

Two new species of *Deleatidium* (*Deleatidium*) (Ephemeroptera: Leptophlebiidae) from the central North Island of New Zealand

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Two new species of mayfly, *Deleatidium* (*Deleatidium*) *crawfordi* sp. nov. and *Deleatidium* (*D.*) *rapidum* sp. nov., are described from the North Island of New Zealand. The larval stages of both species are associated with their respective subimagines and adults. Notes on the ecology of both species are included. One species shows adaptation to relatively fast water flows. Neither species has been identified elsewhere in New Zealand. Diagnostic characters of both species are illustrated.

Keywords: *Deleatidium*, Ephemeroptera, mayflies, mayfly, new species, New Zealand, taxonomy.

Introduction

Deleatidium Eaton, 1899 is the largest genus of the New Zealand Leptophlebiidae with 18 described species, all of which are endemic. The identification of *Deleatidium* can be difficult as finding relatively easily observed morphological features is not easy. The genus has two subgenera, *Deleatidium* (*Deleatidium*) and *Deleatidium* (*Penniketellum*), distinguished in the adult stages by the dissimilarity of the tarsal claws in the case of the former subgenus (Towns and Peters 1996). *Deleatidium* (*Penniketellum*) is restricted to mountainous regions where their gills have adapted to the fast flowing water. This work adds two new species of *Deleatidium* (*Deleatidium*) to the mayfly fauna of New Zealand.

Both species are known only from a single locality in central North Island, which is an area where comparatively little is known of the mayfly fauna.

Materials, methods and conventions

Specimens were collected by William J Crawford from the middle stretches of the Mohaka River

between the Ahimanawa and Kaweka ranges in 2001 and 2002. He also reared subimagines and adults, establishing the association.

Larvae were associated by rearing in aquaria. All specimens are stored in 80% ethanol. Body, forewing and hindwing lengths of imagines and larvae are given, with means in parentheses; length ratios of foreleg segments (femur: tibia: tarsomeres 1–5) are based on the length of tibia (absolute measurements in mm, in parentheses). Intraspecific variation was not noted as specimens of both species were collected from small geographic ranges; however, there was no obvious variation in the specimens that we examined. Collection locations were determined from the topographical map series NZGD 2000/WGS 84a. Area codes are given using the system of Crosby et al. (1998). In this instance they are at the boundary of the Taupo and Hawke's Bay regions (TO/HB). All specimens of *D. crawfordi* were collected within 1.5 km, and all *D. rapidum* within 0.5 km, of their respective type locations. All material is held at Canterbury Museum, Christchurch (CMNZ) or the New Zealand

Arthropod Collection, Landcare Research, Auckland (NZAC).

Systematics

Order Ephemeroptera Hyatt & Arms, 1891

Family Leptophlebiidae Banks, 1900

Genus *Deleatidium* Eaton, 1899

As diagnosed by Towns & Peters (1996: 27–29)

Subgenus *Deleatidium* (*Deleatidium*) Towns & Peters, 1996

As diagnosed by Towns & Peters (1996: 30)

Deleatidium crawfordi sp. nov.

Description: Dimensions (mm). Imago male: length of body 9.5–10.5 (10.0); forewings 9.7–10.5 (10.1). Imago female: length of body 9.5–10.5 (10.0); forewings 10.5–10.8 (10.7). Mature (final instar) larva: length of body 8.0–10.0 (9.3).

Male imago: Head yellowish, blackish around base of ocelli and eyes. Antennal scape and pedicel brownish yellow, flagellum whitish yellow; length 1/3 head width. Eyes in contact dorsally; upper parts yellow, lower parts grey-black. Thorax. Pronotum pale yellow,

mesonotum and metanotum yellow. Scutum with thin brown margin. Sterna yellow with brownish margins. Dark ganglia prominent on sterna of the prothorax and mesothorax. Legs yellowish white, darker at the femoro-tibial articulations. Length ratios of foreleg segments 0.75–0.77: 1.0 (3.0–3.3 mm): 0.03–0.06: 0.32–0.35: 0.23–0.26. Tarsal claws dissimilar; pad without apical hook and claw with prominent opposing hook. Wings. Forewing width 0.32–0.34 (0.33) x length. Longitudinal cross-veins brown, fading to light brown and white posteriorly, membrane uniformly whitish (not hyaline). The largest intercalary vein between ICu and CuP attached at its base to ICu. Hindwing length 0.25 x forewing length. Hindwing width 0.50–0.58 (0.53) x length. Hindwing vein Sc 0.92–0.96 (0.95) x wing length; cross-veins variably visible in posterior half of hindwing; longitudinal veins light brown, Sc a little darker; membrane uniformly greyish. Abdomen. Dorsum generally yellowish, a grey-brown transverse band at the posterior margin of segments 2–7; paired paramedian pale maculae anteriorly on terga 2–8, each outlined by grey pigmentation. Sterna pale yellow with faint grey maculae anterolaterally. Ganglia

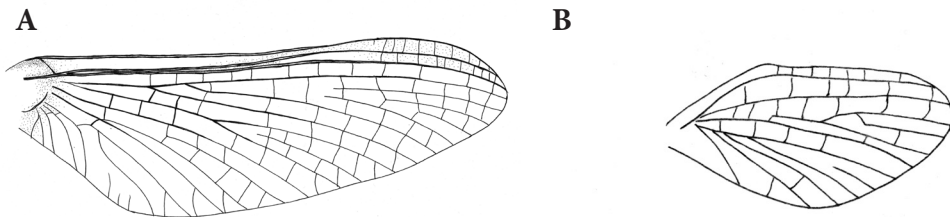


Figure 1. *Deleatidium crawfordi*, male imago. A, forewing. B, hindwing.

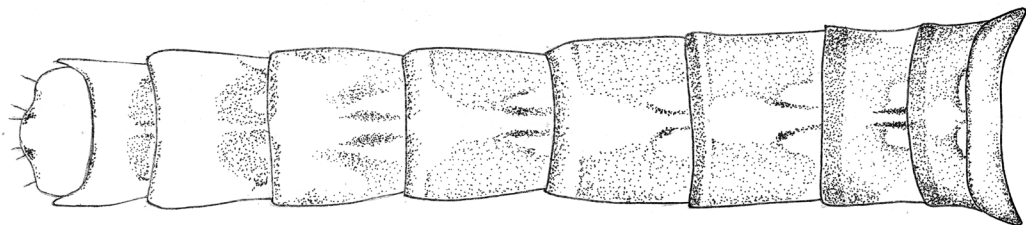


Figure 2. *Deleatidium crawfordi*, male imago, dorsal surface.

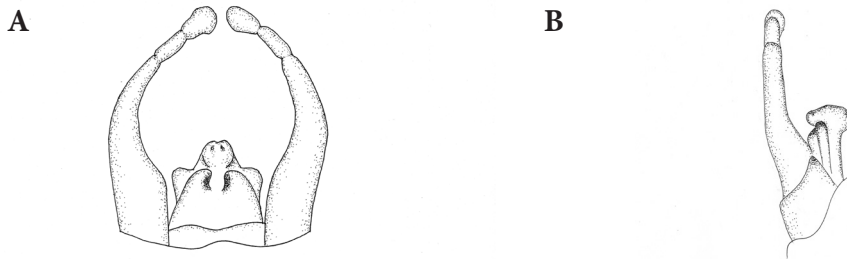


Figure 3. *Deleatidium crawfordi*, male genitalia. A, ventral view. B, lateral view.

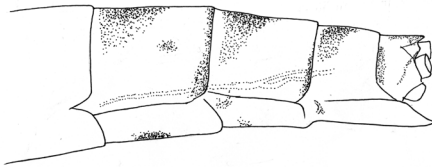


Figure 4. *Deleatidium crawfordi*, female imago, distal abdomen, lateral view.

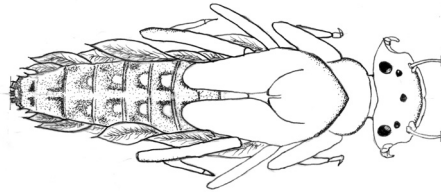


Figure 5. *Deleatidium crawfordi*, mature larva, dorsal view (antennae and caudal filaments truncated).



Figure 6. *Deleatidium crawfordi*, photograph of mature larva, dorsal view (CMNZ 2014.2.24786).

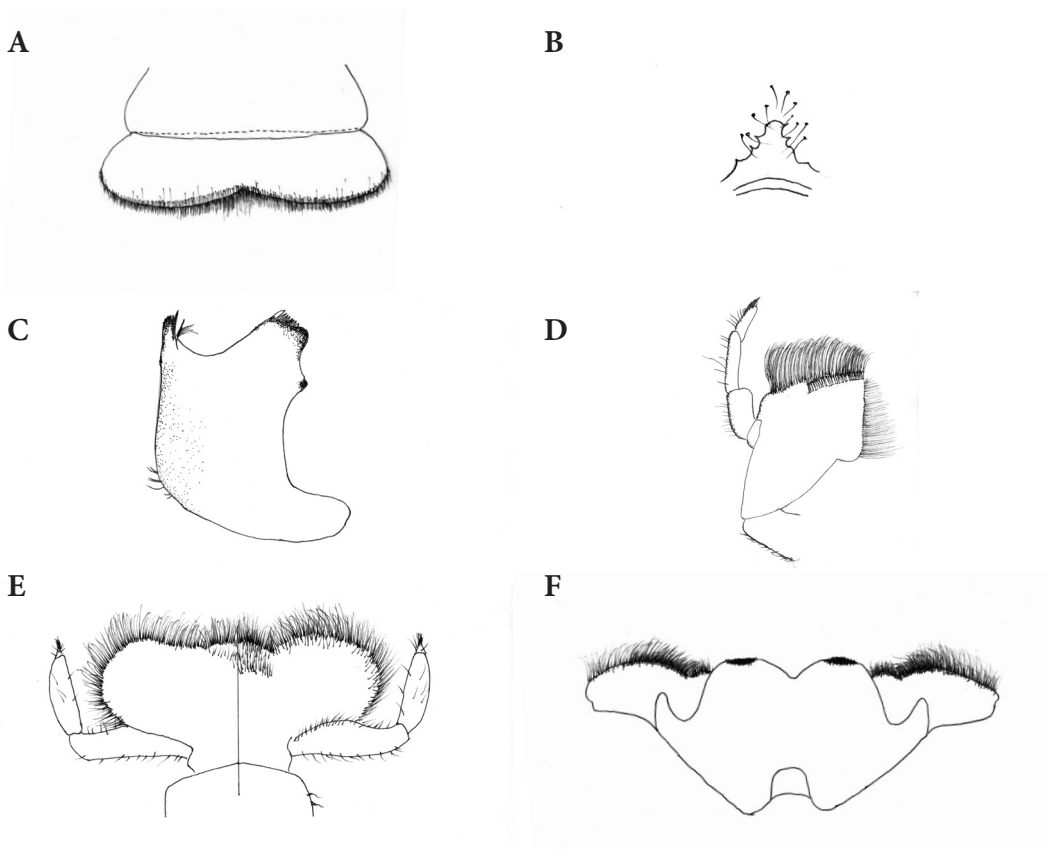


Figure 7. *Deleatidium crawfordi*, larval mouth parts. A, clypeus and labrum. B, enlarged anteromedian emargination. C, left mandible. D, right maxilla. E, labium, in dorsal (left) and ventral (right) views. F, hypopharynx.

dark grey, terminal ganglion sometimes a little darker than the others; connectives usually hyaline, sometimes darker. Genitalia. As illustrated; generally yellowish. In lateral view, penes with a rounded, almost globular upper portion from which paired tapering extensions project, sometimes distally, sometimes curved and directed posteriorly. In ventral view paired tapering apices are separated by a U-shaped indentation. Caudal filaments 12.5–13.0 mm; pale yellow and darker at the articulations.

Female imago: As in the male except as follows: eyes greyish black, separated by 2.5 x diameter of eye. Head whitish yellow, black surrounding the ocelli. Forewing width 0.28 x length. Hindwing width and length as for male. Sternum 7 with

small egg guide extending about one tenth the length of sternum 8. Sternum 9 with U-shaped cleft

Subimago: Head, including eyes, as in male imago. Thorax differs from the imago in that the scutum medial to the medioparapsidal suture is whitish and yellowish brown laterally. Medial two thirds of posterior scutal protuberances whitish. Pigmentation of lateral scutal suture strongly dark brown. Pronotum, metanotum and sterna as in the imago. Legs as in the imago. Wings grey with faint whitish clouding in cells across the mid forewing, less apparent in the female. Veins light brown to white. Appearance of dorsal abdomen as in the imago; sterna pale with prominent blackish ganglia; terminal

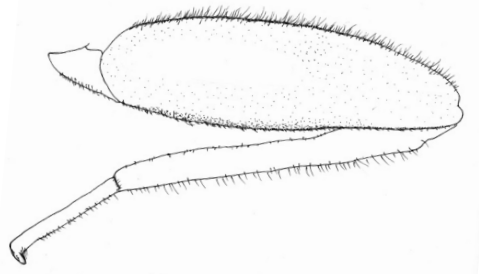


Figure 8. *Deleatidium crawfordi*, larval foreleg.

ganglion darkest. Penes whitish, with paired pigmented maculae on mesial surface of ventral appendages. Apical lobe with median cleavage mark more apparent when viewed ventrally.

Late instar larva: (Figs 5–6). Head including clypeus and labrum yellowish, margins brown. Region between ocelli darker. Eyes of male yellowish with lower portions black; female black. Antennae 1.04–1.61 (1.32) x as long as head. Mouth parts. Clypeus and labrum (Fig. 7A): labrum length 0.64–0.73 x that of clypeus, width 1.27–1.30 x that of clypeus. Anterior margin of labrum with deep median cleft, otherwise smoothly curved and strongly tapering to rounded lateral margins; dorsally with dense feather-like hairs; the anteromedian cleft with 4–6 irregular emarginations (Fig. 7B). Mandibles (Fig. 7C): an irregular cluster of 8–12 hairs at the centre of the outer margin; outer incisors with 3–4 serrations on the mesial surface. Maxillae (Fig. 7D): galea-lacinia with a sub-apical row of 22–23 spines; palp segment 2, 1.23–1.25 x as long as segment 1; segment 3, 0.60–0.85 x as long as segment 2. Labium (Fig. 7E): one shoulder of the submentum with a group of 2 or 3 long spines at the base, the other shoulder without spines; palp segment 2, 0.75 x as long as segment 1; segment 3, 0.47 x as long as segment 2. Hypopharynx (Fig. 7F): lingua rounded apically, each lobe with a crest of small, dark hairs directed mesially; lobes deeply cleft, the cleavage lined with short, fine spines; anterior margin of the superlingua thickly supplied with long fine hairs. Thorax pale yellowish, darker



Figure 9. *Deleatidium crawfordi*, abdominal larval gills 1, 4, 7 (from left to right).

brown at the margins, pleura and sterna whitish. Legs yellowish, postcoxal plate dark brownish, femur of foreleg (Fig. 8) with a proximal pale whitish macula on the anterior surface. Abdomen yellowish with markings as follows: terga 1–9 with posterior transverse dark brown margins and a pale longitudinal mid-dorsal line. Sterna whitish with a prominent expanded blackish ganglia on segment 7 and smaller, paler, ganglia on the remaining abdominal segments. Gills (Fig. 9) single, plate-like and rounded but drawn out apically to fine thread-like filaments about one-tenth length of the gill. Gill 1 longer than wide and with ventral margin expanded basally as a lobe. Gill 7 sometimes lacking an apical filament. Lamellae translucent with blackish tracheae and branches. Posterolateral projections well developed on segments 4–9. Caudal filaments yellowish white 1.29–1.43 (1.33) x body length. Each segment of the filaments with a distal whorl of small white denticles.

Holotype: Male imago, TO/HB, Mohaka River, McVicar Road, New Zealand. 39°12'S 176°37'E. 320 m. 17 March 2001, WJ Crawford (CMNZ 2014.2.47452).

Allotype: Female imago, TO/HB, Mohaka River, McVicar Road, New Zealand. 39°12'S, 176°37'E. 320 m. 5 April 2001, WJ Crawford (CMNZ 2014.2.47453).

Paratypes: All same locality as holotype and allotype; two male imagines, collected 17 March

2001 (CMNZ 2014.2.47455) and 26 March 2001 (CMNZ 2014.2.24806); two female imagines, collected 17 March 2001 (CMNZ 2014.2.47457) and 15 April 2001 (CMNZ 2014.2.47456); one male subimago, collected 13 March 2001 (2014.2.24789); one female subimago, collected 26 March 2001 (CMNZ 2014.2.24809); four larvae, collected 13 March 2001 (CMNZ 2014.2.47454, CMNZ 2014.2.24786) and 26 March 2001 (CMNZ 2014.2.24796, CMNZ 2014.2.24799); one male imago, collected 17 March 2001 (NZAC); one male subimago, collected 26 March 2001 (NZAC); one larva, collected 26 March 2001 (NZAC).

Distribution and habitat: *Deleatidium crawfordi* has only been found at closely adjacent locations in the Mohaka River, near the eastern edge of the Kaweka Forest. The collector of all specimens, William J Crawford, has advised that specimens were collected from stable rocks in shallow slow to moderate flows at the river's edge, and had probably moved there in preparation for emergence. As these are the only records of *D. crawfordi*, its geographical range is unknown.

Remarks: In the imago, characteristic features are the uniformly white translucency of the fore and hindwing membranes. The male genitalia most closely resemble those of *D. acerbum* Hitchings & Hitchings, 2016 and *D. atricolor* Hitchings, 2009 in having paired ventral appendages, but the prominent rounded lateral appendages seen in ventral view are distinctive. Forewing venation in the cubital region is similar to that of *D. myzobranchia* Phillips, 1930 and *D. kawatiri* Hitchings & Hitchings, 2016.

In the subimago, *D. crawfordi* is most likely to be confused with *D. branchiola* Hitchings, 2009, but differs in that the cubital margin of the forewing is basally connected with ICu₁.

The larva of *D. crawfordi* is most likely to be confused with that of *D. vernale* Phillips, 1930, but it can be recognised by an absence of strong pigmentation on all of the abdominal ganglia and their connectives. In the case of

D. vernale the thoracic and abdominal ganglia and connectives are strongly pigmented.

Etymology: Named after William J Crawford in recognition of his contribution to mayfly research in New Zealand, spanning more than thirty years. He has collected specimens, reared life stages and provided much habitat information and advice to research workers. This has been highly valued and much appreciated. Both the species referred to in this paper were first collected by him and he provided all specimens used in its preparation.

***Deleatidium rapidum* sp. nov.**

Description: Dimensions (mm). Imago male: length of body 8.8–10.4 (9.7); forewings 9.4–10.6 (10.1). Imago female: length of body 8.7–10.1 (9.5); forewings 9.9–10.2 (10.0). Mature larva: length of body 8.2–9.3 (8.6).

Male imago: Head whitish, brownish at bases of ocelli and around bases of eyes. Antennae; length about ½ width of head; scape, pedicel and flagellum brownish white; antennal length 3.0 mm. Eyes in contact dorsally, upper parts yellow, lower parts grey-black. Thorax. Pronotum, mesonotum and metanotum yellow with brownish margins. Sterna yellow with brownish margins. Legs whitish, dark brown at the femoro-tibial articulation. Length ratios of the foreleg segments 0.74–0.80: 1.00 (2.9–3.1 mm): 0.04–0.06: 0.20–0.32: 0.22–0.29: 0.05–0.09. Tarsal claws dissimilar; pad without apical hook, claw with prominent opposing hook. Wings. Forewing width 0.33 x length; longitudinal veins pale brownish, darkened at the costal brace, cross-veins paler; membranes pale brownish. The largest intercalary vein between ICu and CuP attached at base to ICu. Many cross-veins, particularly in C, Sc, R1 missing or incomplete and faint in the cubital region. Hindwing length 0.26–0.28 (0.27) x forewing length. Hindwing width 0.53–0.61 (0.57) x length. Hindwing vein Sc 0.95 x wing length. Almost without cross-veins in the posterior half of the wing. Abdomen.

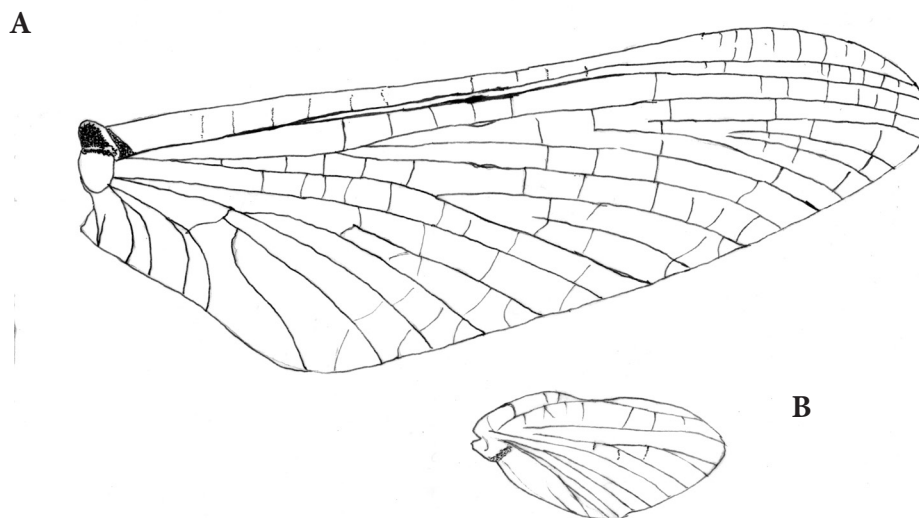


Figure 10. *Deleatidium rapidum*, male imago. A, forewing. B, hindwing.



Figure 11. *Deleatidium rapidum*, male imago, dorsal surface.

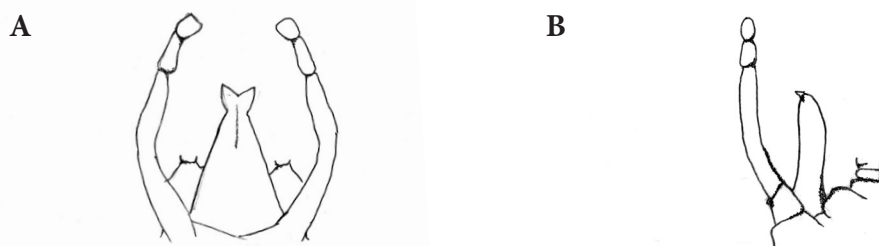


Figure 12. *Deleatidium rapidum*, male genitalia. A, ventral view. B, lateral view.

Dorsum pale greyish yellow, darker brown mesially and with median whitish longitudinal line. Abdominal segments bounded by whitish transverse lines. Anterior margins of segments 2–4 with paired submedian circular whitish marks. Sterna greyish white becoming yellowish anteriorly. Ganglia strongly marked on sternum 7, but successively less so anteriorly. Genitalia. As illustrated; whitish. Penes in ventral view

with tapering bifid apices divided by V-shaped indentation; in lateral view rounded sub-apically, with paired tapered points directed apico-ventrally. Basal third of dorsal surface of forceps with fine hairs. Caudal filaments yellowish with dark brown annulations; length 12.5–12.9 mm.

Female imago: As in the male imago, except as follows: eyes greyish black, separated by 2.8 x

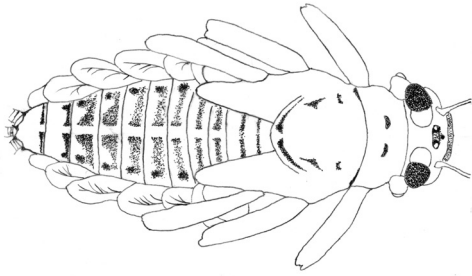


Figure 13. *Deleatidium rapidum*, late instar larva, dorsal view (antennae and caudal filaments truncated).

diameter of eye. Head yellowish white, blackish round the ocelli. Pronotum with two dark brown sub median V-shaped marks. Forewing width 0.31–0.36 (0.34) x length. Hindwing length 0.26–0.28 (0.27) x length of forewing, width 0.50–0.52 (0.51) x length. Hindwing vein Sc length 0.94–0.97 (0.96) x length of wing. Abdominal terga brownish-yellow. Sternum 7 with egg guide undeveloped. Sternum 9 with shallow U-shaped cleft.

Subimago: Head, including eyes, as in the male imago. Thorax. Pronotum whitish with

paired submedian brownish U-shaped marks, mesonotum whitish with narrow dark median longitudinal mark and paired wider submedian brown longitudinal marks; metanotum whitish; scutellum brownish; sternum yellowish. Legs as in the imago. Wings whitish, costal brace and pleural wing recess brownish and distinctly darker than the remainder of the forewing. Dorsal abdomen brownish with median whitish longitudinal line, otherwise as for imago. Sterna as for imago. Penes whitish with median cleavage mark and without ventral appendages. Caudal filament 6.0–7.5 mm in length.

Mid and late instar larvae: (Figs 13, 14). Head including clypeus and labrum yellowish with small dark brown marks dispersed across the central region at the posterior boundary of the clypeus; margins brown. Region between ocelli darker blackish. Eyes of male with upper portions yellowish and lower portions black, female eyes black. Antennae 1.30–1.46 (1.38) x as long as the head. Mouth parts. Clypeus and labrum (Fig. 15A): labrum length 0.50–0.72 x and width 1.36–1.55 x that of clypeus. Anterior margin of labrum with a slight central indentation without



Figure 14. *Deleatidium rapidum*, photograph of mid instar larva, dorsal view (CMNZ 2014.2.47471).

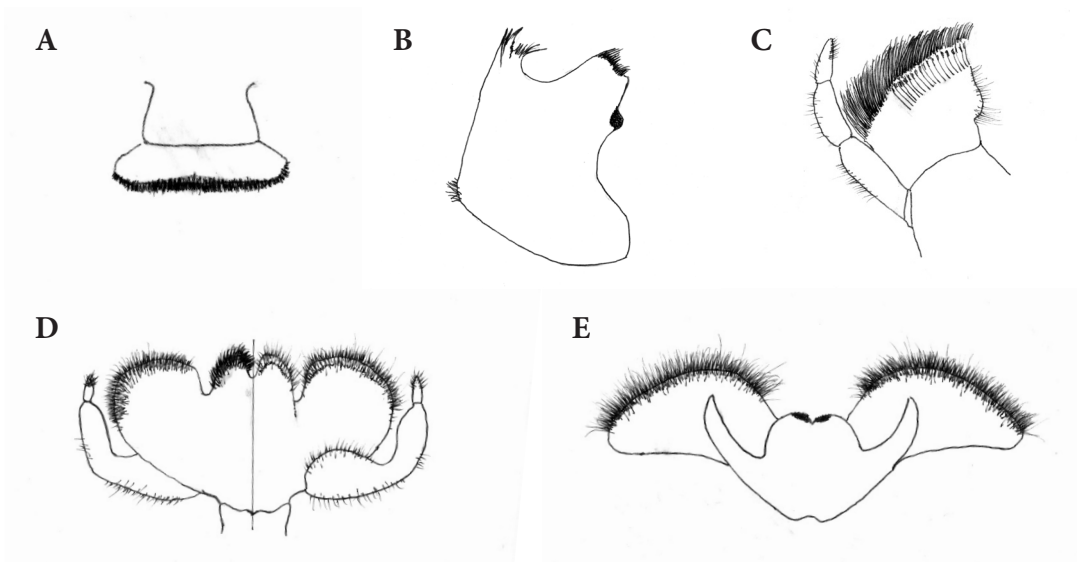


Figure 15. *Deleatidium rapidum*, larval mouth parts. A, clypeus and labrum. B, left mandible. C, right maxilla. D, labium, in dorsal (left) and ventral (right) views. E, hypopharynx.

denticles; smoothly curved to rounded lateral margins, dorsally with dense feather-like hairs. Mandibles (Fig. 15B): an irregular cluster of 12–20 hairs at the centre of the outer margin, outer incisors with 4 serrations on the mesial surface. Maxillae (Fig. 15C): galea-lacinia with a sub-apical row of 17 spines; palp segment 2, 0.86 x as long as segment 1; segment 3, 0.52 x as long as segment 2. Labium (Fig. 15D): with two paired spines on the shoulder of the submentum; palp segment 2, 0.68 x as long as segment 1; segment 3, 0.46 x as long as segment 2. Hypopharynx (Fig. 15E): lingua with two apical lobes, the crest of each with a small tuft of hairs directed mesially; the anterior margin of the superlingua with mesially directed thick, long hairs. Thorax pale yellowish, dark brown markings at the margins; the pronotum with paired submedian curved brown marks; pleura

and sterna whitish. Legs yellowish white with a pale proximal white macula on anterior surface. Abdomen pale yellowish with a pale mid-dorsal longitudinal line, terga 1–5 with variable dark brown marks; terga 6–9 with paired submedian dark brown inverted U-shaped marks. Sterna whitish with a faint blackish ganglion visible on sternum 7 only. Gills (Fig. 16) single, plate-like and rounded; gill 1 wider than long (2: 1) with the ventral margin expanded basally as a lobe; gill 7 curved ventrally beneath the abdomen. Lamellae translucent, tracheae and capillaries black. Posterolateral projections developed on segment 9 only. A group of whitish hairs on sternum 5, becoming more plentiful successively on sterna 6–9. Caudal filaments yellowish white 1.03–1.13 (1.08) x body length. Each segment of the filaments with a distal whorl of pale yellowish denticles.

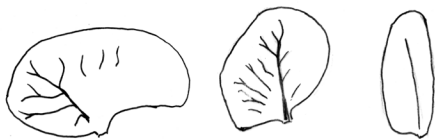


Figure 16. *Deleatidium rapidum*, abdominal gills 1, 4, 7 (from left to right).

Holotype: Male imago, TO/HB, Mohaka River, McVicar Road, New Zealand. 39°12'S, 176°37'E. 320 m. 11 October 2002, WJ Crawford (CMNZ 2014.2.47461).

Allotype: Female imago, TO/HB, Mohaka River, McVicar Road, New Zealand. 39°12'S, 176°37'E.

320 m. 15 November 2002, WJ Crawford (CMNZ 2014.2.47462).

Paratypes: All same locality as holotype and allotype; three male imagines, collected 18 September 2002 (CMNZ 2014.2.24822), 23 October 2002 (CMNZ 2014.2.47464) and 15 November 2002 (CMNZ 2014.2.47463); three female imagines, collected 14 September 2002 (CMNZ 2014.2.24823), 11 October 2002 (CMNZ 2014.2.47469) and 13 November 2002 (CMNZ 2014.2.47466); one male subimago, collected 21 November 2002 (CMNZ 2014.2.47467); one female subimago, collected 15 November 2002 (CMNZ 2014.2.47468); eight larvae, collected 9 September 1998 (CMNZ 2014.2.24815–24818), 14 September 2002 (CMNZ 2014.2.47470), 13 November 2002 (CMNZ 2014.2.47471), 15 November 2002 (CMNZ 2014.2.47472) and 22 November 2006 (CMNZ 2014.2.47473); one male imago, collected 13 November 2002 (NZAC); one female imago, collected 21 November 2002 (NZAC); one larva, collected 9 September 1998 (NZAC).

Distribution and habitat: William J Crawford, the collector of all specimens, described the habitat as fast white-water riffles, runs and rapids. Most larvae were found clinging to large rocks and immovable boulders from which they were difficult to dislodge and hard to reach. As these are the only records of *D. rapidum*, its geographical range is unknown.

Remarks: The male genitalia of the imago most closely resemble those of *D. kawatiri* and *D. autumnale* Phillips, 1930 in lacking ventral appendages. However, the paired penes are apically rolled ventrally, with a sharp subapical margin. *Deleatidium rapidum* can also be distinguished from *D. kawatiri* by the strongly marked ganglion on sternum 7 and from *D. autumnale* by paired submedian whitish circular marks on the anterior margins of dorsal abdominal segments 2–9. The subimago most closely resembles that of *D. townsi* Hitchings, 2009. Although the wings are also almost

uniformly whitish, the costal brace and pleural wing recess is brown and distinctly darker than the remainder of the forewing. The larva most closely resembles *D. myzobranchia*, but differs in the anterior margin of the labrum being without a narrow anteromedian cleft, the submentum having two pairs of spines on the shoulder and prolific whitish hairs on the ventral abdomen sternum 9 and diminishing progressively back to sternum 5. The larval foreleg closely resembles that of *D. crawfordi* (Fig. 8). Many mountain streams in New Zealand are characterised by steep gradients and cool waters (Winterbourn 1997) and are frequently inhabited by *Deleatidium* larvae belonging to the informal ‘myzobranchia group’ (Winterbourn 1978), which is characterised by large laminar gills arranged in a ventral ovate pattern. Larvae are believed to maintain their position in swift water primarily by gripping rock surfaces with their tarsal claws, while the large laminar gills assist the body to align itself so that the forces of lift and drag are reduced (Hitchings 2016). Part of this adaptation involves gill 7 being curved mesially and positioned at least partially beneath the posterior abdomen. In addition, the posterior of the abdomen is held slightly above the substratum by the dense, short hairs on sterna 5–9. In *D. rapidum*, these hairs are denser than in the other five described members of the complex and the ovate gill pattern is most strongly developed. Therefore, it appears that *D. rapidum* is particularly well adapted to a fast water habitat.

Etymology: The species name is derived from rapidum (Latin), “rapid” or “fast” from its preferred stream environment

Acknowledgements

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only provided all of the specimens, but also gave us a careful description of the habitat of these two new species. Without his skills and persistence, this paper would not have been produced.

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