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SOME PERMIAN SPIRIFERIDAN SPECIES (BRACHIOPODA) FROM NEW ZEALAND AND QUEENSLAND

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Abstract

Some Spiriferidan species important for correlation and paleogeography are described and some are newly named from the Middle and Late Permian of New Zealand. Several extend into east Australia. The species belong to the genera *Spinomartinia, Tiramnia, Fusispirifer, Neospirifer, Aperispirifer, Sulciplica, Tigillumia, Nakimusiella,* and *Alispiriferella.* The two latter genera, new to New Zealand, point to paleogeogeographic ties with south Tibet and the Arctic respectively.

Keywords: Permian , Brachiopoda, Spiriferida, New Zealand, Queensland, stratigraphy

INTRODUCTION

For the purposes of detailed Permian correlation within Gondwana by marine invertebrate fossils, Productida are generally most useful, as they may be overwhelmingly abundant, and many species were short-lived. This study shows that some Spiriferida also appear to have had short ranges, and help confirm Productid correlations indicated for the marine sequences of New Zealand and Bowen Basin, Queensland.

The stratigraphy of the relevant New Zealand areas is set out for Wairaki Downs, Southland by Waterhouse (1999), Arthurton, south Otago by Waterhouse (1982), west Nelson by Campbell et al. (1998), east Nelson by Waterhouse (1987c), and in Queensland, Australia for the Bowen Basin by Waterhouse (1987b) and Gympie Basin by Runnegar & Fergusson (1969). The mainly Strophalosiid biozones proposed for east Australia - New Zealand by Briggs (1998) are not followed, at least in the meantime, because a preliminary perusal indicates some difficulties. For example, Briggs (1998) indicated that *Echinalosia* in New Zealand previously assigned to *E. ovalis* belonged to *E. wassi* Briggs. But *E. wassi* appears to be a variant of *E. ovalis*, and the Mantuan Member of the Bowen Basin, with type *E. ovalis*, shares a number of invertebrate species with the so-called *wassi* fauna of New Zealand, indicating correlation, rather than the discrepant ages preferred by Briggs (1998). There appear to be major problems with his scheme especially with regard to New Zealand Permian, partly because of error, and partly because of additional data set aside or overlooked by that author.

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Locality descriptions, repositories, abbreviation

New Zealand fossil localities are recorded in the archival Fossil Record File of the Geological Society of New Zealand. This is arranged numerically within each sheet district of the 1:50 000 New Zealand Infomap 260 series, coded by letter and number. Collections within the range of D44/f108-137 are kept at the Institute of Nuclear and Geological Science, Lower Hutt, New Zealand. They are also assigned a GS locality number and significant specimens carry the prefix BR in the Brachiopod register. The Department of Geology, University of Otago, Dunedin, holds the collections D44/f304-365, 374-377, and important specimens are serially numbered with prefix OU. The prefix UQF refers to specimens kept at the Department of Geology, University of Queensland, Brisbane. The abbreviation OD means by original designation.

STRATIGRAPHIC IMPLICATIONS

Spinomartinia spinosa characterizes the *Spinomartinia spinosa* Zone typically developed in the Arthurton Formation of south Otago, and is now found in the Hilton Limestone Formation at Coral Bluff, Wairaki Downs, and in the same formation at Wether Hill Station, near Ohai, where it was called Speight's Limestone Member by Mutch (1972, in Waterhouse & Mutch 1978). The species is possibly represented in a fauna of the Stephens Subgroup near Mossburn (Hyden et al. 1982), but this fauna contains key species from several faunal zones, and is likely to have been reworked. In addition, material somewhat approaching *S. spinosa* has been recorded from the upper South Curra Limestone of Gympie, southeast Queensland (Runnegar & Fergusson 1969).

Neospirifer arthurtonensis is best known in the *Martiniopsis woodi* Zone of the Arthurton Group, south Otago, but extends into the overlying *Plekonella multicostata* Zone. Now the species is found in the lower Glendale Formation of Wairaki Downs. Accompanying species suggest that a *multicostata* correlation is most likely.

Neospirifer mossburnensis is found in the Wairaki Breccia-Conglomerate at the top of the Permian in the Wairaki Downs, and also in the Stephens Subgroup near Mossburn. Hyden, Begg, Campbell & Campbell (1982) correlated the Mossburn Stephens (which they called Countess Formation) with the Wairaki Breccia, and claimed that it was of Permian age. They also claimed the adjoining Snowdon Formation was Permian, in defiance of Triassic Mollusca described by Waterhouse (1960, 1979) and Triassic plants reported by Retallack (1977). Here the Stephens (=Countess) and Snowdon rocks are regarded as Triassic. The Mossburn fauna in the Stephens Subgroup contains what appears to be an admixture of species from various zones, and is deemed to have been reworked from several Permian faunal levels in Triassic times. A Triassic age is consistent with the underlying Greville Subgroup (Waterhouse 1987c), which contains the Anisian (Middle Triassic) ammonoid

Durvilleoceras woodmani Waterhouse. Both Stephens and Greville belong to the Maitai Terrane. The Snowdon Formation is probably of much the same age as the Greville, and belonging to the Murihiku Terrane, is likely to be separated from the Maitai by a thrust.

Aperispirifer archboldi comes from the lower Letham Formation, Wairaki Downs, and comparable material is also found in the Freitag Formation of western Bowen Basin. The two faunas also share common species of *Wyndhamia, Terrakea* and *Tomiopsis (Ingelarella) undulosa* (Campbell) as noted by Waterhouse (1998).

Aperispirifer parfreyi provides an important link between the Bowen Basin and New Zealand. It is found in the Barfield and Flat Top Formations of the southeast Bowen Basin (*Wyndhamia blakei, Echinalosia ovalis* Zones), and in the Mangarewa Formation of Wairaki Downs (*E. ovalis* Zone). Elsewhere in the Bowen Basin, the species is found in the Mantuan Member of upper Peawaddy Formation, southwest Bowen Basin, and in the upper Blenheim Formation, north Bowen Basin, both in the *E. ovalis* Zone. Rare specimens of *Aperispirifer* from the younger *Terrakea elongata* Zone, in faunal intervals E and F of Eddystone GSQ core 1, western Bowen Basin, and in the uppermost Mangarewa Formation, Wairaki Downs, are allied.

A. wairakiensis hillae occurs in what appears to be the Catherine Sandstone and mudstone of Dry Creek (= Catherine or lower Peawaddy Formation), southwest Bowen Basin. The age is possibly equivalent to part of the Barfield Formation, suggesting that the subspecies narrowly preceeded or co-existed with early *A. parfreyi*.

Nakimusiella oweni from the Pig Valley Formation of east Nelson (Waterhouse 1987c) belongs to a rare genus found elsewhere in the Changhsingian Stage of south Tibet. Late Permian marine faunas are rare in realms beyond the paleotropics, so this may offer valuable confirmation that the Permian faunas of Pig Valley limestones were very late Permian, as proposed by Waterhouse (1982 etc). As shown by Owen (1995) the Pig Valley limestones were involved in substantial reworking in the Triassic. The beds overlie Greville Subgroup with Anisian (Middle Triassic) *Durvilleoceras woodmani,* but unlike the Mossburn fauna, the Pig Valley Permian fauna appears to have been derived from one stratigraphic level, of Late Permian age. The presence of *Nakimusiella* helps confirm this late age. A species somewhat approaching *Nakimusiella* is also present in the Hilton Limestone Formation of Wairaki Downs.

PALEOGEOGRAPHIC IMPLICATIONS

The genera described herein fall into several categories.

Tiramnia is a genus most prominent in the northern hemisphere, and is rare, or not known in Australian Permian. *Neospirifer* is also widespread, and rare in much of the Permian in east Australasia, being restricted to as far as is

known to warm-water faunas of the Bowen Basin and New Zealand.

Spiriferella is particularly common in moderately high paleotemperate latitudes of both hemispheres, in the Canadian-Alaskan and Russian Arctic of the north, and in the Himalaya etc. of the south. *Alispiriferella* represents an extreme example of this form of bipolar distribution (Waterhouse 1967b), being found in the Canadian and Russian Arctic, and in New Zealand.

Spinomartinia and *Sulciplica* are genera that ranged more or less from south Asia (Himalaya) or southeast Asia (Thailand) into Australia and New Zealand. *Nakimusiella* displays a somewhat similar pattern, as a rare Late Permian genus shared between south Tibet and New Zealand.

Aperispirifer is not known for certain beyond east Australia (especially Queensland) and New Zealand. *Tigillumia* is of similarly restricted distribution, and generally occurs with *Neospirifer* rather than *Aperispirifer*.

SYSTEMATIC DESCRIPTIONS

Order SPIRIFERIDA Waagen, 1883
Suborder SPIRIFERIDINA Waagen, 1883
Superfamily **MARTINIOIDEA** Waagen, 1883
Family **MARTINIIDAE** Waagen, 1883
Subfamily **MARTINIINAE** Waagen, 1883
Genus ***Spinomartinia*** Waterhouse, 1968

For many decades the recognition of the genus *Martinia* M'Coy,1844 depended substantially on the absence of internal plates such as adminicula and crural supporting plates, and the presence of micro-ornament in the form of short surface pits. The genus was believed to have ranged from Carboniferous into Permian. A general review of *Martinia* and supposed allies, including the "temporary" genus *Pseudomartinia* Leidhold, is provided by Cooper & Grant (1976, p. 2264). They considered *Rallacosta* Cooper & Grant (1976, p. 2277) from west Texas Permian to be closely allied. Carter et al. (1994) classed *Rallacosta* in Elivellinae Carter, 1994 within Martiniidae. Adminicula, which are ventral plates supporting dental plates from floor of the valve, are present in *Elivella* and in *Rallocosta*, unlike *Martinia* and Martiniidae, and the subfamily Elivellinae should probably be regarded as a full family. In view of the nature of the cardinal process, it may be more closely allied to Spiriferoidea King, 1846. On the other hand *Heteraria* Cooper & Grant (1976, p. 2275-2276) lacks adminicula and has ornament of concentric laminae, without costae. This was included with *Martinia* by Cooper & Grant (1976) and was assigned to Elivellinae by Carter et al. (1994). Its interior suggests that the genus might be better retained as an ally of *Martinia*.

In 1968 *Spinomartinia* was discriminated in New Zealand for forms that came close to *Martinia* in the lack of internal plates, but differed in possessing tiny surface spines. Later Grunt (1977) erected *Tiramnia*, with compact posteriorly placed ventral muscle field, and comparatively simple pallial

lines on the ventral valve. The shell surface was deemed to be smooth, although some question possibly remains over the preservation of the types. Waterhouse in Waterhouse et al. (1981) drew attention to the difficulty of discriminating between *Tiramnia* and *Spinomartinia* in instances where preservation was poor, or where species had conceivably lost spines during evolutionary development. For example, well preserved *Spinomartinia queenslandica* Waterhouse, 1987a from the Brae Formation, southeast Bowen Basin, has tiny pustules restricted to patches and parts of the shell but not seen on most specimens. Shi & Waterhouse (1996, p. 148) pointed out that the small muscle field and very simple pallial lines of *Tiramnia* offered potential discriminants, following the emphasis by Grunt herself. Unlike species in other genera, *S. queenslandica* has elaborate branching pallial lines laterally. Perhaps this offers a means of separating yet another genus, but I hesitate about the reliability of this criterion - especially when the branching is developed laterally, where the pallial lines are faint or missing from other exemplars within the family. Cooper & Grant (1976, pl. 645, fig. 6, 16, 22 etc) showed individuals of *Martinia rhomboidalis* Girty that display either anastomosing or simple pallial lines. The suites of Queensland and New Zealand specimens belonging to *S. spinosa* and *S. queenslandica* suggest that the median ventral groove and the small posteriorly placed muscle field are seen in *Spinomartinia* as well as *Tiramnia*. That of course puts the onus back on to *Tiramnia* for clarification of other criteria for discrimination, including micro-ornament. One additional aspect should considered. The type species of *Spinomartinia spinosa* has not only micro-spines, but comparatively close-set concentric low growth wrinkles, quite regular in specimens especially from the Wether Hill and Nemo blocks of the Hilton limestone, and moderately developed in the types. These are not so pronounced in *S. queenslandica*, but are present, and type *Martinia* also displays subdued concentric wrinkles. *Heteraria* has better defined concentrics, with no microspines, and *Tiramnia uralica* (Chernyshev, 1902, pl. 18, fig. 1-4), the type species of *Tiramnia*, has growth steps and fine concentrics. The strength of growth wrinkles may have reflected environmental conditions - possibly tidal for example, where conditions were rhythmically favorable and unfavorable.

Spinomartinia? adentata (Waterhouse, 1964)

1964 *Martinia adentata* Waterhouse, p. 114, pl. 21, fig. 10-14, text-fig. 53A, B, 54.

The species called *Martinia adentata* Waterhouse from the *Spinomartinia? adentata* Zone, lower Takitimu Group, has fine concentric growth wrinkles, and, according to the text, tiny dense surface pits, 6 in 1 mm. Re-examination of two ventral valves shows that the exterior carries a ferrous stain and is poorly preserved. There are unreliable suggestions of a fine shagreen pattern of pits - 6 in 1mm, and even possible minute spines. But such observations have very low reliability. Internally the ventral muscle field

is large as in *Spinomartinia*, and pallial lines are perhaps closest to those of *Tiramnia* (see Waterhouse 1964, pl. 21, fig. 14, text-fig. 53B). Assignment to *Spinomartinia* is thus favoured by some parameters, but not others.

Spinomartinia spinosa Waterhouse, 1968

1968 *Spinomartinia spinosa* Waterhouse, p. 53, pl. 8, fig. 4, 5, 9-11, pl. 9, fig. 1-8, pl. 17, fig. 4.

cf. 1969 *Martinia* sp. Runnegar & Ferguson, p. 278, pl. 5, fig. 12, 13.

1978 *S. spinosa* Waterhouse; Waterhouse in Waterhouse & Mutch, p. 522, text-fig. 16, 19-25.

1978 *S. spinosa* Waterhouse; Suggate et al., text-fig. 11. 3, fig. 8-10.

1981 *S. spinosa* Waterhouse; Speden, pl. 8, fig. 8-10.

HOLOTYPE: OU 2413, kept at University of Otago, figured by Waterhouse (1968, pl. 9, fig. 2-4), also Suggate et al. (1978) and Speden (1981) OD from *Spinomartinia spinosa* Zone, AG 4 Formation, Arthurton Group near Clinton, south Otago.

DIAGNOSIS: Large transversely to subequally rounded oval to rounded shells with prominent ventral umbo and inflated ventral valve, dorsal valve less inflated, with broad umbo.

MATERIAL: Some 15 ventral valves, 5 dorsal valves and a specimen with valves conjoined from D45/f7578 (GS 5868), "Speight Limestone Member" of Mutch (1972), Wether Hill Station, 2 well preserved ventral valves OU 2575/2026 from D45/f7000. Possible dorsal valve and 8 ventral valves from D44/f376, including OU 18278-18280, Hilton Limestone Formation, Coral Bluff, Wairaki Downs.

DIMENSIONS IN MM: ventral valves, Wether Hill

Specimen	Width	Length	Height	Locality
UQF 77366	47	36	19	D45/f7578
UQF 77367	45	39	17.5	D45/f7578
OU 18278	45	?32	10 flattened	D44/f376

DESCRIPTION: The species is characterized by its well inflated ventral valve with strongly incurved ventral umbo. Material from Coral Bluff is not common, but available material conforms with typical shape, and two specimens show the characteristic interior.

The specimen OU 2595 figured as *Martinia* sp. by Hyden et al. (1982, text-fig. 7a, b) is possibly allied. It comes from the Countess Formation (now Stephens Subgroup) near Mossburn, within a faunule that appears to include material reworked from several fossil zones, athough wrongly regarded by Hyden et al. (1982) as matching the *Wairakiella rostrata* Zone of the Wairaki Breccia-Conglomerate in Wairaki Downs (Waterhouse 1999).

RESEMBLANCES: Ventral valve interiors of a Martiniid were recorded from

the upper part of the South Curra Limestone by Runnegar & Ferguson (1969, pl. 5, fig. 12, 13). The muscle field is rhomboidal with deep radial ridges and grooves, and well formed radial grooves over the floor of the valve. The exteriors are not known, but overall shape suggests an approach to *Spinomartinia spinosa*, although material is too sparse to allow other than a conjectural identification. That would imply that the uppermost South Curra Limestone is as young as Late Permian Lopingian at its top. There is no evidence against such a young age, and other poorly preserved species support a Late Permian age.
DISCUSSION: Locality D45/f7578 is shown roughly by Mutch in Waterhouse & Mutch (1978, text-fig. 2) and the collections come from the band west of the prominent conifer hedge. This seems to be the same as f579 in Mutch (1972) and GS 5683 (= GS 5868) in Waterhouse (1968) involving misprints or mistakes.

Genus **Tiramnia** Grunt, 1977

Tiramnia? arthurtonensis n. sp.

1964 *Martinia* aff. *martinezi* (not Cooper); Waterhouse, p. 119, pl. 22, fig. 1, 2, text-fig. 53C, D.
ETYMOLOGY: Named from Arthurton settlement, south Otago.
HOLOTYPE: Specimen BR 699, figured as above, from G45/f8612 (GS 5078), *Plekonella multicostata* Zone, Arthurton Group, near Arthurton, here designated.
DIAGNOSIS: Little inflated shells, some 8 growth-lines per mm, dental plates low, pallial lines subdued. Muscle field subrectangular, not impressed in secondary shell, and pallial lines poorly marked, unlike typical *Tiramnia*.
RESEMBLANCES: The moderately well preserved specimen from the *Plekonella multicostata* Zone of the Arthurton Group described as *Martinia* aff. *martinezi* (Cooper, 1953) by Waterhouse (1964, pl. 22, fig. 1, 2, text-fig. 53 C, D) displays concentric lines and faint radial striae that form a meshwork pattern. What appeared to be coarse shallow pits were also noted. The ventral muscle field is large and lightly impressed, and pallial lines scarcely visible. Such internal details do not fit with either *Spinomartinia* or *Tiramnia*, but provisionally the species will be referred to *Tiramnia*.

The species is very distinctive, and has been discussed and compared by Waterhouse (1964). A number of differences were noted by Waterhouse (1964) from *Martinia martinezi* (Cooper, 1953) from the El Antimonio beds of Mexico, and these differences are evaluated as meriting full specific differentiation. Of other species, *Martinia rhomboidalis* Girty, 1909 from the Lamar Member, Bell Canyon Formation of Texas is only moderately close, with more elongate inflated shells and long ventral posterior walls. A fine suite was figured by Cooper & Grant (1976, pl. 644, fig. 1-23, pl. 645, fig. 1-39).
DISCUSSION: Cooper & Grant (1976, p. 2264) considered that the shagreen ornament of *Martinia* was an artifact of preservation, and reported that concentric and fine radial markings were visible on their material. They are wrong about *Martinia*, but their own material, if its surface ornament is as described,

may indeed differ from *Martinia*. It is true that they relied on silicified preservation, which is notoriously unreliable as regards very fine detail, so the observation may not be generically significant. Silicification frequently fails to show the growth-lines and growth-lamellae observable where the calcite is preserved. But given that concentric and radial markings were observed, it seems likely they were dealing with species of either *Tiramnia*, whatever that genus has in terms of micro-ornament, or a new genus.

Superfamily **SPIRIFEROIDEA** King, 1846
Family **SPIRIFERIDAE** King, 1846
Subfamily **SPIRIFERINAE** King, 1846
Genus ***Fusispirifer*** Waterhouse, 1966

TYPE SPECIES: *Spirifer nitiensis* Diener, 1897 OD.

SUBFAMILY: Poletaev (1997) indicated that this genus has the apical apparatus and costal development of Spiriferinae, whereas previously the genus has been regarded as a member of Neospiriferinae, including the study by Carter et al. (1994).

DISCUSSION: This genus has been found widely in the Himalaya, and in Western and eastern Australia. Representation in New Zealand is meagre, limited to the present form from the Hilton Limestone Formation, Wairaki Downs.

Carter et al. (1994, p. 346) synonymized the genus *Transversaria* Waterhouse & Gupta, 1983 with *Fusispirifer*. The type species was cited OD as *Fusispirifer marcouiformis* Jin in Zhang & Jin (1976, pl. 12, fig. 9-11, pl. 13, fig. 1, 2, 21-23) from the *Taeniothaerus* assemblage in the Permian Shilong Group of south Tibet. As is clear from the Jin description (provided in translation by Waterhouse & Gupta, 1983, p. 240) and the figures, *marcouiformis* lacks plicae - or at best the plicae are so subdued that their presence was denied by Jin, and do not appear on the illustrations. Therefore the genus is readily distinguished from *Fusispirifer*. The genus thus resembles *Spirifer* and allies quite closely, apart from transverse outline, and this appears to support the Poletaev analysis.

Fusispirifer? sp.

1968 *Aperispirifer* sp. B Waterhouse, p. 36, pl. 3, fig. 10, 14.

DESCRIPTION: Ventral valves BR 460-463 from GS 3615 (D44/f9479) in the Hilton Limestone Formation, Coral Bluff, Wairaki Downs, are very transverse and have wide very low plicae and fine costellae. The specimen BR 462 shows a pedicle callist as a narrow ridge on a possible delthyrial plate, as interpreted from rather poor preservation. The ventral muscle field is very broad. Two other fragments from D44/f9479 also suggest delthyrial plates, between short adminicula supporting dental plates. A small fragment of the posterior ventral valve OU 18281 from Coral Bluff D44/f376 also suggests a plate below the delthyrium.

These specimens are much more transverse than the Coral Bluff material ascribed here to *Neospirifer* sp. The *Neospirifer* specimen of Waterhouse & Mutch (1978, text-fig. 10) from the Hilton Limestone Formation in the Nemo block, Wether Hill Station, is transverse with fine costae, but the umbo is a little more prominent than in the Coral Bluff material.

RESEMBLANCES: *Fusispirifer* was first named from Himalayan material and is moderately common in Western Australia, and throughout the lower and middle Permian of the Bowen Basin (Waterhouse 1987a, p. 22-24), and Malbina Formation Member E of Tasmania (Clarke 1987, p. 267, text-fig. 5A-E). None of the named east Australian species seem particularly close at a specific level, but a Barfield specimen of *Fusispirifer pauciplicus* was figured as showing a somewhat comparable pedicle callist (Waterhouse 1987a, pl. 5, fig. 15). The costae in the Coral Bluff specimens are fine, approaching those of *Fusispirifer* B in Waterhouse (1987a, pl. 5, fig. 16-17) and *F. pauciplicus* Waterhouse (1987a, pl. 5, fig. 15, pl. 6, fig. 1-7, text-fig. 4) from the Oxtrack and Barfield-Flat Top Formations respectively of the southeast Bowen Basin. *F. avicula* (Morris, 1845) has more prominent plicae.

Subfamily **NEOSPIRIFERINAE** Waterhouse, 1968

An important reappraisal of *Neospirifer* Frederiks and the Subfamily Neospiriferinae was provided by Poletaev (1997), based on type and new material. Emphasis was placed in the diagnosis of Neospiriferinae on the absence of stegidial plates, hypodeltidial grooves, and pseudodelthyrial plate, and weak development of the callosity.

Genus ***Neospirifer*** Frederiks, 1924

Neospirifer arthurtonensis Waterhouse, 1968

1968 *Neospirifer arthurtonensis* Waterhouse, p. 28, pl. 2, fig. 14, 16, pl. 3, fig. 1-9, pl. 17, fig. 1, 3, text-fig. 7C, D, 9A, 10-13.

1976 *N. arthurtonensis* Waterhouse; Waterhouse, p. 244, text-fig. 6.5, 7.7.

HOLOTYPE: BR 521, figured by Waterhouse (1968, pl. 3, fig. 1) OD from G45/f8613 (GS 5079), *Martiniopsis woodi* Zone, Arthurton Group, Arthurton.

DIAGNOSIS: Small shells with prolonged ventral umbo, sulcus deep and U-shaped in section, persistent plicae with coarse high costae.

ADDITIONAL MATERIAL: A dorsal valve, 3 ventral valves, and one specimen with valves conjoined, fragmentary, including OU 18282, from D44/f363, Glendale Formation, Wairaki Downs.

DESCRIPTION: The specimens are fragmentary, but show persistent plicae that curve forward and outwards, 5 pairs on ventral valve, 3 pairs on smaller dorsal valve, dorsal fold moderately high, costae strong, and growth lines moderately well developed. Delthyrial plate concave, arched, ventral muscle field broad.

RESEMBLANCES: As far as preserved, the specimens appear to be identical with *Neospirifer arthurtonensis*, described from the *Martiniopsis woodi* Zone

in the Arthurton Group of south Otago. Less well preserved specimens occur in the overlying *Plekonella multicostata* Zone in the same group. The taxon *arthurtonensis* is one of the species recognized as valid *Neospirifer* in a world review by Poletaev (1997). It was noted by Waterhouse (1964) that the species somewhat resembled *N. warchensis* Reed (1931, pl. 4, fig. 9) and also variety *scabrosa* Reed (1944) from the Chhidru Formation of the Salt Range, Pakistan, of approximately lower to middle Wuchiapingian age. Poletaev (1997) synonymized *warchensis* with *N. moosakhailensis*, but there appear to be differences in costation, as explained by Waterhouse (1968). Somewhat surprisingly, as far as I understand the text, Poletaev (1997) concluded that *Neospirifer fasciger* (Keyserling) from the late Early Permian of south Timan was the same as *Neospirifer moosakhailensis* (Davidson) from the Kalabagh Member, Wargal Formation, and Chhidru Formation of the Salt Range, of Late Permian age.

***Neospirifer*? sp.**

MATERIAL: Some 25 ventral valves and 2 dorsal valves from D44/f9479 (GS 3615) and D44/f376, *Spinomartinia spinosa* Zone, Hilton Limestone Formation, Coral Bluff, Wairaki Downs.

DESCRIPTION: Ventral valves small, one measuring 35mm wide, at least 24mm long, and about 12mm high, although these dimensions are approximate because edges are broken. Umbo high and strongly incurved, with posterior walls weakly concave in outline and diverging at some 90-95°. Cardinal extremities as preserved rounded. Sulcus commences at beak, and widens at about 20°, angle increasing anteriorly. Plicae very subdued, 3 pair with narrow fourth pair judged from one specimen, inner pair subangular in profile, and costae low with rounded crests and comparatively broad at about 1mm, but obscure over median shell, numbering about 9 in sulcus. Micro-ornament poorly preserved. An obscure dorsal valve suggests narrow moderately well defined fold and strong costae crossed by low concentric growth laminae. Delthyrium narrow, bordered by broad delthyrial ridges, no umbonal callosity, which suggests that the delthyrium was originally closed by plate, now lost.

Dental plates high, supporting stubby teeth, adminicula largely buried in very thick secondary shell. Posterior muscle field broad, notched by myophragm, divided by low median ridge, bearing broad low adductor ridges and broad diductor scars, marked by strong growth lines parallel to anterior margin, deeply impressed into shell. Lateral posterior valve bearing fine pallial pits. Dorsal interior not known.

RESEMBLANCES: These specimens are moderately close to *Neospirifer arthurtonensis* Waterhouse, 1968 in shape and muscle field, but have more subdued plicae and finer lower costae. The species *arthurtonensis* was de-

scribed mostly from the *Martiniopsis woodi* Zone at Arthurton, and reports of the species from the *Spinomartinia spinosa* Zone cannot be regarded as fully reliable. Compared with present material, one specimen recorded as *Neospirifer* ? sp. from the Nemo block at Wether Hill Station shows stronger plicae and apparently finer costae (Waterhouse & Mutch 1978, text-fig. 11), and another is more transverse with broad low plicae and fine costae (Waterhouse & Mutch 1978, text-fig. 10).

Neospirifer mossburnensis n. sp.

1967a *Neospirifer* sp. Waterhouse, p. 91, text-fig. 28.

1982 *Trigonotreta? nelsonensis* (not Waterhouse); Hyden et al., text-fig. 2a-d.

ETYMOLOGY: From Mossburn, settlement near type locality.

HOLOTYPE: Specimen OU 2590, figured by Hyden et al. (1982, text-fig. 2a-d) from E44/f001, upper Stephens Subgroup, here designated. Likely to have been reworked from beds equivalent to Wairaki Breccia-Conglomerate.

DIAGNOSIS: Transverse shells with broad inner plicae and fine costae.

MATERIAL: Three ventral valves and a dorsal valve from D44/f374, including OU 18283-4, *Wairakiella rostrata* Zone, Wairaki Breccia-Conglomerate, Wairaki Downs.

DIMENSIONS IN MM:

	Width	Length	Height	Valve
OU18283	62	46	?18	ventral
OU18284	50	39	17	dorsal

DESCRIPTION: Ventral valve transverse with broad weakly incurved umbo, wide hinge bearing comparatively high and flat interarea, inclined posteriorly from commissure at about 40°, curved under umbo, marked by vertical and transverse grooves, interrupted by narrow delthyrium with angle of 50°, closed under umbo by delthyrial plate striated by growth lines parallel to anterior curved edge, and bordered by dental ridges, no umbonal callosity. Cardinal margins overall obtuse, but projecting weakly at hinge. Sulcus shallow and narrow posteriorly, and comparatively broad in front, widening at angle of 30° in one specimen, 35° in another, with evenly concave floor, and not prolonged into tongue anteriorly, probably indicating the material not fully mature. Plicae low, innermost pair passes along side of sulcus, not entering it; suggestions of pairs of low plicae laterally. Costae comparatively fine, with rounded crests and very narrow interspaces, increase by branching and insertion, not preserved posteriorly. Growth laminae very low, numbering about 3 in 1mm, and traces of fine radial capillae. Dorsal valve moderately inflated, with well formed interarea almost in the plane of the commissure, wide notothyrium of 110°, abruptly obtuse cardinal extremities. Fold narrow and of moderate height, plicae not conspicuous on internal mould, and only a few costae visible anteriorly.

Ventral interior obscure in Wairaki Downs material, muscle field less

than third of length, moderately broad, weakly impressed, lateral posterior shell thickened. In the dorsal valve, ctenophoridium with strong vertical laminae, well formed sockets, crural plates not clearly shown, no tabellae. Low medium ridge in front, adductors subrectangular and faintly impressed.
RESEMBLANCES: These specimens are identified with the shells misidentified as *Trigonotreta nelsonensis* (not Waterhouse) by Hyden, Begg, Campbell & Campbell (1982) from the upper Stephens Subgroup near Mossburn. The Mossburn specimens show fine costae, subdued plicae, wide not very profound sulcus and ventral muscle field of modest proportions. The generic position of these specimens was not accurately determined by Hyden et al., and examination of the specimens, including well preserved OU 2590 and 2593, shows that there is no umbonal callosity. No delthyrial plate is preserved, but this is likely to be lost, being a delicate structure, and the Mossburn specimens are solitary valves in coarse sediment, believed to have been reworked. The specimens are distinctive, and are here named *Neospirifer mossburnensis*. Dental plates are scapular-shaped, and steeply inclined. Adminicula are also steep and short. The muscle field extends well in front of the adminicula, and bears wide raised adductor platform, and diductor scars just as wide. The posterior shell is thick and the anterior half of the shell very thin and showing ribs from the exterior.

The Mossburn locality has specimens that have been derived from various stratigraphic levels, seemingly including the Wairaki Breccia-Conglomerate or correlative sediment. Hyden et al. (1982) correlated the fossil locality with the Wairaki Breccia, and regarded the formation in which the locality was found as Permian. They also regarded the adjoining Snowdon Formation as Permian. This defied strong evidence for the Snowdon Formation being Triassic as adduced from plants by Retallack (1977) and from Mollusca by Waterhouse (1960, 1979). Thus Hyden, Begg, Campbell & Campbell (1982) misinterpreted the ages of both the Snowdon and Stephens (Countess) faunas and floras.

A few other Wairaki Breccia-Conglomerate specimens have been reported as *Neospirifer* sp. of Waterhouse (1967a, text-fig. 28), including a figured specimen with narrow sharply defined sulcus, well defined plicae, and narrow costae. *Neospirifer* aff. *nelsonensis* Waterhouse (1964, pl. 27, fig. 1) from the Wairaki Breccia-Conglomerate has strong costae and large long ventral muscle field, signifying a different taxon.

Subfamily **TRIGONOTRETINAE** Schuchert, 1893

Genus ***Aperispirifer*** Waterhouse, 1968

Aperispirifer archboldi n. sp.

1964 *Neospirifer wairakiensis* not Waterhouse; Waterhouse, p. 27, pl. 23, fig. 5, 7, 8-10, pl. 24, fig. 1-3, pl. 25, fig. 2-4, 6, 7, text-fig. 61A, 62, 63 (not pl. 23, fig. 4, 6, pl. 25, fig. 1, 5, pl. 35, fig. 4, text-fig. 56-60, 61B = *wairakiensis).*

1968 *Aperispirifer wairakiensis* (Waterhouse); Waterhouse, p. 35.
1978 *N. wairakiensis* not Waterhouse; Suggate et al., text-fig. 4.5, fig. 10, 13.
1981 *A. wairakiensis* (not Waterhouse); Speden, pl. 5, fig. 10,13.
1982 *Aperispirifer wairakiensis* (not Waterhouse); Waterhouse, p. 54, pl. 15a.
ETYMOLOGY: Named for Prof. Neil W. Archbold.
HOLOTYPE: BR 814, figured by Waterhouse (1964, pl. 23, fig. 5, 1982a, pl. 15, fig. a), Suggate et al. (1978, text-fig. 4.5, fig. 10) and Speden (1981, pl. 5, fig. 10), here designated, from GS 6070, *Spiriferella supplanta* faunule, lower Letham Formation, Wairaki Downs.
DIAGNOSIS: Moderately large, not very transverse specimens with heavy secondary callus, plicae moderately persistent, ribs coarse with rounded crests, sulcus narrow for much of length, broad anteriorly.
DISCUSSION: Specimens of this species were described as *wairakiensis* by Waterhouse (1964), but several differences were noted from type *wairakiensis*, and these are now evaluated as being of specific rank. *Aperispirifer wairakiensis* is more transverse with higher ventral umbo, and plicae that are higher posteriorly and fade more anteriorly. In the present species, the inner pair of plicae lie at the edge of the sulcus for much of the length, whereas they are incorporated in the sulcus of *wairakiensis*. The ribs are higher with sharper crests posteriorly in *wairakiensis* and are narrower overall. The sulcus of both species is narrow and deep posteriorly, but it widens and deepens more anteriorly in the new form, although remaining shallow and wide in some specimens. The fold is only moderately defined, and may be broad and low, with gently sloping flanks.

Aperispirifer archboldi is close to *A. lethamensis* Waterhouse, 1968 from the *Lethamia ligguritus* Subzone of the upper Letham Formation in its persistent costae, but costae are broader posteriorly, and plicae have few costae, and the sulcus differs anteriorly. Its growth lamellae are low, and the subplicae within the sulcus more subdued.
DISTRIBUTION: The species is restricted to the *Spiriferella supplanta* faunule in the basal Letham Formation in New Zealand. Few members of this genus have been reported from the Middle Permian of east Australia at this level. But a small dorsal valve UQF 65496 from the Freitag Formation of the southwest Bowen Basin has a broad low fold, comparable to that seen in BR 476 (Waterhouse 1964, pl. 24). Costae are finer than in the Letham specimens.

Aperispirifer lethamensis Waterhouse, 1968

1968 *Aperispirifer lethamensis* Waterhouse, p. 38, pl. 3, fig. 13, pl. 4, fig. 1-7, pl. 5, fig. 2-4, 6, 7, pl. 6, fig. 3, text-fig. 11-13, 14A-C (not pl. 3, fig. 15, pl. 5, fig. 1, 5, 8, pl. 6, fig. 2, text-fig. 11-13, 14D, 15 = *parfreyi*).
1978 *A. lethamensis* Waterhouse; Suggate et al., pl. 4.6, fig. 10-12.
1981 *A. lethamensis* Waterhouse; Speden, pl. 6, fig. 10-12.
1982 *A. lethamensis* Waterhouse; Waterhouse, p. 91, text-fig. 29c.

The species *Aperispirifer lethamensis* is based on material from the *Lethamia ligurritus* Subzone, Letham Formation, Wairaki Downs, at GS 9697 (D44/f9001). Additional D44 specimens and fragments are found at f115 (GS 15210), f126 (GS 15225), f319, f320, f322, f323 and f324.

Aperispirifer wairakiensis (Waterhouse, 1964)

1964 *Neospirifer wairakiensis* Waterhouse, p. 127, pl. 23, fig. 4, 6, pl. 25, fig. 1, 5, pl. 35, fig. 4, text-fig. 56-60, 61B (not pl. 23, fig. 5, 7, 8-10, pl. 24, fig. 1-3, pl. 25, fig. 2-4, 6, 7, text-fig. 61A, 62, 63 = *archboldi*).

1968 *Aperispirifer wairakiensis* (Waterhouse); Waterhouse, p. 35.

In New Zealand, this species is restricted to the lower Mangarewa Formation, in the *Echinalosia maxwelli* Zone. In the correlative *E. maxwelli* Zone of the Oxtrack Formation of the southeast Bowen Basin, *Aperispirifer ovalis* Waterhouse (1987a) is present, readily distinguished from *Aperispirifer wairakiensis* through its shape and few subdued costae. Apart from showing fewer costae, plicae are rather similar in both taxa. They show comparable distribution, including inner pair well within sulcus, fade anteriorly and are angular in cross-section.

Aperispirifer wairakiensis hillae n. subsp.

1953 *Neospirifer* sp. Campbell, p. 9, pl. 2, fig. 1-8.

1964 *Neospirifer* sp. B Hill & Wood, pl. P8, fig. 5 (not pl. P8, fig. 2-4 = *parfreyi*).

1972 *N. wairakiensis* Waterhouse; Hill et al., pl. P8, fig. 5 (not pl. P8, fig. 2-4 = *parfreyi*).

1983 *Trigonotreta* sp. D McClung, p. 66, text-fig. 9, fig. ?1, 3, 4, 7 (not fig. 2, 5, 6 = *parfreyi*).

ETYMOLOGY: Named for Dorothy Hill.

HOLOTYPE: Specimen UQ F 14316 figured by Campbell (1953, pl. 2, fig. 1, 2), Hill & Woods (pl. 8, fig. 5) and Hill et al. (1972, pl. 8, fig. 5) here designated from Dry Creek, southwest Bowen Basin, Queensland.

DIAGNOSIS: Transverse shells with prominent incurved ventral umbo, well defined plicae with angular profile and persisting well forward, inner pair of plicae incorporated anteriorly in broad sulcus, costae moderately high and angular posteriorly.

DISCUSSION: Specimens described as *Neospirifer* sp. by Campbell (1953) and *Neospirifer* sp. B by Hill & Woods (1964, pl. P8, fig. 5) were later ascribed to *N. wairakiensis* in Hill et al. (1972, pl. P8, fig. 5). Specimens figured by McClung (1983, text-fig. 9) from LD 96, west Bowen Basin, are similar in ornament and shape, apart from one of the ventral valves F 12490 (text-fig. 9, fig.1) which is too worn to be sure. The ventral umbo is prolonged posteriorly, with high costae, and the shell has a rhomboid shape, pointing to *Aperispirifer wairakiensis*. But plicae are persistent, the sulcal subplicae only moderately developed, and the sulcus broad and deep anteriorly, approaching *A. parfreyi*. Some of these morphological aspects also appear in the species *A.*

lethamensis, a species slightly older than *A. wairakiensis* and distinguished by its lower umbonal costae, more persistent plicae, and higher ventral interarea, with less alate cardinal extremities, and higher lamellae, and other differences elaborated by Waterhouse (1968). In overall shape, prominence of the ventral umbo, and well defined costae, the specimens come closest to *wairakiensis*, and then to *parfreyi*.

Overall stratigraphic details of these Queensland specimens remains a little uncertain. Hill & Woods (1964) indicate a source from shale, which possibly suggests lower Peawaddy Formation. Parfrey (1988, p. 32, text-fig. 10) showed the specimens as entering above Ingelara Formation, and present in the Catherine Sandstone and the lower Peawaddy Formation. The specimens figured by McClung (1983) came from LD 96, regarded as transitional between Ingelara Formation and Catherine Sandstone (McClung 1983, p. 62).

Aperispirifer parfreyi n. sp.

1952 *Spirifer* aff. *tasmaniensis* (not Morris); Fletcher in Fletcher et al., p. 15, pl. 1, fig. 2.

1964 *Neospirifer* sp. A Waterhouse, p. 134, pl. 26, fig. 1.

1964 *Neospirifer* sp. A Hill & Woods, pl. P8, fig. 2-4 (not Pl. P8, fig. 5 = *wairakiensis hillae*).

1968 *Aperispirifer lethamensis* not Waterhouse; Waterhouse, p. 38, pl. 3, fig. 15, pl. 5, fig. 1, 5, 8, pl. 6, fig. 2, text-fig. 11-13, 14D, 15 (not pl. 3, fig. 13, pl. 4, fig. 1-7, pl. 5, fig. 2-4, 6, 7, pl. 6, fig. 3, text-fig. 11-13, 14A-C = *lethamensis*).

1972 *Neospirifer wairakiensis* (not Waterhouse); Hill et al. pl. P8, fig. 2-4 (not 5 = *wairakiensis hillae*).

1983 *Trigonotreta* sp. D McClung, p. 66, text-fig. 9, fig. 2, 5, 6 (not fig. ?1, 3, 4, 7 = *wairakiensis hillae*).

1987a *A. lethamensis* not Waterhouse; Waterhouse, p. 21, pl. 5, fig. 1-3, 5-8, 10.

1988 *A. wairakiensis* (not Waterhouse); Parfrey, p. 17, pl. 3, fig. 14, 18, 20, 21, 23-25, pl. 4, fig. 1.

ETYMOLOGY: Named for Dr Susan M. Parfrey.

HOLOTYPE: UQF 69977, figured by Waterhouse (1987a, pl. 5, fig. 1, 3), from Barfield Formation, southeast Bowen Basin, Queensland, here designated.

DIAGNOSIS: Transverse shells with ventral umbo only moderately high, well rounded anterior extremities, sulcus well defined, fold moderately high and narrow-crested, plicae high, persistent, pair of subplicae incorporated in sulcus, costae moderately high.

DISCUSSION: Specimens from D44 at f9478 (GS 3616), f9480 (GS 3614), f119 -122 (GS 15215-5218), f124 (GS15219) and ?f350 in the *Echinalosia ovalis* Zone in the Mangarewa Formation, Wairaki Downs, are assigned to the new species *Aperispirifer parfreyi*. Sparse material from the *Terrakea elongata* Zone in the upper Mangarewa Formation (Waterhouse 1964, p. 134)

at D44/f9622 (GS 6071) is not well preserved, and has characteristic shape and very fine costae.

Overall the species falls close to *Aperispirifer lethamensis* Waterhouse, 1968, but has slightly better defined plicae, and lower growth lamellae. The sulcus is shallow posteriorly, and deep anteriorly. Many specimens are transverse, and cardinal extremities tend to be alate, and subplicae are better defined in the sulcus, and the fold lower and broader, compared with *lethamensis*.

The species *Aperispirifer parfreyi* seems to have descended from *lethamensis*, and trends towards *A. nelsonensis* (Waterhouse), which is a very transverse species with low persistent plicae, broad costae and narrow sharp fold. *Aperispirifer wairakiensis* (Waterhouse, 1964) from the *Echinalosia maxwelli* Zone in the lower Mangarewa Formation is also close to the new form, sharing well-defined sulcal subplicae, but its ventral umbo is more prominent, the shape more rhomboid without conspicuous anterior lateral extremities, and costae higher and more angular posteriorly, and plicae high and angular posteriorly, yet fading anteriorly. The overall shape of *parfreyi* is more subrectangular, and the fold slightly broader and lower than in *wairakiensis*.

From the Barfield Formation of the southwest Bowen Basin, specimens figured by Parfrey (1988) as cited, and Waterhouse (1987a, pl. 5, fig. 1-3) have well defined plicae, well defined sulcal subplicae, and broad umbo. These are regarded as typical *A. parfreyi*. Flat Top specimens figured by Waterhouse (1987a, pl. 5, fig. 5-8, 10) are very close to the specimens of *parfreyi* from the *Echinalosia ovalis* Zone of New Zealand. Material illustrated from the Mantuan Member of southwest Bowen Basin as *Neospirifer* sp. A (Hill & Woods 1964, pl. P8, fig. 2-4) and as *N. wairakiensis* not Waterhouse by Hill et al. (1972, pl. P8, fig. 2-4) are transverse, with fine costae, only moderately defined and persistent plicae, low umbones, high fold and well defined sulcus, incorporating an inner pair of plicae. These are close to the specimens of *A. parfreyi* found in the *Echinalosia ovalis* Zone in New Zealand. The specimens figured by McClung (1983) from faunal intervals E and F in GSQ Eddystone core 1 in western Bowen Basin have low plicae fading anteriorly, but shape is typical, apart from what appears to be a shallower sulcus. These come from what appears to be equivalents of the *Terrakea elongata* Zone, rather than the greater age preferred by McClung (1983). The species - indeed the genus, is rare in this zone in both New Zealand and Bowen Basin, and additional material may enable specific discrimination.

Table 1:

Succession of *Aperispirifer* and *Neospirifer (N)* in south Bowen Basin, and New Zealand.

SE Bowen Basin		SW Bowen Basin		New Zealand		
Formation	Species	Formation	Species	Formation	& unit	Species
		(Eddystone E, F)	*parfreyi* var.	Mangarewa	8b	aff. *parfreyi*
Flat Top	*parfreyi*	Mantuan	*parfreyi*	Mangarewa	7b	*parfreyi*
Barfield	*parfreyi*	Lower Peawaddy			6	*parfreyi*
—		Catherine	*wairakiensis hillae*		5	—
		Ingelara				
Oxtrack		*ovalis*			4	*wairakiensis*
Brae	*N. concentrica*			Letham	3	*lethamensis*
—	—				2	—
—		— Freitag	*?archboldi*		1	*archboldi*

Genus ***Sulciplica*** Waterhouse, 1968

TYPE SPECIES: *Sulciplica transversa* Waterhouse, 1968 OD.

DISCUSSION: Shi et al. (1997) pointed out that this genus had a notable and suggestive biogeographic distribution in the Permian, centred in east Australia, and extending to New Zealand, Western Australia and the Shan-Thai terrane of southeast Asia. Some genera extend further west into Tibet, Nepal and northwest India. There is a distinctive suite of such brachiopod genera, including *Bandoproductus* Jin & Sun, *Megasteges* Waterhouse, *Fusispirifer* Waterhouse and *Spinomartinia* Waterhouse.

Sulciplica vellai n. sp.

1965 "*Spirifer*" aff. *vespertilio* Dana not Sowerby; Waterhouse & Vella, p. 66, pl. 3, fig. 1, 2, 3, 5.

1968 *Sulciplica transversa* not Waterhouse; Waterhouse, p. 25, pl. 16, fig. 8, 10.

1998 *Sulciplica transversa* not Waterhouse; Campbell et al., p. 292.

ETYMOLOGY: Named for Paul Vella.

HOLOTYPE: Specimen figured in Waterhouse & Vella (1965, pl. 3, fig. 4) from V 1032, Pariwhakaoho Stream, Flowers Formation, west Nelson, here designated. Kept at Department of Geology, Victoria University. Collection also at M25/f9562 (GS 15239).

DIAGNOSIS: Large transverse shells characterized by up to 20 pairs of plicae on ventral valve, crests rounded. Sulcus with comparatively strong subplicae, grading into plicae on flanks of sulcus and lateral shell.

DESCRIPTION: The species has been described by Waterhouse & Vella (1965) and Waterhouse (1968).

RESEMBLANCES: This species was referred by Waterhouse (1968) to

Sulciplica transversa Waterhouse, 1968, based on *Spirifer vespertilio* Dana, 1847 not Sowerby, 1844 from the Gerringong volcanics (in the Broughton Formation) at Black Head, Gerroa, south Sydney Basin. Tasmanian specimens were described by Morris (1845, pl. 17, fig. 1, 2, not 3) and Clarke (1987, text-fig. 6-8). *Sulciplica transversa* reported from the Moonlight Sandstone Member and lower Blenheim Formation by Waterhouse & Jell (1983, pl. 2, fig. 2, 3) is moderately close to the types, with up to 30 subrounded plicae and very transverse outline. Specimens reported from younger levels in the Bowen Basin have yet to be described.

As Archbold (1995) noted, the Nelson specimens ascribed to *Sulciplica transversa* by Waterhouse & Vella (1965) have finer more rounded plicae than in *S. transversa*. There are about 40 on well preserved valves, whereas the number in Tasmanian specimens is given as 24-36 by Clarke (1987). Evidently a complex cline was displayed by *Sulciplica*, with a number of species becoming larger, more transverse and more plicate during the Permian Period. Early Permian species display few coarse but well rounded plicae (Clarke 1990), and the slightly younger species *Sulciplica stutchburii* (Etheridge, 1892) from the Tiverton Formation shows more sulcal subplicae and angular flank plicae. The Nelson form would fall within this cline, being slightly younger than *Sulciplica transversa*. Other Australian species fall outside the trend.

From Western Australia, *S. occidentalis* Archbold, 1995 is based on a single ventral valve from a Perth Basin bore in the Beekeeper Member of the Wagina Formation, and serves as name-giver for the *Sulciplica occidentalis* Zone. This individual has some 28 plicae, with angular crests, and more sulcal subplicae than in *S. transversa*. The formation is approximately correlative according to Archbold & Dickins (1991) with the Malbina E fauna of Tasmania, and was correlated with Ufimian Stage by Archbold (1995) but is more likely late Kazanian, or Wordian to use the International stage classification. The west Australian specimen is very close to *S. transversa*, and with only one specimen available, would probably be incorporated with *S. transversa* by many authors. In view of the number of fine subplicae in the sulcus, the taxon may be recognized as *Sulciplica transversa occidentalis* Archbold.

DISCUSSION: Archbold (1995, p. 157) referred to Clarke's illustrations of *Sulciplica transversa* as though they were the ones that showed prominent ribs in the sulcus. But the same morphology is adequately conveyed in the original figures by Morris (1845) and Dana (1849), and the generic name as intended conveys precisely that impression. Although Archbold called the lateral undulations "costae", Waterhouse (1968, 1987a) and Clarke (1987) preferred to name the features plicae. The undulations within the sulcus and over the fold may be termed subplicae.

Waterhouse (1968, 1987a) put *Sulciplica* in Licharewiidae, but Clarke (1987) relocated the genus in Spiriferidae, and Archbold (1995) in Subfamily

Spiriferinae. Carter et al. (1994) placed the genus with a query in Trigonotretinae.

Sulciplica sp.

1984 ?*Notospirifer* sp. Campbell et al., p. 277, text-fig. 6.7.

The specimen BR 1637 from GS 12643 (P25/f1) from Stephens Subgroup, Stephens Island, that was misidentified as *Notospirifer* by Campbell probably belongs to *Sulciplica.* There are some 6 pairs of narrow plicae, a median subplication, and 2 further subplicae, one each side, on the specimen which is only 23mm wide. Short adminicula diverge widely.

Family **SPIRIFERELLIDAE** Waterhouse, 1968

Genus ***Spiriferella*** Chernyshev, 1902

Spiriferella sp.

1968 *Spiriferella* sp. Waterhouse, p. 50.

1982 *Spiriferella* sp. Waterhouse, p. 54.

MATERIAL: Some 16 ventral valves at collection D44/f9940, (OU 2462-3), Elsdun conglomerate, Wairaki Downs.

DISCUSSION: A small suite of very worn ventral valves, preserved mostly as internal moulds, was collected by Lucy Force just north of Productus Creek, in what she considered to be Hawtel Formation in Mutch-Force terminology, corrected to Elsdun Formation by Waterhouse (1999). They were noted by Waterhouse (1968), and Alex Mutch (pers. comm.) in Waterhouse (1982) suggested that they came from the ?Glendale limestone, but Force's stratigraphic interpretation seems more likely. Although the locality cannot be refound, the matrix and possibly position suggest that they may have come from basal Elsdun conglomerate (E3) of Waterhouse (1999). The specimens differ from other New Zealand *Spiriferella,* but cannot be specifically delimited, because the ventral exterior is poorly preserved, and the dorsal valve not known. The robust nature of what remains of the ventral valve, together with shape, ornament and interior, suggest a member of the *Spiriferella* lineage B complex of Waterhouse & Waddington (1982), and close to *S. rajah* (Salter). The specimens may have been derived from the *Plekonella multicostata* Zone faunas of the lower Glendale Formation in the Wairaki Downs area. These are regarded as close in age to *Spiriferella rajah* of the Himalaya (eg. Waterhouse 1978).

Spiriferella? sp.

MATERIAL: A ventral valve OU 18285 from D44/f376, *Spinomartinia spinosa* Zone, Hilton Limestone Formation, Coral Bluff, Wairaki Downs.

DESCRIPTION: Valve about 22mm wide and long, but margins broken, with umbo moderately prominent, and narrow shallow sulcus with angle of 10°, showing concave apparently smooth but possibly worn floor. Plicae very subdued, in at least 3 pair but scarcely visible, bearing costae, 3-4 in 5mm anteriorly beside sulcus, micro-ornament obscure. Dental plates short, diverging at about

80° to short adminicula buried in secondary shell, low ridge on posterior wall, delthyrial part obscure. Ventral muscle field long with raised poorly defined adductor platform divided by median groove anteriorly, and vaguely impressed diductor scars. Posterior shell very thick.

RESEMBLANCES: The specimen is unusual for *Spiriferella* in the absence of clearly preserved costae over the sulcus, the extremely faint plicae, and the comparatively long muscle field. Its generic position is not certain, although overall detail suggests *Spiriferella* with a strong approach to *Nakimusiella* Shen et al. *Spiriferella supplanta* Waterhouse, 1964 from the lower Letham Formation (GS 6070, D44/f9621) has less well defined sulcus, stronger plicae and costae, and shorter ventral muscle field. Specimens of *Spiriferella* from the Elsdun conglomerate E 3 have a massive incurved umbo, narrow-crested plicae posteriorly, wide sulcus and large muscle field, and do not strongly approach the present specimen in costae or plicae.

Genus ***Nakimusiella*** Shen, Archbold, Shi & Chen, 1999

TYPE SPECIES: *Nakimusiella selongensis* Shen et al. 1999.

DIAGNOSIS: Variably elongate shells with obsolete sulcus, and simple costae, bifurcating near anterior margin in large specimens.

Nakimusiella oweni n. sp.

1878 *Spirifer glaber* (not Sowerby); Hector, p. xii.

1967a *Spiriferella* n. sp. Waterhouse, p. 92, text-fig. 5G, 32.

ETYMOLOGY: Named for Dr. Stuart Owen.

HOLOTYPE: Specimen BR 654, figured by Waterhouse (1967a, text-fig. 5G, 32) from *Marginalosia planata* Zone, N28/f7474, GS 441, Pig Valley Formation, here designated.

DIAGNOSIS: Small well inflated shells with plicae reduced to one anterior pair, costae low, sulcus shallow, narrow, v-shaped in section, fold low with median anterior groove.

DESCRIPTION: The specimen BR 654 from GS 441, Pig Valley Formation at Wairoa Gorge, east Nelson, as described by Waterhouse (1967a), has only faint costae, numbering 3 in 6mm at the anterior end of the holotype, and one pair of plicae arising well in front of the umbo. Two specimens from the same formation at GS 4596, (N28/f7533), Wairoa Gorge, included by Waterhouse (1964, p. 120) in so-called *Martinia*, may be allied. These were not figured, but the description mentions a low broad fold bearing a faint median depression, as in typical of many Spiriferellidae. The shell was described as smooth, and the dorsal interior not revealed.

RESEMBLANCES: No species of *Spiriferella* Frederiks or the closely allied genera *Elivinia* Frederiks, *Plicatospiriferella* Waterhouse & Waddington, or *Arcullina* Waterhouse have such subdued plicae and faint or no costae (see Waterhouse 1986, Kalashnikov 1998). *Timaniella* Barkhatova is plicate and very transverse. *Alispiriferella* Waterhouse & Waddington may have some-

what subdued plicae and no costae, but is alate. The Nelson form is apparently allied to the very distinctive genus *Nakimusiella* Shen et al. This was described from the Late Permian Changhsingian Stage at the hill of Selong in south Tibet. Only the ventral valve is known, and it displays no plicae, with shallow or no sulcus, and low and few costae in 4-5 pairs that may divide anteriorly. The New Zealand form has slightly deeper sulcus, with non-branching costae, or no costae, and suggestions of faint plication along sulcal margins. The species *Nakimusiella oweni* appears to reinforce a Late Permian age for the New Zealand Wailtian Stage, based on rocks and faunas in the Pig Valley Formation.

Genus ***Alispiriferella*** Waterhouse & Waddington, 1982

TYPE SPECIES: *Spiriferella ordinaria* Einor in Likharev & Einor, 1939 OD.

DIAGNOSIS: Transverse alate Spiriferellidae, subrectangular in outline, with wide well defined sulcus along crest of dorsal fold, costae simple, not complex or numerous. Interior as in *Spiriferella*.

DISCUSSION: This genus was named for two Arctic species, *A. ordinaria* (Einor) found in Novaya Zemlya and Arctic Canada, in beds of Cisuralian age, and *A. gydanensis* (Zavodowsky) from Late Permian Omolon horizon, Kolyma Peninsula, and in Guadalupian of Arctic Canada and Spitsbergen.

Alispiriferella n. sp.

MATERIAL: Six ventral valves and three dorsal valves from D44/f363, *Plekonella multicostata* Zone, lower Glendale Formation, Wairaki Downs.

DIAGNOSIS: Specimens weakly transverse, cardinal extremities elongate, ventral valve well inflated, sulcus well defined, dorsal valve little inflated, fold low and broad, costate, with shallow median groove that is wide anteriorly, 5 pairs of weakly costate plicae on each valve.

DESCRIPTION: Ventral valve moderately inflated, largest specimen 46mm wide, length over 26mm, broken short, and over 20mm high. Dorsal valve less inflated. Ventral umbo prominent, incurved, sulcus sharply defined in small specimens, angle close to 30°, bearing a few costae. Dorsal umbo low, fold low and broad, sides diverging at up to 25°, divided by well defined median channel, which may bear median rib, and 2-3 ribs along each side. Some 5 pairs of plicae laterally on each valve, bearing up to 3 costae anteriorly. Growth lines strong anteriorly, 2-3 per mm, small short pustules visible anteriorly. Cardinal extremities rounded at early growth phase up to width of 5mm, then becoming subalate; ventral interarea high, divided by narrow delthyrium with angle close to 25°, dorsal interarea low, wide low notothyrium.

Teeth supported by short dental plates resting on diverging adminicula, largely buried in secondary tissue. Muscle field wide, with narrow adductor grooves, divided by median ridge in one specimen, diductors broad, striate. Posterior floor pitted. Dorsal interior known only from small specimen, socket plates short, cardinal process obscure, spiralia not known.

DISCUSSION: The species comes close to the Arctic genus *Alispiriferella*, but is more costate than either the type species *Spiriferella ordinaria* Likharev & Einor, or *A. gydanensis* (Zavodowsky).

The dorsal valve of the Glendale material looks to be close to that of *Timaniella* Barkhatova, 1968, but members of this genus are much more transverse and alate, with shallower ventral sulcus. *Timaniella* has only moderately thickened ventral valve, whereas the posterior walls of the present specimens are substantially thickened.

Spiriferella supplanta Waterhouse, 1964 from the lower Letham Formation is more elongate and less costate, with a higher dorsal fold.

Suborder DELTHYRIDINA Ivanova, 1972

Superfamily **INGELARELLOIDEA** Campbell, 1959

[nom. transl. Waterhouse 1998, ex Ingelarellinae Campbell, 1959]

Waterhouse (1998, p. 3) considered that Ingelarellidae may have stemmed from within Delthyridina. They show comparable internal plates, what appears to be allied ctenophoridium, and an external micro-ornament not identical with, but apparently developed from fimbriate, finely pustulose or granular arrays developed in Devonian Delthyridina. Traditionally, as in Carter et al. (1994), the family has been placed with Martiniidae within Martinioidea, but Martiniidae appears to have descended from Ambocoelioidea George, 1931.

Family **INGELARELLIDAE** Campbell, 1959

Subfamily **INGELARELLINAE** Campbell, 1959

Genus ***Tigillumia*** Waterhouse, 1998

TYPE SPECIES: *Martiniopsis biparallela* Waterhouse, 1987a.

DIAGNOSIS: Shells externally like *Martiniopsis* with no plicae, shallow or no sulcus, generally no fold, micro-ornament of shallow elongate exopunctate grooves in quincunx. Adminicula long and close-set, enclosing narrow muscle field rimmed anteriorly each side by high ridges which join anteriorly to form tigillum (see Waterhouse 1998, p. 2) along mid-line. Tabellae of moderate length, moderately spaced.

Tigillumia mintyi n. sp.

Text- fig. 1 a - d

1968 *Ambikella parallela* not Waterhouse; Waterhouse, p. 73, pl. 14, fig. 8 (not pl. 13, fig. 3, 5, 6, pl. 14, fig. 7 = *parallela*).

ETYMOLOGY: Named for Strachan Minty, Beaumont Station, Ohai.

HOLOTYPE: Specimen OU 18289, figured Text-fig. 1a from D44/f376, Hilton Limestone Formation, Coral Bluff, Wairaki Downs.

DIAGNOSIS: Small shells with moderately prominent beaks, ventral valve smooth or with shallow anterior sulcus, adminicula close-set, long, tabellae also close-set and long.

MATERIAL: Some 45 ventral valves and perhaps 6 dorsal valves with a number of additional obscure specimens from D44/f376 (OU 18289-98) and some 5

ventral valves from D44/f9479 (GS 3615), preserved as shells and internal moulds, Coral Bluff, Hilton Limestone Formation. Also in boulder of Tertiary conglomerate at Waituna Stream, GS 7803 (D44/f9524).

DESCRIPTION: Shells small, one ventral valve measuring about 28mm in width, 23mm long and 8mm high, another ventral valve measures 22mm wide, 19mm long and 7mm high. Dorsal valve slightly less inflated. Ventral umbo prominent, incurved, umbonal angle close to 110°, varying to 90°, delthyrium open, cardinal extremities well rounded, surface of shell smooth, or shallow narrow sulcus may commence about posterior third to half of shell length, micro-ornament obscure, unreliably suggestive of rounded pits and short raised ridges. Dorsal valves do not show any clear fold, but poorly preserved anteriorly, so a low anterior fold could have been present.

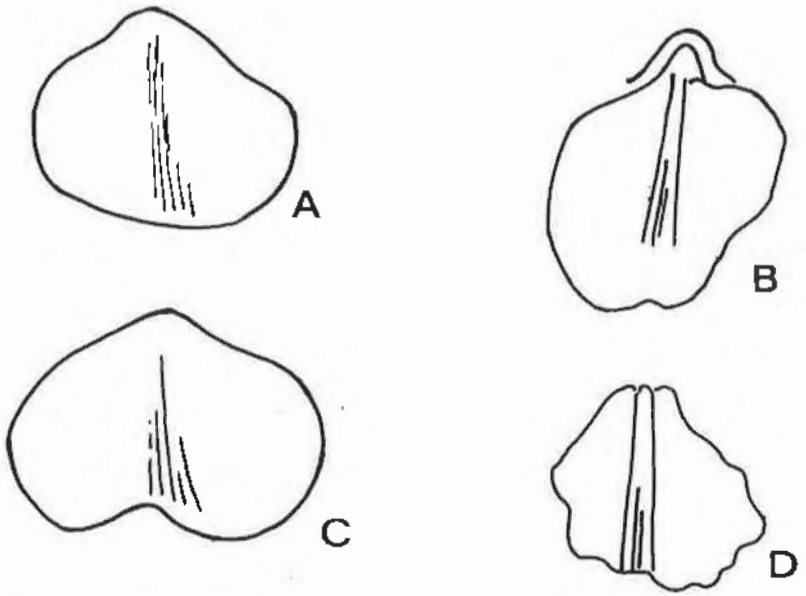
Ventral valve with long high adminicula diverging anteriorly at about 10°, extending a little beyond mid-length, subvertical, converging weakly on scapular-shaped high dental plates, that diverge along inner side of delthyrium, supporting small teeth. Adductor ridge narrow and raised, extending well forward, diductors to each side wide. Floor of valve strongly thickened posteriorly each side of adminicula, and bears pallial pits. Most specimens have lost the anterior shell, and some suggest a low tigillum, others suggest none. Dorsal valves difficult to recognize, appear to be much less thickened posteriorly, and have long subparallel tabellae supporting high crural plates, floor between bearing low medium myophragm or septum, cardinal process not shown, and muscle scars obscure.

RESEMBLANCES: These specimens are moderately numerous in the large pocket of shells clustered over 2-3m within the lowest or westernmost of the bluffs making up Coral Bluff, towards the south end of the outcrops. This location is specified as D44/f376: earlier collections, such as D44/f9479 may also include specimens from the same exposures. The individuals are not well preserved, but are very distinctive, so that even though based largely on incomplete ventral valves, may be readily recognized. They are much smaller than *Martiniopsis woodi* Waterhouse, 1964 from the *M. woodi* Zone of Arthurton, or *M. patella* Waterhouse,1967a from the *Wairakiella rostrata* Zone of Wairaki Breccia-Conglomerate, Wairaki Downs. The adminicula are longer and more close-set, and there are several other obvious differences, including the nature of thickening in the ventral valve. The closest species to the present form is *Tigillumia biparallela* (Waterhouse ,1987a, p. 25, pl. 6, fig. 8-11, 13-15) from the Brae Formation of the southeast Bowen Basin, Queensland. This species is similar in having long subparallel adminicula and tabellae, and the ventral adductors are carried on a narrow median ridge. The Queensland form shows much less posterior thickening in the ventral valve, and has a well formed tigillum. The New Zealand form further differs in the shape of the ventral valve, which displays a more prominent umbo and more

inflated shell. It appears that the two are homeomorphs rather than synchronous, but the similarities are substantial.

A ventral internal mould OU 2473 described as *Ambikella* - now *Tomiopsis (Ingelarella) - parallela* by Waterhouse (1968, pl. 14, fig. 8) is regarded as conspecific. It comes from the Tertiary boulder at GS 7803, with *Spinomartinia spinosa*, and has long subparallel adminicula with what was interpreted as a narrow anterior sulcus, but may be a tigillum. Unlike *Tomiopsis parallela* (Waterhouse), which comes from the *Plekonella multicostata* Zone, it is a narrow shell, and lacks plicae.

DISCUSSION: Photographs of this species will be provided in a forthcoming publication.



Text-fig. 1 Sketches of *Tigillumia mintyi* n. sp. from Coral Bluff, Hilton Limestone Member, D44/f376. A, ventral valve OU 18289, holotype. B, ventral internal mould OU 18291. C, ventral valve OU 18290. D, internal mould, ?dorsal valve, OU 18292. Specimens x 1.5 approx.

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