

THE FOOD OF THE NEW ZEALAND PIGEON (*HEMIPHAGA NOVAESEELANDIAE NOVAESEELANDIAE*)

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SUMMARY: New Zealand pigeons (*Hemiphaga novaeseelandiae novaeseelandiae*) are the main dispersers of large-seeded fruit in indigenous forest. They eat a wide range of plant material including leaves, shoots, buds and flowers as well as fruits. Food items found in the alimentary tracts of 177 pigeons and information from published and unpublished observations showed that 104 plant taxa contributed to the diet. Of these, 78 were indigenous and 26 were exotic species. Feeding on nine of the species found in the dissections had not been recorded elsewhere. Fruits or seeds of 14 species, and material other than fruit of 19 species, were found in the dissections. The list of observations includes 56 species from which fruit is eaten and 43 from which other material is taken.

INTRODUCTION

The New Zealand pigeon (*Hemiphaga novaeseelandiae novaeseelandiae* Gmelin) is indigenous to New Zealand. Once numerous throughout forested country, its numbers were greatly reduced in the nineteenth and early twentieth centuries by excessive hunting and by the destruction of large tracts of native forest (Oliver, 1955). In 1921, however, the New Zealand pigeon was given full protection under the Animals Protection and Game Act and, while some poaching continues, numbers have increased so that today it can usually be seen in or near any reasonably large area of forest, and is a common species in many indigenous forests. It is attracted into suburban gardens by such exotic species as tree lucerne (*Cytisus proliferus*), guavas (*Psidium cattleianum*), plums (*Prunus* spp.) and other fruit trees.

A large proportion of our forest tree and shrub species (including the dominant Podocarpaceae, unlike conifers in Northern Hemisphere temperate forest) has fleshy fruits which are attractive to birds. Pigeons, together with other indigenous birds such as tui (*Prothemadera novaeseelandiae*), bellbirds (*Anthornis melanura*), and silvereyes (*Zosterops lateralis*) continue to have a major role in the dispersal of many of these plants. Several introduced species also share this function, e.g., blackbirds (*Turdus merula*), thrushes (*T. philomelos*), starlings (*Sturnus vulgaris*) and mynas (*Acridotheres tristis*). In pre-European times, other important seed-dispersing species were the North and South Island kokako (*Callaeas cinerea wilsoni* and *C. cinerea cinerea*), the saddleback (*Philesturnus carunculatus*), and possibly the huia (*Heteralocha acutirostris*) and New Zealand

thrush (*Turnagra capensis*). The pigeon is nowadays the only common species which can disperse the large seeds of tawa (*Beilschmiedia tawa*), taraire (*B. tarairi*), and karaka (*Corynocarpus laevigatus*) and no other bird is as important in the dispersal of miro (*Podocarpus ferrugineus*).

It is often difficult to observe accurately what pigeons are eating in indigenous forest. Flowers, buds or even leaves may be mistaken by an observer for fruits. However, study of the gut contents of killed birds can give some factual information. This paper lists:

- (a) food items found in the digestive tracts of 177 dissected pigeons; and
- (b) food items from published and unpublished observations.

The study was undertaken to try to determine the role of the New Zealand pigeon in the dispersal of seed in indigenous forest of the central North Island. No previous substantial study of the food of the pigeon has been made and no adequate description of the digestive tract has been found in the literature reviewed.

MATERIALS AND METHODS

The digestive system

The alimentary canal is composed of the upper oesophagus, 6 cm long; the crop, a simple extension of the oesophagus which can expand to contain up to 50 g of fruit or leaves; the lower oesophagus, 3 cm long; the proventriculus or glandular stomach, 2 cm x 2 cm; the gizzard or muscular stomach, a heart-shaped organ 4 cm x 3 cm with thick, muscular walls and a deeply-ridged horny lining; the duodenal loop, 18 cm long; the small intestine or ileum, 28 cm

long; and the large intestine or rectum, 19.5 cm long, and opening into the cloaca. No caeca were found.

Specimens

Pigeons (177) which had been shot illegally and subsequently confiscated were sent to the Forest Research Institute by the Wildlife Service. Some of the specimens were frozen whole birds and the rest were labeled as "crop and gizzard" samples, but in fact consisted of the proventriculus and gizzard.

The contents of the alimentary tract were examined and recorded and any plant material which could not be identified immediately was placed in 20% alcohol and referred to the Botany Division of the DSIR. Most material was easily identified, especially the crop contents, and samples were checked against herbarium material. Seeds from any part of the gut could usually be recognised as they were not digested, but leaves became progressively more difficult to identify as they moved down the intestine.

RESULTS

Dissections

Details of locality and date of collection are given in Table 1. Of the 177 birds, 141 were from central North Island localities. The type of food, fruit or other plant material (including buds, flowers and leaves) eaten by pigeons shot during different seasons of the year is recorded in Table 2. Results of the examination of the alimentary tracts are summarised in Table 3. The figures refer to the number of birds in which each plant species was found, listed by the month and locality in which the pigeon was shot.

TABLE 1. *Origin of 177 New Zealand pigeons used for examination of food items.*

Locality	No. of birds	Period killed
Northland	17	June-October
Coromandel	1	May
Bay of Plenty	6	April-June
Rotorua	42	April-October
Urewera	12	May-October
Gisborne	15	June-December
Taupo	39	April-July
Taumarunui	27	June-August
Hawkes Bay	5	June
Wellington	1	August
Nelson	1	May
West Coast	2	August-November
Otago	3	December
Unknown	6	-

Gut contents were entirely plant material; no grit was found. In 149 birds (84%) only fruit was present in the gut. Generally, fruit consisted of only one species but occasionally smaller quantities of one or more other species were found. Fruits and seeds from 14 taxa were found in the dissections (Table 3a). Only one exotic species was found, seed from a member of the Leguminosae. Plant material other than fruits and seeds, and including leaves, flowers and buds, came from 18 taxa (Table 3b), including three exotic species.

Approximately 66 % of the birds examined contained miro berries, the greatest number found in one bird being 52; 34 in the crop, 5 in the gizzard, and 13 in the intestine. The fresh weight of 52 miro berries is approximately 50 g. Several of the birds which contained miro berries had five in the gizzard, this apparently being the largest number it could accommodate at one time. Usually when miro berries were present in the gut no other food was found apart from small amounts of miro foliage.

A range of fruits of indigenous species was found, including several species of *Coprosma*, taraire, kohekohe (*Dysoxylon spectabile*) and both species of *Griselinia*. In one pigeon seeds of *Libocedrus plumosa* were identified. Normally these winged seeds are thought to be dispersed by wind. The quantity of fruit found ranged widely, and for small seeds it was sometimes difficult to count accurately the number in the intestine.

The finding of 174 *Ixerba brexioides* seeds in the digestive tract of a pigeon from the lower Kaimais (Table 3) established that this species may be dispersed by pigeons. *Ixerba* bears a fruit described as a capsule (Allan, 1961), containing many small shiny seeds in a sticky orange matrix.

Ten percent (17) of the specimens contained only leafy material or buds and flowers, and in these birds there were often two or more plant species present. One pigeon killed near Rotorua in December contained in its crop alone 14.2 g dry weight of leaves. Most of them were kowhai (*Sophora tetraptera*), but also present were leaves of silver beech (*Nothofagus menziesii*), hard beech (*N. truncata*) and putaputaweta (*Carpodetus serratus*), as well as a few phylloclades of tanekaha (*Phyllocladus trichomanoides*). Most of these leaves were fully mature.

Four percent (7) of the birds contained both fruit and other plant material and 2% (4) contained nothing (see Table 2). Leaves of several exotic species were found in the dissections. These were lupin (*Lupinus* sp.), clover (*Trifolium* sp.) and one leaf which was tentatively identified as *Clerodendron bungei*.

TABLE 2. *Types of food found in the alimentary tracts of pigeons killed in different seasons.*

Alimentary tract contents	Summer	Autumn	Winter	Spring	No	Total
	D J F	M A M	J J A	S O N	date	birds
Nothing	0	2	0	1	1	4
Fruit only	0	38	77	19	15	149
Other plant material only	3	1	9	3	1	17
Both fruit and other plant material	2	4	1	0	0	7
Total	5	45	87	23	17	177
% with other plant material	100	11.11	11.49	13.04	5.88	13.56

Observations

Table 4 summarises published (mainly Classified Summarised Notes in *Notornis*) and unpublished feeding observations, including those of other authors when species they included were new to the list (Buller, 1873; Potts, 1873; M'Lean, 1911; Myers and Atkinson, 1924; A. S. and Amy Wilkinson, 1952; Oliver, 1955). Of 95 species which pigeons have been observed eating, 26 are exotic species; 9 species appear in Tables 3a and 3b which do not appear in Table 4.

The literature survey showed that pigeons feed on a very wide range of plants. Tawa fruits are an important source of food during late summer and early autumn. As well as miro, pigeons eat the fruit of other podocarps such as kahikatea (*Dacrycarpus dacrydioides*), matai (*Podocarpus spicatus*) and rimu (*Dacrydium cupressinum*). Supplejack (*Rhipogonum scandens*) fruits are a common winter pigeon food (A. E. Beveridge, *pers. comm.*). In northern districts the fruit of puriri (*Vitex lucens*) is eaten throughout the year, while taraire fruits are taken throughout winter. When larger fruits are unavailable small fruits are eaten, such as those of wineberry (*Aristotelia serrata*), fivefinger (*Pseudopanax arboreus*) and various *Coprosma* species. These fruits are often ripe in summer and borne in abundance. Table 4 shows the importance of *Fuchsia excorticata*, especially in the summer months. Leaves, buds, flowers and fruit are all taken.

Many exotic fruits are eaten, for example guavas, holly (*Ilex aquifolium*), cherries and small plums (*Prunus* spp.). Gibb (1970) observed that pigeons could swallow plums up to 25 mm in diameter.

As well as fruit, pigeons have been seen eating leaves, buds and flowers of many species, both indigenous and exotic. Examples are *Hoheria* spp., kowhai (*Sophora* spp.), mahoe (*Melicactus ramiflorus*) and *M. lanceolatus*, willow (*Salix* sp.), tree lucerne, broom (*Cytisus scoparius*) and clover (*Trifolium*

spp.). Most of these are eaten in spring and early summer when not much fruit is available, but some leaves are taken throughout the year.

DISCUSSION

The sample studied is biased seasonally as few birds are poached in the summer months when they are in poorer condition for eating. Poachers prefer fat pigeons, especially when they have been feeding on miro fruit which is available in the central North Island from May-August. Fewer exotic than native plant species occur in the dissections as pigeons are generally shot in indigenous forest.

Owing to the differential digestion rates of foods, the results may show some bias towards the less digestible items, e.g., hard seeds. This problem may be overcome if crop contents only are examined.

The literature survey shows bias towards exotic species, as observers often record unusual events rather than more common ones and it is difficult to observe food items taken by pigeons in dense indigenous forest.

The gut examinations provide factual information, but the list of species found in the 177 dissections is much smaller than that derived from the literature survey and other observations. Because few birds were killed between September and April certain important food items were not found in the dissections, e.g., the fruits of tawa and wineberry. Almost no fruits were found in the dissected birds (Table 3a) between November and March, although pigeons have been observed eating such fruit as wineberry and *Fuchsia* sp. during these summer months. This omission, and that of other plant material (Table 3b) between January and April and during September and October, is probably due to the fact that few of the specimens were killed during these months. Table 4 indicates some unusual times for certain fruits to be available, e.g., wineberry in September and mahoe in November/December. Possibly this is due to inaccurate observation.

Certain fruits which are believed to be eaten frequently by pigeons feature only once or twice in Tables 3a and 4, e.g., pigeonwood (*Hedycarya arborea*), hinau (*Elaeocarpus dentatus*), pokaka (*E. hookerianus*) and mangeao (*Litsea calicaris*). Totara (*Podocarpus totara*) is not included either, but in fact this tree may bear its green seeds (on fleshy red or yellow receptacles) too sparsely for the pigeon to gather sufficient without too much effort, especially at a season when the favoured miro fruit are ripe.

Within the range of fruit taken four types can be recognised:

1. Large drupe-like fruit, e.g., miro, tawa, taraire, karaka and puriri.
2. Succulent berries, e.g., *Fuchsia*, wineberry and mahoe.
3. Fruits with seeds in a sticky matrix or arillate, e.g., *Ixerba*, *Alectryon*, *Tetrapathaea* and *Dysoxylon*.
4. Hard or non-succulent seeds, e.g., *Sophora* *Geniostoma* and *Libocedrus*.

The first two categories are the most important in terms of the pigeon's food requirement and the species' dispersal by pigeons.

Seeds dispersal and food habits

Pigeons are known to move from place to place following the supply of fruit (Smith, 1888). Such big birds (50 cm in length) require a large amount of food, and pigeons congregate wherever there is an abundance of fruit on which to feed. They also tend to migrate seasonally, coming down to the low country in the winter (Oliver, 1955). These movements may be towards stands of miro and other fruit-bearing trees, as well as to escape harsh winter conditions. Essentially birds of tall forest, pigeons make frequent sorties into suburban parks and gardens to eat various exotic fruits, and are frequently seen browsing on young willow leaves on river banks, and on kowhai (*Sophora* sp.) and various exotic legume flowers and leaves in spring.

Although pigeons usually eliminate seed and other wastes while perching or feeding they occasionally do so while in flight (Herbert, *pers. comm.*). Dr Moore (Simpson, 1971) described an observation of a pigeon which landed on a boat cruising off the North Auckland coast and regurgitated a fruit of puriri which it must have been carrying for an hour or more. This regurgitation may have occurred because the bird was under stress, but certain other groups of birds eject from the stomach, via the mouth, pellets of indigestible material. It is believed that pigeons may do this sometimes when they have eaten a large amount.

Pigeon-dropped seed normally has a high percentage viability (Beveridge, 1964). Esler (*pers. comm.*) germinated some mahoe (*Melicytus ramiflorus*) and nikau (*Rhopalostylis sapida*) seeds from pigeon droppings collected in April; 84 % of the mahoe and 86 % of the nikau germinated.

A frequently observed feature of pigeon behaviour is that after gorging themselves on fruit, usually of one species, they flop a short distance to a favourite perching tree to sit and digest the food carried in their enlarged crops (A. S. and Amy Wilkinson, 1952). The perching tree is often a tall hardwood on which pigeons can sit in the sun. This behaviour has important consequences in the regeneration of mixed podocarp / hardwood forests.

Beveridge (1973) described the sequence of cyclic regeneration which may be observed in scattered podocarp forest (podocarp / kamahi / scrub hardwoods type). This involves the windfall of a large old podocarp; the invasion of the light gap so caused by tree-ferns (*Dicksonia squarrosa*); the epiphytic growth of hardwoods, especially kamahi (*Weinmannia racemosa*) but also broadleaf (*Griselinia* sp.), on the tree-fern stems; the overwhelming of the host tree-fern by the hardwood as it develops into a large tree suitable for perching on by pigeons; the recruitment of groups of podocarp and other seedlings around the perching tree, mainly from bird-dispersed seed; and finally the development of these into saplings as the crown of the perching tree gradually thins and dies.

As well as miro, matai fruits are probably large enough to attract, and therefore be dispersed by, pigeons, and when kahikatea fruits heavily pigeons consume large quantities of its fruit. Years in which dmu produces good crops of seed (carried on well-developed fleshy receptacles) are infrequent and this irregular fruiting has probably resulted in few observations being recorded of pigeons feeding on rimu fruit.

In seral shrub areas, berry-producing small trees are probably introduced by other birds such as tuis, bellbirds and silvereyes, and once these are established pigeons are attracted to the areas and bring in tawa, miro, and other podocarps. Leaves of *Hoheria* spp. are an important food item all year round and pigeons may enter secondary forest to browse on *Hoheria* foliage. The return of cleared areas to high forest is therefore influenced greatly by pigeons. They also take part in the dispersal of seed of shrubs that produce large quantities of berries, e.g., *Fuchsia* and wineberry, but probably only at the edges of high forest.

Knowles and Beveridge (unpublished report) note that on elevated sites, seedlings of tawa frequently

TABLE 3. *Plant material found in pigeon digestive tracts.*
(a) *Fruits and seeds.*

Species	Locality	Number of birds with food item by month shot												Unknown	Total of each species	
		J	F	M	A	M	J	J	A	S	O	N	D			
<i>Podocarpus ferrugineus</i>	Northland						1			4	3					
	Rotorua					10	4	3		3	S					
	Urewera						5								7	
	Taupo					31	1									
	Gisborne						12									
	Taumarunui						18		7							
	Hawkes Bay							2								116
<i>Coprosma</i> sp.	Taupo					8		1								
	Rotorua								1							10
<i>Beilschmiedia tarairi</i>	Northland								2			1				
	Coromandel					1										4
<i>Dysoxylon spectabile</i>	Northland							3		1						4
<i>Griselinia lucida</i>	Taupo					2			1							
	Taumarunui									1						4
<i>G. littoralis</i>	Rotorua													1		
	Taupo					1										
	Taumarunui									1						3
<i>Griselinia</i> sp.	Urewera													2		
	Hawkes Bay								1							3
<i>Hedycarya arborea</i>	Taupo							2								2
<i>Ixerba brexioides</i>	Bay of Plenty				2											2
<i>Dacrycarpus dacrydioides</i>	Rotorua						1									1
<i>Elaeocarpus dentatus</i>	Northland									1						1
<i>Fuchsia excorticata</i>	Rotorua													1		1
<i>Myrsine australis</i>	Taupo							1								1
<i>Libocedrus plumosa</i>	Northland									1						
*.Family Leguminosae	Otago													1		1
		J	F	M	A	M	J	J	A	S	O	N	D	Unknown	Total	

* Exotic species.

(b) Plant material other than fruits and seeds.

Species	Locality	Number of birds with food item by month shot												Unknown	Total of each species	
		J	F	M	A	M	J	J	A	S	O	N	D			
<i>Hoheria</i> sp.	(1) Rotorua						2									
	Bay of Plenty													1		3
<i>Coprosma</i> sp.	(1) Rotorua						1									
	Taupo					1										2
<i>Melicytus ramiflorus</i>	(1) Hawkes Bay						2									2
* <i>Lupinus</i> sp.	(If) Rotorua							2								2
* <i>Trifolium</i> sp.	(1) West Coast												1			1
<i>Sophora tetraptera</i>	(1) Rotorua													1		1
Family Leguminosae	(1) Otago														1	1
<i>Metrosideros</i> sp.	(1) Wellington								1							1
<i>M. diffusa</i>	(1) Nelson					1										1
<i>M. umbellata</i>	(1) West Coast								1							1
<i>Fuchsia excorticata</i>	(If) Rotorua													1		1
<i>Knightia excelsa</i>	(b) Unknown								1							1
<i>Nestegis montana</i>	(1) Unknown								1							1
<i>Podocarpus ferrugineus</i>	(1) Unknown													1		1
<i>Podocarpus</i> sp.	(1) Rotorua							1								1
<i>Nothofagus menziesii</i>	(1) Rotorua												1			1
<i>N. truncata</i>	(1) Rotorua												1			1
<i>Carpodetus serratus</i>	(1) Rotorua												1			1
<i>Phyllocladus trichomanoides</i>	(1) Rotorua												1			1
* <i>Clerodendron bungei</i>	(1) Rotorua						1									1
		J	F	M	A	M	J	J	A	S	O	N	D	Unknown	Total	

* Exotic species. l, leaves; b, buds; f, flowers.

TABLE 4. Food items recorded by observing feeding pigeons.
 Exotic species are indicated by *, Fruit F, leaves I, buds b, flowers f.

SPECIES	MONTH												Unknown
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	
<i>Alectryon excelsus</i>		F	F	F	F	F	F						
<i>Aristotelia serrata</i>	F	F	F	F			I	Fl	F	F			I
<i>Asplenium bulbiferum</i>													I
<i>Astelia banksii</i>													F
<i>Beilschmiedia tarairi</i>				F	F		F	F	F				
<i>B. tawa</i>	F	F	F	F	F								
* <i>Brassica</i> species (vegetables)													I
* <i>B. napus</i>						I	I	I	I				
<i>Carmichaelia</i> sp.													I
* <i>Chamaecyparis lawsoniana</i>												I	
<i>Coprosma</i> spp.	F												
<i>C. australis</i>		F	F	F	F	I	F						
<i>C. lucida</i>													F
<i>C. robusta</i>													F
<i>Coriaria arborea</i>	F												
<i>Corynocarpus laevigatus</i>													F
<i>Cordyline australis</i>			F			F							
* <i>Cotoneaster</i> sp.							F						
* <i>Crataegus</i> sp.			F	F									
* <i>Cytisus proliferus</i>									Ibf	Ibf	Ibf		
* <i>C. scoparius</i>									Ibf	Ibf			
<i>Cyttaria</i> sp. (fungus on <i>Nothofagus</i> sp.)												F	
<i>Dacrycarpus dacrydioides</i>		F	F	F	F	F							
<i>Dacrydium cupressinum</i>					F								
<i>Dysoxylon spectabile</i>													F
<i>Elaeocarpus dentatus</i>							F	F	F				
<i>E. hookerianus</i>													F
* <i>Erythrina</i> sp.													I
* <i>Eucalyptus</i> sp.								I					
<i>Eugenia maire</i>													F
<i>Fuchsia</i> sp.	Flbf	F	F	F	F						F		
<i>Geniostoma ligustrifolium</i>													F
<i>Grammitis billardieri</i>							I	I					
<i>Griselinia</i> sp.							F						
<i>Hedycarya arborea</i>	F						F			F	F		
<i>Heimerliodendron brunonianum</i>													F
* <i>Hibiscus</i> sp.													I
<i>Hoheria</i> sp.	I	I		I	I	I	I	I	I	I	I	I	
* <i>Ilex aquifolium</i>			F	F									
* <i>Laburnum</i> sp.					I								
<i>Leptospermum scoparium</i>													I
* <i>Ligustrum</i> sp.													F
<i>Litsea calicaris</i>	F												
<i>Lophomyrtus bullata</i>							F	F	F				
* <i>Lotus</i> sp.													I
* <i>Lupinus</i> sp.													I
<i>Macropiper excelsum</i>	F												
* <i>Malus</i> sp.												I	
<i>Melicytus lanceolatus</i>					lb	I							
<i>M. ramiflorus</i>							I			F	F	F	
<i>Mida salicifolia</i>												F	
<i>Muehlenbeckia australis</i>							I						

TABLE 4 - *continued.*

Species	Month												Unknown
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	
<i>Muehlenbeckia complexa</i>						I							
<i>Myoporum laetum</i>													F
<i>Myrsine australis</i>		F	F	F									
<i>M. salicina</i>													F
* <i>Nasturtium officinale</i>													I
<i>Nestegis</i> sp.	F	F	F	F	F	F	F						I
<i>Nothofagus menziesii</i>											I		
<i>Parsonsia capsularis</i>							I	I	I	I			
<i>Plagianthus betulinus</i>													I
<i>Pennantiacorymbosa</i>													I
<i>Planchonella novo-zealandica</i>					F								
<i>Podocarpus ferrilligneus</i>		F	F	F	F	F	F	F	F	F			
<i>P. spicatus</i>		F	F	F	F								
<i>Polystichum richardii</i>													I
* <i>Populus</i> sp.													I
* <i>Prunus</i> sp. (cherry)	F												
* <i>Prunus</i> sp. (plum)	F												
* <i>Prunus</i> sp. (flowering cherry)								I					
<i>Pseudopanax arboreus</i>						F	F						
<i>P. crassifolius</i>							F	F	F				
<i>P. edgerleyi</i>										I		I	
<i>Pseudowintera colorata</i>					F	F	F						
* <i>Psidium cattleianum</i>				F	F		F	F	F	F	F		
* <i>pyrus</i> sp.													I
<i>Rhopalostylis sapida</i>	F			F									
<i>Rhipogonum scandens</i>	F			F			F	F					
* <i>Rosa eglantheria</i>													F
* <i>Salix</i> sp.									I	I	I		
* <i>Sambucus nigra</i>													F
<i>Schefflera digitata</i>					F	F	F	F					
<i>Solanum aviculare</i>	F												
* <i>S. nigrum</i>													F
* <i>S. tuberosum</i>													I
<i>Sonchus</i> sp.													I
<i>Sophora</i> sp.	I	I		I	I	I	I	Ibf	Ibf	Ibf	Ibf	Ibf	
* <i>Sorbus aucuparia</i>	F												
<i>Tetrapathaea tetrandra</i>							F				F		
* <i>Tilia</i> sp.													b
* <i>Trifolium</i> sp.	I	I	I	I	I	I	I	I	I	I	I	I	
<i>Tupeia antarctica</i>													F
* <i>Ulmus</i> sp.						b							
<i>Vitex lucens</i>			F	F	F	F	F	F	F	F	F	F	
* <i>Vida</i> sp.													I

* Exotic species.

F, fruit; I, leaves; b, buds; f, flowers.

occur in clumps away from crowns of parent trees and this is probably because of the dropping of tawa seeds by pigeons from their favoured perching positions. They also suggest a probable reduction of medium and long distance dispersal of tawa by pigeons as a result of the breaking up of extensive tracts of forest, and the consequent reduction of pigeon populations. Macmillan (1972), referring to seed dispersal of supplejack mentioned that the fruit is eaten by the pigeon and that seed passed through the digestive tract is deposited in clusters.

Adaptations

The genus *Hemiphaga* is an old, endemic one which has probably been in New Zealand for ten million years. Its ancestors, on arrival from Australia or possibly Melanesia in the late Tertiary, would have found a closed canopy, mixed rain forest in which angiosperms temporarily dominated over podocarps in a climate somewhat warmer than that of the present (Fleming, 1962a, 1962b). There is speculation about the relationships of the genus, but the genera believed to be most closely related, *Lopholaimus antarcticus*, (the Australian Topknot Pigeon), and *Ducula* (a large genus of fruit pigeons with a tropical-oriental distribution), are both almost entirely frugivorous (Crome, 1975; Goodwin, 1967).

The New Zealand forest, with its distinct seasons and temperate climate, does not produce an abundance of fruit all year round as do the forests of tropical latitudes, and this, combined with the severe climates which occurred during the Pleistocene, and the lack of competition from browsing animals, has resulted in *Hemiphaga* widening its diet to include much leafy material, buds, flowers and shoots, as well as fruit. The kokako has similar food requirements, including both fruit and leaves, but, as it is few in numbers and restricted in its distribution by its inability to fly very far and by the break-up of large areas of forest, it probably does not compete with the pigeon.

Leguminous flowers and foliage are eaten frequently by pigeons, especially in the spring, a fact which leads R. A. Falla (*pers. comm.*) to suggest that there may be a connection between legume browsing and the protein requirement for the production of pigeon milk, with which, as far as is known, all pigeons feed their young for the first two weeks after hatching (Murton, 1964).

In a study of fruit pigeons of tropical Queensland, Crome (1975) found that the breeding season of the seven pigeons he studied coincided with the time of maximum fruit abundance and diversity. The family Lauraceae contributed greatly to the peak of fruit

production and the fruits of Lauraceae are relatively more nutritious than most other species in the area. Tawa, taraire and mangeao, New Zealand's representatives of the family Lauraceae, are much sought after by pigeons. However, *Hemiphaga's* breeding season extends from November to March (summer) and the fruiting season of these three trees begins in late summer. The breeding season begins when there is a relative shortage of available fruit and it is probable that legume browsing has arisen in response to this.

The New Zealand pigeon is a bird with diverse feeding habits, including in its diet a wide range of indigenous and exotic plant species. In winter, miro fruit forms a major part of the pigeon's diet and it is concluded that this bird is the major disperser of this species. It is the only common forest bird able to disperse the large seeds of tawa, taraire and karaka. Therefore, the pigeon is essential for the continued natural regeneration of these trees.

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REFERENCES

- ALLAN, H. H. 1961. *Flora of New Zealand Volume 1*. R. E. Owen, Government Printer, Wellington, New Zealand.
- BEVERIDGE, A. E. 1964. Dispersal and destruction of seed in central North Island podocarp forest. *Proceedings of the New Zealand Ecological Society* 11: 48-55.
- BEVERIDGE, A. E. 1973. Regeneration of podocarps in a central North Island podocarp forest. *New Zealand Journal of Forestry* 18(1): 23-25.
- BULLER, W. L. 1873. *A History of the Birds of New Zealand*. J. Van Voorst, London.
- CROME, F. H. J. 1975. The ecology of fruit pigeons in tropical Northern Queensland. *Australian Wildlife Research* 2: 155-185.
- FLEMING, C. A. 1962a. History of the New Zealand land bird fauna. *Notornis* 9(8): 270-274.

- FLEMING, C. A. 1962b. New Zealand Biogeography. A. Paleontologist's approach. *Tuatara* 10(2): 53-108. pp. 472-473. Thos. Nelson, London and Edinburgh.
- GIBB, J. A. 1970. A pigeon's choice of plums. *Notornis* 17(4): 239.
- GOODWIN, D. 1967. *Pigeons and Doves of the World*. British Museum (Natural History).
- KNOWLES, BARBARA; BEVERIDGE, A. E. (Unpublished). Biological flora of New Zealand. *Beilschmiedia tawa* (A. Cunn.) Benth. et Hook. f. ex Kirk (Lauraceae) Tawa.
- M'LEAN, J. C. 1911. Bush-Birds of New Zealand. *The Emu* 11(1): 5-10.
- MACMILLAN, B. H. 1972. Biological flora of New Zealand 7. *Ripogonum scandens* J. R. et G. Forst. (Smilacaceae) Supplejack, Kareao. *New Zealand Journal of Botany* 10(4): 641-672.
- MURTON, R. K. 1964. Milk, Pigeon. In: A. Landsborough Thomson (Editor). *A Dictionary of Birds*. pp. 472-473. Thos. Nelson, London and Edinburgh.
- MYERS, J. G.; ATKINSON, ESMOND. 1924. The relation of birds to agriculture in New Zealand. VIII. The Pigeon, Kiwis, Rails, and shore-birds. *New Zealand Journal of Agriculture* March, 1924.
- OLIVER, W. R. B. 1955. *New Zealand Birds*. A. H. & A. W. Reed, Wellington, Sydney, London.
- POTTS, T. H. 1873. On the birds of New Zealand. *Transactions of the New Zealand Institute* 6: 139-153.
- SIMPSON, M. J. A. 1971. Travelling seeds. *Wellington Botanical Society Bulletin* 37: 63.
- SMITH, W. W. 1888. On the birds of the Lake Brunner District. *Transactions of the New Zealand Institute* 21: 205-224.
- WILKINSON, A. S.; WILKINSON, AMY. 1952. *Kapiti Bird Sanctuary*. Published for the Editor, R. H. D. Stüdelph, by Masterton Printing Co. Ltd, Lincoln Rd, Masterton, New Zealand.