SHIP RATS (*RATTUS RATTUS* L.) IN A *PINUS RADIATA* PLANTATION

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SUMMARY: Unusually heavy rodent interference with apple-baited live-traps set for brush-tailed possums *(Trichosurus vulpecula* Kerr) in a 15-year-old *Pinus radiata* stand prompted an attempt to reduce the local rodent population by snap-trapping. Twenty-two ship rats *(Rattus rattus* L.) were caught in 192 trap-nights in late July 1975 and seventeen of them were collected for autopsy. Stomach contents consisted largely of invertebrate remains, with lepidopteran larvae, wetas *(Rhaphidophoridae)* and bibionid larvae predominating.

INTRODUCTION

Ship rats *(Rattus rattus* L.) were probably the most recent of the introduced rodents to become established in New Zealand (Atkinson, 1973), but are now the most widespread of the three rat species (Taylor, 1978) and occupy a variety of habitats.

Knowledge of the ecology of this rat in New Zealand is based on a few long-term studies, some completed (Best, 1969, 1973; Daniel, 1972, 1973, 1978; Innes, 1979), and some still in progress (B. M. Fitzgerald, pers. comm.; R. H. Taylor, pers. comm.). There have also been a number of shorter trapping studies, several of which are listed by Daniel (1978).

Virtually all of the studies to date have been conducted in native forest of some kind. Despite the increasingly large area planted in exotic conifers (particularly *Pinus radiata),* published information on rats in New Zealand exotic forests does not extend beyond brief mention that *R. rattus* does occur in these habitats (Wodzicki, 1950; Daniel, 1972).

This paper records the results of a brief rat-trapping programme in a central North Island *P. radiata* plantation where there had been considerable interference by rodents with live-traps set for brush-tailed possums *(Trichosurus vulpecula* Kerr).

STUDY AREA

The study area was in a 15-year-old second-crop *P. radiata* stand situated on the volcanic plateau (480 m above sea level) to the east of Tokoroa in the central North Island (38° 16'S, 175° 59'E). This stand is part of a large block established from natural regeneration in 1960 and is surrounded by other *P. radiata,* with no native forest for several kilometres. At the time of the study the stand was unthinned, but evenly stocked, with a stem density exceeding 1000/hectare. The trees had been pruned to a height of 6 m when nine years old, leaving quantities of slash lying on the ground. The understorey was dominated by ferns (particularly *Blechnum capense, Dicksonia squarrosa, Paesia scaberuia* and *Pteridium aquilinum),* with a few shrubs (mainly *Coprosma robusta* and *Coriaria arborea).*

From July 1973 to December 1975 part of this stand, known as the Fox Road area, was used for a population study of brush-tailed possums in pine plantations (Clout, 1977). Cage traps for the live capture of possums were set out at fixed sites on the ground on an 8 x 8 square grid with 35 m spacing. A further 22 possum traps were placed on outlying trap-lines to the north and west of the main grid and parallel with it.

METHODS AND RESULTS

Interference with possum traps

Possum live-trapping was carried out over one three-night session every month from July 1973 to June 1975. The treadle-operated cage traps were baited daily with pieces of apple coated in aniseed-scented flour placed on the floor of the trap behind the treadle. Trap interference data (missing baits, sprung traps) were usually recorded along with details of any possum captures.

In March 1975 the percentage of unoccupied possum traps with missing baits increased greatly to over 90%, considerably more than in previous trapping sessions (Fig. 1). Possums were able to take baits without being caught, but very little of the increased interference in early 1975 was attributable to this because an experimental poisoning operation, using potassium cyanide paste and compound 1080 (sodium monofluoroacetate) in jam baits, had re-

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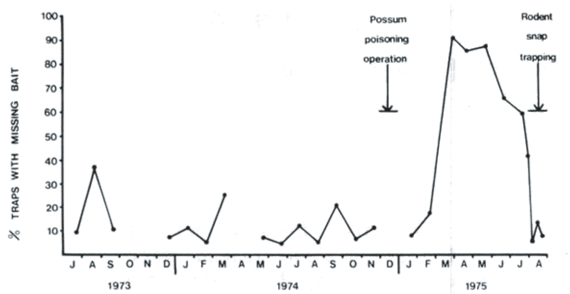

FIGURE 1. *Percentage of unoccupied possum traps with missing baits, Fox Road study area, July 1973 to August 1975.*

moved the previous possum population in December 1974 (Clout, 1977). Rodents, which could take baits and escape through the bars of the cage traps, were suspected of being primarily responsible when rat droppings and pieces of apple peel bearing rodent tooth marks were found near several possum traps with missing baits.

Because removal of baits by rodents seemed to be reducing the chances of possums being caught, it was decided in July 1975 to attempt to reduce the rodent population by snap-trapping and to trap possums in weekly three-night sessions until late August.

Snap-trapping

Preliminary snap-trapping for rodents was conoucted 150 m from the possum live-trapping grid on 23 July 1975, using 12 rat and 12 mouse break-back traps ("Ezeset"), baited with cheese and set for one night. This resulted in the capture of three ship rats, but no house mice *(Mus musculus)*.

Sixty-four rat snap-traps were therefore set out on the central 8 x 8 grid at possum trap sites. They were left in position for a few days and then baited with cheese for three consecutive nights (29-31 July) whilst possum trapping was in progress. The snap-traps were checked every day and cleared and rebaited as necessary.

Twenty-two ship rats were caught over the three nights: 12 (plus one tail) on the first night, five on the second and four on the third. One hedgehog *(Erinaceus europaeus)* was also killed in a snap-trap on the third night. These figures represent a crude capture rate of 11.5 ship rats per 100 trap-nights, which rose to 13.5 per 100 when corrected for sprung traps (Nelson and Clark, 1973).

The rat traps were set again during possum live-trapping in August and some were shifted from the central grid onto the outlying live-trap lines. Ten ship rats were caught, six of them on the central grid. Twelve mouse traps were also set at sites on the central grid during the August trapping, but again no mice were caught.

The snap-trapping appeared to have the intended effect of reducing interference with possum traps. In the late July session the percentage of unoccupied possum traps with missing baits was markedly reduced and in the August sessions it was close to normal (Fig. 1).

Autopsy and stomach analysis

Seventeen of the rats snap-trapped in late July (those from the first two nights) were preserved in 70% ethanol for subsequent autopsy and stomach analysis.

The sample consisted of ten males and seven females. Eight of the males were sexually mature, with scrota] testes and macroscopically visible epididymal tubules, while two had smaller abdominal testes with no tubules visible to the naked eye. None of the females were pregnant, but six of the seven had perforate vaginas and three of these had obvious uterine scars.

Stomach contents were emptied into a small sieve with 1 mm mesh and stirred under running water. A small sample of the contents was stained in a watchglass with Schulze's solution (Peacock, 1940) for a few minutes, turning any cellulose blue. The sample was then spread evenly over a microscope slide, mounted in glycerin, and examined in reflected light under a binocular microscope. The percentage occurrences by volume of various broad categories of food (invertebrate, vertebrate, fungi, other plant) were visually estimated to the nearest 5 % by scanning the slide. App]e (from possum traps) was present in 12 stomachs, but this and fragments of cheese bait were excluded from the estimates of percentage occurrence.

The main food categories were invertebrate remains, fungi and other plant material (including moss and pine needle fragments) (Table 1). No seed or fruit was detected. Definite vertebrate remains (two small grey feathers) were present in one stomach.

Overall, the stomach contents were dominated by invertebrate fragments, which occurred in 16 stomachs, with estimates of percentage occurrence by volume averaging 76%. A more detailed analysis of this part of the diet was therefore carried out, involving the examination of the entire contents of each stomach under a stereo-microscope for identifiable invertebrate remains. Insects were identified to family, with abundance in each stomach being assessed on a three-point scale (Table 2). In

TABLE 1. *Analysis of 17 ship rat stomachs from the Fox Road study area, showing frequency of occurrence of food categories and average percentage occurrence by volume per stomach.*

	Food Category				
	Invert.	Vert.	Fungi	Other plant	Other
Frequency of occurrence: (n = 17)	16	1	12	3	1
Average % occurrence per stomach (and range):	76 (0-100)	trace (0-<5)	14 (0-70)	9 (0-55)	trace (0-<5)

TABLE 2. *Invertebrate remains in* 17 *ship rat stomachs from the Fox Road study area.*

	Lepidoptera				Diptera		Orthoptera (wetas)		Coleoptera	
Stomach No.	Geometridae larvaae	Hepialidae larvae	Tortricidae larvae	Noctuidae larvae	Bibionidae larvae	Muscidae larave	Rhaphido-phoridae	Stenopel-matidae	Pselaphidae adult	Araneida (spiders)
1	***				**		*			*
2	***	*								
3	*	*					*			
4	**		*							
5	***				**					**
6									*	
7		*			***		*			
8							*			*
9		*					*			
10	*	*			*					
11	*	**					*			
12										
13		*						*		
14		*		*		*	*			*
15							*			
16	*	*			*		**			*
17					*					

* = present ** = common *** = abundant

addition to the food items listed, parasitic nematodes were present in four stomachs; three contained two nematodes and the other only one.

Discussion

Diet

The most striking features of the winter diet revealed from the Fox Road sample were the absence of fruit and seed and the preponderance of invertebrates.

The lack of fruit and seed contrasts with the winter diet of ship rats in native forest, where these and other plant foods predominate (Best, 1969; Daniel, 1973; Innes, 1979). This difference probably reflects the relative scarcity of available fruit and seed during the winter in *Pinus radiata* plantations such as the Fox Road stand. The situation may, however, be quite different in summer because *P. radiata* produces large seeds which are palatable to rodents (Badan, 1979), can remain viable within closed mature cones for over six years (Fielding, 1965) and are shed only under hot, dry conditions. The potential therefore exists for the release of large amounts of *P. radiata* seed in unusually hot, dry weather or following fire (Fenton, 1951; Fielding, 1964).

The predominant invertebrate fraction of the stomach contents from Fox Road consisted mainly of lepidopteran larvae, cave wetas *(Rhaphidophoridae)* and bibionid larvae. It is interesting to note that Best (1969) found that the invertebrate fraction of the winter diet in two native forest areas was also dominated by lepidopteran larvae and cave wetas. The bibionid larvae, which occurred in several stomachs from Fox Road, all appeared to be of the species *Philia nigrostigma*. These larvae are gregarious and existed in scattered colonies under damp pine litter in the study area (personal observation).

The two small grey feathers found in one stomach suggest predation on a bird, although scavenging from a carcase cannot be discounted. Ship rats are known to prey on small forest passerines (Atkinson, 1978) and bird remains were detected in stomachs by Best (1969), Daniel (1973) and Innes (1979).

Rat abundance

The crude capture rate of 11.5 ship rats per 100 trap-nights in July 1975 is high compared with other catch / effort results for this species in New Zealand forests (Daniel, 1978). The only higher capture rates on the mainland are those of Beveridge (1964), with a maximum crude capture rate of 22 (average nine) per 100 trap-nights in podocarp forest in the central North Island, and Best (1969, 1978) with a crude capture rate of 13.2-15.8 per 100 trap-nights, also in podocarp forest, on the west coast of the South Island. Several other studies, in a variety of forest types, have all recorded capture rates of less than five per 100 trap-nights (Daniel, 1978; Fitzgerald and Karl, 1979).

Capture rate is influenced not only by density, but also by trappability, so simple comparisons of capture rates may be misleading. For this reason, and because the sample size in this study was small, no strong conclusions can be drawn from the snap-trapping data; they merely indicate that ship rats may sometimes be quite abundant in *P. radiata* plantations.

The data on interference with possum traps are also difficult to interpret. Considering the presence of rat sign, the occurrence of apple bait in rat stomachs and the absence of other potential culprits, it is reasonable to assume that the increased interference from March 1975 was caused mainly by ship rats. Furthermore, the marked rise in interference over that in the previous 20 months suggests that the rat population of the area was higher than usual from March 1975. No reason for this apparent increase can be identified. Climatic records for Tokoroa (N.Z. Met. Service, 1974, 1975) show that the summer of 1974/75 was not especially hot or dry, so it is unlikely that there was an unusually heavy *P. radiata* seedfall which might have caused an increase in rat abundance. The only known disturbances to the area were the possum poisoning operations in December 1974. Because of the timing, it is tempting to speculate that these were linked with the apparent increase (e.g., by secondary 1080 poisoning of rodent predators) but such speculations can be taken no further because of a lack of data.

A feature of the rodent trapping results is that no mice were caught, although ship rats were common. This is interesting, because Badan (1979) found the reverse situation in *P. radiata* plantations near Auckland: no rats were caught although house mice were common. Similar results have been obtained in some Australian *P. radiata* plantations. Kloeden (1973) recorded ship rats, but no house mice, in two Victorian plantations, whereas Suckling *et al*. (1976) and Suckling and Heislers (1978) recorded house mice, but no ship rats, in other plantations in north-eastern Victoria. Barnett, How and Humphreys (1976, 1977), however, recorded both species in New South Wales plantations.

There is clearly much scope for further study of introduced rodents, and the factors governing their abundance, in the extensive monocultures of New Zealand's exotic forests.

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