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NEST-SITE SELECTION OF GREY PARTRIDGE (*PERDIX PERDIX*) ON AGRICULTURAL LANDS IN NORTH-CENTRAL FRANCE

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KEY WORDS : Grey partridge, *Perdix perdix*, nest, habitat selection, management, agricultural land, France.

ABSTRACT

Identification of nesting sites selected by the grey partridge, Perdix perdix*, in agricultural ecosystems is important for effective habitat management, particularly in areas where numbers of this game species have declined. Nest-site selection was investigated on 10 study areas located in contrasting farming regions in North-Central France in 1995-1997. We located 548 nests of radio-tagged hens and used a global compositional analysis to statistically identify preferred habitats. First clutches (*n *= 407) were mainly located in cereals (65%) and linear landscape features (13%), and replacement clutches (*n *= 141) in cereals (37%), other crops (22%) and linear landscape features (18%). Most clutches located in cereals were situated within 20 m of a field margin (78%,* n *= 316). Habitat selection did not differ across years, but displayed differences across study areas and between first and replacement clutches. For first clutches, the most preferred habitats were cereals and linear landscape features, followed by fodder crops, meadows and set-asides, with other crops being the least preferred habitat. This general pattern was observed on all but two study areas, where set-asides were the preferred nesting habitat. For replacement clutches, the overall nest-site habitat use did not differ significantly from a random use. We advocate a division of large fields into smaller ones to create linear habitats. Such management schemes, among others, are proposed to farmers in the context of the Agri-Environmental and Set-aside Schemes.*

I. INTRODUCTION

game bird in Europe has become a management concern and has been listed as a species with an unfavourable conservation status in Europe (AEBISCHER and KAVANAGH, 1997). The numerous studies conducted on this species suggest that its decline could be due to several causes, including an increase in the rate of predation during nesting, increased farming disturbance, reduction of food availability for chicks, and the removal of permanent cover necessary to escape from predators, and for feeding and nesting (reviews *in* POTTS, 1986; BIRKAN and JACOB, 1988).

The hypothesis that the reduction of nesting cover has contributed to the decline of grey partridge is based on the following assumptions. *i*) For nesting, the grey partridge is supposed to prefer linear landscape features such as hedges (BLANK *et al.*, 1967; RANDS, 1988), roadsides and fence-lines (CHURCH, 1984; CARROLL *et al.*, 1990), and grass strips (BIRKAN *et al.*, 1990). *ii*) A positive correlation exists between breeding density and the amount of suitable nesting cover (e.g. RANDS, 1986; PANEK and KAMIENIARZ, 1998). *iii*) The recruitment rate is positively linked to the amount and quality of field boundaries (POTTS, 1986; RANDS, 1987). The reduction of nesting cover mentioned above has occurred since the 1950s, when diversified farming was replaced over most of Western Europe by the intensive production of cereal crops, provoking radical changes in farmland structure and vegetation composition. Most hedges were removed, small fields were merged into a few large ones, and monoculture farming became the rule (POTTER, 1997; RICHARZ *et al.*, 1998).

Although the use of farmlands for grey partridge nesting has been extensively documented (reviews *in* BIRKAN and JACOB, 1988; CARROLL, 1993), nest-site selection has received less attention. This, however, is a key point of the ecological requirements of the species that should be determined to guide the formulation of recommendations for habitat management. Previous studies reported the selection of relatively undisturbed and permanent cover, for example, grassy strips in Beauce, France (BIRKAN *et al.*, 1990), idle uplands in Wisconsin, USA (CHURCH, 1984), and linear landscape features such as roadsides in Dakota, USA (CARROLL *et al.*, 1990) and in Iowa, USA (CAMP and BEST, 1994). In England, until recently, studies focused on hedges at field boundaries and showed the importance of vegetation structure (BLANK *et al.*, 1967; RANDS, 1988). To document nest-site selection in a wide diversity of farmland landscapes, we carried out a large-scale study in North-Central France. We monitored 548 clutches of radio-tagged hens on ten contrasting study areas during three years. The objectives were to describe nest location in farmlands, to identify preferred habitats for nesting and to analyse fate of clutches with regard to environmental characteristics. In this paper, we focus on the first two objectives.

II. MATERIAL AND METHODS

II.1. STUDY AREAS

We monitored grey partridge nests on ten study areas (with surfaces rang-

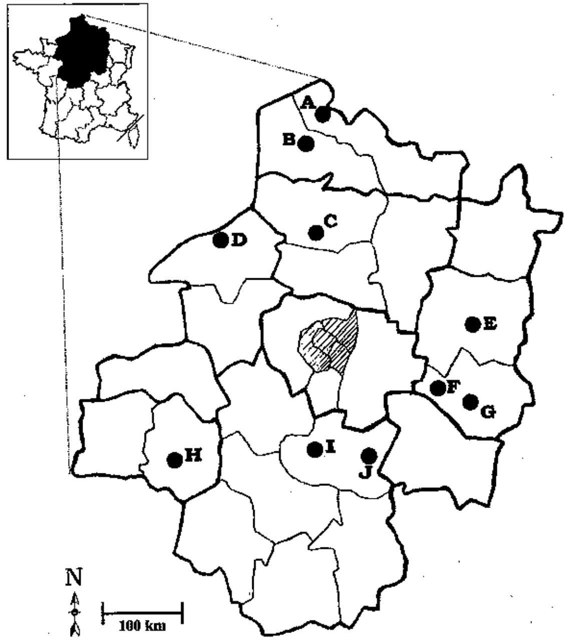

Figure 1: Geographical locations of the 10 study areas monitored during 1995-1997 in North-Central France. Study area A: "Flandres" (2,000 ha); B: "Artois" (2,000 ha); C: "Picardie" (7,600 ha); D: "Pays de Caux" (1,500 ha); E, F and G: "Champagne crayeuse" (6,000; 5,300 and 7,000 ha respectively); H: "Val-de-Loir" (6,000 ha); I: "Beauce" (15,200 ha) and J: "Gâtinais" (5,300 ha). Cross-hatching indicates Paris and its surrounding "departments".

Figure 1 : Localisation géographique des 10 territoires d'étude suivis en 1995-1997 dans le Centre - Nord de la France. A : « Flandres » (2 000 ha) ; B : « Artois » (2 000 ha) ; C : « Picardie » (7 600 ha) ; D : « Pays de Caux » (1 500 ha) ; E, F et G : « Champagne crayeuse » (6 000, 5 300 et 7 000 ha) ; H : « Val-de-Loir » (6 000 ha) ; I : « Beauce » (15 200 ha) et J : « Gâtinais » (5 300 ha). La zone háchurée représente Paris et les départements limitrophes.

farmland and partridge pair density diversities (Table I).

Areas E, F, G, I and J were typical high cereal-oleaginous production farmlands with large fields, and few groves and hedges. In contrast, in areas A, B, C and D, a lower proportion of arable land was planted to cereals, pastures were still present and landscapes were more diversified. Study area H was different from all others. It was characterized by a landscape with many hedges and trees ("bocage" landscape) where extensive stock farming was associated with cereals, maize and vineyards. Study areas were more or less speci-

TABLE I

Distribution (%) of habitat types in arable lands, distribution (%) of groves and copses in study areas, mean field size (ha) and mean number of grey partridges, *Perdix perdix*, breeding (pairs per km²) in spring according to study area. All values are averages for 1995-97. Only main crops included in "other crops" are listed. (): study area surface in ha. North-Central France.

TABLEAU I

Répartition (%) des couverts dans la surface agricole utile, répartition (%) des bois et bosquets dans la surface totale de l'aire d'étude, surface moyenne (ha) des parcelles et effectif moyen (couples par km²) de perdrix grises, *Perdix perdix*, reproductrices au printemps suivant l'aire d'étude. Seuls les principaux couverts de la rubrique « autres cultures » sont indiqués. Les valeurs fournies sont les moyennes calculées sur 1995-1997. () : surface de l'aire d'étude (ha). Centre-Nord de la France. Céréales ; autres cultures : pois fourrager, colza, pomme de terre, maïs, betterave sucrière, tournesol, lin ; cultures fourragères ; prairies pâturées ; jachères ; éléments linéaires.

	Study area									
	A (2,000)	B (2,000)	C (7,600)	D (1,500)	E (6,000)	F (5,300)	G (7,000)	H (6,000)	I (15,200)	H (5,300)
Availability of habitat types in arable lands (%)										
Cereals	27.0	48.9	43.8	40.7	36.8	59.1	46.2	34.4	56.6	41.5
Other crops	58.9	27.9	32.8	43.5	37.9	31.5	42.3	15.0	33.7	41.6
Pea	*5.4*	*3.3*	*8.1*	*5.1*	*9.5*	*7.7*	*12.6*	*0.3*	*5.0*	*0.5*
Oilseed rape	*0*	*0.9*	*2.1*	*0*	*1.6*	*6.7*	*4.1*	*0.7*	*2.6*	*1.0*
Potato	*15.6*	*0.3*	*0.1*	*0*	*7.8*	*1.0*	*2.2*	*0*	*0.9*	*0*
Maize	*18.3*	*15.4*	*18.3*	*3.9*	*0*	*1.6*	*1.8*	*9.1*	*7.4*	*24.3*
Sugar beet	*6.5*	*6.0*	*4.0*	*20.2*	*13.7*	*9.0*	*16.5*	*0*	*14.1*	*6.2*
Sunflower	*0*	*0*	*0*	*0*	*2.0*	*3.0*	*4.4*	*3.3*	*3.1*	*5.7*
Linseed	*5.0*	*1.0*	*0*	*14.2*	*0*	*0*	*< 0.1*	*0*	*0*	*0*
Fodder Crops	0.4	4.1	7.3	0.3	18.1	3.3	6.4	3.3	2.5	1.3
Meadows	8.5	12.9	10.6	10.1	0	0	0.1	37.3	0.1	3.6
Set-asides	3.0	3.5	2.5	4.1	3.7	4.0	3.2	4.2	4.6	10.0
Linear landscape features	2.2	2.7	3.0	1.5	3.6	2.1	1.8	5.8	2.4	1.9
Availability of groves and copses in the study area (%)										
	0	2.3	14.9	0.9	10.9	22.3	14.2	9.4	1	3.5
Mean field size (ha)	3.7	1.7	4.5	6	9.1	6.7	7.4	4.5	5.9	10.1
Mean number breeding (pairs per km²)	27.9	19.5	10.8	27.5	7.1	6.4	9.2	2.9	11.3	14.9

II.2. LAND COVER RECORDING

Each study area was visited in May to map the vegetation cover throughout the study areas, or at least in 50% of the largest ones. Vegetation cover was recorded by plotting crops, groves and linear landscape features on 1:10,000 or 1:5,000 maps. Cover was classified into six habitat types: cereals (wheat, barley, oat, rye), other crops (maize, sunflower, oilseed rape, sugar beet, pea, potato, hemp, linseed), fodder crops (ray-grass, lucerne, clover), meadows (*i.e.* pastures), set-asides (all types pooled), and linear landscape features (*i.e.* hedgerow, bank, roadside, ditch). We calculated $a_i = x_i / \sum x_i$, where x_i was the cover area of cover i and $\sum x_i$ the total area mapped for land cover (excluding groves and copses). a_i was taken as a measure of the availability of cover i in the arable lands. We calculated a_i for the linear landscape features considering that these features were 6-m wide on average.

II.3. RADIOTRACKING OF BREEDING HENS AND CLUTCH SURVEY

Radiotracking was the most effective method for finding clutches independently of habitat type (CARROLL *et al.*, 1990; REYNOLDS *et al.*, 1991). During the years 1995-1997, we placed 10-g radio-tags on 1,009 hens in early spring (BRO *et al.*, 1999), and monitored them daily until the following September.

Clutches could be located when incubation began because hens were rarely absent from their nests (POTTS, 1980; BIRKAN and JACOB, 1988). We found 407 first clutches and 141 replacement clutches. The death of many hens within the first week after release or before incubation, and radio failure, explained most of the discrepancy between the number of radio-tagged hens and the number of clutches found. We recorded habitat characteristics surrounding each clutch, such as the cover type and the distance to the field margin.

II.4. STATISTICAL ANALYSIS

We analysed habitat selection by using a compositional analysis. A full description of the method is given in AEBISCHER *et al.* (1993).

Briefly, given D habitat types, the proportional habitat use is estimated by $u_1, u_2 \ldots u_D$ where u_i is the proportion of clutches found in habitat i, thus $u_1 + \ldots + u_D = 1$ (such set of components is called a composition). A consequence of this unit-sum constraint is that avoidance of a given habitat can lead to an apparent preference for another habitat. For any given habitat j, the log-ratio transformation $U_{(ij)} = \ln(u_i / u_j)$ $(i \in [1 - D], i \neq j)$ renders the $U_{(ij)}$ linearly independent. Let $a_1 + \ldots + a_D = 1$ be the composition of available habitats in the study site and $A_{(ij)}$ the corresponding log-ratio transformation. A relative habitat selection index can be calculated as $d_{(ij)} = U_{(ij)} - A_{(ij)}$ (i.e. the pairwise difference).

The first step of the compositional analysis is to test an overall difference in habitat selection through the following multivariate regression: $(d_{(ij)}$ for $i \in [1 - D]$ $i \neq j) = 0$. The test is based on a generalized likelihood ratio Λ statistic. Under the assumption of multivariate normality of the residuals, the quantity $-N * \ln(\Lambda)$, where N is the number of observations, follows approximately a χ^2 distribution. The distribution of Λ may be derived empirically by data randomisation (SOKAL and ROHLF, 1981) when the multivariate normality assumption is violated.

When the multivariate analysis reveals non-random use of habitat, the second step of the compositional analysis is to highlight where differences are significant by ranking habitat types by order of use. For this purpose, a so-called ranking matrix is built where each element corresponds to $d_{(ij)} = \ln(u_i / u_j) - \ln(a_i / a_j)$ $(i \neq j)$. For each element of the matrix $[(i, j)$ $i \neq j]$, random use is tested through a t test. Although it implies several tests, AEBISCHER *et al.* (1993) recommended to keep $\alpha = 0.05$ rather than correcting it for multiple tests because the Λ statistic of the multivariate analysis previously indicated an overall significant difference. The number of positive elements in each row is an integer ranging between 0 and D-1 that ranks the habitat types in order of increasing use. Indeed, the inequality $d_{(ij)} > 0$ implies that habitat i is more used than habitat j compared to their availability [because $\ln(u_i / u_j) - \ln(a_i / a_j) = \ln(u_i / a_i) - \ln(u_j / a_j)$].

We tested whether the overall habitat selection varied across study areas and years, between first and replacement clutches (hereafter "nest order" effect), and interactions by using a multivariate analysis of variance (MANOVA, proc GLM, SAS INSTITUTE, 1994). Random use was tested through the test of intercept = 0. We used the Wilks' Λ statistic to build the χ^2 test (with $N = 29$ because one study site was not fully monitored in 1995). Data randomization involved 1,000 replicates of the test. The t tests of $d_{(ij)}$ deviation from 0 were performed by using proc UNIVARIATE (SAS INSTITUTE, 1994).

III. RESULTS

III.1. LOCATION OF NESTS IN FARMLANDS

First clutches ($n = 407$) were mainly laid in cereals ($n = 264$) and in linear landscape features ($n = 53$ of which 23 were in banks, 13 on roadsides, 10 in ditches and 7 in hedgerows; Figure 2). Few first clutches were found in set-asides ($n = 25$), other crops ($n = 13$, 5 of which were in oilseed rape, 5 in pea, 1 in sunflower, 1 in linseed and 1 in hemp), fodder crops ($n = 16$) or meadows ($n = 12$). Habitat type was not recorded for 11 first clutches, and 13 first clutches were found in particular places such as forest edges, camping grounds or orchards, not included in the arable land.

Replacement clutches ($n = 141$) were more equally distributed in cereals

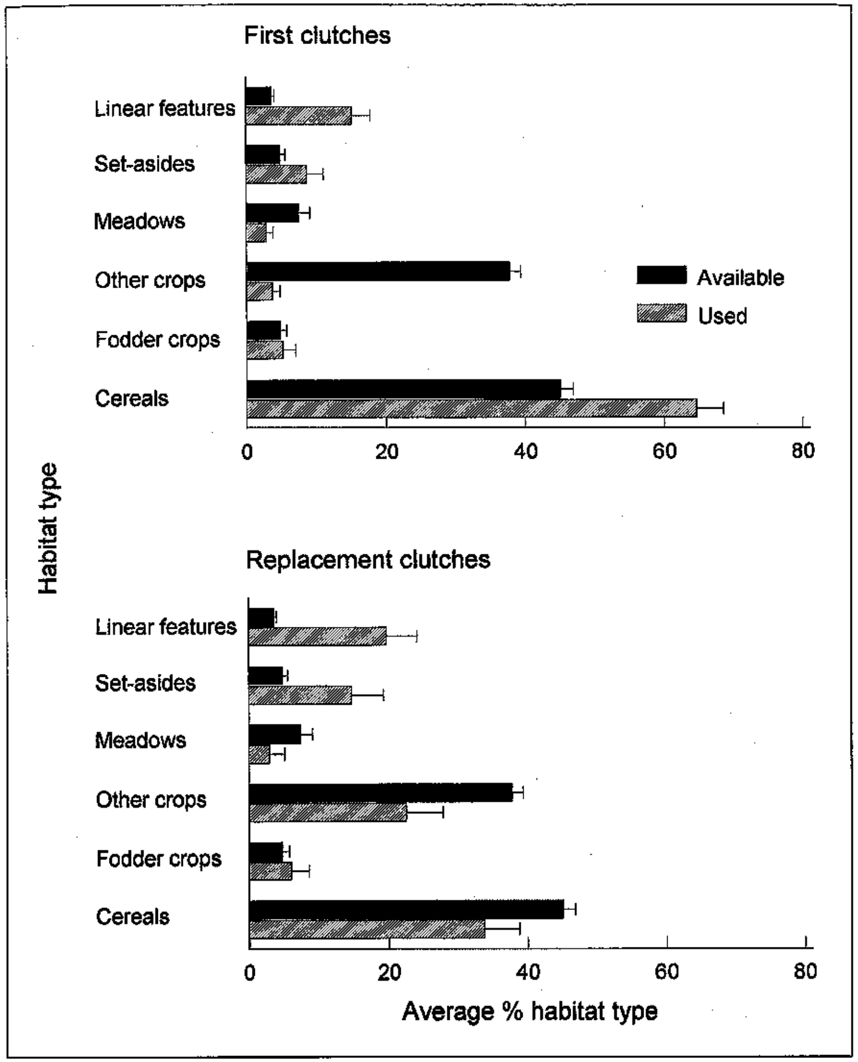

Figure 2: Comparison between the general pattern of habitat use by grey partridges, *Perdix perdix* (% of clutches found in a habitat) for laying of first clutches ($n = 407$) / replacement clutches ($n = 141$) and habitat availability (% of a habitat in the arable lands); mean ± 1 SE across study areas and years. North-Central France, 1995-1997.

Figure 2 : Comparaison du taux d'utilisation des couverts pour la ponte des premières couvées ($n = 407$, en haut) et des couvées de remplacement ($n = 141$, en bas) par les perdrix grises, *Perdix perdix* (% de pontes trouvées dans un couvert donné, en hachuré) à la disponibilité des couverts dans la surface agricole utile (% du couvert dans la SAU, en noir). Moyennes et erreurs-type calculés sur l'ensemble des territoires et des années d'étude. Centre-Nord de la France, 1995-

or hemp). Linear landscape features (n = 25, 8 of which were on roadsides, 8 in banks, 7 in ditches and 2 in hedgerows) and set-asides (n = 14) were also frequented, whereas fodder crops (n = 8) and meadows (n = 3) were used by few hens (Figure 2). Habitat type was not recorded for 2 replacement clutches, and 6 replacement clutches were found in particular places outside the arable land.

Clutches were often found near some particular features creating a micro-heterogeneity in cover. We tried to quantify this aspect for clutches located in cereals because sample size was 316, by pooling first and replacement clutches, study years and study areas. Most clutches were located within 20 m of a field margin (78%, Figure 3). Clutches were often (n = 123) within a few cm or up to 5 m from tractor tyre tracks, or even between them. These data suggest that edge effect was an important factor for clutch location. We could not test whether birds selected these elements because we had no data about their availability. Nests were also located near lanes (n = 19), hedgerows (n = 6), ditches (n = 1), shelters such as stone piles or steel sheets (n = 3), or in the vicinity of features (n = 7) such as stakes or weed plants (thistles).

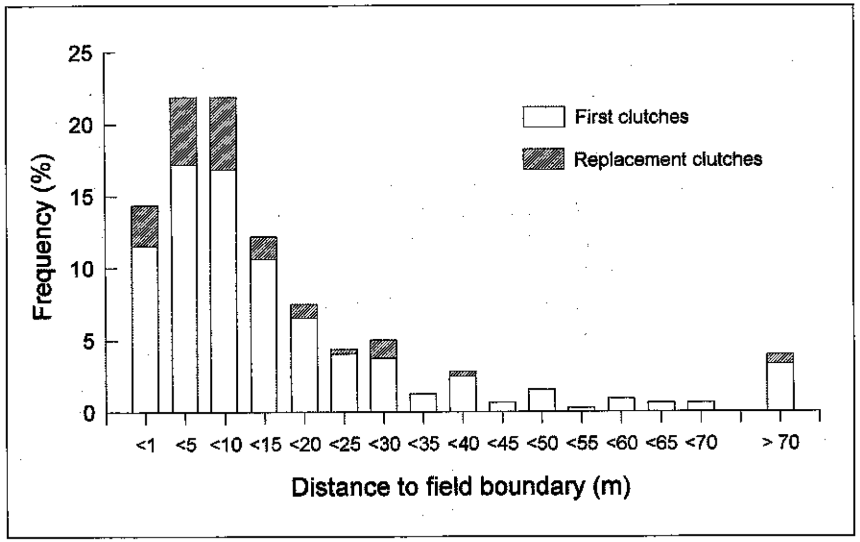

Figure 3: Frequency distribution of grey partridge, *Perdix perdix*, nest locations in cereals in relation to distance (m) from field margins for first (n = 264) and replacement (n = 52) clutches. North-Central France, 1995-1997.

Figure 3 : Distribution de fréquence de la distance (m) des sites de ponte de perdrix grises, *Perdix perdix*, à la bordure des parcelles de céréales pour les premières pontes (n = 264, barres blanches) et les pontes de remplacement (n = 52, barres hachurées). Centre-Nord de la France, 1995-1997.

III.2. NEST-SITE SELECTION

We found significant interactions between "nest order" and both "study area" and "year" (MANOVA, testing the overall habitat selection, $P < 0.05$, Table II). Therefore, we conducted separate analyses for first and replacement clutches. Habitat selection differed across study areas (Table II) for both first and replacement clutches. Because the difference across years was not convincing (probability moderately significant for first clutches, and non significant for replacement clutches, Table II), we did not conduct further analyses of year effects.

Grey partridges did not lay first clutches at random in the different habitats (Wilks' Λ = 0.149, $P < 0.001$, Table II). The ranking matrix ordered the nest-site selection index (*i.e.* index of habitat use compared to habitat availability in the arable lands) as follows: cereals > linear landscape features > set-

TABLE II

Multivariate analysis of variance of nest-site selection by grey partridges, *Perdix perdix*. Tests of random use (intercept effect) and differences across study areas and years for first and replacement clutches. North-Central France, 1995-1997.

TABLEAU II

Analyse de variance multivariée analysant le choix du site de nidification par les perdrix grises, *Perdix perdix*. Tests de l'utilisation aléatoire de l'habitat (effet « intercept ») et des différences entre « territoires » et « années » d'étude pour les premières pontes (en haut) et les pontes de remplacement (en bas). Le text χ^2 est valide sous l'hypothèse d'une distribution multi-normale des résidus. Une probabilité peut être calculée lorsque ce pré-requis n'est pas vérifié par permutation aléatoire des données, l'hypothèse H_0 testée ici étant l'utilisation aléatoire des habitats. Centre-Nord de la France, 1995-1997.

Effect	Wilks' Λ	Under the assumption of multivariate normality of residuals			Randomization under the H_0 hypothesis : random use
		χ^2	*df*	*P*	*P*
First clutches					
Intercept	0.149	55.21	5	**< 0.001**	**0.001**
Study area	0.060	81.78	45	**< 0.001**	
Year	0.522	18.85	10	0.042	
Replacement clutches					
Intercept	0.711	9.89	5	0.078	0.094
Study area	0.042	91.93	45	**< 0.001**	

asides > meadows > fodder crops > other crops (Table III, see rank 1, Figure 2). However, when considering only significant differences in the selection index, fodder crops, meadows and set-asides had the same rank (Table III, see rank 2). Thus the order of nest-site habitat selection was: cereals ≅ linear landscape features >> set-asides ≅ meadows ≅ fodder crops > other crops. Cereals and linear landscape features were significantly more selected than any other habitat types, whereas other crops were significantly less selected. This general pattern of nest-site selection was observed on most study areas (Table IV), with most geographic variation apparently being due to areas H and J, where set-asides were the top-ranking habitat.

Grey partridges apparently used the different habitat types at random for laying replacement clutches (Wilks' Λ = 0.711, P = 0.094, Table II), but the test was not very powerful because of the small sample size (n = 141 for 10 study areas and 3 years).

TABLE III

Ranking matrix for nest-site selection by grey partridges, *Perdix perdix*, comparing the proportional habitat used to lay first clutches to the proportion of habitat available in arable lands. The ranking matrix is antisymmetric, it can be shown in detail or in a simplified way. Elements of the detailed matrix (top right) are: $d_{(i,j)}$, the difference between log-ratios of used and available habitats (M ± SD across study areas and years), and t from a t test (26-28 df) analysing $d_{(i,j)}$ departure from 0. In the simplified matrix (bottom left), the $d_{(i,j)}$ value was replaced by its sign, a triple sign corresponds to a significant P-value of the t-test. For each row i, rank 1 (R_1) represents the number of positive $d_{(i,j)}$ and rank 2 (R_2) the number of significant positive $d_{(i,j)}$ at P < 0.05. Study areas with missing habitat type(s) were not used in the calculations of the corresponding $d_{(i,j)}$. North-Central France, 1995-1997.

TABLEAU III

Matrice de rang de l'indice de sélection relative des couverts par les perdrix grises, *Perdix perdix*, pour les premières pontes, obtenu en comparant le taux de fréquentation des couverts pour la nidification à leur disponibilité dans la surface agricole utile (SAU). La matrice dite de rang est symétrique par rapport à sa diagonale, elle peut être présentée soit sous forme détaillée soit sous forme simplifiée. Les éléments de la matrice détaillée (en haut, à droite) sont : $d_{(i,j)}$, différence entre le logarithme du rapport des utilisations des couverts et le logarithme du rapport des disponibilités (moyennes et écarts-type calculés sur l'ensemble des sites et des années d'étude), t du test t (26-28 dl) testant l'écart des $d_{(i,j)}$ par rapport à 0. Dans la matrice simplifiée (en bas, à gauche), les valeurs de $d_{(i,j)}$ sont remplacées par leurs signes, un signe triple indique que la probabilité du test t est significative (P < 0.05). Pour chaque ligne i, le rang 1 (R_1) représente le nombre de $d_{(i,j)}$ positifs et le rang 2 (R_2) le nombre de $d_{(i,j)}$ significativement positifs. Les territoires d'étude ayant des catégories de couverts non disponibles dans leur SAU n'ont pas été pris en compte dans le calcul des $d_{(i,j)}$ correspondants. Centre-Nord de la France, 1995-1997. Céréales, cultures fourragères, prairies pâturées, jachères, éléments linéaires, autres cultures.

	Cereals	Fodder crops	Meadows	Set-asides	Linear landscape features	Other crops	R_1	R_2
Cereals		4,7 ± 4.1 t = 5.89 P ≤ 0.001	5.2 ± 4.2 t = 5.66 P ≤ 0.001	3.8 ± 4.8 t = 4.18 P ≤ 0.001	1.0 ± 4.6 t = 1.20 p = 0.239	7.4 ± 4.6 t = 8.67 P ≤ 0.001	5	4
Fodder crops	---		- 0.1 ± 5.7 t = - 0.07 p = 0.941	- 1.4 ± 7.5 t = - 0.90 p = 0.378	- 3.8 ± 6.4 t = - 3.00 p = 0.006	- 2.5 ± 5.6 t = 2.32 p = 0.029	1	1
Meadows	---	+		- 1.6 ± 6.3 t = - 1.11 p = 0.279	- 4.4 ± 6.0 t = - 3.41 p = 0.003	- 3.2 ± 5.8 t = 2.59 p = 0.021	2	1
Set-asides	---	+	+		- 3.0 ± 6.6 t = - 2.40 p = 0.023	- 3.8 ± 6.3 t = 3.22 p = 0.003	3	1
Linear landscape features	-	+++	+++	+++		6.4 ± 7.8 t = 4.37 P ≤ 0.001	4	4
Other crops	---	---	---	---	---		0	0

IV. DISCUSSION

Our study confirms that the grey partridge nests in a wide range of places, including hedges and roadsides (e.g. BLANK *et al.*, 1967; CHURCH, 1984; RANDS, 1988; CARROLL *et al.*, 1990); cereals (BIRKAN *et al.*, 1990); row crops such as sugar beets; fodder crops such as ray-grass, lucerne and clover; and meadows and set-asides (see reviews *in* BIRKAN and JACOB, 1988; CARROLL, 1993). However, in contrast to some other studies and thanks to an unbiased method for finding nests (CARROLL *et al.*, 1990; REYNOLDS *et al.*, 1991), our consideration of all available cover allowed us to show that grey partridges prefer certain habitat types and landscape features for nesting. The location of first clutches results from an active choice whereas available habitats seem to be used at random for replacement clutches. However, due to small sample size, this latter finding may result from powerless tests. Two conclusions can be established about first clutches. First, the most preferred

TABLE IV

Ranked relative index of first nest-site selection by grey partridges, *Perdix perdix* (see R_1 Table III) for each study area. The symbol "/" indicates that the choice of the corresponding habitat was not tested because it was absent from the study area. North-Central France, 1995-1997.

TABLEAU IV

Rangs des indices relatifs du choix du couvert de nidification par les perdrix grises, *Perdix perdix* (R_1, voir Tableau III) pour chacun des territoires d'étude. Le symbole " / " indique que le choix du couvert n'a pas pu être testé du fait de l'absence du couvert sur le territoire d'étude. Centre-Nord de la France, 1995-1997. Céréales, cultures fourragères, prairies, jachères, éléments linéaires, autres cultures.

Study area	Cereals	Fodder crops	Meadows	Set-asides	Linear landscape features	Other crops
A	4	1	3	2	**5**	0
B	**5**	0	3	1	4	2
C	**5**	3	0	2	4	1
D	**5**	1	2	3	4	0
E	3	2	/	1	4	0
F	**4**	1	/	0	3	2
G	4	0	1	3	**5**	2
H	4	1	3	**5**	2	0
I	**5**	3	2	0	4	1
J	4	2	1	**5**	3	0

and linear habitat features. Second, edges are an important feature in nest-site choice, as indicated by the selection of linear habitat features and field margins.

As to set-asides, they were moderately used in relation to their availability on arable land. Nevertheless, this cover type globally ranked third as the cover used by grey partridge to lay their first clutches, and it was the most preferred nesting habitat on two study areas. In our analysis, all types of set-asides (see OFFICE NATIONAL DE LA CHASSE, 1998) were pooled in the same category "set-asides" (to reduce the number of habitat types). Some types of set-asides such as those promoted by hunter associations (called "Environment and Wildlife Set-aside" in France) are probably suitable for the grey partridge (OFFICE NATIONAL DE LA CHASSE, 1996), whereas other types of set-asides represent "green traps" because of mowing in June (OFFICE NATIONAL DE LA CHASSE, 1996; POTTS, 1997). Our results simply do not allow us to identify which set-asides improve partridge nesting justifying financial compensation to farmers.

We could not determine the environmental cues influencing nest site selection (edge effect, vegetation structure – height and amount -, quietness, etc.). Although we could not test the hypothesis of edge selection, we found evidence suggesting that the grey partridge selects field margins, tractor tyre tracks, roadsides, ditches and hedges to nest in. Such findings were reported by BIRKAN *et al.* (1990) in an intensive cereal agro-ecosystem, and REITZ *et al.* (1999) confirmed this result. Other studies investigated which habitat components might explain the differences between nest-sites and random plots. Contrasting results were reported. RANDS (1988) showed that, within hedges, the vegetation composition, structure and height were important factors in nest-site selection, whereas CARROLL *et al.* (1990) reported that vegetation density and height did not determine nest-site selection. CARROLL and CRAWFORD (1991), and CAMP and BEST (1994) found that, in roadsides, nest density was positively correlated with plant residue cover, and negatively correlated with the amount of bare ground. We could not test directly for these effects, but we found that 1) crops such as maize, linseed, potato and sunflower were rarely used for laying, and 2) sugar beet, pea and oilseed rape were used more to lay replacement clutches than first clutches. Because the "availability" (i.e. a_i) of habitat types in arable land was the same in May and in late June, whereas vegetation height and leaf area increased between these dates in fields of sugar beet, pea and oilseed rape, the use of these fields for replacement clutches suggests that amount of ground cover and height of vegetation influences habitat selection. We feel that several factors (edge effect, height and amount of cover, cover structure on the ground) are likely to influence nest-site selection, because they are acting together. A favourable site should provide the following characteristics. *i*) A good availability of dead cover to provide materials to build the nest. *ii*) A good cover height and density to hide clutches and sitting hens from predators. *iii*) A presence of boundaries and/or particular features such as stakes, stone, etc., to provide landmarks indicating more or less roughly the nest location. *iv*) A presence of linear features to offer corridors for daily movements and to escape from predators.

We show that cereals are the most preferred nesting cover of grey partridge in a wide range of farmland landscapes in North-Central France. This conclusion is congruent with the positive relationship between the breeding density of grey partridge and the proportion of cereals in arable land reported by RICCI and GARRIGUES (1986). However, the grey partridge prefers to nest near field margins or other edges. Thus, an increase in cereal farming in France might have favoured the grey partridge if field size had remained small and permanent cover strips had not been destroyed. For these reasons, we advocate a division of large fields into smaller ones to favour edges and create linear habitats, and a reduction of farming disturbance due to irrigation or pesticide spraying on field boundaries. However, because small fields have been merged into large ones since the 1950s to increase the efficiency of mechanized farming, the proposition to divide fields must take farmer needs and constraints into account (i.e. ease of planting and management, limited hindrance for farm works, financial compensation). Grassy strips planted between fields, or midfield for the biggest fields, could increase the abundance of edges and nesting sites. Such measures are currently proposed in the context of the Agri-Environmental and Set-aside Schemes: grassy strips, wild bird cover strips, set-aside strips, and "incomplete hedges" (i.e. patchwork of bushes and short dense grassy banks). Studies have recently been conducted to find out which cover type(s) and management practices will best improve game bird nesting (e.g. PASQUET *et al.*, 1998; PEETERS and DECAMPS, 1998). The impact of such measures on game populations has been tested experimentally (e.g. BOATMAN and BROCKLESS, 1998). The results indicate that efficient tools are available for managing farmlands in favour of game birds.

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SÉLECTION DU SITE DE NIDIFICATION CHEZ LA PERDRIX GRISE (*PERDIX PERDIX*) DANS LES AGRO-ÉCOSYSTÈMES DU CENTRE-NORD DE LA FRANCE

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MOTS-CLÉS : Perdrix grise, *Perdix perdix*, nid, choix du site de nidification, aménagement de l'habitat, agro-écosystème, France.

RÉSUMÉ

L'identification des sites de nidification sélectionnés par les perdrix grises, Perdix perdix, *dans les agro-écosystèmes est importante pour l'aménagement de l'habitat, en particulier dans les régions où cette espèce gibier a régressé. Le choix du site de nidification a été étudié en 1995-1997 sur 10 territoires d'étude en milieux agricoles contrastés dans le Centre-Nord de la France. Nous avons localisé 548 pontes à partir de poules perdrix équipées avec un émetteur radio. Nous avons utilisé une analyse statistique compositionnelle pour identifier les couverts sélectionnés. Les premières pontes (n = 407) se trouvaient principalement dans les céréales (65 %) et les éléments linéaires (22 %), les pontes de remplacement (n =141) dans les céréales (37 %), les autres cultures (22 %) et les éléments linéaires (18%). La majorité des pontes situées dans les céréales a été trouvée à moins de 20 m du bord des parcelles (78%, n = 316). Le choix du couvert de nidification n'a pas varié entre les années d'étude, mais a présenté des différences entre les territoires d'étude et entre les pontes (premières ou de remplacement). En ce qui concerne les premières pontes, les céréales et les éléments linéaires ont été les couverts préférés tandis que les autres cultures ont été les moins recherchées ; les fourrages, prairies et jachères occupant une position intermédiaire. Ce schéma général d'utilisation des couverts pour la nidification a été observé sur presque tous les territoires d'étude ; sur deux d'entre eux, les jachères ont été les couverts les plus recherchés. En ce qui concerne les pontes de remplacement, le schéma général d'utilisation des couverts n'a pas significativement différé d'un phénomène aléatoire. Nous recommandons de découper les grandes parcelles de culture en parcelles plus petites pour créer des habitats linéaires supplémentaires. Ces aménagements, parmi d'autres, sont proposés aux agriculteurs dans le cadre des programmes de mesures « agri-environnementales » et de " jachères ".*

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BREEDING OF BEICKI'S BLOOD PHEASANT (*ITHAGINIS CRUENTUS BEICKI*) IN NORTHWESTERN GANSU, CHINA

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KEY WORDS: Beicki's blood pheasant, *Ithaginis cruentus beicki*, pairing, breeding, brooding, behaviour, habitat, nest, egg, clutch size, incubation, adult food, Gansu, China.

ABSTRACT

The breeding of Beicki's blood pheasant, Ithaginis cruentus beicki, *was investigated in April-July 1984-1986 in a 8-km² study area of the Lenglong Mountains, northwestern Gansu, China, by bird counting and sighting, nest searching and crop collection. The blood pheasant mainly used the dragon spruce,* Picea crassifolia, *forest with moss on shaded and semi-shaded slopes at an altitude of 2,250-3,100 m, and alpine shrubs at an altitude of 3,100-3,300 m. The breeding season lasted from April to July. Territorial behaviour occurred during the last ten days of April. Pairing started after the territories were occupied by males. The mating system is monogamous. The ratio between males and females was 1.4:1 (males = 65, females = 46, n = 37 flocks). During the egg-laying period, some unpaired males paired with females which had lost their mate. The male's pre-copulative display is of the frontal type. Blood pheasants nested in the dragon spruce forest with moss and dragon spruce forest with shrubs at an altitude of 2,560-2,900 m. Their nests were located in holes under rocks (n = 2), tree stumps (n = 3), logs (n = 2) and at the base of a tree (n = 1). Egg-laying started in mid-May. The average clutch size was 6.0 eggs (range: 4-9 eggs, n = 7). The incubation period lasted 24 days in artificial incubators. Both parents looked after their young. 79-100% of their food (wet weight, n = 14 crops) comprised mosses (*Abietinella albietina *and* Bryum erythrocarps*) and herbs (*Thermopsis *sp.). No animal food was discovered. The blood pheasant's egg size increases with latitude (r = 0.84, P < 0.05), while the variability of clutch size also increases with increasing latitudes (r = 0.93, P < 0.01). Blood pheasants living at high latitude adopt a breeding strategy of laying large eggs which may produce larger and stronger young.*

I. INTRODUCTION

The blood pheasant, *Ithaginis cruentus*, lives in central Tibet, northwestern