

1 **Running head:** *Supplementary feeding increases risk of nest predation*

2

3 **Provision of supplementary food for wild birds may increase the risk of**  
4 **local nest predation**

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17 In countries such as the UK, USA and Australia, approximately half of households provide  
18 supplementary food for wild birds, making this the public's most common form of active engagement  
19 with nature. Year round supplementary feeding is currently encouraged by major conservation  
20 charities in the UK as it is thought to be of benefit to bird conservation. However, little is understood  
21 of how the provision of supplementary food affects the behaviour and ecology of target and non-target  
22 species. Given the scale of supplementary feeding, any negative effects may have important  
23 implications for conservation. Potential nest predators are abundant in urban areas and some species  
24 frequently visit supplementary feeding stations. We asked if providing supplementary food affected  
25 the likelihood of nest predation in the vicinity of the feeder, by acting as a point attractant for potential  
26 nest predators. We provided feeding stations (empty, peanut feeder, peanut feeder with guard to  
27 exclude potential nest predators) in an area of suburban parkland in the UK and monitored the  
28 predation rate experienced by eggs placed in artificial nests located at distances which replicate the  
29 size of typical suburban gardens. Nest predators (Magpies *Pica pica*, Grey Squirrels *Sciurus*  
30 *carolinensis*) were frequent visitors to filled feeders, and predation caused by Magpies, European Jays  
31 *Garrulus glandarius* and Grey Squirrels was significantly higher when nests were adjacent to filled  
32 feeders. The presence of a feeder guard did not significantly reduce nest predation. As supplementary  
33 feeding is becoming increasingly common during the breeding season in suburban habitats, we  
34 suggest that providing point attractants to nest predators at this time may have previously  
35 unconsidered consequences for the breeding success of urban birds.

36

37 **Keywords:** artificial nest, predation, bird feeding, garden, corvid, Grey Squirrel, Eurasian Magpie,  
38 Eurasian Jay, urban ecology

39

## 40 **Introduction**

41 Garden bird feeding engages more people with wildlife than any other activity. Some 48% of  
42 households in Britain (Davies *et al.* 2009) and 53 million households in the USA feed wild birds (U.S.  
43 Fish and Wildlife Service 2011), providing an enormous and highly localised additional food  
44 resource. For example, in suburban Reading, UK, over 55% of householders provide supplementary  
45 food for wild birds, two-thirds of whom feed year round (Orros & Fellowes 2015a). The majority of  
46 individuals provide peanuts, a range of seed types (e.g. sunflower, nyger, wheat) and fat to birds  
47 visiting their gardens. A conservative estimate suggests that enough food is annually provided in the  
48 UK to support over 30 million garden birds (Orros & Fellowes 2015a). This is reflected by the size of  
49 the bird feeding industry, which ten years ago was estimated to be worth £200 million *per annum*  
50 (British Trust for Ornithology 2006). This figure is likely to be considerably higher today.

51 Supplementary feeding in urban areas affects the abundance and distribution of species as diverse as  
52 the Red Kite *Milvus milvus* (Orros & Fellowes 2014, 2015b), hummingbirds (Hill *et al.* 1998, Courter  
53 *et al.* 2013) and the Blackcap *Sylvia atricapilla* (Chamberlain *et al.* 2005, Rolshausen *et al.* 2009,  
54 Plummer *et al.* 2015). While feeding has been shown to increase adult overwinter survival (Jansson *et*  
55 *al.* 1981, Brittingham & Temple 1988), effects on bird productivity are variable, and overwinter  
56 supplementary feeding has been found to both increase (Robb *et al.* 2008) and decrease (Plummer *et*  
57 *al.* 2013a, b) breeding success in subsequent seasons. Similarly, supplementary feeding experiments  
58 during the breeding period have found mixed results, with evidence for both decreases (Harrison *et al.*  
59 2010) and increases (Peach *et al.* 2013, Smith & Smith 2013) in productivity. Furthermore, feeding  
60 stations may facilitate the transmission of disease (Bradley & Altizer 2007), which can lead to rapid  
61 population declines (e.g. trichomonosis in greenfinch; Robinson *et al.* 2010).

62 Urban birds tend to lay eggs earlier, have smaller clutch sizes, lower nestling weight and lower  
63 productivity per nesting attempt (Chamberlain *et al.* 2009). Open-cup nesters decline with increasing  
64 urbanisation but remain part of the avifauna (Máthé & Batáry 2015) and UK gardens hold significant  
65 populations of several such species (Bland *et al.* 2004). While food availability and habitat suitability  
66 are important limiting factors for urban bird populations (Shochat 2004, Máthé & Batáry 2015), nest

67 predation is a key cause of nest failure for open-cup nesters (Ricklefs 1969, Martin & Li 1992),  
68 possibly also limiting their populations (Jokimaki & Huhta 2000). Predator densities in urban areas  
69 may be higher than in rural areas for some nest predators, such as corvids (Jokimaki & Huhta 2000,  
70 Antonov & Atanasova 2003, Jokimäki et al., 2005, Sorace & Gustin 2009), although it is unclear if  
71 this apparent increase in potential predator density depresses prey populations (Shochat 2004, Madden  
72 et al. 2015). Eurasian Magpies *Pica pica* and introduced Grey Squirrels *Sciurus carolinensis* are  
73 common in UK urban areas and are frequent nest predators (Eaton et al. 2013, Bonnington et al.  
74 2014a). Increased nest predation in an urban area is associated with increased corvid density, although  
75 no association was found with grey squirrel population size (Bonnington et al. 2015).

76 Nest predators, such as Eurasian Magpies and Grey Squirrels, can be attracted by garden feeding  
77 stations (Chamberlain et al. 2005, Väisänen 2008, Bonnington et al. 2014b). As a result, those  
78 providing supplementary food can also purchase caged feeders, which aim to exclude larger species,  
79 including squirrels and corvids. At a domestic garden scale the provision of bird feeders reduces the  
80 local abundance of insects (Orros & Fellowes 2012, Orros et al. 2015), and the provision of  
81 supplementary food for ungulates (Cooper & Ginnett 2000, Selva et al. 2014) and woodland predators  
82 (Borgmann et al. 2013) increased local nest predation. In each case the supplementary food appears to  
83 attract predators to a point source, which in turn foraged locally on other prey. The most parsimonious  
84 explanation is that the presence of a reliable or high quality food resource both increases the numbers  
85 of potential nest predators and the time they spend foraging near the food source.

86 It is not known if supplementary feeding of the type practised by tens of millions of garden owners  
87 increases the risk of local nest predation in urban and suburban habitats. These habitats support  
88 significant populations of native bird species in the UK including a number of open-cup nesting  
89 species that have undergone national declines in recent decades, such as the Blackbird (*Turdus*  
90 *merula*), the Dunnock (*Prunella modularis*), and the UK red-listed Song Thrush (*Turdus philomelos*)  
91 (Gregory & Baillie 1998, Bland et al. 2004). Given the near ubiquity of supplementary feeding in  
92 urban areas, and the recommendation from bird conservation NGOs (e.g. RSPB 2009) to feed birds  
93 throughout the year, it is possible that individuals providing supplementary food in their gardens are

94 inadvertently increasing nest predation rates suffered by their garden birds. To investigate this further  
95 it is first necessary to establish if nest predation is elevated near bird feeding stations. By using both  
96 guarded (food inaccessible to nest predators) and unguarded feeders (food accessible), we can test if it  
97 is the presence of food (both accessible and inaccessible) or the availability (food accessible in  
98 unguarded feeders) of food which affects predation rates.

99 Studying nest predation using real nests would result in considerable practical and ethical challenges.  
100 As a result, artificial nests provide an important tool for studying bird nest predation (Major & Kendal  
101 1996, Miller & Hobbs 2000). Typically nests are baited with quail and/or model eggs and monitored  
102 over a set period. Artificial nests are undefended by adults and lack the activity of real nests;  
103 nevertheless, they provide experimental nest predation data at scales which would be difficult to  
104 achieve in natural studies, while avoiding the ethical issues of experimenting with natural nests  
105 (Major & Kendal 1996, Moore & Robinson 2004). Using camera monitored artificial nests we  
106 investigated nest survival around caged, uncaged and empty bird feeders. Our objectives were to  
107 determine if a) potential nest predators were attracted to bird feeding stations providing  
108 supplementary food, b) if so, if this was associated with differences in rates of nest predation, c) if  
109 increased nest predation was associated with access to food (unguarded feeders) or the presence of  
110 food (guarded and unguarded feeders) and d) if nest predation rates were affected by distance from  
111 the supplementary food source.

## 112 **Materials and methods**

### 113 *Study area*

114 The study was conducted at the University of Reading's Whiteknights Campus (UK; 51°27'N,  
115 0°58'W), in an area of open parkland and woodland comprising approximately 68% natural surfaces  
116 overall, embedded in a typical UK suburban landscape broadly conforming to Marzluff *et al.* (2001).  
117 The town of Reading covers approximately 40 km<sup>2</sup> with a population of 230 000 people (Office for  
118 National Statistics 2013).

### 119 *Experimental design*

120 Experimental work was carried out between the 5<sup>th</sup> of May and the 17<sup>th</sup> of June 2014, which is during  
121 the peak bird breeding season for the UK (Robinson 2005). Fifty-four locations were selected on the  
122 edge of grassy clearings and open spaces with adjacent areas of shrubs and bushes, 50-100m apart,  
123 replicating typical suburban feeder distribution (Fuller *et al.* 2008). The experiment consisted of six  
124 two-week sample cycles. During each cycle, nine peanut feeders (CJ Wildlife small defender feeder,  
125 Shrewsbury, UK) were positioned (three each of empty, filled and unguarded, filled and fitted with a  
126 cage guard). Feeders were randomly placed in each of the study locations, one week before the nests,  
127 to allow habituation. Sites were not reused and all were at least 20 m away from the closest building.  
128 Experimental cycles were staggered at one week intervals to reduce the sampling time required for the  
129 whole experiment.

130 Two artificial nests were placed diametrically opposed ca. 5m ('near') and 10m ('far') from each  
131 feeder ( $\pm 1$  m), replicating typical distances between feeders and suburban garden boundaries (Gaston  
132 *et al.* 2007). In total 108 nests were placed (one 'near', one 'far', at each of the 54 feeder locations).  
133 Nests were constructed of 15x15cm squares of small-gauge wire mesh lined with dried grass and  
134 attached to branches to imitate a Blackbird nest (Kurucz *et al.* 2010, Kurucz *et al.* 2012). Nest height  
135 was at  $1.5 \pm 0.5$ m and were placed to mimic natural blackbird nest-sites and attempted to provide  
136 similar visual accessibility to potential predators following Swanson *et al.* (2012). Two fresh Quail  
137 *Coturnix japonica* eggs were placed in each nest (Buler & Hamilton 2000). Blackbirds are a common  
138 breeding species in UK gardens along with the less common but similarly sized Song Thrush (Bland  
139 *et al.* 2004), making them an appropriate species to simulate. Nests were monitored for seven days  
140 (168 hours) as 90% of predation events occur within 6 days of placement (Burke *et al.* 2004).

141 Each nest was continually monitored by a concealed motion-triggered camera trap (Ltl Acorn 5310;  
142 Ltl Acorn Inc, USA), set to the highest sensitivity setting, taking three photographs with a three  
143 second interval when triggered.

144 Feeders were checked every 3.5 days and refilled where necessary. Feeder usage was sampled using  
145 camera traps, but each was monitored for 3.5 days either at the beginning or end of the week to ensure

146 coverage with limited traps. At any one time one of each feeder type was monitored and two thirds of  
147 all feeders were sampled for usage.

148 Nest fate was recorded and for predated nests, predation time and predator identity determined. Any  
149 damage to or removal of eggs was considered a predation event. Visitation rates per species were  
150 recorded at the feeders; as visitors could not be individually identified, a visitor was considered an  
151 individual when either separated by a photograph without the animal or when four or more minutes  
152 had elapsed without a feeding event.

### 153 *Data Analysis*

154 All analyses were carried out within the program R (R Core Team 2016), with nest survival tested  
155 using Cox's proportional hazard model in base R survival package (version 2.39-4, Therneau 2015).  
156 This approach was used over a logistic exposure or regression approach (Shaffer 2004) because exact  
157 survival time and fate was known for each nest and exposure period did not vary. Covariates were  
158 feeder type (empty, guarded, unguarded), distance from feeder (near, far) and study week block (as a  
159 random effect) with time until predation (hours) and predation status as response variables. No  
160 interaction terms were used. We evaluated the relative fit of each candidate model using Akaike's  
161 Information Criterion with a small-sample bias adjustment, comparing models using Akaike weights  
162 and delta AICc (Burnham & Anderson 2002).

163 Mean daily feeder visitation (as a proxy for usage) was first compared using Kruskal-Wallis tests  
164 between treatment, by individual species, all potential 'predator' species, all small birds and all  
165 animals. Binomial logistic mixed model regression was then used to test for specific relationships  
166 between animal feeder usage and predation overall. Two separate global models were constructed  
167 both with study week block as a random effect factor and whether a nest was predated as the binomial  
168 response variable in the R lme4 package (version 1.1-12, Bates et al 2015). First, a model that  
169 considered overall predator visits and small bird visits to feeders as variables effecting nest predation.  
170 Second, a model considering feeder visits by Squirrels, Magpies and small birds as variables effecting  
171 nest predation. Because Magpie and squirrel visits are subsets of overall predator visits it is not

172 possible to utilise species and overall visits in the same model. Jays were not included in the  
173 individual models due to their infrequent visits. Relative model fit was then separately evaluated using  
174 delta AICc and Akaike weights for both global models as above against a null model containing only  
175 the intercept and study week as a random factor. There was insufficient data to effectively compare  
176 effectors on predation for individual predator species or at specific feeder types.

## 177 **Results**

### 178 *Feeder visitation*

179 Thirty-three of the 54 feeders were monitored (10 empty, 11 guarded, 12 unguarded). Eleven species  
180 were recorded making 5251 individual feeder visits (empty feeders: 17; guarded: 3522; unguarded:  
181 1712 visits).

182 Grey Squirrels contributed 43.9% of visits to unguarded and 9.3% of visits to guarded feeders while  
183 smaller birds were more likely to visit guarded feeders (Table 1). Magpies were a regular visitor to  
184 unguarded feeders but rare at empty and guarded feeders. One exception was an individual guarded  
185 feeder, which did receive frequent visits (Figure 1). Despite predating 27.5% of all recorded nests,  
186 Jays only visited feeders eight times. All species visiting more than two individual feeders (excluding  
187 unknowns) show a significant difference between their feeder usages (Table 1; Figure 1).

### 188 *Nest survival*

189 Of the 108 experimental nests, 102 were successfully monitored, with 74 recorded predation events  
190 (magpie: 37; jay: 28; grey squirrel: 8; one unknown). Six nest predation events were missed due to  
191 camera errors or human interference and so were omitted from the analysis (3 empty, 2 guarded and 1  
192 unguarded). From the different feeder types 51.5% of empty feeder nests, 76.5% of guarded feeder  
193 nests and 88.6% of unguarded feeder nests were predated during the course of the experiment. No  
194 predation events were recorded between 20:10 and 05:32.

195 When AICc selection was carried out on the global hazard model, the AICc selected model with  
196 distance from feeder removed had a delta AICc of less than 2 from the global model so for

197 completeness we present both the global (Wald = 23.05, d.f. = 6.42,  $p < 0.001$ , AICc = 600.4, model  
198 weight = 0.210; Table 2) and AICc selected model (Wald = 22.93, d.f. = 5.43,  $p < 0.001$ , AICc =  
199 598.5, model weight = 0.672; Table 2). Separate post hoc ANOVAs of both models (following  
200 Therneau 2015) found feeder type and week were significant effectors of nest survival overall ( $\chi^2 =$   
201 11.8, d.f. = 2,  $p = 0.003$  and  $\chi^2 = 17.6$ , d.f. = 3.4,  $p < 0.001$  for feeder type and study week  
202 respectively in both models). In both models nests near filled feeders were significantly more likely to  
203 be predated than those near empty feeders and week was a significant covariate with identical hazard  
204 ratios after rounding (Table 2; Figure 2). Nest distance from feeder did not significantly affect  
205 predation rates in the global model ( $p = 0.67$ ) and was eliminated in the AICc selected model (Table  
206 2). No significant difference in survival was found between nests adjacent to guarded and unguarded  
207 feeders (post-hoc Tukey test  $p = 0.82$ ; Figure 2).

#### 208 *Nest predation and feeder usage*

209 Overall feeder activity by predators (Grey Squirrels, Jays and Magpies) was significantly associated  
210 with increased nest predation (Wald  $Z = 2.518$ ,  $p = 0.019$ ) in the AICc selected mixed effect model  
211 (Table 3). In the model considering individual predator usage, Grey Squirrel usage was significantly  
212 associated with increased overall nest predation (Wald  $Z = 2.305$ ,  $p = 0.021$ ) in the AICc selected  
213 model (Table 3). However, support for this model is weak with little separation between all possible  
214 model AICcs and similar Akaike weights in several models (Table 3). Usage by small birds was not a  
215 significant factor in any model (Table 3).

216

#### 217 **Discussion**

218 We that the provision of supplementary food during the breeding season for wild birds in a form  
219 common in urban and suburban habitats may increase the likelihood of local nest predation. The  
220 survivorship of nests adjacent to unguarded feeders was less than 20% of that seen when artificial  
221 nests were placed near empty feeders. There was no difference in nest survival near guarded feeders  
222 when compared with those placed adjacent to unguarded feeders. Increased predation was associated



223 with Magpies, Jays and Grey Squirrels. Magpies and Grey Squirrels were significantly more likely to  
224 visit unguarded feeders, while Jays were largely absent. Overall, nest predation was associated with  
225 increased predator visits, particularly by Grey Squirrels, to feeders. There was no effect on nest  
226 predation rates of distance to feeder at the scales we considered. Species assemblages differed  
227 between treatments; empty feeders received few visits or no visits, guarded feeders were mostly  
228 visited by small passerines and unguarded feeders attracted a higher proportion of corvids and  
229 Squirrels. Despite being unable to feed at guarded feeders, predators still made up 9.4% of total visits  
230 to them. No mammalian nest predators other than Grey Squirrels were recorded despite being present  
231 at the study site and in UK urban areas generally (e.g. Brown Rat *Rattus norvegicus*, mice *Apodemus*  
232 spp., Red Fox *Vulpes vulpes*, Domestic Cats *Felis catus*: Baker & Harris 2007, Thomas *et al.* 2012).  
233 Two nests recorded mouse visits but no predation attempts were observed.

234 Nests adjacent to filled feeders suffered greatly increased predation rates, with the majority of nest  
235 predation events caused by corvids (Magpies and Jays) and Grey Squirrels. Nest predation by corvids  
236 is a frequent occurrence in urban habitats (Jokimaki & Huhta 2000, Thorington & Bowman 2003,  
237 Jokimäki *et al.*, 2005, Bonnington *et al.* 2015), where densities are high due to their omnivorous diet  
238 and adaptability, as well as reduced numbers of larger predators and/or competitors (Soh *et al.* 2002,  
239 Marzluff *et al.* 2007).

240 Despite our record of animal usage and clear evidence for an effect of the presence of supplementary  
241 food, the exact nature of the link between feeder usage and local nest predation remains unclear.  
242 There is a significant positive relationship overall between feeder usage by predators, in particular  
243 Grey Squirrels, and increased nest predation. Predation by Grey Squirrels themselves was lower than  
244 the two corvid species, suggesting there was not a direct link between Squirrel feeder usage and nest  
245 predation by Squirrels. We lack sufficient samples and model support to investigate this further, but  
246 we speculate that their presence at bird feeders may influence predation rates by Jays and Magpies.  
247 We propose two non-mutually exclusive mechanisms that may lead to this.

248 First, Jays and Magpies may be responding to the increased density of other omnivores which have  
249 been attracted by the presence of supplementary food. They in turn may be more likely to enter the

250 feeder area, associating it with increased feeding potential, even if they themselves are not primary  
251 users of the bird feeders. In particular the frequency of Jay predation was unexpected due to their  
252 infrequent attendance at feeders, while Magpies did utilise feeders, but in low numbers. Second, the  
253 presence of Squirrels on feeders may exclude other omnivorous predators as well as small birds,  
254 resulting in increased foraging in the vicinity of the feeders, hence increasing local nest predation.  
255 Taken together, these results suggest that feeder usage by nest predators is associated with increased  
256 predation on our experimental nests, but this effect is not simply a result of nest predators being  
257 attracted to a point source, but instead perhaps also by being attracted by other feeder users to the  
258 vicinity of the food source.

259 We tested to see if nest predation changed with distance from the feeder, but there was no effect. The  
260 distances chosen for the study (5 and 10 metres) were relatively small and are consistent with the  
261 layout of a typical UK suburban garden (Smith *et al.* 2006, Loram *et al.* 2007). However, we suggest  
262 that there could still be a distance effect. While not explicitly recorded, we observed no evidence of  
263 increased predation suffered by nests placed close to an empty feeder when the closest replicate was a  
264 filled feeder. Therefore we suggest that while the increased risk of nest predation is present when  
265 nests are within 10 metres of a feeder, this effect may be lost at a distance up to 40 metres away (the  
266 minimum distance between a feeder and the next closest nest associated with another feeder under our  
267 experimental design). Further testing over a larger range of distances with independent nests would be  
268 required to effectively test this theory.

269 The use of artificial nests does present some interpretive challenges (Buler & Hamilton 2000, Burke  
270 *et al.* 2004, Moore & Robinson 2004). They lack the odours, activity and defending adults of natural  
271 nests (Swanson *et al.* 2012). Concerns have also been raised over the use of Quail eggs in artificial  
272 nests, with suggestions that they may be too large for some small predators (Burke *et al.* 2004). This  
273 also means that artificial nests may not be representative of smaller common UK open cup nesting  
274 birds, such as Robins *Erithacus rubecula* and Dunnocks, in terms of egg and nest size as well as  
275 concealment. Some studies have substituted model eggs made from modelling clay, both to give a  
276 smaller prey item and so that when nests are not monitored by cameras it allows predator

277 identification through marks left on the eggs (Major & Kendal 1996, Burke *et al.* 2004). These studies  
278 have found that rodents (not including Squirrels) cause a significant proportion of artificial nest  
279 predation events. As only two nests were visited by mice and none by rats (and no feeder visits by rats  
280 were recorded) either the system in this experiment is different or previous results have been skewed  
281 by the attraction of these rodents to the smell and/or taste of the model eggs (Rangen *et al.* 2000).  
282 While for practical and ethical reasons the use of artificial nests remains the standard approach for  
283 understanding the causes and consequences of nest predation, such caveats suggest that interpreting  
284 the results of artificial nest studies should be taken as indicative rather than definitive, particularly  
285 when applied to bird species of different sizes or with different nesting habits such as ground or cavity  
286 nesting birds.

287 The urban landscape presents a challenging environment for wild birds to live and breed (Chace &  
288 Walsh 2006, Chamberlain *et al.* 2009). Together with potentially limited natural food (McKinney  
289 2008) and high numbers of generalist predators (Sorace & Gustin 2009), urban areas also hold the  
290 majority of the UK's estimated 10.3 million Cats (Murray *et al.* 2010) which predate millions of birds  
291 annually (Thomas *et al.* 2012, Thomas *et al.* 2014). Nevertheless, significant populations of birds are  
292 supported within urban environments (Bland *et al.* 2004) and species richness can be greater than in  
293 adjacent rural areas (Chace & Walsh 2006), in part because of the combined efforts of millions of  
294 people providing supplementary food (Fuller *et al.* 2008).

295 However, while some species are effectively human commensals, others including open-cup nesters  
296 such as thrushes, are increasingly under challenge in urban habitats (Máthé & Batáry 2015) and do not  
297 necessarily use the supplementary food people supply. In consequence, supplementary feeding may  
298 strongly benefit one avian guild to the detriment of others through increased local nest predation. Any  
299 effect we have on their demographic processes through supplementary feeding may have important  
300 conservation consequences and warrants further investigation. However, while we have shown that  
301 nests close to filled feeders suffer considerably higher predation rates, it is not clear if such predation  
302 would affect the population dynamics of urban birds. As with other anthropogenic pressures (e.g. the  
303 presence of Cats), testing this would not be straight-forward, in particular given the ubiquity of

304 supplementary feeding in urban ecosystems. Nevertheless, while difficult, this work suggests that the  
305 question is worthy of further exploration.

306 Furthermore, we find that feeder type affects the assemblage of species feeding upon it. When feeders  
307 are unguarded, corvids and Grey Squirrels exclude small passerines (this study; Bonnington *et al.*  
308 2014a, Orros & Fellowes 2015a). We suggest that this not only reduces the volume of food available  
309 to target species through competition, it may also support increased population sizes of predatory  
310 species through a demographic response (Davies *et al.* 2009). We suggest that people who choose to  
311 provide supplementary food for birds consider using guarded feeders to minimise opportunities to  
312 support predatory species, and consider in the context of the ecology of their own gardens if feeding  
313 during the breeding season is appropriate.

314 Providing supplementary food during the breeding season is widespread (Orros & Fellowes 2015a)  
315 and can increase local bird population size (Peach *et al.* 2013, Smith & Smith 2013). Urban areas may  
316 be important for the conservation of some bird species and species richness in suburban areas can be  
317 greater than that found in adjacent urban and rural areas largely as a result of the decisions made by  
318 millions of homeowners (Marzluff 2001, Chace & Walsh 2006, Väisänen 2008, Jokimäki &  
319 Kaisanlahti-Jokimäki 2012). Our results suggest a possible negative indirect effect of supplementary  
320 garden bird feeding on local nesting success by attracting nest predators to point sources of food. It  
321 would be unfortunate if our most common act of engagement with wildlife was counter-productive  
322 during the breeding season.

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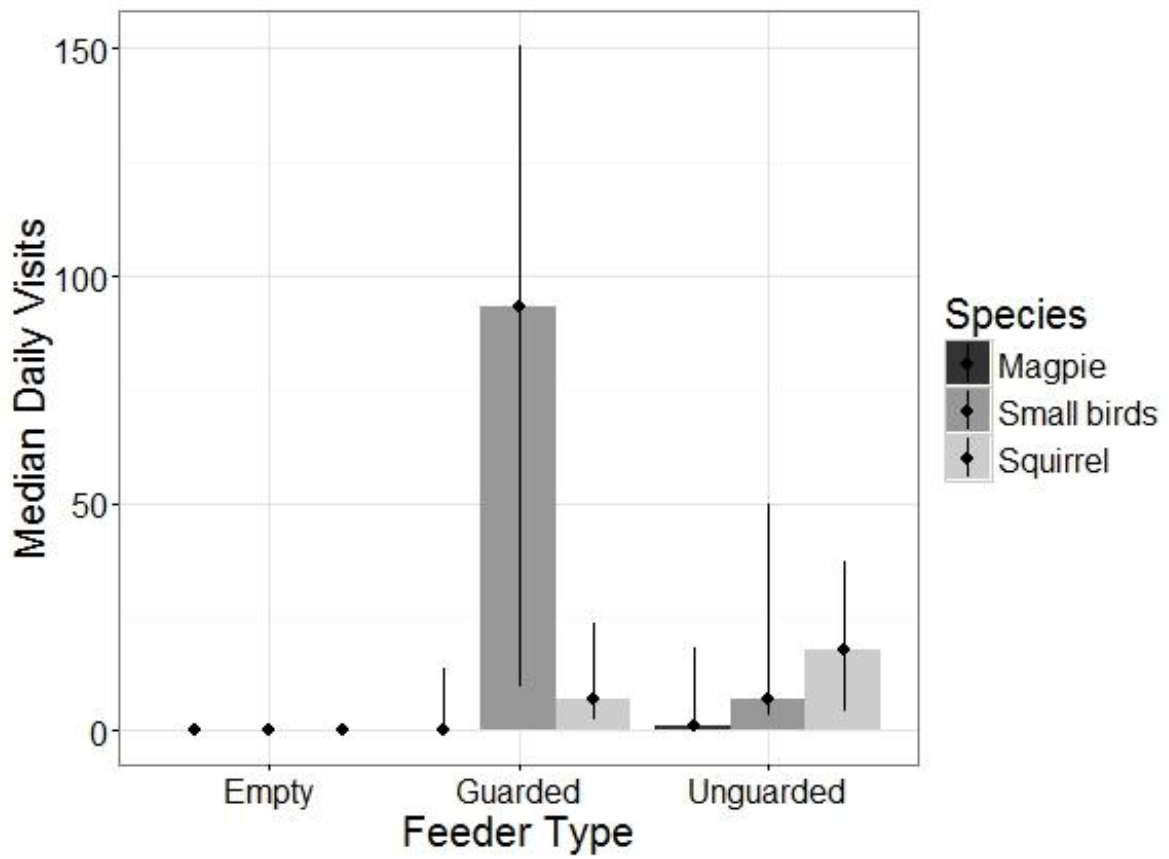
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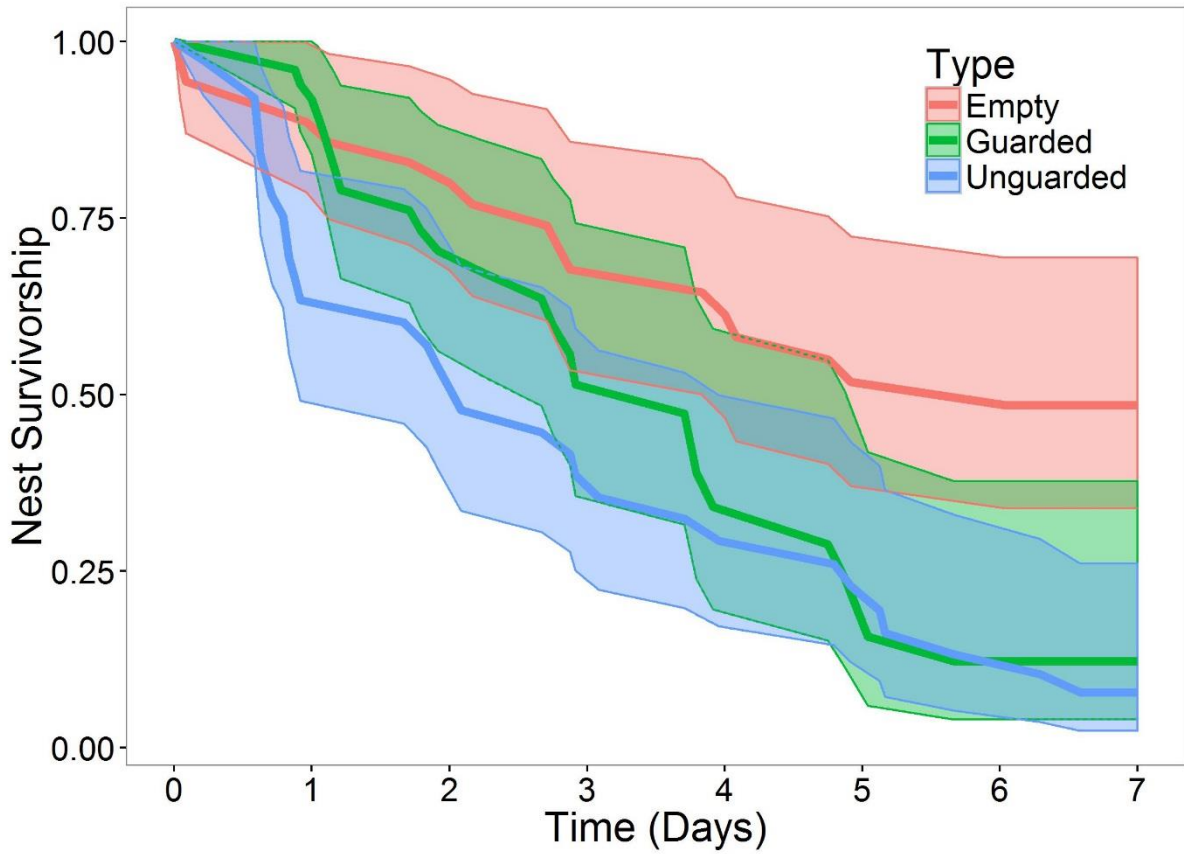
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588 **Figure 1.** Median (+/-IQR) daily animal visits to each feeder treatment by species/grouping. Only species that  
589 visited at least two individual bird feeders are included. Small bird species are great tit (*Parus major*), blue tit  
590 (*Cyanistes caeruleus*), nuthatch (*Sitta europaea*) and robin (*Erithacus rubecula*).

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**Figure 2.** Predicted Cox’s proportional hazard survival distribution by feeder nest type over the course of a mean experimental week (bold lines) with individual 95% confidence intervals (grey). Final predicted survival rates were 0.49, 0.12 and 0.08 for empty, guarded and unguarded feeder nests respectively.

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603 **Table 1.** Median daily species visits and Kruskal-Wallis tests by feeder type (all d.f. = 2). Only common species  
 604 that visited at least two individual bird feeders are included.

<b>Species</b>	<b>Empty median</b>	<b>Guarded median</b>	<b>Unguarded median</b>	<b>Kruskal-Wallis chi-squared</b>	<b>P</b>	<b>Number of feeders where species was recorded</b>
Grey Squirrel	0.0	6.9	17.86	23.02	<0.001	26
Magpie	0.0	0.0	0.9	6.88	0.032	13
Great Tit	0.0	47.7	4.1	25.59	<0.001	27
Blue Tit	0.0	24.6	1.6	18.18	<0.001	21
Nuthatch	0.0	4.9	0.0	13.76	0.001	14
Robin	0.0	0.3	0.0	8.12	0.017	14

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607 **Table 2.** Hazard ratios (relative predation risk; +/- CI) and P values for covariates in the global model where h =  
608 1 is the control (empty) feeder hazard ratio (d.f. = 6.42, AICc = 600.4, model weight = 0.210). After the removal  
609 of distance from the AICc selected model (d.f. = 5.43, AICc = 598.5, model weight = 0.672) the hazard ratios,  
610 CI and P values were identical after rounding.

<b>Covariate</b>	<b>Hazard ratio (h)</b>	<b>Lower 95% CI</b>	<b>Upper 95% CI</b>	<b>P</b>
Guarded	2.14	1.14	3.99	0.017
Unguarded	3.09	1.67	5.73	<0.001
Week (random effect)	1.00	0.58	1.73	0.010
<i>Distance (removed in AICc selected model)</i>	<i>1.08</i>	<i>0.68</i>	<i>1.71</i>	<i>0.740</i>

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623 **Table 3.** Binomial generalised linear mixed effect models of predation against daily visitors with model AICc  
624 values and weights. The grouped predator models consider all predator visits together while the individual  
625 predator models consider them separately. The null model includes only the intercept and study week random  
626 effect. \*indicates significance at the 95% level.

Predator variables	Model	Visit Coefficients	Estimate (95% CIs)	Std. Error	P	Model AICc	Model weight
Grouped predators	Null	Intercept only	0.751 (-0.263 – 2.061)	0.4533	0.0976	84.1	0.024
	Global	All Predators	0.079 (0.022 – 0.155)	0.033	0.016*	79.4	0.255
		All small birds	0.004 (-0.012 – 0.021)	0.008	0.620		
	<b>AICc selected</b>	<b>All Predators</b>	<b>0.068 (0.025 – 0.157)</b>	<b>0.029</b>	<b>0.019*</b>	<b>77.3</b>	<b>0.705</b>
Individual predators	Null	Intercept only	0.751 (-0.263 – 2.061)	0.4533	0.0976	84.1	0.024
	Global	Squirrel	0.068 (-0.004 – 0.141)	0.037	0.066	81.5	0.095
		Magpie	0.131 (-0.081 – 0.342)	0.108	0.225		
		All small birds	0.004 (-0.012 – 0.020)	0.008	0.645		
	Model 2	Magpie	0.178 (0.0197 – 0.414)	0.097	0.068	81.2	0.108
	Model 3	Squirrel	0.084 (0.017 – 0.174)	0.039	0.029*	80.9	0.124
		All small birds	0.005 (-0.010 – 0.219)	0.008	0.519		
	Model 4	Squirrel	0.070 (0.003 – 0.158)	0.038	0.063	79.3	0.277
		Magpie	0.061	0.084	0.469		

			(-0.045 – 0.391)				
	<b>AICc selected</b>	<b>Squirrel</b>	<b>0.090</b> <b>(0.022 – 0.179)</b>	<b>0.039</b>	<b>0.021*</b>	<b>79.1</b>	<b>0.314</b>

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