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A Better Way For Direct Estimation Of The Von Bertalanffy Growth Parameters For Fish

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Abstract: In this study some suggestions were made for the estimation of von Bertalanffy growth parameters in a better way. Parameters k ,L_8 and t_0 in the von Bertalanffy equation can be estimated by different methods. But most of these methods use mean length at age data. Using mean length at age data could create some errors in estimation of parameters. In order to avoid these errors, age should be corrected by using a correction factor. All corrected age and corresponding length were used in estimation by non-linear fitting approach. In this study growth parameters were estimated as L_∞ = 37.494 cm, k=0.1491, t_0=-1.384 by using the correction factors and non-linear fitting approach, and L_∞=37.37 cm, k=0.138, t_0=-1.86 from Von Bertalanffy plot method for given example.

Key words: Von Bertalanffy growth parameters, non-linear fitting, age correction factor

Introduction

Several models have been used to express growth by using simple mathematical equations. The von Bertalanffy growth equation has commonly been used in studies, carried on marine species. Based on physiological concepts, this model has been found to fit data from a wide range of species. However, use of any single model might not represent growth over the entire life span(King, 1996).

The von Bertalanffy equation in terms of length is (Beverton and Holt, 1957)

$$L_t = L_\infty * \{1-\exp[-k*(t-t_0)]\} \quad (1)$$

where L_t is the length at the age t, L_8 is theoretical maximum (or asymptotic) length that the species would reach if it had lived indefinitely, k is a growth coefficient which is a measure of the rate at which maximum size is reached and t_0 is the theoretical age at zero length, often has a small negative value (Avsar, 1998; King, 1996).

There are several procedures available to estimate the parameters of the von Bertalanffy growth curve. These procedures use data from length-frequency distribution, mark-recapture experiments, growth checks formed in hard parts such as scales, otoliths and vertebrae. Most of them involve in using the mean length at the age data, such as Ford-Walford, Gulland and Holt, and von Bertalanffy plot (linearization method)(Erkoyuncu, 1995; King, 1996; FAO, 1992). However, using the mean length at age data might end up with crate the following errors; (Efe,1992; Efe *et al.*, 1994).

Giving equal weight to each point no matter some age classes have much more observation than others.

Samples are collected by monthly and age determination are made on scale or otoliths. Since reading the scales or otoliths do not give accurate enough data to tell how month old the fishes in the same age group. For example, 2 years old fish might have been caught immediately after they reached age 2 or just before reaching age 3. Concequently, this has a major influence on the mean length values.

Sometimes estimated L_8 might be smaller than the ones in the sample.

Except Gulland and Holt method, standard errors of the parameters can not be calculated in most of the methods based on mean length at age data. Thus, significant test of estimated parameters is impossible.

By using mean length at age data, von Bertalanffy growth parameters are estimated by converting the growth equation to a linear form and using linear regression analysis (King,1996). Linearization of the model is accurate with 2 parameter models but it could create some errors as indicated above. As it is known that von Bertalanffy growth curve is non linear and its equation has 3 parameters. In this situation non-linear fitting techniques can estimate more than 2 parameters simultaneously, should be used with some preliminary work for a better estimation.

In this study, some suggestions were made for the estimation of von Bertalanffy growth parameters in a better way. These suggestions are illustrated by using an example.

Materials and Methods

Before the technique apply some preliminary work should be done as follows: Age determination from the any hard part of fish(Chugunova,1963; Chilton and Beamish,1982).

Correction of age: meaning allocation age groups correctly. For this purpose, nominal birth date of any species or stock have to be identified based on

Table 1: A few of the 3125 ages and corrected ages obtained from Equation 2

Fish No.	Length (cm)	Age (Year)	SM	SD	NBM	NBD	CT	Corrected Age (Year)
1	7.0	0	7	15	6	15	0.082192	0.082192
2	8,1	0	8	15	6	15	0,164384	0,164384
3	8,5	0	9	15	6	15	0,246575	0,246575
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
167	11,8	1	1	15	6	15	-0,41096	0,589041
168	12,4	1	2	15	6	15	-0,32877	0,671233
169	12,6	1	4	15	6	15	-0,16438	0,835616
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
3123	22,2	5	2	15	6	15	-0,32877	4,671233
3124	19,7	5	5	15	6	15	-0,08219	4,917808
3125	28,1	6	3	15	6	15	-0,24658	5,753425

gonadosomatic index (GSI) (Anderson and Gutreuter, 1983). By using information giving before, raw age data are corrected by the following equation by aid of any mathematics or related package computer program (Anonymous, 2000);

$$Y_{cor} = T + CT \qquad (2)$$

Where Y_{cor} is corrected age, T is age, CT is Correction coefficient and calculated by

$$CT = ((((SM-1)*30+SD)-(((NBM-1)*30)+NBD))/365 \qquad (3)$$

Where SM is Sampling month, SD is sampling day , NBG is nominal birth month and NBD is nominal birth day.

After this step, corrected ages (as independed variable) and corresponding length (as depended variable) are transferred to any statistic packet program to apply non-linear regression approach (Table 1). In this approach, von Bertalanffy growth equation (Equation 1) is fitted to data to estimate growth parameters.

The present study involved a total of 3125 *Pagellus erythrinus* L., 1758 specimen, caught from Iskenderun Bay by throw survey. Ages were determined by examination of otoliths (Williams and Bedford ,1973). Nominal birth month and day were considered as June and 15th of June respectively for this species (Can,2000). Analysis were performed with 'SPSS for Windows Release 9.0 (SPSS, 1998) and Microsoft Excel (Microsoft,2000) were used. In table 1, for example the first corrected age is calculated using by Equation 2 and 3 as follows;

$$Y_{cor1} = T + CT = 0 + 0.082192 = 0.082192$$

$$CT = ((((SM-1)*30+SD)-(((NBM-1)*30)+NBD))/365$$

$$= ((((7-1)*30+15)-(((6-1)*30)+15))/365 = 0.082192$$

Results and Discussion

The von Bertalanffy growth parameters and related statistics were estimated by von Bertalanffy Plot method and non-linear fitting method, and the results were given in Table 2, 3 and 4. As seen in Table 1, the values of estimated parameters are very close from both two methods. However, this situation might not valid on all data sets as far as using large enough sample and the correct age determination and design is made. In addition, the nature of von Bertalanffy Plot and similar methods standard errors of the parameters could not be calculated.

By using the non-linear fitting for this study, iterations were stopped after 47 model evaluations and 22 derivative evaluations. Iterations have been stopped because the relative reduction between successive residual sums of squares was at 1.000E-08. The regression between corrected ages and corresponding lengths was found significant($P<0.01$) and R^2 was 0.68 (Table 3).

The significant correlation coefficients between estimated parameters were found as $r_{L8,K}=-0.9941$, $r_{L8,to}= -0.8847$ and $r_{K,to}=0.9287$ respectively($P<0.01$) (Table 4).

Non-linear regression is the curve-fitting equivalent of linear regression. In the same way that linear regression results in a value of the intercept and slope that minimizes the sum of squared differences between the observed data and a straight line. Non-linear regression uses the sum of squared differences between the data and the curve. In fitting a growth curve to length at age data, finding the combination of K, L_8, and t_0, the sum of squares of the vertical distance between the data points and the resultant growth curve are

Table 2: Estimated parameters with their standard errors and confidence intervals

	Von Bertalanffy Plot Method	Non-Linear Fitting Method			
	Estimate	Estimate	Asymptotic Std. Error	Asymptotic % 95 confidence interval	
Parameters				Lower	Upper
L_∞	37.370	37.494	2.582	32.431	42.558
K	0.138	0.1491	0.0170	0.115	0.182
t_0	-1.860	-1.384	0.0849	-1.551	-1.218

Table 3: Non-linear regression summary statistics

Source	DF	Sum of Squares	Mean Squares	Sign.
Regression	3	667056.12919	222352.04306	0.000
Residual	3122	10317.22148	3.30468	
Total	3125	677373.35067		
R squared	=1-Residual SS/Corrected SS=0.6878 (%68.78)			

Table 4: Asymptotic correlation matrix of the estimated parameters

	L_∞	K	t_0
L_∞	1.0000	-0.9941	-0.8847
K	-0.9941	1.0000	0.9287
t_0	-0.8847	0.9287	1.0000

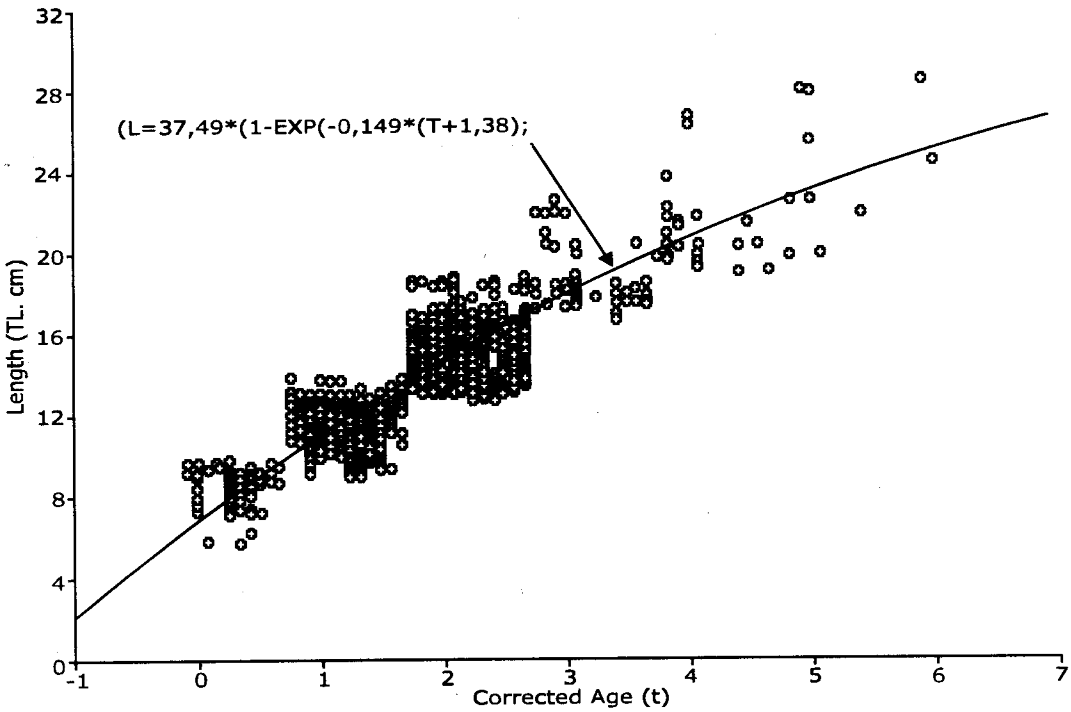

Fig. 1: Scatter plot of the observations and fitted curve of the model by nonlinear fitting method

minimized(King,1996) (Fig. 1).

As a result, it was provided an important advantage to non-linear fitting method compared to mean length at age data. Because it is possible to calculate the standard errors of the parameters and testing of these estimated parameters.

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