Journal of Paleontology, 90(5), 2016, p. 959–980

0022-3360/16/0088-0906
doi: 10.1017/jpa.2016.76

First Cretaceous (Albian) invertebrate fossil assemblage from Batavia Knoll, Perth Abyssal Plain, eastern Indian Ocean: taxonomy and paleoecological significance

Toban J. Wild,[1] and Jeffrey D. Stilwell[1,2]

[1]School of Earth, Atmosphere and Environment, Monash University, Wellington Road, Clayton, Victoria 3800, Australia ⟨toban.wild@monash.edu⟩; ⟨jeffrey.stilwell@monash.edu⟩
[2]Australian Museum, 6 College Street, Sydney, New South Wales 2010, Australia

Abstract.—The first sedimentary rocks from Batavia Knoll, on the western edge of the Perth Abyssal Plain, eastern Indian Ocean, have been recovered, yielding an assemblage of invertebrate fossils hitherto undocumented from this part of the world. The fauna consists of 22 species of Mollusca, including new gastropods, a calliotropid *Planolateralus acanthanodus* n. sp.; a margaritid *Igonoia levimargarita* n. sp.; a procerithiid *Procerithium arenacollicola* n. sp.; and aporrhaids *Drepanocheilus bataviensis* n. sp. and *Anchura pelsaerti* n. sp. In addition, pleurotomariid, ringiculid, and architectonicid gastropod taxa were recovered. Bivalves are represented by members of the Nuculanidae, Inoceramidae, Pinnidae, Buchiidae, Lucinidae, Veneridae, and Hiatellidae. Scaphopods (Dentaliidae) and ammonites (two taxa, of Desmoceratidae and Hamitidae) are also present. Further recovered were one species of Serpulidae (Polychaeta), two of Trachyleberididae (Ostracoda), and a probable echinoid fragment. The fossil assemblage was dominated by shallow marine suspension-feeding taxa (39% of the suite). Detritivorous and herbivorous taxa comprised 22% and 9%, respectively, with nektic and epifaunal carnivores amounting to 30%. Taphonomic analyses of these fossils and their host sedimentary facies revealed the Batavia Knoll sandstone was deposited in a shallow marine environment during a mass-flow event. Biostratigraphic range data of the preserved macro- and microfossil assemblages imply an age of latest Albian, contemporaneous with the rifting of Batavia Knoll from Greater India during the broader India–Australia–Antarctica breakup in the mid-Cretaceous.

Introduction

In late 2011, the Australian research vessel *Southern Surveyor* undertook dredging operations on a number of bathymetric highs (Batavia Knoll, Gulden Draak Knoll, and Dirk Hartog Ridge; Fig. 1) on the eastern Indian Ocean seafloor as part of long-term research led by the University of Tasmania and University of Sydney. The primary objective was to ascertain the nature of the knolls and obtain a greater understanding of the tectonic history of the Australia–India–Antarctica divergence, for which the Perth Abyssal Plain is the focus. As a result of these studies, Williams et al. (2013) determined the knolls were microcontinents, fragments of Greater India isolated during the separation of that plate from the Australian Plate. The steep northwestern scarp of Batavia Knoll was dredged (between –25.332º, 100.285º and –25.343º, 100.298º and depths of 2,870 to 2,730 m; Whittaker et al., 2013), and rock samples of sandstone were recovered therefrom, which proved to be fossiliferous and yielded the first paleontological suite from this region. This collection includes diverse assemblages of macroinvertebrates (Mollusca: Cephalopoda, Bivalvia, Gastropoda, Scaphopoda; Annelida; probable Echinodermata fragments), microinvertebrates (Ostracoda; Foraminifera), and terrestrially derived palynomorphs of spores and pollen. Substantial segments of pholadoid-bored wood are also recorded, attesting to shallow habitats proximal to the shoreline. This paper documents the taxonomic composition and paleoecological significance of the mollusks, annelids, and other invertebrate fossils recovered from Batavia Knoll.

Repositories and institutional abbreviations.—Specimens described herein are housed at the Western Australian Museum (WAM), Perth, and are cataloged with the call number 15.1XX. Other institutions referenced in the text are the Sedgwick Museum (SM), Cambridge; the Geological Society of London Museum (GSL) and the Natural History Museum (NHM), London; and the Geological Survey of India Museum (GSI), Kolkata.

Geological and depositional setting

Batavia Knoll sits on the western limit of the Perth Abyssal Plain, approximately 1,600 km west of the Western Australian coast, the top at a depth of between 1,700 and 2,000 m below sea level (Fig. 1.2). Sedimentary samples recovered therefrom consist of a mixture of sandstone (medium-grained laminated to coarse-grained massive) facies. Those studied herein exhibited low textural maturity, being poorly sorted, having relatively large subhedral quartz (which dominated; ~80% framework

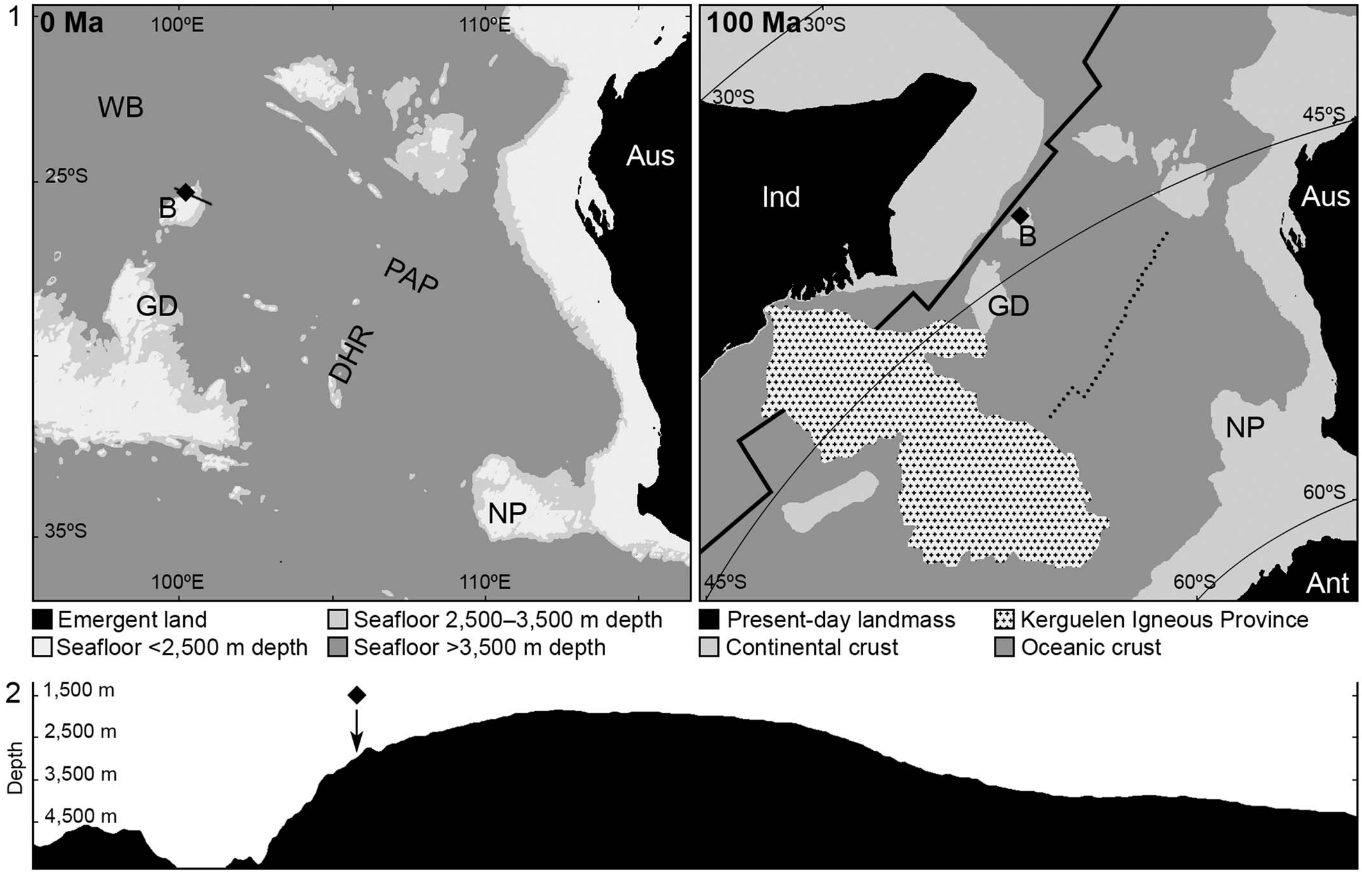


Figure 1. (**1**) Simplified bathymetric map showing features in and around the Perth Abyssal Plain (on left) and a reconstruction of the PAP region ca. 100 Ma (on right), with a fixed Australian reference frame (adapted from Gibbons et al., 2012). Black diamond marks the location of dredging; thin black line across knoll delineates profile; thick black line represents active spreading ridges; dotted black line indicates the extinct spreading center of the PAP. (**2**) East–west profile of Batavia Knoll, 5x vertical exaggeration. Aus = Australia; Ant = Antarctica; B = Batavia Knoll; DHR = Dirk Hartog Ridge; GD = Gulden Draak Knoll; Ind = India; NP = Naturaliste Plateau; PAP = Perth Abyssal Plain; WB = Wharton Basin.

composition), and smaller mica and feldspar framework grains supported by a micritic matrix. The sandstone is massive, and all fossils therein were arranged with haphazard orientations, with no bedding apparent. These fossils are primarily preserved as molds, indicating the rock was permeated by fluid, resulting in the dissolution of original, predominantly aragonitic, shell material through geologic time. Because all rocks were obtained from dredging operations, the relationship between the studied sample and other recovered lithological samples is unknown. Seismological surveys have not yet been conducted across the knoll to ascertain the subsurface structure of the rock units, though the presence of a few small half-graben basins has been inferred (Whittaker et al., 2013). Given the half-graben's similar size and orientation to basins on the Naturaliste Plateau, which is conjugate with southern Batavia Knoll, it is likely these depocenters were formed during the divergence of Australia–Antarctica from Greater India, a process that commenced ca. 132 Ma (Gibbons et al., 2012). A westward ridge jump of the spreading center between ca. 108 and 103 Ma resulted in the rifting of Batavia Knoll and Gulden Draak Knoll, further to the south, from Greater India and the opening of the Wharton Basin (Williams et al., 2013).

We surmise the separation of Batavia Knoll from its parent continent opened a narrow inlet between the two continental blocks (at least one of which, and likely both, was subaerial), with restricted access to global oceanic currents. This supposition is founded on the level of endemism of Mollusca in the Batavia Knoll specimens, indicating poor dispersal capabilities of the marine fauna there. At least 22% of recovered mollusks (at species level) are newly described herein, a relatively high amount considering Batavia Knoll falls within a paleobiogeographic region whose fauna have been robustly studied since the 1840s (e.g., Forbes, 1846). Endemism here is also consistent with known patterns of provincialization resulting from East Gondwana breakup, though these tectonic and paleobiogeographic invertebrate patterns will be explored in a future article and are beyond the scope of this paper. It is into this embayment that the sandstones recovered from Batavia Knoll were deposited.

The poorly sorted, polymictic composition of the samples, together with the lack of sedimentary structures, indicates these rocks were formed during a mass-flow event, which propagated a short distance across the continental shelf before terminating in a shallow marine environment. Close proximity of the deposition site to the paleoshore is evidenced in the presence of a substantial quantity of wood fragments being recovered from the Batavia Knoll sandstone. The majority of these lignitic 'clasts' were heavily bored by pholadoid bivalves (assigned to ichnospecies *Teredolites longissimus* Kelly and Bromley, 1984, and associated with the families Teredinidae Rafinesque, 1815 and Pholadidae Lamarck, 1809; see Fig. 4.14 in Systematic paleontology).

Age determination

The majority of macroinvertebrate taxa recovered from Batavia Knoll belong to long-ranging families, which are present throughout the Mesozoic and Cenozoic. The only families that do not exhibit this expansive range are those of the ammonites, which appeared in the Early Cretaceous—Desmoceratidae (which first appeared in the Valanginian) and Hamitidae (which arose during the Albian; Wright et al., 1996)—thus delimiting the maximum age for the associated strata to the Albian (Fig. 2). Numerous other taxa first appeared in the Albian, including the genera *Drepanocheilus* Meek, 1864, *Igonoia* Squires, 2011, and *Bhimaites* Matsumoto, 1954, which are recorded in Batavia Knoll deposits. *Nuculana socialis* Stoliczka, 1871 is only known from Albian to Cenomanian strata (Stoliczka, 1871; Berizzi and Busson, 1971). Furthermore, in his original description of the species, d'Orbigny (1843, p. 340) states that *Panopea inaequivalvis* is prevalent in, and characteristic of, Albian strata of France.

Aucellina gryphaeoides Sowerby, 1836 is not recorded below the base of the *Mortoniceras inflatum* Ammonite Zone in Europe (Lehmann et al., 2008), and *Bhimaites stoliczkai* Kossmat, 1898 is found to have a similarly timed first appearance datum there (Gale et al., 2011). Huang et al. (2012) dated the base of the *M. inflatum* zone to 103.94 Ma. The type specimen for *B. stoliczkai* was described from the Odiyam Member of the Karai Formation in southern India (Stoliczka, 1865), a unit that straddles the Albian-Cenomanian boundary (Sundaram et al., 2001). The temporal range of both these taxa extends only into the early Cenomanian (Morter and Wood, 1983; Kennedy and Klinger, 2014), restricting the possible age to an approximately 6 Myr window. Further refinement comes with the extinction of *Planohamites* Monks, 2002 at the end of the Albian, 100.5 Ma (Monks, 2002; Gradstein et al., 2012).

The presence of these temporally restricted taxa resolves the age of the Batavia Knoll sandstone, constraining it to the late Albian and probably the early late Albian, ca. 103 to 101 Ma. This age estimation falls within the period of extension between Batavia Knoll and Greater India calculated by Williams et al. (2013). Given the sample site's location on the northwest edge of the knoll, an area conjugate with Greater India (and thus prior to separation a likely terrestrial environment), the genesis of this divergence allowed for the creation of marine conditions in the area, in which the Batavia Knoll fauna could inhabit shallow waters.

An Albian age of the Batavia Knoll sandstone is also supported by the microfossil taxa present. The two ostracod taxa recovered belong to the Trachyleberididae, an extant family with origins in the late Barremian (Karpuk and Tesakova, 2014) and thus present throughout the Albian. In addition, the genus *Spinoleberis* Deroo, 1966 has its first appearance datum in the mid-Albian. Foraminifera recovered are consistent with assemblages recorded by Scheibnerová (1972) during Leg 27 of the Deep Sea Drilling Program in the eastern Indian Ocean, including the Perth Abyssal Plain. The benthic foraminiferal assemblages therefrom were deemed to be of late Albian age. This is consistent with preliminary calcareous microfossil analysis conducted by P. Quilty (personal communication, 2014). Reliable palynological data recovered from Batavia Knoll are extremely sparse (three spore-pollen grains only); investigation of it did not contradict a mid-Cretaceous age, but offered no further refinement.

Paleoecology

The fossil suite of Batavia Knoll encompasses four primary autecological groups: suspension feeders (both infaunal and epifaunal), grazers (epifaunal), deposit feeders (infaunal), and carnivores (epifaunal and nektic). These data are summarized in Figure 3. Gastropod taxa account for 42% of the specific composition, and bivalves 31%. Cephalopoda and Ostracoda each account for 8% (with two representative taxa recovered), and Scaphopoda, Polychaeta, and probably Echinoidea, with one taxon apiece, make up 4% each of the rock's assemblage.

Suspension feeders account for 39% of the biota of the suite, represented by 10 genera (*Turritella*, *Parsimonia*, and all bivalves except *Nuculana*). Of these, the majority is infaunal, with only the serpulid and *Aucellina* occupying epifaunal niches. Most of the filter feeders obtained their nutrients singularly from suspension, though some potentially adopted a bimodal feeding habit. Modern turritellids are predominantly suspension feeders, but some species exhibit both detritivorous and grazing habits (Allmon, 1988; Allmon et al., 1992). They are here counted among the suspension feeders only.

Nuculanoid bivalves are known to obtain nutrients by sediment consumption (Bender and Davis, 1984), as are aporrhaid gastropods (Barnes and Bagenal, 1952). According to Houbrick (1992) modern cerithiids graze on diatoms and microalgae, though his review of *Argyropeza* Melvill and Standen, 1901, the only extant genus of the Procerithiidae, indicates they are deposit feeders (Houbrick, 1980). Which characteristic is ascribable to fossil taxa is unknown; the cerithioid taxa herein (*Procerithium* and *Cirsocerithium*) are considered among the deposit feeders, totaling five species (22%) utilizing this feeding mode. The herbivorous, motile grazers are represented by the margaritid and calliotropid taxa.

Carnivores comprise the remainder of the recovered population (30%), represented by a pleurotomariid, two members of the Architectonicidae, a ringiculid, two ammonite taxa, and a single dentaliid species. The pleurotomariid and architectonicid gastropods were epifaunal, the dentaliid shallowly infaunal, and the two ammonites were highly active, nektonic predators.

The presence of bored wood fragments in the fossil record of Batavia Knoll is indicative of infestation by xylophagous bivalves, which inhabit and consume driftwood and other lignitic substrates (Sellius, 1733). Pholadoid bivalves can consume at least 60 cm^3 in wood material per year per 100 individuals (Amon et al., 2015), suggesting that such substantial fragments of wood would not survive an extended period in marine conditions. Thus, due to their presence, the depositional site is likely in proximity to vegetated land. These autecological and paleoecological data strengthen the sedimentological

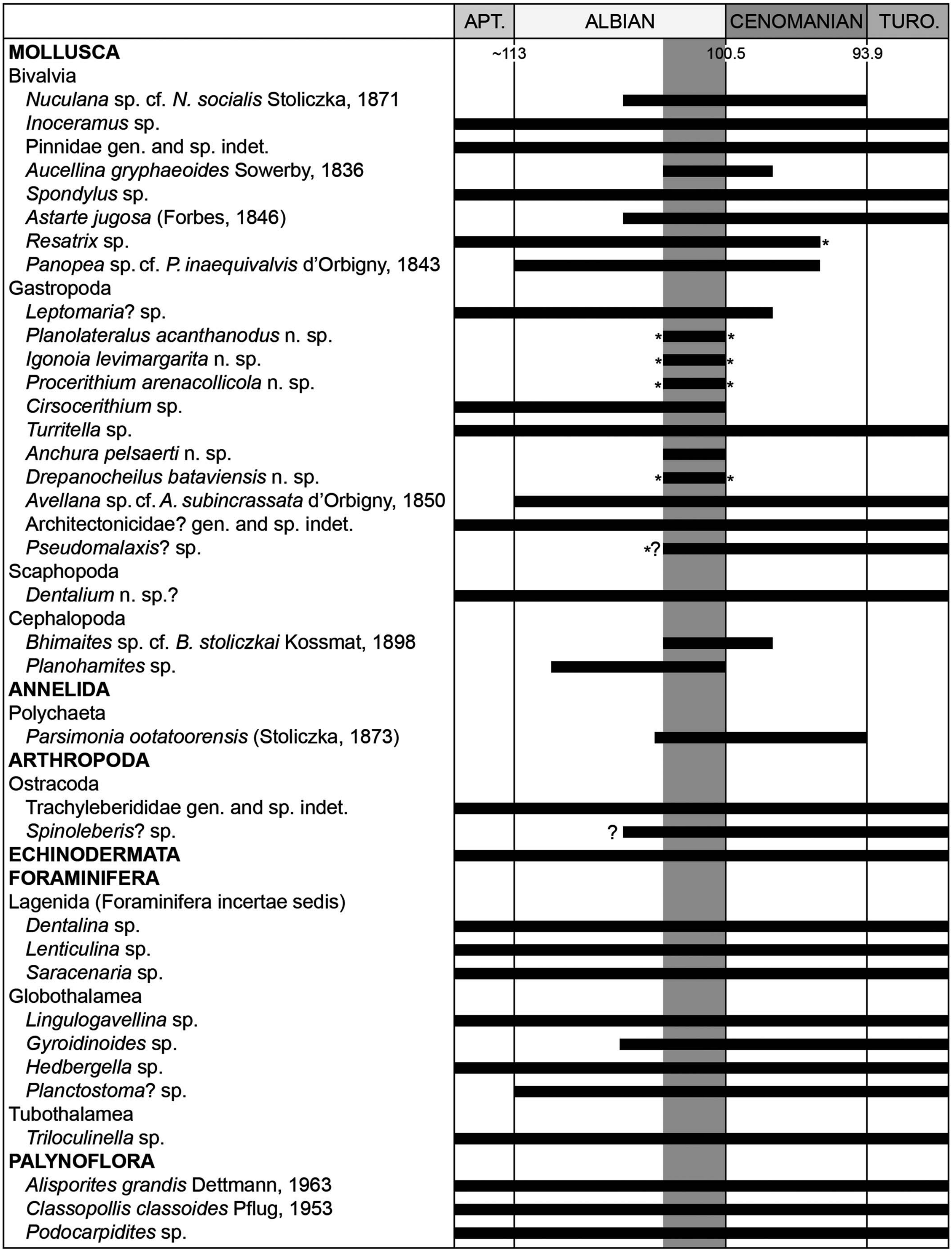


Figure 2. Taxonomic list of all taxa recovered from Batavia Knoll, showing mid-Cretaceous age ranges for each taxon and delimiting the age of the unit to the latest Albian. Asterisks indicate ranges established in this study. Apt. = Aptian; Turo. = Turonian. Absolute ages from Gradstein and Ogg (2012).

https://doi.org/10.1017/jpa.2016.76 Published online by Cambridge University Press

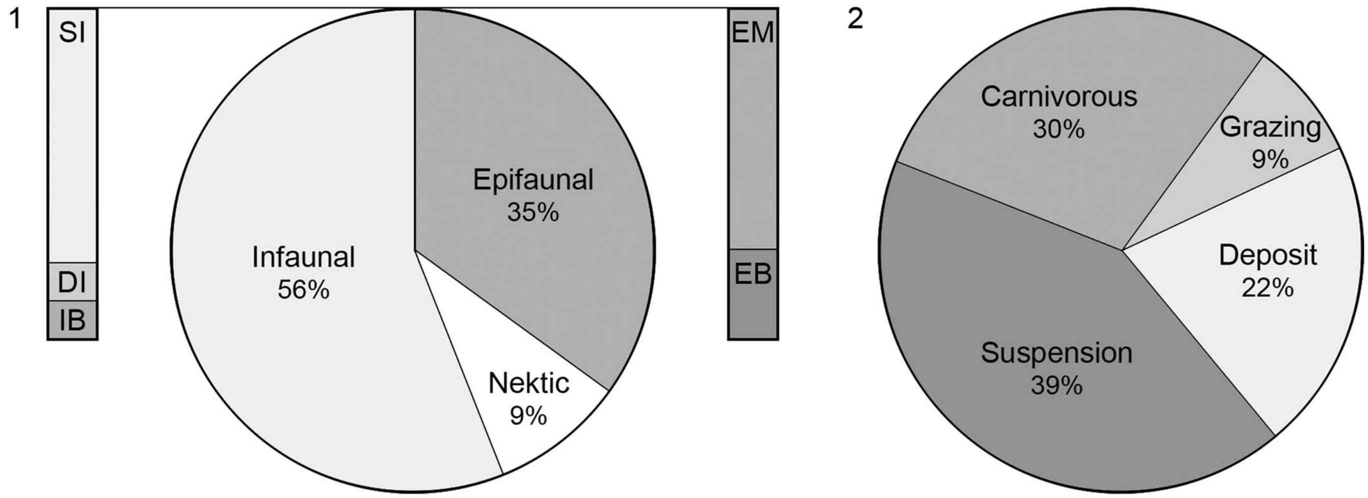


Figure 3. Pie and bar charts of the relative abundance of autecological groups within the Batavia Knoll fossil suite, excluding the recovered Ostracoda and probable echinoid. (**1**) Life habits. (**2**) Feeding mode. EB = epifaunal byssate; EM = epifaunal mobile; DI = deep infaunal; IB = semi-infaunal byssate; SI = shallow infaunal.

interpretation of the depositional site as a shallow marine environment. The ratio of carnivorous, detritivorous, and suspension-feeding taxa in the Batavia Knoll suite plot directly in the inner shelf environment in the trophic analysis model of Scott (1978). Further, the taxonomic composition and trophic structure of Batavia Knoll invertebrates can be estimated for the first time, providing insights into shallow marine Cretaceous habitats in a previously unstudied area of the planet.

Systematic paleontology

The majority of taxa are described from casts, taken using Pinkysill® Putty, a two-part silicone press putty. Bivalve taxonomic hierarchy follows Carter et al. (2011), and that of the gastropods follows Bouchet and Rocroi (2005), with addenda of relevant taxa from works post–2005.

Phylum Mollusca Linnaeus, 1758
Class Bivalvia Linnaeus, 1758
Subclass Protobranchia Pelseneer, 1889
Order Nuculanida Carter, Campbell, and Campbell, 2000
Superfamily Nuculanoidea Adams and Adams, 1858 (1854)
Family Nuculanidae Adams and Adams, 1858 (1854)
Genus *Nuculana* Link, 1807

Type species.—*Arca rostrata* Bruguière, 1789 (=*Arca pernula* Müller, 1779) by original designation.

Nuculana sp. cf. *N. socialis* Stoliczka, 1871
Figure 4.1, 4.2

1871 cf. *Nuculana socialis* Stoliczka, p. 323, pl. 17, fig. 13.
1971 cf. *Nuculana* (sensu stricto) *socialis*; Berizzi and Busson, p. 468, pl. 35, fig. 4.

Occurrence.—Northern Africa and southern India; Albian to Cenomanian.

Description.—Comparatively small shell for genus, but large for species (reconstructed length ~15 mm). Outline subovate; from beak anterior margin moderately declivous, until confluence with moderately convex ventral margin. Dorsoposterior margin not preserved. Inflation moderate. Ornamentation of at least 34 evenly spaced commarginal growth lines, which become more distinct toward the ventral margin. Umbonal region is almost smooth. Taxodont dentition comprises at least 10 small peg-like teeth along the anterodorsal margin.

Materials.—Single right valve mold and steinkern.

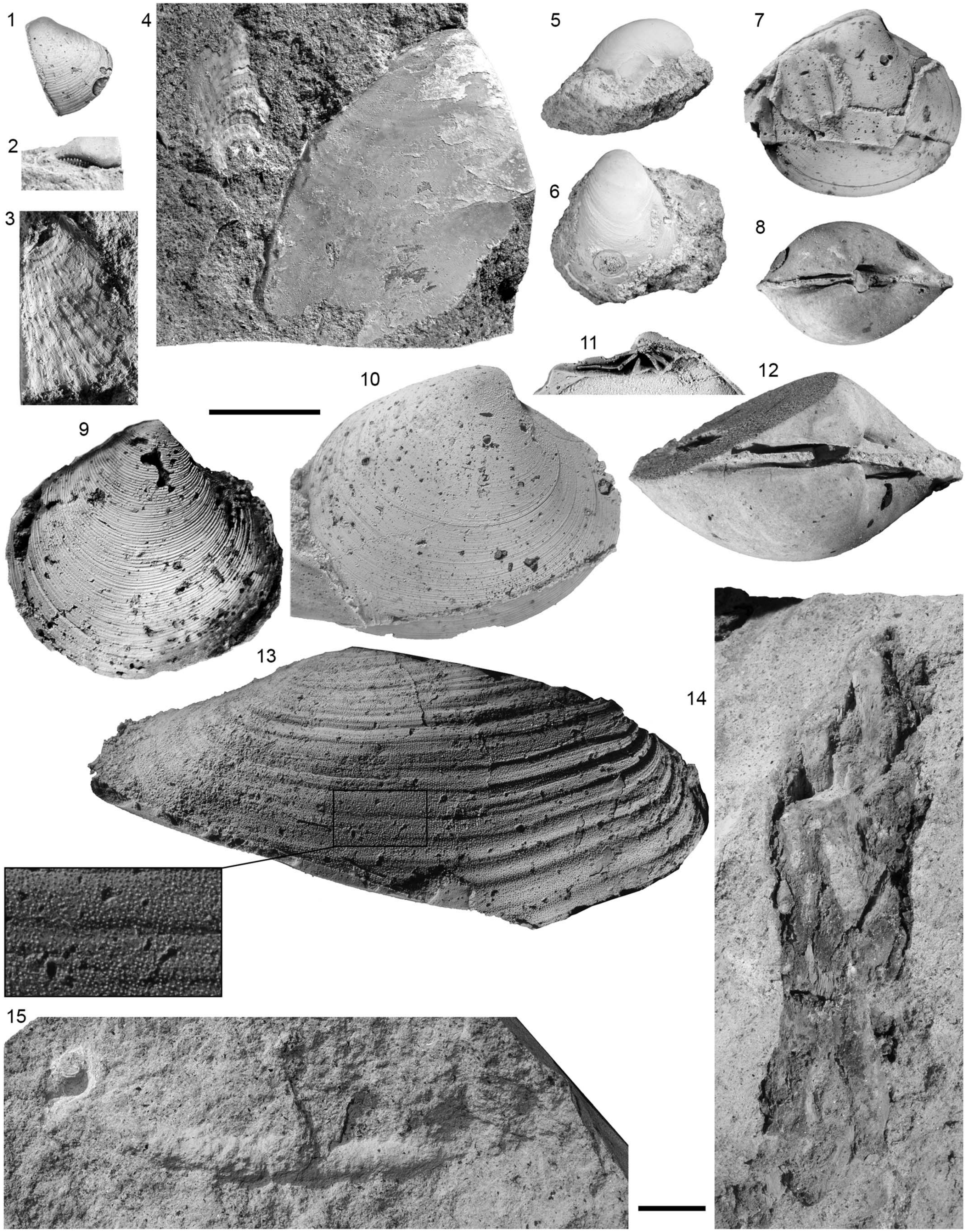
Remarks.—The length and posterior features of the specimen are unknown as the single recovered valve was inadvertently dissected by a rock saw during preparation of the rock. Whether it exhibits the cuneiform posterior habit of *N. socialis* is unclear and thus is left in open nomenclature. If this specimen is conspecific with *N. socialis*, it represents a very large individual of that species as its type material is a third of the size of this specimen (length 4.5 mm, height 2.9 mm; Kendrick and Vartak, 2007). Stoliczka (1871) notes it is a very common species around 'Moraviatoor' (now Maruvattur) in the Dalmiapurum Formation, Uttattur Group (late Albian; Sundaram et al., 2001) of southern India. Berizzi and Busson (1971) record *N.* (s.s.) *socialis* in Cenomanian strata of Djebel Zmertene, Tunisia.

Subclass Autobranchia Grobben, 1894
Infraclass Pteriomorphia Beurlen, 1944
Order Myalinida Paul, 1939
Superfamily Inoceramoidea Giebel, 1852
Family Inoceramidae Giebel, 1852
Genus *Inoceramus* Sowerby, 1814

Type species.—*Inoceramus cuvierii* Sowerby, 1814, by subsequent designation (Cox, 1955).

Inoceramus sp.
Figure 4.4

https://doi.org/10.1017/jpa.2016.76 Published online by Cambridge University Press



https://doi.org/10.1017/jpa.2016.76 Published online by Cambridge University Press

Description.—Shell small for genus, preserved length 22.8 mm. Anterior margin well rounded. Moderately inflated. Ornamentation of broad commarginal symmetrical rugae forming corrugations over entirety of shell, with two or three finer commarginal striations present in the interstacies. Poorly developed radial sculpture present, approximately two striae per millimeter across whole of shell disc, more distinct dorsally.

Materials.—One decorticated left valve fragment.

Remarks.—The shell margins of the recovered specimen are not preserved. Notwithstanding this, the preserved characteristics of the shell conform to those of a relatively small specimen of *Inoceramus*. It could be conferrable to *I. geinitzianus* Stoliczka, 1871 of southern India due to its dimensions (though that species can obtain lengths of 160 mm), degree of inflation, and broad rugose texture with finer interstitial threads (which Stoliczka, 1871, p. 407 states are compact and tightly spaced, a feature that may be obscured by the decorticated nature of the Batavia Knoll specimen). The fine radial sculpture, while not discussed by Stoliczka (1871) in his original description, is depicted in his figures of the species (pl. 27, fig. 5a). *Inoceramus geinitzianus* has been recorded from late Albian to late Turonian rocks in India (Stoliczka, 1871; Kendrick and Vartak, 2007).

Order Pterioidea Gray, 1847 (Goldfuss, 1820)
Superfamily Pinnoidea Leach, 1819
Family Pinnidae Leach, 1819

Pinnidae gen. indet. sp. indet.
Figure 4.4

Description.—Shell subtriangular in outline, relatively small for family (maximum measurable height 13.8 mm). Hinge and ventral margins are unknown, apical angle ~60º. Ornamentation of fine radial riblets, crossed by broad, widely spaced commarginal terraces.

Materials.—Two fragments preserving original shell material.

Remarks.—These specimens exhibit the characteristic trigonal wedge shape of Pinnidae but are quite short for the family. Both recovered specimens are fragmentary single valves.

Order Pectinida Gray, 1854
Superfamily Pectinoidea Rafinesque, 1815
Family Spondylidae Gray, 1826
Genus *Spondylus* Linnaeus, 1758

Type species.—*Spondylus gaederopus* Linnaeus, 1758, by subsequent designation (Schmidt, 1818).

Spondylus sp.
Figure 4.3

Description.—Shell small for genus. Outline obliquely broadly ovate to subtrigonal. Anterior margin straight to merge with highly convex ventral margin. Umbo rounded, raised, delineated by angular ridge, which abruptly descends to shell margin. Ornament of evenly spaced coarse radial ribs, intermittently nodulate, with interstices approximately four times the width of the rib. The coarse ribs sometimes extend beyond the ventral margin of shell. Within the interstices three to five fine radial riblets are present. Slight concentric undulations result in a fine commarginal rugose texture.

Materials.—Two broken decorticated original shell fragments.

Remarks.—The ornament of these specimens is most closely akin to that of *Spondylus calcaratus* Forbes, 1846 (p. 155, pl. 18, fig. 2) from the Turonian to Santonian of southern India, though these specimens are much smaller than any recorded *S. calcaratus* and are not contemporaneous.

Superfamily Buchioidea Cox, 1953 (Fischer, 1886)
Family Buchiidae Cox, 1953 (Fischer, 1886)
Genus *Aucellina* Pompeckj, 1901

Type species.—*Avicula gryphaeoides* Sowerby, 1836 (non Sedgwick, 1829), by subsequent designation (Marwick, 1939).

Aucellina gryphaeoides Sowerby, 1836
Figure 4.5, 4.6

1836 *Avicula gryphaeoides* Sowerby, p. 335, pl. 11, fig. 3.
1893 *Avicula gryphaeoides*; von Strombeck, p. 490.
1901 *Aucellina gryphaeoides*; Pompeckj, p. 354, pl. 16, figs. 6–8.
1902 *Aucellina gryphaeoides*; Wollemann, p. 64, pl. 3, figs. 2, 3.
1905 *Aucellina gryphaeoides*; Woods, p. 72, pl. 10, figs. 6–13.
1936 *Aucellina gryphaeoides*; Rennie, p. 315.
1958 *Aucellina gryphaeoides*; Glaessner, p. 203, pl. 24, fig. 1, text fig. 2.

Holotype.—Lost. Neotype SM B21972 (Woods, 1905, pl. 10, fig. 6), selected by Morter and Wood (1983); Cambridge Greensand, England; early Cenomanian.

Occurrence.—Europe, northern Australia; Early Cretaceous (late Albian) to Late Cretaceous (mid-Cenomanian).

Description.—Moderately small for genus, maximum recorded height ~20 mm. Strongly prosocline in outline, highly inequivalved. Left valve strongly convex with projecting umbo and prosogyous beak. Right valve almost flat and sitting entirely within left valve, being suborbicular in outline. Dorsal margins of right valve subhorizontal until merging with convex, well-rounded anterior and posterior margins. Ornamentation of

←

Figure 4. Cretaceous Bivalvia recovered from Batavia Knoll. (**1, 2**) *Nuculana* sp. cf. *N. socialis* Stoliczka, 1871, WAM 15.120: (**1**) cast of right valve; (**2**) dorsal view of steinkern exhibiting taxodont dentition. (**3**) *Spondylus* sp., left valve, WAM 15.160. (**4**) Pinnidae gen. indet. sp. indet, WAM 15.106 (on left) and *Inoceramus* sp., WAM 15.105 (on right). (**5, 6**) *Aucellina gryphaeoides* Sowerby, 1836, left valves: (**5**) WAM 15.148; (**6**) WAM 15.150. (**7, 8**) *Resatrix* sp., WAM 15.130: (**7**) cast of right valve; (**8**) steinkern. (**9**) *Astarte jugosa* Forbes, 1846, cast of right valve, WAM 15.135. (**10–12**) *Resatrix* sp.: (**10**) cast of right valve, WAM 15.139; (**11**) cast of right valve detailing hinge dentition, WAM 15.126; (**12**) steinkern, WAM 15.104. (**13**) *Panopea* sp. cf. *P. inaequivalvis* d'Orbigny, 1842, cast of right valve, with inset showing shagreen texture (height of box 5 mm), WAM 15.137. (**14**) Oxidized wood fragment showing pholadoid *Teredolites longissimus* Kelly and Bromley, 1984 bore traces, WAM 15.153. (**15**) Probable venerid bivalve escape burrow traces, WAM 15.103. (**1–13**) Specimens coated with ammonium chloride. Scale bar = 1 cm; (**1–13**) use bar above 9, 10; (**14, 15**) use bar between them.

https://doi.org/10.1017/jpa.2016.76 Published online by Cambridge University Press

left valve is of thin commarginal growth lirae, widely spaced near to beak (one to three per millimeter) becoming coarser and more concentrated toward ventral margin (about six per millimeter). Fine radial sculpture on umbo, becoming rapidly indistinct. Right valve similarly adorned with radial striae.

Materials.—Numerous fragmentary original shell fragments, the majority of them preserving the beak, including two juvenile specimens, while some preserve the disc only.

Remarks.—All specimens of this species were of original shell material, predominantly found clustered near the exterior of the sandstone boulder. The majority of specimens were broken, with only the beak region of the left valve preserved in most cases. Many of the unidentifiable shell fragments found in the same area of the boulder likely belong to *Aucellina*. The only right valve recovered was from a single minute juvenile specimen. The paucity of right valves is possibly due to their smaller size and relatively flat profile, making them easier to overlook when examining the rock, or the fact that many of the preserved left valves have not been completely prepared out of the rock. Two juveniles and a subadult specimen were also found. The umbo and byssal ear/notch of right valve are often obscured due to sediment impediment, and the specimens are too small and fragile to clean further.

Aucellina gryphaeoides is an index species for late Albian to mid-Cenomanian strata throughout Europe (Morter and Wood, 1983).

Infraclass Heteroconchia Hertwig, 1895
Order Carditida Dall, 1889
Superfamily Crassatelloidea Férussac, 1822
Family Astartidae d'Orbigny, 1844
Subfamily Astartinae d'Orbigny, 1844
Genus *Astarte* Sowerby, 1817

Type species.—*Venus scotica* Maton and Racket, 1807 by original designation.

Astarte jugosa Forbes, 1846
Figure 4.9

1846 *Lucina jugosa*, Forbes, p. 142, pl. 17, fig. 7.
1871 *Grotriania jugosa*; Stoliczka, p. 289, pl. 10, figs. 12–14.

Holotype.—GSL R10593 (Forbes, 1846, pl. 17, fig. 7); 'Pondicherry,' southern India; Late Cretaceous. (Note: this specimen has been held by the NHM since 1911 [J. Todd, personal communication, 2016] but had not been formally registered within their collection at time of writing [March 2016], and thus does not yet have an official NHM number.)

Description.—Shell average size for genus (25 mm long). Outline suborbicular, slightly longer than high. Umbo is prominent, angular, and protruding. Posterior margin suborthogonal from beak to junction with highly convex ventral margin. Anterior margin slightly convex until merging with ventral margin. Low inflation (laterally compressed), suggesting both lunule and escutcheon are narrow. Ornamentation of ~95 regularly spaced commarginal ribs, highly concentrated toward apex of umbo, strengthening ventrally.

Occurrence.—India; Early Cretaceous (middle Albian) to Late Cretaceous (Cenomanian).

Materials.—Single right valve.

Remarks.—There is a great need to revise the descriptions and taxonomic positions of superficially orbicular bivalves from southern India, as the majority of work done in this area was completed in the nineteenth century and has not undergone significant revision since. The specimen recovered from Batavia Knoll could be reasonably assigned to several genera. The lack of a distinct anterior abductor scar on the preserved specimen, however, precludes it from being considered a member of the Lucinidae, and it is likely to be an astartid.

Stoliczka (1871) recorded '*Grotriania*' *jugosa* from limestone near Odiyam in the Uttatur Group. The only limestone in the vicinity of Odiyam is the Dalmiapuram Formation of late Albian age (Sundaram et al., 2001). Forbes (1846) only gives the locality of his specimens as 'Pondicherry.' The Pondicherry subbasin, within Cauvery Basin, is dated between late Campanian to Maastrichtian and into the Paleocene (Sundaram et al., 2001). *Astarte jugosa* (as *Grotriania*) is noted as being in the Bagh Beds of central India (Chiplonkar, 1939), which have dated to the Cenomanian (Chiplonkar, 1941).

Order Cardiida Férussac, 1822
Superfamily Veneroidea Rafinesque, 1815
Family Veneridae Rafinesque, 1815
Subfamily Meretricinae Gray, 1847 (Gray, 1838)
Genus *Resatrix* Casey, 1952

Type species.—*Resatrix dolabra* Casey, 1952 by original designation.

Resatrix sp.
Figure 4.7, 4.8, 4.10–4.12

1871 cf. *Cytherea lassula* Stoliczka, p. 171, pl. 7, figs. 10–17.

Description.—Shell size typical for the genus; shell trigonally ovate to subcircular in outline, posterior and ventral margins convex, anterior margin subangular. Umbo prominent and projecting toward anterior. Inflation moderate. Escutcheon narrow, lunule shallow, almost absent. Ornamentation of at least 80 fine commarginal striations strengthening from almost smooth umbonal region to ventral margins. Heterodont dentition, right valve with narrow 3a and 1, strongly bifid 3b, anterior laterals AIII and AI elongate, posterior laterals absent. Dentition of left valve unknown.

Materials.—Numerous articulated (or almost so) molds and steinkerns.

Remarks.—This species is similar to bivalves described from the Ariyalur Group (Santonian to Maastrichtian; Sundaram et al., 2001) in southern India by Stoliczka (1871). He assigned them to *Cytherea* Lamarck, 1806, a genus since invalidated as a junior homonym of a hexapod genus, and gave them the specific epithet *lassula*. Species within *Cytherea* were transferred into *Meretrix* Lamarck, 1799, though the general form of *Meretrix* is not consistent with the Batavia Knoll samples. Tapaswi (1987) assigned Stoliczka's *Cytherea* species to *Mesocallista* Cox, 1952. Dentition of Batavia Knoll specimens, however, places them within *Resatrix*, extending the temporal range of *Resatrix* from the early Albian (Casey, 1961) to the late Albian and potentially into the Cenomanian.

Order Hiatellida Carter in Carter et al., 2011
Superfamily Hiatelloidea Gray, 1824
Family Hiatellidae Gray, 1824
Genus *Panopea* Ménard de la Groye, 1807

Type species.—*Mya glycimeris* Gmelin, 1791, by subsequent designation (Schmidt, 1818).

Panopea sp. cf. *P. inaequivalvis* d'Orbigny, 1843
Figure 4.13

1843 cf. *Panopea inaequivalvis* d'Orbigny, p. 340, pl. 358, figs. 5–7.
1949 cf. *Panopea inaequivalvis*; Collignon, p. 25, pl. 4, fig. 1.

Occurrence.—Madagascar and France; Early Cretaceous (Albian).

Description.—Elongate to subquatrate shell, relatively small and narrow for genus. Posterior edge is elongated, with well-rounded, slightly gaping margins. Umbonal region is positioned about one-third of the way in from the obliquely truncated anterior margin. Moderate inflation. Ornamentation dominated by ~25 prominent, equally spaced commarginal ribs. These become broader and more widely spaced toward the ventral margin. Smaller commarginal striations present on the ridges and interstices of the larger better developed ribs. Entire surface of the shell textured with numerous, subequidistant, radial rows of minute tubercules.

Materials.—Single slightly disarticulated mold with steinkern preserved.

Remarks.—The identification of this specimen as *Panopea inaequivalvis* is uncertain due to the unusual microtuberculate texture found across the disc of the shell. Extensive texture of this nature is not a feature before observed in the Hiatellidae, and the only microtuberculate ornamentation recorded for the family is on the juvenile dissoconch of *Hiatella* (*Pseudosaxicava*) Chavan, 1952 from the mid–Jurassic of Europe (Schneider and Kaim, 2011). Otherwise, this specimen conforms well to the characteristics of *P. inaequivalvis*, with the possible exception of not having quite so abrupt truncations of its anterior and posterior margins, as observed in some individuals of this species.

Class Gastropoda Cuvier, 1795
Subclass Vetigastropoda von Salvini–Plawen, 1980
Superfamily Pleurotomarioidea Swainson, 1840
Family Pleurotomariidae Swainson, 1840
Genus *Leptomaria* Eudes-Deslongchamps, 1864

Type species.—*Pleurotomaria amoena* Eudes-Deslongchamps, 1849 by original designation.

?*Leptomaria* sp.
Figure 5.1, 5.2

Description.—Last whorl of average size for the family, 40.7 mm in diameter. Last whorl is subcircular, and the large central void (umbilicus) is suggestive of a strongly phaneromphalous shell when complete. Whorl profile is slightly convex, with rounded periphery. No ornamentation is discernible, apart from possible weak orthocline growth lines.

Materials.—Single fragmentary last whorl mold.

Remarks.—This specimen is provisionally assigned to *Leptomaria* due to its convex, rounded whorl margins. Other pleurotomariid genera usually exhibit greater angularity in their whorl margins. The lack of external sculpture, including the position and form of the selenizone, prohibits more specific identification. Given the fragility of the shells of this family, it is reasonable to assume that the gastropod shell broke apart, perhaps during the mass-flow event that created the Batavia Knoll sandstone, leaving this whorl isolated and fractured.

According to a review of the genus by Monari and Gatto (2013), *Leptomaria* ranged from the Aalenian (Middle Jurassic) to lower Cenomanian (Late Cretaceous) in Europe, from the Pliensbachian to Toarcian (Early Jurassic) in Argentina, and was found during the Callovian (Middle Jurassic) in southern India.

Superfamily Eucycloidea Koken, 1896
Family Calliotropidae Hickman and McLean, 1990
Genus *Planolateralus* Sohl, 1960

Type species.—*Calliomphalus argenteus* Wade, 1926 by original designation.

Planolateralus acanthanodus new species
Figure 5.3–5.9

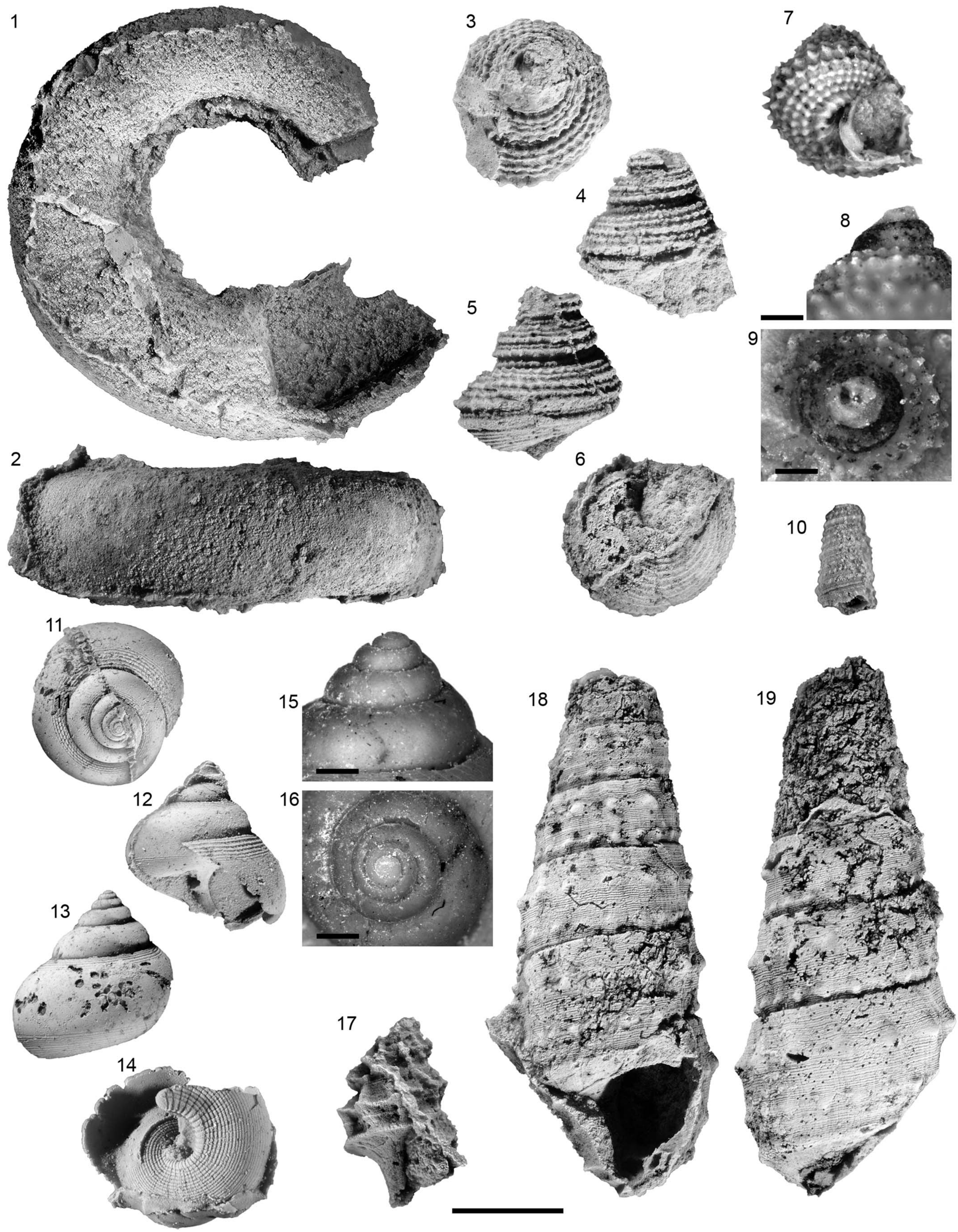
Holotype.—WAM 15.143, an external mold; Batavia Knoll, eastern Indian Ocean; late Albian.

Diagnosis.—Large *Planolateralus*, with deep, channeled sutures; whorls ornamented by up to six sharply nodulate spiral ribs, the fifth of which (from the apical suture) is dominant.

Occurrence.—Batavia Knoll, eastern Indian Ocean; Early Cretaceous (late Albian).

Description.—Trochiform shell, large size for genus (reconstructed height ~17 mm), of at least three teleoconch whorls, sides straight to slightly convex. Protoconch not preserved. Early whorls slightly convex, becoming slightly uni- to biangular on appearance of spiral ornament (two riblets) on second

https://doi.org/10.1017/jpa.2016.76 Published online by Cambridge University Press



https://doi.org/10.1017/jpa.2016.76 Published online by Cambridge University Press

preserved whorl. Narrowly phaneromphalous. Spiral angle of 54º. Sutures deeply channeled, angled at 12º. Teleoconch sculpture consists of strong spiral nodulate ribs, three per whorl in early whorls (central rib strongest), increasing to six per whorl by penultimate whorl. Interstices subequal in width to spiral ribs, devoid of spiral ornament. On later whorls, two spiral ribs (third and fifth from apical suture) maintain greater strength than others until last whorl when third rib weakens to be of equal strength with others; fifth rib remains dominant. Ribs obliquely crossed by strong prosocline growth lines. Last whorl develops an abapical weak nodulate keel, demarcating the slightly convex base. Base ornamented by at least nine equidistant spiral cords on adult shell; juvenile shell possesses three beaded spiral cords on base, crossed by numerous fine axial threads (growth lines). Umbilicus narrow, with crenulated margin, interior of umbilicus ornamented with evenly spaced axial riblets. Aperture rounded to subquadrate, inner lip smooth, columella slightly twisted.

Etymology.—From Latin *acanthus* (spine) and *nodus* (knot/node), referring to the shell's sharp nodulate ornamentation.

Materials.—Single entire mold and fragment of adult shell, six molds of juvenile shells.

Remarks.—Of congeneric taxa, *Planolateralus acanthanodus* is probably most similar to *C. argenteus* Wade, 1926 (p. 179, pl. 55, figs. 4–7, 11), particularly the subspecies *C.* (*P.*) *argenteus spinosum* Sohl, 1960 (p. 56, pl. 5, figs. 19, 23–25), from the Ripley Formation (Maastrichtian) of Tennessee. *Planolateralus argenteus spinosum* bears a well-developed, stronger, nodulate spiral rib near to the abapical suture on its later whorls, consistent with *P. acanthanodus*. The Batavia Knoll species, however, has deeper interstices between the spiral cords and displays sharper nodes than either Wade's or Sohl's figured specimens.

It is probable that the reduced sharpness of the spiral nodes in the adult shell herein, and the corded yet apparently unnoded base, are the result of cumulative abrasion over the life of the snail. It is also possible that these features are due to taphonomic factors.

Superfamily Trochoidea Rafinesque, 1815
Family Margaritidae Thiele, 1924
Genus *Igonoia* Squires, 2011

Types species.—*Igonoia onoensis* Squires, 2011 by original designation.

Igonoia levimargarita new species
Figure 5.11–5.16

Holotype.—WAM 15.114, an external mold; Batavia Knoll, eastern Indian Ocean; late Albian.

Diagnosis.—Large *Igonoia*, bearing up to seven fine beaded ribs on apical surface (subsuture) of whorls; whorl sides smooth or displaying subtle prosocline growth lines.

Occurrence.—Batavia Knoll, eastern Indian Ocean; Early Cretaceous (late Albian).

Description.—Shell large for genus at an average of ~14 mm high, turbiniform, and phaneromphalous. Protoconch conical with one to two convex whorls. Five to six convex whorls in teleoconch. Spire 45% to 50% of total shell height. Pleural angle 80º to 81º and sutural angle 9º to 10º. Sutures impressed, slightly canaliculate. Protoconch and early teleoconch whorls devoid of sculpture; ornamentation begins about fourth whorl with two subsutural spiral ribs of equal strength. The number of subsutural ribs increases with growth, seven present on last whorl. Spiral ribs weaken anteriorly and become rapidly indistinct, leaving whorl sides almost smooth apart from weak prosocline growth lines. Intersection of growth lines and ribs results in beaded texture. Ornament on base consists of ~20 closely spaced spiral ribs, becoming broader and beaded toward umbilicus, resulting in cancellate texture. Umbilicus wide and deep, ornamented with faint reticulated texture. Rim of umbilicus angular and demarcated by moderately strong crenulate spiral rib. Aperture subcircular with thin outer lip.

Etymology.—From Latin *levis* (fine/delicate) and *margarita* (bead/pearl), referring to the subtle, weakly developed beaded ornamentation on the teleoconch whorls.

Materials.—Three external molds.

Remarks.—The species described here is most similar to the late Albian species *Igonoia kieli* Squires, 2011, of which it is undoubtedly phylogenetically allied. The specimens recorded by Squires (2011) in his description of that species are generally smaller than the ones here—no more than 9 mm in height and slightly wider than high. Specimens from Batavia Knoll are marginally taller than wide and reach a reconstructed height of almost 18 mm, though average approximately 14 mm. The ornamentation of the Batavia Knoll specimens is subtler than that of the specimens recorded by Squires (2011) and consists of a greater number of spiral ribs. These specimens also do not exhibit the concave ramp of *I. kieli*. The pleural angle of these specimens is also sharper (81º compared to *I. kieli*'s 87º). The differences here, as well as the paleogeographic distance between recorded species in northwestern North America and the eastern Indian Ocean, warrant the erection of a new species within *Igonoia* for the Batavia Knoll specimens.

Subclass Caenogastropoda Cox, 1960
Superfamily Cerithioidea Fleming, 1822

Figure 5. Cretaceous Gastropoda recovered from Batavia Knoll. (**1, 2**) ?*Leptomaria* sp., WAM 15.102: (**1**) apical view; (**2**) adapertural view. (**3–9**) *Planolateralus acanthanodus* n. sp.: (**3–6**) adult specimen, WAM 15.143: (**3**) apical view; (**4**) apertural view; (**5**) adapertural view; (**6**) abapical view. (**7–9**) Oblique view of juvenile specimen, WAM 15.177: (**7**) showing basal ornamentation, umbilicus, and aperture details; (**8, 9**) detail of protoconch. (**10**) *Turritella* sp., apertural view, WAM 15.154. (**11–16**) *Igonoia levimargarita* n. sp. (**11, 12**) WAM 15.114: (**11**) apical view; (**12**) apertural view. (**13**) Adapertural view, WAM 15.132. (**14**) Abapical view, WAM 15.144. (**15, 16**) Detail of protoconch, WAM 15.132. (**17**) *Cirsocerithium* sp., apertural view, WAM.147. (**18, 19**) *Procerithium arenacollicola* n. sp., WAM 15.136: (**18**) apertural view; (**19**) adapertural view. All specimens are casts and coated with ammonium chloride. (**1–6, 11–14, 18, 19**) Scale bar = 1 cm; (**8, 9, 15, 16**) scale bars = 1 mm; (**7, 10, 17**) scale bar = 5 mm.

https://doi.org/10.1017/jpa.2016.76 Published online by Cambridge University Press

Family Procerithidae Cossmann, 1906
Subfamily Procerithiinae Cossmann, 1906
Genus *Procerithium* Cossmann, 1902

Type species.—*Procerithium quinquegranosum* Cossmann, 1902 by original designation.

Procerithium arenacollicola new species
Figure 5.18, 5.19

Holotype.—WAM 15.136, cast and external mold (with spire broken and steinkern preserved); Batavia Knoll, eastern Indian Ocean; late Albian.

Diagnosis.—Average- to moderately large–sized procerithiid ornamented with two smooth, pointed, nodulate spiral ribs, located centrally and abapically on the whorl, asymmetrically aligned, with fine spiral striae between.

Occurrence.—Batavia Knoll, eastern Indian Ocean; Early Cretaceous (late Albian).

Description.—High-spired turriform shell composed of at least seven slightly convex whorls with a spiral angle of 18º to 20º. Average sized for genus (reconstructed height ~65 mm). Suture weakly impressed and canaliculate, almost flush, with angle of 9º to 10º. Ornamentation of two nodulate spiral ribs; one central and one abapical near the suture, with fine secondary interstitial spiral striations (approximately four per millimeter) between. Tubercles pointed and devoid of sculpture. Nodules on central rib markedly stronger than those lower on whorl. Tubercles asymmetrically aligned. Base of last whorl exhibits additional, slightly tuberculated rib, forming a weak keel. Aperture not well preserved, though appears subcircular with slight angular margins. Anterior canal missing. Apex broken in all specimens, inhibiting protoconch description.

Etymology.—From Latin *arena* (sand), *collis* (hill), and *incola* (resident), referring to both its sandy-substrate life environment and preservation in sandstone on Batavia Knoll.

Materials.—Four external molds, two almost complete and two fragmentary.

Remarks.—The generic assignment of this species is difficult, as no specimen recovered preserves the protoconch. In terms of gross morphology, it is closest to either *Procerithium* Cossmann, 1906 or *Cryptaulax* Tate, 1869, two genera whose similarity is so great that it has been suggested they were based on the same species (Bandel, 2006). Ferrari (2012) argues, however, that certain distinctions can be made between the genera. In the absence of a protoconch, we rely on the diagnostic patterns of teleoconch ornamentation, as described by Ferrari (2012), to place this species within *Procerithium* according to the following criteria: the shell is nonturriculate in outline; axial ornamentation is not well developed on the teleoconch and disappears in mature whorls; and the ornamentation of mature whorls is spiral, noded, and includes distinct secondary spiral striae.

This species appears similar to the rare *Cerithium limbatum* described by Stoliczka (1868, p. 194, pl. 15, figs. 13, 14; non Deshayes, 1864) from the Ariyalur Group (Santonian to Maastrichtian) of southern India. *Cerithium limbatum* possesses two nodulate ribs of even strength, unlike the differing strength of ribs on this specimen. It also exhibits stronger axial ornamentation and a slightly undulating suture. Considering Stoliczka's (1868) specimens were recovered from Upper Cretaceous strata, it is possible the species described here is ancestral to *C. limbatum*. The ornamentation of this species is similar to ?*Metacerithium* sp. of Kiel and Bandel (2004, p. 118, fig. 7C) from the Cenomanian of Germany, which may be conspecific with *C. limbatum* from India and thus may indicate that this species belongs in Campanilidae Douvillé, 1904.

Subfamily Paracerithiinae Cossmann, 1906
Genus *Cirsocerithium* Cossmann, 1906

Type species.—*Cerithium subspinosum* Deshayes in Leymerie, 1842 by original designation.

Cirsocerithium sp.
Figure 5.17

Description.—Slightly small for genus (height 7.8 mm), high-spired shell composed of three biconcave, uniangular whorls. Spiral angle 44º. Sutures impressed. Ornamentation of strong, evenly spaced prosocline axial ribs and a prominent single spiral carina. Sharp nodules at intersection of axial and spiral sculpture. Secondary spiral ribs present midway between central carina and sutures, marginally stronger on adaxial half of whorl, and abutting sutures. Last whorl possesses strong peribasal keel. Base strongly concave and adorned with sigmoidal axial lirae, connecting to axial ribs on teleoconch, and fine spiral striations. Aperture obliquely ovate, descending into a short, straight anterior canal.

Materials.—Single external mold.

Remarks.—The Batavia Knoll specimen differs from other *Cirsocerithium* by the strength of its peribasal keel (usually far more moderate) and concavity of its base (normally ranging from weakly convex to concave). It also possesses fewer teleoconch whorls (three, compared to the typical five or more) than other species in the genus. Its ornament is similar to the type species, *C. subspinosum*, though it has far fewer secondary spiral cords and the nodules on the whorls are much sharper than seen in *C. subspinosum*. Regarding the basal characteristics, *C. collignoni* Kiel, 2006 (p. 459, fig. 3.11–3.14) is nearest in form to the species described here, possessing a relatively sharp keep and concave base. The ornamentation of *C. collignoni,* however, differs too significantly for it to be considered conspecific.

Superfamily Turritelloidea Lovén, 1847
Family Turritellidae Lovén, 1847
Genus *Turritella* Lamarck, 1799

Type species.—*Turritella terebra* Linnaeus, 1758, by monotypy.

https://doi.org/10.1017/jpa.2016.76 Published online by Cambridge University Press

Turritella sp.
Figure 5.10

Description.—Small, high–spired turriform shell composed of at least three orthogonal whorls with a spiral angle of ~12º. Suture flush to slightly impressed. Ornamentation of four evenly spaced spiral ribs; abapical cord, abutting suture, is unadorned, all others weakly nodulate; second from abapical suture is marginally stronger than other nodulate ribs (all of which are stronger than anteriormost rib); fine secondary unnoded spiral striations in interspaces. Tubercles asymmetrically aligned. Apex and later whorls unknown.

Materials.—Single fragmentary mold.

Remarks.—Only three minute volutions of a single individual of this species have been recovered from Batavia Knoll. Several mid-Cretaceous *Turritella* species bear nodulate ornamentation, so without a more complete specimen or better preservation, it is difficult to assign the species here to any one previously documented with any conviction. It is probably most similar to *T. infralineata* Gabb, 1864, from the late early Albian of northern California. The Batavia Knoll specimen exhibits weakly noded spiral ribs with relatively wide interspaces containing unadorned riblets, features seen in *T. infralineata.* The spire angle of the specimen here (12º) is similar to that of *T. infralineata* (11º). It differs in the strength of ribs across the whorl, however, particularly those abutting the sutures. According to Squires and Saul (2006), the posteriormost rib is of equal strength to the others in *T. infralineata*, whereas in the specimen here it is somewhat reduced.

Order Littorinimorpha Golikov and Starobogatov, 1975
Superfamily Stromboidea Rafinesque, 1815
Family Aporrhaidae Gray, 1850
Genus *Anchura* Conrad, 1860

Type species.—*Anchura abrupta* Conrad, 1860 by monotypy.

Anchura pelsaerti new species
Figure 6.1–6.4

Holotype.—WAM 15.113, cast and external mold; Batavia Knoll, eastern Indian Ocean; late Albian.

Diagnosis.—Small *Anchura* possessing unique adapertural digitation on rear of wing; teleoconch ornamented with both spiral and radial elements, the latter diminishing abapically, and the former characterized by a strong subcentral carina between weaker cords.

Occurrence.—Batavia Knoll, eastern Indian Ocean; Early Cretaceous (late Albian).

Description.—Strongly alate aporrhaid, small for genus (maximum height 32 mm). Spiral angle 35º. Sutures impressed. Protoconch unknown. Inflation moderate and relatively uniform from early teleoconch whorls to last whorl. Growth lines prosocline and opisthocyrt below whorl midpoint, and opisthocline and opisthocyrt above. Last whorl strongly biangulate, bearing strong subcentral smooth carina and equally strong peribasal keel above onset of strong basal constriction. Ornament of last whorl consists of three secondary spiral cords, two above and one below the subcentral carination; below peribasal keel, whorl is ornamented with ten subequally spaced spiral threads. Moderately high spire of six convex whorls, occupying approximately 45% of total height. First visible whorl smooth, later spire whorls bear reticulate ornament. Transverse element consists of subequidistant ribs, arising on second visible whorl, decreasing in strength anteriorly, becoming obsolete on penultimate whorl. Spiral element primarily consists of a strong subcentral cord and slightly weaker cord midway between subcentral cord and abapical suture. Secondary spiral ornament of three subequally spaced weak cords posterior to subcentral carination, and a single cord adjacent to abapical suture. Smooth between cords, no interstitial threads. Aperture elongate and teardrop shaped, rounded posteriorly and drawn out into a long, narrow anterior canal, which follows left-curving rostrum. Inner lip with moderately thick callus pad, slightly raised from last whorl at apical limit, forming thin ridge to posterior of aperture. Outer lip slightly callused, expanding to a strongly adaxially developed wing. Wing does not encroach on penultimate whorl and extends orthogonally into an elongate spur reinforced by the spiral carination of the body, with a corresponding incised groove on the interior surface. Shaft divides into two thin spurs approximately 5 mm along length (in type), with posterior spur curving apically. Both spurs are broken, so extent and habit unknown. Minor rounded digitation occurs on the outer lip, approximately halfway between spur and rostrum, projecting anteriorly. Adapertural surface of wing possesses additional short (approximately 2 mm in length on type) blunt projection, formed at the junction of the peribasal keel of the body and ridges running from the rostrum and along base of shaft. Abapical and adaxial of this digitation, between the basal spur ridge and rostral ridge, the wing is devoid of ornamentation.

Etymology.—For Francisco Pelsaert (d. 1630), commander of the Dutch East India Company trading ship *Batavia*, for which the knoll is named.

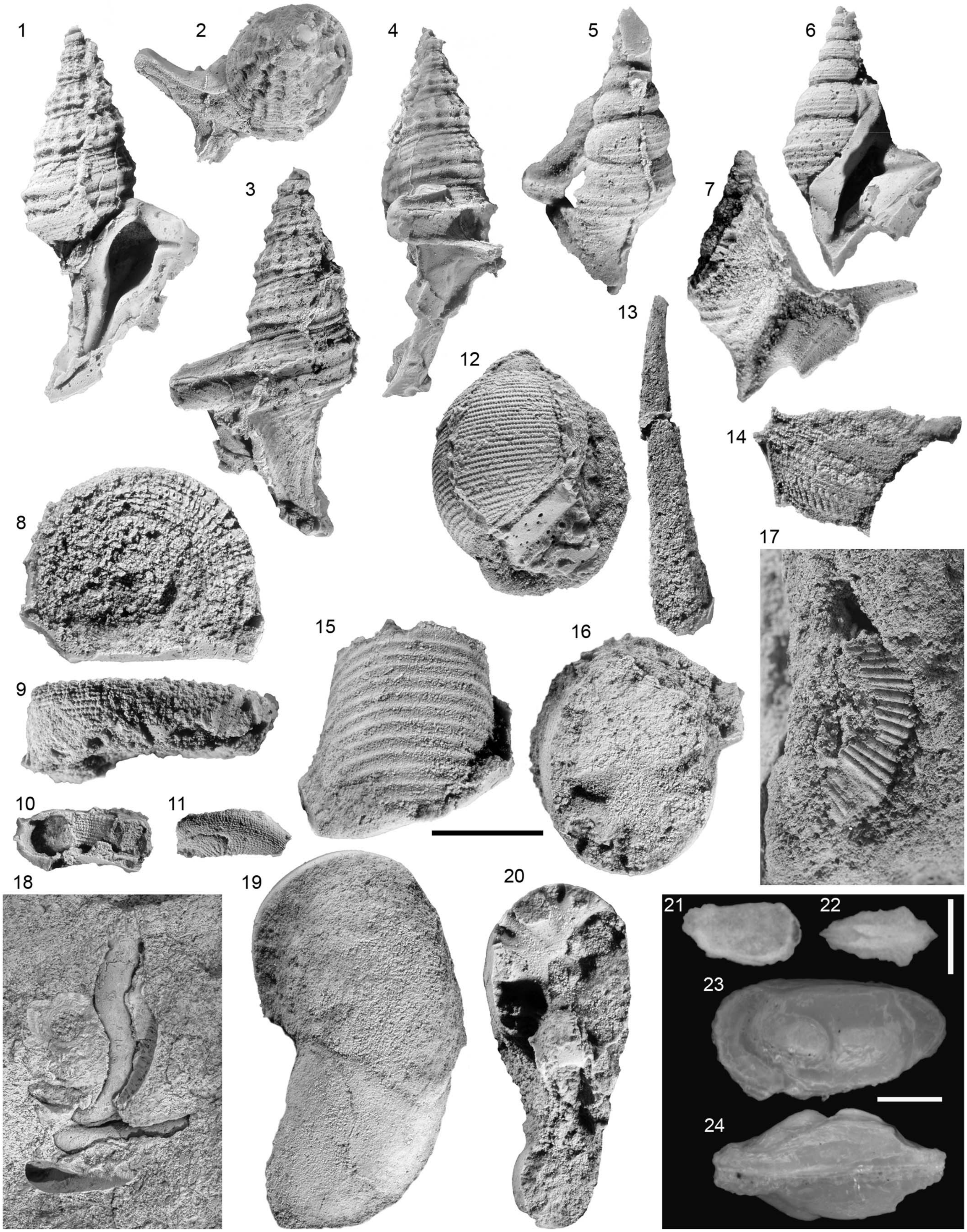
Materials.—Single external mold, designated holotype.

Remarks.—A single specimen was recovered in good preservation state. Ornamentation of this species is not perfectly comparable to any currently described species of *Anchura*, and the third, adaperturally projecting digitation is not previously recorded for the genus. Among smaller *Anchura* species, it is probably closest in morphology to the early Campanian *A. halberdopsis* Elder and Saul, 1996 (p. 384, fig. 3.1–3.4), from which it differs by the spiral, rather than nodulate, sculpture on the body whorl, the penultimate whorl-encroaching wing, and the digitation pattern on the wing.

Genus *Drepanocheilus* Meek, 1864

Type species.—*Rostellaria americana* Evans and Shumard, 1857 (= *Drepanocheilus evansi* Cossmann, 1904) by original designation.

https://doi.org/10.1017/jpa.2016.76 Published online by Cambridge University Press


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24

Drepanocheilus bataviensis new species
Figure 6.5–6.7

Holotype.—WAM 15.112, cast and external mold; Batavia Knoll, eastern Indian Ocean; late Albian.

Diagnosis.—Small *Drepanocheilus* possessing fine spiral sculpture and devoid of axial ornamentation.

Occurrence.—Batavia Knoll, eastern Indian Ocean; Early Cretaceous (late Albian).

Description.—Small for genus (height of reconstructed shell maximum 25 mm), shell moderately thick, strongly alate. Spiral angle 35º to 38º, sutural angle 9º. Sutures impressed. Protoconch unknown. Teleoconch inflation moderate and uniform to last whorl. Growth lines shallowly opisthocline. Last whorl strongly uniangulate, bearing strong subcentral non-tubercle–bearing carina, and poorly developed peribasal keel just below carina and above onset of strong basal constriction. Last whorl ornamented with at least 10 spiral cords, decreasing in strength away from carina. Spire relatively high, occupying approximately 45% of total height and consisting of six strongly convex whorls. Spire whorls ornamented with six subequally spaced spiral cords that increase in strength away from protoconch. Spiral cords weakly developed above midpoint of each whorl. Smooth between cords, with no interstitial threads. No axial sculpture. Ramp angular on early whorls, becoming convex on later whorls. Aperture elongate, sublenticular to subovate with narrow notch, extending into a short, straight anterior canal. Inner lip with thick callus pad, extending from base of siphonal canal to antepenultimate whorl. Outer lip moderately callused, expanding to a strongly adaxially developed wing. Wing encroaches on lower part of penultimate whorl and extends into an elongate, weakly curved, tapering spike reinforced by the spiral carination of the body, with a corresponding incised groove on the interior surface. Small lobe on anterior margin of wing. Length of spike subequal to height of spire.

Etymology.—For its occurrence on Batavia Knoll.

Materials.—Three fragmentary molds (WAM 15.124, 15.129, and 15.158).

Remarks.—This specimen was assigned to *Drepanocheilus* due to the form of the anterior canal and outer lip (Sohl, 1960; Kollmann, 2009). The lack of transverse sculpture in this species is anomalous among *Drepanocheilus*, a genus usually characterized by strong axial ornamentation. This is the only currently documented species of *Drepanocheilus* to exhibit spiral threads to the complete exclusion of axial sculpture. This lack of axials is consistent over all specimens recovered, so is unlikely to be the result of abrasion on the shell removing such sculpture. On comparison with the type species for this genus, *D. evansi*, apart from the aforementioned lack of axial sculpture, this species possesses a thicker callus pad on the inner lip, as well as a more pronounced lobe on the anterior margin of the wing. This species is most similar to *D. herberti* Kiel and Bandel, 2002 from the Santonian of South Africa, though that species is smaller (~11 mm compared with ~23 mm height), possesses more angular late teleoconch whorls, and maintains some axial sculpture through its entire height.

Subclass Heterobranchia Burmeister, 1837
Superfamily Acteonoidea d'Orbigny, 1843
Family Ringiculidae Fischer, 1883
Genus *Avellana* d'Orbigny, 1842

Type species.—*Avellana avellana* Brongniart, 1822 in Cuvier and Brongniart, 1822 by tautonomy.

Avellana sp. cf. *A. subincrassata* d'Orbigny, 1850
Figure 6.12

1842 cf. *Avellana incrassata* d'Orbigny, p. 133, pl. 168, figs. 13–16.
1850 cf. *Avellana subincrassata* d'Orbigny, p. 128.
2015 cf. *Avellana subincrassata*; Ayoub Hannaa et al., p. 56, figs. 14G–14J (further synonymy therein).

Occurrence.—Europe; Early Cretaceous (Albian) to Late Cretaceous (Turonian).

Description.—Shell globular, subovate, average size for genus (height 21.8 mm; width 16.1 mm). Low-spired teleoconch of one or two subtrapezoid, slightly convex whorls; spire somewhat gradate, pleural angle 76º. Inflation moderate in spire, then rapid between penultimate and final whorl. Protoconch not preserved. Sutures moderately impressed, slightly canaliculate. Ornamentation of evenly spaced spiral ribs (at least 31 on body whorl) crossed by thin evenly spaced orthocline axial lirae (four to five per millimeter), resulting in fine clathrose texture; spiral cords three to four times thicker than axials. Aperture holostomatous, teardrop shaped, well rounded anteriorly; labrum strongly thickened; callus projecting approximately halfway up visible surface of penultimate whorl; inner side smooth.

Figure 6. Cretaceous Gastropoda, Scaphopoda, Cephalopoda, Ostracoda, Annelida, and Echinoidea recovered from Batavia Knoll: (**1–4**) *Anchura pelsaerti* n. sp., WAM 15.113. (**1**) apertural view; (**2**) apical view; (**3**) adapertural view; (**4**) lateral view. (**5–7**) *Drepanocheilus bataviensis* n. sp.: (**5**) adapertural view, WAM 15.119; (**6**) apertural view, WAM 15.112; (**7**) apertural view of a somewhat abraded specimen, showing full habit of wing, WAM 15.145. (**8, 9**) ?*Pseudomalaxis* sp., WAM 15.121: (8) apical view; (**9**) adapertural view. (**10, 11**) ?*Architectonica* sp. whorl fragment, WAM 15.122, showing (**10**) umbilical and (**11**) external ornamentation. (**12**) *Avellana* sp. cf. *A. subincrassata* d'Orbigny, 1850, apertural view, WAM 15.181. (**13**) *Dentalium* sp., WAM 15.134. (**14**) Echinoid? fragment, WAM 15.117. (**15–17**) *Planohamites* sp. (**15, 16**) WAM 15.149: (**15**) dorsal view; (16) transverse view. (**17**) Impression of lateral surface, WAM 15.182. (**18**) *Parsimonia ootatoorensis* (Stoliczka, 1873), from surface of the boulder; partial dissolution of calcareous wall reveals growth lines as sharp ridges, WAM 15.101. (**19, 20**) *Bhimaites* sp. cf. *B. stoliczkai* Kossmat, 1898, dorsal views, WAM 15.142. (**21, 22**) Trachyleberididae gen. indet. sp. indet., WAM 15.163: (**21**) left carapace; (22) ventral view. (**23, 24**) ?*Spinoleberis* sp., WAM 15.161: (**23**) left carapace; (**24**) ventral view. (**1–16, 19, 20**) Specimens are casts; (1–20) specimens coated with ammonium chloride. (**1–20**) Scale bar = 1 cm; (**21–24**) Scale bars = 200 μm.

https://doi.org/10.1017/jpa.2016.76 Published online by Cambridge University Press

Materials.—One mold, with steinkern.

Remarks.—The poor preservation of apertural characteristics severely inhibits the accurate identification of this species, as the columella and inner labral features are key in distinguishing between Cretaceous ringiculids (see Squires and Saul, 2001; Stilwell and Henderson, 2002 for brief discussions on the generic significance of these characteristics). On the Batavia Knoll specimen, the columellar folding is not preserved or not observable, nor is it apparent whether the inner surface of the thickened outer lip bears any dentition. The presence and position of an apertural notch is also unknown. Despite these, the specimen conforms well to *Avellana subincrassata* in its size, dimensions, and ornamentation.

Superfamily Architectonicoidea Gray, 1850
Family Architectonicidae Gray, 1850

?Architectonicidae gen. indet. sp. indet.
Figure 6.10, 6.11

Description.—Of average to slightly small size for family (12 mm basal diameter). Markedly phaneromphalus; umbilicus is approximately one-third the diameter of the whorl. Whorl profile is trapezoidal, with rounded basal periphery. Apical surface of single preserved whorl maintains a smooth concentric depression, indicating position of preceding whorl and impressed sutures. Aperture absent. Whorl ornamentation consists of thin, evenly spaced, spiral and axial striations, resulting in a weak reticulate texture. Base ornamented with predominantly axial striations, forming crenulations on meeting the angular umbilical margin. Umbilicus displays same reticulate texture as exterior, though spiral elements are marginally stronger.

Materials.—Single last whorl fragmentary mold.

Remarks.—This specimen is provisionally assigned to Architectonicidae due to its compressed and highly umbilicate form with a trapezoid whorl profile. It possesses ornamentation similar to that of '*Solarium*' *vylapaudiense* Stoliczka, 1868 (p. 257, pl. 20, figs. 5, 6) from the Sillakkudi Formation of southern India (Santonian to Campanian), though *S. vylapaudiense* possesses a strong carination on its body whorls. Indeed, most compressed architectonicid genera exhibit a moderately sharp to strong peribasal keel, which is not seen in the Batavia Knoll specimen. This may indicate that it should instead be considered a member of the Solariellidae (Trochoidea), which also embraces low-spired, compressed forms. The whorl profiles of solariellids, however, are generally well rounded and evenly convex, as opposed to the angularity displayed by this species.

Genus *Pseudomalaxis* Fischer, 1885

Type species.—?*Bifrontia zanclea* Phillipi, 1836 by monotypy.

?*Pseudomalaxis* sp.
Figure 6.8, 6.9

Description.—Shell large for genus, discoidal, broadly umbilicate (umbilicus ~50% of diameter). Spire flat, suture slightly impressed. Whorl margins subquadrate. Coarse sculpture of spiral noded ribs, six per whorl. Rib proximal to outside whorl limit is strongest, giving margin a crenulated appearance. Inside this rib is a weak rib succeeded by a stronger rib, followed by three weaker ribs of equal strength to the second, all of which are noded due to the intersection of axial striae. Lateral whorl surfaces are similarly ornamented, with at least seven spiral beaded ribs of equal strength.

Materials.—Single fragmentary mold, with some original shell preserved.

Remarks.—The subquadrate whorl margins of this specimen are characteristic of *Pseudomalaxis* and its close relatives, though they are usually on the order of a few millimeters in diameter, making this quite a large specimen for the group. The provisional assignment here is due to the poor preservation of the specimen, obscuring much detail, including the protoconch. In addition, this genus is so far unknown from Lower Cretaceous rocks. *Pseudomalaxis* is a predominantly Quaternary genus, with Bieler and Petit (2005) suggesting it definitively only ranges down to the Pliocene. In their catalog of Architectonicidae genera, however, they maintain Cretaceous species as valid members of the genus. The earliest of these, *Pseudomalaxis pateriformis* Stephenson, 1955, is documented from Campanian strata of the southeastern United States (Dockery, 1993). Cladistic studies conducted by Bieler (1988) indicate the *Pseudomalaxis*/*Spirolaxis* Monterosato, 1913 group within the architectonicids diverged from the rest of the family in the Cretaceous, before the divergence of both *Pseudotorinia* Sacco, 1892, and *Heliacus* d'Orbigny, 1842/*Solatisonax* Iredale, 1931 clades. *Heliacus* is well documented from Campanian and younger rocks (e.g., Dockery, 1993), so it stands to reason that *Pseudomalaxis*, which diverged first, is found in older strata than *Heliacus*.

The sculpture of *P. pateriformis* is much finer than that of the Batavia Knoll specimen, with spiral lirae across the whorls (Dockery, 1993, pl. 34, figs. 6–11), rather than the beaded sculpture of the species described herein. Of interest, *P. pateriformis* is also a larger-than-average member of the genus (holotype 13 mm in diameter; Stephenson, 1955), perhaps suggesting a pattern of size reduction within the genus over time.

Class Scaphopoda Bronn, 1862
Order Dentaliida da Costa, 1778
Family Dentaliidae Gray, 1847
Genus *Dentalium* Linnaeus, 1758

Type species.—*Dentalium elephantium* Linnaeus, 1758 by subsequent designation (de Montfort, 1810).

Dentalium sp.
Figure 6.13

Description.—Shell weakly curved, tapering, of average to small size for family (reconstructed fragment length 36.7 mm). Aperture broken. Apex possibly exhibits two or three lateral notches. Circular in cross section at apex, becoming elliptical

https://doi.org/10.1017/jpa.2016.76 Published online by Cambridge University Press

aperturally. No clear ornamentation visible on exterior, though possible longitudinal ribs and oblique striae present.

Materials.—One fragment in two parts, mold and steinkern.

Remarks.—Only a single dentaliid test of significant size was recovered, with a few possible impressions noted in the rock also. Poor preservation inhibited a more specific identification, and more certain description, of this specimen. Aperture of the specimen is missing, so full length is unknown. Overall, its size, degree of curvature, and longitudinal ornamentation place it within *Dentalium*, some species of which do exhibit lateral notches at their apices (Lamprell and Healy, 1998). The Southern Hemisphere Cretaceous scaphopod record is extremely poor, with only 19 species identified from Aptian to Maastrichtian strata, exhibiting a high level of endemicity throughout the period (Stilwell, 1999; Stilwell and Henderson, 2002). Of these, only six are known from mid-Cretaceous (Aptian to Turonian) deposits, and merely two of those are ascribable to *Dentalium*. *Dentalium* sp. A and *Dentalium* sp. B of Stilwell (1999) are recorded from Aptian and Cenomanian rocks, respectively. Neither of these is conspecific with the Batavia Knoll species, the primary difference being the ovate nature of the species here toward its aperture. Given the highly endemic character of Cretaceous Scaphopoda, and the significant paleodistances between known coeval species, it may be necessary to erect a new species to accommodate the Batavia Knoll specimen as new specimens come to light.

Class Cephalopoda Cuvier, 1797
Subclass Ammonoidea von Zittel, 1884
Order Ammonitida Hyatt, 1889
Suborder Ammonitina Hyatt, 1889
Superfamily Desmoceratoidea von Zittel, 1895
Family Desmoceratidae von Zittel, 1895
Subfamily Puzosiinae Spath, 1922
Genus *Bhimaites* Matsumoto, 1954

Type species.—*Ammonites bhima* Stoliczka, 1865 by original designation.

Bhimaites sp. cf. *B. stoliczkai* Kossmat, 1898
Figure 6.19, 6.20

1865 cf. *Ammonites beudanti* Stoliczka, p. 142, pl. 71, figs. 1–4, pl. 72, figs. 1, 2.
1898 cf. *Puzosia stoliczkai* Kossmat, p. 119, pl. 24, fig. 6.
2014 cf. *Puzosia* (*Bhimaites*) *stoliczkai*; Kennedy and Klinger, p. 10, fig. 11a–c (full synonymy therein).

Occurrence.—Spain, France, Persia, northern South America, southern Africa, Madagascar, southern India; Early Cretaceous (late Albian) to Late Cretaceous (early Cenomanian).

Description.—Small for genus (approximately 30 mm in whorl diameter), subinvolute and laterally compressed with rounded venter and slightly concave flanks. Surface ornamentation of poorly developed growth lines and relatively widely spaced ribs. Suture trace is complexly ammonitic and has a dendritic profile.

Materials.—Single fragmentary mold and several steinkern (chamber) fragments.

Remarks.—Due to the incomplete nature of the material and suboptimal preservation of sutural contacts, doubt is cast onto the identification of this specimen. It does, however, conform well to *Bhimaites stoliczkai* in its dimensions, degree of compression, and minimal external ornamentation. It represents a rather small individual, as the species generally reaches an excess of 70 mm in diameter, though specimens of this size have been documented (e.g., Collignon, 1961).

Suborder Ancycloceratina Wiedmann, 1966
Superfamily Turrilitoidea Gill, 1871
Family Hamitidae Gill, 1871
Genus *Planohamites* Monks, 2002

Type species.—*Hamites compressus* Sowerby, 1814 by original designation.

Planohamites sp.
Figure 6.15–6.17

Description.—Average size for genus. Shaft straight to slightly bent, with compressed, ovate cross section (whorl breadth:whorl height = 0.75), possibly tapering to a slight keel along venter. Ornamentation of numerous fine concentric ribs, approximately one per millimeter (eight ribs in 10 mm), with interstices slightly wider than the ribs. Suture ammonitic with subquadrate profile.

Materials.—Single mold with steinkern, with possible fragments (whether of the same or separate individuals is unknown), two impressions of the lateral surface of the shaft.

Remarks.—The compressed transverse whorl section and closely spaced ribs place this species within *Planohamites* Monks, 2002, though the poor preservation and fragmentary nature of specimen(s) inhibit more specific identification. The sutural trace is inconclusive as only a general pattern can be discerned and it could be applied to several genera in a number of families. The ribs of this specimen are finer and subtler than is typical for the genus, and the apparent weak keel is also an anomalous feature.

Phylum Annelida Lamarck, 1809
Class Polychaeta Grube, 1850
Subclass Canalipalpata Rouse and Fauchald, 1997
Order Sabellida Fauchald, 1977
Family Serpulidae Rafinesque, 1815
Genus *Parsimonia* Regenhardt, 1961

Type species.—*Parsimonia parsimonia* Regenhardt, 1961 by original designation.

Parsimonia ootatoorensis (Stoliczka, 1873)
Figure 6.18

1873 *Serpula ootatoorensis* Stoliczka, p. 64, pl. 12, figs. 9, 10.
non 1875 *Serpula ootatoorensis*, Geinitz, p. 283, pl. 63, figs. 4, 5.
1959 *Serpula ootatoorensis*; Besairie and Collignon, p. 199.
1973 *Parsimonia ootatoorensis* (Stoliczka); Chiplonkar and Tapaswi, p. 121, pl. 8, fig. 8.

Holotype.—GSI 01840 (Stoliczka, 1873, pl. 12, fig. 9); Uttatur Group, southern India; Albian to Cenomanian.

Occurrence.—Southern India, Madagascar; late Albian to Cenomanian.

Description.—Straight to submeanderiform tube, moderate to slightly small for species (average diameter approximately 5 mm). Subcircular to subovate in cross section with subcircular, unadorned lumen. Tube wall ranging from thin to comparatively thick. Exterior surface ornamented by regular, concentric growth lines, but otherwise smooth.

Materials.—Numerous tubes throughout the rock, one slightly dissolved specimen from surface of boulder.

Remarks.—*Parsimonia ootatoorensis* is known from numerous specimens within the Batavia Knoll sandstone; however, the majority of these remain within the rock and have not been extracted. They primarily appear as single, isolated tubes (found in cross section during dissection of the boulder) though one cluster of 13 tubes was discovered. Due to their entombment within the rock, their general tube-building habits are unknown, as are their relationships with the substrate. Two instances of colonization of this serpulid on molluscan shells within the Batavia Knoll sandstone are documented; one on the external surface of the ?*Pseudomalaxis* sp. specimen, and several individuals were observed on the external and internal surfaces of a *Procerithium arenacollicola* n. sp. One tube was partially excavated from its block, which revealed an increase in diameter of that specimen from 4.4 mm to 6.3 mm over a length of approximately 40 mm.

The single occurrence of this species at the surface of the boulder (Fig. 6.18) preserves four tube sections, though whether they are attributable to single or multiple individuals is unknown. Partial dissolution of the internal layer of the calcareous tube here results in the growth lines being visible as a series of sharp concentric ridges on the interior surface.

Jäger (2014) emended the identification from Geinitz (1875; and subsequent authors) of this species from upper Cenomanian rocks in Saxony, noting specimens there should correctly be ascribed to *Sabella* Linnaeus, 1767. This leaves *P. ootatoorensis*, with occurrences in Madagascar, southern India, and now Batavia Knoll, as being a purely Gondwanan annelid.

Phylum Arthropoda von Siebold, 1848
Subphylum Crustacea Brünnich, 1772
Class Ostracoda Latreille, 1802
Subclass Podocopa Sars, 1866
Order Podocopida Müller, 1894
Suborder Cytherocopina Baird, 1850
Superfamily Cytheroidea Baird, 1850
Family Trachyleberididae Sylvester-Bradley, 1948
Genus *Spinoleberis* Deroo, 1966

Type species.—*Cythere eximia* Bosquet, 1854 by original designation.

?*Spinoleberis* sp.
Figure 6.23, 6.24

2009 ?*Spinoleberis* Babinot et al., p. 9, pl. 4, figs. 7, 8.

Description.—Carapace average size for genus, at 0.75 mm long, subtrigonal in outline, anterior margin broadly rounded, thickened, and crenulated. Posterior margin narrower, convex, and crenulated. Dorsal margin straight, ventral margin slightly sinuous; margins subparallel, converging toward the posterior. Moderate inflation, having almost equal height to width of articulated carapace. Subcentral tubercle hemispherical and prominent on both valves. Left valve possesses a strong subcentral ridge with a tubercle. Right valve is devoid of this tubercle. Lateral surface appears smooth, excepting crenulations along anterior and posterior margins.

Materials.—Single articulated shell and possible hinge fragment.

Remarks.—This ostracod appears to be aligned with the Albian to Maastrichtian trachyleberidid genus, *Spinoleberis* Deroo, 1966, but *Rehacythereis* Gründel, 1973 or *Cythereis* Jones, 1849 cannot be entirely discounted, although this specimen does not appear to possess the reticulate sculpture of the latter genera. This specimen is herein tentatively assigned to *Spinoleberis* due to its morphological affinity with specimens described by Babinot et al. (2009) from mid to late Albian strata of Madagascar and provisionally assigned by them to the same genus. Due to its size, it is probable the specimen recovered from Batavia Knoll is male.

?Trachyleberididae gen. indet. sp. indet.
Figure 6.21, 6.22

Description.—Small carapace for family at just over 0.3 mm long, subtrigonal in lateral view, moderately inflated in dorsal view (subequal height and width). Anterior margin narrow and quadrate, posterior margin well rounded. Dorsal margin straight, ventral margin convex. Subcentral ridge connects to prominent orbicular tubercle on both valves. Second, slightly less prominent, tubercle sits ventral to orbicular tubercle on ventral margin. In ventral view, lateral margins angular and taper to a point. Surface is finely reticulated.

Materials.—One articulated specimen.

Remarks.—A single extracted ostracod, broadly similar in shape to ?*Spinoleberis* above, yet has a more convex ventral margin and appears to be reverse oriented, with the narrow end being anterior to the wider. Alternatively, the prominent tubercles could be located posteriorly, rather than anteriorly, as is typical. Either of these assertions calls into question the assignment of this specimen within the Trachyleberididae, which do not generally exhibit singular strong posterior tubercles or a narrow anterior margin.

Phylum Echinodermata Klein, 1734
Class Echinoidea Leske, 1778

Echinoidea ord. indet. fam. indet.
Figure 6.14

Description.—Convex shell fragment ornamented predominantly by longitudinal striations. 'Lower' sector (approximately half the width of the fragment) slightly depressed from the 'upper' and striations thereon broadly sigmoidal, curving into the 'point' of the fragment. 'Upper' portion dominated by strong striations crosscutting longitudinal lines at approximately 50º from horizontal. Where these crosscutting striae meet the line of depression a slight crenulated ridge forms.

Materials.—Isolated fragment, mold.

Remarks.—The texture displayed by this shell fragment is not common among any molluscan class, resulting in its tentative identification as an echinoderm fragment. Echinoderm spines are evident in thin sections of the Batavia Knoll sandstone, indicating that this phylum did inhabit the area of deposition. The minute size of the echinoderm spines is indicative of irregular urchins, such as heart urchins and sand dollars. The angled texture of the 'upper' portion could be synonymous with ambulacral groove (petal) patterns. Heart urchins and sand dollars preferentially reside in sandy substrates (Chao, 2000), which is consistent with the other fauna described herein from the Batavia Knoll sandstone.

Acknowledgments

We are indebted to the researchers from the University of Tasmania and University of Sydney (J. Whittaker, J. Halpin, S. Williams, et al.) who undertook the initial voyage to collect samples, especially to J. Whittaker for providing funding from her DECRA grant (DE140100376) to the authors for this research to be completed. Our thanks also go to S. Morton, of the Department of Physics, Monash University, for his phenomenal photography skills. For assistance and clarification of certain taxa, our gratitude goes to R. Squires (for *Igonoia*), E. Kupriyanova and A. Ippolitov (for the serpulid), P. Quilty (for Foraminifera), and C. Mays (for palynomorph grains). We also extend our thanks to editor M. Hautmann and reviewers S. Schneider and S. Kiel for their constructive feedback and improvement of this work.

References

Adams, H., and Adams, A., 1853–1858, The genera of Recent Mollusca arranged according to their organisation, 2, London, Van Voorst, 660 p.

Allmon, W.D., 1988, Ecology of Recent turritelline gastropods (Prosobranchia, Turritellidae): Current knowledge and paleontological implications: Palaios, v. 3, p. 259–284.

Allmon, W.D., Jones, D.S., and Vaughan, N., 1992, Observations on the biology of *Turritella gonostoma* Valenciennes (Prosobranchia: Turritellidae) from the Gulf of California: The Veliger, v. 35, no. 1, p. 52–63.

Amon, D.J., Sykes, D., Ahmed, F., Copley, J.T., Kemp, K.M., Tyler, P.A., Young, C.M., and Glover, A.G., 2015, Burrow forms, growth rates and feeding rates of wood-boring Xylophagaidae bivalves revealed by micro-computed tomography: Frontiers in Marine Science, v. 2, no. 10, doi: 10.3389/fmars.2015.00010.

Ayoub Hannaa, W.S., Radulović, B.V., Radulović, V.J., and Fürsich, F.T., 2015, Gastropods from the lower Cenomanian of Koraćica (Kosmaj Mountain, central Serbia): Neues Jahrbuch für Geologie und Paläontologie - Abhandlungen, v. 276, p. 27–62.

Babinot, J.-F., Colin, J.-P., and Randrianasolo, A., 2009, Les ostracodes de l'Albien-Turonien moyen de la région d'Antsiranana (Nord Madagascar): Systématique, paléoécologie et paléobiogéographie: Carnets de Géologie, v. 2009/01, paleopolis.rediris.es/cg/CG2009_A2001/.

Baird, W., 1850, Description of several new species of Entomostraca: Annals of Natural History: Series 2, v. 10, p. 56–59.

Bandel, K., 2006, Families of the Cerithioidea and related superfamilies (Palaeo-Caenogastropoda; Mollusca) from the Triassic to the Recent characterized by protoconch morphology—including the description of new taxa: Paläontologie, Stratigraphie, Fazies, v. 14, no. C511, p. 59–138.

Barnes, H., and Bagenal, T.B., 1952, The habits and habitat of *Aporrhais pes-pelicani* (L.): Proceedings of the Malacological Society of London, v. 29, no. 2, p. 101–105.

Bender, K., and Davis, W.R., 1984, The effect of feeding by *Yoldia limatula* on bioturbation: Ophelia, v. 23, no. 1, p. 91–100.

Berizzi, A., and Busson, G., 1971, Lamellibranches apto-cénomaniens de l'extrême-sud tunisien: Rivista Italiana di Paleontologia, v. 77, no. 4, p. 437–544.

Besairie, H., and Collignon, M., 1959, Le sysème crétacè á Madagascar, El Sistema Cretácio Volume 2: Mexico City, 20th International Geological Congress, p. 135–198.

Beurlen, K., 1944, Beiträge zur Stammegeschichte der Muscheln: Mathematisch-Naturwissenschaftlichen Abteilung der Bayerischen Akademie der Wissenschaften, Sitzungberichte, v. 1–2, p. 133–145.

Bieler, R., 1988, Phylogenetic relationships in the gastropod family Architectonicidae, with notes on the family Mathildidae (Allogastropoda): Malacological Review, v. Sup. 4, p. 205–240.

Bieler, R., and Petit, R.E., 2005, Catalogue of Recent and fossil taxa of the family Architectonicidae Gray, 1850 (Mollusca: Gastropoda): Zootaxa, v. 1101, p. 1–119.

Bosquet, J., 1854, Monographie des Crustaceés fossiles du terrain Cretacé du Duché de Limbourg: Verhandelingen uitgegeven door de commisie belast met het vervaardigen eener geologische beschrijving en kaart van Nederland, v. 2, p. 1–137.

Bouchet, P., and Rocroi, J.-P., 2005, Classification and nomenclator of gastropod families: Malacologia, v. 47, no. 1–2, p. 1–397.

Bronn, H.G., 1862, Die Klassen und Ordnungen der Weichthiere (Malacozoa): Wisseneschluflich dargstellt in Wort und Bild, 3, Leipzig, Winter, 1306 p.

Bruguière, J.G., 1789, Histoire naturalle des vers, Encyclopédie Méthodique. Volume 1(1), Paris, Panckoucke, p. 1–344.

Brünnich, M.T., 1772, Zoologiae fundamenta praelectionibus academicis accomodata, Hafniae and Lipsiae, Pelt, 254 p.

Burmeister, H., 1837, Handbuch der Naturgeschichte, Zoologie, v. Volume 2: Berlin, Enslin, p. 369–858.

Carter, J.G., et al., 2011, A Synoptical Classification of the Bivalvia (Mollusca): Paleontological Contributions, v. 4, p. 1–47.

Carter, J.G., Campbell, D.C., and Campbell, M.R., 2000, Cladistic perspectives on early bivalve evolution, *in* Harper, E.M., Taylor, J.D., and Crame, J.A., eds., The Evolutionary Biology of the Bivalvia, London, The Geological Society, p. 47–79.

Casey, R., 1952, Some genera and subgenera, mainly new, of Mesozoic heterodont Lamellibranchs: Proceedings of the Malacological Society of London, v. 29, no. 4, p. 121–176.

Casey, R., 1961, The stratigraphical palaeontology of the Lower Greensand: Palaeontology, v. 3, no. 4, p. 487–621.

Chao, S.-M., 2000, The irregular sea urchins (Echinodermata: Echinoidea) from Taiwan, with descriptions of six new records: Zoological Studies, v. 39, no. 3, p. 250–265.

Chavan, A., 1952, Les pélécypodes des Sables Astartiens de Cordebugle (Calvados): Schweizerische Palaeontologische Abhanglungen, v. 69, p. 1–132.

Chiplonkar, G.W., 1939, Lamellibranchs from the Bagh Beds: Proceedings of the Indian Academy of Sciences—Section B, v. 10, no. 4, p. 255–274.

Chiplonkar, G.W., 1941, Age and affinities of the Bagh fauna: Proceedings of the Indian Academy of Sciences—Section B, v. 15, no. 3, p. 148–152.

Chiplonkar, G.W., and Tapaswi, P.M., 1973, Fossil polychaetes from the Upper Cretaceous rock formations of South India—Part I: Proceedings of the Indian Academy of Sciences—Section B, v. 77, no. 3, p. 116–130.

Collignon, M., 1949, Recherches sur les faunes Albiennes de Madagascar I. - l'Albien d'Ambarimaninga: Annales géologiques du Service des Mines, v. 16, p. 1–168.

Collignon, M., 1961, Ammonites néocrétacees du Menabe (Madagascar) 7 - Les Desmoceratidae: Annales géologiques du Service des Mines, v. 31, p. 1–115.
Conrad, T.A., 1860, Descriptions of new species of Cretaceous and Eocene fossils of Mississippi and Alabama: Journal of the Philadelphia Academy of Natural Sciences, Second Series, v. 4, p. 275–298.
Cossmann, M., 1902, Rectifications de nomenclature: Revue Critique de Paléozoologie, v. 6, no. 3, p. 160–162.
Cossmann, M., 1904, Essais de Paléoconchologie Comparée, 6, Paris, M. Cossmann, 151 p.
Cossmann, M., 1906, Essais de Paléoconchologie Comparée, 7, Paris, M. Cossmann, 261 p.
Cox, L.R., 1952, Cretaceous and Eocene fossils from the Gold Coast: Bulletin of the Gold Coast Geological Survey, v. 17, p. 1–68.
Cox, L.R., 1953, Lower Cretaceous Gastropoda, Lamellibranchia and Annelida from Alexander I Land (Falkland Islands dependencies): Falkland Islands Dependencies Survey, Scientific Reports, v. 4, p. 1–14.
Cox, L.R., 1955, Proposed determination of the nominal species to be accepted as the type species of the genus "Inoceramus" Sowerby (J.), 1814 (Class Pelecypoda) and proposed addition of that name to the "Official List of Generic Names in Zoology": Bulletin of Zoological Nomenclature, v. 11, p. 239–245.
Cox, L.R., 1960, Thoughts on the classification of the Gastropoda: Proceedings of the Malacological Society of London, v. 33, p. 239–261.
Cuvier, G., 1795, Second mémoire sur l'organisation et les rapports des animaux à sang blanc, dans lequel on traite de la structure des Mollusques et de leaur division en ordres, lu à la Société d'histoire naturelle de Paris, le 11 Prairial, an Ill: Magazin Encyclopédique, ou Journal des Sciences, des Lettres et des Arts, v. 2, p. 433–449.
Cuvier, G., 1797, Note sur l'anatomie des ascidies: Bulletin de la Société Philomathique de Paris, v. 2, p. 1.
Cuvier, G., and Brongniart, A., 1822, Description géologique des environs de Paris, nouvelle édition, Paris and Amsterdam, G. Dufour and E. d'Ocagne, 428 p.
da Costa, E.M., 1778, Historia Naturalis Testaceorum Britanniae, or, The British Conchology, London, Millan, White, Elmsley, and Robson, 254 p.
Dall, W.H., 1889, On the hinge of pelecypods and its development, with an attempt toward a better subdivision of the group: American Journal of Science and Arts, series 3, v. 38, p. 445–462.
de Montfort, P.D., 1810, Conchyliologie Systematique et Classification Methodique des Coquilles, Paris, Schoell, 676 p.
Deroo, G., 1966, Cytheracea (Ostracodes) du Maastrichtien de Maastricht (Pays-Bas) et des régions voisines; résultats stratigraphiques et paléontologiques de leur étude: Mededelingen van de Geologische Stichting, v. 2, p. 1–197.
Deshayes, G.P., 1864, Description des animaux sans vertèbres découverts dans le bassin de Paris, pour servir de supplément à la description des coquilles fossiles des environs de Paris, comprenant une revue générale de toutes les espèces actuellement connues, 3, Paris, Baillière, 667 p.
Dockery, D.T., 1993, The streptoneuran gastropods, exclusive of the Stenoglossa, of the Coffee Sand (Campanian) of northeastern Mississippi: Bulletin of the Mississippi Office of Geology, v. 129, p. 1–191.
d'Orbigny, A.D., 1842, Paléontologie Française, Terrains Crétacés. Mollusques, 2, Paris, G. Masson, 456 p.
d'Orbigny, A.D., 1843–1848, Paléontologie Française—Terrains Crétacés. III. Lamellibranches: Paris, C. A. Bertrand.
d'Orbigny, A.D., 1850, Prodrome de Paléontologie Stratigraphique Universelle des Animaux Mollusques et Rayonnés, 2: Paris, G. Masson.Douvillé, H., 1904, Mollusques fossiles, Mission scientifique en Perse par J. de Morgan Volume 3: Paris, Leroux, p. 192–380.
Elder, W.P., and Saul, L.R., 1996, Taxonomy and biostratigraphy of Coniacian through Maastrichtian *Anchura* (Gastropoda: Aporrhaiidae) of the North American Pacific Slope: Journal of Paleontology, v. 70, no. 3, p. 381–399.
Eudes-Deslongchamps, E., 1864, Note sur la délimitation des genres *Trochotoma* et *Ditremaria*, 1: Paris, Savy, p. 35–46.
Eudes-Deslongchamps, J.A., 1849, Mémoire sur les Pleurotomaires. Mémoires sur les fossiles des terrains secondaires du Calvados: Mémoires de la Société Linnéenne de Normandie, v. 8, p. 1–157.
Evans, J., and Shumard, B.F., 1857, On some new species of fossils from the Cretaceous formation of Nebraska Territory: Transactions of the Academy of Science of St. Louis, v. 1, p. 38–42.
Fauchald, K., 1977, The polychaete worms, definitions and keys to the orders, families and genera: Natural History Museum of Los Angeles County Science Series, v. 28, p. 1–188.
Ferrari, S.M., 2012, The genera *Cryptaulax* and *Procerithium* (Procerithiidae, Caenogastropoda) in the Early Jurassic of Patagonia, Argentina: Alcheringa, v. 36, no. 3, p. 323–336.
Férussac, A.E.J., 1821–1822, Tableaux Systèmatiques des Animaux Mollusques suivis d'un Prodrome Général pour tous les Mollusques Terrestres ou Fluviatiles Vivants ou Fossiles, Paris and London, Arthus-Bertrand and Sowerby.
Fischer, P.H., 1880–1887, Manuel de conchyliologie et de paléontologie conchyliologique, ou histoire naturelle des mollusques vivants et fossiles: Paris, F. Savy, 1369 p.
Fleming, J., 1822, The philosophy of zoology, a general view of the structure, functions, and classification of animals, 2, Edinburgh, Constable & Co., 618 p.
Forbes, E., 1846, Report on the fossil Invertebrata from southern India, collected by Mr. Kaye and Mr. Cunliffe: Transactions of the Geological Society of London, 2nd series, v. 7, p. 97–174.
Gabb, W.M., 1864, Description of the Cretaceous fossils: California Geological Survey: Palæontology, v. 1, p. 57–243.
Gale, A.S., Brown, P., Caron, M., Crampton, J., Crowhurst, S.J., Kennedy, W.J., Petrizzo, M.R., and Wray, D.S., 2011, The uppermost middle and upper Albian succession at the Col de Palluel, Hautes-Alpes, France: An integrated study (ammonites, inoceramid bivalves, planktonic foraminfera, nannofossils, geochemistry, stable oxygen and carbon isotopes, cyclostratigraphy): Cretaceous Research, v. 32, p. 59–130.
Geinitz, H.B., 1871–1875, Das Elbthalgebirge in Sachsen, 1, Cassel, T. Fischer, 338 p.
Gibbons, A.D., Barckhausen, U., van den Bogaard, P., Hoernle, K., Werner, R., Whittaker, J.M., and Müller, R.D., 2012, Constraining the Jurassic extent of Greater India: Tectonic evolution of the West Australian margin: Geochemistry, Geophysics, Geosystems, v. 13, no. 5, p. 1–25.
Giebel, C.G.A., 1852, Deutschlands Petrefacten: Ein systematisches Verzeichnis aller in Deutschland und den angrenzenden Ländern vorkommenden Petrefacten nebst Angabe der Synonyme und Fundorte: Leipzig, A. Abel.
Gill, T., 1871, Arrangement of the families of molluscs: Smithsonian Miscellaneous Collections, v. 227, p. 1–49.
Glaessner, M.F., 1958, New Cretaceous fossils from New Guinea: Records of the South Australian Museum, v. 13, no. 2, p. 199–226.
Gmelin, J.F., 1791, Caroli a Linné Systema naturae per regna tria naturae. Editio decimatertia, 1, Leipzig, Beer, p. 3021–3910.
Goldfuss, G.A., 1820, Handbuch der Zoologie, *in* Schubert, G.H., ed., Handbuch der Naturgeschichte zum Gebrauch bei Vorlesungen, v. Volume 3: Nuremberg, Schrag, p. 1–696.
Golikov, A.N., and Starobogatov, Y.I., 1975, Systematics of prosobranch gastropods: Malacologia, v. 15, p. 185–232.
Gradstein, F.M., and Ogg, J.G., 2012, The chronostratigrahic scale, *in* Gradstein, F.M., Ogg, J.G., Schmitz, M., and Ogg, G., eds., The Geologic Time Scale, Oxford, UK, Elsevier B.V., p. 31–42.
Gray, J.E., 1824, A supplement to the appendix of Captain Perry's voyage for the discovery of a northwest passage in the years 1819–1820, containing an account of the subjects of natural history. Appendix X. Natural History, Shells, London, J. Murray, p. 211–246.
Gray, J.E., 1826, On a Recent species of the genus *Hinnites* de France, and some observations on the shells of the Monomyaires Lamarck: The Annals of Philosophy, v. 12, no. 5, p. 103–106.
Gray, J.E., 1838, Catalogue of the species of the genus *Cytherea* of Lamarck: The Analyst, v. 8, no. 24, p. 302–309.
Gray, J.E., 1847, A list of genera of Recent Mollusca, their synonyma and types: Proceedings of the Zoological Society of London, v. 15, p. 129–219.
Gray, J.E., 1850, Figures of molluscous animals selected from various authors. Etched for the use of students by M. E. Gray, 4, London, Longman, Brown, Green & Longmans, 219 p.
Gray, J.E., 1854, A revision of the arrangement of the families of bivalve shells (Conchifera): Annals and Magazine of Natural History, series 2, v. 13, no. 77, p. 408–418.
Grobben, C., 1894, Zur Zenntniss der Morphologie, der Verwandtschaftsverhältnisse und des Systems der Mollusken: Kaiserliche Akademie der Wissenschaften (Mathematisch-Naturwissenschaftlichen Classe), Sitzungsberichte, v. 103, no. 1, p. 61–86.
Grube, A.E., 1850, Die Familien der Anneliden: Archiv für Naturgeschichte: Berlin, v. 16, no. 1, p. 249–364.
Gründel, J., 1973, Zur Entwicklung der Trachyleberididae (Ostracoda) in der Unterkreide und in der tieferen Oberkreide. Teil 1: Taxonomie: Zeitschrift für Geologische Wissenschaften, Berlin, v. 1, p. 1403–1474.
Hertwig, R., 1895, Lehrbuch der Zoologie, 3rd ed.: Jena, Gustav Fischer, 599 p.
Hickman, C.S., and McLean, J.H., 1990, Systematic revision and suprageneric classification of trochacean gastropods: Natural History Museum of Los Angeles County, Science Series, v. 35, p. 1–169.
Houbrick, R.S., 1980, Review of the Deep-Sea Genus *Argyropeza* (Gastropoda: Prosobranchia: Cerithiidae), 321, Washington, D.C., Smithsonian Institution Press, 30 p.
Houbrick, R.S., 1992, Monograph of the Genus *Ceritihium* Bruguière in the Indo-Pacific (Cerithiidae: Prosobranchia), 510, Washington, D.C., Smithsonian Institution Press, 211 p.

https://doi.org/10.1017/jpa.2016.76 Published online by Cambridge University Press

Huang, C., Ogg, J.G., and Hinnov, L.A., 2012, Cretaceous, *in* Gradstein, F.M., Ogg, J.G., Schmitz, M., and Ogg, G., eds., The Geologic Time Scale. Volume 2: Oxford, UK, Elsevier B.V., p. 793–850.

Hyatt, A., 1889, Genesis of the Arietidae: Smithsonian Contributions to Knowledge, v. 673, no. 6, p. 1–239.

Iredale, T., 1931, Australian molluscan notes, no. 1: Records of the Australian Museum, v. 18, p. 201–235.

Jäger, M., 2014, Serpuliden und Sabelliden: Geologica Saxonica, v. 60, p. 57–81.

Jones, T.R., 1849, A monograph of the Entomostraca of the Cretaceous Formation in England: Monograph of the Palaeontological Society of London, v. 3.

Karpuk, M.S., and Tesakova, E.M., 2014, New ostracodes of the families Loxoconchidae and Trachyleberididae from the Barremian-Albian of southwestern Crimea: Paleontologicheskii Zhurnal, v. 2, p. 77–80.

Kelly, S.R.A., and Bromley, R.G., 1984, Ichnological nomenclature of clavate borings: Palaeontology, v. 27, no. 4, p. 793–807.

Kendrick, G.W., and Vartak, A.V., 2007, Middle Cretaceous (Cenomanian) bivalves from the Karai Formation, Uttattur Group, of the Cauvery Basin, south India: Records of the Western Australian Museum, v. Sup. 72, p. 1–101.

Kennedy, W.J., and Klinger, H.C., 2014, Cretaceous fauna from Zululand and Natal, South Africa. Valdedorsella, Pseudohaploceras, Puzosia, Bhimaites, Pachydesmoceras, Parapuzosia (Austiniceras) and P. (Parapuzosia) of the ammonite subfamily Puzosiinae Spath, 1922: African Natural History, v. 10, p. 1–46.

Kiel, S., 2006, New and little-known gastropods from the Albian of the Mahajanga Basin, northwestern Madagascar: Journal of Paleontology, v. 80, no. 3, p. 455–476.

Kiel, S., and Bandel, K., 2002, About some apporhaid and strombid gastropods from the Late Cretaceous: Paläontologische Zeitschrift, v. 76, no. 1, p. 83–97.

Kiel, S., and Bandel, K., 2004, The Cenomanian Gastropoda of the Kassenberg quarry in Mülheim (Germany, Late Cretaceous): Paläontologische Zeitschrift, v. 78, no. 1, p. 103–126.

Klein, J.T., 1734, Naturalis dispositio echinodermatum. Accessit lucubratiuncula de aculeis echinorum marinorum, cum spicilegio de belemnitis: Danzig, T.J. Schreiberi, 78 p.

Koken, E., 1896, Die Gastropoden der Trias um Hallstadt: Jahrbuch der Kaiserlich-Köninglichen Geologischen Reichsanstadt, v. 46, no. 1, p. 37–126.

Kollmann, H.A., 2009, A Late Cretaceous Aporrhaidae-dominated gastropod assemblage from the Gosau Group of the Pletzach Alm near Kramsach (Tyrol, Austria). With an appendix on the taxonomy of Mesozoic Aporrhaidae and their position in the superfamily Stromboidea: Annalen des Naturhistorischen Museums in Wien, v. 111, A, p. 33–72.

Kossmat, F., 1898, Untersuchungen über die Südindische Kreideformation: Beiträge zur Paläontologie Österrich-Ungarns und des Orients, v. 11, p. 89–152.

Lamarck, J.-B., 1799, Prodrome d'une nouvelle classification des coquilles, comprenant une rédaction appropriée des caractères géneriques, et l'établissement d'un grand nombre de genres nouveaux: Mémoires de la Société d'Histoire Naturelle de Paris, v. 1, p. 63–91.

Lamarck, J.-B., 1806, Suite des mémoires sur les fossiles des environs de Paris: Annales du Muséum d'Histoire naturelle de Paris, v. 7, p. 130–139.

Lamarck, J.-B., 1809, Philosophie Zoologique, ou Exposition des Considérations Relative à l'Histoire Naturelle des Animaux; à la Diversité de Leur Organisation et des Facultés qu'ils en Obtiennent; aux Causes Physiques qui Maintiennent en Eux la Vie et Donnent lieu aux Mouvements qui'ils Exécutent; enfin, à celles qui Produisent, les Unes le Sentiment, et les Autres l'Intelligence de Ceux qui eu sont Doués, Paris, Chez Dentu et l'Auteur, 888 p.

Lamprell, K.L., and Healy, J.M., 1998, A revision of the Scaphopoda from Australian waters (Mollusca): Records of the Australian Museum, v. Sup. 24, p. 1–189.

Latreille, P.A., 1802, Histoire naturelle, générale et particulière des Crustacés et des Insectes: Histoires des Cypris et des Cytherées, v. 8, no. 4, p. 232–254.

Leach, W.E., 1819, Des nouvelles espéces d'Animaux découvertes par la vaisseau Isabelle dans un voyage au pôle boreal: Journal de Physique, de Chimie, d'Histoire Naturelle et des Arts, v. 88, p. 462–467.

Lehmann, J., Tröger, K.-A., and Owen, H.G., 2008, Ammonites and associated macrofauna from the early Late Albian of the Zippelsförde 1/64 core, NE-Germany: Acta Geologica Polonica, v. 58, no. 4, p. 437–453.

Leske, N.G., 1778, Jacobi Theodori Klein naturalis dispositio echinodermatum; edita et descriptionibus novisque inventis et synonomis auctorem aucta. Addimenta ad J. T. Klein naturalem dispositionem Echinodermatum, Leipzig, G.E. Beer, 278 p.

Leymerie, M.A., 1842, Mémoire sur le terrain crétacé du départment de l'Aube (seconde partie): Mémoires de la Société Géologique de France, v. 5, no. 1, p. 1–34.

Link, H.F., 1807, Beschreibung der Naturalien-Sammlung der Universitaet zu Rostock, 3: Rostock, Adlers Erben., p. 101–165.

Linnaeus, C., 1758, Systema Naturae: Stockholm, Laurentii Salvvi, 824 p.

Linnaeus, C., 1767, Systema Naturae, 12th ed., Stockholm, Laurentii Salvii, p. 533–1327.

Lovén, S.L., 1847, Malacozoologi: Kongliga Vetenskaps-Akademiens Förhandlingar, p. 175–199.

Marwick, J., 1939, *Maccoyella* and *Aucellina* in the Taitai Series: Royal Society of New Zealand, Transactions and Proceedings, v. 68, no. 4, p. 462–465.

Maton, W.G., and Racket, T., 1807, A descriptive catalogue of the British Testacea: Transactions of the Linnean Society of London, v. 8, p. 17–250.

Matsumoto, M., 1954, Family Puzosiidae from Hokkaido and Saghalien: Memoirs of the Faculty of Science, Kyushu University, Series D, Geology, v. 5, p. 69–118.

Meek, F.B., 1864, Check list of the invertebrate fossils of North America: Cretaceous and Jurassic: Smithsonian Miscellaneous Collections, v. 177, p. 1–40.

Melvill, J.C., and Standen, R., 1901, The Mollusca of the Persian Gulf, Gulf of Oman, and Arabian Sea, as evidenced mainly through the collections of Mr. F.W. Townsend, 1893–1900; with descriptions of new species: Proceedings of the Zoological Society of London, v. 2, p. 327–400.

Ménard de la Groye, F.J.B., 1807, Mémoire sur un nouveau genre de la famille des Solénoides: Annales du Muséum d'Histoire naturelle de Paris, v. 9, p. 131–139.

Monari, S., and Gatto, R., 2013, The genus *Leptomaria* E Eudes-Deslongchamps, 1864 (Gastropoda, Pleurotomariidae) from the Early Bajocian of Luxembourg: Systematics and paleobiogeography: Historial Biology, v. 26, p. 1–17.

Monks, N., 2002, Cladistic analysis of a problematic ammonite group: The Hamitidae (Cretaceous, Albian–Turonian) and proposals for new cladistic terms: Palaeontology, v. 45, no. 4, p. 689–707.

Monterosato, T.A., 1913, Note on the genus *Pseudomalaxis*, Fischer, and descriptions of a new species and sub-genus: Proceedings of the Malacological Society of London, v. 10, p. 362–363.

Morter, A.A., and Wood, C.J., 1983, The biostratigraphy of Upper Albian–Lower Cenomanian *Aucellina* in Europe: Zitteliana, v. 10, p. 515–529.

Müller, G.W., 1894, Die Ostracoden des Golfes von Neapal und der angrenzenden Meeresabschnitte, Fauna und Flora Golf von Neapel und der angrenzenden Meeres-Abschnitte, v. Volume 21: Berlin, Zoologische Station zu Neapel, p. 1–404.

Müller, O.F., 1779, Von zwoen wenig bekannten Muscheln, der Schinkenarche und der gerunzelten Mahlermuschel: Beschäftigungen der Berlinische Gesellschaft Naturforschender Freunde, v. 4, p. 55–59.

Paul, H., 1939, Die Muscheln der Magdeburger Kulmgrauwacke: Abhandlungen und Berichte aus dem Museum für Naturkunde und Vorgeschicht und dem Naturwissenscahftlichen Verein in Magdeburg, v. 7, no. 1, p. 165–181.

Pelseneer, P., 1889, Sur la classification phylogénétique des Pélécypodes: Bulletin Scientifique de la France et de la Belgique, v. 20, p. 27–52.

Phillipi, R.A., 1836, Enumeratio molluscorum Siciliae cum viventium tum in tellure tertiaria fossilium quae in itinere suo observavit, 1, Berlin, Berolini, 268 p.

Pompeckj, J.F., 1901, Über Aucellen und Aucellen-ähnliche Formen: Neues Jahrbuch für Mineralogie, Geologie und Paläontologie, B.B., v. 14, p. 319–368.

Rafinesque, C.S., 1815, Analyse de la Nature ou Tableau de l'univers et des Corps Organisés, Paris, Palerme, 223 p.

Regenhardt, H., 1961, Serpulidae (Polychaeta sedentaria) aus der Kreide Mitteleuropas, ihre ökologische, taxionomische und stratigraphische Bewertung: Mitteilungen aus dem Geologischen Staatsinstitut in Hamburg, v. 30, p. 5–115.

Rennie, J.V.L., 1936, Lower Cretaceous Lamellibranchia from northern Zululand: Annals of the South African Museum, v. 31, no. 3, p. 277–391.

Rouse, G.W., and Fauchald, K., 1997, Cladistics and polychaetes: Zoologica Scripta, v. 26, no. 2, p. 139–204.

Sacco, F., 1892, I Molluschi dei terreni terziarii del Piemonte e della Liguria. Parte 11. Eulimidae e Pyramidellidae (parte): Torino, Clausen, 98 p.

Sars, G.O., 1866, Oversigt af Norges marine Ostracoder: Forhandlinger i Videnskabs-Selskabet i Christiania, p. 1–130.

Scheibnerová, V., 1972, Aptian-Albian benthonic foraminifera from DSDP leg 27, sites 259, 260, and 263, eastern Indian Ocean: Initial Reports of the Deep Sea Drilling Project, v. 27, no. 36, p. 697–741.

Schmidt, F.C., 1818, Versuch über die beste Einrichtung zur Aufstellung, Behandlung und Aufbewahrung der verschiedenen Naturkörper und Gegenstände der Kunst, verzüglich der Conchylien-Sammlungen, nebst kurzer Beurtheilung der conchyliologischen Systeme und Schriften und einer tabellarischen Zusamenstellung und Vergleichung der sechs besten und neuesten conchyliologischen Systeme, welchen ein Verzeichniss der am meisten bekannten Conchylien angehängt ist, wie solche nach dem

Lamarkischen System geordnet werden können, 4, Gotha, Justus Perthes, 252 p.
Schneider, S., and Kaim, A., 2011, Early ontogeny of Middle Jurassic hiatellids from a wood-fall association: Implications for phylogeny and palaeoecology of Hiatellidae: Journal of Molluscan Studies, v. 78, p. 1–9.
Scott, R.W., 1978, Approaches to trophic analysis of paleocommunities: Lethaia, v. 11, p. 1–14.
Sedgwick, A., 1829, On the geological relations and internal structure of the Magnesian Limestone, and the lower positions of the New Red Sandstone Series in their range through Nottinghamshire, Derbyshire, Yorkshire and Durham: Transactions of the Geological Society of London, 2nd series, v. 3, p. 35–124.
Sellius, G., 1733, Historia naturalis teredinis seu xylophagi marini tubuloconchoidis speciatim Belgici: Trajecti ad Rhenum, 366 p.
Sohl, N.F., 1960, Archaeogastropoda, Mesogastropoda and stratigraphy of the Ripley Owl Creek, and Prairie Bluff formations: U.S. Geological Survey, Professional Papers, v. 331, p. 1–151.
Sowerby, J., 1814, The Mineral Conchology of Great Britain; or Coloured Figures and Descriptions of Those Remains of Testaceous Animals or Shells Which Have Been Preserved at Various Times and Depths in the Earth, 1, London, Meredith.
Sowerby, J.: 1817, The Mineral Conchology of Great Britain; or Coloured Figures and Descriptions of Those Remains of Testaceous Animals or Shells Which Have Been Preserved at Various Times and Depths in the Earth, 2: London, Meredith, p. 117–194.
Sowerby, J., 1836, Observations on some strata between the Chalk and the Oxford Oolite: Transactions of the Geological Society of London, v. 2, no. 4, p. 103–388.
Spath, L.F., 1922, On the Senonian ammonite fauna of Pondoland: Transactions of the Royal Society of South Africa, v. 10, p. 113–147.
Squires, R.L., 2011, A new genus of Cretaceous margaritine gastropod (Turbinidae) from the northeastern Pacific Ocean: The Nautilus, v. 125, no. 3, p. 137–149.
Squires, R.L., and Saul, L.R., 2001, New Late Cretaceous gastropods from the Pacific Slope of North America: Journal of Paleontology, v. 75, no. 1, p. 46–65.
Squires, R.L., and Saul, L.R., 2006, Additions and refinements to Aptian to Santonian (Cretaceous) *Turritella* (Mollusca: Gastropoda) from the Pacific Slope of North America: The Veliger, v. 48, no. 1, p. 46–60.
Stephenson, L.W., 1955, Owl Creek (Upper Cretaceous) fossils from Crowleys Ridge, southeastern Missouri: U.S. Geological Survey, Professional Papers, v. 274, p. 1–137.
Stilwell, J.D., 1999, Cretaceous Scaphopoda (Mollusca) of Australia and their palaeobiogeographic significance: Alcheringa, v. 23, no. 3, p. 215–226.
Stilwell, J.D., and Henderson, R.A., 2002, Description and paleobiogeographic significance of a rare Cenomanian molluscan faunule from Bathurst Island, northern Australia: Journal of Paleontology, v. 76, no. 3, p. 447–471.
Stoliczka, F., 1863–66, The fossil Cephalopoda of the Cretaceous rocks of southern India. Ammonitidae with revision of the Nautilidae etc.: Memoirs of the Geological Survey of India, Palaeontologia Indica, v. 1, p. 1–216.
Stoliczka, F., 1867–1868, Cretaceous fauna of southern India; Volume II—the Gastropoda: Memoirs of the Geological Survey of India, Palaeontologia Indica, v. 2, p. 1–497.
Stoliczka, F., 1871, Cretaceous fauna of southern India; Volume III—the Pelecypoda: Memoirs of the Geological Survey of India, Palaeontologia Indica, v. 3, p. 1–537.
Stoliczka, F., 1873, Cretaceous fauna of southern India; Volume IV—the Brachiopoda, Ciliopoda, Echinodermata, Anthozoa, Spongizoa, Foraminifera, Arthrozoa, and Spondylozoa; Cretaceous Arthrozoa of Southern India: Memoirs of the Geological Survey of India, Palaeontologia Indica, v. 4, p. 63–69.
Sundaram, R.M., Henderson, R.A., Ayyasami, K., and Stilwell, J.D., 2001, A lithostratigraphic revision and palaeoevironmental assessment of the Cretaceous System exposed in the onshore Cauvery Basin, southern India: Cretaceous Research, v. 22, no. 6, p. 743–762.
Swainson, W., 1840, A Treatise on Malacology or Shells and Shell-Fish, vii, London, Longman, 419 p.
Sylvester-Bradley, P.C., 1948, The shell of the ostracod genus *Macrocypris*: Annals and Magazine of Natural History, v. 12, no. 1, p. 65–71.
Tapaswi, P.M., 1987, Taxonomic studies of the South Indian Cretaceous bivalves: Geological Survey of India Special Publication, v. 11, p. 505–514.
Tate, R., 1869, Contributions to Jurassic palaeontology. I. *Cryptaulax*, a new genus of Cerithidae: Annals and Magazine of Natural History, series 4, v. 4, p. 417–419.
Thiele, J., 1924, Revisions des Systems der Trochacea: Mitteilungen aus dem Zoologischen Museum in Berlin, v. 11, no. 1, p. 49–72.
von Salvini-Plawen, L., 1980, A reconsideration of systematics in the Mollusca (phyllogeny and higher classification): Malacologia, v. 19, no. 2, p. 249–278.
von Siebold, K.T.E., 1848, Lehrbuch der vergleichenden Anatomie der Wirbellosen Thiere. Erster Theil, Berlin, Verlag von Veit and Co., 679 p.
von Strombeck, A., 1893, Über den angeblichen Gault bei Lüneberg: Zeitschrift der Deutschen Geologischen Gesellschaft, v. 45, p. 489–497.
von Zittel, K.A., 1884, Handbuch der Palaeontologie 1, Abt. 2; Lief 3, Cephalopoda: Munich and Leipzig, R. Oldenbourg.
von Zittel, K.A., 1895, Grundzüge der Palaeontologie (Palaeozoologie), vii: Munich and Leipzig, R. Oldenbourg, 972 p.
Wade, B., 1926, The fauna of the Ripley Formation on Coon Creek, Tennessee: U.S. Geological Survey, Professional Papers, v. 137, p. 1–272.
Whittaker, J.M., Halpin, J.A., Williams, S.E., Hall, L.S., Gardner, R., Kobler, M. E., Daczko, N.R., and Müller, R.D., 2013, Tectonic evolution and continental fragmentation of the southern West Australian margin, *in* Keep, M., and Moss, S.J., eds., The Sedimentary Basins of Western Australia IV: Proceedings of the Petroleum Exploration Society of Australia Symposium, Perth, W.A., p. 1–18.
Wiedmann, J., 1966, Stammesgeschichte und System der posttriadischen Ammonoideen: Neues Jahrbuch für Geologie und Paläontologie - Abhandlungen, v. 125, p. 49–79.
Williams, S.E., Whittaker, J.M., Granot, R., and Müller, R.D., 2013, Early India-Australia spreading history revealed by newly detected Mesozoic magnetic anomalies in the Perth Abyssal Plain: Journal of Geophysical Research: Solid Earth, v. 118, p. 1–10.
Wollemann, A., 1902, Die Fauna der Lüneberger Kreide: Abhandlungen der Königlich Preussischen Geologischen Landesanstalt, v. 37, p. 1–129.
Woods, H., 1905, A Monograph of the Cretaceous Lamellibranchiata of England: Palaeontological Society Monographs, v. 2, no. 2, p. 57–96.
Wright, C.W., Calloman, J.H., and Howarth, M.K., 1996, Mollusca 4 (revised), Cretaceous Ammonoidea, *in* Kaesler, R.L., ed., Treatise on Invertebrate Paleontology. Volume L. Boulder, Colorado, and Lawrence, Kansas, The Geological Society of America, Inc., and The University of Kansas.

Accepted 23 March 2016