A new fossil *Adamussium* (Bivalvia: Pectinidae) from Antarctica

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Abstract: *Adamussium jonkersi* sp. nov. is described from the Late Oligocene Destruction Bay Formation, Wrona Buttress area, King George Island (South Shetlands), West Antarctica. The unit, characterized by volcanic sandstone, is a shallow marine succession deposited in a moderate- to high-energy environment. The thin-shelled pectinids, collected from the lower part of the unit, are preserved mostly as complete valves. Shell thickness, sculpture pattern and umbonal angle suggest a free-living, inactive swimming life habit.

Key words: Antarctica, *Adamussium*, Pectinidae, Destruction Bay Formation, Oligocene.

Introduction

Species of the pectinid genus *Adamussium* are recorded from the latest Early Oligocene onwards (Jonkers 2003; Quaglio et al. 2008). The living member of the genus, the circum-Antarctic species *Adamussium colbecki* (Smith, 1902), was the subject of several studies focusing on its geographical distribution (Schiaparelli and Linse 2006), systematics (Barucca et al. 2005), ecology (Stockton 1984), physiology (Chiantore et al. 2003; Heilmayer et al. 2005) and environmental analysis (Corsi et al. 2004; Caroli and Bottoni 2010).
Currently, four species of *Adamussium* are known, all restricted to Antarctica. Here we describe a new species from the middle Late Oligocene Destruction Bay Formation, cropping out at Wrona Buttress, King George Island (KGI).

**Background**

Four species attributed to the genus *Adamussium* have been identified so far from Cenozoic deposits and Recent records from Antarctica. The species *A. alanbeui* Jonkers, 2003 and *A. auristriatum* Quaglio et Anelli, 2008, from Oligocene to Early Miocene rocks, are the oldest known species of this genus (Jonkers 2003; Quaglio et al. 2008). Specimens of *A. alanbeui* and *A. auristriatum* were collected from CIROS-1 and CRP-2/2A drill-cores, Ross Sea, with additional specimens recorded in deposits of the Polonez Cove Formation, Lions Rump area, and the Cape Melville Formation, Melville Peninsula, both at KGI (Jonkers 2003; Quaglio et al. 2008). The second-oldest species, *A. auristriatum*, is recorded from the Early Oligocene Polonez Cove Formation, Vauréal Peak area, KGI (Quaglio et al. 2008). Much younger are *A. colbecki cockburnensis* Jonkers, 2003, found in the Late Pliocene Cockburn Island Formation, cropping out at the homonymous island, and *A. c. colbecki*, identified from the Late Pliocene to Early Pleistocene cores of CRP-1, James Ross Island and from Recent records around Antarctica (Jonkers 2003). The time ranges of all *Adamussium* species are shown in Fig. 1.

![Fig. 1. Stratigraphic ranges of *Adamussium* species (data from Jonkers 2003 and Quaglio et al. 2008).](image)

**Material and methods**

**Geological setting.**—The most extensive outcrops of the Destruction Bay Formation (DBF) occur in coastal cliffs to the northwest of Melville Peninsula (KGI, South Shetlands), named Wrona Buttress, where the unit reaches 90 m (Troedson and Riding 2002) to 100 m thick (Birkenmajer 1987) (Figs 2A, B; 3). Other exposures are found at the northern and southern edges of Cape Melville (Troedson and Riding 2002) (Fig. 2B). The DBF is the middle unit of the Moby Dick Group (see Fig. 2C), which also includes the lower Sherratt Bay Formation (olivine-augite basalt lavas) and the upper Cape Melville Formation (fossiliferous...
Fig. 2. Location maps of the Destruction Bay Formation and other related units. A. Melville Peninsula and vicinity, King George Island, West Antarctica. B. Destruction Bay Formation and other units of the Moby Dick Group. C. Subdivision of the Moby Dick Group (from Birkenmajer 1982).
marine shale, siltstone and fine sandstone) (Birkenmajer 1982, 2001; Birkenmajer et al. 1983; Troedson and Riding 2002). The DBF consists of pale gray to brown sub-horizontal volcanic sandstone, fine to medium and medium to coarse-grained, with occasional muddy and gravelly sandstone beds, tabular to channelized, displaying tabular to trough cross-bedding, with parallel and cross laminations (Troedson and Riding 2002).

Fossils occur throughout the unit, except in the uppermost subunit (Troedson and Riding 2002), and are more common in the bottom to the middle part of the unit (Birkenmajer 1982, 1987). Fossils include brachiopods (Biernat et al. 1985), foraminifers (Birkenmajer and Łuczkowska 1987), molluscs (belemnites, Birkenmajer et al. 1987; bivalves, Studencka 1991; gastropods, Birkenmajer 1982, 1987; Troedson and Riding 2002), cnidarians (solitary corals, Roniewicz and Morycowa 1987), as well as fish and wood fragments (Birkenmajer 1982, 1987; Troedson and Riding 2002; see also Beu 2009).

The pectinid species here described was collected from the lower part of the unit (Fig. 3), ranging from subunits 1 to 2 of Troedson and Riding (2002).

The Moby Dick Group records a glacial event in West Antarctica, with the DBF being an interglacial phase, followed by the glacial deposits of the Cape Melville Formation (Birkenmajer 1987). The DBF, dated as Late Oligocene (25.3 ± 0.8 Ma; Dingle and Lavelle 1998), is interpreted as a shallow marine succession originating from the reworking of basaltic lavas and tuffs of the underlying
Sherratt Bay Formation (Birkenmajer1982). The basal subunits were deposited in a moderate-energy environment and the upper subunits were deposited in a high-energy environment, with a shallowing-upward tendency showing possible prograding architecture (Troedson and Riding 2002).

**Fossil collection.** — The studied shells were collected by A. Gaździcki during the 5th Polish Antarctic Expedition to Artowski Station (1980/1981) and by M. Lavelle and D. Hornby in February 1996. The material includes eleven specimens with thin recrystallized shells, some of them are partial internal and external moulds with some preserved shell material. All examined specimens are still retained in the rock matrix. The specimens are housed in the collections of the Institute of Paleobiology PAS in Warsaw, Poland, under catalogue number ZPAL/L3/38–42, and the British Antarctic Survey (BAS) in Cambridge, United Kingdom, under number P.2904.10.1.

**Measurements and classification.** — Specimens were measured with reference to the hinge line. The length, height and width are in relation to the greatest measured lines parallel, perpendicular and orthogonal to the hinge line, respectively. Elongation and obesity indexes were calculated according to Stanley (1970). Abbreviations in tables are as follows: AA, length of the anterior auricle; E, elongation; H, height; L, length; LV, left valve; O, obesity; OL, length of the outer ligament; RN, rib number; RV, right valve; UA, umbonal angle; W, width.

Pectinid specimens from Wrona Buttress have some of the diagnostic characters of the genus *Adamussium* proposed by Jonkers (2003, p. 67). The characters include: extremely thin shells with low costae formed by simple crenulation of the disc, a straight hinge, and commarginal lirae.

**Systematic paleontology**

**Family Pectinidae Rafinesque, 1815**

**Genus Adamussium Thiele, 1934**

Type species: *Pecten colbecki* Smith, 1902; holotype: a right valve collected from 18 m depth off Franklin Island, Ross Sea, Antarctica, during the “Southern Cross” Expedition; Natural History Museum, London, number 1902.5.16.147 (Jonkers 2003).

**Adamussium jonkersi** sp. nov.

(Figs 4–6, Table 1)

Etymology: After H.A. Jonkers, for his noteworthy contribution to the paleontological studies of pectinids of the Southern Ocean.

**Material.** — Holotype, right valve (L3/41). Paratypes, right valves (L3/38, 40, P.2904.10.1) and left valves (L3/39, 42).

**Diagnosis.** — Radial sculpture of 7–9 broadly undulating, well-developed main plicae, intercalated with faintly developed secondary plicae on the ventral
part of the disc of most specimens; commarginal sculpture of distinct but weak lirae, with groups almost equally and closely spaced down the entire shell; RV anterior auricle rounded, with 3–4 radial costae observed internally.

**Description.** — Shell moderate to small in size, suborbicular (chlamydoid to aequipectinoid); dorsal margin short, ventral margin wide and rounded; equant; apparently very compressed, with moderately convex valves, LV more convex than RV; beaks orthogyrate; umbonal angle narrow \((ca 110^\circ)\); radial sculpture of 7–9 broadly undulating, well-developed main plicae, intercalated with faintly developed secondary plicae towards ventral part of disc; commarginal sculpture of distinct but weak lirae, in groups almost equally and closely spaced down entire shell; hinge line straight; RV auricles apparently asymmetrical, anterior auricle rounded, with 3–4 radial costae observed internally.

**Table 1**

Measurements of representative specimens of *Adamussium jonkersi* sp. nov.

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Valve</th>
<th>H</th>
<th>L</th>
<th>W</th>
<th>E</th>
<th>O</th>
<th>OL</th>
<th>AA</th>
<th>UA</th>
<th>RN</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZPAL/L3/40</td>
<td>RV</td>
<td>40.8</td>
<td>38.4</td>
<td>11*</td>
<td>0.94</td>
<td>3.71</td>
<td>24.5</td>
<td>11.5</td>
<td>110°</td>
<td>9</td>
</tr>
<tr>
<td>ZPAL/L3/41</td>
<td>RV</td>
<td>49.5*</td>
<td>53.5</td>
<td>6.8*</td>
<td>1.08</td>
<td>7.28</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>9</td>
</tr>
<tr>
<td>P.2904.10.1</td>
<td>RV</td>
<td>49.8</td>
<td>44.2</td>
<td>–</td>
<td>0.89</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>100°</td>
</tr>
</tbody>
</table>
Comparison. — The characters of all known Adamussium species are summarized in Table 2. Assessing all of the characters, each species is unique, however, not many of the characters on their own indicate a clear taxonomic affinity between any two taxa. This can be seen from Table 2, where one species seems to be more related to another considering a given character (e.g. the similar opisthocline shape of the valves in A. c. colbecki and A. c. cockburnensis) and to a different species if another character is considered (e.g. the moderate convexity of the valves and symmetrical auricles in A. c. colbecki and A. auristriatum). Finally, A. auristriatum and A. jonkersi sp. nov. are similar in possessing procline valves and striated auricles. A. alanbeui differs from all other species by lacking radial plicae. Apart from this, Table 2 also shows that only A. c. colbecki and A. jonkersi sp. nov.

<table>
<thead>
<tr>
<th>Features</th>
<th>Adamussium c. colbecki</th>
<th>Adamussium c. cockburnensis</th>
<th>Adamussium alanbeui</th>
<th>Adamussium auristriatum</th>
<th>Adamussium jonkersi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>moderate (mean H = 70 mm)</td>
<td>moderate (mean H = 56 mm)</td>
<td>small (mean H &lt; 50 mm)</td>
<td>moderate (mean H = 52)</td>
<td>small (mean H = 45 mm)</td>
</tr>
<tr>
<td>Valves</td>
<td>slightly opisthocline (AVH/PVH = 0.96)</td>
<td>opisthocline (AVH/PVH = 0.91)</td>
<td>acline</td>
<td>procline (AVH/PVH = 1.19)</td>
<td>apparently procline</td>
</tr>
<tr>
<td>Convexity</td>
<td>moderate</td>
<td>weak</td>
<td>weak</td>
<td>moderate</td>
<td>weak</td>
</tr>
<tr>
<td>Greater convexity</td>
<td>LV</td>
<td>LV</td>
<td>LV</td>
<td>RV</td>
<td>LV</td>
</tr>
<tr>
<td>Umbonal angle</td>
<td>very wide (138°)</td>
<td>wide (134°)</td>
<td>narrow (110°–120°)</td>
<td>wide (130°)</td>
<td>narrow (110°)</td>
</tr>
<tr>
<td>Radial sculpture</td>
<td>20 broadly undulatin with intercalated low plicae</td>
<td>15 broadly undulatin with intercalated low plicae</td>
<td>none</td>
<td>10–15 main plicae with intercalated low plicae</td>
<td>7–9 broadly undulatin mainly plicae with intercalated low plicae at ventral margin</td>
</tr>
<tr>
<td>Com-marginal sculpture</td>
<td>distinct lirae</td>
<td>lirae regularly and widely spaced</td>
<td>none</td>
<td>lirae, weakly marked, regularly and widely spaced</td>
<td>distinct but weakly marked lirae, with groups almost equal and closely spaced</td>
</tr>
<tr>
<td>Micro-sculpture</td>
<td>wide to narrow antimarginal ridges</td>
<td>narrow antimarginal ridges</td>
<td>narrow antimarginal ridgelets</td>
<td>narrow antimarginal ridgelets</td>
<td>–</td>
</tr>
<tr>
<td>Auricles symmetry</td>
<td>highly symmetrical (AOL/POL = 1.02)</td>
<td>highly asymmetrical (AOL/POL = 1.4)</td>
<td>slightly asymmetrical (AOL/POL = 1.1–1.3)</td>
<td>highly symmetrical (AOL/POL = 1.01–1.08)</td>
<td>apparently asymmetrical</td>
</tr>
<tr>
<td>Auricles sculpture</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>anterior auricle with radial costae</td>
<td>anterior auricle with radial costae observable internally</td>
</tr>
<tr>
<td>Byssal notch</td>
<td>very deep (arcuate or acute)</td>
<td>deep</td>
<td>very shallow</td>
<td>very deep (acute)</td>
<td>–</td>
</tr>
<tr>
<td>Number of byssal teeth</td>
<td>very variable (mean = 2.5)</td>
<td>–</td>
<td>–</td>
<td>6</td>
<td>–</td>
</tr>
</tbody>
</table>

Table 2
Comparative features of Adamussium colbecki colbecki, A. c. cockburnensis, A. alanbeui, A. auristriatum and A. jonkersi sp. nov. (1 according to Jonkers 2003; 2 according to Quaglio et al. 2008; 3 specimens from Destruction Bay Formation at Wrona Buttress; – not observable).
are morphologically distinct. Therefore, the small morphological differences between the other species possibly indicate either environmentally induced modifications (morphoclines) or gradual, anagenetic evolution.

Despite the poor preservation, *Adamussium jonkersi* sp. nov. easily can be differentiated from *A. auristriatum* by its weaker valve convexity, narrower umbonal angle, apparent asymmetry of auricles, and the fewer plicae, which are better-defined and more widely separated than in *A. auristriatum*, and with intercalated fine plicae observable only at the ventral margin of the valves. *Adamussium jonkersi* sp. nov. also differs from both subspecies *A. colbecki colbecki* and *A. colbecki cockburnensis* in its apparently procline valves, narrower umbonal angle, and the presence of radial costae on the RV anterior auricle.

**Shell microsculpture.** — The commarginal sculpture of *Adamussium jonkersi* sp. nov. is composed of distinct but weak lirae, in groups almost equally and closely spaced down the entire shell. Unlike other species of the genus, the microsculpture is not observed in SEM images (Fig. 6). Several explanations for this are possible, including the loss of ridgelets through ontogenetic development during life, the loss of this fragile microsculptural pattern during diagenetic recrystallization of the shell, or even because this microsculptural feature is absent (at least at the ventral margin of the available shell material studied under SEM).

**Paleoecology.** — According to Stanley (1970), pectinids with a swimming habit are characterized by an inequivalve condition, with the lower (right) valve being more convex than the upper valve, the presence of a thin shell with plicae, a broad umbonal angle (around 105° to 130°), and gapes adjacent to the auricles. Jonkers (2003), based on Stanley (1970), considered that swimming pectinids have an umbonal angle greater than 108° and a ratio between the anterior and posterior auricle lengths smaller than 1.7. However, Hayami (1991) stressed that the presence of radial folds results in an increase in drag coefficient. Stanley (1970) also affirmed that byssally attached pectinids, on the other hand, possess elongated anterior auricles, a byssal notch with no adjacent gapes, and a narrow umbonal angle. Of the features cited above, *A. jonkersi* sp. nov. displays an umbonal angle indicating that...
specimens range from byssate to swimming habits ($100^\circ$ to $110^\circ$), an apparently slight inequivalve condition, and a rather thin shell with broad undulating plicae, which point to a free-swimming habit. The plicate shell, a character present in all *Adamussium* species other than *A. alanbeui*, increases frictional drag in the water, thus reducing swimming capability due to the high-energy demand for swimming (Hayami 1991). The auricles are apparently asymmetrical. However, because of the incomplete preservation of the fossils, the features that would point to a truly byssate habit, such as the presence of a ctenolium and a wide byssal notch adjacent to the anterior auricle, are not observable. Despite the poor preservation, we infer a free-living, non-active swimming habit for *A. jonkersi*. More specifically, we suppose that it had the ability to clasp its valves in order to escape from a potential predator. However, this condition does not exclude the possibility that this scallop lived byssally attached during younger stages, as many pectinids do (Stanley 1970; Gould 1971).

**Taphonomy.** — The assemblage is composed of thin-shelled specimens, preserved as disarticulated, complete or partially fragmentary valves. The shells are in a convex-up orientation, concordant with bedding (Fig. 4). The sedimentological features of the unit indicate an estuarine environment to lower-energy tidal flat (Birkenmajer 1982). The disarticulation of the shells and their preservation in a convex-up orientation indicate lateral transport of the valves for a short distance due to traction currents. Indeed, as demonstrated by the experimental studies of McKittrick (1987) and Simões et al. (2006), convex shells always settle down in a concave-up (unstable) orientation. Hence, the convex-up attitude (stable orientation) of the shells in relation to bedding is achieved when waves, currents and bioturbation are present in the environment (Simões et al. 2006). Hence, despite their reclinant, free-living mode of life, the studied shells of *Adamussium jonkersi* are paraautochthonous (*sensu* Kidwell et al. 1986), and were deposited in a low- to medium-energy environment.

**Final comments**

The modern representative of the genus *Adamussium*, *A. c. colbecki*, is an endemic Antarctic species with a circum-Antarctic distribution (Dell 1972, 1990), and is found in almost all sites protected from high-energy water conditions around Antarctica (Schiaparelli and Linse 2006). Some studies have shown that this Antarctic species is highly sensitive to temperature increase, suggesting that it is physiologically adapted to low environmental temperatures (Viarengo et al. 1999; Peck et al. 2004). Because its ancestral lineage can be traced back to the Oligocene, we conclude that this important component of the Recent Antarctic fauna probably had an evolutionary past related to the Cenozoic cooling history of the continent. In this way, the new taxon contributes to the knowledge of the fossil record of the genus and potentially will help future studies of environmental change in Antarctica during the Cenozoic.
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