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M.K. NICHOLLS & R. CLARKE

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Insects, small mammals and breeding performance of farmland populations of the Common Kestrel *(Falco tinnunculus)* in Sicily

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ABSTRACT

The total Sicilian population of the Kestrel (Falco tinnunculus) *probably amounts to between 5,000 and 7,000 pairs. Kestrels breed between mid April and early June, coinciding with the start of the dry season. Breeding success, observed in different years and different areas between 1980 and 1991, varied between 1.5 and 4.2 young per successful pair. Probably as in other Mediterranean areas, Sicilian Kestrels take fewer mammals than in Northern Europe. Within an area of Sicily where Savi's Pine Vole* (Pitymys savii) *was quite scarce, Kestrels ate more invertebrates throughout the year than on another area with a high frequency of this microtine. This did not affect the breeding performance, which was similar in both areas and similar elsewhere in Europe. Invertebrates, particularly insects, thus assume the role of alternative prey to small mammals.*

INTRODUCTION

The Kestrel *(Falco tinnunculus)* is the most widespread diurnal bird of prey in Sicily, breeding in c.90% of 10x10 km UTM squares (Massa 1985). Its population was conservatively estimated by Iapichino and Massa (1989) as 2000-2500 pairs, but recent censuses indicate that it may be two or three times this level. In some areas diffused pairs nest only 300-400m apart. Roadside censuses yield values of 1 ind./6-13 km in inland and mountainous habitats (Massa 1980) and 1 ind./5-15 km in hilly and flat farmland areas (pers. obs.) Massa (1980) and Cairone (1982) found breeding densities of 5.6-7.5 pairs/km^2 in inland areas, where the Kestrel may be found in scattered colonies. According to winter censuses and observations in the breeding season, its frequency of occurrence is 60% in arable land, 31% in pasture and 50% in Mediterranean shrubland, whilst it is lower (4-15%) in woodland (Massa 1980, pers. obs.). One of the most important vertebrate prey species for the Kestrel (as for other raptors in Sicily) is *Pitymys savii*, a microtine widespread and abundant over much of the island (Massa 1981). However, this small mammal is uncommon or absent in some flat areas of western Sicily, where Kestrels breed and winter. This paper examines differences in breeding performance and feeding habits between two populations of Kestrels, in areas of differing abundance of *P. savii*.

Study areas

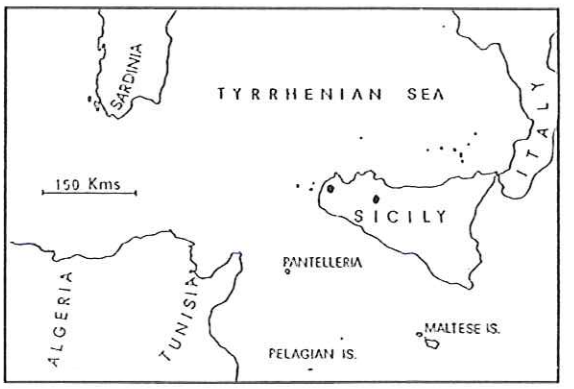

Figure 1 : The island of Sicily, where this research was carried out; dots indicate the two study areas.

The two study areas (Fig. 1) covering 145 and 150km^2 respectively, were in the provinces of Palermo (Area 1) and Trapani (Area 2). The main habitats were arable farmland and pasture. Area 1 was rocky hill-ground, while Area 2 was flat and more intensively farmed. The main crops were wheat, hay and fodder, harvested in late spring-early summer. Both areas comprised about 20% pasture, grazed mainly by cattle in Area 1 and by sheep in

Area 2. In summer, stubbles were burned, ploughed and sown. From 1989 around 10% of arable land was set-aside and consequently not ploughed and sown. Vineyards were widespread and comprised some 20% of both areas. Kestrels in both areas nested mostly in the numerous ruins and old farm buildings which were distributed across the landscape.

METHODS

In the periods 1980-82 and 1990-91 we gathered data on breeding biology and feeding habits of the Kestrel in area 1 (Massa 1980, 1981). From 1988 the breeding pairs in area 2 were censused, collecting data on breeding behaviour and diet. Pellets were collected at roosts and nests monthly from 1988 to 1991; analyses involved estimating the number of items per pellet by matching jaw bones or exoskeleton (di Palma & Massa 1981). On a large scale, or in long term studies, Village (1990, Appendix I) suggests the use of the presence/absence of prey items as a measure of diet variability. However, we observed that when the number of mammals is low, the simple use of the frequency of occurence of prey items might overestimate them (*cf.* Fig. 2; see also Yalden & Warburton 1979). For this reason we counted all the items within each pellet. We analysed overall 647 pellets containing 2398 prey in area 1 and 392 with 3936 prey in area 2.

Population levels of *Pitymys savii* do not show regular cycles in the Mediterranean, so we did not measure vole density. Instead we relied on periodic surveys within the study areas (burrow observations as suggested by Zava & Catalisano 1987; Barn Owl pellet analysis in the same areas) to show the simple presence or absence of this species and thus the frequency of occurrence. Its abundance was very high in area 1 (63%) and much lower in area 2 (less than 10%).

Breeding of Kestrel in Sicily

Kestrels in Sicily bred between mid April and late May or early June (Iapichino & Massa 1989). Egg-laying generally follows the start of the dry season, when rainfall decreases and temperatures increase. Breeding success varies between years and within different areas, probably according to food availability. Fledging success across the Island varies from 1.5 $yr.^{-1}pair^{-1}$ (one extreme case 1.1 $yr.^{-1}pair^{-1}$ in an area with high human disturbance, Cairone 1982) and 4.2 $yr.^{-1}pair^{-1}$ (Iapichino & Massa 1989; present study). In our study, it varied over four years between 2.8 and 3.5 (in area 1) and 1.5 and 4.2 (in area 2). These values match very well those reported by Village (1990) for the UK.

The breeding cycle was observed more accurately in area 2 and results are reported in Table 1.

Breeding success was much poorer in 1989 than in the other three years (Table 1), and this was also the year with least rainfall between January and March (Fig. 2).

	1988	1989	1990	1991
Nests with eggs	6	5	8	5
Eggs laid	29	15	40	24
Mean number of eggs	4.8	3	5	4.8
% of eggs hatched	96.5	80	85	95.8
Mean number of young fledged	3.8	1.5	3.5	4.2
% Young fledged/eggs laid	79.2	50	70	87.5

Table 1: Breeding performance of Kestrels nesting in area 2

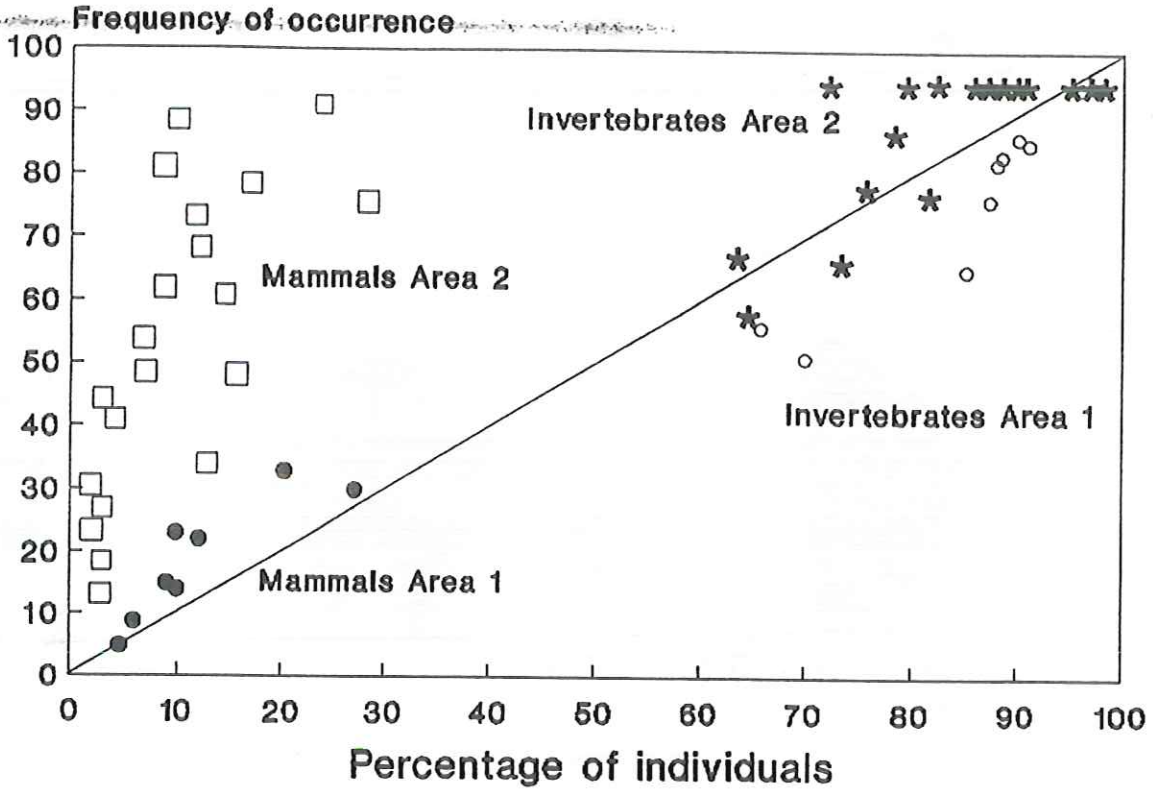

Figure 2 : Correlation between the percentage and the frequency of ocurrence of prey items in the pellets of Kestrels in the two study areas

We found 35 pairs of Kestrels in area 1 and 24 in area 2, corresponding to 24 pairs/100 km^2 and 16 pairs/100 km^2 respectively in areas 1 and 2.

Feeding habits

In area 1, with high frequency of *P. savii*, 80% of the small mammals in the diet of Kestrels was *P. savii* (range 65%-100%), few other species being recorded in pellets *(Mus domesticus, Apodemus sylvaticus, Rattus rattus, Crocidura sicula* and *Suncus etruscus)*. The latter species tend to be nocturnal and, within the same area, we observed a much higher frequency of these mammals in the Barn Owl pellets. On average 20.3% of prey were small mammals, 2.9% birds, 7.4% reptiles and 69.3% invertebrates. Overall, 4-45% of prey items were small mammals, while birds (0-5%) and reptiles (0-17%) were less frequent. Reptiles (mostly lizards) reached a peak between April and August (Fig. 4).

Invertebrates represented 46-95% of prey items, increasing from the summer onwards, reaching peak in winter, and decreasing from early spring to early summer. Conversely, predation of small mammals increased from spring season throughout late summer (that is from laying to post fledging period), becoming scarce or sporadic in autumn and winter.

The mean number of prey items per pellet was 3.7 (range 1.7 - 7.9). These values match the expected predation of Kestrel within the Mediterranean area (Massa 1981, Korpimaki 1985, Village 1990).

In area 2, with few *P. savii*, no other small mammals were alternative prey. Kestrels captured fewer mammals (mean = 8%; range: 1-28.0%) and more invertebrates (mean = 86%; range 62.7-98.3%) than in area 1 (Fig. 5). All prey except invertebrates were infrequent in pellets. The mean number of prey items per pellet was higher in area 2, (mean 10.4; range 2.3 - 25.6). (Fig. 6). Although invertebrate predation was more important throughout the year, seasonal patterns of diet were similar to those in area 1. Invertebrates reached

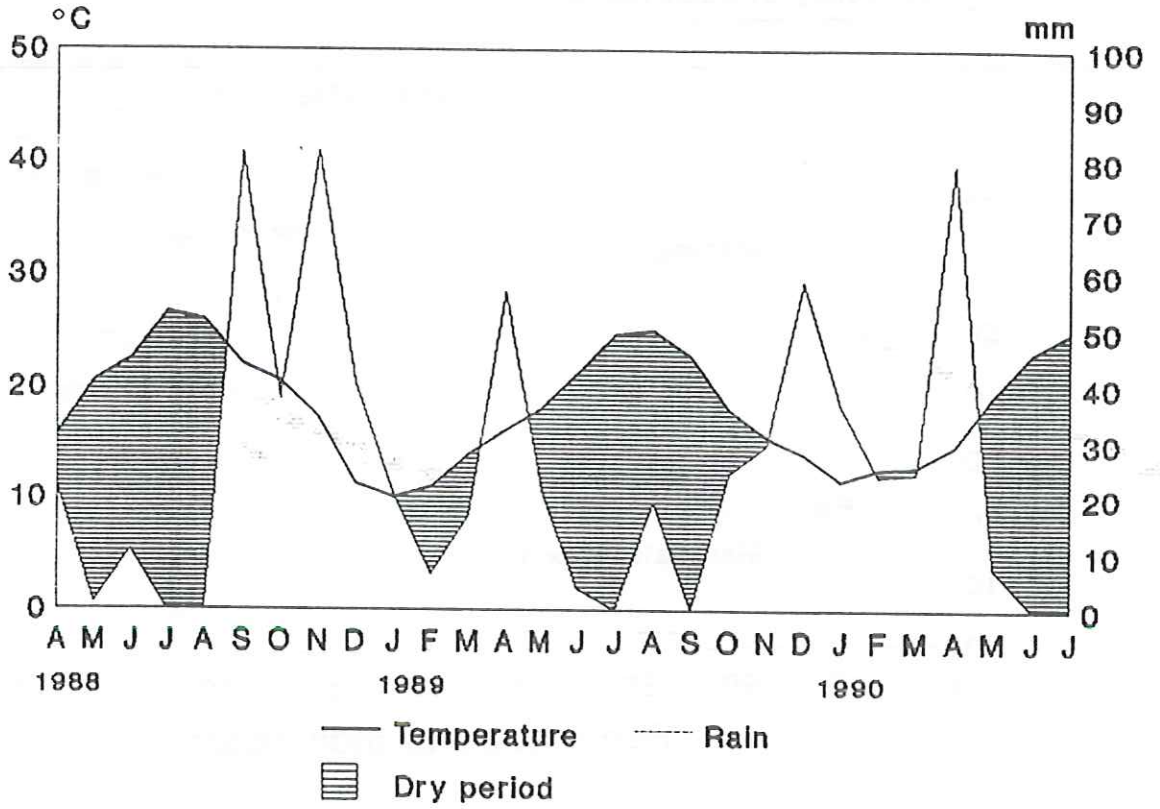

Figure 3 : Meteorological trend (rain and temperature) from April 1988 to July 1990.

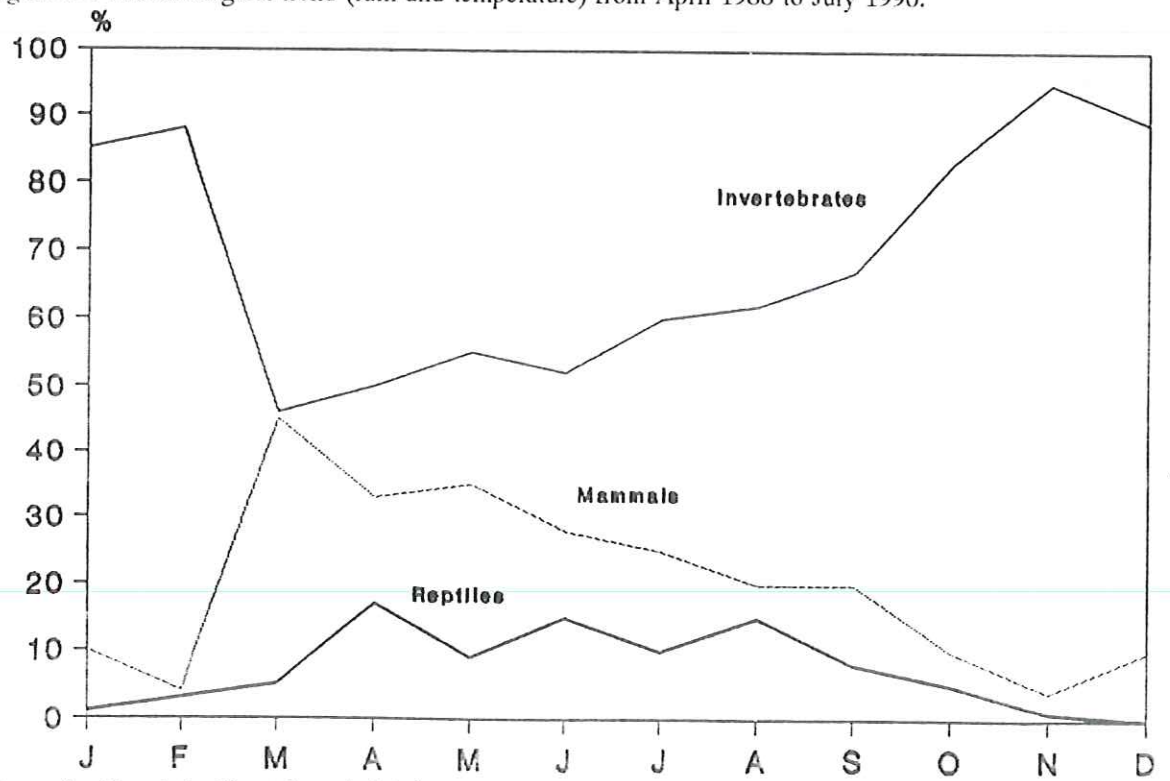

Figure 4 : Trends in Kestrel predation in area 1. Note the increase in small mammals in the pre-laying period.

two peaks, one in summer (largely composed of Orthoptera) and another in autumn-winter (of Coleoptera) (Fig. 7). The main difference between area 2 and area 1 was thus the scarcity of small mammals during the time when kestrels were feeding young.

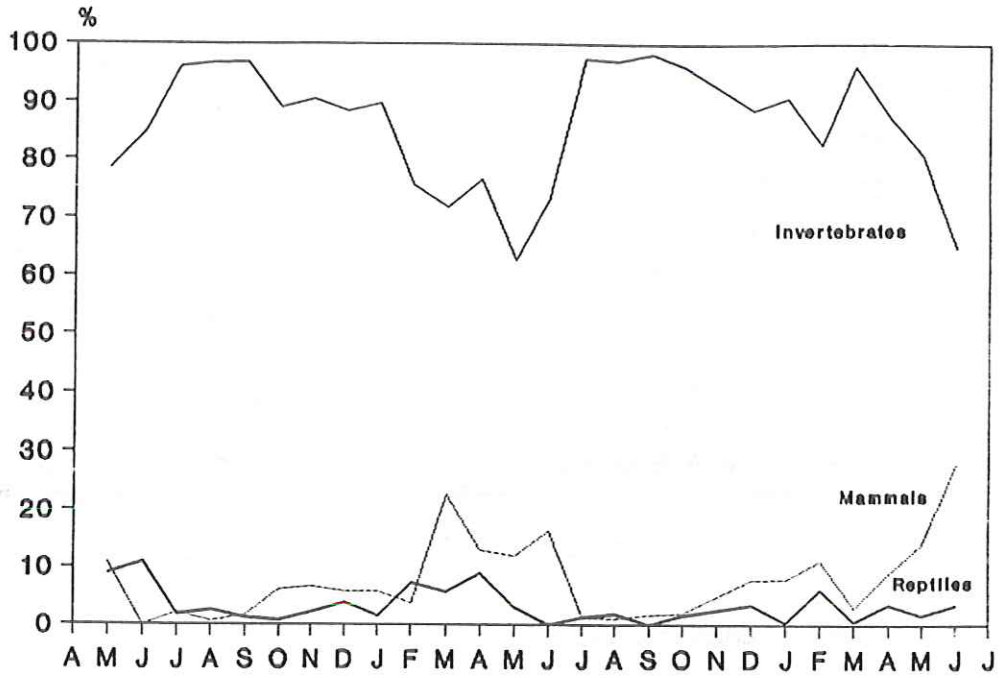

Figure 5 : Trend of Kestrel predation in area 2, from May 1988 to June 1990. Note the higher percentage of invertebrates in respect to area 1.

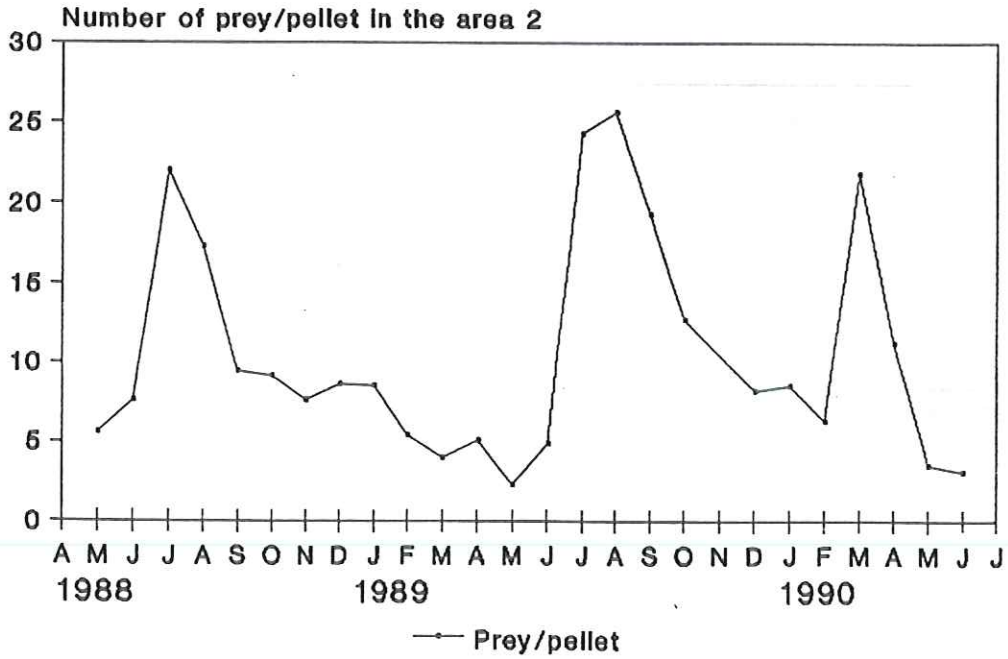

Figure 6 : Mean number of prey per pellet in area 2, from May 1988 to June 1990. Peaks correspond to high numbers of *Gryllus* in the pellets.

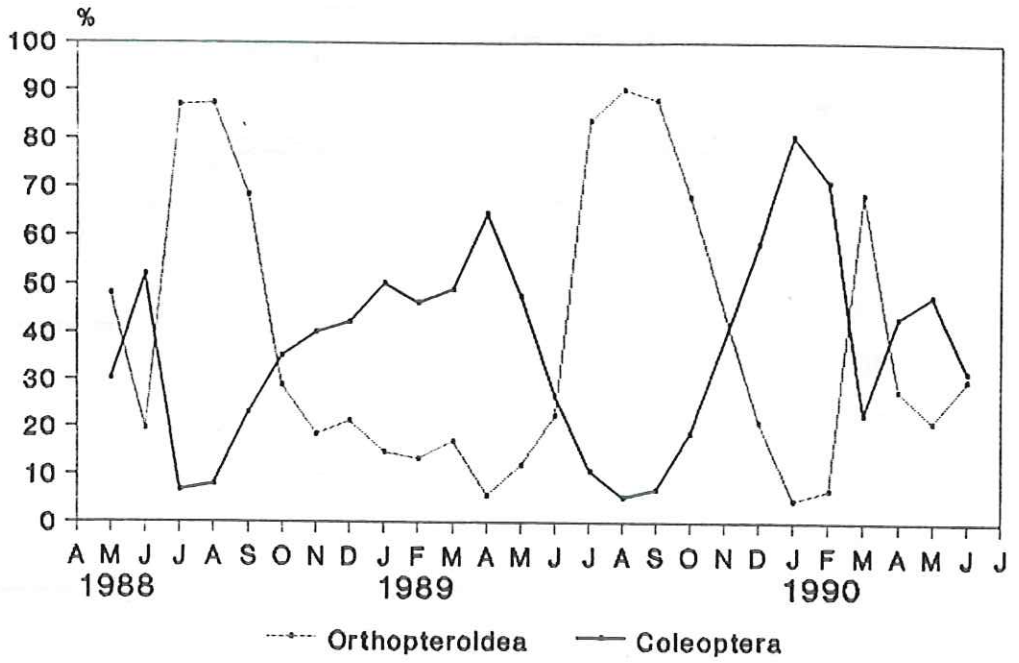

Figure 7 : Trends of predation of Orthoptera and Coleoptera by Kestrels in area 2.

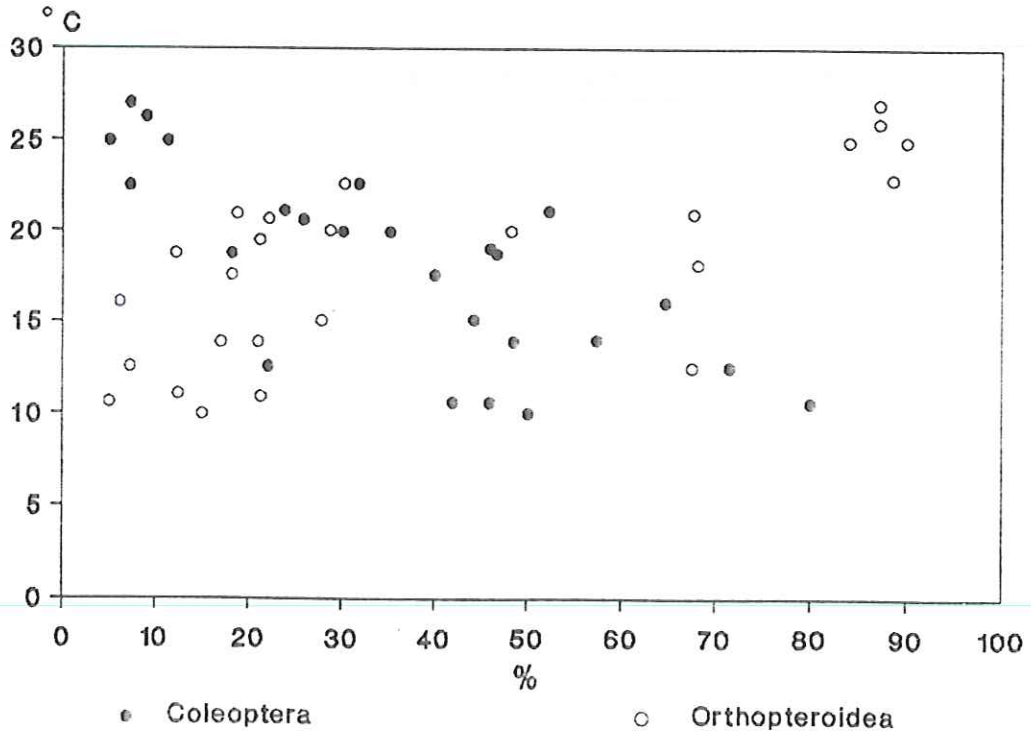

Figure 8 : Correlation between the mean temperature and the percentage of Coleoptera and Orthoptera preyed on by the Kestrel in area 2. (Coleoptera: $r = -0.725$; $p<0.001$; Orthoptera: $r = 0.688$; $p<0.001$)

Insect predation in area 2

The general trend of invertebrate predation in area 2 was roughly correlated with monthly mean temperature . The proportion of Orthoptera among items in Kestrel pellets was positively correlated with mean monthly temperatures ($r=0.688$, $p<0.001$; $n=23$), while the trend was negative for Coleoptera ($r=-0.725$, $p<0.001$; $n=23$) (Fig. 8). (The two percentages are not independent; it may be that only Orthoptera are related to temperature.)

DISCUSSION

Insects constituted the most important prey items in the diet of Kestrels in area 2. During the dry and hot months, Orthoptera are abundant in the harvested fields and stubbles, and are frequently taken by Kestrels. Four genera *(Calliptamus, Oedipoda, Locusta* and mainly *Gryllus)* constituted more than 80% of the Orthoptera, but one genus, *Gryllus*, accounted for the occurrence in July 1988, June and July 1989 and March 1990. It seemed that Kestrels were exploiting the temporarily abundant food source.

In autumn Kestrels were often observed hunting over newly-sown ground and pasture, where they could find a wide variety of species. Insect prey was evenly dispersed, and was mainly Coleoptera such as Scarabaeoidea, (especially *Pentodon bidens* which was available on arable and newly sown fields), *Geotrupes intermedius, Bubas bison* and *Copris hispanus* (scattered over pasture), some Tenebrionidae and Silphidae (respectively detritivorous and necrophagous species, available along field boundaries, roadsides and pasture), some Curculionidae (phythophagous species, wintering underground and probably available, as *P. bidens*, within ploughed and newly sown fields), and finally one Carabidae, *Carabus morbillosus*, a snail predator, inactive in the day time and probably available in the recently ploughed fields or at dusk along field boundaries and roadsides.

In winter, as crops grew, Kestrels hunted less on fields and more on pasture, field boundaries, roadsides and vineyards. These habitats probably provide more small mammals than arable fields.

The later stages of crop growth (late February to late May) - and the consequent decrease of hunting activity by Kestrels in these fields - correspond with the laying season. In June crops are harvested and thus during the hatching post-fledging period, Kestrels may come back to hunt there where they find large populations of invertebrates (cf. Shrubb, 1980, who reports a similar trend, with the exception that fields watched by him were not available for Kestrel hunting until fledging of the young).

Following Karasov (1990), arthropods and vertebrates are similarly metabolized by predators (by c.75%) and metabolized energy should be 19.3 $Kj.g^{-1}$ of dry weight in arthropods and 17.7 in vertebrates. According to different sources quoted by Village (1990), the food intake of a Kestrel should be c.300 $Kj.d^{-1}$ throughout the year; this corresponds with at least 80 grams of arthropods and 90 of vertebrate prey. The energetic cost for capturing one hundred insects is higher than that involved in the capture of 4-5 small mammals. Therefore, availability of invertebrates, particularly in some seasons, but generally throughout the year, is probably higher than vertebrate prey as entire populations of this small raptor may reach a good breeding performance using only this alternative prey.

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