Two new species of *Oxycanus* Walker (Lepidoptera: Hepialidae) from Kosciuszko National Park, one with a sub-brachypterous female

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Abstract *Oxycanus oreades* sp.n. and *Oxycanus oressigenes* sp.n. (Lepidoptera: Hepialidae) are described from the subalpine and alpine zones above 1600 m in Kosciuszko National Park, New South Wales. The females of *O. oreades* are sub-brachypterous and flightless. These species are compared to similar species of *Oxycanus* and to other *Oxycanus* found in the Mt Kosciuszko area. Sub-brachypterous Hepialidae in New Zealand and Europe are discussed. Aspects of the biology of the new species are described and the suitability of *O. oreades* for assessing climatic change is evaluated.

Key words Australia, Hepialidae, sub-brachyptery.

INTRODUCTION

Tindale (1935) revised the genus *Oxycanus* Walker to include 39 Australian species and later revised a further 21 species from New Guinea (Tindale 1955). Viette (1950, 1956) also described species from New Guinea but placed them in *Paraoxycanus* Viette which some authors regard as a synonym of *Oxycanus* (Tindale 1955; Nielsen 1996; Nielsen et al. 2000). There has been no revision of the genus in Australia since Tindale (1935) although he described three further species from Western Australia (Tindale 1955) and two more eastern Australian species (Tindale 1964). An Australian checklist of Hepialidae was published by Nielsen (1996) and the Hepialidae were catalogued for the Australian Faunal Directory by Edwards (2007). The Victorian species were listed by Kallies and Douglas (2008). A world checklist of the Hepialidae was published by Nielsen et al. (2000).

Winglessness, brachyptery and sub-brachyptery are all stages of wing reduction in Lepidoptera and were discussed by Sattler (1991). None of these states in female Hepialidae has been recorded in Australia previously but sub-brachyptery and brachyptery are known in other Hepialidae, not closely related to *Oxycanus*, in alpine environments in Europe and New Zealand.

Tindale (1935) was aware of two species of *Oxycanus* from the Mt Kosciuszko area one of which he described as *Oxycanus nuptialis* Tindale. He illustrated the male (holotype) and a female (paratype), the latter being fully winged. These specimens were collected by Richard Helms in March 1889 at altitudes of approximately 1500 and 1800 m. Helms discussed his collecting localities and dates (Helms 1890) and misidentified the moths as *Porina rufescens* Walker (Helms 1897). Tindale (1935) also recorded *Oxycanus rosaceus* Tindale, collected at an altitude of 1500 m on 12 March 1920 (label in G.A. Waterhouse’s writing) and this was confirmed by our own collecting. *O. rosaceus* has a fully winged female and has also been collected at several localities in Victoria. There are no other published records of *Oxycanus* from the Mt Kosciuszko area and all the specimens located in Australian collections from the vicinity were identified for this paper.

On 14 March 2006 empty pupal shells and flightless females of a species of *Oxycanus* were found on the crest of the Main Range about 1 km SW of the summit of Mt Twynam at an altitude of about 2100 m. Empty pupal shells were also found at several other sites of comparable altitude. More specimens were collected on 13 March 2008 in the same area near Mt Twynam but, while the gravid females were readily found in daylight, males remained unknown. Dedicated light trapping and day searching in 2009 and 2010 produced a series of males and females. In this and other species of *Oxycanus* adult emergence is closely timed to weather fronts (Helson 1970; Common 1990) and this simplified the search for males. Once males, associated with females of *Oxycanus oreades*, had been collected a male captured by Felix Sperling in 2004 was subsequently recognised as conspecific. Both sexes of *Oxycanus oressigenes* were collected unexpectedly but commonly in the search for males of *O. oreades*.

These species are described to facilitate monitoring the possible effects of climatic change on the populations of *O. oreades* to which, owing to its immobility and limited, high altitude distribution, it is likely to be vulnerable. With some 73 described species (Nielsen et al. 2000), *Oxycanus* is too large to revise easily. Consequently *O. oreades* and *O. oressigenes* are compared only with those species sharing similar male genitalia (as illustrated in Tindale (1935)) and appearance or found in close geographical proximity to them.

The terminology of the genitalia is derived from Ueda (1988), Nielsen and Kristensen (1989) and Dugdale (1994).
The term ‘alpine zone’ refers to the area above the climatic treeline and is discussed by Costin et al. (2000). The abbreviation ANIC is used for Australian National Insect Collection, CSIRO Entomology, Canberra, AM for the Australian Museum, Sydney, MM for the Melbourne Museum, Victoria, NSW NPWS for the New South Wales National Parks and Wildlife Service and SAM for the South Australian Museum, Adelaide.

SYSTEMATICS

Oxycanus oreades sp.n. (Figs 1,2,7,8,15,18)

Types. New South Wales, Kosciuszko National Park. Holotype: $\sigma$, 1 km SW Mt Twynam, 36°24'S, 148°18'E, 2100 m, 15.iii.2009, Edwards. In ANIC.

Paratypes: New South Wales, Kosciuszko National Park. 7 $\sigma\sigma$, 25 $\varphi\varphi$, 1 $\sigma\sigma$, 3 km SE Mt Kosciuszko, 36°29'S 148°17'E, 2000 m, 14.iii.2004, Sperling; 2 $\sigma\sigma$, 1 km SW Mt Twynam, 36°24'S 148°18'E, 2100 m, 11.iii.2009, Edwards, Dugdale, Green; 1 $\sigma\sigma$, Charlotte Pass Village, 36°26'S 148°20'E, 1785 m, 5.iii.2010, Edwards; 2 $\sigma\sigma$, 7 $\varphi\varphi$, 1 km SW Mt Twynam, 36°24'S 148°18'E, 2100 m, 6.iii.2010, Edwards; 2 $\varphi\varphi$, 1 km SW Mt Twynam, 36°24'S 147°17'E, 2081 m, 13.iii.2008, McAuliffe, Sweet, Phillips; 3 $\varphi\varphi$, 1.5 km SW Mt Twynam, 36°19'S 148°18'E, 2100 m, 14.iii.2006, Green; 1 $\varphi\varphi$, Blue Lake Lookout, 36°24'S 148°18'E, 2000 m, 15.iii.2009, Edwards. Genitalia tubes 221, 228. In ANIC, AM, SAM and MM.

Diagnosis. Male, antennae broadly bipectinate, pale yellow, wings sparsely scaled, forewing grey with two prominent cream sub-basal spots, hindwing and abdomen basally pinkish ochreous. Male genitalia with an evenly rounded pseudotegumen unornamented except for a ventral bump and short stout anteroventral tooth. Long, narrow, lightly sclerotised twin processes, saccus not invaginated. Female sub-brachypterous. Female anogenital field much broader than high, intergenital lobes lightly sclerotised and not prominent, median piece broadly mound-like.

Male (Fig. 1). Wings sparsely scaled, forewing length 23–25 mm. Above. Head: proboscis absent; labial palpi three segmented, narrow, directed forwards; antennae pale yellow, short, less than half costa, bipectinate, rami in middle about four times shaft, rami ciliated, frons and vertex with long grey scales: thorax, legs dark grey, abdomen basal two-thirds pale pinkish ochreous, distally grey. Forewing costa straight, gently curved towards tip, termen and dorsum evenly rounded; very thinly scaled, grey, three sub-basal cream spots within cell and a cream bar below base of R5, a median irregular transverse row of small cream spots outlined in dark grey, a similar

Figs 1–6. Adults, upperside. (1) Male; (2) female, Oxycanus oreades; (3) male; (4) female, Oxycanus oreissigenes; (5) male, Oxycanus nuptialis; (6) male, Oxycanus incanus. Scale bar 1 cm.
subterminal row of cream spots, sometimes all spots except basal two obsolete, posterior base of wing pinkish ochreous, cilia grey. Hindwing costa straight, apex rounded, termen and dorsum evenly rounded; grey, paler distally, base pale pinkish ochreous, cilia grey. Beneath both wings grey with upperside spots showing through, base hindwing pale pinkish ochreous.

**Female (Fig. 2).** Sub-brachypterous, forewing length variable 18–25 mm. Above: head: proboscis absent, labial palpi very short, three segmented, antenna ochreous, short, serrate, frons and vertex pale grey: thorax and legs pale grey, abdomen swollen, distally pale grey, basal half ochreous. Forewing, reduced by narrowing of wing, venation complete, costa straight, apex sharply rounded, termen and dorsum evenly rounded, very oblique; thinly scaled, pale grey, two sub-basal cream spots margined with dark grey, cream spot below base R5 small, these cream spots often obsolete and replaced by ill-defined dark grey, cilia grey. Hindwing narrow, venation normal, costa straight, apex sharply rounded, termen and dorsum rounded, pale grey, basally ochreous, cilia pale grey. Beneath both wings, pale grey, ochreous at base.

**Male Genitalia (Figs 7,8).** Pseudotegumen heavily sclerotised, evenly rounded, a ventral bump and a short stout anteroventral tooth; twin processes long narrow sclerotised; valvae short stout, slightly incurved with numerous setae, truleum a sclerotised rectangular plate, juxta approximately square, saccus broadly V-shaped not deeply invaginated.

**Female Genitalia (Fig. 15).** Anogenital field much wider than high; dorsal plate broad, subtriangular; intergenital lobes lightly sclerotised and not prominent; side piece long, narrow; median piece simple, mound-like, setose. Ductus bursae short, narrow differentiated from corpus bursae which is ovoid.

**Etymology.** The Oreades are Greek nymphs of the mountains.

**Distribution (Fig. 17).** *O. oreades* adult females have been found only above 2000 m altitude in the Mt Kosciuszko area, from about 1 km SW of the summit of Mt Twynam and at the Blue Lake Lookout. A male was found 3 km SE of Mt Kosciuszko at 2000 m. These sites are shown by open circles in Figure 17. A male has also been found at Charlotte Pass Village at 1785 m but it is not clear if a population is found this low or the male was wind-blown from a higher altitude.

**Biology**

Adults have been collected from 6 to 15 March in different years although on 7 March 2007 a visit to the site where most adults have been seen was too late in the season and empty.
pupal shells attested to an earlier emergence. Like other Australian species of *Oxycanus* the larvae and pupae live in tunnels underground and the adults emerge mostly on a single night, at a closely similar date each year and timed to coincide with the passage of a westerly or south-westerly weather front producing rain and a rapid drop in temperature. Males of *O. oreades*, being fully winged, fly vigorously at night and few may be found in the day. Females (Fig. 18) are unable to fly and may be found plentifully on the day following emergence clinging to vegetation among which they move sluggishly while scattering very high numbers of small spherical white eggs. These may turn black with age. On 15 March 2009 the female moths were active in a strong westerly gale and at a temperature near zero with rime ice remaining on nearby grass stems even at 10:00 h in mostly sunny conditions but with scattered ragged mist patches.

*Oxycanus oreades* occurs as widely scattered demes often up to 1 km apart. Within each of these populations females were found in scattered groups, eight or 10 might be present over 2 m² but the nearest other group might be 10 m or more away. They were found in *Poa-Celmisia* tall alpine herb-field plant communities (Costin et al. 2000) where patches of deep soils (about 30 cm or more) had accumulated. The depth of soil is clearly important but this is probably more for the protection of larvae or pupae from predation than to avoid freezing conditions as, with the normal winter snow cover, these soils rarely freeze even near the surface (K. Green unpubl. obs. 2009). The moths were associated with dense stands of the snow grass, *Poa costiniana* Vickery, and the larvae are conjectured to feed on the underground or basal parts of the live plants, or possibly decaying leaves. Adults were also often found in stands of the snow daisy, *Celmisia costiniana* Gray & Given, usually mixed with snow grass but with always a deposit of dead grass mulch present indicating a former grass sward. They were not found in the stony fieldmark community which was interspersed with the tall alpine herbfield. The cast pupal shells were drawn entirely out of the ground and were very persistent remaining conspicuous for weeks. Occasionally in a close search some much degraded fragments of pupal shells from the previous year were found.

The durations of the egg, larval and pupal stages are unknown. Most adult Hepialidae cannot feed or drink and live only a day or two.

At about the time that adults of *O. oreades* emerge, three species of birds that commonly feed on insects are usually seen in the alpine zone: Australian kestrel (*Falco cenchroides*),
Vigors & Horsfield), little raven (Corvus mellori Mathews) and Richard’s pipit (Anthus novaeseelandiae Gmelin) (Green & Osborne 1994). Only the last two are common and both forage in alpine herb-fields and feed on the commonly available insects, bogong moths (Agrotis infusa (Boisduval)) and grasshoppers (Kosciuscola spp.) and would therefore probably feed on O. oreades. In 2006 and 2008 both these birds were present. In 2009, however, the little raven was conspicuous at altitudes up to 2000 m but the only bird seen above 2000 m when the moths were present was Richard’s pipit. There was a ready source of food in the bogong moths which were hidden in the grass and were still plentiful. Bird predation of males of O. oreades appeared severe and many discarded wings and other body parts sometimes accompanied by telltale bird droppings were found. The droppings were consistent in size with those of Richard’s pipit. Predation of the females appeared light with only a few damaged individuals in spite of their large size, immobility and conspicuous exposure. With pipits as a major predator one would expect female predation to be high and male predation low because pipits are mainly ground feeders and only occasionally take large insects on the wing (Green & Osborne 1994) but the reverse appears to be the case. The other possible major predator on the female moths is the red fox (Vulpes vulpes L.). In the alpine zone their major food in summer and autumn is the bogong moth but, in autumn as bogong moths emigrate and their numbers decline, foxes spend more time foraging in grassland for grasshoppers (Green 2003) and would probably take immobile O. oreades females without leaving any evidence.

Oxycanus oressigenes sp.n. (Figs 3,4,9,10,16)


Diagnosis. Male antennae bipectinate, yellow, wings densely scaled, forewing pattern extremely variable, ground colour ranging from dark grey to pale ochreous yellow with up to three bands of spots broadly parallel to the termen and some sub-basal spots. All except sub-basal spots may be obsolete, they may be grey or enlarged with white ringed by grey, sometimes with a pale longitudinal streak across wing, darker grey anteriorly, a dark grey spot in cell. Male genitalia with pseudotegumen with two strong ventral teeth both bent outwards. Twin processes long, narrow, lightly sclerotised, saccus broadly invaginated. Female with fully developed, sparsely
scaled wings pale ochreous grey, forewing with a longitudinal pale line across wing. Female anogenital field about as wide as high, intergenital lobes sclerotised, prominent and pointing posteriorly, median piece narrowly mound-like.

**Male** (Fig. 3). Forewing length 20–22 mm. Above. Head: antennae ochreous, bipectinate, rami in middle about three times shaft, rami ciliated: thorax, legs dark grey, abdomen basally ochreous. Forewing costa straight, gently curved towards tip, termen and dorsum evenly rounded; thinly scaled, ochreous grey, a dark grey line running from near base to near base of M1 with a pale ochreous spot at the base of R5, a dark spot in cell above base of CuA1, two median transverse rows of grey spots, poorly defined, from near apex to M3 and continuing as a single row to dorsum, an almost obsolete submarginal row of grey spots, a trace of a grey terminal row of grey spots between the ends of the veins, posterior base ochreous, cilia grey. Hindwing costa straight, apex rounded, termen and dorsum evenly rounded; grey, basal fourth pale ochreous, cilia grey. Beneath both wings grey, base both wings pale ochreous.

**Female** (Fig. 4). Wings fully formed, sparsely scaled, forewing length 22–27 mm. Above. Head: proboscis absent, labial palpi very short, three segmented, antenna ochreous, short, bipectinate with rami as long as width of antennal shaft, frons and vertex pale grey: thorax and legs pale ochreous grey, abdomen pale ochreous grey. Forewing, costa straight, apex evenly rounded, termen and dorsum evenly rounded, very thinly scaled, pale ochreous grey, a streak running from base through base of M1 very pale ochreous, anterior of this ochreous grey, posteriorly pale ochreous grey, two rows of median poorly defined grey spots, sometimes with ochreous centres, running from R3 to M1 then a single band of poorly defined pale grey spots running to near dorsum, a subterminal band of a pale grey almost obsolete, base of wing pale ochreous, cilia pale ochreous grey. Hindwing, costa straight, apex broadly rounded, termen and dorsum rounded, pale ochreous grey very slightly paler towards base, cilia pale ochreous. Beneath both wings pale ochreous grey.

**Male Genitalia** (Figs 9,10). Pseudotegumen heavily sclerotised, unevenly rounded, two strong ventral teeth both bent outwards and a short, stout anteroventral tooth; twin processes long, narrow, lightly sclerotised; valvae short, incurved with numerous setae; trilobium a sclerotised rectangular plate; juxta poorly differentiated; saccus V-shaped, deeply and broadly invaginated.

**Female Genitalia** (Fig. 16). Anogenital field about as wide as high; dorsal plate broad, subtriangular; side piece long, narrow; intergenital lobes prominent, sclerotised, backward pointing; median piece simple, narrowly mound-like, setose; ductus bursae poorly differentiated from corpus bursae which is ovoid.

**Etymology.** Oressigenes (Greek): those that are mountain born.

**Distribution.** *O. oressigenes* has been found from Rennix Gap (1600 m) to Charlotte Pass Village (1785 m) and beside the path between Blue Lake Lookout and near the crest of the Main Range at altitudes of 2015 and 2041 m. Above the Blue Lake Lookout they were found on the eastern slope of the Main Range which, at the time of flight, was much more sheltered from the wind than the main localities for *O. oreades*.

**Biology.** The species has a similar general biology to *O. oreades* except that the female is fully winged. Adult females were found on 15 March 2009 and 6 March 2010 in daylight following or during rain resting on a dense sward of *Poa costiniana* accompanied by loose pupal shells, but almost all the males were taken at light in rain. *O. oressigenes* flies with the first rains after about the beginning of March, and into April if no suitable rain occurs during March. As it has a much more extensive distribution than *O. oreades* it may be subject to more varied predation but with very high numbers of adults available, predators are probably quickly satiated.

**DISCUSSION**

Species of *Oxycanus* are notoriously variable in wing pattern and, in general, this is often not a useful feature in distinguishing species. *O. oreades* males do consistently have the two sub-basal cream spots which are not present in *O. oressigenes* which has extremely variable males varying in ground colour from dark grey to ochreous yellow and with numerous spots to almost unsotted. *O. oreades* females are sub-brachypterous while those of *O. oressigenes* are fully winged. Males of *O. oreades* are generally larger and the rami of the antennae are longer than *O. oressigenes*. The male and female genitalia of the two differ as outlined in the diagnoses and Figures 7–10.

These two species share the alpine zone but *O. oreades* alone is found on the highest, most exposed ridges of the Main Range above 2000 m. *O. oressigenes* is distributed widely in the subalpine zone above about 1600 m and extends into the alpine zone above 2000 m in sheltered places. In Figure 17, the filled circles show where loose pupal shells have been found but these could be *O. oreades* or *O. oressigenes*. Pupal shells have been found from 1800 m to 2120 m in the area from Valentines Creek in the northern Kerries to the South Rams-head. This suggests that one of these species at least, probably *O. oressigenes*, is found to the north of Schlink Pass (1800 m).

Sharing the subalpine zone with *O. oressigenes*, is the rarely collected *O. nuptialis* (Figs 5,11,12). This species was known only from Helms’ specimens until it was again collected in 2009 at Daners Gap (1675 m) and Smiggin Holes (1650 m). It is a larger species (forewing length in the male of 29–30 mm), similar in shape to *O. oressigenes* but with a deeper red colour at the base of the hindwing. This fades and shows up badly in the backlighting in Figure 5. The antenna is also notably short compared to the length of the forewing, about a quarter compared to a third in *O. oressigenes*, and the antennal rami are about 1.5 times the width of the shaft. It also has different male genitalia. *O. oressigenes* and *O. nuptialis* are closely related with similarities in the male genitalia and adult appearance.

A widely different species not illustrated here is *Oxycanus subvaria* (Walker) (or a species of the *O. subvaria* complex)
which also shares the subalpine zone with *O. oressigenes*, and is equally as common. This species is fully winged in the female and the adult males are easily distinguished from *O. oreades* and *O. oressigenes* being larger (29–30 mm) with broader wings, and antennae with much shorter rami (about the same length as the width of the antennal shaft) and with very different male genitalia. The pseudotegumen is strongly arched and with a large invagination posterior of the anteroventral tooth (Tindale 1935, fig. 48). The *O. subvaria* complex is widespread and found in Tasmania, Victoria and coastal, central and southern NSW and the Snowy Mountains.

Below 1600 m, between Wilsons Valley and Rennix Gap, two well-known and widespread species are found, *Oxycanus rufescens* and *O. rosaceus*, both easily distinguished from the alpine and subalpine species and both well characterised by Tindale (1935).

So far, *O. oreades*, *O. oressigenes* and *O. nuptialis* are not known from outside the Snowy Mountains and appear to have no close relatives elsewhere. *Oxycanus incanus* Tindale (Fig. 6) which was described from a specimen collected at Jervis Bay, NSW on 3 June 1918 by L.H. Mosse-Robinson is superficially very similar to *O. oressigenes*. From this *O. oressigenes* may be distinguished by having slightly narrower wings and a less salmon-coloured and more yellow base to the hindwing. The male genitalia of *O. incanus* (Figs 13,14), which are illustrated by Tindale (1935), have the teeth of the pseudotegumen differently shaped, spaced and arranged. *O. incanus*, in spite of its superficial similarity to *O. oressigenes* is, based on the male genitalia, more closely related to the group of species including *Oxycanus stellans* Tindale. In these the para-anal sclerite is well developed. The occurrence of the para-anal sclerite was discussed by Dugdale (1994) who found it in all Asian species with *Oxycanus*-like venation but not in New Zealand species. He found it present in Australian taxa but the species described here, with *O. nuptialis* and *O. subvaria* are exceptions. This character needs further investigation in the Australian *Oxycanus*.

Sattler (1991) discussed wing reduction in the females of alpine moths and this was further discussed in relation to the Mt Kosciuszko moths by Edwards (2002). In general the prevalence of wing reduction in females of some moths in alpine habitats is seen as an adaptation to cold and windy weather conditions and is often found in exposed habitats of small extent. Wing reduction in Lepidoptera occurs almost invariably in females; in males it is extremely unusual. In the New Zealand Hepialidae the genus *Aoraia* Dumbleton with 13 species, has at least eight with brachypterous or sub-brachypterous females and all of these are endemic to the South Island (Dugdale 1994). In the European Hepialidae four of the eight species in the genus *Pharmacis* Hübner are known or suspected to be brachypterous and are found in the Alps and the Pyrenees. Males of these may be day-flying, dawn-flying or night-flying depending on the species. All are found above an altitude of 1800 m (Leraut 2006).

Populations of *O. oreades* are clearly fragmented. Genetic interchange may be facilitated by the mobile males but the wing pattern of the single male specimen from SE of Mt Kosciuszko falls outside the range of variation in the males from SW of Mt Twynam (about 9 km distant in a straight line) so there is some evidence of isolation of populations. While the two cream spots are present in the male from 3 km SE of Mt Kosciuszko there are no median or submarginal rows of spots. The immobility and short life of the females suggest that movement of the populations in response to climate change may be slow and, as females have been found only above 2000 m and the highest point of Mt Kosciuszko is 2228 m, it is particularly vulnerable to global warming. The larvae live underground and do not travel, so the species has no dispersal stage. The effects of warming on *O. oreades* may operate directly through temperature on any stage of the life cycle or they may operate through the upward movement of predators of the vulnerable females.

The fairly precise and predictable emergence time each year of *O. oreades* is an aid to monitoring this species to assess climatic change. The two species found above 2000 m both leave loose, cast, pupal shells above ground after eclosion and the simple method of monitoring pupal shells which persist on the surface for a period of months is practicable. Pupal shells
of females of *O. oreades* are much longer (about 50 mm) than female pupal shells of *O. oressigenes* (about 35 mm). The head piece is the most distinctive part of the pupal shell and is often separated from the rest of the shell. The head pieces of the pupal shells may be distinguished by the different rugosity on the scape of the antenna and different proportions in the frons as shown in Figures 19 and 20.

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**References**


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