

Reproductive output of the Kestrel *Falco tinnunculus* in Relation to Small Mammal Dynamics in intensively cultivated Farmland

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ABSTRACT

In 1986-1989, a total of 238 pairs of Kestrel *Falco tinnunculus* nested on lowland farmland (100km²) near Hradec Králové, east Bohemia, of them 227 in plastic nest-boxes. The proportion of Common Vole in the diet increased as its abundance increased in the landscape and ranged between 49.2% and 86.7% by number and 36.2% and 84.9% by weight. In a good vole year, clutch size and number of young produced per pair were significantly higher than in a poor vole year. Nevertheless, natality of Kestrels is also affected by factors other than food. The yearly median data on laying the first egg varied over 15 days, from 19 April (good vole year) to 4 May (poor vole year). The values of breeding density (29 to 101 pairs/100km²) surpassed even that of Kestrels in an urban habitat.

INTRODUCTION

Both the breeding biology and diet of the Kestrel *Falco tinnunculus* have been extensively studied but the effects of the population fluctuations of available prey, i.e. small mammals, have been less frequently examined. The importance of voles in the reproductive output of this small falcon has been shown by several investigators in North and West Europe (Cavé 1968; Village 1980, 1990; Korpimäki 1986; Dijkstra 1988; Meijer 1988; Korpimäki & Norrdahl 1991). In Central Europe, where the Common Vole *Microtus arvalis* has been the most abundant member of the small mammal community on farmland, exhibiting sharp fluctuations in numbers, reproductive output of Kestrels has been studied without any exact estimation of small mammal densities.

This paper is part of an extensive study on predation as a regulating factor in small mammal populations, carried out since 1986 in intensively used farmland in eastern Bohemia. In this area plastic nest-boxes of various types have been installed to increase nest-site availability, decreased drastically by human activities since 1977.

Thus the aim of this study is to clarify the effects of population fluctuations in small mammals, especially the Common Vole, on population dynamics (primarily clutch size variation and production of young) of the Kestrel.

MATERIALS AND METHODS

The study was carried out between 1986 and 1989 in Labe basin lowland, east Bohemia (district of Hradec Králové).

The study area is 100km² in size and considered to be typical intensively cultivated farmland. Only small islands of trees and bushes, some windbreaks and two rivers, break the flat cultivations. Numerous railways and roads criss-cross the area. This predominantly cereal growing habitat is a mosaic of arable fields (72.3%) and meadows or pastures (5.0%) surrounded by woodlands (7.5%), water (0.9%) and inhabited areas (7.3%). Orchards and parks cover 6.4% and wetlands have been preserved in only 0.6% of the area.

Plastic nest-boxes have been used to increase the numbers of avian predators. Old plastic canisters, in which agricultural pesticides or other chemicals are stored (25-30 litres capacity) have been installed upside down on woodland edges, solitary trees or in avenues. A female Kestrel will readily accept a nest-box and lay eggs. Nest material (i.e. hay, straw) is regularly replaced after the breeding season every year. Numbers of nest-boxes erected are given in Table 3. See Dusík *et al.* (1986) and Plesník (1990) for additional details on nest-box production and maintenance.

Standard methods were used to study the Kestrels (Brown 1974; Johnson 1978). Territories were mapped by observing courtship displays from early March to late May. We checked all corvid nests, holes in buildings and nest-boxes in the study area from late March to late July each spring. Nests found were visited to obtain data on time of laying the first egg, clutch size and brood size. Brood sizes were estimated by the number of young fledged.

The diet was studied by identification of prey animals in the pellets, in nest-boxes during nesting and analysis of nesting material after fledging of young (total 3,037 prey items).

The small mammal population fluctuations were studied with snap traps in early June (spring catches) and in late September and early October (autumn catches) in 1986-1989 (in all 22,928 trap nights). In these years, 1,724 specimens were captured, of which 83.9% were Common Vole. Two sample quadrats (an alfalfa field, a mown meadow) were used, each one hectare in size. Thus 242 standard snap traps were distributed over a trapping grid (10x10m) using two traps for each trapping point for six nights. Because of numerous refuges for small mammals on farmland, 200 traps were set in road ditches, railway cuttings, windbreaks, wasteland etc. for 3-6 days. For quadrats, population densities were calculated using standard methods, while the small mammal index was calculated as small mammal number/100 trap-nights for trap-lines.

RESULTS

Figures 1 and 2 show population fluctuations in the Common Vole inhabiting farmland. Density was highest in 1988 (good vole year) and lowest in 1987 (poor year). From the viewpoint of abundance, 1986 and 1989 are considered intermediate vole years.

Figure 1. Small mammal community numbers in various habitats in farmland.

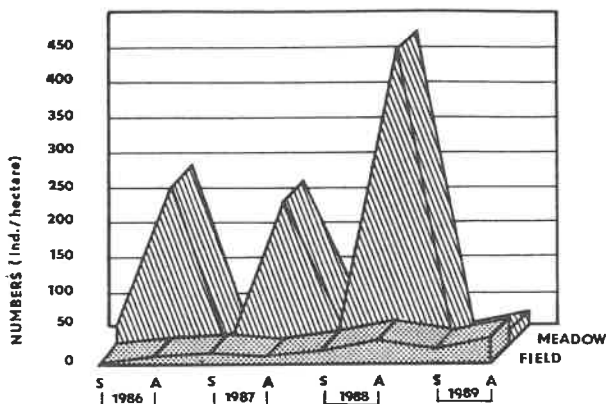
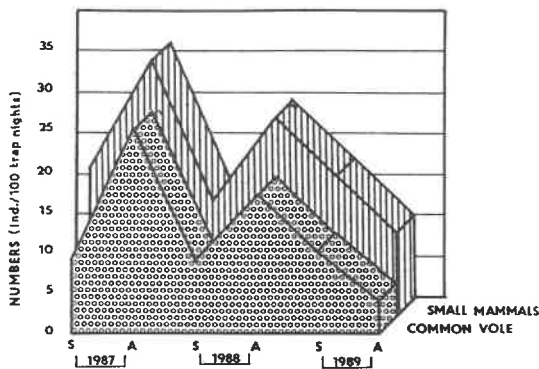


Figure 2. Small mammal numbers in refuges.



Microtus voles were the most important prey group both by number and by mass in the diet of the Kestrel (Tables 1-2). The proportion of Common Vole in the diet increased in proportion to its abundance. Thus the composition of the Kestrel's diet was dependent on the density of the preferred prey species. By numbers, the proportion of other mammals (shrews, moles, mice), birds and insects seemed to fluctuate inversely with the proportion of voles, since these prey groups were most numerous in the diet in 1987. In addition, the diversity of prey was highest in 1987, and lowest in 1988.

Table 1. Proportions (%) of the most important prey species and groups by number in the diet of the Kestrel in 1986-1989. The diversity of food was measured with Shannon and Weaver's (1949) index (H').

Prey species or groups	1986	1987	1988	1989	1986-1989
<i>Microtus arvalis</i>	80.0	49.2	86.7	76.2	73.6
Microtidae, tot.	80.0	49.6	86.7	76.4	73.7
Mammalia, tot.	84.2	68.7	91.7	85.1	83.1
Aves	10.9	14.5	4.5	8.4	9.1
Reptilia				0.3	0.1
Insecta	4.9	16.8	3.8	6.2	7.7
Prey animals	431	675	832	1009	3037
Nests	15	31	39	47	125
Prey items/nest	28.7	21.8	21.3	23.4	24.3
H'	1.35	3.54	0.96	1.82	1.88

Table 2. Proportions (%) of the most important prey species and groups by weight in the diet of the Kestrel in 1986-1989.

Prey species or groups	1986	1987	1988	1989	1986-1989
<i>Microtus arvalis</i>	72.0	36.2	84.9	68.8	64.6
Microtidae, tot.	72.0	38.2	84.9	69.8	64.8
Mammalia, tot.	77.2	67.6	92.4	83.0	80.4
Aves	22.7	32.3	7.6	16.7	19.4
Reptilia				0.2	0.1
Insecta	0.1	0.1	<0.1	0.1	0.1

Both clutch size and number of young fledged were largest in vole peak years and smallest during vole lows ($t = 4.300$, $df = 110$, $p < 0.01$ for clutch size, $t = 2.345$, $df = 101$, $p < 0.05$ for brood size, Student's t -test, two-tailed). The values in intermediate vole years ranged between poor and good.

In our study, egg-laying commenced earlier in the years with high vole abundance than in intermediate or low vole density years.

Table 3. Some features of Kestrel bionomics in farmland, east Bohemia, 1986-1989.

	1986	1987	1988	1989	1986-1989
Number of breeding pairs	21	46	71	100	238
Number of nest-boxes installed	29	62	99	101	291
% of nest-boxes occupied	72.4	70.8	69.7	92.1	81.8
Median date of laying egg	20.IV	4.V	19.IV	1.V	27.IV
(number of clutches)	(19)	(40)	(67)	(91)	(217)
Clutch size (number of nests)	5.48	4.52	5.98	4.17	4.47
	(21)	(44)	(68)	(91)	(224)
Number of fledged young per laying pair	4.95	3.70	5.25	4.17	4.47
Number of fledged young per successful pair (number of nests)	4.95	4.18	5.58	4.40	4.76
	(21)	(39)	(64)	(91)	(215)
Breeding success (young fledged/eggs laid) (in %)	90.4	81.9	87.7	88.1	87.1

DISCUSSION

Our data on the variation in the Kestrel's diet in relation to the density of its main prey, i.e. *Microtus* voles, are in full agreement with those by Cavé (1968), Korpimäki (1986), Village (1980, 1990) and Kostrzewa and Kostrzewa (this volume). Thus *Microtus* voles may be considered the preferred prey in intensively utilised farmland. For clearer knowledge of the most frequent alternate prey, further data from years when voles are scarce are needed. The present results fit with the prediction that the diet of the predator should expand as the abundance of the preferred prey decreases (see also Emlen 1966).

The prey animal chiefly regulating the timing of egg-laying, clutch size and production of young in this raptor in farmland was found to be the Common Vole. Breeding success was lowest in a poor vole year, but higher in intermediate years, probably due to the fact that mortality of eggs and chicks is also affected by factors other than food (e.g. weather, Kostrzewa & Kostrzewa 1990, or predation by martens - but see Cavé 1968).

The total number of Kestrel breeding pairs did not fluctuate closely with *Microtus arvalis* density in the study area, resulting from the continually increased number of plastic nest-boxes installed. Kestrels have preferred these to disused nests of Magpies or wooden nest-boxes. Desertion of the latter for the former, being newly installed, sometimes occurred shortly before egg-laying or even after completion of the clutch (Dusík *et al.* 1986). Results of ringing and wing-tagging show that especially Kestrels hatched in nest-boxes will prefer these. Because plastic nest-boxes have been erected in the area of 536 km² (in 1991 1,000 nest-boxes), displacements of Kestrels have been often observed between various sub-areas. In addition, a poor vole year was not so sharply pronounced as extended low densities in some other microtine cycles. As shown from results of snap-trapping in 1991, no Common Vole was captured in alfalfa field in spring as well as in meadow in autumn. For this year, reproductive output was preliminarily measured as

follows: total 34 breeding pairs, mean clutch size 4.85 and mean number of young fledged per pair only 1.75 (Plesník & Dušek unpubl.)

Due to the good nest-site availability, increased by artificial nest-boxes, the values of breeding density in the intensively utilised lowland area, ranging between 29 and 101 pairs/100km² in 1986 - 1989, mostly surpassed those of Kestrels in both urban habitats and farmland (see R. Kostrzewa 1988 and Plesník 1991).

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American Kestrel *Falco sparverius* - male