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EARLY JURASSIC TEREBRATULIDE BRACHIOPODS FROM ZEALANDIA

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Keywords: Zealandia; New Zealand; New Caledonia; Brachiopoda; Terebratulida; Early Jurassic; Murihiku Terrane; Teremba Terrane.

Abstract. Terebratulides, a minor group in New Zealand and New Caledonian Triassic faunas, become second in prominence only to rhynchonellides in the Jurassic. In this study, a total of seven genera and twelve species are recognised and eight new species are described.

Lobothyris simesi n. sp. is present throughout the Sinemurian to middle Toarcian. *Loboidothyris fordycei* n. sp. is common in the late Sinemurian to Pliensbachian of the Hokonui Hills, and a few specimens are recorded from scattered Pliensbachian-Toarcian localities elsewhere. *Zeilleria spiculata* MacFarlan and Campbell is found in a narrow zone along the Triassic-Jurassic boundary in the Hokonui Hills. *Z. terezowae* n. sp. is found throughout most of the Early Jurassic, while *Z. recessa* n. sp. and *Z. sacciformis* n. sp. have more restricted ranges. The Sinemurian *Aulacothyris stevensi* n. sp. is known from the Hokonui Hills, and the coast north of Marokopa. Two further forms of *Aulacothyris* are present.

Linguithyris agerorum Manceñido was described from Port Waikato, and is here recorded from New Caledonia. *Tegulithyris*? *plencnerae* n. sp. is known from the Sinemurian to Toarcian of Kawhia, and *Rugithyris hasibuani* n. sp. from the Awakino area.

Lobothyris, *Aulacothyris* and *Zeilleria* are cosmopolitan and widely distributed. *Loboidothyris* is also cosmopolitan, but has a Tethyan aspect. *Tegulithyris* and *Rugithyris* are Tethyan. *Linguithyris* is also known from southern Europe, North Africa and western Asia. The highest Early Jurassic brachiopod faunas occur at or just above the *Dactylioceras* band near Kawhia, which is correlated with the top of the early Toarcian and lies above the Toarcian event in Western Europe.

Introduction

This paper is intended as a detailed systematic account of the Early Jurassic terebratulide faunas of New Zealand and New Caledonia (Zealandia, *sensu* Mortimer et al. 2017). It covers the period between the end-Triassic extinction event and the early to mid Toarcian extinctions, and is intended to complement the author's previous work on Middle and Late Jurassic terebratulides (MacFarlan 2016).

The extinction of several groups of brachiopods and molluscs at or near the end of the Triassic meant that Zealandian Early Jurassic marine faunas are quite different to those of the Triassic. Brachiopods as a whole become less prominent, while rhynchonellides become the dominant group. The spiriferides are much reduced and the terebratulides, a minor group in the Triassic, become much more significant, in a trend which led to them becoming the major brachiopod group in the Cenozoic.

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Previous Work

In a paper read to the Wellington Philosophical Society, Hector (1878, p. 537) noted the presence of "the peculiar subgenus of *Terebratula* represented by the typical "*Epithyris elongata*" in the Liassic (Bastion) series". This paper was published only in abstract. The promised substantive paper never appeared, although plates were prepared and were subsequently published by Thomson (1913). Trechmann (1923) described *Terebratula* (*Heimia*?)

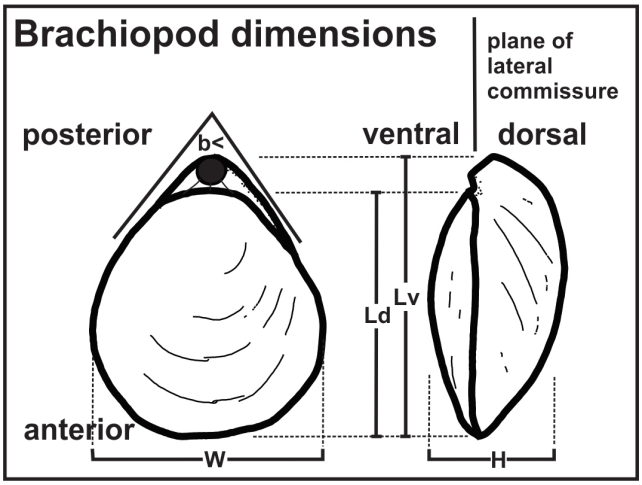


Fig. 1 - Measured dimensions

sp. from the lower slopes of Flag Hill (Ben Bolt), Otapiri Valley, Southland. Marwick (1953) considered this to be Aratauran. MacFarlan and Campbell (2003) described *Zeilleria spiculata* from the latest Triassic and earliest Jurassic, and Manceñido (1993a) described *Linguithyris agerorum* from a single Ururoan specimen from Port Waikato.

Methods

This paper is based on material from the collections of the School of Environment, University of Auckland, the Geology Department, University of Otago, and the National Palaeontological Collection at GNS Science. Methods and taxonomic approach are generally those applied in MacFarlan (1992) and MacFarlan (2016).

All suitable specimens were measured (Fig. 1) and catalogued in the relevant specimen catalogue. Specimens with valid length (Ld or Lv) and width data were used in plotting graphs and for statistics. Working photos and camera lucida drawings were taken where required. No serial sections were made as there were too few well-preserved double-valved shelly specimens available to justify the destruction of any of them. Attempts at imaging the interiors of some *Dactylioceras* bed specimens using micro-CT were made by Tiffany Plencner of the Geology Department, University of Otago, but were unsuccessful.

Abbreviations in measurement tables: dv, dorsal valve; vv, ventral valve; b, both valves; int, internal mould; ext, external mould. Ld, length of dorsal valve (mm); Lv, length of dorsal valve (mm); W, width (mm); H, height (mm); b<, beak angle (°); ant, anterior; post, posterior; F, flattened.

Classification and morphologic terminology follow the revised brachiopod volumes of the Treatise on Invertebrate Paleontology (Kaesler 2000–2007). Authorship for higher taxa, genera and type species also follows Treatise usage unless otherwise stated. Abbreviations used throughout for type species designation are OD (by original designation) and SD (by subsequent designation).

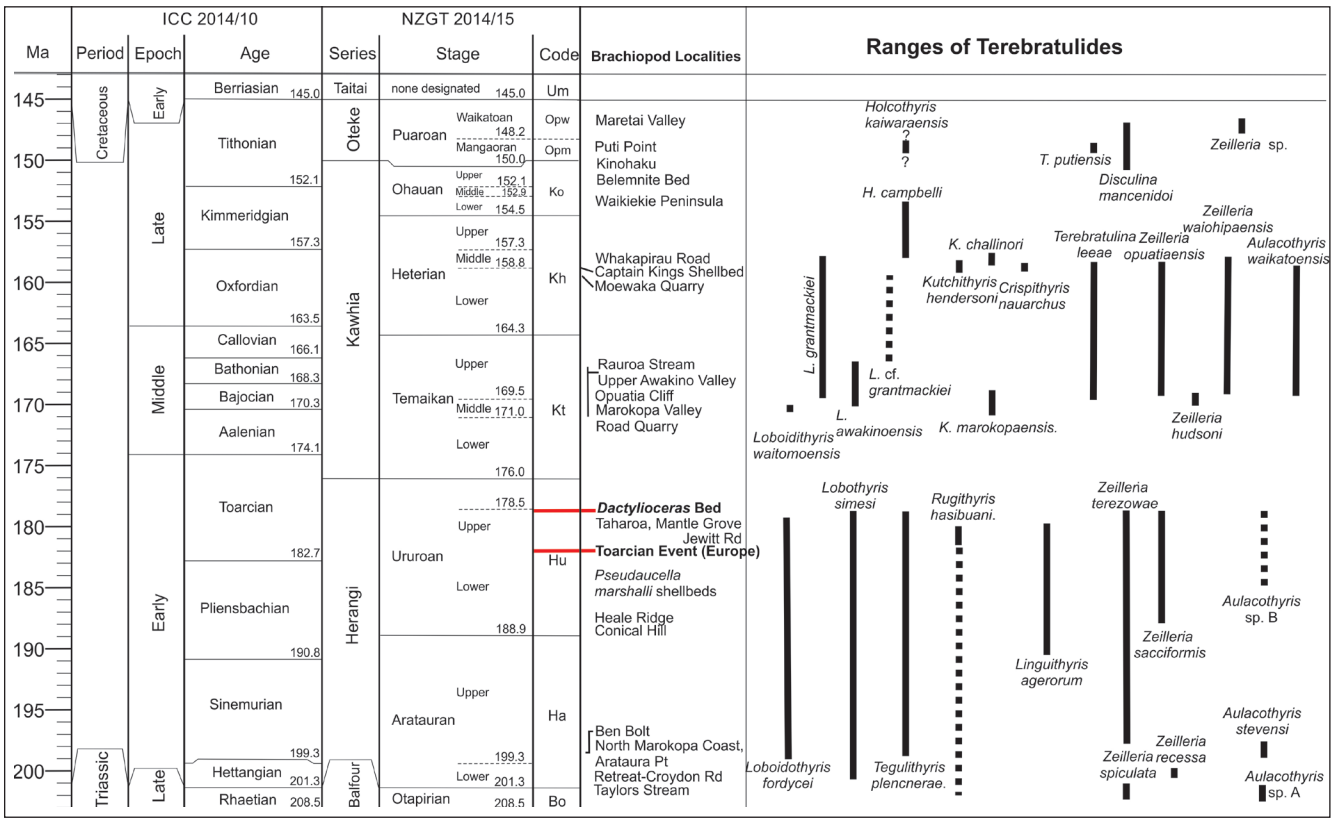


Fig. 2 - Jurassic timescale and range chart showing correlations between New Zealand and international stages (adapted from Raine et al. 2015) and ranges of Zealandian terebratulide species. Late Jurassic terebratulide ranges from MacFarlan (2016).

Locality and collection data: Nearly all localities discussed here are registered in the New Zealand Fossil Record File maintained by the Geoscience Society of New Zealand and GNS Science. Localities are registered by NZMS260 map sheet number and registration number (FR number), with a letter to indicate a recollection (for example R13/f6613A). The associated Fossil Record Electronic Database (FRED) was used extensively to search for collections containing terebratulide material and to obtain locality, stratigraphic and faunal data. New Caledonian collections held in New Zealand are also registered in the Fossil Record File (prefixed NC).

Collections and specimens are catalogued as follows:

Auckland University School of Environment: Collections prefixed AU, brachiopod specimens prefixed B.

Otago University Geology Department: collections under collector's field number, catalogued specimens prefixed OU.

National Paleontological Collection at GNS Science, Avalon: collections prefixed GS, catalogued specimens prefixed BR.

Natural History Museum, London. Brachiopod specimens are prefixed B.

Locality data is summarised in Appendix.

Correlations: Detailed biostratigraphy in this paper is in terms of the New Zealand stage system as originally proposed by Marwick (1951, 1953) and refined and subdivided by Cooper (2004). Correlations with international stages follow Raine et al. (2015). The stage system and the correlations of key localities and horizons are summarised in Fig. 2.

International correlations depend on ammonite work (Stevens 2004, 2007, 2008, 2012a & b, 2014 for New Zealand and Meister et al. 2010 for New Caledonia).

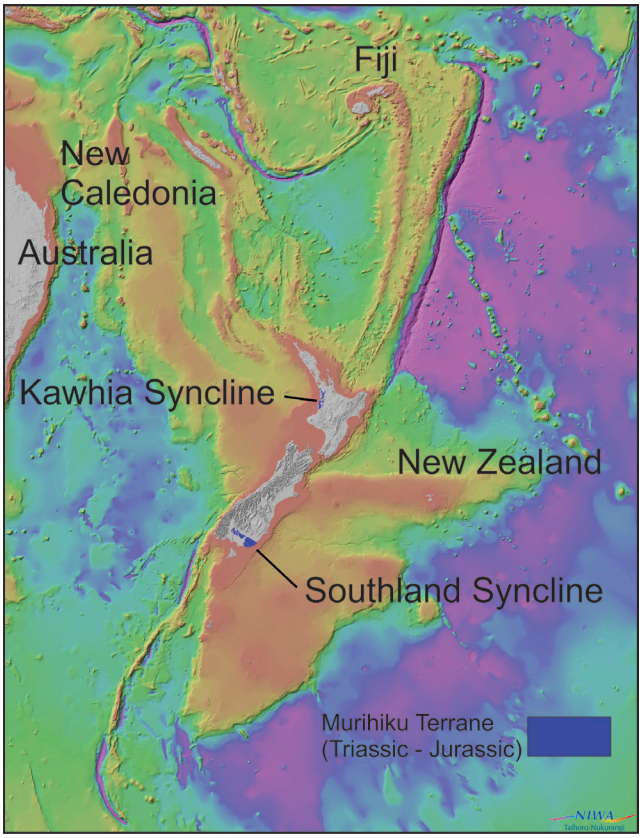


Fig. 3 - Location map of Zealandia Base map: NIWA

Geographic and Stratigraphic Setting

The material described here comes from the Teremba Terrane on the west coast of New Caledonia (Campbell et al. 1985; Aitchison et al. 1995) and the Kawhia and Southland Synclines, which were deposited within the Murihiku Supergroup, Murihiku Terrane (Campbell et al. 2003; Mortimer et al. 2014). The entire area of continental crust surrounding New Caledonia and New Zealand (Fig. 3) is now seen as forming the largely submerged continent of Zealandia (Mortimer & Campbell 2014; Mortimer et al. 2017).

New Caledonia

Jurassic rocks of the Baie de St.-Vincent Group crop out on the west coast of New Caledonia (Fig. 4), principally in the Moindou area (Campbell & Grant-Mackie 1984), and around Baie de St Vincent. (Paris 1981). The key area is Uitoé Peninsula on the south side of the Baie de St Vincent, where Aratauran to Ururoan rocks are exposed, with ammonites described by Meister et al. (2010) giving an Late Hettangian to early Sinemurian age. Overlying localities are Lower Ururoan with the bivalve *Pseudaucella marshalli*.

New Zealand

Kawhia Syncline

The Kawhia Syncline is exposed from Port Waikato to Awakino. Regional geology is described by Edbrooke (2001, 2005). Significant localities are shown in Fig. 5. Key Early Jurassic sections are:

Port Waikato: (Purser 1961; Waterhouse 1978; Hudson 2003). The Early Jurassic of the Port Waikato area is poorly fossiliferous, and the only terebratulide seen in this study is the sole New Zealand specimen of *Linguithyris agerorum*. This is in contrast to the Middle and Late Jurassic, where it is one of the key areas for brachiopod faunas (MacFarlan 1992, 2016).

Kawhia: The west coast of Te Maika Peninsula (Fig. 5 inset) is the type section for the Aratauran and Ururoan stages (Marwick 1953; Fleming & Kear 1960; Martin 1975; Waterhouse & White 1994) and is a key section for this study. Terebrat-

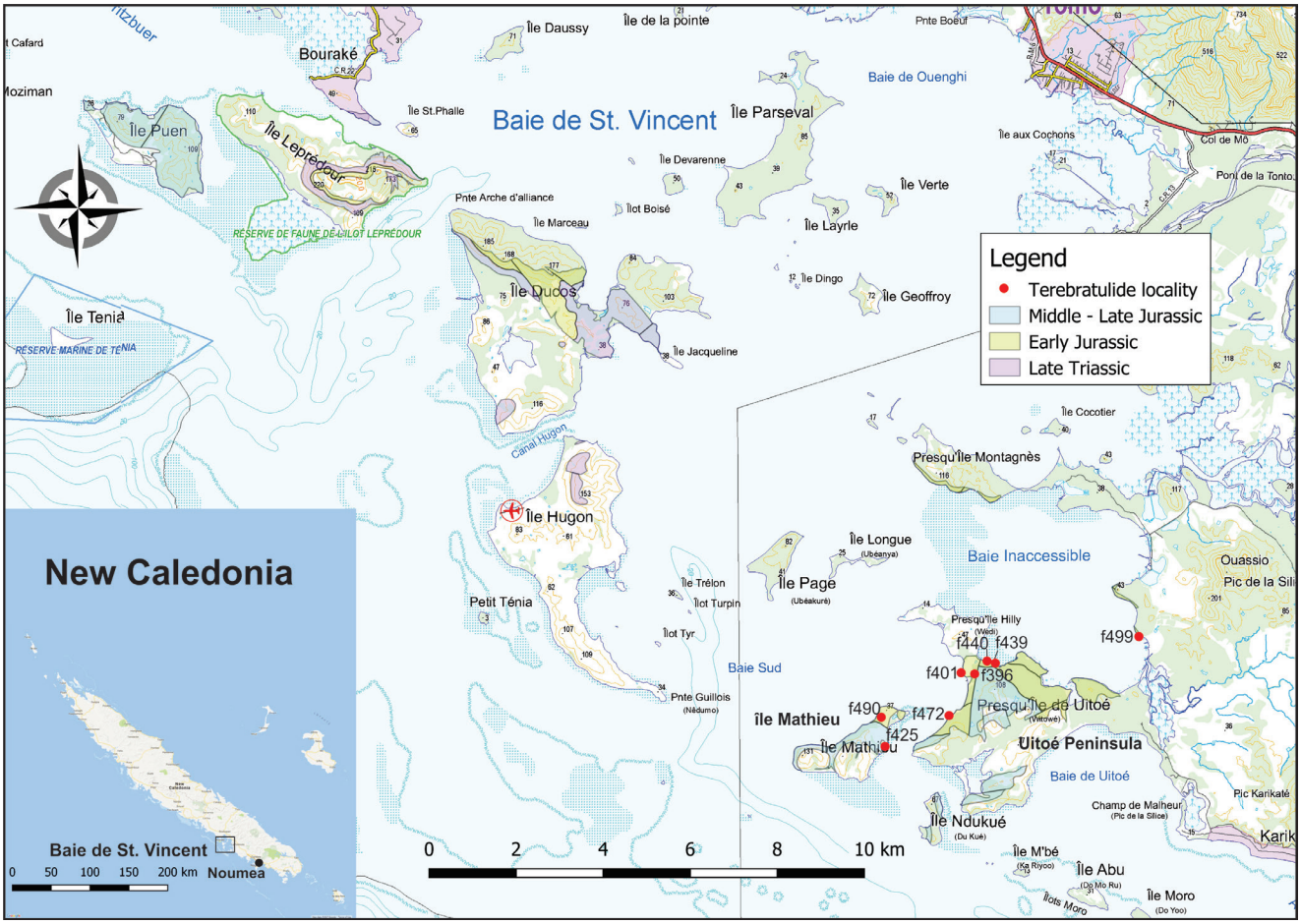


Fig. 4 - Baie de St Vincent, New Caledonia. Base and geology from Gouvernment de Nouvelle-Caledonie data. Inset: New Caledonia. Terebratulide locality numbers are FR numbers with initial NC/ omitted.

ulides were examined from several horizons, of which the Upper Ururoan *Dactylioceras* bed is the most significant.

Akikuni et al. (2010) place the Otapirian-Aratauran boundary in the 11-12 m of strata between R15/f184, with a good Otapirian fauna including the brachiopods *Clavigera* and *Mentzelia kawhiana* and the bivalve *Otapiria dissimilis*, and R15/f190 with the earliest Sinemurian ammonites *Metophioceras marokopaense* and *Nevadaphyllites* cf. *pounamuus*. Zhang and Grant-Mackie (2001) identified a boundary zone between the Triassic and Jurassic at about the same level, based on palynology, and Grant-Mackie (2011) discussed the succession of *Otapiria* in this, and the Awakino Valley. No Hettangian ammonites are known from the Kawhia section, so the Hettangian is very thin or absent (Stevens 2004).

The identification of the ammonite *Juraphyllites* ex gr. *liberus* from R15/f8819, 400m NE of Otamaehu Point, gives a Pliensbachian age to this part of the section (Stevens 2014) while the ammonite *Catacoeloceras grangei* from R15/f8005 (Stevens 2008) allows the *Dactylioceras* band to be correlated with the Crassum Subzone (top of the Early Toarcian).

Raine et al. (2015) define the Upper Ururoan on the lowest occurrence of *Catacoeloceras grangei* in this section. This means that the diverse molluscan and brachiopod fauna characteristic of the beds above the last appearance of *Pseudaucella marshalli* are defined as Lower Ururoan, and the Upper Ururoan is essentially restricted to the *Dactylioceras* bed and the generally unfossiliferous beds above this and below the base of the Temaikan. As *Catacoeloceras grangei* has not been recorded in other sections this definition can only be applied at Te Maika Peninsula.

In previous subdivisions (MacFarlan 1992; Hudson 2003; Cooper 2004), the Upper Ururoan consisted of the interval between the top of the *Pseudaucella marshalli* beds and the lowest Temaikan

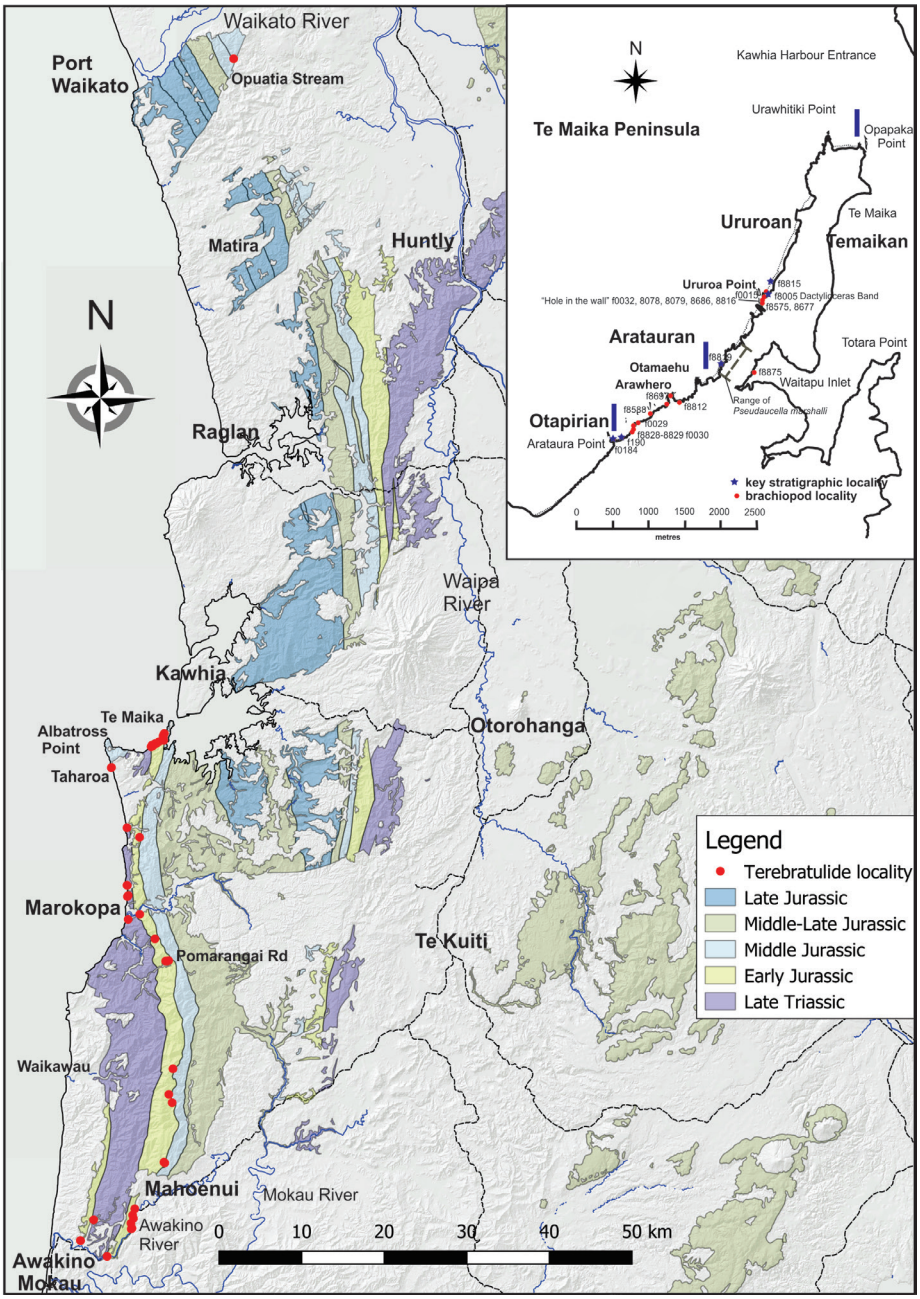


Fig. 5 - Geological map of southwest Auckland Province, showing Kawhia Syncline. Main terebratulide localities shown. Base: LINZ data with geology from GNS Science Q-Map. INSET: Te Maika Peninsula, Kawhia. Geology from Martin (1972). Terebratulide locality numbers are FR numbers with initial R15/ omitted.

fauna. In this paper I use the definition of Hudson (2003, p. 123) "The Upper Ururoan Substage is defined as extending from the last appearance of *Pseudaucella marshalli* to the first appearance of a Temaikan fauna".

As noted by Hudson (2003), the characteristic Upper Ururoan brachiopod faunas do not extend far above the *Dactylioceras* band. R15/f8006 is best regarded as a number for more poorly localised collections just above or below R15/f8005. The highest locality with Ururoan brachiopods recorded is R15/f8815, 45m stratigraphically above the *Dactylioceras* band, with only *Herangirhynchia herangiensis* of the Ururoan fauna present (MacFarlan 1992), together with "*Inoceramus*" *ururoaensis* Speden (Speden 1970) which is one of the few fossils found in overlying beds.

Taharoa: An isolated outcrop on the beach north of Taharoa (R16/f6811) has yielded a diverse Upper Ururoan molluscan and brachiopod fauna (Martin 1975). Stevens (2007) identified *Harpoceras subplanatum* from this locality, indicating an Early Toarcian age, slightly below that of the *Dactylioceras* Band at Ururoa Point.

Coast north of Marokopa: The coast north of the Marokopa River has an Otapirian to Aratauran section mapped by Stevens (2012a). The ammo-

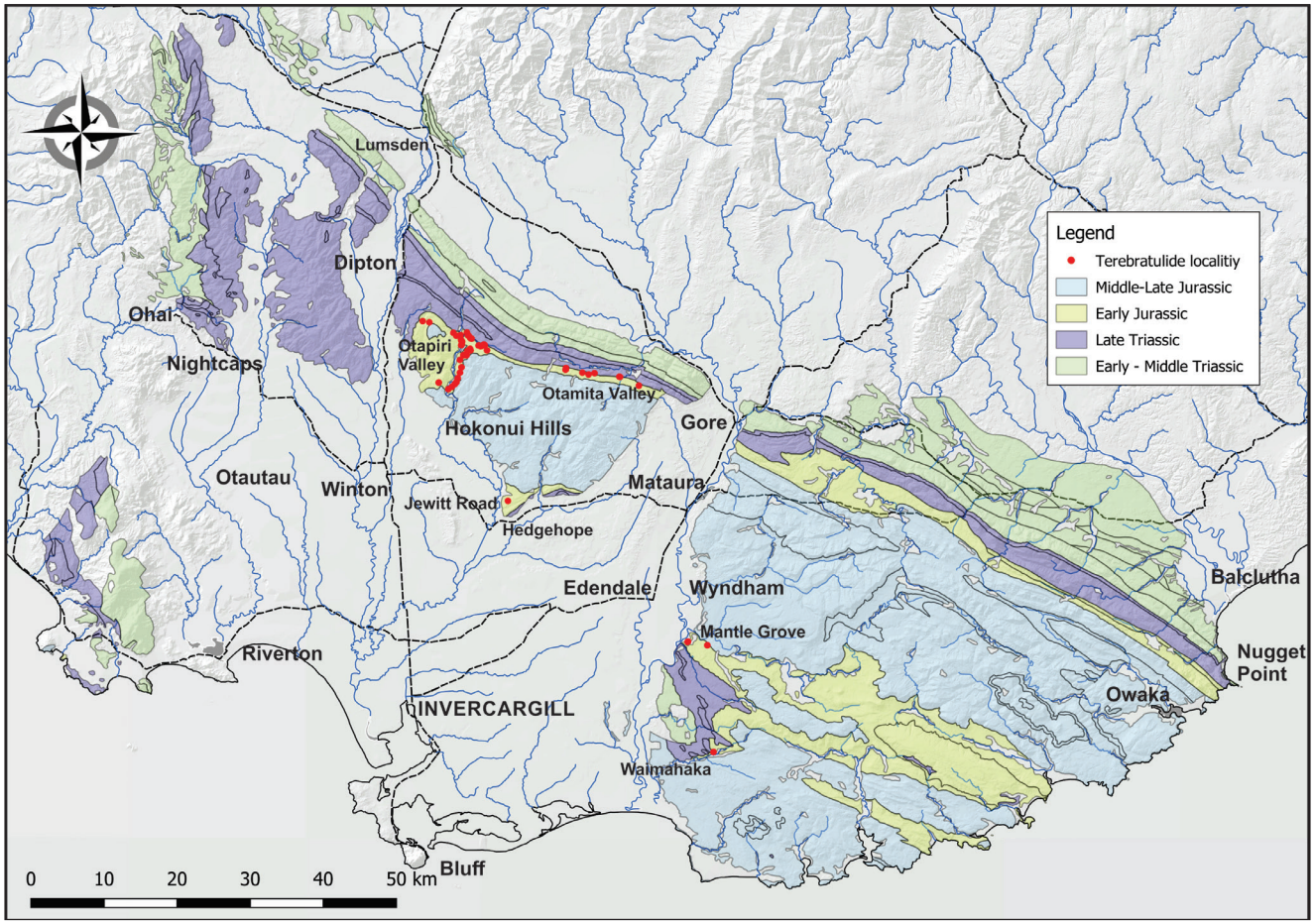


Fig. 6 - Southland, showing extent of Southland Syncline. Main terebratulide localities shown. Base: LINZ data with geology from GNS Science Q-Map.

nites *Metophioceras marokopaense* and *Nevadaphyllites* cf. *pounamuus* indicate the base of the Sinemurian. The Otapirian-Aratauran boundary is obscured in this section but inferred to be a few metres below (see Stevens, 2012a, fig. 4).

Marokopa: The Otapirian-Aratauran boundary is also exposed south of the Marokopa River at its mouth (MacFarlan 1998). The uppermost Hettangian ammonite *Eolytoceras* cf. *tasekoi* in this section (Stevens 2004) indicates that the Hettangian is about 25m thick, and much may be missing. Inland outcrops east of the Manganui Fault are generally weathered, but some terebratulides have been found in the Marokopa Valley and along the Pomarangai Road (MacFarlan 1998).

Awakino: The Awakino Gorge section is Oretian to Ururoan in age (Grant-Mackie 1959; Hudson 2003). The main brachiopod localities are the two quarries beside State Highway 3, which are Upper Ururoan and approximately along-strike. Fault blocks west of the Manganui Fault are of Aratauran age (Campbell and Raine 1989) but terebratulides are rare. In the upper Awakino Valley, north of Mahoenui, a few terebratulides have been collected from tributaries of the Awakino River and from the Rauroa Valley (Hasibuan 1982; Hudson 2003).

Southland

Aratauran and Ururoan strata are found on both flanks of the Southland Syncline but terebratulides are rare except in a few localities (Fig. 6). Regional geology is described by Turnbull and Allibone (2003).

Hokonui Hills: The most complete (but not continuous) Aratauran to Lower Ururoan section is in the Otapiri Valley in the western Hokonui Hills (McKellar 1968, 1977) with diverse brachiopod fau-

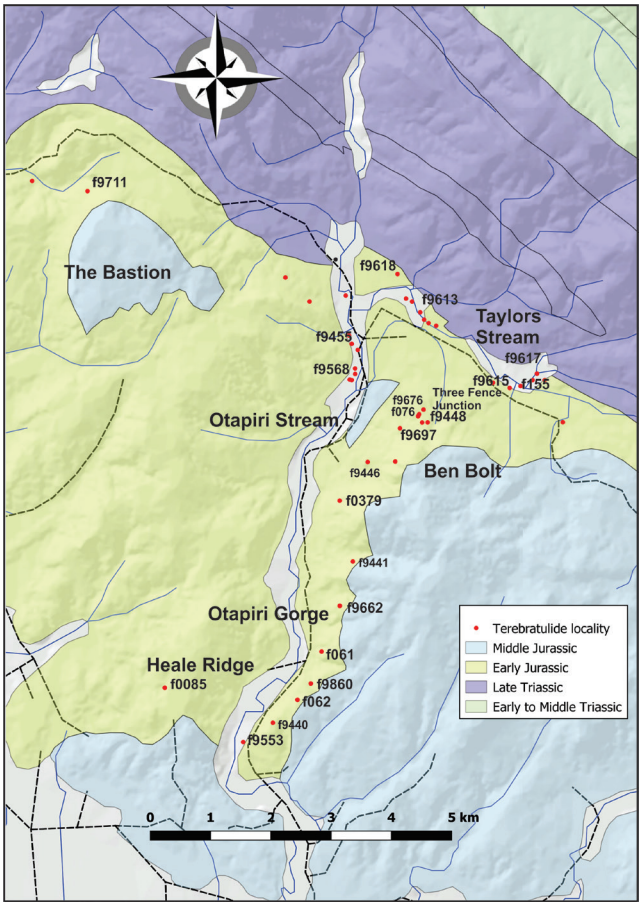


Fig. 7 - Otapiri Valley, Hokonui Hills Main terebratulide localities shown. Base: LINZ data with geology from GNS Science Q-Map. Terebratulide locality numbers are FR numbers with initial E45/ omitted.

nas at several localities (Fig. 7). Ammonite work (Stevens, 2004) allows the recognition of several zones within the Hettangian and Sinemurian.

(1) The lowest zone is Early Hettangian (Planorbis Zone and possibly below), exposed in Taylors Stream north of the road. *Zeilleria spiculata* is common in this area and in the uppermost Otapirian below (MacFarlan & Campbell 2003).

(2) Junction of Taylors Stream and Otapiri – (“*Psiloceras*” bed, E45/f9455 and above), with the ammonites *Waehneroceras otapiriense* and *Murihikuites mackellari*. Johnstoni and Portlocki Zones, Early to Middle Hettangian.

(3) North face of Ben Bolt (Flag Hill of Cox, 1878, McKay, 1878 and Trechmann, 1923). Latest Hettangian. Stevens (2004) suggests that *Paracaloceras (Gyrophioceras) loraense* (at E45/f9448, GS 348) spans the Hettangian-Sinemurian boundary, and that in overlying localities E45/f9677 (GS6594) and E45/f9699 (GS 6758) *Angulaticeras flaghillense* indicates the base of the Sinemurian. The appearance of the rhynchonellide *Herangirhynchia arawheroensis* in this section defines the Upper Aratauran (MacFarlan 1992; Cooper 2004; Raine et al. 2015). This species is present at several localities in the general area of the “Three Fence Junction” in this part of the section.

(4) Further down the Otapiri Valley, several localities have yielded a diverse bivalve and brachiopod fauna, with dwarf *Pseudaucella*. These are inferred to be earliest Ururoan and bivalve and rhynchonellide faunas suggest a transitional to nearshore environment (MacFarlan 1992). A similar fauna occurs at Heale Ridge, west of the Otapiri Valley and Otapiri Fault, where it is overlain by beds with normal-sized *Pseudaucella*. Several bivalves present in the Heale Ridge fauna have links with Argentina (Damborenea & Manceñido 1992). No ammonites have been identified from these areas.

To the east of the Otapiri Valley, collections from the Rhutra Stream and Otamita Valley areas have also yielded Aratauran terebratulide faunas. Stevens (2004) records *Schlotheimia extranodosa* and *Storthoceras* cf. *extracostatum* from near the Otamita Valley locality at the same general stratigraphic level, suggesting a middle Hettangian age.

The only known Upper Ururoan outcrops in the Southland Syncline are in the south limb of the syncline in the Jewitt Road area near Dunsdale in the southern Hokonui Hills (MacFarlan 1992).

Mantle Grove: Ururoan rocks from Mantle Grove near Wyndham have yielded an Ururoan fauna including spiriferide and terebratulide brachiopods. The ammonite *Zugodactylites braunianus* indicates a Lower Toarcian age (Stevens 2008).

Waimahaka: Collections from 5m above the top of the Glenham Porphyry south of Crighton Road, east of Waimahaka are of Early Ururoan age (Coombs et al. 1992).

Systematic Palaeontology

Order **Terebratulida** Waagen, 1883
Suborder **Terebratulidina** Waagen, 1883
Superfamily Loboidothyridoidea Makridin, 1964
Family Loboidothyrididae Makridin, 1964
Subfamily Loboidothyridinae Makridin, 1964

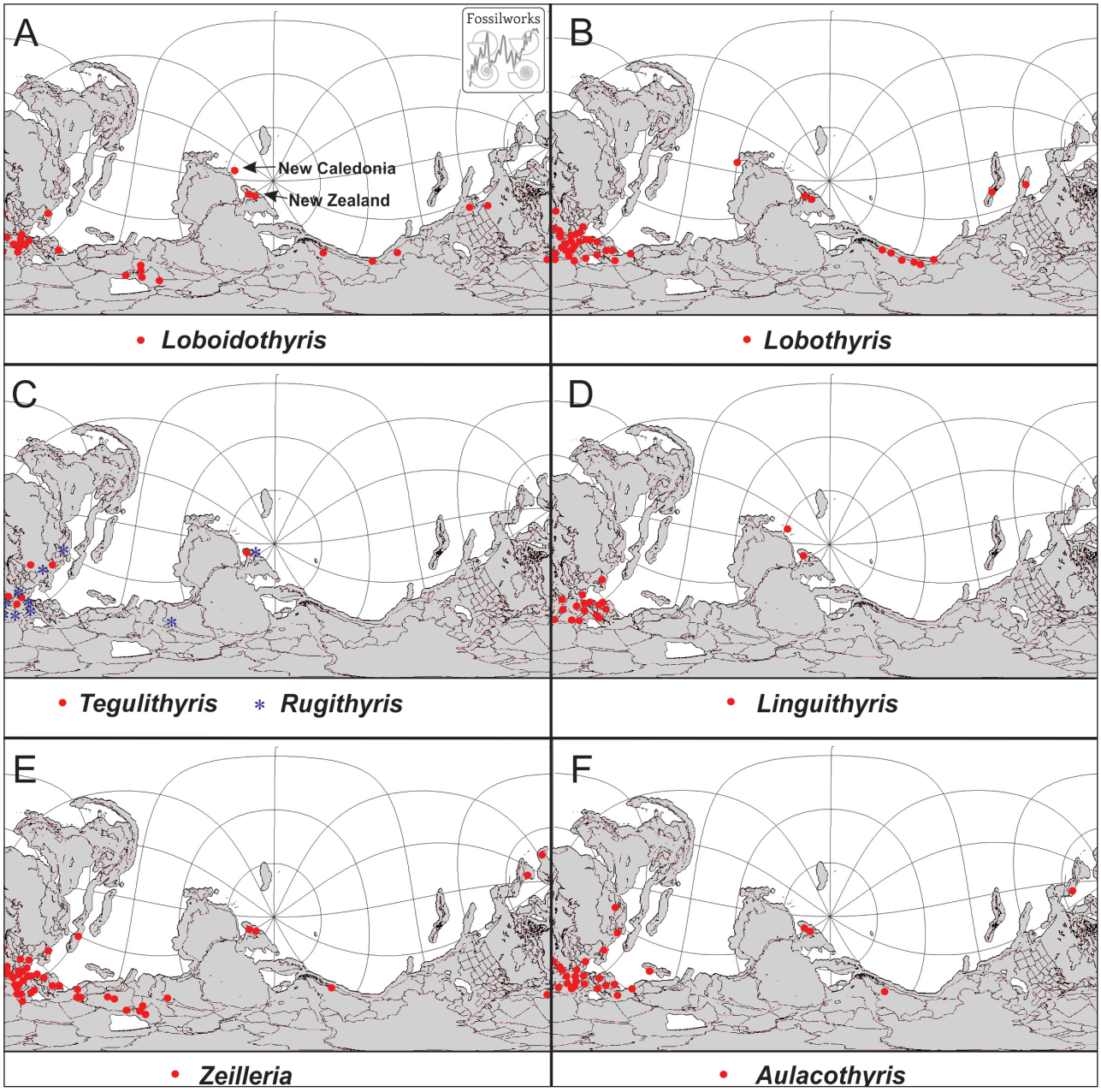


Fig. 8 - World distribution of terebratulide genera.
Data from Fossilworks (downloaded 4 May 2018) and relevant literature.
Base maps from Alroy (2013). Online paleogeographic map generator. http://paleodb.org/?a=mapForm Maps drawn on equirectangular projection for 185 ma, focal co-ordinates -80°, 180°.
New Zealand and New Caledonia in the Jurassic were a series of terranes on the subducted margin of Gondwana, and the positions shown on Diagram A are approximate.

Genus *Loboidothyris* Buckman, 1918

Type species - *Terebratula latovalis* Buckman, 1918 OD

1918 *Loboidothyris* – Buckman, p. 112.
1965a *Loboidothyris* Buckman – Muir-Wood, p. H784.
1983 *Loboidothyris* Buckman – Cooper, p. 99.
2006 *Loboidothyris* Buckman – Lee et al., p. 2082.
2014 *Loboidothyris* Buckman – Alméras et al., p. 18.
2016 *Loboidothyris* Buckman – MacFarlan, p. 471.

Loboidothyris is a widespread Jurassic genus, initially described from Britain but since recorded from France (Alméras et al. 2014), Germany (Cooper 1983), Spain (García Joral & Goy 1984, 2000), Portugal (Andrade et al. 2016), Italy (Ferrari & Manara 1972), Bulgaria (Tchoumatchenko 1996), Crimea (Kamyshan & Babanova 1973), Peru (Sandy 1994), Argentina (Manceñido & Dagis 1992; Manceñido 2002), Chile (Manceñido 1988), Alberta and California (Crickmay 1933), Greenland (Rosenkrantz 1934), Morocco (Alméras & Faure 2008), the Horn of Africa (Muir-Wood 1935), China (Sun et

al. 2017) and possibly Thailand (Alméras 1988). It is also recorded from the Triassic of Peru by Sandy (1994).

Three new species from the Middle and Late Jurassic of New Zealand were provisionally assigned to *Loboidothyris* by MacFarlan (2016). One further species is described here from the Early Jurassic, again with some qualification as no material suitable for serial sectioning was found. It is found in both the Kawhia and Southland synclines, and New Caledonia.

Lee et al. (2006) give *Loboidothyris* a time range of Toarcian to Bajocian, and Alméras et al. (2014) of Aalenian to Bajocian. The New Zealand and New Caledonian material has a much longer time range (Aratauran to Upper Heterian, Sinemurian to late Oxfordian).

Peristerothyris Manceñido, 1983, described from the Pliensbachian of Argentina is larger and more strongly folded than New Zealand and New Caledonian specimens of *Loboidothyris*, but may be related. Jurassic distribution of *Loboidothyris* is shown in Fig. 8A.

Loboidothyris fordycei n. sp.

Fig. 9, 1-26

2009 Terebratulide sp. indet. A (?n. sp.) - MacFarlan et al. p. 266.

Holotype: OU 46807, a ventral valve internal mould and fragments of exterior, from E45/f085 (McF E49). Heale Ridge, Hokonui Hills (Diamond Peak Group). Collected by the author and J.G.G. Morton 27/01/1980.

Paratypes: OU 18333 a double-valved internal mould from the same locality and collection. OU 18335, a dorsal valve internal from the same locality, collected by J.D. Campbell 25/4/1981 (JDC 3651).

Derivation of Name: This species is named for Professor Ewan Fordyce, of the Geology Department, University of Otago, custodian of the Otago University specimens described here, for his help and support on many visits to Dunedin.

Material:

New Caledonia

NC/f0969 (AU 11221).

Kawhia Syncline

Ururoa Point: R15/f032 (McF B3), R15/f8006 (AU 600), R15/f8816 (AU 50). North of Arataura Point: ?R15/f8828 (AU 132). Taharoa: R16/f6811 (GS 9674). North Marokopa Coast: R16/f8644 (GS 10005). Kiritehere Valley: ?R16/f8933 (AU 4314).

Southland Syncline

The Bastion: E45/f9711 (GS 6748), ?E45/f9448 (GS 345). Ben Bolt: E45/f9446 (JDC 737), E45/f9662 (GS 6604). Conical Hill-Otapiri Gorge: E45/f062 (McF C10), E45/f9440 (GS 337), E45/f9568 (McF E48), E45/f9860 (GS 7736, JDC 1837, AU 12474), E45/f0381 (JDC 3997). Heale Ridge: E45/f085 (JDC 3651, McF E49).

A total of 53 specimens were catalogued, of which 44 yielded valid measurements.

Description. Terebratulide of medium size, with subcircular to elongate-elliptical outline. Both valves moderately inflated, the ventral valve generally more so. Anterior commissure shallowly uniplicate to paraplicate.

Ventral valve strongly and evenly convex posteriorly, less convex with broad, blunt poorly-defined central plica anteriorly. Larger specimens have rounded plicae on flanks. Dorsal valve less convex posteriorly, with two relatively narrow-crested rounded plicae separated by broad, shallow sulcus anteriorly. Beak large, inclined to erect, narrowly triangular with bluntly rounded tip. Foramen large, subcircular, permesothyrid, with short pedicle collar. Beak ridges bluntly rounded (Fig. 9.8), deltidial plates probably disjunct. Shell material punctate.

Internal Characters. Dorsal valve with short, broad hinge plate and widely separated sockets. Muscle scars shallowly incised, separated by low, rounded ridges extending for posterior half of valve (Fig. 9.2, 9.11). Muscle scars on ventral valve poorly defined.

Dimensions. Dimensions of types and the New Caledonia specimen, and statistics of Kawhia Syncline and Otapiri specimens are shown in Table 1.

Range and Distribution. Lower Arataura to Upper Ururoan. The species is common in the Otapiri Gorge Lower Ururoan (E45/f062, E45/f9860) and Heale Ridge (E45/f085) and is represented by single specimens at most other localities.

Tab. 1 - Dimensions for *Loboidothyris fordycei*

FR no.	specimen	Lv	Lp	W	H	b<	material	notes
E45/f085	OU 46807	24.2		23.1		90	vv int	Holotype
	OU 18335		18.8	16.2			dv int	Paratype
	OU 18333	22	19.1	18.6	6	94	b int	Paratype
NC/f0969	AU B661	21.0+		16.4		98	vv int	ant margin damaged. slightly distorted
Kawhia-Marokopa	Mean	25	21	18.5	15.3	96	5 specimens	
	S.D.	3.35	2.05	4.08		8		
Otapiri Valley	Mean	22.8	21	18.4	7.9	87.7	39 specimens	
	S.D.	4.34	3.09	3.86	1.69	10.14		

The oldest is a single valve from the Lower Aratauran on the coast north of Marokopa (R16/f8644), which is highest Hettangian-basal Sinemurian on ammonite evidence (Stevens 2004). The youngest are Upper Ururoan, from R16/f6811 Taharoa, and R15/f8006, Ururoa Point above and below *Dactylioceras* Band.

Remarks. Most specimens are present as single valves. On the ventral valves of smaller specimens the folding is slight or absent, while larger specimens have broad, bluntly rounded plicae anteriorly (Fig. 9.1a, 9.6, 9.7). Dorsal valves generally show two narrow rounded plicae on the anterior part, with a broad space in between (Fig. 9.16, 9.20).

The late Middle Temaikan *Loboidothyris marokopaensis* has similar folding in the dorsal valve but much stronger in the ventral, and is generally larger. The Upper Temaikan to Heterian *L. grantmackiei* is generally larger and does not show the folding, *L awakinoensis* is of similar size but less inflated, and also lacks folding. *Lobothyris simesi* n. sp. has a similar range to *L. fordycei*, but is rectimarginate, typically much smaller, with a more elliptical outline, much less inflation and a broader, more bluntly rounded beak.

The sole specimen found from New Caledonia (Fig. 9.22) and the few from the Kawhia Syncline (Fig. 9.23-25) are elongate, with a slightly uniplicate anterior commissure, and a shallow poorly defined fold and sulcus, or none. They may represent a separate form. One specimen from The Bastion may belong in this group. The other specimen from The Bastion is a large, slightly inflated, unfolded ventral valve that is questionably included in this species (Fig. 9.26).

Family Lobothyrididae Makridin, 1964
Subfamily Lobothyridinae Makridin, 1964

Lobothyris Buckman, 1918

Type species - *Terebratula punctata* J. Sowerby, 1813 in 1812-1815, p. 46, OD

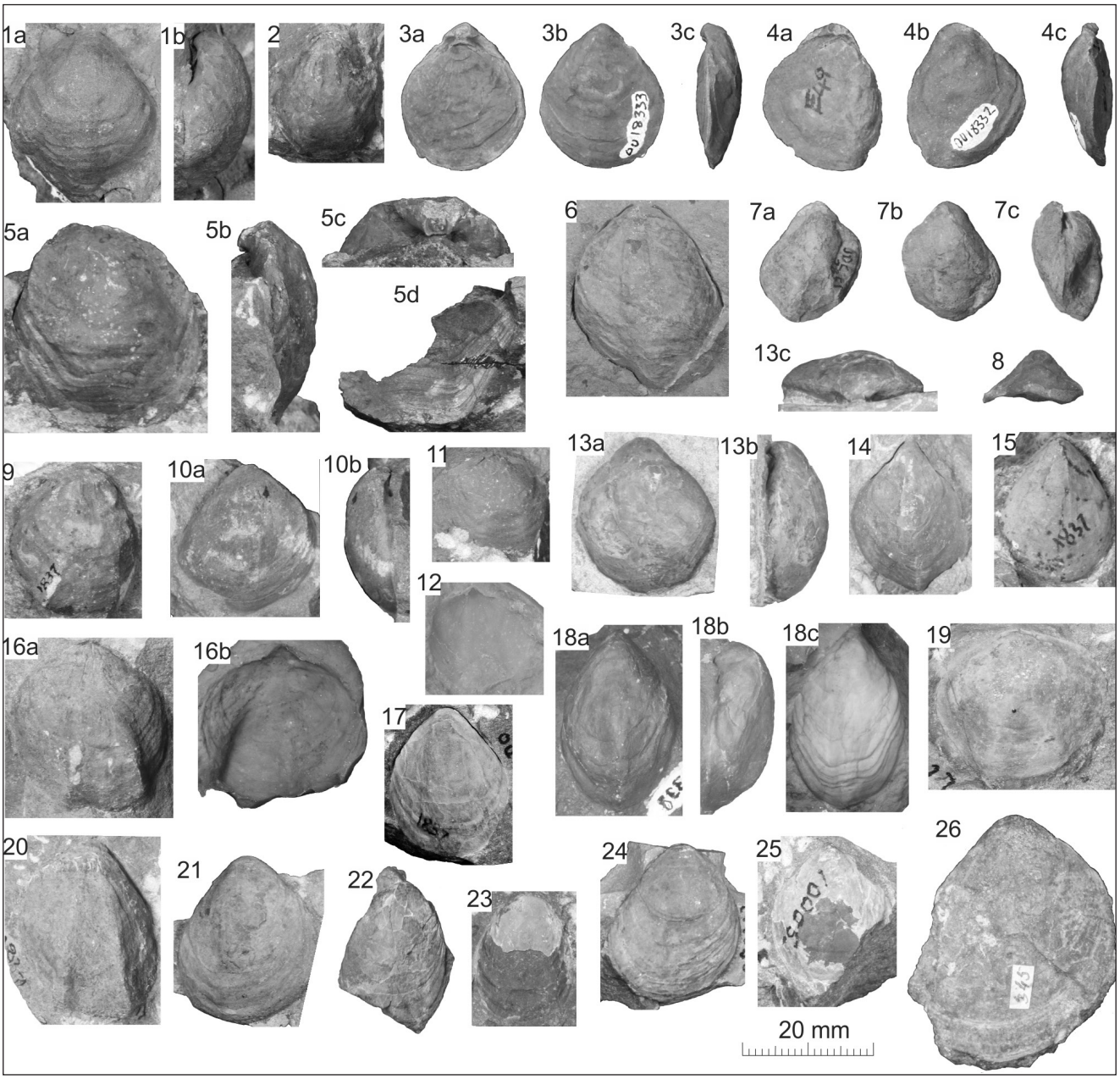
1918 *Lobothyris* Buckman, p. 107.
1934 *Lobothyris* Buckman – Muir-Wood, p. 539.
1965a *Lobothyris* Buckman – Muir-Wood, p. H784.
1983 *Lobothyris* Buckman – Cooper, p. 103.
1990 *Lobothyris* Buckman – Ager, p. 11.
2006 *Lobothyris* Buckman – Lee et al., p. 2103.
2014 *Lobothyris* Buckman – Alméras et al., p. 71.

Lobothyris is a cosmopolitan Early Jurassic genus, known from much of Europe (Alméras et al. 2014), North Africa (Alméras et al. 2014), Pakistan (Ager & Sun 1988), Thailand, (Alméras 1988), China (Sun 1986; Sun et al. 2017), Alaska (Sandy & Blodgett 2011), British Columbia (Thomson & Smith 1992), Nevada (Manceñido & Dagis 1992), Argentina (Manceñido 1991) and Chile (Aberhan 1993).

Ager (1967) noted that "Thus all over the world, literally from China to Chile (and in most regions exclusively) smooth, rectimarginate forms, probably all referable to *Lobothyris*" (p. 141). Ager (1990, p. 11) considered *Lobothyris* to be "a stable rectimarginate stock, which persisted throughout early Jurassic times and spread all over the world".

In the most recent revision of the genus, Alméras et al. (2014) give a time range for *Lobothyris*

Fig. 9 - *Loboidothyris fordycei* n. sp.
1) Holotype, OU 46807 (E45/f085) internal mould, (a) ventral, (b) lateral.
2) Paratype OU 18335 (E45/f085) internal mould, dorsal.
3) Paratype OU 18333 (E45/f085) internal mould (a) dorsal (b) ventral (c) lateral.
4) OU 18332 (E45/f085) internal mould (a) dorsal (b) ventral (c) lateral.
5) OU 46770 (E45/f085) internal mould (a) ventral (b) lateral (c) posterior (d) part external of ventral valve.
6) OU 18331 (E45/f085) internal mould, ventral.
7) OU 19474 (E45/f085) internal mould (a) dorsal, (b) ventral (c) lateral.
8) OU 46802 (E45/f085) latex of beak exterior, dorsal.
9) OU 19468 (E45/f9860) internal mould, dorsal.
10) OU 19472 (E45/f062) internal mould (a) ventral (b) lateral.
11) OU 19464 (E45/f9860) internal mould, dorsal.
12) OU 19470 (E45/f9860) latex of internal mould, dorsal.
13) OU 19463 (E45/f9860) internal mould: (a) ventral (b) lateral (c) posterior.
14) BR 3285 (E45/f9860), internal mould, ventral.
15) OU 19467 (E45/f9860) internal mould, ventral.
16) OU 45633 (E45/f062) internal mould (a) dorsal, (b) latex of exterior.
17) OU 45666 (E45/f9860) internal mould, ventral.
18) OU 18338 (E45/f9860) internal mould (a) ventral (b) lateral (c) latex of exterior, ventral.
19) BR 3275 (E45/f9662) internal mould, dorsal.
20) OU 19469 (E45/f9860) internal mould, dorsal.
21) BR 3201 (E45/f9440), internal mould, ventral.
22) AU B661 (NC/f969) internal mould, ventral.
23) OU 19482 (R15/f032) partly shelly, dorsal.
24) BR 3203 (R16/f6811) internal mould, ventral.
25) BR 3222 (R16/f8644) shelly specimen part replaced by pyrite, ventral.
26) BR 3267 (E45/f9448) internal mould, ventral.



of Hettangian to Aalenian. Other workers (Dagis 1963, 1965; Siblik 1994; Torti & Angiolini 1997) include the Middle to Late Triassic species *Terebratula praepunctata* and other species in the genus. Sandy (1994) records ?*Lobothyris praepunctata* and a new species ?*L. triassicus* from the Triassic of Peru, and Blodgett and Clautice (2000) record *L. praepunctata* and *L.* sp. cf. *L. monstrifer* Dagis from the Norian of Alaska. Jurassic distribution of *Lobothyris* is shown in Fig. 8B.

Lobothyris has been recognised as part of the New Zealand Early Jurassic fauna for some time (MacFarlan 1975, 1980, 1992, 1998; Grant-Mackie et al. 2000; Hudson 2003; MacFarlan et al. 2009) but no species has been described until now.

Lobothyris simesi n. sp.

Fig. 10: 1-22

1923 *Terebratula* (*Heimia*?) sp. - Trechmann, p. 285, pl. XVI figs 4a, 4b).
2009 *Lobothyris* sp. - MacFarlan et al., p. 266.

Holotype: BR 2710, a double-valved shelly specimen from R15/f8005, GS 1194, *Dactylioceras* band (Ururoa Formation), Ururoa Point, Kawhia. Collected by J. Henderson & L.I. Grange 1921.

Derivation of Name: This species is named for John Simes, recently retired Curator for GNS Science, for his help with National Paleontological Collection material and the Fossil Record File over many years.

Material:

Kawhia Syncline

Arataura Point: R15/f029 (McF B19). Arawhero Point: R15/f030 (McF B22).

Otamaehu Point: R15/f8697 (AU 128), ?R15/f8812 (AU

FR no.	specimen	Lv	Lp	W	H	b<	material	notes
R15/f8005	BR 2710	23.6	21.9	19.9	11	87	b shelly	Holotype
Dactylioceras Band and Ururoa Point	average	18.6	17.7	15.4	9	94.2	23 specimens	
	S.D.	3.99	4.16	3.53	2.45	8.16		
Kawhia coast Aratauran	Average	14.3	13.5	11.2	5.4	93.2	8 specimens	
	SD	4.18	4.17	2.79	1.62	7.68		
Pomarangai Rd	Average	14	12.5	11.8	3.9	86.8	6 specimens	
	SD	1.09	0.25	0.9	0.22	7.98		
Awakino Valley	Average	18.3	16.9	14.3	9.5	86.3	3 specimens	
	SD	4.42	3.85	1.68	2.35	2.87		
Otapiri & Ben Bolt Ha	Average	18.1	16.6	14.7	5.8	93.9	51 specimens	
	SD	3.37	3.15	3.14	1.33	10.69		
Otapiri Hu	Average	17	15.9	13.7	5.2	89	5 specimens	
	SD	1.75	0.5	1.48	0.25	6.26		

Tab. 2 - Dimensions for *Lobothyris simesi*.

127). Ururoa Point: R15/f015 (McF B4), R15/f032 (McF B3), R15/f8005 *Dactylioceras* Band (GS 1194, AU 47, ?614, 2994, 12296, JDC 1151, McF B2), R15/f8006 (GS 3150, AU 592, 600), R15/f8078 (AU 595), R15/f8079 (AU 9204), R15/f8575 (JDC 1150), ?R15/f8677 (AU 2995), R15/f8686 (McF B1), R15/f8816 (AU 14811, ?AU 9459). Waitapu Bay, Kawhia Harbour: R15/f8875 (AU 153, 9217). Taharoa Coast: R16/f6811 (AU 154, GS 9674,?AU 8363). North Marokopa Coast: ?R16/f149 (AU 8359). Pomarangai Rd S of Marokopa: R16/f8811 (AU 9464), R16/f8821 (AU 4395). Tributary to Rauroa Stream, Awakino Valley: ?R17/f337 (AU 9309). Awakino Gorge: R17/f8007 (GS 911), R17/f8008 (AU 9468), R17/f8566 (AU 17917).

Southland Syncline

Otapiri Valley at and near Taylors Stream junction: E45/f115 (AU 2807), E45/f9455 (AU 2811), E45/f9568 (JDC 1380, GS 5903). Ben Bolt – Otapiri Gorge: E45/f076 (McF E34), E45/f379 (JDC 4069), E45/f9446 (JDC 737), E45/f9451 (GS 348), E45/f9860 (McF C8). The Bastion: E45/f9448 (GS 345). Heale Ridge: E45/f085 (McF E49). Retreat-Croydon Rd: F45/f8011 (JDC 2479). South Hokonuis (Jewitt Road): ?E46/f056 (McF H25) ?E46/f7538 (GS 5398).

A total of 127 specimens were examined, of which 100 yielded valid measurements.

Description. Terebratulide of small to medium size, with elongate-elliptical outline. Both valves slightly to moderately inflated, equally or ventral valve more inflated. Anterior commissure rectimarginate or with very shallow uniplication, no fold or sulcus. Exterior smooth or with faint growth lines. Beak suberect to erect, broad, rounded-triangular with bluntly rounded tip. Beak ridges bluntly rounded, poorly developed. Foramen large, circular, permesothyrid, deltidial plates conjunct. A short, poorly developed pedicle collar may be present.

Internal Characters: Hingeplate on dorsal valve triangular, cardinal process small, narrow. Paired, slightly incised muscle scars commonly seen on both valves. Those on the dorsal valve are elongate and may be well developed (Fig. 10.7a, 10.9a, 10.16a).

Dimensions. Dimensions of the holotype and statistics of specimens from key areas are shown in Table 2.

Range and Distribution. *Aratauran to Ururoan.* Rare in the North Island Aratauran, where specimens (Fig. 10.6) are small, flattened and often poorly preserved, as are all other terebratulides. It is more common in the Upper Ururoan at Kawhia. There are a few scattered records south of Kawhia. In the Otapiri Valley, it has not been found in the basal Aratauran of Taylors Stream, but is present in the Taylors Junction and Ben Bolt sections, and in the Lower Ururoan of Conical Hill and Heale Ridge. The species is abundant (30 specimens measured) at E45/f9451 (GS 348) on the west side of the Otapiri Stream.

Remarks. The specimen (NHM B48950) figured by Trechmann (1923) as *Terebratula* (*Heimia*?) sp. from the lower slopes of Flag Hill (Ben Bolt) was re-examined at the Natural History Museum in London. It appears to be typical of Otapiri Valley Ururoan members of this species. The long triangular incised muscle scars are clearly shown.

Wanner and Knipscheer (1951) describe *Terebratula*? cf. *punctata* Sowerby from the Early Jurassic of Seram Island in the Indonesian province of Maluku. Their figures closely resemble *L. simesi*, but three of the four specimens measured are larger than any specimens of *L. simesi* measured in this study. Dr Miguel Manceñido (pers. comm. 11/12/2018) has examined the Seram material and does not believe it should be included in *Lobothyris punctata*.

Family Tegulithyrididae Muir-Wood, 1965

Tegulithyris Buckman, 1918

Type species - *Terebratula bentleyi* Davidson, 1851 OD

1918 *Tegulithyris* Buckman, p. 123.
1964 *Tegulithyris* Buckman - Makridin p 264.
1965a *Tegulithyris* Buckman - Muir-Wood p. H801.
1983 *Tegulithyris* Buckman - Cooper, p. 159.
2006 *Tegulithyris* Buckman - Lee et al. p. 2120.
2014 *Tegulithyris* Buckman - Alméras et al. p. 121.

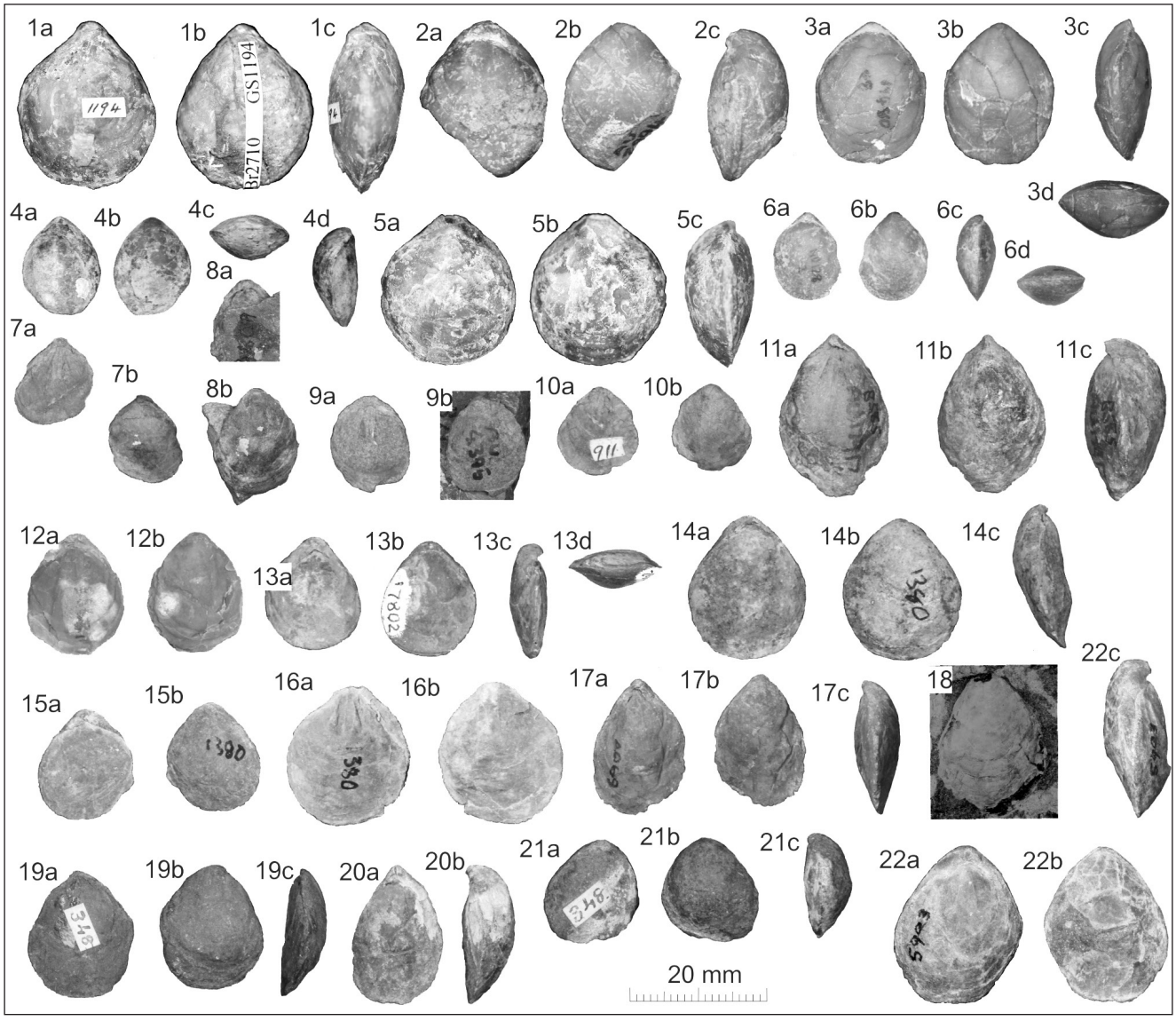


Fig. 10 - *Lobothyris simesi* n. sp.
1) Holotype BR 2710 (R15/f8005) shelly specimen, (a) dorsal, (b) ventral, (c) lateral.
2) AU B574 (R15/f8005) shelly specimen, (a) dorsal, (b) ventral, (c) lateral.
3) OU 19480 (R15/f8005] shelly specimen, (a) dorsal (b) ventral (c) lateral (d) anterior.
4) OU 45685 (R15/f8005) shelly specimen, (a) dorsal (b) ventral (c) anterior (d) lateral.
5) BR 3195 (R15/f8006) shelly specimen, (a) dorsal (b) ventral (c) lateral.
6) AU B572 (R15/f8697) shelly specimen (a) dorsal (b) ventral (c) lateral (d) anterior.
7) AU B605 (R16/f8821) internal mould (a) dorsal (b) ventral.
8) AU B609 (R16/f8821 internal mould (a) dorsal view of beak (b) ventral.
9) AU B610 (R16/f8821) internal mould (a) dorsal (b) ventral.
10) GS BR 3206 (R17/f8007) internal mould (a) dorsal (b) ventral.
11) AU B585 (R17/f8566) internal mould (a) dorsal (b) ventral (c) lateral.
12) OU 45681 (E45/f085) internal mould (a) dorsal (b) ventral.
13) OU 17802 (E45/f085) internal mould (a) dorsal (b) ventral (c) lateral (d) anterior.
14) OU 46743 (E45/f9568) internal mould (a) dorsal (b) ventral (c) lateral.
15) OU 46746 (E45/f9568) internal mould (a) dorsal (b) ventral.
16) OU 46747 (E45/f9568) internal mould, (a) dorsal (b) ventral.
17) OU 45707 (E45/f0379) internal mould (a) dorsal (b) ventral (c) lateral.
18) BR 3256 (E45/f0951) shelly specimen, ventral.
19) BR 3228 (E45/f9451) internal mould, (a) dorsal (b) ventral (c) lateral.
20) BR 3237 (E45/f9451) internal mould with some remaining shell material (a) dorsal (b) lateral.
21) BR 3236 (E45/f9451) internal mould (a) dorsal (b) ventral (c) lateral.
22) BR 3276 (E45/f9568) partly shelly, shell material degraded, (a) dorsal (b) ventral (c) lateral.

FR no.	specimen	Lv	Lp	W	H	b<	material	notes
R15/f8005	AU B576	10.3	9.4	11	5.2	125	b shelly	adhering matrix Holotype.
R15/f8005	AU B575	11.1	9.8	10.2	5	112	b shelly	ant margin part obscured.
R15/f8005	AU B577	9.9	9	9.3	4	116	b shelly	adhering matrix.
R15/f8828	AU B578		9.7	9.7	2.6		b shelly	decorticated. ant and beak damaged.
R15/f8829	AU B579	8.1+	7.1+	9.7			b shelly	dv and beak exposed. ant margin damaged.
R15/f8686	AU B580		10.3	11.7			dv ext	good hinge impression with socket. Finely plicate.
R15/f8816	AU B581	9.9	9.3	11.5+	3.5	114	b shelly	margins damaged.
R15/f8816	AU B627	10.3	9.8	11.8	5.8	108	b shelly	slightly flattened at anterior.
R15/f8816	AU B650	10.6		10.9		112	vv shelly	& ext.

Tab. 3 - Dimensions for *Tegulithyris? plencnerae.*

Tegulithyris is a strongly folded terebratulide originally described from the Middle Jurassic of Britain. Alméras et al. (2014) recorded the genus from the Late Bajocian to Early Callovian of southern England, Germany, France, the Russian Platform and the Caucasus. Jurassic distribution of *Tegulithyris* is shown in Fig. 8C.

Tegulithyris? plencnerae n. sp.

Fig. 11: 1-6.

2009 *Tegulithyris* sp. MacFarlan et al. p. 266

Holotype: B576 from R15/f8005, AU 9197, *Dactylioceras* Bed, Ururoa Formation, Ururoa Point, Kawhia. Shelly specimen with some adhering matrix. Collected by A.B.S. Clarke, N. Hudson and J.A. Grant-Mackie, 18 January 1981.

Derivation of Name: The new species is named for Tiffany Plencner of the Geology Department, University of Otago, for her determined attempts to make CAT scans of the interior of several *Dactylioceras* Band species.

Material:

Ururoa Point, Kawhia: R15/f8005 (*Dactylioceras* Bed) (AU 6425, 9197), R15/f8686 (AU 599), R15/f8816 (AU 50, 9459), Upper Ururoan.

North of Arataura Point, Kawhia: R15/f8828 (AU 132), R15/f8829 (AU 134). Arataurian.

A total of nine specimens were examined, of which five yielded valid measurements.

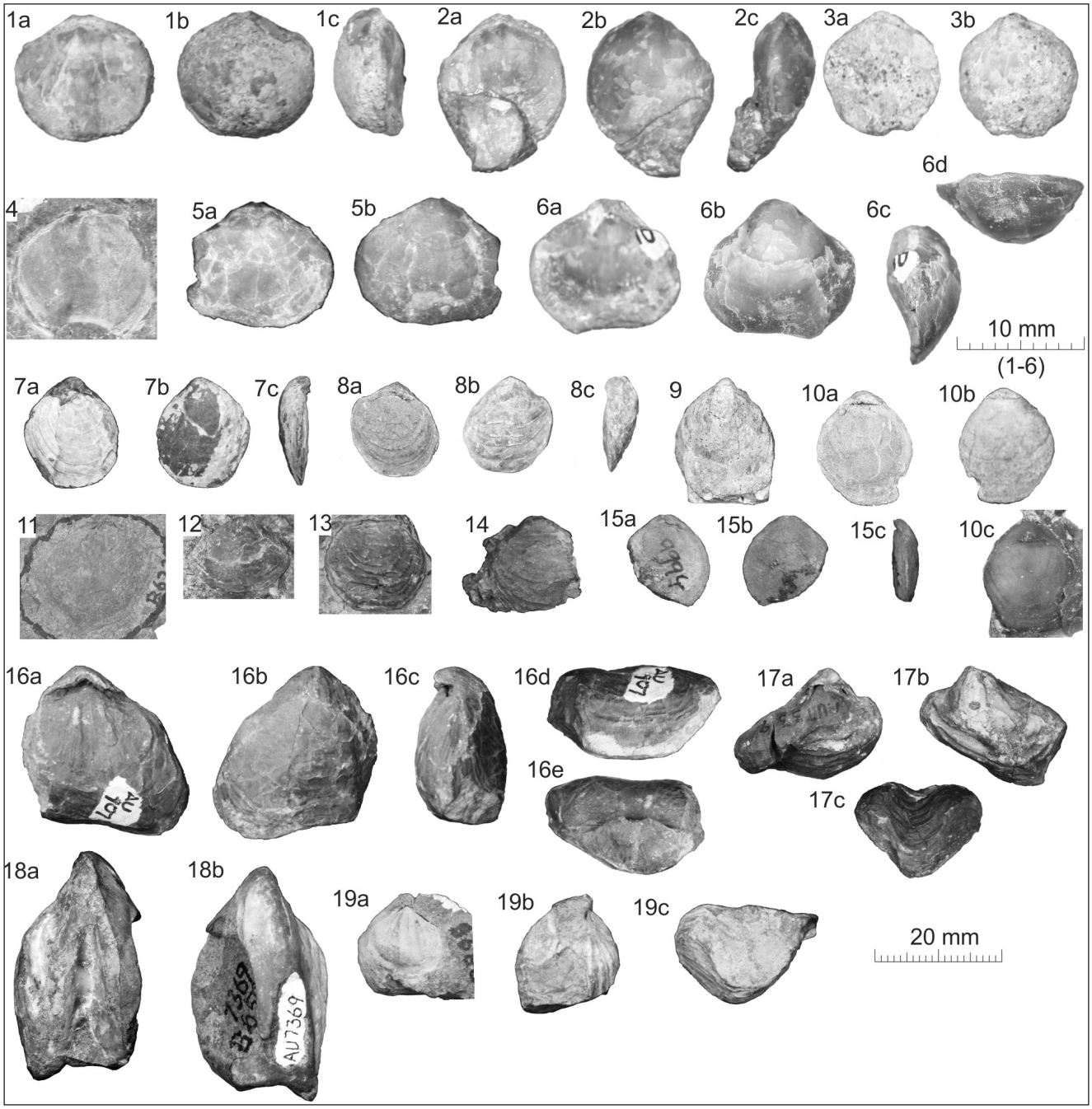
Description. Small terebratulide with subcircular outline. Dorsal valve slightly inflated posteriorly, with narrow rounded central fold flanking two sulci anteriorly. Ventral valve strongly convex, with narrow rounded sulcus anteriorly. Anterior commissure paraplicate. Overall shell form hemispherical. Exterior smooth or with faint concentric growth-lines. Beak short, broad, with narrow beak ridges defining short, broad palintropes. Foramen small, elliptical (?) suberect, permesothyrid. Deltidial plates not seen. Shell finely and densely punctate.

Internal characters not seen. There was insufficient shelly material for sectioning, so internal details are unknown. The hinge plate appears to be broad.

Dimensions. Dimensions of measured specimens are shown in Table 3.

Range and Distribution. Upper Arataurian and Ururoan of the Kawhia Coast. The earliest locality, R15/f8828 is just north of Arataura Point,

Fig. 11 -
1 – 6 *Tegulithyris*? *plencnerae* n. sp. (all x2)
1) holotype AU B576 (R15/f8005) shelly specimen with some adhering matrix (a) dorsal (b) ventral (c) lateral.
2) AU B575 (R15/f8005) shelly specimen (a) dorsal (b) ventral (c) lateral.
3) AU B577 (R15/f8005) shelly specimen with some adhering matrix (a) dorsal (b) ventral.
4) AU B580 (R15/f8686) shelly dorsal valve.
5) AU B581 (R15/f8816) shelly specimen (a) dorsal (b) ventral.
6) AU B627 (R15/f8816) shelly specimen (a) dorsal) (b) ventral (c) anterior.
7 – 15 *Rugithyris hasibuani* n. sp.
7) holotype AU B615 (R17/f227) partly shelly specimen (a) dorsal (b) ventral (c) lateral.
8) AU B614 (R17/f227) internal mould, (a) dorsal (b) ventral (c) lateral.
9) AU B617 (R17/f227) internal mould, ventral.
10) AU B619 (R17/f227) internal mould, (a) dorsal (b) ventral (c) dorsal of latex.
11) AU B622 (R17/f227) internal mould, ventral.
12) AU B587 (R17/f8566) internal mould, ventral.
13 AU B588 (R17/f8566) internal mould, dorsal.
14) AU B589 (R17/f8566) internal mould, ventral.
15) BR 3202 (R16/f8639) internal mould (a) dorsal (b) ventral (c) lateral.
16 – 19 *Linguithyris agerorum* Manceñido, 1993a
16) Holotype AU B319 (R13/f7048) internal mould (a) dorsal (b) ventral (c) lateral (d) anterior (e) posterior.
17) AU B658 (NC/f439) internal mould (a) dorsal (b) ventral (c) anterior.
18) AU B659 (NC/f468) shelly specimen (a) dorsal (b) ventral.
19) AU B660 (NC/f472) shelly specimen (a) dorsal (b) lateral (c) anterior.



while Stevens (2004) records the Early Sinemurian ammonite *Metophioceras marokopaense* from nearby. The latest locality is R15/f8005, the *Dactylioceras* band, Te Maika Peninsula.

Remarks. This species is placed with some doubt in *Tegulithyris* on the distinctive folding with concave anterior part to the dorsal valve. The folding is generally shown only on the anterior part and in some specimens is incipient or poorly developed. This species is small for the genus, with a proportionately smaller foramen.

Lee et al. (2006) gives a time range for *Tegulithyris* as Middle Jurassic (Bathonian-Callovian) and Alméras et al. (2014) as Late Bathonian to Early Callovian but the new species is Early Jurassic.

Family and Subfamily Uncertain
Rugithyris Buckman, 1918

Type species - *Rugithyris subomalogaster* Buckman, 1901

1918 *Rugithyris* Buckman, p. 127.
1965a *Rugithyris* Buckman - Muir-Wood, p. H787.
1983 *Rugithyris* Buckman - Cooper, p. 144.
2006 *Rugithyris* Buckman - Lee et al., p. 2133.
2014 *Rugithyris* Buckman - Alméras et al., p. 127.

FR no.	cat no.	Lv	Lp	W	H	b<	material	notes
R17/f227	AU B615	17.4	15.4	14.7	4.9	100	b part shelly	& part ext. Holotype
R17/f227 (AU 7634) Upper Awakino	Average	16.1	14.7	14.4	5.4	99.3	7 specimens	
	SD	1.7	2.28	2.71	0.62	9.52		
R17/f8566. (AU 16899. 17917). Lower quarry. Awakino Gorge	Average	15.2	12.5	13.2	4.3	108.5	4 specimens	
	SD	0.4	1.55	2.48				

Tab. 4 - Dimensions for *Rugithyris hasibuani.*

Buckman (1918) proposed the genus *Rugithyris*, with *Terebratula subomalogaster* Buckman, 1901 the sole species included. This species is known only from the Late Bajocian of southern England. Dagis (1968) included a new species, *Rugithyris anabarensis* from the Bajocian of Siberia in the genus, but Cooper (1983) doubted this as Dagis's species is strongly biconvex. Alméras et al. (2014) rejected the inclusion of *R. anabarensis*, synonymised *Strongylobrochus* Cooper, 1983 with *Rugithyris*, and also included *Terebratula planiconvexa* Kitchin, 1900 in *Rugithyris*. *T. planiconvexa* was included in *Heimia* Haas, 1890 by Buckman (1918) and in *Kutchithyris* by Mukherjee (2007).

The inclusion of *R. omalogastyr* (type species of *Strongylobrochus*) and *R. planiconvexa* gives a distribution according to Alméras (2014) of England, Germany, Switzerland, Sardinia, Portugal, India (Kutch), Turkmenistan, and the (?)Caucasus, and a time-range of Bajocian to Callovian. This is a Tethyan distribution, although the New Zealand species is somewhat earlier in time (Toarcian). This distribution is shown in Fig. 8C.

Trechmann (1923) described *Terebratula (Heimia)* sp. from Flag Hill and compared it on S.S. Buckman's advice with *T. planiconvexa* Kitchin. Trechmann's specimen (NHM B48950) is of the larger South Island form of *Lobothyris*, and does not resemble the new species.

Rugithyris hasibuani n. sp.

Fig. 11: 7-15

Holotype: AU B615, a double-valved shelly specimen from R17/f227 (AU 7634), tributary of the upper Awakino River. Collected by F. Hasibuan, 7 December 1979.

Derivation of Name: This species is named for Dr Fauzie Hasibuan, who as a graduate student of the Geology Department, University of Auckland, collected the upper Awakino River material.

Material:

Kawhia Syncline: Marokopa Rivermouth: ?R16/f8639 (GS 9994). Upper Awakino Valley: R17/f227 (AU 7634). Awakino Gorge: R17/f8566 (AU 16889, AU 17917), ?R17/f8567 (McF F1). Manganui Rd Awakino: ?R17/f8556 (McF F9).

A total of 16 specimens were catalogued, of which eleven yielded valid measurements.

Description. Medium-sized terebratulide with subcircular outline. Ventral valve moderately to strongly convex posteriorly, slightly convex anteriorly. Dorsal valve flat to shallowly sulcate posteriorly, flat to slightly convex anteriorly. Anterior commissure rectimarginate. Both valves with ornament of strong, semiregular stepped concentrics, which are generally not seen on the valve interior (Fig. 11.13). Beak broad, erect to incurved, with bluntly rounded tip (Fig. 11.10c). Beak ridges blunt, poorly developed. Foramen moderately large, open, permesothyrid, surrounded by short pedicle collar, with conjunct deltidial plates. Shell material punctate.

Internal Characters. Dorsal valve with straight, narrow hingeplate bearing small cardinal process, sockets small, widely separated. No median septum. Ventral valve without dental plates, Muscle scars not seen on dorsal valve, some indistinct markings on posterior central part of ventral valve may be muscle scars (Fig. 11.8a).

Dimensions. Dimensions of the holotype and statistics of specimens from the two main localities are shown in Table 4.

Range and Distribution. All the material is to some extent distorted. Most comes from two localities, R17/f227, in a tributary of the upper Awakino River and R17/f8566, the lower of the two quarries in the Awakino Gorge. Both localities are Upper Ururoan (Grant-Mackie 1959; Hudson 2003). A single specimen from the late Otapirian at Marokopa (R16/f8639) lacks the strong semiregular concentrics, and is doubtfully referred to this species. A small flattened specimen from R17/f8556, Manganui Rd Quarry, Awakino Valley (Aratauran) and a similar one from R17/f8567, Upper quarry, Awakino Gorge, are also doubtfully referred to this species.

Remarks. No suitable material for sectioning was obtained, so the loop is unknown. It is referred to *Rugithyris* as it has the close-spaced concentrics and flatly convex dorsal valve characteristic of the genus (Cooper 1983).

Tab. 5 - Dimensions for *Linguithyris agerorum.*

FR no.	specimen	Lv	Lp	W	H	b<	material	notes
R13/f7048	AU B319	25.4	23.7	25.6+	14.2	73	b int. part ext	Holotype
NC/f439	AU B658	18	17.4	23	14.2	88	b int	distorted. & part ext
NC/f0468	AU B659	35		21.3+	21.5	80	b part shelly	distorted. R flank damaged. & part ext
NC/f472	AU B660	16	13.1	18.4	14.6	103	b int	distorted. part obscured

Superfamily Dyscolioidea Fischer & Oehlert, 1891
Family Nucleatidae Schuchert, 1929
Linguithyris Buckman, 1918

Type Species - *Terebratula bifida* Rothpletz, 1886

1918 *Linguithyris* Buckman, p. 99.
1965 *Linguithyris* Buckman, 1918 - Muir-Wood p. H802.
1993 *Linguithyris* Buckman, 1918 - Manceñido 1993a p 191.
2005 *Linguithyris* Buckman, 1918 - Atrops and Alméras, p. 574.
2006 *Linguithyris* Buckman, 1918 - Lee, p 2144.

Manceñido (1993a) described *Linguithyris agerorum* from a single specimen from the Ururoan of the Port Waikato area, and reviewed the distribution and classification of the Nucleatidae. He records the genus *Linguithyris* from southern Europe (Spain, southern France, southern Germany, Northern Italy, Austria and the Czech Republic, and North Africa (Tunisia, Algeria and Morocco). It extended further in the Middle Jurassic, reaching Britain, the Balkans, the Ukraine, Bulgaria and Crimea. Manceñido (1993a) also noted that the related Middle and Late Jurassic genus *Nucleata* has a similar southern European and North African distribution, with a single specimen of *Nucleata* ex gr. *bouei/planulata* Zeuscher recorded from the Late Jurassic of the Sula Islands in Indonesia. Jurassic distribution of *Linguithyris* is shown in Fig. 8D.

Linguithyris is an important member of Jurassic brachiopod faunas of the Mediterranean Province, which occur mainly in carbonate basins, horsts and platforms with reduced terrestrial influence (Vörös 2005; Colás & García Joral 2012).

A few specimens which may belong to *Linguithyris* or a related form were found from the late Otapirian of Marokopa and Te Maika Peninsula, Kawhia. These require further work.

Linguithyris agerorum Manceñido, 1993a
Fig. 11: 16-19.

1993 *Linguithyris agerorum* Manceñido 1993a p. 191 fig. 1 a-e.
2009 *Linguithyris agerorum* Manceñido - MacFarlan et al. p. 266.

Holotype: AU B319 Internal mould and fragment of exterior, from R13/f7048, AU 907, Opuatia Stream. Collected by K.A. Rodgers and J.A. Grant-Mackie May 1971.

Material:

New Caledonia

Uitoé Peninsula: NC/f439 (AU 7339), NC/f468 (AU 7369), NC/f472 (AU 7373).

Kawhia Syncline

Port Waikato: R13/f7048 (AU 907).

A total of four specimens were examined.

Description. Terebratulide of medium size, with rounded triangular outline. Dorsal valve moderately convex, ventral valve strongly convex posteriorly and with broad, poorly-defined fold anteriorly. Anterior commissure sulcate, with deep rounded deflection about ¾ of valve width and almost the height of the valve. Exterior of shell smooth, with irregularly-spaced, slightly stepped concentrics. Beak small, triangular, incurved, with rounded tip. Beak ridges moderately strong, rounded. Foramen elliptical, permesothyrid. On the holotype only the posterior part of the foramen can be seen (Fig. 11.16a), possibly due to damage or affected by the incurved beak. Disjunct deltidial plates .and a short pedicle collar are shown on AU B660 (Fig. 11.19a, b). Shell punctate.

Internal Characters. Dorsal valve with paired, impressed muscle scars (Fig. 11.16a, 11.19a). No trace of median septum. Hinge plate hidden by incurvature of beak. Small ?gonadal pits on posterior part of ventral valve.

Dimensions. Dimensions of the four specimens are shown in Table 5.

Range and Distribution. Ururoan, Port Waikato; Aratauran, Uitoé Peninsula, New Caledonia.

Remarks. Three specimens of *Linguithyris agerorum* were found in a search of New Caledonian Jurassic fossils held in the University of Auckland School of Environment collections. All are from Uitoé Peninsula. No further specimens from New Zealand have been found despite the extensive searches of collections that have been made in the course of this and earlier projects.

R13/f7048 is in an area with few fossil localities, but appears to lie not far above *Pseudaucella*. NC/f439 has a non-diagnostic fauna but is close to NC/f440, where Meister et al. (2010) lists the Hettangian *Phylloceras*? cf. *psilomorphum* and *Nevadophyllites*? *pounamuus*. *Pseudaucella marshalli* is also present, which is anomalous. NC/f468 and f472 are below *Pseudaucella marshalli* and are Aratauran.

All three New Caledonian specimens are distorted, and the two larger specimens are strongly sulcated anteriorly, although this is accentuated by the distortion. (Fig. 11.17, 11.18).

Suborder **Terebratellidina** Muir-Wood, 1955
Superfamily Zeillerioidea Schuchert, 1929
Family Zeilleriidea Schuchert, 1929
Subfamily Zeilleriinae Schuchert, 1929

Following Manceñido (1993b), Baeza-Carratala & García Joral (2014) and Halamski (2015), the authorship of the Zeillerioidea, Zeilleriidae and Zeilleriinae is accepted as being Schuchert in Schuchert and Levine (1929), rather than Allan (1940).

Genus *Zeilleria* Bayle, 1878

Type species - *Terebratula cornuta* Sowerby, 1824 in 1823–1825. SD Douvillé, 1879, p. 275

1878 *Zeilleria*, Bayle, pl. 9.
1965b *Zeilleria* Bayle – Muir-Wood, p. H821.
1974 *Zeilleria* Bayle – Delance, p. 69.
2006 *Zeilleria* Bayle – MacKinnon et al., p. H2164.
2015 *Zeilleria* Bayle – Alméras et al., p. 7.

Remarks. Members of the cosmopolitan Late Triassic to Cretaceous genus *Zeilleria* are found throughout the New Zealand Jurassic. The earliest is *Zeilleria spiculata* MacFarlan and Campbell, 2003, which is present in a narrow zone across the Triassic–Jurassic boundary in the Otapiri Valley, Southland, and occurs rarely in the Late Otapirian of the Kawhia Syncline and possibly New Caledonia.

Three further species are described here from the Early Jurassic of New Zealand, while MacFarlan (2016) described three species from the Middle and Late Jurassic of New Zealand and placed a fourth in open nomenclature.

The genus is widespread in the Late Triassic and Jurassic in Europe, North America and Asia, and extends into the Cretaceous in Europe. It is recorded from the Jurassic of Argentina by Manceñido (1991) and Manceñido and Dagis (1992). It is also present in the late Triassic of Papua New Guinea (Skwarko et al. 1976) and New Caledonia (Ernst et al. 2015). A zeilleriid close to *Zeilleria* was recorded from the early Cretaceous of Misool Island, Indonesia by MacFarlan et al. (2011).

Jurassic distribution of *Zeilleria* is shown in Fig. 8E.

Zeilleria spiculata MacFarlan & Campbell, 2003

2003 *Zeilleria spiculata* MacFarlan and Campbell, p 213, Fig. 2-3.
2009 *Zeilleria spiculata* MacFarlan and Campbell – MacFarlan et al., p. 266.

For description see MacFarlan and Campbell (2003).

Range and Distribution. Late Otapirian to earliest Aratauran. All but two of the specimens examined by MacFarlan and Campbell (2003) were from the Taylors Stream-Otapiri Stream area of the Hokonui Hills, Southland. This area ranges from uppermost Otapirian to the basal to early Hettangian Planorbis Zone (Stevens 2004).

While searching collections for this project, several specimens were found from three localities, F45/f072 (JGGM 131), F45/f092 (JGGM 172) and F45/ f132 (McF C11) in the Rhutra Stream in the Otamita Valley to the east. At F45/f092, *Z. spiculata* occurs with as yet unidentified psiloceratid ammonites. The other two localities lack definitive Otapirian fossils and are inferred to be Aratauran.

The only specimen recorded by MacFarlan and Campbell (2003) from outside the Hokonui Hills was a single specimen from R18/f6562 (AU 326), high in the Otapirian of the Awakino Gorge. Since then, *Z spiculata* has also been found in the uppermost Otapirian of Marokopa (R16/f6840, GS 10001) and Kawhia (R15/f8834, AU 63). A partial internal mould from New Caledonia (NC/f1110, AU 13980) may also belong to *Z. spiculata*.

Much smaller specimens from E45/f 9454 (GS 351), E45/f9613 (JDC 1287, McF E39) and E45/f9617 (JDC 1291) in Taylors Stream, occur with normal-sized *Z. spiculata*. These have proportionally larger and sharper beaks and well-developed concentrics. They are interpreted here as juveniles but may be separable.

Tab. 6 - Dimensions for *Zeilleria recessa.*

FR no.	specimen	Lv	Lp	W	H	b<	material	notes
F45/f8011	OU 45700	26.7	26.3	20.3	5.6	98	b int	Holotype. sl. distorted. beak flattened; & vv & beak ext.
F45/f8011	OU 45693	27.2		26.3		112	vv int	Paratype. appressed concentrics.
F45/f8011	OU 45694	24.8+	23.6+	16.0+			dv & beak int	ant & L margin damaged.
F45/f8011	OU 45695	15.8		12.8	2.2F		b int. part ext	flattened. margins displaced.
F45/f8011	OU 45696	26.0+	26	21	3.5F		b int	& part ext. flattened. beak broken off.
F45/f8011	OU 45697		22.0+	19.7			dv int	
F45/f8011	OU 45698	19.9	18.4	16.6	2.9F		b int	flattened. distorted.
F45/f132	OU 19258	22.6	20.5	18	6.3	118	b int. part ext	broad hingeplate. thick rounded median septum.

Zeilleria recessa n. sp.

Fig. 12: 1-8

Holotype: OU 45700, a double-valved internal mould and partial external from F45/f8011 (JDC 2479), Diamond Peak Group, Retreat-Croydon Rd, Hokonui Hills. Collected by J.D. Campbell and K.G. Griffin 26/5/1970.

Paratype: OU 45693, a ventral valve internal from the same locality and collection.

Derivation of Name: Latin for "Retreat". Most of the material comes from the Retreat-Croydon Road in the Hokonui Hills.

Material:

Southland Syncline

Hokonui Hills Retreat-Croydon Rd F45/f8011 (JDC 2479), Rhutra Stream: F45/f132 (McF C11).

Eight specimens were examined, of which 5 yielded valid measurements.

Description. Terebratulide of medium size, with elongate elliptical outline, Both valves slightly, and about evenly inflated. Anterior commissure rectimarginate. Ornament of weak irregular or semiregular concentrics. Beak rounded with bluntly triangular tip, erect. Foramen small, probably elliptical, no pedicle collar seen. Beak ridges sharp, strong, foramen mesothyrid. Deltidial plates conjunct. Punctae dense, moderately coarse.

Internal Characters. Dorsal valve with broad hingeplate and high wall-like median septum about 1/3 valve length. Muscle scars paired, slightly appressed (Fig. 12.3, 12.8a). Ventral valve with long, fairly close-spaced divergent dental plates delimiting triangular central umbonal cavity from broad lateral cavities. Muscle scars visible behind central umbonal cavity (Fig. 12.8b).

Dimensions. Dimensions of measurable specimens are shown in Table 6.

Range and Distribution. Most of the described material is from F45/f8011, on north side of Retreat-Croydon Rd. Middle Hettangian ammonites have been found at the same stratigraphic level (Stevens 2004).

A single specimen from F45/f132, Rhutra Stream (OU 19258) has a similar shape but a thicker median septum and hingeplate (Fig. 12.8). It occurs with *Z. spiculata*, and resembles that species in having thicker internal plates.

Remarks. All the material from F45/f8011 is flattened and corroded, with heavy limonite staining.

This species is close to *Zeilleria spiculata* but has thinner, more delicate internal plates and an elongate-elliptical outline, whereas *Z. spiculata* is subcircular to transversely elongate. The long closely set dental plates are distinctive.

This species appears stratigraphically above *Z spiculata* but below the more widely distributed *Z. terezowae* and *Z. sacciformis*.

Zeilleria terezowae n. sp.

Fig. 12: 9 - 27

1879 *Epithyris* - Hector p. 537.
1913 *Epithyris* - Thomson, p. 50, plate III, 7a, 7b.
2009 *Zeilleria* sp. A - MacFarlan et al. p. 266.
2016 *Zeilleria* sp. A - MacFarlan p. 489.

Holotype: OU 45648, a double-valved shelly specimen from R15/f8005G (McF B2) *Dactylioceras* bed (Ururoa Formation), Kawhia. Collected by the author, 7 January 1979. Part of the right flank and anterior margin is missing.

Paratypes: B568, a double-valved shelly specimen from R15/f8005 (AU 9197). Collected by A.B.S. Clarke, N. Hudson and J.A. Grant-Mackie, 18 January 1981. BR 2712, a double-valved shelly specimen from R15/f8006 (GS 3150) (Ururoa Formation), GS 3150. Collected by J. Henderson, L.I Grange 1921 or later NZGS parties. The specimen has a damaged ventral valve.

Derivation of name: this species is named for Marianna Terezow, Collections Manager of GNS Science, who has helped me greatly with the GNS collections in her care.

Material:

Kawhia Syncline

Ururoa Point: R15/f8005 *Dactylioceras* band (GS 1194, AU 47, 614, 9197, McF B2), R15/f8006 (GS 3150, AU 592), ?R15/f8575 (JDC 1150). Te Maika Peninsula Aratauran: R15/f029 (McF B19), R15/f266 (AU 12698), R15/f8588 (JDC 1167), R15/f8697 (AU 128). North Marokopa Coast: ?R16/f8649 (GS 10036). Pomarangai Rd south of Marokopa: R16/f8821 (AU 4395). Upper Awakino Valley: R17/f317 (AU 9290).

Southland Syncline

Taylors Stream: E45/f9613 (McF E39). Otapiri Stream below junction with Taylors Stream: E45/f0380 (JDC 3996). Ben Bolt: E45/f9446 (JDC 737). Conical Hill-Otapiri Gorge: E45/f062 (McF C10), E45/f9440 (GS 337), E45/f9447 (GS 344), E45/f9860 (GS 7736, JDC 1837, McF C8, AU 12474). Heale Ridge: E45/f085 (McF E49). Jewitt Road, Southern Hokonuis: E46/f063, (JDC 4661). Otamita Valley: F45/f8773 (GS 7624).

A total of 137 specimens were catalogued, of which 110 yielded valid measurements.

Description. Terebratulide of small to medium size, with elongate-elliptical to rounded-pentagonal outline, typically with a gently convex to almost straight anterior margin. Valves moderately, evenly and about equally inflated. No fold or sulcus anteriorly. Anterior commissure rectimarginate or with broad, very shallow poorly defined uniplication. Exterior of both valves smooth or with low, irregular growth-lines. The strongest of these are slightly stepped. Beak large, broad, rounded, erect. Foramen elliptical, submesothyrid. Beak ridges strong, narrow, delimiting concave palintropes. Deltidial plates conjunct. Shell strongly, relatively coarsely punctate.

Internal Characters. Dorsal valve with median septum about 0.3 to 0.5 of valve length, high, narrow, wall-like. Hinge plate broad, with long sockets extending from either side of shallow rounded septalium. Cardinal process small, narrow. Muscle scars poorly developed (Fig. 12. 21a). Ventral valve with divergent dental plates delimiting small lateral umbonal cavities, muscle scars on central umbonal cavity.

Dimensions. Dimensions of the holotype and paratypes and statistics for key areas are shown in Table 7.

Range and Distribution. Aratauran and Ururoan. The most common New Zealand Early Jurassic terebratulide, found throughout the Kawhia and Southland Synclines. It has not been found in New Caledonia. The earliest specimen seen is from E45/f9613 at the base of the Jurassic, where it occurs with the latest Triassic and basal Jurassic *Zeilleria spiculata*. It is not common in the Aratauran, but is the commonest terebratulide in the Ururoan of Conical Hill, Heale Ridge and Ururoa Point.

Remarks. In his 1878 paper, Hector noted "Thus the peculiar sub-genus of *Terebratula* represented by the typical *Epithyris elongata*, which has

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Fig. 12 -

1 – 8 *Zeilleria recessa* n. sp.

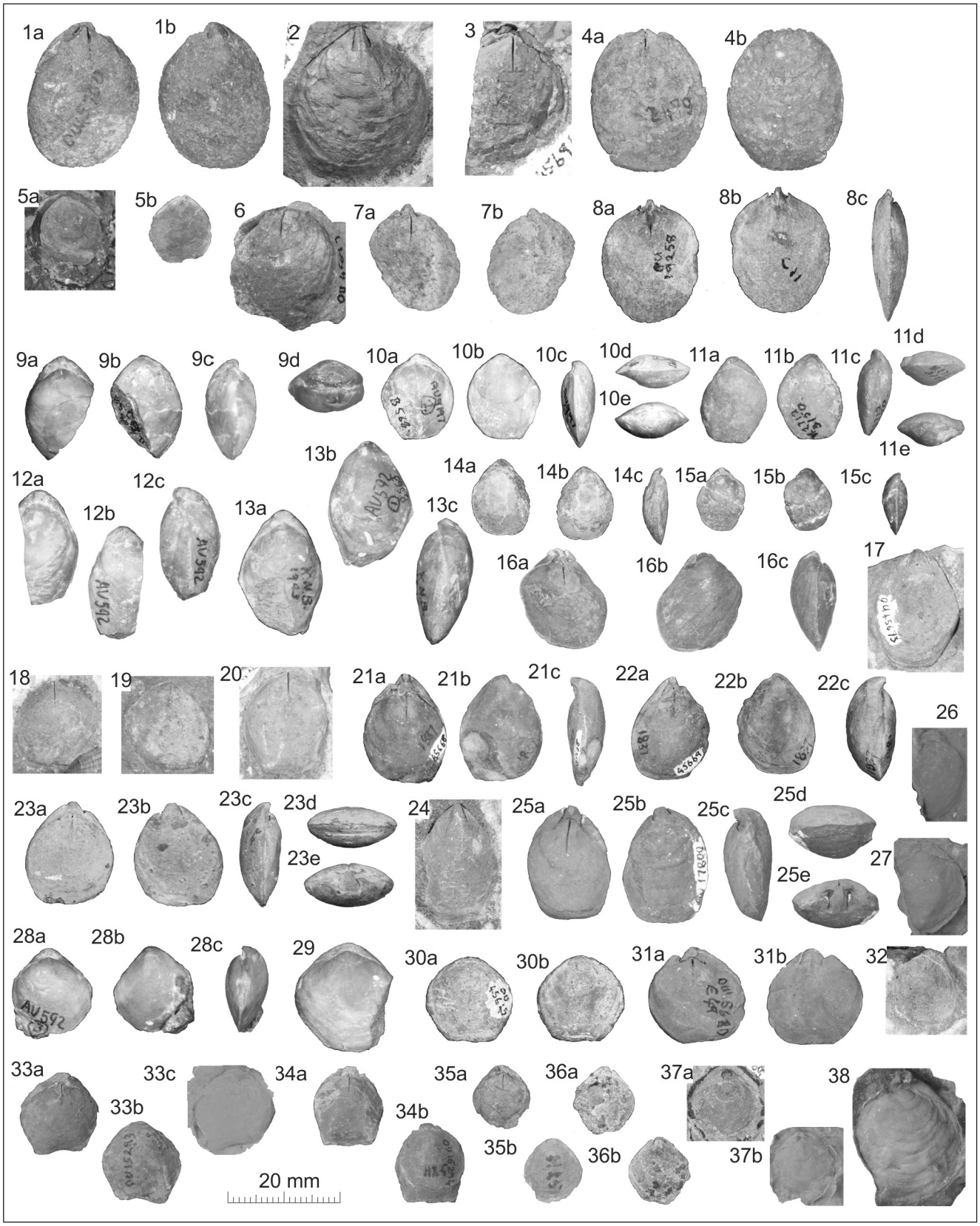
1) Holotype OU 45700 (F45/f8011) internal mould, (a) dorsal) (b) ventral.
2) Paratype OU 45693 (F45/f8011) internal mould, ventral.
3) OU 45694 (F45/f8011) internal mould, dorsal.
4) OU 45696 (F45/f8011) internal mould (a) dorsal (b) ventral.
5) OU 45695 (F45/f8011) internal mould (a) dorsal (b) ventral.
6) OU 45697 (F45/f8011) internal mould, dorsal.
7) OU 45698 (F45/f8011) internal mould (a) dorsal (b) ventral.
8) OU 19258 (F45/f132) internal mould (a) dorsal (b) ventral (c) lateral.

9 – 27 *Zeilleria terezowae* n. sp.

9) holotype OU 45648 (R15/f8005) shelly specimen with part of anterior broken off (a) dorsal (b) ventral (c) lateral (d) posterior.
10) paratype B568 (R15/f8005) shelly specimen (a) dorsal (b) ventral (c) lateral (d) anterior (e) posterior.
11) paratype BR 2712 (R15/f8006) shelly specimen (a) dorsal (b) ventral (c) lateral (d) anterior (e) posterior.
12) B564 (R15/f8005) shelly specimen (a) dorsal (b) ventral (c) lateral.
13) B563 (R15/f8005) shelly specimen (a) dorsal (b) ventral (c) lateral.
14) OU 45653 (R15/f029) shelly specimen (a) dorsal (b) ventral (c) lateral.
15) B570 (R15/f8697) shelly specimen (a) dorsal (b) ventral (c) lateral.
16) OU 45682 (E45/f085) internal mould (a) dorsal (b) ventral (c) lateral.
17) OU 45673 (E45/f9860) internal mould, ventral.
18) OU 45677 (E45/f9860) internal mould, dorsal.
19) OU 45660 (E45/f9860) internal mould, ventral.
20) OU 45661 (E45/f9860) internal mould, ventral.
21) OU 45668 (E45/f9860) internal mould (a) dorsal (b) ventral (c) lateral.
22) OU 45669 (E45/f9860) internal mould (a) dorsal (b) ventral (c) lateral.
23) OU 45634 (E45/f062) internal mould (a) dorsal (b) ventral (c) lateral (d) anterior (e) posterior.
24) OU 45640 (E45/f062) internal mould, ventral.
25) OU 17800 (E45/f085) internal mould (a) dorsal (b) ventral (c) lateral (d) anterior (e) posterior.
26) OU 45704 (E45/f9860) latex mould of brachial valve and beak exterior.
27) OU 45703 (E45/f9860) latex mould of brachial valve and beak exterior.

28 – 38 *Zeilleria sacciformis* n. sp.

28) holotype B565 (R15/f8005) shelly specimen (a) dorsal (b) ventral (c) lateral.
29) OU 45846 (R15/f8005) shelly specimen, dorsal.
30) OU 45645 (R15/f8005) shelly specimen, (a) dorsal (b) ventral.
31) OU 45680 (E45/f085) internal mould, (a) dorsal (b) ventral.
32) OU 45644 (E45/f062) internal mould, dorsal.
33) OU 15293 (E46/f0056) internal mould, (a) dorsal (b) ventral (c) latex of exterior of dorsal valve and beak.
34) OU 15294 (E46/f0056) internal mould, (a) dorsal (b) ventral.
35) OU 45652 (E46/f0056) internal mould, (a) dorsal (b) ventral.
36) OU 45690 (E46/f0056) internal mould, (a) dorsal (b) ventral.
37) OU 45689 (E46/f056) (a) external mould of dorsal valve and beak (b) latex of same.
38) OU 46776 (E45/f085) latex of exterior of dorsal valve and beak.



previously been recorded only from Permian and Carbonaceous strata, is abundant in the Liassic (Bastion) series, and extends downward to the Upper Silurian formation" (p. 537).

The plate in Thomson (1913) is one of those prepared by Sir James Hector but not issued.

Epithyris Phillips, 1841 is short-looped and lacks the median septum and dental plates that can

FR no.	specimen	Lv	Lp	W	H	b<	material	notes
R15/f8005	OU 45648	18.6+	16.3+	12.3+	9.1	78	b shelly	Holotype
R15/f8005	AU B568	15.4	13.6	12.9	6.2	103	b shelly	Paratype
R15/f8006	BR 2712	15.4	13.5	11.5	6	98	b shelly	Paratype
Kawhia coast Aratauran	Average	13.2	11.5	9.7	4.4	79.5	8 specimens	
	S.D.	0.95	1.06	0.75	0.38	9.67		
Dactylioceras Band and Ururoa Point	Average	15.7	14.1	12.1	6.5	91.5	11 specimens	
	S.D.	3.23	3.12	2.19	1.48	6.83		
Otapiri and Ben Bolt	Average	18.6	17.1	14.6	5.6	88.3	5 specimens	
	S.D.	1.72	1.83	1.08	1.18	16.1		
Conical Hill	Average	17.9	15.8	13.7	6.8	83.2	67 specimens	
	S.D.	4.4	4.04	2.94	2.17	18.55		
Heale Ridge	Average	18.6	16.4	13.7	6.8	85.2	17 specimens	
	S.D.	4.52	4.45	2.98	2.47	8.85		

Tab. 7 - Dimensions for *Zeilleria terezowae.*

be seen in the plate. GNS specimen BR 1115 is labelled "Probable hypotype of Hector", and appears to be the original of this figure.

The new species is generally broader and more evenly elliptical than the Temaikan-Heterian *Z. opuatiaensis,* with much stronger, narrower beak ridges. The anterior margin tends to be straight, whereas in *Z. opuatiaensis* it is narrower and convex.

Aratauran specimens from Kawhia are small, generally flattened, and often have a produced anterior margin (Fig. 12.14, 12.15). Specimens from the Otapiri Gorge and Heale Ridge, western Hokonui Hills, are typically larger and more inflated than those from Ururoa Point (Fig. 12.23).

Zeilleria sacciformis n. sp.

Fig. 12: 28 - 38

2009 *Zeilleria* sp. B - MacFarlan et al. p. 266.

Holotype: AU B565 a double-valved shelly specimen from R15/f8006, AU 592, Ururoa Formation, Ururoa Point. Collected 1943.

Derivation of Name: Latin for "sack-shaped" When we first collected this species from Jewitt Road, the late J.D. Campbell likened its shape to a sack of wheat.

Material:

Kawhia Syncline

Ururoa Point: R15/f8005 (JDC 1151), R15/f8006 (AU 592).

Southland Syncline

Otapiri Gorge area: ?E45/f9860 (JDC 1837), E45/f062 (McF C10). Heale Ridge: E45/f085 (McF E49). Jewitt Road, Southern Hokonuis E46/f056 (JDC 2509, McF H25). Crighton Road Waimahaka Valley F47/f0013 (JDC 3796, GP93).

A total of 14 specimens were catalogued, of which 10 yielded valid measurements.

Description. Small terebratulide with subcircular outline and less convex to straight anterior margin. Both valves slightly, about evenly inflated. Dorsal valve convex posteriorly, some specimens with two blunt plicae anteriorly, corresponding part of ventral valve slightly convex, without definite plication. Anterior commissure rectimarginate or biplicate, possibly slightly sulcate. Shell smooth apart from a few semi-regular growth lines which may be slightly stepped. Shell finely and densely punctate. Beak small, broad, erect. with bluntly rounded tip. Foramen small, circular, submesothyrid, with small conjunct deltidial plates. Beak ridges strong, sharply rounded, defining concave palintropes.

Internal characters. Dorsal valve with concave hingeplate, small cardinal process, high narrow wall-like median septum which is about 1/3 to ½ valve length. Ventral valve with widely set, slightly divergent dental plates. Central umbonal cavity large, lateral cavities small, triangular. Muscle scars not prominent.

Dimensions. Dimensions of measured specimens are shown in Table 8.

Range and Distribution. Lower Ururoan (Conical Hill and Heale Ridge, Otapiri) to Upper Ururoan (*Dactylioceras* Bed, Jewitt Road). At all of these it occurs with *Zeilleria terezowae* which in all localities other than Jewitt Road is more common.

Remarks. The plicae are well-developed only in a few Jewitt Road specimens, (Fig. 12.33, 12.34) which larger numbers may show to be a separable form. Two weathered single valves from F45/f0013 in the Waimahaka Valley may also belong here.

This species is smaller and less elongate than *Zeilleria terezowae*, which is rectimarginate. It is much smaller, and less inflated than the middle to Late Jurassic *Z. waiohipaensis*, which has a broader, more robust beak and no trace of any plicae.

Genus *Aulacothyris* Douvillé, 1879

Type species - *Terebratula resupinata* Sowerby, 1816 in 1815–1818 OD

1879 *Aulacothyris*, Douvillé, p. 277.
1965b *Aulacothyris* Douvillé – Muir-Wood, p. H822.
1974 *Aulacothyris* Douvillé – Delance, p. 305.
2006 *Aulacothyris* Douvillé – MacKinnon et al., p. 2167.
2015 *Aulacothyris* Douvillé – Alméras et al., p. 24.

Tab. 8 - Dimensions for *Zeilleria sacciformis.*

FR no.	specimen	Lv	Lp	W	H	b<	material	notes
R15/f8006	AU B565	15.1	13.2	14.3	7.2	94	b shelly	Holotype. good subcircular form. some matrix on ant.
R15/f8005	OU 45645	16.5	14.7	15.6	7.4	107	b shelly	corroded ext. subcircular
R15/f8005	OU 45646	20.1	18.2	17.7+	10	114	b shelly	R flank damaged. tip of beak damaged
E45/f085	OU 45680	17.6	15.9	17.4	5.6F	103	b int	subcircular. slightly distorted. flattened. Slight ant folding
E46/f056	OU 15293	15.5	12.9	14.2	5.8	105	b int	& ext. beak damaged
E46/f056	OU 15294	14.6	13.5	12.6	5.1	97	b int	& part ext
E46/f056	OU 45651	11.4		10.2		105	vv int	good int
E46/f056	OU 45652	11.6	10.6	10.3	3.6	107	b int	& dv & beak ext
E46/f056	OU 45688	13.4	12	10.8	5.5		b int	slightly distorted. beak. ant damaged
E46/f056	OU 45689	12.3	10.9	11.9		111	dv & beak ext	
E46/f056	OU 45690	12.3	11.2	10.9	3.4	88	b int	& part ext. slightly flattened
F47/f0013	OU 45691	12.6		12.8		114	vv int	subcircular. divergent dental plates
F47/f0013	OU 45692	13		11.5+			vv int	a/a. R flank damaged

Remarks. *Aulacothyris* is a widely distributed Early to Middle Jurassic genus that also has a sporadic Triassic distribution. In the most recent revision, Alméras et al. (2015) state that the genus had three acmes, in the Pliensbachian, Late Bajocian and Early Oxfordian with a total range of ?Anisian, and Early Pliensbachian to Early Oxfordian, They recorded it from Europe, western Asia and North Africa (Tunisia) but also list species from Somalia. Mukherjee (2015, 2017) records *Aulacothyris* from the Callovian of the Kachchh and Jaisalimer Basins of north-west India.

Aulacothyris is recorded from the Middle Jurassic of Argentina by Manceñido and Dagis (1992), Manceñido (2002) and Riccardi et al. (2011). Manceñido and Dagis (1992) noted that "For instance, *Aulacothyris* is locally first recorded in the Aratauran (Hettangian?-Sinemurian) of New Zealand and the early Pliensbachian of western Europe (Delance 1974), but not until the Aalenian in Argentina (unpublished data) - a pattern that defies a meaningful and straightforward explanation" (p. 329). The New Zealand species they are referring to is described here as *Aulacothyris* sp. A (Miguel Manceñido, pers. comm. 11/12/2018)

MacFarlan (2016) described *A. waikatoensis* from the Temaikan of Opuatia Cliff, Port Waikato, with one Heterian specimen from south of Kawhia.

Jurassic distribution of *Aulacothyris* is shown in Fig. 8F.

The genus is also recorded from the Triassic of Europe (Detre 1993; Siblik 1994; Siblik & Bryda 2005), Laos and Viet Nam (Khuc 2000) and China (Yang & Xu 1966). A single specimen described as *Aulacothyris* sp. is recorded by Drot (1953) from the Late Triassic of New Caledonia. It is less strongly inflated and less sulcate than the new species. Marden et al. (1987) recorded small *Aulacothyris* from an allochthonous limestone block of Oretian (Early Norian) age in melange from the Ruahine Range in the southern North Island. These are much smaller than the species described here. *Aulacothyris* is recorded from the Norian of Timor by Krumbeck (1924) and Hasibuan (2010).

Aulacothyris stevensi n. sp.

Fig. 13: 1-10

Holotype: OU 46753, a double-valved internal mould and partial external, from E45/f9676 (JDC 1382), north face of Ben Bolt (Diamond Peak Group). Collected by J.D. Campbell.

Derivation of Name: This species is named for Dr Graeme Stevens, Emeritus Scientist at GNS Science, who has helped me for my entire career as a palaeontologist.

Material:

Kawhia Syncline

North Marokopa coast: R16/f8644 (GS 10005).

Southland Syncline

North Face Ben Bolt (Otapiri Valley): E45/f9676 (JDC 1382), E45/f9697 (McF E23).

A total of 17 specimens were catalogued, of which 13 gave valid measurements.

Description. Small to medium sized terebratulide with rounded outline posteriorly and straight to slightly concave anterior margin in plane of commissure, moderate inflation. Dorsal valve slightly and about evenly convex posteriorly, with shallow rounded sulcus anteriorly. Ventral valve

FR no.	specimen	Lv	Lp	W	H	b<	material	notes
E45/f9676	OU 46753	17.7	16.1	17.7	7.4	113	b int. part ext	Holotype
N. Marokopa R16/f8644	Average	16.6	18	15.2	8	100.3	7 specimens	
	S.D.	4.44	2.82	3.31	1.15	11.76		
Otapiri E45/f9676	Average	15.8	14.3	13.3	5.6	109.5	6 specimens	
	S.D.	1.97	1.83	2.48	2.05	6.02		

Tab. 9 - Dimensions for *Aulacothyris stevensi.*

FR no.	specimen	Lv	Lp	W	H	b<	material	notes
E45/f9453	BR 3268	26.5+	26.1	19.6	7.8		b int	tip of beak broken. dv sulcate
E45/f9453	BR 3269	21		13.2		92	vv int	part of damaged dv underneath
R16/f6898	BR 3207	24.5	21.7	16.8			b int. vv ext	distorted. beak crushed. ant margin damaged.

Tab. 10 - Dimensions for *Aulacothyris* sp. A.

more strongly convex posteriorly, slightly and evenly convex anteriorly, without definite fold. Anterior margin deflected by broad, shallow rounded sulcation. Beak broad, erect to slightly incurved, with subcircular foramen. No pedicle collar seen. Beak ridges strong, bluntly rounded, foramen submesothyrid. Palintropes well-defined, concave near beak. Deltidial plates small, conjunct. Exterior with fine concentrics of irregular strength and spacing. Shell densely, moderately coarsely punctate.

Internal Characters. Dorsal valve with broad, slightly concave hingeplate, high wall-like median septum about ¼ to 1/3 of valve length. Muscle scars poorly shown. Ventral valve with short, divergent dental plates and large triangular lateral umbonal cavities. Paired, slightly impressed, poorly defined muscle scars near beak (Fig. 13.5 a & b, 13.6 a & b).

Dimensions. Dimensons of the holotype and statistics from the two main localities are shown in Table 9.

Range and Distribution. All the material comes from three Aratauran localities. In two of these it is associated with late Hettangian to early Sinemurian ammonites (Stevens, 2004).

Remarks. The Temaikan-Heterian *A. waikatoensis* is of similar size to *A. stevensi* but is more inflated and generally more rounded.

Aulacothyris sp. ***A***

Fig. 13: 11-13

Material:

Kawhia Syncline

Anaputa Bay, North Marokopa coast: R16/f6898 (GS 10009), Otapirian.

Southland Syncline

Otapiri Valley below Taylors Stream: E45/f9453 (GS 350), Aratauran.

Description. Medium-sized terebratulide with elongate-elliptical outline. Moderately inflated, with dorsal valve gently convex posteriorly, nearly flat to slightly sulcate anteriorly. Ventral valve more convex anteriorly, with broad, poorly defined fold anteriorly. Anterior margin strongly convex, rectimarginate to slightly sulcate. Exterior smooth with widely spaced rounded concentrics which are also shown on the valve interior. Beak triangular, suberect with sharply rounded tip, foramen probably of moderate size. Dorsal valve with high narrow median septum, about one-third of valve length. Dental plates in ventral valve long, divergent, Muscle scars in both valves poorly defined. Other details not seen.

Dimensions. Dimensions of measured specimens are shown in Table 10.

Range and Distribution. This description is based on the two specimens from E45/f9453 GS 350 (Otapiri Stream below junction). E45/f9556 (GS 9556) is nearby and includes *Paracaloceras* (*Gyrophioceras*) *loraense,* which is Late Hettangian according to Stevens (2004).

Remarks. Specimen BR 3207 from R16/f6898 (GS 10009) (Uppermost Otapirian, north Marokopa Coast, is badly distorted but appears to be the same species.

These specimens can be distinguished from the coeval or slightly later (Late Hettangian-early Sinemurian) *A. stevensi* as the latter is smaller and has a rounded-triangular outline and distinctive straight anterior margin. Unless more material can be found it is best not to erect a new species.

The single specimen described by Drot (1953) from the Otapirian of New Caledonia is smaller and proportionally broader.

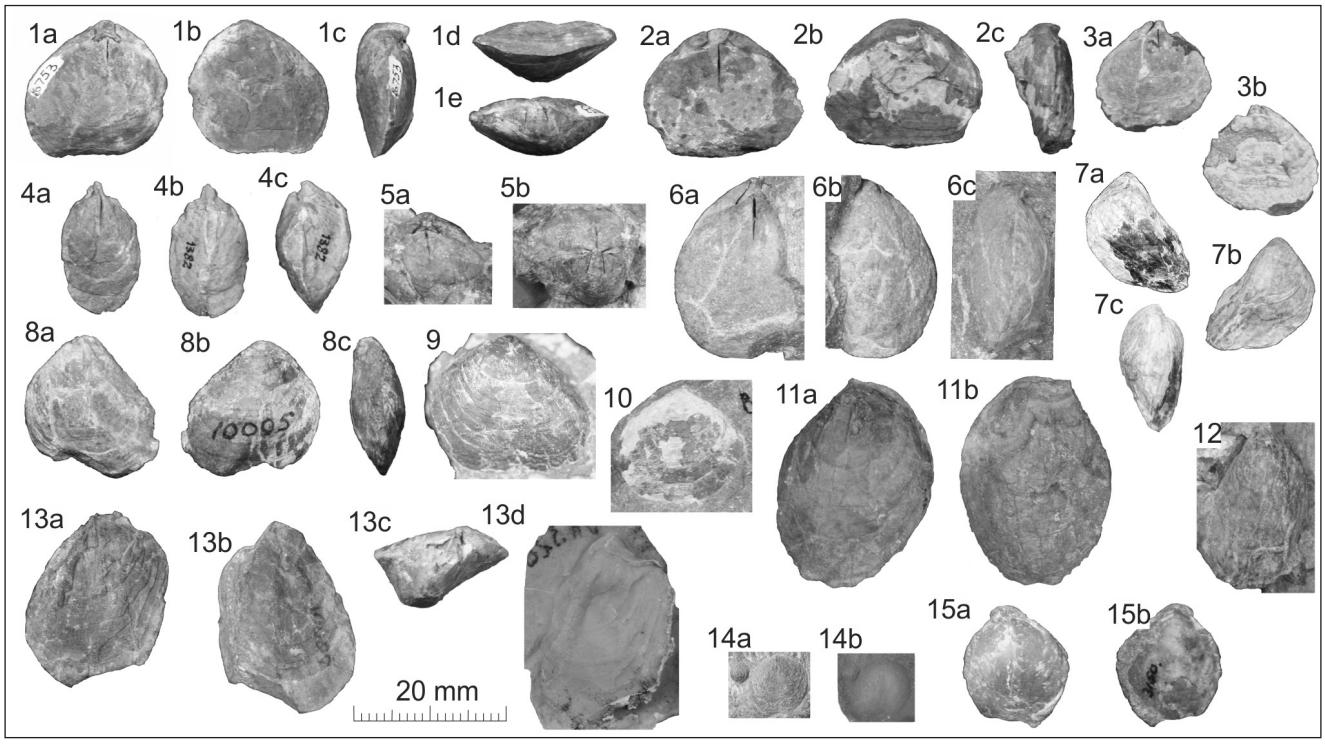


Fig. 13 -
1 – 10 *Aulacothyris stevensi* n. sp.
1) Holotype OU 46753 (E45/f9676) internal mould: (a) dorsal (b) ventral (c) lateral (d) anterior (e) posterior.
2) OU 46754 (E45/f9676) internal mould: (a) dorsal (b) ventral (c) lateral.
3) OU 46755 (E45/f9676) internal mould: (a) dorsal (b) ventral.
4) OU 46752 (E45/f9676) internal mould, laterally distorted: (a) dorsal (b) ventral (c) lateral.
5) OU 46769 (E45/f9676) internal mould: (a) dorsal, posterior part (b) posterior.
6) OU 16413 (E45/f9697) internal mould, (a) dorsal (b) ventral (c) lateral.
7) GS BR 3208 (R16/f8648) partly shelly, (a) dorsal (b) ventral (c) lateral.
8) GS BR 3211 (R16/f8648) shelly specimen, (a) dorsal (b) ventral (c) lateral.
9) GS BR 3209 (R16/f8648) shelly dorsal valve.
10) GS BR 3210 (R16/f8648) part shelly ventral valve.
11 – 13 *Aulacothyris* sp. A
11) GS BR 3268 (E45/f9453) internal mould (a) dorsal (b) ventral.
12) GS BR 3269 (E45/f9453) internal mould, ventral.
13) GS BR 3207 (R16/f6898) (a) dorsal (b) ventral (c) posterior (d) latex of exterior, dorsal.
14 – 15 *Aulacothyris* sp. B
14) B584 (R16/f8934) (a) internal mould, dorsal (b) latex of external, dorsal.
15) BR 3200 (R15/f8006) shelly specimen (a) dorsal (b) ventral.

Aulacothyris sp. ***B***

Fig. 13: 14-15.

Two further specimens from the Kawhia Syncline are much smaller than other New Zealand species of *Aulacothyris*. They probably represent a different species.

Material:
Kawhia Syncline
Ururoa Point Kawhia R15/f8006 (GS 3150). Upper Ururoan. Marokopa Valley: R16/f8934 (AU 4315) Aratauran.

Description. Small terebratulide with subcircular outline, moderately inflated with ventral valve more inflated than dorsal. Dorsal valve convex posteriorly, with shallow, distinct rounded sulcus anteriorly. Ventral valve moderately and evenly inflated, with no distinct fold. Anterior commissure broadly sulcate. Exterior of both valves smooth, with occasional low rounded concentrics anteriorly. Beak rounded, damaged in sole double-valved specimen. Shell densely punctate. Dorsal valve interior (B584, Fig. 13.14a) with high wall-like median septum about 0.4 valve length. Other details not seen.

Dimensions. Dimensions of measured specimens are shown in Table 11.

Range and Distribution. Only two specimens have been seen, which probably belong to the

FR no.	specimen	Lv	Lp	W	H	b<	material	notes
R15/f8006	BR 3200	16.1	15.1	14.5	6.7	95	b shelly	slightly crushed. beak damaged
R16/f8934	B584		8.2	8.1			dv int. ext	high narrow wall-like median septum.

Tab. 11 - Dimensions for *Aulacothyris* sp. B

same species. B584 is from R16/f8934, Marokopa (mapped as Aratauran by MacFarlan (1975), while BR 3200 is from R15/f8006, Ururoa Point (Upper Ururoan).

Remarks. These two specimens are smaller than any other New Zealand species of *Aulacothyris*. The material is insufficient for further comment.

Discussion

Faunal Changes at the Triassic-Jurassic Boundary

The end-Triassic extinction event is regarded as a major, worldwide event (Hallam 1981; Kiessling et al. 2007; Damborenea et al. 2017). In Zealandia, the distinctive Maorian fauna epitomised by *Clavigera*, *Rastelligera* and the trigoniid *Maoritrigonia* disappears and is replaced by more cosmopolitan faunas (Campbell 1991; Fleming 1987; MacFarlan 1992; MacFarlan & Campbell 2003).

The changes began in the Upper Otapirian, with the appearance of *Mentzelia kawhiana* and *Otapiria*. *Zeilleria spiculata* appears in the uppermost Otapirian (MacFarlan & Campbell 2003) and spans the boundary, as do the rhynchonellides *Vincentirhynchia pomeyroli* and *Sakawairhynchia mokauensis*. *Sakawairhynchia marokopana* is found throughout the Otapirian, and extends into the Lower Aratauran. *Mentzelia kawhiana* is replaced by the Aratauran *Mentzelia ongleyi* (Wright and Campbell 1990). *Aulacothyris* sp. A may also span the boundary.

Otapirian terebratulides are poorly known, and need a detailed systematic survey.

Faunal changes in the Toarcian

The brachiopod faunas of the later part of the Ururoan in Zealandia are distinctive, but most species first appear in the Upper Aratauran or earlier in the Ururoan, within the range-zone of *Pseudaucella marshalli*. The most diverse brachiopod faunas are those from Ururoa Point, especially the *Dactylioceras* band, with four species of rhynchonellide (MacFarlan 1992), five species of terebratulide, and at least two species of spiriferide. This fauna does not reach much higher than the *Dactylioceras* band (Hudson 2003).

Ammonites in the *Dactylioceras* band are correlated with the Crassum Subzone of the Bifrons Zone at the top of the Early Toarcian (Stevens 2008). This is considerably higher than the anoxic horizons which are associated with the major extinctions of brachiopods at the Early Toarcian Tenuicostatum-Serpentium Zone boundary in Western Europe (García Joral et al. 2011) but which have a world-wide extent (Gröcke et al. 2011; Al-Suwaidi et al. 2016). The rhynchonellides and terebratulides recovered but the spiriferides and koninckinids became extinct (Vörös et al. 2016).

Analysis of changes in ammonite faunas, especially those from high Northern Hemisphere latitudes, indicates multiple peaks and troughs in extinction rates, suggesting that there were several phases of extinction in the Pliensbachian and Toarcian (O'Dogherty et al. 2000; Dera et al. 2010), with a major diversity peak followed by a sharp decline in the late Bifrons Zone (Caruthers et al. 2013, 2014). A peak and decline at about the same level was shown by Riccardi (2008) from Argentina. In Zealandia the global effects may have been exacerbated by the widespread shallowing that occurred in the Temaikan. As discussed by Hudson (1999, 2003), the break is facies controlled, with non-marine beds at Kawhia, and coarse-grained beds which may represent environments unsuitable for brachiopods elsewhere.

The overlying Temaikan terebratulide and rhynchonellide faunas are entirely different at the species level, and the spiriferides become extinct. The terebratulides remain a major group of brachiopods in the Late Jurassic, and by the Cenozoic are much the larger group. There is a general increase in brachiopod size from Early to Middle Jurassic, which will be examined in future work.

The base of the overlying Temaikan stage was defined on the appearance of the belemnites *Belemnopsis mackayi* or *Belemnopsis deborahae* (Hudson 2003; Cooper 2004; Raine et al. 2015). With the taxonomic revision of Challinor and Hudson (2017), these are now termed *Eobelemnopsis robustus* and *Eobelem-*

nopsis mackayi. Raine et al. (2015) and Challinor and Hudson (2017) correlate the base of the Temaikan with the Late Toarcian (Fig. 2). Lower Temaikan brachiopods are restricted to rare *Aucklandirhynchia aucklandica* (Hudson, 1999), and a more diverse rhynchonellide – terebratulide fauna does not appear until the Middle Temaikan (MacFarlan 2016).

New Caledonia

Terebratulides are not common in the New Caledonian Early Jurassic. Most of the material comes from the Aratauran – Ururoan of Uitoé Peninsula, where three Aratauran localities yielded *Linguithyris agerorum* in contrast to the single specimen known from New Zealand. One specimen of *Loboidothyris fordycei* was found from the Ururoan NC/f969, west of Moindou (Wiley 1996). Other material is indeterminate.

No determinable Middle Jurassic terebratulides were found in New Caledonian collections during work for MacFarlan (2016), but since then a few specimens have been noted from the Temaikan of Ile Mathieu. *Kutchithyris marokopana* and *Loboidothyris waitomoensis* were found at NC/f490. This is the type locality for the rhynchonellide *Caledorhynchia caledonica,* which occurs with the two terebratulide species in the Marokopa Valley. Several specimens of an indeterminate terebratulide were found at NC/f425.

Affinities of Zealandian Early Jurassic terebratulide faunas

The two genera which are the most significant in the Early Jurassic, *Lobothyris* and *Zeilleria,* are cosmopolitan and widely distributed throughout the world (Fig. 8), as is *Aulacothyris*. *Loboidothyris* is also cosmopolitan but has a Tethyan aspect. *Tegulithyris* and *Rugithyris* are Tethyan but less widely distributed. *Linguithyris* is also known from southern Europe, North Africa and western Asia, with one specimen known from the Late Jurassic of Indonesia. The fauna as a whole can therefore be described as cosmopolitan with a Tethyan aspect. This is in contrast to the strongly endemic Late Triassic brachiopod faunas of the Maorian province (Campbell 1985, 1991; MacFarlan 1992) that precede it, and the more overtly Tethyan brachiopod faunas of the Middle and Late Jurassic (MacFarlan 2016).

Bivalves and rhynchonellide and spiriferide brachiopods in the early Jurassic of Zealandia show strong affinities with those of Argentina and Chile (Damborenea & Manceñido 1991), but a similar affinity is not obvious in terebratulide faunas.

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APPENDIX - Locality data

New Caledonia

FR Number	NCTM Easting	NCTM Northing	Locality	Collection number	Stage	Collectors	Terebratulide species
NC/f0396	616020	7558320	Uitoé Peninsula	AU 7227	Ha	J.A. Grant-Mackie	terebratulides indet
NC/f0401	615730	7558350	Uitoé Peninsula	AU 9419	Ha	J.A. Grant-Mackie	terebratulide indet.
NC/f0401	615730	7558350	Uitoé Peninsula	AU 7232	Ha	J.A. Grant-Mackie	terebratulide indet
NC/f0425	614100	7556810	île Mathieu	AU 7256	Kt	J.A. Grant-Mackie	terebratulides indet
NC/f0439	616560	7585000	Uitoé Peninsula	AU 7339	Hu	J.A. Grant-Mackie	*Linguithyris agerorum*
NC/f0468	615490	7574900	Uitoé Peninsula	AU 7369	Hu	J.A. Grant-Mackie	*Linguithyris agerorum*
NC/f0472	615430	7557450	Uitoé Peninsula	AU 7373	Hu		*Linguithyris agerorum*
NC/f0490	614020	7557420	île Mathieu	McF G40	Kt	J.A. Grant-Mackie, N. de Jersey, J.G. Begg, D.A.B. MacFarlan 1981	*Kutchithyris marokopaensis* *Loboidothyris waitomoensis*
NC/f0969	599670	7599400	Moindou-Nessandiou Road	AU 11221	Hu	N. Hudson 22/10/1986	*Loboidothyris fordycei*
NC/f1110	563200	7599200	Tribu Kere	AU 13980	Bo-Ha?	M Wiley 14/12/1994	*?Zeilleria spiculata*

Kawhia Syncline

FR Number	NZMG Easting	NZMG Northing	Locality	Collection no:	Stage	Collector	Terebratulide species
R13/f7048	2673229	6424789	Opuatia Stream, Port Waikato	AU 907	Hu	J.A. Grant-Mackie, KA Rodgers & students 5/1971	*Linguithyris agerorum*
R15/f0015	2664700	6343100	Ururoa Point	McF B4	Hu	D.A.B. MacFarlan 9/1/1979	*Lobothyris simesei*
R15/f0029	2663200	6341700	North of Arataura	McF B19	Ha	D.A.B. MacFarlan 15/1/1979	*Lobothyris simesei* *Zeilleria terezowae*
R15/f0030	2663600	6341800	North of Arawhero	McF B22	Ha	D.A.B. MacFarlan 17/1/1979	*Lobothyris simesei*
R15/f0032	2664600	6342700	Hole in the Wall, Ururoa Point	McF B3	Hu	D.A.B. MacFarlan 8/1/1979	*Loboidothyris fordycei* *Lobothyris simesei*
R15/f0266	2663754	6341918	West of Otamaehu	AU 12698	Ha	J.A. Grant-Mackie, R. Hori	*Zeilleria terezowae*
R15/f8005	2664700	6343100	*Dactylioceras* band Ururoa Point	GS 1194		J. Henderson, L.I Grange 1921	*Lobothyris simesei* *Zeilleria terezowae*
				AU 47	Hu	K.R. Martin	*Lobothyris simesei* *Zeilleria terezowae*
				AU 614	Hu		*?Lobothyris simesei* *Zeilleria terezowae*
				AU 2994	Hu	Stage III 1972	*Lobothyris simesei*
				AU 6425	Hu	J.A. Grant-Mackie 4/1975	*Tegulithyris plencnerae*
				AU 9197		A.B.S. Clarke, N. Hudson, J.A. Grant-Mackie, 18/1/1981.	*Tegulithyris plencnerae* *Zeilleria terezowae*
				AU 12296	Hu	J.A. Grant-Mackie 4/90	*Lobothyris simesei*
				OU JDC 1151	Hu	J.D. Campbell, D.S. Coombs 1966	*Lobothyris simesei* *Zeilleria sacciformis*
				OU McF B2	Hu	D.A.B. MacFarlan 7/1/1979	*Lobothyris simesei* *Zeilleria terezowae*
R15/f8006	2664800	6343100	Ururoa Point close to *Dactylioceras* band	GS 3150	Hu	J Henderson LI Grange 1921	*Lobothyris simesei* *Zeilleria terezowae* *Aulacothyris* sp. B
				AU 592	Hu	1943	*Lobothyris simesei* *Zeilleria terezowae* *Zeilleria sacciformis*
				AU 600	Hu	1943 coll	*Loboidothyris fordycei* *Lobothyris simesei*
R15/f8078	2664605	6342900	Hole in the Wall, Ururoa Point	AU 595	Hu	Wong, Battey, Gardner 1943	*Lobothyris simesei*
R15/f8079	2664570	6342750	Ururoa Point, Hole In the Wall S side	AU 9204	Hu	N Hudson May 10, 1982	*Lobothyris simesei*
R15/f8575	2664600	6342850	Ururoa Point	JDC 1150	Hu	J.D. Campbell, D.S. Coombs 2/1954	*Lobothyris simesei* *?Zeilleria terezowae*
R15/f8588	2663383	6341746	290 m N of Arataura Point	JDC 1167	Ha	J.D. Campbell, D.S. Coombs 2/1954	*Zeilleria terezowae*
R15/f8677	2664701	6343081	Ururoa Point	AU 2995	Hu	Stage III 1972	*?Lobothyris simesei*
R15/f8686	2664605	6342900	Hole in the Wall, Ururoa Point	AU 599	Hu	E.J. Searle & others 1942, 1945	*Tegulithyris plencnerae*
				McF B1	Hu	D.A.B. MacFarlan 7/1/1979	*Lobothyris simesei*
R15/f8697	2663662	6341921	Otamaehu Point	AU 128	Ha	K.R. Martin 1966	*Lobothyris simesei* *Zeilleria terezowae*
R15/f8812	2663754	6341918	240m S of Otamaehu Point	AU 127	Ha	K.R. Martin 12/2/1966	*?Lobothyris simesei*
				AU 14794	Ha		*?Zeilleria* sp. indet.
R15/f8816	2664605	6342900	South side Hole in the Wall	AU 50	Hu	K.R. Martin 2/1965	*Loboidothyris fordycei* *Tegulithyris plencnerae*
				AU 9459	Hu		*?Lobothyris simesei* *Tegulithyris plencnerae*
				AU 14811	Hu	J.A. Grant-Mackie et al 11/1995	*Lobothyris simesei*
R15/f8828	2663287	6341566	32m NE of Arataura Point	AU 132	Ha	K.R. Martin 2/1966	*?Loboidothyris fordycei* *Tegulithyris plencnerae*
R15/f8829	2663195	6341568	230m NE of Arataura Point	AU 134	Ha	K.R. Martin 2/1966	*Tegulithyris plencnerae*
R15/f8834	2662912	6341256	140m SSW of South wall of Arataura Point	AU 63	Bo	K.R. Martin 5/1965	*Zeilleria spiculata*
R15/f8837	2662865	6341212	230m SSW of south wall of Arataura Point	AU 69	Bo	K.R. Martin 5/1965	*?Linguithyris sp.*
R15/f8838	2662818	6341167	280m SSW of south wall of Arataura Point	AU 70	Bo	K.R. Martin 5/1965	*?Linguithyris sp.*
R15/f8875	2664632	6342259	Shore platform at head of Waitapu Inlet, Kawhia Harbour	AU 153	Hu	K.R. Martin 3/1966	*Lobothyris simesei*
R15/f8875	2664620	6342270	Shore platform at head of Waitapu Inlet, Kawhia Harbour	AU 9217	Hu	N. Hudson 25/1/1981	*Lobothyris simesei*
R16/f0149	2660200	6324700	300m N of Tauhua Stream mouth,coast north of Marokopa River	AU 8359	Ha	J.G. Begg et al. 24/2/1982	*?Lobothyris simesei*
R16/f6811	2658300	6339000	Paparoa Point Taharoa	AU 154	Hu	K.R. Martin 1966	*Lobothyris simesei*
				AU 8363	Hu	J.G. Begg 2/82	*?Lobothyris simesei*
				GS 9674	Hu	B.E. Thomson 1/1966	*Loboidothyris fordycei* *Lobothyris simesei*
R16/f6896	2660163	6326518	Coast north of Marokopa River	GS 10007	Bo	C.R. Lennie, B.E. Thomson 1/1967	Terebratulide indet.
R16/f6898	2660110	6329492	South side of Anaputa Bay, coast north of Marokopa River	GS 10009	Bo	B.E. Thomson 1/1966, B.E.Thomson, CR Lennie 9/5/68	*Aulacothyris* sp. A
R16/f6904	2661695	6330544	Coast north of Marokopa River	GS 10042	Hu	B.E. Thomson 1/1967	Terebratulide indet.

Kawhia Syncline

FR Number	NZMG Easting	NZMG Northing	Locality	Collection no:	Stage	Collector	Terebratulide species
R16/f8639	2660012	6320522	South of Marokopa river mouth	GS 9994	Bo	G.R. Stevens, B.E. Thomson, C.R. Lennie 1(	*?Rugithyris hasibuani*
R16/f8640	2660050	6320576	bluff at mouth of Marokopa River	GS 10001	Bo		*?Zeilleria spiculata*
R16/f8644	2660159	6324734	Coast 400 - 500m northwest of Tauhua Stream	GS 10005	Ha	G.R. Stevens, C.R.; Lennie, B.E. Thomson 8/5/1968	*Loboidothyris fordycei* *Aulacothyris stevensi*
R16/f8648	2660211	6323361	Coastal cliffs 110m north-west of mouth of Turiakina Stream	GS 10035	Ha	G.R. Stevens, C.R.; Lennie, B.E. Thomson 10/5/1968	
R16/f8649	2660080	6325194	900-1000m northwest of mouth of Tuhua Stream	GS 10036	Bo-Ha	B.E. Thomson 1/1967	*?Zeilleria terezowae*
R16/f8794	2660307	6323496	base of cliff 1.1 km north of mouth of Turiakina Stream	GS 11445	Ha	I.W. Keyes, G.R. Stevens 23/3/1972	
R16/f8811	2664838	6315548	Pomarangai Rd, 8m up stream through lowest hairpin in 20m above 5m waterfall in main stream.	AU 4197	Hu	D.A.B. MacFarlan, D. Pryor, J.A. Grant-Mackie 10/2/1973	*?Zeilleria terezowae*
R16/f8821	2665021	6315543	Stream through lowest hairpin in Pomarangai Road	AU 4395	Hu	D.A.B. MacFarlan, D. Pryor, J.A. Grant-Mackie 10/2/1973	*Lobothyris simesei* *Zeilleria terezowae*
R16/f8933	2663451	6318240	Ngawaitungirua Stream Kiritehere Valley	AU 4314	Ha?	D.A.B. MacFarlan 18/2/1974	*?Loboidothyris fordycei*
R16/f8934	2663542	6318237	Ngawaitungirua Stream Kiritehere Valley	AU 4315	Ha	D.A.B. MacFarlan 18/2/1974	*Aulacothyris* sp. B
R17/f227	2665600	6298400	Western tributary of Awakino River	AU 7634	Hu	F. Hasibuan 7/12/1979	*Rugithyris hasibuani*
R17/f232	2665700	6302500	Western tributary of Awakino	AU 7639	Hu	F. Hasibuan 10/12/1979	*Zeilleria* sp. indet.
R17/f293	2665400	6289300	Tributary to Rauroa Stream	AU 9265	Kt	N. Hudson 19/12/1981	*Zeilleria* sp. indet
R17/f298	2667600	6298600	Float boulder in tributary to upper Awakino River	AU 9270	Ha - Kt	N. Hudson 21/12/1981	
R17/f317	2665200	6299400	Tributary to upper Awakino River	AU 9290	Hu	N. Hudson 28/12/1981	*Zeilleria terezowae*
R17/f337	2664700	6291100	major tributary to Rauroa Stream	AU 9309	Hu	N. Hudson 12/12/1981	*?Lobothyris simesei*
R17/f8007	2660722	6283197	Awakino Gorge 1.5 km north of Bexley Creek	GS 911	Hu	J. Henderson 1918	*Lobothyris simesei*
R17/f8008	2660900	6284400	Quarry, Awakino Gorge	AU 9468	Hu	L.R.S. Braithwaite, J.A. Grant-Mackie, 13/3/1984	*Lobothyris simesei*
R17/f8556	2656080	6284230	Quarry in Manganui Rd. near foot of first hill north of Awakino	McF F9	Ha	D.A.B. MacFarlan 6/12/1980	*?Rugithyris hasibuani*
R17/f8566	2660600	6283800	Lower quarry, Awakino Gorge	AU 17917	Hu		*Lobothyris simesei* *Rugithyris hasibuani*
				AU 16899	Hu	M. Eagle 22/1/2001	*Rugithyris hasibuani*
R17/f8567	2661060	6285560	Upper quarry, Awakino Gorge	McF F1	Hu	D.A.B. MacFarlan 4/12/1980	*?Rugithyris hasibuani*
R18/f6562	2657520	6279904	Awakino Gorge	AU 326	Bo	J.A. Grant-Mackie 10/1955	*Zeilleria spiculata*

Southland Syncline

FR Number	NZMG Easting	NZMG Northing	Locality	Collection no:	Stage	Collector	**Terebratulide species**
E45/f0056	2158700	5461400	Otapiri Stream west bank, 60m downstream of Taylors Crossing bridge.	GS 13035	Bo	J.I. Raine, H.J. Campbell, 8/6/1981	*Zeilleria spiculata*
E45/f0061	2158500	5454899	East side of Otapiri Gorge N of Conical Hill	McF C9	Hu	D.A.B. MacFarlan 16/5/1979	*Zeilleria* sp. Terebratulid indet,
E45/f0062	2158100	5454099	Hill to east of Otapiri Gorge	McF C10	Hu	D.A.B. MacFarlan 17/5/1979	*Loboidothyris fordycei* *Zeilleria terezowae* *Zeilleria sacciformis*
E45/f0070	2162000	5459399	South branch Taylors Stream	McF E26	Ha	D.A.B. MacFarlan, J.G.G. Morton 22/1/1980	*Zeilleria spiculata*
E45/f0072	2160000	5460699	Taylors Stream, just upstream of footbridge	McF E28	Ha	D.A.B. MacFarlan, J.G.G. Morton 21/1/1980	*Zeilleria spiculata*
E45/f0076	2160100	5458799	North slopes of Ben Bolt	McF E34	Ha	D.A.B. MacFarlan, J.G.G. Morton 23/1/1980	*Lobothyris simesei*
E45/f0080	2160400	5460299	Taylors Stream	McF E40	Ha	D.A.B. MacFarlan, J.G.G. Morton 24/1/1980	*Zeilleria spiculata*
E45/f0085	2155900	5454299	Heale Ridge, W of Otapiri	McF E49, E57	Hu (l)	DMcF, J.G.G. Morton 27/01/1980	*Loboidothyris fordycei* *Lobothyris simesei* *Zeilleria terezowae* *Zeilleria sacciformis*
				JDC 3651	Hu (l)	J.D. Campbell, D.A.B. MacFarlan Stage II class 25/4/1981	*Loboidothyris fordycei*
E45/f0115	2159100	5459899	Otapiri Stream 250-300m below Taylors Stream mouth	AU 2807	Ha	R.A.S Browne	*Lobothyris simesei*
E45/f0121	2158900	5460799	Otapiri Valley	JDC 3896	Ha	J.D. Campbell 6/1/87	*Zeilleria spiculata*
E45/f0142	2159900	5460749	Borrow pit, Otapiri Valley	JDC 3927	Ha	J.D. Campbell 26/5/88	*Zeilleria spiculata*
E45/f0152	2158300	5460700	Otapiri Downs 400m West of Otapiri Stream	JDC 3948	Ha	J.D. Campbell 5/6/87	*Zeilleria spiculata*
E45/f0153	2157900	5461099	Otapiri Downs 1000m West of Otapiri Stream	JDC 3949	Ha	J.D. Campbell 5/6/87	*Zeilleria spiculata*
E45/f0155	2161800	5459299	Quarry, north side Taylors Stream	JDC 3951	Ha	J.D. Campbell, D.E. Lee, D.A.B. MacFarlan, 24/7/2001	*Zeilleria spiculata*
E45/f0276	2153700	5462699	Tributary of Bastion Burn	JDC 4282	Ha	J.D. Campbell, A.R. Orpin 17/6/93	*Zeilleria spiculata*
E45/f0279	2161500	5459399	Taylors Stream, just downstream of bridge	JDC 4059	Bo	J.D. Campbell 25/4/93	*Zeilleria spiculata*
E45/f0349	2156400	5463699	West-facing spur west of Otapiri Stream	JDC 4478	Bo	J.D. Campbell Tom Myers, 5/11/94	*Zeilleria spiculata*
E45/f0360	2162200	5459399	Taylors Stream, stream on N side of The Cornwalls woolshed.	JDC 4058	Ha	J.D. Campbell 10/9/1989	*Zeilleria spiculata*
E45/f0379	2158800	5457400	Southwest Face of Ben Bolt.	JDC 4069	Ha	J.D. Campbell A. Grebneff, M.O. Manceñido, S. E. Damborenea 2/3/1990	*Lobothyris simesei*
E45/f0380	2159100	5459800	Otapiri Stream	JDC 3996	Ha	J.D. Campbell 20/12/1988	*Zeilleria terezowae*
E45/f0381	2160100	5458000	Golightly's Airstrip Ben Bolt.	JDC 3997	Ha	J.D. Campbell 20/12/1988	*Loboidothyris fordycei*
E45/f9440	2157692	5453719	Conical Hill, Otapiri Gorge	GS 337	Hu (l)	A McKay 1878	*Loboidothyris fordycei* *Zeilleria terezowae*
E45/f9446	2159264	5458040	West Face of Ben Bolt.	JDC 737	Ha	J.D. Campbell	*Loboidothyris fordycei* *Lobothyris simesei* *Zeilleria terezowae*
E45/f9447	2160167	5458696	North Face of Ben Bolt.	GS 344	Ha	A. McKay 1878	*Zeilleria terezowae*
E45/f9448	2160258	5458697	West Face The Bastion	GS 345	Ha	A. McKay 1878	*?Loboidothyris fordycei* *Lobothyris simesei*
E45/f9451	2159057	5459499	West side of Otapiri Stream, Otapiri Gorge.	GS 348	Ha	A. McKay 1878	*Lobithyris simesei*
E45/f9452	2159055	5459591	Upper Part of Otapiri Gorge.	GS 349	Ha	A. McKay 1878	*?Lobothyris* sp. indet
E45/f9453	2158954	5460137	Otapiri Gorge.	GS 350	Ha	A. McKay 1878	*Aulacothyris* sp. A
E45/f9454	2159721	5458049	Taylors Stream on Ben Bolt to North Peak section line	GS 351	Ha	A. McKay 1878	*Zeilleria spiculata*
E45/f9455	2159000	5459999	Junction of Taylors Stm and Otapiri	AU 2811	Ha	R.A.S. Browne	*Lobithyris simesei*
E45/f9466	2151865	5463214	Benmore Yards	GS 363	Bo	A. McKay 1878	*Zeilleria spiculata*
E45/f9552	2161343	5459355	Taylors Stream	JDC 735	Ha	J.D. Campbell	*Zeilleria spiculata*
E45/f9568	2159000	5459399	West bank Otapiri Stream	GS 5903	Ha	I.C McKellar 14/7/1953	*Lobithyris simesei*
				JDC 1380	Ha	J.D. Campbell 1956, 1964	*Lobithyris simesei*
				McF E48	Ha	DMcF, J.G.G. Morton, 26/1/1980	*Loboidothyris fordycei*
E45/f9613	2160135	5460522	northwest bank Taylors Stream	JDC 1287	Ha	J.D. Campbell I.C. McKellar 26/1/1955	*Zeilleria spiculata*
				McF E39	Ha	D.A.B. MacFarlan, J.G.G. Morton 24/1/1980	*Zeilleria terezowae*
E45/f9614	2160275	5460342	North bank Taylors Stream	JDC 1288	Ha	J.D. Campbell I.C. McKellar 26/1/1955	*Zeilleria spiculata*

Southland Syncline

FR Number	NZMG Easting	NZMG Northing	Locality	Collection no:	Stage	Collector	**Terebratulide species**
E45/f9615	2161619	5459268	Quarry near Taylors Stream	JDC 1289	Ha	J.D. Campbell I.C. McKellar 26/1/1955	*Zeilleria spiculata*
E45/f9617	2162072	5459505	South bank Taylors Stream	JDC 1291	Ha	J.D. Campbell I.C. McKellar 26/1/55	*Zeilleria spiculata*
E45/f9618	2158704	5461366	Road cutting 100m N of Taylors Crossing bridge	JDC 1293	Bo	J.D. Campbell I.C. McKellar 27/1/55	*Zeilleria spiculata*
E45/f9622A	2158700	5461299	Otapiri Stream downstream of Taylors Crossing	McF E45	Bo	D.A.B. MacFarlan, J.G.G. Morton 25/1/1980	*Zeilleria spiculata*
E45/f9629	2152321	5457968	Ridge Crest, Trig NN (Oreti Valley)	GS 6371	Ha	I.C. McKellar, P.M. Chandler 2/1955	*?Zeilleria spiculata*
E45/f9662	2158802	5455657	southwest slopes Ben Bolt.	GS 6604	Hu	I.C. McKellar	*Loboidothyris fordycei*
E45/f9676	2160118	5458832	north face Ben Bolt.	JDC 1382	Ha	J.D. Campbell (various), J.D. Campbell, A. Grebneff, M.O. Manceñido, S. E. Damborenea 1/3/1990	*Aulacothyris stevensi*
E45/f9697	2159800	5458599	north-west face Ben Bolt	McF E23	Ha	D.A.B. MacFarlan J.G.G. Morton 20/1/1980	*Aulacothyris stevensi*
E45/f9711	2154618	5462530	north-west face The Bastion	GS 6748	Ha	Chandler, P.M.; McKellar, I.C 20/8/1956	*Loboidothyris fordycei*
E45/f9860	2158321	5454369	north-west of Conical Hill, Otapiri Valley	JDC 1837	Hu (l)	J.D. Campbell (various)	*Loboidothyris fordycei* *Zeilleria terezowae* *?Zeilleria sacciformis*
				GS 7736	Hu	I.G. Speden, I.C. McKellar 1/3/1960	*Loboidothyris fordycei* *Zeilleria terezowae*
				AU 12474	Hu	N. Hudson 5/3/1988	*Loboidothyris fordycei* *Zeilleria terezowae*
				McF C8	Hu (l)	D.A.B. MacFarlan 16/5/1979	*Lobothyris simesei* *Zeilleria terezowae*
E45/f9895	2159759	5461156	outcrop and scree, Taylors Stream N of Warwick Downs homestead	JDC 1976	Ha	J.D. Campbell 15/9/1963	*Zeilleria spiculata*
E45/f9910	2160589	5460713	20m N of north-west branch Taylors Stream	JDC 2095	Bo	J.D. Campbell, B.R.Paterson 18/6/1965	*Zeilleria spiculata*
E45/f9911	2160680	5460715	Taylors Stream	JDC 2096	Bo	J.D. Campbell, BRP 18/6/1965	*Zeilleria spiculata*
E46/f056	2165400	5439699	bulldozed pile (farm quarry) just west of Jewitt Rd	JDC 2509	Hu (u)	P.L. Spencer, M.R. Morton, C.J. Paterson, J.D. Campbell, J.R. Boles, 18/8/1970	*Zeilleria sacciformis*
				McF H25	Hu (u)	J.D. Campbell, D.A.B. MacFarlan, 9/3/1982	*?Lobothyris simesei* *Zeilleria sacciformis*
E46/f063	2165650	5439599	Jewitt Road, north side at corner	JDC 4661	Hu (u)	J.D. Campbell AG 25/5/1998	*Zeilleria terezowae*
E46/f7538	2165359	5438131	1.2 km up tributary to Makarewa River	GS 5398	Ha	GG Cossens 1/5/1951	*?Lobothyris simesei*
F45/f0072	2173250	5456049	Quarry on south side of road near Rhutra stream crossing	JGGM 131	Ha	J.G.G. Morton 15/2/1979	*Zeilleria spiculata*
				McF E7	Ha	D.A.B. MacFarlan, J.G.G. Morton 18/1/80 D.A.B MacFarlan, J.D. Campbell 2/2/82	*Zeilleria spiculata*
F45/f0083	2175550	5455649	Tributary of Peel Stream	JGGM 157	Ha	J.G.G. Morton 18/2/1979	*Zeilleria* sp. indet
F45/f0092	2173300	5456059	Outcrop between Rhutra Quarry and road	JGGM 172	Bo-Ha	J.G.G. Morton 23/6/79	*Zeilleria spiculata*
F45/f0132	2173300	5456299	Otamita Valley Road, high roadcut 50m W of Rhutra Stream culvert	McF C11	Ha	D.A.B. MacFarlan 18/5/79 D.A.B. MacFarlan J.D. Campbell 2/2/82	*Zeilleria spiculata* *Zeilleria recessa*
F45/f8011	2183278	5453880	On NE side of Retreat-Croydon Road at bulldozed face	JDC 2479	Ha	J.D. Campbell K.G. Griffin 26/5/1970	*Lobothyis simesei* *Zeilleria recessa*
F45/f8773	2176398	5455408	Otamita Valley 30m south of Otamita-Lora road	GS 7624	Ha	I.C. McKellar 1954	*Zeilleria terezowae*
F47/f0013	2193500	5403799	South of Crighton Road Waimahaka.	JDC 3796 NDJC GP93	Hu	N.D.J. Cook, J.D. Campbell, D.S. Coombs, D.D.L. Pillai 10/5/1983	*Zeilleria sacciformis*