An investigation into the territory characteristics of Whinchat (*Saxicola rubetra*) on a reserve in the Cumbrian Pennines.

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Introduction

As part of a British Trust for Ornithology (BTO) Re-trapping Adults for Survival (RAS) ringing project on Whinchat at the Royal Society for the Protection of Birds (RSPB) Geltsdale Reserve in the Cumbrian Pennines, the altitude, slope and aspect of the slope at each nest was recorded in every year from 2012 to 2019. In addition, the vegetation around each nest and other features were also recorded in every year except 2016. It was hoped that by identifying the territory characteristics and vegetation around nests it would be possible to put in place specific management regimes to benefit the Whinchat population.

Whinchats have declined by 57% between 1995 and 2008 (Baillie el al 2010). They arrive on the Geltsdale reserve in late April/early May and remain until August/September. The number of territories varies from year to year and is declining but can comprise of up to 70 singing males.

RSPB Geltsdale nature reserve is 5500ha and situated in the North Pennines in Cumbria and Northumberland and has been an RSPB reserve since 1975. Most of the area is a Site of Special Scientific and Special Protection Area and Special Area of Conservation. The site comprises of two upland farms, Geltsdale and Tarnhouse with altitudes ranging from 190m asl to 620m asl. Two-thirds of the reserve is unenclosed blanket bog with heather *Calluna vulgaris* dominating with the remainder consisting of mosaics of upland heath and acid grassland, together with smaller areas of enclosed in-bye land and wood pasture.

1. Method

In 2012 to 2019 territories and nest sites were identified in May, June and July. The location of nests sites was recorded using a GPS and pulli colour ringed at the appropriate age. Once young had fledged, the sites were re-visited (but not in 2016) and the vegetation around each nest recorded by eye at a radius of 5m, 50m and

200m. The following vegetation types were recorded as a percentage: Bracken, Rush (*Juncus* sp.), Heather (*Calluna vulgaris*), Tufted Hair Grass *(Deschampsia caespitosa*), Purple Moor Grass (*Molinia caerulea*), other grass species and Bilberry (*Vaccinium myrtillus*). Bracken can form a virtual monoculture although other species such as Common Bent (*Agrostis capillaris*), Corydallis (*Corydalis claviculata*) and Wood-sorrel (*Oxalis acetosella*) can occur as an understorey. The grass species present varied but Yorkshire-fog (*Holcus lanatus*), Wavy Hair Grass (*Deschampsia flexuosa*), Common Bent and Sweet Vernal Grass (*Anthoxanthum odoratum*) were all common. The rush species comprised Soft Rush (*Juncus effusus*), Compact Rush (*Juncus conglomeratus*) and Sharp-flowered Rush (*Juncus acutiflorus*). Heather and Bilberry form virtual monocultures. Tufted Hair Grass was recorded separately from other species of grass as it can reach a height of over one metre and gives structure to the vegetation. Purple Moor Grass was recorded separately as it can form a monoculture and form large tussocks which can be over 30cm high.

The following nest characteristics were also recorded in 2012 to 2019: altitude as shown on a GPS, slope in degrees as estimated by eye, and aspect of the slope measured using a compass. The presence of fence posts, trees, paths and stream were recorded in every year except 2016. It was noticed that nests seemed to be near paths and it was not known if this was because it was easier to find nests near paths, observers spent more time on paths when moving around the reserve or if Whinchats were actively selecting such sites. Trees and fence posts provide song posts.

Altitude, slope and aspect were recorded at approximately 300 nest sites while vegetation and other features were recorded from 264 nest sites.

In 2012, 2013 and 2015 the same information was collected from randomly selected sites resulting in data for 151 sites. This was to ascertain if vegetation and site characteristics were a chance event or actively selected for by the Whinchats.

2. Results

The number of nest sites recorded in each year is shown in table 1 and the number of random sites recorded is shown in table 2.

Table 1. Number of nest sites where vegetation and territory features were recorded

Year	2012	2013	2014	2015	2017	2018	2019	TOTAL
No. of nests	31	50	47	36	41	24	35	264

Table 2. Number of random sites where vegetation and territory features were recorded

Year	2012	2013	2015	TOTAL
No. of nests	61	55	35	151

In retrospect it was decided that the recording of vegetation by eye at 200m was not very accurate and the results from 200m have not been included here.

Chi squared tests were applied to actual nest sites and random sites to ascertain if a characteristic was significant or a chance result. The vegetation percentages were grouped into frequencies 0-10%, 11-20%, 21-30%, 31-40%,41-50%,51-60%, 61-70%, 71-80%,81-90% and 91-100%. In some cases the frequency groupings were lumped as appropriate as chi squared tests are not valid if more than two couple of the expected values are less than 5. In such cases the frequency classes were combined as necessary. The 0.05 significance level was used to decide if percentage vegetation and site characteristics were significant. In some cases the number of results was too small to apply a test, e.g. the presence of a path within 5m, and in such cases only the 50 m results was analysed. The average percentage for all the years for the vegetation types that had significant chi squared results was then calculated. The chi squared results are given in appendix 1.

2.1. Vegetation

The results of the chi squared tests are shown in table 3.

Table 3. Chi Square Results

Vegetation and distance	Chi 2 result	Degrees of freedom	0.05 significance	Significant/not significant
Bracken at 5m	54.22	9	16.92	SIGNIFICANT
Bracken at 50m	72.57	9	16.92	SIGNIFICANT
Rush at 5m	25.15	5	11.07	SIGNIFICANT
Rush at 50m	12.53	5	11.07	SIGNIFICANT
Grass sp. at 5m	9.27	9	16.92	NOT SIGNIFICANT
Grass sp. At 50m	13.45	6	12.59	SIGNIFICANT
Heather at 5m (*Calluna*)	9.61	1	3.84	SIGNIFICANT
Heather at 50m (*Calluna)*	20.59	1	3.84	SIGNIFICANT
Bilberry at 5m (*Vaccinium*)	0.0003	1	3.64	NOT SIGNIFICANT
Bilberry at 50m (*Vaccinium*)	0.22	1	3.84	NOT SIGNIFICANT
Tufted Hairgrass at 5m (Deschampsia)	2.47	1	3.84	NOT SIGNIFICANT
Tufted Hairgrass at 50m	7.54	1	3.84	SIGNIFICANT

Purple Moor-grass at 5m (*Molinia*)	0.89	1	3.84	NOT SIGNIFICANT
Purple Moor-grass at 50m (*Molinia*)	6.23	3	7.81	NOT SIGNIFICANT

The following vegetation chi squared results were not significant: *Vaccinium* at 5m and 50m, *Deschampsia* at 5m, *Molinia* at 5m and 50m and grass sp. at 5m.

2.1.1 Bracken

The chi squared test for Bracken was significant at 5m and at 50m *(x^2* = 54.22033 and 72.56657). The largest contribution to the chi squared test came from the 0-10% class at both 5m and 50m. There were fewer nests in the 0-10% class than would have been expected from the random sites. The other classes were fairly similar for both actual and random indicating that Whinchats prefer to nest in sites with more than 10% bracken at both 5m and 50m distances from the nest site.

2.1.2 Rush

The number of classes for analysis had to be combined for the rush such that the following class divisions were used 0-10% frequency, 11-20%, 21-30%, 31-40%, 41-50%, 51-100%. The chi squared test was significant at 5m and at 50m *(x^2* = 25.14516 and 12.52864). At 5m a significant contribution to the chi squared test was from sites with over 50% rush. There were far more sites identified with more than 50% rush in the landscape randomly, indicating that fewer birds nested where there was more than 50% rush so birds are avoiding sites with more than 50% rush at 5m. At the 50m distance there were more nests is areas with less than 10% rush than you would expect if they were choosing randomly even though there are not many sites with less than 10% rush so birds are favouring sites with less than 10% rush.

2.1.3 Grass species

The chi squared test for grass species was significant at 50m *(x^2* = 13.45431). The largest contribution to the chi squared test came from the 11-20% class. In this case the Whinchats were favouring nest sites with 11-20% grass. There were more nests in this category than would be expected especially given that that there are fewer sites in this class in the landscape when randomly chosen.

2.1.4 Heather

The results for Heather were too few so frequencies were lumped as follows: 0-10%, 11-100% for five metre distances and 0-10%, 11-20%, 21-30% and 31-100% for the 50m category. The chi squared test was significant at both 5m (x^2 = 9.605083) and 50m (x^2 = 30.30634). It showed that birds are not nesting in areas with more than 10% Heather within 5m and 30% Heather within 50m of the nest as much as you would expect if they were choosing nest sites at random.

2.1.5 Tufted Hair Grass

The chi squared test was significant at 50m (x^2 = 7.54). The number of classes for analysis had to be combined for *Deschampsia* at 50m distance such that the following class divisions were used 0-10% frequency and 11-100% frequency. The largest contribution to the chi squared value was from the 11-100% class. The number of nests was fewer than you would expect in sites with over 10% Tufted Hair Grass.

The average percentage cover at 5 and 50m were then calculated for vegetation categories that had significant chi squared results.

Table 3. Average percentage cover for vegetation categories which showed significant chi^2 results

Vegetation	Bracken	Rush	Grass	Heather	Tufted Hair-grass
5m	47.2	6.6		3.3	
50m	48.7	6.1	23	3.7	1.9

2.2. Site characteristic Results

Full site characteristic results for altitude, aspect and slope are given in appendices 2-4. Chi squared tests based on presence or absence were calculated for the fence posts, tree song posts, paths and streams using a 0.05 significant result (greater than 3.841459). The chi squared test results are shown in appendix 5.

2.2.1 Altitude

The altitude was recorded at 288 nests. The full results are given in appendix 2.

Table 4 shows the distribution over the different altitudes. The majority of the nests occurred between 261m and 360m.

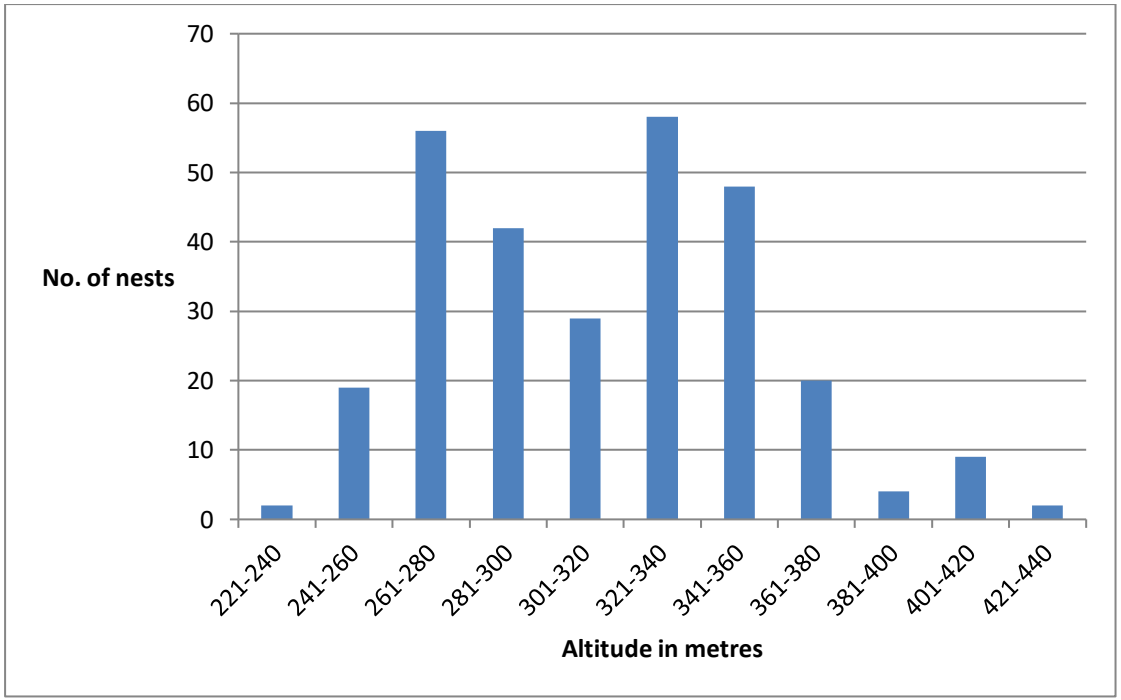

Table 4 Distribution of nest across the various altitudes.

2.2.2 Slope Aspect

The aspect was recorded at 314 nest sites. Table 5 shows the distribution over the eight compass points. The majority of the nests were on a west or north-west facing slope. The fewest nests were on a south or south-east slope. Full results are given in appendix 3.

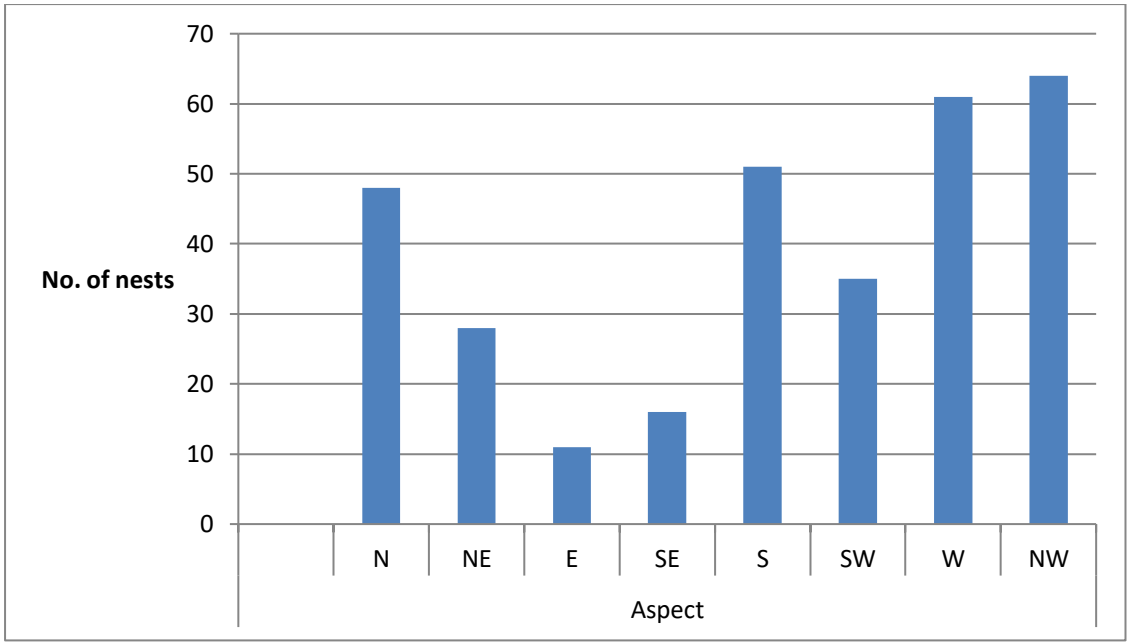

Table 5. Distribution of the nests across eight compass points

2.2.3 Slope

Slope was recorded for 288 nests. The majority (55.9%) of the nests were on flat to a 10 degree slope, only 6% were on a slope of more than 50^{o}. Full results are given in appendix 4.

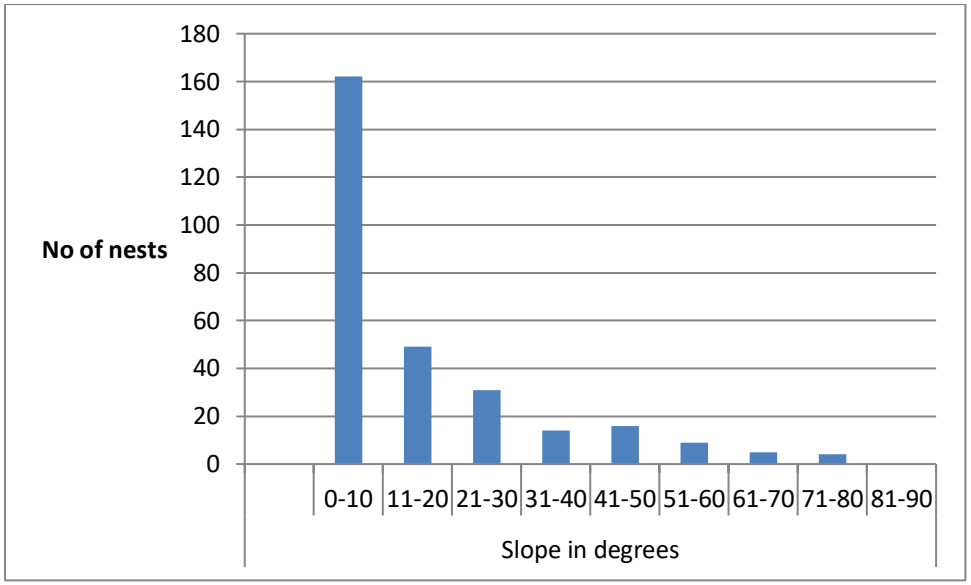

Table 6. Distribution of the nests across the degree of the slope

2.2.4 Fence posts

The chi squared test was significant for the presence of fence posts at 5m and at 50m (x^2 = 11.9186 and 12.77752) showing that fewer nests were found with a fence post within 5m and 50m than would be expected by chance alone.

2.2.5. Tree song posts

The chi squared test was significant at both the 5m and 50m (x^2 = 15.96017and x^2 = 8.778131) for the presence of trees as song posts, showing that more nests were found with a tree song post within 5m and 50m than would be expected by chance.

2.2.6. Paths

The chi squared test was significant (x^2 = 11.27101) for the presence of a path within 50m of a nest showing that more nests than would be expected by chance were found within 50m of a path.

2.2.3 Streams

The chi squared test was significant at both the 5m and 50m distance of a nest site (x^2 = 8.311013 and 6.977483) for the presence of a stream showing that fewer nests were built within 5m and 50m of a stream than would be expected by chance.

3. Discussion

3.1. Vegetation

The vegetation associated with Whinchat populations has been studied in the past. Smith (2020), in a long running Whinchat study (1986-2001) in the Gwent moorland edge, reported that out of 376 nests 65% were in Bilberry, 12% in Bracken and approximately 6% in Heather, Crowberry (*Empetrum nigrum*) and grass species. Smith comments that as the population declined it was the Bracken areas that were deserted first. Fuller et al (2006) looked at the bird communities in the Welsh marginal uplands and collected survey data at 120 sites in 1985–87. This was complemented by habitat descriptions made at exact locations occupied by individual birds. The site characteristics looked at were slope, aspect, altitude, and percentage of Bracken, semi-natural grassland, enclosed improved grassland, Heather/Bilberry mixture, Gorse (*Ulex* sp.), Bilberry, Heather and density of trees as the number of trees per 10 hectares. The data was used to identify broad relationships between habitat and bird communities. Fuller found no significant relationship between density of the Whinchat population and the site characteristics studied. He did find Whinchat was more strongly associated with Bracken than semi-natural grass and improved grassland and Whinchat locations had on average circa 50% for Bracken with a quartile range of circa 25% to circa 75%.

In total contrast is Taylor's (2015) study of the Whinchat on Salisbury Plain. Here Whinchat are inhabiting an area of unimproved chalk grassland which has not been subject to agricultural intensification. Taylor found that the presence and number of Whinchat were significantly correlated with a high percentage of long grass, low species richness, higher percentage of cover at 20cm (indicating a higher vegetation density), higher tussock density and more variation in vegetation heights.

3.2. Site characteristics

Calladine et al (2012) investigated the effect of altitude and aspect on areas occupied by breeding Whinchat. They found that the probability of an area with a south and east facing aspects being occupied by breeding Whinchats exceeded 80% below 300m asl and declined linearly to less than 20% above 500m. For areas with north and west-facing aspects, the probability of occupancy at 300m was 40% and close to zero at 500m. However, if the topography of the area occupied has few south

facing slopes then recording the aspect at the nest site may not necessarily show preference for that aspect. The majority of the slopes on the Geltsdale reserve face west or north rather than east, with some facing south, and hence it is not possible to compare this study to that of Calladine's. No nests were found above 440m.

The presence of tree song posts was shown to be significant both at the 5m and 50m distance with Whinchats choosing sites where tree song posts were present but the presence of fence posts, which can also act as song posts, was significant with Whinchats avoiding nesting near sites where fence posts where present at both 5m and 50m. It is possible that birds were avoiding fence posts as they demarcate boundaries across the landscape, possibly separating different grazing regimes, or perhaps a line of strong perches (compared with tall vegetation, small trees or relatively lower tree guards) provide good points for avian predators such as crows. Taylor (2015) also found that Whinchat were more likely to be found in areas with a higher abundance of perches.

From 2018 to 2020 patches of the reserve have been planted with trees. These all have tree guards of 1m which could be considered to resemble fence posts, with a negative effect, or as song posts, having a positive effect. It appears that Whinchats are initially attracted to areas where there has been tree planting and then, as the tress have grown up to produce a more wooded environment, those areas were not used to the same extent (A. Proud, M. Ketcher personal observation).

Vegetation on paths is often sparser and invertebrates could be more easily observed and collected. It is possible that areas of short vegetation such as on paths warm up more quickly so invertebrate activity is greater than in, for example, dense bracken. It was noticed that Whinchats would like to sit on wire fences along the paths and drop down to collect invertebrates (M.Ketcher, A.Proud personal observation). These could account for the positive significant chi squared test for the presence of paths at 50m distance.

The chi squared test for the presence of streams near the nests showed that the Whinchat appeared to be avoiding sites near streams at both the 5m and 50m distance. There is always the danger of flooding near a stream and also the noise might cover the presence of a predator.

4. Conclusions

The aim of this study was to ascertain if there were any specific characteristics that could be identified to improve the area for Whinchats. As was seen from Fuller's study in 2006, none of the vegetation types or site characteristics examined was significant for Whinchat. In this study the following were significant. Whinchat preferred areas with more than 10% Bracken within a 5m and 50m radius of the nest site. They avoid sites with more than 50% rush within the 5m radius and prefer sites with less than 10% rush in the 50m radius. They preferred sites with 11-20% grass species in the 50m radius. They avoided sites with more than 10% Heather at both 5m and 50m radius. They avoided sites with more than 10% Tufted Hair-grass at the 50m radius. The majority of the nests occurred between 261 and 360m and had a slight preference for west and north-westerly facing slopes. 55.9% of the nests were on slopes of 0-10 degrees. The presence of trees as song posts is positive at both 5m and 50m but fence posts were avoided at 50m radius. The presence of paths at 50m was positive whereas streams were avoided at both 5m and 50m.

None of these factors really lend themselves to any form of positive management to aid the Whinchat population as in essence they are a relatively catholic species in their habitat preferences.

Acknowledgements

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Appendix 1														
Bracken 5m												degrees of freedom	0.01	0.05
Observed	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	Total			
Nests	82	14	8	20	23	7	13	30	33	40	270			
Random	95	5	7	7	3	3	2	6	6	12	146			
Total	177	19	15	27	26	10	15	36	39	52	416			
Expected	114.879808	12.331738	9.7355769 2	17.524038 5	16.875	6.4903846 2	9.7355769 2	23.365384 6	25.3125	33.75				
	62.120192 3	6.6682692 3	5.2644230 8	9.4759615 4	9.125	3.5096153 8	5.2644230 8	12.634615 4	13.6875	18.25				
(o-E)**2/E	9.4105463 4	0.2256878 8	0.3094040 8	0.3498272 1	2.2231481 5	0.0400142 5	1.0945892 7	1.8839031 3	2.3347222 2	1.1574074 1		9		
	17.403065 2	0.4173680 1	0.5721856 3	0.6469407 4	4.1113013 7	0.0739989 5	2.0242404 3	3.4839304 5	4.3176369 9	2.1404109 6				
										Chi sq =	54.220328 6		21.67	16.92
Bracken 50m														
	0-10	Nov-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	Total			
Nests	56	12	26	13	28	22	19	45	28	11	260			
Random	86	10	11	10	7	9	7	5	2	2	149			
Total	142	22	37	23	35	31	26	50	30	13				
(o-E)**2/E	13.009577	0.2818335 7	0.2613229 4	0.1797225 5	1.4863118 3	0.2668992 3	0.3696854 1	5.4944564 6	4.1806482 4	0.9057746 6		9		
	22.701275 4	0.4917901 2	0.4559997 6	0.3136098 1	2.5935642 7	0.4657302 1	0.6450886 3	9.5876421 5	7.2950908 8	1.5805463 8				
										Chi sq =	72.566569 5		21.67	16.92
Rush 5m														
	0-10	11-20	21-30	31-40	41-50	51-100					Total			
Nests	213	17	9	5	8	6					258			
Random	97	13	10	2	6	20					148			
Total	310	30	19	7	14	26					406			
Expected	196.995074	19.064039 4	12.073891 6	4.4482758 6	8.8965517 2	16.522167 5								

	113.004926	10.9359606	6.92610837	2.55172414	5.10344828	9.47783251								
(o-E)**2/E	1.3003252	0.22347093	0.78258196	0.0684309	0.09035017	6.70105836								
	2.26678313	0.38956419	1.36423071	0.11929171	0.15750233	11.6815747								
										Chi sq =	25.1451643			
Rush 50m														
	0-10	11-20	21-30	31-40	41-50	51-100					Total			
Nests	114	44	20	14	5	10					207			
Random	45	28	16	14	6	12					121			
Total	159	72	36	28	11	22					328			
Expected	100.344512	45.4390244	22.7195122	17.6707317	6.94207317	13.8841463								
	58.6554878	26.5609756	13.2804878	10.3292683	4.05792683	8.11585366								
(o-E)**2/E	1.8583213	0.04557297	0.325524	0.76251915	0.54330286	1.08660572								
	3.17911169	0.07796367	0.55688817	1.3044749	0.929452	1.858904								
										Chi sq =	12.5286405			
Grass 5m		0-10	44136	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100			
	actual	98	47	18	21	24	11	12	13	11	5			
	random	61	21	18	11	8	7	5	4	5	6			
		0-10	44136	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100			
	Nests	98	47	18	21	24	11	12	13	11	5	260		
	Random	61	21	18	11	8	7	5	4	5	6	146		
		159	68	36	32	32	18	17	17	16	11	406		
Expected		101.82266	43.546798	23.054187	20.492610	20.492610	11.527093	10.886699	10.886699	10.246305	7.0443349			
		57.177339	24.453202	12.945812	11.507389	11.507389	6.4729064	6.1133004	6.1133004	5.7536945	3.9556650			

Chi-sq		0.14351157	0.27383423	1.10803335	0.01256276	0.60030315	0.02410214	0.11384883	0.41022892	0.05544003	0.59328602			
		0.25556856	0.48765	1.97321007	0.02237204	1.069033	0.04292162	0.20274449	0.73054465	0.09872883	1.05653676			
												df	0.05	0.01
												9	16.9189776	21.6659943
										chi sq=	9.274461			
											not significant			
Grass 50m														
	Observed		0-10	11-20	21-30	31-40	41-50	51-60	61-100			Total		
		Nests	106	62	32	21	14	9	16			260		
		Random	52	17	21	14	9	10	16			139		
		Total	158	79	53	35	23	19	32			399		
		Expected	102.957393	51.4786967	34.5363409	22.8070175	14.9874687	12.3809524	20.8521303					
			55.0426065	27.5213033	18.4636591	12.1929825	8.01253133	6.61904762	11.1478697					
		(o-E)**2/E	0.08991539	2.15036179	0.18626828	0.14317139	0.06506064	0.92326007	1.1290534					
			0.16818706	4.02225946	0.34841549	0.2678026	0.12169617	1.72696129	2.11189845					
										Chi sq =	13.454311 5	df	0.05	0.01
Callina 5m		0-10	44136	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100			
	actual	240	7	6	4	2	2	0	0	1	0			
	random	121	2	5	6	3	4	2	1	2	3			
			0-10	11-100										
		Nests	240	22								262		
		Random	121	28								149		
			361	50								411		
	Expected		230.1265	31.87348										
			130.8735	18.12652										
	Chi-sq		0.423617	3.058517										

			0.744884	5.378064										
										chi sq=	9.605083	df	0.05	0.01
												1	3.841459	6.634897
Calluna 50		0-10	44136	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100			
	actual	237	13	6	2	2	1	0	0	0	0			
	random	126	9	9	9	7	2	4	2	0	1			
		0-10	44136	21-30	31-100									
	Nests	237	13	6	5							261		
	Random	126	9	9	25							169		
		363	22	15	30							430		
Expected		220.3326	13.35349	9.104651	18.2093									
		142.6674	8.646512	5.895349	11.7907									
Chi-sq		1.260838	0.009357	1.058674	9.582227									
		1.947211	0.014451	1.634994	14.79859									
										chi sq=	30.30634	df	0.05	0.01
												3	7.814728	11.34487
Vaccinium 5m		0-10	44136	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100			
	actual	240	7	5	3	2	0	1	2	1	0			
	random	138	4	4	1	0	1	0	1	0	1			
			0-10	11-100										
		Nests	240	21								261		
		Random	138	12								150		
			378	33								411		
	Expected		240.043796	20.9562044										
			137.956204	12.0437956								df	0.05	0.01
												1	3.84145882	6.6348966

	Chi-sq		7.9904E-06	9.1527E-05										
			1.3903E-05	0.0001592 6										
										chi sq=	0.0002726 8			
											not significant			
Vaccinium 50m														
			0-10	10-100										
		Nests	246	15	261									
		Random	86	4	90									
			332	19	351									
	Expected		246.87179 5	14.128205 1										
			85.128205 1	4.8717948 7										
	Chi-sq		0.0030786 3	0.0537949 6										
			0.0089280 2	0.1560054										
										chi sq=	0.2218070 1			
											Not significant			
Descampia 5m														
		0-10	11-100											
	Nests	253	10									263		
	Random	139	11									150		
		392	21									413		
Expected		249.62711 9	13.372881 4											
		142.37288 1	7.6271186 4											

Chi-sq		0.04557329	0.85070138											
		0.07990517	1.49156309							chi sq=	2.46774292			
											not significant			
												df	0.05	0.01
												1	3.84145882	6.6348966
Descampia 50m														
		0-10	11-100											
	Nests	252	9									261		
	Random	134	15									149		
		386	24									410		
Expected		245.721951	15.2780488											
		140.278049	8.72195122											
Chi-sq		0.16040039	2.57977292											
		0.28096981	4.51893109											
										chi sq=	7.5400742	df	0.05	0.01
												1	3.84145882	6.6348966
Mollinia 5m		0-10	44136	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100			
	actual	227	5	5	3	4	2	6	1	4	5			
	random	124	3	5	4	2	6	0	2	0	3			
			0-10	11-100										
		Nests	227	35								262		
		Random	124	25								149		
			351	60								411		
	Expected		223.751825	38.248175 2										

			127.248175	21.751828								df	0.05	0.01
												1	3.84145882	6.6348966
	Chi-sq		0.0471532	0.2758469										
			0.0829139	0.4850462										
										chi sq=	0.8909605			
											not significant			
Mollinia 50m		0-10	44136	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100			
	actual	213	16	16	4	5	2	3	1	0	0			
	random	114	14	5	6	2	3	1	2	1	1			
		0-10	11-20	21-30	31-100									
	Nests	213	16	16	15							260		
	Random	114	14	5	16							149		
		327	30	21	31							409		
Expected		207.872861	19.070906	13.349633	19.706601									
		119.127139	10.929095	7.6503667	11.293398									
Chi-sq		0.1264597	0.4944943	0.5261900	1.1240952							df	0.05	0.01
		0.2206680	0.8628761	0.9181839	1.9615085							3	7.8147279	11.3448667
										chi sq=	6.2344761			
											not significant			

Appendix 2. Distribution of altitude in metres of the nests from 2012-2019

Altitude	221-240	241-260	261-280	281-300	301-320	321-340	341-360	361-380	381-400	401-420	421-440	
Years												
2012		4	5	3	3	3	1					18
2013	2	5	14	7	3	8	9	1				49
2014			12	7	3	5	8	4				39
2015			7	5	1	10	6	2		2		33
2016		2	8	7	7	11	7	4	1	3		50
2017		2	8	4	5	10	7	1	1	3		41
2018		2	1	5	3	6	3	1	2		1	24
2019		2	2	4	4	6	7	7		1	1	34
Total	2	17	56	42	29	59	48	20	4	9	2	288

Appendix 3. Distribution of aspect in degrees of the nests from 2012 -2019

Aspect	North	North-east	East	South-east	South	South-west	West	North-west	Total
Years									
2012	1		1	3	6	2	4	13	30
2013	14	4	6	2	9	1	9	5	50
2014	7	9	1	1	10	6	6	6	46
2015	7	8	1	1	10	6	6	5	44
2016	4	1	1	3	5	7	17	11	50
2017	5	3	1	2	3	8	6	11	39
2018	7	1		1	2	1	5	4	21
2019	2	2		3	6	4	8	9	34
Total	48	28	11	16	51	35	61	64	314

Appendix 4. Distribution of slope in degrees of the nests from 2012 to 2019

Slope	221-240	241-260	261-280	281-300	301-320	321-340	341-360	361-380	381-400	401-420	421-440	Total	Average
Years													
2012		4	4	3	3	3	1					18	292
2013	2	5	14	7	3	8	9	1				49	298
2014			12	7	3	5	8	4				39	311
2015			7	5	1	10	6	2		2		33	325
2016		2	8	7	7	11	7	4	1	3		50	320
2017		2	8	4	5	10	7	1	1	3		40	324
2018		2	1	4	3	6	3	1	2		1	24	323
2019		2	2	4	4	6	7	7		1	1	34	329
Total	2	17	56	42	29	59	48	20	4	9	2	288	

Appendix 5

Chi squared tests

This applies to all 2x2 tables

sig at 5% if CHI-sq value greater than
3.841459
sig at 1% if CHI-sq value greater than
6.634897

Song posts all @5m					
observed		present	absent		TOTAL
	Nests	64	413		477
	Random	29	269		298

		Total	93	682		775
		Expected	57.24	419.76		
			35.76	262.24		
		(o-E)**2/E	0.798351	0.108866		
			1.277897	0.174259		
	Chi ^{2} = 2.359373	Not significant				

Song posts all @50m					
observed		present	absent		TOTAL
	Nests	156	351		507
	Random	71	87		158
	Total	227	438		665
	Expected	173.0662	333.9338		
		53.93383	104.0662		
	(o-E)**2/E	1.682906	0.872191		
		5.400209	2.798739		
Chi ^{2} = 10.75404	Significant at 1% and 5%				

Tree song posts @5m						
	observed		present	absent		TOTAL
		Nests	57	194		251
		Random	11	140		151
		Total	68	334		665
		Expected	42.45771	208.5423		
			25.54229	125.4577		
		(o-E)**2/E	4.980913	1.014078		
			8.27953	1.685653		
	Chi ^{2} = 15.96017					

Tree song posts @50m						
	observed		present	absent		TOTAL
		Nests	114	132		246
		Random	34	80		114
		Total	148	212		360
		Expected	101.1333	144.8667		
			46.86667	67.13333		
		(o-E)**2/E	1.636959	1.142783		
			3.532385	2.466005		

	Chi ^{2} = 8.778131					

Fence posts @5m						
	observed		present	absent		TOTAL
		Nests	7	219		226
		Random	18	129		147
		Total	25	348		373
		Expected	15.14745	210.8525		
			9.852547	137.1475		
		(o-E)**2/E	4.38232	0.314822		
			6.737445	0.484012		
	Chi ^{2} = 11.9186					
Fence posts @50m						
	observed		present	absent		TOTAL
		Nests	42	219		261
		Random	37	77		114
		Total	79	296		375
		Expected	54.984	206.016		
			24.016	89.984		
		(o-E)**2/E	3.06606	0.818307		
			7.019664	1.873491		

	Chi ^{2} = 12.77752					

Path@50m				
Observed		present	absent	TOTAL
	Nests	99	154	253
	Random	34	115	149
	Total	133	269	402
	Expected	83.70398	169.296	
		49.29602	99.70398	
	(o-E)**2/E	2.795186	1.382007	
		4.746189	2.346629	
Chi ^{2} = 11.27001				

Stream@5m					
observed		present	absent		TOTAL
	Nests	10	229		239
	Random	18	133		151
	Total	28	362		390
	Expected	17.15897	221.841		
		10.84103	140.159		
	(o-E)**2/E	2.986829	0.231025		
		4.727497	0.365663		

	Chi ^{2} = 8.311013					

Stream at 50m					
observed		present	absent		TOTAL
	Nests	48	213		261
	Random	35	79		114
	Total	83	292		375
	Expected	57.768	203.232		
		25.232	88.768		
	(o-E)**2/E	1.651673	0.469482		
		3.781461	1.074867		
Chi ^{2} = 6.977483					

Note : This is the full version of the shortened article published in Birds and Wildlife in Cumbria 2020