

LANDSCAPE SELECTION BY GREY PARTRIDGE (*PERDIX PERDIX*) FOR NESTING IN THE FIELDS OF FRENCH CEREAL AGROSYSTEMS

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ABSTRACT

We studied landscape selection by the grey partridge, *Perdix perdix*, for nesting and its demographic implications. We measured six habitat variables for 221 first nests found in fields and for 268 random points in field edges distributed among nine study areas in central northern France. Nests were found by tracking radio-tagged females. A logistic regression model showed that partridge chose to nest close to a path or a road, in areas with a great diversity of crops within a 300-m radius. The proximity of a set-aside field or a permanent cover landscape feature was not important but partridge preferred the closest permanent cover feature to be a woody place (wood, copse or hedgerow), rather than another kind of feature, i.e. mostly areas around buildings. Our data did not reveal any relationship between this landscape level selection and female age, nest fate, chick survival rate or partridge density. These findings suggest that, for improving population dynamics in French intensive cereal agrosystems, one should focus on improving nesting success and chick survival, e.g. by modifying agricultural practices at cereal field edges, rather than on increasing availability of preferred nesting sites.

I. INTRODUCTION

Populations of the grey partridge, *Perdix perdix*, are declining all over Europe (AEBISCHER and KAVANAGH, 1997). In central northern France the decline over the last twenty years has been related to a decline in the adult survival rate (REITZ, 2000). However, to reverse the trend, several demographic parameters probably need to be improved (BRO *et al.*, 2000c). One of the most important parameters that would be to increase

breeding density, as hypothesized by JENKINS (1961a). He suggested that, similar to red grouse, *Lagopus lagopus*, populations, subordinate birds can be prevented from settling to breed (JENKINS *et al.*, 1963). This may result in a reduction in recruitment, as suggested by RANDS (1987). POTTS (1986) also showed that reduced breeding cover can lead to increased winter losses. Another consequence of a shortage in optimal nesting sites could be a fitness cost. A recent theory suggests that nest site selection by birds can result from an adaptive response to minimize predation (MARTIN, 1993, 1998). Nesting in less preferred habitat could then result in higher nest predation. This theory seems to apply to grey partridges in England where some characteristics of hedgerows determine both their selection by partridge for nesting and a lower risk of nest predation (RANDS, 1988).

In cereal agrosystems in France, grey partridge essentially select cereal fields and linear landscape features to nest (BRO *et al.*, 2000a). Indeed, these fields or linear features are not a limiting resource, because different females may build their nests close together (see BIRKAN and JACOB, 1988 for a review). However, the study of BRO *et al.* (2000a) like many others (BLANK *et al.*, 1967, CHURCH, 1984, BRUN, 1991), only focused on the nesting cover type and the presence of particular landscape features or vegetation structures immediately around nests. On a larger scale no particular attention has been paid to landscape characteristics of areas chosen by partridge for nesting and breeding, although these may limit the breeding bird density or partly determine the risks of predation or the amount of feeding resources for the young. Already published data concerned nests in strips (CARROLL and CRAWFORD, 1991), the distance to the proximal field edge (BRO *et al.*, 2000a) or compared the landscape structure around nests in crops with that around nests in permanent cover (PANEK and KAMIENIARZ, 2000). However, no study has focused on selection of particular locations in fields in relation to the landscape characteristics.

The objective of this study is to determine whether grey partridge are selecting particular nesting sites in crops according to crop diversity and presence and proximity of different landscape features such as paths or wooded patches. We also studied the relationships with demography and female age.

II. MATERIAL AND METHODS

II.1. STUDY AREAS AND DATA COLLECTION

Study areas, land cover recordings and techniques to monitor breeding females have been detailed in BRO *et al.* (2000a). The data analysed in this paper were collected on nine study areas denominated A to J (area H not used for this study) scattered throughout central northern France and representative of most common agricultural lands of this region (Table I and Figure 1). The size of each area was at least 15 km².

We classified the monitored females in two categories: one-year-old females and older females. We monitored the fate of each nest (successful, failed by predation on the nest or of the female, other causes of failure) by

TABLE I
Mean grey partridge, *Perdix perdix*, spring density (pairs/km²) in, and main habitat characteristics of, the study areas (central northern France).

TABLEAU I
Densité moyenne de perdrix grises, *Perdix perdix*, au printemps (couples/km²) et principales caractéristiques de l'habitat des terrains d'étude du centre du nord de la France : taille moyenne des parcelles (ha), longueur des éléments fixes linéaires (m/ha), pourcentage de la surface occupé par les éléments boisés (bois, bosquets, etc.), pourcentage de céréales parmi les cultures.

Characteristic	Study area									
	A	B	C	D	E	F	G	I	J	
Mean partridge spring density (pairs/km ²)	27.9	19.5	10.8	27.5	7.1	6.4	9.2	11.3	14.9	
Mean field size (ha)	3.7	1.7	4.5	6	9.1	6.7	7.4	5.9	10.1	
Length of linear features (m/ha)	38	71	44	27	31	35	21	41	25	
% woody places (woods, copses, etc.)	0	2.3	14.9	0.9	10.9	22.3	14.2	1	3.5	
% cereals among crops	27	49	44	41	37	59	46	57	42	

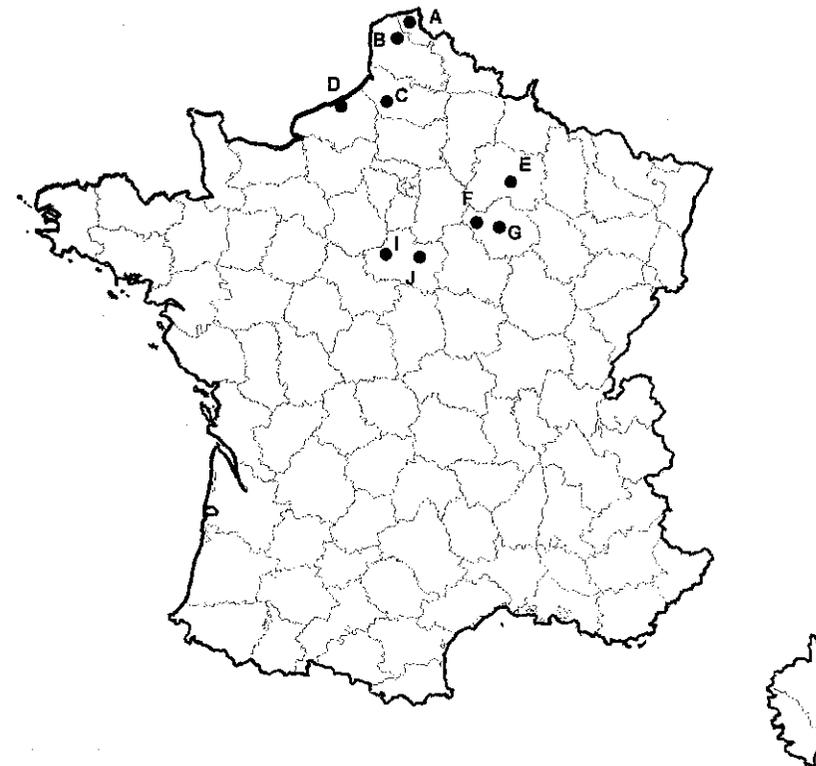


Figure 1: Locations of the nine study areas A to J in central northern France (area H unused for this study).

cessful, hatched eggs were counted. The survival rate of the > 4-week-old chicks after hatching was estimated by the ratio of the young counted in the brood when observed after the crop's harvest to the number of hatched eggs. Partridge spring density was estimated on each area in March during the three years of the field study: partridges were flushed out of sample plots of about 1 km² by a line of walkers, while standing observers at the opposite side of the plot counted them (BIRKAN and JACOB, 1988).

For this study we used 221 first nests found in fields. We considered as a first nest the first one that was discovered for each radiotagged female and that hatched or should have hatched before mid July. Of course, as most nests can only be found during the incubation phase, some nests lost during egg laying could have been missed.

The landscape characteristics of the nest sites were compared to those at about 30 points chosen "at random" in each study area. Random points were determined in three steps: first we selected x and y coordinates at random on a grid-squared map. Secondly, we kept the only points that were located in a field. Thirdly, we translocated the selected points to the closest edge of the field, that could be a permanent linear feature (e.g. a path, a hedgerow) or, more frequently, a boundary with no permanent vegetation between two different crops. This third step was required to obtain random points located as possible real nest sites (except for the distance to permanent landscape features), since most (78%) partridge nests are situated < 20 m to field edges (BRO *et al.*, 2000a).

Landscape characteristics were: distance to the closest path or road (DP), distance to the closest permanent cover feature (DPCF), *i.e.* any permanent feature, except roads and paths (hedgerow, wood, copse, building, etc.), type of this closest permanent cover feature (TPCF) by three categories: hedgerow, non-linear woody feature, other (mostly buildings or their immediate surroundings), number of different crops (NC) and of different permanent landscape features (NPLF) < 300-m radius, and presence < 300-m radius of a set-aside field or of a crop that was similar to a set-aside cover, e.g. alfalfa, rye-grass, etc. (PSA). Set-aside fields were cultivated according to the European Union agriculture policy, farmers earning a grant for this.

The 300-m radius length was chosen to account for all the landscape features that could be used by the females or their broods. We determined this relative to the movements of the birds during the reproductive period: 300 m was the 95% upper limit for the distance separating average May female location and first nest location (REITZ and MAYOT, 2000) and for the distance separating the nest site from the mean location of the brood during the first week after hatching (REITZ, unpub. data).

II.2. ANALYSIS

Landscape characteristics were independent variables of a logistic regression analysis (proc. logistic regression, SPSS, 1999) comparing nesting sites and random edge points. Because of non-linearity, distances to path were divided in three classes (< 50 m, 50 m to 150 m, > 150 m) and number of permanent landscape features entered as a quadratic variable. For the study area a categorical variable was also entered in the model because the proportion

We then used this model to provide each nest with an index of what we term its landscape suitability. The predicted probabilities given by the model for the real nests can be considered as such an index, provided that any study area effect be removed from the logistic equation since, given the same landscape characteristics, the index should be identical for any area. In this way, we computed the weighted mean of the slopes attributed by the final model to each study area and replaced these slopes by their mean in the logistic equation (N.J. AEBISCHER, pers. com.).

A general linear model with an area effect was used to study female age effect on variations of this index and, conversely, to study the index effect on chick survival. The effect on nest predation or success was tested by a logistic regression still with an area effect.

We also used the predicted probabilities for random points to obtain an index of mean landscape quality for nesting. For this, we averaged them for each study area. From this mean we derived an index of nesting habitat availability by multiplying it by the proportion of cereals in the study area, which is the major and preferred nesting habitat (BRO *et al.*, 2000a). The relationship between these indices and spring partridge density was tested by correlation analysis. All analyses were performed with SPSS®, for Windows®, r10.0 (SPSS, 1999).

III. RESULTS

We measured landscape characteristics of 221 first nests in crops and at 268 random points situated in field edges. No relationship was found between nest site selection and two landscape characteristics: the number of proximal permanent landscape features (NPLF) and the presence of a set-aside field in a 300 m-radius (PSA, Table II). Nonetheless, a graphic examination of the data (Figure 2) shows that the proportion of partridges nesting close to a set-aside field was greater than expected in four (D, G, I, J) out of the five study areas (D, F to J) where set-aside fields were the least frequent (where < 50% of the random sites were close to a set-aside field).

The four other characteristics were kept in the model when applying 0.15 as the probability level to get a variable out. However, the distance to the closest permanent cover feature (DPCF) was moderately significant and no clear tendency appeared when looking at the data (Figure 2). The positive sign of the b slope for this variable indicates that, if a real effect would exist, partridges would tend to nest far from such a feature. This particular pattern does not depend on the type of the nearest feature since the introduction in the model of the interaction term DPCF*TPCF does not increase significantly the model's likelihood ($\chi^2_2 = 1.3, p = 0.52$).

The three other variables, *i.e.* the distance to a path or a road (DP), the number of different crops within a 300-m radius (NC) and the type of the closest permanent cover feature (TPCF) play a highly significant role in determining the probability of a site to be a real nest, *i.e.* in discriminating nest sites and random points. This probability increases with the proximity of a path or a road, with the diversity of crops, and when the nearest permanent cover feature is a woody place.

The landscape suitability index for nesting we built from this model does not

TABLE II

Multiple backward logistic regression between the site type (real nest site of grey partridge, *Perdix perdix*, $n = 221$, random point, $n = 268$) and landscape characteristics in 9 study areas of central northern France. b is the parameter estimate in the logistic equation of the final model.

TABLEAU II

Résultats de la régression logistique descendante entre le type de site (site de nid réel de perdrix grise, *Perdix perdix*, $n = 221$, ou point choisi au hasard, $n = 268$) et des caractéristiques paysagères pour 9 terrains d'étude du centre du nord de la France. b est la valeur estimée du paramètre attribué à chaque variable ou chaque modalité de la variable dans l'équation logistique du modèle retenu. Caractéristiques paysagères : nombre d'éléments fixes du paysage différents dans un rayon de 300 m (NPLF) ; présence d'une jachère à moins de 300 m (PSA) ; distance (m) à l'élément fixe, offrant un couvert, le plus proche (DPCF) ; distance (m) au chemin ou à la route le plus proche (DP) ; nombre de cultures différentes dans un rayon de 300 m (NC) ; type de l'élément fixe, offrant un couvert, le plus proche (espace boisé non linéaire, haie ou autre, TPCF).

Landscape characteristic	b	χ^2	df	P
Number of different permanent landscape features within a 300m-radius (NPLF)		3.05	2	0.22
Presence of a set-aside field within a 300m-radius (PSA)		1.78	1	0.18
Distance to the closest permanent cover feature (DPCF) (m)	8.35×10^3	3.11	1	0.08
Distance to the closest path or road (DP) (m)	≤ 50 m 1.08 > 50 m & ≤ 150 m 0.77 > 150 m 0	15.67	2	< 0.001
Number of different crops within a 300m-radius (NC)	0.285	13.76	1	< 0.001
Type of the closest permanent cover feature (TPCF)	(wood) 1.08 (hedgerow) 0.84 (other type) 0	18.03	2	< 0.001

of a nest to be lost by predation of the clutch or of the female (127 hatched nests vs 43 nests lost by predation, $\chi^2_1 = 0.85$, $p = 0.36$) nor in chick survival rate (78 monitored broods, $F_{1,68} = 0.33$, $p = 0.57$).

There was no correlation between the index of nesting landscape quality of the study areas ($n = 9$) and mean spring density of partridge ($r = -0.001$, $p = 1.00$). Neither was there a significant correlation between this density and our index of nesting habitat availability ($r = -0.309$, $p = 0.42$).

IV. DISCUSSION

IV.1. LANDSCAPE SELECTION

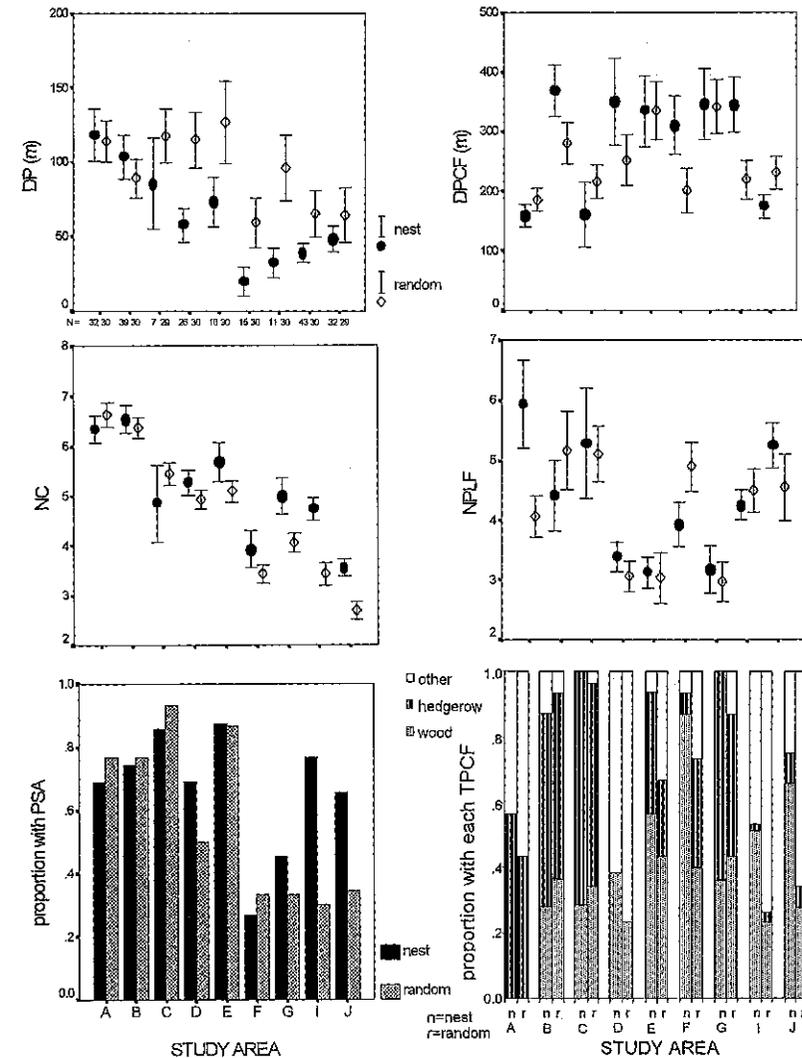


Figure 2: Variations in the landscape characteristics of the grey partridge, *Perdix perdix*, nest sites located in fields and of random points located in field edges, among the study areas (central northern France). For continuous variables: mean \pm 1 SE. DP = distance to the closest path or road, DPCF = distance to the closest permanent cover feature, NC = number of different crops within a 300-m radius, NPLF = number of different permanent landscape features within a 300-m radius, Proportion with PSA = proportion of sites with the presence within a 300-m radius of a set-aside field or of a crop that can be allowed as a set-aside cover, Proportion with each TPCF = proportion of sites where the closest permanent cover feature is of a given type (hedgerow, non-linear woody feature, else). The numbers of nests and random points per study area are given below the DP graph.

Figure 2: Variations des caractéristiques paysagères des sites de nids de perdrix grises, *Perdix perdix*, situés dans les cultures et de points pris au hasard sur une bordure de culture, en fonction des terrains d'étude (centre du nord de la France). Pour les variables continues : moyenne \pm 1 erreur-type. DP = distance (m) à la route ou au chemin le plus proche ; DPCF = distance (m) à l'élément fixe, offrant un couvert, le plus proche ; NC = nombre de cultures différentes dans un rayon de 300 m ; NPLF = nombre d'éléments fixes du paysage différents dans un rayon de 300 m ; Proportion de PSA = proportion de

selection of roadsides for grey partridge to nest (CARROLL *et al.*, 1990), the attractiveness of such a habitat for birds that nest in fields has not been pointed out before. Nonetheless, BIRKAN (1977) suggested that a diversity of crops around winter wheat fields was a favourable situation for a high spring pair density. DAHLGREN (1990) noted that males spend most of their time in a vigilance posture during the pre- and post-hatching period and, in this period, paths are the most frequent places where such behaviour can be efficient against predation risk or disturbance. BRO *et al.* (2000a) also noted that nests which were very far from field edges were frequently situated close to tractor tyre tracks that may play a similar role in disturbance detection or moving ability. The proximity of a path or a road can also help the birds to find a large amount of dead grass, which can be used to build their nest and cover the eggs. This amount has been shown to be a selection criterion for nesting places in hedgerows in England (RANDS, 1988). Another explanation could be that paths and, maybe, crop diversity play a role earlier than in the nesting period, in the territory establishment period ("habitation" phase according to CHURCH *et al.*, 1980), in particular as markers. But this hypothesis is not convincing since the location of the first nest can be quite distant from the average daytime location of the female in the beginning of spring (REITZ and MAYOT, 2000). Moreover, features such as groves or hedgerows seem to be unattractive for nesting. Nonetheless, among the closest permanent cover features, the wooded ones were more frequent than expected. It may correspond to an avoidance of other features, mostly building surroundings, where the disturbance and the predation risk by cats, *Felix catus*, and stone martens, *Martes foina*, are high.

Data analysis did not show any attractiveness of set-aside fields. As a matter of fact, as grey partridge are looking for a high crop diversity near their nest, the result is that set-aside fields in nest surroundings are present more often than expected. This was particularly evident in areas I and J, where crop diversity was low and the difference in crop numbers with respect to nest sites and random points very high. The set-aside effect that could be suspected (Figure 2) was probably only the result of an effect confounded with the crop number.

IV.2. FEMALE AGE, DEMOGRAPHY AND LANDSCAPE SELECTION

Nest losses due to predation are not related to the landscape suitability index for nesting. Unlike RAND's data (1988), our data do not support MARTIN's hypothesis (1993) that predation is less frequent when nests are located in more preferred landscapes. MARTIN's hypothesis is also not supported by the nest habitat examination data of BRO *et al.* (2000a): grey partridge select linear features to nest, and experience a high predation rate in this habitat (BRO *et al.*, 2000b). In the same way, chick survival rate could not be related to landscape selection, although the proximity of a path or a high crop diversity could be very favourable to feed young. Field edges are generally considered rich in arthropods (GREEN, 1984), the main food resource of grey partridge chicks (BIRKAN 1970). But food resources are also available

than others (REITZ *et al.*, 1999), probably by predation. Then, there might be no obvious negative reproductive consequence for females nesting in less-preferred landscapes. This conclusion is akin to that of PANEK and KAMIENIARZ (2000) who noted that grey partridges prefer to nest in permanent cover whereas nests are seemingly safer in cereals. This raises an interesting question of adaptive selection, or of what exactly determines the places where partridge choose to make their nest.

Nest site selection as measured in this study did not seem to depend on the female's age. This suggests the absence of any intra-specific competition in nest site selection, which does not exclude the existence of a competition for recruitment, as shown by RANDS (1987). This is consistent with the absence of gain in reproductive success when nesting in preferred places. Nest site availability does not appear to be a population regulation factor for partridge in our study areas and at the studied scale. RANDS (1986a), like us, did not observe a relationship between partridge density and the amount of suitable nesting cover among different farms. However, he obtained such a relation among parts of several of these farms. This could be interpreted more as the result of a distribution of the birds within the farm limits according to the availability of what they are looking for to nest, rather than a demographic incidence of this availability. Given that several studies showed strong relationships between spring density and some landscape characteristics at large scales (RICCI and GARRIGUES, 1986, PANEK and KAMIENIARZ, 1998, RANOUX, 1998), our results would suggest that factors other than nesting habitat availability are mainly involved in determining breeding density. As we suggested above, landscape characteristics may play a limiting role earlier than in the nesting period, in the "habitation" phase (CHURCH *et al.*, 1980). For example, at that time, the spring agonistic behaviour studied by JENKINS (1961b) depends partly on the amount of vegetation cover. RANDS' findings (1987) are in agreement with such a hypothesis. But it could also be the outcome of predator-prey relationships, predator and alternative prey abundance being linked to landscape characteristics. This second interpretation is consistent with the general results of the survey from which our data are extracted (BRO *et al.*, 2001) that showed that grey partridge females were suffering a high predation rate.

Translated in management terms, our results suggest that the greatest efficiency to improve population dynamics would probably be achieved by giving grey partridge the best conditions to succeed in nesting and rearing broods, rather than increasing the availability of selected nesting sites. To this end, management of agricultural practices that can be recommended, such as limitation of cereal irrigation (BIRKAN *et al.*; 1990), improvement of chick food resource by conservation headlands (RANDS, 1985, 1986b, POTTS, 1997, CHIVERTON, 1999) or cultivation of set-aside strips, should focus on areas where partridge nests are supposed to be more frequent according to our results, *i.e.* near paths and roads and where crop diversity is high.

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SÉLECTION DE L'HABITAT PAR LES PERDRIX GRISES (*PERDIX PERDIX*) NICHÈS DE PRÉDICTION DANS LES CULTURES D'AGROSYSTÈMES CÉRÉALIERS FRANÇAIS

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RÉSUMÉ

Nous avons cherché à savoir si les sites recherchés par les perdrix grises, Perdix perdix, nichant dans les cultures présentaient des caractéristiques paysagères particulières, et si cela avait des implications sur leur démographie. Pour cela, sur neuf terrains d'étude du centre du nord de la France, nous avons mesuré six variables de l'habitat concernant les alentours de 221 nids de première ponte trouvés dans les cultures, et de 268 points pris au hasard en bordure de culture. Les nids ont été trouvés grâce au radiopistage des femelles. Une modélisation par régression logistique a permis de montrer que les perdrix grises nichant dans les cultures préféraient le faire à proximité d'un chemin ou d'une route, et là où il y avait une plus grande diversité de cultures dans un rayon de 300 m. Les perdrix grises ne recherchaient pas particulièrement la proximité d'une jachère ou d'un élément fixe du paysage apportant un couvert. Cependant, elles préféraient que le couvert fixe le plus proche soit une surface boisée, linéaire ou non, plutôt que tout autre, comme principalement les abords des bâtiments. Nos données n'ont révélé aucun lien significatif entre, d'une part, cette sélection de l'habitat et, d'autre part, l'âge des femelles (un an ou plus d'un an), le devenir du nid (éclos ou ayant échoué par prédation des œufs ou de la femelle), la survie des poussins et la densité en perdrix grises au printemps. Ces résultats suggèrent que, dans les plaines de céréaliculture intensive, on aura plus de chances d'améliorer la dynamique des populations de perdrix grises en favorisant la réussite des nids et la survie des jeunes, en particulier par des pratiques agricoles adaptées en bordure des champs de céréales, qu'en augmentant la disponibilité en sites de nids préférés.

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FORMER AND RECENT STATUS OF THE JACK SNIPE (*LYMNOCRYPTES MINIMUS*) BREEDING RANGE IN THE EUROPEAN PART OF RUSSIA

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ABSTRACT

I analysed more than 100 publications of the last 150 years on the jack snipe, *Lymnocyptes minimus*, to study the former and current breeding distributions of the species in the European part of Russia. I classified the breeding records into 3 classes. The confirmed breeding records were those of nests, of downy or unfledged young, and of adult females with a brood patch or eggs in the oviduct. Possible breeding records were observations of adult males displaying in breeding habitats for at least 5-7 days, and the samples of females collected in May-June in breeding habitats, found in the museum collections. Unconfirmed records were records of males displaying for a shorter time in April and May, because they may have been migratory birds. Before 1960 the breeding distribution covered a range extending from the tundra to the mixed forest. The northern limits were the latitudes of 69°N in the Kola Peninsula and of 68°N in the mainland tundra to the east of the White Sea. The southern limit was more questionable because there was not enough information. The most southern locations were at the latitude of 52-53°N. The jack snipe did probably not breed every year in the more southern areas. After 1960, the breeding range seemed to decrease. The southern limit receded to the north. At present, the jack snipe does not breed in the oblasts of Orel, Kaluga, Tula, Ryazan', Moscow, Vladimir, Ivanovo, Yaroslavl, Kostroma, Nizhny-Novgorod nor in the region of Middle Povolzhye. In more northern areas the species is preserved, but its real current status remains unknown. The supposed range decline is mainly attributed to the reclamation of the bogs, drainage of the flood-plains of river valleys, and the construction of dams.