



## Occurrence of loliginid paralarvae around Santa Catarina Island, Southern Brazil

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**Abstract.** Small loliginid squid paralarvae, including *Loligo plei*, are reported in shallow waters (<20 m) off southern Brazil in association with the influence of a summer coastal upwelling of South Atlantic Central Water.

**Keywords:** *Loligo* spp., coastal upwelling, South Atlantic Central Water.

**Resumo. Ocorrência de paralarvas de loliginídeos no entorno da Ilha de Santa Catarina, Sul do Brasil.** Paralarvas de lulas da família Loliginidae, incluindo *Loligo plei*, são reportadas para águas rasas (<20 m) no sul do Brasil associadas a influência da ressurgência costeira da Água Central do Atlântico Sul durante o verão.

**Palavras-chave:** *Loligo* spp., ressurgência costeira, Água Central do Atlântico Sul.

The emerging importance of the loliginid squid fishery off southern Brazil, which bulk is mainly comprised by *Loligo plei* Blainville, 1823 (Perez 2002), has encouraged several studies about their biology, ecology and the fishery (Martins *et al.* in press). Few data however exist on the earliest life stages (*i.e.* paralarvae) to date. This subject is only briefly cited in Haimovici & Perez (1991) and Andriuguetto & Haimovici (1996), supporting the Hanlon *et al.* (1992) observation on the scarcity of information about paralarvae of this family from South America. Thus, the aim of the present study was to report the occurrence of paralarval squid in coastal areas, contributing to the knowledge on squid early-life stages off the Brazilian coast.

In this study, loliginid paralarvae were obtained from 13 sampling surveys conducted at 'Pântano do Sul' Bight (27°47'18"S, 048°31'07"W), south of Santa Catarina Island (Southern Brazil) in three consecutive austral summers (1999, 2000 and 2001). Plankton tows were carried out with a conical plankton net made of 300 µm mesh size and 0.4 m mouth diameter and a length of 1.4 m. Oblique hauls were conducted from bottom to surface in two

sampling stations 6 and 12 m deep respectively at a speed of 3 knots for a period of 8 min. Samples were stored in 4% buffered formalin and brought to the laboratory where organisms were sorted and identified to the lowest possible taxonomic level.

Squid paralarvae were identified following Hanlon *et al.* (1992) and all individuals had their mantle length (ML) measured in millimeters using a stereoscopic binocular microscope at 40 × magnifications. Oceanographic conditions of the bight during the surveys were assessed with a SENSORDATA® SD-202 CTD, and the water masses present at the sampling dates were classified according to the recorded temperature and salinity following Matsuura (1986) and Carvalho *et al.* (1998).

Data showed that the 'Pântano do Sul' Bight was influenced by three types of water masses: (1) Shelf Water (SW, T>20°C; S 35–36.4‰), (2) Coastal Water (CW, T>20°C; S<34‰) and (3) South Atlantic Central Water (SACW, T<20°C; S<36.4‰) (Martins *et al.* in press). Whereas the former two water masses are characteristic of both shelf and inshore areas, the SACW normally occurs underneath

the Brazil current, at around the 200 m isobath, over the shelf break/slope zone (Matsuura 1986). The 1999 summer was regularly dominated by the SW. In contrast, the summers of 2000 and 2001 exhibited the influence mainly of SW and SACW, the latter recorded as subsurface intrusion or upwelling events in association with intense NE wind influence (Martins *et al.* in press).

Overall, 58 plankton samples were obtained in the three summers surveyed (usually 8 samples per sampling trip). From these, squid paralarvae were found in 6 samples. A total of 26 loliginid paralarvae were caught (Table I). The highest catch ( $n = 21$ ) was collected during one sampling trip under the influence of an SACW upwelling episode in 02-03 March 2000 (Table I). Only one and two individuals were collected in the 1999 and 2001 seasons, respectively (Table I).

Seven of the collected paralarvae were identified as *L. plei* according to the chromatophore pattern (Figure 1). The dorsal side of the head in well-preserved individuals exhibited six large reddish chromatophores, forming a hexagon. Ventrally there were also six reddish chromatophores forming a hexagon plus two ones in each side of the head. Two large chromatophores were distinct at the dorsal side of the mantle, while the ventral side presented five longitudinal rows, being three rows of small darkish ones interlaced with two rows of large reddish ones. The remaining 19 individuals had their skin poorly preserved and could not be identified to the species level. Whereas it is possible that a larger number of paralarvae collected could be *L. plei*, the most abundant squid in the area during summer and sustaining an important and traditional artisanal fishery (Perez 2002), the simultaneous presence of *L. sanpaulensis* Brakonieccki, 1984 paralarvae could not be discarded, since mature males and females were occasionally recorded in the bight during all three seasons (unpublished data).

The present report indicates that very small loliginid paralarvae occasionally occur in shallow waters (<20 m) around Santa Catarina Island, Southern Brazil. Considering that paralarvae assessment was not intended in the zooplankton sampling design, catch rates were unlikely to represent paralarval abundance in the area. Nevertheless, the presence of loliginid paralarvae in the study area may be related to (a) the presence of spawning beds within or in the vicinity of the bight, or (b) the inshore transport from other sites around Santa Catarina Island by coastal currents or the dynamics of the SACW upwelling episodes.

In spite to the fact that adult *L. plei* sampled in the three summers were in an advanced stage of

maturity (unpublished data) and that paralarval sizes recorded in the bight approximated hatching sizes reported for the species in the Atlantic (around 1.2 mm, Hanlon *et al.* 1992), exploratory SCUBA surveys in the study site did not confirm the presence of loliginid egg pods on the sea floor. It seems evident that if spawning takes place in the 'Pântano do Sul' Bight, the species does not form large spawning aggregations, as occurs with several loliginid species (Sauer *et al.* 1992). On the other hand, Vecchione (1988) observed some *L. plei* egg beds on sandy bottoms 60 m deep in the eastern Gulf of Mexico, suggesting that spawning off southern Brazil may not be coastal and may occur elsewhere on the continental shelf perhaps in association with the dense offshore squid concentrations which sustain most of the trawling fishery (Perez 2002).



Figure 1. *Loligo plei* paralarvae caught in the 'Pântano do Sul' Bight during 2000 summer (ca. 40 ×). A) Dorsal view, B) Ventral view. Scale bar = 0.5mm.

Despite the small size of paralarvae sampled, these could be several days old, given that temperature has a major effect on the hatching size and growth rates (Villanueva 2000, Vidal *et al.* 2002). This speculation is particularly appealing if one consider the hypothesis of deep spawning grounds occurring within the cold SACW bottom layer, which often occurs as a result of a strong thermal stratification of the water column on the southern Brazilian shelf during summer months (Matsuura 1986, Carvalho *et al.* 1998, Borzone *et al.*

Table I. Number of squid paralarvae de caught in the 'Pântano do Sul' Bight, Santa Catarina Island, Southern Brazil, during the summers of 1999, 2000 and 2001. CW: Coastal Water, SW: Shelf Water, SACW: South Atlantic Central Water. ML = mean mantle length (mm), S.D. = standard deviation (mm).

Date of sampling (day/month/year)	Predominating Water Mass	Number of paralarvae		ML $\pm$ S.D.	Range
		Loliginidae	<i>Loligo plei</i>		
12/12/1998	SW	1	0	1.27	-
09/01/2000*	SW/SACW	1	0	1.60	-
15/02/2000	CW	0	1	2.25	-
02/03/2000**	SACW	12	3	1.59 $\pm$ 0.39	1.26 – 2.84
03/03/2000**	SACW	4	2	1.50 $\pm$ 0.04	1.46 – 1.56
06/01/2001*	SW/SACW	1	1	1.60 $\pm$ 0.20	1.51 – 1.73
	1999		1	1.27	-
Total per season	2000		23	1.57 $\pm$ 0.44	1.26 – 2.84
	2001		2	1.60 $\pm$ 0.20	1.51 – 1.73

\* intrusion of SACW

\*\* upwelling of SACW

1999). This could partially explain why no eggs were found in the area.

Loliginidae paralarvae have been reported to be associated with upwelling areas (Rocha *et al.* 1999, González *et al.* 2005), where highest numbers are often caught during the upwelling events. It is perhaps significant that the highest catch taken in this study (n = 21) took place in such an upwelling event, despite the improper plankton net employed. By comparison, when appropriate plankton nets are employed, usually 1–5 squids are taken per tow (Vecchione, 1987). Moreover, the number of paralarvae caught could be considered high when compared with other studies carried out in wind-driven upwelling areas. For instance, off the Galician coast (north-western Spain) Rocha *et al.* (1999), using a suitable plankton net and intending paralarval abundance assessment, obtained a total of only 42 loliginid paralarvae over a 10 day-long survey.

Apparently, upwelling environments appear to be advantageous for post-hatching survival, due to the fact that paralarvae may find suitable feeding conditions as produced by the nutrient injection provided by the upwelled water (Rocha *et al.* 1999, González *et al.* 2005). At least adult *L. plei* seem to benefit from such upwelling-induced food production concentrating in shallow-waters around Santa Catarina Island where they become available to intense artisanal fishing (Martins *et al.* in press).

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