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HABITAT USE BY THE BANDED RAIL

Summary: The distribution of banded rail habitat use in a saltmarsh was measured by recording the rate at which their footprints accumulated. The relationships between habitat use, time of day, state of the tide, and 15 environmental parameters, were investigated using multivariate analysis. Banded rails were most active in the morning and evening and immediately after a tide. They did not venture far from cover and their activity was greatest at low levels on the shore, and amongst certain vegetation types.

The patterns of habitat use are consistent with the rails being most active at times and places where their prey were most readily available.

The absence of banded rails from the south of the South Island may be related to the dominance of *Leptocarpus similis* in saltmarshes there.

Keywords: Banded rail; Rallus philippensis; Rallidae; habitat use; multivariate analysis; saltmarsh; Nelson; New Zealand.

Introduction

Within its range the banded rail *(Rallus philippensis)* is found in a wide variety of habitats including grassland, scrub, forest, mangroves, freshwater wetland, and saltmarsh (Ripley, 1977). However, on the New Zealand mainland it is confined to freshwater wetlands, saltmarshes, and mangroves in the northern half of the North Island, and to saltmarshes in Nelson and Marlborough in the South Island.

As part of a study attempting to explain the distribution of banded rails in New Zealand I investigated their habitat use in a small saltmarsh near Nelson. Previous descriptions have been anecdotal (e.g., Falla, Sibson and Turbott, 1979; Oliver, 1955).

Most previous studies of relationships between animals and their habitats have compared density and distribution over a range of potential habitats, to determine statistically factors which affect habitat selection. In this study I assess the relationships between habitat use and a number of vegetative and topographic parameters within one habitat patch.

Study Area

This study was carried out in a 1.79 ha saltmarsh in a small bay in the western corner of the Waimea Inlet (Fig. 1). This saltmarsh is typical of most used by banded rails in the Nelson region. It is a relatively small, isolated patch, wider at the head of the bay where the shores are gently sloping, but narrower along the sides of the bay where the shores are steep. The vegetation follows a gradient from scrub above the level of high water spring tides, through zones dominated by the rushes *Juncus maritimus* and *Leptocarpus similis,* to mudflat below the level of low water neap tides.

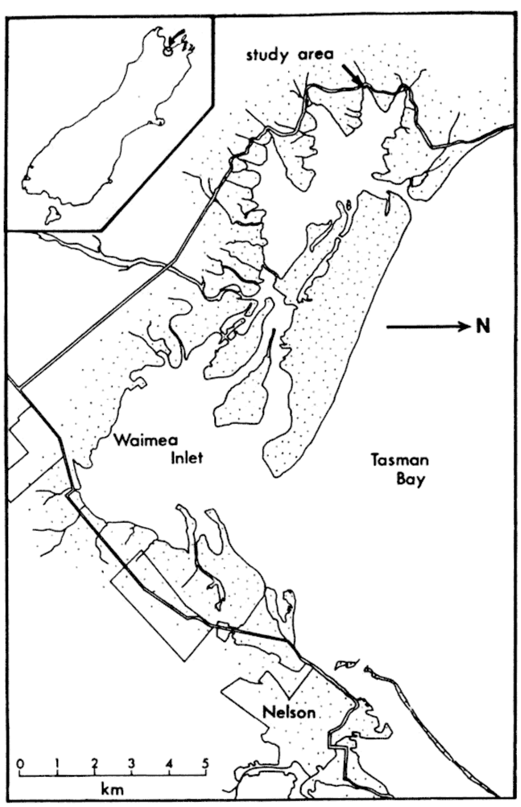

Figure 1: *Waimea Inlet, showing the location of the study area.*

The study was carried out from December 1981 to March 1982, when there were two resident pairs of banded rails and an unknown number of their offspring present.

Methods

Measurements of habitat use and various topographical and vegetative features were made at 94 sample stations each placed 15 m apart in a grid pattern within the saltmarsh (Fig. 2). No stations were more than 15 m seaward or landward of the rushes, because it had previously been determined that banded rails very rarely ventured far from the rushes. Stations could not be established more than 15 m landward of the rushes without destroying the shrubby vegetation.

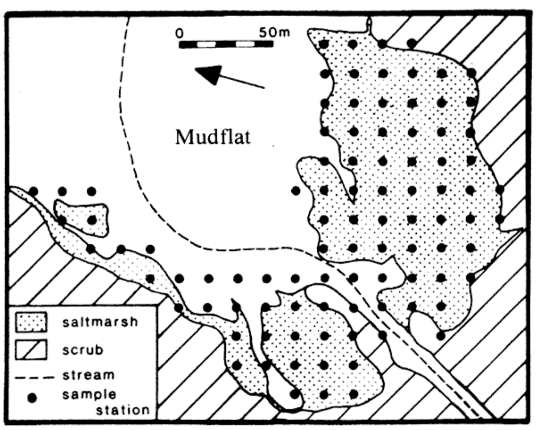

Figure 2: *The study area, showing the location of the sample stations.*

Habitat use

Habitat use was measured by recording the rate at which footprints accumulated at each sample station. At each station a square wooden frame of 0.25 m^2 was placed on the mud and anchored in position with pegs. The frames were 20 mm deep and were filled with fine sand. At most stations a little vegetation had to be removed to accommodate the frame.

Once placed, all frames were checked at irregular intervals of between four and 24 hours from 18/12/81 until 14/2/82 and again from 16/3/82 until 27/3/82. Regular checking of the frames was prevented by the tides, which flooded the saltmarsh at different times each day. Every time the frames were checked the number of banded rail footprints and the length of time the frame had been exposed were recorded. When frames had been covered by the tide or rained upon since the last check, the time exposed was reduced accordingly since both tides and rain obliterate footprints. Only time exposed between half an hour before sunrise and half an hour after sunset was recorded, as banded rails are inactive outside these times. For each check and for each frame a 'footprint rate' was calculated by dividing the number of footprints by the time exposed.

Vegetation sampling

Vegetation data were collected using a modification of Scott's (1965) method. At each station vegetation was sampled at 36 points 1 m apart on a 5 x 5 m grid centred on the sample station. At each point the vegetation was sampled by lowering an 8 mm diameter, calibrated, stainless-steel rod vertically through the vegetation to the ground. The rod was then scanned from ground level to just above the canopy at 5 cm vertical intervals and any plants touching it were recorded. In each 5 cm interval for each group of 36 vegetation samples, the number of "hits" for each species was totalled and divided by 36 to express it as a proportion of the maximum possible number of hits for that species in that interval.

Two biases were inherent in this sampling method and both were corrected for. The first results from the fact that sampling was done with a rod, not a theoretical vertical line with no horizontal dimensions. Unbiased estimates of cover can be produced from such data using a formula modified from Aberdeen (1954):

$$\text{Cover (of one species at one level)} = 1 - (1 - \text{proportion of hits})^{k/v}$$

where k is the area of ground occupied by the plant when viewed vertically from above, and v is the vitual area of the plant, i.e., k plus the area about the plant from which a hit would be recorded.

Most of the plant species in the study area grew in the form of grasses and they could be interpreted simply as linear strips. k was found by measuring the widths and horizontal lengths subtended on the ground of 100 blades of each and finding the average area covered. v was estimated by adding twice the radius of the rod to the average length and width, and multiplying them together to get the area.

The second bias results from the fact that within any height interval each species was recorded only as a hit; the number of hits was not counted. To produce an estimate related to density, as opposed to cover, I used Blackman's (1935) formula:

horizontal area = log(l - cover)$^{-}$1

where the horizontal area of one species at one level is the area of ground covered by that species when viewed vertically from above, plus any area of plant obscured by overlapping plants.

The following set of vegetation parameters, some based on Park (1973), provide quantitative estimates of features of the vegetation likely to be of significance to banded rails:

1. Average canopy height
   This is the average height of the highest hits in each of the 36 samples from around a station.
2. Total cover above 20 cm (TCA20)
   Banded rails stand approximately 20 cm high, hence only vegetation above this height is fully effective in concealing them. TCA20 was calculated as $1 - ((1 - C_{15}) (1 - C_{16}) ...(1 - Cij))$ where Cij is the cover provided by the ith species in the jth level (numbering from the ground). Only levels above 20 cm are included.
3. Estimated stand foliage
   This is the sum of the estimated horizontal area of all species at all levels and is an estimate of total vegetation density.
4. Estimated stand foliage below 20 cm
   This is the estimated stand foliage of all species in the first 20 cm above the ground, which is the area most likely to affect banded rails.
5. Species estimated stand foliage
   This the sum of the horizontal areas of each species at all levels and is an estimate of that species density.

Topographic features

Four topographic measurements were made at each sample station: (1) height of the station above sea level; (2) distance from dry ground, i.e., above the level of high water spring tide; (3) distance from the edge of the mudflat; and (4) distance from vegetation.

Results

Habitat use

There was considerable variation in the footprint rates calculated for each check at each frame, probably because footprint rates varied with the time of day and the state of the tide. To assess the effect of time of day, the day was divided into three periods: (1) Morning (from half an hour before sunrise to 3 1/2 hours after sunrise); (2) Midday (3 1/2 hours after sunrise until 3 1/2 hours before sunset); and (3) Evening (3 1/2 hours before sunset until half an hour after sunset).

For each check, the time that frame had been exposed during each of the periods was calculated and each check was classified as either morning, midday or evening, depending on the period in which the frame had been most exposed. Similarly each check was classified as iether 'tide' of 'no tide' depending on whether or not it had occurred within six hours of the frame being covered by the tide.

Activity was greatest in the morning and evening and just after tides (Table 1) and these differences were significant (two way anova F= 28.02, p<;0.01).

Table 1: *Footprints per hour at different times of day and states of tide.*

TIDE	TIME OF DAY		
	Morning	Midday	Evening
No recent tide	0.0819	0.0467	0.0642
Recent tide	0.2500	0.0895	0.1663

This pattern is not constant throughout the saltmarsh. The different patterns of activity with respect to the time and tide shown at different sample stations indicate that the spatial distribution of activity also changes with time and tide. Activity is not only reduced during the middle of the day but is also more evenly distributed between stations than in the morning and evening (Fig. 3). The pattern is similar with respect to tide (Fig. 4): banded rail activity is greater, and less evenly distributed just after tides.

Those areas with most activity also have the greatest variation in activity; it seems that intense activity is confined to certain parts of the saltmarsh.

Vegetation

Twenty plant species were recorded, though some occurred very infrequently or made up only a very small proportion of the vegetation (Table 2). Only eight of the more abundant species, *Juncus maritimus, Leptocarpus simms, Salicornia australis, Plagianthus divaricatus, Scirpus pungens, Spartina anglica,* grass and gorse *(Ulex europaeus)* were considered further in this study. Three other equally abundant species, *Samolus repens, Bostrichya* sp. and *Muehlenbeckia complexa,* were not considered; *Samolus,* a small herb, and *Bostrichya,* a small alga that grows on rushes, were too short to affect rails; *Muehlenbeckia*

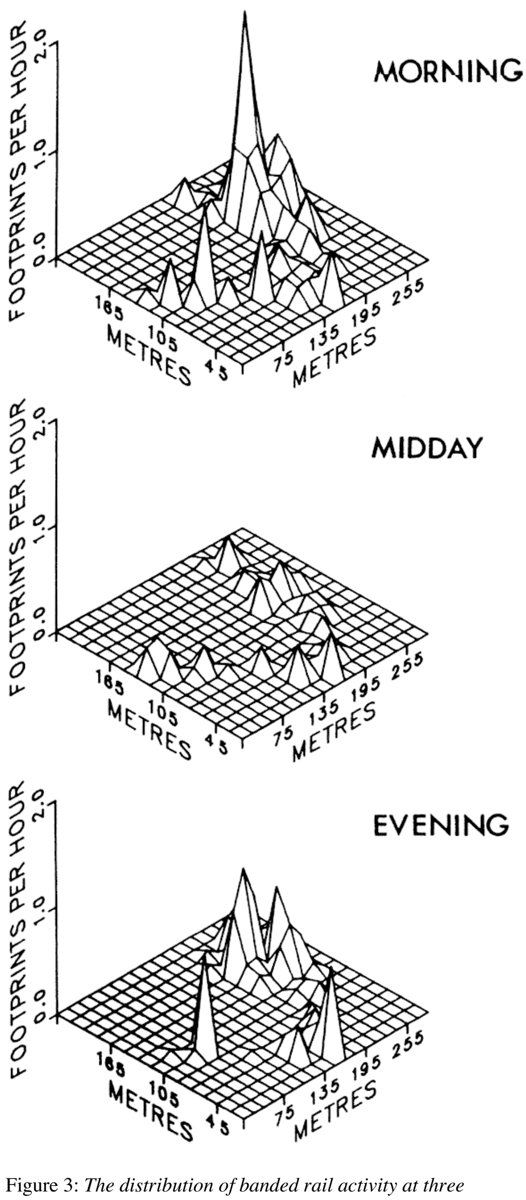

Figure 3: *The distribution of banded rail activity at three times of day. The bottom left axis of each graph is the left axis of Figure* 2.

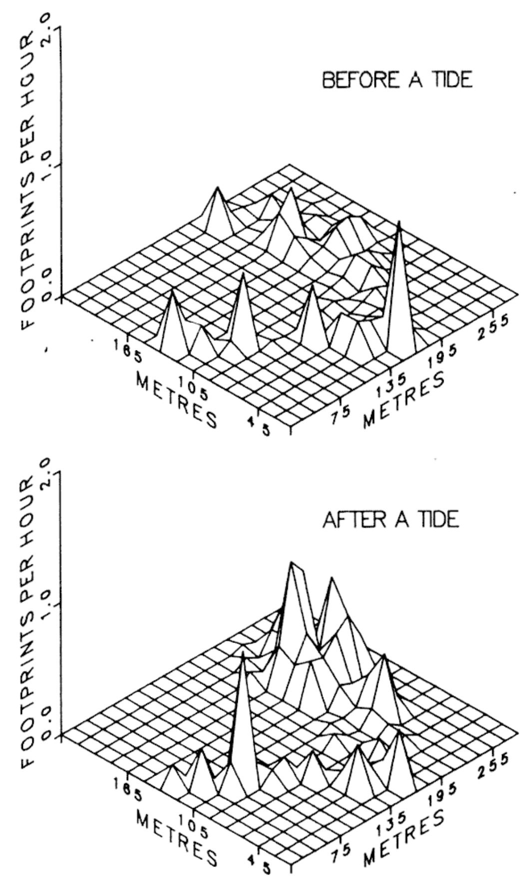

Figure 4: *The distribution of banded rail activity before and after tides. the bottom left axis of each graph is the left axis of Figure 2.*

was always associated with *Plagianthus* from which its effects were indistinguishable.

The vegetation over the study area was far from uniform. Average canopy height and estimated stand foliage below 20 cm both increased toward the landward edge of the saltmarsh. The estimated stand foliage of *Juncus* increased similarly, except that it decreased again at the landward stations. *Salicornia* was confined to the centre of the study area, and *Plagianthus* to landward stations. *Leptocarpus* occurred throughout the saltmarsh but was only important near the landward edge. Gorse, grass,

Table 2: *Percent occurrence and percent of total stand foliage of all plant species.*

Species	% occurrence	% total stand foliage
Juncus maritimus	78.7	39.2
Leptocarpus similis	51.1	11.8
Scirpus pungens	23.4	3.0
Spartina anglica	9.6	1.5
Plagianthus divaricatus	13.8	10.4
Gramineae	19.1	8.6
Salicornia australis	27.7	3.6
Ulex europaeus	8.5	5.9
Samolus repens	26.6	1.1
Bostrichya sp. on *Juncus*	30.9	2.0
Bostrichya sp. on *Leptocarpus*	17.0	0.7
lichen on *Plagianthus*	3.2	0.2
lichen on *Leptocarpus*	4.3	0.1
Muehlenbeckia complexa	9.6	1.0
Rubus fruticosus	5.3	0.2
Triglochin striatum	1.1	<0.1
Selliera radicans	2.1	<0.1
Erica lusitanica	1.1	0.3
Cytisus scoparius	2.1	1.7
algae	1.1	<0.1
debris	31.9	6.1
litter	9.6	2.6

Spartina, and *Scirpus* were patchily distributed; gorse and grass at the landward edge and the other two lower down the saltmarsh.

The relationship between habitat use, vegetation and topography

The relationship between habitat use, measured by footprint rates, and 15 vegetative and topographical parameters measured at the 94 stations was assessed using the generalised linear model of Neider and Wedderburn (1972) and the computer program GLIM (Baker and Neider, 1978). The dependent variable in the model was footprint rate and the independent variables included all the topographic parameters, average canopy height, cover above 20 cm, estimated stand foliage below 20 cm, and the estimated stand foliage of eight plant species. As in multiple regression analysis, variability in footprint rates was partitioned into that explained by the model and that attributed to residual error. Environmental variables were added to the model and their association with footprint rates assessed from their parameter estimates and the resultant reduction in deviance (analogous to sums of squares in multiple regression). A Poisson error structure was used in the model because counts or averages of counts, such as footprint rates, usually have Poisson distributions (Baker and Neider, 1978).

All variables were logged to improve the fit.

The 15 independent variables included in the model were divided into four groups:

1. The height above sea level.
2. Those relating to horizontal position within the saltmarsh vegetation, i.e., distance from dry land, mudflat and vegetation.
3. Those relating to species composition, i.e., the estimated stand foliages of *Juncus, Leptocarpus, Scirpus, Spartina, Salicornia, Plagianthus,* grass, and gorse.
4. Those relating to vegetation structure, i.e., cover above 20 em, estimated stand foliage below 2Ocm and canopy height.

The relative effects of these groups of variables was assessed from the decrease in deviance when the variables in each group were included last in the model; a group was judged to have a separate and significant effect when its deviance was significant. The nature of the effect of each variable (i.e., whether it had a positive or negative association with footprint rate) was judged from its parameter estimate, given that the parameter contributed significantly when

Table 3: *GLIM analysis for morning footprint rates. .**significant at*1%, * *significant at* 5%

Proportion of variation explained by the model = 0.63

Source	D.F.	Deviance	F value	Probability
model	15	19.25	8.88	<0.01
error	78	11.26	-	-
Height	1	1.88	13.02	<0.01
Position	3	3.29	7.60	<0.01
Species composition	8	1.45	1.26	>0.05
Vegetation structure	3	0.79	1.82	>0.05

Variable	Parameter estimate
Height	-2.071**
Distance to dry land	0.455**
Distance to cover	-0.133**
Distance to mudflat	0.017
Average canopy height	0.120
Estimated stand foliage below 20 cm	0.006
Cover above 20 cm	0.213
Juncus	0.034
Leptocarpus	-0.015
Scirpus	-0.031
Spartina	- 0.069
Plagianthus	0.173
Gramineae	0.000
Salicornia	-0.091
Ulex	-0.034

added last to the model. Some other parameters may still have causal effects which are obscured by intercorreiations with those already judged significant.

To explain some of the changes in the distribution of banded rail activity during the day, models were fitted for the morning, midday, and evening footprint rates. In the morning only height above sea level and position within the saltmarsh had significant effects (Table 3), with banded rails most active lower down the saltmarsh near the edge of the saltmarsh vegetation (i.e., far from dry land and close to cover). In the middle of the day, position, structure, and height all had significant effects (Table 4). Banded rails were most active low in the saltmarsh but close to cover or in vegetation that provided good cover. In the evening only height had a significant effect (Table 5) and banded rails were most active in the low reaches.

Table 4: *GLIM analysis for midday footprint rates. ** significant at 1%, *significant at 5%*

Proportion of variation explained by the model = 0.52				
Source	D.F.	Deviance	F value	Probability
model	15	5.72	5.70	< 0.01
error	78	5.22	-	-
Height	1	0.54	8.05	<0.01
Position	3	1.03	5.11	<0.01
Species composition	8	0.64	1.19	>0.05
Vegetation structure	3	0.91	4.52	<0.01

Variable	Parameter estimate
Height	-1.624**
Distance to dry land	0.148
Distance to cover	-0.148**
Distance to mudflat	-0.044
Average canopy height	0.172
Estimated stand foliage below 20 cm	-0.236
Cover above 20 cm	0.889*
Juncus	-0.094
Leptocarpus	-0.078
Scirpus	-0.105
Spartina	-0.051
Plagianthus	-0.082
Gramineae	0.053
Salicomia	-0.070
Ulex	-0.043

Discussion

Banded rails were found to be primarily diurnal with a morning peak of activity and a lesser peak in the evening (Table 1 and Fig. 3), but these two peaks may not occur throughout the year. Two captive rails kept for over a year did not become very active until about an hour after sunrise in winter, whereas in summer they were very active just before sunrise. A late start combined with reduced daylight hours may not give sufficient time for two peaks of activity during the day, and during winter there may be only one. Such a pattern occurs in the black crake *(Porzana flavirostris)* and the cape rail *(Rallus caerulescens)* (Schmitt, 1975, 1976).

The increase in activity recorded after tides (Table 1 and Fig. 4) is probably related to food availability. Two of the banded rail's most important prey are greatly affected by the tide. The crab *Helice crassa* feeds on organic matter it extracts from mud and flotsam left by the tide. Immediately after a tide the mud 'may be easier for the crab to handle and there will be more large, edible flotsam around, so crabs are probably more active and more available to rails at this time. The small snail *Potamopyrgus estuarinus* is washed away from cover during high tides and left scattered when the tide retreats.

If we accept that high activity in the morning and evening are also related to feeding, then changes in

Table 5: *GLIM analysis for evening footprint rates. **significant at 1%,*significant at 5%*

Proportion of variation explained by the model = 0.53				
Source	D.F.	Deviance	F value	Probability
model	15	12.60	5.92	<0.01
error	78	11.06	-	-
Height	1	1.14	8.03	<0.01
Position	3	0.65	1.53	>0.05
Species Composition	8	1.53	1.35	>0.05
Vegetation Structure	3	0.71	1.67	>0.05

Variable	Parameter estimate
Height	-1.969**
Distance to dry land	0.157
Distance to cover	-0.101
Distance to mudflat	0.017
Average canopy height	-0.128
Estimated stand foliage below 20 cm	- 0.335
Cover above 20 cm	0.978*
Juncus	0.250
Leptocarpus	0.014
Scirpus	0.009
Spartina	0.000
Plagianthus	-0.096
Gramineae	0.074
Salicomia	-0.096
Ulex	-0.162

distribution of banded rail activity during the day (Fig. 3) suggest that:

1. In the morning banded rails forage near the mudflat edge of the saltmarsh vegetation.
2. In the middle of the day they feed less and retreat to tall concealing vegetation away from the mudflat.
3. At all times of day they are more active lower down the saltmarsh where the tide floods more often and there is more food.

Though banded rails showed no preference for any particular plants as such, during the middle of the day they did prefer plants of a particular shape (Table 4), i.e., plants that provided good cover. *Juncus,* the dominant species in the saltmarsh, grows in clumps with 'leaves' at an angle to the vertical. It provides good cover and in addition much of the space near ground level is clear, so that banded rails can move without hindrance. In contrast *Leptocarpus* and *Spartina* have vertical 'leaves' which grow densely from rhizomes. They provide little cover and hinder movement. *Salicornia* is short, provides little cover and is very dense near ground level. Grass, gorse and *Plagianthus,* though providing good cover, grow high up the saltmarsh where banded rails seldom venture.

The distributions of two of these species may explain some of the peculiarities of banded rail distribution nationally. *Juncus,* which dominates saltmarshes in Nelson, is replaced by *Leptocarpus* in the southern South Island and there are no banded rails in the large saltmarshes there.

Though the introduced cordgrass *Spartina anglica* was not common in the study area, it is more common in other saltmarshes. Both S. *anglica* and S. *alterniflora,* which has been introduced to northern parts of New Zealand, are vigorous colonisers of mudflats and occasionally replace *Juncus* in the lower reaches of saltmarshes. Where this Occurs saltmarshes may become unsuitable for banded rails.

To summarise, banded rail use of saltmarsh was found to be uneven in both time and space. They were more active in the morning and evening and just after tides than they were at other times. They were most active in the lower reaches of the saltmarsh near the edge of the rush zone in the morning, but they retreated to more concealing vegetation during the day. These patterns seem to be related to the availability of food.

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