SHORT COMMUNICATION

Artificial weta roosts: A technique for ecological study and population monitoring of Tree Weta (*Hemideina*) and other invertebrates

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Abstract: Tree weta (*Hemideina)* are an important component of New Zealand forest ecosystems and have been identified as possible invertebrate indicator species in restoration programmes. We present designs for artificial weta roosts that have been used to monitor tree weta in Hawke's Bay for five years. A variety of invertebrates use the roosts including two species of *Hemideina*. Our data suggest that occupation of roosts may take a number of years, each roost monitors a very limited area, and that occupation by invertebrates fluctuates seasonally. We recommend that data from weta roosts be used primarily for temporal rather than spatial comparisons, and that installation of roosts takes place as far ahead of changes in management as feasible.

Keywords: weta; invertebrate monitoring; *Hemideina*; indicator species.

Introduction

Although tree weta are extremely common in the northern two-thirds of New Zealand, our knowledge of their basic ecology is limited. Much of what we know about tree weta life-history is anecdotal or derived from observations of captive weta (e.g., Barrett, 1991). Tree weta are nocturnal and arboreal which makes study of their behaviour and population dynamics in the wild difficult. The purpose of this paper is to present original designs of artificial weta roosts which have been useful in overcoming some of these difficulties. We provide examples of data obtained from their use over a five year period.

Tree weta are eaten by many predators, both native and introduced [see references in Ramsay (1979)] and the density and behaviour of *Hemideina crassidens* Blanchard (the Wellington tree weta) is apparently detrimentally affected by introduced predators (Rufaut, 1995). Because tree weta are abundant and large they are being used as indicator species for monitoring the "health" of forest ecosystems and the impact of poisoning programmes targeting introduced predators (Spurr and Drew, 1999). Unfortunately there are few data on how suitable weta are for this purpose. Artificial roosts provide a useful tool for the study of population dynamics and behaviour of weta (Ordish, 1992). As this type of information is a necessary prerequisite if weta are to fulfil a role as indicator species the development and application of such roosts is an important step towards their use in conservation programmes.

Roosts based on our designs have recently been used for weta translocation to Somes Island, Wellington (George Gibbs, Victoria University of Wellington, Wellington, N.Z., *pers. comm.*), monitoring effects of poison baiting at Pureora Forest (Ralph Powlesland, Department of Conservation, Wellington, N.Z., *pers. comm.*), and have been employed in several other projects run by the Department of Conservation (Sherley, 1998). Roosts have also been deployed in Karori Nature Reserve, Wellington for which plans to develop a fenced mainland "island reserve" were being developed (Lynch, 1995), and in private gardens. However, our primary objective was to examine the demographics and interaction of two species of tree weta where they exist in sympatry at a reserve in Hawke's Bay.

Methods

We designed an artificial roost to mimic the standing trunks that *Hemideina thoracica* White and *H. trewicki* Morgan-Richards naturally occupy (Trewick and

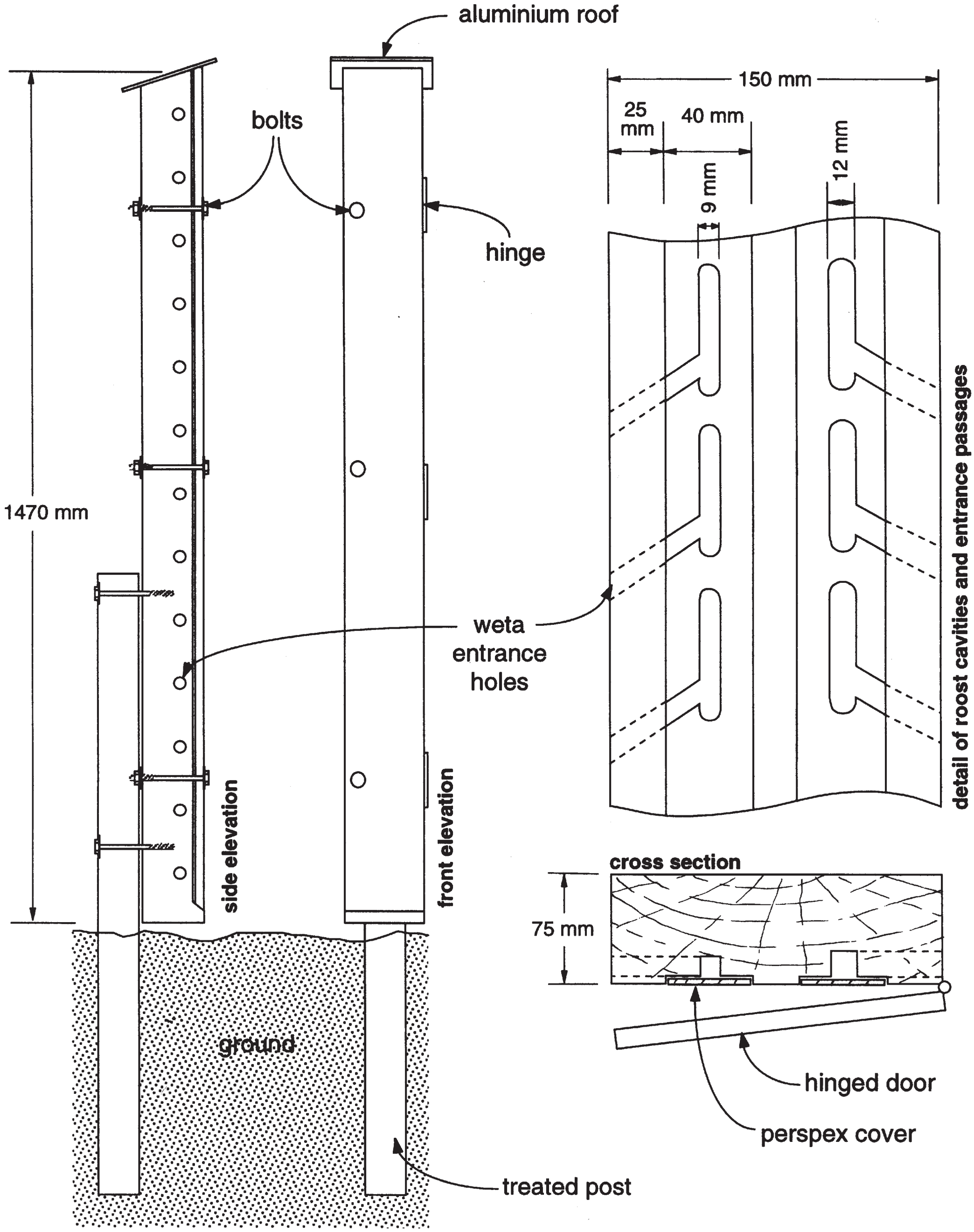

Figure 1. Design of original weta roosts deployed at Mohi Bush in 1994.

Morgan-Richards, 1995), that would allow observation of weta *in situ*. We apply the term 'roost' to a unit containing a number of separate cavities each with an entrance.

The first roost built was designed to be planted like a fence post. The roost had a hinged door that opened to reveal 26 cavities each with a separate entrance channel (Figure 1). The cavities and entrance slots were manufactured with a router and the entire surface was protected by perspex sheet. This transparent cover provided a tactile surface for the weta and a window for the observer when the door was open. The tendency of tree weta to move further into their respective cavities rather than emerge from the roost when disturbed by light made this an effective compromise, and one used previously by Ordish (1992).

A smaller and simpler roost design with 18 cavities (Figure 2) was subsequently developed that could either be planted into the ground or attached to tree trunks. This roost included one large compartment at the top, with a wider opening and space for nine or ten adult weta inside, in addition to a set of smaller compartments. The large compartment was expected to be attractive to adult males which are known to develop 'harems' by permitting adult female weta to occupy a protected cavity thus allowing resident males preferential mating access (Moller, 1985; Gwynne and Jamieson, 1998).

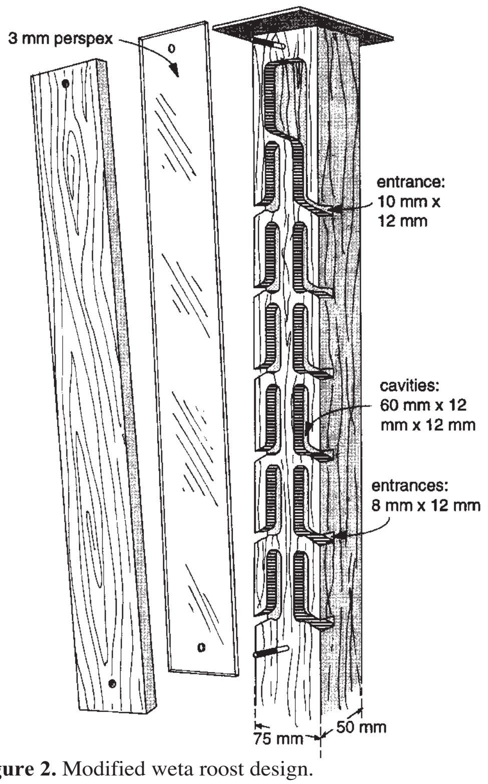

Figure 2. Modified weta roost design.

Six roosts of the original design were placed in Mohi Bush Scenic Reserve, Hawke's Bay (40° 51' S, 176° 53' E) in August 1994 and remain in operation. Three of these that had not been occupied at all after a year were repositioned in August 1995. At this stage the six roosts (#1-6) were located at distances of 110-340 m from one another, between 5 and 28 m from the margins of the reserve (which is surrounded by paddocks). In January 1996 an additional six roosts of the smaller design were positioned in groups of three (#7-9, #10-11) within 15 m of roosts #1 and #3 respectively, giving a total of twelve.

At Mohi Bush the primary purpose of the artificial roosts was to provide a standard, replicated roost habitat from which the demography of the sympatric tree weta species could be inferred. For this reason it was our intention to avoid placing artificial roosts in close proximity to existing natural cavities that might contain weta. The roosts were therefore free-standing, requiring weta to travel on the ground in order get to and from them. Despite the likely effect of extending the time taken for colonisation, this appeared to be the optimal approach (Trewick, 1995).

Observations of weta were made during the day, with the aid of a torch when light was limited in the forest. Weta and other invertebrates present in each numbered cavity were recorded, with details of sex and growth stage noted for tree weta. *Hemideina thoracica* and *H. trewicki* were distinguished using their colour patterns, following Morgan-Richards (1995). The periodicity of observation was largely dependent on access to roosts and availability of observers. In the first two years, observations were usually made once a month, latterly this has reduced to twice a year (see Figures 3 and 4 for observation dates).

Results

Mohi Bush

The roosts provided attractive day-time hiding places for a variety of invertebrates. The most common animals were not tree weta but cave weta (mostly *Talitropsis sedilloti* Hutton), spiders (of several species), and cockroaches (*Celatoblatta* sp.) (Figure 3). Of all invertebrates in roosts at Mohi Bush between 10 October 1994 and 18 October 1999 (n=1642, 5180 cavity observations) 40% were cave weta, 27% spiders and 25% tree weta. Rare occupants included native slugs (n=4), peripatus (n=1), flies, beetles and the nests of spider-parasitising pompilid wasps. *H. trewicki* made up 61% of all tree weta observed (n=438). In both tree

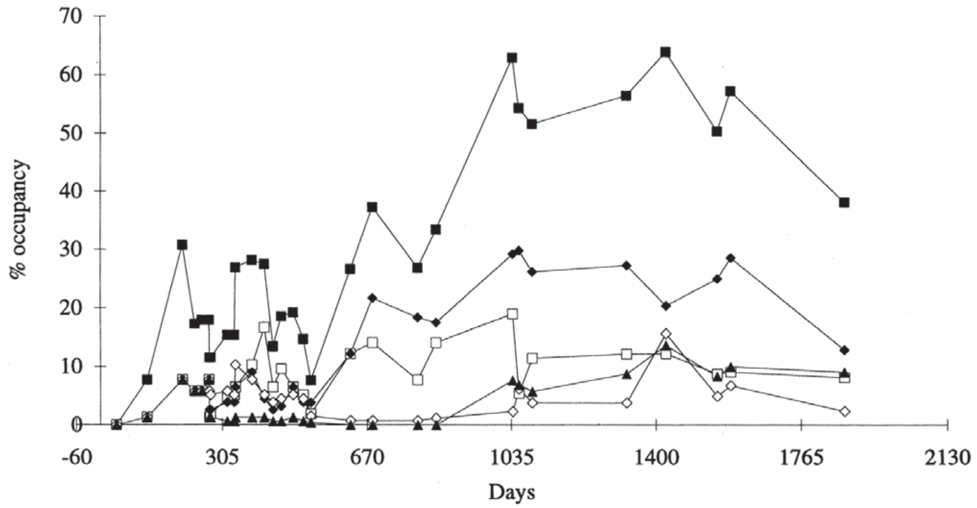

Figure 3. Temporal variation in use of artificial roost cavities by invertebrates at Mohi Bush over five years. Cavity use expressed as proportion (%) of available cavities and includes data from up to 12 roosts. Lines join consecutive sampling events for each group, symbols indicate: filled squares- all invertebrates; filled diamonds- cave weta; open squares- spiders; filled triangles- H. thoracica; open diamonds- H. trewicki. Horizontal axis units are days following installation of roosts. Intervals are annual and indicate 31 July of years 1995-1999.

weta species females slightly outnumbered males (*H. trewicki*: 53% females; *H. thoracica*: 65% females). In natural cavities at Mohi Bush, (assessed prior to installation of roosts) we found 60% of tree weta were *H. trewicki* (n=98). Both tree weta species were found in most roosts, either at the same time or sequentially. Of the six major roosts at Mohi Bush, only in roost #1 have we seen just one species (*H. trewicki*). Other roosts show a range of frequencies of the two species (Figure 5).

Variation in time

The total number of weta and other invertebrates using the roosts at Mohi Bush increased during the first three years of study and showed marked seasonal fluctuations (Figure 3). By July 1997 (end of year 3) maximum occupancy of available cavities reached 60%. Total observed occupancy by all animals was highest at winter visits (June/July) but this seasonality was not so obvious from the data for individual species or groups. The first animals recorded in a roost were cockroaches which were seen just six weeks after roost deployment. These were followed by cave weta and spiders. The first tree weta were not seen until five months after installation.

Variation in space

Although Mohi Bush is a small forest remnant (~60 ha) with a relatively homogenous climate and a single management regime, we observed considerable variation in the use of identical roosts by invertebrates during this study. Although total numbers of animals in roosts tended to increase over time, differences in occupancy rates of different roosts persisted (Figure 4). In addition, the proportion of different taxa varied among roosts set only a few hundred metres apart (Figure 5). Secondary roosts (#7-9, #10-12) placed within 15 metres of roosts #1 and #3 were little used by tree weta in the four years after installation (Figure 6). Tree weta began using roosts (#10-12) near roost #3, three years after installation and 1.5 years after large numbers of weta first occupied roost #3.

Individual cavity-use over time

The use of individual cavities did not appear to be random. On sequential observation visits, cavities that had previously been occupied by any invertebrate tended to be occupied again, often by the same taxon. Cave weta and tree weta appeared to be especially faithful and frequently same sex individuals (unmarked) were seen in the same cavity over sequential visits and through increasing size categories. Cavity-faithfulness is illustrated by data from roost #1 for thirty observation events over five years (Table 1). It is interesting to note that after initial colonisation of roost #1 by a cohort of juvenile *H. trewicki*, occupation by this species diminished two years later (the normal life expectancy of tree weta), to become the domain of cave weta.

Table 1. An example of individual cavity use by weta in artificial roost #1 at Mohi Bush in 1994-1999. Occupancy of left (L) or right (R) cavity of thirteen pairs of separate cavities numbered from the top down, by: *H. trewicki* – 1; two unidentified tree weta – T; cave weta – 3; *H. trewicki* and cave weta – 1'; two cave weta – 3'.

Date	Cavity																									
	1		2		3		4		5		6		7		8		9		10		11		12		13	
	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R
10 Oct 1994																										
26 Dec 1994																										
24 Mar 1995		1	1							1																
24 Apr 1995		1	1												1		1	1		3						
12 May 1995		1	1			1	1	1	1		3		1		1			1			1					
30 May 1995		1	1				1				1				1			1			1		1			
31 May 1995		1			1		1				1				1		1	1			1				1	
3 Jun 1995		1			1	1			1		1				1			1			1					
14 Jul 1995		1	1		1				1		1		1		1			1								
1 Aug 1995		1	1				1		1		1				1			1			1					
4 Aug 1995		1	1	1					1		1		1					1			1					
15 Sep 1995		1	1								1							1			1					
16 Oct 1995	1		1	1	1		1		1									1	1		1					
7 Nov 1995			1						1		1					1	1									
27 Nov 1995			1		1	1	1		1				1				1	1								
27 Dec 1995		1			1				1						3		1	1			1	1				3
22 Jan 1996		1									1				1						1	1				1
10 Feb 1996											1										1	1				1
20 May 1996											1	3			3		3						3			
15 Jul 1996											1				3		3				3		3			
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23 Dec 1996						1											3		3							
5 Jul 1997			3		3						3			3		3	3	3	3		3		3			
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Discussion

The location of the roosts appeared to influence the number of animals that used it. Whether this resulted from environmental heterogeneity or underlying patchiness arising through chance cannot be determined from these data. However, three empty roosts (#2, #4 and #6) which had initially been placed in comparatively dark and cool parts of the bush (>100 m from the edge) where low-level foliage was sparse remained almost unused by any invertebrate for one year. After relocation to bush-edge positions occupancy rates increased within a month. The patchiness of distributions is also evident from the relative frequency of *H. thoracica* and *H. trewicki* at Mohi Bush. Systematic relocation experiments have not been attempted but observations of roosts placed at other sites suggest that tree trunk attachment, tree species and height above the ground are all features that influence the extent to which tree weta use roosts and how fast they move in. Harem cavities incorporated in our second roost design were successful in attracting groups (up to eight) of adult females as well as single adult males.

Data from five years of observations suggest that use of roosts by invertebrates reflects much finer-scale patterns of variation than can be summarised using relatively few sampling sites.

In addition to estimating changes in total numbers, sex ratio and age structure etc. of weta (and other invertebrates), roosts and their use can be modified for behavioural studies. We have developed photo-electric switches linked to data loggers that can be positioned across the entrance to cavities in order to record activity patterns. The use of individual marking will also enhance the information obtained from roosts. Mark and recapture analysis would enable more accurate

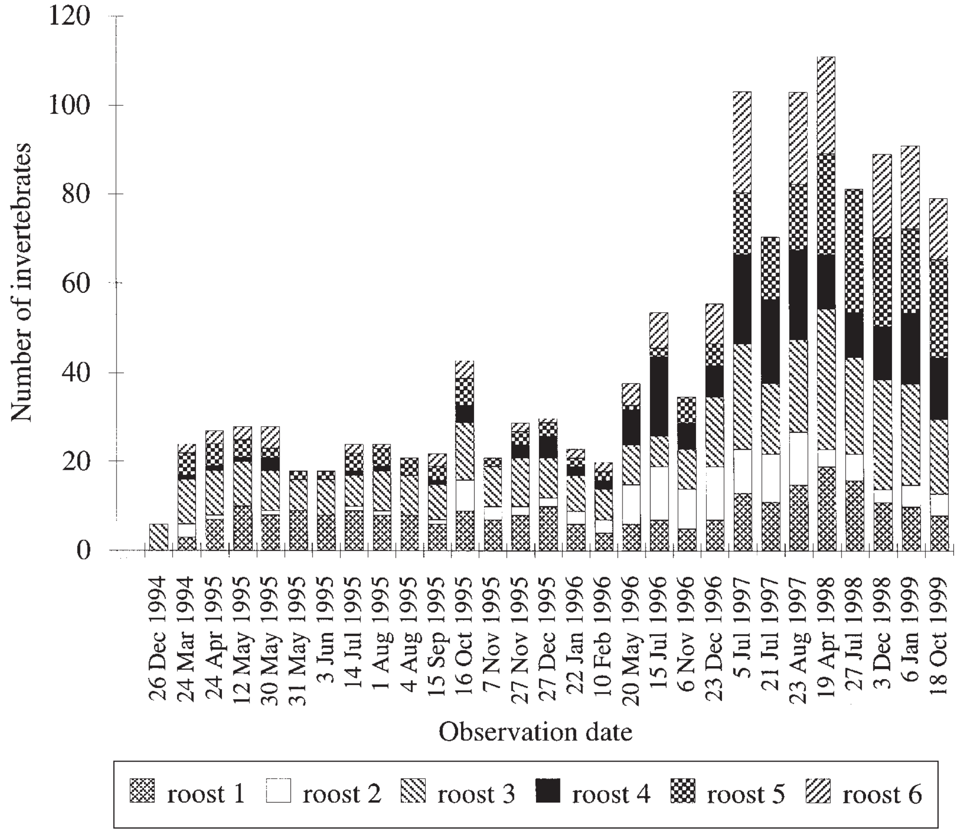

Figure 4. Variation in the number of invertebrates using six artificial roosts at Mohi Bush from 1994-1999. Values are total observed numbers on each visit.

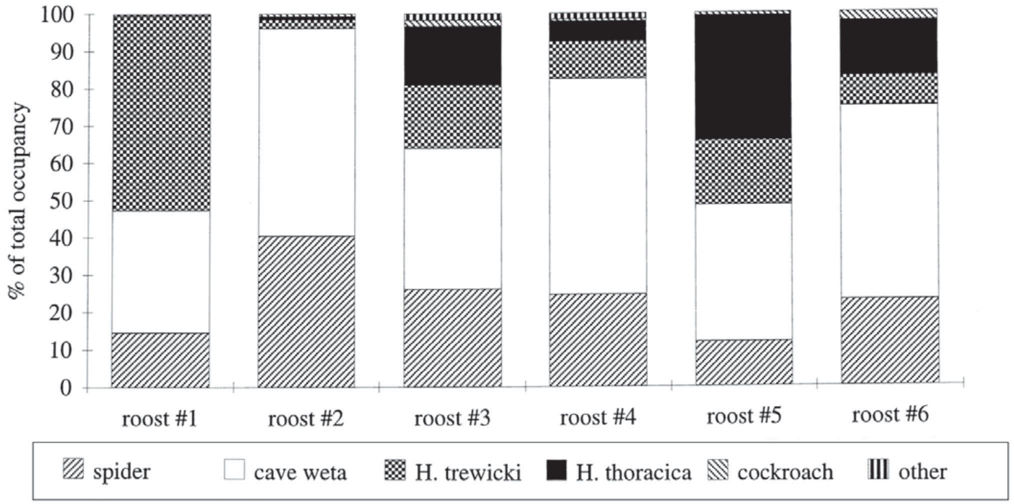

Figure 5. Spatial variation in relative roost occupancy levels among invertebrate groups in six artificial roosts at Mohi Bush (1994-1999).

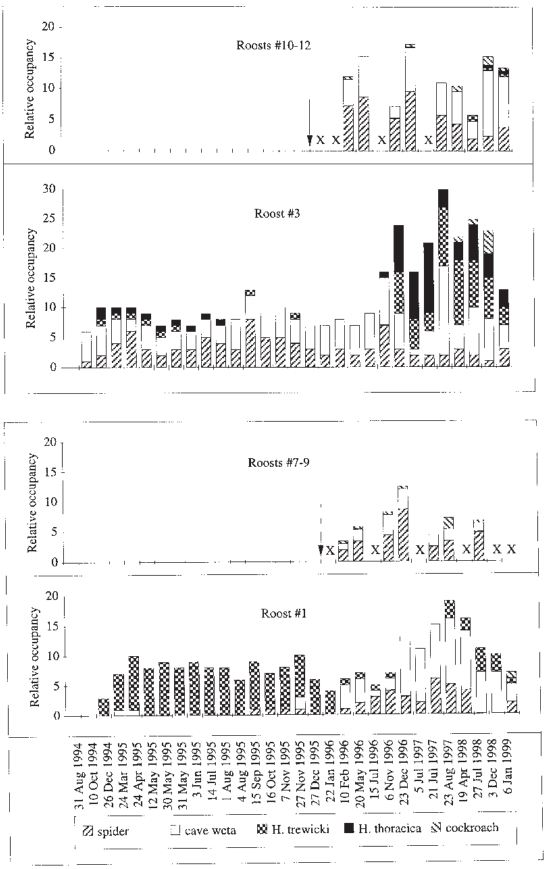

Figure 6. Occupancy of proximate roosts at Mohi Bush (1994-1999). Data from primary roosts #1 and #3 (positioned in 1994) are accompanied by data from secondary roosts #7-9 and #10-12 placed within 15 m of these respectively (arrows indicate installation date). Invertebrate numbers in secondary roost cavities are pooled and adjusted to be equivalent to the 26 holes available in primary roosts. X's indicate no data collected.

estimations of population density and aspects of behaviour such as hole-faithfulness.

The roosts appear to be appropriate devices for monitoring weta and other invertebrate populations through time but 1. may require a long time from establishment before occupancy is sufficient to provide useful information, 2. probably monitor a very small area, 3. cannot easily be compared between sites. Therefore weta roosts once established should not be moved if possible, and analyses should be focused on temporal rather than spatial changes. This requires the deployment of the roosts some years prior to implementation of new management procedures. We suggest that attachment of artificial roosts to trees already inhabited by tree weta may result in more rapid occupation than artificial roosts placed even a matter of metres away from existing habitat. Therefore, for studies that are directed primarily at monitoring changes in weta numbers over time it may be more effective to use large numbers of single or few-hole roosts placed directly on trees at high density and with site replication. Simple roosts of this type can be examined without opening using a torch so that rapid censuses can be made at appropriate intervals.

Acknowledgements

Many thanks to Alan Lee and others at Hawke's Bay Department of Conservation for assistance with the construction, deployment and monitoring of roosts at Mohi Bush. The Karori Reserve Trust provided access to Karori Reserve. George Gibbs, Ralph and Mary Powlesland, Judith and Llyn Richards installed and monitored roosts on their own property. This programme was assisted by grants from the New Zealand Entomological Society 21st Anniversary Trust and the Royal Forest and Bird Protection Society James Sharon Watson Conservation Trust.

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