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Reinstatement of the New Zealand cave wētā genus *Miotopus* Hutton (Orthoptera: Rhaphidophoridae) and description of a new species

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Abstract. Comparison of morphological and genetic data from New Zealand forest cave wētā suggests we should recognise the genus *Miotopus* proposed by Hutton (1898). A new species within this genus is described (*Miotopus richardsi* sp. nov.). Both *Miotopus diversus* (Hutton, 1898) and *Miotopus richardsi* sp. nov. are common in native forests and widespread in New Zealand. Here we provide their known distributions and key traits.

Keywords. Cave wētā, cave cricket, *Miotopus*, *Pleioplectron,* Rhaphidophoridae.

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Introduction

Identifying cave wētā to genus level is made difficult by a limited number of accessible morphological and diagnostically informative characters and very brief descriptions for many of the nineteen genera of New Zealand Rhaphidophoridae (Cook *et al.* 2010). Hutton (1897) described the New Zealand rhaphidophorid genus *Pleioplectron* including four species. A year later, he transferred one of these, *Pleioplectron diversum* to the new genus *Miotopus* as *Miotopus diversus* (Hutton 1898). Hutton cited the presence of the fore femoral retrolateral spine and the subapical inferior pair of spines on the hind tibia as evidence of sufficient differentiation. However, Richards (1959) disagreed and returned *Miotopus diversus* to *Pleioplectron* stating that the differences in spination identified by Hutton (1898) to establish *Miotopus* represented congeneric variation.

In his generic synopsis and species description Hutton (1897) made inconsistent reference to apical spines (see Fig. 1). He described *Pleioplectron* as having one apical spine on the fore femora, two on the middle femora and none on hind femora, and two pairs on each of the fore and middle tibiae, three pairs on the hind tibiae. These are not mentioned in the species descriptions except that *P. diversum* (= *Miotopus diversus*) has a pair of short apical spines on the fore femora. Richards (1959) noted that *Pleioplectron,* including Hutton's type specimens, have a prolateral apical spine beneath the hind femora, but this probably reflects a difference of definition. Spination on the hind femora is quite different from fore and mid femora in all New Zealand species of Rhaphidophoridae; the hind legs being specialised for jumping. Hutton (1897) stated that *Pleioplectron'*s hind tibiae have three pairs of apical spines but Richards (1959) gave four pairs. Again, this most likely reflects a difference in definition, because some taxonomists interpret the pair of superior subapical spines (S21 & S22 in Fig. 1) as the first superior linear spines (see Fig. 2). Hutton generally presented very simple outline drawings of structures, whereas Richards used very detailed drawings of only the hind portion of the abdomen. Modern taxonomy benefits from high quality photographic imagery that helps precisely indicate what structure is being referred to and provides information of colour, patterning and texture.

We have used morphological, spatial and genetic data to review the status of New Zealand Rhaphidophoridae, and found support for *Miotopus* Hutton, 1898 and an additional species in this genus common on South Island which we describe here.

Material and methods

Cave wētā were collected opportunistically around New Zealand using day and night searching of forests and caves, and pitfall trapping. More than 3500 specimens have been catalogued, of which about 1000 have been examined in detail including > 154 putative *Pleioplectron*. Cave wētā material is held in the Phoenix Lab collection at Massey University, with the exception of type material lodged at Te Papa Tongarewa Museum of New Zealand (NMNZ AI.035053 and AI.035054). Relevant specimens were identified based on descriptions by Hutton (1897, 1898) and Richards (1959), and were examined under a dissecting microscope so that adult males and females could be identified. Distinguishing between adults and large juveniles relied on the darker sclerotised bodies and fully formed external genital structures of the former. In particular the pigmentation, shape and sharpness of ovipositors, subgenital plates and cerci were informative about the developmental stage. We looked for the presence/absence of each of 22 apical leg spines (Fitness *et al*. 2015) (Fig. 1), and the combinations and numbers of linear spines on legs, characteristics of antennae and shape of subgenital plate and suranal plate.

Collection acronyms

iNaturalist	=	Available from iNaturalist.org [accessed 1 Sep. 2018]
LCR	=	Landcare Research, Wellington, New Zealand
MPN	=	Phoenix Lab, Massey University, Palmerston North, New Zealand
NMNZ	=	Te Papa Tongarewa Museum, Wellington, New Zealand

We also extracted genomic DNA from representative morphotypes using a salting-out protocol (Trewick & Morgan-Richards 2005). For each sample, a fragment upto ~1500 base pairs (bp) of the mitochondrial cytochrome *c* oxidase I (COI) gene of the mitochondrial genome was amplified using polymerase chain reaction (PCR) with combinations of universal invertebrate primers: LCO1490 (Folmer *et al*. 1994), C1-N-2191, C1-J-2195 and L2-N-3014 (Simon *et al*. 1994). Successful PCR products were prepared using the SAP/EXO1 digest protocol (USB Corp., Cleveland, OH) and sequenced with Bigdye chemistry and an ABI 3730 genetic analyser (Applied Biosystems Inc., Carlsbad, CA). Nucleotide sequences were assembled and aligned using Geneious 'ver.' 9 (Kearse

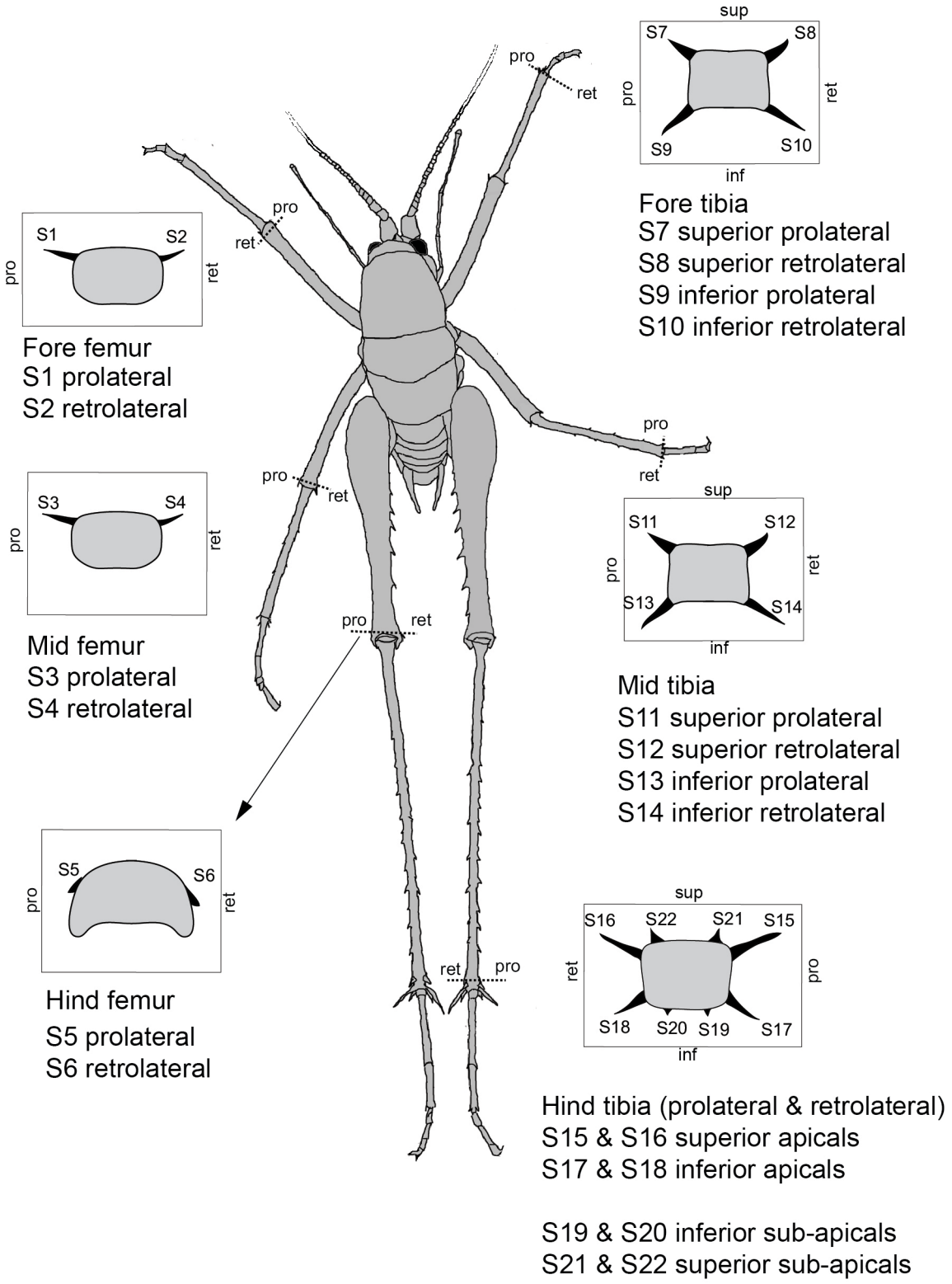

Fig. 1. Apical spine numbering, terminology and position on Rhaphidophoridae, after Fitness *et al.* (2015). Dorsal view, showing cross-sectional relationship of each potential spine on femora and tibiae. Positions are indicated as prolateral (anterior facing), retrolateral (posterior facing), inferior (ventral facing) and superior (dorsal facing) orientations are indicated.

et al. 2012). No insertions/deletions were detected and sequences were translated to confirm that there were no stop codons or frame shifts that would indicate the presence of nuclear paralogs. We examined the relationships of putative *Miotopus* mtDNA COI haplotypes with respect to *Pleioplectron* and other representatives of the New Zealand cave wētā (Allegrucci *et al*. 2010) using phylogenetic reconstruction using Maximum Likelihood and Bayesian inference algorithms implemented in Geneious 'ver.' 9.

Results

Using combinations of apical leg spines and general appearance (Table 1) we identified cave wētā that could be assigned to *Miotopus diversus*, *Pleioplectron hudsoni* Hutton, 1896 and *P. simplex* Hutton, 1896. Although specimens of *Miotopus diversus* are broadly similar in appearance to *Pleioplectron*, including the comparatively short and stout antennae of males, there are clear differences. *Miotopus diversus* differs from *Pleioplectron* by a distinctive apical spine count (*Miotopus* has 2 apical spines on the fore femur, whereas *Pleioplectron* has 1), the presence of dorsal spines on the mid tibia, the subgenital plate shape and the larger size of adults. Females of *Miotopus* and *Pleioplectron* have a different number and shape of serrations towards the ventral tip of the ovipositor. Specimens found at

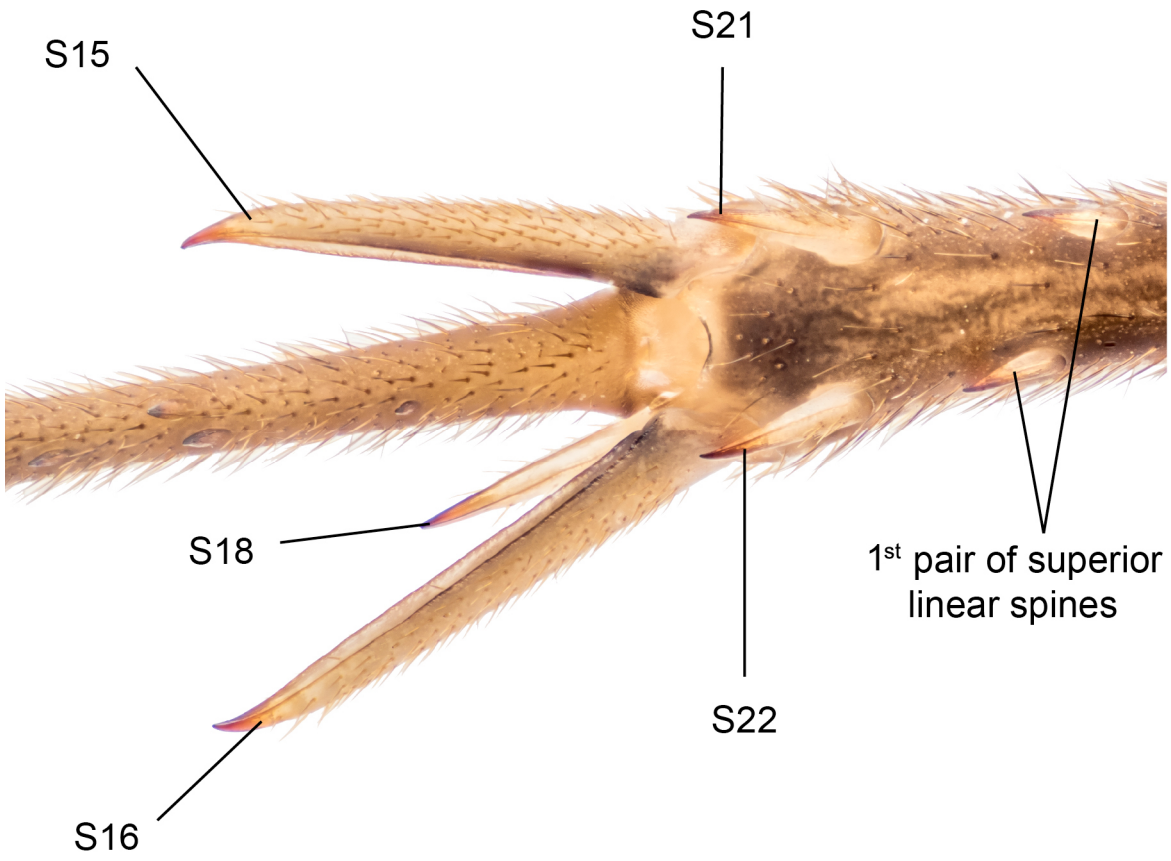

Fig. 2. Apical spines on the left hind tibia of *Pleioplectron simplex* Hutton, 1896 (MPN CW3459), numbered as in Fig. 1 (from Fitness *et al*. 2015). Dorsal view of posterior distal section of left hind tibia including part of first tarsal segment. Four pairs of 'apical' spines are commonly present: the inferior subapical pair S19 & S20 (not visible here); inferior apical pair S17 & S18 (S17 obscured here); superior apical pair S15 & S16; superior subapical pair S21 & S22. Some taxonomists have treated S21 & S22 as the first pair of superior linear spines, resulting in recording of three pairs of 'apical' rather than four.

Table 1. Dimensions and spine counts of *Pleioplectron* Hutton, 1896 and *Miotopus* Hutton, 1898 Rhaphidophoridae. *(4-4-7 in two Lewis Pass specimens).

		Pleioplectron simplex	***Pleiopletron hudsoni***	***Miotopus diversus***	***Miotopus richardsi* sp. nov.**
Sample size		7 (3 ♀♀, 4 ♂♂)	11 (5 ♀♀, 6 ♂♂)	6 (2 ♀♀, 4 ♂♂)	12 (7 ♀♀, 5 ♂♂)
Apical spines fore and mid femur		1 0 1 1	1 0 1 1	1 1 1 1	1 1 1 1
Apical spines tibiae		4-4-8	4-4-6	4-4-8	4-4-8*
Body length (mm)		14.5 (13.7–15.0)	9.4 (8.4–11.1)	13.55 (11.1–14.5)	15.5 (14.0–16.5)
Pronotum length (mm)		4.5 (3.8–5.3)	3.3 (2.8–3.6)	4.85 (3.9–5.9)	5.0 (4.5–5.9)
Ovipositor length (mm)		10.2 (9.9–10.7)	7.4 (6.8–8.1)	11.55 (11.3–11.8)	15.75 (13.9–17.0)
Ratio ovipositor to body length		0.71 (0.70–0.71)	0.78 (0.65–0.79)	0.80 (0.78–0.81)	1.02 (0.96–1.10)
Teeth: ventral valve of ovipositor		5 (5–6)	8 (7–9)	7.5 (7–8)	24 (18–30)
Teeth: dorsal valve of ovipositor		0	0	0	0
Length of hind tibia (mm)		14.3 (12.4–16.4)	11.2 (10.1–12.1)	15.65 (13.0–17.4)	23.35 (19.9–29.2)
Ratio hind tibia to body length		0.99 (0.84–1.13)	1.18 (1.05–1.35)	1.2 (1.0–1.3)	1.5 (1.3–1.8)
Superior spines hind tibia	prolateral	24 (20–29)	20 (18–25)	31 (29–33)	36 (31–41)
	retrolateral	27 (23–32)	21 (19–24)	33 (28–34)	38 (35–44)
Spine density on hind tibia (count/ mm)	prolateral	1.6 (1.5–1.9)	1.79 (1.59–2.38)	2.0 (1.7–2.5)	1.5 (1.3–1.8)
	retrolateral	2.0 (1.5–2.1)	1.96 (1.65–2.11)	2.2 (1.6–2.5)	1.7 (1.4–1.9)
Pairs of articulated spines on hind tibia		0	0	0	3 (3–3)
Superior spines on 1st tarsus segment		8 (5–11)	8 (7–11)	8 (8–8)	7 (4–11)
Superior spines on 2nd tarsus segment		4 (0–5)	3 (2–4)	2 (2–3)	0 (0–1)
Fore tibia, inferior spines	prolateral	3 (3–3)	1 (0–1)	2 (2–2)	2 (2–3)
	retrolateral	3 (3–3)	2 (2–2)	3.5 (3–4)	2 (1–3)
Fore tibia, superior spines		0	0	0	0
Mid tibia, inferior spines	prolateral	3 (3–3)	2 (1–3)	3 (3–4)	2 (1–2)
	retrolateral	3 (2–3)	1 (0–2)	2.5 (2–3)	2 (2–3)
Mid tibia, superior spines	prolateral	0	0	1.5 (1–3)	0
	retrolateral			5 (3–6)	
Hind femur, inferior spines	prolateral	0	0	0	0
	retrolateral	3 (2–4), v. small	1 (0–1), minute	1.5 (1–3), small	1.5 (1–2), small

several locations on North Island are consistent with Hutton's description of *Miotopus diversus,* but most specimens from South Island represent an undescribed species.

In the OR our phylogenetic analysis of a 1435 bp alignment of mtDNA COI, *Miotopus diversus* did not cluster with *Pleioplectron hudsoni* and *P. simplex* (Fig. 3). Instead, other New Zealand Rhaphidophoridae (*Talitropsis* Bolívar, 1882 and *Pachyrhamma* Brunner von Wattenwyl, 1888) included in the analysis fell between the *P. hudsoni* / *P. simplex* clade and the *Miotopus* lineage. A second putative *Miotopus* taxon grouped with *M. diversus* although substitution saturation at the COI locus results in posterior probabilities at nodes < 1. We also examined clustering of COI haplotypes (835 bp) from 41 putative *Miotopus* sampled from around New Zealand and this revealed one cluster consisted of all specimens identified as *M. diversus*, including some

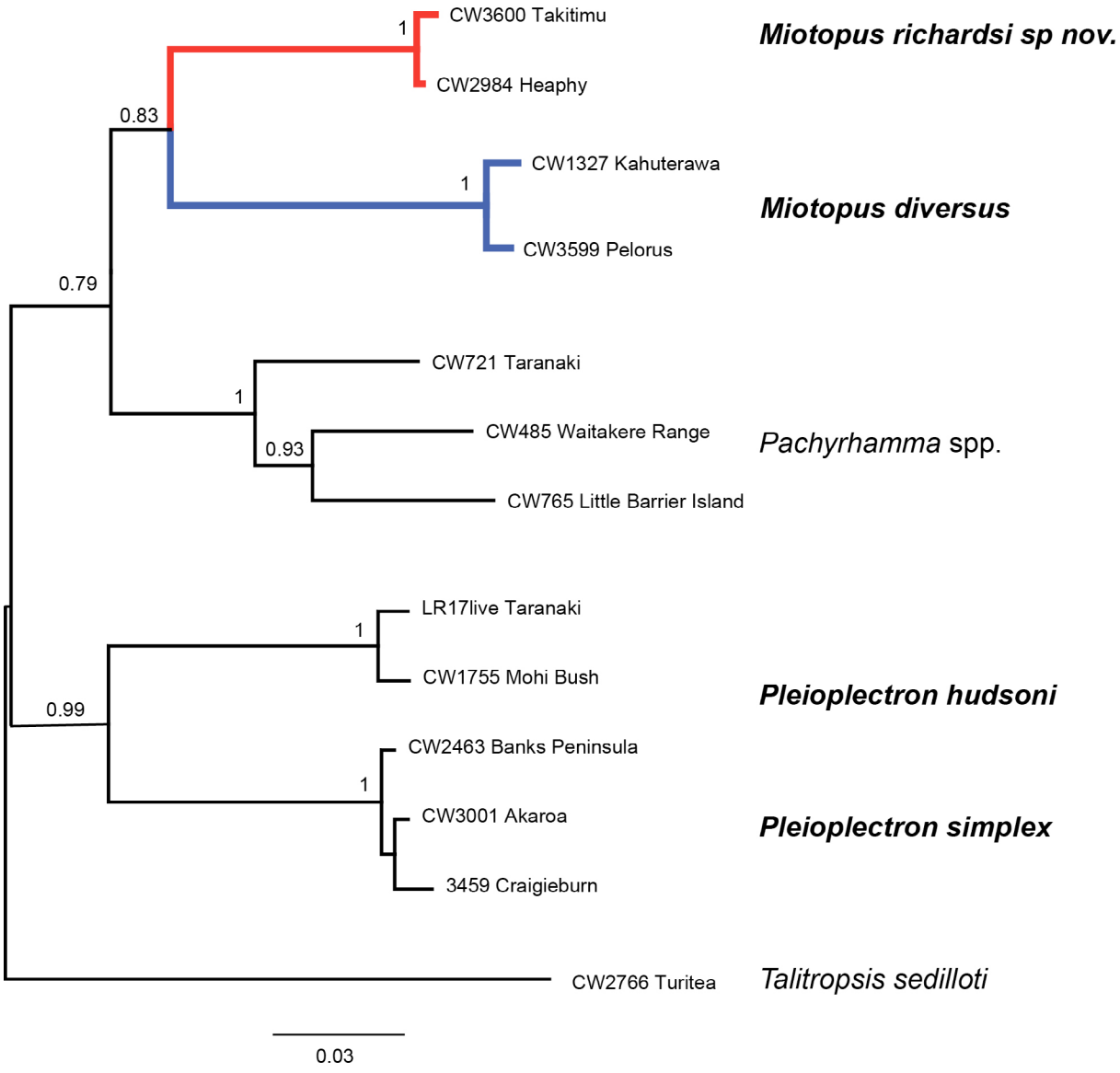

Fig. 3. Phylogenetic relationship of *Pleioplectron* Hutton, 1896 and *Miotopus* Hutton, 1898 inferred from Bayesian Inference of 1435bp mtDNA COI sequence alignment with four 4×10^6 MCMC chains, sampling every 2×10^3 generations.

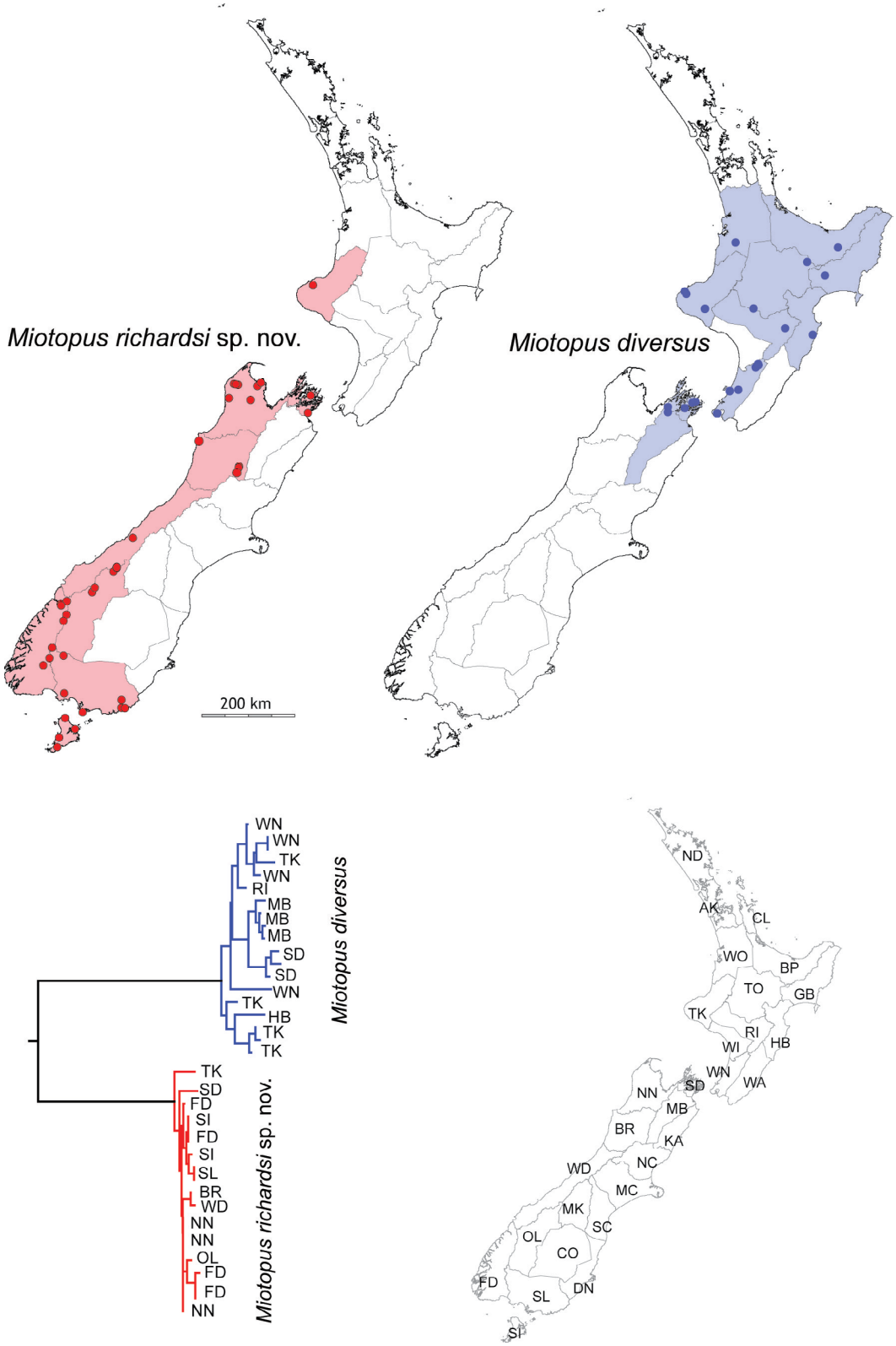

Fig. 4. Known distributions of *Miotopus richardsi* sp. nov. (red) and *M. diversus* (Hutton, 1896) (blue). Reciprocally monophyletic clusters of mtDNA sequences (835 bp COI, ML, HKY, with outgroup removed) of samples that encompass morphological and geographic diversity of the two taxa. Spot locations are indicated (circles) within the relevant New Zealand entomological (Crosby) regions.

individuals collected on South Island. The other cluster consisted of specimens of a novel morphotype predominantly, but not exclusively from South Island (Fig. 4). We found mean genetic distances (HKY) between these putative *Miotopus* haplotype clusters of 0.110 (~11%), but 0.005 and 0.018 within them.

Given the morphological differences coupled with genetic evidence we agree with Hutton's (1898) decision to separate *Pleioplectron* and *Miotopus* and we redefine *Miotopus* here and describe a new southern species.

Order Orthoptera Latreille, 1793
Superfamily Rhaphidophordoidea Walker, 1869
Family Rhaphidophoridae Walker, 1869
Subfamily Macropathinae Karny, 1930
Tribe Macropathini Karny, 1930

Genus ***Miotopus*** Hutton, 1898

Medium size cave wētā (body length 11–17 mm) found in forests and caves, on three main islands of New Zealand. The genus consists of two species that are structurally quite distinct from one another, and share some morphological characteristics with *Pleioplectron*.

The head of *Miotopus* tends to be more elongated than in *Pleioplectron,* coloured mostly brown. Scapes of the antennae are sexually dimorphic, very broad in the males, thinner in the females (Fig. 5). Maxillary palps are long with moderately dense hair. The colour pattern of the upper body parts of the two species is similar, but darker in *P. diversus*, and surprisingly uniform across the whole distribution range with alternating reddish-brown and black patches. The light-coloured patches form a large inverted W-shape on the pronotum, and an X-shape stretching across the mesanotum, metanotum and first abdominal tergite (Fig. 6).

Legs are relatively long in both species, especially so in the newly described species. Fore and mid femora are armed at the apex with a prolateral and a retrolateral apical spine. Fore and mid tibia armed with two pairs of apical spines each, four pairs on the hind tibia. The number of linear spines on all tibiae varies within and between species (Table 1).

Male and female terminalia are species specific (Figs 7–8); cerci long and slender, especially in the males. The upper valves of the ovipositor are scabrous but not serrated (the irregularities being visible only at high magnification), while the lower valves have 7+ shallow teeth near the apex (Fig. 8).

Miotopus diversus Hutton, 1898
Figs 4, 5A–B, 6A–B, 7A–B, 8A–C, 9, 10A–B

Diagnosis

A medium sized cave wētā found in forested areas around the North Island, New Zealand, mainly in leaf litter on the forest floor, or in the roots of trees. Dark brown with visible dark and pale bands on the fore and mid legs, it could be most easily confused with the sympatric *Pleioplectron hudsoni*. However, adult *Miotopus diversus* are larger (see Table 1), usually appear darker in life, and have small spines on the dorsal surface of the mid tibiae, and are further distinguished from *Pleioplectron* by spine count and male terminalia.

Type material

Holotype

NEW ZEALAND: ♀, from Upper Wanganui (as *Pleioplectron diversum*) in Canterbury Museum (Hutton 1897).

Other material

NEW ZEALAND: 1 ♂ from Makaretu, Hawkes Bay (as *Miotopus diversus*) (Hutton 1898).

Material examined

See Table 2.

Description

Head. Mostly brown with vertical pale stripes, covered in fine setae, palps light brown with fine setae, fastigium brown with pale spots on the sides, eyes black and ovoid, antennae long and dark brown. Male antennae are notably thick, densely clothed in setae and abruptly tapering to a thin thread at the end, whereas female antennae are narrow and almost uniformly thin from end to end, scape and peduncle pale (Fig. 5).

Thorax. Pronotum with anterior and posterior margins convex, and sides rounded with a slight outward 'lip', dark brown–red brown with occasional pale markings (Fig. 6A–B).

Legs. Moderately long, hind femora shorter than tibiae, coxae and trochanters cream, femora and tibiae dark brown with cream bands. Fore femora compressed with one prolateral apical spine and one retrolateral apical spine present, short dark setae present. Fore tibiae with two prolateral and three or four retrolateral long, pale to transparent, linear spines positioned in the mid to distal portion of the tibiae. Fore tibiae with two superior apical spines (one prolateral and one retrolateral), pale with dark tip, almost hidden amongst the setae, two inferior apical spines (one prolateral and one retrolateral), inferior apical spines longer than superior spines, articulate, pale with dark tip, longer and thicker than the surrounding setae. Mid femora compressed with one long articulated prolateral apical spine, one long articulated retrolateral apical spine. Mid tibiae with three or four prolateral and two or three retrolateral long, linear spines positioned in the mid to distal portion of the tibiae, prolateral linear spines longer than the retrolateral spines. Mid tibiae with two superior apical spines (one prolateral and one retrolateral), pale with dark tip, two inferior apical spines (one prolateral and one retrolateral), inferior spines longer than superior spines, pale with dark tip. Hind femora with one retrolateral apical spine (sometimes very small), slightly pigmented. Hind tibiae longer than femora with small brown alternate spines along superior surface (Fig. 9). Hind tibiae with two superior subapical spines (one prolateral and one retrolateral), two superior apical spines (one prolateral and one retrolateral), spines twice as long as superior subapical spines, two inferior apical spines (one prolateral and one retrolateral) ⅔ length of superior apical spines above, two inferior subapical spines. Tarsi with four segments, 1st and 2nd segment with a pair of spines on distal end, 1st segment has eight small spines up from the end in alternate fashion; on the underside of the 1st segment minute brown spinules run up the length of the segment either side of the tarsal pad. The 2nd segment has three minute spines above, 4th segment half the length of the 1st segment.

Abdomen. Glossy, brown tones. Short setae covering both tergites and sternites; sternum light brown colour.

Terminalia male (Fig. 7A–B). Cerci long, round, brown in colour, clothed in setae, styli short, not extending beyond the end of the subgenital plate. Subgenital plate is a finger-like protrusion.

Table 2 (continued on next pages). Material of *Miotopus diversus* (Hutton, 1896) examined. All specimens collected in New Zealand. Collector abbreviations: DH = Danilo Hegg; GB = Gareth Boyt; ML = Mike Lusk; MMR = Mary Morgan-Richards; RG = Ron Goudswaard; ST = Steve Trewick.

Entomological Region	Material	Locality	Coordinates	Elevation m a.s.l.	Micro-habitat	Collecting method	Date	Collector	Institution code	Specimen code
TK (Taranaki)	3 ♂♂, 3 ♀♀, 4 nymphs	Egmont National Park, Kaitake Range, Lucy's Gully	-39.14931, 173.94167	200	Under log in forest	Day search	25 Sep. 2006	ST & MMR	MPN	CW459–CW465
TK (Taranaki)	1 ♀	Egmont National Park, Oakura River	-39.19482, 173.99864	400		Night search	1 Apr. 2007	ST & MMR	MPN	CW783
TK (Taranaki)	1 ♂, 3 ♀♀	Lake Rotokare	-39.45409, 174.40923	200		Pitfall trap			LCR	LR-L3-A LR-W19-A, B LR-L59-B
WN (Wellington)	1♂	Palmerston North, Turitea Rd	-40.41566, 175.66390	100			21 Aug. 2004	MMR	MPN	CW133
WN (Wellington)	1♀	Palmerston North, Turitea Rd	-40.41566, 175.66390	100		Night search	15 Mar. 2005	ST	MPN	CW336
WN (Wellington)	1 ♂	Palmerston North, Turitea Reserve	-40.43045, 175.67273	200	Near boat shed	Night search	15 Aug. 2010	ST	MPN	CW1439
WN (Wellington)	4 ♂♂, 1 ♀	Palmerston North, Turitea Reserve	-40.43045, 175.67273	200		Night search	19 Nov. 2010	ST	MPN	CW 1452, CW1459, CW1467–CW1469
WN (Wellington)	1 ♂	Palmerston North, Turitea Reserve	-40.43045, 175.67273	200		Pitfall trap				TD19(1)-b
WN (Wellington)	1 ♀	Palmerston North, Kahuterawa Stream	-40.47068, 175.61204	150	Stream bed		1 Jul. 2009		MPN	CW1327
WN (Wellington)	1 ♂	Wellington, Karori Sanctuary	-41.302893, 174.703689	250			21 Jul. 2004	RG	MPN	CW117

Table 2 (continued).

Entomological Region	Material	Locality	Coordinates	Elevation m a.s.l.	Micro-habitat	Collecting method	Date	Collector	Institution code	Specimen code
WN (Wellington)	1 ♂	Wellington, Karori Sanctuary	-41.302893, 174.703689	250			11 Oct. 2004	RG	MPN	CW182
WN (Wellington)	1 ♂, 1 ♀	Wellington, Karori Sanctuary	-41.302893, 174.703689	250			22 Aug. 2006	RG	MPN	CW475, CW476
WN (Wellington)	1 ♀	Paraparaumu, Nikau Reserve	-40.90624, 175.02093	20			20 Sep. 2004	ST & MMR	MPN	CW153
WN (Wellington)	1 ♀ nymph	Tararua Forest, Otaki Forks	-40.88085, 175.21887	100	Under log in forest	Photograph only	4 Nov. 2017	DH	iNaturalist	8689928
RI (Rangitikei)	1 ♂	Central Ruahine, Yeomans Track	-39.74383, 176.26003	400			10 Apr. 2011	ML	MPN	CW1616
HB (Hawkes Bay)	2 ♀♀	Mohi Bush	-39.85725, 176.90068	350		Night search	8 Oct. 2012	ST	MPN	CW1837, CW1841
GB (Gisborne)	1 ♀	Lake Waikaremoana	-38.797785, 177.120326	600	In hole in tutu shrub		28 Mar. 2004	MMR	MPN	CW75A
TO (Taupo)	1 ♀	Ruapehu, Lake Rotokura	-39.42975, 175.52060	700		Night search	11 Jul. 2006	ST & MMR	MPN	CW452
TO (Taupo)	1 ♀	Whirinaki Forest	-38.57248, 176.70391	400	On tree trunk in podocarp forest		1 Jul. 2007	GB	MPN	CW493
BP (Bay of Plenty)	2 ♂♂, 1 ♀	Waioeka Gorge, Manganuku	-38.290668, 177.385014	200	On vegetation	Night search	2 Jan. 2011	ST	MPN	CW1956, CW1970, CW1971
WO (Waikato)	1♂	Waitomo, Ruakuri Cave	-38.26652, 175.07721	100	On tree	Night search	4 Sep. 2012	ST	MPN	CW1912

Table 2 (continued).

Entomological Region	Material	Locality	Coordinates	Elevation m a.s.l.	Micro-habitat	Collecting method	Date	Collector	Institution code	Specimen code
MB (Marlborough)	1 ♀	Pelorus Bridge, Circle Loop Track	-41.29802, 173.57333	30		Night search		ST & MMR	MPN	CW533A
MB (Marlborough)	2 ♂♂, 1 nymph	Pelorus Bridge	-41.29655, 173.5744	30	In roots of fallen tree	Night search + insect net	6 Oct. 2017	DH	MPN	CW3598, CW3599, CW3790
MB (Marlborough)	1 ♀	Rai Valley, Mt Richmond Estate	-41.20479, 173.57371	50	Pine / beech forest	Day search	15 Jan. 2011	ST	MPN	CW1963
SD (Sounds)	2 ♂♂, 1 nymph	Queen Charlotte Sound, Resolution Bay	-41.11118, 174.22488	0	Clay bank on side of track	Night search + insect net	1 Oct. 2017	DH	MPN	CW3601, CW3602, CW3789
SD (Sounds)	2 ♀♀	Queen Charlotte Sound, Camp Bay	-41.12585, 174.14695	0	Clay bank on side of track	Night search + insect net	2 Oct. 2017	DH	MPN	CW3596, CW3597
SD (Sounds)	3 nymphs	Queen Charlotte Sound, Mistletoe Bay	-41.22236, 173.97254	40	Inside hollow tree	Casual find; collected by hand	4 Oct. 2017	DH	MPN	CW3805–CW3807

TERMINALIA FEMALE (Fig. 8A–C). Subgenital plate with three points, the outer two slightly longer than the middle one. Apex rounded and blunt. Ovipositor reddish-brown with 7–8 teeth on the ventral edge near at the tip.

Miotopus richardsi sp. nov.
urn:lsid:zoobank.org:act:BFDCEBC5-E058-4362-B5B4-42E3D9FAAD8F
Figs 4, 5C, 6C–D, 7C–F, 8D–F, 9, 10C–F

Diagnosis

A medium sized cave wētā found in forested areas of the South Island, New Zealand with a variegated colour pattern. Similar to *Miotopus diversus* based on apical spines with the exception of the presence on hind femora of both prolateral and retrolateral apical spines (n.b. this trait was formerly considered diagnostic of *Pachyrhamma*, see Cook *et al*. 2010). It is easily identified by the very long legs and the

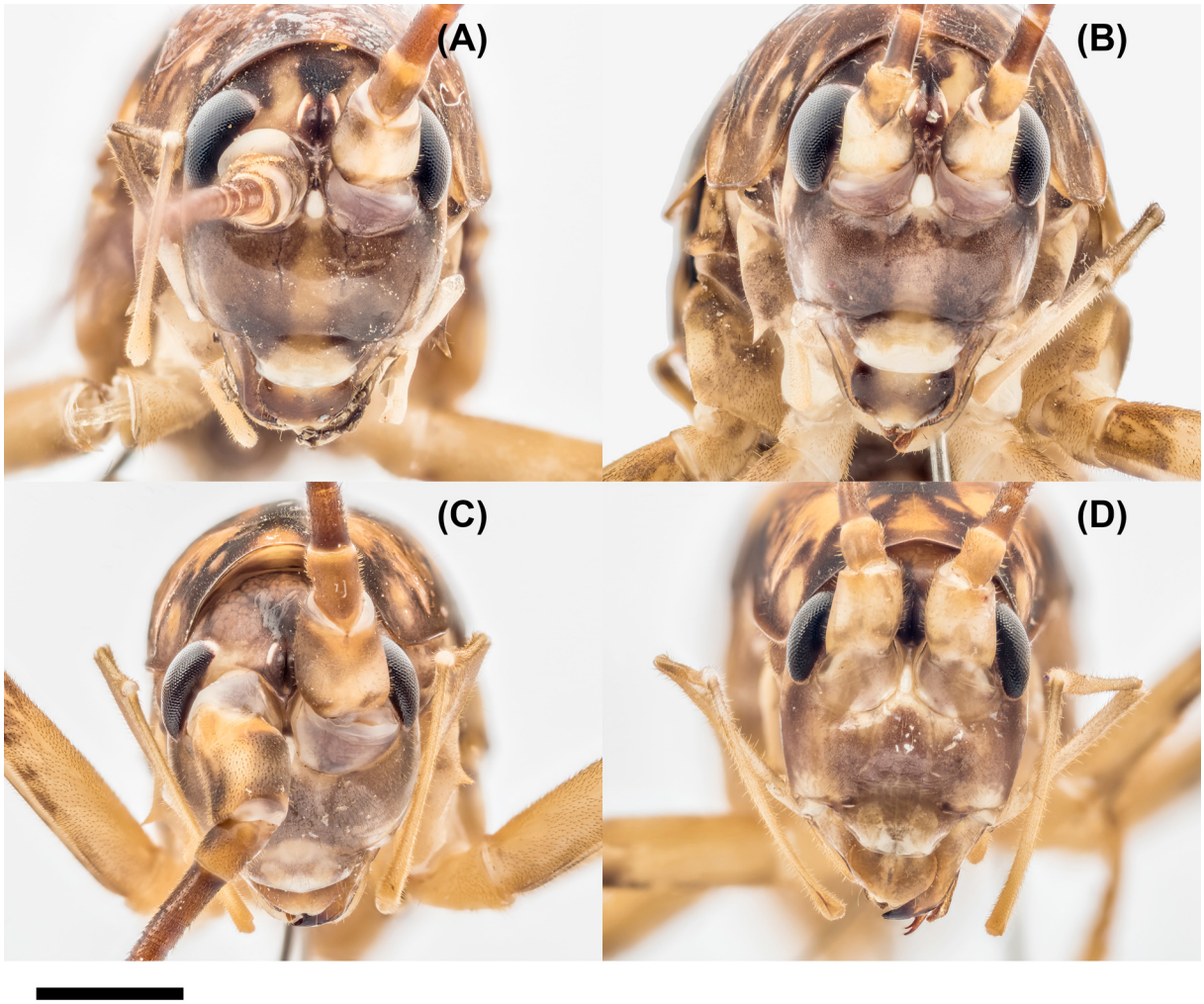

Fig. 5. Head of cave wētā in the genus *Miotopus* Hutton, 1898 showing sexual dimophism. **A–B**. *Miotopus diversus* (Hutton, 1896). **A**. Adult ♂, Resolution Bay, Queen Charlotte Sound (MPN CW3459). **B**. Adult ♀, Camp Bay, Queen Charlotte Sound (MPN CW3596). **C–D**. *Miotopus richardsi* sp. nov. Borland Road, Southland. **C**. Adult ♂ (MPN CW3542). **D**. Adult ♀ (MPN CW3811). Scale bar = 2 mm.

presence of three pairs of prominent, socketed superior spines on the hind tibiae. Female with subgenital plate similar to *M. diversus*, but differs in male genital terminalia. Notably long ovipositor, as long as or longer than body length (Fig. 10C–F).

Etymology

Named for Aola Richards who studied New Zealand cave wētā and published many important systematic papers from 1954 until 1972.

Type material

Holotype

NEW ZEALAND: ♂, adult, Fiordland (FD), Gulliver River, -44.704477, 167.97031, 60 m a.s.l., under large river boulders in native forest, by hand during night search, Jan. 2014, Tony Jewell leg. (MPN CW2619; NMNZ AI.035053).

Paratype

NEW ZEALAND: ♀, adult, Brunner (BR), Lewis Pass, Cannibal Gorge, -42.333962, 172.424113, 820 m a.s.l., on rotting tree stump in native forest, with insect net during night search, 24 Apr. 2017, Danilo Hegg leg. (MPN CW3429; NMNZ AI.035054).

Additional material examined

See Table 3.

Description

Measurements. See Table 1.

Head. Head slightly variegated colouring with a medium brown and golden light brown; covered in fine setae; palps are light golden brown and covered with fine setae; fastigium medium brown with minor golden light brown, with pale spots on the sides; eyes black; antennae long and medium brown with setae; scape and peduncle light golden brown (Fig. 5C–D).

Thorax. Pronotum anterior and posterior margins slightly convex; sides are rounded with a slight outward 'lip'. On the upper surface it bears the markings of a large inverted W, the side-arms fainter than the V in the middle (Fig. 6C–D).

Legs. Long. Hind femora shorter than tibiae. Coxae and trochanters cream in colour, femora and tibiae dark brown with cream bands. Fore femora compressed with one prolateral apical spine and one retrolateral apical spine, short dark setae present. Fore tibiae with two pairs of long, pale linear spines positioned in the mid to distal portion of the tibiae. Fore tibiae with two superior apical spines (one prolateral and one retrolateral), pale with dark tip and almost hidden amongst the setae, two inferior apical spines (one prolateral and one retrolateral), longer than superior spines, articulate, pale with dark tip, longer and thicker than the surrounding setae. Mid femora compressed with one long articulated prolateral apical spine, one long articulated retrolateral apical spine. Mid tibiae with two pairs of long, linear spines positioned in the mid to distal portion of the tibiae, prolateral spines longer than the retrolateral ones. Mid tibiae with two superior apical spines (one prolateral and one retrolateral), pale with dark tip, two inferior apical spines (one prolateral and one retrolateral), inferior spines longer than superior spines, pale with dark tip. Hind femora with one retrolateral and one prolateral apical spine, small, stout, slightly pigmented. Hind tibiae longer than femora with small brown alternate spines along length of the superior surface, three pairs are spur-like and three times the length of the other smaller spines (Fig. 9). Hind tibiae with two superior subapical spines (one prolateral and one retrolateral), two superior apical spines (one prolateral

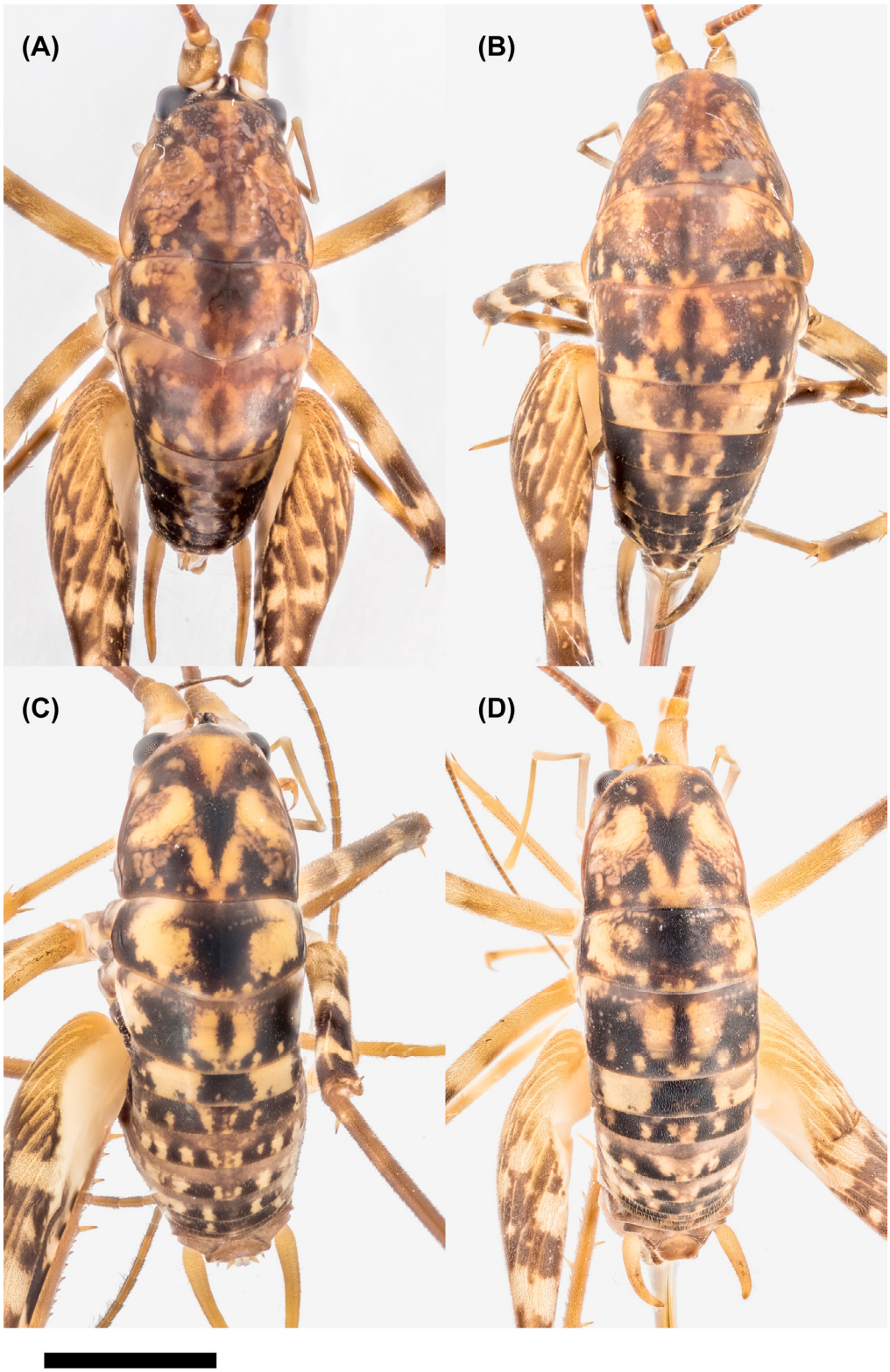

Fig. 6. Dorsal views of cave wētā in the genus *Miotopus* Hutton, 1898. **A–B**. *Miotopus diversus* (Hutton, 1896). **A**. Adult ♂, Resolution Bay, Queen Charlotte Sound (MPN CW3601). **B**. Adult ♀, Camp Bay, Queen Charlotte Sound (MPN CW3596). **C–D**. *Miotopus richardsi* sp. nov. **C**. Adult ♂, Lewis Pass (MPN CW3609). **D**. Adult ♀, Borland Road, Fiordland NP (MPN CW3811). Scale bar = 5 mm.

Table 3 (continued on next pages). Material of *Miotopus richardsi* sp. nov. examined. All specimens collected in New Zealand. [H] = Holotype, [P] = Paratype. Collector abbreviations: DC = Deborah Carden; DH = Danilo Hegg; MMR = Mary Morgan-Richards; ST = Steve Trewick; TJ = Tony Jewell.

Entomological Region	Material	Locality	Coordinates	Elevation m a.s.l.	Micro-habitat	Collecting method	Date	Collector	Institution code	Specimen code
SI (Stewart Island)	2 ♂♂	Port Pegasus, South Pegasus Hut	-47.199964, 167.638315	0	Under tree arch	Caught by hand at night	17 Jan. 2018	DH	MPN	CW3640, CW3641
SI (Stewart Island)	1 ♀	Oban, Horseshoe Point	-46.880401, 168.148586	0	On tree	Night search	20 Apr. 2017	ST & MMR	MPN	CW3481
SI (Stewart Island)	1 ♂	Oban, Raroa Walk	-46.900847, 168.120689	40	On tree	Night search	22 Apr. 2017	ST & MMR	MPN	CW3475
SI (Stewart Island)	1 nymph	Yankee River mouth	-46.694448, 167.891027	0	Coastal rocks at bush edge	Night search + insect net	15 Apr. 2018	DH	MPN	CW3809
SI (Stewart Island)	1 ♂	Doughboy Bay	-47.033764, 167.708637	0	Sea cave	Night search + insect net	21 Apr. 2018	DH	MPN	CW3808
SL (Southland)	1 ♂	Catlins Forest, McLean Falls	-46.57132, 169.34773	50	Rocks on side of walking track	Night search + insect net	22 Oct. 2017	DH	MPN	CW3604
SL (Southland)	1 ♂ nymph	Catlins Forest, Lake Wilkie	-46.57957, 169.43991	10	On tree trunk in podocarp forest	Night search + insect net	22 Oct. 2017	DH	MPN	CW3603
SL (Southland)	1 ♂ nymph	Catlins Forest, McLennan Hut	-46.43216, 169.36144	200	Inside rotting log	Photograph only	12 Dec. 2015	DH	iNaturalist	2626726
SL (Southland)	1 ♀	Takitimu Forest, Lower Princhester Hut	-45.59397, 167.95193	470	On tree trunk	Night search + insect net	21 Oct. 2017	DH	MPN	CW3600
SL (Southland)	1♀	Longwood Range, Cascade Creek	-46.260298, 167.907572	500	Under wooden bridge	Night search	2013	TJ	MPN	CW2567
SL (Southland)	3 ♂♂	Bluff Hill	-46.620853, 168.348742	50	Rata tree trunk and shrubs	Night search	Aug. 2013	TJ	MPN	CW2556, CW2557, CW2564
FD (Fiordland)	1 ♂	Kepler Track, Dock Bay	-45.42701, 167.609053	200	Beech logs	Day search	29 Dec. 2009	ST	MPN	CW972
FD (Fiordland)	3 ♂♂	Cleddau River	-44.677947, 167.963227	20	In road culvert	Night search	Jan. 2014	TJ	MPN	CW2616–CW2618

Table 3 (continued).

Entomological Region	Material	Locality	Coordinates	Elevation m a.s.l.	Micro-habitat	Collecting method	Date	Collector	Institution code	Specimen code
FD (Fiordland)	1 ♂ 1 ♀	Gulliver River	-44.704477, 167.97031	60	Under dry boulder overhang in forest	Night search	Jan. 2014	TJ	MPN	CW2619[H], CW2620
FD (Fiordland)	1 ♂, 1 ♀	Lake Rakatu	-45.62037, 167.59631	190	On tree trunk in native forest	Caught by hand at night	10 Sep. 2016	DH	MPN	CW3810, CW3523
FD (Fiordland)	1 ♂ 1 ♀	Borland Rd	-45.74031, 167.42700	700	Dry rock overhang in road cutting	Night search + insect net	3 Mar. 2017	DH	MPN	CW3542, CW3811
FD (Fiordland)	1 ♂	Eglinton Valley, Knobs Flat	-44.97774, 168.00520	350	In cavity at base of tree trunk	Photograph only	13 Jan. 2009	DH	iNaturalist	3101320
FD (Fiordland)	1 ♀	Eglinton Valley, Lake Gunn	-44.87218, 168.08828	480	In shrubs	Night search + insect net	11 Mar. 2017	DH	MPN	CW3543
OL (Otago Lakes)	1 ♂, 1 ♀	West Matukituki River, Raspberry Flat	-44.50037, 168.75445	450	Under rock overhang in bluffs	Caught by hand at night	21 Feb. 2016	DH	MPN	CW2848, CW2849
OL (Otago Lakes)	1 ♂	East Matukituki River	-44.42167, 168.82668	400	On beech tree trunk	Photograph only	22 Feb. 2016	DH	iNaturalist	8021131
OL (Otago Lakes)	1 ♂ nymph	Makarora River, Cameron Flat	-44.15611, 169.30472	370	On beech tree trunk	Night search + insect net	1 Sep. 2017	DH	MPN	CW3701
OL (Otago Lakes)	3 ♂♂, 2 ♀♀	Hollyford Track upstream of Hidden Falls	-44.63550, 168.11785	50	Under logs or rocks on side of track	Night search + insect net	12 Nov. 2016	DH	MPN	CW3138–CW3140, CW3605, CW3606
WD (Westland)	1 ♂	Copland Track	-43.57632, 169.81347	50			14 Jan. 2004	ST	MPN	CW52
BR (Brunner)	1 ♀	Charleston, Mitchell's Gully Gold Mine	-41.89194, 171.4677783	50	In mining tunnel	Torch + insect net	30 Jan. 2018	DH	MPN	CW3763
BR (Brunner)	1 ♂	Lewis Pass	-42.37139, 172.40372	800	In leaf litter on forest floor	Night search + insect net	25 Apr. 2017	DH	MPN	CW3609
BR (Brunner)	2 ♀♀	Lewis Pass, Cannibal Gorge	-42.34845, 172.41506	820	On rotting tree stump	Night search + insect net	25 Apr. 2017	DH	MPN	CW3429[P], CW3610

Table 3 (continued).

Entomological Region	Material	Locality	Coordinates	Elevation m a.s.l.	Micro-habitat	Collecting method	Date	Collector	Institution code	Specimen code
BR (Brunner)	1 ♂	Lewis Pass, Nina Valley	-42.459738, 172.364717	600	Under large rock in forest	Night search + insect net	26 Jan. 2018	DH	MPN	CW3762
NN (Nelson)	1 ♂	Oparara, Box Canyon Cave	-41.13481, 172.19008	250	In cave		Feb. 2005	DC	MPN	CW345
NN (Nelson)	1 ♀	Takaka, Sky Farm	-40.92435, 172.85541	600	Beech tree trunk	Night search	29 Jan. 2006	ST & MMR	MPN	CW302
NN (Nelson)	1 nymph	Takaka Hill, Summit Walkway	-41.032057, 172.86519	800	Hole in stick	Day search	20 Jan. 2018	ST	MPN	CW3630
NN (Nelson)	1 ♂	Abel Tasman NP, Awapoto Hut	-40.86314, 172.93910	650	On shrub branchlets	Night search + insect net	11 Oct. 2017	DH	MPN	CW3812
NN (Nelson)	1 ♂ 1 ♀ 7 nymphs	Heaphy Track, Gouland Downs Caves	-40.89180, 172.35237	620	Under cave ceiling	Torch + insect net	21 Apr. 2016	DH	MPN	CW3007, CW3008, CW3019–CW3025
NN (Nelson)	1 ♀	Heaphy Track, Three Pointer	-40.88281, 172.30926	800	On tree trunk	Night search + insect net	22 Apr. 2016	DH	MPN	CW2984
NN (Nelson)	1 ♀	Heaphy Track, Perry Saddle	-40.90010, 172.40756	900	Under overhang in bank on side of track	Night search + insect net	19 Apr. 2016	DH	MPN	CW2989
NN (Nelson)	1 ♂ 1 ♀	Heaphy Track, Perry Saddle	-40.90010, 172.40756	900	Under overhang in bank on side of track	Night search + insect net	24 Dec. 2016	DH	MPN	CW3607, CW3608
NN (Nelson)	1 ♀	Mt Arthur, Lower Gridiron Shelter	-41.1704017, 172.69670	800	Under large boulder in forest	Night search + insect net	9 Feb. 2018	DH	MPN	CW3764
SD (Sounds)	1 ♀	Rarangi Beach	-41.39430, 174.04489	0	In cave		11 Dec. 2007	MMR	MPN	CW2430
SD (Sounds)	1 ♀ nymph	Mt Stokes	-41.088055, 174.105	1160	In leaf litter on forest floor	Night search + insect net	29 Jan. 2018	DH	MPN	CW3772
TK (Taranaki)	1 ♀	New Plymouth, Lake Mangamahoe	-39.12904, 174.12570	180	Hollow ponga	Day search	11 Nov. 2006	ST & MMR	MPN	CW1403

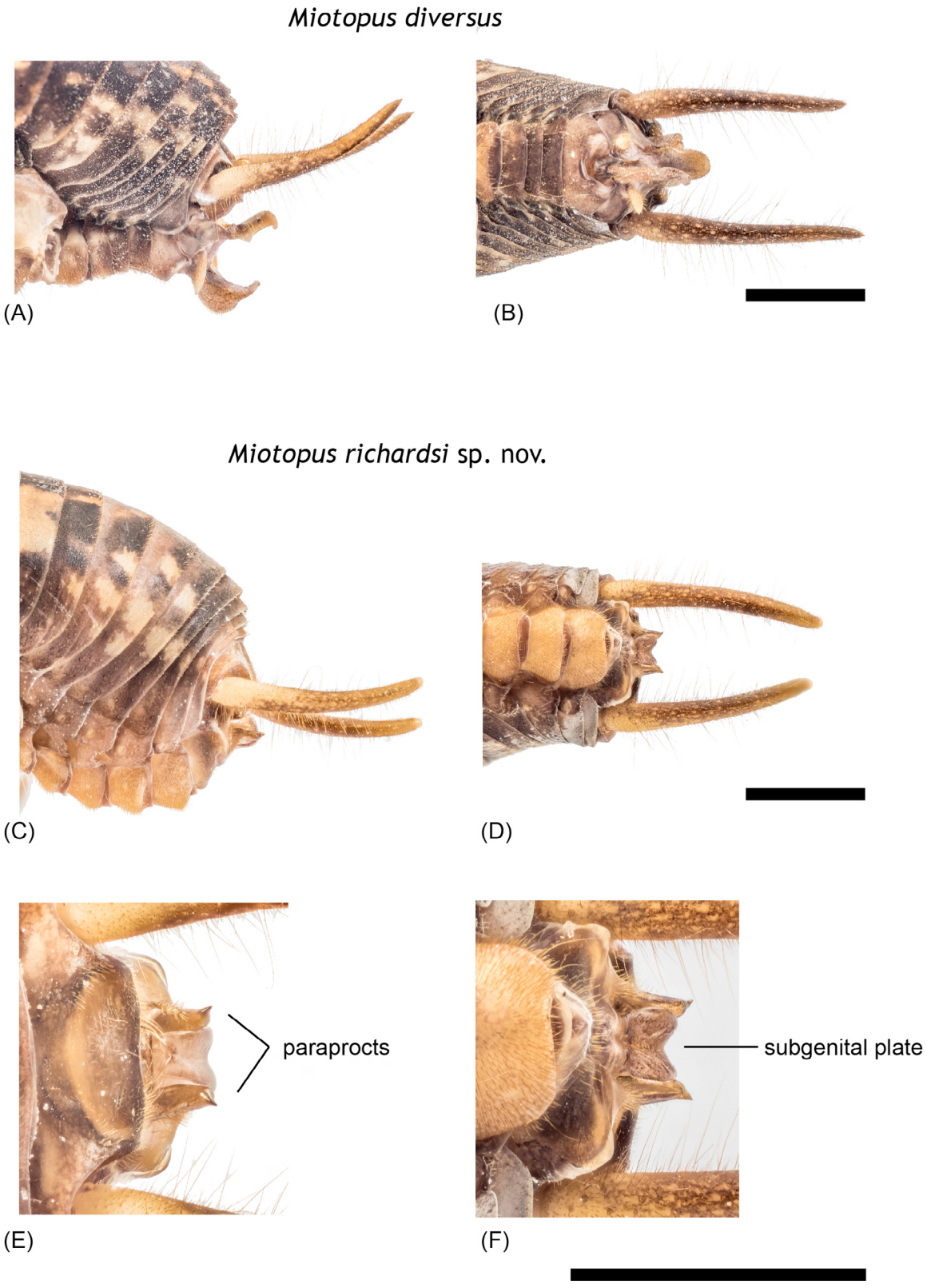

Fig. 7. Male terminalia of *Miotopus* Hutton, 1898 cave wētā. **A–B**. *Miotopus diversus* (Hutton, 1896) (MPN CW3601). **A**. Lateral. **B**. Ventral. **C–F**. *Miotopus richardsi* sp. nov. (MPN CW3542). **C**. Lateral. **D**. Ventral. **E**. Close dorsal. **F**. Ventral views of named structures. Scale bars = 2 mm.

and one retrolateral), twice as long as superior subapical spines, two inferior apical spines (one prolateral and one retrolateral) ⅔ the length of superior apical spines above, two inferior subapical spines. Hind tarsi with 4 segments, 1st and 2nd segment with a pair of spines on distal end. 1st segment has 4–11 small dorsal, alternate spines, and minute brown spinules along the underside of either side of the tarsal pad. The 2nd segment occasionally has one or two small spines above, 4th segment half the length of the 1st segment.

Abdomen. Shiny, brown coloured. Short setae covering both tergites and sternites; sternum pale brown colour.

Terminalia male. Cerci long, round, brown in colour, clothed in setae. Styli reduced, not extending beyond the end of the subgenital plate. Subgenital plate short and bulbous, usually with median groove on ventral surface. Paraprocts adjacent to subgenital plate each bearing a prominent, sharp spine (Fig. 7C–D).

Terminalia female. Subgenital plate simple. Appears as either truncated or sinuous with middle portion of posterior margin slightly indented. Ovipositor very long, as long as or longer than the body length, reddish-brown with 18–30 small teeth on ventral edge near the tip (Fig. 8D–F).

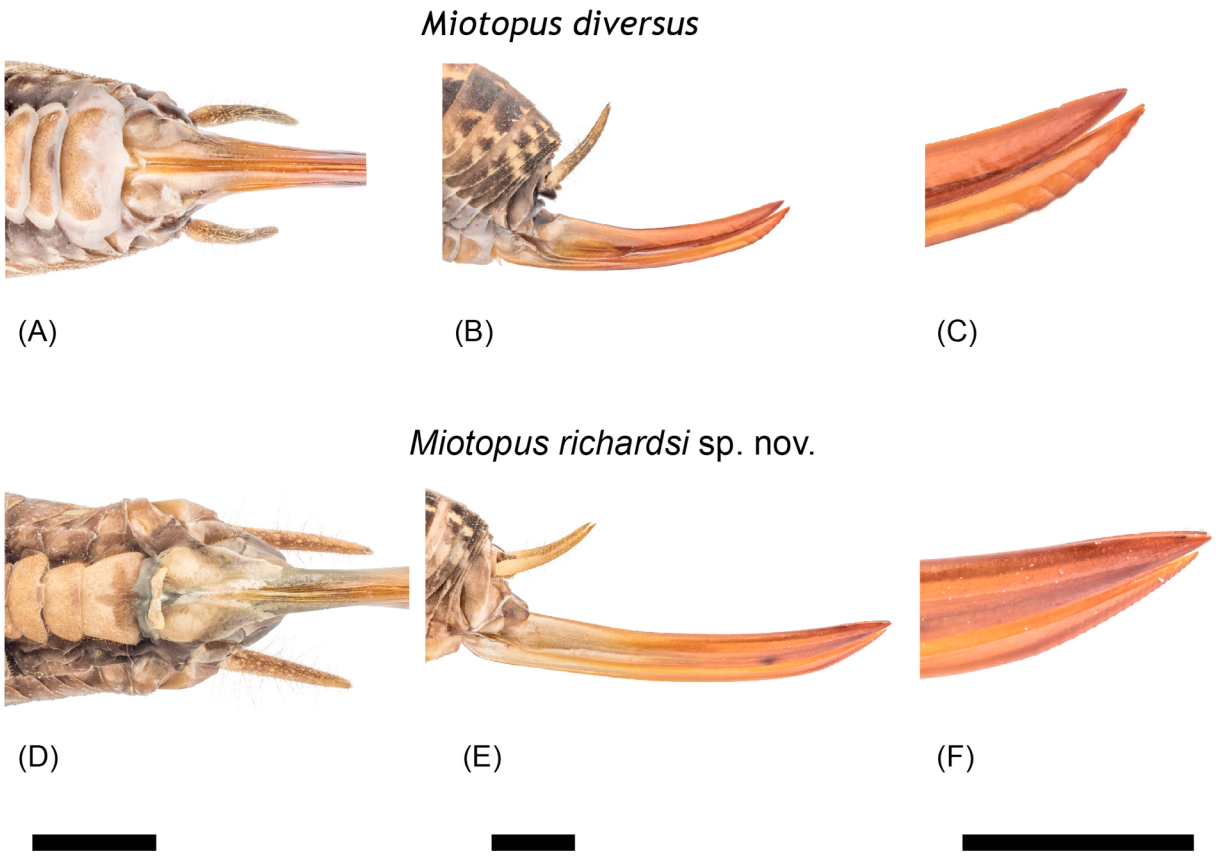

Fig. 8. Female terminalia of *Miotopus* Hutton, 1898 cave wētā. **A–C**. *Miotopus diversus* (Hutton, 1896) (MPN CW3596). **A**. Ventral. **B–C**. Lateral views. **D–F**. *Miotopus richardsi* sp. nov. (MPN CW3543). **D**. Ventral. **E–F**. lateral views. Scale bars = 3 mm.

Discussion

Miotopus richardsi sp. nov. is found in forest habitat and in caves; it is both common and widespread on South Island, from the Catlins Forest across Southland to Fiordland, and the length of the West Coast and of the Southern Alps to Kahurangi and Abel Tasman National Parks (Fig. 4). It is also found on Stewart Island, and in the Taranaki Region on North Island.

Adults have long legs, longer than in all other South Island forest species, except for *Macropathus* Walker (1869). Just like *Macropathus*, it is almost always found during the day suspended upside down, most commonly in cavities at the base of tree trunks, under boulders, branches and logs, under rocky overhangs and in caves. It is very light sensitive and will quickly get away with long leaps if disturbed. In open forest, individuals are rarely found close together. However, dense colonies occur under rocky overhangs and in caves. Under a roof in the bluffs at Raspberry Flat, West Matukituki, fifty to a hundred specimens were found in close proximity to each other, crossing legs and antennae. In the Gouland Downs caves in Kahurangi National Park, the population of *Miotopus richardsi* sp. nov. reaches hundreds if not thousands of individuals, often in direct physical contact with each other. Here they mix with *Pachyrhamma edwardsi* (Scudder 1869) and, in lower densities, *Macropathus filifer* (Walker 1869). *Pachyrhamma delli* (Richards 1954) is also found in the same caves, but occupies small fissures and limestone pockets, and does not mix with the other species of cave wētā.

The body colouring pattern is surprisingly uniform across the whole species' distribution range (Fig. 10C, E–F). Only cave dwelling specimens are generally paler (Fig. 10D). Nymphs look very much like the adults in general colouring, with the 3 pairs of prominent spines on the hind tibiae already noticeable in specimens just a few mm long. This makes the species very easy to recognize. Females have a strong, long and relatively straight ovipositor, as long as, or longer than the body length. They use it to penetrate soft wood in rotting logs, where they lay their eggs (Fig. 10E). Small nymphs of *Miotopus richardsi* sp. nov. have been found right in the core of large rotting logs, suggesting that this is an environment in which they commonly spend the early developmental stages.

Obtaining information about diet depends on sporadic observations, but in *M. richardsi* sp. nov., as in other cave wētā the diet includes fungal and vegetable matter. We documented *M. richardsi* sp. nov.

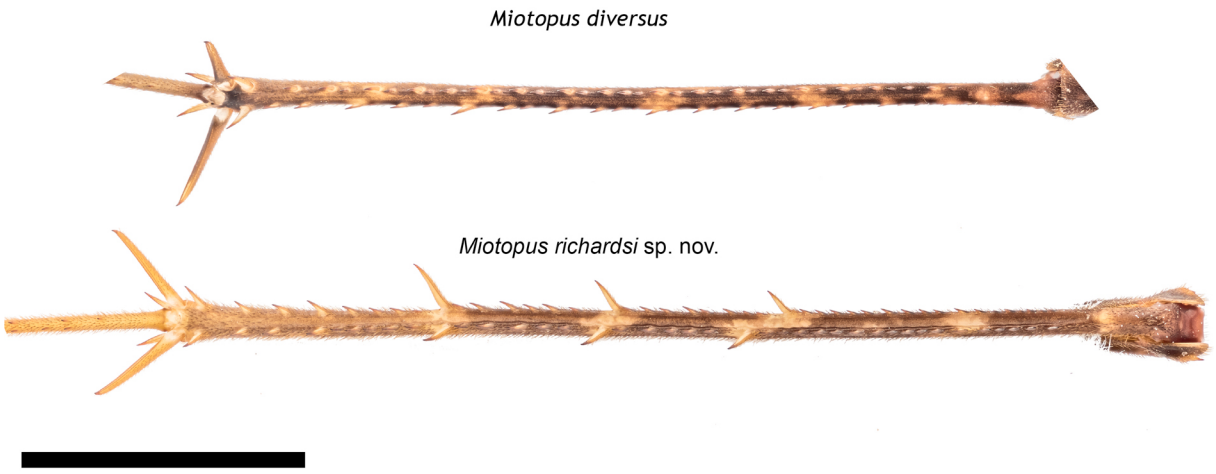

Fig. 9. Left hind tibia of cave wētā in the genus *Miotopus* Hutton, 1898, dorsal view. *Miotopus diversus* (Hutton, 1896) (MPN CW3601) (top) and *Miotopus richardsi* sp. nov. (MPN CW3543) (bottom). Scale bar = 5 mm.

feeding on lichen and leafy liverworts (*Plagiochila* spp.) on tree trunks, and on fungal fruiting bodies on the forest floor. It was also observed feeding on a beech strawberry fungus *Cyttaria gunnii* Berk., a meal it was sharing with a darkling beetle *Zeadelium intricatum* (Broun, 1880). We have also documented an adult *Miotopus* apparently obtaining moisture or slime from the head of a leaf-veined slug (*Pseudaneitea* spp.), while straddling it with its long legs (Fig. 10F), and have seen this behaviour in several other species of cave wētā.

Fig. 10. Living *Miotopus* Hutton, 1898 in their natural environment. **A–B**. *Miotopus diversus* (Hutton, 1896), adult ♂. **A**. Resolution Bay, Queen Charlotte Sound. **B**. Turitea Reserve, Palmerston North. **C–F**. *Miotopus richardsi* sp. nov. **C**. Adult ♀, Brewster Hut Track, Haast Pass. **D**. Female nymph, Gouland Downs Caves, Kahurangi NP. **E**. ♀, laying eggs in rotting wood, Brewster Hut Track, Haast Pass. **F**. ♀, 'licking' the slime off a native leaf-veined slug (*Pseudaneitea* spp.), Raspberry Flat, Matukituki River West Branch.

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