood ratio test, in which likelihood ratios were calculated using the residual sum-of-squares, and tested against chi-square (x^2) statistics (Kimura 1980). Data analyses were conducted by using Program R (R Development Core Team 2014) and Package 'fishmethods' in Program R (Nelson, 2012).

RESULTS

The number of *D. undecimradiatus* samples from each area was thirty-four (34). The size ranges from the Mekong and Mun Rivers were from 8.2 to 23.3 cm TL, and 12.7 to 24.3 cm TL, respectively. Water temperature in the Mun River varied seasonally with an 8°C difference in average water temperature between summer and winter (Figure 1). The numbers of daily rings on the otoliths of *D. undecimradiatus* larvae matched to their known age, except for the 15 day old larvae, whose daily ring count was 14 (Figure 2).

All the spines from the samples were used in the study. However, only 62 otoliths, i.e. 30 and 32 respectively from the Mekong and Mun Rivers, were used in the age reading since the otoliths from 6 samples were either difficult to read or to locate the core. In general, the annual growth rings were clear and readable, in which the estimated ages from all the hard structures were between 1 and 4 years old. The coefficients of variation from the age readings of the hard structures were around 25% (Figure 3). The age of individual fish used for the estimation of growth parameters was the average value from the three readings.

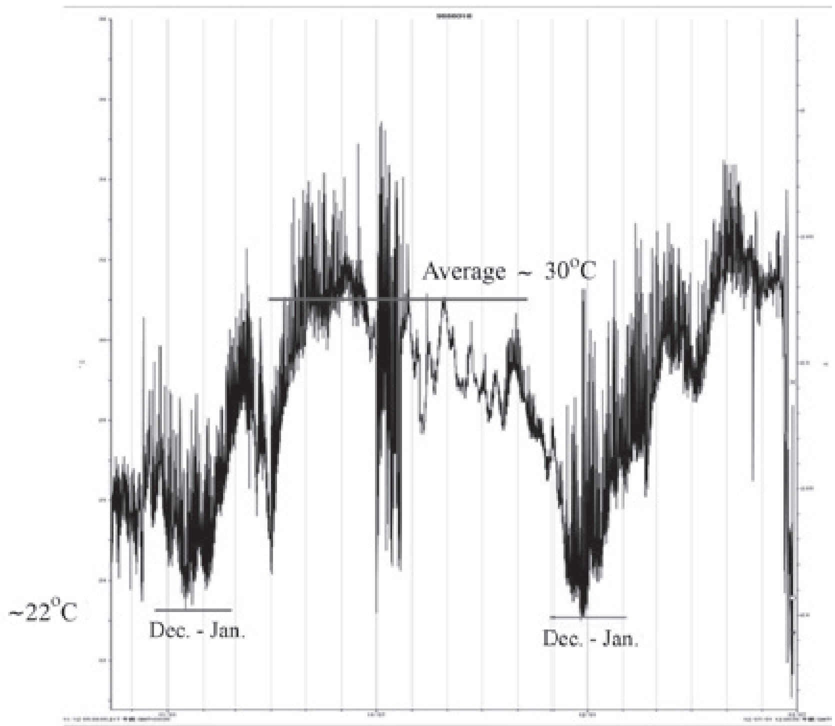

Figure 1. Temporal fluctuation in water temperature in the Mun River between October 2010 to June 2012

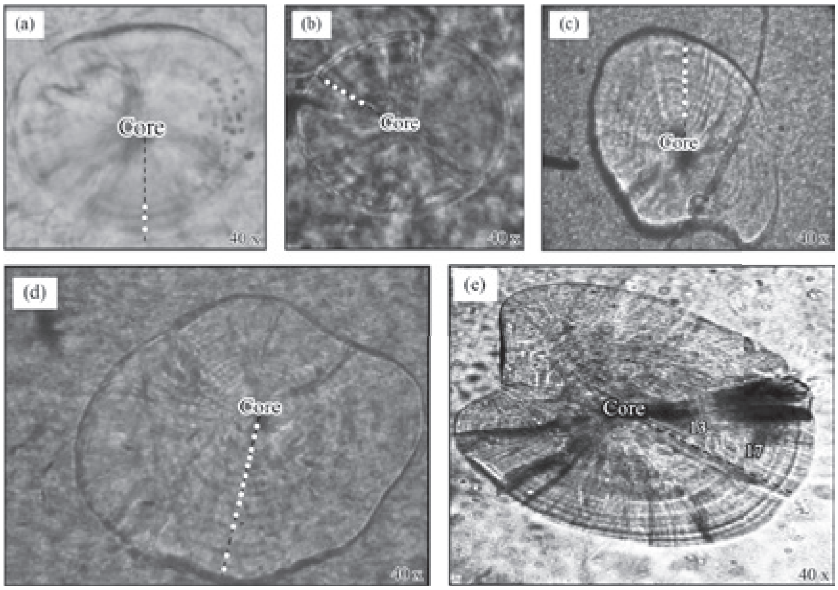

Figure 2. Daily ring counts of *D. undecimradiatus* larvae at age (a) 3 days old, (b) 5 days old, (c) 7 days old, (d) 15 days old and (e) 30 days old.

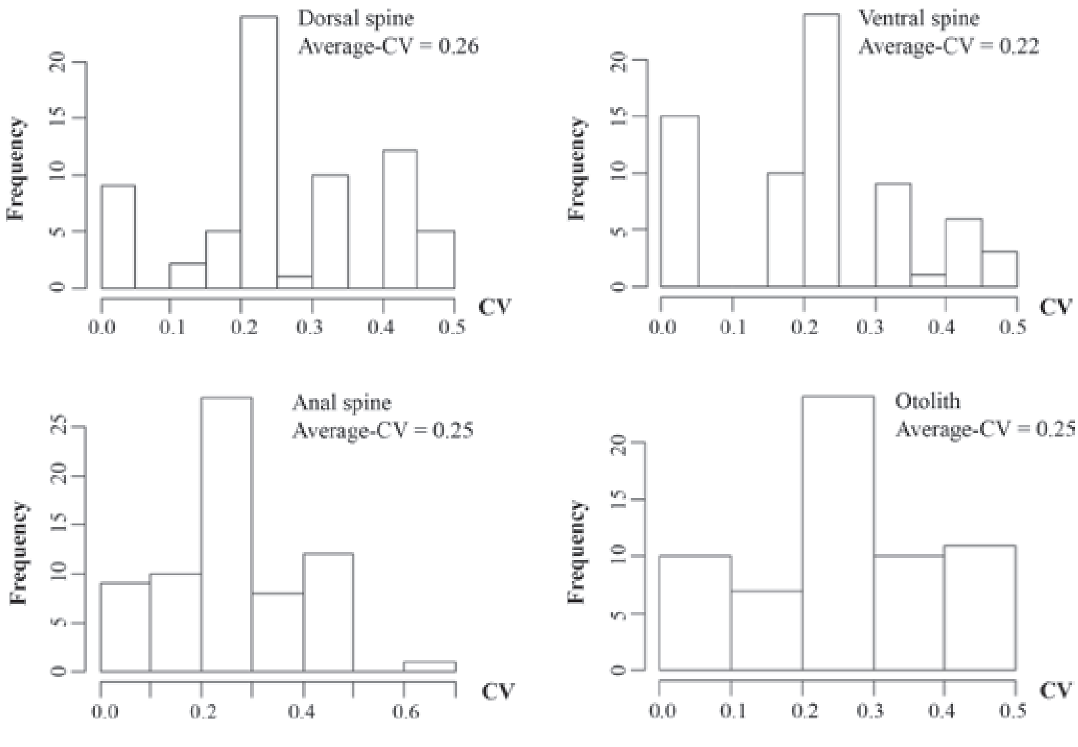

Figure 3. Histogram plots of the coefficient of variations (CV) in age estimation of *D. undecimradiatus* by the 4 hard structures

The estimated asymptotic lengths (L_∞) were between 23.0 and 29.6 cm TL, and growth coefficient (K) ranged from 0.30 to 0.62 per year (Table 1). The modified von Bertalanffy growth model showed that *D. undecimradiatus* has rapid growth in the first two years (Figure 4). Results from the likelihood ratio test showed that the asymptotic lengths and growth rates from the modified VBGF were not significantly different between each pair of the hard structures (*P-value* > 0.05; Table 2). The modified VBGF and growth curves of *D. undecimradiatus* stocks in the Mekong (Equation 3) and the Mun (Equation 4) Rivers were depicted based on the average values of L_∞ and K of each stock (Figure 5) as follows:

$$L_t = 0.15 + (24.87 - 0.15)(1 - e^{-0.47t}) \text{......(3)}$$

$$L_t = 0.15 + (26.05 - 0.15)(1 - e^{-0.44t}) \text{......(4)}$$

Table 1. Asymptotic lengths (L_∞, cm TL) and growth coefficients (K, per year), estimated from the hard structures of *D. undecimradiatus* from the Mekong and the Mun Rivers

Stocks	**Hard structures**	**Estimated values**	
		L_∞ **(cm TL)**	***K*** **(per year)**
Mekong	Dorsal spine	25.7	0.419
Mekong	Ventral spine	24.7	0.471
Mekong	Anal spine	22.5	0.624
Mekong	Otolith	27.4	0.364
Mun	Dorsal spine	29.6	0.305
Mun	Ventral spine	23.0	0.593
Mun	Anal spine	26.0	0.400
Mun	Otolith	25.6	0.456

Table 2. The x^2 (and *P-values*) from the likelihood ratio test comparing L_∞ (above the diagonal) and K (below the diagonal), estimated by von Bertalanffy curves for *D. undecimradiatus* from different hard parts

Hard structures	**Dorsal spine**	**Ventral spine**	**Anal spine**	**Otolith**
(a) Mekong River				
Dorsal spine	-	0.56 (0.91)	0.48 (0.49)	0.79 (0.34)
Ventral spine	0.56 (0.91)	-	0.40 (0.53)	0.77 (0.38)
Anal spine	0.41 (0.52)	0.77 (0.38)	-	0.21 (0.65)
Otolith	0.47 (0.49)	0.78 (0.38)	0.04 (0.84)	-
(b) Mun River				
Dorsal spine	-	0.31 (0.57)	0.30 (0.58)	0.87 (0.35)
Ventral spine	0.80 (0.29)	-	0.03 (0.86)	1.83 (0.18)
Anal spine	0.17 (0.68)	0.14 (0.71)	-	3.07 (0.80)
Otolith	0.59 (0.44)	0.75 (0.39)	2.18 (0.14)	-

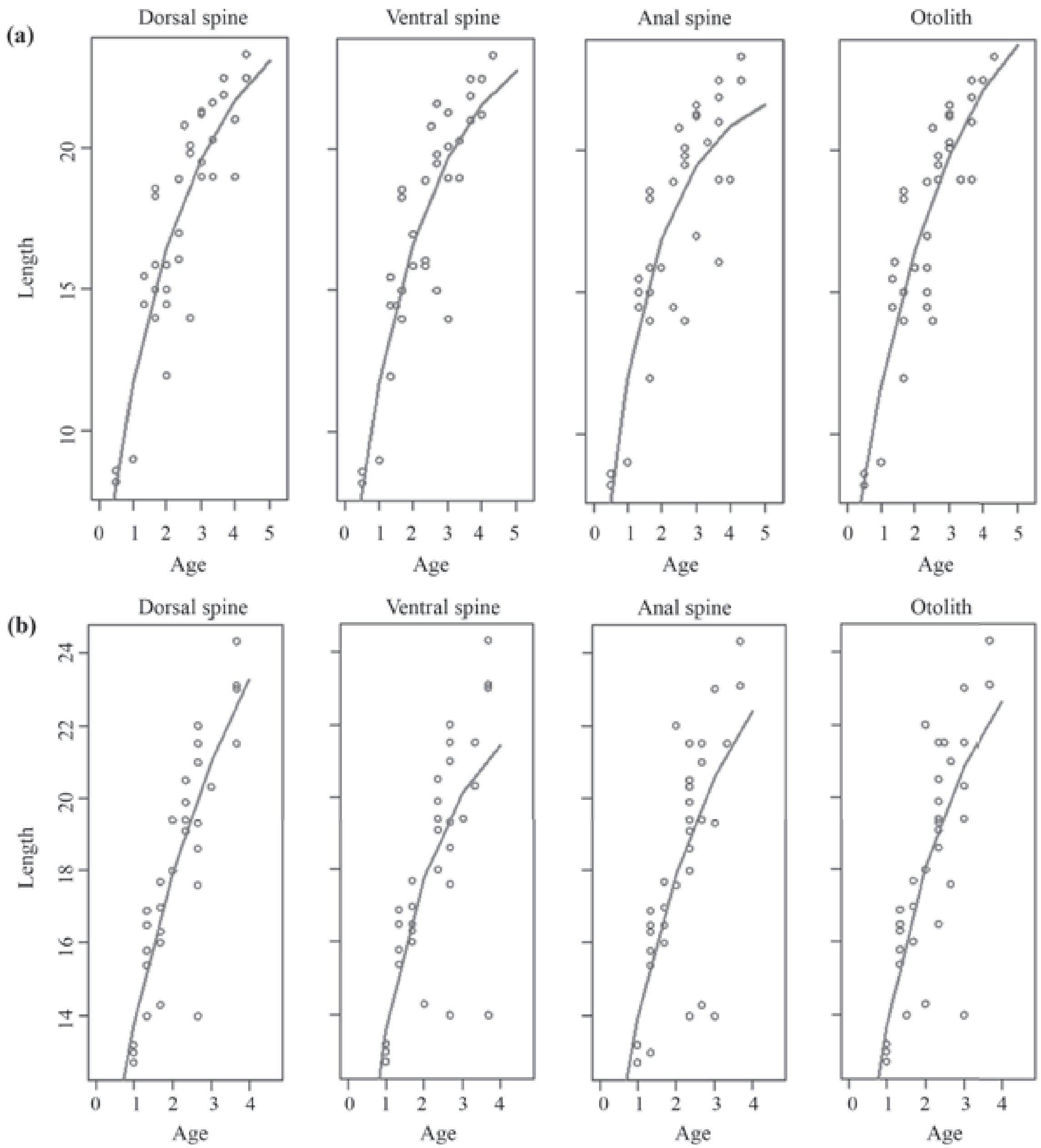

Figure 4. The growth curves of *D. undecimradiatus*, estimated by the hard structures, (a) the samples from the Mekong River, and (b) the samples from the Mun River

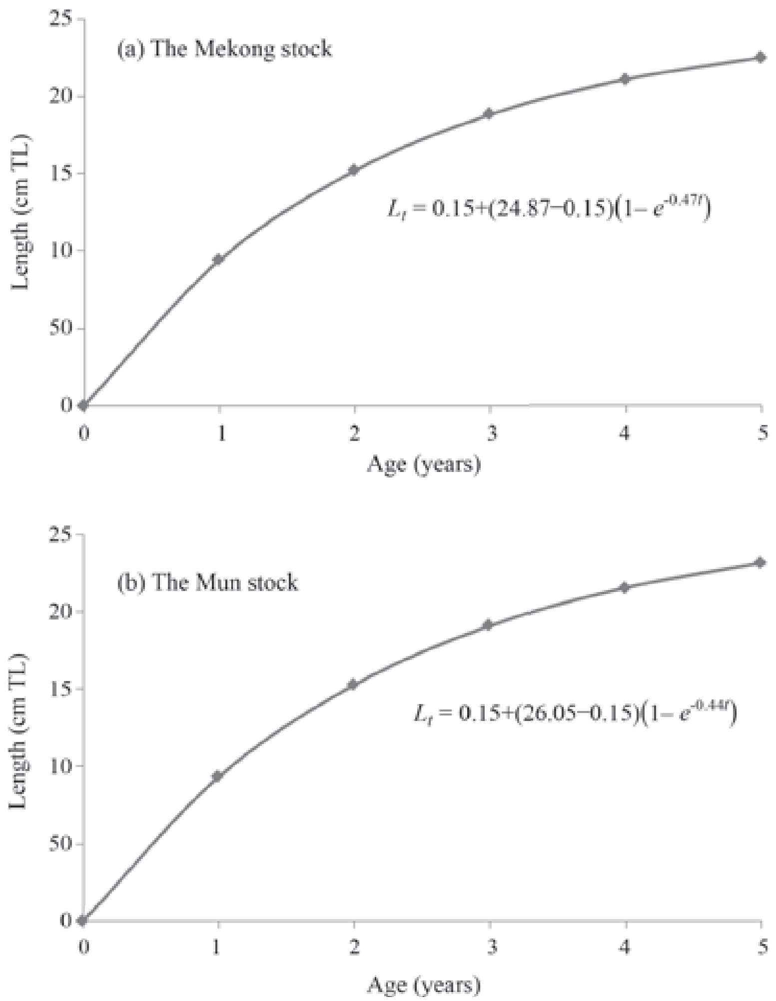

Figure 5. The modified von Bertalanffy growth curves of *D. undecimradiatus* stocks in the Mekong and Mun Rivers

CONCLUSION

Fish aging and growth estimation of *D. undecimradiatus* are feasible using fin spines. Spines are found to be reliable and showed non-statistical differences on the estimated growth parameters (L_∞ and K), compared to the otoliths. One main advantage is that it is a non-destructive process to fish samples therefore it is recommended as an option for age and growth studies instead of using otoliths or length frequency analysis.

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