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Growth Characteristics and Critical Age of *Coilia ectenes taihuensis*

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Abstract

Coilia ectenes taihuensis (Yuan et al. 1986) is the dominant fish species in Taihu Lake, China. The length-weight relationship was expressed as:

$$W = 6.430 \cdot 10^{-6} \cdot L^{2.8603} \quad (r=0.9980)$$

The von Bertalanffy growth formulae of the fish were determined to be:

$$Lt = 349.3384\ (1\text{-}\exp(-0.354\ \{t-0.0319\}))]$$
$$Wt = 121.0399\ [1\text{-}\exp(-0.354\ \{t-0.0319\}))]^3$$

The growth rate in body length decreased gradually with increasing age. The acceleration of growth rate was positive from age 1 to 3.1 years, but thereafter was negative. Studies of the critical age of the population show that the population biomass of *Coilia ectenes taihuensis* (Yuan et al. 1986) is largest at age 3.2. This paper indicates that the growth turning point age of the body and the critical age of the population are important parameters in the study of fishery resources assessment.

Introduction

Coilia ectenes taihuensis (Yuan et al. 1986) (Engraulidae) occurs mainly in lakes of the middle-lower reaches of the Yangtze River and is the dominant fish species in Taihu Lake where it contributes 50% of the annual fish production. The classification and morphology of the fish was described by Yuan et al. (1986). Based on that study, equations are derived which express the growth characteristics and the "critical age" of the fish population, which are useful data for the management of fisheries.

Materials and Methods

A total of 3,964 specimens were collected from a research boat at eight sampling points in Taihu Lake on fixed days every month from January to December in 1983. Also, 25 older fish were selected from fishers' catches. At the sampling site, the body length, body weight and maturity stages were measured. Age, based on scale annuli, was investigated in the laboratory.

The length-weight relationship of the fish was expressed as $W=aL^b$. The growth characteristics and the critical age of the fish were expressed using the growth equation (von Bertalanffy 1938):

$$L_t=L_\infty[1-\exp(-K\{t-t_0\})]$$
$$W_t=W_\infty[1-\exp(-K\{t-t_0\})]^3$$

in which:

W_t = body weight at age t; L_t = body length at age t; W_∞ = asymptotic length; K = a constant related to the curvature of growth curve; t_0 = theoretic age when body weight and length are zero; and t = age in years.

Results and Discussion

As determined from scales, the oldest among the collected fish was aged 5 years; maximum body length was 312 cm and body weight, 110 g.

The length-weight relationship was described by the equation:

$$W = 6.430\cdot10^{-6}\cdot L^{2.8603} \quad (r = 0.9980)$$

Using the length data at different ages (Table 1), according to von Bertalanffy's growth equation, the growth equation of the fish was as follows:

$$L_t = 349.3384\ [1\text{-}\exp^{-0.3540(t-0.0319)}]$$
$$W_t = 121.0399\ [1\text{-}\exp^{-0.3540(t-0.0319)}]^3$$

Differentiating von Bertalanffy's equation, with respect to t, one obtains the growth rate (dl/dt), then the second derivative d^2L/dt^2 and d^2w/dt^2. Thus we have:

Table 1. True, back calculated and theoretical body length (mm) of *Coilia ectenes taihuensis* by age (years).

	Age 1	2	3	4	5
True body length	102	179	230	272	284
Back calculated body length	103	176	226	268	289
Theoretical body length	101	175	227	264	289

$$dL/dt = KL_\infty \exp(-K(t-t_0))$$
$$d^2L/dt^2 = -L_\infty K^2 \exp(-K(t-t_0))$$
$$dW/dt = 3\ W_\infty K \exp(-K(t-to))(1-\exp(-K(t-to)))^2$$
$$d^2W/dt^2 = 3\ W_\infty K^2 \exp(-K(t-to))(1-\exp(-K(t-to)))(3 \exp(-K(t-to))-1)$$

The results, illustrated in Table 2 and Fig. 1, show that increase in age is accompanied by a progressive decrease in length growth rate. Thus, fish grow relatively faster before age 1. Weight growth rate changes, first rising, then after age 3.1 years, decreasing again. At t=3.1 years, acceleration is zero, i.e., growth rate in weight is maximum.

The critical age is the age at which the unexploited biomass of one generation reaches its maximum, or at which the instantaneous rate of increase in weight is equal to the instantaneous rate of natural mortality. A fish population of one generation decreases in part because of natural mortality (M), i.e.,

$$N_t = R\cdot\exp(-M(t-t_r)) \qquad ...1)$$

where N_t = number at age t; R = number of recruits; and t_r = age at recruitment

The critical age was estimated according to von Bertalanffy's equation.

From (1):

$$N_t\cdot W_t = R\cdot e^{-M(t-t_r)}\ W_\infty(1-e^{-K(t-t_0)})^3$$
$$B = N_t\cdot W_t$$
where B = biomass of population

Table 2. Body weight (g) of *Coilia ectenes taihuensis* in each body length group.

Length (mm)	True value (g)			Theoretical value (g)			Relative error (%)		
	Females	Males	Combined	Females	Males	Combined	Females	Males	Combined
57.5	0.75	0.55	0.71	0.74	0.65	0.70	1.80	17.78	2.70
77.5	1.74	1.66	1.66	1.72	1.53	1.63	1.39	7.94	1.80
97.5	3.21	3.12	3.16	3.29	2.96	3.15	2.64	5.10	0.41
112.5	4.70	4.59	4.64	4.94	4.47	4.64	5.11	2.50	2.16
132.5	7.86	6.42	6.92	7.85	7.16	7.56	0.13	11.47	9.20
155.0	13.00	10.23	10.56	12.24	11.25	11.84	5.85	9.88	12.17
175.0	16.00	15.17	16.83	17.26	15.95	16.76	7.90	5.11	0.44

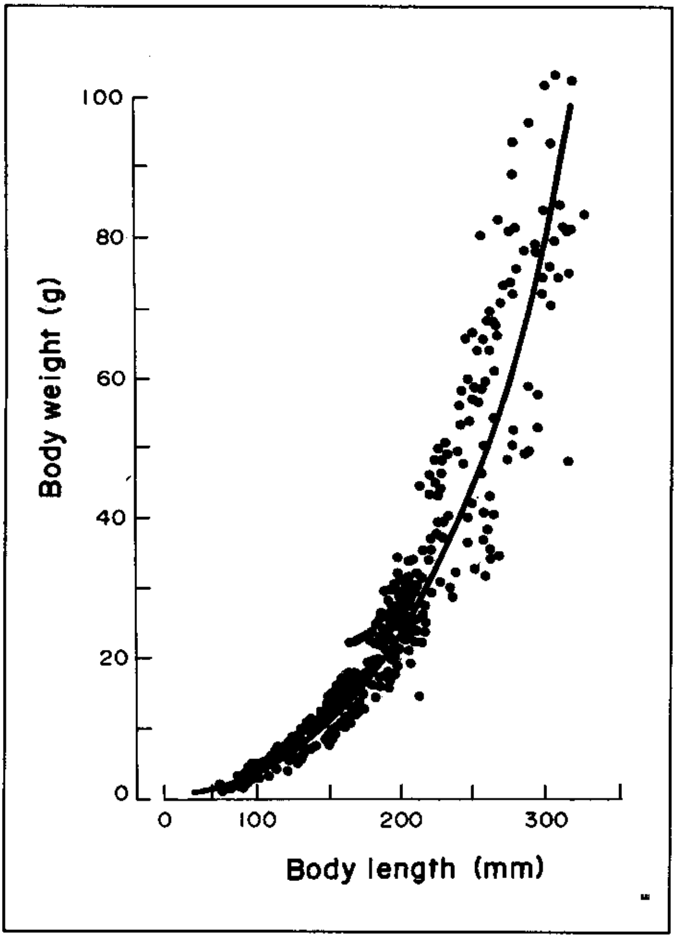

Fig. 1. First and second derivatives of the von Bertalanffy growth equations describing the growth of *Coilia ectenes taihuensis* in Lake Taihu. A = growth rate in length; B = acceleration of growth rate in length; C = growth rate in weight against age; D = acceleration of growth rate.

Differentiating with respect to B:

$$B' = RW_\infty \exp^{t}r\cdot\exp^{-Mt}(1-e^{-K(t-t_0)})\cdot(3k \exp^{-K(t-t_0)}-M(1-\exp^{-K(t-t_0)})$$

if $B' = 0$ then:

$$3k \exp^{-K(t-t_0)}-M+M \exp^{-K(t-t_0)} = 0$$

Age $B' = 0$ is the age of maximum population biomass. Let this age be T; we have:

$$\exp^{-K(T-t_0)}(3K+M) = M$$

Taking logarithms and adjusting the equation gives:

$$-KT+Kt_0 = \ln M-\ln(3K+M)$$

$$T = \frac{Kt_0 - \ln M + \ln(3K+M)}{K}$$

Adjusting the equation the known coefficients, the critical age (T) with M = 0.52 (Tang Yu 1987) is calculated to be 3.2 years. Peak production could be obtained at the critical age if each cohort were harvested once.

The research indicates that both individual population biomass of *Coilia ectenes taihuensis* are maximum at age 3.1-3.2. This is an important parameter in the study of fisheries resources assessment and allocation. From the results, it appears unreasonable to capture juvenile *Coilia ectenes taihuensis* below age 1 in Taihu Lake as is done at present. The size at first capture should be increased. However, a yield-per-recruit analysis is needed to identify the exact size of the fish for optimum exploitation.

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