EFFECTS OF HABITAT CHARACTERISTICS ON THE PREDATION RISK OF GREY PARTRIDGES

F. REITZ and P. MAYOT
Office national de la chasse
Direction de la recherche et du développement
Saint Benoist, F78610 AUFFARGIS, FRANCE
fax: 33 1 30 46 60 99, email: f.reitz@onc.gouv.fr

ABSTRACT

Several habitat characteristics of grey partridges (*Perdix perdix* L.) that had been killed by predators were compared with those of surviving ones. In this way we studied the radiotracking data of adult or subadult hens living in seven study areas that had been killed by a raptor (presumably a harrier, *n*=87), a fox (*n*=49) or a mustelid (*n*=12). Each of these hens was randomly paired with another one placed in the same conditions but which had survived at least one month more and then died of another cause or had no longer been monitored.

We were able to show that the partridges killed by a raptor lived farther from a permanent cover feature and used on average less tall crops than surviving ones. A more detailed analysis suggests that the proximity of a non-linear permanent cover feature or of a set-aside field can significantly reduce the risk of predation by harriers. On the other hand the proximity of a wood or a high density of paths or roads determine a greater risk of predation by mustelids while the proximity of a permanent landscape feature of any kind tends to increase the risk of fox predation.

The conclusions of this study could be a very useful tool for grey partridge population conservation and management since predation is the predominant mortality cause of adult partridges.

KEY WORDS

Circus sp., habitat characteristics, *mustelidae, Perdix perdix*, predation risk, *Vulpes vulpes*

INTRODUCTION

The Grey Partridge (*Perdix perdix* L.) is a species reported as declining or on the verge of extinction in most European countries (Aebischer & Kavanagh, 1997). Habitat alteration due to changes in farming practices is considered the main cause of this vulnerable status (Aebischer & Kavanagh, *op. cit.*). Monitoring of the populations in North-Central France shows that the recent decline recorded there is the result of a very significant decrease in the adult annual survival rate (Reitz, in press). An extensive study recently conducted in the same region established that the main proximate cause of hen mortality is predation (Bro *et al*, in press, for spring and summer mortality, unpub. data for autumn and winter). Therefore, the increase in mortality rate and subsequently the decline of the grey partridge in North-Central France could result from three non exclusive and possibly correlated events: i- a higher abundance of partridge predators, ii- a greater partridge component in the predators' diet following a change in the abundance of other prey or specialization of some predators, iii- a reduced value of the habitat due to land management and farming practices that increases the predation risk for partridges (e.g. reduced abundance of escape cover, food availability, etc...). This third hypothesis can be tested using the data of our extensive study in two ways: at the population level comparing mortality rates of the marked partridges and their causes of death with habitat characteristics in several areas, or at the individual scale by relating the fate of each marked partridge to its proximate habitat characteristics. The first approach, whose results have already been published elsewhere (Bro *et al*, in press), did not reveal any clear relationship between the mortality of the marked partridges and the landscape characteristics measured on ten different areas. But it showed a strong numerical relationship, compatible with the first hypothesis, between the abundance of harriers (hen harrier, *Circus cyaneus* and marsh harrier, *Circus aeruginosus*) that can kill adult partridges and the mortality rate and predation rate of adult hens. The aim of the present paper is to give preliminary results from the second approach.

STUDY AREAS

The data come from the seven of the ten study areas (cf. Bro *et al.*, 1999) that show the most simplified habitat: large fields (mean size from 5 to 10ha), few permanent landscape features and few different crop types. Wild partridge densities varied there during the study period from 5 to 30 breeding pairs/km². The density of harriers (Montagu's harrier, *Circus pygargus*, excepted) ranged during the same period from 0.7 to 4.2 ind./10 km². Roadside fox (*Vulpes vulpes*) counts at night (Stahl & Migot, 1990) gave an abundance index varying from 0.2 to 2 foxes seen per 10 km of roadside. Faeces of medium sized mustelids (stone marten, *Martes foina* or polecat, *Mustela putorius*) were found in 20 to 50% of one-kilometre transects walked along linear or around wooded landscape features.

METHODS

About 30 adult or subadult partridge females were captured and equipped with a transmitter each year during three years in March or April in each of the seven study areas and between September and January during two years in three of these areas. Each bird was located daily to within a 100m x 100m grid square. When a partridge was found dead, marks on the feathers and carcass and/or signs detected in the immediate surroundings allowed us in most cases to determine the cause of death and, in case of predation, the predator responsible (bird of prey, fox, small mammal). We could not distinguish different birds of prey or different mustelid species, but observations and indices suggested that hen harriers and stone martens were the main partridge predators within these two groups.

For the analysis, each of the killed partridges was randomly paired with another « control » partridge which had also been tracked in the same area, marked at the same period, of the same age class but which had survived at least one month more and did not die of the same cause. By this way, we formed *a posteriori* a control batch placed exactly in the same conditions except for the proximate habitat. In a few cases the same partridge but not the same locations was used several times as a control because of the low number of surviving partridges.

To describe the proximate habitat of each predated partridge and of the surviving paired one, we considered their locations during the ten days that preceeded the predation event. The availability of permanent landscape features (PLF) and crops was evaluated by their distance to the centroid of these locations and by their presence within 300m of the centroid. By PLF, we mean any identifiable piece of the landscape except the cultivated fields. So it could be a road, a path, an hedgerow, a ditch, a grove, an isolated tree, an isolated building, a farm, a village, a railway line, etc...The radius length we used (300m) was chosen based on the home range of partridges, the length of an escape flight and the size of fields.

Were determined:

- the distance to the nearest PLF and its type,
- the distance to the nearest PLF, except roads and paths (permanent cover features(PCF)), and its type,
- the distances to the nearest hedgerow and to the nearest wooded patch,
- the number and list of distinct PLF encountered within a 300-m radius,
- the number and list of different types of crops encountered within a 300-m radius.

We also calculated the average height of the crops where the birds were located.

We used the Wilcoxon - Mann - Whitney test for pairwise comparisons to compare the crop heights, the distances to PLF and the numbers of PLF and crops within a 300-m radius for predated partridges and control ones. The MacNemar test for significance of changes was used to compare the presence/absence of some crops or types of PLF within a 300-m radius. Of course, if a type of PLF or crop was not available for a bird (e.g. hedgerows in a study area which has none) or if we were unable properly to quantify this availability (e.g. when a bird lived close to the study area border), the corresponding pair was excluded from the data set. We also modeled, using a logistic regression, the bird fate (predated or not) in relation to the distance to the nearest PCF (<=300m, 301-500m, >500m) and to the shape of this PCF: linear (hedgerows in most cases) or not (woods, copses, orchards, buildings). In this analysis, the data structure (pairwise comparisons) was taken into account by introducing a pair number variable.

RESULTS

<u>Harrier predation</u>

The partridges that were killed by a raptor (presumably a harrier in most cases) lived farther from any PCF (Table 1). No significant difference was apparent for the distance to the nearest hedgerow or wooded patch. However, when modelling the birds fate in relation to the distance to the nearest PCF and to its shape, we found significant distance (P<0.001) and shape (P=0.03) effects. Indeed the number of harrier-killed birds was less than the number of control birds, meaning a protective proximate habitat, only when the feature was not linear and within 500 m of the centroid of the locations (Fig. 1). When examining the proportion of birds whose location centroids were within 300 m of a wooded patch, control birds were again more numerous than harrier-killed birds (29% and 41% respectively) although the difference was not significant (P=0.09). In comparison, these proportions were similar when considering the proximity of one hedgerow (29% and 26% respectively, P=0.84).

The partridges that were killed by a harrier used, in average, lower crops than the control partridges (Table 1). In the same way, the proportion of birds having within a 300-m radius of the centroid of their locations a crop offering tall cover at the end of winter and the beginning of spring (oilseed rape, set-aside or lucerne) was greater for control birds than for harrier-killed birds (40% and 68% respectively, P=0.007). The crop diversity, the presence of a building and the number of PLF (all together or by type) within a 300-m radius seem to have no influence on the risk of predation by harriers.

Fox predation

None of the habitat characteristics studied showed a significant difference between the killed partridges and the control ones (Table 1). However, the distance to the nearest PLF tended to be smaller among the fox-killed birds.

Mustelid predation

The low number of cases leads to analyses with reduced power. Nevertheless, the results clearly showed that the mustelid-killed birds lived closer to a wooded patch than the control ones and had more roads or paths within a 300-m radius (Table 1). We also noted that more of the predated birds tended to live closer to a building (5 out of 12 of the predated birds vs. 2 of the control birds, P=0.38) . On the other hand, they did not differ from control ones for the abundance of PCF within a 300-m radius and the diversity of crops.

DISCUSSION

These results show that a strong relationship can exist between predation risk and the mean location of birds. It would have been interesting to take into account the exact place where the predation occurred. This was not possible, except for hens sitting on eggs, because of the discontinuous radiotracking and because the birds could be moved by the predator after death. Therefore we had to use the locations of the birds during the days before death. We chose a ten-day period as a compromise solution between the need to have a good measure of the area frequented before the predation occurred and the risk of including locations unconnected with the predation. To describe the availability of landscape components, the reference to the centroid of the fixes drastically reduced the available information but was the only practicable solution for a rapid analysis of our very large data set. Further analyses using geographic information systems and more time-consuming methods are planned.

No relationship could be established between the fate of partridges and the amount of all available permanent cover features or the crop diversity within a 300-m radius. This means that the partridges living in a more fragmented landscape did not escape more easily from predation.

However, this study suggests that non-linear permanent landscape features like woods or copses are of great value for partridges to be protected against harrier predation. The absence of a significant difference in the distance to the nearest wooded patch between harrier-killed and surviving partridges could cast doubt on this conclusion but the inclusion in the analysis of faraway woods that probably had no influence on this kind of predation risk could have masked the protective effect of the closest woods.

Crops with tall vegetation also seem to give protection to partridges. These crops prevent partridges from being detected by harriers or harriers from catching them. On the other hand, hedgerows did not appear as an efficient protective habitat although most of them in the three areas where the predation by raptor cases were the most numerous were more than 2m wide with a thick shrub layer. When harriers are abundant and the landscape very open, hedgerows can have a negative effect by attracting partridges (Merrigi *et al*, 1991, Rands, 1986) but also harriers since this kind of feature can be very convenient for them to hunt (Schipper, 1977, Schipper *et al*, 1975). Woods and copses are perhaps less suitable for harriers to hunt near and seem to be less attractive for partridges (Merrigi *et al*, *op cit*), except as escape cover. However they can increase the risk of predation by other raptors like the goshawk (*Accipiter gentilis*)(Dudzinski, 1992).

The hunting behaviour of foxes in farmland is not well documented. However our results are in accordance with the common idea of the fox, an opportunistic predator, searching for food almost everywhere but concentrating on areas containing most of its usual dietary components (microtines, rabbits, fruits), i.e. where permanent vegetation cover exists. Areas with a large number of copses or a high hare density can also be attractive (Goszcynski, 1991).

The results concerning the cases of mustelid predation are in total agreement with the behaviour of these species and, in particular, of the stone marten, which often rests in isolated buildings and forages mainly in linear coverstrips or in woods (Broekhuizen, 1983, Libois & Waechter, 1991).

In the light of these results, it is likely that removal of copses and other uncultivated pieces of land over the last decades in order to increase field size could have modified the harrier-prey relationships in an unfavourable way for partridges. Therefore the third hypothesis that was formulated in the introduction (regression of suitable habitat for partridges) can be considered as validated for the risk of predation by harriers. On the other hand, the increase in partridge predation by mammals, if real, cannot be directly attributed to habitat alteration unless it is assumed that other non-studied factors are involved.

Management perspectives

Partridge predation by mammals was the dominant cause of mortality that we observed in areas of low harrier abundance (Bro *et al*, 1999, Reitz *et al*, 1999). The present results suggest that any management seeking to mitigate this kind of predation should focus on the abundance of predators and the global predator-prey relationships, and not on hypothetical habitat improvement to give partridges greater chances of escaping from predation. Accordingly, it may be possible to increase the abundance of alternative prey without increasing predator abundance, but experiment evidence is sorely lacking (cf. Clark *et al*, 1996). The

only solution that can be proposed nowadays is the control of mammalian predator abundance, although public opinion is against it. Recent work suggests that significant results can be obtained using such means, acting during the reproductive period. Tapper *et al.* (1996) obtained in this way an increase of the late summer hen to cock ratio, indicating a reduction in the nesting hen mortality. However, it is still necessary to directly demonstrate the efficiency of this method in increasing the adult survival rate all through the year.

On the other hand, harrier predation may be significantly reduced by proper habitat management, but will never be negligible since many cases of such predation happen in late spring (Reitz & Mayot, 1997) when escape cover is available everywhere for partridges. We can recommend the conservation or planting of copses and/or the cultivation of strips or patches of crops that can provide a tall cover during a long time (e.g. set-aside fields with an appropriate plant mixture or non-cropped maize).

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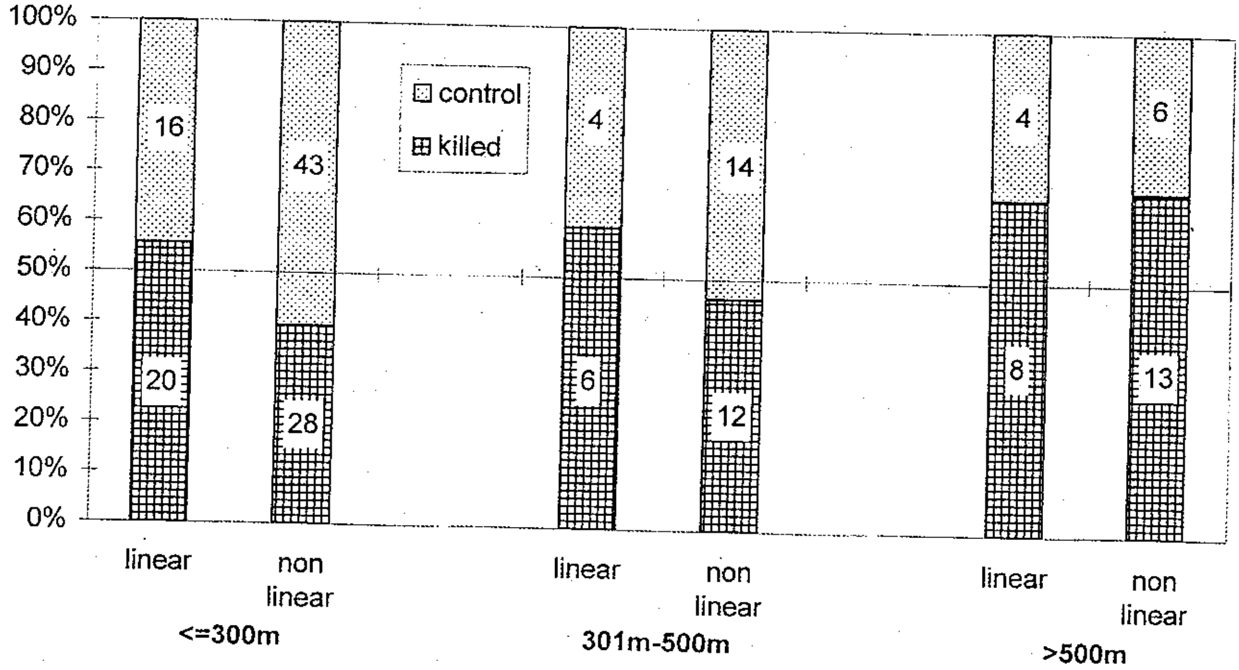
Table 1: Proximate habitat comparisons between partridges killed by a predator and control partridges.

Variable	number of paired data	mean value: killed partridges	mean value: control partridges	P value
predation by harrier cases				
distance to the nearest permanent landscape feature (PLF)				
all types of features	87	86.8m	82.6m	0.93
all types except roads and paths (permanent cover features (PCF)	87	345m	261m	0.03
non-linear wooded patch	86	651m	611m	0.37
hedgerow	69	753m	730m	1.00
number of PLF or crops within a 300-m radius				
PCF	87	1.18	1.30	0.63
roads or paths	87	2.13	2.29	0.25
different types of crops	57	4.09	4.37	0.28
average height of frequented crops	84	29.8cm	34.7cm	0.006
predation by fox cases				
distance to the nearest permanent landscape feature (PLF)				
all types of features	49	56.0m	80.6m	0.09
all types except roads and paths (permanent cover features (PCF)	49	244m	278m	0.30
non-linear wooded patch	49	498m	510m	0.95
hedgerow	35	603m	673m	0.89
number of PLF or crops within a 300-m radius				
PCF	49	1.55	1.63	0.83
roads or paths	49	2.53	2.61	0.60
number of different types of crops	36	4.17	4.25	0.98
average height of frequented crops	47	46.1cm	42.8cm	0.76
predation by mustelid cases				
distance to the nearest permanent landscape feature (PLF)				
all types of features	12	49.6m	77.5m	0.20
all types except roads and paths (permanent cover features (PCF)	12	213m	198m	0.86
non-linear wooded patch	12	368m	722m	0.03
hedgerow	5	550m	448m	0.50
number of PLF or crops within a 300-m radius				
PCF	12	1.42	1.34	0.89
roads or paths	12	2.92	1.83	0.016
number of different types of crops	9	4.9	5.0	0.93
average height of frequented crops	8	51.6cm	55.5cm	0.48

Figure1: Frequency distributions of partridges killed by a bird of prey and control partridges in relation to the distance to the nearest permanent cover feature (i.e. all features, paths and roads excepted) and to the linearity of this feature. The data are presented as the proportion of each type of bird for each distance class and type of feature. The exact numbers are reported in the bars.



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