

DIET OF FERAL PIGS IN THE PODOCARP-TAWA FORESTS OF THE UREWERA RANGES

Summary: Samples of stomach contents were collected from 104 feral pigs (*Sus scrofa*) shot in the Urewera Ranges between December 1982 and June 1985. These were sorted into food items which were dried, weighed, and combined to give estimates of their annual and seasonal diets.

Overall 51.80/0 of the pigs' food was obtained by foraging on the ground, 30.6% by rooting, and 17.6% by browsing and grazing. Their annual diet comprised 71.9% plant material and 28.1% animal material, the proportions being similar in all seasons. The fruits of tawa (*Beilschmiedia tawa*), hinau (*Elaeocarpus dentatus*), and supplejack (*Ripogonum scandens*) together made up one-third of the pigs' diet. These were taken seasonally, comprising 60% of their food in autumn, 42% in winter, and 25% in summer. The other major plant foods were the roots of supplejack, the fronds and stems of tree ferns (*Cyathea* spp.), and the rhizomes and roots of bracken (*Pteridium esculentum*); the first two foods were taken mainly in spring and summer. Earthworms and vertebrate carrion, especially the carcasses of brushtail possums (*Trichosurus vulpecula*), were the main animal foods eaten.

It is suggested that periodic fluctuations in pig numbers may be associated with yearly differences in tawa and hinau fruiting.

Keywords: diet patterns; feeding habits; pigs; *Sus scrofa*; podocarp-mixed hardwood forest; seasonal variation; Urewera.

Introduction

The feral pigs (*Sus scrofa*) in New Zealand are descended mainly from domestic pigs introduced by European visitors and settlers during the late 18th and 19th centuries. They quickly established in the wild and by the mid-1800s were widespread and common in many districts (Thomson, 1922). The subsequent conversion of scrubland and cutover forest to farmland destroyed much of their preferred habitat and progressively reduced their range. In 1971 pigs were present on 28% of New Zealand's land area and were generally in low numbers (Martin, 1972). About half of their current range is land used for livestock farming, and half is plantation or native forest and scrubland.

Little is known of the ecology and environmental effects of feral pigs on the main islands of New Zealand. They are occasionally a pest on farmland, rooting up pasture and killing lambs, but have not generally been considered a problem in forests (Bathgate, 1973). Most native hill country forests appear to support few pigs year round, although some are used seasonally by pigs. An exception are the podocarp-tawa forests of the central North Island in

which pigs periodically reach high numbers and decline again naturally. It is not known how these forests support high numbers of pigs, why their numbers fluctuate, or what the implications are for native flora and fauna.

The objectives of this study were to identify the main foods of feral pigs in podocarp-tawa forest; to determine the relative importance of these foods in the pigs' annual and seasonal diets; and to relate these results to the pigs' ecology. The study was based on the analysis of stomach contents of shot pigs.

Study Area

Most of the pigs shot in this study were from the headwaters of the Waimana River in the northern Urewera Ranges; the others were taken in the adjacent Whakatane, Rangitaiki, and Waiau catchments (Fig. 1). This area is mountainous and mainly forested. All the pigs were killed in podocarp-tawa forest, the main forest type in the northern Urewera Ranges.

Podocarp-tawa forest typically comprises a scattering of large emergent rimu (*Dacrydium cupressinum*) and northern rata (*Metrosideros robusta*)

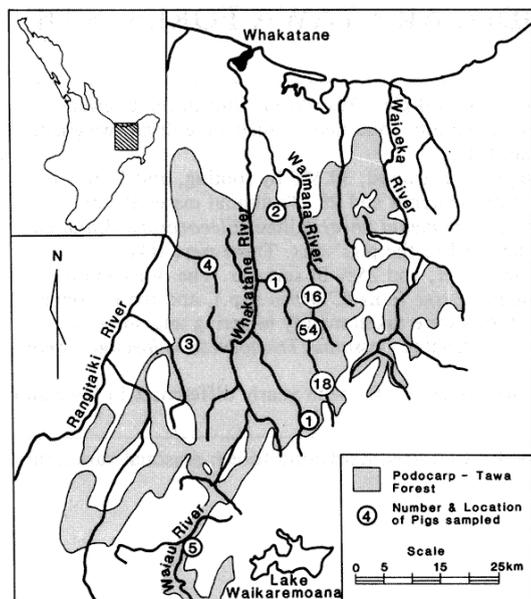


Figure 1: Map of the Urewera Ranges showing the extent of podocarp-tawa forest and the numbers and areas where pigs were shot.

over a dense hardwood canopy predominantly of tawa (*Beilschmiedia tawa*). Other species common in the canopy include hinau (*Elaeocarpus dentatus*), kamahi (*Weinmannia racemosa*), miro (*Prumnopitys ferruginea*) and tawari (*Ixerba brexioides*), and at low altitudes nikau palm (*Rhopalostylis sapida*). The shrub tier contains a wide range of woody species including *Pseudopanax* spp., mahoe (*Meliccytus ramiflorus*), pate (*Schefflera digitata*), and *Coprosma* spp., as well as supplejack (*Ripogonum scandens*) and tree ferns. The ground cover is composed mainly of the ferns *Blechnum*, *Polystichum*, and *Asplenium* spp., and grasses such as *Microlaena avenacea* and *Uncinia* spp. (McKelvey, 1973). Areas burnt in the past are now in successional vegetation of different ages (Payton, Allen and Knowlton, 1984).

Feral pigs have been present in the Urewera Ranges for about 150 years. They have long been hunted for food and recreation, but not intensively enough to have had much effect on their overall numbers. Red deer (*Cervus elaphus*) and brush tail possums (*Trichosurus vulpecula*) are also present in the study area; both species are hunted commercially, the deer

for carcasses and farm stock, and the possums for skins.

Methods

Samples of stomach contents were collected from 104 feral pigs shot by New Zealand Forest Service staff and private hunters between December 1982 and June 1985. A minimum of 25 pigs were sampled in each 3-month season. Only pigs half grown or larger were included.

The samples, which typically comprised 1 litre of contents, were preserved in 10% formalin in the field and stored in plastic bags. Trials with sieves of 2.8, 4.0 and 5.6 mm meshes showed that the 4.0 mm mesh was the most appropriate (based on sorting time, ease of identification, and no significant biases). Subsamples of about 600 ml were later washed over a 4.0 mm mesh and the retained material then sorted macroscopically into food items (method described by Nugent, 1983). The different items were identified to the lowest taxonomic level possible using a reference collection of foods available in the Urewera Ranges. The sorted material was then oven-dried at 85°C to constant weight, and the items were weighed separately to the nearest 0.001 g. No attempt was made to correct these data for differences in fragmentation or digestion of items.

These data are presented as percentage dry weight and as frequency of occurrence. The percentage weights were calculated by converting the weight of each food to a percentage of the total dry weight for that stomach sample, then meaning the percentages for the samples collected in the same season. Occurrence was calculated by expressing the number of samples in which the item was found as a percentage of the number of samples for that season. The seasons were each of 3 months, summer being December to February, etc. Annual diet was estimated by meaning the mean weights and occurrences for the four seasons. One-way analysis of variance was used to test differences in mean weights between seasons. Differences were considered as significant when $p < 0.05$.

Results

Feeding habits

The pigs commonly used three feeding methods; browsing and grazing; foraging on the ground; and rooting (Table 1). Fruits and carrion were the most important foods, providing over half their diet. Rooting was also a major source of food, whereas browsing and grazing provided a comparatively small

part of the pigs' diet. Use of these feeding methods varied seasonally. Foraging was the most productive in autumn and winter when fruit fall was greatest, while rooting, and browsing and grazing were most important in spring and summer.

Annual diet

On average there were five foods in each stomach comprising > 1% of the contents (range 1 to 13), of which one or two usually formed the bulk. The predominant food made up > 50% of the contents of 71 of the stomach samples, and > 80% of 24 samples. Twelve items were found in bulk (i.e., >50% of contents) in one or more of the pigs; these included all of their main foods (see Table 2) as well as several

Table 1 *Feeding habits and main food types of feral pigs.*

Feeding Habit	% Annual Diet	
BROWSING AND GRAZING:		17.6
Fronds & stems of ferns	8.7	
Grasses & herbs etc.	5.7	
Leaves & stems of woody plants	3.2	
FORAGING ON THE GROUND:		51.8
Fruit of woody plants	35.9	
Fungi	0.8	
Vertebrate carrion	15.1	
ROOTING:		30.6
Rhizomes & roots of ferns	5.6	
Roots of woody plants	11.8	
Invertebrates	13.2	
TOTALS:		100.0

Table 2: *Annual and seasonal diet of feral pigs.* ¹Only foods with a mean dry weight > 1.0% of the annual diet were included. Minor foods forming ≥0.01% of the annual diet are listed in Appendix 1. ²Calculated by meaning the frequencies and percentages for the four seasons.

Food Item ¹	% Occurrence	Mean % Dry Weight of Item					Seasonal Difference P
		Annual ² Diet	Annual ² Diet	Summer (n= 26)	Autumn (n= 26)	Winter (n = 27)	
PLANT MATERIAL							
Ferns:							
<i>Cyathea</i> spp. - fronds & stems	78	8.4	12.0	0.4	1.7	19.4	<0.001
<i>Peridium esculentum</i> - rhizomes & roots	8	5.5	3.4	-	9.6	9.1	NS
Monocots:							
<i>Ripogonum scandens</i> - roots	60	11.5	17.0	1.0	3.4	24.7	<0.001
<i>Ripogonum scandens</i> - fruits	62	2.9	1.6	0.1	3.9	5.8	<0.01
Herbs:							
<i>Cirsium</i> spp. - whole plant	38	1.9	1.2	1.2	0.4	4.9	NS
Trees & Shrubs:							
<i>Beilschmiedia tawa</i> - fruits	86	21.4	23.4	36.4	23.6	2.3	<0.001
<i>Elaeocarpus dentatus</i> - fruits	34	9.5	0.1	23.2	14.7	Trace	<0.001
<i>Ixerba brexioides</i> - leaves	60	1.3	0.2	0.6	3.7	0.7	<0.01
Identified minor plant foods:		7.3	9.7	7.3	9.4	2.7	
Unidentified plant material:		2.2	2.8	3.9	1.3	0.9	
PLANT SUBTOTALS:		71.9	71.4	74.1	71.7	70.5	
ANIMAL MATERIAL							
Vertebrates:							
Possum carrion	41	10.6	9.1	8.1	12.8	12.5	NS
Pig carrion	4	1.8	1.9	-	0.7	4.7	NS
Annelids:							
Earthworms	79	10.3	11.1	14.7	8.5	6.7	NS
Identified minor animal foods:		2.9	5.7	1.1	3.4	1.3	
Unidentified animal material:		2.5	0.8	2.0	2.9	4.3	
ANIMAL SUBTOTALS:		28.1	28.6	25.9	28.3	29.5	
TOTALS:		100.0	100.0	100.0	100.0	100.0	

otherwise unimportant foods such as fungi, scarab beetles, and introduced thistles (*Cirsium* spp.).

A total of 124 foods were found in the samples; four were groups of related plants, 82 were plants identified to genus or species, and as leaves and stems, fruit, or roots and rhizomes, and 38 were various types of animal material. Of these, seven formed >5% of the pigs' annual diet, and 11 formed >1% of their diet. These are listed in Table 2 with their percentage occurrence and weights; a further 56 foods which formed 0.01% of the pigs' annual diet are listed in Appendix I.

The pigs' annual diet was made up of 72% plant material and 28% animal. Fruits were the single most important food type; the fruits of tawa and hinau together formed 30.9% of their diet, with the fruits of supplejack, miro and nikau palm contributing another 4.7%. Of the roots and rhizomes eaten, those of supplejack and bracken (*Pteridium esculentum*) were the most important, forming 11.5% and 5.5% of the pigs' diet respectively. The only other major plant food was the young fronds and stems (stipe bases and trunk pith) of tree ferns (*Cyathea* spp.). Introduced thistles and tawari were browsed in small but significant quantities.

The animal material eaten comprised similar amounts of carrion and invertebrates. Carcasses of the brushtail possum made up the bulk of the carrion, with the rest being mostly from pigs and red deer. The invertebrate foods were mainly earthworms, with the rest being the larvae, pupae, and adults of insects, and other arthropods. Representatives of 14 insect families were identified in the stomach samples, but together they formed only 2.7% of the pigs' diet. In addition, parts of geckos (Reptilia: Gekkonidae) were found in two of the pigs.

Seasonal differences in diet

The pigs' diet varied seasonally. Six plant foods (four food types) were eaten in significantly greater amounts in some seasons than in others (Table 2, Fig. 2). The three main fruits in their diet were eaten seasonally: tawa mainly in summer, autumn, and winter; hinau in autumn and winter; and supplejack in winter and spring. Together they comprised 25, 60, and 42% of the pigs' food in summer, autumn, and winter respectively, but only 8% in spring. Of the other foods eaten seasonally, the roots of supplejack and fronds and stems of *Cyathea* spp. were both eaten mainly in spring and summer, and the foliage of tawari in winter (Table 2). These plants accounted for most of the seasonal variations in their respective food

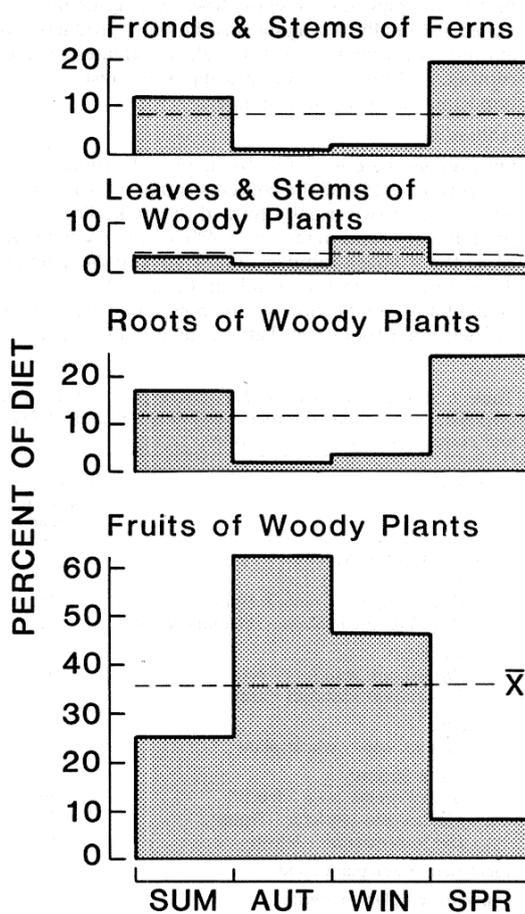


Figure 2: Patterns of use for the four food types with seasonal differences. All were highly significant (i.e., $p < 0.001$). Annual mean values are indicated by horizontal broken lines.

types (Fig. 2).

Similar amounts of fungi, rhizomes and roots of ferns, grasses and herbs, carrion, and invertebrates, were eaten in each season (seasonal difference $p > 0.05$). Together these food types comprised 40% of the pigs' annual diet.

Discussion

The diet of the pigs in the Urewera Ranges was similar in food type and seasonality to that of feral and wild pigs elsewhere although the particular foods differed.

Extensive use by pigs of seasonally available fruits has been widely reported and seems to be the rule in favoured forest habitats. In California the main fruits eaten are acorns (*Quercus* spp; Barrett, 1978); in the eastern United States acorns and hickory nuts (*Carya* spp.; Henry and Conley, 1972); in Europe acorns and beech nuts (*Fagus* spp.; Briedermann, 1967); and on Hawaii banana poka (*Passiflora mollissima*), and guavas (*Psidium* spp.; Griffin, 1978). These fruits were eaten in large quantities during fruit fall, the pigs ignoring their other main plant foods and only returning to them after the supply of fruit has been exhausted. This pattern also occurs in the Urewera Ranges where tawa and hinau fruit apparently fill the same role as acorns, and hickory and beech nuts in the northern deciduous forests.

Three other plant foods were taken in large quantities by the pigs in the Urewera Ranges, the roots of supplejack, fronds and stems of tree ferns, and the rhizomes and roots of bracken. Of these, only bracken has been previously recognised as a major food of feral pigs in New Zealand (Wodzicki, 1950). Their preference for tree ferns has a parallel on Hawaii where feral pigs break open the trunks of tree ferns (*Cibotium* sp.) and eat the soft, starchy core. It is their main food in forested parts of the island, comprising up to 85% of their diet in some areas (Giffin, 1978). The attraction of supplejack roots suggests that they have a high nutrient content.

Feral and wild pigs typically eat some animal foods. In the Urewera Ranges 28% of their diet was animal material, the amounts differing little between seasons. This is less than for the pigs on Auckland Island (Challies, 1975), but much more than that reported elsewhere. Animal foods comprise < 5% of the diet of pigs on Hawaii (Giffin, 1978) and in California (Barrett, 1978); < 10% in the eastern United States (Henry and Conley, 1972); and < 15% in Europe (summarised by Genov, 1981). Carrion and a wide variety of invertebrates including earthworms were the main animal foods eaten by the pigs in all those places.

The diet of the pigs in the Urewera Ranges is varied, and apparently nutritionally well-balanced. They have available a good quantity of fruit for 6 to 9 months in most years, several other major plant foods predictably rich in carbohydrates, and a year-round supply of animal protein. Despite this apparent

balance the pigs fluctuate widely in numbers from year to year (McKelvey, 1973; M. Llewellyn, pers. comm.). These fluctuations are probably linked to the availability of tawa and hinau fruit, with pig numbers increasing when fruit is abundant and declining when it is not. The amount of fruit formed by tawa is known to vary widely between years (Knowles and Beveridge, 1982), and the same is probably true for hinau. Similar fluctuations in pig numbers occur in the eastern United States, where pig productivity is closely linked to the size of the acorn crop (Matschke, 1964).

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Appendix 1: *Minor foods comprising $\geq 0.01\%$ of the annual diet.* ¹Lf = leaves, fronds and/or stems; Rt = roots and/or rhizomes; Ft = fruits and/or seed heads; Ad = adults; La = larvae; Pu = pupae; and Ny = nymphs.

PLANT MATERIAL		Trees & shrubs:	
Fungi:		<i>Aristotelia serrata</i>	Lf
Misc. fungi		<i>Beilschmiedia tawa</i>	Lf
		<i>Carpodetus serratus</i>	Lf
Bryophytes:		<i>Dacrydium cupressinum</i>	Lf
Misc. mosses		<i>Elaeocarpus dentatus</i>	Lf
Misc. liverworts		<i>Griselinia littoralis</i>	Lf
Ferns:		<i>Meliclytus ramiflorus</i>	Lf
<i>Asplenium bulbiferum</i>	Lf ¹	<i>Metrosideros robusta</i>	Lf
<i>Blechnum</i> spp.	Lf	<i>Nothofagus fusca</i>	Lf
<i>Dicksonia squarrosa</i>	Lf	<i>Prumnopitys ferruginea</i>	Ft
<i>Histiopteris incisa</i>	Lf	<i>Schefflera digitata</i>	Lf
<i>Phymatosorus diversifolius</i>	Lf, Rt	<i>Weinmannia racemosa</i>	Lf
Grasses & sedges:		ANIMAL MATERIAL	
<i>Microlaena avenacea</i>	Lf, Ft	Vertebrates:	
<i>Uncinia</i> spp.	Lf, Ft	Deer carrion	
<i>Bromus</i> spp.	Lf	Gecko	
<i>Carex</i> sp.	Lf	Arthropods:	
Other monocots:		Misc. centipedes	
<i>Ripogonum scandens</i>	Lf	Misc. millipedes	
<i>Rhopalostylis sapida</i>	Ft	Misc. amphipods	
Misc. orchids	Lf, Rt	Insects	
Herbs:		Blattodea (1 family)	
<i>Urtica incisa</i>	Lf	Coleoptera (4)	Ad, La ¹
<i>Pratia angulata</i>	Lf	Diptera (4)	La
<i>Sonchus</i> spp.	Lf	Lepidoptera (1)	La, Pu
		Orthoptera (2)	
		Phasmatodea (1)	
		Hemiptera (1)	Ny