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Use of roadsides by diurnal raptors in agricultural landscapes

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Abstract

In a 2772 km survey in western France, we compared the relative abundance and activity of diurnal raptors along motorway verges and secondary roads to those in open cropland, during different seasons and hours of the day. Motorway verges, and to a lesser extent secondary road verges, were used significantly more than adjacent areas by buzzards (*Buteo buteo*), kestrels (*Falco tinnunculus*) and black kites (*Milvus migrans*), but not by harriers (*Circus aeruginosus*, *C. cyaneus*, *C. pygargus*). There was a seasonal shift in the use of roadsides by buzzards and kestrels, with a high use of motorway verges in winter and a low use in summer. Although kestrels and buzzards clearly used verges for hunting, their abundance along roads was not directly related to the relative abundance of small mammals. The supply of perching sites, allowing a less energy-demanding hunting behaviour than flight-hunting, and the width of the verges, appeared important factors in the attractiveness of roadsides for these species. This study shows that roadsides, particularly wide motorway verges, can be managed with respect to the conservation and abundance of raptor species in agricultural landscapes, in providing stable prey habitats and perching sites.

Keywords: Raptor; Conservation; Roadside; Motorway; Farmland

1. Introduction

The prevalence of roads in developed countries means that they are likely to have important impacts on wildlife. Roads contribute greatly to habitat loss and fragmentation, which are major causes of biodiversity reduction (Pimm and Gilpin, 1989; Kruess and Tscharntke, 1994). In developed countries, few landscapes are without roads. For example, in France there are 350,000 km of roads (0.6 km of road per km^2, Legrand et al., 1989), of which 8000 km are existing motorways, with a further 2500 km planned (Burdeau, 1996).

The position of raptors at the top of food chains make them good indicators of ecosystem functioning (cf. their susceptibility to pollutants such as organochlorine insecticides; Newton, 1979). They are often target species in conservation programmes. They have been protected in France since 1976, and in many other European countries for approximately the same period. The situation of some species has improved with this protection. Nevertheless, many species are still vulnerable or in decline at the European scale, such as black kite (*Milvus migrans*), kestrel (*Falco tinnunculus*) or hen harrier (*Circus cyaneus*), because of the alteration of their habitats, mainly by the intensification of agriculture (Tucker and Heath, 1994).

Most studies dealing with the relationships between roads and raptors have attempted to estimate mortality related to traffic, particularly for owls (Bourquin, 1983; Hernandez, 1988; Illner, 1992). There is a particular paucity of published data concerning the extent of use of road verges by raptors, with few references to the type of verges, the habitats near roads or the effect of seasons (Meylan, 1966; Knight and Kawashima, 1993). Yet, the potential importance of roadsides is indicated by the literature on raptors associations with other linear man-made habitats like power lines (review in Williams and Colson, 1989). Power lines provide nesting and perching sites and can allow access to food especially in vegetated portions of rights-of-way.

Roadside habitats are known to contain a high abundance of small mammals, especially in wide verges (Adams and Geis, 1983; Meunier et al., 1999). Some

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authors have suggested that birds of prey use road verges for scavenging (Haug, 1985; Watson, 1986) and for hunting (Meylan, 1966; Michael and Kosten, 1981; Bourquin, 1983; Fajardo et al., 1998). However, they did not compare the abundance of both raptors and prey in roadsides to that in adjacent areas. In a previous study (Meunier et al., 1999) we showed that an extensive management of motorway verges (as opposed to intensive mowing) encourages a favourable habitat for small mammals in a landscape of intensive cropland.

This study was located in the same intensive farmland, and compared two distinct types of roadsides, motorway verges and secondary roads verges, to adjacent fields. The aim was: (1) to obtain quantitative information on the use of road verges by diurnal raptors and to understand what factors determine this usage and; (2) to assess the possibility of managing roadsides for raptor conservation.

2. Methods

2.1. Study area

The study was carried out in an intensive arable plain in western France (35×10 km centred 46° 4′ N, 0° 32′ W, south of Niort, Deux-Sèvres and Charente maritime). The main crops are winter crops (wheat, barley, rape seed and peas) for 41% of the area and 35% of summer crops (maize and sunflowers). Some patches of grassland (13%), isolated hedges and woodlots (11%) are still present (data from IAAT-SPOT Image). This district includes 580 km of roads of which 33 km of motorway. Two road sections were selected, oriented north-south. First, a motorway (A10), constituting a four-lane divided highway consisting of a c. 20 m wide roadway, a 5 m median strip and verges of 8–50 m width on each side (generally 10–20 m). Secondly, a secondary road (D120–D115) of 6 m width with narrow verges of 2–3 m each side, selected parallel to the motorway and 1–6 km apart.

The motorway verges are entirely bordered by a broad mesh wire fence, 1.4 m in height. The vegetation of the motorway verges is similar to surrounding uncultivated areas, most commonly herbaceous fallow with scattered shrubs and small trees (Meunier et al., 1998). A 2 m mown strip was maintained by the roadside. Secondary road verges are mown over their whole width several times a year, though some isolated shrubs, trees and pieces of hedges are conserved. The mean annual traffic is 25,000 cars per day on the motorway, and <1000 cars per day on the secondary road.

2.2. Raptor survey

Data were collected using the road transect method commonly used for raptors (e.g. Craig, 1978; Preston and Beane, 1996). This method yields accurate and precise data in large areas of open vegetation and for conspicuous species, and enables collection of data in all seasons (Fuller and Mosher, 1981; Millsap and LeFranc, 1988; Bibby et al., 1992). Thirty three km were surveyed on each road. On the secondary road, the total distance was longer (38 km), but all sections that crossed villages were removed to obtain 33 km. We drove at 60–70 kmph for safety reasons though this is faster than usual for such recording (Fuller and Mosher, 1981; but see Thiollay, 1976). On the motorway we used the safety lane.

In order to eliminate primary sources of bias such as variable density and behaviour between seasons or times of the day (Burnham et al., 1980; Bibby et al., 1992), we performed 42 surveys (2772 km) distributed as follows. (1) season: seven periods spaced 2 months apart from May 1996 to May 1997 (second half of a month); (2) day: 2 sampling days less than 1 week apart by period; (3) time of the day: 3 different hours a day, the first beginning 1–2 h after dawn according to the season, the second in the 2 h after midday and the third in the 2 h before dusk (a survey round took c. 80 min); (4) direction: we alternated the direction of driving to eliminate potential bias in visibility from one side of the route to the other, from the first to the second day within a sampling period; (5) weather: surveys were performed on calm and clear days, by one trained observer. Because of bad weather conditions for sampling raptors in the second half of November 1996, this sampling period was delayed until the first half of December.

For secondary road transects, we counted all raptors seen in two zones from the road: 0–50 m (zone 1), 50–100 m (zone 2). However, we also registered birds seen beyond 100 m to avoid "heaping" (Burnham et al., 1980, p. 49). For zone 1 we noted if raptors were in or above the road verge zones themselves (<3 m) or beyond. On the motorway, we counted only individuals seen within the verges themselves, because the road-cuttings often prevented the detection of birds further away. We recorded four classes of raptor behaviour, adapted from Masman et al. (1988): (1) perching, (2) walking or alighting on the ground, (3) flight-hunting, (4) and other behaviour (e.g. travelling).

2.3. Data analysis

Our purpose was to compare the use of the different zones of habitats and not to calculate absolute densities. Thus, we considered the number of birds seen by transect during one census as independent observations (Emlen, 1977). Millsap and LeFranc (1988) indicated that unadjusted counts gave reliable indices in studies where trends in raptor numbers over time along the same route were the object of interest. We tested: (analysis 1) the effect of road type in comparing the number of birds (species by species) in motorway verges and in

zone 1 on the secondary road; (analysis 2) the attractiveness of roads in comparing the number of birds in zone 1 and zone 2 from the secondary road. We also controlled for visibility in performing a comparison between zone 2 and 'zone 1 minus verges' (3–50 m). In all analyses, we summed observations made from both sides of the routes. The second zone (50–100 m) was chosen as a reference for fields although it was not particularly far from the road (Hanowski and Niemi, 1995). However, as regards raptors, it is difficult to find an area consistently far from roads in such landscapes. In addition, beyond 100 m, detectability is potentially poorer, even in open habitats (Millsap and LeFranc, 1988).

We tested for an effect of road type (or zone), month and time of the day, as well as their interactions, with the number of birds per transect/census as the dependent variable, using a three-way analysis of variance (GLM procedure; SAS Institute, 1990). Variables that were not statistically significant ($\alpha = 0.05$) were stepwise removed, to obtain the most parsimonious model. A Tukeys' HSD test was used to separate means. Data were log or square-root transformed so as to fulfill the assumptions of normality and homoscedasticity for analysis of variance (Sokal and Rohlf, 1981). The normality of the distribution of residuals was tested using the Shapiro–Wilk test. When there was a significant interaction between road type (or zone) and month, we tested for the effect of road type (or zone) month by month using a Wilcoxon two-sample test.

We tested for difference in distribution of behaviours within species between the three zones (two by two) using the best suitable of χ^2 test, G test or Fisher exact test (Scherrer, 1984). To compare behaviours, we pooled data from all months and time of the day, unless the number of birds was sufficient to separate them. When the number of birds was sufficient, we isolated data of secondary road verges from zone 1 and compared the distribution of behaviour classes with motorway verges and zone 2. We performed these analyses on raw data and presented results as proportions to improve clarity.

3. Results

3.1. General trends in raptor distribution

Of the eight species seen during the study, three were sufficiently numerous for statistical analyses (Table 1). Among the "rare" species, we saw 47 harriers from three species (*Circus aeruginosus*, *C. cyaneus*, *C. pygargus*), two honey buzzards (*Pernis apivorus*), and one sparrowhawk (*Accipiter nisus*). Harriers were never observed above motorway verges and only two hunted in secondary road verges. Beyond verges, 12 were recorded in zone 1 and 14 in zone 2, i.e. they seemed independent of roads.

Table 1
Effects of road type (analysis 1) or distance from road (analysis 2), month and time on the number of raptors (ANOVA results)[a]

	df	F	p	Total r^2
Buzzard				
Analysis 1				0.56
Road	1	10.93	0.002	
Month	6	7.30	< 0.001	
Road × month	6	5.27	< 0.001	
Error	68			
Analysis 2				0.46
Distance	1	1.15	0.287	
Month	6	10.16	< 0.001	
Error	74			
Kestrel				
Analysis 1				0.80
Road	1	1.92	0.172	
Month	6	20.81	< 0.001	
Road × month	6	7.52	< 0.001	
Time	2	6.70	0.003	
Month × time	12	2.34	0.017	
Error	54			
Analysis 2				0.49
Distance	1	27.23	< 0.001	
Month	6	6.11	< 0.001	
Time	2	2.42	0.096	
Error	72			
Black kite				
Analysis 1				0.24
Road	1	0.91	0.346	
Month	3	4.03	0.013	
Error	41			
Analysis 2				0.37
Distance	1	4.33	0.044	
Month	3	2.97	0.044	
Distance × month	3	3.06	0.040	
Error	38			

[a] Road type has two levels (motorway and secondary road), distance from secondary road has two levels (0–50 and 50–100 m), factors month and time have, respectively, seven and three levels regularly spaced during 1 year and 1 day.

3.1.1. Effect of road type

In comparing species abundance between motorway verges and the first zone of secondary roads (0–50 m), we detected a road effect only for buzzards (*B. buteo*, $p < 0.01$, Table 1), which were more numerous in motorway verges than near secondary roads (Fig. 1). Black kites (*Milvus migrans*) were present in our counts only from March to September. Although this species presented the same trend as buzzards (Fig. 1), the difference was not significant.

3.1.2. Secondary road (zone 1) versus agricultural matrix (zone 2)

In this analysis, we detected an effect of distance for kestrels (*Falco tinnunculus*) and black kites (respectively $p < 0.001$ and $p < 0.05$, Table 1), both of which were more numerous in zone 1 (Fig. 1). For kestrels, 45% (64 out of 142) of observations in zone 1 were in road verges

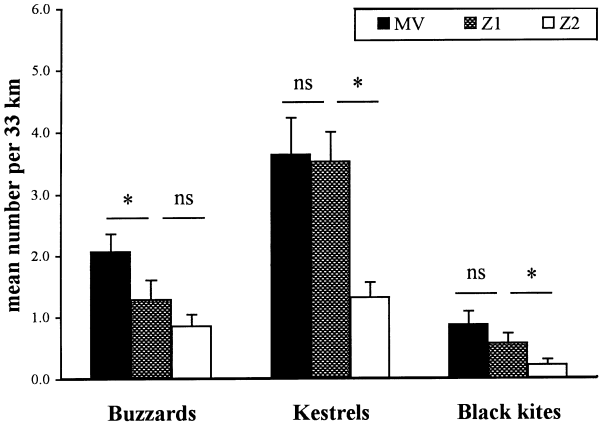

Fig. 1. Mean (±SE) number of raptors along motorway verges (MV), and in two zones along secondary roads: 0–50 m (Z1) and 50–100 m (Z2), during 42 surveys. Horizontal bars indicate comparisons of means by Tukeys' HSD test after an analysis of variance on square-root- (kestrels) or log- (buzzards, black kites) transformed data: $*p < 0.05$; ns $p > 0.05$.

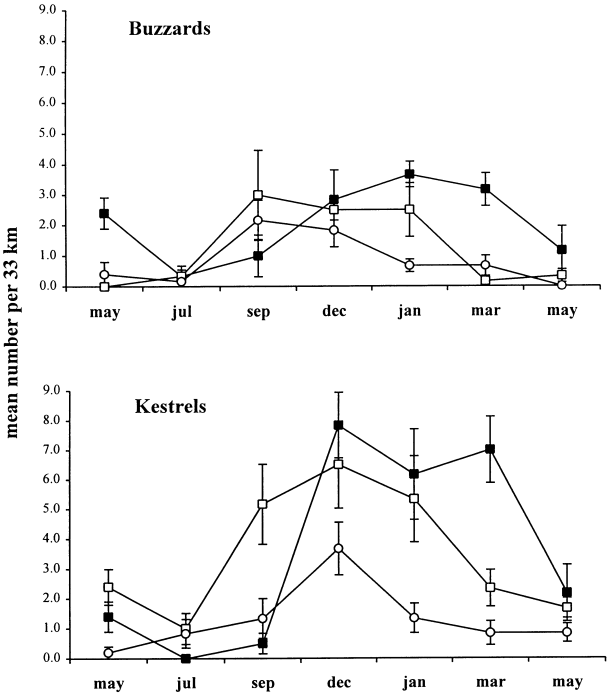

Fig. 2. Mean (±SE) number of raptors along motorway verges (■), and in two zones along secondary roads: 0–50 m (□) and 50–100 m (○), during six surveys per month, from May 1996 to May 1997.

themselves, and the difference between the two zones did not persist if these observations were removed. No kite was observed in road verges themselves. For buzzards, no difference in abundance was detected between the two zones, with (Table 1) or without observations in verges.

3.2. Temporal variation in raptor numbers

3.2.1. Seasonal differences

We detected an interaction between road type and month in analysis 1 for buzzards and kestrels (Table 1). The change in numbers during the course of the year was roughly similar for both species and showed a shift in time beween the motorway and the secondary road transects (Fig. 2). Both species showed a rapid increase in the number of birds in zone 1 in September, with large numbers of birds being observed until January. The same trend was observed in motorway verges, but with large numbers observed from December to March. Buzzards were significantly more numerous in motorway verges than in zone 1 in May 1996 and in March 1997 (Wilcoxon two-sample test, $p < 0.01$). Kestrels were also more numerous in motorway verges than in zone 1 in March 1997 (Wilcoxon two-sample test, $p < 0.05$) but significantly less numerous in September 1996 ($p < 0.05$) and nearly so in July 1996 ($p < 0.1$, no kestrels in motorway verges; Fig. 2). Buzzards showed the same trend as kestrels in September, but with a greater variability, making the difference not significant.

In analysis 2, we did not detect an interaction between distance and month variables for buzzards or kestrels. The numbers of birds showed the same trend during seasons in the two zones, with a maximum in September for buzzards, and in December for kestrels. In contrast, there was an interaction between month and zone for the black kite ($p < 0.05$, Table 1). There were significantly more kites in zone 1 than in zone 2 in July only (Wilcoxon two-sample test, $p < 0.05$), when c. 50% of kites were observed, although the number of kites was always greater in zone 1.

3.2.2. Time of day

We were unable to detect a time effect for buzzards and black kites. For kestrels, on the other hand, the effect of time was significant in analysis 1 ($p < 0.01$, Table 1) and nearly so in analysis 2 ($p < 0.1$; Table 1). In analysis 1, the number of kestrels was significantly greater at midday (mean per 33 km = 4.61, SE = 0.68) than in the morning (2.46 ± 0.54, Tukey HSD test, $p < 0.05$), while the number of kestrels before dusk was intermediate (3.57 ± 0.68). There was never an interaction effect between time and road type or distance, showing that the different habitats were used roughly during same hours.

3.3. Raptor behaviour

3.3.1. Buzzards

The frequency distribution of behaviours in motorway verges was different to that in zones 1 and 2 of the secondary road (G test, $p < 0.001$, $p < 0.05$ respectively). In motorway verges, buzzards were more often perching and did not hunt on the ground (Fig. 3). They exhibited flight-hunting in motorway verges as often as in fields. In addition, the difference between the two secondary road zones was nearly significant (G test, $p < 0.07$). The frequency of perching and flight-hunting

for birds tended to be greater in zone 2 (Fig. 3). However, flight ("other behaviours") could be confused with hunting in this species. No difference was detected when these two behaviour categories (flight-hunting, other) were grouped (χ^2 test, $p > 0.1$).

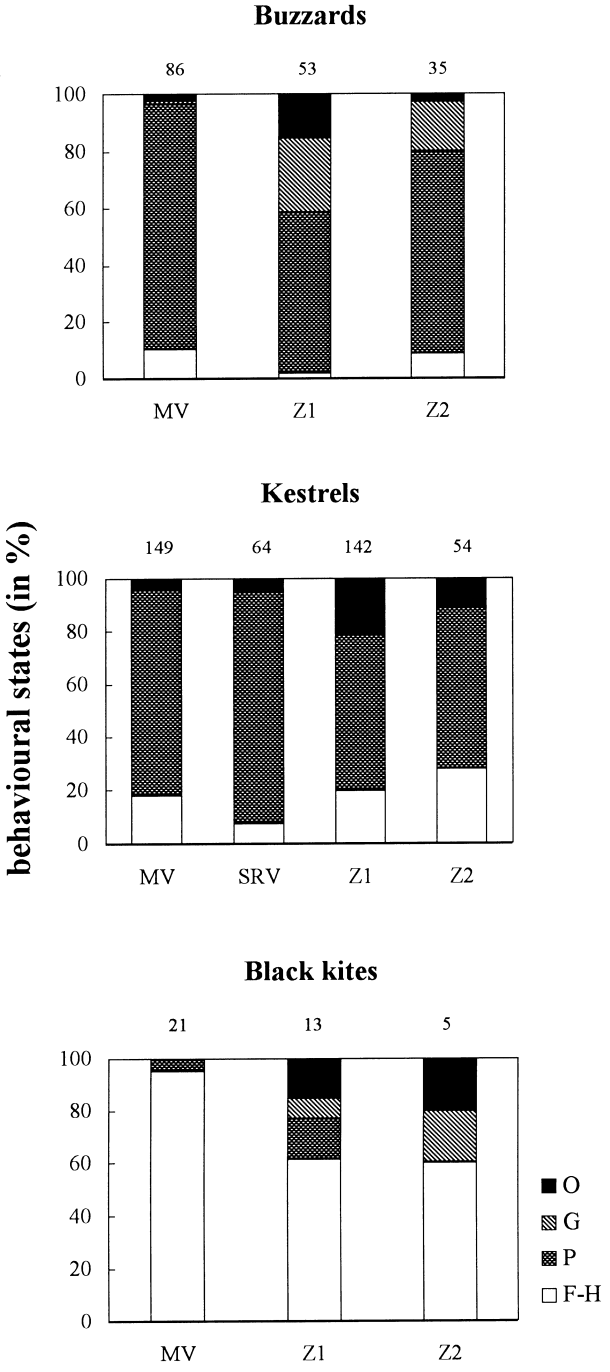

Fig. 3. Frequency distribution (in %) of behaviours of raptors along motorway verges (MV) and in two zones (buzzards, black kites) or three zones (kestrels) along secondary roads: secondary road verges (SRV, 0–3 m), 0–50 m (Z1) and 50–100 m (Z2). Note that Z1 always contains SRV. Behaviours are: flight-hunting (F-H), perching (P), walking or alighting on the ground (G), and other behaviours, i.e. not hunting (O). Numbers above bars indicate total number of observations.

Fig. 4 shows that buzzards in motorway verges used fences for perching, contrary to the situation in fields where they mainly perched on trees (χ^2 test, $p < 0.001$). Along secondary roads, distribution of perch substrates did not differ between the two zones (G test, $p > 0.4$).

3.3.2. Kestrels

Three individuals were seen on the ground and were excluded from the analyses. The distribution in motorway verges was different to that in the two secondary road zones (χ^2 test, $p < 0.001$, zone 1, G test, $p < 0.05$, zone 2), but the two zones did not differ significantly from each other (χ^2 test, $p > 0.1$). The distribution of behaviours in secondary road verges (0–3 m) was different from that occurring in zone 2 (G test, $p < 0.01$) but did not differ from that of motorway verges (G test, $p > 0.1$). Motorway and secondary road verges were characterised by a greater frequency of perching (Fig. 3). The overall frequency of perching was greater in autumn and winter (73% perching, 16% flight-hunting and 11% others) than during the breeding period (42% perching, 42% flight-hunting, 16% others, between

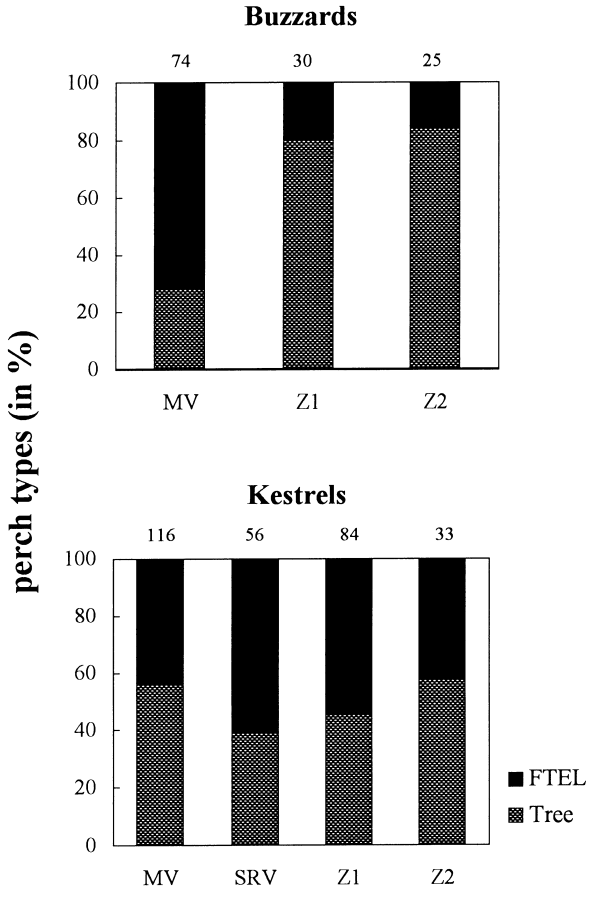

Fig. 4. Frequency distribution (in %) of perch types used by raptors along motorway verges (MV) and along secondary roads (see Fig. 3 for details). Two perch types are distinguished: natural perch (tree) or linear man-made structure such as fence, telephone and electric line (FTEL). Numbers above bars indicate total number of perching observations.

seasons χ^2 test, $p < 0.001$). However, the same relationships between motorway verges and secondary road zones were maintained throughout seasons.

Kestrels used linear structures (fences of motorway verges, or electric and telephone lines) and trees, approximately equally in motorway verges as in fields (Fig. 4, χ^2 test, $p > 0.1$). In secondary road verges themselves, the number of individuals perching on telephone lines was slightly greater, and the difference was at the limit of significance for motorway verges (χ^2 test, $p < 0.06$) and zone 2 (G test, $p < 0.06$).

3.3.3. Black kites

Fig. 3 indicates all behaviours registered, but for statistical analysis we only distinguished flight-hunting from all other behaviours. Frequency distribution in motorway verges was different from that of the two secondary road zones (G test, $p < 0.01$); and almost all individuals seen in motorway verges were flying above and along the road, obviously looking for carrion. The two secondary road zones did not differ (Fisher exact test, $p > 0.5$).

4. Discussion

4.1. General trends

The primary result from our study is that some raptor species used motorway verges (buzzards) and also secondary road verges (kestrels) in preference to cultivated fields, at least during certain seasons. Moreover, motorway verges were generally much narrower than the two other zones, which strengthens this result. Black kites were also more numerous near roads than farther away, and exhibited a slight preference for motorways. This result contrasts with conclusions of Bourquin (1983), who suggested a low use of roads by black kites based on their infrequency as victims of traffic accidents. This shows that roadkill counts cannot be used as an estimate of roadside use. The second major result is the strong effect of season on roadside use. This could explain the low use of roadsides found by Knight and Kawashima (1993) for the red-tailed hawk (*Buteo jamaicensis*), a closely related species to buzzards, in a survey restricted to 2 weeks during the breeding season.

To reach these conclusions we have assumed that few birds were undetected by the observer in the first 100 m. This seems likely given that, after excluding kestrels and buzzards seen in secondary road verges, we did not detect a significant difference between the two secondary road zones. This is consistent with the results of Millsap and LeFranc (1988), who found good detectability in open areas in the first 100 m. As they worked with styrofoam models of perched raptors of size of *Buteo* spp. or less, the 100 m limit that we retained seems conservative. There was a significant difference between the two zones for black kites, but as they were generally seen flying, the probability of missing them seems unlikely at this distance. However, our conclusions needs to be confirmed by an intensive study of individuals whose range overlaps a road, to determine precisely how verges are selected. Some preliminary results on radio-tagged kestrels breeding at < 100 m from a motorway seem to confirm the importance of verges where meadows are scarce (Meunier, 1999).

4.2. Roadside attractiveness related to food resources and hunting behaviour

Behaviour of raptors in roadsides indicated that verges are principally hunting areas. The two most common small mammals in our study site (85% of captures in trap lines, Meunier et al. 1999), the common vole (*Microtus arvalis*) and the greater white toothed shrew (*Crocidura russula*) have diurnal activities and constitute the preferred prey of kestrels and buzzards (Tubbs, 1974; Village, 1990). They were more abundant in motorway verges than in crops (Fig. 5). These results seem to confirm assumptions made by several authors on the role of road verges as a food source for raptors (Michael and Kosten, 1981; Bourquin, 1983; Williams and Colson, 1989). Black kites feed preferentially on carrion, which may be more numerous on roadsides in such landscapes. Similarly, Knight and Kawashima (1993) found a greater abundance of ravens (*Corvus corax*) along highways than in control areas (no highways within 3.2 km) in a desert zone.

However, motorway verges were not particularly exploited by raptors at the time when abundance of prey was higher than in crops. In fact, small mammals were more abundant in motorway verges than in fields after winter crop harvesting but not in spring or in January (Fig. 5). Thus, the greater abundance of kestrels and buzzards in motorway verges than in crops (zone 2)

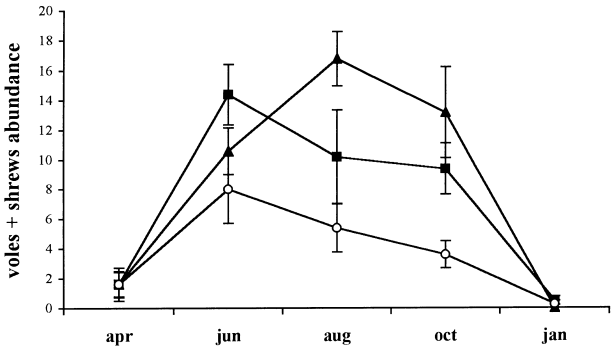

Fig. 5. Mean (±SE) number of monthly captures per 60 trap-nights of *Microtus arvalis* + *Crocidura russula* in the mown (▲) and the unmown (■) part of motorway verges, and in fields (□), from April 1996 to January 1997. *C. russula* was significantly more abundant in mown and unmown part of verges than in fields in August and October, *M. arvalis* in mown verges in August. Source: Meunier et al. (1999).

in May (buzzards only), and particularly January and March, cannot be explained only by the abundance of small mammals. A first explanation is that roadsides might be poor but reliable food sources in winter. Raptors may also find alternative species to small mammals, such as Orthoptera, abundant in roadsides in autumn (Meunier, 1999).

A second hypothesis is related to the influence of season on hunting behaviour of raptors. Harriers were rarely seen hunting on roadsides, despite the importance of voles in their diet (Butet and Leroux, 1993; Salamolard, 1998). This may be because verges are too narrow for their low-flying hunting technique; perch-hunting or hovering is better suited to these habitats. Thus, in addition to the density of prey, their availability to raptors is critical. Although we did not estimate the density of perches in the different zones, they were obviously greater along motorways owing to the presence of the continuous fence in addition to trees and shrubs. Even kestrels used perches in the winter except in good wind conditions (Masman et al., 1988; Village, 1990; Fritz, 1998) to minimise energy expenditure. Thus roadsides may be selected as a hunting site in relation to the density of perches, which permit energetically economic hunting, more than for their prey density.

4.3. Roadsides and raptor conservation in intensive agrosystems

These results have direct implications for conservation planning, all the more as winter is often a period of food shortage for raptors (Village, 1990).

Light management of motorway verges permit the colonisation of natural vegetation and the development of an undisturbed edge-habitat favourable to small mammals (Meunier et al., 1999) and other prey species (Meunier, 1999). In future, open vegetation should be actively managed in motorway verges to maintain a grassland habitat. The case of secondary roads is more critical as verges in our study site were particularly narrow, and have to be mown for safety constraints. However, the number and periods of mowing could be adapted to enhance prey abundance and availability, especially in winter. For example, a strip furthest from the road could be kept unmown for 2–3 years to offer a stable habitat for small mammals.

The width of roadsides seems to play an important role, as buzzards were seen preferentially in motorway verges while kestrels also used narrow roadsides. Kestrels, which are smaller and more agile than buzzards, are probably less sensitive to the traffic as shown by their greater use of the whole verge, while buzzards were principally on fences on the border. Wider verges, up to at least 20 m, could therefore be recommended to maximize the number of raptor species and individuals using them.

The traffic volume on motorways does not seem to be of particular concern for the three dominant species, probably because it is a routine disturbance over time (White and Thurow, 1985; Preston and Beane, 1996). In fact, kestrels seemed more disturbed by our car driving relatively slowly in the safety lane (as they sometimes flew away while we passed) than by the continuous flow of fast vehicles. However, the problem of traffic mortality must be taken into account. Many animals are killed by vehicles and it has been suggested that motorway verges be enclosed to a greater extent by wire mesh fences to decrease traffic mortality, including small species (Chavaren, 1997). On the other hand, the black kite is an opportunistic feeder on dead animals, and therefore benefits from road casualties. This species is of high conservation concern; it is on Annex I of the European Union Wild Birds Directive because of its rapid decline of population size and range, especially in eastern Europe (Tucker and Heath, 1994). So, the stakes must be balanced in face of the species locally concerned.

Estimating the real benefit of road verges on raptors would involve measuring accurately the threats due to traffic. Road kills of raptors seem to have increased in the last few decades (Newton, 1979; Village, 1990). However, there have been few evaluations of the significance of road mortality on raptor populations, except for the barn owl (*Tyto alba*) for which the detrimental effect of roads on local populations is commonly suggested (Illner, 1992; Moore and Mangel, 1996). Our study shows that roadsides can be important resources for diurnal raptors in agricultural landscapes. Their management could be included in a comprehensive strategy for raptor conservation, particularly in counterbalancing the threats due to intensive agriculture.

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