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Supplementary material

Appendix 1

Harness construction

Elastic harnesses were made from a single length of 0.8 mm diameter clear elastic beading thread (Beads Unlimited 'Elasticity') that was threaded through the geolocator loops and fused into a single loop with a battery-operated soldering iron (Figure 1). The soundness of the fused join was tested by attempting to pull the harness apart with reasonable force either side of the join, and any harnesses which showed signs of failing were rejected and remade using new elastic thread. The harness was then glued inside the rear harness tube on the geolocator with superglue because this prevented the harness being completely free running with respect to the tag and asymmetrical once fitted. We found this made fitting quicker and easier but still then allowed some correction for asymmetry once on the bird. The span of each harness was then measured as per Fig.1 in Naef-Daenzer (2007) to 0.5 mm accuracy. We measured the span of each harness twice, or until the same span was measured in two consecutive attempts. The optimal elastic harness span (size) was determined with prior field tests in which we fitted a range of harness sizes to whinchats before the study began and assessed their fit on different sized birds (see below): all the test fitting tags were then removed and the test birds released with only colour rings on. We found that the allometric function developed by Naef-Daenzer (2007) did not give useful fits for our study species or harness design, possibly due to our minor modifications to the standard geolocator design (Figure 1). Through these prior tests we established the common harness span associated with each wing length and used this to best determine which span to first attempt to fit on a captured bird. We made a large number of harnesses across the range of sizes to maximise the chances of fitting the correct harness span to a bird on the first attempt: final span size was determined empirically by trying several, if necessary, until the optimum fit was achieved. Average span fitted was 35.3, 0.1 SE mm (N = 95).

Tie harnesses were made from black nylon braid that was threaded through the attachment loops and tubes as per elastic harness, and loosely tied with a reef knot secured with a small clip during attachment, but then adjustable in the field to achieve the optimal fit for each bird. The harness was glued into the top attachment tube prior to fitting, as per the elastic harness. Final spans could not be measured because they were set only during attachment.

Captures and harness fitting

In Year 1, Whinchats were captured using mist nests and con-specific playback between 12th February and 8th March 2013. In Year 2, birds were captured using a combination of mist nets and baited spring traps with conspecific playback between 4th February and 2nd March 2014. Both capture periods were chosen to maximise geolocator recording and resighting period following capture, whilst minimising the number of transient individuals captured. Upon capture, birds were placed in cotton bags until processing: aged as adult or first winter (Jenni and Winkler 1994), sexed, biometrics recorded and a geolocator fitted. All birds were processed within 30 minutes of capture and most cases within 10 minutes. All birds captured were ringed with unique combinations of two or three colours, including a striped ring for birds with geolocators and an aluminium ring for birds with no geolocator.

In Year 1, tags were fitted to birds with a wing length ≥ 77 mm (flattened wing chord: average across birds fitted with tags = 77.4, 0.2 SE mm, range = 77 - 81 mm, N = 26). Birds with very low pectoral muscle scores were excluded regardless of wing length (fat scores were not used because these were minimal across all wintering birds captured as part of a larger study) to avoid fitting tags to individuals in poor condition. Preliminary analyses revealed no effect of wing length or bird size, nor age and sex on return rates and no interactions between these variables on birds both with and without geolocators; therefore in Year 2 we lowered the threshold for which birds we fitted with geolocators and fitted tags to birds with wings of ≥ 74 mm flattened wing chord to reduce the bias in biometrics between control vs. geolocators, again provided that these individuals had sufficient pectoral muscle scores. These individuals made up a small proportion of those fitted with geolocators in Year 2, with 11 birds (8.5 %) having a wing of < 76 mm and 25 birds (19 %) of < 77 mm.

Only a single observer was required to fit elastic harnesses. Approximately 80 % of elastic harnesses were fitted during the first attempt (i.e. the correct harness span was selected for an individual based on wing length, see above) and all were fitted by the second attempt. When a harness was too small or large for a bird (see below for assessing harness fit), the harness was removed by simply cutting it off to reduce handling time. Elastic harnesses were fitted by holding the bird with the legs facing upwards and slipping the bird’s right leg through the left harness loop and up over the thigh with the free hand. The bird was then rotated to make the other leg easily accessible whilst securing the tag in place on the back, the remaining harness loop slipped over the foot and leg, and a colour-ringing shoe was used to slip the loop over the thigh and into position. This final step required some tension to be applied. With minimal experience it was possible to establish a sub-optimal fit and choose a different harness size before the final step.

For tied harnesses, the legs were placed through the leg-loops by Observer A in exactly the same way as for elastic harness. Once the geolocator and harness was in the correct position, Observer B adjusted the harness and re-tied the knot. Once fit was assessed (see below) Observer B glued the knot in place with superglue using a piece of paper between the geolocator and the bird to prevent glue touching the bird, and trimmed the surplus harnesses ends with scissors. Water was applied to rapidly activate the glue.

Two observers (EB Year 1 or both EB and MB Year 2) assessed all geolocator/harness fits before release. Fit assessment was independent of harness material. With the bird held by the tibia-tarsi, we released any feathers trapped or in abnormal alignment from harness fitting and checked that leg-loops were above both thighs in the correct position. The geolocator was then grasped without touching the harness and we attempted to gently pull the tag away from the bird's body and from left and right and up and down to assess 1: how tight the harness was (by the amount of movement, the amount of force needed to 'pull' the geolocator away from the bird's back without stretching the elastic, if present, and the amount of space between the tag and the back); 2: whether the tag was sitting symmetrically on the back (visually and by whether the geolocator could move to one side more easily than another), and 3: that the geolocator was in the correct position on the lower back with any light-stalk protruding through the feathers. A metal clip spacer inserted between the geolocator and the bird's body was also used in Year 2 to aid consistency in assessment. We discussed harness fit until we were in agreement that the geolocator was an optimal fit (i.e. we were confident that the harness was neither too loose nor too tight to risk the tag falling off or compromising comfort, movement or body mass change) and was scored correctly. Any poorly fitting harnesses were removed and a new harness fitted.

Model Structures

The analyses with respect to our four broad tests were:

1. We investigated the effect of tags on between year resighting rates comparing control and tagged birds. We looked at straightforward differences in resighting rate dependent on tag

presence. We compared resighting rates of control versus tagged birds in each year of the study, and then pooled across years using Chi-squared tests.

2. We then used a binomial logistic regression model with a log-link function to compare the probability of resighting by tag presence, controlling for body mass, added wing loading due to the tag and year of study, and including the interactions body mass * added wing loading * tag presence, body mass * tag presence * year and added wing loading * tag presence * year to test whether any effects of tag presence were dependent on the varying size of the bird and whether any such effects varied between years; all relevant two way interactions were included.

3. We investigated the main effects of harness material and stalk length on resighting rate, controlling for harness fit, order of attachment, Julian date of tagging, year, added wing loading due to the tag and harness, and the body mass of the bird at capture using the 149 tagged birds that we had complete data for (see Table 1). We used a binomial logistic regression model with a log-link function. Analyses were repeated without added wing loading or fit so that the full sample size of N = 156 tagged birds could be used to determine whether the missing data influenced final results.

4. We then investigated the effect of variation in tag mass unconfounded by variation in tag or harness material by restricting analysis to birds tagged with long light stalk tags attached with elastic harnesses (i.e. were all fitted with the same tags). The sample size was 52 birds with complete data which was the largest sample size available within a single treatment group. We used a binomial logistic regression model with a log-link function to compare the probability of resighting by order of attachment, harness fit, body mass of the bird, added wing loading and year. We also tested whether the effects of added wing loading (i.e. the tag mass relative to the size of the bird) were consistent in both years by including the interactions year * added wing loading and wing * body mass.

5. We tested if the effects of tag design depended on harness to affect return rates of tagged birds, or depended on the order of attachment, or the fit of the tag by including the interactions of stalk * harness, stalk * fit & harness * fit and stalk * order & harness * order in the main effects model in analysis 2a above. We identified a potential effect of order of attachment in this analysis so we then explored whether the harness fit might have changed through the experiment. A linear

model was used to predict the fit of the tag by the order and harness material and the interaction order * harness, including year.

6. We tested whether body mass of tagged birds was different to untagged birds by comparing the body mass of tagged birds recaptured in Year 2 (after tag removal) with the body mass of new birds captured within 15 minutes at the same location using a matched-pairs t-test.

Supporting results examining the effects of missing values

1. No tag effect when comparing controls and tagged birds

The ratio of resighting rates for control compared to tagged birds was not significantly different between years when excluding the two birds that lost their loggers between winters (χ^2_1 = 0. 05, P = 0.82). The proportion of control birds ≥ 77 mm that were resighted pooling both years was 29.1 % (N = 240) and was not significantly different from 31.4 % for tagged birds (χ^2_1 = 0. 1, P = 0.72).

Excluding the two birds that lost loggers made little difference: the probability of resighting a bird the following winter was independent of almost all variables, combinations of variables and interactions considered. The top model remained the same as in Table 2 with biological and statistical significance being almost identical. The null model was 0.5 ΔAICc points above the best model that included tag presence. The results were similar when control birds of wing length ≥ 77 mm (i.e. removing the size selection bias for tagged birds to be larger) were compared to tagged birds. The top model of 4 models within 2 ΔAICc had an AIC weight of 0.38 and only contained year; all models contained year, and the three others each paired year with body mass, tag presence or added wing loading; the null model was only 0.5 ΔAICc points above the best model that included tag presence.

2. Harness material but not light stalk length reduced between-year resighting rate of tagged birds

Repeating the analyses of whether the probability of resighting a tagged bird was dependent on whether it had an elastic or tied harness, excluding birds with missing data for fit and added wing loading (N = 156) gave nearly identical results, with a lower probability of resighting if the tag was tied on. Attachment method was present in all models with a significant effect in the full and all top models. Repeating the analyses excluding the two birds that lost their loggers gave nearly identical results with the statistical significance for harness material increasing slightly.

3. The effects of harness material may have been dependent on harness fit

Repeating the analyses excluding birds with missing data for fit and added wing loading (N = 156) gave nearly identical results to those presented in Table S2 and Figure 3: the only potential interaction identified was an effect of harness material depending on order of attachment, with tied tags possibly reducing resighting rates if they were fitted later. Repeating the analyses excluding the two birds that lost their loggers gave similar results, although the top model included only Julian date, harness material and stalk length; the second top model, differing in ΔAICc by only 0.06, was identical to the top model in Table S2.

Table A1: Sample sizes of tagged and control birds split by year of study, tag and attachment type. Total (without missing values) presents the total sample size for birds with complete biometric data only, required for the analysis of tag fit. 'Tag fit categories' presents sample sizes for each fit category with complete biometric data.

Winter	Treatment	Stalk	Material	Ringed Resighted	Total (all)	Tag fit			Total (without missing values)
						Fit 0	Fit 1	Fit 2	
2013	Tagged	Long	Elastic	Ringed	26	11	6	5	22
				Resight	10	5	2	1	8
	Control	-	-	Ringed	37	-	-	-	36
				Resight	16	-	-	-	15
2014	Tagged	Long	Elastic	Ringed	30	7	20	3	30
				Resight	10	1	9	0	10
			Tie	Ringed	17	5	9	2	16
				Resight	1	1	0	0	1
		Short	Elastic	Ringed	30	9	16	5	30
				Resight	13	6	4	3	13
			Tie	Ringed	16	4	8	4	16
				Resight	4	1	1	2	4
		None	Elastic	Ringed	14	3	9	1	13
				Resight	6	2	2	0	6
			Tie	Ringed	23	0	16	6	22
				Resight	5	0	3	1	4
	Control	-	-	Ringed	279	-	-	-	277
				Resight	74	-	-	-	74
Both	Tagged	All	All	Ringed	156	39	84	26	149
				Resight	49	16	23	7	46
Both	Control	-	-	Ringed	316	-	-	-	313
				Resight	90	-	-	-	89

Table A2: Model evaluation of the most important variables predicting resighting rate for tagged birds (N = 149) considering potential interactions with harness fit and attachment order. Models were ranked by AIC and total weight calculated (proportion of top models where a variable was present) within ΔAIC = 2 of the top model (N = 24). The coefficients for the initial full model and the coefficients for the top model (AIC weight 0.07) are also given.

	Total	No.	Full model				Top model R^2 = 0.10			
	weight	models	Est.	SE	z	P	Est.	SE	z	P
[1]Intercept			-5.4	5.2	-1.0	0.30	-0.60	0.70	-0.9	0.3
Tied	1	24	-0.072	2.2	-0.03	0.97	0.079	0.86	0.1	0.9
[2]Julian date	0.7	15	0.036	0.026	1.4	0.15	0.038	0.017	2.2	0.0
Stalk length	0.48	11	-0.58	3.4	-0.2	0.86	-0.91	0.55	-1.7	0.1
Attachment order	0.42	10	0.00021	0.024	0.009	0.99	-0.0012	0.0071	-0.2	0.8
Tied*Order	0.39	10	-0.053	0.030	-1.8	0.077	-0.049	0.025	-1.9	0.0
Body Mass	0.35	9	0.27	0.22	1.2	0.21				
Added Wing loading	0.2	5	-70.7	434.6	0.2	0.87				
Harness fit	0.17	5	-0.78	0.77	-1.0	0.31				
Year 2	0	0	0.69	1.6	0.4	0.67				
Fit*Stalk	0	0	0.49	0.92	0.5	0.60				
Order*Stalk	0	0	-0.011	0.034	-0.3	0.73				
Fit*Tied	0	0	0.64	0.78	0.8	0.41				
Stalk*Tied	0	0	-0.93	2.3	-0.4	0.69				

[1]Intercept = Elastic

[2]Julian date 1 = 1st Feb