Survey report for the giant wēta *Deinacrida pluvialis* in Gloomy Gorge, West Matukituki Valley, Otago.

A joint Southern Lakes Sanctuary and Department of Conservation threatened species programme.

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Summary

A survey of the Nationally Endangered giant wēta (*Deinacrida pluvialis*) was conducted during April 2023 in Gloomy Gorge, a hanging glacial cirque basin in the upper reaches of the Matukituki Valley, Aspiring / Tititea National Park, Otago. Wēta had previously been found in the area on several occasions and a report written. That report recommended further surveys and monitoring of the wēta and outlined the risk of predation by mammals, primarily stoats and rodents. Our survey found 133 live wēta over three days and these were distributed in two separate locations. Our rate of wēta detection was comparable to other searches at four wēta /person/hour. We found multiple live adult wēta at the base of the French Ridge bluff system, an area that receives little direct sunlight and at an elevation of 1200m asl. Elsewhere in the cirque, we found wēta at 1600m on the north-facing side of the valley, a considerably warmer location. We conclude that mammalian predators are likely to be responsible for the observed wēta distribution pattern in the cirque, and this is probably a function of predator energetics and range. We highlight the need for a concerted and well-designed wēta population monitoring regime projected for at least the next ten years. Establishing Gloomy Gorge as an alpine ecological and climate monitoring unit would provide baseline ecological data for the complete range of managed alpine organisms within the cirque including, birds, lizards, invertebrates and vegetation.

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Introduction

New Zealand has 11 species of giant wēta, all members of the endemic genus *Deinacrida* (Orthoptera: Anostostomatidae). These insects are among the largest in Aotearoa / New Zealand with individuals weighing up to 71 grams and reaching 100mm in length. *Deinacrida heteracantha* for example, is considered the heaviest insect in the world.

There are four species of *Deinacrida* in the North Island (including nearby off-shore islands) and seven in the South Island. Of the South Island species, one is not threatened, while the remainder range from At Risk to Nationally Endangered (Hegg 2021a, Trewick *et al*. 2022).

Deinacrida pluvialis

Deinacrida pluvialis (Gibbs 1999) is a moderately-sized alpine wēta with adult females ranging between 40-60mm. Commonly known as the Mt Cook giant wēta, the species seems to have a narrow distribution apparently scattered throughout the central Southern Alps of the South Island, from Mt Alexandra in the north and south to the Cleddau Valley in Fiordland (Figure 1).

This confined distribution and the high rainfall habitat of *D. pluvialis* are probably important aspects of the insect's taxonomy and certainly its conservation situation. Part of the 'pluvialis puzzle' includes another giant wēta , the congeneric *Deinacrida connectens*, which is sympatric with *D. pluvialis* and occupies a similar elevation range, rainfall and alpine plant communities. However, *D. Connectens* is not threatened, has a considerably broader range as it has been found at quite low elevations in the eastern Canterbury foothills (pers. Obs.).

Deinacrida pluvialis and D. connectens share considerable geographic overlap and one might expect them to be sister taxa. However, genetic analysis indicates that *D. pluvialis* is more closely related to *Deinacrida talpa*, another giant weta from the Paparoa Range, far north and to the west of the axial Southern Alps. The situation is further complicated by a close relationship between *D. talpa* and a tree weta *Hemideina broughi* (Trewick and Morgan-Richards 2004).

These taxonomic and biogeographic curiosities highlight our limited understanding of the alpine wēta in their natural habitat. It is important that we act on their behalf if long term survival is the goal. For example, what life history traits does *D. connectens* have that *D*. *pluvialis* may lack for persistence and distribution? In 2021 the DOC panel of wēta experts re-classified *D. pluvialis* as Nationally Endangered (Trewick *et al.* 2022). The new (and undesirable) status was the motivation for this survey.

Previous work

For a comprehensive summary of previous work on *Deinacrida pluvialis*, see Danilo Hegg's 2021 report (appended to this document). Attention toward *D. pluvialis* seems to begin in the 1950s with John Salmon's 1950 notes followed by occasional mountaineer encounters with the insects. Victoria University entomologist George Gibbs visited several high-rainfall locations in Westland (Price Basin) and the Matukituki during the 1990s, culminating in the description of four giant wēta species (Gibbs 1999). Between 2004 and 2015 herpetologist Tony Jewel also found *D. pluvialis* in the upper Matukituki Valley. By 2014 however, Jewel notes a rapid decline in wēta numbers in the head of the Matukituki Valley (Hegg 2021b).

Danilo Hegg re-visited the upper Matukituki Valley in 2017 and 2021 and found no live *D. pluvialis* nor any other evidence of their presence (moults, frass, body parts etc.), concluding that the Upper Matukituki population appears to have become extinct due to rodent and stoat predation (Hegg 2021b).

Undeterred, Danilo then followed up a fresh report of an adult female and two nymphs seen in Gloomy Gorge by Samuel Purdie (Southern Lakes Sanctuary), in November 2020 and March 2021, during lizard surveys (Figure 2).

This survey

In 2022 *Deinacrida pluvialis* was designated as a Nationally Endangered species by the Department of Conservation threatened species panel, which included Danilo Hegg (Trewick *et al*. 2022). The new threat status prompted Southern Lakes Sanctuary[I] (SLS) to submit a Jobs for Nature funding application to the Department of Conservation in late 2022 (https://www.doc.govt.nz/our-work/jobs-for-nature--mahi-mo-te-taiao/). The SLS application goals were four-fold:

1 Widen the search area for *D. pluvialis* within Gloomy gorge.

2 estimate wēta population size and detection rate.

3 map the known distribution of the wēta in Gloomy Gorge.

4 Install wēta monitoring refugia (motels) in the alpine environment.

Tom Reeves (SLS) approached the Department of Conservation directly for collaboration on the recovery project and together Tom, Samuel Purdie (both SLS) and Warren Chinn (DOC) helicoptered into Gloomy gorge, where three nights and two days from April 14 – 17, 2023 were spent searching for wēta. The Department of Conservation shares close operational ties with SLS and the Matukituki Charitable Trust[II] Which maintain a trapping and tracking tunnel programme in the Gloomy Gorge cirque along with Rock Wren population monitoring.

Methods

Survey site

Gloomy Gorge is a deep hanging alpine cirque, some three kms down-valley from the Matukituki head waters and 200m higher in elevation (Figure 2). Following Sam Purdie's wēta find in the cirque, Danilo Hegg spent two nights searching resulting and found nine *D. pluvialis*. Notably, the insects were tightly confined to the foot of bluffs below French Ridge. This location is cold (receiving no direct sunlight in winter), damp and receives an almost continuous trickle of rockfall and winter avalanche debris. Danilo Hegg wrote up his findings from several wēta-hunting trips into the West Matukituki catchment and provided the author with a copy of the report (Hegg 2021b). In his report, Hegg recommended expanding search areas within in Gloomy Gorge, specifically down valley on the true right (below French Ridge Hut).

The glacial topography of Gloomy Gorge forms a natural barrier to the cirque basin and probably increases the survival chances for wēta. Specifically, the steep bluffs and high glaciated amphitheatre of the Maud Francis Glacier encompasses more than 180 degrees of the cirque between French Ridge, Mt Avalanche (2606m) and Rob Roy Peak (2609m) presenting a high and complex alpine environment to any prospective wēta predators. Hegg assumed that the relative inaccessibility of Gloomy Gorge to predators coupled with elevation and cold, shady conditions in the upper cirque act together to keep predator numbers in check (Figure 3). Hegg indicated that all that is required to manage the wēta population is a line of traps, bait stations and surveillance devices straddling the low elevation access point to the cirque, between French Ridge and the slopes of Rob Roy Peak (Figure 2).

[I]Southern Lakes Sanctuary is a trust overseeing environmental protection and ecological restoration projects see https://southernlakessanctuary.org.nz/) [II] https://www.mctrust.co.nz/

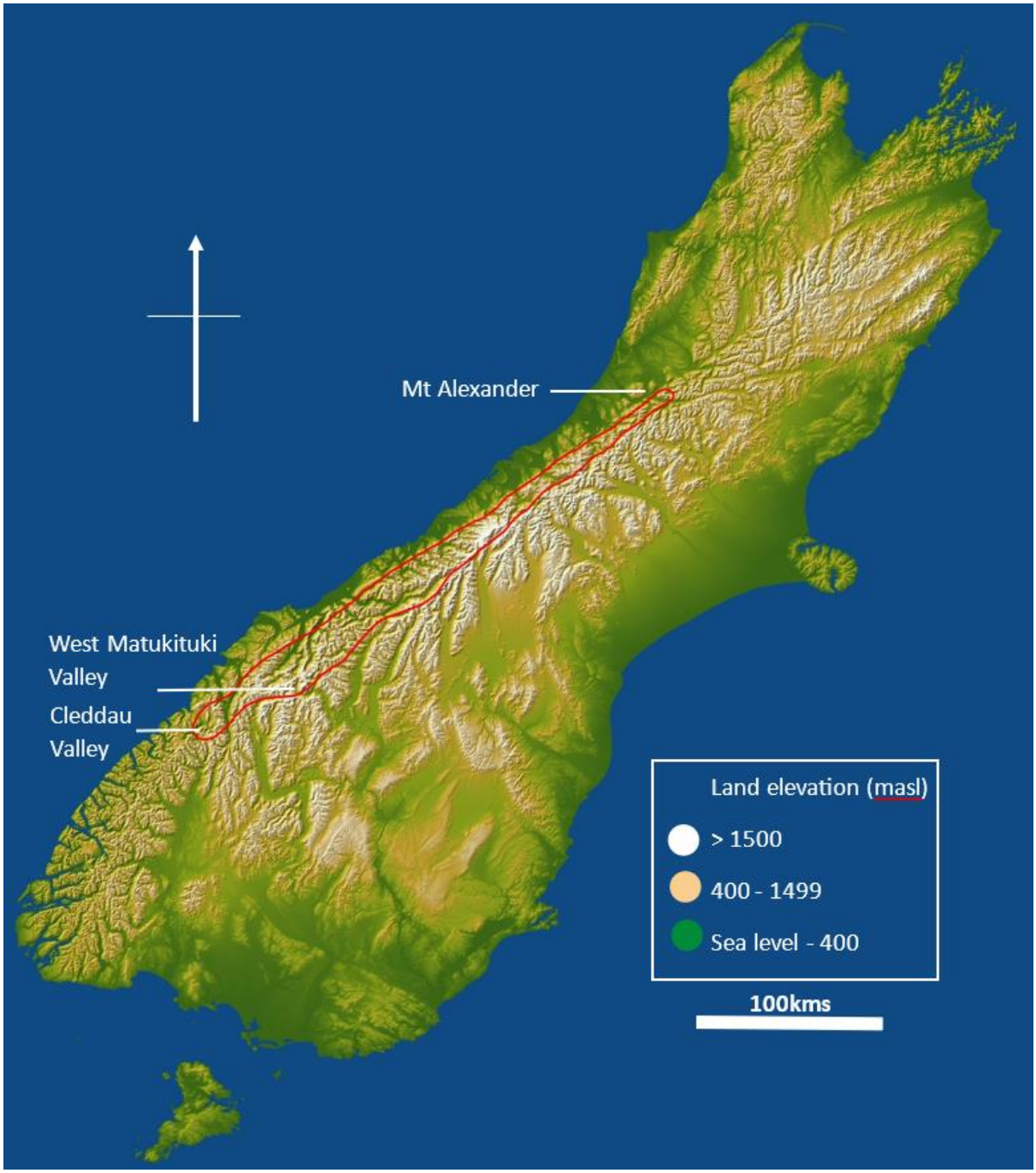

Figure 1. Known distribution of *Deinacrida pluvialis* wēta in the South Island of New Zealand (red polygon). Actual range is an approximation from point observations throughout the Southern Alps. Relief map adapted from: NASA Image courtesy JPL/National Geospatial-Intelligence Agency (https://earthobservatory.nasa.gov/images/5227/topography-of-new-zealand). Wēta distribution adapted from Gibbs (1999) and Hegg (2021a, b).

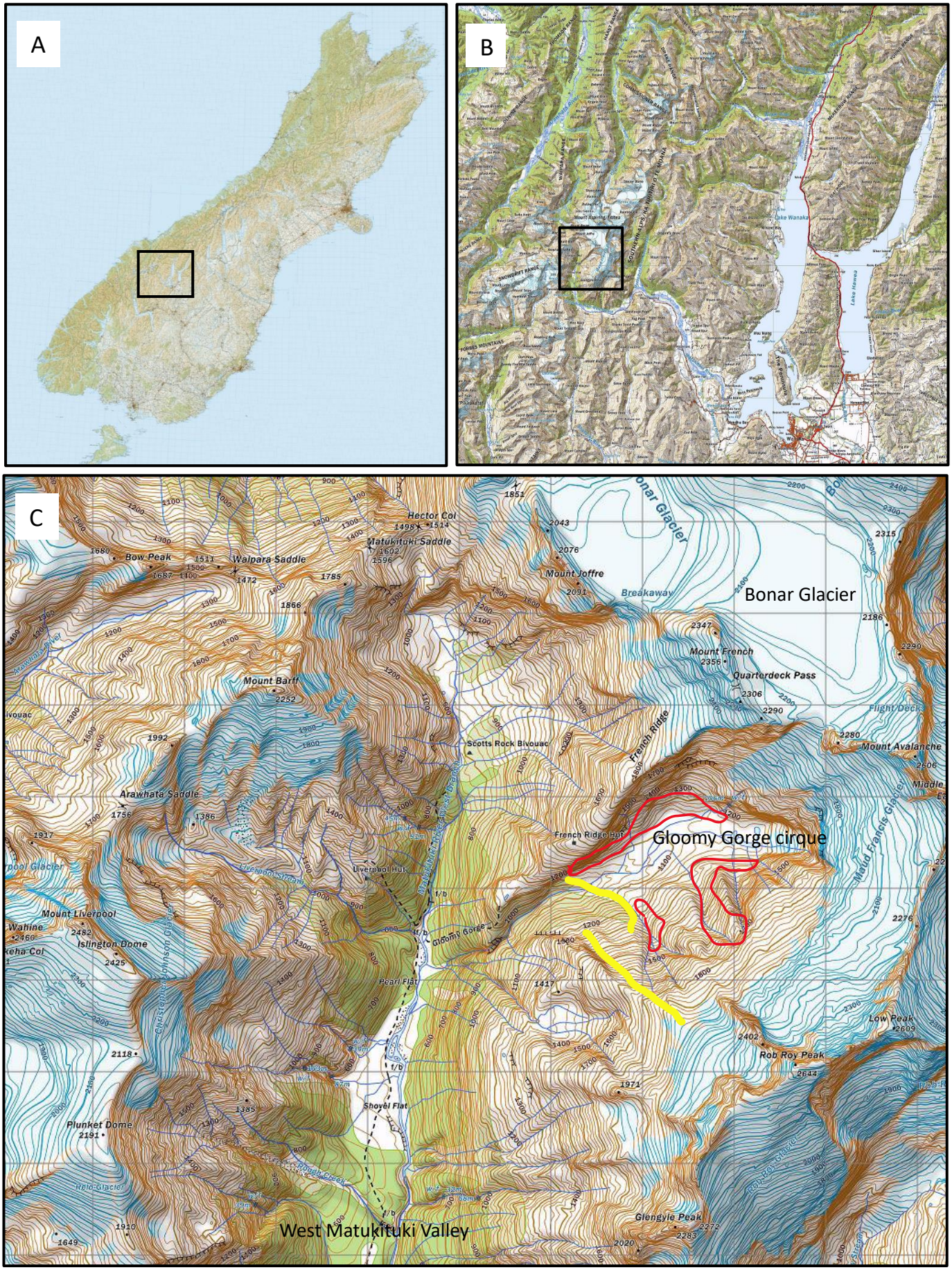

Figure 2. Locality maps. A. South Island, B. Location of West Matukituki Valley in Western Otago, C. Upper West Matukituki Valley and Gloomy Gorge. Red polygons represent wēta locations during our and Hegg's searches. The yellow lines indicate where mammal trap lines could be established as an access barrier to predators from lower elevations.

Wēta searching

Wēta searches were carried out at night by spotlighting (using high power LED headlamps) and hand turning rocks by day (to reveal wēta dens). We searched for wēta over three consecutive nights, repeating locations previously searched by Danilo and Sam Purdie. The third night of wēta searching included talus slopes up-stream of our camp (below Quarterdeck Pass), the cirque basin floor and the lateral moraine system on the true-left of the cirque basin (Figure 2).

A 'Kestrel' instrument was used to record environmental variables (temperature, humidity, air speed and pressure). At night, the Kestrel was equilibrated to free-air conditions for at least 15 minutes by suspending from rocks or vegetation.

Wēta 'motels'

On our final day, three artificial wēta refugia ('motels') were installed, in areas where previously wēta had been found. The refugia were cast from wire mesh reinforced concrete with a vault of approximately 2000 cm^3 in which weta may occupy. The aim was to establish a standardised monitoring system for *D. pluvialis* while potentially affording limited predator protection. Wēta enter the refugia through a 16mm slit that opens into an expanding chamber. The design includes a separate inspection-lid placed over an open pedestal at the rear section of the refuge. The removeable lid allows wēta to be counted while minimising disturbance. The motels will be left in place for the length of the monitoring work (3-5 years at least), or until destruction occurs (the current locations are within a heavy snow-avalanche and fluvial zone).

Results

Figure 4 shows the locations of all *D. pluvialis* wēta found during our survey which includes live adults, nymphs, exoskeletons and parts or frass (droppings). We found 133 live wēta over a total search time of 11 hrs (six hours at night and five by day), equating to four wēta/person/hour. See Table 1 (catch rates), Appendix 2 (observation data) and Appendix 3 for additional photographs of *Deinacrida pluvialis* from Gloomy Gorge.

The majority of live adult wēta (n=27) were located at night directly below French Ridge, on the shady true right flank of the valley. At this location most wēta were found hard against the bluff / talus contact zone, elsewhere they were scattered across the lower talus slopes (Figure 5). Adult wēta were observed easily at night against the bluff face, on vegetation (tussock and *Gaultheria* sp.), perched on rocks or feeding on scree vegetation. Relative humidity was a constant 84%, for the three nights and the average ambient air temperature during night searching was 8^{o}C.

Sam Purdie and Tom Reeves ascended several gullies on the true left of the cirque and found live wēta under rocks at or above 1500m. On the lower, moraine terrace and talus slopes the author found several dead wēta, either whole or body parts, also underneath schist slabs. These appeared to be well used wēta 'dens' (Figure 6).

The highest concentration of wēta (n=76) were nymphs at a single location, possibly from one or several egg broods. The nymphs were located by Sam Purdie, at or above 1600m, during the day and were all under slab rocks on the true left of the cirque basin (the sunny side), some 400m below the Maud Francis Glacier of Rob Roy Peak. Purdie also reported finding wēta body parts during his ascent of the gully (Figure 4 and 6). We did not find equivalent clusters of nymphs on the shaded side of the valley, an area that never received direct sunlight during our visit (Figure 7). Our combined observation rate (four wēta /person/hour) was lower than Hegg or Purdie's 2020 and 2021 Gloomy Gorge search

rates, although this may reflect our pausing to photograph wēta . Nevertheless, our detection rates confirm that Gloomy Gorge is currently a stronghold for the taxon.

Figure 3. Head-wall bluff of Gloomy Gorge cirque **'**presenting a high and complex alpine environment to any prospective wēta predators**'.** At far left is French Ridge (2290m), centre left upper Bonar Glacier névé with glacial ice spilling over from the Flight Deck and Quarter Deck icefalls. Central peaks are (L) Mt Avalanche 2606m, Middle Peak (2518m) and East Peak (2533m). The Maud Francis Glacier spans left to right terminating in active ice falls above the bluffs. Distance across image is about 2.5 kms.

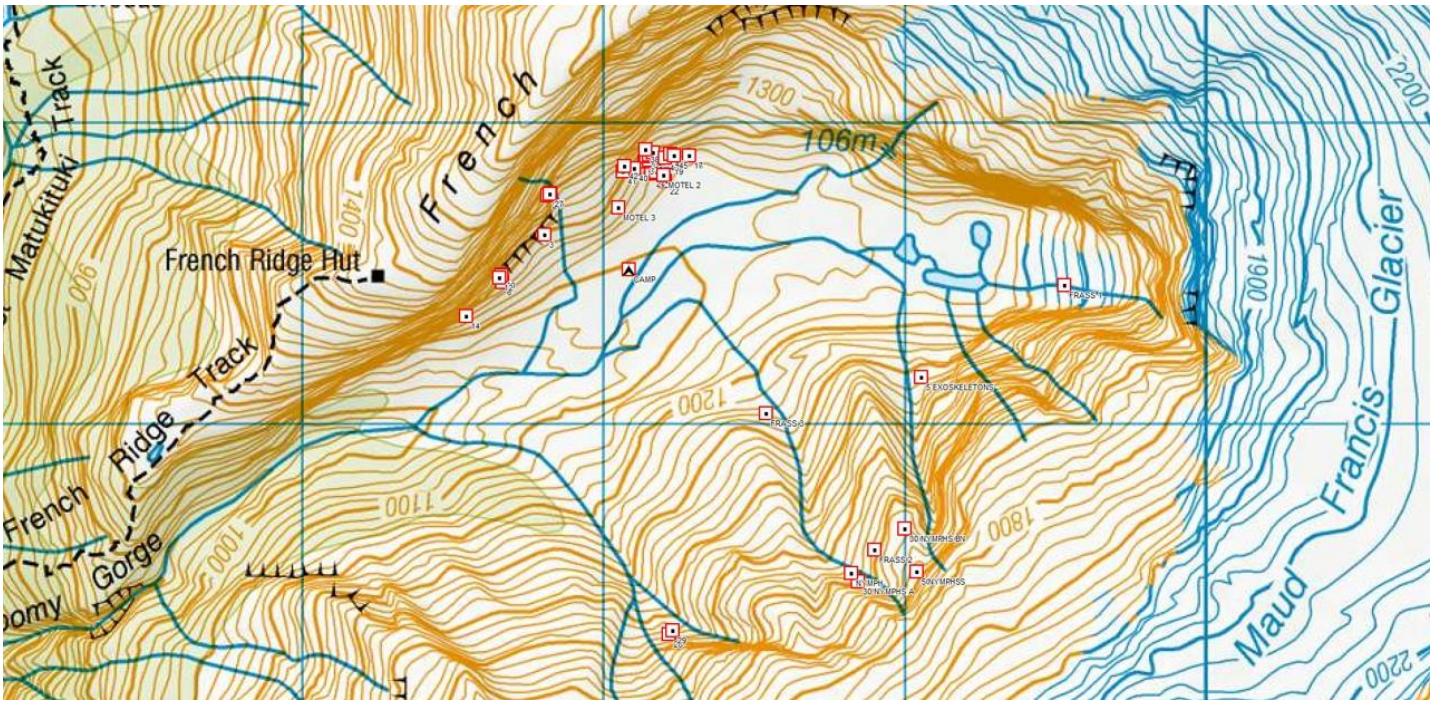

Figure 4. Topo map showing the location of all *Deinacrida pluvialis* wēta encountered during the April 2023 visit to Gloomy Gorge.

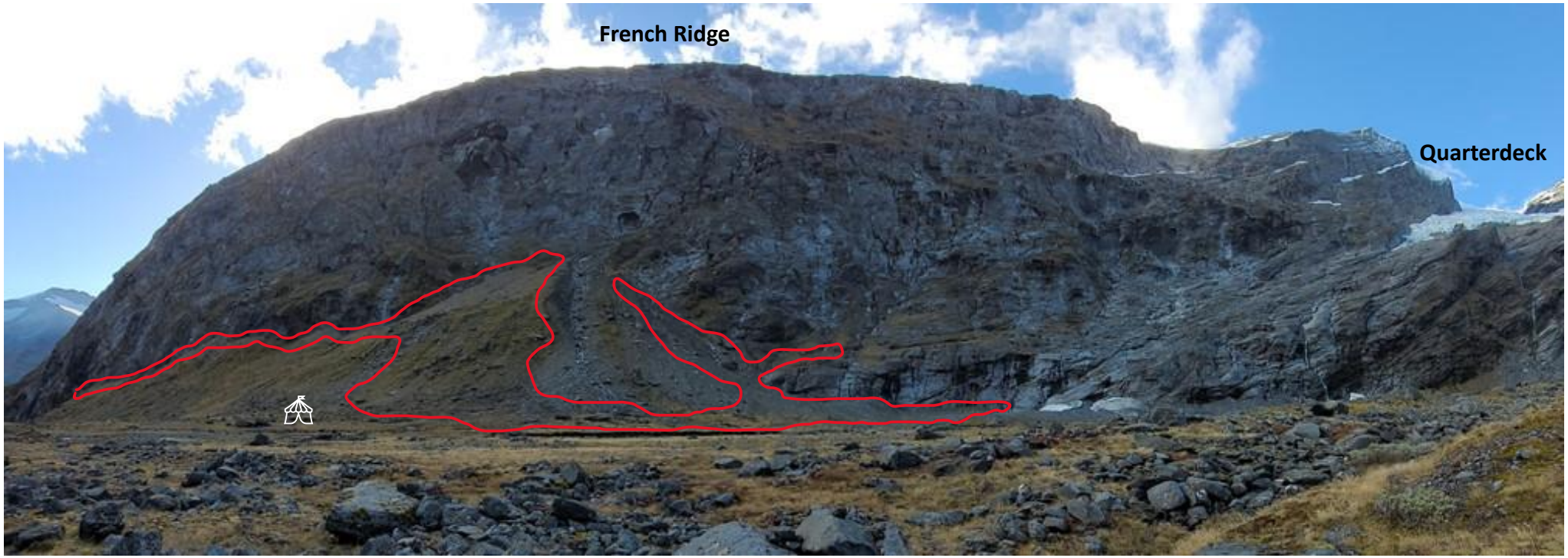

Figure 5. French Ridge (true right) side of Gloomy Gorge cirque. Areas searched for wēta are within the red-lined polygon. The majority of wēta were found at the top of the talus and foot of the main bluff system. The location has considerable risk of rockfall.

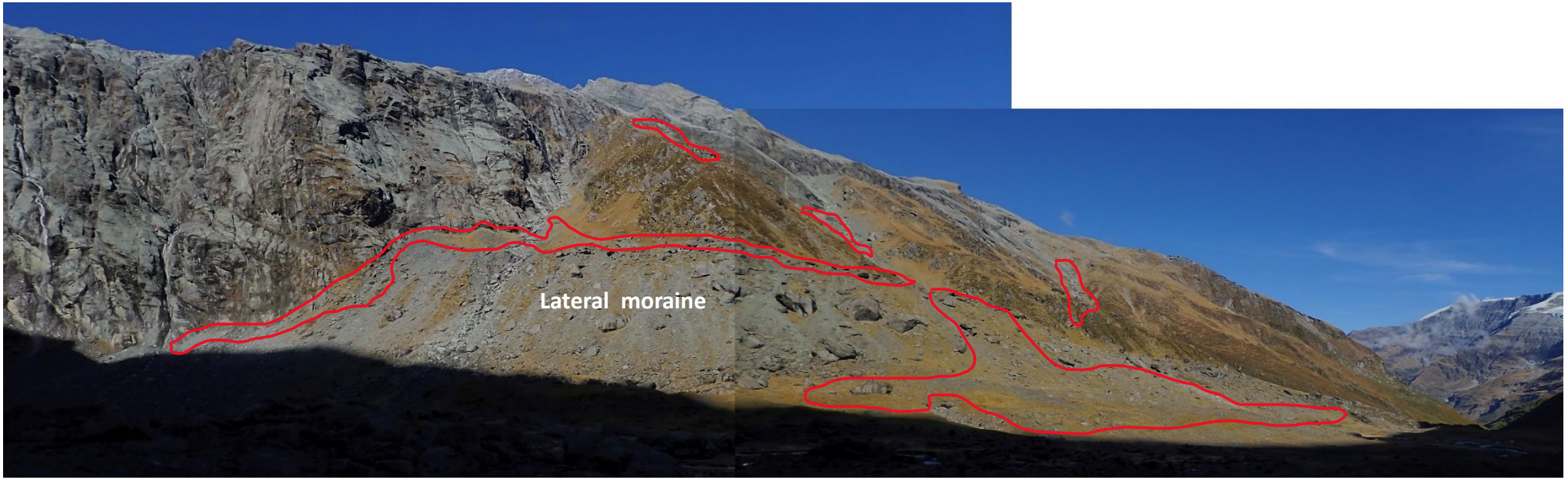

Figure 6. The Rob Roy ridge (true left) side of Gloomy Gorge cirque. Areas searched for wēta are within the red-lined polygon. The majority of wēta were found within the highest polygon. Several dead adults were found under slabs, on the upper surface of the lateral moraine, left of centre.

Figure 7. Down-valley view of Gloomy Gorge with Mt Liverpool at rear. Photograph was taken at 13:00 on April 15, 2023 and illustrates the shading effect on the true right of Gloomy Gorge.

Table 1. Comparative catch rates for *D. pluvialis* between 1992 and 2023 (33 years). Information from Hegg (2021b).

Year	Location	Persons	Number of wēta found	Encounter rate (Wēta /person/hour)
1992	Head waters, West Branch Matukituki River	GG	43	14.3
1994	Price Basin, Westland	GG	Unknown	1.2
2009 (February)	Head waters, West Branch Matukituki River	WC	0	0
2014 (April)	Head waters, West Branch Matukituki River	TJ	2	1.3
2017 (May)	Above Scotts Biv, head waters, West Branch, Matukituki Valley	DH	0	0
2020 (November)	Gloomy Gorge, Matukituki Valley	SP	1(Adult female). 2 (nymphs)	Incidental find
2021a (January)	Head waters, West Branch Matukituki River	DH	0	0
2021b (March)	Rob Roy Peak Basin – West Branch Matukituki Valley	DH	0	0
2021c (March)	Gloomy Gorge, Matukituki Valley	DH	12 (8 Adults 4 nymphs)	4
2021c (March)	Gloomy Gorge, Matukituki Valley	SP	12	6 (approx.)
2023 (April)	Gloomy Gorge, Matukituki Valley	TR, SP, WC	133	4.1 (includes all live wēta)

DH=Danilo Hegg, GG=George Gibbs, SP=Samuel Purdie, TJ=Tony Jewel, TR=Tom Reeves, WC=Warren Chinn.

Wēta detection rates

We can use detection rates as a rough measure of wēta population trends. Between 1992 and 2009 the population of *D. pluvialis* apparently crashed from a detection rate of 14 wēta per person hour to nil (Figure 8). From 2010 onwards detection rates show a recovery of about 0.25 – 0.27 wēta per person-hour. At that rate however, it will take nearly 55 years to return to the detection rate noted by Gibbs in 1992 – well into the 2050s (Figure 9). In the absence of a consistent data series, Figure 8 shows a combination of detection results from the West Matukituki headwaters (the Scotts Biv area) and Gloomy Gorge. We acknowledge that detection bias is difficult to control, across all locations, therefore Figures 8 and 9 are indicative only.

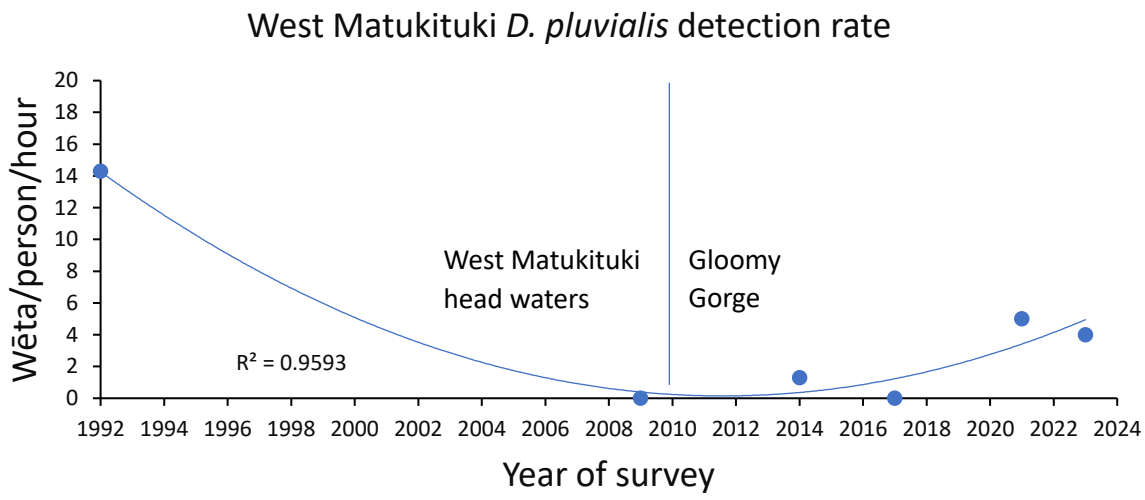

Figure 8. Plot showing wēta detection rates by year for the West Matukituki and Gloomy Gorge sites. Fitted curve is a 2nd order polynomial.

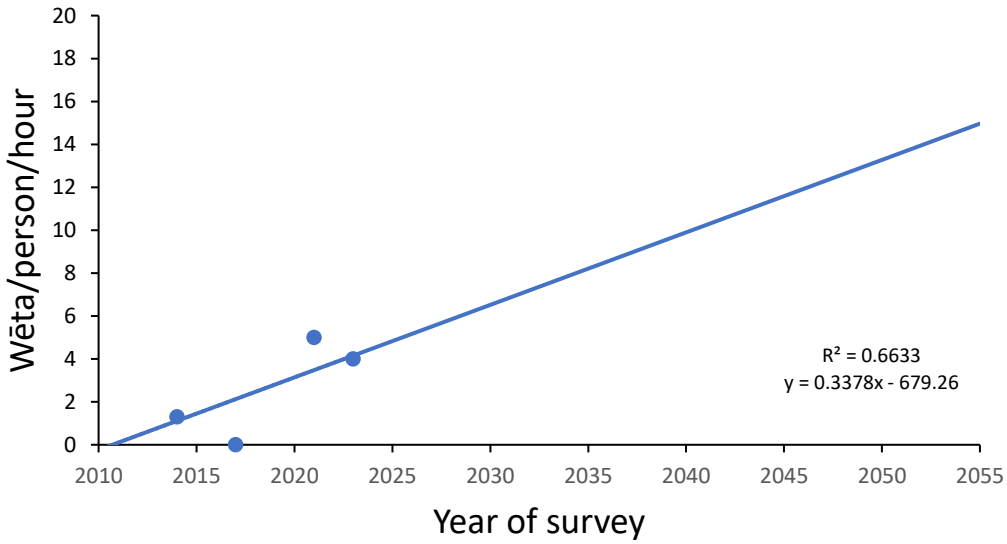

Figure 9. Projected wēta detection rate for the Gloomy Gorge cirque population. At the projected rate it will be at least the year 2055 before wēta numbers are back to the detection levels of Gibbs' 1992 survey in the West Matukituki head waters.

Comparing detection rates between South Island *Deinacrida* species

Population monitoring of giant wēta is challenging due to difficult terrain and access, extensive species range and the intrinsic characteristics of giant wēta ecology – a matter for which we remain largely ignorant. Different species of giant wēta may have varying detection characteristics which are worth teasing apart, at least for refining population monitoring techniques. Table 2 provides a summary of detection rates for the five South Island high-country giant wēta (including *D. pluvialis*) although the values are indicative only as surveyor bias can't be easily controlled. In any case, *D. pluvialis* detection rates have, apparently, been the highest among the five taxa (data are from Hegg 2021a). We note that April was not an optimal time of year for our survey and may have contributed to the lower catch rate than that of Hegg and Purdie who surveyed at the end of a very stable and warm summer spell in 2021.

Table 2. Comparative catch rates between species and survey period

Species	Data period	Location	Average find rate (wēta /person/hour)
D. pluvialis	1990 - 2023	West Matukituki & Gloomy Gorge	4.1
D. connectens	1991-2020	Southern Alps wide	1.9
D. parva	1985-2004	Kaikoura Mountains	1.45
D. talpa	1994-2021	Paparoa Range	0.38*
D. elegans	1991-2020	Kaikoura Mtns and Mt Somers	0.191

**D. talpa* is probably in serious threat of extinction and these data may reflect the severely limited distribution of the insect.

Wēta motel installation

We installed three concrete artificial wēta refuges (motels) near the foot of the French Ridge bluff (Figure 10 a-c). The motels were not baited with any type of attractant (given the risk of mouse presence). All motels were sunk into semi level ground with associated ground cover vegetation. The refugia will be left in place for at least one year and checked when circumstances allow. It is expected that wēta will chance encounter the motels and occupy them. While tracking cards are highly successful for wēta presence/absence, the motels (if occupied) provide direct counts of wēta.

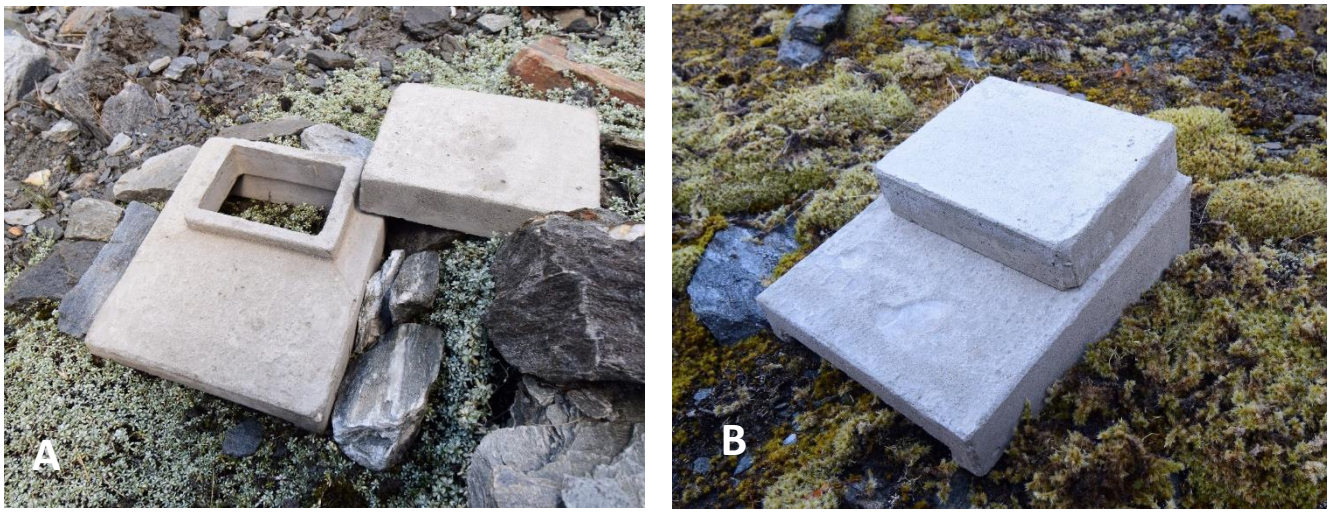

Figure 10 a & b. Concrete wēta motels in situ with inspection lid open. **B** Motel in position with lid closed. Dimensions are approximately 320x270x100mm.

Figure 10 c. Samuel Purdie GPS-logging a wēta motel in Gloomy Gorge.

Other endemic invertebrates

We noted several other alpine invertebrates of interest during our survey including cave wēta (*Pleioplectron thompsoni*: Rhaphidophoridae), Darkling beetles (*Zeadelium* sp. Tenebrionidae:) scuttling spiders (*Cycloctenus westlandicus*: Cycloctenidae), the velvet worm *Ooperipatus viridimaculatus* (Peripatopsidae), endemic millipedes (*Icosidesmus* sp.: Dalodesmidae) and short-legged harvestman (*Nuncia* sp.: Triaenonychidae), among others (Figs 11 a-f). These animals are all nocturnal and were seen during wēta hunting.

Gloomy Gorge cirque is aptly named – it is cold and receives minimal direct sunlight especially on the true-right, where vegetation is limited not only by light and temperature, but by frequent snow avalanches and rockfall (Figures 3, 5, 7.) These conditions maintain a high disturbance regime that promotes pioneer species and limits slow-growing woody vegetation to establish. The invertebrate fauna reflects this scenario through simple trophic structures and cryptic taxa with cold-temperature physiology, low mobility and fecundity. Sandflies were not a problem at camp.

By contrast, on the warmer, sunny side of the cirque, the black mountain cicada (*Maoricicada*) was heard during our survey in snow grass. Similarly, native flies and grass moths (Crambidae) were also present. While inspecting the moraine terrace and talus slopes, Several wēta dens were encountered, all with the remains of dead wēta although determining the cause of death was not possible (Figure 12).

There is merit in conducting a comprehensive invertebrate survey during summer within the cirque. Baseline invertebrate community information would be useful for assessing bird diet (Rock wren and others) and for long-term ecosystem change, particularly with climate change.

Population monitoring

A long-term population monitoring programme needs to be established for *D. pluvialis* in Gloomy Gorge. This would provide basic biological information on wēta activity, distribution and density. Similarly, understanding the impact of predators is required in conjunction with measures of predator control in the cirque is also important (especially so given the cost of these operations).

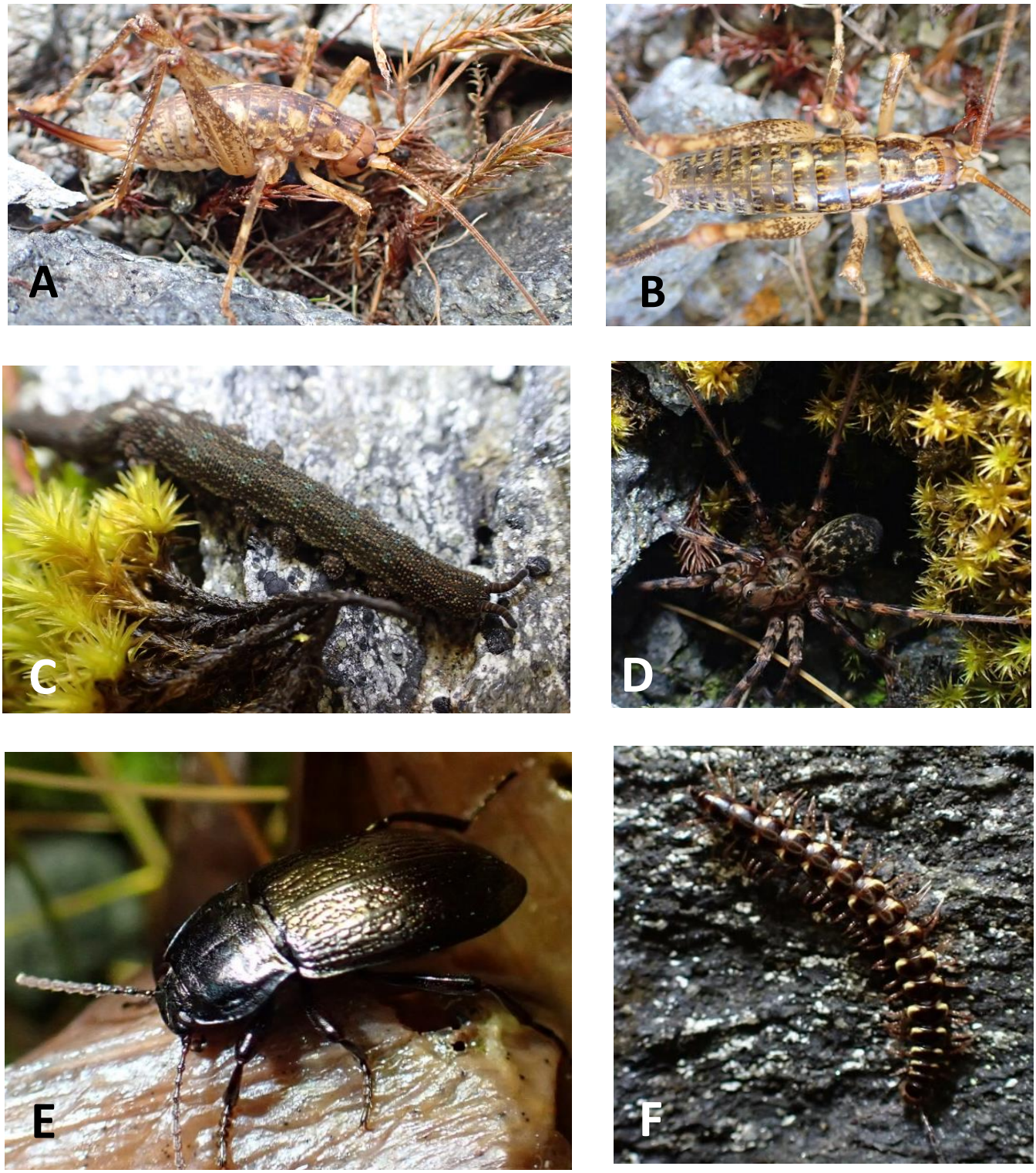

Figure 11 (a-f). Other invertebrates of conservation interest encountered during our wēta search. **A** *Pleiplectron thompsoni* (female L Male R); **B** Mal**e; C** *Ooperipatus viridimaculatus*; D *Cycloctenus westlandicus*; **E** *Zeadelium* sp.(Tenebrionnidae); **F** *Icosidesmus* sp. (Dalodesmidae).

Monitoring wēta reproduction rates and estimating wēta population size in the wild is complex. Several monitoring methods have been tested and proposed, including artificial refuges (Trewick and Morgan-Richards 2000; Bleakley *et al*. 2006), tracking tunnels (Watts *et al*. 2013) and timed night observations (Carpenter *et al*. 2015), motion-sensor cameras and traditional pitfall trapping (Bertoia *et al*. 2023). Tracking tunnels are valuable for presence/absence information (footprints), but they often require

Figure 12 a-c. Typical wēta habitat on the true left (south side) of Gloomy Gorge cirque. A. The sunny talus slopes are scattered with large schist rock slabs. B & C These provide substantial den spaces and several rocks had the remains of adult female and male wēta underneath.

baiting (usually peanut butter), frequent checking and are prone to kea and weather damage in the alpine zone. For alpine environments like Gloomy Gorge, a simple, repeatable and hardy method of wēta monitoring is desired. So far, about four trips have been made into the cirque to search for wēta, all by spotlighting or day-time rock lifting. Danilo Hegg walked in while all other personnel helicoptered, but in all cases, several hours were spent looking for wēta at night – a taxing and expensive enterprise which has considerable risk from rockfall and slips when traversing the base of the French Ridge bluff wall.

The benefit of long-term population monitoring is detecting a biological signal from 'noisy' data. Wēta show relatively low breeding rates (compared to many other insects) and adults may live up to three years (Watts *et al*. 2008), traits that are appropriate for long-term (e.g. 10 year plus) monitoring and estimating population trends. Fortunately, giant wēta establish 'dens' within which females will oviposit multiple egg masses in the substrate. During our survey, several examples of wēta dens were

found under large, schist rock slabs and these may provide a means of population monitoring (Figure 12 a-c).

Population recruitment and survival into the next generation is a primary monitoring goal and estimating the census (total) population size would be included in that effort. Estimating the census population can be carried out over several days using the capture-mark-re-capture method, within a given area, or several areas. The results can then be extrapolated. This approach can only be carried out over a short time-period as the wēta moult, losing any markings.

The simplest method of counting nymphs (i.e. recruitment) is daytime lifting of (marked) slab rocks in spring, immediately photographing the brood (if present) and repeating the operation in autumn and again the following spring. Nymphs can be counted from the photos (and archived) and the den monitored. Monitoring 'wēta rocks' has several draw-backs including crushing wēta on returning the rocks, wēta abandoning the den and the assumption that wēta re-use a disturbed den.

Although our trial of concrete wēta dens may be the first of its kind in the Southern Alps, it assumes that wēta will encounter and occupy the units. Currently, we have no way of predicting this and were reluctant to bait the units (with peanut butter), as this may bias any natural encounter and attract rodents. The best we can do is make an educated guess of suitable locations for installation while exploiting wēta behaviour to investigate cavities and establish dens. Nevertheless, these solid concrete structures are unlikely to be investigated or overturned by kea, can withstand wind, rain, snow and freeze/thaw cycling (eventually frost heave may cause spalling) and will prevent stoat access, but probably not mice. If these refugia are successful, it will be worth installing more in the cirque, especially in stoat-prone areas. A modified version of motel has been manufactured and these are ready to trial next season.

Conclusion

Our survey re-confirmed the presence of *Deinacrida pluvialis* in Gloomy Gorge and broadened the known distribution. The wēta we observed were located either in the lower, cold and shady French ridge bluff area (at approximately 1060m), or higher up on the sunny side of the valley (at approximately 1600m), Figure 2. The addition of a new wēta location, at high altitude, on the sunny side of Gloomy Gorge, provides a strong clue to the impacts of mammalian predators within the cirque (and probably stoats; McAulay *et al*. 2020). Stoat activity is probably limited by ambient temperature and energetically unfavourable places, therefore stoats probably target invertebrates in more favourable zones (e.g. the sunny river bed, moraine terrace on the true left and associated *Chionochloa* tussock slopes (where exo-skeletal remains were found).

McAulay showed that the diets of stoats within Aspiring National Park included 30% invertebrates - with the balance comprising rodents, lizards, birds and vegetation (McAulay *et al*. 2020). Although we don't have direct evidence of stoat predation on *D. pluvialis* in Gloomy Gorge, the assumption that stoats are a threat is prudent until shown otherwise. Among the many challenges of stoat control is meso-predation (prey-switching) which poses a high risk of extinction of localised wēta populations. This scenario is the most likely cause of the *D. pluvialis* population decline in the head waters of the West Matukituki. To that extent, 'fencing off' the entry points to Gloomy Gorge from stoats and, ideally, rodents in summer by trap lines coupled with continued toxin drops, should be a priority (as suggested by Hegg (2021).

Recommendations

The primary task in Gloomy Gorge is to safeguard the current population of *Deinacrida pluvialis*. As a Nationally Endangered taxon, we have a responsibility to ensure population persistence for at least 50 years, in the wild and under a suite of pressures.

To achieve this goal, we need to understand the impact and behaviour of mammalian predators in the cirque and to devise a competent but practical monitoring system for the wēta population. Return trips to the cirque should be routine.

The topography and location of Gloomy Gorge lends itself to developing a standardised 'alpine basin monitoring protocol' This would be similar to the existing Ecological Management Units (EMUs) that DOC manages however a climate change component is also necessary – a Climate Management Unit (CMU). The idea would be to monitor the up-slope movement (or not) of the alpine biota in conjunction with climate trend data (snowlines), population changes and correlated predator densities (Chinn and Chinn 2020).

A long-term data collection and adaptive management plan needs to be drafted for Gloomy Gorge and associated alpine basins. A small telemetry climate station could be established in the cirque.

Modern techniques for acquiring ecological information should be adopted. For example, sampling eDNA from the cirque may provide an efficient and general ecological synopsis of the basin. The method may yield spatial information about predator or wēta 'hot spots' or, contribute to a taxonomic profile of the environment. Stoat gut analysis would also be a useful piece of information from animals caught in the cirque.

For long term information, it will be necessary to re-visit locations elsewhere in the Southern Alps that have *D. pluvialis* records and determine the status and trend of those populations. That information will provide feed-back for the Gloomy Gorge population while building a better picture of the species habitat requirements, distribution and vulnerability.

Wēta translocation research would be a useful endeavour particularly for northern populations, which may be affected sooner by climate change because the freezing level is higher on average and the alps lower in elevation, than those of Aspiring and Aoraki National Parks.

Finally, we strongly recommend wearing safety helmets while working under the French Ridge bluffs. The area receives a steady rain of small stones, snow, ice and particles from above. This is particularly important during west to nor-west winds as the bluffs provide shelter from this wind direction and give a false sense of calm despite material being blown over from French Ridge, some 660m above.

Acknowledgements

We are grateful to Southern Lake Sanctuary for providing resources, personnel, equipment and helicopter flights. The Department of Conservation provided further equipment and resources in addition to administering the Jobs For Nature fund. We thank Aspiring Helicopters for flights to and from Gloomy Gorge.

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Appendix 1. Raw wēta observation data from Gloomy Gorge. April 14-17, 2023.

GLOOMY GORGE *Deinacrida pluvialis* survey April 2023

WĒTA OBSERVATION	DATE	TIME	MAP CYPHER	Alt (masl GPS)	NZTM East	NZTM North	TEMP ºC	R/H %
CAMP SITE			Camp	1087	1258079	5071515		
SUB MALE	14/04/2023	8:45 pm	1	1144	1257800	5071630	8.4	81
SUB MALE	14/04/2023	8:45 pm	2	1144	1257800	5071630	8.4	81
SUB MALE SP	14/04/2023	8:45 pm	3	1144	1257800	5071630	8.4	81
MALE SP	14/04/2023	9:25pm	4	1201	1257661	5071472	8.4	81
SUB ADULT female	14/04/2023	9:25pm	5	1201	1257661	5071472	8.4	81
SUB ADULT	14/04/2023	9:25pm	6	1201	1257661	5071472	8.4	81
SUB ADULT	14/04/2023	9:01pm	7	1198	1257657	5071497	8.4	81
SUB ADULT	14/04/2023	9:01pm	8	1198	1257657	5071497	8.4	81
MALE	14/04/2023	9:01pm	9	1198	1257657	5071497	8.4	81
SUB ADULT	14/04/2023	9:01pm	10	1198	1257657	5071497	8.4	81
FEMALE	14/04/2023	9:18pm	11	1188	1257651	5071487	8.4	81
MALE	14/04/2023	9:18pm	12	1188	1257651	5071487	8.4	81
SUB ADULT	14/04/2023	9:01pm	13	1131	1257539	5071360	8.4	81
SUB ADULT	14/04/2023	9:09pm	14	1131	1257539	5071360	8.4	81
FRASS	15/04/2023	2:00pm	Frass 1	1275	1259485	5071460	NO DATA	NO DATA
5 EXOSKELETONS	15/04/2023	3:30pm	5 Exoskeletons	1316	1259049	5071158	NO DATA	NO DATA
EXOSKELETON	15/04/2023	3:32pm	Exoskeleton	1540	1258789	5070522	NO DATA	NO DATA
NYMP	15/04/2023	3:35pm	Nymph	1561	1258817	5070507	NO DATA	NO DATA
30 NYMPHS	15/04/2023	3:45pm	30 Nymphs	1580	1258995	5070655	NO DATA	NO DATA
30 NYMPHS	15/04/2023	3:45pm	30 Nymphs	1580	1258840	5070480	NO DATA	NO DATA
10 NYMPHS	15/04/2023	4:10pm	10 Nymphs	1691	1259035	5070514	NO DATA	NO DATA
5 NYMPHS	15/04/2023	3:55pm	5 Nymphs	1594	1259035	5070514	NO DATA	NO DATA
FRASS	15/04/2023	3:57pm	Frass 2	1620	1258895	5070585	NO DATA	NO DATA
EXOSKELETON	15/04/2023	3:57pm	Exoskeleton	1620	1258995	5070655	NO DATA	NO DATA
FRASS	15/04/2023	4:25pm	Frass 3	1552	1258534	5071038	NO DATA	NO DATA
MALE	15/04/2023	10:10pm	15	1117	1258281	5071892	8.0	87
MALE	15/04/2023	10:10pm	16	1117	1258281	5071892	8.0	87
MALE	15/04/2023	10:10pm	17	1117	1258281	5071892	8.0	87
MALE	15/04/2023	9:50pm	18	1125	1258216	5071874	8.0	87
MALE	15/04/2023	9:50pm	19	1125	1258216	5071874	8.0	87
FEMALE	15/04/2023	9:26pm	20	1131	1258201	5071808	8.0	87
FEMALE	15/04/2023	9:26pm	21	1131	1258201	5071808	8.0	87
FEMALE	15/04/2023	9:26pm	22	1131	1258201	5071808	8.0	87
SUB MALE	15/04/2023	09:21pm	23	1156	1258156	5071834	8.0	87
SUB ADULT	15/04/2023	09:26 pm	24	1156	1258169	5071837	8.0	87

SUB ADULT	15/04/2023	07:30pm	25	1272	1257811	5071761	8.0	87
SUB ADULT	15/04/2023	07:29pm	26	1272	1257819	5071769	8.0	87
MALE	15/04/2023	07:27pm	27	1272	1257818	5071765	8.0	87
NYMPH	16/04/2023	3:23pm	28	1470	1258212	5070305	NO DATA	N/A
10 NYMPHS	16/04/2023	3:59pm	29	1440	1258224	5070319	NO DATA	N/A
WĒTA MOTEL	16/04/2023	12:48pm	Motel 1	1123	1258195	5071826	N/A	N/A
MALE	16/04/2023	08:10pm	30	1188	1258132	5071873	8 - 9	N/A
FEMALE	16/04/2023	07:27pm	31	1164	1258147	5071877	8 - 9	N/A
3 SUB MALES	16/04/2023	07:27pm	32	1164	1258147	5071877	8 - 9	N/A
MALE	16/04/2023	07:34pm	33	1178	1258138	5071890	8 - 9	N/A
MALE	16/04/2023	07:39pm	34	1178	1258147	5071896	8 - 9	N/A
FEMALE	16/04/2023	07:34pm	35	1178	1258138	5071890	8 - 9	N/A
FEMALE	16/04/2023	07:39pm	36	1178	1258147	5071896	8 - 9	N/A
FEMALE	16/04/2023	07:44pm	37	1178	1258160	5071903	8 - 9	N/A
FEMALE	16/04/2023	07:22pm	38	1178	1258135	5071912	8 - 9	N/A
2 FEMALES	16/04/2023	08:29pm	39	1190	1258097	5071851	8 - 9	N/A
SUB MALE	16/04/2023	08:29pm	40	1190	1258097	5071851	8 - 9	N/A
FEMALE	16/04/2023	08:39pm	41	1190	1258059	5071841	8 - 9	N/A
SUB ADULT	16/04/2023	08:48pm	42	1190	1258065	5071859	8 - 9	N/A
MALE	16/04/2023	09:23pm	43	1185	1258199	5071886	8 - 9	N/A
FEMALE	16/04/2023	09:25pm	44	1185	1258218	5071897	8 - 9	N/A
FEMALE	16/04/2023	09:31pm	45	1185	1258230	5071894	8 - 9	N/A
WĒTA MOTEL	17/04/2023	8:30am	Motel 2	1130	1258195	5071826.6	N/A	
WĒTA MOTEL	17/04/2023	8:30am	Motel 3	1130	1258045	5071720	N/A	

Appendix 1 continued. Wēta observation statistics

Observation	Count	Search hours	11
Adult female	14	Wēta / person / hour	4.03
Subadult female	1		
Adult male	13		
Sub adult male	8		
Sub adults	10		
Nymphs	87		
Exoskeleton	7		
Frass sites	3		
Total live wēta	133		

Appendix 2. Photographs of *Deinacrida pluvialis* and environment of Gloomy Gorge. Taken between April 14 – 16.

Adult male

Adult female

Adult male dorsal

Penultimate instar male

Adult female on Belchnum fern

Adult female feeding on *Raoulia*

Appendix 3. Danilo Hegg's report on *Deinacrida pluvialis* in Gloomy Gorge, 2021

Surveys of the Southern Alps giant wētā *Deinacrida pluvialis* in the Matukituki River West Branch

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Unpublished Report
30 May 2021

Abstract

The Southern Alps giant wētā (*Deinacrida pluvialis*), formally described in 1999, has been recorded in just over 20 discrete locations throughout the Southern Alps, between the Cleddau River in Fiordland and Mt Alexander north of Arthur's Pass. Abundance surveys have only ever been conducted at two sites, in the head basin of the Matukituki River West Branch (1992) and in Price Basin, Westland (1994). Neither location was ever surveyed a second time. The species is currently classified as "Not Threatened" in the New Zealand Threat Classification System.

Here I report on recent searches in the head basin of the Matukituki River West Branch (2014 and 2021), indicating that the largest known population of *Deinacrida pluvialis* is most likely extinct. Predation by stoats and rodents is suspected to be the cause. I also report on a new population discovered in the head basin of Gloomy Gorge, a tributary of the Matukituki River West Branch, during the summer 2020/2021.

I suggest that *Deinacrida pluvialis* should be reclassified as "Endangered". A monitoring regime including several locations across the Southern Alps should be set up to better assess the conservation status of the species. The stoat trapping programme to protect rock wren in the Gloomy Gorge head basin ought to be improved to also target rodents and protect the more vulnerable Southern Alps giant wētā.

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Introduction

The Southern Alps giant wētā (*Deinacrida pluvialis*) was formally described in 1999, although records of collected specimens go back as far as 1946 (Gibbs 1999). The known distribution range of the species extends from the Cleddau River in Fiordland to Mt Alexander north of Arthur's Pass (Fig. 1).

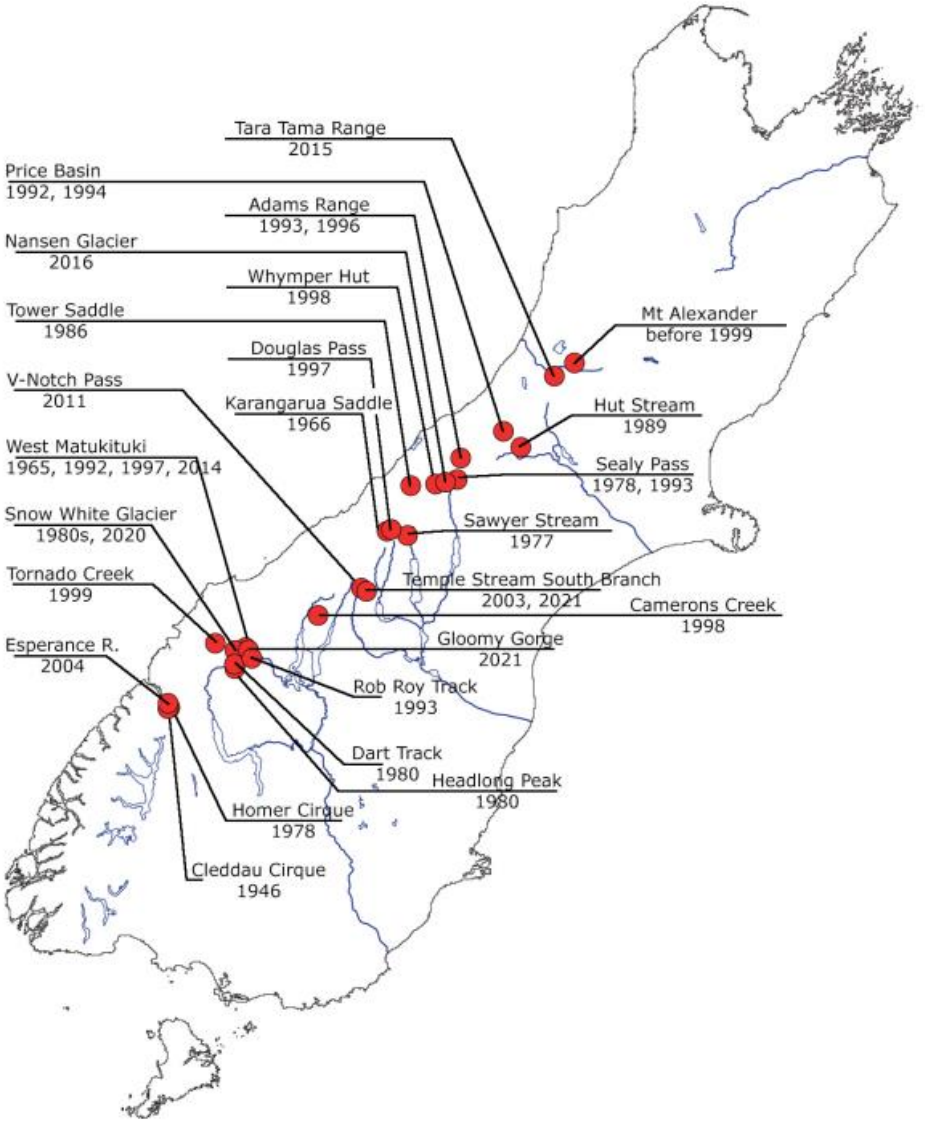

Fig. 1. Known distribution range of *Deinacrida pluvialis*, based on historical and recent records from Sweney (1980), Watt (1980), Meads & Notman (1995), Gibbs (1999), Jewell (2015), iNaturalist.org and personal observations.

While confirmed records of *Deinacrida pluvialis* exist from just over 20 discrete locations, only two sites have ever been formally surveyed to gain an estimate of population density: these are the head basin of the Matukituki River West Branch (1992), where the encounter rate was 14.3 individuals per searcher hour (Gibbs 1999), and Price Basin in Westland (1994), where the encounter rate was 1.2 individuals per searcher hour (Meads & Notman 1995).

There are no published records of follow-up surveys at either site, although Tony Jewell did conduct searches in the head basin of the Matukituki River West Branch in 2014 (Jewell pers. comm.).

Based on the results of the two surveys, Meads & Notman (1995) wrote that *Deinacrida pluvialis* "*appears to be present in relatively good numbers in at least two sites and is not considered to be at threat*". Gibbs (1999) followed suits with the statement "*The species is inaccessible rather than rare for in some favoured habitats, such as the head basin of West Matukituki River (OL), it can be common enough for 43 to be found under rocks in 3 person-hours of searching*". The species is classified as "Not Threatened" in the New Zealand Threat Classification System (Trewick *et al*. 2014).

Tony Jewell's searches in the West Matukituki head basin however indicate a rapidly declining population (Jewell 2014). Following these searches and more surveys in the Homer Tunnel area the following year, Jewell wrote "*I am concerned that the available evidence, both physical and circumstantial, suggests a high level of vulnerability to predatory mammals, and possibly even a Critically Endangered status*" (2015).

Here, I report on searches I conducted in the head basin of the Matukituki River West Branch during the summer 2020/2021. I also searched the head basin of Gloomy Gorge (a suspended valley tributary of the Matukituki River West Branch) following up on a sighting of *Deinacrida pluvialis* by herpetologist Samuel Purdie while surveying for lizards (Purdie 2020).

***Deinacrida pluvialis* surveys in the Matukituki River West Branch head basin**

Gibbs, 22 April 1992

The area searched, between the 890m and the 920m elevation contours (Gibbs 1999), is approximately delimited by line A on the map in Fig. 2.

"*At the time we were responding to a record from a tramper and I remember our amazement that the species could be so abundant, yet unrecorded. The habitat fitted my perception of what we were looking for - simply rocky subalpine grassland or shrubland, not pure rocky scree. We had gone past the rock biv and on to the flattest area of the basin. It was on stable river gravels at a level site close to the river. We camped the night out there away from the river and searched under stones during the evening - where the figures came from. I have not returned there. We scampered back to the car the following morning. I don't remember any sign of rat presence. Wētā were numerous and active and the stones were easy to move and quick to search*" (Gibbs pers. comm.).

43 wētā were found under rocks in 3 person-hours of searching (Gibbs 1999).

Thirty years later, the site searched in 1992 is an alpine meadow covered in tall grass (pers. obs.), and no longer seems to fit the habitat described by Gibbs. More recent searches have thus focused on areas slightly higher up, closer to the cliffs at the head of the valley.

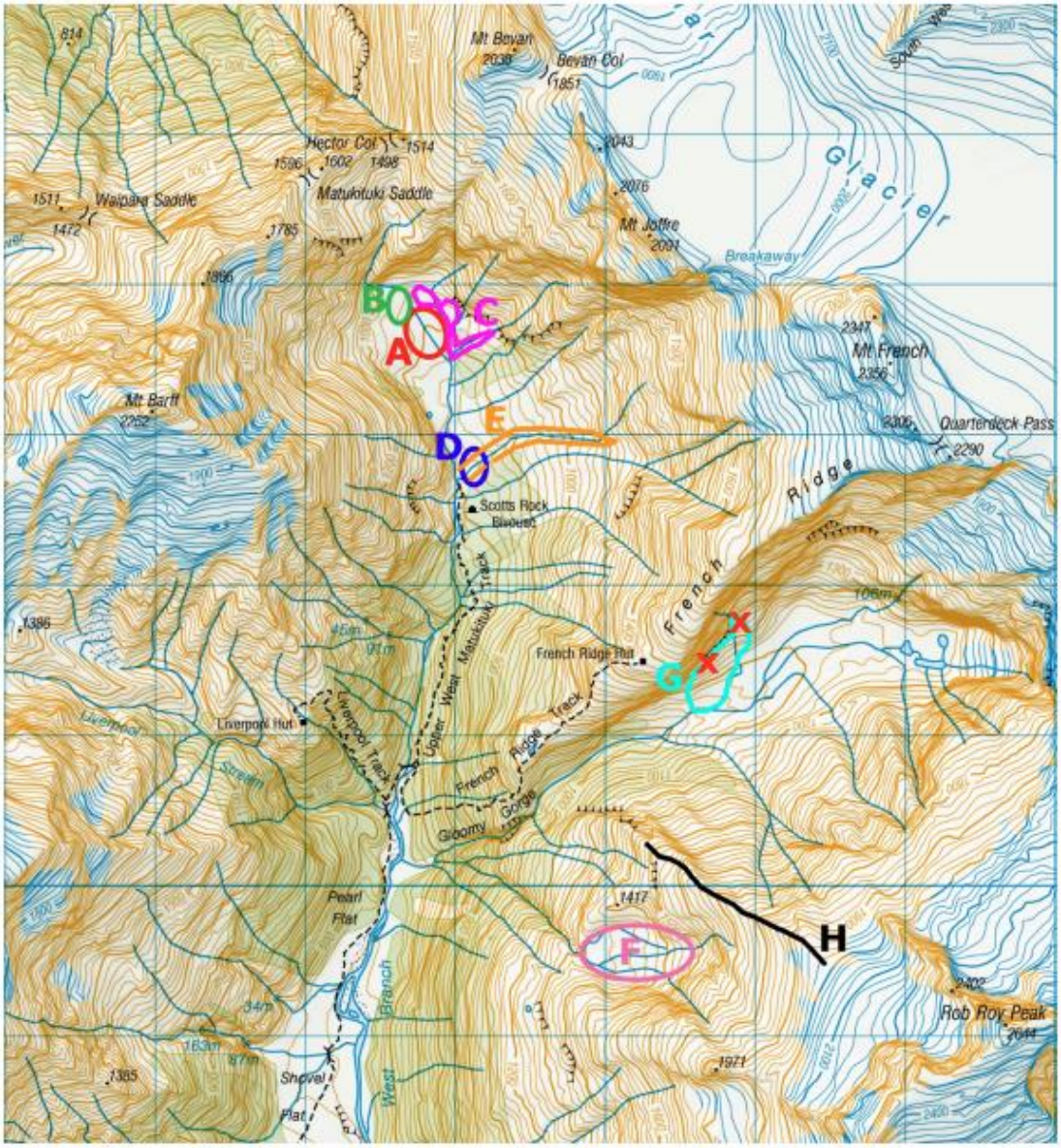

Fig. 2. Areas searched for *Deinacrida pluvialis* in the Matukituki River West Branch. **A.** Gibbs 1992; **D.** Chinn 2009; **B.** Jewell 2014; **E.** Hegg 2017; **B, C, F, G.** Hegg 2021. '**x**' indicates locations where *Deinacrida pluvialis* is currently known to be present (2021). **H** recommended trapline to be added to stop predators entering Gloomy Gorge head basin.

Chinn, 2009

DOC entomologist Warren Chinn searched Area D (Fig. 2) in 2009, turning rocks during the day. Total effort was approx. one hour; no wētā were found (Chinn pers. comm.).

Jewell, 7 April 2014

Tony Jewell searched the area delimited by line B (Fig. 2; Fig. 3A) in daylight for 1.5 hours, turning rocks, in April 2014. He found two wētā (alive) and one dead juvenile (Fig. 3B). The latter appeared to have been killed by a rodent (Jewell 2014).

Fig. 3. A. Habitat where two *Deinacrida pluvialis* were found in April 2014. **B.** Remains of juvenile *Deinacrida pluvialis* killed by rodent. Both images © Tony Jewell.

Hegg, 6 May 2017

I spent five to six hours after dark spotlighting up the stony (dry) creek-bed delimited by line E (Fig. 2), starting at the valley floor (800m) and climbing to the vertical rock bluffs at 1150m of elevation. While I was really searching for Rhaphidophoridae (*Pharmacus* sp.), the habitat would have been excellent for *Deinacrida pluvialis*, with plenty of stones of small to medium size for wētā to hide under. The creek-bed was delimited by scrub in the lower reaches, tussocks and open vegetation higher up. No *Deinacrida pluvialis* were found.

Hegg, 28 and 30 January 2021

Over two days (28 January and 30 January 2021) I spent approximately 16 hours searching for *Deinacrida pluvialis* in areas B and C (Fig. 2) at the head of the Matukituki River West Branch. I searched both during the day (turning stones) and at night (spotlighting). Both nights were mild and dark (no moon); conditions appeared to be ideal.

I found no wētā and no sign of any activity (frass, husks or otherwise).

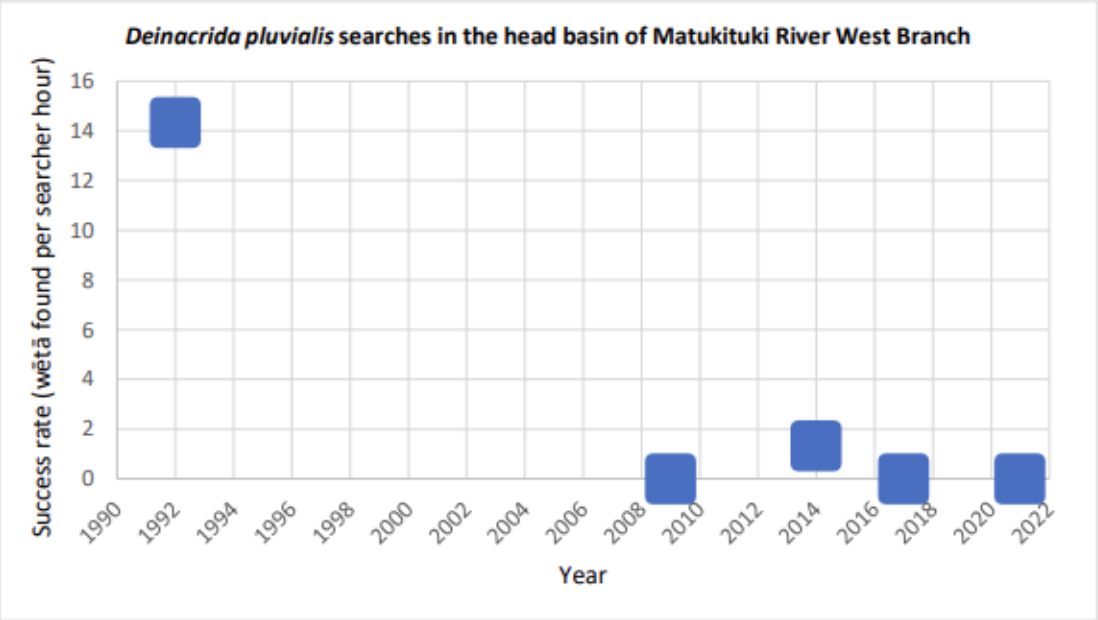

Fig. 4. Comparing the success rate (number of wētā found per searcher hour) on *Deinacrida pluvialis* surveys in the West Matukituki head basin, 1992 until present.

Hegg, 19 March 2021

The low alpine basin directly west of Rob Roy Peak (Area F in Fig. 2) is covered in tussocks (*Chionochloa* sp.) and large boulders; some scrub is present on the lower (western) edge. The upper slopes are made of fine scree – not a suitable habitat for *Deinacrida pluvilais*. During approximately four hours of searching after dark, I found no sign of giant wētā.

Sightings of note include one stoat (alive) and several hares, both alive and dead (one freshly killed, presumably by stoat).

Deinacrida pluvialis surveys in Gloomy Gorge

In November 2020, herpetologist Samuel Purdie found an adult female *Deinacrida pluvialis* and two nymphs under a rock while searching for lizards, in Gloomy Gorge at coordinates E1257572 N5071330 (Purdie 2020), and a male higher up the slope. A giant wētā was also tracked in a DOC tracking tunnel 50m lower down on the same slope, at E1257646 N5071241 (Fig. 8).

The find was followed up with surveys conducted by me during a good weather window in March 2021, and by Samuel Purdie and two others while searching for lizards again only days later.

Hegg, 20-21 March 2021

During two consecutive nights I searched Area G (Fig. 2) by spotlighting; the searched area is also outlined in blue in the image below (Fig. 5). Both nights were cool (temperature under 10°C), dark and foggy / dewy. I moved systematically zigzagging across the slope, and while I stopped to photograph any giant wētā I found, I did not intensify the search where I did find wētā in order to ensure a consistent search effort. The areas searched on the two nights did not overlap significantly.

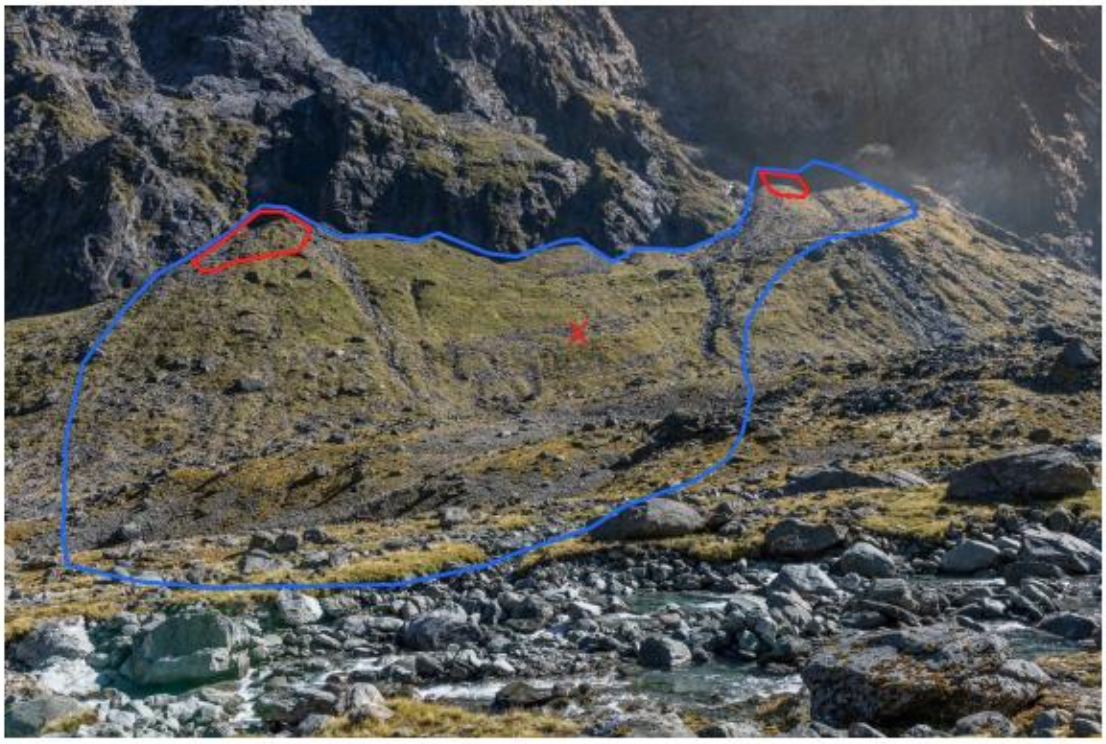

Fig. 5. The slope under the bluffs of French Ridge at the head of Gloomy Gorge. Area searched in blue. Several *Deinacrida pluvialis* were found in each red polygon. 'X' indicates the approximate location of one adult male. The elevation difference from the river to the highest point of the fans is approximately 200m.

The slope consists of two adjacent scree fans at an angle of about 35°, facing south, directly below the large cliffs precipitating from French Ridge. Vegetation is sparse and comprises mostly everlasting daisy (*Anaphalioides bellidioides*), willowherbs (*Epilobium* spp.) and short snowgrass (*Chionochloa* sp.), with the occasional mountain ribbonwood (*Hoheria glabrata*), *Dracophyllum* and

Olearia shrub. There is plenty of exposed loose rock, in the form of small to medium sized stones, mostly covered in moss or lichen.

A total of nine *Deinacrida pluvialis* were found during two nights of searching; all but one were right at the top of the two scree fans, hard against the vertical bluffs above. Five wētā were found at the top of the western fan on the first night; three wētā were found at the top of the eastern fan the following night, and one adult male on bare talus halfway between the two fans. GPS coordinates for each wētā are not reported since half of them fall somewhere on the vertical bluffs above, GPS accuracy being compromised by signal bounce.

The find rate was approximately one individual every ten to fifteen minutes of searching within the red polygons (Fig. 5); the find rate dropped to less than one individual in over four hours searching outside of these areas.

All nine giant wētā found were foraging – three on everlasting daisy (*Anaphalioides bellidioides*) leaves, three on snowgrass (*Chionochloa* sp.), two on lichen and one on moss (Figs. 6, 7).

Purdie, 23-24 March 2021

Samuel Purdie took advantage of the same high-pressure system to conduct more lizard surveys at the same site, and recoded any *Deinacrida pluvialis* he found. Coordinates for each of his finds are reported in Table 1 below. There is an almost complete overlap between the areas of Purdie's and Hegg's finds.

Table 1. *Deinacrida pluvialis* found in Gloomy Gorge during lizard surveys during the summer 2020/2021 (Purdie pers. comm.).

Date	Method	Sex	Age	Eastings	Northings	Notes
18/11/2020	Rock flipping	F	Adult	1257572	5071330	
		F	Nymph			
		M	Nymph			
18/11/2020	Rock flipping	M	Adult	1257714	5071524	
23/3/2021	Rock flipping	F	Adult			
		M	Nymph	1257848	5071721	
23/3/2021	Rock flipping	F	Adult	1257851	5071736	
23/3/2021	Rock flipping	Both	Nymphs	1257839	5071727	Perhaps 20> nymphs found under one rock
24/3/2021	Spotlighting	F	Adult	1257548	5071356	Sitting still
24/3/2021	Spotlighting	M	Adult	1257703	5071436	Feeding on unidentified plant sp.
24/3/2021	Spotlighting	M	Adult	1257629	5071422	Feeding on unidentified plant sp.
24/3/2021	Spotlighting	F	Adult	1257611	5071416	Female resting against rock, nymph resting nearby
			Nymph			
24/3/2021	Spotlighting	F	Adult	1257588	5071402	Feeding on native dandelion sp. and perched on fern
24/3/2021	Spotlighting	M	Adult	1257567	5071375	Sitting still on rock

Fig. 6. Adult male *Deinacrida pluvialis* feeding on *Anaphalioides bellidioides* leaf (top); nymph feeding on snowgrass (*Chionochloa* sp.) (bottom). Gloomy Gorge, Matukituki River West Branch.

Fig. 7. *Deinacrida pluvialis* feeding on moss (top) and on lichen (bottom). Gloomy Gorge, Matukituki River West Branch.

Purdie recorded 7 finds during 70 minutes spotlighting (Table 1). This averages to a success rate of one individual found per ten minutes search effort.

Three wētā found while rock flipping during March 2021 (Table 1) were found within about 10 minutes of each other while conducting lizard day searches. Two searchers were involved. The team moved on once they realized that the habitat was not suitable for lizards (Purdie pers. comm.).

Fig. 8. Giant wētā tracks in tracking tunnel. Gloomy Gorge head basin, Mount Aspiring National Park. Photo © Sam Purdie.

Unsearched habitat in Gloomy Gorge

Immediately to the west of the area searched in Gloomy Gorge (G in Fig. 2; Fig. 5) there are three more scree fans, also directly below the vertical bluffs of French Ridge. Each of these three fans is progressively smaller and more vegetated than the preceding one, moving east to west. The habitat appears suitable, and I expect more *Deinacrida pluvialis* could be found here.

On the opposite side of the river, a large morainic cordon delimits the river flats to the south, a 2km long ribbon of large boulders and scrub. It is conceivable that this would offer good wētā habitat also. The north-facing slopes above offer plenty of stony habitat with varying degrees of vegetation cover. Samuel Purdie however *"spent a decent amount of time spotlighting for geckos at various elevations and kept an eye out for wētā but didn't see any"* (pers. comm.).

Fate of the *Deinacrida pluvialis* population in the West Matukituki head basin

When I searched the West Matukituki head basin in January 2021, I had one big advantage over previous searchers, in the form of detailed and precise information from Tony Jewell about the site where he had found *Deinacrida pluvialis* seven years earlier, including photographs of the habitat. My search was no token gesture either, since I camped at the site for two nights and dedicated two afternoons and two nights to the task, the total search effort exceeding 16 hours. Conditions were good, with mild temperatures, plenty of dew and no moon to cast light after nightfall. In spite of all this, I was not able to find any sign of *Deinacrida pluvialis*.

While Tony Jewell had been able to find *Deinacrida pluvialis* in the West Matukituki head basin in 2014, his find rate was 11 times lower compared to Gibbs' find rate twenty-two years earlier (Fig. 4). Jewell also found clear evidence of predation by rodents (Fig. 3B).

It is also worth noting that the West Matukituki head basin is very frequently visited by trampers and climbers, with several parties walking through or camping here every day during the summer months. The habitat searched by Tony Jewell in 2014 is where climbers usually stash their shoes and any excess gear before tackling the ascent to Bevan Col. It is equally true that nearly all trampers and climbers nowadays are equipped with easy-to-use electronic cameras that make it possible to photograph a giant wētā did they happen to stumble onto one. In spite of all this, there have been no casual observations of giant wētā in the West Matukituki head basin in a very long time.

Based on all this evidence, I can only conclude that the largest known population of *Deinacrida pluvialis* is now extinct, predation by stoats and rodents being the most likely cause.

Deinacrida pluvialis population in Gloomy Gorge

The discovery of a population of *Deinacrida pluvialis* in Gloomy Gorge is a blessing but is no reason to be complacent. Wētā appear to be concentrated in the least productive habitat available, right at the top of south-facing scree slopes and hard under the vertical bluffs precipitating from French Ridge, in almost perennial shade. It is clear from historical records and what we know about the species that this is not the species' typical or favoured habitat. Rather, it is marginal habitat where predator densities are low enough for *Deinacrida pluvialis* to have been able to survive.

Stoats (*Mustela erminea*) are present year-round in Gloomy Gorge thanks to a resident population of hares (*Lepus europaeus*) and are well known predators of wētā (Lavers & Mills 1978, Gibbs 1998, Smith *et al*. 2005, O'Donnell *et al*. 2017, McAulay *et al.* 2020). The Department of Conservation runs stoat traplines in Gloomy Gorge to protect the resident population of rock wren (*Xenicus gilviventris*). Stoat control however is not necessarily going to benefit giant wētā, as it may result in increased numbers of ship rats (*Rattus rattus*) and mice (*Mus musculus*) (Ritchie and Johnson 2009). And while the Gloomy Gorge head basin may be near the maximum altitude level for rats, it certainly lies within the altitude range occupied by mice. Mice are implicated in the decline of the Mahoenui giant wētā *Deinacrida mahoenui* (Chris Green pers. comm.) and of the Mt Arthur giant wētā *Deinacrida tibiospina* (Ian Millar pers. comm., Toy *et al.* 2020) and are especially of concern in the alpine environment, where their population is known to explode in response to tussock masting (Wilson & Lee 2010). Looking at another alpine species of giant wētā, it is of concern that intensive stoat trapping to protect whio (*Hymenolaimus malacorhynchos*) and kiwi (*Apteryx haastii*) on Mount

Arthur is not having any positive impact on the Mt Arthur giant wētā *Deinacrida tibiospina* (Ian Millar pers. comm., Toy *et al.* 2020).

Fig. 9. Gloomy Gorge head basin. The valley floor is entirely covered in moss, lichen and sparse boulders, with little to no tussocks.

The head basin of Gloomy Gorge is a peculiar environment in that it is sheltered to the east and north by vertical bluffs over 600m high, which block the sun for much of the day. In mid-March, the southern (sunnier) edge of the valley floor only gets four hours of direct sunlight, from 11am to 3pm. The slopes directly below the bluffs get even less sunlight. This creates a permanently shady environment that stimies vegetation growth. As a result, the valley floor is entirely covered in moss and lichen, with very little tussock (Fig. 9). The lack of tussock and associated mast seeding in Gloomy Gorge may keep rodent numbers low at all times, to the benefit of giant wētā.

If this assumption is correct, then stoat trapping should be beneficial to the local *Deinacrida pluvialis* population. However, this is a risky experiment to make, when getting it wrong could result in yet another local extinction. Ideally, both rodent and giant wētā numbers should be monitored, and a 1080 drop planned as a back-up in case the rodent population becomes of concern. The effectiveness of the stoat trapping programme could also be improved by adding a trapline along the crest of the spur separating Basin F (Fig. 2) from Gloomy Gorge, from 1400m to 2000m of elevation (Line H on Fig. 2). This spur is the obvious 'road' followed by any predators entering Gloomy Gorge from the south.

The predator control programme in Gloomy Gorge ought to be reviewed by a panel of experts, with the aim of working out an optimum regime for the protection of all species present at the site. The involvement of Zero Invasive Predators (ZIP) should also be considered.

Other populations of *Deinacrida pluvialis* in the Southern Alps

While confirmed records of *Deinacrida pluvialis* exist from just over 20 discrete locations, as shown in Figure 1, many observations were well and truly dated already at the time when the species was described. The map in Figure 1 is thus representative of the historical distribution of the species. The current range is likely to be both smaller and more fragmented.

It is safe to assume that the species is no longer present in the headwaters of the Cleddau or Hollyford Rivers, since both of these very accessible valleys have been repeatedly searched by entomologists and herpetologists alike (Jewell 2015). A recent study (2021) of alpine invertebrates in the Gertrude Valley, using both intensive pitfall trapping and visual searches, has failed to detect any giant wētā (Aaron Bertoia pers. comm.). The most recent confirmed sighting of *Deinacrida pluvialis* in Fiordland is in the Esperance Valley in 2004 (Jewell 2004). I searched the Esperance valley floor in suitable habitat below De Lambert Falls (spotlighting at night) in February 2019 and did not find any giant wētā. A more thorough search is warranted. A putative sighting (not supported by photographs or other evidence) in March 2014 at 1,000m of elevation on the south ridge of Cascade Peak (Milford Sound) (Tiff Stephens and Max Olsen pers. comm.) is credible and worth following up, although the habitat would seem unusual for the species.

The most recent sighting near Mt Cook Village goes back to 1977. It seems most likely that the species is long extinct in the headwaters of the Tasman River. Specimens were also collected on the Dart valley floor below Dart Hut (1980) and at the top of the Rob Roy Track (1993) (Gibbs 1999). Both locations are visited by hundreds of trampers every week – I do not believe *Deinacrida pluvialis* would go unnoticed if it were still present.

All other locations shown in Fig. 1 would need to be properly searched to confirm whether the species is still present or not. A repeat survey of Price Basin ought to be a high priority. The only two sightings that are recent enough for us to be confident that there is still a population present are below the Snow White Glacier in the remote Arawhata River (Whittaker 2020) and in the Temple Stream South Branch (Patterson 2021). No information on population size or density is available for either location.

The conservation status of *Deinacrida pluvialis*

Deinacrida pluvialis is currently rated as "Not Threatened" in the New Zealand Threat Classification System (Trewick *et al*. 2014). This is the result of misguided yet common beliefs that alpine species might be safe from predators, and that if a species has survived until present, it must be fine.

Gibbs (1998) wrote that *Deinacrida pluvialis* is "*potentially vulnerable due to its ground-dwelling lifestyle but is not threatened because its habitats are above the level of rat invasion*". Historical records (Gibbs 1999, Fig. 1) include several observations below 1,000m of elevation, well within the elevation range of rats. There is very much a strong overlap between the altitudinal range of the ship rat (*Rattus rattus*) and of the Southern Alps giant wētā. More crucially however, the altitudinal range of *Deinacrida pluvialis* overlaps entirely with the one of other introduced mammalian predators such as stoat (*Mustela erminea*) and house mouse (*Mus musculus*) (O'Donnell *et al.* 2017). Both of these pose enough of a threat to giant wētā, the former on insects at any life stage (including adults), the latter only on juveniles.

Meads & Notman (1995) wrote that *Deinacrida pluvialis* "*appears to be present in relatively good numbers in at least two sites and is not considered to be at threat*". Gibbs (1999) followed suits with the statement "*The species is inaccessible rather than rare for in some favoured habitats, such as the head basin of West Matukituki River (OL), it can be common enough for 43 to be found under rocks in 3 person-hours of searching*". The problem with these statements is that they are based on surveys made at a single point in time, in the Matukituki River West Basin (1992) and in Price Basin (1994). No follow-up surveys were ever conducted at either location. And while a stable population was assumed (Scenario A in Fig. 10), a declining population trajectory going through the same survey point would seem to be more likely scenario (Scenario B in Fig. 10).

Up until the 1980s, biologists believed that native bird populations that had survived until then would be fine. It is thanks to the work by Graeme Elliott and others (see for example Elliott & O'Donnell 1988) that we know about the complex relationships triggered by masting events, and stochastic extinctions. While the drivers behind invertebrate population dynamics in the alpine regions are different, the outcome is the same in principle. To assume that a species is fine just because it has survived this far is a catastrophic failure to learn from past lessons in New Zealand conservation.

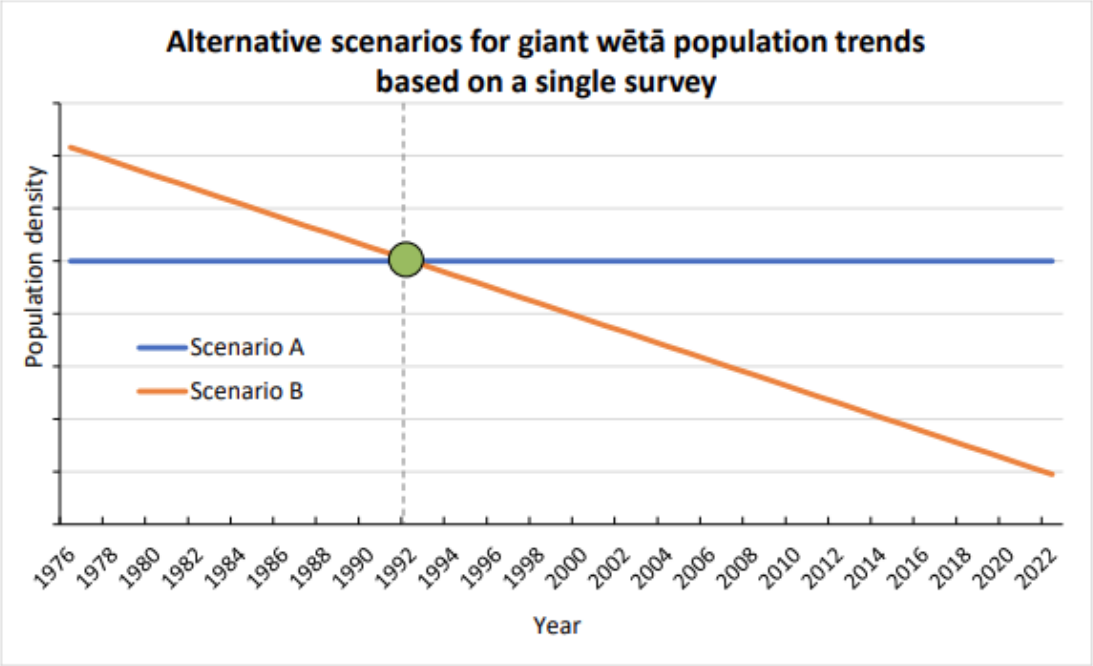

Fig. 10. Alternative scenarios for giant wētā population trends based on a single survey (green circle) conducted in 1992. Simplified, as trends in nature do not follow straight lines.

To assess the conservation status of a species according to the New Zealand Threat Classification System (Townsend *et al.* 2008) requires an estimate of the species' total population size, and of the rate of decline (if the species is declining). Measuring either quantity is nearly impossible for just about any species, except for few intensively managed species for which every individual is known. A certain amount of guesswork is thus required.

Based on the surveys in the West Matukituki head basin by Gibbs in 1992 (Gibbs 1999) and Jewell (2014), I estimate that this population declined by a factor 10.8 in 22 years (Fig. 4), which is equivalent to a decline by a factor 3 (or by 67%) per decade. Assuming that (based on Fig. 1) the entire population consists of between 6 and 15 sub-populations under 500 individuals, then the status of the species would be "Endangered". The actual situation may be better or worse, but without any population surveys to go by, this guesstimate is as good as any.

Worth noting is also the assessment by Jewell (2015), who wrote "*I am concerned that the available evidence, both physical and circumstantial, suggests a high level of vulnerability to predatory mammals, and possibly even a Critically Endangered status*", and "*Adults are too bulky to hide away from rats and mice, and are virtually defenceless, lacking speed, flight, effective biting capacity, or any kind of visual or chemical deterrent. Realistically, they are sitting ducks for rodents and stoats and are probably spiralling rapidly towards extinction throughout their range*".

Summary and Recommendations

- The Southern Alps giant wētā (*Deinacrida pluvialis*), formally described in 1999, has been recorded in just over 20 discrete locations throughout the Southern Alps, between the Cleddau River in Fiordland and Mt Alexander north of Arthur's Pass. Several records have historical value only, since the species has not been observed at some of these locations in several decades.

- Only two published abundance surveys exist: one in the head basin of the Matukituki River West Branch (1992) and one in Price Basin, Westland (1994). Neither location was ever surveyed a second time.

- The species is currently classified as "Not Threatened" in the New Zealand Threat Classification System, under the assumption that the population is both stable and safe from predators.

- Abundance surveys conducted in recent years (2014 and 2021) suggest that the largest known population of *Deinacrida pluvialis*, in the head basin of the Matukituki River West Branch, is now extinct. Predation by stoats and rodents is suspected to be the cause.

- Given that the species appears to have gone from other locations also, it should be reclassified as "Endangered". A monitoring regime including several locations across the Southern Alps should be set up to better assess the conservation status of the species.

- A new population was discovered during the summer 2020/21 in the head basin of Gloomy Gorge, a tributary of the West Matukituki. It appears to occupy marginal habitat where rodent numbers are likely to be low.

- The Department of Conservation runs stoat traplines to protect rock wren in the head basin of Gloomy Gorge. These may not be enough to protect giant wētā due to the release of mesopredators. Both rodents and giant wētā should be monitored, with management actions ready to be implemented if rodent numbers increase as a result of the removal of stoats. The predator control programme in Gloomy Gorge ought to be reviewed by a panel of experts, with the aim of working out an optimum regime for the protection of all species present at the site. Zero Invasive Predators (ZIP) should also be involved.

- A panel of experts should convene and work on the way forward in the management and conservation of *Deinacrida pluvialis* and other alpine giant wētā species in the South Island.

Acknowledgements

Thank you Tony Jewell and Sam Purdie for your passion and enthusiasm for our smaller threatened species, for your time spent surveying, and for sharing the materials included in this report. Thank you also to Warren Chinn and George Gibbs for additional information on sightings or surveys of the Southern Alps giant wētā, and to Ian Millar and the Friends of Flora for an insight into the problems faced by the Mt Arthur giant wētā further north.

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Appendix A – List of known sightings of the Southern Alps giant wētā *Deinacrida pluvialis*, in chronological order

Date	Entomol. Region	Location	NZTM Easting	NZTM Northing	Elevation (m a.s.l.)	Observer(s)	Age and sex	Alive or dead	Evidence	Notes
Unknown	BR	Mt Alexander, Kaimata Range					1 adult ♀	dead	collected UCNZ	Peter Johns collection
Unknown	WD	Snow White Gl. Arawhata River			1850	P. Hellebraker		alive	photograph	
Unknown	BR	Mt French, Hohonu Range	1464300	5273600	1300	P. de Lange, D. Norton		alive	none	Uncertain ID G. Gibbs correspondence
27 Jan 1946	FD	Cleddau Cirque Milford Rd	1202200	5031100	800	J.T. Salmon	1 juv. ♂	alive	collected MONZ	
1965	OL	West Matukituki head basin			900	D. Robertson		alive	photograph	Meads & Notman 1995
Apr 1966	WD	Karangarua Saddle, Landsborough River				G. Caughley	1 adult ♀	alive	collected UCNZ	
18 Oct 1977	MK	Sawyer Stream Mt Cook NP	1367300	5150700	800	W.J. Sweney	2 adult ♂ 3 juv. ♂ 1 juv. ♀	alive	collected LUNZ	Sweney 1980 p. 81, 249, 267
1978	FD	Hollyford River, downstr. Homer Hut			800 - 1000	B. Enting	adult	alive	photograph	G. Gibbs correspondence
20 Feb 1978	WD	Sealy Pass, Scone Creek	1402000	5189300	1725	D. Prouting, W. Woof	1 adult ♀	alive	collected NZAC	
18-24 Feb 1980	OL	Headlong Peak Dart River	1249200	5060100	1830	C.J. Watt		alive	collected in pitfall	Watt 1980
19 Feb 1980	OL	Isobel Gl. Stream, Dart River	1248100	5061700	970	J.S. Dugdale, K.J. Fox	4 juv. ♂	alive	collected NZAC	
15 Jan 1986	WD	Castle Rocks Hut to Tower Saddle	1370100	5184900	1480	J.W. Early	1 juv. ♀	alive	collected LUNZ	
24 Feb 1989	MC	Hut Stream, Mathias River					1 adult ♀	dead	collected UCNZ	Peter Johns collection
20 Apr 1992	WD	Price Basin, Whitcombe River	1433000	5222000	1350 - 1480	J. Heine, G. Gibbs	2 adult ♂ 2 adult ♀ 1 juv. ♂	alive	collected MONZ	

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Date	Entomol. Region	Location	NZTM Easting	NZTM Northing	Elevation (m a.s.l.)	Observer(s)	Age and sex	Alive or dead	Evidence	Notes
22 Apr 1992	OL	West Matukituki head basin	1256000	5073000	890 - 920	G. Gibbs	2 adult ♂ 2 adult ♀ 10 juv.	alive	collected MONZ	
12 Apr 1993	WD	Scone Creek, Perth River	1402000	5189500	1630	G. Lessford, G. Keey	1 adult ♀	dead	collected VUNZ	
16 Apr 1993	OL	Rob Roy Gl. Track, West Matukituki	1260000	5066000	700	B.H. Patrick	1 adult ♂	dead	collected VUNZ	
26 Dec 1993	WD	Barlow River, Adams Range	1404800	5203600	1230	B. Brown	1 adult ♀	dead	collected LUNZ	
Mar 1994	WD	Price Basin, Whitcombe River	1433000	5222000	> 1300	M. Meads, A.H. Whitaker	2 adult ♂ 2 adult ♀ 3 juv.	alive	Found during survey	Meads & Notman 1995
29 Dec 1996	WD	Adams Range	1404800	5204100	1550	G. Goldsworthy	1 adult ♂ 1 juv.	alive	photograph	G. Gibbs correspondence
19 Jan 1997	OL	Bevan Col, West Matukituki	1256100	5075000	1600 - 1700	G. Harper	2 adult ♂ 1 adult ♀	alive	photograph	
28 Dec 1997	WD	Douglas Pass, Karangarua River	1356300	5154900	1360	R. Suisted	1 adult ♂	dead	collected VUNZ	
11 Apr 1998	OL	Camerons Creek, Young Range			900	J. Heine	1 adult ♂	dead	collected VUNZ	
May 1998	WD	Near Whymper Hut, Whataroa River			1700	M.T. Giller	1 adult ♀	dead	collected VUNZ	
8 Feb 1999	WD	Tornado Creek, Olivine Range	1236000	5075800	1020	K. Lloyd	1 adult ♀	alive	photograph	
4 Apr 2003	MK	Temple Stream South Branch	1339200	5112300	1050	D. Hegg	1 adult	alive	none	pers. obs. - walked over our sleeping bags in evening
15 Mar 2004	FD	Esperance Valley, Darran Mts	1202100	5034800	650	T. Jewell	1 juv.	alive	photograph	iNat 72346687
23 Feb 2011	MK	V-Notch Pass, Huxley River	1335800	5114300	1860	I. Millar	1 juv.	alive	none	Ian Millar pers. comm.
Mar 2014	FD	Cascade Peak, Milford Sound	1197500	5043200	1000	T. Stephens, M. Olsen	one wētā	alive	none	Uncertain ID pers. comm.

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Date	Entomol. Region	Location	NZTM Easting	NZTM Northing	Elevation (m a.s.l.)	Observer(s)	Age and sex	Alive or dead	Evidence	Notes
7 Apr 2014	OL	West Matukituki head basin	1255600	5073800	940	T. Jewell	2 adults 1 juv.	alive dead	photograph	iNat 72347322
27 Apr 2014	OL	West Matukituki head basin	1255700	5073750	910	T. Jewell	1 husk		photograph	iNat 72347541
22 Feb 2015	WD	Rocky Creek, Tara Tama Range	1470400	5262100	400 - 620	N. Dickerhof	1 adult ♀	dead	photograph	N. Dickerhof's website in stream bed below biv
3 Feb 2016	WD	Nansen Glacier, Butler River	1394000	5187400	1650	G. Maslowski	1 ♀	alive	photograph	iNat 2955186
17 Mar 2020	WD	Snow White Gl. Arawhata River	1248400	5071200	1420	M. Whittaker	1 adult ♀	dead	photograph	iNat 44428579
18 Nov 2020	OL	Gloomy Gorge, West Matukituki	1257600	5071300	1140	S. Purdie	1 adult ♂ 1 adult ♀ 2 juv.	alive	photograph	iNat 71113979
20-21 Mar 2021	OL	Gloomy Gorge, West Matukituki	1257800	5071500	1150 - 1200	D. Hegg	3 adult ♂ 2 adult ♀ 4 juv.	alive	photograph	iNat 71929106
23-24 Mar 2021	OL	Gloomy Gorge, West Matukituki	1257800	5071500	1150 - 1200	S. Purdie	3 adult ♂ 5 adult ♀ 3 juv.	alive	photograph	
9 Apr 2021	MK	Temple Stream South Branch	1339600	5110300	930	C. Patterson	1 adult ♀	dead	photograph	iNat 73723372