FOODS OF THE AUSTRALIAN BRUSH-TAILED OPOSSUM (*TRICHOSURUS VULPECULA*) IN AN EXOTIC FOREST

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SUMMARY: Foods of the Australian Brush-tailed opossum, *Trichosurus vulpecula,* were identified from stomach contents of 360 opossums collected from May 1975 to May 1976 in Ashley State Forest, Canterbury, New Zealand. Plant species eaten were identified with the aid of reference cuticles prepared from known plant species collected from the study area. Thirty different foods were identified, but only seven were eaten extensively. These were broom *(Cytisus scoparius)* leaves and flowers, blackberry *(Rubus fructicosus)* leaves and fruit, *Pinus radiata* pollen cones, gorse *(Ulex europaeus)* flowers, and grasses.

The opossums showed seasonal preferences for certain food species. Pine pollen was preferred during late winter and spring, blackberry leaves during summer, and grasses and seeds during autumn. Broom leaves formed a large proportion of the diet in all seasons. Huhu beetles *(Prionoplus reticularis)* and nematoceran larvae were also eaten.

There was no evidence in Ashley Forest of opossums causing economic damage to the pine trees.

INTRODUCTION

The adverse effects of opossums *(Trichosurus vulpecula* Kerr) on vegetation in various habitats within New Zealand have been apparent for many years. Kirk (1920) recorded damage caused by opossums to orchards, plantations, gardens and indigenous forests, while Thomson (1922) listed plant species eaten by opossums in indigenous forest. Subsequent work by Zotov (1947), Kean and Pracy (1949), Wodzicki (1950), Mason (1958), Gilmore (1967), Harvie (1973) and Meads (1976) gave information on the foods eaten in, and the extent of damage inflicted upon, indigenous forests.

There has been no information published on the foods eaten by opossums in exotic forests, although there have been reports that damage to pine trees is substantial in some areas. Bathgate (1973) analysed questionnaire returns which showed that damage to exotic trees occurred from browsing and the removal of leading shoots, bark and buds. In the Tasman Pulp and Paper plantation, ring-barking of three-year-old *P. radiata* trees killed 50 percent of the crop in areas adjacent to indigenous forest.

In New Zealand, the area of exotic forests increased by 22 278 ha in 1977 to a total of 4 288 550 ha. With evidence of damage to pine trees by opossums it appeared pertinent that some study of their effect on the pines should be undertaken and this study was aimed at determining:

1. the importance of *Pinus radiata* in the diet;
2. whether the opossums' feeding habits could result in economic damage;
3. the plant species eaten by opossums in an exotic habitat.

STUDY AREA AND METHODS

The present study was carried out in Ashley State Forest, 40 km north of Christchurch (43° 12' S, 172° 35' E). *Pinus radiata* occupied 63 percent of the 5 000 ha planted, with nine other timber species planted over the rest of the area. Among mature stands there were large numbers of fallen trees. Understorey vegetation included large areas of broom *(Cytisus scoparius)* and gorse *(Ulex europaeus),* which were present prior to afforestation, with indigenous species such as wineberry *(Aristotetia serrata),* black matipo *(Pittosporum tenuifolium)* and karamu *(Coprosma lucida).* Bracken fern *(Pteridium aquilinum)* and blackberry *(Rubus fructicosus)* were predominant in some gullies, while in others the original cover of mountain beech *(Nothofagus solandri* var. *cliffortioides)* remained.

The stomachs of fifteen opossums were collected each fortnight from May 1975 to May 1976 inclusive,

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TABLE 1. *Percentage frequency of occurrence of plant fragments identified from opossum stomach contents.*

Season	Foods eaten		Percentage frequency of occurrence
Winter	*Pinus radiata*	pollen cones	24.4
	Pinus radiata	leaves	10.4
Broom	*Cytisus scoparius*	leaves	17.3
Broom	*Cytisus scoparius*	flowers	7.1
Sheep's sorrel	*Rumex acetosella*	leaves	8.2
Blackberry	*Rubus fructicosus*	leaves	7.5
Grasses	(sp. undetermined)	leaves	5.7
Gorse	*Ulex europaeus*	flowers	5.2
Pohuehue	*Muehlenbeckia australis*	leaves	3.5
Sow thistle	*Sonchus oleraceus*	leaves	0.7
Seed tests	(sp. undetermined)		0.5
Hawksbeard	*Crepis capillaris*	leaves	0.5
Wood groundsel	*Senecio sylvaticus*	leaves	0.4
Fungi			0.3
Woolly mullein	*Verbascum thapsus*	leaves	0.2
Nematoceran larvae			0.2
Wineberry	*Aristotelia serrata*	leaves	0.1
Unknown			1.1
Spring	*Pinus radiata*	pollen cones	41.7
	Pinus radiata	leaves	1.1
Broom	*Cytisus scoparius*	flowers	14.7
Broom	*Cytisus scoparius*	leaves	13.0
Gorse	*Ulex europaeus*	flowers	9.3
Grasses		leaves	6.0
Douglas fir	*Pseudotsuga menziesii*	pollen cones	4.9
Blackberry	*Rubus fructicosus*	leaves	1.8
Nematoceran larvae			0.5
Dichondra	*Dichondra* sp.	leaves	0.4
Woolly mullein	*Verbascum thapsus*	leaves	0.3
Clover	*Trifolium repens*	leaves	0.3
Cudweed	*Gnaphalium* sp.	leaves	0.2
Sheep's sorrel	*Rumex acetosella*	leaves	0.2
Hawksbeard	*Crepis capillaris*	leaves	0.13
Pohuehue	*Muehlenbeckia australis*	leaves	0.08
Sow thistle	*Sonchus oleraceus*	leaves	0.05
Catsear	*Hypochaeris radicata*	leaves	0.05
Unknown			4.2
Summer Blackberry	*Rubus fructicosus*	leaves	30.0
Broom	*Cytisus scoparius*	leaves	26.3
Broom	*Cytisus scoparius*	flowers	9.3
Grasses		leaves	9.0
Pohuehue	*Muehlenbeckia australis*	leaves	6.7
	Pinus radiata .	pollen cones	4.6
Douglas fir	*Pseudotsuga menziesii*	pollen cones	4.4
Wineberry	*Aristotelia serrata*	leaves	1.8
Sow thistle	*Sonchus oleraceus*	leaves	1.3
Sheep's sorrel	*Rumex acetosella*	leaves	0.9
Nematoceran larvae			0.8
Bush lawyer	*Rubus cissoides*	leaves	0.75

TABLE 1 *Continued*

Season		Foods eaten		Percentage frequency of occurrence
	Clover	*Trifolium repens*	leaves	0.7
	Hawksbeard	*Crepis capillaris*	leaves	0.6
	Dock	*Rumex obtusifolius*	leaves	0.4
	Willow herb	*Epilobium adenocaulon*	leaves	0.4
		Senecio minimus	leaves	0.3
	Huhu beetle	*Prionoplus reticularis*	(adult)	0.1
	Weed groundsel	*Senecio sylvaticus*	leaves	0.05
	Catsear	*Hypochaeris radicata*	leaves	0.05
	Unknown			2.4
Autumn	Grasses		leaves	26.3
	Broom	*Cytisus scoparius*	leaves	21.3
	Broom	*Cytisus scoparius*	flowers	1.7
	Seeds			21.2
		Pinus radiata	leaves	5.9
		Pinus radiata	pollen cones	1.8
	Blackberry	*Rubus fructicosus*	leaves	4.6
	Sheep's sorrel	*Rumex acetosella*	leaves	3.6
	Pohuehue	*Muehlenbeckia australis*	leaves	3.6
	Kotukutuku	*Fuchsia excorticata*	leaves	2.1
	Sow thistle	*Sonchus oleraceus*	leaves	2.0
	Gorse	*Ulex europaeus*	flowers	1.0
	Clover	*Trifolium repens*	leaves	0.3
	Wood groundsel	*Senecio sylvaticus*	leaves	0.3
	Huhu beetle	*Prionoplus reticularis*	(adult)	0.2
	Catsear	*Hypochaeris radicata*	leaves	0.2
	Dock	*Rumex obtusifolius*	leaves	0.1
	Fungi			0.05
	Catchfly	*Silene gallica*	leaves	0.02
	Unknown			2.7

and each was preserved separately by the injection of 20 mls of F.A.A. (formalin acetic alcohol). Each month the thirty stomachs were divided into five groups of six and the contents of each group mixed by shaking for three minutes on a paint mixer. To ensure that mixing was adequate, stratified samples were taken down through the mixture and subsequently tested for uniformity of species composition. No significant variation occurred ($\chi^2 = 21.42$, $p > 0.05$). The methods used for the stomach analysis are after Gilmore (1967) and Dunnet, Harvie and Smit (1973).

A sample of stomach contents was taken and macerated in a solution of chromic and nitric acid (see Dunnet *et al*.. 1973); half of the sample for five minutes or when the first cuticles cleared and the other half for double the time. The two macerating times were used as the plant cuticles varied in their resistance to the solution and therefore needed a lesser or greater time to clear. The two samples were then stained with toluidine blue, and four slides prepared. A graduated mechanical microscope stage was used to move the slide and the plant fragments, as they appeared, were identified. On each slide 50 fragments were identified. For each month, 20 slides were prepared and 1000 identifications made. The cuticles were identified using a reference cuticle collection of plants collected from Ashley Forest.

Presentation of results

The frequency with which different foods occurred in the stomachs was expressed qualitatively as a percentage frequency of occurrence. Frequency may be expressed either as a percentage of the total

number of foods identified or as a percentage of the total number of stomachs examined. Purchas (1975) found that the relative importance of the different foods was substantially the same however they were expressed. For this analysis, the fragments of each species were counted and expressed as a percentage of the total number of fragments counted. An eye-piece grid and micrometer were used in an attempt to correct for size bias in the fragment sizes.

As several of the foods ingested did not have cuticles, quantification of them required other treatment. For instance, the amount of pine pollen ingested was determined from counts of the pollen cone bracts; likewise, as seed identification was difficult, all seeds were grouped. However, the majority of seeds ingested were from blackberries. The relative proportions of the different plants eaten were determined for each month and then for each season.

RESULTS

Of the 44 plant species collected by the author from the study area, 23 were eaten by opossums. Leaves, flowers and fruits were eaten, sometimes two items coming from one plant species. Including insects and fungi, there were a total of 30 food items eaten but only seven featured prominently in the diet: these were grasses (species not determined), broom leaves and flowers, gorse flowers, P. *radiata* pollen cones and blackberry leaves and fruit. The percentage frequency of occurrence of these foods in the diet of the opossum varied seasonally (Table 1).

The number of food items identified in each season was similar, with 17, 18, 20 and 19 known to be eaten in winter, spring, summer and autumn, respectively. Certain foods, however, made a large contribution to the diet and the four main foods eaten in each season (Table 2) constituted 72.4, 83.2, 83.6, and 82.8 percent of the diet in winter, spring, summer and autumn, respectively, while the remaining fraction consisted of 14-17 species.

TABLE 2. *Percentage frequency of occurrence of four major plant species eaten.*

Species	Winter	Spring	Summer	Autumn
P. radiata	34.8	47.7	9.0	7.7
Broom	24.4	27.7	35.6	23.0
Grasses	5.7	6.0	9.0	26.3
Blackberry	7.5	1.8	30.0	25.8
Total	72.4	83.2	83.6	82.8

Most foods were selected seasonally. However, broom leaves were important throughout the year and were the food item eaten most frequently. The grasses, predominantly Yorkshire fog *(Holcus lanatus)* and cocksfoot *(Dactylus glomerata),* were also eaten throughout the year, but contributed significantly to the diet only in autumn.

Fruits and seeds were abundant in the stomach contents during autumn. Blackberries constituted the bulk of the fruit ingested, but several konini fruits (from *Fuchsia excorticata)* were identified. Broom and gorse flowers were eaten extensively, although gorse flowers were absent from the stomachs during summer. The flowers had a percentage frequency of occurrence of 24.0 in spring, so with pollen cones made up 70.6 percent of the diet.

Blackberry leaves were eaten in all seasons but contributed significantly to the diet only in summer. Flat weed species were also eaten throughout the year but the percentage frequencies of occurrence were always less than one percent, except for sheep's sorrel *(Rumex acetosella)* and sow thistle *(Sonchus oleraceus)*. Sheep's sorrel was abundant along road edges and had the greatest local abundance of all the flat weeds.

The opossums were opportunistic feeders and utilised seasonally abundant foods. The types of foods varied through the year, with pollen cones and seeds contributing in only one or two seasons, while leaves constituted a large proportion of the diet throughout the year (Fig. 1).

Pines as a food source

The pines, although the most common trees present, were relatively poor contributors to the diet in providing needles, but during winter and spring the pollen cones were utilised heavily. Pine needles were eaten in winter, spring and autumn, with the highest percentage frequency of occurrence of 10.4 in winter. Although most of the opossums were taken from stands of P. *radiata,* Douglas fir *(Pseudotsuga menziesii)* needles did occur occasionally in the stomachs. Consequently, needles of the two species were grouped together in the results.

Pollen cones appeared on the trees in mid-winter, and during late winter and spring the cones were a major contributor to the diet, with percentage frequencies of occurrence of 24.4 and 41.7 for winter and spring, respectively. Pollen cones were not available during autumn and although needles were available throughout the year they were not found in the stomachs during the summer.

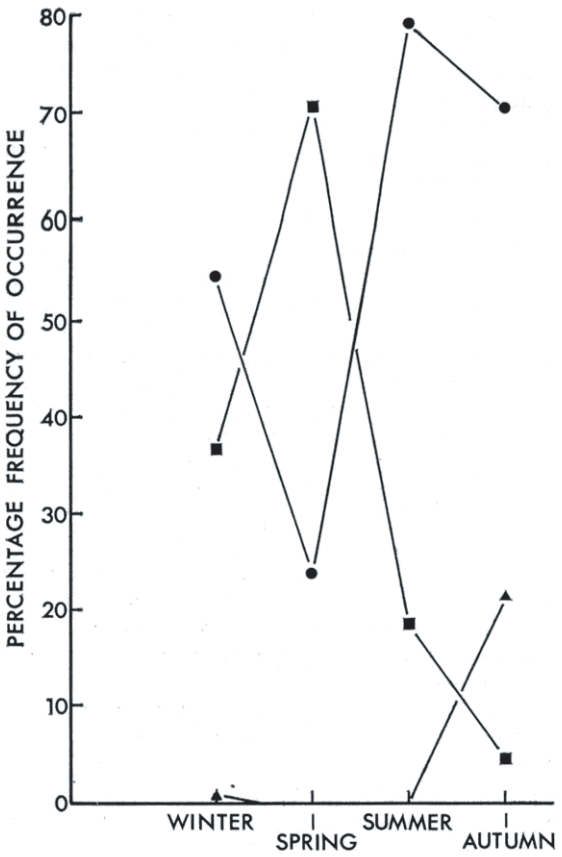

FIGURE 1. *Seasonal variation of percentage frequency of occurrence of leaves (circles), flowers (including pine pollen) (squares), and seeds (triangles).*

Bark and female cones were not identified from the stomach contents. Further, there was no evidence of damage to the pine trees by opossums. The large proportion of pollen cones eaten was not evident from an examination of the trees, but this would be expected as there is a very large quantity of cones available. An inspection of the crowns of trees up to the age of 15 years revealed no damage from bark-stripping. One hare *(Lepus europaeus)* was seen bark-stripping a two-year-old tree and this damage may sometimes be confused with that attributed to opossums.

Miscellaneous food items

During the summer and autumn insects were ingested by opossums. Huhu beetles *(Prionoplus reticularis)* were consistently present in the stomachs, although in low numbers. Huhu beetles were plentiful during summer and as they were slow movers on the ground they could be easily picked up by opossums. Nematoceran larvae were also ingested, and although their percentage frequencies of ocurrence were never greater than 0.8 a small number of stomachs had numbers in excess of 20. These larvae occur in aggregations in the litter layer, which may account for some opossums having large numbers in their stomachs.

Stones were found in a few stomachs.

DISCUSSION

In Ashley State Forest there are few plant species available, compared to the variety available from most other habitats, e.g., 44 identified from Ashley, 140 from an indigenous forest in Westland, J. Polson *(pers. comm.)*. Mason (1958) listed a total of 52 species eaten by opossums in the Orongorongo Valley (Wellington), with some species contributing both leaves and fruit. Even with so few species available, opossums in Ashley Forest showed marked preferences for individual species, for selected parts of plants and also for their seasonal use.

Broom was the most common understorey plant and it was the major contributor to the diet. Gilmore (1967), working on Banks Peninsula, noted the presence of broom in a few stomachs but concluded that it was not a major food item there. Grasses are plentiful throughout Ashley Forest and they were a major contributor to the diet in autumn. Harvie (1973), working in a pasture habitat, found that 30 percent of the intake of opossums was of pasture species and Gilmore (op. cit.) similarly found that grass was eaten in large quantities. Contrary to this, however, Jolly (1976), working in a bush-pasture habitat, found that the pasture habitat had the lowest "habitat preference index". It appears that the consumption of a particular, locally abundant, species may vary between localities and depends on the availability of other palatable species in the same area.

Gilmore (op. cit.) found *Muehlenbeckia* to be an important food throughout the year but to be most important in the spring when there was much new growth present. In this study both *Muehlenbeckia* and blackberry had their lowest percentage frequencies of occurrence in spring, even though new growth was present. The favourability of these two species must have been lowered by the concurrent high preference for pollen cones.

Insects in the diet have been recorded previously by Perham (1924), Gilmore (1967) and Purchas (1975). From the numbers of insects that occurred in some stomachs, it appears that the insects ingested were selected for, rather than ingested fortuitously.

B. D. Bell *(pers. comm.)* noted that opossums actively took moths from around lights.

It appears that opossums are opportunistic feeders, as studies from different habitats have shown that opossums use many plant species as food. The importance of a particular local species appears to be related to the occurrence of other palatables in the same area and the selective preferences for these. Seasonal occurrences of flowers and fruits appear to determine the seasonal diet. The opossums took advantage of flowers and fruits, which made large contributions to the diet in some seasons and negligible contributions in others (Fig. 1). Leaves were available throughout the year, but with the seasonal preferences for flowers and fruits the proportion of leaves in the diet varied inversely with the availability *of* the seasonal foods.

It appears that the opossums could survive by selecting parts of four plant species: 1. *P. radiata;* 2. Broom; 3. Grasses; and 4. Blackberry (Table 2). However, other species were eaten as well, and these may have been important contributors to a balanced diet.

In Ashley State Forest, from examination of the trees, the foods eaten by the opossums, and the past reports of damage, it appears that the opossums are not causing any economic damage. The density of opossums in the area was approximately one per hectare. Constant trapping and poisoning may be holding the opossums at this density, which in turn may account for the lack of damage observed. The amount of understorey vegetation available for food may affect the extent to which the pines are eaten, and therefore it may be advantageous to have an understorey of palatable plant species to reduce the need for opossums to feed on pines.

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