A Preliminary Study of the Winter Roosting Behaviour of Four Woodland Passerines

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SUMMARY

Capsule: Radio tracking four woodland passerine species to their winter roost sites in Gloucestershire, UK.

Aims: (1) To evaluate methods for studying winter roosting behaviour in woodland passerines; (2) to collect preliminary data on intra- and interspecific differences in roost site characteristics and spatial arrangement.

Methods: Ten woodland birds (3 Eurasian Blackbird *Turdus merula*, 3 Dunnock *Prunella modularis*, 2 Great Tit *Parus major*, and 2 European Robin *Erithacus rubecula*), were fitted with a tail-mounted Lotek PicoPip AG337 VHF radio tag (January to March 2022). Tagged birds were located by triangulation, and nightly winter roost locations identified and characterised. GIS was used to quantify roost site fidelity (separation of between-night locations), roosting height, and types of local habitats used.

Results: This study has established that manual tracking of VHF tags is a cost effective and appropriate method for studying passerine winter roosting behaviour. Sample sizes were too small to allow exploration of significant differences between sites, age and sex. European Robins showed the greatest site fidelity in relation to between-night roost positions, with Eurasian Blackbird, Great Tit and Dunnock being more variable in the sites chosen between nights. Eurasian Blackbird and Great Tit roost sites were generally higher above the ground (up to 6m), compared to European Robins and Dunnocks (all sites less than 4m above the ground). Eurasian Blackbirds varied the most in the number of habitats used for roost sites, and European Robins the least variation. Only three out of eleven habitat types (Bramble, Laurel and Sycamore with Ivy) were used by more than one species as a roosting habitat.

Conclusion: Further roosting research should focus on: (1) habitat use in relation to relative availability; (2) increasing samples sizes to allow roosting behaviour in relation to age, sex and sites; (3) the impact of supplementary feeding by humans on roosting behaviour; (4) quantifying the thermal properties of different roost sites; (5) understanding roosting habitat preferences by studying use in relation to proportional habitat availability.

INTRODUCTION

Passerines (perching birds), are the most diverse group of terrestrial vertebrates with over 6000 species worldwide (Raikow & Bledsoe 2000). Over 40% are found in temperate zones (23-66 degrees north/south), largely associated with woodland habitats. In the UK, a national assessment of woodland birds showed a 27% decline since 1970 (Burns *et al.* 2020). A considerable amount of research has investigated these declines for breeding woodland migrants/residents in relation to their ecology and conservation (Bellamy *et al.* 2022). But very little work has been done on the ecology of wintering woodland birds, particularly in relation to identifying factors affecting winter survival. Understanding environmental features that are important to the life histories of different taxa, is vital for underpinning species and habitat management actions (Crofoot *et al.* 2008). Research has been published on roosting and nest site selection during breeding seasons (Nores & Nores, 1994, Coulson 1999, Dunn & Whittington 2005, Liao *et al.* 2008, Meddings *et al.* 2011, Rock *et al.* 2016), and for birds that roost communally or in cavities and nest boxes (Siegefield 1971, Weatherhead 1983, Dominguez 2003, McGowan *et al.* 2006, Smith *et al.* 2008, Gilbert *et al.* 2010, Jaggard *et al.* 2015, Lubbe *et al.* 2018, Goodard 2022). However, studies locating individual roosts outside the breeding season have been few in number, largely due to the logistical problems of data collection (Dhondt *et al.* 2007). For small avian species (< 100g) living at higher latitudes (> 50 degrees), identifying diurnal habitat use can be particularly difficult during the winter months when there are more hours of darkness than daylight (Kendeigh 1934, Ward & Zahavi 1973, Romano 2018), and these birds will spend a considerable proportion of their daily time budget at winter roost sites (Amlaner & Ball 1983, Lima *et al.* 2005). Most work to date has been undertaken for species using nest boxes (Ouyang *et al.* 2017, Typiak & Typiak 2018), or under controlled captive settings in laboratories (Dunnett & Hinde 1953, Amlaner & Ball 1983, Nord *et al.* 2011). This gap in knowledge has been an important ornithological issue for many years. Kendeigh (1934) and Moore (1945) recognised that winter roosting passerines would need to select sites where they could shelter from predators and a range of challenging environmental conditions e.g. low temperature, high precipitation, reduced food availability, and limited visual foraging time. The relevance and urgency of winter roosting studies has also increased in recent years, as environmental pressures grow both on winter foraging during daylight hours, but also on the ability of individuals to lay down appropriate post-breeding body reserves (Jirinec, *et al.* 2016). Basal heat production in birds is reduced is reduced as a consequence of sleep, and individuals therefore need to select relatively sheltered areas where heat loss can be minimised (Kendeigh 1961, Amlaner & Ball 1983). The selection of winter roost locations has the potential, therefore, to impact winter survival rates within and between different taxa (Pinowski *et al.* 2006, Veľký *et al.* 2010). Tree sparrows *Passer montanus* for example, use established breeding nests, or build a new 'winter' nest to maintain overnight body heat (Pinowski *et al.* 2006). Great Spotted Woodpeckers *Dendrocopos major* utilise tree cavities during the winter, and consistently utilise the same roosting holes, even after a predator attack (Mazgajski 2002). Information on winter roost selection and associated behaviours, can be studied by speculative searching of potential roost sites (e.g. Dunsheath & Doncaster 1941). This method provides some general insights into species' roosting preferences and behaviours such as roosting heights, the use of feather fluffing, and placing the head under the wing (Moore 1945). In recent years, these studies have been enhanced by the use of thermal imaging technology to identify the location of roosting birds (Romano 2018). However, this approach does not provide information at an individual level i.e. the frequency of site use by the same individual and how this might change across different timescales (days, weeks) and in relation to age and sex of the bird. In recent decades, advances in VHF radio and satellite telemetry have facilitated the study of species and behaviours that were previously difficult to undertake (Fedak *et al.* 2002). The technique allows free ranging individuals to be located and tracked, with its use expanding in conservation work, due to its diminishing costs and advancements in radio tag size, weight and longevity (Kenwood 2001, Naef-Daenzer *et al.* 2005). This has greatly improved the quality and quantity of data collected, enabling a greater range of questions to be asked for a larger range of species (Kenwood 2001). Although studies using VHF radio telemetry to track birds are now relatively common, the focus of much of this work has been predominantly on movement across landscapes or habitats, diurnal foraging behaviour, territoriality, or the impacts of artificial light on waking and roosting times (Kays *et al.* 2011, Holcom 2021). A number of avian ecological studies have however gleaned additional incidental information on roosting behaviour. These have included information on size of area used for roosting (Leavelle *et al.* 2015, Romano 2018, Holcom 2021), previously unknown night-time habitat use (Wright *et al.*

2021), anti-predator roosting behaviour (Amlaner & Ball 1983, Jirinec, *et al.* 2016, Townsend *et al.* 2009), and the maintenance of social bonds at roost sites (Hill *et al.* 1991, Dhondt, *et al.* 2007). A major issue for winter roost studies, is the difficulty of locating and tracking free-living individuals at night-time. Here we report on a preliminary, proof-of-concept study to investigate potential for using VHF telemetry to investigate winter roost selection in four small passerine birds: Great Tit *Parus major*, European European Robin *Erithacus rubecula*, Dunnock *Prunella modularis* and Eurasian Blackbird *Turdus merula*. The key research aims were: (1) to evaluate the use of VHF telemetry for winter roost studies, (2) to collect preliminary information for the four species on sequential roost locations and habitat preferences.

METHODS

The study species (Great Tit, European European Robin, Dunnock and Eurasian Blackbird), were selected for the study for four key reasons: (i) they are representative of common wintering woodland species in the UK, (ii) they are relatively easy to catch, (iii) they are of sufficient weight to allow tag attachment, and (iv) their roosting behaviour has not previously be studied in the published literature, other than the use of nest boxes for Great Tit. Birds were caught in mist nets between 08:00 and 12:00 at three woodlands in Gloucestershire (UK) between January and March 2022: (1) Ebworth (51.7969N,-2.1493W) an ancient semi-natural beech woodland. (2) Newent (51.9292N, -2.4045W), a semi-urban mixed species woodland, and (3) Stroud (51.7490N,-2.2100W), a semi-rural area adjacent to the Slad valley. Ten Lotek PicoPip AG337 tags were deployed: 3 Eurasian Blackbirds, 3 Dunnock, 2 Great Tit, and 2 European Robin. The tags were 13x5x3mm in size (plus a antenna), and weighed <0.3g (representing between 0.3% and 1.6% of body weight for all the species). This is well within the recommended standard weights for tag applications (Amelon *et al.* 2009). The battery lifespan was approximately 20 days (Lotek 2022). This particular tag was chosen over remote archival tags, because locating individual birds in their chosen roost site in real time was essential to this study (Raine 2006, McLouchlin *et al.* 2010). Birds were ringed and standard biometrics taken (age, wing length, sex), to ensure appropriate body condition and weight (Raim 1978, Calvo & Furness 1992, Naef-Daenzer *et al.* 2001). The VHF tags were applied using non-toxic glue, and tied to the upper end of two central tail feathers following the protocol described by McLoughlin *et al*. (2010) for Twite *Carduelis flavirostris*. Birds were held for between five and eight minutes, to allow glue adhesion and released within 30m of their capture site. Tracking began on the evening following deployment, using a Yagi VHF antenna and a Perdix receiver (Perdix Wildlife Supplies 2022). Standard triangulation was used to obtain bearings from at least three well-separated telemetry positions. A location point was obtained at each location using a Garmin Etrex 10 hand-held GPS unit. Red torch light was used to reduce disturbance when searching less than 20m from a roost location (Tulis *et al.* 2015, Romano 2018, Holcom 2021). The height of the roosting site was additionally assessed at Ebworth. Birds were regularly recorded during daylight hours, to confirm the tags had not fallen off and the birds were still active. Tracking points and triangulation data were uploaded into a shapefile within the geographical information system software *QGIS* (QGIS Development Team 2022). These data were used to create polygons in which the triangulation suggested the birds were roosting, as well as the centroids (centre points) of these areas. Small movements of birds whilst being triangulated can result in ’open’ triangulation areas i.e. where one side of the triangular polygon is clearly indicating a different location. It is therefore important that the tracking is undertaken sufficiently long after sunset (+2 hours) to ensure the birds are ‘static’ at their final roost site. In this study, we assessed this as happening for less than 5% of the triangulation events, and excluded those data where the resulting triangulation suggested a roosting area greater than 5m square. Between-night roosting separation distances were calculated by generating lines between polygon centroids.

RESULTS

The mean distance between roost sites, and the primary vegetation at the roost site in relation to sex, age and site for all tracked individuals are shown in Table 1.

Table 1. Species, site, sex and age for all radio-tracked individuals in relation to mean between-night roost site distance.

Species	Site	Sex	Age (years)	Mean distance between roost locations (m)
Eurasian Blackbird	Ebworth	M	≥1.5	1.8 ± 0.4, n=3
Eurasian Blackbird	Ebworth	F	≥1.5	19.6 ± 13.6, n=5
Eurasian Blackbird	Newent	F	≥1.5	23.0 ± 9.0, n=5
Dunnock	Newent	?	≥0.5	31.5 ± 13.1, n=5
Dunnock	Newent	?	≥0.5	21.0 ± 10.3, n=5
Dunnock	Stroud	?	<0.5	0.4 ±0.1, n=3
Great Tit	Ebworth	M	0.5	4.5 ± 2.2, n=3
Great Tit	Ebworth	F	≥1.5	28.2 ± 11.2, n=3
European Robin	Ebworth	?	<0.5	11.4 ± 0.4, n=11
European Robin	Stroud	?	≥1.5	2.6 ± 1.3, n=6

Sample sizes were too small to allow exploration of significant differences between sex, age and site, or the impacts of meteorological conditions on roosting behaviour. For all individuals combined (Figure 1), European Robins showed the greatest site fidelity in relation to mean between night roost distances (8.3m ± 6.1, n = 17).

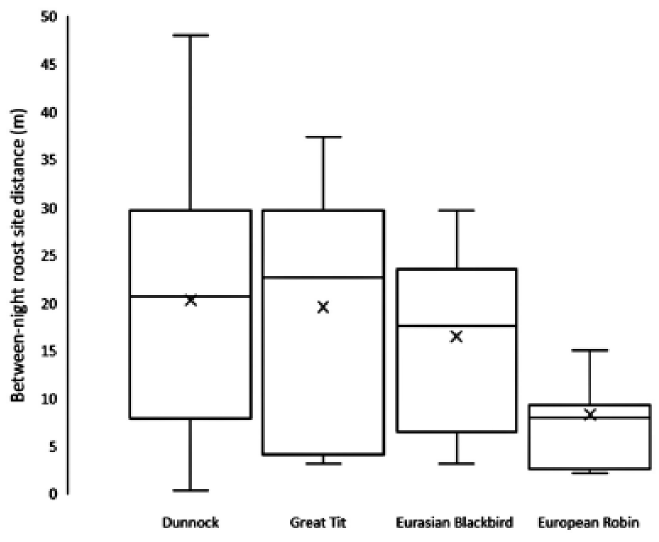

Figure 1. Mean between-night roost site distance (m) for Dunnock (n=13), Great Tit (n=11), Eurasian Blackbird (n=14) and European Robin (n=17). The plot shows the data range (whiskers), the inter-quartile range (box), median (box line), and mean values (x).

The other three species had broadly similar mean between-night roosting distances: Eurasian Blackbird (16.5m ± 8.7, n = 14), Great Tit (19.6m ± 13.0, n = 11) and Dunnock (20.3m ± 14.3, n = 13). Sample sizes were also small for roost site height (Figure 2).

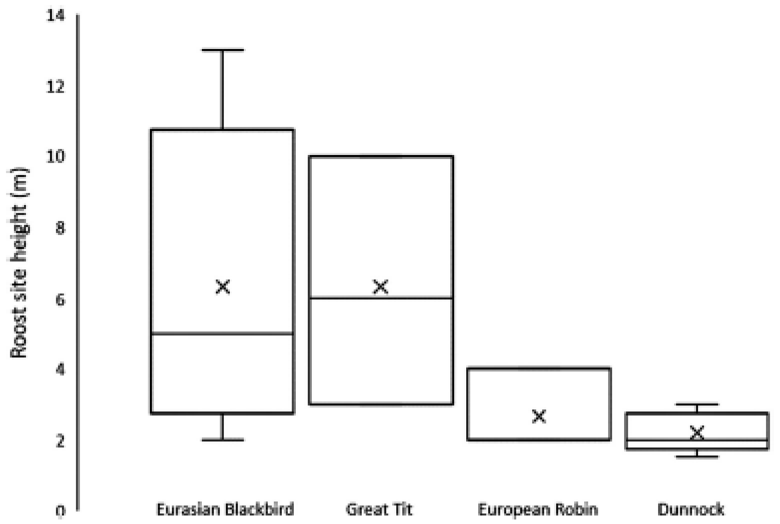

Figure 2. Mean between-night roost site distance (m) for Eurasian Blackbird (n=6), Great Tit (n=6), European Robin (n=3) and Dunnock (n=5). The plot shows the data range (whiskers), the inter-quartile range (box), median (box line), and mean values (x).

Mean roost site heights were above 6m for Eurasian Blackbird (6.3m ± 4.3, n = 6), and Great Tit sites (6.3m ± 3.5, n = 3). European Robin mean roost site heights (2.7m ± 1.2, n = 3) were very similar to Dunnocks (2.2m ± 0.6, n = 5), and all sites for these species were less than 4m above the ground. For each species, the percentage of broad habitat types in which their roost sites were located are shown in Table 2.

Table 2. Number of habitats used by Eurasian Blackbird (n=13), Dunnock (n=13), Great Tit (n=7) and European Robin (n=17), and the percentage of roost locations located in different broad habitat types.

	Percentage of Roosts Within Habitat Type			
Broad Roost Site Habitat	Eurasian Blackbird	Dunnock	Great Tit	European Robin
Bamboo *Bambusa spp*	15			
Beech *Fagus sylvatica* with Ivy *Hedera spp*			43	
Bramble *Rubus spp*	15	31		
Hawthorn *Crataegus monogyna*		23		
Laurel *Laurus spp*			14	94
Leylandii hedge *Cupressus-leylandii* hybrid	23			
Leylandii tree *Cupressus-leylandii* hybrid	8			
Ornamental shrub (species unknown)		8		
Sycamore *Acer pseudoplatanus* with Ivy *Hedera spp*	39		43	
Tree stumps (unknown species) with Ivy *Hedera spp*		38		
Yew *Taxus baccata* with Ivy *Hedera spp*				6
Total Habitat types Used	**5**	**4**	**3**	**2**

Eurasian Blackbirds varied the most in the number of habitats used (5), followed by Dunnock (4) and Great Tit (3). Of the eleven broad habitat types used by all species, European Robins principally used Laurel to for roost sites (96% of 17 roost locations). Only three habitat types (27%) were used by more than one species as a roosting habitat: Bramble (Eurasian Blackbird and Dunnock), Laurel (Great Tit and European Robin), and Sycamore with Ivy cover (Eurasian Blackbird and Great tit).

DISCUSSION

The first aim of the present study was to evaluate VHF radio tagging and tracking as a suitable methodology for studying winter roosting behaviour in woodland passerines. The cost of using GPS or satellite technology can be prohibitive for many studies, especially where tag size and weight is very limited (Hallworth & Marra 2015, Mitchell & Clarke 2019). The alternative is to use VHF-based telemetry. For some studies, it is possible to use automated VHF systems (i.e. in association with 'fixed' recording stations) to overcome the time allocation required for manual tracking (Mitchell & Clarke 2019, Gottwald *et al.* 2019, Lotek 2022a). For this study, it was clear that such an approach would not be suitable. The location of roosts was not predictable (unlike for example the emergence of bats from roost sites), and was invariably in dense vegetation where VHF signals were easily dampened or reflected. By using manual tracking, we were able to hone down the signals to a relatively small area, and then obtain the necessary triangulation bearings to minimise disturbance. The limiting factors then become tag signal duration and strength, and whether the tag remained applied to the bird. Four of the tagged birds were mist-netted after the study was complete, and another observed through binoculars. All of the birds were in good condition in terms of weight and body fat. Three of the birds had shed their central tail feathers, but the remaining tail feathers were in good condition. Four tags retrieved from the field, suggest that they had been 'preened' off by individuals through the loss of central tail feathers. In the light of this, we would recommend back mounting tags as an alternative, or using harnesses for species of sufficient size (e.g. Eurasian Blackbird). The second aim was to collect some preliminary data on winter roosting for a number of individuals of four different woodland species. Our findings suggested that none of the birds were flying large distances to get to their roost sites, but were utilising vegetation in local areas where they were located during diurnal activities. It was also clear, that there were interspecific species differences in roosting behaviour, particularly in relation to variation in roost-site height, the vegetation types used, and the between-night fidelity to a particular site. The tracked Great Tits showed the greatest between-night variation in roost sites. Although nest box studies have suggested most tit species show some degree of fidelity to a particular roosting site, there are records of tits using several locations within 500m of one another (Báldi & Csörgő 1997, Krištín *et al.* 2001, Veľký *et al*. 2010). Birds were also found to be roosting in relatively dense vegetation. Dunsheath & Doncaster (1941) recorded similar behaviour in their random search study. Their results were also similar in showing the frequent use of Laurel by European Robins, and the importance of Ivy covering on trees. Vegetation density is likely to be a function of trying to maximise the thermal properties of roost sites and minimising exposure to wind and precipitation, whilst providing protection from predators (Kendeigh 1961, Marquiss & Newton 1982, Mainwaring 2011). Understanding roost site selection can support management practices in woodlands at both very local (<1ha) and landscape scales (Villén-Pérez *et al.* 2014). Despite its considerable relevance to our knowledge of avian behavioural ecology and practical land management, winter roosting behaviour by passerines remains little studied. We believe this was the first individual-based study of wintering roost behaviour its kind. It has provided useful insights in terms of methodology, as well as suggesting the following as future avenues of research. For example, we were able to identify roosting habitat selection within and between species, an assessment of the proportional availability of habitats at a range of scales was beyond the scope of this study. Such work in future would provide extremely useful information on habitat preferences and avoidance (Mitchell & Clarke 2019). Additionally, the sample sizes of this study did not allow us to account for statistical differences in behaviours that might be age, sex or site specific. Future research should be designed to provide information across these factors. Future roost tracking studies should also attempt to evaluate the impact of supplemental feeding on roosting behaviour. Winter supplementary feeding by humans can alter energy expenditure, time budgets, and the mass of individuals (Enoksson & Nilsson 1983, Robb *et al.* 2008), and the high value food provided at feeders is known to be targeted immediately prior to roosting (van Balen 1980, Jansson *et al.* 1981, Orell 1989, Frances *et al.* 2018). Future roost tracking studies should also be made in conjunction with a hand-held thermal imager. This would maximise the chance of locating birds, whilst minimising roost site disturbance. It would also allow researchers to assess if birds were roosting with other, un-marked individuals, and quantify the relative thermal properties of roost sites (Smith *et al.* 2008, Janousek *et al.* 2014). The energetic significance of the thermal environment at roost locations also needs to be explored in relation to differences in convective and radiative heat exchange. Lastly, although beyond the scope of the present study, we would recommend that triangulation errors for tags are assessed for each study area where tracking is conducted. This is because different habitat characteristics are known to be associated with different triangulation errors (i.e. are site specific), and this can be assessed by placing tags in specific areas within the study site prior to placement on birds (Bartolommei *et al.* 2012).

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