A new volute, *Ericusa ngayawang* sp. nov. (Gastropoda: Volutidae), from the Miocene of South Australia

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Abstract

Ericusa ngayawang sp. nov. is described from shells preserved in the Middle Miocene Cadell Formation in the western Murray Basin of South Australia. At the time the Murray Basin was part of the Southeastern Australian Marine Biogeographic Province. *Ericusa ngayawang* is a small heavily costate species of *Ericusa* with clear affinities to the Early Miocene *E. atkinsoni* of Victoria and Tasmania but can be distinguished from it by its smaller size, more slender proportions and its heavily costate body whorl. *Ericusa atkinsoni* and its relative, *E. macroptera*, inhabited the basins to the east of the Murray Basin during the Late Oligocene and Early Miocene but were extinct there before the end of the Burdigalian Stage of the Early Miocene. The persistence of *E. ngayawang* into the Langhian Stage of the Middle Miocene is another piece of evidence for partial biogeographic isolation of the western Murray Basin from the rest of the Southeastern Australian Province during the Miocene.

Introduction

Ericusa H. & A. Adams, 1858 is an endemic Australian genus of volutid that is characterized by a fusiform shell and a moderately large to large, paucispiral protoconch that has its axis of coiling offset from that of the teleoconch by about 45⁰ or less (Darragh, 1989). The oldest named species of the genus come from the Chattian Stage, Late Oligocene of the Jan Juc Formation in the Otway Basin of Victoria. Two distinct species are present in this formation, indicating that the genus has an older origin and that some diversification had occurred prior to the deposition of the Jan Juc Formation. Indeed, Darragh (1989) reported fragments of an undescribed volutid from the Priabonian Stage (Late Eocene), Narrawaturk Marl (as Browns Creek Clay) that bear similarity to *Ericusa atkinsoni.* These fragments have not been figured so it is not possible to assess whether or not they truly belong to *Ericusa.* There is a distinct possibility that they may belong to a stem-member of the tribe Livoniini to which *Ericusa* belongs (Bail & Poppe, 2001).

40   Among the early occurring species of *Ericusa*, *E. atkinsoni* (Pritchard, 1896) and its relative *E.*
41   *macroptera* (McCoy, 1866) stand out from extant species in possessing a strongly exsert tip of
42   the first protoconch whorl and axial sculpture in form of costae, often with shoulder nodules, on
43   at least the early teoloconch whorls. These two species bear some resemblance to early members
44   of *Livonia*, particularly *L. stephensi* (Johnston, 1880). *Livonia* is the presumed sister genus of
45   *Ericusa* (Darragh, 1989) and the resemblance between *L. stephensi* and especially *E. atkinsoni* is
46   probably an indication that neither is particularly distant from the common ancestor of the two
47   genera. Thus it is plausible that *E. macroptera* and *E. atkinsoni* are an early branch of the genus
48   and may well be the sister group to all other species in the genus. The *E. macroptera – E.*
49   *atkinsoni* lineage was short lived in south eastern Australia and makes its last appearance before
50   the end of the Burdigalian Stage (Early Miocene) in the Fishing Point Marl of the Otway Basin
51   (Darragh, 1989).

52

53   Here a new species of the *E. macroptera – E. atkinsoni* lineage is described from the Langhian
54   Stage (middle Miocene) of the more westerly Murray Basin of South Australia. It indicates that
55   the lineage survived into the Middle Miocene after going extinct in the more easterly Otway and
56   Bass Basins of Victoria and Tasmania. It is further evidence of the biogeographic distinctiveness
57   of the molluscan fauna of the Murray Basin in comparison to more easterly basins during the
58   Miocene.

59

60   **Geological Setting**
61   All of the specimens of the new species described here were collected from the Murbko Marl
62   Member of the Cadell Formation of the Morgan Subgroup (Lukasik & James, 1998; Cowley &
63   Barnett, 2007), at its type section on the east bank of the Murray River, 6 km south of Morgan,
64   South Australia (Fig. 1). The Morgan Subgroup is a part of the Oligo-Miocene Murray Group, a
65   marine sequence filling the western Murray Basin (Ludbrook, 1961; Lukasik & James, 1998;
66   Gallagher & Gourley, 2007). The Murbko Marl Member is a soft grey marl containing an
67   abundant and diverse mollusc assemblage (Lukasik & James, 1998). Much of the Murray Group
68   is composed of porous calcarenites where ground water has stripped away original aragonite,
69   leaving only moulds of aragonitic shells. The Murbko Marl Member is one of very few beds
70   where this has not occurred, making it a favourite destination for amateur collectors and
71   professional palaeontologists alike.
72   Outcrops of the Cadell Formation are restricted to the western part of the Murray Basin, in the
73   vicinity of the town of Morgan. Nevertheless subsurface argillaceous beds that can be correlated
74   with the Cadell Formation extend eastwards into far western Victoria (Gallagher & Gourley,
75   2007)
76   The age of the Cadell Formation is early middle Miocene (Langhian Stage) based on
77   biostratigraphy using planktonic foraminifera (Li & McGowran, 1999).

78

79   **Materials & Methods**

80 The specimens described herein were all collected from the Cadell Formation at its type section.
81 Collection of fossil shells in South Australia is considered "fossicking" and can be conducted on
82 non-reserved public lands without a permit provided no mechanical devices or explosives are
83 used and the specimens are not sold. Most specimens were found in the loose slips of eroded
84 material that cover much of the slope of the Cadell Formation at its type locality but the holotype
85 was excavated from the cliff section, at approximately two thirds of the height of the formation
86 from its base. These specimens have been deposited in the palaeontological collection of the
87 Museum and Art Gallery of the Northern Territory, held at Megafauna Central, in Alice Springs,
88 Northern Territory.
89 The electronic version of this article in Portable Document Format (PDF) will represent a
90 published work according to the International Commission on Zoological Nomenclature (ICZN),
91 and hence the new names contained in the electronic version are effectively published under that
92 Code from the electronic edition alone. This published work and the nomenclatural acts it
93 contains have been registered in ZooBank, the online registration system for the ICZN. The
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95 through any standard web browser by appending the LSID to the prefix http://zoobank.org/. The
96 LSID for this publication is: urn:lsid:zoobank.org:pub:0CFA9C77-D089-49D5-A6FA-
97 EA51099D57E6. The online version of this work is archived and available from the following
98 digital repositories: PeerJ, PubMed Central SCIE and CLOCKSS.
99

100 **Institutional Abbreviations**
101 **NMV** —Museum Victoria, Melbourne, Australia.
102 **NTM** —Museum and Art Gallery of the Northern Territory, Darwin and Alice Springs,
103 Australia.
104 **WAM** —Western Australian Museum, Perth, Australia.
105

106 **Systematic Palaeontology**
107 GASTROPODA Cuvier, 1795
108 CAENOGASTROPODA Cox, 1960
109 NEOGASTROPODA Wenz, 1938
110 VOLUTIDAE Rafinesque, 1815
111 CYMBIINAE H. & A. Adams, 1858
112 LIVONIINI Bail & Poppe, 2001
113 *ERICUSA* H. & A. Adams, 1858
114
115 **Type species** —*Voluta fulgetrum* Sowerby, 1825
116
117 *ERICUSA NGAYAWANG* SP. NOV.
118 urn:lsid:zoobank.org:act:E133FA7E-2327-4AA3-8D55-B7B9DA5CF950
119

120 **Etymology** —Named after the now extinct language spoken in the area that the fossils were
121 found prior to European colonisation (Horgen, 2004). There are few words of this language
122 recorded, so it seems appropriate that the people that spoke this language are at least
123 commemorated here.
124
125 **Holotype** —NTM P11217, an adult shell missing the anterior end of the body whorl (Fig. 2).
126
127 **Paratypes** —NTM P8464, juvenile; NTM P9019, three spire fragments.
128
129 **Type locality and horizon** — Cliffs immediately south of small gully, 4.8 km South of Morgan
130 Ferry – Cadell Road on the east bank of the Murray River, opposite Brenda Park (The type
131 section of the Murbko Marl Member of the Cadell Formation). Langhian Stage, Miocene.
132
133 **Specific diagnosis** —Adult size approximately 70mm. Shell slender with gradually tapering spire. First
134 whorl of protoconch with exsert tip and deviated 40° to 15° from axis. Axial costae persistent from first
135 teleoconch whorl to body whorl. Reflexed outer lip narrow, not winglike.
136
137 **Description** — The shell is small for an *Ericusa* (Fig. 3; Table 1). With an estimated adult length
138 of approximately 70 mm, the holotype lies within the known size range of *Ericusa subtilis*, and
139 exceeds only *E. naniforma* Bail & Limpus, 2013. The protoconch consists of 2 to 2.5 smooth
140 whorls. The first of these is rounded and deviated from the axis of coiling of the rest of the shell.
141 The angle of deviation is less than that observed in other species of *Ericusa* and varies from 40°
142 to 15°. The initial portion of the first protoconch whorl forms a low rounded posterior projection
143 that resembles a more subdued version of the more strongly exsert tip seen in *E. atkinsoni* and *E.*
144 *macroptera*. The adult spire consists of about four whorls with convex profiles. Each spire whorl
145 bears 11 to 12 rounded axial costae that become weakly nodulose on the last half of the last
146 whorl. The spire whorls are crossed with fine spiral threads that attenuate on the last spire whorl
147 although a few weak threads below the shoulders do persist onto the early part of the adult body
148 whorl. There is a narrow and weakly concave posterior whorl slope between the shoulder
149 nodules and the posterior suture. The middle section of the body whorl is mildly ventricose and
150 expands slightly lateral to the level of the shoulder nodules. The anterior end is abruptly
151 contracted and lacks a siphonal fasciole. The axial costae continue to be expressed on the body
152 whorl with only the last example before the outer lip being weakly developed. The costae are
153 weak to obsolete on the posterior whorl slope and bear moderately developed shoulder nodules.
154 Each costa extends anteriorly to about the level of the anterior contraction, whereafter they
155 become obsolete. The adult outer lip is weakly laterally everted and bears a small posterior
156 expansion that is deflected dorsally. The columella is covered with a thin callus and bears three
157 strong columellar plaits. No residual colour pattern could be observed under UV light.
158
159 **Specific comparisons**— Differs from all species of *Ericusa* except *E. atkinsoni* and *E.*
160 *macroptera* in its possession of both axial sculpture and an exsert tip of the protoconch. It differs

161 from *E. macroptera* in the absence of a large, wing-like posterolateral expansion of the outer lip
162 and its far stronger axial sculpture that persists onto the body whorl. It differs from *E. atkinsoni*
163 by its smaller size (adult length approximately 70 mm versus 132-140 mm: Darragh, 1989), the
164 persistence of elongate axial costae onto the body whorl (versus restriction of axial sculpture to
165 short shoulder nodules on the body whorl), and its overall more slender shell with a less tumid
166 body whorl and a relatively longer, more gradually tapering spire. It differs from *Livonia*
167 *stephensi* in its smaller size, more slender form and absence of an exsert tip on the first
168 protoconch whorl (Fig. 3).
169

Discussion

171 *Ericusa ngayawang* is clearly related to *E. atkinsoni*. The latter species is known from the
172 Freestone Cove Sandstone of the Bass Basin, Tasmania and from the Puebla Formation of the
173 Torquay Sub-Basin of the Otway Basin in Victoria (Darragh, 1989; Fig. 4). These two
174 formations considered to be age equivalent (Ludbrook, 1967) and both contain Darragh's (1985)
175 molluscan assemblage VIII. Darragh's numbered molluscan assemblages are a chronological
176 series of assemblage zones that divide the Cenozoic marine sequence of southeastern Australia.
177 The age of the Puebla Formation is well-constrained to the earliest Miocene (Aquitanian Stage)
178 both with microfossil biostratigraphy (Li et al. 1999) and strontium isotope stratigraphy
179 (Dickinson, 2002 reported in McLaren et al., 2009).
180 Younger specimens of *E. atkinsoni* are also known from the Fishing Point Marl (Darragh, 1989;
181 Fig. 4). This unit, which occurs in the main Otway Basin, contains Darragh's (1985) molluscan
182 assemblage IX, and includes a number of first occurrences of younger taxa not found in the
183 Freestone Cove Sandstone, Puebla Formation, or older beds, indicating that it is younger than
184 these. Carter (1958) placed the lower part of the Fishing Point Marl in his foraminifera zone G
185 which correlates with the mid part of the Burdigalian Stage of the Early Miocene (Gallagher &
186 Stanislaus, 2019).
187 Darragh (1989) did not figure the Fishing Point Marl specimens but did mention that they are
188 both smaller and more slender with elongate spires than topotype specimens. In these respects
189 they show similarity to *E. ngayawang* and it is possible that the Fishing Point Marl specimens
190 represent an intermediate population or even an early population of *E. ngayawang*. However
191 Darragh (1985) indicated that the Fishing Point Marl specimens were few in number and of poor
192 preservation, hindering a definitive systematic assessment.
193 Following the deposition of the Fishing Point Marl in the mid Burdigalian Stage, the Miocene
194 climatic optimum (Böhme, 2003) was reaching its zenith and transgressions covered the onshore
195 basins of south eastern Australia for much of the remaining Early and Middle Miocene
196 (McGowran et al., 2004). As a consequence there are many marine mollusc fossil sites dating to
197 the late Early Miocene and Middle Miocene that were traditionally assigned the local stage
198 names Batesfordian, Balcombian and Bairnsdalian, including the famously rich sites of Muddy
199 Creek and Fossil Beach, Balcombe Bay. None of these have yielded an *Ericusa* that can be

200   referred to the *E. macroptera – E. atkinsoni* lineage and it is reasonable to infer that the lineage
201   was extinct east of the Murray Basin before the end of the Burdigalian Stage.
202   Mention should be made of a specimen retrieved from a depth of 73m in Mundys Well in the
203   Murray Basin on Canegrass Station 70 km NNE of the type section for the Murbko Marl
204   Member of the Cadell Formation (Fig. 1). This specimen was referred to *E. atkinsoni* by Darragh
205   (1989) but an examination of the specimen, well over a decade ago, by myself indicated that it
206   was the same species as the one present in the Cadell Formation. Unfortunately the specimen
207   could not be re-located in the collections at the South Australian Museum for measurement and
208   figuring in this paper. The stratigraphic position of the fossils from Mundys Well has never been
209   discussed. Other molluscs from the same level in the well include *Corbula ephamilla* Tate, 1885
210   and the nominate subspecies of *Athleta* (*Ternivoluta*) *antiscalaris* (McCoy, 1866) which are
211   common members of the Cadell Formation assemblage at the type section for the Murbko Marl
212   Member. Gallagher & Gourley (2007) found that the Cadell Formation was extensive in
213   subsurface sections and could be recognised in several boreholes in western Victoria. Given the
214   proximity of Mundys Well to the type section of the Murbko Marl Member of the Cadell
215   Formation, the presence of other mollusc species that are typical of the Cadell Formation and the
216   broad subsurface extent of the Cadell Formation, there is little doubt that the mollusc fossils from
217   Mundys Well were taken from the Cadell Formation, nor is there much doubt that the specimen
218   in question can be referred to *E. ngayawang*.
219
220   The majority of mollusc species in the Cadell Formation are shared with middle Miocene
221   mollusk assemblages from the Otway and Port Phillip Basins. In particular many species are
222   shared with Darragh's (1985) molluscan assemblage XI which is typified by the famously rich
223   deposit at Fossil Beach, Mornington Peninsula in the Port Phillip Basin. Darragh's molluscan
224   assemblage zones were proposed to provide a zonation within the Southeastern Australian
225   Province. This marine province was initially established by Crespin (1950) after she noticed that
226   there was a distinct biogeographic discontinuity between the foraminifera of basins west of the
227   Mount Lofty Ranges and those to the east during the Mio-Pliocene. Initially the eastern province,
228   including the Murray, Otway, Bass, Port Phillip and Gippsland Basins was named the Bass Strait
229   Province (Crespin, 1950) but Darragh (1985) renamed it the Southeast Australian Province.
230
231   The persistence of the *E. macroptera – E. atkinsoni* lineage in the Murray Basin beyond its
232   extinction further east is evidence that the Southeast Australian Province was not
233   biogeographically uniform in the Middle Miocene. There are other examples of persistent
234   mollusc taxa in the Cadell Formation that are only found in older Victorian strata. The possible
235   columbariid *Hispidofusus piscatorius* and the nominate subspecies of the volutid *Athleta*
236   (*Ternivoluta*) *antiscalaris* are present in the Langhian aged Cadell Formation but are only found
237   in Victorian sites that are correlated with the Burdigalian Stage (Darragh, 1969; 1971, as
238   Batesfordian). In addition to these persistent taxa there are several endemic species in the Cadell
239   Formation with related congeners in the Otway or Port Phillip Basins, including cypraeids

240   (Schilder, 1935; Yates, 2008), volutids (Darragh, 1989) and a venerid (Darragh, 1965). These all
241   suggest some form of isolation of the western Murray Basin allowing it to evolve some
242   distinctive taxonomic differences from more easterly basins in the Province. It is interesting to
243   note that this difference is not due to the influence of the Austral-Indo-Pacific Province to the
244   immediate west of the Murray Basin. This province, so-named because it is an extension of the
245   Indo-Pacific Province, shares many warm-water foraminifera and molluscs with the Indo-Pacific
246   Province and none with the Cadell Formation that cannot be found further east. This situation
247   was temporary and the overlying Bryant Creek Foramation of later Langhian age does contain
248   molluscs with affinities to the Indo-Pacific Province including a species each of *Nemocardium*,
249   *Globularia*, *Sphaerocypraea* and a strombid with some resemblance to *Thersistrombus* (A.
250   Yates, personal observations 2009-2021).
251

Conclusions

253   *Ericusa ngayawang* is a species of *Ericusa*, belonging to the *E. macroptera – E. atkinsoni*
254   lineage. It lived in the western Murray Basin during the Langhian Stage of the Middle Miocene,
255   when other members of the lineage had gone extinct elsewhere in the Southeastern Australian
256   Province. The persistence of the lineage in the Western Murray Basin is matched with a few
257   other molluscan taxa. In addition to the persistent lineages there are also some endemic mollusk
258   species in the Cadell Formation. Together these indicate that there was some degree of
259   biogeographic isolation of the western Murray Basin from the rest of the Southeastern Australian
260   Province during the deposition of the Cadell Formation.
261

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267   and Angus Hawke both provided images of fine specimens of fossil Livoniini in their collections
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271

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Figure 1

Locality map of the occurences of *Ericusa ngayawang* sp. nov. and their position within the western Murray Basin of South Australia.

Fossil localities with *E. ngayawang* are marked with stars, the type locality is arrowed. Inset shows the position of the main map (marked as a box) within the Murray Basin (marked as solid light brown colour).

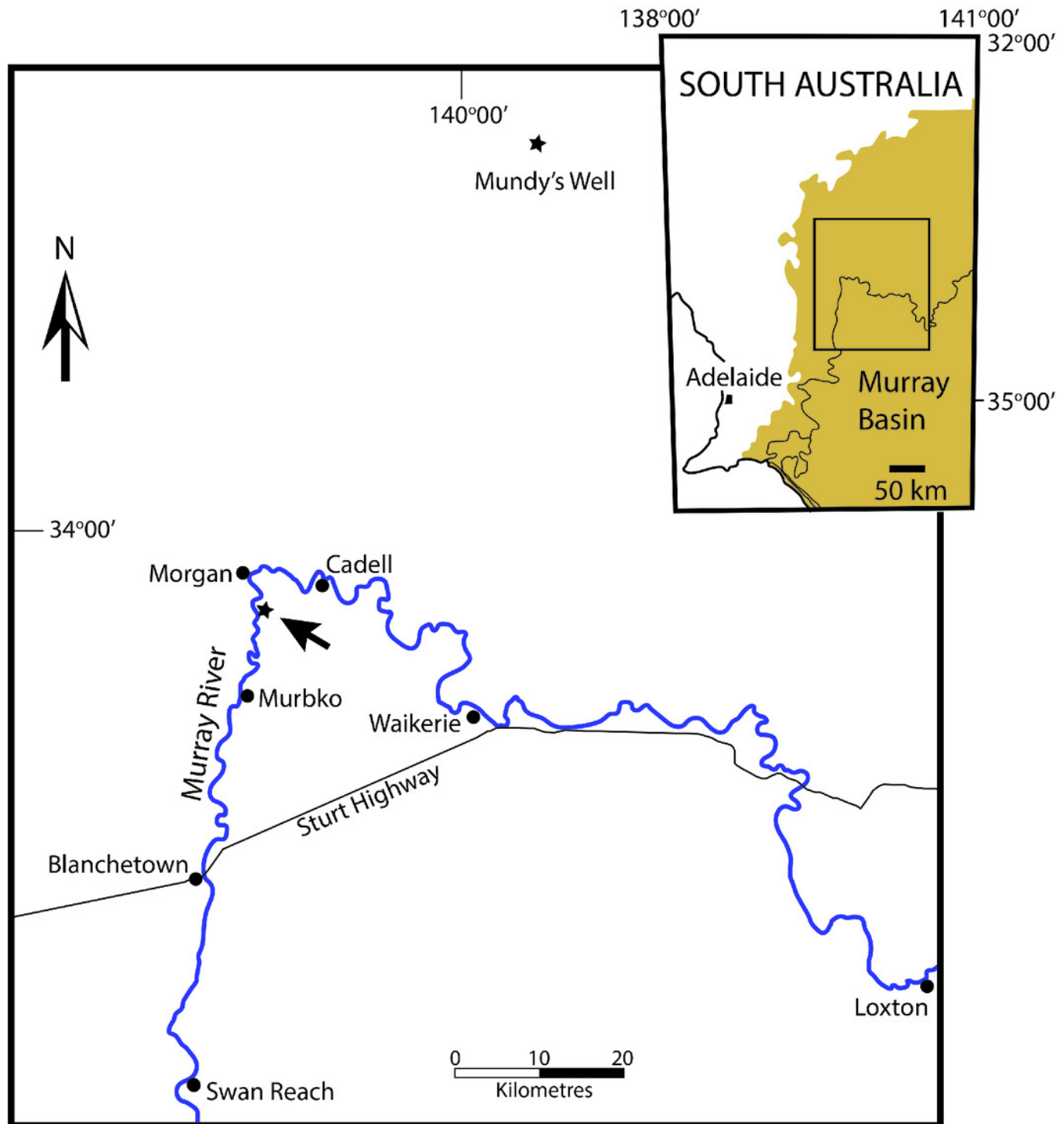



Figure 2

Type specimens of *Ericusa ngayawang* sp. nov.

(A-C) Holotype (NTM P11217) in (A) ventral, (B) labial and (C) dorsal views. (D, E) Juvenile paratype (NTM P8464) in (D) dorsal and (E) ventral views. (F) Close-up view of the protoconch of the holotype (NTM P11217). Scale bar for A-E = 20 mm. Scale bar for F = 5 mm. Specimens have been whitened with ammonium chloride. Photographs by the author.

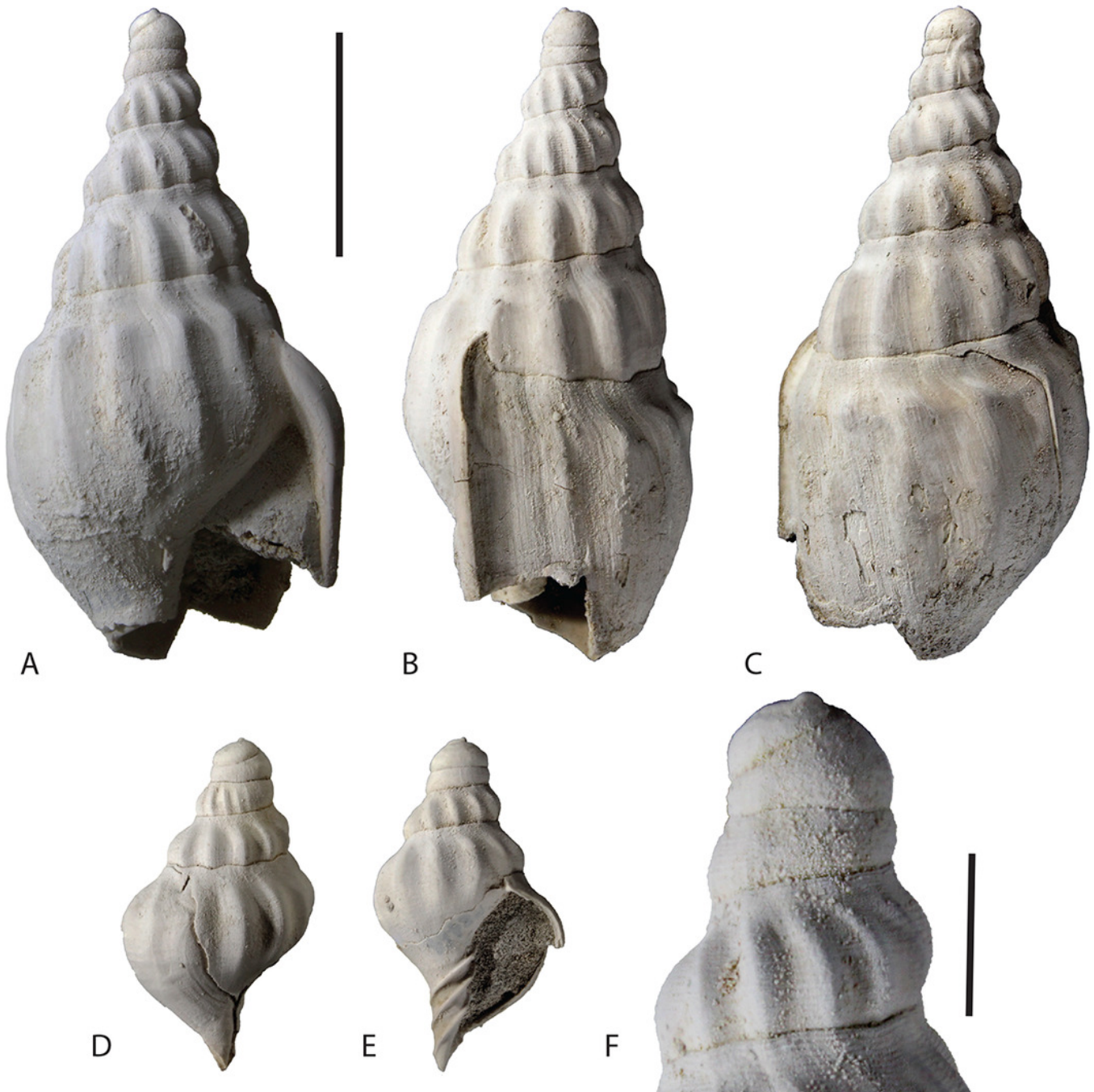



Figure 3

Shells of various Livoniini compared.

(A) Silhouettes from left to right of *Livonia stephensi*, *Ericusa macroptera*, *Ericusa atkinsoni*, *Ericusa ngayawang* sp. nov. and *Ericusa fulgetrum* drawn to scale. (B-F) Reconstructions of adult shells from each species showing diagnostic features (not to scale). (B) *Livonia stephensi*. (C) *Ericusa macroptera*. (D) *Ericusa atkinsoni*. (E) *Ericusa ngayawang* sp. nov. (F) *Ericusa fulgetrum*.

A

B

C

D

E

F

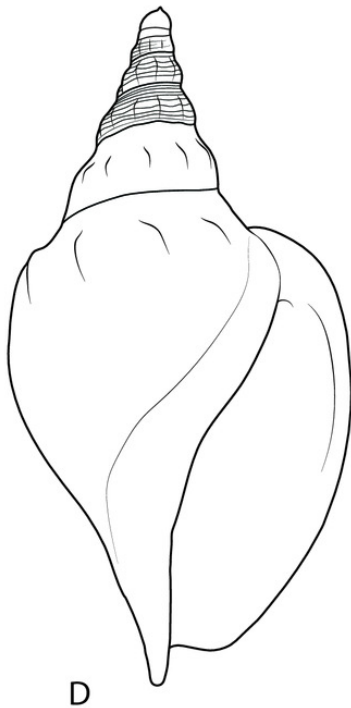
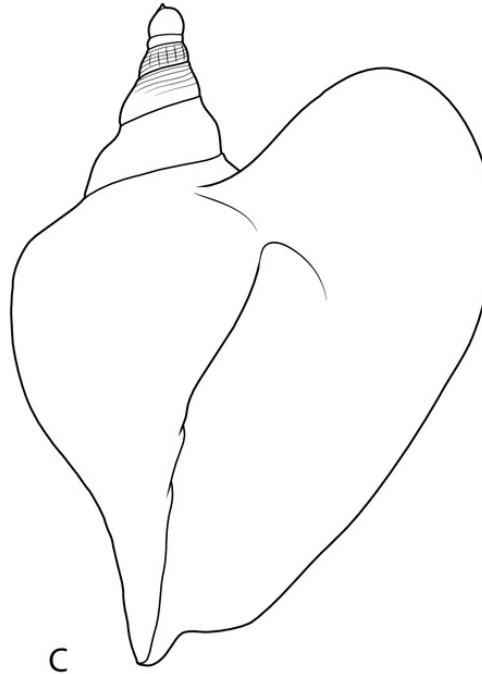
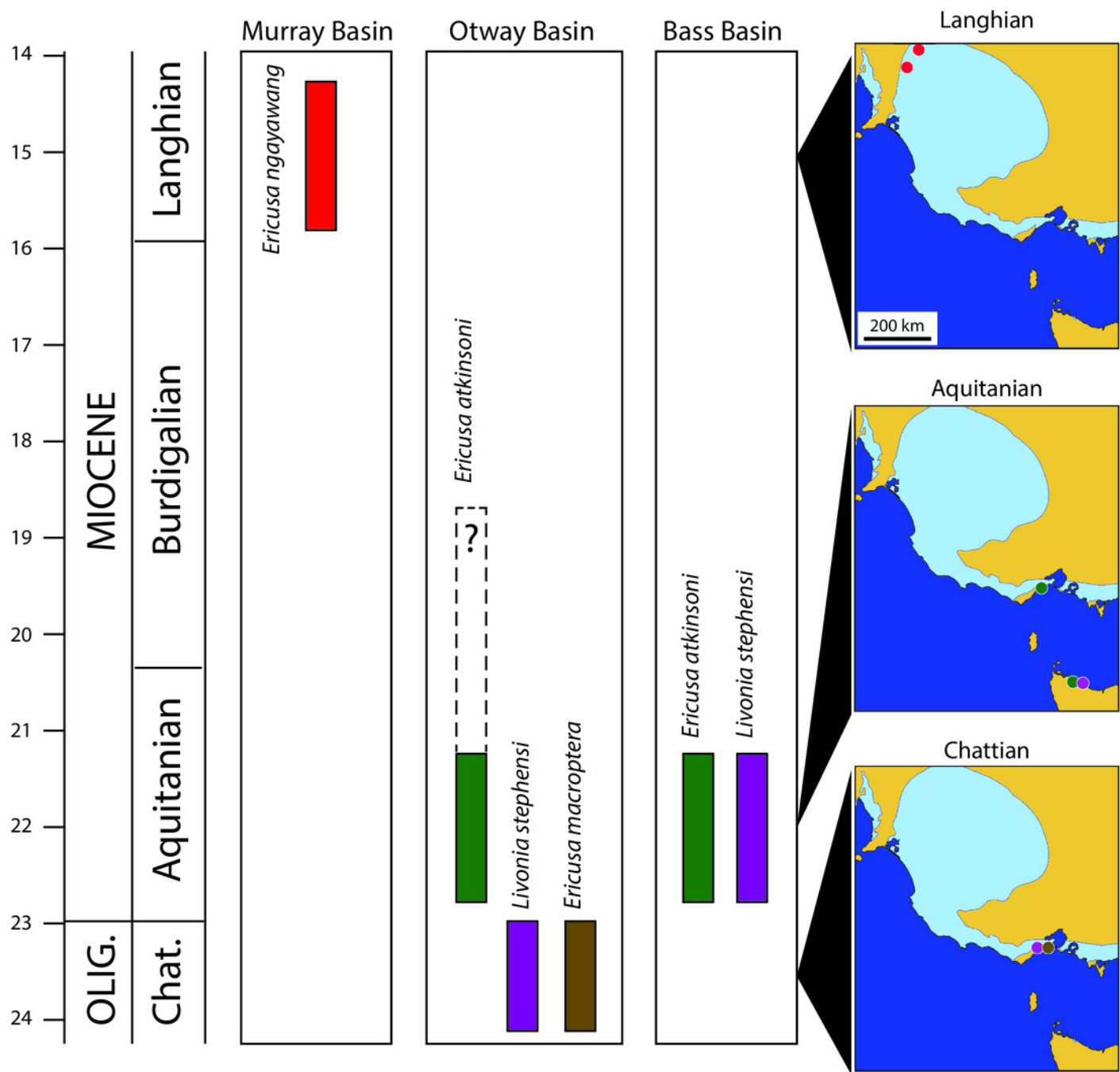



Figure 4

Palaeobiogeography and stratigraphy of selected early Livoniini relevant to this study.

Timescale from Cohen et al. (2013, updated 2020). Stratigraphic columns show known time ranges of species within each relevant basin. Maps show geographic occurrences of species (colour coded to stratigraphic columns) in south-eastern Australia for three stages (Chattian, Aquitanian and Langhian). Dark blue in all maps represents present day seas, tan represents present day land and light blue indicates maximum extent of Cenozoic marine transgression over present day land.

Dimensions of *Ericusa ngayawang* sp. nov. and other selected species of *Ericusa*.

Length measured from the protoconch to the end of the anterior canal along the axis of the shell. Spire height measured from the level of the protoconch to the level of the apertural suture, parallel with the axis of the shell. For those measurements taken from the literature spire height is equal to length minus aperture height. Width measured perpendicular to the axis of the shell at its widest point, between axial costae. Where two measurements appear the specimen is incomplete and the number in parentheses refers to the measurement as preserved, whereas the number not in parentheses is the estimated measurement if complete.

	length (mm)	spire height (mm)	width (mm)
Ericusa macroptera NMV P12379*	125	-	62
Ericusa macroptera NMV P12378*	141	36	64
Ericusa macroptera NMV P48588*	134	47	52
Ericusa atkinsoni NMV P9985*	132	47	66
Ericusa atkinsoni NMV P41723*	140	48	61
Ericusa ngayawang NTM P11217	~70 (59)	30	27
Ericusa ngayawang NTM P8464	30	9	16
Ericusa subtilis WAM 69.515*	67	29	24
Ericusa subtilis WAM 79.391*	71	30	25
Ericusa naniforma WAM S11656[$]	62	18	34

3   * Measurements taken from Darragh (1989).

4   [$] Measurements taken from Bail & Limpus (2013).