Journal of FISH BIOLOGY

fsbi An International Society for Fish Biology

Journal of Fish Biology (2017)
doi:10.1111/jfb.13490, available online at wileyonlinelibrary.com

BRIEF COMMUNICATION

Avoiding being dragged away: finding egg cases of *Schroederichthys bivius* (Chondrichthyes: Scyliorhinidae) associated with benthic invertebrates

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(Received 31 August 2017, Accepted 17 September 2017)

Egg cases of the narrowmouthed catshark *Schroederichthys bivius* were recorded entangled with sponges, corals and tubeworms at different sites in the south-west Atlantic Ocean. This work sheds light on the importance of benthic invertebrates in the life cycle of oviparous chondrichthyan species.

Key words: attachment of eggs; cat sharks; entanglement; epibionts; south-west Atlantic Ocean.

Structured habitats are used as preferred nursery and refuge sites by many fishes. Sponge grounds are essential fish habitats for several fish species throughout the world (Miller *et al.*, 2012; Quattrini *et al.,* 2015). Glass sponges as well as demosponges and calcarean sponges have been used by many fishes to deposit their egg masses (Konecki & Targett, 1989; Munehara, 1991; Akagawa *et al.*, 1995; Barthel, 1997; Freese & Wing, 2003; Busby *et al.*, 2012). Fishes also use polychaete tubes as spawning substrata (Munehara, 1992). As in teleost fishes, oviparous sharks use several invertebrates as egg laying sites by entangling their egg cases around them. The substrata can include dense fields of tubeworms, hydrozoans, corals, macroalgae, bryozoans and poriferans (Able & Flescher, 1991; Ellis & Shackley, 1997; Etnoyer & Warrenchuk, 2007; Concha *et al.*, 2010; Treude *et al.*, 2011; Quattrini *et al.*, 2015).

Scyliorhinidae comprise a large family of sharks present in the Atlantic, Pacific and Indian Oceans (Compagno *et al.*, 2005). The narrowmouthed catshark *Schroederichthys bivius* (Müller & Henle 1838) is the most common scyliorhinid on the

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Argentine continental shelf. It occurs in both the Atlantic and the Pacific Oceans, from 25° 50′ S in southern Brazil to 33° 00′ S in Chile and from 12 to 359 m depth (Soto, 2001; Sánchez *et al.*, 2009; Bornatowski *et al.*, 2014; Weigmann, 2016). This catshark is a common by-catch species in Patagonian coastal trawl fisheries in the south-west Atlantic Ocean (Van der Molen *et al.*, 1998) and also in the shelf-break area on the Patagonian scallop fishing grounds (Schejter *et al.*, 2012). As in skates (Rajiformes), *S. bivius* is oviparous and lays its eggs in a protective leathery cigar-shaped egg case, which has a convex anterior end without tendrils and a posterior end with long, filamentous and coiled tendrils (Mabragaña *et al.*, 2011). The presence of egg cases of *S. bivius* in the south-west Atlantic Ocean associated with several benthic organisms is reported here. Additional information on the presence of epibiotic species recorded on full and empty egg cases is also provided.

The study area comprised the Argentine continental shelf, between 41° and 48° S (from 57 to 144 m depth) and from 53° to 55° S (from 74 to 130 m depth). The egg capsules were collected during four scientific surveys, two onboard the R.V. *E. Holmberg* (Instituto Nacional de Investigación y Desarrollo Pesquero) in 2011 and 2016 using an Engel bottom trawl and the other two onboard the R.V. *Puerto Deseado* (Consejo Nacional de Investigaciones Científicas y Técnicas) in 2012 and 2016 using a bottom shrimp trawl. Egg cases of *S. bivius* were counted and separated from total catch and those found associated with benthic invertebrates were labelled in plastic bags and frozen for further analysis. Date, latitude, longitude and depth were recorded for each haul.

The egg cases of *S. bivius* were mainly associated with three species of benthic organisms by long fibres and coiled tendrils. Egg cases collected north of 46° S (depth range: 75–100 m, $n = 18$, Table SI, Supporting information) were always entangled in the sponge *Tedania (Tedaniopsis) mucosa*. One, two or even three egg cases were observed attached to the same sponge specimen and also a single egg case was observed attached to two sponges [Fig. 1(a)]. Both the coiled tendrils of the posterior end and the attachment fibres of the anterior margin were deeply embedded in the sponge body. In Tierra del Fuego, egg cases were associated with two benthic species: the primnoid coral *Thouarella* sp. ($n = 4$) and the tubeworm *Chaetopterus* cf. *antarcticus* ($n = 1$). In the primnoid coral, only one capsule per coral was observed, between 74 and 130 m depth (Table SI, Supporting information). The egg cases were anchored among the coral through entanglement with the tendrils and anchoring fibres [Fig. 1(b)]. Three additional egg cases were collected associated with other corals, probably belonging to family Primnoidae. A single egg case was found associated with tubeworms at 122 m depth (Table SI, Supporting information) and it was strongly anchored using mainly the posterior end tendrils, which surrounded the tubes with several turns [Fig. 1(c)].

Epibiotic organisms were also detected attached to the egg cases of *S. bivius*. One empty capsule was found almost completely covered by a colonial tunicate belonging to the family Polyclinidae. In addition, egg cases with embryos were found with the stalked barnacle *Ornatoscalpellum gibberum* attached [Fig. 1(d)]. Except for the capsule associated with tubeworms, egg cases associated with the rest of the invertebrates had developing embryos at different stages of development, ranging from initial yolk stages to embryos with a pigmented ocular ring and gill filaments.

Cartilaginous fish are threatened mainly for two reasons; the effects of several fishing-related activities and the effects of habitat loss and environmental degradation

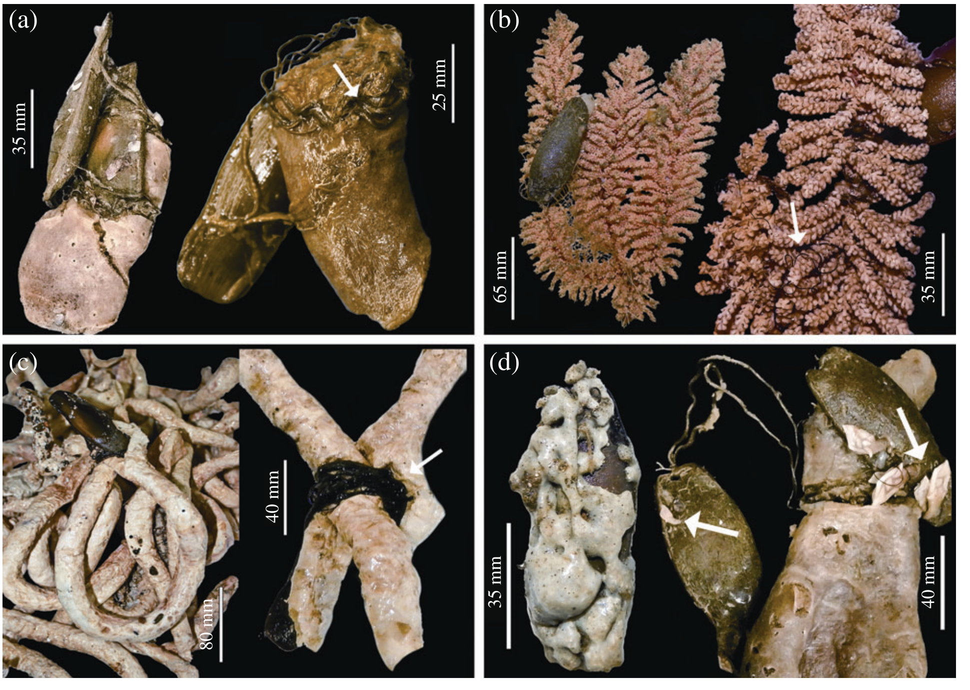

FIG. 1. Egg cases of *Schroederichthys bivius* attached to (a) the sponge *Tedania (Tedaniopsis) mucosa,* (b) the primnoid coral *Thouarella* sp. and (c) the tubeworm *Chaetopterus* cf. *antarcticus*. ➪, Attachment of tendrils and fibres showing the way they are attached to benthic organisms; (d) Epibionts on egg cases: a tunicate, family Polyclinidae (left) and the stalked barnacle *Ornatoscalpellum gibberum* (➪). Arrows indicate the position of the barnacle in the egg case.

(Stevens *et al.*, 2005). As a consequence of their *K* strategy, chondrichthyans are not able to adapt to rapidly occurring critical changes in their environment. Here, several sessile invertebrates have been found to be important in the settlement of *S. bivius* egg cases on the seabed. These associations allow the eggs to be firmly attached to a fixed substratum, hence avoiding being dragged away by currents. Large masses of these invertebrates could also act as nursery habitats for chondrichthyan species as previous authors have reported (Etnoyer & Warrenchuk, 2007; Treude *et al.*, 2011). Indeed, in southern Brazil, *Schroederichthys saurisqualus* Soto, 2001, a deep-water catshark, uses patches of coral for egg-laying (Vooren & Soto, 2004; R. A. Montibeler, unpubl. data).

Egg cases of scyliorhinids exhibit, in general, a spindle-shaped, depressed morphology, with anterior and posterior borders. Depending on the species, coiled, convoluted tendrils or attachment fibres can be present on one or both borders (Ebert *et al.*, 2006). Interspecific modifications in egg case structure may indicate differences in the habitat on which they are deposited and can have important ecological implications (Castro *et al.*, 1988; Ebert *et al.*, 2006; Flammang *et al.*, 2007). Egg cases of *S. bivius* examined here did not show anterior horns, had coiled tendrils at the posterior end and very long, silky attachment fibres near the anterior border. This description adds new information to the morphology of *S. bivius* egg cases, since fibres had not previously been recorded by Mabragaña *et al.* (2011). The presence of these structures is associated with habitats where the eggs can be firmly anchored, such as those with corals, sponges and tubeworms. Oviposition strategy in *S. bivius* would consist in wrapping the tendrils and attachment fibres around sedentary organisms, similar to that reported by different authors for other scyliorhinids (Ebert *et al.*, 2006; Flammang *et al.*, 2007; Concha *et al.*, 2010). An understanding of such biological interaction dynamics is fundamental to preserving marine communities, particularly those associated with the benthos.

Some invertebrates live and feed inside egg cases of elasmobranchs, as in the case of the cocculiniform limpet *Addisonia excentrica* in egg cases of the lesser spotted dogfish *Scyliorhinus canicula* (L. 1758) (Roldán & Luque, 2010). Reports of epibiotic organisms on egg cases are lacking however. Upon anchoring to the bottom, they provide a firm substratum for the establishment of sessile invertebrates such as barnacles and sea squirts.

Egg cases with viable developing embryos were found in most egg cases, suggesting potential laying habitats for *S. bivius* at the sampled sites. For some catsharks, co-occurrence of neonates–juveniles and adults has not been observed and it has been hypothesized that the former would abandon nursery sites after hatching and return after a variable period of time (Ebert *et al.*, 2006 and references therein).

Authors wish to thank M.C. Oddone for her valuable help in getting part of the literature cited and A. Taverna for the sea squirt identification. Finally, we thank two anonymous reviewers for useful suggestions that really improved the original manuscript. This manuscript constitutes a contribution to the Argentinean 'Pampa Azul' Marine National Science Project. This study was partially supported by PICT 2014-0665, PICT 2013-0629 and PIP CONICET 11220130100339.

Supporting Information

Supporting Information may be found in the online version of this paper:
Table S1. Location of fishing hauls in the south-west Atlantic Ocean where egg cases of *Schroederichthys bivius* associated with invertebrates were collected.

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TABLE SI. Location of fishing hauls in the south-west Atlantic Ocean where egg cases of *Schroederichthys bivius* associated with invertebrates were collected

Research Vessel	Year	Latitude S	Longitude W	Depth (m)	Associated invertebrate	Egg cases number
E. Holmberg	2011	45.366	63.370	95	*Tedania (Tedaniopsis) mucosa*	1
E. Holmberg	2011	45.406	64.068	97	*Tedania (Tedaniopsis) mucosa*	1
E. Holmberg	2011	44.128	63.253	84	*Tedania (Tedaniopsis) mucosa*	1
E. Holmberg	2011	44.079	62.372	91	*Tedania (Tedaniopsis) mucosa*	1
E. Holmberg	2016	45.39640	64.04340	98	*Tedania (Tedaniopsis) mucosa*	1
E. Holmberg	2016	45.13960	62.46780	100	*Tedania (Tedaniopsis) mucosa*	2
E. Holmberg	2016	45.36820	63.36870	96	*Tedania (Tedaniopsis) mucosa*	5
E. Holmberg	2016	44.54150	64.10300	89	*Tedania (Tedaniopsis) mucosa*	1
E. Holmberg	2016	43.28320	61.49910	88	*Tedania (Tedaniopsis) mucosa*	1
E. Holmberg	2016	41.31940	59.42600	77	*Tedania (Tedaniopsis) mucosa*	3
E. Holmberg	2016	41.19470	59.27380	75	*Tedania (Tedaniopsis) mucosa*	1
Puerto Deseado	2012	53.26352	64.55565	130	Primnoidae	3
Puerto Deseado	2016	54.11611	65.57616	82	*Thouarella* sp.	3
Puerto Deseado	2016	54.14615	65.58379	74	*Thouarella* sp.	1
Puerto Deseado	2016	54.19915	64.14258	122	*Chaetopterus* cf. *antarcticus*	1