Acta Geologica Polonica, Vol. 68 (2018), No. 4, pp. 663–687
DOI: 10.1515/agp-2018-0036

Inoceramids and associated ammonite faunas from the uppermost Turonian−lower Coniacian (Upper Cretaceous) of the Anaipadi–Saradamangalam region of the Cauvery Basin, south-east India

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ABSTRACT:

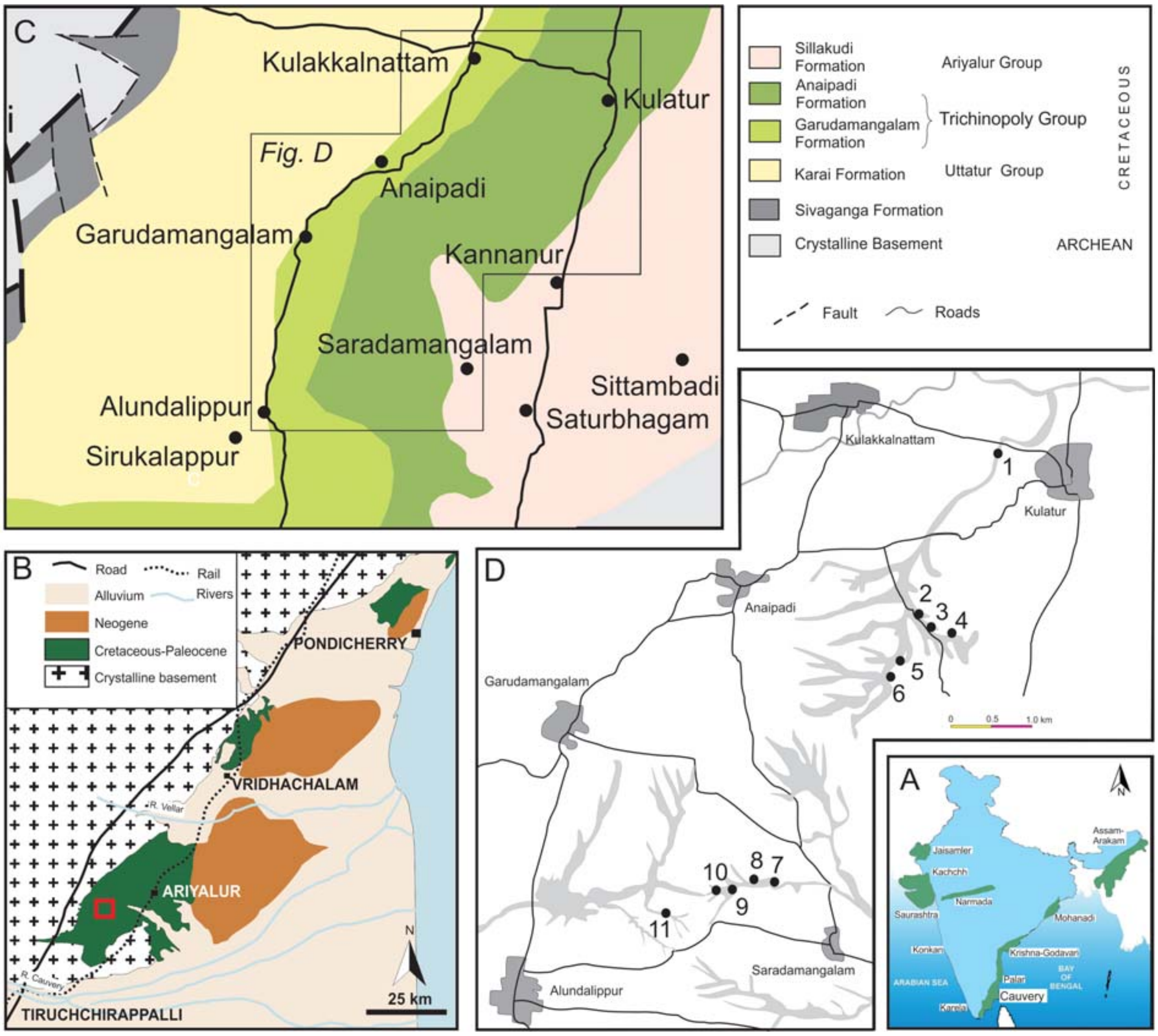
Walaszczyk, I., Kennedy, W.J. and Paranjape, A.R. 2018. Inoceramids and associated ammonite faunas from the uppermost Turonian–lower Coniacian (Upper Cretaceous) of the Anaipadi–Saradamangalam region of the Cauvery Basin, south-east India. *Acta Geologica Polonica*, **68** (4), 663–687. Warszawa.

The lower (but not lowermost) part of the Upper Cretaceous Anaipadi Formation of the Trichinopoly Group in the area between Kulatur, Saradamangalam and Anaipadi, in the south-western part of the Cauvery Basin in south-east India yielded rich inoceramid and ammonite faunas. The ammonites: *Mesopuzosia gaudama* (Forbes, 1846), *Damesites sugata* (Forbes, 1846), *Onitschoceras* sp., *Kossmaticeras* (*Kossmaticeras*) *theobaldianum* (Stoliczka, 1865), *Lewesiceras jimboi* (Kossmat, 1898), *Placenticeras kaffrarium* Etheridge, 1904, and *Pseudoxybeloceras* (*Schlueterella*) sp., are characteristic of the *Kossmaticeras theobaldianum* Zone. The absence of *Peroniceras* (*P.*) *dravidicum* (Kossmat, 1895) indicates the presence of only lower part of this zone, referred to the nominative *Kossmaticeras theobaldianum* Subzone at the localities studied. The inoceramids present are *Tethyoceramus madagascariensis* (Heinz, 1933) and *Cremnoceramus deformis erectus* (Meek, 1877), recorded for the first time from the region. The latter dates the studied interval as early early Coniacian, and allows, for the first time, direct chronostratigraphic dating of the *Tethyoceramus madagascariensis* Zone, and consequently also of the *Kossmaticeras theobaldianum* Subzone. As inoceramids occur in the middle part of the ammonite-rich interval, the *Kossmaticeras theobaldianum* Subzone may be as old as latest Turonian and not younger than early early Coniacian. The base of the Coniacian lies in the lower, but not lowermost part of the Anaipadi Formation. Both inoceramids and ammonites represent taxa known from Madagascar and South Africa.

Key words: Upper Cretaceous; Turonian; Coniacian; Cauvery Basin; SE India; Inoceramids; Ammonites; Biostratigraphy; Stratigraphic correlation.

INTRODUCTION

Inoceramid bivalves are a dominant macrofossil group at the Turonian / Coniacian boundary and through the entire lower Coniacian world-wide. This is well documented throughout the Euramerican biogeographic region, in numerous areas of the Tethyan Realm, in the East African Province (Madagascar), and they are diverse and abundant in the North Pacific Province (biogeographic subdivisions after



Text-fig. 1. Location of the study area (D) on the lithostratigraphic map of the SW part of the Ariyalur Basin (C), its position on the geological map of the Cauvery Basin (red square on B) and location of the Cauvery Basin on the structural map of India (A)

Kauffman 1973). In contrast, late Turonian – early Coniacian inoceramids are very poorly documented in both the Cauvery Basin and the Narmada Valley Basin, the two main areas of Cretaceous outcrops in the Indian subcontinent, all the more surprising given its close proximity to Madagascar at that time.

In the Cauvery Basin sediments of Coniacian age were recognised in the middle/upper part of the Trichinopoly Group (e.g., Sastry *et al*. 1968; Chiplonkar and Tapaswi 1975, 1979; Phansalkar 1976; Phansalkar and Kumar 1983; Ayyasami 2006; Paranjape 2017). Biostratigraphically, the interval was referred to the *Kossmaticeras theobaldianum* ammonite Zone (see Sastry *et al*. 1968), subdivided later into two subzones: a lower, nominate one in which *Peroniceras* was absent, and an upper subzone, marked by the appearance of *Peroniceras* (*Peroniceras*) *dravidicum* (Kossmat, 1895) (Ayyasami and Rao 1984). The upper subzone corresponds to the European *Peroniceras tridorsatum* Zone spanning the late early through middle Coniacian in inoceramid terms (Kaplan and Kennedy 1994).

Inoceramids were first documented from the Trichinopoly Group by Stoliczka (1871). He described three species, all as new: *Inoceramus geinitzianus*, *I. multiplicatus*, and *I. diversus*. His *diversus* (see Stoliczka 1871, p. 407, pl. 27, fig. 6) is an early Turonian *Rhyssomytiloides* (see Ayyasami and Rao

1994; Gale *et al*. in press). *Inoceramus geinitzianus* (= *I. geinitzi* of other authors) (see Stoliczka 1871, p. 407, pl. 27, figs 4, 5) is a late Turonian form, apparently conspecific with *Mytiloides costellatus* (Woods, 1912) (in a narrow sense) and thus has priority over Woods' name. *Inoceramus multiplicatus* (see Stoliczka 1871, p. 406, pl. 28, fig. 1) was interpreted as a Cenomanian taxon by Ayyasami and Rao (1994, fig. 2).

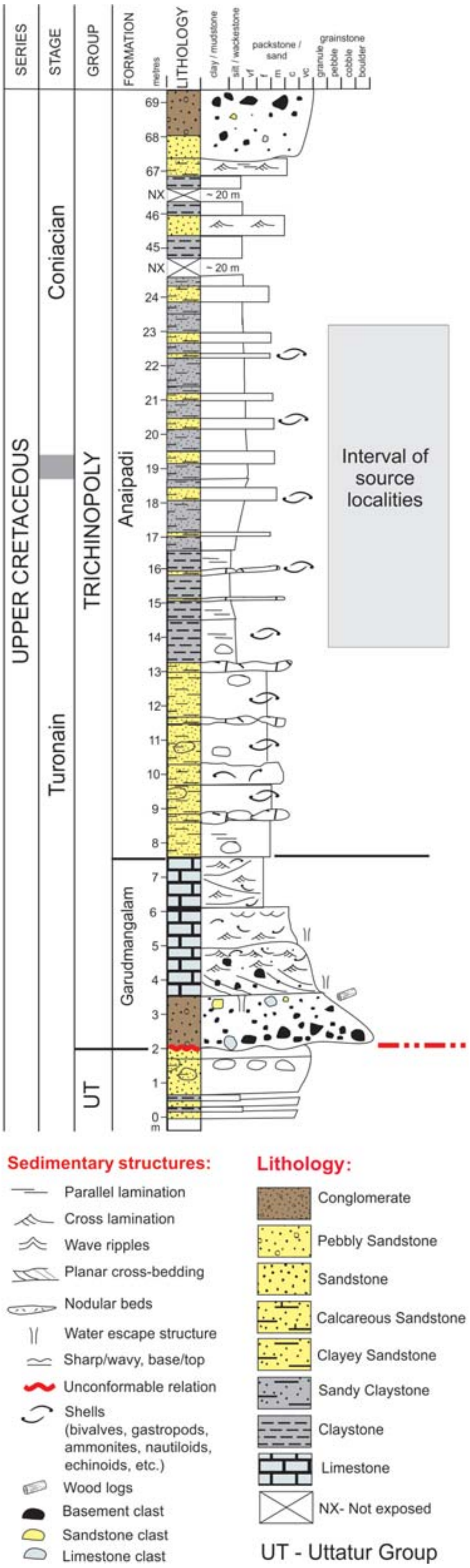
A series of inoceramid taxa were described from the Trichinopoly Group by Chiplonkar and Tapaswi (1974) in their monograph on inoceramids from the Cauvery Basin. Most of their taxa are, however, early–middle Turonian species, with one from the late Turonian. Based on their results, Chiplonkar and Tapaswi (1975) proposed a series of assemblages (zones), of which their assemblage number 3, of *Inoceramus multiplicatus* and *Sphenoceramus diversus* was suggested to be of Coniacian age. Neither of the index species of the assemblage is, however, of Coniacian age. *Inoceramus multiplicatus* of Chiplonkar and Tapaswi is a late Turonian *Mytiloides* species, and *S. diversus* is an early Turonian *Rhyssomytiloides*.

A new inoceramid-based zonation of the Upper Cretaceous of the Cauvery Basin was proposed by Ayyasami and Rao (1994). They recognised two zones in the Coniacian: that of *Inoceramus stantoni* below and *Inoceramus bassae* above. It seems, however, that both of their taxa may actually be *Tethyoceramus madagascariensis* (Heinz, 1932).

The present paper provides descriptions of early Coniacian *Tethyoceramus* and *Cremnoceramus*, together with associated ammonites, from a series of outcrops between Anaipadi and Saradamangalam, providing a well-constrained succession spanning the topmost Turonian through to the lower Coniacian (Text-fig. 1). The succession represents the lower (but not lowermost) part of the Anaipadi Formation in the middle part of the Trichinopoly Group (Text-figs 2, 3). Both inoceramids and ammonites allow direct correlation with well-dated successions in Madagascar and South Africa, and the inoceramids provide a basis for direct correlation with Euramerica (Text-fig. 4). An equivalent succession from a northern part of the Cauvery Basin, from an exposure near the village of Pilmisai, is described by Kennedy and Gale (in press).

STRATIGRAPHICAL SUCCESSION AND LOCALITY DETAILS

The Cretaceous succession of the Ariyalur area is divided into 3 major lithostratigraphic units (Text-



Text-fig. 2. Geological log of the topmost part of the Uttatur Group and of the lower part of the Trichinopoly Group in the south-western part of the Cauvery Basin (after Paranjape 2017)

Group	Formation
Ariyalur (pars)	Sillakudi
Trichinopoly	Anaipadi
	Garudamangalam
Uttatur (pars)	Karai

Text-fig. 3. Lithostratigraphy of the lower Upper Cretaceous of the Cauvery Basin

fig. 3), the Uttatur, Trichinopoly, and the Ariyalur groups. The Trichinopoly Group ranges from late Turonian to Santonian in age, and is further subdivided into the Garudmangalam Formation below and the Anaipadi Formation above.

The Garudmangalam Formation is made up of foreshore and shoreface conglomerates and sandstones, in fining-up successions, and with individual beds also showing normal grading (Paranjape 2017). The sequence begins with a conglomeratic unit displaying an eroded relationship with the underlying sediments of the Uttatur Group. This unit comprises both clast and matrix-supported conglomerates. The clasts are ill-sorted, sub-rounded, pebble to boulder size, and predominantly basement rocks. Clasts of limestone and sandstone belonging to various facies of the Uttatur Group also occur in minor proportions. This unit contains abundant fossil wood ranging from centimetre-sized fragments to logs tens of metres long. The 18 m long fossil tree trunk found and preserved *in situ* at the fossil park near Sattanur also belongs to this facies. Other fossils include bivalves, gastropods, ammonites, and corals.

The conglomeratic beds grade upwards into fossiliferous calcareous sandstones/sandy limestones some of which are very coarse-grained to pebbly.

<table>
<tr><th rowspan="2">Stages</th><th rowspan="2">Substages</th><th colspan="2">Inoceramid zones</th><th colspan="2">Ammonite zones and subzones</th></tr>
<tr><th>Madagascar</th><th>Europe</th><th>Europe</th><th>India</th></tr>
<tr><td rowspan="5">CONIACIAN</td><td rowspan="2">Upper (pars)</td><td>‘*Inoceramus*’ *africanus*</td><td rowspan="2">*Magadiceramus subquadratus*</td><td rowspan="2">*Gauthiericeras margae*</td><td rowspan="4">?
Peroniceras dravidicum</td></tr>
<tr><td rowspan="2">*Platyceramus*</td></tr>
<tr><td>Middle</td><td>*Volviceramus / Pl. mantelli*</td><td rowspan="2">*Peroniceras tridorsatum*</td></tr>
<tr><td rowspan="2">Lower</td><td rowspan="2">*Inoceramus* sp.
T. ernsti
T. basseae
T. madagascariensis</td><td rowspan="2">*I. gibbosus*
C. crassus crassus
C. crassus inconstans
C. walt. hannoverensis
C. deformis erectus</td></tr>
<tr><td rowspan="3">*Forresteria petrocoriensis*</td><td rowspan="4">*Kossmaticeras theobaldianum*
?</td></tr>
<tr><td rowspan="3">TURONIAN (pars)</td><td rowspan="3">Upper</td><td rowspan="3">*Tethyoceramus modestoides*
?</td><td>*C. walters.walters.*</td></tr>
<tr><td rowspan="2">*Mytiloides scupini*</td></tr>
<tr><td>*Prionocyclus germari*
Subprionocyclus neptuni</td></tr>
</table>

Text-fig. 4. Ammonite and inoceramid zonations of the uppermost Turonian and lower Coniacian of SE India

These sandy limestones have been variously referred to in earlier literature as the “Trichinopoly Shell Limestone”, “Garudmangalam Limestone” etc. It should be noted that although they are petrographically limestones at some localities, the majority are calcareous sandstones. The pebbly beds are overlain by coarse to medium grained, sandy limestones. Both the pebbly and coarse grained beds show development of planar, wedge-shaped and trough cross-bedding and ripple lamination, indicating deposition under shallow marine foreshore-shoreface conditions (Paranjape 2017).

The Garudmangalam Formation passes conformably and gradationally upwards into the Anaipadi Formation. The lower part of this formation consists of alternations of fine- to medium-grained, well-sorted clayey and calcareous sandstones with sharp bases and a wavy upper bedding plane, deposited closer to the fair-weather wave base in offshore settings. These sandstones are normally graded, sometimes nodular, cross-laminated and recurrent in the lower part of the succession (Paranjape 2017).

The succession deepens further to beyond storm wave base with a thick succession of claystones. Bed thicknesses vary from 50 to 150 cm. The claystones are brown to reddish brown, calcareous, silty in places and display feeble parallel lamination. Thin beds of limestone / sandy limestone occur intermittently within the claystones. Both claystones and limestones are fossiliferous, containing entire shells of bivalves, ammonites and, rarely, gastropods. The specimens under present study were collected from this part of the succession.

Further upwards in the succession, channelized debris flows are encountered encased in claystones and shales, representing deeper environments. The succession then shallows and coarsens towards the end of the traverse, where the lithology comprises alternate beds of claystones and pebbly sandstones containing abundant logs and shells.

The material described in the present paper was collected from a series of outcrops between Kulatur, Saradamangalam, and Anaipadi, all within the lower Anaipadi Formation (Text-fig. 1D, localities 1 through 11). They come from natural exposures in small cliffs and the bed of a dry, unnamed valley running NE-SW between Kulatur and Anaipadi, and in the unnamed valley west of Saradamangalam. Locality 6, from which most of the inoceramid material comes, is a shell bed, composed mainly of bivalves (of which inoceramids are the main component) and gastropods. There is a continuous belt of fossiliferous sediments within the Anaipadi Formation running NE-SW through the entire area between Kulatur and Saradamangalam. The record is dominated by ammonites; inoceramids occur sparsely, and are common only at locality 6.

REPOSITORIES OF SPECIMENS

All of the material described below is housed in the collections of the Stanisław Józef Thugutt Museum of the Faculty of Geology of the University of Warsaw, Warsaw under repository numbers MWG ZI/95.

SYSTEMATIC PALAEONTOLOGY

Inoceramids (I. Walaszczyk)

Conventions: The terminology and measurements used follow Harries *et al.* (1996).

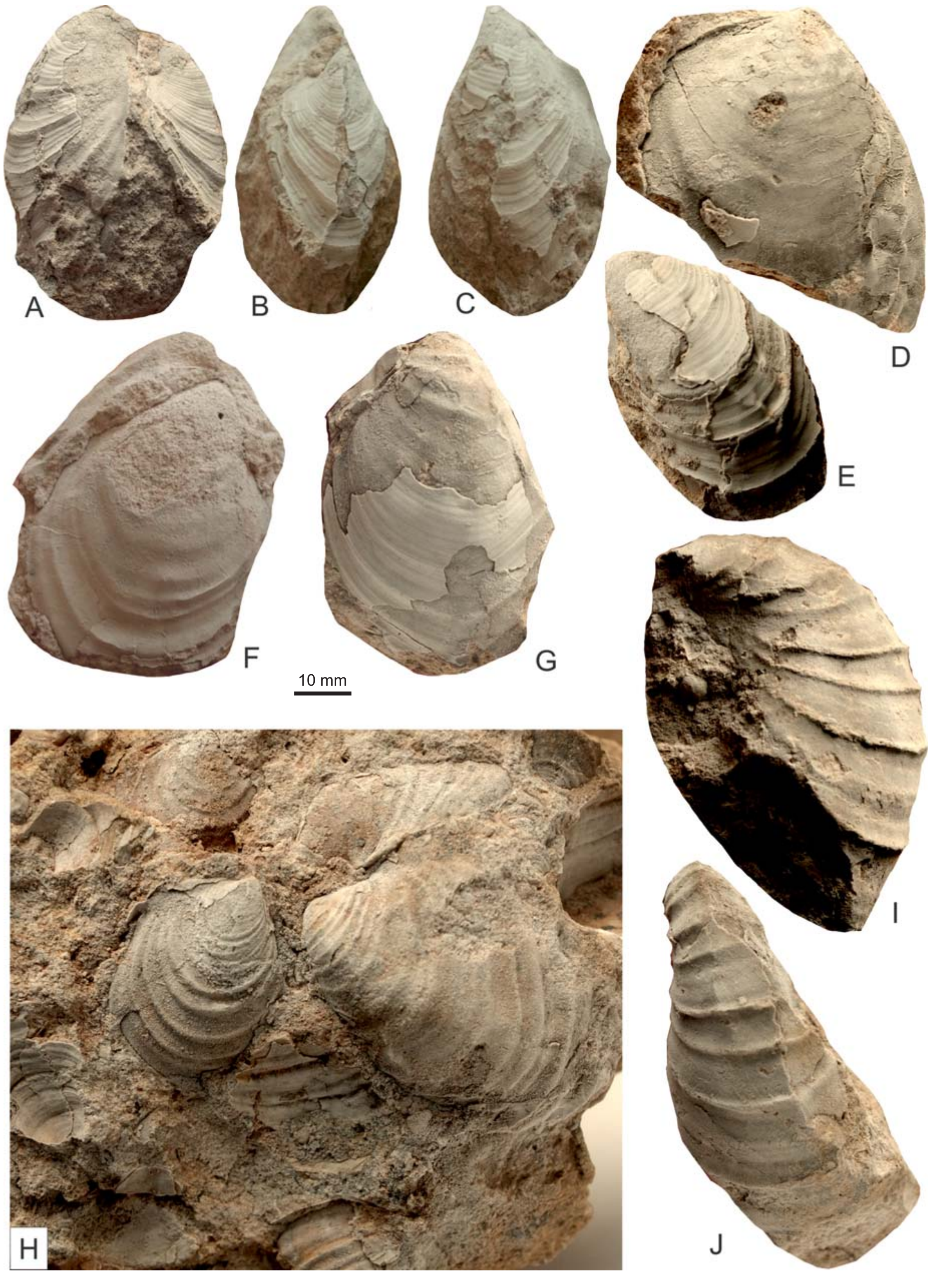
Order Pterioida Newell, 1965
Suborder Pteriina Newell, 1965
Family Inoceramidae Giebel, 1852
Genus *Tethyoceramus* Sornay, 1980

TYPE SPECIES: *Inoceramus* (*Tethyoceramus*) *basseae* Sornay, 1980, pl. 1, figs 1, 4, 6; pl. 2, figs 1–3, by original designation.

REMARKS: For emended diagnosis and discussion, see Walaszczyk and Wood (1999, pp. 419–421).

Tethyoceramus madagascariensis (Heinz, 1933)
(Text-fig. 5)

1930. *Inoceramus madagascariensis* Heinz; Besairie, p. 94.
1932. *Stolleiceramus madagascariensis* Heinz; Heinz, p. 59.
?pars 1933. *Stenoceramus* (*Stenoceramus*) *madagascariensis* Heinz, p. 252, pl. 20, fig. 2 [?non pl. 19, fig. 2].
1933. *Cymatoceramus* (*Cymatoceramus*) cf. *koeneni* (Müller); Heinz, p. 253, pl. 19, fig. 3.
?pars 1957. *Inoceramus langi* Choffat; Sornay, p. 58, pl. 35, fig. 1.
1980. *Inoceramus* (*Tethyoceramus*) *madagascariensis* Heinz; Sornay, p. 11; pl. 1, figs 2, 3, 5; pl. 2, fig. 4; pl. 3, figs 1–3.
1980. *Inoceramus* (*Inoceramus*) *ernsti* Heinz; Kauffman in Klinger *et al*., p. 310, fig. 10G–P.



Text-fig. 5. *Tethyoceramus madagascariensis* (Heinz, 1933); A-C – ZI/95/065, D – ZI/95/066, F, G – ZI/95/067, H – ZI/95/068, I, J – ZI/95/069; all specimens are from locality 6

1980. *Inoceramus frechi* Flegel; Kauffman in Klinger *et al*., p. 314, fig. 10A–F.
non 1981. *Inoceramus* (*Inoceramus*) *madagascariensis* Heinz; Crame, p. 44, figs 8, 9a, b.
non 1983. *Inoceramus madagascariensis* Heinz; Crame, fig. 4g, h.
1992. *Inoceramus madagascariensis* Heinz; Walaszczyk, pl. 29, fig. 3; pl. 30, fig. 3.
1992. *Inoceramus* ex gr. *lamarcki* Parkinson; Walaszczyk, pl. 33, figs 1, 2.
1994. *Inoceramus basseae* Sornay; Ayyasami and Rao, pl. 1A, B.
1994. *Inoceramus stantoni* Sokolow 1914; Ayyasami and Rao, pl. 3G.
non 1996. *Inoceramus*? *madagascariensis* (Heinz, 1933); Crampton, p. 70, fig. 35, pls 16I–O, 17E.
1997. *Tethyoceramus madagascariensis* (Heinz); Walaszczyk, pls 1−4.
1999. *Tethyoceramus madagascariensis* (Heinz); Walaszczyk and Wood, pl. 19, fig. 4.
1999. *Tethyoceramus* sp.; Walaszczyk and Wood, pl. 18, figs 2, 4; pl. 19, fig. 4.
2004. *Tethyoceramus madagascariensis* Heinz, 1933; Walaszczyk *et al*., figs 13, 14A, B, D, F.

LECTOTYPE: The lectotype, by the subsequent designation of Sornay (1980, p. 11), is the original of Heinz (1933, pl. 20, fig. 2) from the basal Coniacian of Manasoa, Madagascar.

MATERIAL: Thirty specimens, MWG ZI/95/065 to ZI/95/094; both single and double-valve; with parts of shell retained in numerous specimens. Most of the specimens are from locality 6, SE of Anaipadi; there are single specimens from localities 10 and 11.

DESCRIPTION: Small to medium size for the genus, inaequilateral, inaequivalve, with LV distinctly more inflated than RV. RV distinctly higher than long, with umbo projecting above hinge line; maximum inflation dorso-central; anterior margin long, straight or slightly concave, passing into regularly rounded ventral margin; posterior margin varies, from almost straight to concave, curved postero-dorsally; disc well separated from posterior auricle, moderately large; hinge line straight, moderately long. RV weakly inflated, subrounded, to oval; beak pointed, not projecting above hinge line. Ornament of both valves similar, composed of raised, distant commarginal rugae, with Anwachsmarken at edges; interrugae spaces widely rounded or flat; growth lines irregular. On posterior auricle rugae may curve postero-dorsally. Inter-rugae spaces grow gradually ventralward.

DISCUSSION: The species is of small to moderate size for the genus, clearly inaequivalve, with the LV more inflated than the RV, moderately inequilateral, and possesses a *Cremnoceramus*-type ornament, with characteristic growth marks [German 'Anwachsmarken'] at the edges of rugae. In spite of secondary deformation (lateral and/or irregular compression) the specific characters of the material studied are well preserved.

Walaszczyk *et al*. (2004) interpreted *T. basseae* as a possible phyletic successor of *T. madagascariensis*, leading further to *T. ernsti* (Heinz, 1928). The former differs, however, in the ornament (a lack of distinct rugae), outline (more subquadrate), and in the regular possession of geniculation (almost missing in Heinz' species) and represents rather a side branch in this clade different from both *T. madagascariensis* and *T. ernsti*.

The specimens from the offshore Alphard Group, South Africa, referred to *Inoceramus* (*Inoceramus*) *ernsti* Heinz, 1928 and to *Inoceramus frechi* Flegel, 1905 (see Kauffman in Klinger *et al.* 1980), and referred subsequently to *T. modestoides* Sornay, 1980 by Walaszczyk *et al.* (2004) may actually represent *T. madagascariensis*.

The genus *Tethyoceramus* is also known from the lower Coniacian of Europe, with some of the specimens referred to *T. madagascariensis* (Walaszczyk 1992, pl. 29, fig. 3; pl. 30, fig. 3; pl. 33, figs 1, 2; see also Walaszczyk and Wood 1999, pl. 19, fig. 4).

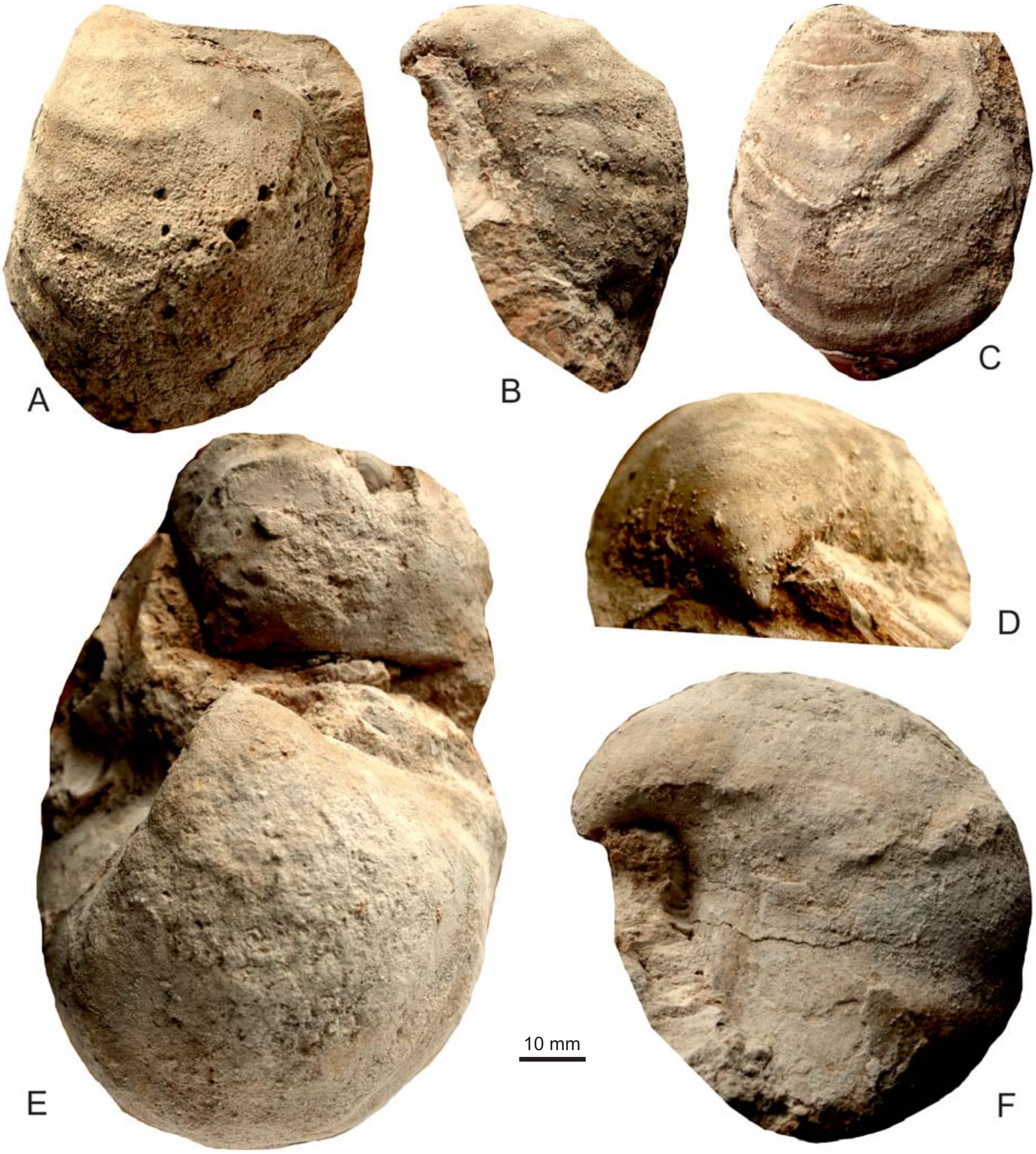
OCCURRENCE: Besides the Cauvery Basin records (herein and in Kennedy and Gale, in press), the species is known from Madagascar (Heinz 1933; Sornay 1980; Walaszczyk 1997; Walaszczyk *et al.* 2004, 2014), South Africa (Kauffman in Klinger *et al*. 1980) and Europe (Walaszczyk 1992; Walaszczyk and Wood 1999), where it appears in the uppermost part of the *Cremnoceramus deformis erectus* Zone.

Genus *Cremnoceramus* Cox, 1969
[non *Cremnoceramus* Heinz, 1932 (*nomen nudum*)]

TYPE SPECIES: *Inoceramus inconstans* Woods, 1912, from the Upper Chalk of Lewes, southern England, by the original designation of Cox (1969).

Cremnoceramus deformis erectus (Meek, 1877)
(Text-fig. 6)

1877. *Inoceramus erectus* Meek, p. 145, pl. 13, fig. 1; pl. 14, fig. 3.



Text-fig. 6. *Cremnoceramus deformis erectus* (Meek, 1877); A, B, D – ZI/95/096; C – ZI/95/097; E, F – ZI/95/095; all specimens are from locality 6

1998. *Cremnoceramus deformis erectus* (Meek, 1877); Walaszczyk and Wood, p. 415, pl. 5, fig. 14; pl. 6, figs 1–6, 8; pls 7, 8; pl. 9, figs 1, 3–6; pl. 10, figs 1–4, 6; pl. 11, figs 1, 3, 5–7; pl. 13, fig. 1; pl. 15, fig. 6 [and literature cited therein].

2000. *Cremnoceramus deformis erectus* (Meek, 1877); Walaszczyk and Cobban, p. 79, pls 19–24; pl. 25, figs 1, 2, 5–8 [and literature cited therein].

MATERIAL: Three specimens, MWG ZI/95/095, ZI/95/096, and ZI/95/097; all from locality 6. Two specimens of moderately preserved internal moulds of LV; one double-valve with almost complete LV and juvenile part of the RV.

DESCRIPTION: ZI/95/095 (Text-fig. 6E, F) is the double-valve internal mould, with almost complete LV and partially preserved RV. The LV is moderately large, with hmax = 78 mm, strongly geniculated, with original shape preserved. The juvenile valve is large (h = 71 mm), subquadrate in outline (l/h = 0.96), moderately inflated (B/h = 0.39), with the maximum inflation central, and with the posterior auricle small, subtriangular, elongated parallel to hinge line. The beak is pointed, and curved dorsally. The anterior margin is straight and long (AM/h = 0.66), passing into regularly rounded ventral margin, and rounded posterior margin. The anterior wall is high, overhanging, rounded. The hinge line is long and straight. The adult stage is almost at a right angle to the commissural plane of the juvenile stage. The juvenile stage is ornamented with distinct commarginal rugae, with interspaces growing gradually ventralward. Details of the ornament are not seen due to poor preservation. The adult stage is almost smooth. The RV is very incomplete; only a part of the juvenile stage is preserved. It shows the pointed beak, curved antero-dorsally, long and straight hinge line, and a part of the anterior margin. Based on the general outline and shape of the preserved part, the RV was less inflated than the RV.

ZI/95/096 (Text-fig. 6A, B, D) is a single LV, moderately large (hmax = 65 mm), strongly inflated, with well-preserved outline and general shape. The valve is distinctly geniculated, with the juvenile stage almost complete; the adult stage only partially preserved. The juvenile stage is moderately large (h = 52 mm), subquadrate in outline (l/h = 0.86), weakly inflated, with maximum inflation dorso-central, and with a narrow posterior auricle. The anterior margin almost straight to slightly convex below the umbo, moderately long (AM/h = 0.58), passing into rounded ventral margin. The growth axis is anteriorly convex. The ornament is composed of regular, widely spaced rugae, having a slightly V-shape outline. The geniculation is less pronounced than in ZI/95/095, attaining c. 60°.

ZI/95/097 (Text-fig. 6C) is a small (hmax = 55 mm) juvenile LV, lacking the beak and slightly incomplete in the antero-dorsal part. The disc well separated from the posterior auricle, which is small, subtriangular in outline. The valve outline subquadrate, with l/h = 0.90. The ornament is composed of relatively well-developed commarginal rugae, with V-shaped rugae in the axial part.

DISCUSSION: The valve outline, general architecture, and ornament match well with these characters in a typical *Cremnoceramus deformis erectus* and the specimens are referred to this typically Euramerican species. *Tethyoceramus madagascariensis*, the other taxon with which the material studied could be compared, is distinctly more elongated parallel to the growth axis (the l/h ratios calculated for the studied specimens and for over 40 specimens of *T. madagascariensis* are statistically different) and, at least as based on the material studied herein and those from Madagascar, distinctly geniculated specimens are extremely rare in this species. Moreover, a V-shaped outline of the commarginal ornament in the axial part of the shell is absent or rarely developed in Heinz' species.

OCCURRENCE: *Cremnoceramus deformis erectus* is a common early Coniacian species in the Euramerican biogeographic region, ranging from the North American Western Interior through the Gulf Coast, Atlantic Coast, Europe, and western Asia (Central Asia) (see Walaszczyk and Wood 1999; Walaszczyk and Cobban 2000; Walaszczyk *et al.* 2014; Cooper *et al.* 2017). It is also known from north-eastern Brazil (Kauffman and Bengtson 1985). The present record of this species is the first from India.

Ammonites (W. J. Kennedy)

Conventions: Dimensions are given in millimetres: D = diameter; Wb = whorl breadth; Wh = whorl height; U = umbilicus; c = costal dimension; ic = intercostal dimension. Figures in parentheses are dimensions as a percentage of the diameter. The suture terminology is that of Korn *et al.* (2003): E = external lobe; A = adventive lobe (= lateral lobe, L, of Kullmann and Wiedmann 1970); U = umbilical lobe; I = internal lobe. The taxonomic scheme of Wright (1996) is followed here.

Order Ammonoidea Zittel, 1884
Suborder Ammonitina Hyattt, 1889
Superfamily Desmoceratoidea Zittel, 1895
Family Desmoceratidae Zittel, 1895
Subfamily Puzosiinae Spath, 1922
Genus *Mesopuzosia* Matsumoto, 1954

TYPE SPECIES: *Mesopuzosia pacifica* Matsumoto, 1954, p. 82, pl. 14, fig. 1; pl. 15, figs 1, 2; pl. 16, figs 1–3, text-fig. 2, by the original designation of Matsumoto (1954, p. 79).

Mesopuzosia gaudama (Forbes, 1846)

(Text-figs 7, 8)

1846. *Ammonites Gaudama* Forbes, p. 113, pl. 10, fig. 3.
1991a. *Mesopuzosia gaudama* (Forbes, 1846); Kennedy and Henderson, p. 891, text-fig. 1.1–1.4 (with synonymy).
2011. *Puzosia* (*Puzosia*) *gaudama* (Forbes, 1846); Klein and Vašiček, pp. 66, 74 (with additional synonymy).
in press. *Mesopuzosia gaudama* (Forbes 1846); Kennedy and Gale, text-fig. 8a–o.

TYPE: The holotype, by monotypy, is BMNH C51065, the original of Forbes (1846, p. 113, pl. 10, fig. 3); it was refigured by Kennedy and Henderson (1991a, text-fig. 1.1, 1.2). Forbes (1846) stated that the specimen was from Vridhachalam (Verdachellum) in Madras State, but it is probably from some other locality, as discussed by Blanford (1862, p. 146) and Sastry *et al*. (1968).

MATERIAL: MWG ZI/95/001, 004, 006, 009, 016, 020, 022, 026, 028, 030, 031, 034, 038, 050, and 051.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
ZI/95/034	54.0 (100)	18.3 (33.9)	24.5 (45.4)	0.75	15.0 (27.8)
ZI/95/031	63.2 (100)	20.8 (32.9)	27.8 (44.0)	0.75	18.6 (29.4)
ZI/95/050	72.9 (100)	– (–)	29.6 (40.4)	–	22.1 (30.3)
ZI/95/004	75.5 (100)	– (–)	33.6 (44.5)	–	22.8 (30.2)
Z1/95/001	135.0 (100)	42.7 (31.6)	53.6 (39.7)	0.79	42.8 (31.7)
ZI/95/009	170.0 (100)	59.0 (34.7)	73.6 (43.3)	0.8	46.6 (27.4)

DESCRIPTION: The specimens range from 54 to 170 mm in diameter. The largest, ZI/95/009, is wholly septate. There are both internal moulds and specimens retaining replaced, sometimes limonitised shell material. Coiling is moderately evolute, with 54% of the previous whorl covered in the largest specimen, the umbilicus comprises around 30% of the diameter, and is shallow, with a low, convex, outward-inclined umbilical wall, the umbilical shoulder broadly rounded. The whorl section is compressed, with whorl breadth to height ratios varying between 0.75 and 0.8, the greatest breadth below mid-flank. The inner flanks are feebly convex, the outer flanks converging to broadly rounded ventrolateral shoulders and a feebly convex venter. Ornament comprises crowded ribs, and periodic widely separated constrictions with associated collar-ribs. The ribs are weak on the umbilical wall, shoulder and innermost flanks, strengthening, straight and prorsiradiate on the inner flanks, then strengthening further, increasing by branching and intercalation, sweeping forwards, concave on the outer flank, and crossing the venter in a marked convexity. The constrictions follow a similar course to the ribs on the flanks, but cross the venter in a narrower, sometimes subangular ventral peak. There is a well-developed adapertural collar rib, and between 14 and more than 20 ribs between successive constrictions.

The sutures are deeply incised, with a trifid E/A and a retracted umbilical lobe.

DISCUSSION: See Kennedy and Henderson (1991a).

OCCURRENCE: Lower Coniacian of Tamil Nadu; Upper Turonian and Coniacian of Madagascar.

Subfamily Desmoceratinae Zittel, 1895

Genus *Damesites* Matsumoto, 1942

TYPE SPECIES: *Desmoceras damesi* Jimbo, 1894, p. 172, pl. 1, figs 2, 3; ICZN Opinion 555 (1959).

Damesites sugata (Forbes, 1846)

(Text-fig. 9A, B, F)

1846. *Ammonites Sugata* Forbes, p. 113, pl. 10, fig. 2a–c.
1991b. *Damesites sugata* (Forbes, 1846); Kennedy and Henderson, p. 471, text-figs 1, 2 (with synonymy).
2013. *Damesites sugata* (Forbes, 1846); Kennedy and Klinger, p. 44, text-fig. 7a–j (with additional synonymy).
in press. *Damesites sugata* (Forbes, 1846); Kennedy and Gale, text-fig. 9a–i (with additional synonymy).

MATERIAL: MWG ZI/95/025, 027.

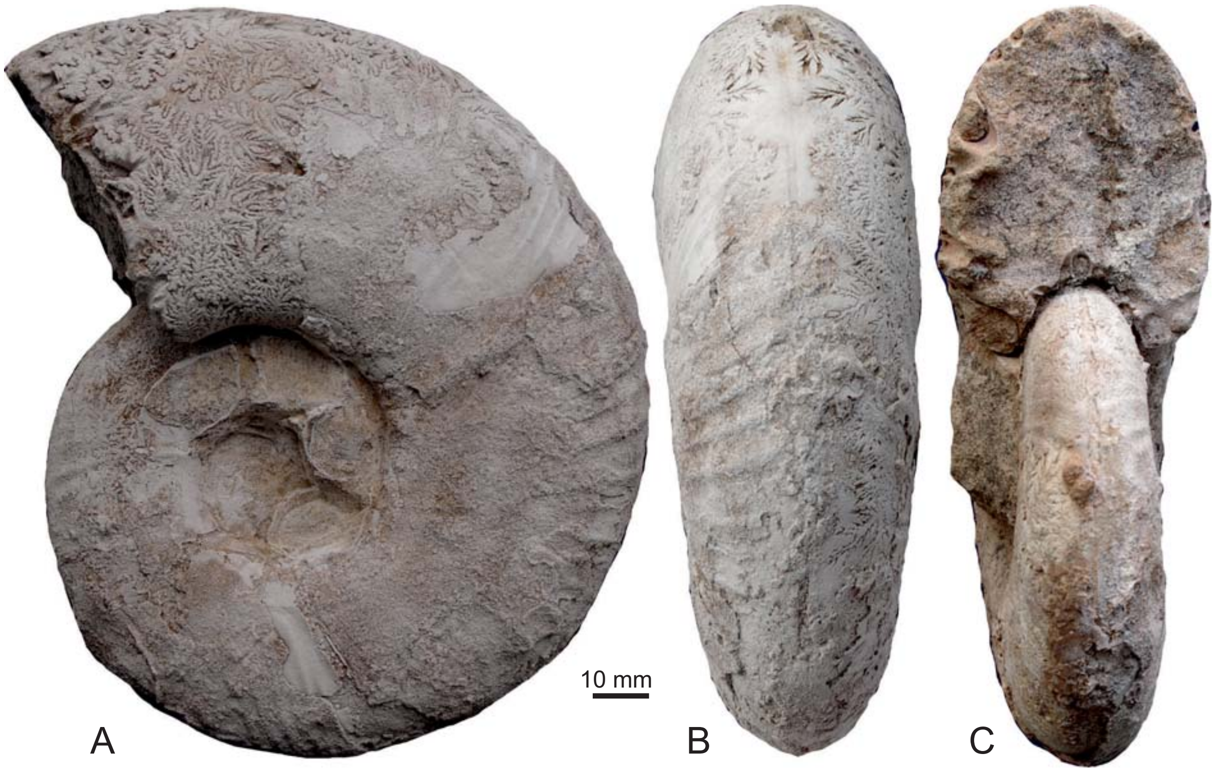
DISCUSSION: A large assemblage of the present species is described by Kennedy and Gale (in press). Of the present specimens, ZI/95/027 a phragmocone 42 mm in diameter (Text-fig. 9F), has the diagnostic keel of *Damesites* well preserved on the adapical part of the outer whorl.

Text-fig. 7. *Mesopuzosia gaudama* (Forbes, 1846); A, C, D – ZI/95/034, locality 8; B – ZI/95/050, locality 2; E, F – ZI/95/001, locality 1

OCCURRENCE: Coniacian to Campanian, Tamil Nadu in south India, Madagascar, Eastern Cape Province, South Africa, Angola, south-eastern France, Austria?, British Columbia, Canada, and Washington State and California in the USA.

Genus *Onitschoceras* Reyment, 1954

TYPE SPECIES: *Onitschoceras matsumotoi* Reyment, 1954, p. 248, pl. 3, figs 1, 2; pl. 5, fig. 7; text-fig. 1, by original designation.



Text-fig. 8. *Mesopuzosia gaudama* (Forbes, 1846); A-B – ZI/95/009, locality 9

Onitschoceras sp.
(Text-fig. 9C–E, G–I)

MATERIAL: MWG ZI/95/017, 032 and 033.

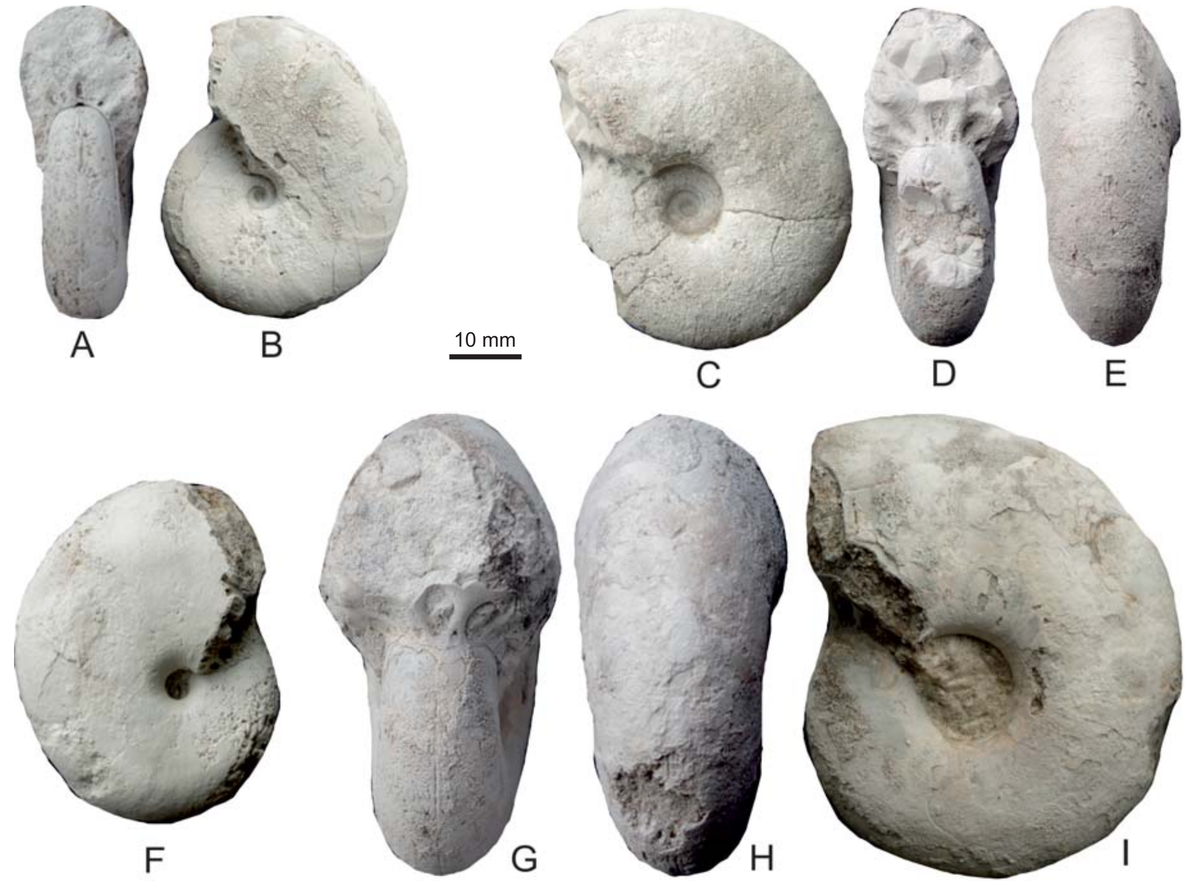
DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
ZI/95/017	52.0 (100)	23.1 (44.4)	23.8 (45.7)	0.97	11.2 (21.5)
ZI/95/033	65.3 (100)	31.4 (48.0)	33.3 (50.9)	0.94	14.5 (22.2)

DESCRIPTION: The specimens are all phragmocones, retaining extensive areas of corroded, in some cases replaced shell material. Coiling is very involute, the umbilicus comprising around 22% of the diameter, of moderate depth, with a very feebly convex, subvertical umbilical wall and broadly rounded umbilical shoulder. The whorl section is barely compressed, with feebly convex inner and convergent outer flanks, the ventrolateral shoulders and venter broadly rounded. The only ornament preserved is a single quite strong rib on two of the specimens (ZI/95/017: Text-fig. 9C–E and 033: Text-fig. 9G–I). The rib is concave on the ventrolateral shoulders, crosses the venter in a broad convexity and is succeeded by a constriction, conspicuous only on the outermost flanks, ventrolateral shoulders and venter. The partially exposure suters are deeply and intricately incised, with narrow – stemmed E/A and A/U2 and bifid A.

DISCUSSION: The suture line indicates these specimens to be Desmoceratinae. The closest comparison is with the specimen of *Onitschoceras matsumotoi* Reyment, 1954, figured by Reyment in 1955 (pl. 2, fig. 9). They lack the distinctive ornament of riblets and lirae of the much better-preserved holotype and paratype (Reyment 1954, pl. 3, figs 1, 2), and have convex, rather than flattened, subparallel flanks. In this respect they are closer to *Onitschoceras*? *ponsianum* de Grossouvre, 1894 (p. 176, pl. 25, figs 1, 5; holotype refigured by Kennedy 1984, pl. 1, figs 1–3). In the absence of better preserved material, they are left in open nomenclature.

OCCURRENCE: As for material.



Text-fig. 9. *Damesites sugata* (Forbes, 1846); A, B – ZI/95/025, locality 8; F – ZI/95/027, locality 1; *Onitschoceras* sp.; C-E – ZI/95/017, locality 10; G-I – ZI/95/033, locality 8

Family Kossmaticeratidae Spath, 1922
Subfamily Kossmaticeratinae Spath, 1922
Genus and subgenus *Kossmaticeras* de Grossouvre, 1901

TYPE SPECIES: *Ammonites theobaldianus* Stoliczka, 1866, p. 161, pl. 87, figs 1–3, by the subsequent designation of Diener (1925, p. 96).

Kossmaticeras (*Kossmaticeras*) *theobaldianum* (Stoliczka, 1865)
(Text-fig. 10)

1865. *Ammonites Theobaldianus* Stoliczka, p. 161, pl. 78, figs 2, 3.

1897. *Holcodiscus Theobaldianus* Kossmat, p. 35 (142); typische Form, p. 36 (143); pl. 7 (18), fig. 5; pl. 8 (19), fig. 1; Varietät; non grobberippte Varietät p. 36 (143); Varietät mit einfach nach vorwärts geneigten Einschnürungen p. 36 (143), pl. 7 (18), fig. 4.

in press. *Kossmaticeras* (*Kossmaticeras*) *theobaldianum* (Stoliczka, 1865); Kennedy and Gale, text-figs 9m, n; 10k–s (with full synonymy).

TYPE: The lectotype, by the subsequent designation of Kennedy and Gale (in press) is the original of Stoliczka (1865, pl. 78, fig. 2). The original is in the collections of the Geological Survey of India, and is from the 'neighbourhood of Anapandy.'

MATERIAL: MWG ZI/95/029, 040, 046, and 048.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
ZI/95/046 c	67.8 (100)	–	27.1 (40.0)	– (–)	26.1 (38.5)
ZI/95/048 c	100.6 (100)	34.5 (34.3)	38.9 (38.7)	0.89	38.6 (38.4)

DESCRIPTION: The specimens are internal moulds of phragmocones retaining traces of recrystallized shell. The largest fragment, ZI/95/040 has a maximum preserved whorl height of just over 39 mm. Coiling is moderately evolute, the shallow umbilicus comprising around 39% of the diameter. The umbilical wall is evenly convex in ZI/95/040 and 046 (Text-fig. 10E), with a broadly rounded umbilical shoulder, but has a well-developed median groove in ZI/95/029 (Text-fig. 10A) and 048 (Text-fig. 10B–D), as a result of which the umbilical shoulder is more narrowly rounded in the latter. The whorl section is compressed, the costal whorl breadth to height ratio varying between 0.82 and 0.89, the inner and middle flanks subparallel and feebly convex, the outer flanks converging to the broadly rounded venter. More than 30 primary ribs arise on the umbilical wall and strengthen across the umbilical shoulder on the outer whorls. Rib direction is variable. The ribs between the successive constrictions are prorsiradiate on the inner flanks and may bifurcate around mid-flank, are generally feebly concave on the outer flank and pass near-straight across the venter, as in ZI/95/048 (Text-fig. 10B–D), but are straight to feebly concave in ZI/95/046 (Text-fig. 10E). The well-developed constrictions, four per half whorl, are straight and prorsiradiate on the inner to middle flanks, concave on the outer flanks and ventrolateral shoulders, and markedly convex over the venter. The adapical collar rib bifurcates on the outer flank, that branch flanking the constriction parallels it, whereas the adapical branch passes straight across the venter, as do the majority of the ribs. There are up to 56 ribs at the ventrolateral shoulder. The suture is deeply and intricately incised, with bifid E/A andA/U2; A and U2 are trifid.

DISCUSSION: The innermost whorls of the present specimens are poorly preserved, but are much more finely ribbed than the outer, as in the proposed lectotype and the variety *crassicosta* of Collignon (1954, p.74), based on the original of Stoliczka (1865, pl. 78, fig. 3), corresponding to the juveniles from Pilmisai described by Kennedy and Gale (in press, text-fig. 10k–s). The present specimens differ in no significant respects from the proposed lectotype. See Kennedy and Klinger (1985, p. 172) for further discussion.

OCCURRENCE: Lower Coniacian, Tamil Nadu, Madagascar, KwaZulu-Natal in South Africa, and Japan.

Family Pachydiscidae Spath, 1922

Genus *Lewesiceras* Spath, 1939

TYPE SPECIES: *Ammonites peramplus* Mantell, 1822, p. 200, by original designation of Spath (1939, p. 296).

Lewesiceras jimboi (Kossmat, 1898)

(Text-fig. 11A–F)

pars 1865. *Ammonites Denisonianus* Stoliczka, p. 133, pl. 65, fig. 4 only.
1898. *Pachydiscus Jimboi* Kossmat, p. 92 (157), pl. 14 (20), fig. 1.
1907. *Pachydiscus Jimboi* Kossmat; Boule *et al*., p. 3 (23), pl. 19 (6), figs 1–4.
1925. *P.* (an *Kossmaticeras*?) *jimboi* Kossmat; Diener, p. 106 (with additional synonymy).
1952. *Lewesiceras jimboi* Kossmat; Collignon, p. 84.
1955. *Lewesiceras jimboi* Kossmat; Collignon, p. 78.

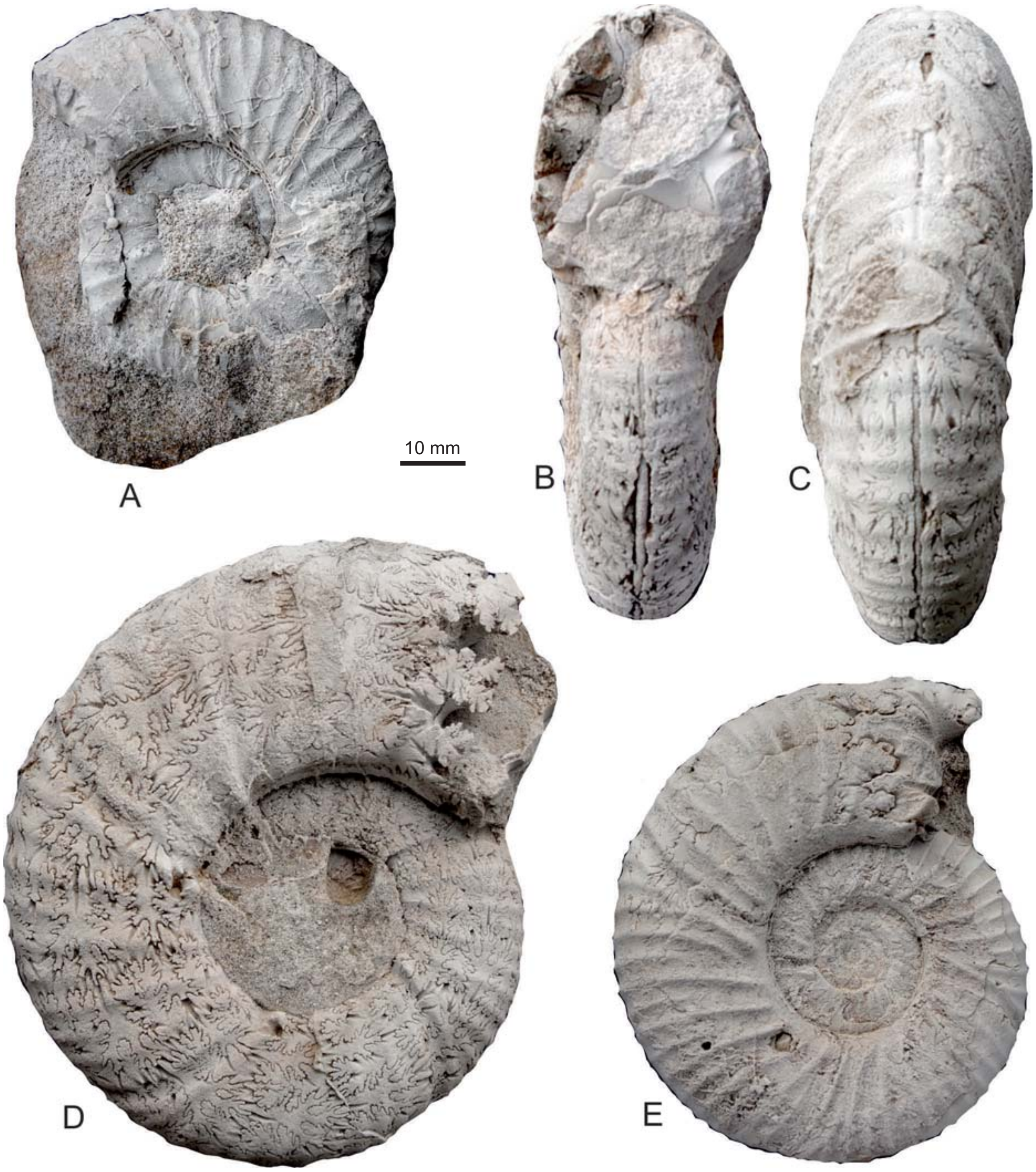
TYPE: The holotype, by monotypy, is the original of Stoliczka (1865, pl. 65, fig. 4), from the Trichinopoly Group north of Anapandy. It was refigured by Kossmat (1898, pl. 14 (20), fig. 1).

MATERIAL: MWG ZI/95/007, 024, and 047.

DIMENSIONS:

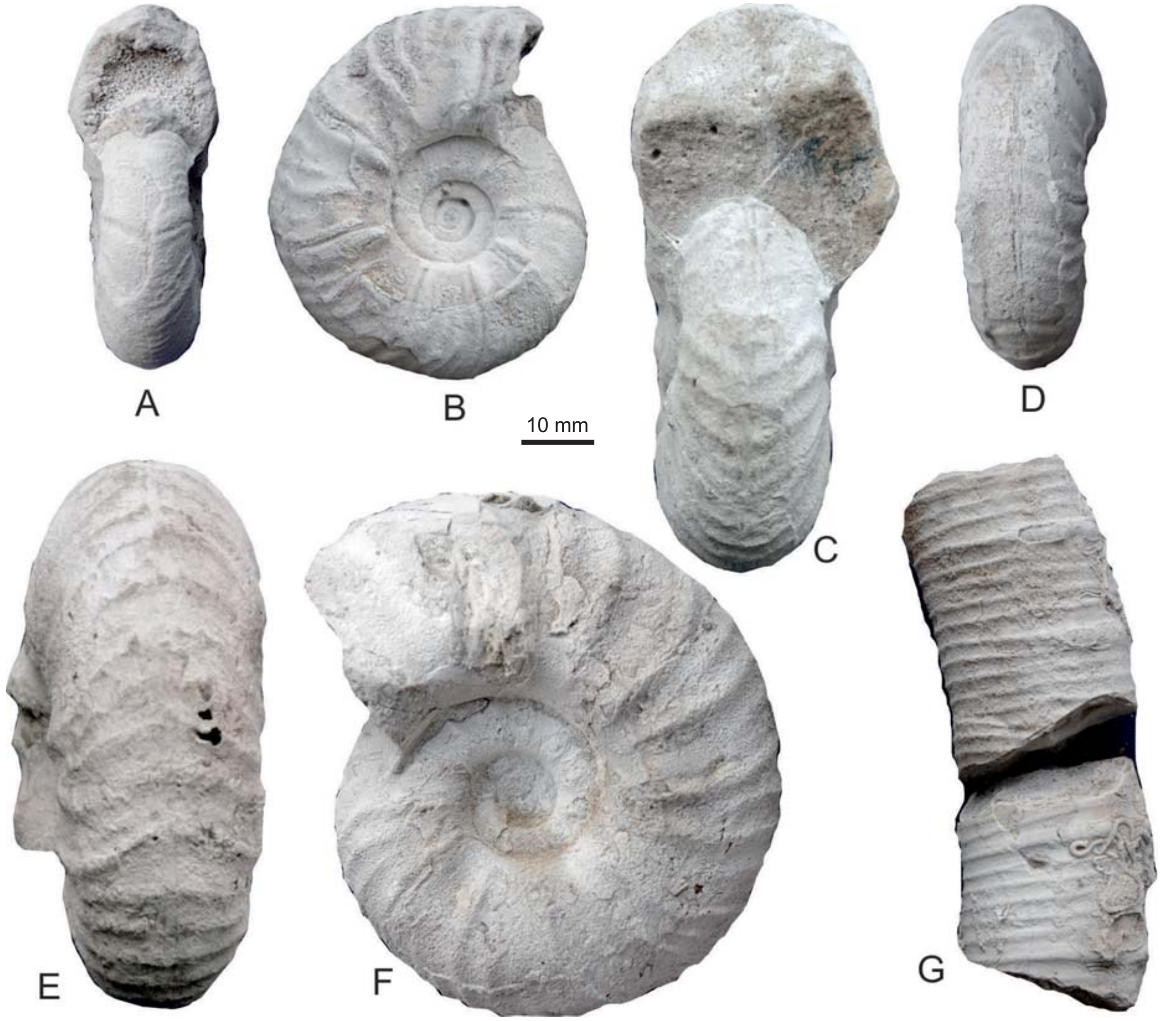
	D	Wb	Wh	Wb:Wh	U
ZI/95/007	51.8 (100)	20.6 (39.8)	21.4 (41.3)	0.96	17.0 (32.8)
ZI/95/047	79.2 (100)	33.7 (42.6)	31.8 (40.2)	1.1	25.5 (32.2)

DESCRIPTION: ZI/95/007 (Text-fig. 11A, B, D) is interpreted as a juvenile of the species, 51.8 mm in diameter. Coiling is moderately involute, the umbilicus comprising 32.8% of the diameter, of moderate depth with a convex, outward-inclined wall and broadly rounded umbilical shoulder. The intercostal whorl section is compressed, with the greatest breadth below mid-flank, the inner flanks convex and subparallel, the outer flanks feebly convex and convergent, the ventrolateral shoulders and venter broadly rounded. Eleven primary ribs arise on the umbilical wall, and strengthen into well-developed umbilical bullae. These give rise to a single rib or a pair of ribs that are straight and prorsiradiate on the inner and middle flanks, flexing forwards and concave on the outer flanks and ventrolateral shoulders and crossing the venter in a marked convexity. Non-bullate primaries and shorter ribs intercalate between, and there are irregularly and variably developed constrictions preceding and succeeding the bullate ribs, which are obtusely subangular on the



Text-fig. 10. *Kossmaticeras* (*Kossmaticeras*) *theobaldianum* (Stoliczka, 1865); A – ZI/95/029, locality 1; B-D – ZI/95/048, locality 3; E – ZI/95/046, locality 5

venter. There are four or five ribs at the ventrolateral shoulder between successive collar ribs. ZI/95/047 (Text-fig. 11C, E, F) is a rather worn individual, 79.2 mm in diameter. Fourteen primary ribs arise on the umbilical wall and strengthen into bullae of variable strength. These give rise to pairs of ribs that are coarse, straight and prorsiradiate on the inner flanks, flex forwards and are concave on the outer flanks, and cross the venter in a broad convexity. Some ribs bifurcate, and additional ribs intercalate, to give a



Text-fig. 11. *Lewesiceras jimboi* (Kossmat, 1898); A, B, D – ZI/95/007, locality 9; C, E, F – ZI/95/047, locality 2; *Pseudoxybeloceras* (*Schlueterella*) sp.; G – ZI/95/036, locality 8

total of more than forty ribs at the ventrolateral shoulder. ZI/95/024 is a 60º sector of body chamber with a maximum preserved whorl height of 41 mm. Strong primary ribs arise on the umbilical wall, and additional ribs intercalate, passing across the venter in a marked convexity.

DISCUSSION: ZI/95/007 (Text-fig. 11A, B, D) closely resembles the slightly larger specimen from Madagascar figured by Boule *et al.* (1907, pl. 19 (6), fig. 2). ZI/95/047 (Text-fig. 11C, E, F) is close to the holotype. *Lewesiceras jimboi* differs from *Lewesiceras vaju* (Stoliczka, 1865) (pl. 65, fig. 3; refigured by Kossmat 1898, pl. 14 (20), fig. 4 and Roman and Mazeran 1913, text-fig. 2), originally described from the Trichinopoly Group of Garudamangalam, in its higher rib density, and well-developed constrictions with associated collar ribs.

OCCURRENCE: Lower Coniacian of Tamil Nadu; 'Senonien Inférieur' of Madagascar.

Superfamily Hoplitoidea H. Douvillé, 1890
Family Placenticeratidae Hyatt, 1900
Genus *Placenticeras* Meek, 1876

TYPE SPECIES: *Ammonites placenta* DeKay, 1828, p. 278, by the original designation of Meek (1876, p. 46).

Placenticeras kaffrarium Etheridge, 1904
(Text-figs 12–14)

1904. *Placenticeras kaffrarium* Etheridge, p. 89, pl. 3, fig. 16.
1989. *Placenticeras kaffrarium* Etheridge, 1904; Klinger and Kennedy, p. 268, text-figs 9–14A, 19, 20, 22–99.

TYPE: The holotype, by monotypy, is the original of Etheridge (1904, p. 89, pl. 3, fig. 16), no. NMP 355, type no. T417 in the collections of the KwaZulu-Natal Museum, Pietermaritzburg, from Umkwelane Hill (Mkweyane), KwaZulu-Natal. It was refigured by Klinger and Kennedy (1989, text-fig. 19).

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
ZI/95/005	70.6 (100) ic	22.4 (31.7)	34.3 (48.6)	0.65	13.0 (18.4)
ZI/95/010	74.3 (100)	23.4	40.4		8.1
ZI/95/045	84.5 (100)	20.9			48.6
ZI/95/021	120.5	37.5	57.3		25.3
ZI/95/008	137.5	43.9	67.5		19.3

MATERIAL: There are fifteen specimens: MWG ZI/95/002, 003, 005, 008, 010, 011, 013, 015, 018, 021, 023, 039, 043–045.

DESCRIPTION AND DISCUSSION: The wide intraspecific variation shown by *Placenticeras kaffrarium* from KwaZulu-Natal was documented in detail by Klinger and Kennedy (1989), and comparable variation in *Placenticeras* from the Narmada Valley in Madhya Pradesh was documented by Bardhan *et al.* (2002) and Gangopadhyay and Bardhan (2007), who assigned their material to *kaffrarium*.

Individuals that lack ornament, corresponding to the lectotype of *Placenticeras umkwelanense* Etheridge, 1904 (p. 89, pl. 3, fig. 17; refigured by Klinger and Kennedy 1989, text-fig. 20a) are very compressed, with a shallow conical umbilicus, very narrowly rounded umbilical shoulder, smooth flanks, and sharp edges to the venter that is concave between, as in ZI/95/013 and 045. Other individuals have feeble ventral clavi and minute umbilical bullae, as in ZI/95/039. ZI/95/002 (~150 mm in diameter), 011, 008 (137 mm in diameter), and 023 (~120 mm diameter) may be adults of this type, the whorl section broadening and the venter changing from sulcate to tabulate to very feebly convex, with blunt, rounded ventrolateral shoulders. These specimens retain recrystallized shell, and the position of the final septum cannot be established.

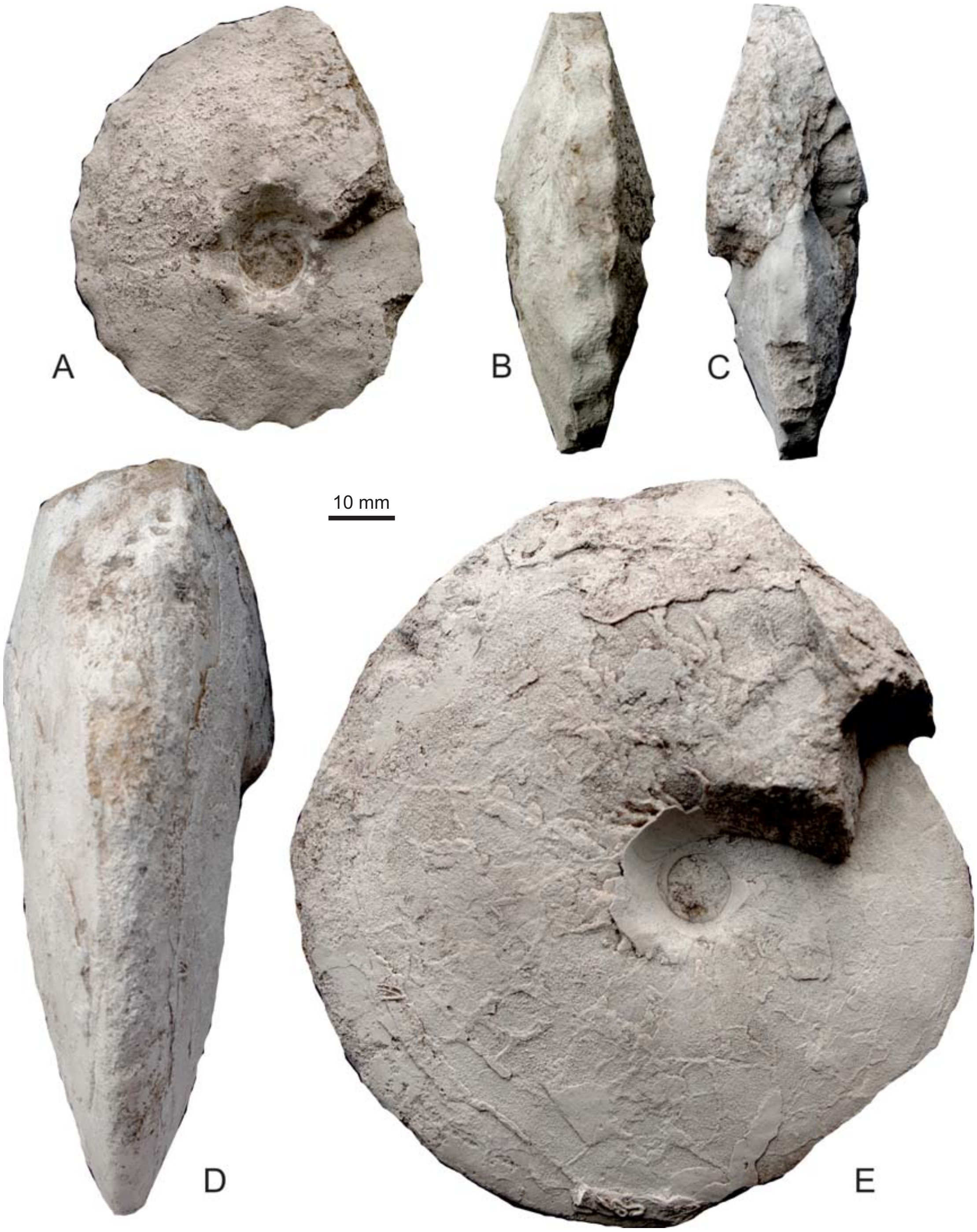
More strongly ornamented individuals correspond to the holotype of *Placenticeras subkaffrarium* Spath, 1921 (p. 247, pl. 21, fig. 2, reillustrated by Klinger and Kennedy 1989, text-fig. 21). Juveniles are represented by ZI/95/005 (Text-fig. 12A–C), 010, and 01?. The first of these has seven to eight well-developed umbilical bullae per whorl and more than an estimated 22 ventral clavi; the bullae give rise to pairs of low, broad, feeble to obsolete ribs with blunt, rounded outer lateral tubercles. ZI/95/021 (Text-fig. 14) is an adult of this group, 121 mm in diameter, with a 240° sector of body chamber. There are blunt umbilical bullae and ventral clavi at the adapical end of the body chamber, but these are rapidly lost, the venter broadens, and becomes feebly convex, with broadly rounded ventrolateral shoulders. ZI/95/015 is a further adult of this group, showing comparable ontogenetic changes on the outer, adult whorl, and 170 mm in diameter; it is tempting to interpret these specimens as adult micro- and macroconch.

The most strongly ornamented variants are represented by poorly preserved juveniles: ZI/95/003, 043, and 044, the largest 96 mm in diameter. These correspond to the holotype of *Placenticeras kaffrarium* Etheridge, 1904 (p. 89, pl. 3, fig. 16; refigured by Klinger and Kennedy 1989, text-fig. 19), and have coarse umbilical bullae that give rise to pairs of blunt ribs with blunt, rounded outer lateral tubercles and strong ventral clavi. What may be a fragment of an adult body chamber of this group, ZI/95/049, with a whorl height of 62 m, has ventral clavi alternating in position on either side of a venter with a blunt, rounded median ridge.

OCCURRENCE: *Placenticeras kaffrarium* ranges from upper Turonian (Madagascar) to middle Coniacian (northern KwaZulu-Natal in South Africa), with additional records from Tamil Nadu, the Bagh Beds of central India, the offshore Alphard Group off Cape Province, South Africa, Angola, and, possibly, Namibia and south-eastern Algeria.

Suborder Ancyloceratina Wiedmann, 1966
Superfamily Turrilitoidea Gill, 1871
Family Diplomoceratidae Spath, 1926
Subfamily Polyptychoceratinae Matsumoto, 1938
Genus *Pseudoxybeloceras* Wright and Matsumoto, 1954

TYPE SPECIES: *Hamites quadrinodosus* Jimbo, 1894, p. 39, pl. 7, figs 3, 4, by the original designation of Wright and Matsumoto (1954, p. 119).



Text-fig. 12. *Placenticeras kaffrarium* Etheridge, 1904, A-C – ZI/95/005, locality 9; D, E – ZI/95/023, locality 10

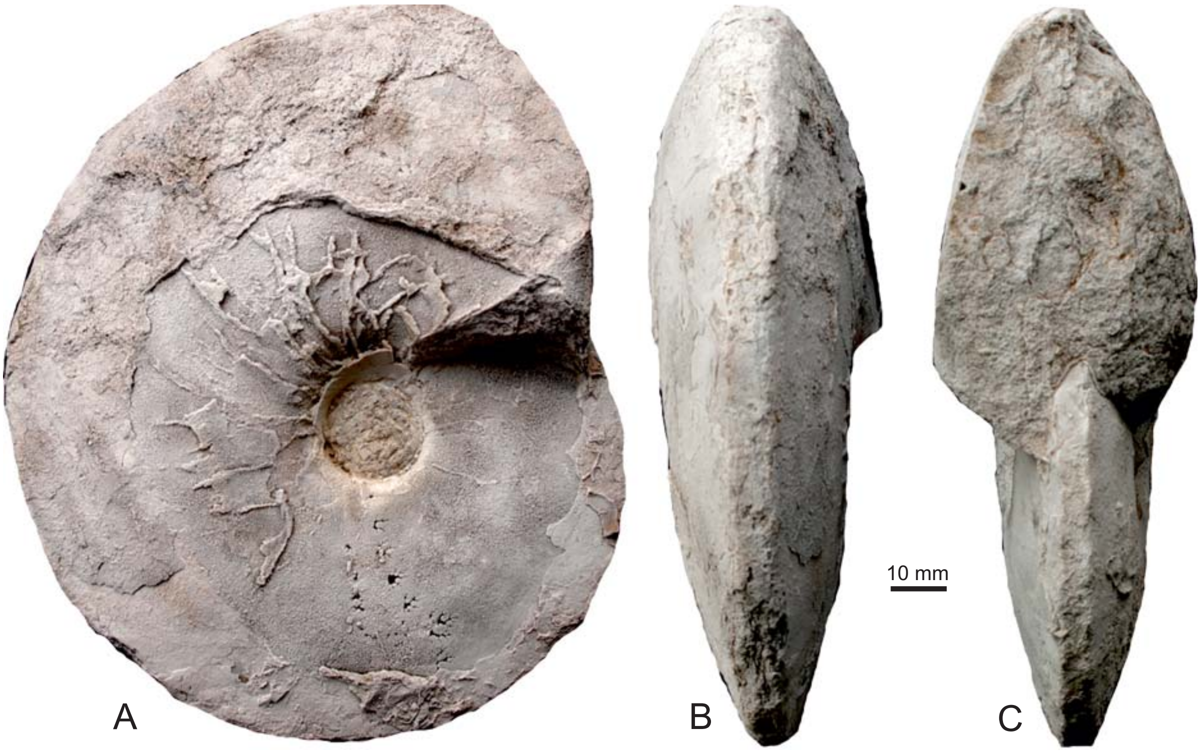
Subgenus *Schlueterella* Wiedmann, 1962

TYPE SPECIES: *Ancyloceras pseudoarmatum* Schlüter, 1872, p. 99, pl. 31, figs 1–3, by the original designation of Wiedmann (1962, p. 205).

Pseudoxybeloceras (*Schlueterella*) sp.

(Text-fig. 11G)

MATERIAL: MWG ZI/95/036, 037.



Text-fig. 13. *Placenticeras kaffrarium* Etheridge, 1904, A-C – ZI/95/008, locality 9

DESCRIPTION: The specimens are very feebly curved fragments, apparently of body chamber, retaining recrystallized shell, the maximum length of ZI/95/036 (Text-fig. 11G) is 40 mm, the maximum whorl height 26 mm, the whorl section oval, with a whorl breadth to height ratio of 0.8.The ribs are of two types; tuberculate and non-tuberculate. The rib index is 10. The non-tuberculate ribs are narrower than the interspaces, transverse across the dorsum, straight and feebly prorsiradiate across the flanks, and transverse across the venter. In the better-preserved specimen (ZI/95/036; Text-fig. 11G), pairs of ribs of the same strength and form as the nontuberculate ribs on the dorsum and flanks, link at a transversely elongate inner ventrolateral tubercle, possibly the base of a septate spine, linked by a strong rib to a conical outer ventrolateral tubercle, again possibly the base of a septate spine. These tubercles are linked across the venter by a strong, transverse rib. There are three or four nontuberculate ribs between successive tuberculate ribs.

DISCUSSION: Slight as the material is, the presence of periodically strengthened ribs with inner and outer ventrolateral tubercles shows these specimens to be a *Pseudoxybeloceras* (*Schlueterella*), albeit specifically indeterminate.

OCCURRENCE: As for material.

DISCUSSION

Age of the fauna

The fauna studied herein comprises ammonites and inoceramids. Ammonites are much better represented, being recorded from almost all localities studied. Inoceramids (at least determinable fragments) were found in localities 6, 9, and 11. The source localities form a belt stretching approximately NE-SW, paralleling the lithostratigraphic boundaries in the area. No clear succession between particular localities was established.

The ammonites are: *Mesopuzosia gaudama* (Forbes, 1846), *Damesites sugata* (Forbes, 1846), *Onitschoceras* sp., *Kossmaticeras* (*Kossmaticeras*) *theobaldianum* (Stoliczka, 1865), *Lewesiceras jimboi* (Kossmat,

Text-fig. 14. *Placenticeras kaffrarium* Etheridge, 1904, A-C – ZI/95/021, locality 10

1898), *Placenticeras kaffrarium* Etheridge, 1904, and *Pseudoxybeloceras* (*Schlueterella*) sp. As with the Pilmisai fauna from north of the area studied here (Kennedy and Gale in press), the present assemblage indicates the *Kossmaticeras theobaldianum* ammonite Zone. The lack in the assemblage of *Peroniceras* (*P.*) *dravidicum* (Kossmat, 1895) indicates that only the lower part of the zone is present, and namely the nominative *Kossmaticeras theobaldianum* Subzone of Ayyasami and Rao (1984; see Text-fig. 4).

Inoceramids from the interval studied are from a middle part of the fossiliferous belt. They are represented by numerous *Tethyoceramus madagascariensis* (Heinz, 1932) and rare *Cremnoceramus deformis erectus* (Meek, 1877). The presence of the latter, the first recorded from India, places the inoceramid levels within the *C. deformis erectus* Zone, which dates the interval as early Coniacian in inoceramid terms, the base of the Coniacian Stage defined at the level of the first appearance of *C. deformis erectus*. Although not yet formalised this level is generally agreed as the most suitable primary marker for the boundary (see Kauffman *et al.* 1996; Walaszczyk and Wood 1999; Walaszczyk *et al.* 2010).

The present material allows, for the first time, direct dating, in terms of the Euramerican inoceramid zonation, of the East African *Tethyoceramus* succession. Based on recent studies in the Manasoa section, in south-west Madagascar (Walaszczyk *et al.* 2004; see also Walaszczyk *et al.* 2014), *T. madagascariensis* is the second member of the *Tethyoceramus* clade, succeeding *Tethyoceramus modestoides* (Sornay, 1980), and succeeded by *T. madagascariensis*, which in turn gave rise to the youngest member, *T. ernsti* (Heinz, 1928). [*Tethyoceramus basseae* (Sornay, 1980) previously regarded as a possible phyletic successor of *T. madagascariensis* (see Walaszczyk *et al.* 2004) is, rather, a side branch; see also the taxonomic part of this paper]. The species of the clade occur in the *Cremnoceramus* dominated interval of the Euramerican biogeographic region (see discussion in Walaszczyk and Wood 1999) confirming its latest Turonian–early Coniacian age. In their chronostratigraphic interpretation of the Madagascan record, Walaszczyk *et al.* (2004) defined the base of the Coniacian at the first appearance of *Tethyoceramus madagascariensis*. This is the oldest member of the *Tethyoceramus* clade which possesses the Anwachsmarken, the characteristic feature of both *Tethyoceramus* and *Cladoceramus* clades, and which in the *Cremnoceramus* clade first appears in *C. deformis erectus*. The present record of co-occurring *T. madagascariensis* and *C. deformis erectus* in the Anaipandi area confirms previous correlations.

Based on inoceramids the *Kossmaticeras theobaldianum* Subzone should be dated as latest Turonian through to early Coniacian. This is also supported by comparison with Madagascar and South Africa, from where this assemblage is also known, although the precise earliest date cannot be established at present. The latest age limit of this subzone is marked by the first appearance of *Peroniceras* (*P.*) *dravidicum* (Kossmat, 1895). (= *Ammonites sub-tricarinatus* d'Orbigny of Stoliczka, 1865, p. 54, pl. 31, fig. 3; see Kennedy 1984; Klinger and Kennedy 1984). The base of the *P. dravidicum* Subzone is equivalent to the base of the European *Peroniceras tridorsatum* Zone, spanning the late early through to middle Coniacian (Kaplan and Kennedy 1994). Accordingly, the *K. theobaldianum* ammonite Subzone spans the latest Turonian through to the mid-early Coniacian as defined in inoceramid terms.

Consequences for lithostratigraphy

The present fauna allows a more precise dating of the lithostratigraphic units present in the area studied. The boundary between the Garadamangalam and the Anaipadi formations is still late Turonian; the base of the Coniacian thus lies within the lower (but not lowermost) Anaipadi Formation. Most of the Coniacian part of the Anaipadi Formation as exposed in the studied area represents the lowermost part of the stage.

Composition of the ammonite fauna

The present assemblage comprises 48 specimens. The breakdown by genus is:
Mesopuzosia: 15 (31.3%)
Damesites: 2 (4.2%)
Onitschoceras: 3 (6.3%)
Kossmaticeras (*Kossmaticeras*): 4 (8.4%)
Lewesiceras: 3 (6.3%)
Placenticeras: 16 (33.3%)
Pseudoxybeloceras (*Schlueterella*): 2 (4.2%)

The fauna from the Pilmisai shell bed north of the present study area, described by Kennedy and Gale (in press), yielded 285 ammonites, but in spite of the present collection being so much smaller, some meaningful comparisons can be made. In both cases, Desmoceratoidea dominate, comprising 56.3% of the present assemblage and 64.5% of the Pilmisai assemblage. If genera common to the two assemblages are compared:

Taxon	Present assemblage	Pilmisai shell bed
Mesopuzosia	33%	27%
Damesites	4.4%	34%
Kossmaticeras	8.8%	24%
Lewesiceras	6.3%	2.1%
Placenticeras	33.3%	1.4%

it will be seen that the generic makeup of the Desmoceratoidea is dominated, in both cases, by *Mesopuzosia*, but *Damesites* and *Kossmaticeras* are common in the Pilmisai fauna but rare in the present assemblage. The most striking difference is the contrast between the occurrences of *Placenticeras*, which makes up 33%, of the present fauna, but only 1.4% of the Pilmisai assemblage. It is not possible to determine if these proportions record differences in life, or are the product of *post-mortem* processes. It should be noted, however, that the present assemblage is of large individuals, including, in the case of *Placenticeras* large adults. The Pilmisai material, in contrast, is dominated by small phragmocones and fragments of phragmocones, the fragmentation possibly a recent phenomenon in part.

BIOGEOGRAPHIC REMARKS

Both the ammonite and inoceramid assemblages described above are dominated by taxa also present in Madagascar and eastern South Africa. Two of the ammonite species, *Kossmaticeras* (*K.*) *theobaldianum* and *Damesites sugata*, are also known from the North Pacific Province, and some occur further west, in the southern South Atlantic (*Placenticeras kaffrarium*, *D. sugata*). *Cremnoceramus deformis erectus* is a member of the *Cremnoceramus* clade, which dominated the latest Turonian through to early Coniacian of the Euramerican biogeographic region.

Acknowledgements

We thank Herbert Klinger for insightful review and comments on the final version of the paper. IW acknowledges financial support from the National Science Centre (NCN) Grant, UMO-2015/17/B/ST10/03228, supporting his works in India in January 2018.

REFERENCES

Ayyasami, K. 2006. Role of oysters in biostratigraphy: A case study from the Cretaceous of the Ariyalur area, southern India. *Geosciences Journal*, **10**, 237–247.

Ayyasami, K. and Rao, B.R.J. 1984. Observations on the biostratigraphic zones of the Trichinopoly Group (Upper Cretaceous), Tamilnadu. Proceedings of the X Indian Colloquium on Micropalaeontology and Stratigraphy, pp. 223–230.

Ayyasami, K. and Rao, B.R.J. 1994. Dispersal of Cretaceous inoceramids in Gondwanaland. Ninth International Gondwana Symposium, pp. 341–355. Oxford and IBH Publishing Pty Ltd.; New Delhi and Calcutta.

Bardhan, S., Gangopadhyay, T.K. and Mandel, U. 2002. How far did India drift in the Late Cretaceous? – *Placenticeras kaffrarium* Etheridge, 1904 (Ammonoidea) used as a measuring tape. *Sedimentary Geology*, **147**, 193–217.

Besairie, H. 1930. Recherches géologique à Madagascar. Thèses présentées à la faculté des Sciences de l'Université de Paris pour obtenir le titre d'Ingénieur-Docteur, 272 p. Toulouse.

Blanford, H.F. 1862. On the Cretaceous and other rocks of the South Arcot and Trichinopoly Districts, Madras. *Memoirs of the Geological Survey of India*, **4**, 1–217.

Boule, M., Lemoine, P. and Thévenin, A. 1906−1907. Paléontologie de Madagascar III Céphalopodes crétaces des environs de Diego-Suarez. *Annales de Paléontologie*, **1**, 173–192 (1–20); **2**, 1–56 (21–76).

Chiplonkar, G.W. and Tapaswi, P.M. 1974. Bivalvia from the Upper Cretaceous of Trichinopoly District, South India – Part 1: Inoceramidae. *Recent Researches in Geology*, **3**, 87–123.

Chiplonkar, G.W. and Tapaswi, P.M. 1975. Biostratigraphy of the inoceramids in the Upper Cretaceous of Trichinopoly District, South India. *Biovigyanam*, **1**, 11–15.

Chiplonkar, G.W. and Tapaswi, P.M. 1979. Biostratigraphy, age and affinities of the bivalve fauna of the Cretaceous of Tiruchirapalli District, South India. *Geological Survey of India, Miscellaneous Publication*, **45**, 137–164.

Collignon, M. 1952. Ammonites néocrétacées du Menabe (Madagascar) II – Les Pachydiscidae. *Travaux du Bureau Geologique du Haut Commissariat de Madagascar et Dependances*, **41**, 1−114.

Collignon, M. 1954. Ammonites néocrétacées du Menabe (Madagascar) III – Les Kossmaticeratidae. *Travaux du Bureau Geologique du Haut Commissariat de Madagascar et Dependances*, **62**, 1−59.

Collignon, M. 1955. Ammonites néocrétacées du Menabe (Madagascar) II – Les Pachydiscidae. *Annales Géologiques du Service des Mines de Madagascar*, **21**, 1−98.

Cooper, R.W., Cooper, D.A., Stevens, J.B, Stevens, M.S., Cobban, W.A. and Walaszczyk, I. 2017. The Boquillas Formation of the Big Bend National Park, Texas, USA, a reference Cenomanian through Santonian (Upper Cretaceous) carbonate succession at the southern end of the Western Interior Seaway. *Acta Geologica Polonica*, **67**, 547–565.

Cox, R.R. 1969. Family Inoceramidae Giebel, 1852. In: Moore, R.C. (Ed.), Treatise on Invertebrate Paleontology, Part N, Vol. 1, Mollusca 6, Bivalvia, pp. 314−321. Geological Society of America, Kansas University Press; Boulder.

Crame, J.A. 1981. Upper Cretaceous inoceramids (Bivalvia) from the James Ross Island Group and their stratigraphical significance. *Bulletin of the British Antarctic Survey*, **53**, 29–56.

Crame, J.A. 1983. Cretaceous inoceramid bivalves from Antarctica. In: Oliver, R.L., James, P.R. and Jago, J.B. (Eds), Antarctic Earth Science. Proceedings of the Fourth International Symposium, held at the University of Adelaide, South Australia, 16 to 20 August 1982, Canberra, pp. 298–302.

Crampton, J.S. 1996. Biometric analysis, systematics and evolution of Albian *Actinoceramus* (Cretaceous Bivalvia, Inoceramidae). *Institute of Geological and Nuclear Sciences Monograph*, **15**, 1−74.

DeKay, J.E. 1828. Report on several fossil multilocular shells from the state of Delaware: with observations on a second specimen of the new fossil genus EURYPTERUS. *Annals of the Lyceum of Natural History*, **2**, 273–278.

Diener, C. 1925. Ammonoidea neocretacea. Fossilium Catalogus (1: Animalia), 29, 244 p. W. Junk; Berlin.

Douvillé, H. 1890. Sur la classification des Cératites de la Craie. *Bulletin de la Société Géologique de France* (3), **18**, 275–292.

Etheridge, R. 1904. Cretaceous fossils of Natal. 1. The Umkwelane Hill Deposit. *Report of the Geological Survey of Natal and Zululand*, **1**, 71–93.

Flegel, K. 1905. Heuscheur und Adersbach-Weckelsdorf. Eine Studie über die obere Kreide im böhmisch-schlesichen Gebirge. *Jahresbericht der Schlesischen Gesellschaft der Vaterland Kultur*, **3**, 123−158.

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* (2), **7**, 97–174.

Gale, A.S., Kennedy, W.J. and Walaszczyk, I. (in press). Upper Albian, Cenomanian and Lower Turonian stratigraphy, ammonite and inoceramid bivalve faunas from the Cauvery Basin, Tamil Nadu, South India. *Acta Geologica Polonica*.

Gangopadhyay, T.K. and Bardhan, S. 2007. Ornamental polymorphism in *Placenticeras kaffrarium* (Ammonoidea:

Upper Cretaceous of India): evolutionary implications. In: Landman, N.H., Davis, R.A. and Mapes, R.H. (Eds), Cephalopods present and past: new insights and fresh perspectives, pp. 97–120. Springer; Dordrecht.

Giebel, C.G. 1852. Allgemeine Palaeontologie: Entwurf einer systematischen Darstellung der Fauna und Flora der Vorwelt, viii + 413 p. Ambrosius Abel; Leipzig.

Gill, T. 1871. Arrangement of the Families of Mollusks. *Smithsonian Miscellaneous Collections*, **227**, xvi + 49 p.

Grossouvre, A. de. 1894. Recherches sur la craie supérieure, 2, Paléontologie. Les ammonites de la craie supérieure. Mémoires du Service de la Carte Géologique détaillée de la France, 264 p. [misdated 1893]. Imprimerie Nationale; Paris.

Grossouvre, A. de. 1901. Recherches sur la craie supérieur, part 1, no. 2, Stratigraphie générale. Mémoires pour servir à l'explication la carte géologique détaillée de la France, pp. 561–1013. Imprimerie Nationale; Paris.

Harries, P.J., Kauffman, E.G. and Crampton, J.S. (Eds.) 1996. Lower Turonian Euramerican Inoceramidae: a morphologic, taxonomic, and biostratigraphic overview. A report from the First Workshop on Early Turonian Inoceramids (Oct. 5–8, 1992) in Hamburg, Germany; organized by Heinz Hilbrecht and Peter Harries. *Mitteilungen aus dem Geologisch-Paläontologischen Institut der Universität Hamburg*, **77**, 641–671.

Heinz, R. 1928. Das Inoceramen-Profil der Oberen Kreide Lüneburgs. Mit Anführungen der neuen Formen und deren Kennzeichnung. Beiträge zur Kenntnis der oberkretazischen Inoceramen I. *Jahresbericht des Niedersächsischen Geologischen Vereins zu Hannover*, **10**, 64−81.

Heinz, R. 1932. Aus der neuen Systematik der Inoceramen. Beiträge zur Kenntnis der oberkretazischen Inoceramen XIV. *Mitteilungen aus dem Mineralogisch-Geologischen Staatsinstitut, Hamburg*, **13**, 1–26.

Heinz, R. 1933. Inoceramen von Madagascar und ihre Bedeutung für die Kreide-Stratigraphie. *Zeitschrift der Deutschen Geologischen Gesellschaft*, **85**, 241–259.

Hyatt, A. 1889. Genesis of the Arietidae. *Smithsonian Contributions to Knowledge*, **673**, xi + 239 p.

Hyatt, A. 1900. Cephalopoda. In: Zittel, K.A. von. 1896−1900, Textbook of Palaeontology, pp. 502–604, transl. Eastman, C.R. Macmillan; London and New York.

Jimbo, K. 1894. Beiträge zur Kenntniss der Fauna der Kreideformation von Hokkaido. *Paläontologisches Abhandlungen, N.S.*, **2**, 147–194.

Kaplan, W. and Kennedy, W.J. 1994. Ammoniten des westfälischen Coniac. *Geologie und Paläontologie in Westfalen*, **31**, 1−155.

Kauffman, E.G. 1973. Cretaceous Bivalvia. In: Hallam, A. (Ed.), Atlas of palaeobiogeography, pp. 353–383. Elsevier Scientific Publishing Company; Amsterdam.

Kauffman, E.G. and Bengtson, P. 1985. Mid-Cretaceous inoceramids from Sergipe, Brazil: a progress report. *Cretaceous Research*, **6**, 311−315.

Kauffman, E.G., Kennedy, W.J. and Wood, C.J. 1996. The Coniacian stage and substage boundaries. *Bulletin de l'Institut Royal des Sciences naturelles de Belgique, Sciences de la Terre*, **66** (Supplement), 81–94.

Kennedy, W.J. 1984. Systematic palaeontology and stratigraphic distribution of the ammonite faunas of the French Coniacian. *Special Papers in Palaeontology*, **31**, vi + 160 p.

Kennedy, W.J. and Gale, A.S. (in press). A Lower Coniacian ammonite fauna from the Cauvery Basin, Tamil Nadu, south India. *Proceedings of the Geologists' Association*.

Kennedy, W.J. and Henderson, R.A. 1991a. Revision of *Ammonites Gaudama* Forbes, 1846 (Cretaceous Ammonoidea). *Journal of Paleontology*, **65**, 891–893.

Kennedy, W.J. and Henderson, R.A. 1991b. A note on *Ammonites Sugata* Forbes, 1846. *Neues Jahrbuch für Geologie und Paläontologie Monatsheft*, **1991**, 470–476.

Kennedy, W.J. and Klinger, H.C. 1985. Cretaceous faunas from Zululand and Natal, South Africa. The ammonite family Kossmaticeratidae Spath, 1922. *Annals of the South African Museum*, **95**, 165–231.

Kennedy, W.J. and Klinger, H.C. 2013. Cretaceous faunas from Zululand and Natal, South Africa. The ammonite Subfamily Desmoceratinae Zittel, 1895. *African Natural History*, **9**, 39–54.

Klein, J. and Vašiček, Z. 2011. Lower Cretaceous Ammonites V Desmoceratoidea. Fossilium Catalogus 1: Animalia, 148, 311 p. Margraf Publishers; Wiekersheim.

Klinger, H.C., Kauffman, E.G. and Kennedy, W.J. 1980. Upper Cretaceous ammonites and inoceramids from the off-shore Alphard Group of South Africa. *Annals of the South African Museum*, **82**, 293–320.

Klinger, H.C. and Kennedy, W.J. 1984. Cretaceous faunas from Zululand and Natal, South Africa. The ammonite subfamily Peroniceratinae Hyatt, 1900. *Annals of the South African Museum*, **92**, 113–294.

Klinger, H.C. and Kennedy, W.J. 1989. Cretaceous faunas from Zululand and Natal, South Africa. The ammonite family Placenticeratidae Hyatt, 1900; with comments on the systematic position of the genus *Hypengonoceras* Spath, 1924. *Annals of the South African Museum*, **98**, 241–408.

Korn, D., Ebbinghausen, V., Bockwinkel, J. and Klug, C. 2003. The A-mode ontogeny in prolecanitid ammonites. *Palaeontology*, **46**, 1123–1132.

Kossmat, F. 1895–1898. Untersuchungen über die Sudindische Kreideformation. *Beiträge zur Paläontologie Österreich-Ungarens und des Orients*, **9** (1895), 97–203 (1–107); **11** (1897), 1–46 (108–153); **11** (1898), 89–152 (154–217).

Kullmann, J. and Wiedmann, J. 1970. Significance of sutures in phylogeny of Ammonoidea. *University of Kansas, Paleontological Contributions*, **42**, 1–32.

Mantell, G.A. 1822. The fossils of the South Downs; or illustrations of the geology of Sussex, xvi + 327 p. Lupton Relfe; London.

Matsumoto, T. 1938. A biostratigraphic study on the Cretaceous deposits of the Naibuti Valley, South Karahuto. *Proceedings of the Imperial Academy of Japan*, **14**, 190–194.

Matsumoto, T. 1942. A note on the Japanese Cretaceous ammonites belonging to the subfamily Desmoceratinae. *Proceedings of the Imperial Academy of Japan*, **18**, 24–29.

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

Meek, F.B. 1876. A report on the invertebrate Cretaceous and Tertiary fossils of the upper Missouri country. In: Hayden, F.V. *Report of the United States Geological Survey of the Territories*, **9**, lxiv + 629 p.

Meek, F.B. 1877. Paleontology. Report of the geological exploration of the 40th parallel. *Professional Paper of the Engineer Department of the United States Army*, **184**, 142–148.

Newell, N.D. 1965. Classification of the Bivalvia. *American Museum Novitates*, **2206**, 1–25.

Paranjape, A.P. 2017. Sequence stratigraphic studies of the Cretaceous succession, Cauvery Basin, Ariyalur area, Tamil Nadu, India. Unpublished Ph.D. Thesis, Savitribai Phule Pune University; Pune.

Phansalkar, V.G. 1976. Palaeontological studies of the Acanthocerataceae from the Upper Cretaceous Rock Formations of Trichinopoly District, South India. Unpublished Ph.D. Thesis, University of Pune; Pune.

Phansalkar, V.G. and Kumar, M.K. 1983. Biostratigraphy of Utatur and Trichinopoly Groups of the Upper Cretaceous of the Trichinopoly District, Tamilnadu. In*:* Phadke, A.V. and Phansalkar, V.G. (Eds), Prof. K.V. Kelkar Memorial Volume, pp. 183–195. Indian Society of Earth Scientists; Pune.

Reyment, R.A. 1954. Some new Upper Cretaceous ammonites from Nigeria. *Colonial Geology and Mineral Resources*, **4**, 248–270.

Reyment, R.A. 1955. The Cretaceous Ammonoidea of Nigeria and the southern Cameroons. *Bulletin of the Geological Survey of Nigeria*, **25**, 112 p.

Roman, F. and Mazeran, P. 1913. Monographie paléontologique de la faune du Turonien du bassin d'Uchaux et de ses dépendances. *Archives du Muséum d'Histoire Naturelle de Lyon*, **12**, 137 p.

Sastry, M.V.A., Rao, B.J.R. and Mamgain, V.D. 1968. Biostratigraphic zonation of the Upper Cretaceous formations of Trichinopoly district, South India. *Memoirs of the Geological Society of India*, **2**, 10–17.

Schlüter, C. 1871–1876. Cephalopoden der oberen deutschen Kreide. *Palaeontographica*, **21**, 1–24 (1871); **21**, 25–120, (1872); **24**, 1–144 (121–264) + x (1876).

Sokolow, D.W. 1914. Kreideinoceramen des russischen Sachalin. *Mémoires du Comité Géologique, Nouvelle Série*, **83**, 95 p. [In Russian with extended German abstract]

Sornay, J. 1957. Inocerames. In: Dartevelle, E. and Freneix, S. Mollusques fossils du Crétacé de la Côte occidentale d'Afrique du Cameroun à l'Angola. II. – Lamellibranches, pp. 56−61. *Annales du Musée Royal du Congo Belge Tervuren (Belgique), Série in-8, Sciences géologiques*, **20**, 271 p.

Sornay, J. 1980. Révision du sous-genre d'Inocérame *Tethyoceramus* Heinz 1932 (Bivalvia) et de ses représentants Coniaciens à Madagascar. *Annales de Paléontologie (Invertébrés)*, **66**, 135–150.

Spath, L.F. 1921. On Cretaceous Cephalopoda from Zululand. *Annals of the South African Museum*, **12**, 217–321.

Spath, L.F. 1922. On the Senonian ammonite fauna of Pondoland. *Transactions of the Royal Society of South Africa*, **10**, 113–147.

Spath, L.F. 1926. On new ammonites from the English Chalk. *Geological Magazine*, **63**, 77–83.

Spath, L.F. 1939. Problems of ammonite nomenclature 6. The genus *Pachydiscus* Zittel. *Geological Magazine*, **74**, 293–296.

Stoliczka, F. 1863–1866. The fossil cephalopoda of the Cretaceous rocks of Southern India. Ammonitidae with revision of the Nautilidae etc. *Memoirs of the Geological Survey of India*. *Palaeontologica Indica*, **3** (1), 41–56 (1863); (2–5), 57–106 (1864); (6–9), 107–154 (1865); (10–13), 155–216 (1866).

Stoliczka, F. 1870–1871. Cretaceous faunas of Southern India. 3. The Pelecypoda with a review of all known genera of this class, fossil and recent, by Ferd. Stoliczka, Ph. D., F. G. S., & c. *Memoirs of the Geological Survey of India*, *Palaeontologica Indica*, **6**, 1–222 (1870); i–xxii, 223–538 (1871).

Walaszczyk, I. 1992. Turonian through Santonian deposits of the Central Polish Uplands; their facies development, inoceramid paleontology and stratigraphy. *Acta Geologica Polonica*, **42**, 1–122.

Walaszczyk, I. 1997. Significance of the ligament area in species level taxonomy of inoceramid bivalves; how much variation is lodged in a single species? *Freiberger Forschungsheft*, C **468**, 289–303.

Walaszczyk, I. and Cobban, W.A. 2000. Inoceramid faunas and biostratigraphy of the Upper Turonian−Lower Coniacian of the Western Interior of the United States. *Special Papers in Palaeontology*, **64**, 1–118.

Walaszczyk, I., Kennedy, W.J., Dembicz, K., Gale, A.S., Praszkier, T., Rasoamiaramanana, A.H. and Randrianaly, H. 2014. Ammonite and inoceramid biostratigraphy and biogeography of the Cenomanian through basal Middle Campanian (Upper Cretaceous) of the Morondava Basin, western Madagascar. *Journal of African Earth Sciences*, **89**, 79–132.

Walaszczyk, I., Marcinowski, R., Praszkier, T., Dembicz, K. and Bieńkowska, M. 2004. Biogeographical and stratigraphical significance of the latest Turonian and early Coniacian inoceramid/ammonite succession of the Manasoa section on the Onilahy River, south-west Madagascar. *Cretaceous Research*, **25**, 543–576.

Walaszczyk, I. and Wood, C.J. 1999. Inoceramids and biostratigraphy at the Turonian/Coniacian boundary; based on the Salzgitter-Salder Quarry, Lower Saxony, Germany, and the Słupia Nadbrzeżna section, central Poland. *Acta Geologica Polonica*, **48** (for 1998), 395−434.

Walaszczyk, I., Wood, C.J., Lees, J.A., Peryt, A., Voigt, S. and Wiese, F. 2010. The Salzgitter-Salder Quarry (Lower Saxony, Germany) and Słupia Nadbrzeżna river cliff section (central Poland): a proposed candidate composite Global Boundary Stratotype Section and Point for the base of the Coniacian Stage (Upper Cretaceous). *Acta Geologica Polonica*, **60**, 445–477.

Wiedmann, J. 1962. Ammoniten aus der Vascogotischen Kreide (Nordspanien). 1, Phylloceratina, Lytoceratina. *Palaeontographica*, **118A**, 119–237.

Wiedmann, J. 1966. Stammesgeschichte und System der posttriadischen Ammonoideen; ein Überblick. *Neues Jahrbuch für Geologie und Paläontologie Abhandlungen*, **125**, 49–79; **127**, 13–81.

Woods, H. 1912. A monograph of the Cretaceous lamellibranchia of England. *Palaeontographical Society, Monograph*, **2**, 262−340.

Wright, C.W. 1996. Treatise on Invertebrate Paleontology. Part L, Mollusca 4: Cretaceous Ammonoidea (with contributions by J.H. Calloman (sic) and M.K. Howarth), xx + 362 p. Geological Society of America and University of Kansas; Boulder, Colorado and Lawrence, Kansas.

Wright, C.W. and Matsumoto, T. 1954. Some doubtful Cretaceous ammonite genera from Japan and Saghalien. *Memoirs of the Faculty of Science, Kyushu University, Series D, Geology*, **4**, 107–134.

Zittel, K.A. von. 1884. Handbuch der Palaeontologie. 1, Abt. 2; Lief 3, Cephalopoda, pp. 329–522. R. Oldenbourg; Munich and Leipzig.

Zittel, K.A. von. 1895. Grundzüge der Palaeontologie (Palaeozoologie), vii + 972 p. R. Oldenbourg; Munich and Leipzig.

Manuscript submitted: 12th November 2018
Revised version accepted: 10th December 2018