Population estimation and breeding success of Whinchat (*Saxicola rubetra*) at RSPB Geltsdale, Cumbria, UK

Elinor Ames (Leigh-on-Sea, United Kingdom)

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Long-term monitoring of Whinchats (*Saxicola rubetra*) requires standardised survey effort and reliable population estimates. Distance sampling was found to underestimate the known population of whinchats at Geltsdale but provided a better index than transect counts. The negative bias may be due to violation of key assumptions of the distance sampling method, and differences in detectability between the sexes and between paired and unpaired males. Improvements to the methods could increase the accuracy of population estimates, but may also increase the complexity of both data collection and statistical analyses. Double sampling may provide a simpler method of correcting for bias, and could also allow measures of productivity and therefore assessment of the impact of management strategies on breeding success.

Details of an MSc research project conducted at RSPB Geltsdale in 2016.

Introduction

The population of Whinchats at RSPB Geltsdale reserve has been closely monitored since 2011. For continued monitoring to be viable and effective, rapid assessment methods which standardise survey effort and provide reliable population estimates are needed. Population indices and abundance estimates of Whinchats produced by line transect surveys and distance sampling were compared with numbers from intensive surveys using a double sampling approach. Factors influencing detectability during transect surveys were investigated, including sex, detection method, breeding status, breeding stage, and incubation activity. Incubation regimes and nest survival were monitored using temperature sensors in nests.

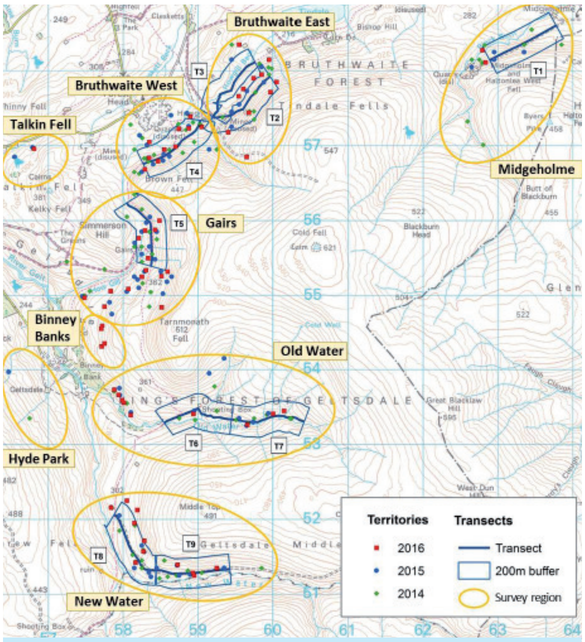

Fig. 1: A map of the study area at RSPB Geltsdale Reserve in the North Pennines, showing the survey regions, transect routes (T1 to T9) and whinchat territories between 2014 and 2016. Known replacement and second broods in 2016 are not shown. A 200-metre buffer on either side of each transect route shows the area covered by each transect survey. In 2016, the survey regions Bruthwaite East (BE), Bruthwaite West (BW) and the Gairs (G) were the focus of intensive searches in May. In June 2016, additional observers enabled searching of Binney Banks (BB), Old Water (OW), New Water (NW), Midgeholme (M), Talkin Fell (TF) and Hyde Park (HP). © Crown Copyright OS 1:50,000 Scale Colour Raster 2016. An Ordnance Survey/ Edina supplied service.

Methods

9 1-km line transect surveys were conducted at Geltsdale between 2014 and 2016 (Fig. 1). Three visits were made to each transect: (1) 15-22 May, (2) 23-30 May, (3) 31 May – 7 June, between 05:00 and 09:00 AM. Sex and detection method were recorded on transect surveys in 2016. Distance sampling (Buckland et al 2001) was performed in 2015 and 2016, and Distance software (Distance 7 Release 1, Thomas et al 2010) used to produce population estimates. Limited numbers of detections necessitated use of data from all

Fig. 2: Whinchat pair in the study area at Bruthwaite East, Transect 2 (Photo: © Stephen Westerberg).

three visits, with abundance estimated from the mean. Transect survey areas were also intensively searched, and the locations of all whinchats recorded, including colour combinations of all colour-ringed individuals. Territory mapping and nest-finding methods were used to estimate the true population. Thermochron® iButton® temperature sensors were placed in nests to record incubation activity (at 2-minute intervals for a 68-hour period; Fig. 8) and monitor nest survival and predation events (at 20-minute intervals for the duration of the nesting period) in 2016.

Results

Intensive sampling, transect counts and distance sampling all detected a decrease in the whinchat population between 2014 and 2016 (Tab. 1).

On a single transect visit, in 2016, a mean of 55% of active territories were detected. Summed maximum counts of males by 200 m section across the three visits for each transect ('Section-maximum') were more highly correlated with the number of territories estimated from intensive sampling ('known' territories) than means or

Tab. 1: Numbers of whinchats recorded by different survey methods between 2014 and 2016. Distance sampling estimates are given with 95% confidence intervals (CI).

Survey	Measure	2014	2015	2016
Intensive Search	Territory	52	42	35
	Pair	36	24	25
Transect Maximum	Male	38	28	24
	Female	9	5	7
Section Maximum	Male		32	30
	Female		6	8
Distance Sampling	Male		33 (CI 21.5-50.1)	27 (CI 17.3 – 41.6)
	0.5*(Individual)		18.5 (CI 13.1 – 26.6)	17 (CI 11.0 – 26.2)

Fig. 3: Study area surrounding Transect 4, Bruthwaite West, RSPB Geltsdale reserve, Cumbria, UK (Photo: © Elinor AMES).

whole transect maxima. A calibration factor of 1.237, obtained from regression, was required to estimate the number of territories from the Section-maximum number of males. Distance sampling underestimated the known population, and a calibration factor (1.298) was required (Fig. 5). Better estimates of the number of territories were produced using the number of males than half the number of individuals (Tab. 1). Proportional changes in distance sampling estimates and known population numbers were significantly correlated; distance sampling therefore provided a better population index than Section-maximum counts.

Tab. 2: Nest survival by year, 2014 – 2016, calculated using the Mayfield method (MAYFIELD 1975, JOHNSON 1979).

YEAR	NEST SURVIVAL
2014	33.3% (CI 17.5 – 62.4%)
2015	34.1% (CI 18.6 – 61.5%)
2016	78.0% (CI 62.4 – 97.3%)
MEAN 2014-2016	49.9% (CI 38.7 – 64.2%)

Males were more detectable than females. Between 2014-2016, males made up 59.9% of the population, but accounted for 85.6% of transect detections. In 2016, 63.3% of male detections were by sound, with male song allowing detections over greater distances than females (Fig. 6). Breeding status also affected detectability; unpaired males were more detectable than paired males. In 2016 paired males were detected singing on only 24% of the occasions they were known to be present compared with 80% of occasions for unpaired males, and were recorded singing on fewer visits than unpaired males. No clear effect of breeding stage was found on detectability, likely due to the small sample size and study methods.

The incubation study suggested that incubating females may be available for only 16% of the time during the transect survey period (05:00 AM to 09:00 AM), and less detectable during this period than later in the day, but this result was not significant due to the small sample size (n=5; Fig. 7), and further studies are needed. Breeding success and nest survival were highest in 2016, and varied between years (Tab. 2). Predation rates were low, and occurred mostly during daylight, in contrast to the findings of Taylor (2015) on Salisbury Plain.

Discussion

Distance sampling provided a better population index than maximum counts from line transects, but underestimated the known population. This may have been due to use of mean rather than maximum counts, and possible violations of key distance sampling assumptions: that distance measurements are exact; individuals are distributed independently of transect lines; individuals on the line are detected with certainty; and individuals are detected at their initial location (Buckland et al 2001, Thomas et al 2010). Overestimation of distances would negatively bias estimates (Buckland et al 2001), and use of laser range finders or recording distances in bands could increase accuracy in future surveys (Buckland et al 2015). The transect routes were fixed along tracks in areas of known high territory density for ease of access and repeatability. However, tracks may influence territory distribution patterns, and avoidance of the transect line by whinchats would negatively bias population estimates; estimates in this study were therefore limited to the area covered by the transect surveys. Where detection on the line is uncertain, for example when individuals are foraging in dense vegetation, more complex methods such as mark-recapture distance sampling, or restricting detection to audible cues such as male song could be used to address this (Buckland et al 2015). Undetected evasive movement of individuals would also cause negative bias in the population estimates; this should be minimised by scanning well ahead and adjusting the speed of travel to detect individuals before they are disturbed (Buckland et al 2001, 2015). Multiple covariate distance sampling could be used to account for variation in detection probabilities between categories such as males and females, or different detection methods (Stanbury & Gregory 2009, Buckland et al 2015). Availability models

Fig. 4: Study area surrounding Transect 5, The Gairs, RSPB Geltsdale reserve, Cumbria, UK (Photo: © Elinor Ames).

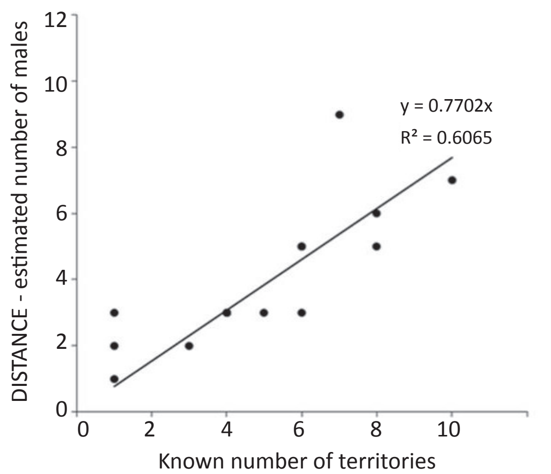

Fig. 5: The relationship between the estimated number of territories generated from Distance analysis and the number of known territories found during intensive searches in each of the one kilometre transect areas in 2015 and 2016. Estimates for the number of territories were generated from the number of males using means of the three transect visits.

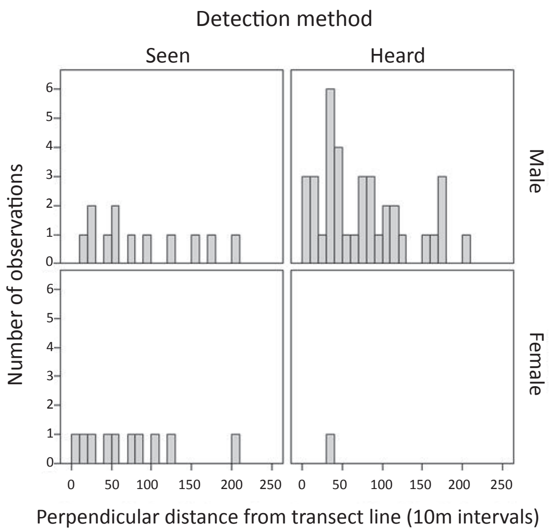

Fig. 6: Distribution of whinchat observations in 2016, in 10m distance intervals from the transect line, for males and females, and for different methods of detection. The detection method refers to the way in which each whinchat was first identified by the observer. Individuals were often seen after first being heard, or heard to sing or call after first being seen. For males, detection by sound includes both song and calls, whereas for females this refers only to calls.

and multipliers may also need to be considered if incubating females are to be included in the analysis (Buckland et al 2015). The higher detectability of unpaired males could also mask the true extent of population declines (Morrison et al 2016), especially if restricting surveys to singing

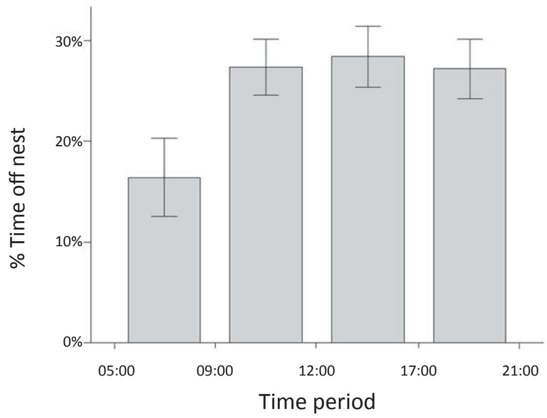

Fig. 7: The percentage of time spent off the nest by female whinchats in 4-hour time periods through the day. The first period, from 05:00 to 09:00 AM, was the time during which transect surveys were undertaken. Timings were obtained from iButtons which recorded nest temperatures at 2-minute intervals for 48 hours in five nests. Bars are ± 1 standard error. Assuming correct identification of arrival and departure events from temperature data, departure and arrival times were accurate to ± 2 minutes; the overall duration of each on- or off-bout was therefore accurate to ± 4 minutes. The difference between the time periods, though notable, is not significant, likely due to the small sample size: Friedman's 2 way ANOVA H=6.918, df=3, p=0.075, n=5.

males. A measure of the proportion of unpaired males, or an additional measure of breeding activity such as the presence of females, nests or behaviour indicating young would therefore be desirable to avoid overestimating the breeding population.

A greater sampling effort and more comprehensive environmental data is needed to fully investigate the preliminary findings of the incubation study. iButtons were found to be frequently removed from nests, and methods were needed to prevent this. Susceptibility to brood parasitization by common cuckoo *Cuculus canorus* may encourage removal of foreign objects from nests; careful fixture and camouflage of iButtons are therefore recommended in future studies to avoid impacts on incubation behaviour (Smith et al 2015). High nest survival demonstrates the potential for high productivity at Geltsdale and the importance of this site for breeding whinchats, but as considerable variation can occur in predator activity and nest survival between years, longer-term studies are needed. Continued monitoring of productivity would enable an assessment of the impact of management strategies and efforts to reverse current population declines.

Conclusion

By accounting for variation in detectability, distance sampling provides a more reliable index than maximum counts from line transects, and may be sufficient for detecting declines and monitoring the overall population trend. However, as an estimator of absolute abundance, distance sampling as conducted here suffers from a considerable negative bias, indicating probable violation of key assumptions and other significant influences on detectability such as sex and breeding status. The accuracy of distance sampling estimates may be improved with some simple alterations to the methods used in the present study, including increasing the accuracy of distance measurements by recording in distance intervals or using laser range finders; including sex and detection method as covariates in the models; and random placement of transects throughout the study area. More complex methods such as incorporating measures of cue frequency in males and female detectability during incubation in availability models, and mark-recapture distance sampling to estimate detectability on the transect line could further improve estimates but would require more advanced statistical methods and data collection and would be more time consuming and resource intensive. If an accurate abundance estimate is required, unless such improvements significantly reduce the bias of distance sampling estimates, it may prove simpler and more cost effective to derive a calibration factor from an intensively sampled subset of survey plots in a double sampling approach (Bart & Earnst 2002, Collins 2007), simultaneously providing the opportunity to record breeding status and productivity and enabling an assessment of the impact of management strategies and efforts to reverse current population declines.

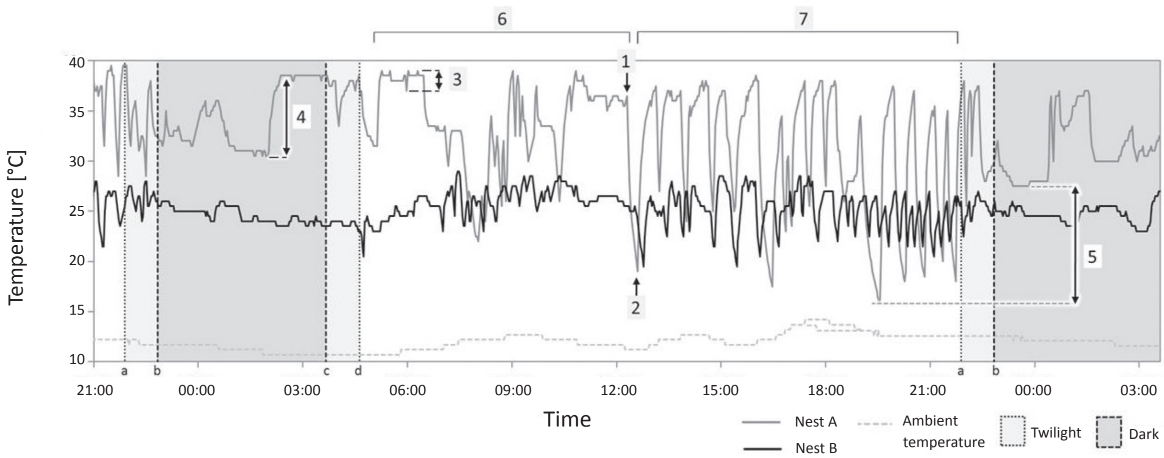

Fig. 8: Example temperature data from two whinchat nests collected over a 30-hour period from 28th to 30th June 2016. Temperatures were recorded at 2-minute intervals using iButtons placed in the nest-cups. Ambient temperature is given for comparison, along with hours of twilight and darkness as defined by (a) sunset, (b) dusk, (c) dawn, and (d) sunrise. A sharp decrease in nest temperature indicates departure of the female from the nest (1), with a sharp increase in temperature on her return (2). Small temperature variations (3) were assumed to be due to behaviour at the nest. Nocturnal variations in temperature were evident (4), but the minimum temperatures reached at night were less severe than those recorded during the day (5) suggesting nocturnal presence of the female at the nest, but reduced contact with nest contents. Mean, minimum and maximum nest temperatures differed between nests. A minimum temperature change threshold was selected for each nest based on the overall range in nest temperatures to aid in the identification of departures; 4 and 1.5 °C for nests A and B respectively. There were some difficulties in interpreting the data during periods of less regular behaviour (6) especially when compared with nocturnal variations. Patterns of behaviour varied through the day, with more time spent on the nest in the first hours after sunrise. In this example, departures from both nests show increased regularity in the afternoon and evening (7). These nests were located less than 5 km apart, and would have been subject to similar weather conditions.

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Author´s address:
Elinor Ames, 9 Bailey Road, Leigh-on-Sea, Essex SS9 3PJ, United Kingdom, ellieames@hotmail.com.