

# THE TRILOBITES *INCAIA* WHITTARD 1955 AND *ANEBOLITHUS* GEN. NOV.

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ABSTRACT. The restudy of British and Peruvian type material together with new material from New Zealand has led to the revision of *Incaia* and to the belief that it represents a distinct trinucleid stock, known at present only from Peru and New Zealand, for which the subfamily Incaiinae is erected. The British species '*Incaia simplicior*' Whittard is excluded from the genus and is proposed as the type of *Anebolithus* gen. nov.

As part of a more general study of the Trinucleidae at present being undertaken by Hughes, the Peruvian type material of *Incaia* and British material previously attributed to the genus have been re-examined. Study of a new species of *Incaia* from New Zealand recently recognized by Wright yields data needed to characterize the genus more fully. Whittard (1966, pp. 273-4, text-fig. 9) believed that British material from the Shelve region was congeneric with *Incaia nordenskiöldi* (Bulman 1931) but the present study shows this not to be so. '*Incaia simplicior*' Whittard from the Arenig (*Didymograptus hirundo* Zone) of the Shelve Inlier in the Welsh Borderland is proposed as the type species of *Anebolithus* gen. nov.

*Incaia* is no longer thought to be closely allied to the Trinucleinae and it is believed that it represents a distinct, possibly primitive, trinucleid stock known at present only from South America and New Zealand.

## SYSTEMATIC DESCRIPTIONS

*Terminology.* The terminology applied throughout is essentially that proposed in the *Treatise*, Part O (Harrington, Moore, and Stubblefield 1959). However, the term 'arc' (referring to the pits on the trinucleid fringe, e.g. E<sub>1</sub> arc) is here preferred to Bancroft's (1929) term 'concentric row' (see also Hughes 1970).

Family TRINUCLEIDAE Hawle and Corda 1847  
Subfamily INCAIINAE subfam. nov.

*Remarks.* The small number of arcs, with pits arranged in radial sulci, combined with the development of large lateral eye tubercles, characterize this monotypic subfamily.

## Genus INCAIA Whittard 1955

*Diagnosis.* Incaiinae with semicircular cephalon; simple, narrow fringe with no pits external to the girder; pits of internal series consist of two or three arcs with pits sunk in radial sulci. Glabella typically trinucleid, pyriform and with three pairs of lateral glabellar furrows; no median node. Genal regions with prominent eye tubercles situated close to axial furrows and approximately opposite mid-point of glabella. Genal spines relatively short extending posteriorly a distance equal to the cephalic length. Thorax typically trinucleid. Pygidium relatively long, being only about two and a quarter times as wide as long; pleural fields faintly furrowed; axis well segmented.

[*Palaeontology*, Vol. 13, Part 4, 1970, pp. 677-90, pls. 127-128.]

*Type species.* *Trinucleus nordenskiöldi* Bulman, 1931.

*Distribution.* The type species is from the Upper Llanvirn of SE. Peru. The only other known occurrence of the genus is from the Caradoc (*Nemagraptus gracilis* Zone) of New Zealand.

*Discussion.* In 1955 Whittard, working only from Bulman's figures, believed that '*T. nordenskiöldi*' was unique in that it possessed a glabella probably without lateral furrows, large eye-tubercles close to the axial furrows and a simple fringe consisting essentially of only two arcs which Whittard interpreted as 'presumably representing  $E_1$  and  $I_1$ '. Following the discovery of trinucleids in Shropshire possessing very simple fringes with the girder external to all the pits, Whittard examined the type specimens of *Incaia nordenskiöldi*. He then modified his earlier views regarding the position of the girder, stating (1966, p. 273) that 'there is no indication of a girder separating external from internal series of pits, although the preservation is such that if a girder existed it should be observable; furthermore, in all cases,  $I_{1-2}$  occur in close association in sulci, and it would be unreasonable to separate them into  $E_1$  and  $I_1$ ; finally, surrounding the fringe there is a peripheral tumid border or rolled margin which clearly resembles the peripheral girder of *Myttonia*.' Whittard thus clearly believed that in *I. nordenskiöldi* the girder was external to all the pits.

The present study has reaffirmed Bulman's statement (1931, p. 86) that all the material of *I. nordenskiöldi* consists of internal and external moulds of cranidia with upper lamella, and that no specimens are known with the lower lamella preserved. It is thus a little difficult to understand Whittard's categorical remarks concerning the existence and position of the girder. He apparently believed that the absence of any structure between the two arcs on the upper lamella which might correspond to a girder on the lower lamella, indicated that there was no such girder. Whilst arcuate structures are commonly developed on the upper lamella between the various arcs, these need not correspond to the position of the girder on the lower lamella in any way [for example in *Cryptolithus* (see Whittington 1968, pl. 89, figs. 1, 2)]. Furthermore, the absence of any such arcuate structures on the upper lamella need not mean that a girder is absent (for example in *Trinucleus* and *Stapeleyella*). The other evidence cited by Whittard as supporting his claim of a peripheral girder is also inconclusive. Although the pits of the two main arcs are fairly close together there is ample space for a girder to be developed between them. The so-called 'tumid border or rolled margin' referred to by Whittard is simply a slightly convex marginal rim (Pl. 127, fig. 7). Although not unlike that developed in *Myttonia*, this rim is of little significance as similar rims are present in many trinucleids [for example *Cryptolithus* and *Salterolithus* (see Whittard 1958, pl. 10, fig. 1, pl. 12, fig. 3)]. Thus it is believed neither position nor existence of the girder is determinable from the type material. In the New Zealand species described below the lower lamella is known and the girder is, in fact, positioned external to both the arcs of pits. Since the cephalon of this new species is so similar to that of *I. nordenskiöldi* it is here considered that they are congeneric, and that the girder in *I. nordenskiöldi* is probably peripheral.

The affinities of *Incaia* are rather uncertain. Whittard, who did not attach any great importance to the presence of lateral eye tubercles, believed *Incaia* to be intermediate between *Myttonia* and *Lordshillia*, possessing the peripheral girder of *Myttonia* and the ordered radial arrangement of the fringe pits of *Lordshillia*. The present authors, however, believe the development of lateral eye tubercles (a feature absent in the

majority of trinucleids), together with the fringe characteristics, is of considerable generic importance, and it is held that *Incaia* is in no way closely related to the early Ordovician trinucleids of the Welsh Borderland. Of trinucleids known from other parts of South America and Australasia, none shows any apparent close affinity to *Incaia*. Of these forms, however, the majority are very different from those known from the rest of the world, e.g. *Famatinolithus*, *Guandacolithus* (Harrington and Leanza 1957), '*Cryptolithus*' *empozadensis* (Rusconi 1953), '*Onnia*' *verrucosa* (Rusconi 1956). From Australia the only form known in any detail is a new species (Moors MS. 1966)<sup>1</sup> from New South Wales. This species, while exhibiting some similarities in fringe characteristics to *Lloydolithus* and *Protolloydolithus*, possesses lateral eye tubercles similar to those of *Incaia*.

Thus although our present knowledge is rather scant, it seems possible that many trinucleids from the present southern hemisphere with lateral eye tubercles may have evolved in isolation. This would necessitate an isolated stock of trinucleids within the 'southern province' of Whittington (1966). Some support for such a concept is given by some other trilobite groups, notably the thysanopygid asaphids of South America which also appear to have evolved in isolation. The probable occurrence in the New Zealand Tremadocian of *Pseudohysterolenus* (Wright 1968), otherwise known only from Argentina (Harrington and Leanza 1957), further suggests an early Palaeozoic 'austral' faunal province.

The significance of the lateral eye tubercles with reference to the evolution and origin of the trinucleids is at present uncertain. *Orometopus*, which has eye tubercles, has often been quoted as a probable trinucleid ancestor, but this is by no means established.

*Incaia nordenskiöldi* (Bulman)

Plate 127, figs. 3, 9, Plate 128, figs. 1, 2

- 1931 *Trinucleus nordenskiöldi* Bulman, p. 85, pl. 11, figs. 2, 3.  
 1955 *Incaia nordenskiöldi* (Bulman); Whittard, pp. 31-2.  
 1966 *Incaia nordenskiöldi* (Bulman); Whittard, pp. 273-4, text-fig. 9.

*Diagnosis.* *Incaia* having  $I_{1-2}$  fully developed with about 16 pits in each arc (half-fringe); occasional pits of  $I_3$  developed, especially posterolaterally; only two or three sulci present between the mid-line and the axial furrow. Eye tubercles slightly posterior of glabellar mid-length. Thorax and pygidium unknown.

*Type locality and horizon.* Upper Llanvirn between Limpucuni and Itchubamba, SE. Peru (see text-fig. 1). Bulman (1931, pp. 8-10) discussed the probable location of these two places and concluded that Limpucuni probably lay to the west of San Juan del Oro and that Itchubamba was between Limpucuni and Quiaca. Efforts by the present authors have also failed to discover the exact position of these places. Map B drawn from information supplied by the Royal Geographical Society shows a somewhat different relative positioning of some of the places in the area, but it should be noted that the accuracy of mapping in this area is only to within about 20 minutes both of longitude and latitude. Maps published at about the time of the Nordenskiöld expedition show one track leading northwards from Sandia through Ichubamba (note spelling) and another from Quiaca to San Juan del Oro. This latter one passes through Huichulluni which may be near Limpucuni (Bulman stated 1931, p. 10, 'Huichiyuni is said to be near Limpucuni'). It is uncertain whether Ichubamba is equivalent to Itchubamba, but in any case it seems unlikely that the expedition passed through Ichubamba. It is quite

<sup>1</sup> A further new trinucleid is now known from New South Wales (see Campbell and Durham, this issue, pp. 573-80).

feasible however that they may have made a detour off to the west of the Quiaca-San Juan del Oro track and made collections on the ridge that runs up between the two tracks mentioned above. Such collections could then quite well be labelled as 'between Limpucuni and I(t)chubamba.' The exact locality for the type material of *I. nordenskioldi* must thus remain uncertain.

*Material.* Ar. 42445a/b (419, 420); Ar. 42446 (418); Ar. 42447 (366); Ar. 42448 (367). Specimens Ar. 42447 and Ar. 42448 are part and counterpart. Numbers given in brackets are original numbers cited by Bulman (1931, p. 86).

<i>Dimensions</i>	A	I	K
Ar. 42445 (419)	4.8	c. 11.0	2.3
Ar. 42446 (418)	4.2	c. 10.3	2.7
Ar. 42447 (366)	5.5	10.6	3.2

All measurements in millimetres. A—maximum sagittal cephalic length; I—maximum transverse cephalic width; and K—maximum transverse glabellar width.

*Discussion.* A full redescription is not deemed necessary until new material becomes available, but the following points are of note in addition to the comments already made in the discussion of the genus concerning the position of the girder. All the known specimens are deformed to some extent and are preserved in a rather soft pinkish-brown shale. It is thought that this rather indifferent mode of preservation accounts for the doubtful occurrence of lateral glabellar furrows and it is probable that three pairs of shallow, typically trinucleid lateral glabellar furrows were developed as are known in *I. bishopi* (see below). The rather large, so-called eye tubercles close to the axial furrows however are consistently developed and it is believed that they represent some form of lateral eye (Pl. 128, fig. 2). This is also supported by the New Zealand material. As pit counts can be made with any certainty on only three specimens, the figure of 'about 16 pits' in each arc (half-fringe) given in the diagnosis should not be taken as a truly diagnostic figure. Further specimens almost certainly would indicate some range in the number of pits developed. Bulman (1931) compared *I. nordenskioldi* with *Trinucleus coscinorrhinus*; differences noted by Bulman between the species would now seem to be of generic or even higher significance.

*Incaia bishopi* sp. nov.

Plate 127, figs. 1, 2, 4-6, 8; Plate 128, figs. 3, 4, 6-14; text-fig. 3

*Diagnosis.* *Incaia* with  $I_{1-2}$  fully developed in radial sulci with approximately 23 pits (half-fringe); about 8 sulci between axial furrows;  $I_3$  pits not known with certainty, no

EXPLANATION OF PLATE 127

- Figs. 1, 2, 4-6, 8. *Incaia bishopi* sp. nov. All specimens from scree material, Paturau River, New Zealand, locality S3/526, grid ref. 907010 1, Internal mould, VA5a  $\times$  3. 2, Dorsal surface of cranium showing caecae, latex cast, DC350b  $\times$  3. 4, Dorsal surface of fringe, latex cast of holotype, VA6b  $\times$  5. 5, Internal mould, VA4a  $\times$  3. 6, Ventral surface of fringe, latex cast of holotype, VA6a  $\times$  4. 8, Internal mould showing three lateral glabellar furrows, VA7  $\times$  4.
- Figs. 3, 9. *Incaia nordenskioldi* (Bulman). All specimens from Upper Llanvirn between Limpucuni and Itchubamba, SE. Peru. 3, Internal mould, Ar. 42446  $\times$  6. 9, Internal mould of holotype, Ar. 42445a  $\times$  6.
- Figs. 7, 10. *Anebolithus simplicior* (Whittard). Specimen from Mytton Flags, (Arenig), small quarry 160 yd. N. 35° E. of Snailbeach Reservoir, Shropshire, England. grid ref. SJ 377023. 7, Lateral view, 10, Dorsal view of internal mould, holotype GSM102178  $\times$  6.



TEXT-FIG. 1. A. Map showing the area of SE. Peru from which *Incaia nordenskiöldi* (Bulman) was collected, together with its general position in western South America (inset); redrawn from Bulman 1931, text-figs. 1, 2. B. Map drawn from information supplied by the Royal Geographical Society.

E arcs developed; 3 pairs of lateral glabellar furrows; median node absent; lateral eye tubercles located at mid-length of cephalon, close to axial furrows; genal caecae sometimes developed. Pygidium with up to 5 weakly developed pleural ribs; up to 16 axial rings.

*Localities and material.*

S3/526 (Collections GS9504, V1593) Type locality. Scree material, Paturau River. Grid ref. 907010 (909012). Specimens VA4-18, 20-4, 26-72, 74-7, 84, 88-115, 118-20, DC350-2, 354-7.

S3/527 (Coll. GS10209) River boulder, Paturau River, Grid ref. 912024 (912024) (Not 899025 as Cooper [1968, p. 79] stated) Spec. DC358.

S3/552 (Coll. V2710) Scree material, Higgins Branch (tributary of Paturau River). Grid ref. 907971 (909969). Specs. VA78-80, 87.

S3/553 (Coll. V2715) River boulder, Paturau River. Grid ref. 908012 (910015) Specs. VA19, 81-3, 85-6, 121.

S3/554 (Coll. V2716) Scree material, Paturau River. Grid ref. 905006 (907008). Spec. VA73.

All *I. bishopi* material is deformed tectonically, and fine morphological features (such as posterior pygidial axial rings and lateral glabellar furrows) are often obliterated. S3 is the Collingwood sheet of the N.Z. 1:63360 map series. Grid references are taken from the second edition (1967); grid references in brackets are taken from the 1945 edition. Numbers 526, etc., refer to collection or locality numbers on that sheet.

*Horizon.* Bishop (1965) described the type locality (S3/526) where *Nemagraptus gracilis* is now known to occur (R. A. Cooper pers. comm.), indicating an early Caradoc age. Bishop (1969) proposed the name Golden Bay Group for strata in which all *Incaia bishopi* localities occur (see also Bishop, in press).

*Type material.* Specimen VA6 (counterparts a and b) is here selected as holotype. Paratypes which are not topotypes are: VA19, VA73, VA78-83, VA85-7, VA121, DC358.

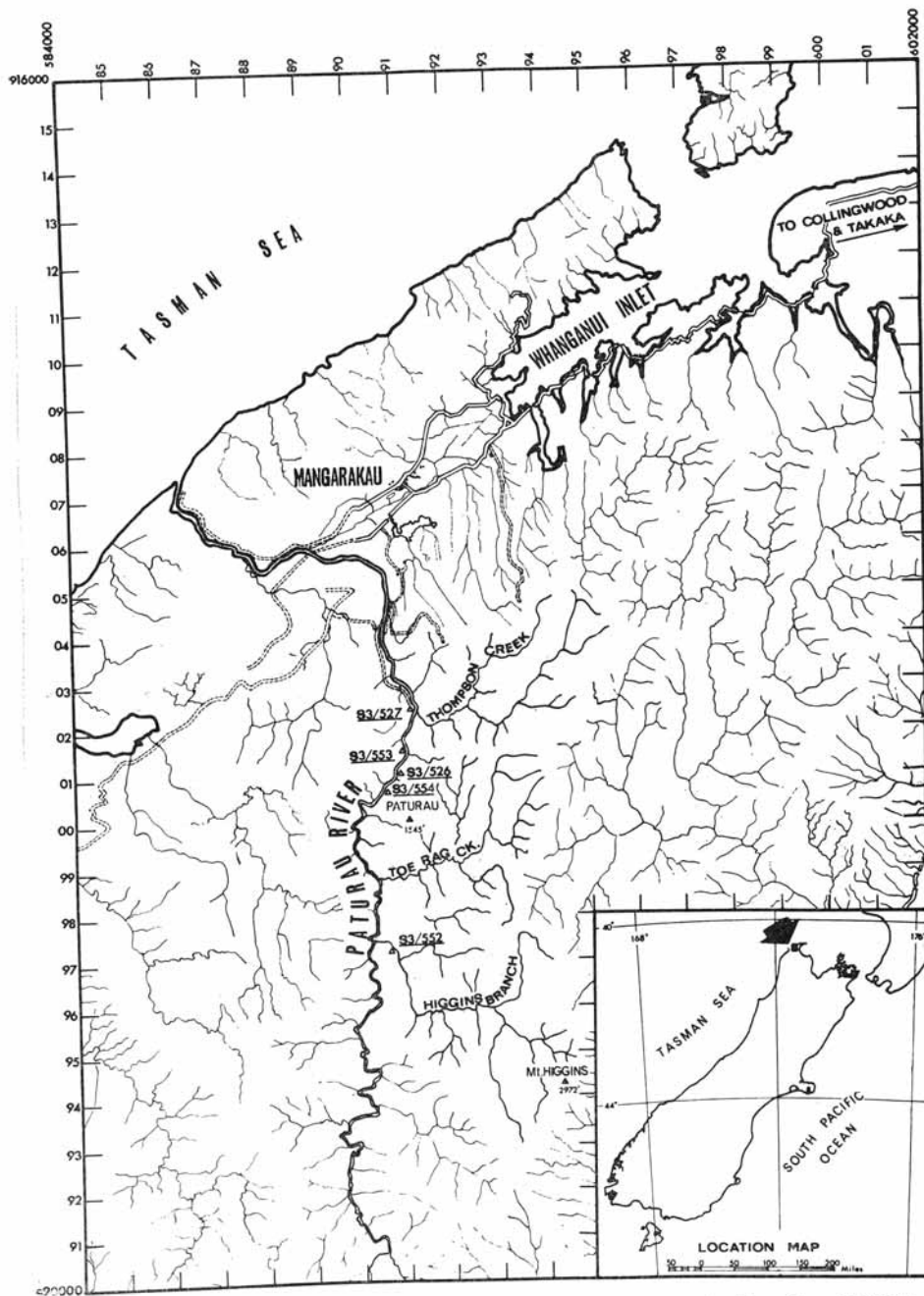
*Description.* Cephalon semicircular, tending to be relatively wider and more rectangular in smaller specimens (VA65) (see text-fig. 4 and Table 1). Glabella typically trinucleid, being pyriform with hemispherical pseudofrontal lobe, maximum width varying from about one-quarter the cephalic width in small specimens to about one-third in larger individuals (see text-fig. 5). Three pairs of lateral glabellar furrows are developed; posterior pair (VA4, 5, 23, 24) transverse, shallow, constricting the glabella just anterior of the broad, shallow occipital furrow to form a prominent occiput; median

EXPLANATION OF PLATE 128

Figs. 1, 2. *Incaia nordenskiöldi* (Bulman). Both specimens from Upper Llanvirn between Limpucuni and Itchubamba, SE. Peru. 1, Internal mould, Ar. 42447  $\times$  6. 2, Latex cast of holotype, Ar. 42445b  $\times$  6.

Fig. 5 ?*Incaia bishopi* sp. nov. From scree material, Paturau River, New Zealand, locality S3/526 grid. ref. 907010. Fringe fragment, VA25  $\times$  8. Orientation uncertain.

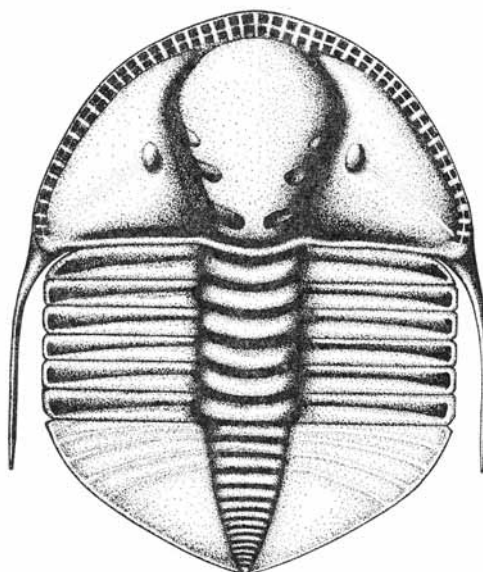
Figs. 3, 4, 6-14. *Incaia bishopi* sp. nov. All from scree material, Paturau River, New Zealand, locality S3/526 grid. ref. 907010 with the exceptions of VA19 and VA121 (figs. 4, 8) which are from a river boulder, Paturau River, New Zealand, locality S3/553 grid. ref. 908012. 3, Ventral surface of fringe fragment showing genal spine, latex cast VA14a  $\times$  4. 4, Dorsal surfaces of two pygidia, upper specimen VA19b, lower VA121, latex cast,  $\times$  4. 6, Internal mould of pygidium, VA8a  $\times$  3. 7, Internal mould of pygidium, VA21a  $\times$  4. 8, Internal mould of pygidium, VA19a  $\times$  4. 9, Internal mould of glabella showing reticulate ornamentation, VA81  $\times$  5. 10, Internal mould of pygidium, VA9a  $\times$  3. 11, Dorsal surface of pygidium, latex cast. DC351b  $\times$  3. 12, Internal mould of pygidium, VA10  $\times$  4. 13, Internal mould of pygidium, VA11  $\times$  3. 14, Internal mould of pygidium, VA20a  $\times$  4.



TEXT-FIG. 2. Map showing *Incaia bishopi* localities. Detailed map and 1000-yd. grid are from N.Z.G.S. S3 (Collingwood), 2nd edition.



glabellar furrows just posterior to mid-length of glabella, developed as small shallow rounded depressions; anterior furrows (VA7, Pl. 127, fig. 8) simply small rounded pits. Axial furrows deep anteriorly, with well-developed apodemal pits, shallowing and widening posteriorly. Genal regions moderately convex with simple curving caecae preserved on some specimens (e.g. DC350, Pl. 127, fig. 2; VA26). Eye tubercles prominent in all specimens as slightly elongated (*exsag.*) (VA4, Pl. 127, fig. 5; VA22) ridges located immediately outside the axial furrows at about mid-length of the cephalon.



TEXT-FIG. 3. Reconstruction of *Incaia bishopi* sp. nov. in dorsal view; surface ornamentation omitted. Magnification c.  $\times 2.5$ .

Posterior margin straight, border furrow broad and very shallow laterally, merging axially with axial furrows. No occipital spine present.

Fringe slightly convex, with a smooth, weakly concave rim. Width up to 2 mm. (*exsag.*) anteriorly being at a maximum in front of apodemal pits; laterally fringe becomes more steeply declined and narrower. Pits confined to radial sulci which are about as wide and rounded as the intervening ridges. Sulci radially arranged except medially where they are locally divergent (VA5, Pl. 127, fig. 1; VA65). Approximately 23 pits of arcs  $I_{1-2}$  are developed on each half-fringe, the two arcs being separated in sulci of the upper lamella by a low rounded ridge which is only very weakly manifested on the intervening ridges and becomes weaker laterally. One poorly preserved specimen (VA65) anteriorly exhibits what may be  $I_3$  pits, but relatively well-preserved specimens (e.g. VA5, 8, 64, DC350) clearly lack such pits. Minor irregularities (perhaps due to tectonic deformation) are present in some specimens (VA30, 73) in the development of



short sulci with only one pit, or a twin pit, developed. Ventral side of lower lamella with angular girder inclined at about 15° to the horizontal (VA6, 15), possessing sparse terrace-lines. Girder continued along the genal spines as an angular ventral edge. Dorsal edge of genal spines, which extend posteriorly for a distance approximately equal to the length of the remainder of the cephalon, is also angular, giving an approximately rhomboidal cross-section. Ventral edge of lower lamella does not lie in a plane;

TABLE 1. Table of the width-length ratios for three cephalon and two pygidia of *Incaia bishopi* sp. nov., both before and after correction by the use of Wellman's method (Wellman 1962). All measurements in millimetres.

Specimen No.	Original (deformed) Dimension (mm)		Uncorrected W:L	Corrected W:L
VA 5 (cephalon)	19.0	11.0	1.73 : 1	2.13 : 1
DC 350 (cephalon)	25.0	10.5	2.38 : 1	1.34 : 1
DC 352 (cephalon)	6.8	4.0	1.70 : 1	2.95 : 1
VA 112 (pygidium)	10.1	5.2	1.94 : 1	2.42 : 1
DC 351 (pygidium)	20.4	6.3	3.24 : 1	1.77 : 1

preglabellar edge and genal flange are relatively dorsally elevated but posterior portion of genal spine approximately coplanar with the rest of the girder (VA6) (see Størmer 1930, p. 106). Suture line apparently intra-marginal except postero-laterally where it becomes dorsal (VA6, 29, 30) cutting across the genal spine without isolating any pits.

External surface of glabella ornamented with a fine reticulate pattern of delicate ridges (VA63; VA81, Pl. 128, fig. 9). Pleural lobes of some pygidia bear fine, close-set pits (see Pl. 128).

Hypostoma unknown.

Thorax typically trinucleid with six segments (VA4, Pl. 127, fig. 5; VA5, Pl. 127, fig. 1; VA16). Axis about one-quarter of total width. Anterior half-ring elevated; axial furrows deep. Pleurae flat, deflected ventrally and posteriorly distally. Pleural furrow expanded laterally, commences near the antero-median angle of pleurae.

Pygidium varies in shape from obtusely sub-triangular (e.g. VA8, Pl. 128, fig. 6) to semi-elliptical (e.g. VA9, Pl. 128, fig. 10). Much of this shape variation however is thought to be due to deformation, and it seems likely that undeformed pygidia were generally slightly more than twice as long as wide, with the smaller individuals being relatively slightly longer (see text-fig. 6). The two pygidia to which Wellman's ingenious method (Wellman 1962) was applied, however, appear to indicate an opposite trend (see Table 1) (see also discussion of biometric data, p. 686). Anterior margin not quite

straight, each side being slightly deflected posteriorly. An elongate triangular anterior border is delimited on each pleural lobe by an angular furrow extending from in front of the anterior axial ring and becoming deeper laterally (VA9, Pl. 128, fig. 10; VA19, Pl. 128, fig. 4). Curvature of postero-lateral margins varies with outline, having a more curved margin in sub-triangular specimens. Axis slightly more convex (*tr.*) than the moderately convex pleural lobes which bear a fine reticulate ornament. Axis varies from one-quarter to one-fifth of width of pygidium, tapers posteriorly to merge into the deflected margin as a broad low swelling. Twelve or thirteen axial rings generally

TABLE 2. Bivariate statistics for the type sample of *Incaia bishopi* sp. nov. A—maximum sagittal cephalic length; B—maximum sagittal glabellar length; I—maximum transverse cephalic width; W—maximum transverse pygidial width; Z—maximum sagittal pygidial length. Measurements are in millimetres.

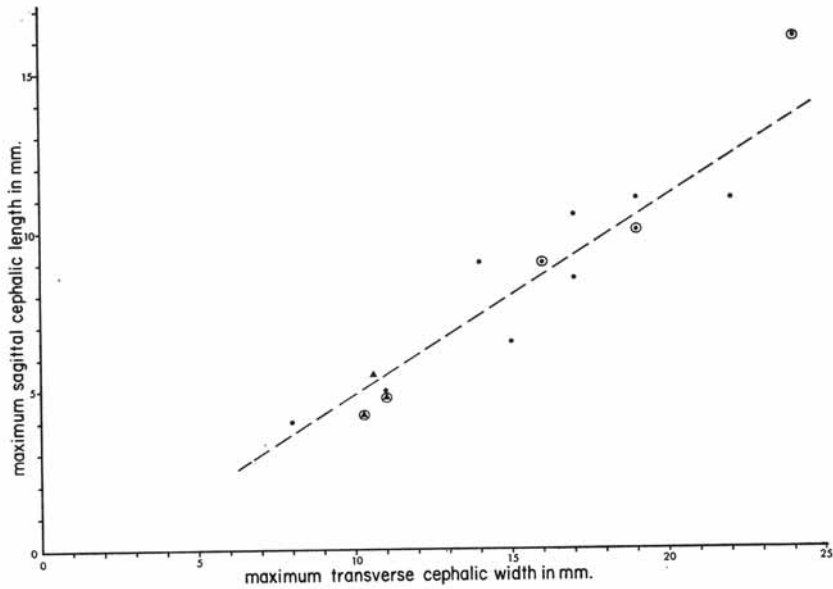
x:y	x	var. x	y	var. y	r	r <sub>e</sub>	α	var. α	a	var. a	n
I:B	16.17	22.966	4.67	2.966	0.93	0.93	1.23	0.0490	0.36	0.0044	6
I:A	15.37	19.697	8.19	7.496	0.91	0.91	1.15	0.0361	0.62	0.0109	8
W:Z	12.12	21.768	5.40	3.554	0.78	0.79	0.91	0.0526	0.40	0.0108	8

present, up to a maximum of sixteen (VA8, Pl. 128, fig. 6; VA11, Pl. 128, fig. 13); inter-ring apodemal pits developed between anterior eight rings. Axial furrows prominent anteriorly, becoming broader, shallower, and more rounded posteriorly. Pleural lobes have up to three to five weakly developed, flat-topped ribs convexly curved anteriorly. Declined border is deepest medially, becoming steeper and lower antero-laterally, terrace-lines present.

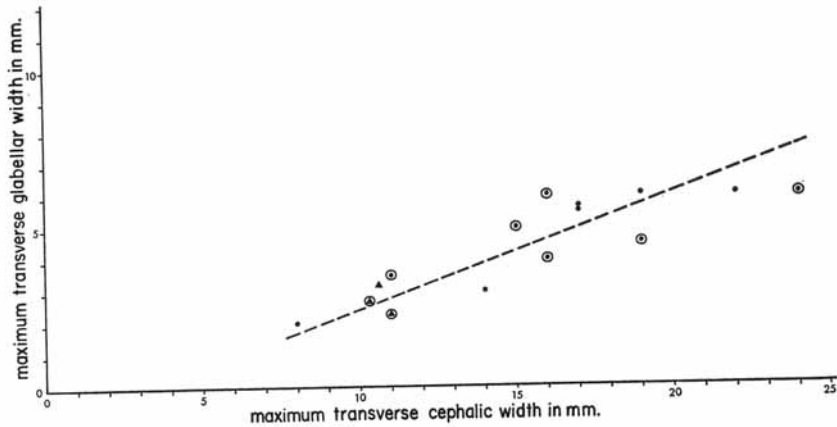
*Biometrical data.* Sufficient data are available for some selected bivariate analyses to be made. Text-figs. 4–6 give plots of the selected parameters, the various bivariate statistics being given in Table 2.

The use of standard bivariate techniques on such distorted material is justifiable provided there was no (primary) current or other orientation of the fossils. However, with tectonically distorted fossils it is impossible to be certain that the (undistorted) material had a random two-dimensional distribution. Therefore this must be assumed. The validity of the statistical approach depends partly on this assumption; it is further assumed that the attitude of the regression line is not affected by the deformation. The small number of specimens may contribute to an erroneous result in the statistical technique (Table 2) as well as the graphic technique (Table 1). Only two bedding surfaces were suitable for study by Wellman's (1962) method in bearing more than one specimen. The lack of agreement between results from the two methods does not indicate where errors occur.

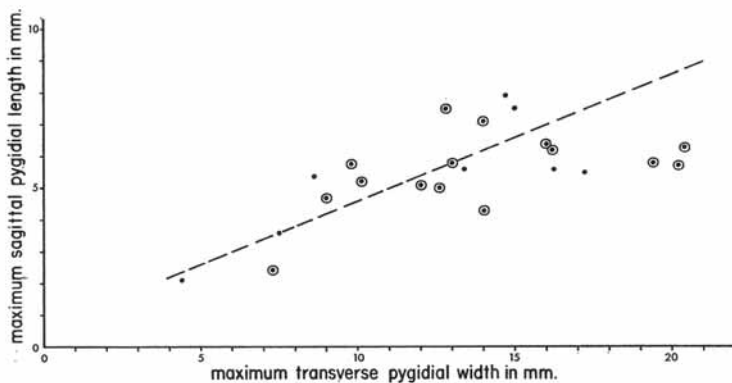
*Discussion.* This species is of interest as it provides confirmation of the presence of the lateral eye tubercle in *Incaia* and the position of the girder, as well as showing details of the glabella, thorax and pygidium. *I. bishopi* differs from *I. nordenskiöldi* in that it has considerably more sulci medially in front of the glabella (i.e. between the extensions of the axial furrows). Furthermore in *I. nordenskiöldi* the lateral eye tubercle appears to be slightly more posteriorly placed.



TEXT-FIG. 4. Plot of maximum transverse cephalic width against maximum sagittal cephalic length. ●—*I. bishopi* sp. nov.; ▲—*I. nordenskiöldi* (Bulman). Encircled points indicate that at least one of the measurements is approximate. All data for *I. bishopi* is from topotypic material (S3/526, see p. 682).



TEXT-FIG. 5. Plot of maximum transverse cephalic width against maximum transverse glabella width. ●—*I. bishopi* sp. nov.; ▲—*I. nordenskiöldi* (Bulman). Encircled points indicate that at least one of the measurements is approximate. All data for *I. bishopi* is from topotypic material (S3/526, see p. 682).



TEXT-FIG. 6. Plot of maximum transverse pygidial width against maximum sagittal pygidial length for *I. bishopi* sp. nov.; all data from topotypic material (S3/526, see p. 682). Encircled points indicate that at least one of the measurements is approximate.

*?Incaia bishopi* sp. nov.

Pl. 128, fig. 5

*Locality and material.* Specimens VA25, 116, 117 and DC353 from locality S3/526 (see p. 682).

*Horizon.* As for *I. bishopi* (see p. 682).

*Discussion.* These four specimens, all fragmental fringe casts, differ from *I. bishopi* in having at least three arcs of pits developed. The best of these specimens (VA25, Pl. 128, fig. 5) is of the same order of size as a cephalon of *I. bishopi* such as VA17 or 65 which almost certainly possess only 2 arcs. However it is known that trinucleid species may exhibit variations in the fringe which may or may not be linked to different growth stages. Thus these specimens of isolated casts of fringe fragments cannot conclusively be said to belong to or differ from *I. bishopi*. No girder is discernable on any of these specimens.

Subfamily TRINUCLEINAE Hawle and Corda 1847

Genus ANEBOLITHUS gen. nov.

Pl. 127, figs. 7, 10

*Diagnosis.* Cephalon semicircular with simple, narrow fringe with no pits external to the girder; pits of internal series consist of three arcs with pits sunk in radial sulci. Glabella typically trinucleid, pyriform with three pairs of lateral glabellar furrows; median node present. No eye tubercles developed on genal regions. Thorax typically trinucleid. Pygidium about four and a half times as wide as long, pleural fields faintly furrowed anteriorly, axis segmented.

*Type species.* *Incaia simplicior* Whittard 1966.

*Type locality and horizon.* Small path-side quarry in northerly trending valley 160 yd. N. 35° E. of the north-eastern corner of Snailbeach Reservoir, Shropshire, England (grid ref. SJ 377023); Mytton Flags, Arenig (*Didymograptus extensus* Zone) about 2000 ft. above Stiperstones Quartzite.

*Distribution.* The genus at present is restricted to the type species. However, a further occurrence of the genus is shortly to be described from the lower Llanvirn of the Builth-Llandrindod Inlier (Hughes 1971).

*Discussion.* Although the details of the fringe are similar to *Incaia*, the lack of large lateral eye tubercles and the presence of a median glabellar node together with other minor morphological features (for full description of morphology see Whittard 1966, pp. 274–6) suggest that *Anebolithus* is closely related to the other Trinucleinae of the Welsh Borderland, e.g. *Bergamia*, *Stapeleyella*, and not to *Incaia*. The combination of peripheral girder and radially disposed pits warrants the erection of *Anebolithus*, which appears to be in an evolutionary series between *Myttonia*, with marginal girder but irregular pits, and *Lordshillia* with radially arranged pits but with one arc external to the girder.

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Both authors would like to extend their thanks to Mr. John Lewis for his skill in preparing the text-figures other than text-fig. 2.

All relevant specimens are referred to by individual numbers; suffixes a or b indicate counterparts; prefixes denote collection in institutions where material is housed, as follows:

Ar.—Swedish State Natural History Museum, Stockholm.

DC—New Zealand Geological Survey, Lower Hutt.

VA—Geology Department, Victoria University of Wellington, Wellington.

GSM—Institute of Geological Sciences, London.

A copy of all the original measurements made on specimens is lodged with each of the first three of the above institutions together with a further copy in the Geological Society, London.

#### REFERENCES

- BANCROFT, B. B. 1929. Some new species of *Cryptolithus*, (s.l.), from the Upper Ordovician. *Mem. Proc. Manchr. lit. phil. Soc.* **73**, 67–96.
- BISHOP, D. G. 1965. Two new Palaeozoic fossil localities in northwest Nelson. *N.Z. Jl Geol. Geophys.* **8**, 1232–3.
- 1969. S2 Kahurangi (1st edition) 'Geological map of New Zealand' 1:63360. Department of Scientific and Industrial Research, Wellington, New Zealand.
- (in press) S3 Collingwood (1st edition), *ibid.*
- BULMAN, O. M. B. 1931. South American graptolites with special reference to the Nordenskiöld collection. *Ark. Zool.* **22A** (3) 1–111.
- COOPER, R. A. 1968. Lower and Middle Paleozoic fossil localities of north-west Nelson. *Trans. R. Soc. N.Z. Geol.* **6**, 75–89.

- HARRINGTON, H. J. and LEANZA, A. F. 1957. *Ordovician trilobites of Argentina*. Dept. Geol. Univ. Kansas, Spec. Pub. 1. 276 pp. 140 figs.
- HARRINGTON, H. J., MOORE, R. C. and STUBBLEFIELD, C. J. 1959. Morphological terms applied to Trilobita. In MOORE, R. C. (ed.), *Treatise of invertebrate paleontology*, Part O. Geol. Soc. Am. and Univ. Kansas Press. pp. 117–26.
- HAWLE, I. and CORDA, A. J. C. 1847. *Prodrom einer Monographie der böhmischen Trilobiten*. 176 pp., 7 pl. Prague.
- HUGHES, C. P. 1970. Statistical analysis and presentation of trinucleid (Trilobita) fringe data. *Palaeontology*, **13**, 1–9.
- 1971. The Ordovician trilobite faunas of the Builth–Llandrinod Inlier, Central Wales, Part II. *Bull. Br. Mus. nat. Hist. (Geol.)* (in press).
- MOORS, H. T. 1966. Some of the stratigraphy and palaeontology of the Cliefden Caves District, near Mandurama. Unpublished M.Sc. thesis, Department of Geology and Geophysics, University of Sydney, Australia.
- RUSCONI, C. 1953. Trilobitas ordovicicos y cambricos de Mendoza. *Bol. paleont. B. Aires.* (**25**), 1–8, figs. 1–10.
- 1956. Fósiles ordovicicos de la quebrada de los Bueyes, (Mendoza). *Revta Mus. Hist. nat. Mendoza*, **9**, (1, 2), 2–15, pl. 1.
- STØRMER, L. 1930. Scandinavian Trinucleidae, with special reference to Norwegian species and varieties. *Skr. norske Vidensk.-Akad. Mat.-naturv. Kl.* 1930, **4**, 1–111, pl. 1–14, figs. 1–47.
- WELLMAN, H. W. 1962. A graphical method for analysing fossil distortion caused by tectonic deformation. *Geol. Mag.* **99**, 348–52, pl. 16.
- WHITTARD, W. F. 1955. The Ordovician trilobites of the Shelve Inlier, West Shropshire, Part I. *Palaeontogr. Soc. (Monogr.)* 1–40, pl. 1–4.
- 1958. The Ordovician trilobites of the Shelve Inlier, West Shropshire, Part III. *Ibid.* 71–116, pl. 10–15.
- 1966. The Ordovician trilobites of the Shelve Inlier, Shropshire, Part VIII. *Ibid.* 265–306, pl. 46–59.
- WHITTINGTON, H. B. 1966. Phylogeny and distribution of Ordovician trilobites. *J. Paleont.* **40**, 696–737.
- 1968. *Cryptolithus* (Trilobita): Specific characters and occurrence in Ordovician of eastern North America. *J. Paleont.* **43**, 702–14.
- WRIGHT, A. J. 1968. Ordovician conodonts from New Zealand. *Nature*, **218**, 1232–6.

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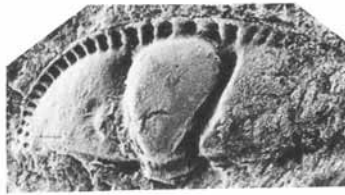
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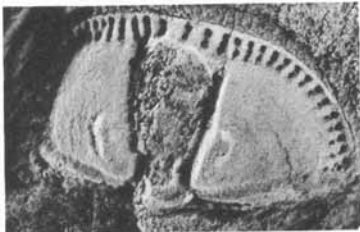
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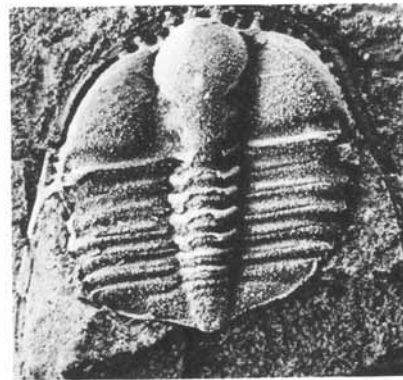
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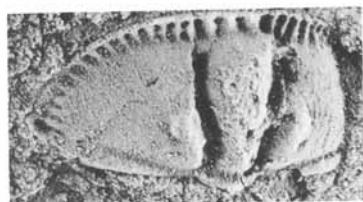
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HUGHES and WRIGHT, *Incaia* and *Anebolithus*





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HUGHES and WRIGHT, *Incaia* from Peru and New Zealand