2020

Best practice techniques for the translocation of giant wētā (*Deinacrida* species)

Corinne Watts, Ian Stringer, Chris Green, Danny Thornburrow, George Gibbs and Ian Millar

Department of Conservation
Te Papa Atawhai

New Zealand Government

Cover: Mahoenui giant wētā (*Deinacrida mahoenui*) *Photo: Danny Thornburrow, Manaaki Whenua - Landcare Research, Hamilton.*

This guide was prepared by Creative Services Team and approved by the Director, Terrestrial Science Unit, Department of Conservation, PO Box 10420, Wellington, New Zealand.

In the interest of forest conservation, we support paperless electronic publishing.

Contents

Best practice techniques for the translocation of giant wētā (*Deinacrida* species)

Corinne Watts[1], Ian Stringer[2], Chris Green[3], Danny Thornburrow[1], George Gibbs[4] and Ian Millar[5]

[1] Manaaki Whenua - Landcare Research, Private Bag 3127, Hamilton 3216, New Zealand

[2] Department of Conservation, PO Box 10420, Wellington, New Zealand

[3] Department of Conservation, Private Bag 68908, Newton, Auckland, New Zealand

[4] School of Biological Sciences, Victoria University, PO Box 600, Wellington 6140, New Zealand

[5] 27 Douglas Road, Nelson 7011, New Zealand

Abstract

This document details best practice techniques for translocating giant wētā (*Deinacrida* species). It outlines methods used in the translocation process, from selecting suitable habitats, time of year for translocation, capturing, transportation and housing wētā, through to release and post-release monitoring. This information is intended to help increase the success rates of giant wētā translocations. Wētā are susceptible to stress but this is not always evident to inexperienced people. **It is essential that a person experienced with translocating threatened wētā is involved at all stages of the translocation process.** Wētā can be translocated relatively quickly but giant wētā are long-lived so expect to wait 7 years or more before monitoring might be able to determine if the insect has established.

Keywords: giant wētā, *Deinacrida*, translocation, best practice, New Zealand

1. Introduction

This best practice document provides guidelines for people intending to plan and carry out translocations of giant wētā and/or assess proposals to translocate these wētā. It provides step-by-step explanations of the procedures associated with handling and monitoring the insects. In addition, you will also need to follow the general guidelines for translocations published by the Department of Conservation (https://www.doc.govt.nz/get-involved/run-a-project/translocation/). This lists the relevant documentation and permits that may be required. You will also need to ensure that the relevant iwi are consulted and your contact person in the Department of Conservation will advise you on what is required for this.

There are 11 species of giant wētā (genus *Deinacrida*) in New Zealand. Four are in the North Island or on its offshore Islands (see section 5.1) and most research has been carried out on them. As a result, much of what we know about giant wētā is derived from these four species, whereas comparatively little is known about the seven South Island species (see below in section 5.2).

All species of giant wētā are protected (Schedule 9, Wildlife Act 1953) so a permit from the Department of Conservation (DOC) is required to handle or transfer them between any locations. Great care should be taken when handling and transferring wētā as, like birds, they are susceptible to stress which is not always evident to inexperienced people. It is therefore essential that a person experienced with translocating threatened wētā is involved during all stages of the translocation process. Collecting, documenting and releasing giant wētā can be accomplished relatively quickly, but these insects have at least a 3-year average generation time, so at least

7 years will need to elapse before monitoring might be able to confirm whether the translocated population has successfully reproduced and survived to a second generation.

The information presented here is compiled from papers and reports on previous translocations and from the authors' expertise in giant wētā translocation. The translocation methods described below are based on established techniques that have been used successfully in previous translocations and are therefore recommended as current best practice. We acknowledge that there is presently no single best technique, so translocation teams can choose the one that is most appropriate to their situation. A good translocation practitioner will always closely monitor the wētā in their immediate care and respond to their needs accordingly. Anyone considering translocating giant wētā should refer to this document as a starting point and then contact their local DOC office.

It is essential that we learn from each translocation because this aids subsequent translocations. Therefore, documenting what was done and monitoring the outcome is a vital element in the translocation process.

1.1 Taxonomy, distribution and threat status

Giant wētā are members of the genus *Deinacrida* (Family Anostostomatidae: Subfamily Deinacridinae), of which there are 11 known species endemic to New Zealand (McIntyre 2001). These large, herbivorous, wingless and nocturnal orthopterans have been the most frequently translocated insects in New Zealand. Most releases have been onto mammal-free offshore islands or fenced sanctuaries on the mainland where there are zero or low densities of introduced mammals (Watts et al. 2008a). Nine species are classified as At Risk under the New Zealand Threat Classification System (Trewick et al. 2016):

At Risk:	*Deinacrida carinata* (Foveaux Strait giant wētā), *D. heteracantha* (wētāpunga), *D. parva* (Kaikōura giant wētā), *D. rugosa* (Cook Strait giant wētā)
At Risk, Relict:	*D. elegans* (mountain-bluff wētā), *D. fallai* (Poor Knights giant wētā), *D. talpa* (Paparoa giant wētā)
At Risk, Naturally Uncommon:	*D. tibiospina* (Mt Arthur giant wētā)
At Risk, Recovering:	*D. mahoenui* (Mahoenui giant wētā)

Two species, *Deincrida connectens* (giant scree wētā) and *Deincrida pluvialis* (Mt Cook giant wētā) are classified as Not Threatened (Trewick et al. 2016). Historically, giant wētā were exterminated from most of mainland New Zealand after rodents were introduced with the arrival of humans, or when their habitat was destroyed (Gibbs 1998; McIntyre 2011). The major threat today is likely to be from rodents (Watts et al. 2008a).

The 11 giant wētā species can be considered in two groups (clades) distinguished by shared biological traits (distribution, DNA, physiology, habitat). The first group (referred to as the 'northern arboreal' group hereafter) contains the three northern species: the Poor Knights giant wētā, wētāpunga and Mahoenui giant wētā. These closely related species live in forest and are predominantly arboreal although they frequently visit the ground, especially for mating and oviposition (Watts & Thornburrow 2011). The remaining eight species form the second group (referred to as the 'southern ground-dwelling' group hereafter) which occur in the southern North Island and throughout the South Island where they live near to or on the ground in grasslands, low-growing shrubs, forest margins or subalpine tussock and herbfields. Most is known about the North Island species, whereas we have only limited knowledge about some of the South Island species. In this report we have divided the species into these two groups ('northern arboreal and 'southern ground-dwelling') so that translocation projects involving any species can be carried out using the same or similar methodologies employed for better known taxa in each group.
In general, the translocation techniques are the same for any species, although the habitat requirements differ for different species.

1.2 Giant wētā life cycle

All insects become larger by moulting, where the older inextensible cuticle is shed, allowing a new soft cuticle (which forms beneath the old cuticle before it is shed) to expand (the insect swallows air to do this) and harden. Hardening is a chemical tanning process that also darkens the cuticle, but it does not occur in joints, which remain flexible. The stages between moults are termed instars, and giant wētā pass through 9–10 juvenile instars. They enlarge 25–40% at each moult. We use the term subadult to distinguish the last juvenile instar. If a leg or antenna is damaged, the appendage will regenerate again over several moults. Once the wētā becomes adult it will not moult again and it will eventually die. Adults are the only stages that are reproductively active.

Eggs can be laid at any time of year, although seldom in winter. They normally remain in the ground for 8–10 months and hatch at any time except winter. Hatching in some eggs may be delayed until the following year. Our information is incomplete for most species of *Deinacrida* (see Stringer & Cary 2001 for more details), but juveniles of northern species usually require 1–2 years to become adults. Adults usually live for up to 1 year, with females likely to live longer than males. So, the complete life cycle usually takes 3 and sometimes 4 years. We do not know developmental periods for alpine and subalpine species, but these are likely to be much longer than for other species.

2. Animal welfare requirements

It is essential, for the welfare of giant wētā, that at least one person with suitable experience (referred to below as a 'giant wētā expert') is involved with all aspects of the translocation. We define a giant wētā expert as someone who has had significant past experience with handling and/or translocating wētā. They will have been involved in research and/or monitoring of wētā and have had their work favourably peer reviewed. This person will be required to have been approved by DOC. Having a giant wētā expert involved in a translocation will also maximise the chance of it having a successful outcome. Such a person should have had suitable training or experience in the capture, handling, holding, rearing and release techniques that will be used. This expert is required on site to demonstrate techniques and provide advice to less-experienced team members (e.g. volunteers).

3. Types of translocations

Giant wētā have most often been translocated to new sites by wild-to-wild translocation, and only occasionally through captive-to-wild translocation.

3.1 Wild-to-wild translocation

Wild-to-wild translocation is the direct transfer from the source population to the release site and immediate release. It is the most commonly used technique to establish new giant wētā populations. Typically, one or two transfers of a large number of wētā have been carried out to establish a population at a suitable release site. Wild-to-wild translocations have the advantage of maximising genetic diversity in the new population. How many wētā need to be translocated to ensure the new population has adequate genetic diversity for long-term persistence depends on the genetic variability of the source population and this is at present unknown for most species. Recently, White et al. (2017) recommended that to establish a Cook Strait giant wētā population with a carrying capacity of 10 000 individuals, future translocations should include a minimum of 70 unrelated individuals to avoid genetic bottlenecks and maintain a higher chance of retaining rare alleles. Founding population size needs further investigation for other giant wētā species and is something that must be considered when planning a translocation.

3.2 Captive-to-wild translocation

Captive breeding of giant wētā for release should only be done when: (1) harvesting sufficient individuals from the source population may potentially harm the source population (as discussed in Box 1), or (2) in a situation where much larger numbers are required than can be readily collected from a source population (e.g. where an arboreal wētā is released in forest and large numbers are required to increase the chances of the insects encountering each other and establishing a population within a time scale that can be observed by subsequent monitoring). Note that a number of skills are required to breed giant wētā and anyone intending to hold captive giant wētā species must have a permit to do this from DOC. An advantage of releasing captive-reared wētā is that once they are successfully reared in captivity then captive individuals can be used to 'top-up' a population while it is establishing. Using captive-bred insects can also reduce the number of insects that need to be taken from the source population.

Wild-to-wild translocations are strongly preferred for the following reasons: (1) wild-to-wild translocations are cheaper and only involve people with wētā expertise for short periods; (2) the founding population is likely to have a better genetic diversity; and (3) wild individuals are better adapted to wild conditions (e.g. are better ability to find refugia when released than captive-reared individuals). Captive-to-wild translocations are likely to involve incremental releases over several years which means that outcome monitoring must be delayed until after the last release.

In general, captive-rearing should be done in an indoor or laboratory situation. Using outdoor cages is discouraged, as they are susceptible to problems such as overheating in sunshine, becoming too humid when built under forest canopy, food plants becoming etiolated and wētā laying eggs in potting mix or soil, thus preventing potted food plants being exchanged with fresh ones.

So far, Cook Strait giant wētā, Mahoenui giant wētā, Poor Knights giant wētā and wētāpunga have been successfully bred in captivity. An example of captive breeding programmes is outlined for wētāpunga (Box 1).

4. Source populations

The genetic diversity and availability of individuals in a source population are key issues that must be considered when planning any translocation, so it is important to consult a wētā geneticist or giant wētā expert before any animals are removed from a population.

In general, it is important to maintain the genetic health and growth rate of source populations, and this should be kept in mind when deciding how many individuals can be harvested from them. Serial translocations from the same sites should be avoided where possible and founder populations should include additional wētā from other genetically diverse areas of the source population. Once a translocated population has established (e.g. after 10 years) its genetic diversity should be surveyed. Ideally, the genetic diversity of the translocated population should be similar to that of the source population. However, if the translocated population is less genetically diverse, then additional 'top-up' translocations should be considered. Genetic samples can be obtained from wētā by taking a small section of the end of one antenna (using sterilized equipment and preserving in 100% ethanol), but this is a specialised task requiring a geneticist to be involved and a permit from DOC.

Ideally, the population dynamics of a giant wētā population should be modelled so that a suitable harvest rate can be determined, but we do not have sufficient information at present on the biology of giant wētā to enable us to do this. We therefore adopt a precautionary approach and recommend limiting harvesting to a small proportion of wētā seen (e.g. by collecting, for example, every 10th wētā found). In addition, as mentioned above, we recommend that wētā are harvested from as wide an area as possible within the source population rather than taking all of them from a small part of the insects' range.

Finally, careful consideration needs to be given to the number and location of source populations used for translocations. Where possible, wētā should be harvested from locations which have similar habitats and climate to the translocation locality. White et al. (2017) also recommended, for genetic reasons, that Cook Strait giant wētā originating from Stephens Island and Mana Island should be kept separate, so they should only be released where they will not mix in future.

Box 1: Wētāpunga case study

Wētāpunga were previously distributed throughout the Northland and Auckland regions before undergoing a dramatic decline. Habitat loss and introduced mammals resulted in their range becoming restricted to just one relict population on Te Hauturu-o-Toi / Little Barrier Island (Hauturu). To secure the species, a recovery programme aimed to set up additional island populations in the Hauraki Gulf. The initial aim was to collect 100 wētāpunga for direct transfer to several newly available islands. The last exotic mammal species, kiore, or Pacific rat (*Rattus exulans*), was eradicated from Hauturu in 2004 and there was concern that it may be too early in the recovery of the wētāpunga population to remove large numbers for transfer. Indeed, annual field surveys during 2005–2009 revealed insufficient subadults or adults to facilitate such direct translocations. Consultation with Iwi and the Little Barrier Island Supporters Trust verified concerns around removing large numbers at that time, whereas there was support for taking low numbers to found captive colonies.

A detailed plan was prepared outlining the frequency of collection, the numbers per collection, intended release dates and timing, assessment of habitat suitability at release sites, methods to be used during capture and release etc. This formed the basis of a translocation proposal that was approved by DOC. Research was required to determine appropriate rearing conditions for housing, feeding, mating and oviposition so just six adults were collected in December 2008 for early tests at the Butterfly Creek facility, Auckland. Then, in May 2009, 12 adults (six of each sex) were collected to begin full-scale rearing. In May 2012 a second colony was started at Auckland Zoo, Auckland. Further cohorts of 12 adults were collected at 3-yearly intervals to augment the colonies.

From 2010 to 2015, captive-reared wētāpunga were released at three different locations on both Motuora and Tiritiri Matangi Islands. Initially the numbers were low (e.g. 25 for the first release) but later, bulk-rearing allowed cohorts of 100 and 380 to be released at a time on each island. Each release (translocation) has been at a different site, so can be monitored independently to determine success. Monitoring has employed both baited tracking tunnels and visual assessments, including artificial refuges. Tracking tunnels have only been used when the population at that site was mostly in the adult stage of their life cycle, as only adults visit the forest floor for behaviour related to mating and oviposition. In 2018, the second island-born generation was detected on each island, thus wētāpunga are now considered established on both islands.

For the purposes of this best practice document, giant wētā should only be kept in captivity to contribute to species recovery or restoration programmes. Once the relevant programme has been completed all remaining captive wētā should be released at the translocation site. Wētā should not be returned to the source population.

Holding protected wētā species for advocacy purposes is not covered in this document and any enquiries concerning this should be directed to DOC.

5. Recommendations for geographic limits for translocating giant wētā species

Historically, it is likely that there was at least one giant wētā species present below the treeline in every region in New Zealand (as is still almost true for tree wētā – they are absent at low altitudes only in the south of the South Island). It is also probable that at least one species of giant wētā became extinct after humans arrived in New Zealand. Generally, habitat or distributional data for giant wētā are too limited to allow firm recommendations to be made. We nevertheless strongly recommend the following geographic limits within which each giant wētā species should be translocated, provided that the release areas have suitable habitat, lack introduced mammalian predators or have good predator control. Note that species that are ecologically similar (e.g. wētāpunga and Mahoenui giant wētā) should not be released in the same area. Also, the geographic limits given in the following text prevent most species with different ecologies (e.g. Mahoenui giant wētā and Cook Strait giant wētā) from being released in the same area. Where this is being considered, then it should be the subject of extensive discussion between all available giant wētā experts.

5.1 North Island giant wētā species

Poor Knights giant wētā (*D. fallai)*

An arboreal giant wētā living in pōhutukawa (*Metrosideros excelsa*) forests on the Poor Knights Islands, off the eastern Northland coast. The Poor Knights giant wētā should remain restricted to the Poor Knights Islands.

Wētāpunga *(D. heteracantha)*

Wētāpunga is an arboreal species inhabiting forests. Wētāpunga should only be translocated to fore*sts within* Northland, Auckland, Hauraki Gulf islands (it was known to be on Great Barrier Island), Coromandel and no further south than North Waikato (use the southern distributional boundary for kauri, *Agathis australis*). See Box 1 for information on relict and current distributions of wētāpunga.

Mahoenui giant wētā (*D. mahoenui*)

Mahoenui giant wētā is an arboreal species of mature scrub and forest. After Europeans arrived, it survived on the mainland primarily in gorse (*Ulex europaeus)* which was introduced as a hedge plant. We suggest that it could be translocated to suitable habitats (including coastal) north of Mt Ruapehu. There have been translocations to several sites in the King Country and islands off Coromandel, all of which have failed except for those to Mahurangi Island (off Hahei) and in a predator-fenced enclosure at Warrenheip (Karapiro) (Watts & Thornburrow 2009).

Cook Strait giant wētā (*D. rugosa*)

Current evidence suggests that this species prefers bush margins and coastal shrub/scrub species (McIntyre 2001). Further study of the Matiu/Somes Island and Zealandia translocated populations may shed light on potential forest habitat preferences. It has been included in the Kapiti Island Restoration Plan (Brown et al. 2016) where a well-designed study could also help resolve habitat preferences. Cook Strait giant wētā should only be translocated to coastal areas from Wellington north to Wanganui west of the main ranges. Cook Strait giant wētā has also been translocated to Cape Sanctuary and are proposed for Young Nick's Head in Hawkes Bay. However, despite suitable habitat being available there has been debate as to whether they should be released east of the main ranges as far north as Gisborne because there is no evidence that they ever occurred there. Therefore, Cook Strait giant wētā should only be translocated to coastal areas from Wellington north to Wanganui west of the main ranges and also to islands within the Marlborough Sounds and Cook Strait area. Translocations to other areas should be regarded as beyond the natural range of the species unless new evidence supports a range extension.

5.2 South Island giant wētā species

Not enough is known about the South Island giant wētā species to provide geographic limits so translocations should at present be done only for research purposes (wild-to-captive only with appropriate permits from DOC) or if a species is threatened and translocation is likely to benefit its long-term survival. A brief account is provided below for the known giant wētā but the only species for which translocation is currently of potential benefit is the Foveaux Strait giant wētā.

Kaikōura giant wētā (*D. parva*)

This is a 'sister' species to Cook Strait giant wētā which is morphologically and ecologically distinct but genetically similar (Cameron 1996). This ground-dwelling wētā is known from subalpine to alpine grasslands in the Seaward Kaikōura Ranges and associated ranges above approximately 900 m in altitude. It is one of three wētā species, along with the mountain-bluff wētā and giant scree wētā, that were affected by severe habitat damage in the Hapuku catchment during the November 2016 Kaikōura earthquake, so its potential recovery should be monitored. At present, this species does not require translocation for conservation purposes but could possibly benefit from being translocated into a rat-free sanctuary in an open grassland valley within the Kaikōura Ranges (e.g. somewhere in Molesworth Station).

Mountain-bluff wētā (*D. elegans*)

This is an unusual species that inhabits rock crevices on cliff faces and rocky bluffs where it is protected from rats. While probably preferring deep, dry crevices, it has been found in shallower crevices and in vertical crevices exposed to the weather. It occurs at altitudes of 600–1700 m and has a disjunct distribution, with the northern populations occupying the Seaward and Inland Kaikōura Ranges and mountains around the Wairau River and a southern population on west-facing bluffs of Mt Somers in mid-Canterbury (Gibbs 1999, 2001). The habitat of the Mountain-bluff wētā in the Hapuku catchment was severely damaged during the November 2016 Kaikoura earthquake. It is therefore likely that the mountain bluff wētā was also severely affected, so its potential recovery should be monitored. This species does not require translocation for conservation purposes.

Mt Cook giant wētā (*D. pluvialis*)

This wētā lives in snow tussock habitat in subalpine to alpine (700–1850 m) slopes and basins in high rainfall areas of the Southern Alps and ranges to the west of the main divide between Mt Alexander and Cleddau Cirque (Gibbs 1999). At present, it does not require translocation for conservation purposes.

Paparoa giant wētā (*D. talpa)*

A sister species of the Mt Cook giant wētā, this wētā excavates long tunnels in soil under carpet grass (*Chionochloa australis)* above the treeline in the granite mountains of the central region of the Paparoa Range – Mt Faraday to Mt Ramsay – at altitudes of 1250–1300 m (Gibbs 1999, 2001). Since Gibbs' (1999) review of the Deinacrida genus, a tramper has reported a large, unidentified wētā – potentially a new species of giant wētā – on the summits of the Victoria Range inland from the current known distribution of the Paparoa giant wētā. This report warrants further investigation. At present, this species does not require translocation for conservation purposes, despite its rarity.

Giant scree wētā (*D. connectens*)

Known as an alpine specialist, the giant scree wētā occurrs on extremely exposed rocky barren slopes, preferring altitudes of approximately 1500 m. It is the most widespread *Deinacrida* species – occurring along the Southern Alps, Kaikōura Ranges, Mt Arthur, and Marlborough Ranges; with definitive geographic races (Gibbs 2001). Habitat of the giant scree wētā is likely to have been severely damaged in the Hapuku catchment during the November 2016 Kaikoura earthquake, so its potential recovery should be monitored. This species does not require translocation for conservation purposes.

Mt Arthur giant wētā (*D. tibiospina*)

This wētā lives amongst the leaf bases of tussocks and flax (*Phormium* spp.) in subalpine tussock and herbfields at 1000–1500 m asl in the Tasman Mountains, northwestern Nelson (Gibbs 2001). Monitoring using tracking tunnels by the Friends of Flora community group on Mt Arthur over the last 2–3 years has detected very little activity from this species. Along with *D. carinata*, they are the least understood of all the giant wētā in New Zealand, especially their distributional limits. At present, this species probably does not require translocation for conservation purposes, but more research is needed.

Foveaux Strait giant wētā (*D. carinata*)

This is the smallest and most southern of the giant wētā species in New Zealand. It is active on the ground, but its preferred habitat is uncertain, although likely to be herbaceous vegetation (Gibbs 2001). It has a very restricted distribution and is only found on three small islands – Herekopare (Te Marama), Kundy and Pig Islands – in Foveaux Strait. Given the very small area of existing habitat on the three islands, survey and monitoring of these populations is recommended. In 2009, 34 Foveaux Strait giant wētā were translocated to Codfish Island / Whenua Hou, but the outcome of this translocation has yet to be determined. Post-release monitoring and consideration for further translocations is recommended.

6. Suitability of a release site for establishing a giant wētā population

Habitat requirements differ between giant wētā species and it is critical that habitat must be matched to the species being translocated. A basic guideline for habitat and daytime refuge requirements for each species is outlined in Table 1, but it is important that shelter (refuge sites) and food are abundant. It is imperative that a wētā expert visits the proposed release site to assess its suitability. If the site contains restoration plantings, then long-term planning is required to ensure that suitable habitat is always present in the future.

We know very little about the habitat requirements for some giant wētā species. This is true for the South Island giant wētā species inhabiting alpine areas (Table 1). For example, can refuges in rock crevices be replaced by similar locations in forest (e.g. under bark, in holes and cracks in tree trunks and branches)? More research is needed on the habitat requirements of these taxa before translocations are considered. In addition, some giant wētā species may be surviving in suboptimal habitats (e.g. Mahoenui giant wētā in gorse habitat).

We do not recommend releasing wētā into cages first to acclimatise them before releasing them into the wild (this procedure is often referred to as a ‘soft’ release).

The presence and abundance of native predators such as tuatara, geckos, saddleback/tīeke, morepork/ruru and weka also need to be considered when selecting a translocation site for giant wētā. If other species, particularly native predators, are also being considered for translocation to a particular location, then the sequence of translocations should allow the giant wētā species to become established before their predators are introduced. Alternatively, much higher numbers should be released in the founder population to allow for the presence of native predators.

Ideally, introduced mammals (especially rodents) should either be absent, controlled to low levels or eradicated from the release site. Watts & Thornburrow (2009) reported that the absence of introduced mammalian predators, particularly rats, was the most important factor determining the success of past Mahoenui giant wētā translocations. Giant wētā may be able to coexist with mice. For example, Cook Strait giant wētā survived when mice were present on Mana Island, including through periodic irruptions of mice to very high densities (McIntyre 2001). In addition, Watts et al. (2012) reported that adult Cook Strait giant wētā survived well and established in Zealandia in the presence of low densities of mice.

Table 1. Habitat and daytime refuge requirements of giant wētā in New Zealand.

GIANT WĒTĀ SPECIES	RECOMMENDED FOR TRANSLOCATION TO ESTABLISH WILD POPULATIONS	HABIT	HABITAT REQUIRED	DAYTIME REFUGE REQUIRED	KEY REFERENCES
Poor Knights giant wētā	No	Arboreal	Forest	Loose bark on pōhutukawa	Richards (1973); McIntyre (2001)
Wētāpunga	Yes	Arboreal	Forest	Loose bark and cavities of kānuka, māhoe and Pōhutukawa; in dead treefern skirts/nīkau palm fronds	Richards (1973); Gibbs (2001); Gibbs & McIntyre (1997); Watts & Thornburrow (2011)
Mahoenui giant wētā	Yes	Arboreal	Mature scrub/forest	Loose bark on mānuka; under dead leaves of cabbage trees/tree ferns, dense foliage	Richards (1994); Sherley & Hayes (1993); Watts & Thornburrow (2009)
Cook Strait giant wētā	Yes	Ground-dwelling	Coastal shrub/scrub-grassland; forest edges	On soil or leaf litter underneath vegetation (e.g. flax, tauhinu, Coprosma repens, rank grass) or other objects	Ramsay (1955); McIntyre (2001); Watts et al. (2009, 2011)
Kaikoura giant wētā	Possibly	Ground-dwelling	Subalpine to alpine grasslands/ herbfields	On soil amongst grass or under stones/logs	Gibbs (2001)
Mountain-bluff wētā	No	Ground-dwelling	Solid, near vertical rocky bluffs or cliff faces at 600–1700 m	Deep narrow crevices	Meads & Notman (1992); Gibbs (1999, 2001)
Mt Cook giant wētā	No	Ground-dwelling	Subalpine to alpine slopes and basins in high rainfall areas with snow tussock and woody shrubs	In cavities under rocks	Gibbs (1999, 2001)
Paparoa giant wētā	No	Ground-dwelling	Carpet grass (Chionochloa australis) above treeline in the granite mountains	Long subterranean burrows in soft organic soils under carpet grass	Gibbs (1999, 2001)
Giant scree wētā	No	Ground-dwelling	Exposed rocky, barren slopes at around 1500 m	Under stones on scree slopes	Field (1980); Gibbs (2001)
Mt Arthur giant wētā	No	Ground-dwelling	subalpine tussock and herb-fields at 1000–1500 m	Leaf bases of tussocks/Astelia/flax	(Gibbs 2001)
Foveaux Strait giant wētā	Yes	Ground-dwelling	Uncertain, probable herbaceous vegetation on ground	Unknown; likely driftwood	Meads & Notman (1995); Gibbs (2001)

7. Transfer team

It is vital to have people with experience in capturing, handling, measuring, captive husbandry and releasing giant wētā involved throughout the translocation process is. It is important to be able to identify the behavioural signs of stress in wētā and to have an understanding of the welfare of these insects. It is also key to building expertise by training people who will have the opportunity to use and build on those skills in the future.

8. Time of year for transfer

Giant wētā can be transferred at any time of the year, although it may be best to avoid the colder winter months. Spring and autumn are ideal because this provides time for them to adapt to their new environment before mating and laying eggs. These seasons are mild and there is a higher likelihood of rain to moisten soil and provide ideal conditions for oviposition. The hot summer months (January and February) should be avoided because of high temperatures, increased risk of stress and the soil being too dry to lay eggs in.

9. Number and size of transfers

The number of individuals released in the first transfer depends on the genetic variation of the source population. In the absence of such data, at least 70–100 unrelated individuals are recommended for the first transfer (White et al. 2017). The population should then be monitored for at least two generations until the wētā is established. A genetic analysis as detailed above should then be made after three generations (10 years) to assist decision-making about further supplementary ‘top-up’ translocations required for genetic diversity.

In the case of captive to wild transfers where the captive population has been reared from limited numbers of founders, more than three transfers may be required. The exact number will depend on the genetic diversity of the founders and will need to be determined on a case-by-case basis (hence the need to take a genetic sample from each insect released into the wild). Refreshing the captive colony with additional, new genetic stock is recommended where possible to augment genetic diversity. Where successive or multiple transfers are used to augment the new population, these should occur every 3 years if wētā of the same age are used. With a 3-year life cycle this will ensure wētā will be in synchrony with the same-aged wētā from previous transfers, i.e. all will be adults at the same time so will be able to interbreed with previously transferred wētā.

10. Composition of transfer group

Previous giant wētā translocations have involved wētā of a variety of ages. However, we now recommend that a cohort of wētā of a similar age (size) are released. This allows founders or their offspring to be recognised when monitoring in subsequent years. If a mixed group is released, then it becomes difficult to determine if they have successfully bred and it then becomes necessary to wait until the youngest individuals released have had time to develop into adults and then die (usually after 3–4 years).

If wētā are to be radio-tracked after translocation as an aid to monitoring, then use only adults as they will not moult. In general, for wild-to-wild transfers we recommend that subadults are transferred because this gives them a chance to adapt to their new environment before they become adults and develop reproductive behaviour. For captive-to-wild transfers it can be beneficial to release wētā at an earlier age because this reduces the level of effort required in captive rearing. This also avoids the problem of later instars experiencing increased mortality during rearing as seen in some species (e.g. wētāpunga). We recommend using an even sex ratio or one biased slightly towards females when transferring wētā.

11. Capture

It is important to include someone experienced with translocating threatened wētā when organising teams for capturing wētā. The method used for capturing wētā depends on the species that is being translocated so it is important to know the habitat preferences (see Table 1) of the insect and thus know where to search. Ground-dwelling species, such as Cook Strait giant wētā, are most readily found at night when they come out to feed and reproduce. Wētā can be found during the day by searching refuges, but they are harder to find and such searching is more destructive. Arboreal giant wētā, including wētāpunga and Mahoenui giant wētā, can be found during the day by searching preferred refuges (e.g. under treefern skirts, treefern crowns, in or between dead nikau palm fronds) but this takes experience, or by searching vegetation at night using a spotlight.

Before planning for a translocation, we recommend a population estimate be made of the source population to evaluate the effect of removing 70–100 wētā from it. However, this is seldom done because of the time and effort involved. When no data are available then we recommend collecting every tenth wētā seen. Wētā not taken should be marked using a small dot of twink or non-toxic, xylene-free fast-drying paint so they can be ignored when the same areas are searched again. It is also important for genetic reasons to collect wētā as widely spread spatially as possible (within the same population) as mentioned above. Do not take all the wētā from just one area of the source population.

Once a wētā has been captured, it is important to examine it. Only take wētā for translocation that are healthy, with all body parts intact (e.g. all leg segments present, antennae complete), no abnormalities and minimal mites.

12. Processing the wētā

Again, it is imperative that a wētā expert leads this. Keep notes of the sex of each wētā, its age and some measurements (e.g. some or all of the following: lengths of mid-dorsal pronotum, metatibia, hind femur and ovipositor; Fig. 1). Also record the overall condition, such as any colour variation and unusual markings. If detailed post-release monitoring is to be undertaken, then attach a small numbered identity tag (or transmitter and record the transmitter frequency) to adults so they can be identified if still alive in subsequent surveys.

Figure 1. Measuring the (A) pronotum length and (B) metatibia of an adult Cook Strait giant wētā using callipers. *Photos: Danny Thornburrow*.

12.1 Determining the sex and age of giant wētā

Adult giant wētā are sexually dimorphic (occurring in two different forms). Female giant wētā have larger bodies and have an ovipositor and a pair of cerci at the end of the abdomen (Fig. 2). The ovipositor is shorter but still quite visible in most juvenile females except for the very smallest. In some species the end of an adult's ovipositor is darkened for more than half its length, whereas less than half is darkened in juveniles. Adult males are smaller, lack an ovipositor, and have two pairs of appendages at the end of their abdomen: a pair of cerci (like females) and an additional a pair of smaller styli (Fig. 2).

It is difficult to distinguish females and males in the first two or three instars because the ovipositor valves in females originate as separate appendages, but the anterior pair are so small that the posterior pair can be confused with developing styli. By about the third instar these ovipositor valves have elongated into four tapering appendages so that juvenile females appear to have six appendages at the end of their abdomens whereas males have four. The genders of juveniles about a quarter the body lengths of adults are, however, easily distinguished (see Stringer & Cary (2001) for more information).

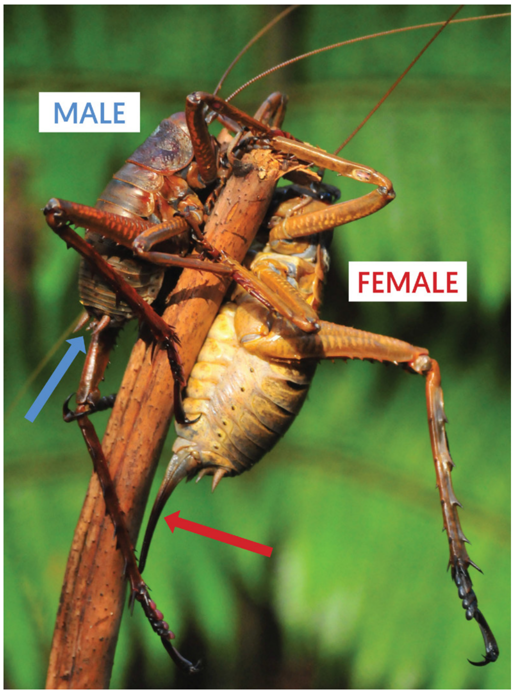

Figure 2. Adult male (left) and female (right) wētāpunga. The ovipositor on the female is indicated by the red arrow and the stylus on the male is shown with the blue arrow. *Photo: Danny Thornburrow.*

12.2 Measuring wētā

It is not essential to measure wētā that are to be translocated but we strongly recommend that it is done in case researchers later want to compare the founder population with the source population. We recommend taking the measurements listed above under 'Processing wētā'.

12.3 Tagging wētā

Giant wētā can be tagged with small individually numbered paper tags (2 × 3 mm) that have been previously soaked in Araldite or clear fibreglass embedding resin (Watts et al. 2011; Fig. 3). These are best attached on the middle of the pronotum using a small amount of quick setting adhesive (e.g. Selleys 'Supaglue gel'; Fig. 3).


Figure 3. Attaching a small individually numbered tag to a Mahoenui giant wētā. *Photo: Danny Thornburrow*.

Only adults should be tagged as they will not moult. In the past, bird bands were sometimes attached to the metatibiae of wētā. However, the latter is a more invasive procedure and is therefore not recommended. Juveniles and subadults cannot be tagged with a paper tag or bird bands because they could prevent the animal from moulting correctly and cause death. Juveniles and subadults can be marked with twink, nail polish, or non-toxic xylene-free quick-drying paint but this will be lost when the wētā moults.

12.4 Attaching transmitters

Attaching radio-transmitters to adult giant wētā is a highly specialised procedure and must only be performed by experienced people approved by DOC. Juvenile and subadult wētā should not have a radio-transmitter attached because this will cause moulting problems that result in death. Transmitters should be as light as possible. Those currently in use weigh less than 1.5 g. Under no circumstances should the weight of the transmitter exceed 5% of the wētā's body weight. Transmitter specifications currently used are:

Maximum weight: 1.1 g for females; 0.87 g for males

Size: 11 × 9 × 6 mm

Antenna: Plastic-coated whip; flexible 0.7 mm diameter wire

Battery life: up to 42 days

13. Care of giant wētā during capture and transfer

Each wētā should be placed in a container which is rodent proof (a 2 L ice-cream container is ideal) but has small air holes perforated into the lid. Mating pairs that were found together should be kept together – in much larger containers (again with air holes). Alternatively, the mating pair could be separated for transit then released beside each other if releasing into the wild or into a full size mating cage if going to captivity. Place a thick wad of damp paper towel on the bottom of the container and include appropriate food plant and vegetation for wētā to hide in and hold onto during transit. The vegetation needs to be dense and sufficient to provide a stable, secure 'perch' and protection against accidental jolting during transfer, e.g. if box is knocked or dropped. Do not include soil.

It is absolutely critical that occupied wētā containers are kept cool and out of direct sunlight. Minimise noise and vibrations and keep boxes upright and move them with care. Cardboard cat boxes or chilly bins are ideal for carrying a number of wētā in plastic ice-cream containers.

14. Release

Ideally, wētā should be released within 24 hours of capture. Release them during the day into suitable refuge sites, as directed by an experienced wētā expert. Again, it is important to know the habitat preferences (Table 1) of the giant wētā species you are transferring so suitable release sites can be chosen. Some wētā will come out in the evening after release but many will remain in the same place until weather conditions are suitable, so putting them in suitable refuge sites allows for variation in behaviour between individuals and for them to remain resting until they have recovered from the transfer process. It is important to provide the wētā with appropriate cover. For example, arboreal species prefer treefern fronds being draped over them. Wētā can also be transferred in ready-made artificial refuges, such as short (200 mm) hollow lengths of bamboo of appropriate width to accommodate the species. Provided these bamboo refuges are pest and disease free they can be left at the release site and, for arboreal species, attached to a suitable bush or tree using a cable-tie, or tied though a hole or node at the top, so the wētā can exit in its own time.

Note that wētā from each translocation should ideally be released at one location, and if later supplementary translocations are made, then release these at different locations well separated from previous release sites, if possible. This will make it easier for subsequent monitoring because the offspring from different releases will not be confused.

Important: Any material including vegetation in the containers used for transferring wētā must not be disposed of in the release site: take it away and dispose of it with domestic rubbish.

Note also, that we do not recommend using 'soft' releases of wētā as mentioned previously (see 'Suitability of a release site for establishing a giant wētā population above).

15. Post-release monitoring

15.1 Purpose

Post-release monitoring informs future management of translocated populations and can help to answer questions such as:

- Will the reintroduction be successful?
- Is management needed/sufficient?
- Will supplementary translocations be needed?
- Is genetic diversity sufficient?
- Does the translocation technique need to be refined?
- Does release site selection need to be refined?

15.2 General considerations

Consult a wētā expert to help design a monitoring plan to detect wētā survival, movement patterns and dispersal. There is currently no standard monitoring method for doing this, but the best methods are listed below. Wētā can be cryptic and particularly difficult to find or detect when they are at low densities (Watts et al. 2008b).

When wētā are released into habitat which is of uncertain suitability, adults should be monitored frequently and as soon as they reach that age if juveniles were released. Monitoring and detecting juveniles is not recommended because this is difficult and there is no adequate monitoring method, especially for arboreal species.

Wētā have long life cycles (3 years or more) so a monitoring plan can involve many years. Monitoring should be done at least after two generations to determine if the transfer was successful and to determine if any top-up transfers are required. You cannot mark an individual externally to follow it through its life cycle, you can only survey for their presence.

If a mixed age-cohort is released then you can monitor them every year to follow the survival of each cohort, but you should always monitor them after the youngest juveniles have had time to mature as adults to determine if the founders have reproduced successfully (usually at least 3–4 years). Successful reproduction will be indicated by the presence of any large juveniles or adults.

Monitoring must relate back to the operational targets stated in the translocation proposal. The design of post-release monitoring should match the questions you are trying to answer and how the data is to be used subsequently. Monitoring is required because of the uncertainties associated with translocations, such as if there is any uncertainty about whether the habitat at the release site is suitable or if there is concern about the density of introduced predators being too high at a release site.

Post-release monitoring is one of the most important parts of the translocation, but it is frequently overlooked. Documenting wētā translocations is a relatively new activity. It is particularly important to record the methods used in detail in order to improve future translocation techniques. Documentation becomes particularly important if a translocation fails.

15.3 Recommended monitoring methods

Searching for giant wētā

Most monitoring of giant wētā has involved searching habitat, particularly refuges, during the day or by using spotlights at night. Some giant wētā, such as wētāpunga and Mahoenui giant wētā, can be found both at night and during the day using a similar amount of search effort. Others, especially ground-dwelling species like Cook Strait giant wētā, are easier to find by searching paths and vegetation at night (Watts et al. 2017).

Visual searching, using spotlights at night, can be used to estimate the number of individuals in the area searched using capture-mark-recapture procedures. This is a technical procedure that requires the use of numerous people searching (for an example, see Watts et al. 2011). Except when using capture-mark-recapture, searching at night will not give a good estimate of wētā density, even when the search is strictly controlled (e.g. same time of night, same marked path and same number of people) because wētā activity is so dependent on weather conditions during the search. Searching for arboreal giant wētā during the day involves examining potential refuge sites, such as cavities or spaces between and under the fronds of tree ferns or palms. Useful distributional information can also be obtained by recording the position of each wētā found with a GPS.

Tracking tunnels

Wētā leave distinctive footprints on tracking tunnel cards, with each tarsus producing a row of up to four closely spaced dots that originate from contact with their tarsal pads (Fig. 4; Watts et al. 2008b). Different species cannot be distinguished from their footprints, so footprints can only be used to identify adults of the largest wētā species present (Watts et al. 2009). Smaller wētā footprints present on a tracking card could have been made by juvenile giant wētā, tree wētā, or ground wētā (Watts et al. 2013). Note that each tracking tunnel only provides a positive or negative result. This follows because when multiple footprint tracks of the largest adult wētā species are present you cannot distinguish whether one individual walked through several times or different individuals went through. Watts et al. (2011; 2013) showed that tracking rates of Cook Strait giant wētā, wētāpunga and Mahoenui giant wētā reflected local population densities. Tracking tunnels are relatively efficient for monitoring and easy to use. They can also be used to track the expansion of a founder colony, as for example, was done with the Mercury Islands tusked wētā after it was released on Red Mercury Island (Stringer et al. 2014). Table 2 provides the lengths of adult wētā footprints on cards to confirm if footprints were made by adult giant wētā.

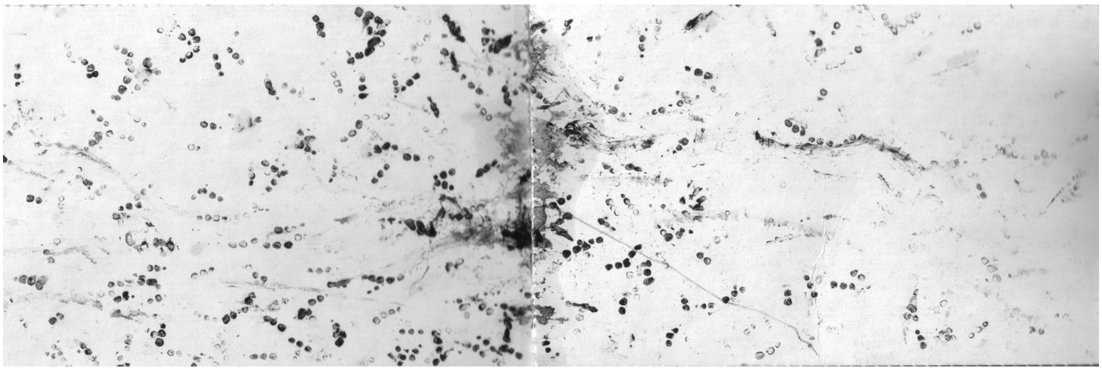

Figure 4. Wētā leave unique footprints on tracking tunnel cards, with each tarsus producing a row of up to four closely spaced dots that come from contact with their tarsal pads.

Table 2. Footprint sizes (mm) of wētāpunga (Watts et al. 2013), Mahoenui giant wētā (Watts et al. 2013) and Cook Strait giant wētā (Watts et al. 2011). If the footprints on tracking cards are greater than the listed measurements in mm, they are adult giant wētā.

GIANT WĒTĀ SPECIES	PROTARSAL	MESOTARSAL	METATARSAL
Wētāpunga	4.3	4.9	8.9
Mahoenui giant wētā	3.8	4.4	7.8
Cook Strait giant wētā	4.1	4.4	5.1

Tracking tunnels ('Black Trakka': Gotcha Traps, Warkworth, NZ) should be spaced approximately 20–30 m apart. This reduces the chance of a single individual wētā walking through two tunnels. Use at least 30 tracking tunnels in a release area. We use pre-inked tracking cards and apply c. 4 g of peanut butter to the middle of each inked area as bait. Tunnels should be set on the ground for up to 4 nights and if possible checked daily, replacing the bait if eaten. Cards are scored as 'adult giant wētā present or absent' and, 'other wētā present or absent'.

There is some evidence that rainfall stimulates ground activity in arboreal species such as Wētāpunga and Mahoenui giant wētā, therefore tracking immediately after, or during, rainfall may give higher scores (Watts & Thornburrow 2011; Chris Green unpubl. data; Corinne Watts unpubl. data). There is also evidence that giant wētā are more active when the moon is 'new' (i.e. dark phase) or obscured by cloud (McIntryre 2001). For new populations, try to target the new moon and rain periods to maximise detections. Certainly, aim for consistency in these and other environmental conditions so monitoring results are comparable between occasions.

Radio-tracking

It is possible to attach micro-transmitters to adult wētā, but this should only be done by researchers for an approved research project. A separate permit will be required from DOC. Transmitters are expensive but can be worthwhile for projects that are well resourced and have enough people to undertake the intensive level of post-release monitoring required (checking the position of each wētā at least once a day). If the translocation involves a giant wētā species that has not been translocated before, then following some individuals in detail can provide useful information for further translocations. Radiotracking some individuals may also be useful if there is some uncertainty about habitat suitability.

One example of using transmitters to monitor wētā was the post-release monitoring of adult Cook Strait giant wētā after their translocation into Zealandia from Matiu-Somes Island (Watts et al. 2012). This included an investigation of their behaviour, movements and survival. The transmitters used were BD-2 transmitters (Fig. 6), weighing up to 1.1 g, with a battery life up to 42 days. They were obtained from Holohil Systems Ltd, Ontario, Canada.

Figure 6. A transmitter attached to a Cook Strait giant wētā translocated from Matiu-Somes Island to Zealandia in 2007. *Photo: Danny Thornburrow*.

16. References

Brown, K.; Rolfe, J.; Adams, L.; de Lange, P.; Green, C. 2016: Kapiti Island ecological restoration strategy. Department of Conservation, Wellington New Zealand. 50 p.

Cameron, W. 1996: A study of the taxonomic status of *Deinacrida parva* and *Deinacrida rugosa* (Orthoptera: Stenopelmatidae), two giant wētā from central New Zealand, Unpublished MSc thesis. Victoria University of Wellington, Wellington, New Zealand.

Field, L. H. 1980: Observations on the biology of *Deinacrida connectens* (Orthoptera: Stenopelmatidae), an alpine weta. *New Zealand Journal of Zoology 7*: 211–220.

Gibbs, G. 1998: Why are some wētā (Othroptera: Stenopelmatidae) vulnerable yet others are common? *Journal of Insect Conservation 2*: 161–166.

Gibbs, G. 1999: Four new species of giant wētā, *Deinacrida* (Orthoptera: Anostostomatidae: Deinacridinae) from New Zealand. *Journal of the Royal Society of New Zealand 29*: 307–324.

Gibbs, G. 2001: Habitats and biogeography of New Zealand's Deinacridine and tusked wētā species. Pp. 35–55 in: Field, L.H. (Ed): The biology of wētā, king crickets and their allies. CABI, Wallingford, UK.

Gibbs, G.M.; McIntyre, M. 1997: Abundance and future options for wetapunga on Little Barrier Island. *Science for conservation No. 48*. Department of Conservation, Wellington. 24 p.

McIntyre, M. 2001: The ecology of some large wētā species in New Zealand. Pp. 225–242 in Field, L.H. (Ed.): The biology of wētās, king crickets and their allies. CAB International, Wallingford, UK.

Meads, M.; Notman, P. 1992: Survey of the status of three species of giant wetas (Deinacrida) on the Seaward and Inland Kaikoura Ranges. *DSIR Land Resources Technical Record 89*. 35 p.

Meads, M.; Notman, P. 1995: Giant weta (*Deinacrida carinata*) on Pig Island, Foveaux Strait. In: Surveys of giant weta. *Science for Conservation No. 16*, Department of Conservation, Wellington.

Ramsay, G.W. 1955: The exoskeleton and musculature of the head, and the life-cycle of *Deinacrida rugosa* Buller, 1870. MSc thesis, Victoria University of Wellington. 163 p.

Richards A.M. 1973: A comparative study of the biology of the giant wetas *Deinacrida heteracantha* and *D. fallai* (Orthoptera: Henicidae) from New Zealand. *Journal of Zoology 169*: 195–236.

Richards, G.E. 1994: Ecology and behaviour of the Mahoenui giant weta, Deinacrida nov. sp. MSc thesis, Massey University, Palmerston North, New Zealand. 184 p.

Sherley, G.H.; Hayes, L.M. 1993: The conservation of a giant weta (*Deinacrida* n. sp. Orthoptera: Stenopelmatidae) at Mahoenui, King Country: Habitat use, and other aspects of its ecology. *New Zealand Entomologist 16*: 55–68.

Stringer, I.; Cary, P. 2001: Postembryonic development and related changes. Pp 399–426 in Field, L.H. (ed): The biology of wētā, king crickets and their allies. CABI, Wallingford, UK.

Stringer, I.; Watts, C.; Thornburrow, D.; Chappell, R.; Price, R. 2014: Saved from extinction? Establishment and dispersal of Mercury Islands tusked wētā, *Motuweta isolata*, following translocation onto mammal-free islands. *Journal of insect Conservation 18*: 203–214.

Trewick, S.; Morris, S.; Johns, P.; Hitchmough, R.; Stringer, I. 2016: The conservation status of New Zealand Orthoptera. *New Zealand Entomologist 35*: 131–136.

Watts, C.; Rohan, M.; Thornburrow, D. 2012: Movements, behaviour and survival of adult Cook Strait giant wētā (Deinacrida rugosa; Anostostomatidae: Orthoptera) immediately after translocation as revealed by radiotracking. *Journal of Insect Conservation 16*: 763–776.

Watts, C.; Stringer, I.; Sherley, G.; Gibbs, G.; Green, C. 2008a: History of wētā translocations in New Zealand: lessons learned, islands as sanctuaries and the future. *Journal of Insect Conservation 12*: 359–370.

Watts, C.; Stringer, I.; Thornburrow, D.; MacKenzie, D. 2011: Are footprint tracking tunnels suitable for monitoring giant wētā (Orthoptera: Anostostomatidae)? Abundance, distribution and movement in relation to tracking rates. *Journal of Insect Conservation 15*: 433–443.

Watts, C.; Stringer, I.; Thornburrow, D.; Sherley, G.; Empson, R. 2009: Morphometric change, distribution, and habitat use of Cook Strait giant wētā (*Deinacrida rugosa* Orthoptera: Anostostomatidae) after translocation. *New Zealand Entomologist 32*: 59–66.

Watts, C.; Thornburrow, D. 2009: Where have all the wētā gone? Results after two decades of transferring a threatened New Zealand giant wētā, *Deinacrida mahoenui*. *Journal of Insect Conservation 13*: 287–295.

Watts, C.; Thornburrow, D. 2011: Habitat use, behaviour and movement patterns of a threatened New Zealand giant weta, *Deinacrida heteracantha* (Anostostomatidae: Orthoptera). *Journal of Orthoptera Research 20*; 127–135.

Watts, C.; Thornburrow, D.; Green, C.; Agnew, W. 2008b: A novel method for detecting a threatened New Zealand giant wētā (Orthoptera: Anostostomatidae) using tracking tunnels. *New Zealand Journal of Ecology 32*: 65–71.

Watts, C.; Thornburrow, D.; Rohan, M.; Stringer, I. 2013: Effective monitoring of arboreal giant wētā (*Deinacrida heteracantha* and *D. mahoenui*; Orthoptera: Anostostomatidae) using footprint tracking tunnels. *Journal of Orthoptera Research 22(2)*: 93–100.

Watts, C.; Thornburrow, D.; Stringer, I.; Cave, V. 2017: Population expansion by Cook Strait giant wētā, *Deinacrida rugosa* (Orthoptera: Anostostomatidae), following translocation to Matiu/Somes Island, new Zealand, and subsequent changes in distribution. *Journal of Orthoptera Research 26*: 171–180.

White, D.; Watts, C.; Allwood, J.; Prada, D.; Stringer, I.; Thornburrow, D.; Buckley, T. 2017: Population history and genetic bottlenecks in translocated Cook Strait giant wētā, Deinacrida rugosa: recommendations for future conservation management. *Conservation Genetics 18:* 411–422.