Zootaxa 5374 (1): 001–034
https://www.mapress.com/zt/

Article

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

https://doi.org/10.11646/zootaxa.5374.1.1
http://zoobank.org/urn:lsid:zoobank.org:pub:072341AB-7693-4DF3-9286-D69D0BBD8FAD

Otapirian (Rhaetian) Terebratulida (Brachiopoda) of Zealandia

DONALD ALEXANDER BANKIER MACFARLAN
13 Fairfax Terrace, Frankleigh Park, New Plymouth 4310, New Zealand
donald.macfarlan@xtra.co.nz; *https://orcid.org/0000-0001-6853-5675*

Abstract

Terebratulides are present throughout the Zealandian Rhaetian (Otapirian local stage), but only *Zeilleria spiculata* has been described to date. Others have been recorded, mainly as *Dielasma*. A total of seven species are recorded here. In this paper, two new species are included in the dielasmatid genus *Tibetothyris* Jin and Sun, 1976. *Tibetothyris hamishi* **n. sp.** is found in New Caledonia and the Kawhia and Southland synclines. *Tibetothyris johnstoni* **n. sp.** is found in New Caledonia, Nelson, and the Taringatura Hills in western Southland. A large, biconvex terebratulide that is common at a few localities in île Ducos and île Hugon, New Caledonia, in Nelson, and probably in Southland, belongs to the cosmopolitan genus *Rhaetina* and is described as *Rhaetina rainei* n. sp.

Lobothyris richardsi **n. sp.** is proposed for a *Lobothyris* with a distinctive straight anterior margin. This has some resemblance to the Siberian and North American Late Triassic species *Lobothyris monstrifera* Dagys, 1963.

As well as *Z. spiculata,* two other species of *Zeilleria* are recognized from the Otapirian of Zealandia. A small form that has some similarity to the Early Jurassic *Zeilleria terezowae* is here named *Z. minima* **n. sp.** A single specimen of a larger, strongly inflated species is described as *Zeilleria* **n. sp.**

The fauna as a whole is cosmopolitan, with affinities to the Circumpacific region.

Key words: New Zealand; New Caledonia; Zealandia; Brachiopoda; Terebratulida; Late Triassic; Murihiku Terrane; Téremba Terrane

Introduction

This paper is intended as a detailed systematic account of the Otapirian terebratulides of Zealandia. It forms part of the author's survey of Late Triassic and Jurassic brachiopods, along with work on the rhynchonellides (MacFarlan 1992), Jurassic terebratulides (MacFarlan and Campbell 2003, MacFarlan 2016, 2019) and latest Triassic and Early Jurassic spiriferinides (MacFarlan 2023).

Terebratulides are a minor group of brachiopods in the Triassic marine faunas of Zealandia and have received little taxonomic attention. In contrast, they become second to the rhynchonellides in terms of specimen numbers and species diversity in the Jurassic, and the most dominant group in the Cenozoic.

A major purpose of this paper is to provide the taxonomic framework for analysis of the effects of the end-Triassic extinction event on Zealandian brachiopod faunas. The terebratulides are one of three major brachiopod groups which span the Triassic-Jurassic boundary in Zealandia, along with spiriferinides and rhynchonellides.

Previous Work

Trechmann (1918) described two new terebratulide species (*Dielasma zealandica* and *Terebratula pachydentata)*, and described three more (*Dielasma* cf. *himalayana*, *Coenothyris* sp. and *Terebratula* cf. *hungarica*) in open nomenclature. Of these, only *Coenothyris* sp. was recorded from the Otapirian. Marwick (1953) figured the same species, with a few comments. The only published addition to the fauna since then is that of *Zeilleria spiculata* MacFarlan and Campbell, 2003, which spans the Triassic-Jurassic boundary (MacFarlan and Campbell 2003,

Accepted by J. Robinson: 24 Oct. 2023; published: 15 Nov. 2023

MacFarlan 2019. MacFarlan et al. (2009) list a total of 13 species of Triassic terebratulide, one of which is Early to Middle Triassic (Malakovian) five are Middle Triassic (Etalian-Kaihikuan) and nine are Late Triassic (Oretian to Otapirian). Most of these are from the unpublished work of Begg (1981).

Methods

This paper is based on material from the collections of the School of Environment, University of Auckland, the Department of Geology, University of Otago, and the National Palaeontological Collection at GNS Science, Lower Hutt. Methods and taxonomic approach are generally those applied in the author's previous works on Mesozoic brachiopod faunas of New Zealand and New Caledonia (MacFarlan 1992, 2016, 2019).

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. All measurement data will be available in a planned update to MacFarlan (2021). 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. Abbreviations used in measurement tables are shown in Fig. 1.

Classification and morphologic terminology follow the revised Brachiopoda 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).

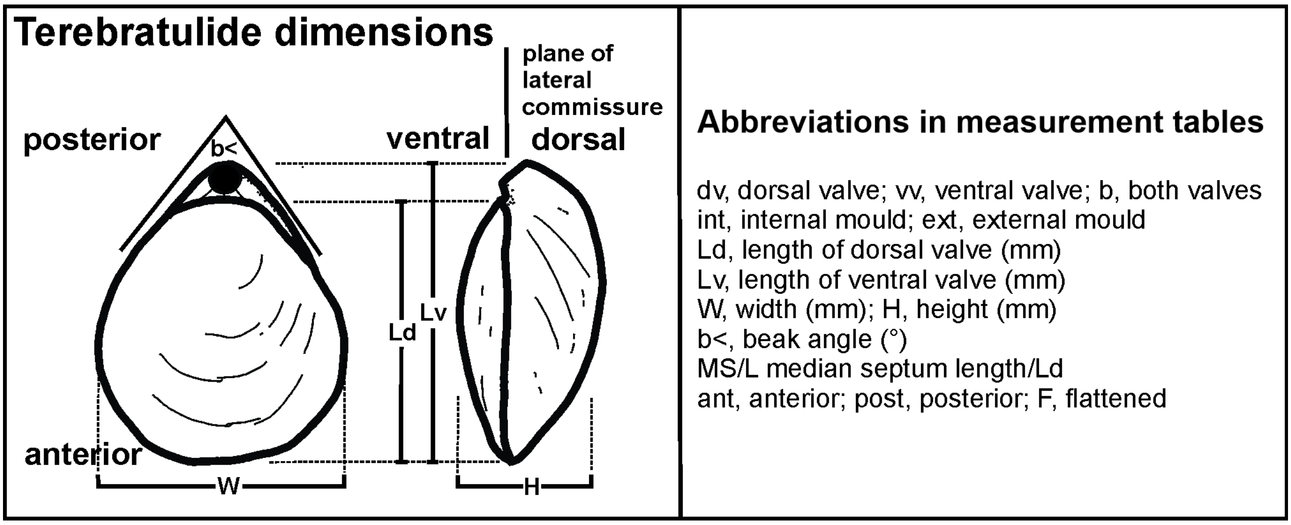


FIGURE 1. Measured dimensions.

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 (Clowes et al. 2021). 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:

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

University of Otago Department of Geology Museum: collections under collector's field number, catalogued specimens prefixed OU. Specimens in J.D. Campbell's catalogue prefixed C.

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

A few localities are not registered in the Fossil Record File. These are listed with the relevant NZMS 260 map sheet number (example E45/f (AU 2819). "Probable" identifications are shown in lists by a question mark in front of the collection number.

Locality data are summarised in Appendix A.

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 (ed.) (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.

The Otapirian stage was further refined by Campbell and McKellar (1956) and Campbell (1956). It is correlative with the international Rhaetian Stage (Cooper et al. 2004, Raine et al. 2015). The upper and lower boundaries of the Otapirian are very close to those of the Rhaetian, but not coincident. Recent work by Rigo and Campbell (2022) in the Kiritehere section (south of Kiritehere Stream) indicates that the Norian-Rhaetian boundary, as defined by a negative $\delta^{13}C_{org}$ shift, occurs 6.4m below the first appearance of ?*Aulacoceras otapiriense*, which defines the base of the Otapirian stage. Akikuni et al. (2010) proposed a Triassic-Jurassic boundary zone about 10 –12m thick at Kawhia and Awakino Gorge between Otapirian and Aratauran faunas. To put this in perspective, Kawhia Syncline Otapirian sections are 800 – 1500m thick (MacFarlan 1998).

Campbell (1956) proposed basal and upper Otapirian faunas based on brachiopods and molluscs. Cooper et al. (2004) recognised two informal divisions, an early Otapirian with faunal assemblages characterised by a large undescribed bivalve *Antiquilima*, and a late Otapirian fauna characterised by the brachiopod *Mentzelia kawhiana* and the bivalve *Otapiria dissimilis*. Although there are a few earlier records that require substantiation, *Otapiria dissimilis* becomes common some distance above *Mentzelia kawhiana* in most sections.

Geographic and Stratigraphic Setting

The material described here comes from the Téremba Terrane on the west coast of New Caledonia (Campbell et al. 1985, Aitchison et al. 1995), and the Kawhia, Nelson and Southland Synclines, which were deposited within the Murihiku Supergroup, Murihiku Terrane of New Zealand (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 and Campbell 2014, Mortimer et al. 2017).

Stratigraphic Summary

Fossiliferous Otapirian rocks are found on the west coast of New Caledonia (Fig. 4A) in the Baie de St Vincent (Paris 1981, Fauré et al. 1982), the Moindou area and Baie de Téremba to the north (Campbell and Grant-Mackie, 1984, Campbell et al. 1985). All the material cited here comes from the islands of île Ducos and île Hugon in the Baie de St Vincent.

Otapirian beds containing terebratulides are present on the western limb of the Kawhia Syncline from Kawhia Harbour south to Awakino Gorge (Fig, 4B). Significant areas are the open (Tasman Sea) coast of Te Maika Peninsula at and south of Arataura Point (Marwick 1953, Martin 1975, Waterhouse and White 1994), the coast north of Marokopa (Stevens 2012), the coast between Kiritehere and Marokopa (MacFarlan 1998) and Awakino Gorge at the southern end of the exposed syncline (Grant-Mackie 1959).

Otapirian strata are present in Nelson (Campbell 1974, Johnston 1982, 1983, Rattenbury et al. 1998). Terebratulides are found in the Eighty-Eight Valley and Highfield areas in the southern part of the Nelson Syncline. A large collection including many terebratulides was collected by Alexander McKay in 1878 at N28/f7454 (GS196) (McKay 1878). This material comes from the Otapirian near the axis of the Eighty-Eight Valley Syncline (Johnston 1983).

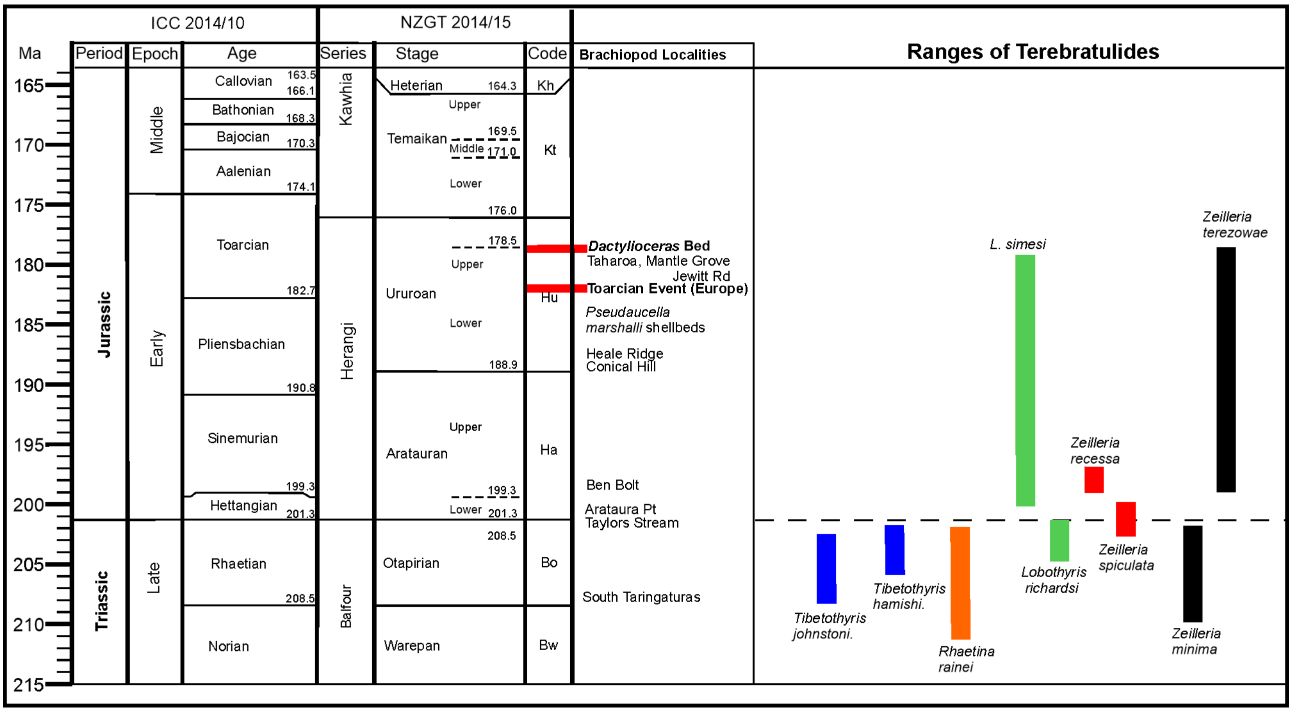


FIGURE 2. Late Triassic - Jurassic timescale and range chart showing correlations between New Zealand and international stages (adapted from Raine et al. 2015) and ranges of Zealandian terebratulide species.

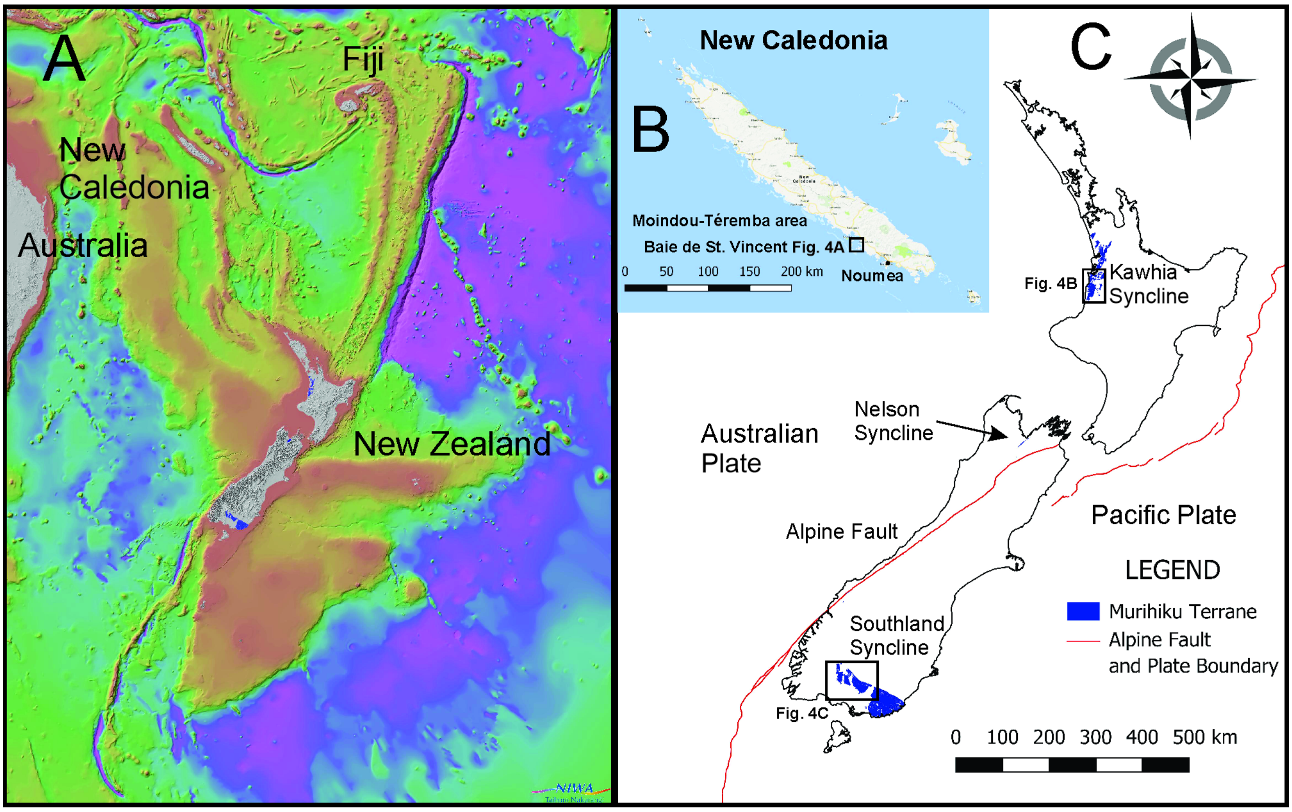


FIGURE 3. A Zealandia, showing the area of submerged continental crust surrounding New Zealand and extending to New Caledonia. Base map: NIWA (National Institute of Water and Atmospheric Research). **B** New Caledonia, showing location of Moindou-Téremba area and Baie de St Vincent (Fig. 4A). **C** New Zealand, showing Kawhia, (Fig. 4B) Nelson and Southland (Fig. 4C) synclines, Alpine Fault and plate boundary.

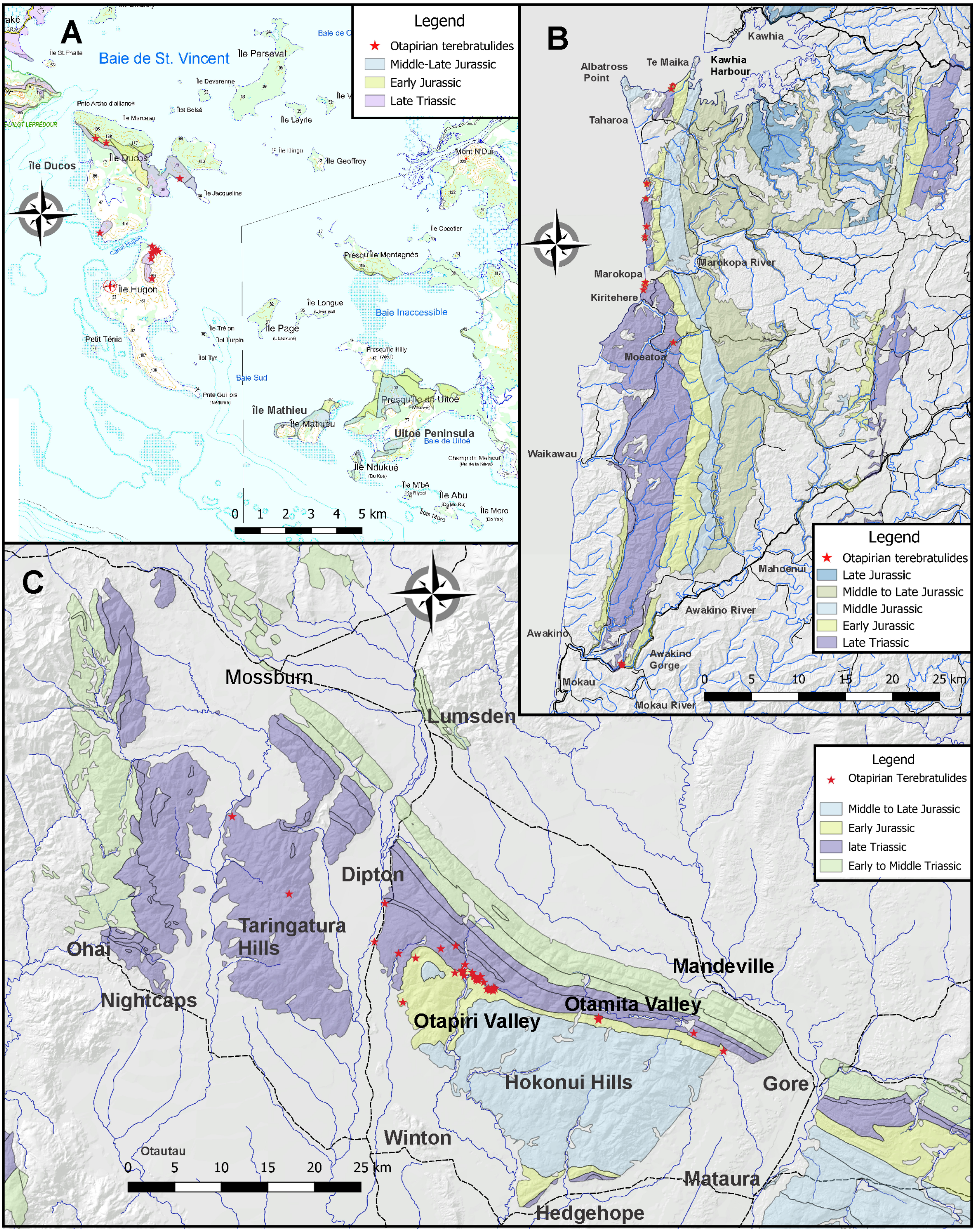


FIGURE 4. Main areas of Triassic–Jurassic strata in this study with main terebratulide localities shown (red stars): **A** Baie de St Vincent, New Caledonia, with areas of Late Triassic and Jurassic rocks indicated. Base and geology from Gouvernement de la Nouvelle-Calédonie data. **B** Southwest Auckland, showing southern part of Kawhia Syncline, with areas of Late Triassic and Jurassic rocks indicated. **C** Western Southland, showing northwestern part of Southland Syncline. Base for B and C: LINZ (Land Information New Zealand) topographic data with geology from GNS Science (Institute of Geological and Nuclear Sciences) 1: 250,000 geological map (Q-Map; Edbrooke et al. 2014, Heron 2014).

Otapirian rocks with diverse brachiopod and molluscan faunas are found throughout the northeast limb of the Southland Syncline from the Taringatura Hills to the east coast at Nugget Point (Fig. 4C) (Campbell 1956, Campbell and McKellar 1956, Turnbull and Allibone 2003, Bishop and Turnbull 1996). Terebratulides are sparsely present in most of this area, but more common in the Hokonui Hills, especially the Otapiri Valley (Campbell 1956, Campbell and McKellar 1956). One prolific early Otapirian locality in the South Taringatura Hills (E45/f 6635) has yielded many small specimens of several species.

Systematic Palaeontology

Phylum BRACHIOPODA Duméril, 1806

Subphylum RHYNCHONELLIFORMEA Williams and others, 1996

Class RHYNCHONELLATA Williams and others, 1996

Order TEREBRATULIDA Waagen, 1883

Suborder TEREBRATULIDINA Waagen, 1883

Superfamily DIELASMATOIDEA Schuchert, 1913

Family DIELASMATIDAE Schuchert, 1913

Subfamily DIELASMATINAE Schuchert, 1913

The cosmopolitan genus *Dielasma* King 1859 has long been recorded as part of the New Zealand Triassic fauna. Trechmann (1918) described *D. zealandica* and listed but did not figure *D*. cf. *himalayana* Bittner 1899. Wilckens (1927) did illustrate this species and Marwick (1953) suggested that more than one species may be present. Both species are from the Kaihikuan shellbed at Caroline Cutting, Southland. More recently Dagys (1959) suggested that *Dielasma hungaricum* and *D. zealandicum* could be included in his new genus *Adygella*.

Begg (1981) records one species of Dielasmatinae from the Malakovian - Etalian (Anisian) of Southland, and a different species from the Oretian (late Carnian - Norian; Cooper et al. 2004). The Malakovian - Etalian species is biconvex. The Oretian species is sulcate but is not figured. Other undescribed species are present in the Late Triassic. The entire group in Zealandia requires revision.

More recent work (Stelhi 1965, Jin et al. 2006) regard *Dielasma* as a cosmopolitan late Paleozoic genus but do not recognize its presence in the Triassic. Feldman (2017) regarded *Tunethyris* Calzada et al. 1994 as a homeomorph of *Dielasma* and described *Tunethyris blodgetti* from the Middle Triassic of Southern Israel. *Tunethyris* is biconvex and has little resemblance to the two species described here.

Tibetothyris Jin and Sun, 1976

1976 *Tibetothyris* Jin and Sun, in Jin et al. 1976 p. 27.
2006 *Tibetothyris* Jin and Sun, 1976; Jin et al. p. H2032.
2017 *Tibetothyris* Jin and Sun, 1976; Sun et al. p. 958.

Type Species *Tibetothyris depressa* Jin and Sun, 1976 (OD).

Jin and Sun (1976) described *Tibetothyris* from the Norian of Tulong, Xizang (Tibet). The type species has not been recorded elsewhere. It is strongly folded and of similar shape to the two New Zealand species.

They also included the much more widespread *Terebratula julica* in *Tibetothyris.* It was described by Bittner (1890) from the Late Triassic of the European Alps but has since been recorded from Hungary (Bittner 1912, Detre

1970), the Sinai (Awad 1945), China (Jin et al. 1976, Sun et al. 2017), East Timor (Krumbeck 1924, Wanner 1956), and California (Smith 1927). *Tibetothyris julica* is more rounded, with the plicae developed only on the anterior part.

The two species described here were originally identified in collections as *Dielasma* sp. and are included in *Tibetothyris* on their similarity in shape and internal characters to *Tibetothyris depressa* and *T. julica.* On both new species the dental plates are short and begin some distnce behind the tip of the beak. It is possible that the posterior ends of these were buried in callus.

Tibetothyris johnstoni new species

Fig. 5: 1–8. Fig. 6 A–B.

Holotype. BR 3420 a double-valved internal mould from N28/f7454, GS 196, Eighty-Eight valley Nelson; collected A. McKay 19/3/1898.

Derivation of name. This species is named for Dr Mike Johnston, geologist, of Nelson.

Material. The data series consists of thirteen specimens, eleven of which yielded valid measurements.

New Caledonia. île Hugon NC/f109a (AU 7165).

Nelson. Eighty-Eight Valley N28/f7454 (GS 196), Ram Creek; N28/f0045 (PGS 40).

Southland. Taringatura Hills E45/f6635 (JDC 241).

Description. Small to medium sized terebratulide with rounded-pentagonal outline. The dorsal valve is moderately convex posteriorly and has a distinct shallow, rounded sulcus anteriorly.

The ventral valve is strongly convex posteriorly, with two close-spaced rounded plicae which diverge behind the beak, separated by a shallow rounded central sulcus. The flanks are broad and slightly concave. The anterior part has a high fold and a narrow, shallowly concave central part. The anterior commissure is strongly sulcate. The shell surface is smooth apart from a few strong, stepped concentrics.

The beak is large and triangular with a bluntly rounded tip. The foramen is large, circular, and mesothyrid, with a short pedicle collar (Fig. 5.1d, 6A). The beak ridges are strong and bluntly rounded. The deltidial plates are small and widely disjunct (Fig. 5.1a, 6A). The dental plates are short, divergent and widely separated. (Fig. 5.2a, 5.7a, b).

The dorsal valve has a hingeplate with a deep U-shaped septalium (Fig, 5.1a, 6A, B), a broad, shallow median septum with longitudinal grooves which appear to be muscle attachments (Fig. 5.1a, 5.2a). A small, high, striated cardinal process is present, and is close to the anterior of the foramen (Fig. 5.2a, 6B).

The shell is coarsely and densely punctate.

Dimensions. Dimensions of the holotype and representative specimens, and statistics for all measurable specimens are shown in Table 1. A length vs width graph is shown in Fig. 9A.

Range and Distribution. Otapirian, early Otapirian in New Caledonia and Southland, late Otapirian in Nelson. Of the 13 specimens measured, nine come from one early Otapirian locality (E45/f6635 (JDC 241) in the South Taringatura Hills, western Southland.

TABLE 1. Dimensions, *Tibetothyris johnstoni* **n. sp.**

FR no.	specimen	Lv	Lp	W	H	b<	**MS/L**	**material**	**notes**
N28/f7454	BR 3420	19.7	16.7	16.3	10.2	79	0.5	b int	Holotype
N28/f7454	BR 3419	26.3+	22.5+	20.5	10.1	77	0.5	b int	
E45/f6635	C1963	20.4	18.8	16.4	9.8	60		b pt shelly	
E45/f6635	C1967	21.9	18.9	17.5	8.9	78	0.6	b int	
E45/f6635	C1970	19.3	15.7	16.2	7.2	72	0.5	b int	
All valid specimens	mean	18.9	17.3	15.4	8.4	71.8		11 specimens	
	S.D.	8.96	8.30	7.33	4.07	30.91			

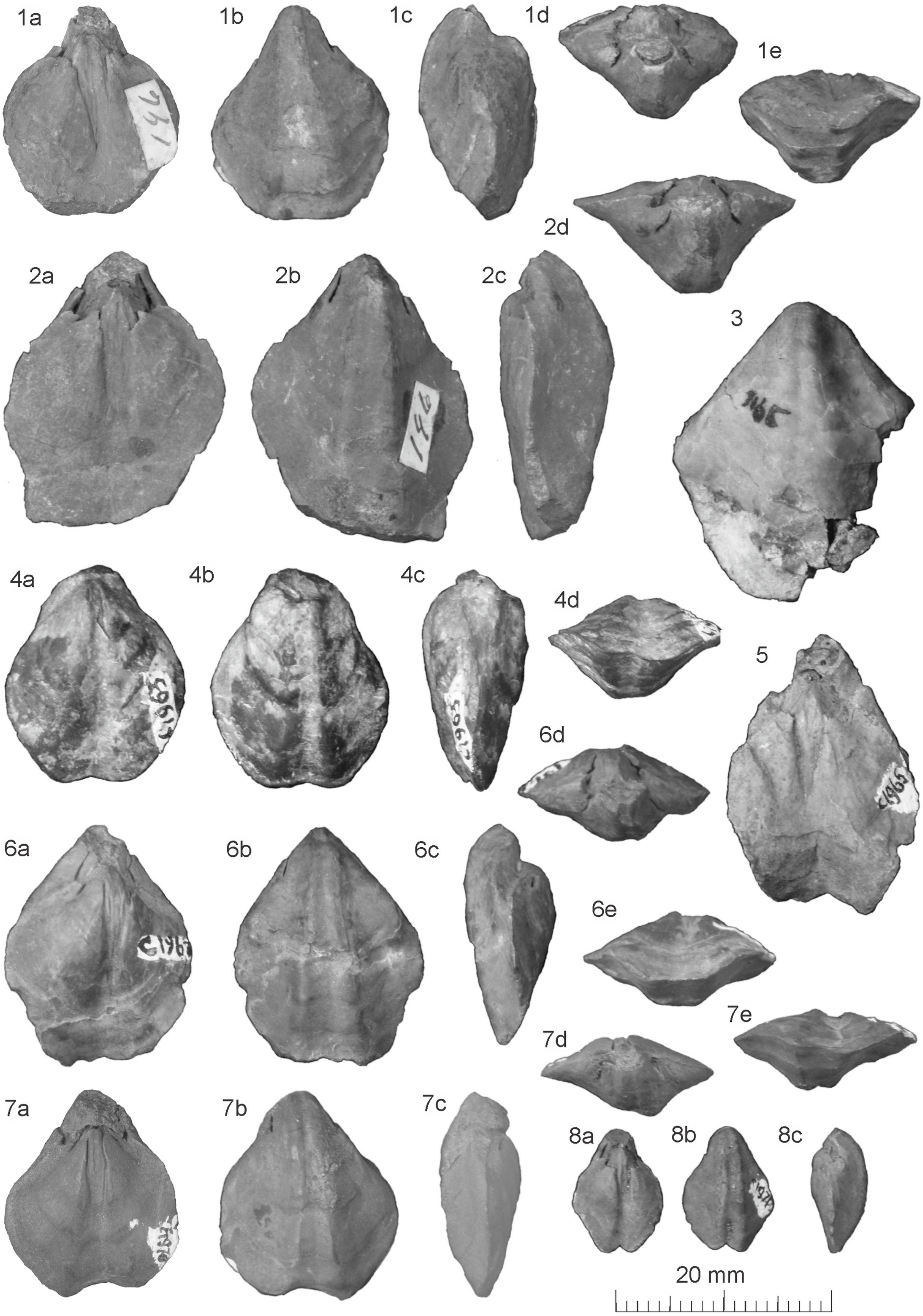


FIGURE 5. *Tibetothyris johnstoni* **n. sp.**

1 Holotype BR 3420 (N28/f7454) (a) dorsal (b) ventral (c) lateral (d) posterior (e) anterior. **2** BR 3419 (N28/f7454) (a) dorsal (b) ventral (c) lateral (d) posterior. **3** B890 (NC/f0109B) shelly specimen, ventral. **4** C1963 (E45/f6635) partly shelly specimen (a) dorsal (b) ventral (c) lateral (d) anterior. **5** C1965 (E45/f6635) internal mould, distorted, dorsal. **6** C1967 (E45/f6635) internal mould (a) dorsal (b) ventral (c) lateral (d) posterior (e) anterior. **7** C1970 (E45/f6635) internal mould (a) dorsal (b) ventral (c) lateral (d) posterior (e) anterior. **8** C1971 (E45/f6635) internal mould (a) dorsal (b) ventral (c) lateral.

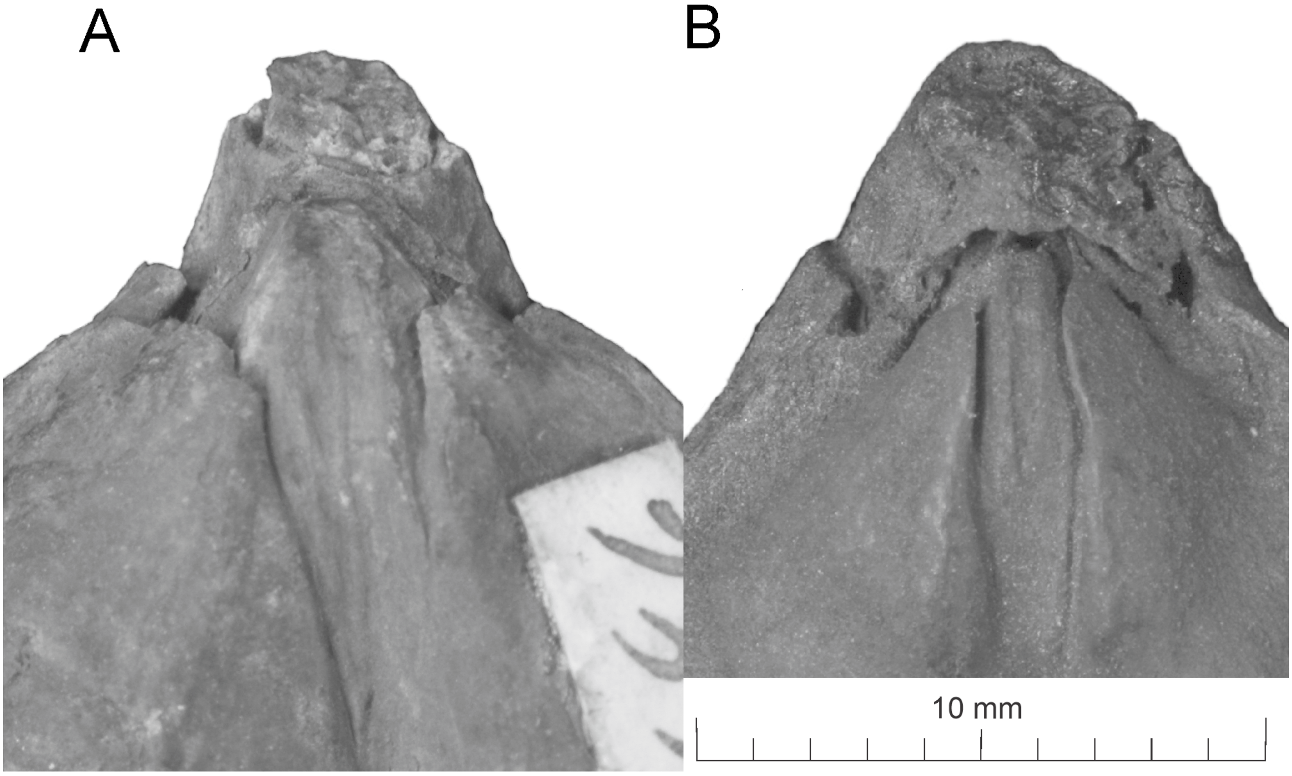


FIGURE 6. Detailed view of beak area, *Tibetothyris johnstoni* n. sp. **A** Holotype BR 3420 (N28/f7454), dorsal view of internal mould showing pedicle collar, ridged septalium, broad median septum and short, widely divergent dental plates. **B** C1970 (E45/f6635) dorsal view of internal mould, showing small cardinal process.

Remarks. This species is close to *Tibetothyris depressa* in shape, but the folding differs. *T. depressa* has strong rounded lateral folds and two weak central folds on the dorsal valve, and a weak central fold on the ventral fold. The anterior commissure is sulciplicate to bisulcate (Jin et al. 1976, Jin et al. 2006, Sun et al. 2017). *T. johnstoni* is more strongly folded. The dorsal valve has similar strong rounded lateral folds and a central sulcus. The ventral valve is strongly convex with two low, incipient or poorly developed rounded folds anteriorly. The anterior commissure is unisulcate. *T. depressa* has long dental plates whereas in *T. johnstoni* the dental plates are short and widely separated.

Tibetothyris hamishi n. sp.

Fig. 7 1–9, 8A–B.

2019: *Aulacothyris* sp. A MacFarlan p. 574, fig. 13 a-d. (NZGS BR 3207 only).

Holotype. OU 47309, a shelly specimen with an external mould of the dorsal valve and beak, from F45/f329, JDC 4216, west of Dolamore Park, Hokonui Hills. Collected by J.D. Campbell and S.R. Owen, 21/10/1992. Shell material altered to clay or zeolite.

Derivation of name. This species is named for Dr Hamish Campbell of GNS Science.

Material. The data series consists of fifteen specimens, thirteen of which yielded valid measurements.

New Caledonia. île Ducos: NC/f050 (GS 12763), NC/f0087 (AU 7168)

Kawhia Syncline. Coast south of Arataura Pt: R15/f8837 (AU 69), R15/f8838 (AU 70). North Marokopa Coast: R16/f6898 (GS 10009), R16/f8645 (?GS 10006). Marokopa: R16/f0337 (AU 12074). Pomarangai Rd E of Moeatoa: R16/f8877A (AU 8987).

Southland Syncline. Otapiri – Taylors Stream: E45/f0279 (JDC 4059), E45/f9622 (JDC 1296). Dolamore Park: F45/f0329 (JDC 4216). Waimumu Valley: F45/f8523 (GS 5188).

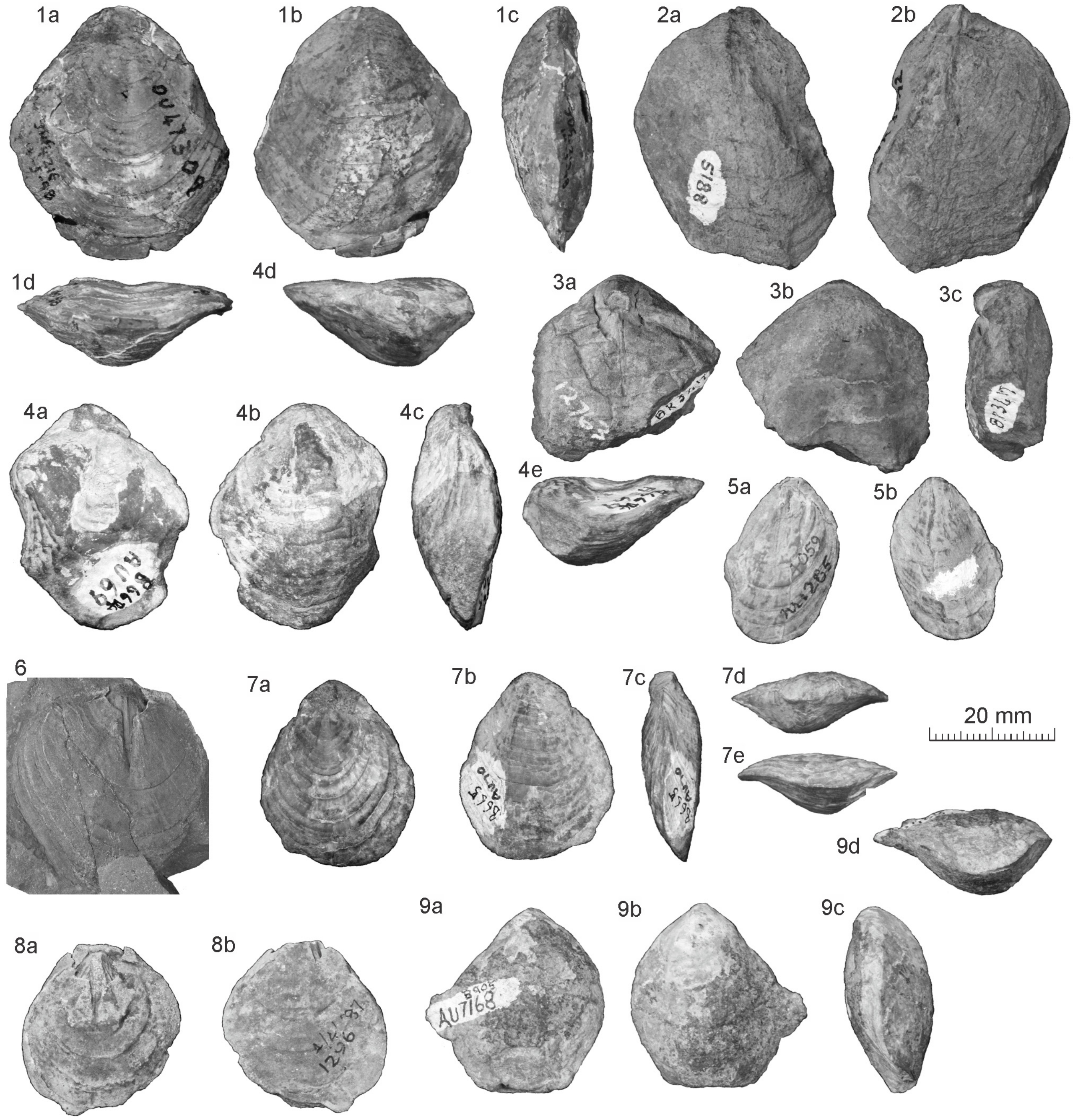


FIGURE 7. *Tibetothyris hamishi* **n. sp.**
1 Holotype, OU 47309 (F45/f0329) internal mould (a) dorsal (b) ventral (c) lateral (d) anterior. **2** BR 3502 (F45/f8523) internal mould (a) dorsal (b) ventral. **3** BR3417 (NC/f0050) internal mould (a) dorsal (b) ventral (c) lateral. **4** B664 (R15/f8837) shelly specimen (a) dorsal (b) ventral (c) lateral (d) posterior (e) anterior. **5** OU 46810 (E45/f0279) internal mould (a) dorsal (b) ventral. **6** B822 (R16/f0377) internal mould, dorsal. **7** B665 (R15/f8838) shelly specimen (a) dorsal (b) ventral (c) lateral (d) posterior (e) anterior. **8** OU 46809 (E45/f9622) internal mould (a) dorsal (b) ventral. **9** B905 (NC/f0087) (a) dorsal (b) ventral (c) lateral (d) anterior.

Description. Small to medium sized terebratulide with elongate elliptical outline. The dorsal valve is moderately convex posteriorly and flatter anteriorly, with a shallow, rounded sulcus developing close to the beak and extending anteriorly.

The ventral valve is strongly convex posteriorly. The anterior part has concave flanks, and a strongly convex central part. The anterior commissure is shallowly sulcate. The shell surface is smooth or has a few strong, stepped concentrics anteriorly. Punctae are coarse and closely spaced.

The beak is large and triangular with a bluntly rounded tip. The foramen is large, circular, mesothyrid, and is surrounded by a short pedicle collar (Fig. 7.1a, 7.3a, 8B). The beak ridges are strong, bluntly rounded. Deltidial plates are poorly shown and are small and widely disjunct (fig. 7.1a, 7.3a).

On the dorsal valve the hingeplate has a broad, shallow U-shaped septalium supported by a wide, shallow median septum with fine longitudinal grooves which appear to be muscle attachments (Fig 7.8a, 8A, B), and a small cardinal process (Fig. 8B). The posterior tip of the dorsal valve reaches the anterior of foramen. The dental plates are short, widely separated and divergent (Fig. 7.8a, b, 8B).

Dimensions. Dimensions of the holotype and representative specimens, and statistics for all measurable specimens are shown in Table 2. A length vs width graph is shown in Fig. 9A.

Range and Distribution. Otapirian of New Caledonia, Kawhia Syncline and Southland. Nearly all the material is late Otapirian, but the specimen from NC/f0087 (île Ducos, New Caledonia) is early Otapirian.

TABLE 2. Dimensions, *Tibetothyris hamishi* n. sp

FR no.	specimen	**Lv**	**Lp**	**W**	**H**	**b<**	MS/L	**material**	**notes**
F45/f0329	OU 47309	39.4	33.8	34.9	13.9	90		b pt shelly	Holotype
NC/f0087	B905	29.6	27.5	24.7	13.4	105		b pt shelly	
R15/f8838	B665	29.8	22.1	24.1	9.0	83		b pt shelly	
F45/f8523	BR 3502	42.0	39.3	31.6	14.7	109	0.4	b int	
All valid	mean	27.9	25.2	23.2	10.0	95.3		13 specimens	
specimens	S.D.	15.25	12.07	10.79	5.13	41.61			

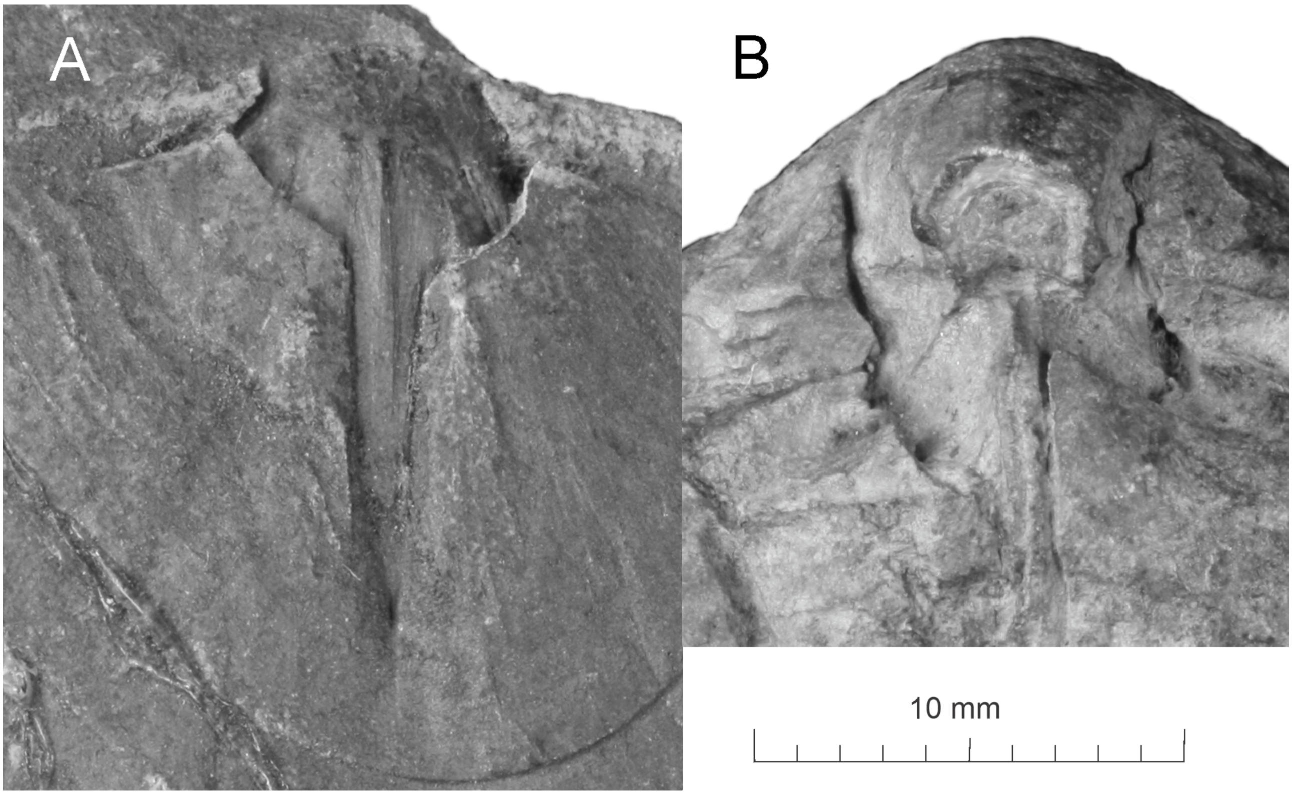


FIGURE 8. Detailed view of beak area, *Tibetothyris hamishi* n. sp. **A** B822 (R16/f0377) internal mould of dorsal valve, showing median septum and septalium. **B** BR 3417 (NC/f0050) dorsal view of internal mould, slightly distorted, showing dental plates, foramen with pedicle collar and cardinal process.

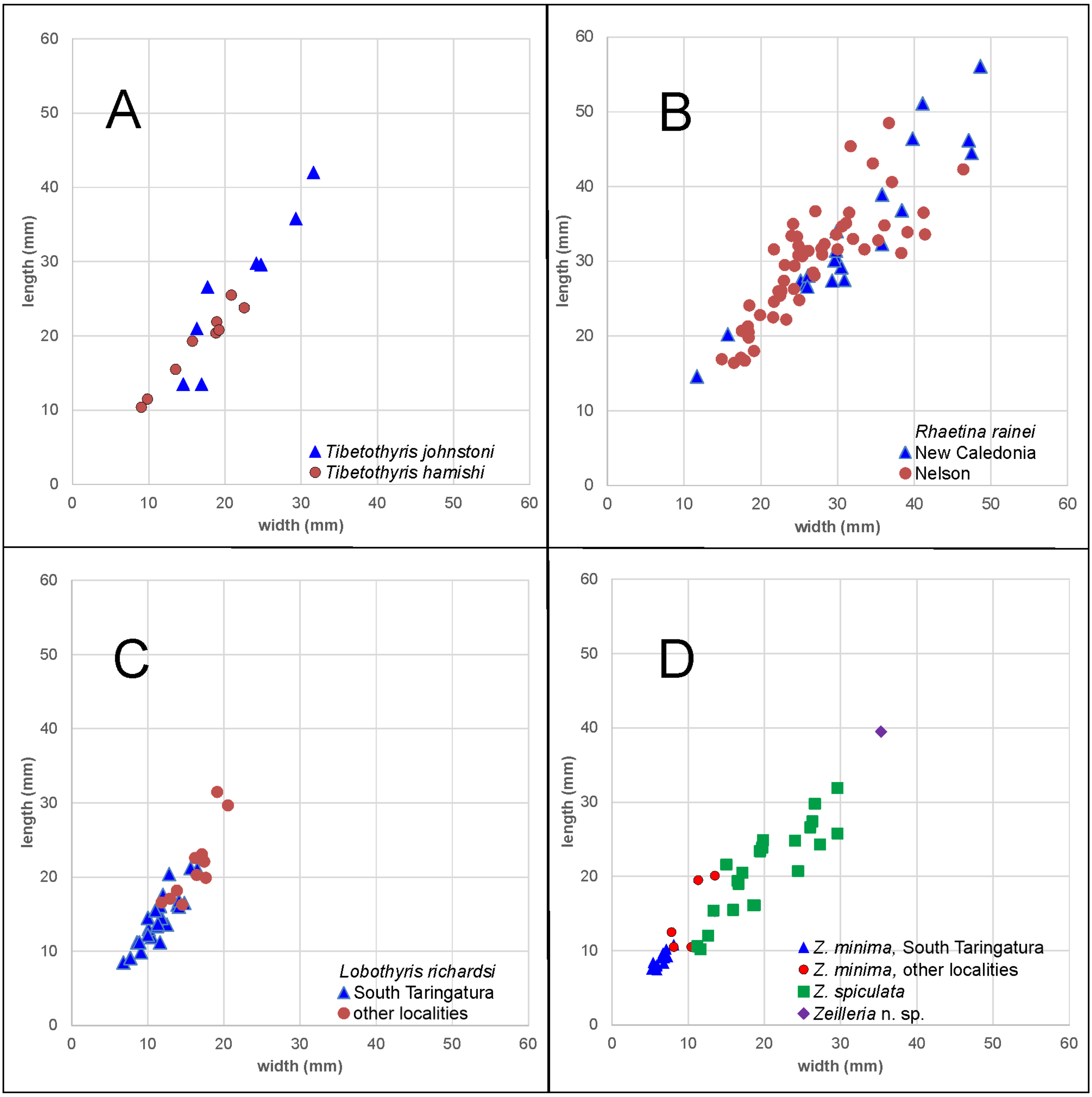


FIGURE 9. Length vs width graphs for ventral valve. **A** *Tibetothyris johnstoni* and *T. hamishi*. **B** *Rhaetina rainei,* New Caledonia and Nelson. **C** *Lobothyris richardsi,* (E44/f6635 South Taringatura Hills and other localities). **D** *Zeilleria minima* (E44/f6635 and other localities), *Zeilleria spiculata* and *Zeilleria* **n. sp.** *Z. spiculata* data from MacFarlan (2021).

Remarks. The shape is distinctive. Specimens from the Oretian and Otamitan of Southland are of similar shape and size but lack the strongly convex central part and concave flanks of the new species. From the limited material examined, they appear to belong to a separate but related species.

BR 3207 (R16/f6898, GS 10009) was figured in MacFarlan (2019, fig 13:13a-d) as *Aulacothyris* sp. A. It is badly distorted, but re-examination shows that it is much better placed in the new species.

This species is larger than *T. johnstoni*, less inflated, and lacks the strong folding on the ventral valve. The dental plates are short and widely separated, resembling those of *T. johnstoni* rather than *T. depressa.*

Family ANGUSTOTHYRIDIDAE Dagys, 1972

***Rhaetina* Waagen 1882**

1882 *Rhaetina* Waagen, p.334.
1965a *Rhaetina* Waagen, 1882; Muir-Wood p. 769.
1977 *Rhaetina* Waagen, 1882; Pearson, p. 35.
2006 *Rhaetina* Waagen, 1882; Jin et al. p. 2050.

Type species *Terebratula gregaria* Suess, 1854. OD.

The genus *Rhaetina* Waagen, 1882 is widely recognised in the Late Triassic of central and eastern Europe (Pearson 1977, Siblík 1999, Siblík and Bryda 2005, Michalik 1975). Pearson (1977) commented that the type species *Rhaetina gregaria* was "without doubt the commonest and most widely distributed of the Rhaetian brachiopods" (p. 38). It has also been recorded from western North America (Ager and Westermann 1963, Sandy and Stanley 1993), Iran (Kristin-Tollmann et al. 1979), China (Yang and Xu 1966, Jin et al. 1976, Sun et al. 2017), Turkey (Bittner 1891, Ager et al. 1978), central and eastern Asia (Dagys 1963, 1974) and Vietnam (Khuc 2000). *Rhaetina* is also present in the European Early Jurassic (Pearson 1977).

Rhaetina has not previously been recognised in Zealandia. It is characterised by a large suberect beak, with a large foramen and well-developed pedicle collar. It often shows considerable variability in shape, size and anterior folding (Pearson 1977, Sandy and Stanley 1993) and can occur in large numbers (Michalik 1975, Pearson 1977). While the loop details of the Zealandian form have not been seen, it agrees with *Rhaetina* in shape, and in the development of folding. Like other species of *Rhaetina* it is variable in shape, and occurs in large numbers at a few localities.

***Rhaetina rainei* n. sp.**
Fig. 10, 1–8, Fig. 11, 1–11. Fig. 12A–C

1951 *Coenothyris* sp. Trechmann 1918; Marwick 1953 p. 34, pl. 1: 8, 9.
NON *Coenothyris* sp. Trechmann, p. 218, pl. 23:7 (fide J.D. Campbell, MS)

Holotype. B876 from NC/f0519 AU 7774, île Hugon. Double-valved shelly specimen with some damage to dorsal valve. Collected by J.A. Grant-Mackie.

Derivation of name. This species is named for Dr Ian Raine of GNS Science.

Material. The data series consists of 129 specimens, 38 from New Caledonia and 91 from Nelson; 23 New Caledonia specimens and 68 from Nelson yielded valid measurements.

New Caledonia. île Hugon: NC/f0004A (AU 7148), NC/f0005 (AU 7146), NC/f0007A (AU 7149), NC/f0008A (AU 7795), NC/f0010A (AU 4155), NC/f503 (AU 7174), NC/f518 (AU 7773), NC/f519 (AU 7774). île Ducos: NC/f0020 (GS 12733), NC/f0023 (?GS 12376), NC/f60A (?AU 7214), NC/f0087A (?AU 6073, AU 7168).

Nelson. Eighty-Eight Valley: N28/f7454 (GS 196), N28/f7455 (GS 197). Ram Creek: N28/f0045 (PGS 40, McF D21), N28/f7860 (AU 7885), N28/f7864 (AU 6521).

Southland Syncline. Oreti Valley: E45/f7484 (?GS372).

Description. Medium sized to large terebratulide with an elongate-elliptical to rounded-triangular outline. The dorsal valve is moderately and evenly convex posteriorly, and generally has two rounded folds anteriorly. Some large specimens are not folded.

The ventral valve is strongly convex posteriorly, and in some specimens is strongly folded anteriorly. The initiation of folds is variable, from 1/5 of valve length in some specimens to near anterior in others. The folds are often stronger on the dorsal valve. The strength can be accentuated by distortion. The anterior margin is uniplicate or parasulcate.

The shell surface is smooth or has fine closely spaced growth lines. Some specimens have stronger, rounded concentrics, which may be visible on the valve interior. Punctae appear to be fine but are poorly shown on shelly New Caledonia specimens and the remnant shell material on Nelson specimens due to recrystallisation.

The beak is triangular and suberect with a bluntly rounded tip. The foramen is large, subcircular (Fig. 10.1a) and permesothyrid (Fig. 11.6a, 6d, 12A–C), and is surrounded by a large, thick pedicle collar. The beak ridges are blunt and poorly defined. The deltidial plates are large and disjunct (Fig. 12C).

In the dorsal valve the hingeplate has broad inner socket ridges and narrow outer ridges, with a distinct cardinal process (Fig. 11.4a, 6a, 9, Fig. 12A, B). There is a low, ridge-like median septum which is about 1/3 of valve length, with a shallow muscle field on either side of the septum (Fig. 11.6a). The loop was not seen.

Dimensions. Dimensions of the holotype and representative specimens, and statistics for New Caledonia and Nelson specimens are shown in Table 3. A length vs width graph is shown in Fig. 9B.

Range and Distribution. Otapirian of Nelson and New Caledonia (Hugon and Ducos). The Nelson material is late Otapirian, the New Caledonia material is both early and late Otapirian.

Marwick (1953) figured *Coenothyris* sp., which was originally reported by Trechmann (1918) from the Warepan of Ram Hill, Nelson (N28/f7522, GS 4559). Re-examination of Marwick's figured specimens (BR 1013 and 1014) show them to belong to the new species (Fig. 11.5). Trechmann's original *Coenothyris* sp. was examined at the Natural History Museum, London, by Dr J.D. Campbell. He stated in an unpublished MS on Late Triassic athyrids of New Zealand and New Caledonia that it is an athyrid.

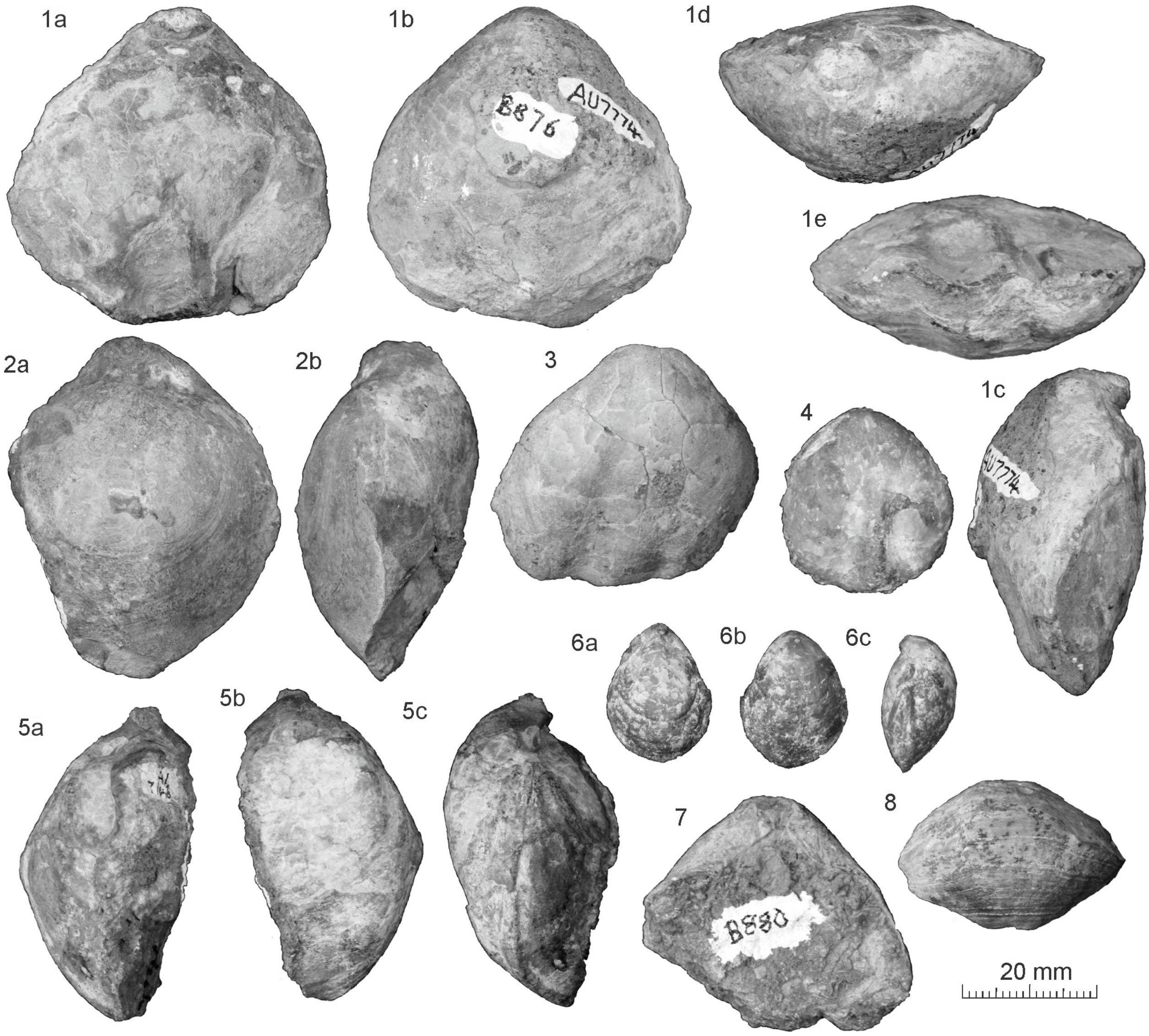


FIGURE 10. *Rhaetina rainei* **n. sp.** (New Caledonia).
1 Holotype B876 (NC/f0519) shelly specimen (a) dorsal (b) ventral (c) lateral (d) posterior (e) anterior. **2** B875 (NC/f0519) shelly specimen (a) dorsal (b) lateral. **3** B871 (NC/f0503) shelly specimen, ventral. **4** B844 (NC/f0007A) shelly specimen, ventral. **5** B881 (NC/f0005A) partly shelly specimen (a) dorsal (b) ventral (c) lateral. **6** BR 3414 (NC/f0020) shelly specimen (a) dorsal (b) ventral (c) lateral. **7** B880 (NC/f0005A) dorsal view of beak. **8** B820 (NC/f0087A) shelly specimen, anterior.

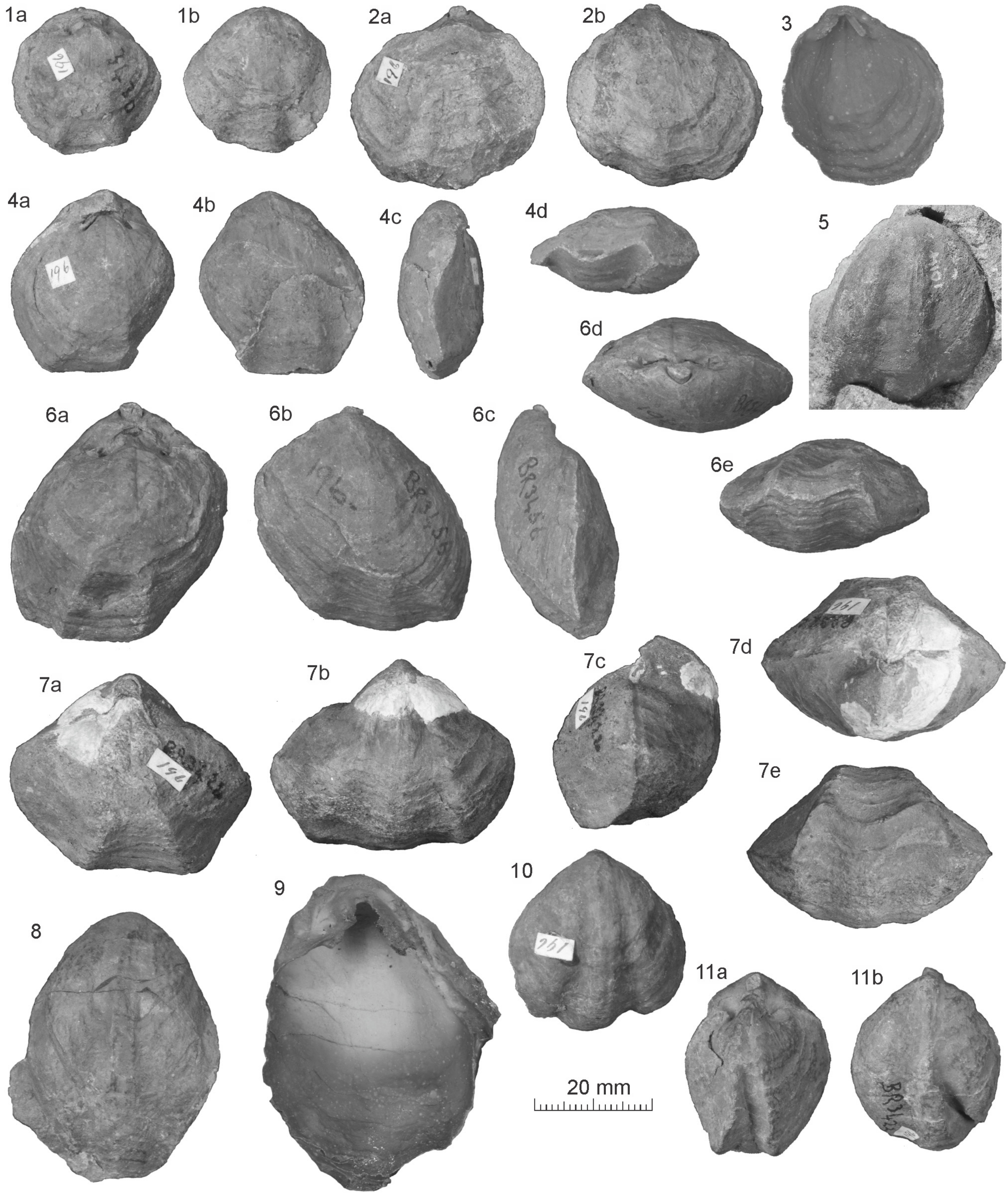


FIGURE 11. *Rhaetina rainei* **n. sp.** (Nelson).

1 BR 3430 (N28/f7454) internal mould (a) dorsal (b) ventral. **2** BR 3461 (N28/f7454) internal mould (a) dorsal (b) ventral. **3** BR 3490 (N28/f7454) latex of dorsal valve interior. **4** BR 3452 (N28/f7454 internal mould (a) dorsal (b) ventral (c) lateral (d) anterior. **5** BR 1014 (N28/f7522) ventral view (Specimen figured by Marwick (1953) as *Coenothyris* sp.; photo Marianna Terezow). **6** BR 3456 (N28/f7454) internal mould (a) dorsal (b) ventral (c) lateral (d) posterior. **7** BR 3424 (N28/f7454) internal mould with remnant shell (a) dorsal (b) ventral (c) lateral (d) posterior (e) anterior. **8** BR3500 (N28/f7455) internal mould, ventral. **9** BR 3498 (N28/f7454) latex of ventral valve interior and beak. **10** BR 3439 (N28/f7454) ventral view. **11** BR 3422 (N28/f7454) internal mould (a) dorsal (b) ventral.

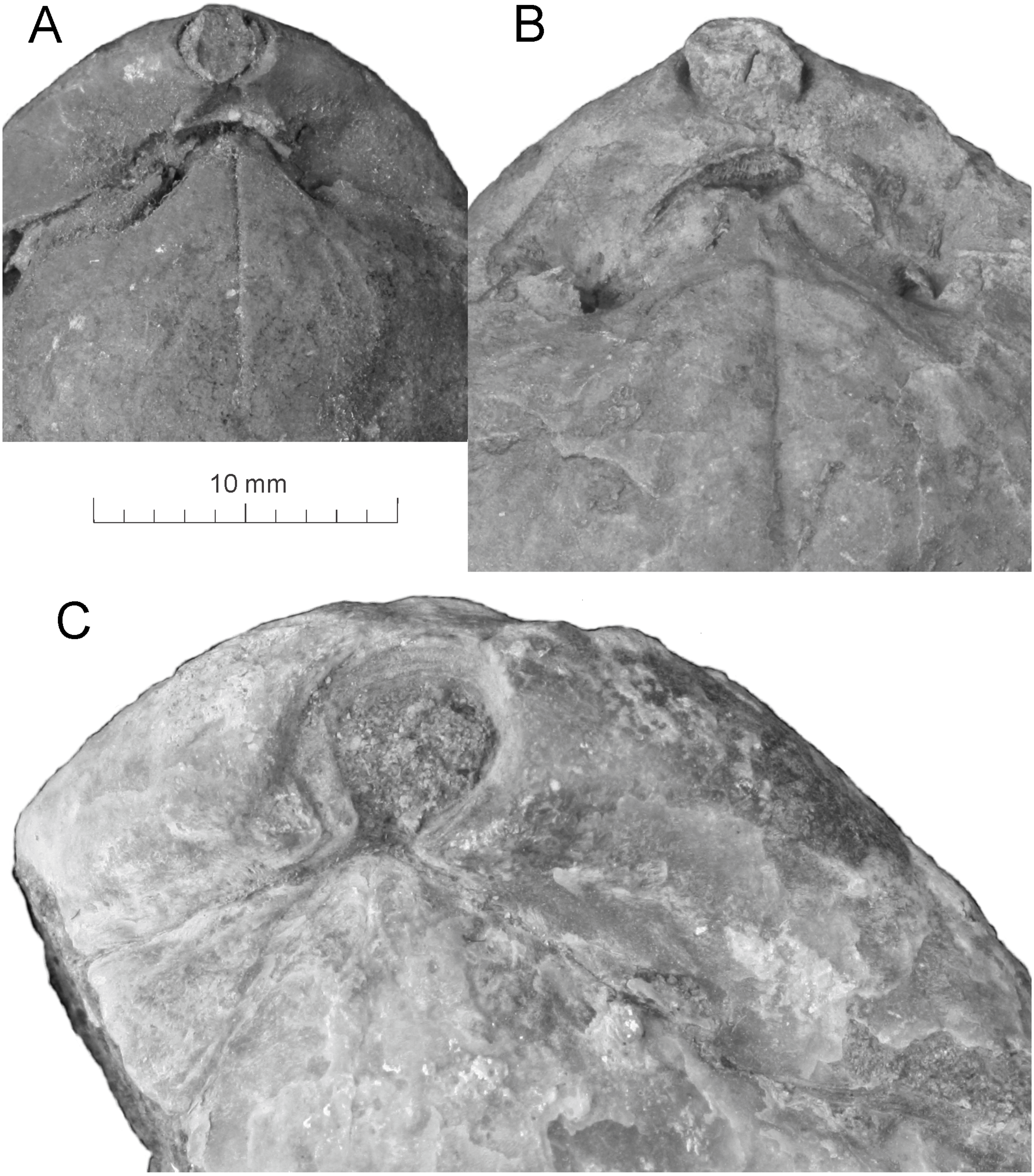


FIGURE 12. Detailed views of beak area, *Rhaetina rainei* n.sp. **A** BR3458 (N28/f7454) dorsal view of internal mould, showing foramen with pedicle collar, and dorsal valve with low, ridgelike median septum. **B** BR3456 (N28/f7454) dorsal view of internal mould showing cardinal process. **C** B877 (NC/f0519) dorsal view of shelly specimen, slightly abraded, showing disjunct deltidial plates and foramen surrounded by pedicle collar.

The largest collection is from N28/f7454, GS 196 (Eighty-Eight Valley, Nelson), and the species is common in several collections from shellbeds in the Bouraké Formation in île Hugon, New Caledonia. Fragments of a large terebratulide from one collection in Southland may belong to this species.

Remarks. This species is present in large numbers in the Otapirian of île Hugon and of the Eighty-Eight Valley of Nelson. It is also present in île Ducos, and a few specimens are known elsewhere. The distribution suggests that it may be a shallow water form.

The variation in shape in this species is considerable, with the larger collections from île Hugon and Nelson showing a range from medium-sized forms with strong folding anteriorly to large, elongate-elliptical specimens with blunt, rounded folds developed only on the anterior part.

TABLE 3. Dimensions, *Rhaetina rainei* n. sp.

FR no.	specimen	Lv	Lp	W	H	b<	material	notes
NC/f0519	B876	46.2	40.8	47.1	25.0	96	b shelly	Holotype
NC/f0007A	B844	27.4		25.2		94	vv shelly	
NC/f0503	B871	36.8		38.4		92	vv shelly	
NC/f0519	B875	51.1	45.6	41.1	21.3	84	b shelly	l flank missing
N28/f7454	BR 3430	24.8	22.8	25.0	11.1	100	b int	poss sl flattened
N28/f7454	BR 3452	30.9	28.2	28.0	14.4	113	b int	fracture on vv
N28/f7454	BR 3456	40.6	36.5	37.1	21.3	8	b int	sl distorted
N28/f7454	BR 3461	31.6	28.5	33.5	28.7	116	b int	sl corroded
New Caledonia	Mean	33.6	27.6	30.9	16.0	89.6		
	S.D.	15.38	16.76	14.23	9.54	34.28	23 specimens	
Nelson	Mean	29.8	25.3	26.6	15.8	97.3		
	S.D.	8.90	7.75	8.49	7.29	27.6	68 specimens	

Family LOBOTHYRIDIDAE Makridin, 1964

Subfamily LOBOTHYRIDINAE Makridin, 1964

Lobothyris Buckman, 1918

1918 *Lobothyris* Buckman, p. 107.
1934 *Lobothyris* Buckman, 1918; Muir-Wood, p. 539.
1965a *Lobothyris* Buckman, 1918; Muir-Wood, p. H784.
1983 *Lobothyris* Buckman, 1918; Cooper, p. 103.
1990 *Lobothyris* Buckman, 1918; Ager, p. 11.
2006 *Lobothyris* Buckman, 1918; Lee et al. p. 2103.
2014 *Lobothyris* Buckman, 1918; Alméras et al. p. 71.
2019 *Lobothyris* Buckman, 1918; MacFarlan p. 558.

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

The genus *Lobothyris* Buckman 1918 is found in Jurassic sequences throughout the world "literally from China to Chile" (Ager 1967). In the most recent revision of the genus, Alméras et al. (2014) gave a time range of Hettangian to Aalenian. Other workers include the Late Triassic species *L. praepunctata* Bittner, 1890 in the genus. This species is recorded from the Late Triassic of Austria (Siblík 1994, Siblík and Bryda 2005), Italy (Torti and Angiolini 1997), the Russian Federation (Dagys 1963), East Timor (Wanner 1956), Alaska (Blodgett and Clautice 2000) and Peru (Sandy 1994). Krumbeck (1924) figured *Terebratula* aff. *praepunctata* and *Terebratula* (?*Waldheimia*) sp. aff. *praepunctata* Bittner, 1890 from Timor.

Dagys (1963) described *Lobothyris monstrifera* and *L. tutchkovi* from the Russian Federation and *L. nux* and *L. kushlini* from Tajikistan. Dagys (1974) made *L. kushlini* the type genus of *Pamirothyris*.

Blodgett and Clautice (2000) recognized *L. monstrifera* from Alaska. Sandy (1994) described ?*Lobothyris triassicus* from the Late Triassic of Peru.

Trechmann (1918) figured *Terebratula* cf. *hungarica* from the Otamita Stream section, Hokonui Hills. The locality is Otamitan (Campbell and McKellar 1960). *Terebratula hungarica* Bittner, 1890 was described from Derno (now Drnava in Slovakia) where it is part of an uppermost Norian fauna. It was placed by Siblík (1967) in *Lobothyris*. Whether Trechmann's material can be included in *Lobothyris* requires further work.

Lobothyris richardsi **n. sp.**
Fig. 13, 1–17, 14A–D.

Holotype. BR 3286, a double-valved shelly specimen, slightly distorted, from R15/f8585, GS 6754, south of Arataura Point, Kawhia. Collected by H.C. Arnold.

Derivation of name. This species is named for Marcus Richards of the Geology Department, University of Otago.

Material. The data series consists of 42 specimens, 8 from the Kawhia Syncline, 26 from the Taringatura Hills locality E45/f6635, and 8 from other Southland Syncline localities. 41 of these yielded valid measurements.

Kawhia Syncline. South of Arataura Point, Kawhia: R15/f8585 (GS 6784). North Marokopa Coast: R16/f8650 (GS 10037), R16/f6896 (GS 10007), R16/f8698 (?GS 10009). Marokopa: R16/f0337 (AU 12074), R16/f8638 (GS 9993). Awakino Gorge: R17/f8574 (AU 341), R18/f6582 (AU 326).

Southland Syncline. South Taringatura Hills: E45/f6635 (JDC 241). Benmore railway cutting: E45/f9578 (?JDC 730). Taylors Stream—Otapiri: E45/f073 (McF E29), E45/f0279 (JDC 4059) E45/f9462 (?GS 359), E45/f9621 (JDC 1295), E45/f9910 (JDC 2095). Reaby Downs, Otamita Valley: F45/f0217 (E. Wright coll.).

Description. Medium-sized terebratulide with elongate, rounded-triangular outline and a straight to slightly convex anterior margin. Both valves are moderately inflated, the ventral valve generally more so. The dorsal valve on some specimens has a broad, shallow flat-floored fold involving almost full width of valve, but there is no definite sulcus. The anterior commissure is deflected by shallow uniplication. The shell exterior is generally smooth, with fine, irregular growth lines. The shell is densely and coarsely punctate.

In the ventral valve the beak is small, erect to suberect, with a rounded tip. The foramen is small, round, epithyrid, and surrounded by a short pedicle collar (Fig. 13.3a, 13.15c, 14A, D) Deltidial plates are small and conjunct (Fig. 14A). The beak ridges are sharply rounded (Fig. 13.9c, 14C). There are no dental plates.

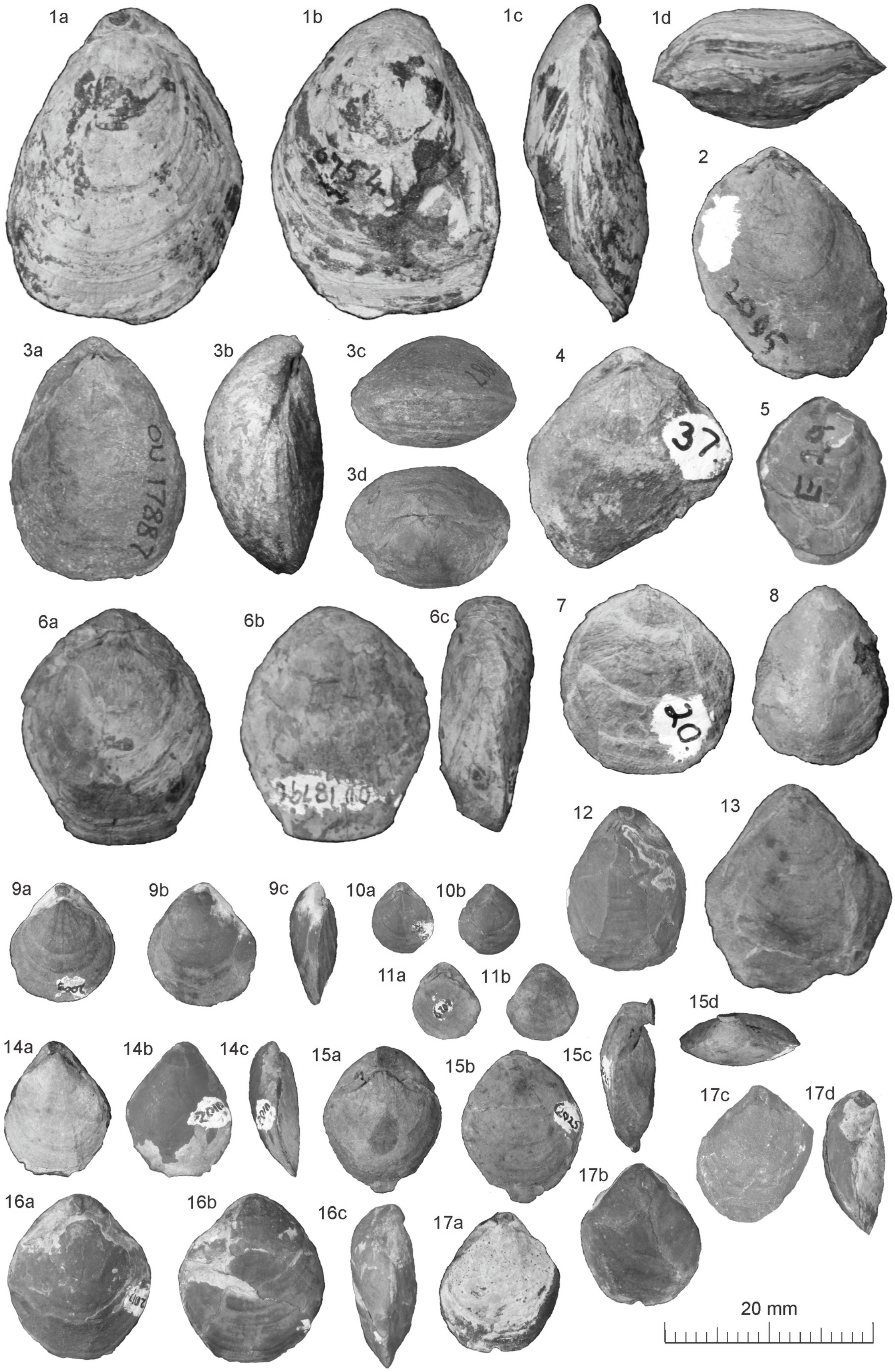
In the dorsal valve the hingeplate is short, narrow and triangular, with a small narrow cardinal process (Fig. 14B, D). There is no median septum. Muscle scars are poorly shown on the dorsal valve of some specimens (Fig. 13.10a, 14C).

Dimensions. Dimensions of the holotype and representative specimens, and statistics for all measurable specimens are shown in Table 4. A length vs width graph is shown in Fig. 9C.

Range and Distribution. Small specimens are common at one locality in the South Taringatura Hills (E45/f6635), which is early Otapirian. All other material comes from the late Otapirian. The species has a wide distribution from Kawhia to Awakino in the Kawhia Syncline, and in the latest Otapirian part of the Taylors Stream – Otapiri section (Southland Syncline), where it is found with *Zeilleria spiculata.* It does not extend into the Aratauran.

TABLE 4. Dimensions, *Lobothyris richardsi* **n. sp.**

FR no.	**specimen**	**Lv**	**Lp**	**W**	**H**	**b<**	**material**	**notes**
R15/f8585	BR 3286	29.7	27.4	20.5	10.9	101	b pt shelly	Holotype sl distorted
E45/f279	OU 18796	22.1	20.1	17.4	8.5	100	b int	beak distorted, pt ext
F45/f217	OU 17887	22.6	21.5	16.2	11.3	95	b int	good spn
Kawhia Syncline	mean	20.3	18.8	15.6	5.8	93.8	6 specimens	
	S.D.	5.45	4.05	2.50	2.67	5.26		
E45/f6635 (South Taringatura Hills)	mean	14.4	13.0	11.6	5.8	79.8	26 specimens	
	S.D.	3.46	3.14	2.36	1.57	9.08		
Other Southland Syncline	mean	22.3	20.9	16.5	8.5	96.6		
	S.D.	8.39	7.89	5.81	3.89	37.36	7 specimens	



...Figure legend continued on the next page

FIGURE 13. *Lobothyris richardsi* **n. sp.**
1 Holotype BR 3286 (R15/f8585) partly shelly specimen (a) dorsal (b) ventral (c) lateral (d) anterior. **2** OU 46808 (E45/f9900) internal mould, ventral. **3** OU 17887 (F45/f0217) internal mould (a) dorsal (b) lateral (c) anterior (d) posterior. **4** B907 (R17/f8574) internal mould, dorsal. **5** OU 46812 (E45/f0073) internal mould, ventral. **6** OU 18756 (E45/f0279) internal mould (a) dorsal (b) ventral (c) lateral. **7** B906 (R18/f6582) internal mould, ventral. **8** BR 3507 (R16/f8650) shelly specimen, ventral. **9** C2009 (E45/f6635) internal mould with remnant shell (a) dorsal (b) ventral (c) lateral. **10** C2018 (E45/f6635) internal mould (a) dorsal (b) ventral. **11** C2029 (E45/f6635) internal mould (a) dorsal (b) ventral. **12** C2020 (E45/f6635) internal mould, ventral. **13** OU 46811 (E45/f0073) internal mould, dorsal. **14** C2010 (E45/f6635) partly shelly internal mould, (a) dorsal (b) ventral (c) lateral. **15** C2025 (E45/f6635) internal mould (a) dorsal (b) ventral (c) lateral (d) posterior. **16** C2017 (E45/f6635) partly shelly internal mould (a) dorsal (b) ventral (c) lateral. **17** OU 47230 (E45/f6635) partly shelly internal mould (a) dorsal (b) ventral (c) latex of exterior, dorsal view (d) lateral.

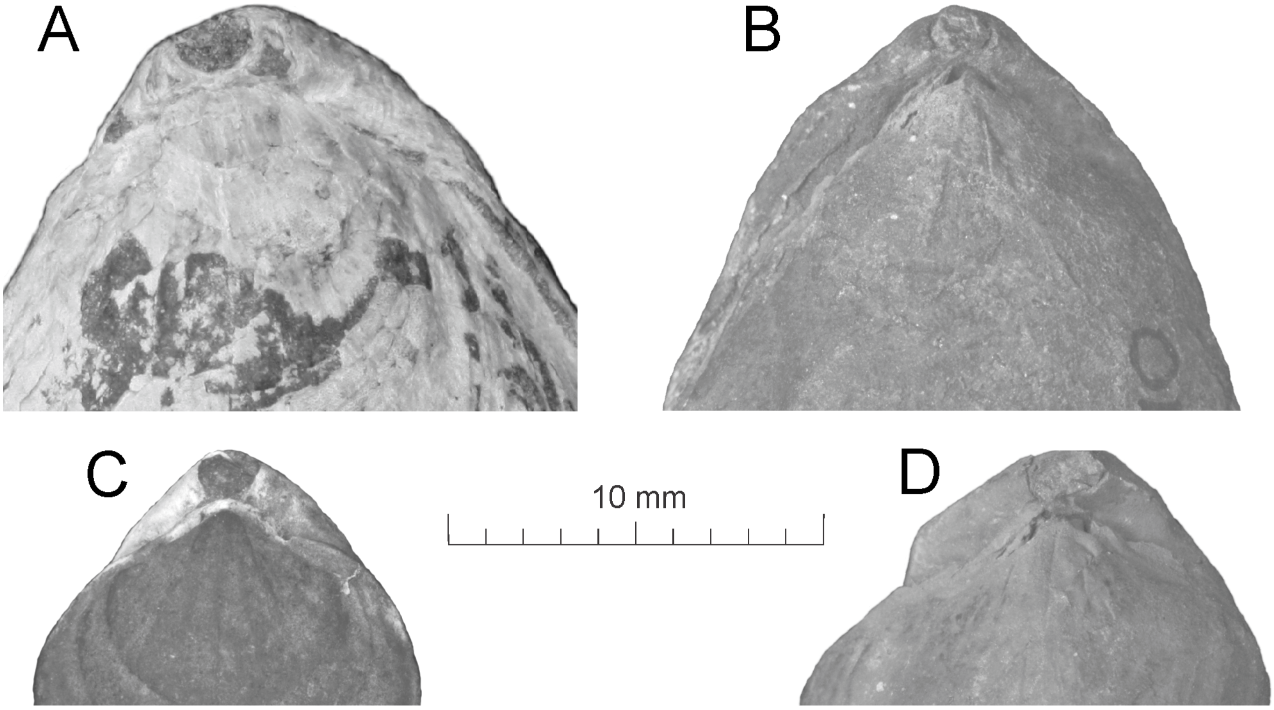


FIGURE 14. Detailed views of beak area, *Lobothyris richardsi* n. sp. **A** holotype, BR3286 (R15/f8585) dorsal view of partly shelly specimen showing beak, foramen and deltidial plates. **B** OU 17887 (F45/f0217) dorsal view of internal mould showing foramen surrounded by pedicle collar. **C** C2009 (E45/f6635) dorsal view of partly shelly specimen showing beak, foramen and deltidial plates, and low muscle scars on dorsal valve. **D** C2014 (E45/f6635) dorsal view internal mould, showing beak, foramen and beak ridges. Left side of ventral valve damaged.

Remarks. This species is included in *Lobothyris* on its shape and internal characters.

The straight anterior margin and small beak distinguish this species from the Jurassic *Lobothyris simesi.* It has a similar shape to the Siberian species *L. monstrifera* Dagys (see Dagys 1963, pl. xxv11 4 – 6), but that species is generally more convex.

L. cf. *monstrifera* is recorded from Alaska (Blodgett and Clautice 2000, Sandy 2001), but Sandy (2001) comments that "serial sections indicate internal differences between this form and typical *Lobothyris* and it is thought to represent a new genus" (p. 397).

Suborder TEREBRATELLIDINA Muir-Wood, 1955

Superfamily ZEILLERIOIDEA Schuchert, 1929

Family ZEILLERIIDEA Schuchert, 1929

Subfamily ZEILLERIINAE Schuchert, 1929

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

Genus *Zeilleria* Bayle, 1878

1878 *Zeilleria*, Bayle, pl. 9.
1965b *Zeilleria* Bayle, 1878; Muir-Wood, p. H821.
1974 *Zeilleria* Bayle, 1878; Delance, p. 69.
2006 *Zeilleria* Bayle, 1878; MacKinnon et al., p. H2164.
2015 *Zeilleria* Bayle, 1878; Alméras et al., p. 7.
2016 *Zeilleria* Bayle, 1878; MacFarlan, p. 488.
2019 *Zeilleria* Bayle, 1878; MacFarlan, p. 568.

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

The cosmopolitan genus *Zeilleria* Bayle has been recognised in Zealandia for some time. *Zeilleria spiculata* MacFarlan and Campbell, 2003 spans the Triassic-Jurassic boundary. Five further species were described from the Jurassic by MacFarlan (2016) and (2019), plus one form left in open nomenclature. This study recognises a further new species from the Late Triassic and one which is represented by a single specimen and is left in open nomenclature.

Zeilleria spiculata MacFarlan and Campbell, 2003

2003 *Zeilleria spiculata* MacFarlan and Campbell, p 213, Fig. 2-3.
2009 *Zeilleria spiculata* MacFarlan and Campbell, 2003; MacFarlan et al. p. 266.
2019 *Zeilleria spiculata* MacFarlan and Campbell, 2003; MacFarlan, p. 568.

For description see MacFarlan and Campbell (2003).

This species is common in the latest Otapirian and earliest Aratauran of the Taylors Creek – Otapiri section in the Hokonui Hills (Southland Syncline). There are also a few records in the late Otapirian in other Murihiku Terrane sections (MacFarlan 2019). This study has added a few further records which are listed in Appendix 1.

Zeilleria minima n. sp.

Fig. 15: 1–15. 16 A–C.

Holotype C81, a double-valved internal mould from E44/f6635, JDC 241, South Taringatura Hills. Collected by J.D. Campbell, May 1949.

Derivation of name. This is the smallest of the *Zeilleria* species from the Zealandian Mesozoic.

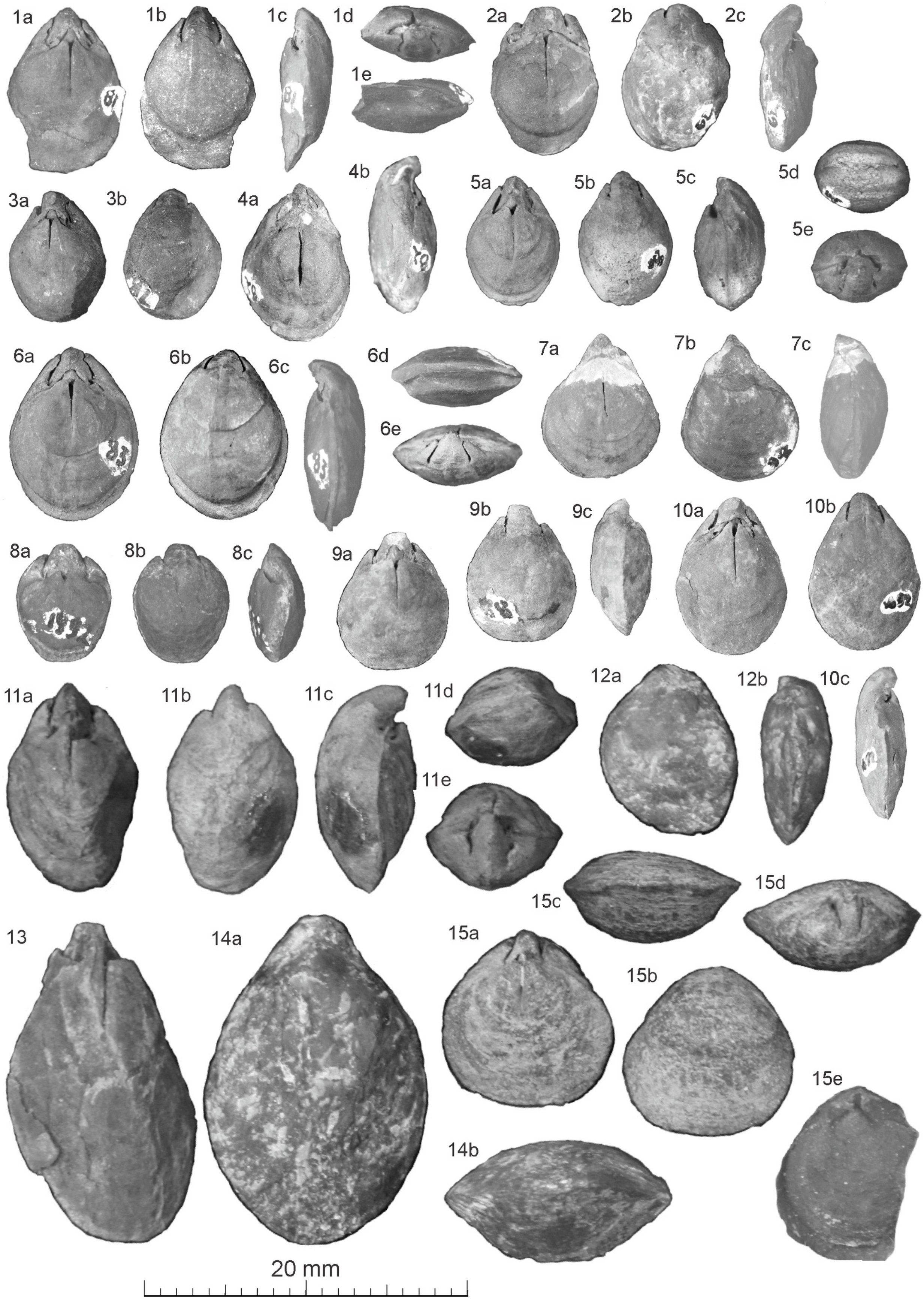
Material. The data series consists of 19 specimens; 12 of these came from the South Taringatura Hills locality E45/f6635, six from late Otapirian localities in New Caledonia, the Kawhia Syncline and Nelson, and one from E44/f8637, a Warepan locality in the South Taringatura Hills. All yielded valid measurements.

New Caledonia. Ducos NC/f0018A (AU 6074).

Kawhia Syncline. Coast north of Marokopa R16/f6899A (GS 10010). Marokopa coast R16/f0050 (McF A19). Awakino Gorge R18/f6562B (AU 8986).

Nelson. Eighty-Eight Valley N28/f7454 (GS 196).

Southland Syncline. South Taringatura Hills, Southland, E44/f6635, JDC 241. E44/f8637, JDC 655 (Warepan).



...Figure legend continued on the next page

FIGURE 15. *Zeilleria minima* **n. sp.**
1 Holotype C81 (E45/f6635), internal mould (a) dorsal (b) ventral (c) lateral (d) anterior (e) posterior. **2** C79 (E45/f6635), internal mould (a) dorsal (b) ventral (c) lateral. **3** C78 (E45/f6635), internal mould (a) dorsal (b) ventral (c) lateral. **4** C82 (E45/f6635), internal mould (a) dorsal (b) lateral. **5** C80 (E45/f6635), internal mould (a) dorsal (b) ventral (c) lateral (d) anterior (e) posterior. **6** C83 (E45/f6635), internal mould (a) dorsal (b) ventral (c) lateral (d) anterior (e) posterior. **7** C86 (E45/f6635), internal mould with remnant shell material, (a) dorsal (b) ventral (c) lateral. **8** C1992 (E45/f6635), internal mould (a) dorsal (b) ventral (c) lateral. **9** C88 (E45/f6635), internal mould (a) dorsal (b) ventral (c) lateral. **10** C1652 (E44/f8637), internal mould (a) dorsal (b) ventral (c) lateral. **11** BR 3421 (N28/f7454) internal mould (a) dorsal (b) ventral (c) lateral (d) anterior (e) posterior. **12** B904 (NC/f0018A) shelly specimen(a) dorsal (b) lateral. **13** BR 3504 (R16/f8899A) internal mould, dorsal. **14** B903 (NC/f0018A) decorticated shelly specimen (a) dorsal (b) anterior. **15** B897 (R18/f6562B) internal mould (a) dorsal (b) ventral (c) anterior (d) posterior (e) latex of beak and dorsal valve exterior.

Description. Small terebratulide with robust shells and elongate-elliptical outline. Both valves are moderately, evenly and about equally convex with no definite fold or sulcus. The anterior commissure is rectimarginate or with a shallow, poorly-defined uniplication. The beak is sharply rounded, erect, and large in proportion to the shell. The foramen is elliptical and permesothyrid. There is no pedicle collar. Deltidial plates are small, triangular and conjunct. The beak ridges are strong and sharply rounded. The shell is coarsely punctate.

The dorsal valve has a narrow hingeplate, with a small poorly defined cardinal process. The median septum is high, wall-like, and generally 0.2 – 0.5 of valve length (Fig. 16A, C). Adductor muscle scars are paired (Fig. 15.6a) and of variable strength at the anterior end of median septum.

The ventral valve has short, thick slightly divergent dental plates (Fig.15.1a, 6a, 10a, b, Fig. 16A-C). Diductor muscle scars are prominent in some specimens (Fig. 15.6b, 10b, 16B), located to the anterior of the beak and between the dental plates.

Dimensions. Dimensions of the holotype and representative specimens, and statistics for all measurable specimens are shown in Table 5. A length vs width graph is shown in Fig. 9D.

TABLE 5. Dimensions, *Zeilleria minima* **n. sp.**

FR no.	specimen	Lv	Lp	W	H	b<	MS/L	material	notes
E34/f6635	C80	8.1	7	5.9	4.3	77	0.5	b int	Holotype
E34/f6635	C79	9.1	8	6.5	3.2		0.5	b int	
E34/f6635	C82	9.7	8.3	6.7	4.1	72	0.6	b int	
N28/f7454	BR 3421	12.5	10.8	7.8	6.2	83	0.3	b int	
All valid specimens	mean	10.8	9.6	7.9	4.3	83.2	19 specimens		
	SD	5.76	5.25	4.14	2.21	39.54			

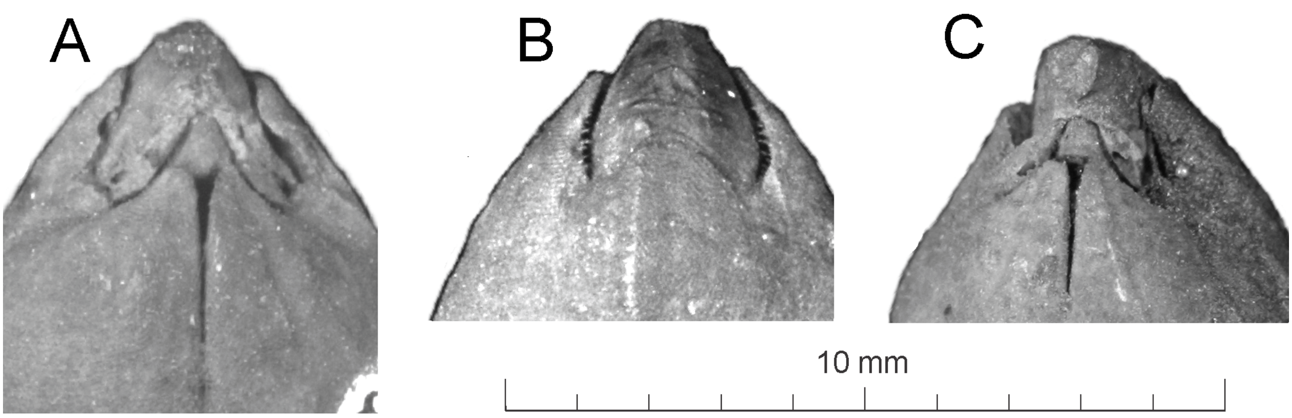


FIGURE 16. Detailed view of beak area, *Zeilleria minima* n. sp. **A** Holotype**,** C81 (E45/f6635) dorsal view of internal mould showing beak with long divergent dental plates, median septum on dorsal valve. **B** same specimen, ventral view showing diductor muscles, **C** C78, same locality, dorsal view of internal mould showing foramen, hingeplate and trace of muscle scars on dorsal valve

Range and Distribution. Otapirian of New Caledonia, and the Murihiku Terrane of New Zealand. One Warepan specimen from Southland.

Remarks. This new species forms part of a group of small rectimarginate *Zeilleria* which include the Early Jurassic *Z. terezowae* MacFarlan, 2019 and the Middle to Late Jurassic *Z. opuatiaensis* MacFarlan, 2016. The new species most closely resembles *Z. terezowae* but is smaller. The larger specimens are proportionately more elongate and more inflated.

Specimens from R16/f050 and R18/f6562 are wider and closer *to Z. terezowae* in shape. They could represent a different species.

***Zeilleria* n. sp.**

Fig. 17.1a–d.

A single specimen, B832 from NC/f0007A (AU 7149) is moderately large with a strongly inflated dorsal valve. It is distinct in shape and size from any other Zealandian *Zeilleria*.

Material. B832, a double-valved shelly specimen from NC/f0007A, AU 7149, Bouraké Formation, île Hugon, New Caledonia, late Otapirian.

Description. Terebratulide of moderately large size with a rounded-heptagonal outline. Both valves are well-inflated, with the dorsal valve more inflated posteriorly. The dorsal valve has a shallow fold anteriorly. The ventral valve lacks a definite fold. The anterior commissure has a broad, shallow uniplication which is about half of the valve width. The exterior of both valves is smooth posteriorly, with low stepped growth lines anteriorly.

In the ventral valve the beak is short, broad, triangular and slightly incurved. The foramen is small, and poorly shown. It is probably submesothyrid. The beak ridges are strong and sharply rounded.

Punctae were not seen, probably due to recrystallisation.

Details of hinge and loop were not seen. The median septum in the dorsal valve is poorly shown but probably about one-third of valve length.

Dimensions. Dimensions of the specimen are shown in Table 6.

TABLE 6. Dimensions, *Zeilleria* **n. sp.**

FR no.	specimen	Lv	Lp	W	H	b<	MS/L	material	notes
NC/f0007A	B832	39.5	37.8	35.3	26.3	131		b shelly	

Remarks. The sole specimen has much greater inflation than *Zeilleria spiculata,* especially of the dorsal valve, and a much smaller beak. It is larger than any measured specimen of *Z. spiculata* (Fig. 9D, MacFarlan 2021). It has much less resemblance to the other Zealandian Late Triassic and Jurassic zeilleriides.

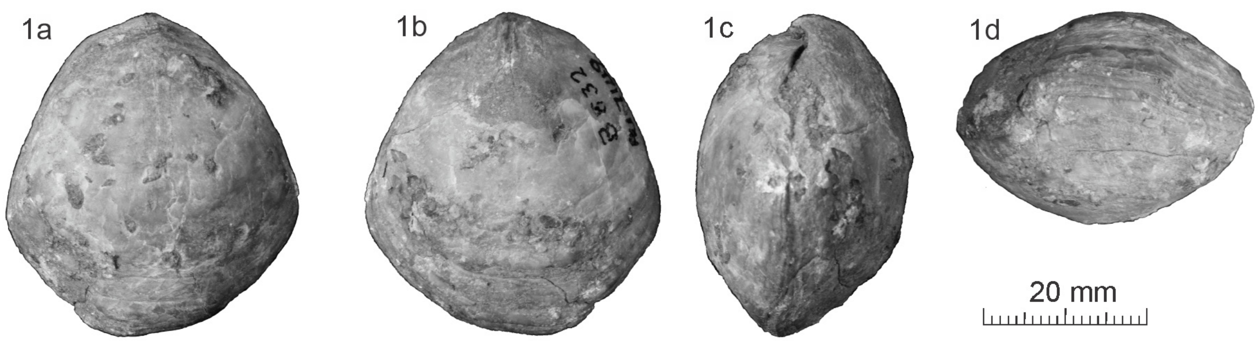


FIGURE 17. *Zeilleria* **n. sp.** (x1)

1 B832 (NC/f0007A) shelly specimen (a) dorsal (b) ventral (c) lateral (d) anterior

Discussion

Faunal Affinities

Tibetothyris, *Rhaetina*, and *Zeilleria* are cosmopolitan. Fig. 18 suggests a circumpacific distribution, although all appear absent from Argentina. *Tibetothyris* is present in Zealandian faunas from the Oretian, and *Zeilleria* is present in the Warepan. *Rhaetina* may also be present in the Warepan. *Lobothyris* is ubiquitous in the Jurassic, and less common but essentially cosmopolitan in the Triassic.

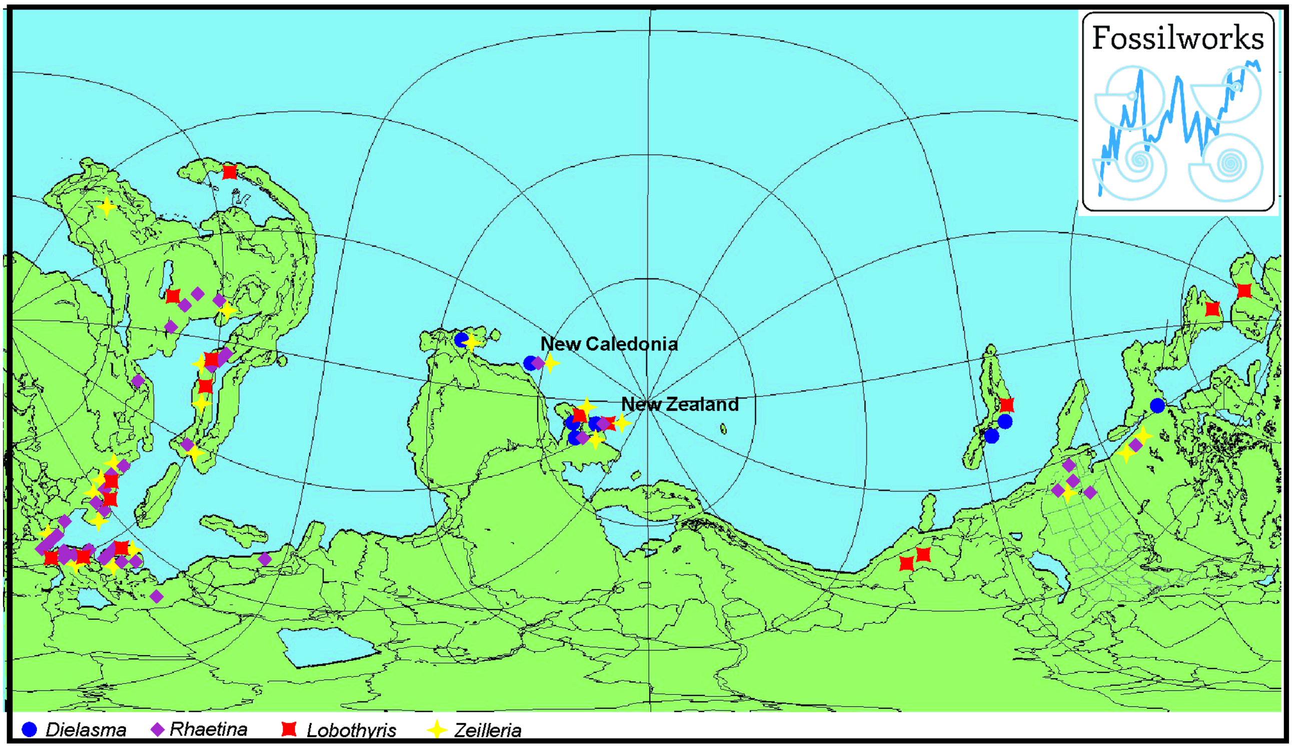


FIGURE 18. World distribution of terebratulide genera. Data from Fossilworks (downloaded 20 August 2021) and relevant literature. Base maps from Alroy (2013). Online paleogeographic map generator. http://paleodb.org/?a=mapForm. The map is drawn on an equirectangular projection for 185 Ma, focal co-ordinates -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 this map are approximate.

Terebratulides at the Triassic-Jurassic boundary

Tibetothyris does not survive the end-Triassic crisis. *Rhaetina* also disappears at or before the end of the Triassic.

Lobothyris richardsi is present, along with *Zeilleria spiculata,* in the highest Otapirian beds of Taylors Stream and the Otapiri Stream in Southland. *Z. spiculata* flourishes in the immediately overlying basal Aratauran in this area, while *L. richardsi* is absent. The basal Aratauran is not recognised in other Murihiku Terrane sections (Stevens 2004, MacFarlan 2019). The genus reappears as *Lobothyris simesi* in higher Aratauran beds and is an important member of Late Aratauran and Ururoan faunas.

A total of seven Otapirian (Rhaetian) terebratulide species from Zealandia are recorded here, while MacFarlan (2019) recprds eleven species from the Aratauran (Hettangian-Sinemurian and early Pliensbachian). *Zeilleria spiculata* spans the Otapirain-Aratauran boundary. In a global context, Curry and Brunton (2007) record 36 Norian terebratulide genera, 23 Rhaetian, 20 Hettangian and 25 Sinemurian (Hettangian figure calculated from Fig. 1931 and 1932).

Zeilleria minima has not been found in the highest Otapirian beds. The larger *Z. terezowae* appears later in the Aratauran and is the other common Early Jurassic terebratulide.

Conclusions

The Rhaetian terebratulide fauna of Zealandia is essentially cosmopolitan, with links to Europe, Asia and North America. This is in contrast to the spiriferinides, which have both strongly endemic and cosmopolitan aspects.

Acknowledgements

To Neville Hudson, School of Earth Sciences, University of Auckland (Auckland), Ewan Fordyce, Sophie White and Marcus Richards, Geology Department, University of Otago (Dunedin); and Mariana Terezow and Chris Clowes, GNS Science (Lower Hutt), for their assistance with access to collections and loan specimens in their care. To Daphne Lee, Geology Department, University of Otago (Dunedin) and Hamish Campbell, GNS Science (Lower Hutt), for reviewing this manuscript, and for advice and encouragement throughout. To Moses MacFarlan for his help with specimen handling and packing in the Panmure fossil store. To the librarians at the GNS Library and the University of Otago Library for their help in finding obscure and rarely used literature. To Katie MacFarlan for help with the French language. To Adam Halamski (Warsaw for a thorough and helpful review of the manuscript.

References

Ager, D.V. (1967) Some Mesozoic brachiopods in the Tethys region. *In*: Adams, C.G. & Ager, D.V. (Eds.), *Aspects of Tethyan Biogeography*. *Systematics Association Publication 7.* Systematics Association, London, pp. 135–151.

Ager, D.V. (1990) British Liassic Terebratulida (Brachiopoda); Part 1. *Palaeontographical Society Monograph*, 143 (582), 1–39, 2 pls.
https://doi.org/10.1080/25761900.2022.12131766

Ager, D.V. & Westermann, G.E.G. (1963) New Mesozoic Brachiopods from Canada. *Journal of Paleontology*, 37 (3), 595–610.

Ager, D.V., Gutnic, M., Juteau, T. & Monod, O. (1978) New Early Mesozoic brachiopods from southern Turkey. *Bulletin of the Mineral Research and Exploration Institute of Turkey*, 91, 59–75.

Aitchison, J.C., Clarke, G.L., Meffre, S. & Cluzel, D. (1995) Eocene arc-continent collision in New Caledonia and implications for regional southwest Pacific tectonic evolution. *Geology*, 23 (2), 161–164.
https://doi.org/10.1130/0091-7613(1995)023%3C0161:EACCIN%3E2.3.CO;2

Akikuni, K., Hori, R.S., Vajda, V., Grant-Mackie, J.A. & Ikehara, M. (2010) Stratigraphy of Triassic-Jurassic boundary sequences from the Kawhia coast and Awakino gorge, Murihiku Terrane, New Zealand. *Stratigraphy*, 7 (1), 7–24.

Allan, R.S. (1940) A revision of the classification of the terebratelloid Brachiopoda. *Canterbury Museum, Records*, 4 (6), 267–275.

Alméras, Y., Cougnon, M. & Fauré, P. (2014) Les Brachiopodes Jurassiques (Terebratulidina). Principaux genres et leur évolution. Les espèces, extentions verticales et leurs répartitions géographiques. *Strata*, 49, 1–198.

Alméras, Y., Cougnon, M. & Fauré, P. (2015) Les Brachiopodes Jurassiques (Terebratellidina). Principaux genres et leur évolution. Les espèces, extentions verticales et leurs répartitions géographiques. *Strata*, 51, 1–111.

Alroy, J. (2013) Online paleogeographic map generator. Available from: http://fossilworks.org/?a=mapForm (accessed 25 October 2023)

Awad, G.H. (1945) On the occurrence of Marine Triassic (Muschelkalk) deposits in Sinai. *Bulletin de L'Institut d'Egypte*, 27, 397–429.

Baeza-Carratalá, J.F. & García Joral, F. (2014) Crural bases position as a structural criterion for supraspecific diagnosis of Early Jurassic zeilleriid brachiopods. *Acta Palaeontologica Polonica*, 59 (3), 651–661.
https://doi.org/10.4202/app.2012.0068

Bayle, C.E. (1878) Fossiles principaux des terrains de la France. *Explication de la Carte Géologique de la France, Mémoire*, 4 (1), 158 pls., no text.

Begg, J.G. (1981) *The basement geology and palaeontology of the Wairaki Hills, Southland.* Unpublished Ph.D. Thesis, University of Otago, Dunedin, 400 pp.

Bishop, D.G. & Turnbull, I.M. (Compilers) (1996) *Geology of the Dunedin area. Institute of Geological and Nuclear Sciences 1:250 000 Geological Map 21*. Institute of Geological & Nuclear Sciences Limited, Lower Hutt, 52 pp., 1 folded map.

Bittner, A. (1890). Brachiopoden der Alpinen Trias. *Abhandlungen der kaiserlich-königlichen geologischen Reichsanstalt*, 14, 1–325, pls. 1–41.

Bittner, A. (1891) Triaspetrefakten von Balia in Kleinasien. *Jahrbuch der Kaiserlich-Königlichen geologischen Reichsanstalt*, 41, 97–116.

Bittner, A. (1899) Trias Brachiopoda and Lamellibranchiata. *Memoirs of the Geological Survey of India, Palaeontologia Indica*,

Series 15, 3 (2), 1–76, pls. 1–12.
Bittner. A. (1912) Brachiopoden aus der Trias des Bakonyer *Waldes Resultate der Wissenschaftlichen Erforschung des Balatonsees, II Band: Paläontologie der Umgebung des Balatonsees*, 1 (1), 1–60
Blodgett, R.B. & Clautice, K.H. (2000) *Fossil locality map for the Healy A-6 quadrangle, south-central Alaska*. *Report of Investigations 2000-5.* Alaska Department of Natural Resources, Anchorage, Alaska, 43 pp. https://doi.org/10.14509/2680
Buckman, S.S. (1918) The Brachiopoda of the Namyau Beds, Northern Shan States, Burma. *Memoirs of the Geological Survey of India, Palaeontologia Indica*, New Series, 3 (2), 1–299. [published for 1917]
Calzada, S., Peybernes, B., Kamoun, F. & Youssef, M.B. (1994) *Tunethyris*, un nouveau genre de brachiopode du Trias de Tunisie centrale. *Revue de Paleobiologie*, 13 (1), 117–124
Campbell, H.J. & Grant-Mackie, J.A. (1984) Biostratigraphy of the Mesozoic Baie de St. Vincent Group, New Caledonia. *Journal of the Royal Society of New Zealand*, 14 (4), 349–366. https://doi.org/10.1080/03036758.1984.10421736
Campbell, H.J., Grant-Mackie, J.A. & Paris, J.P. (1985) Geology of the Moindou-Téremba area, New Caledonia. Stratigraphy and structure of the Téremba Group (Permian—Lower Triassic) and Baie de St. Vincent Group (Upper Triassic—Lower Jurassic): *Géologie de France*, 1, 19–36.
Campbell, H.J., Mortimer, N. & Turnbull, I.M. (2003) Murihiku Supergroup, New Zealand: redefined. *Journal of the Royal Society of New Zealand*, 33 (1), 85–95. https://doi.org/10.1080/03014223.2003.9517722
Campbell, J.D., (1956) The Otapirian stage of the Triassic System in New Zealand. Pt. 2. *Transactions of the Royal Society of New Zealand*, 84 (1), 45–50.
Campbell, J.D. (1974) Biostratigraphy and structure of Richmond Group rocks in the Wairoa River - Mt Heslington area, Nelson. *New Zealand Journal of Geology and Geophysics*, 17 (1), 41–62. https://doi.org/10.1080/00288306.1974.10427988
Campbell, J.D. & McKellar, I.C. (1956) The Otapirian Stage of the Triassic System of New Zealand, Pt. 1. *Transactions of the Royal Society of New Zealand*, 83 (4), 695–704.
Campbell, J.D. & McKellar, I.C. (1960) The Otamitan Stage (Triassic): Definition and type locality. *New Zealand Journal of Geology and Geophysics*, 3 (4), 643–659, https://doi.org/10.1080/00288306.1960.10420151
Clowes, C.D., Crampton, J.S., Bland, K.J. Collins, K.S. Prebble, J.G., Raine, J.I., Strogen, D.P., Terezow, M.G. & Womack, T. (2021) The New Zealand Fossil Record File: a unique database of biological history. *New Zealand Journal of Geology and Geophysics*, 64 (1), 62–71. https://doi.org/10.1080/00288306.2020.1799827
Cooper, G.A. (1983) The Terebratulacea (Brachiopoda), Triassic to Recent: A Study of the Brachidia (Loops). *Smithsonian Contributions to Paleobiology*, 50, 1–445. https://doi.org/10.5479/si.00810266.50.1
Cooper, R.A. (Ed.) (2004) The New Zealand Geological Timescale. *Institute of Geological & Nuclear Sciences Monograph*, 22, 1–284.
Curry, G.B. & Brunton, C.H.C. (2007) Stratigraphic distribution of brachiopods. *In*: Kaesler, R.L. (Ed.), *Treatise on Invertebrate Paleontology. Part H. Brachiopoda. Vol. 6. Revised.* Geological Society of America, Boulder, Colorado and Paleontological Institute, Lawrence, Kansas, pp. 2901–3081. https://doi.org/10.17161/dt.v0i0.5578
Dagys, A.S. (1959) Novye triasovye rody Terebratulida [New genera of Triassic Terebratulida]. *Lietuvos TSR Mokslu, Akademija Geologijos ir Geografijos Institutas, Moksliniai Pranesimai SSR, Trudy*, Series B, 9, 23–41, 1 pl. [in Russian]
Dagys, A.S. (1963) *Verkhnetriasovye brakhiopody yuga SSSR [Upper Triassic brachiopods of the southern USSR]*. Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izdatel'stvo Akademii Nauk SSSR, Moscow, 248 pp., 106 figs., 31 pls. [in Russian]
Dagys, A.S. (1974) Triasovye brakhiopody (morfologiya, sistema, filogeniya, stratigraficheskoye znacheniye I biogeografiya) [Triassic Brachiopoda (morphology, systematics, phylogeny, stratigraphic distribution, and biogeography)]. *Akademia Nauk SSSR Sibiroskoe Otdelenie Institut Geologii I Geofiziki (IGIG) Trudy [Institute of Geology and Geophysics, Academy of Sciences of the USSR, Siberian Branch, Transactions]*, 214, 1–386, 171 figs., 49 pls. [in Russian]
Delance, J.H. (1974) Zeillerides du Lias d'Europe Occidentale. *Memoires Géologiques de L'Université de Dijon*, 2, 1–406.
Detre,.C.H, (1993) Carnian brachiopods of Hungary. *In*: Palfy, J. & Vorös, A. (Eds.), *Mesozoic Brachiopods of Alpine Europe*. Hungarian Geological Society, Budapest, pp. 27–30.
Douvillé, H. (1879) Note sur quelques genres de brachiopodes (Terebratulidae et Waldheimiidae). *Société Géologique de France, Bulletini*, Series 3, 7, 251–277.
Duméril, A.M.C. (1806) *Zoologie analytique ou méthode naturelle de classification des animaux.* Allais, Paris, xxiv + 344 pp.
Edbrooke, S.W., Heron, D.W., Forsyth, P.J. & Jongens, R. (Compilers) (2014) *Geological Map of New Zealand 1:1 000 000. Digital vector data. GNS Science Geological Map 2*. GNS Science, Lower Hutt, 1 DVD.
Fauré, P., Paris, J.-P. & Campbell, H.J. (1982) *Notice explicative sur la feuille La Tontouta. Carte geologique it l'echelle 1:50,000.* Bureau de Recherches Geologiques et Minieres, Orleans. [map]
Feldman, H.R. (2017) *Tunethyris blodgetti* sp. nov. (Brachiopoda, Terebratulida) from the Middle Triassic of the Makhtesh

Ramon, southern Israel. *Annales Societatis Geologorum Poloniae*, 87, 89–99. https://doi.org/10.14241/asgp.2017.004

Grant-Mackie, J.A. (1959) Hokonui stratigraphy of the Awakino-Mahoenui area, South-West Auckland. *New Zealand Journal of Geology and Geophysics*, 2 (4), 755–787. https://doi.org/10.1080/00288306.1959.10422769

Halamski, A.T., Bitner, M.A., Kaim, A., Kolar-Jurkovsek, T. & Jurkovsek, B. (2015) Unusual brachiopod fauna from the Middle Triassic algal meadows of Mt. Svilaja (Outer Dinarides, Croatia*). Journal of Paleontology*, 89 (4), 553–575. https://doi.org/10.1017/jpa.2015.34

Heron, D.W. (Custodian) (2014) *Geological Map of New Zealand 1:250 000, digital vector data. GNS Science Geological Map 1*. GNS Science, Lower Hutt, 1 DVD.

Jin, Y.G., Sun, D.L. & Rong, J.Y. (1976) Mesozoic and Cenozoic Brachiopods from the Mount Jolmo Lungma Region. *In:* Xizang Scientific Expedition Team of Chinese Academy of Sciences (Ed.), *A Report of Scientific Expedition in the Mount Jolmo Lungma Region (1966–1968). (Palaeontology). Fasc. II*. Science Press, Beijing, pp. 271–346, pls. 1–10. [in Chinese]

Jin, Y-G., Lee, D.E., Sun D-L, Smirnova, T.N., Dagys, A.S. & Sandy, M.R. (2006) Dielasmatoidea. *In:* Kaesler, R.L. (Ed.), *Treatise on Invertebrate Paleontology. Part H, Brachiopoda. Vol. 5. Revised.* Geological Society of America, Boulder, Colorado and Paleontological Institute, Lawrence, Kansas, pp. 2029–2053.

Johnston, M.R. (1982) *Sheet N28 BD, Red Hills. 1st Edition. Geological map of New Zealand 1:50,000.* D.S.I.R., Wellington, Map (1 sheet), 47 pp. (notes).

Johnston, M.R. (1983) *Sheet N28 AC, Motupiko 1st Edition. Geological map of New Zealand 1:50,000.* D.S.I.R., Wellington, Map (1 sheet), 40 pp. (notes).

Kaesler, R.L. (Ed.) (2000–2007) *Treatise on Invertebrate Paleontology. Part H. Brachiopoda. Vols. 1–6. Revised.* Geological Society of America, Boulder, Colorado and Paleontological Institute, Lawrence, Kansas, 539 + 3226 pp.

Khuc, V. (2000) The Triassic of Indochina Peninsula and its interregional correlation. *In:* Yin, H., Dickins, J.M., Shi, G.R. & Tong, J. (Eds.), *Permian-Triassic Evolution of Tethys and Western Circum-Pacific. Developments in Palaeontology and Stratigraphy*, 18, pp. 221–233. https://doi.org/10.1016/S0920-5446(00)80013-8

King, W. (1859) On *Gwynia*, *Dielasma*, and *Macandrevia*, three new genera of Palliobranchiata Mollusca, one of which has been dredged in the Strangford Lough. *Dublin University Zoological and Botanical Association, Proceedings*, 1 (3), 256–262. [also published in *Natural History Review*, 6, 516–520]

Kristan-Tollmann, E., Tollmann, A. & Hamedani, A. (1979) Beiträge zur Kenntnis der Trias von Persien. I—Revision der Triasgliederung, Rhätfazies in Raum von Isfaham und Kossener Fazieseinschlag bei Waliabad SE Abadeh. *Mitteilungen der österreichischen geologischen Gesellschaft*, 70, 119–190.

Krumbeck, L. (1924) Die Brachiopoden, Lamellibranchiaten und Gastropoden der Trias von Timor. Part 2. *Paläontologischer Teil. Paläontologie von Timor*, 13 (22), 1–275, pls. 179–198.

Lee, D.E., Smirnova, T.N. & Dagys, A.S. (2006) Lobothyridoidea. *In*: Kaesler, R.L. (Ed.), *Treatise on Invertebrate Paleontology. Part H. Brachiopoda (Revised). Vol. 5*. Geological Society of America and Paleontological Institute, Boulder, Colorado and Lawrence, Kansas, pp. 2082–2135. https://doi.org/10.17161/dt.v0i0.5578

MacFarlan, D.A.B. (1992) Triassic & Jurassic Rhynchonellacea (Brachiopoda) from New Zealand & New Caledonia. *Royal Society of New Zealand, Bulletin*, 31, i–x + 1–310.

MacFarlan, D.A.B. (1998) Mesozoic stratigraphy of the Marokopa area, southwest Auckland, New Zealand. *New Zealand Journal of Geology and Geophysics*, 41 (3), 297–310. https://doi.org/10.1080/00288306.1998.9514812

MacFarlan, D.A.B. (2016) Middle and Late Jurassic terebratulides from New Zealand. *Palaeoworld*, 25 (4), 467–495. https://doi.org/10.1016/j.palwor.2016.07.001

MacFarlan, D.A.B. (2019) Early Jurassic Terebratulide Brachiopods from Zealandia. *Rivista Italiana di Paleontologia e Stratigrafia*, 125 (3), 551–586. https://doi.org/10.13130/2039-4942/12160

MacFarlan, D.A.B. (2021) *Measurement data for Zealandian Mesozoic brachiopods*. *GNS Science Report 2021/45*. GNS Science, Lower Hutt, 11 p. https://doi.org/10.21420/JAVG-GQ03

MacFarlan D.A.B. (2023) Latest Triassic and Early Jurassic Spiriferinida (Brachiopoda) of Zealandia (New Zealand and New Caledonia). *Zootaxa*, 5277 (1), 1–58. https://doi.org/10.11646/zootaxa.5277.1.1

MacFarlan, D.A.B. & Campbell, J.D. (2003) *Zeilleria spiculata*, a new terebratulide brachiopod from the latest Triassic-earliest Jurassic of New Zealand. *Journal of the Royal Society of New Zealand*, 33 (1), 213–221. https://doi.org/10.1080/03014223.2003.9517728

MacFarlan, D.A.B., Bradshaw, M.A., Campbell, H.J., Cooper, R.A., Lee, D.E., MacKinnon, D.I., Waterhouse, J.B., Wright, A.J. & Robinson, J.H. (2009) Phylum Brachiopoda : lamp shells. *In:* Gordon D.P. (Ed.), *New Zealand inventory of biodiversity. Vol. 1. Kingdom Animalia: Radiata, Lophotrochozoa, Deuterostomia.* Canterbury University Press, Christchurch, pp. 255–267.

MacKinnon, D.I., Lee, D.E., Baker, P.G., Smirnova, T.N. & Dagys, A.S. (2006) Terebratellidina. *In*: Kaesler, R.L. (Ed.), *Treatise on Invertebrate Paleontology. Part H, Brachiopoda (Revised). Vol. 5*. Geological Society of America, Boulder, Colorado and Paleontological Institute, Lawrence, Kansas, pp. 2163–2252.
https://doi.org/10.17161/dt.v0i0.5579

Manceñido, M.O. (1993) Early Jurassic Brachiopods from Greece: A Review. *In*: Palfy, J. & Vörös, A. (Eds.), *Mesozoic Brachiopods of Alpine Europe.* Hungarian Geological Society, Budapest, pp.79–100.

Martin, K.R. (1975) Upper Triassic to Middle Jurassic stratigraphy of south-west Kawhia, New Zealand. *New Zealand Journal of Geology and Geophysics*, 18 (6), 909–938.
https://doi.org/10.1080/00288306.1975.10423534

Marwick, J. (1951) Series and Stage Divisions of New Zealand Triassic and Jurassic rocks. *New Zealand Journal of Science and Technology*, B32 (3), 8–10.

Marwick, J. (1953) Divisions and faunas of the Hokonui System (Triassic and Jurassic). *New Zealand Geological Survey Paleontological Bulletin 21*. New Zealand Geological Survey, Wellington, 141 pp.

McKay, A. (1878) Report on the Wairoa and Dun Mountain districts. *Report of Geological Explorations, New Zealand Geological Survey 1877–78*, 12, 119–159.

Michalik, J, (1975) Genus *Rhaetina* Waagen, 1882 (Brachiopoda) in the uppermost Triassic of the West Carpathians. *Geologicky Zborník—Geologica Carpathica*, 26 (1), 47–76.

Mortimer, N. & Campbell, H.J. (2014) *Zealandia: Our continent revealed*. Penguin, Auckland, 272 pp.

Mortimer, N., Campbell, H.J., Tulloch, A.J., King, P.R., Stagpoole, V.M., Wood, R.A., Rattenbury, M.S., Sutherland, R., Adams, C.J., Collot, J. & Seton, M. (2017) Zealandia: Earth's hidden continent. *GSA Today*, 27 (3), 27–35.
https://doi.org/10.1130/GSATG321A.1

Mortimer, N., Rattenbury, M.S., King, P.R., Bland, K.J., Barrell, D.J.A., Bache, F., Begg, J.G., Campbell, H.J., Cox, S.C., Crampton, J.S., Edbrooke, S.W., Forsyth, P.J., Johnston, M.R., Jongens, R., Lee, J.M., Leonard, G.S., Raine, J.I., Skinner, D.N.B., Timm, C., Townsend, D.B., Tulloch, A.J., Turnbull, I.M. & Turnbull, R.E. (2014) High-level stratigraphic scheme for New Zealand rocks. *New Zealand Journal of Geology and Geophysics*, 57 (4), 402–419.
https://doi.org/10.1080/00288306.2014.946062

Muir-Wood, H.M. (1934) On the internal structure of some Mesozoic Brachiopoda. *Philosophical Transactions of the Royal Society of London*, Series B, 223, 511–567.
https://doi.org/10.1098/rstb.1934.0012

Muir-Wood, H.M. (1955) *A History of the Classification of the Phylum Brachiopoda.* British Museum (Natural History), London, 124 pp.

Muir-Wood, H.M. (1965a) Mesozoic and Cenozoic Terebratulidina *In:* Moore, R.C. (Ed.), *Treatise on Invertebrate Paleontology. Part H. Brachiopoda*. Geological Society of America and University of Kansas Press, New York and Lawrence, Kansas, pp.762–816

Muir-Wood, H.M. (1965b) Zeilleriacea. *In:* Moore, R.C. (Ed.), *Treatise on Invertebrate Paleontology. Part H. Brachiopoda*. Geological Society of America and University of Kansas Press, New York and Lawrence, Kansas, pp. 821–830.

Paris, J.-P. (1981) Géologie de la Nouvelle-Calédonie, un essaie de synthèse. *Memoires. B.R.G.M.*, 113, 1–278.

Pearson, D.A.B. (1977) Rhaetian brachiopods of Europe. *Neue Denkschriften des Naturhistorischen Museums in Wien*, 1, 1–85, 22 figs., 7 pl.

Raine, J.I., Beu, A.G., Boyes, A.F., Campbell, H.J., Cooper, R.A., Crampton, J.S., Crundwell, M.P., Hollis, C.J. & Morgans, H.E.G. (2015) *Revised calibration of the New Zealand Geological Timescale: NZGT2015/1. GNS Science Report 2012/39*. GNS Sciences, Lower Hutt, 53 pp.
https://doi.org/10.1190/ice2015-2211449

Rattenbury, M.S., Cooper, R.A. & Johnston (compilers) (1998*)* Geology of the Nelson area*. Institute of Geological and Nuclear Sciences 1:250 000 Geological Map*, 9, 1–67, 1 map.

Rigo, M. & Campbell, H.J. (2022) Correlation between the Warepan/Otapirian and the Norian/Rhaetian stage boundary: implications of a global negative $\delta^{13}C_{org}$ perturbation. *New Zealand Journal of Geology and Geophysics*, 65 (3), 397–406.
https://doi.org/10.1080/00288306.2021.1896558

Sandy, M.R. (1994) Triassic-Jurassic articulate brachiopods from the Pucara Group, central Peru, and description of the brachidial net in the spiriferid Spondylospira. *Palaeontographica*, Abteilung A, 233, 99–126.
https://doi.org/10.1127/pala/233/1994/99

Sandy, M,R. (2001) Mesozoic articulated brachiopods from the Western Cordillera of North America: their significance for palaeogeographic and tectonic reconstruction, palaeobiogeography and palaeoecology. *In:* Brunton, C.H.C., Cocks, L.R.M. & Long, S.L. (Eds.), *Brachiopods past and present*. *Systematics Association Special Vol. 63*. Taylor & Francis, London, pp. 394–410.

Sandy, M.R. & Stanley, G.D. (1993) Late Triassic brachiopods from the Luning Formation, Nevada, and their palaeobiogeographical significance. *Palaeontology*, 36, 439–480.

Schuchert, C. & LeVene, C.M. (1929) Brachiopoda (Generum et Genotyporum Index et Bibliographia). *In*: Pompeckj, J.F. (Ed.), *Fossilium Catalogus. I: Animalia. Part 42.* W. Junk, Berlin, pp. 1–140.

Schuchert, C. (1913) Class 2. Brachiopoda. *In*: von Zittel, K.A., *Text-book of Palaeontology. Vol. 1. Part 1. 2nd Edition, Translated and edited by C. R. Eastman*. MacMillan & Co., Ltd., London, pp. 355–420, fig. 526–636.

Siblík, M. (1967) n.k. *In*: *Ramenonozci noru z lokality Drnava. (Slovensky kras)*. Geologické práce, Bratislava, pp. 81–97, pls. I–IV.
Siblík, M. (1994) The Brachiopod Fauna of the Wetterstein Limestone of the Raxalpe (Austria). *Jahrbuch der Geologischen Bundesanstalt*, 137 (2), 365–381.
Siblík, M. (1999) On Carnian Brachiopods of the Gaisberg near Kirchberg in Tirol (Northern Calcareous Alps, Tyrol). *Abhandlungen der Geologischen Bundesanstalt*, 56 (2), 113–120.
Siblík, M. & Bryda, G. (2005) Brachiopods from the Upper Triassic reef habitats of the Northern Calcareous Alps (Dachstein Limestone, Hochschwab, Austria). *Rivista Italiana di Paleontologia e Stratigrafia*, 111 (3), 413–437. https://doi.org/10.13130/2039-4942/6329
Smith, J.P. (1927) Upper Triassic Marine Invertebrate Faunas of North America. *US Geological Survey Professional Paper*, 141, 1–262. https://doi.org/10.3133/pp141
Sowerby, J. de C. (1823–1825) *The Mineral Conchology of Great Britain. Vol. 5*. Published by the author, London, 168 pp.
Stelhi, F.G. (1965) Paleozoic Terebratulida *In:* Moore, R.C. (Ed.), *Treatise on Invertebrate Paleontology. Part H, Brachiopoda*. Geological Society of America, New York, New York and University of Kansas Press, Lawrence, Kansas, pp. 730–762.
Stevens, G.R. (2004) Hettangian-Sinemurian (Early Jurassic) ammonites of New Zealand. *Institute of Geological & Nuclear Sciences*, Monograph 23, *New Zealand Geological Survey paleontological bulletin*, 76, 1–107.
Stevens, G.R. (2012) Otapirian and Aratauran sequences (latest Triassic and earliest Jurassic) along the northern Marokopa coast (SW Auckland, New Zealand) and observations on the Triassic/Jurassic boundary in New Zealand. *New Zealand Journal of Geology and Geophysics*, 55 (1), 37–51. https://doi.org/10.1080/00288306.2011.615939
Sun, D.L., Xu, G.R. & Qiao, L. (2017) Triassic brachiopod genera on type species from China. *In*: Rong, J.Y., Jin Y.G., Shen S.Z. & Zhan R.B. (Eds.), *Phanerozoic Brachiopod Genera of China.* Science Press, Beijing, pp. 883–1011.
Torti, V. & Angiolini, L. (1997) Middle Triassic Brachiopods from Val Palina, Bergamasc Alps, Italy. *Rivista Italiana di Paleontologia e Stratigrafia*, 103 (2), 149–172. https://doi.org/10.13130/2039-4942/5287
Trechmann, C.T. (1918) The Trias of New Zealand. *Quarterly Journal of the Geological Society, London*, 73 (3), 165–246, 9 pl, map, sect. https://doi.org/10.1144/GSL.JGS.1917.073.01-04.10
Turnbull, I.M. & Allibone, A. (Compliers.) (2003) The geology of the Murihiku area. *Institute of Geological and Nuclear Sciences 1:250 000 Geological Map*, 20, 1–74, 1 folded map.
Waagen, W.H. (1882) Salt Range Fossils. I. Productus-Limestone Fossils. *Geological Survey of India, Memoirs, Palaeontologia Indica*, *S*eries 13, 4 (1), 329–390, pls. 25–28.
Waagen, W.H. (1883) Salt Range Fossils. I. Productus-Limestone Fossils. *Geological Survey of India, Memoirs, Palaeontologia Indica*, *S*eries 13, 4 (2), 391–546, pls. 29–49.
Wanner, J. (1956) Zur Stratigraphie von Portugiesisch Timor. *Zeitschrift der Deutschen Geologische Gesellschaft*, 108, 109–140. https://doi.org/10.1127/zdgg/108/1956/109
Waterhouse, B.C. & White, P.J. (1994) *Geology of the Raglan-Kawhia area. Institute of Geological & Nuclear Sciences 1:50,000 Geological Map 13*. Institute of Geological & Nuclear Sciences, Lower Hutt, 48 pp., 1 folded map.
Williams, A., Carlson, S.J., Brunton, C.H.C., Holmer, L.E. & Popov, L.E. (1996) A supra-ordinal classification of the Brachiopoda. *Philosophical Transactions of the Royal Society of London*, Series B, 351, 1171–1193, 6 figs. https://doi.org/10.1098/rstb.1996.0101
Wilckens, O. (1927) Contributions to the palaeontology of the New Zealand Trias. *New Zealand Geological Survey paleontological bulletin*, 12, 1–65.
Yang, T.Y. & Xu, G.R. (1966) *[Triassic Brachiopods of Central Guizhou (Kweichow) Province, China]*. Geological Publishing House, Beijing, 151 pp., 14 pls. [in Chinese with English summary]

Appendix A: Locality data

New Caledonian grid references are in terms of IGN72 Grand Terre – UTM Zone 58S
New Zealand grid references are in terms of New Zealand Mapping Grid (NZMG).
Zealandian Stage abbreviations: Bo – Otapirian, Ha - Aratauran, Hu - Ururoan, Kt -Temaikan
"Probable" identifications are indicated by a question mark in front of the collection number
Collections that are not registered in the Fossil Record File are listed with the NZMS260 map sheet number.

New Caledonia

FR Number	NCTM Easting	NCTM Northing	Locality	Stage	Collection no:	Collectors	Terebratulide species
NC/f0004A	607730	7563290	North île Hugon	Bo(L)	AU 7148	J.A. Grant-Mackie 13/10/1979	*Rhaetina rainei*
NC/f0005A	607720	7563010	North île Hugon	Bo(U)	AU 7146	J.A. Grant-Mackie 19/10/1979	*Rhaetina rainei* .
NC/f0007A	607870	7563170	North île Hugon	Bo(U)	AU 7149	J.A. Grant-Mackie 1979	*Rhaetina rainei* *Zeilleria* sp.
NC/f008A	607690	7562830	North île Hugon	Bo(U)	AU 7795	J.A. Grant-Mackie 19/10/1979	*Rhaetina rainei*
NC/f0010A	607960	7563100	North île Hugon	Bw-Bo	AU 7155	J.A. Grant-Mackie 14/10/1979	*Rhaetina rainei*
NC/f0018A	605680	7567350	North île Ducos	Bo(U)	AU 6074	J.A. Grant-Mackie 19/10/1979	*Zeilleria minima*
NC/f0020	605690	7567220	North île Ducos	Bo(U)	GS 12733	HJ Campbell 19/10/1979	*Rhaetina rainei*
NC/f0023	606080	7567050	North île Ducos	Bo(U)	GS 12736	HJ Campbell 19/10/1979	*Rhaetina rainei*
NC/f0050	608760	7565740	East île Ducos	Bo	GS 12763	HJ Campbell 24/10/1979	*Tibetothyris hamishi* *?Zeilleria spiculata*
NC/f0060A	607720	7566280	Baie des Moustiques, Ducos	Bo	AU 7214	J.A. Grant-Mackie 19/10/1979	*?Rhaetina rainei*
NC/f0087	605820	7563780	SW île Ducos		AU 6073	H.J. Campbell	*Rhaetina rainei*
NC/f0087A	605820	7563780	SW île Ducos	Bo(l)	AU 7168	J.A. Grant-Mackie 19/10/1980	*Tibetothyris hamishi* *Rhaetina rainei*
NC/f0109A	607710	7562110	Central north île Hugon	Bo(L)	AU 7165	J.A. Grant-Mackie 16/10/1979	*Tibetothyris johnstoni*
NC/f0503	607720	7563060	Northernmost slope île Hugon	Bo(L)	AU 7147	J.A. Grant-Mackie	*Rhaetina rainei*
NC/f0518	607780	7563130	île Hugon	Bo(U)	AU 7773	J.A. Grant-Mackie	*Rhaetina rainei*
NC/f0519	607810	7563070	île Hugon	Bo(L)	AU 7774	J.A. Grant-Mackie	*Rhaetina rainei*
NC/f1110	563200	7599200	Tribu Kere, Moindou	Ha	NC256	M. Wiley 17/12/1994	*?Zeilleria spiculata*

Kawhia Syncline

FR Number	NZMG Easting	NZMG Northing	Locality	Stage	Collection no:	Collector and date.	Terebratulide species
R15/f0182	2663000	6341500	N side Arataura	Bo	AU 12686	Z. Wangping, J.A. Grant-Mackie, Y. Jingshan, L. Xiaochi 3/12/1988	*Zeilleria spiculata*
R15/f0189	2663000	6341500	SW Kawhia Coast, N face of Arataura Point.	Bo	AU 12683		*Zeilleria spiculata*
R15/f8585	2662731	6341307	S of Arataura Point, S Kawhia	Bo	GS 6754	HC Arnould	*Lobothyris richardsi*
R15/f8834	2662912	6341257	S of Arataura Point, S Kawhia	Bo	AU 64	K.R. Martin 5/1965	*Zeilleria spiculata*
R15/f8837	2662865	6341212	S of Arataura Point, S Kawhia	Bo	AU 69	K.R. Martin 5/1965	*Tibetothyris hamishi*
R15/f8838	2662818	6341167	S of Arataura Point, S Kawhia	Bo	AU 70	K.R. Martin 5/1965	*Tibetothyris hamishi*
R16/f0337	2659836	6319805	Coast between Marokopa river mouth and Waipaua Stream	Bo	AU 12074	F. Hasibuan, J.A. Grant-Mackie, J.D.; Campbell, H.J. Campbell. 29/1/1986	*Tibetothyris hamishi* *Lobothyris richardsi*
R16/f6896	2660163	6326518	Coast north of Marokopa River	Bo	GS 10007	C.R. Lennie, B.E. Thomson 1/1967	*Lobothyris richardsi*
R16/f6898	2660110	6329492	South side of Anaputa Bay, north of Marokopa River	Bo	GS 10009	BE Thomson 1/1966, BE Thomson, CR Lennie 9/5/68	*Tibetothyris hamishi* ?*Lobothyris richardsi*
R16/ f6899A	2660202	6331090	South side of Parahaki Head, north of Marokopa River	Bo	GS 10010	C.R. Lennie, G.R. Stevens, B.E. Thomson, 9/5/1968	*Zeilleria minima*
R16/f8638	2659959	6320250	Coast between Marokopa river mouth and Waipaua Stream	Bo	GS 9993	C.R. Lennie, G.R. Stevens, B.E. Thomson, 10/5/1968	?*Lobothyris richardsi*.
R16/ f8640A	2660051	6320577	Outcrop forming bluff at mouth of Marokopa River	Bo	GS 10001	B.E. Thomson, N.T. Thomson, R.R. Thomson, 8/1969	?*Zeilleria spiculata*
R16/f8645	2659992	6325288	Headland N of Tauhua Stream, coast north of Marokopa River	Bo	GS 10006	C.R. Lennie, G.R. Stevens, B.E. Thomson, 1/1967	?*Tibetothyris hamishi*
R16/f8650	2659997	6325471	Headland N of Tauhua Stream, coast north of Marokopa River	Bo	GS 10037	B.E. Thomson 1/1967	*Lobothyris richardsi* *Zeilleria spiculata*
R16/ f8877A	2663000	6314200	Pomarangai Rd NE of Moeatoa	Bo	AU 8987	J.A. Grant-Mackie, N. Hudson. 17/1/1982	*Tibetothyris hamishi*

......*Continued on the next page*

Kawhia Syncline (Continued)

FR Number	NZMG Easting	NZMG Northing	Locality	Stage	Collection no:	Collector and date.	Terebratulide species
R17/f8574	2657433	6280089	North bank Awakino River, in lower gorge	Bo	JAG-M 37 AU 341	J.A. Grant-Mackie 2/1956	*Lobothyris richardsi*
R18/f6562	2657520	6279904	Awakino Gorge, road cutting on sharp corner	Bo	JAG-M 20 AU 326, 386	J.A. Grant-Mackie 10/1955	*Zeilleria spiculata, Lobothyris richardsi,* *Zeilleria minma*

Nelson

FR Number	NZMG Easting	NZMG Northing	Locality	Stage	Collection no:	Collector	Terebratulide species
N28/f0045	2509300	5968999	West side Ram Creek valley	Bo	PGS 40	P.G Scadden 16/5/1978	*Tibetothyris johnstoni Rhaetina rainei*
N28/f0045	2509300	5968999	West side Ram Creek valley	Bo	McF D21	D.A.B. MacFarlan 6/12/1979	*Rhaetina rainei*
N28/f7454	2509003	5968482	Trigonia beds, Eighty-eight Valley.	Bo	GS 196	A. McKay 19/3/1878	*Tibetothyris johnstoni Rhaetina rainei Zeilleria minima*
N28/f7455	2509003	5968482	'Spiriferina beds' Eighty-eight Valley, Nelson.	Bo	GS 197	A, McKay, 1878	*Rhaetina rainei*
N28/f7860	2509088	5968821	Hillside track north of Ram Ck	Bo	AU 7885	JA Grant-Mackie 7/1/1967	*Rhaetina rainei*
N28/f7864	2509039	5968967	Hillside track north of Ram Ck, boulders	Bo	AU 6521	JA Grant-Mackie 8/1/1967	*Rhaetina rainei*
N28/f7522	2508996	5968847	West side of Ram Hill	Bw-Bo	GS 4559	H.W. Wellman, D. Hamilton 1/1948	*Rhaetina rainei*

Southland Syncline

FR Number	NZMG Easting	NZMG Northing	Locality	Stage	Collection no:	Collector & Date	Terebratulide species
E44/f8637	2134071	5477895	Sunnyvale, South Taringaturas	Bw	JDC 655	JD Campbell 4/1950	*Zeilleria minima*
E45/f0073	2161000	5460099	Taylors Stream, Otapiri Vly	Bo	McF E29	D MacFarlan, J.G.G. Morton 22/1/1980	*Lobothyris richardsi*
E45/f0279	2161500	5459399	Taylors Stream, Otapiri Vly	Bo	JDC 4059	J.D. Campbell 25/4/1993	*Tibetothyris hamishi* *Lobothyris richardsi* *Zeilleria spiculata*
E45/f6635	2140152	5469593	South Taringatura Hills	Bo	JDC 241	J.D. Campbell 24/5/1993	*Tibetothyris johnstoni* *Lobothyris richardsi* *Zeilleria minima*
E45/f7484	2150403	5468580	Oreti Railway Cutting, Dipton	Bo	GS 372	A McKay 1878	?*Rhaetina rainei*
E45/f9462	2161984	5459275	East Branch, Taylors Stream, Otapiri Vly	Bo	GS 359	A McKay 27/3/1878	?*Lobothyris richardsi*
E45/f9578	2149286	5464449	Benmore railway cutting	Bo	JDC 730	J.D. Campbell 1/1954	?*Lobothyris richardsi*
E45/f9621	2159000	5461999	Otapiri Stream above Taylors Stream	Bo	JDC 1295	J.D. Campbell 13/5/1987	*Lobothyris richardsi*
E45/f9622	2158754	5461139	Otapiri Stm, downstream of Taylors Crossing	Bo	JDC 1296	I.C. McKellar, J.D. Campbell, 27/1/1955	*Tibetothyris hamishi* *Zeilleria spiculata*
E45/f9910	2160589	5460713	Outcrop north of NW branch Taylors Stream		JDC 2095	J.D. Campbell, B.R.Paterson 18/6/1965	*Lobothyris richardsi*
F45/f0217	2183500	5454599	South of Waterfall Creek, Otamita Valley	Bo	EW coll	E Wright 12/4/1989.	*Lobothyris richardsi*
F45/f0329	2186700	5452699	Dolamore Park to Otamita Downs road	Bo	JDC 4216	J.D. Campbell, S.R. Owen 21/10/1992	*Tibetothyris hamishi*
F45/f8523	2186681	5452658	Roadside, Waimumu Valley	Bo	GS 5188	A.C.Beck, B.L. Wood 16/8/1948	*Tibetothyris hamishi*