Naefia (Coleoidea) from the late Cretaceous of southern India

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Synopsis

The coleoid *Naefia*, previously known only from Chile, is described from the late Cretaceous Ariyalur Group of Pondicherry, southern India. Two of the specimens described each possess a well-preserved conotheca from which the form of the pro-ostracum is deduced.

Introduction

The enigmatic coleoid *Naefia neogaeia* Wetzel was first described by Wetzel (1930) from the Quiriquina Formation (Campanian–Maastrichtian) of the island of Quiriquina, Chile. He based his description on two small phragmocones that differed from true belemnites by their acute apical angle and unusual siphuncle. Jeletzky (1966) later recognized its affinities with *Groenlandibelus rozenkranzi* (Birkelund), a late Cretaceous sepiid, and included both in his new family Groenlandibelidae. *Naefia* has not been recognized from anywhere outside Chile.

In the collections of the British Museum (Natural History) are three phragmocones from the Campanian to Maastrichtian Ariyalur Group of Pondicherry, southern India, which resemble both *Naefia* and *Groenlandibelus*. The phragmocones possess many of the features of *Naefia*, and are probably congeneric with it. The purpose of this paper is to describe in detail the first specimens of *Naefia* to be found outside Chile, and to make some comments on the shell structure of this genus.

The following abbreviations have been used: BMNH, British Museum (Natural History), specimen numbers prefixed by C; GPIK, Geologisches und Paläontologisches Institut, Kiel; MMK, Mineralogical Museum, Copenhagen; Dlmax, maximum lateral diameter; Dvmax, maximum dorsoventral diameter; Dlmin, minimum lateral diameter; Dvmin, minimum dorsoventral diameter.

Systematic descriptions

Subclass **COLEOIDEA** Bather, 1888

Order **?SEPIIDA** Zittel, 1895

Family **GROENLANDIBELIDAE** Jeletzky, 1966

TYPE GENUS. *Groenlandibelus* Jeletzky, 1966.

DISCUSSION. Jeletzky (1966) erected this family for those coleoids possessing narrow belemnite-like phragmocones, reduced rostra, oblique sutures, a wide siphuncle, and a caecum and prosiphon in their protoconchs. On this evidence he considered the family an early specialized member of the Sepiida, other members of which have similar phragmocones. However, Donovan (1977) has recently questioned the validity of this assignment and considered the Groenlandibelidae, the genus *Spirula*, and similar forms, separate from the Sepiida. Reitner & Engeser (1982) went further, placing the Groenlandibelidae and *Spirula* in a separate order, the Spirulida, mainly on the form of their protoconchs. Unfortunately, the specimens described below are incomplete, and no further light can be shed on the problem until more examples are found complete with their protoconchs.

Genus *NAEFIA* Wetzel, 1930

TYPE SPECIES. *Naefia neogaeia* Wetzel, 1930, by original designation.

DIAGNOSIS. Groenlandibelidae characterized by a very narrow phragmocone (5·5–15°). Rostrum apparently much reduced or absent. Pro-ostracum spatulate, *Chondroteuthis*-like, with median keel and ridged asymptotes.

RANGE. Campanian–Maastrichtian of Chile, southern India and possibly the Antarctic Peninsula.

DISCUSSION. The form and affinities of *Naefia* have been discussed by Jeletzky (1966), and more recently by Biró-Bagóczky (1982) and Stinnesbeck (1986). Jeletzky (1966) re-examined the type specimens of *Naefia neogaeia* (GPIK 121a, b) and deemed them to be close to *Groenlandibelus rozenkranzi* (Birkelund) (holotype MMK MGUH.7758; see Birkelund 1956), uniting them in his new family Groenlandibelidae.

Naefia aff. *neogaeia* Wetzel, 1930
Figs 1–4

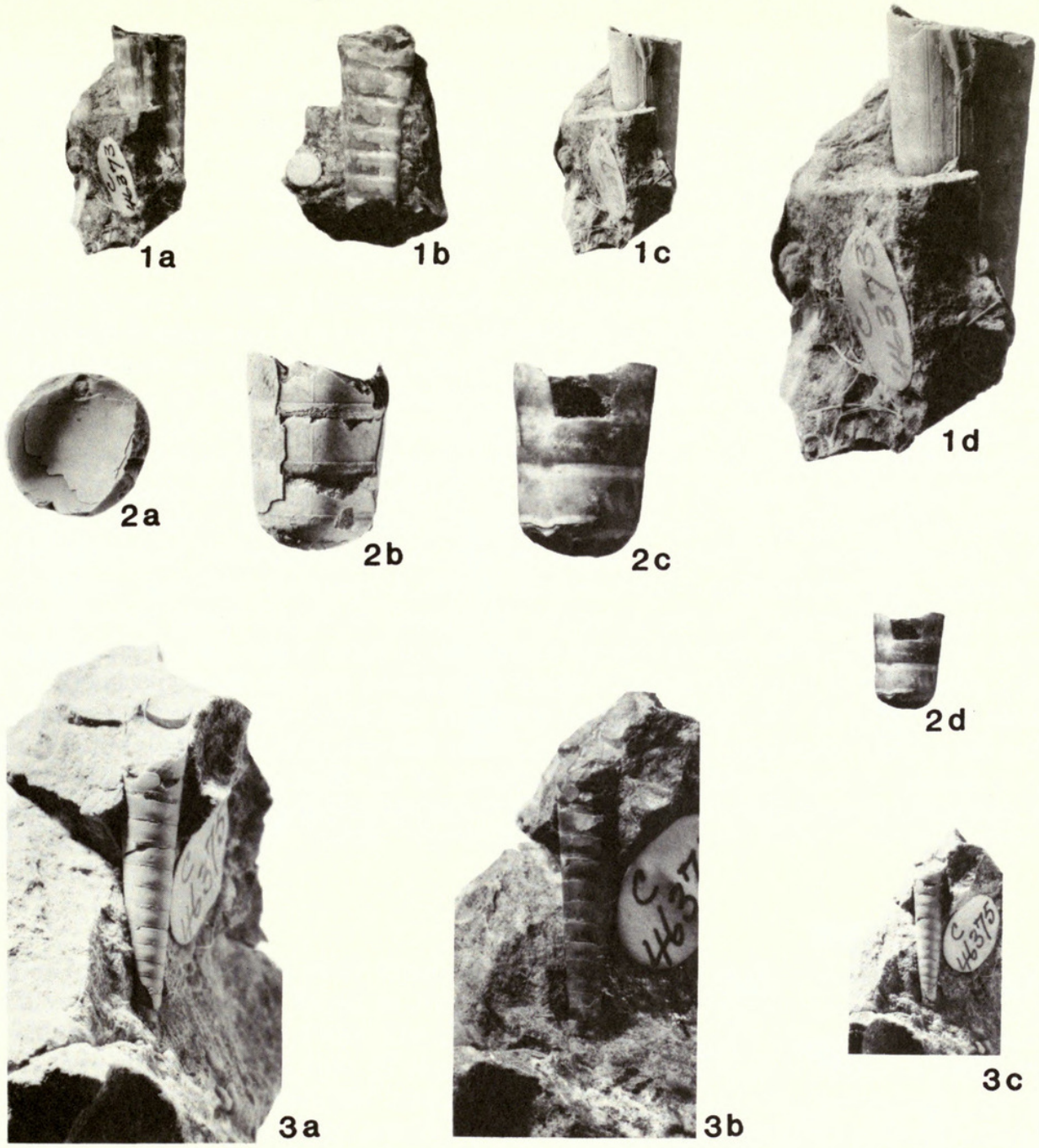
v 1846 *Belemnites* Forbes: 118; pl. 9, figs 4a, b (*non* fig. 3).
aff. v 1930 *Naefia neogaeia* Wetzel: 92; pl. XIV, fig. 3.
aff. 1982 *Naefia neogaeia* Wetzel; Biró-Bagóczky: A20; pl. 1, figs 1–5.
aff. 1986 *Naefia neogaeia* Wetzel; Stinnesbeck: 209; pl. 6, figs 6–7.

MATERIAL. Three phragmocones (BMNH C.46373-5) from the Campanian to Maastrichtian Ariyalur Group (Mettuveli–Valudayur formations), Pondicherry, southern India.

DESCRIPTION. *Naefia* aff. *neogaeia* is a small to medium-sized regular orthoconic phragmocone, with an apical angle of 5·5–8·5°, and apparently without a rostrum. The camerae are relatively high, the height to diameter ratio being 0·30–0·45. The septal sutures are oblique, and each possesses a ventral lobe. Details of the siphuncle are limited, but the connecting rings appear to be expanded adorally in the centre of the camerae. The pro-ostracum is *Chondroteuthis*-like, with a narrow spatulate form, a relatively wide median field, ridged median asymptotes and narrow hyperbolar zones.

Specimen C.46373 (original of Forbes 1846: pl. 9, fig. 4a) (Figs 1a–d, 4). This specimen is the largest of the three (maximum preserved length 24.5 mm), and consists of an orthoconic phragmocone with seven camerae preserved, although with apex and aperture missing. The maximum diameters of the shell are: 9·35 mm (Dlmax) and 9·80 mm (Dvmax), while the minimum diameters are: 6·25 mm (Dlmin) and 6·80 mm (Dvmin). The phragmocone has a regular undeflected axis and an apical angle of 8·5°. In cross section the phragmocone is slightly compressed. The height of the apical-most preserved camera is 3·05 mm, while that of the oral-most camera is 3·60 mm. The septal sutures are oblique to the long axis, and a ventral lobe is seen where the venter is exposed. The siphuncle is difficult to observe in this specimen. The dorsal conotheca is well preserved, and bears a median field with a median keel, ridged median asymptotes and narrow hyperbolar zones (see discussion below). However, it is not clear in hand specimen how many layers comprise the conotheca, although it appears to be more than one (cf. Jeletzky 1966).

Specimen C.46374 (original of Forbes 1846: pl. 9, fig 4b) (Figs 2a–d). This specimen is also an orthoconic phragmocone (maximum preserved length 11·80 mm), but with only three camerae (from the mid-region) preserved. The maximum diameters are: 8·45 mm (Dlmax) and 8·75 mm (Dvmax), while the minimum diameters are: 7·50 mm (Dlmin) and 7·65 mm (Dvmin). This phragmocone is generally similar to the last, with an undeflected long axis, an apical angle of 8° and a slightly compressed cross section. The height of the apical-most preserved camera is 3·30 mm, while that of the oral-most camera is 3·95 mm. The sutures are less oblique in this specimen than in the last, but again, a ventral lobe is developed. The siphuncle is just visible beneath the conotheca, and it is evidently marginal. Its actual form is difficult to determine in hand specimen, but the ?connecting rings appear to expand adorally. The width of the siph-



Figs 1–3 *Naefia* aff. *neogaeia* Wetzel. Ariyalur Group, Campanian–Maastrichtian, Pondicherry, southern India. Fig. 1, C.46373. 1a, dorsum, uncoated, × 1; 1b, right lateral view showing oblique septa (venter to right), uncoated, × 1; 1c, dorsum, coated, × 1; 1d, same view showing detail of the pro-ostracum, coated, × 2. Fig. 2, C.46374. 2a, oral-most septum showing ventrally-placed siphuncle, coated, × 2; 2b, dorsum showing median keel, coated, × 2; 2c, oblique ventral view (displaced to the left) showing faint outline of the siphuncle through the conotheca, uncoated, × 2; 2d, same view, uncoated, × 1. Fig. 3, C.46375. 3a, right lateral view showing oblique septa (venter to right), coated, × 2; 3b, oblique ventral view (displaced to the right), showing the ventral lobes, uncoated, × 2; 3c, same view, coated, × 1.

uncle is 1·50 mm where it is exposed on the lower surface of the apical-most septum. The conotheca is well preserved on the venter, but less so on the dorsum. However, enough is preserved to enable one to distinguish a median keel similar to that seen in the median field of the first specimen.

Specimen C.46375 (Figs 3a–c). This is a small (preserved length 17·35 mm) orthoconic phragmocone with 14 camerae, but without the apex or aperture preserved. The shell is slender and fragile, and is partly embedded in a matrix of bioclastic limestone. The following diameters

were obtained: 4·25 mm (Dvmax); 1·95 mm (Dlmin), giving an indication of its small size. This phragmocone, like those described above, is regular in form, with a straight long axis, and an apical angle of 5·5°. It is slightly compressed in cross section. The height of the apical-most camera is 0·75 mm while that of its oral-most camera is 1·25 mm. The protoconch is not preserved. The septal sutures are notably oblique, and a ventral lobe is very clearly displayed. The siphuncle is visible in the spar-filled camerae, and is marginal, close to the venter. Although again difficult to confirm in hand specimen, the connecting rings appear inflated adorally in the centre of the camerae. Unfortunately no details of the form of the septal necks can be determined. There are no traces of conotheca preserved with this specimen.

FORM OF THE PRO-OSTRACUM. The well-preserved conothecae of C.46373–4 enable a reasonably accurate picture of the pro-ostracum of this species to be drawn. It possesses a relatively broad median field (in comparison with that of *Groenlandibelus*, see below) in the centre of which is a median keel. The median keel is itself divided by a sulcus running down its centre (Figs 1d, 4). The median field is bounded by median asymptotes which are unique in that each has a narrow ridge bounded by two sulci (Figs 1d, 4). The median asymptotes are bounded in turn by narrow hyperbolar zones, approximately one-third of the width of the median field. The parabolar growth lines of the median field are difficult to discern, and this makes estimation of the overall length of the pro-ostracum difficult. In form, the pro-ostracum described resembles that of the early Jurassic ?belemnoteuthid *Chondroteuthis* which is spatulate although much narrower than the 'typical' belemnite pro-ostracum (e.g. as figured by Crick, 1896). However, the pro-ostracum of *Chondroteuthis* attains a great length, up to three times that of the phragmocone (Jeletzky 1966), and it lacks the distinct ridged asymptotes seen in these specimens of *Naefia* (see Böde 1933) (Fig. 5). The morphological similarity of *Chondroteuthis* to the Groenlandibelidae has been noted elsewhere, although on different features (Jeletzky 1966), but it is unlikely that it is directly related to this family. Pro-ostraca of the Belemnitellidae (a late Cretaceous boreal belemnite family) also resemble that of *Naefia*, possessing a median keel bounded in

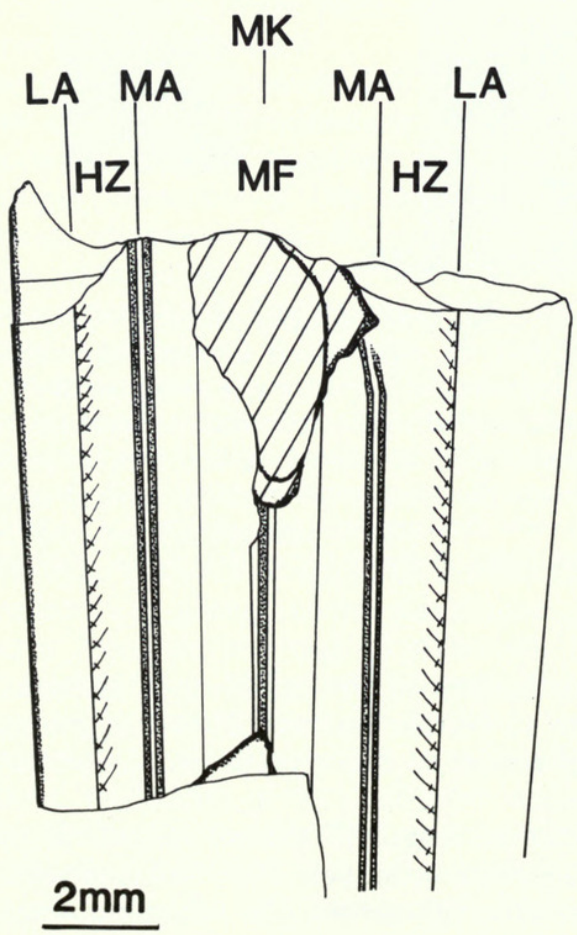


Fig. 4 Simplified camera-lucida drawing of the dorsal conotheca of specimen C.46373, showing the divided median keel and ridged median asymptotes. Cross-hatched area represents a detached conothecal fragment. Key to symbols: MK, median keel; MF, median field; MA, median asymptote; HZ, hyperbolar zone; LA, lateral asymptote.

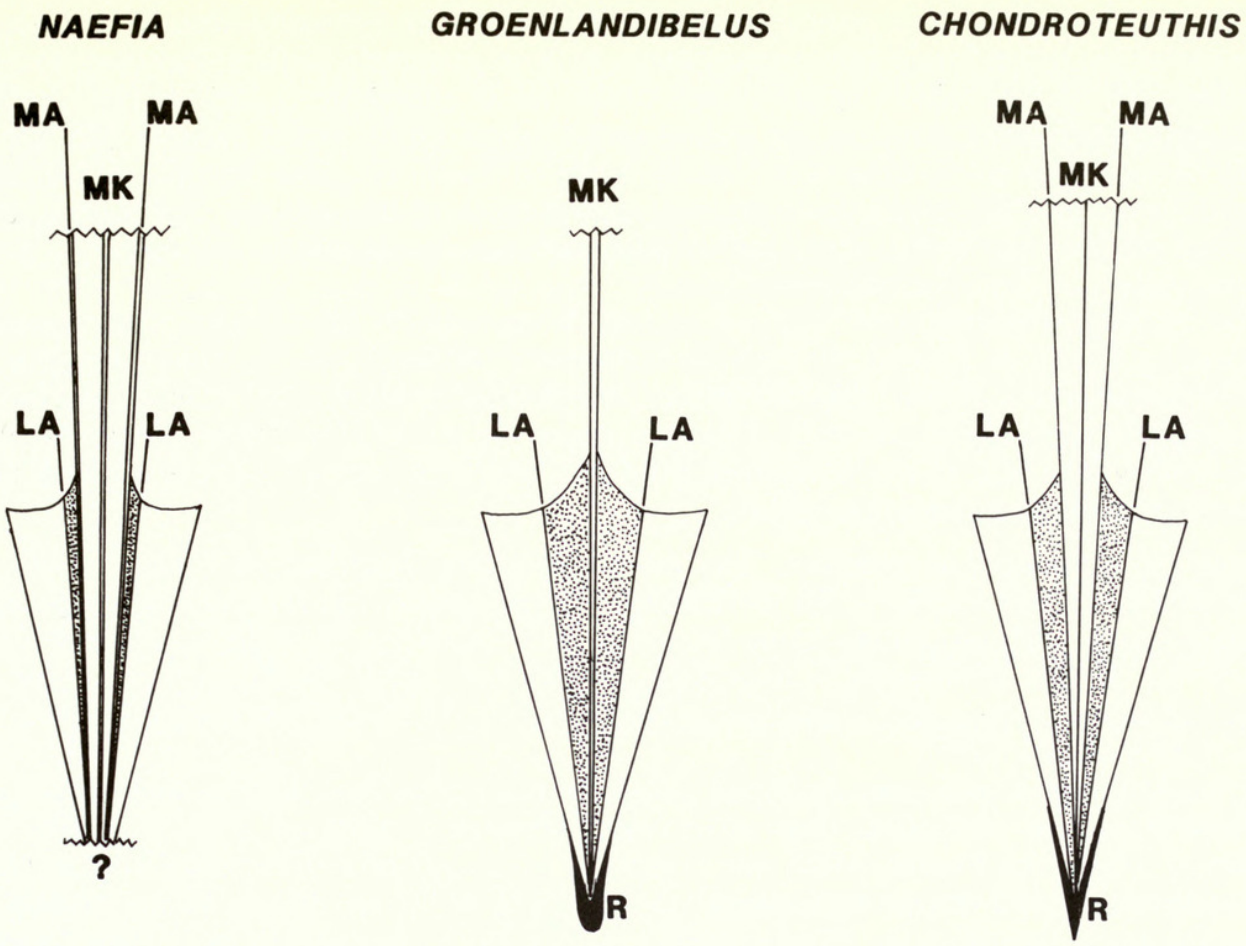


Fig. 5 Schematic comparison of the phragmocones and pro-ostraca of *Naefia*, *Groenlandibelus* and *Chondroteuthis*, not to scale. Stipple, hyperbolar zones; R, rostrum. Other symbols as given in Fig. 4.

some cases by ridges (Jeletzky 1966; Gustomesov 1980). However, belemnitellid phragmocones possess a ventral process not found in *Naefia*, and they have smooth median asymptotes and shorter camerae (Gustomesov 1980). The pro-ostracum of the other groenlandibelid, *Groenlandibelus*, is very different from that of *Naefia* (Fig. 5). Although both possess a median keel, *Groenlandibelus* lacks the additional median field that *Naefia* has, having instead very broad hyperbolar zones (Birkelund 1956; Jeletzky 1966). These broad zones are similar to those seen in the diplobelinid belemnites (Jeletzky 1966, 1981), which are also characterized by a median keel. Stinnesbeck (1986) has described a faint line on the dorsal conotheca of his Chilean *Naefia*, and this could be an incompletely preserved median keel as seen in the Indian specimen C.46374 (Fig. 2b). He also suggested that the conothecal growth lines of his specimens indicated the presence of a narrow pro-ostracum, which would appear to agree well with the Indian specimens.

The form of the pro-ostracum of the Indian *Naefia* does not necessarily preclude their assignment to the Groenlandibelidae (cf. Stinnesbeck 1986). Owing to the fragile nature of this structure (see Hewitt & Pinckney 1982), little is known about the variation in form of the pro-ostracum at genus and family level, although it is generally assumed that variation is small in taxa of low rank. Indeed, the only other sepiid pro-ostracum known, that of *Vasseuria* (Naef 1922: text-fig. 94e) is apparently spatulate (like *Naefia*), rather than thin and diplobelinid-like (as in *Groenlandibelus*).

Discussion. The specimens described above are similar to *Naefia neogaeia* Wetzel and *Groenlandibelus rozenkranzi* (Birkelund) in the overall form of the phragmocone, the obliquity of its sutures and the presence of a ventral lobe. They apparently lack rostra (like *N. neogaeia*) and

differ from *G. rozenkranzi* in possessing a *Chondroteuthis*-like pro-ostracum. In addition, the Indian forms are rather larger than these species, with an extremely acute apical angle (5·5–8·5°, compared with 12·5–14° for *N. neogaeia* and 14–15° for *G. rozenkranzi*). Despite this, the broad morphological similarity between the Indian and Chilean forms would suggest they are congeneric. More certain attribution of the Indian forms to *Naefia neogaeia* depends on the definite recognition of the form of the pro-ostracum in topotypes of this species. The morphological differences between the Indian forms and *Groenlandibelus rozenkranzi* would appear to prevent their assignment to *Groenlandibelus* (see below).

In his original description of *Naefia neogaeia*, Wetzel (1930: 92) included some specimens described by Kilian & Reboul (1909) from Antarctica. Although stating their phragmocones were orthoconic, these authors gave no further morphological details, and this assignment must be treated with some doubt. Wetzel (1930) also referred to the Indian phragmocones figured by Forbes (1846). However, he excluded them from this species because they occurred with several fragments of belemnite rostra (see below).

AGE AND STRATIGRAPHICAL HORIZON. The molluscan fauna described by Forbes (1846) from Pondicherry has long been noted for its richness. The ammonites have been used as an example of a high diversity Maastrichtian fauna (Kennedy 1977: text-fig. 31). It includes a rich association of the genera *Brahmaites*, *Gaudryceras*, *Pachydiscus* and *Phylloptychoceras* (amongst others), indicating an age of Campanian to Maastrichtian (Kossmat 1897; Bhalla 1983; Henderson & McNamara 1985).

The belemnite phragmocones described above were found at Pondicherry with some poorly preserved fragments of rostra. The latter were tentatively assigned a new species name (*Belemnites? fibula*) by Forbes (1846) and consist of fragments of a compressed species, apparently possessing broad lateral depressions (Doyle 1985), which has been assigned to the early Cretaceous genus *Parahibolites*. Kossmat (1897: pl. VI, fig. 7) described more of these fragments and recognized that they were found in the ammonite-poor *Trigonarca* Beds (Mettuveli Formation, Maastrichtian). There is no direct evidence to link the belemnite phragmocones (treated entirely separately by Forbes, 1846) and the rostra, either morphologically or stratigraphically. The phragmocone of *Parahibolites* and its related forms (e.g. *Neohibolites*) is typically belemnitic, with an apical angle of 25–30° and a broad spatulate pro-ostracum, unlike that described above. In addition the matrix adhering to the rostra is a glauconitic sand, unlike the bioclastic shelly limestone enclosing the phragmocones. This limestone matrix is like that attached to the ammonites described by Forbes (1846), which are preserved in the British Museum (Natural History). The phragmocones may therefore have come from the ammonite-rich and stratigraphically lower Valudayur Beds (Valudayur Formation, Campanian–Maastrichtian).

Conclusions

1. *Naefia* differs from *Groenlandibelus* primarily on the form of its pro-ostracum, suggesting significant differences may exist in this feature at the generic level in other phragmocone-bearing coleoids.

2. The groenlandibelids were restricted to the Campanian–Maastrichtian time interval, *Groenlandibelus* in the boreal regions (only Greenland so far) and *Naefia* in the austral regions (South America, southern India and possibly Antarctica). Their phylogenetic relationships are as yet unclear.

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References

Bhalla, S. N. 1983. India. *In* Moullade, M. & Nairn, A. E. M. (eds), *The Phanerozoic Geology of the World*, **II Mesozoic** (B): 305–352. Amsterdam.

Birkelund, T. 1956. Upper Cretaceous belemnites from West Greenland. *Meddr Grønland*, Copenhagen, **137** (9): 1–28, pl. 1.

Biró-Bagóczky, L. 1982. Contribución al conocimiento de *Naefia neogaeia* Wetzel, Coleoidea, en la Formación Quiriquina, Campaniano–Maastrichtiano, Region del Bió-Bió, Chile, Sudamerica (36° 30′–36° 45′ Lat. Sur). *Actas III Congr. geol. Chileno*, Concepción, **1:** A17–A28.

Böde, A. 1933. *Chondroteuthis Wunnenbergi* n. gen., n. sp., eine neue Belemnoideenform in günstiger Erhaltung. *Jber. niedersächs. geol. Ver.*, Hannover, **25:** 33–66.

Crick, G. C. 1896. On the proostracum of a belemnite from the Upper Lias of Alderton, Gloucestershire. *Proc. malac. Soc. Lond.*, **2:** 117–119.

Donovan, D. T. 1977. Evolution of the Dibranchiate Cephalopoda. *In* Nixon, M. & Messenger, J. B. (eds), The Biology of Cephalopods. *Symp. zool. Soc. Lond.*, **38:** 15–48.

Doyle, P. 1985. 'Indian' belemnites from the Albian (Lower Cretaceous) of James Ross Island, Antarctica. *Bull. Br. Antarct. Surv.*, Cambridge, **69:** 23–34.

Forbes, E. 1846. Report on the Cretaceous fossil invertebrates from south India, collected by Mr Kaye and Mr Cunliffe. *Trans. geol. Soc. Lond.*, **7:** 97–174.

Gustomesov, V. A. 1980. [The phragmocone in the genus *Belemnella*]. *Paleont. Zh.*, Moscow, **1980** (1): 72–77. [In Russian; Engl. transl. *Paleont. J.*, Washington, **14** (1): 58–62].

Henderson, R. A. & McNamara, K. J. 1985. Maastrichtian non-heteromorph ammonites from the Miria Formation, Western Australia. *Palaeontology*, London, **28:** 35–88.

Hewitt, R. A. & Pinckney, G. 1982. On the occurrence and microstructure of the phragmocone and pro-ostracum of the belemnite genus *Acroteuthis* Stolley. *Palaeontographica*, Stuttgart, (A) **179:** 142–147.

Jeletzky, J. A. 1966. Comparative morphology, phylogeny and classification of fossil Coleoidea. *Paleont. Contr. Univ. Kans.*, Lawrence, **42** (Mollusca Art. 7). 162 pp., 25 pls.

—— 1981. Lower Cretaceous diplobelinid belemnites from the Anglo-Paris Basin. *Palaeontology*, London, **24:** 115–145.

Kennedy, W. J. 1977. Ammonite evolution. *In* Hallam, A. (ed.), Patterns of evolution, as illustrated by the fossil record. *Devs Palaeont. Stratigr.*, Amsterdam, **5:** 251–304.

Kilian, W. & Reboul, P. 1909. Les Céphalopodes Néocrétacés des îles Seymour et Snow-Hill. *Wiss. Ergebn. schwed. Südpolarexped.*, Stockholm, **3 Geol. Pal.** (6): 1–75, pls 1–20.

Kossmat, F. 1897. The Cretaceous deposits of Pondicherri. *Rec. geol. Surv. India*, Calcutta, **30:** 51–110.

Naef, A. 1922. *Die fossilien Tintenfische; eine paläozoologische Monographie.* 322 pp. Berlin.

Reitner, J. & Engeser, T. 1982. Phylogenetic trends in phragmocone-bearing coleoids (Belemnomorpha). *Neues Jb. Geol. Paläont. Abh.*, Stuttgart, **164**: 156–162.

Stinnesbeck, W. 1986. Zu den faunistischen und palökologischen Verhältnissen in der Quiriquina Formation (Maastrichtian), Zentral Chiles. *Palaeontographica*, Stuttgart, (A). (In press).

Wetzel, W. 1930. Die Quiriquina-Schichten als Sediment und paläontologisches Archiv. *Palaeontographica*, Stuttgart, **73:** 49–104.