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Age and Growth of Two Co-occurred Anchovy Species (*Encrasicholina puntifer* and *E. heteroloba*) during Autumn Larval Anchovy Fishing Season in I-lan Bay, NE Taiwan

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ABSTRACT

The commercial larval anchovy fishery in the I-lan Bay is mainly composed of two cogeneric anchovy species, *Encrasicholina puntifer* and *Encrasicholina heteroloba*, during autumn. A single technical "stock" has been proposed applying to the larval anchovy resource for the simplicity of management purpose. In this study, the sagitta growth and the growth curves are estimated separately, and the rates of specific and absolute growth are evaluated accordingly. The comparison of *E. puntifer* with *E. heteroloba* indicates that there are differences on the sagitta growth, specific and absolute growth of standard length at age. *E. puntifer* are significantly larger at comparable ages. There is a slight interannual difference, though the effect is not as significant as the specific effect. It is premature yet to conclude that a single technical "stock" management on the autumn anchovy resources might be reasonable.

Key words: *Stock, Sagittae growth, Gompertz equation, Growth rate.*

INTRODUCTION

Larval anchovy fishery is a special practice in the coastal waters of Taiwan and Japan (Young *et al.*, 1992 and Dhugal *et al.*, 1998). Basically, four fishing grounds are known in the waters around Taiwan, i.e., I-lan (north-eastern), Tan-shui /Nan-liao (north-western), Tong-shiau/Lihshoei (west-central), and Fong-liao (southwestern) (Yu and Chiu, 1994). At least twelve anchovy species are identified from the larval "stock" (Young *et al.*, 1994) and among them three species (*Engraulis japonica, Encrasicholina puntifer* and *Encrasicholina heteroloba*) are found to be the most dominant ones in the catch composition (Lee and Lee, 1990; Young *et al.*, 1992). For management purpose, a single larval stock has been treated technically in I-lan Bay area (Chiu *et al.*, 1997) and in Fongliao area (Tsai *et al.*, 1996), because the applied fishing gear, the fishing season and ground are the same.

To examine the appropriateness of the technical "stock" of larval anchovy fishery in I-lan Bay, we studied the age and growth of two major species of the autumn stock. Our work assumed sagittae (otoliths) increment as an indicator of daily growth (Pannella, 1971; 1974) and verified the growth curves of *E. puntifer* and *E. heteroloba* for the first month of their early life when the species were subjected to the impact from the commercial fishing practice.

MATERIALS AND METHODS

The anchovy samples were obtained from the commercial pair-trawler catch in I-lan Bay, NE Taiwan (Fig. 1). In general, the

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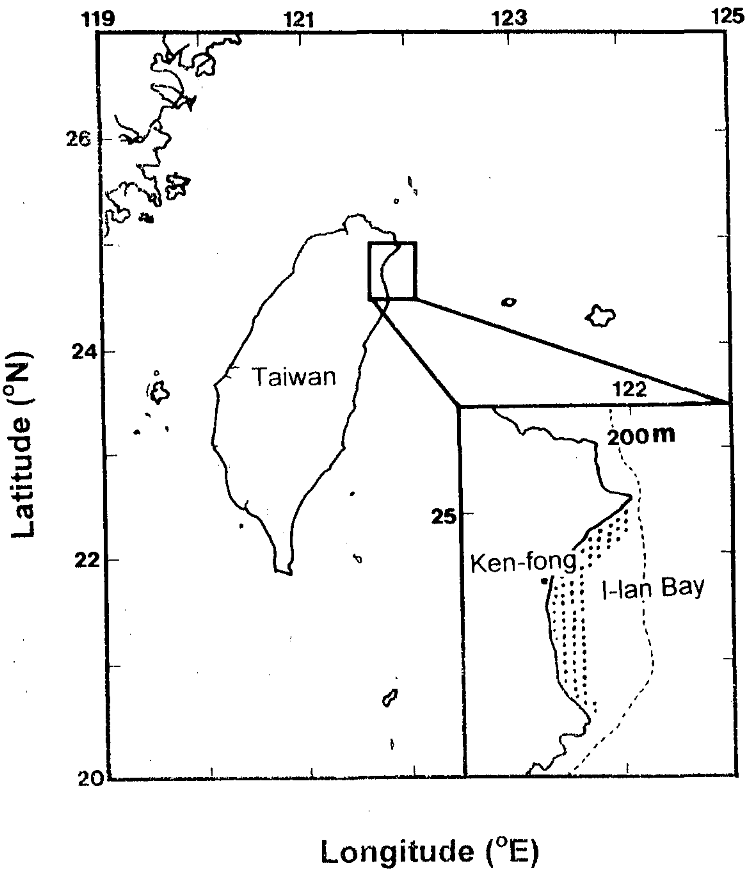

Fig. 1. Larval anchovy fishing ground off Ken-fong in I-lan Bay, NE Taiwan.

fishing gear and catching method used by local fishermen is quite uniform, having a headline of about 100 m and a cod-end mesh of 1.6 mm. We made the comparison over a three-year period from 1993 to 1995. The sampling schedules of the last two years are clearly marked (Table 1), however samples from 1993 were retrieved from the fish collection of Economic Fish Lab., Department of Zoology, National Taiwan University. For each sample 200 g of larvae was sub-sampled for further treatment.

Sagittae were obtained from larvae that have been already identified to the species level. The larvae were placed on a slide, taking standard length of fish to the nearest 0.01 mm with dial calipers and teased the otoliths from the head region. The sagittae were then mounted on a glass slide and read immediately. The sagitta length was measured with a micrometer eyepiece and the growth increments were measured with a compound microscope at magnifications of 200-400x. Linear regression was applied to estimate the growth of sagitta relative to the standard length. The growth of larval anchovy was fit into the Gompertz equation ($L_t = L_o \exp(K(1-e^{-at}))$, where L_t = length at age t; L_o = estimated length of a newly hatched anchovy larva (t = 0), t = age of fish, K = specific growth rate at t = 0, and a = growth coefficient (Zweifel and Lasker, 1976). The use of Gompertz-type function instead of von Bertalanffy's is due to the growth of larval fishes tends to undergo exponential decay with time. The growth equation is estimated using a program of nonlinear fitting by iteration method.

Table 1. Basic sampling information for growth comparison of anchovy species

Sampling date	Species composition (%)			Sea surface temperature
	E. puntifer	*E. heteroloba*	Others	
1994/07/06	21.5	10.7	67.8	27.77
1994/07/23	26.2	32.3	42.5	27.89
1994/09/10	4.6	32.7	62.7	27.14
1994/09/22	13.5	69.7	16.8	25.29
1994/10/06	21.6	74.5	3.9	24.17
1994/10/21	72.2	2.0	25.8	23.65
1994/11/24	87.4	9.3	3.3	21.44
1995/07/10	1.1	35.9	63.0	27.16
1995/07/25	25.9	20.7	53.4	28.48
1995/08/13	7.9	51.5	40.6	27.13
1995/09/09	2.5	56.3	41.1	28.01
1995/09/23	1.0	87.3	11.7	26.40
1995/10/04	2.6	88.2	9.2	25.39
1995/10/23	3.0	87.4	9.6	24.56
1995/11/11	3.2	94.0	2.7	21.40

RESULTS

I. Growth of Sagittae

There are significant relationships between sagitta growth and body length for *E. puntifer*. The linear relationship between sagitta length (OR) and standard length (SL) is: OR (mm) = -0.2917 + 0.0279 * SL (mm) (N = 223, $P < 0.001$, r = 0.9027; Fig. 2). Both the coefficients of intercept and slope are significant, although young larvae having SL less than 18 mm have larger sagitta than that estimated.

Similar pattern of sagitta growth is also found in *E. heteroloba*. The linear relationship between sagitta length (OR) and standard length (SL) is: OR (mm) = -0.1600 + 0.0208 * SL (mm) (N = 468, $P < 0.001$, r = 0.9327; Fig. 2). Both coefficients of intercept and slope are significant, but larger larvae having SL greater than 25 mm have larger sagitta deviated from the estimated.

Analysis of covariance of sagitta lengths indicated that there were significant differences between the means of the independent variables, regression coefficient or the elevations of the regression curves for the species. Higher elevation (D = 0.1317) of *E. heteroloba* was found ($P < 0.001$), however its regression coefficient was lower (D = -0.0071, $P < 0.001$), i.e., *E. heteroloba* had a bigger sagitta than *E. puntifer* at early stage, but had a slow accretion afterward.

II. Age and Growth

Assuming that the increments were deposited daily as the larvae recruited to the I-lan Bay, the growth curve estimated for *E. puntifer* was $L_t = 6.576 \exp(2.099 (1-e^{-0.0380t}))$ (N = 23, $P = 0.000$) and that for *E. heteroloba* was $L_t = 6.468 \exp(1.796 (1-e^{-0.0448t}))$ (N = 24, $P = 0.000$) (Fig. 3). The extrapolated length (L_o) of newly hatched larval anchovy was found similar between the two species. However, specific growth rate was found to be significant different, i.e., *E. puntifer* grew faster than E. heteroloba at comparable age (Table 2). The absolute growth rate for *E. puntifer* was 0.75 (mm/day) around the mode of body length at 20 mm SL, while that of *E. heteroloba* was 0.61, i.e., the difference was 0.14 mm SL per day.

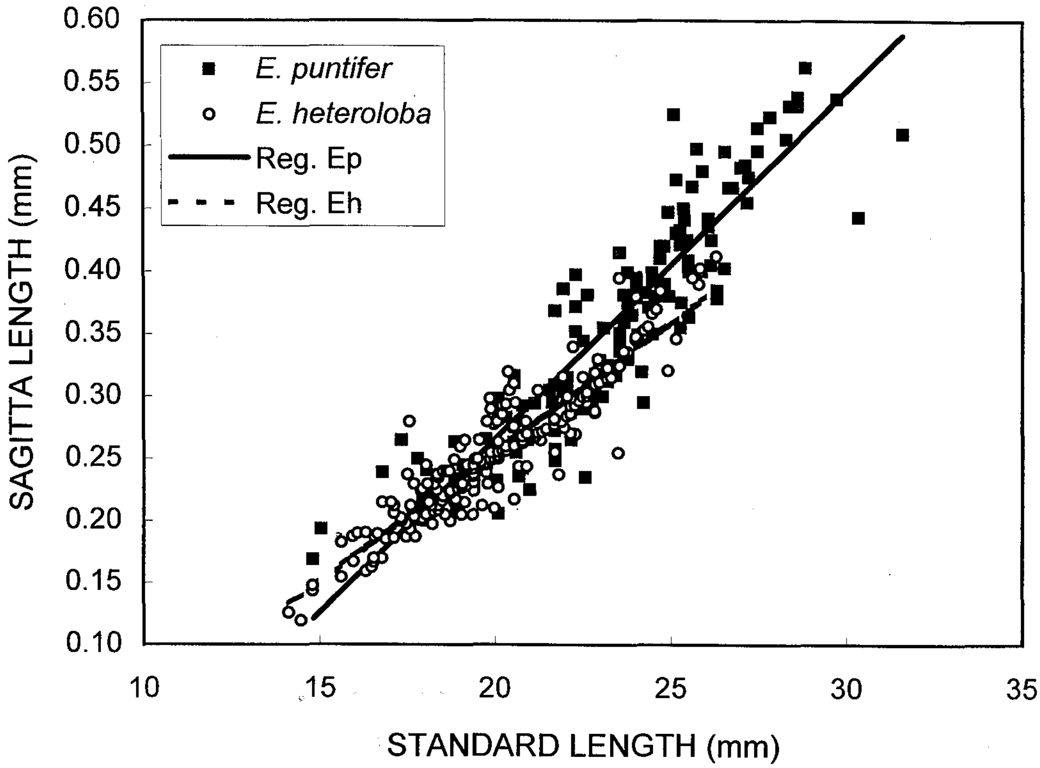

Fig. 2. Sagitta growths of *Encrasicholina puntifer* and *Encrasicholina heteroloba* as the fisher recruit to the I-lan Bay area becoming the "stock" of anchovy fishery.

III. Inter-annual Growth Difference

The age of larvae constituted the stock of the fishery indicated no annual difference during 1993-1995 by analysis of variation treated annual and specific effects simultaneously ($P = 0.309$). On the other hand, the age structure of the two species was significantly different (D = 2.11 d; $P = 0.000$), with the average ages of 24.24 d and 22.13 d for *E. puntifer* and *E. heteroloba*, respectively. For larva that grew to 20 mm SL became the major component for catch, the estimated age of *E. puntifer* was 20.77 d and that of *E. heteroloba* was 22.01 d. There was a slight inter-annual difference, but the effect was not as significant as the specific effect (Fig. 4).

DISCUSSION

In general, the definition of a stock is an intraspecific group of randomly interbreeding individuals with temporal and spatial integrity, which is characterized by a disjoint distribution and discontinuous genetic pattern (Dizon *et al.*, 1992). A single species of marine fish can occur over a wide range within which its distribution is discontinuous, and the subregions that can be recognized of having sub-populations are defined as stocks (Smith *et al.*, 1990). For instance the Atlantic herring, which might have the richest stock structure among all marine species, can be subdivided into at least 7 stocks in North Atlantic (Iles and Sinclair, 1982). On the other hand, for the application of multispecies approach to fishery management, sometimes several similar species were lumped together as a mixed "stock" or technical "stock" for simplicity, reality and managing feasibility (Hilborn, 1976; Tsai *et al.*, 1996; Chiu *et al.*, 1997).

E. puntifer and *E. heteroloba* are the

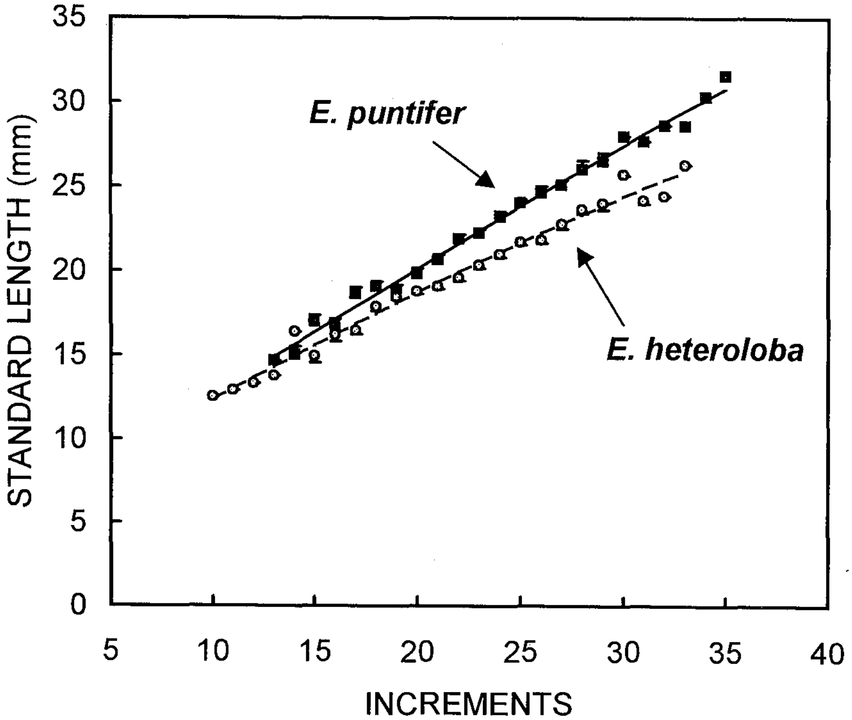

Fig. 3. Gompertz curves fitted to the standard length at age of *Encrasicholina puntifer* and *Encrasicholina heteroloba*.

Table 2. Growth rates of *E. puntifer* and *E. heteroloba* larvae predicted from the Gompertz equation at various times indicated by ring counts

Age (increments)	Specific growth rate (% per day SL)		Absolute growth rate (mm per day)	
	E. puntifer	*E. heteroloba*	*E. puntifer*	*E. heteroloba*
10-11	-	5.16	-	0.64
15-16	4.53	4.10	0.74	0.64
20-21	3.73	3.26	0.75	0.61
25-26	3.07	2.60	0.73	0.56
30-31	2.53	2.07	0.70	0.51
34-35	2.17	-	0.66	-

two species co-occurred in the fishing ground at I-lan area, previously treated as a single technical stock. During the fishing phase of I-lan Bay, since these species share the same temporal and spatial factors and are subjected to the same gear and fishing pressure, for the easiness and convenience in management these two species have been treated as a "stock". However, the results of our study indicated that the growth of sagitta and specific growth rate are different between these species. The sagitta growths of the two species indicate that *E. heteroloba* has bigger sagittae as the fish hatch, however the accretion of the sagitta is greater in *E. puntifer* (Fig. 2). Also, the growth patterns of the larvae are different; the rapid growth of *E. puntifer* apparently accounts for the difference in length at age as compared to

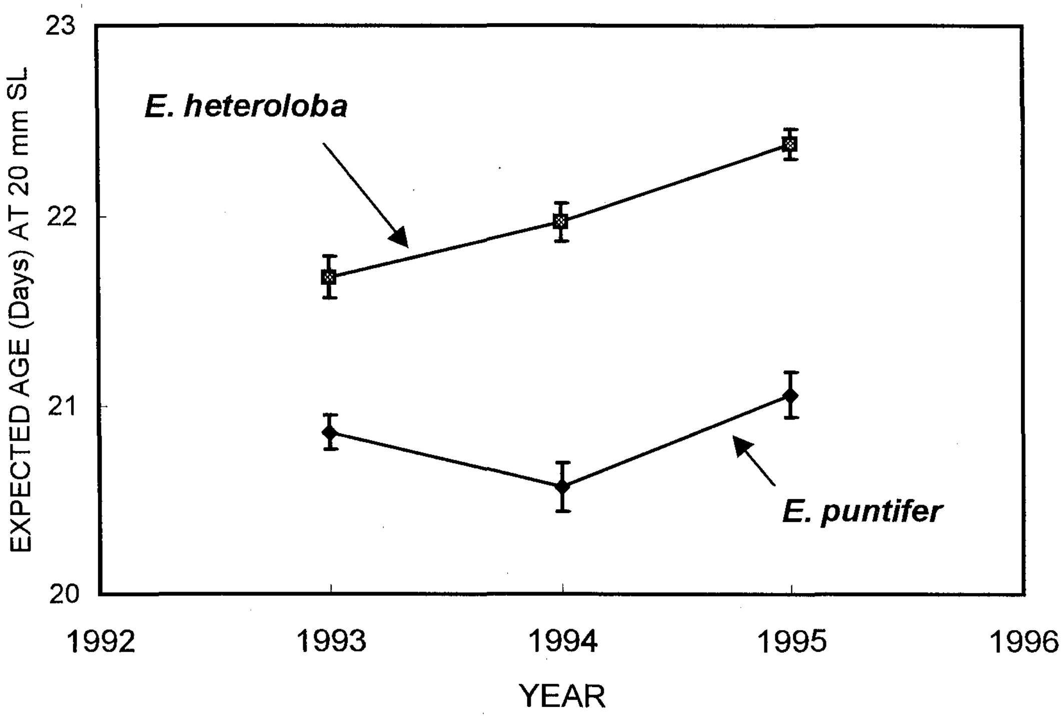

Fig. 4. Inter-annual variation of the age of larval anchovy as the standard lengths of larval *Encrasicholina puntifer* and *Encrasicholina heteroloba* reaching 20 mm SL.

E. heteroloba during their fishing phase at I-lan Bay (Fig. 3, Table 2). In our observation, an inter-annual difference is not confirmed by statistical significance in the growth pattern within each of these species (Fig. 4). This suggests that a fairly homogeneous "stock" is practicable by the combination of two anchovies. However, Chen (1990) estimated the specific growth rate of *E. puntifer* during 1987-1988 period to be 0.833-0.900 mm/day, which was much higher than our result and might indicate annual difference. This mixed conclusion obtained from longer period of observation can not rule out the possibility of inter-annual variation on the growth of larval anchovies during their feeding phase in I-lan Bay. Since both interspecific and inter-annual differences could cause differences in growth of anchovies in the fishing ground, it is premature yet to conclude that a single technical "stock" management on the autumn anchovy resources might be reasonable.

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宜蘭灣兩同出現鯷魚(*E. puntifer* and *E. heteroloba*)之成長--兼論視同單一系群之合適性

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秋季宜蘭灣之魩仔魚資源係由兩同屬異種之鯷魚-刺公鯷(*Encrasicholina puntifer*)及異葉公鯷(*E. heteroloba*)所組成。曾有一時提議，技術性地將此一資源以單一"系群"加以處理，以達漁業管理上之簡便性。為檢驗此舉之合適性，本研究分別估計兩魚種之矢石(sagitta)成長及體長(standard length)曲線，然後據之計算其相對及絕對成長率，並加以比較。

比較刺公鯷和異葉公鯷之差異，發現在矢石成長，以及各日齡之體長相對和絕對成長率，在統計上都有顯著之不同。在特定之日齡上，刺公鯷之體長皆大於異葉公鯷。兩魚種在不同年間亦有些微差異，但不若種間之效應明顯。因此，技術性地以單一系群處理秋季魩仔魚資源，尚有可議之處。

關鍵詞：系群，矢耳石成長，成長曲線，成長率。

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