HETEROMORPH AMMONITES FROM THE UPPER MAASTRICHTIAN OF PONDICHERRY, SOUTH INDIA

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ABSTRACT. The heteromorph ammonites (Ancyloceratina) from the Upper Maastrichtian Valudavur Formation (Valudayur Group, *Anisoceras* beds of authors) of Pondicherry, south India are revised in a sequel to the previously published account of the normally coiled Phylloceratina, Lytoceratina and Ammonitina. Twelve species referred to eight genera are recognized, of which *Cyrtoptychoceras* is a new representative of the Polyptychoceratinae. The fauna is of great importance in the development of heteromorph ammonite taxonomy, although a source of great confusion to previous workers. It represents the most diverse Upper Maastrichtian heteromorph assemblage known.

WE recently described (Kennedy and Henderson, 1992) the normally coiled ammonites from the Upper Maastrichtian Valudavur Formation (Valudayur Group, *Anisoceras* beds of authors) of Pondicherry, south India, based on the Kaye and Cunliffe and other collections in The Natural History Museum, London, notably those described by Forbes (1846). In that work we discussed the history of research of these faunas, their stratigraphic context, and age. In this sequel, we describe the heteromorph Ancyloceratina. Fragments, notably of *Glyptoxoceras*, were sufficiently common that some early workers referred to what Rajagopalan (1965) termed the Valudavur Formation as the *Anisoceras* Beds (e.g. Kossmat 1895–8). Specimens of *Glyptoxoceras* (*Hamites* and *Anisoceras* of nineteenth century workers) from this unit have been a source of confusion since their initial description by Forbes (1846), who referred fragments of the same specimen to different species, as demonstrated by Phillips (1977). D'Orbigny (1847*a*, 1847*b*) gave names to a series of fragments from Pondicherry collected by members of the crew of the *Bonite* from near Valadour in 1837 (Chevalier 1844), and his work was presumably in press when Forbes's work appeared; he subsequently placed several of his Pondicherry species in synonymy with those of Forbes in the *Prodrome* (d'Orbigny 1850). Stoliczka (1866) referred specimens from Pondicherry and other localities at different stratigraphic levels to Forbes's species. Kossmat (1895) clarified certain relationships, but nevertheless increased confusion by referring what have subsequently been shown to be individuals of the same species to different taxa. Shimizu (1935) examined Forbes's types, and introduced a number of new taxa as well as a measure of confusion as to the nature of the types, considering some of Forbes's specimens to be holotypes rather than syntypes. It is to Matsumoto (1959*a*) that we owe clarification of this taxonomic confusion, and to Phillips (1977) for carefully listing all type and figured specimens. It remains, however, that some specimens have been referred to up to three different species by successive authors, while we ourselves differ from the work of Kossmat in recognizing *Diplomoceras cylindraceum* (Defrance, 1816) among specimens he referred to *Hamites* (*Anisoceras*) *rugatus* (Forbes, 1846).

Specimens described by Forbes (1846) were collected by C. T. Kaye and C. E. Cunliffe (see Kaye 1840), two amateur geologists on the staff of the Madras Civil Service. Their specimens were donated to the Geological Society of London, and are listed by Blake (1902), having catalogue numbers with the prefix R. They were transferred to the British Museum (Natural History) (now The Natural History Museum, London) in 1911. When first examined by one of us (W.J.K.) many of the figured specimens bore small green labels (and many still do), making them easily

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recognizable. Many specimens were glued to labelled boards, and it is these specimens identified with Forbes's, d'Orbigny's or Kossmat's names that are here regarded as the type series of Forbes's species. In the case of the *Glyptoxoceras*, the type series, so interpreted, generally consist of several species. In some cases specimens have become separated from boards (from which they were ultimately removed and recatalogued in the 1970s), and some bear notes in L. F. Spath's hand indicating them to be 'types', a view we have accepted. There remain, however, specimens from the Kaye and Cunliffe Collection that cannot be conclusively shown to be types; we refer to these as possible types in the following account.

We set out below our conclusions as to the identity of the species named by Forbes (1846) and d'Orbigny (1847*a*), authors of the first accounts of the Pondicherry fauna. Their subsequent history and usage is detailed in the taxonomic part of the work.

Forbes (1846); type species are indicated thus (*):
Ammonites Cunliffei Forbes, 1846 (p. 109, pl. 8, fig. 2) = *Indoscaphites cunliffei* (Forbes, 1846)*.
Ammonites Pavana Forbes, 1846 (p. 110, pl. 7, fig. 5) = *Indoscaphites pavana* (Forbes, 1846).
Ammonites? indicus Forbes, 1846 (p. 114, pl. 8, fig. 9) = *Hoploscaphites indicus* (Forbes, 1846).
Baculites vagina Forbes, 1846 (p. 114, pl. 10, fig. 4) = *Eubaculites vagina* (Forbes, 1846).
Baculites teres Forbes, 1846 (p. 115, pl. 10, fig. 5) = *Fresvillia teres* (Forbes, 1846).
Hamites subcompressus Forbes, 1846 (p. 116, pl. 11, fig. 6) = *Glyptoxoceras rugatum* (Forbes, 1846).
Hamites tenuisulcatus Forbes, 1846 (p. 116, pl. 10, fig. 8; pl. 11, fig. 3) = *Glyptoxoceras tenuisulcatum* (Forbes, 1846).
Hamites indicus Forbes, 1846 (p. 116 (*pars*), *non* pl. 11, fig. 4) = *Glyptoxoceras indicum* (Forbes, 1846).
Hamites large-sulcatus Forbes, 1846 (p. 117, pl. 11, fig. 1) = *Glyptoxoceras largesulcatum* (Forbes, 1846).
Hamites rugatus Forbes, 1846 (p. 117, pl. 11, fig. 2) = *Glyptoxoceras rugatum* (Forbes, 1846)*.
Hamites nereis Forbes, 1846 (p. 117, pl. 10, fig. 7) = *Glyptoxoceras rugatum* (Forbes, 1846).
Hamites undulatus Forbes, 1846 (p. 118, pl. 10, fig. 6) = *Cyrtoptychoceras undulatus* (Forbes, 1846)*.
Ptychoceras sipho Forbes, 1846 (p. 118, pl. 11, fig. 5) = *Phylloptychoceras sipho* (Forbes, 1846)*.

D'Orbigny (1847*a*):
Baculites ornatus d'Orbigny, 1847*a* (pl. 3, figs 3–6) = *Eubaculites vagina* (Forbes, 1846).
Hamites constrictus d'Orbigny, 1847*a* (pl. 3, figs 7–8) = *Phylloptychoceras sipho* (Forbes, 1846).
Hamites acuticostatus d'Orbigny, 1847*a* (pl. 3, figs 9–10) = *Glyptoxoceras largesulcatum* (Forbes, 1846).
Hamites acuticostatus d'Orbigny, 1847*a* (pl. 3, figs 11–12) = *Glyptoxoceras rugatum* (Forbes, 1846).
Hamites indicus d'Orbigny 1847*a* (pl. 3, figs 13–14) = *Diplomoceras cylindraceum* (Defrance, 1816)?
Hamites simplex d'Orbigny, 1850 (= d'Orbigny, 1847*a*, pl. 3, figs 15–17) = *Glyptoxoceras rugatum* (Forbes, 1846).

To the ten species of Forbes accepted as valid here, we add *Diplomoceras cylindraceum* (Defrance, 1816), recognized among the syntypes of *Hamites rugatus* (Forbes, 1846).

This fauna, with twelve species and eight genera, is the most diverse Upper Maastrichtian heteromorph assemblage known.

CONVENTIONS

Repositories of specimens. These are indicated by the following abbreviations:
BMNH: The Natural History Museum, London.
GSC: Prefixes catalogue numbers of the Geological Society of London Collections, transferred to The Natural History Museum (then the British Museum (Natural History)) in 1911.
MNHP: Muséum National d'Histoire Naturelle, Paris.

Dimensions are given in millimetres. The term rib index applies to the number of ribs in a distance equal to the whorl height at the mid point of the interval counted.

Suture terminology. The system of Wedekind (1916), as reviewed by Kullmann and Wiedmann (1970) is used; E, external lobe; L, lateral lobe; U, umbilical lobe; I, internal lobe.

SYSTEMATIC PALAEONTOLOGY

Suborder ANCYLOCERATINA Wiedmann, 1966, p. 54
Superfamily TURRILITACEAE Gill, 1871, p. 3
Family DIPLOMOCERATIDAE Spath, 1926, p. 81
[= Neocrioceratinae Spath, 1953, p. 17]
Subfamily DIPLOMOCERATINAE Spath, 1926, p. 81
[= Scalaritinae Ward, 1976, p. 455]
Genus GLYPTOXOCERAS Spath, 1925, p. 30
[= *Neohamites* Brunnschweiler, 1966, p. 48]

Type species. Hamites rugatus Forbes, 1846, p. 116, pl. 11, fig. 6, by original designation (Spath 1925, p. 30, as *Hamites* (*Anisoceras*) *rugatus* (Forbes) Kossmat).

Glyptoxoceras rugatum (Forbes, 1846)

Plate 1, figs 1–2, 5–16; Plate 2, figs 10–11, 14–29; Plate 3, figs 1–3; Plate 4, figs 2, 12–15; Text-fig. 1A, E.

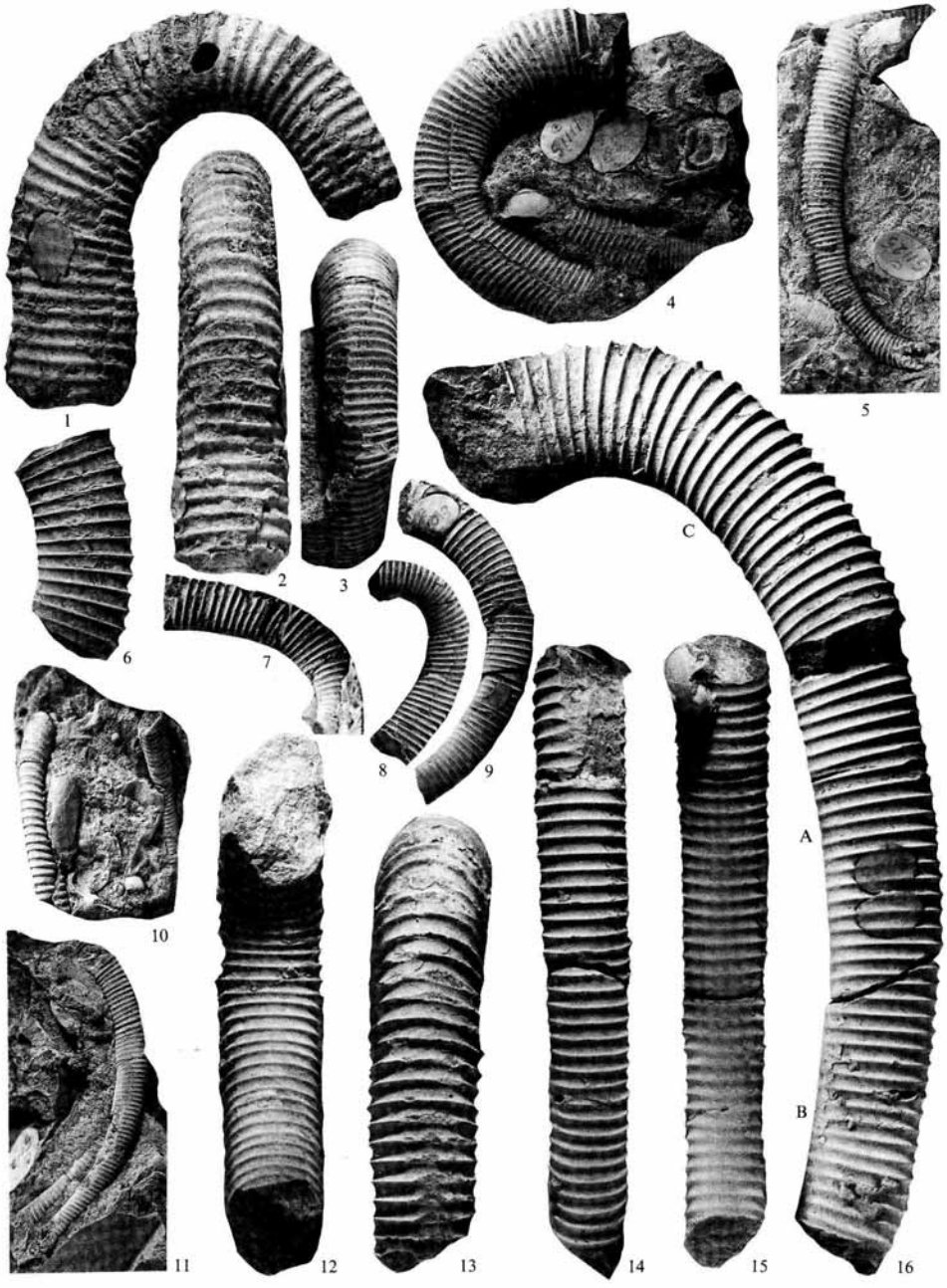
1846 *Hamites subcompressus* Forbes, p. 116, pl. 11, fig. 6.
1846 *Hamites rugatus* Forbes, p. 117, pl. 11, fig. 2.
1846 *Hamites nereis* Forbes, p. 117, pl. 10, fig. 7.
1847*a* *Hamites acuticostatus* d'Orbigny, pl. 3, figs 11–12 only.
1847*a* *Hamites simplex* d'Orbigny, pl. 3, figs 15–17 (*non* d'Orbigny, 1842).
1850 *Hamites subcompressus* Forbes; d'Orbigny, p. 216.
1850 *Hamites rugatus* Forbes; d'Orbigny, p. 216.
1850 *Hamites nereis* Forbes; d'Orbigny p. 216.
1861 *Hamites rotundus* Sowerby?; Binkhorst, p. 34, pl. 5*b*, figs 2–4; pl. 5*c*, fig. 1.
1866 *Anisoceras rugatum* Forbes; Stoliczka, p. 178, pl. 85, figs 10–13.
1866 *Anisoceras subcompressum* Forbes; Stoliczka, p. 179, pl. 85, fig. 7.
1866 *Anisoceras indicum* Forbes; Stoliczka, p. 181 (*pars*), pl. 85, figs 3–5 only.
?1866 *Anisoceras nereis* Forbes; Stoliczka, p. 182, pl. 85, figs 17–18.
?1866 *Anisoceras* sp? Stoliczka, p. 179, pl. 85, fig. 19.
non 1871 *Anisoceras rugatum* Forbes; Griesbach, p. 63, pl. 3, fig. 4.
1890 *Hamites recticostatus* Seunes, p. 239, pl. 9, fig. 6.
1895 *Hamites* (*Anisoceras*) *subcompressus* Forbes; Kossmat, p. 145 (49), pl. 19 (5), figs 10–12.
1895 *Hamites* (*Anisoceras*) *rugatus* Forbes; Kossmat, p. 146 (*pars*), *non* pl. 19 (5), figs 7–9 (= *G. indicum*, *D. cylindraceum*).
?1895 *Hamites* (*Anisoceras*) sp.; Kossmat, p. 148 (52).
1895 *Hamites* (*Anisoceras*) *nereis* Forbes; Kossmat, p. 148 (52).
non 1903 *Anisoceras subcompressum* Forbes; Whiteaves, p. 338, pl. 45, fig. 1.
non 1906 *Hamites* (*Anisoceras*) *subcompressus* Forbes; Woods, p. 339, pl. 43, fig. 2.
?1925 *Glyptoxoceras* cf. *rugatum* (Forbes); Spath, p. 30, pl. 1, fig. 4.
?1930 *Diplomoceras* (*Hamites*) sp. Wetzel, p. 90.
1930 *Glyptoxoceras braziliense* Maury, p. 184, pl. 11, fig. 6.
1935 *Glyptoxoceras rugatum* (Forbes); Shimizu, p. 273, text-figs 1–9.
1935 *Glyptoxoceras circulare* Shimizu, p. 272, text-figs 10–11.
1935 *Glyptoxoceras subcompressum* (Forbes); Shimizu, p. 272, text-fig. 12.
1935 *Glyptoxoceras indicum* var. *intermedium* Shimizu, p. 272.
1940 *Glyptoxoceras* cf. *rugatum* (Forbes); Spath, p. 47, pl. 1, fig. 1.
non 1952 *Diplomoceras*? *subcompressum* (Forbes), 1845; Usher, p. 110, pl. 29, fig. 3.
1959*a* *Glyptoxoceras rugatum* (Forbes); Matsumoto, p. 169.
1959*a* *Glyptoxoceras subcompressum* (Forbes); Matsumoto, p. 169.
1962 *Diplomoceras* (*Glyptoxoceras*) cf. *subcompressum* (Forbes); Wiedmann, p. 208, pl. 12, figs 1–2.
1966 *Glyptoxoceras indicum* (Forbes, 1846); Brunnschweiler, p. 44, pl. 6, figs 1–3; text-fig. 28.
1966 *Glyptoxoceras circulare* Shimizu, 1935; Brunnschweiler, p. 46, pl. 6, figs 4–6; text-fig. 29.

1966 *Glyptoxoceras nipponicum* Shimizu, 1935; Brunnschweiler, p. 46, pl. 6, figs 7–9; text-fig. 30.
1966 *Glyptoxoceras bullarense* Brunnschweiler, p. 47, pl. 6, fig. 10; text-fig 31.
1966 *Neohamites giraliensis* Brunnschweiler, p. 48, pl. 7, figs 1–2; text-fig. 32.
1966 *Neohamites rugatus* (Forbes, 1846); Brunnschweiler, p. 49, pl. 7, figs 4–6; text-fig. 33.
1966 *Neohamites cardabiensis* Brunnschweiler, p. 51, pl. 7, figs 7–9; text-fig. 35.
1966 *Neohamites largesulcatus* (Forbes, 1846); Brunnschweiler, p. 51, pl. 1, fig. 8; pl. 8, figs 3–6; text-fig. 36.
1966 *Neohamites soufoulisi* Brunnschweiler, p. 53, pl. 8, fig. 2; text-fig. 37.
non 1966 *Diplomoceras* aff. *subcompressum* Forbes; Collignon, p. 6, pl. 457, fig. 1861.
non 1969 *Glyptoxoceras subcompressum* Forbes subsp. *coarctum* Collignon, p. 41, pl. 529, figs 2084–2085.
non 1976 *Glyptoxoceras subcompressum* (Forbes); Ward, p. 456, pl. 1, figs 1–5; text-fig. 3.
non 1976 *Glyptoxoceras subcompressum* (Forbes): Ward and Westermann, p. 357, text-figs 1–3.
non 1976 *Diplomoceras* (*Glyptoxoceras*) *subcompressum* (Forbes, 1845); Klinger, p. 80, pl. 34, fig. 6.
1977 *Neohamites subcompressus* Kennedy, text-fig. 31, 6.
non 1982 *Diplomoceras* (*Glyptoxoceras*) *subcompressum* (Forbes, 1846); Immel *et al.*, p. 26, pl. 9, figs 4–5; pl. 10, fig. 7; pl. 11, fig. 4.
1986*a* *Glyptoxoceras* cf. *subcompressum* (Forbes, 1846); Kennedy, text-fig. 9*f–g*.
1986*a* *Glyptoxoceras* cf. *circulare Shimizu*, 1935; Kennedy, text-fig. 9*i–j*.
1987 *Glyptoxoceras* cf. *circulare* Shimizu, 1935; Kennedy, p. 180, pl. 4, figs 1–3; pl. 26, figs 7, 10–12, 15.
1987 *Glyptoxoceras* cf. *subcompressum* (Forbes, 1846); Kennedy, p. 179, pl. 26, figs 1–6, 8–9, 13–14, 19–21.

Types. Lectotype, here designated, is BMNH C51110, the original of Forbes 1846 (pl. 11, fig. 2), GSC R10499. The lectotype, here designated, of *Hamites subcompressus* Forbes, 1846, is shown in Plate 1, figures 12–16. It is broken into three parts (Pl. 1, fig. 16). The middle fragment (A), as noted by Phillips (1977, p. 125), GSC R10491, is the original of Kossmat (1895, pl. 19(5), fig. 10), and possibly the original of Forbes (1846, pl. 11, fig. 6). The adapical fragment (B) corresponds with Forbes's plate 11, figure 4*a*, *c*, the figured syntype of *Hamites indicus*. Fragment C was never figured. The lectotype, here designated, of *Hamites nereis* Forbes, 1846, plate 10, figure 7, is BMNH C51109, GSC R10502. In each case lectotypes are designated because Forbes cited the 'dimension of largest specimen', indicating that he possessed more than one of each species. The holotype of *Glyptoxoceras circulare* Shimizu, 1935 (text-figs 10–11) is BMNH C51112. Possible paralectotypes of *Hamites subcompressus* are BMNH C51112, the original of Kossmat (1895, pl. 19(5), fig. 4*c* = GSC R10497; Pl. 2, fig. 16), and BMNH C51103, the original of Kossmat (1895, pl. 19(5), fig. 11; Pl. 1, fig. 9, herein). Topotypes BMNH C51125 (Pl. 1, fig. 5), C51131 and C51139 are possible syntypes of *Hamites indicus* that belong to the present species, as are BMNH C51120–51122 (Pl. 1, figs 10–11; Pl. 4, fig. 2), syntypes of *Hamites undulatus* Forbes, 1846; and BMNH C51098–51099, which are syntypes of *Hamites largesulcatus* Forbes, 1846 (Pl. 3, figs 1–3; Pl. 4, figs 13–15) (all *ex* Kaye and Cunliffe Collection). Other topotypes are BMNH C4049 (5 fragments, no history), C4050 (12 fragments, no history); C4109 (history uncertain, the original of Shimizu 1935, figs 6–9), C5114–5116 (no history), BMNH C24201 (4 fragments, *ex* Kaye Collection), C51126–51129 (*ex* Geological Society Collection), and C2402 (*ex* Kaye Collection). All are from the Valudavur Formation of Pondicherry, south India.

EXPLANATION OF PLATE 1

Figs 1–2, 5–16. *Glyptoxoceras rugatum* (Forbes, 1846). 1–2, BMNH C51110, GSC R10499, the lectotype, the original of Forbes (1846, pl. 11, fig. 2). 5, BMNH C51125, a possible syntype of *G. indicum*. 6, BMNH 24202. 7, BMNH C5116. 8, BMNH C51139, a possible syntype of *G. indicum*. 9, BMNH C51103, a syntype of *Glyptoxoceras subcompressum* figured by Kossmat (1895, pl. 19 (5), fig. 11*a–b*). 10, BMNH C51120, a syntype of *C. undulatum*. 11, BMNH C51122, a syntype of *C. undulatum*. 12–16, BMNH C51100, a specimen broken into 3 fragments, of which A is GSC R10491, the original of Kossmat (1895, pl. 19 (5), fig. 10), and possibly Forbes (1846, pl. 11, fig. 6), and thus a possible syntype of *G. subcompressum*; B is probably the original of Forbes (1846, pl. 11, fig. 4), and a syntype of *G. indicum*; C was never figured by Forbes.
Figs 3–4. *Glyptoxoceras indicum* (Forbes, 1846), BMNH C51111, GSC R10500, a syntype of *G. rugatum*, the original of Kossmat (1895, pl. 19 (5), fig. 7*a–b*).
All from Pondicherry, south India. Figs 1–9, 12–16, ×1; figs 10–11, ×1·3.



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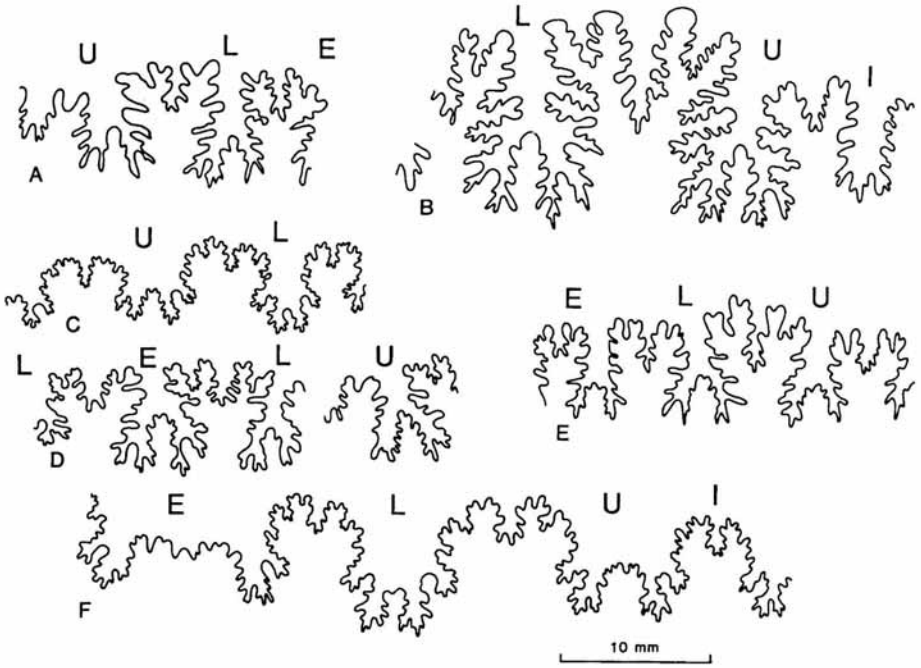

TEXT-FIG. 1. Suture lines. A, E, *Glyptoxoceras rugatum* (Forbes, 1846), BMNH C51110 and C51112 respectively. B, *Diplomoceras cylindraceum* (Defrance, 1816), BMNH C51102. C, F, *Eubaculites vagina* (Forbes, 1846), BMNH C2597 and C51148 respectively. D, *Glyptoxoceras largesulcatum* (Forbes, 1846), BMNH C4051.

Description. The early growth stages are shown by a series of evenly ribbed and occasionally constricted fragments down to whorl heights of as little as 3 mm. They vary from compressed to subcircular in cross section and are slightly curved, defining obtuse or acute angles, or straight. The same shapes characterize the largest fragments, indicating a planispiral shell, polygonal in outline, and made up of straight shafts connected by obtuse or acute angles. The lectotype of *Hamites rugatus* (Forbes 1846, pl. 11, fig. 2) is a wholly septate fragment consisting of two diverging shafts linked by a curved sector (Pl. 1, figs 1–2). It has a maximum preserved whorl height of 19·8 mm, and a whorl breadth to height ratio of 0·87; the rib index is 8, the ribs blunt, somewhat weakened on the dorsum but strengthening progressively across the flanks, and strong and transverse on the venter. They are prorsiradiate at the smallest and largest diameters preserved, but markedly rursiradiate on the curved sector. The lectotype of *Hamites subcompressus* Forbes, 1846 (Pl. 1, figs 13–16) is a curved body chamber, 150 mm long. The whorl section is compressed oval, with flattened subparallel flanks and a broadly rounded dorsum and venter. The costal whorl breadth to height ratio is 0·73, and the rib index varies between 7 and 8. The ribs are relatively weak and transverse on the dorsum, but strengthen across the flanks, where they are feebly prorsiradiate, and on the venter, where they are transverse. The ribs are distinctly narrower than the interspaces, but show some variation, being blunter on the internal mould than where shell is preserved. The holotype of *Glyptoxoceras circulare* Shimizu, 1935 (Text-figs 10–11; Pl. 4, fig. 12) is a broken, straight shaft 95 mm long, with a circular cross section, embedded in matrix. The style of ribbing is, so far as visible, like that of the lectotype of *subcompressus*, with a rib index of six. Suture (Text-fig. 1A, E) with moderately incised, bifid lobes and saddles.

Discussion. We regard *Hamites rugatus*, *H. nereis* and *H. subcompressus* of Forbes (1846) as synonyms, and as first revising authors select the name *rugatus* for the species. Also regarded as

conspecific is *G. circulare*, and some of the syntypes of *Hamites indicus* of Forbes. The characteristic features of the species are the polygonal coiling, relatively large size, and rib density. When compared with other species in the Pondicherry fauna, *Glyptoxoceras tenuisulcatum* (Forbes, 1846) has an initial helix, and much finer ribbing that is oblique on the venter of the shaft, rather than being transverse (Pl. 2, figs 2, 6, 8, 30). *Glyptoxoceras largesulcatum* (Forbes, 1846) (Pl. 3, figs 4–9; Pl. 4, figs 16–18) has very distant, annular ribs, and is only known as straight shafts. *G. indicum* (Forbes, 1846) (Pl. 1, figs 3–4; Pl. 2, figs 1, 3–5, 7, 9, 12–13) has a quite different coiling, with an initial helix, and oval planispiral later whorls, being adult at a much smaller size (Pl. 1, figs 3–4). When these species are removed from the Pondicherry fauna, the numerous remaining fragments form a species that is variable in whorl section and ribbing density, but of similar coiling and ribbing style. *Hamites nereis* (Forbes, 1846) (Pl. 2, figs 10–11), referred to *Pseudoxybeloceras* by some authors, is a pathological *rugatum* in which ventral ribbing is interrupted, as a result of non-lethal injury to the mantle margin (Pl. 2, fig. 10).

Of species from Pondicherry illustrated by d'Orbigny (1847*a*), one of the specimens of *Hamites acuticostatus* (pl. 3, figs 11–12) may belong here; it is shown as being 40 mm long, with a compressed whorl section, and rib index of 4. The second specimen illustrated by d'Orbigny (pl. 3, figs 9–10) seems to be a *G. largesulcatum*. The *Hamites simplex* of d'Orbigny from Pondicherry (pl. 3, figs 15–16) is a curved fragment 30 mm long, and is clearly *G. rugatum*.

We refer a number of non-Indian records to *G. rugatum* on the basis of coiling style, ribbing and age (see synonymy), but reject small fragments that are significantly older where the coiling style is unclear, believing them to be unidentifiable as to genus in some cases. Thus fragments from the Upper Maastrichtian of the Maastricht area, described as *Hamites rotundus* by Binkhorst (1861) are referred to *G. rugatum* (see also Kennedy 1987), as is *G. recticostatus* (Seunes, 1890) from the Upper Maastrichtian of southeastern France, and *G. braziliense* (Maury, 1930), from Brazil. Study of more than 100 *Glyptoxoceras* from the Upper Maastrichtian Miria Formation of western Australia (to be described elsewhere), has convinced us that *G. indicum*, *G. circulare*, *G. nipponicum*, and *G. bullarense*, *Neohamites giralensis*, *N. rugatus*, *N. cardabiensis*, *N. largesulcatus*, and *N. soufoulisi* of Brunnschweiler (1966) represent but a single form, conspecific with *Glyptoxoceras rugatum*.

The *Glyptoxoceras subcompressum* of Ward (1976, p. 456, pl. 1, figs 1–5; text-fig. 3) and Ward and Westermann (1976, text-figs 1–3) has a quite different, ellipsoidal coiling when compared to the Pondicherry material, with an initial helix with its axis of coiling at 90° to that of the planispiral whorls; it is of late Santonian or early Campanian age.

Occurrence. Maastrichtian of south India, Brazil, Chile (?), Western Australia, northern Spain, south-east France, and the Maastricht area in the Netherlands and Belgium.

Glyptoxoceras indicum (Forbes, 1846)

Plate 1, figs 3–4; Plate 2, figs 1, 3–5, 7, 9, 12–13

	1846	*Hamites indicus* Forbes, p. 116 (*pars*), non pl. 11, fig. 4 (= *G. rugatum* (Forbes, 1846)).
non	1847*a*	*Hamites indicus* Forbes; d'Orbigny, pl. 3, figs 13–14 (? = *Diplomoceras cylindraceum* (Defrance, 1816)).
	1850	*Hamites indicus* Forbes; d'Orbigny, p. 215.
	1866	*Anisoceras indicum* Forbes sp.; Stoliczka, p. 181 (*pars*), *non* pl. 85, figs 1–5.
	1866	*Anisoceras tenuisulcatum* Forbes; Stoliczka, p. 177 (*pars*), pl. 85, fig. 14 only.
	1895	*Hamites* (*Anisoceras*) *indicus* Forbes; Kossmat, p. 145 (49) (*pars*), p. 19 (5), fig. 4*a–c*.
	1895	*Hamites* (*Anisoceras*) *rugatus* Forbes; Kossmat, p. 146 (*pars*), pl. 19(5), fig. 7 only.
non	1906	*Hamites* (*Anisoceras*) *indicus* Forbes; Woods, p. 340, pl. 44, fig. 2.
non	1921	*Diplomoceras*? *indicum* Forbes sp.; Spath, p. 256, p. 23, fig. 5.
	1935	*Glyptoxoceras indicus* (Forbes); Shimizu, p. 272.
	1954	*Glyptoxoceras*; Wright and Matsumoto, text-fig. 5.
	1959*a*	*Glyptoxoceras indicum* (Forbes, 1846); Matsumoto, p. 167, pl. 41, figs 2–6; text-fig. 80.

non 1966 *Glyptoxoceras indicum* (Forbes, 1846); Brunnschweiler, p. 44, pl. 6, figs 1–3; text-fig. 28 (= *G. rugatum*).
non 1969 *Diplomoceras indicum* Forbes *octosulcatum* subsp. nov; Collignon, p. 45, pl. 530, fig. 2090.
non 1976 *Diplomoceras* (*Glyptoxoceras*) *indicum* (Forbes), 1845; Klinger, p. 79, pl. 34, figs 3, 5 .
1977 *Glyptoxoceras indicum*; Kennedy, text-fig. 31. 11–12.
non 1982 *Diplomoceras* (*Glyptoxoceras*) *indicum* (Forbes, 1846); Immel *et al.*, p. 26, pl. 10, figs 5–6.

Types. The lectotype, by the subsequent designation of Matsumoto (1959*a*, p. 167), is BMNH C51113, the original of Kossmat (1895, pl. 19 (5), fig. 4), GSC R10496. Paralectotypes include a part of the lectotype of *G. rugatum*, BMNH C51100, the original of Forbes (1846, pl. 11, fig. 4*a*, *c*); BMNH C51111, the original of Kossmat (1895, pl. 19 (5), fig. 7*a–b*), GSC R10500, referred by Kossmat to *G. rugatum*. Possible paralectotypes are BMNH C51130, C51132–51134, C51136, C51138 that belong to the present species; other possible paralectotypes are referred to *G. rugatum* and *G. largesulcatum* under these species; all from the Valudavur Formation of Pondicherry, south India. Topotypes are BMNH C4050 (2 fragments), C51117, and C82502–82503 (*ex* Marsham Collection).

Description. The early whorls (Pl. 2, figs 1, 4–5, 7, 9) are in the form of a very low helix, with a total diameter to the spire of 22 mm, the translation rate being very low. The whorl section is circular at this stage, with coarse, blunt ribs, separated by somewhat wider interspaces, and a rib index of 6–7. Ribs are weakest on the inner whorl face, feebly rursiradiate, strengthening and strongly rursiradiate on the upper whorl face, strongest and markedly prorsiradiate on the outer whorl face and weakened and feebly convex on the lower. The lectotype (Pl. 2, figs 3, 12–13) is 35 mm long, entirely body chamber, consisting of the external mould of a smaller, straight shaft, connected by a strongly curved portion to a longer, straight shaft. The maximum preserved whorl height is 7 mm, the whorl section circular, the rib index 7. Ribs are strong, sharp and narrower than the interspaces. They are feebly prorsiradiate on the flanks of the shaft, and pass straight across the venter, but change to markedly rursiradiate on the hook. BMNH C51111 (Pl. 1, figs 3–4) is more complete, consisting of the displaced fragments of straight shaft, a curved sector and a second, shorter, straight shaft, the whole forming an asymmetric U. The specimen is partly crushed, but where well preserved, has a maximum whorl height of 12 mm, and a whorl breadth to height ratio of 0·96. The ribbing style is comparable to that of the lectotype; feebly prorsiradiate on the smaller shaft, becoming markedly rursiradiate on the hook and large shaft, but the rib index, 9, is slightly higher on the final shaft. There is a prominent constriction and terminal collar at the aperture, suggesting the specimen to be adult.

Discussion. Forbes (1846, pl. 11, fig. 4*a–c*) figured only a fragment of what has been subsequently designated the lectotype of *G. rugatum* to illustrate the species *indicus*. Stoliczka (1866, pl. 85, figs 1–5) used the name, but none of his figured specimens belong to the species as defined here. Kossmat (1895) pointed out that the specimen figured by Forbes as *indicum* was identical to Forbes's *Hamites subcompressus* (they were shown by Phillips (1977, p. 124) to be based on bits of the same specimen), and figured a syntype of Forbes's *indicus* (1895, pl. 19 (5), fig. 4*a–b*; pl. 2, figs 3, 12–13) as well as

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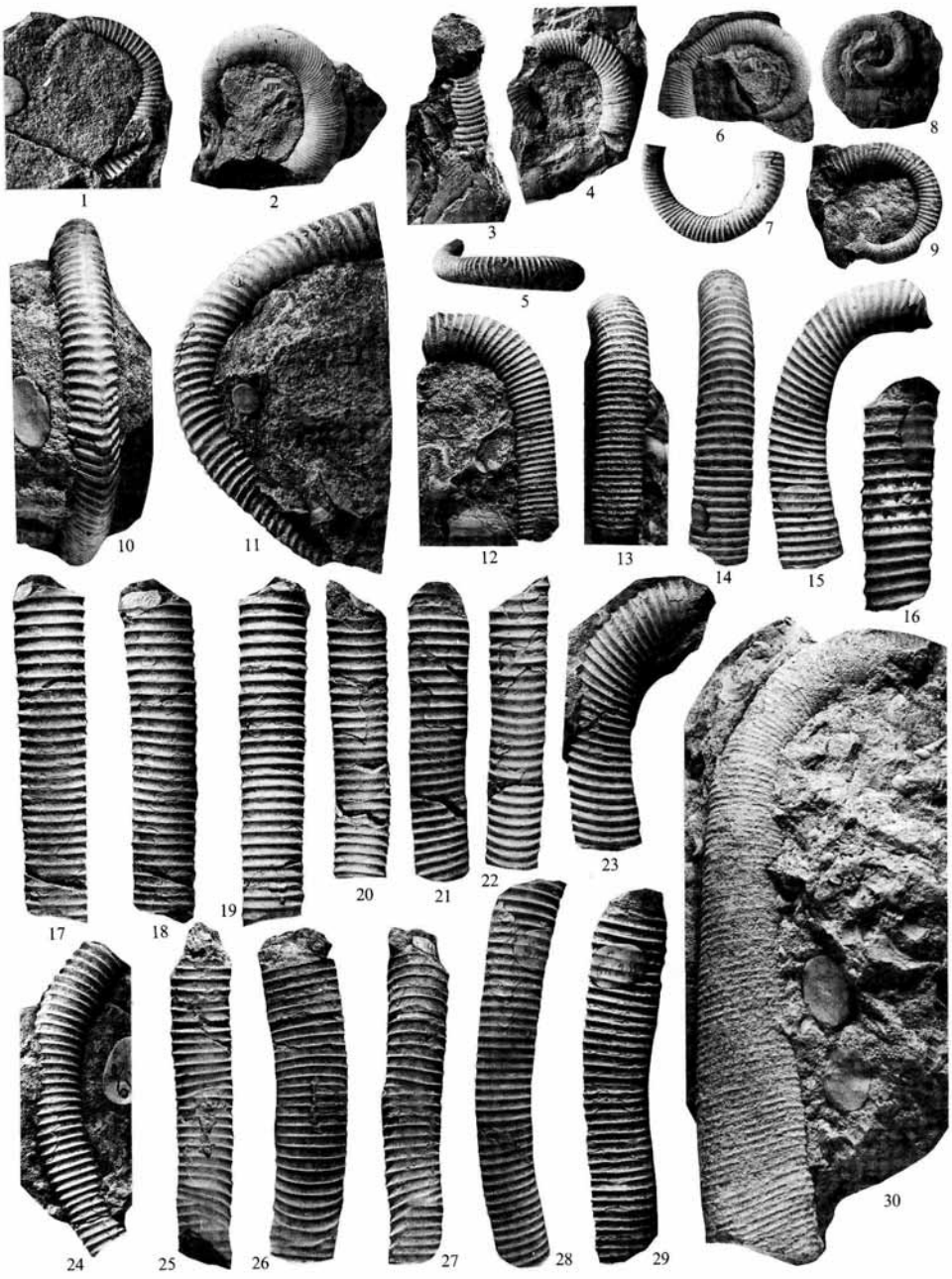
EXPLANATION OF PLATE 2

Figs 1, 3–5, 7, 9, 12–13. *Glyptoxoceras indicum* (Forbes, 1846). 1, BMNH C51134, a possible paralectotype. 3, 12–13, BMNH C51113, GSC R10496, the lectotype, the original of Kossmat (1895, pl. 19 (5), fig. 4*a–b*). 4, BMNH C51133, a possible paralectotype. 5, 7, BMNH C51138, a possible paralectotype. 9, BMNH C51136, a possible paralectotype.

Figs 2, 6, 8, 30. *Glyptoxoceras tenuisulcatum* (Forbes, 1846). 2, BMNH C51107, a paralectotype. 6, BMNH C51135, a paralectotype. 8, BMNH C51106, a paralectotype. 30, BMNH C51104, GSC R10493, the lectotype, the original of Forbes (1846, pl. 10, fig. 8).

Figs 10–11, 14–29. *Glyptoxoceras rugatum* (Forbes, 1846). 10–11, BMNH C51109, GSC R10502, the lectotype of *Hamites nereis* Forbes (1846, pl. 10, fig. 7). 14–15, BMNH C4049, the original of Shimizu (1935, text-figs 6–9). 16, BMNH C51112, R10497, a paralectotype, the original of Kossmat (1895, pl. 19 (5), fig. 4*c*). 17–19, BMNH C4049. 20–22, BMNH C4049. 23, BMNH C51114. 24, BMNH C51115. 25–27, BMNH C4049. 28, BMNH C51131. 29, BMNH C51128.

All from the Valudavur Formation, Pondicherry, south India. All × 1.



KENNEDY and HENDERSON, *Glyptoxoceras*

a syntype of Forbes's *rugatus* (Kossmat 1895, pl. 19 (5), fig. 7; Pl. 1, figs 3–4) which we identify with *Glyptoxoceras indicum*. Shimizu (1935) considered Forbes's figured specimen to be the holotype of *indicum*, but Matsumoto (1959*a*, p. 167) correctly recognized (following Kossmat 1895, p. 145 (49)) that *Hamites indicus* of Forbes was based upon a number of syntypes, and designated BMNH C51113, the original of Kossmat 1895 (pl. 19 (5), fig. 4*a–b*; pl. 1, figs 3–4) as lectotype. So defined, *G. indicum* is a distinctive species, characterized by the presence of an initial helix, followed by a single elliptical whorl, beautifully illustrated by examples from the Maastrichtian of California (Matsumoto 1959*a*, pl. 41, figs 2–6). This coiling style immediately separates *G. indicum* from *G. rugatum* and *G. largesulcatum*, while *G. tenuisulcatum*, with similar coiling, has a much higher rib index, the ribs oblique on the venter of shafts rather than transverse, and reaches a much larger size (Pl. 2, figs 2, 6, 8, 30).

The *Glyptoxoceras indicum* of Brunnschweiler (1966, p. 44, pl. 6, figs 1–3; text-fig. 28) is *G. rugatum*. *Diplomoceras indicum ocstosulcatum* Collignon, 1969 (p. 45, pl. 530, fig. 2090), from the Lower Campanian of Madagascar, is based on a straight shaft 80 mm long, a coiling style quite unlike that of *G. indicum*. The Santonian–Campanian fragments from Zululand and Pondoland (Woods 1906, pl. 44, fig. 2; Klinger 1976, pl. 34, figs 3, 5) are indeterminate. The *Diplomoceras* (*Glyptoxoceras*) *indicum* of Immel *et al.* (1982, pl. 10, figs 5–6) from the Santonian of Austria are of uncertain affinities in our view, being densely ribbed curved fragments only. The *Glyptoxoceras subcompressum* of Ward and Westermann (1976, text-figs 1–3) and Ward (1976, pl. 1, figs 1–5; text-fig. 3) consists of an initial helix, followed by one and a half elliptical whorls, rather as in *G. indicum*, but the plane of coiling of the helix is 90° to that of the late whorls.

Occurrence. Maastrichtian of south India and California.

Glyptoxoceras tenuisulcatum (Forbes, 1846)

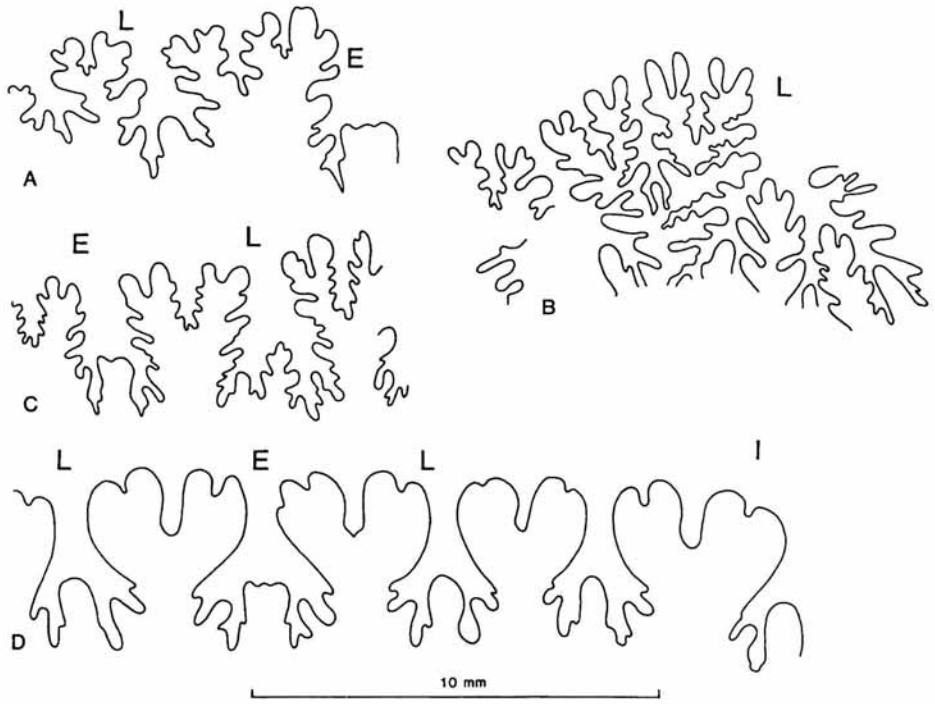
Plate 2, figs 2, 6, 8, 30; Text-fig 2B

1846 *Hamites tenuisulcatus* Forbes, p. 116, pl. 10, fig. 8; pl. 11, fig. 3.
1850 *Ancyloceras tenuisulcatus* Forbes; d'Orbigny, p. 214.
1865 *Anisoceras tenuisulcatum* Forbes sp.; Stoliczka, p. 177, pl. 85, figs 14–16.
1895 *Hamites* (*Anisoceras*) *tenuisulcatus* Forbes; Kossmat, p. 147 (51), pl. 19 (5), figs 5–6.
1959*a* '*Hamites*' *tenuisulcatus* Forbes; Matsumoto, p. 168.
1977 *Diplomoceras tenuisulcatum* (Forbes); Phillips, p. 49.
1979 *Glyptoxoceras* cf. *indicus* (Forbes, 1846); Birkelund, p. 55.

Types. The lectotype, by the subsequent designation of Matsumoto (1959*a*, p. 168), is BMNH C51104, the original of Forbes (1846, pl. 10, fig. 8), GSC R10493. Paralectotypes are BMNH C51107, the original of Forbes (1846, pl. 11, fig. 3*a–b*); BMNH C51105, the original of Forbes (1846, pl. 11, fig. 3*c–e*); GSC R10495; BMNH C51106, the original of Kossmat (1895, pl. 19 (5), fig. 5*a–b*), GSC R10494; BMNH C51108 (4 specimens), and C51135, all from the Valudavur Formation of Pondicherry, south India (*ex* Kaye and Cunliffe Collection). BMNH C82504 is a topotype (*ex* Marsham Collection).

Description. The earliest stages are in the form of a low loose helix, with a low translation rate (Pl. 2, figs 2, 6, 8) and a slightly compressed, subcircular whorl section. Ornament is of very fine, delicate ribs, with a rib index of 14. The ribs are weak on the inner whorl face, but strengthen over the juncture of inner and upper whorl faces, are concave on the upper, markedly prorsiradiate on the outer, sweeping back and markedly concave across the lower whorl face. These helices can be linked, via BMNH C41105, to the lectotype (Pl. 2, fig. 30) which is a shaft and part of a helicoid whorl, in all 94 mm long. The whorl breadth to height ratio is 0·9 at the greatest whorl height preserved, and the rib index 15 or 16. The ribs are very fine, sharp and narrower than the interspaces. They are transverse to feebly concave on the dorsum, sweeping forwards and markedly prorsiradiate on the flanks, and markedly oblique on the venter, rather than transverse. Suture florid, with deeply incised bifid elements (Text-fig. 2B).

Discussion. Matsumoto (1959*a*) thought *tenuisulcatus* might be a *Diplomoceras*, but the helicoid whorls indicate, rather, that it is a *Glyptoxoceras*; *Diplomoceras* have ptychoceratid early growth stages (Matsumoto 1984, p. 31, pl. 8, fig. 3; Matsumoto and Miyauchi 1984, p. 68, pl. 27, fig. 2;



TEXT-FIG. 2. Suture lines. A, *Indoscaphites cunliffei* (Forbes, 1846), BMNH C51090. B, *Glyptoxoceras tenuisulcatum* (Forbes, 1846), BMNH C51105. C, *Fresvillia teres* (Forbes, 1846), BMNH C41505. D, *Phylloptychoceras sipho* (Forbes, 1846), BMNH C41502.

text-fig. 11*a*). *Glyptoxoceras tenuisulcatum* differs from all other described *Glyptoxoceras* in the very fine ornament, markedly prorsiradiate on the flanks, and oblique, rather than transverse on the venter, as well as its retention of helicoid coiling to a much larger size than *D. indicum*, the other species in which helices are known.

Occurrence. Maastrichtian of south India and Denmark.

Glyptoxoceras largesulcatum (Forbes, 1846)

Plate 3, figs 4–9; Plate 4, figs 16–18; Text-fig. 1D

1846	*Hamites large-sulcatus* Forbes, p. 117, pl. 11, fig. 1.
1847*a*	*Hamites acuticostatus* d'Orbigny, pl. 3, figs 9–10 only.
1850	*Hamites indicus* Forbes; d'Orbigny, p. 215 (*pars*).
1866	*Anisoceras large-sulcatum* Forbes; Stoliczka, p. 180, pl. 85, figs 8(?)–9.
1895	*Hamites* (*Anisoceras*) *largesulcatus* Forbes; Kossmat, p. 147 (51).
1959*a*	*Glyptoxoceras*(?) *largesulcatum* (Forbes); Matsumoto, p. 169.
non 1966	*Neohamites largesulcatus* (Forbes, 1846); Brunnschweiler, p. 52, pl. 1, fig. 8; pl. 8, figs 3–6; text-fig. 36 (=*G. rugatum*).
non 1969	*Glyptoxoceras largesulcatum* Forbes; Collignon, p. 46, pl. 530, fig. 2091.
1977	*Neohamites largesulcatus* (Forbes, 1846); Phillips, p. 124.

Types. Lectotype, here designated, is BMNH C51094, the original of Forbes (1846, pl. 11, fig. 1), GSC R10498; paralectotypes are BMNH C51095–51099; C51098–51099 are *G. rugatum* (Pl. 3, figs 1–3; Pl. 4, figs 13–15). All are from the Valudavur Formation of Pondicherry, south India (*ex* Kaye and Cunliffe Collection). Topotypes are BMNH C24200 (*ex* Kaye Collection), and C4051.

Description. The lectotype (Pl. 3, figs 4, 8–9), is a straight body chamber fragment 54 mm long, with a maximum preserved whorl height of 23·5 mm. The whorl section is a compressed oval, with a costal and intercostal whorl breadth to height ratio of 0·84. There are 4·5 ribs in a distance equal to the whorl height. In profile, the interspaces are symmetrically concave, and terminate at the sharp rib crests, a very distinctive ornament indeed. The ribs are slightly weakened and concave on the dorsum, feebly prorsiradiate on the flanks and strengthened slightly and transverse on the venter. BMNH C51095 (Pl. 3, fig. 7) is also a straight body chamber fragment, 54·5 mm long, with a costal whorl breadth to height ratio of 0·91, and an intercostal whorl breadth to height ratio of 0·95. The rib index is 4·5 to 5. BMNH C51096 (Pl. 4, figs 16–18) is 80 mm long, with a rib index of 5. BMNH C51097 (Pl. 3, fig. 6) is 36·5 mm long, with a rib index of 5. A topotype, BMNH C4051, shows the suture (Text-fig. 1D), which is moderately incised, with broad-stemmed bifid lobes and narrower-necked bifid saddles.

Discussion. The Geological Society of London catalogue lists only one specimen under *Hamites largesulcatus*, and this is designated lectotype above. There are, however, five other specimens in The Natural History Museum collections, labelled, in L. F. Spath's hand, '*Diplomoceras* (cotypes of *Ham. largesulcatus* Forbes)'. In the absence of the original boards to which the specimens were glued, as well as the original labels, these are taken to be syntypes, as Forbes refers to both straight and curved specimens, including what is clearly BMNH C51098 (Pl. 3, figs 1–3) 'the most curved specimen bearing two oval varices' (Forbes 1846, p. 117). This specimen and paralectotype C51099 (Pl. 4, figs 13–15) are referred to *G. rugatum*.

One of the specimens of *Hamites acuticostatus* d'Orbigny, 1847*a* (pl. 3, figs 9–10) has a circular whorl section, is 27 mm long, with a whorl height of 15 mm, and a rib index of 3. It appears to belong to the present species. The other fragment illustrated as *acuticostatus* has a compressed whorl section and rib index of 4, and seems to be a *G. rugatum*.

The distant, sharp ribbing, with symmetrical interspaces distinguishes *G. largesulcatum* from all other species of the genus.

Occurrence. As for types.

Genus DIPLOMOCERAS Hyatt, 1900, p. 571
[= *Eudiplomoceras* Brunnschweiler 1966 p. 18]

Diplomoceras cylindraceum (Defrance, 1816)

Plate 6, figs 1–3; Text-figs 1B, 3

1816 *Baculites cylindracea* Defrance, p. 160.
?1847 *Hamites indicus* d'Orbigny, pl. 3, figs 13–14.
1895 *Hamites* (*Anisoceras*) *rugatus* Forbes sp.; Kossmat, p. 146 (50) (*pars*), pl. 19 (5), figs 8–9 only.
?1980 *Diplomoceras* sp., cf. *D. notabile* Whiteaves; Matsumoto and Morozumi, p. 23, pl. 16, fig. 3.
?1981 *Diplomoceras* cf. *notabile* Whiteaves; Matsumoto, p. 291, pl. 47, fig. 8; pl. 48, fig. 6.

EXPLANATION OF PLATE 3

Figs 1–3. *Glyptoxoceras rugatum* (Forbes, 1846). BMNH C51098, one of the syntypes of *Hamites largesulcatus* Forbes, 1846.

Figs 4–9. *Glyptoxoceras largesulcatum* (Forbes, 1846). 4, 8–9, BMNH C51094, GSC R10498, lectotype, the original of Forbes (1846, pl. 11, fig. 1). 5, BMNH 24200, a topotype. 6, BMNH C51097, a paralectotype. 7, BMNH C51095, a paralectotype.

All from the Valudavur Formation, Pondicherry, south India. All ×1.

KENNEDY and HENDERSON, *Glyptoxoceras*

1984 *Diplomoceras notabile* Whiteaves; Matsumoto and Miyauchi, p. 68, pl. 27, fig. 2; text-fig. 11*a*.
1986 *Diplomoceras lambi* Spath; Macellari, p. 17, text-figs 3.13, 14.1, 15–16.
1876 *Diplomoceras cylindraceum* (Defrance); Kennedy, p. 181, pl. 17, fig. 3; pl. 18, fig. 5; pl. 21, figs 2–3, 5–6; pl. 22, fig. 6; pl. 23, figs 1–2; pl. 24, figs 1–3; pl. 25, figs 1–8; pl. 26, fig. 18; pl. 33, fig. 16; pl. 36, fig. 6; text-figs 9–10 (with synonymy).
1988 *Diplomoceras cylindraceum* Defr. *lvovensis* Michailov; Alizadze *et al.*, p. 378, pl. 27, fig. 1.
1989 *Diplomoceras lambi* Spath; Olivero and Zinsmeister, p. 627, text-figs. 2.1–2.4.
1989 *Diplomoceras maximum* Olivero and Zinsmeister, p. 629, text-figs 2.5, 4.1–4.4, 5.1–5.4.
1989 *Diplomoceras*; Kennedy, text-fig. 18*g*.

Type. Neotype, designated by Kennedy (1987, p. 183, pl. 24, figs 1–3), is no. 10511 in the collections of the Institut Royal des Sciences Naturelles de Belgique, from the Upper Maastrichtian Nekum or Meersen Chalk of St Pietersberg, Maastricht, The Netherlands.

Description. BMNH C51102 (Pl. 6, figs 1–3), the original of Kossmat (1895, pl. 19 (5), fig. 9), a syntype of *Hamites rugatus* Forbes, 1846, is an initially slightly curved, thereafter straight shaft, 180 mm long, with a whorl breadth to height ratio of 0·86 at the smaller and 0·85 at the larger end, where the maximum preserved

TEXT-FIG. 3. *Diplomoceras cylindraceum* (Defrance, 1816). BMNH C51101, the original of Kossmat (1895, pl. 19 (5), fig. 8); Valudavur Group; Pondicherry, south India (*ex* Kaye and Cunliffe Collection), ×1.

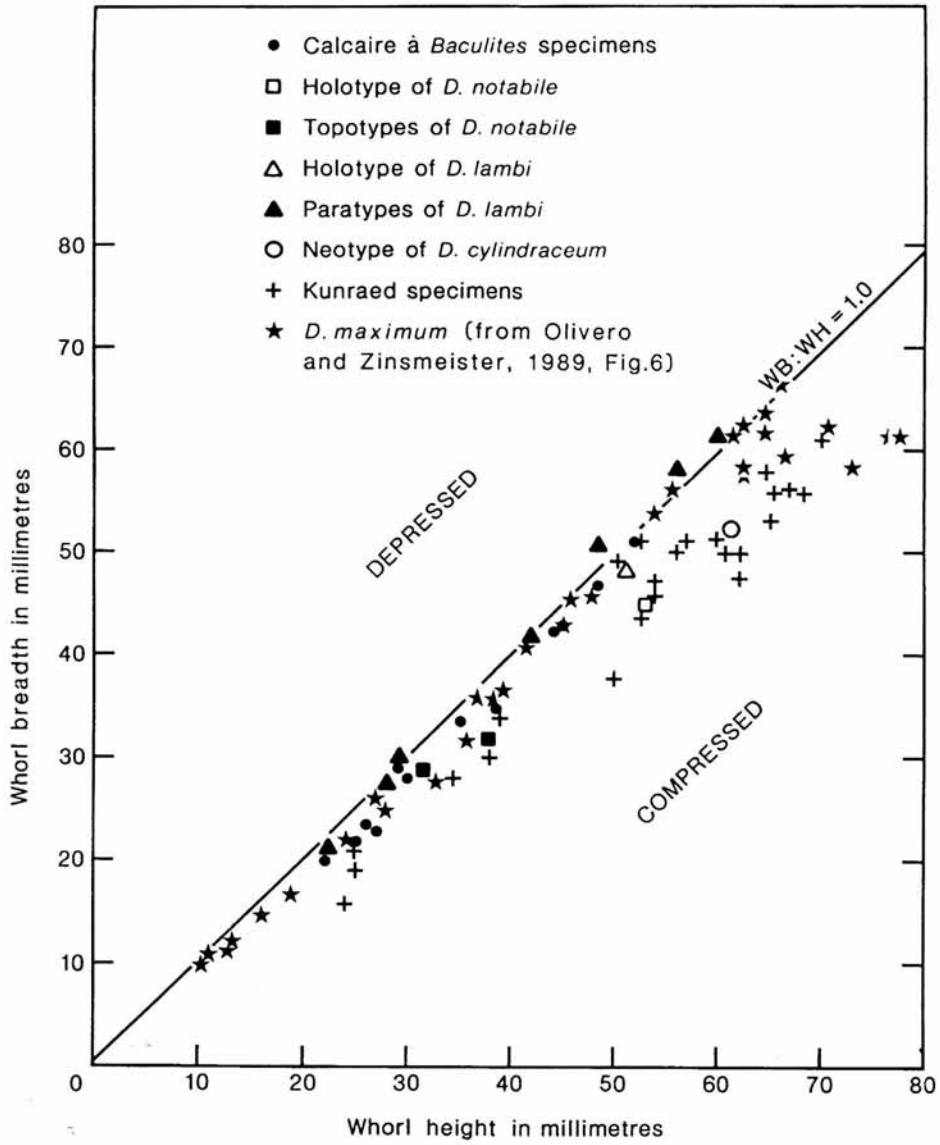
whorl height is 28 mm. The flanks are broadly and evenly rounded, the dorsum and venter more narrowly so, with an oval whorl section. The specimen is partially septate. Ornament is subdued on the mould, but sharp where shell is preserved. The rib index is 12–13, the ribs transverse on dorsum and venter and varying from feebly rursiradiate to feebly prorsiradiate on the flanks, and only slightly weaker on dorsum than venter. Where well-preserved, they are narrower than the interspaces, with blunt crests. BMNH C51101 (Text-fig. 3; the original of Kossmat 1895, pl. 19 (5), fig. 8) is a wholly septate fragment of a shaft and part of the curved sector, with a maximum preserved whorl height of 40 mm on the shaft close to the curved sector, where the rib index is 14–15, the ribs markedly inclined on the flank. The whorl breadth to height ratio cannot be determined. Even larger is an unregistered fragment of a straight shaft, with a whorl height of more than 50 mm.

Suture (Text-fig. 1B) with deeply incised symmetrically bifid lobes and saddles.

Discussion. Kennedy (1987) described a suite of more than 70 specimens from the type area in The Netherlands, as well as a smaller suite of well-preserved specimens from the Calcaire à *Baculites* of Manche, France (Kennedy 1986*b*). Kennedy and Summesberger (1986) redescribed the type material of *Hamites hampeanus* Hauer, 1847 (p. 75), a synonym, and Kennedy and Summesberger (1987) described material from Lvov in the Ukraine, showing the variety *lvovensis* of Mikhailov (1951) to be based on crushed specimens of *D. cylindraceum*. These workers considered *D. cylindraceum* to be a widely varying species in terms of whorl breadth to height ratio and rib index, encompassing both *Diplomoceras notabile* Whiteaves, 1903 (p. 335, pl. 44, fig. 4), originally described from British Columbia, and *D. lambi* Spath, 1953 (p. 17, pl. 2, figs 1–3), originally described from Antarctica. Olivero and Zinsmeister (1989) in seeming ignorance of the description of the neotype of *cylindraceum*, as well as other topotype material, held *D. lambi*, *D. notabile* and a new species, *D. maximum* Olivero and Zinsmeister, 1989 (p. 629, text-figs 2.5, 4.1–4·5, 5·1–5.4) to be different from *D. cylindraceum*. According to these authors, the diagnostic features of these species include: *D. lambi*, circular whorl section and rib index of 13–20; *D. notabile*, compressed whorls, and slight sutural difference; *D. maximum*, circular whorl section, rib index ranges from 9 to 13, average 11–12. For *D. cylindraceum* they quote Kennedy (1986*b*) and Kennedy and Summesberger (1986) as indicating a rib index of 11–13. In fact material from The Netherlands (Kennedy 1987) has whorl breadth to height ratios of 0·77–1·02, and a rib index of 15–17 at whorl heights of 55–60 mm, and up to 20 or more in the largest fragment.

Text-figure 4 plots the whorl breadth to height ratio of type material of all these species, additional specimens from The Netherlands, the Calcaire à *Baculites* of the Coténtin Peninsula in France, and the Indian examples. The whorl section of the neotype of *D. cylindraceum* and the holotype of *D. notabile* are both compressed. Whiteaves (1903) gives a ratio of 0·81 at the smaller and 0·84 at the larger end of the holotype. The rib index is 15, so that the specimen falls within the range of *D. cylindraceum*. The types of *D. lambi* in the collections of The Natural History Museum have a whorl breadth to height ratio of 0·95 to 1·06, overlapping that of *D. cylindraceum*, as does the rib index of 13, 14 and 17. The larger suite described by Olivero and Zinsmeister (1989) with a rib index of 13–20 and circular cross section also overlaps with the topotype assemblage and other European material. There are thus no grounds for separating these in species in our view. *D. maximum* cannot be differentiated from *D. cylindraceum* on whorl section, showing a whorl breadth to height ratio that varies from 0·79–1. The rib index is as low as 7 in specimens with a whorl height of 10 mm, but varies up to 15 at a whorl height of 16 mm, and is generally between 10 and 13 in larger specimens. To us it appears to be no more than the paucicostate part of a population which clearly overlaps with European material. Indeed, the plot of rib index versus whorl height in Olivero and Zinsmeister (1989) shows what is to us an arbitrary separation between *D. maximum* and *D. lambi*; taken together, the overlap with European *D. cylindraceum* is even more obvious. We see no grounds for treating all of the forms discussed here as anything more than a variable *D. cylindraceum*.

Hamites indicus d'Orbigny, 1847*a* (pl. 3, figs 13–14) is shown as a 22 mm long fragment with a compressed whorl section and feebly prorsiradiate narrow, straight flank ribs, the rib index being 14, and may well be a juvenile *D. cylindraceum*.



TEXT-FIG. 4. Plot of whorl breadth versus whorl height for selected specimens referred to *Diplomoceras cylindraceum* (Defrance, 1816).

Occurrence. Where well dated, this species is Maastrichtian, ranging to the very top of the stage. There are records from south India, Japan, Alaska, British Columbia, California, Chile, the Antarctic Peninsula, Western Australia, Madagascar, Zululand (South Africa), the USSR, Italy, northern Spain, France, Belgium, The Netherlands, Germany, Denmark, Poland, Austria, Bulgaria, and, possibly, New Zealand, Greenland and Brazil. A slightly lower appearance, in the Upper Campanian, is suggested by records from Japan (Matsumoto and Morozumi 1980; Matsumoto 1984; Matsumoto and Miyauchi 1984).

Subfamily POLYPTYCHOCERATINAE Matsumoto, 1983, p. 193

[nom. transl. Wiedmann, 1962, p. 185, *ex* Polyptychoceratidae Matsumoto]

Genus PHYLLOPTYCHOCERAS Spath, 1953, p. 16

[= *Neocyrtochilus* Anderson, 1958, p. 189]

Type species. Ptychoceras sipho Forbes, 1846 (p. 118, pl. 11, fig. 5), by original designation.

Phylloptychoceras sipho (Forbes, 1846)

Plate 4, fig. 7; Plate 5, figs 18–32; Text-fig 2D

1846	*Ptychoceras sipho* Forbes, p. 118, pl. 11, fig. 5.
1847*a*	*Hamites constrictus* d'Orbigny, pl. 3, figs 7–8.
1850	*Ptychoceras sipho* Forbes; d'Orbigny, p. 215.
1850	*Hamites constrictus* d'Orbigny, p. 215.
1866	*Ptychoceras sipho* Forbes; Stoliczka, p. 194, pl. 90, figs 5–9.
1895	*Hamites* (*Ptychoceras*) *sipho* Forbes sp.; Kossmat, p. 150 (54).
1953	*Phylloptychoceras sipho* (Forbes); Spath, p. 19, pl. 11, fig. 7.
?1958	*Neocyrtochilus bryani* Anderson, p. 189, pl. 72, fig. 5.
1965	*Phylloptychoceras sipho* (Forbes); Howarth, p. 386, pl. 11, fig. 1.
1970	*Phylloptychoceras sipho* (Forbes); Henderson, text-fig. 7*b*.
1977	*Phylloptychoceras sipho*; Kennedy, text-fig. 3120.
?1986	*Phylloptychoceras* sp. Stinnisbeck, p. 200, pl. 15, fig. 3; text-fig. 22.
1989	*Phylloptychoceras*; Kennedy, text-fig. 18*f*.

Types. Lectotype, by the subsequent designation of Howarth (1965, p. 386) is BMNH C51153, the original of Forbes (1846, pl. 11, fig. 5*a*), GSC R10504; paralectotype BMNH C51154 is the original of Forbes (1846, pl. 11, figs 5*b*, *e*), GSC R10506; paralectotype BMNH C51155 is the original of Forbes (1846, pl. 11, figs, 5*c*, *f*), GSC R10507; paralectotype BMNH C41502 is probably the original of Forbes (1846, pl. 11, fig. 5*d*); unfigured paralectotypes are BMNH C41503, C51156–51161, all from the Valudavur Formation of Pondicherry, south India (*ex* Kaye and Cunliffe Collection). Topotypes are BMNH C3521, and 24199. The holotype of *Hamites constrictus* d'Orbigny, 1847 (pl. 3, figs 7–8), is MNHP R982 (Pl. 5, figs 27–28), also a topotype of *P. sipho*.

Description. The earliest developmental stages are shown by BMNH C51155 and 51160 (Pl. 5, figs 18, 24), which consist of minute subparallel shafts in tight contact, linked by narrowly curved sections, where shafts are separated by a tear-shaped opening; the shell is smooth, but for prorsiradiate growth lines. BMNH C51161 is a similar fragment (Pl. 5, fig. 19), but much larger. BMNH C51154 (Pl. 5, fig. 23) is the same size and shape as BMNH C51161, with a circular cross section and feeble ornament of low, broad, feebly prorsiradiate ribs, and a single constriction. If, as seems likely, these are correctly interpreted as successive growth stages of the same form (rather than of macro- and microconchs), then the shell consisted of four closely adpressed subparallel shafts, the first three and part of the fourth being septate. The lectotype (Pl. 5, figs 31–32) is the best-preserved of the adult specimens, and is 107 mm long. The whorl section is subcircular, slightly compressed at the adapical end, and consists of a slightly curved shaft and short recurved crozier. The whorl breath to height ratio is 0·83 at the mid-point of the shaft, but becomes markedly depressed and reniform on the final curved sector. Ornament on the shaft is of low, broad, distant, rounded ribs; the rib index is two. Ribs are weak and transverse on the dorsum, straight and feebly prorsiradiate on the flanks, and strong and transverse across the venter. The ribs weaken, narrow and crowd on the final section of the shaft and the initial part of the hook, disappearing altogether on the final section of the hook, where they are replaced by crowded growth lines. The final, adult aperture appears to have been flared and trumpet-shaped, as suggested by BMNH

C41503. Suture (Text-fig. 2D) greatly simplified with narrow-stemmed, bifid saddles with only minor indentations; lobes have narrow necks, with splayed, bifid lateral elements and a larger median element, entire in L and U.

Discussion. Hamites constrictus d'Orbigny, 1847*a* (pl. 3, figs 7–8) is based on a Pondicherry specimen of *P. sipho* (Pl. 5, figs 27–28). The holotype of *Neocyrtochilus bryani* Anderson, 1958 (p. 189, pl. 72, fig. 5) is based on a small smooth form with ptychoceratid coiling like the early stages of the present species, and said, by Anderson, to be of Maastrichtian age; it is a possible synonym, as is the *Phylloptychoceras* sp. of Stinnisbeck (1986, p. 200, pl. 15, fig. 3; text-fig. 22), from the Maastrichtian of Chile.

Occurrence. Maastrichtian of south India and, possibly, Chile and California, and the Biscay region of France and Spain.

Genus CYRTOPTYCHOCERAS nov.

Derivation of name. Kyrtos (Greek), curved; *ptychos* (Greek), fold; and *keros* (Greek), horn.

Type species. Hamites undulatus Forbes, 1846 (p. 118, pl. 10, fig. 6).

Diagnosis. Small, whorl height less than 4 mm before aperture; consisting of a single endogastrically curved shaft; whorl section circular, ornamented by low, broad, straight prorsiradiate flank ribs that are transverse on the venter. Apertural region expanded into a smooth, trumpet-shaped section succeeded by constrictions, and terminal linguoid ventral process.

Discussion. Shape and style of ribbing, plus apertural modifications correspond to those of Polyptychoceratinae, as in *Phylloptychoceras* described above. It differs from all other genera assigned to the subfamily in consisting of a single, curved shaft, rather than several subparallel ones. It differs from all known Diplomocertinae in rib style and form of aperture. There are closer similarities to Baculitidae, but the transverse ribbing on dorsum and venter, with no development of dorsal and ventral rostra throughout ontogeny is a differentiating feature from genera such as *Fresvillia* Kennedy, 1986*b*, and species such as *Baculites columna* Morton, 1834.

Occurrence. Upper Maastrichtian Valudavur Formation of Pondicherry, south India.

Cyrtoptychoceras undulatus (Forbes, 1846)

Plate 4, figs 1, 3–6, 8–11

1846 *Hamites undulatus* Forbes, p. 118, pl. 10, fig. 6.
1850 *Hamites undulatus* Forbes; d'Orbigny, p. 216.
1866 *Anisoceras undulatum* Forbes; Stoliczka, p. 177, pl. 85, fig. 6.
1895 *Hamites* (*Anisoceras*) *undulatus* Forbes sp.; Kossmat, p. 148 (52).
1977 *Hamites undulatum* (Forbes); Phillips, p. 84.

EXPLANATION OF PLATE 4

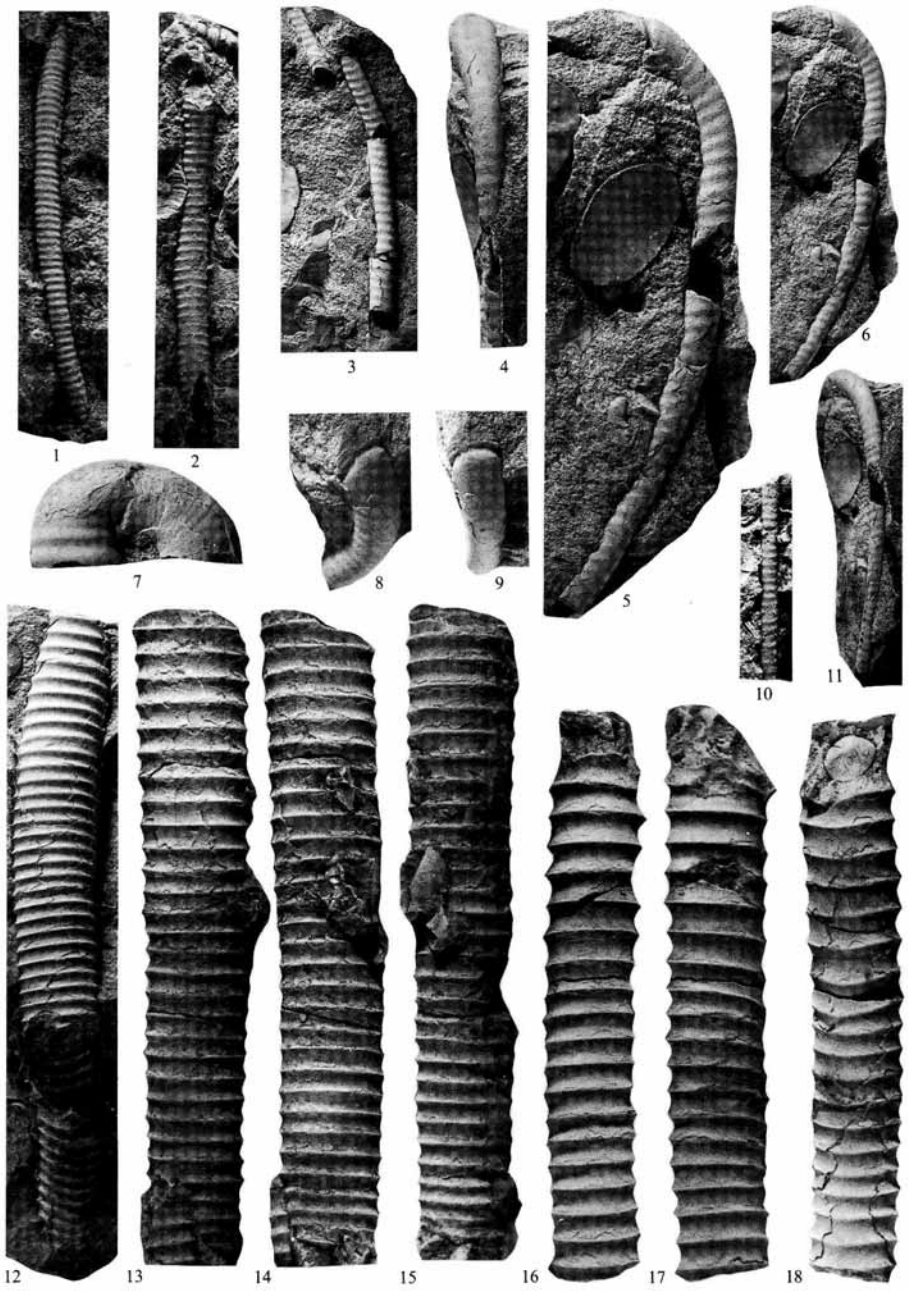
Figs 1, 3–6, 8–11. *Cyrtoptychoceras undulatum* (Forbes, 1846). 1, BMNH C51124, a paralectotype. 3, BMNH C51119, a paralectotype. 4–6, 8–9, 11, BMNH C51118, GSC R10503, the lectotype, the original of Forbes (1846, pl. 10, fig. 6). 10, BMNH C51123, a paralectotype.

Figs 2, 12–15. *Glyptoxoceras rugatum* (Forbes, 1846). 2, BMNH C51121, a syntype of *Hamites undulatus* Forbes, 1846. 12, BMNH C83624, the holotype of *Glyptoxoceras circulare* Shimizu, 1935. 13–15, BMNH C51099, a syntype of *Hamites largesulcatus* Forbes, 1846.

Fig. 7. *Phylloptychoceras sipho* (Forbes, 1846). BMNH C51159, a paralectotype.

Figs 16–18. *Glyptoxoceras largesulcatum* (Forbes, 1846). BMNH C51096, a paralectotype.

All from the Valudavur Formation, Pondicherry, south India. Figs 6–7, 11–18, ×1; figs 1–5, 8–11, ×2.



KENNEDY and HENDERSON, *Cyrtoptychoceras*, *Phylloptychoceras*, *Glyptoxoceras*

Types. Lectotype, here designated, is BMNH C51118, the original of Forbes (1846, pl. 10, fig. 6), GSC R10503. Paralectotypes are BMNH C51119, C51123 and C51124; paralectotypes BMNH C51121 (Pl. 4, fig. 2), BMNH C51122 (Pl. 1, fig. 11) and C51120 (Pl. 1, fig. 10) are *Glyptoxoceras rugatum*. All are from the Valudavur Formation of Pondicherry, south India (*ex* Kaye and Cunliffe Collection).

Description. The lectotype (Pl. 4, figs 4–6, 8, 9, 11) is an incomplete body chamber 46 mm long, with the adult aperture preserved. The greater part of the specimen is slightly curved, curvature increasing towards the adult aperture, with the venter convex and dorsum concave in profile. The whorl section is circular, and expands very slowly. Ornament is of low, broad, blunt ribs, as wide as, or narrower than the interspaces. The ribs are transverse on the dorsum, feebly prorsiradiate on the flanks, and somewhat strengthened and transverse on the venter. The rib index is 2.

The whorl expansion rate increased markedly on the final sector before the aperture and ornament is lost, leaving a 4 mm smooth section of shell, which terminates at a broad, deep constriction, prorsiradiate on the flank, and transverse on the venter, with a narrow, sharp adapical collar-rib. Beyond the collar, there is a further sector of shell, preserved on the ventral and ventrolateral regions only. It bears a series of weak riblets, the terminal one defining a broad linguoid ventral apertural process (Pl. 4, figs 4, 5, 8, 9). BMNH C51119 is a series of near-straight sections of body chamber (Pl. 4, fig. 3). BMNH C51124 (Pl. 5, fig. 1) shows the ventral ornament, BMNH C51123 (Pl. 4, fig. 10) may show that of the dorsum, but is very small. None of the specimens show the suture.

Discussion. See under genus.

Occurrence. As for types.

Family BACULITIDAE Gill, 1871, p. 3

[= Eubaculitinae Brunnschweiler, 1966, p. 24]

Genus EUBACULITES Spath, 1926, p. 80

[= *Giralites* Brunnschweiler 1966, p. 33; *Eubaculiceras* Brunnschweiler 1966, p. 36; *Cardabites* Brunnschweiler 1966, p. 38]

Type species. *Baculites vagina* var. *Ootacodensis* Stoliczka, 1866 (p. 199, pl. 90, fig. 14, ?15), by original designation.

Eubaculites vagina (Forbes, 1846)

Plate 5, figs 10–13; Plate 7, figs 1–18; Plate 8, figs 1–12; Plate 9, figs 1–13; Plate 10, figs 1–3; Text-fig. 1C, F

1846 *Baculites vagina* Forbes, p. 114, pl. 10, fig. 4.
non 1846 *Baculites vagina* Forbes; Darwin, p. 216 [= *E. carinatus* (Morton, 1834)].
1847*a* *Baculites ornatus* d'Orbigny, pl. 3, figs 3–6.
1850 *Baculites vagina* Forbes; d'Orbigny, p. 215.
1866 *Baculites vagina* Forbes; Stoliczka, p. 198 (*pars*), pl. 91, figs 1–6; *non* var. *ootacodensis*, p. 199, pl. 90, figs 14–15.
1895 *Baculites vagina* Forbes (a) Typische Form; Kossmat, p. 155 (59), pl. 19 (5), fig. 17.
non 1897*b* *Baculites vagina* Forbes; Kossmat, pl. 6, fig. 4 [= *E. carinatus* (Morton, 1834)].
1989 *Baculites vagina* Forbes; Crick, p. 78, pl. 17, fig. 5.
non 1907 *Baculites vagina* Forbes var. *cazadorana* Paulcke, p. 11, pl. 16, fig. 5*a–c*.
non 1907 *Baculites vagina* Forbes; Boule *et al.*, p. 45 (65), pl. 8 (15), fig. 3.
non 1923 *Baculites vagina* Forbes; Spengler, p. 54, pl. 4, fig. 9.
non 1924 *Baculites* cf. *vagina* var. *otacodensis* Stoliczka; Crick, p. 140, pl. 9, figs 4–5 [?*E. carinatus* (Morton, 1834)].
non 1924 *Baculites* cf. *vagina* var. *simplex* Kossmat; Crick, p. 140, pl. 9, figs 6–7 [? = *E. carinatus* Morton, 1834].
non 1924 *Baculites* cf. *vagina* Forbes; Crick, p. 130, pl. 9, figs 1–3 [= *E. carinatus* (Morton, 1834) and *E. latecarinatus* Brunnschweiler, 1966].
1925 *Baculites vagina* Forbes; Diener, p. 63 (*pars*).

non 1926 *Eubaculites vagina* (Forbes); Spath, p. 80.
non 1930 *Baculites vagina* (Forbes); Wetzel, p. 90, pl. 10, figs 3–4 [= *E. carinatus* (Morton, 1834)].
non 1931 *Baculites vagina* Forbes; Basse, p. 20, pl. 2, figs 6–10.
non 1936 *Baculites vagina* Forbes var. *vanhoepeni* Venzo, p. 116 (58), pl. 10 (6), figs 11–12 [= *Baculites vanhoepeni*].
non 1940 *Eubaculites vagina* (Forbes); Spath, text-fig. 1*a* [= *E. carinatus* (Morton, 1834)].
non 1966 *Eubaculites vagina* (Forbes); Brunnschweiler, p. 29, pl. 1, fig. 7; pl. 2, figs 1–14; text-figs 12–14.
1971 *Eubaculites vagina* Forbes; Collignon, p. 15, pl. 645, fig. 2391.
1976 *Eubaculites vagina* (Forbes, 1845): Klinger, p. 87, pl. 35, figs 1–4; pl. 36, figs 1–4; pl. 37, figs 1–5; pl. 38, figs 1–3, ?4; pl. 39, fig. 2; pl. 42, fig. 1, *non* figs 4, 7, 9, 11; pl. 43, figs 5–12.
1977 *Baculites vagina*; Kennedy, text-fig. 31. 1–3.
1980 *Eubaculites vagina* (Forbes); Kennedy and Klinger *in* Klinger *et al.*, p. 299, text-fig. 5*a–c*.
1987 *Eubaculites vagina* (Forbes); Kennedy, p. 194.
1989 *Eubaculites*; Kennedy, text-fig. 17*i–j*.

Types. Lectotype, here designated, is BMNH C49726, the original of Forbes (1846, pl. 10, fig. 4), GSC R10488; paralectotypes are BMNH C51140–51150, from the Valudavur Formation of Pondicherry, south India. There are also the following topotypes: BMNH C2582, C77593–77598 (*ex* Kaye Collection); C2583, C73567–73569, C73590 (*ex* Marsham Collection); C2597 (*ex* Forbes Collection); C26299–26300 (*ex* Spath Collection); C77599–77600.

Dimensions.	Wb	Wh	Wb:Wh	Dorsum	Venter	Rib index
BMNH C51144	7·8	11·8	0·66	4·8 (61·5)	1·0 (12·8)	Smooth
BMNH C51151	11·0	15·7	0·70	6·3 (57·3)	2·0 (18·2)	Smooth
BMNH C51145	—	21·5	—	9·1 (—)	4·1 (—)	3
BMNH C51149	15·0	23·6	0·64	10·4 (69·0)	3·0 (12·7)	3
BMNH C77594	16·5	23·7	0·69	11·8 (71·5)	4·0 (24·2)	Smooth
BMNH C51142	16·0	23·8	0·67	11·0 (68·8)	4·4 (27·5)	Smooth
BMNH C51150	16·6	25·9	0·64	10·4 (62·6)	3·2 (19·2)	2
BMNH C51148	19·3	26·7	0·72	16·3 (84·4)	5·1 (19·1)	2·5
BMNH C51143	19·3	28·2	0·68	13·2 (68·3)	3·2 (16·6)	2
BMNH C51147	19·0	29·2	0·65	17·0 (89·5)	3·0 (15·8)	2
BMNH C26300	21·4	30·0	0·71	17·0 (79·4)	3·8 (17·8)	2
BMNH C51441	21·1	30·6	0·69	14·9 (70·6)	3·6 (17·1)	2
BMNH C49762	21·5	32·0	0·67	16·0 (74·4)	5·4 (16·9)	3
BMNH C51146	—	36·0	—	19·1 (—)	9·2 (—)	—
BMNH C77953	26·5	38·8	0·69	19·0 (71·7)	5·5 (20·8)	2
BMNH C51140	32·0	50·0	0·64	24·5 (76·6)	8·7 (27·2)	3

(measurements were taken at the larger end of the specimen; width of dorsum and venter, expressed as a percentage of whorl breadth are shown in parentheses)

Description. The whorls expand quite rapidly, and the shell is slightly curved. The whorl section is compressed, the whorl breadth to height ratio varying between 0·6 and 0·73. The dorsum is broad and flattened, the venter narrow and tabulate, with sharp or narrowly rounded edges. In feebly ornamented variants the whorl section is the more compressed, dorsal flanks are divergent, the mid-flank region rounded, and the outer flanks convergent. In strongly nodate variants the whorl section is less compressed, the inner flanks flattened and divergent, with maximum breadth at the mid-lateral tubercle and with flattened to feebly concave ventral flanks in costal section. The venter is distinctly tabulate from as little as 9 mm whorl height, the only smaller specimens seen being poorly preserved, but with a narrowly rounded venter at a whorl height of 8 mm.

A wide range of variation in ornament is attributed to the species. At one extreme (Pl. 5, figs 10–13; Pl. 7, figs 4–9, 10–12; Pl. 8, figs 10–12) are variants ornamented by growth lines only. These are sharp on the shell surface (e.g. Pl. 5, fig. 10), but subdued on the mould (Pl. 5, fig. 12). They are broadly convex over dorsum, sweep back across the dorsolateral region, are markedly concave on the dorsal half of the flank, but projected strongly forwards on the ventral half, to intersect the line of the venter at an acute angle. They flex back and are convex over the juncture of flank and venter, passing straight across the venter. Stronger ornament takes the form of broad, ill-defined ribs on the dorsal half of the flanks that strengthens into a feeble mid-lateral node, as in BMNH C2582 and C73567.

In specimens such as BMNH C77594 (Pl. 7, figs 13–15), ornament is better differentiated, with a rib index of 2–3·5. The ribs are distant, low and transverse on the dorsal half of the flank, and strengthen into a crescentic mid-lateral tubercle, but decline on the outer flank. As ornament strengthens, a second, dorsolateral tubercle develops, a condition well illustrated by the lectotype (Pl. 7, figs 16–18), with a rib index of 3. As well as this variation between individuals, ornament changes, generally strengthening, as size increases (Pl. 7, figs 1–3, 13–18; Pl. 8, figs 1–9). A notching of the tabulate venter may develop (Pl. 7, fig. 16; Pl. 8, fig. 3), producing an undulose profile to the shell margin but is of variable development within and between individuals. In coarsely ornamented individuals, the dorsolateral tubercle is markedly elongated parallel to the margin of the shell (e.g. BMNH C26300), and the dorsolateral margin undulose in profile (Pl. 9, fig. 13); a broad rib links to the lateral tubercle, which varies from crescentic and oblique (BMNH C7759; Pl. 9, figs 1–2) to elongated parallel to the length of the shell (BMNH C51141; Pl. 8, fig. 5). The largest specimen seen (BMNH C51140; Pl. 10, figs 1–3) has a whorl height of 49·5 mm, a whorl breadth to height ratio of 0·6, and a rib index of 5. A marked concavity occupies the ventral part of the flanks, and strengthened growth lines – or riblets – link dorsolateral and mid-lateral tubercles, and extend to the ventrolateral margin. One fragment, BMNH C51146 (Pl. 9, figs 9–10), shows the aperture, with short dorsal and long ventral rostrum.

Suture (Text-fig. 1C, F) with very broad E with broad shallow median saddle; E/L narrower, bifid, L broader than E/L and bifid, L/U much broader than other saddles, U of intermediate width. All saddles are broad-based, and lobes E, L and U have wide necks.

Discussion. The diagnostic features of the type assemblage of *E. vagina* are the presence of a tabulate venter from an early stage, and binodose ornament on the flanks of a shell that is slightly curved, with a moderately high expansion rate. When compared with other species, these differ as follows:

Eubaculites carinatus (Morton, 1834, p. 4, pl. 13, fig. 1; holotype is no. 72866 in the collections of the Academy of Natural Sciences, Philadelphia; Text-fig. 5A–C), originally described from the Maastrichtian Prairie Bluff Chalk of Wilcox County, Alabama, has the tabulate venter of the present species, but a flank ornament of concave ribs only, without tubercles. The name *carinatus* has priority over *Baculites tippaensis* Conrad, 1858 (p. 334, pl. 35, fig. 27) and *B. spillmani* Conrad, 1858 (p. 335, pl. 35, fig. 24), originally described from the Owl Creek Formation of Tippah County, Mississippi; and *Baculites lyelli* d'Orbigny 1847*a* (pl. 1, figs 3–7), originally described from Quiriquina Island, Chile among others (see Kennedy 1987, p. 195 for an extensive synonymy).

Eubaculites labyrinthicus (Morton, 1834, p. 44, pl. 13, fig. 10, syntypes are nos 72868–72869 in the collection of the Academy of Natural Sciences, Philadelphia; Text-fig. 5D–K) originally described from the Maastrichtian Prairie Bluff Chalk of Alabama, is known in that region as fragments with whorl heights of up to 17·5 mm. The dorsum is flattened, with a dorsolateral node

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EXPLANATION OF PLATE 5

Figs 1, 3–5. *Indoscaphites pavana* (Forbes, 1846). BMNH C51092, GSC R10480, holotype, the original of Forbes (1845, pl. 7, fig. 5).

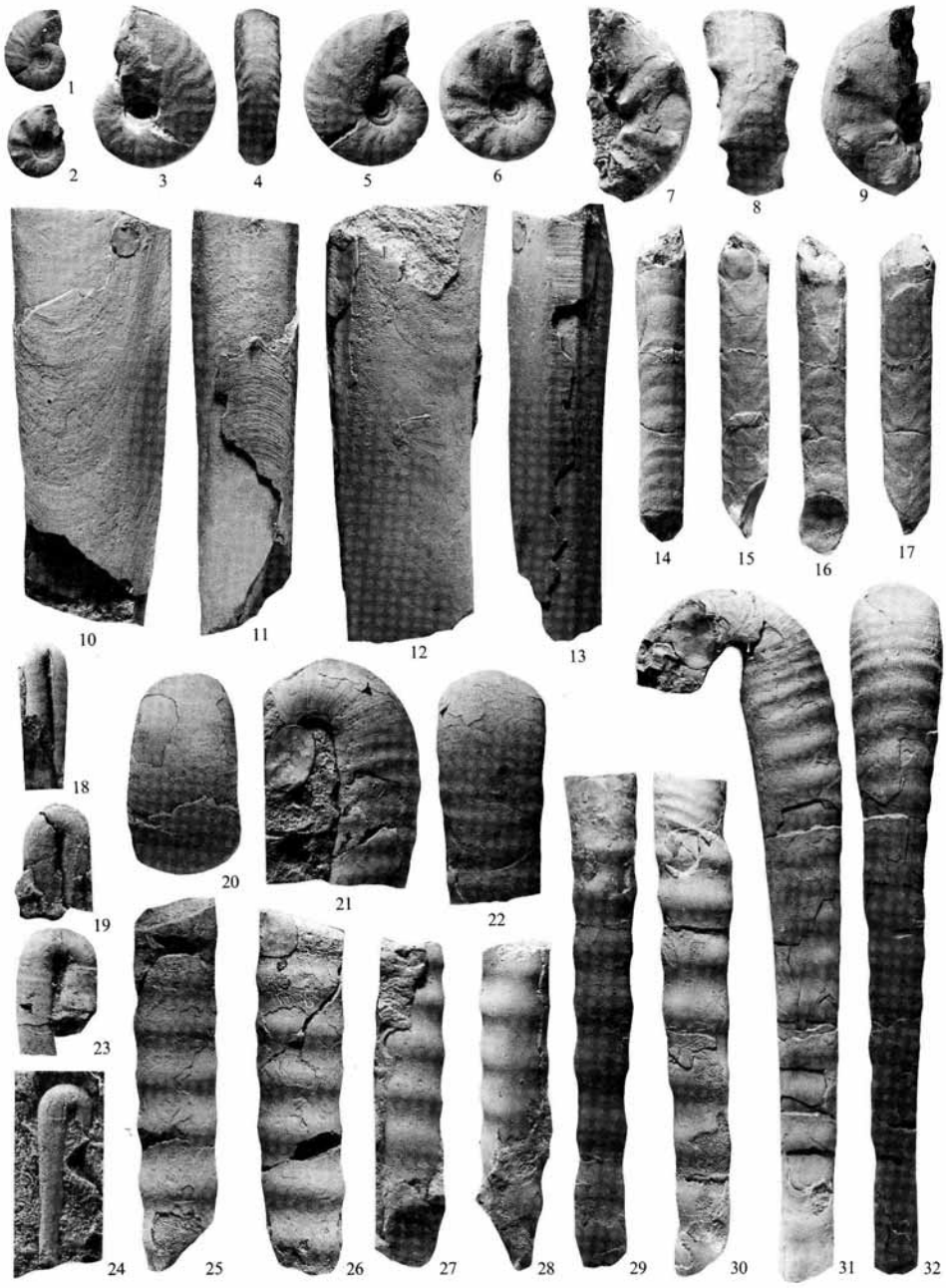
Figs 2, 6–9. *Indoscaphites cunliffei* (Forbes, 1846). 2, 6, BMNH C51089, the original of Forbes (1846, pl. 8, fig. 2*c*). 7–9, BMNH C51091, paralectotype.

Figs 10–13. *Eubaculites vagina* (Forbes, 1846). BMNH C51142, a paralectotype; 10, shows the shell surface; 12, the internal mould.

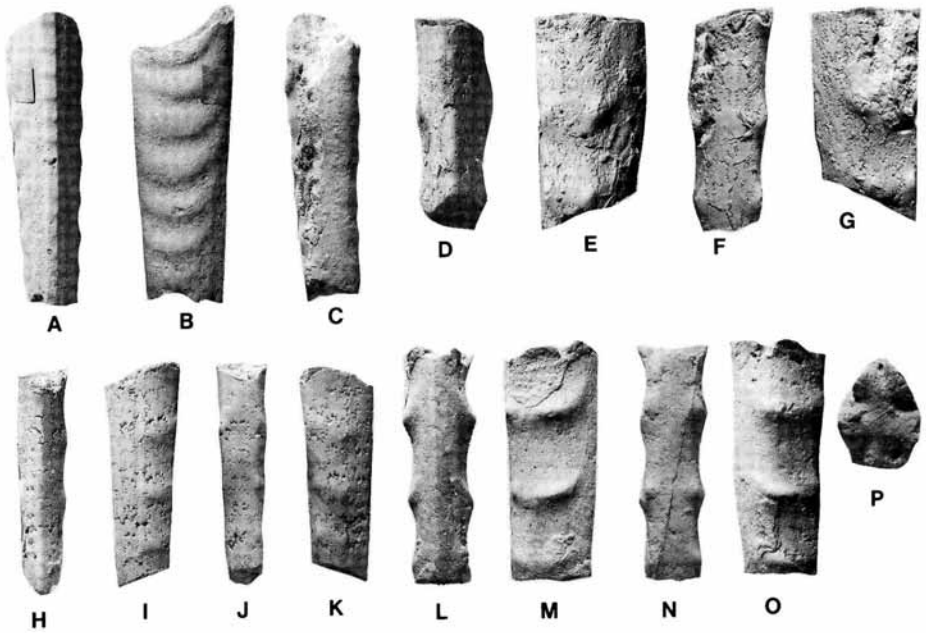
Figs 14–17. *Fresvillia teres* (Forbes, 1846). BMNH C51152, GSC R10490, holotype, the original of Forbes (1846, pl. 10, fig. 5).

Figs 18–32. *Phylloptychoceras sipho* (Forbes, 1846). 18, BMNH C51155. 19, BMNH C51161, a paralectotype. 20, BMNH C51159, a paralectotype (see also Pl. 4, fig. 7). 21–22, BMNH C51159, a paralectotype. 23, BMNH C51154, GSC R10506, a paralectotype, the original of Forbes (1846, pl. 11, fig. 5*b*, *e*). 24, BMNH C51160, a paralectotype. 25–26, BMNH C51156, a paralectotype. 27–28, MNHP R982, the holotype of *Hamites constrictus* d'Orbigny, 1847. 29–30, BMNH 24199, a topotype. 31–32, BMNH C51153, GSC R10504, the lectotype, the original of Forbes (1846, pl. 11, fig. 5).

All from the Valudavur Formation, Pondicherry, south India. Figs 1–2, 10–17, 20–23, 25–32, ×1; figs 3–9, 18–19, 24, ×2.



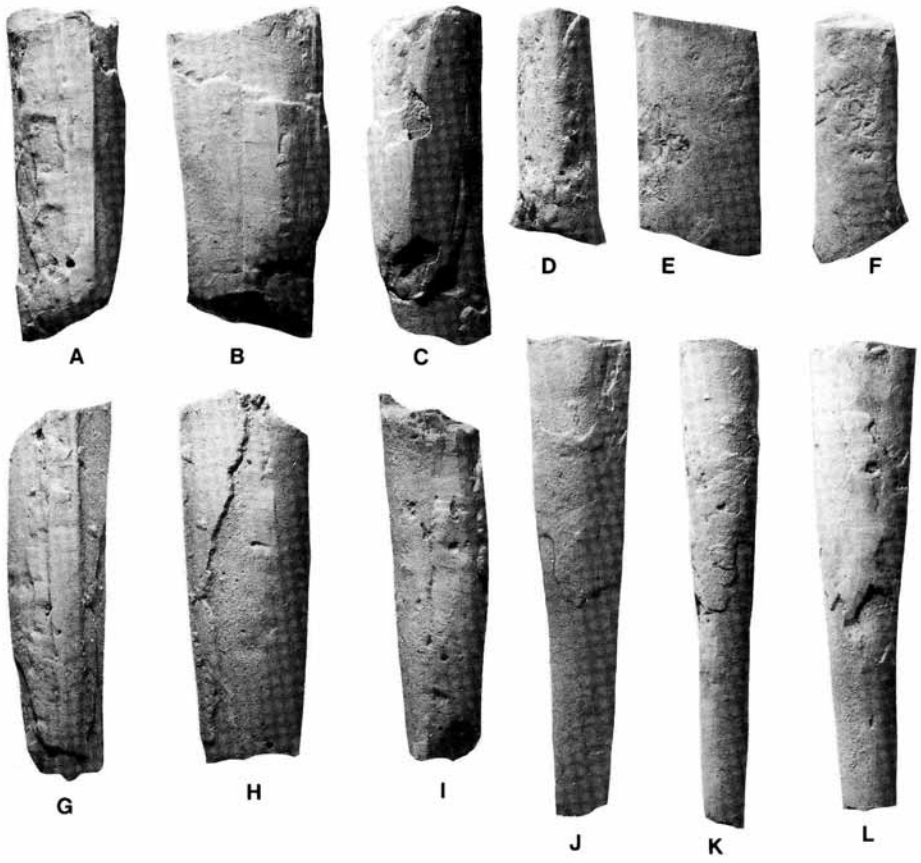
KENNEDY and HENDERSON, *Indoscaphites, Eubaculites, Fresvillia, Phylloptychoceras*



TEXT-FIG. 5. A–C, *Eubaculites carinatus* (Morton, 1834); holotype, no. 72866, collections of the Academy of Natural Sciences, Philadelphia; Prairie Bluff Chalk; Wilcox County, Alabama. D–K, *Eubaculites labyrinthicus* (Morton, 1834); syntypes, nos 72868–72869, collections of the Academy of Natural Sciences, Philadelphia; Prairie Bluff Chalk; Alabama. L–P, *Eubaculites ootacodensis* (Stoliczka, 1866); cast of lectotype; the original is in the collections of the Geological Survey of India, from Ootacod, south India (Stoliczka 1866, p. 199, pl. 90, fig. 14). All ×1.

elongated parallel to the length of the shell, linked by a low broad rib to a similarly elongated but obliquely placed mid-lateral tubercle that gives rise to delicate prorsiradiate riblets and striae, which also intercalate. The rib index is 2. This is similar to the ornament of *E. vagina*, but the venter of *E. labyrinthicus* is fastigiate rather than broadly tabulate, immediately differentiating the two species.

Eubaculites ootacodensis (Stoliczka, 1866) (= *Baculites vagina* Forbes var. *Ootacodensis* Stoliczka, 1866, p. 199, pl. 90, figs 14, ?15) (lectotype, designated by Kennedy 1987, p. 195 in the original of Stoliczka 1866, pl. 90, fig. 14, shown here as Text-fig. 5L–P), originally described from Ootacod, south India, has a binodose lectotype with fastigiate venter, which separates it from *E. vagina* (see Kennedy 1987, p. 194 for a synonymy). *E. simplex* (Kossmat, 1895) (= *Baculites vagina* Forbes var. nov. *simplex* Kossmat, p. 156 (60), pl. 19 (5), figs 13*a–b*, *non* 14*a–b* (= *E. carinatus*)) (lectotype, designated by Kennedy 1987, p. 195, is the original of Kossmat 1896, pl. 19 (5), fig. 13; Text-fig. 6D–F), from Ariyalur, south India, has a completely smooth lectotype, with a narrowly rounded, fastigiate venter, immediately separating it from *E. vagina*. Kennedy (1987, p. 194) thought *simplex* to be a synonym of *E. ootacodensis*, but study of large collections from Western Australia show, rather, that it is the senior synonym of *Eubaculiceras compressum* Brunnschweiler, 1966 (p. 36, pl. 4, figs 15–17; pl. 5, figs 1–3; text-fig. 21), *E. fastigiatum* Brunnschweiler, 1966 (p. 37, pl. 5, figs 7–9; text-fig. 22), *Cardabites tabulatus* Brunnschweiler, 1966 (p. 38, pl. 5, figs 12–15; text-fig. 23), and



TEXT-FIG. 6. A–C, G–L, *Eubaculites vagina* (Forbes, 1846); casts of the originals of: A–C, G–I, Stoliczka 1866, plate 91, fig. 1; J–L, plate 91, fig. 2; in the collections of the Geological Survey of India; from Pondicherry, south India. D–F, *Eubaculites simplex* (Kossmat, 1895, p. 156 (60), pl. 19 (5), fig. 13); cast of the lectotype; from Ariyalur, south India, collection as above. All ×1.

Cardabites scimitar Brunnschweiler, 1966 (p. 38, pl. 5, figs 16–21; text-fig. 24). The Australian material has both fastigiate and narrowly tabulate venters, and feeble undulations on the flank of some specimens. The venter of tabulate variants is always much narrower than in smooth variants of *E. vagina*.

Eubaculites latecarinatus (Brunnschweiler, 1966, p. 33, pl. 3, figs 13–14; pl. 4, figs 1–5; text-figs 17–18), of which *Giralites quadrisulcatus* Brunnschweiler, 1966 (p. 35, pl. 4, figs 11–14; text-fig. 20) and *Eubaculites ambindensis* Collignon, 1971 (p. 18, pl. 646, fig. 2393) are synonyms (see revision in Klinger (1976), and Klinger and Kennedy (*in* Klinger *et al.* 1980, p. 296, text-figs. 2–4, 5*d*)), is characterized by a lack of flank ornament and a broad tabulate venter. Lack of ornament alone distinguishes it from ribbed and tuberculate specimens of *E. vagina*, and large collections of *latecarinatus* from Zululand never show significant flank ornament, although the venter may

become notched, so that the species and populations seem distinct enough. More difficult is the distinction between *E. latecarinatus* and the smooth *Eubaculites* in the Pondicherry fauna (Pl. 5, figs 10–13; Pl.. 7, figs 4–9, 10–12; Pl. 8, figs 10–12; Pl. 9, figs 9–10; see also Stoliczka 1866, pl. 91, fig. 1 (Text-fig. 6A–C, G–I), and pl. 91, fig. 2 (Text-fig. 6J–L; the latter feebly binodose at the larger end), and the question as to whether or not these smooth individuals should be segregated as *E. latecarinatus* rather than being referred to *E. vagina*. Some *E. latecarinatus* at least have a much more compressed whorl section than the smooth Pondicherry forms, which also lack the pronounced corrugated venter of South African specimens (e.g. Klinger and Kennedy *in* Klinger *et al.* 1980, fig. 4) and their dorsal grooves and median ridge (Klinger and Kennedy *in* Klinger *et al.* 1980, fig. 30). On balance, given the apparent transition from smooth to ribbed and tuberculate individuals in the Pondicherry assemblage (not seen in South African and Australian *E. latecarinatus*), we treat them as a single species, admitting however, that some smooth individuals of *E. vagina* are morphologically inseparable from some *E. latecarinatus*.

Occurrence. Maastrichtian of Pondicherry, south India, and Madagascar. Zululand representatives (Klinger 1976) may be better referred to *E. labyrinthicus* (Morton, 1834).

Genus FRESVILLIA Kennedy, 1986*b*, p. 61

Type species. Fresvillia constricta Kennedy, 1986*b* (p. 62, pl. 14, figs 39–42; text-fig. 10*a*).

Fresvillia teres (Forbes, 1846)

Plate 5, figs 14–17; Text-fig. 2C

1846 *Baculites teres* Forbes, p. 115, p. 10, fig. 5.
1850 *Baculites teres* Forbes; d'Orbigny, p. 215.
1866 *Baculites teres* Forbes; Stoliczka, p. 197 (*pars*), pl. 90, fig. 12 only, *non* fig. 13 [not a baculitid].
1895 *Baculites teres* Forbes sp.; Kossmat, p. 155 (59).
1897*b* *Baculites teres* Forbes; Kossmat, p. 64.
1953 '*Baculites*' *teres* Forbes; Spath, p. 16.
1959*b* *Baculites*(?) aff. *B. teres* Forbes; Matsumoto, p. 163, pl. 45, figs 5–6; text-figs 82*a–c*, 83.
1986*b* *Baculites teres* Forbes; Kennedy, p. 62.
1986 *Baculites*(?) *teres* Forbes; Stinnisbeck, p. 204.

Types. The holotype, by monotypy, is BMNH C51152, the original of Forbes (1846, pl. 10, fig. 5), GSC R10490, from the Valudavur Formation of Pondicherry, south India (*ex* Kaye and Cunliffe Collection). Topotypes are BMNH C2586, and C41504–41505, removed by L. F. Spath from the type series of *Phylloptychoceras sipho*.

Description. The holotype is a fragment 46·5 mm long, septate throughout, and retaining partially exfoliated shell material. The shell is straight, slowly expanding, with a circular whorl section. Ornament is of low, broad ribs. These are weakest on the dorsum, which they cross in a broad convexity. They strengthen on the dorso-lateral area, sweep back and are markedly concave across the middle of the flank, sweeping forwards and

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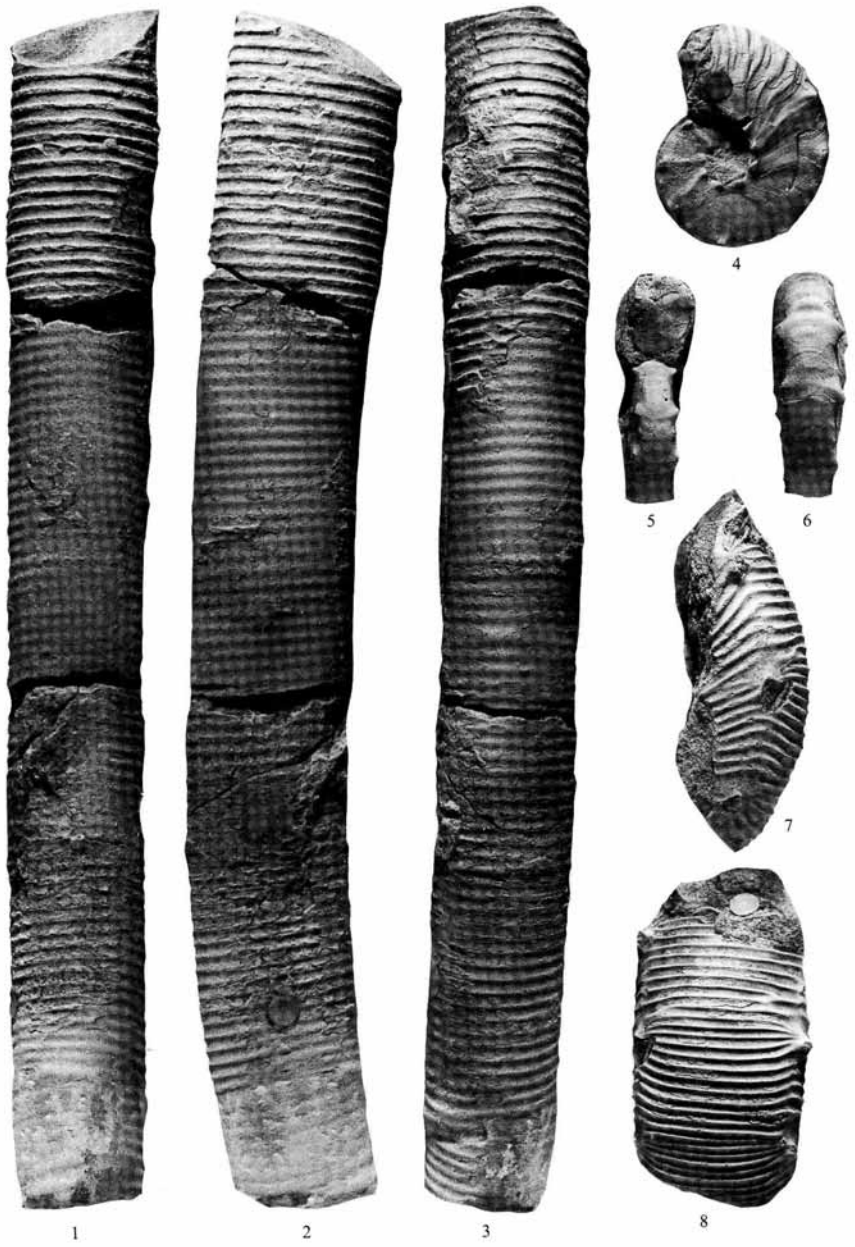
EXPLANATION OF PLATE 6

Figs 1–3. *Diplomoceras cylindraceum* (Defrance, 1816). BMNH C51102.
Figs 4–6. *Indoscaphites cunliffei* (Forbes, 1846). BMNH C5109, GSC R10480, lectotype, the original of Forbes (1846, pl. 8, fig. 2*a–b*).
Figs 7, 8. *Hoploscaphites*? *indicus* (Forbes, 1846). BMNH C51093, GSC R10489, the original of Forbes (1846, pl. 8, fig. 9).
All from the Valudavur Formation, Pondicherry, south India. All ×1.



KENNEDY and HENDERSON, *Diplomoceras*, *Indoscaphites*, *Hoploscaphites*?

straight on the ventral flanks, strengthening and crossing the venter in a broad convexity, where they are scale-like, and separated by narrow interspaces. Both ribs and interspaces are ornamented by delicate growth lines and striae, and fine riblets are developed in the outer flank. The course of the ornament thus defines a short, blunt, dorsal rostrum, and a longer, blunt ventral one. Suture (Text-fig. 2c) baculitid, with triangular, moderately incised bifid lobes and saddles.

Discussion. F. teres differs from the type species, *F. constricta* Kennedy, 1986*b* (p. 62, pl. 14, figs 39–42; text-fig. 10*a*) from the Upper Maastrichtian Calcaire à *Baculites* of Manche, France, which lacks the well-differentiated ribbing of *F. teres*, and has constrictions. *Baculites lechides* Brunnschweiler, 1966 (p. 23, pl. 1, figs 1–3; text-fig. 8) may be a *Fresvillia*, but the (worn) suture is simple in Brunnschweiler's figure. It differs from *F. teres* in having a compressed whorl section and widely separated, narrow ribs; it is perhaps closer to '*Baculites*' *columna* Morton, 1834 (p. 44, pl. 19, fig. 8), first described from the Maastrichtian Prairie Bluff Chalk of Alabama (see also Stephenson 1941, p. 405, pl. 76, figs 1–4; and Matsumoto 1959*b*, p. 161, pl. 30, fig. 1; pl. 34, fig. 4; pl. 43, fig. 4; text-figs 80–81), which also has narrow, distant ribs and a much simpler suture than *F. teres*. So too does '*Baculites*' *vincenti* Stinnisbeck, 1986 (p. 203, pl. 9, fig. 4; pl. 10, figs 3–6; text-fig. 23*a–e*), where the suture is even more simplified, and more polyptychoceratid than baculitid.

Occurrence. Maastrichtian of south India and California.

Superfamily SCAPHITACEAE Gill, 1871, p. 3
[*nom. transl.* Wright and Wright, 1951, p. 13, *ex* Scaphitidae Gill]
Family SCAPHITIDAE Gill, 1871, p. 3
Subfamily SCAPHITINAE Gill, 1871, p. 3
[*nom. transl.* Wright, 1953, p. 473 *ex* Scaphitidae Gill]
Genus HOPLOSCAPHITES Nowak, 1911, p. 565
[= *Mesoscaphites* Atabekian, 1979, p. 523 (*nom. nud.*]

Type species. Ammonites constrictus J. Sowerby, 1817, p. 189, pl. A, fig. 1, by original designation.

Hoploscaphites (?) *indicus* (Forbes, 1846)

Plate 6, figs 7–8

1846 *Ammonites*? *indicus* Forbes, p. 114, pl. 8, fig. 9.
1850 *Ammonites indicus* Forbes; d'Orbigny, p. 213.
1898 *Holcodiscus indicus* Forbes; Kossmat, p. 35 (142).
1925 *Kossmaticeras indicum* Forbes; Diener, p. 98.
1977 *Hoploscaphites indicum* (Forbes); Phillips, p. 90.

Type. Holotype, by monotypy, is BMNH C51093, the original of Forbes (1846, pl. 8, fig. 9), GSC R10489, from the Valudavur Formation of Pondicherry, south India (*ex* Kaye and Cunliffe Collection).

Description. The holotype is a body chamber fragment 52 mm long, with traces of a spar-filled nucleus preserved in the dorsal impressed zone. Coiling appears to have been moderately involute, with the whorls in

EXPLANATION OF PLATE 7

Figs 1–18. *Eubaculites vagina* (Forbes, 1846). 1–3, BMNH C77569. 4–6, BMNH C51144, a paralectotype. 7–9, BMNH C77598. 10–12, BMNH C73569. 13–15, BMNH C77594. 16–18, BMNH C49762, GSC R10488, the lectotype, the original of Forbes (1846, pl. 10, fig. 4).
All specimens from the Valudavur Formation, Pondicherry, south India. All ×1.

KENNEDY and HENDERSON, *Eubaculites*

contact, although the body chamber itself has what might be interpreted as an eccentric umbilical seam. The whorl section is depressed, with a rounded-rectangular cross section, the whorl breadth to height ratio 2·24, the greatest breadth at mid-flank. The umbilicus is deep, with a rounded wall merging with a broadly rounded umbilical shoulder. The flanks are flattened, the ventrolateral shoulders broadly rounded, and the broad venter flattened. Ornament consists of fine, sharp ribs, narrower than the interspaces. Most ribs arise at the umbilical seam, are initially weak, but strengthen to the umbilical shoulder, where a few bifurcate, and at least one bears a tiny tubercle. The ribs are variably prorsiradiate on the flank, and there are rare bifurcations and intercalations low on the flank. Groups of three or four ribs converge on, and are linked at horn-like ventral clavi (of which only two survive on the fragment), with about five nontuberculate ribs between the clavi. This bunching of ribs at clavi produces marked irregularities in rib spacing on the outermost flanks and ventrolateral shoulder. The ventral clavi are linked across the venter by four or five looped ribs, the adapical ones being concave, the adapertural ones being convex on the shoulders, before passing straight across the venter. They occasionally bifurcate, and show minor irregularities where they approach the ventral tubercles.

Little can be made of the fragmentary inner whorl, other than the outline of a tangential section. This suggests rather more compressed phragmocone whorls, with similar ribs to the body chamber and ventral tubercles. No trace of the suture survives.

Discussion. The fragmentary holotype, with its fine, sharp, looped ribs and depressed whorl section stands apart from the other scaphitids in the Pondicherry fauna. In general style, the ornament is closest to certain late Campanian *Hoploscaphites* which, although much older, have the same basic style of ribs and tubercles, as in *Hoploscaphites ikorfatensis* Birkelund, 1965 (p. 102, pl. 24, figs 1–4; pl. 25, figs 1–2; pl. 26, fig. 1; text-figs 59, 93, 121.3), or various forms illustrated by Schlüter (1871, pl. 27, figs 5–7). However, the depressed whorls and very distant nodes of *H. indicus* distinguish it from all of these.

Occurrence. As for type.

Genus INDOSCAPHITES Spath, 1953, p. 14

Type species. Ammonites cunliffei Forbes, 1846, p. 109, pl. 8, fig. 2, by original designation.

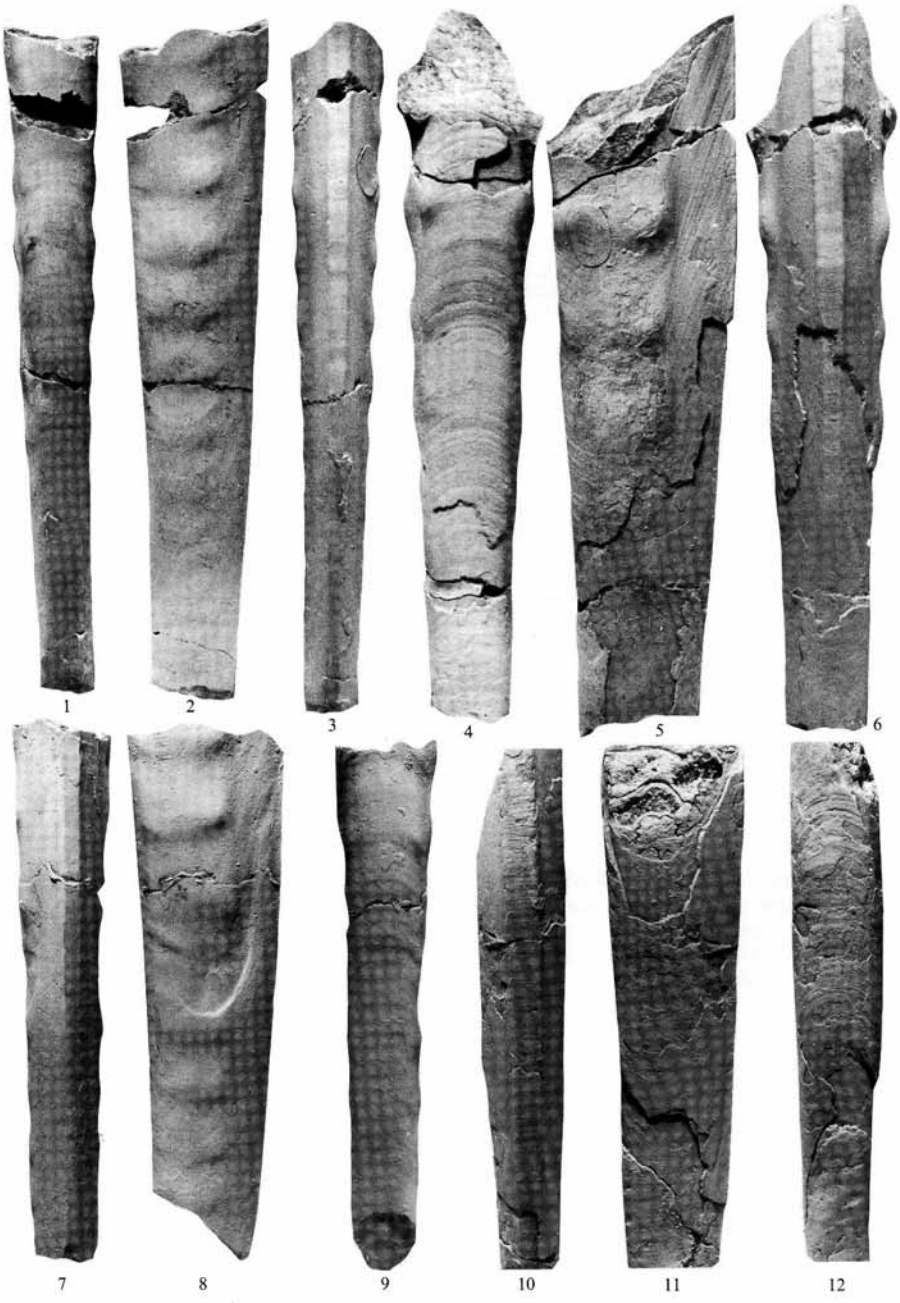
Indoscaphites cunliffei (Forbes, 1846)

Plate 5, figs, 2, 6–9; Plate 6, figs 4–6; Text-fig. 2A

1846	*Ammonites Cunliffei*, p. 109. pl. 8, fig. 2.
1850	*Ammonites Cunliffei* Forbes; d'Orbigny, p. 213.
1865	*Ammonites Cunliffei* Forbes; Stoliczka, p. 97, pl. 50, fig. 3.
1898	*Scaphites Cunliffei* Forbes sp.; Kossmat, p. 31 (138).
1903	*Ammonites* cf. *Scaphites pavana* Pervinquière, p. 126.
1907	*Scaphites Cunliffei* Forbes; Pervinquière, p. 124 (*pars*), pl. 4, figs 36–40, *non* figs 41–42 [= *I. pavana*]; figs A–C on the explanation of pl. 4; text-figs 42–44, *non* text-fig. 45 [= *I. pavana*].
1911	*Acanthoscaphites Cunliffei* Forbes; Nowak, p. 565.
1916	*Hoploscaphites Cunliffei*; Nowak, p. 66.
1925	*Acanthoscaphites Cunliffei* Forbes; Diener, p. 205.
non 1921	*Scaphites Cunliffei* Forbes sp., Van Hoepen, p. 28, pl. 5, figs 5–7.
1953	*Indoscaphites cunliffei* (Forbes); Spath, p. 14.
1977	*Indoscaphites cunliffei*; Kennedy, text-fig. 31.7–8.
1977	*Indoscaphites cunliffei* (Forbes); Phillips, p. 99.
1989	*Indoscaphites*; Kennedy, text-fig. 17*e*.

EXPLANATION OF PLATE 8

Figs 1–12. *Eubaculites vagina* (Forbes, 1846). 1–3, BMNH C51149, a paralectotype. 4–6, BMNH C51141, a paralectotype. 7–9, BMNH C2597. 10–12, BMNH C51145, a paralectotype.
All from the Valudavur Formation, Pondicherry, south India. All ×1.



KENNEDY AND HENDERSON, *Eubaculites*

Types. Lectotype, here designated, is BMNH C51090, the original of Forbes (1846, pl. 8, fig. 2*a–b*, *d*), GSC R10477. Paralectotypes are BMNH C51089, the original of Forbes (1846, pl. 8, fig. 2*c*), GSC R10478, and BMNH C51091, all from the Valudavur Formation of Pondicherry, south India (*ex* Kaye and Cunliffe Collection).

Dimensions.	D	Wb	Wh	Wb:Wh	U
BMNH C51090	35·0 (100)	12·2 (34·9)	12·9 (36·9)	0·95	10·0 (28·6)
at c	23·8 (100)	9·0 (37·8)	11·4 (47·9)	0·79	5·8 (24·4)
BMNH C51091	10·2 (100)	6·1 (59·8)	4·3 (42·1)	1·41	3·3 (32·4)

Description. The lectotype is a complete adult, the paralectotypes are juveniles. All retain traces of original shell material. The early growth stages are moderately involute, with a rounded whorl section and faint constrictions, plus an ornament of low, irregular ribs and growth striae only. By a diameter of 6·5 mm, the distinctive ornament of the species has appeared. This consists of weak, distant umbilical bullae (six or seven per half whorl at a diameter of 10·5 mm in BMNH C51089) connected by low, rounded, straight to feebly concave prorsiradiate ribs to stronger conical ventrolateral horns, the ribs broadening as they cross the flanks. The ventrolateral horns are linked across the venter by a low, broad convex rib or ribs, while there are low, variable and irregular intercalated ribs, growth lines and grooves between tuberculate groups; some ribs show a trace of an outer ventrolateral node. By this ontogenetic stage the whorl section has become progressively more compressed, the sides flattened, with greatest breadth at the umbilical tubercle, the venter very broad and rounded. The somewhat larger paralectotype, BMNH C51089 (Pl. 5, figs 7–9) shows a comparable ornament at a maximum preserved diameter of 15 mm, although there are low intercalated ribs extending to mid-flank, and distinct looping of ventral ribs and striae between the ventrolateral tubercles.

The lectotype (Pl. 6, figs 4–6) is septate to a diameter of approximately 21 mm, with two-thirds of a whorl of body chamber. The ornament of the phragmocone is as described above. The body chamber shows markedly eccentric, scaphitoid coiling, although the whorls remain in contact. The umbilical seam becomes distinctly undercut, with a sharp umbilical shoulder. The umbilical bullae become sharper and more pronounced and are progressively deflected forwards as size increases. The broad, simple ribs of the phragmocone give way to groups of much finer, sharper, irregularly developed strongly flexed prorsiradiate ribs and striae which occasionally bifurcate around mid-flank where intercalatories are inserted. They link in groups to the ventral tubercles, which are irregularly developed and disappear before the adult aperture is reached. The ribs are convex across the venter and variably developed, both linking tubercles and intercalating.

On the last sixth of a whorl before the aperture, beyond the last ventral tubercle, the ventral and ventrolateral ribbing strengthens markedly, with many ribs branching. The aperture itself is simple and entire.

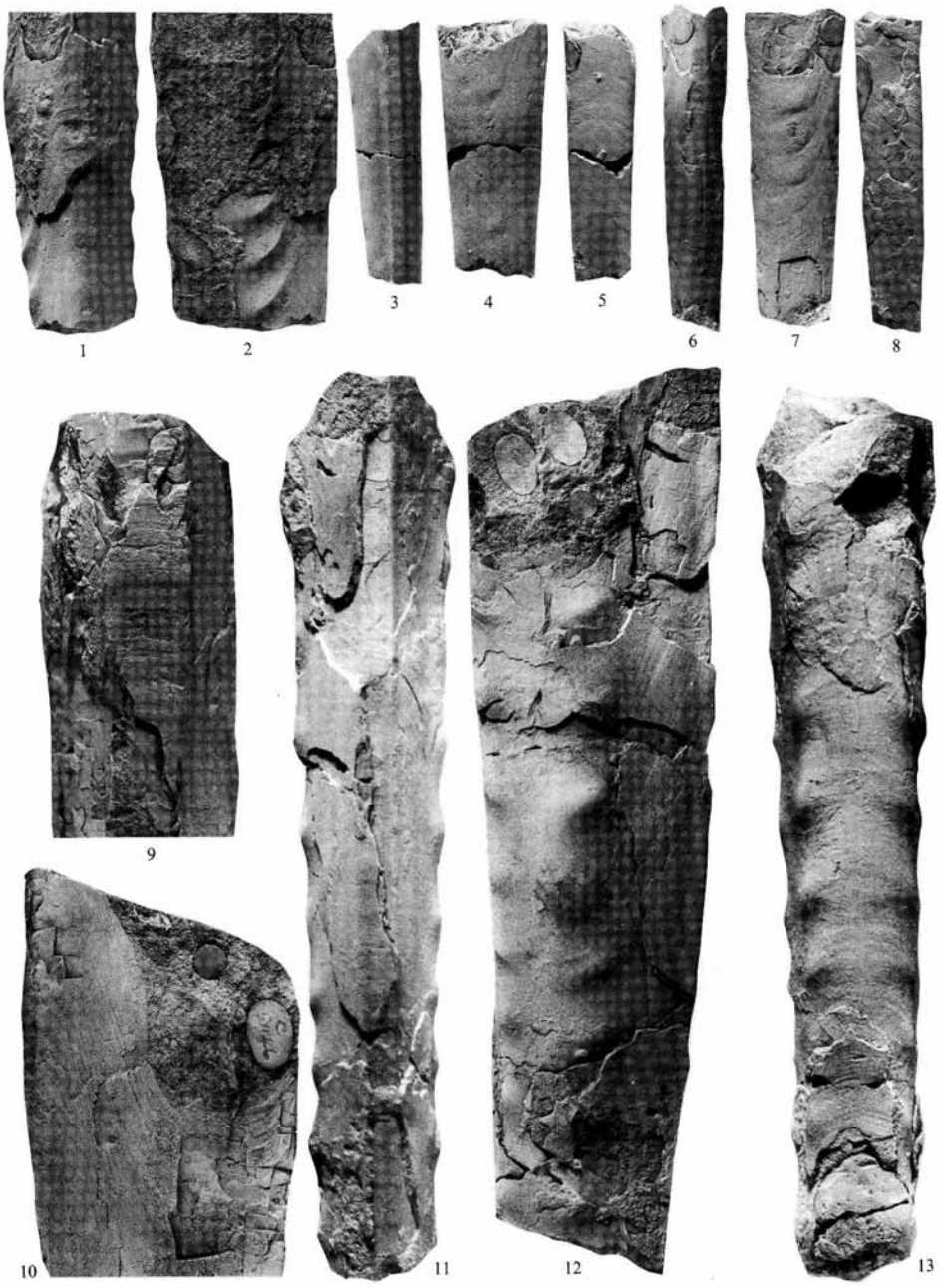
The suture line (Text-fig. 2A) is relatively simple, with asymmetrically bifid E/L and L/U; L is deep and asymmetrically trifid.

Discussion. The coarseness of flank ribs and development of strong ventrolateral horns immediately distinguishes this species from *I. pavana* (Forbes, 1846), discussed further below. Spath (1953, p. 14) thought there were morphological transitions between *Indoscaphites* and *Hoploscaphites* of the *quadrangularis* group, but these are a much larger US Western Interior scaphitid stock, referred to *Jeletzkytes* Riccardi, 1983, and bear no resemblance to the present form.

Occurrence. Maastrichtian, south India and Tunisia.

EXPLANATION OF PLATE 9

Figs 1–13. *Eubaculites vagina* (Forbes, 1846). 1–2, BMNH C7759. 3–5, BMNH C77597. 6–8, BMNH C73567. 9–10, BMNH C51146, a paralectotype. 11–13, BMNH C77593.
All from the Valudavur Formation, Pondicherry, south India. All ×1.



KENNEDY and HENDERSON, *Eubaculites*

Indoscaphites pavana (Forbes, 1846)

Plate 5, figs 1, 3–5

1846 *Ammonites Pavana* Forbes, p. 110, pl. 7, fig. 5.
1850 *Ammonites Cunliffei* Forbes; d'Orbigny, p. 213.
1865 *Ammonites Pavana* Forbes; Stoliczka, pp. 90, 98.
1898 *Scaphites Pavana* Forbes sp.; Kossmat, p. 31 (138).
1907 *Scaphites Cunliffei* Forbes; Pervinquière, p. 124 (*pars*), pl. 4, figs 41–42 only; text-fig. 45 only.
1953 *Indoscaphites pavana* (Forbes); Spath, p. 14.
1977 *Indoscaphites pavana* (Forbes); Phillips, p. 100.

Type. Holotype, by monotypy, is BMNH C51092, the original of Forbes 1846 (p. 110, pl. 7, fig. 5), GSC R10480, from the Valudavur Formation of Pondicherry, south India (*ex* Kaye and Cunliffe Collection).

Description. The holotype is only 12·2 mm in diameter, with half a whorl of body chamber, and retains much of the original shell material. Coiling is moderately involute, ammonitic rather than scaphitoid. The earliest whorls visible are compressed and rounded, but as diameter increases they become even more compressed and flat-sided. Ornament is present from the smallest diameters visible. It consists of approximately sixteen low, broad, flexuous, prorsiradiate primary ribs on the outer whorl. Initially single, they branch on the inner flank as size increases, and are accompanied by similarly flexuous growth striae. At the largest diameters preserved, these are almost falcoid: feebly concave and prorsiradiate on the inner flank, convex at mid-flank, and concave on the ventrolateral shoulder, where they bear small ventral clavi. The clavi are connected across the venter by a low convex rib or ribs, striae and growth lines, which also occur between ribs. The suture, which is imperfectly exposed, is little incised, and of *Hoploscaphites* type.

Discussion. The holotype of *Indoscaphites pavana* is easily separated from *Indoscaphites cunliffei* of similar size (Pl. 5, figs 2, 6–9), where the whorl section is broader, tubercles stronger, and ribs distant and straight, rather than crowded and flexuous. The style of ventral ornament is of the same basic type, as in the coiling, and the two species are certainly congeneric. Some authors (e.g. Pervinquière 1907) have regarded them as conspecific, but we have studied all the available specimens, including those from Tunisia; there are no intermediate forms.

Occurrence. Maastrichtian of south India and Tunisia.

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EXPLANATION OF PLATE 10

Figs 1–3. *Eubaculites vagina* (Forbes, 1846). BMNH C51140, a paralectotype; Valudavur Formation; Pondicherry, south India, × 1.

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KENNEDY and HENDERSON, *Eubaculites*

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