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Description of a unique catshark egg capsule (Chondrichthyes: Scyliorhinidae) from the North West Shelf, Western Australia

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Abstract

A review of the chondrichthyan reference collection of the Western Australian Museum led to the discovery of several lots of previously undescribed catshark egg capsules (Chondrichthyes: Scyliorhinidae) that initially could not be assigned to any particular genus due to their novel morphology. These egg capsules bear unique, well-developed ridges running longitudinally along the length of the egg capsule and are T-shaped in cross section, with one of these egg capsules having an embryo inside. The egg capsules and the embryo are described in detail, and compared against other genera of Australian catsharks. It is hypothesised that the egg capsules belong to the genus *Apristurus* Garman based on the gross morphology of the embryo. There are two candidate species of Australian *Apristurus* whose egg capsule remain unknown and to which genus the egg capsules could belong. However, based on the gross morphology of the embryo, it is possible that they represent an undescribed species.

Zusammenfassung

Bei einer gründlichen Nachuntersuchung der Referenz-Sammlung von Knorpelfischen im Westaustralien-Museum wurden mehrere Reihen von bisher unbeschriebenen Katzenhai-Eikapseln (Chondrichthyes: Scyliorhinidae) gefunden, die wegen ihrer andersartigen Ausgestaltung zunächst nicht einer bestimmten Gattung zugeordnet werden konnten. Diese Eikapseln zeigen sonst nicht vorkommende gut ausgebildete Leisten, die in Längsrichtung der Eikapsel verlaufen und im Querschnitt eine T-Form zeigen; eine der Eikapseln enthält einen Embryo. Die Eikapseln und der Embryo werden genau beschrieben und mit denen anderer Gattungen australischer Katzenhaie verglichen. Der Gesamtgestaltung des Embryos nach dürften diese Eikapseln zur Gattung Apr*isturus* Garman gehören, so die Arbeitshypothese. Es gibt zwei in Frage kommende Arten der australischen Gattung *Apristurus*, deren Eikapsel bisher unbekannt ist und denen diese Eikapseln womöglich zuzuordnen sind. Geht man von der Gesamtgestaltung des Embryos aus, könnte es sich aber auch um eine bisher unbeschriebene Art handeln.

Résumé

Un inventaire de la collection de référence de Chondrichthyens du Western Australian Museum a permis la découverte de plusieurs lots d'oeufs en coques de requins-chats non décrits jusqu'ici (Chondrichthyes : Scyliorhinidae) qui, au départ, n'ont pas pu être attribués à un genre particulier à cause de leur morphologie originale. Ces oeufs en coques portent des stries uniques, bien développées, longitudinales, tout au long de la coque et ont une section en forme de T, et une de ces coques contenait un embryon. Les oeufs en coques et l'embryon sont décrits en détails et comparés à ceux d'autres genres de requins-chats australiens. On avance l'hypothèse que les coques appartiennent au genre *Apristurus* Garman sur base de la morphologie apparente de l'embryon. Il y a deux espèces possibles d'*Apristurus* australiens dont les oeufs en coques sont inconnus et auxquels ces oeufs-là pourraient appartenir. Toutefois, compte tenu de la morphologie générale de l'embryon, il est possible qu'ils proviennent d'une espèce non décrite.

Sommario

Una rivisitazione della collezione di condroitti del Western Australian Museum ha portato alla scoperta di molti lotti di capsule ovigere di gattuccio non descritte (Chondrichthyes: Scyliorhinidae), che, per la loro morfologia, non erano state assegnate a nessun genere. Queste capsule sono caratterizzate da ben sviluppate creste che percorrono tutta la loro lunghezza e che in sezione trasversale hanno forma a T. Una di esse conteneva all'interno un embrione. Le capsule e l'embrione sono descritte in dettaglio e comparate con quelle dei generi di gattuccio australiani. Sulla base della morfologia dell'embrione è stato ipotizzato che le capsule appartengano al genere *Apristurus* Garman. Esistono due specie australiane di *Apristurus* le cui capsule ovigere sono sconosciute e alle quali potrebbero appartenere quelle descritte in questo articolo. Tuttavia, sulla base della morfologia dell'embrione, è possibile che le capsule appartengano ad una specie non descritta.

INTRODUCTION

Recent taxonomic revisions, species descriptions

and nomenclatural changes to the Australian chondrichthyofauna (eg. Huveneers 2006; Last et al. 2006, 2007, 2008a-c; Yearsley & Last 2006; Last & Gledhill 2007; Jacobsen & Bennett 2007, 2009; Last & Chidlow 2008; Last & Stevens 2009) prompted a review of the chondrichthyan reference collection at the Western Australian Museum (WAM) to update or correct the nomenclature and species assignments of its specimens. During the course of that review, a number of interesting taxonomic finds arose. One of these was the discovery of several lots of a unique egg capsule belonging to a species of shark from the family Scyliorhinidae (catsharks).

The egg capsules discovered in the WAM collection were identifiable as scyliorhinid egg capsules due to their size, overall shape, and presence of an embryo associated with one of the egg capsules. However, it was immediately apparent that they represented an undescribed egg capsule, being unlike any other egg capsule yet described for a chondrichthyan fish. The character unique to these novel egg capsules was the presence of well developed ridges, T-shaped in cross section, that run longitudinally along the length of the egg capsules, with the egg capsules bearing very short horns and tendrils.

The unique characteristics of the egg capsules made it initially impossible to place them within a genus. However, an examination of the only embryo associated with the egg capsules provisionally identifies the species as a member of the genus *Apristurus* Garman, 1913. Although species of *Apristurus* are known to occur in the region, the egg capsules were recovered from localities from which specimens of *Apristurus* are not yet known (Last & Stevens 2009). Further, the gross morphology of the embryo does not agree with the *Apristurus* candidate species that are known to occur closest to the localities of the egg capsules and may therefore represent an undescribed species. This contribution describes these novel egg capsules and the associated embryo, and compares them to the other catshark genera, and members of *Apristurus*, known to occur in Australian waters.

MATERIALS AND METHODS

Morphometrics and meristics: Measurements of the dimensions of the egg capsule followed Gomes & de Carvalho (1995) with terminology adapted by Ebert et al. (2006) and Flammang et al. (2007), with the addition of egg capsule depth (ECD), the greatest transverse depth of the egg capsule.

Morphometric measures of the embryo follow Compagno (1984, 2001) with scyliorhinid adaptations from Human (2006). Total length of the embryo was taken via direct measurement, and a limited number of morphometrics were estimated to the nearest 0.5 mm from stereomicroscope photographs of the embryo and calibrated scale bar. With the proposed placement of the embryo within the genus *Apristurus*, morphometrics were again estimated from the stereomicroscope photographs using the methodology of Nakaya et al. (2008a).

Table I. Weight, morphometric measures (mm), and measurements as percentage of ECL (in brackets) of the egg capsules. Abbreviations – Wt, egg capsule empty dry weight (g); ECL, egg capsule length; ABW, anterior border width; ACW, anterior case width; WCW, minimum waist width; PCW, posterior case width; PBW, posterior border width; and ECD, maximum depth.

	P.28064-011	P.28097-005	P.30047-001
Wt	1.23	1.56	1.51
ECL	48	50	57
ABW	19 (39.6)	12 (24.0)	13.5 (23.7)
ACW	19 (39.6)	18.5 (37.0)	19.5 (34.2)
WCW	18 (37.5)	18.5 (37.0)	18 (31.6)
PCW	22 (45.8)	21.5 (43.0)	21 (36.8)
PBW	6 (12.5)	4.5 (9.0)	2.5 (4.4)
ECD	15 (31.3)	16 (32.0)	16 (28.1)

Photographs of the egg capsules were taken using a SLR digital camera. The embryo was mounted on a pin and photographs were taken using a Leica MZ16A stereomicroscope with a 0.63x lens, and Leica DFC 500 camera. The scale bar was calibrated using vernier callipers and Leica Application Suite ver.3.6.0 immediately prior to the photographs being taken.

Study material: All lots are deposited in the Western Australian Museum (WAM) ichthyological reference collection: WAM P.28064-011, single empty egg capsule, collected by N. N. Sinclair and P.F. Berry aboard *R.V. Courageous* scampi survey, 17 August 1983 from 450-452 m at 18º01'S 118º13'E, approx. 100 km SW of Rowley Shoals, Western Australia; WAM P.28097-005, single empty egg capsule, collected by N. N. Sinclair and P. F. Berry aboard *R.V. Courageous* scampi survey, 22 August 1983 from 410-414 m at 18°15'S 118°02'E, approx. 180 km SW of Rowley Shoals, Western Australia; WAM P.30047-001, single egg capsule with associated embryo, collected during a CSIRO scampi survey, February/March 1989, North West Shelf, Western Australia, with no further details.

Table II. Morphometric measures, and proportions as percentage of total length, of the embryo (WAM P.30047-001) estimated from photographs (Figs 4-6) taken using a stereomicroscope and calibrated scale bar. Two sets of measures are provided using the methodologies of Compagno (1984, 2001) and Human (2006), compared to Nakaya *et al*. (2008a), respectively. ‡Morphometric character number of Nakaya et al. for equivalent (or near equivalent) measurement. * Total Length was taken via direct measurement of the embryo. ? indicates that the corresponding morphometric measurement could not be estimated from the photographs using the methodology of Nakaya et al. (2008a). † Morphometric character of Nakaya et al. (2008a).

Morphometric	Per Compagno & Human		Per Nakaya et al.		
	mm	%	‡	mm	%
Total length*	27		1	27	
Snout to 1st dorsal origin	15	55.6	5	15	55.6
Interdorsal space	1	3.7	34	1	3.7
2nd dorsal-caudal space	1.5	5.6	-		
Snout to anal origin	15.5	57.4	9	?	?
Snout to pelvic origin	12.5	46.3	7	12.5	46.3
Snout to pectoral origin	8	29.6	6	8.5	31.5
Snout to vent length	13.5	50.0	8	13.5	50.0
Pectoral to pelvic space	3.5	13.0	37	3	11.1
Pelvic to anal space	0.5	1.9	-		
Anal to caudal space	2.5	9.3	-		
Head width at posterior margin of orbit	5	18.5	-		
Interorbital space	4.5	16.7	30	4.5	16.7
Snout to 1st gill slit	8.5	31.5	11	8.5	31.5
Snout to spiracle	7	25.9	12	7	25.9
Snout to orbit	5	18.5	13	5	18.5
Eye length	1.5	5.6	26	1.5	5.6
Snout to mouth	4.5	16.7	16	4.5	16.7
Snout to nares	3	11.1	-		
Mouth length	1	3.7	22	1	3.7
Mouth width	1.5	5.6	21	1.5	5.6
Nostril width	1.5	5.6	-		
Inner internares space	2	7.4	23	2	7.4
Outer internares space	4	14.8	-		
Pectoral length	3.5	13.0	-		
Pectoral anterior margin	2.5	9.3	52	3	11.1
Pectoral posterior margin	3	11.1	53	?	?
1st dorsal length	3	11.1	43	3.5	13.0
1st dorsal base	3	11.1	44	3	11.1
1st dorsal height	1	3.7	45	?	?
Pelvic length	3	11.1	57	3	11.1
Pelvic height	1.5	5.6	-		
2nd dorsal length	4	14.8	47	4	14.8
2nd dorsal base	2.5	9.3	48	2.5	9.3
2nd dorsal height	1	3.7	49	1.5	5.6
Anal length	4	14.8	62	?	?
Anal height	1	3.7	65	?	?
† PreD1-insertion length			4	17	63.0
† Pre-outer nostril length			14	3	11.1
† Pre-inner nostril length			15	3.5	13.0
† Nostril length			28	1.5	5.6
† Nostril-mouth space			29	1	3.7
† D1-D2 insertions			36	4	14.8
† P1-P2 origins			39	4	14.8
† P1 width			55	3	11.1

RESULTS

Egg capsule description: The weights and morphometric dimensions of the egg capsules are given in Table I, and photographs of each of the egg capsules are provided in Fig. 1. The egg capsules have an overall shape typical of scyliorhinid sharks (Ivanov 1987; Gomes & de Carvalho 1995; Ebert et al. 2006; Flammang et al. 2007), with a quadrangular outline rounded at the posterior end, posterior and anterior portions of the capsule separated by a waist, anterior horns, and posterior tendrils.

Although present in these egg capsules, the waist is only marginally narrower than the anterior and posterior case widths and is poorly defined. The egg capsules possess very short horns on either side of a relatively broad anterior margin. Only WAM P.28097-005 possessed what appeared to be a full complement of the tendrils, which had otherwise snapped off partially or totally on the other egg capsules. A single tendril extends from each side of the egg capsule. The tendrils were relatively short compared to other scyliorhinid egg capsules and very thick at their origins, but tapered quickly and tightly coiled. The lateral margins of the egg capsule turn abruptly medially at the posterior of the egg capsule, allowing for a very short posterior margin. The tendrils curve around tightly at the posterior, leaving little space between the tendrils and the posterior margin.

The ridges on the egg capsules are well developed, more so than in any other chondrichthyan egg capsule so far described. The ridges run longitudinally along the length of the egg capsule. The ridges are T-shaped in cross section (Fig. 2) and obscured the location of both the anterior and posterior fissures, which could not be located on any of the egg capsules. Each egg capsule had a lateral ridge on each of their sides, however, the number of ridges on the egg capsule surfaces varied between egg capsules, and each surface. WAM P.28064-011 possessed five ridges on one surface and six on the other, WAM P.28097-005 possessed six and seven ridges on each of its surfaces, respectively, and WAM P.30047-001 also possessed six and seven ridges, respectively.

Embryo description: The embryo (WAM P.30047-001) was approximately 27 mm TL and 0.2 g, attached by a yolk stalk to a yolk sac measuring 14 mm x 13 mm x 9 mm and weighing 1.2 g (Fig. 3).

Estimated morphometrics of the embryo are provided in Table II. There were few differences between the two morphometric methodologies, although several additional morphometrics were included following the Nakaya et al. (2008a) methodology.

The embryo (Figs. 4-6) was characterised by possessing a greatly depressed head and flat snout that is pointed and wedge-shaped in lateral view, with simple nasal flaps and no nasoral grooves, an arched mouth with well developed upper and labial furrows, body not compressed, spindle or tadpole shaped, a large first dorsal fin proceeded closely by a larger second dorsal fin, moderately sized, paddle shaped pectoral fins, very large pelvic fins and anal fin and a moderately-sized caudal fin with no crest of denticles. The mouth of the embryo was wide open.

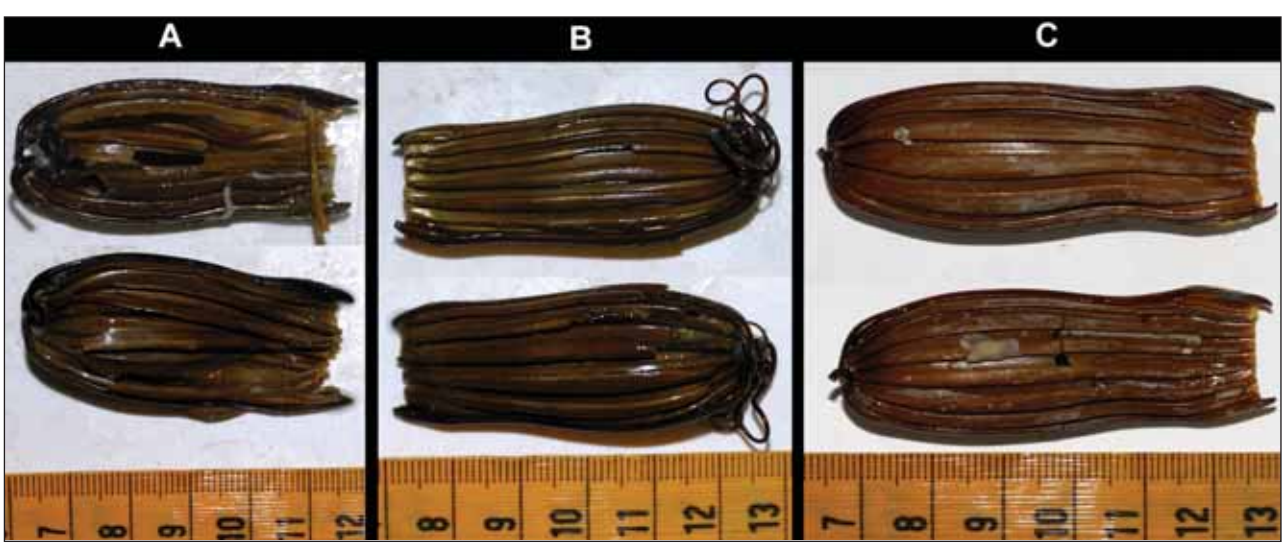

Fig. 1A-C. Photographs of the egg capsules collected on the North West Shelf assigned to *Apristurus*. Both surfaces are shown for each egg capsule under its respective subheading. A) WAM P.28064-011, ECL 48 mm; B) WAM P.28097-005, ECL 50 mm; and C) WAM P.30047-001, ECL 57 mm (which contained the only associated embryo).

Fig. 2. Cross section of part of an egg capsule (WAM P.30047-001) illustrating the T-shape nature of the ridges. Photo by B. A. Human.

Fig. 3. Embryo (WAM P.30047-001; 27 mm TL) in ventral aspect with attached yolk sac. Photo by B. A. Human.

DISCUSSION

Whereas the taxonomy of Australian sharks and rays are relatively well known, due in large part to the taxonomic works mentioned above, descriptions and species identification of egg capsules for oviparous chondrichthyans are less well known and are lacking in the literature, despite their potential use as taxonomic characters (see Gomes & de Carvalho 1995; Flammang et al. 2007). While recent species descriptions have included examples of egg capsules where known, egg capsules remain unknown for many Australian oviparous chondrichthyans. Likewise, descriptions of scyliorhinid egg capsules are limited (Springer 1979; Gomes & de Carvalho 1995; Ebert et al. 2006; Flammang et al. 2007).

The embryo is apparently in early to mid development judging by the presence of external gill filaments protruding through the gill slits and spiracles. Given the lack of information available regarding hatching times for *Apristurus* (and other scyliorhinids in general), the embryo's age can not be determined, but development of *Apristurus* embryos take 24-27 months in 5° C water based on observations of conspecifics at the Monterey Bay Aquarium (Flammang 2005; Flammang et al. 2007). Jones & Geen (1977) removed complete egg capsules from freshly caught *Apristurus brunneus* and maintained them in 10°C water. After a period of 7½ months, the embryos were approx. 30 mm (about the size of the current embryo), after 14 months were 55-60 mm long, and are free swimming at approx. 70-80 mm.

Although the author concedes that morphological features of an embryo at this stage of development are far from diagnostic for any particular species, the gross morphology of the embryo was developed well enough that there is little doubt that the shark belongs to the family Scyliorhinidae. Through a process of elimination of all other possible scyliorhinid genera known to occur in Australia, the combination of the above characters observable in the gross morphology suggest that the embryo belongs to the genus *Apristurus* Garman, 1913.

The definition of the genus *Apristurus* is a catshark of the Scyliorhinid subfamily Pentanchinae Smith & Radcliffe and tribe Pentanchini Smith & Radcliffe, with a combination of characters including a greatly depressed head and flat snout that is pointed and wedge-shaped in lateral view; nasal flaps simple and not elongate; nasoral grooves absent; mouth arched with well developed upper and lower labial furrows; body soft and relatively stocky, not compressed, spindle or tadpole shaped; two large dorsal fins, with

first subequal or smaller than second; pelvic fins that are larger than the second dorsal fin; a large anal fin that is larger than the pelvic and dorsal fins, and is separated from the lower caudal lobe by a notch only; and lacking a distinct crest of denticles on the upper or lower margins of the caudal fin (Nakaya 1975; Springer 1979; Compagno 1988).

The overall gross morphology and proportions of the embryo agree with *Apristurus*. Of the other scyliorhinid genera present in Australia, the embryo cannot be placed within the genus *Atelomycterus* because that genus possesses expanded nasal flaps that are fused into a nasal curtain, whereas the nasal flaps are simple on the embryo in question. The embryo is excluded from the genera *Figaro*, *Galeus* and *Parmaturus* because these possess distinct crests of denticles on the upper caudal fin margin (and lower caudal fin margin in *Figaro* and *Parmaturus)*, whereas no denticle crests are evident on the present embryo. *Cephaloscyllium* possesses a first dorsal fin that is much larger than the second dorsal fin, and no labial furrows; the opposite is true for the embryo in question. The anal fin is larger than the second dorsal fin in the embryo examined here, which is the opposite of that found in the genera *Aulohalaelurus*, *Bythaelurus* and *Halaelurus*, where the anal fin is subequal to the first dorsal fin. The genus *Asymbolus* has poorly developed labial furrows, expanded nasal flaps, and dorsal fins that are well separated from each other and the caudal fin, whereas the dorsal fins are close together and narrowly separated from the caudal fin in the embryo.

Egg capsules described for members of the genus *Asymbolus* have long tendrils, much longer than those observed on the present egg capsules, have fine silky longitudinal striations with long silky filaments emanating from the sides, which are lacking in the current egg capsules and the anterior horns are longer for *A. vincenti* compared to those observed on the current egg capsules, although the anterior horns are barely developed in *A. analis* egg capsules (Waite 1906; Whitley 1938). The egg capsules of *Atelomycterus* are smooth with no striations, elongate with a greatly depressed and tapering posterior margin and the long posterior horns are very close together and touch each other in some instances, producing only

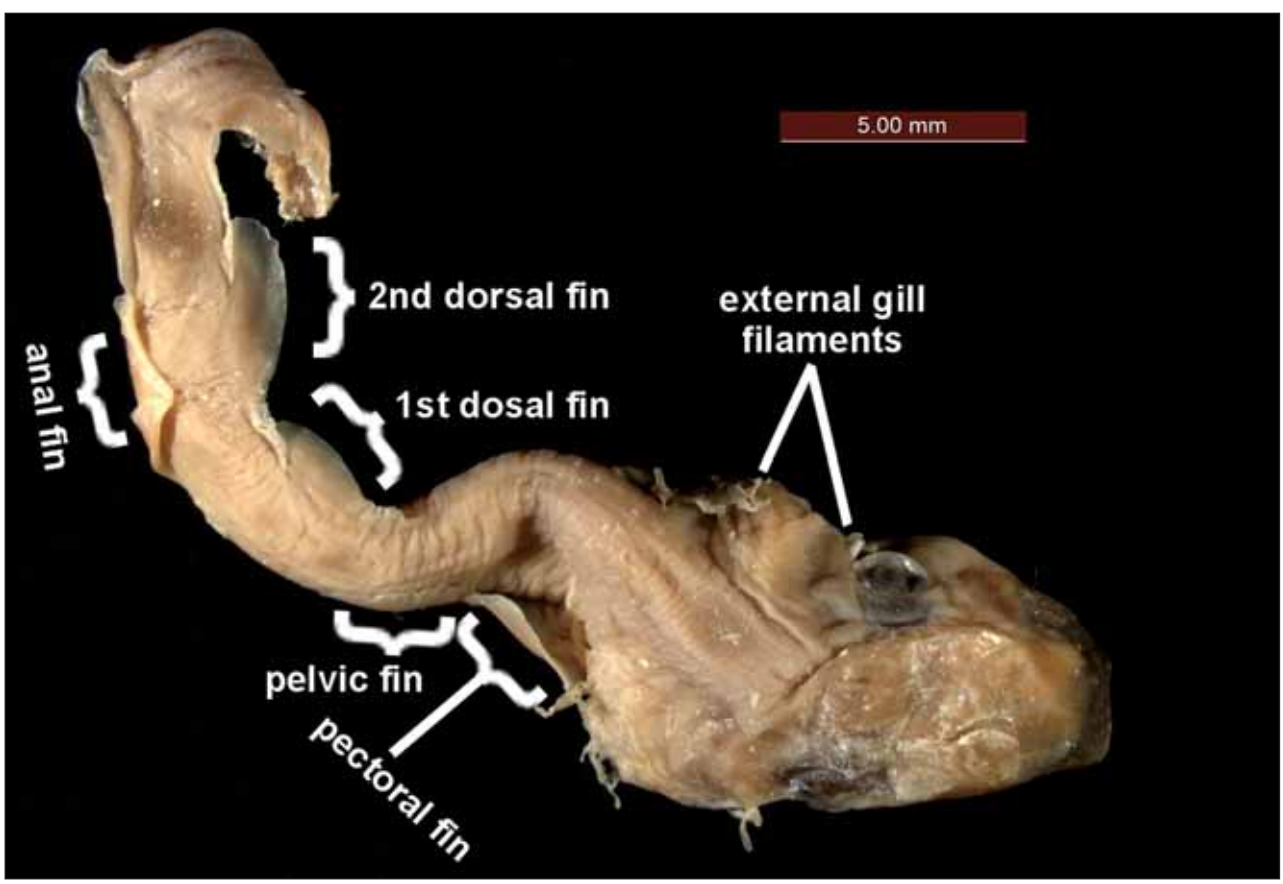

Fig. 4. Stereomicroscope photograph of the embryo (WAM P.30047-001) in dorsal view. Photo by C. Whisson.

short tendrils from the posterior end (Whitley 1939; Compagno & Stevens 1993a; Bor et al. 2003). The *Atelmycterus* egg capsule illustrated by Whitley (1938) is unlikely to be from that genus. Egg capsules are unknown for *Aulohalaelurus*, but the genus is presumedly oviparous (Springer 1979; Last & Stevens 2009). Members of the genus *Bythaelurus* variably display retained oviparity, probably giving birth to live young with egg capsules observed *in utero* being described as thin, fragile bags (eg. *B. lutarius*, *B. clevai),* or are egg layers (eg. *B. canescens*, *B. dawsoni*, *B. hispidus?)* producing tough egg capsules (Bass et al. 1975; Springer 1979; Séret 1987; Francis 2006). The egg capsules of *B. canescens* and *B. dawsoni* are very similar in overall form of the current egg capsules, although egg capsules of *B. dawsoni* only possess fine striations, whereas *B. canescens* egg capsules do have prominent striations (Springer 1979; Francis 2006). The egg capsules and reproduction remain unknown for the Australian representative, *B. incanus* (Last & Stevens 2009), however, the embryo in question here would have to undergo dramatic ontogenetic changes prior to hatching for it to be considered a member of *Bythaelurus*. Although egg capsules remain unknown for most Australian *Cephaloscyllium* (Last et

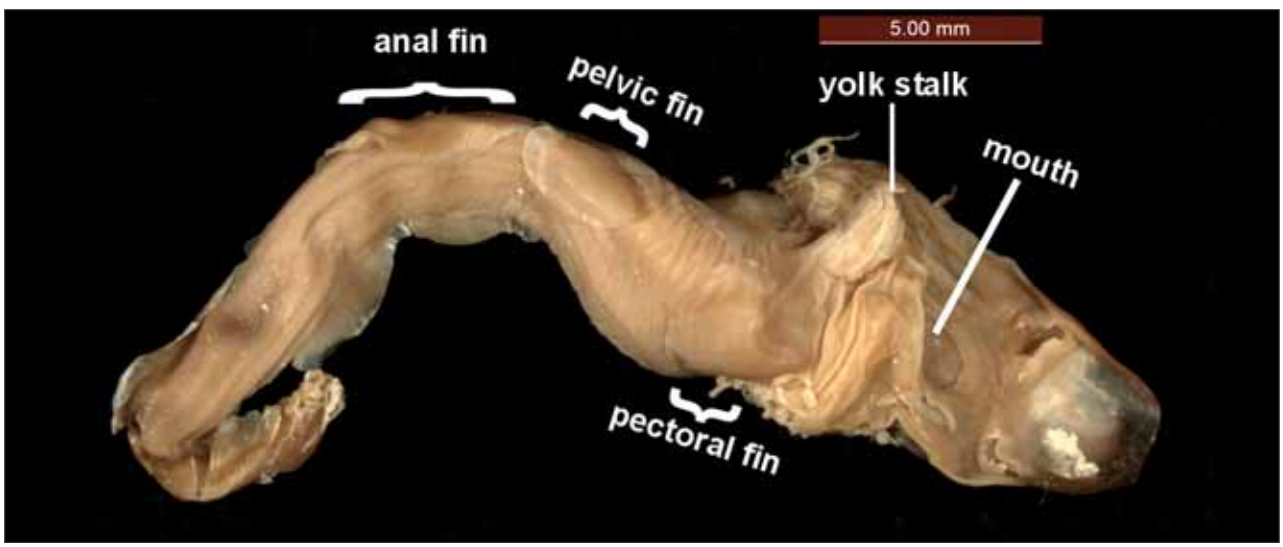

Fig. 5. Stereomicroscope photograph of the embryo (WAM P.30047-001) in ventral view. Photo by C. Whisson.

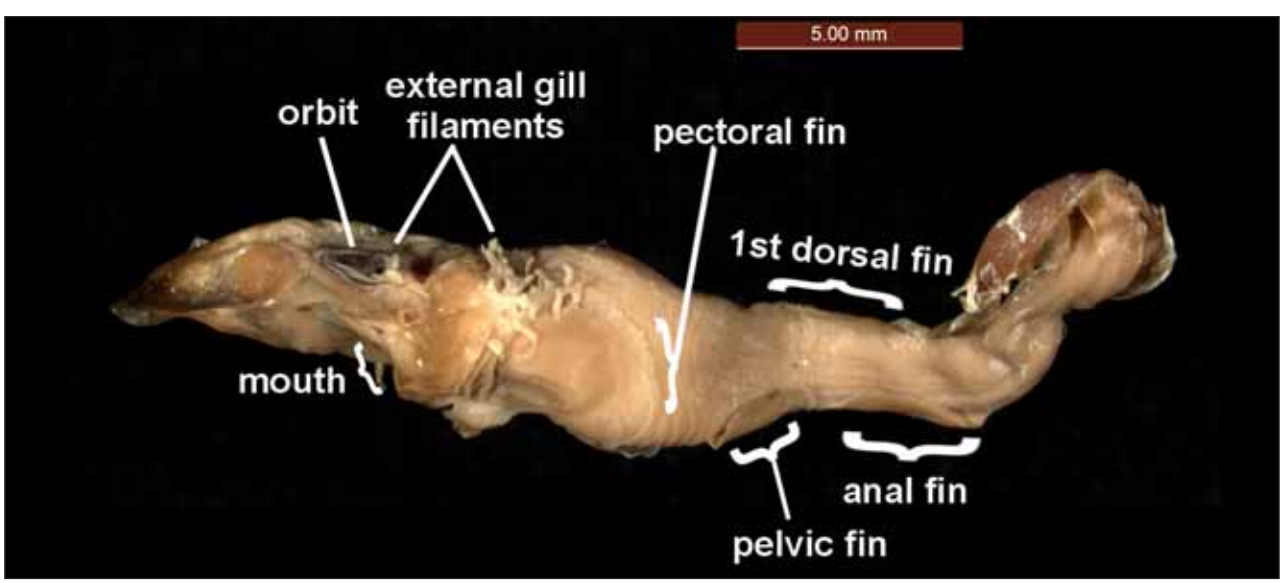

Fig. 6. Stereomicroscope photograph of the embryo (WAM P.30047-001) in lateral view. Photo by C. Whisson.

al. 2008c; Last & White 2008), those that are known are highly variable in form. *Cephaloscyllium albipinnum*, *C. hiscosellum*, and *C. variegatum* possess egg capsules that are similar in overall form with the present egg capsule, however, they have tendrils at their anterior ends and are smooth, as may be the case for *C. signourum* (Last et al. 2008b; White & Ebert 2008; Last & White 2008). *Cephaloscyllium laticeps* possesses distinctive and unique egg capsules that are laterally expanded, with long tendrils at both the anterior and posterior ends, and pronounced transverse ridges (Whitley 1938, as a synonym of *Parascyllium*; Springer 1979; Last et al. 2008b). Egg capsules appear to be unknown for the genus *Figaro*, despite *F. boardmani* being reported as being oviparous in the literature (Gledhill et al. 2008; Last & Stevens 2009). Egg capsules are also unknown for the only Australian representative of the genus *Galeus*, *G. gracilis* (Compagno & Stevens 1993b; Last & Stevens 2009). Elsewhere, *Galeus* egg capsules are known to vary greatly, from having a distinct waist and long tendrils at both the anterior and posterior ends, or long tendrils only at the posterior ends, to having egg capsule that closely resemble those of *Atelomycterus* and having fine or no striations (Nakaya 1975; Soto 2001; Iglésias et al. 2002). In the extreme, *Galeus polli* is known to have retained oviparity and give birth to live young (Springer 1979; Ebert et al. 2006). *Halaelurus sellus*, the only Australian representative of that genus, has an egg capsule with a distinct waist, no anterior horns, curved posterior margin with reduced horns and tendrils, and no striations (White et al. 2007). Other members of *Halaelurus* have similarly shaped egg capsules, but variably have anterior tendrils, with anterior and posterior tendrils varying in length between species, but all of them lack striations (Springer & D'Aubrey 1972; Nakaya 1975; White et al. 2007; Akhilesh *et al*. 2011). *Parmaturus bigus* is the only Australian representative of that genus (Last & Stevens 2009). Known from a single female specimen, the female aborted an egg capsule on capture that was presumably discarded because it was not described or illustrated (Séret & Last 2007). Elsewhere, the egg capsules of *Parmaturus* are elongate, with an indistinct waist, poorly to moderately developed anterior and posterior horns and tendrils (Cox 1963; Flammang 2005).

Chondrichthyan egg capsules with longitudinal striations have been described for species within several scyliorhinid genera, including *Apristurus* (Nakaya 1975; Springer 1979; Ebert et al. 2006; Flammang et al. 2007; Nakaya et al. 2008b), *Asymbolus* (Whitley 1938), *Bythaelurus* (Springer 1979, as a synonym of *Halaelurus)*, *Cephaloscyllium* (Whitley 1938), *Galeus* (Nakaya 1975; Springer 1979), *Schroederichthys* (Springer 1979; Gomes & de Carvalho 1995), and *Scyliorhinus* (Gomes & de Carvalho 1995), in most cases however, these are described as fine striations. Some *Cephaloscyllium* bear egg capsules with well developed ridges running transversely across the surface, but these are simple ridges and not T-shaped in cross section (Whitley 1938, as a synonym of *Parascyllium*; Springer 1979; Last et al. 2008b).

Flammang et al. (2007) list the descriptions available for egg capsules of the genus *Apristurus* and summarise the state of knowledge, to the time of that study, of egg capsules for the genus. Of the eight Australian representatives of *Apristurus*, egg capsules are known for *A. ampliceps*, *A. australis*, *A. longicephalus*, *A. melanoasper*, *A. pinguis*, and *A. platyrhynchus* (Nakaya 1975; Ivanov 1987; Nakaya & Sato 2000; Iglésias et al. 2004; Flammang et al. 2007, *A. ampliceps* as *Apristurus* sp. D *sensu* Last & Stevens 1994; Kawauchi et al. 2008; Nakaya et al. 2008b; Sato *et al*. 2008) and the current egg capsules do not correspond to any of those species. Egg capsules remain unknown for *A. bucephalus* and *A. sinensis* (Sasahara et al. 2008; White et al. 2008).

Amongst *Apristurus*, *A. laurussonii*, *A. macrorhynchus*, *A. manis*, *A. melanoasper*, *A. microps*, *A. pinguis*, *A. platyrhynchus*, *A. saldanha*, *A. spongiceps* have longitudinal striations on their egg capsules (Nakaya 1975; Nakaya & Sato 1998; Iglésias et al. 2004; Ebert et al. 2006, egg capsule assumed to be *A. saldanha* through process of elimination; Flammang et al. 2007; Kawauchi et al. 2008; Nakaya et al. 2008b), and of these, *A. laurussonii* and those assumed to belong to *A. saldanha* appear to have the strongest ridges but are simple in cross section, unlike the egg capsules in question.

Of those species whose egg capsules remain unknown, *A. bucephalus* is known to occur in the south-west of Western Australia (Last & Stevens 2009), a minimum of approximately 1700 km south of where the egg capsules were collected. In contrast, *A. sinensis* has been recorded from off central Western Australia and off Ashmore Reef (Last & Stevens 2009), approximately 500 km south and 900 km north, respectively, making it the most likely potential candidate based on distribution.

The known depth range of *A. sinensis* is 940-1290 m (Last & Stevens 2009), whereas the egg capsules

were collected from a depth range of 410-452 m. While it is certainly plausible that *A. sinensis* may exploit a shallower depth for a nursery, its extensive range (western and eastern Australia, South China Sea, and perhaps New Zealand (Last & Stevens 2009)) would suggest that if it did occur at such depths, that it might be reasonable to expect that specimens would have been captured which would corroborate its occurrence at such depths. However, the assignment of *A. sinensis* to Australian specimens is only tentative and the *A. sinensis* group in Australia displays three distinct genetic variations. Therefore data recorded for that species elsewhere may not be applicable to Australian examples, and perhaps even the populations within the Australian subset (White et al. 2008; Last & Stevens 2009).

Further, the gross morphology of the embryo does not agree with that of *A. sinensis*, which has relatively smaller pectoral and pelvic fins, and possesses a longer interspace between the pectoral fin insertion and pelvic fin origin than what is observed on the embryo. The author recognises that interpretation of the embryos' morphology is limited due to ontogeny and associated allometric growth, therefore cannot be considered definitive. However, it is typical in vertebrates that appendages grow only towards the later stages of development, therefore it is unlikely that the fins of the embryo are going to become proportionately smaller, and may in fact become proportionately larger.

The specific identity of the egg capsules in question could not be resolved in the current investigation. While there are potential described species that are candidates, there are morphological and/or distributional inconsistencies preventing any of these potential candidates from being assigned to the egg capsules based on our current knowledge of those taxa. A further possibility, is that the egg capsules belong to an as yet undescribed species of *Apristurus*. The morphometrics and gross morphology of the embryo suggest this.

Western Australia, and particularly the North West Shelf, remains a poorly surveyed region compared to other areas of Australia, such as southern Western Australia and central eastern Australia, as examples. It is likely that the known distributions and diversity of *Apristurus* in Western Australian waters may reflect the relatively low sampling effort that the region has received, and that their diversity and distributions are underestimated. Further surveying of Western Australia is needed, particularly of the North West Shelf, in order to resolve species distributions, taxonomic questions, and may ultimately lead to the discovery of the true taxonomic identity of the egg capsules in question.

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