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A NEW *THYREOPHAGUS* MITE FROM HONEYDEW SCALE INSECTS ON BLACK BEECH *(NOTHOFAGUS)*

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ABSTRACT

Thyreophagus australis, sp. nov. is described and illustrated from the tests vacated by the honeydew coccid insect, *Ultracoelostoma* sp., in *Nothofagus solandri solandri* bark and from *Acrogenotheca* sooty mould fungi collected at Staveley, Canterbury, New Zealand.

KEYWORDS

Thyreophagus australis; mite; new species; beech *Nothofagus solandri*; honeydew; *Ultracoelostoma*; sooty mould fungi *Acrogenotheca*

INTRODUCTION

The honeydew beech forest, east of New Zealand's Southern Alps, is a distinctive ecosystem. A key species is the coccid scale, *Ultracoelostoma* sp. (Morales, 1988), which feeds on the beech tree's sap before excreting it as honeydew on the beech bark. The native bellbird, *Anthornis*, and vespid wasps feed on honeydew and it is gathered and sold by apiarists. Bark samples containing the secreted, protective shells (tests) of the honeydew coccid, *Ultracoelostoma* sp., were collected and found to contain a new species of mite, which was grown to maturity with milk powder. OConnor, (pers comm) assigned the mite to the genus *Thyreophagus*, an advanced Acaridae genus.

Fain (1982), in a review of *Thyreophagus*, reported that many species were collected near coccids and other insects. Klimov (1998) established the tribe Thyreophagini and restricted *Thyreophagus* to hold only three species. OConnor (1998) provided a key to the genera of the acarid mites including *Thyreophagus* and Klimov (2000) selected 40 characters as a basis for understanding the systematics of the Acaridae.

MATERIALS AND METHODS

During September 2002, I scraped bark containing many embedded sessile adult honeydew coccids and sooty mould fungi from black beech, *Nothofagus solandri solandri*. The scrapings were held in 25 ml vials at 80% RH and 20°C and examined every few days for the presence of insects and mites. In November 2002, a thriving colony of several hundred astigmatic mites was seen in and near the bark cavities that the coccids had occupied. These were transferred to a 25 ml vial with a few grams of whole milk powder. On this diet, the mite numbers increased and produced hundreds of phoretic hypopi (deutonymphs). Mites were cleared in chloral hydrate and mounted in Hoyer's. Illustrations were made with a camera lucida. All measurements are in micrometres (µm). Idiosoma and leg chaetotaxy follows Klimov (1998, 2000), which is based on Griffiths et al (1970, 1990).

SYSTEMATIC SECTION

Family ACARIDAE Latreille, 1802
See OConnor (1998) for family synonomy.
Subfamily RHIZOGLYPHINAE Oudemans, 1923

Genus *Thyreophagus* Rondani, 1874

Type species *Acarus entomophagus* Laboulbene, 1852.
Synonyms *Monieziella* Berlese, 1897
Fumouzea Zachvatkin, 1953 (Klimov, 1998)
Michaelopus Fain and Johnson, 1974

Adults

Hughes (1976) defined the genus on the lack of setae *sc, i, hi, d1, d2* and la in the adult. OConnor (1998) gave generic characters as follows: setae ve absent; dorsal cuticle

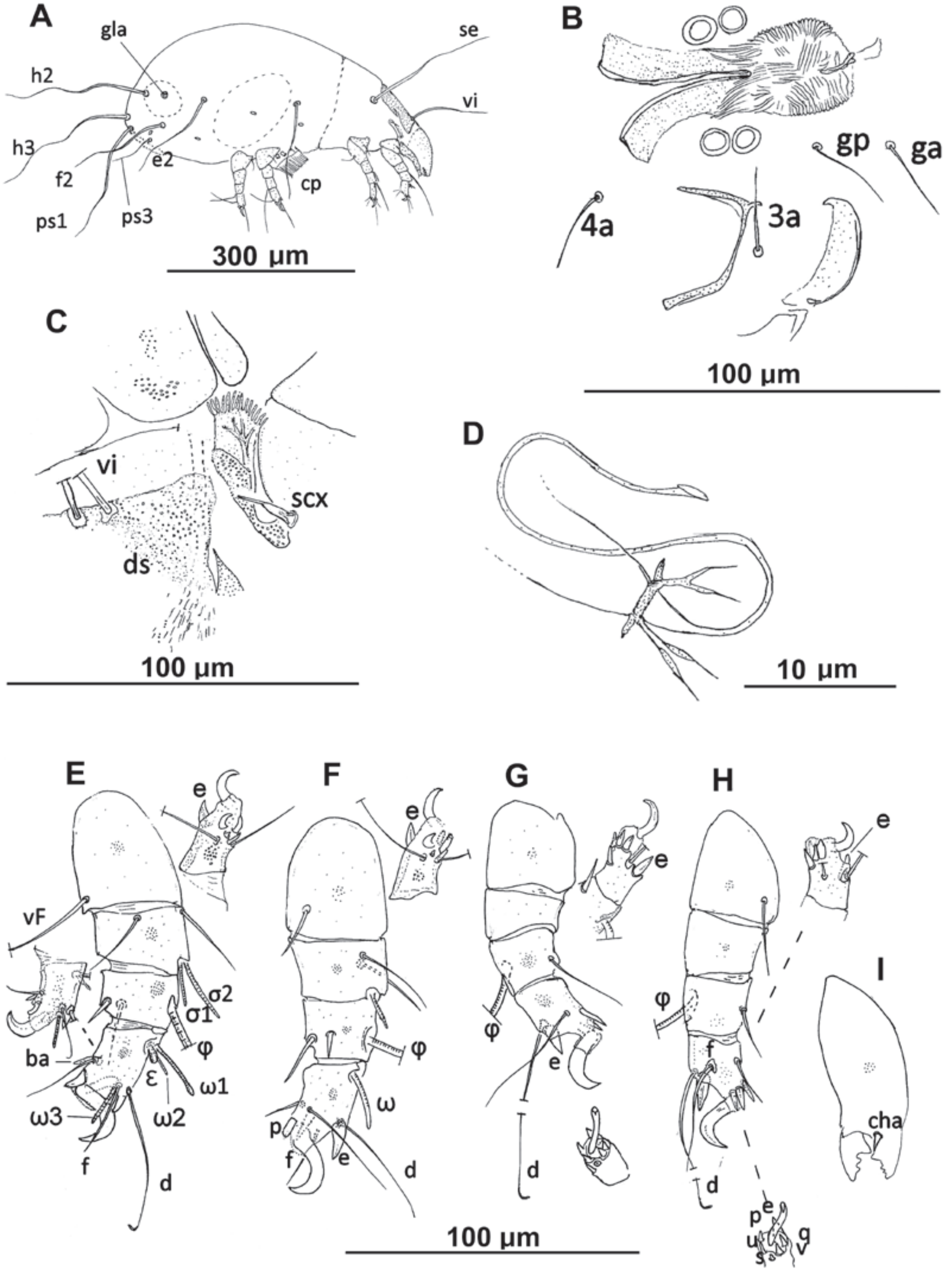

Figure 1. *Thyreophagus australi*s sp. nov. female. **A** - lateral view showing loss of dorsal hysterosomal setae. **B** - genital area. **C** - podocephalic canal floor (ds = dorsal shield). **D** - bursa copulatrix. **E – H** - legs I – IV with insets of tarsal ends; for III and IV setae are removed to show spine pattern. I – chelicerae

smooth; hysterosomal setae filiform; seta *ft* absent on tarsi I and II; tarsi short. Usually found associated with insects and sub-cortical habitats.

Klimov (2000) described the generic characters of *Thyreophagus* as; solenidion ω_3 short and club-shaped in males but longer and tapering in females. In the hypopus, ω_3 is inserted to tarsus I adjacent to ω_1. There is a reduction of Grandjean's organ (cheek gland); an absence of heteromophic males and the loss of setae ve in the hypopus. These advanced features are present in the new species described below. OConnor (1998) provided a diagnosis of *Thyreophagus* deutonymphs as; eyes widely separated in middle of propodosoma; distinct lenses present; usually on wood-associated insects. Fain (1982) based most of his species on females; he gave systematic value to the spermathecal sclerites (sperm store) of the females; number length and shape of tarsal spines and solenidia; the pattern of punctation and striation on the propodonotal shield (dorsal anterior) and leg chaetotaxy were also given weight to separate species. He listed the setae present to be designated in the older setae naming scheme *vi, sc x, sc e,* (3 propodosomal) *d4, d5, l1, l2, l3, l5, a1,*(7 hysterosomal) and *cx* I, *cx* III, *ga, gm* and *gp* (ventral) in females while in males, additional anal setae are present *a1, a2,* and *a3*.

Thyreophagus australis sp. nov.

Description

Female (Fig. 1)

Globose (not elongate) body in cultured material, but can be dorso-ventrally flattened, tanned gnathosoma and legs, white/clear shiny cuticle; legs becoming tanned in older specimens; more elongate body in wild-caught material July 2009. Holotype 480 long and 260 wide, paratypes averaged 460 long and 210 wide (n=5 range 420 - 500 x 190 – 220); anterior dorsal (propodonotal) shield 100 long, 85 wide as illustrated with punctuate markings and lateral incision. Small propodonotal lateral shields punctuate; adjacent to distinct podocephalic canal floor with about 15 membranous fingers as illustrated. Cheliceral seta c*ha* stout spine 9; scx 20 smooth, curved to blunt point, basal third thicker. Present as setiform; c_p e_2 and f_2 at hysteronotum lateral edges; *d* series lacking entirely (based on pore im position); f_2, h_2, ps_1 and ps_2 make up the seven pairs of setae, as in tritonymph. The posterior setae (h_2, h_3) filiform, corkscrewed are the longest (250 – 280); *vi* 105; *se* (260-280). Oil glands gla displaced posteriorly. Ventral coxal setae; *1a, 3a, 4a* and genitals *ga* and *gp*.

Solenidia; on leg I, ω_1, ω_2 and ω_3 all rather straight, 22, 9 and 15 respectively; σ_1 curved tapering to point, 25; σ_2 straighter, 15; ε (famulus) inflated, 4 and inserted at base of ω_1. Solenidiotaxy: tarsus 3, 1, 0, 0; tibiae 1, 1, 1, 1: genua 2, 1, 0, 0.

All legs with e as stout apico-lateral terminal spine10 long, 4 deep. Setae *d, f, la* and *ra* setiform on legs I and II; *d* longest with hooked slightly foliate end, 70 and 80 on I and II respectively. Legs I and II with six terminal spines, *e, p, q, s, u, v* and four setiform setae, *f, d, la,* and *ra*. Leg III with seven spines *e, s, p, q, u, v* and three setiform setae *f, d,* and *r*. On leg IV, there are six terminal or sub-terminal spines and four setae, *d, f, r,* and *w*. Legs III and IV *d* 90 - 110, hooked swollen tip. Chaetotaxy I – IV; tarsi 10, 10, 10, 10, tibiae 2, 2, 1, 1; genua 2, 2, 0, 0; femora 1, 1, 0, 1; trochanters 1, 1 ,1, 0.

Genital region between legs III and IV; two pair genital papillae; seta *ga, gp*. Thus *ga* added to tritonymph chaetome. Genital valves Y-shaped; valves thin cuticle plates; epigynium large as illustrated; receptacle seminalis sclerite sperm store base, store-ovary duct bases with Y-shaped sclerites, as illustrated. Holotype aberrant with anterior right genital papillae absent; left *ga, gp* absent.

Male (Fig. 2)

Only homeomorphic males seen (generic character of Klimov (1998)). The mean length x width of three paratypes was 450 x 210, range 420 – 490 x 200 – 230. Dorsal shield thin, punctate with lateral notches; 90 x 75. Male's general facies as for the female; globose with white shiny cuticle; same chaetotaxy, with three pairs of short setae ad_{1-3} flanking sucker; *vi* 90, *se* 200, *scx* as in female. Podocephalic anatomy as in female. Penis almost straight 10, housed in sclerotised structure between legs IV. Lumen smooth for terminal 10 then spirally corrugated as sperm pump for 10. Anal suckers 20 in diameter as illustrated. Seta ad_3 anterior to suckers is minute; ad_2 and ad_3 lateral, thick and posterior 6. Posterior, lateral to suckers is strip of reticulate, punctuate cuticle 13 long and 75 wide. No post-dorsal hysterosomal or projecting shield. Legs as illustrated, tanned, short, punctate. Segment lengths for tarsus (including claw) to femur respectively I, 44, 16, 20, 36; II, 44, 16, 20, 40; III, 40, 16, 16, 28; IV, 32, 20, 16, 32. Claws 16 long, stout, retractable. The chaetotaxy of tarsi

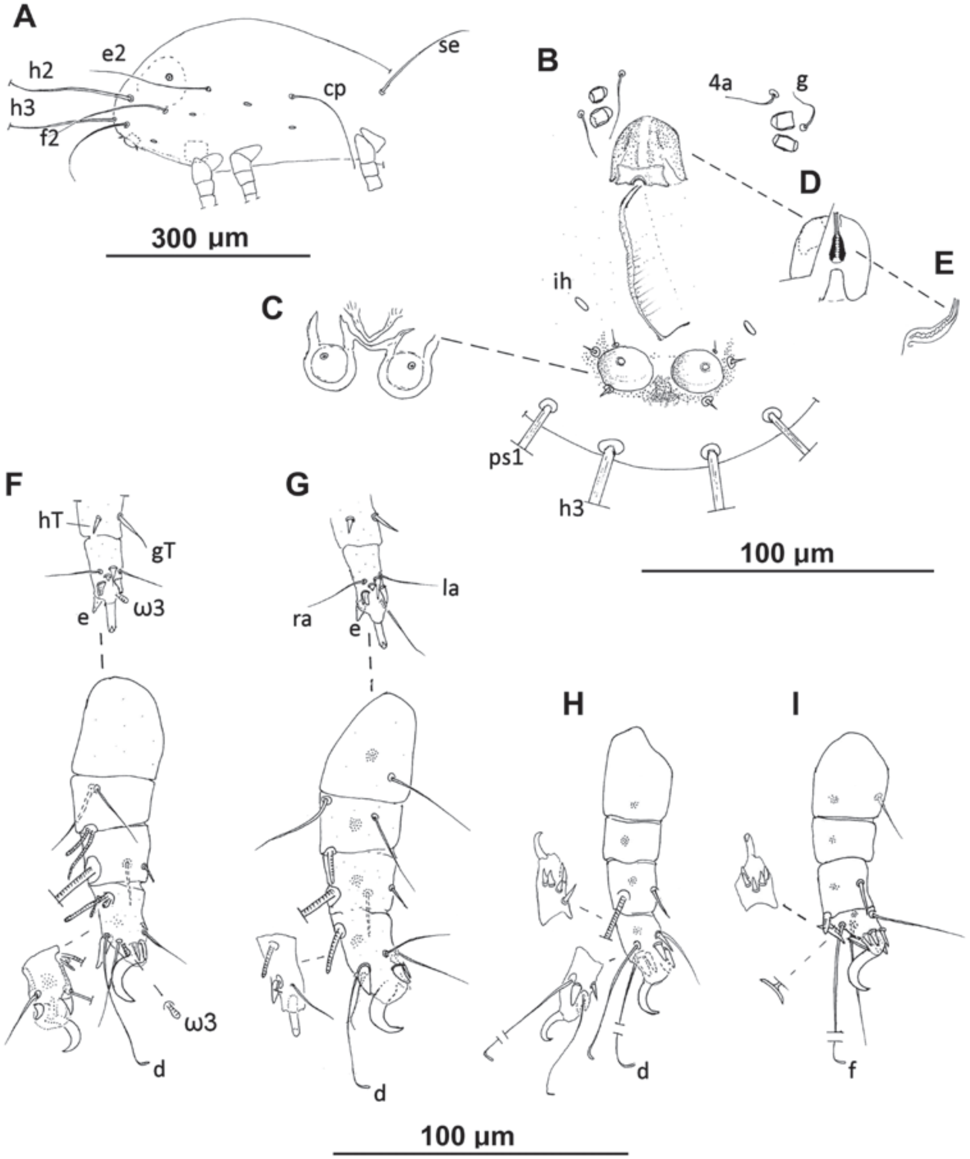

Figure 2. *Thyreophagus australis* sp. nov. male. **A** - lateral view of body. **B** - ventral view showing genital region. **C** - chitinized sub-skeleton of anal suckers. **D** - cut away view of chitinised housing of penis to show penis. **E** - lateral view of penis. F – I - legs I – IV

I, II and III as for female. On leg IV, *d* and *e* are modified into suckers while *f, w* and *r* are setiform; s, p, q, u, v spines. Tarsal chaetotaxy is therefore 10, 10, 10, 10; as in the female. Seta *d*, I-III terminal hook as in female; *d* III, 110; *f* IV, 100.

Solenidia: On tarsus I: ω_1, ω_2 and ω_3 19, 7 and 4 long respectively; ω_3 short, bent and club-tipped. Famulus (ε) as in female. On genua I σ_1 and σ_2 20 and 14 respectively with σ_2 tapered. II, ω 15 and genua II σ, 10. On tibia IV, φ is short, blunt.

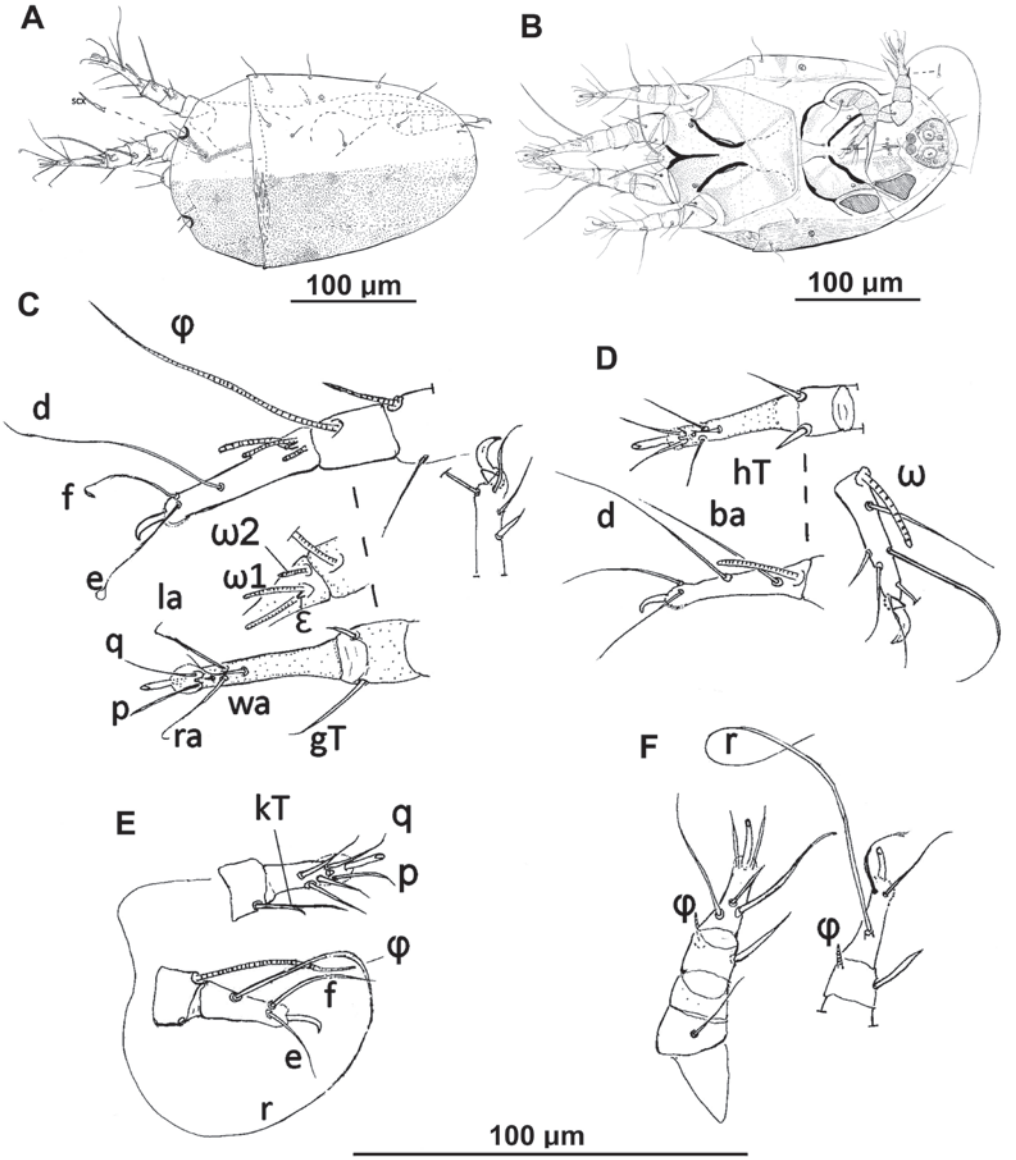

Figure 3. *Thyreophagus australis* sp. nov. hypopus. **A** - dorsal view. **B** - ventral view. **C – F** - legs I – IV in dorsal and ventral views; for leg II (**D**) ventral view of six ventral setae and dorsal view of four dorsal setae

Hypopus (Fig. 3)
All material from laboratory cultures. Post-dorsal shield lateral edge turned under in all mounted material. Hypopi are sclerotized; deep bodied, almost circular (depth = width) in cross section when alive. They bear the six characters outlined by Klimov (1998) for the genus but with seta *e* of tarsus I without foliar saucer; Setae of legs often thickened, but afoliate – see discussion. Body 220 long x 164 wide (range 240 – 264; 152 – 184; n=4 paratypes). Propodonotum finely and evenly punctuate

82 long x 154 wide; hysteronotum tanned and punctate as propodonotum: striate at segugal furrow, 164 long (paratypes n = 5). Gnathosoma 15 x 15. Eyes as se alveoli, cup shaped 10 wide 75 apart: inner pigmented layer (retina) 5 wide.

Dorsal setae present include *vi, ve, si, scx,* c_{1-3}, *cp,* d_{1-3}, e_{1-2}, h_{1-3}. All dorsal setae 15-30 long, curved and setiform. Setae *scx*, 21 stouter basal third 2 wide, then setiform curved; blunt ended, (non-bifid).

Length of femur, genua, tibia and tarsus (including claw) for legs I – IV respectively I 32, 16, 20, 50; II 30, 16, 16, 40; III and IV 12, 12, 12, 32. Tibia same length as genua.

Leg chaetotaxy: trochanter 1, 1, 1, 0; femur 1, 1, 0, 1; genua 2, 2, 0, 0; tibia 2, 2, 1, 1. Tarsi 9, 9, 8, 8.

Tarsus I with *e, f, p, q* terminally inserted; *p* and *q* slightly thickened but with attenuated tips; e and *f 25* terminating slightly foliate; *s* setiform 4; *la* and *ra* decurved at tip, thickened, afoliate, inserted proximal to *s*. Dorsally *d* 50 inserted 10 proximal to *e*. Tibia I with *hT* 8 spine-like and *gT* 16 setiform.

Tarsus II with *e, f, p, q* as on I with s vestigial (alveolus only); *wa* spinous flanked by *la* and *ra*. Seta *ba*, filiform inserted 7 distal to ω; *d* as on tarsus I. Thus tarsus II has four terminal setae, three mid-ventral (*wa, la, ra*) and one mid-dorsal (*d*) and one proximal dorsal (*ba*) making nine. Tibia II setae as for tibia I, but *hT* a stouter spine on II.

Tarsus III with *e, f, p* and q thickened with attenuated tips; three ventral setae similarly shaped. Seta *r* 150. On tibia III, *kT* thick, bifurcate; φ 50 tapers evenly to a point; Genua III nude, nG lost. Tarsus IV similar to tarsus III, *r* 120; tibia IV φ 9, even taper, pointed. Possibly barbs on *r* III and IV and *kT* of IV. Sternum 42 long. Post-ventral sucker plate length x width is 40 x 37; largest sucker diameter 8.

Solenidiontaxy: Tarsi 3+ ε, 1, 0, 0. Tibia(Φ) 1, 1, 1, 1. Genua 1, 1, 0, 0; ω_3 near ω_1. ω_1, ω_2 and ε (pointed) 16, 18, 3 long; ω23 stout on tarsus II. Gnathosoma α 42.

Larva (Fig. 4)
Egg shaped, three paratypes 140 x 100, 230 x 95, 210 x 100. Claparede's organ 7.5 x 3; form as for genital papillae. Legs, body and gnathosoma weakly tanned 35 x 24. Dorsal shield 35 - 40 x 35 - 40, smooth; *vi* 25; *se* (50 - 70); *scx* 8 as a curved spine thickened at basal third. Flattened finger-like membranous anterior floor to the podocephalic canal as in all other instars except hypopus. Sejugal furrow prominent.

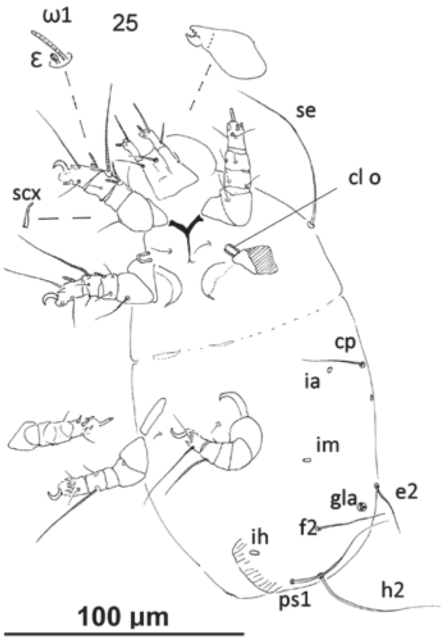

Figure 4. *Thyreophagus australis* sp. nov. larva in ventral view (cl o = Claparedes organ coxal rods)

Post-sejugal hysterosomal setae restricted to 3a and only five pairs of caudo-lateral setiform setae. Setae c_p, e_2 (both 30), h_2 70 on the lateral margin; f_2 30, ps_1 60. Legs I – III 48, 48 and 42 long from proximal femur to claw (8) tip. Leg I: φ 52, ω_1 8 slightly clubbed, ε inflated 2.5 x 1.5, σ tapering to point 8; ω_2, ω_3, absent, σ_1 8, σ_2 4, *f* 8, *d* 22 hooked, *la* and *ra 12* setiform, *u* and *v* as curved spines 2.5. Leg II: ω 4, φ 40, *d* 24 hooked, *f* 9, *vF* 11, *cG* and *mG* 5, *gT* 4 spine, *hT* 4. Leg III: φ, 28; σ and *nG* absent. Trochanter, femur and genua nude; *d* 32, *f* 9, *wa, p, q, u, v,* all 2.4. Leg chaetotaxy: trochanter to tarsus I, 0 1 2 2 11; II, 0 1 2 2 11; III, 0 0 0 1 11.

Protonymph (Fig. 5)
Body length x width of 5, 278 x 147 (range 272 – 290, 140 – 160). Sejugal furrow distinct. Dorsal shield 50 x 50 punctate. *vi* 40, *se* 90, *scx* 13. Podocephalic canal anatomy as in adult with associated finger like swellings below end of podocephalic canal. Added to the larval hysterosomal

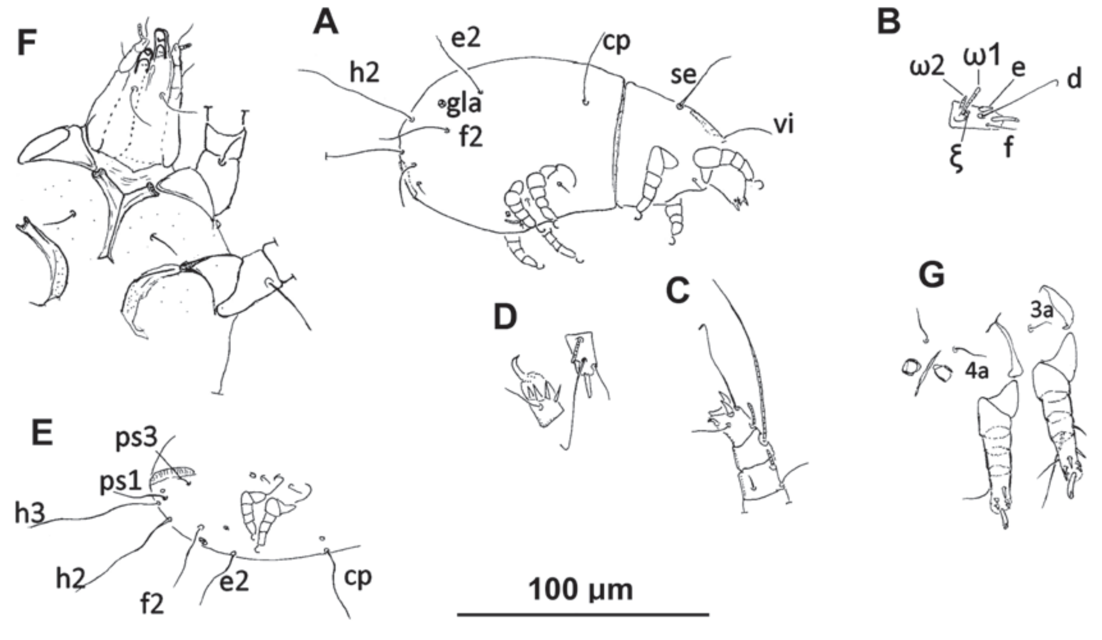

Figure 5. *Thyreophagus australis* sp. nov. protonymph. **A** - latero-ventral view. **B** - dorsal view of tarsus I. **C** - leg II in more detail with claw retracted. **D** - spine pattern on leg III. **E** - ventral view. **F** - sternum. **G** - view of legs *III and IV and genital region*

chaetome are *4a*, h_3 and ps_3. Also added, leg IV and ω_2. c_p 40, e_2 100, f_2 70, h_2 60, h_3 140, ps_1 25, ps_3 16; all filiform. Genital opening 20 long; one pair genital papillae. Leg length I - IV including claws from five individuals, 70, 67, 56, 50. Legs tanned, punctate.

Tritonymph (Fig. 6)

Length 450, width 230. Body globose. Dorsal shield 65 x 65. Second pair of genital papillae, seta *gp* and ω_3 added to protonymph. Leg segment lengths, Tarsi to femur I to IV including claw (12): I 32 12 12 28; II 28 12 12 30; III 28 12 8 20; IV 28 12 8 20. *vi* 50, *se* 150, c_p 100, e_2 80, f_2 110, $h_{2,3}$ 210, ps_1 110, ps_3 40. Solenidion ω_3, 10, straight evenly tapering to blunt tip (female form); inserted dorsally mid way between ω_1 and *d*; not as in adults (apically) or as in hypopus (same field as ω_1 and famulus). Legs I – IV with φ 90, 70, 70, 27. No sexual dimorphism detected in tritonymphs. Podocephalic entrance floor with up to 15 finger-like structures as other stages. Leg chaetotaxy and solenidiotaxy as for adults (Except for ω_3).

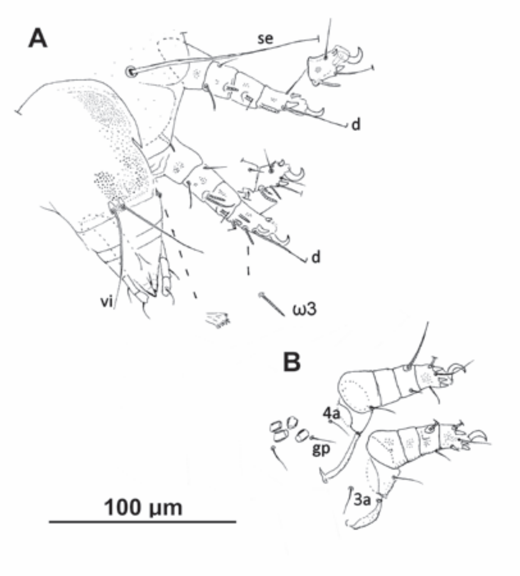

Figure 6. *Thyreophagus australis* sp. nov. tritonymph. **A** - dorsal shield and legs I and II (solenidia removed to emphasise ω3 insertion and shape). **B** - ventral view of legs III and IV and genital region

Ova

Smooth shelled; average length x width 133 x 65 (range 120 – 140 x 60 – 70, n=6). Up to three present at a time in female's body (in culture).

Type material

Holotype female. Paratype females homeomorphic males, hypopi, larvae and protonymph, all from culture on milk powder grown from mites taken from black beech *Nothofagus solandri* bark collected at breast height, northern side, from the car park at the end of Flynn's Road, Sharplin Falls Scenic Reserve, Alford Forest; NZ Map 260 Series K36 (Methven) Map ref 298 824, Staveley, Canterbury, New Zealand; altitude 460 m. All material collected by JM Clark in September 2002 and 23 July 2005. Types slide mounted in Hoyer's gum-chloral medium. Bulk material (non-type) in glycerol alcohol or dry held in Canterbury Museum, Christchurch, New Zealand. Additional bulk culture material is held at Museum of Zoology, University of Michigan, Ann Arbor, USA.

Holotype female; paratype female, male, protonymph, deutonymph and larvae deposited in the Canterbury Museum, Rolleston Avenue, Christchurch, New Zealand. Paratype females, males, larvae, protonymphs and deutonymphs, deposited in the New Zealand Arthropod Collection, Mt Albert Road, Auckland, New Zealand and the Museum of Zoology, University of Michigan, Ann Arbor, USA.

Etymology

Thyreophagus australis is named for its southern location.

BIOLOGY AND DISCUSSION

Diagnosis

This is the second species of *Thyreophagus* recorded from New Zealand and it is the first native species. Unlike *T. entomophagus* which has an elongate body, *T. australis* has a globose body. *T. entomophagus* (a cosmopolitan synanthropic species) has a projecting shelf posterior to the male anal suckers while this is absent in *T. australis*. *T. australis* bears more massive claws (18 - 19 long) than *T. entomophagus* (11 - 12 long). *T. australis* has larger spinous terminal setae on all legs and distinctive sclerites at the base of the spermatheca of the female's bursa copulatrix. Also, *T. australis* has much longer (up to 280 long) postero-lateral setae than *T. entomophagus*ε and the famulus is slightly inflated.

The possession of an elongate body of both sexes and the protruding shelf of the male are used as generic characters (Zachvatkin 1941, Fain 1982, OConnor 1998) but not by Klimov (2000). Wild-captured material in July 2009 from the type locality was more elongate than cultured 2005 material. *T. australis* hypopus has many similarities with *T. entomophagus* hypopus; *ba near* ω on tarsus II, lack of distinctly foliate setae, genua shorter or same as tibiae. Hypopus clearly differing from *T. entomophagus* as *hT* is spinose on tibia I in *T. australis* while setiform in *T.entomophagus*. In *T. entomophagus,* Fain et al. (2000) give ω tarsus II as 13 long in *T. entomophagus* while in *T. australis,* it is 23.

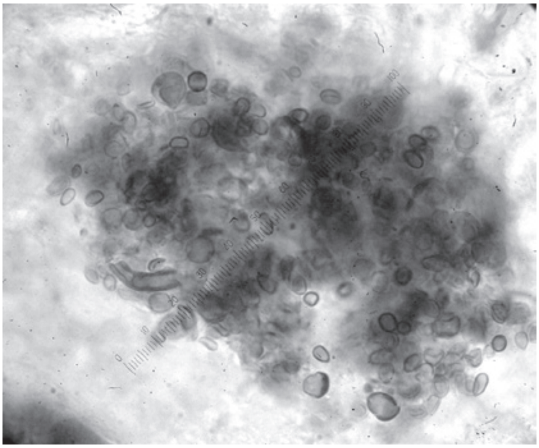

Figure 7. Photomicrographs of bolus of *Acrogenotheca* sp. from gut of wild-captured *Thyreophagus australis* sp. nov.

Biology

Morales et al. (1988) and Morales (1991) reviewed the predators and parasites of the *Ultracoelostoma* sp. coccid but did not include mites. A second sample from the type locality on 23 July 2005 revealed thriving colonies of a few dozen *T. australis* of mixed ages in the used and vacant tests of the *Ultracoelostoma* sp. coccid. Clearly visible inside these mites were several red/brown/yellow boluses which were the same colour as the inner lining of the coccid test (Fig. 7). This suggests that *Thyreophagus* feeds on the accumulated cast skins and the inner layers of the waxy/lipid test after the coccid's use. Access to the female's test by the mite is probably gained after the first instar coccid crawlers hatch and leave the test via the anal tube. Mites were also observed with fungal spores and hyphae in their gut.

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LEPIDOPTERA OF MATAWAI PARK, CANTERBURY

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ABSTRACT

A list is given of 51 moth species collected in newly established native shrubland/forest at Matawai Park, Rangiora, mid-Canterbury, by malaise trapping in 2005, and UV light-trapping during the evening of 7 January, 2008.

KEYWORDS

Lepidoptera; urban; species list; Matawai Park

INTRODUCTION

Matawai Park (situated at M35 2477 5766) is a 4.4 hectare scenic reserve in urban Rangiora, North Canterbury, which is administered by an advisory group under the auspices of the Waimakariri District Council. It lies on an old flood plain between the Ashley and Waimakariri rivers, 6 km from the east coast and at an altitude of 20 m above sea level.

Before human occupation, the site's vegetation consisted of lowland podocarp - hardwood swamp forest and wetland, in a site dominated by the hydrological dynamics of the flood plain. From the mid 1800s, the Rangiora district was logged for timber to meet the demands of a growing population, and the site was cleared and drained for farming. Typical soil types are heavy clays and silts and, as the town expanded, this area was too wet to build on and so the site remained as grassy, wet paddocks. The last remnants of the original forest in Rangiora were removed in the decades just preceding the development of the park in 1970.

In 1972 - 73, soil and rubble from road widening was dumped at the site and was formed into mounds and hollows. A pond was dug and fed by springs within the park. This landscaping significantly changed the natural soil structure and drainage patterns, forming the park topography we see today. Since then, the planting of over 20,000 native trees and shrubs has formed bush/shrub areas which surround a network of mown grass alcoves and open spaces, making the park about half native tree/shrub plantings and half mown grass. The park is now bounded on all sides by suburban streets and town housing. The nearest remaining natural native forest is the foothills beech forest, 16 km to the northwest.

Initial plantings were native species from a range of sources, which stood a good chance of survival. In 1993, a management plan was prepared, determining that Matawai Park should reflect the native flora of the Canterbury region rather than a restoration of the earlier Rangiora Bush. Soon after, the principles of a modified ecological model of self-sustainability were adopted, meaning that ecological processes in the park should, where practical, mirror those of nature, rather than park management by a gardening approach. This means for example, that as trees die, they are left to rot in situ, providing greater habitat for decomposers and invertebrates. The self-sustainability model is limited by many urban factors, but helps to increase native biodiversity and promote cost effective management. Appropriate plant species enrichment and management is ongoing as growth proceeds and add to the plants and invertebrates already self-introduced to the park. The park's wide range of native Canterbury flora is arranged in a mosaic of plant communities; lowland podocarp swamp and dryland forest, shrub and margin communities, beech forest, short tussock grassland, waterways, wetland, 'coastal' and open mown-grass communities. The communities are arranged loosely from the 'mountains to the sea' to mirror plant distribution in Canterbury.

Nearly 40 years after the park was formed, the springs still flow, feeding stable waterways, which are slow flowing, with mostly muddy beds. Some of the waterways are shaded under a forest-like canopy, others are more open and there is a small pond.

The tallest trees in the park are now over 10 m high, and many plants are now regenerating naturally. The ground litter layer is well established under a variable canopy, and an increasing number of rotting logs are present on the ground in the 'forest' type vegetation. As the time goes on, developing ecological processes are leading to broadening of available habitats and an increased biodiversity. These factors lead to a more natural distribution of flora and fauna within the park. Matawai Park is habitat for a variety of native fauna and is a popular local park with opportunity for a wide range of passive recreation and study.

METHODS

JBW and GMW installed a malaise trap in the park at a secluded forested site on 12 March 2005 and removed the catch at eight regular intervals until 11 December 2005, thus covering the autumn to early summer season. Brian H Patrick, Otago Museum, identified the Lepidoptera caught. The survey concluded with a light-trapping operation by BWF using an 80-watt mercury vapour light suspended over a white sheet on the evening of 7 January 2008.

Notes on the taxa, food plants (in square brackets), are largely from Ward et al. (1999); species names from Dugdale (1988), from the Landcare Research website (see references below) and from Patrick and Dugdale (2000).

RESULTS

MT indicates a malaise trap catch; UV a light trap catch. All recorded species are endemic unless indicated otherwise with an asterisk.

List of Lepidoptera caught:

Family Cosmopterygidae (7 species, 4 endemic, 1 adventive, 2 others). Small moths, pointed wings with long hair fringes and diverse life histories.
Pyroderces deamatella (Walker, 1864) MT

Family Crambidae (226 endemic species, 7 adventive, all named). Small, often brightly-coloured, associated mainly with grasslands, mostly nocturnal moths with larvae of each sub-family specializing on feeding on mosses, grasses, ferns, foliage or the roots of plants.
Eudonia leptalea (Meyrick, 1884) MT
Eudonia sabulosella (Walker, 1863) (sod web-worm) MT
Orocrambus flexuosellus (Doubleday in White and Doubleday, 1843) [grasses] MT
Scoparia chalicodes Meyrick, 1884 MT
Scoparia (s.l.) diphtheralis (Walker, 1866) MT
Udea flavidalis (Doubleday *in* White and Doubleday, 1843) [Muehlbeckia etc] MT

Family Depressariidae (16 species, 13 endemic, 3 adventive, all named). Mine moths
Agonopteryx alstromeriana (Clerck, 1759) MT

Family Gelechiidae (49 species, 39 endemic, 10 adventive, all but one named). Small moths, mostly leaf miners, and most species fly at dusk or by night.
Anisoplaca achyrota (Meyrick, 1885) MT

Family Geometridae (340 endemic species, 8 adventive, all named). Medium sized moths with triangular wings and usually slender abdomen (except *Declana* spp. which resemble Noctuidae in appearance). Larvae are loopers and most are specialist feeders on flowers, shrubs, herbs or trees.
Asaphodes aegrota (Butler, 1879) [herbs] UV
Austrocidaria gobiata (Felder and Rogenhofer, 1875) [*Coprosma* spp.] MT UV
Austrocidaria similata (Walker, 1862) [Coprosma spp.] MT UV
**Chloroclystis filata* (Guenée, 1857) [flowers, *Hebe* etc] Tasmanian MT
Chloroclystis inductata (Walker, 1862) [flowers] MT
Cleoria scriptaria (Walker, 1860) [*Pseudowintera colorata*, kawakawa, kowhai; eats holes in leaves] MT
Declana leptomera (Walker, 1858) [polyphagous] MT UV
Declana niveata (Butler, 1879) [*Hoheria angustifolia*] MT UV
Epiphryne verriculata (Felder and Rogenhofer, 1875) [*Cordyline* spp] MT
Epyaxa lucidata (Walker, 1862) MT
Epyaxa rosearia (Doubleday in White and Doubleday, 1843) [herbs] MT
Homodotis megaspilata (Walker, 1862) [*Coprosma* spp.] MT UV
Hydriomena deltoidata (Walker, 1862) [*Plantago* spp.] MT UV
Pasiphila sandycias (Meyrick, 1905) [*Coprosma* spp.] MT
Pseudocoremia suavis Butler, 1879 [polyphagous] UV

Xanthorhoe semifissata (Walker, 1862) [*Cardamine* spp.] UV
Xyridacma ustaria (Walker, 1863) [*Pittosporum* spp.] MT

Family Hepialidae (27 named endemic species). Large moths with heavy abdomen, ponderous flight, with most species displaying variable wing patterns. Larvae live in subterranean tunnels and emerge at night to browse on grasses or mosses. Most species are regarded as crop pests, especially *Wiseana* species.

Wiseana copularis (Meyrick, 1912) UV
Wiseana umbraculata (Guenée, 1868) UV

Family Noctuidae (139 endemic species, 32 adventive, all named). Large nocturnal moths whose larvae are either specialist or generalist feeders on plant foliage.

**Agrotis ipsilo*n (Hufnagel, 1766) [polyphagous] UV
Graphania insignis (Walker, 1865) [herbs] UV
Graphania mutans (Walker, 1857) [herbs] MT UV
Graphania plena (Walker, 1865) [herbs] MT UV
Graphania ustistriga (Walker, 1857) [herbs] UV
Meterana levis (Philpott, 1905) [*Plagianthus* spp] MT UV
Persectania aversa (Walker, 1856) [grasses] MT UV
Proteuxoa comma (Walker, 1856) [polyphagous] UV
Tmetolophota atristriga (Walker, 1856) [grasses] MT UV
Tmetolophota steropastis (Meyrick, 1887) [*Phormium* spp. (flax)] UV

Family Oecophoridae (259 endemic species, 12 adventive, all named). Small, dull-coloured mostly nocturnal moths whose larvae feed on leaf litter, either on the ground or perched on rocks or trees.

Atmotricha chloronota Meyrick, 1914 MT
Barea exarcha (Meyrick, 1883) MT
Stathmopoda horticola Dugdale, 1988 MT
Tingena melinella (Felder and Rogenhofer, 1875) MT
Trachypepla contritella (Walker, 1864) MT

Family Saturniidae (1 adventive species). Very large moths with doubly bipectinate antennae, often displaying colourful eyed wing markings and active at most times of the day, depending on species. Large larvae in final instar with sharp stinging hairs. Larvae feed on leaves of trees and shrubs. At the moment only one species is found in New Zealand (mainly North Island and as far south as Christchurch in the South Island).

**Opodiphthera eucalypti* (Scott, 1864), adventive (introduced), [*Eucalyptus* spp., other trees, mostly fruit bearing] UV

Family Tineidae (97 species, 84 endemic, 13 adventive, all but one named) Small moths whose larvae feed mainly on fungi, lichens and detritus. The most familiar members of the family are the clothes moths, which have adapted to feeding on stored fabrics.

**Opogona omoscopa* (Meyrick, 1893) [detritus] MT

Family Tortricidae (leaf-rollers) (174 endemic species, 11 adventive, all named). Small, bell-shaped moths, often orange, brown or yellow in colour. Their specialist larvae feed from within rolled-up leaves on various plants. Larvae wriggle vigorously when disturbed in their leaf roll. Several species are regarded as fruit tree pests.

Cnephasia jactatana (Walker, 1863) [polyphagous] MT
Cryptaspasma querula (Meyrick, 1912) MT
Ctenopseustis obliquana (Walker, 1863) [polyphagous; an apple pest species] MT
Leucotenes charactana (Dugdale, 2000) MT
Planotortrix excessana (Walker, 1863) [polyphagous; an apple pest species] MT
**Sperchia intractana* Walker, 1869 MT

DISCUSSION

Due to gale force winds arriving at Matawai Park during the single night's moth survey in 2008, the trapping procedure had to be terminated earlier than intended. However, 22 moth species were recorded on this occasion, 10 of which were new records not recorded in the 2005 survey. A small number of moth species additional to those listed above have yet to be identified.

During the summer months of the 2007 - 08 period, several other sites, mostly in the Christchurch area, were also surveyed for moth species by BWF. The only moths recorded at Matawai Park and not at any other of these additional sites were *Tmetolophota steropastis* and *Wiseana copularis*. The former species is a specialist caterpillar feeder on flax that is present in Matawai Park. The *Wiseana* species, like most hepialids, would be expected to specialise as a grass feeder. However, it is puzzling why this moth species was not recorded at other nearby sites, unless its flight period is exceptionally early or late.

Although none of the species of Lepidoptera recorded in the two surveys, so far identified, is regarded as 'at risk', the cosmopterygid species recorded from the 2005 survey belongs to a family about which very little ecology is known in New Zealand.

Reasons for an increase in moth species richness as a result of the second moth survey may be attributed to several factors. There may have been an increase in host availability since the first survey or the moth trapping technique and equipment used in the second survey may have attracted different species. Physical factors such as temperature, humidity and moon phase are all factors that influence moth activity. These factors vary on a nightly basis. More survey data of a botanical nature and further moth trapping sessions are required before accurate reasons can be concluded for the moth species richness of Matawai Park. Additional moth surveys at Matawai Park are needed before a comprehensive moth list can be established. However, the 2005 and 2008 entomological surveys of Matawai Park, in urban Rangiora indicate a site with great potential for the study of environmental and ecological education, especially in the field of Lepidoptera.

ACKNOWLEDGEMENTS

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EXCAVATIONS AND CHRONOLOGY AT THE REDCLIFFS FLAT SITE, CANTERBURY, NEW ZEALAND

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ABSTRACT

The Redcliffs Flat site is one of a number of early Maori archaeological sites that cluster near the mouth of the estuary of the Avon and Heathcote Rivers. Although several have been the subject of archaeological investigations, the chronology and extent of the Redcliffs Flat site remain poorly understood. Recent excavations associated with the redevelopment of a suburban section allow some progress to be made on both fronts. A small excavation here yielded a surprising amount of faunal, lithic and stratigraphic information. The site is shown to have extended to close to the edge of the estuary at the time of occupation and a radiocarbon date on a fragment of moa eggshell confirms the fourteenth to early fifteenth century status of the site. The radiocarbon chronology of the sites of the wider Redcliffs area is reviewed in light of this result.

KEYWORDS

midden; radiocarbon chronology; moa; Waitaha penguin; Maori prehistory

INTRODUCTION

Redcliffs is the scene of numerous archaeological investigations going back to the beginnings of archaeology in New Zealand (Haast 1874a, b; McKay 1874; Meeson 1889; Skinner 1923, 1924; Duff 1956, 1963; Trotter 1967, 1975; Holdaway and Jacomb 2000; Jacomb 2008). The sites at Redcliffs, specifically Redcliffs Flat (M36/24 in the New Zealand Archaeological Association Site Recording Scheme), Moa-bone Point Cave (M36/25), the Sumner Burial Ground (M36/22) and Moncks Cave (M36/47) have played an important part in the development of ideas about the origins of Maori and the relationship between "Moa-hunters" and Maori.

The dunes in which the Redcliffs site is situated have been extensively modified since the site was first discovered in 1851 (Trotter 1967) to make them suitable for residential development. The once rolling dune land has been almost completely levelled and the ground is now more-or-less completely covered with houses, parks and a school. The site is principally known through a number of small excavations near the rear of the school, on a property known historically as "Hamilton's". Other evidence recorded during the excavation of a sewer trench down the length of Main Road in 1969 led Michael Trotter (1975, fig. 1d) to infer that the site extended at least as far as the road and possibly some distance further to the east. In spite of the relatively large number of investigations at the site, there is surprisingly little known about its stratigraphy, extent and chronology. The true extent of the site has never been established.

SETTING AND SITE DESCRIPTION

Redcliffs is a suburb of Christchurch situated at the edge of the Avon-Heathcote Estuary near the point where the North Canterbury plains coastline meets the edge of the Port Hills on the north side of Banks Peninsula (Fig. 1). The Redcliffs site (often known as Redcliffs Flat to differentiate it from the nearby Moa-bone Point Cave and Sumner Burials sites) lies in dune land between high cliffs to the west and the estuary to the east. The edge of the site is approximately 300 m from the current estuary shore. The shoreline has probably changed since the time of occupation and it is likely that it was much closer then than today. The extent of the site itself is not known with any certainty as there is no archaeological evidence visible from the surface. However, it is reasonable on the basis of existing records to infer that the site covers an area of about 1-2 ha. Where intact archaeological deposits have been encountered they have typically comprised semicircular earth ovens with charcoal and oven stones, along with shell and bone midden and flakes of basalt that is assumed to be from a source nearby (Trotter 1975).

The part of the site that is reported here is situated on private property at 27 Main Road, Redcliffs. The

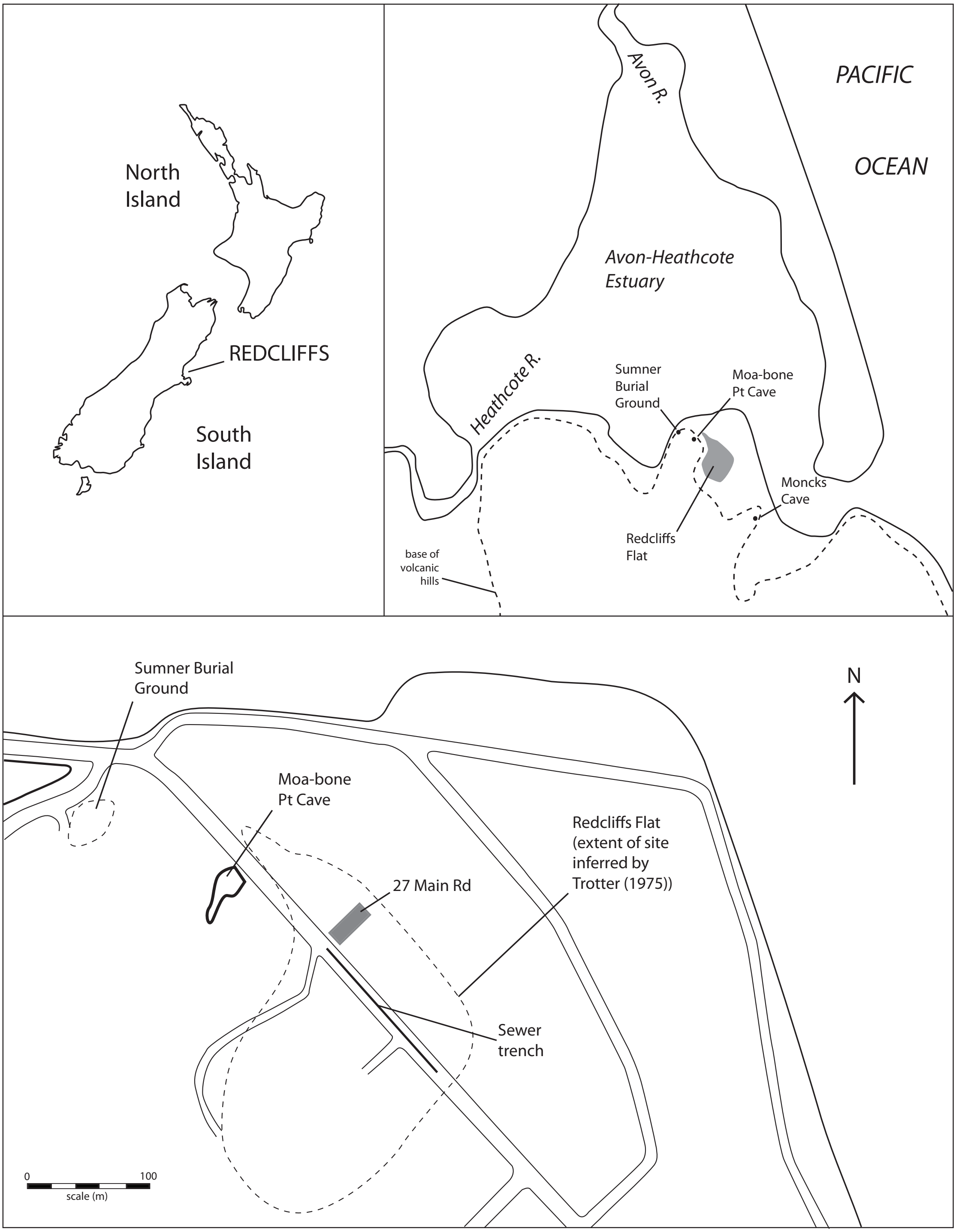

Figure 1. Location of the Redcliffs archaeological site and other sites mentioned in the text

property is adjacent to a small park that overlooks the Avon-Heathcote Estuary. The land had been levelled at some stage to provide a building platform and was originally rolling dune land (Trotter 1967). The property lies within the boundary of the site inferred by Trotter (1975). Following the demolition of an existing dwelling on the property ahead of the construction of a new house in 2003, midden became visible on the ground surface. To allow any archaeological evidence to be documented the foundation trenches for the new construction were excavated by hand by a small team under the direction of the author. Apart from a surface scatter of shell and bone that appeared after the existing house was removed, the only visible evidence of the site before the foundation trenches were excavated was a circular charcoal stain that was the surface indication of an underground earth oven.

INVESTIGATION AIMS AND METHODS

The aims of the investigation were to record any intact stratigraphy within the foundation trenches, to recover and analyse any faunal remains and material culture found, and to recover samples for radiocarbon dating.

The foundation trenches were excavated stratigraphically by hand methods using natural layers and by arbitrary 50 mm spits where the depth of any cultural deposit was greater than 50 mm. The investigation commenced at the southwest corner of the foundations and proceeded in a counter-clockwise direction. All material recovered was sieved through a 3 mm screen and was provenanced according to its distance along each trench (see Appendix 1). The faunal and lithic analyses were carried out using the comparative collections of the Archaeology Laboratories at the University of Otago. This paper reports the results, which include a radiocarbon age determination on one sample from the site and analysis of all faunal and material culture evidence encountered.

EXCAVATION RESULTS

The investigation had the following aims:

- to record any intact stratigraphy both within the cave and outside
- to recover samples for radiocarbon dating
- to recover and analyse any faunal and artefactual remains.

The primary objectives of the investigation were to determine when and for how long the site was occupied. Additional objectives were to determine whether or not there was evidence for multiple occupations of the site, and whether there was any difference in occupation time between the interior and the exterior. The site was excavated by natural stratigraphy and by arbitrary 50 mm

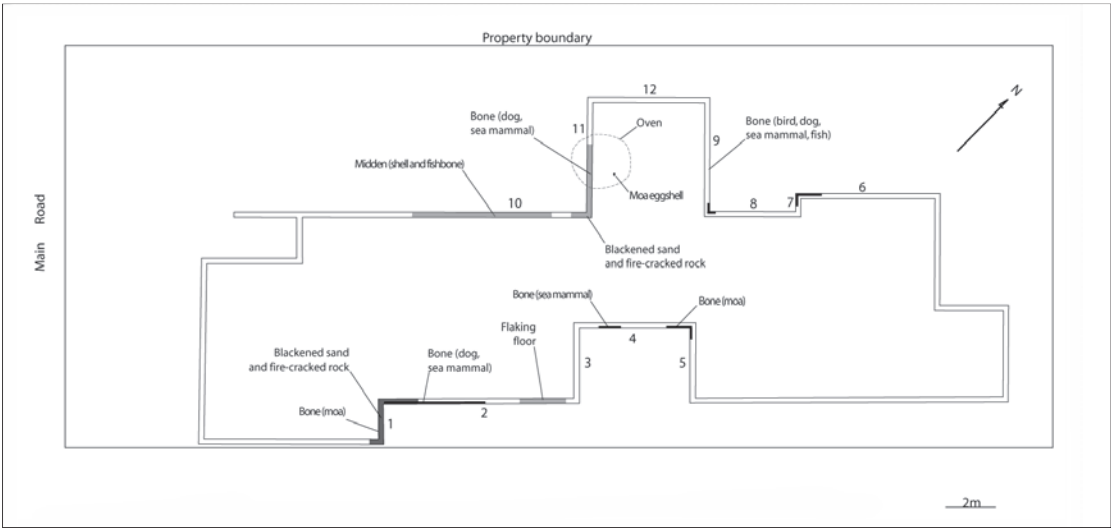

Figure 2. Building site at 27 Main Rd showing locations of foundation trenches and archaeological deposits

spits where the depth of cultural deposit was greater than 50 mm.

All material recovered was sieved through a 3 mm screen and the sieve contents retained for analysis.

EXCAVATION RESULTS

Stratigraphy and radiocarbon dates

A total of 20 m^2 was excavated, of which some 20 percent contained archaeological deposits (Fig. 2). The stratigraphy was very simple and comprised an overburden of clean sand with occasional pockets of construction material such as brick fragments, nails, etc. In several places this overburden sealed layers or lenses of cultural material beneath. The nature of the cultural material varied across the site and included charcoal-stained sand, fire-cracked rock, shell midden, fish bone, sea mammal bone, moa bone, and flakes of fine-grained basalt thought to be from a local source.

The stratigraphy varied across the site but can be summarised as follows:

0-250 mm	Sand with the occasional fragment of twentieth-century house construction debris
250-350 mm	Up to three lenses or layers of cultural material in sand that is generally charcoal stained
350-500 mm	Clean sand

It should be noted that the thickness of the overburden was not uniform and in some places was completely absent. For example, the oven in the north-central part of the property was visible from the surface. Also, some layers were only present in parts of the site. The topsoil and buried topsoil in Trench 8 was not seen anywhere else. The site was much disturbed by use in historical times and, as well as being well turned over for gardening and other activities, had modern rubbish pits in Trenches 2, 3 and 8 (Fig. 3). There was also some disturbance in Trench 4, which included a sheep bone in the interface of Layers 1 and 2. For this reason none of the material provenanced to either the rubbish pits or Trench 4 can be confidently attributed to the prehistoric sample.

Features

The oven, mentioned above, was visible as a circular area of charcoal-stained sand with fragments of charcoal and fire-cracked basalt ovenstones. Dating samples were obtained from this oven including a sample of unburnt moa eggshell which was submitted to the Waikato Radiocarbon Laboratory for AMS dating.

Other features encountered included a flaking floor in the northern part of Trench 2, a shell midden in Trench 10 and two concentrations of bone that included fragmentary moa in Trenches 1 and 2 (Figs 2 and 3).

The shell midden was situated in the north-central part of the site and comprised two layers or lenses of shell separated by about 10 cm of clean sand.

Material culture

Material culture was limited to items of stone – primarily a concentration of basalt flakes found in Trench 2 (Table 1, Appendix 1) and identified as a flaking floor. These included 661 unmodified flakes or pieces of shatter, 15 modified flakes and a small piece of pumice. One piece of basalt may have been used as a hammer-stone.

Table 1. Summary of lithic analysis (see Appendix 1 for details)

Material	Waste	Modified	Total
Basalt	642	11	653
Chert	6	1	7
Obsidian	5	1	6
Pumice	1	0	1
Silcrete	8	2	10
Total	**662**	**15**	**677**

The modified stone included a basalt adze preform and four polished basalt adze fragments, two worked flakes of silcrete, a chert flake and a single flake tool of obsidian that was green in transmitted light which is consistent with a Mayor Island source (Fig. 4).

Fauna

Although only a relatively small area of site was investigated, a reasonably wide range of fauna was encountered, including mammals, birds, fish and shellfish. The small amount of material recovered meant that no subsampling was necessary and the full sample was analysed (Appendix 2). The material collected was identified in the Otago Archaeology Laboratories. Minimum numbers of individuals were calculated using paired elements following Grayson (1984). The results are presented as follows:

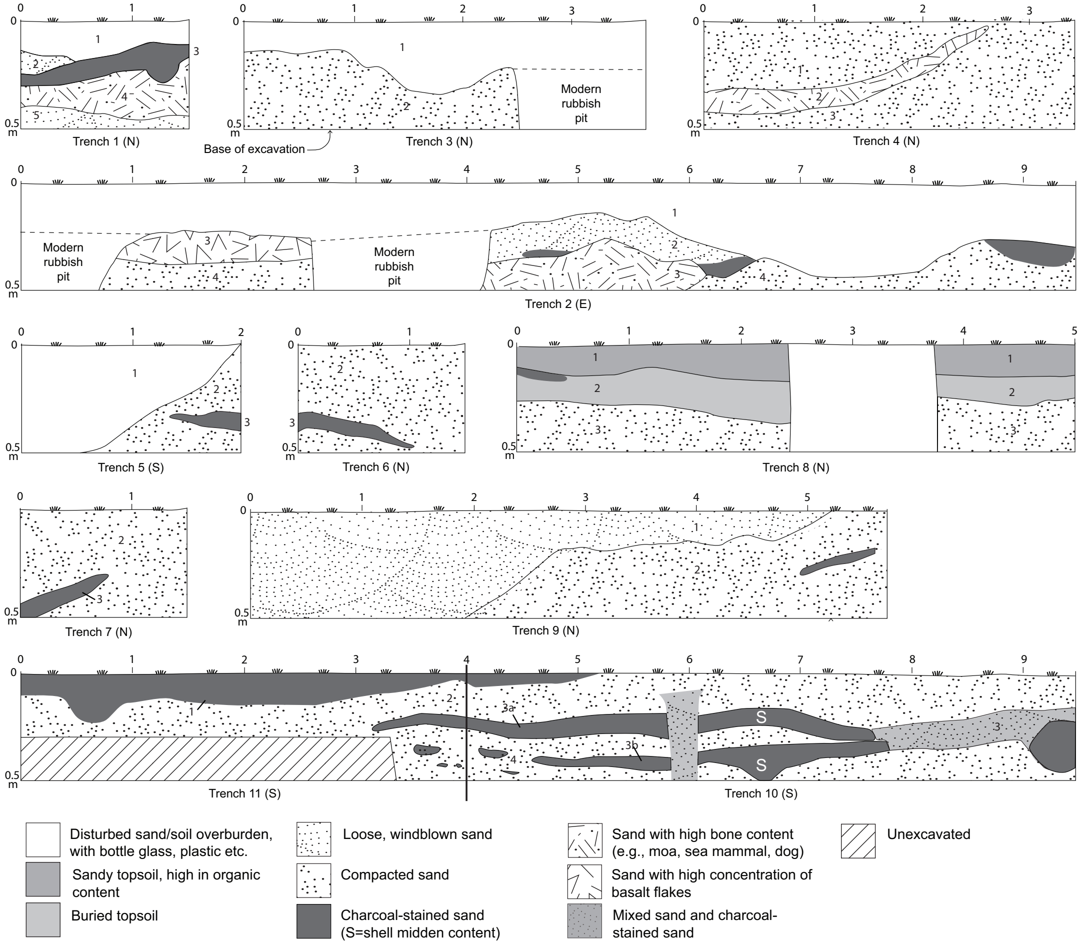

Figure 3. Section drawings showing all cultural deposits found at the site

Mammals

Mammal bones found at the site included those of dog (*Canis familiaris*), New Zealand fur seal (*Arctocephalus forsteri*), Hooker's sea lion (*Phocarctus hookeri*) and sheep (*Ovis aries*). The sheep bones were found in Layers 1 and 2 of Trench 4 (along with some of the sea lion bones) which attests to the degree of disturbance that has occurred at the site from dune levelling, house construction, gardening and other post-depositional activities. The majority of the remaining mammal bones were found in undisturbed deposits and can be assumed to be pre-European in origin.

Birds

At least nine avian species were recovered including two chickens (*Gallus gallus)* and single individuals of black swan (*Cygnus atratus*), pukeko (*Porphyrio melanotus*), shag sp., penguin (recently identified new species *Megadyptes waitaha* (Boessenkool et al. 2009)), New Zealand pigeon (*Hemiphaga novaseelandiae*), spotted shag (*Stictocarbo punctatus*) and moa, including moa eggshell. The moa bones are too fragmentary to be identified using morphological characteristics but are currently in the process of being analysed for DNA characterisation along with the eggshell fragments.

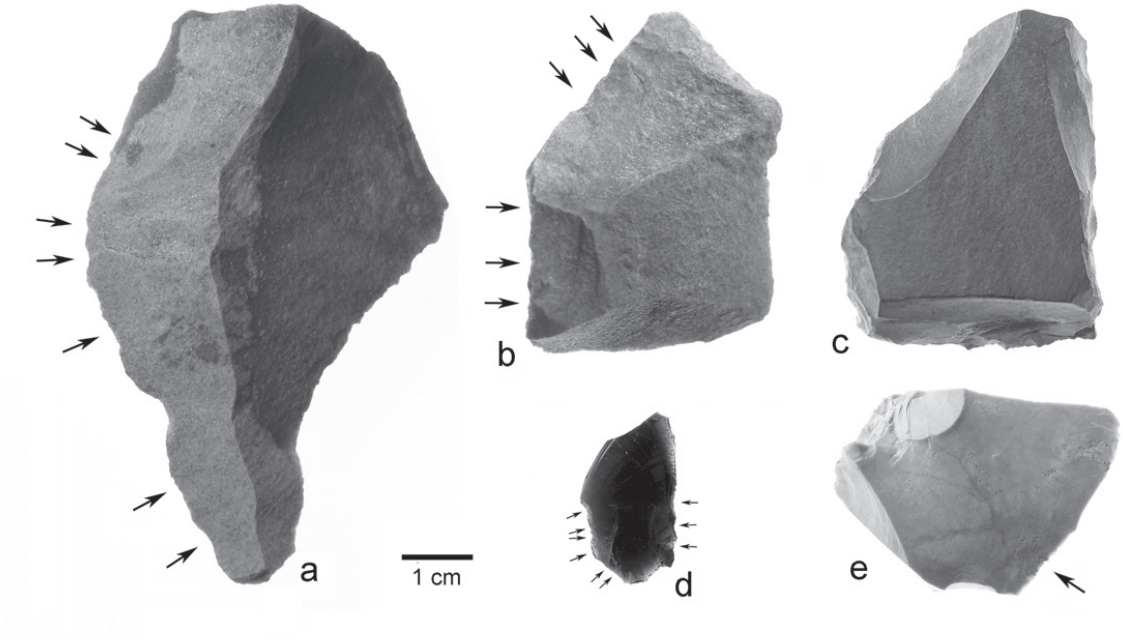

Figure 4. Worked stone found during excavations at 27 Main Rd, Redcliffs. Arrows indicate retouch or use wear. **a** - silcrete flake tool found on the surface near the oven; **b** - silcrete flake tool found in Trench 10, Layer 1; **c** - broken basalt adze preform found in Trench 2, Layer 3; **d** - obsidian flake tool found in Trench 2, Layer 1; **e** - chert flake found in Trench 2, Layer 3, with very slight use wear in zone indicated by arrow

Fish

Only one diagnostic fish bone was recovered – a snapper (*Pagrus auratus*) premaxilla.

Shellfish

The shellfish were analysed by counting bivalve hinges and dividing the total by two (Table 2, Appendix 3). There was only one univalve, a paua. Shellfish recovered included both soft shore (cockle and pipi) and rocky shore (paua and mussel) species, although the rocky shore species are only minimally represented.

Table 2. Results of shellfish analysis.

Species	MNI
Cockle (*Chione stutchburyi*)	34
Pipi (*Paphies australis*)	39
Paua (*Haliotis* sp.)	1
Mussel (*Mytilus* sp.)	1

Radiocarbon date

A single radiocarbon date was obtained on a fragment of moa eggshell from the top few centimetres of the large oven feature (Wk 23491). Moa eggshell is considered to be one of the most reliable materials to use for radiocarbon dating because of its inherent stability and resistance to contamination and because of its minimal inbuilt age (Higham 1994). The result of the eggshell determination is as follows:

Wk23491	CRA	604 ± 30 BP
Calibrated age	1 :	AD 1325-1345, AD 1390-1420
	2 :	AD 1310-1360, AD 1380-1430
δ	δ13C :	-10.2 ± 0.2

DISCUSSION

Site extent

The archaeological evidence from this investigation confirms that the Redcliffs Flat site extended as far towards the northeast as inferred by Trotter (1975). In other words, its northeastern margin was effectively at the shoreline of the estuary at that time (eg see Trotter 1975, fig. 1c for 1850 estuary extent). The site's northwestern and southwestern extents are limited by the presence of steep cliffs. There are no such topographical limitations to the southeast, so the extent of the site in this direction is less certain. However, in spite of ongoing redevelopment of this residential area there have been no reports of archaeological evidence to suggest that the site extends beyond the area suggested by Trotter (1975).

Stratigraphy

The stratigraphic record from the site indicates that much of its surface – at least on the portion that is the subject of this report - had been effectively planed off, along with any natural overburden, during earthmoving works associated with the development of the residential section. In addition, subsequent earth disturbance from residential activities resulted in the introduction of modern material into the site including sheep and chicken bones, as well as glass, bricks and nails. However, enough intact deposit remains for a general understanding of the site's depositional sequence to be inferred. The occupational deposit was laid down on a clean sand dune surface. The undulating nature of the basal layer suggests that the dune surface was not level at the time of occupation. It is possible that natural hollows were favoured because of the shelter they would have offered. The deposits of lightly charcoal-stained sand that resulted in the lensing in Trench 10 are likely to have been blown from elsewhere in the site, over a relatively brief period.

The absence of any significant vertical stratigraphy in the site does not necessarily mean that there is no time depth to the occupation. It is not unreasonable to expect sites like Redcliffs to have been sequentially occupied – perhaps over a number of decades – resulting in a "horizontal stratigraphy" as has been surmised at other sites including Rakaia River Mouth (Orchiston 1974), Panau (Jacomb 2000) and Karamea (Jacomb et al. in press).

Features

The oven, flaking floor, shell midden and bone concentrations indicate the range of activities that occurred at the site. Each was situated in separate parts of the site indicating specialisation of activities into discrete areas. The oven and shellfish midden were situated on the northern part of the property and the stone-working floor and bone concentrations were in the southern part.

Material culture

The flaked basalt and broken basalt adze preform indicate the manufacture of adzes at the site. The flakes with polished surfaces indicate refurbishment of adzes or re-use of larger adzes to make smaller artefacts. Significantly the basalt indicates use of local stone. In a similar vein, the absence of metasomatised argillite from the Nelson Mineral Belt in the site may indicate that earlier exchange systems and networks were no longer in action (Walter et al. in press).

The silcrete artefacts are relatively small examples for sites of this period. The main sources of this stone are in Otago although there was also a source at Grays Hills in the McKenzie Basin and there were smaller outcrops in North Canterbury; at View Hills for example. Silcrete artefacts – particularly blades – are often associated with the butchering of large game such as moa and sea mammals. Given the presence of both in the site it is reasonable to assume that function for the two artefacts of silcrete found here. Few artefacts of silcrete have been recorded north of Banks Peninsula, and the Redcliffs site, where 40 silcrete blades and 14 snapped blades have been documented (Jacomb 1995), may be considered to be the effective northern limit of its distribution.

Apart from the very small tool shown in Fig. 4d, all of the obsidian found was in the form of sub-centimetre sized pieces of shatter. All of the obsidian is green in transmitted light which suggests a Mayor Island source. The small amount found, combined with the small size of the pieces, suggests that there was no regular access to this material during the occupation of this part of the site.

The chert flakes are from an unknown source although it is likely to be local, since small amounts of chert are often found in Canterbury sites (eg see Burrage nd). Only one flake showed any sign of use. The volume of chert was much greater than that of the obsidian. Chert is probably functionally interchangeable with obsidian and the dominance of chert in this assemblage is significant as it again suggests a loss of ready access to obsidian.

Fauna

The faunal range is not unexpected and is consistent with that previously reported from Redcliffs. It shows that moa, sea mammals and a range of birds, as well as dog, were eaten at the site along with fish and shellfish. The mollusc remains suggest that local estuarine shellfish beds were favoured over more distant rocky shores. Snapper is a very rare visitor to this coast now but has been found in early archaeological sites as far south as Papatowai (Anderson and Smith 1992) as well as at Panau on Banks Peninsula (Jacomb 2000) and Moncks Cave (Jacomb 2008). The pukeko and chicken bones were found either in the modern Layer 1 overburden in Trench 2 or in the modern rubbish pit in Trench 3 and are not part of the prehistoric faunal sample.

The identification of large penguin bones to species has never been straightforward (eg Trotter 1975 app. II; Worthy 1997, p. 130; 1998), with the result that many have been misidentified as their closest fit – yellow-eyed penguin (*Megadyptes antipodes*). The recent discovery of a new species of penguin (*Megadyptes waitaha*) that became extinct following Polynesian settlement of New Zealand and was replaced by *M. antipodes* (Boessenkool et al. 2009) calls many of the earlier identifications into question. The single *M. waitaha* bone found at the Redcliffs site is consistent with an early occupation that occurred while that species was extant.

Chronology

Thirteen radiocarbon dates have previously been obtained from archaeological deposits at Redcliffs, of which eight are from the Redcliffs Flat site and five from Moa-bone Point Cave (M36/25) (Fig. 5). All of these dates were obtained at a time when many of the factors that are now known to affect the accuracy of the radiocarbon method were not well understood, including problems of inbuilt age associated with long-lived tree species (Anderson 1991) and pre-treatment, condition and contamination issues associated with bone (Petchey 1999). For this reason all but two of these dates (NZ1111

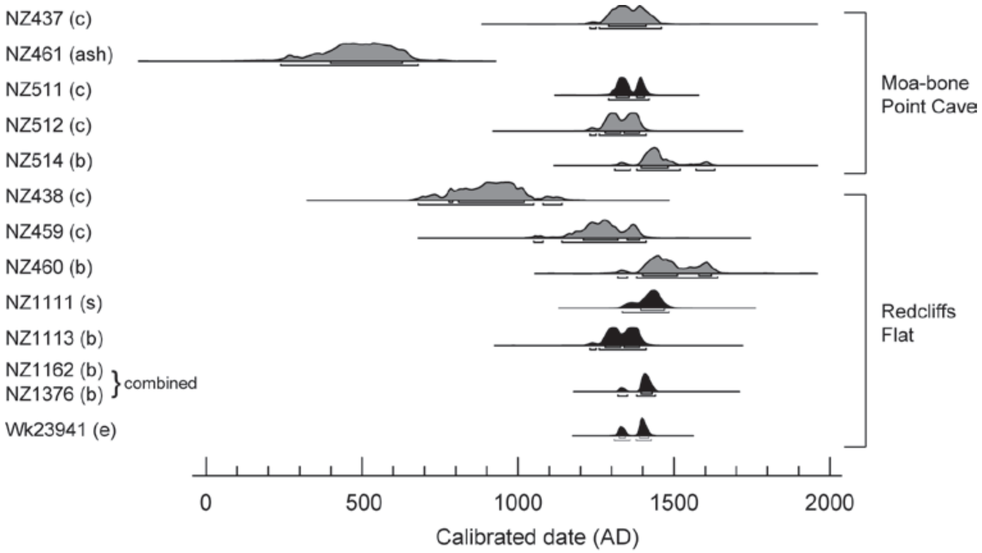

Figure 5. Radiocarbon dates for Redcliffs Flat and Moa-bone Point Cave (s=marine shell, c=charcoal, b=moa bone collagen, e=moa eggshell date reported in this paper). Age ranges with grey fill were assessed (Anderson 1991, Petchey 1997) as unreliable, as were NZ511, NZ1162 and NZ1376, which are here considered acceptable (see text). The radiocarbon determinations were calibrated using OxCal v3.10 (Bronk Ramsey 2005); Southern Hemisphere Atmospheric data from McCormac et al (2004) with the Hughen et al. (2004) modelled marine curve, with ΔR set at -25±15 yr (Higham and Hogg 1995) for the marine sample. All but Wk23941 were first reported by Trotter (1967, 1975) but conventional ages as recalculated by the Institute of Geological and Nuclear Sciences for dates measured prior to 1988 (see Challis 1995, p. 86) used here. Note that three dates from Redcliffs Flat are not shown because they were on bone carbonate which is considered unreliable for radiocarbon dating (Petchey 1999).

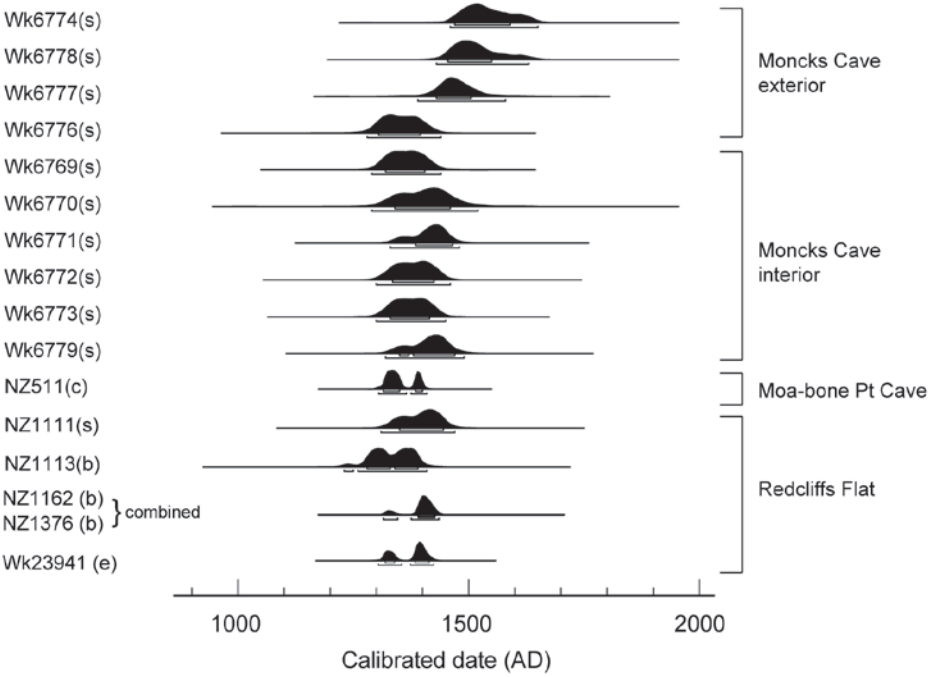

Figure 6. Acceptable Radiocarbon age estimates for Redcliffs Flat, Moa-bone Point Cave and Moncks Cave (s=marine shell, c=charcoal, b=moa bone, e=moa eggshell). Calibration data as for Figure 5

and NZ1113) have been classed as unreliable. A third date, from the lower cultural layer in the interior of Moa-bone Point Cave (NZ511) which had been rejected by Anderson can probably be added to the list of reliable dates as its sample was from the outermost layer of a post, with bark, reducing any suspicion that inbuilt age could affect its reliability (eg see McFadgen and Goff 2005). Two further dates, on moa bone collagen (NZ1162, NZ1376), were rejected by Petchey on the grounds that they could not be "validated through comparison with stratigraphically associated [dated] samples which are acceptable" (1997, p. 103). However, given the fact that the two dates (duplicates of a single sample) were found close to the middle of a site that has been shown to be a single layer deposit (Trotter 1975) with (now) three acceptable dates that lie in the same range, it is probably reasonable to accept these two dates after all. Since they are duplicates on a single sample it is appropriate to combine them. Their calibrated range after combining their conventional ages (Oxcal 3.10 R_Combine) is as follows:

Calibrated age 1σ : AD 1395-1430 (68.2%)
2σ : AD 1320-1350 (9.8%), AD 1380-1440 (85.6%)
X2-Test : df=1 T=1.8(5% 3.8)

A further site nearby, which lacks evidence for the hunting of moa, Moncks Cave (M36/47), is well dated with ten radiocarbon age estimates on cultural deposits (Holdaway and Jacomb 2000; Jacomb 2008). Moncks Cave is the only other site of any size in the wider Redcliffs area. Its dates range from the early 14th to the 16th centuries, although those from the interior of the cave have a much shorter span, indicating an age range between the 14th and early 15th centuries. The fauna from Moncks Cave is markedly different from that of the other Redcliffs Flat sites and contains none of the taxa that are thought to have gone extinct shortly after Polynesian settlement (Jacomb 2008).

All of the acceptable dates from Redcliffs Flat, Moa-bone Point Cave and Moncks Cave are presented here (Table 3; Fig. 6).

Table 3. Radiocarbon dates from archaeological sites at Redcliffs. List excludes dates culled by Anderson (1991) and Petchey (1999) except for NZ511 (see text). All Moncks Cave dates marine shell (*Austrovenus stutchburyi*)

Provenance	Conventional Age	Calibrated Age	Lab. No.
Redcliffs Flat			
Marine shell in oven fill (Trotter 1975)	924 ± 42 BP	1σ AD 1350-1445 2σ AD 1310-1470	NZ1111
Moa bone collagen from same context as NZ1111 (Trotter 1975)	701 ± 60 BP	1σ AD 1280-1330 AD 1340-1390 2σ AD 1230-1250 AD 1260-1410	NZ1111
Moa bone collagen from Sewer Trench, duplicate of NZ1376 (Trotter 1975)	622 ± 44 BP	1σ AD 1315-1355 AD 1380-1410 2σ AD 1290-1430	NZ1162
Moa bone collagen from Sewer Trench, duplicate of NZ1162 (Trotter 1975)	537 ± 45 BP	1σ AD 1405-1445 2σ AD 1320-1350 AD 1380-1470	NZ1376
Moa eggshell from oven at 27 Main Rd (this paper)	604 ± 30 BP	1σ AD 1325-1345 AD 1390-1420 2σ AD 1310-1360 AD 1380-1430	Wk23941
Moa-bone Pt Cave			
Large post outer rings (Trotter 1975)	640 ± 25 BP	1σ AD 1315-1350 AD 1385-1400 2σ AD 1305-1365 AD 1375-1410	NZ511
Moncks Cave interior			
G13 layer 2 lens 1 (Jacomb 2008)	980 ± 40 BP	1σ AD 1320-1450 2σ AD 1290-1440	Wk6769
G13 layer 2 lens 2 (Jacomb 2008)	910 ± 70 BP	1σ AD 1340-1460 2σ AD 1290-1520	Wk6770
G14 layer 2 spit 1 (Jacomb 2008)	900 ± 40 BP	1σ AD 1385-1465 2σ AD 1330-1480	Wk6771
G14 layer 2 spit 2 (Jacomb 2008)	950 ± 45 BP	1σ AD 1335-1425 2σ AD 1300-1460	Wk6772
G14 layer 2 spit 3 (Jacomb 2008)	960 ± 40 BP	1σ AD 1330-1415 2σ AD 1300-1450	Wk6773
L14 layer 2 (Jacomb 2008)	900 ± 45 BP	1σ AD 1350-1370 AD 1380-1470 2σ AD 1320-1490	Wk6779
Moncks Cave exterior			
K39 layer 2 spit 2 (Jacomb 2008)	780 ± 45 BP	1σ AD 1455-1550 2σ AD 1430-1630	Wk6778
K39 layer 2 spit 4 (Jacomb 2008)	830 ± 45 BP	1σ AD 1430-1505 2σ AD 1390-1580	Wk6777
K39 layer 2 spit 6 (Jacomb 2008)	1000 ± 45 BP	1σ AD 1305-1395 2σ AD 1280-1440	Wk6776
I45 layer 2 (Jacomb 2008)	750 ± 40 BP	1σ AD 1470-1590 2σ AD 1460-1650	Wk6774

The dates for Redcliffs Flat are too widely separated across the site to be combined for a refined age range but a crude estimate can be obtained by looking at the relationships between the standard errors. The three dates for Redcliffs Flat (one of which is a combined date) overlap at 1 sigma between AD1350 and 1390. This range is in close agreement with the date from Moa-bone Point Cave (lower layer) and suggests that both sites were occupied during the mid-late 14th to early 15th centuries. Although it is clear that the occupation of Moncks Cave extended well into the 15th and possibly 16th century, the occupation of its interior cannot be distinguished on the basis of existing radiocarbon evidence from the dated occupations at Redcliffs Flat. This means that the difference in fauna (and absence of moa at Moncks Cave) could be attributed to seasonality. It is only through analysis of the material culture evidence that a chronological difference can be identified. The artefacts found at Redcliffs Flat, the Sumner Burials and Moa-bone Point Cave (lower layer) are of types that Golson (1959) ascribed to the Archaic Phase of New Zealand East Polynesian Culture. Those found at Moncks Cave, on the other hand, are predominantly of types that appear intermediate between those of Golson's Archaic assemblage and those of the later prehistoric period (eg see Jacomb 1995; Holdaway and Jacomb 2000).

CONCLUSION

The stratigraphy, material culture, fauna and radiocarbon date from the small area investigated at 27 Main Rd, Redcliffs, are all consistent with the site being part of the main Redcliffs Flat occupation. The fact that no intact stratigraphy was found more than about half-way across the property suggests that this may mark the eastern extent of the site. The eastern boundary of the property coincides with a drop of about a metre to the adjacent park which was created on reclaimed mudflat according to Trotter (1975, p. 190).

Evidence previously recovered from the various deposits investigated at Redcliffs, including its varied faunal lists, range of material culture items, burials and stratigraphy – in the context of its broad ranging local environments – has been used to interpret it as a permanent overwintering base camp (Orchiston 1974; Trotter 1975; Anderson 1989; Challis 1995). Nothing was found during the current study to contradict this.

Although more radiocarbon determinations on reliable samples are needed to date the site with any certainty, the four acceptable dates on samples from Redcliffs Flat indicate that the spans of occupation for the Redcliffs sites (including the interior of Moncks Cave) lie within the mid-late 14th to early 15th centuries AD. The addition of the Moncks Cave exterior dates suggests that the occupation of the wider Redcliffs area was effectively over by about the end of the 16th century.

The evidence of loss of exchange networks described above is consistent with a date for this part of the site that lies within the mid to late part of the range that is usual for sites associated with moa hunting. The short timeframe indicated between the occupation of the Redcliffs Flat sites with their broad-spectrum hunting pattern and that of Moncks Cave with its highly specialised shellfish gathering regime is relevant to emerging discussions of the rapidity of the change from the one to the other that resulted from human impact on a naive or pristine environment (eg Holdaway and Jacomb 2000; Jacomb 2008; Jacomb et al. in press).

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Appendix 1. Results of lithic analysis.

Bag No.	Trench	Distance	Layer	Stone type	Waste flake	Modified flake	Total	Comments
1	4			basalt	9	1	10	one flake has a possible retouch scar
2	1			basalt	0	1	1	adze fragment with polish, found in N face
3	10		5	basalt	4	0	4	
4	2	1-4 m	3	basalt	8	0	8	
5	11		2	basalt	1	1	2	one flake has a possible retouch scar
6	7		2	basalt	2	0	2	
7	2		1	pumice	1	0	1	
8	2	5-8 m	1	basalt	2	0	2	
9	9		1	silcrete	1	0	1	recent edge damage
10	2	1-5 m	1	obsidian	0	1	1	green
11	2	1-4 m	3	basalt	1	0	1	
12	2	1-4 m	3	basalt	0	1	1	adze fragment with polish
13	3	rubbish pit		basalt	5	0	5	
14	9			basalt	3	1	4	
15	9		5	basalt	4	0	4	
16	2	1-4 m	3	basalt	0	1	1	adze fragment with polish
17	2	1-4 m	1	silcrete	1	0	1	weathered
18	10		1	silcrete	0	1	1	
19	surface		surface	silcrete	1	0	1	half weathered
20	3	rubbish pit		silcrete	1	0	1	

21	10		1	basalt	4	0	4	
22	10	1 m from N	5	basalt	4	0	4	
23	4	E end		basalt	18	0	18	
24	9			basalt	1	0	1	
25	surface			basalt	2	1	3	
26	surface			silcrete	0	1	1	some recent damage
27	4			silcrete	1	0	1	weathered with recent edge damage
28	9			chert	1	0	1	
29	2	1-4 m		basalt	0	1	1	adze preform
30	surface			basalt	6	1	7	
31	4			basalt	3	0	3	found in N face
32	1	E end		basalt	3	0	3	
33	2	1-4 m	3	chert	0	1	1	
34	2	1-4 m		chert	1	0	1	
35	2			basalt	0	1	1	adze fragment with polish
36	4			basalt	6	0	6	sieved sample
37	10			basalt	1	0	1	
38	2			basalt	10	0	10	
39	9			silcrete	3	0	3	recent breaks
40	2	1-4 m		basalt	0	1	1	possible hammer-stone fragment
41	2	1-4 m		chert	4	0	4	
				obsidian	5	0	5	from bag 41
42	2	1-4 m		basalt	8	0	8	
43	9			basalt	0	0	0	ovenstone fragments
44	2	1-4 m		basalt	537	0	537	sieved sample

Appendix 2. Results of faunal analysis (excluding shellfish).

Bag No.	Trench	Distance	Layer	Species	Element*	Side	MNE	Notes	MNI
1	2	1-4 m	1	*Cygnus atratus*	UL	R	1	C	1
2	2	1-4 m	1	*Gallus gallus*	FEM	L	1	C	2
3	2	1-4 m	1	*Porphyrio melanotus*	UL	L	1	C	1
4	2	1-4 m	1	unid.	?HUM	R		P	
5	2	1-4 m	1	*Gallus gallus*	HUM	R	1	DS	
6	2	1-4 m	1	not identified	DIGIT			C	
7	2	1-4 m	1	*Gallus gallus*	HUM	L	1	C	
8	2	1-4 m	Rubbish pit	*Cygnus atratus*	FEM	R	1	C	1
9	2	1-4 m	Rubbish pit	*Gallus gallus*	TT	R	1	PS	
10	2	1-4 m	Rubbish pit	unid.	?				

11	3	-	Rubbish pit	*Gallus gallus*	TMT	R	1	C	
12	3	-	Rubbish pit	*Cygnus atratus*	CC	R	1	DS	
13	3	-	Rubbish pit	*Cygnus atratus*	CMC	L	1	C	
14	3	-	Rubbish pit	*Gallus gallus*	HUM	L	1	PS	
15	3	-	Rubbish pit	*Cygnus atratus*	TMT	L	1	PS	
16	3	-	Rubbish pit	not identified	DIGIT			C	
17	3	-	Rubbish pit	not identified	SCAP			C	
18	9	-	-	shag sp.	FEM	R	1	C	1
19	9	-	-	fur seal?	FEM		1	Juv.	1
20	9	-	1	*Canis familiaris*	RAD	R	1	PS (joins 26)	2
21	9	-	1	*Canis familiaris*	UL	R	1	DS	
22	9	-	-	*Canis familiaris*	RAD	R	1	C	
23	9	-	1	*Canis familiaris*	RAD	R	1	D (joins 23)	
24	9	-	-	*Pagrus auratus*	Premax	L	1	C	1
25	4	-	-	*Phocarctus hookeri*	HUM	R	1	D	1
26	4		1 & 2	*Ovis aries*	RIB	1			1
27	1		-	*Megadyptes waitaha*	HUM	R	1	C	1
28	2	-	1	*Hemiphaga novaseelandiae*	COR	L	1	D	1
29	2	-	1	*Stictocarbo punctatus*	COR	L	1	C	1
30	11	-	2	not identified	DIGIT			C	
31	11	-	2	not identified	RAD			DS	
32	2	1-4 m	3	*Canis familiaris*	HUM	R	1	D	
33	2	1-4 m	3	*Canis familiaris*	TOOTH		1		
34	2	1-4 m	3	sea mammal	PEL	L			
35	2	1-4 m	3	sea mammal	FEM	L		S	
36	2	1-4 m	3	sea mammal	SCAP	L			
37	2	1-4 m	3	sea mammal	SCAP	L			
38	10	-	3a	sea mammal	CAR	L			
39	2	5-8 m	3	*Canis familiaris*	CR		1	fragments	
40	2	5-8 m	3	sea mammal	FEM			S	
41	2	5-8 m	3	sea mammal	FEM			S	
42	2	5-8 m	3	*Canis familiaris*	PEL	R	1		
43	2	5-8 m	3	*Canis familiaris*	V-CE 1		1		
44	2	5-8 m	3	*Arctocephalus forsteri*	V		1		
45	2	5-8 m	3	*Canis familiaris*	RIB		1	P	
46	2	5-8 m	3	*Arctocephalus forsteri*	RAD	R	1	S	
47	2	5-8 m	3	*Stictocarbo punctatus*	TT	R	1	DS	

48	2	5-8 m	3	sea mammal	PEL?				
49	Surface	Near oven		moa eggshell fragment			1		
	Trenches 1, 2, 3, 4, 8, 10		1 (Trench 2, 8), 2 (Trench 4), 3 (Trench 2, 3, 10)	moa bone fragments				too fragmentary to identify on orphological grounds	

*UL=ulna; FEM=fumur; HUM=humerus; TT=tibiotarsus; TMT=tarsometatarsus; CMC=carpometacarpus; CC=coracoid; SCAP=scapula; RAD=radius; PREMAX=premaxilla; CAR=carpal; CR=cranium; PEL=pelvis; V=vertebra; CE=cervical. P=proximal; D=distal; S=shaft; C=complete.

Appendix 3. Results of shellfish analysis.

Bag No.	**Trench**	**Distance**	**Layer**	**Species**	**MNE**	**Comments**
1	1			*Chione stutchburyi*	6	N face
2	2		2	pipi	5	sieved midden sample
				Chione stutchburyi	19	
				paua	1	
3	10		3a	pipi	12	
				Chione stutchburyi	7	sieved sample
				mussel	1	
4	10	1 m from N end	3b	pipi	57	
				Chione stutchburyi	1	
				mussel	1	
5	7		2	*Chione stutchburyi*	1	
6	4			*Chione stutchburyi*	4	sieved sample
7	10	5 m from N end	3a	*Chione stutchburyi*	34	
				pipi	1	

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A DESCRIPTION OF THE HETEROMORPHIC DEUTERONYMPH (HYPOPUS) OF *MYIANOETUS ANTIPODUS* FAIN AND GALLOWAY, 1993 (ACARI: ASTIGMATA: HISTIOSTOMATIDAE)

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ABSTRACT

The heteromorphic deuteronymph (hypopus) of *Myianoetus antipodus* Fain and Galloway 1993 was cultured from white-flippered penguin *Eudyptula minor albosignata* burrow floor material from the species type locality, Motunau Island, New Zealand (the mite's type locality). It is described and illustrated.

KEYWORDS

Myianoetus antipodus, Histiostomatidae, penguin guano mite, deuteronymph

INTRODUCTION

Myianoetus antipodus Fain and Galloway is known from the male, female, tritonymph and protonymphs collected on Motunau Island from the nests of white-flippered penguin, *Eudyptula minor albosignata*. Motunau Island is the type locality for *M. antipodus*. The larva and hypopus were not described in the original 1993 description from material collected from a penguin burrow on 8 November 1991. As part of a recent ecological study on Motunau Island, the burrow floor material from white-flippered penguins was collected on 20 August 2009 and held at room temperature, low light and high relative humidity. Larva and protonymphs of *M. antipodus* swarmed from the culture in mid-September 2009. Adult mites from the culture matched the original description by Fain and Galloway (1993) although, in females, many tarsal spines were longer in the new material. Therefore the deuteronymphs collected from these cultures are tentatively assigned to that species. Histiostomatidae (= Anoetidae) mites are common inhabitants of wet microhabitats (Bongers et al. 1993). The layer of guano, feathers and organic material in the floor of the burrow of the white-flippered penguin provides such a habitat for *M. antipodus*.

DESCRIPTION

Deuteronymph

All measurements in micrometres (μm). Leg setae names follow that of Bongers et al (1985) for *M. simplex* (Mahunka, 1972). Body sub-circular; length including gnathosoma 197 (180-220) long x 138 (125-160) wide, (n=6). Body and legs pigmented; punctation on gnathosoma and legs I and II. Slide mounted material have legs folded anteriorly and posteriorly. Gnathosoma 20 long, 10 wide at base; solenidion α, 45. Apical setae 8.

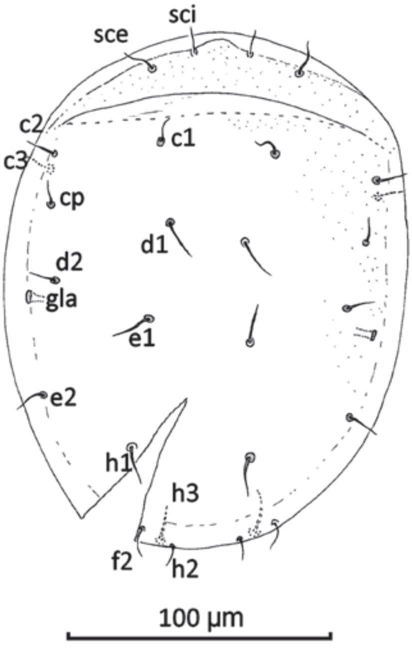

Figure 1. Dorsal shield of the deuteronymph or hypopus of *Myianoetus antipodus* Fain and Galloway, 1993

Dorsum (Fig. 1)
Prodorsal shield narrow, 30 long. *sci* filiform 7, sce filiform, 13. Post-dorsal shield smooth, pigmented. Setae of dorsal shield filiform 8-15; *d1* and *e1* longest, *h2* shortest *5*. Cupules not seen. Opisthonotal *gla* near *d2*.

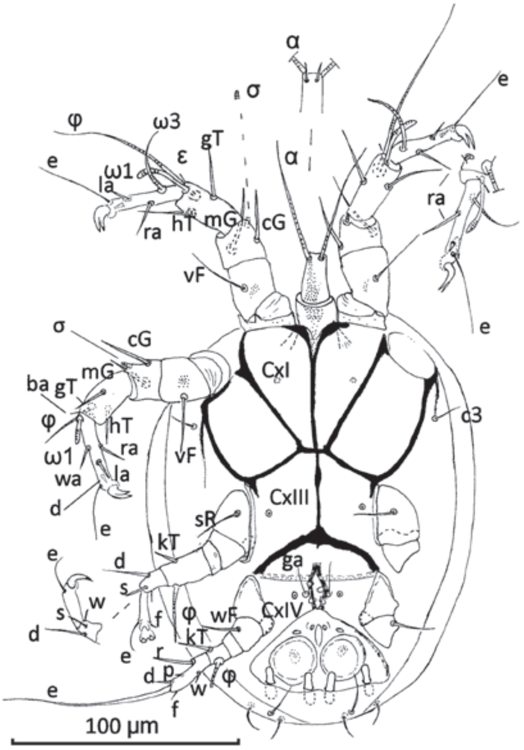

Figure 2. Ventral view of the deuteronymph or hypopus of *Myianoetus antipodus* Fain and Galloway, 1993

Venter (Fig. 2)
Epimeres I fused to sternum that continues to epimere III; Epimerite II strong thus coxal fields I and II enclosed. Epimeres III fused medially in apodeme. Attachment organ (=sucker plate) triangular, 65 wide, 40 long; anterior suckers small, laterals absent, medial suckers large 20-24 in diameter. Two pairs of posterior hyaline finger shaped setae 10 long, 3 wide forming a row on plate posterior. Genital atrium with two pairs of papillae; ga 10. Coxal setae *CxI, CxIII* and *CxIV* vestigial.

Legs: Femora fused to genua in legs I and II. Leg I – IV segment lengths for femora+genua, tibia and tarsus including claw; I - 50, 30, 50; II - 35, 27, 45; III – 20, 20, 40; IV – 20, 8, 25. On legs III and IV, tibia and tarsus are fused and there is little movement between genua and tibia. Tarsus III with mid-articulation permitting distal section rotation. Legs I – III with small pretarsal pad, claw bifid, sharply pointed. Chaetotaxy of Legs I – IV: I - 0, 1, 2, 2, 4; II – 0, 1, 2, 2, 6; III – 1, 0, 0, 1, 5; IV – 0, 1, 0, 1, 6. Seta of leg I and II all spines except *vF*, and *e* that are filiform. On leg I: *vF* 25, *mG* 30, *cG* 30; *gT* 20, *hT* 25; *ra* 15, *la* 8, *e* 35. Thus *wa* not seen. On leg II: *vF* 25, *cG* 20, *mG* 20, *gT* 15, *hT* 15; *ba* 5, *wa* 10, *ra* 12, *d* 12, *la* 5, *e* 10. On leg III, all setae spines except filiform *sR* and *e*: *sR* 20, *kT* 10; *d* 20, *s* 10, *w* 5, *f* 5, *e* 15. On leg IV: *wF* 17, *kT* 12, *r* 20, *d* 5, *w* 5, *f* 5, *p* 10, *e* 80. Solenidiotaxy for legs I – IV: I – 0,0,1,1,3; II – 0,0,1,1,1; III – 0,0,0,1,0; IV – 0,0,0,1,0. Epsilon δas a thin rod 5; leg I δ1 21 curved ventrally with inflated distal third; δ3 curved dorsally, tapered to blunt tip 25; δ70; δ1 vestigial, blunt 2. On leg II, δ1 2, δ20, δ1 12. On leg III & IV, δ20, 10 respectively.

Six slide-mounted specimens deposited in the Canterbury Museum, Christchurch.

DISCUSSION

If the characters described here are put into the key to deuteronymphs of Myianoetus (Mahunka 1972), M. antipodus will come out as M. tuerkorum Scheucher, 1957, described from a starling nest in Germany. However, it differs from that species in the presence of a well developed posterior apodeme of coxal field II, which is short and weak in M. tuerkorum and the relatively longer dorsal hysterosomal setae.

Fain and Galloway (1993) noted similarities in the adult morphology of M. antipodus and that of M. simplex Mahunka, 1972. The deuteronymph of M. antipodus differs from that of M. simplex, as redescribed by Bongers et al. (1985), primarily in the longer dorsal hysterosomal setae; the reduction of the anterior median sucker of the attachment organ to a vestigial alveolus but present and well developed in M. simplex; the form of setae of tarsi I-II, which is long and filiform in M. antipodus but short and foliate in M. simplex; and the length of solenidion phi IV, which is slightly longer than tibia IV in M. antipodus but longer than tarsus IV in M. simplex.

ACKNOWLEDGMENTS

The Department of Conservation issued the Permit CA-17699-DOA for research on Motunau Island. Norton Hiller, Chris Challies and David Hawke provided support in various ways. Pavel Klimov and Barry OConnor improved the paper.

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Bongers MGH, OConnor BM, Lukoschus FS (1985) Morphology and ontogeny of histiostomatid mites (Acari: Astigmata) associated with cattle dung in the Netherlands. *Zoologische Verhandelingen* 223:4–56.

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THREE NEW SPECIES OF DELEATIDIUM *(DELEATIDIUM)* (EPHEMEROPTERA: LEPTOPHLEBIIDAE) FROM NEW ZEALAND

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ABSTRACT

Three new species of mayfly, *Deleatidium (Deleatidium) townsi, D. (D.) atricolor* and *D. (D.) branchiola* all from the South Island of New Zealand are described. The larval stage of each species is included and associated with its respective adults. Notes on ecology are given and distribution maps provided. Diagnostic characters of the species are illustrated and keys provided for larval, subimaginal and adult life stages.

KEYWORDS

Ephemeroptera; key; mayflies; Leptophlebiidae; *Deleatidium*; new species; New Zealand; distribution; phylogeny; taxonomy

INTRODUCTION

The genus *Deleatidium* (Eaton 1899), with eleven presently described species included in two subgenera, *Deleatidium (Deleatidium) and D. (Penniketellum)*, is the most common mayfly genus in New Zealand Streams. Large populations are widely distributed in rivers and Streams of both the North and South Islands. Towns and Peters (1979; 1996) reviewed the genus and reported that, at that time, the state of taxonomy was such that "identification of described species has proved almost impossible." Their work subsequently placed the genus on a more clearly defined footing, redescribed the existing seven species and added three new ones. They also erected two subgenera, *Deleatidium (Deleatidium)* and *Deleatidium (Penniketellum)*, the former with eight species and the latter with two. A further species has since been added to *D. (Penniketellum)* (Hitchings 2008). This work adds three new species to *Deleatidium (Deleatidium),* with distribution maps and keys to their identification.

MATERIALS, METHODS AND CONVENTIONS

Larvae were associated with adults by rearing in aquaria. Specimens, including type specimens, are stored in 80% ethanol. Dimensions of body lengths for imagos and larvae are given with their means in parentheses, as are those for the fore- and hind wings. Length ratios of the foreleg segments (femur: tibia: tarsomeres 1-5) are based on the length of the tibia (absolute measurement in mm, in parentheses).

Collecting sites are grouped into regions of New Zealand using the system of Crosby et al. (1976). Each region has been allocated a two letter code. In the South Island these are as follows:
BR - Buller; CO - Central Otago; DN - Dunedin; FD - Fiordland; KA - Kaikoura; MB - Marlborough; MC - Mid Canterbury; MK - McKenzie; NC - North Canterbury; NN - Nelson; OL - Otago Lakes; SC - South Canterbury; SD - Marlborough Sounds; SI - Stewart Island; SL - Southland; WD - Westland.

Abbreviations in site descriptions: Ck – Creek; i – imago; L – Lake; Stm – Stream; si - subimago; Trib – Tributary; Vly - Valley.

Map references and altitudes are given in metric coordinates from the map series NZMS 260. The first group of five figures gives the east-west grid coordinate to the nearest 100 metres. The second group of five figures gives the north-south grid coordinate. The final group of one or more figures gives the height above mean sea level in metres. Information relating these grid references to the Canterbury Museum mayfly database is given elsewhere (Hitchings 2001).

Collections: Except for specimens held at the New Zealand Arthropod Collection, Landcare Research, Auckland, New Zealand (NZAC), National Museum of Natural History, Washington DC, USA (NMNH) and in the personal collection of IM Henderson, Massey University, Palmerston North, New Zealand (IMH), all are held at Canterbury Museum, Christchurch, New Zealand (CM).

Collectors: AJC, AJ Campey; ARW, AR White; EDW, E Edwards; H&Q, TR Hitchings & PJ Quinn; IMH, IM

Henderson; IPS, IP Smith; JBW, JB Ward; J&GW, JB & GM Ward; JRJ, JR Jackson; MLP, ID McLellan, P Lambert & J Porteous; OSF, OS Flint Jr; P&M, BH Patrick & H Murayama; PEP, PE Penney; PJQ, PJ Quinn; PMJ, PM Johns; RWH, RW Hitchings; SAN, J Sanders; SJM, SJ Morris; TRH, TR Hitchings; VMS, VM Stout; DRT, DR Towns; W&T, SF Watson & G Temm.

SYSTEMATIC SECTION

Order EPHEMEROPTERA Hyatt and Arms, 1891
Family LEPTOPHLEBIIDAE Banks, 1900

Genus *Deleatidium* Eaton, 1899
As described by Towns and Peters (1996): 27-28.

Subgenus *Deleatidium (Deleatidium)* Towns and Peters 1996
As described by Towns and Peters (1996): 30.

***Deleatidium (Deleatidium) townsi* sp. nov.** (Figs 1-9)

Description
Dimensions (mm)
Male: length of body 7.4-8.8 (8.5); forewings 8.2-9.4 (8.8). Female: length of body 6.6-7.7 (7.2); forewings 8.6-10.0 (9.2). Mature larva: length of body 6.5-7.5 (6.9)

Male imago
Head yellowish brown, blackish near the base of the ocelli and eyes. A larger blackish macula between the antennal scapes. Antennal scape yellowish brown, pedicel and flagellum yellowish. Eyes in contact on the meson of the head; upper portions yellowish and lower portions greyish black.

Figure 1. *Deleatidium townsi* sp. nov. Tarsal claws of male imago

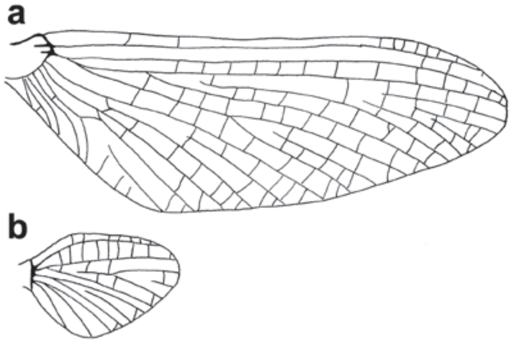


Figure 2. *Deleatidium townsi* sp. nov. **a** - forewing and **b** - hind wing of male imago

Figure 3. *Deleatidium townsi* sp. nov. Dorsal abdomen of male imago

Thorax. Pronotum pale brown with paired brown submedian longitudinal lines. Pronotal margins darker. Mesonotum and metanotum pale greyish brown with paired submedian brownish marks. Posterior margin of scutellum dark brown. Thoracic sterna pale brownish, carinae darker and margins blackish. Small blackish marks on the pleura of the second and third legs. Legs yellowish white with the distal margins of femora and tarsi darker; length ratios of foreleg segments 0.63-0.76: 1.00 (3.4-3.5 mm): 0.04-0.05: 0.33-0.46: 0.39-0.44: 0.29-0.31: 0.08-0.11; tarsal claws of a pair dissimilar, one pad like without an apical hook, the other hooked and with an opposing hook (Fig. 1). Wings, (Figs 2a, b). Forewing width 0.34-0.35 (0.34) x length; longitudinal and cross veins yellowish, darker at the wing base; cells C and Sc uniformly whitish, membranes hyaline.

Hind wing width 0.52-0.58 (0.54) x length and length 0.23-0.27 (0.25) x that of fore wing; vein Sc 0.82-0.90 (0.87) x wing length; cross veins indistinct and faint in the basal half of the wing; both longitudinal and cross veins without colour except yellowish at wing base; membranes hyaline.

Dorsal abdomen (Fig. 3) yellowish white. Terga 1-9, each with a dark brown posterior transverse margin interrupted mesially on terga 3-5 by a whitish mark. Terga 1-7 usually with small or large paired, lateral dark brown maculae, often reduced to spots on 3 and 4; sterna 1-6 hyaline; sterna 7-9 greyish yellow; abdominal ganglia hyaline. Genitalia (Fig. 4a, b) greyish yellow with the apices of the penes and distal half of the forceps paler; penes tapering almost to a point and fused almost to the apices, with paired, fused ventral projections. Penes wedge shaped in lateral view. Styliger plate shallowly cleft at apex. Outer margin of forceps segment 1 slightly concave basally; forceps 3 flattened apically. Caudal filaments greyish yellow with darker annulations at the articulations. Terminal filament longer than cerci.

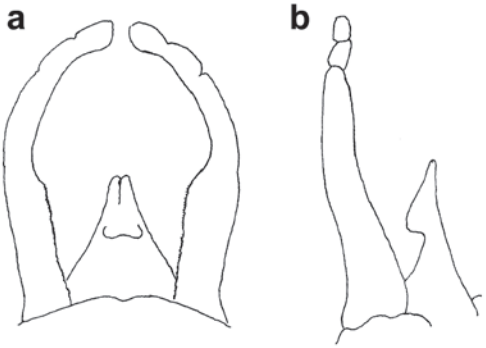


Figure 4. *Deleatidium townsi* sp. nov. Genitalia of male imago in **a** - ventral view and **b** - lateral view

Female imago

As in male, except as follows. Eyes greyish black, separated by three times the diameter of the eye. Dorsal thoracic segments yellowish white. Prominent blackish marks on the pleura of the second and third legs. Forewing width 0.30-0.38 (0.34) x length. Hind wing width 0.48-0.60 (0.52) x length and length 0.20-0.23 (0.22) x that of forewing; vein Sc 0.94-0.95 (0.95) x wing length. Abdominal terga usually as for the male imago, but some females show terga 1 and 2 or 3, and 6-7 more strongly pigmented, with paired sub median blackish irregular maculae. Sternum 7 with narrow egg guide extending about one tenth along sternum 8 (Fig. 5a, b). Sternum 9 with a shallow v-shaped apical cleft.

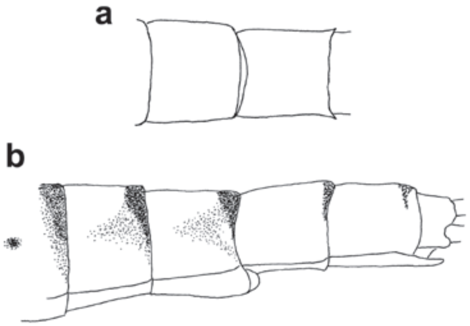


Figure 5. *Deleatidium townsi* sp. nov. **a** - sterna 7 and 8 and **b** - lateral view of female imago

Subimago

As in male imago, except as follows. Head of male greyish black posterior to the ocelli. Antennal scape whitish. Pronotum whitish with backish posteromedian marks. Mesonotum with anterior third brownish except for broad whitish submedian longitudinal marks. Notal furrows brownish, darker in the apical half. Mesonotal sutures dark brown. Metanotum whitish with brown lateral margins. Sterna whitish with the mesothoracic lobes of the furcasternum pale orange.

Legs yellowish white with darker markings at the apical articulation of the femora. Wing membranes and veins uniformly pale grey.

Abdomen. Terga whitish with black markings. Sterna whitish with a darker ganglion sometimes visible on sternum 7. Genitalia, cerci and terminal filament whitish. Penes may show a cleavage mark between the apical lobes for one-tenth to one-fifth their length.

Late instar larva (Fig. 6)

Head pale yellowish; clypeus yellowish, washed with dark brown, darkest near the base; labrum whitish, darker basally; irregular blackish markings between the ocelli. Eyes of female black; male, yellowish with lower portion black. Antennae 1.7x as long as head.

Mouthparts. Clypeus and labrum (Fig. 7a): labrum length 0.65-0.70(0.68)x that of clypeus, and width 1.19-

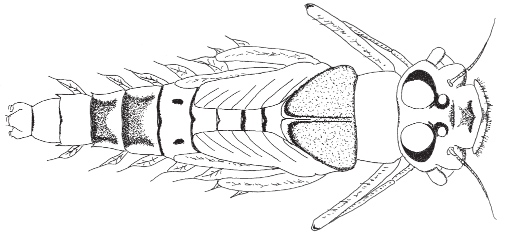


Figure 6. *Deleatidium townsi* sp. nov. Mature larva (dorsal view with antennae and caudal filaments truncated)

1.22(1.20)x that of clypeus; anterior margin with deep median cleft, otherwise smoothly curved and strongly tapering to rounded lateral margins; dorsally with dense hairs; the anteromedian cleft (Fig. 7b) with four small emarginations. Mandibles (Fig. 7c): 0-4 hairs at the centre of the outer margin; outer incisors with 0-3 serrations on the mesial surface. Maxillae (Fig. 7d): galea-lacinia with a subapical row of 22-28 spines; palp segment 2 0.93-1.07(1.02)x as long as segment 1 and segment 3 1.00-1.40(1.30)x segment 2. Labium (Fig. 7e): each shoulder of submentum with a row of 7-9 long spines near the

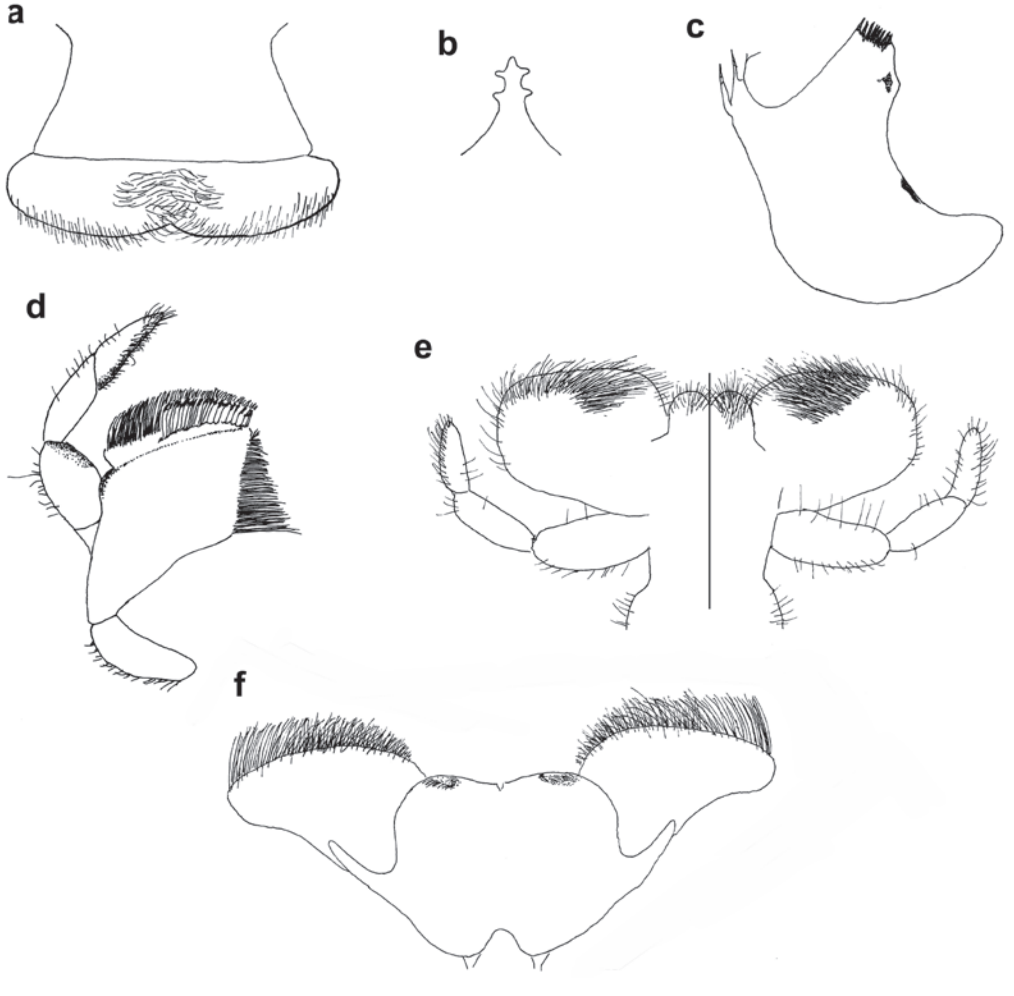


Figure 7. *Deleatidium townsi* sp. nov. Mouth parts of larva: **a** - clypeus and labrum with **b** - enlarged anteromedian emargination; **c** - left mandible; **d** - right maxilla; **e** - labium, in dorsal (left) and ventral (right) views; **f** - hypopharynx

base; palp segment 2 0.64-0.71(0.68)x as long as segment 1 and segment 3 0.80-0.90 (0.85)x segment 2. Hypopharynx (Fig. 7f): lingua rounded apically and fused except for a shallow medial cleavage mark; each lingual lobe with a small sclerotised crest with small hairs and spines directed mesially.

Thorax whitish. Mesonotum brownish yellow, darker at the margins. Pleura and sterna white except for the blackish marks on the pleura of the second and third legs. Legs whitish, darker at the lateral margins and at the apical articulations of femora, tibiae and tarsi; washed with pale brown at midlength on the anterior surface of femora. Larval foreleg (Fig. 8).

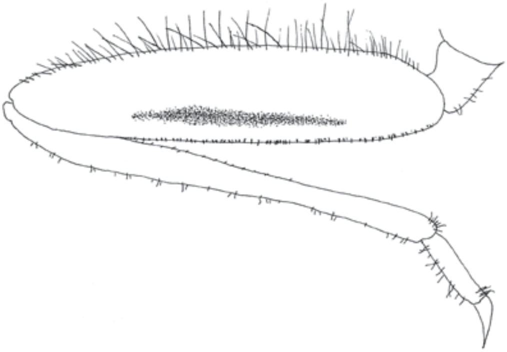


Figure 8. *Deleatidium townsi* sp. nov. Foreleg of larva

Abdomen whitish with dark brown to blackish markings as follows: terga 1-8 at the posterior transverse margins; 1-5 usually with submedian paired small maculae, 6 and 7 with broad posterior marks. Sterna white with ganglion sometimes visible on 7. Gills (Fig. 9a-c) single and plate like, tapering to a thread-like filament apically for about 1/3 to 1/2 their length; gill 1 barely expanded basally; lamellae translucent with darker tracheae and branches. Posterolateral projections moderately developed on segments 6 or 7 to 9. Caudal filaments yellowish white, 1.1-1.6x body length. Each segment of the filaments with a distal whorl of small white denticles.

Type data

Holotype: ♂ imago, NC, Glentui River, Mt Thomas Forest, New Zealand, 24491 57789, 400m, 14 February 2001, JB & GM Ward (CM).

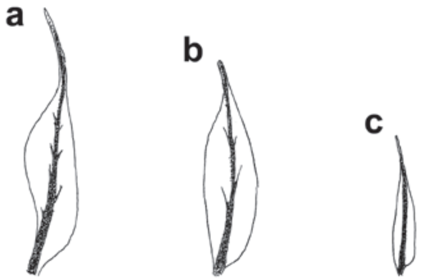


Figure 9. *Deleatidium townsi* sp. nov. Abdominal gills, **a** - 1; **b** - 4; **c** - 7

Allotype: ♀ imago, same data as holotype.
Paratypes: NZAC -1♂ and 1♀ imago, 1 ♂ and 1♀ subimago, 2 larvae; NMNH- 2 ♂ imagos,1♂ subimago and 2 ♀ subimagos; IMH - 1♀ imago.

Other material examined
The following non type examples:
BR ♀ si, Blackball Ck, 23797 58707, 70m, 5 Nov 2004, J&GW; ♂ i, Carter Ck, Buller, 24396 59372, 150m, 16 Mar 1993, JBW; ♀ i, Durville River at Ella Hut, 24773 59065, 660m, 4 Jan 1999, IMH (IMH); ♀ si, Fuchsia Ck, Buller, 24007 59290, 20m, 24 Dec 2000, J&GW; ♂♀ i, Fuchsia Ck West, Buller, 24006 59291, 60m, 30 Nov 1999, J&GW; larvae, Little Ten Mile Ck, 24007 59295, 30m, 6 Dec 2002, TRH; larvae, Lyell Ck, Buller, 24315 59343, 140m, 26 Jan 1995, TRH; ♂♂♀♀ i, Maruia River (Right Branch), 24649 58779, 980m, 1 Feb 1999, SJM; larva, Moonlight Ck, Andersons Flat, 23830 58804, 200m, 25 Sept 2001, PJQ; larvae, Murray Ck, 24183 58967, 250m, 4 Jan 2000, J&GW; larvae, Nine Mile Ck., 23990 59296, 10m, 3 Dec 2004, TRH; ♀♀ i, Rahu River, 24404 38737, 440m, 6 Jan 2001, J&GW; ♂ si, Ten Mile Ck, Buller, 24002 59292, 20m, 24 December 2000, J&GW; larvae, Waiwhero Stm., 23720 58885, 10m, 19 Nov 2000, TRH.
MB larvae, Kohuru Ck, 25467 59882, 370m, 14 January 2002, TRH; larvae, Kohuru Ck trib., 25472 59877, 340m, 14 Jan 2002, TRH; larvae, St. Ronans Stm, 25016 59184, 690m, 12 Dec 2003, TRH; larvae, Wairau River trib. 25028 59249, 680m, 15 Jan 1996, TRH.
MC larvae, Bealey River, 23937 58043, 710m, 9 Feb 1994, TRH; ♂♂ i, Cave Stm, 24068 57833, 800m, 22 Jan 2001,

OSF (NMNH); ♀ i & si, larvae, Reid Stm, Staverley, 23818 57278, 435m, 7 Jan 1995, JBW.
NC ♂♀ i, Glentui River, 24488 57789, 400m, 14 Feb 2001, OSF (NMNH); ♂♀ si & i, Halpin Ck, 23942 58028, 655m, 22 Jan 2002, J&GW; larvae, Sudden Valley, 24035 58079, 1260m, 5 Jan 1962, JRJ; ♀ si, larva, Waterfall Ck, Ashley, 24484 57755, 320m, 22 Oct 2002, TRH; ♀ si, Wooded Gully, 24560 57793, 320m, 10 Feb 2001, OSF (NMNH).
NN larvae, Hope R., 24804 59503, 390 m, 25 Aug 2000, TRH; ♀ si, Maitai River, 25381 59898, 175m, 19 Dec 1996, SJM; ♂ si, Maitai River Trib., 25385 59897, 100m, 21 Dec 1995, JBW; ♂ i, Myttons Ck, 24753 60109, 850m, 26 Dec 1996, EDW; larva, Nuggety Ck, Wangapeka, 24735 59706, 350m, 27 Dec 2002, AJC; larvae, Suspicion Ck, 24744 60341, 985m, 27 Oct 1963, VMS; larva, Ugly River, 24499 60075, 340m, 20 Feb 2000, ARW; larva, Wangapeka River, Siberia Flat, 24708 59735, 350m, 26 Dec 2002, AJC; larvae, Whirlwind Stm., Mt Frederick, 24154 59450, 860m, 24 Jan 1989, IDM.
SC ♀ i, Gunns Bush, 23475 56138, 305m, 8 Feb 2001, OSF (NMNH); ♂♂♀♀ i, Gunns Bush, 23492 56140, 250m, 26 Dec 1996, J&GW; larvae, Hook Bush, 23492 56161, 190m, 31 Oct 1998, H&Q.
WD ♀ i, Jackson Stm, 23893 58276, 300m, 30 Dec 2002 J&GW; ♀ si & i, Kellys Ck, 23933 58217, 355m, 25 Jan 2002, JBW; larva, Otehake R., E. Br., 24045 58119, 1040m, 27 Dec 2008, SAN.

Intraspecific variation

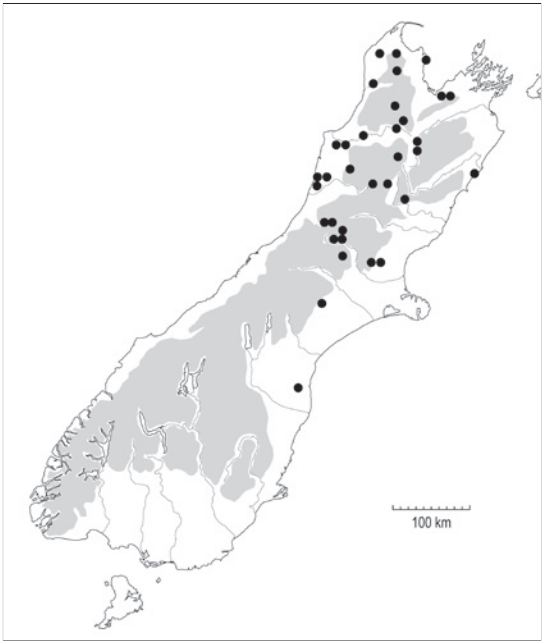
Larval specimens from northwest Nelson and South Canterbury show almost no maculae on abdominal terga.

Distribution and habitat (Map 1)

The species appears to be restricted to the northern half of the South Island and ranges in altitude from near sea level in northern Westland to 1260m in the central Southern Alps. Stm habitats are typically fast flowing and usually with forest canopy. Populations appear to be often small and dispersed. Trapping with UV lights has resulted in the capture of relatively small numbers of winged stages.

Discussion

Deleatidium (Deleatidium) townsi sp. nov. is a member of the informal *"lillii"* (Winterbourn 1978) group of leptophlebiids most closely resembling *Deleatidium (D.) cerinum,* with which it is sympatric in the northern South Island. It may be distinguished from the latter as follows: in the male imago by the strongly tapering penes as seen ventrally and their wedge shape as seen laterally; in the female imago by the presence of the narrow egg guide on sternum 7; in the larva by gills reduced to thread-like filaments by about one third length, maxillary palp 1 is broader in proportion to its length than with *Deleatidium (D.) cerinum* and maxillary palp 3 the longest of the palp segments, rather than the shortest (Fig. 7d).



Map 1. Collection localities of *Deleatidium (Deleatidium) townsi* in the South Island. Land over 700 m shown in grey

Derivation of name

Named after David R Towns whose work with the Leptophlebiidae has been a major contribution to the better understanding of taxonomy of New Zealand's mayfly fauna.

Deleatidium (Deleatidium) atricolor sp. nov.

(Figs 10-16)

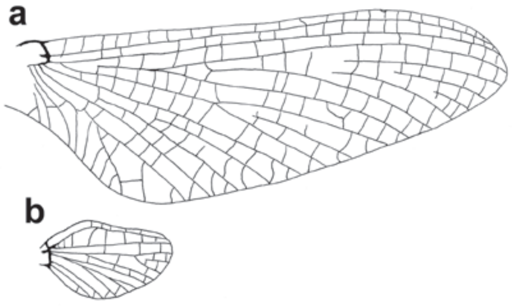


Figure 10. *Deleatidium atricolor* sp. nov. **a** - forewing and **b** - hind wing of male imago

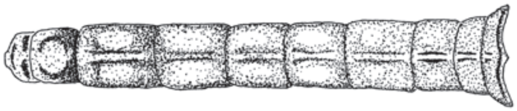


Figure 11. *Deleatidium atricolor* sp. nov. Dorsal abdomen of male imago

Description

Dimensions (mm)

Male: length of body 8.8-9.5 (9.2); forewings 9.8-11.6 (10.7). Female: length of body 9.2-12.2 (10.7), forewings 11.1-13.8 (12.5). Mature larva: length of body 9.4-11.2 (10.3).

Male imago

Head brownish, darker at sutures. Antennal scape yellowish brown, pedicel and flagellum yellowish. Eyes with upper portion yellowish and lower portion grey narrowly separated at meson of head.

Thorax. Pronotum yellowish brown; mesonotum blackish brown; scutellum dark brown. Thoracic sterna brownish; carina darker; pleura yellowish brown, darker at the margins. Legs yellowish; femurs blackish on the distal surfaces and at the femoro-tibial articulation. Length ratios of the foreleg segments: 0.81: 1.00 (2.7 mm): 0.06: 0.32: 0.29: 0.22: 0.08; pretarsal pad without an apical hook. Wings (Figs 10a, b). Forewing width 0.33 x length; longitudinal and cross veins blackish brown; cells C and Sc uniformly brownish; other membranes faintly brownish. Posterior margin basal to vein CuP slightly concave. Hind wing width 0.57x length and length 0.27x that of forewing; vein Sc 0.96x wing length; cross veins few and faint in the posterior half of the wing; both longitudinal and cross veins brownish; membranes pale brownish.

Abdomen (Fig. 11). Terga blackish; terga 5-8 with paired, submedian, crescent shaped marks; sterna 2-7 with blackish ganglia. Genitalia (Fig. 12a, b) greyish yellow with penes and forceps darker distally. Apices of penes fused, rolled ventrally and with paired rod-like ventral appendages at one-third length from apex. Proximal surfaces of forceps 1 with short, fine hairs from base to midlength. Styliger plate apical margin slightly emarginated. Caudal filaments greyish yellow with darker annulations at the articulations.

Female imago

As in male, except as follows. Eyes uniformly grey. Scutellum yellowish brown. Forewing width 0.3 x length. Hind wing width 0.58x length and length 0.27x that of forewing. Vein Sc 0.86x wing length. Membranes hyaline.

Abdomen. Terga blackish with paired sub median greyish maculae on segments 4-6. Sternum 9 with shallow apical cleft.

Male subimago

As in the male imago, except as follows. Thorax. Pronotum dark brown, mesonotum greyish with paired dark brown oval submedian bands directed caudad. Lateronotal sutures black. Metanotum greyish with black

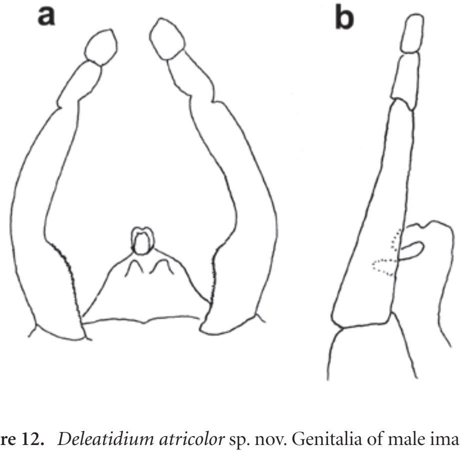


Figure 12. *Deleatidium atricolor* sp. nov. Genitalia of male imago in **a** - ventral view and **b** - lateral view

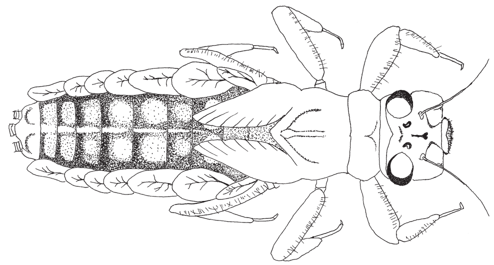


Figure 13. *Deleatidium atricolor* sp. nov. Mature larva (dorsal view with antennae and caudal filaments truncated)

lateral sutures. Pleura greyish with black margins. Legs dark brown, with femora and femoro-tibial articulations blackish on distal surfaces. Fore and hind wings brownish with diffuse darker clouds at cross veins.

Abdomen. Terga blackish except for paired submedian maculae prominent on terga 5 and 6. Caudal filaments with whorls of spines; some spines as long as the distance between whorls

Late instar larva (Fig. 13)
Head greyish yellow to brownish black; clypeus greyish yellow with dark brown margins. Eyes of female black,

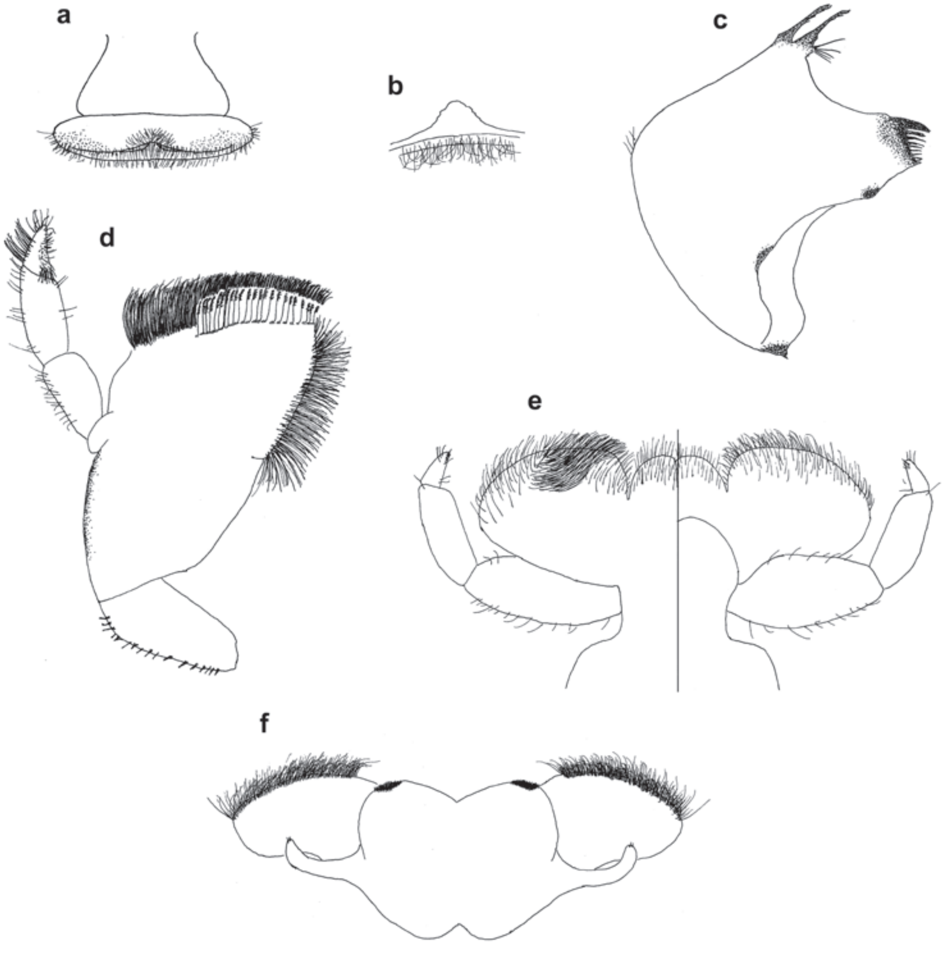


Figure 14. *Deleatidium atricolor* sp. nov. Mouth parts of larva: **a** – clypeus and labrum with **b** – enlarged anteromedian emargination; **c** – left mandible; **d** – right maxilla; **e** – labium, in dorsal (left) and ventral (right) views; **f** – hypopharynx

male, brown with lower portion black. Antennae 1.7 x as long as head.

Mouthparts. Clypeus and labrum (Fig. 14a): length 0.53-0.71 (0.63)x that of clypeus, and width 1.14- 1.21 (1.17)x that of clypeus; anterior margin with shallow median cleft, otherwise smoothly curved to elliptical lateral margins; the anteromedian cleft shallow and irregularly cleft (Fig. 14b). Mandibles (Fig. 14c): 6-12 hairs in two groups at centre of anterior margin; outer incisors with 4-5 serrations on the medial surface. Maxillae (Fig. 14d): galea-lacinia with a subapical row of 16-20 spines; palp segment 2 0.1.00-1.10 (1.06)x as long as segment 1 and segment 3 0.55-0.67 (0.61x as long as segment 2. Labium (Fig.14e): shoulders of submentum without spines near the base; palp segment 1 with a well developed prolateral swelling; palp segment 2 0.72-0.88 (0.79)x as long as segment 1 and segment 3 0.42-0.55 (0.46)x as long as segment 2. Segment 2 with only one or two large spines apically; segment 3, with a cluster of apical hairs, and a row of 8-10 spines straddling the apex. Hypopharynx (Fig. 14f): lobes of the lingua separated by a v-shaped emargination; a sclerotised crest of small hairs and spines borne on a swelling on each lobe.

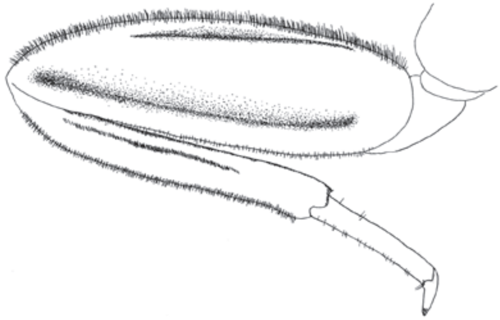


Figure 15. *Deleatidium atricolor* sp. nov. Foreleg of larva

Thorax brownish grey, darker at the margins and at the anterior margin of the mesonotum. Sterna whitish. Dark brown patches on the anterior surfaces of the coxae. Legs yellowish grey. Fore femur (Fig. 15) usually with two parallel, blackish, longitudinal marks on the anterior surface, the retrolateral the more prominent.

Abdomen. Terga blackish with a pale mid-dorsal line.

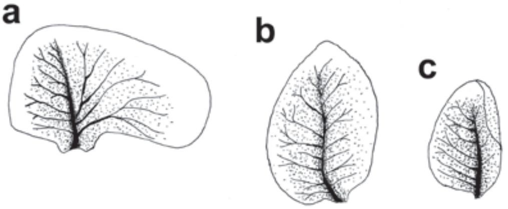


Figure 16. *Deleatidium atricolor* sp. nov. Abdominal gills, **a** - 1; **b** - 4; **c** - 7

Terga 3 or 4-8 with paired submedian grey maculae often indistinct. Sometimes smaller paired submedian grey maculae at the anterior margins of terga 2-6. Sterna white with blackish ganglia visible on segments 1-7, the latter the largest and darkest; short hairs dense on segment 9 and diminishing successively forward to segment 3. Gills (Figs 16a-c) single and plate-like, rounded apically and forming an adhesion disc. Gill 1 1.6 x as wide as the length of the lamella; gill 7 sometimes folded ventrally. Lamellae translucent with numerous blackish tracheae. Posterolateral projections small, best developed on segment 9. Caudal filaments 1.22-1.30x as long as body; yellowish, with darker annulations of small denticles

Type data

Holotype: male imago, MB, Edwards River, St James Range, New Zealand, 24883, 58670, 800m, 29 January 2002, Terry R Hitchings, Canterbury Museum, Christchurch, New Zealand.

Allotype: female imago, Judges Ck, Raglan Range, New Zealand, 25064, 59055, 1020m, 23 October 2002, Eva Pietrzykowlska.

Paratypes: MB ♂♀ i, ♂ si Smyths Stm, Fowlers Pass, 24856 58781, 1120m, 23 Nov 2004, TRH; ♀ si, Pass Stm Trib, 12 Nov 2002, TRH; larvae, Smyths Stm, Fowlers Pass, 24941 58933, 1220m, 10 Dec 2006, TRH.
OL, ♂ i, Whitbourn Vly, 21543 56257, 1035m, 12 Jan 2007, IMH.

Repositories

NZAC –MB ♀ si, Smyths Stm 24856 58781, 1120m, 25 Nov 2004, TRH; larvae, Judges Ck, 25044 59045, 940m, 26 Jan 2002, TRH; IMH- OL ♀ i, Whitbourn Vly, 21543 56257, 1035m, IMH.

Other material examined

The following non type examples:

BR larvae, Alfred River Trib, 24486 58767, 500m, 9 Feb 2003, TRH; larvae, Boyle River, 24619 58541, 580m, 17 Apr 2004, TRH; larvae, Frazer Stm, 24498 58765, 500m, 9 February 2003 TRH; larvae, Maruia River Trib, 24609 58702, 780m, 16 Jan 2009, TRH.

CO ♀ i Old Man Range, Obelisk, 22125 55337, 1620m, 4 Jan 2007, P&M;

KA larvae, Hapuku River Br, 25654 58847, 790m, 22 Oct 2007, S&G.

MB larva, Ada River Trib, 24770 58792, 800m, 10 March 2003, TRH; larvae, Clarence River Trib, 24958 58594, 850m, 23 Mar 2008 RWH; larvae, Coldwater Ck, 25038 59049, 920m, 10 Dec 2003, TRH; larvae, Connors Ck Trib, 24999 59111, 850m, 12 Dec 2003, TRH; larvae, Edwards River, St James Range, 24883 58670, 800m, 29 Jan 2002, TRH; larvae, Hapuku River, 25654 58847, 790m, 22 Oct 2007, W&T; larvae, Judges Ck, Wairau River, 25044 59045, 940m, 26 Jan 2002, TRH; larvae, Pass Stm Trib, 24894 58771, 1060m, 12 Nov 2002, TRH; larvae, Rainbow River, 25003 59075, 830m, 20 Jan 2003, G&P; larvae, Sandy Stm, L Tennyson, 24888 58873, 1100m, 9 Dec 2003, TRH; larvae, Smyths Stm, St James Range, 24869 58782, 1130m, 19 March 2002, TRH; ♀ i, Smyths Stm, 24856 58781, 1120m, 23 Nov 2004, TRH; larvae, Waiau River, 24788 58808, 770m, 22 Nov 2004, TRH.

MC larva, Acheron River Trib, 24022 57628, 760m, 5 Nov 2003, TRH; larvae, Dry Acheron River, 24020 57559, 680m, 18 Dec 2008, TRH; larvae, Kiwi Stm Trib, 23707 57831, 1200m, 16 Feb 2005, SFW; larvae, Waimakariri River, 23844 58069, 880m, 14 Jan 2006, SFW.

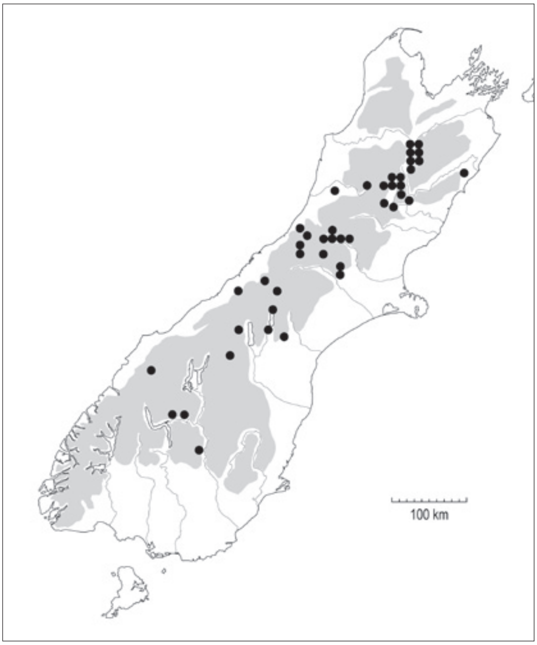
MK larvae, Dobson River, Spring Ck, 22661 56889, 644m, 28 Jan 2005, TRH; larvae, Fork Stm, 23017 56884, 790m, 29 Jan 2005, TRH; larvae, L Tekapo Trib, 23147 57055, 750m, 27 Jan 2005, TRH; larvae, Paddy's Market Stm,23228 56782, 520m, 9 Feb 2007, IPS; ♂ i Quailburn, Omarama, 22546 56444, 800m, 31 Oct 2003, PMJ.

NC larvae, Andrews Stm Trib, 24129 58036, 760m, 5 Oct 2002, SFW; larvae, Bealey River, 23906 58094, 1040m, 15 Jan 2006, TRH; larvae, Minga River Trib, 23989 58059, 1300m, 9 Jan 2005, W&T; larvae, Rough Ck, 23926 58056, 790m, 16 Jan 2006, TRH.

NN larva, Six Mile Ck, Rainbow, 24984 59253, 1480m, 4 Feb 2004, ARW.

OL larvae, Cardrona River, 21902 55731, 920m, 8 Feb 2007, IPS; ♂♂ i, Whitbourn Vly, 21543 56257, 1035m, 12 Jan 2007, IMH.

WD larvae, Copland River, 22636 57262, 430m, 28 Sept 2000, PEP; larvae, Cropp River, 23449 57903, 820m, 24 Oct 1996, MLP; larvae, Otira River, 23895 58109, 1270m, 14 Jan 2006, TRH; larva, Prices Stm Trib, 23441 57843, 1250m, 28 Jan 2000, SJM; larvae, Twin Ck, 23924 58098, 880m, 16 Dec 2006, TRH.



Map 2. Collection localities of *Deleatidium (Deleatidium) atricolor* in the South Island. Land over 700 m shown in grey

Distribution and habitat (Map 2)

The species is relatively plentiful within the mountains of central Marlborough, the adjacent Buller catchment, the Southern Alps and in smaller populations in the Otago Lakes region of the South Island. It is largely confined to the alpine regions above the treeline.

The species shows ovate body type, clinging habit and abdominal gills overlapping to form an adhesion disc, a characteristic adaptation to fast flowing water.

Attention has been drawn to the possibly melanistic colouration of this species referred to as *Deleatidium (D.)* sp. "A" (Hitchings in press), which may have arisen from the exposure of its habitat to high levels of solar ultraviolet radiation.

Discussion

The male genitalia of *Deleatidium((D.) atricolor* sp. nov. in some respects resembles those of *D. (D.) magnum* but can be distinguished by (1) the penes only half the length of forceps 1, (2) the apices of the penes rolled ventrally, and (3) ventral appendages rod-like and rounded apically. It can be distinguished from the male imagos of other species by the following combination of characters: (1) Apices of the penes rolled ventrally and with paired rod-like ventral appendages (Figs 11a, b). (2) In ventral view, penes expanded laterally at midlength. It can also be distinguished from *D. (D.) myzobranchia* by the presence of paired rod-like mid ventral projections.

Deleatidium (D.) atricolor is one of several closely related *Deleatidium* species with larvae having abdominal gills rounded on all lamellae strongly developed as an adhesion disc and with the seventh gill folded and turned beneath the abdomen. These have become known as the “myzobranchia complex” (Winterbourn 1978). Four members of this complex can be identified with an expansion of the key of Towns and Peters (1996).

1. Ventral abdominal ganglia strongly pigmented on sternum 7only . . . . ***myzobranchia***
   Ganglia strongly pigmented on at least sterna 3-7 . . . **2**
2. Dorsal abdomen with pale mid-dorsal line and paired pale submedian maculae on terga 3 or 4-8 . . . ***atricolor***
   Dorsal abdomen without, or almost without pale mid-dorsal line or pale sub median maculae on terga 3 or 4-8 . . . . **3**
3. Abdomen with dense fine hairs on sternum 9, diminishing to 6 . . . . ***cornutum***
   Abdomen with fine hairs almost entirely confined to sternum 9 . . . . ***patricki***

The larvae of *D. (D.) atricolor* may also be distinguished from *D. (D.) myzobranchia* by comparison of the markings on the foreleg femora (Figs 15 and 23) and from *D. (P.) cornutum* by comparison of the dorsal abdominal body markings (Fig. 13 and Towns & Peters 1996 fig. 249).

Derivation of name

From Latin *atricolor*, ‘of a black colour’, with reference to the predominant body colour of larval and adult life stages.

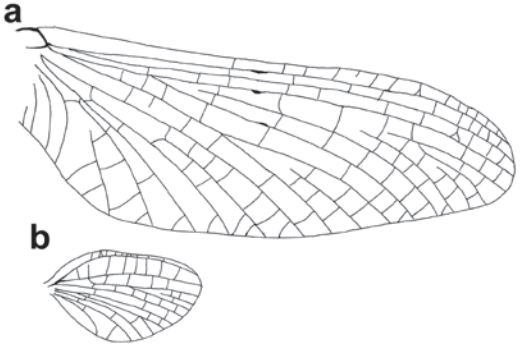


Figure 17. *Deleatidium branchiola* sp.nov. **a** – forewing and **b** - hind wing of male imago

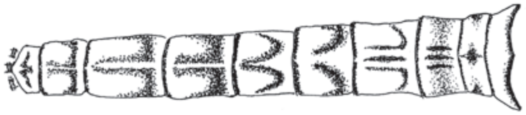


Figure 18. *Deleatidium branchiola* sp.nov. Dorsal abdomen of male imago

Deleatidium (Deleatidium) branchiola sp. nov.

(Figs 17-24)

Description

Dimensions (mm)

Male imago: length of body 7.9-8.0 (8.0); forewings 8.4-9.6 (9.0). Female: length of body 7.8-8.6 (8.1); forewings 8.6-9.5 (9.0). Mature larva: length of body 7.4-8.5 (7.9).

Male imago

Head brownish, paler near the anterior margins, blacker between the ocelli. Antennal scape, pedicel and flagellum brownish. Eyes almost in contact, upper portion yellowish brown, lower portion grey.

Thorax. Pronotum, mesonotum and metanotum uniformly brown, darker at the sutures and margins. Pleura yellowish brown. Posterior margin of scutellum dark brown. Sternum blackish brown, carinae paler, ganglia darker. Legs uniformly pale yellowish brown, darker at the articulations of the coxae, femora and tibiae. Length ratios of the foreleg segments: 0.67-0.89: 1.00

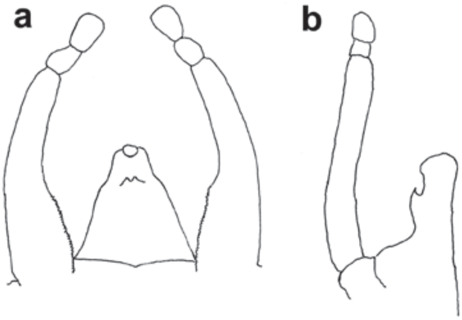


Figure 19. *Deleatidium branchiola* sp.nov. Genitalia of male imago in **a** - ventral view and **b** - lateral view

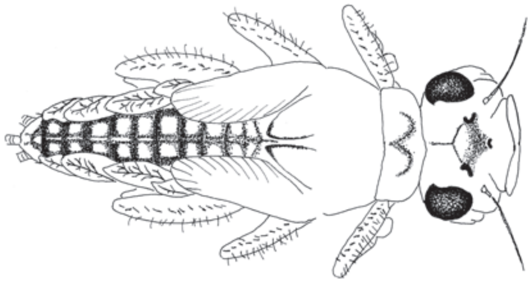


Figure 20. *Deleatidium branchiola* sp.nov. Mature larva (dorsal view with antennae and caudal filaments truncated)

(2.7-3.0 mm); 0.07-0.10: 0.33-0.37: 0.30-0.37: 0.22-0.23: 0.10-0.11; tarsal claws of a pair dissimilar, one pad like, without an apical hook, the other hooked with an opposing hook. Wings (Figs 17a, b). Forewing width 0.34- 0.35 (0.35)x length; longitudinal and cross veins yellowish, darker at the wing base, membranes hyaline. Posterior margin basal to vein CuP slightly concave. Hind wing width 0.56-0.60 (0.58)x length and length 0.23-0.27 (0.25)x length of forewing; vein Sc 0.88-0.94 (0.91)x wing length; cross veins few and faint in the posterior half of the wing; both longitudinal and cross veins without colour except at wing base; membranes hyaline.

Dorsal abdomen (Fig. 18) yellowish brown, darker at the lateral and posterior margins; terga 3 and 4 with three parallel median longitudinal marks. Terga 5-9 with diffuse, paired sub median dark brownish maculae, paler centrally and posteriorly; sterna yellowish, washed with brown; prominent brownish black abdominal ganglia and connectives. Genitalia (Figs 19a, b) yellowish white, darker at the lateral margins; penes tapering almost to a rounded apex; apices of penes rolled ventrally. Paired ventral projections at midlength, pointed and curved apically. Forceps segment 1 inner surfaces with setae. Styliger plate shallowly cleft apically. Caudal filaments yellowish with darker annulations at the articulations; filaments 1.3-1.5x as long as body.

Female imago

As in the male except as follows. Eyes greyish black, separated by 5x the width of an eye. Sternum and carinae yellowish brown. Forewing width 0.33-0.38 (0.36)x length. Hind wing width 0.55-0.57 (0.56)x length and length 0.22-0.24 (0.23)x that of forewing. Sternum 9 with a shallow, wide v-shaped emargination.

Subimago

As in the male imago, except as follows. Head: scape, pedicel and flagellum brownish grey. Pronotum greyish yellow with submedian dark brown marks. Mesonotum whitish with paired submedian longitudinal brown marks; lateroparapsidal and lateral scutal sutures blackish. Metanotum whitish with blackish lateral margins. Sterna whitish; carinae blackish. Legs greyish yellow, darker at the articulations of the coxae, femora and tibiae. Wing membranes and veins uniformly pale greyish.

Abdomen. Terga greyish brown with dark brown markings; sterna whitish with darker lateral posterior bands; genitalia, cerci and terminal filament whitish. Penes fused to apices but with a small cleavage mark.

Late instar larva (Fig. 20)

Head yellowish brown, darker between the ocelli and eyes; scape and pedicel brownish, flagellum yellowish; labrum yellowish, darker at basal margin; clypeus yellowish, darker mesially. Eyes of female blackish, male upper portion brownish yellow, lower portion black. Antennae 1.32-1.60 (1.46)x as long as head.

Mouthparts. Labrum (Fig. 21a): length 0.56-0.82 (0.69)x that of clypeus and width 1.14-1.16 (1.15)x that of clypeus; labrum anterior margin flat with shallow median cleft and with ill defined flat topped denticles; lateral margins elliptical. Mandibles (Fig. 21b): 11-13 hairs at the centre of the outer margin; outer incisors with 2-3 serrations on the mesial surface. Maxillae (Fig. 21c): galea-lacinia with a subapical row of 23-28 spines; palp segment 2 1.00-1.17 (1.09)x as long as segment 1and segment 3 0.71-0.92 (0.82) x as long as segment 2. Labium (Fig. 21d): shoulders of submentum with 2-3 spines near the base; palp segments 2 and 3 almost without spines except apically; palp segment 2 0.72-0.82 (0.76)x as long as segment 1 and palp segment 3 0.33-0.50 (0.44)x as long as segment 2. Hypopharnyx (Fig. 21e): lobes of lingua separated by a v-shaped emargination; sclerotised crest of small hairs and spines borne on a swelling on each lobe.

Thorax brownish yellow; pronotum with submedian dark brown paired crescent shaped marks directed posteriorly. Thoracic sterna whitish; dark brown patches

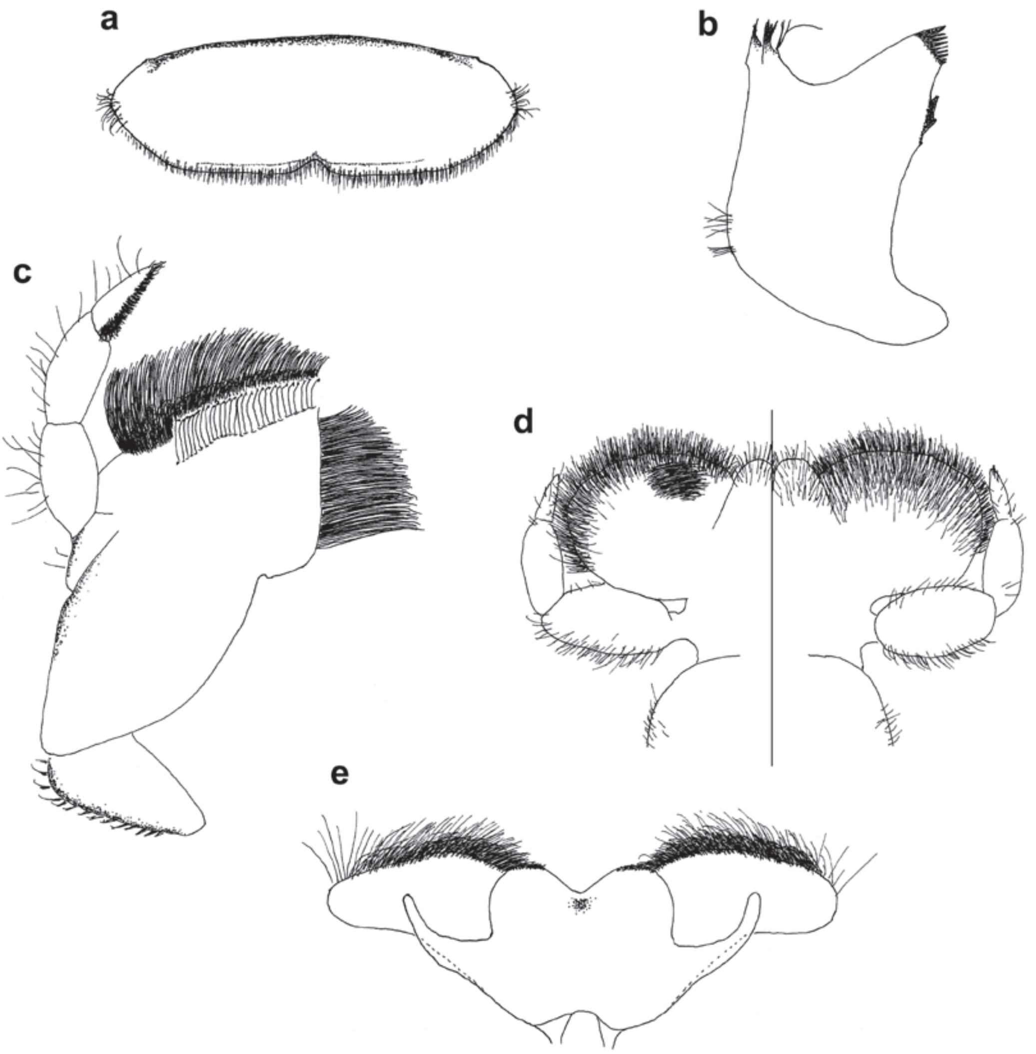


Figure 21. *Deleatidium branchiola* sp.nov. Mouth parts of larva: **a** - labrum; **b** - left mandible; **c** - right maxilla; **d** - labium, in dorsal (left) and ventral (right) views; **e** - hypopharynx

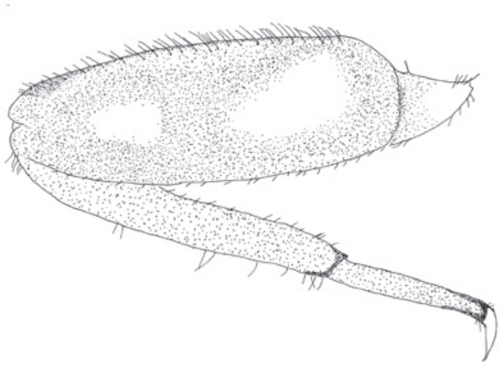


Figure 22. *Deleatidium branchiola* sp.nov. Foreleg of larva

on the thoracic sterna of the coxae. Legs (Fig. 22): brownish yellow; femora each with two pale yellowish maculae, one basal and one apical. A larval foreleg of *Deleatidium (D.) myzobranchia* is shown for comparison (Fig. 23).

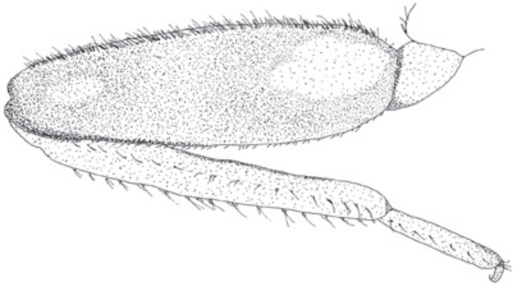


Figure 23. *Deleatidium (D.) myzobranchia.* Foreleg of larva of voucher specimen, WN Kaiwharawhara, Wiltons Bush, 26 Jan 1981, DRT

Abdomen dark brown, each segment with a darker transverse posterior band; terga 4 and 5 with paler median maculae; terga 6-9 with pale median line directed longitudinally. Sterna whitish with very few abdominal hairs; dark brown ganglia visible on segments 3-7, that on 7 the largest and darkest. Gills (Figs 24a-d) single, plate-like, apically rounded, translucent and with blackish tracheae about equally developed between dorsal and ventral lobes. Gill 1 the smallest and about 2/3 the length of gill 2. Dorsal lobe of gill 1 almost 2 x width of ventral lobe. Sterna 1-7 with blackish ganglia and connectives. Small posterolateral projections on segments 7-9 only. Caudal filaments 1.18-1.19 (1.19)x as long as body; pale yellowish with darker annulations.

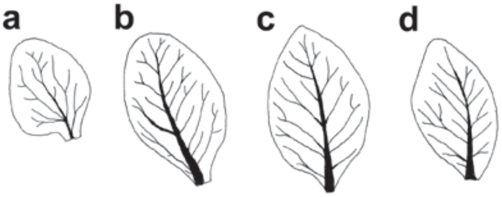


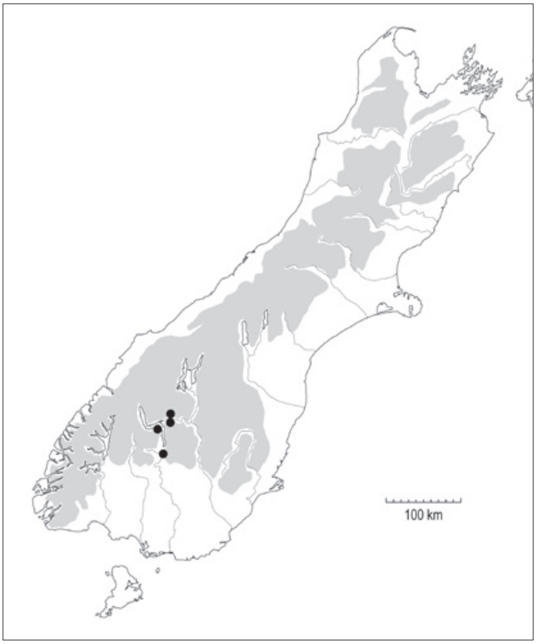
Figure 24. *Deleatidium branchiola* sp.nov. Abdominal gills, **a** - 1, **b** - 2, **c** - 4, **d** - 7

Type data
Holotype: ♂imago, CO, Mataura River tributary, Hector Mts, New Zealand, 21762 55202, 620m; 10 December 2007, TR Hitchings, Canterbury Museum, Christchurch, New Zealand.
Allotype: ♀imago: same data as holotype.
Paratypes: ♂♀ i, ♂♀ si, larvae: same data a holotype.

Repositories: NZAC- ♂♀ i, ♂♀ si, larvae: same data as holotype.

Other material examined
The following non-type examples:
CO larvae, Fosters Ck, Hector Mts, 21779 55205, 730m, 10 December 2007, TRH; larvae, Mataura River Trib, 21762 55203, 650m, 1 Feb 2007, IPS & TRH.
OL larvae, Three lagoons, Collins Ck Trib, 21659 55556, 1550m, 4 Feb 2007, BHP; larvae, i & si, Kawarau River Trib, 21883 55715, 900m, 8 Feb 2007, IPS;

Distribution and habitat (Map 3)
Deleatidium (Deleatidium) branchiola seems to be confined to small streams forming the headwater catchments of southern Lake Wakatipu and the adjacent upper Mataura River. The mountains are largely unforested with tundra-like vegetation. The few collecting sites have been at altitudes above 700m, in small pools within slow-flowing reaches of alpine streams.



Map 3. Collection localities of *Deleatidium (Deleatidium) branchiola.*in the South Island. Land over 700 m shown in grey

Discussion

The alpine region of southern New Zealand is the habitat of several species of *Deleatidium*, such as *D. (D.) atricolor,* which show adaptation to fast water and possibly high UV exposure (Hitchings 2009). *Deleatidium (D.) branchiola,* lacking larval gills modified to form an adhesion disc and melanistic body colouration, does not appear to be one of these. Its apparently very restricted present distribution may be a consequence of near extinctions during the Pleistocene ice advances and retreats. Survival may have occurred at lower altitudes and in slower waters than inhabited by various members of the "myzobranchia complex".

The male imago of *Deleatidium (D.) branchiola* can be distinguished from others of the genus by a combination of the following characters: the apices of the penes rolled forward; the paired mid apical projections tapering and curved apically; tarsal claw pad without an apical hook. In the subimago both males and females have wing veins and membranes pale greyish, tarsal claw pads without apical hooks, blackish ganglia on sterna 1-7 and also blackish connectives. In the larvae, gill 1 apically rounded and smaller than gill 2.

Keys to adults and subimagos

The paired ventral appendages on the penes of male *D. (D.) branchiola* are similar to those borne by *D. (D.) atricolor, D. (D)) cerinum, D. (D). fumosum and D. (D.) magnum. D. (D). branchiola* can be identified by modifying the key given in Towns and Peters (1996).

In the imago:

1. Forewing with red or reddish brown pigmentation in the costal and subcostal area . . . . ***magnum***
   Forewing without reddish or brownish pigmentation in the costal andsubcostal area **2**
2. Tarsal pad with a hook . . . . ***cerinum, fumosum***
   Tarsal pad without a hook **3**
3. Ventral appendages of penes apically rounded and projecting at right angles to the penes . . . . . ***atricolor***
   Ventral appendages of penes apically pointed and directed apically **. . . . .** ***branchiola***

In the subimago:

1. Wings clouded at the cross veins . . ***atricolor, magnum***
   Wings unicolourous **2**
2. Wings white . . . . ***cerinum***
   Wings grey **3**
3. Abdominal ganglia not visible or visible only on sternum 7 . . . . ***fumosum***
   Abdominal ganglia and connectives visible on sterna 1-7 . . . . ***branchiola***

Derivation of name

From Latin (with diminutive suffix) *branchiola,* "a little gill", a reference to the small size of larval gill 1, compared with the next five successive gills. In all other known *Deleatidium* species gill 1 is the largest.

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