

RESEARCH NOTE

Egg masses of the Patagonian squid *Doryteuthis (Amerigo) gahi* attached to giant kelp (*Macrocystis pyrifera*) in the sub-Antarctic ecoregion

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Abstract

Egg masses of the Patagonian squid *Doryteuthis (Amerigo) gahi* attached to giant kelp (*Macrocystis pyrifera*) in the Magellanic channels of the sub-Antarctic ecoregion in southern South America is documented for the first time. Of seven egg masses observed between 2008 and 2011, one was taken to the laboratory to be analysed and photographed. Comprising long transparent capsules containing eggs, the masses were strongly attached to the stipes of *M. pyrifera*. This macroalgae is a potentially important economic resource due to its multiple industrial uses; this study shows that it also serves an important ecological role as a spawning substrate for *D. gahi*.

Coastal ecosystems in the Magellanic channels of the sub-Antarctic ecoregion (southern tip of South America) are heterogeneous environments with different types of biotypes (Soto et al. 2012) that include a great diversity of algae and molluscs (Santelices & Marquet 1998; Valdovinos et al. 2003). The macroalgae *Lessonia* spp. and *Macrocystis pyrifera* (Linnaeus) C. Agardh are one of the dominant groups of marine benthic flora, especially on rocky boulders and rocky shores in Magellanic Province (Mansilla & Ávila 2011; Martin & Zuccarello 2012). *Macrocystis pyrifera* has been identified as an ecosystem engineer in the region (Coleman & Williams 2002; Ríos et al. 2007), and it plays an important role in the reproductive biology of amphipods and fishes (e.g., Moreno & Jara 1984; Cerda et al. 2010).

The Patagonian squid *Doryteuthis (Amerigo) gahi* (d'Orbigny 1835) is a pelagic species that occurs from the Magellan region northward to southern Peru in the south-east Pacific Ocean and to the San Matías Gulf in the south-west Atlantic (Roper et al. 1984; Ibañez et al. 2005). It supports an important fishery on the Patagonian shelf (Jereb et al. 2010). Some studies have been

conducted along the Chilean coast on its fisheries biology (e.g., Vega et al. 2001) and phylogenetics (Ibañez et al. 2012), but most biological studies of this species have been conducted in the south Atlantic (e.g., Barón 2001, 2003).

Around the Falkland Islands, *D. gahi* attach egg masses to the stipes of *M. pyrifera* and *Lessonia* spp. (Arkipkin et al. 2000), but this spawning behaviour has not been reported in Chile or the fjords and channels in the Magellan region. The objective of this study was to determine if, in fjords and channels in the Magellan region, *D. gahi* also attaches its egg masses to *M. pyrifera*, which is abundant in this region and a potentially important economic resource.

Materials and methods

Egg masses were photographed attached to *Macrocystis pyrifera* at five locations in the Strait of Magellan, one location in Almirantazgo Sound, and one location in Beagle Channel (Fig. 1, Table 1). Twenty-one egg capsules from one egg mass in the Strait of Magellan at Punta Santa

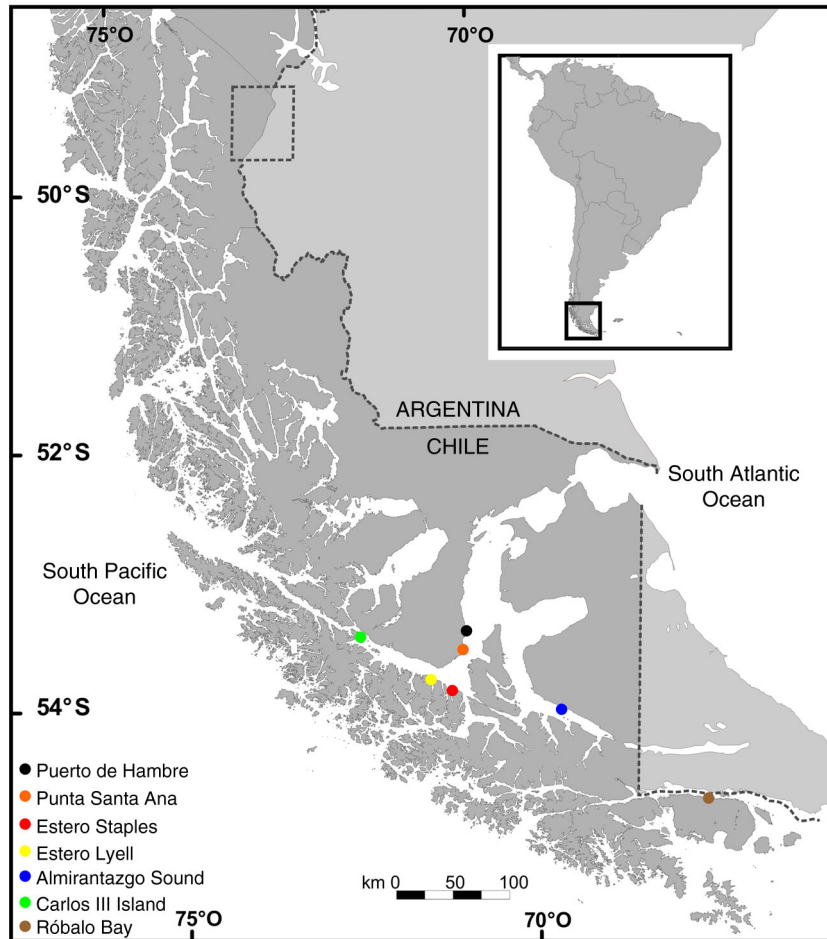


Fig. 1 Locations where *Doryteuthis gahi* egg masses were observed attached to *Macrocystis pyrifera*.

Ana ($53^{\circ}37,7'S$; $70^{\circ}54,8'W$) were collected and transported to the Laboratory of Antarctic and Sub-Antarctic macroalgae of the Universidad de Magallanes. Eggs were kept in 80-L aquaria with nearly constant air flow, salinity of 31, temperature of $8 \pm 1^{\circ}C$ and a 12:12 photoperiod. To identify the egg masses, we randomly selected seven of the capsules and made the following measurements, in

accordance with Barón (2003) for *Doryteuthis* spp.: capsule length and weight, number of eggs in each capsule, egg diameter (mm) and number of dark chromatophores in the cheek patch area—two oval areas located at the posterior half of the ventral surface of the head (Vecchione & Lipinski 1995). Paralarvae were photographed using an Olympus SZ61 stereomicroscope (Tokyo, Japan) attached to Moticam 200 camera (Motic, Hong Kong, China). Measurements were made using Micrometrics SE Premium software.

Table 1 Dates and locations of *Doryteuthis gahi* egg masses observed attached to *Macrocystis pyrifera*.

	Date	Location
Puerto de Hambre	20-05-2011	$53^{\circ}36'S$; $70^{\circ}55'W$
Punta Santa Ana	15-01-2010	$53^{\circ}37'S$; $70^{\circ}54'W$
Estero Staples	05-06-2009	$54^{\circ}02'S$; $71^{\circ}14'W$
Estero Lyell	08-04-2011	$54^{\circ}01'S$; $71^{\circ}22'W$
Carlos III Island	10-06-2008	$53^{\circ}39'S$; $72^{\circ}13'W$
Almirantazgo Sound	25-05-2009	$54^{\circ}13'S$; $69^{\circ}38'W$
Róbal Bay	29-04-2009	$54^{\circ}55'S$; $67^{\circ}39'W$

Results and discussion

Seven egg masses (one at each location) were observed attached to *Macrocystis pyrifera* (Fig. 2). Egg capsules from the egg mass at Punta Santa Ana had an average length of 61 ± 1.9 mm and an average weight of 5.6 ± 0.6 g ($n = 7$) (Fig. 3), and contained an average of 56 ± 7 eggs ($n = 7$), with an average egg diameter of 2.5 ± 0.2 mm.

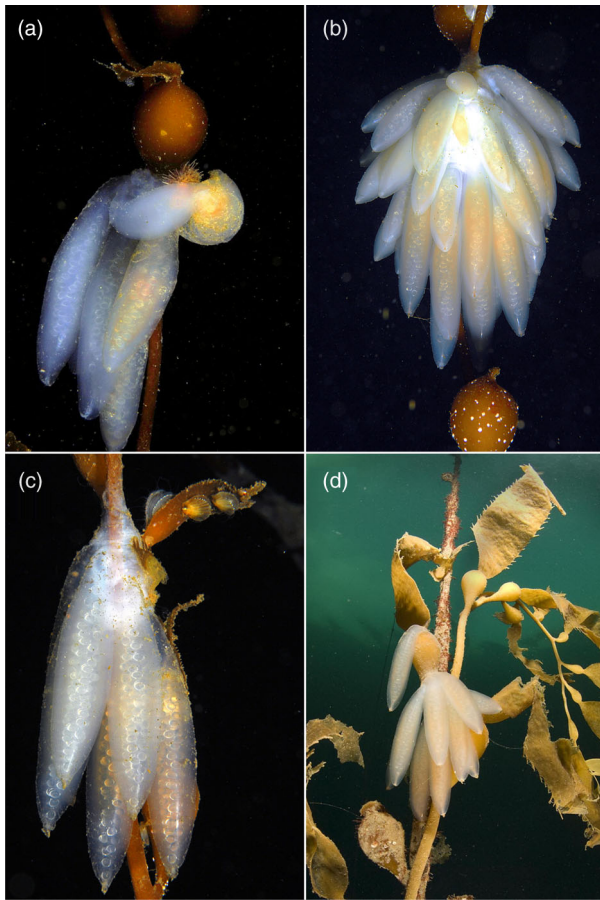


Fig. 2 Egg masses of *Doryteuthis gahi* attached to *Macrocyctis pyrifera* stipes. Egg masses (a) and (b) were collected at Estero Staples, (c) at Estero Lyell and (d) at Puerto de Hambre. (Photos by Mathias Hüne.)

Arkhipkin et al. (2000) reported very similar measurements for this species with an average egg capsule length of 54.93 ± 8.87 mm, an average number of 73 ± 22.85 eggs and an average egg diameter of 2.0–2.5 mm. Most paralarvae had three to four chromatophores in each cheek patch. These measurements are similar to those reported for *Doryteuthis gahi* (Arkhipkin et al. 2000; Barón

2003), suggesting that the egg masses we observed were spawned by *D. gahi*.

This is the first report of *D. gahi* egg masses attached to *M. pyrifera* in the Magellanic channels of the sub-Antarctic ecoregion. *Macrocyctis pyrifera* is a characteristic component of benthic ecosystems in this region (Mansilla & Ávila 2011). Charles Darwin observed these submarine forests during the *Beagle* expedition and noted their importance for the associated fauna (Darwin 1839). In this context, we highlight two aspects about the importance of *M. pyrifera* forests for the sub-Antarctic channel ecosystem: (a) their structural complexity could affect local conditions, such as currents and light intensity in the water column, resulting in increased biodiversity (Stachowicz 2001); (b) they provide a spawning substrate for invertebrates such as *D. gahi* that migrate into the calm waters in the interior of the channels to spawn.

Around the Falkland Islands, egg masses are found attached to stipes of both *Lessonia* spp. and *M. pyrifera*, but more often to *Lessonia* spp. (Arkhipkin et al. 2000; Brown et al. 2010). In our study, although *M. pyrifera* and *Lessonia* spp. were present at all locations, egg masses were found attached only to *M. pyrifera*. The congener *Doryteuthis opalescens* (Berry 1911) spawns in coastal water off California, where *M. pyrifera* is also present (Graham et al. 2007), but attaches its eggs to sandy substrate (Young et al. 2011). *Doryteuthis gahi* could be one of the few squid species that attaches its egg masses to kelp.

With diverse industrial uses, including providing phyco-colloids in the form of alginate (Mansilla & Ávila 2011), *M. pyrifera* is a potentially important economic resource in the study region. Information is available about the biological basis for the sustainable exploitation of *M. pyrifera* (Mansilla et al. 2009), but caution is needed given that this kelp serves not only as a habitat for many animals but also as a spawning substrate for some benthic (e.g., gastropods) and pelagic (e.g., squid) species. This increases the ecological importance of conserving *M. pyrifera* forests.

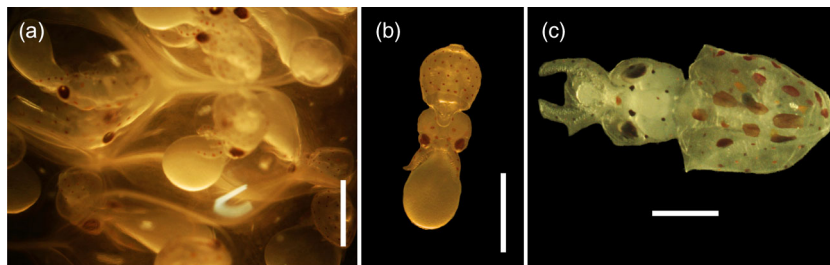


Fig. 3 (a) Close-up of *Doryteuthis gahi* egg mass showing developing embryos; (b) *D. gahi* hatchling paralarva with attached yolk sac; (c) advanced paralarva. Scale bars are 1 mm.

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