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Statolith age validation and growth of *Loligo plei* (Cephalopoda: Loliginidae) in the north-west Gulf of Mexico during spring/summer

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Statolith validation and age and growth analysis was undertaken for the loliginid squid *Loligo plei* in the north-west Gulf of Mexico off Galveston, Texas. Statolith increments were shown to be laid down daily based on tetracycline staining of 19 individuals maintained in captivity. Ageing of field-captured individuals from late summer revealed that this species has rapid growth rates and a life span of about five months at least during the warm period of the year in this region of the Gulf of Mexico.

Loligo plei is a wide ranging loliginid in the western Atlantic and occurs in continental shelf waters from Cape Hatteras in North America to Fortaleza, Brazil as well as Bermuda, the Bahamas and the Caribbean Sea (Cohen, 1976). Preliminary age and statolith validation experiments of *L. plei* were undertaken to discern firstly if statoliths can be used as reliable ageing tools in this species and secondly, to investigate the age and growth during spring/summer in the Gulf of Mexico, off the Texas coast.

Individuals of *L. plei* were dip-netted at night off the stern of the RV 'Erin Leddy Jones' (Marine Biomedical Institute). Squid used for statolith validation experiments were captured on the evenings of 19 July and 16 August 1994 ~32 n.m. and 12 n.m. respectively off Galveston. Squid were maintained on board ship in either a 1020-l rectangular horizontal tank or a 550-l horizontal cylindrical tank with bubbling oxygen and added ice in plastic bags. On return to port early the following morning, squid were either injected with a solution of tetracycline/seawater at a concentration of 6 g ml^{-1} (Jackson, 1990) and released immediately into a tank, or placed in plastic bags (two per bag with oxygen) and exposed for 2 h to a solution of tetracycline/seawater at 250 mg l^{-1} (Jackson, 1990). All squid were maintained in closed seawater systems at the National Resource Center for Cephalopods in either a 1500-l, 2 m diameter circular tank under constant light or a ~2700 l raceway with no artificial illumination but located near a large window for normal diel periodicity.

A total of 19 tetracycline stained individuals (11 males, eight females, mantle lengths (ML) 81–180 mm) of *L. plei* were successfully maintained for up to 29 d, and their statoliths prepared and examined after Jackson (1990). Increments were counted between the tetracycline mark and the statolith margin for 18 of the squid by using a combination of incident and fluorescent light (after Jackson et al., 1997). The largest specimen stained (180 mm ML male) was injected a second time with tetracycline 19 days after the first staining and continued to live for a further 11 days. The increments were therefore counted between the two tetracycline marks.

Collection of individuals for ageing were undertaken on the night of 10 August 1994 by dip-netting (32 n.m. off Galveston) and frozen. Statoliths were ground and polished after Jackson (1990). Statolith increment counts (for both field and tetracycline stained specimens) were undertaken from three replicate counts that differed less than 10% from the mean (after Jackson et al., 1997). No counts were excluded. A total of 50 individuals were aged (25 males, 25 females).

A paired *t*-test revealed that there was no significant difference between the number of elapsed days and the number of statolith increments laid down ($P=0.59$; N=19, Figure 1). Thus we can accept the hypothesis that statolith increments are laid down daily in *L. plei*.

Based on preliminary ageing, *L. plei* has relatively rapid non-asymptotic growth (Figure 2) and a short lifespan with all individuals <6 months old. The majority of individuals were mature. The oldest male and female aged were 160 d, 200 mm ML, 142 d 105 mm ML respectively. Only two of the males were not mature

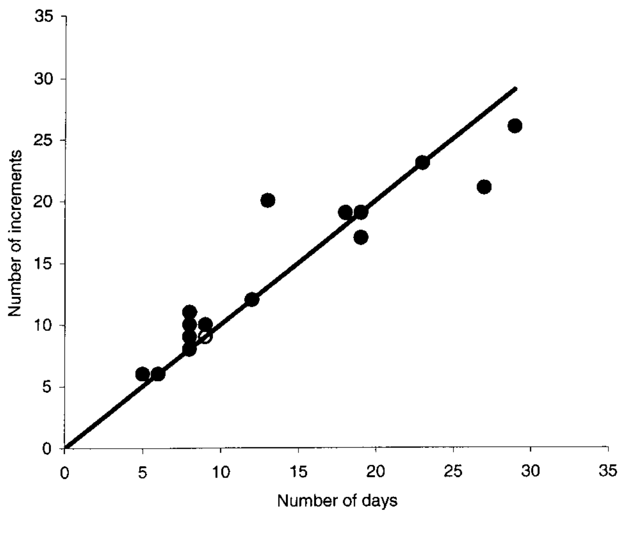

Figure 1. The relationship between the number of elapsed days and the number of statolith increments laid down in 19 individuals of *Loligo plei* maintained in captivity. The hollow circle represents two data points. The line represents a 1:1 correlation between number of days and number of increments.

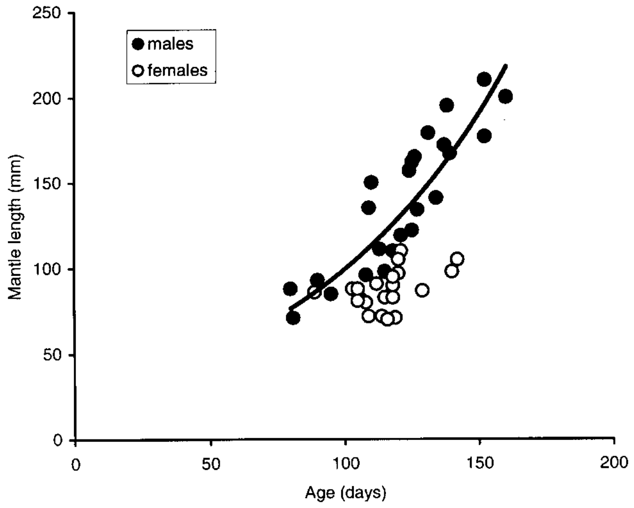

Figure 2. The relationship between age and mantle length for field-captured individuals of *Loligo plei* in the Gulf of Mexico.

and were 90 and 115 d old. The youngest mature male and female was 80 d and 103 d respectively. The youngest immature female was 103 days. Only five aged females were not mature and the oldest immature female was aged 142 days. All animals hatched between early March and late May with a peak in April and were growing through a period of warming temperatures (see Jackson et al., 1997, figure 7).

The males were larger and had faster growth rates than females. For example, at 150 d females were <120 mm whereas males reached >200 mm (Figure 2). It was not possible to model female growth due to the limited size and age range in our sample. Males had exponential growth for both ML; $y=26.92e^{0.0131x}$, r^2 0.74 and weight; $Y=2.7282e^{0.208x}$, r^2 0.62. Exponential curve fits were slightly better than either linear or power curves.

The relatively rapid growth and early maturity of *L. plei* was possibly due to the warm water temperatures experienced during the spring/summer period (Forsythe, 1993) in the Gulf of Mexico. The short lifespan and early maturity of *L. plei* is comparable to both other shallow water tropical (e.g. Arkhipkin & Nekludova, 1993; Jackson & Moltschaniwskyj, 2002) and warm water (Jackson et al., 1997) loliginids that also appear to have lifespans less than 200 days.

The wide geographical range of *L. plei* make it an interesting candidate to explore plasticity in growth and reproduction rates over different environmental temperatures. Squid are now known to display different growth strategies depending on environmental temperatures (e.g. Forsythe, 1993; Jackson et al., 1997; Hatfield, 2000; Forsythe et al., 2001; Jackson & Moltschaniwskyj, 2002). Our samples came from the warm summer period in this relatively shallow, productive region of the Gulf of Mexico. It is likely that individuals from cooler regions or cooler times of the year will have slower growth and delayed maturity.

An important contribution of this preliminary study has been the documentation of daily periodicity of the statolith increments. Validation studies are still few in number (Jackson & O'Dor, 2001) and there is a continuing need to obtain validation information for other squid species.

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