Design and use of artificial refuges for monitoring adult tree weta, *Hemideina crassidens* and *H. thoracica*

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A B S T R A C T

Artificial refuges were investigated for assessing populations of tree weta (Orthoptera: Anostostomatidae) in New Zealand by testing refuge design with adult *Hemideina crassidens* and *H. thoracica* in the laboratory, in a temperature-controlled glasshouse and in the field at six forest sites covering a range of altitudes and vegetation types. In laboratory and glasshouse tests, both species preferred refuges made from aged pine (*Pinus radiata*) to fresh pine, and willow wood (*Salix alba*) to pine. Neither species of adult entered holes 10 mm in diameter, but both entered holes 16 mm or 25 mm in diameter. Adult *H. crassidens* preferred galleries with tapering terminations to rounded terminations, refuges without Perspex observation windows, and refuges made from willow wood over those made of concrete. Adult *H. thoracica* preferred refuges made from concrete to willow wood. Adult mice (*Mus musculus*), which are potential predators of weta, were largely excluded from galleries with entrances ≤ 18 mm in diameter. In the field, the number of tree weta found in artificial refuges varied amongst the six sites. Weta first appeared 1–9 months after refuges were set, and reached maximum numbers after 2–14 months. Both species usually occurred singly in galleries and most frequently in long, upturned galleries. The number of weta in refuges varied little with height above ground, but there is evidence that this was positively correlated with the number of weta in natural cavities and was higher where rodents were controlled. There was no difference between the number of weta found in refuges in the interior of a forest and near the forest edge.

Keywords: tree weta, *Hemideina crassidens*, *H. thoracica*, Orthoptera, Anostostomatidae, occupancy rate, height effect, forest edge effect, population assessment, mouse exclusion

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1. Introduction

Tree weta in the genus *Hemideina* (Orthoptera: Anostostomatidae) are a conspicuous component of the invertebrate fauna of New Zealand because they are both relatively common and large (adult bodies are usually 4–6 cm long; large-headed males can reach 7 cm long). Fewer tree weta occur where introduced rodents are present (Moller 1985; Newman 1994; Rufaut 1995), so estimates of weta numbers are thought to be a useful indication of the effectiveness of rodent control measures in native forest. However, tree weta are hard to sample because they usually rest during the day in holes or cavities. They prefer living trees to dead wood, and are seldom found in holes in rotting wood (Asher 1977). The tunnels and cavities they hide in during the daytime are termed galleries by Field & Sandlant (2001); they form relatively stable homes, which weta will groom and enlarge and often return to over extended periods (Sandlant 1981; Moller 1985; Ordish 1992; Field & Sandlant 2001). Weta are often hard to observe when they are in their galleries, particularly when a tunnel bends and obscures direct observation. Several weta may also form a harem of one adult male with juveniles and adult females (reviewed by Field & Sandlant 2001); such weta must be removed if they are to be counted. This is both time consuming and, in some cases, impossible without destroying the hole or injuring some weta. Artificial refuges that allow easy inspection avoid these problems and have been widely used for monitoring purposes where rodents are being controlled. However, we do not know what factors influence the number of weta found in artificial refuges, and there is also doubt over whether artificial refuges can be used to accurately estimate weta population density (Trewick & Morgan-Richards 2000). As a first step towards understanding this, we examined some of the design features of artificial refuges that affect the number of weta found in them. This was done with caged weta in the laboratory and in a temperature- and humidity-controlled glasshouse. In the laboratory, we also investigated what entrance-hole diameter could be expected to exclude adult house mice (*Mus musculus* L.); these are the smallest mammalian predators of weta in New Zealand (Newman 1994; Miller & Miller 1995), so it is desirable that refuge design excludes mice whilst still allowing access to adult weta.

We also investigated some factors that influence the use of artificial refuges in the field. Previous field work indicates that tree weta may take a number of years to occupy artificial refuges, that each refuge probably monitors a very limited area, and that the number of weta in refuges fluctuates (Ordish 1992; Trewick & Morgan-Richards 2000; Spurr & Berben 2004; Powlesland et al. 2005). Therefore, we did preliminary investigations into whether the number of weta found in artificial refuges was related to the density of weta in the field, and whether it was affected by rodent control. We also investigated how the number of weta found in artificial refuges varied with height above ground, time after being set out, and proximity to a forest edge.

2. Methods

2.1 LABORATORY EXPERIMENTS WITH ADULT WETA

Experiments were conducted in a temperature-controlled room maintained at 18–19°C during the day and unregulated at night, when the temperature occasionally dropped to a minimum of 12°C. Five glass tanks (30 × 40 × 30 cm high) were used. Each had a removable lid, which consisted of a wooden frame surrounding a sheet of Perspex, in the centre of which was a hole (occupying about two-thirds of the total area of the lid) that was covered with fine insect mesh. In each tank, there was a layer of leaf litter from native bush (1–2 cm deep), some dead branches, a dish of water, and a container (bottom half of a plastic 2-L ice-cream container) of damp vermiculite for oviposition. The tanks were sprayed with a mist of water twice per week to maintain humidity.

Each experiment was run separately with wild-caught *Hemideina crassidens* Blanchard and *H. thoracica* White. One male and two female weta were placed in each of the five glass tanks 2 days before a trial to allow them to acclimatise. A pair of refuges that differed in one design feature was then introduced into each glass tank; different design features were tested in different tanks (refuge designs A–E below). The refuges were hung from dead branches and were situated near opposite sides of each tank. The following day, the number of weta in each refuge was recorded and the weta were then removed from the refuges and replaced in the tanks. A newly constructed set of identical refuges was then used for the next trial, with each comparative test being moved to the next tank. This was repeated over 5 days, so that each pair of refuges was tested with the weta in each tank. The position occupied by each pair of refuges within each tank was randomised, but the sequence in which comparative tests were offered was not randomised. A new set of five pairs of refuges with different design features from those previously tested (refuge designs F–J below) was then introduced and similarly tested. The ten pairs of refuge designs were tested in two groups (A–E and F–J) in the order listed below:

- A Entrance-hole diameters of 10 mm v. 16 mm, using the refuge design shown in Fig. 1A & B).
- B Round (16-mm diameter) v. square-section (16 mm × 16 mm) entrance holes (Fig. 1A, B & C).
- C With and without a small projection over each entrance hole (round hole, 16 mm in diameter) (Fig. 1D). Each projection was 20 mm wide and 2 mm thick, and extended 10 mm from the surface of the refuge.
- D Galleries with rounded v. tapering internal terminations (Fig. 1A, B & E).
- E Construction materials of newly purchased, untreated pine (*Pinus radiata* D. Don) v. willow (*Salix alba* L.) wood (Fig. 1A & B).

F Construction materials of willow v. mahoe (*Melicytus ramiflorus* J.R. et G. Forst) wood. Each refuge was cylindrical (70 mm in diameter, 130 mm long) with a 16-mm diameter hole bored through the centre, which had a wad of cotton wool closing one end (Fig. 2).

G Construction materials of willow wood v. concrete (Fig. 2).

H Wet v. dry refuges. Wet refuges were soaked in water for 5 minutes before being placed in a tank (Fig. 1A & B).

I With and without a Perspex observation window. The design was the same as in Fig. 1A & B, with an additional 2-mm thick Perspex sheet screwed over the galleries. The access cover could be closed to cover the Perspex.

J Construction materials of new untreated pine v. pine that had been weathered outside for 2 months prior to the test (Fig. 3A & B).

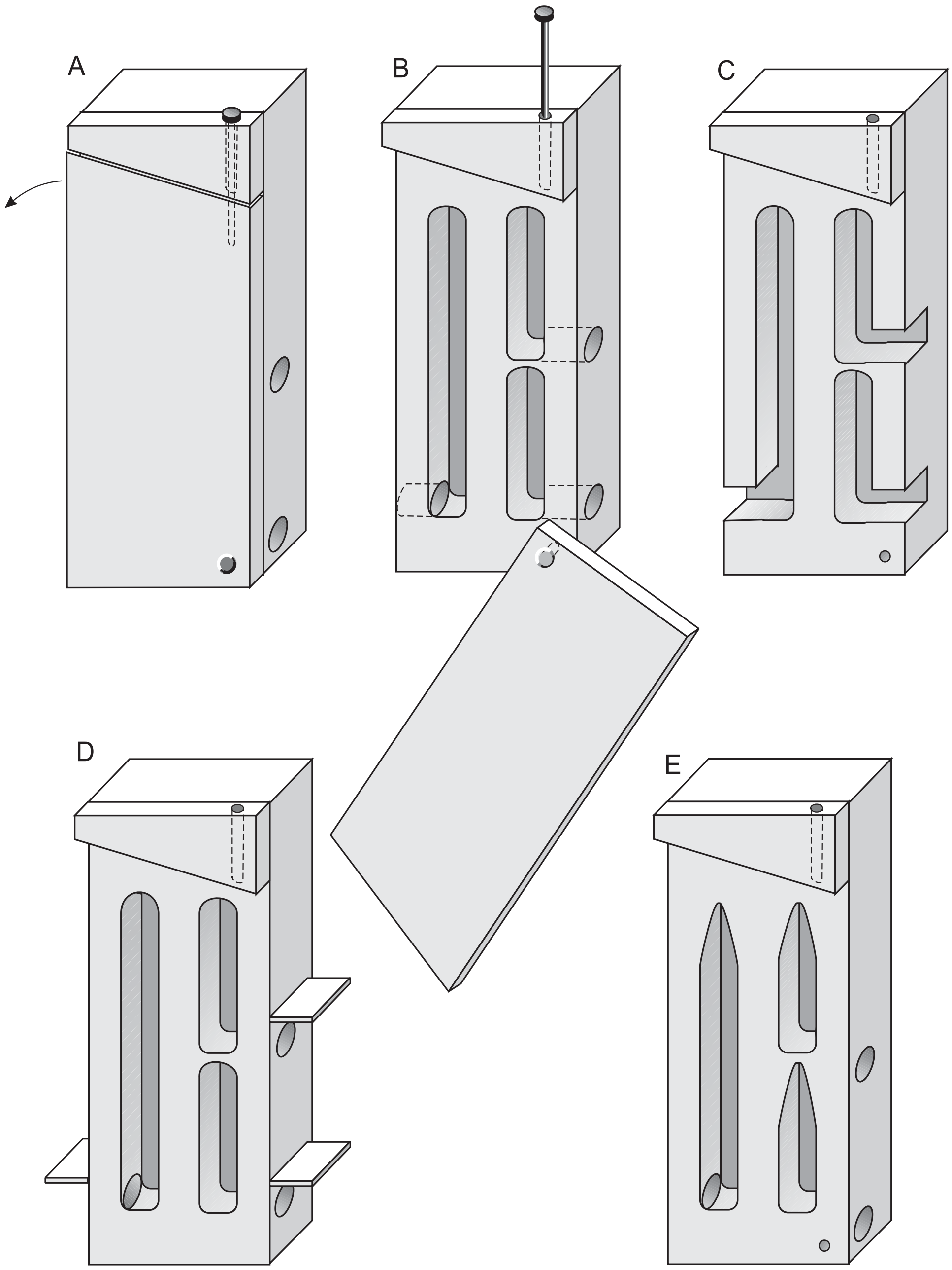


Figure 1. Designs of artificial weta-refuges used to test weta (*Hemideina crassidens* and *H. thoracica*) preferences in the laboratory. A. Basic design with a round entrance hole. Overall dimensions are 200 × 70 × 45 mm deep. The access cover can be rotated anticlockwise to inspect the galleries, as shown in Fig. 1B. B. Basic design shown in Fig. 1A with a round entrance hole (access cover opened). C. Square-section entrance holes (access cover removed). D. Projections above entrance holes (access cover removed). E. Galleries with tapering terminations (access cover removed).

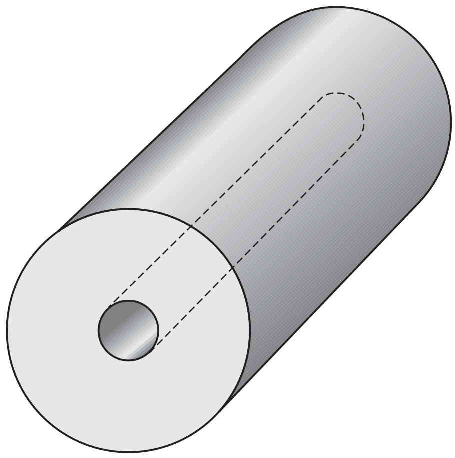


Figure 2. Artificial refuge used for comparing whether weta (*Hemideina crassidens* and *H. thoracica*) prefer refuges made from pine (*Pinus radiata*), concrete or mahoe wood (*Melicytus ramiflorus*). One end of the gallery was plugged with cotton wool. Overall dimensions: 130 mm long and 70 mm in diameter, with a 16-mm hole.

This experimental design was used because insufficient numbers of adult weta were found for us to be able to use new weta for each trial. As a result, all tests except for the first in each series involved two potential biases, resulting from possible carry-over effects on weta behaviour from earlier trials. Firstly, the trials usually involved comparing a unique design feature against one that was common to most of the other trials. For example, the entrance holes in all refuges used in the first set of five trials were round except in the test where round and square entrance holes were compared. Thus, the second to fifth trials had a potential bias because of previous familiarity with one of the features being compared. However, the fact that weta would often readily adopt a new gallery type, even when presented with a choice between this new design feature and the previously familiar one, suggests that any such bias was relatively small. Secondly, the order in which tests were presented to each cage of weta was not randomised, meaning that the same sequence of comparisons was used for every group of weta. However, since each comparison was usually testing a very different aspect of gallery design, e.g. entrance-hole diameter versus construction material, the order of testing is unlikely to have been important.

2.2 EXCLUDING MICE FROM REFUGES

Access of mice to refuges was investigated by presenting individual mice with refuges that had different-sized entrance holes; each refuge contained a piece of commercial mouse pellet (1 cm in diameter and 3 mm thick). The experiment was run in a temperature-controlled room at 18–20°C. Mice were housed individually in five commercial rearing containers (45 × 30 cm, with a wire cage lid) provided with wood shavings 2 cm deep, excess mouse pellets, and water. Each mouse was presented overnight with a single artificial weta refuge. The following day, the number of pellets in each gallery was recorded, new pellets were supplied to the same refuges, and the refuges were then moved to the next mouse container. The five refuges were of the type shown in Fig. 1A & B but had entrance-hole diameters of either 14, 16, 18, 20 or 22 mm. This was repeated over 5 days, until each mouse had been presented with each of the five different sizes of entrance hole. The entire test was then repeated using new mice and newly constructed refuges.

2.3 TESTS IN A GLASSHOUSE

These tests were conducted in a glasshouse, where the temperature was regulated between 14°C and 20°C, and the relative humidity between 60% and 80%. Five cages, $2 \times 1 \times 1$ m high, were used. Each had a wooden frame covered with fine aluminium insect mesh. They were provided with moist soil and dead branches. Sufficient vegetation germinated and grew in the cages to provide food for the weta. No water was provided, but the cages were sprayed with an atomiser when necessary to keep the soil moist. Mixed groups of adult *H. crassidens* and *H. thoracica* were used as described below. They were acclimatised to the cages for 7 days before the tests.

The experiment consisted of presenting five pairs of refuges that each differed in one design feature to the weta in each of the five cages once. Four weta were placed in each cage to start with, but one weta died in three of the cages; these weta were not replaced. Refuges were left in the cages for 5 days, and the number of weta found in them was recorded daily. Weta were left in the refuges until the end of the 5-day period, when the refuges were removed. As in the laboratory tests outlined above, new refuges were used in subsequent tests, the positions of these refuges within the cages were randomised, and the sequence of design features tested was moved forward by one cage. The order in which the tests were presented was not randomised because the design features being tested were unrelated. The entire test sequence was then repeated once using different weta. However, during this second test sequence, only three weta were used in each cage, any weta that died were replaced with live weta of the same sex, and each pair of refuges was left in each cage for 7 days.

The following pairs of refuge designs were tested:

1. Entrance holes 15 mm v. 25 mm in diameter (Fig. 3A & B).
2. Entrance holes opening onto vertical v. horizontal (downward) surfaces (Fig. 3C & D).
3. Galleries with single v. multiple entrances (Fig. 3C & E).
4. Presence v. absence of weta faecal material. Weta faecal pellets were left in water for a week; the resulting liquid was then poured into the galleries of a refuge (Fig. 3A & B) the morning before a test commenced, so that the refuge had dried before nightfall when the weta became active.
5. Presence v. absence of a transparent acetate observation window. The observation window was stapled over the galleries beneath the access cover, but otherwise the design used was that shown in Fig. 3A & B.

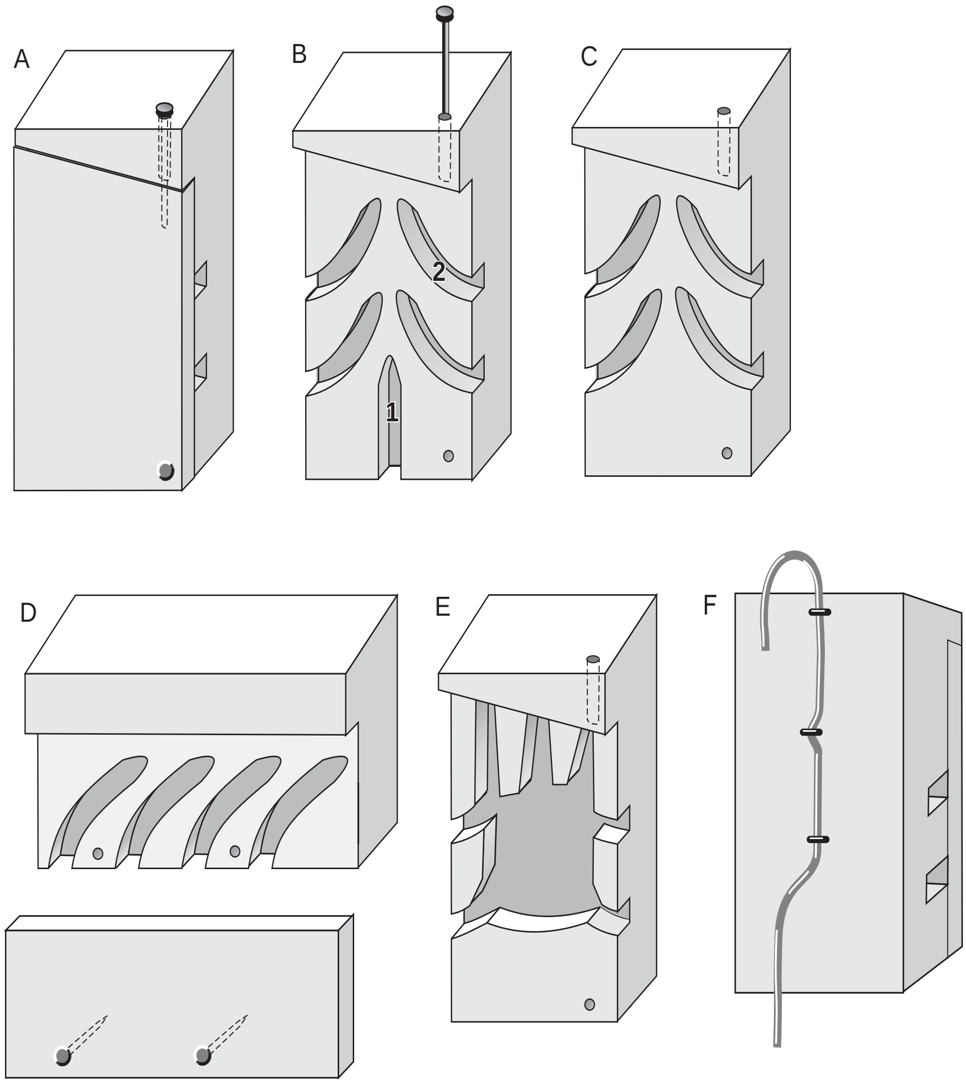


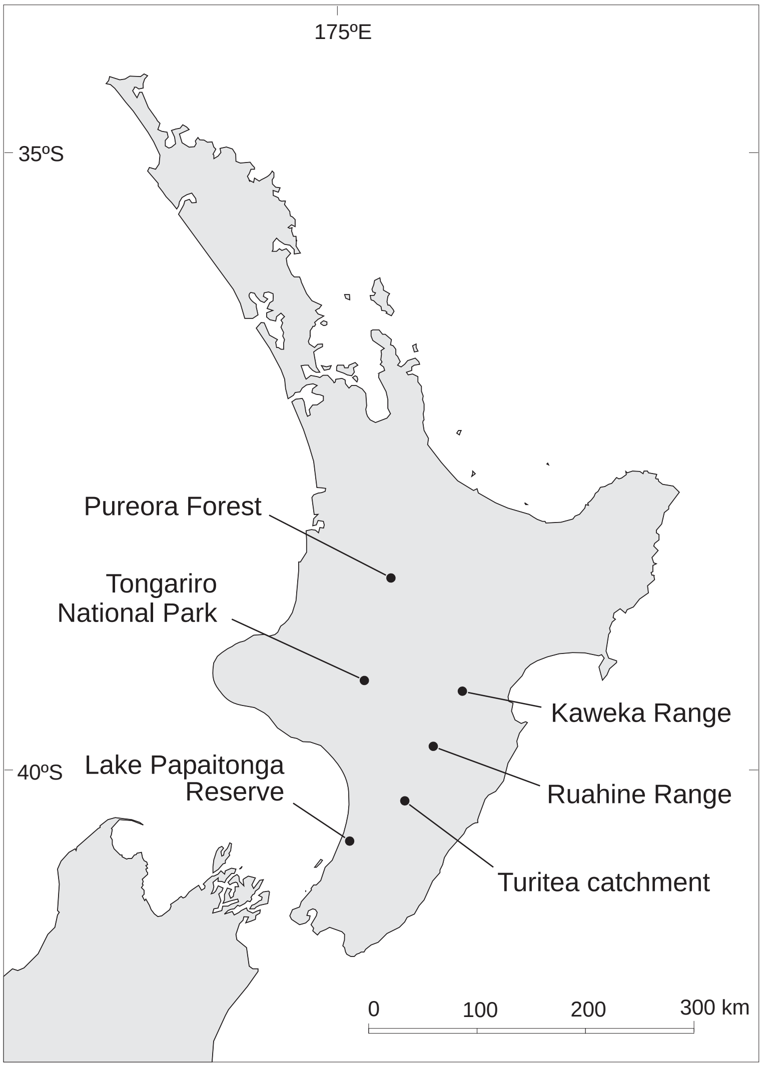
Figure 3. Designs of artificial refuges used in the field and for testing weta (*Hemideina crassidens* and *H. thoracica*) preference in a glasshouse. Overall dimensions: 200 × 100 × 50 mm deep. A. Basic design with access cover closed. B. Basic design with access cover removed to show the galleries. Normally, the access cover can be rotated anticlockwise to allow inspection, as shown in Fig. 1A. Gallery numbers relate to those used in Table 4. C. Side-opening entrance holes (access cover removed). D. Downward-opening entrance holes (access cover removed. E. Single large gallery with four openings (access cover removed). F. Modification to the back of a basic design (Fig. 3A & C) for hooking onto high branches. The wire extension fits loosely into an aluminium pole for lifting and moving the refuge.

2.4 USE OF ARTIFICIAL REFUGES IN THE FIELD

Artificial refuges were set out at six forest sites in the North Island of New Zealand (Fig. 4) between 27 August 1999 and 14 July 2000. Detailed descriptions of the forest types and vegetation cover at the locations where refuges were placed are given in Appendix 1; the species of tree weta present at each site, and the dates when the refuges were set out and when rodent control was started are given in Appendix 2; and the species of tree that the refuges were attached to are given in Appendix 3. Plants are usually referred to by their common names in this report, but a list of the specific names of the plants is provided in Appendix 4.

Ten to 75 refuges were set out along sample lines that were 25–75 m long (Appendix 2). A sample line consisted of a marked route along a compass bearing. Refuges were nailed to successive tree trunks (> 10 mm diameter) within about 2 m of a marked route, and the heights of refuges above ground and the tree species to which they were attached were recorded. When a

Figure 4. Map of the North Island of New Zealand, showing sites where artificial refuges were tested.



sample line included different-sized refuges, small refuges (Figs 5 & 6) were interspersed between medium (Fig. 3B) and large (Fig. 7) refuges. The number of tree weta in each artificial refuge was recorded at intervals of 1–3 months. Every attempt was made to leave the weta undisturbed where they were, but some left before the refuge lids could be closed again; no attempt was made to reintroduce these weta to their refuge.

2.4.1 Occupancy in relation to the edge and interior of a forest

Three pairs of sample lines were set up in the Turitea catchment (Fig. 4); one line of each pair was along the forest edge and the other was parallel to this, c. 200 m inside the forest. These paired sample lines consisted entirely of either small (Fig. 5), medium (Fig. 3B) or large (Fig. 7) refuges set 1–2 m apart and nailed to tree trunks c. 0.5 m above the ground. Those at the forest edge were attached to the trunks of the outermost trees or shrubs, where they were 1–4 m from the outer foliage. All of the small refuges and half of the medium and large refuges were made from untreated pine. The remaining medium and large refuges were made from willow.

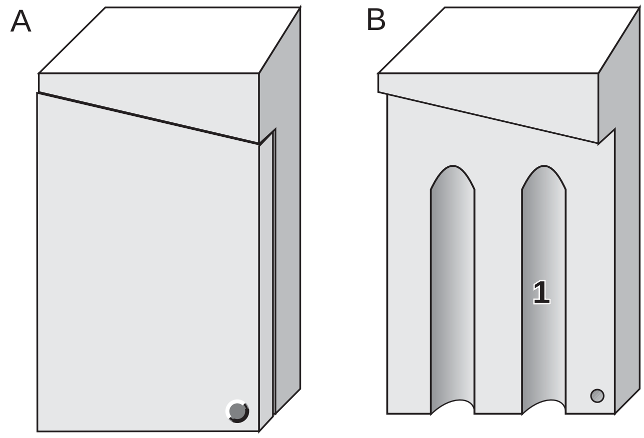


Figure 5. Small artificial refuge made from untreated pine (*Pinus radiata*) used at Lake Papaitonga Reserve, Pureora Forest, Tongariro National Park, Kaweka Range and in the Turitea Catchment. Overall dimensions: 90 × 60 × 18 mm deep. A. Access cover in normal closed position. B. Access cover removed to show galleries. Gallery numbers relate to those used in Table 4.

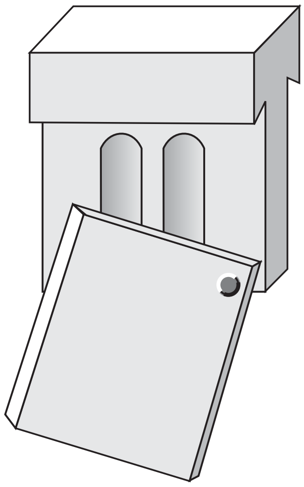


Figure 6. Small artificial refuge made from untreated pine (*Pinus radiata*) used in the Ruahine Range. This refuge had a pair of galleries on opposite sides. Overall dimensions: 100 × 100 × 50 mm deep.

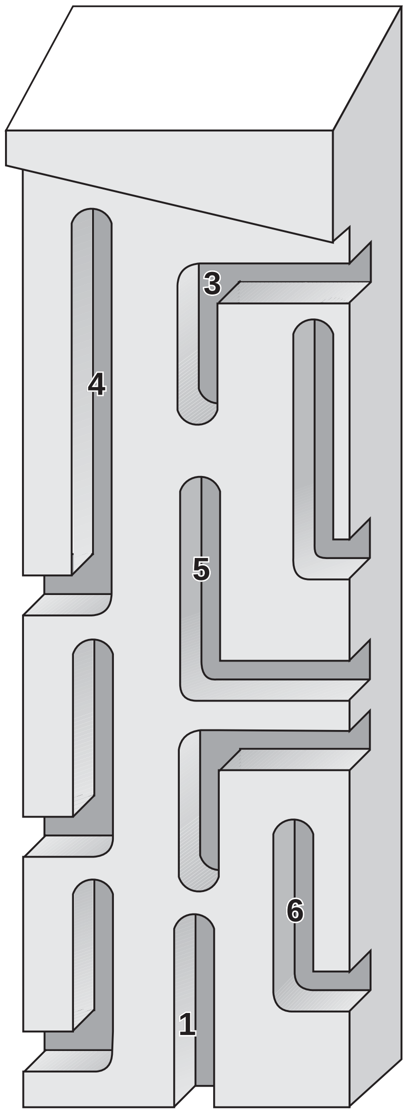


Figure 7. Large artificial refuge made from untreated pine (*Pinus radiata*) or willow (*Salix alba*) used in Tongariro National Park, Kaweka Range and in the Turitea Catchment. Gallery numbers relate to those used in Table 4. Overall dimensions are 400 × 100 × 50 mm deep. Gallery numbers relate to those used in Table 4.

2.4.2 Occupancy in relation to height above ground

The relationship between the height of refuges above the ground and the number of weta in them was investigated in the Turitea catchment using 40 pairs of medium-sized refuges (Fig. 3A, B & F) and nine pairs of large refuges (Fig. 7). On each tree, one refuge was set within c. 0.5 m of the ground and the other was set in the canopy, 2–9 m above the ground. The refuges were set along the same sample lines as outlined in section 2.4.1 for medium-sized refuges, with 20 pairs of refuges at the bush edge and another 20 pairs inside the forest (Appendix 2). Half the pairs of medium-sized refuges were made from untreated pine and half were made from untreated willow wood. These were set along the sample line in the following order: two pine refuges were attached to the first tree (one in the canopy and one near the ground); the second tree had a pine refuge in the canopy and a willow refuge near the ground; the third tree had a willow refuge in the canopy and a pine refuge near the ground; and two willow refuges were attached to the fourth tree. This pattern was repeated five times along each line. The same pattern was used for large refuges (half made from pine and half made from willow wood). Here, five pairs of large refuges were set at the bush edge and four pairs were set inside the forest.

Refuges near the ground were nailed to tree trunks while those set in the canopy were equipped with wire hooks for suspending them from forks of branches. The latter were hung so that they lay in contact with a vertical branch. To facilitate the placement and retrieval of the refuges set high, the wire hook had a downward extension (Fig. 3F), which could be captured with the tubular end of an extendable aluminium pole.

2.4.3 Occupancy in relation to density of weta in a forest

The relationship between the number of weta found in refuges and the estimated density of weta in the surrounding forest was investigated in the Turitea catchment and at Lake Papaitonga Reserve (Fig. 4). At each site, eight 10×10 m plots were established more than 10 m apart. These plots were arranged in two rows of four in the Turitea catchment, and in pairs at four locations at Lake Papaitonga. Within each plot, five small artificial weta refuges (Fig. 5) and one medium-sized refuge (Fig. 1A & B) were set out on separate trees. Rodents were being poisoned at two locations at Lake Papaitonga, and possums were being poisoned at the other two locations. There was no mammalian control at the Turitea site. At Lake Papaitonga, brodificoum poison (Talon) was dispensed in rodent bait-stations, which were 50 m apart (see Bennett et al. (2002) for details of the poison operation). One search for weta was undertaken in each plot 12 months after the weta refuges were set out, and the number of weta in each refuge was counted at the same time for comparative purposes. The plots were searched by systematically exploring every hole and crevice that was within c. 3 m of the ground and that appeared suitable for sheltering a weta. Where necessary, holes and crevices were enlarged and every weta was removed and counted.

2.5 ANALYSIS

Results from the laboratory and glasshouse experiments were analysed using Analysis of Variation (ANOVA). The number of weta found in each variant of each refuge was first totalled over the experimental period. The two totals were then compared for each type of refuge, and glass tank or cage was included as a blocking factor. For the experiments in the glasshouse, cages in which no weta were found in either variation of a refuge were excluded from the analysis, and data for refuges comparing entrance holes opening onto vertical and horizontal surfaces were log transformed to make the residual variance homogeneous.

Field results were analysed using a generalised linear model with binomial errors to examine the relationship between the proportion of time refuges were occupied, site and height; the results were weighted by the number of times each refuge was examined. The site × height interaction allowed us to test how the relationship differed between the six locations (four at Lake Papaitonga and two in the Turitea catchment). Other factors, such as whether rodent control was carried out in the area, or proximity to the edge of the forest, together with the appropriate interaction terms, were then added as required. A similar analysis was used to examine the relationship between the number of weta found in artificial refuges and the height of the refuge above the ground, using a Poisson regression on data from medium-sized refuges in the Turitea catchment, which were pooled over the last four sample occasions.

The relationship between the density of weta in natural refuges and those found in artificial refuges was examined by regressing the average number of weta per quadrat at each location against the average number of weta per artificial refuge per quadrat at each location. All data were $\log(n + 1)$ transformed prior to analysis to normalise them.

Confidence intervals for proportions were determined using the method of Agresti & Caffo (2000).

3. Results

3.1 LABORATORY EXPERIMENTS WITH ADULT WETA

When given a choice of entrance diameters, no adults of either species were found in galleries with 10-mm diameter entrance holes, whereas some individuals of both species were found in galleries with entrance holes 16 mm in diameter (Table 1). Both species of adult weta preferred refuges made from aged pine timber over refuges made from newly purchased pine timber, and those made from willow wood over fresh pine timber. *Hemideina crassidens* preferred refuges without Perspex observational windows, refuges with galleries that had tapered terminations over those with rounded terminations, and refuges made from willow wood over those made from concrete, whereas

TABLE 1. RESPONSES OF ADULT *Hemideina crassidens* AND *H. thoracica* TO VARIATION IN REFUGE DESIGN IN THE LABORATORY.

Refuges used in tests C–J had openings 16 mm across. (df = 1, 4 for all results; LSD = least significant difference.)

TEST	REFUGE MODIFICATION	*H. crassidens*				*H. thoracica*			
		MEAN	LSD	*F*	*P*	MEAN	LSD	*F*	*P*
A	Entrance 10 mm diameter	0	1.36	42.7	0.003	0	2.08	3.5	0.135
	Entrance 16 mm diameter	3.2				1.4			
B	Round entrance (16 mm diameter)	8.6	3.79	3.10	0.153	5.0	3.73	0.56	0.497
	Square entrance (16 mm × 16 mm)	6.2				6.0			
C	Projection above entrance	4.8	4.89	1.29	0.319	3.6	7.48	1.59	0.276
	No projection	6.8				4.2			
D	Tapering termination to galleries	8.8	3.47	13.56	0.021	3.6	4.25	0.62	0.477
	Rounded termination to galleries	4.2				4.8			
E	Made from willow wood	13.6	2.96	143.7	< 0.001	5.8	1.96	18.0	0.013
	Made from pine timber	0.8				2.8			
F	Made from mahoe wood	6.6	4.56	0.37	0.576	3.2	2.69	3.45	0.137
	Made from willow wood	7.6				1.4			
G	Made from concrete	4.2	2.96	20.2	0.011	5.8	1.67	36.0	0.004
	Made from willow wood	9.0				2.2			
H	Wet refuge	10.4	6.77	7.78	0.049	7.4	7.48	1.59	0.276
	Dry refuge	3.8				4.0			
I	With Perspex observational panel	3.2	4.06	17.96	0.013	2.2	2.72	2.67	0.178
	Without Perspex observation panel	9.4				3.8			
J	Made from weathered pine	12.8	4.39	48.4	0.002	7.0	2.55	27.4	0.006
	Made from new pine	1.8				2.2			

H. thoracica preferred refuges made from concrete over those made from willow wood. Neither weta species showed a strong preference for wet v. dry refuges, refuges with square v. round openings, refuges made from mahoe wood v. willow wood, or refuges with galleries that opened onto plain vertical surfaces v. those that opened beneath overhang projections (Table 1).

3.2 EXCLUDING MICE FROM REFUGES

Fewer than 21% of food pellets were removed by mice from galleries with entrance-hole diameters of 18 mm or less, whereas most of the pellets were removed from galleries with entrance-hole diameters of 20 mm or 22 mm (Table 2). Some of the smaller entrance holes were gnawed by the mice, but only one, which had a diameter of 14 mm, was enlarged sufficiently during the second night for mice to remove the food pellet from the gallery on each subsequent night (Table 2). This indicates that adult mice can access food in refuges through entrance holes with diameters of 14 mm or greater, but that access is greatly restricted when the entrance hole has a diameter of 18 mm or less.

TABLE 2. NUMBER OF FOOD PELLETS TAKEN FROM ARTIFICIAL REFUGES BY MICE (*Mus musculus*) OVERNIGHT.

Each refuge had three galleries with the same size of entrance hole, and each gallery was provisioned with one pellet, which was replenished daily.

	DAY	ENTRANCE DIAMETER (mm)				
		14	16	18	20	22
Replicate 1	1	0	0	0	2	3
	2	0	1	0	2	3
	3	*1	0	0	3	3
	4	*1	1	2	2	3
	5	*1	1	2	3	3
Replicate 2	1	1	0	0	3	2
	2	0	0	1	1	2
	3	0	1	0	1	3
	4	0	0	0	3	3
	5	0	0	1	3	3
Total % pellets taken		13%	13%	20%	77%	93%

* Entrance enlarged by mice.

3.3 TESTS IN A GLASSHOUSE

When tested together, adults of neither species showed a clear preference for galleries with entrances that opened onto vertical surfaces v. those that opened downwards onto horizontal surfaces, for entrances that were 15 mm v. 25 mm in diameter, for tunnel-like galleries v. large expanded single galleries, for galleries with or without faecal material, or for galleries with or without an acetate observation window (Table 3).

TABLE 3. RESPONSES OF ADULT *Hemideina crassidens* AND *H. thoracica* TO DIFFERENT REFUGE MODIFICATIONS.

Tests were done in a controlled-temperature glasshouse. (LSD = least significant difference, except in trial 2, where the result is a least significant ratio given as a percentage.)

TRIAL	REFUGE MODIFICATION	MEAN	LSD	df	REPLICATE 1		REPLICATE 2	
					F	*P*	*F*	*P*
1	Entrance 15 mm diameter	3.5	4.44	1, 4	0.53	0.506	0.09	0.783
	Entrance 25 mm diameter	2.3						
2*	Entrance on side of vertical surface	0.7	445%	1, 5	7.10	0.045	0.17	0.696
	Entrance downward on horizontal surface	5.3						
3	Four small galleries	4.4	4.40	1, 6	0.02	0.894	0.02	0.894
	Single large gallery (four openings)	4.1						
4	Faecal matter in galleries	5.2	6.78	1, 6	0.05	0.829	0.08	0.781
	No faecal matter in galleries	4.6						
5	Acetate sheet present	4.3	2.02	1, 8	0.00	1.000	1.87	0.209
	No acetate sheet	4.3						

* Data normalised by log transformation.

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