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Radio-tracking small farmland passerines: trade-offs in study design

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Abstract Information on the relevant spatial scale for controlling pest birds causing significant crop damage is generally lacking. Here, we assess the potential of 2 radiotracking systems (hand-held vs. elevated twin-Yagi antennae) for monitoring pest bird ranging behaviour on and around an arable farm. Radio-transmitters were fitted to 19 European greenfinches (*Carduelis chloris*) in the summer and 25 house sparrows (*Passer domesticus*) in the winter. Greenfinches were most likely to be detected in or near *Brassica* seed crops, particularly on the study farm, but 12% travelled large distances (>3 km) between *Brassica* crops in the landscape. Even though house sparrow home ranges were widely dispersed across the landscape, most overlapped with the farm boundary and were positively associated with woody vegetation. Relative to hand-held antennae, the elevated twin-Yagi system increased the detection radius for tagged birds from 100 m to 2000 m and also the number of location data, albeit over a more restricted area.

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Keywords arable crops; bird damage; home range; introduced species; pest management; spatial scale; woody vegetation

INTRODUCTION

Strategies to improve both vertebrate and invertebrate biodiversity in the agricultural landscape need to be employed at spatial scales beyond the field and/or farm scale units in which agriculture is typically managed (Hendrickx *et al.* 2007; Billeter *et al.* 2008; Gabriel *et al.* 2010). This is because different taxa respond to agricultural practice at different, and often multiple, spatial scales (Olff & Ritchie 2002; Tscharntke & Brandl 2004). However, although the management of agricultural pest species is likely influenced by similar processes (Tscharntke *et al.* 2007; Schellhorn *et al.* 2008), attention to date has focused on the correct spatial scales for controlling invertebrates (*e.g.* Vialatte *et al.* 2007; Werling & Gratton 2010). To the best of our knowledge, studies on the relevant spatial scale to control vertebrate agricultural pests are limited to just a handful of mammals (Smallwood & Geng 1997; Ouin *et al.* 2000; Gentle *et al.* 2007; Morilhat *et al.* 2008) and a single bird, the common starling (*Sturnus vulgaris*) (Clergeau 1995; Clergeau & Fourcy 2005). This lack of attention on bird pests is surprising, since bird damage to horticultural crops is a significant problem for growers around the globe. In Australia, for example, damage to horticultural and arable production caused by both native and introduced

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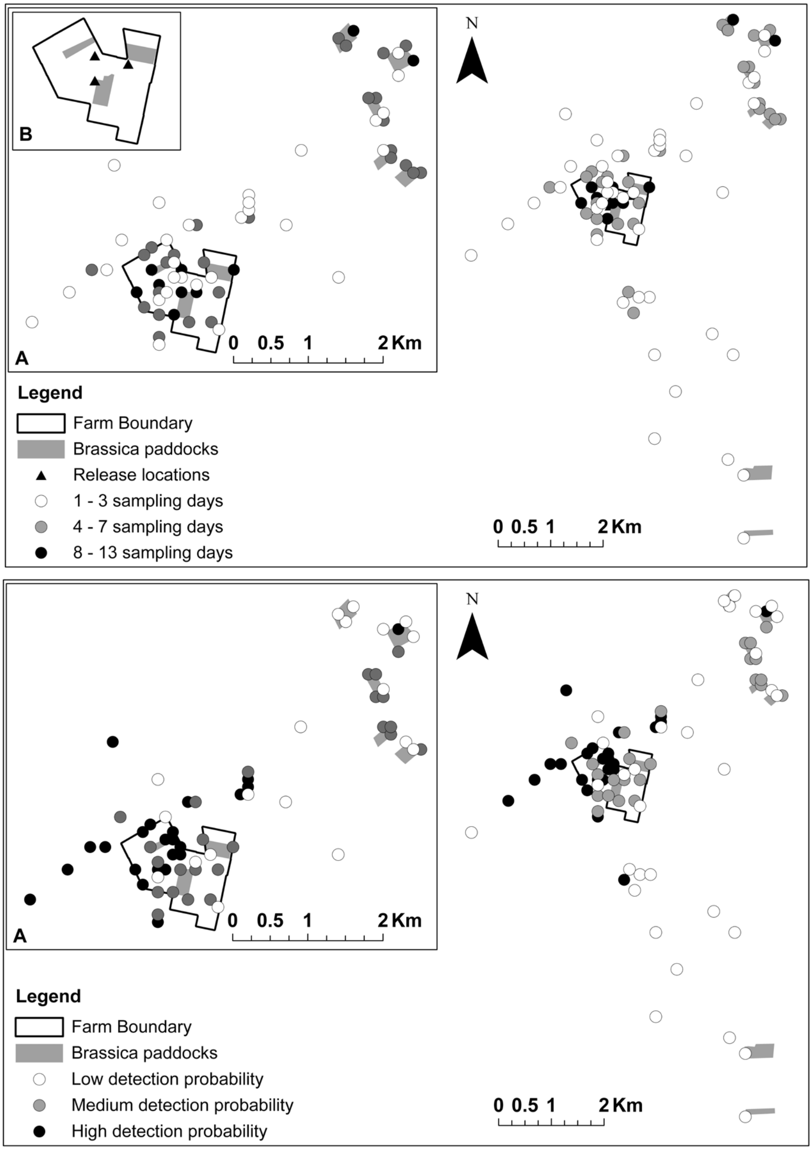

Fig. 1. Map of study area in which greenfinch were radio-tracked on the Canterbury Plains from Feb–Mar 2008. Upper figure: location of *Brassica* paddocks on and near the study farm and location of sampling grid points (n = 80) and number of days each grid square was visited; (A) enlarged map of the study farm, and (B) release locations for tagged birds. Lower figure: probability of detecting a tagged greenfinch (n = 19) at each sampling grid point (calculated as the number of unique tags detected divided by the number of sampling days per grid square); (A) enlarged map of study farm and *Brassica* paddocks to the north.

bird species is estimated to cost nearly US$250 million p.a. (Tracey *et al.* 2007). Similarly, in the United States, the introduced starling is estimated to cause crop damage equivalent to US$800 million p.a. (Pimental *et al.* 2005). In addition to these direct costs, pest birds are often responsible for causing other environmental, social and economic problems, such as an increased risk of livestock and human disease transmission (Bomford & Sinclair 2002; Pimental *et al.* 2005).

In New Zealand, introduced European birds, which often occur at very high densities relative to their native ranges (MacLeod *et al.* 2009), are widely regarded as horticultural pests (Porter *et al.* 1994). Bird damage is reported for a wide variety of crops, most frequently for cereals during the harvest period (Coleman & Spurr 2001). However, high-value specialty seed crops (especially *Brassica* species, such as radishes, canola, etc.), which are often grown in smaller areas and mature later in the growing season than grain crops, are also particularly prone to damage (Coleman & Spurr 2001). House sparrow (*Passer domesticus*) and European greenfinch (*Carduelis chloris*) are the species considered most harmful (Dawson 1970; Gillespie 1982; Coleman & Spurr 2001), with grain and *Brassica* seeds predominant in their diets (MacMillan 1981; Gillespie 1982;

Table 1. Field trials to assess the effect of varying the height of the radio-transmitters above the ground and observer distance from the radio-transmitter on ability to detect a signal using a hand-held antenna.

Distance from radio-transmitter	Location of transmitter			
	In ditch	On ground	1 m above ground	2 m above ground
100 m	Weak	Weak	Weak to strong *	Strong
200 m	None	None	Weak to strong *	Strong
300 m	None	None	Weak	Weak to strong *
400 m	None	None	None	Very weak

* Indicates signal variation in relation to the position of the antenna relative to the ground (*i.e.*, either shifting the height of the antenna, or moving it from parallel to perpendicular to the ground).

MacMillan & Pollock 1985). Habitat composition at the farm-scale, which is an important predictor of the number and distribution of these species in the breeding season and winter, alone does not account for temporal and spatial variation in bird densities on arable farms (MacLeod *et al*. 2011). Thus, control actions involving multiple farms are likely needed to manage these pest bird species, but the appropriate spatial scale and level of involvement and management required by individual landowners still needs investigation (MacLeod *et al*. 2008; Moller *et al*. 2008).

Here we start to address this knowledge gap by testing the feasibility of using radiotracking studies to monitor the ranging behaviour of house sparrows and European greenfinches within and beyond the scale of the individual farm. We also provide some preliminary information on the spatial scale at which management likely needs to be applied for their successful control.

METHODS

Radiotracking was carried out around a predominantly arable farm (120 ha) on the Canterbury Plains (near Leeston); both it and other nearby farms had paddocks planted with *Brassica* crops during the summer (Fig. 1). Surveys were carried out when radish (*Raphanus sativus*) seed crops are most susceptible to damage (Feb/Mar 2008), and again when growers often used poison bait to control pest bird populations (Jul 2009). Although we planned to track both pest species in both surveys, we were only able to capture (for transmitter attachment) greenfinches in the 1st survey and house sparrows in the 2nd survey.

Transmitters were attached using a tail-mount technique (Calladine *et al*. 2006; Siriwardena *et al*. 2006), being secured to the base of the shaft of fully-grown central tail feathers using glue and a thin strip of cloth tape. Tagged birds were also fitted with uniquely numbered metal bands to ensure that these individuals could be identified if recaptured at a later date. Radio-transmitters were only attached to individuals if the total device weight was less than 5% of the bird's body mass (Appendices A and B). Each radio-transmitter had a unique frequency.

Crop damage period

Birds were caught using mist nets in the 3 *Brassica* paddocks on the study farm during 19–22 Feb 2008. Radio-transmitters (*c*. 1.3 g, pulse rate 40 ppm, SS Model, expected battery life 10–14 days; SirTrack Ltd., New Zealand) were fitted to 19 greenfinches (Appendix A).

Controlled field trials were carried out to assess the effect of varying the height of the radio-transmitters above the ground as well as the observer's distance from the radio-transmitter on their ability to detect a signal using a hand-held antenna. The observer was working at ground level and the transmitter was placed at 1 of 4 different positions (in a ditch, on the ground, 1 m, and 2 m above the ground). The observer recorded the strength of the signal heard at varying distances from the location of the transmitter, by stopping at 100-m intervals to determine its strength until only a very faint signal could be heard.

Rather than attempting to obtain accurate location fixes, we assessed the probability of detecting the birds with hand-held antennae in the area over a 2-week period (21 Feb–7 Mar 2008; Fig. 1), with particular focus on the radish seed paddocks on and around the farm. For each day (between 0730 hours and 1700 hours), all points sampled were at least 200 m apart (roughly equivalent to the minimum transmission distance of known-location tags at 1 m above ground; Table 1). The number of tagged individuals detected per sampling square per sampling day was calculated.

Winter period

Birds were caught using mist nets at 2 sites at the centre of our study area (Fig. 2a) during 8–13 Jul 2009. Radio-transmitters (*c*. 0.9 g, pulse rate 40 ppm, BD-2 Model, estimated battery life of 42 days; Holohil Systems Ltd., Canada) were fitted

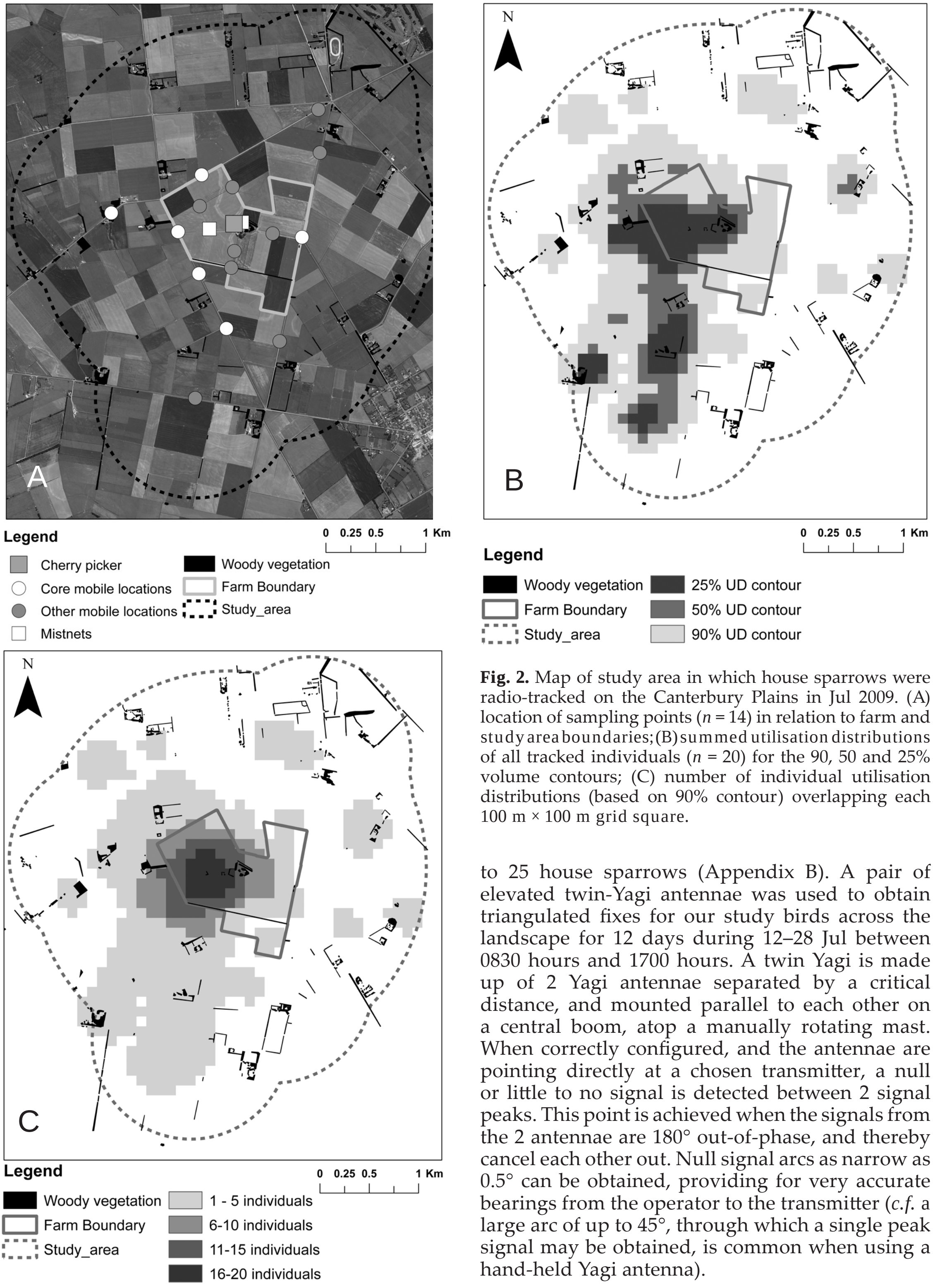

Fig. 2. Map of study area in which house sparrows were radio-tracked on the Canterbury Plains in Jul 2009. (A) location of sampling points (n = 14) in relation to farm and study area boundaries; (B) summed utilisation distributions of all tracked individuals (n = 20) for the 90, 50 and 25% volume contours; (C) number of individual utilisation distributions (based on 90% contour) overlapping each 100 m × 100 m grid square.

to 25 house sparrows (Appendix B). A pair of elevated twin-Yagi antennae was used to obtain triangulated fixes for our study birds across the landscape for 12 days during 12–28 Jul between 0830 hours and 1700 hours. A twin Yagi is made up of 2 Yagi antennae separated by a critical distance, and mounted parallel to each other on a central boom, atop a manually rotating mast. When correctly configured, and the antennae are pointing directly at a chosen transmitter, a null or little to no signal is detected between 2 signal peaks. This point is achieved when the signals from the 2 antennae are 180° out-of-phase, and thereby cancel each other out. Null signal arcs as narrow as 0.5° can be obtained, providing for very accurate bearings from the operator to the transmitter (*c.f.* a large arc of up to 45°, through which a single peak signal may be obtained, is common when using a hand-held Yagi antenna).

Table 2. Field trials to assess the effect of varying the height of the radio-transmitter above the ground and the observer distance from the radio-transmitter and height above the ground on ability to detect a signal using the aerial twin-Yagi antennae. For explanation of a null signal see 'Winter period' section of Methods.

Distance from observer (m)	Antennae *c*. 17 m above ground		Antennae *c*. 4 m above ground	
	Transmitter on ground	Transmitter 1.5 m above ground	Transmitter on ground	Transmitter 1.5 m above ground
350	-	-	Strong	Strong
400	Strong	Strong	-	-
800	Strong	Strong	Medium	Medium
1000	-	-	Weak	Weak
1300	-	-	Very weak – no null	Weak
1320	Medium	Weak	-	-
1500	-	-	Very weak – no null	Very weak – no null
1800	Weak	Weak	-	-
1900	-	-	Very weak – no null	Very weak – no null
2000	Weak	Medium	-	-
2500	Weak	Weak	-	-
3000	Weak	Weak	-	-

For the controlled signal trials, the observer recorded the strength of the signal detected using a twin-Yagi antenna located *c*. 4 m and 17 m above the ground. The distance of the transmitter from the observer was increased until only a faint signal could be heard when the transmitter was placed on the ground or 1.5 m above the ground.

The 1st antennae (mounted in a cherry picker, *c*. 17 m above the ground) was at a fixed location in the centre of our study area (Fig. 2a), and the 2nd was attached to a trailer (*c*. 4 m above ground) and moved to 14 different locations within 1.8 km of the first (Fig. 2a). The mobile unit was moved between 4–5 locations per day, with sampling effort among the mobile locations randomised in relation to both sampling day and time of day. A subset of core mobile locations (< 1.2 km of the cherry picker) was visited at least 4 times during the monitoring period (Fig. 2a). The study area was defined as the maximal extent of the 1 km radii around all mobile sampling locations, which approximately overlapped with a 2 km radius around the cherry picker (Fig. 2a).

The location of tracked birds was triangulated by obtaining fixes of each individual from the fixed and mobile sampling locations within a few minutes of each other, with the signal direction (the magnetic compass bearing) and signal strength recorded. Fixes with very weak signals, or detected outside the study area, were excluded from the dataset. Post-filtering, only individuals with more than 5 records (Calenge 2006) were considered for the home range analysis ($n = 20$; Appendix B). Fixed-kernel utilisation distributions (*UD*, Van Winkle 1975) were used to define the spatial probability distribution of each tracked bird over a raster composed of 100 m × 100 m grid squares, using a bivariate-normal model (Calenge 2006) specifying a neighbourhood smoothing parameter of 150 m (the approximate accuracy of the fixes, based on information from a known-location tag).

Three activity ranges (measured using the 25%, 50% and 90% probability volume contours; *25UD*, *50UD* and *90UD*) were used to describe the distribution of individual house sparrows in the study area. The *90UD* measures the minimum home range size for each bird (Börger *et al*. 2006). The *50UD* and *25UD* indicate high-use areas where there is a relatively high probability of detecting an individual compared to other areas within its *90UD*. Mean spatial overlap was estimated for all 3 activity ranges from the percentage *UD* overlap of each individual with all other tracked individuals, using the home range (*HR*) and volume of intersection (*VI*) methods (Fieberg & Kochanny 2005; Calenge 2006). The probability of detecting an individual within and outside the farm boundary was also calculated.

Finally, the area of woody vegetation available for each individual was calculated as the proportion of grid squares within its home range overlapping woody vegetation, and the probability of that bird being detected in or near woody vegetation was calculated as the summed *UD* volume for all grid squares overlapping woody vegetation. The location of woody vegetation patches within the study area was determined using a series of georeferenced aerial photos (see Fig. 2a; sourced

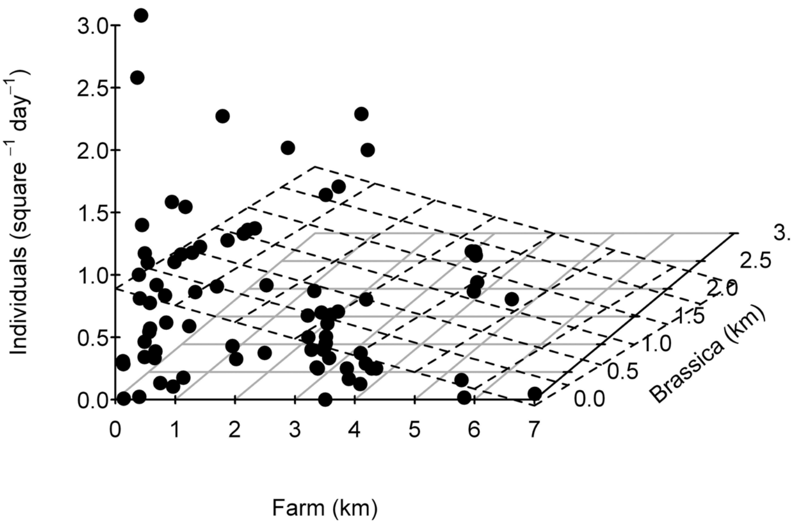

Fig. 3. Number of 19 tagged greenfinch individuals detected per 100 m × 100 m grid square (n = 80) per sampling day in relation to distance (km) from the study farm centre (approximate location of release) and nearest *Brassica* crop (predominantly radish seed crops) in the Canterbury Plains (New Zealand) during the peak period of crop damage (Feb–Mar) in 2008. Parameter estimates [± SE] for the best-fit linear regression model: *intercept* = 0.890 ± 0.109, $slope_{farm}$ = -0.134 ± 0.040; $slope_{Brassica}$ = -0.119 ± 0.09. See Table 3 for the best-fit model.

from Environment Canterbury, New Zealand). Polygons were drawn around any visible woody habitat features (which included isolated or patches of trees as well as shelterbelts), using geographical information software (ESRI® ArcMap™ 9.2). Raster squares (using the same 100 m × 100 m grid as for the *UD* analysis) which overlapped at least one woody vegetation polygon were identified.

RESULTS

Signal detection trials

During the radio-transmitter signal detection trials, the height of the radio-transmitter above the ground and its distance from the antenna influenced the observer's ability to detect a signal using both the hand-held and the elevated antennae (Table 1).

For the hand-held antennae, a signal was only detected at 100 m when the transmitter was located in a ditch or on the ground. The strength of the signal detected at relatively short distances from the transmitter (100–200 m) increased when the transmitter was elevated to 1–2 m off the ground, but weakened as the observer moved away. Only a weak signal was detected when the observer was 400 m from a transmitter that was positioned 2 m above ground.

For the twin-Yagi antennae positioned *c*. 4 m and 17 m above the ground, medium strength signals were detected up to *c*. 0.8 and 2 km away, respectively, for a known-location tag held *c*. 1.5 m high (Table 2). When the transmitter was placed on the ground, weak signals were still detected at these distances. Using the 17-m high antenna, weak signals were also detected, for transmitters placed either on or 1.5 m above the ground, up to 3 km away.

Crop damage period

The probability of detecting tagged greenfinches decreased with distance from the centre of the farm and, to a lesser extent, *Brassica* seed paddocks (Table 3; Fig. 3). Two tagged individuals were detected within several different *Brassica* seed paddocks about 3 km north of the study site, but none were detected in the paddocks 4.5 km to the south (Fig. 2). Another 8 tagged individuals were detected outside the farm boundary on at least 1 occasion.

Winter period

Home ranges (*90UD*s) of tagged house sparrows were on average 104 ha, with *25UD*s and *50UD*s covering a tenth and a quarter of the area, respectively (Table 4). Even though *90UD*s were widely dispersed across the landscape, most overlapped with the farm boundary (Figs. 2b and 2c). On average, *c*. 60% of an individual's *90UD* area overlapped with the study farm (where the birds were originally captured); this increased to >70% for *25UD*s and *50UD*s. The probability of overlap among individual *90UD*s (both in terms of area and time) was also relatively high (*c*. 40% and 70%, respectively), but this was substantially reduced for *25UD*s (*c*. 17% and 8%; Table 4). The probability of detecting a bird in grid squares overlapping woody vegetation was significantly greater than expected for both *50UD*s (t = 3.09, *d.f.* = 19, P = 0.006) and *90UD*s (t = 3.66, *d.f.* =19, P = 0.002), but not for *25UD*s (Fig. 4; t = -2.13, *d.f.* = 19, P = 0.05).

DISCUSSION

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This study assessed the potential of 2 radiotracking systems (hand-held vs. elevated twin-Yagi antennae)

Table 3. Model comparison of linear regressions to test effect of distance from farm and *Brassica* crops on the number of 19 tagged greenfinch individuals detected per grid square per sampling day (*n* = 80 grid squares) in Feb–Mar 2008.

Model	*AIC*	*Ì ("*	Weight
Null	146.8	13.3	0.001
Distance to farm	135.3	1.8	0.293
Distance to *Brassica*	144.3	10.8	0.003
Distance to farm & *Brassica*	133.5	0.0	0.703

for monitoring pest bird ranging behaviour in and around an arable farm. Relative to the hand-held antennae system, the detection radius for tagged birds increased by at least 8-fold but up to 20-fold depending on the height of the twin-Yagi antennae. This allowed us to triangulate the location of individual birds, sometimes several times a day. By enhancing the scale and frequency of the location data in this way, it was possible to estimate the minimum home range (*90UD*) sizes of individual birds and identify high-use areas (*50UD* and *25UD*) in the study region.

As the detection radius for signals was very low with the handheld antennae system, it was only possible to record whether or not an observer detected a tagged individual at specific locations. However, because the hand-held antennae are portable and simple to use, observers were able to move relatively easily between key points (in our case, *Brassica* crops) in the landscape. While this provided some information about the movement of a subset of individuals among *Brassica* crops in the landscape, it is possible that other individuals were present in the crops but were not detected.

Both surveys were labour-intensive, but show some promise for monitoring pest bird movements at different spatial scales and resolution. Future studies aiming to track the movements of small passerines in the agricultural landscape need to bear in mind these trade-offs in design. Future research should also aim to quantify the error associated with measuring the position of known-location transmitters in the field as well as identify the optimal number of location records required to accurately measure home range sizes (Börger *et al.* 2006).

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During crop maturation, the probability of detecting tagged greenfinches decreased in relation to distance from both farm centre and *Brassica* crops. However, over a 2-week period, 2 individuals were detected in or near radish paddocks *c.* 3 km beyond the study farm boundary. This indicates that at least 12% of the tagged population undertook large-scale movements between patches at the landscape scale during that time, while another 44% were detected outside the farm boundary.

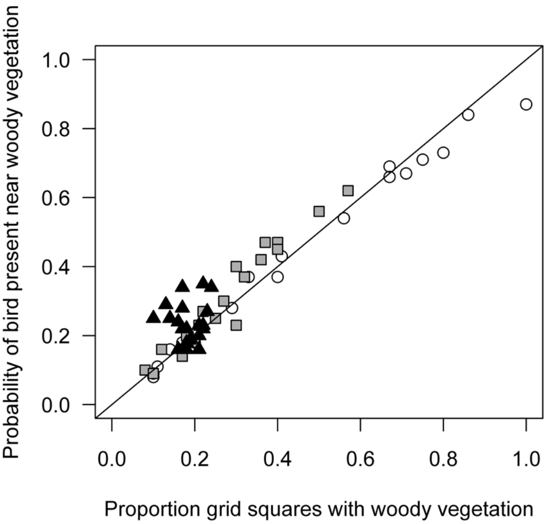

Fig. 4. Probability of detecting a tracked house sparrow (*n* = 20) near woody vegetation relative to the proportion of grid squares that overlap woody vegetation within its home range (measured using the utilistation distribution contours: 25% [open circles], 50% [grey squares] and 90% [black triangles]) in Jul 2009. If the probability of detecting a bird in woody vegetation was directly proportional to the proportion of gird squares with woody vegetation present, all points would fall on the line.

In the mid-winter period, home ranges (*90UDs*) of tagged house sparrows were on average slightly smaller than the farm area (104 vs. 120 ha) but only 60% of the area overlapped with the farm boundary. Thus, over a relatively short-time period (*c.* 2 weeks), house sparrows were regularly moving beyond the farm boundary. There was a high degree of overlap among individuals in their *90UDs*, but little overlap in their *25UDs*, suggesting that high-use areas were dispersed. The strong positive association with woody vegetation within *90UD* areas, but not in *25UD* areas, also suggests that other resources must influence the distribution of birds with their high-use areas. Due to the limited area and duration of our study, we did not attempt to identify whether *25UD* areas were associated with other key habitat features.

To determine whether these results are indicative of movement patterns for greenfinch and house sparrow on arable farms in general, and to understand seasonal changes in movement patterns, this study would need to be replicated over a number of randomly selected farms across seasons for several years.

Table 4. Summary of home range area information for 20 house sparrows radiotracked on the Canterbury Plains in Jul 2009 in relation to the farm boundary and location of other tracked individuals. Home range area was assessed using 3 measures of the utilisation distribution based on the 25%, 50% and 90% probability volume contours (*25UD*, *50UD* and *90UD*).

Variable	Range measure	Mean	SE	Minimum	Maximum
Range area (ha)	*25UD*	9.5	1.3	5	24
	50UD	26.1	3.6	14	68
	90UD	104.2	11.2	46	241
Within farm boundary (% range area)	*25UD*	75.8	10.8	0	100
	50UD	72.7	10.1	0	100
	90UD	62.5	8.4	5	95
Individual overlap (% range area)	*25UD*	16.9	2.6	1	30
	50UD	29.4	3.7	2	49
	90UD	42.8	3.2	15	62
Individual overlap (% range volume)	*25UD*	8.3	1.4	0	17
	50UD	28	3.7	1	49
	90UD	71.2	6.3	20	100

Implications for management

Taken together, our radio-tracking results demonstrate that ranging behaviour of both greenfinches and house sparrows is beyond the farm-scale; individual house sparrows frequently disperse from farms during the winter, and individual greenfinches can move relatively large distances (>3 km) in a short time within the crop maturation period. These preliminary measures of bird movement suggest that a winter bird-pest-control programme would need to be implemented at a spatial scale that goes beyond the farm boundary. This supports earlier observations from bird surveys, which also suggest that implementing a bird control programme (such as poisoning) on individual farms during the winter is unlikely to reduce breeding bird densities on that farm (MacLeod *et al*. 2011). The efficacy of larger-scale control would depend on the level of involvement of landowners within the estimated foraging range.

In broad terms, our results also suggest that house sparrows are strongly associated with woody vegetation in the winter period, providing further support for the hypothesis that reducing the proportion of shelterbelts on farms may also be an effective method of reducing pest bird abundance on farms (MacLeod *et al*. 2011). However, shelterbelts provide many other important ecosystem services (such as wind reduction, climate control, stock protection, biodiversity conservation; Burke 1998; Haslem & Bennett 2008; Fischer *et al*. 2010; Hanspach *et al*. 2011), so a detailed cost-benefit analysis of any boundary habitat manipulation would be a priority. An experimental manipulation would also be required to test whether removal of shelterbelts does indeed reduce bird damage risk at the farm scale.

Conclusions

Our study has demonstrated the feasibility of using radiotracking technology to monitor pest bird movements in the farm landscape over short time-frames. It has also highlighted potential trade-offs in the study design influencing the scale and frequency of location records. Preliminary estimates of ranging behaviour for greenfinch in summer and house sparrow in winter indicate that these species frequently travel beyond the farm boundary. This suggests that farm-scale management is unlikely to control pest bird populations. However, our study was limited to observations from 1 arable farm in the Canterbury Plains and a single season for each species, so future studies need to test whether these findings apply across seasons at the wider landscape scale.

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Appendix A. Summary of capture, biometric and location records for 19 greenfinches fitted with radio-transmitters in Feb 2008.

Tag	Age	Sex	Date of capture	Body mass (g)	Tag:body mass (%)	No. of location records	No. of days relocated	Date of last location record	No. of grid squares located
14	JUV	F	19 Feb 2008	28.6	4.5	0	0	19 Feb 2008	0
10	JUV	F	19 Feb 2008	29.0	4.5	2	1	19 Feb 2008	2
12	JUV	M	19 Feb 2008	30.8	4.2	19	9	06 Mar 2008	12
24	JUV	M	19 Feb 2008	28.3	4.6	57	7	28 Feb 2008	20
28	JUV	M	20 Feb 2008	28.2	4.6	0	0	20 Feb 2008	0
20	JUV	M	21 Feb 2008	28.2	4.6	20	7	07 Mar 2008	15
26	JUV	F	21 Feb 2008	28.5	4.6	35	11	07 Mar 2008	20
22	JUV	F	21 Feb 2008	29.5	4.4	7	2	26 Feb 2008	6
18	JUV	F	21 Feb 2008	28.4	4.6	30	9	06 Mar 2008	16
16	JUV	M	21 Feb 2008	29.0	4.5	6	5	26 Feb 2008	3
42	JUV	M	21 Feb 2008	28.5	4.6	1	1	21 Feb 2008	1
30	JUV	M	21 Feb 2008	30.1	4.3	19	6	07 Mar 2008	13
44	JUV	M	21 Feb 2008	28.2	4.6	9	5	07 Mar 2008	6
36	JUV	M	21 Feb 2008	28.9	4.5	33	7	05 Mar 2008	18
48	JUV	F	22 Feb 2008	27.5	4.7	8	4	03 Mar 2008	8
38	JUV	M	22 Feb 2008	29.6	4.4	2	1	22 Feb 2008	2
30	JUV	M	22 Feb 2008	28.5	4.6	19	6	07 Mar 2008	13
40	JUV	M	22 Feb 2008	28.5	4.6	50	11	07 Mar 2008	21
34	JUV	M	22 Feb 2008	28.5	4.6	7	5	04 Mar 2008	6

Appendix B. Summary of capture, biometric and location records for 20 house sparrows fitted with radiotransmitters in Jul 2009 as well as utilisation distribution (*UD*) area estimates, degree of overlap with the farm boundary and other individuals. Note transmitters were fitted to another 5 birds but they were excluded from our analyses as we obtained less than 5 location records for those individuals.

Tag	Sex	Body mass (g)	Tag: body mass (%)	Date of capture	No. of location records	No. of days re-located	Date of last location record	*UD* area (ha)			*UD* overlap with farm (%)			*UD* overlap with other individuals (%)					
								25UD	*50UD*	*90UD*	*25UD*	*50UD*	*90UD*	*25UD*	*50UD*	*90UD*	*25UD*	*50UD*	*90UD*
141	F	28	4.3	08 Jul 2009	23	12	28 Jul 2009	9	24	82	44	43	45	7	23	55	3	19	72
190	M	28	4.3	08 Jul 2009	16	8	23 Jul 2009	10	30	111	0	0	5	22	34	44	14	41	90
200	F	26	4.6	08 Jul 2009	20	11	28 Jul 2009	24	68	241	100	100	95	2	2	15	1	1	20
242	M	31	3.9	08 Jul 2009	7	4	27 Jul 2009	17	41	122	100	88	61	1	10	32	0	10	48
260	F	30	4.0	08 Jul 2009	16	9	27 Jul 2009	7	19	98	100	88	80	16	25	38	10	30	76
280	M	29	4.1	08 Jul 2009	21	10	27 Jul 2009	5	14	60	100	100	95	24	35	49	7	22	57
321	F	26	4.6	10 Jul 2009	15	8	27 Jul 2009	10	25	90	19	30	31	7	19	38	3	16	51
337	M	28	4.3	10 Jul 2009	9	8	28 Jul 2009	5	14	46	100	100	86	30	38	61	14	37	85
352	F	27	4.4	10 Jul 2009	21	11	28 Jul 2009	6	16	90	100	100	86	22	46	51	8	34	85
370	M	28	4.3	10 Jul 2009	29	11	28 Jul 2009	6	15	68	78	63	50	26	41	54	12	31	77
380	M	27	4.4	11 Jul 2009	25	10	27 Jul 2009	8	22	119	100	100	90	27	40	44	17	49	100
420	M	28	4.3	11 Jul 2009	18	10	28 Jul 2009	12	31	121	90	73	50	11	19	38	8	22	61
431	M	26	4.6	11 Jul 2009	27	11	28 Jul 2009	7	20	109	68	54	43	26	34	43	12	32	80
461	M	29	4.1	11 Jul 2009	12	6	27 Jul 2009	10	30	114	100	100	86	17	30	35	7	30	66
502	M	27	4.4	11 Jul 2009	7	4	27 Jul 2009	14	36	120	100	100	88	10	25	38	5	26	65
511	M	30	4.0	11 Jul 2009	24	10	27 Jul 2009	9	25	109	100	88	67	21	36	44	11	35	85
530	F	25	4.8	11 Jul 2009	17	11	28 Jul 2009	5	14	72	100	100	69	25	49	62	12	41	100
541	M	29	4.1	12 Jul 2009	19	11	28 Jul 2009	10	29	111	100	100	92	14	30	46	8	32	78
581	M	28	4.3	13 Jul 2009	10	7	27 Jul 2009	9	27	92	0	7	14	5	9	27	1	6	31
592	F	27	4.4	13 Jul 2009	16	9	27 Jul 2009	7	22	109	16	19	18	24	42	42	14	46	94