Folia Zool. – 53(2): 179–188 (2004)

Distribution of foraging rooks, *Corvus frugilegus*, and rookeries in a landscape in eastern England dominated by winter cereals

Christopher F. MASON* and Sheila M. MACDONALD

Department of Biological Sciences, University of Essex, Colchester CO4 3SQ, UK; e-mail: masoc@essex.ac.uk

Received 25 November 2003; Accepted 24 March 2004

A b s t r a c t . The distribution and number of colonies of rooks *Corvus frugilegus* L. was studied over a three-year period in a landscape in eastern England dominated by winter cereals. Individual rookeries were generally small and not evenly distributed, with a total of 1561– 1637 nests in a 325 km^2 study area over the three years. The distribution of groups of rookeries (main colony with satellites) was associated with the amount of grassland, a colony of 100 nests requiring some 122 ha of grass within 1 km. Feeding habitat and preferences of rooks were studied throughout one year. The most consistently used feeding habitat was grassland and it was strongly preferred, with a peak in June. Winter cereals were used from October to March, but were never preferred, other crops being used seasonally. Flock size peaked in February and was smallest during the breeding season, when the mean distance of feeding flocks from the colony was less than 1 km. Increases in land given over to horses, riding and turf production could benefit rooks in the study area.

Key words: rook, *Corvus frugilegus*, grassland, feeding preferences

Introduction

The rook *Corvus frugilegus* L. is a social crow, breeding in colonies, foraging in flocks primarily on the ground and utilizing a range of animal and vegetable foods. It has been perceived as an agricultural pest and as such has been much studied in the past (L o c k i e 1955, D u n n e t t & P a t t e r s o n 1968, P a t t e r s o n et al. 1971, F e a r e et al. 1974). The rook probably evolved as a grassland feeder (L o c k i e 1955) and grassland invertebrates form an important component of the diet, especially in spring and summer. B r e n c h l e y (1984) considered that the optimum habitat for rooks was one consisting of 45% tillage and 55% grass.

In much of eastern England, livestock farming has declined over the last 40 years, grassland being converted to intensive arable farming, with extensive pesticide use to eliminate both insects and weed seeds. Furthermore, there has been a switch from spring-sown cereals to those sown in the autumn, reducing the availability of overwinter stubbles (O ' C o n n o r & S h r u b b 1986). Autumn-sown cereals grow quickly in mild autumns and are then too tall and dense by the turn of the year for some species which forage for invertebrates on the ground (M a s o n & M a c d o n a l d 1999a). This intensification has led to a severe decline over the last 20 years in the populations of many bird species associated with farmland (F u l l e r et al. 1995, B e n t o n et al. 2003); within the present study area bird species have been similarly affected (M a s o n & M a c d o n a l d 1999b, 2000). O ' C o n n o r & S h r u b b (1986) provided evidence from a number of local investigations to conclude that there had been a decline in the rook population in the UK. There

* Corresponding author

appears, however, to have been a recovery in numbers since then, with an apparent national increase of some 40% between 1975–77 and 1996 (Marchant & Gregory 1999).

There have been no studies of habitat use by rooks in the U.K. during this period of agricultural intensification over the last 20 years. Here we report on the size and distribution of rookeries in relation to land-use in an area of largely arable farmland in eastern England. We also provide information on the seasonal utilization of and preferences for farmland habitats by foraging rooks.

Study Area and Methods

The study was carried out in the Tendring District of northeast Essex, eastern England (51˚50'N 1˚10'E), a peninsula 325 km^2 in area, bounded on three sides by estuaries and the North Sea coast. Arable agriculture occupies some 63% of the area, with an additional 13% of grassland, most of it improved. Built-up areas comprise 14% of the total, the remainder being woodland (5.6%) and minor habitats.

Rookeries were located in February and March 2001 by driving all roads in the district. A rookery was defined as any active nest, or group of nests 100 m or more from the next nearest nest (Sage & Vernon 1978, Marchant & Gregory 1999). Rookeries were counted in the last week of March and the first week of April in 2001, 2002 and 2003 by two observers, and an agreed count recorded.

To investigate any relationship between land-use and the position of rookeries within the landscape, the land-use within 1 km of each rookery (314.2 ha) was mapped and the area measured in 2003. Macdonald & Whelan (1986) found that the great majority of rooks in spring foraged at distances of less than 1 km from the colony.

The land-use in each of 50 fields of known area (total area 735 ha) was determined in each month from October 2001 to October 2002 inclusive. The fields were a random subset of the 150 randomly selected fields studied by Mason & Macdonald (1999a). The crops and/or state of cultivation were recorded over a five-day period in the middle of each month, the percentage of the total area under each crop/state of cultivation being calculated.

Flocks of feeding rooks were located by driving across the district, ensuring general coverage of the study area throughout each month. Observations were made at all times of day. When a feeding flock was located, both the number of birds present and the crop/state of cultivation they were utilizing were recorded. The distance from the nearest rookery was noted. The sample size consisted of observations on a minimum of 40 flocks each month. For each month the total number of birds counted in each type of cultivation was determined and foraging preferences calculated using the preference index of Jacobs (1974).

Results

The distribution of rookeries in the district is shown in Fig. 1. The colonies were not evenly distributed, with the larger ones generally near the coast. There were substantial areas of farmland with no rookeries, although suitable nesting habitat existed. Rookeries were in small spinneys (woodlands of less than 1 ha), groups of trees, sometimes in gardens, and occasionally in single isolated trees. Some 93.5% of nests were in deciduous trees.

There were 49 rookeries in 2001. One new rookery was established in 2002 containing 12 nests, 750 m from an established colony, which itself declined by 8 nests between 2001 and 2002. Four new rookeries were established in 2003 (of 1, 8, 16, 18 nests), at distances of

Fig. 1. The distribution and size of rookeries within the study area.

250–1250 m from established colonies, two of which had declined between 2002 and 2003. One rookery of 19 nests disappeared in 2003 when the single tree in which it was located was cut down. Overall, 1561 nests were recorded in 2001, 1637 in 2002 and 1700 in 2003. However, there was no significant increase overall in rookery sizes (sign test), with some colonies increasing while others decreased. Of the 54 rookeries present in 2003, nine contained ten nests or fewer, thirty 11–40 nests, nine 41–70 nests, while only 6 rookeries were larger than this, up to 128 nests. The mean rookery size was 31.9, 32.7 and 32.1 nests in the three consecutive years of the study (median size 25 nests in all years). The overall density for the study area was 6.6 nests km^{-2} of agricultural land, and 5.0 nests km^{-2} for the study area as a whole.

To examine the relationship between rookery size in 2003 and the amount of grassland, rookeries within 1km of one another were grouped on the assumption that they consisted of a main colony with satellites. There were 24 such groups. The amount of grassland (ha) within envelopes of 1 km enclosing the groups was calculated. There was a significant relationship between group size and the total amount of grassland (Fig. 2):

$$\text{Log (colony size)} = 0.84 \text{ (log grass ha)} + 0.25 \ (t = 3.9, p < 0.001)$$

All but one individual rookery (which declined from four nests to a single one over the study period) was situated within 50 m of grassland.

The seasonal changes in land-use and the number of rooks associated with them are presented in Table 1. The predominant crops were winter cereals, made up of equal amounts of barley and wheat, and the seasonal cycle of growing, harvesting and preparation of the land for the next crop were the major influences on land-use. Very little spring cereal (barley) was grown, sugar beet and oilseed rape making up most of the other land under arable crops. Only 3.6% of the total area was under grass, and there was only a small area under set-aside. The category “other crops” in Table 1 comprised salads, onions and field beans.

Grassland was used by fewest birds in the autumn and early winter, but the proportion of birds feeding on grass increased during the breeding season and when young left the nest, peaking in June when most birds were feeding on grass (Table 1). The grassland used was not only pasture and grass cut for hay or silage but also included grass grown for turf, amenity grassland and roadside verges.

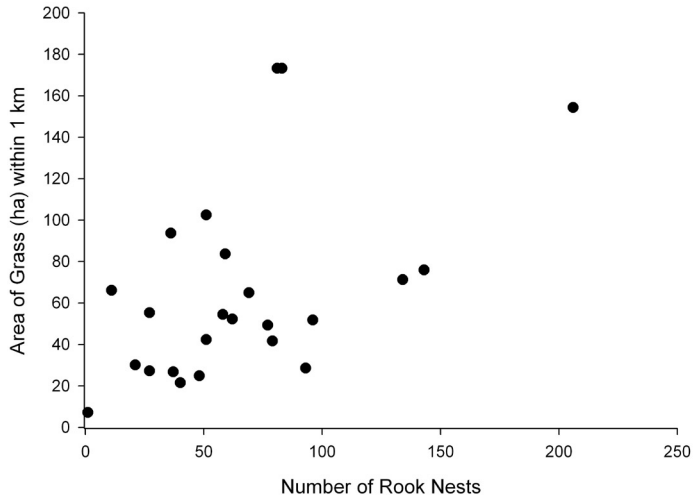

Fig. 2. Relationship between colony size (main colony and satellites) of rooks and the area of grassland within1 km.

Stubbles, especially weedy stubbles, were utilized mainly in the autumn and ploughed land mainly in January, February and August. Harrowed land (i.e. fields with soil broken and levelled ready for seeding) was utilized mostly in the autumn. The use of winter cereals as foraging habitat peaked in February and March but cereals were not used at all after April, when the crop was probably too tall to allow foraging. Rooks utilized the small amount of spring barley heavily during its period of germination and early growth.

Sugar beet, oilseed rape and potatoes were generally avoided, except when bare ground was exposed immediately after harvesting. Peas were used briefly when ripe and after harvest, presumably because of the spillage of seed. There was little use of set-aside (arable land taken out of cultivation).

The Jacobs D preference index was used to determine whether birds were using farmland habitats more or less in proportion to their availability. The results are shown in Figs 3 and 4. Grass was strongly preferred throughout the year, peaking in spring and early summer. Weedy stubble and harrow were utilized in the autumn and winter, but not at other times. There were preferences for plough only in July and August. Clean stubble was generally used much less than its availability. Sugar beet, peas and oilseed rape (not shown) were largely avoided, except for a slight preference for peas just prior to harvest in July and for rape in the early stages of growth in October. Winter cereals, the dominant land-use for most of the year, were used much less than their availability. There was a strong preference for the small amount of spring cereal during germination and early growth. A strong preference for set-aside (not shown) occurred only in June and July.

The mean size of foraging flocks is shown in Fig. 5. Flock size increased during the autumn and winter to a peak in February, thereafter declining sharply at the start of breeding activity. Flock size remained low until June, when it increased to a further peak in August. The mean distance of foraging flocks from the nearest rookery is shown in Fig. 6. The foraging distance fell steadily during the autumn and winter to a low in March and April. During March to May, when birds were incubating eggs and rearing nestlings, 79% of rooks foraged within 1 km of the nearest rookery; a further 15% were foraging at distances greater than 1 km on newly emerged spring cereals.

Table 1. Changes in land-use on 735 ha farmland in eastern England (2001–2002) and percentage of rooks feeding in each category.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Weedy Stubble	4.5	4.5	1.4	1.4	1.4	1.4	0.2	0	0	0	0	3.8	11.6
% Rooks	27.3	34.2	9.1	2.8	4.9	0.7	0	0	0	0	0	28.3	17.1
Clean Stubble	18.0	10.4	3.3	1.9	0	0	0	0	0	15.9	50.2	36.1	4.7
% Rooks	16.4	3.8	2.3	1.2	0	0	0	0	0	11.8	19.8	10.2	10.2
Plough	11.4	5.8	10.3	16.4	20.8	9.6	6.1	0	0	2.3	4.9	15.2	9.0
% Rooks	3.4	5.4	2.4	13.9	10.2	3.7	0	0	0	5.3	15.0	1.8	0
Harrow	7.2	3.2	2.4	3.3	3.3	14.9	21.6	6.1	6.1	9.3	11.6	26.1	24.5
% Rooks	19.6	11.9	31.0	35.6	8.4	11.1	11.7	3.1	1.1	17.1	12.0	18.7	23.6
Winter Cereal	28.4	46.4	53.5	53.5	53.5	53.5	53.5	53.5	53.5	38.6	10.1	0	32.0
% Rooks	13.4	17.7	25.6	23.3	46.6	47.6	2.3	0	0	0	0	0	14.4
Spring Cereal	0	0	0	0	0	0	0.9	0.9	0.9	0.9	0.9	0	0
% Rooks	0	0	0	0	0	0	36.5	25.6	0	0	0	0	0
Sugar Beet	10.9	10.1	10.1	4.1	0	0	0	11.3	11.3	11.3	11.3	11.3	11.3
% Rooks	0.8*	1.3*	0	0	0	1.2*	0	3.7	0	0	0	0	0
Oilseed Rape	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9	1.8	0	2.9	3.1
% Rooks	1.0	0	2.9	0	0	0	0	0	0	0	0	0	5.2
Peas	0	0	0	0	0	0	0	4.1	4.1	4.1	0	0	0
% Rooks	0	0	0	0	0	0	0	0	0	6.9	17.8*	0	0
Potatoes	0	0	0	0	0	0	0	4.2	4.2	2.6	0	0	0
% Rooks	0	1.6*	0	0	0	0	0	0	0	0	0	0	0
Other Crops	1.9	1.9	1.3	1.3	3.3	3.6	0.7	2.9	2.9	7.2	7.2	0.8	0
% Rooks	0	0	0	0	0	0	0	0	0.6	2.6	0	0	0
Set-aside	3.2	3.2	3.2	3.2	3.2	2.5	2.5	2.5	2.5	2.5	0.2	0.2	0.2
% Rooks	1.0	0	0	2.5	0	0	1.4	3.2	7.0	6.2	0	3.4	0
Grass	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
% Rooks	17.1	24.0	26.7	20.7	29.7	35.8	48.1	62.1	83.8	49.0	34.5	36.5	26.0
Total Rooks	1258	1285	2257	2373	2848	1074	784	845	956	1542	2197	1131	1251

* in recently harvested crops

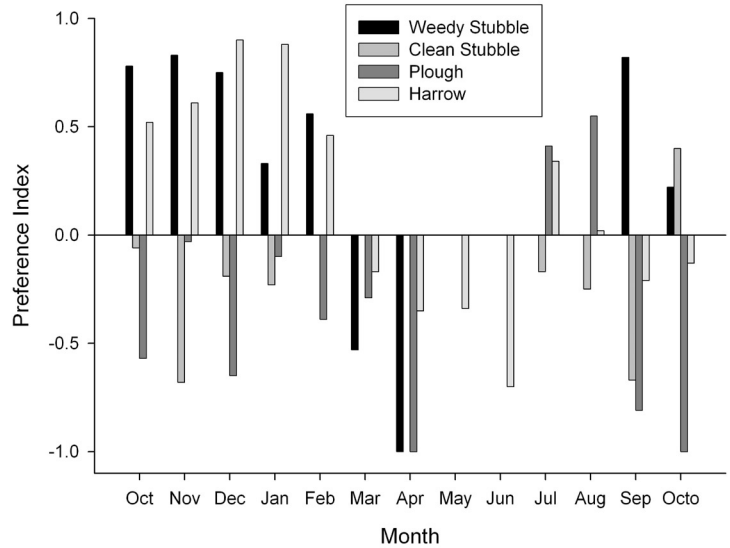

Fig. 3. Foraging preferences by rooks (weedy and clean stubbles, ploughed and harrowed land).

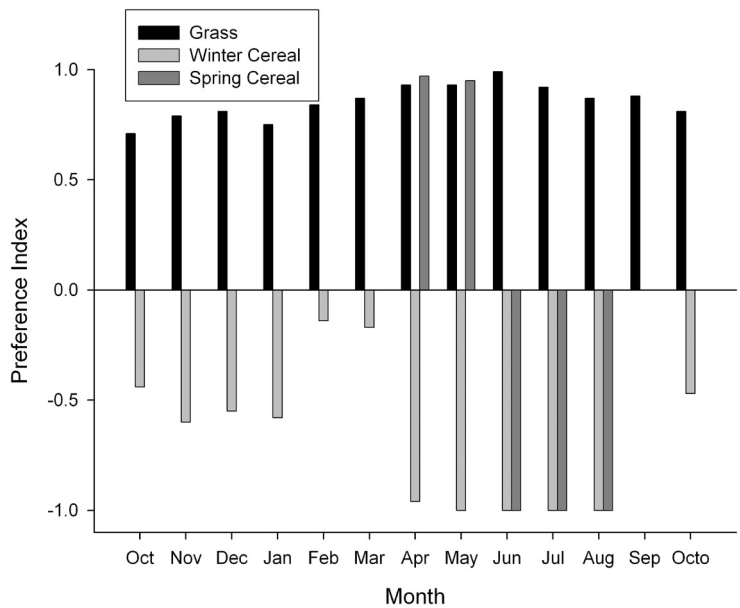

Fig. 4. Foraging preferences by rooks (grassland, winter and spring cereals).

Discussion

Land-use was described in each month from observations of 50 randomly selected fields totalling 735 ha. The proportion of land under different crops in each month was very similar to that observed in the more extensive earlier studies in the district by M a s o n & M a c d o n a l d (1999a, 2000), where study areas totalled 1815 ha and 4000 ha respectively. The land-use recorded in this study was therefore representative of the district as a whole.

Because of the high density of roads in the area and the conspicuous nature of the birds early in the breeding cycle, we believe that all rookeries were located. Five rookeries found in subsequent years were all in sites searched in 2001. The mean rookery size (32.2 nests over the three years) was very similar to that recorded for eastern England (32.9 nests) and southeast England (28.0 nests) in the 1996 national survey (Marchant & Gregory 1999). The overall nest density in the study area (5.0 nests km^{-2}) compares with 3.5 nests km^{-2} (eastern England) and 5.2 nests km^{-2} (southeast England) in the 1996 survey (calculated from data in Table 2 of Marchant & Gregory 1999).

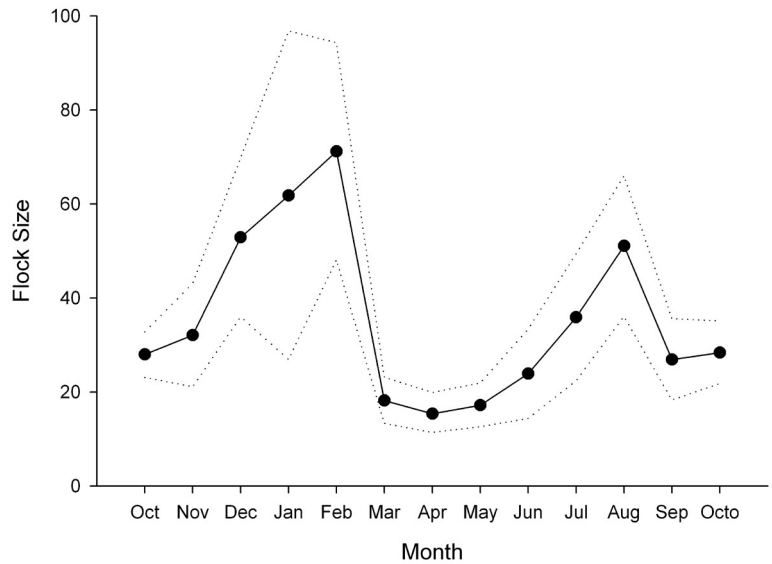

Fig. 5. Monthly mean size (± SE) of rook flocks.

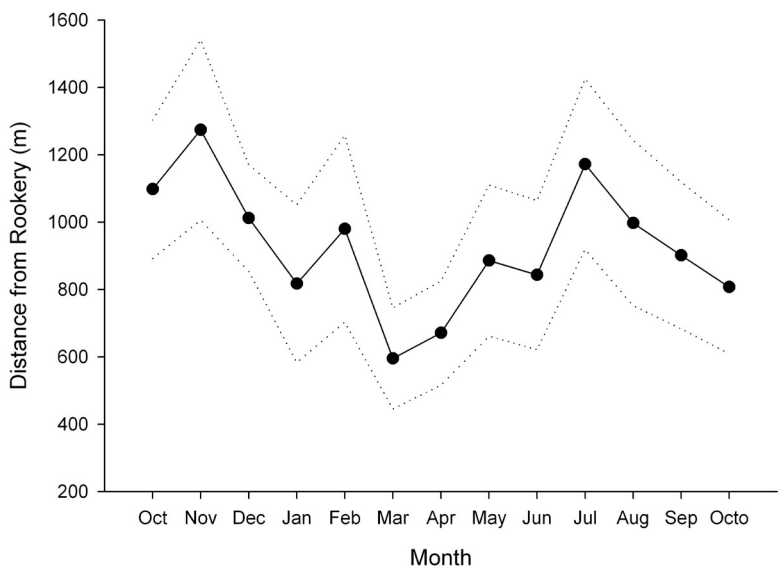

Fig. 6. Monthly mean distance (± SE) of rook flocks from nearest colony.

Young rooks are fed almost exclusively on soil-dwelling invertebrates during their first two weeks of life (Lockie 1955). Permanent grassland is likely to be the most reliable source of such food. The size of groups of rookeries (main rookery with satellites) was strongly related to the amount of grassland within one km of the group in the study area, while all but one small individual rookery was situated adjacent to grassland. Rookery size was also related to area of grassland in northern England (Griffin & Thomas 2000). The majority of rooks in our study area fed in grassland from late April to June inclusive and the preference index reached a maximum at this time, emphasising the importance of grass to the success of breeding. Most rooks were then also foraging within one km of the colony, as also observed by Macdonald & Whelan (1986) and Kasprzykowski (2003). Brenchley (1984) showed that rook densities were highest with a combination of 55% grass and 45% tillage, a pattern broadly confirmed by the large-scale bird distribution study of Atkinson et al. (2002). Our study area as a whole had only 13% grass, which might explain the patchy distribution of rooks. Although, in this study, we did not quantify the types of habitat in areas with suitable nesting sites but no rooks, in an earlier study of farmland birds (Mason & Macdonald 2000) six tetrads (2400 ha in total) with no rooks but with suitable nesting sites averaged only 5% grassland (range 0.8–10.0%). In the present study, all but one of the rookery groups had least 20% grassland within 1 km – the exception was a small, isolated colony which declined to a single nest. Extrapolation from the regression of colony size with area of grassland suggests that a colony (with satellites) of 100 nests would require some 122 ha of grassland within 1 km, 39% of the total area. The variation in the overall relationship may be related to the quality of individual grasslands as foraging habitat for rooks.

The population of rooks in the United Kingdom increased by some 40% between the mid-1970s and 1996, though it was not as high as in the mid-1940s (Marchant & Gregory 1999). This is in contrast to the decline in many farmland bird species over the last three decades and may seem surprising in view of the conversion of much permanent grassland to arable in lowland England. The reason for the increase is unknown but several suggestions were made by Marchant & Gregory (1999). Foraging opportunities provided by outdoor piggeries, landfill sites and increased carrion on roads could be considered in our study area. However, although we have frequently observed rooks foraging at piggeries in eastern England, the heavy nature of the soil in our study area militates against outdoor piggeries. There is only one landfill site in the district. Although rooks will take carrion from roads, they do so infrequently and of 125 observations of carrion-feeding by birds in eastern England, only two related to rooks (Mason & Macdonald 1995). Two agricultural changes may be benefiting rooks in the study area. Firstly, there has been an increase in the amount of land given over to horses, riding schools and liveries, especially around villages, as farmers diversify their operations. Much of this grazing land has been converted from arable. Grassland strips around arable fields are also created to allow horse riding away from roads. Secondly, there has been an increase in the land devoted to turf production; while still occupying a small area, turf fields were extensively used by rooks throughout the year.

The months of June and July are considered critical to the survival of rooks, especially recently fledged birds, because dry weather often renders soil invertebrates unavailable, while the grain harvest has not yet started. During harvesting, modern machinery produces far less spillage than in earlier years (Dunnet & Patterson 1968, Murton 1971, Feare et al. 1974, O'Connor & Shrubb 1986). Some 84% of rooks were feeding

on grassland in June. By July the percentage had fallen as barley stubbles became available by mid-month, while some land had been ploughed and harrowed, allowing rooks access to the soil. During June, and to a lesser extent in July to September, rooks were observed foraging on estuarine mudflats and salt marshes at a number of sites – 7.5% of the total birds recorded in June, with flocks of up to 50 individuals. This might indicate some difficulties in feeding on agricultural land but alternatively rooks may have learnt to exploit a novel habitat rich in invertebrates.

Grassland was highly preferred as a feeding habitat throughout the year, despite occupying only a small area. Preference for this habitat increased to a maximum in spring and early summer, as described above. A number of authors have found permanent grass to be a preferred habitat for winter foraging (Waite 1984, Tucker 1992, Wilson et al. 1996, Rolando et al. 1998). In our study area, many of the other available feeding locations were used less than would be expected from their availability in the landscape. This is especially clear with winter cereals, which, although exploited by rooks, was never a preferred feeding habitat, as observed also by Tucker (1992) and Kasprzykowski (2003). Winter cereals were avoided entirely from May, when presumably the crop was too tall to allow efficient foraging. Fields with spring cereals were heavily utilized by rooks for a short time in April and May but the crop quickly became too tall. Weedy stubbles were a preferred feeding habitat in autumn and winter, but conventional clean stubbles, with little weed growth, were used much less than their availability. Similarly, ploughed land was used much less than its availability, but when harrowed to produce a seedbed in autumn and early winter it became a preferred feeding habitat. Set-aside land was used preferentially in June and July, presumably after it had had time to develop populations of invertebrates and weed seeds (Kennedy 1992, Draycott et al. 1997). Food put out for livestock, an important food source for rooks in cold conditions in some areas (Feare et al. 1974), is almost unavailable in our study area, and we have only one record of its use, in May.

The mean flock size was smallest in spring when birds were breeding. It rose to a peak in August but subsequently declined, probably as a greater range of foraging opportunities were available post harvest. Mean flock size then rose to a peak in February, before falling dramatically with the onset of the next breeding cycle. Macdonald & Whelan (1986) also recorded flocks at their largest in late winter in Ireland. The distance that flocks were recorded from the nearest rookery was least during the breeding season, when most birds were found within 1 km, as found also by Macdonald & Whelan (1986); birds foraging at greater distances were making use of fields of newly germinated spring barley. The foraging distance was greatest in summer and late autumn, a pattern different from that of Macdonald & Whelan (1986), who recorded peaks in late summer and late winter. Patterson et al. (1971), in northeast Scotland, found the winter feeding range to be the smallest. The birds in the study of Macdonald & Whelan (1986) were tagged and could be directly related to their origin, whereas birds in our study could not. Furthermore we were aware of a substantial flock of rooks flying at dawn into our study area from the north across an estuary on many mornings in winter, returning at dusk. Clearly therefore the rooks we recorded feeding in our study area in winter were not all birds from local rookeries and indeed it is possible that some local birds may have foraged outside of the study area in winter. Differences in availability of patchy resources are likely to explain variations in foraging distances in the different study areas.

In conclusion, the distribution and amount of grassland, a scarce resource in this study area dominated by winter cereals, determined the distribution and size of rookery groups, with breeding rooks absent from substantial parts of the study area lacking grass, despite

suitable nesting habitat. Rooks ranged more widely outside the breeding season, taking advantage of feeding opportunities provided by the farming cycle, but grassland remained a preferred habitat. Changes in land-use, such as the increases in grassland for horse-riding and increasing turf production, could prove beneficial to the species.

LITERATURE

ATKINSON P.W., FULLER R.J. & VICKERY J.A. 2002: Large-scale patterns of summer and winter bird distribution in relation to farmland type in England and Wales. *Ecography 25: 466–488*.

BENTON T.G., VICKERY J.A. & WILSON J.D. 2002: Farmland biodiversity: is habitat heterogeneity the key? *Trends Ecol. Evol. 18: 182–188*.

BRENCHLEY A. 1984: The use of birds as indicators of change in agriculture. In: Jenkins D. (ed.), Agriculture and the environment. *Natural Environment Research Council, Cambridge: 123–128*.

DRAYCOTT R.A.H., BUTLER D.A., NOSSMAN J.J. & CARROLL J.P. 1997: Availability of weed seeds and waste cereals to birds on arable fields in spring. In: Proceedings of the 1997 Brighton Crop Protection Conference. *British Crop Protection Council, Farnham: 1155–1160*.

DUNNET G.M. & PATTERSON I.J. 1968: The rook problem in north-east Scotland. In: Murton R.K. & Wright E.N. (eds), The problems of birds as pests. *Academic Press, London: 119–139*.

FEARE C.J., DUNNET G.M. & PATTERSON I.J. 1974: Ecological studies of the rook (*Corvus frugilegus*) in north-east Scotland: food intake and feeding behaviour. *J. Appl. Ecol. 11: 867–896*.

FULLER R.J., GREGORY R.D., GIBBONS D.W., MARCHANT J.H., WILSON J.D., BAILLIE S.R. & CARTER N. 1995: Population declines and range contractions among lowland farmland birds in Britain. *Conserv. Biol. 9: 1425–1441*.

GRIFFIN L.R. & THOMAS C.J. 2000: The spatial distribution and size of rook (*Corvus frugilegus*) breeding colonies is affected by both the distribution of foraging habitat and by intercolony competition. *Proc. R. Soc. Lond. B 267: 1463–1467*.

JACOBS J. 1974: Quantitative measurement of food selection. *Oecologia 14: 413–417*.

KASPRZYKOWSKI Z. 2003: Habitat preferences of foraging Rooks *Corvus frugilegus* during the breeding period in the agricultural landscape of eastern Poland. *Acta Ornithol. 38: 27–31*.

KENNEDY P.J. 1992: Ground beetle communities on set-aside and adjacent habitats. In: Clarke J. (ed.), Set-aside. *British Crop Protection Council, Farnham: 154–164*.

LOCKIE J.D. 1955: The breeding and feeding of jackdaws and rooks with notes on carrion crows and other Corvidae. *Ibis 97: 341–369*.

MACDONALD R.A. & WHELAN J. 1986: Seasonal variation in feeding range and flock structure of the Rook *Corvus frugilegus* in eastern Ireland. *Ibis 128: 540–557*.

MARCHANT J.H. & GREGORY R.D. 1999: Numbers of nesting Rooks *Corvus frugilegus* in the United Kingdom in 1996. *Bird Study 46: 258–273*.

MASON C.F. & MACDONALD S.M. 1995: Corvids feeding on carrion. *Bird Study 42: 255–256*.

MASON C.F. & MACDONALD S.M. 1999a: Habitat use by Lapwings and Golden Plovers in a largely arable landscape. *Bird Study 46: 89–99*.

MASON C.F. & MACDONALD S.M. 1999b: Winter bird numbers and land-use preferences in an arable landscape in eastern England. *Bird Conserv. Internatl. 9: 119–127*.

MASON C.F. & MACDONALD S.M. 2000: Influence of landscape and land-use on the distribution of breeding birds in farmland in eastern England. *J. Zool. 251: 339–348*.

MURTON R.K. 1971: Man and Birds. *Collins, London*.

O'CONNOR R.J. & SHRUBB M. 1986: Farming and Birds. *Cambridge University Press, Cambridge*.

PATTERSON I.J., DUNNET G.M. & FORDHAM R.A. 1971: Ecological studies of the rook, *Corvus frugilegus* L., in north-east Scotland. Dispersion. *J. Appl. Ecol. 8: 815–833*.

ROLANDO A., PEILA P. & MARCHISIO M. 1998: Foraging behaviour and habitat use in corvids wintering on farmland in northern Italy. *Avocetta 22: 56–64*.

SAGE B.L. & VERNON J.D.R. 1978: The 1975 national survey of rookeries. *Bird Study 25: 64–86*.

TUCKER G.M. 1992: Effects of agricultural practices on field use by invertebrate-feeding birds in winter. *J. Appl. Ecol. 29: 779–790*.

WAITE R.K. 1984: Winter habitat selection and foraging behaviour in sympatric corvids. *Ornis Scand. 15: 55–62*.

WILSON J.D., TAYLOR R. & MUIRHEAD L.B. 1996: Field use by farmland birds in winter: an analysis of field type preferences using resampling methods. *Bird Study 43: 320–332*.