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On the age and growth of flounder *Paralichthys orbignyanus* (Jenyns, 1842) in Bahía Blanca Estuary, Argentina

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Abstract

Estimates of age and growth of flounder *Paralichthys orbignyanus* (Jenyns,1842) were made by analysing fish from commercial catches in Bahía Blanca estuary (39° LS). A total of 823 fish caught by fishing fleets operating in the estuary were collected between February 1997 and January 1998. Age was determined *via* scale reading and growth estimation parameters using von Bertalanffy's equation. Annulus formation occurred in August. The age for the total population, which ranged from 7.7 to 87.5 cm TL was 0–7. Age ranged from 0 to 6 years (21.5–71.9 cm TL) in males and from 0 to 7 years (24.9–87.5 cm TL) in females. Length–weight relationships were W(g) = 0.0093 L(cm) exp. 3.03 for the total population, W(g) = 0.0147 L(cm) exp. 2.91 for females, and W(g) = 0.0168 L(cm) exp. 2.87 for males, respectively. As from age three, females were longer and heavier than males. The growth parameters estimated for the total population, for females and for males were $L\infty = 83.29$, 79.66, and 46.11 cm, respectively; k values were 0.18, 0.23, and 0.92, respectively, and t_0 values were −1.87; −1.54, and −0.62, respectively. Similarly to other flounders, *P. orbignyanus* is a typical inhabitant of estuaries and coastal regions. Adults stay in the study area mainly during spring and summer, they go outside or offshore during the spawning period and then they return to the estuary for feeding and recovering.

Introduction

The flounder *Paralichthys orbignyanus* (Jenyns, 1842) is a commercially important species of the genus *Paralichthys* generally found in the shallow waters from Río de Janeiro (22° S), Brazil, southwards San Matías Gulf (41° S) in Argentina (Fabré & Díaz de Astarloa, 1996; Cousseau & Perrotta, 1998; Díaz de Astarloa & Munroe, 1998). It is a typical benthonic fish with a wide temporal and spatial distribution in Bahía Blanca estuary. Like other benthonic species, its capture is not abundant. In addition, and even though this species is commonly captured all along the year, maximum catches are registered from November to March. It is generally caught as a companion fauna of other commercially important species representing only 1% of the total annual volume captured in the region.

To date no studies have been carried out on the age and growth of *P. orbignyanus* although it constitutes the basis of important fisheries all over the world. Two species other than *P. orbignyanus* of the genus *Paralichthys* live in Argentinean waters, *P. isosceles* being the only taxa that has been studied to date. These investigations are focused on age and growth (Fabré & Cousseau, 1990), population dynamics (Fabré, 1992), otolith morphology (Fabré, 1988), and feeding habits (García, 1987).

The objectives of this study were to determine the age structure of the population of *P. orbignyanus* in Bahía Blanca estuary, Argentina, and the growth estimate parameters by sex and for the whole population.

Study area

Bahía Blanca estuary is located between 38° 45′ 39° 25′ S and 61° 15′ 62° 30′ W (Fig. 1) and is classified as a salt marsh. It covers an area of 1900 km^2 at high tide, while at low tide this area is reduced to 750 km^2. This mesotidal estuary is formed by a North–West to South–East channel, separated by islands and wide tidal flats, with two well-defined zones: an inner zone and an external zone. The former is described in terms of salinity and temperature as being vertically homogeneous while the latter is characterised by a large water exchange which extends from the vicinity of Belgrano Port to the mouth of the estuary (Piccolo & Perillo, 1990).

Bahía Blanca estuary is very shallow, its mean depth reaches approximately 10 m, and it is highly turbid owing to the turbulent mixing of waters as well as the predominance of fine sediment. The behaviour of the estuary is complex all along the year; it depends on fresh water inflow from rivers and creeks, giving rise to a low and variable runoff. It is a seasonally mixed estuary with a tendency towards hypersalinity in summer (Hoffmeyer, 1994).

Figure 1. Map of Bahía Blanca estuary, Argentina, showing *P. orbignyanus* commercial fishing locations.

Materials and methods

Data sources

P. orbignyanus was sampled monthly from commercial catches from February 1997 to January 1998 in Bahía Blanca estuary (Fig. 1). Captures were carried out with shrimp nets. The total sampling included 823 specimens.

Total length (TL) measured to the nearest mm and total weight (TW) in g were measured for each fish. Sex was determined macroscopically.

Scale reading

Age was determined from fish scales which were extracted from the area above the central line on the left flank, between the dorsal fin and the area behind the operculum (Fig. 2). They were subsequently preserved dry. Scale reading was carried out through binocular lenses using a 22.5-time magnification microfiche reader.

The zone where growth was interrupted was labelled as a mark (Fig. 3). Marking periodicity was determined through the analysis of the scales extracted on a monthly basis all throughout the year. Such scales were divided into two groups, one including individuals with growth edge and another including individuals without it. Results were expressed as percentages.

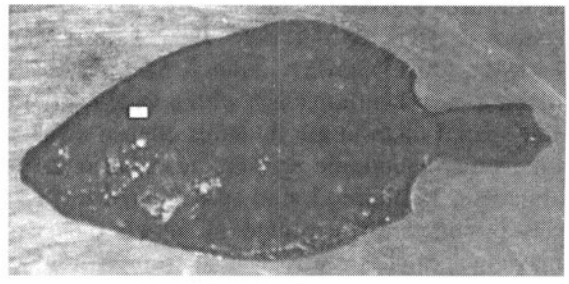

Figure 2. Example of *P. orbignyanus*. □: Location of scale sampling.

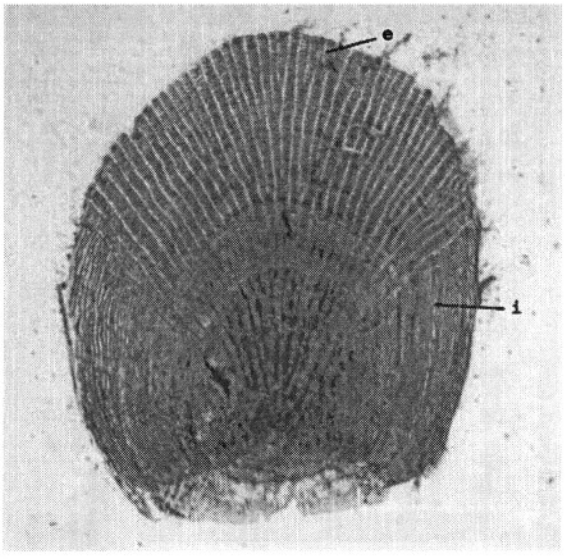

Figure 3. Scale of *P. orbignyanus* . **e**: growth edge and **i**: growth interruption mark.

Reproduction

Sex and maturity were determined by macroscopic observation of gonads. Four stages of sexual development were identified in both sexes: (1) immature, (2) onset of maturity, (3) maturity, and (4) newly spawn. The monthly gonadosomatic index (GSI) for females and males was also calculated using the expression GSI = (GW/TW) × 100, where GW = gonad weight, and TW = total weight.

Length–weight relationship

Length–weight relationship was estimated using the model $W = axL^b$. Parameters a and b were calculated by least-squares on natural logarithm transformed data. The comparison of the estimated gradients for males and females was carried out *via* covariance analysis (ANCOVA).

Growth

Growth was assumed to follow von Bertalanffy's model expressed in terms of the equation $L_t = L\infty (1 - e^{-k(t-t_0)})$ where L_t = mean length at age t, $L\infty$ = maximum mean length if the fish were to grow indefinitely, K = proportionality coefficient with which the fish reached $L\infty$; t_0 = length of fish at age 0.

Growth parameters in von Bertalanffy's equation were estimated by sex and for the total population following Allen's (1966) method. The length-at-age data for 28 unknown-sex fish (< 21.5 cm TL) were included in the curves corresponding to females and males.

Results

Total population size showed a wide distribution which ranged from 7.7 to 87.5 cm TL (Fig. 4a). Mean length and standard deviation by sex and for the total population are shown in Table 1. A clear difference between sexes was observed; males exhibited a significantly lower length range than females (Fig. 4b; Table 1).

Aging and validation

Aging interpretation was validated by analysing the edge of scales all throughout the year. A wide growth edge was observed on all scales from the fish caught during the period extending from January to April (summer). Fifty-five percent of the captured fish showed a growth interruption

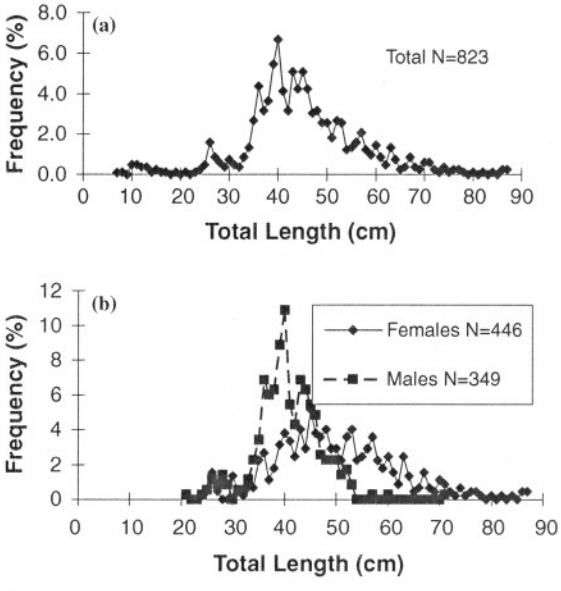

Figure 4. Length frequency of *P. orbignyanus* , (a) total population and (b) by sex.

Table 1. Mean total length and standard deviation (S.D.) for *P. orbignyanus* total population and for females and males. *N* = sample size

	Mean total length (cm)	S.D.	*N*
Total population	45.23	11.80	823
Juveniles	15.24	5.88	27
Males	41.15	6.06	349
Females	50.24	11.58	446
Indeterminate	46.1	–	1

mark, a phenomenon that was indicative of growth absence during August (Fig. 5). In addition, yearly verifications showing that *P. orbignyanus* had only one growth period per year, followed by a growth interruption, allowed for assigning the equivalent of one year to each annulus.

Length-age relationship

Eight age groups, between 0 and 7, were determined. The size ranges with their corresponding mean size and standard deviation for the whole population as well as for females and males are shown in Fig. 6 a–c, respectively. The age of juveniles, ranging from 7.7 to 27.1 cm TL, was 0. Female size range was from 24.9 to 87.5 cm, their age groups being from 0 to 7. Male size range was from 21.5 to 71.9 cm, their age groups being from 0 to 6.

Length–weight relationship

The length–weight relationship parameters estimated by sex and for the whole population are shown in Fig. 7. The statistical comparison of the estimated straight line slopes for females and males indicated no significant differences ($p > 0.05$).

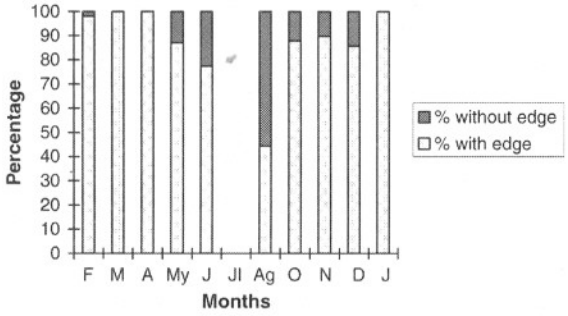

Figure 5. Monthly distribution of *P. orbignyanus* scale edge.

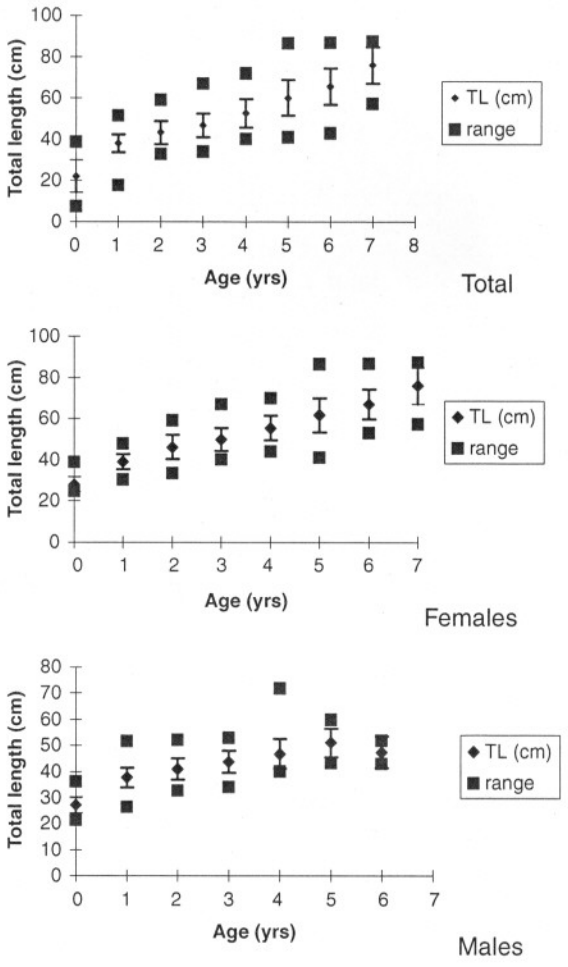

Figure 6. Mean total length, standard deviation, and range per age in *P. orbignyanus* total population and in females as well as males.

Reproduction

The GSI was not similar for both sexes. Females exhibited higher values than males every month (Fig. 8). Fig. 9 shows the percentage of different gonads maturity stages for males and females separately. In males, the highest percentage for stage III (mature) was registered in November and it subsequently decreased until March. In females, the highest percentage for stage III was registered in November and January.

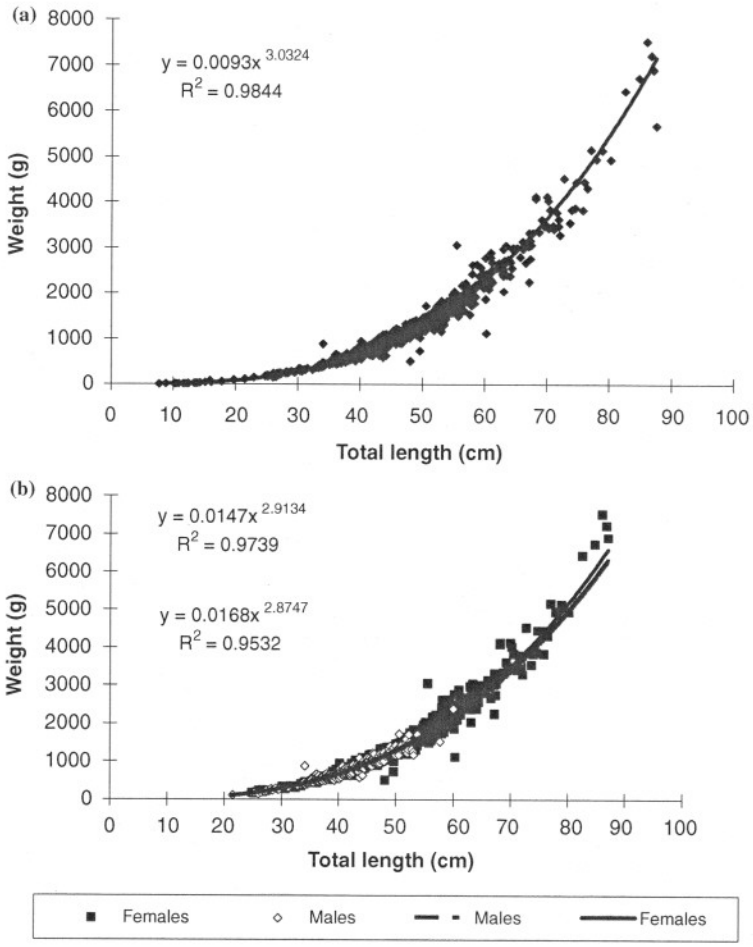

Figure 7. Length–weight relationship in *P. orbignyanus* , (a) total population and (b) by sex.

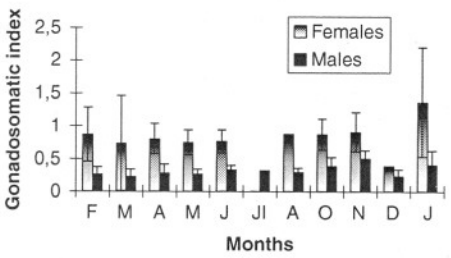

Figure 8. Monthly gonadosomatic index *P. orbignyanus* females and males.

Growth

The estimated values for $L\infty$, K and t_0 parameters in von Bertalanffy's equation corresponding both to the whole population and to both sexes are shown in Table 2. Differences between growth parameters were observed between sexes, i.e. $L\infty$ for females was higher than $L\infty$ for males. In contrast, exactly the opposite was observed for constant K.

Discussion

Results from the present study indicate that *P. orbignyanus* active growth period occurs in summer and that growth interruption marks are formed in winter. This is in agreement not only with a report on *P. isosceles* by Fabré & Cousseau (1990), who observed the same frequency in the annual formation of marks as that in *P. adspersus* from the central coast of Perú (Escobar, 1995), but also with reports on other fish such as *Pseudopleuronectes yokohamae* (Tianxiang & Shengmin, 1986),

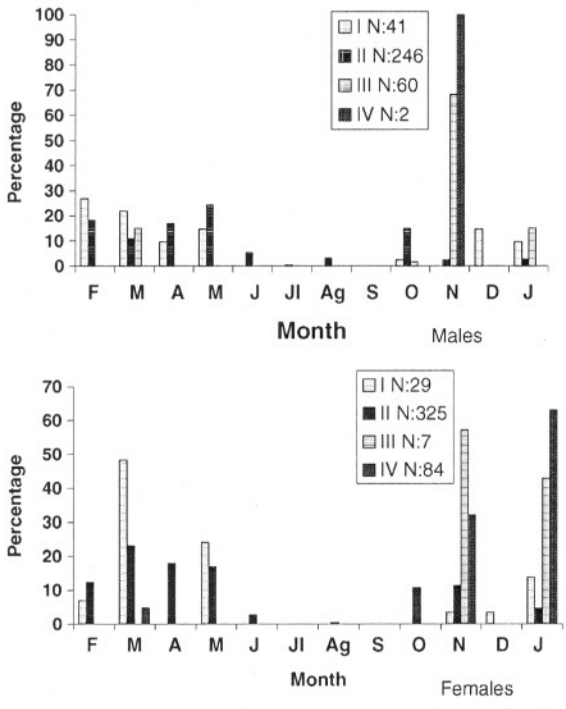

Figure 9. Percentage of different gonad maturity stages for *P. orbignyanus* males and females.

Table 2. Growth parameters corresponding both to *P. orbignyanus* total population and to females and males

	$L\infty$ (cm)	k	t_0
Total	83.29 ± 3.86	0.18 ± 0.019	−1.87 ± 0.134
Females	79.66 ± 2.72	0.23 ± 0.021	−1.54 ± 0.121
Males	46.11 ± 0.36	0.92 ± 0.042	−0.62 ± 0.035

Pleuronectes platessa (Welleman & Storbeck, 1995), and *Parophrys vetulus* (Mac Lellan & Frago, 1995).

The maximum ages recorded in the present research for both sexes corresponded to 6 years in males and 7 years in females, respectively. This could therefore be indicative of the fact that *P. orbignyanus* is not a long-living species. In this respect, similar data have been reported about *P. adspersus* by Escobar (1995), who found that the maximum age registered for this species was 6 years and the longest size was 74 cm. In addition, Díaz de Astarloa (1994) and Díaz de Astarloa & Munroe (1998) observed that the longest TL for *P. orbignyanus* was 61 cm for males and 103 cm for females ($n = 154$), respectively although they made no reference to age.

The comparison of the results collected in the present study on the length–weight relationship in *P. orbignyanus* with those obtained by Iwata et al. (1995) in *P. olivaceus* shows very similar estimates. The weight of *P. olivaceus* specimens registered after one year of laboratory experiments is in agreement with the average weight registered in specimens corresponding to class 0 in *P. orbignyanus* in the present study.

In our research, a significant difference was observed between sexes in *P. orbignyanus*. From age three, females were longer and heavier than males. Larger size in females could be indicative of a life history strategy supportive of increasing egg production (Roff, 1983; Beckman et al., 1989 in Masuda et al., 2000).

The growth difference between females and males was also observed in *P. adspersus* females which exhibit a length significantly larger than males (Escobar, 1995). The length growth registered in *P. orbignyanus* males and females in our study was significantly higher than that in *P. isosceles* reported by Fabré & Cousseau (1990).

In view of the data collected from the analysis of gonadal maturity stage and GSI carried out in the present study, it can be concluded that spawning occurs in the period extending from November to January. In this respect, reference could be made to studies by Camina (personal communication) asserting that eggs and larvae of this species were found in January and February in the area next to the estuary mouth. This could be indicative of the occurrence of spawning in the area out of the estuary in agreement with observations on other species such as *Cynoscion guatucupa* (Lopez Cazorla, 1987, 1996, 2000). A similar behaviour has been described for other Pleuronectidae (*Kareius bicoloratus*) which spawns off the coast at depths ranging from 20 to 50 m and once larvae reach a 10 and 15 mm length, they approach the coast, migrating to nursery grounds (Tsurata, 1978, 1991 in Malloy et al., 1996).

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