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Small Mammal Populations in Pine and Native Forests in North-eastern New South Wales

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Abstract

Populations of small mammals were examined in a *Pinus taeda* plantation and moist native forest in north-eastern New South Wales. Although six species, *Rattus fuscipes*, *R. lutreolus*, *R. rattus*, *Mus musculus*, *Melomys cervinipes* and *Antechinus stuartii*, were trapped, only *R. fuscipes* had viable populations in both vegetation types. *R. fuscipes* showed differences in body weight and nipple number in the two habitats, which indicates that different selection pressures may operate on this species in different forest types. *R. lutreolus*, *R. rattus* and *M. musculus* populations were restricted to the plantation area. *A. stuartii* and *M. cervinipes* populations occupied only native forest, although individuals of *A. stuartii* were trapped in the pine plantation. These findings contrast with previous studies in pine plantations in Victoria.

Introduction

The rapidly accelerating use of such intensive forestry practices as woodchip extraction and the establishment of conifer plantations has made it desirable to assess the response of various fauna to these practices.

Mammal populations subjected to extrinsic perturbations such as low- and high-intensity fires (Leonard 1970; Christensen and Kimber 1975; Newsome *et al.* 1975) and habitat destruction (Tyndale-Biscoe and Smith 1969) have been examined. Work in Victoria (Warneke 1971; Suckling *et al.* 1976) has suggested that severe habitat alteration may not be detrimental to the long-term survival of small mammal populations which colonize pine plantations in areas formerly occupied by native forest.

This paper presents data on the population biology of small mammals occupying pine plantations and adjacent wet sclerophyll–warm temperate rain forest in the north-east of New South Wales.

Methods

Study Area

The study area was at Clouds Creek in north-eastern New South Wales, where a 950-ha *Pinus* spp. plantation has been established on a site formerly occupied by wet sclerophyll forest and rain forest. The major vegetational components of the area have been described (Barnett *et al.* 1976).

Trapping

After 1500 trap nights of survey trapping in February 1975, two contiguous 'main' grids (10 by 10 traps with 25-m spacing) were established across the interface of the pine plantation and native forest. The 'pine' grid, established in a 6-year-old *Pinus taeda* L. planting, was extended in May 1975 from 6·25 ha to 7·50 ha. The 'native' grid, initially covering 6·25 ha of rain forest and we

sclerophyll forest, was extended to 7·25 ha in May 1975 and 10·90 ha in August 1975. These extensions were made in order to increase the number of individuals of all species caught, to extend the pine grid into a *P. radiata* D. Don. planting of similar age, and to incorporate more structural complexity into the main grid area by covering creeks, roads and firebreaks. During May 1975 three minor grids were established in the pine plantation. Two of them had seven by seven traps with 25-m spacing, one in 6-year-old *P. taeda* central to the entire plantation, the other on the periphery of the plantation in 24-year-old *P. taeda* adjacent to Clouds Creek. The third consisted of two contiguous sets of five by five traps with 25-m spacing, across the interface of 5-year-old *P. taeda* and 10-year-old *P. elliottii* Engel. plantings, more than 300 m from the periphery of the plantation.

Trips were made to the study area in February, May, August and October 1975 and in February 1976. The main grids were trapped on alternate nights for 2 weeks on all trips except that in October 1975, when the pine grid was not trapped. The minor grids were trapped for 2 weeks on alternate nights in May 1975, but on successive nights for 1 week during August 1975 and February 1976.

Elliott 'type A' small mammal traps (Elliott Scientific Equipment, Upwey, Vic.) were used and baited with rolled oats and peanut butter. During winter all traps were partly enclosed in polythene bags. Wherever a small mammal was trapped, an additional trap was put out, in order to provide at least one more trap than the number of individuals using that position.

Individuals were weighed and had their reproductive and general body condition recorded at each capture; on initial capture they were toe-clipped to provide individual identification. On their first capture in each trapping period individuals were bled from the optic sinus; their plasma was analysed later to determine their physiological status. These results will be reported elsewhere.

Statistical Analysis

All the data on the movements of the small mammals and data for comparisons of body weight between sexes and age-classes of *A. stuartii* were inappropriate for parametric analysis; therefore, a non-parametric analysis of variance and follow-up procedure was used (Hollande and Wolfe 1973). Other sample means were compared by the method of least significant difference following an analysis of variance using an unweighted means solution (Winer 1971).

Results

Six small mammal species were trapped on the study area: one marsupial, the brown phascogale *Antechinus stuartii* Macleay, and five murid rodents: the bush rat *Rattus fuscipes* (Waterhouse), the swamp rat *Rattus lutreolus* (Gray), the black rat *Rattus rattus* (L), the mosaic-tailed rat *Melomys cervinipes* (Gould), and the house mouse *Mus musculus* L. These species will be dealt with individually.

Rattus fuscipes

This was the only small mammal species which had resident populations in both the pine and native forests. Its distribution in the pine plantation was peripheral, being trapped only in the main pine grid and in the native vegetation adjacent to the creek in the 24-year-old pine grid. In the latter area this species was trapped only during May and August 1975. One juvenile male was trapped in the central pine grids during February 1976.

Over the 12 months that the two main grids were trapped, the size of the population in the pines decreased while that in the native area increased (Table 1). The density was lowest in the pines during August and in the native area during October. Males on both main grids showed a far higher trapping turnover rate, as measured by minimum survival, than did females. Sex ratio was never significantly different from parity.

On the criterion that pregnant and post-partum females had prominent or distended teats (Wheeler 1970; Wood 1971), females over 90 g weight were found to be mature at Clouds Creek. Males over 100 g weight were termed mature. Recently

weaned individuals (30 ± 10 g) were present on the native grid during all sampling periods, with peak numbers in February 1976. Mature females were recorded both with the more usual nipple formula of $2+3 = 10$ and the less usual one of $1+3 = 8$. Of the 14 examined, 67% of those in the pine area and only 25% of those in the native area had the $2+3$ arrangement.

Table 1. Structure, density and minimum survival values for populations of three species of small mammals in native and pine forest

Year	Month	No. of individuals			Density	Minimum survival	
		♂	♀	Total	(individuals ha^{-1})	♂	♀
			R. fuscipes in main native forest grid				
1975	Feb.	1	3	4	0·64	—	—
	May	3	4	7	0·97	0·000	0·333
	Aug.	5	5	10	0·92	0·000	0·250
	Oct.	3	3	6	0·55	0·200	0·600
1976	Feb.	7	8	15	1·38	0·333	0·666
			R. fuscipes in main pine forest grid				
1975	Feb.	8	11	19	3·04	—	—
	May	4	4	8	1·07	0·125	0·182
	Aug.	1	2	3	0·40	0·000	0·250
1976	Feb.	2	1	3	0·40	0·000	0·000
			A. stuartii in main native forest grid				
1975	Feb.	8	13 (4)[A]	21	3·35	—	—
	May	8	17 (7)	25	3·45	0·375	0·538
	Aug.	11	13 (3+)	24	2·20	0·250	0·471
	Oct.	0	7 (3+)	7	0·64	0·000	0·385
1976	Feb.	8	2(1)	10	0·92	0·000	0·143
			M. cervinipes in main native forest grid				
1975	Feb.	3	2	5	0·80	—	—
	May	3	5	8	0·97	0·667	0·500
	Aug.	2	1	3	0·28	0·500	0·200
	Oct.	1	3	4	0·37	0·000	0·000
1976	Feb.	1	3	4	0·37	0·000	0·333

[A] Values in parentheses are numbers of females in their second year.

Table 2. Variation in body weights of mature and immature *R. fuscipes* in native and pine forest
Values are mean weights in grams, ± standard errors, with numbers of individuals in parentheses

Year	Month	Native forest grid		Pine forest grid	
		Immature	Mature	Immature	Mature
1975	Feb.	53·7±12·5 (3)	120·0 (1)	58·1± 3·3 (7)	127·2± 7·1 (12)
	May	62·0±11·4 (3)	112·0± 2·2 (4)	56·0±12·2 (4)	130·8±10·3 (4)
	Aug.	54·7±11·2 (7)	116·0±12·2 (3)	60·0 (1)	140·0± 6·0 (2)
	Oct.	63·3±11·1 (3)	117·0±17·0 (2)	—	—
1976	Feb.	52·7± 8·1 (7)	114·4± 9·2 (8)	88·0 (1)	132·0± 7·0 (2)

Body weights of mature females were greater in pine than in native forest ($P < 0{\cdot}005$); this difference accounts for the higher body weights of mature animals in the pines when populations are compared (Table 2). The maximum male body

weights were 168 g in the native area and 155 g in the pines, while for females they were 110 g and 170 g respectively.

Comparisons of the mean distance moved between successive captures (Table 3) showed that males moved significantly further than females in October ($P < 0{\cdot}005$) and February 1976 ($P < 0{\cdot}05$) but not at other times. There were no significant differences in movement when pine and native areas were compared.

Table 3. Distances moved between successive captures for male and female *R. fuscipes* in native and pine forest

Values are means, in metres, ± standard errors, with numbers of individuals in parentheses

Year	Month	Native forest grid		Pine forest grid	
		Males	Females	Males	Females
1975	Feb.	45·0±23·6 (3)	—	36·1± 5·0 (9)	32·9±8·7 (12)
	May	117·8±28·7 (12)	67·0±12·0 (5)	36·0±13·6 (5)	43·9±6·4 (9)
	Aug.	27·5±20·1 (4)	39·2±24·2 (6)	208·3±92·8 (3)	43·6±4·5 (7)
	Oct.	165·0±23·8 (6)	35·6± 7·4 (11)	—	—
1976	Feb.	166·7±71·7 (3)	46·7±11·7 (15)	—	—

Antechinus stuartii

In the study area, populations of this species were confined to native vegetation. Of the 10 individuals captured on all pine grids, only one was a female and this was associated with the creek-side native vegetation on the 24-year-old pine grid. Males were caught in the pine grids during all trapping periods except October, when no independent males were alive.

Over the 12 months of study 31 female and 27 male *A. stuartii* individuals were trapped on the native forest grid. The size of the population in this area based on known-to-be-alive estimates, and its density, are given in Table 1. The known-to-be-alive population estimates differ from the numbers caught only by one male in May 1975. Three females and four males were found dead in the traps during August, the only month with any trap mortality.

Minimum survival values show that there was a high turnover rate of all individuals on the study area.

The size of litters of seven females examined at Clouds Creek varied between seven and eight, with a mean of $7{\cdot}7+0{\cdot}18$. All females examined had eight nipples. Females which had bred in 1974 comprised between 23% (August) and 43% (October) of the female population in 1975; at least three females in each of these samples had bred the previous year (Table 1).

The death of one pouch young in each of two litters and the loss of one entire litter as a result of a trapping accident, occurred during the October sample period. Marking of the litters during October showed that the only first-year female trapped in February 1976 belonged to this cohort.

There was no significant variation in mean body weight within the first- and second-year female cohorts between trapping periods in February, May and August 1975. Males were heavier ($P < 0{\cdot}01$) in May and August 1975 than they were in February of that year (Table 4).

Second-year females were heavier than first-year females in February ($P < 0{\cdot}01$) and May 1975 ($P < 0{\cdot}005$) but not significantly different in August. Males were

heavier than first-year females ($P < 0{\cdot}01$) in Feburary, May and August 1975, but they were heavier ($P < 0{\cdot}01$) than second-year females only in August 1975 (Table 4).

There was an increase in male movement (Table 4) between February and August 1975 ($P < 0{\cdot}05$) but the increase in movement between February–May and May–August was not significant. Females within age classes moved similar distances during all trapping periods, and only during February 1975 was the comparison between age classes significant ($P < 0{\cdot}05$).

Table 4. Seasonal variation in body weights and mean distance between successive captures of *A. stuartii*

Values are means ± standard errors, with numbers of individuals in parentheses

Year	Month	Males	Females >1 y old	Females <1 y old
		Body weight (g)		
1975	Feb.	27·8± 0·8 (8)	26·5± 1·7 (4)	21·6± 0·5 (9)
	May	35·6± 2·7 (7)	26·4± 1·1 (7)	20·3± 0·7 (9)
	Aug.	37·9± 1·0 (8)	25·7± 0·9 (3)	23·7± 1·5 (3)
	Oct.	—	27·7± 2·7 (3)	32·0 (1)
1976	Feb.	28·2± 2·0 (8)	28·0 (1)	21·0 (1)
		Distance between captures (m)		
1975	Feb.	25·0± 9·1 (6)	68·3±10·1 (6)	35·7± 8·8 (7)
	May	71·3± 8·7 (24)	37·7± 7·9 (13)	56·5±14·0 (13)
	Aug.	133·8±38·2 (4)	80·0±10·2 (10)	52·1± 6·0 (14)
	Oct.	—	50·0±18·4 (6)	56·0±12·8 (5)
1976	Feb.	58·8±13·4 (4)	55·0±20·2 (3)	30·0 (1)

Melomys cervinipes

This species was restricted to the wet sclerophyll forest and rain forest on the main native-forest grid. Two juvenile females of 31 and 37 g were caught on the periphery of the native forest during survey trapping in February 1975, but all individuals trapped on the grid were at least 75 m from the periphery.

Increasing the area of native forest trapped during May and August did not increase the size of the population sampled. Density remained low throughout the study (Table 1). A total of seven males and eleven females were trapped during the year and minimum survival values were low throughout.

Maturity was assessed by the prominence of nipples or scrotal testes and occurred in both sexes at about 60 g body weight. Coat colour changed from smoky grey to light brown as individuals matured. All mature females had a nipple number of $0+2 = 4$. The presence of juveniles (<40 g) in the population only in October and February suggests that breeding was restricted to late winter and spring.

Mature males ($75{\cdot}7\pm6{\cdot}2$ g; $n = 7$) and mature females ($65{\cdot}1\pm1{\cdot}5$ g; $n = 7$) had similar body weights, but the heaviest male (105 g) was considerably larger than the heaviest female (70 g). The distances moved between successive captures were similar in immature males ($58{\cdot}3\pm29{\cdot}2$ m; $n = 13$) and immature females ($55{\cdot}0\pm55{\cdot}0$ m; $n = 2$), and in mature males ($75{\cdot}0\pm16{\cdot}7$ m; $n = 6$) and mature females ($73{\cdot}0\pm13{\cdot}6$ m; $n = 10$). There was no significant differences among any of these movements.

Rattus lutreolus

Nine *R. lutreolus* individuals were trapped a total of 20 times during February and May 1975. All captures were made in the peripheral 37 m of the main pine grid and there was a complete turnover of individuals between trips. Only one male was captured; this was an immature weighing 46 g. Three females weighing over 70 g were observed to have a nipple formula of $2+3 = 10$; females under this weight had undistended nipples. The mean movement between successive captures for *R. lutreolus* was $20 \cdot 5 \pm 7 \cdot 4$ m ($n = 11$).

Rattus rattus

All 21 captures of 18 individual *R. rattus* were in the four pine grids. Six male and two females were snap-trapped in the central pine grids at the completion of the study in February 1976; two had previously been live-trapped in the same area. Immature male *R. rattus* weighing 46 and 54 g were trapped in May 1975 and February 1976. The mean body weight of mature males ($115 \cdot 7 \pm 10 \cdot 0$ g; $n = 6$) was similar to that of mature females ($110 \cdot 3 \pm 12 \cdot 7$ g; $n = 14$) over the year. All females had a nipple formula of $3+3 = 12$.

Mus musculus

This was the third rodent species trapped exclusively in the pine grids. Eight individuals were trapped 13 times in May and August 1975, with a 5 : 3 sex ratio. One juvenile, a male weighing 6 g, was trapped in August. Mean body weights of males ($14 \cdot 5 \pm 0 \cdot 7$ g; $n = 4$) and females ($15 \cdot 0 \pm 1 \cdot 0$ g; $n = 3$) were similar. Females were trapped only in the creekside vegetation on the periphery of the 24-year-old pine grid.

Discussion

Three of the six species of small mammals trapped at Clouds Creek were recorded solely in the plantation area, including both species of introduced rodents, *Mus musculus* and *Rattus rattus*.

The black rat, *R. rattus*, was infrequently live-trapped, but males and females were present on all pine grids. This species was closely associated with windrows in its distribution (unpublished data of the authors), and males greatly outnumbered females in both live-trapped and snap-trapped samples. The distribution of *M. musculus* was restricted to the peripheral 40 m of the pine plantation, and only during August were both males and females caught on either the main pine grid or the grid in 24-year-old pine. This sudden appearance and disappearance of *M. musculus* may be explained by its colonizing abilities (Anderson 1970; Newsome *et al.* 1975).

The distribution of *Rattus lutreolus* was also restricted in both space and time. Little data have been published on this species, but Braithwaite (personal communication) believes the mobile nature of populations of this species could be correlated with the moisture content and penetrability of the soil in which its burrow system is built. No explanation is readily available for the high proportion (66%) of immatures trapped or the absence of mature males.

Melomys cervinipes was semiarboreal (indicated by its behaviour on release from the traps) and restricted to the native forest. The few data available from this study

agree with those already published for this species (Wood 1971; Freeland 1972), the presence of juveniles in October and February suggesting a late winter–spring breeding season. The low densities and minimum survival values for this species may be a reflection of its semiarboreal behaviour and its pronounced dietary preference for foliaceous material (Freeland 1972).

The *Antechinus stuartii* population was restricted to native vegetation, although males of this species were found in the pines throughout most of the year. Many of the biological parameters of *A. stuartii* at Clouds Creek were within the range of those previously recorded (Wood 1970; Leonard 1972) but the density was considerably lower than that of populations in similar vegetation types 40 km south (Fletcher, personal communication) and in subtropical rain forest in south-eastern Queensland (Wood 1970). The timing of the male die-off at Clouds Creek was in late August 1975, similar to that (late August) of more southern populations (Wakefield and Warneke 1967; Leonard 1972) but 3–4 weeks earlier than in south-eastern Queensland (Wood 1970). The mean body weight of males was significantly higher ($P < 0{\cdot}01$) in May 1976 ($46{\cdot}8 \pm 2{\cdot}7$ g; $n = 6$) than in May 1975 (Table 4), which indicates the variations which can occur annually. In February, post-partum females moved significantly further between successive captures than did recently weaned first-year females; the weight differences between female cohorts remained significant until just before the breeding season.

The only small mammal species with viable populations in both native and pine forests was *Rattus fuscipes*, although none were captured in pines more than 300 m from the periphery. The low trapping success for this species ($2{\cdot}6\%$ in 7372 trap nights) is not unusual (Warneke 1971; Taylor and Horner 1973) but, coupled with a low and variable density, leads to difficulties in interpreting data. Juveniles were present on the native forest grid throughout the year, with a peak in February, which indicates a year-round breeding season similar to that in south-eastern Queensland (Wood 1971; Freeland 1972) but different from the spring–summer season of more southern populations (Wheeler 1970; Warneke 1971; Robinson 1976); juveniles were recorded in the pine grid only in February and May 1975.

The subspecies of *R. fuscipes* occurring at Clouds Creek, *R. f. assimilis*, is the only native Australian rodent with a variable nipple formula (Taylor and Horner 1973). The region of overlap between the southern ($2+3 = 10$) and northern ($1+3 = 8$) nipple formulae is in north-eastern New South Wales. At Clouds Creek both variants occur, 57% of females having $1+3 = 8$. Of the 14 mature females examined on both the pine and native forest grids, 75% in the native forest had $1+3 = 8$ nipples, whereas 67% in the pine forest had $2+3 = 10$, and the latter group were significantly heavier than the former. This pronounced difference between female *R. fuscipes* in two habitats, and the very limited movement between the pine and native forests (unpublished data of the authors), suggests a measure of separation between the populations in the two areas.

Small mammal populations at Clouds Creek are, with the exception of *R. fuscipes*, confined either to native forest or pine plantation. The euryphagous rodents *Rattus rattus*, *R. lutreolus*, *R. fuscipes* and *M. musculus* appear better able to adapt to the establishment of pines in north-eastern New South Wales than do the insectivore *A. stuartii* or the semiarboreal folivore *M. cervinipes*. This is in contradistinction to evidence from Victoria (Warneke 1971; Suckling *et al.* 1976), where *R. fuscipes* and *A. stuartii*, as well as *A. swainsonii*, have populations in *Pinus radiata* plantations.

In the temperate forests of Victoria and South Australia *R. fuscipes* changes from a diet of predominantly plant material in winter to animal material in summer (Wheeler 1970; Warneke 1971; Robinson 1976) whereas in subtropical forests in south-eastern Queensland it feeds predominantly on plant material throughout the year (Freeland 1972). It is apparent, therefore, that the same species may respond to similar alterations in habitat in different ways at different localities. The reasons for these differing responses can only be elucidated by a more thorough examination of the environmental requirements of these species in several areas with different habitat modifications.

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