

¹Zoology Department, University of Otago, P.O. Box 56, Dunedin, New Zealand and Ecosystems Consultants, P.O. Box 6161, Dunedin, New Zealand.

²Manaaki Whenua - Landcare Research, P.O. Box 3127, Hamilton, New Zealand.

SHORT COMMUNICATION

CALIBRATION OF TUNNEL TRACKING RATES TO ESTIMATE RELATIVE ABUNDANCE OF SHIP RATS (*RATTUS RATTUS*) AND MICE (*MUS MUSCULUS*) IN A NEW ZEALAND FOREST

Summary: Ship rat (*Rattus rattus*) and mouse (*Mus musculus*) density and habitat use were estimated by snap trapping and tracking tunnels at Kaharoa in central North Island, New Zealand. Eighty-one ship rats were caught in an effective trapping area of 12.4 ha. Extinction trapping gave an estimated density of 6.7 rats ha⁻¹ (6.5–7.8 rats ha⁻¹, 95% confidence intervals). A linear relationship existed between ship rat trapping and tracking rates. Estimating the density of mice was impossible because trapping rates increased rather than decreased during the experiment. Comparisons of density from tracking and trapping rates of mice may be confounded by interference by rats, but this requires further investigation.

Keywords: Ship rats; mice; density; habitat use; density estimation; rodents.

Introduction

Snap trapping and footprint tracking are the techniques commonly used to provide relative indices of rodent density in New Zealand (Fitzgerald, 1978; King and Edgar, 1977; Innes, 1990; Innes *et al.*, 1995). Measures of relative density usually require less time and effort than measures of absolute density (Caughley, 1977), but they assume equal catchability or trackability at different times, places or habitats. Comparisons of relative indices of population abundance to infer changes in real abundance also assume that trapping or tracking success is directly related to absolute abundance. Traps, tracking, or counting techniques can “saturate”, so non-linear calibrations are sometimes obtained (Caughley, 1977; Sandlant and Moller, 1989; Fletcher *et al.*, 1995). Tanaka (1960) confirmed that non-linear functions can occur when trapping is used as an index of relative abundance but concluded that the relationship was reasonably reliable at densities below 20 captures per 100 trap nights. One competitor or predator may alter the response of another species to traps or tunnels so that the index of relative abundance is confounded. For example, ship rats (*Rattus rattus* L.) may limit mouse (*Mus musculus* L.) use of traps and tunnels.

Indices of ship rat and mouse relative density have not previously been tested against estimates of absolute density but are used to help to evaluate the need for and efficacy of rodent control programmes. Accordingly, the aims of this study were to compare estimates of ship rat relative density obtained by

footprint tracking with estimates of absolute density obtained by extinction trapping, and to determine whether ship rat removal affected mouse tracking results.

Methods

Study area

The study was carried out at Kaharoa (37° 57' S, 176° 25' E), a forest remnant (c. 381 ha), located 23 km north of Rotorua, Bay of Plenty, New Zealand. Kaharoa's vegetation has been much modified by burning in Polynesian times, browsing mammals and logging. Mixed broadleaf/ hardwood forest with a scattering of isolated large podocarps dominates a mosaic of forest, scrubland and grassland associations (Shaw, 1985). A detailed description of the study area is given in Brown (1994).

Grid trapping and tracking experiment

We used the “Zippin Removal” method (Zippin, 1958) to establish the absolute density of rodents. This method uses plots of nightly catch against cumulative catch to estimate (by extrapolation) the number of rodents left untrapped in the study area.

A 300 x 300 m grid was established using a compass and hip chain. One hundred and sixty-nine “Ezeset Supreme” rat snap traps were placed on the grid at 25 m intervals under 39 natural and 130 artificial (65 plastic and 65 metal) tunnels. Natural

tunnels were used on one side of the grid, plastic tunnels in the middle and metal tunnels on the other side. Plastic tunnels were white and measured 600 x 150 x 150 mm; metal tunnels were green and measured 450 x 150 x 150 mm; and natural tunnels were constructed of logs and fern fronds, approximately 600 x 200 x 150 mm in size. Tunnels were used to reduce the risk to non-target species. Traps were baited with a peanut butter and rolled oats mixture. We noted at each trap site each day if rodents (ship rats or mice) were caught, bait was taken, or the trap was sprung. Trap success was corrected for sprung traps (Nelson and Clark, 1973).

Ship rats were later dissected to determine their breeding condition and maturity. The sex, breeding condition, age, and trap location of each rat caught was recorded. Age was determined by dissection and males were classified as adult if they had visible tubules in the cauda epididymus and females as adult if they were pregnant or had scars on the uterus.

Twenty-eight rodent footprint-tracking tunnels (King and Edgar, 1977) were placed within one metre of traps, at 50 m intervals on four lines 100 m apart. Tracking tunnels were baited with peanut butter each day and tracking rates were recorded on the night of 11 January 1994 and over five consecutive nights (21-25 January 1994) in association with extinction trapping. Trapping tunnels and unset traps were put in place at least three days before use.

Each trap and tracking tunnel site was also defined in terms of topography (gully, face, ridge) and vegetation type (forest, scrub). The incised nature of Kaharoa's landscape meant that topographies were generally well defined. "Gully" was defined as gully bottom and <5 m up a slope of at least 20°. "Ridge" was defined as ridge top and <5 m down a slope of at least 20°. "Face" was defined as the slope between ridge and gully.

The effective trapping area was estimated by adding a boundary strip (after Dice, 1938) to the 300 m x 300 m area trapped. The boundary strip was determined by adding the radius ($r=56$ m) of a circular average home range of 1 ha, based on radio telemetry of ship rats at Rotoehu Forest (Hooker and Innes, 1995). Rotoehu and Kaharoa forests are both central North Island mixed broadleaf/hardwood forests with similar rat tracking rates (J. Innes, *unpubl. data*). This resulted in an effective trapping area of 12.4 ha at Kaharoa.

Results

Similar numbers of ship rats were trapped in forest and scrubland ($\chi^2=2.7$, d.f.=1, $P=0.279$), while mice were more often caught in scrubland ($\chi^2=22.2$,

d.f.=1, $P=0.0001$) (Fig. 1). No differences in trap success in gullies, faces or ridges within the forest were detected for ship rats ($\chi^2=0.7$, d.f.=2, $P=0.680$) and there were insufficient data to make the same comparison for mice.

The number of adult rats trapped declined quickly over the five-day trapping period ($n = 29, 9, 2, 3,$ and 3 each day), while the number of juvenile rats caught remained similar for the first three nights

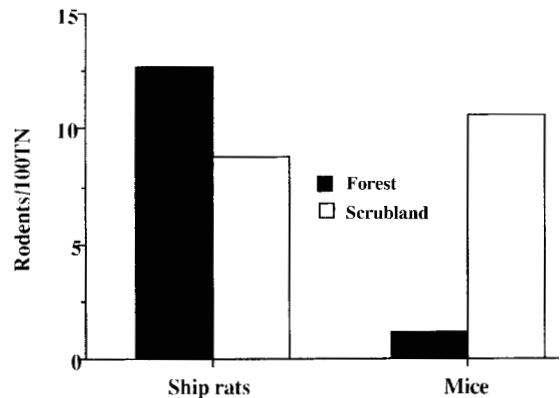


Figure 1: Capture rates for rats and mice in rat traps in forest and scrub areas at Kaharoa in January, 1994.

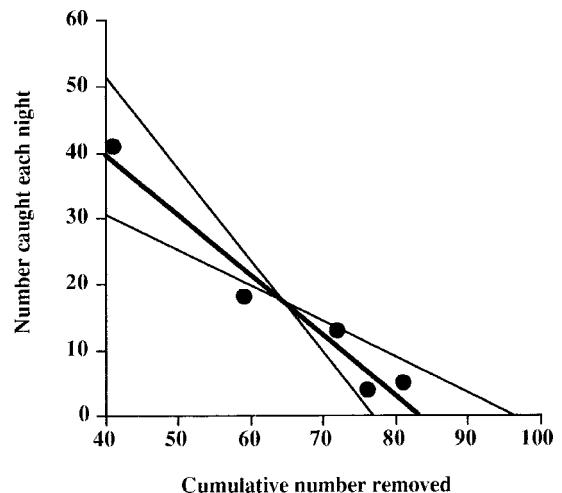


Figure 2: Nightly catch of ship rats (dots) plotted against the cumulative number of rats killed in the Zippin removal method experiment at Kaharoa in January, 1994. The simple linear regression is given by the bold middle line. The upper and lower 95% confidence intervals for the regression are given by the outer lines.

before also declining ($n = 12, 9, 11, 1,$ and 2 each day). Fifty six percent of the 80 rats aged (81 rats were caught but one rat was lost and therefore could not be aged or sexed) were adults which were more trappable than juveniles as the numbers of each age class caught on nights 1-2 and 3-5 were significantly different ($\chi^2=4.9, d.f.=1 P=0.0272$). The sex ratio of the rats caught was 45 males: 35 females and showed no significant change over the five days ($\chi^2=0.036, d.f.=1, P=0.8499$). Thirty-two percent of 19 adult females were pregnant.

The minimum density of rats in the study area was 6.5 ha^{-1} (81 in 12.4 ha). When nightly catch was plotted against cumulative catch, a simple regression estimated that 83 rats were present in the 12.4 hectares (6.7 rats ha^{-1}) (Fig. 2). Using the minimum known to have been present, and the upper 95% confidence interval leads to a range of 6.5 to 7.8 rats ha^{-1} . The near-complete removal of the resident rats in five days, evidenced by their disappearance from both traps and tracking tunnels, suggests that the estimate of the total number present at the beginning of the experiment was reasonably precise.

The nightly tracking rate was then plotted against the absolute density of rats calculated to have been still present on each successive night of the removal experiment (Fig. 3). A simple linear regression explained 98% of the variance ($P<0.01$, Fig. 3).

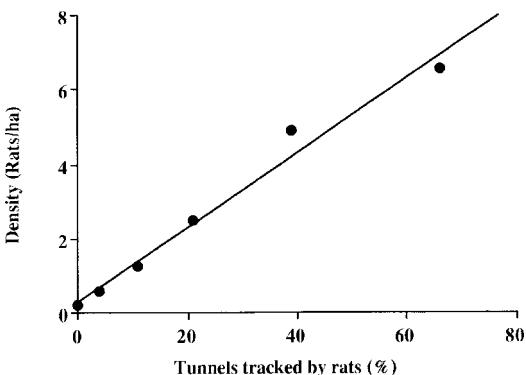


Figure 3: Calibration of nightly tracking rate against number of rats still alive in successive nights of the Zippin removal method experiment at Kaharoa in January, 1994. The absolute density on each night was calculated as the average of the density at the end of trapping on the previous night, and the density at the end of the current night for which tracking rate was measured. The linear regression of best fit is described by $\text{Density} = 0.293 + 0.100 (\% \text{ tunnels tracked})$.

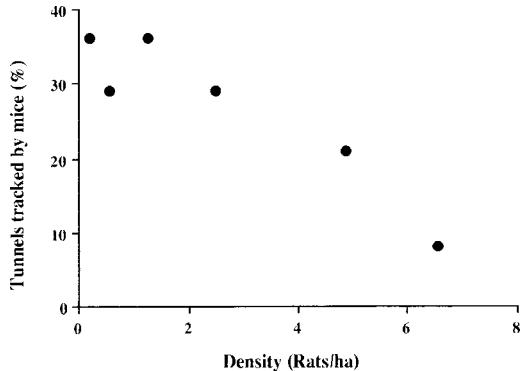


Figure 4: Correlation between mouse tracking rates and density of ship rats still alive as removal trapping progressed.

The rate at which mice used tracking tunnels increased significantly when ship rat density was reduced by extinction trapping, despite progressive removal of mice on successive days ($r^2=0.87$, $P<0.05$, Fig. 4). Two, 3, 3, 6 and 6 mice were killed on successive days of removal trapping.

Discussion

The Zippin removal method used in this experiment assumes: (1) births, deaths, immigration and emigration remain negligible during the period of trapping, (2) the probability of capture is the same for each animal, and (3) the probability of capture remains constant throughout the experiment. Given the short time frame of the removal (5 days) it is unlikely that birth rates, death rates, and emigration influenced our results. Immigration was possible (Innes and Skipworth, 1983) but probably minimal due to the short time frame, small number of rats caught on days 4 and 5, and tight regression obtained ($r^2=0.98$). The unstated assumption why immigration was possible but not emigration is one of a vacuum effect.

Significantly more adult rats were caught earlier in the experiment than later, indicating that adults were more trappable on average than young. However, as with potential immigration, the tight regression obtained suggests that this age effect had negligible influence on the result. The use of constant trapping methods and constant trap placement, and consistently fine weather experienced during the experiment suggest that variation in capture probability from these sources was unlikely.

The tight linear relationship between ship rat tracking rates and ship rat absolute density in this

study was obtained by rapid and artificially imposed changes to the population at only one place. The calibration may not be as accurate at other places and times because of habitat and seasonal influences on home ranges and behaviour. Dowding and Murphy (1994) also showed that home range changed with season. Our calibration was for tracking rates measured on a grid layout, and results may be different had a single line of tracking tunnels been used. Therefore, the results shown in Fig. 3 can not as yet provide managers with a reliable means of determining rat absolute density from tracking rates. We urge that removal trapping experiments be coupled with routine rodent monitoring by tracking tunnels to test the effect of these other variables. However, a very high proportion of variance was explained by the regression, and there was little if any sign of saturation of the tracking rate index even at a rat density comparatively high for mainland forests (Innes, 1990). These are reasons for optimism that the relative index based on tunnel tracking rates is a reliable and cheap method to monitor fluctuations of rat abundance in the same place.

The increases in mouse tracking rates (Fig. 4) as the experiment progressed were similar to the increases in mouse indices that have been reported after ship rat poisoning operations (Innes *et al.*, 1995; Miller and Miller, 1995). They may have been triggered by the removal of rats (Fig. 2) or may have resulted from a learned attraction to baited tunnels and traps. Mouse trapping rates also increased during this study. Mice are neophilic (Crowcroft, 1973), so it is unlikely that they initially avoided the tracking tunnels. Tracking tunnels were in place in the forest 11 days before the removal experiment, so any "new object reactions" were even less likely to have affected mouse behaviour in this study. However, by obtaining food at tracking tunnels mice may have become increasingly attracted to snap traps. Alternatively, scent marking at tunnels by rats could lead to mice avoiding them. It is clear that mice and rats can quickly detect the death of nearby conspecifics (Fitzgerald, Karl and Moller, 1981; Hickson, Moller and Garrick, 1986), so they may be able to do the same between species. Further manipulation experiments are needed to determine whether increased mouse tracking and trapping rates are a numerical or functional response to rat removal.

The impact of rats on mouse population demography and behaviour may depend on microhabitats, especially ground cover. Although mice occur in a wide variety of habitats in New Zealand (Murphy and Pickard, 1990), they are most abundant in areas with dense ground cover, when ship rats and other predators are present (Alterio, 1994; Moller, 1978; C.M. King and J. Innes *unpubl.*

data). The higher numbers of mice in scrubland detected in this study (Fig. 1) may therefore be related to the presence of dense ground cover. Where mice did occur in forest at Kaharoa, they were mostly found near tracks that supported denser ground cover than did surrounding forest.

It is important to determine whether rats affect mouse tracking and snap-trapping rates if such indices are to be used as a reliable means of comparing actual mouse densities. For example, the similar trapping rates of rats observed in forest and scrubland in this study (Fig. 1) may indicate that any behavioural interference (e.g. predation or exclusion through scent marking) to mice is likely to be equal in each habitat. In that case, the major decrease in trap success for mice in forest (Fig. 1) may reflect lower actual mouse density there. But if behavioural interference from rats is much stronger in the absence of dense ground cover, then comparison of densities in the different habitats from tracking rates are likely to be confounded.

If an interference phenomenon does occur, it could affect comparisons of relative density of mice between periods of different rat abundance at the same place and from place to place. In view of the widespread and frequent use of rodent snap-trapping and tracking indices of abundance in New Zealand, we advocate that studies like ours are replicated widely. Only then can we gauge whether tracking and trapping rates reliably estimate rat and mouse abundance, especially where the species interact.

Acknowledgements

Equipment and/or financial support was given by the NZ Lottery Grants Board, Department of Conservation, Landcare Research NZ Limited, James Sharon Watson Conservation Trust, Nga Manu Trust, Native Forest Restoration Trust (Inc.), Otago University and the Ornithological Society of NZ (Inc.). Nicholas Alterio's wages were provided by the University of Otago and a Task Force Green grant from the Employment Service. We would like to thank Kay Clapperton, Colin O'Donnell, Kim King, Rosemarie Patterson and three anonymous referees for their valuable comments on early drafts of this short communication.

References

- Alterio, N.J. 1994 (unpublished). *Diet and movements of carnivores and the distribution of their prey in grassland around yellow-eyed penguin* (*Megadyptes antipodes*) *breeding*

- colonies*. MSc thesis, University of Otago, Dunedin, N.Z. 120 pp.
- Brown, K.P. 1994 (unpublished). *Predation at North Island robin* (*Petroica australis longipes*) and *North Island tomtit* (*Petroica macrocephala toitoi*) nests. MSc thesis, University of Otago, Dunedin, N.Z. 154 pp.
- Caughley, G. 1977. *Analysis of vertebrate populations*. John Wiley & Sons, London, U.K. 234 pp.
- Crowcroft, P. 1973. *Mice all over*. The Chicago Zoological Society, Brookfield, Illinois, U.S.A. 123 pp.
- Dice, L.R. 1938. Some census methods for mammals. *Journal of Wildlife Management* 2: 119-130.
- Dowding, J.E.; Murphy, E.C. 1994. Ecology of ship rats (*Rattus rattus*) in a kauri (*Agathis australis*) forest in Northland, New Zealand. *New Zealand Journal of Ecology* 18: 19- 28.
- Fitzgerald, B.M. 1978. Population ecology of mice in New Zealand. In: Dingwall, P.R.; Atkinson, I.A.E.; Hay, C. (Editors), *The ecology and control of rodents in New Zealand nature reserves*, pp. 163-173. Series No. 4, Department of Lands and Survey Information, Wellington, N.Z. 237 pp.
- Fitzgerald, B.M.; Karl, B.J.; Moller, H. 1981. Spatial organization and ecology of a sparse population of house mice (*Mus musculus*) in a New Zealand forest. *Journal of Animal Ecology* 50: 489-518.
- Fletcher, D.J.; Moller, H.; Clapperton, B.K.; Fechney, T.; Meenken, D. 1995. *Spotlight counts for assessing rabbit abundance*. University of Otago Wildlife Management Report Number 62, University of Otago, Dunedin, N.Z. 43 pp.
- Hickson, R.E.; Moller, H.; Garrick A.S. 1986. Poisoning rats on Stewart Island. *New Zealand Journal of Ecology* 9: 111-121.
- Hooker, S.; Innes, J.G. 1995. Ranging behaviour of forest-dwelling ship rats, (*Rattus rattus*) and effects of poisoning with brodifacoum. *New Zealand Journal of Zoology* 22: 291-304.
- Innes, J.G. 1990. Ship rat. In : King C.M. (Editor), *The handbook of New Zealand mammals*, pp. 206-225. Oxford University Press, Auckland, N.Z. 600 pp.
- Innes, J.G.; Skipworth, J.P. 1983. Home ranges of ship rats in a small New Zealand forest as revealed by trapping and tracking. *New Zealand Journal of Zoology* 10: 99-110.
- Innes, J.; Warburton, B.; Williams, D.; Speed, H.; Bradfield, P. 1995. Large-scale poisoning of ship rats (*Rattus rattus*) in indigenous forests of the North Island, New Zealand. *New Zealand Journal of Ecology* 19: 5-17.
- King, C.M.; Edgar, R.L. 1977. Techniques for trapping and tracking stoats (*Mustela erminea*); a review, and a new system. *New Zealand Journal of Zoology* 4: 193-212.
- Miller, C.J.; Miller, T.K. 1995. Population dynamics and diet of rodents on Rangitoto Island, New Zealand, including the effect of a 1080 poison operation. *New Zealand Journal of Ecology* 19: 19-27.
- Moller, H. 1978 (unpublished). *A weta and rodent study on Arapawa Island*. File report, Ecology Division, DSIR, Nelson, N.Z. 26 pp.
- Murphy, E.C.; Pickard, C.R. 1990. House mouse. In: King, C.M. (Editor), *The handbook of New Zealand mammals*, pp. 225-245. Oxford University Press, Auckland, N.Z. 600 pp.
- Nelson, L. Jr.; Clark, F.W. 1973. Correction for sprung traps in catch/effort calculations of trapping results. *Journal of Mammalogy* 54: 295-298.
- Sandlant, G.R.; Moller, H. 1989. Abundance of common and German wasps (Hymenoptera: Vespidae) in the honeydew beech forests of New Zealand in 1987. *New Zealand Journal of Zoology* 16: 333-343.
- Shaw, W.B. 1985 (unpublished). *The vegetation and flora of part of Kaharoa State Forest (S.F. 33), Rotorua Conservancy*. New Zealand Forest Service Report, NZ Forest Service, Rotorua, N.Z. 18 pp.
- Tanaka, R. 1960. Evidence against reliability of the trap-night index as a relative measure of population in small mammals. *Japanese Journal of Ecology* 10: 102-106.
- Zippin, C. 1958. The removal method of population estimation. *Journal of Wildlife Management* 22: 82-90.