

# Emsian Chitinozoa from the Buchan area of southeastern Australia

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Emsian chitinozoans from two sections through the Taravale Formation, near Buchan, southeastern Australia are documented. The fauna bears little resemblance to those extracted from contemporaneous successions in other parts of the globe. Seven chitinozoan assemblages are recognised with local stratigraphic application. Possible reasons for the unique composition of the fauna include biased preservation, highly developed endemism in the Emsian and an unusual depositional environment. The last suggests a degree of facies dependency in chitinozoans. Fifteen new species: *Angochitina chillkalla*, *A. kurnai*, *A. warrugang*, *Bursachitina* (*Bursachitina*) *ngarigo*, *B. (B.) talenti*, *B. (Amplichitina) bidawal*, *B. (A.) jaimathang*, *B. (A.) kurritgo*, *B. (A.) rasilis*, *Eisenackitina birubi*, *E. hebeta*, *E. subditiva*, *E. warnangatte*, *E.?* *vieta*, and *E. yaraan* are described. Two new subgenera are erected, *Bursachitina* (*Bursachitina*) and *B. (Amplichitina)*.

**Key words:** Chitinozoa, Devonian, Australia, taxonomy, stratigraphic distribution, palaeobiogeography.

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## Introduction

Extensive studies of conodont faunas from the Taravale Formation by Mawson (1987) documented continuous marine successions spanning most of the Emsian. The bed-by-bed sampling by Mawson resulted in one of the most comprehensive biostratigraphic studies of Emsian sequences in Australia. The presence of chitinozoans in the Taravale Formation was confirmed by Winchester-Seeto & Paris (1989) and the firm dating of the sequence provided a perfect opportunity for the first intensive examination of chitinozoans from the Emsian in Australia.

The objectives of this study were: to describe and document chitinozoan faunas from the Emsian of Buchan area, to identify stratigraphically

useful assemblages that could locally subdivide the sequences and to compare the assemblages with contemporaneous faunas from across the globe. The independent stratigraphic framework erected by Mawson (1987) was an ideal starting point from which to launch such a study.

There have been several investigations worldwide of Emsian chitinozoans since the 1960's, including studies from South America (Lange 1967; Da Costa 1967, 1971; Volkheimer *et al.* 1986), North Africa (Taugourdeau & Jekhowsky 1960; Jardiné & Yapaudjian 1968; Massa & Moreau-Benoit 1976; Boumendjel 1985; Boumendjel *et al.* 1988) and southwest Europe (Cramer 1964; Diez & Cramer 1978; Paris 1981a, b). Of these, only Paris (1981a, b) and Boumendjel (1985) illustrate their faunas with electroscan micrographs. The SEM micrographs allow the faunas to be compared with some degree of confidence with new assemblages from geographically distant sites. The results of other studies must be treated with some caution, especially where apparently very long-ranging species occur; many of these determinations have been based on superficial similarities in overall shape.

## Geological setting

The Taravale Formation forms part of the Buchan Group, located in northeastern Victoria (Fig. 1); it conformably overlies the Buchan Caves Limestone and interfingers northwards with the Murrindal Limestone (Teichert & Talent 1958; Mawson 1987). The succession consists of nodular limestones, shales and impure limestone and has been interpreted as representing deposition on a broad, gently sloping marine shelf (Talent 1965, 1969). Vandenberg (1988: p. 140) quotes Talent who suggests that the Taravale Formation represents an abrupt deepening and subsequent shallowing on a regional scale. For further information of the geology of this area see Teichert & Talent (1958) and Mawson (1987).

The limestones and shales of the Taravale Formation contain a moderate abundance of macrofossils, including some corals, brachiopods and trilobites (Teichert & Talent 1958). The oldest known ammonoids occur in the lower segment of the Taravale, e.g. *Lobobactrites* sp., *L. inopinatus* Teichert 1948, *Talenticeras talenti* Erben 1964, and *Teicherticeras desideratus* (Teichert 1948) (Mawson 1987). An abundant, but poorly preserved fauna of dacroconarids has been noted by Mawson (1987); other microfossils are represented by conodonts, ostracodes, and uncommon to rare agglutinated foraminiferans. The foraminifers belong to the genera *Thuramina*, *Tolypamina*, and *Hyperamina*, but the most common is *Thuraminoides sphaeroidalis* Plummer 1945, whose widespread distribution is consistent with a planktonic habit; it has been suggested that this fossil may not belong to the Foraminifera (K. Bell, personal communication). Palynological residues contain chitinozoans, rare scolecodonts and the linings of agglutinated foraminiferans. The apparent pelagic nature of

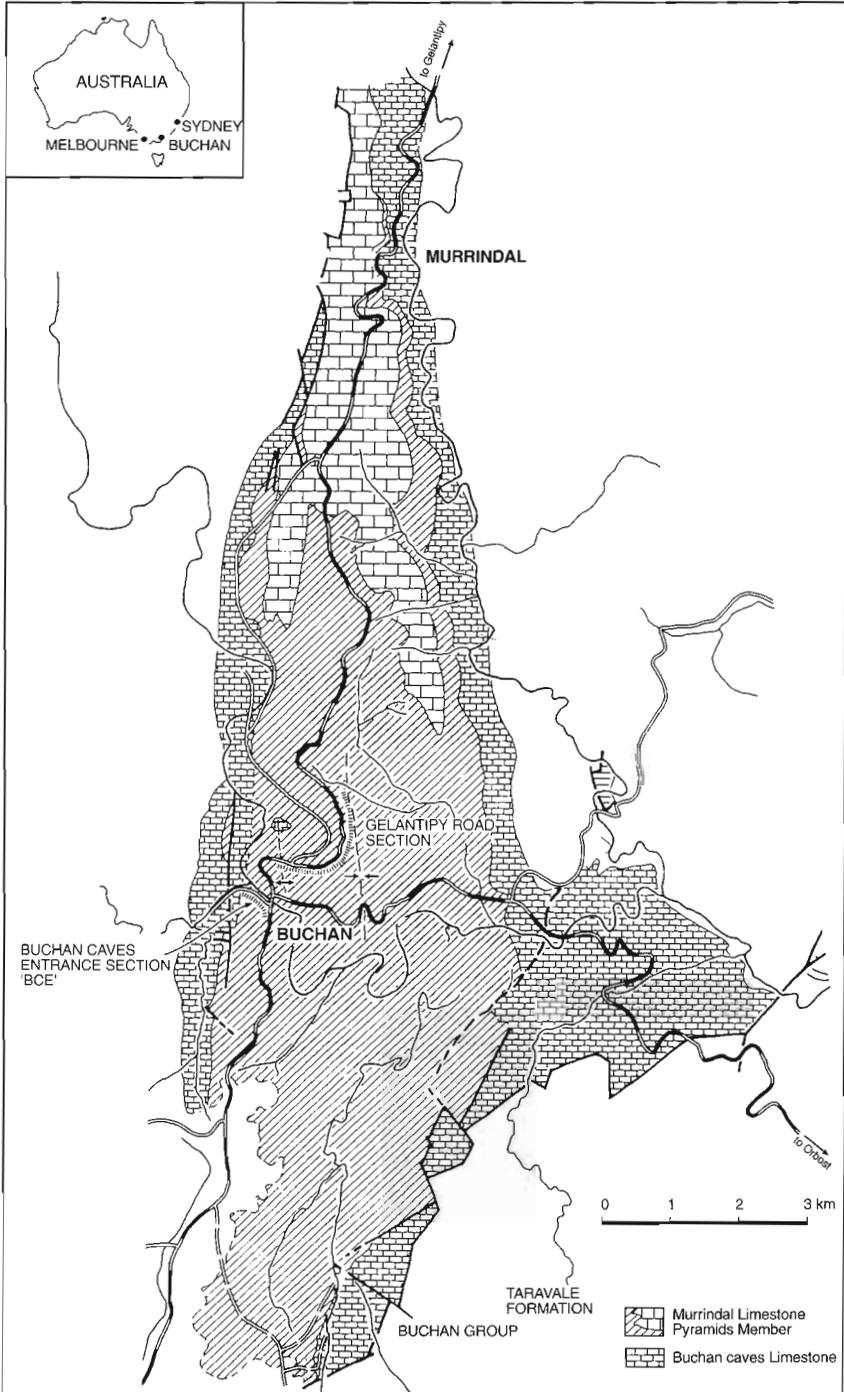


Fig. 1. Distribution of the Buchanan Group in the vicinity of Buchanan, southeastern Australia (modified from Mawson 1987).

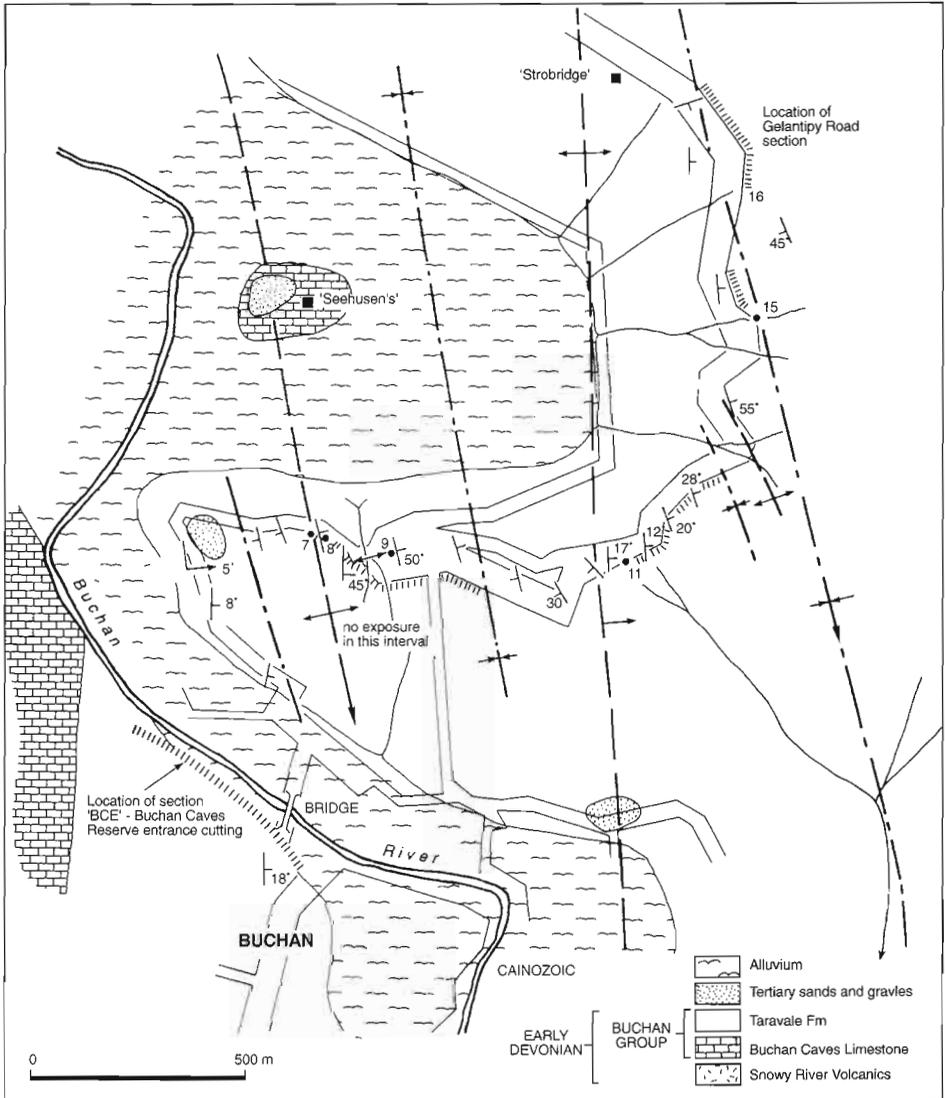


Fig. 2. Location of stratigraphic sections of the Taravale Formation sampled for this study; Buchanan Caves Entrance section was measured along the road to the Buchanan Caves Reserve and the Gelantipy Road section followed the Buchan-Gelantipy Road north of Buchanan (modified from Mawson 1987).

many of the fossils thus indicates a distal deposit, possibly near the outer edge of a shelf. Mawson *et al.* (1992: p. 43) noted that the conodonts extracted from this formation were dominated by polygnathids and pandorinellinids; this association has been designated a Polygnathid Biofacies and its co-occurrence with the pelagic fossils suggests deposition in deeper, relatively quiet waters.

Chitinozoan studies centred on two sections (Fig. 2), parallel to those used by Mawson (1987). The first was a short section along the side of the road adjacent to the Buchan Caves Reserve Entrance, covering the interval late *Polygnathus dehiscens* to *P. perbonus* conodont zones. A longer section, through road-cuttings for 3.5 km along the Buchan–Gelantipy Road north of Buchan was also examined, this section overlapped initially with the Buchan Caves Entrance section, commencing in the *P. dehiscens* conodont Zone and extended in an almost continuous outcrop to the *P. serotinus* conodont Zone.

## Methods

Collection procedures involved closely spaced sampling following the sections described by Mawson (1987) and using a similar numbering system. This allowed a direct comparison of results and a close correlation of the two microfossils.

The extraction methods outlined by Paris (1981a) were employed in this study, except that no attempt was made to bleach the specimens with Schulze's solution because of the fragile nature of most of the vesicles. Nitric acid was used when necessary to destroy amorphous organic material and to remove excess salts.

## Chitinozoan data

Because the yields were relatively low, 100 g of rock was processed to obtain sufficient numbers for taxonomic and stratigraphic study, this is twice the size usually required in studies of chitinozoans extracted from carbonates both within Australia and in other parts of the world (Paris 1981a; Winchester-Seeto 1993a, b). Preservation in general was quite poor, although chitinozoan vesicles were for the most part three dimensional with only a small amount of compression. Fig. 3 displays the percentage of indeterminate forms compared with the percentage of individuals from the 'thin-walled' genera. In some segments of the section, e.g. from sample 9T/166 to 9T/230.5 the large number of indeterminate forms parallels the large percentage of individuals with thin vesicle walls and conversely, the reduced percentage of unrecognisable forms parallels a concomitant drop in the dominance of thin-walled species. This pattern is not evident, however, in the upper part of the section, where the changes are more blurred, perhaps other factors came in to play in this interval. The reasons for the sudden changes in dominance of thin or thick-walled genera are unclear as there are no accompanying lithological or palaeontological changes indicating environmental disturbances.

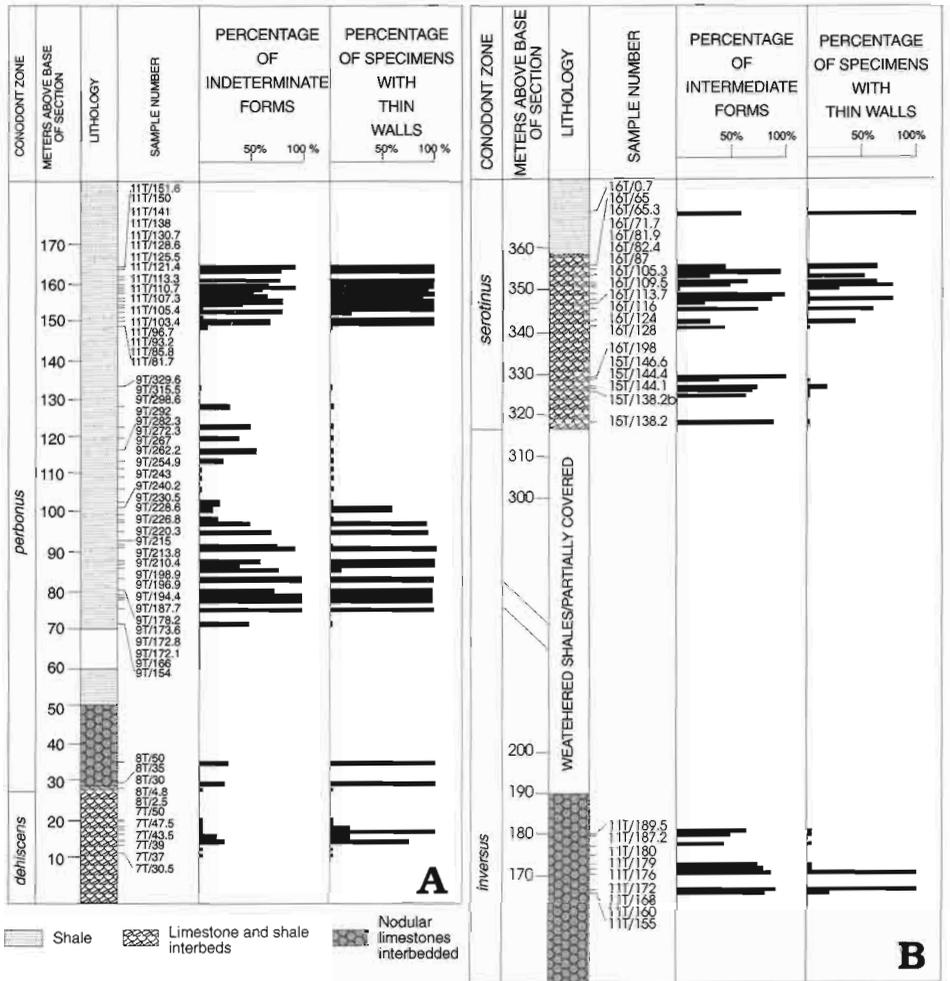


Fig. 3. Comparison of the percentage of indeterminate specimens and the percentage of the fauna with thin vesicle walls for each sample from the lower (A) and upper (B) parts of the Gelantipy Road section.

### Stratigraphic distribution of chitinozoans

**Chitinozoan assemblages in the Taravale Formation.** — Fifty-five species were identified in the two sections, grouping into seven assemblages. The assemblages were determined as far as possible on the first appearance of species that were easily recognisable and reasonably abundant. Although the sections were nearly continuous, yields varied greatly; some considerable portions of the sequence yielded no chitinozoans, thus the record appears somewhat discontinuous. In other segments of the section, there was a high percentage of indeterminate forms.

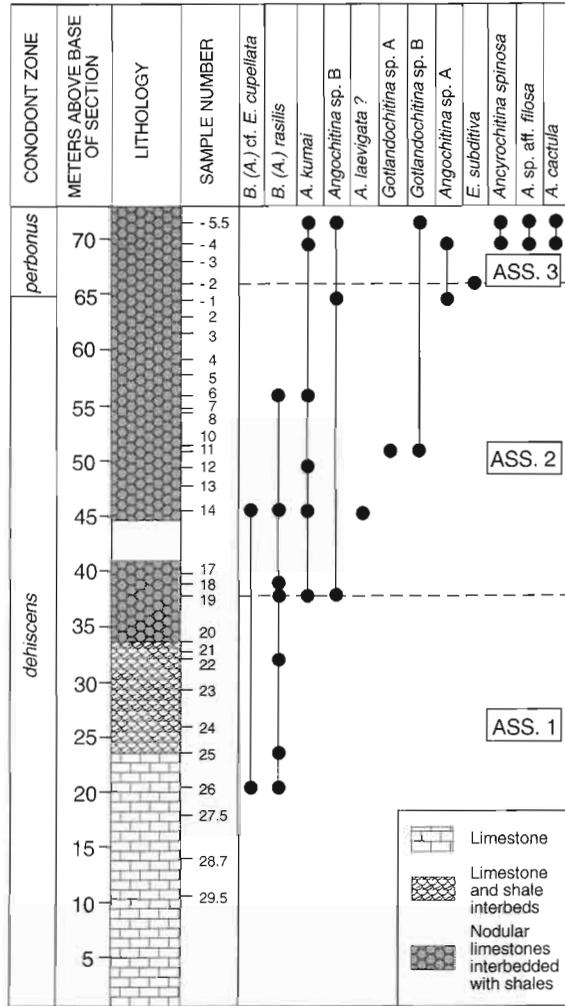


Fig. 4. Stratigraphic ranges of Emsian chitinozoans from the Buchan Caves Entrance section of the Taravale Formation, near Buchan, Victoria.

**Assemblage data.** — Assemblage 1, found in both the Buchan Caves Entrance section (Fig. 4) and in the Gelantipy Road section (Fig. 5), is located wholly within the *P. dehiscens* conodont Zone. It commences with the first appearance of *Bursachitina (Amplichitina) rasilis* sp. n. and is found in association with *Bursachitina (A.) cf. E. cupellata* Wrona 1980.

Assemblage 2, defined by the first appearance of *Angochitina kurnai* sp. n., overlaps the latter part of the range of *Bursachitina (A.) rasilis* in the Buchan Caves Entrance section, but this is not observed in the Gelantipy Road section possibly due to the large number of non-yielding samples. This assemblage commences within the *P. dehiscens* Zone and extends into *P. perbonus* Zone. In the Buchan Caves Entrance section, *Eisenackitina subditiva* sp. n., which defines the next assemblage, overlaps with the

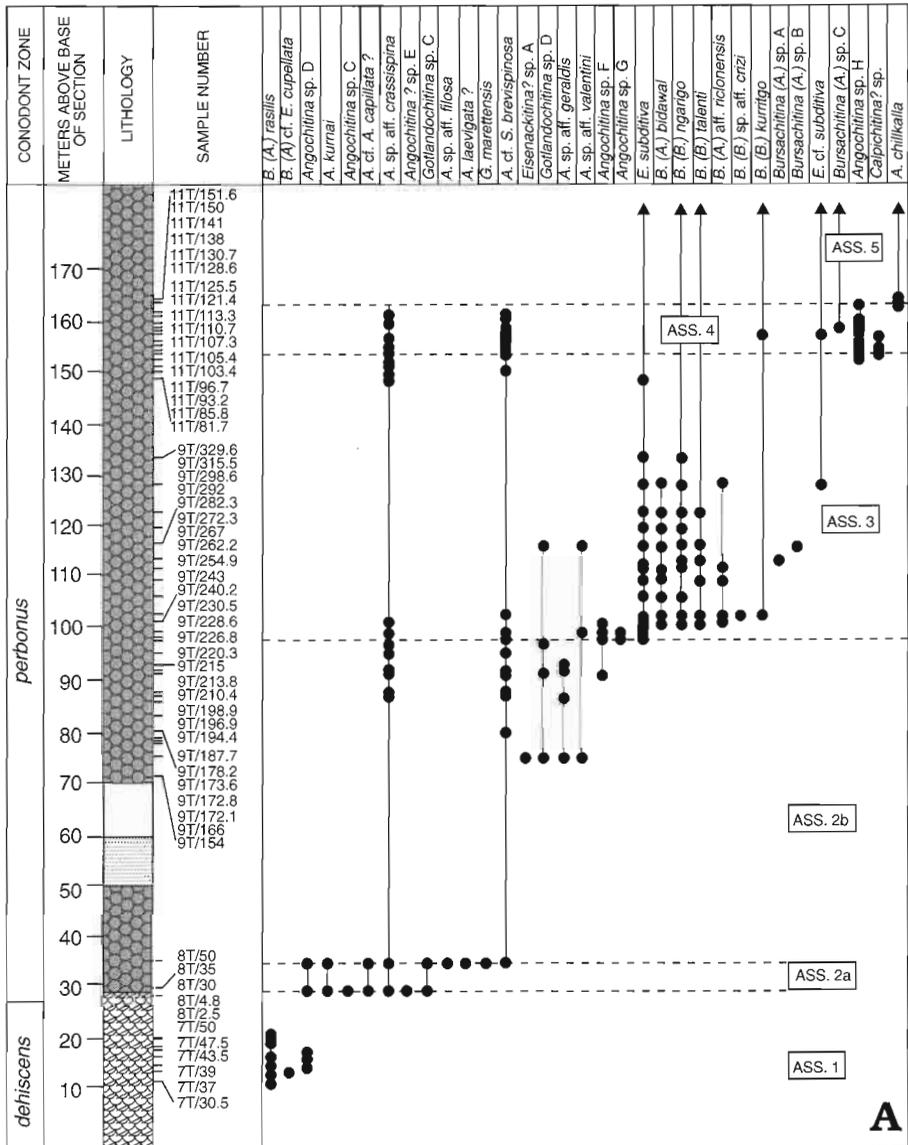
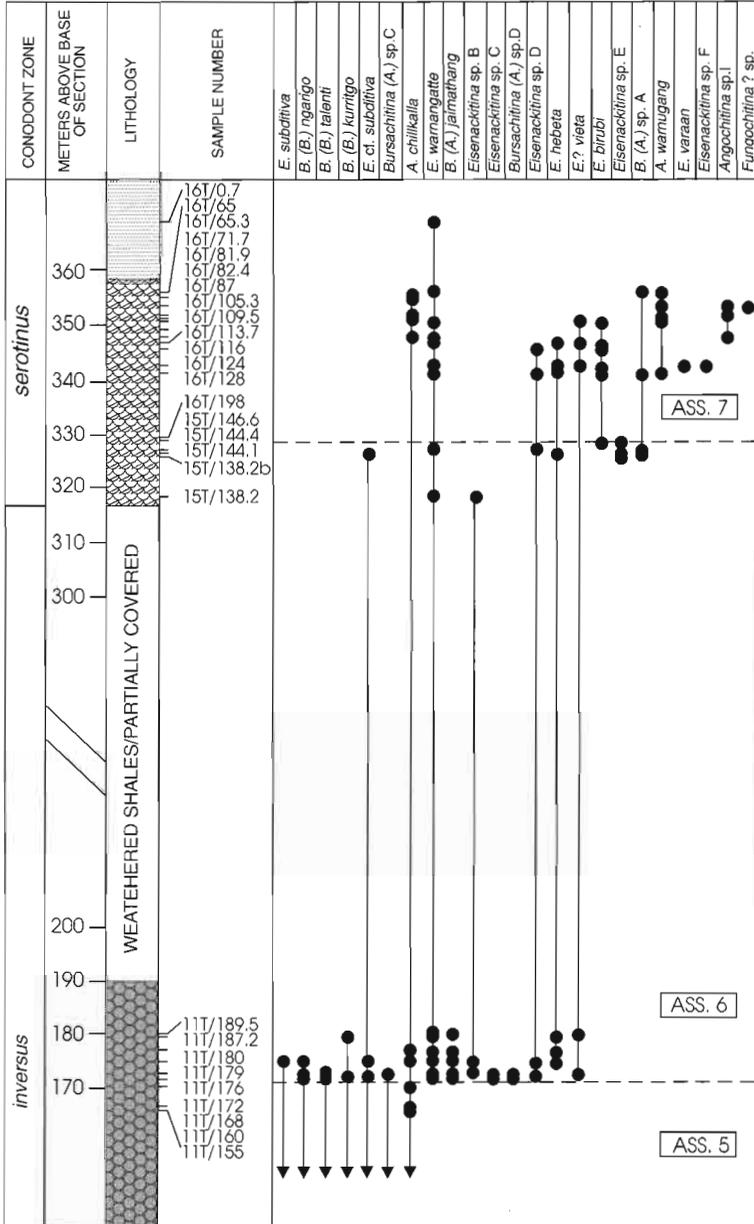


Fig. 5. Stratigraphic ranges of Emsian chittinozoans from the lower (A) and upper (B) parts of the Gelantopy Road section of the Taravale Formation, near Buchan. See legend from Fig. 4. The base of the *P. serotinus* conodont Zone is based on the first occurrence of the conodont species *Polygnathus pseudoserotinus* Mawson 1987.

upper range of *A. kurnai*. However, in the Gelantopy Road section there is a gap of approximately 70 m between the last appearance of *A. kurnai* and the first appearance of *E. subditiva*; this 'gap' contains several indeterminate forms, but *Angochitina* sp. aff. *Sphaerochitina geraldis* Cramer & Diez 1978, *Angochitina* cf. *A. capillata* Eisenack 1937?, *A. cf. S. brevispinosa*

**B**



Grignani & Mantovani 1964 and *Gotlandochitina* sp. D can be identified. This segment, appearing only in the Gelantipy Road section, has been termed Assemblage 2b.

*Eisenackitina subditiva* makes a distinct and dramatic entrance approximately 3 m above the *P. dehiscens*-*P. perbonus* boundary in the Buchan Caves Entrance section. Although first appearing somewhat higher in the

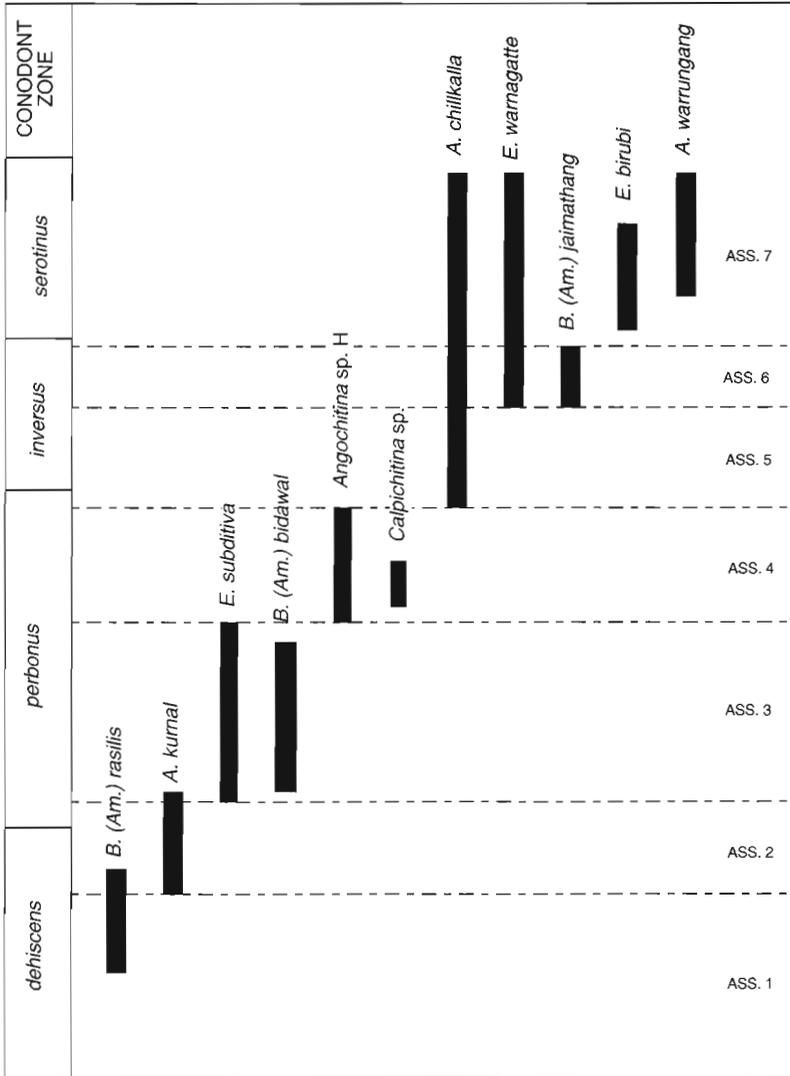


Fig. 6. Ranges of the stratigraphically important chitinozoan species from the Taravale Formation.

Gelantipy Road section, the entrance of *E. subditiva* marks a major change in the composition of the fauna. Assemblage 3 is characterised by the dominance of species of *Bursachitina* and *Eisenackitina*, generally in quite large numbers; *E. subditiva* is accompanied by *Bursachitina (Amplichitina) bidawal* sp. n., *Bursachitina (Bursachitina) ngarigo* sp. n., *Bursachitina (B.) talenti* sp. n. and *Bursachitina (A.)* sp. aff. *riclonensis*.

The abundant collection of robust species from Assemblage 3 is succeeded by a poorly preserved group of species, principally those with thin vesicle walls. Assemblage 4, in the upper portion of the *P. perbonus*

conodont Zone, is defined by the range of *Angochitina* sp. H. Other recognisable components of the assemblage are *Calpichitina?* sp., *Angochitina* cf. *A. capillata*, and *Angochitina* cf. *S. brevispinosa*.

The appearance of *Angochitina chillkalla* sp. n. heralds the beginning of the upper part of the section and ranges through all of the next three assemblages. *Angochitina chillkalla* first appears approximately 3 m below the boundary between the *P. perbonus*–*P. inversus* conodont zones. There are no other identifiable elements of this assemblage.

The definition of Assemblages 4 and 5 depends on both the dominance of species of thin-walled genera such as *Angochitina* and *Gotlandochitina* and on the absence of more robust forms. Better preserved specimens would probably lead to a more satisfying delineation of these assemblages, further studies of other Emsian successions within Australia are therefore warranted.

Assemblage 6 begins at the first appearance of *Eisenackitina warnangatte* sp. n. and *Bursachitina (Amplichitina) jaimathang* sp. n. The assemblage commences in the *P. inversus* conodont Zone, approximately 10 m above the *P. perbonus*–*P. inversus* boundary, and continues into the *P. serotinus* conodont Zone.

*Angochitina chillkalla* and *E. warnangatte* persist well into the *P. serotinus* Zone and into Assemblage 7. The incoming of *Eisenackitina birubi* sp. n. delineates the commencement of the Assemblage. *Angochitina warrungang* sp. n. appears in its upper part. Tabs 1–4 summarise the distribution of chitinozoan species in the two sections.

The *P. perbonus* conodont Zone in this area can be subdivided by four assemblages (i.e. Assemblage 2 to 5 inclusive). Only one assemblage is located mostly within the following *P. inversus* conodont Zone (Fig. 6). This disparity is consistent with the conodont zonal duration times proposed by Burrows *et al.* 1993), where the *P. perbonus* Zone was suggested to be much longer in duration than the *P. inversus* Zone.

## Comparison with other contemporaneous assemblages

Of the fifty-five species identified in the Taravale Formation, fifteen are described as new, and a further fifteen are probably new, but more material is needed to confirm this. A deliberately conservative approach has been taken in taxonomy because of the poor preservation of the fauna.

Only five species from the total number of 55 species identified from the Taravale Formation appear to bear a relationship with other species from the Emsian, and even then the relationship is only tentative. *Angochitina laevigata* Diez & Cramer 1978 from Spain, which ranges from Pragian to late Emsian (Diez & Cramer 1978), may have a parallel in the Taravale Formation. *Eisenackitina yaraan* sp. n. has been tentatively synonymised with *Desmochitina* cf. *D. amphorea* Eisenack 1931 from the late Emsian of Germany (Pichler 1971). *Gotlandochitina marettensis* var. *goliath* Paris

1981 from the late Emsian of France (Paris 1981b) may be related to species from the *P. perbonus* conodont Zone and *Angochitina* sp. B may be conspecific with *Angochitina milanensis* Collinson & Scott 1958, described by Jardiné & Yapaudjian (1968) from the Saharan Emsian. *Bursachitina* (A.) sp. aff. *riclonensis* Paris 1981 is similar to *B. riclonensis*, a characteristic species of the Emsian in many parts of the world (Paris *et al.* in press); the relationship between *B. (A.) riclonensis* and *B. (A.)* sp. aff. *riclonensis* is uncertain.

Eight other species from the Taravale Formation show similarities to long ranging species from both Australia and other continents: *Ancyrochitina spinosa* ranges from the Silurian to Middle Devonian of Europe, North America and Australia; *Angochitina cactula* Winchester-Seeto 1993 occurs in the Pragian of Australia and Poland; *Angochitina* cf. *A. capillata* Eisenack 1937 ranges from the Early to Middle Devonian of Europe, Africa, North America and Australia; *Angochitina* sp. aff. *A. crassispina* Eisenack 1964 has been previously found in the Pragian of Australia; *Angochitina* sp. aff. *A. filosa* Eisenack 1955 is possibly related to *A. filosa* ranging from the Silurian to Emsian in Europe, South America and Australia; *Angochitina* sp. cf. *Sphaerochitina brevispinosa* is similar to a species from the Silurian of North Africa; *Angochitina* sp. A may be a representative of *Angochitina mourai* Lange 1952, reported from the Silurian of South America and North Africa and from the Middle and Late Devonian of South America, however, *A. mourai* is more typical of the Late Devonian; finally *Angochitina* sp. H possibly belongs with *Angochitina dimorpha* Taugourdeau & Jekhowsky 1960 from the Early to Late Devonian of North Africa and Pragian of Australia. None of these species is useful for detailed biostratigraphic study.

## **Why is the fauna from the Taravale Formation unique?**

Previous studies of chitinozoans from the Early Devonian of Australia have been able to identify key index fossils that show very similar ranges to those observed in European biozonations (e.g. Winchester-Seeto 1993a, b). This contrasts sharply with the results of this study.

There are several reasons that might explain the unique composition of the chitinozoan fauna from Victoria. The first is that preservation is quite selective, favouring the conservation of robust forms and obliterating, or rendering unidentifiable the more delicate, thin-walled species. The bias in preservation may explain, in part, why some species from contemporaneous faunas are not present in the Taravale Formation, but does not address all of the problem. Paris (1981a) erected a biozonation of south-west Europe based on chitinozoans. In the Emsian three zones were recognised, based on the ranges of *Bulbochitina bulbosa* Paris 1981 and *Bursachitina riclonensis* and the overlap of *B. bulbosa* and *B. riclonensis*. These species are quite robust and have relatively thick vesicle walls, thus

their absence from the Taravale fauna cannot be totally due to biased preservation. Boumendjel *et al.* (1988) present the results of studies in North Africa; the assemblages identified contain 24 species with both thin and thick walls — only two of which occur in the Taravale fauna.

The study from the Algerian Sahara by Boumendjel *et al.* (1988) highlights another reason for the differences noted in the Victorian collection of species. Six genera, found in coeval successions on other continents that have not been observed in Australian Devonian sequences, i.e. *Amoricochitina*, *Cingulochitina*, *Linochitina*, *Margachitina*, *Urnochitina*, and *Urochitina*. The reasons for the absence of these genera is unclear, but the problem of these particular truant genera persists through all the studies of Early Devonian strata in Australia completed to date (Winchester-Seeto 1993a, b).

The Emsian has been recognised as the 'interval of highest provincialism' in the Devonian (Boucot *et al.* 1969; Boucot 1988), and this may help explain the peculiar Taravale fauna. High levels of endemism have been identified amongst trilobites (Eldredge & Ormiston 1979), brachiopods (Savage *et al.* 1979), rugose corals (Oliver & Pedder 1979), and gastropods (Blodgett *et al.* 1990). Planktic groups, in general, show a lower degree of endemism than do the benthic fauna; e.g. conodonts show endemism at the species level, but not at the generic level (Klapper & Johnson 1980; Charpentier 1984).

Perhaps the distribution of chitinozoans reflects the pattern of other fossil groups. This apparent endemism, however, relates primarily to species dispersion; the absence of chitinozoan genera common to other continents can be observed at least back to the Lochkovian. It is generally believed that the distribution of chitinozoans suggests a planktic habit for at least part of the organisms life-cycle and it is thus difficult to imagine the mechanism that would totally isolate Australian faunas from those in other regions of the world. Klapper & Johnson (1980) discussed the effects of transgression-regression sequences on conodont faunas and speculated that the large expanse of epeiric seas, resulting from Middle Devonian transgressions, led to cosmopolitan faunas. Conversely, the much smaller extent of epeiric seas in the Early Devonian might have accounted for the higher degree of endemism in conodonts at the species level. Similarly, the limited extent of the epicontinental seas may have disrupted Early Devonian shallow marine circulation, culminating in the restriction of currents near Australia and effectively isolating chitinozoan faunas. Whether this explanation is sufficient remains to be seen.

It is noteworthy that, to date, few studies of Emsian faunas have extracted chitinozoans from nodular limestones. Most other investigations have concentrated on shales and siltstones; Jardiné & Yapaudjian (1968) processed grey-black micaceous shales from a shallow-marine environment, Massa & Moreau-Benoit (1976) concentrated on shales and siltstones with some carbonates, similar to the sediments studied by Boumendjel *et al.* (1988), and Diez & Cramer (1978) extracted chitinozoans

from the olive-coloured strata of the La Vid Shales. The studies from South America located chitinozoans in predominantly from the Paraná, Paranaíba, and Amazon Basins. De Melo (1988) interprets the overall palaeogeography of this area as being close to emerged areas, particularly in the Early Emsian and undergoing progressive transgression towards the Late Emsian. These are represented in the main by marine shales, that may be bioturbated or richly fossiliferous as in the Paraná Basin. Paris (1981b) centred his search on highly fossiliferous, bioclastic limestones and shales from western France.

The Taravale Formation contrasts with the other studies in representing an apparently deeper environment of deposition. The unique nature of the Taravale fauna may be related to the relatively unusual environment, if this is the case then the composition of the fauna may be facies dependent. Facies related distributions of chitinozoans have been documented by Wright (1976) and Al Ameri (1983) both of whom noted a change in faunal composition with distance from shore-line (and consequent changes in depth) and possibly an association with 'open marine' conditions. Grahn (1982) detected a weak preference in some chitinozoans for shallow water conditions, in others for a restricted environment, with a slightly stronger, but still minor, effect of the type of sea-bottom.

The peculiar composition of the chitinozoan fauna from the Taravale Formation may be a reflection of one or a combination of the factors discussed above. This question will not be settled until further studies of Australian chitinozoans from several different depositional environments have been undertaken. Unfortunately, despite several attempts to locate other successions covering some or all of the Emsian with suitable strata for such a study, none has so far yielded chitinozoans; these include forays into the Murrumbidgee Group, southern New South Wales and Broken River Group, northern Queensland.

## **Taxonomic problems**

Some elements of the fauna from the Taravale Formation presented quite a taxonomic challenge. Laufeld (1974: p. 123) noted that in some instances 'the species of an assemblage of a certain age may have their morphological counterparts in similar environments in the same or another geological system'. This problem, where some species mimic the shapes of those from other time-intervals was apparent in this study. *Eisenackitina subditiva* sp. n., for instance, is almost indistinguishable in shape from *Eisenackitina bohémica* (Eisenack 1934), from the Lochkovian. Similarly, *Bursachitina* (*Amplichitina*) *bidawal* sp. n. is almost identical to *Eisenackitina* sp. 1 described by De Bock (1982) from the Ludlow of France. In both cases the surface ornament is the only feature that distinguishes between the two species, this can cause major problems where the surface ornament is eroded. In other cases, the differences may include only a couple of minor

features; *Eisenackitina* sp. E from this study, differs only in size and ornament from *Bursachitina bursa* (Taugourdeau & Jekhowsky 1960).

The comparative minor dissimilarities between the sets of species described above emphasise the need for taxonomic decisions to be based on detailed SEM observation of the ornamentation and on a reasonably sizable population to allow for statistical analysis of size and proportions. These two precautions should eliminate most problems. The close similarity of two species is most common with species with comparatively simple morphology and may reflect convergent evolution.

## Systematic Palaeontology

As there is no universally accepted suprageneric nomenclature for chitinozoans, the system used by Laufeld (1974) has been followed with the genera listed alphabetically.

All measurements are taken in micrometers. Abbreviations used in the text are: L — length of vesicle; Lc — length of chamber; Ln — length of neck; Dmax — maximum diameter of chamber; Dn — diameter of neck; Da — diameter of aperture; Lsp — length of spines. Morphological terms used in this paper are those defined by Laufeld (1974: pp. 37–38) and Paris (1981a: figs 56, 57).

A correction factor of 0.7 has been used for those individuals whose diameter has been distorted by total flattening, this follows, in part, the precedent set by Jaglin (1986). Most of the specimens recovered in this study were in full relief, or only partially flattened, consequently the procedure was used infrequently.

Type and figured specimens are housed in the collections of the Museum of Victoria, Melbourne (numbers prefixed by NMV P). Localities are designated as BCE for samples from the Buchan Caves Entrance section and 7T, 8T, 9T, 11T, 15T and 16T for the section along the Gelantipy Road (Fig. 2). Numbers of specimens in particular samples are listed in Tabs 1–4.

Genus *Ancyrochitina* Eisenack 1955

*Ancyrochitina spinosa* (Eisenack 1932)

Figs 4, 7C, Tab. 1.

*Conochitina spinosa* sp. n.; Eisenack 1932: p. 270, pl. 12: 11–13.

*Ancyrochitina spinosa* (Eisenack); Eisenack 1955: p. 18, pl. 2: 1–2; Eisenack 1959: p. 18, pl. 2: 1–2.

*Ancyrochitina* cf. *A. spinosa* (Eisenack); Urban & Kline 1970: p. 71, pl. 18: 1–3, 14; Urban 1972: p. 11, pl. 1: 2–3.

*Ancyrochitina spinosa* var. *gibba*; Winchester-Seeto 1993b: fig. 14H.

**Remarks.** — Individuals of this species from Buchan are very similar to the collection of *A. spinosa* var. *gibba* from Martins Well in Queensland, both in overall shape and surface sculpture. Specimens from Victoria are slightly longer than those from the older section in Queensland and

maximum diameter is considerably larger. The neck is longer on specimens from the Buchan sequence ( $L_n/L = 0.39-0.44$ ), placing it closer to the range mentioned by Dunn (1959) for *A. spinosa* ( $L_n/L = 0.40-0.47$ ).

The same range of shape can also be observed on species designated *A. cf. A. spinosa* by Urban & Kline (1970), Urban (1972) and those originally assigned to *A. spinosa* by Eisenack (1932, 1955, 1959). The absence of 'antler-like' spines mentioned in the original description by Eisenack (1932) and subsequently by Urban & Kline (1970) may be due to poor preservation of the surface ornamentation on specimens from both Victoria and Queensland.

Urban & Kline (1970: p. 71) differentiated *A. cf. A. spinosa* on the appearance of the neck, that increases in diameter above what appears to be the prosome and then continues as a broader cylindrical tube to the oral periphery. This feature is observed in the illustrations by Eisenack (1932, 1955, 1959), Urban & Kline (1970), Urban (1972), and Winchester-Seeto (1993b and Fig. 7C, herein). *A. spinosa* (Eisenack), however, in general displays a cylindrical neck of the same width along its entire length e.g. as seen in Cramer (1964: pl. 20: 1), Da Costa (1971: fig. 9), Hou (1978: pl. 49: 10) and in some of the illustrations by Dunn (1959: pl. 127: 19, 20, 23, but not figs 21 and 22). The size, general proportions and chamber shape in populations of *A. spinosa* var. *gibba* and typical *A. spinosa* overlap; it is possible that the division between the two groups is largely artificial. There is no stratigraphic difference between the two groups, with *A. spinosa* var. *gibba* occurring in the Silurian, Early and Middle Devonian and *A. spinosa* recovered over the same time interval. As well as having a large stratigraphic range this species has a wide geographic spread occurring in Australia, China, Europe, and North and South America.

**Dimensions.** — Taken from three specimens from samples BCE-4 and BCE-5.5: *L* — 126–163 (mean. 144.3); *L<sub>c</sub>* — 70–100 (mean. 85.2); *L<sub>n</sub>* — 56–63 (mean. 57.9); *D<sub>max</sub>* — 74–93 (mean. 85.1); *D<sub>n</sub>* — 26–30 (mean 29.6);  $L_n/L = 0.39-0.44$ ;  $L/D_{max} = 1.7-1.8$ .

**Occurrence.** — Taravale Formation, (see Tab. 1, Fig. 4); Wenlock of Gotland; Pridolian *Beyrichenkalk* Baltic erratics of Germany, Silurian; Cedar Valley Formation of Missouri and Iowa, (*P. varcus* conodont Zone).

Genus *Angochitina* Eisenack 1931

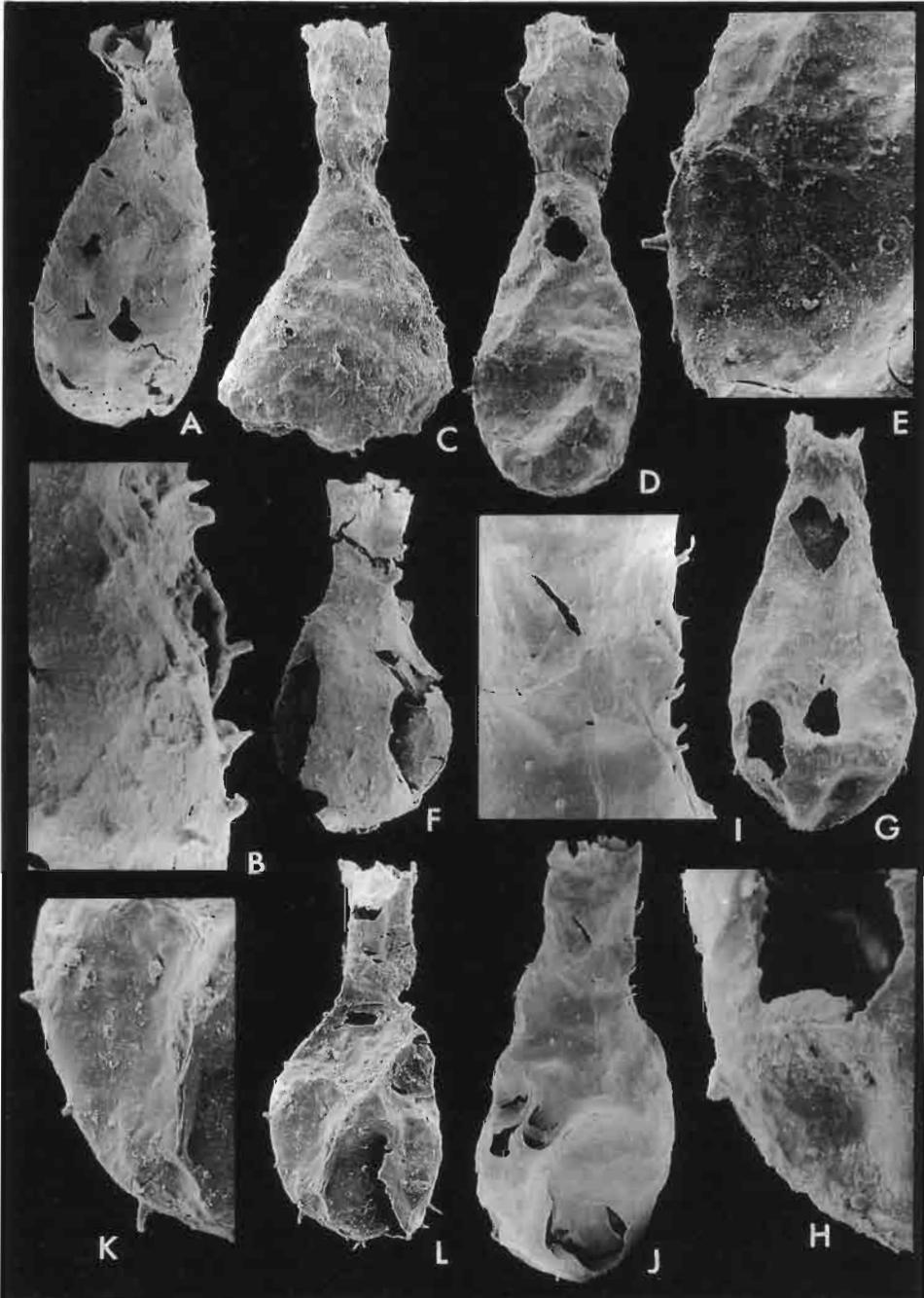
*Angochitina cactula* Winchester-Seeto 1993

Figs 4, 7D–E, K–L, Tab. 1.

*A. cf. A. crassispina?* Eisenack; Wrona 1980: p. 129, pl. 27: 1–6.

*A. cactula* sp. n.; Winchester-Seeto 1993b: fig. 11A–E.

Fig. 7. □A–B, I–J. *Angochitina chillkalla* sp. n. A–B. Holotype NMV P138537 from sample 16T/65.0; × 300 (A) and enlargement (B) × 1300. I–J. Specimen NMV P138538 from sample 11T/150.0; × 350 (J) and enlargement (I) × 800. □C. *Ancyrochitina spinosa* (Eisenack 1932), specimen NMV P138539 from sample BCE-4; × 300; □D–E, K–L. *Angochitina cactula* Win-



chester-Seeto 1993. D. Specimen NMV P138540 from sample BCE-5.5;  $\times 300$  (D) and enlargement (E)  $\times 900$ . L–K. Specimen NMV P138541 from sample BCE-5.5;  $\times 300$  (L) and enlargement (K)  $\times 850$ . □F. *Angochitina* sp. cf. *A. capillata* Eisenack 1937 specimen NMV P138542 from sample BCE-4;  $\times 300$ . □G–H. *Angochitina laevigata* Diez & Cramer 1978?, specimen NMV P138543 from sample BCE-14;  $\times 300$  (G) and enlargement (H)  $\times 700$ .

Tab. 1. Distribution of chitinozoans from the Buchan Caves Entrance section (BCE).

Meters above base of section	21.9	23.8	32.3	37.4	39.3	45.7	49.6	55.2	51.6	63.8	65.5	69.0	71.5
Sample number	BCE-26	BCE-25	BCE-22	BCE-19	BCE-18	BCE-14	BCE-12	BCE-11	BCE-6	BCE-1	BCE-2	BCE-4	BCE-5.5
<i>B. (A.) rasilis</i>	11	1	1	13	4	75			5				
<i>B. (A.)</i> sp. cf. <i>E. cupellata</i>	1					5							
<i>A. kurnal</i>				5		2	3			17		6	21
<i>Angochitina</i> sp. B				2						7			2
<i>A. laevigata?</i>						2							
<i>Gotlandochitina</i> sp. A								1					
<i>Gotlandochitina</i> sp. B								2					1
<i>Angochitina</i> sp. A										4		1	
<i>E. suditva</i>											102		
<i>Ancyrochitina spinosa</i>												2	2
<i>A. sp. aff. filosa</i>												7	16
<i>A. cactula</i>												15	38
sp. indet.													4

**Remarks.** — Vesicle shape and major dimensions coincide closely with specimens from the Martins Well fauna except that the maximum diameter sometimes occurs near the midlength of the vesicle, rather than always near the aboral edge. *A. cf. A. crassispina* depicted by Wrona (1980) differs only in being slightly larger and having a much longer neck ( $L_n/L - 0.47-0.53$ , dimensions taken from specimens illustrated by Wrona 1980: pl. 27: 1-6). Fig. 8A-B shows the relationship between *A. cf. A. crassispina* and specimens of *A. cactula* from the Taravale Formation.

Poor preservation obscures much of the detail of the ornamentation of this species. When present, however, the spine form is the same as that on specimens from Martins Well. The distribution of spines is similar, as evidenced by the scars of broken spines and it follows the same pattern of reduced thickness and length on the neck.

*Angochitina cactula* differs from *A. sp. aff. geradis* (Cramer & Diez 1978) in having a wider vesicle ( $D_{max}$  is 57-82 m for *A. cactula* vs. 85 m for *A. sp. aff. geradis*) and differs from *Angochitina* sp. F and *Angochitina* sp. G in having a longer neck ( $L_n/L$  ranges 0.35-0.45 for *A. cactula* and 0.26-0.35 for *Angochitina* sp. F; average  $L_n$  is 68.2 m for *A. cactula* vs. 46.8 m for *Angochitina* sp. G). *Angochitina cactula* can also be distinguished by the presence of a thin, but conspicuous, fringed collar, not apparent on *Angochitina* sp. G.

Some difficulties may arise in distinguishing *A. cactula* from *A. sp. aff. Sphaerochitina brevispinosa* Grignani & Mantovani (1964) where the neck of *A. cactula* has been partially compressed; in some cases the neck may

then resemble the characteristic neck constriction of *A. sp. aff. S. brevispinosa*. Careful examination of the poorly preserved individuals shows that the neck of *A. cactula* is subcylindrical with a sudden 'flare' at the collar, or may be subconical with an widening beginning at the point of flexure. This contrasts with *A. sp. aff. S. brevispinosa*, which has a subcylindrical neck, with a sudden expansion of the neck well below the collar. These differences are subtle however, and may not be apparent with a small number of very poorly preserved individuals.

**Dimensions.** — Taken from 14 specimens from samples BCE-4 and BCE-5.5: L — 136–206 (mean 153.2); Lc — 88–133 (mean 105.7); Ln — 48–85 (mean 68.2); Dmax — 57–82 (mean 66.4); Dn — 23–39 (mean 30.7); Lsp — 4–7 (Av 7.1); Ln/L — 0.35–0.44; L/Dmax — 2.2–2.9.

**Occurrence.** — Taravale Formation, (see Tab. 1, Fig. 4); Pragian Martins Well Limestone of northern Queensland; Pragian of southeast Poland.

### *Angochitina sp. cf. A. capillata* Eisenack 1937?

Figs 5A, 7F, Tabs 1–2.

*Angochitina cf. A. capillata* Eisenack; Winchester-Seeto 1993a: p. 744, fig. 7.9.

**Remarks.** — The vesicle silhouette resembles that of *A. capillata* as illustrated by a number of authors e.g. Dunn (1959), Urban (1972) and that depicted as *A. cf. A. capillata* by Lange (1967) and Winchester-Seeto (1993a). Minor differences include a more variable neck length to that described by Dunn (i.e. Ln/L — 0.20–0.45 in the collection from the Taravale Formation, as opposed to Ln/L — 0.30–0.38 for the group from Iowa) and a smaller vesicle than those from the Paraná Basin (L — 133–160 m for vesicles from the Taravale Formation; L — 152–278 m for vesicles from the Paraná Basin). Individuals from the Garra Limestone differ in having a slightly narrower chamber than those from Victoria (Dmax — 64–78 for the Taravale collection and mean Dmax — 49–73 for the group from the Garra Limestone).

The ornamentation on the Buchan specimens has been considerably eroded. The few preserved spines are short, fine and erect as described by Dunn (1959), but the overall spine density appears to be slightly lower than any of the previous illustrations or descriptions. It is not possible to assess the full range of spine-form on the specimens from the Gelantipy Road section and thus the existence, or absence, of bifurcate spines remains in doubt. Both Eisenack (1937) and Dunn (1959) insisted on excluding specimens with bifurcate spines from *A. capillata*, for this reason, *A. cf. A. capillata* was used by Lange (1967) and Winchester-Seeto (1993a) to differentiate this variation. The group from the Taravale Formation has been tentatively placed in *A. cf. A. capillata* because of the otherwise close resemblance to individual specimens from the Garra Limestone.

The silhouette of this species also resembles many examples of the species *Sphaerochitina sphaerocephala* Eisenack 1932 (e.g. Eisenack 1972a: pl. 19: 2–16, 18–21). Paris *et al.* (1985: p. 21) discusses the problem

caused by the wide variety of forms being assigned to this taxon and suggests that only those 'specimens with a spheroid body and a cylindrical neck and having minute and inconspicuous ornamentation of microcones or microverrucae' should be included. This concept has been adopted in the present study; thus the short spines observed on the chamber and neck preclude the inclusion of this group in *S. sphaerocephala*.

**Dimensions.** — Taken from six specimens from 8T/35, 8T/50.0, 9T/198.7 and 9T/226.8: L — 133–160 (mean 141); Lc — 93–109 (mean 99.5); Ln — 27–60 (mean 45.7); Dmax — 64–78 (mean 71.7); Dn — 27–40 (mean 32.6); Ln/L — 0.20–0.41; L/Dmax — 1.8–2.1.

**Occurrence.** — Taravale Formation (see Fig. 5A, Tabs 1–2); Lochkovian-Pragian of the Garra Formation, Australia; Eifelian (*P. varcus* conodont Zone?) Wapsipinicon Formation of Iowa; Eifelian (*P. varcus* conodont Zone) Solon Member of the Cedar Valley Formation, Iowa; Middle Devonian Ponta Grossa Shale of the Paraná Basin; Lochkovian Ouan-Kasa Formation of Libya.

### *Angochitina chillkalla* sp. n.

Figs 5A–B, 7A–B, I–J, Tabs 3–4.

Holotype: NMV P138537 (Fig. 7A–B).

Type horizon and locality: Taravale Formation, 355m above the base of the Gelantipy Road section (sample 16T/65) at Buchan, Victoria, Australia.

Derivation of name: From the Australian Aboriginal word *chillkalla*, meaning prickle, referring to the short, sharp, simple spines.

**Diagnosis.** — A species of *Angochitina* with a club-shaped vesicle and a relatively short, cylindrical to sub-conical neck. The surface is covered with short, sturdy, pointed, simple spines.

**Description.** — This species has a moderate sized vesicle featuring an elongate ovoid chamber, with maximum diameter near the midpoint of the chamber or in the lower third. The base of the chamber is strongly convex. Flexure is indefinite and the neck is relatively short, always being less than half the vesicle length (Ln/L — 0.30–0.46). The shape of the neck varies from cylindrical to sub-conical. The spines are fairly sparsely set (3–12/100  $\mu\text{m}^2$ ).

**Remarks.** — There is some degree of similarity to specimens cited as *Angochitina pilosa* (Collinson & Scott 1958) by Paris (1981b: pl. 3: 11, 13) from the Emsian of France. *A. chillkalla* differs in being much smaller (mean L — 200  $\mu\text{m}$  for *A. pilosa*).

Individuals of *A. cf. A. capillata* found stratigraphically lower in this section also resemble *A. chillkalla*, but can be distinguished by the sub-conical neck of *A. cf. A. capillata* and the relatively narrower chamber (L/Dmax — 1.8–2.1 for *A. cf. A. capillata*; L/Dmax — 1.9–2.7 for *A. chillkalla*).

**Dimensions.** — Taken from nine specimens from samples 11T/150, 11T/155 and 16T/65: L — 139–170 (mean 153.8); Ln — 46–68 (59.2); Lc — 78–109 (mean 95.5); Dmax — 54–75 (mean 66.7); Da — 20–34 (mean 29.4); Ln/L — 0.30–0.46; L/Dmax — 1.9–2.7; Da/Dmax — 0.3–0.6.

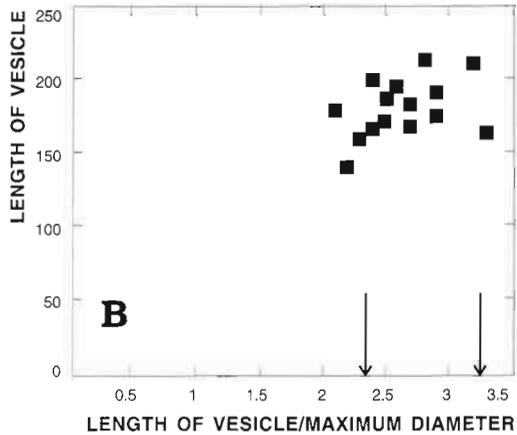
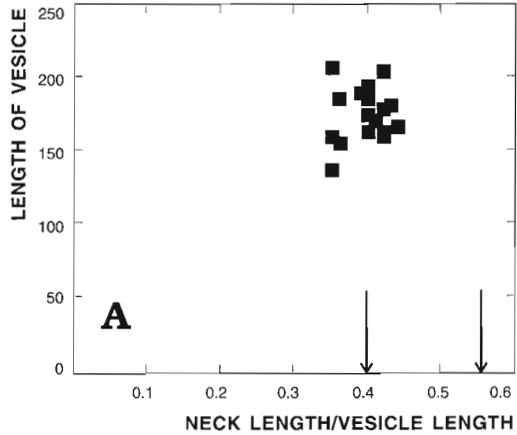


Fig. 8. Intraspecific variation of *Angochitina cactula* Winchester-Seeto 1993 in samples BCE-4 and BCE-5.5 of the Buchan Caves Entrance section of the Taravale Formation, comparing the total length of the vesicle to length of neck/total length (A) and total length of vesicle to length/maximum diameter of vesicle (B). Arrows indicate the range of neck length/total length found on *Angochitina* sp. cf. *A. crassispina* as illustrated by Wrona (1980: pl. 27: 1–6).

*Angochitina* sp. aff. *A. crassispina* Eisenack 1964

Figs 5A, 9A–B, Tab. 2.

*Angochitina* sp. aff. *A. crassispina* Eisenack; Winchester-Seeto 1993a: fig. 7.8; Winchester-Seeto 1993b: fig. 11G–H.

**Remarks.** – All specimens have broken and partially flattened vesicles resulting in considerable erosion of the ornamentation on the specimens from sample 8T/35 and shape distortion due to compression. Nonetheless the individuals closely resemble *A. sp. aff. A. crassispina* from both the Garra Limestone and the Shield Creek Formation (Winchester-Seeto 1993a, b). The Emsian specimens are somewhat larger than those from either of the older sections (L – 151–187m) and the necks are slightly longer ( $L_n/L$  – 0.36–0.50), but ornamentation has the same form and density as that found previously.

This study has considerably extended the known range of this species and it is now recognised from the Early Pragian (*E. sulcatus* conodont

Zone) in the Shield Creek Formation and the Garra Limestone and in the Emsian (*P. perbonus* conodont Zone).

**Dimensions.** — Taken from 3 specimens from samples 8T/35 and 8T/50.0: L — 151–187 (mean 170.3); Lc — 75–120 (mean 100.4); Ln — 67–75 (mean 70); Dmax — 57–65 (mean 61.8); Dn — 24–32 (mean 28.9); Lsp — 4; Ln/L — 0.36–0.50; L/Dmax — 2.3–2.7.

**Occurrence.** — Taravale Formation (see Tab. 2, Fig. 5A); Pragian (*E. sulcatus* conodont Zone) Shield Creek Formation of northern Queensland and Garra Limestone of New South Wales.

### *Angochitina* sp. aff. *A. filosa* Eisenack 1955

Fig. 9D–E.

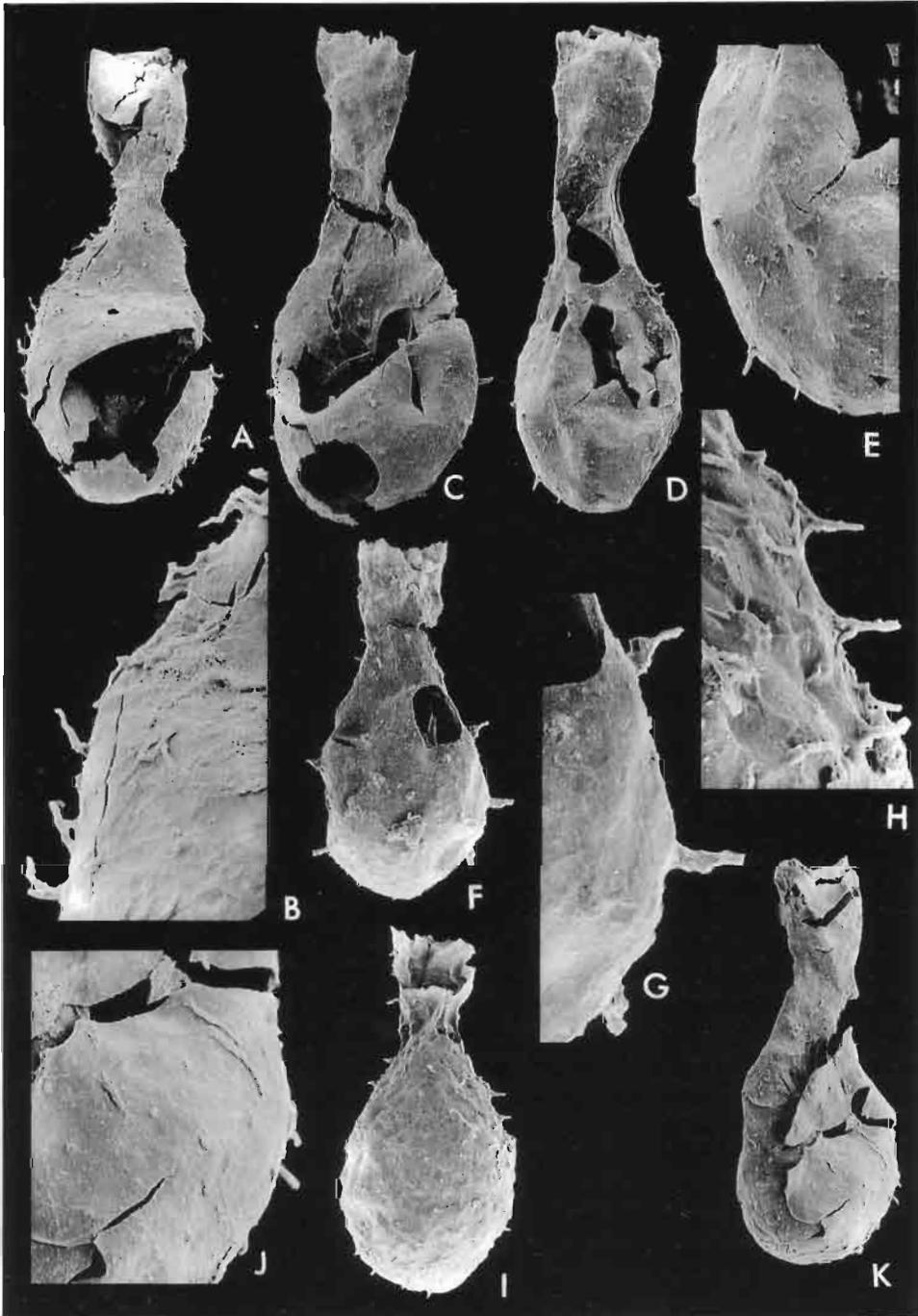
**Description.** — *A.* sp. aff. *A. filosa* has a slender ovoid to pear-shaped chamber, with maximum diameter occurring at, or slightly below the mid-point of the chamber. The base is strongly convex, with no apparent basal edge. A basal scar may be evident, sometimes occurring on a slight bulge protruding from the centre of the base. The vesicle displays a gentle flexure, leading to a sub-cylindrical or slightly conical neck. The neck varies in length from 40 to 54% of the total vesicle and may be greatly widened at the aperture (i.e. increased up to 35%). The aperture is surrounded by a short, fringed collar. Ornamentation consists of short, sparsely distributed spines, scattered over most of the vesicle, but not on the collar.

**Remarks.** — *Angochitina* sp. aff. *A. filosa* differs from *A. filosa* described by Eisenack (1955, 1968), Cramer (1964, 1967, 1973), and Cramer & Diez (1978) in having no forked spines, very few spines on the neck and in having shorter, more sparsely distributed surface sculpture. All of these observations may, however, be the result of surface erosion of the specimen. The only other dissimilarity is the relatively shorter neck on the specimens from Victoria.

The collection of specimens from Victoria differs markedly from the individuals of *A. filosa* from Martins Well (Winchester-Seeto 1993b) and those from Poland, described by Wrona (1980). The Victorian specimens are much larger than those from Martins Well, have a more distinct flexure and a wider aperture. In addition the Victorian group has fewer spines and only simple spines have been observed. These two occurrences of *A. filosa* appear to form a distinct, stratigraphically significant group and may represent a new variety of *A. filosa*.

*Angochitina* sp. aff. *filosa* is much larger than most similar species from the Taravale Formation (e.g. *A. cactula*, *A.* cf. *S. brevispinosa*, and *Angochitina* sp. G). It has a proportionally longer neck than *A. cactula*, *A.* sp.

Fig. 9. □A–B. *Angochitina* sp. aff. *A. crassispinata* Eisenack 1964, specimen NMV P138544 from sample 8T/50.0; × 300 (A) and enlargement of wall showing spines (B) × 1100. □C. *Angochitina* sp. cf. *S. brevispinosa* Grignani & Mantovani 1964, specimen NMV P138545 from sample 8T/50.0; × 300. □D–E. *Angochitina* sp. aff. *A. filosa* Eisenack 1955, specimen NMV P138546 from sample BCE-5.5; × 300 (D) and enlargement of lower vesicle wall (E) × 650.



□ F–I. *Angochittina kurnai* sp. n. F–G. Specimen NMV P138547 from sample BCE-4;  $\times 320$  (F) and enlargement of lower vesicle wall showing spine-form (G)  $\times 900$ . I–H. Holotype NMV P138548 from sample BCE-4;  $\times 300$  (I) and enlargement of chamber wall (H)  $\times 1400$ . □ J–K. *Angochittina* sp. aff. *A. valentini* Cramer 1964, specimen NMV P138549 from sample 9T/166;  $\times 300$  (K) and enlargement of lower vesicle wall (J),  $\times 800$ .



aff. *S. brevispinosa*, *Angochitina* sp. F, and *Angochitina* sp. G, and has a narrower chamber than *Angochitina* sp. aff. *S. geradis*.

The only other report of *A. filosa* in the Emsian is that in the Paraná Basin by Da Costa (1971), illustrated by silhouette photographs, consequently it is not clear whether there is any relationship between the species reported from Brazil and that found in Victoria.

**Dimensions.** — Taken from nine specimens from samples BCE-4 and BCE-5: L — 198–232 (mean 211.6); Lc — 99–127 (mean 111.8); Ln — 82.0–118.8 (mean 102.9); Dmax — 60–69 (mean 66.3); Dn — 25.8–30.0 (mean 27.8); Dcoll — 34.4–43.0 (mean 35.5); Ln/L — 0.40–0.54; L/Dmax — 2.9–3.9.

Taken from 1 specimen from sample 8T/50.0: L — 187; Lc — 99; Ln — 88; Dmax — 51; Dn — 20; Dcoll — 29; Ln/L — 0.47; L/Dmax — 3.6.

### *Angochitina kurnai* sp. n.

Figs 5A, 9F–I, 4, Tabs 1–2.

Holotype: NMV P138548 (Fig. 9H–I).

Type horizon and locality: Taravale Formation, 69 m above the base of the Buchan Caves Entrance section (sample BCE-4) at Buchan, Victoria, Australia.

Derivation of name: Named after a local Aboriginal clan inhabiting the Buchan Caves area of Victoria, the Kurnai.

**Diagnosis.** — A species of *Angochitina* with an oval to egg-shaped chamber; maximum diameter occurs near, or just below the mid-length of the vesicle. Ornamentation consists of a sparse distribution of short, conspicuous, simple spines. Each spine has a wide base, resembling buttress roots of trees; the base and spine appear to be hollow.

**Description.** — The chamber has a strongly convex base and an inconspicuous flexure with no apparent shoulders. The squat neck ranges in shape from sub-cylindrical to sub-conical and a small collar with a crenulate edge may be discernible. The surface of the vesicle is peppered with strong, short spines, sparsely set spines ( $1\text{--}3/100\ \mu\text{m}^2$ ), decreasing in length on the neck.

**Remarks.** — This species most closely resembles *Angochitina devonica* Eisenack 1955 in shape, but *A. kurnai* can be readily distinguished by its spine form.

**Dimensions.** — Taken from six specimens from samples BCE-1, 4, 14, and 19: L — 123–170 (mean 142); Lc — 72.0–103.6 (mean 90.1); Ln — 45–67 (mean 54.4); Dmax — 58–78 (mean 66.8); Dn — 23–34 (mean 27.5); Lsp — 3–11 (mean 7.6); Ln/L — 0.36–0.41; L/Dmax — 1.9–2.3.

Taken from 3 specimens from samples 8T/35 and 8T/50: L — 98–141 (mean 121.3); Lc — 62–96 (mean 79); Ln — 36–46 (mean 42.3); Lsp — 4–7 (mean 5.3); Ln/L — 0.32–0.37; L/Dmax — 2.0–2.3.

### *Angochitina laevigata* Diez & Cramer 1978?

Figs 5A, 7G–H, 4, Tabs 1–2.

?*Angochitina laevigata* n. sp.; Diez & Cramer 1978: p. 208, pl. 1: 28, 29.



**Remarks.** — The specimens from the Taravale Formation are very similar to those described and figured by Diez & Cramer (1978), differing only in a slightly narrower chamber on the individuals from Australia (i.e. mean  $L/D_{max}$  is 2.2 for the Australian group and 1.6 for the Spanish group) and a more convex base. The surface of the vesicle is mostly smooth, with only a few spines or spine-bases visible, predominantly on the flanks of the chamber. The spine distribution is close to that described by Diez & Cramer (1978), but poor preservation makes further observations impossible, therefore this group has been only tentatively placed with *A. laevigata*.

There is a resemblance between the vesicle shape of this species and some specimens of *Angochitina dimorpha* Taugourdeau & Jekhowsky 1960. *A. dimorpha*, however, has many more spines than are evident on the individuals from the Taravale Formation.

**Dimensions.** — Taken from three specimens from samples BCE-14 and 8T/50.0:  $L$  — 131–155 (mean 140.3);  $L_c$  — 99–130 (mean 115.2);  $L_n$  — 18–32 (mean 25.3);  $D_{max}$  — 61–67 (mean 63.5);  $D_n$  — 21–35 (mean 28.5);  $L_n/L$  — 0.13–0.25;  $L/D_{max}$  — 2.14–2.30;  $D_n/D_{max}$  — 0.33–0.57.

**Occurrence.** — Taravale Formation (see Figs 4, 5A, Tabs 1–2); Lochkovian to Emsian La Vid Shales of Spain.

### *Angochitina* sp. aff. *A. valentini* Cramer 1964

Figs 5A, 9J–K, Tabs 2–3.

**Description.** — These are large vesicles with a somewhat conical neck, widening towards the aperture. A small, thin collar may be present, flaring towards the crenulate oral periphery. The chamber has an elongate, slender ellipsoid form, with the maximum diameter in the lower half to lower third of the vesicle. Flexure is gradual, but definite and the base is convex.

Sparsely set short, slender, simple spines dominate the chamber and lower neck. The upper neck, however, may have a few small, fine spines, decreasing in size and density toward the aperture.

**Remarks.** — The strongly conical neck, sloping shoulders and ellipsoid chamber closely match the range of shapes described and depicted by Cramer (1964) for the Silurian species *Angochitina valentini*. The specimens from the Taravale Formation are slightly smaller than those from Spain and the necks are slightly shorter (i.e.  $L_n/L$  — 0.40–0.47 for the specimens illustrated on pl. 21: 3–6 in Cramer 1964;  $L_n/L$  — 0.38–0.39 for the group from the Taravale Formation). The type specimens of *Angochitina valentini* bear no spines or other ornamentation and thus differ considerably from the individuals found in Australia; the material from Victoria has a sparse sprinkling ( $3/100 \mu m^2$ ) of slender, simple spines.

**Dimensions.** — Taken from three specimens from samples 9T/166 and 9T/282.6:  $L$  — 170–190 (mean 179);  $L_c$  — 106–116 (mean 109.9);  $L_n$  — 64.5–75.0 (mean 69.1);  $D_{max}$  — 68–68 (mean 68);  $D_n$  — 34–37 (mean 36.3);  $L_{sp}$  — 9–14 (mean 11);  $L_n/L$  — 0.38–0.39;  $L/D_{max}$  — 2.5–2.6.

*Angochitina warrugang* sp. n.

Figs 5B, 10B–C, H–I, Tab 4.

Holotype: NMV P138552 (Fig. 10H–I).

Type horizon and locality: Taravale Formation, 353.7 m above the base of the Gelantipy Road section (sample number 16T/71.7) at Buchan, Victoria, Australia.

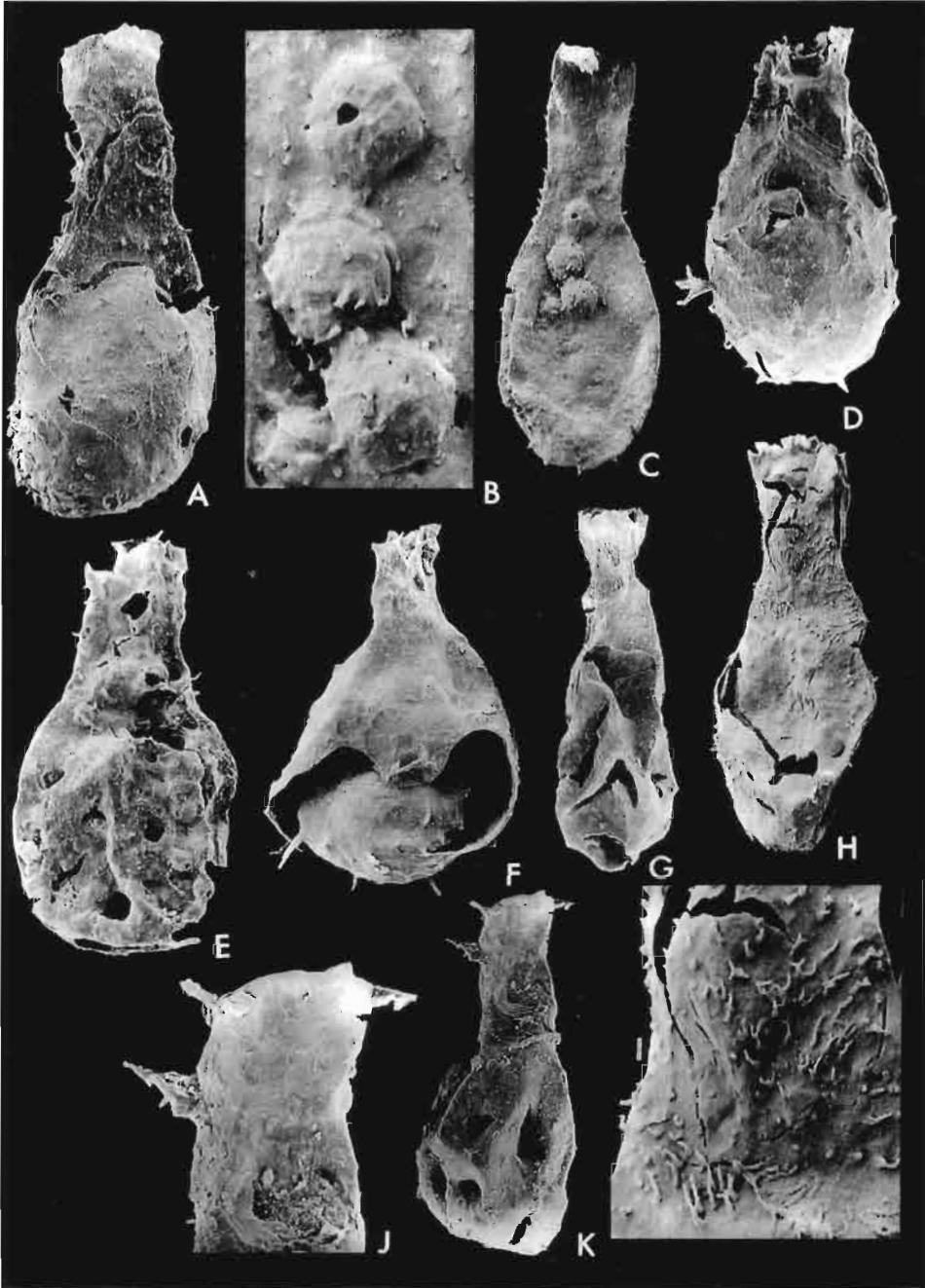
Derivation of name: From the Australian Aboriginal word *warrugang*, meaning snow gum, referring to the shape of the multiramified spines resembling a snow gum tree.**Diagnosis.** — A species of *Angochitina* with a cylindro-ovoid vesicle. The neck is relatively short and the vesicle surface is carpeted with close-set, short, fine spines; these may be simple but are more commonly bifurcate or multiramified.**Description.** — The vesicle shows a distinct, but gentle flexure and the neck varies from cylindrical to sub-conical. A short, thin collar with a crenulate edge may be present. The chamber has the maximum diameter near the centre and the base may be strongly convex, but is often flat in compressed specimens. Fairly densely spaced spines (9–18/100  $\mu\text{m}^2$ ) cover the entire vesicle except the collar.**Remarks.** — *Angochitina warrugang* shows some similarity to *Fungochitina pilosa* (Collinson & Scott 1958), but is clearly differentiated by the ovoid, rather than sub-conical chamber. The dominance of bifurcate and multiramified spines on *A. warrugang*, as opposed to the few observed on *F. pilosa* confirm the difference.**Dimensions.** — Taken from nine specimens from samples 16T/71.7 and 16T/65: L — 141–173 (mean 137.3); Ln — 33–60 (mean 43.3); Lc — 96–122 (mean 111); Dmax — 45–72 (mean 58.3); Da — 21–41 (mean 28.4); Lsp — 2–4; Ln/L — 0.20–0.38; L/Dmax — 2.4–3.5.*Angochitina* sp. cf. *Sphaerochitina brevispinosa* Grignani & Mantovani 1964

Figs 5A, 9C, Tabs 2–3.

? *Sphaerochitina* cf. *S. brevispinosa* Grignani & Mantovani; Rahmani 1978: p. 379, pl. 2: 6.**Remarks.** — This species bears a striking resemblance in size and shape to that described and depicted by Rahmani (1978) from the Silurian of Morocco. He noted a peculiar constriction at the base of the neck, sometimes as narrow as half the maximum diameter of the aperture. This distinctive feature is found on all members of the group from the Gelantipy Road section, with the proportion of minimum diameter of the neck versus maximum diameter of the aperture ranging from 0.5–0.65 (i.e. Dn min/Da — 0.50–0.65). The narrowing at the base of the neck is also found on type specimens of *Sphaerochitina brevispinosa*. *Angochitina* sp. cf. *S. brevispinosa* can be differentiated from *S. brevispinosa* by the wider aperture and

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Fig. 10. □A. *Angochitina* sp. aff. *S. geradis* Cramer & Diez 1978, specimen NMV P138550 from sample 9T/166;  $\times$  300. □B–C, H–I. *Angochitina warrugang* sp. n. B–C. Specimen NMV P138551 from sample 16T/71.7;  $\times$  350 (A) and enlargement of neck showing neck with unusual structure of vesicle wall, possibly the result of parasite damage (B)  $\times$  1400. H–I. Holotype NMV P138552 from sample 16T/71.7;  $\times$  350 (H) and enlargement of lower neck



ornament (I)  $\times 1100$ .  $\square$ D. *Angochitina* sp. B, specimen NMV P138553 from sample BCE-19;  $\times 400$ .  $\square$ E. *Angochitina* sp. A, specimen NMV P138554 from sample BCE-1;  $\times 300$ .  $\square$ F. *Angochitina* sp. C, specimen NMV P138555 from sample 8T/35;  $\times 350$ .  $\square$ G. *Angochitina* sp. F, specimen NMV P138556 from sample 9T/226.8;  $\times 300$ .  $\square$ J-K. *Angochitina* sp. D, specimen NMV P138557 from sample 8T/35;  $\times 350$  (K) and enlargement of neck (J)  $\times 800$ .

more conical shape of the neck on *S. brevispinosa* and the more tear-drop shaped chamber; *Angochitina* sp. cf. *S. brevispinosa* has the maximum diameter located nearer the middle of the chamber giving a rounder, more elliptical form.

The surface of the chamber and lower neck is sparsely covered with fine, relatively short spines. These spines are predominantly simple, but a few appear with bifurcate terminations. *S. brevispinosa* has a fine tuberculate ornamentation, but this is not present on the specimens from Australia. Rahmani (1978) reports a similar surface sculpture for the older specimens from Morocco, but some spines can be discerned on the silhouettes. The spines present on the specimens from Australia suggest that the genus is more likely to be *Angochitina*. The specimens from the Silurian of Morocco have been tentatively synonymised because the poor illustrations make definitive comparison difficult and because of the stratigraphic distance between the two disjunct occurrences.

This species also resembles some examples of *Angochitina echinata* Eisenack 1931 (e.g. Eisenack 1972a: pl. 17: 4, 8–9, 14). However, *A. echinata* differs in having a longer neck, a denser covering of ornamentation and in lacking evidence of a constriction at the base of the neck. Although superficially similar to *Angochitina kurnai* sp. n., *Angochitina* sp. cf. *S. brevispinosa* differs in being much larger and in lacking the characteristic broad-based spines of *A. kurnai*.

This species can be distinguished from other similar species in the Taravale Formation by the presence of the peculiar narrowing of the neck. However, some difficulties are encountered where specimens are fully or partially compressed.

**Dimensions.** — Taken from twelve specimens from samples 8T/50.0, 8T/178.3, 9T/220.3, 11T/105.4, 11T/121.4, 11T/128.5 and 11T/138: L — 139–206 (mean 174.4); Lc — 93–122 (mean 115.5); Ln — 46–73 (mean 58.5); Dmax — 49–78 (mean 63.9); Dn min — 14–27 (mean 22.1); Da — 20–37 (mean 31.6); Ln/L — 0.29–0.39; L/Dmax — 2.3–3.5; Dn min/Da — 0.50–0.65.

**Occurrence.** — Taravale Formation (Fig 5A, Tabs 2–3); Silurian of Morocco.

### *Angochitina* sp. aff. *Sphaerochitina geradis* Cramer & Diez 1978

Figs 5A, 10A, Tab. 2.

**Description.** — A species with a cylindro-ovoid vesicle. The chamber has a slender, ellipsoid form and a slightly flattened base resulting from partial compression of the test. Flexure is indistinct, leading to a cylindrical neck with a straight oral periphery. The neck is quite short, taking up less than half the total length of the vesicle (i.e. Ln/L — 0.39).

The vesicle surface is quite sparsely covered with short, simple spines decreasing in size on the upper part of the neck. Most spines have a wide, almost triangular base, thinning towards the distal end. In between the spines the vesicle wall has a fine, granular appearance.

**Remarks.** — The Australian specimens fit into the size range described for *Sphaerochitina geradis* from the Lochkovian of Spain and their general proportions are similar (for example  $L_n/L = 0.39$  on a specimen from the Taravale Formation, and  $L_n/L = 0.32-0.43$  for the individuals from Spain; measurements were taken from pl. 3: 29–30, in Cramer & Diez 1978). Although the spine form is also very similar, with a triangular base and a thin distal end (Cramer & Diez 1978: pl. 3: 20), they describe the distribution pattern as having the longest spines occurring most densely on the neck (Cramer & Diez 1978: p. 176); this is not apparent on the Australian specimens.

There has been confusion for some time about the taxonomic differences between the two genera *Angochitina* and *Sphaerochitina*. Paris (1981a: p. 253) distinguishes *Sphaerochitina* on the presence of tubercles or thorns densely distributed on the vesicle (i.e. more than  $15/100 \mu\text{m}^2$ ). Using this criterion, the species from the Taravale Formation has been placed with the *Angochitina*.

The single specimen of *Angochitina* sp. aff. *S. geradis* can be differentiated from *Angochitina* sp. F and *Angochitina* sp. G by the proportionally longer neck ( $L_n/L = 0.39$  for *A.* sp. aff. *S. geradis* vs.  $0.26-0.35$  for *Angochitina* sp. F and  $0.33-0.34$  for *Angochitina* sp. G). *Angochitina* sp. aff. *S. geradis* also has a much longer vesicle than *Angochitina* sp. G.

**Dimensions.** — Taken from one specimen from sample 9T/166:  $L = 200$ ;  $L_c = 122$ ;  $L_n = 78$ ;  $D_{\text{max}} = 85.1$ ;  $D_n = 40.5$ ;  $L_{\text{sp}} = 4$ ;  $L_n/L = 0.39$ ;  $L/D_{\text{max}} = 2.4$ .

### *Angochitina* sp. A

Figs 4, 10E, Tab. 1.

**Description.** — The vesicle is cylindro-spheroidal displaying a gentle flexure. The base is strongly convex with no apparent basal edge. Very little ornamentation has been preserved and only simple spines have been observed on the neck, flanks and base; a few spines show a bipodal insertion.

**Remarks.** — These specimens are strongly reminiscent of *Angochitina mourai* Lange 1952 (Lange 1952, 1967; Eisenack 1955; Collinson & Scott 1958; Dunn 1959; Da Costa 1967, 1971), the shape and major dimensions are very similar, but the poor preservation precludes definitive assignment. In particular the presence of the distinctive wide collar and coalescent spines of *A. mourai* are unable to be verified in the fauna from the Taravale Formation.

There is also a similarity in shape to *Gotlandochitina labdata* Diez & Cramer 1978 (formerly *A.?* sp. aff. *mourai* in Paris 1976, pl. 17: 3, pl. 24: 12–13). However, there is no evidence of distally coalesced spines on the specimens from Australia.

*A. mourai* has been reported from the Silurian of the Amazon by Da Costa (1971: p. 227) and in North Africa by Grignani (1967: p. 318), but has otherwise only been found in Middle and Late Devonian strata. More,

and better preserved specimens are needed to judge whether *Angochitina* sp. A could be an intermediary between the two disjunct occurrences.

**Dimensions.** — Taken from two specimens from sample BCE-1: L — 153–167; Lc — 100–102; Ln — 51–67; Dmax — 85–88; Dn — 26; Lsp — 4–9; Ln/L — 0.3–0.4; L/Dmax — 1.7–1.9.

### *Angochitina* sp. B

Figs 4, 10D, Tab. 1.

**Description.** — This small species has a sub-cylindrical vesicle with maximum diameter in the lower half to lower third of the chamber. The neck is poorly differentiated, but is very short and has a prominent collar. Distortion resulting from full or partial compression changes the base from strongly convex to slightly flattened.

Poor preservation has left spines on only one specimen. These spines are most prominent on the aboral half of the vesicle. They vary from simple to bifurcate or trifurcate and they may exhibit broad bases. No linear arrangement of spines is apparent, but the more complex, broad based spines are found only on the middle of the chamber.

**Remarks.** — The poor preservation of *Angochitina* sp. B limits the veracity of any comparison, however, this species shows many similarities to *Angochitina milanensis* Collinson & Scott 1958. Some specimens figured by Collinson & Scott (1958: pl. 1: 1) are very similar in shape and the few spines that can be observed on the Australian fauna have the same form. The Australian specimens are much smaller than those described by Collinson & Scott (1958) and Legault (1973). The neck is relatively smaller than that on the groups from Africa or America, and is comparatively poorly differentiated — these two features may be due to the distortional effects of flattening. Oral flaring apparent on the Australian specimens has not been observed on those from Africa (Legault 1973: p. 30).

Paris *et al.* (1985) and Boumendjel *et al.* (1988) report specimens of *Gotlandochitina milanensis* (Collinson & Scott 1958) bearing little resemblance to the Australian material, whose ornamentation shows no evidence of 'lines' of spines. The Australian material maybe more closely related to that figured by Jardiné & Yapaudjian (1968), the only other reported occurrence in the Emsian.

**Dimensions.** — Taken from three specimens from samples BCE-1 and BCE-19: L — 117–129 (mean 123.6); Lc — 89–102 (mean 99.3); Ln — 21–29 (mean 25.6); Dmax — 57–65 (mean 61.5); Dn — 29–41 (mean 35.3); Lsp — 13; Ln/L — 0.17–0.24; L/Dmax — 1.9–2.3.

### *Angochitina* sp. C

Figs 5A, 10F, Tab. 2.

**Description.** — A small species with an ovoid chamber, a short, cylindrical neck and poorly defined flexure. The base is highly convex and the basal edge is well-rounded. Ornamentation consists of short, simple and bifurcate spines — these are mostly thick but occasional fine spines are

found amongst the more substantial ones. The spines are found mostly on the lower two thirds of the vesicle. Some specimens have spines on the neck, but none are found near the oral periphery.

**Remarks.** — The size, shape and dimensions of this species is close to that for *Angochitina caeciliae* Paris 1976 from St. Cenéré (Paris 1976) and the Garra Limestone (Winchester-Seeto 1993a). Poor preservation precludes definitive species assignment, but the lack of spines near the oral edge and the paucity of complex spine-morphology suggests that this species does not belong to *A. caeciliae*.

**Dimensions.** — Taken from three specimens from sample 8T/35: L — 80–123 (mean 107.6); Lc — 58–90 (mean 76.3); Ln — 22–42 (mean 31.3); Dmax — 35–57 (mean 54.3); Dn — 20–21 (mean 20.5); Ln/L — 0.25–0.34; L/Dmax — 2.3–2.7; Dmax/Dn — 2.3–2.7.

### *Angochitina* sp. D

Figs 5A, 10J–K, Tab. 2.

**Description.** — These have a relatively small vesicle, with a spherical to oval chamber and medium length cylindrical neck. Shoulders are indistinct and flexure is gentle. Vesicles in full relief have a strongly convex base, becoming flattened when the specimen is compressed. The vesicle wall is studded with a small number of large, sturdy and conspicuous spines. The spines are a mixture of simple and bifurcate forms, most with thick-set bases. On some specimens neck spines can be found with elongate, very wide, possibly coalesced bases, that are flattened longitudinally. Spines occur dominantly on the middle and lower part of the chamber and upper part of the neck, but not on the collar.

**Remarks.** — The generally poor preservation of this species, with few spines left intact, makes an accurate species assignment difficult. The flattened neck spines are reminiscent of *Angochitina ceratophora* Eisenack 1964 (e.g. Laufeld 1974: fig. 14) but *Angochitina* sp. D differs in being much smaller and in having a slightly fatter chamber. *Angochitina ceratophora* is known only from the Silurian. There are also similarities with some individuals of the species *Gotlandochitina ramosa* (Paris 1976) (e.g. Chlupáč *et al.* 1985: pl. 3: 4). Although *G. ramosus* is generally quite similar in size and shape, it differs in having longer, finer spines more densely distributed on the vesicle and in having more spines near the aperture.

**Dimensions.** — Taken from five specimens from samples 7T/39 and 8T/35: L — 128–150 (mean 136.4); Lc — 72–90 (mean 80.5); Ln — 40–64 (mean 52); Dmax — 57–64 (mean 60); Dn — 20–29 (mean 25.6); Ln/L — 0.30–0.45; L/Dmax — 2.0–2.3.

### *Angochitina?* sp. E

Figs 5A, 11A–B, Tab. 2.

**Description.** — This species has a narrow, elongate ellipsoid chamber. Flexure is gentle and indistinct, leading to a conical neck, widening slightly

Tab. 4. Distribution of chitinozoans in the upper part of the Gelantipy Road section.

Meters above base	162.9	63.2	165.0	167.6	171.4	173.2	174.2	176.5	177.0	180.4	181.5	319.6	325.6	325.7	326.0	328.1	329.0	342.5	343.3	344.9	345.5	346.2	347.0	350.7	351.6	353.7	355.0	355.1	368.0		
Sample number	11T/150.0	11T/151.6	11T/155.0	11T/160.0	11T/168.0	11T/172.0	11T/176.0	11T/179.0	11T/180.0	11T/187.2	11T/189.5	15T/138.2	15T/138.2b	15T/144.1	15T/144.5	15T/146.6	16T/198.0	16T/128.0	16T/124.0	16T/116.0	16T/113.7	16T/109.5	16T/105.7	16T/87.0	16T/82.4	16T/81.9	16T/71.1	16T/65.3	16T/65.0	16T/0.7	
<i>B. (A.) rasilis</i>																															
<i>B. (A.) cf. E. cupellata</i>																															
<i>Angochitina</i> sp. D																															
<i>A. kumai</i>																															
<i>Angochitina</i> sp. C																															
<i>A. sp. aff. crassispina</i>																															
<i>A. sp. cf. capillata?</i>																															
<i>Angochitina?</i> sp. E																															
<i>Gotlandochitina</i> sp. C																															
<i>A. sp. aff. filosa</i>																															
<i>A. laevigata?</i>																															
<i>G. maretensis?</i>																															
<i>A. cf. S. brevispinosa</i>																															
<i>Eisenackitina?</i> sp. A																															
<i>Gotlandochitina</i> sp. D																															
<i>A. sp. cf. S. gerdais</i>																															
<i>A. sp. aff. valentini</i>																															
<i>Angochitina</i> sp. F																															
<i>Angochitina</i> sp. G																															
<i>E. subditiva</i>								1?																							
<i>B. (A.) bidawal</i>																															
<i>B. (B.) ngarigo</i>						6	6	2																							
<i>B. (B.) talenti</i>						2	4																								
<i>B. (A.) sp. aff. riclonensis</i>																															
<i>B. (B.) sp. aff. krizi</i>																															
<i>B. (B.) kurritgo</i>						2	1		1																						
<i>Bursachitina (A.) sp. A</i>																															
<i>Bursachitina (A.) sp. B</i>																															
<i>E. cf. subditiva</i>						5	5	8					7																		
<i>Angochitina</i> sp. H	8																														
<i>Calpichitina?</i> sp.																															
<i>A. chillkalla</i>	13	1	2	1	4			1	1													1			8	3		1	7		
<i>E. warnagatte</i>						14	21	14	15	9	1	1			1	1		20	31		32	1		2					1	1	
<i>B. (A.) jaimathang</i>						12	10	3	1	1																					
<i>Eisenackitina</i> sp. B						1	9	1		1																					
<i>Eisenackitina</i> sp. C						4	11																								
<i>Bursachitina (A.) sp. C</i>							5																								
<i>Bursachitina (A.) sp. D</i>						1	3																								
<i>Eisenackitina</i> sp. D						4	2														3		9								
<i>E. hebata</i>							2	6	1				1?		1		3	4		3											
<i>E.? vieta</i>						1				2									13		13		11		1						
<i>E. birubi</i>															13		10	29	4	15					1						
<i>Eisenackitina</i> sp. E												1	4		3																
<i>B. (B.) sp. A</i>													4	1				4													1?
<i>A. warrugang</i>																			2			1	1		3	8			2		
<i>Fungochitina?</i> sp.																														2	
<i>Angochitina</i> sp. I																							1			1	2				
<i>E. varaan</i>																					16										
<i>Eisenackitina</i> sp. F																					3										
sp. indet.			9		75	113	43	11	13	8	7	2	35	5	12	15	26	1	2	22	5		1	3	7	11	13	7			
<i>Angochitina</i> sp. indet.	87	11		6	19	1	1	2		11	16			3	1			2	40	10		19	4		5	5			2	2	

at the aperture. The base is highly convex, tending to a chevron shape in some specimens.

Most spines are broken, many with only scars of the bases as evidence of their presence. These scars appear all over the surface of the chamber and on the upper neck; few spines can be observed on the lower neck. There is no indication of alignment of spines. On the upper neck spines are concentrated near the oral opening and may appear as simple, ramified or coalesced. The only spines preserved on the chamber can be found on the basal edge and are node-like (perhaps due to breakage of the upper portion of the spine) or may have a strong, bifurcate form.

**Remarks.** — The poor preservation of specimens makes species assignment, and even generic assignment difficult. Superficially the group appears to be similar to *Ancyrochitina*, but spines are not restricted to the basal edge and the vesicle shape is not typical. Lack of evidence of vertical alignment of spines suggests the group does not belong to *Gotlandochitina*.

The Taravale specimens display similarities to some individuals of *Ramochitina magnifica* Lange 1967 (e.g. Lange 1967: fig. 49). The spine form and distribution, especially the concentration of spines near the aperture and vesicle shape are all very similar. Da Costa (1971: p. 255) describes the spine shapes for *R. magnifica* as ranging from simple to ramified and coalesced, all of which can be seen on the individuals from the Taravale. The size of type specimens of *R. magnifica* is twice that of collection from Victoria and, although the proportions are the same. Recent reexamination of the type specimens of *R. magnifica* by Y. Grahn (personal communication) has established that there is a vertical alignment of the spines, this suggests that *R. magnifica* and *Angochitina?* sp. E are not conspecific.

**Dimensions.** — Taken from two specimens from sample 8T/35: L — 142–165; Lc — 99–104; Ln — 43.5–61.0; Dmax — 55–58; Dn — 32–35; Lsp — 7–12; Ln/L — 0.30–0.37; L/Dmax — 1.9–2.5.

### *Angochitina* sp. F

Figs 5A, 10G, Tab. 2.

**Description.** — *Angochitina* sp. F has a narrow elongate club-shaped chamber, with maximum diameter in the lower third of the chamber or near the basal edge. The base is weakly convex or may be slightly flattened. The chamber contracts considerably towards the oral end and is surmounted by a short, conical or funnel shaped neck with an expanded aperture and a short, indistinct collar. The surface may have a sparse sprinkling of simple spines.

**Remarks.** — *Angochitina* sp. cf. *S. brevispinosa* shows a number of similarities to this species but may be distinguished by its more elliptical shape and distinct flexure. The maximum diameter is closer to the middle of the chamber, giving a highly convex base to *Angochitina* sp. cf. *S. brevispinosa*, contrasting strongly with the club-shaped vesicle and flattened base of *Angochitina* sp. F.

Hou (1978) erected a new species *Angochitina liujingensis* whose silhouette resembles that of *Angochitina* sp. F. The poor quality of the photographs makes it difficult to compare the two species, but *Angochitina* sp. F is much larger and has a conical neck, whereas *A. liujingensis* has a cylindrical neck with an expanded collar; some photographs of latter give the impression of a conical neck and are therefore confusing.

*Angochitina* sp. F differs from *Angochitina* sp. G in having a thinner, more elongate chamber and a distinct conical neck, in contrast to the cylindrical neck of *Angochitina* sp. G.

**Dimensions.** — Taken from five specimens from samples 9T/213.8 and 9T/226.8: L — 166–194 (mean 176.3); Lc — 116–125 (mean 120.6); Ln — 44–69 (mean 55.7); Dmax — 54–77 (mean 62.9); Dn — 30–41 (mean 32.5); Ln/L — 0.26–0.35; L/Dmax — 2.5–3.1.

### *Angochitina* sp. G

Figs 5A, 11C, Tab. 3.

**Description.** — This species has a cylindro-ovoid vesicle with a gentle, but definite flexure. The chamber is a narrow ellipse, with maximum diameter near the middle. The base is convex, but may appear flattened in compressed specimens. A short, cylindrical neck sits on top of the chamber (Ln/L — 0.33–0.34) with an indistinct collar sometimes displaying a crenulate edge. Short, thorn-like spines are sparsely distributed on the lower neck and on the chamber, while fine spines can be discerned on the upper neck of some specimens.

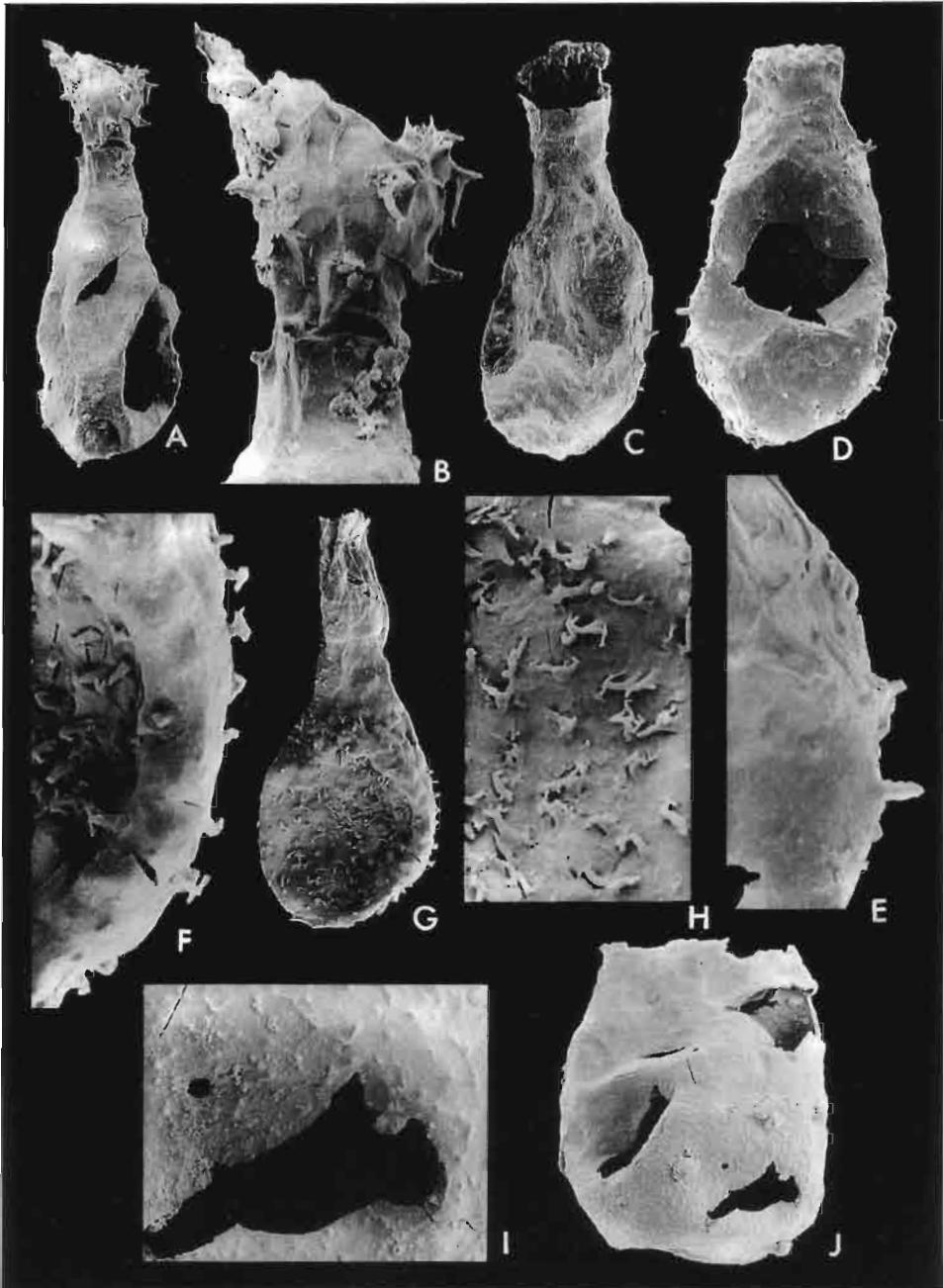
**Remarks.** — The poor preservation of most specimens makes comparisons difficult.

**Dimensions.** — Taken from four specimens from samples 9T/226.8 and 9T/282.6: L — 131–156 (mean 139.6); Lc — 87–105 (mean 92.7); Ln — 44–51 (mean 46.8); Dmax — 40–78 (mean 59.9); Dn — 25–37 (mean 30.9); Ln/L — 0.33–0.34; L/Dmax — 2.0–3.3.

### *Angochitina* sp. H

Figs 5A, 11D–E, Tabs 3–4.

**Description.** — A species of *Angochitina* with a club-shaped vesicle. The chamber is ovoid and maximum diameter occurs in the lower third of the chamber. Flexure is gentle and generally indistinct, leading to a short, sub-cylindrical or sub-conical neck (Ln/L — 0.20–0.42). A small collar is generally present and may flare slightly at the aperture. There is no apparent basal edge; the base is strongly convex. Short, sturdy spines are distributed at random and fairly sparsely across the surface of the vesicle (1–3/100  $\mu\text{m}^2$ ). Spines are dominantly simple, but rare bifurcate spines can be observed.



from sample 9T/226.8;  $\times 350$ . □D-E. *Angochittina* sp. H, specimen NMV P138560 from sample 11T/138;  $\times 400$  (D) and enlargement of lower chamber wall (E)  $\times 1400$ . □F-H. *Angochittina* sp. I. F-G. Specimen NMV P138561 from sample 16T/71.7;  $\times 350$  (F) and enlargements of lower vesicle wall showing spine form (F)  $\times 1200$  and (H)  $\times 1400$ . □I-J. *Bursachittina* (*Bursachittina*) sp. aff. *B. krizi* (Paris & Laufeld 1981). I-J. Specimen NMV P138562 from sample 9T/243;  $\times 300$  (J) and enlargement of lower chamber wall (I)  $\times 1100$ .

**Remarks.** — The shape and general proportions are similar to *Angochitina chillkalla* sp. n., but the vesicle size is slightly smaller and the spine density slightly lower than *A. chillkalla*.

*Angochitina dimorpha* Taugourdeau & Jekhowsky 1960 is very similar to *Angochitina* sp. H (e.g. Taugourdeau & Jekhowsky 1960: figs 39–40; Winchester-Seeto 1993b: fig. 10F–G). There are some small differences however, *Angochitina* sp. H is slightly larger and the spine density is lower than that observed on *A. dimorpha*. In Australia, the two occurrences are fairly widely separated stratigraphically, i.e. *E. sulcatus* and *P. perbonus* conodont zones, with no intermediate occurrences. Taugourdeau & Jekhowsky (1960), on the other hand, show the range of *A. dimorpha* as Early to Late Devonian. It is quite possible that *Angochitina* sp. H is *A. dimorpha*, but has been placed in open nomenclature pending the discovery of specimens in between the disjunct occurrences.

**Dimensions.** — Taken from eight specimens from samples 11T/105.4, 11T/138 and 11T/150; L — 130–138 (mean 133.7); Ln — 34–54 (mean 44.3); Lc — 81–96 (mean 89.4); Dmax — 42–62 (mean 56.5); Da — 19–30 (mean 26.2); Ln/L — 0.26–0.40; L/Dmax — 2.1–3.2; Da/Dmax — 0.3–0.7.

### *Angochitina* sp. I

Figs 5B, 11F–H, Tab. 4.

**Description.** — This species has a cylindro-ovoid vesicle. The maximum diameter occurs near the centre of the chamber and the base is strongly convex. Flexure is gentle, with no real development of shoulders. The chamber is topped with a sub-cylindrical neck of moderate length, ending in a relatively long, possibly flared, collar. The most distinctive feature is the surface sculpture, consisting of a moderately dense scattering of short spines (Lsp — 4–5  $\mu$ m). These occur dominantly on the chamber, decreasing in size on the neck. Spine-form ranges from simple to bifurcate, multiramified, T-shaped or the spines may have bizarre shaped tips (Fig. 11F, H).

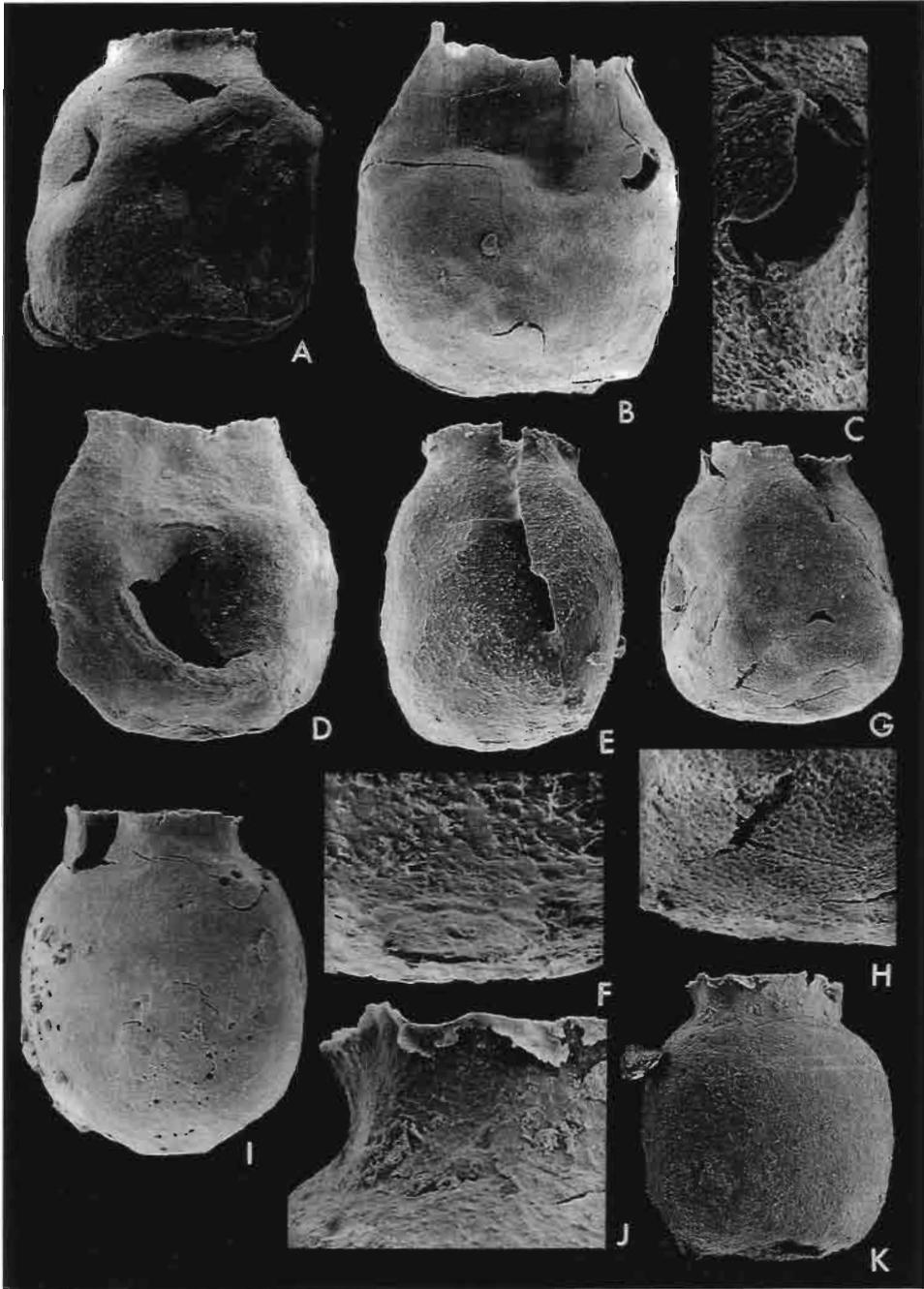
**Remarks.** — The peculiar form of the ornamentation sets this species from any other.

**Dimensions.** — Taken from two specimens from sample 16T/71.7; L — 148–153; Ln — 52–60; Lc — 93–96; Dmax — 61–63; Da — 23–24; Ln/L — 0.35–0.39; L/Dmax — 2.4–2.4.

### Genus *Bursachitina* Taugourdeau 1966

**Remarks.** — Paris (1981a: p. 136) resurrected the genus *Bursachitina* for a readily recognised group of small species with squat, sub-conical vesicles. This grouping is a useful construct because it is easily distinguished and is taxonomically cohesive. However, in the course of this

Fig. 12. □A–D, G–H. *Bursachitina (Bursachitina) ngarigo* sp. n. A. Specimen NMV P138563 from sample 9T/243;  $\times$  400. B–C. Specimen NMV P138564 from sample 9T/272.5;  $\times$  300 (B) and enlargement of upper chamber wall (C)  $\times$  1400. D. Specimen NMV P138565 from sample 9T/272.5;  $\times$  300. G–H. Holotype NMV P138566 from sample 9T/315.5;  $\times$  300 (G) and enlarge-



ment of lower chamber wall (H)  $\times 900$ .  $\square$ E-F, I-K. *Bursachitina (Bursachittina) talenti* sp. n. E-F. Specimen NMV P138567 from sample 9T/272.5;  $\times 300$  (E) and enlargement showing basal callus (F)  $\times 1000$ . I. Specimen NMV P138568 from sample 9T/282.6;  $\times 300$ . J-K. Holotype specimen NMV P138569 from sample 9T/272.5;  $\times 300$  (K) and enlargement of collar (J)  $\times 1150$ .

study, a number of moderately sized species with slightly more elongate vesicles were found whose general characteristics and ornamentation indicated an obviously close relationship to *Bursachitina*. Inclusion of these new species in *Bursachitina* would destroy the integrity of taxon and thus two new subgenera have been erected.

Subgenus *Bursachitina* subgen. n.

Type species: *Desmochitina bursa* Taugourdeau & Jekhowsky 1960.

**Diagnosis.** — Species of *Bursachitina* (*Bursachitina*) have a small, squat vesicle ranging from sub-conical to sub-spherical in shape, with maximum diameter equal to, or almost equal to the total vesicle and/or chamber length. A cylindrical or slightly flared collar is present and in some species is well developed. Flexure is usually indistinct, but the vesicle may be greatly constricted at the oral pole with shoulders weakly expressed. The aboral margin is rounded, leading to a flat or convex base. An indistinct mucron is always present. No spines are found on members of this sub-genus; the vesicle walls may be smooth, felt-like or granular in appearance, or may present a reticulate pattern.

**Remarks.** — *Bursachitina* (*Bursachitina*) may be distinguished from *Bursachitina* (*Amplichitina*) by the small size and squat shape of the vesicle. Total vesicle length is generally less than 150  $\mu\text{m}$ , but ranges up to 170  $\mu\text{m}$  in some species and the proportion of length to maximum diameter ranges from 1.0 to 1.3 (the length of chamber versus maximum diameter ranges from 0.9 to 1.2), indicating a squat shape. Traditional members of the genus *Bursachitina*, such as *B. bursa* (Taugourdeau & Jekhowsky 1960), *B. krizi* (Paris & Laufeld 1981), and *B. maritima* (Paris 1980) belong to this subgenus.

*Bursachitina* (*Bursachitina*) *ngarigo* sp. n.

Figs 5A–B, 12A–D, G–H, Tabs 3–4.

Holotype: NMV P138566 (Fig. 12G–H).

Type horizon and locality: Taravale Formation, 127.9 m above the base of the Gelantipy Road section (sample number 9T/315.5) at Buchan, Victoria, Australia.

Derivation of name: Named for an Aboriginal tribe living in the vicinity of the Buchan Caves, the Ngarigo.

**Diagnosis.** — A species of *Bursachitina* (*Bursachitina*) with a short, squat sub-conical to sub-spherical vesicle, covered with a reticulate surface ornament.

**Description.** — *Bursachitina* (*B.*) *ngarigo* has an inflated appearance and a short, squat form (i.e.  $L/D_{\text{max}}$  is equal to or just greater than 1). The flanks range from almost parallel to convex, with the maximum diameter occurring anywhere from the middle of the vesicle to just above the basal edge. Thus the vesicle shape may vary from sub-conical to sub-spherical, or even sub-cubic, with a slight narrowing occurring near the aperture. The base is generally flat, but may be weakly convex in some specimens, with a faint basal scar appearing as a shallow, barely perceptible depression.

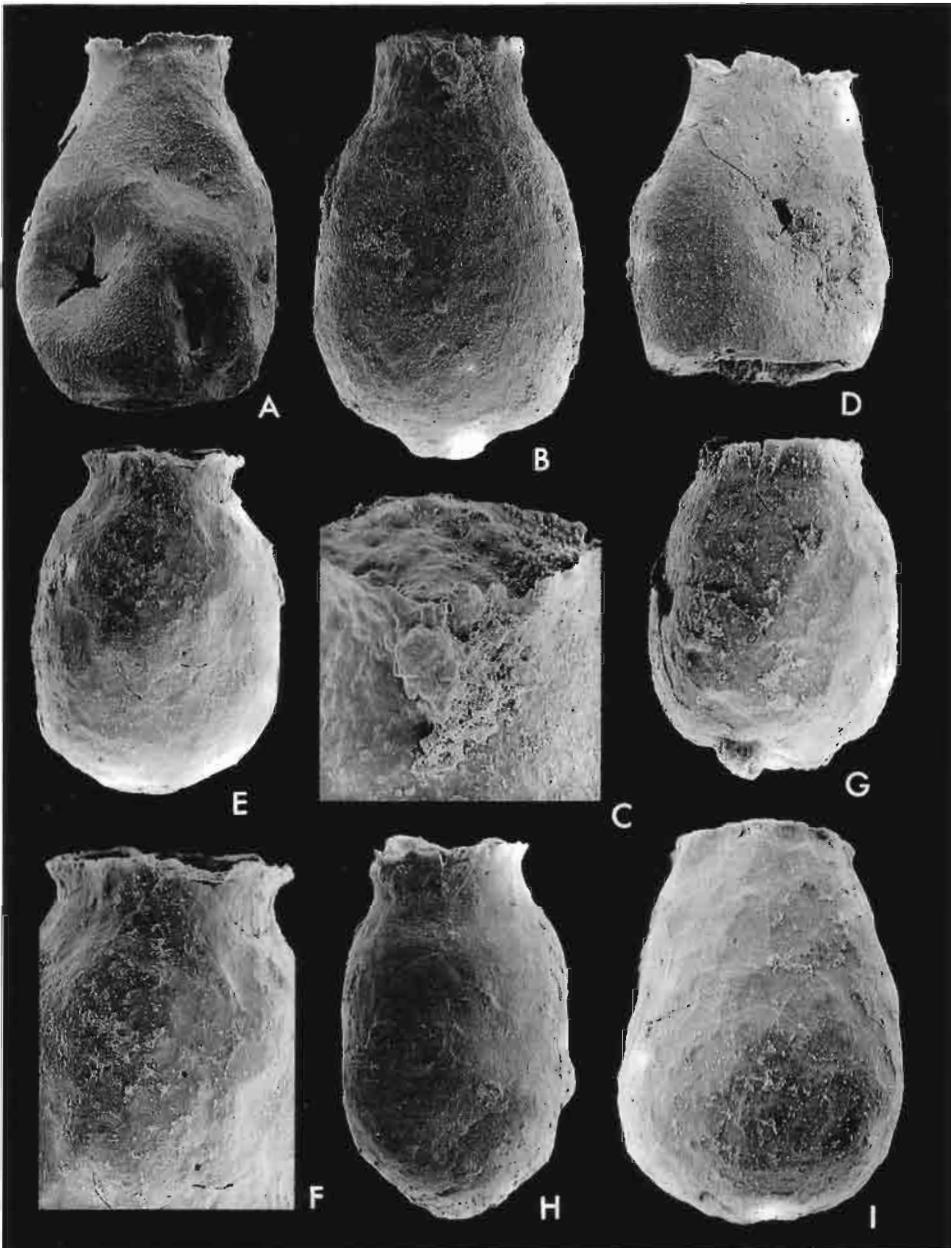


Fig. 13. □A, D. *Bursachitina (Amplichitina)* sp. aff. *B. ricolonensis* Paris 1980. A. Specimen NMV P138570 from sample 9T/315.5;  $\times 300$ . D. Specimen NMV P138572 from sample 9T/243;  $\times 300$ . □B–C. *Bursachitina (Amplichitina) bidawal* sp. n. B. Holotype NMV P138571 from sample 9T/243;  $\times 400$  (B) and enlargement of collar and operculum (C)  $\times 900$ . □E–G, I. *Bursachitina (Amplichitina) rasilis* sp. n. E–F. Holotype NMV P138573 from sample BCE 14;  $\times 300$  (E) and enlargement of collar (F)  $\times 450$ . G. Specimen NMV P138574 from sample BCE 14;  $\times 300$ . I. Specimen NMV P138575 from sample BCE 14;  $\times 300$ . □H. *Bursachitina (Amplichitina)* sp. B. specimen NMV P138576 from sample 9T/282.6,  $\times 300$ .

The vesicle is surmounted by a thin collar that flares slightly, giving a recurved aspect. An operculum is located at the base of the collar.

All specimens have a somewhat eroded surface, but a clear reticulate pattern can be discerned. The ornament is most developed near the aboral end of the vesicle, it is less noticeable at the oral end of the test, but is not apparent on the collar.

**Remarks.** — This species closely resembles *Eisenackitina oviformis* (Eisenack 1972). The size, shape and proportions match those depicted by Eisenack (1972a, b), Cramer (1973), Laufeld (1974), and Wrona (1980). The main difference lies in the surface sculpture, *B. (B.) ngarigo* has a reticulate ornament, composed of a series of low, fused ridges (Fig. 12C, H). The ornamentation on *E. oviformis* has been variously described as finely tuberculate (Eisenack 1972a: p. 72), 'granulate' (Laufeld 1974: p. 82) and 'verrucate' (Wrona 1980: p. 141) and even specimens with eroded surfaces bear little resemblance to *B. (B.) ngarigo*. Wrona (1980: p. 141) described a wide, bowl-shaped basal callus as a distinctive character for *E. oviformis*, this is quite different to the faint basal scar found on *B. (B.) ngarigo*.

There is also some similarity to *B. bursa* (e.g. Eisenack 1972a: figs 22–24), but *B. (B.) ngarigo* is much larger. Specimens with silhouettes like those of Fig. 12A, may be confused with *Desmochitina aranae* Urban 1972 (e.g. Wright 1976: figs 3.1–3.5), but the surface sculpture serves to differentiate the two species.

**Dimensions.** — Taken from 17 specimens from samples 9T/240.2, 9T/243, 9T/267, 9T/272.5, 9T/315.5, 11T/172 and 11T/179: L — 100–156 (mean 129.5); Dmax — 96–138 (mean 120.1); Da — 49–101 (mean 69); L/Dmax — 1.0–1.2; Da/Dmax — 0.47–0.68.

*Bursachitina (Bursachitina) sp. aff. B. krizi* (Paris & Laufeld 1981)

Figs 5A, 11I–J, Tab. 3.

**Description.** — This species has an ovoid to sub-spherical vesicle, with weak to strongly convex flanks and the maximum diameter at the mid-length of the vesicle. A well-rounded basal edge leads to a flat base carrying an inconspicuous basal scar. A very short, nearly cylindrical collar surrounds the aperture. Fine tubercles fused into short crests cover the surface of the chamber.

**Remarks.** — The surface sculpture of this species is strongly reminiscent of *B. krizi*. Superficially the form is also similar, but *B. (B.) sp. aff. B. krizi* displays a greater convexity of the flanks creating a narrower aperture. While there is some overlap in size and general proportions, *B. (B.) sp. aff. B. krizi* is larger in all dimensions.

There are also a number of similarities to *E. oviformis*, especially in size and shape (e.g. Eisenack 1972a, b), however *E. oviformis* has a wider, more flared collar and a generally more egg-shaped vesicle. The two species can be distinguished easily by ornamentation; the surface of *E. oviformis* is

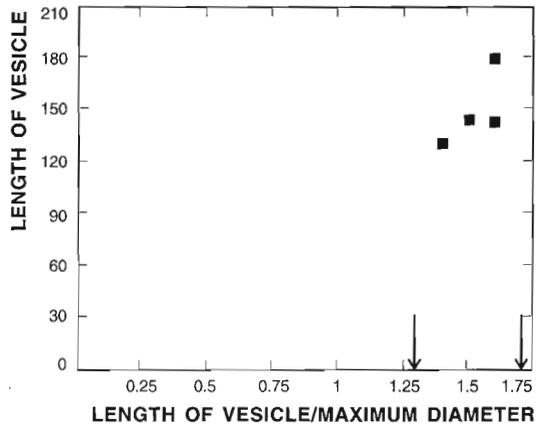


Fig. 14. Intraspecific variation in proportions of vesicles of *Bursachitina* (*Amplichitina*) *bidawal* sp. n. Arrows indicate the range of L/Dmax found on *Eisenackittina* sp. 1 as illustrated by Bock (1982: pl. 1: 15–22).

'finely tuberculate' (Eisenack 1972a), while that of *B. (B.)* sp. aff. *B. krizi* has low, fused crests.

The small size and squat shape of this species indicates placement in the subgenus *Bursachitina* (*Bursachitina*) rather than in the genus *Eisenackitina*. The style of the ornamentation can occur in either genus.

**Dimensions.** — Taken from the only two specimens available: L — 115–138; Dmax — 104–112; Da — 63–82; L/Dmax — 1.1–1.2; Da/Dmax — 0.60–0.73.

### *Bursachitina* (*Bursachitina*) *kurritgo* sp. n.

Figs 5A–B, 18D–G, Tabs 3–4.

Holotype: NMV P138590 (Fig. 18F–G).

Type horizon and locality: Taravale Formation, 173.2 m above the base of the Gelantipy Road section (sample number 11T/172) at Buchan, Victoria, Australia.

Derivation of name: From an local Aboriginal tribal word *kurritgo*, meaning cold, referring to the surface sculpture that resembles the skin on a person who is cold.

**Diagnosis.** — A species of *Bursachitina* with a sub-conical to sub-cubic vesicle, with weakly convex flanks and a relatively long, sub-cylindrical collar. The vesicle surface is covered with minute cones or verrucae.

**Description.** — *E. kurritgo* has a moderately sized, somewhat squat chamber, which varies in shape from subconical to subcubic. The flanks are weakly convex and the maximum diameter occurs near the middle of the chamber. There is a sudden constriction of the chamber near the base of a well developed, relatively long collar (Lcoll/L — 8–15%). The basal margin is bluntly rounded and the base is flat or weakly concave. A small basal callus can be found as a circular pit, indented slightly in the centre of the base. Minute cones or verrucae cover the vesicle surface, except for the collar and basal callus.

**Discussion.** — Other Emsian species share a common form with *B. (B.) kurritgo*, but the microornament serves to distinguish this species from *Bursachitina* (*Bursachitina*) *talenti* sp. n. and *B. (B.) ngarigo* sp. n. Small members of *E. subditiva* sp. n. might also be confused, but *B. (B.) kurritgo*

differs in having different surface sculpture, and less well developed neck and shoulders.

*E. oviformis* has a similar size and shape, but *B. (B.) kurritgo* has a more distinct, longer collar and a sudden constriction at the base of the collar, not evident on *E. oviformis*. The basal callus of *B. (B.) kurritgo* is a simple structure and shows none of the concentric rings previously noted on *E. oviformis* (e.g. Laufeld 1974).

**Dimensions.** — Taken from four specimens from samples 9T/243, 11T/121 and 11T/172: L — 108–146 (mean 127.4); Dmax — 93–133 (mean 116.3); Da — 48–82 (mean 71.3); Lcoll — 9–22 (mean 16); L/Dmax — 1.1–1.2; Da/Dmax — 0.52–0.61.

### *Bursachitina (Bursachitina) talenti* sp. n.

Figs 5A–B, 12E–F, I–K, Tabs 3–4.

Holotype: NMV P138569 (Fig. 12J–K).

Type horizon and locality: Taravale Formation, 113 m above the base of the Gelantipy Road section (sample number 9T/272.5) at Buchan, Victoria, Australia.

Derivation of name: In honour of Professor John Talent, for his contribution to palaeontological knowledge in Australia and globally.

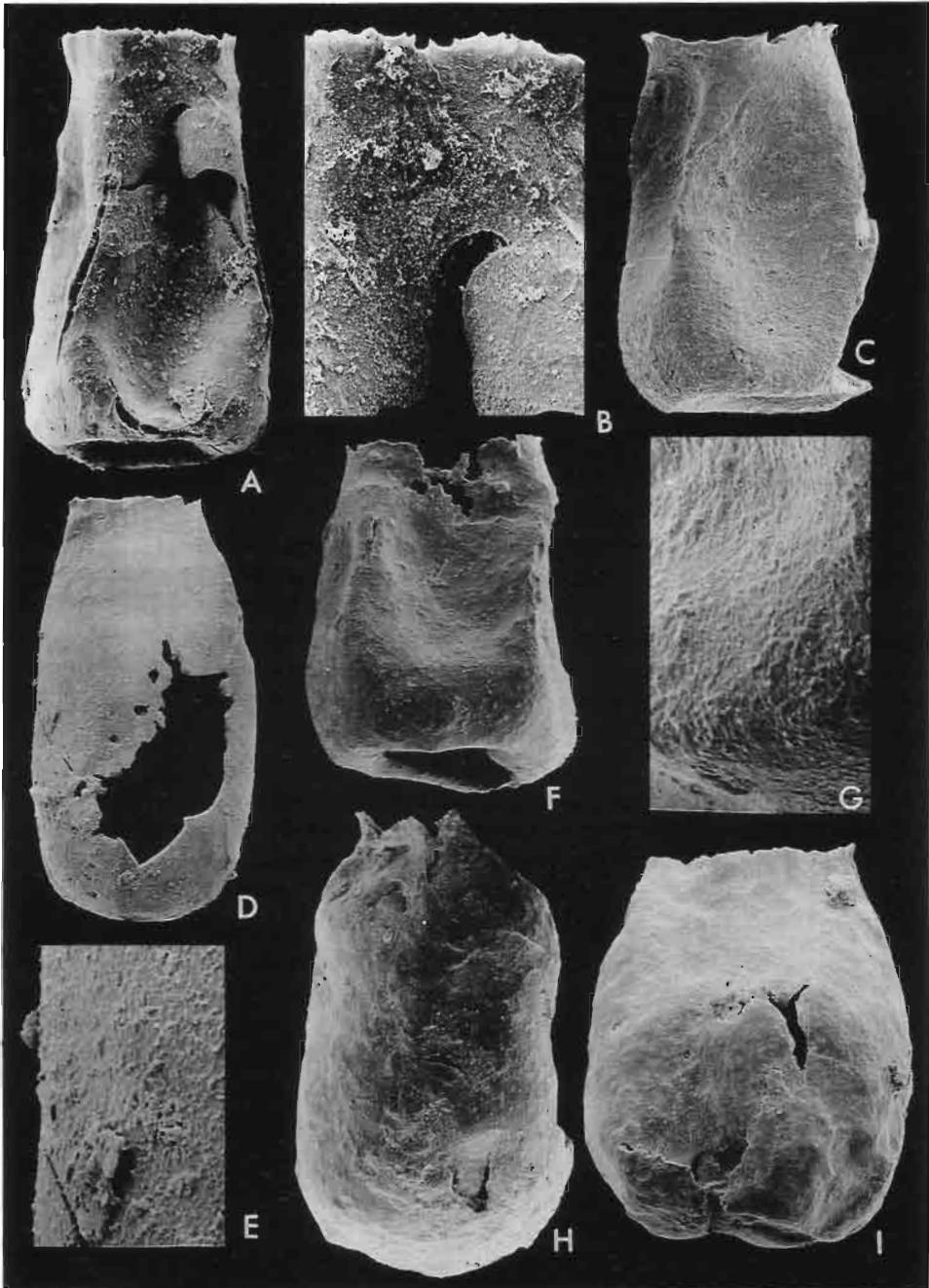
**Diagnosis.** — A species of *Bursachitina (Bursachitina)* with a sub-spherical vesicle and short, conspicuous neck, thinning to a widely expanded collar at the aperture. The vesicle surface has a granular appearance.

**Description.** — *B. (B.) talenti* is a small to medium sized species with a sub-spherical, inflated vesicle. The maximum diameter occurs either at the mid-point, or in the upper half of the length of the chamber. A sudden constriction can be observed at the base of a short collar, producing a conspicuous flexure and definite shoulders.

Nine to eighteen per cent the total vesicle length is taken up by the collar which is thin considerably towards the oral edge, expanding greatly at the aperture where there is a straight or crenulate periphery. The aperture is very large, ranging from 58 to 75% of the maximum diameter. The rounded basal edge leads to a base which may be flat, slightly concave or convex with a basal callus raised on a slight swelling or protuberance (e.g. Fig. 12I). A simple, circular pit with a slightly raised edge serves as the basal callus, with no evidence of concentric rings. The entire vesicle surface has a coarsely granulate appearance, diminishing slightly on the upper collar.

**Remarks.** — *Bursachitina (B.) talenti* is a quite distinctive species. There are some similarities to *B. (Amplichitina) rasilis* sp. n., but *B. (B.) talenti* differs in having a sub-spherical vesicle as opposed to the sub-cylindrical to sub-conical shape of *B. (A.) rasilis* sp. n. and in having a granular ornamentation. *Eisenackitina oviformis* is also superficially similar, but

Fig. 15. □A–B. *Bursachitina (Amplichitina)* sp. cf. *E. cupellata* Wrona 1980. A–B. Specimen NMV P138577 from sample BCE 14; × 300 (A) and enlargement of collar (B) × 900. □C, F–G. *Bursachitina (Amplichitina) jaimathang* sp. n. C. Holotype NMV P138578 from sample 11T/172; × 300. F–G. Specimen NMV P138579 from sample 11T/172; × 300 (F) and enlarge-



ment of lower vesicle wall showing minute verrucae ornament (G)  $\times 900$ . □D–E. *Bursachittina* (*Amplichittina*) sp. A. D–E. Specimen NMV P138580 from sample 9T/272.5;  $\times 250$  (D) and enlargement of mid-chamber wall (E)  $\times 950$ . □H. *Bursachittina* (*Amplichittina*) sp. C, specimen NMV P138581 from sample 11T/176,  $\times 300$ . □I. *Bursachittina* (*Amplichittina*) sp. D, specimen NMV P138582 from sample 11T/172;  $\times 300$ .

can be distinguished by having no conspicuous collar and by the presence of low, fused ridges on the vesicle surface.

This species resembles some extremes of intraspecific variation of the species *E. subditiva* sp. n., in particular the short, bulbous forms. *Bursachitina* (*B.*) *talenti* can be differentiated by the granular vesicle surface and by the wider aperture (Da/Dmax ranges from 0.4 to 0.6 for *E. subditiva* whereas Da/Dmax ranges from 0.58 to 0.75 for *B. (B.) talenti*).

**Dimensions.** — Taken from six specimens from samples 9T/272.5, 9T/282.6 and 11T/172: L — 136–163 (mean 146.2); Dmax — 108–139 (mean 125.8); Da — 73–91 (mean 80.8); Lcoll — 11–29 (mean 18.8); Da/Dmax — 0.58–0.75; L/Dmax — 1.00–1.26.

### *Bursachitina* (*Bursachitina*) sp. A

Figs 5B, 26A–D, Tab. 4.

**Description.** — *Bursachitina* (*B.*) sp. A has an inflated ovoid to sub-cubic chamber which narrows suddenly to a short neck. The chamber is surmounted by a short collar, with a crenulate edge. A thick operculum with a roughened surface nestles into the collar. Chamber flanks may be sub-parallel or may be inclined slightly towards the aperture. Maximum diameter occurs near the mid-point of the chamber or in the lower third. A broadly rounded basal margin leads to a flat base where the basal callus appears as a wide, shallow depression. The surface has a 'shaggy' guise, with a tangled ornament. Bare patches can be seen in between the ornamentation where the periderme has been stripped away and an organic membrane covers some of the ornament. No ornamentation occurs on the basal callus and it is considerably diminished on the neck.

**Remarks.** — Although it has a similar size and shape to *Eisenackitina subditiva* sp. n., the peculiar ornament and thicker operculum of *Bursachitina* (*B.*) sp. A distinguishes the two. The simple form of the basal callus on *Bursachitina* (*B.*) sp. A is quite distinctive, appearing as merely a shallow depression, not elevated on a protuberance, as commonly found in *E. subditiva* sp. n. nor with a raised ridge surrounding it as in *Bursachitina* (*Amplichitina*) *bidawal* sp. n. The latter species can also be separated from *Bursachitina* (*B.*) sp. A by their differing ornament.

**Dimensions.** — Taken from two specimens from samples 15T/144.1 and 16T/128: L — 137–144; Dmax — 107–122; Da — 56–59; L/Dmax — 1.1–1.3; Da/Dmax — 0.50–0.55.

Subgenus (*Amplichitina*) subgen. n.

Type species: *Bursachitina bidawal* sp. n.

**Derivation of name.** — From the Latin *ampli* meaning larger, referring to the larger size of this subgenus compared to *Bursachitina* (*Bursachitina*).

**Diagnosis.** — Species of *Bursachitina* (*Amplichitina*) have a medium-sized, sub-conical to sub-cylindrical vesicle, with maximum diameter of the vesicle smaller than total vesicle length. A cylindrical or flared collar is generally present and may be relatively long and distinct. Flexure is

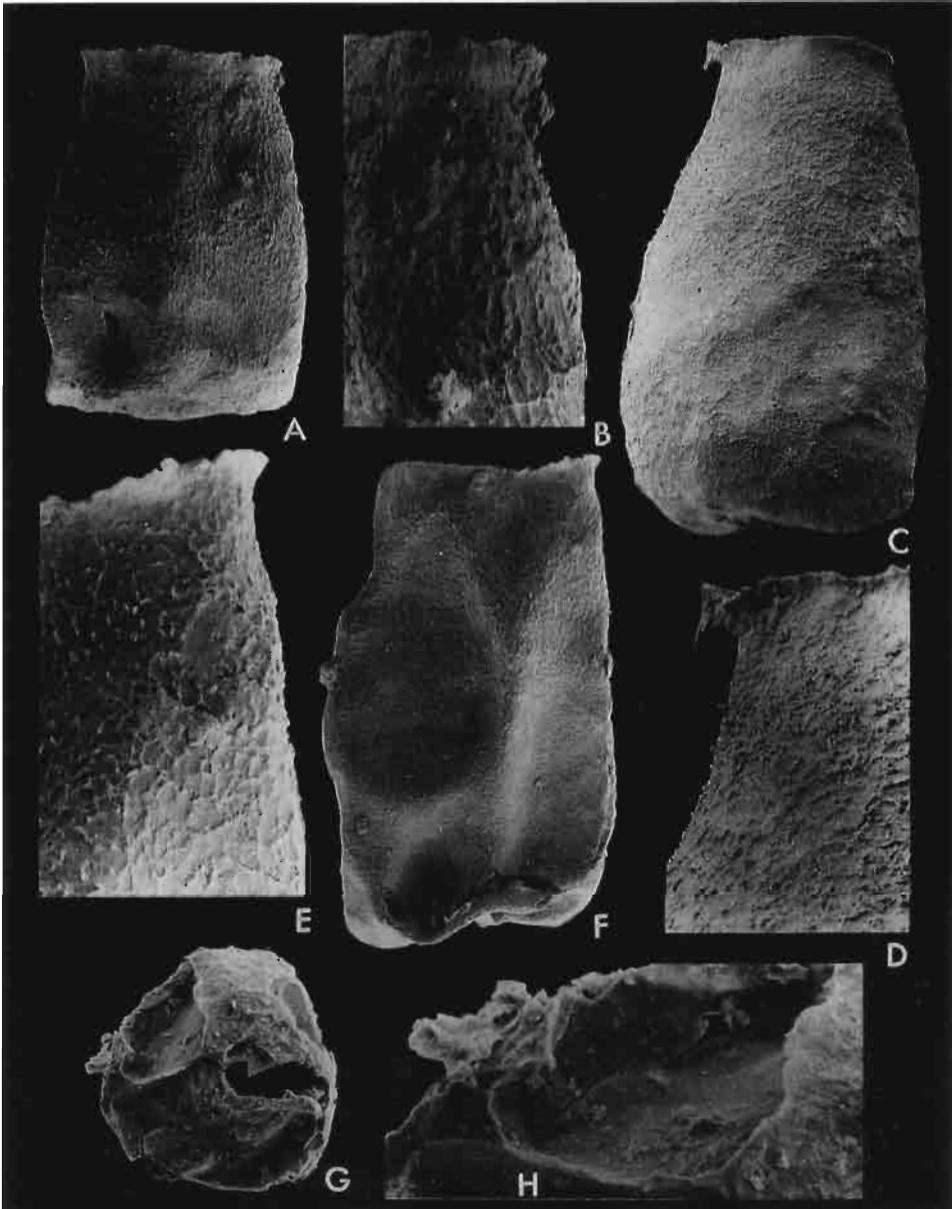


Fig. 16. □A-F. *Eisenackitina birubi* sp. n. A-B. Holotype NMV P138583 from sample 16T/124;  $\times 350$  (A) and enlargement of upper chamber wall and collar (B)  $\times 1000$ . C-D. Specimen NMV P138584 from sample 16T/124;  $\times 300$  (C) and enlargement of collar (D)  $\times 900$ . E-F. Specimen NMV P138586 from sample 16T/124;  $\times 300$  (F) and enlargement of collar (E)  $\times 800$ . □G-H. *Calpichitina?* sp., specimen NMV P138586 from sample 11T/121.4;  $\times 400$  (G) and enlargement of vesicle wall (H)  $\times 1500$ .

distinguishable in some species and may be well developed. The aboral margin is rounded and the base ranges from flat to convex or may be

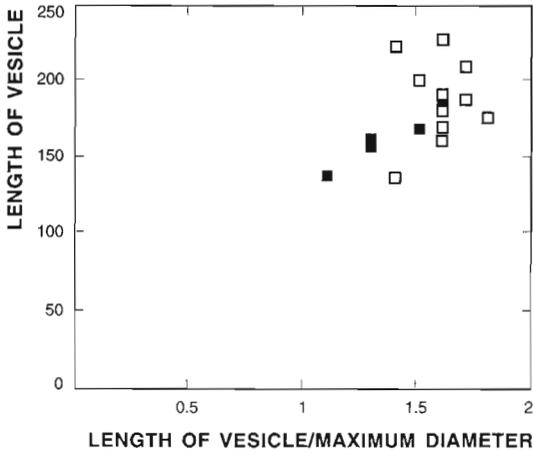


Fig. 17. Intraspecific variation of proportions of vesicles of *Eisackitina birubi* sp. n. (open squares) and *Bursachitina* (*Amplichitina*) *jaimathang* sp. n. (black squares).

ogival; the mucron may be elevated slightly from the base. Vesicle ornament varies from smooth, spongy, felt-like, reticulate or may have a granular texture; no spines are present.

**Remarks.** — Species belonging to *Bursachitina* (*Amplichitina*) can be differentiated from *Bursachitina* (*Bursachitina*) by their moderate size and more elongate vesicle with a proportionally narrower chamber. The vesicle of *B. (Amplichitina)* varies between 140 to 200  $\mu\text{m}$  in length; and the proportion of vesicle length to maximum diameter ranges from 1.2 to 1.9 (length of chamber versus maximum diameter ranges from 1.1–1.9). Thus extremes of intraspecific variation from species within each subgenus may overlap, but the average of populations falls into one of the two groups. This problem emphasises the importance of basing taxonomic assignment on a population rather than on an individual.

Species of *Eisenackitina* can be easily distinguished by the ornamentation consisting of spines, cones, tubercles, or sharp ridges; none are found on species of *B. (Amplichitina)*.

### *Bursachitina (Amplichitina) bidawal* sp. n.

Figs 5A, 13B–C, Tab. 3.

Holotype: NMV P138571 (Fig. 13B–C).

Type horizon and locality: Taravale Formation, 102.6 m above the base of the Gelantipy Road section (sample number 9T/243) at Buchan, Victoria, Australia.

Derivation of name: Named for an Aboriginal tribe living near the Buchan Caves in Victoria, the Bidawal.

**Diagnosis.** — A species of *Bursachitina* (*Amplichitina*) with a marked flexure, shoulders and a narrow aperture. The flanks of the chamber are sub-parallel for almost half the total length of the chamber and the maximum diameter of the vesicle occurs well above the basal edge, between 1/2 to 2/3 down the total vesicle length. The chamber narrows

conspicuously in the upper third of the chamber. The basal callus is elevated on a protuberance from the base.

**Description.** — The dominant feature of this species is the somewhat inflated appearance and the definite, marked flexure and shoulders. The aperture is quite narrow (i.e. 39–63% of the maximum diameter) and may be surrounded by a thin collar that spreads away from the operculum. The operculum is flat and disc-like. Surface appearance varies from smooth to coarsely granular.

**Remarks.** — *B. (Amplichitina) bidawal* is a confusing species because it is almost indistinguishable from one described by De Bock (1982) as *Eisenackitina* sp. 1. The range of shape variation, size, general proportions and surface appearance are very close, or identical for the two taxa (see Fig. 14). De Bock's species, however, comes from Ludlow strata and there have been no reports of this species between Ludlow and Emsian. *Eisenackitina lagena* (Eisenack 1968) also displays some similarity, but can be differentiated by being much smaller and having a narrower aperture.

This species has been assigned to *B. (Amplichitina)* rather than *Eisenackitina* primarily because of the lack of spinose ornament.

**Dimensions.** — Taken from four specimens from samples 9T/243, 9T/282.6 and 9T/315.5: L — 132–181 (mean 151); Dmax — 90–115 (mean 99.3); Da — 46–51 (mean 48.5); L/Dmax 1.4–1.6; Da/Dmax 0.40–0.54.

*Bursachitina (Amplichitina) sp. cf. Eisenackitina cupellata*  
Wrona 1980

Figs 4, 5A, 15A–B, Tabs 1–2.

**Description.** — The vesicle has a sub-conical form, varying from squat to elongate, with the maximum diameter near the basal edge. The basal edge is very well-rounded and the base is flat to slightly concave. The chamber flanks are nearly straight, widening slightly to a conspicuous collar with a crenulate edge. The aperture is approximately 70% of the maximum diameter, but no operculum has been observed. The surface of the vesicle is smooth to felt-like.

**Remarks.** — This species resembles *E. cupellata* from the Lochkovian and Early Pragian of Poland (Wrona 1980) and Australia (Winchester-Seeto 1993a). The Emsian group, while close to the overall size of individuals in the Polish collection, has a slightly larger aperture. The main differences lie at the aboral end of the vesicle, *B. (A.) sp. cf. E. cupellata* has the maximum diameter closer to the basal edge than observed on *E. cupellata* and the basal callus is much smaller. The base of the Emsian group is flat to weakly concave, whilst the base is often strongly convex in the Lochkovian collections.

**Dimensions.** — Taken from one specimen from sample BCE-14: L — 174; Dmax — 100; Da — 74; L/Dmax — 1.7; Da/Dmax — 0.74.

Taken from two specimens from sample 7T/37: L — 138–181; Dmax — 116–129; Da — 82; L/Dmax — 1.2–1.5; Da/Dmax — 0.64–0.74.

*Bursachitina (Amplichitina) jaimathang* sp. n.

Figs 5B, 15C, F–G, Tab. 4.

Holotype: NMV P138578 (Fig. 15C).

Type horizon and locality: Taravale Formation, 173.2 m above the base of the Gelantipy Road section (sample number 11T/172) at Buchan, Victoria, Australia.

Derivation of name: Named for an Aboriginal tribe, living near Buchan Caves in Victoria, the Jaimathang.

**Diagnosis.** — A species of *B. (Amplichitina)* with a truncated, sub-conical vesicle and a flat to weakly concave base. The surface has a granular appearance and is covered with microverrucae.

**Description.** — The truncated sub-conical vesicle has weakly convex flanks in the upper part of the chamber. Maximum diameter occurs in the lower third of the chamber, below which the walls of the vesicle curve strongly towards the well-rounded basal edge. The base is flat to weakly concave, but commonly caves inwards in compressed specimens. The aperture is surrounded by a short collar with a crenulate edge. Minute ornamentation in the form of microverrucae give a granular appearance to the surface, like a sugar-frosting.

**Remarks.** — The outline of *B. (A.) jaimathang* is very close to that of *B. (A.)* sp. cf. *E. cupellata* from the lower part of the Gelantipy Road section (i.e. early Emsian, *P. dehiscens* conodont Zone) and the size and proportions overlap. The granular surface of *B. (A.) jaimathang* serves to differentiate the two taxa, because *B. (A.)* sp. cf. *E. cupellata* has a smooth exterior. It is unlikely that the microverrucae would erode away completely due to their minute size and thus this feature could be used to determine the species even for poorly preserved specimens.

Compressed individuals of *B. (A.) jaimathang* may resemble *Bursachitina ricolonensis* Paris 1981; however *B. (A.) jaimathang* is much larger (mean length of vesicle is 163.8 microns, whereas *B. ricolonensis* has a mean vesicle length of 85 microns, Paris 1981b: p. 62). Paris (1981b: p. 61) also refers to an 'S' shaped curvature of the chamber wall, which is not apparent on *B. (A.) jaimathang*.

**Dimensions.** — Taken from five specimens from samples 11T/172 and 11T/176: L — 139–189 (mean 163.8); Dmax — 115–126 (mean 120.6); Da — 67–90 (mean 77.6); L/Dmax — 1.1–1.6; Da/Dmax — 53–72.

*Bursachitina (Amplichitina) rasilis* sp. n.

Figs 4, 5A, 13E–G, I, Tabs 1–2.

Holotype: NMV P138573 (Fig. 13E–F).

Type horizon and locality: Taravale Formation, 45.7 m above the BCE section (sample number BCE-14) at Buchan, Victoria, Australia.

Derivation of name: From the Latin *rasilis*, meaning scraped, shaved, smooth, referring to the surface appearance.

**Diagnosis.** — A species of *B. (Amplichitina)* with a medium to large vesicle. The chamber shape varies from ovoid to sub-cylindrical, to sub-conical and is surmounted by a conspicuous collar, whose width varies from 6 to 12% of the total vesicle length. The collar flares considerably and is

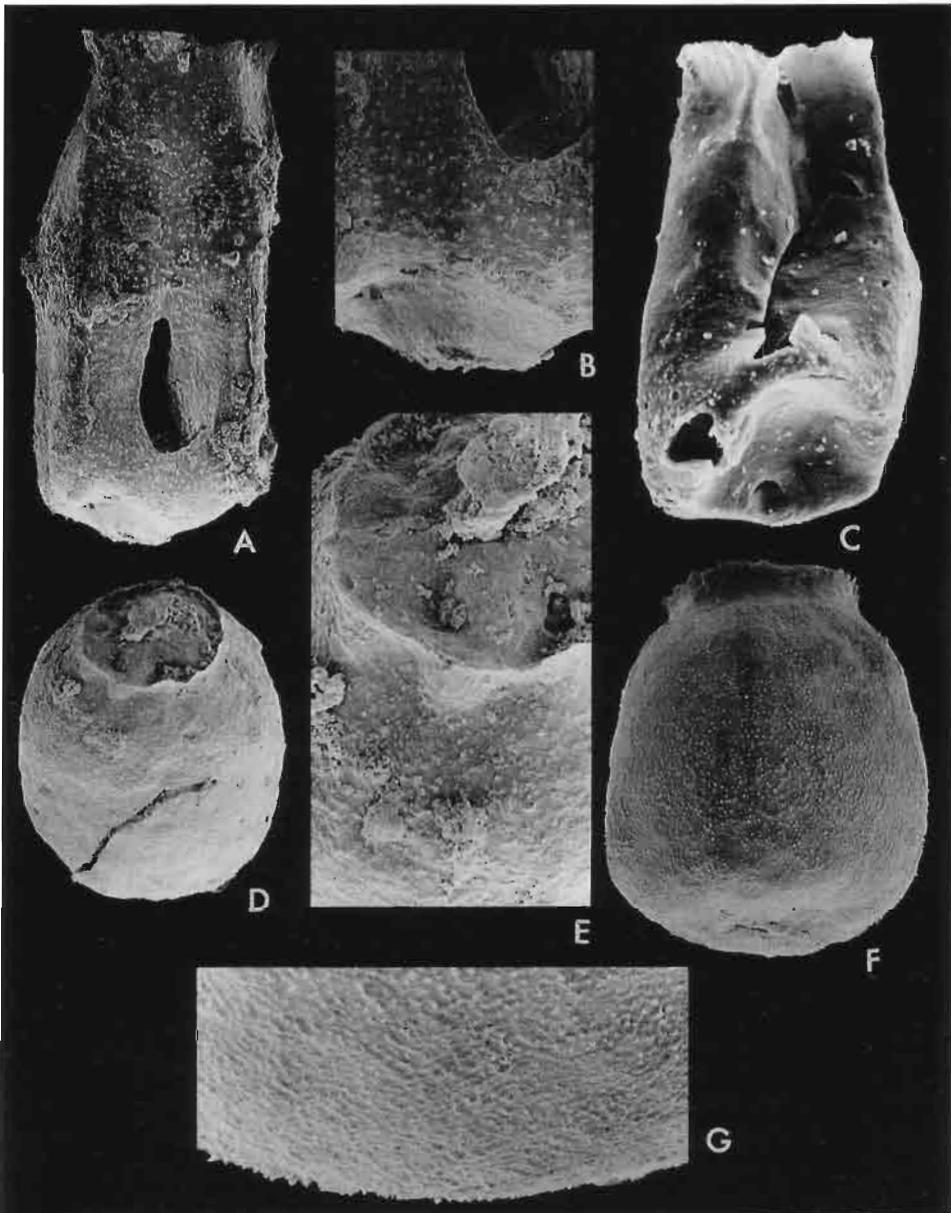


Fig. 18. □A-C. *Eisenackittina hebata* sp. n. A-B. Holotype NMV P138587 from sample 11T/179;  $\times 300$  (A) and enlargement of basal callus (B)  $\times 800$ . C. Specimen NMV P138588 from sample 16T/124;  $\times 300$ . □D-G. *Bursackittina (Bursackittina) kurritgo* sp. n. D-E. Specimen NMV P138589 from sample 9T/243;  $\times 350$  (D) and enlargement of collar and operculum (E),  $\times 1150$ . F-G. Holotype NMV P138590 from sample 11T/172;  $\times 300$  (F) and enlargement of lower chamber ornament (G)  $\times 1000$ .

commonly folded, giving a striate appearance. The vesicle surface is unornamented and resembles a bald head.

**Description.** — A great deal of intraspecific variation occurs in the vesicle shape, with maximum diameter occurring at the midlength or in the lower third of the vesicle. Some specimens lack flexure (Fig. 13I), while others have conspicuous flexure and shoulders may be apparent. The flanks are generally convex and the basal edge is broadly rounded, leading to a convex base, where and basal callus occurs. This scar may be quite large, up to 40  $\mu$ m in diameter and is occasionally elevated on a protuberance from the base.

The vesicle is constricted near the base of a relatively wide, flaring collar, with an operculum occurring very close to the top edge of the collar. The aperture ranges from 56 to 75% of the maximum diameter. The surface is unornamented, but has a pitted, roughened appearance with shallow depressions and low ridges occurring at random — this may be the result of damage and partial flattening of the specimen.

**Remarks.** — This species falls within the range of intraspecific shape variation of a number of species — specifically *Desmochitina aranae* Urban 1972, *Desmochitina minor* Eisenack 1931 (in Paris 1976), *Eisenackitina bohémica* (Eisenack 1934), and *B. oviformis* Eisenack 1972. *Bursachitina* (A.) *rasilis* is readily distinguished by its relatively larger size and its lack of ornamentation.

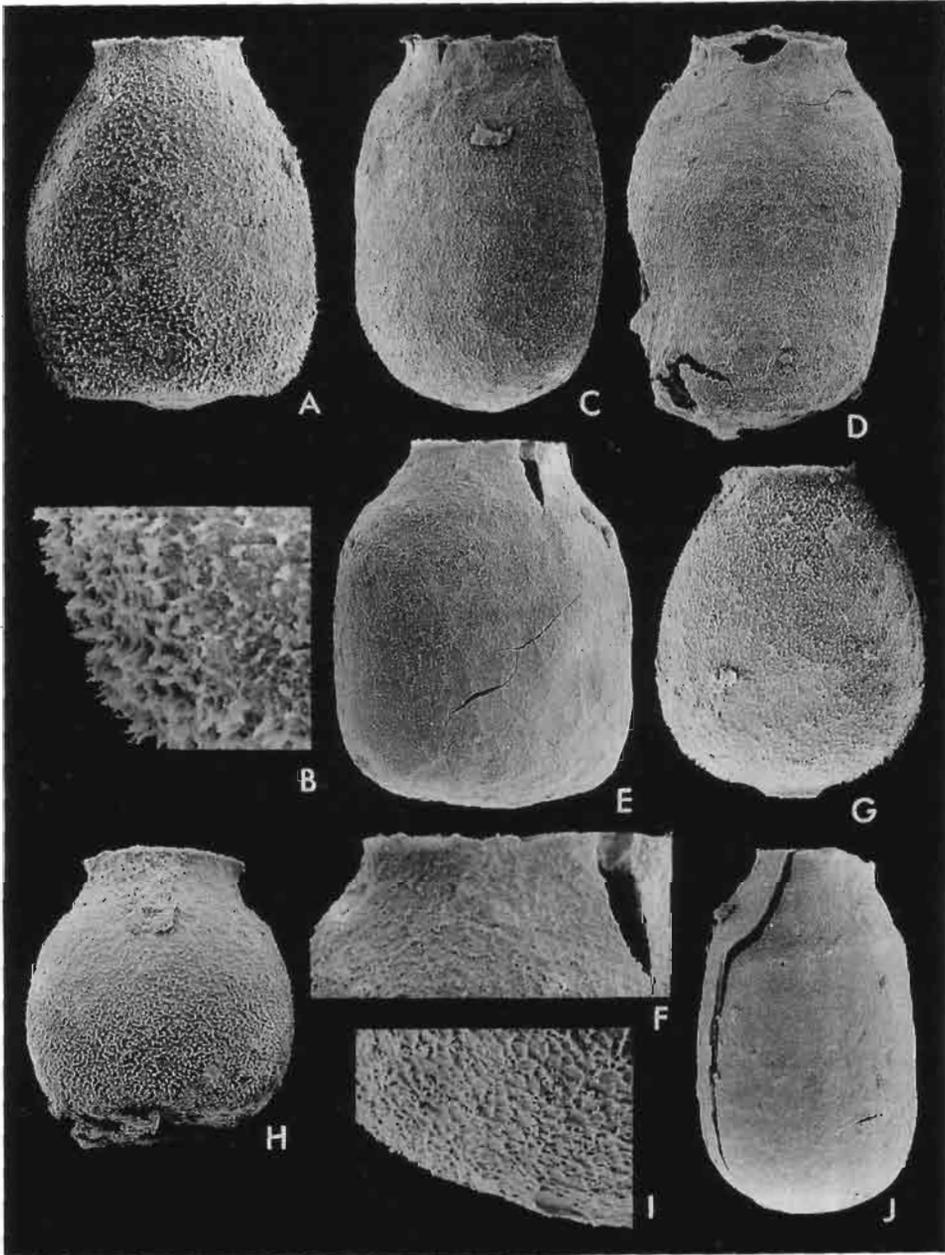
**Dimensions.** — Taken from nine specimens from samples BCE-14, 19, and 26; L — 139–202 (mean 163.7); Lcoll — 9–21 (mean 13.2); Dmax — 92–129 (mean 112.2); Da — 58–95 (mean 72.7); L/Dmax — 1.30–1.74; Da/Dmax — 56–74%.

Taken from five specimens from samples 7T/37, 7T/39, 7T/43.5; L — 129–172 (mean 150.3); Lcoll — 14–17 (mean 16.2); Dmax — 94–133 (mean 112.3); Da — 59–90 (mean 71.2); L/Dmax — 1.20–1.46; Da/Dmax — 60–67%.

*Bursachitina* (*Amplichitina*) sp. aff. *B. riclonensis* Paris 1981  
Figs 5A–B, 13A, D, Tabs 3–4.

**Description.** — This species has a moderately sized, inflated vesicle, with an elongate ovoid to subconical chamber. Flexure is well defined with sloping shoulders. The chamber narrows considerably in the upper third and maximum diameter occurs near the centre of the vesicle. A well rounded basal edge leads to a flat or weakly concave base. The aperture is surrounded by a thin, slightly flared collar which is often folded. Fine granular ornament may be found covering the vesicle surface, or it may be smooth.

**Remarks.** — The closest Emsian species is *Bursachitina riclonensis*, but there are a number of distinctions: *B.* (A.) sp. aff. *B. riclonensis* is approximately twice the size of *B. riclonensis* and the aperture is relatively narrower (i.e. Da/Dmax — 58–77% for *B. riclonensis*, but is only 35–63%



× 1300. C, I. Subcylindrical specimen NMV P138592 from sample 9T/315.5; × 300 (C) and enlargement of the base (I) × 1000. D. A tall, possibly distorted specimen NMV P138593 with the operculum in place, from sample 9T/262.2; × 300. E-F. A sub-cubic specimen NMV P138594, with no ornament left intact, from sample 9T/262.2; × 300 (E) and enlargement of the collar (F) × 650. G. Specimen NMV P138595 with basal callus elevated on a protuberance, from sample BCE-2; × 300. H. Short specimen NMV P138596 from sample BCE-2; × 300. J. Thin, sub-cylindrical specimen NMV P138597, with eroded ornament, from sample 9T/262.2; × 300.

for *B. (A.)* sp. aff. *B. riclonensis*). The position of the maximum diameter is also different, whereas *B. riclonensis* has its maximum diameter in the lower 1/3 of the vesicle, near the basal edge, this occurs in the middle 1/3 of the chamber in *B. (A.)* sp. aff. *B. riclonensis* causing the flanks to assume a more convex form and the shoulders to be more pronounced. Surface appearance differs in a more coarsely granular ornament on *B. (A.)* sp. aff. *B. riclonensis*.

**Dimensions.** — Taken from six specimens from samples 9T/240.2, 9T/243, 9T/262.2, 9T/267 and 9T/315.5: L — 118–176 (mean 149.2); Dmax — 100–129 (mean 111.8); Da — 57–66 (mean 59.6); L/Dmax — 1.2–1.5; Da/Dmax — 39–63%.

### *Bursachitina (Amplichitina)* sp. A

Figs 5A, 15D–E, Tab. 3.

**Description.** — *B. (Amplichitina)* sp. A has a relatively large vesicle in the shape of a elongate ellipse, approaching a sub-cylindrical form in some specimens. The chamber narrows slightly near the aperture and is surmounted by a short collar with a wavy edge which flares slightly at the aperture. The flanks of the vesicle are weakly convex and maximum diameter is attained in the upper half of the length of the vesicle and is maintained into the lower third, thus giving a straight-sided aspect. Although strongly convex in three dimensional specimens, the base may appear flat in compressed individuals. A basal callus is present, but not prominent and appears as a small, slightly recessed pit. The surface is covered with a fine, felt-like ornamentation, with no definite form or pattern.

**Remarks.** — In general shape, *B. (Amplichitina)* sp. A bears a slight resemblance to *Eisenackitina elongata* Eisenack 1972. The specimens illustrated by Eisenack (1972b: pl. 33: 15–16) are larger than those from the Taravale Formation, but some overlap in size occurs in the lower range. Eisenack's species, however, has a short, distinct copula, but this has not yet been observed on individuals of *B. (Amplichitina)* sp. A.

*Eisenackitina oviformis* is also of a similar shape (Eisenack 1972a), but may be distinguished by the ornamentation which consists of low, raised ridges resembling a jigsaw pattern.

**Dimensions.** — Taken from three specimens from samples 9T/240.2 and 9T/272.5: L — 189–260 (mean 218.4); Dmax — 104–140 (mean 122.9); Da — 67–91 (mean 81); Da/Dmax — 0.61–0.75; L/Dmax — 1.65–1.86.

### *Bursachitina (Amplichitina)* sp. B

Figs 5A, 13H, Tab. 3.

**Description.** — This species is variable in size, but has a narrow, elongate cylindro-ovoid vesicle ending in a sharply pointed, ogival base. The base may display a central pit, or may exhibit a small mucron. Sub-parallel to weakly convex flanks emerge as the maximum diameter is found approximately 1/4–1/3 down the length of the vesicle and extends for nearly half

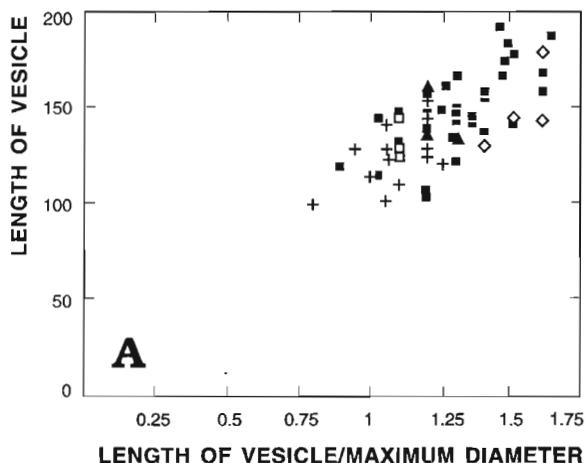
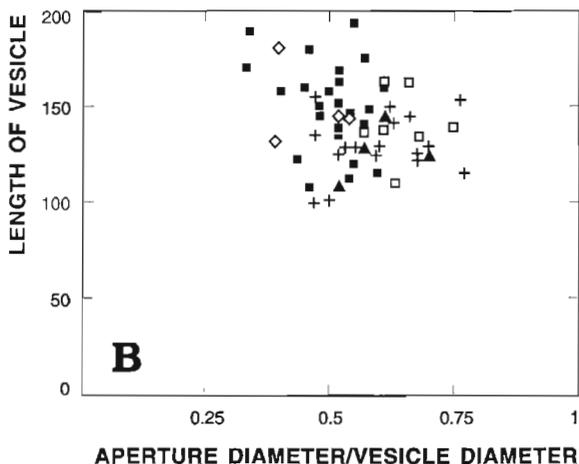


Fig. 20. Comparison of intraspecific variation in vesicle proportions (A) and relative aperture diameter (B) of five species: *Bursachitina* (*Bursachitina*) *ngarigo* sp. n. (plus symbol), *Bursachitina* (*Bursachitina*) *talenti* sp. n. (black triangles), *Bursachitina* (*Amplichitina*) *bidawal* sp. n. (open diamonds) *Bursachitina* (*Bursachitina*) *kurritgo* sp. n. (open squares) and *Eisenackitina* *subditiva* sp. n. (black squares).



the total vesicle length. Flexure is quite distinct and shoulders may be developed. A thin, conspicuous collar recurves away from the relatively large aperture (i.e. 70–80% of the maximum diameter). The vesicle exterior is generally unornamented, but is pitted and irregular — this may be due to a deteriorated surface.

**Remarks.** — Some individuals of *Eisenackitina bohemica* have a very similar shape, especially those that are seen as transitional to *Urnochitina urna* (Eisenack 1934) (e.g. Paris 1981a: pl. 27: 12). The overall dimensions of *B. (Amplichitina)* sp. B fit within the range of *E. bohemica*, for example the measurements of the population from Saint-Germain-sur-Ay (Paris 1981a: p. 157), except that the apertural diameter relative to the maximum diameter is larger in *B. (Amplichitina)* sp. B. Other differences include the cylindrical collar and the appearance of the maximum diameter at the basal edge in *E. bohemica*.

This species has been excluded from the genus *Urnochitina* because of the lack of a copula and from the genus *Eisenackitina* because of the unornamented vesicle surface.

**Dimensions.** — Taken from two specimens from samples 9T/282.3 and 9T/282.6: L — 138–175; Dmax — 86–100; Da — 56–75; Da/Dmax — 0.7–0.8; L/Dmax — 1.6–1.8.

### *Bursachitina (Amplichitina) sp. C*

Figs 5A–B, 15H, Tabs 3–4.

**Description.** — A moderate to large species with a sub-cylindrical to ovoid vesicle. The flanks are sub-parallel and the maximum diameter occurs between the upper third of the vesicle length and the midpoint of the chamber. There is a sudden constriction of the chamber to a relatively narrow aperture (Da/Dmax — 0.4), resulting in sloping shoulders; a sub-cylindrical collar tops the chamber. The basal margin is well rounded and the base is highly convex to sub-conical in shape. A basal callus appears as a shallow, circular pit elevated on a protuberance from the base. The vesicle surface is smooth or granulate in appearance.

**Dimensions.** — Taken from 3 specimens from samples 11T/128.5 and 11T/176: L — 139–224 (mean 181.4); Dmax — 78–116 (mean 100.5); Da — 40.7–51.6 (mean 46); L/Dmax — 1.7–1.9; Da/Dmax — 0.40–0.44.

### *Bursachitina (Amplichitina) sp. D*

Figs 5B, 15I, Tab. 4.

**Description.** — This species has a moderate sized sub-cylindrical to ovoid vesicle, with maximum diameter near the middle of the chamber. The flanks are weakly convex and the chamber narrows slightly towards the aperture, where straight edged collar is present but not well developed. The basal margin is broadly rounded, leading to a broad concave base, with the basal callus appearing as a slight indent at the centre. The test wall is relatively thick and the exterior is smooth.

**Remarks.** — The nondescript shape of the vesicle means that it is superficially similar to a number of species. Lack of any indication of ornament precludes inclusion with *B. (B.) ngarigo* sp. n., *B. (B.)* sp. aff. *krizi*, *Eisenackitina* sp. C, *E. subditiva* sp. n., and *E. oviformis*. This species can also be distinguished from *E. subditiva* by the absence of a well developed collar and differs from *E. oviformis* by being much larger.

**Dimensions.** — Taken from four specimens from samples 11T/172 and 11T/176: L — 125–176 (mean 147.7); Dmax — 107–142 (mean 119.8); Da — 56–86 (mean 69.1); L/Dmax — 1.1–1.3; Da/Dmax — 0.5–0.6.

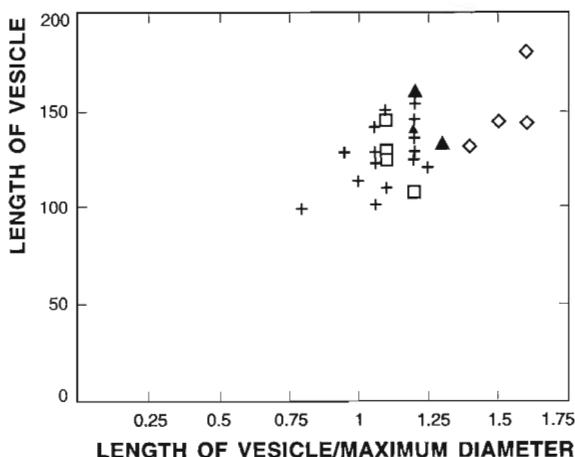
Genus *Calpichitina* Wilson & Hedlund 1964

### *Calpichitina?* sp.

Figs 5A, 16G–H, Tab. 3.

**Description.** — This species has a small, sub-spherical to lenticular vesicle. The aperture is moderate in size and is surrounded by a 'rolled' lip.

Fig. 21. Comparison of intraspecific variation in vesicle proportions of four species: *Bursachittina* (*Bursachittina*) *ngartgo* sp. n. (plus symbol), *Bursachittina* (*Bursachittina*) *talenti* sp. n. (black triangles), *Bursachittina* (*Amplichittina*) *bidawal* sp. n. (open diamonds) and *Bursachittina* (*Bursachittina*) *kurritgo* sp. n. (open squares).



The vesicle surface is smooth; no basal callus or operculum has been observed. The sides of the chamber are indented (see Fig. 16G–H) demonstrating some lateral aggregation, but it is uncertain whether this is a primary feature, or whether it occurs as a result of disaggregation of the vesicles and subsequent compaction. As no operculum has been observed it is impossible to verify the presence of chainlike structures.

**Remarks.** — Poor preservation of the vesicles precludes any meaningful comparison and the absence of an operculum makes generic assignment uncertain.

**Dimensions.** — Taken from two specimens from sample 11T/121.4: L — 36–65; Dmax — 56–99; Da — 32.0–47.6; L/Dmax — 0.64–0.66; Da/Dmax — 0.48–0.57.

Genus *Eisenackitina* Jansonius 1964

**Emended diagnosis** (modified from Paris 1981a). — Species of *Eisenackitina* have a subcylindrical, ovoid or weakly conical chamber. No neck can be discerned, but a collar is generally present. The basal margin is rounded and maximum diameter is usually situated near the aboral margin, leading to a flat or convex base which may have a protuberance at the centre. A short mucron is generally present and may be represented by a shallow, circular pit. The operculum is discoid and is located near the edge of the collar. The thick test is ornamented with isolated spines, cones or tubercles, or fused spines; these may be eroded to form sharp ridges, or low, rounded rugae and commonly forms a polygonal pattern can by interlocking of the ridges and rugae.

**Remarks.** — Studies of the Emsian fauna from the Taravale Formation have revealed a number of new species with general characteristics identical to those of *Eisenackitina*, but with more complex ornamentation. Indeed the intraspecific variation of one species, *E. subditiva* sp. n., ranges from simple and bifurcate spines to fused spines and sharp ridges within

the one population. In a few cases it is clear that some of the more dramatic changes in ornamentation may be simply due to erosion of the vesicle surface.

*Bursachittina* (*Amplichittina*) is the closest genus and may be differentiated by less developed ornamentation, i.e. smooth, spongy, felt-like, reticulate or granular.

### *Eisenackitina birubi* sp. n.

Figs 5B, 16A–F, Tab. 4.

Holotype: NMV P138583 (Fig. 16A–B).

Type horizon and locality: Taravale Formation, 343.3 m above the base of the Gelantipy Road section (sample number 16T/124) at Buchan, Victoria, Australia.

Derivation of name: From the Australian Aboriginal word *birubi*, meaning Southern Cross, referring the type locality in the Southern Hemisphere.

**Diagnosis.** — A species of *Eisenackitina* with a subcylindrical to subconical vesicle and a flat to weakly convex base. The ornament has a clearly discernible reticulate form.

**Description.** — *Eisenackitina birubi* has a relatively wide sub-cylindrical to subconical vesicle narrowing slightly towards the aperture. Maximum diameter is located near the midpoint of the chamber, or in the lower third. No neck is apparent and there is thus no flexure. A small collar with a crenulate edge may be present. The basal margin is blunt or broadly rounded and the base varies from flat to weakly convex. There is a relatively wide basal callus, appearing as a central pit, surrounded by a raised ridge. Surface ornamentation displays a clear reticulate pattern, varying from thick and spongy to a series of intersecting, low ridges.

**Remarks.** — Extremes of intraspecific variation of this species overlap with *Eisenackitina warnangatte* sp. n. and *Bursachittina* (*Amplichittina*) *jaimathang* sp. n. in size and shape. In both cases the reticulate pattern of the ornamentation serves to differentiate *E. birubi* from the other two species. *E. warnangatte* also differs in having the basal callus elevated away from the base and in having a slightly narrower aperture ( $Da/D_{max}$  — 0.45–0.63 for *E. warnangatte*;  $Da/D_{max}$  — 0.50–0.75 for *E. birubi*). Fig. 17 demonstrates the relationship between *B. (A.) jaimathang* and *E. birubi*; although they are very close, *E. birubi* has a slightly longer vesicle.

**Dimensions.** — Taken from eleven specimens from samples 15T/146.6, 16T/124 and 16T.128: L — 138–228 (mean 190);  $D_{max}$  — 96–155 (mean 119.6);  $Da$  — 55–99 (mean 74);  $L/D_{max}$  — 1.40–1.75;  $Da/D_{max}$  — 0.50–0.75.

### *Eisenackitina hebeta* sp. n.

Figs 5B, 18A–C, Tab. 4.

Holotype: NMV P138587 (Fig. 18A–B).

Type horizon and locality: Taravale Formation, 176.5 m above the base of the Gelantipy Road section (sample number 11T/179) at Buchan, Victoria, Australia.

Derivation of name: From the Latin *hebetis*, meaning blunt, dull; blunt refers to the rounded, convex base and dull refers to the generally unexciting shape.

**Diagnosis.** — A species of *Eisenackitina* with a relatively large subcylindrical to subconical vesicle and a large callus dominating the base (this may be either inverted or everted). Minute cones, verrucae or rugae cover the vesicle surface.

**Description.** — This species has a relatively large ( $L = 194\text{--}228\ \mu\text{m}$ ), subcylindrical to subconical vesicle. Maximum diameter occurs near the centre or in the lower third of the vesicle and there is a slight narrowing of the chamber towards the aperture ( $D_a/D_{\text{max}} = 0.58\text{--}0.80$ ). The collar is subcylindrical or may flare slightly with a flat or crenulate edge. The operculum, when present, is domed and has a roughened appearance. A well-rounded basal edge leads to a base which may be flat, with an inverted basal callus, or may be moderately convex with an everted callus. In either case the callus is very large ( $D_{\text{callus}} = 30\text{--}43\ \mu\text{m}$ ) and dominates the base.

Minute cones, verrucae or rugae may cover the surface, though vesicles with eroded surfaces may appear smooth. The ornamentation decreases in prominence towards the aperture and is absent on the collar and basal callus.

**Discussion.** — The size and shape of this species is close to that of a number of taxa. *Desmochitina oblonga* Taugourdeau & Jekhowsky 1960 (Taugourdeau & Jekhowsky 1960: fig. 101) may be distinguished by its more convex base and smooth surface. *Conochitina brevis* Taugourdeau & Jekhowsky 1960 has a much larger aperture ( $D_a/D_{\text{max}} = 0.75\text{--}1.00$ ; measurements were taken from Taugourdeau & Jekhowsky 1960: figs 47–49). *Eisenackitina* sp. B from the Taravale Formation is superficially similar but differs in having wider vesicle ( $D_{\text{max}} = 120\text{--}137$ ).

**Dimensions.** — Taken from five specimens from samples 11T/179, 15T/146.6, 16T/124 and 16T/128:  $L = 194\text{--}228$  (mean 216.3);  $D_{\text{max}} = 103\text{--}120$  (mean 108.7);  $D_a = 60\text{--}86$  (mean 70.8);  $D_{\text{callus}} = 30\text{--}43$  (mean 39);  $L/D_{\text{max}} = 1.9\text{--}2.1$ ;  $D_a/D_{\text{max}} = 0.58\text{--}0.80$ .

### *Eisenackitina subditiva* sp. n.

Figs 4, 5A–B, 19A–J, 22A–C, 23I, Tabs 1–3.

*Eisenackitina* sp.; Winchester-Seeto & Paris 1989: fig. 1a–f.

Holotype: NMV P138598 (Fig. 19A–B).

Type horizon and locality: Taravale Formation, 65.5 m above the base of the BCE section (sample number BCE-2) at Buchan, Victoria, Australia.

Derivation of name: From the Latin, *subditivus*, meaning counterfeit, referring to the close resemblance to *Eisenackitina bohémica*.

**Diagnosis.** — A highly polymorphic species of *Eisenackitina* with a prominent basal callus sometimes elevated on a truncated conical protuberance from the base. Minute and densely spaced ornamentation consists of simple and bifurcate spines occasionally with elongate bases, eroding to a series of cones or low, intersecting ridges.

**Description.** — There are many different shape variants of this species; chamber shape varies from oviform through sub-cylindrical, sub-conical, hemispherical to almost cubic or cylindrical forms. Flanks may be sub-parallel, or range from weak to strongly convex and shoulders may be

weakly expressed, sloping or well developed. The maximum diameter is rarely found at the basal edge, it occurs anywhere between the upper third of the vesicle to low in the middle third. The basal edge is broadly rounded and the base may be flat, concave or convex and may have a truncated conical protuberance. A prominent scar dominates the base and may be sunken within slight circular ridge at the edge of the callus.

A conspicuous collar often surmounts the vesicle and generally recurves away from the operculum. The width of the collar varies enormously, but in many cases its absence is caused by the stripping away of external layer of the vesicle. The collar edge may be smooth or slightly crenulate. When present, the operculum is flat to slightly dome-shaped, and may sit at the extreme edge of the chamber or be located within the collar.

*E. subditiva* has an unusual surface sculpture consisting of minute, simple and bifurcate spines, some with elongate bases. These spines may intersect to form interlocking ridges, and, when eroded, the surface frequently resembles a hedge maze. Further erosion creates a faint granular texture, and at the extreme, a smooth surface. The densest covering occurs at the aboral margin, thinning towards the collar; both the collar and basal callus are smooth.

**Remarks.** — *E. subditiva* presents a number of shape variants that closely resemble those observed in *E. bohémica* (e.g. Eisenack 1972b: pl. 33: 1–14, and De Bock 1982: pl. 3: 1–6). However *E. subditiva* has an even greater range of intraspecific variation (see Figs 19A–J, 22A–C).

The size and general proportions of *E. subditiva* are almost indistinguishable from those of *E. bohémica* from France and Bohemia described by Paris (1981a), and those depicted by Eisenack (1972b), however individuals of *E. subditiva* are larger than those from the Montagne Noire (De Bock 1982). Although *E. bohémica* is very similar to *E. subditiva*, the latter can be distinguished by the shape of the collar; where *E. bohémica* has a subcylindrical collar (Paris 1981: pp.155–156), the collar of *E. subditiva* flares, presenting a recurved aspect.

The main distinguishing feature of this new species is the form of the ornamentation; *E. bohémica* has relatively long, sparsely set discrete, simple spines. In contrast, *E. subditiva* has interlocking, bifurcate spines, with elongate bases in addition to the simple ones. This difference can also be detected in specimens with eroded surfaces — the ornament of *E. bohémica* erodes to form individual cones or tubercles (e.g. Paris 1981a: pl. 27: 15–19), whereas the vesicle surface of *E. subditiva* may display a faint granular texture, but more often has a jig-saw appearance of low ridges.

Laufeld (1974: p. 123) alludes to the problem of similar morphologies, suggesting that the close resemblance of some species to others of a different age is related to 'having counter-parts in similar environments', implying that some elements of shape may be a result of convergent evolution. This is particularly true for species with a simple morphology, where subtle differences are difficult to detect. *E. bohémica* and *E. subditi-*

va have been distinguished almost entirely on the ornamentation, if the exterior of the vesicle is badly damaged, or the surface is coated or eroded, the two species are difficult to separate, thus it is important to have a number of well-preserved specimens before a decision can be confidently made.

It is difficult to determine whether the smooth surface on some specimens from the Gelantipy Road section is caused by erosion of the periderre, or by the addition of some organic coating — this surface is observed only on specimens from the samples 9T/262.2, 9T/272.2 and 9T/282.6 (see Fig. 19E, J).

There is a superficial resemblance between *E. subditiva* and other species from the same assemblage, namely *Bursachittina* (*Bursachitina*) *kurritgo* sp. n., *Bursachitina* (*B.*) *ngarigo* sp. n., *Bursachittina* (*B.*) *talenti* sp. n., and *Bursachitina* (*Amplchitina*) *bidawal* sp. n. (see Tab. 5). The vesicle of *E. subditiva* is covered with minute, simple and bifurcate spines (many with elongate bases). These may erode to form a reticulate pattern, then to a faintly granular ornament and finally to a smooth surface. This contrasts strongly with the minute, but conspicuous, simple spines, cones and verrucae on the vesicle of *Bursachitina* (*B.*) *kurritgo*. *Bursachitina* (*A.*) *bidawal* can be differentiated by its coarsely granular surface and by the strong development of shoulders much further down the vesicle. Similarly, *Bursachittina* (*B.*) *talenti* is distinguished from *E. subditiva* by the coarsely granular surface and by the more restricted proportions of vesicle length versus maximum diameter ( $L/D_{max}$  ranges from 1.0–1.3 for *B. (B.) talenti* and 1.1–1.6 for *E. subditiva*). Finally, *Bursachitina* (*B.*) *ngarigo* exhibits only a faint basal scar, quite different to the prominent, definite scar of *E. subditiva* (see Fig. 19A–B). *E. subditiva* and *Bursachitina* (*A.*) *bidawal* can be readily separated from the other three species by considering the distribution of length versus diameter of aperture/maximum diameter (Fig. 20). Thus a combination of shape, general dimensions and surface ornament can be used to obtain a clear definition of each species (see Figs 20, 21).

**Dimensions.** — Taken from 27 specimens from sample BCE-2:  $L$  — 108–194 (mean 151.3);  $D_{max}$  — 110–162 (mean 127.7);  $D_a$  — 53–78 (mean 66.2);  $L/D_{max}$  — 0.95–1.60;  $D_a/D_{max}$  — 0.44–0.60.

Taken from 23 specimens from samples 9T/243, 9T/262.2, 9T/267, 9T/272.5, 9T/282.3, 9T/315.5 and 9T/329.6:  $L$  — 112–185 (mean 153.6);  $D_{max}$  — 89–138 (mean 114.6);  $D_a$  — 42–84 (mean 62.6);  $L/D_{max}$  — 1.1–1.6;  $D_a/D_{max}$  — 0.43–0.60.

*Eisenackitina* sp. cf. *E. subditiva* sp. n.

Figs 5A–B, 22D–F, Tabs 3–4.

**Description.** — These are egg-shaped to sub-conical vesicles with an inflated appearance. The maximum diameter occurs near the middle of the chamber making the flanks highly convex. The basal edge is well-rounded and the base varies from flat to strongly convex. An indistinct, but large

basal callus may be present as depressed pit in the centre of the base. The aboral half of the vesicle has strongly sloped shoulders but no neck is visible. A small, cylindrical or slightly flared collar may be present, but is commonly barely discernible. The aperture is generally relatively small ( $Da/D_{max} = 0.41-0.58$ ) but may occupy up to 72% of the maximum diameter.

A spongy, reticulate pattern covers the surface of the vesicle, sometimes including the collar. This may take on a granular appearance in specimens with eroded exteriors.

**Remarks.** — The overall appearance and size range is strongly reminiscent of *E. subditiva*. However, this species represents an extreme of shape not seen in *E. subditiva*. The maximum diameter appears generally higher on the vesicle, i.e. near the middle; whereas on *E. subditiva* the maximum diameter is closer to the basal edge. Other important differences are the much smaller collar on *E. sp. cf. E. subditiva* and the presence of surface ornament on the collar of several specimens, a feature rarely seen on *E. subditiva*. Surface sculpture has a different appearance on *E. sp. cf. E. subditiva* where it has a smaller and slightly spongy pattern. The close match of size and proportions suggests a close relationship between *E. subditiva* and this species, but the two have been separated pending the discovery of more specimens.

A number of individuals of *E. bohémica* depicted by Taugourdeau & Jekhowsky (1960: figs 82, 84–86) closely resemble *E. sp. cf. E. subditiva* in shape. They make no mention of surface sculpture and the relationship is therefore difficult to establish. Moreover, these particular individuals are Silurian in age.

Superficially this group resembles *Bursachitina ricolonensis*; however, *E. sp. cf. E. subditiva* is nearly twice the size of *B. ricolonensis*, does not have the 'S' shaped flanks described by Paris (1981b: p. 61) and has a reticulate surface ornament, not the granular one found on *B. ricolonensis*.

**Dimensions.** — Taken from ten specimens from samples 9T/315.5 11T/176, 11T/179 and 15T/144.1: L — 122–173 (mean 150);  $D_{max}$  — 97–139 (mean 123.6);  $Da$  — 56–101 (mean 71.3);  $L/D_{max}$  — 1.0–1.4;  $Da/D_{max}$  — 46–72.

### *Eisenackitina? vieta* sp. n.

Figs 5B, 27E–H, Tab. 4.

Holotype: NMV P139229 (Fig. 27G–H).

Type horizon and locality: Taravale Formation, 181.5 m above the base of the Gelantipy Road section (sample number 11T/189.5) at Buchan, Victoria, Australia.

Derivation of name: From the Latin *vetus*, meaning shrivelled, wrinkled, referring to the rugae pattern of ornamentation giving a faintly wrinkled appearance.

**Diagnosis.** — A possible species of *Eisenackitina* with a squat, inflated vesicle, a flat base and very short neck. Fine rugae cover the vesicle surface giving a ridged, wrinkled appearance.

**Description.** — *Eisenackitina? vieta* has a moderate to large vesicle with chamber that ranges in shape from subconical or funnel-shaped to sub-

cubic; chamber flanks may be subparallel, weakly convex or inclined towards the aperture. Maximum diameter occurs near the centre of the chamber which tapers to a very well-rounded basal edge. The base is flat but may also be slightly concave, with a large basal callus appearing as a simple circular pit. Flexure varies from indistinct to well defined and sloping shoulders may be present. A very short, cylindrical 'neck' tops the chamber ( $L_n/L = 9-21\%$ ). In deformed specimens this neck may be pushed to one side leading to a degree of asymmetry (like a sack of potatoes). A small collar may be present and the operculum (only present in one specimen) is domed and rough.

Faint rugae cover the vesicle surface, diminishing in size and coarseness from the midpoint of the vesicle to the aperture.

**Remarks.** — This species does not fit readily into any established genus; the specimens are too large for *Bursachitina* and the presence of a distinct neck and shoulders makes it difficult to conclusively assign the species to *Bursachitina* or *Eisenackitina*. Assignment to *Lagenochitina* is possible, but the surface ornament is unusual. *Eisenackitina* has been chosen tentatively as the most likely genus.

Amongst the species from the Buchan area, *Eisenackitina warnangatte* sp. n. is the most likely to be confused, but *E.?* *vieta* can readily distinguished by the presence of a short 'neck' and a flat base.

There is an uncanny resemblance in size and shape to *Lagenochitina brevicollis* Taugourdeau & Jekhowsky 1960 (e.g. Taugourdeau & Jekhowsky 1960: figs 109-110; Cramer 1964: pl. 24: 9, 10), but these reports are from Middle Ordovician and Silurian localities. Taugourdeau & Jekhowsky (1960) make no reference to the ornamentation on the vesicle and Cramer erects a subspecies for those specimens with small granules coating the surface. Da Costa (1971) assigns specimens with fine tubercles to *L. brevicollis* from the Silurian of the Amazon Basin and the Early Devonian (Emsian) of the Paraná Basin; these specimens are different in size to *E.?* *vieta* and are poorly illustrated making it difficult to verify their assignment.

**Dimensions.** — Taken from seven specimens from samples 11T/189.5 and 16T/124:  $L = 152-195$  (mean 170.7);  $L_n = 15-32$  (mean 20.3);  $D_{max} = 104-151$  (mean 124.2);  $D_a = 41-76$  (mean 58.1);  $L/D_{max} = 1.3-1.5$ ;  $D_a/D_{max} = 0.39-0.69$ ;  $L_n/L = 9-21\%$ .

### *Eisenackitina warnangatte* sp. n.

Figs 5B, 23E-H, Tab. 4.

Holotype: NMV P138606 (Fig. 23E-F).

Type horizon and locality: Taravale Formation, 173.2 m above the base of the Gelantipy Road section (sample number 11T/172) at Buchan, Victoria, Australia.

Derivation of name: Named for an Aboriginal tribe living in areas adjacent to the Buchan Caves, the Warnangatte.

**Diagnosis.** — A species of *Eisenackitina* with a sub-conical to club-shaped chamber. The chamber flanks are straight from the maximum diameter to the collar and are inclined towards the aperture. The base is convex with

the central, flattened part raised slightly. Tiny verrucae and rugae cover the surface of the vesicle.

**Description.** — The chamber is sub-conical to club-shaped with inclined flanks that are straight from the base of the collar to the maximum diameter. There is no distinct neck and no shoulders are apparent. The apical angle is generally less than 40, but some rare exceptions range up to 46. A very short collar (Lcoll — 5–10  $\mu\text{m}$ ) may be present and this may flare slightly at the oral edge. Maximum diameter occurs in the lower third of the vesicle, near the basal edge. A flattened base occurs in compressed specimens, but it is usually highly convex. The basal callus appears as a smooth, raised mound with a flattened top, and is relatively large (Dcallus — 20–41  $\mu\text{m}$ ).

Ornamentation consists of faint, minute verrucae and rugae covering the entire surface, except the basal callus and collar.

**Remarks.** — As is generally the case with species of *Eisenackitina*, this species resembles a number of other taxa. *E. warnangatte* shows some similarity to *E. subditiva* sp. n., but is easily distinguished by the much smaller collar and narrower vesicle relative to maximum diameter (L/Dmax is 1.5–1.8 for *E. warnangatte* and 0.95–1.60 for *E. subditiva*). The basal callus is also shaped differently; where the basal callus on *E. subditiva* is sunken within a circular ridge, this is not seen on *E. warnangatte*.

Some silhouettes of *Conochitina lagenomorpha* Eisenack 1931 show features resembling those of *E. warnangatte* (e.g. Eisenack 1968: pl. 26: 10–12). The two can be differentiated by the generally straight flanks of *E. warnangatte*, as opposed to the S-shaped vesicle walls of *C. lagenomorpha* and the presence of a raised section in the centre of the base on *E. warnangatte*. *B. (Amplichitina) jaimathang* sp. n. also has a similar form, but differs in having a wider vesicle and a more flattened base.

**Dimensions.** — Taken from 9 specimens from 11T/172, 11T/176, 11T/179, 11T/189.5 and 16T/124: L — 185–202 (mean 198.8); Dmax — 102–133 (mean 119.5); Da — 54–78 (mean 64.3); L/Dmax — 1.5–1.8; Da/Dmax — 0.53–0.63.

### *Eisenackitina yaraan* sp. n.

Figs 5B, 23A–D, Tab. 4.

?*Desmochitina* sp. cf. *D. amphorea* Eisenack; Pichler 1971: p. 331, pl. 6: 80.

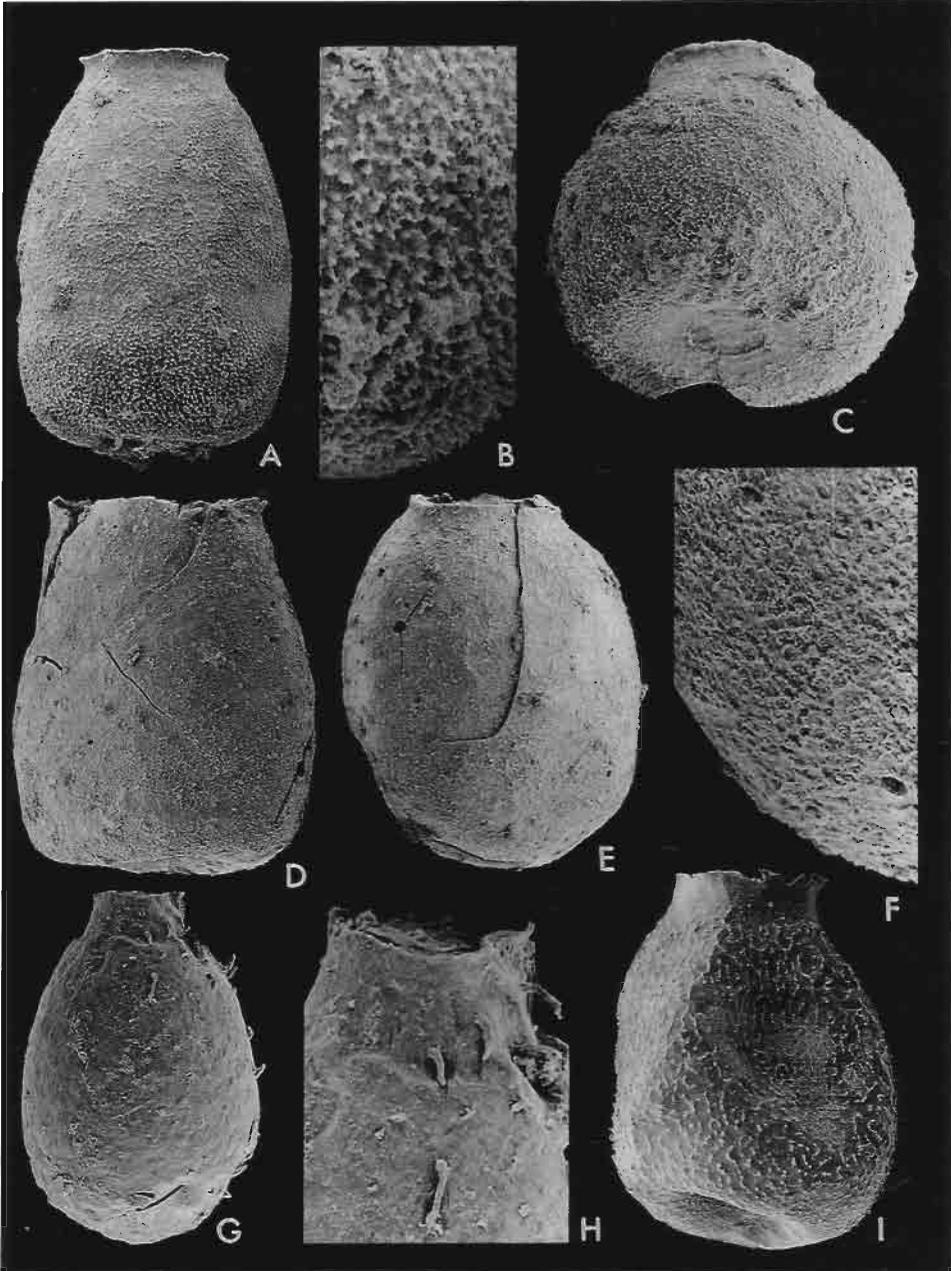
Holotype: NMV P138604 (Fig. 23A–B).

Type horizon and locality: Taravale Formation, 343.3 m above the base of the Gelantipy Road section (sample number 16T/124) at Buchan, Victoria, Australia.

Derivation of name: From the Australian Aboriginal word *yaraan*, meaning White Gum, a native tree, referring to the shape of the gum-nut (fruit) that resemble the shape of the vesicle.

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Fig. 22. □A–C. *Eisenackitina subditiva* sp. n. A–B. Holotype NMV P138598 from sample BCE-2;  $\times 300$  (A) and enlargement of lower chamber wall showing minute ornamentation with



bifurcate spines (B)  $\times 1000$ . C. Short, bulbous specimen NMV P138599 with a large basal callus, from sample BCE-2,  $\times 300$ . □D–F. *Eisenackittina*-sp. cf. *E. subditiva* sp. n. D. Specimen NMV P138600 from sample 9T/315.5  $\times 300$ . E–F. Specimen NMV P138601 from sample 9T/315.5;  $\times 300$  (E) and enlargement of lower chamber wall (F)  $\times 1100$ . □G–H. *Eisenackittina*? sp. A, specimen NMV P138602 from sample 9T/166;  $\times 400$  (G) and enlargement of collar and operculum (H)  $\times 900$ . □I. *Eisenackittina* sp. D, specimen NMV P138603, note the peculiar form of the ornamentation, from sample 11T/176;  $\times 350$ .

**Diagnosis.** — A species of *Eisenackitina* with an ovoid vesicle, a small collar and a strongly convex base. The surface is dotted with very fine, short, simple spines.

**Description.** — *Eisenackitina yaraan* has an ovoid shaped vesicle. There is no apparent flexure and no shoulders. A small, slightly flared collar surmounts the chamber. Maximum diameter is located in the lower third of the chamber and the base is strongly convex. A small mucron appears in profile as a slightly flattened area in the centre of the base; it is a shallow depression, surrounded by a raised rim. Surface sculpture consists of a relatively sparse sprinkling (approx.  $6/100 \mu\text{m}^2$ ) of fine, very short (Lsp — 1–2 m), simple spines.

**Remarks.** — Amongst the Australian chitinozoans from the Emsian, *Eisenackitina* sp. C is the closest species. The surface ornamentation of densely packed, sharp cones on *Eisenackitina* sp. C serves to differentiate the two.

*Eisenackitina yaraan* sp. n. is very similar in shape and general proportions to *Desmochitina* sp. cf. *D. amphorea*, depicted by Pichler (1971: pl. 6: 80) from the late Emsian of Germany. The only real difference is that the Australian group are slightly larger than those from Germany. Pichler (1971) describes the surface as covered with fine granules, and it is probable that under light microscopy the very short spines would have that appearance. The two species have been only tentatively synonymised because of this minor disparity in description of the surface.

**Dimensions.** — Taken from three specimens from sample 16T/124: L — 139–161 (mean 149.6); Dmax — 136–147 (mean 139.3); Da — 68–83 (mean 75.4); L/Dmax — 1.0–1.1; Da/Dmax — 0.61–0.69.

**Occurrence.** — Taravale Formation (see Fig. 5B); late Emsian Heisdorf-Schichten, Germany.

### *Eisenackitina?* sp. A

Figs 5A, 22G–H, Tab. 3.

**Description.** — This is a small species with a slightly egg-shaped vesicle and a strongly convex base. The chamber has a slender, ovoid form and the maximum diameter occurs at the mid-length of the chamber or slightly below. The chamber narrows to a very short, cylindrical 'neck' ( $L_n/L$  — 7–12% of total vesicle length); the neck varies greatly in diameter, but this may reflect breakage and compression of the vesicle. A small collar that widens slightly at the aperture may be present, and the collar edge is generally straight.

Better preserved specimens display short, simple spines, or more commonly, scars of spine bases. Although not observed on all specimens, the spines appear to cover the chamber and neck with a maximum density of  $6/100 \mu\text{m}^2$ .

**Remarks.** — The closest described species is *Lagenochitina* sp. cf. *L. brevicollis* Taugourdeau & Jekhowsky 1960 discovered by Legault (1973) in the Middle Devonian Hamilton Formation of Ontario. This species has

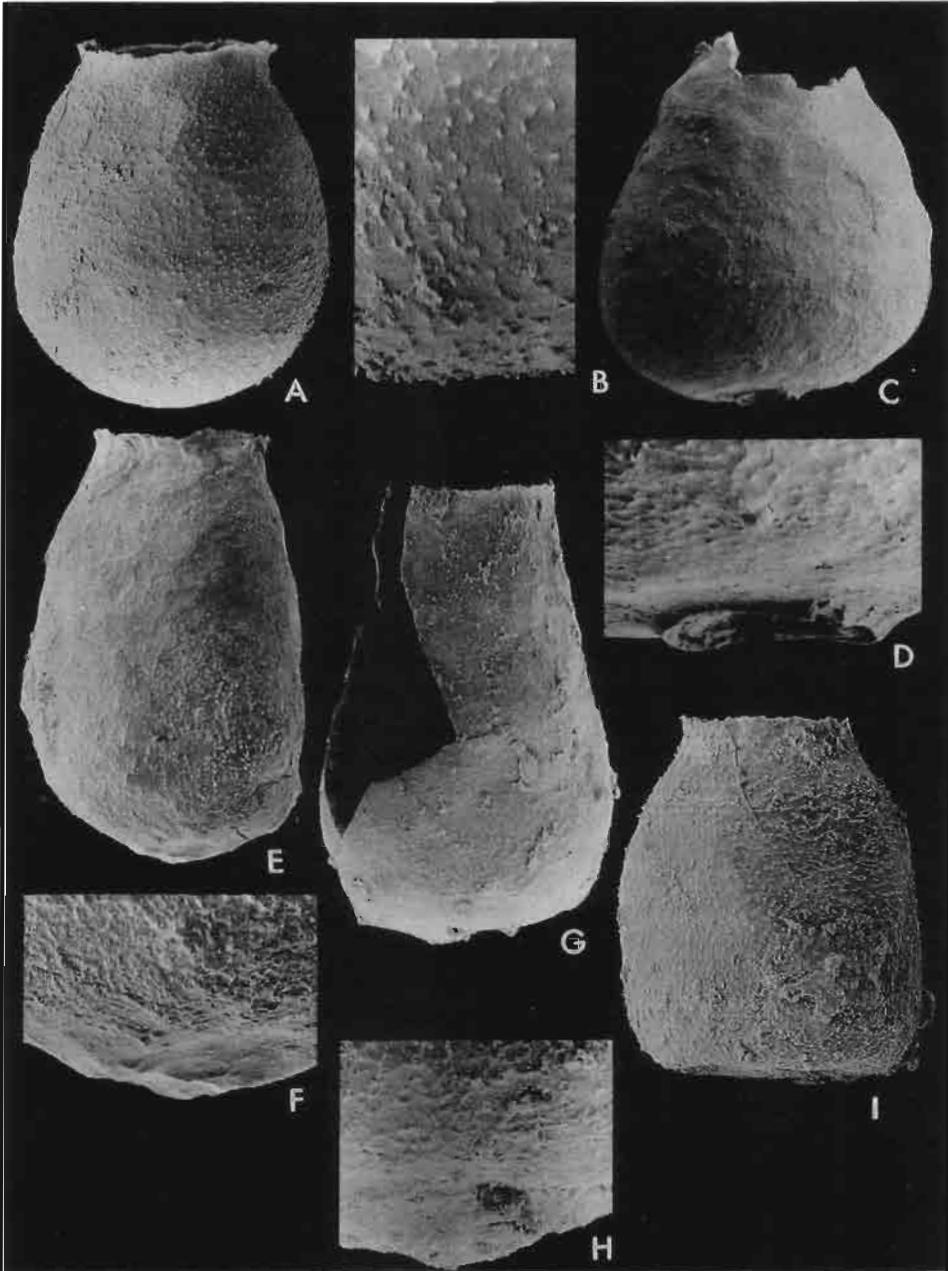


Fig. 23. □A-D. *Eisenackittina yaraan* sp. n. A-B. Holotype NMV P138604 from sample 16T/124;  $\times 300$  (A) and enlargement of lower chamber showing details of ornament (B)  $\times 800$ . C-D. Specimen NMV P138605 from sample 16T/124;  $\times 300$  (C) and enlargement of basal callus (D)  $\times 800$ . □E-H. *Eisenackittina warnagatte* sp. n. E-F. Holotype NMV P138606 from sample 11T/172;  $\times 300$  (E) and enlargement of the basal area (F)  $\times 800$ . G-H. Specimen NMV P138607 from sample 11T/189.5;  $\times 300$  (G) and enlargement of base (H)  $\times 900$ . □I. *Eisenackittina subditiva* sp. n., specimen NMV P138608 from sample 11T/179;  $\times 300$ .

an very similar range of shape, size and proportions to the group from the Taravale Formation. There are also a number of similarities to *L. brevicollis* depicted by Taugourdeau & Jekhowsky (1960), Cramer (1964) and Da Costa (1971). The globular chamber and strongly convex base, the very short, cylindrical neck and slight widening of the neck at the aperture are common to *L. brevicollis* and the Australian group. The major difference lies in the ornamentation, Legault describes the surface of *L. sp. cf. brevicollis* as 'laevigate'. Cramer (1964: p. 351) notes a granulate surface on some specimens of *L. brevicollis* and Da Costa (1971: p. 244) describes fine tubercles covering the vesicle. However in none of these cases have spines been observed on the surface of the vesicle. It is possible that due to the very short nature of the spines they may have appeared as tubercles under the light microscope, but this is difficult to verify with the illustrations provided. Interestingly Da Costa's material, with the finely tuberculate ornament was found in Early Devonian strata of the Paraná Basin, the smooth specimens described by Taugourdeau & Jekhowsky (1960) were Ordovician and those found by Cramer (1964) were Silurian. It is also possible that *L. brevicollis* has a broken 'neck' and may not really belong to *Lagenochitina*.

None of the specimens from Buchan are particularly well preserved; many display breakage of the chamber near the apertural pole with some showing evidence of a collar. The small number of specimens makes it difficult to be positive that this 'neck' is not a broken segment of some longer structure as would be seen in an species of *Angochitina* or *Gottlandochitina*. Nonetheless the presence of a collar strongly suggests that this 'neck' is merely a relatively short narrowed region of the chamber. The presence of spinose ornamentation raises further complications with the generic placement of this species. Although it is closest to *Lagenochitina sp. cf. L. brevicollis*, the presence of spines suggests that it does not belong to that genus; Paris (1981: p. 242) noted that *Lagenochitina* has no spines, bristles or tubercles. The next, closest taxon is *Eisenackitina*, but this genus has no differentiated neck, and has the maximum diameter near the basal edge (Jansonius 1964: p. 912), quite unlike the species from Victoria. The Taravale group has been tentatively placed in the genus *Eisenackitina* as the closest possible alternative, but there remains uncertainty as to the most appropriate generic placement.

**Dimensions.** — Taken from five specimens from samples 9T/166, 9T/213.8, 9T/226.8 and 9T/182.3; L — 96–122 (mean 109); Ln — 7–15 (mean 10); Dmax — 60–81 (mean 69.8); Dn — 24–41 (mean 33.2); Dmax/L — 0.59–0.66; Dn/Dmax — 36–58%.

### *Eisenackitina sp. B*

Figs 5B, 24C, Tab. 4.

**Description.** — A subcylindrical vesicle with weakly convex flanks inclined slightly towards the aperture characterises this species. The maximum diameter occurs in the lower third of the chamber, but not at the

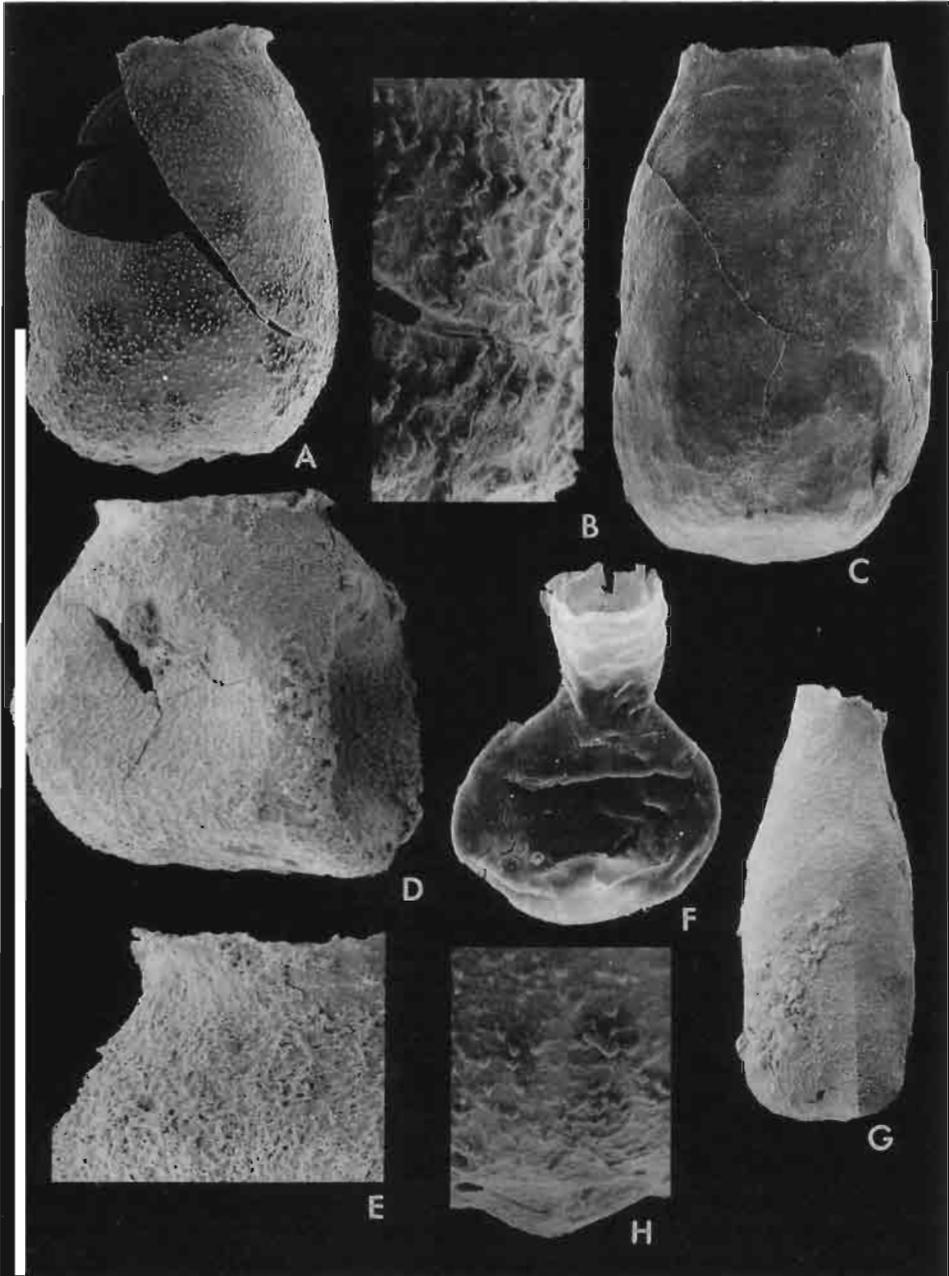


Fig. 24. □A–B, H. *Eisenackitina* sp. C, specimen NMV P138609 from sample 11T/176;  $\times 300$  (A) and enlargements of chamber wall showing minute, sharp cones (B)  $\times 1400$  and basal callus (H)  $\times 900$ . □C. *Eisenackitina* sp. B, specimen NMV P138610 from sample 11T/172;  $\times 300$ . □D–E. *Eisenackitina* sp. E, specimen NMV P138611 from sample 15T/146.6;  $\times 300$  (D) and enlarged view of collar (E)  $\times 1000$ . □F. *Fungochitina?* sp., specimen NMV P138612 from sample 16T/71.7;  $\times 350$ . □G. *Eisenackitina* sp. F, specimen NMV P138613 from sample 16T/124;  $\times 250$ .

aboral edge. A short, but distinct collar surmounts the vesicle, flaring slightly away from the aperture. The basal margin is blunt to moderately sharp, leading to a flat or weakly concave base, with a small basal callus. Surface ornamentation has a faintly polygonal structure, possibly the remnants of rugae or even spines.

**Remarks.** — There is a great deal of similarity in outline and size with *Conochitina brevis* and *C. brevis* var. *conica* (Taugourdeau & Jekhowsky 1960: figs 47–49). The maximum diameter of *Eisenackitina* sp. B is, however, larger (Dmax is 125  $\mu\text{m}$  for *Eisenackitina* sp. B and 100  $\mu\text{m}$  for *C. brevis*) and this is reflected in the relative proportion of length to maximum diameter (L/Dmax is 1.5–1.8 for *Eisenackitina* sp. B, 2.0–2.1 for *C. brevis*, measurements were taken from figs 47–48 in Taugourdeau & Jekhowsky 1960). Despite a superficial resemblance, *Eisenackitina* sp. B is larger than *Eisenackitina subditiva* sp. n. and can also be differentiated by the presence of a distinct and generally large collar on *E. subditiva*.

**Dimensions.** — Taken from four specimens from samples 11T/172, 11T/176 and 11T/179: L — 184–219 (mean 201); Dmax — 120–138 (mean 125); Da — 77–90 (mean 85.5); L/Dmax — 1.5–1.8; Da/Dmax — 0.64–0.75.

### *Eisenackitina* sp. C

Figs 5B, 24A–B, H, Tab. 4.

**Description.** — *Eisenackitina* sp. C has an oviform to sub-conical vesicle, narrowing slightly towards the oral end. The vesicle is always longer than wide and the maximum diameter may be found at the mid-length of the chamber or in the lower third, but not at the aboral edge. A distinct, flared collar surrounds the aperture and sloping shoulders may appear on some specimens. The basal edge is well-rounded and the base may be flat or indented in the centre of the base, or may be convex with the basal callus elevated (i.e. the callus may be pushed into the vesicle or may be everted).

Ornamentation consists of a moderately dense covering of sharpened simple cones or tubercles, resembling pimples (i.e. 12 cones per 100  $\mu\text{m}^2$ ). Occasionally two or three cones are linked, giving an elongate base. As the surface erodes it takes on a coarse, pimply appearance and ultimately a smooth surface.

**Remarks.** — In many ways *Eisenackitina subditiva* sp. n. is very similar. The size and shape of the two species overlap to a considerable extent, except for the diameter of the aperture which is slightly wider, relative to maximum diameter on *Eisenackitina* sp. C (see Fig. 25). Ornamentation, however, easily distinguishes the two species, where *E. subditiva* has simple and bifurcate spines, eroding to a pattern of low, intersecting ridges, *Eisenackitina* sp. C is covered with coarse, sharp cones and tubercles, giving a 'pimply' appearance on eroded surfaces. The ornament is also denser on *E. subditiva* with 18–20 spines per 100  $\mu\text{m}^2$  compared to 12 cones per 100  $\mu\text{m}^2$  on *Eisenackitina* sp. C.

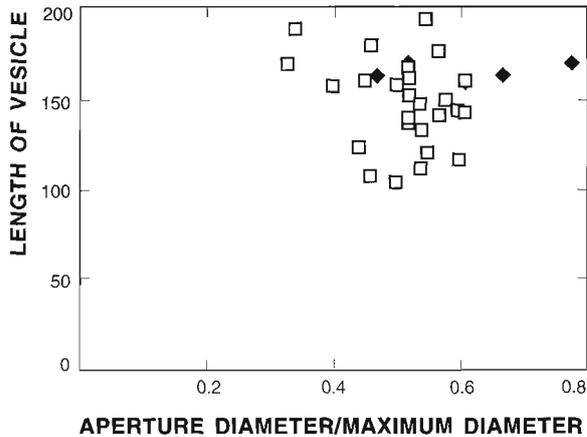


Fig. 25. Intraspecific variation of vesicle proportions of *Eisenackitina subdittva* sp. n. (open squares) and *Eisenackitina* sp. C (black diamonds).

Some specimens of *Eisenackitina bohémica* bear a resemblance to *Eisenackitina* sp. C, especially in ornamentation (e.g. those figured by De Bock 1982: pl. 4: 1–7, pl. 5: 1–6). The two species differ, however, in shape, with *Eisenackitina* sp. C never having the maximum diameter at the basal edge, as observed on *E. bohémica*. *Eisenackitina* sp. C also has a relatively wider aperture (Paris 1981a: p. 155, notes that  $Da/D_{max}$  is 0.46 for *E. bohémica*, while 0.64 for *Eisenackitina* sp. C).

Superficial similarities with *Eisenackitina oviformis* Eisenack are apparent (e.g. Eisenack 1972a, b), but the two can be differentiated by the larger size and coarser ornamentation of *Eisenackitina* sp. C.

**Dimensions.** — Taken from six specimens from sample 11T/176: L — 159–174 (mean 166.6);  $D_{max}$  — 102–122 (mean 115); Da — 59–95 (mean 73.6);  $L/D_{max}$  — 1.4–1.6;  $Da/D_{max}$  — 0.50–0.78.

### *Eisenackitina* sp. D

Figs 5B, 22I, Tab. 4.

**Description.** — This species of *Eisenackitina* has an ovoid, globose vesicle, with distinct flexure and the maximum diameter situated near the aboral margin. The flanks are strongly convex in the lower half of the chamber, but are inclined towards a relatively narrow aperture. The chamber is topped with a wide, gently flared collar. A broadly rounded aboral margin leads to a convex base and the basal callus may be elevated on a protuberance. Surface sculpture is distinctive and consists of fine or coarse curved ridges, infrequently intersecting to give a faint reticulate pattern. The ornamentation is most noticeable on the aboral part of the chamber, and no pattern can be discerned on the collar.

**Dimensions.** — Taken from three specimens from samples 11T/176, 11T/179 and 16T/124: L — 134–145 (mean 140.7);  $D_{max}$  — 92–118 (mean 105); Da — 42–63 (mean 55);  $L/D_{max}$  — 1.2–1.5;  $Da/D_{max}$  — 0.31–0.57.

Tab. 5. Major differences between five species : *Bursachittina (Bursachittina) ngarigo* sp. n., *Bursachittina (Bursachittina) talenti* sp. n., *Bursachittina (Amplichittina) bidawal* sp. n., *Bursachittina (Bursachittina) kurrigo* sp. n. and *Eisenackitina subditiva* sp. n.

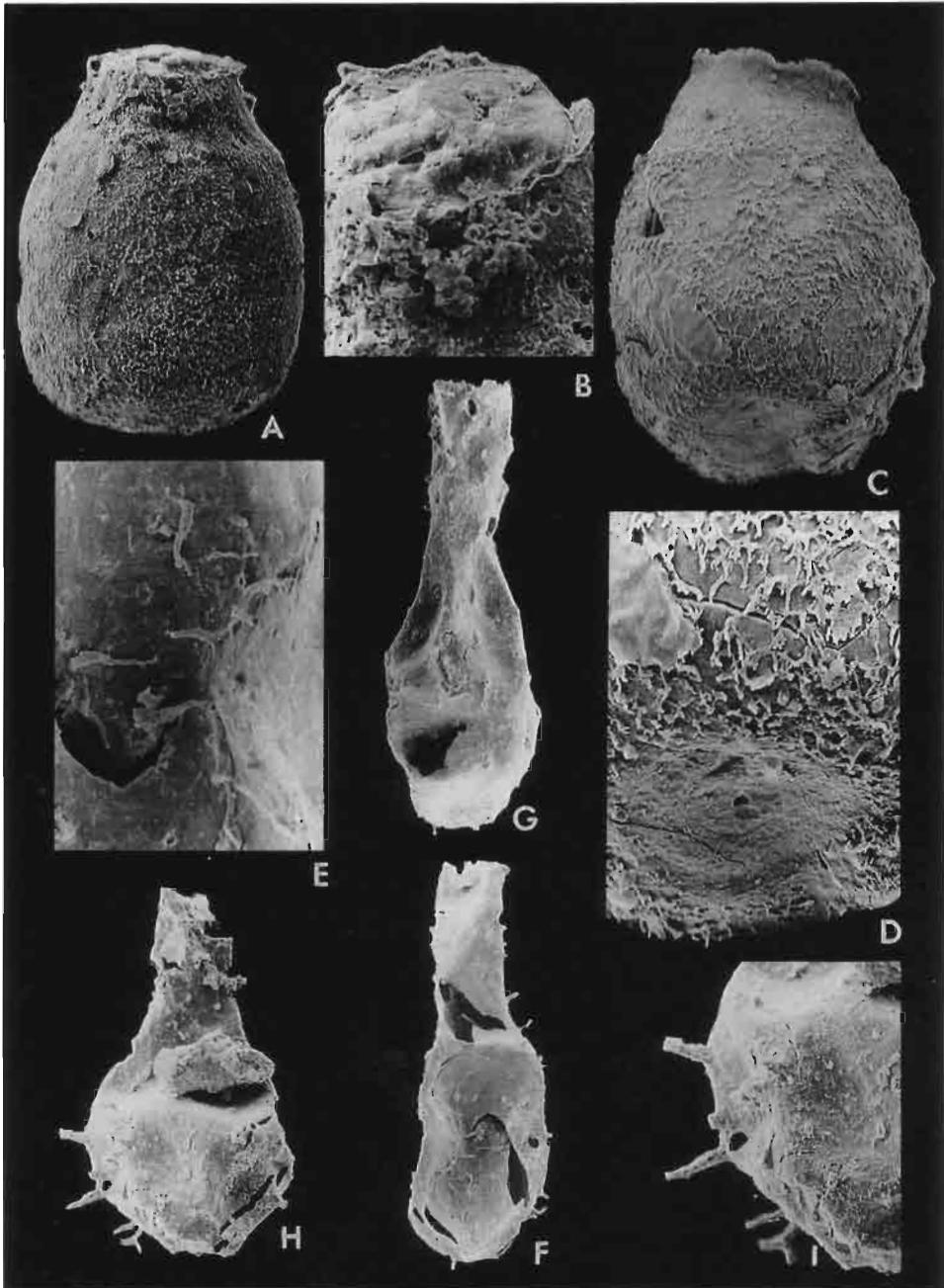
	<i>B. (B.) ngarigo</i>	<i>B. (B.) talenti</i>	<i>B. (A.) bidawal</i>	<i>B. (B.) kurrigo</i>
<i>B. (B.) talenti</i>	Surface of <i>B. (B.) talenti</i> is coarsely granulate and is reticulate in <i>B. (B.) ngarigo</i>  Da/Dmax is 0.47–0.68 in <i>B. (B.) ngarigo</i> and 0.58–0.75 for <i>B. (B.) talenti</i>			
<i>B. (A.) bidawal</i>	Surface is coarsely granulate on <i>B. (A.) bidawal</i> ; reticulate on <i>B. (B.) ngarigo</i>  <i>B. (B.) ngarigo</i> has no flexure or shoulders	<i>B. (B.) talenti</i> is subspherical; <i>B. (A.) bidawal</i> is subcylindrical to subconical  Da/Dmax is 0.58–0.75 for <i>B. (B.) talenti</i> and 0.39–0.63 for <i>B. (A.) bidawal</i>  L/Dmax is 1.0–1.3 for <i>B. (B.) talenti</i> and 1.4–1.6 for <i>B. (A.) bidawal</i>		
<i>B. (B.) kurrigo</i>	Surface of <i>B. (B.) kurrigo</i> has minute cones/spines or verrucae; <i>B. (B.) ngarigo</i> has a reticulate surface	Length of <i>B. (B.) talenti</i> is 136–163 microns; length of <i>B. (B.) kurrigo</i> is 108–146 microns	<i>B. (B.) kurrigo</i> has minute cones and verrucae; <i>B. (A.) bidawal</i> is coarsely granulate  <i>B. (B.) kurrigo</i> has less well developed shoulders  L/Dmax is 1.4–1.6 for <i>B. (A.) bidawal</i> and 1.1–1.2 for <i>B. (B.) kurrigo</i>	
<i>E. subditiva</i>	Surface of <i>E. subditiva</i> has minute spines; this erodes to a reticulate surface, similar to the surface of <i>B. (B.) ngarigo</i>  Basal scar is very prominent on <i>E. subditiva</i> (see Fig. 20A)	Surface of <i>B. (B.) talenti</i> is coarsely granulate, whereas <i>E. subditiva</i> is covered with minute spines  L/Dmax is 1.0–1.3 for <i>B. (B.) talenti</i> and 1.1–1.6 for <i>E. subditiva</i> (see Fig. 20A)	Surface of <i>B. (B.) talenti</i> is coarsely granulate; <i>E. subditiva</i> has minute spines  Shoulders are more developed and occur lower down the vesicle of <i>E. subditiva</i>	Surface of <i>B. (B.) kurrigo</i> has minute cones or simple spines; <i>E. subditiva</i> has simple and bifurcate spines  L/Dmax is 1.1–1.2 for <i>B. (B.) kurrigo</i> and 1.1–1.6 for <i>E. subditiva</i> (see Fig. 20A)

### *Eisenackitina* sp. E

Figs 5B, 24D–E, Tab. 4.

**Description.** — This species has a short, squat vesicle with a truncated conical or ovoid shape. The maximum diameter occurs at the mid point of the chamber and the flanks vary from strongly to weakly convex. Flexure is indistinct and the vesicle is topped with a collar that may flare gently. A broadly rounded basal margin leads to a flat or convex base where the basal callus appears as a wide, shallow pit. The surface is covered with

Fig. 26. □A–D. *Bursachittina (Bursachittina)* sp. A. A–B. Specimen NMV P138614 from sample 15T/144.1; × 300 (A) and enlargement of collar and operculum (B) × 700. C–D. Specimen



P138615 from sample 16T/128;  $\times 300$  (C) and enlarged view of basal callus and ornament (D)  $\times 800$ .  $\square$ E-F. *Gotlandochittina* sp. C, specimen NMV P138616 from sample 8T/50.0;  $\times 300$  (F) and enlargement of mid-chamber wall (E)  $\times 1200$ .  $\square$ G. *Gotlandochittina* sp. B, specimen NMV P138617 from sample BCE 11;  $\times 300$ .  $\square$ H-I. *Gotlandochittina* sp. A, specimen NMV P138618 from sample BCE 11;  $\times 300$  (H) and enlargement of lower chamber wall showing spine-form and linear arrangement (I)  $\times 600$ .

spines conjoined to form an ornament of thickly matted ridges that erodes to form an interlocked polygonal pattern.

**Remarks.** — There is a clear resemblance in shape to between this species and *Bursachitina bursa* (e.g. Eisenack 1972a: pl. 18: 22–23 and Diez & Cramer 1978: figs 44–45). *Eisenackitina* sp. E is, however, much larger and has a distinctive ornament.

**Dimensions.** — Taken from two specimens from samples 15T/144.1 and 15T/146.6: L — 126–138; Dmax — 118–159; Da — 81–95; L/Dmax — 0.9–1.1; Da/Dmax — 0.6–0.7.

### *Eisenackitina* sp. F

Figs 5B, 24G, Tab. 4.

**Description.** — This species is characterised by the elongate, very narrow, subcylindrical vesicle, with a slightly constricted neck area. The maximum diameter occurs in the upper third of the chamber, and the flanks are subparallel from there to the basal edge. There is only a gentle flexure, with marginally inclined flanks towards the aperture, where a small collarete is present. The basal edge is broadly rounded, the base is flat and only slightly indented at the basal callus. Surface ornament is rugate, with small spine-like 'peaks'. The ornamentation diminishes in scale towards the collar.

**Remarks.** — The large size and narrow vesicle separate this species from all others. It is also possible that this represents a teratological form of *E. hebata* sp. n.

**Dimensions.** — Taken from two specimens from sample 16T/124: L — 217–253; Dmax — 88–97; Da — 53–54; L/Dmax — 2.5–2.6; Da/Dmax — 0.55–0.62.

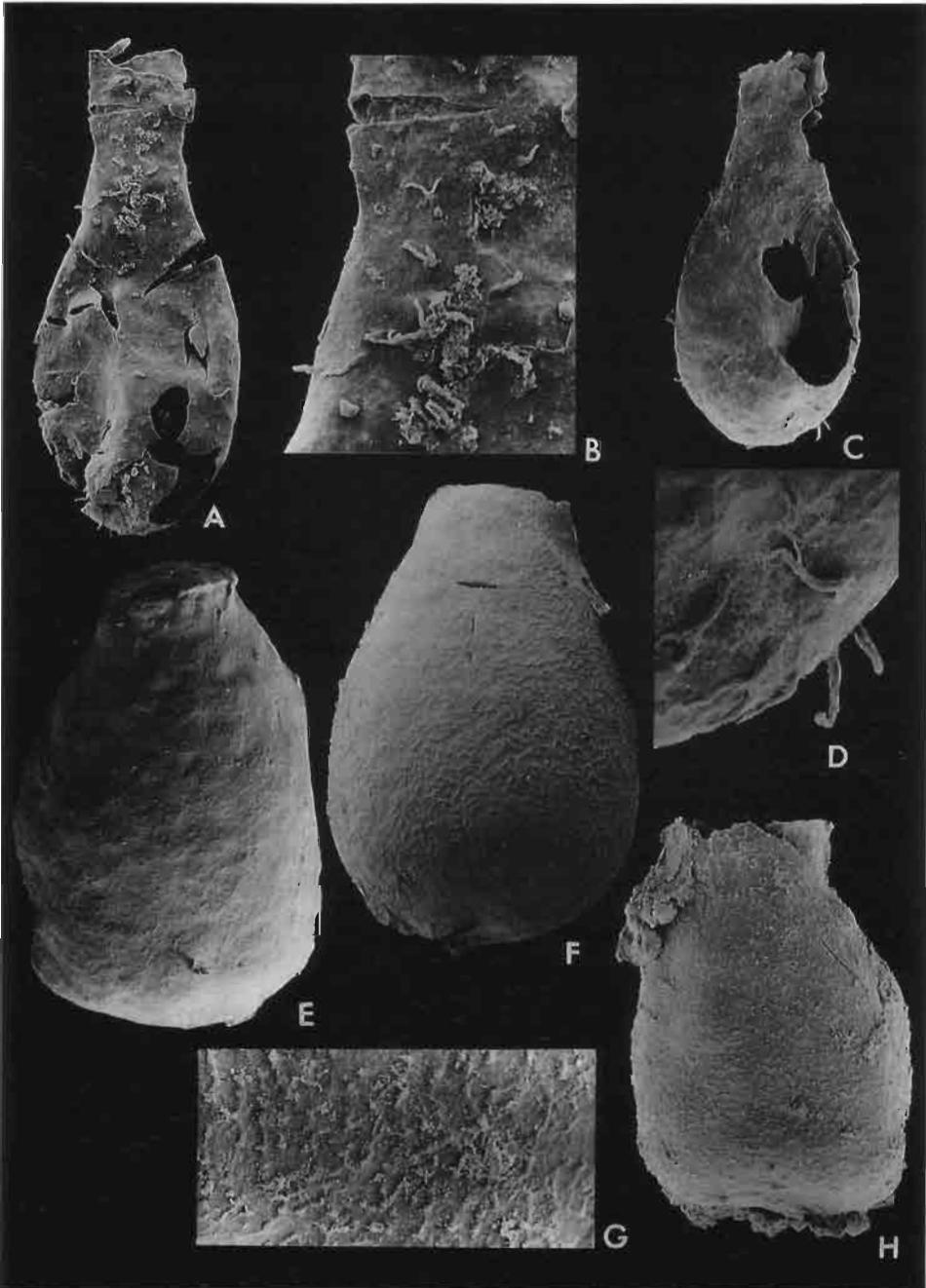
Genus *Fungochitina* Taugourdeau 1966

### *Fungochitina*? sp.

Fig. 24B, F, Tab. 4.

**Description.** — This species is characterised by a subspherical to subconical chamber. Flexure is distinct and the chamber is topped by a short, subconical neck ( $L_n/L = 0.3$ ). A small, flared collar is present. The base is strongly convex, possibly exaggerated by almost total compression of the chamber. Evidence of spinose ornament covering the vesicle can be seen in the broken spine bases. These indicate a fairly dense covering and occasionally, simple isolated spines are observed.

**Remarks.** — This species of *Fungochitina* resembles specimens of *Sphaerochitina schwalbi* Collinson & Scott 1958 (e.g. Grignani 1967: pl. 2: 16). While the size and general proportions overlap with *S. schwalbi* (Collinson & Scott 1958: p. 22), the lack of intact ornament means that it is not possible to verify the relationship between the two species.



specimen NMV P138620 from sample 8T/50.0;  $\times 300$  (C) and enlargement of lower vesicle wall (D)  $\times 1500$ . □E–H. *Elsenackittina? vieta* sp. n. E. Specimen showing asymmetrical distortion NMV P138621 from sample 16T/124;  $\times 300$ . F. Specimen displaying large basal callus NMV P138622 from sample 16T/124,  $\times 300$ . G–H. Holotype NMV P139229 from sample 11T/189.5;  $\times 300$  (H) and enlargement of chamber wall showing ornament (G)  $\times 1200$ .

*Fungochittina?* sp. has been only tentatively placed in this genus as it lacks ornamentation and the chamber shape is difficult to discern.

**Measurements.** — Taken from one of the two available specimens from sample 16T/71.7: L — 114; Ln — 34.5; Lc — 79.5; Dmax — 87; Da — 39; L/Dmax — 1.9; Ln/L — 0.3.

Genus *Gotlandochittina* Laufeld 1974

*Gotlandochittina maretensis* Paris 1981a

Figs 5A, 27C–D, Tab. 2.

?*Angochittina bifurcata* Collinson & Schwalb; Da Costa 1971: p. 224: 14.

?*Gotlandochittina* sp. aff. *marettensis* Paris; Paris 1981b: p. 66, pl. 5: 13.

?*Gotlandochittina maretensis* var. *goliath* Paris; Paris 1981a: p. 265, pl. 36: 1. 2.

**Remarks.** — The size and shape of the vesicle is similar to that described and depicted by Paris (1981a, b), except that the chamber has a more slender, ovoid form and the base is generally more convex than that found in the French group.

The ornament is greatly eroded, with only a few spines preserved and consequently this species has been only tentatively synonymised with *G. maretensis* var. *goliath*. The few spines left intact are predominantly bifurcate and are restricted to middle part of the chamber; no spines have yet been found on the neck on the Australian specimens. Little evidence of a linear arrangement of spines or even of spine-bases has been observed on the individuals from the Taravale Formation but this may be a result of breakage of the vesicle or it may be due to poor preservation of the surface.

**Dimensions.** — Taken from two specimens from sample 8T/50.0: L — 167–187; Lc — 109; Ln — 58–78; Dmax — 75–78; Dn — 30.6; Lsp — 8.5; Ln/L — 0.35–0.42; L/Dmax — 2.1–2.5.

**Occurrence.** — Taravale Formation, Emsian (Fig. 5A, Tab. 2); ?late Emsian Formation des Marettes, France.

*Gotlandochittina* sp. A

Figs 4, 26H–I, Tab. 1.

**Description.** — The single specimen recovered from this sample is poorly preserved, showing considerable erosion of surface detail and partial flattening. The chamber is broadly ovate, with a convex base and no apparent basal edge. Flexure is inconspicuous and the neck is subcylindrical.

Ornamentation consists of robust spines on the chamber and lower part of the neck. The position of the scars from broken spines suggests a strong, linear pattern, thereby placing the species in the genus *Gotlandochittina*. Both simple and bifurcate spines have been observed.

**Remarks.** — *Gotlandochittina* sp. A resembles *Angochittina caeciliae* Paris 1976 in overall shape and in the form of the spines, however, *A. caeciliae* shows no linear arrangement of ornamentation. This species also shows some similarity to *Angochittina kurnai* sp. n., but differs in having bifurcate spines amongst the simple ones and in lacking the hollow 'triangular' appearance of the spines on *A. kurnai*.

**Dimensions.** — Taken from the single specimen available: L — 160; Lc — 88; Ln — 71; Dmax — 62; Dn — 24; Lsp — 17; Ln/L — 0.45; L/Dmax — 2.6; Dmax/Dn — 2.5.

### *Gotlandochitina* sp. B

Figs 4, 26G, Tab. 1.

**Description.** — This species has a relatively large vesicle and a slender, ovoid chamber with maximum diameter at the mid-point of the chamber length. An inconspicuous flexure tapers to a short neck, occupying less than half the length of the vesicle (Ln/L — 0.35–0.42). The neck is relatively narrow, but spreads out towards the aperture, giving a sub-conical appearance to the upper part of the neck. The base is strongly convex.

No ornamentation has been preserved intact, but a number of prominent scars indicate that the spines occurred in rows (8–10 per vesicle) on the chamber and neck. Some scars show evidence of possible double insertion of spines indicating a bipodal form.

**Dimensions.** — Taken from two of the three available specimens from samples BCE 11 and BCE-5.5: L — 211–215; Lc — 125–138; Ln — 73–90; Dmax — 73 (both); Dn — 34 (both); Ln/L — 0.35–0.42; L/Dmax — 2.9 (both).

### *Gotlandochitina* sp. C

Figs 5A, 26E–F, Tab. 2.

**Description.** — All individuals of this species are distorted somewhat by compression of the vesicle. In general the chamber has a slender, ovoid shape, with a gentle flexure and inconspicuous shoulders. The neck is cylindrical to sub-cylindrical and occupies between a quarter to less than half the total length of the vesicle (i.e. Ln/L — 0.23–0.39). A thin collar flaring slightly at the aperture, can be found on some specimens and it may display a crenulate edge.

Fine spines of a medium-length are dispersed over the chamber and neck, but do not occur on the collar. These spines are dominantly simple, but some are bifurcate near the distal end. Many of the spines are curved or may be bent close to the end. Ornamentation is best preserved where the vesicle is 'indented', thus offering some protection and it is difficult to determine the pattern of spine dissemination. The scars left by broken spines and the few spines remaining intact suggest that they occurred in rows, thus the group has been placed in the genus *Gotlandochitina*.

**Remarks.** — Eisenack (1968) figures some examples of the Silurian species *Angochitina densebarbata* Eisenack 1968 that resemble specimens of *Gotlandochitina* sp. C (e.g. Eisenack 1968: pl. 28: 33). The range of size, shape and spine-form of the two species overlap. However, the spines of *Gotlandochitina* sp. C differ in being shorter, finer and in not displaying the entangled distal ends described by Eisenack (1968: p. 178). There is also no evidence of a linear arrangement of spines on *A. densebarbata*.

**Dimensions.** — Taken from two specimens from sample 8T/50: L — 125–173; Lc — 96–105; Ln — 29–68; Dmax — 49–58; Dn — 21–31; Lsp — 7–10; Ln/L — 0.23–0.39; L/Dmax — 2.5–3.0.

### *Gotlandochitina* sp. D

Figs 5A, 27A–B.

**Description.** — *Gotlandochitina* sp. D has a large, cylindro-ovoid vesicle. The slender, ellipsoid chamber leads gently to a sub-cylindrical neck, with an indistinct flexure and sloping, inconspicuous shoulders. Maximum diameter occurs near the mid-length of the chamber. A collar with a crenulate edge may be present. The base is generally strongly convex but may become slightly flattened with compression of the vesicle.

Ornamentation consists of fine, short spines arranged in rows parallel to the axis of symmetry. The spines are relatively sparsely distributed ( $3\text{--}4/100\ \mu\text{m}^2$ ) over the vesicle, becoming shorter on the neck. Simple, bifurcate or multifurcate spines occur, with up to two branchings being visible. Branching may occur on a short stem similar to a candelabra, or, more commonly, from the base in an antler-like fashion.

**Remarks.** — *Gotlandochitina* sp. D resembles *Gotlandochitina maretensis* var. *goliath* Paris 1981 in having a large size and fits into the range of shapes depicted by Paris (1981a, b). The main differences are the much shorter spine-length, the presence of multifurcate spines and the proportionally shorter neck of *Gotlandochitina* sp. D (i.e. for *Gotlandochitina maretensis* var. *goliath* Ln/L is 0.38–0.55, while for *Gotlandochitina* sp. D Ln/L is 0.25–0.38). Some specimens of *Gotlandochitina kutjala* Winchester-Seeto 1993 are also similar; *Gotlandochitina* sp. D, can distinguished by the relatively shorter neck and the presence of maximum diameter at approximately the midpoint of the chamber length, rather than lower on the vesicle. The presence of antler-like bifurcate and multifurcate spines on *Gotlandochitina* sp. D also serves to differentiate the two.

This is most probably a new species, however the small number of specimens and the poor preservation leaving no individual with shape or ornamentation intact makes a new species assignment risky.

**Dimensions.** — Taken from four specimens from samples 9T/166 and 9T/213.8: L — 163–196 (mean 180.5); Lc — 111–129 (mean 122.1); Ln — 41–70 (mean 58.4); Dmax — 57–77 (47.9) (note: all vesicles are distorted); Dn — 34–37 (mean 36.5); Lsp — 5–8 (mean 6); Ln/L — 0.25–0.38; L/Dmax — 2.3–2.9.

## Conclusions

(1) Seven chitinozoan assemblages have been recovered from the Taravale Formation. On a local basis, the assemblages are stratigraphically useful as they sub-divide the sections into quite small time units.

(2) With conodont studies giving a firm biostratigraphic basis, it is clear that chitinozoans can give a finer division of time than has previously been possible.

(3) Comparison with contemporaneous studies from other continents shows the Taravale fauna to be unique. Unfortunately this prevents inter-continental correlation until further studies can be carried out.

(4) The reasons for the novel composition of the fauna may be due to provincialism of Australian chitinozoans of this time-interval, reflecting the high degree of endemism of many other fossil groups, or the Taravale fauna may be the reflect a facies control on the distribution of chitinozoans.

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