SECTION A

Albian and Cenomanian belemnites of the Family *Dimitobelidae* from Australia
Section A. Albian and Cenomanian Dimitobelidae from Australia

A. 1 Abstract

Representatives of the Family *Dimitobelidae* (Mollusca:Cephalopoda) are abundantly represented in Australian Early Cretaceous shallow marine strata, especially those related to the epeiric sedimentary record of the Great Artesian Basin. The taxonomy, biostratigraphy and distribution of Albian and Cenomanian Australian representatives of the family are revised, utilising all known collections. The genus *Dimitobelus* Whitehouse (early Albian - mid Cenomanian) occurs in both the Great Artesian Basin of eastern Australia and the Carnarvon Basin of Western Australia. This genus embraces six named species: *D. diptychus* (McCoy) (earliest Albian - mid Cenomanian), *D. stimulus* Whitehouse (Albian), *D. dayi* Doyle (earliest Albian – early late Albian), *D. liversidgei* Etheridge (late Albian), *D. plautius* sp. nov (early Albian) and *D. hendersoni* sp. nov. (late Albian). A new genus, *Microbelus*, is represented by *M. haigi* sp. nov. and *M. tumidus* sp. nov. which are endemic to the Cenomanian upper Gearle Siltstone, Carnarvon Basin, Western Australia.

A. 2 Introduction

*Dimitobelus* is the characteristic genus of the Dimitobelidae, a distinctive group of Southern Hemisphere Cretaceous belemnites first recognised by Whitehouse (1924) and now known to be latitudinally restricted to the Austral Realm (Stevens, 1973; Doyle, 1988). The family is characterised by a cylindrical or clavate guard with anteriorly placed ventro-lateral grooves, and lacking ventral and apical grooves. Whitehouse originally separated four component genera, *Peratobelus*, *Dimitobelus*, *Tetrabelus* and *Cheriobelus*. *Dimitobelus* guards are characteristically depressed with dorsally curving ventro-lateral grooves.

The first representatives of *Dimitobelus* appeared in the earliest Albian within Australia and the genus enjoyed a wide distribution in Albian time (Australia, New Zealand, New Guinea, Antarctic Peninsula, Argentina and probably the Falkland Plateau). A similar distribution pattern occurred in the Cenomanian (Western Australia, New Zealand, ? New Guinea and the Antarctic Peninsula). However in the Late Cretaceous the genus became restricted to a southern polar distribution with records only from the Antarctic Peninsula (Campanian) and New Zealand (Santonian-Maastrichtian).
Six nominal species of *Dimitobelus* have been recorded from Australia. Most representatives of the genus have been documented from Albian formations of the Eromanga Basin, a very extensive epeiric sedimentary system developed in eastern Australia (Figure A. 2.1)(Exon and Senior, 1976; Senior et al., 1978). *Dimitobelus* is also known from the Albian strata from the subjacent Carpentaria, Laura, Maryborough and Surat Basins. The genus is extensively represented in the Carnarvon Basin in Western Australia where it ranges through the Albian into the Cenomanian.

This paper revises the Australian species of *Dimitobelus*, drawing on extensive collections now available. In the course of the study, a new genus, *Microbelus*, has been recognised from Cenomanian strata from the Western Australian Carnarvon Basin. This genus was probably more widely ranging in the Australian region. However, marine Cenomanian strata are lacking in eastern Australia due to widespread withdrawal of epicontinental seas at this time (Figure A. 2.2).
Figure A. 2. Emergent areas (unshaded) and the extent of marine flooding (shaded) of Australia during the Albian (A) and Cenomanian (B) (after Frakes et al., 1987).

A. 3 Collections and localities

The specimen suite evaluated here is held by a number of repositories, as follows: SAM, South Australian Museum, Adelaide; GSSA, Geological Survey of South Australia; UA, University of Adelaide; NMV, Museum of Victoria; QGS, Queensland Geological Survey; UQ, University of Queensland; QM, Queensland Museum; JCU, James Cook University; AM, Department of Palaeontology, Australian Museum; US, University of Sydney; CPCC, Commonwealth Palaeontological Collections Canberra; WAM, Western Australian Museum; UWA, University of Western Australia; GSWA, Geological Survey of Western Australia; HM, Hunterian Museum, Department of Geology, University of Glasgow; BM, British Museum (Natural History), London. Locality numbers, prefixed ‘L’ refers to specific sites registered by these repositories. Modern collections are in general accurately located. However, locality records for older collections are commonly imprecise. Where possible these have been assigned approximate geographic coordinates.

In addition to the extensive collection of belemnites held by museums and other repositories, new field collections from the northern Eromanga Basin and
material from newly obtained drill core from the Carnarvon Basin have been included in the study. All collections have been placed within the lithostratigraphic framework of the basins to which they relate utilising published geological maps, generally at 1:250,000 scale. This in turn has provided the superpositional basis for biostratigraphic evaluation.

For the Carnarvon Basin, a suite of stratigraphic wells drilled in the last decade by the Geological Survey of Western Australia (GSWA) and collaborators has provided an especially useful suite of collections for which superpositional relationships are well established.

A. 3. 1 Morphological terminology and measurements

Guard terminology is based on the contributions of Swinnerton (1955), Glaessner (1945), Day (1968), Stevens (1965) and Challinor (1990). The apical region is that portion of the axis posterior to the position of maximum inflation; the stem region is that portion of the guard between the axis of maximum transverse inflation and the position of the protoconch; the alveolar region is that portion of the guard anterior to the protoconch.

The following order has been generally adopted in the systematic descriptions of belemnite guards:

1) General remarks: (i) size and shape of guard, (ii) ratio of length to maximum transverse diameter.
2) Outline of guard: (i) position of maximum transverse diameter (Dl\text{max}), (ii) outline shape posterior to Dl\text{max} including nature of apex and apical angle, (iii) outline shape anterior to Dl\text{max}.
3) Profile of guard shape including the position of the maximum dorso-ventral diameter (Dv\text{max}).
4) Cross-sectional shape of apical, stem and alveolar regions.
5) Grooves on surface of guard (if present).
6) Lateral lines on surface of guard (if present).
7) Internal structures: (i) apical line, (ii) alveolar angle, (iii) protoconch, (iv) phragmocone (if preserved).

The term ‘guard’ is used in preference to the term ‘rostrum’, which is favoured by European workers.

A. 3. 1. 1 Outline

The outline of the guard is its form as seen in dorsal or ventral view and is symmetrical in all known representatives of the Dimitobelidae. The outline may reflect hastate (spear-like), clavate (club-like), cylindrical or conical guard shapes and is considered an important taxonomic feature. In hastate guards, the position of maximum transverse inflation (Dlmax) is readily determined. It is clear on the guards of some taxa (e.g. *D. liversidgei*), whereas for others it is ill-defined and cannot be exactly located. In such cases Dlmax has been located at the most proximal apical site possible.

Posterior to Dlmax guard outlines may converge very gradually, defining an elongate, pointed apical region, or converge rapidly to produce a shortened, blunt apical region (see Swinnerton, 1955)(Figure A. 3. 1). Shape of the apical region commonly characterises individual species. In *Dimitobelus* the outline of the apical region is short and abrupt and either pointed or very obtuse to rounded, and in species with an apical canal an apical perforation is present (e.g. in *D. dayi*).

In hastate outlines, the sides of the guard converge anteriorly from Dlmax to the axis of minimum transverse diameter (Dlmin), which maybe located some distance anterior of the position of the protoconch. Anterior to this the sides diverge to accommodate the phragmocone. In *Dimitobelus*, the sides of the guard may at first converge quite rapidly anterior to Dlmax, producing a marked feature of the outline, but thereafter converge gradually.

In cylindrical guards, except for the apical region which is typically short, the sides are approximately parallel throughout the length of the guard, but usually diverge some distance anterior to the protoconch to accommodate the phragmocone. In conical guards the sides diverge throughout the length of the guard.
The degree of hastation may change during ontogeny. For instance, *D. diptychus* is usually more hastate in later growth stages.

Figure A. 3. 1 Outline of apical region of belemnite guards (a) very acute and constricted (attenuated); (b) very acute; (c) acute; (d) moderately obtuse and constricted; (e) moderately obtuse; (f) very obtuse and rounded (after Swinnerton, 1955, Text Fig. 3, Stevens, 1965, fig. 14).

A. 3. 1. 2 Profile

The profile is shown in lateral views of the guard. In most species of *Dimitobelus* it is symmetrical or almost so and similar in shape to the outline, but is typically less hastate. In some species (e.g. *D. diptychus*), where the outline is clearly hastate, the profile is less so or not at all. The apex is eccentric in guards with an asymmetric profile and positioned dorsally with the line of the ventral surface is more distinctly curved than the line of the dorsal surface.

A. 3. 1. 3 Cross-section

The shape of the cross-sections provide a valuable specific characters, in addition to measurement of cross sectional dimensions. It varies from rounded to semi-elliptical and typically changes along the guard length.

A. 3. 1. 4 Surface grooves

Only ventro-lateral grooves and dorso-lateral grooves are present in *Dimitobelus*, and they are best developed in the anterior portion of the stem region becoming less clearly inscribed towards the apex. The detail of their morphology is useful in discriminating between species. In the alveolar region the ventro-lateral grooves are typically straight, narrow, and deeply incised, running approximately...
parallel to venter. At about the position of the protoconch they curve sharply towards the mid-line of the flanks of the guard. The curved posterior portion of the ventro-lateral grooves in *Dimitobelus* connects with the anterior termination of the lateral lines. Though the actual junction of the groove with the lateral lines has been observed in few specimens it appears that the ventro-lateral line is essentially a continuation of the ventro-lateral groove. These two features either relate to the same structure, or to colinear and adjoining structures in the soft-part organization of *Dimitobelus*. A dorso-lateral groove may also be present in *Dimitobelus*, and may be colinear to a dorso-lateral line, mirroring relationships between the ventro-lateral groove and line. The two sets of grooves and lines are not symmetrical about the flank mid-line of the guard, but are dorsally offset. The dorso-lateral grooves follow a similar course to that of the ventro-lateral grooves, but their curvature is slight and they essentially continue the trend of the lateral lines, but may show a slight dorsal deflection towards the anterior. In most *Dimitobelus* species, the dorso-lateral grooves are obscure where only a faint dorso-lateral depression marks the groove position.

Whitehouse (1924) placed great emphasis on the relationships of lateral grooves to the lateral lines in the Dimitobelidae, and the issue of whether the grooves are independent of, or connected to, the lateral lines. Stevens (1965) considered that the lateral lines are dependent on the placement and depth of the lateral grooves, and their apparent independence merely reflected abrasional removal of the connecting portion of the lateral lines. The ventro-lateral grooves are usually well developed in *Dimitobelus*. Stevens (1965) considered that they mark the sites of prominent blood vessels.

A. 3. 1. 5 Lateral lines

Lateral lines are present on the flanks of many belemnite guards and may represent the course of longitudinal blood vessels in contact with the guard surface or the line of termination against the guard of the lateral structures such as fins. In his review of these features, Stevens (1965) suggested that if they represented the course of blood vessels, other vascular markings may be expected to occur as frequently as lateral lines, but they only occur in one family, the Belemnitellidae.
Lateral lines are present on the flanks of most species of *Dimitobelus*, though commonly they have been removed from individual specimens by corrosion. Stolley (1911) used the term 'Laterallinien' for lateral grooves and 'Doppellinien' for lateral lines. However in this study the term 'lateral lines' is used for Stolley's 'Doppellinien' and Swinnerton's 'lateral grooves'. The term 'lateral grooves' is restricted to true grooves as represented in the Dimitobelidae.

The paired lateral lines of *Dimitobelus* are a distinguishing feature for this southern hemisphere genus. Only single lateral lines are evident in northern hemisphere Early Cretaceous belemnites such as *Belemnitella* and *Actinocamax*, and such features are noticeably absent from others such as *Belemnelloclamax* (Christensen, 1997a). The depth of incision of the lateral lines appears to vary between species being deeply incised in *D. diptychus* (McCoy), and less so in *D. liversidget* (Etheridge). The paired lateral lines are commonly well preserved in the apical region, becoming indistinct in the stem and alveolar regions.

When well-preserved in *Dimitobelus* the lateral lines appear on the dorso-lateral surface of the posterior apex, and continue anteriorly along a slightly dorso-lateral or central course across the anterior apical and stem regions. In the anterior portion of the stem region, the lateral lines link with the ventro-lateral grooves and the dorso-lateral grooves (or depressions). The lateral lines are paired and remain together along all sections of the guard.

A. 3. 1. 6 Internal structures

The apical line is the central axis of the guard to which the calcite prisms of which it is constructed converge and marks successive positions of the apex during growth. In *Dimitobelus* the apical line is always markedly eccentric and ventrally placed. In some species such as *D. diptychus* and *D. dayi* an apical canal follows the course of the apical line and communicates to the exterior via an apical perforation.

The alveolar region of guards contains a conical hollow, the alveolus. The alveolar angle is the angle subtended by the alveolar walls as measured in the dorso-ventral plane. For *Dimitobelus* this angle is commonly within a range of 25°-27°.
The protoconch and phragmocone are rarely preserved in *Dimitobelus* but when present the protoconch is usually central or slightly ventral in position. The phragmocone is typically displaced a little towards the dorsum.

A pseudoalveolus (Stolley, 1911), a structure resulting from an enlargement of the alveolus by exfoliation of the alveolar walls, is commonly developed in *Dimitobelus* but is variably developed, or entirely lacking, in specimens representing individual species. It is developed where the anterior fringes of the growth lamellae abutting the alveolus are feebly crystalline. The development of a pseudoalveolus is usually accompanied by the development of an axial projection (‘Nadelspitze’ of Stolley, 1911, p. 186; Whitehouse, 1924, p. 413, 1925, pl. 2, figs. 8, 10, 11c), a needle-like spine that projects into the pseudoalveolus. Stolley (1911) regarded this structure as being the anterior extremity of the embryonic guard projecting into the pseudoalveolus, but Whitehouse (1924) considered that its development was unrelated to ontogeny of the guard. Stevens (1965) adapted Stolley’s interpretation, envisaging the protoconch, and the apex of the alveolus, as being immediately anterior to the tip of the axial projection prior to the development of the pseudoalveolus.

Detailed studies of internal structures of the belemnite guard and the phragmocone of Boreal belemnites are due to Christensen (1925) and Hanai (1953). Though the shape of the guard is related to internal parameters such as the distance from the apex to the protoconch and the depth of the alveolus, the detail of internal structures of the guard have little taxonomic value. In northern hemisphere belemnites, such as *Belemnitella, Belemnella* and *Actinocamax*, the ‘Schatsky index’, reflecting the distance between the protoconch and the beginning of the ventral fissure on the wall of the alveolar cavity, is important (Birkelund, 1957; Stevens, 1965). But for the belemnites in this study, the ventral groove, when present, is strictly a surface feature of the guard and not related to the development of a fissure connecting to the alveolus.
A. 3. 2 Dimensions

Measured dimensions (in millimetres) adopted for this study follow Avias (1953) and Stevens (1965) (Figure A. 3. 2) as follows:

L - total preserved length, i.e. from apex to the point where the sides of the guard intersect the sides of the phragmocone. Descriptive size terms related to length (L) are as follows: diminutive (< 10 mm), small (10-40 mm), medium (40-70 mm), and large (> 70 mm).

X - length from the apex to the Dl\textsubscript{max}, position of maximum inflation shown in outline.

Dv\textsubscript{max} - dorsoventral diameter at position of maximum inflation

Dl\textsubscript{max} - lateral diameter at position of maximum inflation.

Terms and ratios used to describe the shape of the transverse section of the guard are:

- Rounded - Dl\textsubscript{max}:Dv\textsubscript{max} = 1
- Elliptical - Dl\textsubscript{max}:Dv\textsubscript{max} = 1.1-1.2
- Semi elliptical - flattened on the ventral surface. Dl\textsubscript{max}:Dv\textsubscript{max} = 1.3-1.4
- Depressed - flattened on both dorsal and ventral surfaces, subquadrate; Dl\textsubscript{max}:Dv\textsubscript{max} ≥ 1.4

The value of the ratios varies from genus to genus, especially between hastate and non-hastate forms. Although the wide range of variability within belemnite species limits the usefulness of these ratios, they do provide a useful basis for comparison between species. With few exceptions, Australian Cretaceous belemnite guards are in general only partially preserved and complete specimens, from which the full range of measurements can be obtained, are uncommon. Suites of measurements that adequately define the range of variation are rarely obtained.
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Figure A. 3. 2 Outline (left) and profile (right) of a belemnite guard to illustrate symbols used for measurements (modified from Stevens, 1965).

A. 3. 3 Illustrations

The diagrams of cross-sections were prepared by tracing the outline and internal structures showing in polished thin sections. This gives an accurate representation of width and the number of internal growth bands as well as presence (depth and location) of grooves and lines.

Specimens illustrated in the plates were coated with ammonium chloride sublimate prior to photography.
A. 4 Systematic Descriptions

Class CEPHALOPODA Cuvier, 1795
Subclass COLEOIDEA Bather, 1888
Order BELEMNITIDA Zittel, 1895
Suborder BELEMNOPSEINA Jeletzky, 1965
Family Dimitobelidae Whitehouse, 1924

**Diagnosis:** Cylindrical and clavate guards bearing a pair of ventro-lateral grooves at least on the anterior portion of the guard, in the alveolar region. Devoid of apical grooves; unpaired ventral or dorsal alveolar grooves are never present.

**Discussion:** The Family Dimitobelidae comprised of the genera *Peratobelus* Whitehouse, *Dimitobelus* Whitehouse, and *Tetrabelus* Whitehouse (=*Cheriobelus* Whitehouse) was established by Whitehouse (1924) for a group of Cretaceous belemnites from eastern Australia. It represents a distinctive Cretaceous belemnite clade characteristic of mid to high Southern Hemisphere latitudes where its members are diagnostic of the marine Austral Realm that developed in the Early Cretaceous Period and continued through to the end of the Cretaceous extinction event. The Dimitobelidae are likely to have evolved from a southern outlier of a more northern belemnite group in the late Early Cretaceous, perhaps the Tethyan *Hibolithes*, as this genus is characterised by well developed lateral lines and a commonly reduced single ventral alveolar groove (Doyle, 1987a).

This study has also recognised a new diminutive genus *Microbelus* referred to the Dimitobelidae and represented by two new species, *M. haighi* and *M. tumidus*. 
Genus *Dimitobelus* Whitehouse, 1924

*Dimitobelus* Whitehouse, 1924, p. 412.

*Cheriobelus* Whitehouse, 1924, p. 414.

**Type Species:** by original designation. Objective synonym *Belenmites canhami* Tate 1880 (= *Belenmitella diptycha* McCoy 1867a; see Glaessner, 1957, p. 88); Albian, Great Artesian Basin.

**Diagnosis:** Guards hastate in outline, less so or cylindriconal in profile. Ventrolateral grooves clearly inscribed are confined to the alveolar region and anterior portion of the stem region. Dorso-lateral grooves lacking or rudimentary, forming weak, obscure depressions or lines. Ventro-lateral grooves are straight in the alveolar region and lie sub-parallel to the venter, but posteriorly towards the stem region they curve towards the mid-line of the flanks and progressively weakening. Lateral lines paired, always present in apical and stem regions, centrally placed, becoming deflected dorsally near the apex.

**Description:** Diminutive to large, slender to robust guards, subhastate to hastate in outline and commonly markedly depressed in cross section. Profile subhastate to cylindriconal, asymmetrical or symmetrical. Ventral surface is commonly flattened. Transverse sections elliptical to subcircular in stem and apical regions, typically subquadrate in alveolar region. Paired, short ventro-lateral grooves are well developed; dorso-lateral grooves lacking or forming indistinct depressions or lines. Grooves are confined to the alveolar region and anterior portion of the stem region. Ventro-lateral grooves are initially straight and extend along one quarter to one third of the guard. They become weaker posteriorly where they deflect dorsally, curving towards the mid-line of the flanks to meet the lateral lines. Dorsal-lateral grooves, where developed, follow a similar course but curve more gently towards the mid-flank region. In stem and apical regions, lateral lines are generally well developed and centrally placed, becoming gently deflected dorso-laterally towards the apex. The phragmocone is slightly offset dorsally and has a ventrally incurved protoconch; it penetrates a quarter to a third of the guard. Apical line is excentric, offset slightly towards the ventral surface.
Range: Albian-Cenomanian of Australia, Antarctica, New Zealand and New Guinea.

Discussion: Originally described by Whitehouse (1924), *Dimitobelus* was established to encompass all “clavate (hastate) belemnites with dorso-lateral (ventro-lateral) grooves and lateral lines, both of which may be straight or somewhat curved. The alveolus is normal, but generally a pseudoalveolus with axial projection is developed. A ventro-lateral (dorso-lateral) groove may be formed by the furcation of the lateral lines, but it becomes isolated.”

The nature and position of the ventro-lateral grooves is definitive for *Dimitobelus*. Whitehouse followed Tate (1880, p.104) and Etheridge (1902a, p. 45-47) in assigning the strongly developed grooves in *Dimitobelus* and *Cheriobelus* as dorso-lateral in position. This was questioned by Glaessner (1957; 1958) who regarded the dominant grooves in *Dimitobelus* as ventro-lateral in position, a view that has been followed by all subsequent authors and is adopted here.

Woods (1917) interpreted the dominant grooves in the New Zealand species *B. superstes* Hector and *B. lindsayi* Hector (designated by Whitehouse as the type species of *Cheriobelus*) as ventro-lateral. Although the phragmocone is rarely preserved in *Dimitobelus* (or *Cheriobelus*), due to development of a pseudoalveolus, it has been described *in situ* for both *Dimitobelus superstes* and *Dimitobelus lindsayi* by Stevens (1965) where the position of the siphuncle clearly indicates the orientation of the guard and confirms the ventro-lateral position for the dominant pair of grooves.

Whitehouse (1924) placed great taxonomic importance upon the relationships of the grooves to the lateral lines. For *Dimitobelus* he considered that the ‘dorso-lateral’ grooves and the ‘ventro-lateral’ grooves (if developed) connected with the lateral lines. According to Whitehouse, in *Cheriobelus*, lateral lines are lacking and the ‘dorso-lateral’ grooves and rudimentary dorso-lateral grooves, if present, are independent whereas for *Tetrabelus* Whitehouse he considered the lateral lines as derived from the dorso-lateral grooves and the ventro-lateral groove as independent.

*Cheriobelus* was originally characterised as having a clavate guard, with dorso-lateral grooves that do not continue as lateral lines. However the genus has been placed as a synonym of *Dimitobelus* by several authors (Glaessner, 1957; Stevens, 1965; Doyle, 1987a) because specimens of the type species of both genera (*B. canhami* Tate...
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and B. lindsayi Hector) typically show a confluence of ventro-lateral grooves with the lateral lines.

There has been some confusion in the separation of Tetrabelus and Dimitobelus. Tetrabelus was originally erected by Whitehouse (1924), with the Indian Belemnites seclusus Blanford (1861) as the type species, to encompass “clavate (hastate) belemnites provided with dorso-lateral lines, but having, in addition, independent ventro-lateral grooves”. The taxon was grouped with, but considered as subgenetically distinct from Dimitobelus sensu stricto by Glaessner (1958) and Stevens (1965). However, Doyle (1985) retained it as of full generic status, based on its compressed transverse section and ventrally curving grooves whereas Dimitobelus has a depressed section and dorsally curving grooves.

Although Whitehouse (1924) recorded Tetrabelus as occurring in Australia, this has proven to be incorrect. The specimen described by Gürich (1901, pl. 29, figs. 2, 3) from White Cliffs, N. S. W. as Belemnites kleini and referred to Tetrabelus by Whitehouse has a subcircular section and long ventro-lateral grooves and represents Peratobelus. The specimen figured by Etheridge (1902b, pl. 9, figs. 3, 4) also referred to as Tetrabelus by Whitehouse (1924) has a depressed guard typical of Dimitobelus. Tetrabelus macgregori Glaessner (1945) originally described from New Guinea and also recorded from New Zealand by Stevens (1965) is considered here as a synonym of Dimitobelus diptychus.

Peratobelus Whitehouse is allied to Dimitobelus Whitehouse, but distinguished by the presence of long, straight, ventro-lateral grooves. Dimitobelus guards are typically more hastate and show lateral lines and a pseudoalveolus, features not shown by Peratobelus.

Skwarko (1966) described Dimitobelus (?) youngensis from the Mullaman Beds of the Northern Territory but these are now assigned a pre-Albian age (Henderson, 1998a) and this species is probably a synonym of Aptian Peratobelus bauhinianus (Skwarko, 1966, see Section B).

Within Australia, Dimitobelus has previously been described only from Albian strata, but the range extends into the Cenomanian. Other ranges of Dimitobelus are
noted as Albian – Campanian in Antarctica (Doyle, 1987a), Albian – Maastrichtian in New Zealand (Stevens, 1965), and Albian – Cenomanian? of the New Guinea Papuan Basin, contiguous with Carpenteria Basin (Glaessner, 1945; 1958). Four previously described species of *Dimitobelus* are recognised in this study: *Dimitobelus diptychus* (McCoy, 1867a), *Dimitobelus stimulus* (Whitehouse, 1925), *Dimitobelus liversidgei* (Etheridge, 1892) and *Dimitobelus dayi* (Doyle, 1987a), as well a two new species *Dimitobelus hendersoni* and *Dimitobelus plautus* and two unnamed taxa *Dimitobelus* sp. nov. ? 1 and sp. nov. ? 2.

*Dimitobelus diptychus* McCoy

Pl. 1, figs. 1-13

**Synonymy:**

1867a  *Belemnitella diptycha* McCoy, p. 356.
1867b  *Belemnitella diptycha* McCoy, p. 42.
1867c  *Belemnitella diptycha* McCoy, p. 196.
1870  *Belemnites australis* Phillips in Moore, p. 258, pl. 16, figs. 3 and 4 only.
1880  *Belemnites canhami* Tate, p. 104, pl. 4, figs. 2a-c.
1889  *Belemnites canhami* Tate; Tate, p. 230.
1892  *Belemnites canhami* Tate; Etheridge in Jack and Etheridge, p. 490, pl. 35, figs. 3-5, 7-9, 12-14.
1902a  *Belemnites canhami* Tate; Etheridge, p. 49.
1902a  *Belemnites eremos* Tate; Etheridge, p. 51, pl. 7, figs. 18-21.
1902b  *Belemnites canhami* Tate; Etheridge, p. 45, pl. 8, figs. 8-9; pl. 9, fig. 2.
1902b  *Belemnites* sp.; Etheridge, p. 46, pl. 9, figs. 3-4.
1902  *Belemnites canhami* Tate; Etheridge and Dun, p. 80.
1902  *Belemnites eremos* Tate; Etheridge and Dun, p. 81.
1924  *Dimitobelus canhami* (Tate); Whitehouse, p. 412, figs. 2, 3, 7.
1925  *Dimitobelus canhami* (Tate); Whitehouse, p. 35, pl. 2, figs. 1-7, 9-11.
1957  *Dimitobelus diptychus* (McCoy); Glaessner, p. 88.
1958  *Dimitobelus macgregori* Glaessner, p.219, fig. 5.
1959  *Dimitobelus diptychus* (McCoy); Dorman and Gill, p. 91, pl. 8, figs. 1-2.
1965  
*Dimitobelus macgregori* (Glaessner); Stevens, p. 121, 135, pl. 21, figs. 10-12; pl. 24, figs. 1-3.

1965  
*Dimitobelus diptychus* (McCoy); Day, p. 419.

1966  
*Dimitobelus diptychus* (McCoy); Ludbrook, p. 191, pl. 27, figs. 1-11.

1968  
*Dimitobelus diptychus* (McCoy); Hill et al., p. k.7, pl. KII, figs. 14 a-c.

1969  
*Dimitobelus diptychus* (McCoy); Day, p. 145, 148.

**Types:** Lectotype NMV P2177, Allaruu Formation (Albian), collected by J. Sutherland and D. Carson from west bank of Flinders River at the base of Walker’s Table Mountain, Queensland, 20°56’S, 144°13’E, and described by McCoy (McCoy, 1867a, p.356). This specimen was designated the holotype by Doyle (1987a) but is one of four specimens assigned to this species by McCoy.

Remainder of type series: NMV P2178-80, Base of Walker’s Table Mountain, west bank of Flinders River, Allaruu Formation, Qld 20°56’S, 144°13’E.

**Additional Material:** Approximately 260 specimens.

**Eromanga Basin, Queensland:** SAM P31592, 20 km north of Hughenden, Doncaster Member, 20°38’S, 144°13’E; NMV P 310419-24, 5 miles SE of Roma, Doncaster Member, c.26°36’S, 148°51’E; QGS L1512, Tambo, Doncaster Member, 24°50’2’S, 146°16’E; QGS L813, south bank of Flinders River at Sussex Rush, 6 miles WNW of Hughenden, Ranmore Member, 20°48’S, 144°07’E; QGS F1369, Cambridge Downs Run, Flinders River, 7 ml from Richmond Downs Station, Ranmore Member, 20°35’S, 143°18’E; QGS F1370, Aramac Well at 238 ft, Aramac Town, Coreena Member, 22°59’S, 145°15’E; QGS F1372, Aramac Well, Coreena Member, 22°58’S, 145°14’E; QM F1307, western Queensland (unlocalised); QM F2105, Tarbrax Station, near Maxwellton, Mackunda Formation, 21°06’S, 142°26’E; QM F1383, F1407, Hughenden, Ranmore Member, 20°50’S, 144°11’E; QM F2727, F27742, Richmond, Allaruu Formation, 20°44’S, 143°08’E; QGS 270, Barcaldine Downs, Mackunda Formation, 23°42’S, 145°33’E; QM F27918, F6152-6157, Winchester Downs, 50 miles SW of Richmond, Mackunda Formation, 21°11’S, 142°37’E; QM F36160, Flinders River at Marathon Homestead, Allaruu Formation, 20°49’S, 143°35’E; JCU 11616-11617, Quarry 15 km east of Julia Creek, Toolebuc Formation, 20°38’02’S, 141°54’01’E; JCU L910, Flinders River, east of
Glendower homestead, Ranmoor Member, 20°40'S, 144°32'E; JCU L912, Flinders River, east of Glendower homestead, not in situ, Ranmoor Member, 20°41'S, 144°34'E; JCU F11632 L913, and approximately 30 specimens, Flinders River, east of Glendower homestead, lower Ranmoor Member, 20°42'S, 144°36'E; JCU L914 (approximately 15 specimens), east of Wongalee Station, Ranmoor Member, 20°38'S, 144°29'E; JCU L916 (3 specimens), near Jones Valley Station, not in situ, Ranmoor Member, 20°32'S, 143°58'E; JCU L921 (approximately 15 specimens), Flinders River, east of Glendower, Ranmoor Member, 20°49'S, 144°20'E; AM F10475-6, south central Queensland, locality unknown; AM F10924-F10925, Marion Downs Station, Toolebuc Formation, 23°22'S, 139°39'E; AM F113967-113973, 113975-113987, Dunraven Station, west of Hughenden, Toolebuc Formation, 20°28'S, 143°57'E; AM F7125, near watershed of Baroo and Ward Rivers, Allaru Formation, c. 24°58'S, 146°09'E; AM F87634, Hughenden district, Ranmoor Member, 20°50'S, 144°11'E.

Eromanga Basin, South Australia: SAM T 1311, described by Etheridge (Etheridge, 1902a, pl. 7, fig. 18), as Belenmites canhami Tate, SAM T 1312, described by Etheridge (1902a, pl. 7, figs. 19-20), as Belenmites eremos Tate, SAM 7011, T1326, T1328, Stuart's Creek, southern end of Lake Eyre, Oodnadatta Formation, 29°42'S, 137°02'E; SAM P36629, Wooldridge Creek (Fossil Creek), Iodnonden Station, N.W. of Oodnadatta, Oodnadatta Formation, 27°15'S, 135°58'E; GSSA M2472, 6 miles northeast of Lagoon Hill, 5 miles southeast of Primrose Hill, Oodnadatta Formation, 28°13.75'S, 136°28'E; GSSA M2473-81, Kurillina run, north side of Neales River, Oodnadatta Formation, 28°02'S, 136°14'E; NMV P310414-18, Lake Eyre, Oodnadatta Formation, 28°14'S, 136°35'E; NMV P5975, near Warrina, South of Oodnadatta, Oodnadatta Formation, 28°11'S, 135°49'E; NMV P2223-9, Woodduck Creek, Peake Station, Central Australia, Oodnadatta Formation, 27°56'S, 136°13'E; NMV P2232, Kuryapundy Swamp, from a well 100ft. deep (locality uncertain); NMV P310426-29, 14 miles SE of Algebuckinna, Oodnadatta Formation, 28°07'S, 135°59'E; NMV P 310449-51, Cootarooorina district, Oodnadatta Formation, 28°00' S, 135°18' E; NMV P310467, Primrose Springs, Peake Station, Oodnadatta Formation, 28°05'S, 135°50'E; NMV P310468, Woodduck Creek, Peake Station, Oodnadatta Formation, 27°56'S, 136°13'E; HM S8430-8477, Woodduck
Creek, northwest of Lake Eyre, South Australia, Oodnadatta Formation, 27°56′S, 136°13′E; AM F87632, S.A./N.S.W. border, locality uncertain.

**Laura Basin, Queensland:** QGS F9681, L925, tributary of Piccaninny Creek about 1 mile upstream from NE side of road, Coen district (unlocalised); QM F33235, Hahn Tableland, west of Laura, Wolena Claystone, 15°50′S, 144°20′E; JCU 11620-11621, Laura, Tablelands, Far North Queensland 15°56′S, 144°10′E.

**Carpentaria Basin, Queensland:** SAM P18962, Near Kamileroi, 108 miles north of Cloncurry, Normanton Rd, Allaru Formation, 19°23′S, 139°71′E.

**Carnarvon Basin, Western Australia:** NMV P310425, 1 mile south of Cardibia Pool, Cardibia Station, Carnarvon, Gearle Siltstone, 23°15′S, 114°07′E; WAM 70.1146a-g, some 6.5 miles east of Murchison House homestead, basal Gearle Siltstone, 27°38′S, 114°20′E; WAM 83.582, Winning Station, hill 2 km south along Vermin fence, south from Bannawong bore, basal Gearle Siltstone, 23°22′S, 114°52′E; WAM 91.808-810, Cardabia Station, marly hill near Cardabia Creek, SE from Point Cloates, basal Gearle Siltstone, 23°34′S, 113°42′E; WAM 91.818-822, Wandagee Station, dam excavation on the plain near the shearing shed, ~ 15 ft. below the surface, basal Gearle Siltstone, 23°45′S, 114°33′E; WAM 91.827-837, Murchison House Station, basal Gearle Siltstone, 27°38′S, 114°14′E; WAM 91.838-845, 91.847, white cliff, ~ 4 miles NW of Murchison House, basal Gearle Siltstone, 27°36′S, 114°12′E; WAM 97.705, Alinga Point, Alinga Formation, 27°37′S, 114°10′E; WAM 97.721, 1.2 km south of Giralia No. 1, upper Gearle Siltstone, 23°00′S, 114°10′E; UWA CS-MM (approximately 20 specimens), Cardibia Station, Mia Mia, basal Gearle Siltstone, 114°20′E, 23°22′S; UWA TP-PP (approximately 10 specimens), Thirdine Point, Pillawarra Plateau, upper Gearle Siltstone, 27°36′S, 114°13′E; UWA 2/11/99-15 (approximately 15 specimens), Hill Springs Station, Whitby dam, basal Gearle Siltstone, 24°23′S, 115°01′E; UWA 2/11/99-16-1 to 3 and approximately 10 unnumbered specimens, upper Gearle Siltstone, Cenomanian, MacDonald Dam, 24°10′S, 114°29′E; UWA 23/3/93 (approximately 13 specimens), Alinga Point, Alinga Formation, 27°35′S, 114°11′E; GSWA Barrabiddy 1, see Appendix A. 1, Gearle Siltstone, 23°49′57″S, 114°20′E; GSWA Boologooro 1, see Appendix A. 2, Gearle Siltstone, 24°19′27.3″S, 113°53.3″E; GSWA Edaggee 1, see Appendix A. 3, Gearle Siltstone, 25°21′27.0″S, 114°14′04.9″E.
Diagnosis: Medium to large, elongated, robust guards. Outline symmetrical, hastate; profile asymmetrical, cylindroconical. Transverse sections depressed elliptical in stem region. Deeply incised, well-developed ventro-lateral grooves are inscribed on the anterior part of the guard; they extend along one third of rostrum, curving slightly dorsally in anterior portion of stem region. Lateral lines well developed and dorsally placed. Alveolar region narrow, apical region obtuse. The apical line is arched, tracing a gentle ventrally concave curve.

Dimensions (mm):

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Description: Medium to large *Dimitobelus*; with a weakly hastate outline, and the guard length more than five times the diameter. Apical region obtuse, tapering to a distinct point; apex mucronate. Alveolar region narrow in comparison; the stem extends from the position of the protoconch to the point of maximum inflation (Figure A. 3. 2). Profile asymmetrical and cylindroconical, with the ventral surface commonly flattened and slightly arched, especially towards the apex. Dorsal surface is flat and broad. Lateral surfaces are gently convex. Transverse section is semi-elliptical in stem and apical regions but almost equi-dimensional in the alveolar region (Figures A. 4. 1 to A. 4. 4). Two deeply incised ventro-lateral grooves in alveolar region extend onto the anterior part of the stem. They are straight in alveolar region, then deflected dorsally in stem region. Dorso-lateral grooves faintly impressed, and gently curved to almost straight. On mid-stem region, in line with the termination of the phragmocone, the ventro-lateral and the dorso-lateral grooves converge. Paired lateral lines variably impressed, strongly marked on some guards, obscure on others. They are positioned just dorsal of mid-flank, almost straight, and extend across the stem region almost to the apex. The phragmocone is central to slightly dorsal in position, with a small bulbous protoconch, and penetrates a third to a quarter the length of the guard. A pseudo-alveolus and apical canal are commonly developed. The apical line is in general ventrally offset and gently arched towards the ventral surface, most noticeably in the apical region.

Figure A. 4. 1 *Dimitobelus diptychus* (McCoy). JCU F11632 L913, Flinders River east of Glendower homestead, Ranmoor Member, northern Eromanga Basin. Transverse section at axis of maximum inflation, with growth lines that show faint and variable records of the lateral lines. Section is elliptical with apical line ventrally placed. Growth lines crowded on the ventral surface which is flattened. Magnification: x 2.75.
Remarks: *D. diptychus* McCoy (1867a) was originally placed in *Belemnitella* because its paired grooves were mistakenly considered as dorso-lateral in position, as characteristic of this northern hemisphere genus. Following description by Tate (1880) of *B. canhami*, this species was designated the type species of *Dimitobulus* by Whitehouse (1924) but is now is regarded as a synonym of *D. diptychus*. The lectotype of *D. canhami* (NMV P2177) was first figured by Dorman and Gill (1959, pl. 8, figs. 1, 2) and is refigured here (pl. 1, fig. 11). In guard shape and disposition of the ventro-lateral grooves and dorso-lateral lines, this specimen is indistinguishable from *D.*
**diptychus.** Similarly, the specimen figured by Phillips (Phillips, 1870, pl. 16, figs. 3, 4) as *B. australis* is indistinguishable from, and synonymous with, *D. diptychus*.

Some intraspecific variation is apparent within *Dimitobelus diptychus*. The stem ranges in cross-sectional shape from elliptical to sub-circular (Figure A. 4. 5). Tapering of the stem towards the alveolar region is also variable within the species with some specimens noticeably more hastate than others. The axial line is always ventrally curved (cyrtolineate) but the degree of curvature is variable. There is marked variation in the depth to which ventro-lateral grooves are incised, but their length is consistent within the species. This may be an artefact of preservation caused by post mortem degradation of the guard surface through abrasion, or by solution during exposure, diagenesis or during passage through the alimentary tract of a predator. Taper of the apical region is acute, generally subtending an angle of about 30°, but the range is from 18° to 40°. Intraspecific variation is also apparent between specimen suites from eastern and western basins. The dorso-lateral grooves are much more deeply inscribed in the Western Australian specimens of *D. diptychus* than in their eastern counterparts. Samples from Western Australia tend to be broader in outline in the comparison with eastern specimens, which are somewhat wider in profile view relative to the outline (Figure A. 4. 5).

![Figure A. 4. 5: Cross-sectional measurements for *Dimitobelus diptychus*. Variation in the degree of depression separates the eastern and western specimen suites at maturity.](image-url)
JCU 11620 (pl. 2, fig. 12) from the Albian Wolena Claystone of the Laura Basin is a pathological specimen with the robust profile, outline and transverse section and deeply incised, well-developed ventro-lateral grooves diagnostic of *D. diptychus*. However, it has an unusually inflated posterior stem region, an unusually depressed anterior sector and a bent, acute apex. $D_{\text{max}}:D_{\text{vmax}}$ is 1.3 for this specimen, within the range established for *D. diptychus* as is the apical angle (18°).

*D. diptychus* also exhibits distinct ontogenetic variation. Juveniles show a weaker cyrtolineate apical line in comparison to more mature specimens. The immature forms are commonly more cylindrical, with flattening of the dorsal and ventral surfaces less apparent. The ventro-lateral and lateral lines become more deeply incised mid-way through ontogeny, presumably due to an increase in bulk muscular tissue attaching to the guard. The cross-section in early growth is rounded but is progressively transformed by the addition of growth laminae that are variable in thickness into a cross-section that is more sub-quadrilateral (see Figures A. 4. 3 and A. 4. 4). Guards also become more tapered towards the alveolar region as growth proceeds. Slender, juvenile specimens of *D. diptychus* somewhat resemble *D. stimulus* but are distinguishable by a more robust, and more clearly hastate, morphology. A more substantial juvenile specimen suite is available from collections from the Carnarvon Basin, largely from the lower Gearle Siltstone, than from eastern Australia. Comparable juvenile growth stages are represented in collections from the Ranmoor Member of the northern Eromanga Basin.

**Discussion:** *D. diptychus* has been compared to *D. supertes* (Hector) from New Zealand by Whitehouse (1925) and to *D. macgregori* (Glaessner) from New Guinea by Doyle (1985). Stevens (1965) considered *D. supertes* as distinct, being discriminated by more prominent ventro-lateral grooves, a more cylindrical shape, with less clearly marked lateral lines. In New Zealand, *D. supertes* ranges from Motuan to Mangaotanean (middle Albian to Coniacian-Santonian).

Glaessner (1958) described *D. macgregori* from Albian strata of New Guinea, and based separation of this species from *D. diptychus* (McCoy) on the less clavate shape of the guard, with less severe flattening of the dorso-lateral surface. He measured $D_{\text{max}}:D_{\text{vmax}}$ as 1.3 (range 1.2 - 1.4) indicating a slightly less depressed shape
than typical of *D. diptychus* where this ratio has an average of 1.4, (range 1.3 to 1.5). However, the cross-sectional shape of Glaessner’s species fits into the range of variation shown by *D. diptychus*. The less clavate shape attributed to *D. macgregori* relates to the large size of the type specimen with *D. diptychus* becoming more hastate when mature. As a consequence of these observations, *D. macgregori* is also regarded here as a synonym of *D. diptychus*. The established range of the species in New Guinea (upper Albian to Cenomanian) overlaps with that known from Australian (Albian to Cenomanian).

Skwarko (1966) described *D. diptychus* from the Albian of Northern Territory but, as noted by Doyle (1987b), the material is poorly preserved rendering specific assignment questionable.  

*Dimitobelus stimulus* (Whitehouse) closely resembles *D. diptychus* but is more slender, less hastate and is weakly depressed (Dl\textsubscript{max}:Dv\textsubscript{max} 1.1 for *D. stimulus* compared to *D. diptychus* Dl\textsubscript{max}:Dv\textsubscript{max} 1.4). *D. diptychus* differs from *D. liversidgei* primarily in adult size and in the nature of its apical region. Its apex is obtuse and eccentric whereas that of *D. liversidgei* is acute and almost central in position. Day (1968) noted that in Queensland these two species appear to be stratigraphically separated, with *D. diptychus* occurring in the pre-Toolebuc units (Ranmoor and Coreena Members of the Wallumbilla Formation) and *D. liversidgei* in the Toolebuc, Allaru and Mackunda Formations. However, both species are recorded here as having the same range confirming the observation of Whitehouse (1925) and Ludbrook (1966) who noted the two species as occurring together in South Australia strata.  

**Distribution and Age:** The type series of *D. diptychus* described by McCoy (1867a) was collected from the lower Allaru Formation exposed at the base of Walker’s Table Mountain near Hughenden Queensland. The species is widely distributed in the northern Eromanga Basin where it ranges through the upper, Ranmoor Member, of the Wallumbilla Formation, and the Toolebuc, Allaru and Mackunda Formations, spanning the Albian Stage (see Section C). Within the Hughenden district, the species is especially prolific within the Ranmoor Member.  

The species is represented in the Allaru Formation of the Carpentaria Basin and the Wolena Claystone of the Laura Basin, both units of Albian age. Within the
southern Eromanga Basin, *D. diptychus* is prolific in the Albian Oodnadatta Formation, with collections from this unit known from Woodduck Creek, Primrose Springs, Wooldridge Creek, Algebuckinna and the Oodnadatta district. Ludbrook (1966) identified specimens from the Albian Oodnadatta Formation from the north bank of the River Neales as *D. diptychus*, which occurs in association with prolific *D. stimulus*. Other specimens are from Stuart’s Creek, Lake Eyre district, as figured by Etheridge (1892a, pl. 7, figs. 18, 19, 21).

*D. diptychus* is well represented in the Carnarvon Basin where it ranges from early Albian to Cenomanian. It is represented in the early Albian lower Gearle Siltstone by collections from Murchison House, Wandagee, Cardabia, Winning, Giralia and Hills Springs Stations. Recently drilled stratigraphic core holes intersecting this unit contain a prolific record of *D. diptychus*. The best record is from Boologooroo 1 where the species is represented through ~65 m of section representing the entire lower Gearle Siltstone but the species is also common in core of this unit from Barrabiddy 1 and Edaggee 1. There are also records for the Albian Alinga Formation, from Alinga Point and from south of Giralia Bore No. 1 (see McWhae et al., 1958).

*D. diptychus* is also characteristic of the upper Gearle Siltstone of Cenomanian age, with collections from Thirdine Point, Pillawarra Plateau and from core intersections from Edaggee 1 and Boologooroo 1. Occurrences from Cenomanian strata of the Carnarvon Basin have been noted by Stevens (1965) and Pirrie et. al. (1995). *D. diptychus* has not been documented from Cenomanian strata of eastern Australia because marine sequence of this age is not represented.

Reports by Etheridge (1902a; 1902b) of *D. diptychus* occurring in the White Cliffs opal fields in New South Wales is anomalous. Whitehouse (Whitehouse, 1926, p. 277) and others (David, 1950, p. 486; Vallance and Packham, 1959, p. 162) tentatively assigned the White Cliffs strata as Aptian. Specimens held by the Australian Museum from this locality are undoubtedly *Peratobelus*, consistent with this age assignment.
**Dimitobelus stimulus** Whitehouse

Pl. 2, figs. 3-7

**Synonymy:**

1925  
*Dimitobelus stimulus* Whitehouse; Whitehouse, p. 35, pl. 2, figs. 8, 12-17.

1925  
*Dimitobelus stimulus* var. *extremus* Whitehouse, p. 35, pl. 2, figs. 18-20.

1965  
*Dimitobelus stimulus* Whitehouse; Stevens, p. 121.

1966  
*Dimitobelus stimulus* Whitehouse; Ludbrook, p. 192, pl. 27, figs. 12-21.

1966  
*Dimitobelus stimulus* var. *extremus* Whitehouse; Ludbrook, p. 192.

1987  
*Dimitobelus stimulus* Whitehouse; Doyle p. 163-166, pl. 22, figs. 11-15.

1987  
*Dimitobelus stimulus* var. *extremus* Whitehouse; Doyle p. 166, pl. 22, fig. 16, pl. 23, figs. 1 and 2.

2001  
*Dimitobelus* (*Dimitobelus*) *stimulus* Whitehouse; Stilwell and Crampton, p. 391-394, figs. 2a-c.

**Type:** Holotype: HM S5594, Kurillina run 4, south bank of Kurillina Creek, Oodnadatta Formation (Albian), Woodduck Creek district, South Australia 27°57.5’S, 136°11.5’E as described and figured by Whitehouse (1925).

Remainder of type series: HM S5590-5593 and HM S5595-97, 6 miles northeast of Lagoon Hill, 5 miles southeast of Primrose Hill, Oodnadatta Formation (Upper Albian), South Australia 28°13.75’S, 136°28’E.

**Additional Material:** Approximately 65 specimens.

**Eromanga Basin, Queensland:** QGS 270A.1, Barcaldine Downs Station, Mackunda Formation, 23°42’S, 145°33’; QSQ F1372, figured by Etheridge 1892, pl. 35, fig. 18, Allaru Formation, Aramac district, c. 22°55’, 145°13’; UQ F16922, Currane Station, 9 miles north of Dartmouth, Allaru Formation, 23°24’S, 144°45’E; QM F6152-6157, Winchester Downs Station, 50 miles SW of Richmond, Mackunda Formation, 21°11’S, 142°37’E; JCU F11633 L910, and approximately 20 unnumbered specimens, Flinders River east of Glendower homestead, Ranmoor Member, 20°40’S, 144°32’E; JCU F11634 L914 and approximately 10 unnumbered specimens, east of Wongalee Station, Ranmoor Member, 20°38’S, 144°29’E; AM F87634, Hughenden district, Ranmoor Member, 20°50’S, 144°11’E; AM F7125, watershed of the Barcoo and Ward rivers,
Allaru Formation, c. 24°58'S, 146°09'E; AM F113974, F113988 & 113989 Dunraven, Hughenden district, Toolebuc Formation, 20°28'S, 143°57'E; NMV P2231, Kuryapundy Swamp, Central Australia (from a well 100ft. deep), (unlocalised).

**Eromanga Basin, South Australia:** NMV P310411-13, Lake Eyre, Oodnadatta Formation, 28°14'S, 136°35'E; NMV P310446-8, Dalhousie Station, Oodnadatta district, Oodnadatta Formation, 26°27'S, 135°31'E; NMV P310430-442, cliff banks of Neales River, 14 miles SE of Algebuckinna, Oodnadatta Formation, 28°07'S, 135°59'E; NMV P310452-58, Woodduck Creek, Peake Station, Oodnadatta Formation, 27°58'S, 136°125'E; GSSA M2481-95, Kurillina run, north side of Neales River, Oodnadatta Formation, 28°02'S, 136°14'E; HM S8478-S8536, Woodduck Creek, Oodnadatta Formation, 27°56'S, 136°13'E.

**Laura Basin, Queensland:** QM F33230, F33237, F33240, Hann Tableland, south of Laura, Wolena Claystone, 16°54'S, 145°14'E; JCU 11622, tablelands north of Laura, Wolena Claystone, 15.6°S, 144°10'E; JCU 11619, tableland north of Laura, Wolena Claystone, 15°56'S, 144°10'E.

**Carpentaria Basin, Queensland:** UQ L679, Little Bynoe Crossing, Little Bynoe River, Normanton Formation, 17°54'S, 140°51'E.

**Carnarvon Basin, Western Australia:** WAM 01.92, Barrow Island, Mardie Greensands Member, 20°47'S, 115°24'E; WAM 91.823-6, Wandagee Station, ~ 15 ft. below the surface, Gearle Siltstone 23°45'S, 114°33'; UWA CS-MM (approximately 20 specimens), Cardibia Station, Mia Mia, basal Gearle Siltstone, 114°20'E, 23°22'S; UWA 2/11/99-15 (approximately 25 samples), Hill Springs Station, Whitby Dam, Kennedy Range, basal Gearle Siltstone, 24°09'S, 114°26'E; GSWA Barrabiddy 1, see Appendix A. 1, basal Gearle Siltstone, 23°49'57"S, 114°20'E; GSWA Boologooro 1, see Appendix A. 2, Gearle Siltstone, 24°19'27.3"S, 113°53.3"E; GSWA Edaggee 1, see Appendix A. 3, Gearle Siltstone, 25°21'27"S, 114°14'04.9"E; GSWA Yinni 1, see Appendix A. 4, basal Gearle Siltstone, 26°03'22.8"S, 114°48'58.5"E.

**Other:** SAM P3016, Northern Territory (unlocalised).

**Diagnosis:** Medium sized, slender, subhastate to subcylindrical *Dimitobelus*. Outline symmetrical and subhastate, as is profile. Apex acute. Transverse sections are
elliptical and slightly depressed. Lateral lines paired and well developed, straight and centrally placed, but posteriorly may converge to a single structure and become deflected dorsally in the apical region. Pseudoalveolus and axial projection are common in this species.

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**Description:** Medium sized, subhastate to subcylindrical, slender guards with the length ranging to 80 mm and more than five times the diameter. Outline symmetrical and subhastate; maximum point of inflation at mid-length of the guard, or displaced slightly towards the apical region. Profile is subhastate and symmetrical with the dorsal and ventral surfaces slightly flattened. Transverse section weakly depressed (Dlmax:Dvmax 1.1; Figures A. 4. 6 and A. 4. 7), becoming more flattened towards the alveolar region. In alveolar region, the ventro-lateral grooves curve dorsally to join with straight, well-developed and centrally placed lateral lines. Lateral lines are paired, some 1mm apart and extend for the entire length of the guard. Dorso-lateral grooves commonly developed on the alveolar region and straight. The phragmocone is commonly not well preserved due to development of a pseudoalveolus. The apical
line is curved slightly ventrally with the development of an apical canal common in this species.

![Figure A. 4. 6 Dimitobelus stimulus Whitehouse.](image)

JCU F11633 L910, Ranmoor Member, Eromanga Basin. Cross section through the point of maximum inflation, at the boundary between the stem and apical regions; weakly depressed. Magnification: x 3.6.

![Figure A. 4. 7 Dimitobelus stimulus Whitehouse.](image)

JCU F11634 L914, Lower Ranmoor Member, Eromanga Basin. Juvenile specimen sectioned in the anterior stem region, showing a large apical canal. Magnification: x 4.5

**Discussion:** *Dimitobelus stimulus* was established by Whitehouse (1925), for slender guards, with a depressed cross-section. Whitehouse noted that the lateral lines appeared straight and centrally placed, giving rise anteriorly to either a single groove or pair of diverging grooves.

Specimens figured by Whitehouse (1925) were lodged in the Hunterian Museum (HM S5595-5597) along with four other guard fragments (HM S8433-8436). It may be presumed that this collection represents the type series for the species. However, re-examination of specimens HM S8433-8436 shows them to be *D. diptychus* due to their characteristically flattened rostra and the distinctively placed, off-centre lateral lines.

*Dimitobelus stimulus* is similar to *D. diptychus* such that both species generally develop diverging dorso-lateral and ventro-lateral grooves. Whitehouse (1925) considered *D. stimulus* as distinctive in its less clavate shape and in the lateral lines which are straight and central. The profile of *D. stimulus* is more subhastate than that
of *D. diptychus* and transverse sections are less depressed (D\textsubscript{lmax}:D\textsubscript{vmax} ~1.1 compared to ~1.4). *D. stimulous* resembles juveniles of *D. diptychus*, but can be easily distinguished by the subhastate profile, and near perfectly elliptical transverse section. Most other species of *Dimitobelus* are more flattened (semi-elliptical) and hastate than *D. stimulous*.

*D. liversidgei* Etheridge Jnr (1892) was previously included as a synonym of *D. stimulous* by Day (1968) as both have slender guards with acute, almost central apices. However, *D. liversidgei* is distinguished by its long, acutely pointed apical region, distinctly clavate outline, more depressed cross-section (D\textsubscript{lmax}:D\textsubscript{vmax} ~1.3) and weaker development of ventro-lateral grooves.

Variation in shape has been noted for *D. stimulous*. Whitehouse (1925) proposed the varietal name *D. extremis* for longer, more cylindrical and more gently tapering forms which retained the straight and strictly central lateral lines characteristic of *D. stimulous sensu stricto*. However, Ludbrook (1966) re-examined the type series (HM S5595-S5597) of this form but could not discriminate it from the *D. stimulous* s. s.. *D. stimulous* var. *extremis* represents extreme morphs of this taxon where guards are particularly long and slender but there is no break in the range of variation linking to *D. stimulous* s.s.. Slender guards described by Doyle (1987a) from the Albian Kotick Point Formation of the Antarctic Peninsula and assigned as *D. stimulous* var. *extremus* are closely comparable to Whitehouse’s lectotype. The specimen from Alexander Island, West Antarctica, described by Willey (1972) as *D. macgregori* was reassigned by Doyle (1987a) to *D. stimulous*. However, it is poorly preserved and its identity is uncertain.

**Distribution and Age:** The type series described by Whitehouse (1925) was collected from the Oodnadatta Formation from Woodduck Creek in the southern sector of the Eromanga Basin, South Australian. Other collections from this formation are from the Lake Eyre district, Neales River Algebuckinna district and Dalhousie Station. An Albian age was assigned to this unit (Ludbrook, 1966).

*D. stimulous* is also represented in the northern Eromanga Basin, mostly by collections from the Ranmoor Member of the Wallumbilla Formation (early to mid Albian) exposed along the Flinders River east of Hughenden but also the late Albian...
Mackunda Formation. In the Laura Basin *D. stimulus* is present in early Albian Wolena Claystone.

The species is prolific in the basal Gearle Siltstone (Albian) of the Carnarvon Basin exposed on Hills Springs, Wandagee and Cardibia Stations. A single specimen is recorded from the upper Aptian Mardie Greensand at Barrow Island Western Australia but was not collected in situ and its provenance is suspect. *D. stimulus* is present in all four cored stratigraphic wells from the Carnarvon Basin where it occurs throughout the lower Gearle Siltstone.

*D. stimulus* Whitehouse ranges through the Albian; it commonly occurs with *D. diptychus* (McCoy) and *D. dayi* (Doyle) in the Great Artesian and Carnarvon basins.

**Dimitobelus liversidgei Etheridge**

Pl. 2, figs. 1-2

**Synonymy:**
1902a *Belemnites? Liversidgei* Etheridge; Etheridge, p. 48.
1902b *Belemnites? liversidgei* Etheridge; Etheridge, p. 81.
1968 *Dimitobelus? liversidgei*; Etheridge; Hill et. al., p. k.7, pl. KII, fig. 17.

**Types:** Lectotype (designated here): QGS F1371, figured by Etheridge 1892, pl. 35, fig. 17, Allaru Formation, Rockwood Station, Aramac district.

Remainder of the type series: QGS F5631, figured by Etheridge 1892, pl. 35, fig. 20, F5629, F5630 and eighteen unnumbered specimens, within the same rock slab as the lectotype.

**Additional material:** Approximately 30 guards.

NMV P310444-5, Kingston Station, near Longreach, Allaru Formation, 144°13′E, 23°24′S; JCU F11624-F11630 L924, Daunton South Station, Ilfacombe, upper Allaru Formation, Eromanga Basin, Queensland, 144°49′59″E, 23°17′18″S; JCU F11631, L925 and 15 unnumbered specimens, Glenferrie Station, upper Allaru Formation, Eromanga Basin, Queensland, 144°45′21.5″E, 23°30′21.5″S.
Diagnosis: Diminutive, slender, hastate, weakly depressed guards with an acute, sharply pointed apex and an elongate and a highly attenuated anterior segment which tapers almost to a point. Grooves and lines not evident.

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Description: Guard small, less than 40 mm long, hastate in shape with an elongate, strongly attenuated anterior segment which tapers to a termination that is less than 1 mm across. The point of maximum diameter is positioned adapically at about one third of the guard length. Alveolus not developed. Dv_max is approximately 8 to 10 times length of the guard, depending on the preservation of the delicate anterior extension. Outline and profile are symmetrical with the point of maximum diameter in apical third of guard. Apex is acute (~20°) and tapers to a point. Transverse section oval and slightly depressed. Axial line generally central but eccentric near the apex and offset presumably towards the ventral surface. Ventro-lateral grooves and lateral lines are unknown for this species.

Discussion: The type series described by Etheridge (1892) was figured by Hill et al. (1968, pl. K11, fig. 17) and is re-illustrated here (pl. 2, fig. 3) consists of over 20 current aligned specimens partially exposed on a small slab of fine sandstone. Two of these specimens were individually illustrated as hand drawings, out of context, by Etheridge (1892) but can be recognised within the slab. One of the original illustrations (pl. 35, fig. 20) is an incomplete specimen with only the apex retained and is now numbered QGS F5631. The original of his plate 35, figure 17 can be recognised because it is translucent and shows the axial line as he noted in his figure caption and is the only specimen of the group with this attribute and resembling the illustration. It is now numbered QGS F5630 and is designated here as the lectotype. This specimen is
a substantially complete guard but the distinctive anterior portion is missing. Such is generally the case for the type series but some of the unnumbered specimens show a part of the guard anterior confirming that it is tapered and narrow. The specimen referred to *D. liversidgei* by Etheridge in his plate 35, figure 19 is not in evidence and its status is uncertain.

All of the specimens available are embedded in rock matrix which supports their delicate form especially the attenuated anterior portion. All specimens are slender with an attenuated, sharply pointed apex where preserved but within the type series some specimens are more slender than others. Most have been abraded on their exposed surfaces but some are sufficiently intact to show that surface lines and grooves are not developed. Measurements of both cross-sectional diameters can rarely be obtained but partial sections revealed by several specimens show that the cross-section is oval and weakly depressed \((D_{\text{max}}:D_{\text{vmax}} \sim 1.1 - 1.2)\). Some specimens have preserved the anterior termination, in general only a fraction of a millimetre across, which shows only the presence the axial line which can be seen through translucent shell. An alveolus is not developed.

Guards of this species somewhat resemble those of juvenile *D. diptychus* in shape, being pinched in the posterior alveolar region, and with the maximum point of inflation located towards the apex. *D. liversidgei* is set apart from other Albian *Dimitobelus* by its small size, slender form, its very distinctively tapered and attenuated anterior segment of the guard, and absence of lateral grooves and lines.

**Distribution and Age:** *Dimitobelus liversidgei* is known only from the Allaru Formation of the Aramac and Longreach – Ilfracombe districts and is of late Albian age.

**Dimitobelus dayi** **Doyle**

Pl. 2, figs. 9-11

**Synonymy:**

1987a *Dimitobelus dayi* Doyle, p. 169, pl. 23, figs. 8-10.

**Types:** Holotype: BMNH C35019, Hughenden district, north Queensland, unlocalised. Remainder of type series: BMNH C 35000, 35002, 35010, Hughenden district, unlocalised.
Additional Material: Approximately 55 specimens.

**Eromanga Basin, Queensland:** NMV P31592, 20 km north of Hughenden, Ranmoor Member, 20°38’S, 144°14’E; QM F6149–6151, Mountain View Station, Hughenden, Ranmoor Member, 20°47’S, 144°19’E; JCU F116635 L910/3 and approximately 10 unnumbered specimens, Flinders River, east of Glendower homestead, Ranmoor Member, 20°40’S, 144°32’E; L912, Flinders River, east of Glendower homestead, not in situ, Ranmoor Member, 20°41’S, 144°34’E; L914, east of Wongalee Station, Ranmoor Member, 20°38’S, 144°29’E; L921, Flinders River, east of Glendower homestead, Ranmoor Member, 20°49’S, 144°20’E; AM F17715-17717, Prairie district, unlocalised.

**Laura Basin, Queensland:** JCU 11623, tableland north of Laura, Wolena Claystone, 15°56’S, 144°10’E.

**Carnarvon Basin, Western Australia:** UWA 2/11/99-15 (6 specimens), Whitby Dam, Kennedy Range, near Hills Springs Station, basal Gearle Siltstone, 24°23’S, 115°01’E; WAM 91.846, white cliffs, NW of Murchison House, basal Gearle Siltstone, 27°36’S, 114°12’E; UWA CS-MM (10 specimens), Cardibia Station, Mia Mia, basal Gearle Siltstone, 114°20’E, 23°22’S.

**Diagnosis:** Medium sized, tumid *Dimitobelus*. Outline is symmetrical and hastate, as is profile. Transverse sections depressed elliptical to sub-circular. Axis of maximum diameter located close to apex which is abbreviated and rounded. Paired lateral lines prominent.

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**Description:** Guard medium sized, robust, with a hastate outline. Profile is subsymmetrical and hastate with the ventral and dorsal surfaces gently arched. Guard length approximately five times the maximum diameter. Point of maximum inflation occurs in posterior portion of guard. Apex is obtuse, rounded, rarely terminating in a sharp point. Transverse sections are semi-elliptical and depressed \((D_{\text{max}}:D_{\text{vmax}} 1.2)\) and the ventral surface may show some flattening (Figures A. 4. 8 and A. 4. 9). Apical canal positioned ventrally and commonly well developed. Apical line curved, convex towards the ventral surface, typically excavated as a canal. Pseudoalveolus generally developed. Vento-lateral grooves variably developed, commonly obscure; they are deflected dorsally converging on the lateral line on some specimens, including the holotype. The lateral lines are deeply incised, centrally placed, and continuous from the alveolar to the apical region.

**Figure A. 4. 8** *Dimitobelus dayi* Doyle. JCU F11635, Rannoo Member, northern Eromanga Basin. Transverse section at posterior of stem region showing semi-elliptical, depressed outline, slightly ventrally placed apical canal and clearly incised, centrally placed lateral lines. Magnification x 2.5.

**Figure A. 4. 9** *Dimitobelus dayi* Doyle. JCU F11623, Wolena Claystone, Laura Basin. Small specimen sectioned in the stem region showing a weakly elliptical outline and weak registration of lateral lines. Magnification x 2.8.

**Discussion:** Doyle (1987a) based the original description of his *D. dayi* on specimens from the Wilkins Collection held by the British Museum of Natural History, from the Hughenden area, Queensland. As reported by Doyle (1987a), the species had previously been identified as a variant of *D. diptychus* (McCoy) by Day (1969) in his
review of the Tambo fauna. However, its specific identity is clear. The tumid shape of the guard with a rounded apical termination, weak to absent ventro-lateral grooves but distinctive paired lateral lines set *D. dayi* apart from other members of the genus. *D. dayi* has a symmetrical profile, whereas that of *D. diptychus* is asymmetrical and its apex terminates in a distinct point. *D. dayi* is slightly less depressed in cross-section than most *D. diptychus* (Figure A. 4. 10).

*Dimitobelus dayi* exhibits some intraspecific variation. Although all specimens show an abrupt apex, the apical angle varies between 50°-75°. An apical canal and pseudoalveolus are typical but variably developed, features reflecting quality of preservation. Whereas the ventral surface is always convex in cross-section, the dorsal surface may show incipient flattening.

For some juveniles, the lateral lines are more dorsally placed than typical of the species and extend the entire length of the guard. In general, lateral grooves are more deeply incised on specimens that show dorsal flattening of the guard.

![Graph](image)

**Figure A. 4. 10 Relationship of Dv_max with Dl_max for D. diptychus and D. dayi.**

**Distribution and Age:** *D. dayi* has been principally found in the early Albian Ranmoor Member exposed along the Flinders River to the east of Hughenden. It is likely that the type series for which locality details are not known other than the district of Hughenden, are also from this unit.
D. dayi is present in the early Albian Wolena Claystone from the Laura Basin (JCU F11623). In the Western Australian Carnarvon Basin the species is represented in the basal Gearle Siltstone outcropping in the Murchison House district and near the Hills Springs Station (UWA 2/11/99-15). Other specimens are from the basal Gearle Siltstone at Mia Mia, Cardibia Station.

The species is early Albian in age and is characteristic of the older part of the Tambo fauna.

**Dimitobelus (?) hendersoni sp. nov.**

Pl. 3, figs. 5-6

**Type Material:** Holotype: GSWA F51430; Paratypes F51431, UWA CS-MM (approximately 25 un-numbered specimens). All from Cardibia Station, Mia Mia, Carnarvon Basin, Western Australia, basal Gearle Siltstone, 114°20’E, 23°22’S.

**Additional material:** GSWA Barrabiddy 1, see Appendix A. 1, basal Gearle Siltstone, 23°49’57”S, 114°20’E; GSWA Boologooro 1, see Appendix A. 2, Gearle Siltstone, 24°19’27.3”S, 113°53.3”E.

**Etymology:** In recognition of Professor Bob Henderson, James Cook University, who has provided invaluable contributions towards the completion of this manuscript.

**Diagnosis:** Medium sized, slender, cylindroconical guards. Outline and profile are symmetrical. Transverse sections are almost circular. Apex is acute. Grooves lacking, lateral lines faint or absent. Alveolus prominent, deeply set, extending to the mid-length of the guard.

**Dimensions (mm):**

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</table>
**Description:** Guard slender, outline symmetrical and cylindroconical as is the profile. Apical region attenuated and apex is slightly dorsally deflected, apical angle approximately 20°. Apical line is centrally placed. Guard circular to very weakly compressed in cross-section. Transverse sections are subcircular to weakly compressed ($D_{\text{max}}$:$D_{\text{max}}$ 0.96-1.0; Figure A. 4. 11). $D_{\text{max}}$ is approximately 6 times the length of guard at maturity. Guard surfaces smooth, completely lacking grooves. Shallow, faint paired lateral lines are present in some specimens, and extend from the alveolus to the apex. Some specimens show a broad weak ventral groove in the alveolar region. Alveolus is centrally placed and deeply set, extending to the mid length of the guard. It is commonly accentuated by development of a pseudoalveolus.

**Discussion:** These guards are characteristically slender and cylindrical in form and most show well preserved outer surfaces. The anterior part of the alveolar region is missing from all specimens. However, for some the guard walls surrounding the alveolus are thin indicating that the missing anterior part of the alveolar region is small. Extrapolation to completeness, based on the thickness of the circum-alveolar guard walls, indicates that the maximum guard length at maturity does not exceed 55 mm. Juvenile specimens less than 30 mm long when reconstructed are particularly slender, with length some eight times the maximum diameter, and adults become more robust. Many specimens show exfoliation of growth laminae, both on the outer surface and also on the walls of the alveolus.

Given that ventro-lateral grooves cannot be demonstrated, although they could be represented on the missing anterior part of the alveolar region, reference to *Dimitobelus* is questionable. However, the paired lateral lines shown by some specimens clearly indicate affinities with this genus. In shape, the lack of grooves and the absence of lateral lines on many specimens, guards of *D. hendersoni* bear some resemblance to those of *D. liversidgei* from the Eromanga Basin. However, a larger size at maturity, the deep alveolus, and the lack of taper in the anterior region are clear discriminating characteristics.

**Distribution and Age:** *D. hendersoni* is known only from the basal Gearle Siltstone, which is assigned an Albian age, from a single locality in the Carnarvon Basin in association with adult and juvenile *D. diptychus*, *D. stimulus* and *D. dayi*. 
Dimitobelus plautus sp. nov.

Pl. 2, fig. 8

Type Material: Holotype: QM F33232; Paratypes QM F33231, F33236 and F33238. All from Hann Tableland, south of Laura, Laura Basin, far northern Queensland, Wolena Claystone, 16°54'S, 145°14'E.

Additional material: JCU F11655, F11656, Tablelands, north of Laura, Laura Basin, far northern Queensland, Wolena Claystone, 15°56'S, 144°10'E; QGS F9689, F9692, F9696 L925, tributary of Piccaninny Creek about 1 mile upstream from NE side of road, Coen, 13°09'S, 142°40'E, Carpentaria Basin.

Etymology: From the Latin plautus, recognising the broad, flat cross-sectional profile of this species.

Diagnosis: Medium sized, hastate guards. Outline and profile are symmetrical. Transverse sections are elliptical with slightly flattened dorsal and ventral surfaces. Apical and alveolar regions are attenuated. Grooves faint, paired lateral lines evident.
Dimensions (mm):

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**Description:** Medium sized *Dimitobelus* with flattened guards ranging to some 50 mm in length. Length of guard approximately six times the maximum diameter, which occurs around mid length. Outline hastate; profile mildly hastate, stem region long, gently tapering, apical region acute (apical angle ~ 20°). Apex positioned slightly dorsal of centre. Guards are depressed and elliptical in transverse section (Dlmax:Dvmax 1.3; Figure A. 4. 12).

![Figure A. 4. 12 Dimitobelus plautus sp. nov. QM F33238, Wolena Claystone, Laura Basin. Transverse section showing elliptical outline, with slightly flattened dorsal and ventral surfaces. Faint impressions of dorso-lateral grooves and lateral lines are evident. Point of maximum inflation at mid stem region. Magnification x 6.8.](image)

Dorsal and ventral surfaces markedly flattened in profile. Ventro-lateral grooves faintly incised, straight in alveolar region and curving gently towards mid-region of anterior stem. Dorso-lateral grooves faintly impressed and broad; straight in alveolar region and gently curving on the anterior stem region towards the mid-line, then straightening to become parallel to ventro-lateral grooves. Paired lateral lines are centrally placed and extend from the stem region to the apex. Alveolus is relatively short and a pseudoalveolus with an axial projection is commonly developed. Phragmocone is not known. Axial line is gently curved towards the ventral surface.

**Discussion:** *Dimitobelus plautus* is most similar to *D. stimulus*. Both are slender guards with acute, almost central apices and prominent centrally placed paired lateral lines.
and both have similar cross sections (Figure A. 4.13). However, they differ markedly in attenuation of the apical and alveolar regions.

![Graph](image.png)

Figure A. 4. 13 Relationship of \(Dv_{\text{max}}\) and \(Dl_{\text{max}}\) for *Dimitobelus stimulus* and *D. plautus*.

The long, acutely pointed apical region of *D. plautus* separates the species from *D. diptychus* McCoy; and the size of the guard, depressed cross-section and surface grooves enables easy distinction from *D.iversidgei*.

Intraspecific variation within *D. plautus* is prominent. Flattening of ventral and dorsal surfaces in profile is variable with some specimens being more robust with greater inflation. The alveolar region is variously attenuated ranging from strongly tapered to less so (see pl. 2, fig. 10) and approaching *D. diptychus* in this regard.

**Distribution and Age:** *D. plautus* is best known from the Hann Tablelands near Laura within the Laura Basin where it occurs in the Wolena Claystone which is assigned as early Albian age (Haig and Lynch, 1993). Other specimens were located near Coen in the Carpentaria Basin (GQS F9689, 9692, 9696).

* **Dimitobelus sp. nov. ? 1**

Pl. 3, figs. 1-3

**Material:**

**Carnarvon Basin, Western Australia:** GSWA F51426, UWA TP-PP 5, Thirdine Point, Pillawarra Plateau, upper Gearle Siltstone, 27°36’S, 114°13’E; GSWA F51427 and
F51428, Boologooro 1, see Appendix A. 2, upper Gearle Siltstone, 24°19′27.3″S, 113°53.3″E; GSWA Edaggee 1, see Appendix A. 3, upper Gearle Siltstone, 25°21′27″S, 114°14′04.9″E.

**Dimensions (mm):**

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**Description:** Guard small in size with length ranging to 37 mm and nearly 5 times the diameter at the point of maximum inflation. The outline is symmetrical and semi-hastate; profile is asymmetrical and sub-cylindrical. The dorsal surface is more arched than its flattened ventral counterpart. The position of maximum inflation (Dl_{max}) occurs in the mid-flank of the guard, within the stem region. Transverse sections are semi-elliptical and depressed (Dl_{max}:Dv_{max} 1.2). The apex is not preserved but appears to be acute. Vento-lateral grooves are visible in the alveolar region, and converge to meet faint lateral lines that extend from alveolar region to apex. Dorsal grooves faintly impressed and broad, straight in alveolar region and gently curving on the anterior stem region towards the mid-line at Dv_{max}, then recurving to become parallel to the ventro-lateral grooves. Paired lateral lines extend from alveolar to the apex. Apical line is ventrally placed, and an apical canal commonly forms.

**Discussion:** The juvenile form is more cylindrical, and transverse section not as depressed as in adult specimens. The outline of the juvenile guards is similar to that of the adults but the profile is less curved bounding surfaces. The apex is acute to very acute and Dv_{max} is at mid-flank, similarly to the adult form.

This species is similar in outline and profile to *D. diptychus* but the apical region, although incomplete in the material available, is decidedly more tapered. The point of maximum inflation is more anteriorly positioned than that of *D. diptychus*, with a gentle taper towards the alveolar region of the guard. The presence of ventro-lateral grooves, which converge to join lateral lines, places this form within *Dimitobelus*. *D. dayi* is similar in that it has weak to absent ventro-lateral grooves with
distinctive paired lateral lines, but differs in shape. *Dimitobelus* sp. nov.? 1 is most similar to *D. liversidei* in transverse sections (Dlmax:Dvmax ~ 1.1-1.2 for *D. liversidei*, 1.2 for *D. sp. nov. ? 1) and the point of maximum inflation is also similarly positioned around the mid-flank of the guard. Difference in profile and alveolar regions separate *Dimitobelus* sp. 1 from *D. liversidei*.

This small group of specimens, the largest of which may still be immature, appears to represent a discrete taxon but more material is needed before formal naming is warranted.

**Distribution and Age:** Specimens of *Dimitobelus* sp. nov.? 1 were collected from the upper Gearle Siltstone of the Carnarvon Basin at Thiridine Point, Pillawarra Plateau and from core obtained from GSWA Edaggee 1 and GSWA Boologooro 1. This unit is of Cenomanian age (see Section C).

**Dimitobelus sp. nov. ? 2**

Pl. 3, fig. 4

**Material:** GSWA F51429, UWA 23/3/93 3, Alinga Formation, late Albian, Alinga Point, Carnarvon Basin 27°35'S, 114°11'E.

**Dimensions (mm):**

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**Description:** Guard diminutive, semi-clavate in shape. Outline is symmetrical and the profile almost so; point of maximum inflation decidedly posterior of the mid length. Transverse sections are semi-elliptical. Apex is moderately obtuse and the apical canal is centrally placed. Ventral and dorsal surfaces are flattened. Ventral surface has a central, broad, deep groove extending from the alveolar region almost to the apex. Faint ventro-lateral grooves are also present, positioned near the mid-flank and almost straight. The guard reduces in width anteriorly and shows a slight waist in profile near its anterior termination.

**Discussion:** This guard somewhat resembles juveniles of *D. diptychus* in shape, being pinched in the posterior alveolar region, and with the maximum point of inflation
located towards the apex. It is set apart from other Albian *Dimitobelus* by its diminutive size and prominent single ventro-lateral groove. Given that only a single, diminutive and possibly immature specimen with this distinctive form is available, it is left under open nomenclature. It could possibly represent a pathological example of *D. diptychus*.

**Distribution and Age:** The specimen is from the lower Alinga Formation of late Albian age.

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**Genus Microbelus nov.**

**Type Species:** *Microbelus haigi* sp. nov.

**Etymology:** prefix *micro-* reflecting to the diminutive size of the guard; suffix -*belus*, identifying membership of the Family Dimitobelidae.

**Diagnosis:** Guard diminutive, semi-clavate in shape, inflated with DL_{max} located towards the apex. Transverse sections depressed with a flattened ventral surface. A single ventro-lateral groove extends almost the full length of the guard. Alveolus inconspicuous and phragmocone unknown.

**Range:** Cenomanian of Western Australia.

**Discussion:** The genus *Microbelus* is established here for distinctive diminutive belemnites that occur only from the Cenomanian upper Gearle Siltstone of the Carnarvon Basin, Western Australia. The two included species, *Microbelus haigi* and *M. tumidus* are unlike any previously described members of the family. They share a globular, clavate form with an inflated apical region. The presence of ventro-lateral grooves confirms reference to the Family Dimitobelidae.

The evolutionary derivation of *Microbelus* is uncertain. In some aspects of its morphology, the diminutive size and the tapered guard anterior and in the case of *Microbelus tumidus* the poor representation of ventro-lateral grooves, suggests a connection to the Albian *Dimitobelus* *liversidgei*. 
Section A. Albian and Cenomanian Dimitobelidae from Australia

![Figure A. 4. 14 Relationship of Dv_max and Dl_max in Microbelus haigi and Microbelus tumidus.]

**Microbelus haigi sp. nov.**

Pl. 3, figs. 9-13

**Type specimens:** GSWA F51432 (holotype), GSWA F51433- F51436 (paratypes), remainder of type series UWA 2/11/99-16 7– 2/11/99-16 20, upper Gearle Siltstone, Cenomanian, MacDonald Dam, Carnarvon Basin 24°10'S, 114°29'E.

**Additional Material:** approximately 74 guards (UWA 2/11/99-16), both fragmentary and complete, from the mid-Cenomanian (uppermost Gearle Siltstone), MacDonald Dam, Carnarvon Basin.

**Etymology:** In recognition of Professor David Haig, University of Western Australia, who collected most of the specimens.

**Diagnosis:** Guard diminutive and globular, less than 20 mm in length, semi-clavate in shape, point of maximum inflation well posterior of mid-length. Outline is symmetrical; profile asymmetrical. Transverse sections are semi-elliptical and depressed. Apex is eccentric and ventrally placed.

**Dimensions (mm):**

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UWA 2/11/99-16 17 17.6 7.0 2.4 3.2
UWA 2/11/99-16 9 18.0 5.6 3.1 4.0

**Description:** Extremely small in size, with guard length ranging to 18 mm. The guard length is approximately four times the diameter at the position of maximum inflation. The outline is symmetrical and clavate, narrowing anteriorly; profile is asymmetrical and sub-clavate. The maximum lateral (Dl<sub>max</sub>) and ventral (Dv<sub>max</sub>) diameters occur in the posterior third of the guard. The apex ranges from acute to obtuse with apical angles ranging between 15° - 30°. Transverse sections are depressed and subquadrate (Dl<sub>max</sub>:Dv<sub>max</sub> 1.3; Figure A. 4. 14). Ventro-lateral grooves are well developed and deeply incised, extending from the alveolar region to the apex. They are positioned at the margin of the flattened ventral surface. Flanks and dorsal surface are weakly convex. A small pseudoalveolus is commonly developed, obscuring the nature of the alveolus proper. Phragmocone unknown. Apical line is centrally placed, and an apical canal is commonly present.

**Figure A. 4. 15** *Microbelus haigi* sp. nov. UWA 2/11/99-16-1. Transverse section at point of maximum inflation, adapical of mid stem. Note the quadrate shape and flat venter, with two deeply incised ventro-lateral grooves running entire length of guard. Magnification x 30.

**Discussion:** *Microbelus haigi* sp. nov. is a miniature species with a guard which is subquadrate in transverse section, an attribute shared with juvenile *D. dayi* which is also clavate in form, being most inflated in the apical region and gradually tapering to the anterior margin. However, it is easily distinguished from this species other *Dimitobelus* by to its diminutive size and distinctive, strongly marked ventro-lateral
grooves that extend the entire length of the guard. A minute alveolus appears to be present but is commonly overprinted by a small pseudoalveolus, similar to that formed in *D. dayi*.

*Microbelus haigi* appears to have been a species with a short life span, extending over only a few years. Cross-sections (Figure A. 4. 15) show few growth laminae, apparently no more than five in some cases, although those first formed adjacent to the axial canal are poorly preserved and difficult to recognise. Most of the guard is comprised of just one or two thick annual increments followed by slow growth at maturity as registered by one or two thin laminae at the periphery.

**Distribution and Age:** *Microbelus haigi* sp. nov. is known only from the upper Gearle Siltstone, Carnarvon Basin which is Cenomanian in age (Hocking et al., 1987).

### *Microbelus tumidus* sp. nov.

Pl. 3, figs. 7-8

**Type Material:** GSWA F51437 (holotype); GSWA 51438, UWA TP-PP 1-2 (paratypes).

All from Thridine Point, Pillawarra Plateau, Carnarvon Basin, uppermost Gearle Siltstone, 27°36’S, 114°13’E.

**Etymology:** From the latin *tumidus*, recognising the rotund, bulbous outline of this species.

**Diagnosis:** Diminutive guards, less than 11 mm in length, clavate in shape. Apical and stem regions strongly inflated, alveolar region narrow. Transverse sections are semi-elliptical with a depressed ventral surface. Apex is centrally placed.

**Dimensions (mm):**

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**Description:** Extremely small in size with guard length ranging to approximately 11mm and approximately twice the diameter at the position of maximum inflation. The outline is symmetrical and strongly clavate; profile is almost symmetrical and clavate. Apex rounded, apical region is bulbous; the stem region is very short and
guards taper anteriorly to a narrow alveolar region. The maximum lateral diameter (Dl_{max}) is positioned just posterior of the guard mid-length. The dorsal surface and flanks are rounded, whereas the venter is flattened. Transverse sections are depressed and oval (Dl_{max}:Dv_{max} 1.5; Figure A. 4. 14). The apex is centrally placed and the apical angle is strongly obtuse. Faint ventro-lateral grooves extend from the apex to the alveolus, being a little more pronounced in the alveolar region. They are positioned close to the mid-flank. A pseudoalveolus is commonly developed, obscuring the form of the alveolus which is very small if indeed developed. Phragmocone unknown. Apical line is ventrally placed, and an apical canal is commonly formed.

Discussion: Although Microbelus tumidus sp. nov. is represented by only 3 specimens, it is very distinctive with a minute guard which is globular and abbreviated, narrowing abruptly to the alveolar region which is unusually slender. It is distinguishable from M. haigi sp. nov. by its more globular shape.

Age and Distribution: Microbelus tumidus is known only from the upper Gearle Siltstone exposed at Thiridine Point, Pillawarra Plateau, Carnarvon Basin, Western Australia where is associated with juvenile D. diptychus and Dimitobelus sp. nov ? 1. This unit is of Cenomanian age (Campbell and Haig, 1999).

A. 5 Biostratigraphic Summary

The geographic and age distributions of Albian and Cenomanian Dimitobelidae from Australia is summarised in Figure A. 5. 1. Dimitobelus diptychus is long ranging, distributed through the Albian and into the Cenomanian. Dimitobelus dayi and D. stimulus are confined to the Albian. D. liversidgei, D. hendersoni sp. nov. and D. plautus sp. nov have more limited ranges, both chronologically and geographically.. These species occur in separated basins and appear to be short-ranging. Two discrete species left under open nomenclature are restricted to the Carnarvon Basin and are of disjunct (Albian and Cenomanian) ages.

Microbelus is described from two different West Australian localities exposing the upper Gearle Siltstone (Cenomanian) of the Carnarvon Basin succession.
Figure A. 5.1. Summary of the age and distribution of the *Dimitobelus* and *Microbelus* species that are represented within Australia. Diagram not to scale.
Figures 1-13. *Dimitobelus diptychus* (McCoy). 1-12, ventral outline, profile and dorsal outlines. 1, 5, 6, Albian, Carnarvon Basin, Western Australia. UWA 2/11/99-16-1 x2, UWA 2/11/99-16-2 x 2, UWA 2/11/99-16-3 x 2. 2-4, Cenomanian, Carnarvon Basin, Western Australia. UWA TP-PP1 x 1.5, UWA TP-PP2 x 1.5, UWA TP-PP3 x 2.5. 7, syntype, Albian, Eromanga Basin, South Australia. SAM T1311 x 1. 8, Albian, Eromanga Basin, South Australia. NMV P310414 x 1. 9, 10, Late Albian, Carnarvon Basin, West Australia. UWA 2/11/99-15-1 x 1, UWA 2/11/99-15-2 x 1. 11, cast of holotype, Albian, Eromanga Basin, Queensland. NMV P2177 x 1. 12, Albian, Eromanga Basin, Queensland. JCU F11617 x 1.5. 13, left profile and inner, Albian, Eromanga Basin, South Australia. SAM T1312 x 1.
EXPLANATION OF PLATE 2


Figure 10. *Dimitobelus plautus* sp. nov. 10, ventral outline, profile and dorsal outline, Albian, Laura Basin, Far North Queensland. QMF 33232 x 1.

Figure 11. *Dimitobelus* sp. indet. 11, ventral outline, profile and dorsal outline. Albian, Laura Basin, Far North Queensland. JCU 11620 x1.
EXPLANATION OF PLATE 3

Figures 1 - 3. *Dimitobelus* sp. nov.? 1-3 ventral outline, profile and dorsal outline. 1, upper Cenomanian, Carnarvon Basin, Western Australia. GSWA F51427 Boologooro 1 289.0 m, x 1.75. 2, Cenomanian, Carnarvon Basin, Western Australia x 1.5. GSWA F51428 Boologooro 1 294.4 m, x 1.75. 3, Cenomanian, Carnarvon Basin, Western Australia. GSWA F51426, x 1.3.

Figure 4. *Dimitobelus* sp. nov.? 2. 4, ventral outline, profile and dorsal outline. Late Albian, Carnarvon Basin, Western Australia. GSWA F51429 x 2.5.

Figure 5 and 6. *Dimitobelus (?)hendersoni* sp. nov. 5, 6 ventral outline, profile and dorsal outline. 5, Late Albian, Carnarvon Basin, Western Australia. GSWA F51430 x 1. 6, Late Albian, Carnarvon Basin, Western Australia. GSWA F51431 x 1.

Figure 7 and 8. *Microbelus tumidus* sp. nov. 7, 8 ventral outline, profile and dorsal outline. 7, holotype, Cenomanian, Carnarvon Basin, Western Australia. GSWA F51437 x 3.5. 8, paratype, Cenomanian, Carnarvon Basin, Western Australia. GSWA F51438 x 3.5.

Figs. 9-13. *Microbelus haigi* sp. nov. 9-13 ventral outline, profile and dorsal outline. 9, holotype, mid Cenomanian, Carnarvon Basin, Western Australia. GSWA F51432 x 3. 10, paratype, mid Cenomanian, Carnarvon Basin, Western Australia. GSWA F51433 x 3. 11-13, mid Cenomanian, Carnarvon Basin, Western Australia. GSWA F51434-F51436 x 3.