Abundance and future options for wetapunga on Little Barrier Island

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CONTENTS

Abstract

A survey to assess the distribution and abundance of the nocturnal wetapunga was carried out over 40 nights in the vicinity of the Ranger's house on Little Barrier Island between November 1994 and May 1995. A total of only 41 weta were located, 17 of them on the last two nights. In comparison with previous surveys, this assessment suggests the species may have declined still further and its range on the island might well be seriously fragmented. Numbers were too low for an extensive radiotelemetry tracking study which had been planned to reveal movements and habitat occupancy by adults. However, our observations and some limited tracking showed that sub-adults are relatively sedentary and are faithful to shelter sites whereas adults move over considerable distances, finding a new shelter each night. This behaviour study was backed up with observations on the closely-related Poor Knights giant weta in a large outdoor cage at Wellington Zoo. Since future eradication of kiore is planned for the island, the opportunity was used to established a permanent monitoring programme for larger ground-active invertebrates and weta, using pitfall traps and tree-hole refuges. The report includes preliminary results from this monitoring and strongly recommends that wetapunga be protected in a large predator-free enclosure on the island to build up sufficient numbers for transfer to a new predator-free island habitat.

1. Introduction

New Zealand's largest insect, the wetapunga (*Deinacrida heteracantha*) (Fig. 1), was formerly widespread over the Northland peninsula and Great Barrier Island (Colenso, 1882; Dieffenbach, 1843; Buller, 1895; Hutton, 1897). Buller (1895) considered it "very abundant in all the woods at the far north". Today it occurs as a unique, declining population on one island which it shares with an alien predator, kiore, (*Rattus exulans*).

As one of New Zealand's most outstanding endemic animals, wetapunga's present status gives great cause for concern. This investigation was designed to follow up previous surveys by Meads & Ballance (1990), and Meads & Notman (1993) in which attention was drawn to the diminishing numbers of wetapunga and recommendations were made to obtain information on habitat use and to consider strategies for recovery.

The present study was done in the light of plans for eventual eradication of kiore from Little Barrier Island (DoC 1994). It was thus concerned not only with an investigation of behaviour and habitat use by wetapunga to provide means for estimating its abundance, but also attempted to establish a monitoring baseline for other large invertebrates which are at risk from kiore predation. With the low numbers of wetapunga on the island, it proved necessary to use a captive population of the Poor Knights giant weta

FIGURE 1. WETAPUNGA ON LITTLE BARRIER ISLAND.

1.1 OBJECTIVES

- To provide an assessment of habitat use and abundance of wetapunga.
- To test survey methods for wetapunga and set up monitoring of other invertebrates prior to rat eradication.
- To recommend a strategy for wetapunga conservation.

1.2 VISITS TO LITTLE BARRIER ISLAND

Three trips were made:

November	15-30 November, 1994 (G. Gibbs [until 19th], M. McIntyre, J. Brown)
January	10-28 January, 1995 (J. Brown)
May	2-10 May, 1995 (G. Gibbs, M. McIntyre)

2. Assessment of numbers

One of the goals of this investigation was to obtain some idea of the density of wetapunga and comment on the present conservation status of the population. Earlier records include some non-quantitative indications from the late 1950s (Richards, 1973) and two reports to DoC (Meads & Ballance, 1990 and Meads & Notman, 1993), in which spotlighting counts are given.

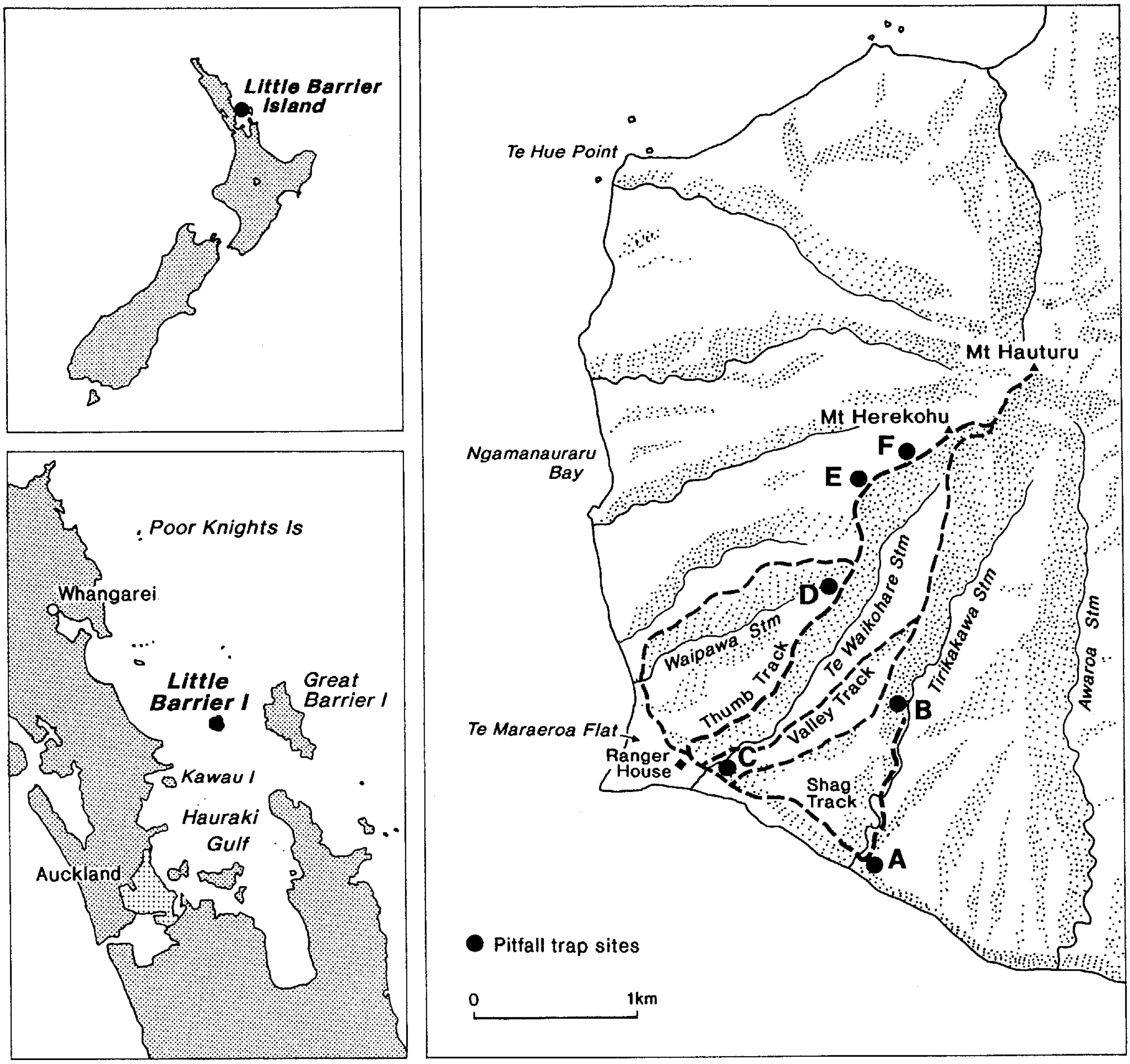

FIGURE 2. MAP SHOWING LOCATION OF LITTLE BARRIER ISLAND AND PITFALL TRAP SITES NAMED IN THIS STUDY.

2.1 METHODS

Previous searches for wetapunga have used night spotlighting to locate animals amongst the vegetation. This method is less than ideal for critical quantitative assessment because of problems arising from variations in observers' skills, weather conditions and behavioural features of the individual wets. However, since radiotracking was to be used in this study to gain vital information about the movements and use of habitat by immature and mature wets, spotlighting was necessary for catching animals.

Search effort is only one of many factors that lead to wets being seen. It is cited here simply to indicate how many nights were spent on weta hunting. For instance, on the November trip, all 12 weta were located during the first four nights despite a total of 14 nights of spotlighting. Locations are shown in Figure 2.

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2.2 RESULTS

In November, all 12 wetapunga found were in the general vicinity of the Ranger's house in the Te Waikohare Stream valley. Of those seen, 10 were captured for measuring. By January, only four could be located here, the fifth was from the Awaroa Valley 2.5 km to the east. The total of 24 found in May were mainly from the Waipawa Valley (17) with 5 in the vicinity of the Ranger's house and three near the grave site on Te Maraeroa flat (Table 1).

TABLE 1. NUMBERS OF WETAPUNGA FOUND BY DEDICATED NIGHT SPOTLIGHTING ON THE LOWLAND AREA BETWEEN WAIPAWA STREAM TO THE WEST AND AWAROA STREAM TO THE EAST, LITTLE BARRIER ISLAND BETWEEN OCTOBER 1992 AND MAY 1995.

	MEADS & NOTMAN	THIS STUDY		
	OCT 1992	NOV 94	JAN 95	MAY 95
No. of search nights	6	14	18	8
No. of searchers	2	3	1	2
No. of wetapunga	29	12	5	24

A log book of recorded weta sightings made by kakapo researchers has been kept at the bunkhouse since October 1989. A total of 25 wetapunga have been noted (apart from those of the present study) between 27/10/89 and 17/4/95. Of these, 15 were assumed to be adult females, 5 adult males and 5 immatures. Wetapunga have been seen in widely scattered localities: 6 around the summit area, 5 in the forest zone 340–460 m, 13 in the vicinity of the Ranger's house and one in the Awaroa valley.

2.3 DISCUSSION OF POPULATION SIZE

All knowledge of wetapunga abundance on Little Barrier Island comes from either the generalised comments of Aola Richards (1973) or subsequent surveys in which night spotlighting has been used. Whilst acknowledging that these estimates are seriously flawed, the fact remains that they are all we have. The important questions are whether the population has been and is still declining, and whether it has reached a critical level.

In spite of our lack of confidence in the quality of the data, we believe the only conclusion can be that the present wetapunga population is at an all time low in the vicinity of the Ranger's house. The present search was by far the most intensive done to date, yet if failed to find sufficient animals for the planned radiotracking study. There is no question that wetapunga were far more abundant and widespread at the time of Richard's visits (late 1950s). She notes that wetapunga were "... quite common around the homestead, ..." (p.224).

Also that they occurred on the *Muehlenbeckia*-covered boulder bank near the boatshed, in a number of fan palms (*Chamaerops humilis*) in the garden and in certain large kanuka trees.

At the time of Meads and Notman's visit (1992) there were no wetapunga to be found on the boulder bank, but they were able to locate individuals in the garden rimu tree and to find faecal pellet evidence beneath the kanuka forest along the Valley track in the Te Waikohare valley. Our search failed to confirm their presence in this valley, in the garden rimu tree or on the boulder bank.

The decrease in numbers observed by us between November 1994 and January 1995 cannot be taken too seriously. Although it might be assumed the missing insects had been taken by predators, it is equally likely that the large sub-mature wetapunga, which were repeatedly seen in the same places during November, had passed their final moult and, as adults, become far more mobile and hence difficult to locate by January (see 3.2).

Our conclusion is that numbers have certainly not shown any sign of recovery since 1992 and are probably still in decline. Moreover, as they decline, wetapunga are disappearing from certain areas and thus in an overall sense are becoming critically fragmented in their occupation of this part of the island.

However, the investigation ended on a brighter note as a result of our decision to search an area of low nikau forest near the mouth of the Waipawa Stream on the last two nights. Here 17 wetapunga of mixed ages were found in only 6.5 person hours, which suggests that at least some localities still retain reasonable populations. There is no information regarding the rat numbers at this locality.

While fluctuations in abundance are obviously significant, the main concern, in the context of this unique population, is its vulnerability. It has survived in the presence of a limited suite of predators on Little Barrier, yet it disappeared over a few decades in Northland when ship rats arrived. Their predation threat is discussed in section 3.3. In our view, there are no grounds for complacency. Numbers on the island are very low and have reached the point where research is hampered and numbers for transfer are not available. Our investigation points to the need for urgent action to propagate the species.

3. Habitat use

In contrast to the majority of giant weta, wetapunga are arboreal forest insects. In the tall forest environment of Little Barrier Island spotlighting, or indeed any human searching, undoubtedly gives very biased results because weta can only be seen readily on the lower part of tree trunks and occasionally in low-growing foliage. A large proportion of potential habitat simply cannot be adequately searched. In order to find out how much time wetapunga spend in "invisible" places, we proposed to track animals day and night using radiotelemetry.

This investigation intended to monitor a cohort of six radio-tagged individuals over periods of 10–14 days to gain some idea of individual movement patterns and habitat use. However, due to the difficulty experienced in finding weta on all three visits, this part of the programme could not be completed to our satisfaction. Nevertheless some behavioural data were gained from three sources: limited radio-tagging in November (section 3.2); observations on accessible weta near the bunkhouse (section 3.1); and from behavioural studies at Wellington Zoo on a closely related species from Poor Knights Island (section 4.).

3.1 USE OF SHELTERS

Wetapunga shelter by day under loose bark, amongst dense "skirts" of dead leaves which occur under certain tree-fern crowns, under epiphytes or in the hanging foliage of rimu or nikau palms. Adults and penultimate instars require large cavities to conceal their bulk.

The "concealment behaviour" of different weta species has been a crucial factor in their survival on the mainland of New Zealand in the face of introduced predators. For instance, differences in their choice of daytime shelters between tree weta species (*Hemideina*) and giant weta species (*Deinacrida*) has been largely responsible for the former remaining abundant on the mainland while the latter have become extinct (except on the South Island mountains). The wetapunga on Little Barrier Island display all the features that led to its prompt extinction in Northland in the 1880s. The insect's sheer bulk is clearly a significant problem for concealment. Few, if any, crevices are large enough to permit an adult to enter yet small enough to exclude rats or the prying beaks of insectivorous birds such as the saddleback.

Our observations on an exceptionally large pohutukawa tree near the bunkhouse (the "weta tree"), show that wetapunga daytime shelters may not even conceal them from human eyes. At night, their anti-predator strategies are virtually non-existent. Several large immature wetapunga under close observation on the "weta tree" were seen to emerge from their day shelters at darkness and sit, fully exposed, on the bark without moving before returning to their shelters by dawn. These observations are confirmed from both the radiotelemetry data (section 3.2) and the Wellington Zoo study described below (section 4.).

Our rather fragmentary knowledge of shelters and concealment by wetapunga suggest that this arboreal forest weta makes use of naturally available (i.e., unmodified by the weta) above-ground shelters for its concealment by day. Immatures tend to remain faithful to a particular shelter for long periods (perhaps weeks) whereas adults move about. For the smaller immatures, this strategy is probably a reasonably "secure" one, especially against mammals, given that they evidently do not use pheromone markers. However, sexually mature adults, which possibly mark their shelters with pheromone, are likely to be at risk to scent-tracking mammals. It is fortuitous, therefore, that the adults keep on the move. The security of their temporary shelters against saddlebacks is discussed further below (section 3.3).

3.2 RADIOTRACKING STUDY

Five weta (3 females and 1 male in last juvenile instar, 1 adult female) were fitted with radio transmitters. Their locations and activity, as far as could be ascertained, were monitored by radiotelemetry over periods ranging from 2–12 days in November 1994. A total of 134 fixes (38 during the day, 108 nocturnal) were made on weta locations. Specifications for each weta are outlined in Table 2.

TABLE 2. RADIOTRACKING SPECIFICATIONS AND DATA SUMMARY.

	TRANSMITTER NO.				
	TX92	TX98	TX99	TX95	TX97
sex	female	female	female	male	female
growth stage	last instar	last instar	last instar	last instar	adult
area	"Weta" tree[1]	"Weta" tree	"Weta" tree	Shag track	Shag track
no. days tracking	10	11	12	2[2]	9
no. diurnal fixes	8	9	10	2	9
no. nocturnal fixes	28	31	29	9	21
no. daytime shelters	2	1	2	2	6
site occupation days[3]	5	10	12	1	13[4]
dispersal[5] (m)	3	0.6	0	19.2	23.2
weight gain[6] (g)	-3.2	+2.2	+2.0	-	+4.2

[1] A large pohutukawa on east side of stream beside Ranger house; three on same tree.
[2] Weta lost, transmitter recovered.
[3] Consecutive days occupation of same daytime shelter.
[4] Possibly two but did not leave and return in between.
[5] Total distance moved between day shelter sites (excluding nocturnal routes).
[6] Body weight after removal of transmitter minus weight at time of capture.

The three near-adult juvenile females stayed on the same tree throughout the tracking period and were relatively sedentary. All showed a tendency to return repeatedly to the same day shelter site, at least within the period of monitoring, hence the low rate of dispersal. On some occasions the weta were visible behind bark during the daytime, even when supposedly hidden.

There was some individual variation in behaviour patterns, perhaps related to the moulting cycle. Female TX98 was fitted with a radiotransmitter 12 hours after moulting. It lost body weight while moulting, but exceeded its pre-moult weight by the end of the tracking time. After moulting it spent long periods (4.5 – 7 hours) apparently sitting inactive beside a daytime refuge in a bark crevice on the lower trunk about 1.4 m above the ground. Female TX99 was clearly in an intermoult period. It made repeated nocturnal trips along the same branch then into foliage several meters above and returned to the same bark crevice lower on the tree during the daytime. A gain in body weight over the tracking period is consistent with feeding activity implied by the nocturnal trips. A decrease in body weight indicated that female TX92 may have been about to moult. There was also a decline in its nocturnal activity over the last three nights of surveillance, as typically occurs before moulting.

Unlike the juvenile females, the adult female, TX97, did not return to any previous shelter site once it had left. It stayed entirely above ground, moving at night in the intermeshing and relatively low (5–7 m) forest canopy (mainly tree fern, second-growth puriri, mahoe and karaka) above the range of observation. By the end of its tracking period, it appeared to be moving away from its capture area and in this regard it is a pity that tracking ended at that point. It was recovered (to remove the transmitter) from under a skirt of tree fern fronds about 5 m above ground. There is no evidence that it came to the ground during the time it was tracked, although the splayed state of the ovipositor suggested that it had laid eggs, although perhaps not recently, as there were no fresh soil particles adhering or lodged between parts. A weight gain over the tracking period is consistent with feeding in the foliage and/or the development of eggs.

The sub-adult male, TX95, also appeared to be mobile unlike the sub-adult females. Unfortunately this weta was lost (but the transmitter recovered) after two days. In that time it moved between trees, using different shelter sites and not returning once it had left. It was also clearly visible during the day in a relatively unprotected shelter site for part of the monitoring period. It came to the ground at least once, and was possibly also on the ground when the transmitter came off.It is not clear whether this was caused by predation or failure of the adhesive.

These preliminary observations show differences in behaviour of juvenile and adult females. It would now be especially desirable to obtain information on the activity of males. On a daily basis, the adult female seemed to move a few metres at a time from its previous shelter site, with nocturnal diversions in between. It is now important to establish whether this pattern is dispersal in the migratory sense, or whether the animal has a home range area. This could be crucial to interpretation of future survey data, and possibly to any plans to manage a particular site to protect weta.

The present observations also highlight the extent to which these weta are exposed to potential predators at night. They also confirm that they may also be poorly concealed during the day, and that some of their daytime shelter sites offer little protection from any probing predator such as saddlebacks.

The use of radiotelemetry can extend appreciation of habits of wetapunga and threats to their survival beyond the range of a ground-based observer using a spotlight. The gain in body weight noted in three out of four weta for which data was available suggests that they are not unduly disadvantaged by carrying a radiotransmitter. Observations in November 1994 and May 1995 of some colour-marked weta without transmitters, which were poorly hidden, and in two cases partly exposed during the day, suggest that this is a behavioural character and that the transmitter did not impair concealment.

3.3 DISCUSSION OF PREDATORS AND ROLE OF SHELTERS

We have outlined evidence for a declining population of wetapunga on its sole remaining refuge. Why is this happening? With no obvious deterioration in their physical habitat, the almost inescapable conclusion is that predation must be the key factor. The capacity for increase in the wetapunga population is not keeping up with the present level of predation.

Potential and actual predators are reviewed by Richards (1973). Direct evidence of wetapunga predation has only been recorded for moreporks, although harrier roosts on the Poor Knights Islands contained remains of *Deinacrida fallai* and it might be assumed they could do likewise on Little

Barrier. Kiore are often assumed to be important predators, at least of smaller immatures, but there is little direct evidence from Little Barrier apart from an entry in the “weta logbook” for 19/11/92 in which an adult male weta was “found predated on east arm of T19. Rat bite marks obvious on near legs. Jan & Arnold Heine” and a comment that “the kiore-eaten remains of a wetapunga abdomen was observed near the bridge to the ranger’s house ...” in Meads & Notman, 1993. Neither record is proof that the rat killed the weta.

In the intervening 35+ years since Richard’s study, cats were eradicated in 1980 (Veitch, 1983); saddlebacks were introduced in 1984 (Meads & Notman, 1993) and rat poisoning around the Ranger’s house ceased sometime in the past two years (C. Smuts-Kennedy, pers. comm.). The net result of these management changes have clearly been bad for wetapunga. Kiore are now common around the Ranger’s house, as are saddlebacks.

Direct evidence of predation is always very difficult to obtain — a predation event is rapid and with a rare prey item, the chances of obtaining evidence are very remote. Nevertheless, the potential role of saddlebacks was emphasised by an observation made by M. McIntyre and J. Brown on 23/11/94 in which a group of 6–7 saddlebacks were noted entering the skirt of dead leaves around a treefern (*Cyathea dealbata*) near the bunkhouse. This fern was known to have several juvenile wetapunga sheltering in it at the time. No further weta were found on that treefern. The ability of saddlebacks to prey upon weta was highlighted by a study on Motuara Island in Queen Charlotte Sound (Pierre, 1995). The study recorded that weta (*Hemidenia crassidens* and *Hemiandrus similis*) made up 36% of male prey items (number not mass), 19% of females and 19% of juveniles. Weta up to an estimated length of 60 mm were eaten.

From this necessarily speculative consideration of predation pressure and wetapunga behaviour in relation to refuge shelters, we can only conclude that this weta is particularly vulnerable in the face of vertebrate predators and likely to succumb if predator numbers remain at the present level. It has a low innate strategy for survival compared with tree weta. Evidence for this is its early demise on the mainland. We thus consider that in the short term the remaining wetapunga must be protected from predation and that in the long term populations should be established on islands without rats or saddlebacks.

Ironically, if kiore are eradicated on Little Barrier, one of the immediate impacts could be an increase in predation by moreporks. These nocturnal predators currently rely, to some extent, on kiore. Sudden cessation of this food source could direct the attention of owls to wetapunga, especially on moonlit nights. A situation like this was noted in November 1994 by M. McIntyre on the Mercury Islands. When kiore was eradicated from Red Mercury Island there was an influx of moreporks onto nearby rat-free Middle Island, where previously they were rarely seen or heard. It is unlikely, however, that this sort of response would constitute more than a temporary threat.

4. Behaviour

Due to the difficulty of finding sufficient animals for a productive study of behaviour on Little Barrier, the focus of this part of the study was moved to a captive population of Poor Knights giant weta at Wellington Zoo. This weta species is very closely related to the wetapunga (Morgan-Richards, 1995), lives in a similar habitat and, we believe, can provide us with an understanding of some basic features of behaviour relevant to Little Barrier Island giant weta.

4.1 METHODS

A behaviour study was carried out between 16 February and 23 June, 1995 by John Brown for his BScHons research project (Brown, 1995). A total of 30 all-night observations were made inside a large outdoor cage with natural vegetation and a starting population of 49 giant weta. The weta under study were penultimate instar and adults and the study period allowed observation of maturation moults, sexual behaviour and daily activity patterns during summer and autumn.

4.2 USE OF DAYTIME SHELTERS

A variety of artificial shelters were available in the zoo cage so that observations could be made to investigate the importance of day refuges for these arboreal weta and their usage of them.

In the cage environment, weta were found to vary greatly in their degree of faithfulness to a particular shelter. While the majority of weta were not found at any one site for more than four weeks at a time, one female consistently occupied a shelter for 13 weeks and one male was found in the same site for 9 weeks. On the other hand, three males never rested in the same site twice. Females were consistently more site specific than males. These results indicate that, unlike tree weta (*Hemideina* species), these giant weta do not have a strong attachment to a particular shelter. However, this result needs to be interpreted in the light of the degree of observer disturbance necessary in order to reveal where weta are hiding by day; it is possible that the disturbance resulting from the study itself stimulated them to move more frequently.

The cage study also provided data on how much time weta spent inside shelters and at what time of night they emerged. Again, there was much individual variation. Some did not emerge at all on some nights. Some rested by day in foliage, particularly after moulting. Adults spent more time out of shelters and moving than juveniles. Weta typically remained in their shelters for the first 1–3 hours of the night, although some individuals emerged at sunset. On emergence they normally moved only a short distance from their resting site. Observations we made on Little Barrier Island in general confirm these findings.

4.3 ACTIVITY TIMES

The peak of weta activity in the cage occurred around the middle of the night and most wetas sought shelter 2–3 hours before dawn. Adult females tended to emerge from shelters earliest in the evening, followed by adult males and juvenile females, with juvenile males appearing last. Females spent significantly more time feeding than males, with their peak feeding activity in the first half of the night. Unlike the other two weta groups observed, adult females commonly moved over the ground and fed on dead leaves, grass shoots and other insects. Adult males, in contrast, spent less time feeding and more time moving, either looking for or following females.

Adult males, when not moving, tended to wave their antennae more than other weta, perhaps obtaining olfactory information. The role of fresh faecal pellets for orientation or sex attraction was examined but although weta were occasionally seen investigating pellets, they did not appear to navigate with reference to the pellets.

4.4 DISCUSSION

These well substantiated cage observations generally correlate well with the opportunistic observations on the island. The activity times and behavioural differences between adults and juveniles match perfectly. The lack of commitment to any one resting site in adults is possibly significant in relation to predator risk although it is difficult to predict the outcome when the two chief predators are as different as a nocturnal mammal and a diurnal bird. On the one hand, a regularly-frequented and olfactorily-marked refuge could be highly secure from day-active predators yet nevertheless attract a nocturnal rodent, whereas a temporary shelter “camp” under loose dead leaves or bark would be more at risk from diurnal avian predators. Meads & Ballance (1990) make the point that predator avoidance behaviour of invertebrates can be related to the presence or absence of predators (see Moller 1985, Bremner *et al*. 1989, McIntosh & Townsend 1994). Thus the rise of saddleback numbers since their liberation on Little Barrier Island in 1984 could have a greater impact on weta than if the birds had been there all along.

5. Census methods for wetapunga

It is clear from this study that we are no further ahead with census methods for assessing wetapunga densities. While ideally a type of attractant trap should be used in preference to night spotlighting, to date there is no substitute for the visual search as used in this study. Fresh carrot baits and sacking shelters were tried to no avail. Calico and plastic sheeting on the ground for faecal pellet assessment was also tried but at such a low population density, it failed to provide quantitative information. What is needed is research into the pheromone of giant weta or any other odour which might serve as an attractant. A start has been made to research this approach in collaboration with Dr Stephen Foster (HortResearch, Auckland) on the Mana Island giant weta, *Deinacrida rugosa*.

At present, with a high commitment of human search time, it is possible to estimate local population densities. These need to be reviewed in conjunction with information on distribution patchiness. Wetapunga are poor subjects for the use of artificial refuges or trapping methods as a means of estimating density.

6. Invertebrate monitoring

An objective for this study was to set up a simple monitoring procedure for key taxa of invertebrates suspected to be at risk from kiore predation, with a view to measuring the impact of kiore and the recovery of invertebrate fauna following kiore eradication. For these purposes, the key taxa are inferred to be the larger ground-active fauna such as beetles, ants, weta, spiders, amphipods and isopods, or the larger invertebrates that live in crevices in tree trunks such as weta and cockroaches.

6.1 METHODS

In order to establish some baseline data on the abundance of these larger invertebrates, two "permanent" sampling methods were established on the island — pitfall traps and tree-hole refuges — and initial samples taken during our survey visits.

The pit-traps comprised a piece of PVC downpipe, inside diameter 75 mm and 160 mm long, sunk flush with the ground surface. When set for a fauna sample, each downpipe section had a tightly fitting paper cup pressed into it so the top of the cup was about 60 mm below the surface and contained Gault's solution (Appendix) to a depth of about 20 mm. This trap design is almost identical to those used by Moeed & Meads (1985), in the Orongorongo Valley and for several other island studies, hence allowing direct comparison of catches. For the monitoring baseline study, 54 pit traps were installed on 17–18 November, 1994 in 6 groups of 9, each group arranged at random over areas of 70–400 m^2 (depending on topography and vegetation). Representative sites were selected from sea-level pohutukawa forest to moss forest at 620 m (Fig. 2). Table 3 indicates the major features of each site.

Tree-hole refuges suitable for monitoring tree weta and other larger tree trunk invertebrates consisted of blocks of untreated timber approximately 50 x 40 x 170 mm with a 20 mm hole drilled through the centre. The upper end was fitted with a cork and the numbered refuges nailed to tree trunks about 2–3 m above ground level in positions which permitted visual inspection of the tunnel with a penlight torch. Four groups of refuge traps were established as indicated in Table 4.

TABLE 3. FEATURES OF HABITATS ON LITTLE BARRIER ISLAND SAMPLED BY PITFALL TRAPPING.

SITE	ALTITUDE (m)	VEGETATION	LITTER
A Tirikakawa Stream	2	coastal pohutukawa forest	dead leaves on beach pebbles, very open and windy
B Tirikakawa Stream	60	tall rata/tawa forest with sparse understorey	moist, deep litter on sheltered stony river terrace, deep humus in patches
C Te Waikohare Stream	10	floodplain tall kanuka forest with sparse understorey	moderate humus of small-leaved kanuka
D Thumb track	250	ridge-top kauri/beech forest with kiekie and kauri grass understorey	poorly decomposed kauri litter with some humus
E Thumb track	550	ridge-crest tawa/*Quintinia* forest with dense broadleaf fern understorey	deep moist litter and humus between tree roots
F Thumb track	620	steep ridge-crest, low windswept *Quintinia/Ixerba* moss-forest	soft, deep, moist humus and rootlets

TABLE 4. LOCATIONS OF TREE-HOLE REFUGE TRAPS ON LITTLE BARRIER ISLAND, NOVEMBER 1994 – MAY 1995.

	NUMBER OF TRAPS	LOCATION	SET-UP
Group A	22	Vicinity of stream past Ranger's house from lower bridge to house garden	Nov 1994
Group B	15	Vicinity of gate to Shag track from the bunkhouse	Nov 1994 + May 1995
Group C	14	Along Shag track and up Tirikakawa valley track	Nov 1994
Group D	30	Along Hamilton track from 200' sign to the beech forest	May 1995

6.2 PITFALL TRAP RESULTS

Traps set for 84 nights during the survey (55 nights in November, 13 in January and 16 in May) caught a total of 19,568 macro-arthropods. The "microarthropods" (i.e., Collembola and Acari) were not counted. Beetles dominated the total counts as shown in Table 5, due to large numbers of small individuals less than 5 mm long, but when only the larger arthropods over 5 mm are considered, amphipods and ants become the major components of the catch.

The density of arthropods varied between the six sampling sites, with Site C in kanuka forest near the Ranger Station yielding the maximum (15.3 per trap-night) and site D in kauri/beech forest the minimum (0.8 per trap-night) as shown in Table 6. Larger arthropods are not well represented, especially when only the individuals over 10 mm are considered. Many of these latter group are carabid beetles which forage at night and are usually regarded as distasteful to

TABLE 5. TOTAL NUMBERS OF MACROARTHROPODS (i.e., EXCLUDING COLLEMBOLA AND MITES) AND THOSE OVER 5 mm TOTAL LENGTH FROM PITFALL TRAPS AT 6 SITES ON LITTLE BARRIER ISLAND, NOV 1994 – MAY 1995.

ARTHROPOD GROUP	SITES						TOTAL	TOTAL >5 mm
	A	B	C	D	E	F		
cockroaches	2	2	0	0	1	0	5	5
weta	4	92	124	33	35	15	303	253
beetles	1,462	575	10,556	238	763	212	13,806	128
wasps/ants	675	150	466	54	345	279	1,969	1,088
flies	88	116	71	133	185	15	608	53
caterpillars	10	4	12	15	5	6	52	50
plant bugs	10	3	11	3	10	7	44	3
millipedes	19	17	6	5	5	0	52	39
centipedes	3	8	3	7	14	4	39	34
isopods	254	17	125	9	7	1	413	361
amphipods	929	100	93	19	559	195	1,895	1,582
spiders	76	81	106	84	76	31	454	285
pseudoscorpions	8	3	12	5	5	1	34	0
TOTALS	3,540	1,168	11,585	605	2,010	766	19,674	3,881

TABLE 6. THE SIZE OF MACROARTHROPODS CAUGHT IN PITFALL TRAPS ON LITTLE BARRIER ISLAND EXPRESSED AS NUMBER PER TRAP NIGHT.

	TOTAL NUMBERS		ONLY THOSE >5 mm		>10 mm
SITE	NUMBER PER TRAP NIGHT	DOMINANT ARTHROPOD GROUP	NUMBER PER TRAP NIGHT	DOMINANT ARTHROPOD GROUP	NUMBER PER TRAP NIGHT
A	4.7	beetles	2.3	beetles	0.04
B	1.5	beetles	0.4	weta	0.08
C	15.3	beetles	1.0	weta	0.09
D	0.8	beetles	0.2	spiders	0.03
E	2.7	beetles	1.0	amphipods	0.13
F	1.0	beetles	0.3	beetles	0.03

small mammals. Cave weta dominated the >10 mm class at two lowland valley sites (Tirikakawa and Te Waikohare stream valleys).

Carabid beetles in the pit-trap collection were identified by Ian Townsend (30B The Avenue, Levin). A total of 9 species were recognised, none endemic to the island, as shown in Table 7. One introduced species is represented, the remainder being typical northern North Island taxa. The other taxa were not identified beyond Order level.

TABLE 7. SPECIES OF CARNIVOROUS GROUND BEETLES (FAMILY CARABIDAE) TAKEN IN PITFALL TRAPS ON LITTLE BARRIER ISLAND TO INDICATE THEIR BIOGEOGRAPHIC AFFINITIES. (IDENTIFICATION AND DISTRIBUTIONS FROM IAN TOWNSEND, LEVIN.)

SUBFAMILY	GENUS AND SPECIES	STATUS	SIZE (mm)	DISTRIBUTION
Agoninae	*Ctenognathus parabilis*	NZ endemic	12	northern N.I.
	Ctenognathus bidens	"	16	widespread N.I.
Broscinae	*Mecodema pluto*	"	25	Coromandel Ra.
Harpalinae	*Lecanomerus sharpi*	"	6	northern N.I.
	Gaioxenus pilipalpis	"	12	widespread N.I.
Lebiinae	*Anomotarsus variegatus*	Australia introduced	5	N.I. and Nelson
Licininae	*Dichrochile maura*	NZ endemic	10	northern N.I.
Pterostichinae	*Holcaspis hispida*	"	17	N.I.
	Aulacopodus calathoides	"	11	northern N.I.

6.3 TREE-HOLE REFUGE TRAP RESULTS

Artificial weta refuges were nailed to tree trunks on a trial basis in November 1994 and, with some re-positioning in May 1995, were established in four groups as a "permanent" monitoring device for crevice and hole-dwelling weta.

Group A refuges were checked in January 1995 and all groups in May 1995 providing the records shown in Table 8.

Tree weta (*Hemideina thoracica*) utilised the refuges in Groups A and B only, i.e., on pohutukawa, kohekohe, rimu, *Coprosma* and tree-ferns near the Ranger Station. Of the 30 refuges checked in May in this area, eight (=27%) contained tree weta. In contrast, the refuges along the Tirikakawa Stream were occupied by cave weta, including some very small ones, with no sign of tree weta in this area. Spiders, which fill the holes with their silk webbing, could be a deterrent to future occupancy by weta.

TABLE 8. TREE-HOLE REFUGE TRAP RESULTS (TRAP NUMBER CITED); n/r = NOT RECORDED.

VISIT	TRAP GROUP (SEE TABLE 3)	NUMBER OF TRAPS	OCCUPIED BY TREE WETA	OCCUPIED BY CAVE WETA	OCCUPIED BY SPIDERS
Jan 1995	A	22	8,9,15,16	n/r	n/r
May 1995	A	22	7,8,9,15	1,4,6,18	2,3,5,10,12,14, 16,17,19,20,22
"	B	8	1,2,7,8		3,5
"	C	14		3,4,5,8,10,11, 12,13	1,6,9,14
"	D	7	all empty		

6.4 DISCUSSION OF MONITORING BASELINE

Although pitfall trapping as a survey technique has many critics (e.g., Topping & Sunderland, 1992) it is simple to operate and clearly gives a crude measure of ground-active invertebrates. More importantly in the present case, it gives a size distribution of invertebrates which is highly significant in terms of rodent predation stress. Islands with no rodents have a ground invertebrate fauna which is not only richer in numbers but contains more of the larger individual animals (Notman, 1984).

To put the Little Barrier pitfall results in context, they can be compared with those from the Orongorongo Valley, southern North Island (Moeed & Meads 1985), where all predators are present and Maud Island, Pelorous Sound, northern South Island, where no mammalian predators and very few reptiles presently exist (Notman, 1984). Table 9 shows the comparison of invertebrate densities.

The studies are not all directly comparable because no 5 mm size distinction was made in the Orongorongo study. However, they indicate that the invertebrate fauna of Little Barrier Island is more dense at three of the six sites than the mainland samples but is distinctly less dense than predator-free Maud Island when invertebrates >5 mm are considered. The macroinvertebrate fauna of Little Barrier Island is thus much as expected for an island with only one mammalian predator. If kiore could be eradicated, the density of larger invertebrates might be expected to rise to values similar to those of Maud Island. Continuation of the present sampling procedure should be adequate to reveal and quantify this predicted change.

Tree-hole refuges are more difficult to compare with other sites. A recent study of Wellington tree weta on the Chetwode Islands (Rufaut, 1995) used 99 artificial tree-hole refuge traps similar to those on Little Barrier Island to

TABLE 9. COMPARISON OF PITFALL CATCHES AT ORONGORONGO VALLEY, MAUD ISLAND AND LITTLE BARRIER ISLAND EXPRESSED AS NUMBER PER TRAP PER NIGHT.

ORONGORONGO VALLEY (MOEED + MEADS 1985)		LITTLE BARRIER ISLAND (FROM TABLE 6)			MAUD ISLAND (NOTMAN 1984)	
excl. microarthropods no size limit			no size limit	>5 mm	>5 mm	
Broadleaf A	1.9	A	4.7	2.3	max	15.0
		B	1.5	0.4		
Broadleaf B	2.1				min	2.0
		C	15.3	1.0		
Hard beech	1.4	D	0.8	0.2		
		E	2.7	1.0		
Silver beech	1.6					
		F	1.0	0.3		

measure weta density two years after kiore had been eradicated. In a six-month period over summer, a total of 70% of the traps became occupied by tree weta. Ordish (1992) used ten artificial boxes of a different design (much larger) in a Wellington garden over a 4-year period and found that all became occupied by tree weta, with the population in the refuges reaching 54 weta at its peak. It is anticipated that if tree weta populations increase as a result of kiore eradication on Little Barrier Island, as they have on the Chetwodes, the refuge traps will detect it. Although there is no evidence of tree weta in the kanuka/manuka along the Hamilton track at present (Group D), this appears to be a suitable habitat and is thus likely to provide a good indication of weta population expansion in the future.

7. Recommendations for wetapunga conservation

The present study was immensely useful, for although it failed in some respects, the documentation of weta numbers came at an opportune time to confirm the decline suspected in previous surveys (Meads & Ballance, 1990; Meads & Notman, 1993).

The bad news is that the wetapunga population is but a shadow of its former size on Little Barrier Island. The good news is that it is not too late to propagate the weta in a managed rat-free enclosure to boost numbers for a transfer to a predator-free island in the Hauraki Gulf. Preliminary ground-work at Wellington Zoo shows this approach should be successful with minimal cost and human input.

The assumption is that predators are responsible for the decline. There is, however, no direct evidence for this. The principle factors that coincide with wetapunga decline since the study of Aola Richards in the late 1950s are:

- an increase in kiore due to the elimination of cats,
- an increase in kiore around the Ranger's house due to cessation of poison controls there,
- build up in numbers of the re-introduced saddleback.

The two main predators are complimentary, with rats by night and saddlebacks by day. We believe this combination is putting extreme pressure on the remaining wetapunga in the vicinity of the ranger station, but that some enclaves of the weta still remain. The fact that these seem to be isolated from each other is cause for concern in itself, given that small isolated population samples are at risk of extinction from chance ecological or genetic events as well as predation.

Our recommendations are:

- Wetapunga must be established on another island with suitable habitat which is predator-free to ensure continued survival of this threatened species. The priority for this is high.
- Since the wetapunga population on Little Barrier Island is too low to collect sufficient wild animals for immediate transfer, it is necessary to bring adults into captive enclosures or cages for breeding purposes. It is also essential to have a well-established captive colony as a backup over the rat eradication

period. Priority here is for an outdoor rat-proof enclosure on the island. It could also be profitable to take a few pairs for cage rearing and propagation at a location where the expertise for rearing the closely related Mahoenui weta is available.

Hopefully, the wetapunga population will survive until the planned kiore eradication of Little Barrier Island takes place (DoC, 1994) and will increase subsequently. In the worst scenario, the transferred weta could be the sole remaining population of wetapunga. In the more satisfactory scenario in which both the original and the transferred weta succeed, we will have a useful experimental set-up by which to measure the impact of saddlebacks on this giant weta (provided the recipient island is kept free from saddlebacks!). Moreover, two separate populations of our largest giant insect are obviously more secure than one as at present.

In the meantime, further radiotracking on the Waipawa Stream population of wetapunga (assuming this enclave maintains itself) is desirable to bring our habitat and movement study to a more meaningful conclusion. Information on whether the movements of adults represent random migrations or a home range will be crucial to interpretation of future survey data and possibly for management of wetapunga within a particular site.

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10. Appendix 1

Gault's Solution (for pitfall traps):

Sodium chloride (salt)	50g
chloral hyrdrate	10g
potassium nitrate	10g
water	1000ml