

THE IDENTITY OF THE NON-MARINE OSTRACOD *CYPRIS SUBGLOBOSA* SOWERBY FROM THE INTERTRAPPEAN DEPOSITS OF PENINSULAR INDIA

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ABSTRACT. During an investigation of type collections in The Natural History Museum, London, made in India during the nineteenth century, the syntypes of *Cypris subglobosa* Sowerby have been re-discovered. This species is shown to belong to the genus *Paracyprretta* and to be confined to the Upper Cretaceous, and possibly Palaeocene, non-marine intertrappean deposits of the Indian Deccan Volcanic Province. The numerous and widespread Recent and Quaternary records of this taxon are of a separate species that belongs to the genus *Cypris*. The examination of comparative material from a number of localities in India reveals the presence of two other contemporary species of *Paracyprretta*, *P. jonesi* Bhatia and Rana and *P. elizabethae* sp. nov., which is formally described herein.

KEY WORDS: *Cypris subglobosa*, intertrappean beds, Deccan Volcanic Province, late Cretaceous, ?Palaeocene, India.

SINCE its original description, the non-marine ostracod *Cypris subglobosa* J. de C. Sowerby (*in* Malcolmson 1840) has been confused by a number of subsequent authors, who have led others along various paths of error. The present contribution is an attempt to rectify the situation by re-examining Sowerby's syntypes in the collections of the Department of Palaeontology, The Natural History Museum, London (NHM). Additional specimens from the NHM, together with other, contemporary material, from a number of intertrappean localities within the Deccan Volcanic Province of Peninsular India, were also examined. Together with *C. subglobosa*, a number of other species, all of which are demonstrated to belong to *Paracyprretta* Sars, are shown to occur in these deposits.

The resolution of this problem is imperative, given particularly the increased interest in the Deccan volcanics, which were extruded in the late Cretaceous (probably entirely Maastrichtian), and earliest Palaeocene. Their significance in the debate concerning alleged mass extinctions at the Cretaceous/Tertiary boundary is considerable (Bajpai and Prasad 2000). Ostracoda, together with Charophyta, palynomorphs, Mollusca and the bones and comminuted eggshells of dinosaurs, are very abundant fossils in the intertrappean deposits. The ostracods have been the subject of considerable research.

PREVIOUS RESEARCH ON INDIAN NON-MARINE UPPER CRETACEOUS OSTRACODA

Sowerby (1840), Carter (1852), and Jones (*in* Hislop 1860) first reported Ostracoda from the intertrappean beds. Following these pioneering studies, Bhatia and co-workers (Bhatia and Rana 1985; Bhatia *et al.* 1990*a, b*, 1996) described ostracods from a number of localities and discussed their age and biogeographical affinities. Prasad (1986) recorded five species of Ostracoda from Asifabad in Andhra Pradesh, while Mathur and Verma (1988) described a fauna from the intertrappean beds of Rajasthan. Singh (1995) and Singh and Sahni (1996) discussed the age and faunal affinities of the Bombay intertrappeans, based on a variety of fossil groups with special attention being given to the Ostracoda. Udhoji and Mohabey (1996) considered the Ostracoda in their study of the age and palaeozoogeographical implications of the late Cretaceous Lameta Formation of Maharashtra. Sahni and Khosla (1994) and Khosla and Sahni (2000) reported the occurrence of Ostracoda in the Lameta Formation of the Jabalpur Cantonment in Madhya Pradesh. Bhandari and Colin (1999) described an important fauna from Anjar, Kachchh.

The faunas from three localities in Kachchh (Kutch), in the state of Gujarat, have been published in recent years: from Lakshmipur (Whatley and Bajpai 2000a), Anjar (Whatley and Bajpai 2000b), and Kora (Bajpai and Whatley 2001). Another fauna, with several new taxa, has been described from two localities, Chandarki and Yanagundi in Gulbarga District, Karnataka State (Whatley *et al.* 2002). A further paper by the same authors, on the Ostracoda from Mohagaonkala in the Chhindwara District of Madhya Pradesh, has also been published (Whatley *et al.* 2003a) and another on the Ostracoda from Mamoni, in the Kota District of Rajasthan (Whatley *et al.* 2003b).

Further work on the intertrappean Ostracoda is in hand. Studies of other taxa from the collections in The Natural History Museum, London, and from new Indian localities, as well as a comprehensive review of Indian intertrappean Ostracoda, with particular reference to their age, palaeoecology, zoogeographical distribution, affinities and evolution are in progress.

Many of the species encountered in these recent studies by two of us (RW and SB) had not been described previously, and many have been assigned to genera not hitherto recorded from these deposits. Other species are shown to have been previously assigned incorrectly to contemporary species described from Mongolia and China. Whatley and Bajpai (2000c) have shown that the Indian late Cretaceous intertrappean ostracods do not, as previously stated by many authors, indicate close Asian affinities. Rather, at the specific level they clearly constitute an endemic Indian fauna, in that the only species to occur in both India and China (although it is not recorded in Mongolia) is the European species *Frambocythere tumiensis* (Helmdach), although the occurrences differ at subspecies level. In other respects, they exhibit as much affinity with African and European late Cretaceous ostracods as they do with other Asian faunas. Chinese and Mongolian faunas, while containing representatives of many of the genera that occur in India, are dominated by *Cypridea*, its allies and descendants. *Cypridea* and allies, however, are absent from most contemporary Indian faunas and where they do occur, they are always very subordinate.

The Indian intertrappean Cypridacea are quite similar to African and European Cretaceous taxa, although no species seem to occur in common. However, the abundant and diverse species of the cytherid *Gomphocythere* Sars in the Indian fauna are somewhat similar to such African species as *Cytheridella* sp. of Colin *et al.* (1997) from the Upper Cretaceous of Mali, West Africa and even to such species as *Theriosynoecum camerounensis* Colin from the Aptian/Albian of Cameroun and a number of species, referred to variously as *Theriosynoecum* and *Metacypris* Brady and Robertson, by Colin and Dépêche (1997, pl. 5) from Chad. *Theriosynoecum silvai* (Silva) and *T. munizi* (Silva), described by Silva (1978) from the contemporary and almost adjacent Aripé Basin in Brazil, are also similar in some respects.

Age of the faunas

Most of the intertrappean ostracod faunas described by the various authors cited above are of late Cretaceous, Maastrichtian age, based on localities whose absolute age is known from radiometric dates obtained on the basalt flows that constrain them. Most modern studies on the age of the Deccan Traps, based on radiometric analyses, indicate that the volcanic activity was initiated during the Maastrichtian, at about 68 Ma and ceased during the early Palaeocene at around 60 Ma, with the major pulse at 65 Ma (Duncan and Pyle 1988; Sahni and Bajpai 1988; Venkatesan *et al.* 1996).

Many species are also shared with the Maastrichtian Lameta Formation, which is stratigraphically contiguous with the intertrappeans but is not constrained by lava flows. A feature of the Upper Cretaceous ostracod faunas of the intertrappeans is that each new locality studied seems to contain a percentage of new species, which often subsequently prove to be to a certain degree endemic, while the remainder are more geographically widespread, perhaps more environmentally tolerant taxa. To what extent this is environmental/ecological and to what extent truly zoogeographical is a moot point. The differences in the faunas of even quite closely situated localities do not, however, seem to be due to their being of different ages, largely because of the wealth of radiometric dates available.

The material we have studied in the NHM collections is variously labelled 'Cretaceous' or 'Tertiary'. Many intertrappean localities once considered to be Tertiary, some even Neogene, are now known, on the basis of radiometric and/or palaeontological evidence, to be late Cretaceous in age. Samples from many of

these localities are frequently full of comminuted fragments of dinosaur eggs (Bajpai and Srinivasan 1993; Srinivasan 1996) and their skeletal remains are also not uncommon (Sahni and Bajpai 1988). On the basis of all the Ostracoda and associated fossil biota we believe most, if not all of the NHM samples to be from the Upper Cretaceous although, as indicated below, one sample is possibly of Tertiary, probably Palaeocene age.

MATERIAL

Following a thorough study of The Natural History Museum's collections and registers, a large number of Indian Intertrappean ostracods of important historical and taxonomical significance have come to light. These include syntypes of two species, *Cypris subglobosa* and *C. cylindrica* described by J. de C. Sowerby (in Malcolmson 1840), which had previously been considered lost. They were found (unnamed) in the J. G. Malcolmson Collection, transferred to the NHM when the Geological Society of London's (GSL) overseas collections were donated and rehoused there in 1911. Unfortunately, a similar success cannot be claimed for three other Intertrappean species described in the nineteenth century: *Cypris hislopi*, *C. hunteri* and *C. strangulata* described by Jones (in Hislop 1860), or for the material described by Carter (1852) from Bombay: *Cypris semi-marginata*, *C. cylindrica* Sowerby, and *Cypris* sp.

Sowerby studied material collected by Malcolmson in the 1830s from the Sichel Hills (near Munoor, near Hutnoor and in the Mucklenudy Pass, leading to the Berar Valley). Jones studied material collected in the 1830s in the neighbourhood of Nagpur, by the Revs Hislop and Hunter, two clergymen with an interest in natural history. Carter's material was collected by himself from non-marine shales on the island of Bombay. From their description and illustration it is clear that Jones' species were represented by matrix-free specimens. However, virtually all the material in the NHM collections attributable to the Revs Hunter and Hislop are hand specimens in the form of pieces of (mainly) chert, containing impressions or moulds of ostracods, often in a good state of preservation.

In our search for the Jones (1860) Collection, we have consulted the list of types and figured specimens in the collections of the GSL, verified and arranged by Blake (1902), after curation by Sherborn nine years prior to the transfer of these collections to the NHM, then the British Museum (Natural History). Blake recorded the type and figured specimens of other fossils in the GSL Collection described in Hislop (1860). Significantly, however, none of the three ostracod species described by Jones in this paper is listed by Blake. As we have long suspected, Jones's material came neither to the GSL nor to the NHM. We presume, therefore, that it was either sold with his effects on his death, or is otherwise lost.

In Blake's (1902) list of the type and figured specimens recognised and catalogued by C. D. Sherborn, the type and figured specimens of plate 47 of Sowerby (1840) are as follows: figure 2, *Cypris cylindrica* are referred to numbers R 10407 and R 10409 in the GSL collections, those of figure 3 of the same plate, *Cypris subglobosa*, to numbers R 10407 and R 10410.

When the overseas part of the GSL collections came to the NHM in 1911, it was for the most part re-registered. In the NHM Mollusca Collection we have found a large piece of rock still with its green label 10407, and with two other labels attached: one reads 'Nr. Nutnoor (*sic*), Sichel Hills, Malcolmson', the other 'figs 1, 2, & 3', seeming, therefore, to refer to Sowerby's plate 47. The rock is indeed packed with charophytes (fig. 1), *Cypris cylindrica* (fig. 2) and *Cypris subglobosa* (fig. 3) (less common).

In spite of a diligent search, we have found no record of anything labelled R 10409 or R 10410 in the NHM collections. It is probable, however, that these were mounts of matrix-free material that were re-registered and re-mounted when they came to the NHM in 1911. We do not think it is a coincidence that the only two micropalaeontological slides labelled 'Sichel Hills, India, J. G. Malcolmson Coll'n. Pres. Geol. Soc. 1911' contain respectively what are obviously *Cypris cylindrica* (BMNH no. In 33805–33823) and *C. subglobosa* (In 33796–33804). Indeed, we strongly suspect that these were previously registered as numbers R 10409 and R 10410, respectively, when they were in the GSL collections. We must add, however, that these two slides are not labelled with the names of the species nor is there any further information given in the Museum's registers. It is not surprising, therefore, that they were not found by previous workers searching for Sowerby's species.

Notwithstanding this, we strongly contend that the specimens in rock R 10407 and in the two slides (In

33805–33823) and (In 33796–33804) were available to Sowerby (1840) when he made his descriptions and that they are all, therefore, strictly syntypes. Given this, any of them can be chosen as the lectotype and paralectotypes when *C. cylindrica* and *C. subglobosa* are re-described. We are even more certain that these specimens are the syntypes of Sowerby's species as Jones (1860, p. 186) stated 'Mr. Sowerby has described . . . two species of *Cypris* from the fossiliferous chert of the Sichel Hills; namely *Cypris cylindrica* . . . and *Cypris subglobosa* . . .'. 'I have examined the original specimens presented by Dr. Malcolmson to the Geological Society . . .', etc. It was, of course, these specimens that came to the NHM in 1911. From the rock specimen still labelled R 10407, we have cut out several additional specimens of *C. subglobosa* using a vibratool. These form part of the type collection upon which we based our redescription of the species below.

There are, we have discovered, in both the collections of Ostracoda and Mollusca, numerous hand specimens from the Indian intertrappeans (mainly of chert) containing ostracods. Some contain little else. Those containing other species are to be the subject of another publication, but those in which we have encountered *Cypris subglobosa* are as follows:

In 33786–33794. Ostracoda (no other identification) Cretaceous. Chikni, India. Presented by the Geological Society of London, 1911. John G. Malcolmson Collection. Nine specimens. Contains *Cypris subglobosa* Sowerby and '*Cypris*' sp. Whether these specimens of *C. subglobosa*, in spite of being from the Malcolmson Collection, are strictly syntypes depends on whether this locality is in the Sichel Hills and whether Sowerby had it to hand when he described the species. We suspect that he saw this material since it comprises matrix-free specimens.

In 33824. This is a small piece of chert, labelled 'Intertrappean Beds, Central India. Hislop & Hunter Collection'. We have encountered in this a number of ostracod species not seen in other hand specimens in the Museum's collection. We also saw a group of *C. subglobosa*, one of which was the longest specimen of the species we encountered (1.5 mm). While all discrete specimens have been photographed with standard scanning electron microscope (SEM) techniques, these specimens that are still adhering to the matrix have been photographed using the environmental chamber on the SEM. These are shown in Text-figure 2A–B.

I 33777. Chert specimen labelled 'Chikni (Malcolmson Colln)'. This contains a single, deeply embedded carapace of *C. subglobosa*, which is not illustrated here. This specimen is arguably also a syntype. However, another piece of (unnumbered) chert in the Mollusca collections from the same locality contains another specimen illustrated in Text-figure 2c.

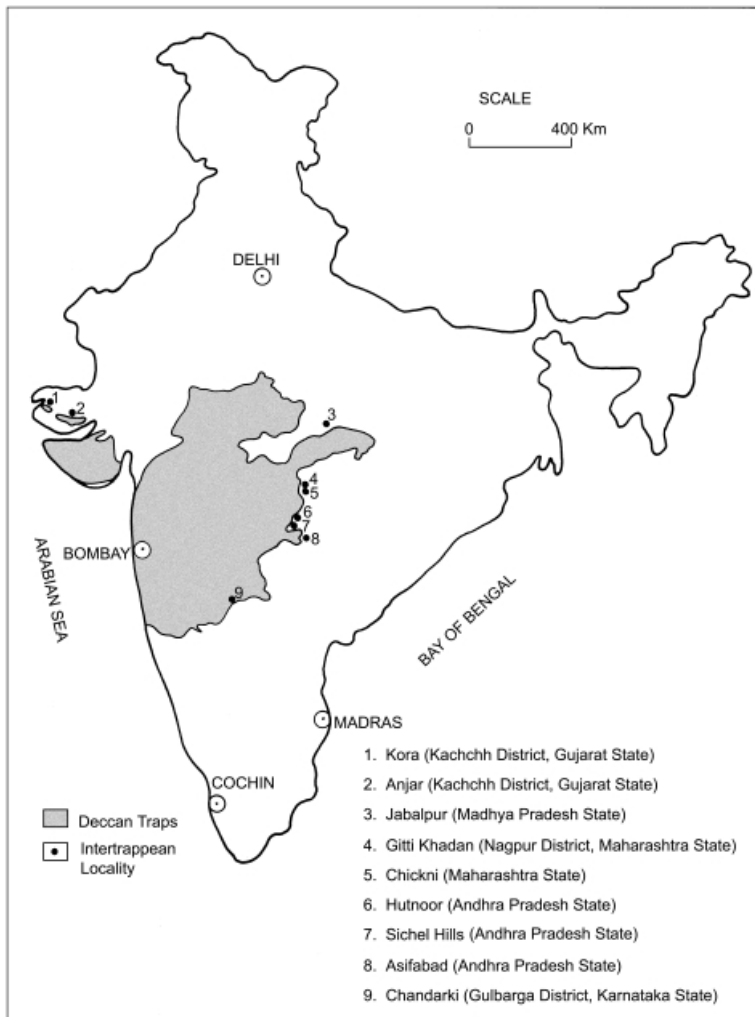
I 7232. This is a slide labelled '*Cypris semiglobosa*. Tertiary. (Intertrappean beds), Nagpur, India. Rev. Hunter Collection, bequeathed 1877. 3 specimens.' We can find no record of this species nor its author. The generic name is in ink, written at the time of its registration; the specific name, however, is in pencil, but they appear to be in the same hand. One of these specimens is *Cypris subglobosa* and we suspect that its incorrect labelling as *C. semiglobosa* is a simple error made during registration.

GSL 10407. As indicated above, this is the original rock, still preserved in the Mollusca collections, with two labels respectively containing the words 'Nr Nutnoor (*sic*), Sichel Hills, Malcolmson' and 'figs 1, 2 & 3'. The latter clearly indicates that the specimens from which Sowerby (1840) made his original illustrations (pl. 47, figs 1–3) came from this rock. Unfortunately, none is marked in any way. Three specimens of *Cypris subglobosa*, extracted from this rock by vibratool, are illustrated in Plate 1, figures 18–19 and Plate 2, figures 1–4.

In addition to the material of this species from the NHM, we have other material from a number of intertrappean localities in India and access to other specimens in a number of Indian University museum collections. Reference is made to some of these in discussion of the distribution of the species. The various localities mentioned in the text are given in Text-figure 1.

SYSTEMATIC PALAEOLOGY

All type and figured specimens are deposited in the Micropalaeontology collections of the Department of Palaeontology, The Natural History Museum, London (NHM) with catalogue numbers prefixed by I, In, or Io (for the older collections), latterly by OS. Other material is housed in the Bajpai Collection in the Museum of the Department of Geology, Roorkee University, India, with catalogue numbers prefixed RUSB. The following conventions are employed: RV, right valve; LV, left valve; C, articulated carapace; A, adult; juv., juvenile, rpc, radial pore canal; npc, normal pore canal. All dimensions are in millimetres



TEXT-FIG. 1. Map of India, showing the outcrop of the Deccan Traps and the location of the principal localities mentioned in the text.

and the size convention for the length of adults is as follows: <0.40 very small, 0.40–0.50 small, 0.50–0.70 medium, 0.70–1.0 large, >1.0 very large.

Phylum CRUSTACEA Pennant, 1777
 Class OSTRACODA Latreille, 1806
 Order PODOCOPIDA G. W. Müller, 1894
 Suborder PODOCOPINA G. W. Müller, 1894
 Superfamily CYPRIDACEA Baird, 1845
 Family CYPRIDIDAE Baird, 1845
 Subfamily CYPRETTINAE Hartmann, 1963
 Genus PARACYPRETTA Sars, 1924

Type species (by original designation). *Paracyprettia ampullacea* Sars, 1924.

Remarks. Sars erected this genus for three South African species that he studied live, having reared them in aquaria in his laboratory in Norway, from dried mud sent from the Cape Peninsula. This material was supplemented by other material sent preserved in alcohol. A palaeontological diagnosis based on Sars (1924, p. 152), on the diagnosis of the hard parts given by Swain in the Treatise on Ostracoda (*in* Moore and Pitrat 1961, p. Q224) and from the personal observations of RCW is as follows:

Rather short, subovate, very strongly inflated ventro-laterally and very strongly flattened ventrally. Dorsal margin strongly arched with maximum height at about mid-length. Ventral margin with shallow oral concavity; often obscured in lateral view by ventro-lateral tumidity. Anterior margin strongly laterally compressed, broadly rounded; posterior margin more bluntly rounded. Both end margins with apices below mid-height. Surface punctate or papillate. Ornament may be strongly aligned parallel to the margin ventrally. Live specimens with strong setae over entire surface. Left valve larger than right and projecting strongly beyond it anteriorly. Calcified inner lamella well developed, widest anteriorly. Right valve with strongly chitinized septae on inner lamella anteriorly.

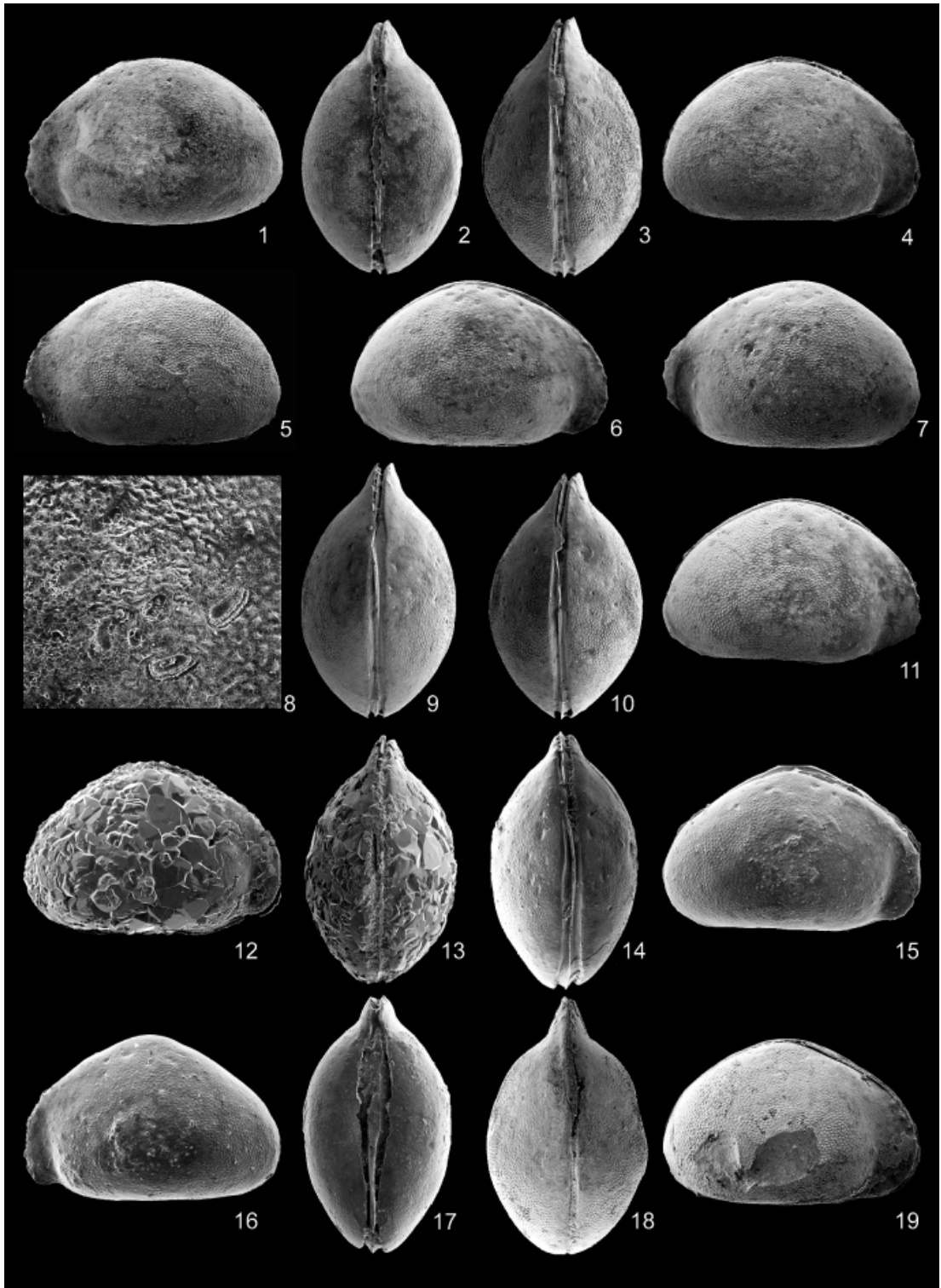
The genus is known from the Upper Cretaceous in India but does not seem to occur in the subcontinent today, although it is common in the Recent of southern South Africa (Sars 1924; Martens *et al.* 1996, 1998). Martens (1984) initially recorded it from the Sudan, stating (p. 160) that this was its first record north of southern South Africa and that it had never been encountered in the intervening, very well-documented Recent ostracod faunas of East Africa. However, subsequently (*in* Dumont *et al.* 1986) he changed the generic identification of the species in question to *Strandesia* Stuhlmann. All known Recent species of the genus are parthenogenetic and, interestingly, none of the fossil intertrappean species from India has males.

Given the confusion evidenced in the synonymy below, between *Paracyprretta* Sars, *Cypris* O. F. Müller, *Eurycypris* G. W. Müller and *Chlamydotheca* Saussure, it is probably useful to consider the carapace characters that separate them; the genera also differ significantly in their appendage morphology. *Eurycypris* is now considered to be a junior synonym of *Cypris*. The cosmopolitan genus *Cypris* is somewhat similar to *Paracyprretta* in dorsal view and has similar ornament. However, in lateral view it is much more elongated posteriorly, much less ventro-laterally tumid and *Cypris* lacks the projection of the LV beyond the RV anteriorly. *Chlamydotheca* is confined to the Americas and is much less strongly tumid ventro-laterally. *Cyprretta* Vávra, also from South and East Africa, Aldabra and Sri Lanka, is much less inflated and has the RV slightly larger than the left. Another genus with which Indian Cretaceous *Paracyprretta* has been confused is *Altanicypsis* Szczechura, 1978. Szczechura (1978, pp. 90–91) did not even mention *Paracyprretta* in her discussion of the relationships of her new genus. This is because the two genera are quite distinct. *Altanicypsis* is characterized by a distinct lip-like extension, which occurs only on the antero-ventral part of the right valve.

The following species of *Paracyprretta* have been described previously in the intertrappean deposits of Peninsular India: *Paracyprretta bhatiai* (Khosla and Sahni, 2000); *Paracyprretta jonesi* Bhatia and Rana,

EXPLANATION OF PLATE I

Figs 1–19. *Paracyprretta subglobosa* (Sowerby, 1840). 1–2, 4, lectotype, NHM no. In 33797, carapace, left lateral, ventral and right lateral views, respectively; $\times 29$. 3, 5, paralectotype, NHM no. In 33796, carapace, dorsal and left lateral view, respectively; $\times 28$. 6–9, paralectotype, NHM no. In 33802, carapace, right and left lateral, detail of right external muscle-scar, and dorsal views, respectively; $\times 31$ (muscle-scars; $\times 135$). 10–11, paralectotype, NHM no. In 33803, carapace, dorsal and right lateral views, respectively; $\times 31$. 12–13, paralectotype, NHM no. In 33787, recrystallised (opalised) carapace, right lateral and dorsal views, respectively; $\times 29$. 14–17, NHM no. OS 15947, carapace, dorsal, right and left lateral, and ventral views, respectively; $\times 31$. 18–19, paralectotype, NHM no. OS 15944, carapace, dorsal and right lateral views, respectively; $\times 30$. 1–11, from the Sichel Hills, India, J. G. Malcolmson Collection (ex Geological Society of London, presented 1911), late Cretaceous. 12–13, from Chicki, India, J. G. Malcolmson Collection (ex Geological Society of London, presented 1911), late Cretaceous. 14–17, from Nagpur, India, bequeathed by Rev. Hunter, 1877, labelled ‘Tertiary’. 18–19, from ‘near Nutnoor’ (*sic*), Sichel Hills, India, late Cretaceous, collected by J. G. Malcolmson (ex Geological Society of London, presented 1911); extracted from the original rock (GSL 10407) by vibratool.





TEXT-FIG. 2. A–C, *Paracyprretta subglobosa* (Sowerby, 1840). A, group of carapaces embedded in chert, NHM no. In 33824, Hislop and Hunter Collection, labelled ‘Intertrappean beds, central India’. B, close-up of the two carapaces seen in the lower part of A. C, carapace, in chert embedded in basalt, NHM Mollusca Collection (unregistered), from Chicknee (Chickni).

1984; *Paracyprretta subglobosa* (Sowerby, 1840); *Paracyprretta* sp. of Mathur and Verma 1980. To these we now add the new species *Paracyprretta elizabethae* sp. nov., described herein. We place *P. bhatiai* within the synonymy of *P. jonesi* and recognize *Paracyprretta* sp. as a probable juvenile of *P. subglobosa*.

Paracyprretta subglobosa (Sowerby, 1840)

Plate 1, figures 1–19; Plate 2, figures 1–2, 4; Text-figure 2A–C

- 1840 *Cypris subglobosa* J. de C. Sowerby, in Malcolmson, description in unpaginated explanation of pl. 47, fig. 3.
 ?1988 *Paracyprretta* sp. Mathur and Verma, p. 172, pl. 1, fig. 7a–b.
 1990b *Altanicypriis szczechurae* (Stankevitch); Bhatia, Srinivasan, Bajpai and Jolly, p. 118, pl. 1, figs 9–10.
 2003b *Paracyprretta subglobosa* (Sowerby); Whatley, Bajpai and Whittaker, pl. 1, figs 1–2.
 non 1859 *Cypris subglobosa* Sowerby; Baird, p. 232, pl. 63, fig. 2.
 non 1886 *Chlamydotheca subglobosa* Sowerby; Brady, p. 300, pl. 38, figs 24–27a.
 non 1906 *Eurycypris subglobosa* (Sowerby); Vávra, p. 420, pl. 24, figs 9–13.
 non 1912 *Cypris subglobosa* Sowerby; G. W. Müller, p. 180.
 non 1968 *Cypris subglobosa* Sowerby; Bhatia, p. 470, pl. 1, fig. 2a–g; pl. 5, fig. 10.
 non 1972 *Cypris subglobosa* Sowerby; Okubo, p. 61, pls 1–4.
 non 1976 *Cypris subglobosa* Sowerby; Neale, pp. 125–132.
 non 1985 *Cypris subglobosa* Sowerby; Martens and Toguebaye, p. 147 (and synonymy).
 non 1998 *Cypris subglobosa* Sowerby; Rossi, Schön, Butlin and Menozzi, p. 262, table 1.

Lectotype. NHM no. In 33797. Articulated carapace. Designated herein from a syntype in the Malcolmson (1840) Collection, Upper Cretaceous, Sichel Hills. Illustrated in Plate 1, figures 1–2, 4.

Paralectotypes. NHM no. Io 691. Articulated carapace, syntype from Malcolmson Collection, Tertiary, Sichel Hill (*sic*). [Unfigured]. There is no way of determining the exact age of this specimen. However, from our knowledge of the local stratigraphy, it is more likely to be late Cretaceous than Tertiary. NHM no. In 33796. Articulated carapace, syntype from Malcolmson Collection, Upper Cretaceous, Sichel Hills (Pl. 1, figs 3, 5). NHM no. In 33802. Articulated carapace, syntype from Malcolmson Collection, Upper Cretaceous, Sichel Hills (Pl. 1, figs 6–9). NHM no. In 33803. Articulated carapace, syntype from Malcolmson Collection, Upper Cretaceous, Sichel Hills (Pl. 1, figs 10–11). NHM no. In 33787. Articulated carapace, ?syntype from Cretaceous, Chickni (Pl. 1, figs 12–13). NHM no. OS 15944, excavated from GSL 10407. Articulated carapace, syntype from Malcolmson Collection, Nr Nutnoor, Sichel Hills (Pl. 1, figs 18–19). NHM no. OS 15945, excavated from GSL 10407. Articulated carapace, syntype from Malcolmson Collection, Nr Nutnoor, Sichel Hills (Pl. 2, fig. 1). NHM no. OS 15946, excavated from GSL 10407. Articulated carapace, syntype from Malcolmson Collection, Nr Nutnoor, Sichel Hills (Pl. 2, figs 2, 4).

Additional material. NHM no. OS 15947 (ex slide no. I 7232). Articulated carapace. Tertiary, Nagpur. Rev. Dr Hunter Collection, bequeathed 1877. Illustrated in Plate 1, figures 14–17. This is more probably, on the basis of local

stratigraphy, to be late Cretaceous than Tertiary but we cannot be certain of this. NHM no. In 33824. Carapaces embedded in chert. 'Intertrappean beds, central India'. Hislop and Hunter Collection (Text-fig. 2A–B). Carapace in chert embedded in basalt. Chicknee (Chickni). NHM Mollusca Collection (unregistered) (Text-fig. 2C).

Diagnosis. A very large, inflated species of *Paracyprretta* with strongly laterally compressed anterior margin, minute papillate ornament which is not concentrically orientated nor paralleling the margins, a 'flap' of the LV overlapping the RV in the ocular region and a subtle change in slope in dorsal view between the lateral and anterior surfaces. In dorsal and ventral views, the posterior termination is rather rounded.

Description. Very large. Subovate to rounded subtriangular in lateral view. Inflatedly fusiform in dorsal and ventral views, with anterior margin laterally compressed, greatest width centrally and rather rounded posteriorly. In these views, the posterior end is rounded. In dorsal view, the lateral surface is convex and not medianly flattened, and there is a subtle, 'shoulder-like' break of slope at about one-sixth of the distance from the anterior margin. In ventral view the ventral margin is flattened. Anterior margin strongly laterally compressed, well-rounded but asymmetrical with apex below mid-height; the antero-dorsal slope is long and more gently convex than the antero-ventral slope and with a recessed area between its ventral extremity and the ventro-lateral surface. The outline of the anterior margin of some specimens is broken by small pore conuli. Posterior margin bluntly and asymmetrically rounded, with long (especially in RV) gently convex postero-dorsal slope; apex below mid-height. Dorsal margin strongly arched, with apex at about mid-length. Ventral margin flattened, largely obscured in lateral view by valve tumidity. LV larger than RV with pronounced overlap particularly dorsally and antero-dorsally. Most specimens also demonstrate the overlap anteriorly and also illustrate a 'flap-like' extension of the dorsal margin of the LV overlapping the RV in the ocular region, from which a ridge, somewhat oblique to the commissure, extends posteriorly. This is particularly well-illustrated by paralectotypes In 33796 and In 33803 (Pl 1, figs 3 and 10, respectively). Lateral surface covered evenly with small papillae which are not aligned parallel to the margins, nor concentrically. A line of shallow oval depressions parallel the dorsal margin and a row of pore conuli occur along the anterior margin and a further, less distal row behind them (see LV of paralectotype In 33797 (Pl. 1, fig. 7) and both right and left lateral views of illustrated specimen no. OS 15947 (Pl. 1, figs 15–16). Pore conuli also occur along the dorsal margin and on the dorso-lateral surface. The break in slope between the lateral and ventral surfaces is abrupt and the ridge that this forms sweeps up onto the antero-lateral surface. Internal features not seen, except for the impressions of muscle scars seen from the exterior in some specimens. These comprise a complex of adductor scars of variable size in an irregular double row, with two large, prominent, subovate mandibular scars antero-ventrally.

Dimensions

	Length	Height	Width
Lectotype (In 33797) C	1.40	0.90	0.91
Paralectotype (Io 691) C	1.05	0.81	0.80
Paralectotype (In 33796) C	1.46	0.94	0.95
Paralectotype (In 33802) C	1.30	0.84	0.85
Paralectotype (In 33803) C	1.30	0.82	0.82
Paralectotype (In 33787) C	1.38	0.90	0.89
Paralectotype (OS 15944) C	1.32	0.85	0.83
Paralectotype (OS 15945) C	1.33	0.85	0.83
Paralectotype (OS 15946) C	1.48	0.96	0.91
Figured specimen (OS 15947) C	1.30	0.83	0.82

Remarks. We experienced some difficulty in deciding whether the micropapillate ornament of this species was original or an artefact of preservation. We thought that the original ornament was possibly micropunctate and that the papillae were a reflection of this, owing to the carapace preservation being in the form of moulds. However, we have examined in detail all the specimens, some of which demonstrate the remains of various layers of shell, and conclude that the original ornament was most likely to have been papillate, especially since the pore conuli also appear as positive structures. This conclusion is strongly supported by the fact that specimens examined from a number of different localities and lithologies, and possibly of different ages, are all papillate.

The present species differs from *Paracyprretta elizabethae* sp. nov. and *P. jonesi* in its papillate ornament, which is not concentrically orientated nor aligned parallel to the ventral margin, in its

possession of a 'flap' of shell in the ocular region of the LV which overlaps the RV, and in the shallow depressions which parallel the dorsal margin. *P. subglobosa* in dorsal and ventral views is rather rounded posteriorly, while the other two species are more pointed. *P. elizabethae* is much less strongly inflated, its anterior margin is much less strongly laterally compressed, and it possesses keel-like structures antero- and postero-ventrally. *Paracyprretta* sp. of Mathur and Verma (1988) is tentatively placed here. This, from their outline drawings, is clearly *Paracyprretta* but is much smaller (length 0.615 mm, height 0.433 mm, width 0.600 mm) than any of the three species recognised here. Since it is illustrated with a rounded posterior in dorsal view (*ibid.*, 1988, pl. 1, fig. 7B), a feature unique in this study to *P. subglobosa*, it is probably a young instar of this species. The ornament of the species is not mentioned in its description.

Baird (1859) made the original mistake concerning the identity of this species when, in describing the Recent Entomostraca taken from some freshwater pools in Nagpur by the Rev. Mr. Hislop, he stated (p. 232) that 'It is interesting to find two species of *Cypris* in a recent state, that have been already described as fossil'. It is clear that what Baird saw were not the syntypes available to Sowerby (1840) and that, since he described the colour of the specimens as green, the material was indeed Recent. None of the syntypes available to Sowerby is green. Baird's illustration (pl. 63, fig. 2) is clearly of a different species from that of Sowerby (*in* Malcolmson 1940, pl. 47, fig. 3). We have recovered the Recent material in question, still preserved in the NHM, and we will illustrate it and give the species in question a new name in a subsequent paper. This Recent species, very well illustrated by Neale (1976), belongs to the genus *Cypris*. Bhatia (1968) compounded the problem when he also assumed that only one species was involved. He stated (p. 470) that 'Both Baird and Brady were, no doubt, familiar with Sowerby's species, and it seems fairly certain that the forms described as *Cypris subglobosa* by Sowerby, Baird and Brady are all conspecific'. Brady's (1886) material was from the Recent of Ceylon. Bhatia's material, which is conspecific with that of Baird and Brady, is from the Pleistocene Upper Karewa Series of Kashmir. Because of this earlier misidentification, Bhatia and Rana (1984) were unable to recognize that the species they described as *Paracyprretta jonesi* was actually closely related to the true *Cypris subglobosa* Sowerby.

Martens and Toguebaye (1985, pp. 148–149) listed a very large number of records of *Cypris subglobosa* through the tropics/subtropics from the Caribbean through West Africa, the Mediterranean region, southern ex-USSR, Iran, Afghanistan, India, Ceylon, Indonesia, China and Japan. However, only those from the Indian intertrappeans are valid citations; the remainder belong to the unnamed Recent species mentioned above.

Paracyprretta elizabethae sp. nov.

Plate 2, figures 3, 5–13, 15–16, 18

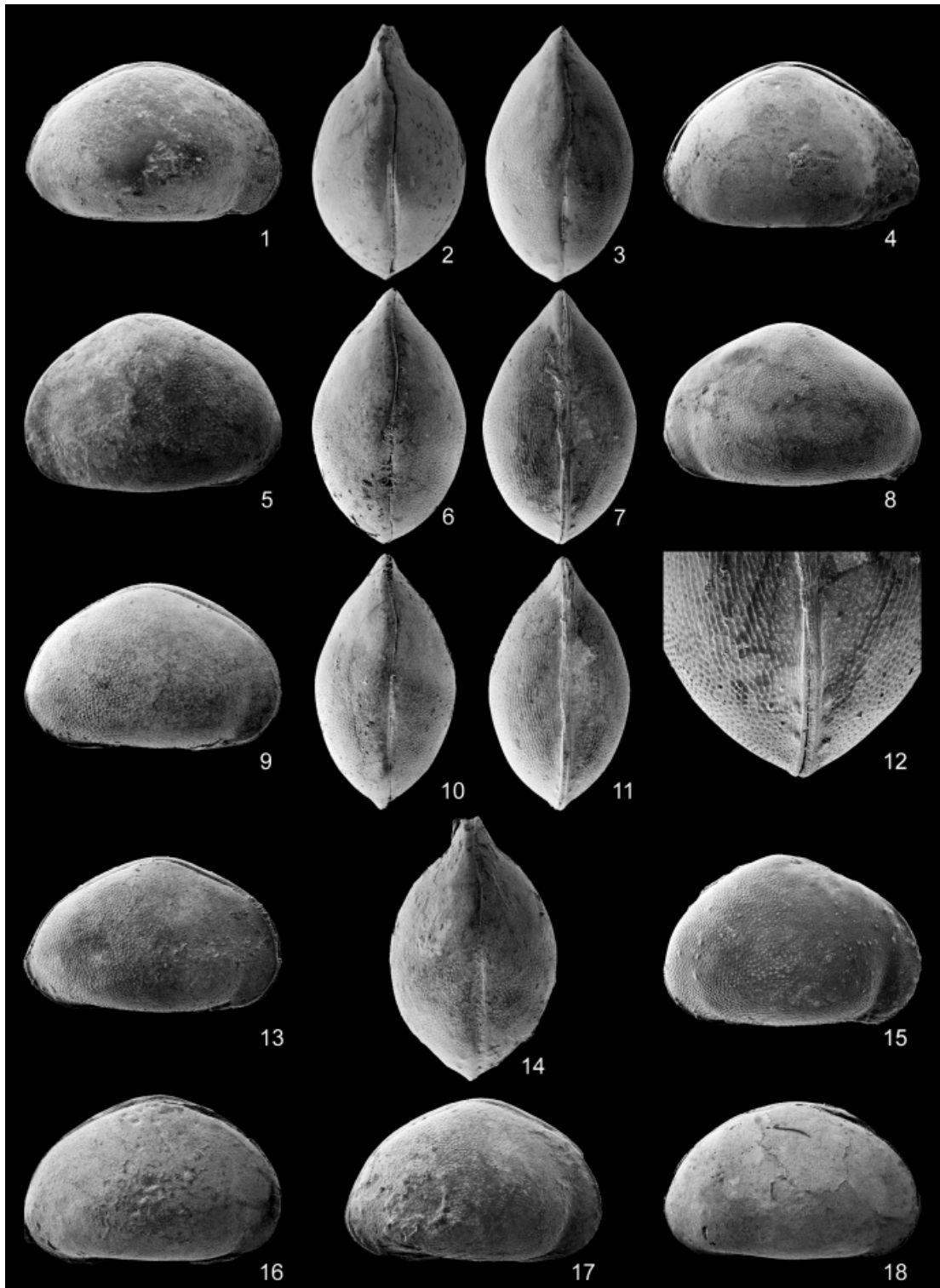
?1986 *Paracyprretta jonesi* Bhatia and Rana; Prasad, p. 71, figs 14–15.

EXPLANATION OF PLATE 2

Figs 1–2, 4. *Paracyprretta subglobosa* (Sowerby, 1840). 1, paralectotype, NHM no. OS 15945, carapace, right lateral view; $\times 30$. 2, 4, paralectotype, NHM no. OS 15946, carapace, dorsal and right lateral views, respectively, both from 'near Nutnoor' (*sic*), Sichel Hills, India, late Cretaceous, collected by J. G. Malcolmson (ex Geological Society of London, presented 1911); extracted from original rock (GSL 10407) by vibratool; $\times 27$.

Figs 3, 5–13, 15–16, 18. *Paracyprretta elizabethae* sp. nov. 3, 8, paratype, RUSB 6201, carapace, dorsal and left lateral views, respectively; $\times 30$. 5, paratype, RUSB 6200, carapace, left lateral view; $\times 33$. 6–7, 9, 12, paratype, RUSB 6202, carapace, dorsal, ventral and right lateral views, $\times 30$, and detail of postero-ventral area, $\times 60$ respectively. 10–11, 13, holotype, RUSB 6203, carapace, dorsal, ventral and right lateral views, respectively; $\times 27$. 15, paratype, RUSB 6204, RV, lateral view; $\times 29$. 16, paratype, RUSB 6205, carapace, right lateral view; $\times 29$. 18, paratype, RUSB 6206, carapace, right lateral view; $\times 31$. 3, 5–13 are all from Kora, western Kachchh, Gujarat State, India. 15 is from Anjar, Kachchh, Gujarat State. 16 and 18 are from Chandarki, Gulbarga District, Karnataka State, India. All late Cretaceous (Maastrichtian).

Figs 14, 17. *Paracyprretta jonesi* Bhatia and Rana, 1984. RUSB 6207, carapace, dorsal and right lateral views, respectively, from Chandarki, Gulbarga District, Karnataka State, India. Late Cretaceous (Maastrichtian); $\times 27$.



Derivation of name. Named in honour of Her Majesty Queen Elizabeth II, in whose Fiftieth Jubilee year this paper was written.

Holotype. An articulated carapace, RUSB 6203, from Kora, western Kachchh (Kutch), Gujarat State, India. From brownish yellow splintery Maastrichtian shale, immediately below lava flow; see Bajpai and Whatley (2001, pp. 93–94, figs 1–2). Illustrated in Plate 2, figures 10–11, 13.

Paratypes. C. RUSB 6200, from Kora (Pl. 2, fig. 5). C. RUSB 6201, from Kora (Pl. 2, figs 3, 8). C. RUSB 6202, from Kora (Pl. 2, figs 6–7, 9, 12). C. RUSB 6204, from Anjar, Kachchh (Kutch), Gujarat State, India. From Maastrichtian (Bajpai and Prasad, 2000) ostracod-bearing level above the third iridium level of Bajpai (1996); see also Whatley and Bajpai (2000b, p. 173 and Bhandari and Colin 1999, fig. 1) (Pl. 2, fig. 15). C. RUSB 6205, from Chandarki, Gulbarga District, Karnataka State. From Upper Cretaceous weathered cherts and marls in a stream section; see Whatley *et al.* (2002, Pl. 2, fig. 16). C. RUSB 6206, from Chandarki (Pl. 2, fig. 18).

Material. Some 50 specimens from various Indian Upper Cretaceous intertrappean localities. Almost all are articulated carapaces.

Diagnosis. A very large, subovate and moderately inflated species of *Paracyprretta*. Regularly fusiform in dorsal and ventral views, with posterior end pointed. Punctate over entire lateral surface with concentric disposition of puncta, and strong alignment parallel to margin ventrally. Small keels occur ventrally, on either side of the oral concavity.

Description. Very large. Irregularly subovate in lateral view and somewhat swollen ventro-laterally. Small keel-like structures occur ventrally, on either side of the oral concavity. Regularly fusiform in dorsal and ventral views, with anterior margin only slightly more laterally compressed than posterior; posterior pointed. Anterior margin broadly and only slightly asymmetrically rounded, with antero-dorsal slope gently convex to almost straight; apex variably situated, never far below mid-height but more ventral in LV than RV. Anterior cardinal angle not apparent. Posterior margin bluntly pointed, more so in RV than LV with, in most specimens, an apex considerably below mid-height. Postero-dorsal slope with a slight cardinal angle, more marked in LV than RV. Dorsal margin very strongly arched and almost umbonate in some specimens; maximum height at about mid-length. Ventral margin flattened with symmetrical oral concavity, largely obscured in lateral view. LV larger than RV with conspicuous overlap anteriorly, antero-dorsally, postero-ventrally and mid-ventrally. The limit of the ventro-lateral inflation is clearly seen on the antero-ventral surface but less markedly on the postero-ventral. Ornament punctate over the entire lateral surface. There is an overall concentric disposition of the puncta but this is only strongly developed ventrally, with the individual elements being formed into a series of lines which parallel the margins. Small, low pore conuli occur across the lateral surface, including the anterior margin. In some specimens they are more prominent and seem to occur in clusters (C. RUSB 6204, Pl. 2, fig. 15). Internal features not seen.

Dimensions

	Length	Height	Width
Holotype C. RUSB 620	1.48	0.90	0.82
Paratype C. RUSB 6200	1.23	0.87	0.77
Paratype C. RUSB 6201	1.37	0.88	0.78
Paratype C. RUSB 6202	1.36	0.88	0.82
Paratype RV. RUSB 6204	1.54	1.03	–
Paratype C. RUSB 6205	1.37	0.88	0.78
Paratype C. RUSB 6206	1.28	0.80	0.78

Remarks. This species has a similar size range to *P. subglobosa*, but is punctate rather than papillate and its ornament is concentric and strongly orientated parallel to the ventral margin, while that of *P. subglobosa* is not disposed in this manner. This species is also notably less inflated than *P. subglobosa* and is more gracile and regularly fusiform in dorsal and ventral view, with the anterior margin much less strongly laterally compressed. In these views, the posterior end is pointed, while in *P. subglobosa* it is rounded. In addition, although *P. subglobosa* lacks the two ventral keels, it possesses a small ‘flap-like’ structure in the oral region of the LV which overlaps the RV, the shallow oval depressions that parallel the dorsal margin,

while the pore conuli along its anterior margin are rather more prominent than in the present species. The ornament of this species is similar to that of *P. jonesi*, but that species is much more inflated, more laterally compressed anteriorly and altogether much less gracile. *P. elizabethae* seems to have been overlooked in earlier studies of the three Indian localities in which we have encountered it. Prasad (1986) illustrated a species from the intertrappean beds of Asifabad in Adilabad District, Andhra Pradesh State. It is not possible from either his description or illustrations to be absolutely certain, but this record seems to be of the present species.

Paracyprretta jonesi Bhatia and Rana, 1984

Plate 2, figures 14, 17

- 1984 *Paracyprretta jonesi* Bhatia and Rana, p. 30, pl. 2, figs 1–3.
 1994 *Altanicypris* sp. Sahni and Khosla, p. 458, figs n–p.
 1996 *Paracyprretta jonesi* Bhatia and Rana; Udhoji and Mohabey, p. 143, pl. 2, figs 4–6.
 2000 *Paracyprretta* sp. Bajpai and Prasad, p. 258, fig. 2f.
 2000 *Altanicypris bhatiai* Khosla and Sahni, p. 58, pl. 1, figs a–g.
 2000b *Paracyprretta bhatiai* (Khosla and Sahni); Whatley and Bajpai, p. 174, pl. 1, figs 1–3.
 2002 *Paracyprretta bhatiai* (Khosla and Sahni); Whatley, Bajpai and Srinivasan, p. 3, figs 1–5.

Material. A single articulated carapace, RUSB 6207, from the Upper Cretaceous intertrappeans of Chandarki, Gulbarga District, Karnataka State, India; see Whatley *et al.* (in press *a*).

Dimensions. Illustrated specimen RUSB 6207: length, 1.48; height, 0.94; width, 0.95.

Remarks. This species was originally described by Bhatia and Rana (1984) from Gitti Cadan, near Nagpur. However, despite the fact that these authors stated (p. 33) that ‘This is the most common ostracode in almost all the samples we have examined . . .’, they illustrate only three rather distorted or partly broken carapaces (pl. 2, figs 1–3). Although they designated (*ibid.*, p. 32) figure 1 as the holotype, and figures 2 and 3 as paratypes, they are not given catalogue numbers. The holotype seems to be very distorted, in that the anterior margin is narrower than one would expect and as the dorsal and ventral views of the paratypes seem to indicate. Also, although figure 2 is described as a dorsal view, the nature of alignment of the puncta is more reminiscent of the ventral surface; the overlap is equivocal, probably due to distortion, in that at the anterior the LV seems to overlap the RV, while the reverse seems to hold posteriorly. Figure 3 is certainly a ventral view, although the carapace must be very distorted since the RV seems to overlap the LV. This does not agree with the assertion by Bhatia and Rana (1984, p. 30) that the left valve is larger than the right, ‘overlapping it all around and projecting beyond the right anteriorly’. The size of the holotype is given as ‘1.4 mm in length, 1.1 mm in height and 0.80 mm in thickness. The range in size of other adult specimens is length 1.5 mm to 2.0 mm, height 1.0 mm to 1.7 mm and thickness 0.9 mm to 1.1 mm’.

In consequence of the poor illustration and preservation of *P. jonesi*, it has been difficult to ascertain its taxonomic status. Initially, we considered it to represent the adults of what we now have identified as *P. elizabethae* sp. nov. However, since we have specimens of the latter which exceed the size of the holotype of *P. jonesi*, we now regard them as distinct taxa. *Paracyprretta jonesi* differs from *P. elizabethae* in its greater tumidity as seen in dorsal view and in its more laterally compressed and projecting anterior margin in the same view. However, in its punctate ornament and the orientation of the puncta parallel to the ventral margin ventrally, it resembles *P. elizabethae*. *Paracyprretta jonesi* is very similar in dorsal and ventral view to *P. subglobosa* but in that species the ornament is papillate and not orientated parallel to the ventral margin.

Only Udhiji and Mohabey (1996), among the various authors who, in various intertrappean localities have encountered this species, have correctly identified it. Sahni and Khosla (1994) and Khosla and Sahni (2000) seem to have been influenced by the misleading illustrations of the type material by Bhatia and Rana (1984) and, therefore, considered the species they encountered in the Upper Cretaceous Lameta Formation of the Jabalpur Cantonment to be new. Two of us were misled in the same way (Whatley and

Bajpai, 2000b and Whatley *et al.* 2002), but we now consider *Altanicypris bhatiai* Khosla and Sahni (2000) to be a junior synonym of *Paracypretta jonesi* Bhatia and Rana (1984).

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