The first record of *Agerostrea ungulata* (von Schlotheim, 1813) (Bivalvia: Ostreoidea) from the Upper Maastrichtian of KwaZulu, South Africa, with a discussion of its distribution in southeast Africa and Madagascar

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Recent (2005) excavations for expansions to the harbour at Richards Bay, KwaZulu-Natal, South Africa, yielded a single specimen of the ostreid *Agerostrea ungulata* (von Schlotheim, 1813). This is the first, and thus far only, record of this species from the Upper Maastrichtian of South Africa. Its distribution in southeast Africa and Madagascar is discussed

Key words: Cretaceous, Maastrichtian, Ostreoidea, South Africa.

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INTRODUCTION

Recent (2005) submarine excavations for expansion to the harbour at Richards Bay, KwaZulu-Natal, South Africa, yielded new and additional invertebrate faunas that had not been found during previous excavations in 1997. The cephalopods and nannofossils from the latter works were described by Klinger *et al.* (2001) and the reader is referred to this for a full faunal list and map of the locality. Material from this most recent excavation was collected from spoil heaps deposited next to the excavated area. Apart from the ammonites described by Klinger *et al.* (2001), additions to the fauna include *Kitchinites* sp. nov. and *Discoscaphites* sp. (Klinger & Kennedy 2007) and a single specimen of the ostreid, *Agerostrea ungulata*. This is the first and only record of this species from the Upper Maastrichtian of KwaZulu.

SYSTEMATIC PALAEONTOLOGY

Class **BIVALVIA** Linné, 1758
Subclass **PTERIOMORPHA** Beurlen, 1944
Superfamily **OSTREOIDEA** Rafinesque, 1815
Family **OSTREIDAE** Rafinesque, 1815
Subfamily **LIOSTREINAE** Vyalov, 1983

Genus ***Agerostrea*** Vyalov, 1936
(Vyalov 1936, p. 20; Stenzel 1971, p. N1158; Malchus 1990, p. 160).

Type species
Ostracites ungulatus von Schlotheim, 1813, p. 112 (= *Ostrea larva* Lamarck, 1819, p. 216), by original designation of Vyalov (1936, p. 20).

Discussion
The genus as reviewed by Malchus (1990) is largely compact foliated; hollow structural chambers and chalk-filled chambers are rare to absent. These characters suggest that the genus is derived from compact-foliated *Curvostrea* and thus homoeomorphic with the contemporaneous genus *Rastellum*.

Agerostrea ungulata (von Schlotheim, 1813)
Figs 1–2
1813 *Ostracites ungulatus* von Schlotheim, p. 112.
1871 *Ostrea* (*Alectryonia*) *ungulata Lam.*; Stoliczka, p. 470, pl. 47 (figs 3–4).
1896 *Alectryonia ungulata* Schlotheim sp.; Bullen Newton, p. 136, fig. on p. 138.

1906 *Ostrea* (*Alectryonia*) *ungulata* Schloth.; Boule & Thévenin, p. 6(48), pl. 1 (fig. 5,5a).
1922 *Alectryonia ungulata* Schloth.; Cottreau, p. 146(38).
1930 *Alectryonia ungulata* Schlotheim; Besairie, p. 234, pl. 22 (fig. 7).
1931 *Ostrea* (*Alectryonia*) *ungulata* Schlotheim; Basse, p. 50, pl. 7 (fig. 14); pl. 8 (figs 3–6).
?1932 *Alectryonia ungulata* Schlotheim; Basse, p. 9 (97), pl. 1 (figs 21–21a)
1932 *Ostrea* (*Alectryonia*) *ungulata* Schlot.; Collignon, p. 12(44), pl. 2(5) (figs 4–5).
1971 *Agerostrea ungulata* (von Schlotheim); Stenzel, p. N1158, fig. J133, 1.
1990 *Agerostrea ungulata* (Schlotheim, 1813); Malchus, p. 162, pl. 15 (fig. 8) (with additional synonymy).

Diagnosis

Slender falcate (anterior convex), tapering ventrally, strongly plicate around commissure, plicae may become acutely angled in larger specimens, central shell field smooth, with or without ears (anterior ear may be lacking), few thin lath chomata dorsally, adductor scar comma-shaped, close to hinge.

Discussion

The species is distinguished from falcate congeners and species of *Rastellum* (Faujas-Saint-Fond, 1799) by its smooth central field in both valves and general absence of shell chambers (with respect to *Rastellum*). According to Stenzel (1971), chomata are tubercle-like and surround the commissure; however, this is a character Malchus *et al.* (1994) found on *Rastellum diluvianum* (Linné) rather than *Agerostrea.*

Occurrence

The type locality is St Pietersberg (near Maastricht) in the Netherlands, Maastrichtian. Other occurrences include Central Europe, Spain, North Africa, the Middle East, south India and Pakistan. The occurrence of the species in Madagascar and southern Africa merits discussion.

DISTRIBUTION IN MADAGASCAR AND SOUTHEAST AFRICA

Agerostrea ungulata is well known from the upper Campanian? and lower Maastrichtian of Madagascar, with records from the Majunga and Morondava basins, and from the east coast (see Boule & Thévenin 1906; Cottreau 1922; Besairie 1930; Basse 1931, ?1932; Collignon 1932, 1951, 1954, 1968; Besairie & Collignon 1956, 1971; Furon 1963). It is extremely abundant at localities exposing lower Maastrichtian rocks on the east coast (*cf.* Collignon 1932, p. 12 (44)). In the Collignon Collection, which is currently housed in the Centre des Sciences de la Terre, Université de Bourgogne at Dijon, one of us (HCK) has located hundreds of specimens from Collignon's (1971) lower Maastrichtian, Zone of *Pachydiscus gollevillensis* & *Pachydiscus neubergicus* at Gisements 666, Antsoha, and 667, 'S.S. Ouest de Antsoha (Belo sur Tsiribihina)' on the east coast of Madagascar. In contrast, in the southeastern part of the African continent *A. ungulata* is poorly documented. Before the present discovery, the only illustrated record of the species was by Bullen Newton (1896, p. 136) (see also Rennie 1936*a*, p. 278) based on a single specimen presented to the Natural History Museum (London) by a Mr D. Draper 'which he had found on the beach at Sofala, off S.E. Africa, and which had evidently, from the colour of its matrix, been washed out of a red-coloured limestone formation'. The exact provenance of this specimen is unknown and according to Bullen Newton (1896, p. 139) it was waterworn. Subsequently, Bullen Newton (1924) discussed and listed the invertebrate faunas collected by Teale in the Sheringoma (Cheringoma) Plateau and Buzi River Valley regions of Mozambique (see Teale 1924, pl. 8 for map). Unfortunately, only the cephalopod faunas collected from these areas were described by Crick (1924), which include, amongst others, *Baculites sheringomensis* Crick (*nom. nud.*?), *B.* cf. *vagina* var. *ootacodensis* Stoliczka and *B.* cf. *vagina* var. *simplex* Kossmat. These are unambiguous representatives of the Maastrichtian baculitid genus *Eubaculites* Spath, 1926, and were tentatively referred to *Eubaculites carinatus* (Morton, 1834) by Klinger & Kennedy (1993, p. 235). Bullen Newton meticulously listed the occurrence of the invertebrate faunas from sections in the Cheringoma Plateau and Buzi River Valley. *Eubaculites* and *A. ungulata* occur in both areas, and in the the cliff section at Maxemeje (Bullen Newton 1924, p. 143, section iii) co-occur at the same locality, albeit at different levels (C and E, respectively). Even though the bivalve faunas were never formally described and illustrated, we have little reason to doubt Bullen Newton's identification of *A. ungulata,* especially by the association of the latter with a typical Maastrichtian *Eubaculites* ammonite fauna (see also Bullen Newton 1909, p. 12). Also, the locality of the specimen described by him in 1896 was suggested to be the Buzi River Region (Bullen Newton 1924, p. 142). Rennie (1936*b*, p. 326) considered the species to be characteristic of the calcareous facies of the Sheringoma (Cheringoma) region. Since then, no unambiguous records of *A. ungulata* from Mozambique have been verified. Furon (1963, p. 339) listed '*Alectryonia*' *ungulata* from the 'Upper Senonian (of) the Cheringoma Plateau (between Beira and the mouth of the Zambesi) and the Buzi Valley (west of Sofala)' and Flores (1973, p. 90) mentioned the presence of '*Alectryonia (Lopha) ungulata* of Senonian to Paleocene age' from the Grudja Formation 'To the northwest of Beira, on the Inhaminga 'high' ' overlying the Sena Formation. According to the outcrop map of the Cheringoma Formation in Flores (1973, p. 98), this is the general area of Teale's (1924, pl. 8) Buzi River Valley locality.

The occurrence of *A. ungulata,* or rather its absence, apart from a single specimen in the whole of KwaZulu, specifically in outcrop in the Lake St Lucia area and near Monzi, Mfolozi Valley and in boreholes ZOE.A,B and C in northern KwaZulu (Du Preez & Wolmarans, 1986; Klinger, unpubl. data) and from submarine excavations at Richards Bay is less clear.

Agerostrea ungulata typically occurs in marly limestones and chalk of Campanian to Maastrichtian age in western Europe, northern Africa, Pakistan (Baluchistan), India and Madagascar. In contrast to *Rastellum diluvianum, A. ungulata* or its close ally *A. lunata* (Nilsson) from southern Sweden have not been found in glauconitic or siliciclastic sediments in Central Europe (see Malchus *et al.* 1996 for a review).

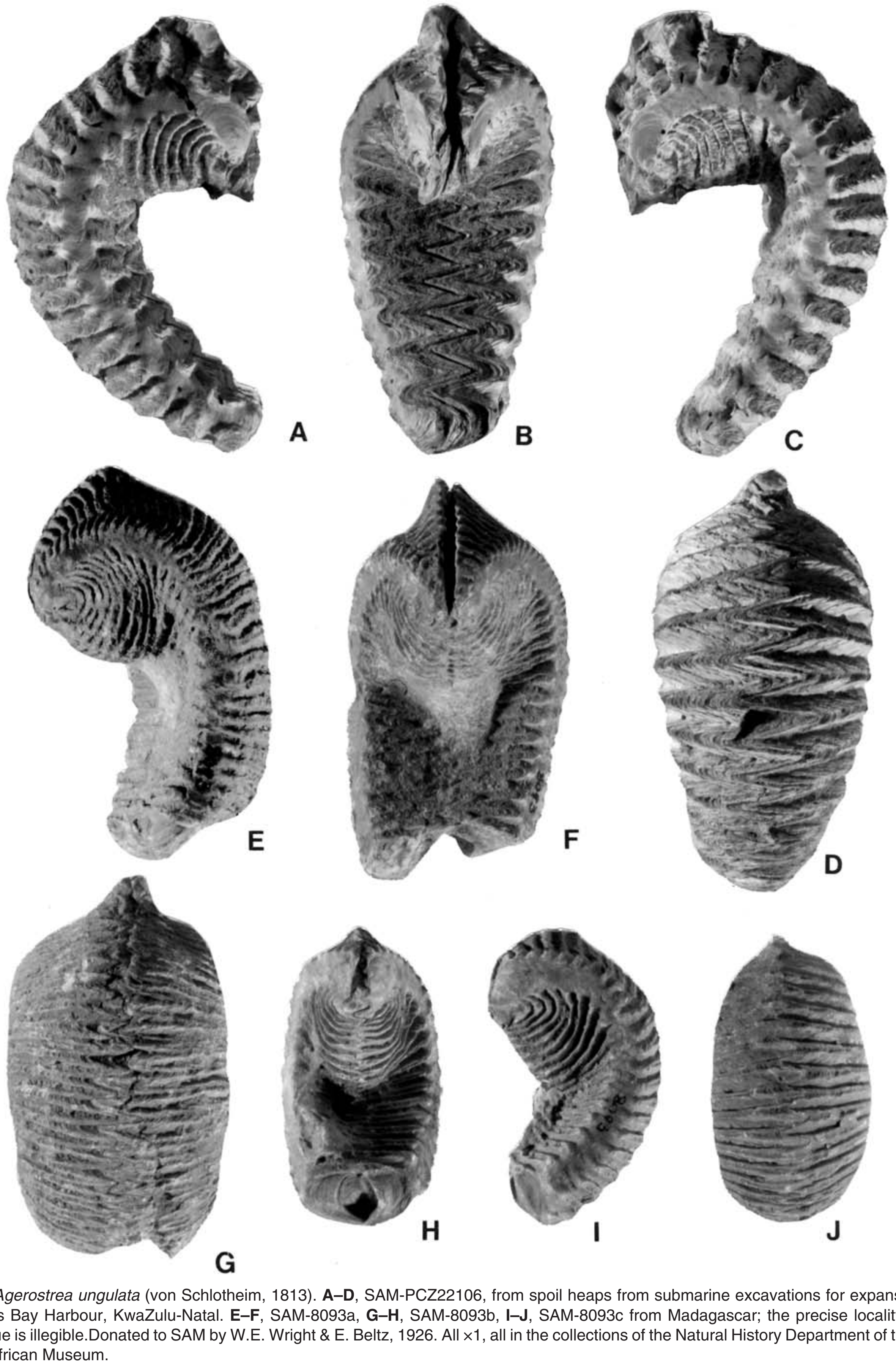

Fig. 1. *Agerostrea ungulata* (von Schlotheim, 1813). **A–D**, SAM-PCZ22106, from spoil heaps from submarine excavations for expansions to Richards Bay Harbour, KwaZulu-Natal. **E–F**, SAM-8093a, **G–H**, SAM-8093b, **I–J**, SAM-8093c from Madagascar; the precise locality in the catalogue is illegible.Donated to SAM by W.E. Wright & E. Beltz, 1926. All ×1, all in the collections of the Natural History Department of the Iziko South African Museum.

Fig. 2. SAM-GMC22181, from the Lower Maastrichtian, Zone of *Pachydiscus gollevillensis* & *Pachydiscus neubergicus* at Gisement 666, Antsoha (Belo sur Tsiribihina). ×1, in the collections of the Natural History Department of the Iziko South African Museum; specimen donated to Klinger by General Collignon in 1973.

These observations certainly explain the abundant occurrence of *A. ungulata* in Madagascar and its records from Mozambique; in both areas the species has been recorded from calcareous marls. Matrix from a specimen of *A. ungulata* (Fig. 2A–E) from the east coast of Madagascar at Gisement 666, Antsoha, yielded a rich microfauna. The benthic foraminifera are indicative of a shallow, warm-water depositional environment. In addition, they give a date of late rather than early, Maastrichtian, as defined by Collignon (1971) as his lower Maastrichtian zone of *Pachydiscus gollevillensis* and *Pachydiscus neubergicus* (I. McMillan, pers. comm.). We can thus infer that optimum conditions for the occurrence in Madagascar of *A. ungulata* include a warm, shallow-marine, chalky to marly depositional environment.

Detailed sedimentological data for the Cheringoma and Buzi regions of Mozambique are not available, apart from the references by Teale (1924, p. 119) to 'limestone' and Rennie's (1936*b*, p. 326) 'calcareous Upper Cretaceous facies' and we cannot comment further on these records.

In contrast, the Upper Cretaceous of KwaZulu consists predominantly of glauconitic silts and hard, calcareous concretions. We must, however, clearly differentiate between the Maastrichtian facies of Richards Bay, and those of northern KwaZulu in outcrop in the St Lucia region, Monzi, and in boreholes ZOE.A–C in northern KwaZulu as discussed in part by Klinger *et al.* (2001, p. 274–5). The Maastrichtian sediments from Richards Bay are younger than those outcropping to the north in the St Lucia area and near Monzi In the latter region, inoceramid bivalves are abundant. Towards the top of the exposed sections ammonites disappear, and inoceramid debris becomes abundant (Kennedy & Klinger 1975, p. 281). This same inoceramid debris facies has been found at the top of the sections in boreholes ZOE.A–C in northern KwaZulu (Klinger, unpubl. data). In contrast, the matrix of the Richards Bay material lacks inoceramid debris, indicating that it post-dates the global extinction of the true inoceramids in the mid-Maastrichtian. The only inoceramids recorded from Richards Bay are two specimens of *Tenuiptera.* Thus not only are the Maastrichtian subcrops in Richards Bay younger (late Maastrichtian) than those of the St Lucia and northern KwaZulu region, but they also occur in a different facies; fossiliferous glauconitic silts versus glauconitic silts with only inoceramid debris and rare ammonites. The holococcolith assemblage at Richards Bay is also possibly indicative of a relatively shallow-water, but low-energy depositional environment as well (Klinger *et al.* 2001, p. 278).

Cooper's (2002, p. 48) discussion of *A. ungulata* is difficult to comprehend. He described a new subspecies, *A. mesenterica africana* from the lower Maastrichtian in a roadside quarry at Klinger & Kennedy's (1975, p. 283) locality 20 near Monzi, on the basis of which he defined his 'Agerostrea facies'. According to Cooper, this facies defines the mid-upper slope between 250 and 500 metres in depth. In discussing *A. mesenterica africana,* Cooper (2002, p. 48) regarded *A. ungulata* as 'a problematical species' and interpreted the latter *sensu* Coquand (1869). Surprisingly, no reference was made to subsequent, especially Madagascan, records of the species, nor those from Mozambique. Furthermore, in his fig. 19 (Cooper 2002, p. 55) depicting 'The statigraphic distribution of oyster species in the Cretaceous southeast Africa' *Agerostrea ungulata zuluana* Cooper is listed in the Maastrichtian, but no record exists of a description of this species; we have to assume that this is an error for *A. mesenterica africana* Cooper.

The foraminifera from the Maastrichtian of KwaZulu, both at Richards Bay and to the north in the St Lucia area and in boreholes ZOE.A–C, differ significantly from those of the east coast of Madagascar mentioned above. The latter are indicative of higher water temperatures in Madagascar than in KwaZulu. (I. McMillan, pers. comm.)

It thus seems that the virtual absence of *A. ungulata* in KwaZulu, in contrast to its abundance in Madagascar, and records from the Cheringoma and Buzi Regions of Mozambique may be due to the different depositional environments which include water depth, energy levels and water temperature. The fact that only a single specimen of *A. ungulata* was found in lithologies not usually associated with this species, suggests that the occurrence at Richards Bay may be allochthonous.

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