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GROWTH OF ANCHOVY LARVAE *ENGRAULIS RINGENS* IN CENTRAL CHILE, DETERMINED BY DAILY INCREMENT COUNTS IN OTOLITHS[1]

CRECIMIENTO DE LARVAS DE ANCHOVETA *ENGRAULIS RINGENS* EN CHILE CENTRAL, DETERMINADO POR CONTEO DE INCREMENTOS DIARIOS EN OTOLITOS[1]

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ABSTRACT

Growth rates of anchovy larvae *Engraulis ringens* were determined in the Talcahuano zone (36°35'S), near to the southernmost limit of its geographical range of distribution. The ageing method used was daily ring counts in otoliths. Growth of otoliths is allometric in relation to larval size, and to age. A power and Schnute equations were the best fits for larval length as a function of age, in the size interval considered, but we prefered to use the former because of its parsimony.

E. ringens shows a low growth rate in the studied area, probably due to harsh environmental conditions.

Probable ecological consequences of this finding are discussed.

Key words: anchovy larvae, growth rate, otoliths, daily increments.

RESUMEN

Se determina tasas de crecimiento de larvas de anchoveta *Engraulis ringens* en la zona de Talcahuano (36°35'S), cerca del límite sur de distribución de la especie. Para estimar la edad se utilizó el número de anillos diarios en los otolitos. otolitos.

Los otolitos muestran un crecimiento alométrico en relación a la talla larval, y a la edad. Un modelo potencial y un modelo de Schnute proporcionaron el mejor ajuste para la relación longitud vs. edad, en el rango de tallas consideradas. Para fines prácticos preferimos considerar el primero debido a su mayor simplicidad.

E. ringens muestra una baja tasa de crecimiento en la zona de estudio, debido probablemente a condiciones ambientales adversas.

Se discuten las probables consecuencias de este hecho.

Palabras claves: larva anchoveta, tasa crecimiento, otolitos, incrementos diarios.

INTRODUCTION

The geographical range of distribution of the anchovy *Engraulis ringens* extends from 04°30'S off Zorritos in Perú to 39°47'S off Corral, Chile (Jordán, 1982). Within this range the anchovy finds a wide spectrum of environmental conditions to which their populations have to adapt themselves. Reproductive activity has been detected over all its geographical range based on ichthyoplankton surveys (Rojas *et al.*, 1983).

One of the reproductive centers is located in the Talcahuano area (36°40'S). A local artisanal fishery has sporadically exploited this stock since 1940 (A. Arrizaga, pers. comm.). During 1966 to 1972 this species together with *Clupea bentincki* contributed a significant amount to the landings of the industrial fleet. Since 1976 the anchovy population experienced a drastic decrease in abundance being replaced in the landings by the jack mackerel (*Trachurus murphyi*).

In this area, we have observed spawning

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activity (i.e. eggs in the plankton) over the whole year. Mixed-layer temperatures in this region have a narrow annual range (11-13°C), close to the lower limit for successful development in this species. Therefore, it seems a relevant research objective to characterize larval growth for *E. ringens* in this extreme habitat.

In order to measure growth rates, a precise and accurate determination of age is needed. This is provided by daily rings technique in otoliths, structures which have been observed in a large number of species (Brothers *et al.*, 1976). In other *Engraulis* species the first ring is formed at the end of the yolk absorption period, i.e. at first feeding (Methot & Kramer 1979, Tsuji & Aoyama 1984). This developmental event is reached a certain number of days after hatching (or spawning if preferred) depending on temperature. For *E. ringens* laboratory studies show that yolk absorption takes place aproximately in 9 days after spawning at 12-13°C, and in this paper we assume that the first ring will be deposited at that date. Daily rings in this species have been previously recorded by Rojas de Mendiola & Gómez (1981).

In the present study we determine the growth rate of the anchovy from daily increments in otoliths, and we compare our results with those obtained for other related species.

MATERIALS AND METHODS

Planktonic samples were taken during April 1985 (18-IV; 24-IV) from the adjacent coastal zone off Concepción Bay (36°35'S; 73°03'W). They were collected using a 0.6 m diameter net, 330 μm mesh, and preserved in 80% ethyl alcohol. Surface temperature at sampling was 12.5°C.

Anchovy larvae were sorted and measured (± 0.1 mm) under stereomicroscope in the laboratory. No shrinkage correction was applied. Sagittae were dissected out from otic capsules, using transmitted polarized light, and mounted on slides with Entellan (Merck, T.M.).

Under the compound microscope both otoliths were measured at the diameter, i.e. longest axis, and radius, i.e. longest distance from nucleus to outer margin (± 2.5 μm). Rings were counted by two independet readers at 1000X. Average readings were

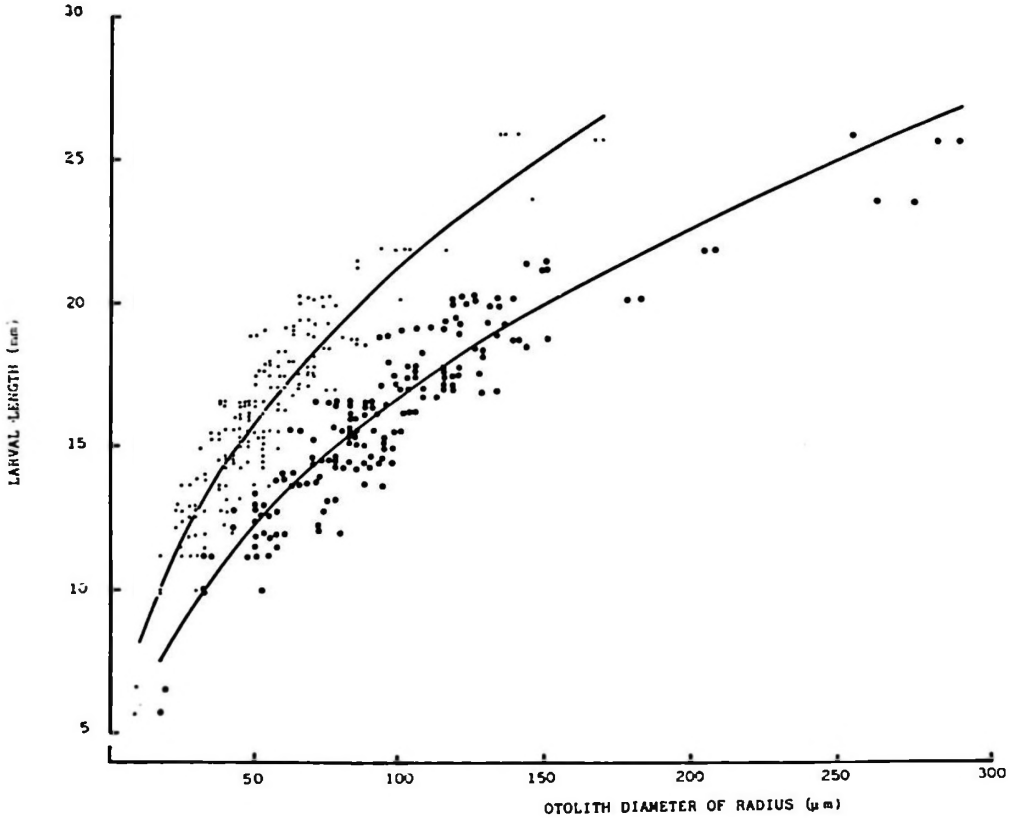

Figure 1. **Relationship between larval length and otolith size.**
Small black circles: otolith radius (upper line). Black dots: otolith diameter (lower line)

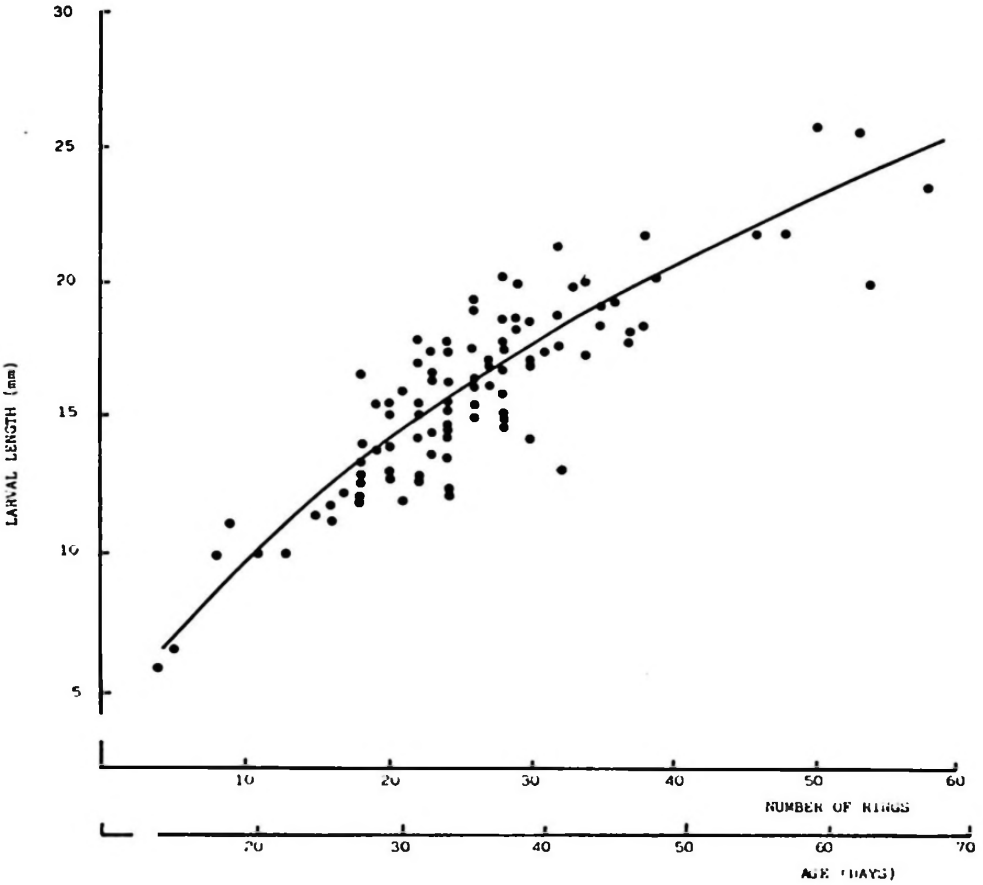

Figure 2. **Power relationship between age (number of rings) and larval length**

used, but counts were only accepted when they did not depart 3 units from one another.

The number of increments was assumed to represent the age in days after yolk absorption. Comparisons of growth rates with other species are done considering growth after that developmental event. Since available data in the literature do not permit direct comparisons, growth rates were obtained from fitted curves.

RESULTS

In the size range analyzed here, the growth pattern of the sagittae, using both diameter and radius, is allometric with respect to larval length (Table 1, Figure 1). The same kind of relationship could be observed when considering age, or number of rings. This implies that initially sagittae are circular, but at certain age or size they become ellipsoidal in shape. The biggest otoliths analyzed here (over 250 μm) showed projections in their margins. Because the growth of the otolith is allometric with respect to larval length and age, i.e. the rings widen with age, counts are more accurate in older and larger larvae.

The relationship between larval length and age was best described by a simple power function (Figure 2). However the proposed relationship must be considered valid only for the size range investigated here (from 6 mm NL to 26 mm SL). The results indicate that initially growth rates are higher (0.66

TABLE 1
Relationship between otolith radius and diameter with larval length

Relationship $Y = ax^b$	Parameters a	b
Otolith radius vs. Length	2.9407	0.4321**
Otolith diameter vs. Length	2.1498	0.4451**

**$P < 0.001$.

TABLE 2
Growth relationships

	MODEL	PARAMETERS	RESIDUAL SUM OF SQUARES
Power	$Y = aX^b$	a = 2.8877 b = 0.5296	281.4
Schnute[1]	$Y = \left(a^b + (c^b - a^b)\frac{(1-e^{-dx})}{(1-e^{-d100})}\right)^{1/b}$	a = 2.0000 b = 0.1445 c = 26.4041 d = 0.0411	281.1
von Bertalanffy[2]	$L = L_\infty (1-e^{-Kt})$	L_∞ = 37.4858 K = 0.0158	283.8

[1]Schnute (1981).
[2]L_∞ is only a parameter that describes larval growth. It does not have the conventional meaning.

TABLE 3
Comparison of growth rates for some clupeiform species
Growth rates in mm/day

Species	Size intervals [mm] 5-10	11-15	16-20	21-25	T°C	Reference
Engraulis ringens	0.66	0.40	0.30	0.24	12.5	This study
Engraulis mordax	0.54	0.67	0.63	—	16.2	Methot & Kramer, 1979
Engraulis mordax	0.33	0.42	—	—	14.4	Methot & Kramer, 1979
Engraulis mordax	0.45	0.48	—	—	13.0	Methot & Kramer, 1979
Sardinops sagax	1.00	0.75	1.00	0.66	18.6	Butler & Rojas, 1985
Sardinops sagax	0.65	0.40	0.29	—	12.5	Castillo *et al.*, 1985

TABLE 4
Relative abundance of eggs and larvae *E. ringens*. Ichthyoplankton survey data
(From: Rojas *et al.*, 1983)

	DATE	No. Stat.	$\bar{X}$ E [+ St.]	$\bar{X}$ L [+ St.]	$\bar{X}$ L / $\bar{X}$ E
SOUTH	81-VIII	87	2849 [10]	295 [40]	0.1035
	81-XI/XII	86	2342 [18]	337 [57]	0.1439
NORTH	81-VIII/IX	75	917 [5]	235 [35]	0.2563
	82-II	91	174 [5]	40 [22]	0.2299

$\bar{X}$ E Average number of eggs per positive station.
$\bar{X}$ L Average number of larvae per positive station.
[+ St.] Number of positive stations with eggs or larvae.

mm/day at 5-10 mm length) and gradually they become lower (0.24 mm/day at 21-25 mm lenght).

Table 2 shows a comparison of growth rates by size intervals, obtained from the literature for some clupeiform species.

DISCUSSION

Based on the work of Methot & Kramer (1979) where they found no big differences in growth rates of northern anchovy larvae in a 3°C temperature range (13 to 16°C), it is fair to assume that the results presented here for *E. ringens* based on data collected during Fall, are valid for the whole year, considering the narrow temperature range of the waters off the Talcahuano zone (11 to 13°C).

Continue reproductive activity is observed for *E. ringens*, i.e. eggs detected all over the year in the plankton, and relatively high numbers of eggs and larvae are detected by ichthyoplanktonic surveys conducted in the central coast of Chile (Rojas *et al.*, 1983). This indicates that environmental conditions in the area of Talcahuano despite being harsh, permit this species to develop and grow, but at a lower rate compared with that reported for the sardine (*Sardinops sagax*) in Peru (Butler & Rojas de Mendiola, 1985). However, if we compare the growth rates of anchovy and sardine (Castillo *et al.*, 1985) in the Talcahuano zone, there are no differences between them, and both observed values are low. Then, it is apparent that environmental conditions in the study area, do effectively impose some restrictions on the development of these clupeiform species. This is indirectly supported by eggs and larvae abundance information. Considering the data obtained by Rojas *et al.*, (1983) from ichthyoplankton surveys conducted in the northern (18-30°S) and central-south (33-42°S) zones, we could use the relative proportion of larvae to eggs as a rough index of survival (Table 4). In the Talcahuano area these indexes are lower than those determined for the northern zone, for both Winter (August) and Summer (November-December), meaning probably a lower survivorship due to harder environmental conditions. Of course, the effect of other potential sources of mortality cannot be discounted.

Butler & Rojas de Mendiola (1985) reported very high growth rates for sardine larvae in peruvian waters at 18.6°C. They pointed out that this would attenuate the levels of interspecific competition with the anchovy, which shows a significant lower growth rate at that temperature. In the Talcahuano area at 12.5°C, however, we did not detect such a difference. This results suggest that, because of the similar growth rates observed for these two species, any diminished mutual competitive pressure that could have obtained in the northern zone should be, for all intends and purposes, absent at these latitudes, with the obvious ecological implications.

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