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Black-headed Gulls *Chroicocephalus ridibundus* feeding on Mayfly *Ephemera danica*

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Food and feeding behaviour of Black-headed Gulls *Chroicocephalus ridibundus* was determined during the annual hatch of the mayfly *Ephemera danica* in May and June 1972 around the Castle Caldwell Peninsulas, Lower Lough Erne, Co. Fermanagh. There were in excess of 300 pairs of Black-headed Gulls breeding on that part of Lower Lough Erne in 1972. Both adult and nestling Black-headed Gulls fed extensively on the mayfly. The dynamics of predation indicate there was reduced predation by adult gulls on mayfly when density of hatching mayfly was high.

Introduction

This paper is concerned with food and feeding behaviour of Black-headed Gulls *Chroicocephalus ridibundus* during the breeding season in Ireland. A comprehensive review of feeding habitats and food in Britain has been provided by Vernon (1970, 1972). On farmland, Black-headed Gulls feed extensively on earthworms (*Lumbricus* spp.) as well as insects, especially adult craneflies *Tipula paludosa* and other adult Diptera as well as beetles, caterpillars and adult moths and butterflies, whilst food taken on inland aquatic habitats in summer include adults of mayflies, stoneflies, caddisflies and midges. The protein-rich diet provided by such invertebrates is clearly important during the breeding season. Further, a full list of the usual and not-so-usual foods can be found in Cramp and Simmons (1983). The Irish ornithological literature does not contain any comparable information for this island.

I conducted a project on Black-headed Gulls in Co. Fermanagh in 1972, at a time when their numbers were high. In the Castle Caldwell area of Lower Lough Erne there were two areas where Black-headed Gulls nested. One of the areas just to the west of Castle Caldwell, known as the Lowery Islands (H0559), had two islands that held about 250 apparently occupied nests (AONs) on the larger and about 50 AONs on the smaller island, whilst a small islet to the south-west of Rosscor Island (G9958) held about 35 AONs (pers. obs.). The Lowery Islands were no longer used by nesting Black-headed Gulls by 1980 as cattle had been able to gain access from the adjacent mainland shore (pers. obs.). There were 20 AONs and 26 AONs in 1999 and 2000 respectively, on

Plate 64. Black-headed Gull (Michael Finn).

floating vegetation between the islands and the adjacent shoreline; Black-headed Gulls have not nested in the area since 2004 (Brad Robson (RSPB) pers. comm.). The change in fortune of Black-headed Gulls breeding around Castle Caldwell is similar to that in other parts of the west of Ireland. A survey in Connemara in 1977-78 showed the gulls to be numerous (Whilde 1978), whilst a similar survey in 1992-93 showed a reduction of a third (Whilde *et al.* 1993). Another survey in 2010 showed a further reduction of another third, down to 3,014 AONs (McGreal 2011). Today the Black-headed Gull is a red-listed species in Birds of Conservation Concern in Ireland (Colhoun & Cummins 2013).

In particular, the project concerned Black-headed Gull predation on the Mayfly *Ephemera danica*. This mayfly has a two-year life cycle in Ireland; although some populations have a three-year life cycle (Greenwood 1986) during which time nymphs are found on the bottom of many limestone lakes, like Lough Erne. In early summer (hence the name mayfly) nymphs rise to the surface of the water (anglers refer to this stage as the hatch) and moult into flying sub-imagos (the adult non-breeding stage). Timing of the hatch is probably governed by water temperature and day-length (Macan 1982). Sub-imagos fly to bushes and trees surrounding the lake where they undergo an almost immediate second moult into imagos (the adult breeding stage). Within a couple of days, imagos dance in swarms along the shoreline (often on calm sunny evenings) when they mate, after which females oviposit on the surface of the water. The imagos then die. It is during the hatch that *E. danica* are particularly vulnerable to predation by both fish and birds, as they remain on the surface film until the wings fully develop (Whelan 1980, Harker 1989). Anglers also take advantage of the hatch to catch Brown Trout *Salmo trutta* using a variety of artificial flies (Harris 1952). There was much debate in the 1970s surrounding the impact of Black-headed Gull predation on the numbers of *E. danica* and interestingly, that debate continues today (Brad Robson (RSPB) pers. comm.).

It has been stated that tern chicks are provisioned in June and early July at a time when the days are longest for foraging and when food is most abundant (Cabot & Nisbet 2013) (a modification of the hypothesis of Lack (1968)). Perhaps Black-headed Gulls do likewise and time their breeding to coincide with peaks in food abundance. However, there are no data on the timing of egg-laying in Britain or Ireland (Cramp & Simmons 1983, BTO Birdfacts (bto.org/birdfacts, accessed 13 April 2015)). Broad patterns of the timing of breeding are available (e.g. Ferguson-Lees *et al.* (2011)) and show eggs from the end of April to mid July and young from mid May to the end of August (incubation period 23–26 days and fledging at about five weeks). As part of this project I wished to determine the timing of breeding of Black-headed Gulls to see whether this coincided with emergence of mayflies.

Study site and methods

The study took place during the hatch of *E. danica* in the late spring and early summer of 1972 around the Castle Caldwell peninsulas on Lower Lough Erne, Co. Fermanagh. The diet of Black-headed Gulls was determined by examining the crops of both adults and chicks. Fourteen adults were shot on three dates (31 May, 5 and 6 June) either at their colony on the Lowery Islands (ten individuals) or whilst feeding in the Castle Caldwell area (four individuals). Ten chicks were humanely killed at the Lowery Islands colony (8, 9 and 14 June); the chicks were aged between approximately four and 14 days. The crops were removed from the freshly-killed birds and were stored in preservative. The crops were opened later and their contents examined. At that time a license was not required to kill Black-headed Gulls.

Predation of sub-imagos by Black-headed Gulls during the hatch was watched on eight occasions at three sheltered bays of similar size (about 100 m^2) around the Castle Caldwell peninsulas. The three bays were the south side of Rossmore Bay (H024598) (25 May); Eagle Point (H045609) (23 May and 3 June) and Crannoges (H026588) (22 and 31 May, and 1, 2 and 6 June). The three bays were chosen because they had different densities of *E. danica* nymphs (determined from previous Ekman grab sampling) and thus were expected to yield varying numbers of hatching sub-imagos. Each watch lasted one hour during which time the number of sub-imagos hatching was counted and the number of sub-imagos taken by Black-headed Gulls and other predators was noted. Observations were made from a boat anchored close by with observations aided by 10x40 binoculars when necessary.

Transects were taken across the Lowery islands to determine the median hatching dates of the young birds. Transects were taken on four occasions (31 May, 3, 8 and 14 June) and the numbers of eggs and young were recorded.

Results

The crop contents of adult Black-headed Gulls and chicks are shown in Tables 1 and 2, respectively. All four adults shot in the feeding area had crops that contained *E. danica* only, one containing 313. Of the ten adults at the colony, three had empty crops. Of the seven with prey in their crops five contained exclusively, or near exclusively, *E. danica.* Of the remaining two gulls, one had various aquatic prey species in its crop with *E. danica* in the minority, whilst the other had been feeding in surrounding fields as shown by the oligochaeta. Therefore, it is clear that the majority of gulls had been feeding over water, and the majority of those had taken advantage of the *E. danica* hatch.

Only half of the ten chicks had food in their crops. Of these five, two had been fed nearly exclusively on *E. danica*, a third had a varied aquatic invertebrate diet with a large

Table 1. Crop analysis of 14 adult Black-headed Gulls on Lower Lough Erne, 1972.

Date	Time/BST	Place	Crop fullness	Prey	Number of prey items
31 May	1600	colony	¾	***E. danica***	139
				Chironomidae adult	1
31 May	1600	colony	trace	***E. danica***	7
31 May	1900	colony	empty		0
31 May	1900	colony	trace	***E. danica***	11
				Coleoptera adult	1
31 May	1900	colony	empty		0
31 May	1900	colony	¼	Coleoptera adult	2
				Chironomidae adult	2
				other Diptera larva	2
				Oligochaeta	1
05 Jun	1730	colony	¾	***E. danica***	227
				Trichoptera adult	11
05 Jun	1730	colony	trace	***E. danica***	21
05 Jun	1730	colony	empty		0
05 Jun	1730	colony	full	*Anguilla anguilla* elvers	34
				Chironomidae adult	18
				E. danica	6
				Trichoptera adult	2
				Gerridae adult	1
31 May	1600	feeding area	¾	***E. danica***	192
31 May	1600	feeding area	¾	***E. danica***	206
31 May	1630	feeding area	full	***E. danica***	313
06 Jun	1700	feeding area	¼	***E. danica***	42

Table 2. Crop analysis of ten chick Black-headed Gulls on Lower Lough Erne, 1972.

Date	Time/BST	Crop fullness	Prey	Number of prey items
08 Jun	1700	trace	***E. danica***	2
			Tipulidae adult	6
08 Jun	1700	¾	***E. danica***	110
			Lepidoptera larva	1
09 Jun	1200	¾	***E. danica***	52
			other Ephemeroptera	3
			Trichoptera adult	27
			Chironomidae adult	41
			Coleoptera adult	1
09 Jun	1200	empty		0
09 Jun	1630	½	***E. danica***	104
			Trichoptera adult	1
09 Jun	1630	empty		0
14 Jun	1145	full	Coleoptera adult	121
			Diptera adult	150
14 Jun	1145	empty		0
14 Jun	1700	empty		0
14 Jun	1700	empty		0

proportion of *E. danica*, and a fourth contained two *E. danica*, whilst the fifth had probably been provisioned from farmland. Like the adult gulls, chicks were heavily fed with *E. danica* during the hatch.

Black-headed Gulls took *E. danica* during all eight predation observation sessions. Furthermore, gulls took far more (87.9%) *E. danica* than any other species of predator observed (Figure 1). At six of the observation sessions Chaffinches *Fringilla coelebs* also took *E. danica* (5.6%), whilst the remaining three predators, Coot *Fulica atra*, ducklings of Mallard *Anas platyrhynchos* and fish took the remainder. Black-headed Gulls took *E. danica* by surface-dipping, Chaffinches by aerial pursuit, Coot and Mallard ducklings by surface feeding whilst swimming, and fish from beneath the water. Other birds seen feeding on *E. danica* during the hatch (but not during the eight observations) included Barn Swallow *Hirundo rustica*, Pied Wagtail *Motacilla alba,* and Sandwich Tern *Sterna sandvicensis*. These three species captured the sub-imagos by aerial pursuit. It appears that while other birds took *E. danica,* the Black-headed Gull was the most important predator (Figure 1).

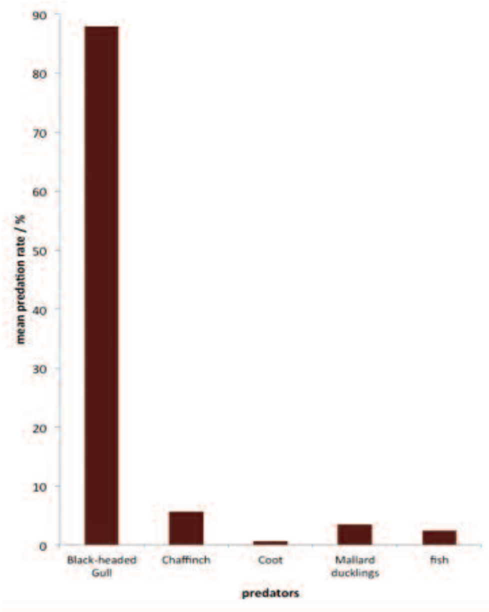

Figure 1. Percentage of observed captures of *E. danica* by different predator species. The mean predation rates were the average from all dates and sites.

The dynamics of the eight predation events can be seen in Figure 2. The individual events are shown as diamond symbols whilst the curve, the functional response curve, has been derived from Holling's (1959) disc equation using the data from the eight predation events. The functional response shows that as the number of sub-imagos hatching increases so the gulls take a smaller proportion of the available prey. The functional response would appear to show a typical type 2 response, although there are no observations at low densities of hatching sub-imagos from which it may have been possible to distinguish a type 3 response (Appendix 1).

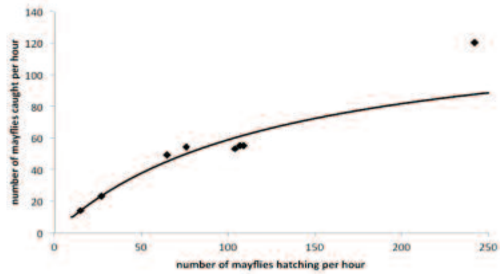

Figure 2. The relationship between the number of mayflies caught by Black-headed Gulls per hour and the number of mayflies hatching per hour. The curve shows the line derived from Holling's disc equation (see text and Appendix 1 for explanation).

The rate of hatching of Black-headed Gull eggs on Lowery Island is shown in Figure 3; the diamonds on the figure are the data points for each of the four dates with the vertical axis being drawn on a logit scale. The regression shows the line of best fit for these data and indicates that the median hatching date was 11 June 1972 (Appendix 2).

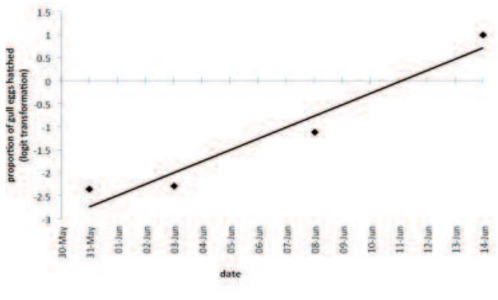

Figure 3. The proportion of Black-headed Gull eggs hatched on the Lowery Islands with time; the median hatching date being 11 June 1972 (see text and Appendix 2 for explanation).

Discussion

Both Cramp and Simmons (1983) and Vernon (1972) show the catholic nature of Black-headed Gull diet, with Vernon (1972) saying that Black-headed Gulls 'frequently flight-feed for mayflies (Ephemeroptera) as they appear in May and June'. As the gulls have such a broad diet they are able to switch

Plate 65. Black-headed Gull (John Fox).

quickly to whatever prey becomes abundant; hence the switch to mayflies in the early summer. It is clear from this study on Lower Lough Erne that during the hatch of *E. danica*, Black-headed Gulls relied heavily upon them with the majority of adults feeding on them, and their young being fed on them as well. No attempt was made to determine provisioning rates of young Black-headed Gulls by their parents, so it is not possible to explain why half of the sampled chicks had no food in their crops.

The dynamics of the predation events indicate a reduced predation rate by gulls when sub-imago density is high (Figure 2); this being a type 2 functional response of the predation events (Begon *et al.* 2006). This swamping effect of prey upon their predators has been observed in the field in both animals and plants (e.g. Ims 1990), including birds (Newton 1998). The result of the present study shows that in areas of Lower Lough Erne where the density of *E. danica* was low, then gulls removed a disproportionately larger number of their prey which might render low-density local populations of *E. danica* susceptible to extinction. The study did not begin until the mayfly hatch was well underway so it is not possible to comment on the hypothesis that the earliest mayfly to hatch might have suffered little predation because the gulls did not switch to them as soon as they became available. However, this seems unlikely as *E. danica* is just one species of the aquatic insects that hatch throughout the spring and summer on Lower Lough Erne. Despite the concerns of local anglers about the effect of Black-headed Gulls on the numbers of *E. danica* hatching both in 1972 and today, the mayfly hatch is still healthy (Brad Robson (RSPB) pers. comm.).

The median hatching date for Black-headed Gulls in 1972 was 11 June at a time when sub-imagos provided an abundance of food for the young birds. It is possible Black-headed Gulls on Lower Lough Erne anticipate the timing of the mayfly hatch and time their breeding season accordingly just as terns time their breeding to coincide with maximum day-length (Cabot & Nisbet 2013). Despite the variety of aquatic insects hatching throughout the summer, it is the sheer numbers and large size of *E. danica* that make them such an attractive prey.

In conclusion, it can be seen that sub-imagos of *E. danica* are an important component of the diet of breeding Black-headed Gulls and their chicks on Lower Lough Erne and further, despite large losses of sub-imagos to predation by gulls, their synchronous hatching swamps the gulls and permits large numbers of mayflies to complete their life-cycle and thus maintain their population.

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Appendix 1

Holling (1959) described the relationship between consumption rate and prey density – the so-called 'functional response' (Solomon 1949) of which there are three main types. Type 1 shows the consumption rate rising linearly with prey density; type 2 shows the consumption rate rising with prey density, but with a gradual deceleration until a plateau is reached; type 3 is like a type 2 response, but at low prey density there is a short accelerating phase. Begon *et al.* (2006) provides a good explanation of functional responses.

Appendix 2

The proportions of Black-headed Gull eggs hatched on each date have been transformed to logit values which is normal for such data (Zar 2010). The median hatching date was 11 June 1972 (the logit transformation of 0.5 [proportion of eggs hatched] being 0).

Reproductive output of Hen Harriers *Circus cyaneus* in relation to wind turbine proximity

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Keywords: *Circus cyaneus*, Hen Harrier, reproductive output, wind energy

Plate 66. Female Hen Harrier (Shay Connolly).

Despite the growing importance of wind energy development in Ireland, and concerns about its potential ecological impact on birds, there is a notable lack of published scientific information in this area. As a bird of conservation concern, the Hen Harrier *Circus cyaneus* inhabits upland areas with potential for wind energy resources. This study assessed the breeding performance of Hen Harriers across Ireland in relation to wind farm development by analysing the breeding output from 84 nests located at varying distances from wind turbines. Three measures of breeding performance were investigated: (a) nest success (the proportion of nests that fledged one or more young), (b) fledged brood size (the average number of fledged chicks per successful nest), and (c) overall productivity of breeding pairs (the average number of fledged chicks across all nesting attempts). No statistically significant relationships were found between these breeding parameters and distance of the nest from the nearest wind turbine. However, lower nest success within 1 km of wind turbines than at greater distances was sufficiently close to statistical significance, and with a sufficiently small sample size, that this difference may be of biological relevance. Nests within 1 km of wind turbines which were successful had similar fledged brood sizes to those of nests at greater distances from turbines. These findings support previous research which highlighted the importance of areas within a 1 km radius of raptor nests. Our results provide the first insight into the potential effects of wind turbines for breeding success of Hen Harriers, which should be taken into consideration in assessments of wind farm impacts on this vulnerable species. Further work is required to quantify (a) direct Hen Harrier mortality through collisions, (b) habitat loss and displacement caused by wind turbines and (c) to continue ongoing monitoring of breeding success in order to confirm whether the effect of wind farm proximity suggested here is consistent. This work will support the development of an integrated management strategy for Hen Harriers in Ireland.

Introduction

The Hen Harrier *Circus cyaneus* is a territorial bird of prey that breeds in upland areas in Ireland. It is an Annex I species on the European Birds Directive 2009/147/EC (OJEU 2010) and is on the Amber List of Birds of Conservation Concern in Ireland (Colhoun & Cummins 2013), where an increase in breeding numbers has been reported in recent years

(Ruddock *et al.* 2012). However, this increase is possibly an artefact of increased survey effort, and with a population estimate of 128–172 breeding pairs the species remains vulnerable and is rare in the Republic of Ireland (Ruddock *et al.* 2012).

Once common across the Irish uplands, Hen Harrier populations have shown significant fluctuations over time in response to human-related pressures, particularly habitat modification and loss (O'Flynn 1983). Extensive afforestation over the past 60 years has resulted in the loss of large areas of open habitat traditionally used by breeding Hen Harriers (O'Leary *et al.* 2000, Avery & Leslie 2010). This species has responded to these habitat modifications across its range by nesting in young conifer plantations (Norriss *et al.* 2002, Barton *et al.* 2006, Wilson *et al.* 2009). Although this apparent ability to adjust to a changing landscape may allow the species to persist in the short term, research suggests that in some instances these new habitats may prove to be an 'ecological trap' where Hen Harrier productivity is too low to maintain populations in the longer term (Wilson *et al.* 2012). Young conifer plantations provide dense vegetation cover suitable for nesting, but may be associated with higher rates of nest predation or with lower prey availability in areas surrounding the nest, leading to lower breeding output and a mismatch between the species' habitat preferences and the actual value of these habitats (Wilson *et al*. 2012). This complex ecological relationship between Hen Harriers and their surroundings, with continuing changes in availability and suitability of their preferred habitats, is further complicated with the recent expansion of wind energy across many upland areas in Ireland.

Renewable energy is a growing component of Ireland's energy supply and wind power in particular is central to the Irish Government's energy production strategy (DCENR 2012). This sector has developed rapidly in recent years with the construction of over 200 onshore wind farms (more than 1,600 individual turbines) across the island of Ireland (IWEA 2014). The contribution of wind energy to the total energy consumption in Ireland increased from 1% in 2000 to 15% in 2012 (Howley *et al.* 2014). Wind energy is commonly recognised as a 'green' power technology that can reduce our dependence on fossil fuels (Leung & Yang 2012). However, there are growing concerns that it may carry an ecological cost, particularly for birds, and there is a pressing need for information on the ecological impacts of wind farms (Drewitt & Langston 2006, De Lucas *et al.* 2007, Stewart *et al.* 2007, Rourke *et al.* 2009). In Ireland, concerns about the effects of wind farms on birds, as well as on other taxa and on the abiotic environment, combined with a lack of robust data have been identified as significant barriers to on-going wind energy development (Rourke *et al.* 2009, Scannell 2011). Despite this, relatively few studies to date have assessed the impacts of wind farms on birds in Ireland (Percival 2003, Madden & Porter 2007). There is an urgent need to evaluate the potential effects of wind farms on bird populations, particularly Hen Harriers (Irwin *et al.* 2011, Ruddock *et al.* 2012), in order to inform conservation and mitigation measures.

The impacts of wind turbines on birds are not yet fully understood, but it is clear that there is considerable variation across regions and between species (Pearce-Higgins *et al.* 2012, Northrup & Wittemyer 2013, May *et al.* 2015). The potential negative effects of wind turbines on birds include direct mortality caused by collision with turbine blades, and indirect effects such as displacement due to disturbance, loss of foraging or nesting habitat, and barrier effects (Stewart *et al.* 2007, Campedelli *et al.* 2014). Impacts appear to be more significant for populations of long-lived, large bird species with low productivity, particularly rare birds of conservation importance (Drewitt & Langston 2006, Pearce-Higgins *et al.* 2009a). Due to their distribution in habitats that are optimal for wind energy production, Hen Harriers are considered to be highly sensitive to wind farm developments (McCluskie 2015, McGuinness *et al.* 2015). Foraging Hen Harriers have been shown to avoid wind farm infrastructures with displacements of up to 0.5 km from turbines reported (Madders & Whitfield 2006, Pearce–Higgins *et al.* 2009b, Garvin *et al.* 2011). However, wind turbines are reported not to cause displacement of Hen Harrier nests (Madden & Porter 2007, Robson 2011). Similarly, wind turbines are reported not to influence the location of Montagu's Harrier *Circus pygargus* nests (Hernández-Pliego *et al*. 2015). Although Hen Harrier ecology and behaviour makes for a low level of collision risk, direct mortality resulting from collision with turbines has been recorded in some studies (Whitfield & Madders 2006, Fennelly 2015, McCluskie 2015). While individual effects of wind farms may have only minor ecological effects on a bird species, collectively, a number of effects may be significant and potentially greater than the sum of the individual effects (Masden 2010). Although these impacts have the potential to affect breeding output of some bird species (Martínez-Abraín *et al.* 2012, Northrup & Wittemyer 2013), no work has been published to date, in Ireland or elsewhere, on the effects of wind farm developments on Hen Harrier breeding productivity. Here we study the breeding performance of Hen Harriers in relation to wind farms at sites across Ireland. By analysing data from Hen Harrier territories, located at a range of distances from active wind farms, we aim to (i) assess whether nests located in proximity to wind turbines suffer reduced productivity and, if so, (ii) determine the maximum distance from turbines at which this effect is significant. To our knowledge, this is the first study to assess the effects of wind farms on the breeding performance of Hen Harriers.

Methods

Data were collected each year between 2007 and 2013 during the Hen Harrier breeding season (April-August) at a selection of sites across the species' Irish range (counties Kerry, Limerick, Tipperary, Clare, Galway, Tyrone and Roscommon). During this period, vantage point watches overlooking areas of suitable habitat were carried out to locate active territories by recording Hen Harrier courtship and territorial behaviours. Further observations of birds engaging in nest building, prey delivery and other nest-associated behaviours were used to identify nest locations. Nests were then regularly monitored by remote observation until the conclusion of the breeding season in order to determine breeding outcome and check for fledged young. All fieldwork was carried out under licence issued by National Parks and Wildlife Service (NPWS).

The distance to the nearest wind turbine was calculated for all nests in order to analyse the effect of wind farms on breeding Hen Harriers using ArcMap 10.2 (ESRI). Previous research has indicated that avoidance of wind farms by breeding Hen Harriers may occur within 1 km of turbines (Pearce–Higgins *et al.* 2009b) and that foraging behaviour of breeding pairs can be influenced by habitat changes at varying distances of 1, 2 and 3 km from the nest (Arroyo *et al.* 2009). To allow for detection of different processes occurring at these scales, nests were grouped according to their distance to the nearest turbine into the following distance bands: 0–1 km, 1–2 km, 2–3 km and >3 km.

Three measures of breeding performance were calculated for each distance band: (a) nest success (the proportion of nests that fledged one or more young); (b) fledged brood size (the average number of fledged chicks per successful nest); and (c) overall productivity of breeding pairs (the average number of fledged chicks across all nesting attempts). Differences in measures of breeding performance between the different distance bands were analysed using fixed-effect one-way ANOVAs and one-tailed T-tests following examination of the distributions of data to ensure that assumptions of normality and homogeneity of variance were met. Minitab was used for all statistical analyses.

Plate 67. Male Hen Harrier (Andy Hay, rspb-images.com).

Results

Between 2007 and 2013 a total of 84 Hen Harrier territories across Ireland were monitored, and their breeding outcome determined. Linear distances from these nests to the nearest wind turbine ranged from 0.4 km to 7.0 km. Nest success for all territories monitored was 53.6%, with 45 successful and 39 failed nests. The mean fledged brood size was 2.4 (±0.1 se) chicks per successful nest and mean nest productivity was 1.3 (±0.2 se) chicks per nesting attempt.

When grouped according to distance from the nearest turbine, nest success was lowest (33.3%) at nests located in the 0–1 km band (n = 9). Nest success was 60.0% in both the 1–2 km (n = 20) and 2–3 km (n = 20) bands, and 51.4% for nests located at more than 3 km from wind turbines (n = 35) (Figure 1). However, differences between the four distance bands were not statistically significant ($F_{3,80} = 0.72$, $P = 0.542$). When the success of nests in the 0–1 km band (nest success = 33.3%) was compared with the success of all nests more than 1 km from wind turbines (nest success = 56.0%), the difference approached statistical significance (one-tailed T-value = 1.29, df = 82, P = 0.10).

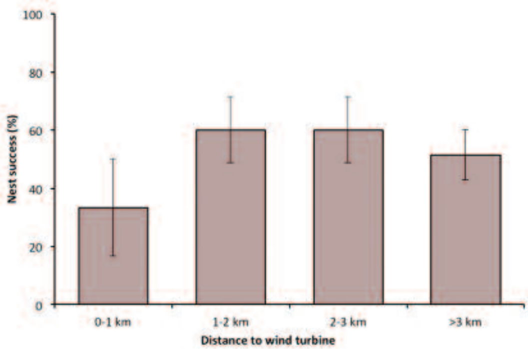

Figure 1. Mean Hen Harrier nest success rates (± se) from 2007 to 2013 across Ireland, classified by the distance of nests to the nearest wind turbine. Nest success is defined as the proportion of nests that fledged one or more young. Sample sizes in each distance band are 9, 20, 20 and 35, respectively.

There was no significant difference in fledged brood size which ranged from 2.33 to 2.58 chicks per successful nest, between distance bands ($F_{3,80}$ = 0.26, P = 0.853) (Figure 2). Productivity was lowest for nests closest to wind turbines (0–1 km, 0.78 chicks per nesting attempt) but not statistically different from those nests in the other bands (1.55, 1.35 and 1.23 chicks per nesting attempt at 1–2 km, 2–3 km and >3 km respectively) (F-value = 0.68, df = 3, P = 0.566).

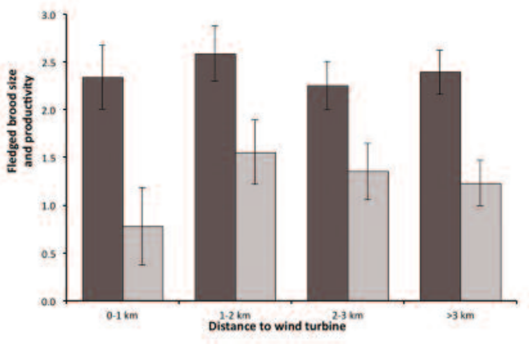

Figure 2. Mean Hen Harrier fledged brood size (dark bars; the average number of fledged chicks per successful nest) and productivity (light bars; the average number of fledged chicks across all recorded nesting attempts) (± se) from 2007 to 2013 across Ireland, classified by the distance of nests to the nearest wind turbine. For sample sizes see Figure 1.

Discussion

We found no significant differences between three measures of breeding output from Hen Harrier nests located at different distances from wind turbines. However, non-statistically significant lower nest success rates and productivity were observed within 1 km of active wind turbines. Due to limited availability of data, a consequence of the species' rarity and restrictions on research activities, it is not possible to investigate differences in breeding success at a finer scale. Of the nine nests monitored in the 0–1 km band during this study, 33.3% were successful, while nest success in all other distance bands was 56.0% (n = 75). Hen Harrier nest success rates vary considerably throughout their range, and are influenced by many external factors, though they are typically similar or greater than the rates observed in this study for nests located more than 1 km from turbines (Baines & Richardson 2013, McMillan 2014). Relationships between the presence of wind turbines and the breeding success of local bird populations have been the subject of few investigations to date. From the available literature on this topic it appears that such relationships are species and/ or area specific (Dahl *et al.* 2012, Martínez-Abraín *et al.* 2012, Hatchett *et al.* 2013). Even where impacts on reproductive success are reported, these do not necessarily translate into negative population level effects (Martínez-Abraín *et al.* 2012). However, impacts which of themselves do not impact significantly on a bird species may, when combined with other effects, lead to cumulative negative impacts (Masden 2010, Schaub 2012).

No trend in fledged brood size with increasing distance from wind farms was observed, suggesting that any potential impact of wind turbines on Hen Harrier breeding output is mediated through nest success rather than clutch or brood sizes. The apparent lower productivity (average number of fledglings per nesting attempt) close to turbines in this study, although not statistically significant, may be the result of failed nesting attempts (66.7%), rather than reduced performance of those nests producing fledglings. A similar phenomenon has been reported for a wind farm in Norway in an area occupied by breeding White-tailed Eagles *Haliaeetus albicilla,* where reduced breeding success within 0.5 km of wind turbines was the result of abandonment of territories rather than a reduction in fledged brood size at nests close to turbines (Dahl *et al*. 2012). Although the impacts of wind farms on breeding productivity are recognised as being a crucial determinant of a population level impact (Drewitt & Langston 2006), the scientific literature currently available relates only to impacts on abundance and distribution, while the current study is the first of its kind on the effects on breeding output. Human activities (such as recreation, forestry operations and wind farm development) have been reported to impact on Hen Harriers at distances ranging between 0.5 km and 1 km (Ruddock & Whitfield 2007), while reduced densities of Hen Harriers have sometimes been reported within 0.5 km of operational wind turbines (Pearce-Higgins *et al.* 2009b). Research on the spatial ecology of Hen Harriers has shown that foraging females spend most of their time within 1 km of the nest, while males hunt mostly within 2 km of the nest (Arroyo *et al*. 2009, Irwin *et al.* 2012). Therefore, landscape and habitat changes within 1 km of the nest may influence the foraging behaviour of both male and female Hen Harriers, while changes up to 2 km from the nest are more likely to affect males only (Arroyo *et al.* 2014). In the context of the current study this suggests that, if wind farm presence does have an effect on breeding Hen Harriers, this is most likely to affect nests located within 1 km of wind farms, where the overlap between turbines (and associated infrastructure) and the areas used for foraging by breeding birds is likely to be greatest.

Nest success, productivity and fledged brood size observed in the current study are consistent with those

Plate 68. Female Hen Harrier (Neill O'Reilly).

reported for Hen Harriers in other parts of the species' range (Fielding *et al.* 2011, McMillan 2014). However, considerable variation has been reported in the breeding output of Hen Harrier populations in Scotland (Etheridge *et al*. 1997, Amar *et al.* 2008, Baines *et al.* 2008), England (Natural England 2008), and Ireland (Irwin *et al.* 2011). As a result, establishing clear cause-and-effect relationships regarding Hen Harrier population parameters presents a considerable challenge. In Ireland, geographic variation in breeding output (Irwin e*t al.* 2011) and on-going regional declines (Ruddock *et al.* 2012) may hinder attempts to understand the effects of single variables such as wind farm development. A further constraint in research on rare species, and raptors in particular, which occur at low densities is that the sample sizes required for robust statistical analysis are often difficult to achieve (Morrison 1988). Although ecological research benefits from studying abundant species or frequent events to understand natural processes, rare species are often of higher ecological, conservation, management and policy interest. This is particularly true of the interaction between Hen Harriers and existing and planned wind farms in the Irish landscape. As the study of such interactions will typically be based on small sample sizes, the use of a standard set of statistical tools may be difficult or inappropriate, making statistical analyses difficult to obtain where they are most needed (Ellison & Agrawal 2005). Despite using the largest existing data set on breeding Hen Harriers in Ireland, the sample size available for some distance bands in this study was notably small, calling for precautionary interpretation of results. This is of particular importance when interpreting observed differences which, although not statistically significant, may be biologically meaningful (Martínez-Abraín 2008).

Over most of terrestrial Ireland, wind farms tend to be situated at higher elevations than the majority of the surrounding land. This means that their placement is non-random with respect to other land uses and habitat types that have been associated with Hen Harrier distribution, breeding activity and nest success. These include commercial forestry (Madders 2003, Wilson *et al.* 2012), heather-dominated habitats (Arroyo *et al.* 2009, Redpath *et al.* 1998) and intensive

Plate 69. Hen Harriers (Usna Keating).

farmland (Arroyo *et al.* 2009, Wilson *et al.* 2009). It is possible, therefore, that any observed relationships between wind farm proximity and Hen Harrier breeding success, such as those discussed here, may be wholly or partly due to the influence of landscape elements which may be linked to wind farm developments (e.g. changes in land use associated with wind farm construction) (Nayak *et al.* 2010) or to other unrelated practices (e.g. agricultural intensification, afforestation or peat extraction) (O'Leary *et al.* 2000, Amar & Redpath 2005).

The information presented here relates to established operational wind turbines, and it should be noted that the impacts of wind farm construction on breeding Hen Harriers may be of a substantially different nature. Research on other bird species indicates that the construction phase is probably the most critical aspect of wind farm development, and that effects on bird populations reported at operational wind farms may in fact be the result of declines occurring during the construction period (Douglas *et al.* 2011, Pearce-Higgins *et al.* 2012). Little information is available on the effects of wind farm construction activities on breeding Hen Harriers, although disruption at distances of up to 1 km has been reported (Ruddock & Whitfield 2007). The Bird Sensitivity Mapping tool recently developed by BirdWatch Ireland, provides detailed guidance on conservation and an indication of the areas where Hen Harriers are most sensitive to wind energy development (McGuinness *et al.* 2015).

Implications for conservation

Although no statistically significant impact of wind turbines on Hen Harrier breeding performance was detected in the current study, a pattern of reduced nest success and productivity was observed within a 1 km radius of wind turbines. Careful location of wind farms and turbines could mitigate potential negative effects (De Lucas *et al.* 2007), and the findings of this study suggest that the location of Hen Harrier breeding sites should be taken into account at the planning stage of wind farms.

Notwithstanding the limitations discussed above, this study draws upon the most extensive data set available on breeding Hen Harriers in Ireland and improves our understanding of the effects that wind energy development may have on breeding Hen Harriers. However, further work is needed to confirm the extent of these effects. Other lines of research necessary to gain a comprehensive understanding of the overall effects of wind farms on Hen Harriers include studies on the impacts of wind farm construction activities, potential displacement of foraging and nesting Hen Harriers by wind turbines, effects of wind farm developments on Hen Harrier prey availability and abundance, risks of direct mortality by collision with wind turbines, relationships between Hen Harrier breeding success and other potentially confounding landscape variables, and analysis of the effects of wind farm developments at a meta-population scale.

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Whooper *Cygnus cygnus* and Bewick's *C. columbianus bewickii* Swans in Ireland: results of the International Swan Census, January 2015

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A census of Whooper Swan *Cygnus cygnus* and Bewick's Swan *C. columbianus bewickii* populations took place in Ireland over the weekend of 17/18 January 2015. This census was the seventh in a series of international co-ordinated censuses of the European flyways of these species and takes place every four to five years. A total of 1,327 count units were covered and a total of 15,104 Whooper Swans were counted in 495 flocks, representing a decline of 0.2% in the total number of birds recorded when compared with the 2010 census results. The total number of flocks recorded was substantially higher than in 2010. The weather in the weeks leading up to the 2015 census was generally mild and wet, resulting in an abundance of available wetlands throughout the country, and in a widely scattered distribution. The proportions of juveniles recorded in flocks and the mean brood sizes, at 22.3% and 2.39 respectively, were especially high when compared with previous censuses, indicating a successful breeding season in 2014. A total of ten internationally important and 15 nationally important sites were identified, with Lough Neagh, Upper Lough Erne, Lough Beg and the Shannon Callows being the most important sites. The total number of Bewick's Swans recorded was just 21 in four flocks, and this represents a significant further decline (of 74%) in numbers wintering here.

Introduction

Each winter, Ireland plays host to more than 10,000 migratory swans distributed across low-lying wetland and grassland habitats. These are predominantly Whooper Swan *Cygnus cygnus,* with small numbers of Bewick's (or Tundra) Swan *C. columbianus bewickii.* Whooper Swans have a widespread breeding distribution across Northern Europe (including Iceland), Russia and Siberia. Their wintering distribution is

Plate 70. Whooper Swans (Michael O'Clery).

patchy, although relatively well defined. Five populations are recognised (Brazil 2003, Wetlands International 2006), and birds over-wintering in Ireland come almost exclusively from the Icelandic-breeding population. The Tundra Swan *Cygnus columbianus columbianus* has a more coastal breeding range in the northern parts of North America, Russia and Siberia. Their wintering range is also quite dispersed. There are five populations of Tundra Swan, two of which are of the race known as Bewick's Swan. The majority of these swans breed in northern Russia and winter in northwest Europe (Wetlands International 2006). These migratory swan populations have been monitored in Britain and Ireland since the 1950s. The first co-ordinated international census for both species was carried out in 1986, and they have since been conducted every four to five winters, usually in January. These censuses aim to monitor numbers of these species, and also to assess breeding success and changes in habitat preferences.

The Icelandic-breeding Whooper Swan population has sustained an ongoing increase in numbers, from 16,742 in 1986 to 29,232 in January 2010 (Hall *et al.* 2012). Numbers in Ireland over the same period increased from 10,306 (Merne & Murphy 1986) to 14,981 (Boland *et al.* 2010). In contrast, the numbers of Bewick's Swan wintering in Britain and Ireland continues to decline, and 7,079 were recorded in Britain and Ireland in 2010, including just 80 in Ireland (Boland *et al*. 2010). This represents a considerable decline from the 2,700 recorded in Ireland during the census in 1956/57 (Merne 1977).

The seventh international census took place over the weekend of 17/18 January 2015. This paper presents the results of that census, including an update on total numbers wintering in Ireland, and how these have changed over time at a regional scale (county level). It also provides details on productivity, reflecting the 2014 breeding season.

Methods

The overall census in Ireland, Britain and Iceland was co-ordinated by the Wildfowl and Wetlands Trust. Counts in Ireland were organised through the Irish Wetland Bird Survey (I-WeBS) and the Irish Whooper Swan Study Group (IWSSG). The census was scheduled for the weekend of 17/18 January 2015. Most coverage was by volunteer birdwatchers and professional staff involved in I-WeBS or WeBS (the Wetland Bird Survey in the UK), including conservation staff from the National Parks and Wildlife Service (in the Republic of Ireland), Northern Ireland Environment Agency, Royal Society for the Protection of Birds and Craigavon Borough Council (in Northern Ireland). Surveying was also undertaken by IWSSG members, especially in areas not regularly covered by waterbird counters.

Every attempt was made to ensure that all areas which held birds during previous international swan censuses and during regular I-WeBS and WeBS core counts in recent winters were covered. Full details of the methods have been published in Colhoun *et al.* (2000). Most of the totals in this paper are presented at county level. Site totals are expressed as an amalgamation of totals from those count units which are part of the same wetland complex, and include the collection of roosting and feeding areas used by the same flock(s) of swans. Once data were compiled, an assessment of the extent of coverage was made for each site complex, and aerial census results were used where ground-based coverage was considered incomplete.

Results

Coverage

A total of 1,327 count units (904 in the Republic of Ireland and 423 in Northern Ireland) were covered by 197 observers. Overall, coverage was completed between 10 January and 2 February, with the large majority (95%) covered on the scheduled weekend or within three days either side of it, while the remaining 68 count units were covered outside this period. During the lead-up to the census weekend the weather had been very mild and wet with air temperatures dropping to below zero degrees Celsius between 17 and 19 January, i.e. the census weekend. Thereafter, for the remainder of the month, temperatures were sustained at freezing point, or above (Met Éireann 2015).

Whooper Swan

Whooper Swans were recorded in all counties other than Carlow and Dublin. In total, 15,104 were counted in 495 flocks (Table 1). This represents an increase of less than 1% in the total number of birds recorded when compared with the published total from the 2010 census (Boland *et al.* 2010). However, additional counts totalling 155 birds in six flocks in Donegal and Clare have been submitted since publication of the 2010 census, resulting in an upward revision of the 2010 total to 15,136. Thus, the overall total for 2015, when compared with the actual census total in 2010, is slightly lower by 0.2%. There was an increase of 10% in the total number of swans recorded in the Republic of Ireland, and a decrease of 24% in Northern Ireland, with respective totals of 11,586 and 3,518 recorded (Table 1). Despite the apparent stability in numbers overall, there was a substantial increase in the number of flocks reported both in Northern Ireland and in the Republic of Ireland, to 495 overall, and representing a 27% increase when compared with 2010.

The distribution of Whooper Swans during this census is illustrated in Figure 1. At county level, highest numbers were recorded in Galway, Roscommon, Mayo and Cavan, but there

Table 1. Numbers, age structure and brood sizes of Whooper Swans in January 2015 at county* level, for Northern Ireland and the Republic of Ireland, and overall. Figures in parentheses represent percentage change when compared with the 2010 census.

County	Total	Flocks	Aged	% Juv	Total no. of broods	Brood size							Mean Brood size
						1	2	3	4	5	6	7	
Antrim	769 (48)	25 (92)	769	19.5	60	24	18	10	7	1	-	-	2.05
Armagh	465 (-8)	19 (46)	313	19.8	30	11	11	5	1	2	-	-	2.07
Down	515 (-6)	12 (20)	515	28.3	62	17	13	18	7	6	1	-	2.60
Fermanagh	784 (-23)	32 (19)	733	19.1	60	15	24	13	4	2	2	-	2.33
Londonderry	648 (-61)	26 (-10)	581	26.0	61	24	16	9	7	5	-	-	2.23
Tyrone	337 (-3)	10 (0)	247	14.6	16	5	7	3	1	-	-	-	2.00
NI total	**3,518 (-24)**	**124 (22)**	**3,158**	**21.7**	**289**	**96**	**89**	**58**	**27**	**16**	**3**		**2.26**
Cavan	1,053 (20)	48 (55)	815	27.4	29	8	10	8	2	1	-	-	2.24
Clare	632 (20)	22 (10)	578	20.1	24	8	6	5	3	2	-	-	2.38
Cork	244 (-5)	9 (-31)	232	26.7	13	4	6	1	2	-	-	-	2.08
Donegal	499 (-29)	29 (61)	441	17.7	23	8	10	3	2	-	-	-	1.96
Galway	1,793 (63)	43 (26)	1,407	19.5	38	9	13	12	3	1	-	-	2.32
Kerry	470 (-12)	8 (33)	390	10.3	0	-	-	-	-	-	-	-	-
Kildare	162 (45)	3 (-40)	28	35.7	2	-	-	2	-	-	-	-	3.00
Kilkenny	22 (>500)	2 (100)	22	4.5	1	1	-	-	-	-	-	-	1.00
Laois	120 (-21)	4 (100)	74	27.0	3	-	2	1	-	-	-	-	2.33
Leitrim	302 (124)	23 (77)	251	29.1	17	2	7	4	3	1	-	-	2.65
Limerick	133 (-65)	3 (-25)	133	13.5	8	2	4	-	2	-	-	-	2.25
Longford	213 (11)	11 (83)	167	17.4	1	-	1	-	-	-	-	-	2.00
Louth	93 (-50)	2 (0)	32	21.9	0	-	-	-	-	-	-	-	-
Mayo	1,248 (37)	49 (63)	1,069	25.7	50	15	13	9	9	4	-	-	2.48
Meath	209 (-18)	10 (67)	103	26.2	7	2	2	1	1	-	1	-	2.71
Monaghan	496 (23)	13 (-38)	373	17.2	11	-	4	5	2	-	-	-	2.82
Offaly	489 (20)	14 (180)	258	23.3	0	-	-	-	-	-	-	-	-
Roscommon	1,367 (34)	45 (50)	790	24.8	28	6	4	11	7	-	-	-	2.68
Sligo	179 (-4)	4 (-56)	156	22.4	11	3	4	-	-	1	2	1	3.18
Tipperary	246 (-11)	7 (-13)	128	24.2	11	-	6	1	4	-	-	-	2.82
Waterford	320 (-28)	4 (-56)	320	26.3	12	1	5	1	5	-	-	-	2.83
Westmeath	389 (-38)	7 (-22)	370	18.1	23	4	2	13	3	1	-	-	2.78
Wexford	791 (23)	9 (80)	602	27.7	63	14	22	16	5	5	1	-	2.49
Wicklow	116 (183)	2 (0)	107	31.8	10	1	4	4	1	-	-	-	2.50
RoI total	**11,586 (10)**	**371 (29)**	**8,846**	**22.5**	**385**	**88**	**125**	**97**	**54**	**16**	**4**	**1**	**2.48**
All-Ireland total	**15,104 (0)**	**495 (27)**	**12,004**	**22.3**	**674**	**184**	**214**	**155**	**81**	**32**	**7**	**1**	**2.39**

* County-level totals are based on the locations of the flocks, and differs slightly from treatment of county-level totals in previous years, such as 2010 (Boland *et al.* 2010), where the flocks were first compiled at site level and then at county level. The most notable differences, therefore, occur in counties with wetland complexes spanning multiple counties, e.g. Shannon and Fergus Estuary, Lough Ree and River Foyle.

was considerable variation in almost all counties when compared with 2010 (Table 1). Increases took place in 14 counties, and these were greatest in Galway (+692 birds), Roscommon (+350) and Mayo (+340). Decreases took place in 16 counties, and these were greatest in Londonderry (-1,025 birds), Limerick (-243) and Westmeath (-243). At a flock level, increases were reported in 18 counties and decreases in nine counties.

The 1% flyway and all-Ireland thresholds are currently estimated at 270 and 150 birds respectively (Crowe & Holt 2013, Wetlands International 2015). Accordingly, when totals are examined at a wetland site or complex level, internationally

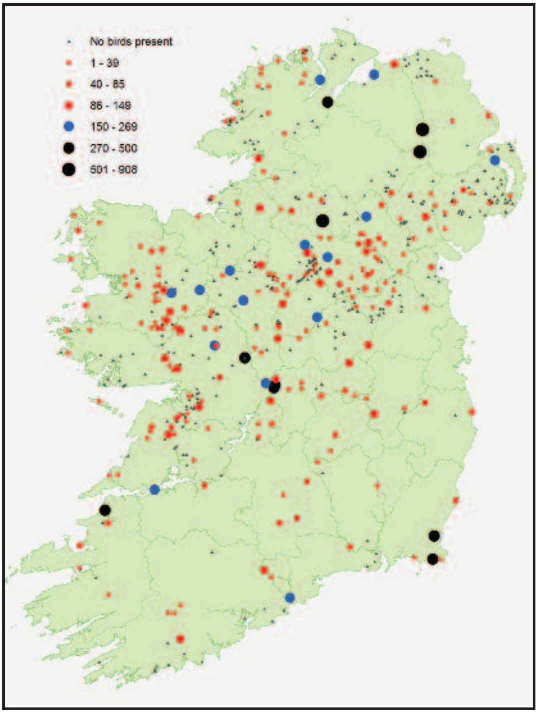

Figure 1. Distribution of Whooper Swans in Ireland in January 2015. Large black and blue symbols represent internationally and nationally important sites based on 1% thresholds of 270 and 150 respectively.

and nationally important concentrations were recorded at ten and 15 sites respectively (Table 2). However, it should be noted that assessments of site importance based on counts in January alone are limited as they do not reflect the importance of sites in other months, especially during arrival in October and November and prior to departure in spring. Lough Neagh, Upper Lough Erne and Lough Beg continue to support highest numbers, though the latter two show a decline when compared with the 2010 census. The total recorded at Lough Foyle, another site that was among the most important in 2010, was much lower during this census, and it has dropped from international to national importance. A significant drop in total numbers was also recorded at the adjacent Lough Swilly, which has been shown to be part of the same overall complex as Lough Foyle. Most of the other internationally important sites showed increases when compared with 2010, most notably Tacumshin Lake, while a single flock of 365 at a site at Kilmacshane (Galway) was the highest single flock total reported in the Republic of Ireland, and elevates this new site to one of international significance for Whooper Swan (Table 2).

Large-scale variation in numbers continues to occur at site level. During this census, there were changes in status at 15 of the 25 internationally and nationally important sites listed when compared with 2010 (Table 2); i.e. there was a change in the category in which the site was listed. Specifically, 11 sites listed as internationally or nationally important were not listed in 2010, and a further four sites declined in status, from international to national importance. Numbers at a further ten sites listed in 2010 were below the thresholds and are not listed in Table 2. These include three sites that were internationally important in 2010, namely Little Brosna Callows, Lough Iron and the Blackwater Callows.

In total, 12,004 individuals (80% of all swans recorded) were aged, of which 22.3% were juvenile (Table 1). This includes 22.5% juveniles in the Republic of Ireland and 21.7% in Northern Ireland. A total of 674 broods were recorded, ranging between broods of one and a peak of seven in one flock in Sligo. The mean brood size overall was 2.39, and for counties where greater than ten families were checked, mean brood sizes ranged between a low of 1.96 (Donegal) and a peak of 3.18 (Sligo). The mean brood size was larger in the Republic of Ireland (2.48) when compared with Northern Ireland (2.26), and this result seems to be attributable to apparent differences in brood structure when analysed at such a broad scale (Figure 2). The proportion of juveniles and mean brood sizes seemed to be lowest in northern parts of Ireland and higher elsewhere, perhaps suggesting there may have been a latitudinal influence on the distribution of juveniles and family groups. However, there were so significant patterns shown during this census in brood size ($F = 1.807$, $P = 0.1955$) or in the proportion of juveniles ($F = 2.17$, $P = 0.1584$).

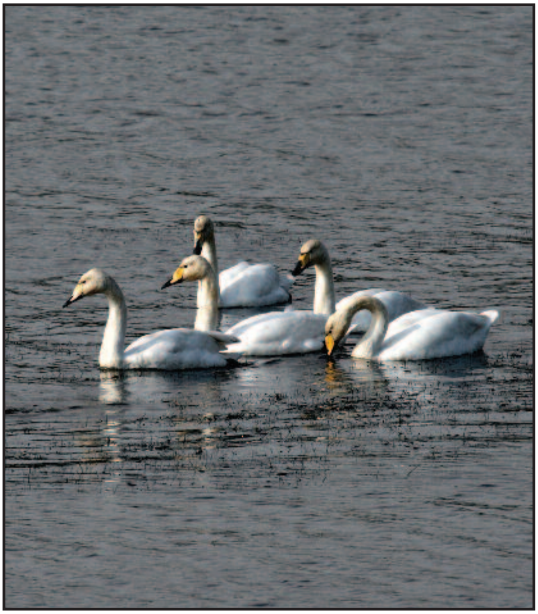

Plate 71. Whooper Swans (Oran O'Sullivan).

Table 2. Internationally and nationally important sites for Whooper Swans recorded in January 2015. Flyway thresholds after Crowe and Holt (2013) and Wetlands International (2015).

Site	County	Count	% change (2010)
Internationally important sites (1% flyway threshold = 270)			
Lough Neagh	Antrim/ Londonderry/ Tyrone/ Armagh/ Down	908	1
Upper Lough Erne	Fermanagh	689	-14
Lough Beg	Antrim/ Londonderry	679	-25
Shannon Callows	Offaly	465	28
Wexford Harbour & Slobs	Wexford	382	-7
River Suck	Roscommon	381	15
Kilmacshane*	Galway	365	-
Cashen River & Estuary	Kerry	341	-33
River Foyle	Donegal/ Tyrone/Londonderry	332	10
Tacumshin Lake*	Wexford	316	829
Nationally important sites (1% all-Ireland threshold = 150)			
Shannon & Fergus Estuary**	Clare	246	-27
Brees Wetlands*	Mayo	231	425
Garryduff*	Galway	228	-
Lough Swilly**	Donegal	223	-34
Glen Lough*	Westmeath	215	139
East Ballinamore Lakes	Cavan	210	56
Ballyhaunis Lakes*	Mayo	208	86
Castleplunket Turloughs*	Roscommon	195	255
Strangford Lough	Down	178	29
Lough Oughter Complex**	Cavan	176	-51
Lower Blackwater River*	Waterford	175	130
Lough Gara*	Sligo	159	31
North East Galway Lakes*	Galway	157	>1,000
Lough Foyle**	Londonderry/ Donegal	157	-82
Finn-Lacky Catchment*	Monaghan	156	53

* Did not qualify in 2010
** Moved from international to national importance

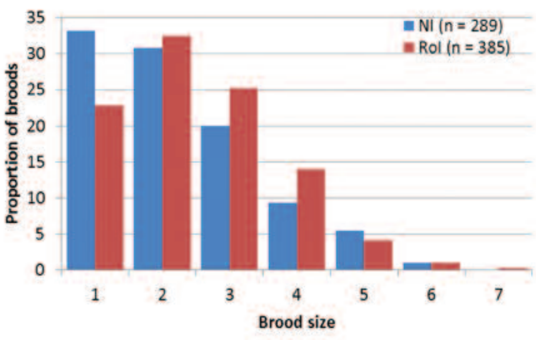

Figure 2. Proportions of total broods of different sizes in Northern Ireland and the Republic of Ireland in January 2015.

Bewick's Swan

A total of just 21 Bewick's Swans was recorded in four flocks (Table 3). The majority were recorded at the North Slob (Wexford). This is the first census when no birds were recorded in Northern Ireland.

Habitat

The habitat utilised was recorded for 84% of swans overall (Figure 3). Whooper Swans were recorded in 25 out of the 30 habitat types available for selection, with the highest proportion recorded on dry improved pasture (40%), on turloughs or callows (13%) or on waterbodies (9%).

Table 3. Totals of Bewick's Swans recorded in January 2015.

Site	County	Count	% juv
Brideswell	Roscommon	2	-
The Cull & Killag (Ballyteige)	Wexford	3	0
Wexford Harbour & Slobs	Wexford	13	15*
Tacumshin Lake	Wexford	3	-

* Two broods of one juvenile each.

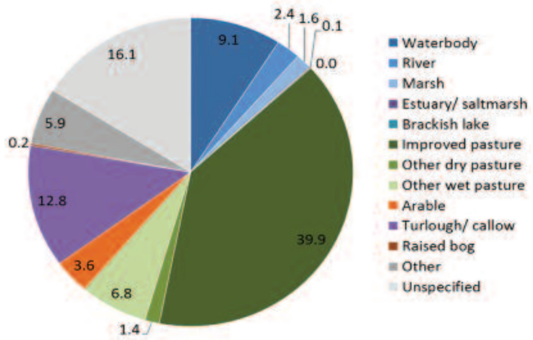

Figure 3. Habitats used by Whooper Swans during January 2015.

Discussion

Distribution and abundance

The overall total number of Whooper Swans recorded in Ireland in 2015 (at 15,104) is similar to that for 2010 (updated census total of 15,136). This result means that the 2015 census marks the first since 1995 where there was no further increase in numbers, implying that totals here are stable. Boland *et al.* (2010) indicated that the rate of increase in 2010 was beginning to decline. It is unfortunate that the Bewick's Swan has continued its downward trend in Ireland, with just 21 recorded in four flocks. With a decline at flyway scale and a substantial decline at their key Wexford haunts, the Wexford Slobs, Tacumshin and Killag in the south and east of the county, the continued future presence of this species in Ireland is in doubt.

The weather in the months leading up to the census was relatively mild and wet (Met Éireann 2014, 2015), which resulted in an abundance of available wetlands and in generally favourable habitat conditions for swans overall. These conditions were in stark contrast to those in 2010, when especially cold conditions prevailed (Boland *et al.* 2010). During that census, with many of the smaller wetlands frozen over and habitat conditions in an extremely poor state, swan flocks were recorded in previously unknown and unusual locations. Therefore, it was expected that the results of the 2015 census would reveal the distribution of swans as markedly different when compared with 2010.

Despite the similarity in total numbers recorded in Ireland during both the 2010 and 2015 censuses, Whooper Swans were clearly more dispersed in 2015, with a 27% increase in the number of flocks recorded. Conversely, the total number of flocks exceeding 100 swans was greater in 2010 (35) when compared with 2015 (23). Furthermore, there was large-scale variation in totals at the county level, revealing differences in distributions between censuses. The majority of swans during this census were reported on grasslands, with a slightly higher proportion on waterbodies when compared with 2010.

Because of the recorded difference in distribution, sites that qualified as internationally and nationally important were also quite different when compared with previous censuses. There were many new sites of importance identified during this census when compared with 2010, presumably the result of a greater spread in the distributions of birds. The majority of internationally important sites have retained this status, while only a small proportion of the sites that were nationally important in 2010 have remained on the nationally important list in 2015. Among the internationally important sites in 2010, declines in numbers have resulted in a loss of some key sites to national importance, most notably Lough Foyle, Lough Oughter, Lough Swilly and the Shannon and Fergus Estuary.

Breeding success

The overall mean brood sizes and proportions of juveniles of Whooper Swans in 2015 were both higher when compared with censuses carried out since 1995 (Cranswick *et al.* 1996, Colhoun *et al.* 2000, Crowe *et al.* 2005, Boland *et al.* 2010). The variation in productivity at county and at regional levels possibly reflects a tendency for family groups to congregate at certain sites, and it seems that family groups were less prevalent in the northern part of Ireland in January 2015 (Donegal and Northern Ireland). Reasons for these patterns remain unclear.

Ongoing monitoring at a selection of sites across Ireland in the intervening years (IWSSG unpublished) has shown that mean brood sizes and proportions of juveniles have been widely variable since the last census. Most notable was the substantial decline in the proportion of juveniles to a low of just 14% and 15% in Northern Ireland and the Republic of Ireland, respectively, in 2011/12. The WeBS and I-WeBS trends indicate that total counts have also varied during the intervening period; the I-WeBS trend (I-WeBS unpublished)

Plate 72. Whooper Swans (Michael O'Clery).

showed that there had been a decline in numbers to levels reported during the mid to late 1990s. Therefore, the improvement in breeding success shown here is a welcome result.

Conclusion

The results from the current census (January 2015), especially when compared with 2010, clearly illustrate that swan distributions are strongly influenced by the availability of suitable habitats, which in turn are substantially affected by weather conditions. The winter of 2014/15 was mild in the weeks and months leading up to the census, meaning that there was a diversity and abundance of wetlands available throughout Ireland, and this is possibly why swans were so widely dispersed. Thus, it is important to reiterate that the primary purpose of thorough international censuses is to generate the most robust possible total number of birds, which then facilitates assessment of trends and of site importance at national and international scales. These assessments cannot rely solely on national monitoring schemes, such as WeBS and I-WeBS, because of the widely dispersed nature of swans, especially as flocks are often reported considerable distances from wetlands. It is widely known that waterbirds are highly mobile outside the breeding season, and that they can move significant distances during a given winter. Thus, information on the importance of sites is better examined over the course of a season, based on information gathered in conjunction with WeBS and I-WeBS, rather than on a snapshot such as the census reported here.

Results of this census indicate that numbers in Ireland have stabilised, despite a notable increase in breeding success (2014) when compared with previous censuses. It is important that the Whooper Swan trend is closely monitored through WeBS and I-WeBS over the coming years to track ongoing year to year changes. Furthermore, the Irish Whooper Swan Study Group continues to undertake monitoring of breeding success at a number of sites throughout Ireland, and this information is important to help explain the trends shown. Hopefully, a combination of trend and productivity information will indicate that there is no significant reversal of the positive trend that has been evident for so long.

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Egg fostering in Little Terns *Sternula albifrons* in response to nest abandonment following depredation

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Keywords: Breeding success, conservation management, Corvidae, depredation, Little Tern, *Sternula albifrons*

Plate 73. Little Tern (Michael Finn).

Shoreline habitats of the Little Tern *Sternula albifrons* have been affected by increased human disturbance leading to a considerable contraction in breeding range, and they are increasingly restricted to a small number of large intensively wardened colonies. Increased concentration at such sites has the potential to exacerbate the impact of depredation on overall colony breeding success. To minimise the impact of depredation by corvids, wardens at Kilcoole Little Tern colony (County Wicklow) have employed a strategy of fostering eggs abandoned by the parents of partially depredated nests, into other nests with the same incubation schedule. Fostering attempts in 2011 led to the successful hatching and rearing of two chicks by foster parents, while three chicks were reared using the same methods in 2014. This is apparently the first time this strategy has been employed with a member of the family Sternidae. Fostering eggs in this way from partially depredated nests may be a useful conservation management strategy, particularly for very rare species.

Introduction

Increasing human disturbance of shoreline habitats has inflicted pressure on shore-nesting birds. Little Terns *Sternula albifrons* are an important example of this phenomenon. Little Terns typically nest in colonies on shingle beaches (Gochfeld & Burger 1996). The recent atlas (Balmer *et al.* 2013) showed a large contraction in the range of the Little Tern in Ireland and Britain, with breeding increasingly restricted to a small number of larger, protected colonies. While these efforts have helped stabilise Little Tern numbers, these colonies are vulnerable to depredation, requiring intensive protection and management efforts.

BirdWatch Ireland and the National Parks and Wildlife Service have carried out a colony protection and management project at the Little Tern colony at Kilcoole, County Wicklow since 1985 (O'Briain & Farrelly 1990). This project has led to

Plate 74. Little Tern (Ronnie Martin).

a dramatic increase in Little Tern numbers at Kilcoole, with 155 breeding pairs recorded in 2015 (Doyle *et al.* 2015). However, the colony is still vulnerable to tidal effects and to depredation. Corvids are a significant threat to Little Tern nests and have taken eggs every year since the project began, apart from 2013, causing significant losses in 2011 and 2012 (Keogh *et al.* 2011, 2012, 2013, O'Connell *et al.* 2014a).

Methods

As part of the Kilcoole Little Tern protection scheme, the colony is monitored by wardens 24 hours a day. Therefore, all Little Tern breeding activity has been closely monitored. The beach is scanned frequently each day to check that terns in known nests are incubating (indicating that the nest is active) and to find new nests. When new nests are located their exact position is noted, and the nest given a unique code (see Results) written on a pebble placed ca. 1 metre away so that it can be easily monitored. The placement of markers has been given careful consideration and made as unobtrusive as possible so that predators are not attracted to the vicinity. Nests are again visited near the end of the incubation period to check for chick hatching success. This close monitoring gives an excellent picture of the progress throughout the season and the outcome of each breeding attempt.

To minimise losses from depredation events, a strategy of egg fostering (the placing of eggs abandoned after partial depredation of a nest, into another nest) has been employed by wardens since 2011. In order to ascertain whether a nest is abandoned the partially depredated nests are observed closely over several hours for returning adults, particularly after 'dreading' activity; nests are considered abandoned if no adults returned. Foster nests are identified as those with incubation schedules exactly matching the partially depredated nests and which contained only one or two eggs (i.e. not the typical maximum clutch of three (Gochfeld & Burger 1996)). Abandoned eggs are, where possible, placed in nests which have been partially depredated, therefore, replacing eggs that have been lost, and avoiding disturbance to nests which have not had eggs depredated. This strategy has been employed in order to maximise productivity at the colony.

Plate 75. Little Tern (Michael Finn).

Results

Between 23–27 May in the 2011 season, 36 eggs from 16 nests were depredated by a Rook *Corvus frugilegus* (Keogh *et al.* 2011). In some cases, not all eggs were destroyed and adult terns frequently returned to incubate a single remaining egg. However, the terns usually abandoned the egg within a day. When these abandoned eggs were placed into new nests, the foster parents were observed to return and incubate immediately, apparently unperturbed by the gain of an extra egg. This method was carried out with three eggs, one from nests K10, K42 and N10 (nests are identified by the unique code attributed to them when discovered by the wardening team), which were placed in nests K2, K40 and K8 respectively. The eggs placed in nests K2 and K8 hatched successfully and the chicks were tended by the foster parents. The egg placed in nest K40 failed to hatch.

Ten Little Tern nests experienced either full or partial depredation on 9 June 2014. Three of the partially depredated nests (K20, K36 and K37) were confirmed abandoned the next day. The abandoned eggs were fostered into two partially depredated nests where adults were continuing to incubate. The egg from K37 was placed in K32 and the eggs from K20 and K36 were placed in K53, bringing both nests up to three eggs. The fostered eggs were accepted and all eggs in both nests hatched successfully. The parents of K32 raised two chicks of their own plus an additional foster chick and the parents of K53 raised two foster chicks as well as one of their own.

Discussion

By fostering abandoned eggs in this way colony productivity may be maximised. It is unknown why the parents of partially depredated nests abandon them in the majority of cases. Parent birds perhaps anticipate the return of the predator for the rest of the clutch, so causing them to abandon. The parents may also abandon in order to lay another full clutch elsewhere in an effort to maximise their output. However, the offspring of late re-laid clutches are likely to have a lower survival rate than earlier clutches (Nager *et al.* 2000). When eggs were placed into two partially depredated nests in 2014

(K32 and K53), the parents of these nests were the only ones not to abandon nests which had suffered partial depredation (O'Connell *et al.* 2014a). It may be that the bringing of these clutches up to full size stimulated the parents to continue incubating and prevented the abandonment of the nests. These nests suffered no further depredation events, perhaps due to wardening efforts or increased vigilance from the parents. One of the fostered eggs (from K42 in 2011) failed to hatch, although it is possible it may have been embryonically dead before fostering, or it may have succumbed to the cold in the time between abandonment and being placed in the new nest.

Seabirds have been shown to readily accept eggs from different nests in cross-fostering experiments (Silva *et al.* 2007, Divoky & Harter 2010, Morales *et al.* 2010). Little Terns have previously been shown to accept their own eggs after tidal inundation and placement of some 'lost' eggs in new nests by wardens (O'Connell *et al.* 2014b). However, this is the first time (as far as we are aware) that fostering of eggs in other nests as a conservation measure in response to nest abandonment has been recorded in the family Sternidae. It is also worth noting that in four of the five nests used as recipients of fostered eggs, the fostered eggs increased the number of eggs in the nest to three from an original clutch of two, showing that the Little Tern is willing to accept more eggs than had been originally laid.

Fostering abandoned eggs into other nests has been shown to be a potentially useful management tool in seabird conservation. In the case of rare breeding species, such as the Little Tern, maximising the productivity of the small number of wardened colonies is important, as so much of the species' breeding success depends on these areas. While the impact of the fostering attempts carried out at Kilcoole was limited, this strategy may be useful in the case of even rarer species where it is necessary to ensure the maximum number of individuals survive to fledging.

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Disturbance response of Great Northern Divers *Gavia immer* to boat traffic in Inner Galway Bay

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Keywords: Boat traffic, disturbance, *Gavia immer, Gavia stellata,* Great Northern Diver, Red-throated Diver

A survey of Great Northern Divers *Gavia immer* at Inner Galway Bay (57 observations of 64 birds) indicate that they do not show a 'flush' response to boat traffic, even when the survey boat passed within 10 to 20 m of some birds, although some did show a 'dive' response. However, two of three Red-throated Divers *Gavia stellata* showed a 'flush' response at distances of about 15 m, and just over 100 m, from the survey boat.

Introduction

Divers are generally regarded as highly sensitive to disturbance. For example, Furness *et al.* (2013) classified the sensitivity of Black-throated *Gavia arctica,* Red-throated *Gavia stellata* and Great Northern Divers *Gavia immer* to disturbance from ship and helicopter traffic as 5 on a scale of 1 to 5, where 5 represents "strong escape behaviour, at a large response distance". Furthermore, the guidance for carrying out European Seabirds at Sea (ESAS) surveys refer to the need to scan the sea area ahead of the ship "to detect the takeoff of usually very wary seaduck and divers well ahead of the approaching platform" (Camphuysen *et al.* 2004). However,

Plate 76. Great Northern Diver (Michael O'Clery).

there appears to be very little published evidence on the response of divers to marine traffic.

Inner Galway Bay supports an internationally important population of Great Northern Divers, with a mean annual peak count of 197, and a maximum count of 305, during 2009/10 to 2013/14 (Irish Wetland Bird Survey data, accessed at www.birdwatchireland.ie/?tabid=111 on 31 October 2015), compared with the 1% international importance threshold of 50. Great Northern Divers occur around the entire shoreline of Inner Galway Bay, but little is known about their distribution in offshore waters in the bay as the I-WeBS counts do not cover these areas, and there have not been any detailed Seabirds at Sea surveys within the bay. The proposed Galway Harbour Extension project is projected to cause a 25% increase in shipping traffic (from 177 to 210 vessels per year), and a 20% increase in recreational and fishing boat activity in winter (from 10 to 12 boats per day, excluding weekly yacht races). Due to their perceived sensitivity to disturbance, the potential impact of this increase in marine traffic on the Great Northern Diver population of Inner Galway Bay was an issue of concern. Therefore, a survey was carried out to quantify the response of Great Northern Divers to boat traffic. Here we report the results of this survey, and provide the first published evidence about the response of Great Northern Divers to marine traffic.

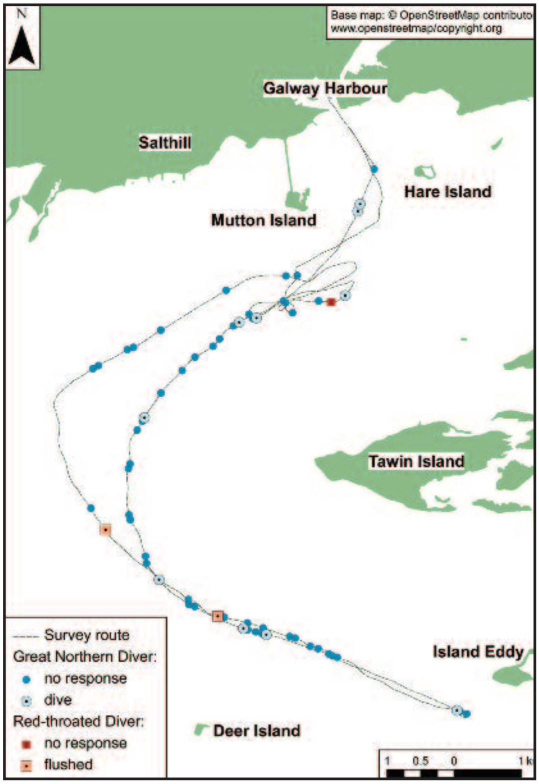

Figure 1. Survey route and distribution of diver observations, Galway Bay, January 2015.

Methods

The survey was carried out between 09.00-12.00 hours on 22 January 2015. Conditions were excellent for surveying with a sea state of 1-2. The survey used the Cailín Ór ferry. This is a Kingfisher 50 Class VI boat with a length of 15.45 m, breadth of 5 m, draft of 2 m and 41 gross tonnage. The boat provided an observation deck around 4 m above the sea surface. The survey covered a route of around 37 km from Galway Harbour (grid ref M3024) around Tawin Island (M2919), to Island Eddy (M3215), then back across the middle of the bay, picking up the shipping channel off Black Rock (M2621) and following the shipping channel back into the harbour (Figure 1). The boat was driven at constant speeds of 5 knots on the outward leg (to Island Eddy), and 10 knots on the return leg. These speeds were selected as they represent typical speeds for boats in Inner Galway Bay during winter. The survey was carried out by three observers (the authors of this paper). Paul Troake is an accredited European Seabirds at Sea surveyor.

At the start of the survey, initial training in distance estimation was carried out. This involved the three observers independently estimating the distance of the boat from fixed points (such as a buoy), and comparing this with the true distance as measured by the navigation system in the boat. During the survey, each diver encountered within 500 m of the boat was noted, the time of the observation was recorded, and a GPS waypoint was taken representing the position of the boat at the time of the observation. The closest distance from the bird at which the boat passed was recorded using the following distance bands: 0 to 50 m, 50 to 100 m, 100 to 150 m, 150 to 200 m, 200 to 300 m, 300 to 400 m and 400 to 500 m. For birds showing a disturbance response, we also recorded the initial distance at which the bird was located, compared to the distance at which it showed a disturbance response (if within different distance bands). We classified the nature of the disturbance response (if any), as either 'flush' or 'dive'. The 'flush' response was recorded for birds that took flight in response to the approach and/or passage of the boat. The 'dive' response was recorded for birds that appeared to dive in response to the approach and/or passage of the boat. It can be difficult to determine whether a dive is due to the influence of the boat, as divers feed by diving. However, 'dive' responses were recorded for two scenarios: where the bird was not actively feeding as the boat approached but then dived; and/or when the bird dived using a sudden movement, different from its normal dive. Nevertheless, there will be some uncertainty in assigning the 'dive' response and we took a conservative approach (i.e. assigning a 'dive' response when there was any uncertainty about whether the dive was due to disturbance). Note that part of the return survey route followed the outward route. Therefore, some birds may have been involved in more than one observation.

Results

A total of 57 observations of 64 Great Northern Divers, and three observations of three Red-throated Divers were recorded. In addition, one Great Northern Diver, four Red-throated Divers and two unidentified divers were seen in flight only (not flushed by the boat). No Great Northern Divers were flushed by the boat, even though the boat passed within 10 to 20 m of some birds. Ten Great Northern Divers were recorded showing the 'dive' response, all within the 0 to 50 m and 50 to 100 m distance bands (Table 1). All six birds recorded within the 0 to 50 m distance band showed the 'dive' response (n = 4 at 5 knots; n =2 at 10 knots). Within the 50 to 100 m distance band, one of seven observations at a speed of 5 knots showed a 'dive' response, compared to three out of seven observations at a speed of 10 knots. It should also be noted that, as mentioned above, there is considerable uncertainty in assigning the 'dive' response, and some birds recorded as showing this response may just have been feeding normally. In several observations of birds showing the 'dive' response, it was noted that the birds resumed feeding normally, or swimming (for birds that had not been feeding), immediately after the boat passed. The distribution of Great Northern Diver 'dive' responses did not show any obvious pattern of being associated with the middle of the bay (Figure 1), although the pattern will be biased by uneven distribution of observations within the 0 to 50 m and 50 to 100 m distance bands.

Two of the three Red-throated Divers recorded showed the 'flush' response (at distances of about 15 m, and just over 100 m, from the boat), while the third was recorded at a long distance from the boat (400 to 500 m). Both birds that flushed flew considerable distances before resettling (0.5 to 1 km, and more than 1 km, respectively).

Table 1. Numbers of Great Northern Divers by distance band and their response to the approach and or passage of the boat, Galway Bay, January 2015.

	5 knots		10 knots		
Distance band (m)	**dive response**	**no response**	**dive response**	**no response**	**Totals**
0-50	4	0	2	0	6
50-100	1	6	3	4	14
100-150	0	6	0	4	10
150-200	0	2	0	3	5
200-300	0	16	0	6	22
300-400	0	3	0	1	4
400-500	0	1	0	2	3

Plate 77. Great Northern Diver (Michael O'Clery).

Discussion

This survey indicates that in Inner Galway Bay, Great Northern Divers are not significantly disturbed by medium-sized craft travelling at slow to moderate speeds. While the survey was only carried out on a single day, it is notable that not a single incident of a Great Northern Diver being flushed by the boat was observed. The results of the survey accord with the casual observations of two of the authors that Great Northern Divers in Irish coastal waters are not very sensitive to disturbance by marine traffic. In Cork Harbour, Great Northern Divers regularly feed in and around the main navigation channel at the mouth of the harbour and have been observed to tolerate close passage by large ships and smaller craft without any significant response (TG, pers. obs.). Similarly, in Inner Galway Bay, Great Northern Divers in the area around the existing harbour do not show any significant response to normal ship and boat traffic (CP, pers. obs.). However, Great Northern Divers have been flushed when driven directly at in a rigid inflatable boat (RIB) at speeds of 20 to 30 knots (CP, pers. obs.).

Our results may appear to be in conflict with the general perception in the literature about the disturbance sensitivity of divers. However, we have not found a single study that reports detailed observations, or quantitative data, on the disturbance response of Great Northern Divers. Nevertheless, it is possible that Great Northern Divers in areas with low levels of ship and boat traffic may be more sensitive to disturbance. The limited data collected in this survey does suggest that Red-throated Divers may be more sensitive to disturbance. Previous research and observations have indicated that this species is very sensitive to disturbance: Topping and Petersen (2011) state that Red-throated Divers often flush at distances of about 1 km from an approaching ship, while Schwemmer *et al.* (2011) detail research that they carried out in the German North Sea in which they determined that Red-throated Divers and Black-throated Divers avoid active shipping lanes. However, the two Red-throated Divers that flushed in our survey did so at much closer distances from the boat than is implied by the above observations.

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Great Crested Grebes *Podiceps cristatus* in County Cavan, summer 2014: population levels and breeding success

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Keywords: Breeding success, Great Crested Grebe, *Podiceps cristatus,* population census

A repeat census was undertaken between late May and late July 2014 at 115 lakes in County Cavan to establish if the population of Great Crested Grebes *Podiceps cristatus* had changed since the last census in 1986-88. The total of 479 birds observed (estimated population 532 birds) represented a decrease of 33% in the population since the last census. The 2014 census also recorded a decrease of 12% in the observed population at 46 lakes, compared with a 1975 census. Sixty-nine pairs were observed with a total of 152 young; an average of 2.2 young per successful pair.

Introduction

The Great Crested Grebe *Podiceps cristatus* has a widespread distribution, particularly throughout the temperate lower latitudes of Europe. The nominate subspecies breeds and winters in northwest Europe (Wetlands International 2002). There are few data available to examine the degree of migration throughout Europe, and it is likely that the majority of birds breeding in Ireland and Britain are resident, but with some immigration resulting from cold weather movements (Crowe 2005). It has been shown (Balmer *et al*. 2013) that the Irish population has increased its breeding range by 9% since 1968-72 (Sharrock 1976), although most birds are found north of a line from Dundalk to Limerick. In County Cavan, Great Crested Grebes breed mostly on large and small eutrophic lakes, but also can be found on slow flowing sections of river. Due to persecution in the 19th century the breeding population in Ireland and Britain was reduced to only 32 known pairs in 1860, but with subsequent protection there has been continued growth in the population (Prater 1981). The number of Great Crested Grebes observed in Ireland was very limited, and few specimens were obtained, except during very severe winters (Thompson 1851). Today the largest numbers of Great Crested Grebes in Ireland are found at Lough Neagh with 1,827 breeding pairs (Perry *et al.* 1998). They are predominately piscivorous and breeding productivity and abundance is largely dependent on the quantity of available fish prey (Winfield *et al*. 1989, Perry *et al.* 1998). In terms of European conservation status, the Great Crested Grebe is Amber listed for both the breeding and winter seasons, the qualifying criterion being a species that has declined by 25-50% over 25 years (Colhoun & Cummins 2013). The purpose of the current census was to establish if there had been a change in the summer population since the last census. Breeding success was also recorded.

Census methods and previous history

The census methods in this survey were the same as those for surveys carried out in 1975 and 1986-88 (Lovatt 1988). Each lake was thoroughly searched for Great Crested Grebes, using

Plate 78. Great Crested Grebe (Szabó József).

binoculars and a telescope. Counts took place from the shoreline or from the best vantage points overlooking each lake. Up to 15 minutes was spent at most waters, but longer periods of time were required to observe larger lakes. Fourteen lakes were revisited as it was felt birds might have been hidden on the first visit, despite up to 30 minutes having being spent surveying each one. Estimated totals were also calculated having watched the behaviour of single birds sitting on the water close to the reed beds. If an observed bird was considered to be quartering a territory, swimming into and out of a reed bed or chasing away a rival bird, it was considered that another bird was present and concealed on a nest. There were also birds which appeared to be non-breeders, and in common with the 1986-88 survey, the counting unit was the individual bird.

For breeding birds, lakes were searched for adults with young birds. The number of pairs was arrived at by observing adult birds feeding young. When there were several pairs with young on the same lake, care was taken to observe which adult birds were feeding young, so as to count the correct brood size. These counts were undertaken at the same time as the count and estimate of all adult birds.

The 1975 survey was carried out between 6 June and 15 June (Preston 1975), while fieldwork in 1986-88 was carried out in the periods 22 June to 13 July 1986, 2 June to 17 July 1987 and 12 June to 2 July 1988 (Lovatt 1988). Most of the 1986-88 survey took place in June, so the results are comparable with the 1975 survey. The current survey was carried out between 30 May and 26 July 2014.

Results

Number of birds observed and estimated

The results of the surveys of 1986-88 and 2014 are shown in Table 1. The total number of birds observed in 1986-88 was 720, while the number estimated was 813 birds present at a total of 115 sites. The total number of birds observed in 2014 was 479, while the number estimated was 532 birds present at the same 115 sites. These figures represent a decline of 33% and 35% respectively between these two surveys. Comparable data are available for 46 lakes in all three surveys (1975, 1986-88 and 2014), and these results are shown in Table 2. There was an increase of 44% in the number of birds observed from 1975 to 1986-88, but a decrease of 12% from 1975 to 2014. Of the 115 sites surveyed in 2014, 87 were occupied compared with 96 occupied in 1986-88. No birds were present at 13 sites in both 1986-88 and 2014.

Plate 79. Great Crested Grebe (Szabó József).

Table 1. Great Crested Grebe census of County Cavan in 2014, with counts from 1986-88 shown for comparison (birds observed and estimated are shown separately).

Lake	Grid Ref	Observed 1986-88	Observed 2014	Estimated 1986-88	Estimated 2014
Acurry L	N585990	0	2	0	2
Aghavoher L	H294198	2	2	2	2
Amoneen L	H357212	2	2	2	2
Anagh L	H290188	2	2	2	2
Annagh L	H395125	9	2	10	2
Ardan L	H355120	11	8	14	8
Ardra L	H296002	0	0	0	0
Asturrall L	H570005	0	0	0	0
Atrain L	H364050	4	2	4	4
Aghabane L	H295085	4	0	4	0
Bailieborough L	N677964	2	0	2	0
Ballymagauran L	H215130	0	4	0	5
Barn L	H321162	1	0	2	0
Barnagrow L	H670070	12	1	14	2
Bawn L	H300070	7	6	8	8
Bawndoora L	N323924	0	0	0	0
Beahy L	H443057	8	4	8	4
Bellaboy L	H210172	2	2	2	2
Black L	H360138	9	4	10	4
Black L	N339920	0	0	0	0
Bracklagh L	N395825	0	3	0	4
Brackley L	H190205	8	8	8	14
Bun L	H377148	6	2	6	2
Bunerky L	H190185	4	9	6	10
Carrafin L	H380105	5	4	6	5
Carrawtraw L	H376093	3	6	4	6
Claragh L	H470148	0	0	0	0
Clonamullig L	H312160	4	2	4	2
Clonty L	H275123	2	0	2	0
Commonsgate L	H380157	4	2	4	2
Convent L	H306088	0	0	0	0
Coologe L	H236130	3	2	4	2
Coppony L	H470130	2	2	2	2
Corglass L	H350988	6	7	8	8
Cornalara L	H748030	2	0	2	0
Corraghy L	H690052	2	1	2	2
Corraneary L	H650052	5	2	6	2
Corrarod L	H410163	3	2	4	2
Creeny L	H374180	0	0	0	0
Cuillaghan L	H305183	22	2	24	2
Dawan L	N343940	No water	0	No water	0
Dawsons L	H366163	4	0	4	0
Deralk L	H338095	7	4	14	4
Derrybrick L	H350115	24	4	28	4
Derrycassan L	H225120	4	5	4	5
Derrygeeraghan L	H350145	4	4	4	4
Derrygid L	H398090	4	10	4	10
Derrykerrib L	H400205	2	2	4	2
Derryvonny L	H375225	3	12	4	14
Disert L	H290078	2	1	2	2
Drumanny L	H365128	18	7	26	8

Table 1 (Continued).

Drumard L	H360205	11	12	12	12
Drumard L extension	H368215	4	4	4	6
Drumellis L	H401158	6	4	6	6
Drumgorry L	H415163	2	2	2	2
Drumlane L	H340110	11	2	14	4
Edenterrif L	H380202	5	6	6	6
R. Erne (part of Inishmuck)	H362115	8	0	10	0
River Erne	H366143	2	0	2	0
Farnham L	H392070	12	12	14	12
Garfinny L	H350102	36	10	38	12
Garty L	N280980	10	4	10	4
Glasshouse L	H260060	20	12	20	12
Gowna L	N290900	16	21	16	21
Green L	H425035	0	0	0	0
Greenville L	H275132	2	0	2	0
Grilly L	H386182	2	2	2	2
Holy L	H318170	4	2	4	2
Inchin L	H385080	16	9	18	10
Inishmuck L	H360105	9	13	10	13
Kilconny L	H358179	7	2	8	2
Killybandrick L	H430160	11	4	12	4
Killylea L	H395205	12	5	14	8
Killynaher L	H322153	4	2	6	2
Killywilly L	H300170	24	8	28	8
Lakefield L	H200180	4	2	4	2
Lavey L	H500022	4	8	4	8
Lisgrey L	N593899	0	0	0	0
Lisnannagh L	H495031	9	0	10	0
Long L	H330166	2	0	2	0
Long L adjacent	H324172	2	0	2	0
Lower L	N265980	2	2	2	2
Milltowm L	H710039	4	4	4	4
Muddy L	H720058	3	0	4	0
Nadreegeel L	N550937	3	6	4	6
Oughter L	Square H30	86	66	92	75
Parisee L	H398164	10	9	10	9
Pleasure L	H314068	2	3	2	4
Portaliff L	H315060	0	1	0	2
Putiaghan L	H369150	2	2	2	2
Quivvy L	H385210	13	6	16	6
Ramor L	N580865	10	17	12	17
Roosky L	H646042	1	1	2	2
Round L	H390153	9	6	10	8
Rud L	H283159	1	2	2	2
Shancorry L	H372188	0	0	0	0
Shanteron L	H457064	0	2	0	2
Sheelin L	N450850	7	9	8	9
Shinan L	H710053	0	0	0	0
Sillan L	H700066	20	8	22	8
Skeagh L	H652010	5	4	6	4
Steepleton L	H728053	2	2	2	2
Swan L	N315918	2	6	4	6
Swellan L	H412040	2	5	4	6
Tacker L	H690080	6	2	6	4
Tawlaght/Carrs L	H340035	8	5	8	6
Teemore L	H353200	2	2	2	2

Table 1 (Continued).

Templeport L	H215165	13	5	13	6
Togher L	H279150	0	0	0	0
Tomkin Road L	H310174	2	0	2	0
Tonawolly L	H384150	2	0	2	0
Town L	H305075	9	5	10	5
Tully L	H345098	6	3	6	4
Tullyroane L	H395145	5	4	6	4
Tullyguide L	H320084	0	2	0	2
Total		**720**	**479**	**813**	**532**
Percentage decrease from 1986-88			**33%**		**35%**

Table 2. Great Crested Grebe census of County Cavan, showing counts of birds at 46 lakes where counts were carried out during three censuses (1975, 1986-88 and 2014).

Lake	Grid ref.	1975	1986-88	2014
Aghavoher L	H294158	0	2	2
Ardan L	H355120	16	11	8
Barn L	H321162	0	1	0
Barnagrow L	H670070	2	12	1
Bawn L	H300070	5	7	6
Black L	N339920	0	0	0
Bun L	H377148	2	6	2
Carrafin L	H380105	2	5	4
Carrawtraw L	H376093	6	3	6
Clonamullig L	H312160	4	4	2
Clonty L	H375123	2	2	2
Corglass L	H350088	4	6	7
Corrarod L	H410163	2	3	2
Cuillaghan L	H305183	6	22	2
Deralk L	H338095	12	7	4
Derrybrick L	H350115	18	24	4
Derrygid L	H398090	20	4	10
Drumellis L	H401158	0	6	4
Drumgorry L	H415163	4	2	2
Drumlane L	H340110	14	11	2
Drumanny L	H365128	16	18	7
Farnham L	H392070	8	12	12
Garfinny L	H350102	10	36	10
Garty L	N280980	6	10	4
Gowna L	N290900	6	16	21
Greenville L	H275132	0	2	0
Holy L	H318170	6	4	2
Killybandrick L	H430160	4	11	4
Killynaher L	H322153	2	4	2
Killywilly L	H300170	14	24	8
Lakefield L	H200180	4	4	2
Lisgrey L	N593899	2	0	0
Milltown L	H710039	6	4	4
Nadrageel L	N550937	2	3	6
Parisee L	H398164	2	10	9
Ramor L	N580865	12	10	17
Round L	H390153	6	9	6
Sheelin L	N450850	7	7	9
Skeagh L	H652010	0	5	4
Swan L	N315918	2	2	6
Tacker L	H690080	6	6	2
Tawlaght/Carrs L	H340035	4	8	5
Templeport L	H215165	6	13	5
Togher L	H279150	0	0	0
Town L	H305075	5	9	5
Tully L	H345098	2	6	5
Total 46 lakes		**257**	**371**	**225**
Percentage change from 1975			**up 44%**	**down 12%**

Breeding results

A total of 69 pairs were recorded with young birds. Of these, 19 pairs had one young, 23 pairs had two, 21 pairs had three and six pairs had four, resulting in a total of 152 young birds. This gives an average of 2.2 young per pair.

Discussion

The reason for the observed decline in the Great Crested Grebe population in County Cavan is not understood, but there may be several contributing factors. Fluctuating water levels caused by high rainfall may have impacted on the success of breeding Great Crested Grebes over the years. In

Plate 80. Great Crested Grebe (Szabó József).

the Lough Oughter complex the water levels are influenced by the confluence of the Annalee, Cavan and Erne Rivers, which flow into the lake. This results in very high water levels during rainy conditions. It takes a considerable time for water levels to subside here, and this is likely to be problematic for all breeding water birds. There has been little evidence of a decline in fish stocks at lakes, and the bag size recorded from fishing activities has been stable (Inland Fisheries Ireland pers. comm.). This suggests that a lack of food is not a significant factor in the long term decline in Great Crested Grebe numbers.

Introduced American Mink *Neovison vison* have been observed at a number of lakes, including at two during the 2014 survey, and it is possible predation of young grebes may occasionally take place. During a survey around Mullingar on the Rivers Glore and Inny and at a polluted Lough Ennell, a total of 2,510 Mink scats were examined (Ward *et al.* 1986). The total percentage frequency of food categories for birds was 17.2%. Rails (Rallidae) and ducks or geese (Anatidae) made up 10% of this total. Badgers *Meles meles* have also been known to take birds along rivers. They prey on young birds in nests, such as Kingfisher *Alcedo atthis* and Dipper *Cinclus cinclus,* which they are able to access by vertical digging (Smiddy 1996), although this is probably not a common practice. In a recent British Broadcasting Corporation Spring Watch programme, it was discovered that a Badger was responsible for taking Avocet *Recurvirostra avosetta* chicks at an island site. Pike *Esox lucius* might be a predator of young birds, and a fisherman reported attacks on a family of recently fledged Great Crested Grebes at a lake where he was fishing. A Lesser Black-backed Gull *Larus fuscus* was observed taking an egg from a nest close to a shoreline at Lough Oughter in 2014. Eggs in the nests of grebes are usually covered over with nesting material when the incubating adult leaves, in order to avoid egg predation. However, they may be exposed during incubation changeover between the parent grebes, although this gull attack is considered unusual.

Waters at many lakes have been polluted due to agricultural developments since the 1970s. At Lough Sheelin, phosphates originating from intensive agricultural developments led to progressive enrichment of the lake which resulted in the Brown trout *Salmo trutta* population declining (Champ 1998, 2003). However, better land management is slowly helping to reduce lake enrichment. The Zebra Mussel *Dreissena polymorpha* was first observed in Ireland during 1997 (Minchin & Moriarty 1998), and was present at Lough Sheelin in 2001, and they have since spread into other lakes in County Cavan (Martin O'Grady, Inland Fisheries Ireland, pers. comm.). Zebra Mussels feed on nutrients in the water and this has resulted in lakes becoming clearer, with increased plant growth. The impact of Zebra Mussels on other fauna in Ireland is not known at this time. There are no lakes of high status in County Cavan based on three biological quality parameters, aquatic flora, phytoplankton and fish (McGarrigle *et al.* 2010).

It might be considered that the cold winters of 2009-10 and 2010-11 may have had an impact on the population of summering Great Crested Grebes, resulting in a greater drop in numbers at that time. The Bird Atlas 2007-11 (Balmer *et al*. 2013) states that wintering numbers have declined in the Republic of Ireland by 31% during the period 1994-95 to 2008-09, with a recent decline also noted in Northern Ireland. Winter numbers monitored by the Wetland Birds Survey in the United Kingdom have shown a long term shallow increase, but they may now be in shallow decline (Calbrade *et al.* 2010). There have been big changes in numbers of Great Crested Grebes at some lakes in County Cavan. At Annagh Lake numbers dropped from nine to two, at Barnagrow Lake from 12 to one, at Quivvy Lake from 13 to six and at Lough Sillan from 20 to six. Boating activities have been established at these lakes with speed boat and water-skiing occurring at Lough Sillan, and may be a reason for the decline in numbers. Cruise boats are active at Quivvy Lake and swimming takes place at Annagh Lake as well as much fishing from boats. Numbers declined from 36 to ten at Garfinny Lake and from 20 to 12 at Glasshouse Lake. Most of these birds were non breeders. Numbers declined at Cuillaghan Lake from 22 to two, at Derrybrick Lake from 24 to four, at Killywilly Lake from 24 to eight and at Templeport Lake from 13 to five. The Canada Goose *Branta canadensis* has become established as a breeder at these four lakes since 1986-88, and their territories may be partly responsible for reduced numbers. Reduced numbers were also recorded at Drumlane Lake, down from 11 to two, at Drumanny Lake from 18 to seven, at Lisnannagh Lake from nine to zero and with smaller reductions at other lakes. Predation might be considered a reason at these waters.

Breeding birds

During the early part of the survey no young birds were present as it was too early in the season for young Great Crested Grebes to be hatched. No young birds were recorded at 36 lakes surveyed from 30 May to 5 June. The first breeding success was noted on 6 June with a single bird at a small lake. A further 31 lakes were surveyed without young being seen, before a total of six young birds was present on 13 June. It was July before the main hatching of young was recorded, and most young were present by the end of that month. A pair of birds was displaying on 25 July and birds were still sitting on nests at two sites on 15 August. Perhaps these birds had possibly failed in an earlier breeding attempt. The summer of 2014 was very good with long periods of dry weather which would have been favourable for a successful breeding season for Great Crested Grebes. This may lead to an increase in the adult breeding stock in the next few years. In a year with flooding, nests could become submerged and this would have an impact on breeding success.

Conclusion

There appears to be no single reason for the decline in Great Crested Grebe numbers in County Cavan in the summer season between 1986-88 and 2014. Flooding during the breeding season in years between these surveys could be an influencing factor on the breeding population, and the severe winters of 2009-10 and 2010-11 might have also reduced the population. There has been no collapse of fish stocks over the period when breeding birds and their young depend upon an adequate food supply. There is no evidence that predation has any significant impact on numbers. Sporting activities are evident at a few lakes and this may impact on numbers of Great Crested Grebes there. Canada Geese, which have increased in numbers, may have become territorial competitors at some lakes. It is suggested a further survey is required in five to ten years to establish if there are any further changes in the numbers of Great Crested Grebes, as well as in their breeding success. A starting period from late June is recommended as the first recorded date for a young bird was 6 June in 2014. This would better facilitate the counting of young birds and the recording of adults. Access to lakes would be easier at this later time also as much of the silage (grass) cutting would have taken place by then.

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Food provisioning of Little Grebe *Tachybaptus ruficollis* chicks

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Keywords: Food provisioning, Little Grebe, *Tachybaptus ruficollis*

A study of food provisioning of Little Grebe *Tachybaptus ruficollis* chicks showed that a single chick (Nest 1) received 1,456 food deliveries, while two chicks (Nest 2) received 755 food deliveries during 30 hours of observations. Mean food provisioning rate (FPR) for Nest 1 was 0.79 food deliveries per min^{-1} (SD = ± 0.64). Mean FPR for Nest 2 was 0.43 food deliveries per min^{-1} (SD = ± 0.27). Four observation periods chosen at random for Nest 2 showed that the percentage of fish delivered ranged from 46.5% to 93.5%. Deliveries of fish at Nest 1 were rare, and there was no significant difference in mean FPR between Nest 1 and Nest 2.

Introduction

The nominate race of Little Grebe *Tachybaptus ruficollis* is found throughout Europe. It is widespread in Ireland both in the breeding season and in winter. Its breeding range has decreased by 9% and its winter range has increased by 24% over 40 and 30 years, respectively (Balmer *et al.* 2013). Little Grebe studies in Ireland are severely limited, the most comprehensive being an analysis of Nest Record Cards covering Britain and Ireland as a whole (Moss & Moss 1993). Despite the paucity of Little Grebe studies in the literature, the feeding ecology of grebes as a taxonomic group is well documented focusing chiefly on the composition of diet, and due to their catholic tastes, the high occurrence of parasitism (Fjeldså 1981, Storer 2000, Sitko & Heneberg 2015). To the best of the author's knowledge, studies of food provisioning of Little Grebe chicks are non-existent, the closest being a passing reference to adults feeding young on fish fry (Vinicombe 1982). A possible explanation of this is that they have a tendency to nest in thick emergent vegetation which makes clear observation difficult. The nests under observation for this study were exposed and the young were fed on open water. These grebes were habituated to the presence of humans, allowing close approaches. These conditions provided a unique opportunity to study the rate at which chicks were fed, the differences in feeding rates between nests with different numbers of chicks, and the behaviour of both adults and chicks during hunting and food deliveries.

Study area and methods

The study area was located in a group of small man-made lakes located in Waterock Golf Course, near Midleton, County Cork (W8675). Each lake had varying amounts of submerged and emergent plant vegetation. Two nests were chosen for study, Nest 1 and Nest 2 being located on different, but nearby, ponds. Nest 1 contained a single chick, Nest 2 contained two chicks; it originally contained three chicks but one died shortly after the commencement of observations. Each nest was

Plate 81. Little Grebe (Shay Connolly).

observed for 30 hours with observation periods lasting from between one and four hours. All observations lasted for the whole of the hour in which they were commenced. Field observations occurred from 24 July to 29 August 2015. All observations took place within 29 days after the chicks had hatched. Only heavy rain prevented observations from taking place as such conditions would drive the grebes to cover. The number of successful food deliveries was counted for each observation period. A successful food delivery was defined as food being given to the chick by the adult and then swallowed by the chick. Rejected food items or food items that the chicks dropped and did not retrieve were not counted as successful food deliveries. A food provisioning rate (FPR) was calculated for each nest as follows; FPR = total number of feeds during observation period (T_F)/total number of minutes in observation period (T_M); e.g. when $T_F = 20$ and $T_M = 120$ then FPR = T_F/T_M = 0.16 feeds per minute^{-1}. This value gave an estimate as to the average number of food deliveries per minute of an observation period.

While chicks were still being incubated, observations were made from discrete vantage points, at least 10 m from the nest. This was done to prevent chilling of the chicks through adult desertion of the nest, therefore allowing the adult to continue to provision the chicks with food at a 'natural' rate. Once the young were regularly swimming by themselves, closer approaches were possible. Closer approaches were necessary at Nest 2 in order to accurately count the number of deliveries as due to the temporary brood division behaviour exhibited by Little Grebe adults (Fjeldså 2004), chicks could be with different parents at opposite ends of the lake. A close approach allowed clear views of both chicks, ensuring a high degree of accuracy for the FPR. Tall emergent vegetation around the lake containing Nest 2 prevented the grebes from detecting the observer in such situations. During brood divisions, attention was drawn to an imminent food delivery by the loud, rapid begging calls of the young. The behaviour of the adult and juvenile Little Grebes during such interactions was recorded through direct observation and note taking. Data were analysed using SPSS® 20. A mean and standard deviation was generated for the FPR (Table 1). The percentage of fish that was delivered as prey was calculated for four randomly selected feeding bouts (Table 2). An independent samples t-test was used to compare mean FPR for Nest 1 and Nest 2. A line graph showing the changes in FPR for the first 29 days after hatching was prepared for both nests (Figure 1). A two-period moving average was applied to the data to remove the effects of outliers.

Results

The single chick in Nest 1 received 1,456 food deliveries during thirty hours of observations, while the two chicks in Nest 2 received 755 food deliveries during the same period. Mean FPR for Nest 1 was 0.79 food deliveries per min^{-1} with a standard deviation of ± 0.64. Mean FPR for Nest 2 was 0.43 food deliveries per min^{-1} with a standard deviation of ± 0.27 (Table 1). Identification of food items delivered was possible when the birds provided good views. Larvae of unidentified species, an adult damselfly of the Coenagrionidae, and small Sticklebacks *Gasterosteus* species were included amongst prey items. Prey items too small for observation through binoculars were also delivered. Such items were almost certainly microinvertebrates as consumption of proportionally large quantities of microinvertebrates is known from studies of other similar sized species of grebes such as the Hoary-headed Grebe *Poliocephalus poliocephalus* (Fjeldså 1988). For Nest 2, a sample of four observation periods were chosen at random and the number of fish delivered as a percentage of total food

Table 1. Mean Food Provisioning Rate (FPR) and Standard Deviation (SD) for Little Grebe chicks from Nest 1 and Nest 2.

	1 chick (Nest 1)	2 chicks (Nest 2)	Total
Mean	0.79	0.43	0.61
N	15	15	30
Standard deviation	0.64	0.27	0.51

Table 2. Fish as a percentage of total prey items in diet of Little Grebe chicks at Nest 2 (ObP = Observation Period).

	ObP 1	ObP 2	ObP 3	ObP 4
No. of prey	43	53	21	31
% of fish	46.5	66.0	80.9	93.5

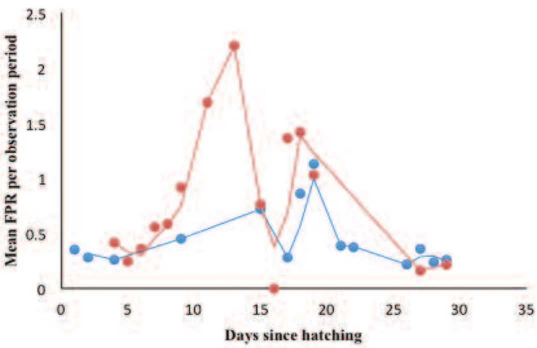

Figure 1. Changes in Food Provisioning Rate (FPR) for Little Grebe chicks from Nest 1 (red) and Nest 2 (blue).

Plate 82. Adult Little Grebe on nest (Ronan O'Sullivan).

deliveries was calculated. Percentage fish delivered ranged from 46.5% to 93.5% (Table 2). The independent samples t-test comparing the mean FPR between the two nests produced a P value = >0.05, therefore, no significant difference in mean FPR existed between Nest 1 and Nest 2. Change in the FPR during the first 29 days after hatching of the young is shown for both nests (Figure 1).

Discussion

Hunting and feeding

Adult Little Grebes were observed to use two main hunting strategies; diving and skim feeding. One adult from Nest 2 was once seen lunging upward from the water in an attempt to catch a large dragonfly. While riding on an adult's back, chicks as young as nine days old were observed stretching out their necks to catch small midges. Chicks from Nest 2 were observed gleaning emergent and overhanging vegetation, presumably feeding on small arthropods. Feeding took place in concentrated bouts of activity followed by periods when both adults and young became inactive and remained stationery on the surface.

Having surfaced with a fish, the adult Little Grebe would hold it by the head and vigorously thrash it against the water to either kill or stun it. The fish would then be passed to a chick. The chick would adjust the fish in its bill so that it too was holding the fish by its head. The chick would then proceed to imitate the adult in the thrashing behaviour. As the chick thrashed the fish, the adult would remain in attendance. The adult would dip its head under water periodically and if the chick had dropped the fish or the fish had escaped, the adult would pursue and recapture the fish, returning it to the chick. Large fish were often half swallowed and then regurgitated by the chick and thrashed several times more. This may have aided in the swallowing process.

Aggression

At Nest 1, as the chick became more independent and less time was spent on an adult's back, one adult would hunt for the chick while the other adult either loafed, preened, or hunted for food itself. The chick would stay close to the adult that was provisioning it. No aggression was ever observed towards the chick in Nest 1. At Nest 2, temporary brood division took place. This was accompanied by the adults displaying clear 'in-chick, out-chick' behaviour, first documented in the Great-crested Grebe *Podiceps cristatus* (Simmons 1970). The 'in-chick, out-chick' behaviour would manifest itself in the adult Little Grebe with a bird almost exclusively feeding its favoured chick. If both chicks were with an adult, the less-favoured chick would be fed very rarely and would often be aggressively driven away with pecks to the head and body. Aggression towards young would also occur if an adult surfaced without food and the chick approached making a begging call. In such situations the adult would chase and attack the chick, irrespective of its 'in-chick, out-chick' status.

Behaviour at the nest

Nest 1: This nest was wrecked during inclement weather the day after the chick hatched. The adult grebes rebuilt the nest but it was only observed to be used once; an adult with the chick on its back sat upon the nest during a torrential rain shower. Despite its lack of use, the nest remained at the core of the grebes' territory with the adults behaving aggressively towards other birds that approached it (Moorhen *Gallinula chloropus* also nested at this lake). The juvenile was seen associating with the nest site as late as 26 October 2015, 99 days after hatching.

Nest 2: During the first ten days of life, the chicks remained in the nest resting on the back of an adult. If chicks entered the water during this period it was the result of them falling off the adult's back whilst the adult stood up, or the chicks fell from the nest into the water in their eagerness to be fed by a returning adult bird. Only once during this initial ten-day period were the chicks left unattended at the nest. As the chicks grew larger, less time was spent on the back of an adult. Food deliveries were given to chicks either in the water or on an adult's back. Upon the chicks being able to swim competently, the nest was abandoned. Subsequent visits to the nest site as late as 26 October 2015 revealed one of the chicks (now a juvenile bird) still present near the nest, 87 days after hatching.

Statistical analysis

The lack of statistical significance between mean FPR for both broods is striking, despite the discrepancy between food deliveries to chicks from both broods. This discrepancy could be explained by the adult grebes at Nest 1 delivering smaller prey items to the chick and having to increase the number of feeds the chick received in order to compensate for this. From qualitative observation, deliveries of fish at Nest 1 were rare. In contrast, fish made up a proportionately large element of the prey delivered at Nest 2 (Table 2). The statistically similar mean FPRs may also be due to the small sample size in the study. It is recognised that this study lacks the statistical rigour of larger, more long-term studies. The changes in mean FPR for both nests over the first 29 days are shown in Figure 1. Taking into account the lack of statistical difference between mean FPR for both nests, the disparity in the trend lines is probably due to the difference in food (invertebrates versus fish) provisioned to either nest. Both nests show an increase in mean FPR up to day 15; this is followed by an abrupt decline, later followed by another increase. Both nests then show a steady decline. These data can be interpreted as follows; an initial increase in mean FPR is followed by a steady decline in the amount of food provisioned as the chicks grow older.

Conclusion

The Little Grebe is one of the most poorly studied birds in its order. The diminutive size of the birds and their predilection for nesting and feeding amongst dense, emergent vegetation provide obstacles to accurate quantitative observation. The description of the behaviour of both adults and chicks during feeding interactions is novel to this study and provides data on their basic ecology. It is hoped the study of FPR presented in this paper will act as a baseline for future studies on the behaviour and feeding ecology of this species.

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Biometrics of Pied Wagtails *Motacilla alba yarrellii* in County Cork

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Biometrics of Pied Wagtails *Motacilla alba yarrellii* in County Cork are described. Wing length and weight of adult males and females differed significantly, as did tarsus and bill length, although to a lesser degree. First-winter males had significantly longer wings than first-winter females, but there was no significant difference in their tarsus and bill length. Adult birds (sexes combined) had significantly longer wings than first-winter birds, but there was no significant difference in other measurements. Adult and first-winter birds (sexes combined) were significantly heavier in April, compared to February, although the level of significance was less for adults. The two heaviest birds were captured in April, both first-winter females with well-developed brood patches.

Introduction

About 30,500 birds per annum have been ringed in Ireland over the 40 year period 1975 to 2014 (Tierney 2015). However, there is a huge disparity in the number of individuals ringed annually between different species, with many common species being rarely, or only occasionally, ringed. There are a number of reasons why this may be so, including the research interests of bird ringers, the conservation status of species and the ease, or difficulty, with which certain species can be captured. The Pied Wagtail *Motacilla alba yarrellii* is a

Plate 83. Pied Wagtail (Michael O'Clery).

common and widespread species throughout Ireland at all times of the year, and its conservation status has not changed over a 40 year period (Balmer *et al.* 2013). This subspecies is largely resident (Cramp 1988) and is 'green' listed in Birds of Conservation Concern in Ireland (Colhoun & Cummins 2013). However, despite the widespread nature of this species, very few have been ringed (annual mean of 58 during 2009-2013) (Tierney 2015). The Pied Wagtail is well known to use communal night roosts during autumn and through the winter. Roosts are frequently situated in urban and industrial habitats, where the temperature is often a few degrees higher than the surrounding countryside (Cramp 1988, pers. obs.).

The reluctance of bird ringers in Ireland to publish the results of their work has been commented upon (Hutchinson 1989: 36, 1997: 280). Bird ringers regularly collect basic data on the biometrics of the species they study, and such data may be of great interest in the wider context of the species concerned at a European or worldwide scale. Few of these data have been published for Ireland. Therefore, this paper reports on biometrics of Pied Wagtails collected during February and April 1990 at a roost site at Little Island, Co. Cork.

Study area and methods

In early 1990 we examined a night roost of Pied Wagtails at an industrial site at Little Island, Co. Cork. The birds were roosting on pipes, walkways and support frames around stainless steel vats. The site had lighting throughout the night, and industry personnel often worked in close proximity to roosting birds. We made two catches of birds at night, using mist nets, one in February (134 new birds) and one in April (29 new birds and an additional 11 re-trapped from the February catch) (Smiddy & O'Halloran 1990). We assessed the age and sex of each bird using published criteria (Cramp 1988, Svensson 1992). Standard measurements of wing (maximum chord, to the nearest 1 mm) were taken using a stopped rule, while a steel callipers was used to measure the tarsus and bill (tip to distal corner of nostril, to the nearest 0.1 mm) (Cramp 1988, Svensson 1992). Weights were recorded to the nearest 0.1 g using a digital balance. It was possible to age all birds as either adult (more than one year old) or first-winter (less than one year old). The sex of all adults was established on plumage criteria, although the sex of most of the first-winter birds could not be established beyond doubt (Cramp 1988, Svensson 1992). This fact means that it has not been possible to make statistical comparisons between the sexes from the two age groups because of small sample sizes, although we have done so by combining males, females and unsexed birds in both age groups. Statistical analysis was carried out using the MINITAB 14 package.

Results and discussion

The number of birds using the roost between January and July 1990 ranged from 350 to zero (Table 1). Measures to prevent birds from roosting (for hygiene, and health and safety

Plate 84. Pied Wagtail (Oran O'Sullivan).

reasons) in certain parts of the complex were underway by early April (enclosing pipes in fine mesh wire netting) although a natural decline in the number of birds using the roost would be expected by that date. The ratio of first-winter to adult birds was 1.2: 1 (n = 163), and the ratio of adult females to males was 1.1: 1 (n = 73). The wing length and weight of adult males and females differed significantly (one-way ANOVA: wing $F_{1,71} = 96.19$, $P = <0.001$; weight $F_{1,58} = 19.65$, $P = <0.001$), males being longer-winged and heavier than females. The tarsus and bill length of adult males and females also differed significantly (tarsus $F_{1,70} = 8.05$, $P = 0.006$; bill $F_{1,71} = 5.99$, $P = 0.017$) (Figure 1, Table 2). First-winter males had significantly longer wings than first-winter females ($F_{1,28} = 35.58$, $P = <0.001$). However, there was no significant difference in tarsus and bill length between first-winter males and females (tarsus $F_{1,28} = 3.11$, $P = 0.089$; bill $F_{1,28} = 3.09$, $P = 0.090$) (Table 2). The sample of weight data for sexed first-winter birds was too small for detailed analysis.

Table 1. Counts of Pied Wagtails roosting at Little Island, Co. Cork. Scaring measures had been put in place by 6 April 1990.

Date	No. of birds
8 January 1990	350
22 February 1990	200
6 April 1990	50
18 May 1990	5
6 July 1990	0

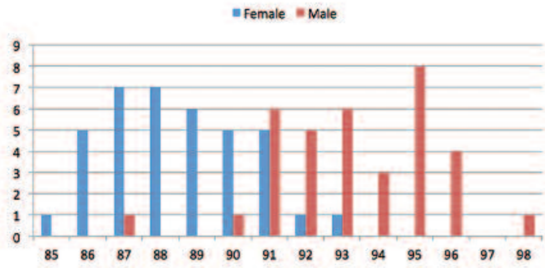

Figure 1. Wing length of adult female and male Pied Wagtails at Little Island, Co. Cork, February and April 1990 (n = 38 females, 35 males).

Table 2. Measurements (mm) and weight (g) of adult and first-winter Pied Wagtails at Little Island, Co. Cork, February and April 1990, showing mean, standard error, range and sample size. [1] M = male, F = female, US = unsexed; [2] weight data refers only to February.

Body part	Age and sex[1]	Mean	Standard error	Range	Sample
Wing	Adult M	93.3	0.4	87-98	35
	Adult F	88.5	0.3	85-93	38
	1st winter M	91.7	0.5	89-96	15
	1st winter F	87.9	0.4	86-91	15
	1st winter US	87.8	0.3	83-92	60
Tarsus	Adult M	24.9	0.2	22.0-26.7	35
	Adult F	24.2	0.1	21.3-25.6	37
	1st winter M	25.2	0.2	23.0-26.4	15
	1st winter F	24.4	0.3	21.2-25.6	15
	1st winter US	24.5	0.1	21.7-26.7	59
Bill length	Adult M	9.4	0.1	8.3-10.4	35
	Adult F	9.2	0.1	8.4-9.8	38
	1st winter M	9.4	0.1	8.5-10.1	15
	1st winter F	9.2	0.1	8.8-9.8	15
	1st winter US	9.2	0.1	8.2-10.4	58
Weight[2]	Adult M	23.9	0.3	21.2-27.0	26
	Adult F	22.1	0.3	19.0-25.2	34
	1st winter M	24.0	0.3	22.3-25.1	10
	1st winter F	22.7	0.7	20.3-24.5	5
	1st winter US	21.9	0.2	19.0-27.8	57

Adult birds (sexes combined) had significantly longer wings than first-winter birds ($F_{1,161}$ = 27.89, P = <0.001), but there was no significant difference in other measurements (tarsus $F_{1,159}$ = 0.10, P = 0.755; bill $F_{1,159}$ = 1.09, P = 0.298; weight $F_{1,130}$ = 2.86, P = 0.093) between the two age groups. Adult and first-winter birds (sexes combined) were significantly heavier in April, compared to February (adult $F_{1,75}$ = 6.07, P = 0.016; first-winter $F_{1,92}$ = 14.50, P = <0.001). The two heaviest birds were captured in April, both first-winter females with well-developed brood patches, so were probably breeding nearby (29.5 g and 28.7 g). The heaviest of these had originally been captured in February when it weighed 25.8 g.

Surprisingly few studies on the biometrics of Pied Wagtails of the subspecies *yarrellii* have been published. Details from studies in Scotland and England have been summarised by Dougall and Appleton (1989). Some differences are described between these studies, especially in age and sex ratios and in weight changes throughout the winter. There are some similarities and differences between the study described here and those described by Dougall and Appleton (1989). However, the overall small sample and time-restricted nature of this study makes it unwise to expand on these differences. However, the importance of publishing even short term or opportunistically collected data is emphasised, especially if there is no immediate prospect of expanding on the work. Although Cramp (1988) gives some biometric data for Irish birds, these are not separated from British birds; therefore, this is the first published information on the biometrics of Pied Wagtails for Ireland.

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Colonisation and breeding status of the Great Spotted Woodpecker *Dendrocopus major* in the Republic of Ireland

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The Great Spotted Woodpecker *Dendrocopus major* has been absent historically as a breeding species from Ireland. Although there is no conclusive scientific evidence that it ever bred, the species supposedly went functionally extinct in Ireland following deforestation in the 17th and 18th centuries, and bones attributed to the species have been reported from County Clare. It has been a vagrant to Ireland since the early 19th century with small influxes noted in some winters, many of which have been attributed to the northern population *(D. m. major)*, although with few proved to be so. The first breeding record for the island of Ireland was in 2006 when a juvenile was seen in a garden in County Down. Proof of breeding in the Republic of Ireland was first obtained in 2008 when a juvenile was observed at a nut feeder in County Dublin, and the first occupied nests (seven in Wicklow) were discovered in 2009. The number of occupied nests has continued to increase each year to 2015, when 35 were recorded. However, range expansion to date outside the core breeding area of County Wicklow appears to be slow. A total of 148 occupied nests were recorded during the seven years 2009-2015, 141 in County Wicklow, although breeding has also been recorded in seven other eastern counties. Most nests have been found in mature oak woodland (77% of nests) and most nests holes have been excavated in oak trees. Nest holes are frequently used in subsequent years. Predators include Sparrowhawk *Accipiter nisus,* and the Pine Marten *Martes martes* has been suspected as a nest predator. Studies of the genetics of Irish birds strongly indicate that the founding population originated in Britain, rather than continental Europe.

Introduction

The Great Spotted Woodpecker *Dendrocopus major* is the most widespread species of woodpecker in the world (Gorman 2014). Its global distribution extends from Britain, Spain and the Canary Islands eastwards across Europe and Asia as far as Japan and Kamchatka. Its latitudinal limits in Europe stretch from arctic taiga forests in northern Scandinavia to the Mediterranean Sea (Cramp 1985). Up to 26 subspecies have been described across its geographical range

Plate 85. Female Great Spotted Woodpecker at nest (Dick Coombes).

Plate 86. Great Spotted Woodpecker nest in an Alder tree (Dick Coombes).

(Cramp 1985, Parkin & Knox 2010), but some authors accept a more conservative 14 (del Hoyo *et al.* 2002). British birds are often treated as an endemic race *(anglicus)* (Parkin & Knox 2010), although some authorities include them in the central European race *(pinetorum)* (del Hoyo *et al.* 2002). Throughout its range it is a resident species and is generally highly sedentary, southern populations particularly so. Ringing recoveries have shown that most British Great Spotted Woodpeckers do not travel more than 5 to 20 km during their lives (Robinson *et al*. 2015). However, juvenile dispersal often involves movements of over 100 km and up to 600 km across its range (Winkler *et al.* 1995). The northern populations *(D. m. major)* of Scandinavia and Siberia are, however, subject to irruptive movements, and individuals may travel more than 3,000 km (Winkler *et al.* 1995).

Ecology and habits

Great Spotted Woodpeckers are found in all habitats wherever there are trees mature enough to accommodate nest-holes (Cramp 1985). They are distinctive birds with striking black and white plumage and can be vocal, especially near the nest. However, outside the breeding season they can be quite elusive, often remaining high in trees. Drumming is the woodpecker's method of proclaiming territory (they do not sing) and although it can be heard in any month, it is at its peak in early spring. It is an iconic woodland sound, which can carry for hundreds of metres, made by birds of either sex striking the bill rapidly (at a frequency of 10-14 strikes per second) on a resonating piece of wood, usually a dead branch. Great Spotted Woodpeckers are for the most part solitary, except when active near the nest or during courtship (Cramp 1985). They are relatively long-lived; the five oldest ringed birds recorded in Britain ranged from 10 years and 3 months to 11 years and 1 month (Robinson *et al.* 2015). They can breed in their first year. A single clutch of four to six white eggs is laid on the bare wood at the bottom of a nest chamber which is excavated by both sexes to a depth of 25 to 35 cm. The entrance hole is 5 to 6 cm in diameter. Incubation takes 10-13 days and is carried out by both sexes, and the fledging period is 20-24 days (Cramp 1985).

Status in Ireland

Historically, the Great Spotted Woodpecker has long been considered absent as a breeding species from Ireland, Iceland

and the Isle of Man (Cramp 1985). Although there is no conclusive scientific evidence that it ever bred, the species supposedly went functionally extinct in Ireland following deforestation in the 17th and 18th centuries. Bones attributed to the species were reported from cave excavations in County Clare in 1903-1905 (Scharff *et al.* 1906). One of the two specimens found at that time has been dated at 3,750 years before the present (± 35, un-calibrated) placing the species in the Bronze Age (D'Arcy 2006).

About 18 individuals were recorded in Ireland as vagrants in the first half of the 19th century, with at least 15 of them occurring between October and February in widely separated counties from north to south (Thompson 1849, 1851). Some 39 occurrences were reported by Ussher and Warren (1900), including those listed by Thompson. These authors noted small influxes in some winters (e.g. 1889/90) and that most had occurred in the eastern half of Ireland, with only four in the west; Kerry (1), Mayo (1) and Sligo (2). Kennedy *et al.* (1954) reported that birds had been obtained in over forty instances between October and February, inclusive of those noted previously (Thompson 1849, 1851, Ussher & Warren 1900), but there were other records also of birds having been seen; an influx in the winter of 1949/50 involving at least nine individuals. While Kennedy *et al*. (1954) state that probably all of the Great Spotted Woodpeckers found in Ireland were of the northern population *(D. m. major)*, evidence was provided to show that only five were actually of this race.

By 1965 there were over 55 records of this woodpecker, all occurring between September and May, but with the majority between November and February, having been recorded in every county except Cavan, Donegal, Leitrim, Longford, Tyrone and Westmeath (Ruttledge 1966). A trawl through Irish Bird Reports (1953-2003) and the Irish Rare Bird Report (2004) reveals an irregular pattern of occurrence over the 52 year period (1953-2004). Birds were recorded in 15 of those years, but in general numbers were small. Single birds were recorded in ten different years, and no birds at all over one eight year period (1980-1987). There were, however, three winters in which multiple birds were recorded; 1962/63 (5 birds), 1968/69 (at least 25 birds) and 1971/72 (8 birds). The influx of 1968/69 was believed to refer primarily to birds of the northern race *(D. m. major)*, based on the fact that two birds (Clare and Down) were positively identified as belonging to that race. Due to the high dependency of Great Spotted Woodpeckers inhabiting northern conifer regions on the seeds of pine and spruce as a food source in winter, they are subject to southward autumn irruptions in years when the seed crop is poor or fails (Cramp 1985). These birds return north again the following spring. The invasion of 1962/63 in Ireland coincided with large numbers of these birds on the east coast of England, clearly indicating an irruption occurred on a broad front (Hutchinson 1989). However, a female obtained in Fermanagh in December 1959 was found to belong to the British race *(D. m. anglicus)* (Hutchinson 1989). During this period the various woodpecker races from Russia and Scandinavia *(D. m. major)*, northern Europe and the near continent *(D. m. pinetorum)* and Britain *(D. m. anglicus)* were separated on the basis of biometrics; namely wing length, where long-winged birds were thought to belong to the nominate race. A recent study suggests that the wing length of British Great Spotted Woodpeckers is more variable than originally thought (Smith 2010), as previously suggested (Coulson & Odin 2007), and states that only in extreme cases is it possible to determine the race of an individual bird on wing length alone, although patterns of occurrence of long-winged birds are informative.

The Great Spotted Woodpecker is the most widespread and abundant of the three woodpecker species occurring in Britain, (the others being Lesser Spotted Woodpecker *Dendrocopos minor* and Green Woodpecker *Picus viridis*) and the population there has increased dramatically in recent decades by 133% and 196% in England and Wales, respectively (Risely *et al.* 2008). Indeed, the longer term increase between 1967 and 2008 was 386% (Baillie *et al.* 2010). A number of factors may have contributed to this dramatic rise in numbers, one of them being the increased amount of standing dead wood made available in the 1970s as a result of Dutch Elm Disease. This provided an abundance of food in the form of insects associated with the dead wood.

It was suggested that up to the 1980s nest site interference from Starling *Sturnus vulgaris* was a significant cause of nest failure and delayed breeding in the Great Spotted Woodpecker, and may have been sufficiently high to affect their population and habitat distribution (Smith 2005). The decline in Starling numbers since then in Britain has led to increased breeding success of the woodpeckers and may have allowed them to expand their breeding distribution into less wooded habitats. Maturation of new forests and increased uptake of provisioned food in gardens during winter may also have been factors in their increase (Baillie *et al.* 2010).

That the status of the Great Spotted Woodpecker was also undergoing change in Ireland was slow to register in the minds of Irish ornithologists. In 2005, a juvenile frequented a garden near Killoughter in County Wicklow for two weeks during September (Milne & McAdams 2008a). At the time, it was generally assumed that this bird was an early immigrant arriving at the start of an irruption from northern Europe. Two more birds (adults) were recorded the same autumn in Cavan and Dublin (Milne & McAdams 2008a). In March and April 2006, a drumming bird was present at Tomnafinnoge Wood in south Wicklow (Jerry Cassidy, pers. comm.). Other birds were recorded also in 2006; four in Down, one in Dublin and one in Meath (Milne & McAdams 2008b). The first breeding record for the island of Ireland was also in 2006 when a juvenile was seen in a garden in County Down, Northern Ireland (Hillis 2010), and there have also been subsequent breeding records there (McComb *et al.* 2010).

One bird was heard calling in an oak wood near Rathdrum, County Wicklow on 1 June 2007 (Milne & McAdams 2009). Other birds were also recorded that year, including a juvenile and an adult in County Down (Milne & McAdams 2009). The number of records increased considerably in 2008, with singles at Clear Island (Cork) and Great Saltee Island (Wexford) in April and May, respectively (Fahy 2010). Birds were also present at several sites in Wicklow, and drumming birds and a pair were chasing each other in courtship near Rathdrum (Dick Coombes, pers. obs.). Proof of breeding in the Republic of Ireland was finally achieved in July 2008 when a juvenile was observed at a nut feeder in Brittas, County Dublin, quickly followed by other juveniles at Bray and Ballyduff, both County Wicklow (Fahy 2010, Stephen Newton, pers. comm.).

It was against this backdrop of mounting evidence that Great Spotted Woodpeckers had a foothold as a breeding species in Ireland that a small group of observers came together in 2009 and began focusing their efforts at locating as many birds as possible, and ultimately to discover nests. Although some members of the group changed during the period of this study, several core members remained throughout. This paper summarises the results of observations, made over seven years, on the breeding behaviour of this newly arrived colonist in Ireland.

Survey methodology

Suitable sites (initially focusing on those dominated by oak woodland in County Wicklow, but spreading further afield in latter years) were surveyed for breeding Great Spotted Woodpeckers between February and June in each of the seven years from 2009 to 2015 by a small team of fieldworkers. Most of the effort was focused in Wicklow, but some sites in other eastern counties were also examined from 2010 onwards. Several methods were used to detect the presence of woodpeckers at any given site, the main ones being:

- To listen for drumming, usually in the first two hours of daylight and mainly from mid-February to mid-April.
- To walk in suitable habitat listening for the distinctive 'pic pic' call, or to obtain sightings of birds.
- To look for feeding signs or old nest holes or roost holes in dead trees and branches.
- As our expertise in finding nests developed we also learned to listen for the loud calls of chicks from an active nest during the latter end of the breeding season.

As observers became more experienced with the birds' distinctive 'jizz' and undulating flight, their ability to pick out birds at long range or high in trees increased. In many cases, reports from other birdwatchers and members of the public, usually of drumming birds, were followed up by members of the group. Other potential woodpecker breeding areas were identified through local knowledge, personal observation or consultation of Google Earth imagery.

Sites where woodpecker activity was noted once were revisited as often as possible to establish if breeding was taking place, and again in subsequent years. Sites where no activity had been noted in one season were also revisited in subsequent years to eliminate the possibility that birds had since moved in to establish a territory. In order to prove that breeding was taking place, multiple visits were often necessary in order to build up information on each site. This typically started with confirming the presence of a single bird, sexing it if possible (males have a small red patch on the nape, females show a black nape). Confirming the presence of a pair often took several visits. Proof of breeding was achieved when an occupied nest was found or in some cases when recently fledged young were located. Searches for nest holes were repeated at different times of day and using different routes through the woods in order to view tree trunks in various light conditions and from a variety of angles. Surveying was carried out as and when time and weather permitted, and not in a structured or regular way.

To confirm if a nest hole was occupied during the incubation stage, a system of tapping a stone rapidly against a piece of wood or a tree trunk at a distance of about 30 m was used. This would often encourage a bird to respond by appearing briefly at the entrance hole. As many visits as possible were made to each nest, but due to logistical constraints and the relatively short time window when nests are active, some nests were only visited once or twice. Details of behaviour, habitat and tree species used for nesting were recorded at each nest site, and where possible the height of the nest hole above the ground was estimated. Compass readings of the direction each nest hole faced were made and for conciseness were rounded to the nearest cardinal point i.e., within 45° either side of north, east, south and west. Nest locations were approximately plotted using both aerial photography, Ordnance Survey Ireland six inch and Discovery Series maps using ARC Gis 10.0, although some nest sites were accurately recorded as a ten figure grid reference using a hand held GPS unit set to the Irish National Grid.

Nest holes from each previous breeding season were rechecked annually to confirm if they were being used in subsequent years. In cases where it was clear a nest hole was no longer in use, a search of the surrounding area took place in an effort to discover if the pair had relocated nearby. To assess fledging success and to determine fledging dates, extended observations took place at some nests to observe young making their first flight from the nest hole. In some cases, locating recently fledged young in the vicinity of the nest was also used as confirmation of breeding success. Juveniles were identified by the red crown which is retained until their first moult in the autumn. For the purpose of completeness, some additional records of birds, nests and other proof of breeding, reported by people outside the study group, are included in the overall compilation of breeding data presented in this paper.

Genetic study

The colonisation of an island by a new species provides researchers with a unique opportunity to determine the genetic origin of the newly arrived colonists. Two schools of thought existed at the time on the origins of the County Wicklow and Northern Ireland breeding populations of Great Spotted Woodpecker. One was that the species had arrived from Ireland's nearest landmass (Britain) while the alternative was that the species could have arrived from Scandinavia during an irruption and remained as a breeding species. Other studies have been able to extract DNA for genetic research at both the population and individual level from feathers and egg shell membranes such as those deposited in the nests of Spectacled Eider *Somateria fischeri* (Pearce *et al.* 1997). The possibility of doing something similar was considered for the Irish population of Great Spotted Woodpecker by collecting suitable material from nests once breeding was complete. Therefore, we set out to complete a study which compared the control region sequences (mitochondrial DNA; mtDNA) from modern and museum specimens in Ireland to those from Britain and continental Europe in a phylogeographic analysis to decipher the origins of the newly established populations and of past vagrants in Ireland. Unfortunately, little genetic material was available from across the natural range of the species to compare with the Irish population. All such material is stored on the online GenBank database, which is designed to provide and encourage access within the scientific community to the most up to date and comprehensive DNA sequence information.

The study team therefore contacted licensed bird ringers across Europe through the European Union for Bird Ringing (EURING) and asked ringers to collect and send feathers dislodged during ringing of Great Spotted Woodpeckers during the breeding season, thereby reducing potential sampling of birds on migration. Genetic material was collected from a total of 41 modern Irish, British and continental European individuals (including birds from Poland, Switzerland, Germany, Wales, Scotland, England, and Belgium) which were then subjected to molecular analysis. Shed feathers were collected non-invasively from nests after young had fledged in Ireland, and blood and feather samples were also collected, under licence, from captured individuals in Ireland, Britain and continental Europe. Tissue samples were also taken from individuals found dead or from individuals recently deposited in museum collections.

Colour ringing

A study to colour ring birds using a tape lure and mist nets (under licence from National Parks and Wildlife Service (NPWS) and the British Trust for Ornithology (BTO)) was instigated in 2010 with a view to monitoring movements of woodpeckers in the study area. The NPWS licence only permitted birds to be caught outside the breeding season. This study did not progress beyond the capture and ringing of a single female as once the breeding season was complete it became clear that the likelihood of encountering birds was low, although the study had hoped to document individual activity and site fidelity to nesting sites.

Results

Although the first breeding record for the Republic of Ireland was in 2008 (a juvenile observed in County Dublin in July), the first occupied nests (seven in Wicklow) were not discovered until 2009. The number of occupied nests continued to increase each year to 35 in 2015 (Table 1, Figure 1). Over the seven years of this study (2009-2015) a total of

Table 1. Number of occupied nests (n = 148) of Great Spotted Woodpecker recorded in the Republic of Ireland between 2009 and 2015.

County	2009	2010	2011	2012	2013	2014	2015
Wicklow	7	11	17	17	27	28	34
Dublin	-	-	1	-	-	-	-
Wexford	-	-	-	1	1	2	-
Kilkenny	-	-	-	1	-	-	-
Monaghan	-	-	-	-	-	-	1
Total nests	**7**	**11**	**18**	**19**	**28**	**30**	**35**

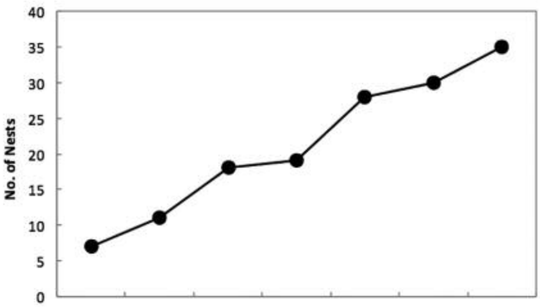

Figure 1. Number of occupied nests (n = 148) of Great Spotted Woodpecker recorded in the Republic of Ireland between 2009 and 2015.

148 occupied nests have been recorded (Figure 2), 141 of these being in County Wicklow (note that these are cumulative figures where some occupied nests have been used in more than one season). Nests have been discovered also in four other eastern counties: Dublin (1), Wexford (4), Kilkenny (1) and Monaghan (1) (Table 1). A total of 96 individual trees have been used for nesting. Breeding has been proven at a further 38 locations in eight counties. No nests have been discovered at these locations, but recently fledged young, or adults carrying food for young, have been observed, thus confirming that breeding did in fact take place (Table 2). Such breeding locations have not been mapped.

Nests were located mainly in the eastern half of County Wicklow, from Bray at the extreme northern county boundary to the Shillelagh area in the south. Woodpecker activity and a few nests were also found west of the Wicklow Mountains, although the amount of effort expended there was minimal due to distance and time constraints. The highest concentration of documented nests was in the wooded valleys of Glendalough, Laragh and Clara Vale, which are connected by the Avonmore River, and it was here that the main breeding activity was first recorded in 2009. The density of occupied nests increased annually in this area to a high of 13 in 2015. Small clusters of nests were also found in the Lough Dan and Lough Tay valleys, which are further upstream on the Avonmore River system, and the Tinahely and Shillelagh area further south. Nests in other parts of County Wicklow and in other counties were more widely dispersed.

Habitat and tree species

The predominant habitat in which nests were found was mature oak woodland (77% of nests). A further 6% were found in coniferous woodland and 7% in farmland with scattered

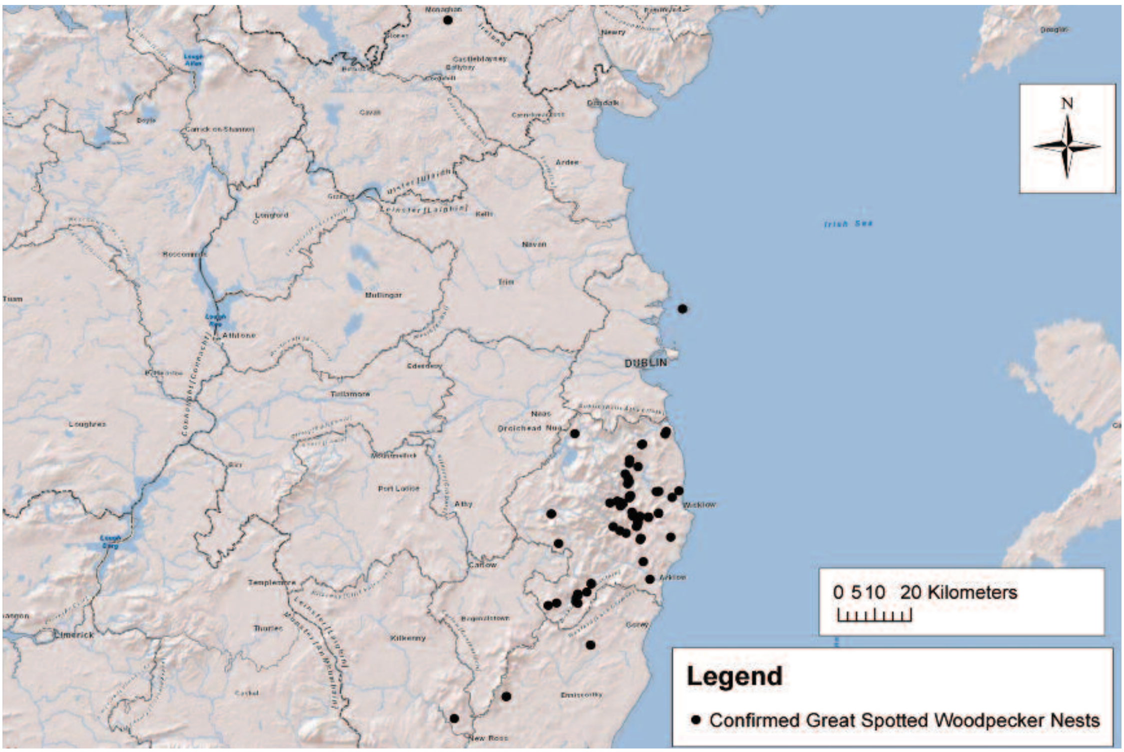

Figure 2. Confirmed breeding sites for Great Spotted Woodpecker in the Republic of Ireland between 2009 and 2015 (note that these are cumulative figures where some occupied nests have been used in more than one season).

Table 2. Records of Great Spotted Woodpecker nesting activity (n = 38) where proof of breeding was confirmed by means other than discovery of an occupied nest (e.g. adults carrying food or recently fledged young observed) in the Republic of Ireland between 2008 and 2015. A juvenile seen in Wicklow in September 2005 is excluded as it is not clear that breeding took place that year.

County	2008	2009	2010	2011	2012	2013	2014	2015
Wicklow	3	-	1	2	2	2	10	8
Dublin	1	-	-	-	1	1	-	-
Louth	-	-	-	-	2	-	-	-
Meath	1	-	-	-	-	-	-	-
Wexford	-	-	1	-	-	-	-	1
Kilkenny	-	-	-	-	-	-	-	-
Carlow	-	-	-	-	-	-	-	1
Monaghan	-	-	-	-	-	-	1	-
Total sites	**5**	**0**	**2**	**2**	**5**	**3**	**11**	**10**

copses and treelines. The other 10% were evenly divided between mixed woodland (especially with a high component of Beech), parkland (including one garden) and birch and willow (*Salix* species) swamp scrub. In the first two years of the study almost all nests were found in oak woodland. In later years, a gradual shift towards more diverse habitats was noted. Occupied nests were found in 13 species of tree and in one wooden electricity pole. The variety of tree species used increased over time; just two species in 2009 compared to eight in 2015. Oak was the dominant choice of nest tree with 115 of the 148 nests being in such trees (Table 3).

Nest holes were almost invariably in dead branches in live trees or in the trunks of dead trees. Approximately 10% of nest holes were excavated into live wood (mainly oak). About 5% of entrances had the appearance of semi-natural holes, often where a branch had broken off and some element of rot had entered the trunk, apparently offering a weak point at which excavation could start. Some 80% of nests were in trunks or branches of a relatively small diameter of 25 to 30 cm at the entrance hole height (note that accurate measurements could not be made at most of the nest holes due to their height above the ground, but estimates of trunk diameter were made by sight, comparing them with known trunks which had been measured). In many cases, the trees chosen for nesting were thinner than the average tree in the area. Most nest holes (76%) were positioned between 5 and 11 m above the ground (Figure 3). The lowest nest was just 1.5 m above the ground and the highest was 19.8 m.

Table 3. Species of tree (and one electricity pole) in which occupied Great Spotted Woodpecker nests (n = 148) were found in the Republic of Ireland between 2009 and 2015.

Tree species	Year						
	2009	2010	2011	2012	2013	2014	2015
Oak *Quercus* sp.	6	10	15	16	21	22	25
Ash *Fraxinus excelsior*	1	-	1	-	-	-	-
Beech *Fagus sylvatica*	-	1	-	-	1	1	-
Sycamore *Acer pseudoplatanus*	-	-	1	-	-	-	-
Spanish Chestnut *Castanea sativa*	-	-	1	1	1	1	1
Larch *Larix decidua*	-	-	-	1	1	-	-
Alder *Alnus glutinosa*	-	-	-	1	-	1	1
Birch *Betula* sp.	-	-	-	-	1	1	1
Scots Pine *Pinus sylvestris*	-	-	-	-	2	2	3
Eucalyptus *Eucalyptus* sp.	-	-	-	-	-	1	-
Poplar *Populus* sp.	-	-	-	-	-	-	1
Spruce *Picea* sp.	-	-	-	-	-	-	2
Pine *Pinus* sp.	-	-	-	-	-	-	1
Electricity pole	-	-	-	-	1	1	-
Total nests	**7**	**11**	**18**	**19**	**28**	**30**	**35**

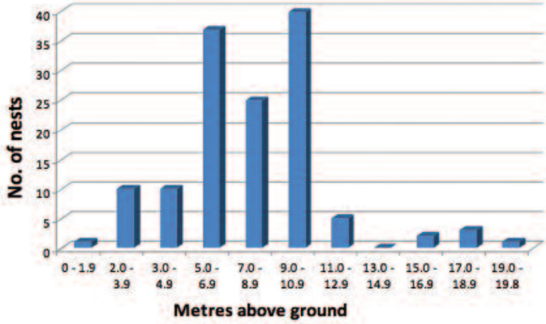

Figure 3. Height of nest holes above ground (n = 134) of Great Spotted Woodpecker in the Republic of Ireland between 2009 and 2015.

Plate 87. Great Spotted Woodpecker nest in an electricity pole (indicated by red arrow) (Dick Coombes).

Throughout the study period, at newly found nest sites, occasional old nest holes were found in the same or nearby trees, suggesting that breeding had already taken place in at least one of the previous years. A second or third nest hole was sometimes excavated (and used) in the same tree as a previous nest. Where this occurred, the new hole was typically positioned approximately 1 m below the old one, often directly below it, but sometimes at 90° or even 180° from the old hole. Holes tended to be reused in subsequent years if the entrance remained reasonably intact. Those that had widened through weathering were usually abandoned. Compass readings of the direction in which nest holes faced, showed a clear bias towards north (39% of nests), with just 13% facing south. East and west were almost equal at 23% and 25% respectively (Figure 4).

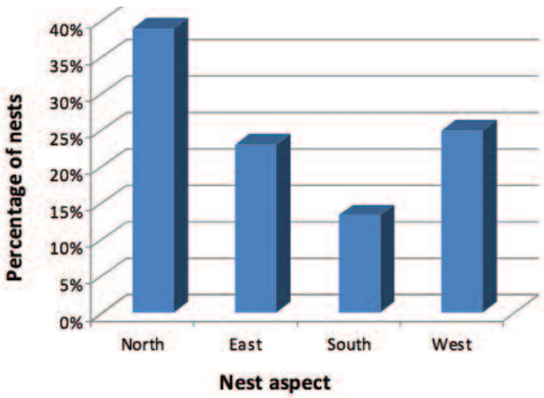

Figure 4. Aspect of nest holes of Great Spotted Woodpecker calculated to the nearest 45^0 either side of each cardinal point (n = 134) in the Republic of Ireland between 2009 and 2015.

Plate 88. Great Spotted Woodpecker nest in a Scots Pine (Dick Coombes).

For the purposes of recording and analysis, each tree used for nesting was termed a site. There were 96 different sites in total (95 trees and one electricity pole). In 13 of these sites, new holes were excavated in the same tree (and used) in subsequent years, making a total of 109 separate nest holes. A total of 66 sites were used just once, including 25 new nest sites found in 2015, which have only been observed for one season. Thirty sites were reused in at least one other season, mostly just a second year (16 sites), but two sites were used

Plate 89. Great Spotted Woodpecker nest in an Ash tree (Dick Coombes).

Plate 90. Great Spotted Woodpecker nest in a live Oak (Dick Coombes).

for six seasons (Table 4). Occupied nests in any one year were generally more than 1 km apart, however in later years of the study, nests were found at greater density in some core areas, the closest proximity being about 400 m. When new nests were found in a previous year's territory, they were usually within 60 to 200 m of the previous year's nest. Nest holes were sometimes excavated in one spring but not used until the following season. Others were not used at all for nesting, although at least some were observed being used for roosting in winter (see Mazgajski 2002).

Eggs and young

We found that the tapping technique used to ascertain if nests contained incubating birds was not always effective as nests which had registered no response were later found to contain young on a subsequent visit. However, it proved a useful tool to monitor a large number of nests when time did not permit waiting to see if a changeover took place. The earliest date for the start of incubation was confirmed for 27 April. Seeing adults carrying food to a nest was the usual indicator that hatching had taken place.

Clutch and brood sizes could not be accurately assessed as no attempt was made to see inside the nest chambers. However, in the last five or six days before fledging nestlings will poke their heads out of the nest entrance, and while the hole is only wide enough to permit one chick at a time to appear, it was possible to distinguish some individuals by the head patterns (extent of red on the crown) and thereby confirm at least a minimum number of young in the nest. These observations were very time consuming and could only be carried out at a limited number of nests each season. Counts of two young were typical but three were recorded at approximately ten nests. However, if nests contained one or more young with similar head patterns it would not be possible to differentiate them using this method. The only complete count of a brood was at a deserted nest in 2010, when five dead young, approximately one week old, were extracted from a nest at Tomnafinnoge Wood.

Table 4. The number of years that Great Spotted Woodpecker nest sites were used consecutively in the Republic of Ireland between 2009 and 2015 (n = 96; 95 in trees and one in electricity pole).

No. of years used	1 yr	2 yrs	3 yrs	4 yrs	5 yrs	6 yrs
No. of nest sites	66	16	7	4	1	2

Plate 91. Great Spotted Woodpecker chicks showing variation in extent of red on crown (Dick Coombes).

Fledging

Fledging dates ranged from 24 May to 29 June. The average fledging date for the first four years of the study was quite consistent, ranging from 4 to 6 June, while in 2014 and 2015 it was 8 June and 7 June respectively. The average date for 2013 was 13 June, approximately one week later than most years (Table 5). In the few cases where it was possible to accurately monitor nests from the point of hatching to young birds leaving the nest, fledging periods were consistent with the 20 to 24 day range given by Cramp (1985). However, a notable long fledging period of 27 days was recorded at one nest in 2013 and another of 30 days in 2014.

Fledging success could only be 100% proven at a small number of nests each year, where young were observed leaving the nest. Time constraints prevented daily visits to every nest. However, in the few days before fledging, young birds poke their heads out of the nest hole, calling loudly, looking around and jerking the body as if to leave the nest. Nests that were found to be empty a day or two after such activity was observed were presumed to have been successful and the fledging date could be estimated to within one or two days.

Mortality

Five nests were known to have failed during the study:

- 2010: One-week old chicks deserted in nest after only the female was observed bringing food for several days. Male may have been predated by Sparrowhawk *Accipiter nisus*, which was active in the area.
- 2014: Nest silent one week before chicks due to fledge. Freshly dead female found near nest with wounds, and

Table 5. Earliest, latest and mean fledging dates of Great Spotted Woodpecker from nests where dates could be estimated to within ± 2 days in the Republic of Ireland between 2009 and 2015.

	2009	2010	2011	2012	2013	2014	2015
Earliest Date	1-Jun	30-May	30-May	24-May	6-Jun	2-Jun	29-May
Latest Date	11-Jun	14-Jun	12-Jun	24-Jun	28-Jun	29-Jun	19-Jun
Mean ± (SE)	5 Jun (1.6)	6 Jun (1.9)	4 Jun (0.9)	5 Jun (1.7)	13 Jun (1.0)	8 Jun (1.1)	7 Jun (0.9)
Sample Size (N)	7	9	17	18	27	27	30

Plate 92. Dead Great Spotted Woodpecker nestlings from an abandoned nest (Dick Coombes).

mustelid odour noted; Pine Marten *Martes martes* suspected as predator.

- 2015: Nestlings apparently predated in nest. Nest hole widened.
- 2015: Nest in dead pine torn apart approximately one week before due to fledge. Pine Marten predation was strongly suspected.
- 2015: Nest with young deserted for no apparent reason.

Five cases of mortality of adult or fledged young were recorded during the study, two of which were of juveniles hitting windows. A dead juvenile was also found below a nut feeder in a garden and an adult was observed being taken from a feeder by a Sparrowhawk. A dead adult female was found below a nest, apparently predated.

Pine Martens were recorded by trail camera close to two used woodpecker nests near Annamoe in County Wicklow (Declan Murphy, pers. comm.). The entrance holes of both nests appeared to have been widened during the winter and scratch marks on the damaged trunk suggested that a mammal, such as a Pine Marten, was responsible.

Genetic study

The genetic study points strongly to a British origin for the now well established Irish populations, and it appears as though the separate breeding groups in the Republic of Ireland and Northern Ireland were founded from different areas. The diverse nature of the haplotypes found in Ireland may also suggest that the separate Irish breeding populations have been founded from multiple localities within Britain, rather than a single origin. This research also confirms that Great Spotted Woodpecker populations in Britain show evidence of a continental influence (McDevitt *et al.* 2011).

Further notes

Just one bird, a female, was trapped and colour ringed before the breeding season in 2010. It was observed using the same nest for three consecutive seasons up to 2012. At one site in May 2015 a woodpecker's nest hole which had been used successfully during the two previous seasons, was found to have been taken over by a pair of Starlings. No direct evidence of interaction between the two species was noted. At five or six used woodpecker's nests, Blue Tits *Cyanistes caeruleus* and Great Tits *Parus major* were found to be breeding in subsequent years.

Many nests were tracked down by watching adults carrying food for young, and several of these involved adults gathering peanuts at garden feeders. Birds, especially juveniles, were quite regularly recorded at feeders in gardens; the peak period for this behaviour was from mid-June to September.

Discussion

The results of this study and other anecdotal evidence show that Great Spotted Woodpecker is now firmly established as part of the breeding avifauna in the Republic of Ireland with a similar, albeit less documented, colonisation by the species in Northern Ireland. It is clear that colonisation in the Republic of Ireland started on the east coast, specifically in County Wicklow, and in Northern Ireland in County Down. It is perhaps no surprise that the pioneer settlers moved into the prime habitat available close to where they presumably made first landfall, that is, mature oak woodland, of which there is plenty in County Wicklow. The steady increase in Great Spotted Woodpecker activity being observed and nests being found, plus the spread into more diverse habitats in recent years, suggests that this species has now successfully established a viable breeding population in Ireland.

The pressure of numbers as the population increased in Britain appears to have been responsible for the range expansion across the relatively narrow Irish Sea. During the study period the species was increasingly being sighted in the Isle of Man, with nests discovered in 2009 and 2010 (McDevitt *et al.* 2011) and this expansion was further evidenced by the results of the recent *Bird Atlas* (Balmer *et al.* 2013).

Although the number of nests monitored in this study is relatively small, it is worth comparing some of the results with research carried out elsewhere. A study of breeding Great Spotted Woodpeckers in a 76 ha suburban forest in Stuttgart (Germany) found that the birds generally excavated a new nest every year (David Eggeling, pers. comm.). In our study nest holes were frequently reused. Such nest site fidelity may be a result of the low population density in Ireland. The colour ringed female was faithful to the same nest for at least three years, though it is not known if the same male was involved. Cramp (1985) states that pair bonds last for at least one season, and one example of about 2.5 years is cited, which was believed to be a case of attachment to territory rather than to a mate. The low number of available mates at this early stage of colonisation must surely affect bonding and perhaps nest site fidelity.

Nest Record Scheme data in Britain show an average first egg date of 4 May (Robinson *et al.* 2015) and using average incubation and fledging periods, the average fledging date there can be extrapolated to approximately 9 June. This is two or three days later than the average date for Irish nests. The 2013 average fledging date of 13 June was notable as it was approximately one week later than most of the other years of the study. That spring had been perceptibly cold and it was noted that occupancy at many woodpecker sites started later than usual. In April that year, Met Éireann recorded below Long Term Average (LTA) mean temperatures at all stations (Met Éireann 2013), with Dublin Airport recording minima of -5.6°C on 6 April, the lowest April air temperature at the station since 1942. Therefore, it seems likely that the cold weather in the period before egg-laying was the main factor which delayed breeding in that year. Low temperatures may have delayed development of invertebrates, thus reducing food availability for woodpeckers feeding young in the nest, which in turn may have extended fledging periods. At one nest the fledging period was 27 days, three to four days longer than usual, and while hatching dates were not known at most nests almost all nests fledged late in 2013, including two on 23 June and one on 28 June.

Looking to the future, it is difficult to predict the speed with which Great Spotted Woodpeckers are likely to expand their breeding range to the rest of Ireland. Further expansion is likely to be slow in light of their proven sedentary nature, and over the seven years of monitoring, most new territories have been relatively close to existing nests and territories. The higher density of nests found in some areas in the later years of this study suggests that offspring are setting up territories very close to their natal sites, possibly as close as 1 to 3 km, and not venturing great distances. However, the number of Great Spotted Woodpeckers being reported through social media and websites, such as 'Irish Birding', is increasing, many from outside County Wicklow. While most reports refer to single birds as yet, the recent presence of woodpeckers in Counties Kildare, Offaly, Cavan and Sligo suggest that it will only be a matter of time before these counties and others will be added to the eight (Wicklow, Wexford, Dublin, Louth, Meath, Kilkenny, Carlow, Monaghan) where breeding has already been confirmed by a variety of means.

The lack of significant stands of native woodland could be considered a factor limiting the spread of Great Spotted Woodpeckers in Ireland, particularly in large areas of the west and northwest. However, in the course of this study, the finding of nests in treelines on farm lanes, coniferous plantations and even within a garden, suggests that the low area percentage of broadleaf woodland in Ireland is unlikely to significantly halt the Great Spotted Woodpecker's potential range expansion.

It is also worth considering that the influx of birds from Britain, which started in the mid-2000s, may be on-going, thus augmenting the established population on a continuing basis. Influxes from Scandinavia during irruption years have always been difficult to detect due to the small volume of records, but today, such influxes may go undetected as immigrants will blend with the established breeding population. There is good genetic diversity within the establishing population and further additions to this would only be to the benefit of the species in the long term.

In terms of conservation measures for the species, woodpeckers, like many birds, are vulnerable to disturbance or loss of nest sites during the breeding season. In May 2015,

Plate 93. Great Spotted Woodpecker nest (arrowed) in a dead Poplar tree on a garden boundary in Co. Wicklow (Dick Coombes).

an occupied nest in a mature spruce forest in south Wicklow was threatened by clear felling operations. Local vigilance resulted in agreement being reached with Coillte (the landowners) and the forestry contractors to leave a 50 m exclusion zone around the nest tree while felling continued in the rest of the wood. The young fledged successfully. If woodpeckers continue the recent trend of moving into commercial coniferous plantations to breed, it is hoped that this kind of co-operation may become a regular occurrence in the future.

Indeed sympathetic forestry management following best practice elsewhere, such as continuous cover forestry and retention of standing deadwood, should be encouraged, and recommendations for appropriate forest management practices made to those engaged in harvesting and managing forests. These measures would also benefit a suite of other woodland species of birds, bats, other mammals and invertebrates. Questions remain to be answered as to the long term impact of the arrival of woodpeckers in Ireland, but as primary cavity nesters, excavating their own nest holes in trees, they provide nest sites for other species of birds in subsequent years, as recorded in this study, and it is probable that other taxa such as bats will benefit too as secondary users of woodpecker holes.

Although this has at times been a challenging task which was taken on by a small dedicated team of observers and enthusiasts we encourage others to take up the challenge on their local patch; our understanding of this iconic woodland species in Ireland will only increase as a result.

Acknowledgements

Despite their increasing numbers, Great Spotted Woodpeckers are scarce and elusive in Irish woodland and tracking down birds and their nests requires much effort, time and no small amount of perseverance. We extend a special thanks to the small, enthusiastic team who carried out the bulk of the hard work, namely Jerry Cassidy, Shane Farrell, Aidan G. Kelly, Cóilín MacLochlainn, Declan Murphy and Christian Osthoff, who found the first nest in 2009. We also thank all the many other observers, landowners and members of the public who helped with locating and reporting birds and allowing access to land and those who facilitated the genetic and ringing study. They include: Wesley Atkinson, Jez Blackburn, Magorzata Bujoczek, Andrew Butler, Glauco Camenisch, Ruth Carden, Sarah Carty, Robert Christian, Przemek Chylarecki, Ilaria Coscia, Shay Fagan, Ann Fitzpatrick, David Fuller, Joe Hobbs, Łukasz Kajtoch, Michael Kane, Tom Kealy, Rolf Keidel, Allan McDevitt, Tomasz D. Mazgajski, Steve Millar, Jason Monaghan, Chris Murphy, Jimmy Murphy, Steve Newton, Eanna O'Flynn, Gerry O'Neill, Dermot O'Shea, Oran O'Sullivan, Gilberto Pasinelli, Jo Ranke, Phillippe Schepens, Joe Shannon, Chris Sharpe, Ken Smith, Robert Vaughan and Alyn Walsh. Licenses for the genetic and ringing study and to photograph birds at the nest were provided by National Parks and Wildlife Service and the British Trust for Ornithology. Andrew Kitchener and Nigel Monaghan allowed access to, or provided museum samples from, the National Museums of Scotland, Edinburgh and the National Museum of Ireland, Natural History Division, Dublin, respectively. The genetic study was funded by the Heritage Council, Ireland (Research Grant Scheme No. R00464, 2010).

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