Diet of the Kestrel *Falco tinnunculus* in the breeding season

Erkki Korpimäki

Korpimäki, E. 1985: *Diet of the Kestrel* Falco tinnunculus *in the breeding season.* — Ornis Fennica 62:130–137.

Prey remains and pellets of the Kestrel *Falco tinnunculus* were collected in the breeding season at 92 nest sites in the Kauhava region, western Finland, in 1972–83 (2 613 prey items). Voles were the most abundant prey group (46.3 % by numbers), followed by insects (25.3 %), shrews (11.9 %), birds (9.1 %), mice (6.7 %), lizards (0.5 %) and frogs (0.3 %). The proportion of *Microtus* voles in the diet correlated positively with their abundance in the field in 1977–83. Towards the end of the breeding season, the proportion of *Microtus* spp. in the diet decreased, due to the changes in the snow and vegetation covers. In small fields fewer members of *Microtus* spp. were caught and more shrews and birds than in medium-sized and large fields, which agrees with the prediction that a predator living in a poor environment cannot be a food specialist. The composition of the diet was dependent on the density of the preferred prey species (in this case the Common Vole). Even in peak vole years, the diet of the Kestrel included several other prey groups and the species thus tended to be a food generalist.

Erkki Korpimäki, kp. 4, SF-62200 Kauhava, Finland

Introduction

The population dynamics of the Kestrel *Falco tinnunculus* were examined in relation to the numbers of small mammals in Southern Ostrobothnia, western Finland, in 1977–83 (Korpimäki 1984 and unpubl.). The prey animals chiefly regulating the population numbers, clutch sizes and production of young in this raptor were found to be the Field and Common Vole (*Microtus agrestis* and *M. arvalis*). Although we now have quite precise data on the breeding biology of the Kestrel, there are only a few minor investigations on the food of this bird of prey in North Europe (e.g. in Finland Karjalainen & Mikkola 1970, Korpimäki et al. 1977, Itämies & Lindgren 1980 and in Norway Hagen 1952). Consequently, the aim of the present paper is to study the composition of the diet of the Kestrel in relation to the fluctuations in the small mammal populations. The numbers of small mammals have only rarely been taken into consideration in dietary investigations on this raptor (but see Village 1982).

Material and methods

Prey remains and pellets were gathered in the breeding season at 92 nest sites in the Kauhava region (63°N, 23°E), western Finland, in 1972, 1975 and 1977–83. The main study area includes the extensive arable land in the Alajoki plain in the communes of Kauhava and Lapua (for details, see Korpimäki 1984). Food samples were collected at 72 nests in this area, where the falcons bred both in open twig nests and in nest-boxes and buildings (Korpimäki 1983). The other samples were gathered in the central and eastern parts of Kauhava (14 nest sites), Jepua (3), Alahärmä (1), Lappajärvi (1) and Purmo (1).

The male Kestrels began bringing food to their mates at least a week before egg-laying and continued doing so until the nestlings were about two weeks old (Tinbergen 1940, Piechocki 1982, my own observations). The females plucked and ate the prey animals in or near the nest, often on the same stone or in the same tree. At the end of the nestling period, both mates hunted and prey was brought directly to the young (Tinbergen 1940). The fledglings can stay some days in trees near the nest and I collected pellets and prey remains from the nest and from the ground near the nest after the breeding season. Since the efficiency of the sampling depends on the number of times remains are collected (Tinbergen 1946, P. Sulkava 1972, Kellomäki 1977, this study, Table 1), I gathered the pellets twice or three times in some nests, especially in 1982 and 1983. This method yields a significantly higher number of prey animals from a nest (t-test, $P<0.001$) than one sampling visit and also allows study of seasonal variation in the diet. On the other hand, the number of collecting visits does not affect the food composition (Table 1).

The pellets and prey remains were dried after collection. Then the samples were carefully examined and all bones, feathers, scales and parts of insects were separated (the median of the treatment time per nest was 2 hours). As a single examination reveals only 50–70 % of the bones significant for identification (Korpimäki 1981), the pellets were checked three times, which reveals 80–100 % of the bones of even small prey species, such as shrews.

Small mammals were identified by the diagnostic features according to Siivonen (1974) and the numbers of individuals were determined by counting the mandibles. In the identification of mammals the greatest difficulty was the separation of the Field and Common Vole, since both species occur in the study area (Korpimäki 1981). If the joint branch of the mandible was broken, the site of the foramen was undistinguishable. Consequently, not all individuals of these voles could be determined to the species.

Birds were mostly identified with the aid of the humeri, by comparing the bones with reference material from

museum collections. In a few cases beaks, legs, metacarpals and feathers were also used in the determination. Lizards and frogs were identified according to the methods presented by Yalden & Warburton (1979). The detailed methods for determination of insects will be given elsewhere (Itämies & Korpimäki 1985).

The small mammal populations in Alajoki were studied with snap traps in May and early June (spring catches, 5372 trap nights) and in late August and early September (autumn catches, 5472 trap nights). Fifty to sixty traps were set at distances of 10 m in cultivated fields, abandoned fields, and pine and spruce forests. The area of the sample plots ranged from 0.5 to 0.6 ha. The traps were kept in the same place for four (sometimes only three) days and were checked once a day (see Korpimäki 1981, 1984 for additional details on the method).

Results

Diet composition. The diet of the Kestrel comprised 11 mammal, 29 bird, 1 lizard and 1 frog species (Table 2 and Appendix 1). In addition, insects were found in the diet. Voles formed the most abundant food item group and their frequency was also highest (99 %). The most important vole species in the diet was the Common Vole, followed by the Bank Vole *Clethrionomys glareolus*, Field Vole and Water Vole *Arvicola terrestris*. Shrews occurred quite regularly among the prey items (constancy 78 %), and the most abundant species was the Common Shrew *Sorex araneus*. Mice were recorded only in small numbers, but fairly regularly (constancy 74 %). The diet also included a Brown Rat *Rattus norvegicus* and a Pygmy Weasel *Mustela rixosa*. Mammals were the main group in the diet of the Kestrel, 65 % by number and 72 % by weight.

Birds formed 9 % of the prey by number and 27 % by weight, and were found quite regularly in the nests (constancy 77 %). The most abundant species were the Redwing *Turdus iliacus*, Fieldfare *T. pilaris*, *Phylloscopus* spp. and Chaffinch *Fringilla coelebs*. When the falcon's own young died of starvation in the nest, they were quite often eaten by the

Table 1. The effect of the number of collecting times on the recorded food composition of the Kestrel in the breeding season.

Prey species or groups	No. of collecting times: One (64 nests) N	%	Two or three (18 nests) N	%
Soricidae	161	11.6	119	11.8
Microtidae	698	50.1	478	47.3
Muridae	84	6.0	73	7.2
Mustela rixosa	1	0.1	–	–
Mammalia, tot.	944	67.8	670	66.3
Aves	115	8.3	82	8.1
Reptilia	6	0.4	7	0.7
Amphibia	6	0.4	1	0.1
Insecta	322	23.1	251	24.8
Prey animals	1393	100.0	1011	100.0
Prey items/nest	21.8	56.2		

Table 2. The diet of the Kestrel in western Finland in the breeding season. Combined data from 1972–83. Mean weights of small mammals from Korpimäki (1981), of other mammals from Siivonen (1974), of birds from v. Haartman et al. (1963–72), of frogs from Glutz v. Blotzheim & Bauer (1980), of lizards from Avery (1971), and of insects from Itämies & Korpimäki (1985). Constancy (C) is the percentage of nests in which the prey species or group was found.

Prey species or groups	Weight g	Numbers of prey N	%	Prey biomass g	%	C
Sorex araneus	7.5	297	11.4	2228	4.2	77.2
S. minutus	3.5	9	0.3	32	0.1	8.7
Sorex sp.	7.5	3	0.1	23	0.0	3.3
Neomys fodiens	14.5	1	0.0	15	0.0	1.1
Soricidae, tot.	7.4	310	11.9	2298	4.4	78.3
Microtus arvalis	23.5	319	12.2	7497	14.3	76.1
M. agrestis	25.0	97	3.7	2425	4.6	41.3
Microtus sp.	24.5	536	20.5	13132	25.0	94.6
Microtus sp., tot.	24.2	952	36.4	23054	43.8	97.8
Clethr. glareolus	16.5	219	8.4	3614	6.9	71.7
Arvic. terrestris	170.0	38	1.5	6460	12.3	22.8
Microtidae, tot.	27.4	1209	46.3	33128	63.0	98.9
Rattus norvegicus	222.5	1	0.0	223	0.4	1.1
Micromys minutus	8.0	49	1.9	392	0.8	30.4
Mus musculus	15.0	123	4.7	1845	3.5	56.5
Micromys/Mus	11.5	2	0.1	23	0.0	2.2
Muridae, tot.	14.2	175	6.7	2483	4.7	73.9
Mustela rixosa	52.0	1	0.0	52	0.1	1.1
Mammalia, tot.	22.4	1695	64.9	37961	72.1	100.0
Aves	60.0	237	9.1	14217	27.0	77.2
Amphibia	36.0	7	0.3	252	0.5	5.4
Reptilia	3.0	14	0.5	42	0.1	12.0
Insecta	0.2	660	25.3	132	0.3	60.9
Total	20.1	2613	100.1	52654	100.0	100.0

Table 3. The proportions (%) of the most important prey species and groups by number in the diet of the Kestrel in 1977–83. The annual differences were examined with the χ^2-test; significant differences between the adjacent columns are shown (* = P<0.05, ** = P<0.01, *** = P<0.001). The diversity of the food was measured with Shannon & Weaver's (1949) index (H').

Prey species or groups	1977		1978		1979		1980		1981		1982		1983
Soricidae	5.0		7.8	*	12.1		16.4		19.3		21.2	***	6.5
Microtus arvalis	20.3		16.3		12.7		3.0		4.3	***	11.8	***	4.9
M. agrestis	3.8		1.3		2.2		2.4		2.4	***	9.8	***	1.5
Microtus sp.	36.1		21.6		19.6		8.5		6.7		22.2		9.6
Microtus sp., tot.	60.1	***	39.1		34.5	**	13.9		13.4	***	43.8	***	16.0
Clethrionomys glareolus	8.8		8.5	**	15.9	**	4.2		3.5	**	9.1	**	3.7
Arvicola terrestris	0.7		0.3		–		0.6		1.2		3.3		4.0
Microtidae, tot.	69.7	***	47.9		50.4	***	18.8		18.1	***	56.2	***	23.8
Muridae	4.7		5.5		8.2		1.2		7.9		8.5	**	4.3
Mammalia, tot.	79.3	***	61.4	**	70.7	***	36.4		45.3	***	85.9	***	34.6
Aves	5.0		3.8	*	7.4	***	21.8	**	11.8	**	5.4	***	21.0
Amphibia	–		–		0.5		–		0.8		0.2		0.6
Reptilia	0.5		0.5		–		0.6		–		0.4		1.9
Insecta	15.1	***	34.3	***	21.3	***	41.2		42.1	***	8.1	***	42.0
Prey animals	557		399		403		165		254		482		324
Nests	26		13		13		8		10		11		9
Prey items/nest	21.4		30.7		31.0		20.6		25.4		43.8		36.0
H'	1.86		1.86		2.02		1.65		1.82		2.21		1.84

other nestlings. Both lizards (*Lacerta vivipara*) and frogs (*Rana temporaria*) were taken, but their proportions in the diet were small. Insects were a surprisingly abundant prey group by number (25 %), but by weight their proportion was very small (0.3 %). The details on the species of insects will be given elsewhere (Itämies & Korpimäki 1985).

The heaviest prey animals were young Pheasants *Phasianus colchicus*, Partridges *Perdix perdix*, the Brown Rat and the Water Vole, and the lightest were insects and the Lesser Shrew *Sorex minutus*. The mean weight of the Kestrel's prey animals was 20.1 g. All the Pheasants and Partridges were brought to the nest at the end of the nestling period, when both mates were hunting for food for the young (Tinbergen 1940). They were probably taken by the larger female.

Variation in diet: annual differences. The diet varied significantly between the consecutive years in the period 1977–83 (χ^2-test, P<0.01, Table 3); only the difference between 1980 and 1981 was not significant. The proportions of *Microtus* spp. were highest in 1977–79 and 1982. In 1977–79 the Common Vole was clearly more abundant in the food than the Field Vole, but in 1980–83 the numbers of both species were almost equal. The Bank Vole did not show such clear variation in its occurrence as was found in *Microtus* spp., but its proportion was highest in 1979. Shrews were most common in 1980–81, when the proportions of voles were lowest, and in 1982 as well.

The proportions of birds and insects seemed to fluctuate inversely with the proportions of mammals, because these prey groups were most numerous in the diet in 1980–81 and 1983. The numbers of frogs and lizards varied irregularly. The diversity of food was highest in 1979 and 1982, and lowest in 1980.

Seasonal variation. The seasonal variation of the diet was studied by dividing the breeding period into three parts (1 May to 15 June = mainly the egg-laying and incubation time, 16 to 30 June = the hatching and the first half of the nestling period, and 1 to 31 July = the latter half of the nestling period). The division of the nestling period into two parts is justified by the much greater weight increase of the nestlings during the first half (Korpimäki et al. 1979).

Towards the end of the breeding season, the proportion of *Microtus* spp. decreased, while the proportions of shrews and birds increased correspondingly (Table 4). The number of Water Voles in the diet also seemed to increase as the breeding season progressed, but the differences were not significant. There was no great variation in the catches of Bank Voles, mice, frogs or lizards. The diet differed significantly between the first part of the breeding season (1 May to 15 June) and the other periods (χ^2-test, P<0.01). The diversity of food was lowest and the number of prey groups smallest in the first part, after which the number of prey groups increased and the diet was much more diversified.

Variation between habitats. The main hunting habitats of the Kestrel in the study area were fields (Korpimäki 1978) and the densities of the breeding populations were greater in large fields (area >50 km^2) than in small fields (<10 km^2) (Korpimäki unpubl.). Possible differences in the food composition were studied and the results are shown in Table 5. The proportions of *Microtus* spp. were lowest in small fields. The Bank Vole was caught most abundantly in large fields. Most mice were caught in medium-sized fields. The proportion of shrews in the diet was higher in small and medium-sized fields than in large fields. In small fields the Kestrels frequently

Table 4. Seasonal variation of the most important prey species and groups by number in the diet of the Kestrel (combined data from 1977–83). The seasonal differences were examined with the χ^2-test and niche breadth was measured with the diversity index. See Table 3 for additional explanations.

Prey species or groups	1 May–15 June	16–30 June	1–31 July
Soricidae	6.8 *	12.7	15.1
Microtus spp.	47.4 **	37.3 **	27.8
Clethrionomys glareolus	8.0	8.1	6.2
Arvicola terrestris	–	2.8	4.8
Microtidae, tot.	55.4	48.1 *	38.8
Muridae	7.6	6.8	7.2
Mammalia, tot.	69.9	67.6	61.2
Aves	4.4 *	9.1	9.6
Amphibia	–	0.2	–
Reptilia	0.4	1.1	0.3
Insecta	25.3	22.0 *	28.9
Prey animals	249	472	291
Prey groups	22	30	27
H'	1.89	2.16	2.11

preyed on birds, while in the fields of other size classes the proportions of insects were high. The diets in the different-sized fields differed significantly from each other (χ^2-test, $P<0.001$). The diversity of food was higher in small fields than in medium-sized and large fields.

The clutch size ($\bar{x} \pm SD$) in small fields (5.0 ± 0.7, $N = 5$) seemed to be smaller than in medium-sized (5.4 ± 0.8, $N = 14$) and large fields (5.4 ± 0.9, $N = 56$), but the difference was not significant (t-test).

Diet in relation to the small mammal population. The diet was examined in relation to the small mammal populations in Alajoki in 1977–83. The correlations between the proportions in the diet and the densities in spring trappings (ind./100 trap nights) were calculated separately for the different small mammal species and groups. Only two significant positive correlation coefficients were recorded: for the Common Vole (Fig. 1) and the group of *Microtus* spp. ($r = 0.83$, $P<0.05$). The r-values for other prey mammals were as follows: shrews 0.19, Field Vole 0.14 and Bank Vole 0.25. They were all positive, but far from statistical significance.

Table 5. Variation of the Kestrel's diet between habitats (small fields: area <10 km^2, medium-sized fields: 10–50 km^2 and large fields: >50 km^2). Combined data from 1972–83. The differences between habitats were examined with the χ^2-test. See Table 3 for additional explanations.

Prey species or groups	Small fields	Medium-sized fields	Large fields
Soricidae	15.8	14.7 *	10.9
Microtus spp.	31.6***	39.1	36.0
Clethrionomys glareolus	7.0	5.5 **	9.2
Arvicola terrestris	0.9	0.2	1.8
Microtidae, tot.	39.5	44.8	47.0
Muridae	8.8	10.9 ***	5.5
Mustela rixosa	–	–	0.1
Mammalia, tot.	64.0 *	70.4 **	63.4
Aves	27.2***	7.6	8.4
Amphibia	–	0.4	0.3
Reptilia	–	0.6	0.6
Insecta	8.8 **	21.0 **	27.3
Prey animals	114	524	1975
Nests	9	16	67
H'	2.31	2.15	2.18

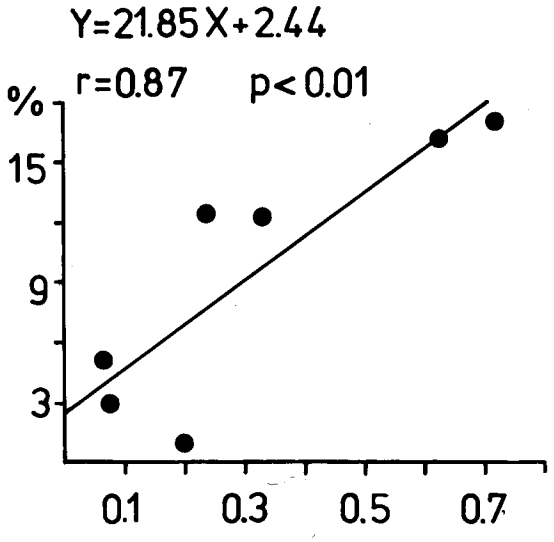

Fig. 1. Regression of the proportion (%) of the Common Vole in the Kestrel diet on the densities in the field (ind./100 trap nights, horizontal axis) in 1977–83.

Discussion

The well-known difficulty of analysing pellets of hawks, compared with those of owls, is ascribed to their stronger beaks and talons, which make it easier to dismember the prey, and to their powerful digestion. For example, the proportion of undigested food (e.g. hairs, feathers and bones) in the pellets of the Short-eared Owl *Asio flammeus* is 45 % (Chitty 1938), but in the pellets of the Kestrel it is only 30 % (Yapp 1969). Pasanen & S. Sulkava (1971) have shown that the nestlings of the Rough-legged Buzzard *Buteo lagopus* digest their food more effectively than the adult birds. However, according to my observations even soft scales of lizards, thigh bones of frogs and legs or heads of insects can be found in the pellets of adult and young Kestrels. Consequently, the method used is accurate enough to determine the falcon's diet (see also Crichton 1977).

Diet composition. In the present study area the Kestrel caught almost all the available animals of the same size as itself or smaller. Accordingly, it has a fairly wide choice of prey, compared with, for exam-

ple, the most numerous owl species (Tengmalm's Owl *Aegolius funereus*) in the study area. This owl concentrates entirely on mammals and birds even in poor vole years (Korpimäki 1981). The largest prey mammals and birds indicate that the hawk can carry surprisingly heavy burdens, weighing even more than itself. On the other hand, the lightest prey animals were very small (mean weight of insects in the diet only 0.2 g, Itämies & Korpimäki 1985).

Uttendörfer's (1939, 1952) pioneering investigations were followed by several other studies on the diet of the Kestrel in Europe (Appendix 2). Voles, especially *Microtus* spp., were the most important prey group of the Kestrel almost everywhere. In Ireland microtines are completely lacking (Southern 1964) and the proportions of mice and birds in the diet are high. The number of shrews is greatest in Northern Europe and in Scotland (Village 1982). Insects are the most abundant prey group in other studies from Great Britain, in Hungary and in the arid Mediterranean area. In urban areas the proportion of birds can be high, e.g. 76 % in cities in Great Britain (Yalden 1980).

The diversity of the Kestrel's food during breeding increased significantly from south to north in Europe (Fig. 2), but not from west to east. This latitudinal

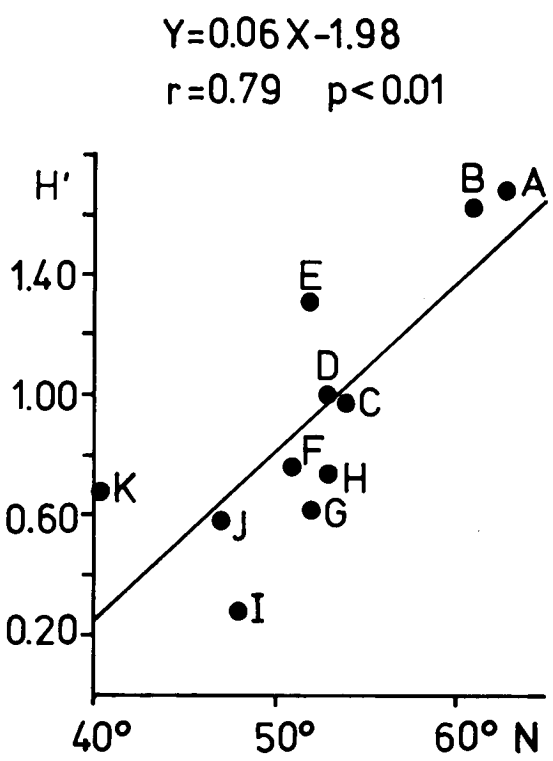

Fig. 2. Regression on latitude (N) of the diversity (H') of the Kestrel diet in Europe. The characters beside the dots show the countries in Appendix 2.

trend can be due to the greater fluctuations in vole populations in Northern Europe (e.g. Kalela 1962). In this study a scarcity of voles caused a switch to alternative prey groups. Small mammals are scarce in the Mediterranean area and there the Kestrel concentrated on the most common resource (i.e. insects). When examining the food of European owls, Herrera & Hiraldo (1976) also concluded that most of the species expanded their diets from Southern Europe to Scandinavia.

Annual variation in diet. In the study area, the Common Vole lives mainly in cultivated fields with low grass. The Field Vole favours high vegetation and abandoned fields. The Bank Vole most often occupies forests and the edges of fields. The Kestrel always takes its prey from the ground and it localizes small mammals by sight (e.g. Uttendörfer 1952). As high vegetation affords shelter from hunting raptors (Wolff 1962), the Kestrel mainly catches its prey in cultivated fields (56 % of hunting observations, N = 1250, Korpimäki 1978) and the most important prey species is the Common Vole, which was also the species preferred to the other small mammals in Alajoki (Korpimäki 1985).

The proportions of Common Voles in the diet correlated positively with their densities in the field during the study period, but the densities of other small mammal species did not correlate with their numbers in the diet. Consequently, these results supported the prediction of optimal foraging in the sense that the compositon of the diet is independent of the abundance of alternative prey, and depends only on the density of the preferred prey species (Schoener 1971, Pulliam 1974, Charnov 1976).

Korpimäki (1985) pointed out that the Kestrel was a food generalist compared with *Asio* spp. (*A. otus* and *A. flammeus*) in Alajoki. This is supported by the fact that even in good vole years (e.g. 1977) the diet of the falcon included many other prey groups. This catholic predation may be caused by the limited availability of voles in the breeding season, when the abundance of these prey animals is lower than at other times. Further, the community of birds of prey is quite diverse in Alajoki (Korpimäki 1984) and the food niches of the most common species (the Kestrel and *Asio* spp.) overlapped to a fairly high degree (Korpimäki 1985). Thus, interspecific competition for food might also force the Kestrel to hunt many different prey groups in addition to microtines.

Seasonal variation in the diet. Seasonal variation in the availability of the Kestrel's food is caused by changes in the snow and vegetation cover and in the behaviour of the prey animals. The latter changes are due to variation in the age and sex structure of the animal populations, in their reproduction status and in their mobility.

When the Kestrels arrive in the study area, at the

end of March and in April, the snow is just melting in the fields. The vegetation of the previous summer has been pressed down on the ground and no new vegetation has grown up. The melting snow forces Common and Field Voles to leave their holes and come out into the open, where they are easy to catch. At the end of May, the vegetation starts growing in the fields and the snow has just melted in the forests, forcing the shrews to come up out of the ground, and increasing their risk of getting caught. At the end of June the vegetation in the fields is at its densest and this reduces the catchability of small mammals. On the other hand, the "above-ground" activity and the number of young Water Voles increase in summer (Gaisler & Zejda 1973), and due to reproduction, the densities of the birds and insects increase continuously in June and July. Consequently, the proportions of Water Voles, birds and insects increase in the diet. Similar decreases of mammals and increases of birds were noted in the diets of the Sparrowhawk *Accipiter nisus* (P. Sulkava 1972), Pygmy Owl *Glaucidium passerinum* (Kellomäki 1977) and Tengmalm's Owl (Korpimäki 1981) during their breeding seasons in Finland.

Village (1982) studied the seasonal variation of the diet of the Kestrel throughout the year in Southern Scotland and found no marked changes in the frequency of voles or shrews. The occurrence of birds was largely confined to the June–July period and earthworms were taken mainly in late winter and early spring, but almost never in June–July. The differences compared with the present study were due to the different snow conditions, vegetation cover, available prey animals and migrating habits of the Kestrel.

Variation in diet between habitats. Kuusela (1983) showed that the clutch sizes of Finnish Kestrels were greatest in agricultural land and forest clearings. When voles were scarce, the breeding population concentrated in large fields in my study area. The present results on the variation of the diet between different-sized fields also indicated that the most favourable breeding territories were located in medium-sized and large fields. Although the food samples from the small fields were collected mainly in peak vole years, the proportions of *Microtus* spp. in the diet were lower and the numbers of birds higher than in fields of other size classes. This difference may be caused by the distribution of the preferred prey species (Common Vole), which is most abundant in large fields (S. & P. Sulkava 1967, Korpimäki unpubl.). The food in the small fields was more diverse than in larger agricultural areas. This accorded with the prediction that a predator living in an environment where food is scarce cannot be a food specialist, since the search for prey is so time-consuming (e.g. MacArthur & Pianka 1966, Emlen 1968).

Acknowledgements. I wish to thank Mikko Hast, Ossi Hemminki and Sakari Ikola for help in the field, Eero Korhonen for the statistical computer programmes, Mirjam Taurén and Anna Damström for checking the language, and Harto Lindén and Juha Tiainen for valuable comments on my manuscript. Financial support for the present study was provided by the Finnish Cultural Foundation, the Oulu Student Foundation, the Jenny and Antti Wihuri Foundation, the Emil Aaltonen Foundation and the Academy of Finland.

Selostus: **Tuulihaukan pesimäaikainen ravinto**

Aineistoa tuulihaukan pesimäaikaisesta ravinnosta kerättiin 92 pesältä Kauhavan seudulta, Etelä-Pohjanmaalta vuosina 1972, 1975 ja 1977–83 (yhteensä 2 613 saalista). Myyrät olivat tärkein saalisryhmä (46.3 % saaliiden lukumäärästä), sitten seurasivat hyönteiset (25.3 %), päästäiset (11.9 %), linnut (9.1 %), hiiret (6.7 %), sisiliskot (0.5 %) ja sammakot (0.3 %, taul. 2 ja liite 1). Tärkeimpien saalislajien, kenttä- ja peltomyyrien prosenttiosuudet ruokalistalla ja tiheydet maastossa korreloivat positiivisesti vuosina 1977–83 (kuva 1). Päästäisten, lintujen ja hyönteisten osuudet vaihtelivat päinvastaisesti *Microtus*-myyrien osuuksien kanssa (taul. 3). Pelto- ja kenttämyyrien merkitys ravinnossa väheni ja päästäisten, vesimyyrien, lintujen ja hyönteisten määrä lisääntyi pesimäkauden edetessä (taul. 4). Tämä johtui lumipeitteessä ja kasvillisuudessa tapahtuneista muutoksista sekä eri saalislajien lisääntymistilassa ja aktiivisuudessa olevista eroista. Pienten peltojen lähellä pesivät tuulihaukat pyydystivät *Microtus*-lajeja vähemmän sekä päästäisiä ja lintuja enemmän kuin suurten peltolakeuksien haukat (taul. 5). Ravinnon monimuotoisuus kasvoi etelä–pohjoinen suunnassa Euroopassa (kuva 2 ja liite 2).

Tuulihaukan ravinnon koostumus oli riippuvainen suosituimman saaliin (kenttämyyrän) tiheydestä. Tärkeimpiä vaihtoehtoisia saaliita olivat pelto- ja metsämyyrät, hiiret, päästäiset, hyönteiset ja linnut. Tuulihaukalla oli tuottavassa ympäristössä (suurilla pelloilla) yksipuolisempi ravinto kuin köyhillä habitaateilla (pienillä pelloilla). Myös myyräkantojen huippuvuosina tuulihaukan ruokalista sisälsi useita saalisryhmiä pikkujyrsijöiden lisäksi. Siten laji on ravinnonkäytöltään generalisti.

References

Avery, R. A. 1971: Estimates of food consumption by the lizard Lacerta vivipara Jacquin. — J. Anim. Ecol. 40:351–366.

Bouma, J. P. 1931: Voedsel-onderzoek bij den torenvalk. — Org. Cl. Ned. Vogelk. 4:14–18.

Cavé, A. J. 1968: The breeding of the Kestrel in the reclaimed area Oostelijk Flevoland. — Netherlands Journ. Zool. 18:313–407.

Charnov, E. L. 1976: Optimal foraging attack strategy of a mantid. — Amer. Nat. 110:141–151.

Chitty, D. 1938: A laboratory study of pellet formation in the Short-eared Owl (Asio flammeus). — Proc. Zool. Soc. Lond. A 108:266–287.

Crichton, J. 1977: The pellet analysis technique as a method of investigating the food habits of the Kestrel (Falco tinnunculus). — Unpubl. Honours thesis, Univ. Edinburgh.

Emlen, J. M. 1968: Optimal choice in animals. — Amer. Nat. 102:385–389.

Fairley, J. S. & McLean, A. 1965: Notes on the summer food of the Kestrel in Northern Ireland. — British Birds 58:145–148.

Gaisler, J. & Zejda, J. 1973: Above-ground activity of a population of the Water Vole (Arvicola terrestris Linn.) on a pond. — Zool. Listy 22:311–327.
Glutz v. Blotzheim, U. N., Bauer, K. M. & Bezzel, E. 1971: Handbuch der Vögel Mitteleuropas. Band 4. — Akademische Verlagsgesellschaft, Wiesbaden.
Glutz v. Blotzheim, U. N. & Bauer, K. M. 1980: Handbuch der Vögel Mitteleuropas. Band 9. — Akademische Verlagsgesellschaft, Wiesbaden.
v. Haartman, L., Hildén, O., Linkola, P., Suomalainen, P. & Tenovuo, R. 1963–72: Pohjolan linnut värikuvin. — Otava, Helsinki.
Haas, G. 1936: Zur Brutbiologie des Turmfalken. — Mitt. Vogelwelt 35:81–99.
Hagen, Y. 1952: Rovfuglene of viltpleien. — Oslo.
Herrera, C. M. & Hiraldo, F. 1976: Food-niche and trophic relationships among European owls. — Ornis Scand. 7:29–41.
Itämies, J. & Korpimäki, E. 1985: Insect food of the Kestrel, Falco tinnunculus, during breeding in western Finland. — Aquilo, Ser. Zool. 23 (in press).
Itämies, J. & Lindgren, E. 1980: Tuulihaukkojen "pulaajan" ravinnosta. — Oulun Luonnon Ystäväin Yhdistyksen tiedotuksia 5:12–13.
Kalela, O. 1962: On the fluctuations in the numbers of arctic and boreal small rodents as a problem of production biology. — Ann. Acad. Sci. Fenn., Ser. Biol. 66:1–38.
Karjalainen, Y. & Mikkola, H. 1970: Tuulihaukasta ja sen kolopesinnästä Kainuussa. — Kainuun Linnut 1:15–17.
Kellomäki, E. 1977: Food of the Pygmy Owl Glaucidium passerinum in the breeding season. — Ornis Fennica 54:1–29.
Korpimäki, E. 1978: Havaintoja seitsemän petolintulajin saalistustavoista I–II. — Suomenselän Linnut 13:40–44, 86–89.
Korpimäki, E. 1981: On the ecology and biology of Tengmalm's Owl (Aegolius funereus) in Southern Ostrobothnia and Suomenselkä, western Finland. — Acta Univ. Oul. A 118. 1981. Biol. 13:1–84.
Korpimäki, E. 1983: Tuulihaukkapönttökokeilun tuloksia. — Lintumies 18:132–137.
Korpimäki, E. 1984: Population dynamics of birds of prey in relation to fluctuations in small mammal populations in western Finland. — Ann. Zool. Fennici 21:287–293.
Korpimäki, E. 1985: Prey choice strategies of the Kestrel Falco tinnunculus in relation to available small mammals and other Finnish birds of prey. — Ann. Zool. Fennici 22:91–104.
Korpimäki, E., Ikola, S., Haapoja, R. & Kirkkomäki, J. 1977: Sarvi-, suo- ja helmipöllön, tuuli- ja sinisuohaukan ekologiasta Lapuan–Kauhavan Alajoella v. 1977. — Suomenselän Linnut 12:100–117.
Korpimäki, E., Ikola, S. & Haapoja, R. 1979: Tuulihaukan Falco tinnunculus ravinnontarpeesta ja pesäpoikasten painon kehityksestä (Summary: Food requirements and weight development of nestling Kestrels). — Lintumies 14:49–53.
Krampitz, H.-E. 1949: Beitrag zur Lebensweise und Ernährung des Turmfalken in der Grotadt. — Jber. vogelkd. Beob. Station Untermain 22:20–30.
Kuusela, S. 1983: Breeding success of the Kestrel Falco tinnunculus in different habitats in Finland. — Proc. 3rd Nordic Congr. Ornithol. 1981:53–58.
MacArthur, R. H. & Pianka, E. R. 1966: On optimal use of a patchy environment. — Amer. Nat. 100:603–609.
Mouillard, B. 1935: Notes sur la biologie du Faucon crécelle. — Alauda 7:522–534.
Ortlieb, R. 1963: Über die Brutbiologie des Turmfalken. — Falke 10:39–42.
Pasanen, S. & Sulkava, S. 1971: On the nutritional biology of the Rough-legged Buzzard, Buteo lagopus lagopus Brünn., in Finnish Lapland. – Aquilo, Ser. Zool. 12:53–63.
Piechocki, R. 1982: Der Turmfalke. — Die Neue Brehm-Bücherei, A. Ziemsen Verlag, Wittenberg Lutherstadt, 6. Aufl.
Pulliam, H. R. 1974: On the theory of optimal diets. — Amer. Nat. 108:59–74.
Schoener, T. W. 1971: Theory of feeding strategies. — Ann. Rev. Ecol. Syst. 2:369–404.
Shannon, C. E. & Weaver, W. 1949: The mathematical theory of communication. — Univ. of Illinois Press, Urbana, 177 pp.
Shrubb, M. 1980: Farming influences on the food and hunting of Kestrels. — Bird Study 27:109–115.
Siivonen, L. 1974: Pohjolan nisäkkäät. — Otava, Helsinki.
Southern, H. N. 1964: A handbook of British mammals. — Oxford.
Sulkava, P. 1972: Varpushaukan, Accipiter nisus (L.) pesimisbiologiasta ja pesimisaikaisesta ravinnosta. — Phil. Lic. thesis, Dept. Zool., Univ. Helsinki.
Sulkava, S. & Sulkava, P. 1967: On the small-mammal fauna of Southern Ostrobothnia. — Aquilo, Ser. Zool. 5:18–29.
Thiollay, J. M. 1968: Le régime alimentaire de nos rapaces: quelques analyses françaises. — Nos Oiseaux 29:249–269.
Tinbergen, L. 1940: Beobachtungen über die Arbeitsteilung des Turmfalken (Falco tinnunculus L.) während der Fortpflanzungszeit. — Ardea 29:63–98.
Tinbergen, L. 1946: Sperver als Roofvijand van Zangvogels. — Ardea 34:1–123.
Uttendörfer, O. 1939: Die Ernährung der deutschen Raubvögel und Eulen. — Neudamm.
Uttendörfer, O. 1952: Neue Ergebnisse über die Ernährung der Greifvögel und Eulen. — Stuttgart.
Village, A. 1982: The diet of Kestrels in relation to vole abundance. — Bird Study 29:129–138.
Wendland, V. 1953: Populationsstudien an Raubvögeln. — J. Ornithol. 94:109–111.
Wolff, W. J. 1962: Enkele waarmeningen over de invloed van de vegetatie op het jagen van de torenfalk (Falco tinnunculus). — Manuscript.
Yalden, D. W. 1980: Notes on the diet of urban Kestrels. — Bird Study 27:235–238.
Yalden, D. W. & Warburton, A. B. 1979: The diet of the Kestrel in the Lake District. — Bird Study 26:163–170.
Yapp, W. B. 1969: The composition of raptor pellets. — Ibis 111:613.

Received March 1984

Appendix 1. List of the bird species found in the Kestrel's diet during breeding in western Finland. Combined data from 1972–83.

Bird species	No. in diet	Bird species	No. in diet
Falco tinnunculus	11	*Phylloscopus* sp.	1
Perdix perdix	8	*Phylloscopus* sp. size	20
Phasianus colchicus	4	*Regulus regulus*	1
Vanellus vanellus	1	*Ficedula hypoleuca*	2
Aegolius funereus	1	*Anthus pratensis*	1
Jynx torquilla	1	*A. trivialis*	1
Alauda arvensis	1	*Anthus* sp.	5
Parus major	4	*Sturnus vulgaris*	2
P. major size	6	*S. vulgaris* size	1
P. montanus	2	*Chloris chloris*	1
Turdus viscivorus size	1	*Carduelis spinus*	1
T. pilaris	22	*Fringilla coelebs*	13
T. pilaris size	1	*F. coelebs* size	41
T. philomelos	2	*Emberiza citrinella*	6
T. iliacus	32	*E. hortulana*	3
T. iliacus size	11	*E. schoeniclus*	5
Turdus sp.	6	*Emberiza* sp.	6
Saxicola rubetra	8	*Passer domesticus*	3
Phoenicurus phoenicurus	1		
Sylvia curruca	1	All total	237

Appendix 2. The diet of the Kestrel in different countries in Europe. The data are from A) Finland (the present study), B) Norway (Hagen 1952), C) Ireland (Fairley & MacLean 1965), D) Great Britain (Yalden & Warburton 1979, Shrubb 1980, Yalden 1980), E) the Netherlands (Bouma 1931, Tinbergen 1940, Cavé 1968), F) West Germany (Haas 1936, Krampitz 1949, Glutz v. Blotzheim et al. 1971), G) East Germany (Wendland 1953, Ortlieb 1963, Glutz v. Blotzheim et al. 1971), H) Poland (Glutz v. Blotzheim et al. 1971), I) France (Thiollay 1968), J) Hungary (Glutz v. Blotzheim et al. 1971) and K) Italy and Corsica (Mouillard 1935, Glutz v. Blotzheim et al. 1971). For other explanations, see Table 3.

Prey groups	A	B	C	D	E	F	G	H	I	J	K
Soricidae	11.9	22.7	0.9	3.2	6.9	0.3	–	–	0.2	–	0.2
Talpidae	–	–	–	–	0.1	–	–	–	–	–	–
Leporidae	–	–	–	–	0.5	0.1	–	–	–	–	–
Cricetidae	–	–	–	–	–	–	1.2	–	–	–	–
Microtidae	46.3	34.2	–	11.7	47.6	85.1	87.1	88.5	92.8	7.3	3.3
Muridae	6.7	–	44.0	2.6	5.3	1.2	1.0	1.8	0.2	–	7.5
Spalacidae	–	–	–	–	–	0.1	0.6	–	–	–	–
Mustelidae	0.0	–	–	–	–	–	–	–	–	–	–
Mammalia, tot.	64.9	56.9	44.9	17.5	60.4	86.8	90.4	90.3	93.2	7.3	11.0
Birds	9.1	5.0	46.0	8.3	35.1	2.2	7.1	6.8	0.2	1.5	0.8
Reptilia	0.5	6.8	9.0	1.4	3.1	3.2	1.2	1.6	–	7.5	5.8
Amphibia	0.3	0.5	0.1	–	–	–	0.6	0.4	–	–	–
Pisces	–	–	–	–	0.1	–	–	–	–	–	–
Invertebrates	25.3	30.9	–	72.7	1.4	7.8	1.3	0.7	6.5	84.0	82.3
Prey animals	2613	220	420	2557	2245	2021	519	673	4104	619	1624
H′	1.69	1.63	0.98	1.02	1.32	0.78	0.62	0.74	0.28	0.60	0.68