

Survival rates of Russian Woodcocks

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We analysed 324 recoveries from 2,817 Russian Woodcocks ringed as adult or yearling in two areas in Russia (Moscow and St Petersburg). We suspected that birds belonging to these two areas may experience different hunting pressure or climatic conditions, and thus exhibit different demographic parameters. To test this hypothesis, we analysed spatial and temporal distribution of recoveries, and performed a ringing-recovery analysis to estimate possible survival differences between these two areas. We used methods developed by Brownie *et al.* in 1985.

We found differences in temporal variations of the age ratio between the two ringing areas. The geographic distribution of recoveries along migrating flyways was slightly different. Woodcocks from the St Petersburg population were recovered in more northern and western countries. The annual recovery rates for adults and juveniles are $f_{ad}=0.038 \pm 0.007$ and $f_{juv}=0.056 \pm 0.008$ for the Moscow area and $f_{ad}=0.061 \pm 0.007$ and $f_{juv}=0.090 \pm 0.007$ for the St Petersburg area. Results confirm our hypothesis of two distinct Russian Woodcock populations. Mean survival rate was 0.52 ± 0.04 . Our survival analysis, however, did not detect survival differences between Woodcocks from St Petersburg and Moscow or between adults and yearlings. This may be to the result of small sample sizes.

This was the first demographic study of European Woodcocks ringed near their breeding areas and recovered over a large geographic scale. Continued ringing to increase samples will be necessary to analyse the distribution of recoveries more precisely in countries where they are numerous.

Introduction

Many migratory bird populations experience high hunting pressure, mostly on their wintering grounds. This has an adverse effect on population dynamics. We were interested in how hunting pressure (proportion of the total population that is hunted) varies in time and space, to understand how animal populations are effected by hunting. Quantifying hunting pressure is a major question in conservation biology. But it is difficult to determine because most studies focused on birds ringed on their wintering grounds, where they are hunted. The proportion of birds killed by hunters may provide indices quantifying hunting pressure within the borders of their wintering grounds, but it cannot evaluate effects on their breeding areas and on their migratory flyways. Our study attempts to estimate demographic differences from Woodcocks ringed in different places on their breeding ground and potentially recovered all over Europe.

Eurasian Woodcocks (*Scolopax rusticola*) are a major game species breeding mostly in Palaearctic countries and north-eastern Europe, and hunted over most of its migratory and wintering ranges. Several papers have highlighted the importance of ringing in the description and quantification of demographic variations in bird populations (Green 1999, Peach *et al.* 1999, Spina 1999). Previous studies used ringing data to investigate Woodcocks demographic parameters in relation to

hunting pressure (Gossmann *et al.* 1994 in France, Marcström 1994 in Sweden, Hirons 1988 in Britain) but very few used modern statistical models to give accurate estimates of survival (Hoodless and Coulson 1994, Tavecchia *et al.* 2002).

We considered two distinct populations of Woodcocks ringed on their wintering grounds in Russia and tested if Woodcocks breeding in these two areas belong to different populations. We compared the variations of the age-ratios, and the spatial and temporal distributions of recoveries. We then used the recovery model of Brownie *et al.* (1985) to test the effect of ringing place on survival and recovery rate.

Material and methods

Data

Woodcocks were caught in Autumn, at night with headlights and handnets. Adults and yearlings were ringed in eight sites in Russia. We grouped these sites into one of two ringing areas, according to geographical proximity (Figure 1). The Moscow group comprises birds ringed near the towns of Jaroslavl', Tver, Vladimir, Smolensk and Kostroma; the St Petersburg group comprises birds from the regions of St Petersburg, Pskov and Shenkursk. Repetition of ringing and recoveries are summarised in Table 1.

Figure 1. Ringing sites of European Woodcock grouped into two ringing regions in Russia.



Table 1. Number of ringings and recoveries of European Woodcocks. Birds were ringed in the vicinity of Moscow and St Petersburg, Russia during autumn 1994–2001.

	Moscow		St Petersburg		Total	
	Ringing	Recoveries	Ringing	Recoveries	Ringing	Recoveries
Adults	166	19	576	65	742	84
Yearlings	619	49	1,456	195	2,075	244
Total	785	68	2,032	260	2,817	328

These regions were geographically separated, therefore Woodcocks ringed in each area should experience different constraints and exhibit differences in their distribution and demographic parameters. Differences would allow us to quantify variations in hunting pressure on Woodcocks in Europe.

Analysis

Age-ratio (number of adults/number of juveniles) is a function of reproductive success. We believe that reproductive success may be affected by geographical and climatic conditions. Therefore we compared the annual variations of the age-ratios for the two ringing groups.

Spatial distribution of recoveries is not a robust parameter to detect survival variations, because it requires estimates of both hunting pressure and of the probability that the ring will be reported (e.g., interpretation of these results is problematic when there is a high survival but very few rings are reported). Distribution of recoveries can provide some descriptive information about migratory flyways. We examined the percentages of Woodcocks from the two groups that were recovered in each of the countries where recoveries occurred.

We then used the demographic model developed by Brownie *et al.* (1985) to estimate survival. This model estimates survival probabilities from maximum likelihood procedures, using the Akaike's Information Criterion (AIC) (Akaike 1973). It estimates survival from (1) the number of

ringed and released individuals and (2) the number of individuals that are recovered. The probability of a bird being recovered depends on three probabilities: (i) the probability a bird is killed by a hunter, (ii) the probability that the hunter finds the bird and (iii) the probability the hunter reports the ring back to the ringing organisation. Probabilities (ii) and (iii) cannot be estimated separately, but their product is. The product of the three probabilities is the *recovery rate*.

This model allowed us to test whether the Woodcocks ringed on the two areas belonged to distinct populations, by testing the influence of the place of ringing (*p*) on survival and recovery rates. We also tested if these two parameters depend of the age of ringing (*a*), and the year (*t*).

Results

Analysis of ringing and recoveries

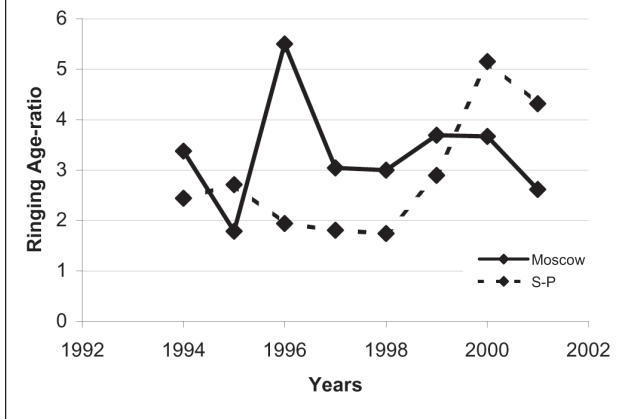
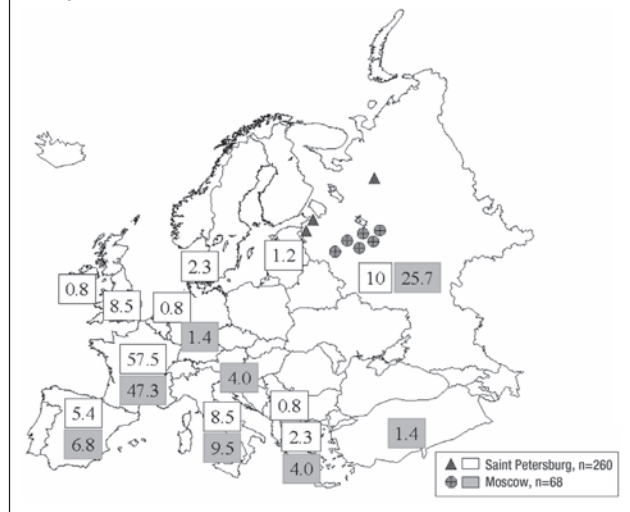
During 1994–2001 we captured and ringed 2,817 Woodcocks (1,915 in the St Petersburg group and 902 in the Moscow group). We obtained 333 recoveries (259 from St Petersburg and 74 from Moscow).

The age-ratio of birds ringed varied among years ($\chi^2=27.85$, $df=7$, $P=0.0002$) and these variations were different between ringing areas (effect year*place, $\chi^2=22.72$, $df=7$, $P=0.002$) (Figure 2).

Birds were recovered in every month except June, July, and August. Most recoveries occurred during November to January (and in April for Woodcocks ringed in the Moscow area). For both populations, recoveries occurred mostly in France (47.3% and 57.2% of recoveries from Moscow area and St Petersburg area respectively), Russia (25.7% and 9.7% resp.) and Italy (9.5% and 8.6% resp.). Woodcocks ringed in St Petersburg were recovered over a larger geographic range that included more northern and western countries: Britain (8.6%), Denmark (2.3%), Latvia (1.2%) and Ireland and Netherlands (0.8%) (Figure 3).

Survival estimations

We started model selection from the global model $S(p*a*t) f(p*a*t)$. This global model fit the data well (Bootstrap test, 100 simulation, 38% of deviances up to our model's one). We then tried to determine more parsimonious models. All tested models and results are shown in Table 2. The model with the higher likelihood (lower AIC) was $S(.) f(p+a+t_{SPP})$, in which survival rate is constant, recovery rate depends on ringing place, age of the bird, and year, but only for Woodcocks ringed in St Petersburg. This model, however, was similar to model $S(.) f(p+a+t)$, which assumes an effect of year on recovery rates of both populations. There was an effect of age of the Woodcock and year on recovery rate but, even if the best models assume an effect of ringing place on recovery rate, this effect was not significant (LRTTest – Model 2 vs Model 3: $\chi^2=2.06$, $df=1$, $P=0.15$). None of the tested parameters had any effect on survival. The mean survival rate was $S = 0.52 \pm 0.04$. Adult recovery rate for birds ringed in Moscow ($f_{ad.mos}$) was 0.38 ± 0.07 and for birds ringed in St Petersburg ($f_{ad.SP}$) was 0.61 ± 0.07 .

Figure 2. Yearly variation in age-ratio for European Woodcock ringed on the two ringing areas in Russia.**Figure 3.** Sites and percentages of ring recoveries of European Woodcock ringed on two areas in Russia and recovered in European countries.**Table 2.** Models tested, Akaike Information Criterion (AICc), Delta AICc, and their compared likelihoods using ringing data from recoveries of European Woodcocks.

	Model	AICc	ΔAICc	Model Likelihood	Number of Parameters	Deviance
1	S(.) f(p + t/SPP + a)	2555.096	0	1	12	146.39
2	S(.) f(p+a+t)	2557.057	1.96	0.3751	12	148.351
3	S(.) f(a+t)	2557.099	2	0.3673	11	150.41
4	S(a) f(a+t)	2557.108	2.01	0.3656	12	148.402
5	S(a) f(p+a+t)	2557.293	2.2	0.3334	13	146.569
6	S(p) f(a+t)	2558.485	3.39	0.1837	12	149.779
7	S(p) f(p+a+t)	2559.074	3.98	0.1369	13	148.349
8	S(p+a) f(p+a+t)	2559.3	4.2	0.1222	14	146.555
9	S(a) f(p+t)	2559.605	4.51	0.1049	12	150.9
10	S(t) f(p+a+t)	2559.894	4.8	0.0908	19	137.028
11	S(.) f(p+t)	2561.27	6.17	0.0456	11	154.581
12	S(.) f(p+a)	2567.493	12.4	0.002	4	174.885
13	S(p*a*t) f(p*a*t)	2583.807	28.71	0	68	128.619

Survival of yearling muscovite Woodcocks ($f_{juv.Mos}$) was 0.56 ± 0.08 and was 0.89 ± 0.07 for Woodcocks ringed in St Petersburg ($f_{juv.SP}$).

Discussion

There were important annual variations in the age ratio for both ringing areas. But these variations were not similar. If Woodcocks belonging to these two ringing areas were from the same population, the age ratios would not differ. This supports our hypothesis. Because birds are ringed on their breeding grounds, however, this result cannot provided information about geographical variation of hunting pressure.

Temporal distribution of recoveries was similar in both groups. The spatial distribution shows that Woodcocks ringed in the Moscow area are recovered mostly in south-western Europe, while those ringed in St Petersburg are recovered, as expected, in more north-western countries (Britain, Denmark, Latvia, The Netherlands and Ireland). This also confirms our hypothesis, and was helpful in the interpretation of survival analysis' results.

Although we expected differences in survival according to ringing place, our model selection shows that survival was similar for the two groups. Age-dependant models estimated survival (S) at 0.55 ± 0.04 for adult birds and 0.43 ± 0.07 for yearlings, but this difference is not significant. These results are different from previous studies on Woodcocks (Tavecchia *et al.*, Hoodless and Coulson, op. cit.) and unusual for a migratory game bird (e.g., McGowan and Otis 1998 for mourning dove and Reynolds *et al.* 1995 for female mallards). This lack of differences between ages and locations may be a result of our small sample size.

The slightly better likelihood of model with no time-dependence for recovery rate of birds ringed in the area with the smallest dataset (Moscow) confirms this hypothesis. We believe there is a multiplicative effect of at least year and ringing place, but our dataset is too small to allow its detection. Additional ringing in Russia will allow us to explore this hypothesis further.

Our estimations of annual survival was higher than those of Tavecchia *et al.* for birds ringed and recovered along French Atlantic regions (0.44 for adults and 0.34 for

yearlings). It is difficult to determine if these differences could be caused by biological and climatic factors, or just the small size of our dataset. We believe, however, that the high hunting pressure that occurs on this species in the western part of France could explain this difference because Tavecchia *et al.*'s dataset focused on this heavily hunted segment of the Woodcock population.

Higher recovery rates for juveniles was not surprising and because Woodcocks are migratory birds, individuals that survive to their first year are more experienced and less likely to be shot in subsequent years. The absence of an effect of ringing area on recovery rate was unexpected, although the best models all included this effect. Thus we believe this effect exists but is relatively small. Estimated recovery rates include the reporting rate probability and the probability of being shot. The lower recovery rate for both adults and yearlings ringed in Moscow probably means that these birds are either less likely to be hunted or less likely to be retrieved and reported.

Countries bordering the Mediterranean usually exhibit high hunting activity (McCulloch *et al.* 1992). Because many of the Woodcocks ringed in Moscow seem to winter in these countries, lower hunting pressure is not a likely explanation for lower recovery rates. Estimating reporting rate was difficult because we had no way to evaluate the proportion of rings reported by hunters (see for example Brownie *et al.* op.cit. and Cooch and White 2002). It may be higher, however, in northern European countries where information campaigns are common and people more aware of the importance of ringing. This may partially explain higher recovery rates for Woodcocks ringed in St Petersburg, because they were only recovered in these countries.

Conclusion and perspectives

Although we were not able to detect differences in survival for Woodcocks ringed on our two sites, our study highlighted interesting differences from the various ringing areas. This method allowed us to determine different migratory flyways and to highlight some differences among Woodcocks wintering in two areas of Russia. We realise, however, that our results need to be developed further. For example, it would be interesting to analyse the spatial distribution of recoveries amongst regions within each country more precisely. This analysis might be particularly informative in France, which is a migratory crossroads for Woodcocks breeding in Eastern Europe. A more precise analysis of the origin of Woodcocks recovered in different French regions would probably give more information about migratory flyways. Our dataset was too small to permit these analyses, but continued Woodcock ringing in Russia should provide more useable data in the future. This should allow us to obtain more detailed estimations of demographic parameters, and therefore test our hypotheses about survival and recovery rates.

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Identification test of suitable Woodcock breeding habitats in mountain areas

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The main objective of this first identification test of suitable Woodcock breeding habitat in mountain areas is to apply it to a wildlife habitat management. This aim has been developed by the Hunter Association of Isère (a French *département*) and is supported by the General Council of the Isère *département*.

The study area includes the Vercors, Chartreuse and Belledune mountains. From 1992 to 2002, 169 randomly chosen listening points were visited within the framework of a national Woodcock breeding survey initiated by the *Office national de la chasse et de la faune sauvage* in order to detect the presence of roding males. The habitats were described for each point situated in a 500 m-radius area and for 25 vegetation classes given by the *Institut Forestier National*. Moreover, altitude and exposure were noted. A uni-variate analysis, and then a χ^2 test allowed us to describe the favourite Woodcock habitats: high coniferous and mixed forests, young coniferous and deciduous forests, moors and pastures but also a 1,037–1,939-m high altitude and N, NE, W, NW exposures. From these characteristics a map has been drawn of the afforested habitat that is potentially suitable for Woodcocks during the breeding period. This map appears to be consistent with other studies, and with the breeding sites known in the *département*.

Introduction

The Woodcock (*Scolopax rusticola*), is present in all the temperate and forested regions of the Eurasian continent. France is situated at the far western part of the breeding area. In this country, the Woodcock breeds in the large forests situated in plain and in the mountainous forests (Ferrand and Gossmann 1995). The deciduous and mixed forests are considered to be the better habitats (Hirons 1987). In Isère, a French *département* located in the Alps, the Woodcock is a regular breeder.

Because of that, the Hunter Association of Isère has always been interested in the conservation of this species and its habitat. With the support of the General Council of Isère, a research programme has been initiated in order to identify the key Woodcock habitats during the breeding period.

The objective of this paper is to present a first approach to modelise the breeding-Woodcock distribution according to habitat quality.

Material and methods

Study area

The study mainly focused on three mountain massifs located in the southern part of the Isère *département*. The Belledune massif is a hilly and crystalline, moderately forested with mixed forests, and with annual rainfalls of about 1,600 mm. The Chartreuse massif is hilly and made up of alternating limestone and marl strata. It is thickly forested, and mainly with spruce. The annual amount of rainfall is more than 2,000 mm. The Vercors massif is a

limestone one with a large plateau at 1,600 m altitude. Its important forest cover is dominated by conifers. The annual rainfalls are less than 1,400 mm. Besides that, data are collected every spring in all the forests of the Isère *département*.

Data collection

Presence/absence

The presence/absence data of breeding Woodcocks were taken from the national annual survey based on the observations of roding males at randomly chosen listening points (for this method, see Ferrand 1993; Ferrand and Gossmann 2000).

Data are collected with the help of the French Woodcock network, supported by the *Office national de la chasse et de la faune sauvage* and the Hunter Associations. This survey has been applied in Isère as of 1992. A total of 223 listening points were visited (Figure 1) and their co-ordinates digitalised. From these, 169 data located in the three study massifs were used for this study.

Habitat description

The habitat was described within a 500 m-radius from the listening point, i.e. within a 78-ha area. This value is close to the one obtained for the daily roding area (Ferrand 1989). The habitat was defined from the map of the forest structure drawn by the *Inventaire Forestier National*, which represents a geo-referenced data base at a 1:25000 scale. Twenty-four forested habitats are identified (see Table 3). The minimum mapped surface area is determined by a 2-ha polygon. This type of document is available for the whole Alps.

Topographic data

Altitude and exposure were shown to act upon the distribution of the Woodcocks in their mountain breeding areas (Mulhauser 2001). The altitude of each listening point was defined for six classes: the first class starts at a 134-m altitude and each class is equidistant by 300 m. The exposure was noted according to eight possibilities: north, north/east, east, south/east, south, south/west, west and north/west.

Data analysis

After Marly *et al.* (1993), all observations were considered as being time independent. Because of the random sampling design, a listening point may be selected several times, but others only once. Therefore, we only analysed the data in terms of presence/absence in order to maintain the data set's homogeneity. Moreover, a roding male may be observed several times at the same listening point and during the same evening session. This is why, the number of contacts cannot be easily transformed into the number of individuals and Woodcock densities remain difficult to assess.

A univariate analysis was made by taking the three variables: forest habitat, altitude and exposure, independently into account. This analysis was made by a χ^2 test and a selection index (Hirons 1987). This index is

equal to the % of roding locations in a variable type / % of area occupied by the variable. A value >1 indicates preference, <1 avoidance and $= 0$ no choice.

Results

Statistical results

Altitude

The statistical analysis shows a preference for altitude ($\chi^2 = 12.52$, $df=5$, $p<0.05$). According to the selection index, the Woodcock prefers the 1,037–1,939 m altitude range (Table 1). This altitude corresponds to the mountain region and part of the sub-alpine region.

Table 1. Selection index values according to altitude.

Altitude (m)	Selection index
134–434	0
435–735	0.19
736–1,036	0.55
1,037–1,337	1.23
1,338–1,638	1.36
1,639–1,939	3.83

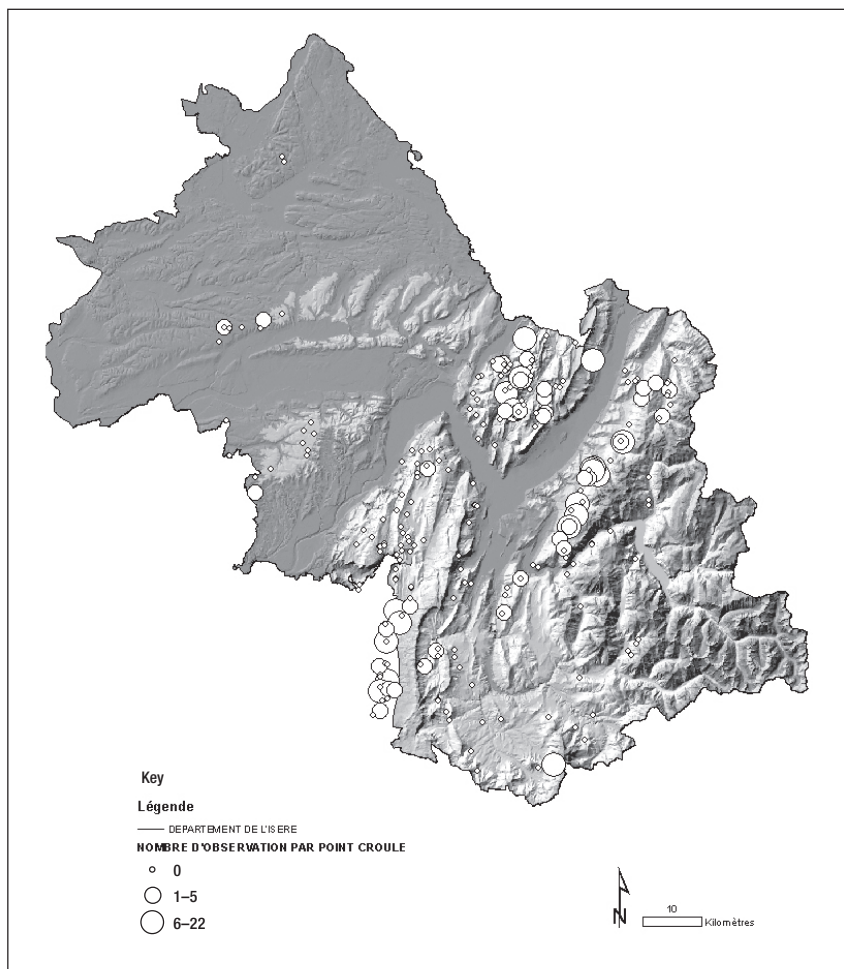


Figure 1. Listening points visited during the annual breeding Woodcock survey in Isère as of 1992.

Exposure

A χ^2 test shows that exposure has an impact on Woodcock habitat choice ($\chi^2 = 11.52$, $df=5$, $p<0.05$). The selection index stresses the preference for north, north/east, west and north/west exposures (Table 2).

Forest habitat

Woodcock distribution appears to be linked to the forest-habitat types ($\chi^2 = 23.36$, $df=5$, $p<0.05$).

The selection index shows the Woodcock's preference for high coniferous forests (Table 3). Unmixed deciduous forests are relatively rare in the mountain and alpine regions. However, pure beech forests exist northerly oriented exposure areas (Patou 1984), but are not selected by Woodcocks.

Mapping results

A map was drawn of the habitats selected by the Woodcocks that, first of all, showed their forest habitat (Figure 2). The two other variables were combined with this forest habitat to define four potential classes:

- suitable forest habitat only
- suitable forest habitat + suitable exposures
- suitable forest habitat + suitable altitudes
- suitable forest habitats + suitable altitudes + suitable exposures.

The most complete model (three variables) is supposed to be the most suitable Woodcock breeding habitat.

Table 2. Selection index values according to exposure.

Exposure	Selection index
North	1.51
North-east	1.15
East	0.52
South-east	0.59
South	0.74
South-west	0.93
West	1.31
North-west	1.33

Table 3. Selection index values according to habitat.

Forest type	Selection index
High deciduous forest	/
High pine forest	0
High coniferous forest (small diameter)	1.57
High coniferous forest (medium diameter)	1.40
High coniferous forest (big diameter)	2.34
Mixed forest (deciduous>coniferous)	0.81
Mixed forest (coniferous>deciduous)	1.06
High and young oak forest	/
High and young beech forest	0.76
High and young deciduous forest	1.61
High and young coniferous forest	0.82
Young oak forest	0
Young chestnut forest	/
Young beech forest	0
Young deciduous forest	0.10
Other deciduous woodlands	0.57
Other coniferous woodlands	0.96
Fragmented deciduous woodlands	0.10
Fragmented coniferous woodlands	0
Deciduous shoots	0.56
Coniferous shoots	2.34
Margin deciduous woodlands	0.67
Margin coniferous woodlands	0
Moors	1.77
Pastures	1.84
Open area	0.34

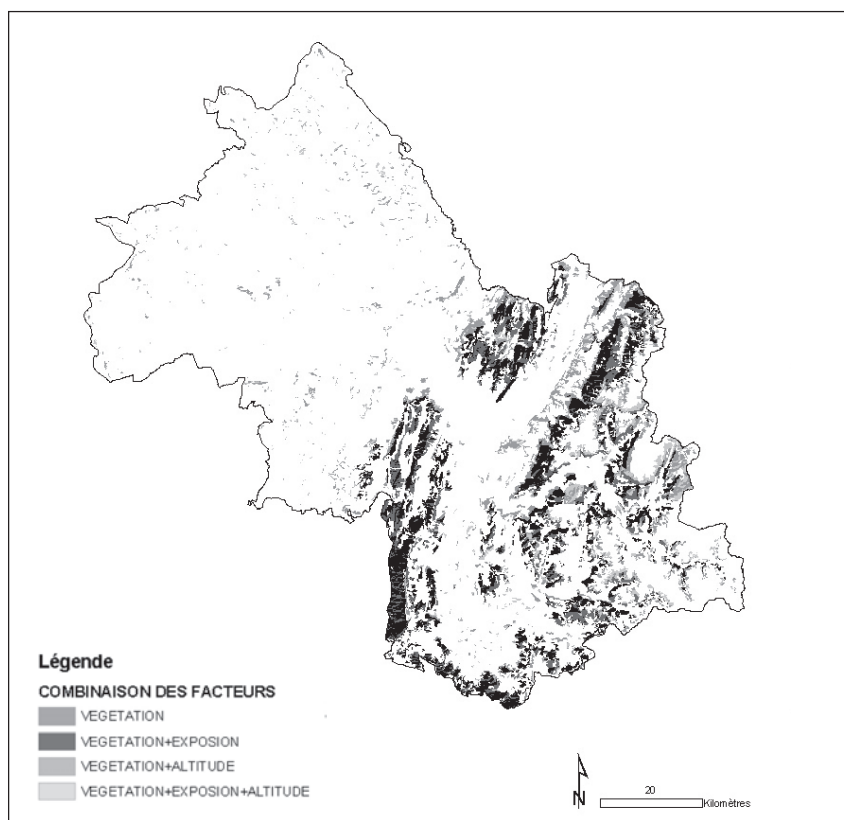


Figure 2. Map of the potential Woodcock breeding habitat in Isère département by roding-male habitat preference (the areas considered to be the most suitable ones are indicated in lightest grey).

Discussion and conclusion

Our study shows that, overall, in the Alps, the Woodcock prefers the mountain stratum, and the low sub-alpine stratum during the breeding period. This result is in accordance with the one obtained by Mulhauser (2001) in the Jura mountains in Switzerland. These altitudes correspond to rather wet habitats where Woodcocks may easily find food for them, and their broods, and as late as in July. The same explanation holds for their preference to stay in north- and westward exposed areas. Such sites are less exposed to sunlight and will keep moisture for a much longer time, especially the humidity due to snowfalls.

Earthworm abundance appears to be a key factor for Woodcock distribution during the breeding period (Hirons 1987). This is clearly linked to the humus type (Duriez 2003). In our study area, the fir (*Abies alba*), spruce (*Picea abies*) and Douglas fir (*Pseudotsuga menziesii*) forests produce a type of mull humus that is rich in invertebrates, and especially in earthworms. And this is why the selection of a coniferous habitat can be explained by the possibility that it may create favourable sites for Woodcock broods.

On the other hand, the selection of pastures seems to be linked to the surface area that was taken into account for

the habitat description around the listening points. Indeed, the pastures and forests greatly overlap in the mountain and sub-alpine regions. Moreover, roding males are attracted by open areas during their roding flights. And as a consequence, this type of habitat seems to be more closely related to roding behaviour than to breeding conditions.

To test validity of the map drawn in this study we compared it with the map of nests and broods that have been found in Isère since the '80s. A good correlation appears: 85% of nest or brood data (28/33) are located at a more or less 150-m distance from suitable defined sites (Figure 3). Only five data are located outside this area.

This first model approach of the Woodcock's distribution in mountain areas seems very consistent with the bibliographic and field data. Of course, the statistical analysis is simple and does not take the interactions between the factors into account. For example, the forest type can be partly explained by altitude and exposure. To get a more precise model, the application of a general linear model should improve the results. However, a definite description of environmental factors in a numeric dataset is not available. For example, an understorey description is not available although this is very important for Woodcocks. Indeed, the chicks should be able to walk

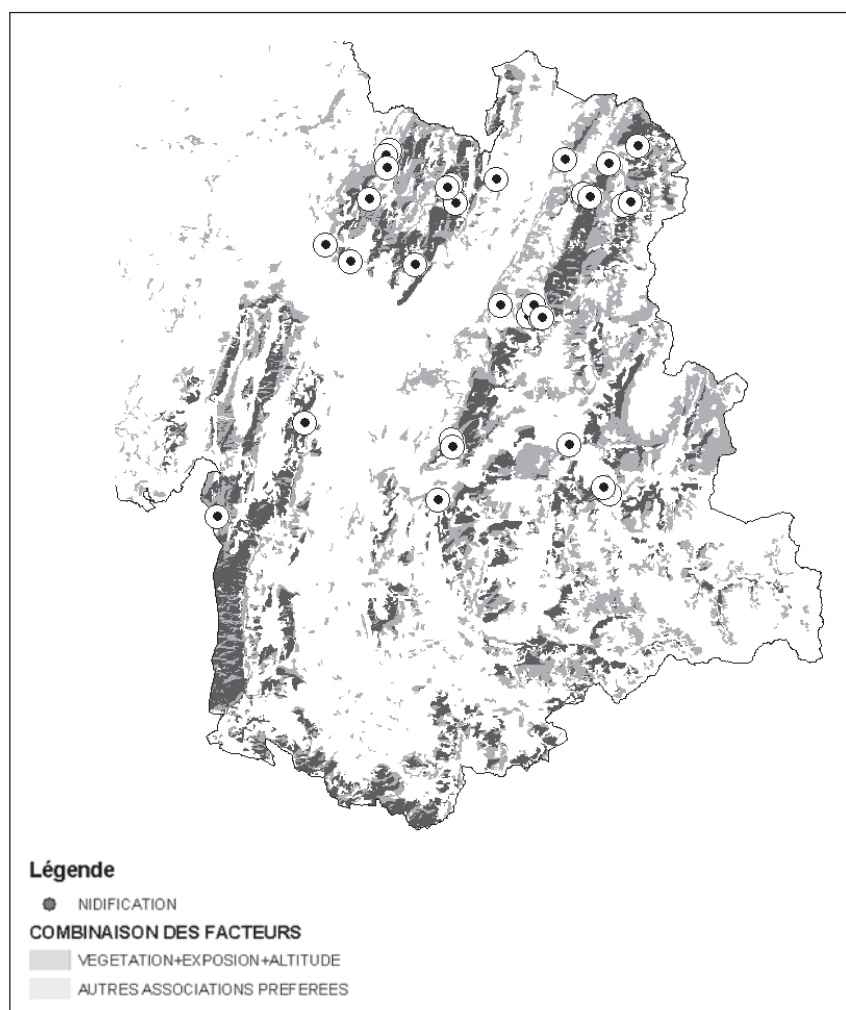


Figure 3. Comparison between the suitable Woodcock habitat map and data of nests and broods found since the 1980s.

and also be protected against predators. So, the understorey quality should be an important factor. Many observers consider that the *Megaphorbiaie* could have a great impact on Woodcock presence. This type of habitat is very often situated in micro-clearings created by fallen trees or due to the relief. It is dominated by dicotyledonous plants with large leaves (*Aconitum* sp., *Adenostyletalia allaria*, *Cicerbito* sp., ...) which grow quickly after the snow has melted. The soil is deep, continuously moist but well aerated. An intense biological activity and great food richness is associated with it (Delarze 1998). In the mountain regions, *Mercurialis perennis* cited as a Woodcock indicator plant (Hirons 1987) is common. Finally alder forests in the sub-alpine region may be compared to *Megaphorbiaie* and should be an important Woodcock habitat.

It is obvious that all these factors should be taken into account for future research in order to provide wildlife managers with a precise decision tool.

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The origins of Woodcocks wintering in France

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Abstract

Knowledge of the origin of wintering birds is a crucial question in conservation biology since, regarding their spatial distribution, animals have to withstand different constraints due to climate, geography and, for quarry species, variation in hunting policies. Management of wintering populations, as required, implies co-operation among the countries concerned by the species' distribution area, and a precise quantification of their origins. Unfortunately, most studies based on recaptures or recoveries gave only information about the origin and destination of banded individuals.

In this paper, we used the birds recovered on their breeding grounds and along the migratory flyways of European Woodcocks ringed in France while wintering, to quantify the origins of this wintering population. Based on previous studies and the distribution of our recoveries, we identified two main migratory flyways: the one along the North Sea to Finland and Scandinavia, and the other one that goes through Austria and Hungary, and crosses the Eastern European countries up to western Russia and the Baltic countries. We divided France into seven large regions and used a multistate capture-recovery parameterisation to estimate the proportions of individuals using one or the other flyway. The regions were classified by climatic conditions and hunting pressure.

Our method requires that:

1. all breeding grounds are identified,
2. the number of breeding sites is at least one more than the number of breeding populations.

We showed that, in all French regions, eastern Woodcocks outnumbered the Fennoscandian Woodcocks. However, the proportions varied significantly along a north-west–south-east gradient (from 70% of Eastern Woodcocks in the most north-western region to 100% in the most south-eastern one). We also highlighted a decrease in the proportion of Fennoscandian Woodcocks wintering in France over the last 15 years, and the explanation of that trend remains to be found.

We believe that our method is applicable to other species for which the necessity appears to quantify the composition of their populations made up of individuals of different origins, and their spatial variations.

Snipe

Influence of human activities on habitat use by African Snipe (*Gallinago nigripennis*) in Kenya

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In Africa today many bird species that inhabit wetlands and grasslands are threatened by anthropogenic causes of habitat loss and modification. These habitat changes are caused by cultivation, livestock grazing, burning, forestry and modifications of hydrological regime. This study investigated how African Snipes (*Gallinago nigripennis*) are affected by degradation of wetlands and wet grasslands, which are used as breeding and foraging areas by the species. The study was carried out in Lake Ol Bolossat (altitude 2,340m; 360 26' E, 00 09'S) basin in the central highlands of Kenya during the period January 1998–December 2000. Snipes were studied by field observation, trapping and marking, and monitoring the movements of marked individuals. Human activities were studied through observations of the daily activities of selected individuals. The impact of these activities on wetlands and grasslands was studied by measuring changes in the areas of habitats and their use by Snipes. The total area used for feeding and nesting by African Snipes was 2,814 ha. The wetlands in that area supported 143 nests, which were located in marshes (63 nests), wet grassland (70 nests) and abandoned cultivation (10 nests). During 1999–2000 the coverage of natural pasture decreased by 11%, while lake-edge and stream-edge marshes decreased by 20%. As a result, the area under cultivation expanded by 120%, while that of mud flats increased by 27% because of reduced water supply and siltation in Lake Ol Bolossat and the affluent streams. The main cause of habitat degradation and loss were agricultural encroachment, overgrazing, burning, and drainage of wet areas by peasant farmers. These human activities constitute a serious threat to African Snipes and other wetland birds in central Kenya. It is therefore imperative to involve landowners in developing and implementing management plans for Important Bird Areas in Africa.

Introduction

Africa has abundant freshwater resources in its 83 river and lake basins, 20 of which are found in East Africa. Inland wetlands are freshwater ecosystems, which are associated with those river and lake basins. The wetlands cover about 1% of Africa's total surface area and about 4% of East Africa. In spite of their small land cover, African wetlands are an important source of livelihood and income for nearly 12% of the continent's human population. Wetlands are traditionally used for domestic and farm water extraction, fishing, extraction of fibre and medicinal plants, subsistence agriculture and livestock grazing (Denny 1985).

African wetlands support a rich and valuable biological diversity upon which millions of people depend for their livelihoods and for economic development (NEPAD 2003). However, wetlands are rapidly becoming degraded or destroyed primarily because of drainage for agriculture, over-extraction of freshwater resources and development activities, such as the expansion of human settlements and the associated production of waste material. Persistent drought and intensification of livestock grazing are also having far reaching negative effects on African wetlands. These activities threaten wetland biodiversity, particularly resident birds.

African Snipes (*Gallinago nigripennis*) are endemic to the continent, where they inhabit upland marshes and wet grasslands. Snipes are tactile surface foragers, which mainly feed on invertebrates found in wet substrates. The food resource for both resident and Palearctic Snipes varies with changes in soil moisture and soil type (Gichuki 2002). The availability of wet and productive substrate is

essential for the survival and reproductive success of Snipes in tropical areas. In order to achieve those lifetime goals, the Snipes should be able to identify suitable wet substrate, monitor changes in its moisture content and changes in food abundance.

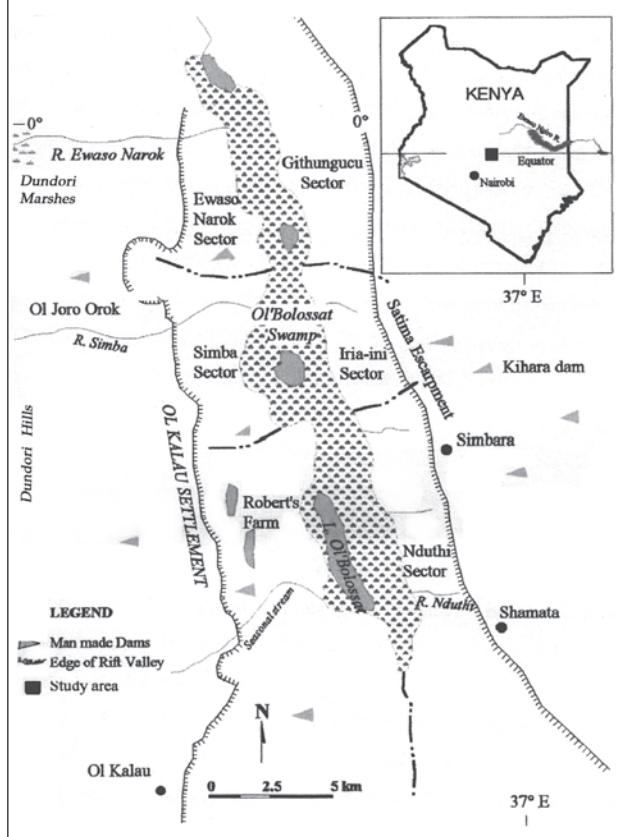
Sharing their habitat with people and livestock, however, poses a major challenge for African Snipes. This is because human and livestock activities interfere with the availability of food, nest sites and anti-predator cover. In many parts of Africa, especially in Ethiopia, Kenya and Rwanda, African Snipes mainly inhabit agricultural landscapes, where they share marshes, wet grasslands and water edges with livestock or other large mammals. In such modified habitats, Hardy *et al.* (1986) showed that regular monitoring can detect the impact of changing cropping regimes, grazing patterns and utilisation of controlled fire as a habitat management tool on Snipes and other birds that occupy open habitats.

The purpose of this study was to determine how African Snipes adjusted their foraging and nesting strategies in response to human-induced habitat alterations in the study area. The specific objectives were: to determine patterns of habitat use for foraging and nesting, establish habitat factors that influence choice of nesting sites and to determine the effects of human activities, particularly wetland drainage and livestock grazing on African Snipes in a tropical upland lake basin in Kenya.

Study area

The study area was Lake Ol Bolossat (360 26' E, 000 09'S) in central Kenya (Figure 1). Lake Ol Bolossat

Figure 1. Lake Ol Bolossat basin showing the main geographical features and the study sectors (redrawn from Survey of Kenya Topo Maps, 1971).



(10,000 ha) is a fresh-water lake situated at 2340 m.a.s.l. on a flat plain. The lake is shallow, ranging in depth from 0.5 to 1.75 metres. On the eastern edge, there is a 36 km long Sattima escarpment that rises to 2,550 m.a.s.l. The watershed of the lake covers approximately 540 km² and includes the escarpment, and northern slopes of Nyandarua Mountain Range (4,030 m) and Dunderi Hills (2,760 m). This internal drainage basin receives water from rainfall, underground seepage and surface runoff from the surrounding highlands (Blomqvist 1997). The land in the lake basin and its watershed is good for agriculture and hence the main economic activities were livestock-rearing, cultivation and farm forestry. Lake Ol Bolossat has a resident population of African Snipes, which co-exist with herbivorous ducks, shorebirds, pelagic foragers and fishing birds. In total 285 species of birds inhabit the lake and bordering woodland on the rift-valley escarpment.

The study area lies on the Equator and between March and April, the south-east monsoon winds, which pick up moisture from the Indian Ocean, bring rains to central Kenya (Ojany and Ogendo 1988). Annual rainfall distribution is mainly bi-modal, with peaks separated by two to five relatively dry months from June to October (Blomqvist 1997). Rainfall in Lake Ol Bolossat basin averages 725 mm per annum and occurs mainly in April, June, July and August.

The principal habitats of African Snipe in Lake Ol Bolossat basin are water edges, wet grassland, marshes and wet

farmland, especially along the water drainage channels. Continuous streams and underground water seepage in the lake basin maintained wet soil conditions and continuous growth of tall grass and marshes vegetation. Areas with short but wet grass were used by young African Snipes as well as the Palearctic Common Snipes (*Gallinago gallinago*). The Snipes avoided wooded areas and cultivated fields with trees. African Snipe were resident and bred in the study area almost all year around, as noted by Britton and Brown (1980) in suitable areas in East Africa.

Materials and methods

Determination of foraging range sizes and local movement

African Snipes were caught in four-shelf mist-nets erected on 3-m bamboo poles. The Snipes were caught at dawn (05.00 to 07.00 h) or late evening (18.00 to 19.00 h). Snipes were ringed with a "B" size, aluminium, East Africa Natural History Society ring. In addition, a combination of coloured plastic rings were used to aid identification. Mist-netting was "opportunistic"; its objective was to catch as many birds as possible during the period between January 1998 and December 2000. The daily activity budget of marked focal birds was described in terms of five major activities: feeding, vigilance, resting, flying and aggression. The minimum convex polygon (MCP) was used to determine the foraging range sizes of marked Snipes. The foraging range size was simply defined as the total area used by an individual for its normal activities of feeding or rearing young (Laundre and Keller 1984). The proportional overlap in the ranges of neighbouring birds was determined from the number of locations within shared parts of their foraging ranges.

The movements of marked birds were monitored for a specific period, usually three to five hours per day for three days in a week. Colour-marked birds were sought all along the eastern and western shores of the lake at the same time. Once found, their locations and altitude were taken with locating equipment, the Geographical Positioning System (GPS), and subsequently marked on a large-scale map of the study area. The distance of marked birds from the site of marking was estimated. Marked birds were also captured through mist-nets erected at different sites in the lake basin.

The movement and habitat utilisation by African Snipes were also studied from six radio-tagged individuals. Four birds were radio-tagged at Lake Ol Bolossat in January 1998. The radio-tagged birds were located with a tracker-receiver (TR2) and a hand-held Yagi antenna, and could be detected for up to a maximum distance of 2 km within the basin.

Radio-tagged birds were also flushed out of the grass or rushes and they were watched as they flew until they went out of sight. The distance flown by radio-tagged Snipes was estimated using a range finder for short distances (< 1 km) within the lake basin. The long distance movements of birds between the lake and the surrounding highlands were initially estimated by

measuring the shortest distance between the marking site and the recovery site on a large-scale map of the area. These long-distance flights of marked birds were later confirmed by use of GPS.

Assessment of habitat availability and use

The habitats available to foraging Snipes at Lake Ol Bolossat were identified from an official land-use map (Survey of Kenya: 1:50,000), and from ground surveys carried out during the study period. The habitats available for foraging were; lake marshes, stream marshes, pasture fields, cultivated areas and mud flats. The coverage of each habitat type was determined from a representative sample area of 720 hectares, which covered both the eastern and western shores of the lake. The area under each habitat was determined with a planometer (Wehde *et al.* 1980) and expressed as a percentage of the total sample area (White and Garrot 1990). The changes in the areas of each habitat type were determined during each year.

Habitat use by Snipes was determined from all locations where marked or unmarked Snipes were found in the study area, except those locations where Snipes nested or roosted at night. All daily locations were grouped into four time blocks, namely: early morning (06.01 to 09.00), late morning (09.01 to 12.00), early afternoon (12.01 to 15.00) and late afternoon (15.01 to 18.00). The number of locations in each time block was expressed as a percentage of the total locations in all habitats. Seasonal changes in habitat use were determined from the Snipes that were resident in the study area. Initial habitat use was determined from the proportional usage values of marked birds that exceeded proportional availability values. The proportions of usage and availability were then separately ranked in ascending order. The differences in the respective rankings between usage and availability were then compared by using the Friedman (χ^2) Test (Conover 1980; Zar 1996).

Assessment of environmental factors and measurement of habitat parameters

The environmental factors expected to influence initiation of breeding in African Snipes were availability of nest sites, rainfall, and fluctuations in lake water levels. Nesting habitat availability was determined from proportional cover (%) of tussock grass, and height (cm) of herbaceous vegetation. The cover of tussock grass at the breeding site was measured by using a 1-m² quadrat placed at 10 m intervals along a 200-m transect, which was perpendicular to the lake-edge. The height of natural vegetation was estimated by randomly selecting plants within the quadrat, irrespective of species, and measuring their height using a metre rule. Six transects were established along the declining gradient from the cultivated land to the lake edge, at Nduthi, Iria-ini and Githunguchu on the eastern shore and at Robert's Farm, Simba and Ewaso Narok on the western shore.

The factors expected to influence nesting density were competition for nest sites between individual Snipes and habitat characteristics. Competition between individuals, particularly breeding males was assessed from the

frequency of aerial displays and territorial conflicts. Habitat characteristics that were expected to influence nesting density were proportional coverage (%) of tall grass, short grass, marshes, cultivation and areas of bare ground. These habitat characteristics were assessed from extended transects established in the study sites.

Assessment of habitat factors influencing choice of nest sites

A large-scale map (1:10,000) of each sector was used to plot the distribution of various habitat types available to nesting African Snipes. Habitat types considered to be available were: lake-edge marsh, stream-edge marsh, tall wet grassland, short wet grassland and abandoned cultivation. The area of the site covered by each habitat type was calculated and expressed as a proportion of total available habitats. The habitat was recorded for each nest found at the egg stage. In order to determine whether African Snipes exhibited preferences for nesting in particular habitats, numbers of nests were compared with expected numbers for each habitat, which were estimated by multiplying the total number of nests recorded by the proportion of the study area covered by each habitat. To establish the factors that influenced nest placement several habitat variables were recorded at each nest at a randomly selected site within a radius of two metres from the active nest. The habitat variables recorded at active nests and at random sites were water depth, clump density, clump height, clump diameter, and height of adjacent vegetation. The measurements taken at the nest sites and random sites were compared and analysed by one-way ANOVA.

Results

Daily movements and foraging range size

African Snipes were active in the foraging areas for 800–830 minutes per day. They spent most of the daytime feeding, mainly in grassland areas, and moved to the lake marshes for roosting at night. Six African Snipes, comprising two adult males, two adult females and two juveniles were radio-tagged and their movements monitored in 1999 at the study site. The radio signals of one adult male and one juvenile were lost within two days of tagging. Their radios were, however, subsequently recovered and fixed on a new adult male and a new juvenile trapped at the same site as the previous individuals. The other four radio-tagged birds remained in the study area for periods of at least 30 to 40 days. Radio-tagged individuals moved an average distance of 600 m between feeding and roosting areas. One radio-tagged male, however, moved a maximum distance of 1,450 m from its feeding site on the eastern shore of the lake to the western shore. Adult males appeared to commute longer distances than adult females and juveniles (Table 1). The latter appeared to forage in the same areas.

A total of 41 diurnal locations were made over 40 days while 20 nocturnal locations were made over a period 13 nights. During daylight hours, the radio-tagged Snipes were active up to mid-morning, then rested with intermittent feeding until late afternoon when they

Table 1. The daily commuting distance (m) of radio-tagged Snipes from feeding sites (grassland) to roosting sites (marshes) in Lake Ol Bolossat in 1999. Data were derived from the number of direct flights of six birds observed over a period of 20–30 days.

Age / sex	N	Mean distance (m) \pm SD	Range (m)
Adult male	25	654.3 \pm 90.2	580 – 786
Adult female	18	573.0 \pm 83.6	526 – 681
Juvenile	14	567.5 \pm 58.9	497 – 667

Table 2. The foraging range size (ha) of marked African Snipes at Lake Ol Bolossat 1998–2000. Data were derived from locations of colour-marked and radio-tagged birds.

Age / sex	N	Mean range size (ha \pm SD)	Range (ha)
Adult male	20	54.2 \pm 7.3	42.3 – 67.4
Adult female	24	36.5 \pm 5.2	29.6 – 43.5
Juvenile	17	26.5 \pm 8.6	19.3 – 32.4

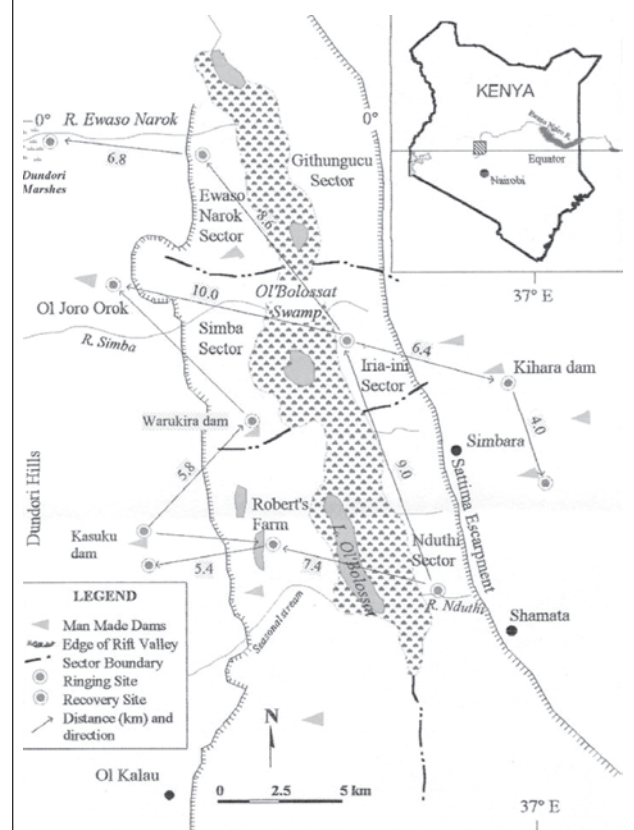
resumed intensive feeding activities. Signal reception at night was weak and continuously interrupted, which implied that the radio-tagged birds were feeding in the marshes as late as midnight when monitoring of birds stopped. The radio-tagged birds left the feeding areas or mudflats and grasslands between 10 and 20 minutes after sunset. Some birds spent five to ten minutes flying in circles before heading for the marshes where they spent the night. Mean minimum convex polygon range areas of African Snipes at Lake Ol Bolossat were 45 ha for adults and 26 ha for juveniles. The foraging range sizes varied significantly among adult males, adult females and juveniles (ANOVA $F = 18.66$, $df = 2,60$, $P < 0.05$). The adult males had significantly larger foraging ranges than females and juveniles. Adult females also had larger foraging range areas than independent juveniles (Table 2). Adult males frequently changed feeding sites during the day while females and juveniles appeared to feed and rest at one site for extended periods.

Local movement and site fidelity

African Snipes made fairly localised movements in the Lake Ol Bolossat basin and its environs (Figure 2). Of 217 locations of six radio-tagged birds recorded over a period of ten weeks, 82% were within 1,500 m of the tagging site. The majority of the rest of the locations were between 1,501 and 3,000 m, but the maximum distance traversed by one radio-tagged bird was 20.9 km over a period of 30 days. Eighty-six per cent of radio-locations were within the altitude range of 2,300–2,500 m. Nearly 61% of the locations were actually in the lake basin while 39% of the locations were in the surrounding highlands. Within the lake basin, African Snipes flew for a mean distance of 3.50 ± 0.31 km ($n = 13$) and a maximum distance of 6.4 km.

During this study, 126 African Snipes were permanently ringed at four study sites with aluminium rings. The average recovery rate of marked birds in the study area was 68%. Twenty-one (17%) were relocated or

Figure 2. Local movements of four radio-tagged Snipes.



recaptured at their ringing sites while the remaining 105 (83%) were found less than 40 km away. Thus, African Snipes tended to remain within the lake basin for most of the year. A comparison of 21 dry season and 18 wet season locations of marked birds located in Lake Ol Bolossat indicated that foraging ranges of Snipes expanded significantly during the dry season (Mann-Whitney $U = 92.6$, $P < 0.05$). This dry season range expansion was not significant among parenting birds.

Habitat availability

African Snipes of Lake Ol Bolossat foraged in five main habitat types: lake-edge marsh, stream-edge marsh, pasture fields, cultivated fields and mud flats. The proportional coverage of each habitat type changed during the study period. The changes in habitat areas were attributed to human activities as well as natural causes, such as changes in lake water level and soil deposition by flowing surface water. Pasture fields and lake-edge marsh covered 71.5% of the sample area in 1999. In 2000, however, the coverage of pasture fields, lake-edge and stream-edge marshes decreased due to reclamation for cultivation by local farmers (Table 3).

Stream-edge marsh and pasture fields suffered the greatest loss (proportional change 53% and 11% respectively) due to reclamation for cultivation. During the same year, the area under cultivation expanded by 120%. The area under cultivation increased steadily during the study period. As cultivated land expanded, more soil was transported by running water to the lake basin from the steep Sattima Escarpment, thereby expanding the

Table 3. The relative availability of different habitats used by African Snipes for foraging at Lake Ol Bolossat in 1999 and 2000. The proportion of the area comprised by each habitat was determined from a sample area of 720 ha. Gain/Loss is the percentage change between 1999 and 2000.

Habitat types	Year and % area available		
	1999	2000	Gain/Loss
Lake-edge marsh	37.2	34.0	-8.6
Stream-edge marsh	13.4	6.3	-53.0
Pasture fields	34.3	30.6	-10.8
Cultivated fields	10.7	23.5	+119.6
mud flats	4.4	5.6	+27.3

marginal wetlands, particularly mud flats. African Snipes moved to foraging sites in the cultivated areas as a result of loss of their preferred feeding sites in the grasslands and stream marshes.

Habitat use for foraging

African Snipe spent varying durations of daytime feeding in lake-edge marsh, stream edge, pasture fields, cultivated fields and mudflats. Fifty-three per cent of locations were in stream-edge marsh and 23% in pasture fields. The birds also spent a considerable part of the day feeding in isolated puddles and patches of livestock dung in the cattle enclosures. There was significant variation in the use of stream-edge marshes (Kruskal-Wallis test $\chi^2 = 15.03$, $df=4$, $P < 0.001$) and pasture fields (Kruskal-Wallis test $\chi^2 = 19.37$, $df=4$, $P < 0.05$) in relation to time of day. Both habitats were frequently used by livestock, especially in the mid-morning and mid-afternoon, and hence the birds avoided the habitats during those periods. There was no significant variation in the daily habitat use of all the other habitats.

Comparisons of habitat use by African Snipes in relation to habitat availability revealed that the birds used stream-edge marshes and cultivated fields more frequently than expected from their available proportions during the dry season (Table 4). Lake-edge marshes and pastures, which were relatively dry, were used significantly less than their available proportions. During the wet season, there was no significant preference for any habitat. However, the Snipes appeared to actively select wetter microhabitats, such as water edges, irrigation channels and temporary wetlands. There was a marked increase in the utilisation of exposed soil or mud flats whose availability increased with the advancement of the wet season. The use of pasture fields increased significantly because of the availability of shallow-water pools and wet soil during the wet season.

Habitat used for nesting

African Snipes nested in five habitat types: tall wet grassland (36%), stream-edge marsh (28%), lake-edge marsh (16%), short wet grassland (13%) and abandoned cultivation with regenerating herbs (7%). Nests were not randomly distributed in the five main habitats available (Table 5). Comparisons of nest distribution against random expectation indicated significant differences in the way nests were distributed in the five habitat categories ($\chi^2 = 84.3$, $df = 4$, $P < 0.001$). Stream-edge marsh, tall wet

Table 4. Dry and wet season habitat used for foraging by African Snipes at Lake Ol Bolossat in 1997–1998.

Habitat type	% habitat available	Dry-locations	% dry season	Wet-season locations	% wet season
Lake-edge marsh	34.2	17	21.0	15	18.8
Stream-edge marsh	12.9	29	35.8	24	30.0
Pasture fields	35.1	8	9.9	18	22.5
Cultivated field	13.5	21	25.9	14	17.5
Mudflats	4.4	6	7.4	9	11.3
Total	-	81	-	80	-

Table 5. Comparison of expected and observed use of different habitats for nest placement by African Snipes at Lake Ol Bolossat, Kenya in 1999 and 2000.

Habitat types	% area	Nests observed	Nests expected
Lake-edge marsh	35.3	23	50.4
Stream-edge marsh	15.0	40	21.4
Tall wet grassland	16.7	52	23.8
Short wet grassland	26.7	18	38.2
Abandoned cultivation	6.3	10	4.4

Data on percentage area were based on a breeding area of 210 ha.

grassland and abandoned cultivated land were used more than expected for nesting. In contrast, short grass and lake-edge marsh were used significantly less than expected from their availability in the study area. This pattern of nest distribution did not change significantly during the study period.

Generally, the characteristics of nests built in different habitats were similar. Nests constructed in marshes associated with edges of dams, lakes and streams, as well as those in wet grassland, were not significantly different with respect to water depth (ANOVA, $F = 2.79$, $df = 2,33$, $P > 0.05$), site elevation (ANOVA, $F = 2.93$, $df = 2,33$, $P > 0.05$) and vertical stem density (ANOVA, $F = 1.87$, $df = 2,33$, $P > 0.05$). Similarly, nest site characteristics did not differ significantly with respect to clump diameter, species diversity and height of surrounding vegetation. However, the location of the nests varied significantly with respect to the distance to the nearest actively cultivated fields (nest site, mean = 65.5 7.6 m; random location mean = 39.8 6.1 m) (ANOVA, $F = 6.98$, $df = 2,33$, $P < 0.01$). This result indicated that the breeding birds avoided nesting in sites close to human activities.

Discussion and conclusions

Daily foraging behaviour pattern

African Snipes in Lake Ol Bolossat spent most of the day feeding. The observed rapid fluctuations of signal reception from radio-tagged birds at dusk and dawn implied that some Snipes foraged at night close to the roosting sites in the marshes. Foraging activities were extended into the night for one to two hours before sunrise and after sunset. Studies of the foraging behaviour of other species of Snipes have shown that night-foraging is a common behaviour, especially in moonlight (Rouxel 2000).

Feeding activities were most intensive during the first and the last three hours of daylight. The observation that radio-tagged birds flew with other unmarked birds directly from the roosting site to the foraging site that they had used during the previous day implied that information about source of food was stored in the memory and could be transmitted to other individuals through behaviour. Ward and Zahavi (1973) showed that roosts of birds are important information centres for finding food.

African Snipes are intensive foragers that spent a long time feeding at one patch. They commuted for relatively short (< 1 km) distances between the diurnal foraging sites and nocturnal roosting sites and the majority of birds remained close to the site of tagging. Adult males, females and juveniles foraged in the same areas. However, the disappearance of one radio-tagged male and one juvenile, which were also colour-ringed, implied that some Snipes moved out of the study area for varying periods. Such short-term excursions of several days from a regular feeding site have been reported in Common Snipe in Northern Ireland (Veiga 1997).

The foraging-range sizes of African Snipes at Lake Ol Bolossat were relatively small (< 55 ha). The ranges of adult males were larger than those of females and juveniles, because adult males frequently changed feeding sites during the day while females and juveniles tended to feed and rest in the same site for extended periods. Adult male Snipes appeared to have a different food-finding strategy than that of adult females and immature birds. Age and nutritional requirements and risks of predation are likely to have influenced food-finding decisions of individual Snipes (Krebs and Kacelnik 1991). Pasture fields and lake marshes remained the largest foraging habitats of Snipes. The area of open grassland decreased by 11% due to conversion into cultivated lands. Cultivated land provided temporary food sites but the expansion of settlements reduced the nesting areas of the Snipes.

African Snipes spent most of the day foraging in stream-edge marshes, grasslands and mud flats. Other habitats were used less frequently. The use of stream-edge marshes and natural grasslands, however, varied significantly with the time of the day. The Snipes frequently foraged at stream edges and wet grassland habitats especially during the first three hours of daylight and the last three hours before sunset. These periods of high utilisation coincided with the periods when large numbers of livestock that grazed in the study area were absent. The two habitats were also rich in food resources for Snipes. The Snipes appeared to optimise foraging when disturbance or risks to predation are low (Hoodless *et al.* 2000).

Local movement and site fidelity

African Snipes moved locally within Lake Ol Bolossat Basin. The majority of radio-tagged birds were relocated within the lake basin and within a relatively short distance from the marking sites. However, sub-adult birds and juveniles appeared to fly outside the basin to the surrounding uplands. Studies of radio-tagged Common Snipes in Europe have shown that breeding Snipes make fairly localised movements.

African Snipes appeared to make seasonal altitudinal movements that related to rainfall pattern in East Africa. Evidence from this study showed that African Snipes exhibited altitudinal movements from the lake basin to the highlands. Some Snipes, especially adult birds, moved from the highland dams, ponds and marshes to the lake basin prior to the onset of breeding. A small proportion of the Snipes, however, remained and bred in the highland wetlands. Apparently the shift of Snipes from the highlands to the lake basin could be attributed to breeding and roosting habitat availability in the lake basin.

Immature birds dispersed from the breeding sites in the lake basin to the highland wetlands for feeding. This movement of Snipes could be attributed to dispersal from a high-density area in the lake basin to the low-density areas in the upland wetlands. However, the upland dams, marshes and ponds seemed to offer a narrow range of foraging opportunities for Snipes compared to the availability of rich and stable food resources in the lake basin. The lake basin had natural foraging habitats as well as man-made habitats, such as irrigated fields, which were suitable for foraging by Snipes during the dry season.

It is important to note that most of the birds were resident in Lake Ol Bolossat basin. However, there was a strong tendency for more African Snipes to disperse westwards than eastwards. This is probably because the steep Rift Valley escarpment on the eastern edge of the lake acted as a physical barrier to movement of Snipes. Furthermore, there were more wetlands on the western than on the eastern highlands (Gichuki 2002). Furthermore, African Snipes showed marked site fidelity with some ringed adults being recaptured in the original lake-edge ringing site after almost two years. While adults were recaptured four to seven times during the study period, immature birds were recaptured less frequently, indicating that they moved out of the study area for extended periods. In fact, some ringed juveniles were recaptured as breeding Snipes nine months later in the same areas where they had been ringed, clearly emphasising the attachments that African Snipes have with good quality habitats.

Distribution of nests and nest-site selection

The distribution of bird nests in an area can be a good indicator of local variations in habitat quality. African Snipe nests were distributed in patches within Lake Ol Bolossat Basin. Nests were concentrated in permanently wet sites, especially at the estuaries of streams and springs draining into the lake. Most of these wetlands were found on the eastern margins of the lake, where water supply was constant and wetlands permanent. The western shore of the lake had smaller and less continuous wetlands than the eastern shore. Grazing of the vegetation by thousands of cattle, sheep and donkeys reduced anti-predator cover of Snipe nests. Grazing animals also caused damage to nests and eggs of Snipes.

More Snipes preferred nest sites in tall wet grassland, stream-edge marshes and lake-edge marshes than elsewhere. Adult birds and young birds breeding in the area for the first time probably used low quality habitats as the residents occupied the best sites. Nests placed in short grassland and abandoned cultivation were vulnerable

to predation. Tall trees would also hinder aerial courtship displays and were likely to harbour avian predators.

African Snipes built their nests selectively with respect to water depth, site elevation above the ground, and density of vertical plant stems. Breeding birds preferred to build nests on sites with moist soil or shallow water as well as on elevated sites with dense vegetation. In Lake Ol Bolossat, tussock-grass clumps were preferred, perhaps because they were dense, well elevated above ground, and were separated by open spaces with moist soil or shallow water. These habitats provided protective cover and feeding sites for parenting adults and their young. Furthermore, Snipes nesting in different habitats preferred sites with similar characteristics, and all avoided nesting close to tall trees and sites that were frequently used by people or livestock (Davies and Houston 1984; Curie and Burke 2000).

Impacts of human and livestock activities

This study has shown that African Snipes were resident in Lake Ol Bolossat. The birds spent most of the day feeding and foraging ranges were relatively small and fluctuated in size, increasing during the dry season and decreasing during the wet season. Evidence from more than a hundred ringed birds and a few radio-tagged birds indicated that African Snipes made fairly localised movements and were faithful to safe and food-rich sites. The birds also showed significant habitat preferences for nest site selection and nest placement. These findings have implications when considering the impact of human activities on African Snipe.

African inland wetlands constitute an important natural resource. They enhance diverse and rich production in fisheries. Fresh water is a critical resource throughout the continent and wetlands filter and store water, which recharges underground aquifers, thereby making clean water available to people, livestock and wildlife. Africa's wetlands are also valuable grazing areas for livestock, especially during the dry periods. In fact, the African river floodplains and lakes with marginal wetlands are responsible for the diversity of wildlife in the continent (Howard 1992). Birds constitute the most important and the most conspicuous component of wetland biodiversity. These values attract humans into wetlands.

Lake Ol Bolossat basin and its biodiversity face threats from natural processes and human activities, just as other wetlands in Africa. The El Nino phenomenon and spells of prolonged drought that affected the continent in between 1970s and 1990s have been the major natural threats. Accumulation of silt and organic matter in the basin, however, has progressive negative effects on water volume and its retention. These natural processes have long term effects on the capacity of Lake Ol Bolossat to continue supporting its 185 species of birds, including resident African Snipe and the migrant palearctic Snipes. Increasing aridity is likely to change wetland plant communities, water supply and availability of food and nest sites for sites.

The main anthropogenic threat to African Snipes in Lake Ol Bolossat was drainage of wetlands for agriculture.

Reclaimed wetlands produce new soil, which permits enhanced food production. The presence of water for irrigation also sustains agriculture throughout the year. Drainage of wetlands removes permanent feeding and nesting sites for Snipes. Biomass harvesting for farm use also threatens the nesting sites of Snipes by removing anti-predator cover for foraging and breeding birds. Burning of marshes and grasslands to renew pasture or create new farmland, especially during the dry period destroys nests and kills nestlings as well as removing anti-predator cover for all the ground nesting birds. Livestock grazing has similar but less severe effects than fire on African Snipes. Grazing animals trample the nests, eggs and chicks, and crop the grass, thereby exposing the foraging birds to predators. The collection of Snipe eggs and trapping of incubating birds by local villagers is another growing threat which has the potential to eliminate Snipes from Lake Ol Bolossat basin and other parts of central Kenya.

African Snipes have shown limited ability to adapt to changing habitat and food conditions in Lake Ol Bolossat. Few birds that nested in overgrazed grassland or in abandoned cultivation reared young successfully (Gichuki 2002). Furthermore, Snipes foraging in cultivated areas mainly did so at dusk or at night when workers were away from the fields. This study has shown that conservation of Snipes and wetlands in Africa is necessary. Because of the social and economic interactions between people and wetlands, it is absolutely essential to empower communities to conserve wetlands and birds in their villages. While utilisation of wetland resources, including birds will continue in Africa, it is necessary to develop sustainable mechanisms to ensure that natural resources regenerate. The New Partnership for Africa's Development (NEPAD) recognises wise use of wetlands and their conservation as a priority area. Responsible use of wetlands and their rich biological diversity can help Africa to meet the Global Millennium Development Goals by ensuring a stable supply of clean water, facilitating sanitation, enhancing food security, conserving biological diversity and reducing poverty in the continent.

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Breeding biology and habitat selection of the Common and Great Snipe in Belarus

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Data on the breeding biology and habitat selection of the Common Snipe (*Gallinago gallinago*) and Great Snipe (*Gallinago media*) in Belarus were collected under the framework of the OMPO (Migratory Birds of Western Palearctic) International Program "Snipes" during 2000–2001. This was the first detailed study of Snipe species in Belarus. Some additional information was gathered as part of the bird monitoring program of the Institute of Zoology of Belarusian National Academy of Sciences during 2002–2003. Data on the displaying activity, arrival and breeding phenology, main laying period, breeding success and predation rate for the Common and Great Snipes were collected. More than 100 Great Snipes and 40 Common Snipes were caught during the reproduction period in order to obtain morphometric parameters of breeding birds.

Extensive counts on the breeding grounds showed that open transitional mires and fens were the optimal breeding habitats for the Common Snipe in Belarus. Common Snipe densities averaged 18.3 and 21.0 pairs per 100 ha of transitional mires and fens respectively. Vegetation structure and soil moisture were the main factors influencing the distribution of breeding birds. The Common Snipe prefers habitats with high soil moisture and vegetation taller than 20 cm but it avoids very tall, dense grass.

Most leks of Great Snipe (71%) were found in floodplain meadows and 18% were found in fen mires. Only a few leks were located in transitional mires (6%) or in areas that had been drained (6%). To study the habitat requirements I recorded seven different parameters, including moisture, soil penetrability, earthworm density and vegetation height, at feeding, lek and nest sites. The Great Snipe selects sites with moderate moisture and high biomasses of earthworms.

Introduction

The Common Snipe (*Gallinago gallinago*) is one of the most numerous breeding species of waders in Belarus. However, there have been very few recent studies of Common Snipe numbers and they were conducted in a limited number of localities (Duchits 1972, Bishnev 1989). The Great Snipe (*Gallinago media*) was historically considered as the most common breeding species in all regions of Belarus where suitable habitats occurred. Moreover, the Great Snipe was one of the main species hunted during the spring and autumn hunting periods (Fedyushin and Dolbik 1967). These authors wrote that during one autumn day a hunter was able to shoot up to 40 birds. However, later studies suggested that Great Snipe numbers have declined, and the species remains common only in few places (Nikiforov *et al.* 1997). The main aims of this study were (1) to estimate the size and distribution of the breeding population of Snipes in Belarus, (2) to document key breeding sites for the Common and Great Snipes in Belarus, (3) to evaluate the breeding density of both species in different types of habitats, (4) to collect information on breeding biology. The study was conducted under the framework of the International Program OMPO during 2000–2001. Additional information was collected during 2002–2003 as a part of the Bird Monitoring Program of the Institute of Zoology, National Academy of Sciences of Belarus.

Study areas

I carried out studies during 2000–2003 in the majority of the administrative districts of Belarus (Figure 1). Over 118 wetlands of different vegetation types were selected to investigate the numbers, distribution and densities of the

Common Snipe and Great Snipe. The size of wetlands ranged from 100 to 19,000 ha. The total area of the surveyed wetlands was more than 70,000 ha. The relationship between Snipe abundance and habitat variables was studied at selected sites totalling about 5,000 ha. Habitat data relating to feeding sites of the Great Snipe were collected at two sites between 15 May and 10 June. One plot was placed on rich fen Dikoe (vicinity of Belovezskaya Puscha, 52°57' N 24°10' E), the other was located on the floodplain meadows of the Pripiat River (Turov vicinity, 52°05' N, 27°45' E).

Figure 1. Administrative districts of Belarus covered by surveys during 2000–2003 (grey).



Methods

Census methods and studies of breeding biology

To define the breeding density of Common Snipe, drumming males were counted on transects within three hours of dawn or dusk during three periods: 15–30 April, 10–25 May and 5–20 June. To determine the breeding density in habitats with small numbers of birds I used the method of territory mapping (Bibby *et al.* 1992). Great Snipes were counted on the lekking arenas during late evening. Displaying males were counted from a distance of 10–20 m. To estimate total numbers, birds flushed were also counted. The combined search method described by Kålås (2000) and Kuresoo and Luigujõe (2000) was used to find lekking arenas. This method included daytime surveys in optimal feeding habitats, as the lekking arenas are often situated near the feeding area, in combination with the late evening counts of displaying males. During the study 60 Great Snipe leks, including 10 previously known, were investigated.

To analyse the timing of breeding I used the ‘main laying period’ (MLP) concept as described by Väisänen (1977), whereby the MLP of a population is the shortest period during which about 80% of the clutches are started. I determined the MLP from a histogram with class intervals of five days. About 10% of clutches were excluded at each end of the distribution, and the period was made accurate to the nearest half-class.

Capture, measurements and sex determination

Breeding adult Snipes were caught using mist-nets and nest-traps. Breeding Great Snipes were caught by placing 12 m mist-nets around lekking arena and birds were then flushed into them by several people dragging a rope. I measured the length of the white area on the tail of Great Snipe to the nearest 0.1 mm with callipers (the length of the continuous white part of the outermost tail feather from the tip to the first dark spot, Höglund *et al.* 1990). Common Snipe were sexed using morphometric criteria as suggested by Devort *et al.* (1986) and Czajkowski (2002). To establish the sex of Great Snipes I also employed morphometric criteria (Höglund *et al.* 1990). The males have a smaller head (total head length <99 mm, compared to female >99 mm, overlap in the range 98–99 mm) and lower body mass (during the breeding period males weight seldom >160g). The tips of their wings are also very worn and broken during the period of lekking activity.

Measurements of habitat parameters

Seven habitat variables were determined during the period 15 May–10 June on several breeding plots and feeding sites. I followed the methodology of Bibby *et al.* (1992) and Løfaldli *et al.* (1992) and considered the following parameters:

a) Vegetation variables included:

1. the height of herbs and tussocks within 5 cm of the sampling point;
2. the horizontal cover (detectability) determined by placing a Snipe-sized decoy at the flushing site and

measuring the distance N, E, S and W to the point where it was no longer visible (mean of four measurements); and

3. the vegetation density, determined using a chequer board with 10x10 cm subdivisions to produce an index of 0–10...100 that was recorded at a distance of 5 m.

b) Soil variables included:

4. moisture estimated on a scale from 1 (dry) to 5 (surface covered >1 cm water); and
5. soil penetrability, measured (in cm) by dropping a pointed iron pin (8 mm diameter and 180 g) from 1.5 m height (the mean of three drops was used).

c) Earthworm biomass and density

6. biomass was the total wet weight (g/m²) of worms collected in a 15x15x8 cm (deep) soil sample.
7. density was the number of worms in a soil sample expressed as individuals per m². To determine the density of earthworms, 36 soil samples from the exact flushing sites of Great Snipes and 16 similar samples from random sites were collected in two types of habitats.

Results

Common Snipe

Breeding density and habitat selection

In the majority of surveyed habitat types, the number of Common Snipes recorded in April was two to three times higher than in May. The highest breeding densities of Common Snipe between mid-May and mid-June were recorded in the open fens and transitional mires, where maximum densities of 30–40 pairs/100 ha were recorded (Table 1). These types of habitats were dominated by sedge-hypnum communities (main species *Carex acuta*, *C. omskiana*, *C. rostrata*, *C. diandra* and others) and mire forbs (*Menyanthes trifoliata*, *Comarum palustre*, *Calamagrostis neglecta* and others). Notably, Common Snipe avoided the large tracts of rush *Phragmites communis*, which was common in many mire complexes. Only low densities bred on the open bogs where they occupied transitional habitats at the edges of raised bogs. My observations suggest that Common Snipe avoided drained wetlands. Preliminary analysis indicated that the breeding density was related to the hydrological conditions and the vegetation structure of the habitats (Mongin 2002). Stable hydrological conditions in the wetlands correlated with stable numbers of Common

Table 1. Breeding densities of Common Snipe during mid-May to mid-June in relation to habitat.

Habitat types	Mean density (pairs/100 ha)	± SD	Range of density (pairs/100 ha)	N
Open bogs (oligotrophic)	0.07	0.04	0.08–0.1	5
Open transition mires (mesotrophic)	18.3	14.00	2.6–37.6	12
Open fens (eutrophic)	21.0	13.07	2.5–47.1	17
Floodplain meadows	5.3	3.09	1.5–11.9	14

Snipe. Very hot weather in May and June 2000–2001 had a pronounced negative impact on the hydrological conditions of the majority of the habitats studied. The water level of some fens dropped by 25–30 cm. This resulted in a two to five-fold decrease in the densities of breeding birds in the majority of the wetlands during the breeding season. Snipes essentially disappeared from the habitats, which were overgrown by tall, dense grass by late May–early June.

There was a statistically significant increase in mean breeding density in more humid habitats (ANOVA: $F_{3,21}=9.14$, $P<0.001$) (Figure 2). Common Snipe density was positively correlated with soil moisture (Spearman $r_s=0.80$, $P<0.0001$). Statistically significant differences in breeding density (ANOVA: $F_{2,17}=4.42$; $P<0.05$) were also found in relation to the vegetation height (Figure 3). Thus, my analysis indicates that the Common Snipe prefers habitats with high soil moisture and vegetation in the height range 20–40 cm.

Breeding phenology and success

The Common Snipe is one of the earliest breeders among the waders in Belarus. The first birds usually arrive at the end of March or early April. The mean date of arrival in southern Belarus (vicinities of Turov, 52°05' N, 27°45' E) during a six-year study (1995–2000) was 25 March. The earliest observation was made on 12 March 2000; the latest record was on 6 April 1996. According to the database of the Laboratory of Ornithology, Institute of Zoology, Common Snipe arrive later in the more northern regions of Belarus. The mean date of Common Snipe arrival at the Berezinski biosphere reserve (54°43' N, 28°19' E) during 1985–1989 was 1 April. The earliest date of arrival was 20 March 1989 and the latest date was 5 April 1986. In the vicinity of Surazh (Vitebsk region, 55°24' N, 30°44' E), the mean date of Common Snipe arrival was 3 April (11 years of observation, 1974–1984). The earliest record of arrival was 20 March 1989 and the latest was 5 April 1986. Analysis shows that the mean date of arrival

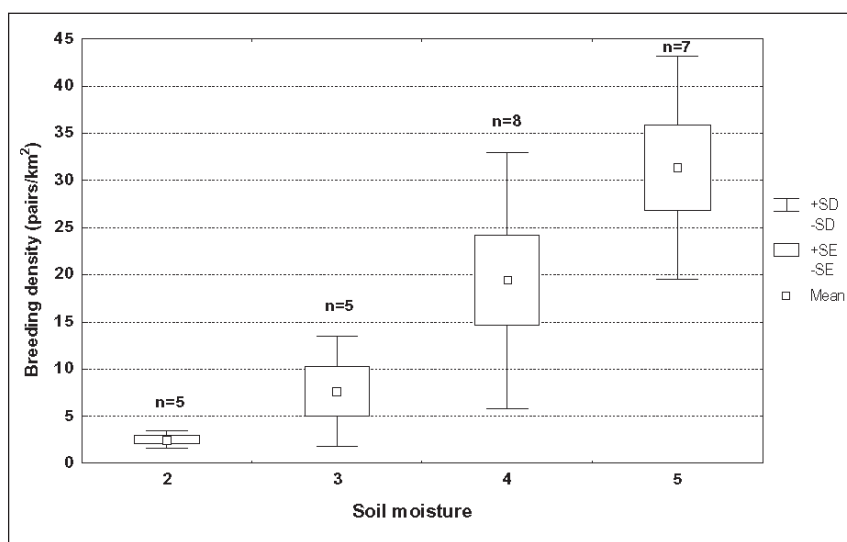


Figure 2. Mean breeding density of Common Snipe in relation to soil moisture.

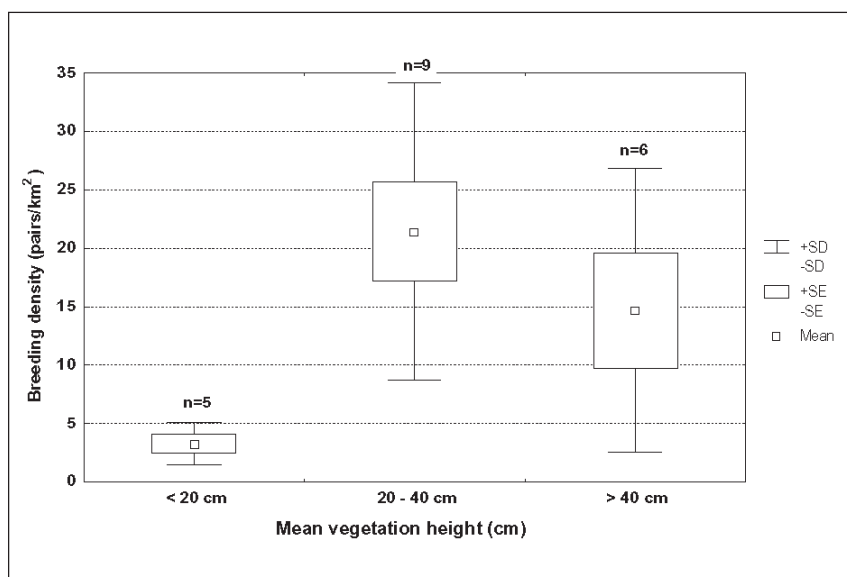


Figure 3. Mean breeding density of Common Snipe in relation to vegetation height.

differed between southern and northern parts of Belarus: (ANOVA, $F_{2,19}=4.11$ $P<0.05$, Newman-Keuls test $P<0.05$).

The first clutches appeared in mid-April. The earliest recorded first-egg date was 16 April. The mean first-egg date was 10 May ± 18 days. The main laying period (MLP) lasted 47.5 days (Figure 4). I estimated the average success of nesting based on the observations of 21 nests. Thirty-eight per cent of all nests failed, the reasons for nest failure were as follows: 37.5% of unsuccessful nests were crushed by livestock, 25% were destroyed by corvids, 12.5% were lost due to disturbance caused by human activities and the cause of loss was uncertain for 25%.

Great Snipe

Habitat selection

Floodplain meadows were the most intensively used breeding habitats of the Great Snipe (Table 2). About 71% of the 55 leks found during this study were located in this

Table 2. Habitat use of the Great Snipe according to the distribution of lekking arenas and all observations during the breeding season.

Habitat	Leks		All observations (breeding time)	
	Number	%	Number	%
Floodplain meadows	39	70.9	90	70.9
Fens	10	18.2	26	20.5
Transitional mires	3	5.5	6	4.7
Meliorated lands, polders	3	5.5	5	3.9
Total	55		127	

type of habitat. Ten leks (18.2%) were found in fen mires. Only a few leks were located in the transitional (mesotrophic) mires (5.5%) and in the drained areas (5.5%). The drained lands used were undergoing the process of secondary swamping, or were temporary inundated by recent floodwater. In the majority of cases, leks, feeding grounds, and nesting sites were located in close proximity to each other. Mean values for environmental parameters for each type of site are shown in the Table 3. Statistically significant differences were found for two variables. Horizontal cover was higher at the feeding grounds than at nest sites ($t=2.51$ $P<0.05$). Vegetation height differed between leks, feeding grounds and nesting sites (ANOVA, $F_{2,53}=19.65$ $P<0.001$). Vegetation height was higher at the feeding grounds than both the nesting sites and leks (Tukey's test for unequal N, $P<0.001$).

Feeding grounds were typically located close to the lekking arenas, but often in wetter areas in the floodplain meadows and on the drier patches in the fen mires. The birds tended to feed in areas with higher average biomass and density of earthworms than randomly selected sites (Table 4), but the difference was not statistically significant (2-way ANOVA: habitats (meadows/fens) $F_{1,48}=0.47$ $P=0.49$; sites (feeding/random) $F_{1,48}=2.95$ $P=0.09$).

Breeding phenology and success

The Great Snipe arrives later than the Common Snipe. The first birds were observed in April (between 4 and 28 April). Lekking males were recorded from mid-April to the end of June. First clutches of the Great Snipe were recorded during the last ten days of April, the earliest first-egg date being 24 April. Fresh unincubated clutches were

Table 3. Mean habitat variables at feeding (Dikoe fen and floodplain meadows of the Pripyat River), nesting and lek sites of the Great Snipe.

	Vegetation height (cm)		Height of tussocks (cm)		Vegetation density		Horizontal cover (m)		Soil penetrability (cm)		Moisture		N
	Mean	\pm SD	Mean	\pm SD	Mean	\pm SD	Mean	\pm SD	Mean	\pm SD	Mean	\pm SD	
Feeding sites:													
A. Dikoe fen	35.0	8.37	19.7	8.98	77.3	10.33	4.9	0.96	12.3	2.29	3.3	0.52	6
B. Floodplain meadows	39.2	14.30	0.8	3.24	55.3	30.93	13.1	7.32	6.7	1.29	2.7	0.61	30
Nest sites	20.1	11.04	3.8	6.50	78.3	20.00	5.4	2.25	-	-	3.2	1.30	9
Lek sites	15.5	6.25	3.0	5.37	55.0	33.76	-	-	-	-	3.5	1.13	11

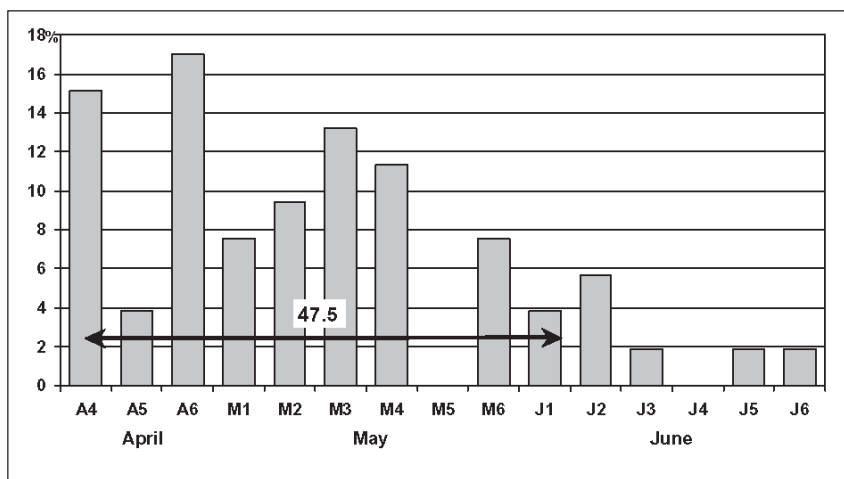


Figure 4. Breeding phenology (first-egg date) and the main laying period (MLP) of the Common Snipe in Belarus ($n=53$). The black horizontal line on the histogram shows the length of MLP to the nearest half-class. Data are grouped to the five-day periods.

found until 20 June. The mean first-egg date was 12 May+14 days and there is no significant difference between the mean first-egg dates of Common Snipe and Great Snipe ($t=0.78$ $P=0.44$). The main laying period of the Great Snipe (MLP) lasts about 35 days (Figure 5). Data on predation rate were collected in the floodplain meadows. 70% of a small sample of nests ($n=9$) failed. Clutches were destroyed by grazing cattle (75%) and corvids (25%). These meadows had a very high cattle grazing rate (up to 30–50 cows per 100 hectares) and the breeding habitats were trampled down. The mean grass height was 5–8 cm in floodplain meadows during mid-May.

Table 4. Earthworm biomass and density in feeding sites of the Great Snipe and random sites of two types of habitats.

Feeding sites:	Earthworm biomass (g/m ²)		Earthworm density (number/m ²)		N
	Mean	±SD	Mean	±SD	
A. Dikoe fen	14.1	10.95	81.5	33.46	6
B. Floodplain meadows	32.5	47.24	125.9	145.35	30
Random sites:					
A. Dikoe fen	12.2	28.86	29.6	53.82	6
B. Floodplain meadows	7.8	15.26	40.0	57.19	10

Morphometric measurements and weight

It is interesting to note that the mean length of white on the tail of the Belarusian Great Snipes was closer to the Estonian population than to Norwegian birds (Kålås *et al.* 1997a). These authors reported that the white spot on the tail showed a higher divergence between Norwegian and Estonian populations compared to other morphometric measurements. I found that males of the Great Snipe changed weight during the breeding period although differences were not statistically significant ($F_{4,80}=1.11$, $P=0.36$, Figure 6). The lowest body mass of males coincided with the mean first-egg date (14 May).

Discussion

Breeding density and habitat selection

The highest densities of Common Snipe occurred in April rather than May, probably as a result of display activity by migrating males which breed in more northern and eastern grounds. This has been reported by Mal'chevskiy and Pukinskiy (1983) for the Leningrad region of Russia. My study found that fens and transitional mires are the optimal breeding habitats for the Common Snipe. Similar results have been described by other authors (Švažas *et*

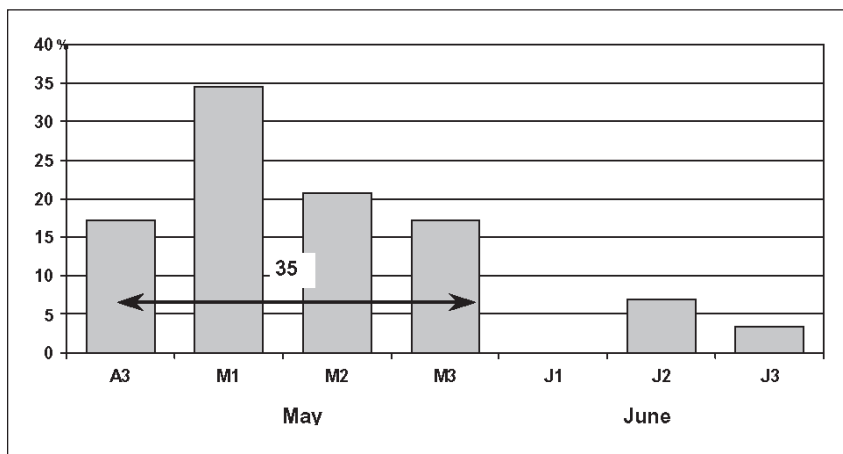


Figure 5. Breeding phenology (first-egg date) and the main laying period (MLP) of the Great Snipe in Belarus ($n=29$). The black horizontal line on the histogram shows the length of MLP to the nearest half-class. Data are grouped to the ten-day periods.

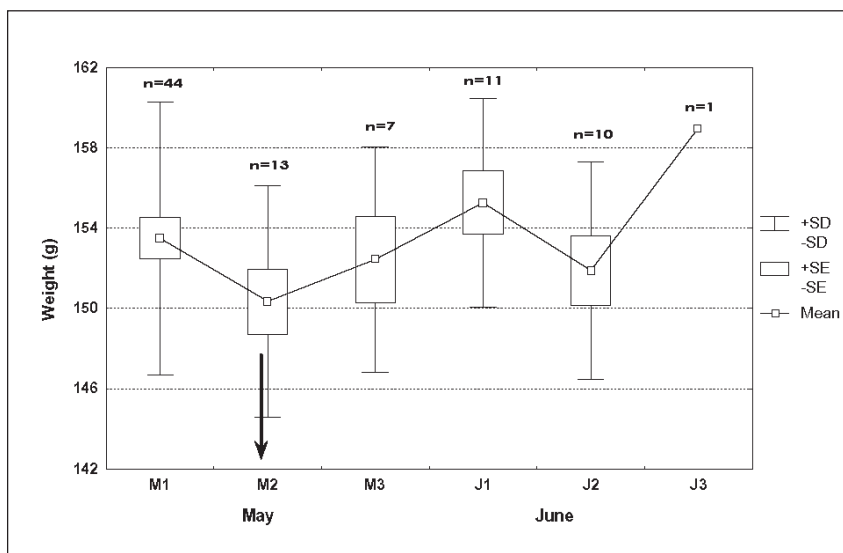


Figure 6. Temporal change in the weight of male Great Snipe during the breeding period. The arrow indicates the mean first-egg date.

al. 2001, Grishanov and Yarovikova 2002). The Common Snipe prefers habitats with high soil moisture. The dominant role of the hydrological regime for breeding density has also been shown in the work of Grishanov and Yarovikova (2002). It is likely that this factor is connected with availability of earthworms, the main prey for the Common Snipe. Hoodless *et al.* (2000) described the influence of the same habitat characteristics on the density of wintering Snipes and explained it by availability of invertebrates for feeding and by the better cover for resting in tall vegetation. Another important parameter is the vegetation height. It seems that the Common Snipe needs vegetation taller than 20 cm but that it avoids very tall, dense grass. Very tall and dense vegetation probably prevents the detection of, and escape from, potential predators and may hinder the movement and feeding of chicks.

Unlike the Common Snipe, the Great Snipe is more numerous in floodplain meadows and also occupies open fens. Other authors have reported similar findings for nearby geographical regions (Kuresoo and Luigujõe 2000, Kuresoo *et al.* 2001, Aunins 2001, Švažas *et al.* 2001). Great Snipe chose habitats according to certain parameters that were probably related to the abundance of earthworms. Earthworm biomass correlates well with soil moisture and penetrability (Løfaldli *et al.* 1992). Penetrability and earthworm biomass in fen mires in this study were very similar to Norwegian data for this habitat type (Løfaldli *et al.* 1992). The habitat characteristics of feeding sites in floodplain meadows in Belarus were similar to corresponding data for floodplain meadows in Estonia and Latvia (Kuresoo *et al.* 2001, Aunins 2000). As in these latter countries, the Great Snipes selected the sites with moderate moisture where soil penetrability was higher than the average for the whole meadow. Thus, as concluded by others (Løfaldli *et al.* 1992, Kålås *et al.* 1997b) the Great Snipe is a food and habitat specialist that occupies the habitats with high biomasses of earthworms.

Breeding phenology and success

Common Snipe arrive several days earlier in the southern part of Belarus than in the north, probably as a result of isothermal differences in March (1–2°C difference). The MLP is somewhat longer than reported for the Snipe populations in England and the Netherlands (Väisänen 1977). A wide range of egg-laying dates may indicate that some birds lay two clutches in a season. For example, the Ringed Plover (*Charadrius hiaticula*) has an MLP of 55 days and lays two clutches during the breeding season in Belarus (Pinchuk *et al.* 2002). Drumming by male Common Snipe in the floodplain meadows of the Pripyat River was recorded as late as 18 July 2002. Mal'chevskiy and Pukinskiy (1983) also mention late displaying birds recorded up to mid-July in several seasons (Leningrad region, Russia). The same data may also be explained by a hypothesis on the coexistence of two sub-populations of the Common Snipe inhabiting different groups of habitats in the eastern Baltic region (Švažas *et al.* 2001). This hypothesis may also explain an extremely protracted breeding period and significant changes of the breeding densities in different types of habitats. According to Švažas *et al.* (2001), the birds from the first group nest only before the beginning of June in the areas with

unstable hydrological conditions or overgrown with tall grass, while the birds from the second group occupy habitats with stable conditions and short grass during the entire breeding period and lay eggs throughout the breeding period, even in early July. The existence of different breeding sub-populations of the Common Snipe inhabiting various types of habitats has been confirmed by genetic analysis (Paulauskas and Švažas 2001).

The Great Snipe arrives later than the Common Snipe, but the peak of egg-laying in this study occurred at the same time. Its MLP is shorter than that of the Common Snipe but still constitutes a longer period than the MLP recorded for the northernmost species of waders (Väisänen 1977). The breeding success of Common Snipe was similar to the figures reported by other authors (Glutz von Blotzheim *et al.* 1977, Mason and Macdonald 1976, Green 1988 in Švažas *et al.* 2001, Grishanov and Yarovikova 2002). The rate of Great Snipe nest loss was high relative to my data for the Common Snipe (38%). I explain such a high nest loss by peculiarities of the places where the counts were carried out. Samples of nests for both species were small and further work is required to properly assess breeding success in Belarus.

Morphometric measurements and weight

Kålås *et al.* (1997a) suggested that morphometric divergence between Estonian and Norwegian Great Snipes may have been brought about by selection and/or stochastic processes (genetic drift, founder effects) as a result of the fragmentation of populations. Because of a high return rate to breeding sites for Great Snipe, the exchange of genes between the Estonian and Scandinavian populations has probably been lower than the Belarusian and Estonian ones. Great Snipe males expose their tails frequently during display and more white on the tails in the Estonian population may be a consequence of sexual selection under different natural conditions.

Changes in weight during the breeding season may be related to maximum lekking activity in males around the time of egg-laying. According to Norwegian researchers, Great Snipe males may lose 5% of their body mass during four–five hours of nocturnal display on the lek (Kålås 2000).

Conclusions

My study suggests that there is an overlap in habitat use between the Common Snipe and Great Snipe. However, as originally suggested by Løfaldli *et al.* (1992), the Common Snipe utilises wetter habitats. The Great Snipe prefers floodplain meadows and the drier parts of fen mires, while the Common Snipe occupies rich fens and transitional mires, which is where I registered the maximal breeding density. These species have many similarities and utilise similar prey (Kozlova 1962, Løfaldli *et al.* 1992, Rouxel 2000). In some circumstances they might compete for food resources. It is interesting to note that ratios of weight and bill size in Common and Great Snipes equal 1.5 and 1.1 respectively. Giller (1984) has suggested that such a difference in the ratios for similar species may be the result of the competition between species.

Acknowledgments

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Display activity and breeding biology of Jack Snipe in the Bolshezemelskaya tundra

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Display activity and breeding biology of Jack Snipe were studied in the Bolshezemelskaya Tundra (Vorkuta District) in 2001–2002. The main objective of the study was the improvement of a census method applied during the breeding period. The study area was situated in the east of the Bolshezemelskaya Tundra, in the southern sub-area of the tundra zone.

Display and song activities of males were estimated by a special index based on the number of songs per 30 minutes. Display activity was estimated practically every day for 4–24 hours both by day and at night. It was found that weather is one of the significant factors that may influence the display activity of the Jack Snipe. Strong wind and heavy precipitation as well as low temperature caused their display activity to stop. The highest level of display activity was observed on warm evenings. The registration of this activity has shown that late afternoon and evening is the best time for Jack Snipe counting. Males display most actively between 15.30 and 20.30 h local time. The most active displays lasted from 10 June until about 25 June. Displaying ended in the middle of July.

A comparison of the special index and minimal Jack Snipe numbers calculated on the basis of the number of nests found and the number of displaying males in the study plot has shown that the index is related to bird numbers and density. A special index value of more than nine, recorded at the best time to count them corresponds to at least two pairs/km² of Jack Snipes.

Jack Snipes arrive in the tundra in the beginning of June. Two weeks later laying begins and lasts until the beginning of July including replacement clutches. Seven nests of Jack Snipe were found. All nests were located in the sedge mires within composite peat bogs. Replacement of the clutch after destruction of the first one was proved by ringing. The incubation period lasted at least 25 days for one clutch and 30 days + 8–9 hours for the second clutch. Such a long incubation period was likely due to unfavourable weather conditions during the summer of 2002. When incubation started with the laying of the last egg, only females were found to incubate the clutch. Single birds cared for broods in all cases. Some characteristics of the display flight are discussed.

Introduction

The biology of the Jack Snipe still remains poorly studied. Even the duration of the incubation period is not exactly known and there is no definite knowledge about its relation within a family group, the bonds and mating system (Cramp and Simmons 1983).

The current state of its breeding population and entire numbers are unknown as well. This is mainly because of its secret behaviour at every stage of its life cycle but also because the main breeding areas of the Jack Snipe are difficult to access. Jack Snipes widely disperse during migration and in their wintering grounds, they do not gather in large flocks. Therefore, it is very difficult to count these waders correctly and estimate their total numbers.

The main objective of our study was the improvement of a census method applied during the breeding period. In accordance with this final aim the following objectives were pursued:

- to find a study area of high densities of Jack Snipes
- to count Jack Snipes by different methods
- to estimate their numbers.

Study area

The vicinity of the village of Sovetskyi in the Vorkuta District (Komi Republic) was chosen as a study area. The territory is situated in the eastern part of the

Bolshezemelskaya tundra within 67°15'–67°30' N, 64°25'–64°35' E in the tundra zone (Figure 1).

In general, the landscape of the study area is slightly hilly. Large territories of flat, composite peat-bogs are surrounded by a hilly watershed. Shrub tundras prevail on watersheds, everywhere. In these types of tundras, dwarf birch (*Betula nana*) and some willow species, e.g. downy willow (*Salix lapponum*), woolly willow (*Salix lanata*) and *Salix glauca* dominate. Shrubs may reach 75–80 cm in height.

There are many small lakes and ponds within the peat-bog systems. Some lakes have been overgrown by sedges and cotton-grasses a long time ago, and have become fen mires. There are small streams, that belong to the Usa and Vorkuta river basins. They start within the peat-bog systems.

The study plot was occupied by a large and composite peat-bog system that is typical for the region. It was outlined by watersheds in the south and west, the road in the north and north-east and the streamhead in the east and south-east. Big hills covered with dwarf birch, Labrador tea (*Ledum palustre*) and low willow shrubs are located in the centre of the study plot. The greatest part of the study plot (approximately 50–60%) was occupied by extensive palsas mires with up to 1.5 metre high-frost peat mounds or “palsas” covered by low shrubs of Labrador tea (*Ledum decumbens*), northern bilberry (*Vaccinium uliginosum*), cowberry (*Vaccinium vitis-idaea*), cloudberry (*Rubus chaememorus*), mosses and lichens. Between these peat palsas, flat swamp mires are located

overgrown by dense sedges (*Carex stans*), cotton-grasses (*Eriophorum angustifolium*, *E. russeolum*, *E. medium*), bog moss (*Sphagnum* spp.) and some other moss species (e.g. *Calliergon sarmentosum*, *Tomenthypnum nitens*). There are dense willow bushes (*Salix lanata*, *S. phylicifolia*, *S. lapponum*) of up to 2.5 metres high along the creeks and between the massifs of peat palsas. The study plot's area was 1.7 km².

The actual field works in the Vorkuta district lasted from 15 June to 6 August in 2001 and from 7 June to 12 August in 2002.

In 2001 spring was early, but the weather in June was generally cool, wet and cloudy. The total number of really warm days with a day-time temperature of +15° C did not exceed seven. Despite a cool month of June, plant vegetation and insect emergence took place 15–20 days earlier than normal. Strong, cold rain continued during half of a day on 20 June, but this did not adversely affect wader reproduction, since the birds were still incubating at that time. July was in general quite cold and cloudy, with frequent rain, drizzle or fog, and a day-time temperature usually not exceeding +16° C. However, a few days of hot and sunny weather with temperatures reaching +28° C by day occurred from 12 to 17 July. The first half of August was sunny, warm and quiet, with a day-time temperature of up to +25–27° C. Despite apparently unfavourable weather condition and a high numbers of avian predators, in a context of low rodent abundance, the wader's nesting success was high.

In general 2002 was characterised by cold and wet weather. Spring came as usual for this area. Most of the snow melted 15 June because it had snowed little in the winter, and heavy rains fell in the end of May. Summer and autumn were cold and very wet. Sometimes it was pouring for more than 15 hours and there were storms. Lemmings, voles and predators were very numerous.

Birds of prey were common. Overall the breeding conditions were unfavourable for waterfowl, waders and other bird species.

Materials and methods

Jack Snipes were counted by visual observations of displaying males with 8x and 12x binoculars. The squares of the study plots and the distances between consecutive area changes by displaying males were measured with GPS "Garmin 12XL". In 2001, the study plot area was about 7 km², but in 2002 it was reduced to 1.7 km² only. In 2002, we tried to count Jack Snipes with the help of mist-nets that we put in the feeding habitats of Jack Snipes. Five mist-nets of 10 metres and five shovels each were used. Size of the meshes was 15 × 15 mm.

Display and song activities of the males were estimated by a special index, i.e. the number of songs per 30 minutes. The activity of displaying males was estimated during 4–24 hours continuously and almost every day, both in the day time and at night. The duration of the uninterrupted counts depended on weather conditions only. Jack Snipes were counted from the beginning of the field works in the study plot till the late display activity of males in summer. The duration of the visual observations for displaying Jack Snipe males was 332 hours in total. The height of the display flights was calculated comparatively to the height of the lowest edge the clouds, which was defined relatively to the height of neighbouring mountain chain and the altitude of the ground surface.

Nests were searched purposefully by combing the breeding habitats on foot in both years, and with the help of a cord in 2001. Nest diameter was measured perpendicularly with a precision of 0.1 cm. Egg size was measured with a plastic slide gauge with a precision of 0.1 mm.



Figure 1. Location of the study area.

Adult Jack Snipes were caught in their nest with a hoop-net or at their nest site with a mist-net. All caught Jack Snipes were ringed with metal rings. The weight of downy young and adult birds was measured with a "Pesola" spring balance. Seven Jack Snipe nests were found in total, two of them were found in 2001 and five in 2002. In total, five adults and 13 downy young were caught and ringed. To study the parental participation in incubation, one of the nests was observed from a shelter during 17 hours in total.

Results

Display activity

Daily activity of displays

Registration of display activity has shown that late afternoon and evening is the best time for Jack Snipe counting. Males will display in the most active way between 15.30 and 20.30 h local time. The intensity of demonstration flights is much lower or drops to zero before and after the mentioned interval. Unlike observations made in the southern parts of the species range (Cramp and Simmons 1983, Kozlov 2001) we did not register a high peak of display in the early hours and at night. There was a small peak of display activity in the morning between 06.00 and 09.00 h. After 21.30 to 05.00 h Jack Snipes do not display, although from time to time we registered 1–2 display calls (Figure 2). However, the observed connection is not quite strict. When the weather is more favourable in the first half of the day than in the afternoon, Jack Snipes are more active in the morning. This was mainly connected with the daily weather changes. Even at warm nights the display activity was quite low.

Seasonal trends in display activity

According to my observation, in 1982–1997 the Jack Snipe males started displaying immediately on arrival. Display flights were observed between 10–27 June 1982, between 14 June–5 July 1983, and 9–27 June 1984 (Morozov 1987). However, we did not make any special observations of Jack Snipe in those years.

Unfortunately, in 2001 and 2002 we started our observations after the arrival of the first Jack Snipes in the study area in the Vorkuta town vicinity. Therefore, the beginning of the display period was not precisely defined. Later on 15 June 2001, the display activity had decreased. Active displaying Jack Snipe males were observed on 7 June 2002 – the first day of our field works. The end of their display was recorded on 12 July 2001 and 15 July 2002. So, the duration of the period of display flights was at least 38 days in 2002.

The display activity of Jack Snipes changed during their display period. The most intense display activity lasted from the end of the first decade of June till the middle of the third decade of June: 8–24 June in 2002. With time the display activity became less intensive. Males sometimes displayed in the afternoon, mainly after 17.00–18.00 h and the number of display flights were much lower than in the beginning of June. That period lasted from 24 June until 4 July. The display period would be over in the middle of July (Figure 3 and Figure 4).

Figure 3. Display activity of Jack Snipe in the beginning of the breeding season.

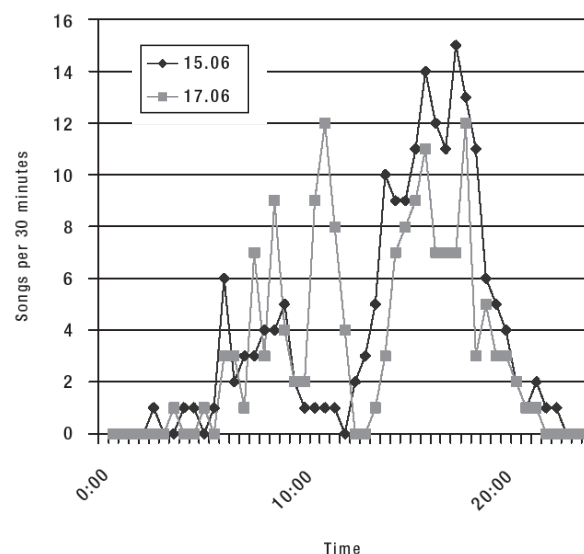


Figure 2. Daily display activity of Jack Snipe.

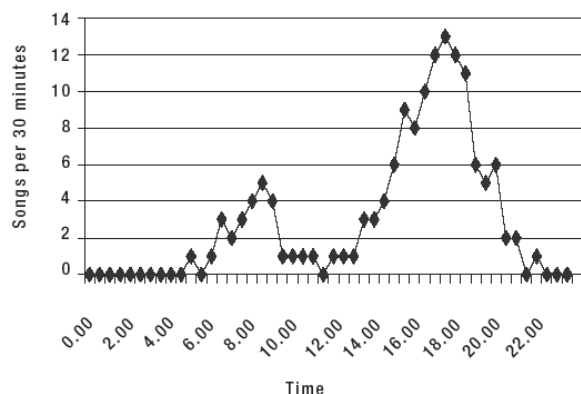
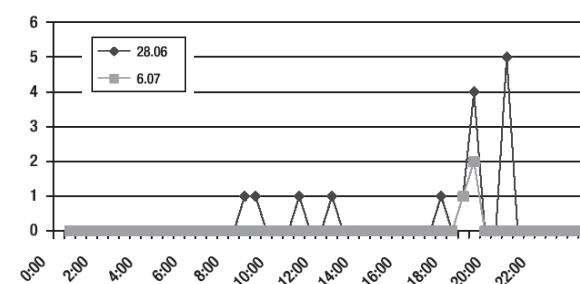


Figure 4. Display activity of Jack Snipe at the end of the breeding season.



Weather and display activity

Weather is one of the significant factors that may influence the display activity of the Jack Snipe. According to visual observations Jack Snipe males do not display on stormy days with much precipitation. There were seven of such days for the whole display period of Jack Snipe in 2002. By strong wind (more than 12 m per sec.) and lack of precipitation, the Jack Snipes will still display, although their display activity is lower. Strong wind will distort the location of the calls and therefore it is much more difficult to spot a displaying male.

Obviously, the Jack Snipes would display reluctantly at low temperatures or would not display at all (Figure 5). The highest level of display activity is observed in warm evenings. Calm, sunny afternoons are the most favourable times to display. On clear or slightly cloudy days with gentle winds, the Jack Snipes also display actively. Calm and cloudy days are favourable for bird counting. However, the display activity is less than that on clear days (Figure 5).

Some characteristics of display flights

We could not observe the whole display flight from its upward flight to landing. Usually, the male is spotted at the moment it swoops and produces a specific sounds. So, one may watch bird only from the beginning of that moment.

The display territory was found to be enormous and considerably exceeding the study plot. In principle, a displaying male is observed with a 8x binocular at a distance of 900–1,000 m, and at a 1.2–1.3 km distance with a 12x binocular, because from a larger distance a bird of such size is not seen. This is also why the displaying males disappeared soon, after several swoopings, but not ceasing their display flights. Some references that state that the display territory is 1.5–3.0 km (Kozlov 2001) are not reliable, since a bird of this size cannot be seen at more than at a 1.3 km distance, even with a 12x binocular.

The longest distance from which it is possible to hear the display song of a Jack Snipe was 700 m in quiet weather. When the weather was very windy it was possible to hear

its song from not more than 300 m. The usual height of display flights was about 200 m above the ground surface, while the highest one would reach 300 m. As our visual observations revealed, the males display territories completely overlap. All males inhabiting the study area will display over the whole territory. Meetings of males in the air never became territorial conflicts. Birds would stop displaying and fly together for about 100–200 m and after that they would continue to display while moving in the same directions.

Jack Snipe numbers and density

Estimation of numbers

Our attempts to use the mist-nets to catch Jack Snipes and find out how many birds were staying in study area, failed. And this because the weather conditions were unfavourable throughout the whole season of 2002. Non-stop rain and fog poured through the mist-nets and they became visible for birds while losing their catching characteristics. Secondly, the chosen mist-net height was wrong. They were too high for open places and subject to winds, which frightened the birds.

We may therefore provide only rough estimations of the numbers of Jack Snipes within study area. Male density in breeding habitats accounted for 1.3 male/km² in 1982 and 0.5 male/km² in 1983 according to the data obtained near the Vorgashor settlement, which is 15 km to the west of Vorkuta (Morozov 1987). My observations showed that no more than four males were heard displaying at the same time for long-hours over the 1.7 km² study plot in 2002. Besides, four nests were found in the study plot. So, it was certain that at least four pairs of Jack Snipe inhabited the study plot. And therefore, the density of Jack Snipes could not be less than 2.2 pairs/km². However, this estimate was calculated on the basis of observations of maximum numbers of displaying males and the numbers of nests found in the study plot. In my opinion, this is the lowest level of number estimation.

Display activity and numbers

A comparison between the Jack Snipe minimal number estimation based on the numbers of found nests and the numbers of Jack Snipe males that are displaying at the

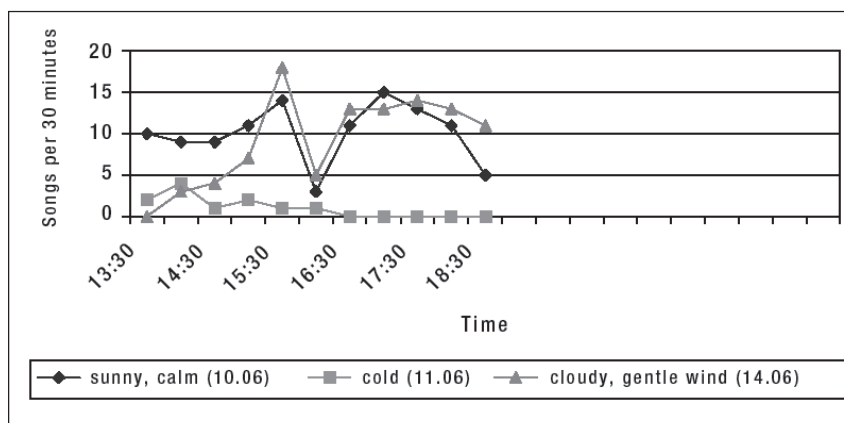


Figure 5. Display activity of Jack Snipe in different weather.

same time over whole study plot (1.7 km²), and the special index (number of songs of males per 30 minutes) could be used as a parameter of Jack Snipe numbers and density. My suggestion is that the value of the special index of more than nine (between 10 and 18) in the first half of June corresponds to at least four–five pairs (or two pairs/km²) of Jack Snipes present in the area.

Breeding

Habitats and sites

The massifs of the composite peat bogs are the breeding habitats of the Jack Snipe in the Bolshezemelskaya tundra. They consist of extensive palsa mires with up 1-m high frost peat mounds or palsas covered by low shrubs. Between these peat palsas one may find flat fen mires overgrown by dense sedges, cotton-grasses, sphagnum and some other mosses. There are dense willow bushes between these massif of palsas.

All nests were situated exactly in flat fen-sedge mires within composite peat bogs (Figure 6). However, the details of these nest locations were to some extent rather different. One nest was located almost in the centre of a large sedge fen mire in a very wet plot with bog moss and a thinned out sedge cover. Six nests were located at the margin of a small fen and the sedge mires in plots with little moss hummocks and solitary dwarf willows and birches (*Betula nana*).

All nests were located on the top of mosses or moss-sedge hummocks under the shelter of sedge leaves or sometimes willow twigs. The vegetation in the plots where nests have been found, differs by the great number of small moss hummocks and a reduced, low grass cover. The floristic composition is characterised by few ("key") plant species – *Carex stans*, *Comarum palustre*, *Sphagnum* spp. *Aulacomnium palustre*, and *Drepanocladus aduncus* (the last one only occurs in very wet plots).

Season

Jack Snipes will arrive in tundra in the beginning of June. Two weeks later egg laying begins and this will last till the beginning of July, including the replaced clutches. Nests

with new and almost new clutches were found on 21 June 2001, 20 June 2002, 4 July 2002 (replacement clutch) and 8 July 2002. The dates of downy young hatchings are 3 and 9 July 2001, 13 and 30 July 2002 and 7 August 2002. An unskilfully-flying young bird with down plumage on its head was observed on 16 August 1983. The latest observation of a Jack Snipe was made on 7 September 1982 (Morozov 1987).

Nests and clutches

Seven Jack Snipe nests were found and their destinies were monitored. All nests were located in the sedge mires inside composite peat bogs. All nests were lined with old dry sedge leaves. The nests sizes were (mm): 1. D = 90–140 (103.6 ± 3.1, n = 14), d = 70–80 (74.3 ± 1.1, n = 14), h = 25–40 (35.3 ± 2.0, n = 7). Two nests were destroyed by domestic reindeers, and probably by a Hen Harrier. A 10–12 day replacement time for a clutch (after destruction of the first one) was proved by ringing.

All clutches contained four eggs, including the replacement one. The egg sizes were (mm): 35.7–40.7 × 26.4–29.9 (38.16 ± 0.27 × 27.52 ± 0.14, n = 28). These sizes are fully within the variability stated in the literature (Witherby *et al.* 1940, Makatsch 1974). The weight of fresh eggs (g): 12.8–15.8 (14.2 ± 0.3, n = 8).

According to published information, the incubation period of Jack Snipe will last at least 24 days (Witherby *et al.* 1940; Cramp and Simmons 1983). According to my data, one lasted at least 25 days for one clutch and 30.3 days (30 full days and eight or nine hours) for the second clutch. Such a long incubation period for the second nest was likely due to unfavourable weather conditions during the summer of 2002.

Incubation started with the laying of the last or third egg, and only females were seen to incubate the clutch. When frightened away from their nest, the birds would not come back to it for a long time. If not disturbed, the birds would still spent much time away to feed themselves. According to our visual observations of one nest the birds were absent for 1.5–2.5 hours. The eggs would become considerably cold during that time. It was the female with a ring that always returned to the nest on foot. Although our data are incomplete, they may serve as indirect evidence to prove the female's hatching of the clutch. A lasting absence from the nest, whereby the eggs would cool off may be the reason for the long incubation period of Jack Snipe.

Broods

The downy young hatched on 3 and 9 July 2001, on 13 July 2002, on 30 July 2002 (replacement clutch) and the single downy young of one nest hatched on 7 August 2002. The other two eggs of the last nest were infertile and the embryo of the third egg was dead. I guess that the third clutch has been replaced as well. The weights of just-hatched downy young were 8.5–10.6 g (9.5 g ± 0.2, n = 14).

Only one bird always appeared near the chicks when they were still in their nest. In three cases we were sure that

Figure 6. Fen mire in the study plot.



these birds were females because they were caught and ringed right in the beginning of incubation and their cloaca features confirmed their sex.

After leaving the nest, the broods were difficult to spot although we tried and undertook daily long-time efforts to find them. We had only four observations of broods with always one bird near them. Broods will wander from place to place and are confined to the wettest parts of sedge mires with a rare sedge cover, separated by exposed moss patches.

Drepanocladus aduncus is the most preferred moss for the fledglings to hide in. Presumably, the fledglings of Jack Snipes will more often hide in sedge tufts, like the downy young of Wood Sandpiper and Common Snipe will do, but we were never able to observe this.

Conclusion

The census method thus could be based on the observation of singing males of Jack Snipe in their breeding grounds. The best period for such counts is in the first and second decades of June, the best time is during the interval between 15.30 and 20.30 h (local time) and the best weather is in calm sunny afternoons or on slight cloudy days with gentle wind. Numbers could be estimated by using a special index like the number of songs per 30 minutes and by taking the numbers of males that were heard to display at the same time into account. However, I do not find this is a correct way to transform a special index into density or actual numbers.

The breeding habitats of Jack Snipe in the Bolshezemelskaya tundra are massifs of the composite peat bogs. All nests were situated exactly at flat fen-sedge mires within those peat bogs. The vegetation of the sites where nests have been found, may be distinguished by the great number of small moss hummocks and a reduced grass cover of small height. Floristic composition is characterised by few (four to five) plant species.

The possibility of replacement of a clutch 10–12 days after the destruction of the first one, was proved by ringing. The incubation period of the Jack Snipe is longer in comparison with one of the other waders of similar size and it lasted more than 25 days. The possible reasons for that are the following: only one female was discovered to incubate its clutch and it spent much time away feeding. Adult Jack Snipes and their broods will inhabit the same habitats all the time. These are fen sedge mires.

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Breeding density and habitat use of Common Snipe in upland Britain

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The Common Snipe (*Gallinago gallinago*) is a bird of conservation concern in Britain and Ireland owing to substantial declines in the size and range of the breeding population on lowland farmland. Currently little is known about breeding densities and habitat use on upland moorland. In this study, the mean density of breeding Snipe across four moors in Northumberland, England was 2.28 ± 0.15 birds km^{-2} (approximately 1.14–1.34 pair km^{-2}). Snipe densities in marsh and acid grass were approximately 3.7 x and 2.2 x higher than on heath and heath-grass mix habitats. Densities on acid grass were four times higher than on improved grassland. Territories were not located randomly with respect to habitat availability. They contained more marshy grassland and acid flush habitats and less dry heath than expected from habitat distribution on the four study moors. Within habitats, Snipe were flushed from locations that were closer to ditches or pools and characterised by wetter soil and more uneven swards than randomly selected points. Feeding sites had similar vegetation to resting sites, but feeding took place in wetter soil, closer to ditches or pools. This study indicates that the use of moorland by breeding Snipe is dependent upon the availability of wet habitats and unimproved grassland and we discuss the potential effects of upland management on these habitats and Snipe populations.

Introduction

The Common Snipe (*Gallinago gallinago*) is a bird of conservation concern in Britain and Ireland owing to a decline of 67% in numbers during 1974–1999 (Gregory *et al.* 2002). In southern England, its presence is closely associated with marshy ground and breeding success is influenced by the time during April–August for which the soil remains moist enough for it to probe for earthworms and crane-fly (*Tipulidae*) larvae (Green 1988).

Consequently, since the late 1940s, breeding numbers have declined and population fragmentation has occurred as a result of agricultural intensification. This has involved the conversion of wet grassland to arable land or, where grass remains, increased drainage and higher rates of livestock grazing (Robins 1987, Marchant *et al.* 1990, Gibbons *et al.* 1993). Breeding Snipe are now very patchily distributed in the lowlands of England and Wales, where they are confined to the remaining wet pastures, coastal grazing marshes and fens, many of which are managed for nature conservation and may support relatively high densities (Gibbons *et al.* 1993, Wilson *et al.* 2005).

Breeding Snipe are currently more widespread and numerous in northern Britain and Ireland and are regular breeders on moorland and rough pastures in upland areas (Gibbons *et al.* 1993). However, despite the increasing importance of these habitats as Snipe numbers continue to decline in the lowlands, current population estimates suffer from a lack of comprehensive upland survey data. The utilisation of moorland habitats and changes in upland populations are poorly documented compared with lowland grassland, although there is some evidence that agricultural improvement of rough pastures has been detrimental to breeding Snipe (Baines 1988).

The aim of this study was to quantify breeding Snipe densities in upland habitats and to assess habitat requirements by examining territory dispersion and the characteristics of feeding areas.

Study areas

Snipe were surveyed on four areas near Otterburn, Northumberland in 2000 and 2002. Two, 'Otterburn' (centre $55^{\circ}17'N$ $2^{\circ}09'W$) and 'Bellshiel' ($55^{\circ}19'N$ $2^{\circ}18'W$) were on the MoD's Otterburn Training Area, one was on Ray Demesne Estate ($55^{\circ}12'N$ $2^{\circ}04'W$) and one on Emblehope moor ($55^{\circ}15'N$ $2^{\circ}25'W$), part of Northumberland Estates. The study areas were 9.2–14.3 km^2 and consisted of undulating moorland and marginal farmland at altitudes of 220–470 m asl. Each area consisted of a similar mosaic of habitats of which heather *Calluna vulgaris*-dominated heath and heath-acid grassland mixtures were dominant at the higher altitudes, with grasses and rushes more extensive on the lower slopes. Boggy pools were common at Otterburn and Bellshiel as a result of artillery practice and unimproved grassland on all four moors was broken up by ditches. Meadows and improved pastures comprised less than 8% of each study area. The main livestock were sheep, typically at summer densities of 1.0–1.5 ewes ha^{-1} on the grass moor.

Methods

Breeding Snipe surveys

The study areas were divided into six to nine counting blocks of 0.60–2.34 km^2 and observers walked to within 100 m of every point within these blocks between the hours of 05.20 to 09.00 BST and 17.00 to 21.00 BST. Most (89%) surveys were conducted in the morning. All Snipe seen and heard were recorded and drumming displays and chipping calls were noted. Birds which started drumming once disturbed were recorded as drumming, as this is standard practice in breeding wader survey methodology (Smith 1981, 1983). The likelihood of double counting was minimised by marking the positions of all birds on a 1:10,000 scale map and recording the distance and direction of any movements. Two surveys of each study area were conducted between mid-April and

late May, with counts of each block on average 22 days apart. There were four observers in 2000 and five in 2002. Each counted similar numbers of blocks within each study area and no observer counted the same block during both surveys within the same year. Surveys were not conducted on days with heavy rainfall or winds exceeding force 5 on the Beaufort scale.

Flush point records

Details of the location and habitat for 186 Snipe flushed on the study areas between mid-April and mid-August 2002 were recorded. During the systematic surveys 112 (60%) encounters were made before 09.00 and after 17.00 BST and the remainder consisted of incidental records made at other times of day. The distance of the bird from the observer when flushed was noted, as was evidence of feeding in the form of probe holes and droppings at the flush site. The distance between the flush point and the nearest wet ditch or marshy pool was recorded. Within a 3-m radius of the flushing point, the dominant species of vegetation was recorded along with the mean vegetation height (to the nearest 10 cm). Also within a 3-m radius, tussocks and soil wetness were scored on categorical scales of one to five (even sward to large tussocks and dry ground to waterlogged soil). A measure of horizontal cover was obtained at 55 flush points using a cardboard silhouette of a Snipe with a wire stake and recording the distance (to the nearest metre) at which the silhouette was completely obscured by vegetation in the four cardinal directions. For comparison the same habitat variables were recorded from 119 random points (horizontal cover recorded at 52 points), determined from randomly selected 8-figure grid references and located in the field with a hand-held GPS (Magellan 300), during May–August.

Habitat classification

Habitat maps were drawn at a scale of 1:10,000 for each study area during May 2002 using the Phase 1 mapping system (NCC 1990) to classify habitat patches. For Otterburn and Bellshiel modifications were made to existing maps produced for the MoD in 1994. The maps were registered in the GIS package MapInfo 7.0 (MapInfo Corporation 2002) and the areas of each habitat patch measured. Snipe were recorded in seven types of habitat: (1) dry heath, (2) wet heath and blanket bog, (3) dry heath-acid grassland mosaic, (4) wet heath-acid grassland mosaic, (5) marsh or marshy grassland and acid flush, (6) unimproved acid grassland, and (7) semi-improved and improved grassland (see Table 1 for details of characteristic species of each habitat). Woodland, bracken (*Pteridium aquilinum*), rocky outcrops, pools, watercourses, roads and buildings comprised the remaining habitats that were mapped.

Statistical analysis

Snipe densities were calculated from the number of birds seen or heard in each habitat during the systematic surveys, with drumming birds attributed to the habitat at the centre of their display flights. Densities were analysed by using Snipe numbers for each habitat within survey within study area within year as the dependent variable in

a generalised linear model (GLM) with Poisson errors and a logarithmic link function with $\log_e(\text{area})$ specified as an offset. Explanatory factors tested in the model were habitat, survey, study area, year and the interactions study area \times habitat and year \times habitat. Overdispersion of data with respect to the Poisson distribution was corrected by specifying the dispersion parameter as the residual deviance divided its degrees of freedom. For estimation of breeding density across the four moors, Green's (1985) method (maximum count made within three hours of dawn or dusk during April and May \times 1.74) was also used.

The positions of all drumming and chipping Snipe from both surveys within each year were digitised in MapInfo 7.0 and the points were buffered with circles of 100 m radius to represent the average extent of territories (3.14 ha). A radius of 100 m was chosen because the mean size of nine drumming territories measured from diagrams in Tuck (1972) was 1.90 ha (equivalent to a circle of radius 78 m) and Reddig (1978) and Cramp and Simmons (1983) gave typical radii of 75–125 m and 75–100 m. Where points on the two counts were within 200 m and hence probably represented the same bird, the point from the second count was removed from the analysis. Habitat proportions within territories were compared with habitat proportions in the study areas using compositional analysis (Aitchison 1986, Aebischer *et al.* 1993). To avoid problems with too many null proportions in the analysis dry heath and dry heath-acid grassland were combined to make one habitat category, as were wet heath and wet heath-acid grassland. The proportion of all the habitats unsuitable for Snipe (woods etc.) was used as the denominator in log-ratios and null proportions were replaced by 0.0001. Because unmated males may have moved display locations between the two counts (Cramp and Simmons 1983), the analysis examined the selection of habitats not only within the territories of breeding pairs but also an unknown number of potential territory locations displayed over by unpaired males.

Table 1. Description of predominant vegetation types on four moors in Northumberland, England and estimated densities of breeding Snipe from surveys in 2000 and 2002.

Habitat	Characteristic vegetation species	Density (birds km ⁻²)
Dry heath	<i>Calluna vulgaris</i> , <i>Vaccinium myrtillus</i>	1.40 \pm 0.23
Wet heath + blanket bog	<i>Calluna vulgaris</i> , <i>Erica tetralix</i> , <i>Eriophorum vaginatum</i> , <i>Molinia caerulea</i> , <i>Sphagnum</i> spp.	1.20 \pm 0.42
Dry heath-grass mix	<i>Calluna vulgaris</i> , <i>Deschampsia flexuosa</i> , <i>Nardus stricta</i>	1.56 \pm 0.27
Wet heath-grass mix	<i>Calluna vulgaris</i> , <i>Erica tetralix</i> , <i>Eriophorum vaginatum</i> , <i>Molinia caerulea</i>	1.64 \pm 0.20
Acid grass	<i>Deschampsia flexuosa</i> , <i>Nardus stricta</i> , <i>Molinia caerulea</i> , <i>Festuca ovina</i> , <i>Juncus squarrosus</i>	3.13 \pm 0.36
Improved grassland	<i>Lolium perenne</i> , <i>Poa trivialis</i> , <i>Trifolium repens</i> , <i>Ranunculus acris</i>	0.78 \pm 0.33
Marsh + acid flush	<i>Juncus effusus</i> , <i>Juncus articulatus</i> , <i>Molinia caerulea</i> , <i>Eriophorum vaginatum</i> , <i>Carex nigra</i> , <i>Sphagnum</i> spp.	5.40 \pm 0.57

The means of flushing distances and habitat variables did not differ significantly between incidental records and those made during systematic counts when the effects of study area and date were controlled for in an analysis of covariance (ANCOVA) and hence subsequent analyses were based on the full dataset. Differences in vegetation height, distances to a ditch or pool and horizontal cover between flush and random sites or feeding and resting locations were examined by ANCOVA models including habitat and study area as factors and date as a covariate. These variables had non-normal distributions and were $\log_{10}(x)$ or $\log_{10}(x+1)$ -transformed. Examination of the distribution of the residuals suggested that use of the same ANCOVA model was justified for the tussock and soil wetness variables. The dominant species of vegetation at flushing and random sites was grouped as (1) heather, (2) grasses, (3) rushes, (4) cotton grass, (5) sedges and (6) mosses for analysis. GLMs were performed in GENSTAT 7.2 (Lawes Agricultural Trust 2003). All other statistics were calculated in SYSTAT 9 (SPSS Inc. 1999). Means are presented as back-transformed logarithm values with first-order approximation standard errors.

Results

Snipe densities

Mean Snipe density across the four study areas, excluding areas occupied by roads, buildings and woods, was 2.28 ± 0.15 birds km^{-2} (approximately 1.14 pair km^{-2} assuming an equal sex ratio). Mean pair density calculated from maximum counts of drumming males was

1.34 ± 0.31 pair km^{-2} . Densities ranged from 0.78 to 5.40 birds km^{-2} across the habitats, with the highest density recorded in marsh (Table 1). There were significant differences in Snipe density between habitats and study areas ($F_{6,76} = 17.58$, $P < 0.001$ and $F_{3,76} = 19.01$, $P < 0.001$ respectively). The effects of year, survey and the interactions between study area and habitat and between year and habitat were not significant. Snipe densities in marsh and acid grass were approximately 3.7 x and 2.2 x higher than on heath and heath-grass mix habitats. Densities on acid grass were 4 x higher than on improved grassland.

Habitat composition within territories

Habitat composition within territories differed significantly between study areas relative to availability ($\Lambda = 0.808$, $\chi^2_{12} = 49.25$, $P < 0.001$), but not between years ($\Lambda = 0.995$, $\chi^2_4 = 1.16$, $P = 0.885$). Within each area the habitat composition of territories differed significantly from random (Otterburn $\Lambda = 0.760$, $\chi^2_4 = 20.31$, $P < 0.001$, Bellshiel $\Lambda = 0.679$, $\chi^2_4 = 12.78$, $P = 0.012$, Ray Demesne $\Lambda = 0.386$, $\chi^2_4 = 89.72$, $P < 0.001$, Emblehope $\Lambda = 0.434$, $\chi^2_4 = 29.21$, $P < 0.001$). Snipe territories contained on average a higher proportion of marsh, a similar proportion of grass and a lower proportion of dry heath, wet heath and other habitats than was available within the study areas (Figure 1). Habitat rankings and the significance of differences in the relative use of habitats varied slightly between study areas, but mean rankings indicated that marsh had the highest use relative to availability (mean rank 3.75), followed by wet heath (2.50) and grass (2.00), with dry heath (1.25) and other habitats (0.50) little used (Table 2).

Figure 1. Comparison of mean habitat proportions (+ se) within Snipe territories (black bars) with the habitat compositions of four study areas in Northumberland, England (white bars): (a) Otterburn, (b) Bellshiel, (c) Ray Demesne, (d) Emblehope.

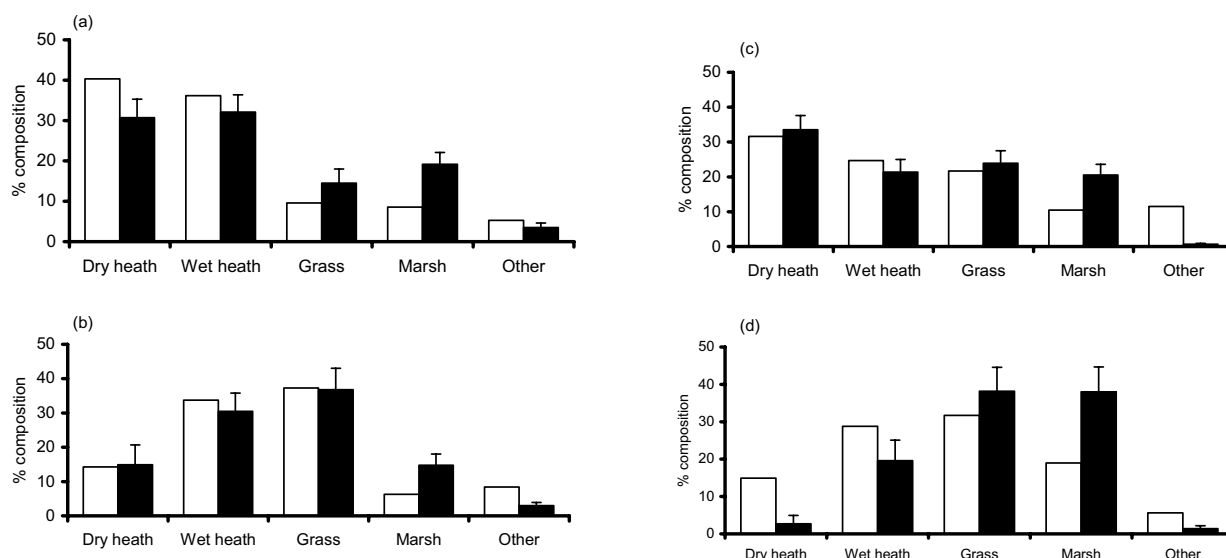


Table 2. Ranking matrices, based upon mean log-ratio differences, comparing habitat composition within Snipe territories (rows) against habitat composition within the study area (columns). Data for 2000 and 2002 were analysed together because there were no differences between years. A positive sign indicates that a habitat was used more than expected from its availability, a negative sign that use was lower than expected from availability and a triple sign indicates that the difference was significant at $P < 0.05$.

	Dry heath	Wet heath	Grass	Marsh	Other	Rank
Otterburn						
Dry heath		-	+	---	+	2
Wet heath	+		+++	-	+++	3
Grass	-	---		---	+	1
Marsh	+++	+	+++		+++	4
Other	-	---	-	---		0
Bellshiel						
Dry heath		---	---	---	-	0
Wet heath	+++		+	+	+++	4
Grass	+++	-		-	+++	2
Marsh	+++	-	+		+++	3
Other	+	---	---	---		1
Ray Demesne						
Dry heath		+	+	-	+++	3
Wet heath	-		-	---	+++	1
Grass	-	+		-	+++	2
Marsh	+	+++	+		+++	4
Other	---	---	---	---		0
Emblehope						
Dry heath		---	---	---	-	0
Wet heath	+++		-	-	+	2
Grass	+++	+		-	+++	3
Marsh	+++	+	+		+++	4
Other	+	-	---	---		1

Table 3. Habitat characteristics at random points for the main vegetation communities on the four study areas.

Habitat	<i>n</i>	Vegetation height (cm)	Tussocks	Soil wetness	Distance to ditch (m)
Dry heath	16	27 ± 1	2.1 ± 0.3	2.3 ± 0.3	67 ± 1
Wet heath	6	29 ± 1	2.5 ± 0.5	2.5 ± 0.4	19 ± 2
Dry heath-grass	14	25 ± 1	2.9 ± 0.3	1.7 ± 0.3	58 ± 1
Wet heath-grass	46	27 ± 1	2.6 ± 0.2	2.4 ± 0.2	39 ± 1
Grass	27	22 ± 1	2.9 ± 0.2	1.8 ± 0.2	83 ± 1
Marsh	10	26 ± 1	2.8 ± 0.4	2.7 ± 0.4	32 ± 1
<i>F</i> -value (df 5,109)		<i>F</i> = 0.69	<i>F</i> = 1.10	<i>F</i> = 2.36	<i>F</i> = 2.52
<i>P</i> -value		<i>P</i> = 0.630	<i>P</i> = 0.365	<i>P</i> = 0.045	<i>P</i> = 0.034

Table 4. Comparison of habitat measures at 186 Snipe flushing sites and 119 random locations on four study areas during April–August 2002. Means are back-transformed from the logarithm scale. Tussocks and soil wetness were recorded on five-point categorical scales. Acid grass and improved grassland were treated as one habitat category. The interactions location type x habitat and location type x study area were included in the models. These were all non-significant with the exception of the location type x study area interaction in the model comparing tussock scores ($F_{3,286} = 2.84$, $P = 0.038$).

Variable	Flush sites Mean ± se	Random locations Mean ± se	Location type		Habitat		Study area		Date	
			$F_{1,286}$	<i>P</i>	$F_{5,286}$	<i>P</i>	$F_{3,286}$	<i>P</i>	$F_{1,286}$	<i>P</i>
Vegetation height (cm)	29 ± 1	25 ± 1	2.64	0.105	2.23	0.052	0.68	0.565	3.43	0.065
Tussocks	3.1 ± 0.1	2.6 ± 0.1	7.83	0.005	2.23	0.052	1.78	0.152	1.09	0.298
Soil wetness	3.3 ± 0.1	2.3 ± 0.1	23.67	<0.001	6.04	<0.001	7.89	<0.001	1.72	0.191
Distance to ditch/pool (m)	12 ± 1	40 ± 3	29.11	<0.001	4.26	0.001	4.07	0.007	2.64	0.105
Horizontal cover (m) ^a	14 ± 1	14 ± 1	0.01	0.930	1.08	0.379	1.01	0.392	0.38	0.537

^a Residual df = 88

Habitat use by feeding and resting Snipe

Comparison of habitat measures at random points across habitats revealed no difference in mean vegetation height or tussock score but significant differences in soil wetness and the distance to the nearest ditch (Table 3). There was no difference in mean vegetation height between Snipe flush sites and random points, but the sward was more uneven (i.e. the tussock score was higher) at flush sites on three study areas (Table 4). Controlling for differences between habitats, Snipe flush sites were closer to wet ditches or pools than random points and the soil was wetter. There was no difference in horizontal cover between flush points and random points. There was a significant difference in the dominant vegetation species between Snipe flush sites and random points ($\chi^2_5 = 68.99$, $P < 0.001$). Flush sites were characterised by more rushes (dominant at 36% of flush sites compared to 3% of random points) and grasses (30% compared to 22%) and random points by greater dominance of heather (27% compared to 6% at feeding sites) and cotton grass (29% compared to 14%).

Further comparison of habitat measures at 80 Snipe flush points with evidence of recent feeding and 106 points where birds were presumed to be resting (no droppings or probe holes) revealed that feeding birds were closer to ditches or pools (6 ± 1 m compared to 18 ± 2 m for resting birds, $F_{1,167} = 10.42$, $P < 0.001$) and used areas with wetter soil (mean score 3.9 ± 0.3 compared to 2.9 ± 0.2 , $F_{1,167} = 9.17$, $P = 0.003$). The distance of Snipe from ditches increased during the breeding season. There were no differences in vegetation height, sward structure or horizontal cover.

Nest sites

Fourteen Snipe nests were found incidentally during the surveys and other fieldwork. The earliest nest was found on 25 April and the latest on 27 July, with the majority located in late April–early May. On average nests were 200 ± 62 m from the nearest patch of marsh (range 0–795 m). Nest sites were typically dominated by soft rush (*Juncus effusus*), jointed rush (*Juncus articulatus*), wavy hair-grass (*Deschampsia flexuosa*) or cotton grass (*Eriophorum vaginatum*). The vegetation within 3 m of

nests was taller than that at random points (median 32.5 cm compared to 25.0 cm, Mann-Whitney $U_{14,119} = 1092.5$, $P = 0.048$) but the distribution of vegetation heights at nest sites (range 19–58 cm) was similar to that at random points (Kolmogorov-Smirnov $d_{14,119} = 0.28$, $P = 0.247$ after subtraction of the difference in the medians).

Discussion

Density and distribution

The densities of Snipe recorded in this study were low relative to those in the best lowland habitats in England and Ireland (e.g. 21.8–45.6 pairs km⁻¹, Smith 1983, Nairn *et al.* 1988), but moorland constitutes an important habitat for the British and Irish Snipe population because it is far more extensive than the remaining suitable lowland habitats. This study suggests that breeding Snipe distribution in upland areas is likely to be patchy, with only low densities in extensive areas of dry heath but relatively high densities in areas with a mosaic of habitats including significant patches of marshy grassland and acid flush. This is in accordance with the findings of Tharme *et al.* (2001), who recorded an avoidance of heather-dominated habitats and increased densities on moors with higher proportions of bog and flush habitats. The most recent national breeding bird data suggest that Snipe abundance is lower on the drier, southerly moorland in the Peak District and the North York Moors than on the wetter, northerly moors in the North Pennines and the Scottish Borders (Gibbons *et al.* 1993).

As in lowland habitats, the availability of suitable feeding areas appears to determine the density of breeding Snipe on moorland. Despite the limited sample, the range of situations in which nests were found in this study is indicative that nest sites are not limiting. Green *et al.* (1990) have shown that on lowland wet grassland incubating females often walk to feeding areas within 70 m of the nest but also fly to ditches and pools. On the study areas used in this work marshy grassland and acid flush habitats were selected for feeding and this is likely to explain why territories were located close to such areas.

Feeding areas

Our data on Snipe flush locations suggest that during daylight hours Snipe make regular use of areas with above average soil wetness that are close to ditches and pools within all utilised habitats. Vegetation height and structure appeared to be relatively unimportant when the effects of habitat were controlled for. Feeding sites were closer to ditches and pools than sites used by resting birds presumably because waterlogged soil around the edges meant that these were the places that remained soft enough for the Snipe to probe and forage efficiently. Ditches and flushes also support a much higher abundance of insects than heather-dominated moorland and are frequently utilised by other birds such as the meadow pipit (*Anthus pratensis*) and red grouse (*Lagopus lagopus scoticus*) when rearing broods (Coulson and Whittaker 1978, Hudson 1986).

Ditches and flushes may not be the best areas for earthworms because earthworm density is often negatively related to soil moisture content. Earthworm densities are also very low in moorland peat (1–20 m⁻²), and rough grassland is likely to provide the most productive feeding areas for earthworms (average density 390 m⁻², Coulson 1988). It seems likely, therefore, that most Snipe spent an appreciable proportion of their foraging time on grassland. Green (1988) has demonstrated that on lowland wet grassland the length of the Snipe's breeding season is determined by the duration for which the soil remains soft enough for the birds to probe for food. In the uplands there is likely to be greater potential for re-nesting following the loss of a clutch or brood because most marsh and flush habitats remain damp throughout the summer.

Effects of upland management

Owing to its specialist requirements, the Snipe is susceptible to habitat change resulting from changes in land management in the uplands. Farming, grouse management and afforestation are likely to have affected the distribution of breeding Snipe in upland areas in the past. Of these, farming is likely to be having the greatest effect currently. Between 1980 and 1990 sheep numbers in the uplands more than doubled (Fuller and Gough 1999), resulting in many areas in a shift from heather-dominated habitats to heather-grass mosaics. While this may have made some moors more attractive to breeding Snipe, it seems likely that the increased sheep densities will have resulted in increased trampling rates of Snipe nests (Fuller and Gough 1999), as demonstrated with cattle on lowland wet grasslands (Green 1988), and in greater numbers of carrion crows *Corvus corone* and jackdaws *Corvus monedula* potentially causing higher rates of nest predation (Fuller *et al.* 2002, Henderson *et al.* 2004). These effects are difficult to quantify and their impact may be less severe than in lowland areas if birds have a more protracted period during which to lay replacement clutches in the uplands. The agricultural improvement of pasture fields adjoining moorland has been shown to be detrimental to most breeding waders, including Snipe (Baines 1988) and this was evident in the present study from the low density of Snipe on improved grassland compared to areas of rough acid grass.

During the 1970s and 1980s much time and money were spent on upland drainage in Britain to lower the water table to benefit livestock production and red grouse. This was ineffectual at high altitudes (above 500 m) and at lower altitudes the effects of drainage on vegetation growth were typically confined to an area within 2–3 m of the drain edge (Stewart and Lance 1983, Coulson *et al.* 1990). However, it may have removed pockets of deep, wet peat at lower altitudes (Usher and Gardner 1988, Coulson *et al.* 1990) and hence resulted in a loss of the acid flush habitat important to Snipe in heather-dominated areas. Moorland drainage has now been largely abandoned and conservation grants are available for blocking drains, which may over time result in better conditions for Snipe.

It has been estimated that 5–15% of the British uplands are managed for red grouse shooting (Brown and

Bainbridge 1995), which equates to 20–60% of the heather-dominated area (Ball *et al.* 1983). This management typically consists of the rotational burning of heather and the culling of predators. It seems unlikely that heather burning has much effect on Snipe because they avoid areas of dry heath, although efficient predator control might be expected to increase breeding success. However, the results of an extensive survey of grouse moors and other unkept moors by Tharme *et al.* (2001) suggest that grouse moor management has no effect on breeding densities of Snipe.

Acknowledgements

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Some behavioural aspects of Jack Snipe (*Lymnocryptes minimus*), wintering in France

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In France, the Jack Snipe winters especially in the Channel and Atlantic regions and in the Mediterranean as well. Because of a secretive life, the winter behaviour of this cryptic species is not very well known. This work is a first step to improve the knowledge in this field.

The study took place in three sites: the Camargue (South of France) and the Loire river estuary in 2000/01 and 2001/02, and Noirmoutier Island (west of France) in 2001/02. In total, 26 Jack Snipes were radio-tagged during the two years of study. Of these, only five have been studied for a sufficient period of time to get enough data.

The analysis of the data show an important heterogeneity in the behaviour of the Jack Snipe. Birds may stay at the same site at day and night. Some of these birds don't leave their site while others move from one site to another. Some birds can present another pattern and move from a daily site to a nocturnal site every day at dusk. At dawn, they come back to their previous daily site.

Fourteen Jack Snipes left the study area after radio-tagging in the Camargue. No one was relocated within a 5km-radius. This observation leads us to think that, in a large suitable habitat, the Jack Snipes are able to be very mobile during the winter period.

Introduction

In Europe, the Jack Snipe, (*Lymnocryptes minimus*), mainly winters in the British Isles, Denmark, Germany France, Spain and Italy (Cramp and Simmons, 1983; Fox, in prep.). But the wintering range of this species also spreads over Central and West Africa. In France, the Jack Snipe winters especially in the Channel and Atlantic regions and the Mediterranean as well (Yeatman-Berthelot 1991). The number of wintering Jack Snipe in France is unknown as neither specific census data, nor appropriate field survey techniques are currently available. However, a recent hunting statistics found the French hunting bag should be around 50,000 individuals (Tesson and Leray 2000). Recently, the analysis of European hunting bags and ringing data lead to consider the total autumn European population could be in the order of 2.5 to 3 million and the breeding population in the order of 500,000 pairs (Wetlands International 2002, Kalchreuter 2003).

In spite of this relatively high abundance, many aspects of the biology of the Jack Snipe remain unknown because of the secretive behaviour of this species. Very few specific studies have been performed during the wintering period (Pedersen 1995) and the breeding period (Morozov 2002).

This study was undertaken to improve our knowledge on the spatial use of the Jack Snipe during the winter period using radiotelemetry.

Methods

Study sites

The study took place in three sites: the Camargue and the Loire river estuary (Massereau Reserve) in 2000/01 and 2001/02, and the Noirmoutier Island (Mullambourg Reserve) in 2001/02 (Figure 1).

Jack Snipes were searched for in saltmarshes and freshwater habitats with low vegetation. In the Camargue, study areas were composed of *Obione* sp. and *Salicornia* sp. or *Typha* sp. In the Loire river estuary, study areas were vegetated with *Carex* sp., *Baldingera arundinacea* and *Glyceria aquatica* or in grazed or mowed reeds of *Phragmites communis*. In Noirmoutier Island, study area was grazed or mowed salt-marshes with *Juncus maritimus* and *Scirpus maritimus*.

Catching method

Three different methods were used to catch Jack Snipe:

- Mistnets (12 m x 3 m; mesh 19 mm to 30 mm) put up alone or in lines. These nets are especially efficient at twilight.
- A horizontal net was used in the Camargue. This net (10 m x 10 m) was carried by six persons. The net was taut and dragged horizontally above the ground by two people at the front and four others along the back of the net. Once disturbed and located, the aim was to

capture the Jack Snipe by flushing it under the net by the people walking behind. The net was then pulled down to immobilise the bird. (For more complete information, see Lepley *et al.* 2005).

- A pointing dog and a handnet (diameter 0.80 m; stick 5 m) were also used. The pointing dog has to point regularly to the birds at a distance of around one metre. Once the dog points, the handnet is put down at a random one metre in front of the dog.

Radio-tagging

The Jack Snipes were radio-tagged with transmitters from Biotrack® (type PIP 2; 1.2g). The transmitters were glue-mounted on the back, at the bottom of the neck where we can find a naked zone. They are given to have a \pm three weeks life duration and a distance of detection of around 300 metres. In one case, the detection reached around 800 m and the life duration 7.5 weeks.

In Loire river estuary and Noirmoutier Island, each bird was located every two hours, from two hours before sunrise to two hours after sunset. In some cases the locations were performed till 1 a.m., in other ones the locations were made from the middle of the night to sunrise in order to observe any nocturnal movements.

In the Camargue, the birds were located one to four times per 24 hours, as the number of simultaneously equipped birds as well as the relocation difficulties prevented us to locate each individuals more than a day on average.

Results

In the total, 26 Jack Snipes were radio-equipped during the two study years: one in Loire river estuary, two in Noirmoutier Island and 23 in the Camargue (12 in 2000/01 and 11 in 2001/02).

The period of location greatly varies from one study site to another and among the birds (Table 1). The three birds of the Atlantic study sites, were monitored between nine and 53 days for a number of locations comprised between 45 and 264. In the Camargue, the average period of location was four days.

Table 1. Characteristics of the radio-tagged Jack Snipes data set.

Site	Bird	Date of capture	Period of location (days)	No. of locations (day/night)
Loire river estuary (Massereau Reserve)	1	December 6, 2001	9	45 (22 / 23)
Noirmoutier Island (Müllembourg Reserve)	2	November 26, 2001	53	264
Noirmoutier Island (Müllembourg Reserve)	3	December 01, 2001	21	114 (64 / 50)
Camargue	4	January 10, 2001	22	66 (50 / 16)
Camargue	5	January 24, 2001	21	24 (20 / 4)
Camargue	6	January 30, 2001	1	-
Camargue	7	January 31, 2001	1	-
Camargue	8	February 7, 2001	7	8 (4 / 4)
Camargue	9	February 7, 2001	2	2 (2 / 0)
Camargue	10	February 9, 2001	6	18 (12 / 6)
Camargue	11	February 9, 2001	7	16 (10 / 6)
Camargue	12	February 12, 2001	2	9 (6 / 3)
Camargue	13	February 15, 2001	1	-
Camargue	14	February 15, 2001	1	-
Camargue	15	February 15, 2001	1	-
Camargue	16	December 3, 2001	14	2 (2 / 0)
Camargue	17	December 4, 2001	6	3 (3 / 0)
Camargue	18	December 5, 2001	10	4 (4 / 0)
Camargue	19	December 5, 2001	9	2 (2 / 0)
Camargue	20	December 5, 2001	1	-
Camargue	21	December 5, 2001	1	-
Camargue	22	December 10, 2001	1	-
Camargue	23	December 10, 2001	7	3 (3 / 0)
Camargue	24	January 23, 2002	1	-
Camargue	25	February 5, 2002	7	5 (5 / 0)
Camargue	26	February 5, 2002	1	-

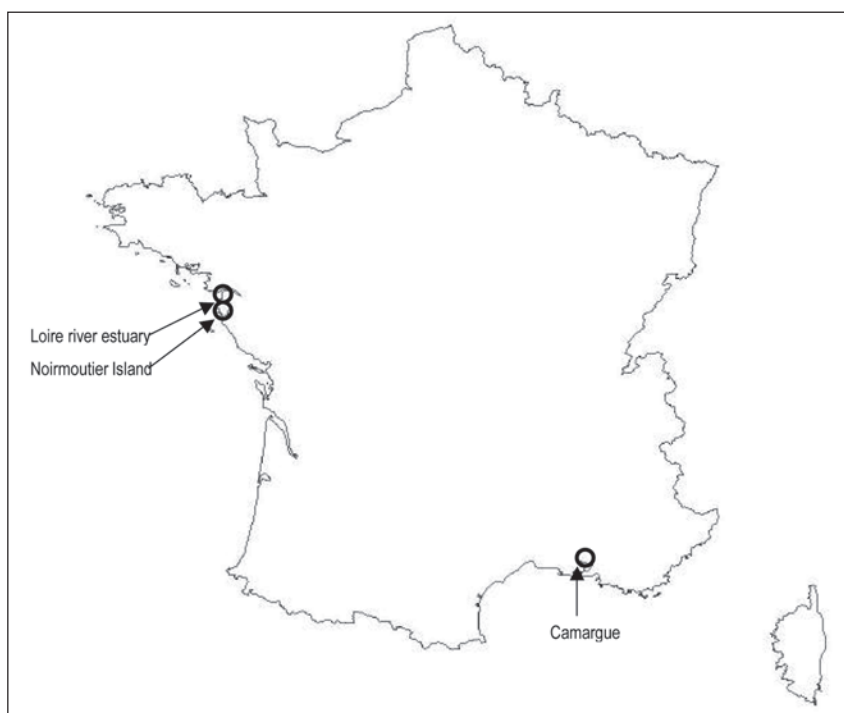


Figure 1. Location of the three study sites.

Among the 26 radio-tagged birds, 14 individuals from the Camargue were not relocated within a 5 km-radius and then probably left the study area. The very large available marshes area in this study site probably offer a great opportunity to the Jack Snipes to change their wintering site after catching.

The results are mainly focused on birds 1, 2, 3, 4 and 5 (Table 1).

Macro habitat distribution

In the Loire estuary, the bird permanently stayed in a marsh vegetated with *Carex* sp., (*Baldingera arundinacea*), and *Glyceria aquatica*. Cows use these marshes in spring and summer and some plots are mowed (Figure 2). In winter, the marshes are subject to shallow flooding.

Birds 2 and 4 showed somewhat regular movements between daily roost and nocturnal foraging area. During the day, Bird 2 was mainly located on the border of ditches, in two marshes with *Juncus maritimus* and *Puccinellia* sp. in a protected area or in ponds with

Salicornia sp.. During the night, this Jack Snipe was in general located in a pond with *Scirpus maritimus*. This bird clearly presented a circadian rhythm (Figure 3).

Bird 3 is completely different to the previous one. This Jack Snipe spent a first 10-day period in a protected area (the Müllembourg Reserve) and a second 10-day period in the ponds with *Salicornia* sp., *Polypogon monspeliensis* and *Aster tripolium*. In the middle of this period, this bird was located two days in the pond with *Scirpus maritimus* (Figure 4).

Bird 4 was located on a marsh with *Obione* sp., *Salicornia* sp. or *Typha* sp. in the Camargue. It seems that this bird stay in the marsh with *Obione* sp. during the day and *Typha* sp. during the night. This bird also presented a circadian rhythm (Figure 5).

Bird 5 was also located in the Camargue on a marsh with *Obione* sp. and *Salicornia* sp. This Jack Snipe spent the whole period on the same marsh, during the day and night (Figure 6).

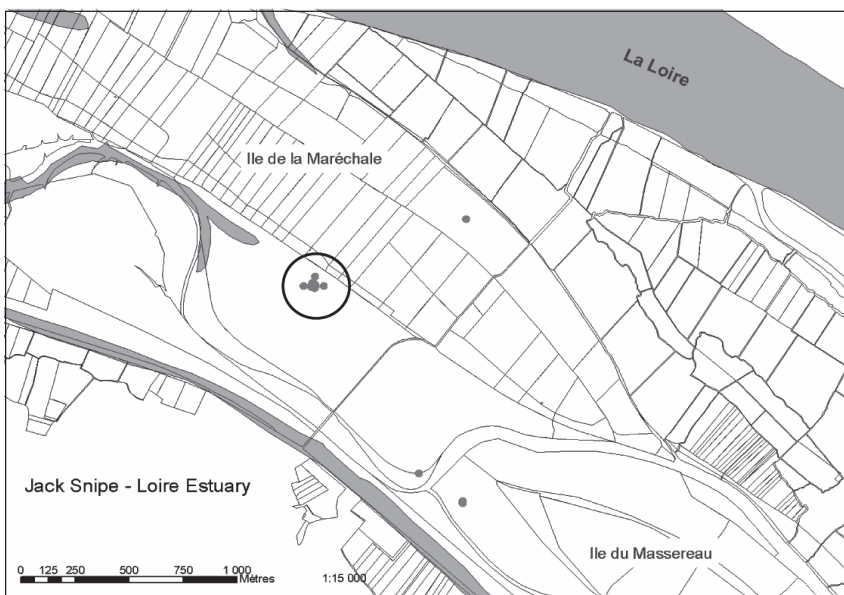


Figure 2. Dispersion pattern of Bird 1 (cf. Table 1). Diurnal locations.

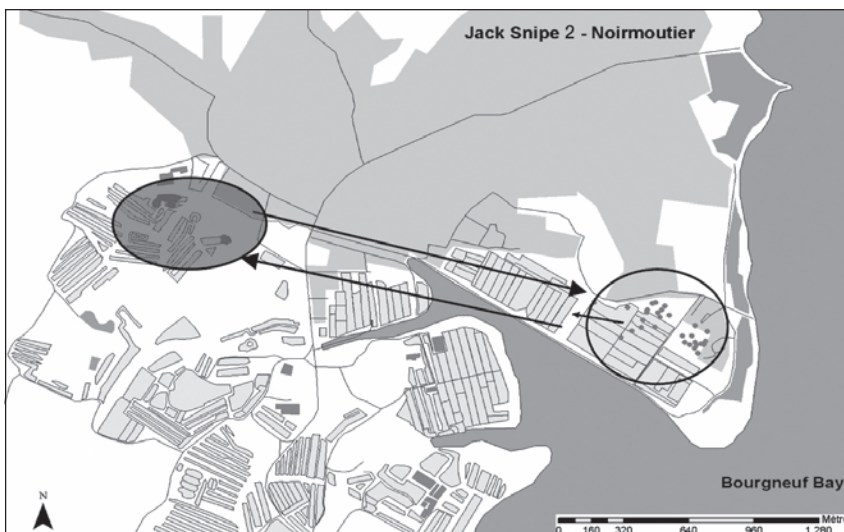


Figure 3. Dispersion pattern of Bird 2 (cf. Table 1). The nocturnal locations are indicated by the dark circle.

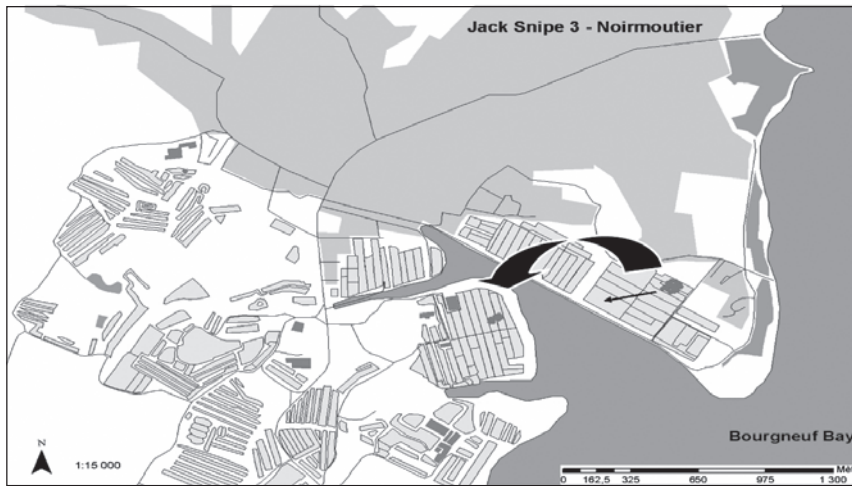


Figure 4. Dispersion pattern of Bird 3 (cf. Table 1). Diurnal locations.

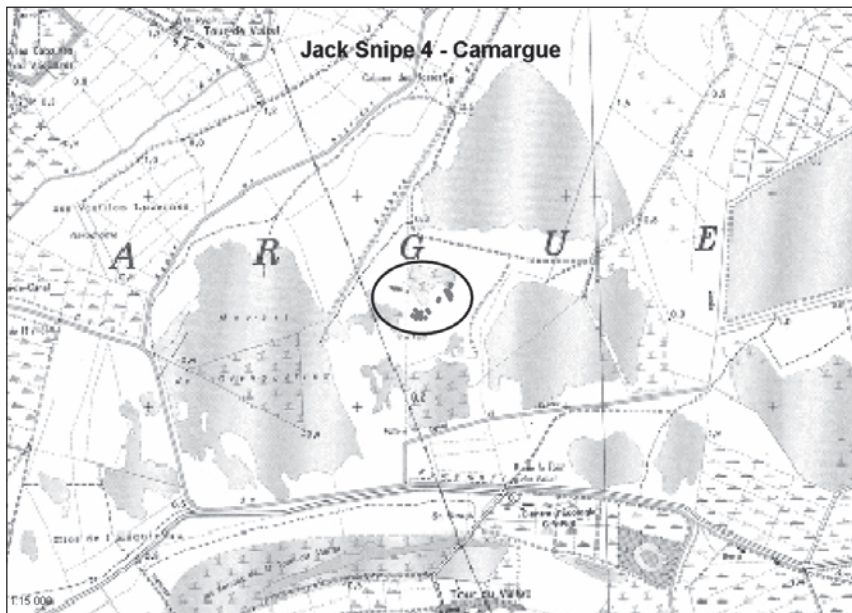


Figure 5. Dispersion pattern of Bird 4 (cf. Table 1). Diurnal locations.

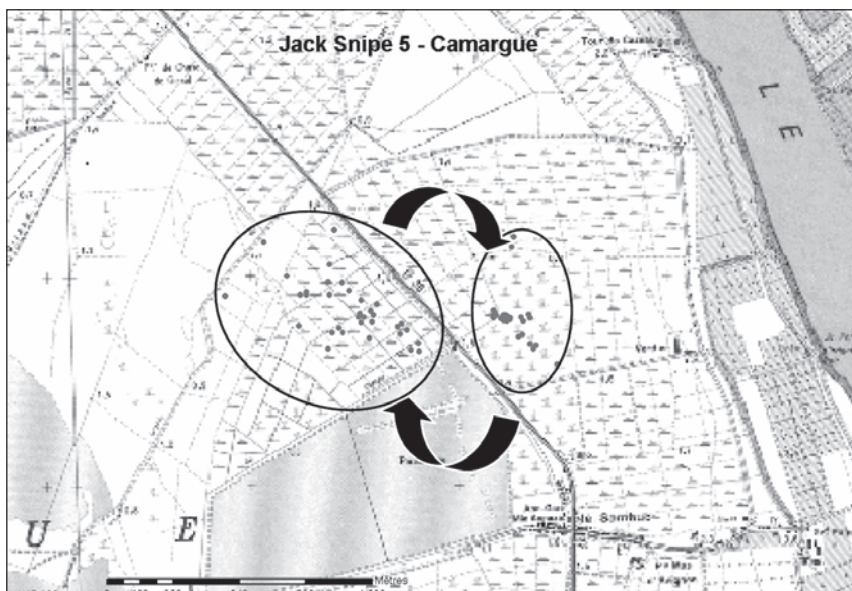


Figure 6. Dispersion pattern of Bird 5 (cf. Table 1). Diurnal locations.

Dispersion pattern

The crepuscular movements were obtained for four Jack Snipes. In the Camargue, the average distance of nocturnal dispersion was 750 m (50–5,000). In Loire river estuary, this distance was comprised between 800 m and 1,200 m. In Noirmoutier Island, one Jack Snipe regularly moved along 1,650 m and another one along 650 m.

Discussion and conclusion

In wintering, the Jack Snipes would tend to show two different strategies in spatial use. Some birds change areas between day and night. They perform a commuting flight at dawn and dusk between their roosting and foraging places. This daily rhythm may be performed during most of the winter while some other birds stay at the same place during daytime and night although they may change their permanent location after some days spent in the previous one. In this case, we can suppose that the tranquillity and feeding conditions are sufficient to encourage the bird not to move. Finally, a third category of birds stays at the same place during daytime and night but only for some days. Compared to Pedersen (1995), the radio-tagging of several individuals clearly show an inter-individual heterogeneity in the Jack Snipe daily behaviour in winter.

The Pedersen study (1995) showed that the Jack Snipes use a very small area at day and at night (app. 0.15 km² in total). Our study confirms this, and in particular that this area covers no more than some tens of square metres but can change from day to day or from night to night.

Our results must be taken with caution because over half the radio-tagged birds left the study area. Of course, this can be due to radio reception problems but can also be due to a certain wintering erratism of the Jack Snipe during the wintering period. This erratism could be the result of a cold period which occurred during our study or because of habitat modification like water-level changes which seem to have a high impact on the behaviour of Jack Snipes. These events favour bird movements as shown by Pedersen (1995) and also increase the risks of mortality linked to predation or hunting.

Two major problems were encountered in the Camargue. The first one was the type of glue used. Several attempts were made using different types of glue. The tag-cement glue appeared the most efficient with a maximum duration of eight weeks. The second problem was the distance of reception. Whereas in Noirmoutier Island, the bird could be located at 800 m, in the Camargue any bird could be located at more than 200 m probably because of the rather tall vegetation and of the relatively important surface area of private estates where regular access was

denied. For these reasons, many birds were lost very quickly and unfortunately the data set related to them is very small.

During our study an important step has been got over: the capture of Jack Snipes in winter. Now, the catching of birds should not be an obstacle to develop further research. However, radio-telemetry problems linked to the bird size, its general behaviour and its very wet habitat have to be solved before we can improve our knowledge of this species by the way of radio-tagging.

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Woodcock and Snipe

Wing survey of Woodcock and Snipe in Denmark

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The Woodcock wing survey in Denmark was initiated in 1969 and, with the exception of the period 1972–1974, has continued ever since. A wing survey of Snipes started in 1979 and has been running each year to the present day. The wing survey of Woodcock and Snipes is part of the overall Danish wing survey, which also includes ducks, geese, gulls and coot. The survey is based on voluntary assistance from hunters who are asked to send wings from bagged birds. The wings are provided with information on shooting date, place and hunting method. The wings are determined to species and age. From the data geographical and temporal distributions are prepared as well as estimation of the breeding success. The information is supporting the Danish authorities in the management of the game species in relation to preamble of the Danish Game Act and the EU-bird Directive.

Introduction

To obtain valid figures on the bag size of game species in Denmark an official Game Bag Record was introduced in 1941. According to the Game Act all licence holders are obliged to report annually on their personal bag during the past hunting season, specified to species or species groups, and to counties. This routine has been followed since. The Woodcock (*Scolopax rusticola*) had from the very beginning its own space in the Bag Record, whereas Common Snipe (*Gallinago gallinago*), Great Snipe (*Gallinago media*) and Jack Snipe (*Lympnocryptes minimus*) were not included until 1943 and then as a group “Snipes”. Therefore, the Bag Record informs about the total Snipe bag only and no details about the specific species. The hunting season for the specific species has changed over the years; the Great Snipe has been totally protected since 1967 and the Jack Snipe has been protected since 2004 (Table 1).

Wing survey for Woodcock was initiated in 1970 and has been carried out since then, except in 1982 and 1983. For Snipes the wing survey was introduced in 1979 and has been carried out every year since then as a part of a more comprehensive survey, which includes all huntable species connected to water and wetlands (ducks, geese, coot and gulls). The results of the wing survey are published annually (e.g. Clausager 2003).

The wing survey is carried out on a voluntary basis and advertisements in hunting magazines, newspapers and public information material request the hunters to send in wings from bagged birds included in the survey, giving particulars on shooting date, place and on the hunting

method used. Instructions and special post-paid envelopes are distributed to the contributors. Nearly all wings sent in are accompanied with details of exact dates and places, and 90% with details of hunting method.

This paper presents the results from the wing survey including the geographical and temporal distribution of the bag, hunting methods used, reproduction rates of the specific species and annual bag size.

Material

Wings of Woodcocks collected 1985–2002 and wings of Common Snipes and Jack Snipes collected 1979–2002 have been used for the analyses (Table 2). Information about the bag of Woodcock and “Snipes” is obtained from the official Danish Bag Record.

Results

Woodcock

Temporal distribution of the bag

The major part of the Woodcock bag taken in Denmark derives from migrants passing through in autumn. The Danish breeding population was, in the late 1980s, 1,500–2,000 ‘pairs’ (Jacobsen 1997) and thus constitutes only an insignificant proportion of the total bag. Therefore the temporal distribution reflects very much the migration pattern of the Woodcock through Denmark. The Woodcock migrates during the night and rests during the

Table 1. Hunting seasons for Woodcock and Snipes in Denmark since 1941.

Period	Woodcock	Common Snipe	Great Snipe	Jack Snipe
1941–1954	24 September–7 April	1 August–31 December	1 August–31 December	1 August–31 December
1955–1966	24 September–7 April	16 August–31 December	16 August–31 December	16 August–31 December
1967–1972	24 September–31 December 1 Mar–7 April	16 August–31 December	Protected	16 August–31 December
1972–1983	24 September–31 December	16 August–31 December	Protected	16 August–31 December
1983–2003	1 October–31 December	1 September–31 December	Protected	1 September–31 December
2004–	1 October–15 January	1 September–31 December	Protected	Protected

Table 2. Number of wings of Woodcock, Common Snipe and Jack Snipe received during 1979–2002.

Year/Species	Woodcock	Common Snipe	Jack Snipe
1979	—	343	27
1980	—	630	53
1981	—	1,280	101
1982	—	758	51
1983	—	757	69
1984	—	544	62
1985	231	388	31
1986	652	302	36
1987	511	458	44
1988	542	1,059	73
1989	592	845	62
1990	537	805	71
1991	441	484	31
1992	628	339	42
1993	495	295	13
1994	505	556	80
1995	306	530	62
1996	476	499	57
1997	313	646	35
1998	439	411	42
1999	579	640	60
2000	1,117	659	99
2001	1,039	525	92
2002	825	421	60

day. The average migration period is mid-October – ultimo November (primo December). However, the Woodcock may interrupt the migration for shorter or longer periods depending on the weather conditions. In mild periods the Woodcock will normally stay for a longer period than in cold spell periods. This means that the autumn migration may fluctuate very much from year to year. In mild autumns the start of the migration may be delayed two to three weeks compared to colder autumns where the first birds may appear early in October. In mild winters a considerable number of birds end their migration already in Denmark and stay until the spring migration back to the breeding grounds starts.

In autumn 1994 the migration pattern was very much like the average (Figure 1). In 1985 the migration was very much delayed (Figure 2), opposite to 1990 where it started very early (Figure 3). In autumn 2000 there was a considerable influx of birds in the second half of December resulting in a high number taken in the last week of the month (14% of the total bag compared to the average of 4.5%).

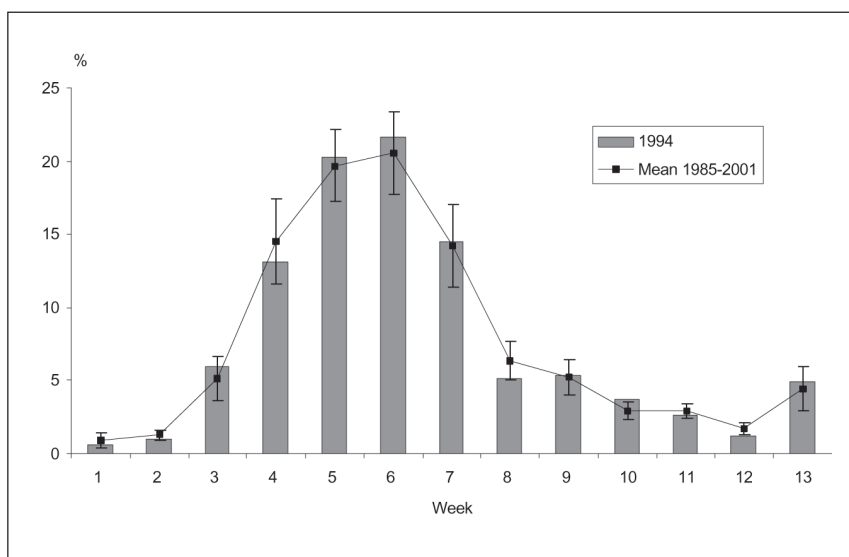


Figure 1. Temporal distribution of 504 wings of Woodcocks bagged during the hunting season 1994 and the mean temporal distribution of the period 1985–2001 with 95% confidence intervals indicated. Week 1 = 1–7 October; 2 = 8–14 October, etc.

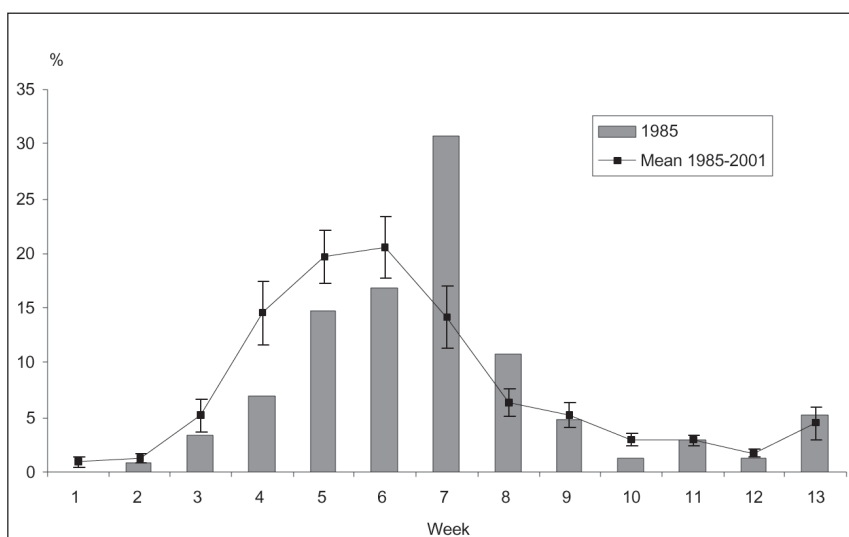


Figure 2. Temporal distribution of 231 wings of Woodcock shot in autumn 1985 and the mean temporal distribution of the period 1985–2001 with 95% confidence intervals indicated. Week 1 = 1–7 October; 2 = 8–14 October, etc.

Geographical distribution of the bag

In the official Bag Record the hunters only inform about the county where they have taken their bag. In the wing survey the hunters report the exact shooting sites, which results in a much more detailed geographical distribution of the bag. The Woodcock is a species which migrates during the night. When dawn appears the migration is suspended and the birds come down for resting. Birds reaching larger waters like the North Sea may interrupt their migration before dawn, and thus a concentration of birds builds up in coastal areas. This is convincingly demonstrated in Figures 4 and 5, where most of the birds are shot along the west coast of Jutland adjacent to the North Sea.

Hunting methods

The Woodcock has always been an attractive game species in Denmark, and Woodcock hunting is rich in tradition. The enthusiastic Woodcock hunter prefers a pointing dog to find and flush the birds. This is also

indicated in the wing survey, where 66% of the Woodcocks of which wings have been received have been taken by the use of pointers (Table 3). However, detailed analyses of the total Woodcock bag indicate that this proportion is much too high (Clausager 2000a), and a more realistic proportion is 25%. The remaining are shot more accidentally on battues, pheasant shooting and other types of hunting.

Table 3. Distribution (in %) of wings from Woodcock on the most commonly used hunting methods compared to the distribution based on detailed analyses of the total Woodcock bag (Clausager 2000).

Hunting method	Wing survey (%)	Total bag (%)
Flight hunting	1	1
Flushed birds	6	10
Use of pointers	66	25
Battues	17	30
Other methods	10	34

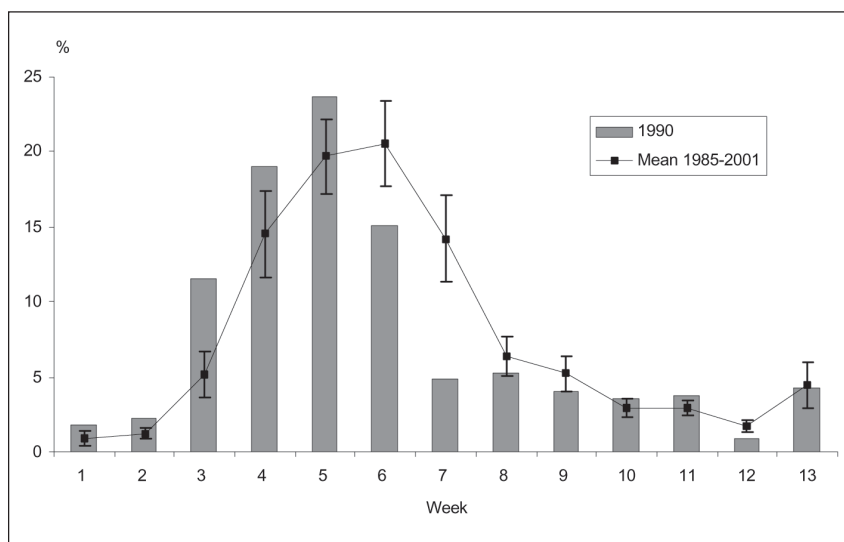


Figure 3. Temporal distribution of 537 wings of Woodcock shot in autumn 1990 and the mean temporal distribution of the period 1985–2001 with 95% confidence intervals indicated. Week 1 = 1–7 October; 2 = 8–14 October, etc.

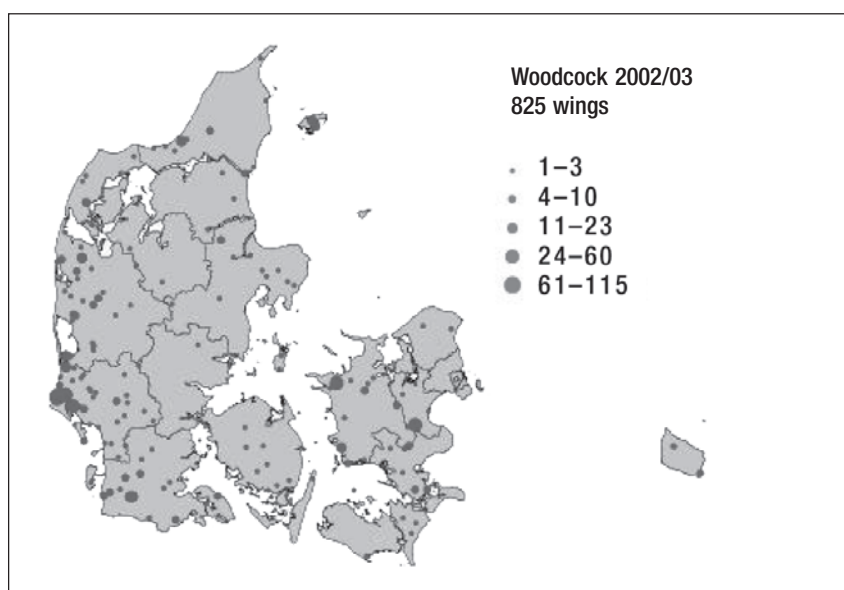


Figure 4. Geographical distribution of 825 wings from Woodcock bagged during the 2002/03 hunting season.

Reproduction

Ageing of wings received informs about the result of the recent breeding season. The age ratio found among the wings does not directly express the breeding success as immature birds most likely are shot more easily than adults. Therefore the age ratio has to be considered as a breeding index and by comparing fluctuations from year to year the development in the breeding success can be assessed. From Figure 6 it is seen that the reproduction in 1992 and 2002 was very poor, opposed to 2000 where it was very successful. The average reproduction index is 2.2 varying from 0.8 to 3.2.

Bag of Woodcock

Since 1972 when spring shooting terminated in Denmark the annual bag of Woodcock has gradually increased with fluctuations from year to year (Figure 7). The bag size is more dependent on the actual weather conditions during the migration period than on the reproduction success. In 1992 the reproduction index was the lowest for more than 20 years, but in this year the bag was well above average (34,000 birds against 24,500).

Common Snipe

Temporal distribution of the bag

The major part of the Danish bag of Common Snipe derives from migrating birds passing Denmark during autumn. The Danish breeding population is 2,500–3,000 pairs (Grell 1998). The autumn migration of the Common Snipe initiates already in late July and therefore the migration is in full progress when the hunting season opens on 1 September. The temporal distribution of the bag is already declining since the start of the hunting season, indicating that the migration has peaked before the hunting season starts. Two-thirds of the bag is taken in the first five weeks of the season and in December the average proportion makes up 1–2% (Figure 8). In mild autumns some birds stay until the end of the hunting season, as in 2000 where 5% of the wings derived from birds shot during the last 10 days of December. Every year a few individuals winter in Denmark.

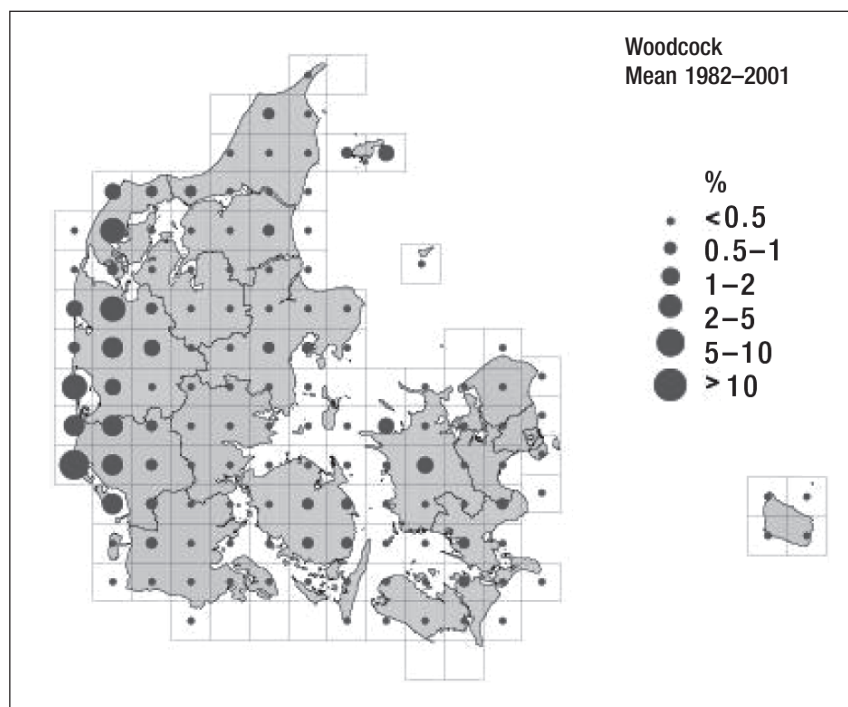


Figure 5. Mean geographical distribution (in %) of wings from Woodcock bagged in the period 1982–2001.

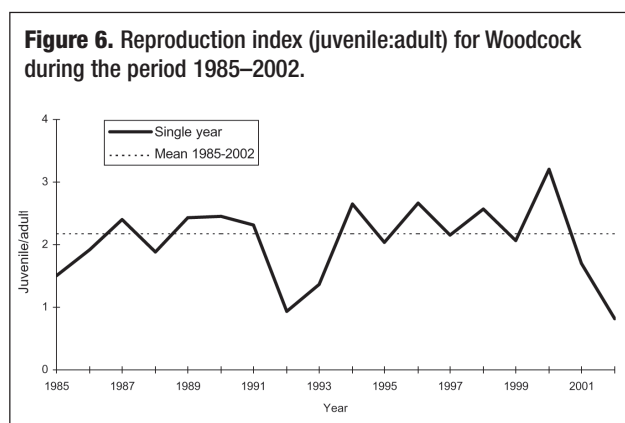


Figure 6. Reproduction index (juvenile:adult) for Woodcock during the period 1985–2002.

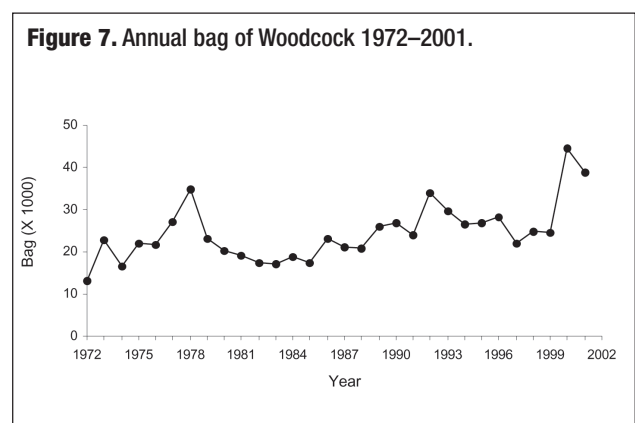


Figure 7. Annual bag of Woodcock 1972–2001.

Geographical distribution of the bag

In the official Bag Record the hunters only inform about the county where they have taken their bag. In the wing survey the hunters report the exact shooting sites which results in a much more detailed geographical distribution of the bag. The Common Snipe is closely connected to wetlands and therefore the major part is shot in regions with large areas of meadows, marshland, etc. Such habitats are found most widespread in the western parts of Denmark, and consequently most Snipes are bagged here (Figure 9). Two-thirds of the Snipe bag derives from the four most western situated counties.

Hunting methods

Although the Common Snipe is an attractive game species nearly 70% of the Snipe hunters only shoot one or two birds per season and only 4% of the hunters has a bag of more than ten Snipes per year (Clausager 2000b). The wing survey indicates that about half of the Snipes are bagged during flight hunting, especially early morning, while the other half is taken by use of pointers, or the birds are just flushed (Table 4).

Common Snipe bag

In the official Game Bag Record the Common Snipe and Jack Snipe have always been combined into one group "Snipes". Therefore the bag size of the two species has not been known before the wing survey started in 1979. The total Snipe bag increased from 40,000 to 75,000 from the mid-1940s to the mid-1970s. Then it started declining and reached a more or less stable level of 25,000 in the 1990s (Figure 10). The decrease in the bag was mainly caused by a decrease in the Common Snipe bag as this species constitutes 90% of the total Snipe bag. The declining bag has mainly been caused by drainage of wetlands for agricultural and forestry purposes, in the

Table 4. Distribution (in %) of wings from Common Snipe in the most commonly used hunting methods.

Hunting method	%
Flight hunting	45
Birds flushed	30
Use of pointers	20
Battues	2
Other methods	3

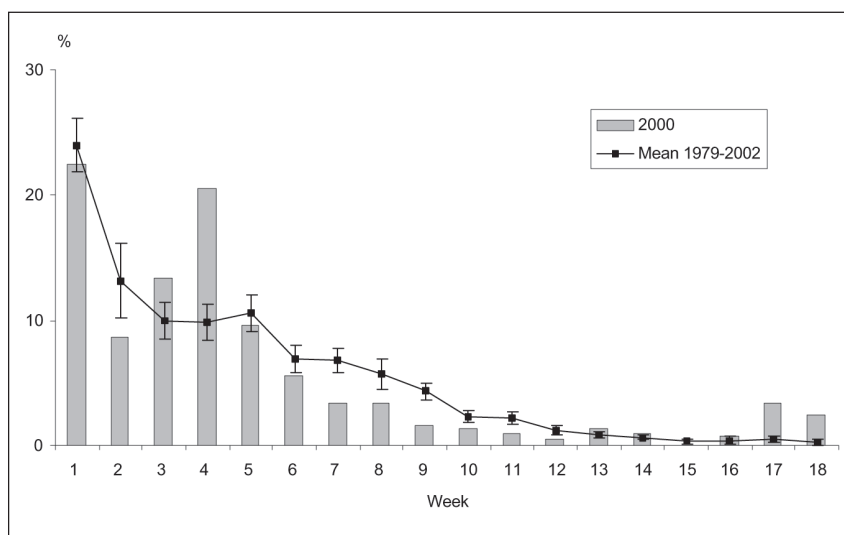


Figure 8. Temporal distribution of 658 wings of Common Snipe bagged during the hunting season 2000 and the mean temporal distribution of the period 1979–2002 with 95% confidence intervals indicated. Week 1 = 1–7 September; 2 = 8–14 September, etc.

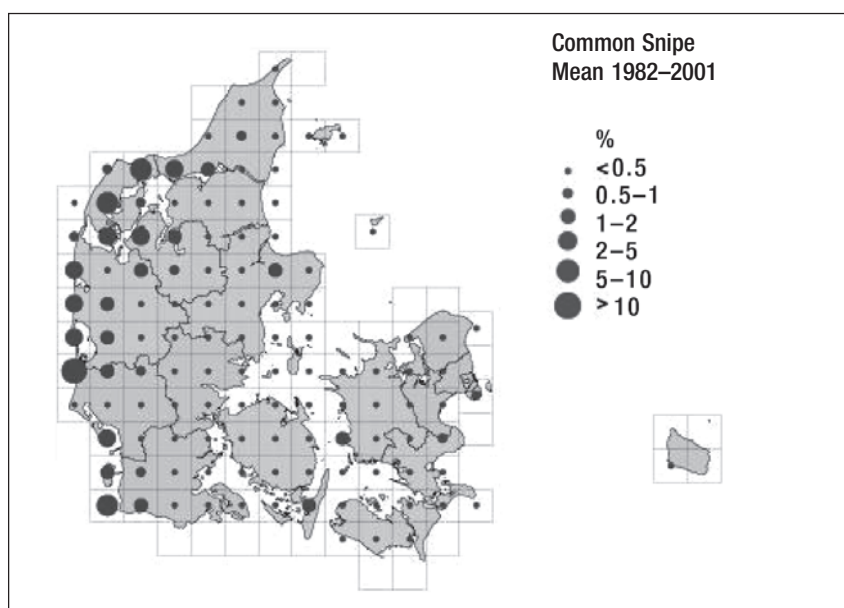


Figure 9. Mean geographical distribution (in %) of wings from Common Snipe bagged in the period 1982–2001.

breeding regions, along the migration routes and in winter quarters. In Denmark a postponement of the start of the hunting season from 16 August to 1 September in 1983 also impacted on the bag size of the Common Snipe.

Reproduction

Ageing of wings received informs about the result of the recent breeding season. The age ratio found among the wings does not directly express the breeding success as immature birds are most likely shot more easily than adults. Therefore the age ratio has to be considered as a breeding index and by comparing fluctuations from year to year the development in the breeding success can be assessed. Figure 11 shows that the average reproduction index for the period 1983–2002 is 3.6 varying from 1.8 to 6.8.

Jack Snipe

The Jack Snipe is not breeding in Denmark and occurs only during migration periods and as a scarce winter guest, though in mild winters probably some thousands are present (Grell 1998). Until now it has not been possible to age the Jack Snipe from characteristics on the wings.

Temporal distribution of the bag

The autumn migration period through Denmark is within the open season and therefore the temporal distribution of

the wings demonstrates the migration pattern very well. As rather few wings are received from each season the temporal distribution of the individual years is rather dubious, therefore all wings received during the period 1983–2002 are combined and thus present the mean autumn migration pattern (Figure 12).

Geographical distribution of the bag

The Jack Snipes are shot either in relation to general Snipe hunting or more accidentally when the birds are flushed. As the autumn migration of the Jack Snipe is later than that of the Common Snipe specific Snipe hunting is more or less terminated when the Jack Snipe migration peaks. As the Jack Snipe occurs widespread with no larger concentrations specific hunting on the species is not exercised in Denmark. There is a tendency that the species prefers more dry habitats than the Common Snipe during the autumn migration and therefore the Jack Snipes occur more inland (Figure 13).

Bag of Jack Snipe

The bag of Jack Snipe comprises a few thousand birds each season (see Figure 10). During the past 20 years the bag size has been rather constant, probably because the species has not been affected to the same degree of drainage of wetlands as the Common Snipe. Furthermore, the bag size has not been influenced by the shortening of

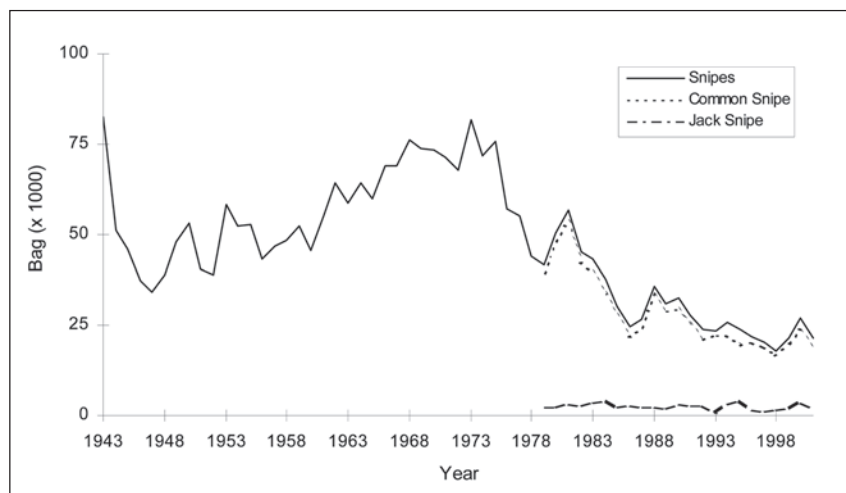


Figure 10. Annual bag of “Snipes” 1943–2002 and annual bag of Common Snipe and Jack Snipe 1979–2002.

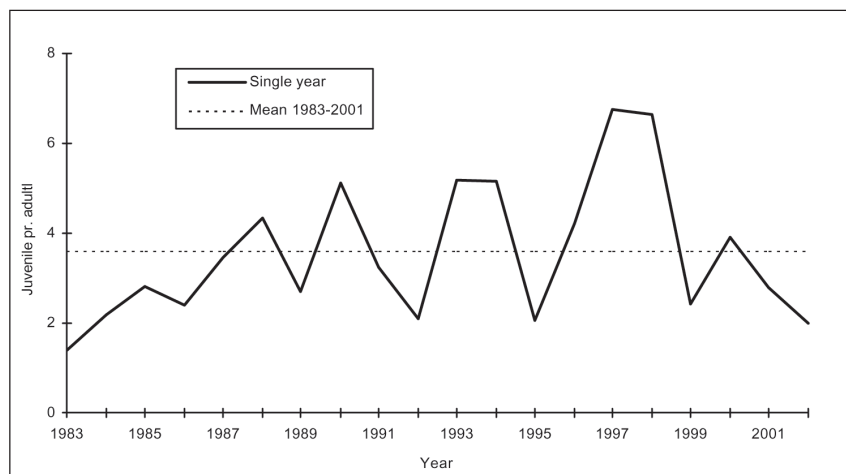


Figure 11. Reproduction index (juvenile:adult) for Common Snipe during the period 1983–2002.

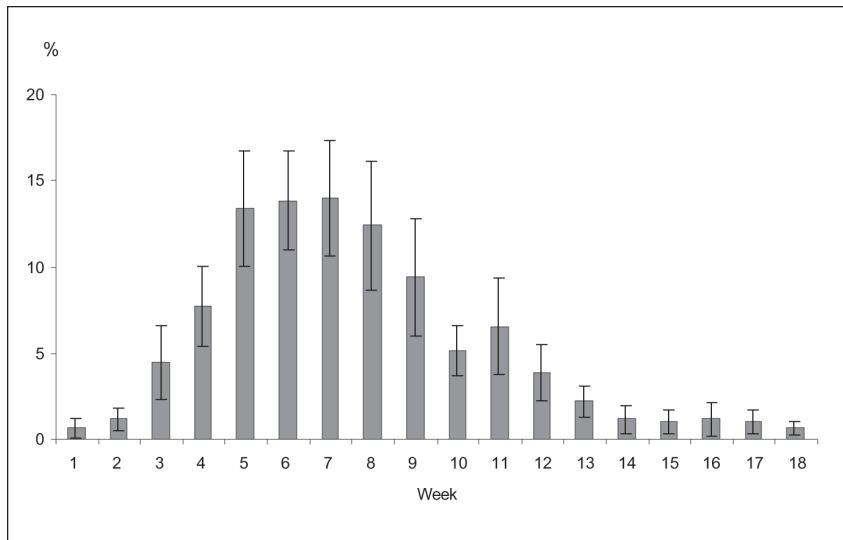


Figure 12. Mean temporal distribution of the Jack Snipe bag in Denmark of the period 1983–2002 with 95% confidence intervals indicated. Week 1 = 1–7 September; 2 = 8–14 September etc.

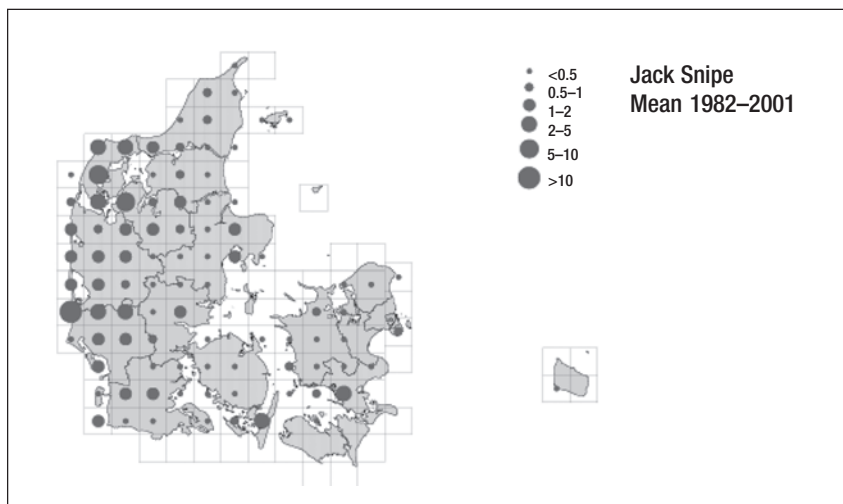


Figure 13. Mean geographical distribution (in %) of wings from Jack Snipes bagged in the period 1982–2001.

the hunting season from 1983 as the migration period is from mid September to mid November.

Acknowledgements

The Danish wing survey is carried out on a voluntary basis and could not be a success without assistance from the hunters who, year after year, contribute wings. All hunters who sent in wings are thanked for their participation. T. Fox is thanked for valuable comments on the manuscript.

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Mission:

To sustain and
restore wetlands,
their resources and
biodiversity for
future generations

This volume is the Proceedings of the 6th Woodcock and Snipe Workshop organised by the Woodcock and Snipe Specialist Group of Wetlands International and IUCN–The World Conservation Union. This international meeting was organised in November 2003 in Nantes, France and attended by 40 participants from 12 countries.

It contains 18 papers covering topics as different as breeding biology, ecology, behaviour, population dynamics, monitoring and hunting bags. These papers focused on Woodcock (*Scolopax rusticola*), Common Snipe (*Gallinago gallinago*), Great Snipe (*Gallinago media*) and Jack Snipe (*Limnocryptes minimus*). A paper on African Snipe (*Gallinago nigripennis*) is also presented. A general paper describes the conservation status of the world's Woodcocks and Snipes.

The workshop was characterised by high scientific quality and a large geographical coverage of the papers. These are the ways towards which the Woodcock and Snipe Specialist Group aims to work.

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