

HABITAT USE AND MOVEMENTS OF THE OPOSSUM
(TRICHOSURUS VULPECULA)
IN A PASTORAL HABITAT ON BANKS PENINSULA

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SUMMARY: The habitat use and movements of a population of Australian, brush-tailed opossums, *Trichosurus vulpecula* (Kerr), were studied by live-trapping, spotlighting and radio-telemetry in a mixed pasture, bush and scrub habitat on Banks Peninsula, New Zealand. Resident opossums had distinct ranges that for some animals varied in position and size and, for all, varied in intensity of use of habitat types during the year. Seasonal foods and breeding behaviour were reasons for shifts in ranges and changes in their sizes. Range sizes seemed to be dependent mainly on the location of the animals' requirements rather than behaviour intrinsic to the opossums themselves. Apples and walnuts were highly favoured foods in autumn and attracted resident animals from up to 1600 m away. Pasture was little used by the population. Habitat use results are compared with previous food analysis studies and discussed in relation to the design of opossum control programmes.

INTRODUCTION

The Australian brush-tailed opossum, *Trichosurus vulpecula* (Kerr), was first introduced into New Zealand in about 1840 (Pracy, 1974) and is now widely distributed and abundant. Opossums are found in indigenous and exotic forests, scrubland and pasture, and because of their abundance, feeding habits, and implication in the transmission of diseases, are regarded as a pest in all four habitats.

A knowledge of the movements and range use of opossums helps in an understanding of their ability to adapt to these habitats and is useful in planning control programmes. These aspects of their ecology are still not well known. Dunnet (1956, 1964) interpreted some of the basic movement patterns of opossums in savannah-woodland in Australia. Live-trapping provided insufficient observations to permit him to analyse seasonal changes in movements. In New Zealand, previous movement studies (Winter, 1963, Crawley, 1973), and current research by the Ecology Division of the Department of Scientific and Industrial Research (Bell, pers. comm.) have been confined to native forest or to a forest remnant. No research has been published on opossum movement patterns in a pastoral habitat where movements are likely to differ from those in native forest because of the less uniform distribution of food and shelter.

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Sanderson (1966) and Jewell (1966) have pointed out the need to investigate not just the size of mammal home ranges but also the factors affecting range sizes and habitat use within ranges. This has been the approach attempted in this study.

A preliminary study by the author (Jolly, 1973) showed that changes in opossum movement patterns were induced by seasonal food sources, resulting in seasonal concentrations of animals in particular habitats, for example in and around fruit trees. The present study examined these changes in habitat usage in more detail and followed the changing movement patterns of individual animals throughout the year.

STUDY AREA

The study was carried out in Birdlings Valley* on the western side of Banks Peninsula (Fig. 1). The valley, like most on Banks Peninsula is a mixture of pasture, exotic trees, native forest and scrub. Two patches of secondary-growth, native forest, each of about 2 ha, were included in the 47 ha study area (Fig. 2). Each had a low canopy (12 m maximum), comprising mainly ngaio (*Myoporum laetum*), titoki (*Alectryon excelsus*), mahoe (*Melicytus ramiflorus*), and manatu or lowland ribbonwood trees (*Plagianthus betulinus*). The undergrowth, dominated by korokio (*Corokia cotoneaster*), *Coprosma* species and lianes, particularly *Muehlenbeckia australis*, was

* Birdlings Valley is the unofficial local name.

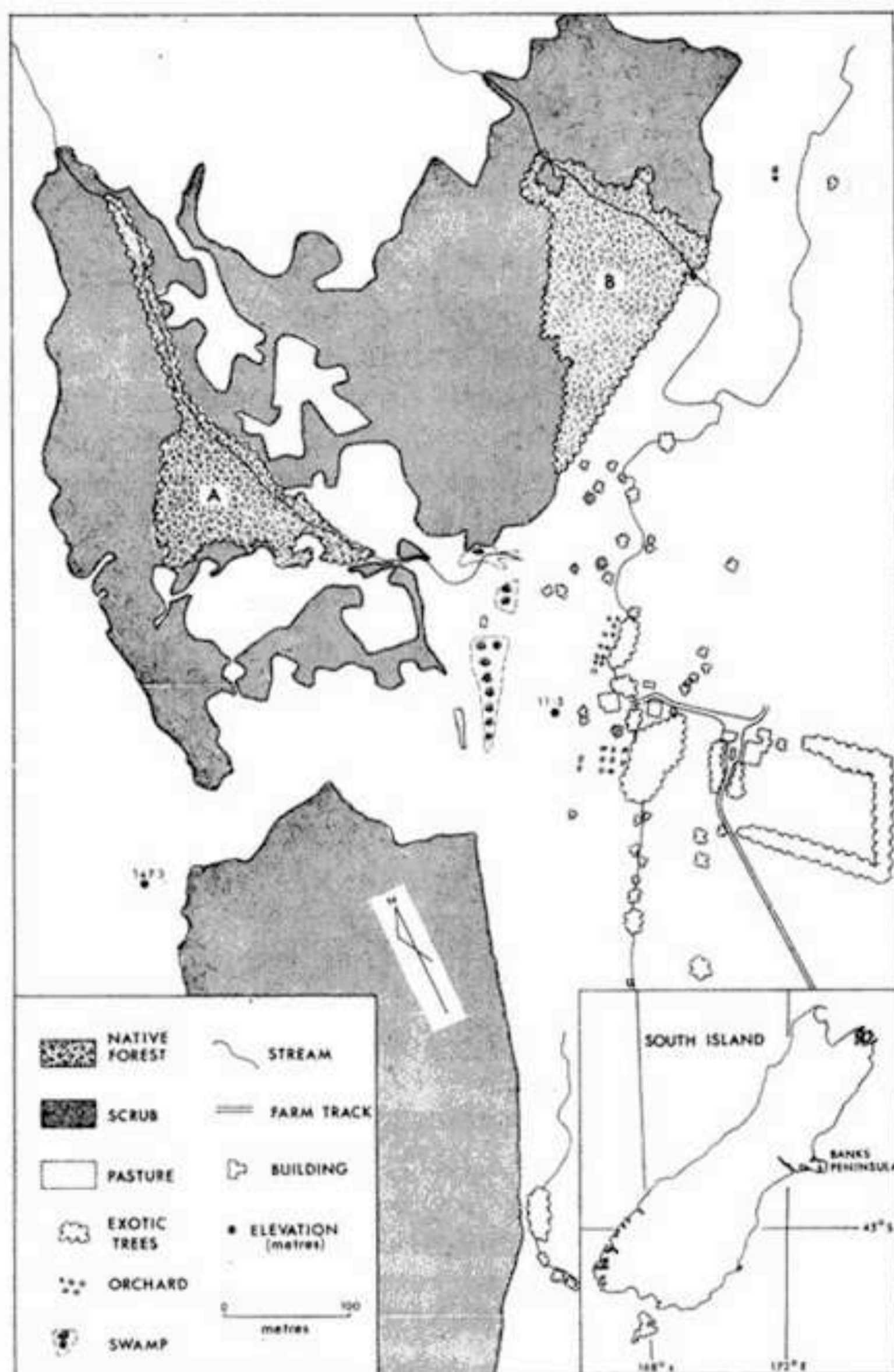


FIGURE 1. Map of the study area at Birdlings Valley on Banks Peninsula showing the distribution and relative areas of the main vegetation types. 'A' and 'B' denote the two patches of native forest referred to in the text.

dense in parts. Elsewhere stock had formed tracks and clear areas.

Surrounding the native forest on the valley sides were dense stands of exotic broom (*Cytisus scoparius*), some gorse (*Ulex europaeus*), some areas of mixed exotic shrubs, particularly hawthorn (*Crataegus monogyna*) and some rough grassland.

The valley floor was mostly poor quality pasture in which cocksfoot (*Dactylis glomerata*), browntop (*Agrostis tenuis*) and white clover (*Trifolium repens*) were abundant. Three paddocks were planted with turnips (*Brassica rapa*) and chou moellier (*Brassica oleracea*). Willows (*Salix* spp.), poplar (*Populus nigra* and *P. alba*), gums (*Eucalyptus globulus*) and macrocarpas (*Cupressus macrocarpa*) were scattered about



FIGURE 2. The study area at Birdlings Valley showing native forest and scrub on the valley side and pasture with exotic trees on the valley floor.

the valley floor. There was also four large walnut trees (*Juglans regia*) and three small orchards containing mostly apple (*Malus* spp.), and stone-fruit trees (*Prunus* spp.).

METHODS

Collection of Movement Data

Field work was carried out from October 1972 to February 1974, usually for one week per month but on alternative weeks during the opossum breeding seasons in autumn and spring 1973.

Three techniques were used for range estimates: trapping, spotlighting and radiotelemetry. Any one of these, used on its own, appeared inadequate in this type of habitat.

(a) Trapping: trapping was necessary for marking and inspecting the animals and provided movement data in all habitat types within the study area. It has the disadvantages that it interrupts the normal activities of the animals and provides little movement data compared with the other techniques used.

(b) Spotlighting: both the animals' positions and the type of activity they were engaged in were revealed by spotlighting. Disturbance of the opossums was minimised by the use of both a dimmer fitted to the spotlight and colour-coded, ear tags which permitted distant identifications of opossums in pasture (at up to 70 m with binoculars). However, in scrub and the low canopy bush, the animals were often disturbed before they could be seen.

(c) Radiotelemetry: the equipment and technique used was similar to that described by Ward (1972),

except that the "Tait CB4" receiver used in the present study received over a greater distance (about 0.75 km in open country). Transmitters were placed on three adult animals of each sex resident in the study area for more than three months. These animals lived in the three main regions within the study area: valley floor, area A and surrounding scrub, and area B and surrounding scrub (Fig. 1). Radiotelemetry permitted the location, and often the activity, of this limited number of animals, to be determined whenever it was required in all habitats.

Interpretation of Movement Data

As opossums use more than one den site, Dunnet (1956) preferred the term "individual range" to that of "home range" to describe the region within which an animal confines its activities. In this study the term was applied to the animal's activities over the whole year, its annual individual range, or over part of it, its weekly or seasonal individual range.

In most movement studies home ranges of mammals have been represented in one of two ways. Either a boundary is drawn around the points of observation (Dalke and Syme, 1938; Blair, 1940; Stickel, 1954), or the probability of an animal being at a certain distance from a point is calculated and the distribution of the animal's activity within its range is assumed to be normal or unimodal (Hayne, 1949; Harrison, 1958; Jenrich and Turner, 1969; Koepl, Slade and Hoffmann, 1975).

Neither method was very suitable for determining opossum individual ranges in the type of habitat in this study area. Opossum ranges did not have fixed boundaries since forays, either to seasonal food sources or associated with breeding behaviour were common. In a "boundary" type of range determination these forays would either be excluded, or would be included along with large areas never used by the opossum. The distribution of activity within their ranges was not necessarily normally distributed or unimodal (see particularly Fig. 3, 22 Aug-30 Oct, and Fig. 6, 8-11 January).

I have illustrated seasonal individual ranges by plotting the actual positions where animals were trapped, seen or radio-located so that each map portrays the actual distribution of activity of the animal as revealed by one or more of the field techniques.

Individual range sizes were calculated by the modified minimum area method of Harvey and Barbour (1965), as used for opossums by Ward (pers. comm.). Outer points less than half the length of the range apart (half the maximum distance between observations) were joined in a clockwise

direction. Points further away were included by connecting them with a pathway assumed to be 1 m wide. This method has limitations in that it assumes a boundary and includes all the area within as part of the range, but it does include seasonal forays.

To analyse habitat use by the opossums the study area was divided into broad habitat categories: orchard trees (including walnut trees), other exotic trees, pasture, native forest, broom, gorse and mixed scrub. Comparative habitat usage was determined by calculating the percentage occurrence of animals in each habitat type and by an analysis of habitat preference. The latter relates the observed frequency of occurrence of an animal in a habitat type to the area of that habitat type within the animal's range. The expected frequency of occurrence in each habitat type, E_x , when the observations of the animal, are distributed randomly throughout the range is given by:

$$E_x = \frac{\text{area of habitat X}}{\text{area of individual range}} \times N$$

where N = total number of observations of the animal.

A second habitat preference index (Franklin, Mossman and Dole, 1975) was used for the population as a whole.

$$\text{H.P.I.} = \frac{\% \text{ of the population occurring in the habitat}}{\text{area of habitat as \% of the study area}}$$

This index also relates frequency of occurrence in a habitat type to the area of that habitat. A habitat preference index of 1.0 indicates no preference and only a random distribution of activity in that habitat.

These habitat preference estimates are approximate because the actual amount of habitat available is not fully represented by measuring its surface area on a map. The largest error, for exotic trees, was reduced by using the surface area of a hemisphere for each tree summed for all exotic trees.

RESULTS

Population Size, Density and Composition

Seventy-eight animals were marked but those present in one season varied from 47 in both winter and spring 1973, to 65 in autumn 1973. The approximate minimum density, estimated by the number of all marked individuals present in the whole study area in any one season, ranged from 1.0 animal per ha in winter and spring to 1.4

animals per ha in autumn. However, the extreme densities, determined from all known marked and unmarked animals, for any one habitat and obtained from average spotlight counts, were 12 animals per ha in autumn and 0.4 animals per ha in winter.

Some animals, mostly young ones, were present in the study area only temporarily, whereas others were resident. The population was therefore divided into residents (present more than three months) and transients.

Individual Ranges and Habitat Use

Nineteen resident animals were recorded more than 10 times; four of these were recorded over 40 times and three over 100 times.

It was found, from animals recorded 40 or more times in any one season, that about 25 records were needed to delimit 90% of an animal's range area and 15-20 records to give 90% of its range

length. These numbers of records were needed within one season since shifts in range occurred between seasons and were obtained for 10 seasonal ranges.

Maps of the individual ranges were taken from sections of the study area map (Fig. 1). They portray the seasonal ranges of four adults, selected as they were frequently-recorded residents in two regions of the study area.

Two seasonal individual ranges of male 41 are shown in Figure 3. This animal was active on the valley floor. Its range size varied considerably, from 0.32 ha in autumn to 1.61 ha in spring.

Throughout autumn he appeared to feed solely in a walnut tree and in willow trees nearby. For part of this season he was mating with a female

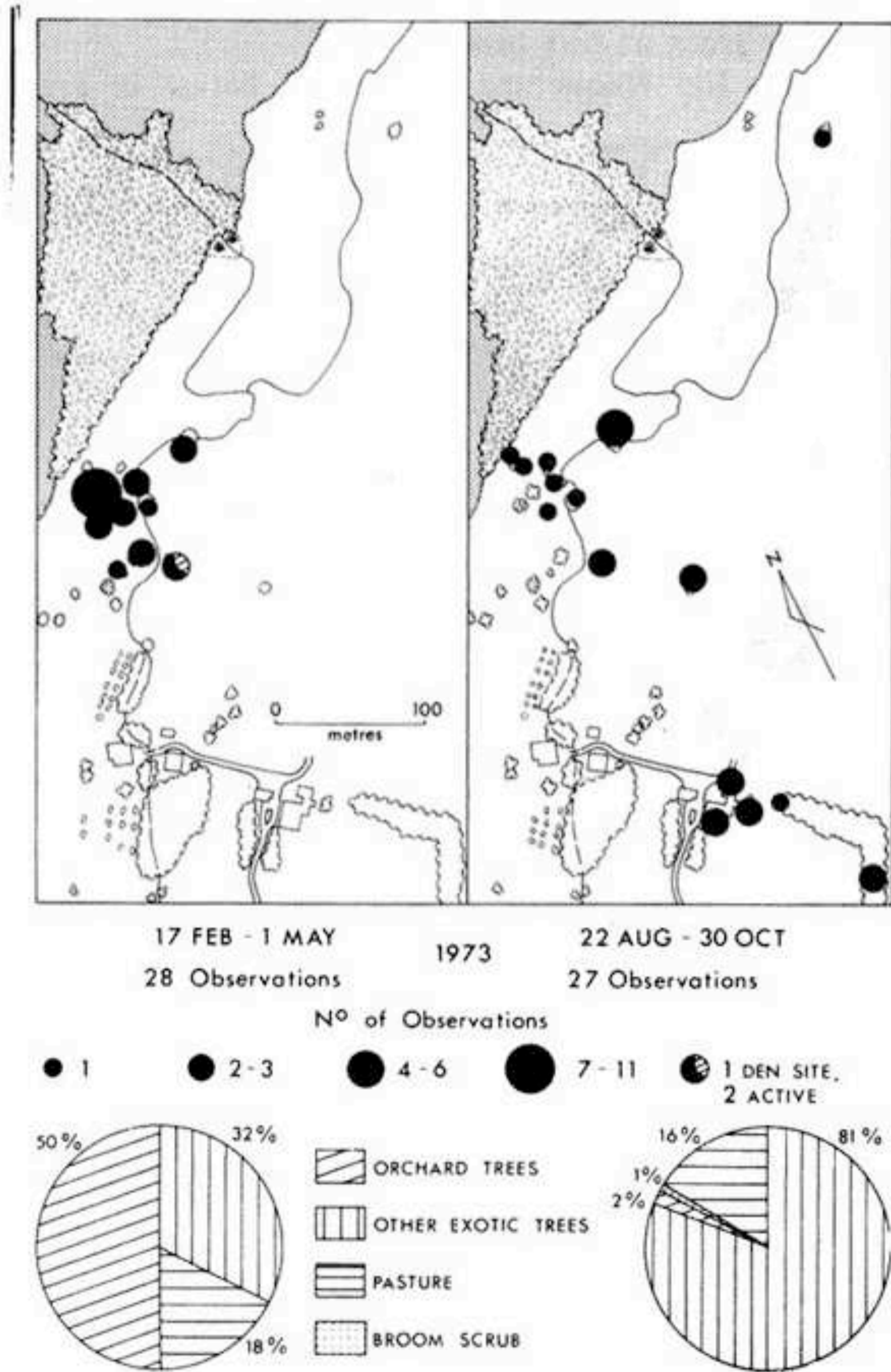


FIGURE 3. Seasonal individual ranges and habitat use by male 41.

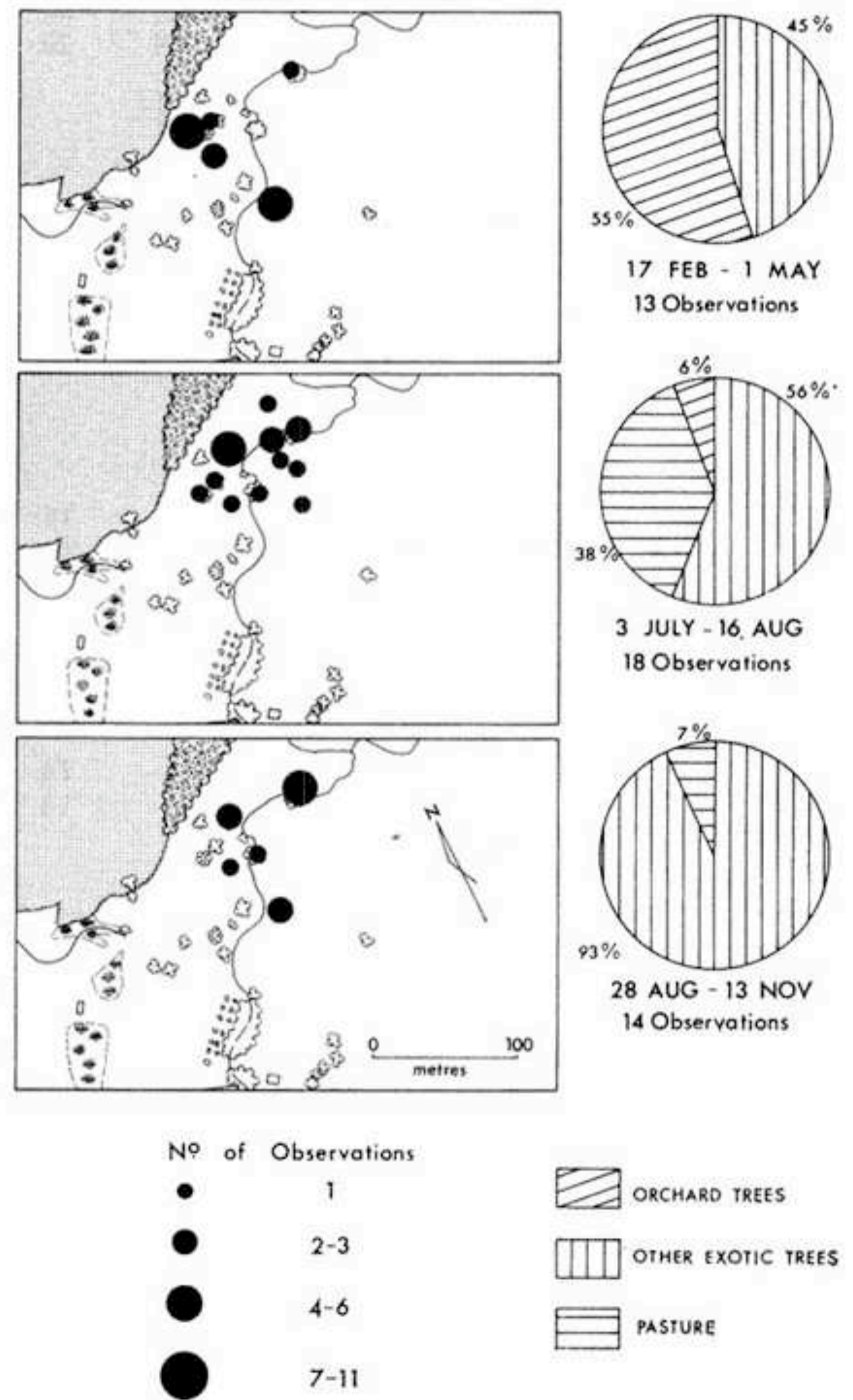


FIGURE 4. Seasonal individual ranges and habitat use by female 40.

TABLE 1. Analysis of seasonal habitat preference of two opossums resident in the pasture and exotic tree sections of the study area.

	Pasture	Orchard Trees	Other Exotic Trees	Native Forest	Mixed Scrub	Total
Male 41 autumn 1973						
O	5	14	9	0	0	28
E	21.0	0.3	3.9	0.8	1.9	28
$\frac{(O-E)^2}{E}$	12.90	672.29	6.58	0.85	1.96	
	$X^2 = 693.87$		$p < 0.005$			
Male 41 spring 1973						
O	2	1	16	0	1	20
E	15.0	0.2	2.8	0.6	1.4	20
$\frac{(O-E)^2}{E}$	11.27	3.20	62.23	0.60	0.11	
	$X^2 = 77.41$		$p < 0.005$			
Female 40 autumn 1973						
O	0	7	6	—	—	13
E	9.6	0.8	2.8	—	—	13
$\frac{(O-E)^2}{E}$	9.36	49.60	3.45	—	—	
	$X^2 = 62.41$		$p < 0.005$			
Female 40 winter 1973						
O	9	1	10	—	—	18
E	12.9	1.1	3.9	—	—	18
$\frac{(O-E)^2}{E}$	2.74	0.01	9.21	—	—	
	$X^2 = 11.96$		$p < 0.005$			
Female 40 spring 1973						
O	1	0	13	—	—	14
E	10.1	0.8	3.1	—	—	14
$\frac{(O-E)^2}{E}$	8.18	0.85	31.95	—	—	
	$X^2 = 40.98$		$p < 0.005$			

whose range was confined to the same small area around these trees. In spring he was seen feeding on the staminate cones of a macrocarpa tree 300 m further up the valley, as well as heavily utilising the same willow trees used in autumn. He was also mating with another more wide ranging female. Pasture was little used as a food source at any time of the year.

Female 40 was the mate of male 41 in autumn. Her range (Fig. 4) varied little in position or size (0.3 ha) throughout the study, and has probably been static for many years; Gilmore (1966) marked

this animal in the same area eight years previously.

In autumn she fed in the same walnut tree as male 41, and like him, was also often observed in other nearby exotic trees. In winter exotic trees, particularly willows which were still in leaf, formed the most used habitat. Female 40 also fed on pasture species in winter, one of the few animals seen to do so at any time of the year. An even higher proportion of her activity was in exotic trees in spring and willows were frequented more than in any other season.

The analysis of habitat preference for both these animals showed that the distribution of their activity was significantly non-random in autumn and spring (Table 1). The high frequency of occurrence of these animals in the small orchard tree habitat in autumn and in exotic trees in spring contributed very greatly to this departure from random. The activity of female 40 in winter was also significantly non-random, largely because of her frequent use of exotic trees at this time.

Female 103 frequented the native forest in area

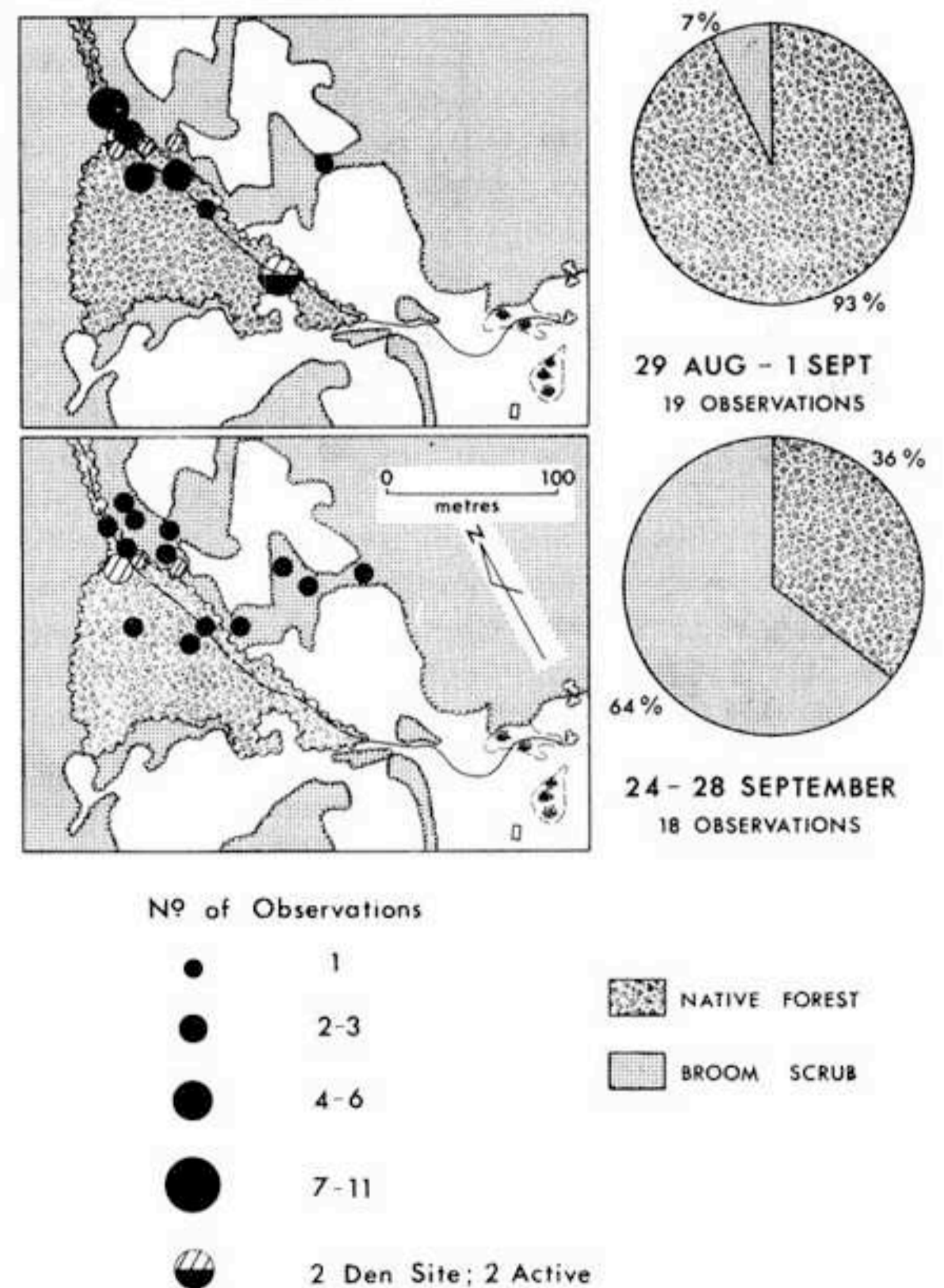


FIGURE 5. Seasonal individual ranges and habitat use by female 103.

A throughout the study. In autumn, however, she also travelled to the walnut trees on the valley floor thus greatly extending her range (range lengths: 241 m autumn; 169 m spring). She was more active within the bush than in the surrounding broom scrub in late August but when the broom came into flower in late September her activity there increased greatly (Fig. 5).

Male 93 was also active in and around the native

forest in area A (Fig. 6). In mid September most of his activity was divided between broom and native forest, while his dens were in "under-runners" on the east side of the creek. In November, most of his activity was in broom high on the west side of the valley and he also found dens there. At this time the broom was in full flower, and appeared to provide much of his food. In January this opossum was again more active in native forest, but he also travelled down to one of the orchards to feed in the early part of the evening. He returned later to feed in the native forest and also used dens high on the valley side. His range was therefore longer in January (405 m) than in November (305 m) or September (265 m).

TABLE 2. Analysis of seasonal habitat preferences of two opossums resident in the native forest and scrub sections of the study area.

	Pasture Trees	Orchard	Native Forest	Broom Scrub	Mixed Scrub	Total
Female 103 29 Aug.-1 Sept.						
O	—	—	13	1	—	14
E	—	—	8.5	5.4	—	14
$\frac{(O - E)^2}{E}$	—	—	2.33	3.64	—	
$X^2 = 5.97 \quad p < 0.025$						
Female 103 24-28 Sept.						
O	—	—	5	9	—	14
E	—	—	8.5	5.5	—	14
$\frac{(O - E)^2}{E}$	—	—	1.47	2.29	—	
$X^2 = 3.76 \quad n.s.$						
Male 93 10-14 Sept.						
O	0	0	6	8	2	16
E	2.1	0.9	3.7	4.3	4.9	16
$\frac{(O - E)^2}{E}$	2.08	0.96	1.46	3.13	1.77	
$X^2 = 9.40 \quad n.s.$						
Male 93 13-16 Nov.						
O	0	0	3	12	0	15
E	1.9	0.9	3.4	4.0	4.6	15
$\frac{(O - E)^2}{E}$	1.95	0.90	0.06	15.60	4.65	
$X^2 = 23.16 \quad p < 0.005$						
Male 93 8-11 Jan.						
O	0	4	11	3	0	18
E	2.3	1.1	4.1	4.9	5.6	18
$\frac{(O - E)^2}{E}$	2.34	7.90	11.37	0.71	5.58	
$X^2 = 28.98 \quad p < 0.005$						

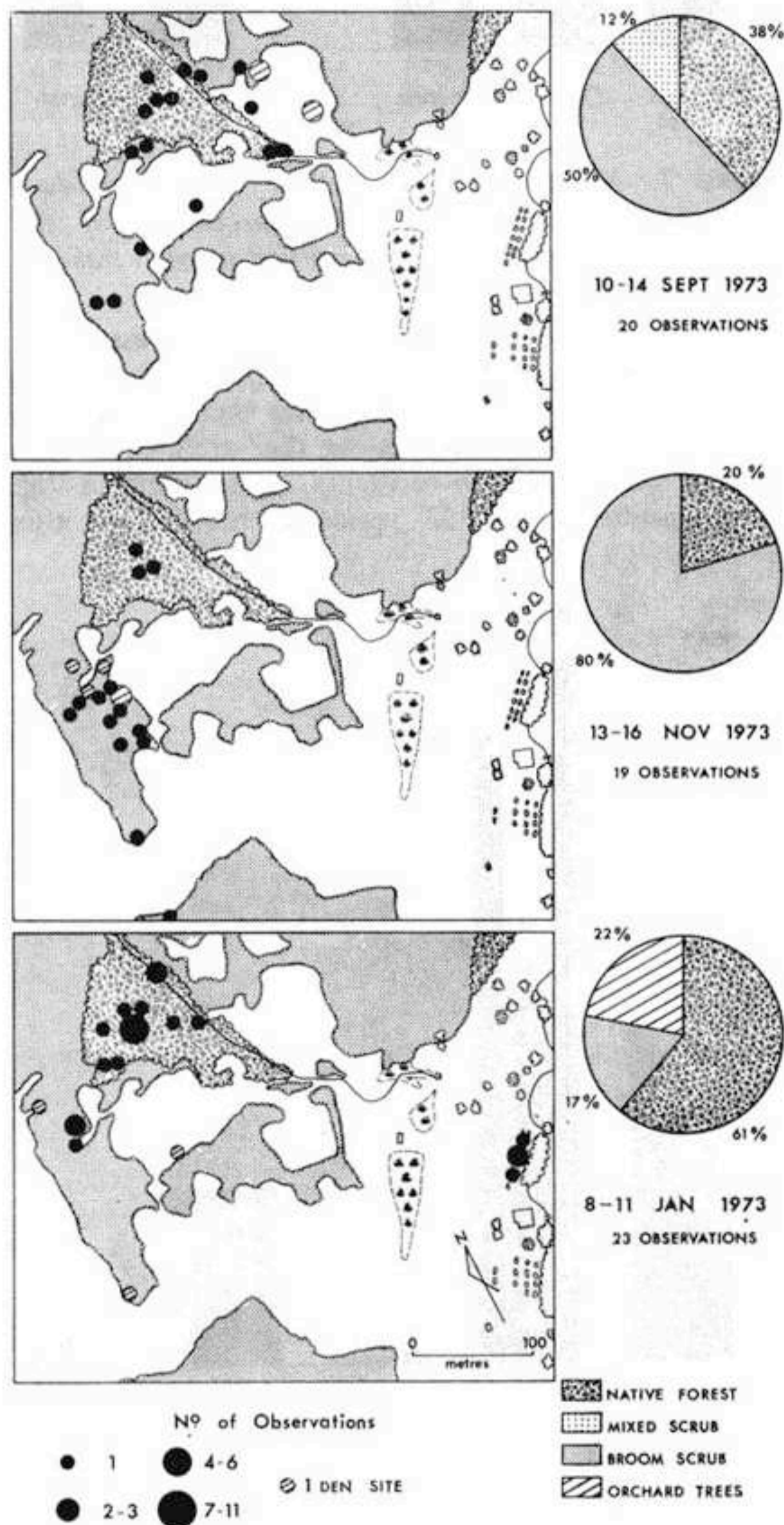


FIGURE 6. Seasonal individual ranges and habitat use by male 93.

The analysis of habitat preference of female 103 (Table 2) showed that the distribution of her activity was significantly non-random at the end of August before the broom came into flower. In late September, when the broom was in flower, her activity was more evenly spread between native forest and broom and did not deviate from random significantly.

The greatest contribution to the significantly non-random distribution of the activity of male 93 came from his frequent occurrence in broom in November and native forest and orchard trees in January.

Size and Permanence of Individual Ranges

Annual range sizes also varied (Table 3). Those of animals resident on the valley floor (male 41; females 40, 111) tended to be smaller than those of animals resident in native forest and scrub on the valley sides (males 48, 93; females 55, 103, 108). The maximum range lengths recorded for the 41 residents were 1600 m for males and 516 m for females. Two males had range lengths of this size, resulting from forays out of the study area to an orchard in the neighbouring valley. In one case, at least, the animal had returned by the following night.

At least some resident animals had long established individual ranges. Three females, that were first caught by Gilmore (pers. comm.) from 1965 to 1967, and all 11 animals marked in 1971 and recaptured in 1973, still occupied the same ranges. Two of those caught by Gilmore were then immature and had therefore occupied the same ranges throughout their adult lives.

TABLE 3. *Annual range sizes of frequently observed resident animals.*

Individual	No. of observations	Range length (m)	Range area (ha)
Male 41	126	550	2.38
Male 48	112	348	3.42
Male 93	115	407	3.64
Female 40	72	110	0.32
Female 111	40	164	0.57
Female 55	64	445	1.24
Female 103	81	241	1.18
Female 108	19	516	1.00

Habitat Usage by the Resident Population

The habitats in which the greatest proportions of residents were observed were exotic trees (gums, macrocarpas and more particularly willows),

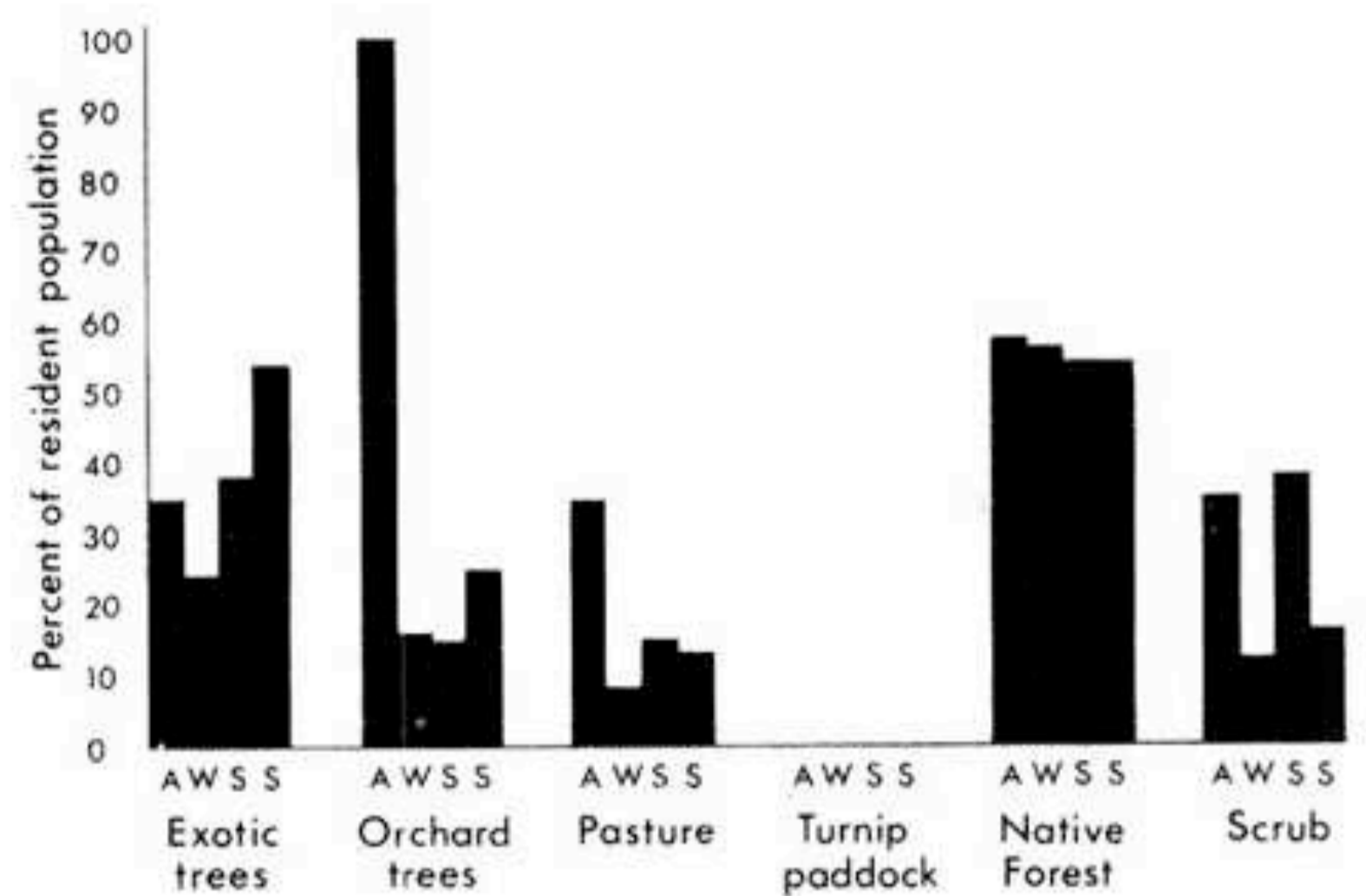


FIGURE 7. *Seasonal habitat usage by the resident population as expressed by the percentage of the resident population that was observed in each habitat.*

orchard trees (apples, pears, peaches and especially walnuts), and native forest (Fig. 7). Pasture was little used and most opossums seen there in autumn were crossing the paddocks to the orchards. Only three animals, all non-residents, were seen in the turnip paddocks. All 23 residents marked at this

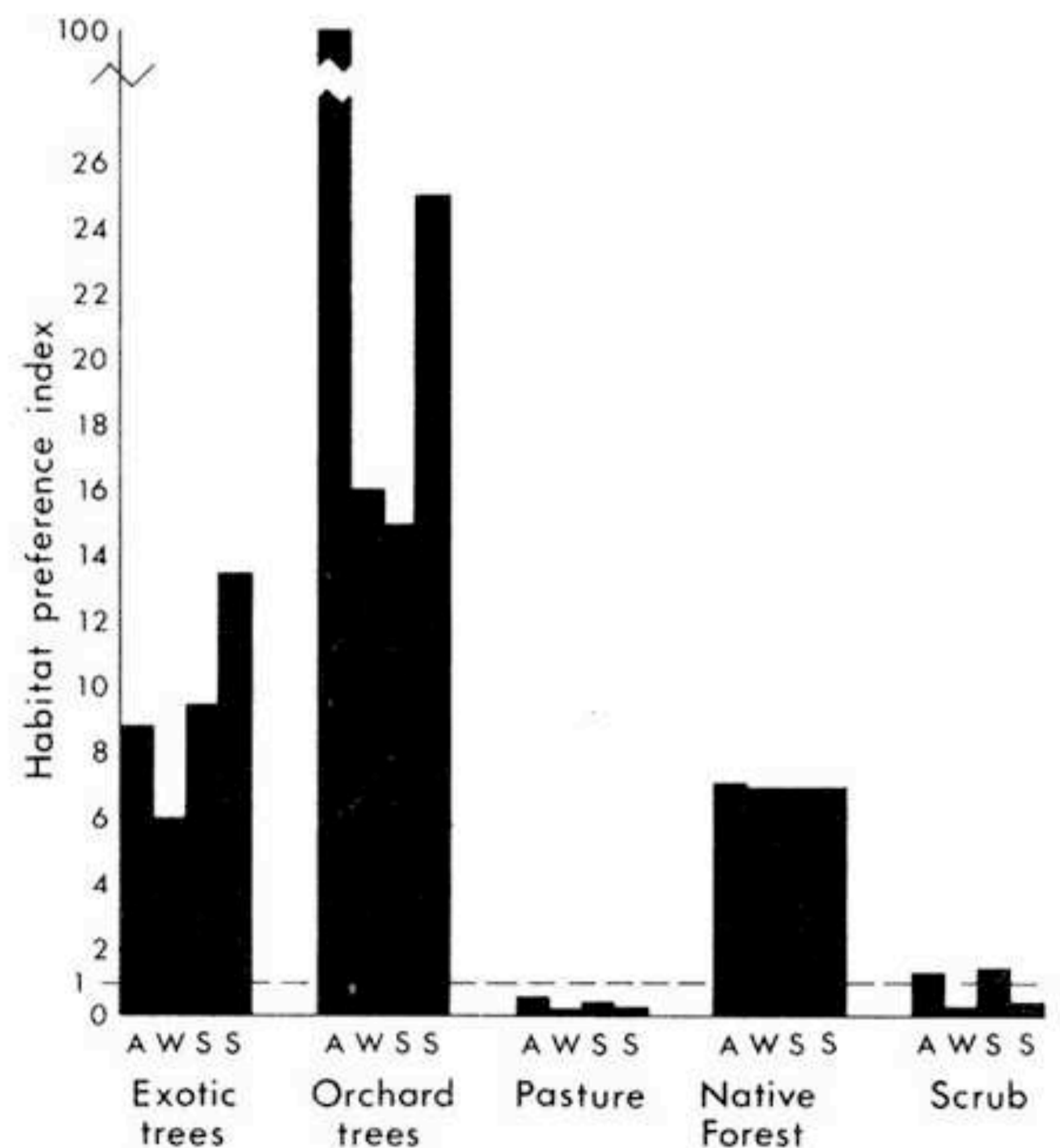


FIGURE 8. *Seasonal changes in the habitat preference of the resident population. The habitat preference index relates the percentage of the population seen in each habitat to the area of that habitat available.*

stage of the study fed in the fruit trees in autumn, including 16 normally resident in bush and scrub. These animals tended to arrive at the fruit trees in the first two hours of darkness and to leave again by 1.00 a.m. Six out of nine additional animals, thought to be resident around the edge of the study area, as well as many transient animals, also fed in the orchard trees.

The habitat preference index for the population is shown in Figure 8.

The habitat most highly preferred during the year was orchard trees in autumn. In winter and spring the animals did not feed in them, but used them as "resting" places. Native forest was also preferred and used to a similar extent in all seasons. The use of bush and scrub is underestimated in both Figures 7 and 8, because it was more difficult to observe animals there than in the more open valley floor habitats. Pasture was not a preferred habitat.

Direct observations also suggested that pasture was not an important food source. Opossums were seen feeding on pasture species on only seven occasions, whereas they were seen feeding in fruit trees on 250 occasions and in willow trees on 80 occasions.

DISCUSSION

In this non-uniform habitat, all resident opossums had distinct ranges that, for some animals, varied in position and size, and, for all, changed in intensity of habitat use during the year. I have suggested that two factors are involved in shifts in ranges: seasonal foods, and breeding.

Long trips to seasonal food sources were detected for all residents in native forest and scrub. This behaviour complicates the assessment of range sizes, particularly the use of mean range size, in this habitat. Seasonal movements should be included in the measurement of individual range sizes, and not considered to be forays out of the range, because seasonal foods are important to the population. Clearly, the position of seasonally available foods affects range sizes, and the latter will differ in other localities. Even within this study area, only the ranges of animals normally resident in native forest and scrub are extended by the utilisation of fruit trees. Animals resident in area A had to travel further to the orchards than those resident on the hillside nearby. Thus a mean range size in this non-uniform habitat has little meaning. Range sizes seem to be determined by the location of the animal's needs rather than by behaviour intrinsic to the opossum itself.

Maximum range sizes are probably more bio-

logically meaningful. They may be determined by the balance between energy spent in travelling to and from a food source, and the energy gained there.

In the small sample of individual range sizes given in Table 3, the ranges of males were larger than those of females (male, 2.38-3.64 ha; female, 0.32-1.24 ha). The maximum range length for all residents was also larger for males (1600 m) than females (516m). The size of male ranges may also be more variable between seasons. This is suggested by the difference between the overlapping ranges of male 41, whose range varied in size considerably between seasons (0.32-1.61 ha), and female 40 whose range size was constant. Similarly, the ranges of female 103 changed little in size when the broom flowered (Fig. 5), whereas the range of male 93 altered considerably (Fig. 6).

Gilmore (1967) found, in a study of opossum foods at Birdlings Valley, that native species comprised the greatest percentage occurrence of foods in faecal samples. Native forest was also a preferred habitat in the present study. Gilmore did not find remains of apples, walnuts or broom flowers in faeces, but felt this was a weakness of the technique. He also found no trace of leaves of willows or other exotic trees, but did not trap extensively over the valley floor (pers. comm.). Exotic trees were found to be a preferred habitat in this study.

Gilmore (1967) and Harvie (1973) who studied opossum foods in pastoral land near Wanganui, found that pasture species comprised 20-30% of the opossums' diet. In my study the pasture habitat was not preferred and observations of opossums feeding there were rare. No resident animals were seen in the turnip paddocks although turnips appear to be a favoured food elsewhere (Gilmore 1967).

This difference in results occurs partly because of the different methods used. Gilmore (1967) stated that percentage occurrence of foods in faecal samples may tend to overestimate a food eaten frequently but in small quantities. This type of feeding could be underestimated by direct observation. Grasses were present in some places within the bush and scrub, and Gilmore believes (pers. comm.) that the pasture species recorded may have been taken from there, rather than from the paddocks on the valley floor or the large areas of grass on the hillsides.

Harvie (1973) determined the diet of opossums by stomach analysis, and concluded that a considerable quantity of pasture (4.7 kg per ha per day) was eaten, because of the high estimated density of opossums (43 per ha) and the proportion of pasture species in their diet (30%).

This high density was estimated by spotlight counts (Quinn, 1968) and is much greater than equivalent estimates by spotlight in pasture at Birdlings Valley (0.4-12.0 per ha). The difference in densities is one possible reason for the different feeding habits of opossums in the two studies. Other factors could be the quality and availability throughout the year of alternative foods and the quality of the pasture itself. The distance between food and den sites and the "underfoot" conditions may also prevent use of a favoured food. The valley floor at Birdlings Valley was waterlogged throughout the winter of 1973 and this may have deterred the opossums from moving to the turnip paddocks which were on the far side of the valley from native forest and scrub.

The concentration of opossums at highly favoured, localised food sources provides an opportunity where control measures can be applied more effectively and more cheaply than if the effort is spread over a wide area. It is well known that opossums use seasonal foods. This study has shown the extent to which the population used one seasonal food. Some residents travelled 1600 m to seasonal foods.

Elsewhere, winter feed crops, shelter belts of pine trees at the time the pollen is ripe, and small blocks of erosion-control, poplar and willow plantings can be similarly attractive.

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