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Two new species of *Adontorhina* Berry, 1947 (Bivalvia: Thyasiridae) from the Porcupine Bank, off the west coast of Ireland

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Abstract

A minute bivalve, *Adontorhina keegani*, new species (Thyasiridae) is described from the Porcupine Bank, west of Ireland. The new species occurs between 300 and 789 m on the continental slope. The shell is elongate and compressed, with a flattened posterior and complete lack of radial sulcus. The shell has a hinge margin bearing irregular granules and noticeably low umbones, located in the posterior. Hydroids were found growing on the margins of the shell, indicating a shallow burrowing habit. *Adontorhina similis,* new species, was previously recognized as a European variety of *Mendicula pygmaea* Verrill & Bush, 1898, but is here shown to be a distinct species. The hinge bears irregular granules, which precludes classification as a *Mendicula* species. The shell is elongate, moderately inflated with prominent umbones and a pointed posterior margin. The posterior flank of the shell is flattened and does not bear hydroids. In comparison with previously described species of *Adontorhina*, the new species are more elongate and less inflated.

Key words: Bivalvia, Thyasiridae, *Adontorhina*, irregular hinge granules, hydroids, Porcupine Bank

Introduction

The family Thyasiridae comprises a group of mostly small to minute bivalves, including ten genera from around the world. Members of this family are predominantly found in cool water, living infaunally, from the sublittoral zone to hadal depths. An adaptation shared by some Thyasiridae and Lucinidae is the burrowing foot which creates a mucus-lined inhalant tube enabling the animals to live below the redox potential discontinuity layer in the sediment. Thyasirids are often found in nutrient poor or ‘stressed’ areas which causes an exclusion of most other bivalve species (Kauffman, 1967) as well as being a frequent component of deep-sea benthic faunas (Payne & Allen, 1991).

The genus *Adontorhina* Berry, 1947, is composed of a group of three small species, so far recognised only from the west coast of North America and the north-western Pacific Ocean. The genus is distinguished from other thyasirid genera by unusual granules on the hinge plate. The type species, *Adontorhina cyclia* Berry, 1947, was described from the southern California Pleistocene, but living populations were subsequently found off California (Jones, 1965; Jones & Thompson, 1986) and as far north as Alaska (Scott, 1986; Coan *et al.* 2000). The range of the species was later extended to the north-western Pacific (Kamenev, 1996). Scott (1986) and Coan *et al.* (2000) described two additional species in the genus but, as yet, no species of *Adontorhina* have been recorded from outside the North Pacific Ocean.

The taxonomic placement of this genus by some authors has been met with controversy. Categorized by some as belonging to the subfamily Axinopsidinae Bernard, 1983, some authors (Berry, 1947; Hertlein &

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Grant, 1972) questioned its placement in the family Thyasiridae Dall, 1900, owing to its lucinid features (chiefly, the single demibranch, lack of radial sulcus and expanded anterior). However, living animals display anatomical features which easily separate them from the Lucinidae, namely the digestive pouches and the lack of an exhalant siphon.

In recent surveys carried out by the National University of Ireland, Galway, a number of thyasirid species were collected from slope and abyssal depths around the Porcupine Bank, off the west coast of Ireland. Two of the thyasirid species collected, showed a resemblance to *Mendicula pygmaea* Verrill & Bush, 1898, and shared the character of the irregular granules on the hinge plate which was illustrated by Oliver & Killeen (2002, Plate 23C–F). The presence of this character suggests that such species are better placed in the genus *Adontorhina* Berry, 1947. Furthermore, one of the species (*Adontorhina keegani*, new species) has a high occurrence of hydroids attached to the shell, suggesting a shallow burrowing existence, similar to that indicated for *M. pygmaea* by Ockelmann in Oliver & Killeen (2002, Figure 4).

Materials and methods

Specimens were obtained during the Celtic Explorer cruises CE03 and CE04 by the National University of Ireland Galway to investigate the benthic fauna of the deep sea off the west coast of Ireland in October 2003 and February 2004 respectively. The samples were taken using an Ekman box corer (0.25 m^2 surface area).

Gross anatomy was examined from formalin-preserved material lightly stained in Ehrlich’s haematoxylin. The shells were dissolved using a 5% dilution of acetic acid in water. The remaining periostracum was removed using fine needles. Specimens for sectioning were fixed in 2.5% Gluteraldehyde in 0.4M cacodylate buffer and seawater (pH 7.2 and 1100mOsM) for 12 hours. The specimens were then rinsed in buffer and post fixed in 2% osmium tetroxide in buffer for 1 hour. Specimens were then dehydrated in a series of Ethanol, transferred to Araldite (Epoxy resin) and heated at 55°C for 48 hours. The embedded animals were then sectioned at 2 µm thickness at 25 µm intervals on a Reichert-Jung microtome. These sections were stained with toluidine blue and examined under a compound microscope. Temporary mounts were made using glycerine and the gross morphology was drawn. Pencil illustrations were prepared using a camera lucida on a Nikon microscope and then inked by tracing onto transparent velum. Shells were mounted on stubs and coated with gold for examination with a Hitachi S-Series Scanning Electron Microscope. Additional material from the North Sea oilfields was provided by the staff of National Museum of Wales. Material from the western Atlantic was provided by Professor John Allen of the University Marine Biological Station Millport. High definition photographs of type material of *Mendicula pygmaea* were provided by Ellen Strong (Department of Invertebrate Zoology) at the National Museum of Natural History, Smithsonian Institution, USA. Type material is held at the National Museum of Ireland – Natural History and the National Museum of Wales.

Institutional abbreviations:

NMINH	National Museum of Ireland – Natural History
NMW	National Museum of Wales

Systematics

Family Thyasiridae Dall, 1900

Genus *Adontorhina* Berry, 1947

Type species: *Adontorhina cyclia* Berry, 1947

Description. Shell small, fragile, compressed to orbicular; surface sculpture of smooth commarginal striae, radial sulcus reduced or lacking. Beaks prosogyrous, low on the dorsal margin. Periostracum thin, lightly straw coloured. Ligament mostly internal, set on a narrow sunken shelf posterior to the beaks. Hinge plate composed of two sections, both anterior and posterior to the beaks; without true teeth but with irregular granules varying between species from weakly to strongly expressed. All possess a single demibranch. Foot with heel, lateral pouches relatively small and undivided. Surface of lateral pouches has the appearance of arborescent tufts.

Remarks. The irregular granules on the hinge margin have only been reported in this genus. Indeed, when first discovered Berry (1947) recorded "I have been unable to find any described genus or species to which it can be referred", owing to the uniqueness of the granular hinge. A large majority of the shells in the Thyasiridae have either edentulous hinges or underdeveloped tubercles instead of teeth (Payne & Allen, 1991). Coan *et al*. (2000) separated the externally similar *Adontorhina* from *Leptaxinus* Verrill & Bush, 1898, on the basis of the distinctive hinge. Scott (1986) remarked that there is wide variation in strength of expression of the irregular granules across the genus. While the granules on the hinge plate is the strongest character uniting the species of *Adontorhina*, all have a reduced sulcus, low umbones and the lateral pouches are undivided and not thrown into numerous lobes. The foot of each species is noticeably shortened with a deep sagittal groove.

Adontorhina keegani Barry & McCormack, new species

(Figures 1–3)

Type locality. Porcupine Bank, 53° 29.9'N, 13° 59.9'W, 300 m Eastern Atlantic.

Holotype. A complete shell, collected by P.J. Barry (10/11/03), NMINH.2006.57 Measurements (Length x height x breadth) 0.94 mm x 0.7 mm x 0.38 mm.

Paratypes. Three complete shells, as holotype, NMINH.2006.64.1–4. Measurements 0.6 mm x 0.42 mm x 0.3 mm; 0.73 mm x 0.55 mm x 0.35; 0.68 mm x 0.49 mm x 0.33 mm.

Two paratypes prepared for electron microscopy, NMINH.2006.65. Measurements 0.92 mm x 0.7 mm x 0.37 mm. NMW.Z.2007.008. Measurements 0.98 mm x 0.76mm x 0.5 mm.

Etymology. Named after Professor Brendan F. Keegan in recognition of his contribution to marine science studies in Ireland over many years.

Material examined. CEO3 Station 8 52° 59.9'N, 13° 59.9'W, 191.6 m, 4 specimens; CEO3 Station 09, 53° 29.9'N, 13° 59.9'W, 300 m, 3 specimens; CEO4 Station 05, 52° 59.9'N, 12° 44.9'W, 789 m, 8 specimens.

Distribution. Found in muddy sand on the Porcupine Bank, West of Ireland, on either side of the highest point of the bank. Depth range 300 – 789 m.

Shell description. Shell minute, maximum length to 0.98mm, fragile, compressed; elongate oval, length / height ratio of 1.2-1.36; inequilateral, anterior end longer; anterodorsal margin straight initially, rising above the horizontal plane before descending into broadly rounded anterior; ventral margin weakly curved until intersected by the weak posterior sulcus; umbones small, sunken, orthogyrate; prodissoconch I approximately 130 µm in diameter; lunule obscure, with raised commissure; escutcheon obscure; periostracum thin, lightly straw coloured; surface smooth near the umbones, thickened commarginal striae towards the margins, radial striae few, confined to the posterior (Figure 1A); colour white, transparent in juveniles; ligament mostly internal, on a sunken plate, one third the length of the dorsal margin; hinge plate composed of two sections (Figure 1E), anterior section thinner than posterior section. Irregular granules visible in both valves, anterior and posterior to the beak; directly below the beak, hinge plate is not visible.

Internal anatomy. Both adductor muscles are relatively large, the posterior muscle is rounded but with a tapered ventral end; both muscles are divided into quick and catch areas (Figure 2); anterior muscle much larger than the posterior. There is a single point of mantle fusion to form the posterior exhalent aperture. The

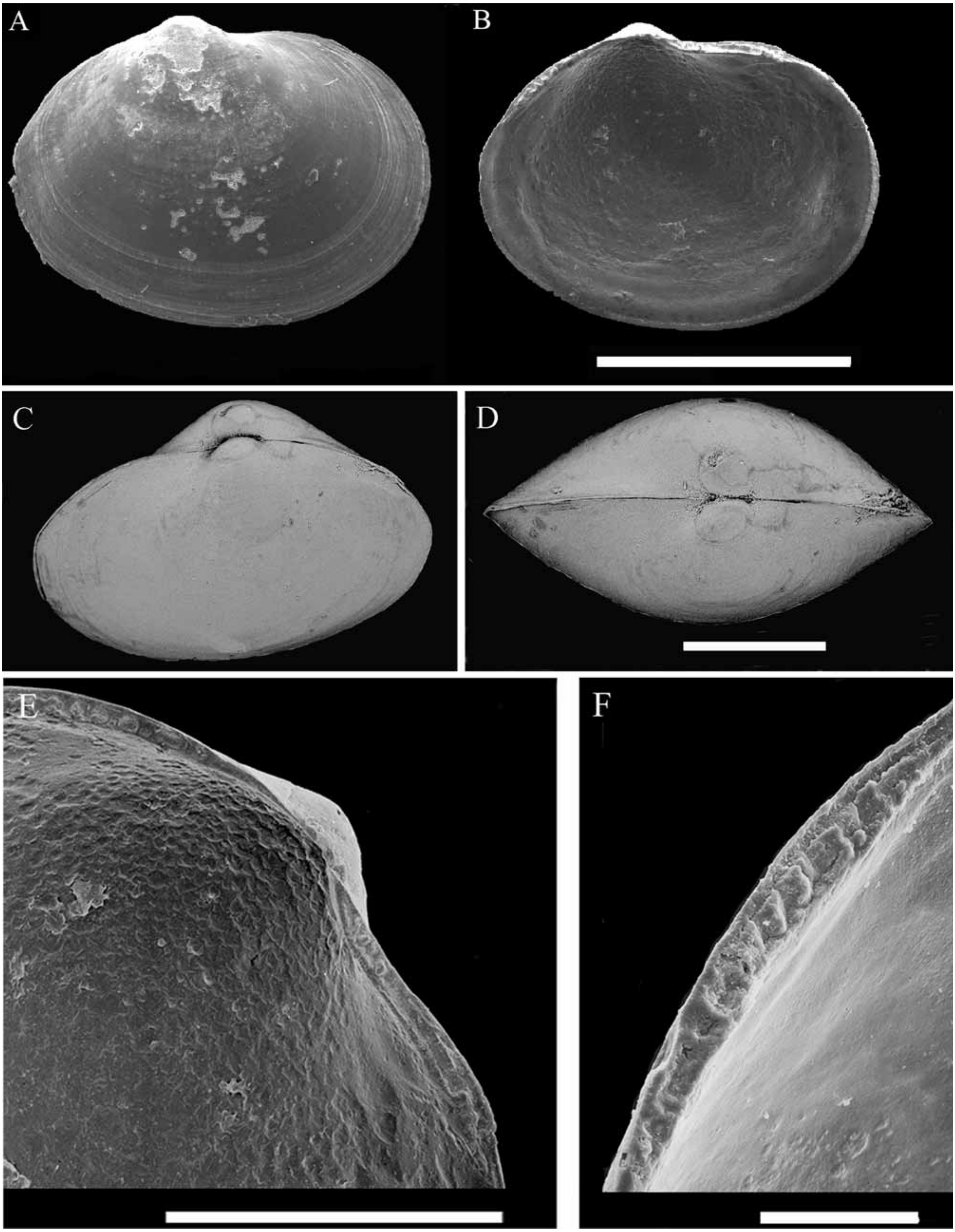

FIGURE 1. Exterior (A) and interior view (B) of the valves of *Adontorhina keegani* (NMINH.2006.65). Scale bar = 500 µm. (C) Dorsal view and oblique view (D) of *Adontorhina keegani* (NMW.Z.2007.008). Scale bar = 500 µm. (E) Hinge of *Adontorhina keegani*. Scale bar = 300 µm. (F) Close up of hinge of *A. keegani*. Scale bar = 100 µm.

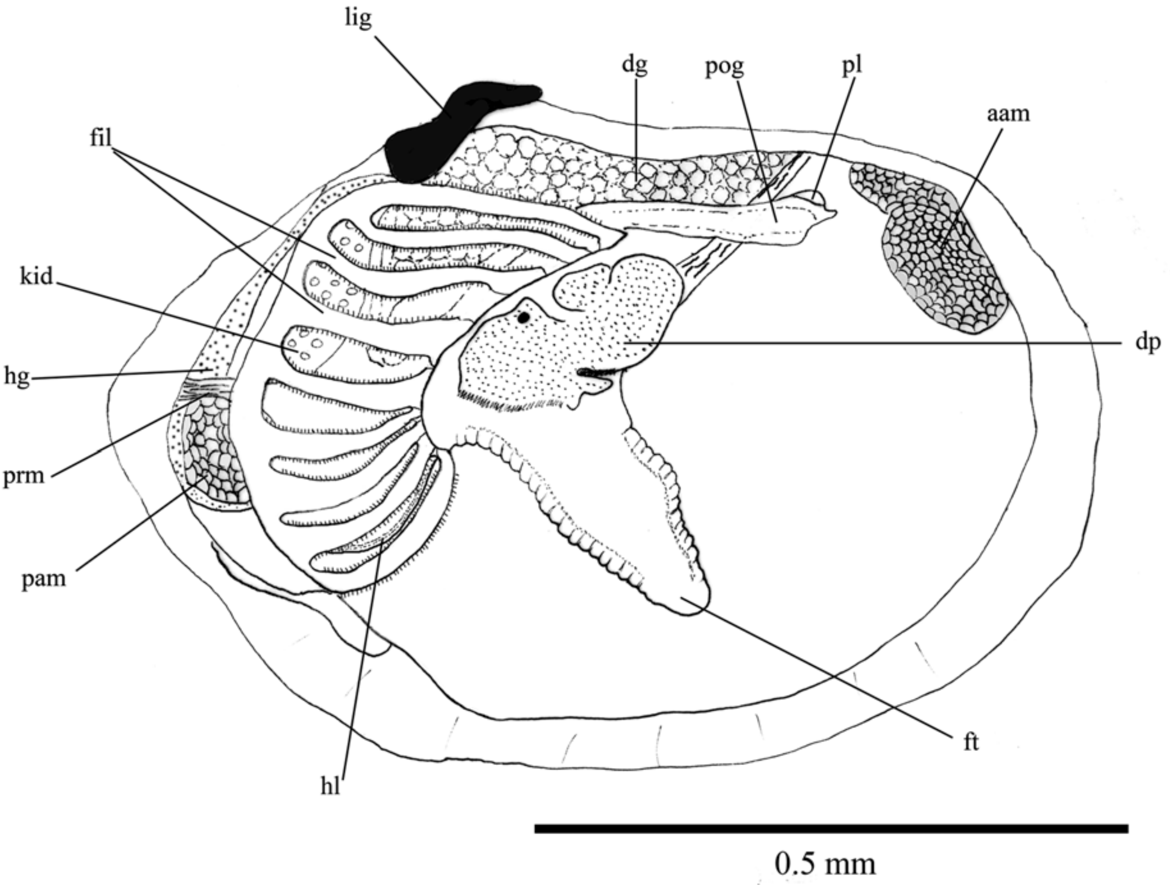

FIGURE 2. Generalized diagram of the gross anatomy of *Adontorhina keegani*, from CEO4 Stn. 05 on the Porcupine Bank. Key: aam, anterior adductor muscle; dg, digestive gland; dp, digestive pouch; fil, gill filaments; ft, foot; hg, hindgut; hl, heel; kid, kidney; lb, lobes; lig, ligament; pam, posterior adductor muscle; pl, palps; pog, proximal oral groove; prm, pedal retractor muscle.

FIGURE 3. Specimens of *Adontorhina keegani* showing the presence of hydroids, also showing the single specimen found without hydroids. Scale bar = 500 µm.

mantle is thin, and contains a small glandular area below the anterior adductor muscle; inner mantle fold not expanded, with a small cluster of gland cells overlain by a thin layer of radial muscle; rejection tract wide and shallow; middle and outer mantle folds very short, forming a shallow periostracal groove. Each gill has a single demibranch, comprised of seven to eight filaments; gill filaments type 2 (Dufour, 2005); filaments short but laterally expanded with well developed filamentar muscles; latero-frontal cilia well developed; interfilamentar junctions occur. Labial palps small, positioned near the end of the proximal oral groove; groove very long, wide. Oesophagus short, descending into a small stomach. Hindgut loops very high before descending along the posterior margin, through the pericardium, becoming markedly widened as it descends down to the posterior adductor muscle. The lateral pouch is very small (in contrast to most other thyasirids); just visible underneath the anterior end of the gill filaments with one marked indentation in its surface; pouch unlobed, not divided. Digestive gland and kidney large (consistent with the other species in the Thyasiridae). Foot short and well ciliated, the cilia extending back over the heel; tip of the foot very narrow and pointed; heel very well developed as are the pedal retractor muscles; heel large, extending very far down into the mantle cavity; heel sagittally grooved; pedal retractor muscles well developed.

Differential diagnosis. The distinctive biangulate posterior shell margin separates *Adontorhina keegani* from other *Adontorhina* species. Also, *A. keegani* is markedly smaller than other species of *Adontorhina* which are usually 1.5 to 3 mm in diameter (Scott, 1986). The internal anatomy appears reduced compared to other *Adontorhina* species, with few gill filaments to each demibranch and small lateral pouches. The hindgut of *A. keegani* is greatly expanded in comparison with most other thaysirid species. Further features which separate *A. keegani* from other *Adontorhina* species can be found in Table 1.

Remarks. Hydroids were found growing on the valves of living specimens of *A. keegani* (Figure 3). Only one specimen out of fifteen was recorded as being free of epifauna.

Most of the specimens had a disproportionate grouping of hydroids on the posterodorsal margin. The hydroids on the posterior were always the largest and in some cases, grew to double the length of the shell they were attached to. Smaller hydroids were observed on the ventral and anterior margins. The occurrence of this epifauna was limited to the vertical axis of the shell, present only where the margins meet.

TABLE 1. Character matrix for *Adontorhina* species including the species described herein, *Adontorhina keegani* and *Adontorhina similis*.

	Adontorhina cyclia	*Adontorhina sphaericosa*	*Adontorhina lynnae*	*Adontorhina keegani*	*Adontorhina similis*
Shell Outline	Subcircular	Roundly subovate	Subovate	Elongate oval	Subovate
Shell Inflation	Moderate	Orbicular	Moderate	Compressed	Moderate
Escutcheon	Weak	Deeply cleft	Obscure	Obscure	Obscure
Shell posterior end	Rounded	Rounded	Acutely angulate	Biangulate	Acutely angulate
Umbones	Moderately inflated	Inflated, pronounced	Inflated, pronounced	Sunken	Inflated, pronounced
Beak position	Central	Posterior	Central	Posterior	Posterior
Hinge plate	Thickened	Thickened	Narrow	Narrow	Narrow
Geographical range	Northeast Pacific	Northeast Pacific	Californian coast	Porcupine Bank	Northeast Atlantic

Adontorhina similis, Barry & McCormack, new species

(Figures 4–5)

Mendicula pygmaea Oliver & Killeen (2002, p.56–58, plate 23)
Thyasira subtrigona Hartley (1984, p. 192)

Type locality. Porcupine Bank, 53°07.77'N, 13°13.37'W, 252 m Eastern Atlantic.

Holotype. A complete shell, collected by P.J. Barry, NMINH.2006.58. Measurements (Length x height x breadth). 1.14 mm x 0.78 mm x 0.62 mm.

Paratypes. Three specimens, as holotype, NMINH.2006.64.1–2. Measurements 1.25 mm x 0.94 mm x 0.6mm; 1.17 mm x 0.91 mm x 0.6 mm ; 0.91 x 0.69 x 0.44 mm.

Etymology. From the Latin similis, 'similar,' referring to the high degree of similarity in external appearance to *Mendicula pygmaea*.

Material examined. CEO3, Station GT, 54° N, 12° 24'W, 320 m 2 spec.; CEO3 Station 9, 52° 30'N, 14°W, 300 m 11 spec.; SFO3 Grab 7, 53°07.77'N, 13°13.37'W 252 m 6 spec.; SFO3 Grab 8, 53°07.77'N, 13°13.37'W 252 m 5 spec.; SFO3 Grab 15, 52°52.42'N, 12°26.52'W 382 m 8 spec.; SFO3 Grab 17, 52°38.77'N, 12°11.08'W 330 m 4 spec.; NMWZ.2001.097, ERT 92/082A 60° 36'N, 01° 39'E 130–145 m 200 spec.;

Distribution. Porcupine Bank, west of Ireland. Depth range 252–382 m. North Sea oilfields. Depth range 85–161 m (Oliver & Killeen, 2002).

Description. Shell minute (maximum size 2 mm), fragile, moderately compressed, colour white; subovate, longer than high (Figure 4); inequilateral, beaks in posterior; very thin, transparent periostracum; sculpture of weak commarginal striae; sulcus absent, posterior flank flattened; umbones inflated, pronounced, prosogyrate; prodissoconch I approximately 150 µm in diameter; lunule indistinct; escutcheon obscure; anterodorsal margin weakly curved, straight in some specimens, anterior broadly rounded; posterior markedly angulate; posterodorsal margin straight, sloping; hinge plate thin, divided into two sections, anterior section thicker, both with irregular granules (Figure 4C–D, F–H); small cardinal tubercle in the right valve with a corresponding depression in the left valve.

Internal anatomy. The anterior adductor muscle is larger than the posterior muscle (Figure 5); both muscles are divided into quick and catch areas; anterior muscle is elongate, while the posterior is round. Single point of mantle fusion occurs beneath the gill axis, forming the posterior aperture; mantle folds thin and extended, particularly the middle fold which is filled with glandular tissue; all mantle folds have a small area of concentric muscle within their tips; centre of the mantle edge has a single strand of radial muscle but is otherwise filled with a large blood space; inner mantle is fold compressed, with a poorly defined rejection tract; on the inner surface of the mantle edge between the inner and middle folds, the area has small underdeveloped lobes or folds; periostracal groove deep. There is no region of glandular tissue underneath the anterior adductor muscle. Each gill has a single demibranch comprised of ten to eleven filaments; ascending lamellae three quarters the length of the descending lamellae; filaments thin with well-developed eu-laterofrontal cilia; gill filaments type 2 (Dufour, 2005); where interfilamentar fusion occurs, the abfrontal areas and blood space remains wide and forms a strong connection; filamentar muscles absent. Labial palps relatively large, triangular. Oesophagus thickened, leading into a very large stomach. Hindgut loops above the stomach and descends around the outside of the posterior adductor muscle. Lateral pouches undivided, unlobed and end in a pointed tip ventrally; there are two tubules leading into the pouches. Kidneys paired, small. Foot short with a well developed heel; ventral portion of the heel contains glandular tissue which continues out to the tip of the foot; heel sagittally grooved; tip of the foot is undifferentiated from the heavily ciliated stem.

Differential diagnosis. The sharp angle created by the posterior shell margin in combination with the flattened posterior flank differentiates *Adontorhina similis* from other *Adontorhina* species. *A. similis* is similar to *Adontorhina lynnae* Valentich Scott, 2000; however, *A. lynnae* has larger, prominent umbones and a more densely granulated hingeplate. Internally, *A. lynnae* differs in having almost double the number of gill filaments in each demibranch and the labial palps are far more reduced than those in *A. similis*. The lateral pouches are larger and develop lobes on the posterior surface while the lateral pouches of *A. similis* are relatively smooth and simple. Further features which separate *A. similis* from other species of *Adontorhina* can be found in Table 1.

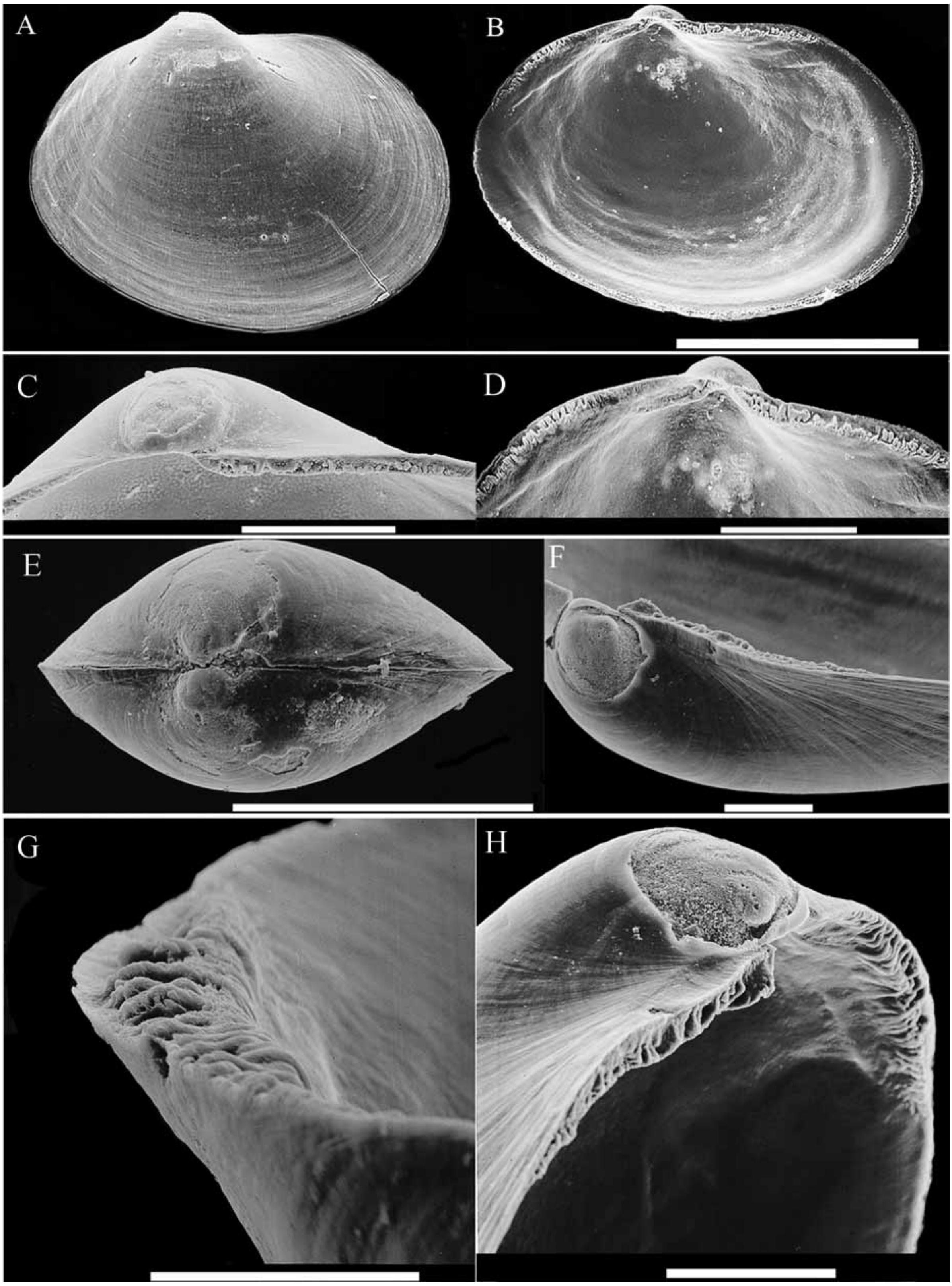

FIGURE 4. (A) Exterior and (B) interior view of *Adontorhina similis* from SFO3 Grab 15 on the Porcupine Bank. Scale bar = 500 µm. (C) Portion of hinge and (D) complete hinge of *Adontorhina similis*. Scale bar = 200 µm. (E) Dorsal view of *Adontorhina similis*. Scale bar = 1 mm. (F) Oblique view of hinge of *Adontorhina similis*. Scale bar = 100 µm. (G) Oblique view of portion of hinge. Scale bar = 50 µm. (H) Oblique view of whole hinge margin. Scale bar = 100 µm.

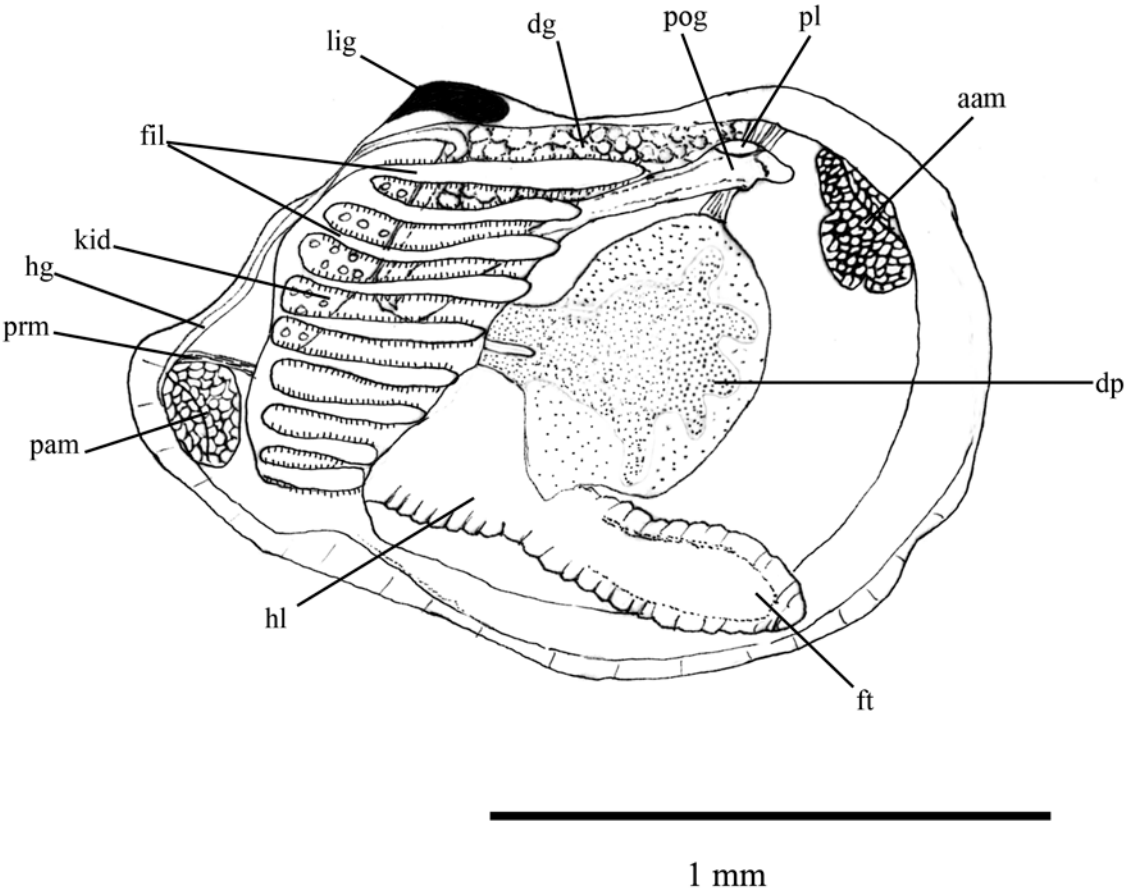

FIGURE 5. *Adontorhina similis*: internal morphology as seen from the right side of a wholemount, specimen from SFO3 Grab 15. (For legend of abbreviations see Figure 2).

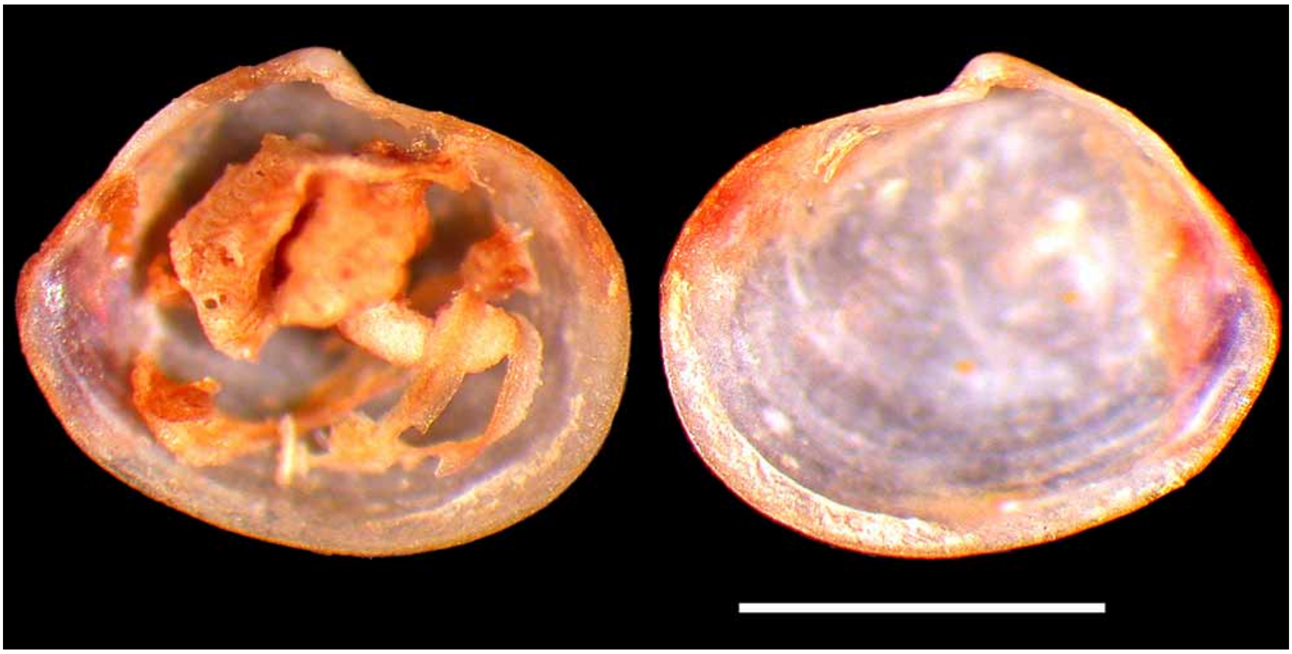

FIGURE 6. Internal view of *Mendicula pygmaea* Verrill & Bush, 1898, Lectotype, USNM 78368. Scale bar = 500 µm.

Remarks. Oliver & Killeen (2002) were the first to recognise the irregular granules in this species but declined to erect a new species. Specimens of *Mendicula pygmaea* Verrill & Bush, 1898, from the east coast of America were not available for them to examine. Examination of the holotype of *M. pygmaea* (Figure 6) and fresh material from the northwest Atlantic for the present study confirmed the lack of teeth in *M. pygmaea* (Figure 7). However, the European specimens, previously identified as *M. pygmaea*, have irregular granules on the hinge plate (Figure 4C–D, F–H), a feature which precludes inclusion in *Mendicula*. Furthermore, examination of the internal anatomy has shown additional differences between these species. The adductor muscles of *M. pygmaea* are smaller than those in *A. similis* as are the lateral pouches. The foot of *M. pygmaea* does not contain as well-developed a heel as that of *A. similis*. *M. pygmaea* from the northwest Atlantic remains a valid species, however, the European form can no longer be recognised as *M. pygmaea* and is here described as *Adontorhina similis*.

Oliver & Killeen (2002) reported that specimens which had previously been recorded as *Thyasira subtrigona* Jeffreys, 1858, by Hartley (1984) were actually specimens of *A. similis* (although Oliver & Killeen listed them as *Mendicula pygmaea*). The type specimen of *Thyasira subtrigona* was destroyed (Jeffreys, 1864) and has been considered a *nomen dubium* by van Aartsen & Carrozza (1997). Other authors have recognized *T. subtrigona* as a member of the superfamily Galeommatoidea (Bowden & Heppell, 1968; Oliver & Killeen, 2002).

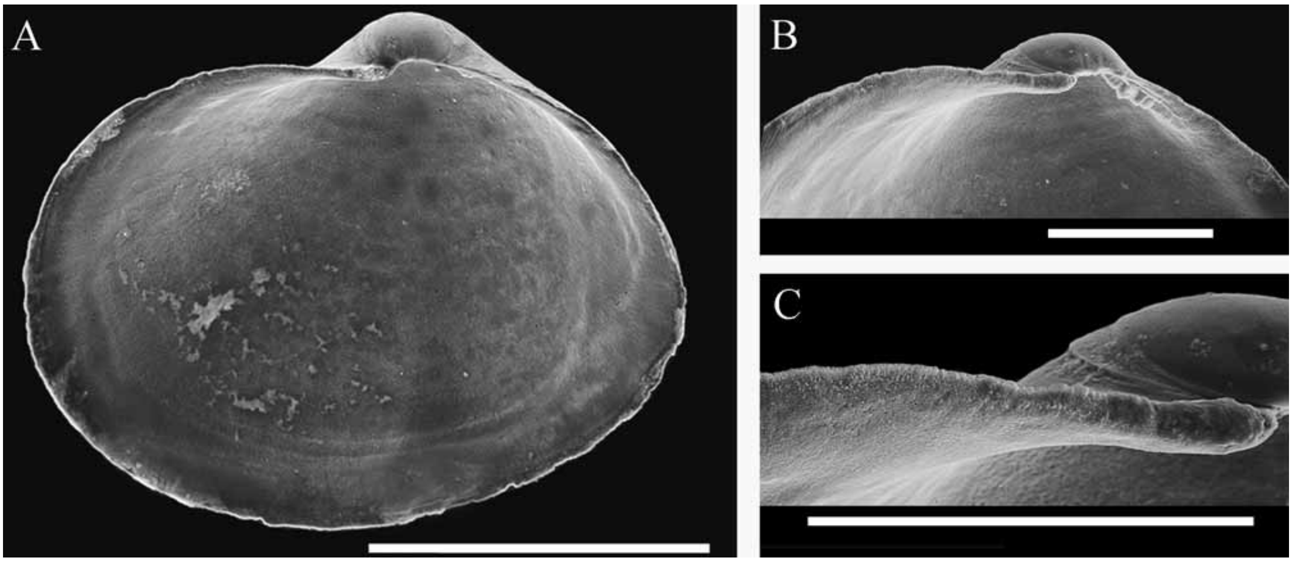

FIGURE 7. (A) Internal view of right valve of *Mendicula pygmaea* from the western Atlantic (39° 54.1' N, 70° 10.7' W, 457 m). Scale bar = 500 µm. (B) View of total hinge margin. (C) Close up view of anterior portion of hinge.

Discussion

Two new species of *Adontorhina* were collected from the top of the Porcupine Bank, west of Ireland, the first recorded specimens of *Adontorhina* Berry, 1947, from outside the Pacific. The genus *Adontorhina* now includes five species, encompassing a wide variety of shell types, ranging from the orbicular *Adontorhina sphaericosa* Scott, 1986, to the compressed elongate form of *Adontorhina keegani*. The only constant character of the shell uniting each *Adontorhina* species is the irregular granules on the hinge plate, which is known to vary considerably not only between species, but between individual specimens (Scott, 1986). With the wide variation in form and geographical separation of species from the Pacific and Atlantic, the genus may not be monophyletic. An investigation into the possible polyphyletic nature of the *Adontorhina* genus is currently being conducted (Barry & McCormack, in prep.). Under current classification, the newly described species must be assigned to the *Adontorhina* genus as no other thyasirid genera support the condition of the granules on the hinge plate.

Upon initial examination, it appeared that specimens of *Mendicula pygmaea* had been collected off the west coast of Ireland, adding to the records of this species with an apparent amphi-atlantic distribution (Høisæter, 1986; Seaward, 1990; Oliver & Killeen, 2002). However, comparison of type material of *M. pygmaea* (Figure 6), fresh material from the west Atlantic (courtesy of John Allen) (Figure 7) and the current material indicated that specimens collected from the Porcupine Bank are quite distinct from *M. pygmaea*. The irregular granules of the hinge precludes incorporation into *Mendicula* as the type species *Mendicula memorata* Iredale, 1924, possesses a single tubercle in each valve with an otherwise unaltered, smooth hinge margin. Samples from the North Sea provided by P. Graham Oliver and included in the study by Oliver & Killeen (2002) were determined to be the same as *Adontorhina similis*. Specimens examined by Høisæter (1986) who reported finding *Thyasira* (*Mendicula*) *pygmaea* off Norway, were not available for examination and cannot be confirmed as *A. similis*, so the amphi-atlantic distribution of *M. pygmaea* cannot be confirmed or disproved at this time.

Generally, species of Thyasiridae have been recorded to be deep burrowing species (Allen 1958; Dufour & Felbeck, 2003) but a more motile, shallower digging habit may be employed by *A. keegani* and *A. similis*, as illustrated by Oliver & Killeen (2002, Figure 4—labelled *Mendicula pygmaea*). The presence of hydroids on the shell of *A. keegani* indicates that this species is a shallow burrower as the suspension feeding hydroids need to be supplied with a constant flow of water (Ruppert & Barnes, 1994). This theory was first proposed for thyasirids by Payne & Allen (1991) who noted ‘attached hydroids’ on the more elongate forms. A similar state of association has been recorded before in a shallow burrowing bivalve—Edwards (1965) found a ‘frill’ of hydroids on and around the ventral and anterior regions of the shells of *Nucula sulcata* Bronn, 1831, a shallow burrowing protobranch. With the same condition existing on the present species, one can assume that a relatively, shallow habitat is shared by *A. keegani*, otherwise it would not support such a dense growth of hydroids.

The foot of each animal is much shorter than that of other species of the Thyasiridae (Payne & Allen, 1991). *Thyasira flexuosa* Montagu, 1803, can extend the foot up to fifteen times the length of the shell (Dufour & Felbeck, 2003). Even if the foot of the animals considered here were capable of such extension, the relative scale of the animal would restrict the depth of burial in the sediment as the foot is responsible for the construction and maintenance of the inhalant tube. This further indicates a shallower position in the sediment relative to other thyasirid species.

The gills of *A. keegani* and *A. similis* have a single demibranch with type 2 gill filaments (Dufour, 2005). The single demibranch is characteristic of the small thyasirids e.g. *Adontorhina*, *Axinulus*, *Leptaxinus* and *Mendicula*. This single demibranch condition is not indicative of the presence or absence of symbiotic bacteria (Dufour, 2005) although the structure of the gill filaments may be the determining factor. A species with a single demibranch, *Axinulus croulinensis* Jeffreys, 1847, has type 2 gill filaments without abfrontal extensions and only a small quantity of symbiotic bacteria (Dufour, 2005). While all species of the family Lucinidae have a single demibranch and symbiotic bacteria present, the gill filaments are thicker and have much larger extension of the abfrontal tissue (Taylor & Glover, 2000). It would appear that the abfrontal tissue volume, the epithelia of which the bacteria colonise (Reid & Brand, 1986; Dufour, 2005), is linked to symbiont presence. The observations carried out in this study could not confirm the presence of bacteria in the gill filaments of *A. keegani* and *A. similis*, but the limited volume of abfrontal tissue in the gill filaments, would suggest a lack of symbiotic bacteria or low quantities if present.

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