

# 1 Nest monitoring does not affect nesting success of Whinchats

## 2 *Saxicola rubetra*

3 Jennifer A. Taylor<sup>1</sup>, Ian G. Henderson<sup>2</sup>, Ian R. Hartley<sup>1</sup>

4 <sup>1</sup>Lancaster Environment Centre, University of Lancaster, Lancaster, LA1 4YQ, UK. E-mail:  
5 j.taylor7@lancaster.ac.uk; i.hartley@lancaster.ac.uk

6 <sup>2</sup>British Trust for Ornithology, The Nunnery, Thetford, IP24 2PU, UK. E-mail:  
7 ian.henderson@bto.org

### 8 Abstract

9 It is important to assess the effect that research activities may have on animals in the wild, especially  
10 when key parameters, such as breeding success, could potentially be influenced by observer activity.  
11 For birds, some studies have suggested that nest monitoring can increase the chances of nest failure  
12 due to predation, while others suggest that human nest visits may actually deter mammalian predators.  
13 Nest monitoring visits can also influence breeding success more indirectly by altering parental  
14 provisioning behaviour. Here, the influence of monitoring activities on nest success in a ground  
15 nesting, grassland bird, was examined. First, during the egg phase, a sample of nests were not visited  
16 between the initial finding event and the estimated hatching date; instead the nest status was assessed  
17 from afar. Daily Survival Rates (DSR) for these nests were compared to nests visited every two days.  
18 Second, during the nestling phase, the effects of observer nest visits on parental provisioning  
19 behaviour were determined. Nest visits were found not to significantly affect egg DSR and parental  
20 provisioning was disrupted for a maximum of 20 minutes (0.52% of the nestling period) following an  
21 observer visit. Therefore we conclude observer visits have minimal effects on nest success in  
22 Whinchats.

### 23 Introduction

24 Accurate quantification of breeding success in birds almost always requires nest visits by the  
25 researcher. There has long been concern that these necessary visits may impact a bird's breeding  
26 success, biasing estimates and possibly reducing breeding success in the very species scientists are  
27 aiming to conserve or understand (Reynolds & Schoech 2012). Reviews on the topic have found that  
28 effects of researcher visits to nests vary widely among species, sometimes even within the same  
29 habitat (Weidinger 2008; Ibanez-Alamo *et al.* 2012). It is, therefore, particularly important for  
30 researchers to monitor the effect of disturbance from their research activities and use this information

31 when interpreting their findings and when planning future research projects (O'Grady *et al.* 1996;  
32 Price 2008; Reynolds & Schoech 2012).

33

34 Disturbance by researchers during nest monitoring activities can potentially influence the outcome of  
35 a nest either directly, by encouraging nest desertion (Tremblay & Ellison 1979; Piatt *et al.* 1990), or  
36 indirectly, by increasing the risk of predation. Parents may be forced to leave nests unguarded (Strang  
37 1980) and researchers may draw attention to a nest by creating olfactory or visual trails leading to it  
38 (Whelan *et al.* 1994) and eliciting conspicuous parental defence behaviours such as alarm calling  
39 (Major 1990; Weidinger 2008; Jacobson *et al.* 2011). A review by Götmark (1992) found researcher  
40 activities had reduced nesting success in 49% of studies but a recent meta-analysis on 25 species from  
41 six orders found that researcher visits did not affect the probability of nest failure through predation  
42 (Ibanez-Alamo *et al.* 2012). In fact, nest visits by observers may actually have reduced the risk of  
43 predation for passerines and ground nesting birds, as the presence of humans may deter mammalian  
44 predators (Macivor *et al.* 1990; Ibanez-Alamo & Soler 2010; Ibanez-Alamo *et al.* 2012, but see  
45 Skagen *et al.* 1999).

46 Nest monitoring visits also can affect breeding success by altering the parents' behaviour. Animals  
47 tend to respond to human disturbance as though it was a potential predation event (Frid & Dill 2002;  
48 Beale & Monaghan 2004; Price 2008). This may lead to a temporary suspension of nestling  
49 provisioning (Wheelwright & Dorsey 1991; Michl *et al.* 2000; Zhao 2005; studies reviewed in Lima  
50 2009; Tilgar *et al.* 2011; Paclik *et al.* 2012; Ghalambor *et al.* 2013; Mutzel *et al.* 2013; Vitousek *et al.*  
51 2014; but see Hakkarainen *et al.* 2002) and a corresponding increase in vigilance, nest guarding and  
52 nest defence behaviours (Montgomerie & Weatherhead 1988; Wheelwright & Dorsey 1991; reviewed  
53 in Frid & Dill 2002 and Price 2008; Caro 2005; Mutzel *et al.* 2013). This behaviour is potentially  
54 adaptive, as the risk of the predator finding the nest is reduced (Eggers *et al.* 2005, 2008), the parent  
55 can invest more time and energy in active nest defence (Montgomerie & Weatherhead 1988) and the  
56 parents' survival chances may also be increased (Lima 2009). There is, however, a trade-off in that  
57 the food supply to the nestlings is reduced, which can impact offspring condition and possibly their  
58 future survival chances and reproductive output (Trivers 1972; Clark & Ydenberg 1990; Dale *et al.*  
59 1996; Michl *et al.* 2000; Frid & Dill 2002; Price 2008; Martin & Briskie 2009; Lima 2009). When  
60 disturbance is repeated and frequent, the temporary suspension of feeding has the potential to cause  
61 harmful cumulative consequences, with young fledging at smaller sizes (Scheuerlein & Gwinner  
62 2006; Thomson *et al.* 2006; Tilgar *et al.* 2011). Some studies found that parents will compensate by  
63 provisioning at a higher rate after a predation threat (Paclik *et al.* 2012; Mutzel *et al.* 2013 but see  
64 Tilgar *et al.* 2011) and by provisioning larger load sizes (Eggers *et al.* 2008; Lima 2009). However,

65 there is limited scope for compensation as a nestling's digestive system can only process a certain  
66 quantity of food within a given time period (Eggers *et al.* 2005).

67 The response of the parents to a perceived 'predation threat' will vary depending on the balance  
68 between the potential 'value' of the nestlings and on the perceived risk to the parents (Trivers 1972;  
69 Montgomerie & Weatherhead 1988; Clark & Ydenberg 1990). The potential 'value' of the nestlings  
70 depends on nestling age (Dale *et al.* 1996; Michl *et al.* 2000; Pavel & Bures 2001; Zhao 2005), brood  
71 size (Tilgar & Kikas 2009), nestling condition (Michl *et al.* 2000), the parent's investment so far  
72 (Dale *et al.* 1996; Pavel & Bures 2001) and the potential for re-nesting (reviewed by Martin 1987;  
73 Michl *et al.* 2000). For example, parents may risk more and resume feeding earlier for larger broods  
74 (Tilgar & Kikas 2009) or nestlings in better condition (Michl *et al.* 2000) and female parents may take  
75 more risks than male parents for younger nestlings if they have invested more in the nestlings up to  
76 this stage (Michl *et al.* 2000; Pavel & Bures 2001; Dale *et al.* 1996). The perceived risk to each parent  
77 may depend on the type of predator (Bures & Pavel 2003; Martin & Briskie 2009; Tilgar *et al.* 2011;  
78 Ippi *et al.* 2013), the sex, size, condition and experience of the parent (Martindale 1982; Montgomerie  
79 & Weatherhead 1988; Lima 2009), and the protection offered by the surrounding nesting habitat  
80 (Eggers *et al.* 2008; Lima *et al.* 2009; Martin & Briskie 2009). For situations where a species can  
81 actively defend the nest against a predator, parents may remain close to the nest following a predation  
82 threat, and restrict their foraging range (Marzluff 1985; Martindale 1982; Hakkarainen *et al.* 2002;  
83 reviewed in Lima 2009). The parent that is most effective at defending the nest often remains closer to  
84 the nest than their partner (e.g. Gila Woodpecker, Martindale 1982). In species where neither parent is  
85 actively able to defend the nest contents against predators, the optimal strategy is likely to be nest  
86 crypsis and the minimisation of parental activity around the nest (Burhans 2000; Bures & Pavel  
87 2003).

88 In this paper we aim to explore the potential effects of visiting Whinchat nests to monitor  
89 reproductive success. Daily survival rates during the egg phase will be compared between nests which  
90 received visits every two days, and those that were visited only once. Previous studies suggest that  
91 where the main predators are mammalian, as appears to be the case in this study (Taylor *et al.* in  
92 prep), the nest predation rates may be reduced by more frequent monitoring visits. Additionally, we  
93 quantify the provisioning behaviour of parents in relation to researcher nest visits. It is predicted that  
94 the Whinchat parents will reduce nestling provisioning until the perceived threat has diminished to  
95 avoid disclosing the nest location and to allow more time to be allocated to nest guarding and  
96 vigilance behaviours. To this end, it is also predicted that parents are likely to remain in the vicinity of  
97 the nest immediately after a predation threat, to enable earlier nest predator detection, and will avoid  
98 long foraging trips until the perceived threat has diminished.

99 **Methods**

100 *Study site*

101 The study site was located on the west section of Salisbury Plain, Wiltshire, in southwest England  
102 (51°11'52" - 51°16'4"N; 1°57'32" - 2° 9'32"W). The site has been under military ownership since the  
103 early 20<sup>th</sup> century and the west section is predominantly used by the military for training. The majority  
104 of the area is classified as agriculturally unimproved grassland (Walker & Pywell 2000)..

105 *Nest visit experiment during egg phase*

106 Nests were found for all known breeding pairs within the study site. The locations of all nests were  
107 recorded using a Geographical Position System (GPS) reading at the nest site. Nests were also marked  
108 in the field using an unobtrusive 50cm bamboo cane 2-3 m from the nest. In 2014, nests were paired  
109 in the order of finding, with alternate nests being designated as 'visit' nests and 'distance-visit' nests.  
110 Daily watches of breeding adults early in the season and recording of behaviour and nest building  
111 activity enabled hatching date to be estimated to within two days. Visit nests were visited every two  
112 days and distance-visit nests were not visited after the initial nest finding event, until the estimated  
113 hatching date. Distance-visit nests were assessed from a distance every two days, to determine  
114 whether they were still active, by observing the female leaving the nest and returning to incubate, or  
115 via alarm calling parents on the territory when the researcher was in the vicinity. After the initial nest  
116 finding, the observer never went closer than 20 m to the distance-visit nests and, in general, stayed at  
117 least 80 m away.

118 *Disturbance experiment during nestling provisioning*

119 Thirty-nine monitored nests were included in the experiment: 20 in 2013 and 19 in 2014. The  
120 researcher approached the nest and set up a small video camera on a tripod, pointing at the nest, one  
121 metre away. Marker canes were placed into the ground at 20, 40, 60 and 80 m from the nest, to  
122 facilitate distance estimation. The observer then retreated to at least 80 m to watch the parents during  
123 their subsequent provisioning activities. The video camera recorded provisioning visits by the parents,  
124 and the observer recorded the parents' distances from the nest once every minute for the hour  
125 following the disturbance event. To account for the variable nature of provisioning rates the  
126 experiment was conducted on each nest three times, when the nestlings were 6, 7 and 8 days old; the  
127 period of maximum provisioning rate. Provisioning watches were conducted between 9 am to 6 pm,  
128 which avoided times when feeding rates may be particularly high or when the need to feed nestlings  
129 would be more urgent. Watches were not conducted in moderate to heavy rain. Due to weather  
130 conditions, access restrictions and predation of nests, there were some cases where it was not possible  
131 to undertake all three replicates (25 nests with 3 days of data, 8 nests with 2 days of data and 4 nests  
132 with 1 day of data). Provisioning data from two nests were excluded: one because of technical

133 problems with the camera and one because the local topography prevented observations without  
134 disturbing the birds.

### 135 *Nestling condition*

136 Six days after hatching, all nestlings were weighed and had their tarsi measured, although due to  
137 occasional access restrictions, this occurred a day either side in a minority of cases. An index of body  
138 condition was calculated by regressing an individual's weight (g) against their size (measured by  
139 tarsus (mm)) and by extracting the residuals for use in the analysis (Davies *et al.* 2014). Body  
140 condition was normally distributed. The necessary assumptions that mass and tarsus length were  
141 linearly related (LM: Est = 0.813 +/- 0.021,  $p < 0.0001$ ,  $n = 385$ ) and that condition was independent  
142 of tarsus length (Pearson's Product Moment Correlation Coefficient (PMCC) = -1.56,  $df = 385$ ,  $p = 1$ )  
143 were upheld (Green 2001). Nestling body condition was then averaged for nestlings within a nest to  
144 produce a mean value per nest.

### 145 Data analysis

146 The data were analysed using the R statistical package version 2.3.1 (R Development Core Team  
147 2014). A logistic exposure model (see Shaffer 2004), with 'visit' or 'distance-visit' as a factor, was  
148 used to assess the influence of nest visits on the Daily Survival Rate (DSR) for the egg phase of the  
149 breeding cycle. Only first broods were included in the analysis to avoid pseudo-replication. The time  
150 since the disturbance event was split into 12 five-minute periods, with the number of feeds calculated  
151 for each observation period and then averaged over the three replicates for each nest. Based on pilot  
152 data from 2012, five minutes was selected as long enough to allow provisioning events to occur, but  
153 short enough to detect the gradual pattern of change in provisioning rate after a predation event. The  
154 sex of the provisioning parent was determined in 98% of feeds. The number of feeds per five-minute  
155 period was positively skewed and therefore was square root transformed for use in the analysis. A  
156 Non-linear Least Squares (NLS) model of the form:  $\text{asymptote}/(1 + \exp((\text{midpoint} - \text{time since nest}$   
157  $\text{disturbance})/\text{slope}))$ , was used to produce an equation for the relationship between time since  
158 disturbance and parental provisioning rate to determine the length of time provisioning was disrupted.  
159 GAMMs were used to examine the variation in number of feeds with parental sex, brood size and  
160 nestling condition.

161 Linear Mixed Models (LMM) were used to assess the time until the first feed after nest disturbance  
162 (latency to feed), and how this varied due to parental sex, brood size and chick condition, with nest as  
163 the random effect. The latency to feed was positively skewed and therefore was square root  
164 transformed to an approximately normal distribution. The global model, which included two  
165 interaction effects of parental sex and brood size and parental sex and nestling condition, was

166 simplified via backwards stepwise deletion using the drop1 command in R (Chambers 1992). For each  
167 nest, the mean latency to feed for both parents was calculated over the 1 – 3 observation periods.

168 The percentage of time spent 20 m or less from the nest was investigated in the same way as the  
169 number of feeds: the data were split into 12 five-minute blocks of time. For each block the number of  
170 distance observations where a parent was 20 m or less from the nest was divided by the total number  
171 of distance observations for that parent within the five minute block. This percentage was then  
172 averaged for each 5 minute block over the 1-3 observation periods per nest. The percentage of time  
173 spent 20 m or less from the nests was selected because within 20 m was considered a distance that the  
174 parents could still see the nest, and any approaching predator from, well before the predator got close  
175 enough to attack, therefore suggesting a preference for nest guarding and vigilance. The percentage of  
176 time spent 20 m for less from the nest was positively skewed, however, transformation did not  
177 improve the distribution, and the final model residuals did not reflect any problems despite the skew.

## 178 Results

### 179 *Effect of nest visits on egg survival*

180 There was no significant difference in the Daily Survival Rate for the egg phase between visit and  
181 distance-visit nests (Logistic-exposure GLM: ANOVA,  $p = 0.569$ ,  $df = 122$ ,  $n = 124$  observation  
182 intervals from 17 visit nests and 18 distance-visit nests).

### 183 *Effect of nest visits on parental provisioning behaviour*

184 The starting values for the NLS model were chosen based on Figure 1. To account for the repeated  
185 measures of the 12 five minute blocks for each nest, a global model with a random effect of nest was  
186 used (AIC = 618); this had a lower AIC than the global model with nest and year random effects (AIC  
187 = 620) and the global model without a random effect (AIC = 695). The model parameters are  
188 displayed in Table 1. Residual plots confirmed the model was a good fit. After a nest disturbance  
189 event, the parental provisioning rate increased up to a maximum level at around 20 minutes where it  
190 levelled off (S1). This asymptote translates to 1.12 feeds (95% CI: 1.11 – 1.14) in five minutes.

### 191 *Variations in parental response to disturbance due to parental sex and nestling condition*

192 The global model allowed different smoothing slopes for the provisioning rates for each parental sex  
193 and included a parental sex and condition interaction and a brood size term. A model allowing the  
194 smoothing slope to change with nestling condition was too complex to fit with the data available:  
195 separately evaluating this model without the other variables indicated that there was not a significant  
196 change in slope with condition. A global model with a random effect of nest had an AIC of 1042, as  
197 opposed to a global model with year and nest as random effects, AIC = 1044, and a global model

198 without random effects, AIC = 1190. Therefore only a random effect of nest was used. The best  
199 model had a smoothed term for time since disturbance, and included parental sex and brood size terms  
200 (Table 2). Brood size did not have a significant effect on the provisioning rate (GAMM:  $p > 0.223$ )  
201 but it was included in all models as a control for variations in brood sizes between nests.

202 There was a marginally significant difference in the response of males and females, with males  
203 provisioning generally at a higher rate: (GAMM: Est = 0.0709 +/- 0.0292,  $p = 0.0152$ ,  $n = 852$   
204 observations from 37 groups, Figure 1) but, as GAMMs rely on approximation, only probabilities less  
205 than 0.01 provide strong evidence of an effect (Zuur *et al.* 2009). The smoothed term is highly  
206 significant ( $p < 1 \times 10^{-16}$ ), and the model AIC without the smoothed term is much higher (Table 2),  
207 indicating the smoothed term is necessary. Residual plots confirmed the global model and end model  
208 were both good fits for the data.

#### 209 *Latency to feed*

210 The global model had a brood size and parental sex interaction and a nestling condition and parental  
211 sex interaction. A random effect of nest did not change the AIC value (both equalled 236), but a linear  
212 mixed model was used anyway to give a conservative model. None of the variables had a significant  
213 effect on latency to feed and all dropped out of the model in backwards stepwise deletion (Likelihood  
214 ratio test:  $p > 0.177$ ).

#### 215 *Parental distance from the nest with time after a predation threat*

216 Initially the pattern in the data was explored by via a GAMM. A GLMM (Generalised Linear Mixed  
217 Model) was considered suitable as the effective degrees of freedom (edf) from the GAMM was 1,  
218 which indicated that the data followed a linear trend. Ideally a binomial model should be used as the  
219 dependent variable is in the form of a proportion and therefore bounded between 0 and 1. However, a  
220 binomial model gave warning messages due to the lack of variability in the data. Therefore, a  
221 Gaussian model was also fitted to confirm the results. For both models, the end results were  
222 qualitatively similar, therefore only the results of the Gaussian GLMM are reported.

223 The AIC was lower for a global GLMM model just with nest as a random effect as opposed to  
224 territory and year (-132 as opposed to -130), both random effect models were better than a GLM  
225 without random effects (AIC = -9.74). The AIC reduced when the sex and time since disturbance  
226 interaction was removed (AIC = -145 as opposed to -131). The amount of time that the parents spent  
227 within 20 m of the nest did not change significantly with increasing time since the nest disturbance  
228 event (GLMM: Est = 0.000446 +/- 0.000408,  $df = 0.0844$ ,  $t = 1.09$ ,  $p = 0.275$ ,  $n = 885$  observations in  
229 39 groups). Males spent significantly less time within 20 m of the nest than females (GLMM: Est = -  
230 0.0550 +/- 0.0143,  $df = 0.0855$ ,  $t = -3.85$ ,  $p = 0.000125$ ,  $n = 885$  observations in 39 groups). However,

231 the magnitude of the difference was small, with males spending about 5% less time within 20 m of the  
232 nest than females. The variance of the random intercept for nest was 0.0149.

## 233 Discussion

234 Despite the study site consisting largely of unmanaged grassland, where researcher trails may be more  
235 obvious compared to sites with shorter vegetation, monitoring visits to nests did not significantly  
236 increase the chances of nest failure. This supports the findings from similar studies of ground-nesting  
237 grassland birds (Cotter & Gratto 1995; O’Grady *et al.* 1996; Lloyd *et al.* 2000; Jacobson *et al.* 2011).  
238 Salisbury Plain supports large populations of other species of ground nesting birds including Meadow  
239 Pipits, Skylarks, Yellowhammers and Reed Buntings (Stanbury *et al.* 2002, 2005) and there were  
240 many other trails in the vegetation from related work on Whinchats and from other people such as  
241 soldiers training, farmers, security forces and other researchers. Therefore, the predators may not have  
242 learned to associate trails with nests (Hannon *et al.* 1993; O’Grady *et al.* 1996; Weidinger 2008). The  
243 main predators of nests on Salisbury Plain were found to be nocturnal (Taylor *et al.* in prep), which  
244 suggests mammalian predators. Various other studies have found that mammalian predators are  
245 deterred by human scent trails and therefore visited nests are actually less likely to be predated  
246 (Macivor *et al.* 1990; Ibanez-Alamo & Soler 2010; Ibanez-Alamo *et al.* 2012). However, this pattern  
247 was not observed in this study. The lack of organised predator control on Salisbury Plain, along with  
248 the random nature of scent trails discussed above, could explain the lack of deterrence of mammals to  
249 human scent trails. Alternatively, different predators may vary in their response to human scents, for  
250 example with foxes deterred but stoats attracted, so thereby leading to no overall effect (Jacobson *et*  
251 *al.* 2011).

252 Nest disturbance temporarily reduced the provisioning rate of parents; similar effects of disturbance  
253 have been found in other studies (e.g. Delaney *et al.* 1999; Steidl & Anthony 2000; Verhulst *et al.*  
254 2001). This parental response is considered an adaptation to: reduce the risk of revealing the nest  
255 location, allow more time to be invested in defence and vigilance behaviours, and reduce adult  
256 predation risk (reviewed in Martin & Briskie 2009 and Lima 2009). However, parental response to a  
257 perceived predation risk can have real consequences on breeding success (Zanette *et al.* 2011).

258 It took approximately 20 minutes for the provisioning rate to recover, assuming the asymptote of the  
259 NLS model (Table 1) represents the undisturbed provisioning rate. The mean provisioning rate  
260 recorded for undisturbed nests of nestlings in approximately the same age range (5 – 8 days old), from  
261 pilot data in 2012, was 1.35 feeds (95% CI: 0.983 – 1.73, n = 16 nests) in five minutes. The asymptote  
262 provisioning rate of 1.12 is within this range, therefore supporting this assumption. In an average  
263 summer day there are 960 minutes of daylight, therefore 2.08% of the day’s provisioning is affected  
264 by disturbance from a nest visit during the day. When not conducting the disturbance experiment,



265 nests were visited three times in the 12 – 13 days of the nestling period, which is 60 minutes of  
266 reduced provisioning out of 11520 minutes (0.52% of the nestling period). The Whinchat parents may  
267 have reacted more strongly to disturbance in this experiment due to the presence of the camera and  
268 tripod at their nest in addition to the researcher visit, therefore this disturbance estimate is  
269 conservative. It does not appear that disturbance, at the level usually undertaken by researchers during  
270 the nestling phase in this project, would adversely affect offspring fitness.

271 Unlike results reported elsewhere, the change in the provisioning rate after disturbance and the latency  
272 to return to feed did not vary significantly with parent sex (Dale *et al.* 1996; Michl *et al.* 2000; Pavel  
273 & Bures 2001; Zhao 2005), brood size (Tilgar & Kikas 2009) or nestling condition (Michl *et al.*  
274 2000). It is possible that this was due to the age of the nestlings used in the experiment. In Whinchats,  
275 parental care is female biased, with only females incubating the eggs and brooding the nestlings,  
276 though both sexes provision the nestlings (Cramp 1988). Therefore, nestlings may have more  
277 reproductive value to the female early in life than the male. The pilot data from 2012 suggested that  
278 the males' proportional investment in the nestlings (reflected in his provisioning behaviour) increased  
279 as they aged. Therefore by 6 – 9 days old the nestlings are probably equally valuable to both parents  
280 (as also suggested by Tilgar & Kikas 2009). The lack of an effect of nestling condition and brood size  
281 on the provisioning rate and latency to feed may be due to a lack of variation in nestling condition on  
282 Salisbury Plain as food does not appear to be limiting at the site (Taylor *et al.* in prep). If this study  
283 was conducted on a site with larger variations in nestling condition, a difference in risk taking for  
284 different quality broods (Michl *et al.* 2000; Tilgar & Kikas 2009) may have been apparent.

285 The percentage of time the parents spent 20 m or closer to the nest did not vary significantly with time  
286 since the nest disturbance event. Parents generally always spent a high percentage of their time (70 –  
287 80%) within 20 m of the nest. Preliminary analysis using the actual distances of parents from the nest,  
288 rather than the percentage of time parents spent within 20 m, also found no change in the mean  
289 distance over time. As food appears to be relatively abundant on the study site, the parents may not  
290 need to travel far from the nest to forage (Andersson 1981), allowing them to spend most of their time  
291 close to the nest and thereby be able to guard the nest more effectively (Marzluff 1985; Martindale  
292 1982; Hakkarainen *et al.* 2002; reviewed in Lima 2009). Whinchats cannot aggressively defend their  
293 nests from approaching humans, or other predators, by attacking. However, they do use alarm calling  
294 and perching in close proximity to the approaching individual to quiet their young and as distraction  
295 techniques (Montgomerie & Weatherhead 1988; Caro 2005; Lima 2009). The change in provisioning  
296 pattern suggests Whinchats did spend a larger proportion of their time exhibiting nest guarding or  
297 vigilance behaviours immediately after a nest disturbance event, rather than foraging to provision  
298 nestlings, and then this reduced over time leading to an increased provisioning rate (reviewed in Frid  
299 & Dill 2002, Price 2008 and Lima 2009).

300 From this study we have found that nest monitoring visits every two to three days are not detrimental  
301 to Whinchat breeding success. Visits did not significantly affect the egg phase DSR and though  
302 parental provisioning rates were reduced for about 20 minutes following the disturbance, this equates  
303 to only 0.52% of the available foraging time during the nestling phase and therefore is unlikely to  
304 have a severe impact on nestling development. This is reassuring as it suggests that routine  
305 monitoring activities did not affect the outcome of nesting attempts. However, it is still important to  
306 take precautions to minimise any potential impact (Jacobson *et al.* 2011; Reynolds & Schoech 2012)  
307 and follow guidelines for nest monitoring (Martin & Geupel 1993; Ferguson-Lees *et al.* 2011).  
308 Depending on the research aims, it may be possible to use temperatures sensors placed in nest cups to  
309 monitor clutch and brood survival, reducing the number of visits necessary (Hartman & Oring 2006;  
310 Weidinger 2006; Jacobson *et al.* 2011; Mougeot *et al.* 2014), or to monitor using micro-nest cameras  
311 which has the added advantage of identifying the nest predators (Pietz & Granfors 2000).

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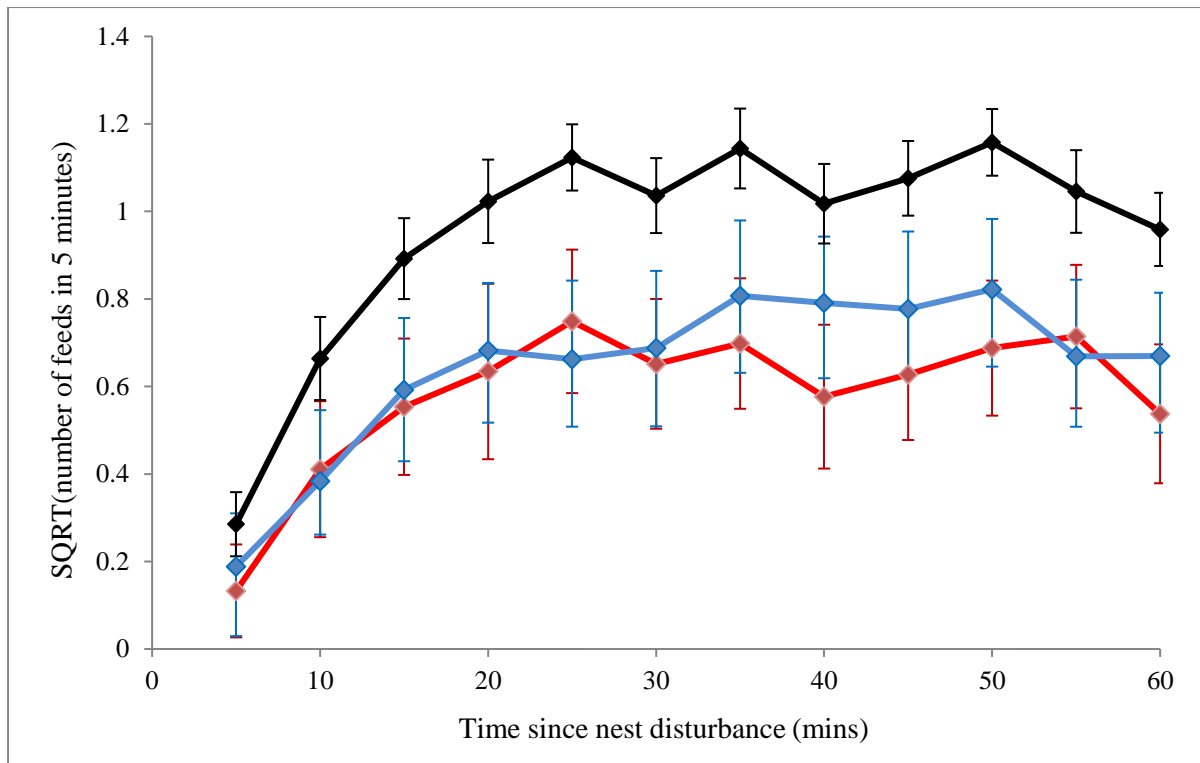
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474

475 **Figure 1.** The square rooted mean number of feeds for all feeds (black), males (blue) and females (red)  
 476 over all nests in each 5 minute period since the nest disturbance event up to 60 minutes (n = 36 females,  
 477 n = 35 males, but from 37 different nests as one nest only had a male parent and two only had female  
 478 parents). The bars display the 95% confidence intervals.

479

480

481 **Table 1.** An NLS model of the change in square rooted provisioning rate per five minute block, with  
482 time since a nest disturbance event. Nest was a random effect, there were 37 groups with a total of 444  
483 observations. The model log likelihood = -304.1, deviance = 608, residual df = 439, the standard  
484 deviation of the random asymptote for each territory is 0.298. The model equation: square rooted  
485 number of feeds in 5 minutes =  $1.06/(1+\exp((8.12-\text{time since nest disturbance})/3.45))$ .

486

Parameters estimates	
Asymptote	1.06 +/- 0.004
Midpoint	8.12 +/- 0.004
Slope	3.45 +/- 0.004

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488

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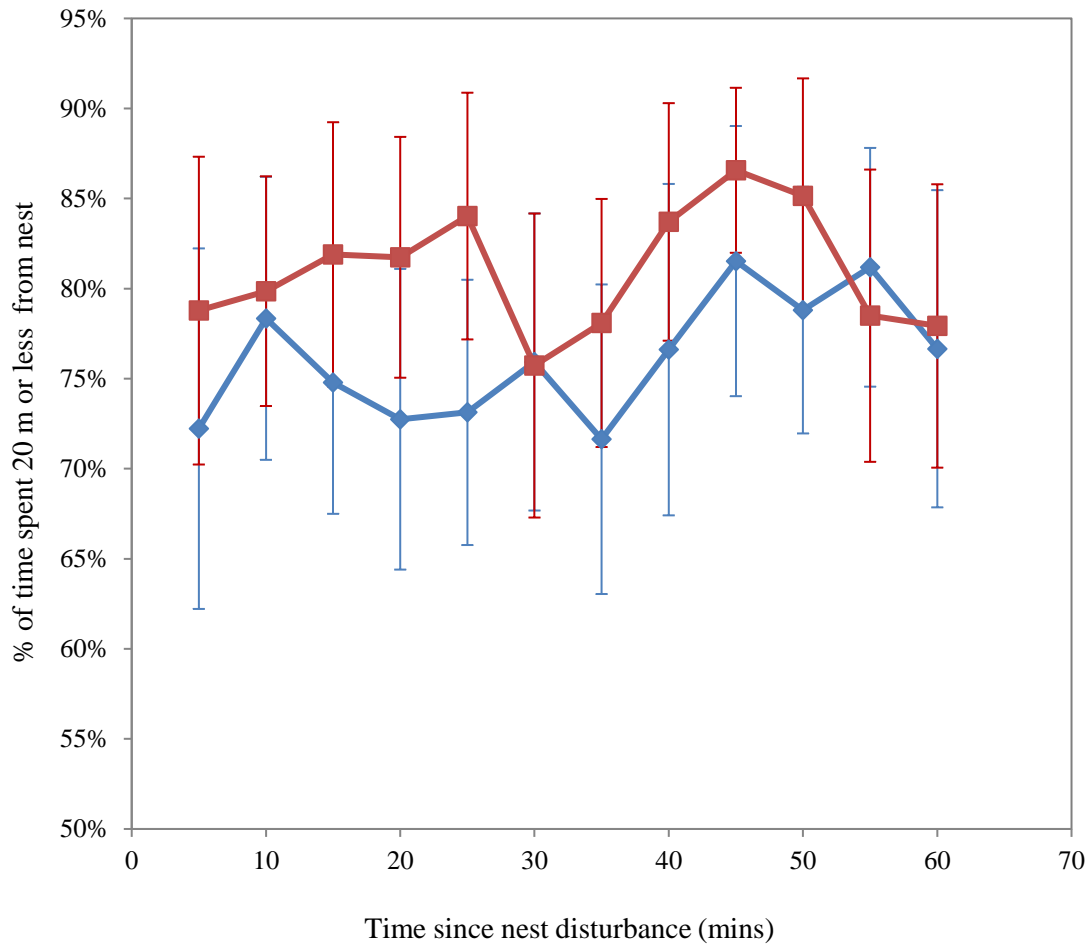
490 **Table 2.** Model selection for a GAMM looking at the variation in response to nest disturbance through  
 491 provisioning rate, due to differences of parental sex or in average nestling condition at 6 days old. Brood  
 492 size was included in all models to control for any effect of variation in brood size between nests (3 nests  
 493 of 3, 7 nests of 4, 8 nests of 5 and 19 nests of 6) on the provisioning rate. Nest was included as a random  
 494 effect to account for repeated measures of provisioning rate, which was calculated for 12 five minute  
 495 periods for each nest. Time = time since nest disturbance by the researcher, condition = average nestling  
 496 condition for a nest when the nestlings were 6 days old, S = a smoother term, sex = male or female  
 497 parent, : = interaction effect. N = 852 observations from 37 nests.

Model	AIC
S(time) + sex + brood size	1038
S(time) + sex + condition + brood size	1040
S(time) +sex : condition + brood size	1042
S(time) + brood.size	1042
S(time : sex) + sex : condition + brood size	1052
Time + sex + brood size	1089
Sex + brood size	1139

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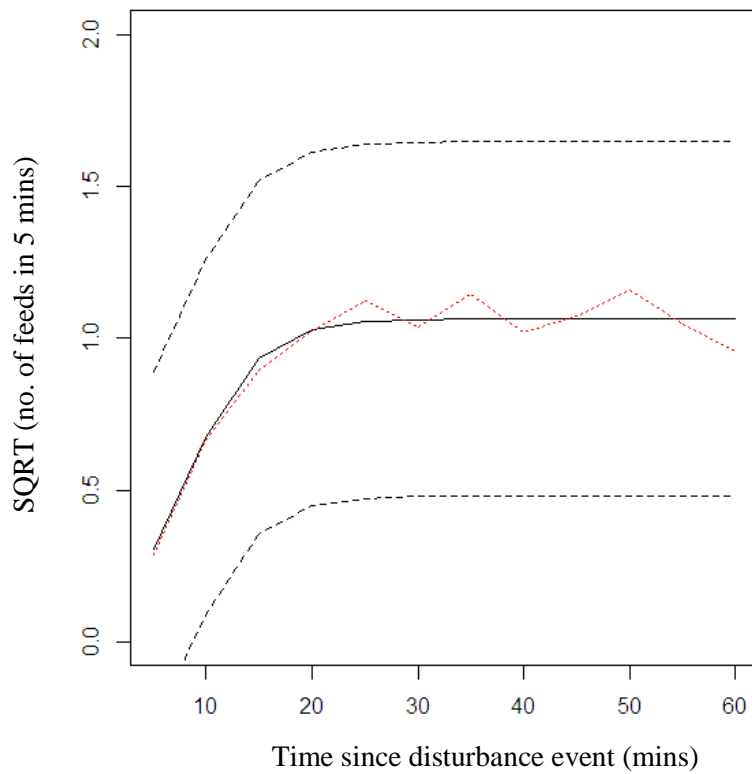
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502 **Figure 2.** The mean percentage of time spent within 20 m of the nest for males (blue), and females  
 503 (red), with increasing time since a nest disturbance event. The bars display the 95% confidence intervals  
 504 (n = 885 observations in 39 groups).

505



506

507 **S1.** An asymptotic random effects NLS model of the change in provisioning rate per five minute block  
 508 with time since a nest disturbance event, the solid line is the value for an average nest, 95% of nests are  
 509 within the dotted lines (n= 444 in 37 groups). The red line is the square-rooted mean provisioning rates  
 510 per 5 minutes block from the raw data.

511

512