

REVISION OF AN EARLY ARENIG TRILOBITE FAUNULE FROM THE CAROLINE CREEK SANDSTONE, NEAR LATROBE, TASMANIA

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Abstract

A trilobite faunule from the Caroline Creek Sandstone near Latrobe, Mersey District, Tasmania is revised with five species being recognised, namely, *Etheridgaspis carolinensis* (Etheridge), *Carolinites tasmaniensis* (Etheridge), *Tasmanocephalus stephensi* (Etheridge), *Parabasilius ? lewisi* (Kobayashi), *Protoencrinurella ? subquadrata* (Kobayashi). *Carolinites tasmaniensis* is recognised as a senior synonym of the type species of the genus, *C. bulbosus* Kobayashi, and of *C. genacinaca nevadensis* Hintze. *Tasmanocephalus* is referred to the Missisquoiidae and *Etheridgaspis* to the Hystriacnidae. The age of this faunule is considered to be early Arenig (*D. deflexus* zone).

Introduction

The fauna of the Caroline Creek Sandstone has not been fully described but a trilobite faunule from a prolific locality near Latrobe in the Mersey River District of northern Tasmania (Fig. 1) was extensively collected during the latter part of the nineteenth century and collections dispersed to numerous museums in many parts of the world. Robert Etheridge Jr (1883) published the first taxonomic study of this material. He erected *Conocephalites stephensi* for a number of cranidia and *Dikelocephalus tasmaniensis* for several pygidia, as well as referring to two species of *Asaphus* and four generically-unassigned species of ptychoparioids in open nomenclature. He concluded that the age was equivalent to that of the Lingula Flags in Britain and the Potsdam Sandstone of North America (i.e. Late Cambrian).

In 1919 Etheridge revised the taxonomy of the faunule without illustration. He assigned *Dikelocephalus tasmanicus* to *Crepicephalus* and recognised that *Conocephalites stephensi* was the cranidium of the same species. He erected three species for the four non-asaphids he had left in open nomenclature in 1883 and referred them questionably to *Ptychoparia*.

The further study of this faunule was undertaken by Kobayashi (1936, 1940). In 1936 he reported on the collection in the British Museum (Natural History) recognising the generic distinctions of Etheridge's species *stephensi* with the name *Tasmanocephalus* and

assigning an Early Ordovician age to the faunule. In 1940 he carried out a full revision based on a new collection sent to him by Dr A. N. Lewis but unfortunately did not refer to the original material of Etheridge. He erected two genera (*Carolinites* and *Etheridgaspis*) and four species (*C. bulbosa*, *C. quadrata*, *Prosopiscus ? subquadrata* and *Asaphellus lewisi*) assigning two of Etheridge's 1919 species (*carolinensis* and *johnstoni*) to his second new genus.

Subsequent references to this faunule have relied upon Kobayashi's determinations (e.g. Banks, 1962) but no further taxonomic study has been attempted. With the recognition of the biostratigraphic utility of species of *Carolinites* in several parts of the world and revision of *C. bulbosus* by Henderson (1983), still not based on Etheridge's material, a review of the whole faunule has once again become necessary.

Latex casting techniques provide greater morphological detail than was previously available. We have attempted to illustrate as many specimens as possible to provide fuller understanding of each taxon and to avoid misinterpretations based on too few, often deformed specimens.

In the face of relatively poor preservation (see below) we have been fortunate in having available not only the collection of the Tasmanian Museum (prefixed Z) including the type collections of both Etheridge (1883) and Kobayashi (1940) but also two large topotype collections; one is the George Sweet Collection

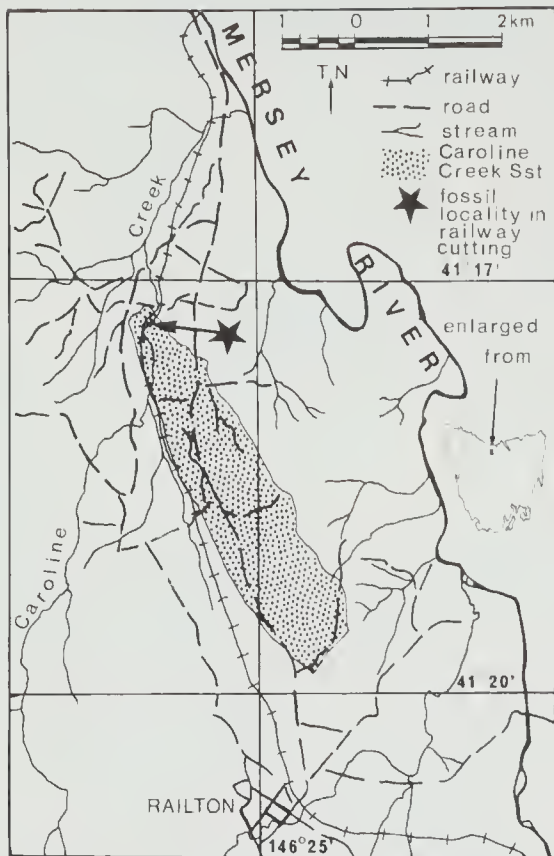


Figure 1. Locality map redrawn from Sheffield 1 mile to 1 inch geological map, Geological Survey of Tasmania.

housed in the Museum of Victoria (prefixed NMVP) and the other in the Australian Museum, Sydney (prefix AMF) acquired by exchange with the Tasmanian Museum probably on the initiative of R. Etheridge Jr.

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Age of the faunule

Although originally thought to be of Cambrian age (Etheridge, 1883) Kobayashi (1936,

1940) and subsequent authors recognised their Early Ordovician age. The faunule as here revised contains:

Etheridgaspis carolinensis (Etheridge, 1919)

Tasmanocephalus stephensi (Etheridge, 1883)

Carolinites tasmaniensis (Etheridge, 1919)

Parabasilius ? lewisi (Kobayashi, 1940)

and *Protoencrinurella ? subquadrata* (Kobayashi, 1940)

The first two listed species are not known from outside Tasmania and the last two listed species are too poorly known to be useful for precise correlation, although *Protoencrinurella* in association with *Carolinites* may have some significance (see below). Fortey (1975) has shown the utility of species of *Carolinites* for biostratigraphic subdivision of the Arenig and Llanvirn of Spitsbergen and it seems reasonable to use the same tool for age determination of the Caroline Creek Sandstone faunule.

The synonymy of *C. tasmaniensis* (see below) including *C. genacinaca nevadensis* Hintze, allows direct correlation with the top few metres of the Kirtonryggen Formation and basal 3 m of the Olenidsletta Member of the Valhallfonna Formation. This level was correlated (Fortey, 1976) with the early Arenig *D. deflexus* graptolite zone of the British sequence based on the co-occurring graptolites. Legg (1978) showed *Carolinites* and *Protoencrinurella* first appearing in his fauna 3a so that if this association in the Caroline Creek Sandstone was contemporaneous the same correlation through the early Bendigonian of Victoria to the *D. deflexus* zone of Britain is achieved (Legg, 1978, fig. 7; Skevington, 1963). However, Legg's (1976) *C. bulbosus* material appears conspecific with *C. genacinaca* Ross, 1951.

The only other attempt to correlate this faunule with a particular Arenig zone was by Singleton (in Banks, 1962) who provided a late Arenig age in the zone of *D. hirundo*. He gave no explanation of the basis for this correlation, thus preventing evaluation. However, from the range of *C. tasmaniensis* in Spitsbergen and the allied *C. genacinaca* in Spitsbergen and Western Australia this correlation appears

unreasonable. Unfortunately that dating of the faunule has been followed by some subsequent collators (e.g., Banks and Burrett, 1980, p. 365; Webby *et al.*, 1981) although confusion is apparent in other discussions of its correlation. We are able to conclude that the trilobites described below from the Caroline Creek Sandstone indicate an early Arenig age (i.e. early Bendigonian in the Victorian graptolite sequence or *D. deflexus* zone in the British succession) which is somewhat older than previously thought.

Preservation

The fossils are contained in a ferruginous, fine to medium grained sandstone as internal and external moulds of disarticulated exoskeletal components. There has been some post-depositional deformation of most specimens, the amount depending on the orientation in the bedding plane. Although most often showing some skewness in the bilateral symmetry, the deformation may be directly in the sagittal or transverse direction so that measurements of specimens could not be used confidently in comparative studies. Moreover, we believe that it was this distortion which induced Etheridge to recognise a second asaphid species in 1883 and a second species of *Etheridgaspis* in 1919 and Kobayashi (1940) to recognise a second species of *Carolinites*.

The coarseness of the matrix has in most cases allowed penetration of latex into pore spaces at the mould surface so that the latex cast appears to be finely pustulose. However, in most cases the very irregular nature of the pustules makes it obvious that they are not of biological origin. The tubercular ornament of *E. carolinensis* is evident on internal moulds, so this, and the terrace lines on *Tasmanocephalus*, are clearly exoskeletal ornament.

The relatively coarse matrix and disarticulated exoskeletal fragments, and endemic nature of most of the species suggest a fairly high energy and nearshore (respectively) environment of deposition.

Systematic palaeontology

Terminology follows Harrington, Moore and Stubblefield (1959) as far as possible; glabella in-

cludes occipital ring; all dimensions in the sagittal or exsagittal direction are discussed in terms of length and all dimensions in the transverse direction are discussed in terms of width (for example the anterior cranial border whose sagittal dimension is often important in specific description is described in terms of long or short in our terminology). The state of preservation of the fossils removes any confidence in the use of any biometrics so no measurements or reconstructions are included in the descriptions; sizes of individuals are indicated in the explanations of plates and most distinguishing characters are not measurements.

Class Trilobita

Family Hystricuridae Hupe, 1953

Etheridgaspis Kobayashi, 1940

Type species (by original designation):
Ptychoparia ? carolinensis Etheridge, 1919.

Diagnosis: Hystricurids with rounded glabellar anterior, almost parallel-sided glabella; well-impressed pit-like 1p glabellar furrow isolated from axial furrow; shallow 2p glabellar furrow low at axial furrow; preglabellar field shorter than short uniform anterior border; palpebral lobe wide, defined by well-impressed palpebral furrow, situated level with midlength of glabella, becoming longer with growth; librigena with high eye socle, elevated rear area of genal field and strong genal spine. Pygidium transverse; axis of four rings and long terminus reaching border furrow; pleural and interpleural furrows impressed; border narrow, poorly differentiated, convex in section.

Remarks: *Etheridgaspis* was placed by Kobayashi (1940) in the Solenopleurinae along with *Hystricurus* Raymond, 1913 but Henningsmoen (in Harrington *et al.*, 1959) was unable to assign it to an order or family. Important similarities with *Hystricurus* and other members of the Hystricuridae make assignment to that family quite likely. Structure of the anterior of the cranidium, size, shape and position of the palpebral lobe, shape of posterior cephalic limb, impression of pleural and interpleural furrows on pygidium and structure

of pygidial border all suggest relationship with the Hystricuridae. The major distinguishing feature is the well-impressed 1p glabellar furrow and distinct 2p furrow but it should be noted that several lineages thought to have begun in the Hystricuridae (Chatterton, 1971; Fortey & Owens, 1975) involved definition and then deepening of the glabellar furrows. *Omuliovia* Chugaeva, 1962 (type species *O. mira* Chugaeva, 1962) appears superficially similar to *Etheridgaspis* but is clearly distinguished by its lack of a preglabellar field, faint glabellar furrows, its entirely different palpebral structure in particular the course of the palpebral furrow, and its wide concave pygidial border. If this similarity has any phylogenetic basis it could be used in support of the suggestion by Fortey & Owens (1975) that the Bathyuridae, where *Omuliovia* is placed, may have evolved from the Hystricuridae.

In the absence of a clear understanding of a lineage beyond *Etheridgaspis* we assign it to the Hystricuridae but recognise the difficulty of expanding the family concept to include forms with well-impressed glabellar furrows, which may ultimately make diagnosis of the family impossible and force *Etheridgaspis* out.

***Etheridgaspis carolinensis* (Etheridge, 1919)**

Plate 14, figures 1-15; plate 18, figure 15;
text-fig. 2

- 1883 *Conocephalites stephensi* Etheridge, pl. 1, fig. 3 and librigena in fig. 2 (NOT pl. 1, figs 1, 2).
1883 (?) *Conocephalites* sp. Etheridge, pp. 156, 162, pl. 1, figs 8, 9, 11.
1883 (?) *Conocephalites* sp. Etheridge, p. 157, 162, pl. 1, fig. 10.
1888 *Conocephalites* sp. indet. Johnston, p. 37, pl. 1, figs 7, 10, 11, 16.
1888 *Conocephalites stephensi* Etheridge; Johnston, pl. 1, fig. 14 (NOT figs 3, 4).
1919 *Ptychoparia* (?) *carolinensis* Etheridge, p. 391.
1919 *Ptychoparia* (?) *johnstoni* Etheridge, p. 392.
1940 *Etheridgaspis carolinensis* (Etheridge); Kobayashi, p. 71, pl. 12, figs 10, 11.
1940 *Etheridgaspis johnstoni* (Etheridge); Kobayashi, p. 72, pl. 12, figs 12-14.
1940 *Carolinites bulbosa* Kobayashi, pl. 12, fig. 7 (NOT fig. 6).

Lectotype (designated herein): Z1385 the incomplete cranidium figured by Etheridge (1883, pl. 1, figs 8, 9) and herein (Text-fig. 2A, B).

Other material: The specimens of both *E. carolinensis* and *E. johnstoni* figured by

Etheridge (1883) and Kobayashi (1940) as well as some 40 or 50 disarticulated cranidia, librigenae, and pygidia in the Sweet collection and in the Australian Museum Collection.

Diagnosis: As for genus.

Description: Cranidium of low convexity with glabella standing above abaxially rising cheeks; glabella longer than wide (but exact shape uncertain as all cranidia exhibit some post depositional distortion and an undistorted specimen could not be recognised), with straight only slightly forwardly converging lateral margins, with well-rounded anterior, with broad median ridge and evenly sloping sides down to the axial furrow, with two pairs of lateral glabellar furrows; furrow 1p very distinctive, isolated from axial furrow, pit-like on internal moulds but slightly elongate oblique to the axis on the external surface; furrow 2p joining the axial furrow, narrow and relatively indistinct; lobes 1p and 2p of equal length but with frontal lobe occupying nearly half glabellar length; occipital furrow well-impressed, of uniform length, transverse; occipital ring of uniform length, as long as lobe 1p, without median node; preglabellar field very short, of variable length due to distortion after burial; anterior border furrow well-impressed, as long as anterior border, of uniform length; anterior border short, convex, gently arched both forward in dorsal view and upwards in anterior profile, of uniform length; fixigenae narrow (approximately as wide as occipital ring length), rising up abaxially; palpebral lobe short, wide (as wide as interocular cheek), with arcuate abaxial margin but approximately exsagittal adaxial margin defined by palpebral furrow, convex in anterior profile, raised above cheek; palpebral furrow broad, shallow, but distinct, in exsagittal line, finishing forward against a very indistinct eye ridge, continuing posteriorly behind lobe into broad librigenal furrow beneath eye; posterior cephalic limb short and wide, projecting beyond palpebral lobes, occupied mainly by long posterior border furrow; posterior border short, of uniform length except adaxially (tapering to axial furrow); faeial suture diverging gently forward from the palpebral lobes,

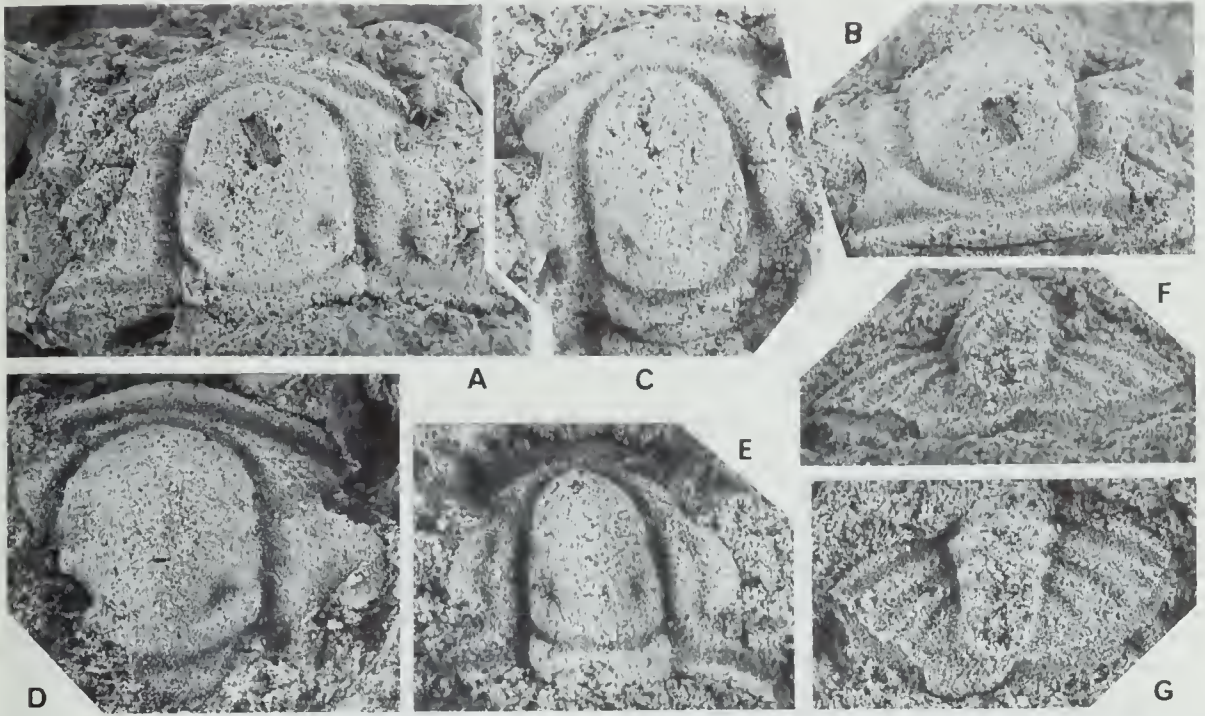


Figure 2. *Etheridgaspis carolinensis* (Etheridge, 1919). All internal moulds. A, B, dorsal and anterior oblique views of lectotype cranidium Z1385, $\times 4$. (Figured by Etheridge, 1883, pl. 1, figs 8, 9). Matrix has been prepared away to expose posterior cephalic limbs. C, cranidium Z1386, $\times 4$. (Figured by Etheridge, 1883, pl. 1, fig. 10). D, cranidium Z1380D, $\times 4$. E, cranidium Z146A, $\times 6$. (Figured by Kobayashi, 1940, pl. 12, fig. 12). F, G, posterior and dorsal views of pygidium Z146B, $\times 5$. (Figured by Kobayashi, 1940, pl. 12, fig. 13).

straight for the short distance to the anterior border then turning adaxially in rather angular change of direction before crossing border diagonally over a short distance. Librigena with high convex visual surface attached; visual surface sloping forward, very short and globular in juveniles but more elongate with ends less curved in larger specimens, with wide shallow furrow running beneath it on librigena; genal field highest just behind eye, sloping both abaxially and anteriorly with base of visual surface sloping at same angle as genal field, extremely narrow anteriorly, widest along posterior margin, with posterior margin transverse along facial suture and including part of posterior border furrow abaxially; lateral border furrow wide, well-impressed, with marked shallowing posteriorly near base of genal spine; border convex, of uniform width, with terrace lines near margin, extended posteriorly into strong

genal spine of approximately half length of librigena; doublure extending forward of genal field indicating a normal ptychoparioid rostral suture pattern.

Pygidium transverse, with axis strongly convex and standing high above pleural fields; axis of three clearly defined rings and posteriorly rounded terminus twice as long as each ring, extending to edge of border furrow; tapering only gently posteriorly; pleural area crossed by well-impressed pleural furrows becoming more posteriorly directed towards the rear, with each rib bearing a shallow but distinct interpleural furrow; border furrow ill-defined; border defined more by lack of pleural furrows than by border furrow, flat on top but with convex roll over margin, with slight posteromedial invagination.

Ornament over entire exoskeleton, except for furrows, consisting of fine granules spread

sparsely and a dense set of fine pustules in between.

Remarks: Although both Etheridge (1883, 1919) and Kobayashi (1940) recognised two species of this genus from the one locality we consider that the variation in width of glabella, in length of prelabellar field and anterior border, and in width of cheeks is all due to post depositional distortion which affected almost every specimen examined from this locality. This distortion is so common that no confidence can be attached to measurements of relative proportions of the glabella. The variation in these features is not due to growth, as small cranidia (e.g., Pl. 14, fig. 11) may have short wide glabellae of similar proportions to larger ones. Another feature of note is the variation in the degree of arching of the anterior margin of the cranidium when viewed from above—this variation which is also the result of distortion indicates that anterior border and preglabellar field have been distorted and should not be used (especially their dimensions) for specific discrimination. For these reasons we are convinced that this single locality yields remains of only one species of *Etheridgaspis*.

Family TELEPHINIDAE Marek, 1952

***Carolinites* Kobayashi, 1940**

Type species (by original designation):
Carolinites bulbosus Kobayashi, 1940 =
Carolinites tasmaniensis (Etheridge, 1919).

Remarks: This genus has been the centre of considerable study over the last 35 years with the most exhaustive treatment by Fortey (1975). This restudy of the type species serves to clarify its synonymy; the generic concept and affinities have been adequately covered previously.

***Carolinites tasmaniensis* (Etheridge 1919)**

Plate 15, figures 1-17

- 1883 'fragmentary head shield, allied to *Bathyrurus*'
Etheridge, p. 157, pl. 1, fig. 12.
1888 *Bathyrurus* (?) sp. Johnston, p. 37, pl. 1, fig. 19.
1919 *Ptychoparia* (?) *tasmaniensis* Etheridge, p. 392.
1940 *Carolinites bulbosa* Kobayashi, p. 70, pl. 12, fig. 6
(NOT pl. 12, fig. 7).
1940 *Carolinites quadrata* Kobayashi, p. 70, pl. 12, figs 8,
9.
1940 *Carolinites* (?) *tasmanensis* (sic) Etheridge;
Kobayashi, p. 71.

- 1953 *Carolinites genacinaca nevadensis* Hintze, p. 146, pl.
20, figs 3-6.
1970 *Carolinites* ex gr. *genacinaca* Ross; Bursky, p. 103,
pl. 6, fig. 10.
1975 *Carolinites genacinaca nevadensis* Hintze; Fortey, p.
115, pl. 38, figs 4-13.
NOT
1976 *Carolinites bulbosa* Kobayashi; Legg, p. 5, pl. 1, figs
20, 25, 26, 29, 30, 34.
NOT
1983 *Carolinites bulbosus* Kobayashi; Henderson, p. 146,
fig. 1A-H, K.

Material: Holotype Z1387. The material of Kobayashi (1940) as well as the specimens figured herein and a number of others in the Sweet Collection and the Australian Museum Collection are all available topotypes.

Diagnosis: Member of *Carolinites* with bacculae of variable size but always smaller than in other known species; glabella broadly rounded anteriorly; fixed cheeks of variable width but generally narrow. Librigena with strongly inflated band subparallel to base of eye; genal spine not longer than librigenal length, straight and in exsagittal line, not expanded at base, arising from near posterior of cheek. Pygidium with two transaxial furrows well impressed and a third poorly impressed; border furrow well impressed; pleural areas narrow and protruding.

Description: Glabella subquadrate, with greatest width generally about 0.25 of length from anterior, forward expansion extremely weak, rounded anterolateral corners and broadly rounded to slightly flattened anterior, without lateral glabellar furrows; occipital furrow deep, transverse, short; occipital ring flat in lateral profile, of uniform length except laterally, shortening slightly and turning forward laterally to run across axial furrow as low ridge into posteroproximal corner of fixigena at baccula; bacculae of variable size but always quite small; fixigena triangular in shape, flat to slightly sloping laterally, narrow; palpebral lobe narrow, defined by well impressed palpebral furrow with marked ridge on its adaxial edge; posterior border furrow well impressed, shorter than posterior border, of uniform length. Librigena with large bulbous visual surface, narrow, with distinct furrow beneath eye then prominent ridge subparallel to margin of eye just abaxial to the furrow and disappearing for-

ward where border and eye converge, with genal spine no longer than librigena itself arising from posterior part of librigena and lying almost in an exsagittal line, with lower margin of visual surface at low angle to plane of genal spine and posterior border (eye apparently tilted forward).

Pygidium convex with axis standing high above pleural areas; axis crossed by two well impressed transaxial furrows and a third poorly impressed transaxial furrow, consisting of three rings and short ill-defined terminus with steep posterior slope; pleural area narrow, of almost uniform width throughout, crossed by three distinct pleural furrows, markedly convex, with prominent protruberance from posterior rib; border furrow well impressed, overhung by pleural areas so not visible in dorsal view except posteriorly; border narrow, uniform.

Remarks: Examination of the specimen figured by Etheridge in 1883 (pl. 1, fig. 12) and later (1919) named *Ptychoparia ? tasmaniensis* showed that it was conspecific with Kobayashi's *Carolinites bulbosa* and had been misrepresented in the original line drawing. The reason was probably that he drew the edge of the border at the edge of the piece of rock and then misinterpreted the border (which was actually inside but parallel to the edge of the rock) as a preglabellar field—a natural mistake after just drawing three cranidia of *Etheridgaspis carolinensis* where this arrangement occurs. Significantly the glabella was correctly shown with a subtle forward expansion and this feature alone confirms that the illustration is of a *Carolinites* specimen among the species now known from the site. The holotype is figured herein (Pl. 15, fig. 7) after preparation to remove more of the external mould on the right cheek. Kobayashi (1940, p. 71) clearly did not look at the holotype but discussed Etheridge's figure only. The palpebral lobes were not illustrated by Etheridge and Kobayashi's comment on the size of the eye is not applicable when the extra preparation exposes its full extent. His reference to a broad free cheek is an error as he had no free cheek available and probably meant fixed cheek; the fixigena is of comparable width to that of other cranidia of this species which have narrower fixigena than other

species of the genus. Convexity of the glabellar anterior is not an admissible feature in this collection of variously distorted cranidia. Examination of some 50 topotype cranidia shows that only one species of *Carolinites* is present, that being Etheridge's *C. tasmaniensis* with *C. bulbosus* and *C. quadratus* of Kobayashi as junior subjective synonyms.

Fortey (1975, p. 102) outlined the diagnostic features of *G. genacinaca nevadensis* Hintze as small bacculae barely indenting the base of the glabella, relatively narrow fixigenae for the genus, straight genal spine originating posteriorly on the librigena, an inflated band parallel to the base of the eye on the librigena, and only two pygidial axial rings clearly defined by deep transaxial furrows. He stated that the inflated librigenal band was perhaps the most diagnostic of all and we agree fully. *Carolinites tasmaniensis* has all these attributes and must be considered the senior synonym of *C. genacinaca nevadensis*. The Australian material identified as *C. bulbosus* by Legg (1976) and Henderson (1983) has the glabella more indented by bacculae, has wider fixigenae, and the genal spines are well advanced on the librigenae. All of these features suggest *C. genacinaca* Ross, 1951 as noted by both those authors. The librigena of Legg (1976, pl. 1, fig. 29) does appear to have the inflated band but it is not clear if all his material is from one horizon or not and a more detailed study would be necessary to determine whether or not more than one species is represented in Legg's *C. bulbosus*.

Family MISSISQUOIIDAE Hupe, 1955

The family was restricted (Shergold, 1975; Ludvigsen, 1982) to include only *Missisquoia* Shaw, 1951 and *Parakoldinioidia* Endo, 1937 but Fortey (1983) considered these two genera as synonymous. He separated *Lunacrania* Kobayashi, 1955 within the family on the basis of "minute palpebral lobes well removed from the glabella". The cheeks in his species of *Lunacrania* are narrower relative to the width of the glabella than in *P. depressa* Stitt, 1971 where the interocular cheek is also only slightly narrower than the glabella. Moreover, Fortey (1983, p. 196) acknowledged narrower fixed

cheeks within *Lunacrania* so the only generic taxobase could be size of the palpebral lobes. This hardly seems a satisfactory generic taxobase when the palpebral structure of his (Fortey, 1983, pl. 25, figs 5 and 9) specimens attributed to *Parakoldinioidia* and *Lunacrania*, respectively, are compared; the length appears to be little different and the width, if different, would be no more than a specific taxobase. As the characters quoted by Fortey (1983) appear to grade through the species assigned to *Parakoldinioidia*, *Lunacrania* and *Missisquoiia* and as no other features present themselves as generic taxobases we consider that the senior synonym, *Parakoldinioidia*, may encompass all the species of the Missisquoidae considered by Shergold (1975), Ludvigsen (1982) and Fortey (1983). However, no diagnosis has been offered since 1955. There do appear to be good reasons for this oversight because each family character is found in genera outside the family and the pygidia included seem to have no unifying features. Perhaps most diagnostic of the family are the transverse (or almost so) lateral glabellar furrows, the anteromedian glabellar notch, and the posteriorly situated palpebral lobes. The marginal pygidial spines are not considered to be more than generically significant, if that, because production of a macropleural segment in the pygidium appears to have been a relatively simple process occurring in a number of trilobite families. *Tasmanocephalus* may be regarded as having descended from *Parakoldinioidia*, most probably from the *M. depressa* side of the genus with accompanying development of a macropleural segment in the pygidium and reduction in size and posterior migration of the palpebral lobe.

No known trilobites appear to have descended directly from *Tasmanocephalus*. However, a comparison of *T. stephensi* with species of *Perischoclonus* Raymond, 1925 (see Whittington, 1963, pl. 22) and *Raymondaspis* Pribyl in Prantl & Pribyl, 1949 (see Whittington, 1965, pls 55-59) prompts us to conclude that *Tasmanocephalus* may be an offshoot from an evolutionary lineage leading from *Parakoldinioidia* through *Perischoclonus* to *Raymondaspis* or at least from the Missisquoidae to the Styginidae. Particularly significant in

Perischoclonus and *Raymondaspis* are isolation of 2p and 3p glabellar furrows from the axial furrow with markedly divided eye ridges reaching axial furrow at glabellar lobe 3p (Whittington, 1965, pl. 22, figs 4, 6), the anteromedian notch and small posteriorly-situated palpebral lobes (Whittington, 1963, pl. 22, figs 2, 4 and 1965, pl. 56, figs 6-10), wide cranial border constricted in front of glabella, low ridge running from the anterolateral corners of the glabella into fixigena (Whittington, 1963, pl. 22, figs 1, 4 and 1965, pl. 58, fig. 4), and structure of the hypostome with long almost exsagittal median furrows on the median body (Whittington, 1965, pl. 55, figs 2, 7, 8). The forward expanding glabellae of *Perischoclonus* and *Raymondaspis* are a progression from the subrectangular to slightly expanding glabellae in *Tasmanocephalus* and subrectangular or tapering glabellae of *Parakoldinioidia*. Development of styginid morphology involves progressive effacement of furrows and widening of the border most noticeably in the pygidium but the juvenile pygidium of *Raymondaspis* (Whittington, 1965, pl. 57, fig. 10) has pleural and interpleural furrows well-impressed and the pleural ribs are extended into short spines, much as in *Parakoldinioidia*. The postaxial median ridge of *P. depressa* (Stitt, 1971, pl. 8, fig. 8) is present in *Raymondaspis* but is broader in *Perischoclonus* and less distinct in *Tasmanocephalus*. With sufficient common features to link these four genera we suggest that evolution from the Missisquoidae to the Styginidae took place on the North American craton with *Tasmanocephalus* representing a lineage that migrated to Australia during the late Tremadoc.

This phylogenetic placement for *Tasmanocephalus* lends weight to the arguments of Ludvigsen (1982, p. 119) that out of the Leiostegioidea the Missisquoidae gave rise to the Styginidae. Lane & Thomas (1983, p. 155) preferred to derive the Styginidae from the Corynexochida without investigating Ludvigsen's proposal closely. However, features quoted in support of their alternative, namely a postaxial ridge on the pygidium, an anteriorly expanding glabella extending far forward and

the type of hypostome are all known in *Parakoldinioidia* and/or *Tasmanocephalus*. The only other feature quoted, width of the rostral plate, seems to us less important than the attitude of the connective sutures and the width relative to hypostomal width. In the Corynexochida connective sutures are normal to the margin whereas in Missisquoiidae and Styginidae they are markedly oblique across the doublure. A number of the rostral plates attributed to their Scutelluina and figured (Lane & Thomas, 1983, text-fig. 3) recently are narrow if measured posteriorly and indeed styginid rostral plates narrower than the hypostome are not uncommon (e.g. Harrington *et al.*, 1959, figs 275, 276. To our knowledge the rostral plate is always wider than the hypostome in the Corynexochida.

The inadmissible nature of these criteria apart, the Corynexochida lack the anteromedian glabellar notch of the Missisquoiidae and early Styginidae, a feature that, although known in several trilobite lineages in different superfamilies, could be confidently expected in the ancestral stock, even if only in the early growth stages, of a family like the Missisquoiidae where it is universally present. Moreover, the Corynexochida in general have relatively long palpebral lobes contrasting with the generally short palpebral lobes of the Missisquoiidae, Styginidae, and derivatives of the latter family. It seems most likely that the one or two species whose palpebral lobe length is at odds with this generalisation have derived that character along offshoots from the main development of the groups.

Homeomorphous similarities between Corynexochida and Missisquoiidae, Styginidae etc., particularly in the glabella, are considered to result from development of the same feeding habit and therefore the same anterior alimentary specialisations in two separate stocks of trilobites. In categorising trilobite morphologies based on inferred feeding habits Jell (1981) proposed the dorypygid morphology with bulbous, anterolaterally expanded glabella reaching anterior border furrow; large pygidium often spinose; fewer than 10 thoracic segments. The Corynexochida, early Styginidae and a number of Leiosteigioidea including

Missisquoiidae exhibit this broad morphology but phylogeny is established on other features.

Tasmanocephalus Kobayashi, 1936

Type species (by original designation): *Conocephalites ? stephensi* Etheridge, 1883.

Diagnosis: Glabella subrectangular, with three pairs of well-impressed almost transverse lateral furrows, with 1p furrow expanded posteriorly at adaxial end, with distinct invagination (probably a muscle attachment site) anteromedially; preglabellar field absent; anterior border shorter in front of glabella; palpebral lobes short, situated well away from glabella and well to posterior opposite glabellar lobe 1p; rostral plate narrow; librigena with long flat genal spine deflected laterally, with border furrow extending onto genal spine. Pygidium with long axis of seven or more rings plus a long terminus reaching border furrow; pleural areas with pleural and interpleural furrows impressed; border distinct, narrow, defined by very shallow furrow; pair of strong marginal spines arising from border adjacent to end of fourth pygidial segment.

Remarks: *Tasmanocephalus* is very similar to *P. depressa* in cranial features such as glabellar furrows, glabellar shape and convexity, anteromedian glabellar notch, low ridge from anterolateral corners of glabella, structure of the border, short wide posterior cephalic limb, and structure of the hypostome with long almost exsagittal median furrow. However, position and structure of the palpebral lobes, course of the eye ridge and structure of the pygidial border and marginal spines are sufficient to separate these two genera. *Raymondaspis* is distinguished by its glabellar shape, less distinct glabellar furrows, general effacement of all furrows particularly on the pygidium, and kidney-shaped palpebral lobe close to the glabella. *Perischoclonus* may be distinguished by its lack of an anteromedian glabella notch, its less prominent eye ridges, its smaller 2p and 3p glabellar furrows, its better impressed pleural furrows, and its lack of marginal pygidial spines. Hintze (1953, p. 227) claimed 'considerable resemblance' between his *Pseudoolenoides* and *Tasmanocephalus* but it

would appear that his genus, if related at all, is related to the *P. stitti* side of *Parakoldinioidea* with the convex glabella having furrows low on the side, narrow convex border, and more elongate subtriangular pygidium. These features, among others, distinguish it from *Tasmanocephalus*.

***Tasmanocephalus stephensi* (Etheridge, 1883)**

Plate 16, figures 1-14; plate 18, figures 8-12;
text-fig. 3

- 1883 *Conocephalites* ? *stephensi* Etheridge, p. 153, pl. 1, figs 1, 2. (NOT pl. 1, fig. 3 or librigena in fig. 2).
1883 *Dikelocephalus tasmanicus* Etheridge, p. 155, pl. 1, fig. 4.
1888 *Conocephalites stephensi* Etheridge; Johnston, p. 37, pl. 1, figs 3, 4 (NOT librigena in 4).
1888 *Dikelocephalus tasmanicus* Etheridge; Johnston, p. 37, pl. 1, fig. 8.
1919 *Crepicephalus tasmanicus* (Etheridge); Etheridge, p. 390.
1936 *Tasmanocephalus stephensi* (Etheridge); Kobayashi, p. 180, pl. 20, figs 11-14; pl. 21, figs 2-4. (NOT pl. 21, fig. 1 or the librigena in fig. 2).
1940 *Tasmanocephalus stephensi* (Etheridge); Kobayashi, p. 69, pl. 12, figs 1-4.
1940 Free cheek gen. et sp. indet. Kobayashi, pl. 12, fig. 15.
1940 *Asaphellus lewisi* Kobayashi, pl. 12, fig. 18. (NOT pl. 12, figs 16, 17, 19).

Lectotype (designated herein): Z1378 the damaged cranidium figured by Etheridge (1883, pl. 1, fig. 1) and herein (Pl. 16, fig. 12).

Diagnosis: As for genus.

Description: Moderately large trilobite of fairly low convexity. Cranidium subrectangular with only posterior limbs projecting beyond this shape; glabella also subrectangular, between 0.3 and 0.5 times as wide as long, appearing to expand very gently forward in some specimens to a widest point at the posterior of the frontal lobe, anterior truncated to very broadly convex forward, with three pairs of lateral glabellar furrows and distinct anteromedian indentation in glabella; furrow 1p with deep pit near adaxial end, possibly forked adaxially, angled slightly behind transverse line from axial furrow adaxially, well-impressed at axial furrow; furrow 2p also with deeper pit adaxially, shallowing at axial furrow and appearing in some individuals to be isolated from axial furrow, running transversely; furrow 3p closer to axial furrow than 2p, shallower than 2p, almost isolated

from axial furrow, transverse; lobes 1p, 2p, and 3p almost equal in length, lobe 1p longest abaxially, 2p longest adaxially; frontal lobe almost twice as long as any of others; occipital furrow well impressed, with marked apodemes laterally, curving forward laterally but transverse medially; occipital ring shortest laterally behind apodemes, flat to gently convex in lateral profile; axial furrow well-impressed, with marked pit anteriorly in front of eye ridge but behind strong trunk issuing from anterolateral corner of glabella just behind border furrow; eye ridge prominent, running into posterior corner of frontal glabellar lobe as low ridge across axial furrow, consisting of two parallel trunks widely separated by distinct furrow through medial part of its extent but unseparated at ends; palpebral lobe short, highly arcuate, elevated around outer edge, elevated above cheek, situated opposite lobe 1p; fixed cheeks rising up abaxially, but with palpebral lobe sharply elevated above cheek, with distinct caecal network of fine ridges running forward from eye ridge; posterior cephalic limb short, wide but only half width of interocular cheek; posterior border furrow well-impressed, as long as posterior border, occupying most of posterior cephalic limb; preglabellar field absent; anterior of glabella encroaching into posterior of anterior border; anterior border short in front of glabella, nearly twice as long laterally, with fine terrace lines marginally; anterior border furrow short in front of glabella but slightly longer and with gently tapering sides laterally; facial suture diverging only very slightly forward in gentle curve, crossing border diagonally, transverse behind palpebral lobe then meeting posterior margin in low angle. Librigena with strong genal spine and sloping steeply laterally; eye socle high, with curved upper margin in horizontal plane, with distinct furrow beneath it above genal field; genal field sloping down laterally and posterolaterally to genal angle; border furrow well-impressed anteriorly, shallowing a little posteriorly but well-impressed again at genal angle and along posterior edge, extending a short distance and then fading out along genal spine, situated closer to adaxial side of genal spine; border flat

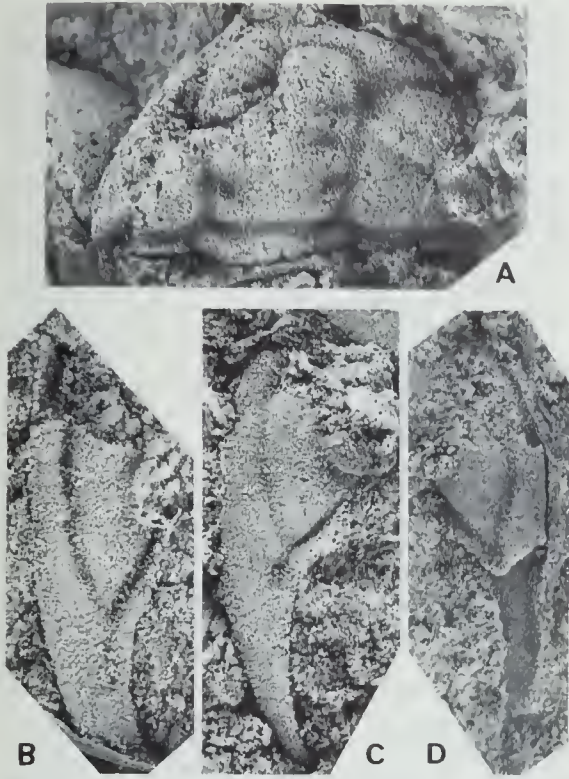


Figure 3. *Tasmanocephalus stephensi* (Etheridge, 1883). A, internal mould of cranium Z1379, $\times 4$. (Figured by Etheridge, 1883, pl. 1, fig. 2 and by Kobayashi, 1936, pl. 21, fig. 2). The librigena illustrated by Etheridge is evident but at a steeper angle to the cranium than originally depicted—see explanation in text. B, latex cast of librigena showing forward extension of the doublure, NMVP71239, $\times 4$. C, latex cast of librigena NMVP71240, $\times 3$. D, internal mould of librigena showing forward extension of the doublure NMVP71241, $\times 3$.

to gently convex, sloping down to margin, becoming wider and flatter from near midlength of librigena to genal spine, short and convex posteriorly inside genal angle; genal spine nearly twice length of librigena, comparatively flat and wide, becoming more rounded posteriorly; doublure narrow but extending well forward adaxial of genal field so rostral plate must have been quite narrow.

Hypostome subquadrate, with convex median body; anterior margin transverse, with strong medial depression; anterior wings short turned strongly dorsally; median body with slightly inflated anterior lobe and short

posterior lobe, divided by strong median furrow, lateral borders widened posteriorly, sloping ventrally away from border furrow; border furrow broad laterally, with two distinct and elongate pits—one at posterior of anterior lobe of median body and other laterally behind posterior lobe, short and sharp posteriorly; posterior border short, tapering to sagittal line; posterior margin broadly arched forward over sagittal line.

Pygidium approximately semicircular, with pair of marginal spines; axis of seven rings and a long terminus probably containing several more rings, tapering evenly posteriorly to rounded posterior at border furrow, with apodemal pits evident laterally in transverse transaxial furrows of internal moulds; axial rings becoming shorter and increasingly poorly defined posteriorly; pleural areas with well-impressed long pleural furrows having broad U-shaped, section, with on each pleural rib well-impressed interpleural furrow having short almost V-shaped section, with furrows at increasing angle to transverse line towards posterior, becoming less distinct posteriorly; border furrow distinct but poorly impressed, of uniform width throughout; border narrow and uniform, with marginal terrace lines, weakly convex and downsloping to margin; marginal spines broadly based, tapering rapidly to point, issuing from border opposite pleural furrow of fourth pygidial segment. Surface of exoskeleton without ornament.

Remarks: Etheridge (1919) and Kobayashi (1940) both concluded that the cranidia and pygidia which they first thought belonged to different species should be united as herein. Comparison with *Parakoldinioidia* above, further suggests the assignment of these exoskeletal parts to the one species. Close examination of the syntype (Etheridge, 1883, pl. 1, fig. 2) thought to have its librigena slightly dislodged but essentially in place, shows that the free cheek is in fact not in place; it is back to front and actually belongs to *Etheridgaspis carolinensis*. It is also clear that the librigena (Etheridge, 1883, pl. 1, fig. 3) assigned to this species belongs to *Etheridgaspis carolinensis*; this is deduced from the length of the palpebral lobe compared to the visual surface of the

larger specimens, from the ornament, and from the length of the posterior cephalic limb compared to the length of facial suture on librigena.

Family ASAPHIDAE Burmeister, 1843

Parabasilicus Kobayashi, 1934

Type species (by original designation):
Parabasilicus typicalis Kobayashi, 1934.

Parabasilicus ? lewisi (Kobayashi, 1940)
Plate 17, figs 1-10; plate 18, figs 13, 14;
text-fig. 4

- 1883 *Asaphus* sp. a. Etheridge, p. 156, pl. 1, figs 6, 7.
1883 *Asaphus* sp. b. Etheridge, p. 156, pl. 1 fig. 5.
1888 *Asaphus* sp. indet. Johnston, pl. 1, figs 9, 17, 18.
1919 *Bathyrurus* (?) spp. Etheridge, p. 392.
1940 *Asaphellus lewisi* Kobayashi, p. 74, pl. 12, figs 16, 17, 19 (NOT fig. 18).

Lectotype (designated herein): Z133, the damaged cranidium figured by Kobayashi (1940, pl. 12, fig. 16) and herein (Pl. 17, fig. 2).

Diagnosis: Member of *Parabasilicus* with glabella narrowest at posterior of palpebral lobe, expanding both forward and back quite strongly, with short highly areuate palpebral lobes projecting a considerable distance laterally, with occipital and posterior border furrows impressed, with strongly forked posterior to hypostome and ridge on outer edge of posterior spine running well onto anterior lobe of median body, without genal spine, with concave border on both cranidium and pygidium, without furrows on pygidial pleural fields, and with low indistinct axis.

Description: Cranidium of moderate convexity, with palpebral lobes elevated above glabella and anterior sloping down to margin; glabella waisted near rear of palpebral lobe, expanding forward to well rounded anterior some distance from border, without furrows, with weak occipital furrow, without a node visible on available specimens; axial furrow weakly impressed, most obvious between palpebral lobes and at posterior margin; preglabellar field as long as border, flat, downsloping; anterior border flat, downsloping to margin, longest sagittally; palpebral lobe short, close to glabella, highly arcuate abaxially, projecting strongly abaxially, highest part of cranidium, flat, without palpebral furrow; facial suture

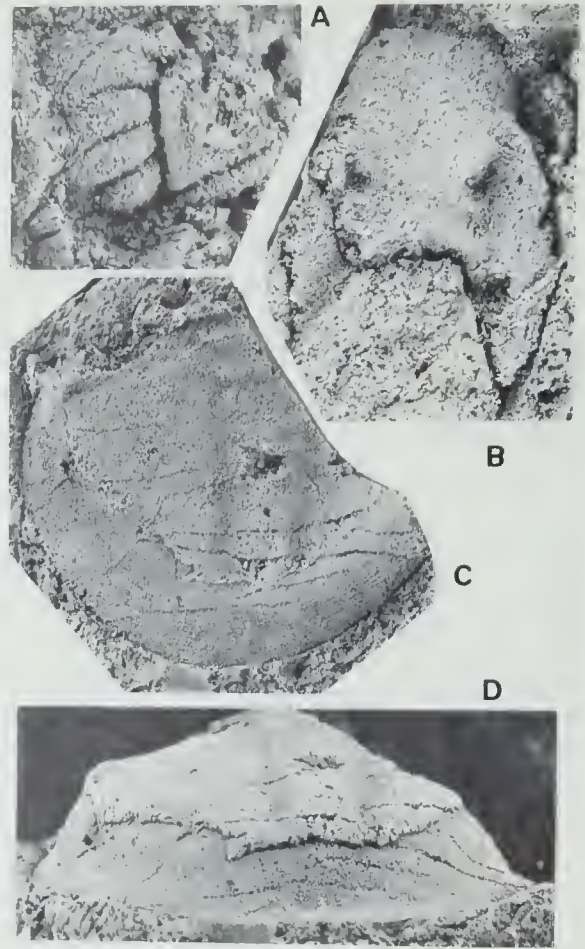


Figure 4. A, *Protoencrinurella ? subquadrata* (Kobayashi, 1940), latex cast from partial external mould of cranidium showing forward expanding glabella, AMI-65513, $\times 7$. B-D, *Parabasilicus ? lewisi* (Kobayashi, 1940). B, internal mould of hypostome Z1384, $\times 5$. (Figured by Etheridge, 1883, pl. 1, fig. 7). C, D, dorsal and posterior views of internal mould of damaged pygidium Z1382, $\times 1.5$. (Figured by Etheridge, 1883, pl. 1, fig. 5).

diverging forward gently from palpebral lobes to widest point at border furrow, curving adaxially on border to run parallel to but well inside margin in normal isotelliform manner, almost transverse behind palpebral lobe, turning sharply back distally to meet posterior margin at 90° ; posterior cephalic limb short and wide, with faint posterior border furrow on it. Librigena with low but distinct eye socle above

wide shallow furrow parallel to base of eye; border furrow wide, shallow, virtually disappearing near genal angle along lateral border, entirely absent along posterior border; border gently convex, tapering posteriorly to nothing at genal angle; doublure convex ventrally, tapering strongly to posterior, with distinct terrace lines parallel to margin; genal angle just under 90°, without spine. Hypostome large, with very strongly forked posterior; anterior margin almost transverse, with shallow median depression; anterior wings not greatly expanded, extending strongly dorsally and posteriorly; sharp lateral notch with angular anterior edge of shoulder overhanging notch; shoulder greatly expanded posteriorly into broad flat projection, with sharp ridge along abaxial edge of shoulders running forward up onto anterior lobe of median body; median body with large inflated anterior lobe and short low posterior lobe; median furrow reduced to pair of prominent pits; another pair of shallow pits situated just behind the median furrow near posterior margin (presumably homologous with those often found in the posterior border furrow of hypostomes e.g., in *Asaphopsoides florentinensis* (Etheridge, 1905); border furrow not evident; posterior margin between projections transverse with high marginal downturn.

Pygidium semicircular, of relatively low convexity; axis low, tapering posteriorly to narrowly rounded posterior at inner edge of border furrow, with seven or more indistinct rings; pleural areas without furrows except for well impressed anterior border furrow; articulating facet steep, weakly concave, at low angle to transverse line; border furrow distinct but expressed only as a change of slope from pleura to border; border flat to slightly downsloping, tapering forward; doublure wide, tapering forward, with small notch in inner edge posteromedially to accommodate axis.

Remarks: Assignment of this relatively poorly-known asaphid species is fraught with difficulties and the assignment to *Parabasilicus*, itself a poorly-understood genus (Jaanusson in Harrington *et al.*, 1959), is and will probably remain tentative. The assignment is proposed on the basis of the effacement of the furrows but with the shape of the glabella and axis evi-

dent, and on the structure of the hypostome (cf. Kobayashi, 1934, pl. 41, fig. 3). Other features observable on both Tasmanian and Korean specimens, appear to be within the limits of generic variation. The situation of the palpebral lobes a little further back and lack of genal spines serve as specific taxobases to identify the Tasmanian species.

Kobayashi (1934) dated the Korean *Parabasilicus* as late Llandeilo and Harrington & Leanza (1957) identified the genus in northern Argentina in sediments of Llanvirn age so this Tasmanian occurrence in the early Arenig suggests that the genus may have been longer ranging than originally thought.

Family PLIOMERIDAE Raymond, 1913

Protoencrinurella Legg, 1976

Type species (by original designation): *Protoencrinurella maitlandi* Legg, 1976.

Protoencrinurella ? subquadrata (Kobayashi, 1940)

Plate 18, figures 1-7; text-fig. 4

1940 *Prosopiscus* (?) *subquadratus* Kobayashi, p. 70, pl. 12, fig. 5.

Material: This is a rare species with only the figured specimens and a few other less complete fragments available in the collections. The holotype specimen is mislaid at present but is almost certainly in the collection of the Tasmanian Museum.

Diagnosis: Glabella with straight parallel sides, tending to expand slightly adjacent to frontal lobe, broadly rounded anteriorly; occipital ring elongate medially, tapering to axial furrow; lateral glabellar furrows wide, slit-like, inclined only gently to transverse line as they approach axis; furrow 3p with transverse lateral section then turned posteriorly in adaxial section; small, posteriorly directed fixigenal spine present at genal angle. Pygidium with five pairs of marginal furrows; pleural ribs becoming elongate away from axis then tapering again in free section beyond margin of pygidium; interpleural furrows absent.

Description: Cranium apparently twice as wide as long (This is not certain as all available specimens seem to be slightly shorter than nor-

mal for the family and may be distorted.); glabella subquadrate, with straight parallel sides or expanding forward adjacent to frontal glabellar lobe, but with occipital ring noticeably narrower than rest of glabella, with broadly rounded anterior, with three pairs of wide slit-like lateral glabellar furrows; glabellar lobes 1p to 3p subequal in length at axial furrow, with 1p tapering adaxially and others of uniform length; furrow 3p with transverse section at axial furrow turning posteriorly and running in a widely convex and posteriorly inclined adaxial section; frontal lobe longer than others; occipital furrow running in anteriorly convex arch, almost meeting with furrow 1p; occipital ring markedly elongate medially, tapering to nothing laterally well inside the lateral margin of the glabella; anterior border short and rim-like; palpebral lobe at high angle to transverse line, of uniform width, curving strongly adaxially and running to axial furrow at posterior of frontal lobe as narrow cye ridge; posterior border becoming elongate abaxially, with short posteriorly directed fixigenal spine at the genal angle.

Pygidium transverse; axis of five rings and short triangular terminus, tapering posteriorly quite strongly; pleural areas crossed by well-impressed pleural furrows curving posteriorly distally and becoming almost exsagittal by fourth and fifth furrows, without interpleural furrows; pleural ribs becoming more elongate laterally towards the margin of pygidium, tapering again as free marginal spines distally; fifth pair of ribs enclosing axial terminus except for single point at posterior margin medially; marginal spines apparently quite short and downturned.

Remarks: Assignment of this poorly-preserved plimerid species is difficult as some important generic taxobases are not available (e.g. structure of fixigena forward of eye ridge, tips of pygidial pleurae). It is assigned to *Protoencrinurella* on the basis of features which Legg (1976) quoted as distinguishing the genus from its close relatives; these features are possession of palpebro-ocular ridges (Pl. 18, fig. 4), sinuous 3p glabellar furrows (Pl. 18, figs 2-4), and inflated pygidial pleurae (Pl. 18, figs 4, 7). On the other hand the glabella of the Tasma-

nian species is more quadrate than forward expanding and the lengths of the glabellar lobes are somewhat variable (cf. Pl. 18, fig. 2 where they increase in size forward with Pl. 18, fig. 4 where they appear to be of more even sizes). Otherwise there seems to be a reasonable comparison between the two species which may be distinguished by the glabellar differences mentioned above.

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Explanation of Plates

PLATE 14

Etheridgaspis carolinensis (Etheridge, 1919)

- Figure 1. Latex cast of incomplete cranidium showing large palpebral lobes and downturned posterior cephalic limb, NMVP74262, $\times 4$. (A) left anterior oblique view, (B) dorsal view.
- Figure 2. Latex cast of very small librigena showing short highly-arcuate eye, short genal spine and elevated posterior of the genal field, NMVP74263, $\times 4$. (A) dorsal view, (B) lateral oblique view.
- Figure 3. Internal mould of damaged librigena showing more elongate eye, Z1380A, $\times 3$. Figured by Etheridge (1883, pl. 1, fig. 3).
- Figure 4. Internal mould of librigena showing forward extension of the doublure, ornament, border furrow shallowing near genal angle, forward sloping genal field, and strong furrow beneath eye, NMVP74264, $\times 2.5$.
- Figure 5. Latex cast of smallest librigena available showing short arcuate eye, posteriorly shallowing border furrow, terrace lines on border and strong genal spine, NMVP74265, $\times 6$.
- Figure 6. Internal mould of damaged cranidium, NMVP74266, $\times 4$.
- Figure 7. Internal mould of damaged cranidium, NMVP74267, $\times 4$.
- Figure 8. Internal mould of damaged cranidium, Z144, $\times 3$. Figured by Kobayashi (1940, pl. 12, fig. 10).

- Figure 9. Latex cast of librigena showing large eye, prominent subocular ridge, and posteriorly situated short genal spine, NMVP74276, $\times 6$.
- Figure 10. Latex cast from incomplete external mould of librigena with most anteriorly placed genal spine of all available specimens, NMVP74277, $\times 6$.
- Figure 11. Latex cast of librigena, NMVP74278, $\times 5$. (A) dorsal view, (B) lateral oblique view.
- Figure 12. Latex cast of large cranium showing glabellar furrows, terrace lines on anterior border, wide palpebral lobe and apparently distorted by shortening in sagittal direction, NMVP74270, $\times 5$. (A) anterior oblique view, (B) dorsal view.
- Figure 13. Internal mould of poorly preserved pygidium, NMVP74271, $\times 6$.
- Figure 14. Latex cast from incomplete external mould of small pygidium, NMVP74272, $\times 4$.
- Figure 15. Latex cast of pygidium showing pleural and interpleural furrows, narrow border and axial structure, NMVP74273, $\times 4$.
- Figure 10. Latex cast from incomplete external mould of cranium showing glabellar furrows and large palpebral lobe, NMVP74269, $\times 2.5$. (A) dorsal view, (B) anterior oblique view.
- Figure 11. Latex cast of small cranium, AMF65503, $\times 6$.
- Figure 12. Internal mould of small librigena, NMVP74279, $\times 3.5$.
- Figure 13. Internal mould of librigena, AMF65507, $\times 7$. (A) lateral view, (B) dorsal view.
- Figure 14. Latex cast from incomplete external mould of cranium showing well-impressed border furrow, NMVP74280, $\times 6$.
- Figure 15. Latex cast from incomplete external mould of pygidium, NMVP74281, $\times 7$.
- Figure 16. Latex cast of poorly preserved pygidium showing narrow pleural areas, AMF65508, $\times 9$.
- Figure 17. Latex cast from incomplete external mould of pygidium showing axial structure, narrow pleural areas, and well-impressed border furrow, NMVP74282, $\times 6$. (A) dorsal view, (B) posterolateral oblique view.

PLATE 15

Carolinites tasmaniensis (Etheridge, 1919)

- Figure 1. Latex cast from incomplete external mould of cranium in lateral oblique view, NMVP74274, $\times 5$.
- Figure 2. Latex cast from incomplete external mould of cranium showing baccula, AMF65504, $\times 6$. (A) lateral view, (B) dorsal view.
- Figure 3. Internal mould of cranium, Z1380B, $\times 4$. (A) dorsal view, (B) anterolateral oblique view. Figured by Etheridge (1883, pl. 1, fig. 12).
- Figure 4. Latex cast from incomplete external mould of cranium, AMF65505, $\times 7$.
- Figure 5. Latex cast from incomplete external mould of cranium Z142, $\times 6$. Figured by Kobayashi (1940, pl. 12, fig. 9).
- Figure 6. Latex cast from incomplete external mould of cranium showing ridge on inner edge of palpebral furrow, glabellar shape and lack of glabellar furrows, NMVP74275, $\times 6$. (A) dorsal view, (B) anterolateral oblique view.
- Figure 7. Internal mould of damaged holotype cranium, Z1387, $\times 5$. (A) dorsal view, (B) anterior oblique view.
- Figure 8. Latex cast of damaged cranium, AMF65506, $\times 5$.
- Figure 9. Internal mould of damaged cranium, NMVP74268, $\times 4$.

PLATE 16

Tasmanocephalus stephensi (Etheridge, 1883)

- Figure 1. Internal mould of medium sized cranium, NMVP74283, $\times 2$. (A) dorsal view, (B) anterior oblique view.
- Figure 2. Latex cast of hypostome showing terrace lines, wide shoulder, median furrow, and medially tapering posterior border, AMF65509, $\times 5$.
- Figure 3. Latex cast of hypostome, Z134, $\times 3$. (A) dorsal view, (B) left lateral oblique view. Figured by Kobayashi (1940, pl. 12, fig. 18).
- Figure 4. Latex cast of hypostome, AMF65510, $\times 5$.
- Figure 5. Latex cast of librigena in lateral oblique view, NMVP74284, $\times 3$.
- Figure 6. Latex cast from incomplete external mould of librigena showing border furrow, eye socle, and broad genal spine, NMVP74285, $\times 3.5$. (A) lateral oblique view, (B) lateral view.
- Figure 7. Latex cast of cranium showing narrow posterior cephalic limb, elevated short palpebral lobe, and anterior marginal terrace lines, Z148, $\times 3$. (A) anterior oblique view, (B) dorsal view.
- Figure 8. Latex cast from incomplete external mould of cranium showing glabellar furrows, eye ridge, caeca in front of eye ridge, and palpebral lobe, NMVP74286, $\times 3$.

Figure 9. Latex cast of incomplete cranium, NMVP74287, $\times 4$.

Figure 10. Latex cast of small incomplete cranium, NMVP74288, $\times 2$.

Figure 11. Latex cast of incomplete cranium showing glabellar furrows, NMVP74289, $\times 3$.

Figure 12. Internal mould of damaged cranium, Z1378, $\times 3$. Figured by Etheridge (1883, pl. 1, fig. 1).

Figure 13. Latex cast from incomplete external mould of large laterally compressed pygidium, NMVP74290, $\times 3$.

Figure 14. Latex cast of slightly distorted pygidium, NMVP74291, $\times 2.5$.

PLATE 17

Parabasilicus ? lewisi (Kobayashi, 1940)

Figure 1. Internal mould of laterally compressed cranium showing occipital and posterior border furrows and anteriorly expanding glabella, NMVP74292, $\times 5$.

Figure 2. Internal mould of damaged cranium showing outline of glabella, palpebral lobes, and course of facial suture, Z133, $\times 2$. (A) dorsal view, (B) anterolateral oblique view. Figured by Kobayashi (1940, pl. 12, fig. 16).

Figure 3. Internal mould of incomplete cranium showing palpebral lobe and occipital furrow, NMVP74293, $\times 2$.

Figure 4. Latex cast of laterally compressed cranium, AMF65511, $\times 3.5$.

Figure 5. Internal mould of hypostome, NMVP74294, $\times 5$.

Figure 6. Latex cast of pygidium, NMVP74295, $\times 3$.

Figure 7. Latex cast of damaged hypostome showing second pair of shallower pits behind the median furrow, NMVP74296, $\times 4$.

Figure 8. Latex cast of pygidium, NMVP74297, $\times 1.5$.

Figure 9. Latex cast of ventral surface of librigena showing posteriorly tapering doublure and anterior sutural margin of doublure, NMVP74298, $\times 2.5$.

Figure 10. Internal mould of damaged pygidium showing concave border, inner margin of doublure and space between doublure and dorsal exoskeleton, NMVP74299, $\times 2$.

PLATE 18

Figs 1-7 *Protoencrinurella ? subquadrata* (Kobayashi, 1940)

Figure 1. Internal mould of cranium showing short genal spine, NMVP74300, $\times 8$.

Figure 2. Latex cast of cranium, NMVP74301, $\times 8$.

Figure 3. Latex cast of glabella showing glabellar furrows with change of direction of 3p, NMVP74302, $\times 6$.

Figure 4. Latex cast from incomplete external mould of cranium, NMVP74303, $\times 6$.

Figure 5. Latex cast from incomplete external mould of pygidium showing abaxially elongate pleural ribs, NMVP74304, $\times 7$.

Figure 6. Internal mould of pygidium, NMVP74305, $\times 8$.

Figure 7. Latex cast of two incomplete pygidia, NMVP74306 and 74307, $\times 8$.

Figs 8-12 *Tasmanocephalus stephensi* (Etheridge, 1883)

Figure 8. Latex cast from external mould of fragment of left anterolateral corner of pygidium showing terrace lines, NMVP74308, $\times 3$.

Figure 9. Latex cast from incomplete external mould of pygidium showing axial and pleural structure, NMVP74309, $\times 3$.

Figure 10. Internal mould of pygidium, Z1381, $\times 3$. Figured by Etheridge (1883, pl. 1, fig. 4).

Figure 11. Latex cast of small pygidium, NMVP74310, $\times 3$.

Figure 12. Latex cast from damaged external mould of slightly distorted pygidium, Z1380C, $\times 3$. (A) dorsal view, (B) right lateral oblique view.

Figs 13, 14. *Parabasilicus ? lewisi* (Kobayashi, 1940)

Figure 13. Internal mould of librigena showing lack of genal spine, course of facial suture, and terrace lines on doublure anteriorly, NMVP74311, $\times 2.5$.

Figure 14. Internal mould of damaged librigena showing anterior extension of border in front of facial suture, NMVP74312, $\times 4$.

Figure 15. *Etheridgaspis carolinensis* (Etheridge, 1919). Latex cast of librigena, AMF65512, $\times 5$.

