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Latest Triassic and Early Jurassic Spiriferinida (Brachiopoda) of Zealandia (New Zealand and New Caledonia)

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Abstract

The Late Triassic spiriferinides of Zealandia include the endemic or Austral genera *Rastelligera*, *Psioidea* and *Psioidiella*, and the cosmopolitan *Zugmayerella. Mentzelia kawhiana* is revised and placed in *Callospiriferina*. It appears in the late Rhaetian and is found in the Téremba Terrane in New Caledonia and throughout the Murihiku Terrane in New Zealand. The spiriferinides were severely affected at the Triassic–Jurassic boundary in Zealandia as elsewhere, but a moderately diverse fauna developed in the Early Jurassic. This has strong links to South America, and affinities with southern Europe and North Africa. In this study, a total of six species of Jurassic spiriferinides are recognised. *Callospiriferina ongley* is present in middle and late Hettangian and Sinemurian faunas. It is succeeded in the Pliensbachian and early Toarcian by *Callospiriferina radiata*. Two species of *Spiriferina* are recognised. *S. sophiaealbae* **n. sp.** first appears in the Middle Hettangian and is present in the Southland and Kawhia Synclines until the early Toarcian. *S. arakiwa* **n. sp.** is found mainly on the southwest limb of the Southland Syncline in the Pliensbachian and early Toarcian. The non-costate European genus *Cisnerospira* is represented in Zealandia by the small *C. antipoda* **n. sp.** This species ranges from Hettangian to early Toarcian. Two specimens of a spiriferinide with a costate sulcus are tentatively identified as *Dispiriferina* sp. cf. *D. chilensis*. The highest stratigraphic level at which Zealandian spiriferinides have been found is that of the *Dactylioceras* band at Kawhia, which is correlated with the Crassum Subzone of the Bifrons Zone (highest Early Toarcian) and includes three species of spiriferinide. This suggests that the Zealandian spiriferinides survived the Toarcian Event, only to meet their demise slightly later.

Key words: New Zealand, New Caledonia, Zealandia, Brachiopoda, Spiriferinida, Early Jurassic, Murihiku Terrane, Téremba Terrane

This paper is intended as a detailed systematic account of the spiriferinide faunas of Zealandia from the end-Triassic extinction event to the group's final demise in the Toarcian. It is part of the author's survey of Zealandian Jurassic brachiopods, along with the work on rhynchonellides (MacFarlan 1992) and terebratulides (MacFarlan & Campbell 2003, MacFarlan 2016, 2019). The Late Triassic species described as *Mentzelia kawhiana* (Trechmann, 1918) is revised as it appears to belong to the same genus as two Jurassic species.

Previous work

Hector (1886) figured and named *Spiriferina radiata* but did not provide a description. Trechmann (1918) described *Mentzelia kawhiana* and *Mentzelia* cf. *ampla* Bittner, 1890 from the Late Triassic of the Te Maika Peninsula. Trechmann (1923) described *Spiriferina* (?) sp. from Ben Bolt, which he considered to be "a degenerate survivor of one of the Spiriferids of the Triassic" (p. 286).

Marwick (1953) described *Spiriferina ongleyi* from the Aratauran of Ben Bolt and described and designated a neotype for *Spiriferina radiata* Hector, 1886. Wright & Campbell (1990) recognised that *Mentzelia kawhiana* and *Spiriferina ongleyi* are congeneric and suspected that they may form a lineage. Damborenea & Manceñido (1992) compared the Jurassic molluscan and brachiopod faunas of New Zealand with those from Argentina, commented on the similarities of *S. ongleyi* and *S. radiata* to Argentinian forms, and recorded *Spiriferina* cf. *muensteri* (Davidson,

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1851) from both areas. Grant-Mackie *et al.* (2000) included both *S. ongleyi* and *S. radiata* in *Mentzelia*, and MacFarlan *et al.* (2009) listed a total of five species of spiriferinide from the New Zealand Jurassic.

Methods

Methods and taxonomic approach are generally those applied in MacFarlan (1992, 2016 and 2019). The measurement scheme is that of Manceñido (1981) (Fig. 1). All suitable specimens were measured and catalogued in the relevant specimen catalogue. Preliminary measurement data for all specimens are presented in MacFarlan (2021). Specimens with valid length (Ld or Lv) and width data were used in plotting graphs and for statistics. Working photos were taken where required. No serial sections were made as nearly all the specimens are moulds, and most are of single valves.

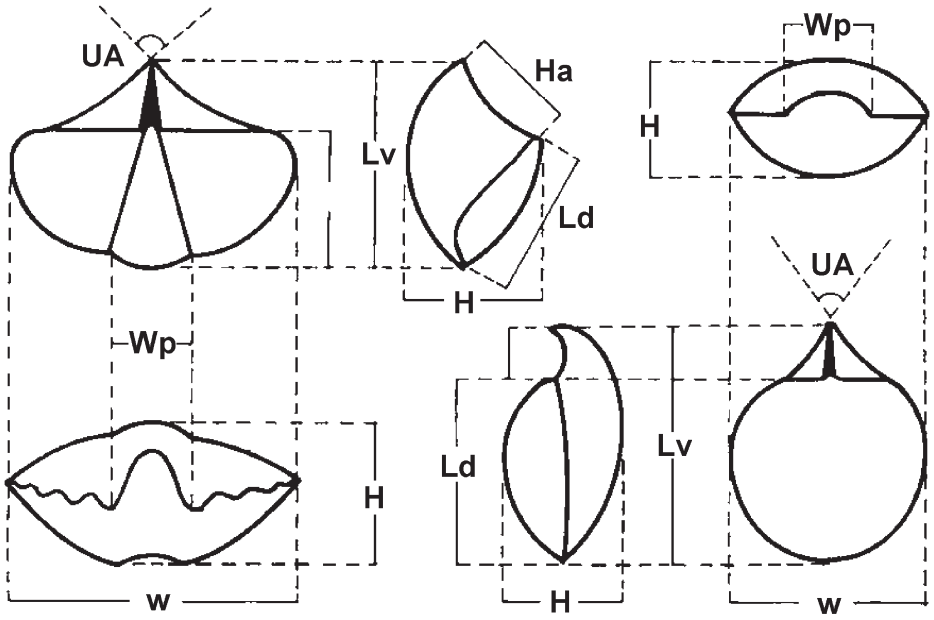


FIGURE 1. Measured dimensions (after Manceñido 1981).

Classification

Classification and morphologic terminology follow the revised Brachiopoda volumes of the Treatise on Invertebrate Paleontology (Kaesler, 1997–2007). 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).

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 spiriferinide 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 of Otago Department Department of Geology, 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.

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

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 (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).

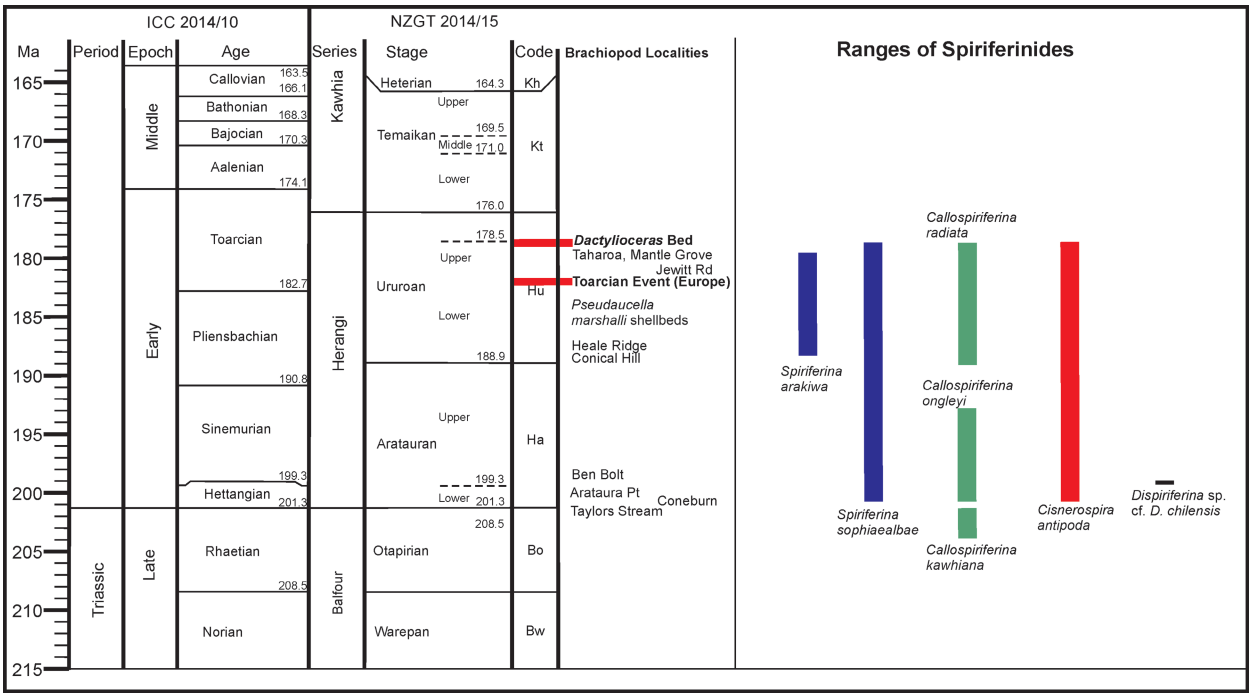


FIGURE 2. Late Triassic—Middle Jurassic timescale and range chart showing correlations between New Zealand and international stages (adapted from Raine *et al.* 2015) and ranges of Zealandian spiriferinide species.

Geographic and Stratigraphic Setting

The material described here comes from sedimentary successions within the Téremba Terrane on the west coast of New Caledonia (Campbell *et al.* 1985, Aitchison *et al.* 1995, Maurizot *et al.* 2020) and the Kawhia, Nelson and Southland Synclines within the Murihiku Supergroup, Murihiku Terrane (Campbell *et al.* 2003, Mortimer *et al.* 2014, Campbell 2019). The close faunal similarity between New Caledonian and New Zealand Triassic and Jurassic faunas has long been recognised (Campbell and Grant-Mackie 1984, Grant-Mackie *et al.* 2000, Maurizot & Campbell 2020). Macrofossils are rare in Otapirian and Early Jurassic parts of the Rakaia and Pahau terranes, and spiriferinides have not been recorded.

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, Campbell 2019, Mortimer *et al.* 2020).

Latest Triassic and Early Jurassic stratigraphy of these areas is summarised below. Early Jurassic biostratigraphy is discussed in more detail by MacFarlan (2019).

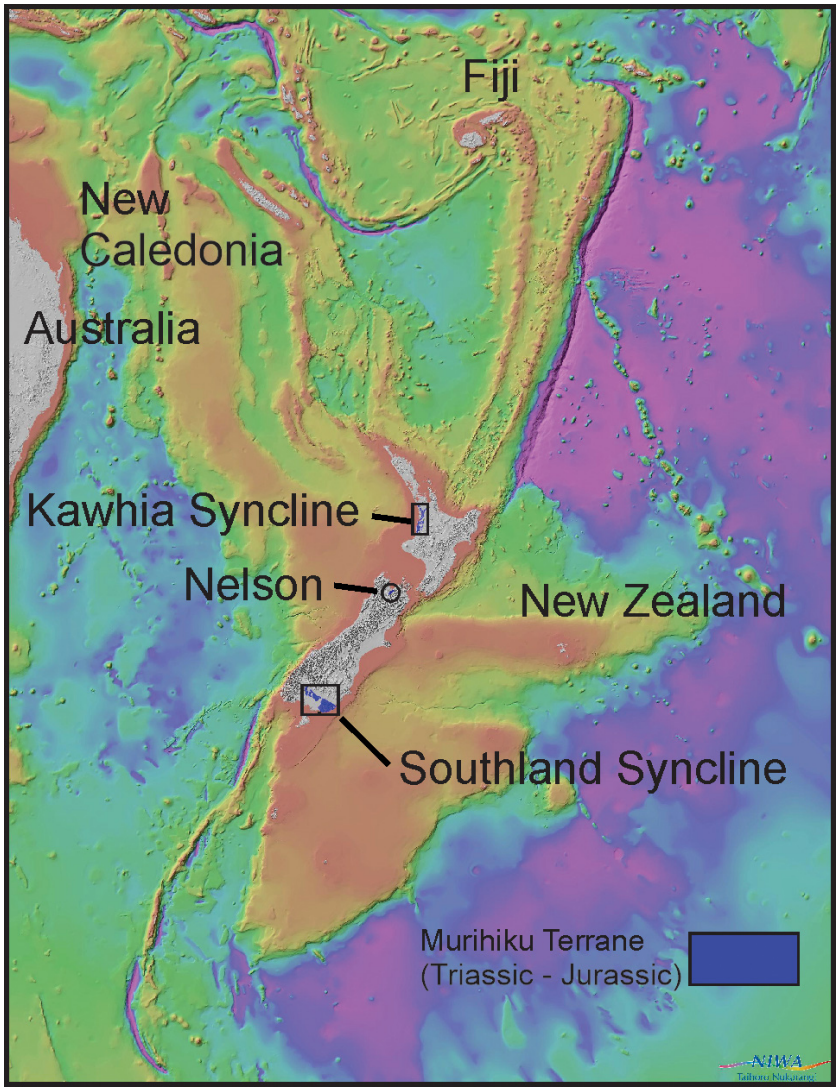


FIGURE 3. Zealandia, showing the area of submerged continental crust surrounding New Zealand and extending to New Caledonia. Murihiku Supergroup in blue, with the small area of Murihiku in Nelson circled. Areas of Fig. 4B and C indicated. Base map: NIWA (National Institute of Water and Atmospheric Research).

New Caledonia

Otapirian and Early Jurassic rocks outcrop extensively in the Baie de St Vincent on the west coast of New Caledonia, notably on the islands of Hugon and Ducos and the Uitoé Peninsula (Paris 1981, Fauré *et al.* 1982) (Fig. 4A) and in the Moindou area and Baie de Téremba (Paris 1978) to the north (Campbell & Grant-Mackie 1984, Campbell *et al.* 1985). Spiriferinides are moderately common in the Otapirian but are rare in the Aratauran and Ururoan. They are recorded from one Aratauran and one Ururoan locality on Uitoé Peninsula and two Aratauran localities on île Mara.

Kawhia Syncline

The Kawhia Syncline is exposed from Port Waikato southwards to Awakino (Fig. 4B) but no spiriferinides have been found north of Kawhia. Key sections (Fig. 5A) are on Te Maika Peninsula on the south side of Kawhia Harbour (Marwick 1953, Martin 1975, Waterhouse & White 1994). Ururoa Point, between the south wall of the "Hole in the Wall" and the *Dactylioceras* band is an important area for the Upper Ururoan. The ammonite *Catacoeloceras grangei* Stevens, 2008 from R15/f8005 allows the *Dactylioceras* band to be correlated with the Crassum Subzone (top of the Early Toarcian) (Stevens 2008). This ammonite was identified by Spath (1923) as *Dactylioceras*. Spiriferinides are rare in the Aratauran and Ururoan below this.

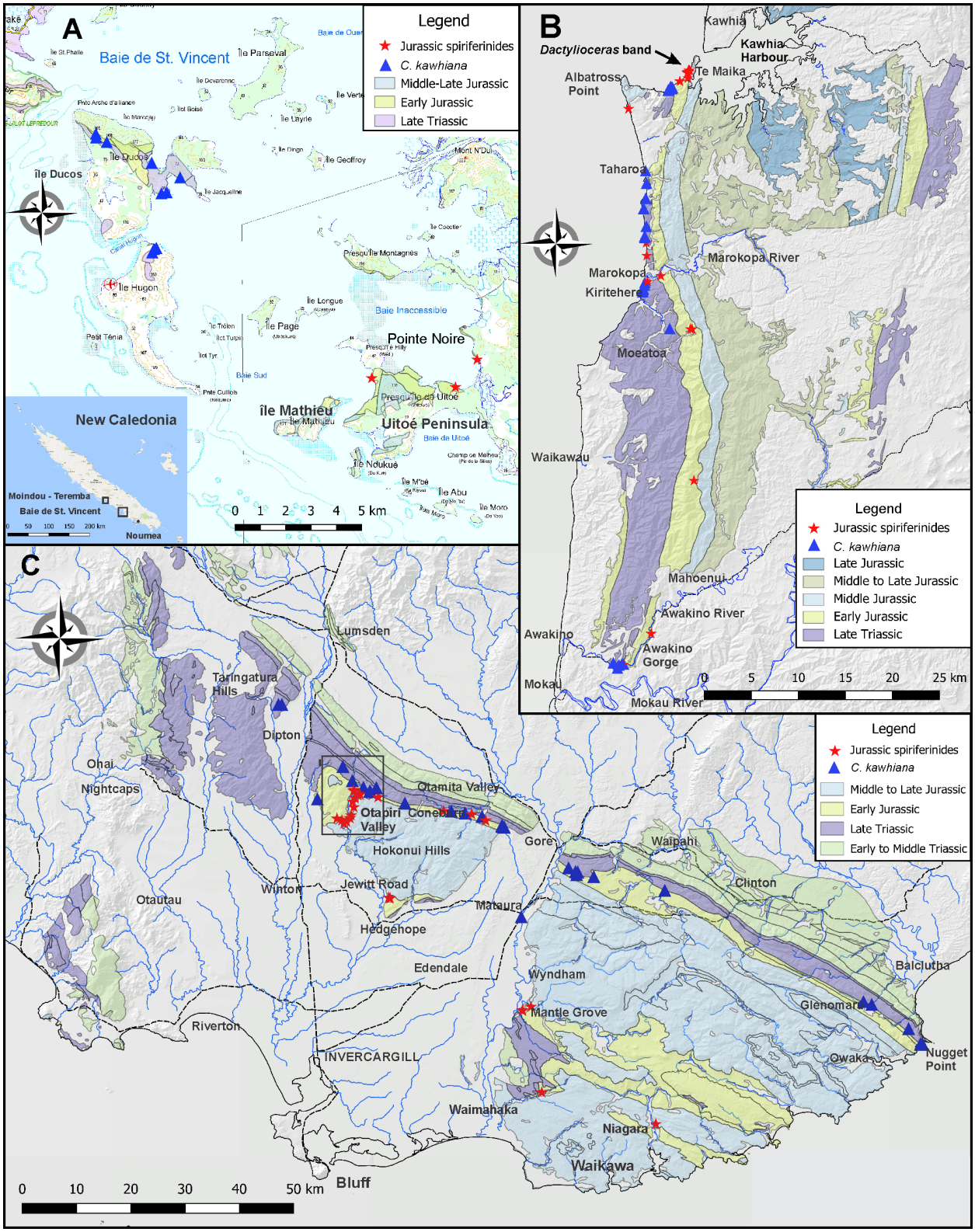


FIGURE 4. Main areas of Triassic–Jurassic strata in this study: **A** Baie de St Vincent, New Caledonia, with areas of Late Triassic and Jurassic rocks indicated. Base and geology from Gouvernment de Nouvelle-Calédonie data. Inset: New Caledonia showing area of Figure 4A and location of Moindou-Téremba area. **B** Southern Kawhia Syncline, southwest Auckland, showing Kawhia Syncline, with areas of Late Triassic and Jurassic rocks indicated. Main spiriferide localities shown. **C** Southland, showing extent of Southland Syncline. Rectangle shows Otapiri Valley (Fig. 5B). Base for B and C: LINZ (Land Information New Zealand) topographic data with geology from GNS Science (Institute of Geological Sciences) 1: 250,000 geological map (Q-Map) (Edbrooke *et al.* 2014, Heron 2014).

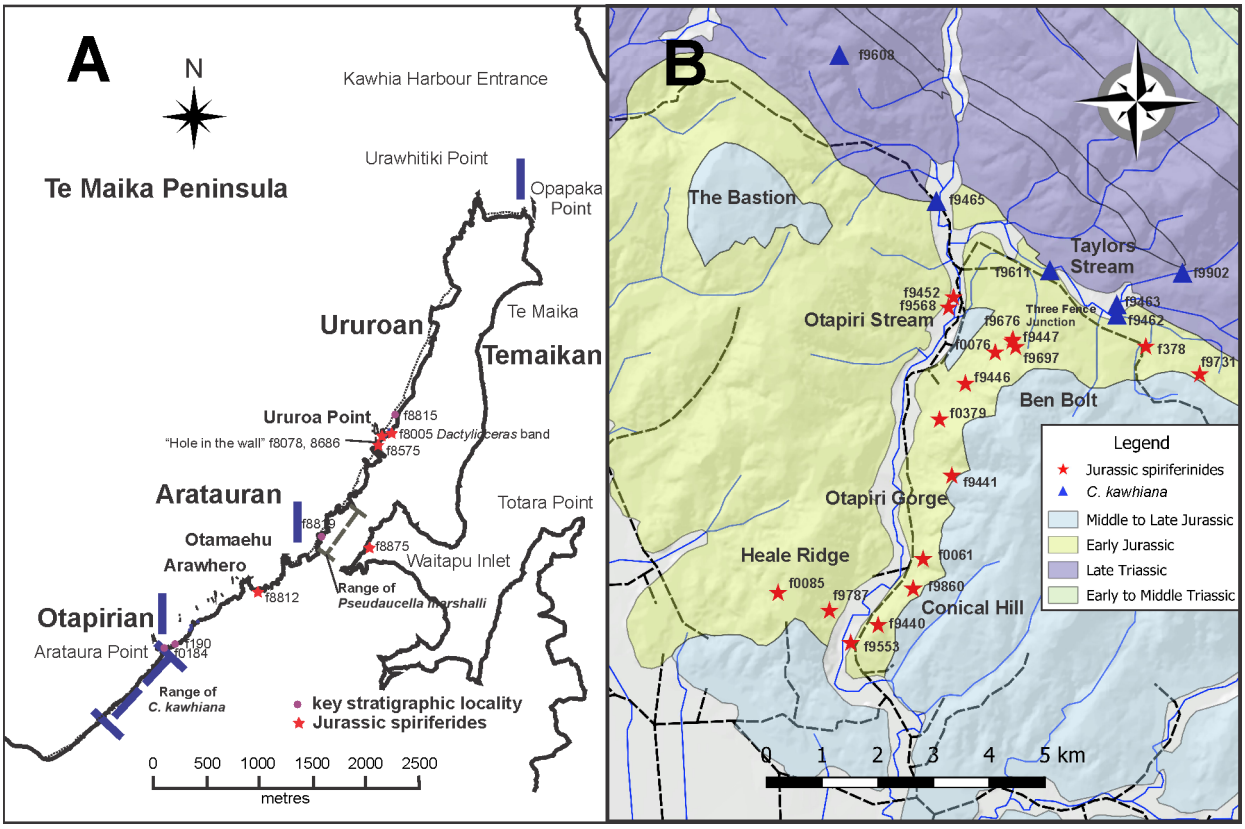


FIGURE 5. A: sketch map of Te Maika Peninsula, Kawhia. Geology from Martin (1975). Spiriferide locality numbers are FR numbers with initial R15/ omitted. **B**: Otapiri Valley, Hokonui Hills, with areas of Triassic and Jurassic rocks indicated. Base: LINZ data with geology from GNS Science Q-Map. Spiriferinide locality numbers are FR numbers with initial E45/ omitted.

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

Latest Triassic and Early Jurassic rocks are well-exposed on the coast north of Marokopa (Stevens 2012a), between Kiritehere and Marokopa (MacFarlan 1998), and in the Awakino Gorge (Grant-Mackie 1959, Zhang & Grant-Mackie 2001, Grant-Mackie 2011). Spiriferinides are present throughout the latest Triassic in these areas, and there are a few scattered records in the Early Jurassic.

Nelson

Otapirian strata are present in Nelson (Campbell 1974, Johnston 1982, 1983, Rattenbury *et al.* 1998). Spiriferinides are found both in the northern part of the syncline northeast of Richmond and the Eighty-eight Valley and Highfield areas in the southern part of the Nelson Syncline. No Early Jurassic faunas are known.

Southland

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) (Turnbull & Allibone 2003, Bishop & Turnbull 1996). The Early Jurassic is present but is less fossiliferous. It is overlain diachronously by very shallow marine to non-marine sediments with belemnites and rare rhynchonellides of lower Temaikan (late Toarcian to Aalenian) age (Hudson 2003, Challinor & Hudson 2017).

Otapiri Valley The most complete (but not continuous) Arataurán to Lower Ururoan section is in the Otapiri Valley (Fig. 5B) in the western Hokonui Hills (McKellar 1968, 1977), where ammonite work (Stevens 2004) allows the recognition of several zones within the Hettangian and Sinemurian. Spiriferinides appear to be absent in the Early Hettangian in Taylors Stream (Planorbis Zone and possibly below).

The earliest Jurassic spiriferinides in this section appear to be from E45/f9452 and E45/f9568 in the Otapiri Stream. Stevens (2004) identified the Late Hettangian (Angulata Zone) ammonites *Ectocentrites* cf. *petersi* Hauer and *Phylloceras psilomorphum* Neumayr from this locality.

Spiriferinides, especially *S.. ongleyi*, (here placed in *Callospiriferina* Rousselle 1977) are common at several localities on Ben Bolt (latest Hettangian and basal Sinemurian). The type locality of *C. ongleyi* (E45/f9446) is on the west face of Ben Bolt, and several localities (notably E45/f9447, E45/f9676 and E45/f9697) on the northwest face in the vicinity of the "three fence junction" (Fig. 5b).

Higher in the sequence, shallow marine beds at Conical Hill (E45/f9860) and Heale Ridge (E45/f085) have yielded large numbers of spiriferinides, mainly *S. radiata* (also placed in *Callospiriferina.* These are inferred to be basal Ururoan and include a diverse rhynchonellide and terebratulide fauna (MacFarlan 1992, 2019) which suggests a nearshore fauna as described by MacFarlan (1992). Most spiriferinides in the Ben Bolt and Otapiri sections are found as single valves.

Otamita Valley Aratauran beds in the Otamita Valley are more poorly exposed than in the Otapiri to the west. F45/f8683 in the Coneburn, a tributary of the Otamita Stream, has yielded *Otapiria marshalli* (Trechmann 1923) and the Middle Hettangian ammonites *Kammerkarites frigga* (Wähner) and *K. megastoma* (Gümbel) (Stevens 2004), together with three of the spiriferinide species described here. This appears to be the earliest Jurassic spiriferinide locality in Zealandia.

Jewitt Road 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 spiriferinide and terebratulide brachiopods. The ammonite *Zugodactylites braunianus* (d'Orbigny) indicates an Early Toarcian age (Stevens 2008).

Waimahaka Collections from 5m above the top of the Glenham Porphyry south of Crighton Road, east of Waimahaka are of Lower Ururoan age (Coombs *et al.* 1992) and include the Ururoan marker bivalve *Pseudaucella marshalli* (Trechmann).

Waikawa Valley A disused quarry in the Waikawa Valley north of Niagara (G47/f8523) has yielded a small but diverse Ururoan fauna including *Pseudaucella marshalli*, the rhynchonellide *Aucklandirhynchia sexagesimae* MacFarlan 1992 and spiriferinides.

Systematic Palaeontology

Introduction

Formal classification follows Carter (2006).

The order Spiriferinida appeared in the earliest Devonian, later than their impunctate counterparts the Spiriferida (Carter & Gourvennec 2006, Carlson 2016). The Spiriferida were a major group in the Palaeozoic but were badly affected by the Permian–Triassic crisis. They lingered into the earliest Triassic (Chen *et al.* 2005, He *et al.* 2012, Waterhouse 2016). The Spiriferinida diversified in the Triassic and reached their acme as one of the major groups of brachiopods in the Middle and Late Triassic (Guo *et al.* 2020). They declined in the Rhaetian and were nearly extinguished at the end of the Triassic. The few genera present in the Jurassic disappeared by the Toarcian.

Jurassic spiriferinides were assigned to *Spiriferina* d'Orbigny until the mid 20th century, and often later (for example Rollier 1916 and Ager 1987). Jiménez de Cisneros (1921) suggested a four-part subdivision for Spanish Subbetic Basin species and showed a rather complex diagram of the relationships between species. Corroy (1927, p. 6, my translation) divided the spiriferinides of the European Early Jurassic into four groups:

I Group of non-costate spiriferinides: Type *Spiriferina alpina* Oppel.
II Group of spiriferinides with barely visible costae: Type *Spiriferina tumida* von Buch.
III Group of spiriferinides with strong costae: Type *Spiriferina walcotti* Sowerby.
IV Group of multicostate spiriferinides. Type *Spiriferina quenstedti* Rollier.

Members of all four of these groups can be recognised within the Zealandian Early Jurassic.

Siblík (1965) described the new genus *Dispiriferina* for the multicostate spiriferinides, with *Spiriferina davidsoni*

Deslongchamps, 1855 as type species. *S. quenstedti* is listed by Alméras (1964) and discussed by Alméras & Fauré (2000), who retained it in *Spiriferina*.

Rousselle (1977) completed the formalisation of Corroy's groups by describing *Liospiriferina*, with *L. rostrata* as type and *Callospiriferina* with *C. tumida* as type. She synonymised *Spiriferina alpina* (Oppel, 1861) with *L. rostrata* (von Schlotheim, 1822), but *S. alpina* was retained as a separate species by Siblík (1993) and subsequent authors. Manceñido (2004) reviewed earlier work, especially that of Jiménez de Cisneros, and described the new genus *Cisnerospira*. Baeza-Carratalá *et al.* (2016) reviewed this genus and its included species in the western Tethys and assigned it to the subfamily Paralaballinae.

He *et al.* (2015), working on Anisian spiriferinides, modified the subfamily and family-level classification of Carter (2006) and included *Liospiriferina* in their new subfamily Quinghaispiriferininae. A later phylogenetic analysis of Mesozoic spiriferinides by Guo *et al.* (2020) presented several possible relationships but did not revise the classification, so Carter's 2006 classification is used here, with *Cisnerospira* retained in the Paralaballidae as in Baeza-Carratalá *et al.* (2016).

Order SPIRIFERINIDA Ivanova, 1972

Suborder SPIRIFERINIDINA Ivanova, 1972

Superfamily SPIRIFERINOIDEA Davidson, 1884

Family SPIRIFERINIDAE Davidson, 1884

Subfamily SPIRIFERININAE Davidson, 1884

Spiriferina d'Orbigny, 1847

1847 *Spiriferina* d'Orbigny, p. 268.
1877 *Spiriferina* d'Orbigny, 1847; Dall, p. 65.
1965 *Spiriferina* d'Orbigny; 1847; Pitrat, p. 711.
1989 *Spiriferina* d'Orbigny, 1847; Cooper, p. 67.
2006 *Spiriferina* d'Orbigny, 1847; Carter, p. 1930.
2013 *Spiriferina* d'Orbigny, 1847; Alméras & Cougnon, p. 25.

Type Species. *Spirifer walcotti* J. de C. Sowerby, 1823 SD Dall, 1877, p. 64.

Spiriferina is used here for strongly ribbed spiriferinides with a narrow V-shaped sulcus and fold, which are close to the type species, *Spiriferina walcotti*, and to *S. muensteri* (Davidson 1851). The alternative view is that the type species should be the unribbed *Terebratulites rostratus* von Schlotheim 1822, which means that the non-costate *Liospiriferina* Rousselle, 1977 is an objective synonym of *Spiriferina*. The issue is summarised by Baeza-Carratalá *et al.* (2016), who follow the revised Treatise on Invertebrate Paleontology (Carter 2006) in retaining *S. walcotti* as type species, and this is followed here.

In this sense, *Spiriferina* is known from the Jurassic of Britain (Sowerby 1823, MacKinnon 1974, Ager 1994), Western Europe (Alméras & Cougnon 2013), Austria (Siblík 1999) Bulgaria (Tchoumatchenko 1996), Algeria (Alméras *et al.* 2007), Morocco (Rousselle 1977), Greenland (Rosenkrantz 1934) and Argentina (Manceñido 1981, Damborenea & Manceñido 1992). *Spiriferina retziaeformis* Wanner & Knipscheer 1951 from the Early Jurassic of the Indonesian island of Seram is small and strongly costate with a high beak on the ventral valve. It also appears to belong to *Spiriferina* as understood here. World distribution of *Spiriferina* and of other Jurassic spiriferinide genera recognised from Zealandia is shown in Fig. 6.

Two Zealandian species are included in *Spiriferina*, one of moderately large size and one small.

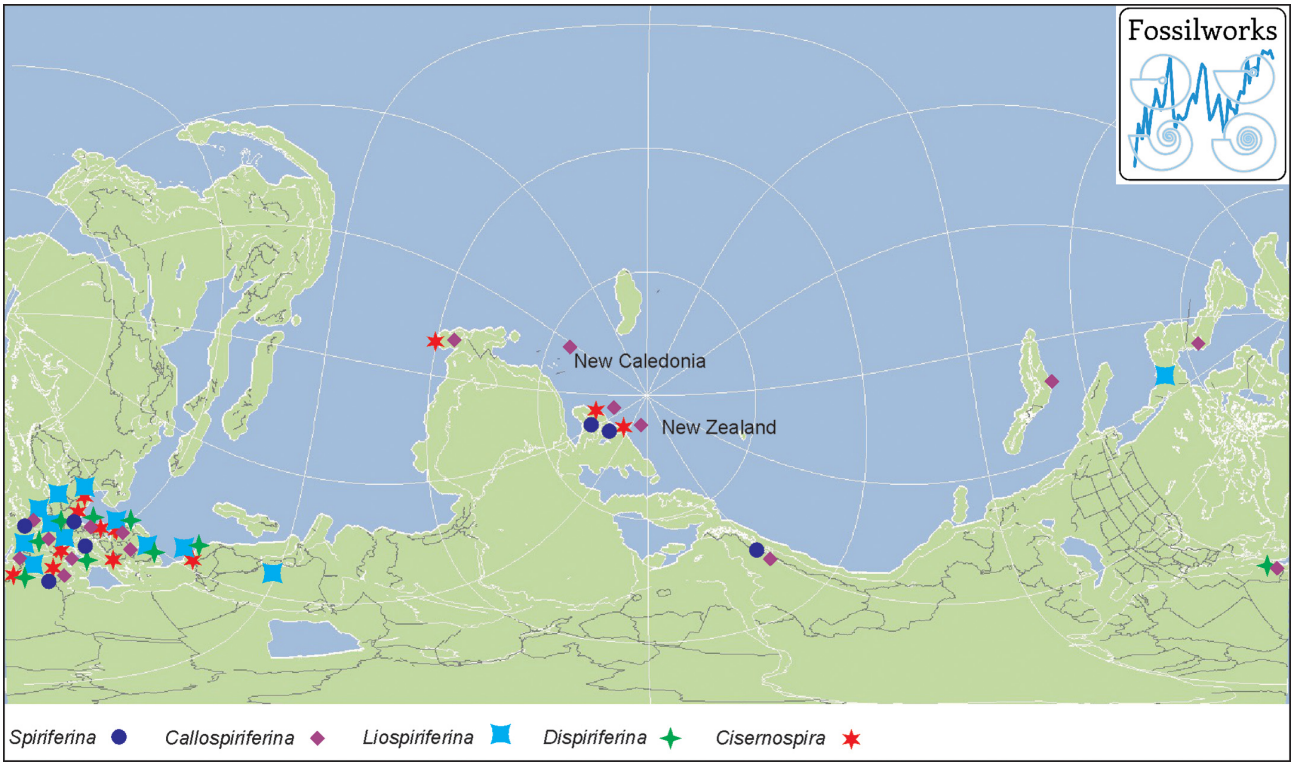


FIGURE 6. World distribution of spiriferinide genera. Data from Fossilworks (downloaded 2 April 2020) and relevant literature. Base maps from Alroy (2013). Online paleogeographic map generator. http://paleodb.org/?a=mapForm Maps drawn on equirectangular projection for 185 ma, focal co-ordinates -80°, 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 this map are approximate.

Spiriferina arakiwa new species

Fig. 7: 1–13, Fig. 8A.

2009 *Spiriferina* n. sp. B; MacFarlan *et al.* p. 266.

Holotype. OU 15292, a double-valved internal mould and partial external, from H46/f056, McF H25, Jewitt Road, southern Hokonui Hills. Collected by J.D. Campbell and the author, 9 March 1982. The specimen is distorted.

Derivation of name. Ara-a-kiwa (the whales' way) is the Māori name for Foveaux Strait between the south coast of the South Island and Stewart Island or Rakiura. The new species is present in several localities along the southern limb of the Southland Syncline close to the strait. The name arakiwa is proposed as a noun.

Material. A total of 21 specimens were catalogued from seven collections, of which 15 yielded valid measurements.

Kawhia Syncline. Taharoa: R16/f6811 (AU154).

Southland Syncline. Otapiri Valley: Conical Hill E45/f8960 (JDC 1837), E45/f0061 (McF C9).

Heale Ridge: E45/f0085 (McF E49). Jewitt Road, S. Hokonui Hills: E46/f0056 (McF H25). Crighton Road, Waimahaka: F47/f0013 (JDC 3796). Waikawa Valley: G47/f6523 (GS 7061).

Description. Medium sized spiriferinide, wider than long (most specimens with ventral valve 10–24 mm long, 10–32mm wide). Hingeline long, straight with rounded cardinal extremities, rounded flanks and anterior margin. Maximum width in posterior part of valves. Dorsal valve moderately convex, ventral valve more inflated with wide area and distinct sharply rounded apex. Ventral interarea flat, broadly triangular. Narrow, well-developed angular fold in dorsal valve, corresponding v-shaped sulcus in ventral valve. Flanks of each valve with 4 to 5 strong costae with rounded crests and troughs. Anterior commissure deflected by narrow uniplication. Shell coarsely punctate.

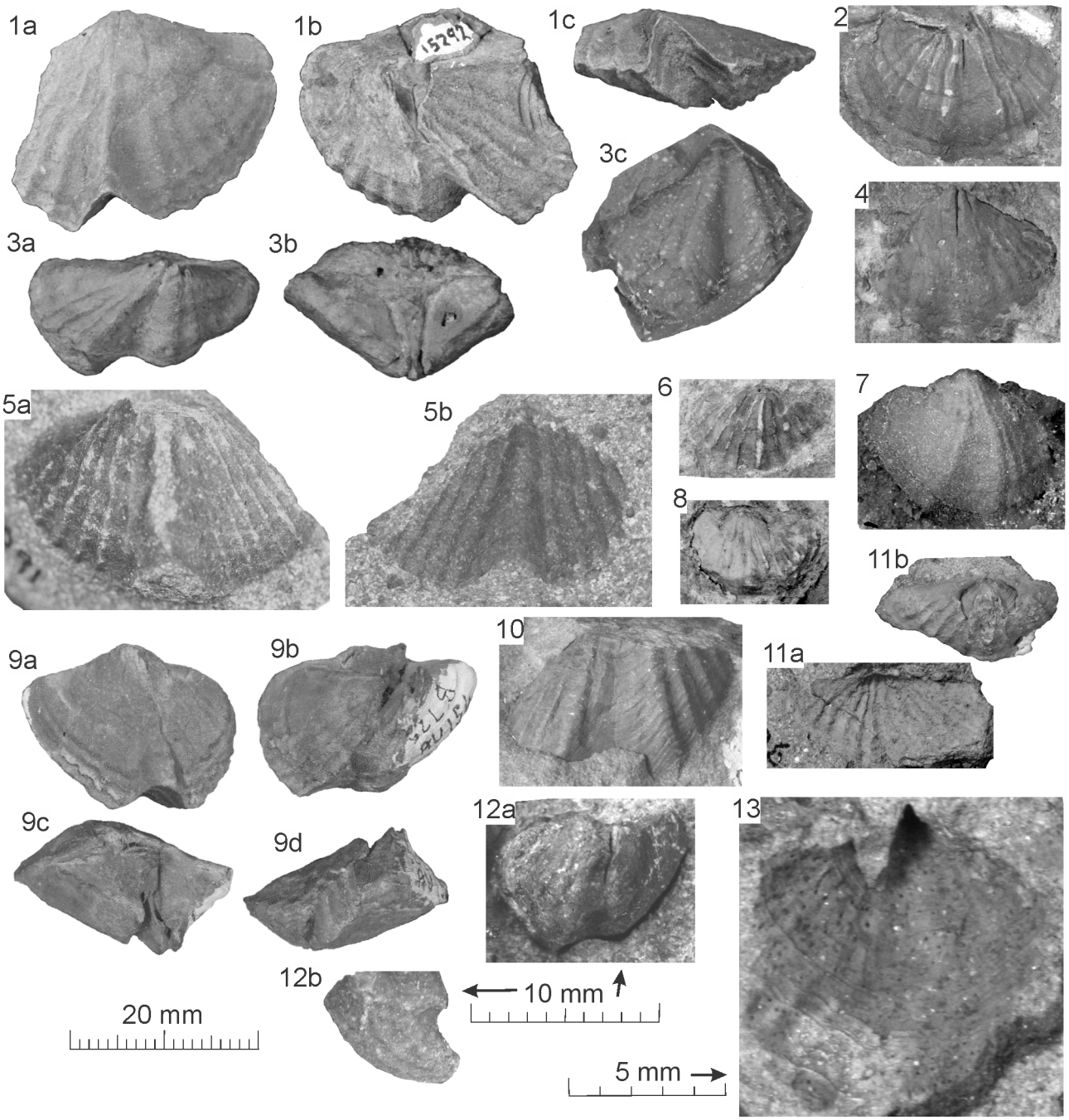


FIGURE 7. *Spiriferina arakiwa* **n. sp.** (1–11 x1.5, 12 x3, 13 x5). 1 Holotype OU 15292 (E46/f056) internal mould, distorted. (a) dorsal (b) ventral (c) anterior. 2 AU B727 (R15/f6811) internal mould, ventral. 3 OU 47250 (E45/f085) (a) ventral (b) posterior (c) latex of ventral exterior. 4 OU 46850 (E45/f9860) internal mould of ventral valve. 5 BR3297 (G47/f6523) internal and external mould of dorsal valve (a) interior (b) exterior. 6 OU 47244 (F47/f0013) internal mould of dorsal valve. 7 OU 47276 (E45/f0061) latex of external mould, ventral valve. 8 OU 46831 (F47/f0013) internal mould of dorsal valve. 9 AU B728 internal mould (a) dorsal (b) ventral (c) posterior (d) anterior. 10 OU 47279 (E45/f0076) partial internal of ventral valve. 11 OU 46832 (F47/f0013) mould of dorsal valve (a) exterior (b) oblique view of interior to show hinge and sockets. 12 OU 47225 (E45/f0061) ventral valve (a) ventral view of internal mould (b) latex of exterior, lateral (x3). 13 OU 46871 (E45/f9860) external mould of ventral valve, showing spine bases (x5).

Concentric ornament of foliaceous growth lamellae on both valves, stronger and more closely spaced near the anterior margin. Some specimens show the bases of widely spaced spines, which are more closely spaced near the anterior margin (Fig. 7.13, Fig. 8A). Other specimens do not show spines, possibly as a result of wear. Spines are poorly shown on the holotype, but a few show small matrix plugs indicating that they are hollow and tubular.

Internal Characters Dorsal valve with broad, thin concave hinge plates and small, close-set sockets (Fig. 7.11b). Cardinal process small, not prominent. Ventral valve with short, narrow median septum and short dental plates which are thick and rounded posteriorly. Delthyrium triangular, open.

Dimensions. Dimensions of the holotype and representative specimens, and statistics for all specimens with valid measurements are shown in Table 1.

TABLE 1. Dimensions, *Spiriferina arakiwa*.

FR no.	specimen	Lv	**Ld**	**W**	**H**	**Ha**	**Wp**	**UA**	**material**	**notes**
E46/f0056	OU 15292	24.5	23	28.4	10.2	6.7	10		b int, ext	HOLOTYPE
R16/f6811	B727	14.9		19.5		5.0	8.1		vv int	
E45/f085	OU 47250	24.0		10.2		10.2	9.4	100.0	vv int, ext	
G47/f6523	BR 3297		22.6	32.6+			9.9		dv int, ext	
All valid	average	14.3	11.4	16.5	11.2	6.7	5.3	104.8	15 specimens	
specimens	S.D.	7.96	6.73	8.79	5.28	3.28	3.17	50.57		

Range and distribution. Ururoan (Pliensbachian—Early Toarcian). The distribution is unusual, with three of the six localities on the southern limb of the Southland Syncline.

Remarks. The new species resembles the type species of *Spiriferina* (*S. walcotti*), from the Hettangian and Sinemurian of Europe (Ager 1994), in having strong costae and a narrow v-shaped fold, but *S. walcotti* is more rounded in outline with a proportionally shorter hingeline and less well-developed interarea. It is possibly closer to the European S. *muensteri*, which has blunter costae, and a beak which projects more strongly posteriorly and not as high an area. The larger size distinguishes it from the much smaller, very strongly costate *S. sophiaealbae* Fig. 10A).

OU 47225 from the Otapiri Gorge (E45/f0061) is small, with a high ventrally-projecting apex, but is distorted (Fig. 7.12a,b). It may represent a different species. Other specimens in the same collection are more typical of *S. arakiwa* (Fig. 7.7). *Callospiriferina radiata* is present in the same collection.

Spiriferina sophiaealbae **new species**

Fig. 8B, Fig. 9: 1–12.

1992 "*Spiriferina*" cf. *muensteri* (Davidson); Damborenea & Manceñido p. 139, pl. 2 fig. 11–14.
2009 *"Spiriferina"* cf. *muensteri* (Davidson, 1851); MacFarlan *et al.* p. 266.

Holotype. AU B725, a double-valved internal mould from R16/f8821, AU 4395, exposure in stream above lowest hairpin bend in Pomarangai Road, Marokopa. Collected by D. Pryor, J.A. Grant-Mackie and the author, 10 February 1973.

Derivation of name. This species is named for Sophie White of the Geology Department, University of Otago, who has helped me on successive visits to Dunedin.

Material. A total of 21 specimens from eight collections were catalogued. 14 specimens yielded valid measurements.

Kawhia Syncline. Te Maika Peninsula: R15/f8005 *Dactylioceras* band (AU 614), R15/f8575 (AU 9209) R15/f8686 (AU 604), R15/f8816 (AU 14811). Marokopa R16/f8821 (AU 4395).

Southland Syncline. Otapiri Valley: E45/f9860 Conical Hill (JDC 1837), E45/f085 Heale Ridge (McF E49), Otamita Valley: F45/f8683 (JDC 1393).

Description. Small, strongly costate spiriferinide with high ventral umbo, wider than long. Most specimens with ventral valve 4–7.5 mm long, 7–14 mm wide. Hingeline straight, with maximum width close to hinge, lateral and anterior margins convex.

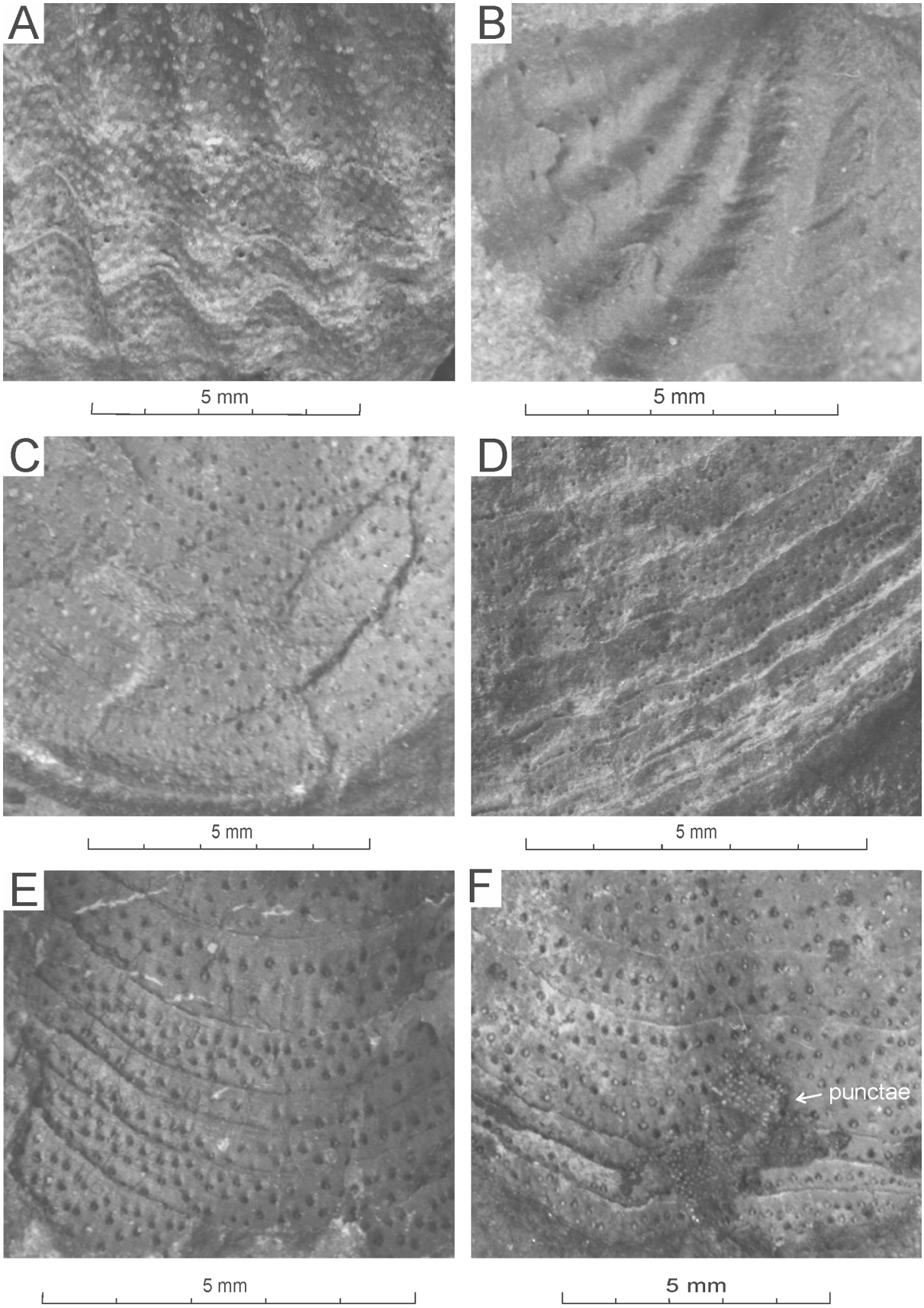


FIGURE 8. Spine bases. A *Spiriferina arakiwa* AU B728 (R15/f6811), B *Spiriferina sophiaealbae* OU 46816 (E45/f9860), C *Cisnerospira antipoda* AU B702 (R16/f6811), D *Callospiriferina kawhiana* C1827 (E44/f8632), E *Callospiriferina ongleyi* OU 46828 (E45/f9676), F *Callospiriferina radiata* BR 3295 (E45/f9860), note small patch of altered shell material with preserved punctae.

Dorsal valve slightly to moderately, but evenly convex. Ventral valve with high, sharply pointed apex. Interarea concave, delthyrium narrow, open. Each valve with three or four strong triangular costae on each flank, with narrow crests and troughs, crossed by a few foliaceous growth lamellae and finer growth lines. Widely spaced spines of crescentic section, generally close to the crests of the costae, are visible on a few specimens (Fig. 8B). Punctae fine, poorly shown or not seen on most specimens.

Internal Characters Dorsal valve with broad, thin posteriorly projecting concave hinge plates, narrow, close-set sockets, small cardinal process (Fig. 9.10). Ventral valve with median septum about half valve length, short dental plates (Fig. 9.3, 9.11).

Dimensions. Dimensions of the holotype and other representative specimens, and statistics for specimens from the Kawhia and Southland Synclines with valid measurements are shown in Table 2.

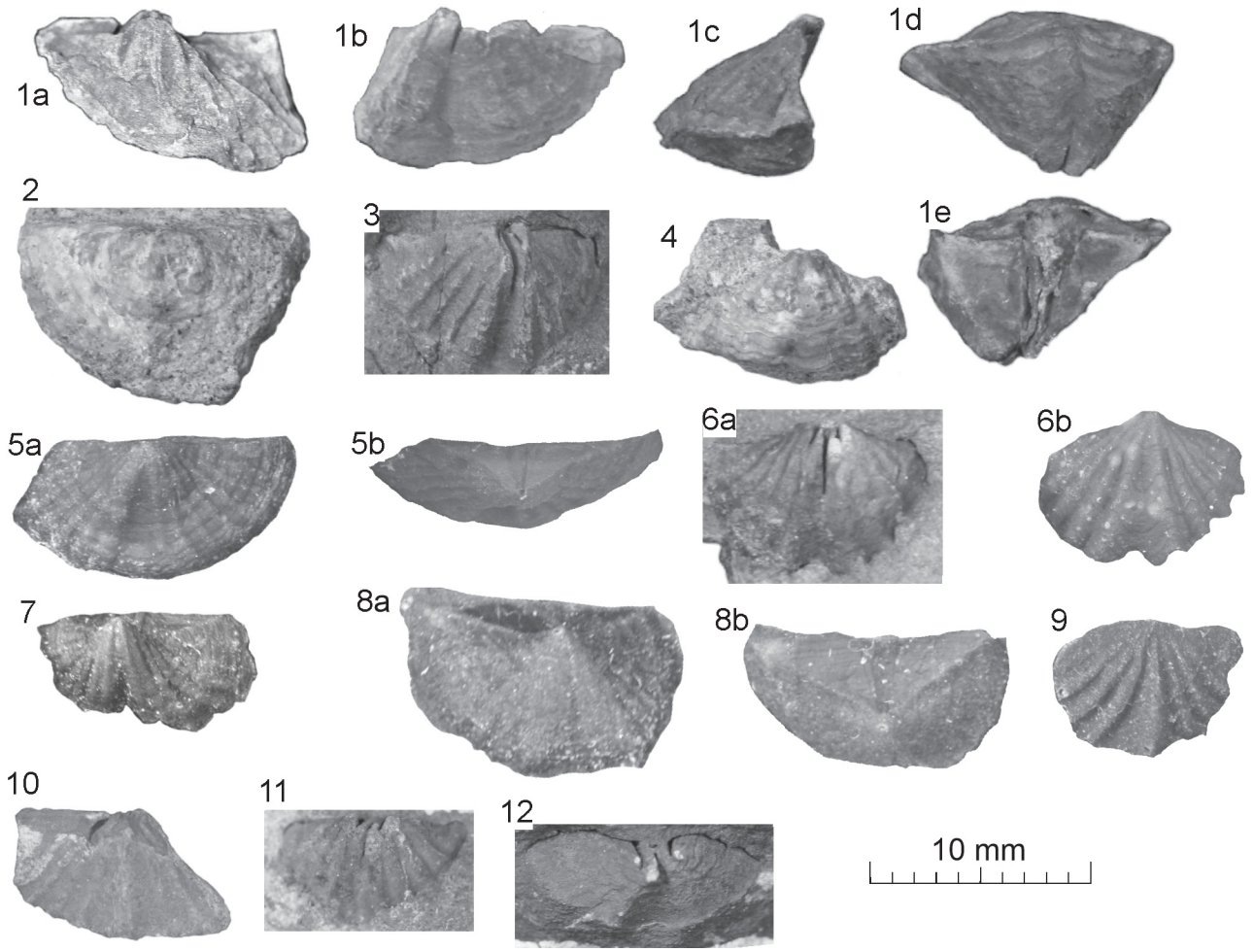


FIGURE 9. *Spiriferina sophiaealbae* **n. sp.** (x3). 1 Holotype AU B725 (R16/f8821) internal mould, distorted (a) dorsal (b) ventral (c) lateral (d) anterior (e) posterior. 2 AU B735 (R15/f8005) ventral valve, shelly. 3 AU B719 (R15/f8686B) internal mould of ventral valve. 4 AU B708 (R15/f8005) ventral valve, shelly. 5 AU B724 (R16/f8821) ventral valve, latex of exterior (a) ventral (b) posterior. 6 OU 46816 (E45/f9860) ventral valve (a) internal mould (b) latex of external. 7 AU B723 (R16/f8821) ventral valve, latex of exterior. 8 OU 47224 (F45/f8683) latex of ventral valve exterior (a) ventral (b) posterior. 9 OU 46890 (E45/f085) dorsal valve, latex of exterior. 10 AU B762 (R16/f8821) partial dorsal valve internal mould, oblique to show hinge plate. 11 OU C3042 (E45/f9860) ventral valve internal mould. 12 OU 47164 (E45/f9860) ventral valve, oblique.

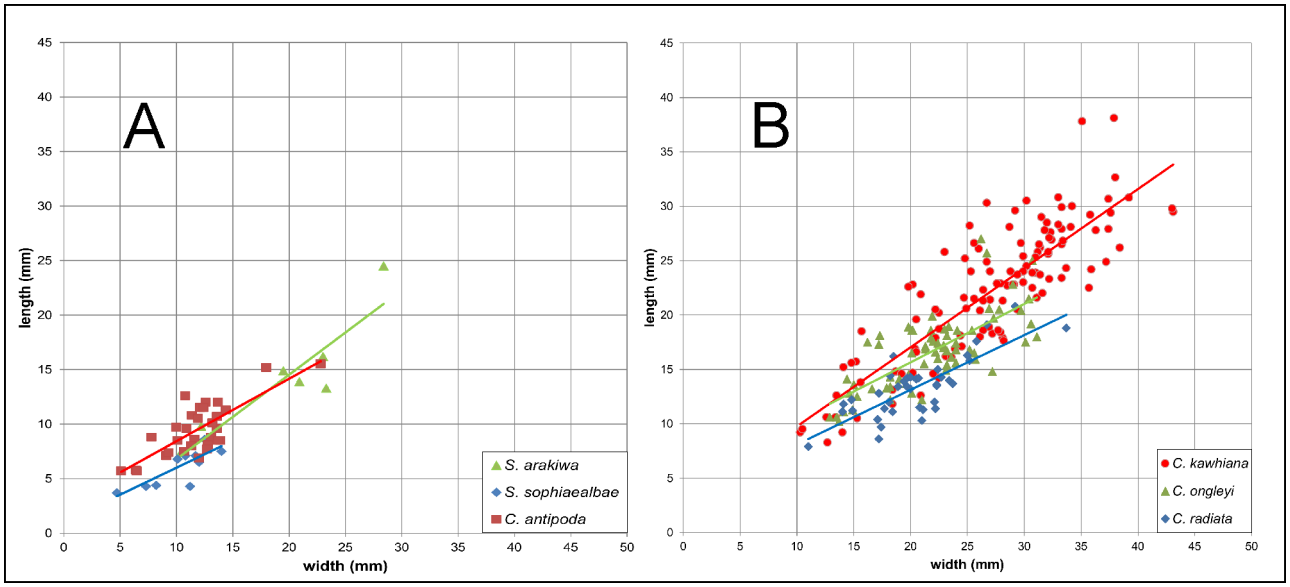


FIGURE 10. Length vs width plots, ventral valve, with linear trend lines. A: *Spiriferina arakiwa*, *S. sophiaealbae* and *Cisnerospira antipoda*. B: *Callospiriferina kawhiana, C. ongleyi and C. radiata.*

TABLE 2. Dimensions, *Spiriferina sophiaealbae.*

FR no.	specimen	Lv	Ld	W	H	Ha	Wp	UA	material	notes
R16/f8821	B725	6.5	6.5	12.0	7.2	4.9	4.0	98.0	b int	HOLOTYPE
R15/f8005	B735	7.1		11.7		2.9	2.0	128.0	vv shelly	
R15/f8686B	B719	7.3		10.6			2.4		vv int	
R16/f8821	B724	7.5		14.0			3.2		vv ext	
E45/f9860	OU 46816	6.8		10.1			3.3		vv int, ext	
Kawhia	Mean	6.2	5.5	10.2	4.8	3.0	2.9	114.7	8 specimens	
Syncline	SD	1.44	1.28	2.72	2.45	1.18	1.07	12.47		
Southland	Mean	6.0	6.5	10.0		2.6	3.1		6 specimens	
Syncline	SD	3.20	3.25	4.53		1.23	1.66			

Range and distribution. Lower Aratauran to Ururoan. The earliest record is Middle Hettangian, from F45/f8683, Coneburn, Otamita Valley. It is present in the Lower Ururoan of Conical Hill, Otapiri Gorge, and in several North Island Upper Ururoan localities, including the *Dactylioceras* bed at Kawhia.

Remarks. This species was first noted and figured by Damborenea & Manceñido (1992) from the earliest Ururoan (Pliensbachian) of Southland as *Spiriferina* cf. *muensteri*. They compared the New Zealand specimens with similar but larger specimens from the Pliensbachian of Argentina.

S. muensteri (Davidson, 1851) is widely distributed in Europe and North Africa (Alméras and Cougnon 2013). It is generally larger than the New Zealand species, with blunter costae and a more posteriorly directed beak in the dorsal valve.

In shape and size the new species resembles the strongly costate *Suessia dissymetrica* Revert, 1971. However, that species is described by Revert as asymmetric and impunctate, and his description makes no mention of spines.

Subfamily PARALABALLIDAE Carter, 1994

Cisnerospira Manceñido, 2004

2004 *Cisnerospira* Manceñido p. 272.
2007 *Cisnerospira* Manceñido, 2004; Williams *et al.* p. xlix.
2016 *Cisnerospira* Manceñido, 2004; Baeza-Carratalá *et al.* p. 1084.

Type species. *Spiriferina adscendens* Deslongchamps 1858 (OD).

Cisnerospira was proposed by Manceñido (2004) and described in more detail by Baeza-Carratalá *et al.* (2016), who placed it in the subfamily Paralaballidae and reviewed its distribution in detail. The genus is characterised by a well-developed subpyramidal ventral valve and smooth, non-costate valves. The ventral valve is much higher than the dorsal. The subpyramidal ventral valve and high ventral umbo allow separation from the other non-costate Jurassic spiriferinide, *Liospiriferina*.

The type species was originally described from Normandy in France (Deslongchamps 1858). Baeza-Carratalá *et al.* (2016) include twelve species in the genus, eight of them tentatively. The genus is present in the Pliensbachian and Toarcian of France (Alméras and Fauré 2000), Portugal (Comas-Rengifo *et al.* 2015, da Rocha *et al.* 2016), Spain (Alméras & Fauré 2000, Baeza-Carratalá *et al.* 2011), Austria (Vörös *et al.* 2003, Siblík 2009), Hungary (Dulai 1992, 2003, Vörös 2009), Slovakia (Siblík 1967), Turkey (Vörös & Kandemir 2011). World distribution is shown in Fig. 6.

Cisnerospira antipoda new species

Fig. 8C, Fig. 11: 1–8, Fig. 12: 1–5.

2009 '*Spiriferina*'? n. sp. A; MacFarlan *et al.* 2009 p. 266.

Holotype. B695 a double-valved shelly specimen with some damage to the apex of the beak, from R15/f8005, AU 9197, *Dactylioceras* band, Ururoa Point, Kawhia. Collected by A.B.S. Clarke, N. Hudson and J.A. Grant-Mackie 18 January 1981.

Derivation of name. While the type species is described from France, the modern work on this genus has had a Spanish focus. The new species is described from New Zealand, on the opposite side of the globe. The name *antipoda* seems appropriate.

Material. A total of 56 specimens from 27 localities were catalogued, of which 41 yielded valid measurements.

Kawhia Syncline. *Dactylioceras* band: R15/f8005 (AU 9197, 12296, ?AU 6425). Ururoa Point: R15/f8006 (GS 3150, AU 600), R15/f8078 (AU 9203), R15/f8575 (AU 9209, JDC 2509), R15/f8686 (AU 599), R15/f8816 (AU 50). Paparoa Point, Taharoa: R16/f6811 (AU 154, 4394, ?AU 8363, AU 9464). Marokopa: R16/f8642 (AU 9469, R16/f4648 (GS 10035), R16/f8840 (AU 4225). Pomarangai Road, Marokopa: R16/f8811 (AU 9464). Awakino Gorge, lower quarry: R17/f8565 (AU 330).

Southland Syncline. Otapiri Stream below junction with Taylors Stream: E45/f9568 (JDC 1380). Conical Hill: E45/f9860 (JDC 1837). Heale Ridge: E45/f085 (McF E49). Jewitt Road: E46/f0056 (JDC 2509, McF H25, E46/f063 (JDC 4661). Coneburn, Otamita Valley: F45/f8683 (JDC 1393).

Mantle Grove: F46/f091 (JDC 4664).

Description. Small spiriferinide, most specimens with ventral valve–12 mm long, 7–13 mm wide. Outline semicircular, generally wider than long, with straight hingeline extending for most of valve length. Dorsal valve moderately and evenly convex. Hinge sockets broad, rounded.

Ventral valve hemiconical with high apex with narrow rounded tip and high, laterally convex, triangular interarea which on larger specimens overhangs the hingeline. No fold or sulcus, but anterior commissure may show shallow, rounded, poorly defined uniplication. Shell coarsely punctate, exterior smooth or with weak, irregular growth lines. Fine tubular spines are visible on some external moulds, (Fig. 8C, Fig. 12.3, 12.5a), but in most specimens are not preserved. Delthyrium open, triangular, bounded by high, narrow dental plates, median septum present from apex (Fig. 11.3a, 11.8d).

Dimensions. Dimensions of the holotype and some other well-preserved specimens, and statistics for specimens from key areas are shown in Table 3.

Range and distribution. This species is present in the Aratauran at Marokopa (R16/f8840), the Otapiri Valley (E45/f9568) and the Coneburn, Otamita Valley (F45/f8683). The earliest of these is F45/f8683, which is Middle Hettangian. It is moderately common in the Ururoan, especially the Upper Ururoan of Ururoa Point and Taharoa.. It is generally found in offshore sequences.

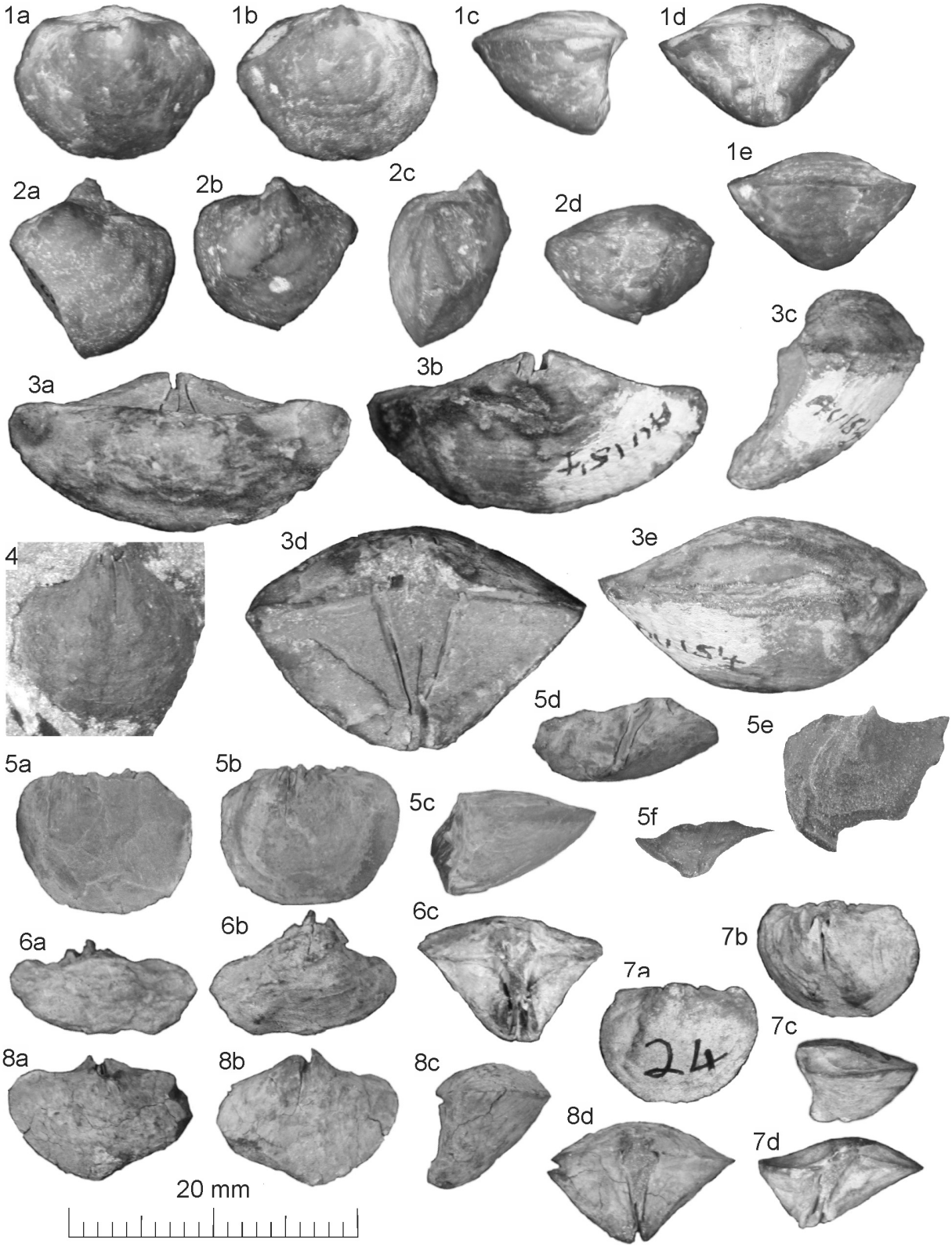


FIGURE 11. *Cisnerospira antipoda* **n. sp.** (x2.5). 1 Holotype AU B695 (R15/f8005) shelly specimen (a) dorsal (b) ventral (c) lateral (d) posterior (e) anterior. 2 AU B705 (R15/f8005) shelly specimen (a) dorsal (b) ventral (c) lateral (d) posterior. 3 AU B687 (R16/f6811) internal mould (a) dorsal (b) ventral (c) lateral (d) posterior (e) anterior. 4 OU 47196 (E46/f0056) internal mould, ventral. 5 AU B702 (R16/f6811) internal mould (a) dorsal (b) ventral (c) lateral (d) posterior (e) latex of ventral valve, ventral (f) posterior of latex. 6 OU 47203 (E46/f0056) internal mould (a) dorsal (b) ventral (c) lateral. 7 AU B691 (R17/f8595) internal mould (a) dorsal (b) ventral (c) lateral (d) posterior. 8 OU 47206 (E46/f0056) internal mould (a) dorsal (b) ventral (c) lateral (d) posterior.

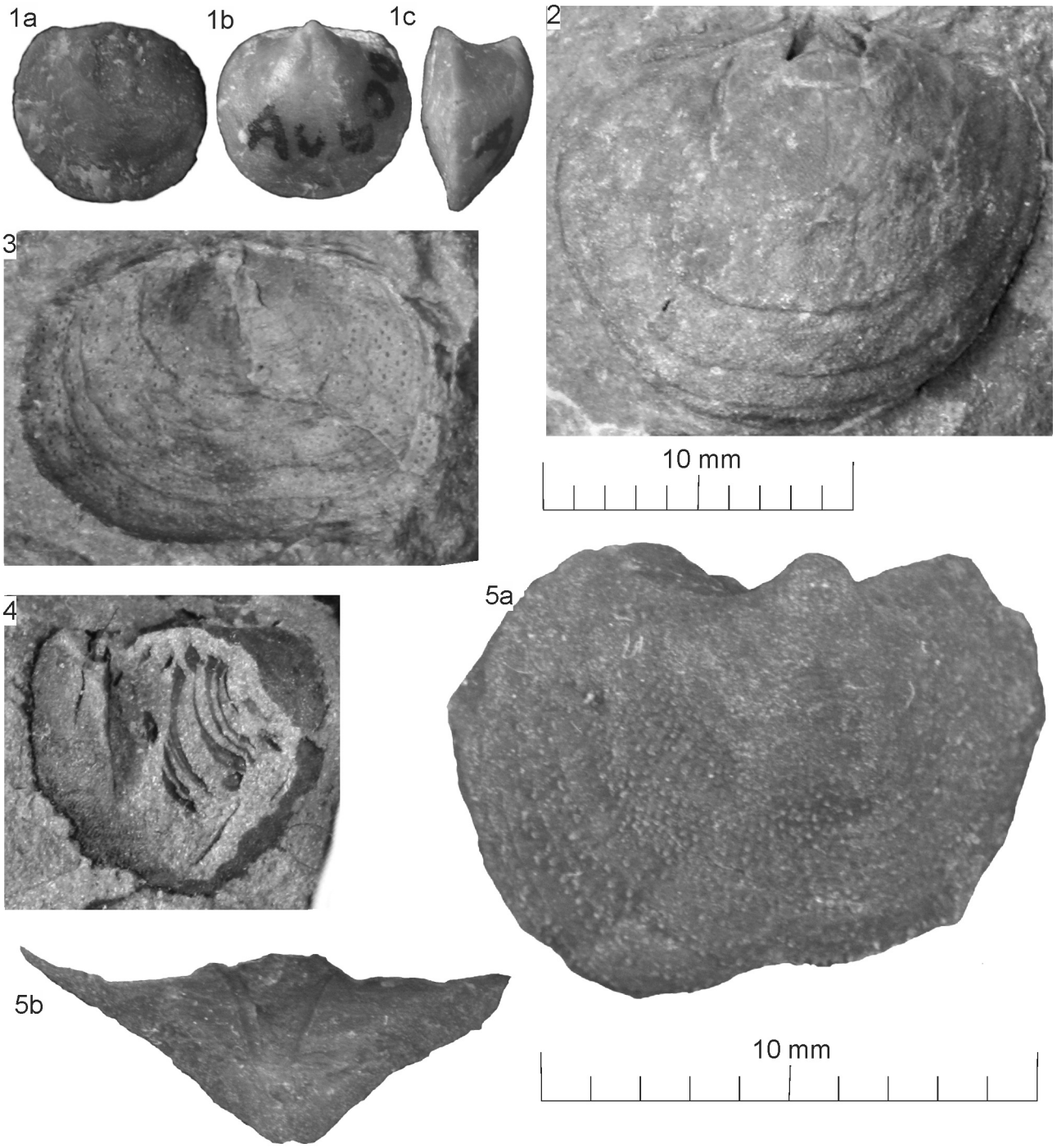


FIGURE 12. *Cisnerospira antipoda* **n. sp.** (1–4 x5, 5 x8). 1 AU B688 (R15/f8006) shelly specimen (a) dorsal (b) ventral (c) lateral. 2 OU 46771 (E45/f0085) internal mould, dorsal. 3 AU B737 (R16/f8642) external mould of dorsal valve, showing spine bases. 4 OU 47197 (E46/f0056) internal mould of ventral valve, broken with spiralium showing. 5 OU 46773 (E46/f0063) latex of ventral valve and part dorsal, showing spine bases (a) ventral (b) posterior (x8).

Remarks. The largest specimen from Paparoa Point, Taharoa (AU B687, Fig.11.3a–e) is almost twice the size of most *Dactylioceras* band specimens and is wider in proportion (possibly in part due to distortion). Otherwise there is little geographic variation in size.

This species is rectimarginate or with a shallow, poorly defined uniplication and no definite fold or sulcus. The type species, *C. adscendens,* is typically larger, with a strongly inflated dorsal valve, a strong rounded uniplication and a distinct fold and sulcus (Baeza-Carratalá *et al.* 2016). Other species illustrated by Baeza-Carratalá *et al.* (2016) are also larger and have a well-developed uniplication.

TABLE 3. Dimensions, *Cisnerospira antipoda.*

FR no.	specimen	Lv	Ld	W	H	Ha	Wp	UA	material	notes
R15/f8005	B695	10.7	10.5	13.6	8.9	7.1		96	b shelly	HOLOTYPE
R16/f6811	B687	15.5	9.1	22.8	13.5	9.7		97	b int, ext	
	B702	11.5	10.6	12.4	5.5	6.3		104	b int, ext	
E46/f0056	OU 47203	8.1	5.9	12.8	8.4	3.4		88	b int, pt ext	
	OU 47206	7.7	7.8	12.7	8.2	5		95	b int, pt ext	
Kawhia	Mean	9.9	8.7	11.5	7.2	5.0		99.6	10 specimens measured	
Syncline	S.D.	1.84	2.67	2.63	2.62	1.52		8.53		
Taharoa—	Mean	11.7	9.1	13.0	9.5	6.2	3.1	95.5	7 specimens measured	
Awakino	S.D.	4.86	3.47	5.82	5.30	1.89	0.00	5.68	7 specimens measured	
Otapiri and	Mean	7.9	10.3	11.4		4.0	4.3		6 specimens measured	
Otamita	S.D.	3.87	5.48	5.81		1.95	2.14			
Jewitt Road	Mean	8.7	8.1	11.5	7.1	4.0	5.1	96.7	17 specimens measured	
	S.D.	3.11	3.67	3.99	3.06	1.37	2.55	34.39		

Spiriferina cf. *darwini* is described by Wanner & Knipscheer (1951) from the Lower Jurassic of Seram in Indonesia and commented on by Baeza-Carratalá *et al.* (2016). It is slightly larger than the new species, with a deep rounded sulcus and uniplicate anterior commissure.

Superfamily PENNOSPIRIFERINOIDEA Dagys, 1972

Family PENNOSPIRIFERINIDAE Dagys, 1972

Subfamily PENNOSPIRIFERININAE Dagys, 1972

Callospiriferina Rousselle, 1977

1977 *Callospiriferina* Rousselle, p. 157.
2006 *Callospiriferina* Rousselle, 1977; Carter, p. 1924.
2013 *Callospiriferina* Rousselle, 1977; Alméras & Cougnon, p. 21.

Type Species: *Spirifer tumidus* von Buch, 1837 (OD).

The genus *Callospiriferina* was proposed by Rousselle (1977) to include spiriferinides with rounded costae of moderate strength, and with dental plates enveloped in callus.

The three previously described Zealandian species all have costae of variable strength, from barely perceptible to low and bluntly rounded, and which are much weaker or absent on the flanks. Callus is developed to some extent on *C. kawhiana* (Trechmann, 1918), but not on the other two species, which in general have more delicate internal plates on the ventral valve.

Callospiriferina is known from Spain (Alméras & Fauré 2000), France (Alméras & Fauré 2000, Alméras and Cougnon 2013), Portugal (Alméras *et al.* 1996), Italy (Taddei Ruggiero & Vörös 1987), Austria (Boehm *et al.* 1999, Siblík 1999), Hungary (Dulai 1992, 2003), the Balkans (Radulovic 1995), Britain (Hollingworth *et al.* 1990), Morocco (Rousselle 1977), Algeria (Alméras *et al.* 2007), Alaska (Sandy & Blodgett 2000) and Argentina (Manceñido 1981, Damborenea & Manceñido 1992). The genus is reviewed, mainly from a western European perspective by Alméras & Cougnon (2013). It has not previously been recorded from the Late Triassic.

Spiriferina krumbecki Wanner & Knipscheer from the Early Jurassic of Seram (Wanner & Knipscheer 1951) has weakly developed costae and is of comparable size and shape to *C. ongleyi* and may belong to *Callospiriferina*. World distribution of *Callospiriferina* is shown in Fig. 6.

Wright & Campbell (1990) recognised that *Mentzelia kawhiana* and *Spiriferina ongleyi* were congeneric. Wright (1990) showed sections of internal moulds of "*M." kawhiana* and *"M." ongleyi*, made with sections parallel to the

anterior commissure. No section intervals are stated. The spiralia are shown clearly, but the sections are difficult to interpret.

Grant-Mackie *et al.* (2000) and MacFarlan *et al.* (2009) also included *Spiriferina radiata* (Hector, 1886) in *Mentzelia*, indicating that the three commonest latest Triassic–Early Jurassic spiriferinides in Zealandia are congeneric.

Callospiriferina kawhiana (Trechmann, 1918)

Fig. 8D, Fig. 13: 1–12, Fig. 14: 1–7.

1918 *Mentzelia kawhiana* Trechmann, p. 228, pl XXIII 10a, 10b.
1945 *Mentzelia kawhiana* Trechmann,1918; Allan, p. 16.
1953 *Mentzelia kawhiana* Trechmann; Marwick, p. 34, pl. 1.10, 11.
1978 *Mentzelia kawhiana* Trechmann; Suggate *et al.* p. 192, fig. 4.37 12, 14.
1981 *Mentzelia kawhiana* Trechmann; Speden & Keyes, p. 32, pl. 11.12, 14.
2009 *Mentzelia kawhiana* Trechmann, 1918; MacFarlan *et al.* p. 266.
2013 *Mentzelia kawhiana* Trechmann, 1918; Campbell *et al.* p. 41.

Holotype. Trechmann collection, Natural History Museum, London (NHM B50433) "in the Arcestes and Hectoria Beds, in the cliff section south of Kawhia Harbour. Rhaetic." (Trechmann 1918, p. 228). Subsequent collections with better locality data show that the species is relatively common in the north-eastern 680m of the rather featureless coast backed by cliffs (Fig. 5A) south of Arataura Point (Martin 1975 and FRED data).

Material. A total of 233 specimens from 79 localities were catalogued, of which 151 specimens yielded valid measurements. 108 of the collections examined contained definite or probable *C. kawhiana.* These are listed below.

New Caledonia. île Ducos: NC/f0018A (AU 6074), NC/f0020 (GS 12733, AU 7175), NC/f0023 (GS 12326, AU 7179), NC/f050 (GS 12673), NC/f0060 (AU 7214), NC/f0082A (?AU 7799), NC/f518 (?AU 7773), NC/f0564 (?AU 7798). île Hugon: NC/f0005 (?AU 7146), NC/f0007A (/AU 7149).

Kawhia Syncline. Kawhia Coast: Unregistered: Trechmann coll (holotype, *M.* cf. *ampla* NHM B50492, AU 21755, Kawhia Museum coll.). R15/f0024 (McF B13), R15/f0026 (McF B15), R15/f8578 (JDC 1157), R15/f8580A (GS 12306), R15/f8585 (GS 6754), R15/f8833 (GS 11802), R15/f8834 (AU 63), R15/f8835 (AU 64), R15/f8836 (AU 68), R15/f8837 (AU 69), R15/f8838 (AU 70), R15/f8839 (AU 72, 73), R15/f8844 (AU 66), R15/f8848 (AU 67).

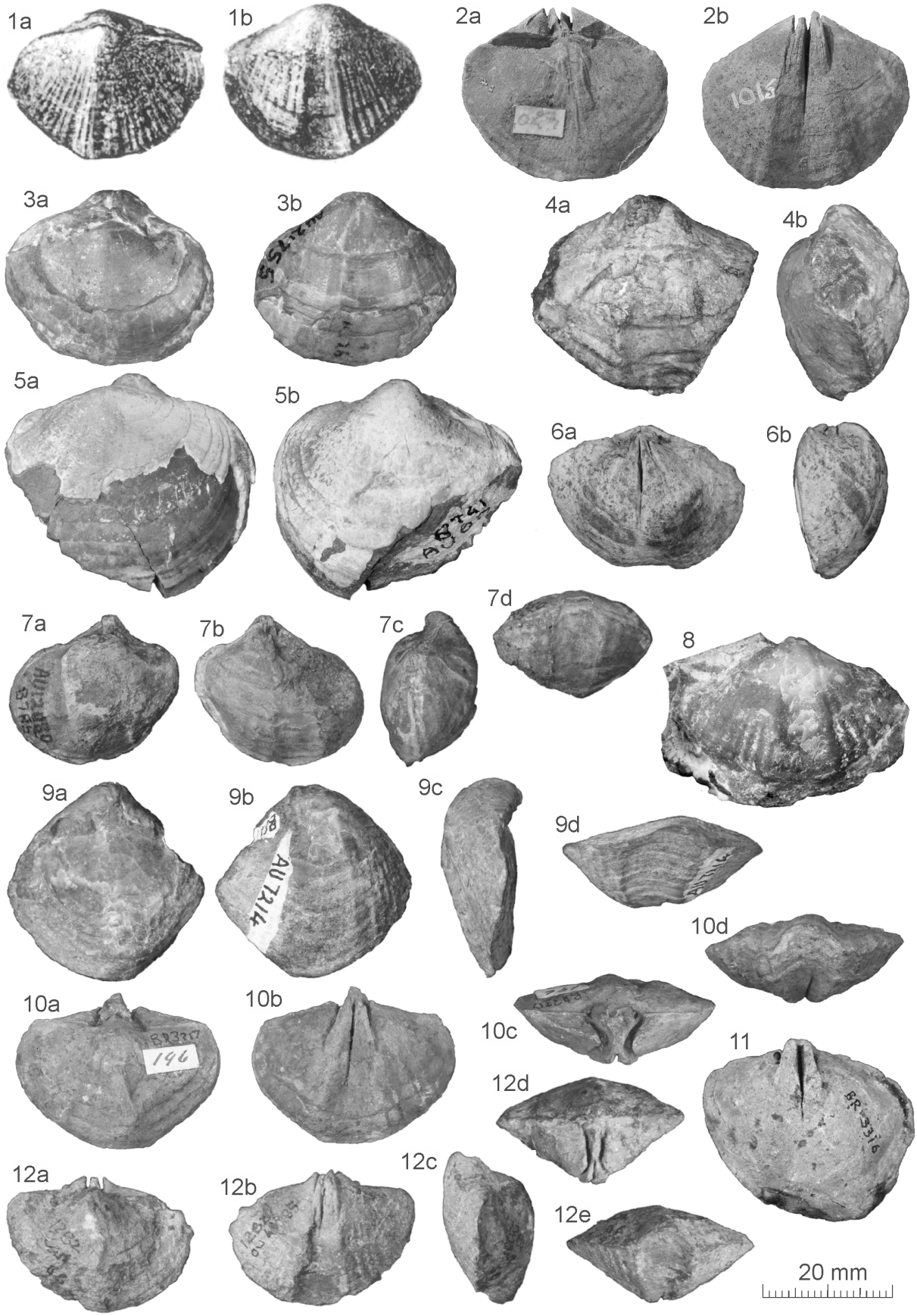
Coast north of Marokopa River: R16/f0144 (?AU 9475), R16/f0146 (?AU 9471), R16/f0148 (AU 8358), R16/f0151 (AU 8362), R16/f6896 (GS 10007), R16/f6898 (GS 10009), R16/f6899 (GS 10010), R16/f6903 (GS 10041), R16/f6907 (GS 10045), R16/f8645 (GS 10006), R16/f6850 (GS 10037). Marokopa coast: R16/f0003 (GS 11772), R16/f0004 (GS 11773), R16/f0005 (GS 11774), R16/f0050 (McF A19), R16/f0317 (AU 14313), R16/f0328 (AU 12695), R16/f0339 (AU 15009), R16/f0343 (AU 12079), R16/f0344 (AU 12080), R16/f8638 (GS 9993), R16/f8639 (GS 9994), R16/f8777 (JDC 2783, AU 8987).

Kiritehere Valley: R16/f8919 (AU 4300), R16/f8928 (AU 4309), R16/f8931 (AU 4312), R16/f8932 (AU 4313). Pomarangai Road Moeatoa: R17/f8877A (AU 8987). Awakino Gorge: R17/f0559 (AU 12167), R17/f8574 (AU 7857), R17/f8612 (GS 7587). R18/f0092 (AU 12141), R18/f0094 (AU 14388), R16/f0098 (AU 12170), R18/f0107 (AU 12166), R18/f6562 (MAG 2/1), R18/f6564 (AU 12135).

Nelson. N27/f0056 (GS 12916), N28/f9454 (GS 196), N28/f9455 (GS 197), N28/f7514 (GS 4551).

Southland Syncline. Dipton Stream: E44/f0450 (JDC 836) E44/f8632 (JDC 837). Benmore: E45/f9608 (JDC 1282). Otapiri Valley: E45/f 9462 (GS 359), E45/f9463 (GS 360), E45/f9465 (GS 362), E45/f9469 (GS 366), E45/f9611 (OU 3748, JDC 1285), E45/f9902 (JDC 2088), E45/f (RBH 17, Maling T13.9). Lora–Otamita Divide: E45/f9714 (GS 6751). Otamita Valley: F45/f8680 (GS 6606), F45/f (EW 319). Otamita–Waimumu Road: F45/f0281 (JDC 4126), F45/f0329 (JDC 4216), F45/f0330 (JDC 4654), F45/f0331 (JDC 4655). F45/f8523 (GS 5188), F45/f8589 (JDC 864), F45/f8733 (GS 7601). East of Gore, Diamond Peak: F45/f0360 (JDC 4726), F45/f0363 (JDC 4726), F45/f0365 (JDC 4728), F45/f0414 (JDC 4762), F45/f9507 (GS 4408), F45/f (AU 1557). Mataura: F46/f9488 (GS 470). Waipahi: G45/f8624 (GS 5145).

Glenomaru: H46/f0188 (JDC 4105), H46/f8633 (GS 7157). Nugget Point: H46/f8559 (JDC 960), H46/f8627 (GS 7128), H46/f8664 (JDC 1426), H46/f8772 (JDC 2396).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11
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12e
20 mm

FIGURE 13. *Callospiriferina kawhiana* (x 1.2). 1 Holotype NHM B50493 (R15/f) shelly specimen (a) dorsal (b) ventral (from Trechmann 1918). 2 BR 1015 (F46/f9488) internal mould (original of Marwick (1953) pl. 1 10 and 11) (a) dorsal (b) ventral. Photos: M. Terezow. 3 AU B742 (R15/f) shelly specimen (a) dorsal (b) ventral. 4 NHM B50492 (R15/f) fibreglass mould, (a) ventral (b) lateral (Mentzelia cf. ampla of Trechmann (1918). 5 AU B741 (R15/f8636) partly shelly specimen, (a) dorsal (b) ventral. 6 AU B745 (R16/f8919) internal mould (a) ventral (b) lateral. 7 AU B785 (R16/f0317) (a) dorsal (b) ventral (c) lateral (d) anterior. 8 BR 3405 (NC/f0023) shelly specimen, ventral. 9 AU B811 (NC/f0060A) shelly specimen (a) dorsal (b) ventral (c) lateral (d) anterior. 10 BR 3317 (N28/f9454) internal mould (a) dorsal (b) ventral (c) posterior (d) anterior. 11 BR 3316 (N28/f9454) internal mould, ventral. 12 OU 47283 (E45/f9608) internal mould (a) dorsal (b) ventral (c) lateral (d) posterior (e) anterior.

TABLE 4. Dimensions, *Callospiriferina kawhiana*.

FR no.	specimen	Lv	Ld	W	H	Ha	Wp	UA	material	notes
R15/f	B50433	25.0		31.0					HOLOTYPE	Measurements from Trechmann (1917)
R15/f	B50492	30.9	26.2	34.0+	20.2	3.6		118.0	Fibreglass replica	*M*. cf. *ampla* of Trechmann (1917)
New Caledonia	mean	24.0	19.5	27.5	11.5	5.1	9.1	123.1	12 specimens measured	
	S.D.	5.93	6.65	5.74		1.02	2.67	10.66		
Kawhia	mean	25.0	22.9	29.7	14.0	5.1	12.4	120.5	23 specimens measured	
	S.D.	7.88	8.07	8.46	5.53	2.24	4.62	30.05		
Marokopa coast north of	mean	15.6	13.7	20.1	6.6	2.3	7.8	125.7	9 specimens measured	
	S.D.	7.01	6.10	7.47	2.91	1.06	3.49			
Marokopa River mouth	mean	22.1	17.8	26.9	11.8	3.5	9.8	124.3	15 specimens measured	
	S.D.	5.99	6.05	7.61	5.07	1.87	3.30	13.94		
Awakino Gorge	mean	24.9	23.7	30.5	11.9	4.6	10.6	128.4	12 specimens measured	
	S.D.	11.64	10.71	13.74	5.73	2.55	5.05	56.14		
Nelson	mean	21.3	21.9	26.6	13.0	6.1	9.8	133.4	10 specimens measured	
	S.D.	7.51	9.98	9.74	6.13	2.48	3.94	42.59		
Dipton Stream	mean	22.6	18.1	28.3	8.5	4.3	11.6	139.6	9 specimens measured	
	S.D.	9.71	9.98	14.02	4.42	1.69	6.03	46.16		
Otapiri Valley	mean	19.7	17.0	24.1	10.2	3.7	10.3	129.0	24 specimens measured	
	S.D.	6.82	5.85	7.49	3.48	1.46	4.00	28.38		
Otamita—Waimumu Road	mean	23.7	17.9	28.7	10.6	4.8	10.4	128.9	15 specimens measured	
	S.D.	7.85	7.88	8.98	3.87	2.06	3.61	43.13		
East of Gore	mean	22.1	21.3	30.5	13.1	5.2	10.1	129.0	6 specimens measured	
	S.D.	11.74	10.74	15.48	6.64	2.74	5.36	62.68		
Nugget Point	mean	24.1	21.0	27.7	13.2	4.7	10.0	116.6	5 specimens measured	
	S.D.	12.11	10.61	14.22	6.35	2.41	5.28	54.26		

Description. Spiriferinide of moderately large size (length of ventral valve generally 15–30 mm, width 20–35mm). Hingeline straight, about 0.7 to 0.8 of valve width, with rounded flanks and anterior margin, shells generally robust. Dorsal valve slightly to moderately inflated, about evenly convex posteriorly, with shallow, narrow fold anteriorly. Ventral valve strongly inflated posteriorly, with highly convex beak and less convex flanks, anteriorly with narrow shallow rounded sulcus. Each valve has 4 to 8 shallow, rounded costae on each flank, becoming weaker laterally. The costae begin in the umbonal region or just anterior and are not present on the beak. They are very weak or absent on some specimens. The sulcus and fold are non-costate.

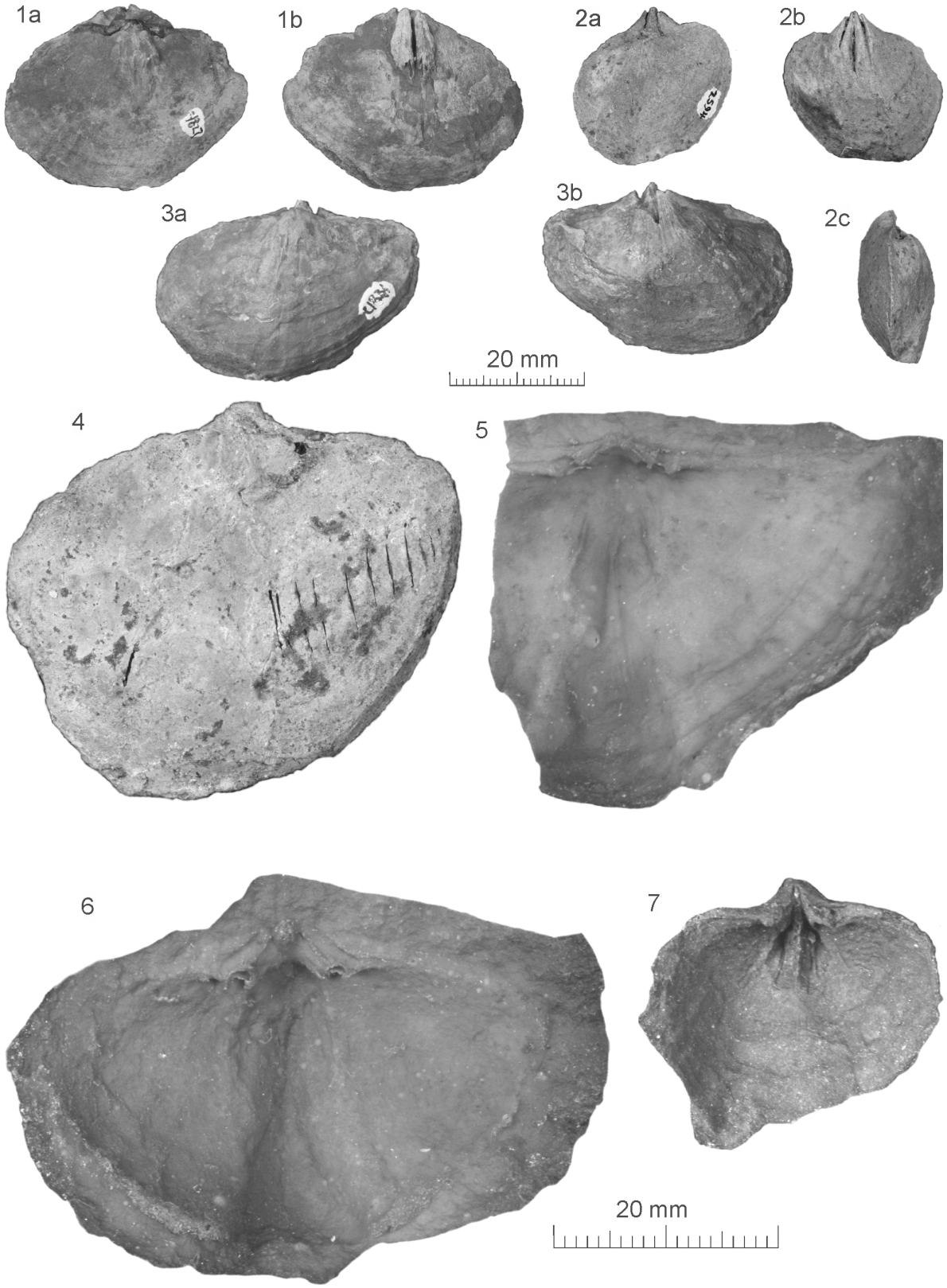


FIGURE 14. *Callospiriferina kawhiana* (x1.2 and x 2). 1 C1827 (E44/f8632) internal mould (a) dorsal (b) ventral (x1.2). 2 C2594 (E45/f9611) internal mould (a) dorsal (b) ventral (c) lateral (x1.2). 3 C1831 (E44/f8632) internal mould (a) dorsal (b) ventral (x1.2). 4 BR 3316 (N28/f9454) internal mould, dorsal view showing imprint of spiralia on shell interior (x2). 5 BR 3398 (F45/f8680) latex of internal mould, dorsal valve (x2.). 6 BR 3397 (F45/f8680) latex of internal mould, dorsal valve showing hinge plate and cardinal process (x2). 7 OU 47208 (E45/f) latex of internal mould, ventral showing hinge plate (x2).

Shell material is finely punctate, but the punctae are often difficult to see and may be affected by recrystallization. A few specimens from Southland show the bases of fine, close-spaced spines arranged in irregularly concentric rows. They are tubular, as plugs of matrix can occasionally be seen within the mould of the spine. They are generally seen close to the margins (Fig. 8D). Most specimens show no trace of spines and spines are not mentioned by Trechmann (1918).

Internal characters The dorsal valve has a short hinge plate, close-set sockets and thick rounded inner socket ridges carrying crural bases. The cardinal process may be prominent, elliptical and rounded (Fig. 14.6) or may be small and poorly defined (Fig. 14.5). The spiralium in internal moulds of damaged or distorted shells is occasionally seen appressed to the surface of the valve interior (Fig. 14.4).

The ventral valve has a long median septum which may extend as a shallow ridge to the anterior part of the valve. The dental plates are thick and prominent, divergent, and are not in contact with the median septum.

Dimensions. Dimensions of the holotype and Trechmann's *M.* cf. *ampla*, and statistics for specimens from key areas are shown in Table 4.

Range and distribution. This species is widely distributed in the upper Otapirian of New Caledonia, Kawhia, Nelson and Southland Synclines. The presence of *C. kawhiana* and the pterioid bivalve *Otapiria dissimilis* indicates an informal upper Otapirian zone (Campbell 1956, 1997, Cooper 2004, MacFarlan 1992, 1998).

Remarks. This is a relatively common and easily recognisable species in New Caledonia and throughout the Murihiku Terrane in New Zealand. It is robust, and often preserved as double valves. It reaches a larger maximum size than either of the Zealandian Jurassic species of *Callospiriferina* (Fig. 10B).

Although individual specimens vary in shape, size and the strength of costae, there seems to be little geographic variation in shape or ornament in this species (Fig. 13, 14) Nelson specimens are often more strongly costate than others.

Status of *Mentzelia* cf. *ampla* Bittner of Trechmann (1918)

1918 *Mentzelia* cf. *ampla* Bittner, 1890; Trechmann p. 228, pl. XXIII 9.
1945 *Mentzelia* cf. *ampla* Bittner, 1890; Allan, p. 16.
1953 *Mentzelia* cf. *ampla* Bittner; Marwick, p. 34.
2009 *Mentzelia* cf. *ampla* Bittner, 1890; MacFarlan *et al.* p. 266.

Examination of a fibreglass mould of Trechmann's specimen (B50492) (Fig. 13 4a, 4b), shows it to be well within the morphological range of *C. kawhiana*, and *Mentzelia* cf. *ampla* should therefore be removed from the Zealandian fauna.

Callospiriferina ongleyi (Marwick 1953).

Fig. 8E, Fig. 15: 1–21, Fig. 16: 1–6.

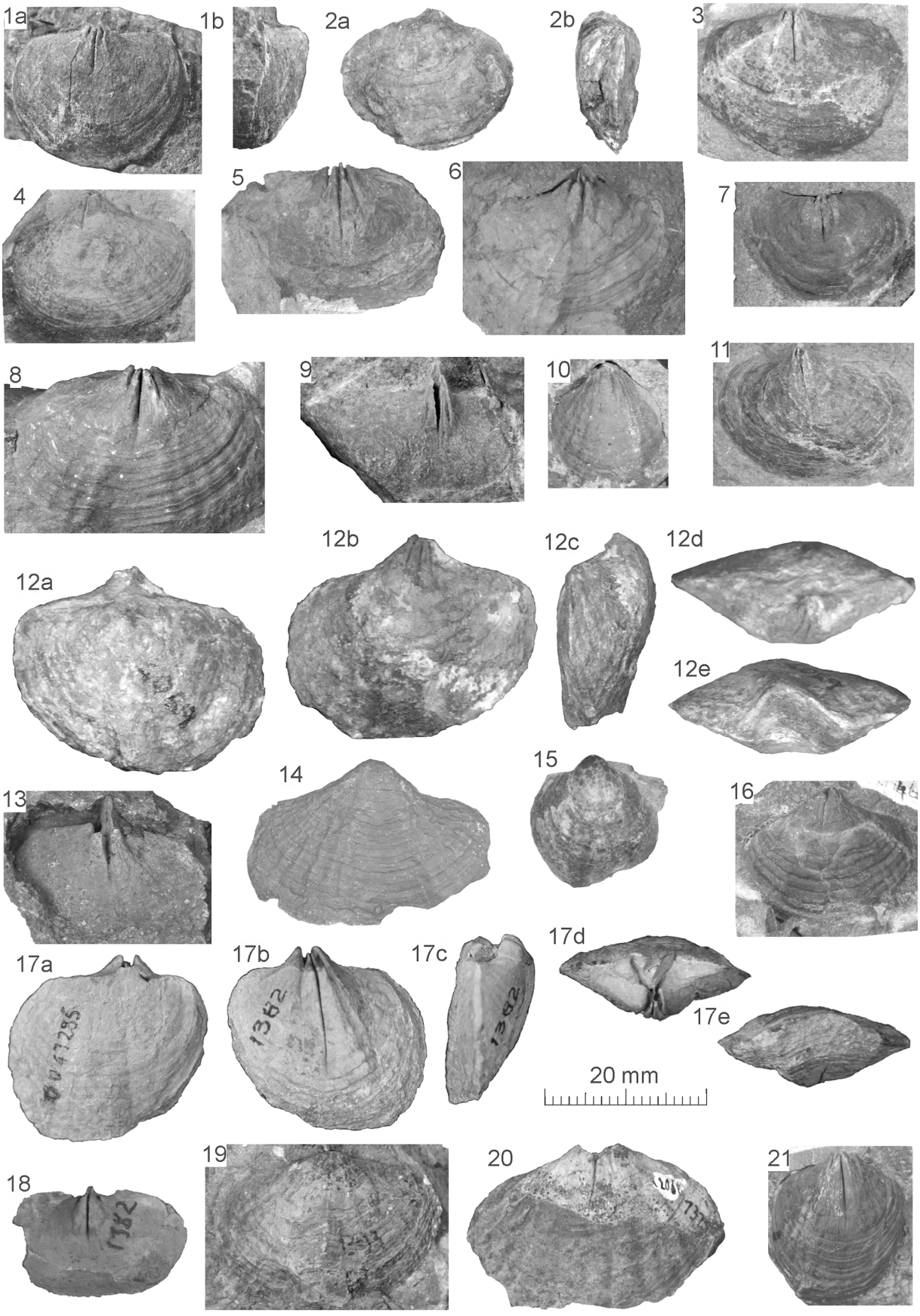
1923 *Spiriferina* (?) sp., Trechmann, 1923 p. 285, pl. XVI, figs 11 a, b.
1953 *Spiriferina ongleyi* Marwick, p. 86, pl. 15 fig. 18.
1978 *Spiriferina ongleyi* Marwick; Suggate *et al.* p. 713 fig. 11.7 19.
1981 *Spiriferina ongleyi* Marwick; Speden & Keyes, p. 44, pl. 17.19.
1992 "*Spiriferina*" *ongleyi* Marwick; Damborenea & Manceñido p. 136, Pl. 2 fig. 1–3.
2009 *Mentzelia ongleyi* (Marwick, 1953); MacFarlan *et al.* p. 266.

Holotype. BR 1117 from F45/f9446 (GS 343) Flag Hill (Ben Bolt), an internal mould of a ventral valve, collected by A. McKay 1878.

Material. A total of 133 specimens from 24 collections were catalogued, of which 73 yielded valid measurements.

New Caledonia. Uitoé Peninsula: NC/f401 (AU 9419), NC/f647 (AU 9608). île Mara: NC/f0165 (AU 5785), NC/f0170 (AU 5790).

Kawhia Syncline. Te Maika Peninsula Kawhia: R15/f8812 (AU 14794). Coast north of Marokopa: R16/f8644 (GS 10005). Awakino Gorge: R18/f0138 (AU 18823).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17a
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21

FIGURE 15. *Callospiriferina ongleyi*. (x 1.5). 1 Holotype BR 1117 (E45/f9446) (a) ventral (b) lateral Photos: M. Terezow. 2 BR 3308 (E45/f9447) internal mould (a) dorsal (b) lateral. 3 BR 3310 (E45/f9447) internal mould of ventral valve. 4 C2059 (E45/f9446) internal mould of ventral valve. 5 C2177 (E45/f9446) internal mould of ventral valve. 6 C2054 (E45/f9446) internal mould of ventral valve. 7 OU 46823 (E45/f0379) internal mould of ventral valve. 8 C2055 (E45/f9446) internal mould of ventral valve. 9 AU B753 (NC/f170) internal mould of ventral valve. 10 OU 46828 (E45/f9676) internal mould of ventral valve. 11 AU B718 (R18/f0138) internal mould of ventral valve. 12 OU 46825 (E45/f0379) internal mould (a) dorsal (b) ventral (c) lateral (d) posterior (e) anterior. 13 AU B754 (NC/f170) internal mould of ventral valve. 14 OU 46824 (E45/f0379) latex of ventral valve exterior. 15 AU B712 (R15/f8812) decorticated shelly ventral valve. 16 OU 46842 (E45/f9676) internal mould of ventral valve. 17 OU 47285 (E45/f9676) internal mould (a) dorsal (b) ventral (c) lateral (d) posterior (e) anterior. 18 OU 46836 (E45/f9676) internal mould, ventral. 19 OU 47216 (F45/f8683) internal mould of dorsal valve. 20 C2068 (E45/f9446) internal mould of ventral valve. 21 OU 47153 (E45/f9676) internal mould of ventral valve.

Southland Syncline. Otapiri Stream*:* E45/f (AU 2819), E45/f9452 (GS 349). Ben Bolt: E45/f (AU 6409), E45/f (AU 9838), E45/f (OU 47286), E45/f0076 (McF E34), E45/f0132 (RBH 16), E45/f0178 (AU 6639), E45/f0379 (JDC 4069), E45/f9446 (GS 343, JDC 737), E45/f9447 (GS 344), E45/f9676 (JDC 1382), E45/f9697 (McF E23). Otapiri Gorge: E45/f9452 (GS 349). Otamita Valley, Peel Stream: F45/f0083 (JGGM 157). Retreat–Croydon Road: F45/f8011 (JDC 3479). Coneburn: F45/f8683 (JDC 1393). Jewitt Road: E46/f0063 (?JDC 4661).

Description. Medium-sized spiriferinide, with dorsal valve generally 12–25 mm long, valves 15–30 mm wide. Hingeline straight, about 4/5 of valve width. Cardinal extremities, flanks and anterior margin rounded. Maximum width in posterior part. Dorsal valve generally wider than long, moderately and evenly convex posteriorly, with narrow, rounded fold anteriorly.

Ventral valve with narrow posteriorly directed umbo, broad, moderately low interarea, narrow, open triangular delthyrium. Valve moderately convex posteriorly, with narrow, U-shaped sulcus anteriorly, anterior commissure uniplicate.

Flanks of both valves with about 2 to 6 rounded costae, with some variation in strength between specimens, some are non-costate. No costae on fold or sulcus.

Concentric ornament of semiregular, stepped growth lines. Shell material punctate, exterior with fine tubular (?) spines (Fig. 8E).

Internal Characters Dorsal valve with short hingeline with small round cardinal process (Fig. 16.1). Some specimens with paired, incised muscle scars separated by low ridge.

Ventral valve with a high, narrow median septum on floor of valve and thicker, curved dental plates which do not join to median septum (Fig. 15.5, 15.8, Fig. 16.5, Fig. 16.6a). Small, slightly incised muscle scars visible on a few specimens (Fig. 15.6).

Dimensions. Dimensions of the holotype and statistics for specimens from key areas are shown in Table 5.

TABLE 5. Dimensions, *Callospiriferina ongleyi*.

FR no.	specimen	Lv	**Ld**	**W**	**H**	**Ha**	**Wp**	**UA**	**material**	**notes**
E45/f9446	BR 1117	18.1		23.2		4.5	10.1	140	vv int	HOLOTYPE
New Caledonia	mean	13.5	16.0	19.3		3.0	7.6	117.7	4 specimens measured	
	S.D.	6.43	8.00	8.21		1.50	3.62	51.18		
Otapiri—Ben Bolt	mean	16.8	15.9	21.8	8.2	14.8	9.3	126.7	59 specimens measured	
	S.D.	5.94	7.74	7.80	4.18	51.73	3.35	48.11		
Otamita, eastern	mean	16.7	14.1	21.1		4.7	8.3	121.5	14 specimens measured	
Hokonuis	S.D.	5.55	5.77	6.95		1.95	3.08	52.13		

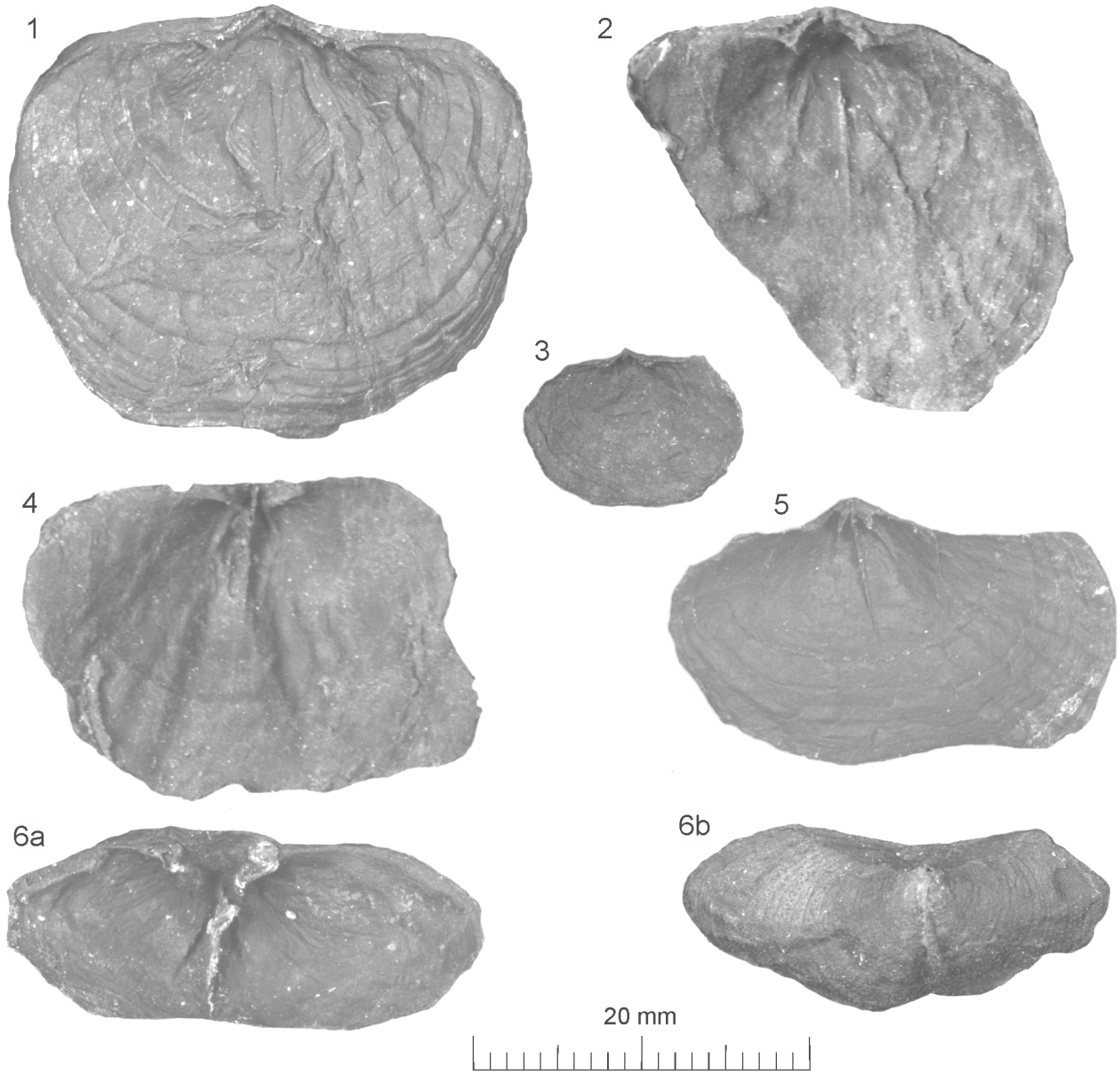

FIGURE 16. *Callospiriferina ongleyi.* latex moulds (x 2.5). 1 OU 46897 (E45/f0379) dorsal valve, latex of interior. 2 OU 46895 (E45/f0379) dorsal valve, latex of interior. 3 OU 47218 (F45/f8683) dorsal valve, latex of interior. 4 OU 46822 (E45/f0379) ventral valve, latex of interior. 5 OU 47142 (E45/f9676) ventral valve, latex of interior. 6 OU 47238 (E45/f9676) ventral valve (a) latex of interior (b) latex of exterior.

Range and distribution. Aratauran. *Callospiriferina ongleyi* is rare in New Caledonia and the Kawhia Syncline south of Kawhia. It is not found in the earliest Aratauran of Ben Bolt. The earliest appearance is at F45/f8683 in the Coneburn (Middle Hettangian). In the Otapiri Valley it first appears at E45/f9452 (GS 349), where adjacent localities have yielded Late Hettangian ammonites (Stevens 2004). It is common at a few localities on the northern slopes of Ben Bolt, and in the Otamita Valley, and appears to be part of a nearshore fauna.

Remarks. The shape, especially of the ventral valve, is variable. Costae are of variable strength but generally weak, and some specimens are smooth. Specimens from E45/f0379 (Ben Bolt) generally have stronger costae than those from some nearby localities.

Specimens from two collections from île Mara, New Caledonia are thick-shelled with dental plates partly submerged in callus (Fig. 15.9, 15.13). The lithology is a coarse to medium sandstone.

OU 46836 (E45/f9676) is proportionally broader, with deeply impressed muscle scars on the ventral valve. The dental plates are visible on the mould, but short. This appears to be similar to the île Mara specimens (Fig. 15.18).

OU 46828 (E45/f9676) is relatively narrow, with a broad rounded sulcus demarcated by two relatively strong costae (Fig. 15.10).

Callospiriferina ongleyi is smaller and proportionally slightly wider than *C. kawhiana* (Fig. 10B). The median septum and dental plates are narrower and more delicate than in *C. kawhiana* and muscle fields are not as well developed.

Juveniles and some small specimens can be difficult to distinguish from *Cisnerospira antipoda*. At similar size, *C. ongleyi* tends to be wider in proportion, and with a less inflated ventral valve. AU B737 (R16/f8642) is best placed in *Cisnerospira antipoda* (Fig. 12.3) but also has some resemblance to *C. ongleyi.*

Callospiriferina radiata (Hector, 1886)

Fig. 8F, Fig. 17: 1–24, Fig. 18: 1–6.

1886 *Spiriferina radiata* Hector, p. 70, fig. 36 no. 4.
1953 *Spiriferina radiata* Hector; Marwick, p. 85, pl. 15, fig. 19, 20.
1978 *Spiriferina radiata* Hector; Suggate *et al.* p. 713, fig. 11.7 13.
1981 *Spiriferina radiata* Hector; Speden & Keyes, p. 44, pl. 17.13.
1992 "*Spiriferina*" *radiata* Hector; Damborenea & Manceñido p. 139, Pl. 2 fig. 6–10.
2009 *Mentzelia radiata* (Hector, 1886); MacFarlan *et al.* p. 266.

Neotype. BR 1121, from E45/F 9440, GS337. An internal mould of a ventral valve, with damage to apex and part of posterior. Collected by A. McKay 1878. Designated as neotype by Marwick (1953).

Material. A total of 116 specimens from 11 collections were catalogued, of which 75 yielded valid measurements.

Kawhia Syncline. *Dactylioceras* band, Kawhia: R15/f8005 (AU 6425). Paparoa Point, Taharoa: R16/f6811 (AU8363). Upper Awakino Valley: R17/f317 (AU 9490).

Southland Syncline. Heale Ridge: E45/f085 (McF E49). Conical Hill: E45/f9440 (GS 337), E45/f9860 (JDC 1837, McF C8, GS 7736, AU 12474). Otapiri Gorge: E45/f9441 (GS 338), E45/f9553 (JDC 738), E45/f9787 (GS 7257). Lora–Otapiri Divide: E45/f9731 (?GS 7562). Mokoreta River bank, near Wyndham: F46/f9504 (?GS 7562).

Description. Spiriferinide of medium size, wider than long, (ventral valve generally 8–18 mm long, valves 12–25 mm wide). High procline umbo on ventral valve. Hingeline long, straight, with maximum width anterior of hingeline, outline anterior of hingeline rounded.

Dorsal valve with generally rounded outline, moderately convex, with narrow, rounded fold.

Ventral valve hemipyramidal with high umbo, which is generally anterior of the hingeline. Interarea broad, triangular, sulcus shallow, relatively narrow.

Both valves generally with four to six rounded costae on each flank, weakening towards margins. On some specimens the costae are very weak or not developed. Costae crossed by fine growth-lines and foliaceous growth lamellae. No costae in sulcus or fold. Exterior with fine tubular spines, in general only the spine bases are preserved (Fig. 8F). Shell material punctate (Fig.18.6b).

Ventral valve with short, relatively thick, straight, divergent dental plates bounding delthyrium and extending to apex. Median septum high, narrow wall-like, about half of valve length, extending to apex but ending anterior of delthyrium opening, not connected with dental plates (Fig. 17.2a, 17.5a), Delthyrium narrow, triangular, open (Fig. 17.4b, 17.5c).

Dorsal valve with narrow rounded hinge plate, shallow, well-separated sockets. Small round or transversely elongate cardinal process. Some specimens with paired, slightly incised muscle scars separated by low ridge-like median septum (Fig. 17.24).

Dimensions. Dimensions of the neotype and of two Kawhia Syncline specimens, and statistics for specimens from key Southland Syncline areas are shown in Table 6.

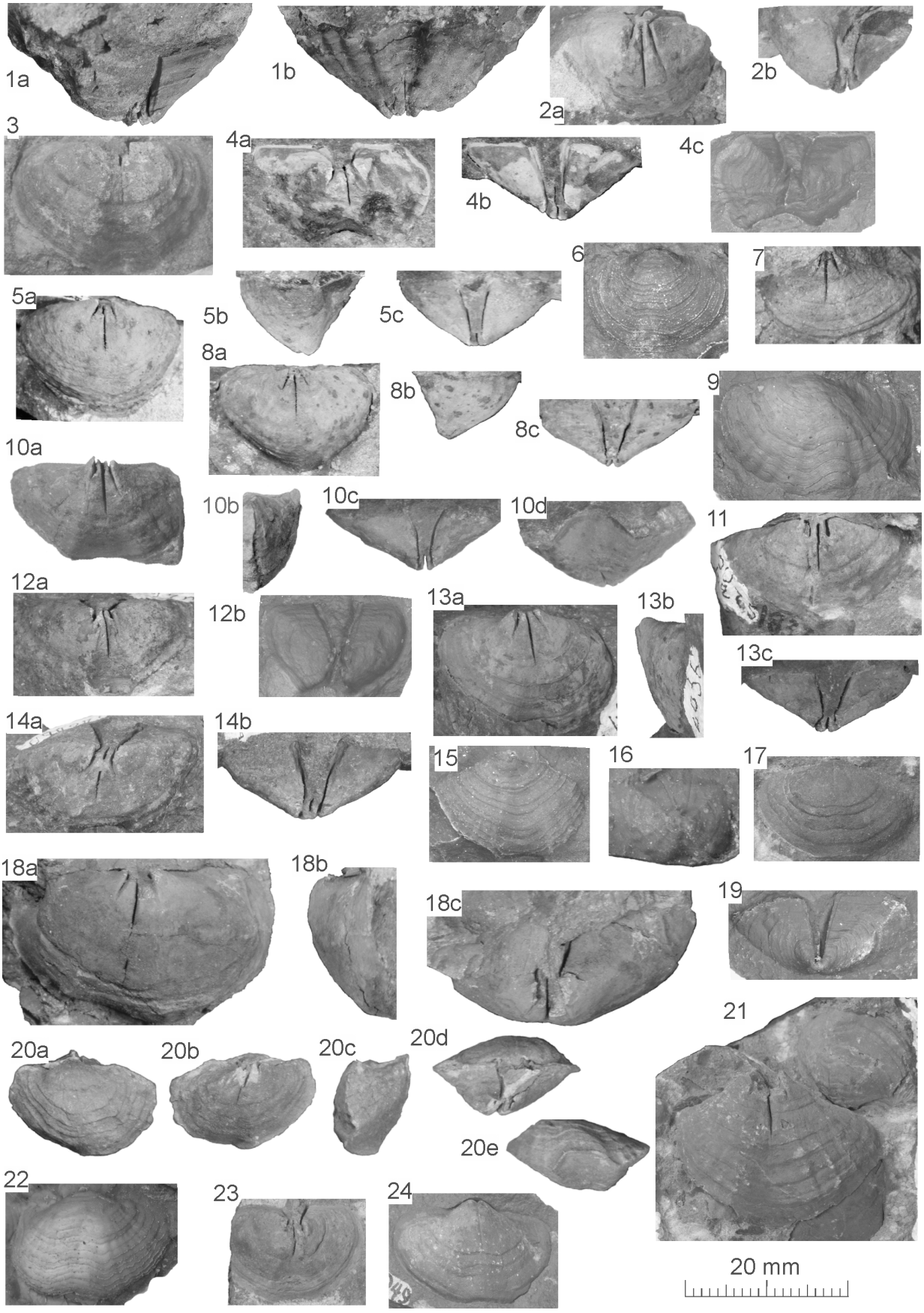
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FIGURE 17. *Callospiriferina radiata.* (x1.5). 1 Holotype NZGS BR 1121 (E45/f9440) ventral valve (a) posterior (b) anterior. Photos: M. Terezow. 2 C4259 (E45/f9860) internal mould of ventral valve (a) ventral (b) posterior. 3 BR 3304 (E45/f9440) internal mould of ventral valve. 4 C3046 (E45/f9860) internal mould of ventral valve (a) ventral (b) posterior (c) latex of interior. 5 C4257 (E45/f9860) internal mould of ventral valve (a) ventral (b) lateral (c) posterior. 6 C3048 (E45/f9860) dorsal valve, latex of exterior. 7 OU 46851 (E45/f9860) internal mould of ventral valve. 8 OU 46817 (E45/f9860) internal mould of ventral valve (a) ventral (b) lateral (c) posterior. 9 OU 47167 (E45/f9860) dorsal valve, latex of exterior. 10 C4264 (E45/f9860) internal mould of ventral valve (a) ventral (b) lateral (c) posterior (d) anterior. 11 OU 46865 (E45/f9860) internal mould of ventral valve. 12 OU 46861 (E45/f9860) ventral valve (a) internal mould (b) latex of exterior. 13 C4036 (E45/f9860) internal mould of ventral valve (a) ventral (b) lateral (c) posterior. 14 OU 46868 (E45/f9860) internal mould of ventral valve (a) ventral (b) posterior. 15 BR 3292 (E45/f9860) ventral valve, latex of exterior. 16 OU 46888 (E45/f0085) dorsal valve, latex of exterior. 17 OU 47170 (E45/f9860) internal mould of dorsal valve. 18 OU 46820 (E45/f0085) internal mould of ventral valve (a) ventral (b) lateral (c) posterior. 19 C4034 (E45/f9860) ventral valve, posterior view of latex. 20 OU 46821 (E45/f0085) internal mould of both valves (a) dorsal (b) ventral (c) lateral (d) posterior (e) anterior. 21 OU 46878 (E45/f0085) internal mould of ventral valve. OU 46879 (ventral valve) also in view. 22 OU 46889 (E45/f0085) dorsal valve, latex of exterior. 23 C4260 (E45/f9860) internal mould of ventral valve. 24 C3049 (E45/f9860) internal mould of dorsal valve.

TABLE 6. Dimensions, *Callospiriferina radiata*.

FR no.	specimen	Lv	Ld	W	H	Ha	Wp	UA	**material**	**notes**
E45/f9440	BR 1121	12.3		24.5+		11.5	8.3		vv int	NEOTYPE
R15/f8005	B818	9.9		16.2		2.8	3.7	105	vv shelly	Only Kawhia
R17/f317	B734	18.8		33.7		6.2	14.7	138.0	vv int, ext	Syncline specimens measured
E45/f9860	Mean	12.9	12.7	19.6	12.1	7.2	6.6	107.5	55 specimens measured	
Conical Hill	S.D.	5.31	5.47	6.73	4.55	3.12	2.44	47.84		
E45/f085	Mean	13.8	13.5	21.3	9.0	6.9	7.8	124.8	14 specimens measured	
Heale Ridge	S.D.	5.41	4.73	6.39	4.50	2.88	2.65	45.21		

Range and distribution. This species is common in the Lower Ururoan of the Otapiri Gorge (Conical Hill and nearby Otapiri Gorge localities, Heale Ridge). Most of the material comes from E45/f9860 (Otapiri Gorge north of Conical Hill) and Heale Ridge (E45/f0085).

It is not recorded from New Caledonia, and only two specimens have been found in the Kawhia Syncline, one from the *Dactylioceras* band (R15/f8005 AU 6425) and one from the upper Awakino Valley (R17/f317, AU 9490).

Remarks. Damborenea & Manceñido (1992) discussed the "*Spiriferina*" *radiata–tumida* plexus in the Pliensbachian of western Argentina, which involves range of forms that are close to *C. radiata* and differ at a subspecies level from *C. tumida.*

Subfamily DISPIRIFERININAE Carter, 1994

Dispiriferina Siblík, 1965

1965 *Dispiriferina* Siblík p. 79.
1977 *Dispiriferina* Siblík, 1965; Rousselle p. 159.
2006 *Dispiriferina* Siblík, 1965; Carter, p. 1929.
2013 *Dispiriferina* Siblík, 1965; Alméras & Cougnon, p. 24.

Type species. *Spiriferina davidsoni* Deslongchamps, 1855 (OD).

Dispiriferina was proposed by Siblík (1965) to include multicostate spiriferinides with costae in the fold and sulcus. As well as the type species, he suggested that *S. collenoti* Deslongchamps, 1884, *S. deslongchampsi* Davidson, 1852

and *S. segregata* Di Stefano, 1886 were related to the new genus. Rousselle (1977) figured *Dispiriferina davidsoni* and *D. ? oxyptera* Buvignier, 1843 from the Early Jurassic of the Middle Atlas of Morocco. Alméras & Cougnon (2013) reviewed the genus and included all the species listed by Siblík and Rousselle. The genus is recorded from France and Slovakia, (Siblík 1965), Morocco (Rousselle 1977) and Spain (Comas-Rengifo *et al.* 2006), Italy (Taddei Ruggiero & Vörös 1987) and Turkey (Vörös & Kandemir 2011). World distribution is shown in Fig. 6.

Carter *et al.* (1994) revised the classification of the spiriferinide brachiopods and placed *Dispiriferina* in the new subfamily Dispiriferininae. This classification was followed by Carter (2006).

Dispiriferina sp. cf. *D. chilensis* (Forbes, 1846)

Fig. 18: 7, 8.

Material. Two ventral valve internals, C2061 and C2062, from Ben Bolt: E45/f9446 (JDC 737).

Description. Medium sized spiriferinide, slightly wider than long, (dorsal valve 20–21 mm long, 22.7 and 25.9 mm wide). with hingeline about two-thirds of valve width. Maximum width posterior of half valve length. Lateral and anterior margins convex. Flanks moderately convex, with shallow, poorly defined sulcus. C2062 (Fig. 18.7) has about eight moderately strong rounded costae on each flank, and a shallow, poorly defined sulcus with five more bluntly rounded costae. Part of the right flank is damaged. C2061 (Fig. 18.8) is of similar size and shape but has a better-defined concave sulcus with about three barely discernible costae.

Area low, triangular, with rounded apex, open delthyrium. Median septum narrow, about 0.3 of valve length, dental plates thicker but short. Posterior part of valve with thickened muscle field.

Dimensions. Dimensions of both specimens are shown in Table 7.

TABLE 7. Dimensions, *Dispiriferina* cf. *chilensis.*

FR no.	specimen	Lv	Ld	W	H	Ha	Wp	UA	material	notes
E45/f9446	C2062	20.2		22.7		5.9	12.0	148	vv int	R margin damaged, fine sharp costae, costae in sulcus
	C2064	21.2		25.9			11.5	130	vv int	faint costa in sulcus

Range and Distribution. Mid-Aratauran of Ben Bolt, Otapiri Valley.

Remarks. These two specimens are the only Zealandian Jurassic spiriferinides seen to date with costae developed in the fold and sulcus.

Forbes (1846) described *Spirifer chilensis* from material collected on the Beagle Expedition (1831–1836) from the Jurassic of Chile and sent to him by Charles Darwin. The species was redescribed by Manceñido (1981) as *Spiriferina chilensis* from the Lower Jurassic of Neuquén Province, Argentina. It is listed by Aberhan (1993) from the Sinemurian of Chile, where it is the essential element of the *Spiriferina chilensis* association.

Manceñido (1981) suggested that "a case could be made for the retention of Siblík's *Dispiriferina* as a subgenus of *Spiriferina* (s.l.) in which *S. chilensis* could probably be accommodated" (p. 652). This proposal is accepted here, with *Dispiriferina* treated as a genus as in Siblík (1965) and subsequent authors.

The New Zealand specimens are generally similar to *D. chilensis* but are smaller and less inflated than the specimens figured by Forbes (1846) and Manceñido (1981).

Discussion

Preservation of spines and punctae

Spines are present on a number of Jurassic spiriferinides but are rarely described in any detail. Rollier (1917), Corroy (1927) and Rousselle (1977) all mentioned spines on a few Jurassic species but provided no details or descriptions. Spines on *Spiriferina walcotti* from Britain are described by MacKinnon (1974) as "hollow spines, on average 80µm in diameter at their bases and tapering distally to about 35µm, which project at low angles towards the commissure" (p. 196).

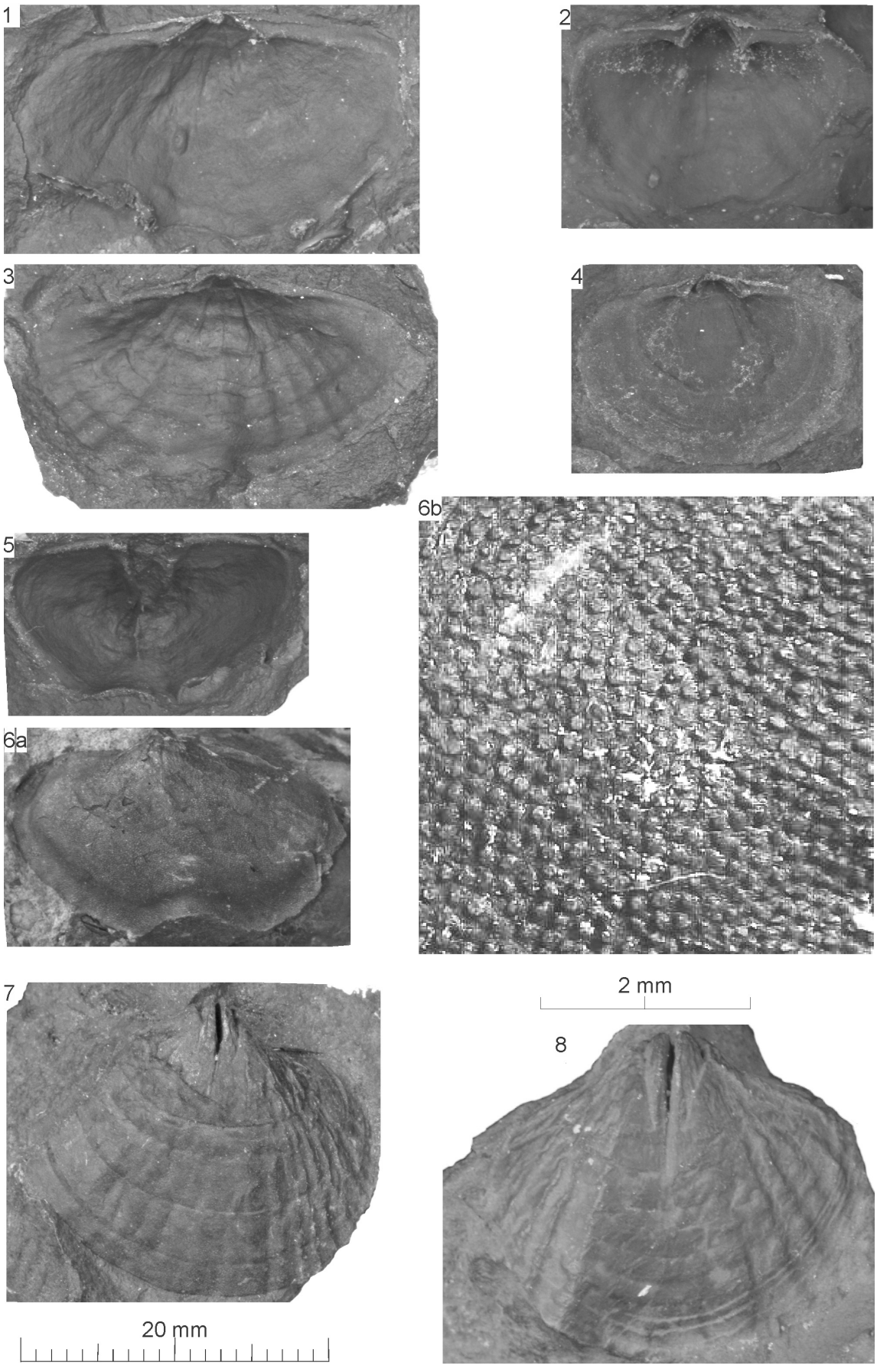
1
2
3
4
5
6a
6b
2 mm
7
20 mm
8

FIGURE 18. *Callospiriferina radiata*. (x3). 1 OU 47167 (E45/f9860) dorsal valve, latex of interior. 2 OU 46818 (E45/f9860) dorsal valve, latex of interior. 3 C4258 (E45/f9860 dorsal valve, latex of interior. 4 C3048 (E45/f9860) dorsal valve, latex of interior. 5 BR 3287 (E45/f9860) internal mould of ventral valve, latex of interior. 6 OU 46872 (E45/f0085) (a) internal mould of dorsal valve, (b) part of valve enlarged to 20x to show impressions of punctae. *Dispiriferina* sp. cf. *D. chilensis* (x3). 7 C2062 (E45/f9116) internal mould of ventral valve. 8 C2061 (E45/f9116) internal mould of ventral valve.

The original brief description of *Cisnerospira* by Manceñido (2004) does not mention spines, but Baeza-Carratalá *et al.* (2016) stated that "micro-ornament consists of very fine and dense spinules with quincuncical arrangement" (p. 1084). In his description of *Dispiriferina*, Siblík (1965) does not mention spines, but Deslongchamps (1855) illustrated spines on the type species, *D. davidsonii.*

The best illustration of spines on a Jurassic spiriferininde is in Halamski *et al.* 2007 fig. 1B, which shows fine spines preserved on a specimen of *Callospiriferina tumida*. From the photo and scale they appear to be of the order of 1mm in length and 0.1mm across, and best-developed near the anterior margin. Professor Halamski commented that this was due to "exceptional material and an exceptional preparator", Canon Gonzague Dubar (1896–1977) of Lille, France (Email; 15 March 2022).

The Zealandian species of *Spiriferina*, *Cisnerospira* and *Callospiriferina* described here all show spine bases as outward projections on a few well-preserved external moulds (Fig. 8). Only the spine bases are preserved, and no indication of spine length or shape can be given. In a few spine bases, a plug of matrix is preserved within the spine base, indicating that they may have been hollow, at least in part. Spine bases in *Spiriferina sophiaealbae* (Fig. 8B) appear to be crescentic in section.

Spine bases can be distinguished from punctae, which are preserved on many moulds as more or less cylindrical plugs of soft clay matrix. These are readily removed in cleaning and handling, Fig. 8F shows a small patch of preserved punctae, which are more closely spaced than the spine bases. The interior of one specimen of *Callospiriferina radiata* (OU 46872 from E45/f0085) shows close-spaced rounded projections which may be punctae or pustules on the interior surface (Fig. 18.6b). Spines have not been preserved on any shelly specimen seen in this study, and punctae are poorly preserved, probably as a result of recrystallisation.

Spiriferinides in the latest Triassic of Zealandia

The large, alate *Rastelligera* Hector, 1878, with its distinctive "comb-tooth" hinge structure and the related genus *Psioidiella* Campbell, 1968 are among the most common spiriferinides in the Late Triassic of Zealandia (Campbell 1968, 1991a). In the Rhaetian (Otapirian local stage) *Rastelligera* of the *gypaeetus—elongata* group are found throughout the middle and upper Otapirian in New Zealand but have not been reported from New Caledonia. *Psioidiella* is rare in both the New Zealand and New Caledonian Otapirian. The genus is present from the Oretian (Norian) (Campbell 1968), and is also present in Spitzbergen (J.D. Campbell det, fide H.J. Campbell 2018). The relationship between *Rastelligera* and the similar *Canadospira* Dagys, 1972, known from Canada (Logan 1967), New Guinea (Skwarko *et al.* 1976) and Japan (Ager & Minato 1983) suggests that the two genera form a group with a bipolar boreal–antiboreal distribution. Other key members of this endemic fauna are the large athyrid *Clavigera planchesi* (Deslongchamps, 1864) and the trigoniid *Maoritrigonia* Fleming.

An incomer in the late Norian is the strongly costate *Zugmayerella taringaturaensis* Campbell, 1991, which is common in New Caledonia and found throughout the late Norian and Rhaetian of New Zealand. *Zugmayerella* has a world-wide distribution and is present in Indonesia, the North-west Shelf of Australia, and South America (Campbell 1991b, MacFarlan *et al.* 2011).

The next incomer is *Callospiriferina kawhiana*. Its appearance, and the slightly later appearance of the pterioid *Otapiria dissimilis* (Cox) define an informal late Otapirian zone (Cooper 2004). In the latest Otapirian, the appearance of the rhynchonellide *Vincentirhynchia pomeyroli* (Drot, 1953) and the terebratulide *Zeilleria spiculata* MacFarlan and Campbell, 2003 are further precursors of faunal change.

The End-Triassic Event

The End-Triassic Event in Zealandia is marked by the extinction of the distinctive Maorian fauna epitomised by *Clavigera*, *Rastelligera* and *Maoritrigonia*. The long-lived rhynchonellide *Sakawairhynchia marokopana*

MacFarlan, 1992 survived the boundary, as did *S. mokauensis* MacFarlan, 1992 and *Vincentirhynchia pomeyroli* (Drot, 1953).

Early Jurassic spiriferinides

There are major gaps in the earliest Jurassic record in most of New Zealand (Stevens 2004) and New Caledonia (Meister *et al.* 2010). Only the sequence in the Otapiri Valley is more or less complete, but not continuous. The Triassic–Jurassic boundary runs along Taylors Stream, a tributary of the Otapiri Stream (MacFarlan & Campbell 2003). *Zeilleria spiculata* flourished in the earliest Jurassic beds in Taylors Stream. Spiriferinides are absent in the earliest Jurassic beds in the Otapiri Valley. The athyrides are extinct, and no trigoniids are known from the Aratauran and Ururoan (Hettangian to mid–Toarcian) of Zealandia.

The earliest Jurassic spiriferinides appear to be from the Coneburn in the Otamita Valley to the east of the Otapiri, where the Middle Hettangian at F45/f8683 has yielded *Spiriferina sophiaealbae, Cisnerospira antipoda* and *Callospiriferina ongleyi*. Spiriferinides are present in the Otapiri Valley from the Late Hettangian.

Campbell (1997) suggested that *Psioidiella* "was still extant in New Caledonia in the Hettangian" (p. 231) but provided no details. J.D. Campbell's field books, held by the Geology Department, University of Otago, record *Psioidiella* from JDC 3202, NC/f0384, east coast Baie Inaccessible, along with an Aratauran fauna including psiloceratid ammonites. Attempts to locate this collection in Dunedin have not yet succeeded.

Affinities of the Zealandian Jurassic Spiriferinides

All four of the spiriferinide groups outlined by Corroy (1927) can be recognised in the Zealandian Early Jurassic.

I Group of non-costate spiriferinides: *Cisnerospira antipoda.*
II Group of spiriferinides with barely visible costae: *Callospiriferina ongleyi*, *C. radiata.*
III Group of spiriferinides with strong costae: *Spiriferina arakiwa*, *S. sophiaealbae*.
IV Group of multicostate spiriferinides: *Dispiriferina* cf. *chilensis*.

The affinities of the Zealandian spiriferinides are initially with southern Europe and North Africa (Fig. 6). There are strong links to Argentina (Damborenea & Manceñido 1992) and Indonesia (Wanner & Knipscheer 1951). The strongly endemic or Austral faunas of the latest Triassic are replaced by a much more widespread fauna. This echoes the trend seen in terebratulides (MacFarlan 2019) and to some extent in rhynchonellides (MacFarlan 1992).

Nearshore and offshore faunas

The prolific nearshore brachiopod faunas of the north to northwest face of Ben Bolt in the Otapiri Valley are dominated by *Callospiriferina ongleyi* and the terebratulide *Loboidothyris fordycei* MacFarlan 2019. Higher in the sequence at Conical Hill and Heale Ridge, *C. ongleyi* is replaced by *C. radiata. L. fordycei* and the rhynchonellide *Aucklandirhynchia sexagesimae* are common. The spiriferinides and *L. fordycei* are almost all preserved as single valves.

In other sections with an offshore aspect, spiriferinides are much less common, with *Cisnerospira antipoda* and *Spiriferina sophiaealbae* having the widest distribution. Other generally offshore brachiopods include *Herangirhynchia herangiensis* MacFarlan 1992*, Lobothyris simesi* MacFarlan 2019 and *Zeilleria terezowae* MacFarlan 2019.

Dead Clades Walking?

Jablonski (2001, 2002) introduced the concept of "dead clades walking" for groups that survive an extinction event only to fall into a marginal role and eventually disappear, citing the Jurassic spiriferinides as an example. Vörös *et al.* (2016) discussed this further, pointing out that the two remaining spire-bearing orders (Spiriferinida and Athyridida) had only a muted recovery after the end–Triassic crisis, and did not survive the Toarcian crisis. Vörös *et al.* (2019) suggest that this may have been due to the restrictions the calcareous spiralia impose on the lophophore of these groups, in contrast to the less constrained lophophore of the terebratulides and rhynchonellides. This had previously been suggested by Ager (1987).

Early Jurassic spiriferinides are recorded from Alaska (Sandy and Blodgett 2000), Greenland (Rosencrantz 1934), South America (Forbes 1846, Manceñido 1981, Damborenea & Manceñido 1992, Aberhan 1993), Indonesia

(Wanner & Knipscheer 1951) Most of these are Pliensbachian. The Zealandian occurrences range from middle Hettangian to Toarcian (see Appendix 1). Vörös *et al.* (2019) suggest that by the Toarcian the spiriferinides were geographically restricted to the Western Tethys, apart from "a single occurrence in New Zealand" (p. 718). Barnes *et al.* (2021) show that "dead clades walking" are a pervasive and complex macroevolutionary pattern.

The diversity of the Zealandian Early Jurassic spiriferinide fauna described here tends to suggest that the view of the Jurassic spiriferinides as a "dead clade walking" and simply waiting for extinction is influenced mainly by hindsight. Zealandian Jurassic spiriferinides are reasonably diverse. They tend to be smaller in size than their Late Triassic counterparts, and while they are found in most Early Jurassic sections, they are abundant only in the Otapiri Valley sections. This is in contrast to the Late Triassic, where the late Otapirian *Callospiriferina kawhiana* is ubiquitous and often abundant.

The Toarcian Event

The brachiopod faunas of the later part of the Ururoan local stage are distinctive. The most diverse faunas are those of the *Dactylioceras* band (Fig. 19) with four species of rhynchonellide (MacFarlan 1992), five species of terebratulide (MacFarlan 2019) and the three species of spiriferinide recorded here. This fauna does not extend much above the *Dactylioceras* band. R15/f8006 is best regarded as a number for more poorly localised collections just above or below R15/f8005 (Hudson 2003). 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, 1970 which is one of the few fossils found in overlying beds.

FIGURE 19. The *Dactylioceras* band at Te Maika Peninsula, Kawhia. The bluish-green rock (marked at beach level in the left photo) is the band, the overlying rocks are muddy siltstones and very fine sandstones with fine, light-coloured tuff beds. Left taken January 1979, right November 2010 with Clemens Ullmann beside the outcrop.
Was this the spiriferinides last stand?

The correlation of the *Dactylioceras* band with the Crassum Subzone of the Bifrons Zone at the top of the Early Toarcian (Stevens 2008) is supported by the correlations of the outcrop at Paparoa Point on the Taharoa coast south of Kawhia and of Mantle Grove in the Mataura Valley, Southland with the underlying Fibulatum Zone (Stevens 2007, 2008). Both of these are also some distance above the Toarcian Event at the base of the Toarcian (Fig. 2) There is little change in brachiopod faunas within this interval, so the Toarcian Event that devastated marine faunas in the Early Toarcian Tenuicostatum–Serpentium Zone boundary in most other parts of the world (García Joral *et al.* 2011, Gröcke *et al.* 2011, Al-Suwaidi *et al.* 2016), with the extinction of the spiriferinides and koninckinids (Baeza-Carratalá *et al.* 2015) does not appear to have affected Zealandia in the same way.

If the Toarcian crisis was at least partly caused by increasing temperatures (Garcia Joral *et al.* 2011, Baghli *et al.* 2020, Ullmann *et al.* 2020) the near-polar position of Zealandia could have allowed a temporary refuge for the spiriferinides.

Ammonite faunas from high Northern Hemisphere latitudes indicate multiple peaks and troughs in extinction rates that suggest 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). Riccardi (2008) recorded a peak and decline at about the same level in Argentina. In Zealandia the global effects may have been exacerbated by the widespread shallowing that occurred in the Ururoan and 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.

As mentioned above, the *Dactylioceras* band is close to the top of the range of the Zealandian Early Jurassic brachiopod fauna. Brachiopods are rare in the early Temaikan (latest Toarcian to Aalenian) of Zealandia. Challinor & Hudson (2017) define an earliest Temaikan *Eobelemnopsis* zone, based on the appearance of *Eobelemnopsis mackayi* (Stevens, 1965) or *E. robustus* Challinor & Hudson, 2017, and consider that this zone is late Toarcian. The rhynchonellide *Aucklandirhynchia aucklandica* MacFarlan, 1992 occurs with *E. mackayi* at a few localities on Ben Bolt, Hokonui Hills, in sandstones which overlie diachronously the finer-grained Aratauran sediments that contain spiriferinides. From the Middle Temaikan (late Aalenian to Bajocian) a more varied terebratulide fauna with the rhynchonellides *Auckandirhynchia* MacFarlan, 1992, *Caledorhynchia* MacFarlan, 1992 and *Kawhiarhynchia* MacFarlan, 1992, and the terebratulides *Kutchithyris* Buckman, 1918 *Loboidothyris* Buckman, 1918 and *Zeilleria* Bayle, 1878 is present (MacFarlan 1992, 2016).

Conclusions

The Zealandian Jurassic spiriferinides show a vigorous faunal recovery after the End-Triassic Event, after a possible hiatus in the earliest Jurassic. The new fauna is reasonably diverse, and spiriferinides are fairly common in some shallow-water faunas in the Otapiri Valley. Shell size is rather smaller than in the Triassic. The fauna is cosmopolitan, and has strong links to South America and to southern Europe and North Africa, and some links to Indonesia. The final demise of the spiriferinides in Zealandia probably occurs after the Toarcian Event in the Northern Hemisphere and South America and may be partly facies-related.

In memoriam Jack Grant-Mackie

Professor Emeritus Jack Grant-Mackie died in February 2021, while this paper was in preparation. Jack influenced my entire career, from undergraduate studies at the University of Auckland, to his supervision of my M.Sc. project on the Triassic and Jurassic of the Marokopa area, and his enthusiastic support of my PhD at Otago University. We stayed in close touch and discussed several times the Jurassic brachiopod survey of which this paper forms a part.

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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.

île New Caledonia

FR Number	NCTM Easting	NCTM Northing	Locality	Stage	Collection no:	Collectors	spiriferinide species
NC/f0005	607720	7563010	Conspicuous bedding exposed on broad round of northeast ridge of hill 121, overlooking Chez Durand, c. 90 m above sea level, north île Hugon.	Bo	AU 7146	J.A. Grant-Mackie 19/10/1979	*Callospiriferina kawhiana*
NC/f0007	607870	7563170	Just below change in slope to sand-wharf, c. 55 m above sea level, north-east end of northeast ridge of hill 121, north île Hugon.	Bo	AU 7149	J.A. Grant-Mackie 1979	*Callospiriferina kawhiana*
NC/f0018	605680	7567350	Near top of bull-dozed track c. 90 m above sea level, between hills 189 and 169, north île Ducos.	Bo	AU 6074	J.A. Grant-Mackie 19/10/1979	*Callospiriferina kawhiana*
NC/f0020	605690	7567220	Road cutting exposure in Terebratula shellbed, on bull-dozed track below HJC574 (NC/f19) at c. 65–70 m above sea level, south flank of hill 169, north île Ducos.	Bo	GS 12733	H.J. Campbell 19/10/1979	*Callospiriferina kawhiana*
					AU 7175	J.A. Grant-Mackie 19/10/1979	*Callospiriferina kawhiana*
NC/f0023	606080	7567050	Road side exposure in brachiopod limestone on bull-dozed track, south flank of hill 169, c. 30–35 m above sea level, north île Ducos.	Bo	GS 12736	H.J. Campbell; 19/10/1979	*Callospiriferina kawhiana*
					AU 7179	J.A. Grant-Mackie 26/10/1979	*Callospiriferina kawhiana*
NC/f0050	608760	7565740	Shore platform and coastal cliffs, south coast, northwest of île Jacqueline, east île Ducos.	Bo	GS 12763	H.J. Campbell 24/10/1979	*Callospiriferina kawhiana*
NC/f0060	607720	7566280	Well-exposed beds, shore platform at head of Baie des Moustiques, central north île Ducos.	Bo	AU 7214	J.A. Grant-Mackie 19/10/1979	*Callospiriferina kawhiana*

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FR Number	NCTM Easting	NCTM Northing	Locality	Stage	Collection no:	Collectors	spiriferinide species
NC/f0082	608070	7565160	Distinctive bed exposed all along coastal cliff and shore platform outcrop to south of hill 36, south coast central île Ducos.	Bo	AU 7799	J.A. Grant-Mackie 19/10/1979	?*Callospiriferina kawhiana*
NC/f0165	570390	7591540	Marsh side exposure, east side, south end of marsh, île Mara.	Ha	AU 5785	H.J. Campbell 1976	*Callospiriferina ongleyi*
NC/f0170	570730	7591160	Low hillside outcrops west side southeast headland, île Mara.	Ha	AU 5790	H.J. Campbell 1976	*Callospiriferina ongleyi*
NC/f0384	619600	7559000	East coast Baie Inaccessible	Ha	JDC 3202	J.D. Campbell, H.J. Campbell, 1/12/1975	*Psioidiella* sp. (fide JDC)
NC/f0401	615730	7558350	Uitoé peninsula—low promontory of north end of beach in central west coast, 300 m north of wharf.	Ha	AU 9419	J.A. Grant-Mackie	*Callospiriferina ongleyi*
NC/f0518	607780	7563130	île Hugon—on north slope of hill 121 at head of small north flowing gully next west of sand wharf, at c. 60 m above sea level and directly between NC/f504 and NC/f7.	Bo	AU 7773	J.A. Grant-Mackie	*Callospiriferina kawhiana*
NC/f0564	608260	7565200	île Ducos—point to west of île Jacqueline, 150 m west of NC/f563 and 400 m east of NC/f111.	Bo	AU 7798	J.A. Grant-Mackie	*Callospiriferina kawhiana*
NC/f0647	618800	7558000	Uitoé peninsula—north coast of isthmus intertidally 200 m northwest of end of exposure and 300 m southeast of NC157.	Hu	AU 9608	J.A. Grant-Mackie; 19/10/1981	?*Callospiriferina ongleyi*

Kawhia Syncline

FR Number	NZMG Easting	NZMG Northing	Locality	Stage	Collection no:	Collector and date.	spiriferinide species
R15/f			"in the *Arcestes* and *Hectoria* beds, in the cliff-section south of Kawhia Harbour. "	Bo	NHM B50433	C.T. Trechmann	*Callospiriferina kawhiana*
R15/f			"Several hundred feet above the *Pseudomonotis ochotica* beds north of Albatross Point, Kawhia"	Bo	NHM B50492	C.T. Trechmann	*Callospiriferina kawhiana*
R15/f			*Spiriferina* beds? Nth of Arawi Point Kawhia	Bo	AU 21755		*Callospiriferina kawhiana*
R15/f0024	2662800	6341400	Coast South of Arataura Point, cliff behind long beach, 200m S of Arataura Point.	Bo	McF B13	D.A.B. MacFarlan 13/1/1979	*Callospiriferina kawhiana*
R15/f0026	2662800	6341300	Coast South of Arataura Point Kawhia. From cliff behind beach 330m South of Arataura Point South wall.	Bo	McF B15	D.A.B. MacFarlan 13/1/1979	*Callospiriferina kawhiana*
R15/f8005	2664700	6343100	*Dactylioceras* Bed, Ururoa Point,	Hu	AU 614		*Spiriferina sophiaealbae*
					AU 6425	J.A. Grant-Mackie 4/75	*Callospiriferina radiata*
					AU 9197	A.B.S. Clarke, N. Hudson, J.A. Grant-Mackie 18/1/1981.	*Cisnerospira antipoda*
					AU 12296	J.A. Grant-Mackie 4/1990	*Cisnerospira antipoda*
R15/f8006	2664800	6343100	Post-*Dactylioceras* beds. 60–240 m ne of stack at Ururoa Point. 120 m north of Ururoa Point. Used as general F.R. no. for collections just above or below the *Dactylioceras* Band.	Hu	GS 3150	J. Henderson, L.I Grange 1921, RAS Browne ?1943, H Arnold 1953-56, C.A. Fleming, D Kear, R.A. Couper Dec 1956	*Cisnerospira antipoda*
				Hu	AU 600	1943 coll	*Cisnerospira antipoda*
R15/f8078	2664550	6342800	Northern side of hole on rock Ururoa Point, Te Maika Peninsula, Kawhia Harbour.	Hu	AU 9203	N. Hudson 10/5/1982	*Cisnerospira antipoda*

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FR Number	**NZMG Easting**	**NZMG Northing**	**Locality**	**Stage**	**Collection no:**	**Collector and date.**	**spiriferinide species**
R15/f8575	2664600	6342850	20m NE of smaller of two stacks at Ururoa Point, open coast, Kawhia.	Hu	AU 48	K.R. Martin 1966	?*Cisnerospira antipoda*
					AU 9209	N. Hudson 13/5/1982	*Spiriferina sophiaealbae*
					JDC 1150	J.D. Campbell, D.S. Coombs 2/1954	*Cisnerospira antipoda*
R15/f8578	2662500	6341000	620m SE of south wall of Arataura Point.	Bo	JDC 1157	J.D. Campbell, D.S. Coombs 8/02/1955	*Callospiriferina kawhiana*
R15/f8580	2662540	6341040	450m southwest from Arataura Point.	Bo	GS 12306	KJ McNaught 1976	*Callospiriferina kawhiana*
R15/f8585	2662731	6341307	60m south of south wall of Arataura Point and north of zig zag.	Bo	GS 6754	H. Arnould	*Callospiriferina kawhiana*
R15/f8686	2664605	6342900	100m S of Ururoa Point.	Hu	AU 599	E.J. Searle & others 1942, 1945	*Cisnerospira antipoda*
					AU 604	P.N.C. Wong 1942	*Spiriferina sophiaealbae*
R15/f8812	2663754	6341918	240 m SW of Otamaehu Point (west face), immediately NE of stream. Southwest Kawhia.	Ha	AU 14794		*Callospiriferina ongleyi*
R15/f8816	2664605	6342900	On south side of point with natural tunnel 140m south of stack at Ururoa Point, 30.5m below *Dactylioceras* bed.	Hu	AU 50	K.R. Martin 2/1965	*Cisnerospira antipoda*
					AU 14811	J.A. Grant-Mackie *et al* 11/95	*Spiriferina sophiaealbae*
R15/f8833	2662959	6341301	Coast 110m south southwest of south wall of Arataura Point.	Bo	GS 11802	KJ McNaught 1964	*Callospiriferina kawhiana*
R15/f8834	2662912	6341256	Coast 140m south southwest of south wall of Arataura Point.	Bo	AU 63	K.R. Martin May 1965	*Callospiriferina kawhiana*
R15/f8835	2662912	6341256	Coast 160m south southwest of south wall of Arataura Point.	Bo	AU 64	J.A. Grant-Mackie May 1965	*Callospiriferina kawhiana*

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FR Number	NZMG Easting	NZMG Northing	Locality	Stage	Collection no:	Collector and date.	spiriferinide species
R15/f8836	2662819	6341213	Coast 200m south southwest of south wall of Arataura Point.	Bo	AU 68	K.R. Martin May 1965	*Callospiriferina kawhiana*
R15/f8837	2662865	6341212	Coast 230m south southwest of south wall of Arataura Point.	Bo	AU 69	K.R. Martin May 1965	*Callospiriferina kawhiana*
R15/f8838	2662818	6341167	Coast 280m south southwest of south wall of Arataura Point.	Bo	AU 70	K.R. Martin	*Callospiriferina kawhiana*
R15/f8839	2662818	6341167	Coast 320m south southwest of south wall of Arataura Point.	Bo	AU 72	K.R. Martin May 1965	*Callospiriferina kawhiana*
R15/f8839	2662818	6341167	Coast 320m south southwest of south wall of Arataura Point.	Bo	AU 73	K.R. Martin May 1965	*Callospiriferina kawhiana*
R15/f8844	2662723	6341033	Coast 440m south southwest of south wall of Arataura Point.	Bo	AU 66	K.R. Martin May 1965	*Callospiriferina kawhiana*
R15/f8848	2662630	6340990	Coast 560m south southwest of south wall of Arataura Point.	Bo	AU 67	K.R. Martin Jan 1966	*Callospiriferina kawhiana*
R15/f8875	2664620	6342270	Waitapu Bay, Te Maika Peninsula, Kawhia Harbour	Hu	AU 9217	N. Hudson	*?Callospiriferina ongleyi*
R16/f0003	2659850	6319850	Coast about 350m south of mouth of Marokopa River.	Bo	GS 11772	K.J. McNaught 13/3/1965	*Callospiriferina kawhiana*
R16/f0004	2659800	6319800	Coast about 480m south of mouth of Marokopa River.	Bo	GS 11773	K.J. McNaught 13/3/1965	*Callospiriferina kawhiana*
R16/f0005	2659800	6319750	Coast about 640m south of mouth of Marokopa River.	Bo	GS 11774	K.J. McNaught 13/3/1965	*Callospiriferina kawhiana*
R16/f0050	2659700	6319700	Marokopa Coast. North of point impassable at high tide, North of Waipaua Stream; collection from large fallen blocks at foot of cliff.	Bo	McF A19	D.A.B. MacFarlan 10/12/1978	*Callospiriferina kawhiana*
R16/f0144	2660000	6325400	North side of headland 600m North of Tauhua Stream mouth.	Bo	AU 9475	J.A. Grant-Mackie; L.R.S. Braithwaite	*?Callospiriferina kawhiana*
R16/f0146	2660100	6325200	North end of Tauhua Beach 600m North of stream mouth.	Bo	AU 9471	J.A. Grant-Mackie; L.R.S. Braithwaite	*?Callospiriferina kawhiana*

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FR Number	NZMG Easting	NZMG Northing	Locality	Stage	Collection no:	Collector and date.	spiriferinide species
R16/f0148	2660200	6323700	Coastal outcrop about 500m South of mouth of Tauhua Stream Marokopa. 75m south of small fishing bach.	Bo	AU 8358	J.G. Begg 24/2//1982	*Callospiriferina kawhiana*
R16/f0151	2660100	6331100	South side Parahaki Peninsula, Taharoa.	Bo	AU 8362	J.G. Begg 26/2//1982	*Callospiriferina kawhiana*
R16/f0317	2660032	6320257	Low outcrop in intertidal zone on S side of mouth of Marokopa River.	Bo	AU 14313	Zhang, W.; Li, Xiao Chi, Yu, J.; J.A. Grant-Mackie 4/12/1988	*Callospiriferina kawhiana*
R16/f0328	2659900	6320200	Marokopa Coast c.50m S of mouth of river; 1m below prominent 5-10cm tuff and 50m N of f327.	Bo	AU 12695	M. Adachi, J.A. Grant-Mackie; J.D. Campbell, F. Hasibuan, H.J. Campbell 28/1/1986	*Callospiriferina kawhiana*
R16/f0339	2659800	6320000	Marokopa Coast c.260m S of river mouth and c.100m N of large rock fall.	Bo	AU 15009	M. Adachi, J.A. Grant-Mackie; J.D. Campbell, F. Hasibuan, H.J. Campbell 29/1/1986	*Callospiriferina kawhiana*
R16/f0343	2659800	6320000	Marokopa Coast in small rockfall 10m N of R16/f0342 (which comes from clearly designated site above) and 10m S of R16/f0339 and c. 300m S of river mouth.	Bo	AU 12079	F. Hasibuan; J.A. Grant-Mackie; J.D. Campbell, H.J. Campbell.. 30/1/1986	*Callospiriferina kawhiana*
R16/f0344	2659800	6320100	Marokopa Coast 50m N of R16/f0343 and c.100m S of R16/f0327.	Bo	AU 12080	F. Hasibuan; J.A. Grant-Mackie; J.D. Campbell, H.J. Campbell.. 30/1/1986	*Callospiriferina kawhiana*
R16/f6811	2658300	6339000	Paparoa Pt, Taharoa coast 920 m SSE of island south of Albatross Point, at outcropping bluff under sand dunes	Hu	AU 154	K.R. Martin 1966	*Spiriferina arakiwa* *Cisnerospira antipoda*
					AU 4394	D.A.B. MacFarlan, D.C. Lawton 1974	*Cisnerospira antipoda*
					AU 8363	J.G. Begg 2/82	*?Cisnerospira antipoda* *?Callospiriferina radiata*
R16/f6896	2660164	6326518	At base of cliff about 900m NW along coast from prominent headland (GS 10006) north of mouth of Tauhua stream.	Bo	GS 10007	C.R. Lennie, B.E. Thomson, G.R. Stevens 9/5/1968	*Callospiriferina kawhiana*

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FR Number	**NZMG Easting**	**NZMG Northing**	**Locality**	**Stage**	**Collection no:**	**Collector and date.**	**spiriferinide species**
R16/f6898	2660110	6329492	South side of Anaputa Bay, north Marokopa coast	Bo	GS 10009	B.E. Thomson 1/1966, B.E. Thomson, C.R. Lennie 9/5/68	*Callospiriferina kawhiana*
R16/f6899	2660202	6331090	South side of Parahaki Head, north Marokopa coast.	Bo	GS 10010	B.E. Thomson Jan 1967. Recollected B.E. Thomson & C.R. Lennie 9/5/1968	*Callospiriferina kawhiana*
R16/f6903	2659897	6328401	Boulders at mouth of small stream, 3.75 km NW of mouth of Tauhua stream.	Bo	GS 10041	B.E. Thomson, Jan 1967, recoll Aug 1969.	*Callospiriferina kawhiana*
R16/f6907	2660101	6332418	Rocky outcrop on coast near Tokapae	Bo	GS 10045	B E Thomson Jan 1967, recoll Aug 1969.	*Callospiriferina kawhiana*
R16/f8638	2659959	6320250	Sandstone and siltstone outcrops about halfway between mouths of Marokopa river and Waipaua Stream.	Bo	GS 9993	C.R. Lennie, G.R. Stevens, B.E. Thomson 10/5/1968	*Callospiriferina kawhiana*
R16/f8639	2660012	6320522	Outcrops at beach level on seaward side of point immediately south of mouth of Marokopa River.	Bo	GS 9994	G.R. Stevens, C.R. Lennie, B.E. Thomson, 10/5/1968	*Callospiriferina kawhiana*
R16/f8642	2660300	6320600	First outcrop past southern end of Marokopa settlement, southern margin of Marokopa River, 200m up river from bluff at mouth	Ha	AU 9469		*Callospiriferina ongleyi* *Cisnerospira antipoda*
R16/f8644	2660159	6324734	400-500 m northwest along coast from mouth of Tauhua stream.	Ha	GS 10005	G.R. Stevens, C.R. Lennie, B.E. Thomson,. 8/5/1968, recoll B.E. Thomson *et al.* 1969, G.R. Stevens & I.W. Keyes 1972	*Callospiriferina ongleyi*
R16/f8645	2659992	6325288	Prominent headland 1 km northwest from mouth of Tauhua stream.	Bo	GS 10006	G.R. Stevens, C.R. Lennie, B.E. Thomson, Jan 1967, recoll 9/5/1968.	*Callospiriferina kawhiana*
R16/f8648	2660211	6323361	Coastal cliffs 55 chains north west of mouth of Turiakina Stream.	Ha	GS 10035	B.E. Thomson Jan 1967	*Cisernospira antipoda*
R16/f8650	2659997	6325471	On northern flank of prominent headland 1200-1600m northwest of Tauhua Stream, north Marokopa Coast.	Bo	GS 10037	B.E. Thomson Jan 1967	*Callospiriferna kawhiana*
R16/f8777	2659783	6319532	Coast between Marokopa River and Waipaua Stream. Cliff 190m N of Waipaua Stream.	Bo	JDC 2783	J.D. Campbell, R.T. Lamb 13/12/1972	*Callospiriferina kawhiana*

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FR Number	**NZMG Easting**	**NZMG Northing**	**Locality**	**Stage**	**Collection no:**	**Collector and date.**	**spiriferinide species**
R16/f8811	2664838	6315548	Pomarangai Rd, 8m upstream through lowest hairpin in 20m above 5m waterfall in main stream.	Hu	AU 9464	G.R. Stevens, C.R. Lennie, B.E. Thomson Jan 1967	*Cisnerospira antipoda*
R16/f8821	2665021	6315543	Stream through lowest hairpin in Pomarangai Road, top of 2nd waterfall in small very steep side valley.	Hu	AU 4395	D.A.B. MacFarlan, D. Pryor, J.A. Grant-Mackie 10/2/1973	*Spiriferina sophiaealbae*
R16/f8840	2661705	6321215	Marokopa Valley Road, 900m east of Kiritehere turnoff in road cut.	Ha	AU 4225	D.A.B. MacFarlan 29/11/1973	*Cisnerospira antipoda*
R16/f8877	2663000	6314200	Pomarangai Road 2nd bridge on road, 1 km NE of Moeatoa, approx. 100 m w of 2nd bridge. In an old quarry at the side of road	Bo	AU 8987	J.A. Grant-Mackie; N. Hudson 17/1/1982	*Callospirifernia kawhiana*
R16/f8919	2662645	6315610	700 m up small stream which crosses Kiritehere—Moeatoa road 2.6 km from Kiritehere school	Bo	AU 4300	D.A.B. MacFarlan 11/12/1974	*Callospirifernia kawhiana*
R16/f8928	2662992	6314960	Hillside east of stream which joins Mangakokopu from north 900 m upstream of Moeatoa	Bo	AU 4309	D.A.B. MacFarlan 17/2/1974	*Callospirifernia kawhiana*
R16/f8931	2662799	6314600	450 m up small stream which joins Mangakokopu from north 900 m upstream of Moeatoa	Bo	AU 4312	D.A.B. MacFarlan 17/2/1974	*Callospirifernia kawhiana*
R16/f8932	2663159	6314406	500 m up small stream which joins Mangakokopu from north 900 m upstream of Moeatoa	Bo	AU 4313	D.A.B. MacFarlan 17/2/1974	*Callospirifernia kawhiana*
R17/f317	2665200	6299400	Unnamed tributary stream of Awakino River, entering river from true right just north of northern end of Gribbins Road.	Hu	AU 9290	N. Hudson 28/12/1981	*Callospiriferina radiata*
R17/f0559	2657522	6279995	Farm track cutting on N side of Awakino Gorge c. 230m SW of N91/f574 (Awa 28). Cutting is c. 70m long.	Bo	AU 12167	F. Hasibuan, J. Yu, J.A. Grant-Mackie 15/1/1989	*Callospiriferina kawhiana*
R17/f8565	2660628	6283108	Main Road, lower Awakino Gorge 600m chains upstream from mouth of Mangahururu Stream	Hu	AU 330	J.A. Grant-Mackie Oct 1955	*Cisnerospira antipoda*
R17/f8574	2657600	6280200	Farm track on north side of Awakino gorge, c. 35m W. of R17/f (Awa29)	Bo	AU 7857	F. Hasibuan, J. Yu, J.A. Grant-Mackie 15/1/1989	*Callospiriferina kawhiana*
R17/f8612	2656609	6280022	Awakino Gorge road, on east side of prominent bend at top of Otapirian sequence. Recollection of J.A. Grant-Mackie's location.	Bo	GS 7587	NZGS party May 27, 1959	*Callospiriferina kawhiana*

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FR Number	NZMG Easting	NZMG Northing	Locality	Stage	Collection no:	Collector and date.	spiriferinide species
R18/f0092	2657300	6279800	Awakino gorge road cutting half way between N91/f563 and 562.	Bo	AU 12141	J.A. Grant-Mackie; Zhang, W.; Li, Xiao Chi; Yu, J. 9/12/1988	*Callospiriferina kawhiana*
R18/f0094	2657520	6279904	Awakino Gorge road cutting c. 110m S of very sharp bend and 30m S of R15/f0093. Blocks fallen from site above road at clearly visible horizon.	Bo	AU 14388	Zhang, W.; Li, Xiao Chi; Yu, J.; J.A. Grant-Mackie 9/12/1988	*Callospiriferina kawhiana*
R18/f0098	2657700	6279900	Awakino Gorge road cutting 5m E of R18/f0097	Bo	AU 12170	F. Hasibuan, J. Yu, J.A. Grant-Mackie 14/1/1989	*Callospiriferina kawhiana*
R18/f0107	2657200	6279800	Farm track cutting on N side of Awakino Gorge about half way between N91/f573 and f574 and 300-400m SW of Awa 27.	Bo	AU 12166	F. Hasibuan, J. Yu, J.A. Grant-Mackie 15/1/1989	*Callospiriferina kawhiana*
R18/f138	2657700	6279800	Roadside, Awakino Gorge, c.112m E of bend where road turns from N-S to E-W	Ha	AU 18823	K. Akikuni, J.A. Grant-Mackie; R.S. Hori, 19/11/2005	*Callospiriferina ongleyi*
R18/f6562	2657520	6279904	Main Road, E arm of hairpin bend 1600m E of *Monotis* beds (R17/f8555).	Bo	McF MAG2	D.A.B. MacFarlan 27/2/2002	*Callospiriferina kawhiana*
R18/f6564	2657050	6279460	Awakino Gorge, road cutting 700 m NE of quarry entrance and gas pipeline access road.	Bo	AU 12135		*Callospiriferina kawhiana*

Nelson

FR Number	NZMG Easting	NZMG Northing	Locality	Stage	Collection no:	Collector	spiriferinide species
N27/f0056	2528300	5984100	Just on east side of ridge crest southeast of Champion Road reservoir.—boulders partly buried in soil and from immediately underlying outcrops.	Bo	GS 12916	Johnston, M.R.; 10/12/1980	*Callospiriferina kawhiana*
N28/f7454	2509003	5968482	Trigonia beds, Eighty-eight Valley.	Bo	GS 196	A. McKay; 19/3/1878	*Callospiriferina kawhiana*
N28/f7455	2509003	5968482	'Spiriferina beds' Eighty-eight Valley, Nelson.	Bo	GS 197	A, McKay, 1878	*Callospiriferina kawhiana*
N28/f7514	2509448	5969130	East side of saddle of north branch Ram Stream.	Bo	GS 4551	H.J. Ferrar, P. Vella, D. Hamilton, 9/2/1948	*Callospiriferina kawhiana*

Southland Syncline

FR Number	NZMG Easting	NZMG Northing	Locality	Stage	Collection no:	Collector & Date	spiriferinide species
E44/f8450	2145810	5475355	Dipton West, 1234 m above base Otapirian	Bo	JDC 836	J.D. Campbell, D. S. Coombs	*Callospiriferina kawhiana*
E44/f8632	2145170	5475344	Dipton West Hill, 402 metres west of spot height 1178'.	Bo	JDC 837	J.D. Campbell Jan 1953	*Callospiriferina kawhiana*
E45/f			North slopes of Ben Bolt, McKay's *Plagiostoma* beds	Ha	AU 6409	R.A.S. Browne	*Callospiriferina ongleyi*
E45/f			Ben Bolt	Ha	AU 9838		*Callospiriferina ongleyi*
E45/f			Hut site, 50 yds N of Otapiri Creek,	Ha	AU 2819	R.A.S. Browne 1944	*Callospiriferina ongleyi*
E45/f				Ha	RBH 17	R.B. Hutchison	*Callospiriferina kawhiana*
E45/f			Ben Bolt, N face 50 yds below Warwick Downs boundary fence	Ha	OU 47286	?R.A.S Browne	*Callospiriferina ongleyi*
E45/f				Bo	Maling T13.9	P.B. Maling	*Callospiriferina kawhiana*
E45/f0061	2158500	5454899	East side of Otapiri Valley, on steepest part of slope, next ridge north of S169/f860 (E45/f9860)	Hu	McF C9	D.A.B. MacFarlan 16/5/1979	*Spiriferina arakiwa*
E45/f0076	2160100	5458799	North slopes of Ben Bolt, on narrow crest of ridge.	Ha	McF E34	D.A.B. MacFarlan, J.G.G, Morton 23/1/1980	*?Spiriferina arakiwa Callospiriferna ongleyi*
E45/f0085	2155900	5454299	Heale Ridge. Rocks in line of small heaps about 400 metres north of end of road.	Hu	McF E49, E57	D.A.B. MacFarlan, J.G.G. Morton 27/01/1980 (& later)	*Spiriferna arakiwa Spiriferina sophiaealbae Callospiriferina radiata Cisnerospira antipoda*
E45/f0132	2160190	5458909	Top of steep north facing hill on Ben Bolt's northern flank. 980 metres due north of Ben Bolt trig.	Ha	RBH 16	R.B. Hutchison	*Callospiriferna ongleyi*
E45/f0178	2160100	5458799	Atractites bed, Boundary fence, Ben Bolt	Ha	AU 6639	R.A.S. Browne 1944	*Callospiriferna ongleyi*
E45/f0378	2162500	5458700	Otapiri-Mandeville Road. Outcrop to east of road about 300m south of corner near WG Wadsworth's woolshed gate	Ha	JDC 4056	J.D. Campbell 9/9/1989	Spiriferinide indet

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FR Number	**NZMG Easting**	**NZMG Northing**	**Locality**	**Stage**	**Collection no:**	**Collector & Date**	**spiriferinide species**
E45/f0379	2158800	5457400	E45/588574 SW Face of Ben Bolt, on steep W facing slope of small W-flowing stream with kowhai grove.	Ha	JDC 4069	J.D. Campbell, A. Grebneff. M.O. Manceñido, S.E. Damborenea 2/3/1990	*Callospiriferna ongleyi*
E45/f9440	2157692	5453719	Conical Hill, Otapiri Gorge	Hu	GS 337	A. McKay 1878	*Callospiriferna radiata*
E45/f9441	2159018	5456392	Tableland above One Tree Bluff, Otapiri Gorge.	Hu	GS 338	A. McKay 1878	*Callospiriferna radiata*
E45/f9446	2159264	5458041	Upper Plagiostoma Beds, West Face of Ben Bolt.	Ha	GS 343	A. McKay 1878	*Callospiriferna ongleyi*
E45/f9446	2159264	5458040	Upper Plagiostoma Beds, West Face of Ben Bolt.	Ha	JDC 737	J.D. Campbell 2/1952	*Callospiriferna ongleyi* *Dispiriferina* sp. cf. *chilensis*
E45/f9447	2160167	5458696	North face of Flag Hill.	Ha	GS 344	A. McKay 1878	*Callospiriferna ongleyi*
E45/f9452	2159055	5459591	Lower part Lower Plagiostoma Beds, upper Otapiri Gorge.	Ha	GS 349	A. McKay 1878	*Callospiriferna ongleyi*
E45/f9462	2161985	5459275	East Branch of Taylors Stream.	Bo	GS 359	A. McKay 27/3/1878	*Callospirifernia kawhiana*
E45/f9463	2161982	5459458	Beds underlying lower cannonball sandstone at junction of the three branches of Taylor's Creek.	Bo	GS 360	A. McKay 1878	*Callospirifernia kawhiana*
E45/f9465	2158751	5461321	Taylor's Crossing, Otapiri Stream	Bo	GS 362	A. McKay 1878	*Callospirifernia kawhiana*
E45/f9469	2152321	5457968	North Branch Taylor's Stream	Bo	GS 366	A McKay 27/3/1878	*Callospirifernia kawhiana*
E45/f9553	2157200	5453399	Otapiri Valley Road, where road climbs over ridge from Conical Hill. In fence cutting by northern end of roadcut, on eastern side of road.	Ha	JDC 738	J.D. Campbell 2/1952	*Callospiriferina radiata*
E45/f9568A	2158966	5459406	Right bank of Otapiri Stream by open square plantation, 560m downstream from Taylor's Stream—Otapiri Stream junction.	Ha	JDC 1380	J.D. Campbell 1956, 1964	*Cisnerospira antipoda*
E45/f9608	2157016	5463942	Small knob 1100m due S of South Peak of Benmore.	Bo	JDC 1282	J.D. Campbell, I.C. McKellar 25/1/1955	*Callospirifernia kawhiana*
E45/f9611	2160783	5460077	Outcrop 160 yds downstream from upper swing bridge, Taylor's Stream, on S bank.	Bo	JDC 1285	J.D. Campbell, I.C. McKellar 26/1/1955	*Callospirifernia kawhiana*

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FR Number	NZMG Easting	NZMG Northing	Locality	Stage	Collection no:	Collector & Date	spiriferinide species
E45/f9676	2160118	5458832	North face Ben Bolt. Low rocky scarp 200m NNW from junction of 3 fences.	Ha	JDC 1382	J.D. Campbell	*Callospiriferna ongleyi*
E45/f9697	2159800	5458599	NW face Ben Bolt. Small, flat area just above old, winding, disused track, in scrubby patch W of small gully.	Ha	McF E23	D.A.B. MacFarlan, J.G.G. Morton 20/1/1980	*Callospiriferina ongleyi*
E45/f9714	2168417	5457145	Lora—Otamita Divide, on ridge 2.2 km S of Bare Hill.	Bo	GS 6751	P.M. Chandler, I.C. McKellar 25/10/1956	*Callospiriferna kawhiana*
E45/f9731	2163465	5458203	North side Warwick Downs-Lora Station road, 400 m north northeast of road at point 3 km from Lora Station homestead.	Ha-Hu	GS 7562	S.K. Skwarko, I.C. McKellar 30/11/1956	*?Callospiriferina radiata*
E45/f9787	2156820	5453978	West Side Otapiri Gorge, 900m west northwest of Conical Hill, on east facing slope	Hu	GS 7257	I.C. McKellar 1/10/1953	*Callospiriferina radiata*
E45/f9860	2158321	5454369	Bench on ridge NW of Conical Hill, Otapiri Valley	Hu	JDC 1837	J.D. Campbell (various)	*Spiriferna arakiwa* *Spiriferina sophiaealbae* *Callospiriferina radiata* *Cisnerospira antipoda*
					GS 7736	I.G. Speden, I.C. McKellar 1/3/1960	*Callospiriferina radiata*
					AU 12474	N. Hudson 5/3/1988	*Callospiriferina radiata*
					McF C8	D.A.B. MacFarlan 16/5/1979	*Callospiriferina radiata*
E45/f9902	2163159	5460026	Main branch of Taylors Stream, right bank, in patch of bush, downstream from the mouth of a SE-flowing tributary.	Bo	JDC 2088	J.D. Campbell, B.R. Paterson 6/6/1965	*Callospiriferina kawhiana*
E46/f056	2165400	5439699	Bulldozed pile just west of Jewitt Road, worked by farmer as quarry.	Hu	JDC 2509	P.L. Spencer, M.R. Morton, C.J. Paterson, J.D. Campbell, J.R. Boles 18/8/1970	*Cisnerospira antipoda*
					McF H25	J.D. Campbell, D.A.B. MacFarlan 9/3/1982	*Spiriferina arakiwa* *Cisnerospira antipoda*

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FR Number	**NZMG Easting**	**NZMG Northing**	**Locality**	**Stage**	**Collection no:**	**Collector & Date**	**spiriferinide species**
E46/f063	2165650	5439599	Jewitt Road, north side at corner, silage pit excavation	Hu	JDC 4661	J.D. Campbell, A. Grebneff 25/5/1998	*?Callospiriferina ongleyi* *Cisnerospira antipoda*
F45/f			Diamond Peak, SSW from Gore.	Bo	AU 1557	Pres by Dr F.W. Hilgendorf	*Callospiriferina kawhiana*
F45/f			Otamita Valley	Bo	EW 319	E. Wright	*Callospiriferina kawhiana*
F45/f0083	2175550	5455649	On east bank of major tributary of Peel stream 100 m south of road.	Ha	JGGM 157	J.G.G Morton 18/2/1979	*Callospiriferina ongleyi*
F45/f0281	2179500	5455299	Gordon Stream, 140 paces north of pumphouse east wall, downstream from road bridge.	Bo	JDC 4126	J.D. Campbell, D.S. Coombs 13/6/1991	*Callospiriferina kawhiana*
F45/f0329	2186700	5452699	Roadside exposure under tutu bush Dolamore to Otamita Downs Rd, S side 450 m W of back entrance to Dolamore Park.	Bo	JDC 4216	Campbell, J.D.; Owen, S.R. 21/10/1992	*Callospiriferina kawhiana*
F45/f0330	2182600	5454699	McLeod property, Dolamore Park Road, S of waterfall track scraping across strike	Bo	JDC 4654	J.D. Campbell A. Grebneff 13/5/1998	*Callospiriferina kawhiana*
F45/f0331	2186450	5452799	Farm quarry, Dolamore Waimumu Saddle Rd W of Dolamore Park.	Bo-Ha	JDC 4655	J.D. Campbell A. Grebneff 13/5/1998	*Callospiriferina kawhiana*
F45/f0360	2199800	5444499	Diamond Peak Station, on farm road, ridge end low road cut on E side of road.	Bo	JDC 4722	J.D. Campbell 29/12/1998	*Callospiriferina kawhiana*
F45/f0363	2200200	5444399	Diamond Peak Station N of and within view of Diamond Peak and the station homestead, W of N/S fence.	Bo	JDC 4726	J.D. Campbell 10/2/1999	*Callospiriferina kawhiana*
F45/f0365	2200000	5443899	Diamond Peak Station. N slope of Diamond Peak down spur from gap between peaks.	Bo-Ha	JDC 4728	J.D. Campbell 20/12/1998	*Callospiriferina kawhiana*
F45/f0414	2203150	5443550	Off eastern end of Mountain Rd Gore, sizeable farm quarry, beyond the end of the farm road on topo map.	Bo	JDC 4762	J.D. Campbell A. Grebneff 21/5/1999	*Callospiriferina kawhiana*
F45/f8011	2183278	5453880	On NE side of Retreat-Croydon Road at bull-dozed face, big exposure	Ha	JDC 2479	J.D. Campbell K.G. Griffin 26/5/1970, J.D. Campbell, D.A.B. MacFarlan 6/1983.	*Callospiriferina ongleyi*
F45/f8523	2186681	5452658	Long exposure at roadside, Waimumu Valley.	Bo	GS 5188	A.C. Beck, B.L. Wood 16/8/1948	*Callospiriferina kawhiana*

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FR Number	NZMG Easting	NZMG Northing	Locality	Stage	Collection no:	Collector & Date	spiriferinide species
F45/f8589	2186219	5452925	Saddle on Otamita-Waimumu Road between Boundary Creek and Waimumu Stream. Hokonui S.D.	Bo	JDC 864	J.D. Campbell Sept 1953	*Callospiriferina kawhiana*
F45/f8680	2176941	5455691	Otamita valley. in bank of north flowing tributary, about 500 m in south of southeast from nearest point of S-bend.	Bo	GS 6606	J.D.Campbell, C.A. Fleming 30/1/1956	*Callospiriferina kawhiana*
F45/f8683	2180699	5455070	Otamita Valley, west branch of Coneburn. 500 m west of junction with main stream. in north bank 240 m south of Otamita Valley Road	Ha	JDC 1393	J.D. Campbell, I.C.McKellar, C.A. Fleming, A.R, Mutch 31/1/1956	*Spiriferina sophiaealbae* *Callospiriferina ongleyi* *Cisnerospira antipoda*
F45/f8733	2186312	5452835	Boundary Creek-Waimumu Stream road. cutting about 2 km east from highest part of road	Bo	GS 7601	S. Skwarko 13/2/1957	*Callospiriferina kawhiana*
F45/f9507	2198508	5445182	North side of creek near trig C, 201m at 190 degrees from trig C (946 feet). Waikaka survey district.	Bo	GS 4408	B.L. Wood Feb 1950	*Callospiriferina kawhiana*
F46/f0085	2190000	5418899	Mantle Grove, scraping at gateway (ca 5 m east of gate), southeast of farm shed—off Wilson Road south of Mokoreta River.	Hu	JDC 4328	J.D. Campbell, A. Grebneff 25/2/1998	Spiriferinide indet.
F46/f0091	2189950	5418849	Mantle Grove, Wilson Rd, south of Wyndham. Small left bank outcrop c. 2 m above small north flowing stream that passes sheepyard and *Dactylioceras* loc f085. About 32 m downstream of f090.	Hu	JDC 4644	J.D. Campbell, A. Grebneff 16/3/1998	*Cisnerospira antipoda*
F46/f9488	2189794	5436168	East bank Mataura River, 2.50 km below bridge and township of Mataura.	Bo	GS 470	A McKay 1879	*Callospiriferina kawhiana*
F46/f9504	2191537	5419563	Mokoreta River bank, Wyndham S.D. 3.2 km at 144° from trig A.	Ha-Hu	GS 3516	R.W. Willett	*?Callospiriferina radiata*
F47/f0013	2193500	5403799	South of Crighton Road on south facing slope.	Hu	JDC 3796 NDJC GP93	N.D.J. Cook, J.D. Campbell, D.S. Coombs, D.D.L. Pillai 10/5/1983	*Spiriferina arakiwa*

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FR Number	**NZMG Easting**	**NZMG Northing**	**Locality**	**Stage**	**Collection no:**	**Collector & Date**	**spiriferinide species**
G45/f8624	2216220	5441004	W of Waipahi Station Road. Very small outcrop in corner of paddock by creek junction.	Bo	GS 5145	B.L. Wood 2/2/ 1950	*Callospiriferina kawhiana*
G47/f6523	2214478	5397919	Disused quarry on ridge, 1.4 km northeast of corner of Waikawa—Tokonui Road with Waikawa—Catlins Road.	Hu	J108, J76	Mr Haldone, pres to I.G. Speden	*Spiriferina arakiwa*
H46/f0188	2254300	5419899	Silage pit excavation west of Glenomaru stream, south of farm road at bridge.	Bo	JDC 4105	J.D. Campbell, S.R. Owen 18/3/1991	*Callospiriferina kawhiana*
H46/f8559	2263602	5412641	Face at south end of Roaring Bay.	Bo	JDC 960	J.D Campbell Dec 1953	*Callospiriferina kawhiana*
H46/f8559	2263602	5412641	Face at south end of Roaring Bay.	Bo	JDC 3232	J.D Campbell 23/1/1976	*?Callospiriferina kawhiana*
H46/f8627	2263282	5412636	Bed forming face (cliff) at north side of bay south of Roaring Bay. Bottom of face in bush, approximately 45-52 m above sea level.	Bo	GS 7128	I.C. McKellar, I.G. Speden 16/9/1957	*Callospiriferina kawhiana*
H46/f8633	2252773	5420413	Cutting on northwest side of logging (hauler) track 10 m southwest of wire gate, 1.1 km at 356° from trig F.	Bo	GS 7157	I.C. McKellar, I.G. Speden 17/9/1957	*Callospiriferina kawhiana*
H46/f8664	2263329	5412545	Outcrop north from break in exposure (scree) to northern cliffed wall of first bay south of Roaring Bay.	Bo	JDC 1496	J.D. Campbell, D.S. Coombs 25/1/1958	*Callospiriferina kawhiana*
H46/f8722	2261086	5415433	Summit of ridge east of Ward Road straight, Otekura.	Bo	JDC 2396	J.D. Campbell, T.M. Frankham 12/12/1969	*Callospiriferina kawhiana*