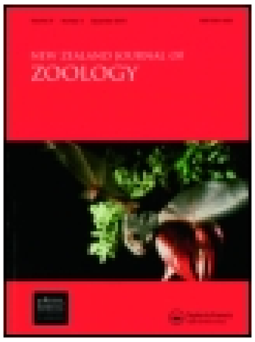

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Food habits of the ferret (*Mustela putorius furo* L.) at Pukepuke Lagoon, New Zealand

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The food habits of 44 tagged ferrets at a wildlife management reserve in the Manawatu dune country were examined from analysis of 333 scats, collected over a period of 34 months. Of the 203 scats containing prey, mammals occurred in 54.7%, birds and eggs in 33.5%, frogs in 17.2%, and eels in 13.3%. The 21 insects occurring in 10.3% of the scats may have been taken as prey, but their importance in the diet is probably minimal. There was significant monthly variation in the occurrence of all prey groups, related to changes in availability or vulnerability of the prey populations. Female ferrets apparently ate the smaller prey items more often than males, but the differences were significant only for mice. No assessment of the effects ferrets have as predators on any of the prey populations is possible from this study.

INTRODUCTION

Observations on the feeding habits of ferrets (*Mustela putorius furo*) in New Zealand have been recorded by Marshall (1963). Fitzgerald (1964) examined the gut contents of 98 ferrets from various parts of New Zealand and scats collected from a rabbit enclosure at Kourarau (Wairarapa); he subsequently extended this survey to 180 ferrets, and his results were recorded by Gibb & Flux (1973).

Mr R. B. Lavers live-trapped mustelids at the Pukepuke Wildlife Management Reserve, Manawatu, North Island, from November 1970 to July 1973 to obtain data on their populations, home ranges, and food habits from which their effect as waterfowl predators could be assessed. Ferrets, stoats (*M. erminea*), and weasels (*M. nivalis*) occur in the area, but only ferrets were caught and tagged at all frequently (44 individuals). Lavers (1973a) published the trapping results to July 1972, and included data on the physical condition, breeding, spatial distribution, and movement of the ferrets. The scats he collected from the tagged ferrets to July 1973 are the subject of this study.

The study area is mapped in Fig. 1. Trapping was most intensive within the boundary of the 121 ha reserve, where swamp vegetation—mainly *Typha muelleri* (raupo), *Carex secta* (niggerhead), *Phormium tenax* (flax), and *Cordyline australis* (cabbage tree)—predominates. Areas of pasture, cut-over pine forest, and dunes outside the reserve were also included in the trapping area.

METHODS

Within the reserve live-traps were placed at approximately 200 m intervals; an outer trap line, with traps set at 400 m intervals, was operated only from April to July 1972. Traps were set on 4 or 5 successive nights each month, but at first were not baited. Bait (a smear of rabbit gut and a dead white mouse) was introduced in February 1972, and the mean number of captures per 100 trap nights then increased from 1.62 to 9.86. Captured ferrets were examined and released; their scats were collected from the traps and preserved in 70% ethanol.

Scat analysis

The scats were examined in a petri dish containing 70% ethanol under a low-power binocular microscope. The samples were not washed or sieved because several kinds of prey may form distinct portions of the sample, and are easier to identify if unmixed (Korschgen 1971). There was little extraneous matter in the scats anyway. Scats containing only white mouse bait, grit, or ferret hairs were classified as empty.

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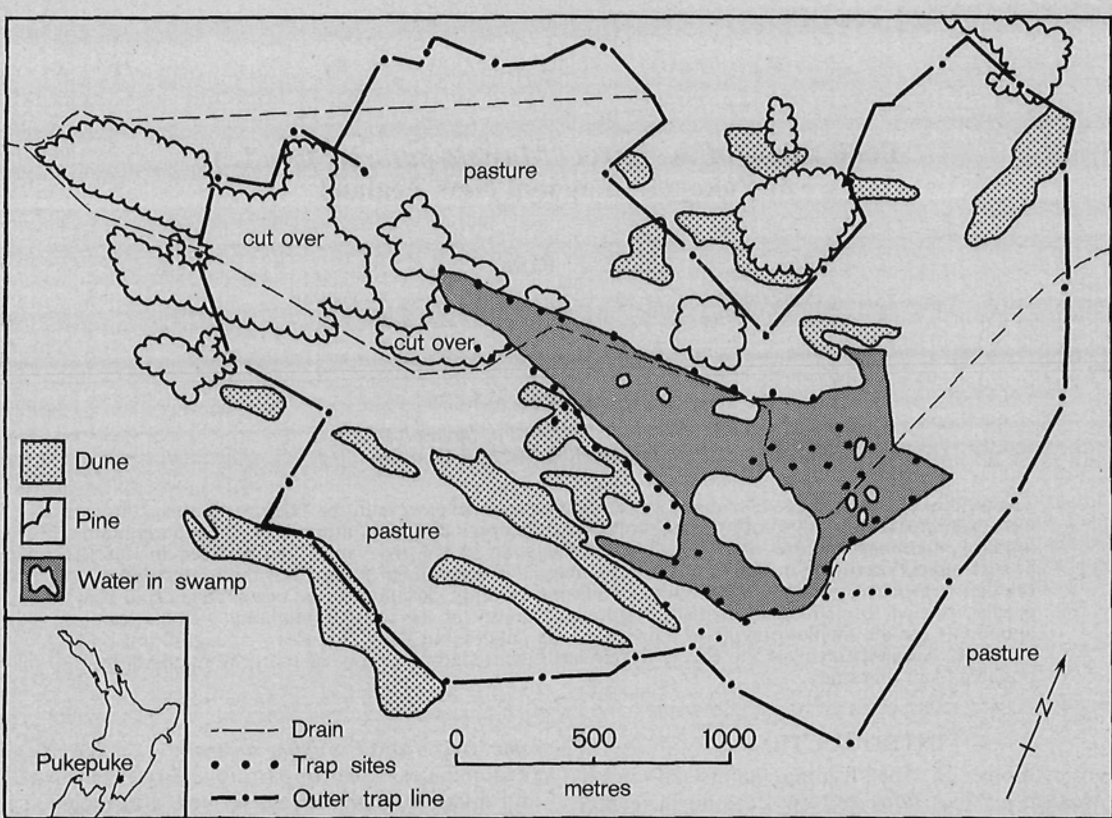

Fig. 1. Pukepuke Wildlife Management Reserve, New Zealand; ferret live-trapping area, Nov. 1970–Jul. 1973.

Hair and feather remains were identified from their microscopic structure, using a key published by Day (1966) for stoats and weasels in Britain plus a reference collection of New Zealand material. Feather structure permits classification only to ordinal level, a major limitation.

Bones and teeth of small prey (i.e., mice, frogs, and eels) occurred frequently in the scats, and were identified against reference skeletons. Skeletal remains of young lagomorphs and birds, if present, were usually too fragmentary for identification. Hedgehog remains were identified more frequently from spines than from hairs.

Invertebrates were usually classified to ordinal level, though a few of the larger insects were identified further. They were also placed in one of 3 size classes (<5 mm, 5–10 mm, >10 mm). The small amounts of plant material found suggested that plants were not eaten deliberately in any quantity, and they were therefore not identified. Other authors working on the food habits of *Mustela* species have made the same assumption (Walton 1968, Day 1968).

Scott (1941) recommended the separation of prey items into those killed and those taken as carrion; but the evidence on which such separation is based is often fallible, so we did not attempt it.

When working with scats from live-trapped mustelids it is possible to record a single prey item more than once. Certain ferrets were captured on 3 or 4 successive nights, and some of their scats contained the same prey on consecutive nights. The rate of passage of different prey items through the gut can be estimated from feeding experiments. Dearborn (1932), Goethe (1940), Short (1961), and Sibbald *et al.* (1962) have carried out feeding experiments on various *Mustela* species, but only Dearborn recorded the time taken for all traces of a meal to disappear from the scats. He found feathers in the faeces of a captive mink (*M. vison*) for 4 days after it had been fed a sparrow. Miss J. Moody, Ecology Division, DSIR (pers. comm.) has carried out feeding experiments on captive stoats in New Zealand, and found that bones and teeth passed through the gut fairly quickly, but hair and feathers took much longer and continued to appear in the scats for several days. Therefore, in order to lessen the amount of error from this source, prey items were not included in the results if they had occurred previously

Table 1. Vertebrate prey identified in 203 scats from ferrets (*Mustela putorius furo*) live-trapped at Pukepuke Wildlife Management Reserve, Nov. 1970–July 1973

Prey item	*n*	Occurrence of scats (%)	Occurrence of prey (%)
BIRD	68	33.5	27.8
Egg	12	5.9	4.9
Passeriformes	23	11.3	9.4
Ralliformes	7	3.4	2.9
Anseriformes	6	3.0	2.4
Unid. bird	20	9.9	8.2
MAMMAL	111	54.7	45.3
Mouse (*Mus musculus*)	33	16.3	13.5
Rat (*Rattus norvegicus* or *R. rattus*)	5	2.5	2.0
Lagomorph (*Oryctolagus cuniculus* or *Lepus europaeus*)	26	12.8	10.6
Opossum (*Trichosurus vulpecula*)	22	10.8	9.0
Hedgehog (*Erinaceus europaeus*)	17	8.4	6.9
Unid. mammal	8	3.9	3.3
Frog (*Litorea aurea* or *L. ewingi*)	35	17.2	14.3
Eel (*Anguilla australis* or *A. dieffenbachii*)	27	13.3	11.0
Unid. prey items	4	2.0	1.6
	245	**120.7***	**100.0**

*Not 100 because some scats contained more than one prey item

that month (i.e., up to 4 days before) in scats of the same individual. Prey items so excluded are listed in the Appendix; they form 8.24% of the total vertebrate items identified.

EXPRESSION OF RESULTS

Englund (1965) discussed several methods used to express the results of food habit analyses. The commonest give the proportions of each item in the total food volume, in the total scats, or in the total items identified. In this study the frequency of occurrence of prey was expressed as a percentage of the number of scats containing prey, because:

(a) Although the volumetric method has been claimed to be the most accurate for scat analyses (Lockie 1959), it requires specific correction factors calculated from detailed feeding experiments. These were not available.

(b) Most authors studying the food habits of mustelids have used the frequency of occurrence method, either as a percentage of total scats (or stomachs) or as a percentage of total items, and therefore some general comparisons with other work are possible.

One major disadvantage of expressing occurrences as a percentage of total items is that the relative importance of one prey species can be influenced by the occurrence of others (Englund 1965). This can make comparison of different predator populations with access to different numbers of prey species very difficult. Therefore, the occurrence of prey as a percentage of total scats containing prey was preferred for this study.

Englund (1965) lists the disadvantages of expressing the frequency of occurrence as a percentage of scats containing prey. The main problem is that the importance of smaller items in the diet is overestimated, and vice versa. This can be corrected for to some extent by treating invertebrate items separately. Estimation of prey units, as used by Southern (1954) for tawny owl (*Strix aluco*) prey, can give a better idea of the relative importance of each prey species in the total diet. This was tried, but was rejected because too many assumptions had to be made about the food requirements of the ferret, the weight of the prey species (especially the unidentified birds), and the amount a ferret would eat from the carcass of one prey animal.

RESULTS

FOODS EATEN BY FERRETS

Altogether 333 scats were examined from 44 tagged ferrets; 110 were classified as empty, and the remaining 223 contained a total of 267 vertebrate prey items, of which 22 items (in 21 scats) were excluded on the assumption that they represented a prey individual which had already been counted that month, in the scats of the same ferret. Hence, 203 scats contained a total of 245 vertebrate prey items (Table 1). (N.B. One scat contained one prey item that had been recorded previously and one that had not, which explains why the 203 scats containing prey and the 21 containing previously recorded prey do not add up to 223.) These 203 scats also contained 149 invertebrate prey items (Table 2).

SEASONAL VARIATION IN DIET

Table 3 shows the numbers of prey items identified each month; invertebrates are not included. The number of samples from each year was too small to test for differences between years (1970, n=5; 1971, n=19; 1972, n=116; 1973, n=61), so the data from all years were combined.

Each prey species was tested for variation between months using the χ^2 statistic; only mice showed significant variation (χ^2=30.79, $0.01 > P > 0.001$, 11 d.f.). Therefore, to establish general feeding trends, the prey species were classified into 4 groups: rodents (rats and mice); large mammals (lagomorphs and opossums); birds (including eggs); and frogs, eels, and hedgehogs (which are all less active in winter, and may therefore be less available as prey). The unidentified prey items other than birds were excluded because they could not be placed into a group. Fig. 2 shows the monthly occurrence of these groups.

The occurrence of all prey groups so defined varied significantly between months:

rodents	$\chi^2=29.8$	$P<0.005$	11 d.f.
large mammals	$\chi^2=27.2$	$P<0.005$	11 d.f.
birds	$\chi^2=23.2$	$0.025>P>0.01$	11 d.f.
frogs, eels, hedgehogs	$\chi^2=27.8$	$P<0.005$	11 d.f.

DIFFERENCES IN DIET BETWEEN SEXES

Fig. 3 compares the percentage occurrence of prey in the scats of male and female ferrets. It suggests that males take more of the larger prey (i.e., lagomorphs and opossums), whereas the females take more mice and frogs. The frequencies of occurrence in the scats of each sex were tested using the χ^2 statistic, but the difference was significant only for mice ($\chi^2=13.25$, $P<0.005$, 1 d.f.).

DISCUSSION

SOURCES OF BIAS OR ERROR

Interpretation of scat analysis results should take into account the reliability and limitations of the method. Individual animals vary in trap sensitivity, and therefore trapping gives only a sample, possibly a biased one (Lockie 1966). The problems of identifying carrion and recording the same prey item more than once have already been discussed (see Methods). Other sources of error in this type of study are:

(a) Prey without indigestible remains. Latham (1952) states that "digestion of certain food materials may be so complete that recognisable remains cannot be found in faecal samples". Comparisons with stomach analyses may help to indicate the extent of this error, but some foods may still be missed.

(b) Identification of extraneous material. With scat analysis it is not certain that what appears in the scats was taken as prey. Plant and insect material, for example, may be eaten with other foods but not sought out by the ferret. Most invertebrates < 10 mm long were probably eaten accidentally, because when found there were only one or two specimens per scat. Those that occurred in larger numbers at a time, i.e., Diptera and Coleoptera larvae, were also probably accidental since they are commonly associated with carcasses.

Table 2. Invertebrates recorded from 203 ferret scats, Pukepuke, Nov. 1970–July 1973

	Length >10 mm	5–10 mm	<5 mm	
Insect				
Coleoptera, adult*	10†	4	9	**23**
larva	—	34	15	**49**
Lepidoptera, larva	5†	—	—	**5**
Diptera, larva	1	12	14	**27**
Hymenoptera	—	—	5	**5**
Siphonaptera	—	—	2	**2**
Unid. insect	6†	8	16	**30**
Crustacean				
Isopoda	—	2	—	**2**
Amphipoda	—	—	1	**1**
Arachnid				
Araneae	—	—	3	**3**
Pseudoscorpiones	—	1	—	**1**
Mollusc				
Gastropoda	—	—	1	**1**
	22	**61**	**66**	**149**

*Those >10 mm were *Pericoptus* sp.
†Possibly taken as prey

Table 3. Monthly incidence of vertebrate prey items in 203 ferret scats from Pukepuke (—, nil)

	Summer D	J	F	Autumn M	A	M	Winter J	J	A	Spring S	O	N	
Egg	2	2	2	—	—	2	—	1	1	—	—	2	**12**
Passeriformes	3	2	3	2	2	—	1	4	1	1	2	2	**23**
Ralliformes	1	1	—	2	—	2	1	—	—	—	—	—	**7**
Anseriformes	—	—	1	1	—	2	—	—	—	—	—	2	**6**
Unid. bird	1	2	3	3	—	4	—	1	2	—	2	2	**20**
Mouse	—	—	3	3	6	3	8	6	3	—	1	—	**33**
Rat	—	—	—	1	—	—	1	—	1	1	1	—	**5**
Lagomorph	3	2	3	1	2	1	2	2	2	3	3	2	**26**
Opossum	2	1	—	1	1	2	1	3	4	3	2	2	**22**
Hedgehog	2	2	3	2	4	2	—	—	2	—	—	—	**17**
Frog	2	1	3	10	3	5	4	—	3	1	2	1	**35**
Eel	—	2	6	8	4	2	1	2	—	—	2	—	**27**
Unid. mammal	2	—	—	1	1	—	—	1	—	2	—	1	**8**
Unid. prey	1	—	—	1	—	—	—	1	—	—	1	—	**4**
	19	**15**	**27**	**36**	**23**	**25**	**19**	**21**	**19**	**11**	**16**	**14**	**245**
Total scats	15	12	24	29	20	23	17	19	12	9	12	11	**203**

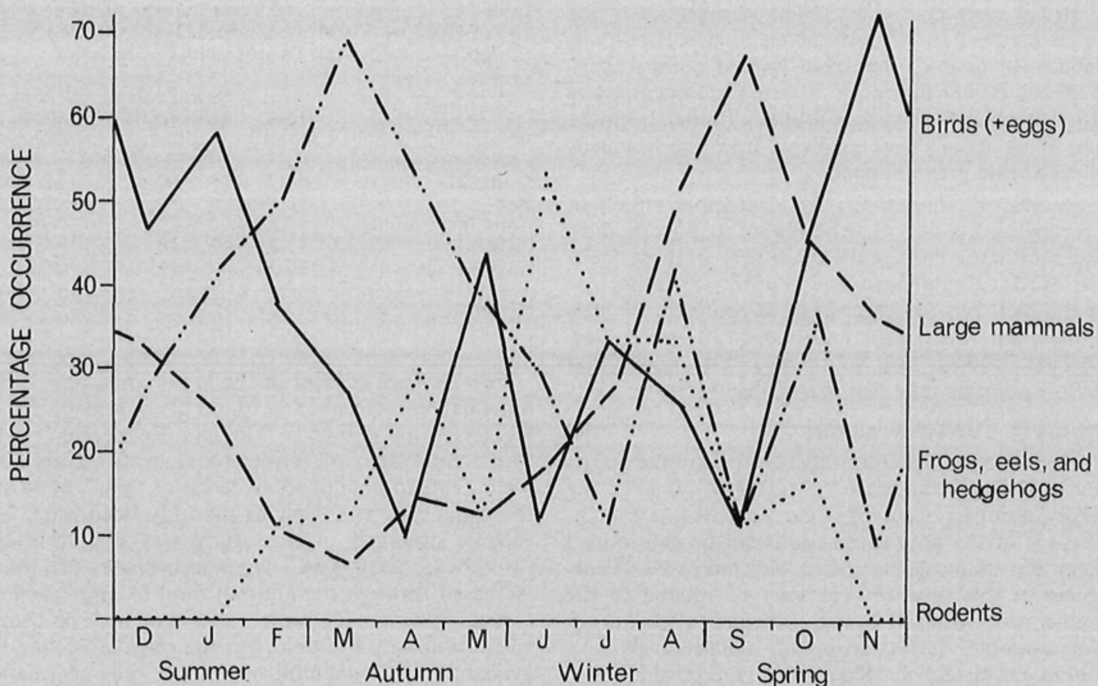

Fig. 2. Monthly occurrence of prey groups in 203 ferret scats from Pukepuke.

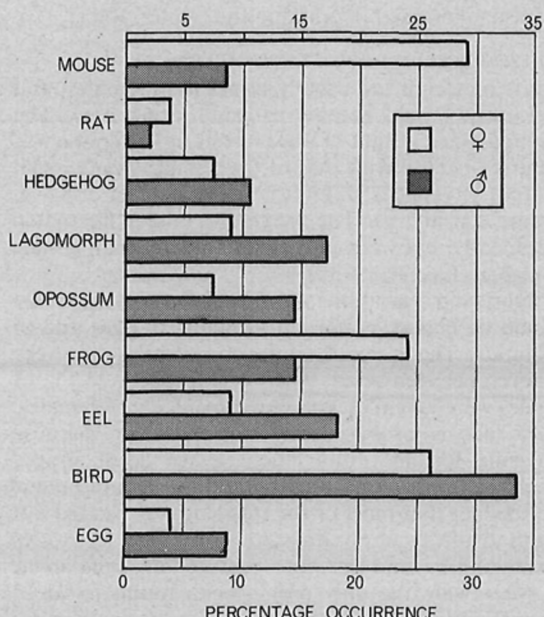

Fig. 3. Foods eaten by 23 ♂ (105 scats) and 19 ♀ (79 scats) ferrets at Pukepuke.

Of the 149 invertebrates recorded, 21 (i.e., those >10 mm long, excluding Diptera larvae) could have been taken as prey (see Table 2). This gives an estimate of 10.3% occurrence in the scats, but because it is not certain that they were prey they have been omitted from the discussion, except for comparisons with other work on mustelids. This should not unduly affect the suggested feeding trends, because invertebrates are small and of little significance in the diet.

Foods eaten by ferrets

Food habit studies are highly specific to time and place, and therefore even general comparisons are of limited value. A further difficulty arises when results expressed in different terms are compared. As previously mentioned (see Methods) the comparison of studies using the frequency of occurrence expressed as a percentage of total prey items is strictly limited if scats often contain more than one prey item. This study can be compared directly only with those of Walton (1968) on British polecats and Fitzgerald (1964) on New Zealand ferrets (Table 4).

The results of the 2 New Zealand studies are similar. Mammals occur most frequently, and their percentage occurrence is similar to that in the diet of British polecats (52.6%). The significance of the larger proportion of birds taken in this country is difficult to assess from these limited comparisons. Walton's (1968) figure for invertebrate occurrences (36.8%) includes all species found, although he noted that many species were probably from the stomachs of vertebrate prey animals.

Studies on *M. putorius* by Kratochvil (1952) in Czechoslovakia and Goethe (1938) in Europe indicate that mammals are the main prey in those areas too. Birds, amphibians, and reptiles are important in the diet, but invertebrates are probably of little significance. Fish were found only in the 2 New Zealand studies, but Southern (1964) noted that British polecats take fish, particularly eels.

Table 4. Comparison of food habits of ferrets as revealed by 3 separate studies. Data expressed as % occurrence in scats or stomachs (—, nil)

	This study	New Zealand (Fitzgerald 1964)	Britain (Walton 1968)
Mammal	54.7	60	52.6
Bird	33.5	36	21.0
Amphibian/reptile	17.2	13	39.5
Fish	13.3	10	—
Invertebrate	10.3*	11	36.8

*Estimate

Seasonal variation in diet

There was significant monthly variation in the occurrence of large mammals ($\chi^2=27.2$, $P<0.005$); the largest numbers occurred in early spring (see Fig. 2). The age of the prey eaten could not be determined definitely in most instances, but increased occurrences at this time of year may be related to the greater proportion of young in the prey populations. For example, ferret droppings collected from a rabbit enclosure at Kourarau (Fitzgerald 1964) between June and January indicated that most young rabbits were taken in October, whereas adults were taken mainly in June or July.

The proportion of scats containing bird remains increased significantly in the spring and summer months ($\chi^2=23.2$, $0.025>P>0.01$). The birds most frequently identified were passerines, which occurred throughout the year. The few ducks and rails recorded were all taken during November–March, when young birds are in the population, and in May–June, in the duck-shooting season. Age identification was again uncertain. The eggs taken may also be from these ground-nesting birds.

Significantly more hedgehogs, eels, and frogs were eaten in the autumn months than at any other time ($\chi^2=27.8$, $P<0.005$). Several facts could increase the vulnerability of poikilotherms to capture in the autumn. Severe drops in the water level of the lagoon such as occurred from December 1972 to April 1973 could be important, but samples were too small for this to be certain. Eels are known to migrate over land in wet weather, and may be more vulnerable to predation at this time.

The sizes of hedgehog spines found (< 12 mm) indicated that predation was entirely on young individuals. The occurrence of hedgehog remains in the scats corresponds almost exactly with the appearance of young in the population, from December to May. It is possible, therefore, that increase in size rather than reduced activity in winter may be a factor in securing hedgehogs from predation.

Few rats are present in the study area, and their remains were infrequently found in the scats (2.5%). But ferrets are known to take rats; Fitzgerald (1964) found that 20% of ferret stomachs from around New Zealand contained evidence of them. Most of the significant variation in monthly occurrence of rodents observed in this study was due to mice ($\chi^2=29.8$, $P<0.005$). The occurrence of mice increased through the autumn months and reached a peak in winter. Possibly more mice may be eaten when more are available, but the relative decline in availability or vulnerability of other prey species in the winter could also be important.

Gibb & Flux (1975) discuss the seasonal variation in prey found in the ferret stomachs examined by Fitzgerald; lagomorphs occurred mainly in the summer, birds were fairly constant all year, and rodents increased in autumn and winter.

Differences in diet between sexes

Male mustelids are usually larger than females, and therefore should be able to catch larger prey. The annual mean weight of male ferrets at Pukepuke was approximately twice that of the females (male mean 1114.0 g, range 750–1500 g; female mean 555.8 g, range 400–800 g). The weights of males fluctuated seasonally, but were consistently greater than female weights (Lavers 1973b).

Observed variations in diet between the sexes could be biased by uneven sampling of ages and of habitats. The ratio of adults to juveniles was very uneven between sexes; when first trapped, 26.1% of males were juveniles, compared to 73.7% of females. Age bias is probably minimal, however, because juvenile females attain the average adult weight within a few months. Any habitat bias could be due to the fact that most of the trapping was carried out around the swamp, although ferrets had territories extending beyond this, into pasture and dune areas.

Mice were the only prey species found to occur significantly more in the scats of one sex (female; $\chi^2=13.25$, $P<0.005$), although the males appeared to take more of the larger prey (Fig. 3). Fitzgerald (1964) and Day (1968) obtained similar results in the occurrence of prey of male and female stoats and weasels, although no result was significant. Male stoats and weasels in Britain tended to take more lagomorphs and fewer small rodents in comparison to females (Day 1968), and in New Zealand, male stoats tended to take more rabbits and rats and fewer insects than the females (Fitzgerald 1964). In an interim analysis of a continuing survey, C. M. King & J. Moody (pers. comm.) found that male stoats in New Zealand took significantly more opossums and fewer mice than females (n=809 stomachs).

Predation

It was not possible from this study to estimate predation pressure on any prey species. In order to do this more information than that obtained from scat analysis is required, particularly the relative numbers of predators and prey in the study area. The hunting behaviour of the predator is also important; *M. putorius* and other mustelids are known to kill surplus prey and store it for consumption later (Winter 1958, Usinger 1956). If this occurs frequently, scat analysis may not reflect the true predation pressure on a species, and seasonal trends may be obscured.

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Appendix. Prey items excluded from the results because they are assumed to be the same as those which occurred previously that month in scats of the same ferret.

	Ferret No.	Sex	Prey item		Ferret No.	Sex	Prey item
Dec. 1970	901	♂	Lagomorph	Aug. 1972	921	♀	Mouse
Feb. 1972	921	♀	Unid. bird	Sep.	913	♀	Opossum
,,	920	♀	Unid. bird	,,	922	♀	Lagomorph
,,	917	♂	Frog	,,	913	♀	Opossum
Mar.	2357	♂	Frog, opossum	Nov.	913	♀	Passerine
May	922	♀	Unid. bird	Feb. 1973	2364	♂	Eel
,,	913	♀	Mouse	Mar.	2364	♂	Frog
Jun.	2364	♂	,,	Apr.	8925	♂	Eel
,,	2356	♂	,,	,,	8926	♀	Unid. bird
Jul.	913	♀	Opossum	May	913	♀	,, ,,
,,	2356	♂	Mouse				