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A revision of the distribution maps and database of New Zealand mayflies (Ephemeroptera) at Canterbury Museum

TERRY R HITCHINGS
Canterbury Museum, Rolleston Avenue, Christchurch 8013, New Zealand
thitchings@internet.co.nz

TIM R HITCHINGS
Canterbury Museum, Rolleston Avenue, Christchurch 8013, New Zealand
hitchwill@xtra.co.nz

MATTHEW D SHAW
Canterbury Museum, Rolleston Avenue, Christchurch 8013, New Zealand
mshaw@canterburymuseum.com

ABSTRACT

New Zealand mayflies form an important component of the freshwater aquatic fauna, being of particular interest to conservationists, bio-geographers, recreational fishermen and all people with an environmental concern for the health of rivers and streams. The database lists more than 10,800 records largely based on Canterbury Museum's mayfly collection. For the 39 species with previously published maps, more comprehensive maps with many additional datapoints are now given. A further 11 wholly new maps for recently described species are added. The database is at present being expanded to incorporate uncertainty estimates of site location data, and the data for Canterbury Museum specimens is being transferred to the Vernon Collection Management system, which will aid specimen retrieval. These additions are explained. The possible conservation status of some mayfly species is discussed.

KEY WORDS

Ephemeroptera; mayflies; distribution; New Zealand.

INTRODUCTION

Phillips (1930) prepared the first comprehensive survey of the mayfly fauna as then known, including locality data. A distribution map for one New Zealand mayfly species was given by Wisely (1962). Maps for 30 Leptophlebiidae distributions were given by Towns and Peters (1996). The initial Canterbury Museum database (Hitchings 2001) included 5,737 records and 39 species maps. Fifty mayfly species in 19 genera and 8 families have now been described and their distributions are mapped in this paper. Each record in the database corresponds to one or more individuals collected on the same date at a particular site and preserved in 75% ethanol. More than 88% of these records are for specimens held in Canterbury Museum and all these records are being transferred to the Vernon Collection Management system.

METHODS, MATERIALS AND CONVENTIONS

In addition to aerial nets for winged and sieves for aquatic life stages, more comprehensive collecting methods have recently been employed by collectors and Museum staff. These include the use of ultraviolet lights (15 W) for subimagos and imagos and electric fishing techniques (A. Staniczek and A. Sinton: pers. comm.) for larvae. The latter method has given access to deeper waters than have usually been searched. Many of the specimens in the collection are due to the efforts of collectors who have been primarily interested in other orders.

Comprehensive keys for most life stages have been given for species of the Leptophlebiidae by Towns and Peters (1996), the Nesameletidae (Hitchings and Staniczek 2003) and the Rallidentidae (Staniczek and Hitchings 2013). Recently, individual species descriptions have been given by Hitchings (2008, 2009 and 2010) and Winterbourn (2009). The most comprehensive keys to identification of the larval stages of genera are those of Winterbourn et al (2006).

The existence of two species described in the literature, *Coloburiscus tonnoiri* Lestage, 1935 and *Oniscigaster intermedius* Eaton, 1899 remains uncertain. The Auckland Islands endemic species *Cryophlebia aucklandensis* (Peters, 1971) is also not included in these maps. The ubiquitous genus *Deleatidium* Eaton, 1899 has been divided into two sub genera, *Deleatidium* and *Penniketellus* Towns & Peters, 1979 (Towns and Peters 1996) and these are indicated (*D.*) and (*P.*) respectively in the map captions. Following the species name the number of records used to prepare the map is given in brackets.

Abbreviations used in the original Microsoft Access database (Hitchings 2001) are used along with the following additions: GPS = geo-positional site, lat = latitude, long = longitude, m = altitude in metres above sea level, LINZ = Land Information New Zealand. Canterbury Museum's Vernon database includes all of these data together with unique specimen accession numbers for specimens held at this museum eg CMNZ 2014.2.20912–14 (in this example a record consists of a specimen lot based on three specimens). Note that the maps included here also include data from records of catches identified by the authors but held at other institutions or by private collectors.

The vial labels including their five figure easting and northing grid references are presently being rechecked against the original database and transcription errors detected and corrected. Locality names are amended to conform to the standard New Zealand Gazetteer names. Map grid references have been converted to decimal latitude and longitude using the online conversion tool available from Land Information New Zealand (http://apps.linz.govt.nz/coordinate-conversion/), using co-ordinate conversion with the free format entry advanced option and WGS1984 datum.

RETROSPECTIVE ESTIMATES FOR MAYFLY CO-ORDINATE DATA

The site descriptions supplied in the database are brief, most often naming only the watercourse collected from. Why would future users trust the accompanying point data? The watercourses sometimes extend over considerable distances and maximum uncertainty estimates based just on these site descriptions would often encompass 20,000 to 50,000 metres and sometimes more. For co-ordinate data to be trusted and reliably interpreted by future users, we are supplementing co-ordinate data with uncertainty estimates and brief rationales for uncertainty estimates.

Most of the mayfly records at Canterbury Museum, that is, the Vernon accessioned specimens owned by Canterbury Museum, present a different situation from many other geo-referencing efforts. Elsewhere a principal challenge has been to establish co-ordinates for named places in legacy data (Chapman and Wieczorek 2006). However, this class of data applies to only a small proportion of these mayfly records since the mayfly database has been routinely furnished with mappable co-ordinates as it was created. Canterbury Museum has been fortunate that several local entomologists have consistently provided co-ordinate data (e.g. Ward and Henderson 1993; Fuller et al 2013). As a result of this approach, the present database is well furnished with co-ordinate data; the quality of this data is variable, but most often of high quality. The current challenge has been to apply retrospective uncertainty estimates to Canterbury Museum data in an efficient and transparent manner. Standard guidelines (eg Chapman and Wieczek 2006) do not cover this type of geo-referencing task. We use a standard definition of co-ordinate uncertainty: "the horizontal distance (in metres) from the given decimal latitude and decimal longitude describing the smallest circle containing the whole of the location" based on the Darwin Core Standards (http://rs.tdwg.org/dwc/terms, accessed 3 February 2015).

For the mayfly database, co-ordinate data has been assembled as follows: map grid references were either supplied by the collector, most typically referenced from the MS 260 map series, or were derived from the site and description by the authors. Whether co-ordinates were supplied originally or secondarily derived was not originally recorded, but is often known by the authors. All co-ordinates have been individually checked either using Topo50 maps or more recently on the website NZ Topo Map (www.topomap.co.nz) or with the software Freshmap for Windows Version 1.0 (www.freshmap.co.nz).

Currently each mayfly specimen is being assigned an individual number and accessioned into Canterbury Museum's Vernon Collection Management System. The co-ordinates are being supplemented with uncertainty estimates and accompanying brief rationales (see Table 1 for examples).

INTERPRETING UNCERTAINTY ESTIMATES FROM VERNON MAYFLY DATABASE

The following caveats apply. The uncertainty estimates have been applied according to the authors' knowledge of individual collectors, and usually to all of that collector's records. Only occasional adjustments have been made within the set of uncertainty estimates and rationales as applied to an individual collector. Otherwise it has been assumed that a given collector has consistent standards in data collecting.

Thus uncertainty estimates and comments have not been reviewed for individual records. The overall purpose of the rationales and uncertainty levels is to provide useful information that gives some confidence in the estimate; in the absence of a rationale, uncertainty might have to be subsequently inflated due to a lack of information. The authors consider that future data users will have some rationale to better assess the records that interest them.

SPECIES DISTRIBUTION MAPS

On the maps (Figs 1–50) all records within a circular area with diameter 10 km have been aggregated to a single dot. The clustering of collecting sites on a map is frequently an artefact of the nature of the collecting effort. A row of stream sites adjacent to a road is often obvious. For this Museum, collecting opportunities have been much greater in the South Island than in the North Island.

Unroaded, remoter areas do not necessarily mean the absence of mayflies but the lack of collecting opportunity in those places.

The doubling of records since the last maps were published (Hitchings 2001) has not greatly altered the overall distribution patterns. Thirteen additional newly described species have been added.

Cook Strait remains an effective barrier to mayfly migration, with 10 species restricted to the North Island and 12 to the South Island. Seven species are not only widely distributed in the North Island but extend into northwest Nelson and northern Westland as described earlier (Hitchings 2001).

The extent to which a collector has been able to collect all the species present at a particular site is hard to estimate. Both the techniques employed, time spent, species life histories, water flow characteristics and many

VARIOUS COMMENTS INCLUDING RATIONALE FOR UNCERTAINTY LEVEL	UNCERTAINTY LEVEL
Description of locality is vague; given LAT/LONG is based on a reasonable assumption about intersection between the likely road access and a particular stream. Nothing known about the collector. Accuracy very approximate.	2,000 metres
The senior author's knowledge of this site indicates difficulty in accurately locating sites without GPS, since there are very few usable landmarks.	1,000 metres
The collector is known by the senior author to provide accurate grid references.	1,000 metres
The collector provided site names that describe the general area only. However, the senior author located points on the watercourses where, based on access routes, he was fairly certain the collecting sites were.	300 metres
The collector was known to use older maps to derive grid references.	200 metres
The collector supplied reliable local data. If there was any ambiguity, the collector was consulted and map grid reference decided by discussion.	100 metres
The collector provided GPS readings	50 metres

Table 1. Accuracy scale for uncertainty estimates

other abiotic factors influence success in building a species list for a location. These lists provide the records for the database. The resulting map distributions will always be incomplete. For these reasons distribution maps such as that for *Rallidens platydontis* Staniczek & Hitchings, 2014 found at present in the southern and eastern South Island may prove to have a continuous range rather than several apparent discrete populations as implied by the map. Similarly *Deleatidium* (*D.*) *branchiola* Hitchings, 2009 and *Deleatidium* (*D.*) *kiwa* Hitchings, 2010 will probably be found to have more extended distributions than is known at present.

Species likely to continue to be of sufficiently restricted distribution to be regarded as potentially endangered are *Aupouriella pohei* Winterbourn, 2009, *Deleatidium* (*P.*) *insolitum* (Towns & Peters, 1979), and *Nesameletus vulcanus* Hitchings & Staniczek, 2003, as is apparent from their distribution maps. *Nesameletus vulcanus* seems to be present as two disjunct populations showing some morphological differences.

DATABASE AVAILABILITY

A fully checked and verified specimen-based database incorporated within the Vernon Collection Management System at Canterbury Museum is expected to be complete by late 2016. We expect that these data will be available online after 2016, but in the interim, data on which these maps are based can be made available to *bona fide* researchers who contact the senior author.

ACKNOWLEDGEMENTS

This database and mayfly collection has only been made possible thanks to the efforts of 161 largely voluntary field collectors who, in the last 75 years, have traversed the back country of New Zealand and donated the results to this Museum. Specimens from selected regions and held by other museums have also been identified and the data incorporated in these maps. Their loans have added significantly to the species coverage. In particular Auckland Museum, Florida A&M University, USA and the National Museum of Natural History, Washington DC, USA are to be thanked.

Thanks are due to Lynette Hartley, Janette Leyland and Rachael Fone who are undertaking accessioning of the mayfly collection and incorporating it within the wider Canterbury Museum collection and Vernon database. Mike Winterbourn's helpful advice and guidance have been very much appreciated. Ian Henderson's mapping programme "Amnesia" has been invaluable in the preparation of mayfly distribution maps. Canterbury Museum and the curator responsible for invertebrates, Cor Vink, are thanked for providing research facilities and the professional support needed to bring this project to fruition.

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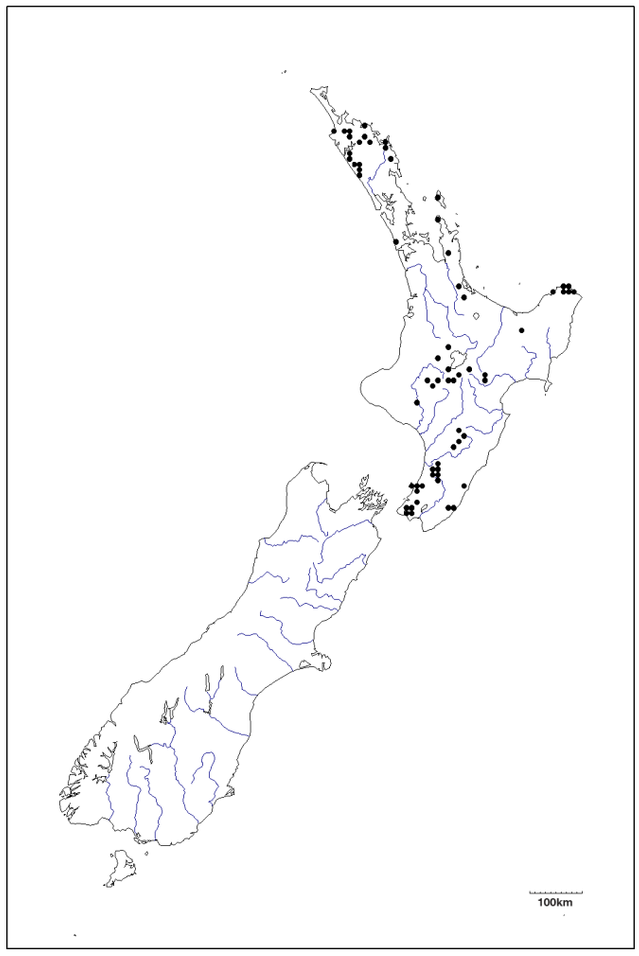

Fig 1: *Acanthophlebia cruentata* (Hudson, 1904) (117 records).

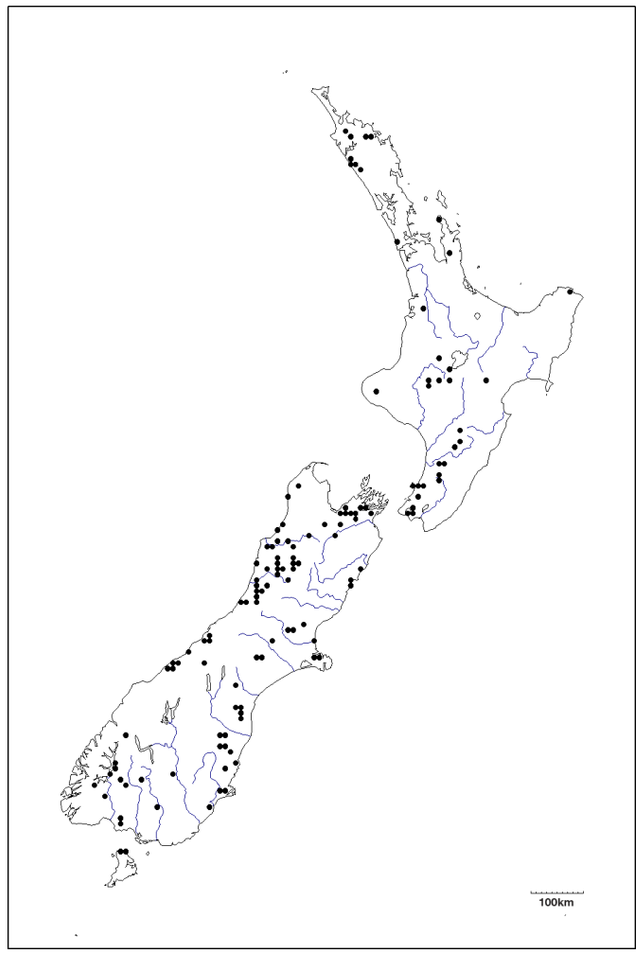

Fig 2: *Ameletopsis perscitus* Eaton, 1899 (239 records).

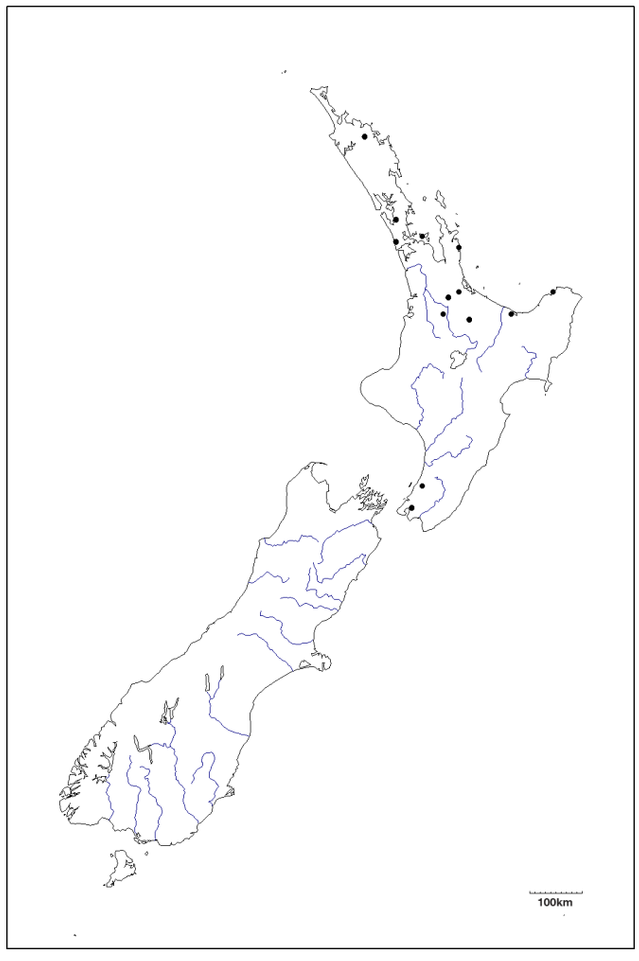

Fig 3: *Arachnocolus phillipsi* Towns & Peters, 1979 (18 records).

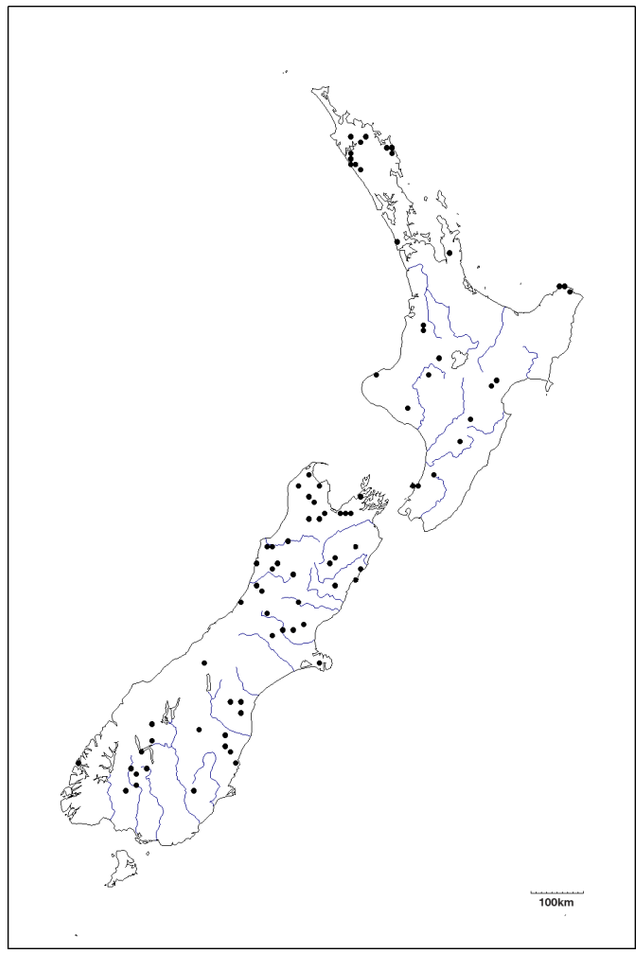

Fig 4: *Atalophlebioides cromwelli* (Phillips, 1930) (181 records).

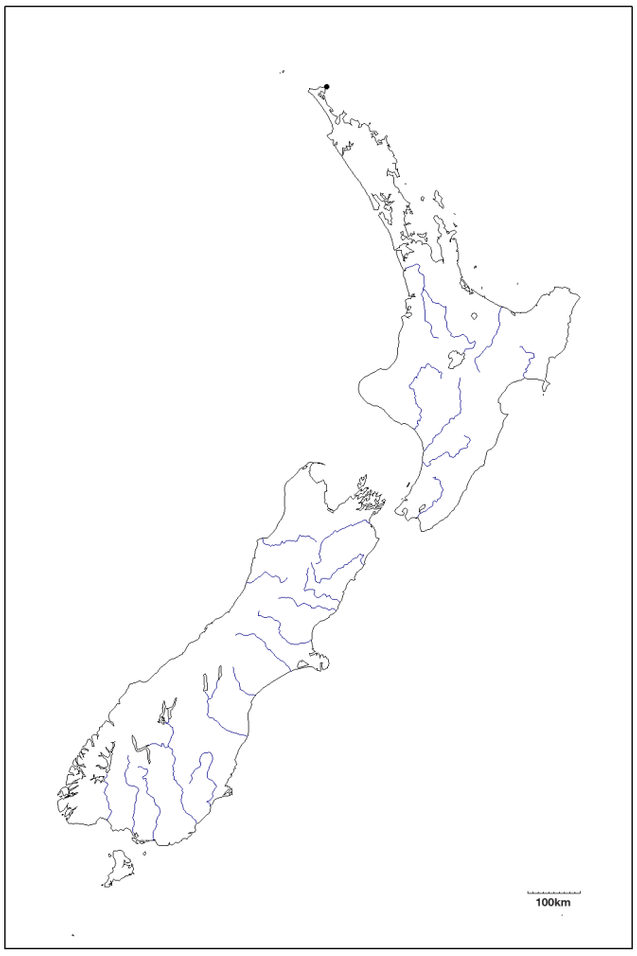

Fig 5: *Aupouriella pohei* Winterbourn, 2009 (1 record).

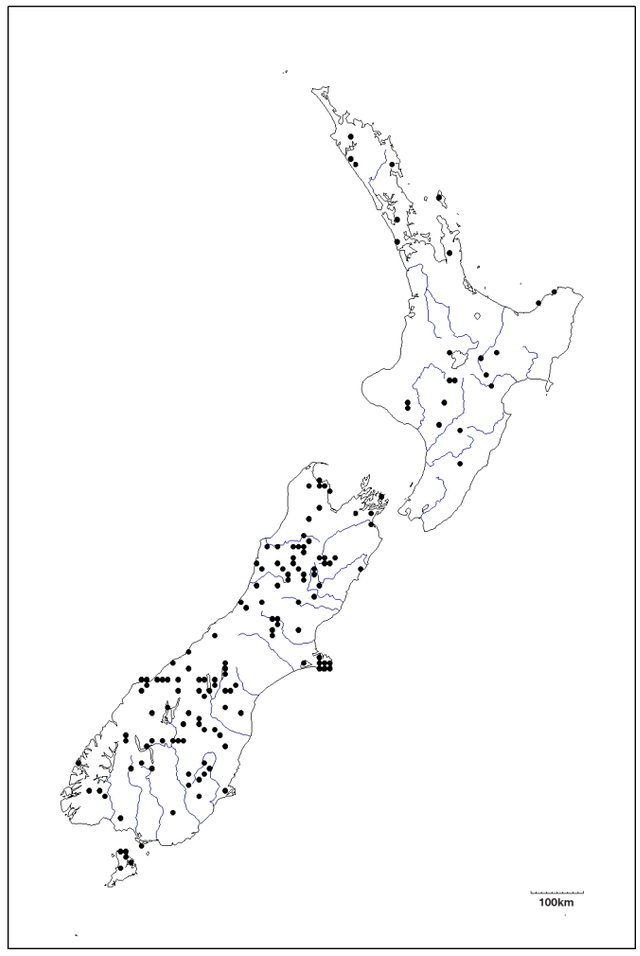

Fig 6: *Austroclima jollyae* Towns & Peters, 1979 (218 records).

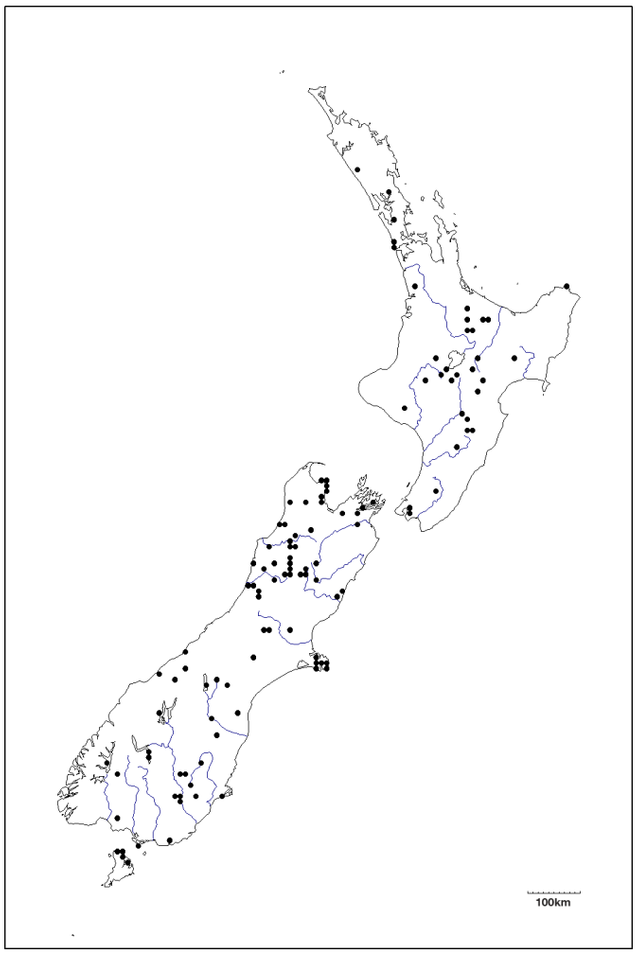

Fig 7: *Austroclima sepia* (Phillips, 1930) (180 records).

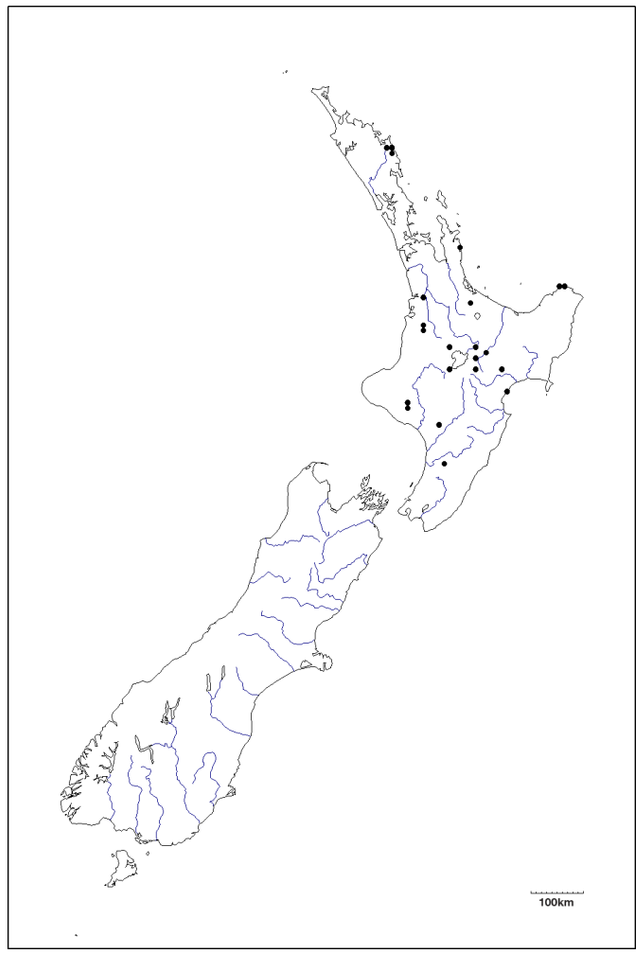

Fig 8: *Austronella planulata* Towns, 1983 (25 records).

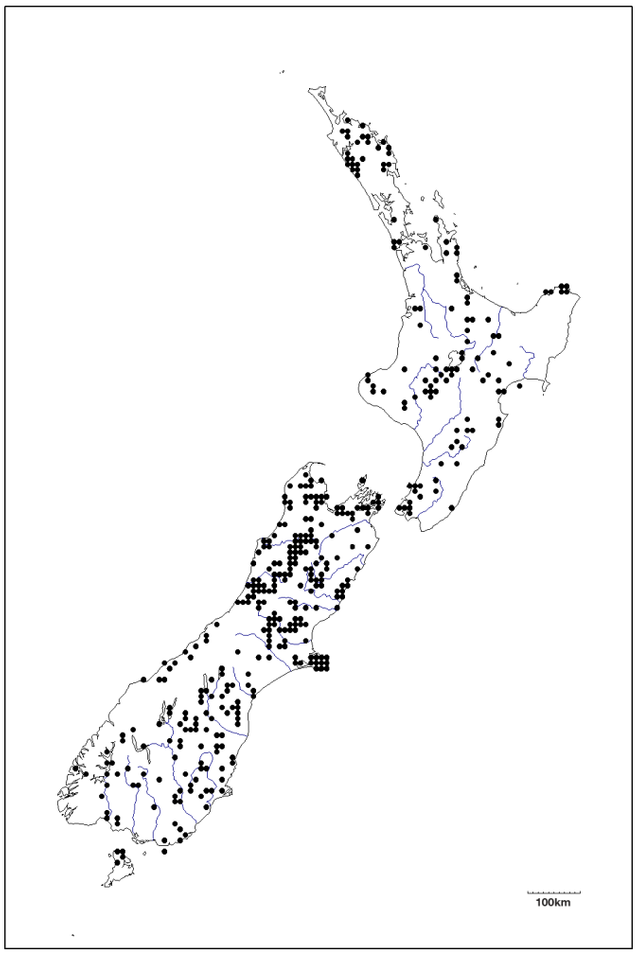

Fig 9: *Coloburiscus humeralis* (Walker, 1853) (986 records).

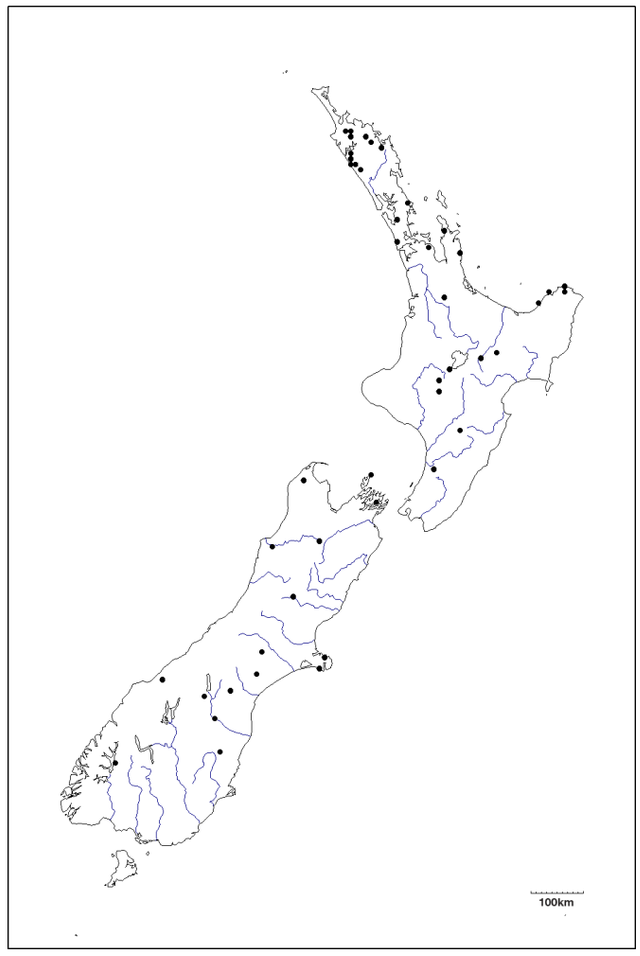

Fig 10: *Deleatidium* (*D.*) *angustum* Towns & Peters, 1996 (67 records).

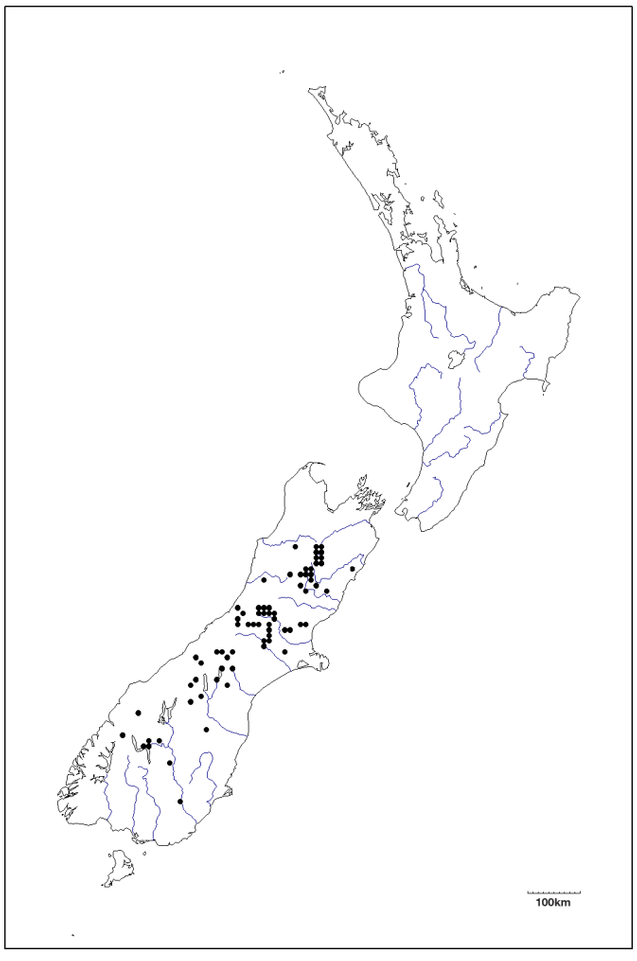

Fig 11: *Deleatidium* (*D.*) *atricolor* Hitchings, 2009 (173 records).

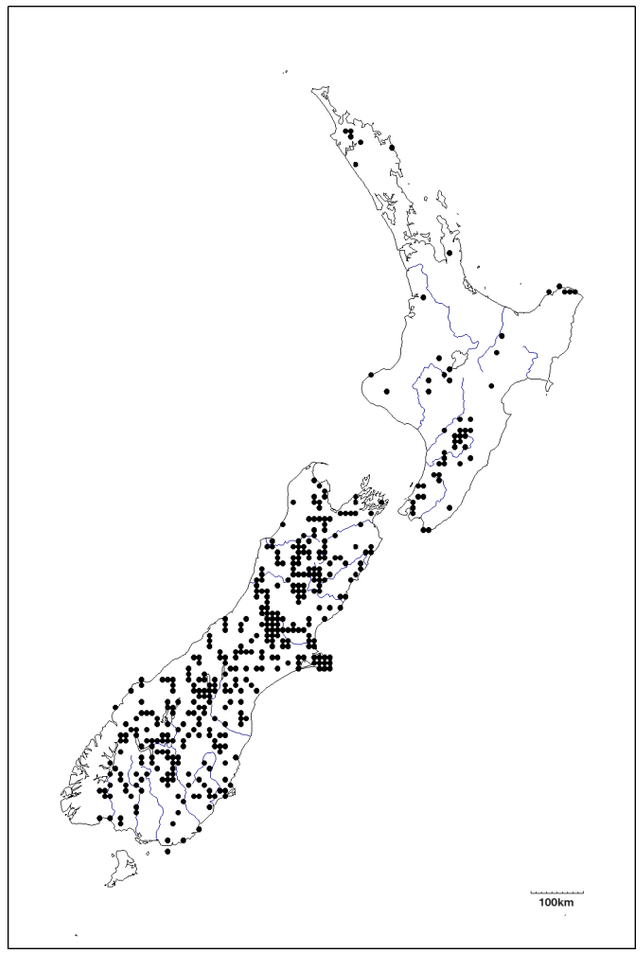

Fig 12: *Deleatidium* (*D.*) *autumnale* Phillips, 1930 (907 records).

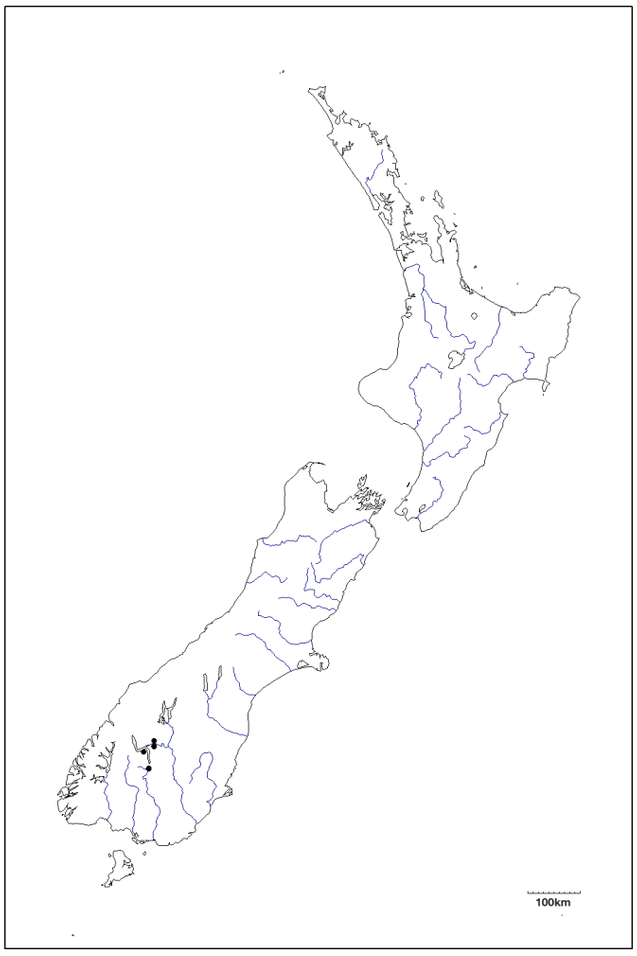

Fig 13: *Deleatidium* (*D.*) *branchiola* Hitchings, 2009 (6 records).

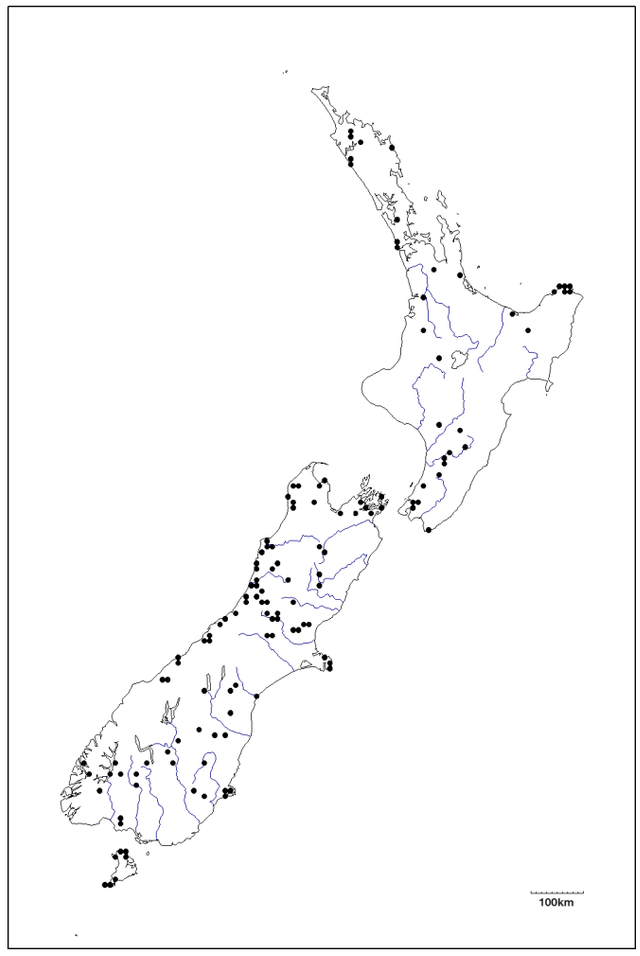

Fig 14: *Deleatidium* (*D.*) *cerinum* Phillips, 1930 (213 records).

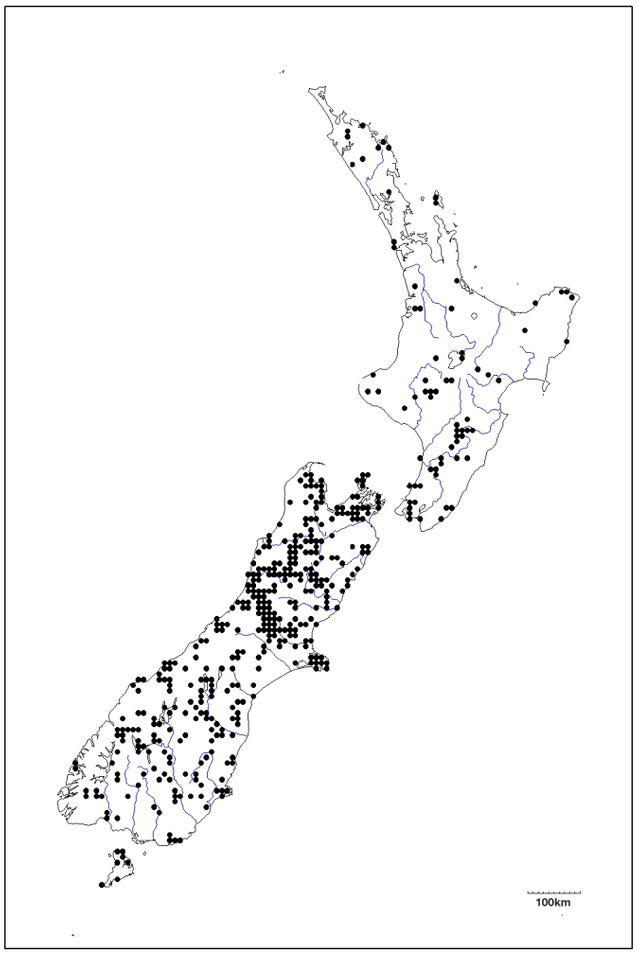

Fig 15: *Deleatidium* (*D.*) *fumosum* Phillips, 1930 (968 records).

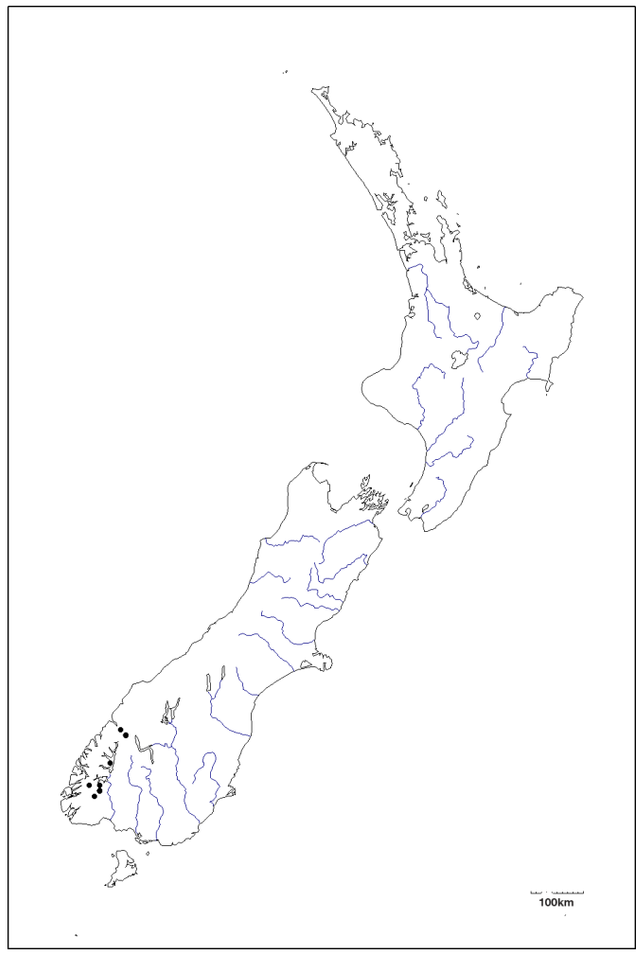

Fig 16: *Deleatidium (D.) kiwa* Hitchings, 2010 (16 records).

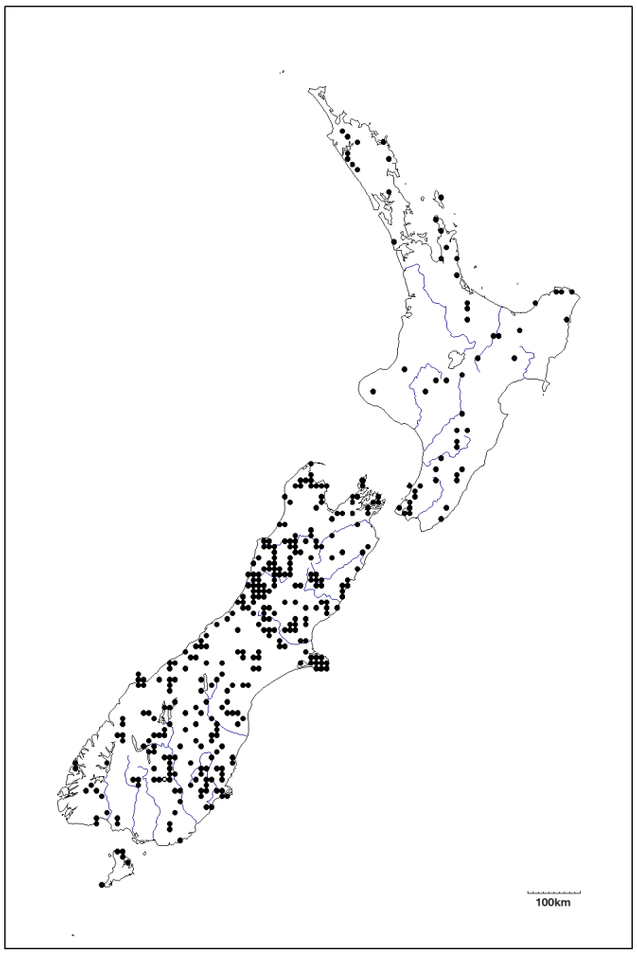

Fig 17: *Deleatidium* (*D.*) *lillii* Eaton, 1899 (732 records).

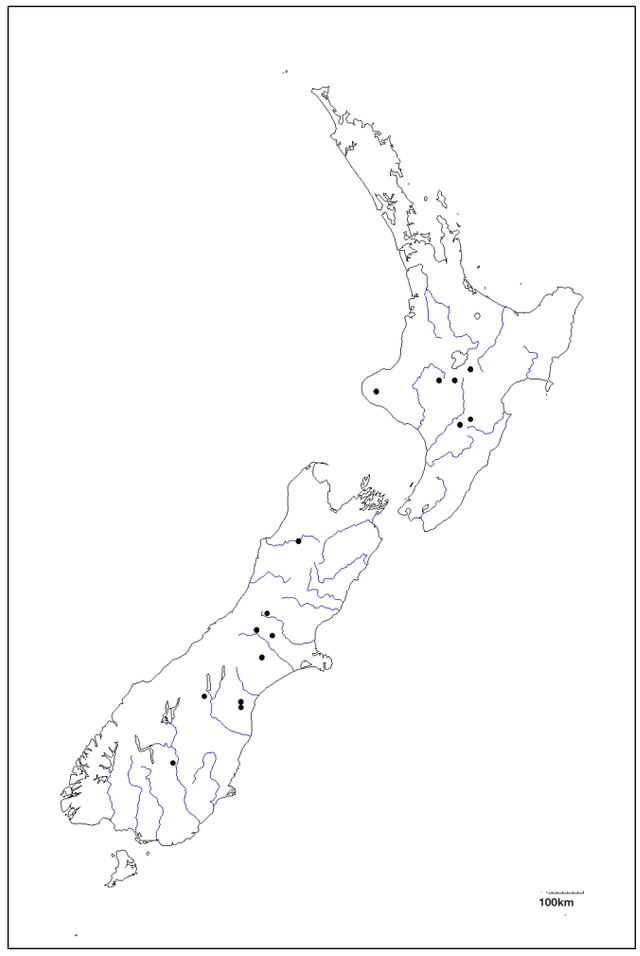

Fig 18: *Deleatidium* (*D.*) *magnum* Towns & Peters, 1996 (26 records).

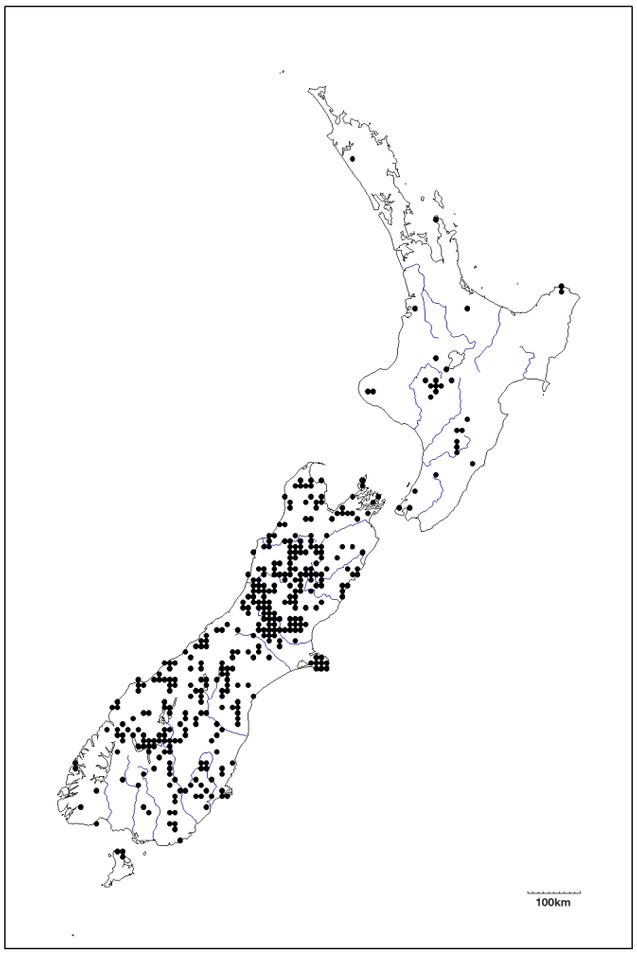

Fig 19: *Deleatidium* (*D.*) *myzobranchia* Phillips, 1930 (959 records).

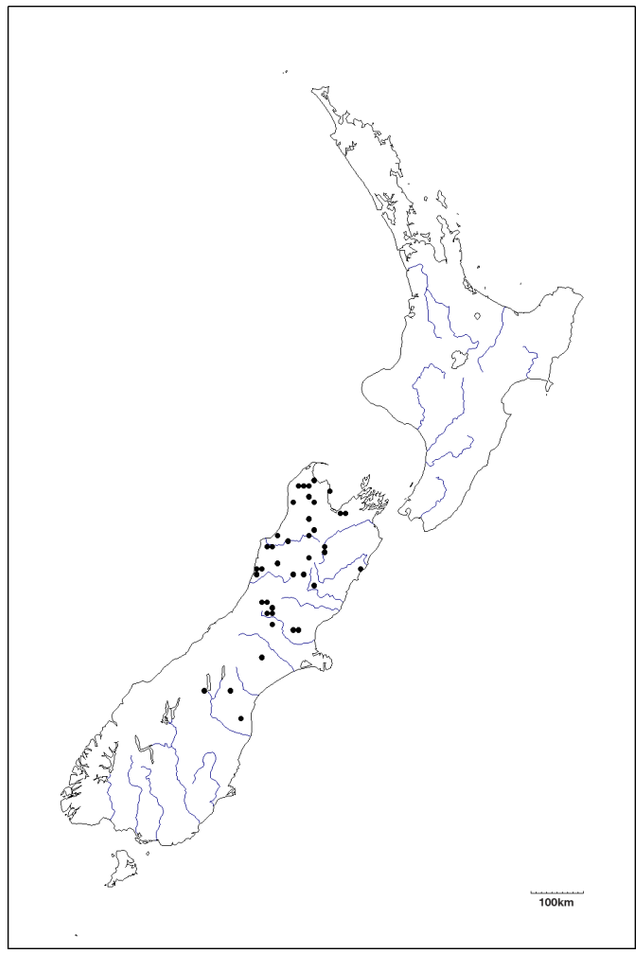

Fig 20: *Deleatidium* (*D.*) *townsi* Hitchings, 2009 (84 records).

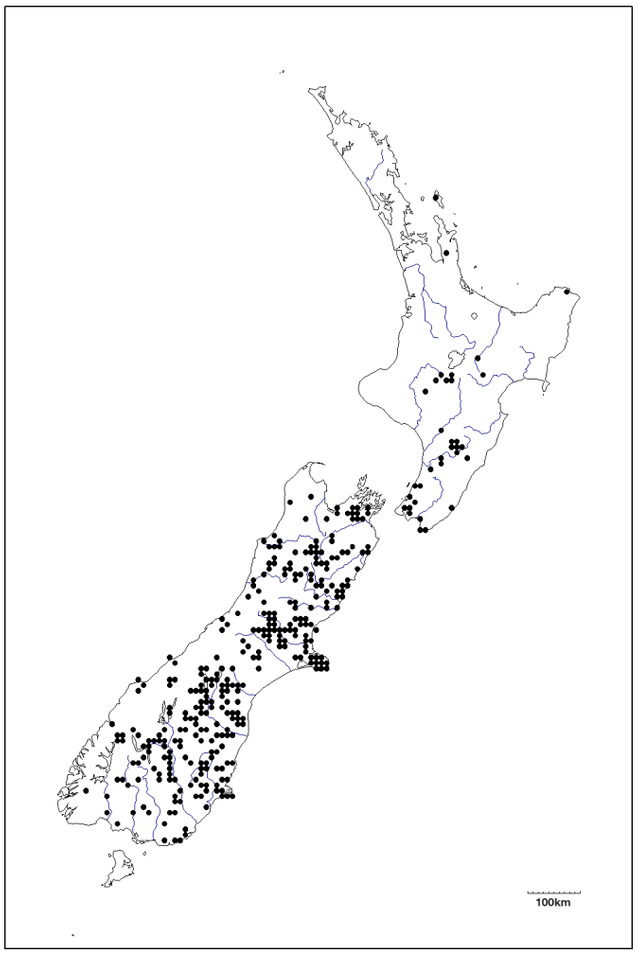

Fig 21: *Deleatidium* (*D.*) *vernale* Phillips, 1930 (743 records).

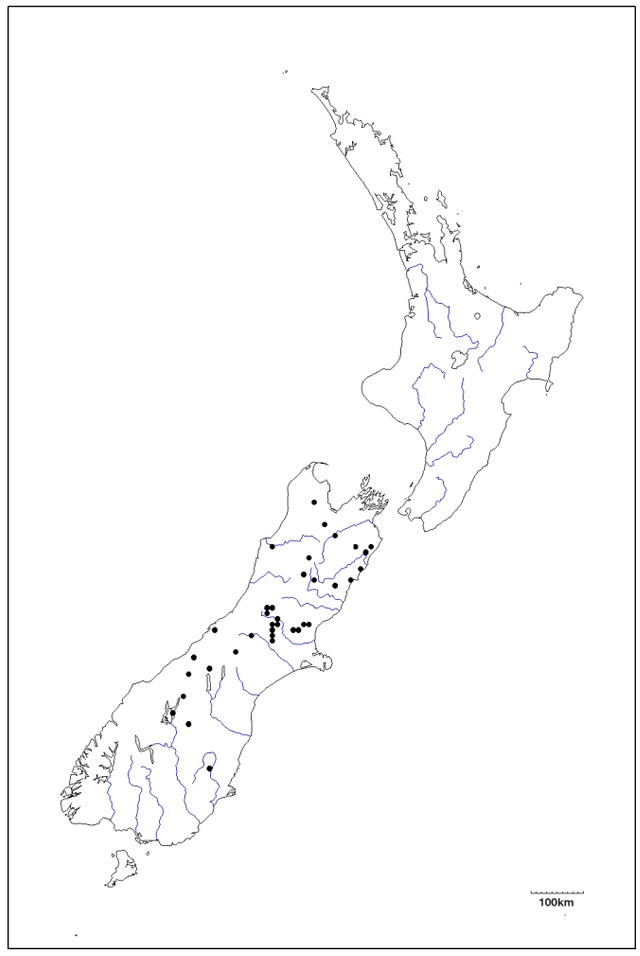

Fig 22: *Deleatidium* (*D.*) *wardorum* Hitchings, 2010 (78 records).

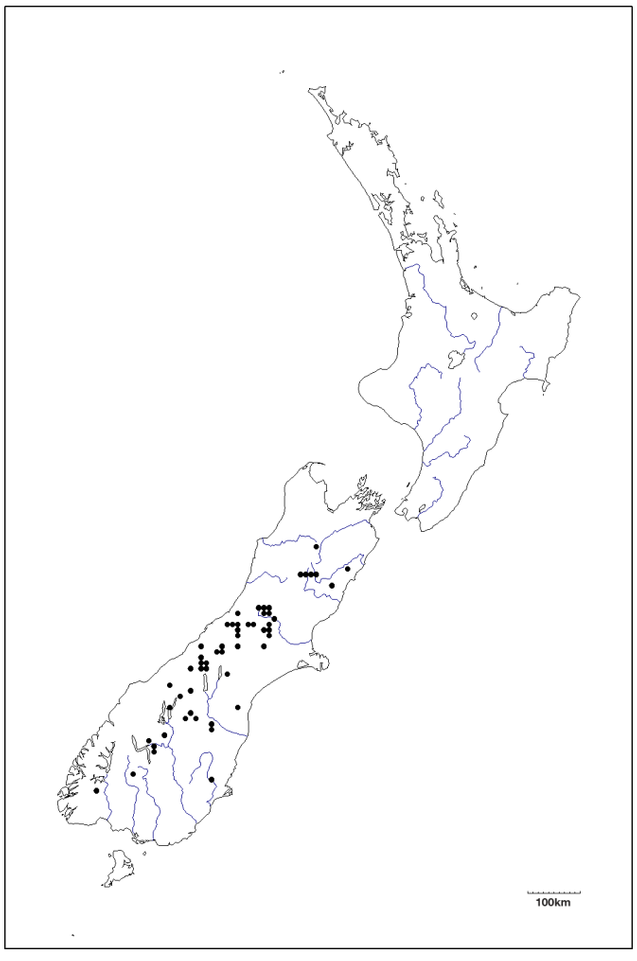

Fig 23: *Deleatidium* (*P.*) *cornutum* Towns & Peters, 1996 (127 records).

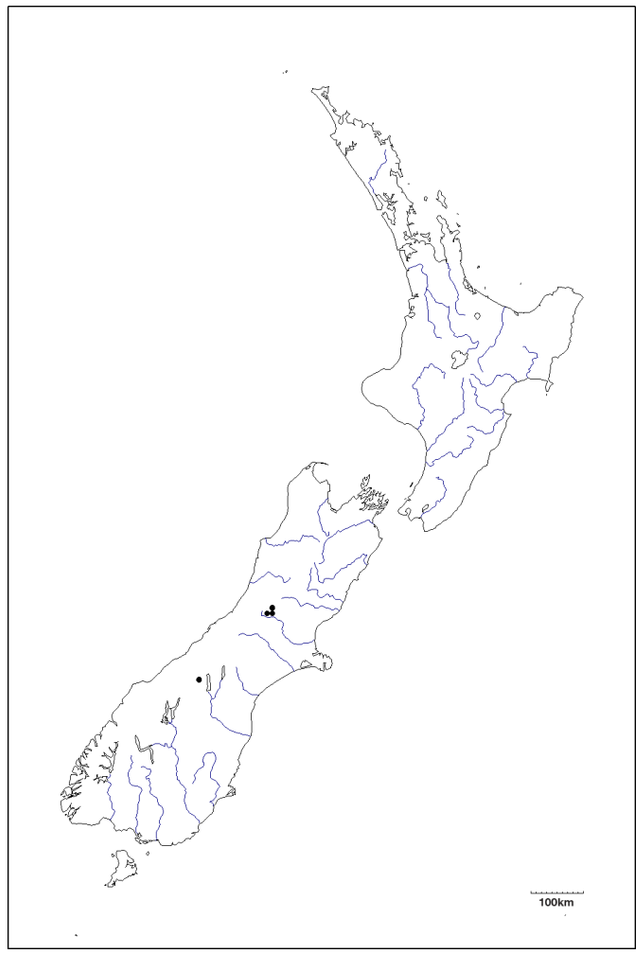

Fig 24: *Deleatidium* (*P.*) *insolitum* (Towns & Peters, 1979) (10 records).

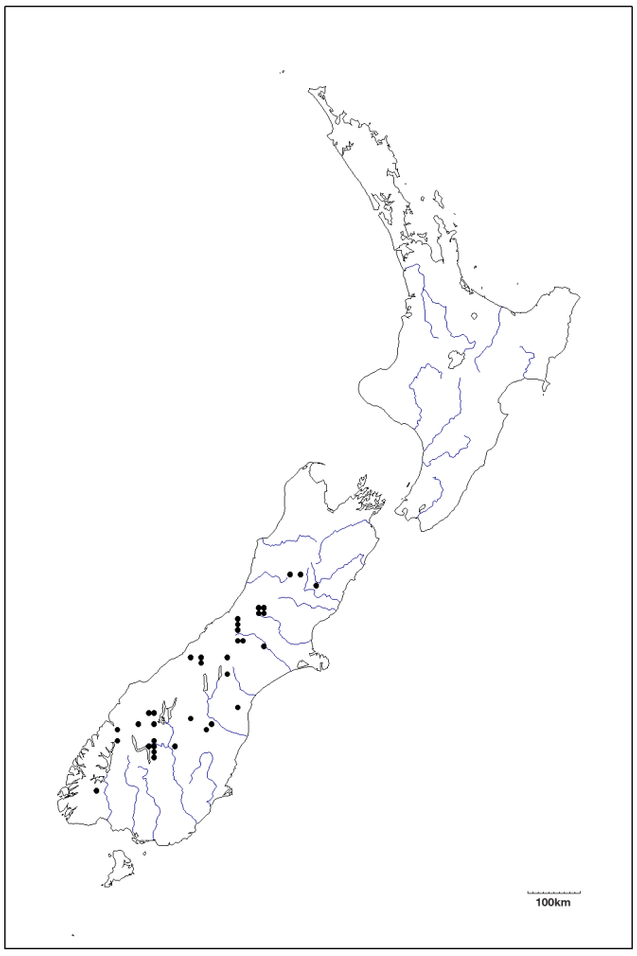

Fig 25: *Deleatidium* (*P.*) *patricki* Hitchings, 2008 (59 records).

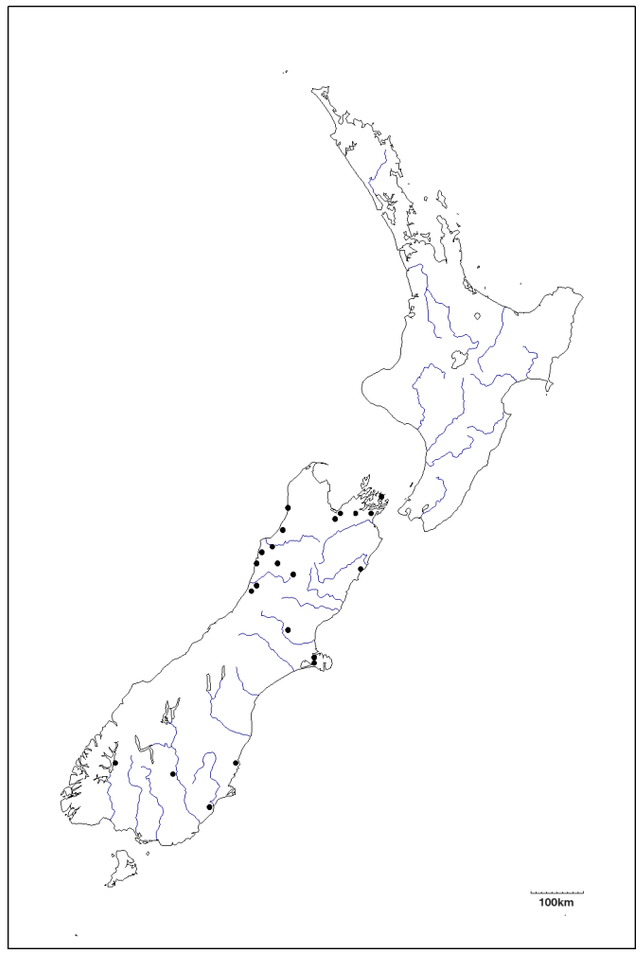

Fig 26: *Ichthybotus bicolor* Tillyard, 1923 (31 records).

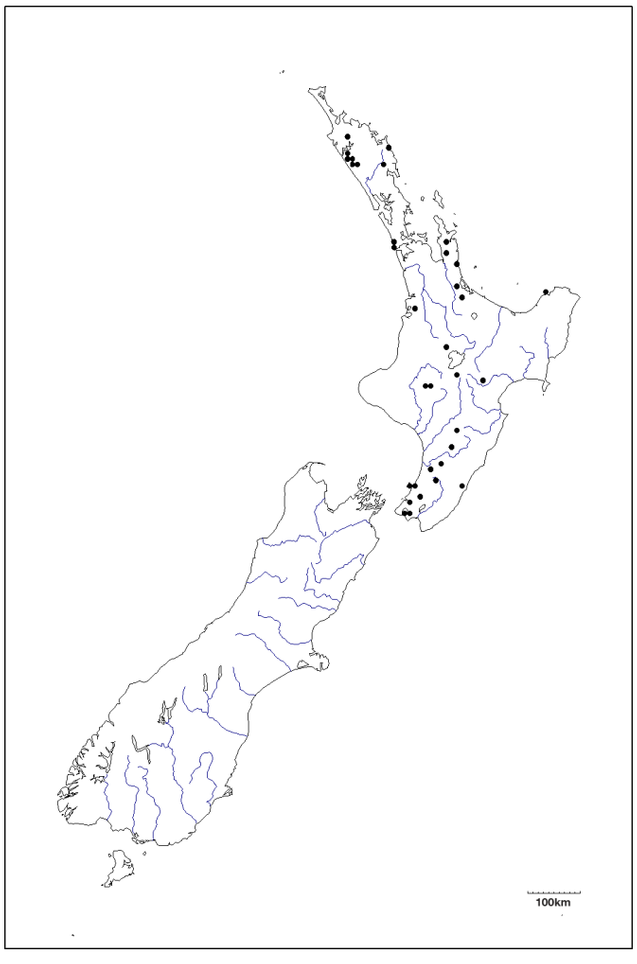

Fig 27: *Ichthybotus hudsoni* (McLachlan, 1894) (55 records).

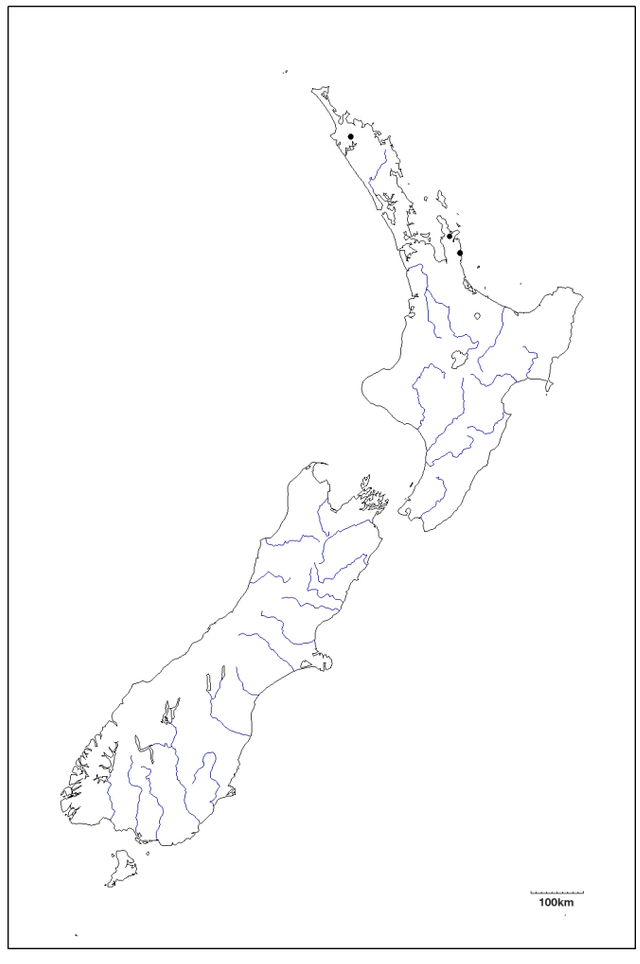

Fig 28: *Isothraulus abditus* Towns & Peters, 1979 (4 records).

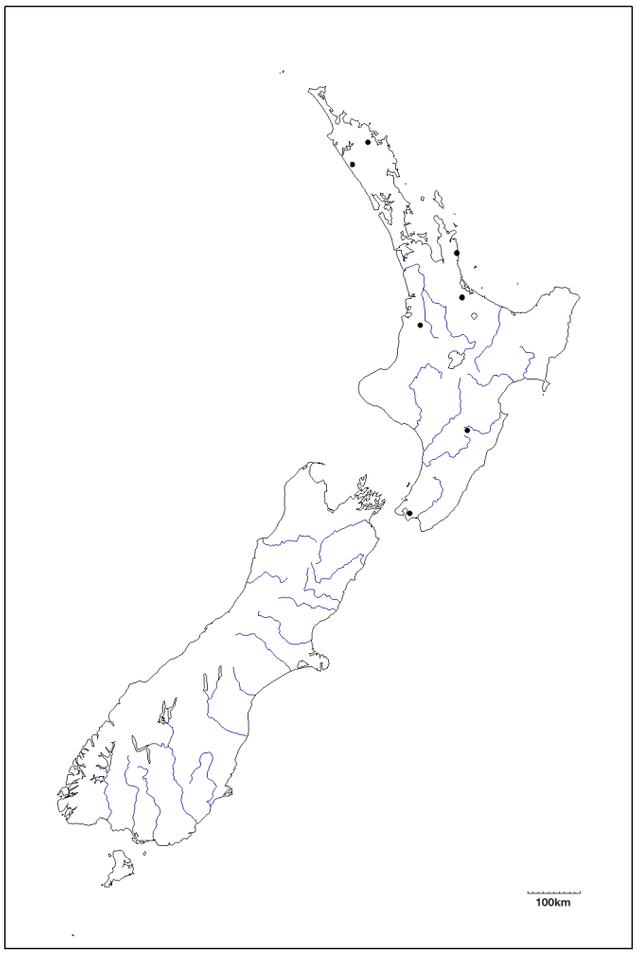

Fig 29: *Mauiulus aquilus* Towns & Peters, 1996 (9 records).

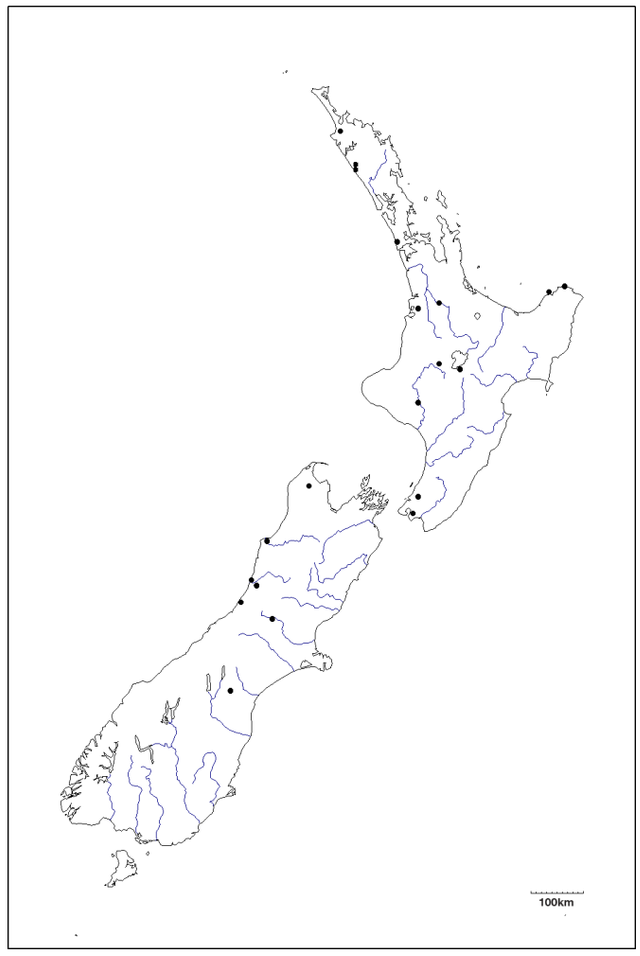

Fig 30: *Mauiulus luma* Towns & Peters, 1979 (23 records).

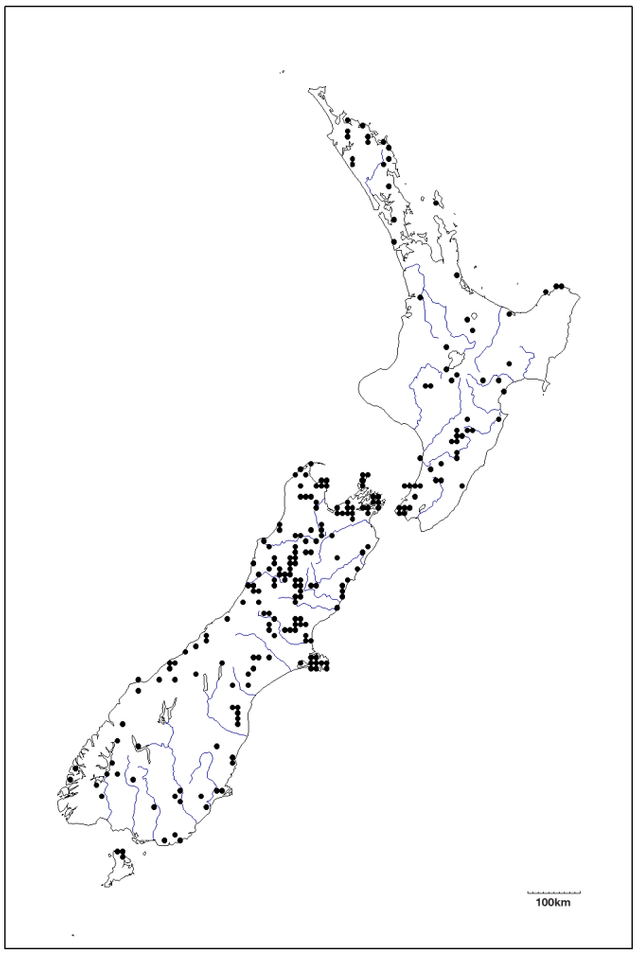

Fig 31: *Neozephlebia scita* Walker, 1853 (535 records).

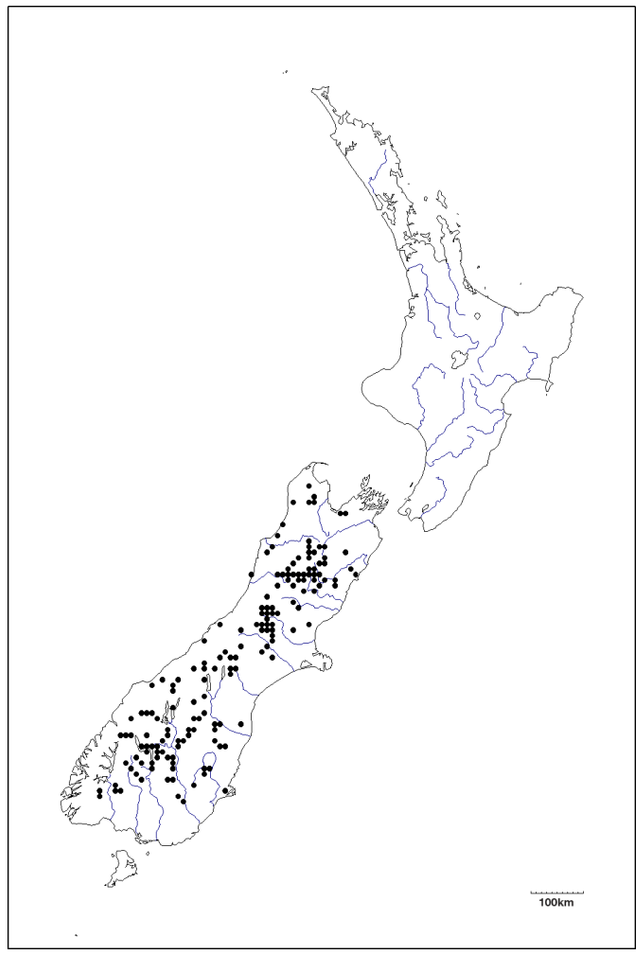

Fig 32: *Nesameletus austrinus* Hitchings & Staniczek, 2003 (409 records).

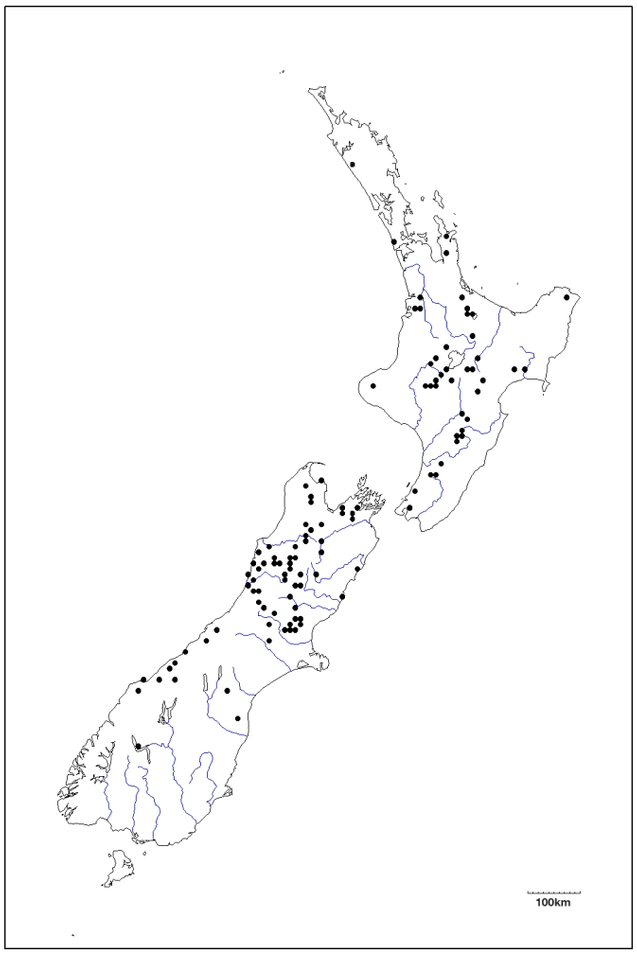

Fig 33: *Nesameletus flavitinctus* Tillyard, 1923 (236 records).

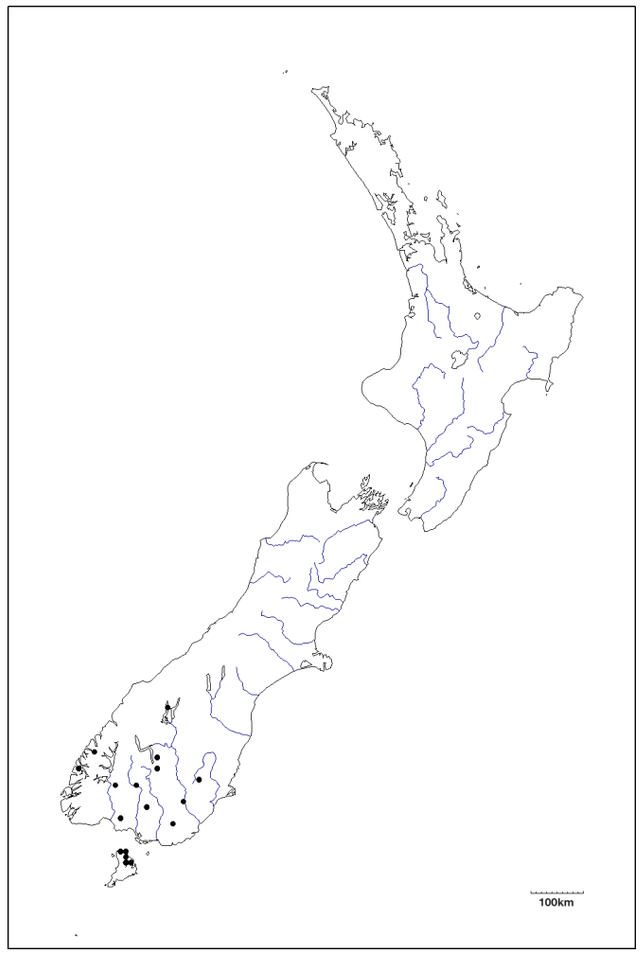

Fig 34: *Nesameletus murihiku* Hitchings & Staniczek, 2003 (36 records).

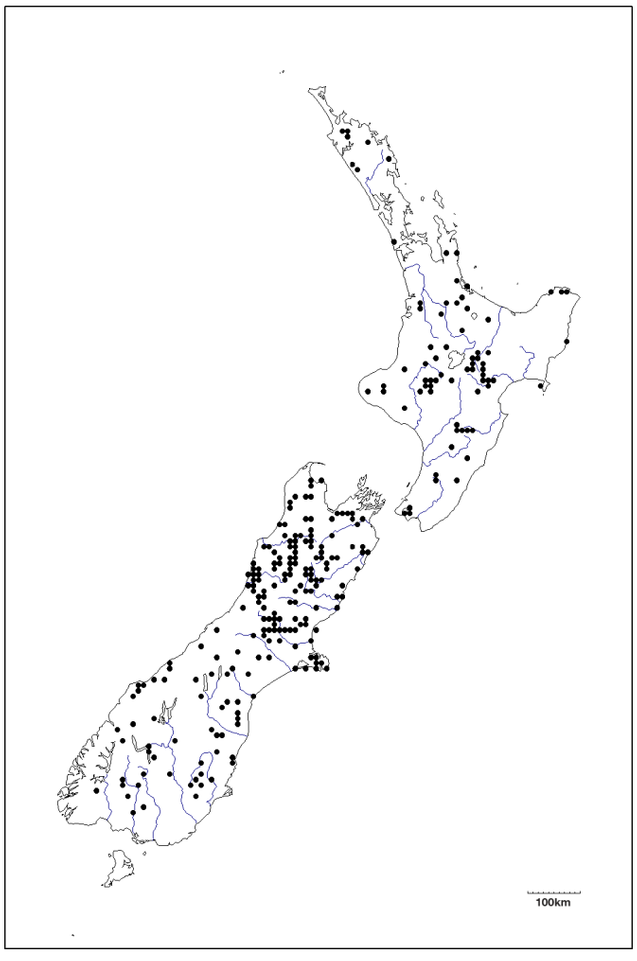

Fig 35: *Nesameletus ornatus* Eaton, 1883 (587 records).

Fig 36: *Nesameletus vulcanus* Hitchings & Staniczek, 2003 (42 records).

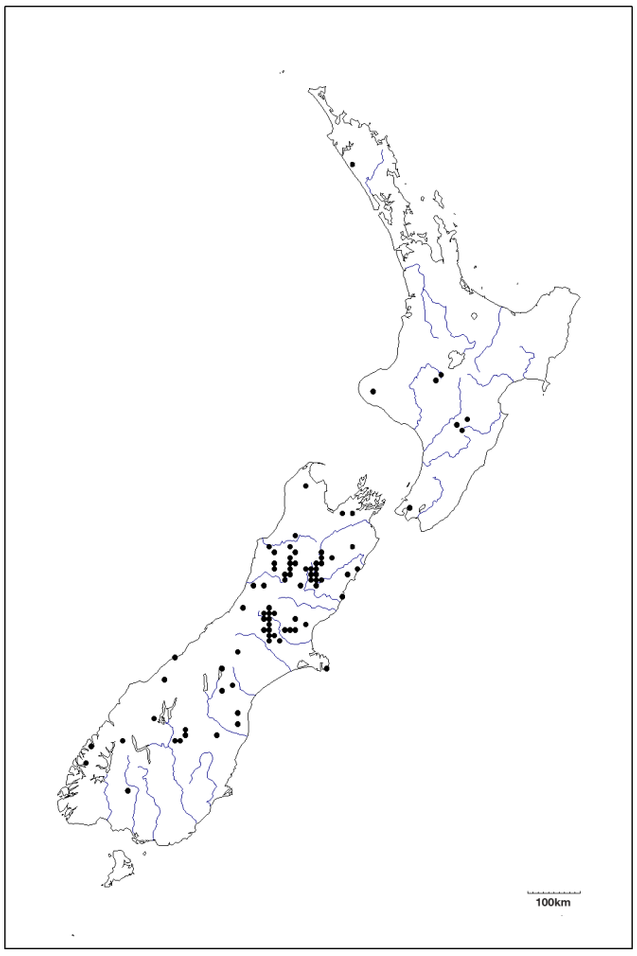

Fig 37: *Oniscigaster distans* Eaton, 1899 (146 records).

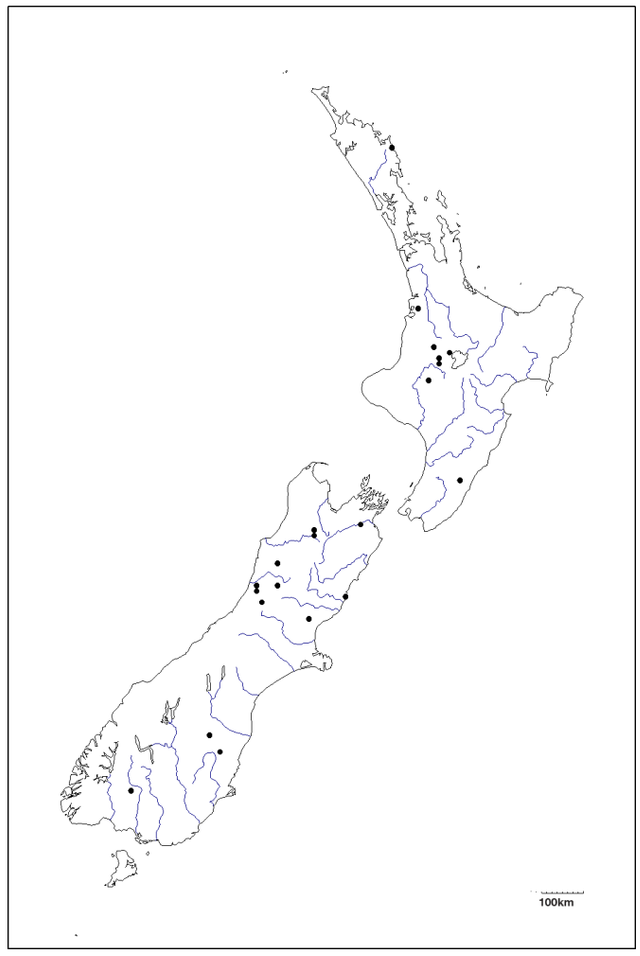

Fig 38: *Oniscgaster wakefieldi* McLachan, 1873 (40 records).

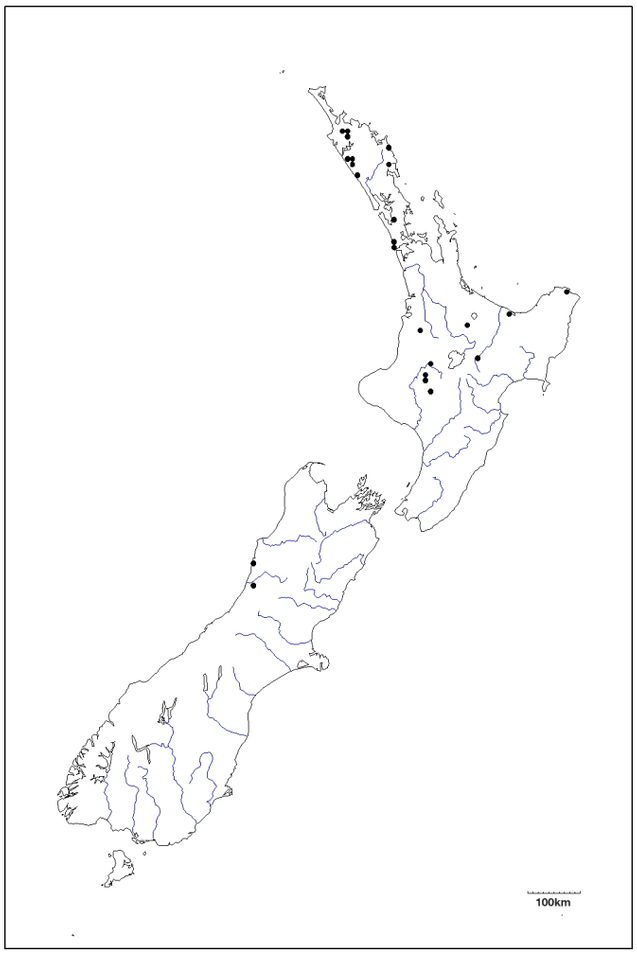

Fig 39: *Rallidens mcfarlanei* Penniket, 1966 (68 records).

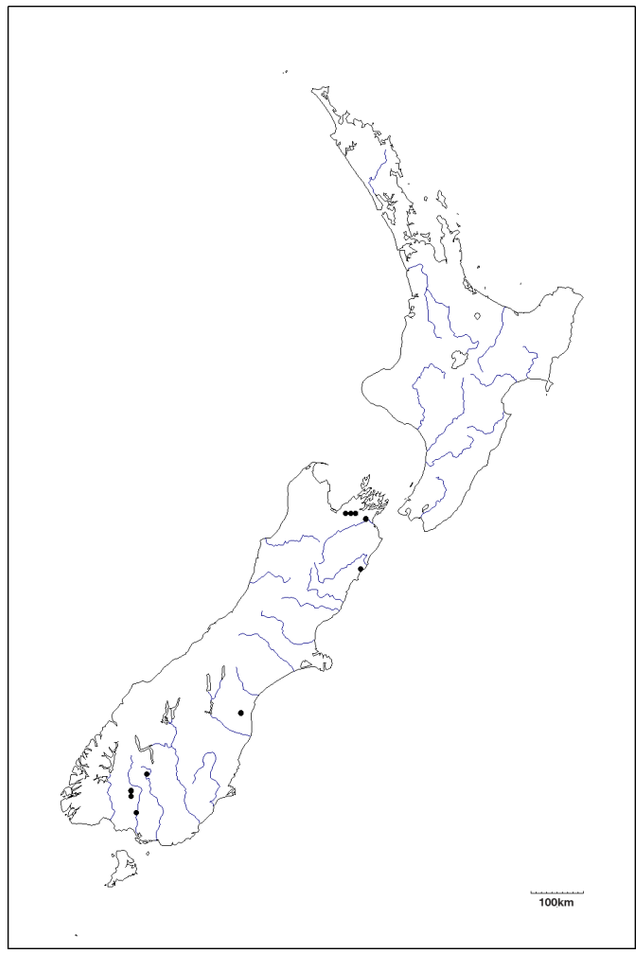

Fig 40: *Rallidens platydontis* Staniczek & Hitchings, 2014 (27 records).

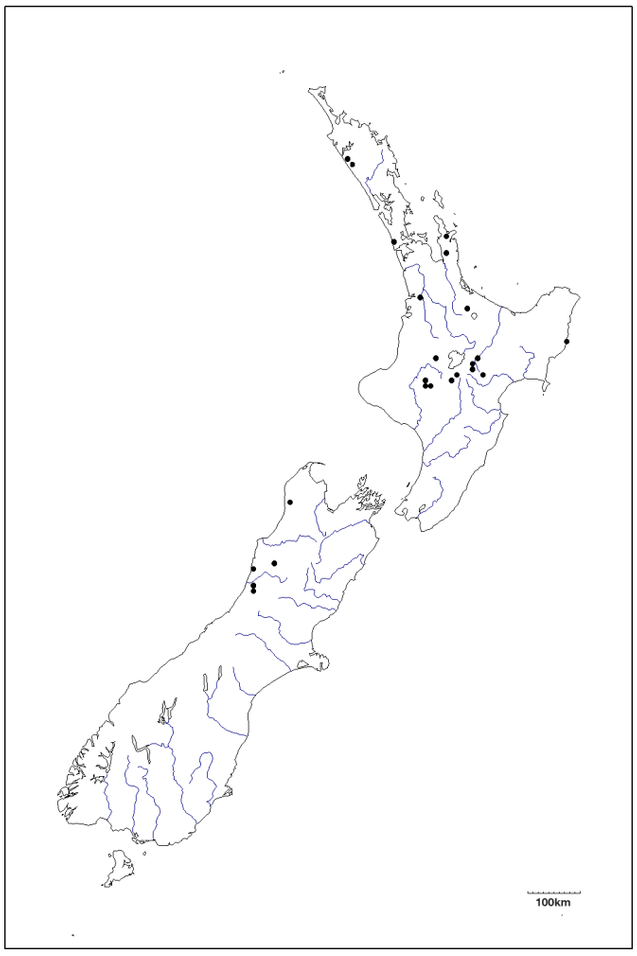

Fig 41: *Siphlaenigma janae* Penniket, 1962 (53 records).

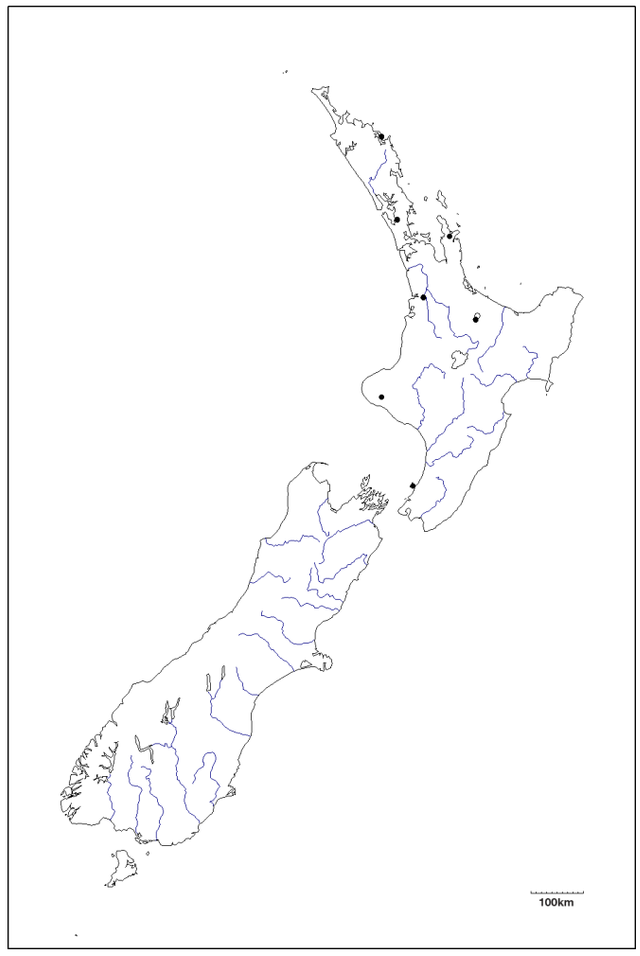

Fig 42: *Tepakia caligata* Towns & Peters, 1996 (8 records).

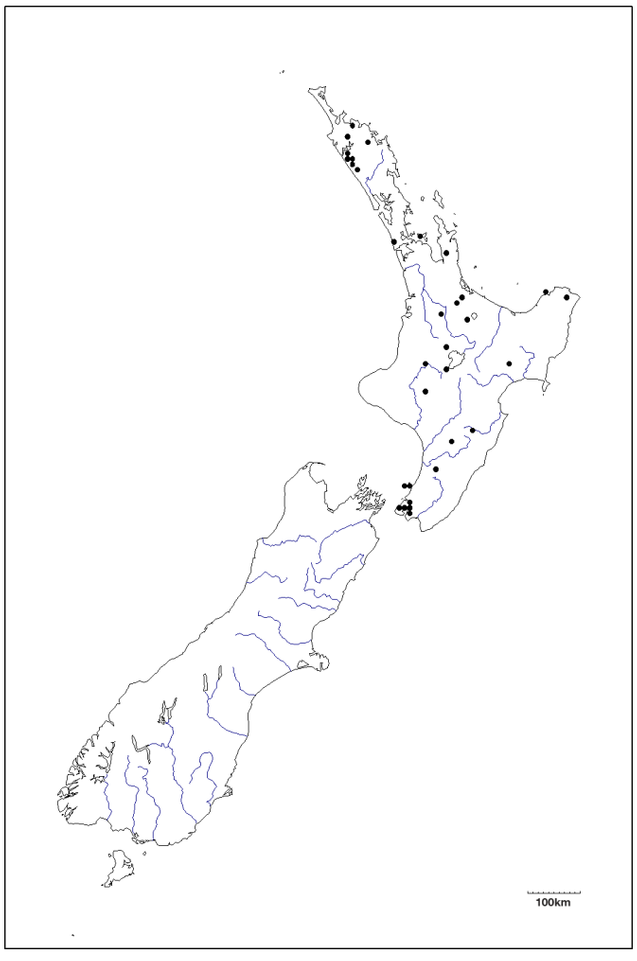

Fig 43: *Zephlebia borealis* (Phillips, 1930) (50 records).

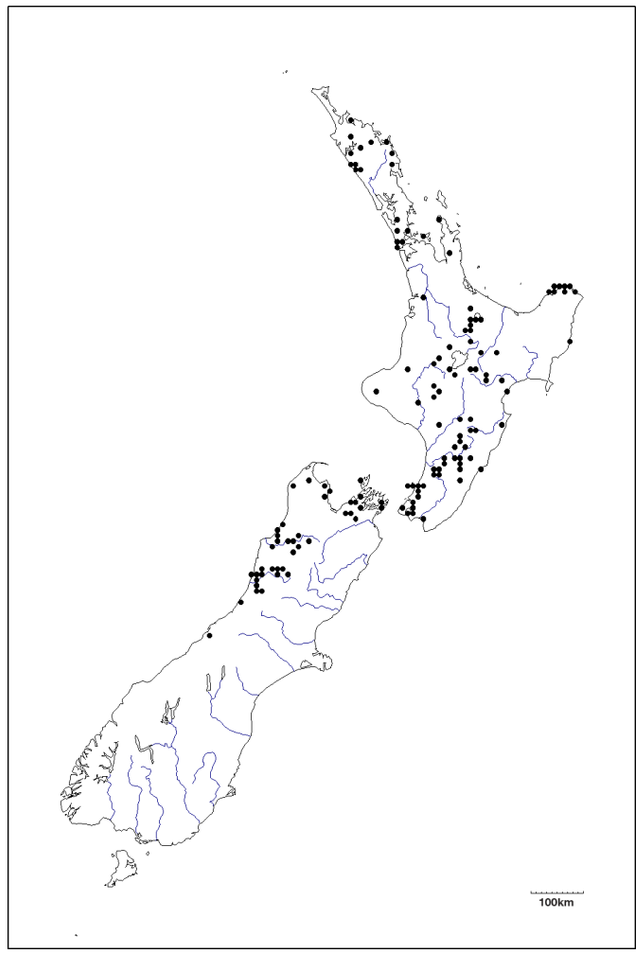

Fig 44: *Zephlebia dentata* (Eaton, 1871) (234 records).

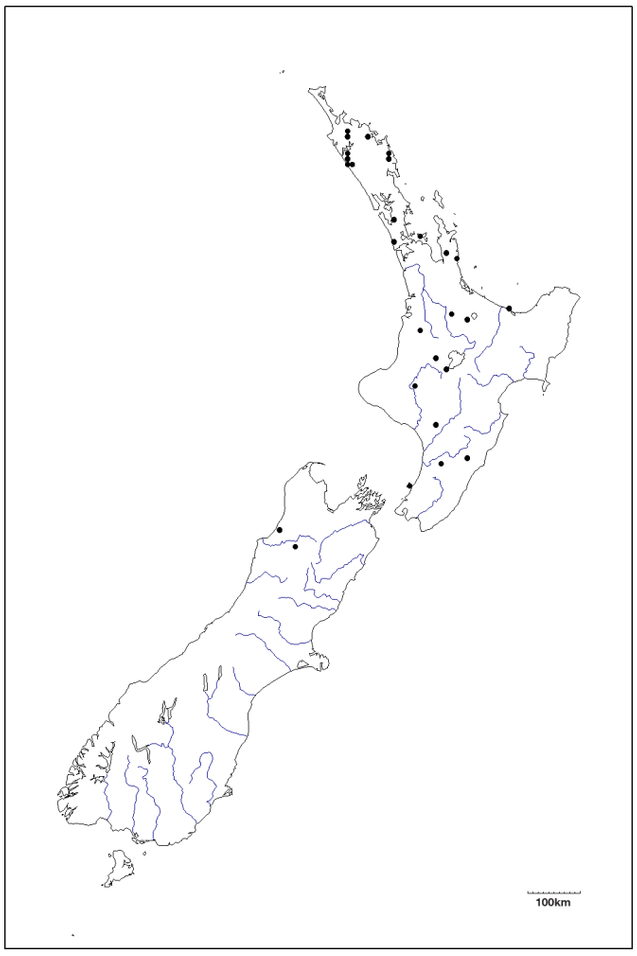

Fig 45: *Zephlebia inconspicua* Towns, 1983 (43 records).

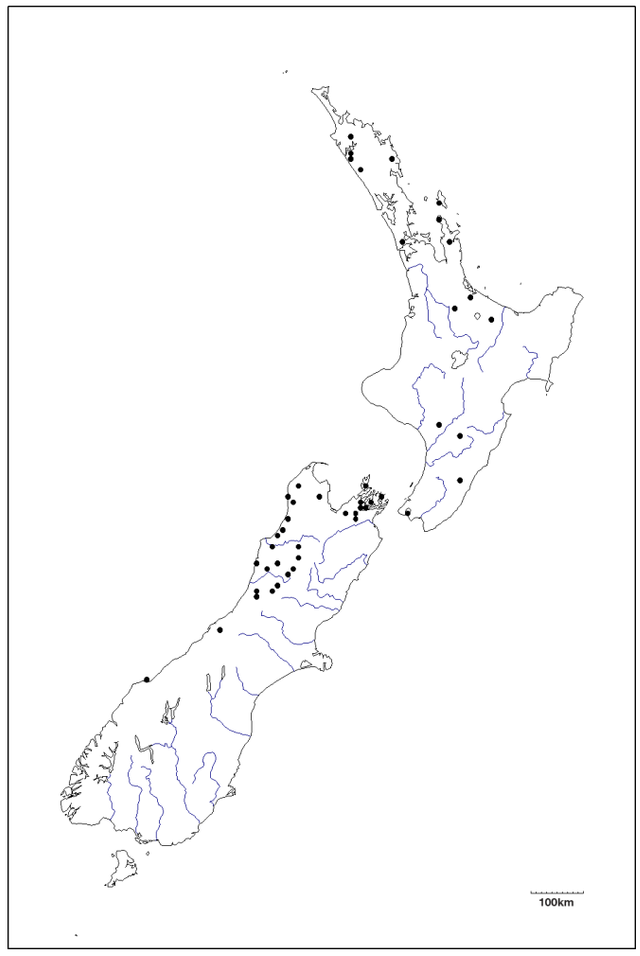

Fig 46: *Zephlebia nebulosa* Towns & Peters, 1996 (64 records).

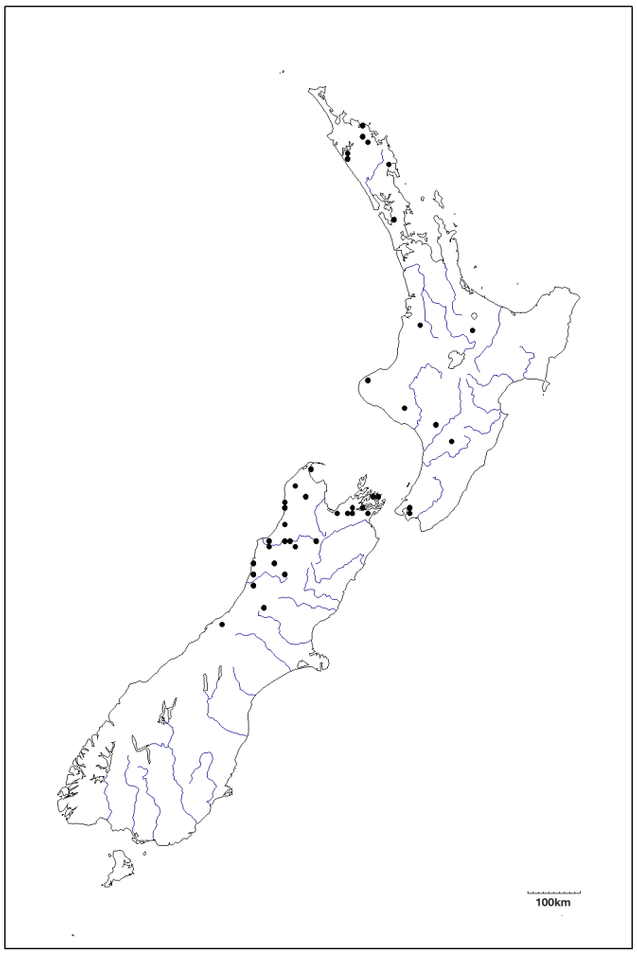

Fig 47: *Zephlebia pirongia* Towns & Peters, 1996 (54 records).

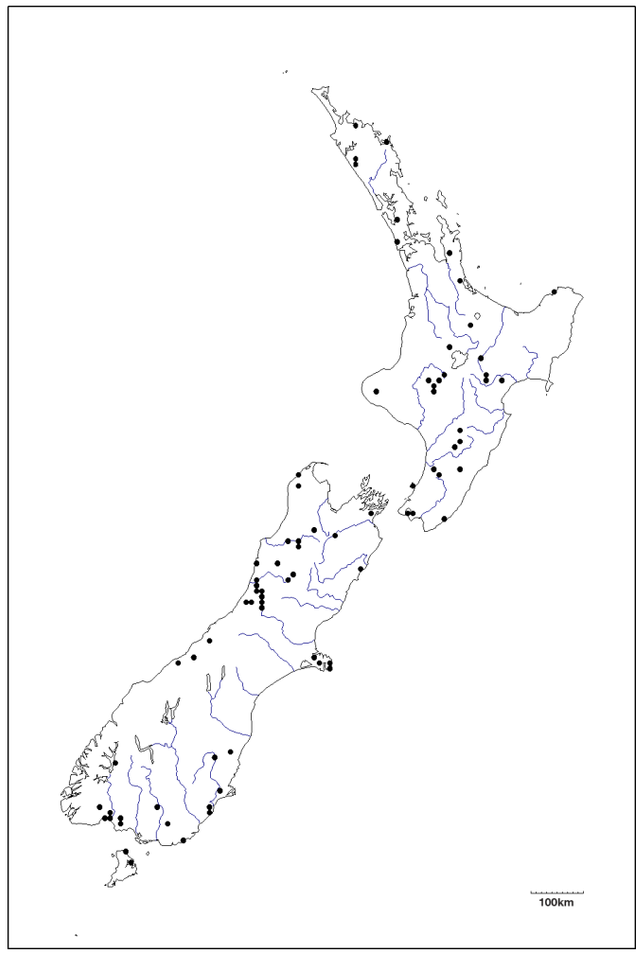

Fig 48: *Zephlebia spectabilis* Towns, 1983 (127 records).

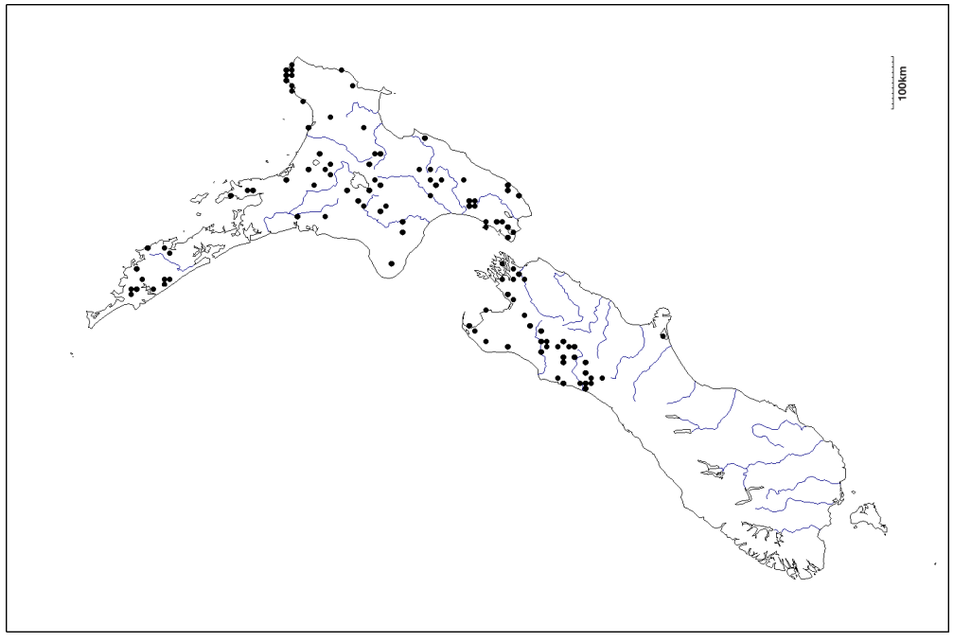

Fig 50: *Zephlebia versicolor* (Eaton, 1899) (180 records).

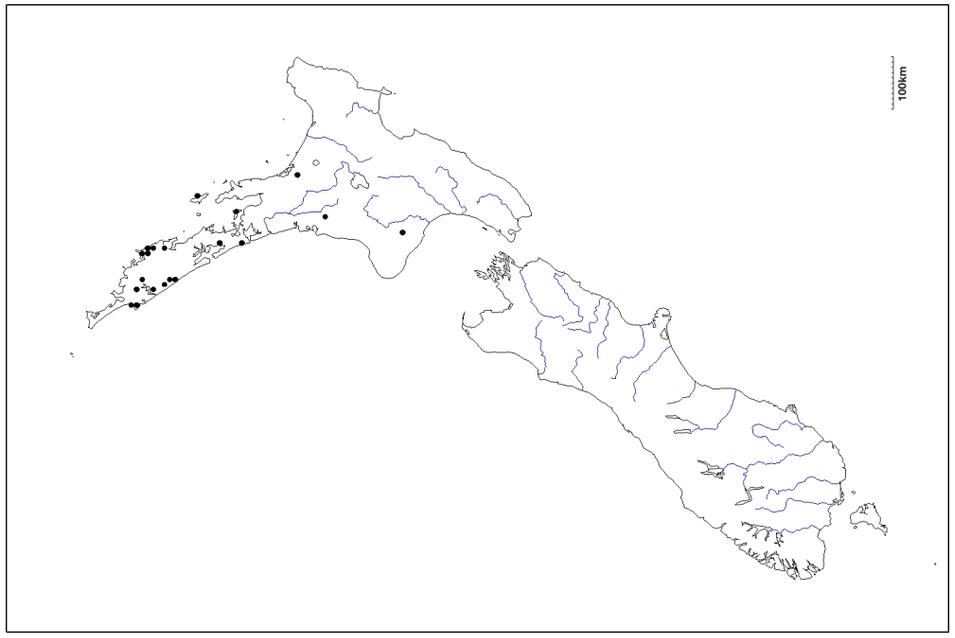

Fig 49: *Zephlebia tuberculata* Towns & Peters, 1996 (31 records).

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Harvesting of ngā hua manu (bird eggs) in Te Waipounamu (South Island), New Zealand

ROGER FYFE
Canterbury Museum, Rolleston Avenue, Christchurch 8013, New Zealand
rfyfe@canterburymuseum.com

KYLE DAVIS
Te Rūnanga o Ngāi Tahu, Te Whare o Te Wai Pounamu, PO Box 13 045, Christchurch 8141
Kyle.Davis@ngaitahu.iwi.nz

ABSTRACT

The presence of large quantities of moa egg shell in a number of archaeological contexts has been interpreted as testimony that eggs formed a substantial seasonal component of the moa hunter diet as well as serving a wide range of other functions such as grave goods and raw material for artefacts. Despite the archaeological potential of eggshell, apart from moa, the analysis of eggshell in archaeological sites in New Zealand is to date non-existent. Eggshell is almost impossible to reliably identify taxonomically based on morphology alone and even where it has been retained, archaeological eggshell is often archived without taxonomic identification. This paper utilises ethno-historical evidence to establish that the eggs of a wide range of species are known to have been exploited in Te Waipounamu (the South Island) of New Zealand. The eggs of seabirds in particular, offered a significant resource that remained a seasonal focus of economic activity until the early twentieth century. The application of scientific advances in eggshell identification techniques are reviewed for their potential to be used to overcome perceived problems with the interpretation of eggshell in archaeological assemblages in New Zealand.

KEYWORDS

bird eggs; eggshell; genetic analysis; mass spectrometry; ethno-history; seasonal harvesting; archaeology.

INTRODUCTION

This paper undertakes a selected literature review of a variety of sources including recorded Māori traditional and ethno-historical accounts pertaining to harvesting bird eggs, the breeding biology of species identified in these accounts and the research outcomes of recent genetic and mass spectrometry analyses pertaining to eggshell. Although it might seem that these disparate sources are inherently incompatible it will be demonstrated that it is possible to draw a number of conclusions as to what this corpus of accounts can reliably establish about the Māori cultural practice of bird egg harvesting. It is not the purpose of this paper to undertake any in-depth critical analysis of the sources themselves, but to cautiously extract information deemed relevant to making a robust contribution to the current understanding of the economic role of bird egg harvesting in New Zealand.