Spatial distribution of breeding meadow birds – implications for conservation and research

JORT VERHULST[1], SIMONE DE BROCK[1], FRANK JONGBLOED[1], WILLEM BIL[2], WIM TIJSEN[3] & DAVID KLEIJN[1,4]

[1]Nature Conservation and Plant Ecology Group, Wageningen University, Droevendaalsesteeg 3a, PO Box 47, 6700 AA, Wageningen, The Netherlands; Jort.Verhulst@gmail.com
[2]VRS Menork. De Buorren 91, 8408 HL Lippenhuizen, The Netherlands
[3]De Dolven 39,1778 JP Westerland, The Netherlands
[4]Alterra, Centre for Ecosystem Studies, Droevendaalsesteeg 3, PO Box 47, 6700 AA, Wageningen, The Netherlands

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Although numerous studies have focused on the nest and chick phase of waders, spatial data on their territory use or foraging range are rare. We quantified spatial habitat use relative to the nest site of eleven adult Northern Lapwings *Vanellus vanellus* during the nest phase and of eleven adult Redshanks *Tringa totanus* mainly during the chick phase. Both species used areas of about 0.6 ha, 72–80% of observations of adults being within 60 m of the nest site; and about half the nests were located at what seemed to be the border of the territory. Considering this small spatial scale of habitat use, our results suggest that the field scale may be too large for the implementation of habitat improvement and protection measures, such as agri-environment schemes.

INTRODUCTION

All over W Europe, populations of farmland birds are in decline (Burfield *et al*. 2005, Donald *et al* 2001). Since 1975, an ever-increasing area of agricultural land in the Netherlands has been designated as meadow bird reserve or managed under agri-environment schemes specifically for the benefit of meadow birds. Despite the fact that in 2006 conservation activities were being implemented on about 150,000 ha (van Brederode & Laporte 2006), the decline of meadow birds has never been more rapid with populations dropping almost 5% per year during 2000–2004 (Teunissen & Soldaat 2006).

One of the main causes of these declines is the uniformity of the landscapes produced by modern farming. It is increasingly being recognized that farmland wildlife requires habitat heterogeneity at different spatial scales (Benton *et al.* 2003, Vickery *et al.* 2001). For example, Northern Lapwings *Vanellus vanellus* nesting in arable fields have higher breeding success when nests are near pastures, the preferred foraging habitat of chicks, and within fields broods select those parts with a retarded crop growth (Galbraith 1988). Although numerous studies have focused on the nest and chick phases of waders, spatially explicit data on their territory use or foraging range are rare. Thus, the spatial scale at which heterogeneity needs to be present is largely unknown.

We present results of an exploratory study examining the spatial scale of territory use by two wader species in wet grasslands. We focused on Northern Lapwing and Redshank *Tringa totanus* which in recent years have both suffered moderate declines in the Netherlands (Teunissen & Soldaat 2006) and more severe declines in surrounding W European countries (Burfield *et al*. 2005). We quantified spatial habitat use relative to the nest site of adult lapwings during the nest phase and of adult Redshanks mainly during the chick phase. We examined whether common principles emerged in relation to both species despite their characteristic differences and the fact that they were studied at different stages of the breeding cycle. We discuss the potential implications of the results for conservation management and highlight knowledge gaps relating to spatial habitat use and foraging behaviour of meadow birds during the breeding season.

METHODS

Northern Lapwing study

Lapwings were studied during the 2004 breeding season on the small polder "De Dulf" in the province of Friesland in the north of the Netherlands (Table 1). This area, which is managed as a meadow bird reserve, has vegetation with species characteristic of moderate nutrient-enrichment (e.g. *Caltha palustris*, *Carex* sp.). In winter, lower fields are flooded but in spring the water level is reduced. Half the fields are mown in mid June and the rest are grazed with cattle. In some fields, grazing starts during the breeding season. The surrounding polders consist mainly of grassland used for dairy farming and some fields are the subject of agri-environment schemes for the benefit of meadow birds.

Since 2000, nest traps have been used during the last ten days of the incubation period to catch and individually colour-mark adult lapwings (rings on both legs, on one a ring with a letter and on the other a ring with a number). Because females tend to return to the nest first after disturbance, hardly any males were caught. Hence, only two ringed males were present and the results for these were omitted from the analysis. Birds were observed from a dyke and a road surrounding the polder. Also, two hides were placed in the centre of the study area to enlarge the area that could be overseen (see Fig. 1a for an overview of the lapwing study area). Because rings were difficult to read from the observation points, individuals were followed for two consecutive hours once birds had been identified. During this period a time budget was made of its behavioural activities. Only positions of birds that were spatially (e.g. after flying) or temporally (e.g. after incubating) separated were considered independent observation points and used for the analysis of spatial habitat use. Observations were limited to the incubation period because birds had been generally absent in the pre-breeding stage and a low hatching rate precluded observations in the post-breeding stage.

Redshank study

The Redshank study was carried out in the "Westerlanderkoog" in the province of Noord-Holland in the northwest of the Netherlands during the 2004 breeding season (Table 1). The Westerlanderkoog is a wet grassland polder with long, narrow fields surrounded by ditches. A large part of the polder is managed as a reserve for wintering geese (mainly Brent Geese *Branta bernicla*) and breeding meadow birds. Fields are not mown before 15 June. Two fields in the central part have postponed mowing (8 and 15 June) under an agri-environment scheme. In early spring, farmyard manure is applied but until mid May, swards are kept short by grazing geese. The vegetation has grass species characteristic of nutrient rich conditions. The Westerlanderkoog is surrounded by a high dyke and a road and both were good for making observations (see Fig. 1b for an overview of the Redshank study area). The tidal flats of the Wadden Sea are within 1 km of the polder.

Since 2000, Redshanks have been caught in the Westerlanderkoog using a nest trap or scoop net and individually colour-marked (single ring with a letter and two numbers). The use of a scoop net is possible because in the last week before hatching Redshanks tend to stay on the nests even when people approach. Because both males and females incubate, both sexes have been caught and were used in the analysis. Compared with lapwings, individually marked Redshanks were easier to identify because of their longer legs and their habit of sitting on fence poles. However, because of the Redshank's later breeding season, the vegetation was taller making it impossible to distinguish between different behaviours once they were on the ground. We therefore aimed at maximizing the number of independent observations per individual Redshank. Observations were considered independent if they were separated in time (at least four hours) or in space (at least 100 m). During incubation, Redshanks present in their territories were very inactive. Moreover in 2004 a number of the birds were only ringed at the end of the incubation period. Therefore, few Redshank observations were made during incubation but many during the chick phase. Spatial use of habitat by Redshanks did not differ significantly between the incubation phase and the chick phase (see results), so data for both periods were pooled in the analysis.

Analyses

All observations were plotted onto maps and distance from the nest was measured for each individual observation point. Only lapwings observed for more than four hours and Redshank with more than ten independent observations were included in the analyses. Observations were grouped into 15 m distance classes with observations of incubating birds being excluded. Patterns in the distribution of observations over the distance classes were analysed using nested ANOVA's (GenStat, Release 7.1, VSN International Ltd, UK) with the factor "distance class" nested within the factor "bird" and individual birds were considered replicates. For Redshank, we used an unpaired t-test to determine whether the mean distance to the nest differed between observations made in the nest phase and the chick phase. Additionally, we estimated territory size per individual using the minimum convex polygon (Harris *et al*. 1990).

RESULTS

Northern Lapwing

Eleven females were observed for more than four hours (Table 1). In total 38 nests were found, of which 12 were replacement clutches. Eight nests hatched, eight were abandoned, and the remaining 22 nests were probably depredated. Only four broods were observed. Three of them moved to grazed pasture about 200 m from the nest; the fourth female was seen trying to lead her chicks to grazed pasture.

Lapwing females were observed significantly more often within 45 m of the nest than further away (Fig. 2a) and 72% of observations were within 60 m. Birds were incubating during 53% of observation time and feeding during 25%. Birds were out of sight 8% of the time.

Observations of individual lapwings often formed irregular clusters with very skewed distributions relative to their nests (Fig. 1a). Five of the eleven lapwings observed had their nest sites on the edge of the cluster. Most birds were observed within a relatively small area and the average apparent territory size was only 0.68 ha (SE 0.18).

Two colour-marked birds were observed once on conventionally managed agricultural grasslands outside the reserve at 300 and 475 m from the nest.

Redshank

Eleven birds (including three pairs) were observed with sufficient frequency to merit analysis of their spatial distribution. During the breeding phase, seven birds were observed 31 times and during the chick phase, eleven birds were observed 187 times. On average, broods were observed for 18.7 days

Table 1. Characteristics of the Northern Lapwing and Redshank study areas in the Netherlands during the 2004 breeding season.

	Lapwing	Redshank
Coordinates of study area	53°03'N; 6°00'E	52°53'N; 4°55'E
Size of study area (ha)	30	25
No. of breeding pairs	25	25
No. of colour-ringed birds present	21	25
No. of colour-ringed birds in analyses	11	11
Males	0	4
Females	11	7
Duration of study (weeks)	9	10

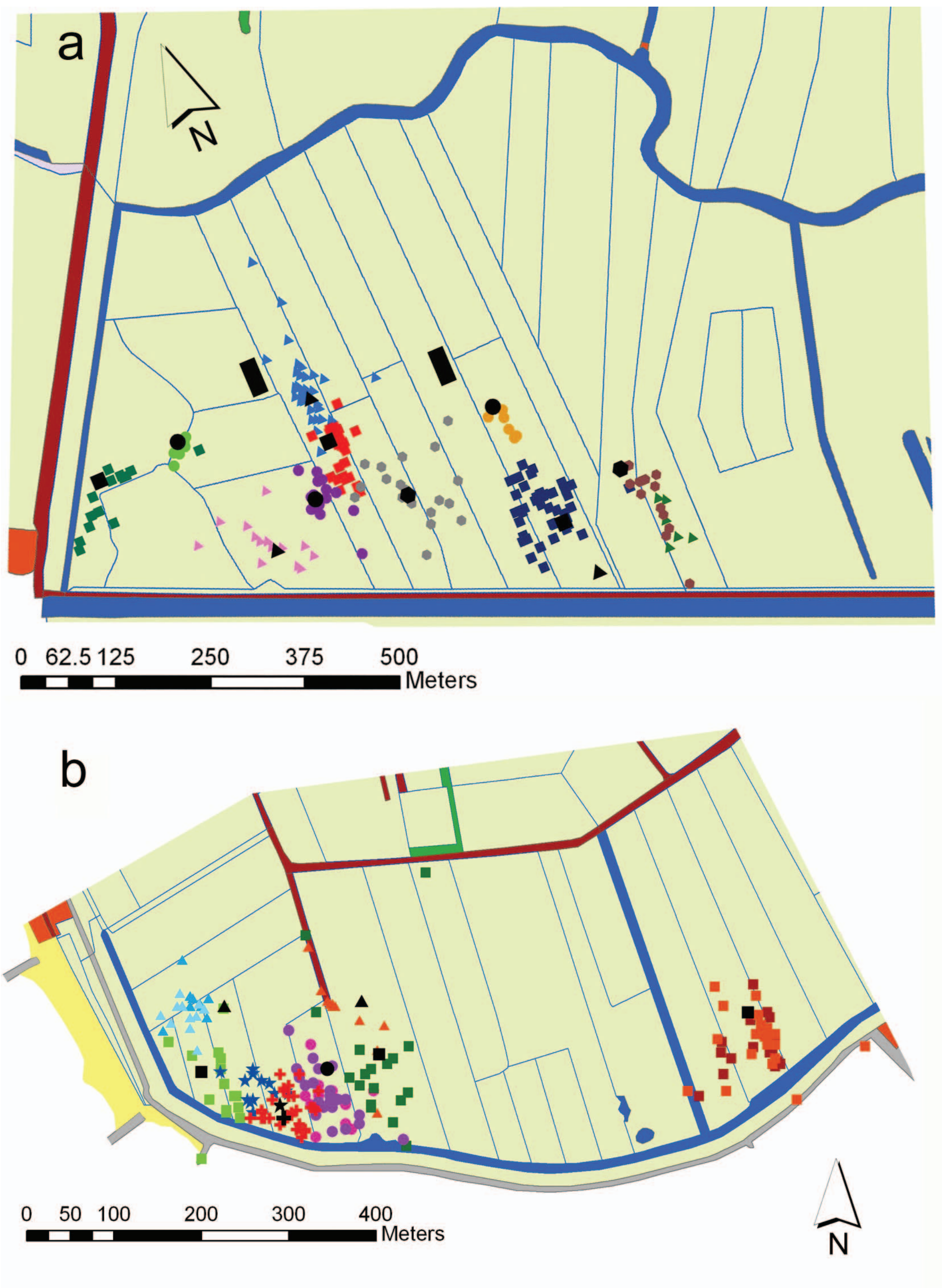

Fig. 1. Spatial distribution of observations and nests of (a) eleven female Northern Lapwings and (b) five individual Redshanks and three Redshank pairs. Different symbols and colours refer to different individuals. For each individual, the nest site is indicated with the same, larger symbol in black. For Redshank, pairs have the same symbol but closely related colours. No distinction has been made between Redshanks in the incubation phase and the chick phase. In the lapwing study area, the two black rectangles show the locations to the two observation hides. Background colours represent the following: dark red: roads; dark green: deciduous woodland; light green: meadows; yellow: beach; pale red: buildings; blue: water; grey: dyke.

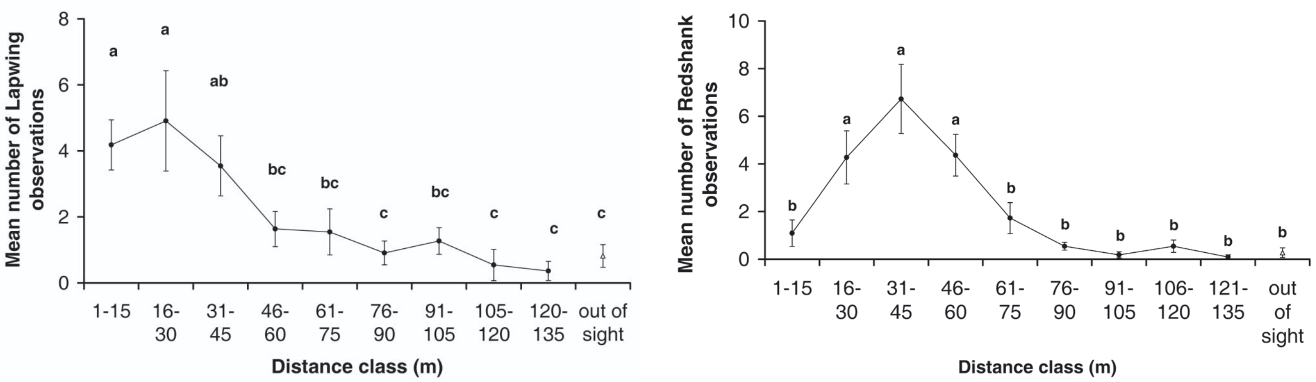

Fig. 2. Mean number of (a) Northern Lapwing and (b) Redshank observations at increasing distance from the nest in study areas in the Netherlands during the 2004 breeding season. The letters (a, b & c) indicate statistically homogenous data groups that are significantly different from each other at the level of $\alpha = 0.01$ (e.g. there were significantly more observations of Lapwings within 30 m of the nest (group a) than further than 46 m (groups b & c)).

(SE 1.7) and the average time between the last observation in the nesting phase and the first in the chick phase was 6.7 days (SE 1.7).

Redshanks were most often seen 15–60 m from the nest or the former nest (Fig. 2b); with 84% of observations in this range. Remarkably, the distances to the nest did not differ between the nest and chick phases (nest phase 50.2 m, SE 9.1; chick phase 45.8 m, SE 3.0; $t_{7.4} = -0.46$, p = 0.661).

Redshank observations and nest sites are depicted in Fig. 1b. Even in the chick phase, for which we have most data, most adults stayed very close to the nest site; only one of the eight broods moved as much as 200 m from the nest site. Seven nests were found in the south-west part of the area within 200 m of each other. Nevertheless, the overlap in spatial distribution of these birds is remarkably low. As for lapwing, four of the eight nests were on or just next to the edge of the cluster of observations. The eleven birds with at least ten independent observations had an average apparent territory size of 0.56 ha (SE 0.20).

Three colour-marked Redshanks were observed once on the tidal flats of the Wadden Sea >1 km from their nests. One of these observations occurred during incubation while the other two were during the chick phase.

DISCUSSION

Habitat heterogeneity at multiple spatial scales is increasingly being recognized as one of the key-factors determining the success of farmland wildlife (Benton *et al*. 2003, Vickery *et al*. 2001). Yet, we know hardly anything about the spatial scale with which farmland wildlife perceives the landscape and requires heterogeneity, even for such a relatively well-studied species-group as meadow birds. To our knowledge, this exploratory study is the first spatially-explicit analysis of habitat use by meadow birds. Observations were carried out in just a single year on only two species. Therefore care should be taken in interpreting the results and applying them to other situations. Nevertheless, a number of aspects seem to be significant.

In both species the adults spent most of the time in very small areas of about 0.6 ha. For lapwing, this is within the range reported in previous studies (0.3–1.6 ha; Berg 1993, Byrkjedal *et al.* 1997, Parish & Coulson 1998). Redshanks do not seem to be territorial during incubation (Hale 1956), but do defend areas of several hectares around their chicks against predators (Hale 1980). Of our observations of the adults of both species, 72–80% were within 60 m of the nest site.

The adult lapwings that were not incubating spent 53% of the time foraging. In this species, prey intake rate is positively correlated with egg-volume (Blomqvist & Johansson 1995) and egg-volume is positively correlated with chick size. Larger chicks have a higher growth rate and survival probability than smaller chicks (Galbraith 1988, Hegyi & Sasvári 1998a). This highlights the importance of the abundance of resources in the immediate vicinity of the nest site.

In this study, Redshank broods hardly moved at all over an 18-day period with only one brood dispersing as far as 200 m from the nest. The Redshank study site was managed specifically for grassland breeding waders and habitat quality was probably uniform in both space and time. This makes extensive moves unnecessary especially since moving broods may decrease chick survival (e.g. Blomqvist & Johansson 1995, Lengyel 2006). Grassland breeding waders are capable of moving considerable distances as illustrated by a pair of Redshank travelling 2 km with their one-day-old chicks (Hale 1980). Blomqvist & Johansson (1995) found that lapwing broods moved 9–332 m and Schekkerman & Müskens (2000) found a maximum dispersal distance for Black-tailed Godwit *Limosa limosa* broods of 1.6 km, but 50% stayed within 250 m of the nest. This suggests that broods of meadow birds are also capable of moving over considerable distances, but apparently they tend to stay close to the nest site when conditions are favourable.

In both species, about half the nests were located at what seemed to be the edge of the territory; certainly it was the edge of the area used by the adults. This may have been the result of territorial behaviour by neighbours. Alternatively, preferred foraging sites were not evenly distributed around the nests. We expected nests to be well within the boundary of each territory, and this result may have significant implications for other studies of meadow bird ecology. Many studies aim to explain breeding success by random samples of the environmental characteristics of the immediate vicinity of nests (e.g. Hegyi & Sasvári 1998b, Smart *et al*. 2006, Whittingham *et al.* 2002). Our results suggest that a description of environmental quality at random points around a nest may not correlate with the way that the quality of the habitat is perceived by the birds, because the birds may only use a restricted part of the area.

Implications for conservation management and future research

All our results point towards the importance of the presence of resource-rich patches at a very small scale (within no more than <200 m of one another; Fig 1). In such conditions, resources will be accessible to both adults and young and chicks will not be forced to move great distances. This should enhance chick survival (Blomqvist & Johansson 1995, Galbraith 1988, Lengyel 2006). Currently, conservation management such as agri-environment schemes is implemented at the field scale. Our results suggest that this may be too large for the creation of the heterogeneity the birds need; especially in areas where fields are large. More attention should be given to intra-field heterogeneity.

Several studies have clearly indicated the importance of territory quality for nest site selection and the breeding success of meadow birds (e.g. Berg 1993, Smart *et al.* 2006). Nevertheless birds may compensate poor territory quality by foraging outside their territory, as observed by Galbraith (1989) and Hegyi & Sasvári (1998b). Hegyi & Sasvári (1998b) found lapwing foraging trips away from nest or chicks generally to be restricted to distances of around 200 m. However, occasionally we observed adult lapwing and Redshank foraging at high quality feeding areas well over 200 m from the nest. Female lapwings might have been foraging outside their territories for at most 8% of the time they were observed. This is close to the 9% reported by Berg (1993). We therefore need to establish the importance of foraging outside the territory, particularly whether this depends on the quality of the territory compared with surrounding areas and whether there are costs associated with these foraging trips, such as an increased risk of predation.

In summary, our results highlight the importance of spatially explicit research. More such studies should be carried out for other farmland bird species or for the same species in other habitats (especially in intensively managed farmland). Insight into these spatially explicit processes is essential for the design of management practices that may further contribute to stable meadow bird populations.

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