Growth curves and specific growth rate of
Concholepas concholepas (Bruguière, 1789)
(Gastropoda: Muricidae) in culture experiments*

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SUMMARY: Concholepas concholepas makes up the most important gastropod fishery within its geographical distribution range. This species has been the subject of a significant number of publications, most of them relating to Chilean sites. The purpose of this paper is to estimate the growth parameters, albeit in a preliminary fashion, for Peruvian specimens in experimental culture conditions, and to determine the specific growth rate and the empirical production index based on the Specific Growth Rate (SGR). Length and weight data were grouped to estimate growth parameters ($K$ and $L_\infty$) with the von Bertalanffy plot and a modification of the Gulland and Holt plot. The SGR was also calculated using weight at recapture. The estimated growth parameters indicate a faster growth rate in comparison with previous growth studies reported in other populations.

Key words: Concholepas, growth assessment, gastropods, aquaculture.

INTRODUCTION

The muricid Concholepas concholepas (Bruguière, 1789) represents the most important gastropod fishery within its geographical distribution range, which extends from the central coast of Peru (6° 55’ S, 79° 52’ W) to the south of Chile (55° S, 68° W) (Álamo and Valdivieso, 1987). This species has been the subject of a significant number of publications (Castilla, 1988; Rabí et al., 1996), most of them relating to Chilean sites. Peruvian studies are scarce and some exist only as internal reports in fishery research institutions.

C. concholepas is commonly known as loco in Chile and chanque or tolina in Peru. C. concholepas
has been exported to China and especially Japan as a less expensive substitute of the abalone (*Haliotis* spp.) foot. Like the abalone, *C. concholepas* has a large foot, which is a popular seafood and important economic resource, but being a muricid the main biological and ecological features are very different from the haliotid.

At present, research is basically oriented to finding the best management and recovery techniques for the resource including aquaculture for raising animals and re-seeding depleted areas and the application of fishery models (Yield-per-recruit, Egg-per-recruit) to establish the maximum yield and the minimal catch size. For most fishery models, growth parameters are highly important for stock assessment and estimation of mortality and effort parameters.

Previous growth studies were carried out in very limited areas of the Chilean coast and are inapplicable to other areas (Bustos *et al*., 1986; Wolff, 1989; Stotz and Pérez, 1992).

Before this note, growth studies within Peruvian localities have not been developed or published and most of the previous management decisions were based on an empirical theory adopting data from Chilean publications, developed with study sites mostly in the central and southern coasts where the resource is more abundant. Recently, Guiñez *et al.* (1992) made the first attempt to define a genetic population structure. Their results suggest that local populations studied in north, central and south of Chile and south of Peru do not form one panmictic population, since there is a significant genetic distance (D = 0.1 units in Nei’s index) between the central and the northern Chile populations.

The aim of this note is to suggest preliminary *C. concholepas* growth parameter estimates for Peruvian specimens in experimental culture conditions, and to determine a specific growth rate and an empirical production index.

**MATERIALS AND METHODS**

For this study we collected two groups of *C. concholepas* individuals (30 juveniles of length 30 ± 5 mm and 10 adults of length 76 ± 12 mm, as the first group) from the intertidal zone at Port Ilo (South Peru) (17º 38’ S, 71º 20’ W). The second group (35 juveniles of length 35 ± 6 mm) was collected from the intertidal zone at Catarindo Bay (Arequipa, Peru) (17º 00’S, 71º 20’ W). Both samples were packed in isothermic boxes with plastic bags containing sea water ice and cooled sea water at 4 ºC. Then they were shipped by air to IMARPE’s main wet laboratory and then transplanted into plastic cages submerged in 300 l tanks with daily water renovation and constant aeration. The water temperature during the experiment oscillated between 14 and 20 ºC, same as the natural conditions outside the wet laboratory; the experiment was conducted under natural photoperiod.

Individuals were fed with a monospecific diet, based on live intertidal mussels *Semimytilus algosus* (Gould, 1850) provided *ad libitum*. *C. concholepas* samples were tagged with colored and numbered bee tags, sexed, weighed and measured. The experiment was monitored as follows: the first group of juveniles and the adults was measured monthly for a 10-month period and the second group was studied monthly for a 5-month period (February 1993 to November 1993 and August 1994 to January 1995, respectively).

To optimize the Gulland and Holt method, a modification of the Gulland and Holt plot improved by Munro (1982) was used based on growth increment data to estimate *K* with a previous estimate of *L*∞.

The specific growth rate (SGR) was also measured using the function described by Brown (1946), and reviewed by Ricker (1975),

\[
Y_r = Y_{im} e^{g (tr - tm)}
\]

where *Y*∞ is the final yield in weight at recapture, *Y*∞ is the initial weight, *g* is the specific growth rate and the term (tr - tm) represents the time period between marking and recapture. To estimate this parameter we use the percentage form:

\[
g = \frac{\ln Y_r - \ln Y_{tm}}{tr - tm} \times 100
\]

An empirical production index for the whole sample is defined by *Y* = *g* (tr-tm) in % g month⁻¹.

**RESULTS AND DISCUSSION**

From periodic surveys of the Peruvian artisanal diving fishery a maximum observed peristomal length of 123.5 mm was determined for the whole Peruvian range of the species. For the models assumptions, this maximum peristomal length is
used as the $L_\infty$ parameter, corrected with a 0.95 factor (Taylor, 1958), which results in $L_\infty = 130$ mm.

The average growth increment for both sample groups was 3.57 mm month$^{-1}$ (SD = 2.45) and 3.32 g month$^{-1}$ (SD = 1.56), without significative differences between sexes and sample localities.

The regression parameters from the von Bertalanffy’s plot (Fig. 1) are presented in Table 1. These parameters provide the following equations:

$$L_t = 130 \{1-e^{-0.55(t)}\}$$

$$W_t = 461.37 \{1-e^{-0.55(t)}\}^3$$

Parameters obtained from the Gulland and Holt model (Munro’s optimization) (Fig. 2) are presented in Table 1, which result in the following VBGF:

$$L_t = 130 \{1-e^{-0.5(t)}\}$$

The curves described by the VBGF with our estimated parameters are based on a relative age, due $t_0$ was assumed as $t_0 = 0$ (Fig. 3).

The specific growth rate (SGR) shows a range of $g = 3.43$ to $g = 0.51 \%$ g day$^{-1}$, very dependent on size classes. The SGR mean was $g = 0.899 \%$ g day$^{-1}$ for the studied size classes.

The empirical production average index result was: $Y = g$ (30 days) = 26.8 % g month$^{-1}$ for the studied range of lengths (35-55 mm). That means an important increase of biomass per month, probably related with predator size, prey consumption and water temperature (González et al., 1990).

The estimation of growth parameters from laboratory growth rate data in marine benthic invertebrates is reviewed by Yamaguchi (1975) and used for the abalone (Haliotis spp.) by Greenier and Takekawa (1992). Yamaguchi (1975) also indicates some problems and corrections to optimize estimations. One of the problems is the difference between the observed growth rates calculated from increments of size in a given period and instantaneous growth rates obtained from nonlinear growth curves.

The growth parameters are not as readily estimated from a simple approximation of the observed growth rates as they are from instantaneous growth rates. Another problem comes from the fact that lar-

<table>
<thead>
<tr>
<th>Von Bertalanffy’s plot</th>
<th>Gulland and Holt, Munro method</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a = 0.3384$</td>
<td>$a = 0.248$</td>
</tr>
<tr>
<td>$b = 0.5542$ (± 0.075)</td>
<td>$b = -0.00251$</td>
</tr>
<tr>
<td>$r = 0.8856$</td>
<td>$r = -0.745$</td>
</tr>
<tr>
<td>$L_\infty = 130$ mm</td>
<td>$L_\infty = 130$ mm</td>
</tr>
<tr>
<td>$W_\infty = 461.37$ g</td>
<td>$k = 0.55$ (± 0.1) year$^{-1}$</td>
</tr>
<tr>
<td>$k = 0.55$ (± 0.1) year$^{-1}$</td>
<td>$k = 0.5$ year$^{-1}$</td>
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![Fig. 1. – Von Bertalanffy’s plot (linear regression) to estimate VBGF parameters. The points represent the sampling data in the same period of time, and the line es their linear regression.](image1)

![Fig. 2. – Gulland and Holt regression plot, including the Munro’s modification to use a given $L_\infty$ parameter.](image2)

![Fig. 3. – Estimated von Bertalanffy growth curves of *C. concholepas*, in laboratory conditions. The age is expressed in relative age, and the size in length and weight, the parameters have been obtained with the von Bertalanffy’s (VB) plot and the Gulland and Holt (G&H) plot.](image3)
val and early juvenile development of marine macrozoo-benthos is not well understood.

Despite many studies in larvae and early life of *C. concholepas* (DiSalvo, 1988; Inestrosa et al., 1993 and Campos et al., 1994) it is still easy to obtain erroneous estimates of recruitment sizes; this is important to obtain the size at \( t_0 \), and individual growth rates for the initial size classes.

In our experiments, the best approach was achieved by the VBGF expressed in weight (Fig. 3). Gompertz and von Bertalanffy models fit the data similarly, and may be equally appropriate for describing observed growth data (Ricker, 1975). The Gompertz model, however, is most often used to describe ‘weight at age’ relationships.

The upper portion of the S-shaped Gompertz curve is similar to the von Bertalanffy curve. Only the portion of the curve beyond the inflection point usually fits the data when applied to length data (Ricker, 1975).

In the Chilean experimental culture data (Méndez and Cancino, 1990, 1992), with the same prey species, *Semimytilus algosus*, and similar experimental conditions, the growth rates show significant differences in comparison to this study. A maximum of 2.27 ± 0.45 mm month\(^{-1}\) in small sized individuals (5 to 20 mm of peristomal length) represents a slow growth rate for the corresponding size classes. The maximum observed lengths and the estimates of \( L_\infty \) in Chilean publications are higher especially from central and the southern Chile (Bustos et al., 1986; Stotz and Pérez, 1992; Castilla and Jerez, 1986).

The \( K \) and \( t_0 \) parameters cannot be compared without the use of a growth performance index (Pauly and Munro, 1984) because growth parameters are highly related and dependent on each other.

The genetic distance between populations is possibly one important factor to explain differences in growth rates. While subpopulations of *C. concholepas* are not yet clearly defined, the non panmictic theory has been discussed by Guíñez et al. (1992) giving new gaps to bridge in the definition of the genetic features of the Chilean and Peruvian populations.

Fishery regulations are in accordance with the differences in growth and especially with maximum lengths. In Chile the minimal legal size for catching is 100 mm. On the other hand, Peruvian regulations only require 80 mm as minimal legal size. Chilean fisheries managers are at present proposing the need to reduce the minimal legal size to 80 mm, but only for the northern regions of Chile, from 25\(^\circ\) S to the Peruvian frontier (18\(^\circ\) S).

We need to be careful when applying our experimental growth parameters to natural areas and conditions. In our experiments we ensure an abundant and preferred food supply. In natural conditions prey diversity and competition could severely affect the feeding process and condition factor. Shepherd and Hearn (1983) estimated a mean growth rate of 3.25 mm month\(^{-1}\) for the abalone *Haliotis laevigata* (Donovan, 1808) during the first year, and a mean length of 39 mm at 1 year, in cage experiments from which all other algivorous molluscs had been removed and to which suitable algae had been introduced as *ad libitum* feeding. These rates are almost twice those recorded in Shepherd (1988) (1.69 mm month\(^{-1}\) in the same species and size classes) in the under-boulder natural habitat where other grazing gastropods and chiton occur in high densities.

In comparison with laboratory cultured algivorous gastropods as haliotids, trochids and strombids, *C. concholepas* as a predator shows a higher growth rate and a higher specific growth rate (SGR).

In conclusion, the preliminary results seem to show faster growth rates for *C. concholepas* populations in the south of Peru, but to be conclusive we need to determine growth parameters in the natural areas and during long periods to determine the seasonality of growth.

REFERENCES


