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Predominantly northward dispersal of Grey Herons *Ardea cinerea* from a heronry in Greater Manchester, UK

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In 1988 a ringing study was commenced with the aim of determining patterns of dispersal from a large heronry in Greater Manchester, north-west England. Between 1988 and 2008, over 900 nestling Grey Herons *Ardea cinerea* were ringed at the heronry, rings from 53 of which were subsequently recovered. The overall annual recovery rate was 5.7% but this declined significantly from 7.5% between 1988 and 1996 to 3.8% between 1997 and 2007. Around 60% of ring recoveries were within the first year of the bird's life. There was a statistically significant bias in dispersal direction towards the north-east, with a number of birds being reported in midwinter up to 100 km to the north-east. This predominantly north-eastward dispersal may have been associated with a range extension in that direction, facilitated by a succession of milder winters.

Dispersal is a fundamental life-history process and, in most bird species, post-fledging dispersal occurs once young become independent of their parents (Newton 2008). Dispersal distance and direction are highly variable within and between species, and for large colonial birds it may be necessary for birds to explore potential new feeding and breeding sites further afield (Newton 2008). The Grey Heron *Ardea cinerea* is a widely distributed breeding species in Britain with around 13,400 nesting pairs estimated in 2003 (Baker *et al* 2006). Ring recoveries have shown that young birds disperse a median distance of 60 km from their natal site within the first few months of fledging; dispersal is in all directions, with the longest movements being to the south (Marquiss 2002). Mortality is high during the first winter, particularly during cold weather, and birds surviving to breeding age return to a median distance of 28 km from their natal colony (Marquiss 2002).

North-west England held three of the ten largest heronries in the UK in 2005 (Norman 2008, J.H. Marchant pers. comm.). Over the past 20 years, Botany Bay Wood, the largest heronry in Greater Manchester, held between 80 and 120 occupied nests and in 2008 contained around 40% of the nesting herons in Greater Manchester (S.M. Suttill pers. comm.). In 1988 a ringing study was commenced with the aim of determining patterns of dispersal from the colony. Here, the results of recoveries from over 900 nestlings ringed at the site have been analysed.

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METHODS

Study site and data collection

The study site was located within Botany Bay Wood, Worsley, Greater Manchester, UK at 53°29'N 2°25'W. It is a planted mixed woodland comprising mainly Scots pine *Pinus sylvestris*, silver birch *Betula pendula*, larch *Larix decidua*, oak *Quercus robur* and beech *Fagus sylvatica* with an understorey of *Rhododendron* sp. It is a private site but is used for leisure activities, primarily clay pigeon shooting. The heronry was first established in the 1930s but was not surveyed systematically until 1988. Before this, it was thought to hold around 10 pairs (Holland *et al* 1984) but, since 1988, there have been between 80 and 120 occupied nests annually, although accurate counts are difficult owing to the dense understorey. No survey was undertaken in 2001 owing to restrictions imposed during an outbreak of foot-and-mouth disease. The site is several kilometres away from suitable wetland feeding sites and birds can regularly be seen flying to and from the heronry in all directions during the nesting season.

Nests were mainly at heights of 10–15 m in mature Scots pine, often with several nests in the same tree. In the mid 1990s the colony relocated 200 m to the east in an area of younger Scots pine plantation but reverted to the original site after a few years following the introduction of clay pigeon shooting within 600 m of the heronry. During the 1980s and 1990s some birds nested in beech, larch and oak peripheral to the pine plantation but since 2000 almost all

Ringing of pulli was undertaken during April and May every year since 1988, with the exception of 2001. Clutch, total brood and live brood sizes were recorded for all broods in which pulli were ringed, noting numbers of unhatched eggs and dead young within, around or beneath the nest. Analysis was restricted to those nests which were accessible and in which at least one nestling was of a suitable size to ring. Grey Herons are generally single brooded in the UK (Cramp & Simmons 1977) and all data refer to first broods or first replacement broods; although a variable number of pairs attempt second broods, no visits were made to the heronry after May. All recoveries were reported through the British Trust for Ornithology and date of finding, distance and direction of movement were recorded. A few ringed birds were found dead underneath nests prior to fledging and these have been excluded from the analyses.

Statistical analysis

Differences between years for mean clutch, total brood and live brood sizes were analysed using a one-way Analysis of Variance (ANOVA). Differences between recovery rates were tested using a modified binomial test. The mean dispersal direction was calculated and a Rayleigh's Uniformity Test was carried out to test for a bias in dispersal direction against the null hypothesis of a uniform distribution of directions. All analyses were carried out using SPSS, except for analysis of direction data which was carried out using Oriana 3.0 (Kovach Computing Services, Anglesey, Wales).

RESULTS

Clutch and brood sizes

Mean clutch, total brood and live brood sizes ± SD were calculated for each season and analysed for significant differences between years. The overall mean clutch size was 2.76 ± 0.87 while mean brood size was 2.69 ± 0.88 and mean live brood size was 2.58 ± 0.84 (n = 412). Although there were fluctuations from year to year, with slightly reduced clutch and brood sizes in recent years, there was no significant trend observed in any of these figures (ANOVA, $P > 0.1$).

Recovery rates

Over the study period, a total of 905 nestlings were ringed and 53, all but two from separate broods, were subsequently recovered away from the heronry, giving an overall recovery rate of 5.7% (Fig 1). Most birds were found either dead or injured and in only one case was the bird subsequently released alive. 60% of recoveries were reported within the first year after ringing, with 17% in the second year (Fig 2). The longest time from ringing to recovery was 7.5 years. None were reported from known nesting sites.

For the purpose of analysing recovery rates, the study period was divided into two unequal periods, with approximately equal numbers of birds ringed in each period. During the initial nine years of the study (1988–96), the overall recovery rate was 7.5%, but the figure was considerably lower at 3.8% for the subsequent eleven years (binomial test, $P < 0.02$; Table 1). However, there may still be some recoveries to come of birds ringed during the latter period of the study. For birds recovered within the first year after ringing, recovery rates were 4.4% and 2.6% for the early and late periods of the study respectively (Table 1), although this difference was not statistically significant (binomial test, $P > 0.05$).

Dispersal

All but one of the Grey Heron recoveries were within the UK, at distances of between 2 and 138 km from the heronry. The only foreign recovery received during the study was from The Gambia (Clark *et al* 1996): this bird, ringed in 1993, was caught in a fisherman's trap there in October of its second year and released alive. Excluding this individual, mean dispersal distance ± SD was 45.5 ± 34.6 km. There was a predominantly northerly direction of dispersal, with 35 of 53 recoveries being from sites lying north of the colony (*ie* dispersal direction between 270° and 90°) and only 18 of 53 were in a southerly direction (*ie* dispersal direction between 90° and 270°). The dispersal directions were not uniformly distributed but were significantly biased towards the north-east, with a mean dispersal direction of 29.4° (Rayleigh's Uniformity Test, n = 53, Z = 3.10, $P < 0.05$; Fig 3). Several of the most northerly recoveries were of birds found in midwinter, in North Yorkshire (4), Humberside (1) and Durham (1), although sample sizes were too small for a separate analysis of dispersal at different seasons. During the study period an additional 30 nestlings were ringed at another colony to the south of Greater Manchester. A single bird was recovered from this colony which had travelled 58 km northwards before its first November.

Table 1. Recovery rates from Grey Herons ringed during the early or late period of the study.

Period	1988–1996	1997–2007
Number ringed	478	427
Number recovered	36	16
Overall recovery rate	7.5%	3.8%*
Recovered in first year	4.4%	2.6%†

*Significantly lower than the earlier period (binomial test: $P < 0.02$)
†Not significantly lower than earlier period ($P > 0.05$)

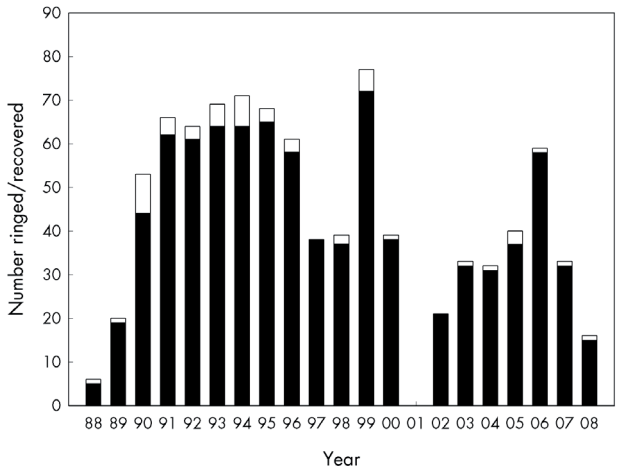

Figure 1. Numbers of Grey Herons ringed and subsequent recoveries in each year of the study. Column height shows total numbers of nestlings ringed, with numbers of subsequent recoveries shown in white.

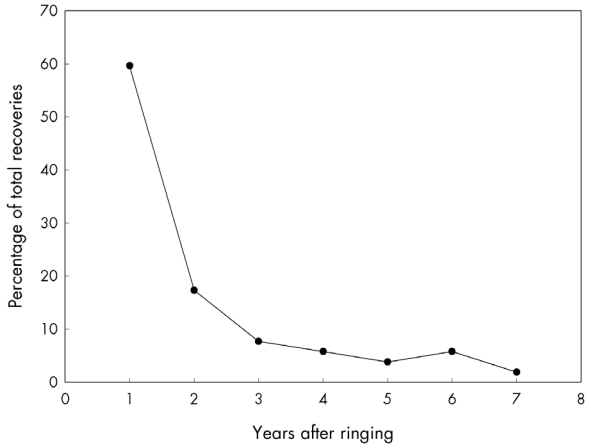

Figure 2. Proportions of Grey Heron recoveries at different intervals after ringing.

DISCUSSION

There were no significant variations in clutch, brood or live brood sizes during the course of the study. It has previously been reported that brood sizes elsewhere have declined in response to populations approaching limiting density (Norman 2008), particularly after a series of mild winters in which first-year survival would have been expected to be high. In some years at the Botany Bay Wood colony, nestling mortality increased, probably as a result of lower temperatures, or wet or windy weather at critical periods in the nesting cycle. Although the total number of nests in Botany Bay Wood had decreased slightly by the end of the study, other new sites within the county had been colonised and the total nesting population of Greater Manchester was probably at an all-time high.

Recovery rates of Grey Herons ringed in Botany Bay Wood had fallen significantly by the second period of the study. The phenomenon of declining recovery rates has been noted recently for a variety of species in the UK (Robinson *et al* 2009). Possible reasons include reduced use of the countryside for recreation or sport or people's reluctance to handle dead birds following recent health scares relating to avian influenza. Very recently, the use of an internet address on rings has led to an increased reporting rate (J.A. Clark pers comm).

The main finding from the study is the non-random dispersal of young birds from the colony, with a strong bias towards the north-east. The single northerly recovery from the smaller colony outside Greater Manchester shows that this phenomenon is not unique to the Botany Bay Wood heronry. One possible explanation is that there have been no prolonged periods of cold weather in recent years and so the necessary stimulus for birds to move south during spells of hard weather has been lacking. In milder winters, birds may be able to disperse more in a northerly direction, and this may be associated with an extension of the breeding range northwards. Recent analyses of census data have shown that nesting populations have increased in the north while remaining stable in the south (Marchant *et al* 2004). An extreme example of northward dispersal was the bird ringed as a nestling in Cheshire which was subsequently recovered in midwinter in Iceland (Mead & Clark 1993). Grey Herons ringed in northern Spain have been recovered as far north as Denmark and Sweden (Bernis 1966) and northward dispersal is a well-known phenomenon in Danish-ringed birds (Bønløkke *et al* 2006). However, a large study of German Grey Herons showed that the vast majority of birds disperse significant distances to the south-west (Goedecke 2009), possibly because winters in Central Europe are substantially colder than in the UK, and several birds from Germany have been recovered in West Africa, in the same area as the Gambian recovery from the present study.

The study site is located to the west of centre within England on a north–south plane so that there are few geographical or habitat constraints upon the dispersal of birds in any direction. A predominantly southward or westward dispersal might be anticipated if birds were moving in response to cold weather. However, a statistically significant dispersal in a north to north-easterly direction was clearly identified. The Pennines form a potential physical barrier approximately 30 km to the east and yet all of the long-distance recoveries to the north were at locations either within or to the east of the Pennines, with none found directly to the north in Lancashire or Cumbria. A lack of feeding areas is unlikely to have influenced this distribution as there are many suitable

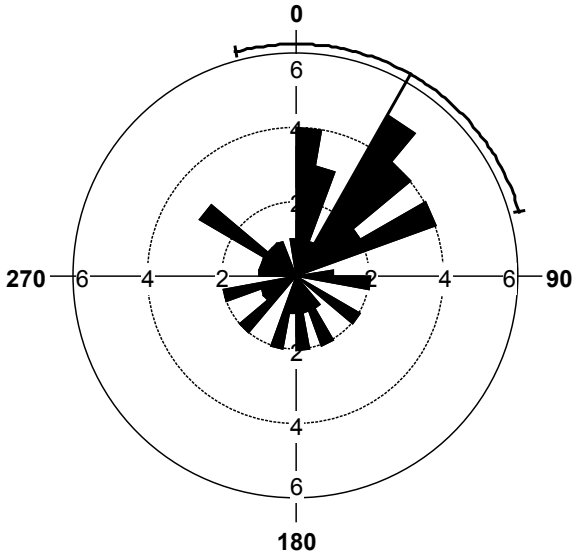

Figure 3. Frequency distribution of dispersal directions (degrees) for Grey Herons from Botany Bay Wood. Outer axis shows bearing in degrees, inner axis shows number of dispersal events in each direction. Bold lines show the mean angle and 95% confidence interval.

wetland habitats in lowland Lancashire and in Cumbria. Such long-distance north-eastward dispersals were noted quite soon after fledging and several birds were recovered within three months of fledging. An extreme example of such a movement is of a bird ringed in the neighbouring county of Cheshire, which was recovered on Humberside, 170 km north-east, only a few weeks after fledging (Norman 2008). The scarcity of westward movements cannot be explained by Manchester being located towards the west of the country; although the Irish Sea would act as a barrier to further dispersal, there is also extensive suitable feeding habitat in Merseyside, Cheshire and North Wales, which have provided very few recoveries of birds ringed in the study site.

The Little Egret *Egretta garzetta* has recently colonised Britain from the south and in 2008 Cattle Egret *Bubulcus ibis* nested for the first time in south-west England, most likely as a response to climatic change. Northward dispersal of Grey Herons, as found in the present study, may constitute a similar response to changing climatic conditions in north-western Europe.

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