Effect of PIT Tags on the Survival and Recruitment of Great Tits Parus major

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Effect of PIT tags on the survival and recruitment of Great Tits *Parus major*

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We describe the use of subcutaneous passive integrated transponder (PIT) tags in nestling and adult Great Tits *Parus major*. We investigated whether subcutaneous PIT tags affected fledging success, winter condition, survival and/or recruitment. We found no negative effects of PIT tags on any of these measures either in juveniles or in adults. Subcutaneous PIT tags have the advantage that the risk of tag loss is negligible and that further data collection can be automated. The subcutaneous implantation of PIT tags provides a promising technique for researchers aiming at gathering short or long-term data without the need to handle or disturb small birds after implantation.

Key words: transponder, subcutaneous, implantation, fledgling success, recruitment, survival, *Parus major*

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Introduction

Passive integrated transponder (PIT) tags offer a useful technique for monitoring animal activity in the wild. PIT tags, designed for implantation, do not require batteries and, thus, potentially, have an unlimited lifespan. These tags permit collection of data without handling or disturbing animals after being equipped with a PIT tag. Placing antenna at sites that are known to be regularly visited by tagged individuals, such as nests or feeders, could be used to collect automated data that provide information about behaviour (e.g. roosting, feeding activity, and movements) and may allow survival estimation.

PIT tags have been used to quantify the provisioning and feeding behaviour of birds (Boisvert & Sherry 2000, Ballard *et al.* 2001, Freitag *et al.* 2001, Ottosson *et al.* 2001, Weimerskirch *et al.* 2001), to monitor the survival of individuals (Becker & Wendeln 1997, Dittmann & Becker 2003, Gendner *et al.* 2005) and to identify nests in the wild (Booms & McCaffery 2007). To date, PIT tags have been used primarily in large adult birds (Weimerskirch *et al.* 2001, Ballard *et al.* 2001, Gauthier-Clerc *et al.* 2004, Low *et al.* 2005), but also in chicks of large birds (e.g. Carver *et al.* 1999, Applegate *et al.* 2000, Jamison *et al.* 2000, Gauthier-Clerc *et al.* 2004). Investigators have reported no negative effects of these tags on behaviour or survival (Clarke & Kerry 1998, Carver *et al.* 1999, Jamison *et al.* 2000, Gauthier-Kenward *et al.* 2001, Clerc *et al.* 2004, Low *et al.* 2005).

For passerines, PIT tags have generally been attached externally to metal or colour rings (Boisvert & Sherry 2000, Ottosson *et al.* 2001, but for internal use see Keiser *et al.* 2005). Because externally attached tags may be lost (Jamison *et al.* 2000), subcutaneously injected PIT tags would be preferable, especially for monitoring the behaviour or survival of individuals over extended periods. However, for small passerines, the effects of subcutaneous PIT tags could differ from those on larger birds. The behaviour of adult and juvenile Dark-eyed Juncos *Junco hyemalis* with and without subcutaneous implanted PIT tags did not differ (Keiser *et al.* 2005), but the possible effects of these tags on fitness components in passerines have not been investigated. Our objective was to determine if the subcutaneous use of PIT tags had adverse effects on juvenile and adult Great Tits *Parus major* and, specifically, to determine if PIT tags influenced fledging success, condition, survival, and recruitment.

Methods

Data collection

We studied Great Tits in the Lauwersmeer (53°23'N, 6°14'E), a wetland area in The Netherlands. In 2005, we placed 50 nest boxes in each of 12 woodlots. Beginning in April, boxes were checked weekly to determine laying dates, hatch dates, and clutch sizes. When 2 days old (day 0 = hatching day), nestlings were bled and subsequently sexed using molecular methods (Griffiths *et al.* 1998). At day 6, nestlings were ringed with a metal ring and, at day 14, they were weighed (± 0.1 g) and ringed with three colour rings to allow individual identification after fledging. At day 14, the mean weights were 15.61 ± 1.39 g (n = 1675) for female nestlings and 16.32 ± 1.41 g (n = 1626) for males. Juveniles typically fledge when 20 days old (2005–06 first broods: 20.36 ± 1.48 days, n = 383 nests).

Survival during the post-fledging period was estimated by observation of colour-ringed juveniles from June–October 2006, following a fixed protocol with constant effort in the whole study area. Twice a month, each woodlot and its surroundings were checked for 4 hrs and colour-ringed birds were identified using binoculars. Observations began when the first juveniles fledged. In addition, from September–December 2005 and 2006, juveniles and adults were captured in mist nets, weighed, and measured. In mid-December, all boxes were checked for roosting birds.

PIT tags

In 2005, we conducted a pilot experiment to test the feasibility and potential impact of subcutaneous injection of PIT tags on nestlings. Nestlings in 24 of 258 nests were randomly chosen for implantation. Within these 24 nests, 54 of 181 nestlings (27 random females and 27 random males) were injected on day 10 and checked for infection on day 14. During 2006, two or three juveniles per nest were randomly assigned to receive a subcutaneous PIT tag on day 14. Overall, 444 of 1557 nestlings were implanted (Table 1). In 2005, adult Great Tits captured during the non-breeding season (see above) were divided into an experimental group implanted with PIT tags (n = 42) and a control group (n = 99). Adults were implanted using the same protocol described for juveniles.

We used Trovan ID100 (Trovan, Ltd., Douglas, UK) implantable PIT tags (2.12 x 11.5 mm; 0.1 g). These tags provide a unique 5-byte code read with either a portable or stationary reader. PIT tags, provided pre-sterilized and ready to use with a disposable needle, were injected subcutaneously in

Table 1. Survival between day 14 and fledging for Great Tit nestlings implanted ('tagged') and not implanted ('control') with a PIT tag in the breeding season 2006.

		First broods		Second broods	
		n	% fledged	n	% fledged
Control	females	432	90.5	133	95.5
	males	427	90.2	121	99.2
Tagged	females	172	91.3	53	100
	males	171	95.9	48	100

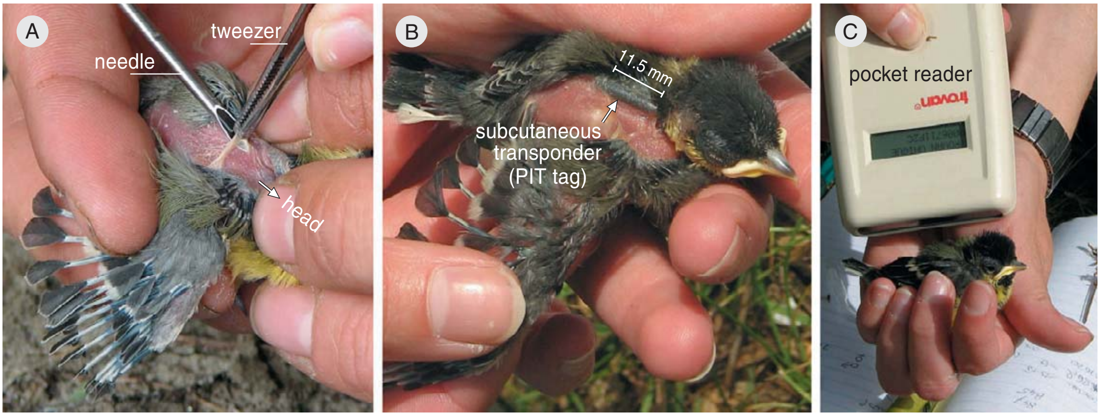

Figure 1. (A) A nestling Great Tit (day 14) being implanted with a PIT tag using a sterile disposable needle. The injection is facilitated by pulling up the skin with a pair of tweezers. (B) After injection, the PIT tag remains visible under the skin in the middle part of the back. The wound is closed with tissue glue. (C) The PIT tag code is checked with a hand pocket reader before replacing the nestling in the nest.

the back of birds above the scapula and in the featherless area on the right side (Fig. 1A). During each procedure, one person held the bird while a second person injected the PIT tag. To facilitate injection, the second person gently pulled up the skin using a pair of tweezers with round extremities (Fig. 1A). The perforation of the skin, located below the implanted tag, was closed by applying a small quantity of topical adhesive (NEXABAND® S/C, Abbott Laboratory) and pressing the skin with a cotton stick for one second (Fig. 1B). The procedure did not require anesthetic and the injection did not cause any bleeding. After about 2 min, the wound was checked and a Trovan LID 570 Pocket Reader was used to check whether the PIT tag was detected after implantation (detection range is 380 mm with a pocket reader and 240 mm with a GR250 reader; Fig. 1C).

Statistical analyses

Binominal response models with logit-link functions were used to study the impact of the implantation of PIT tags on fledging success (defined as the survival between day 14 and fledging) and recruitment of nestlings (defined as the probability of a locally born bird to enter the breeding population the following year knowing that it fledged). We used Generalized Linear Mixed Models (GLMM) where woodlot, nest box nested within woodlot, and individual nested within nest box were fitted as random effects (using MLwiN v. 2.02; Rasbash *et al.* 2004). Presence/absence of a subcutaneous PIT tag was fitted as fixed effect as well as several covariates that may bias the outcome of the estimated effects of PIT tag: sex, hatching date and mass at day 14. All continuous explanatory variables were centred around the mean by subtracting the mean trait value of the population of that year from the individual trait (Rasbash *et al.* 2004). In 2005, all nestlings implanted at day 10 successfully fledged so we could not analyze fledging success. In addition, sample sizes were not balanced, with 54 implanted nestlings and 1726 non-implanting nestlings. Therefore, to analyze recruitment, we reduced the sample size of the non-implanted birds by randomly picking 100 nestlings (50 females and 50 males).

Capture-recapture data analyses were carried out using MARK v. 5.1 (White *et al.* 1999). Post-fledging survival (φ) and recapture probabilities (p) were estimated for each month (t) of the resighting period using Cormack-Jolly-Seber models. Starting from a basic time-dependent model known to have a good support of the data (Michler, unpubl. data), we examined the effects of treatment (two groups: implanted vs. non-implanted; effect of implantation denoted as T in the model) on survival. We tested whether the two models $\varphi(t)p(t)$ (model 1) and $\varphi(t+T)p(t)$ (model 2) differed using a Likelihood Ratio test. Goodness-of-fit analysis was performed on the full time-dependent model using the median $\hat{c}$-approach. Our global model was an appropriate starting model ($\hat{c}=1.65$).

For re-captured fledglings, we compared the mass of implanted nestlings (corrected for the PIT tag mass of 0.1 g) to that of non-implanted nestlings using *t*-tests for independent samples (STATISTICA v. 7.0). We used a binominal response model with logit-link function (see above) to estimate adult winter survival, with the survival probability from winter to the subsequent breeding season used as a dependent variable. The presence/absence of a PIT tag, sex, and centred winter mass (see above) were included in the model. Level of significance of the explanatory variables was set at $P < 0.05$. All means are given with standard errors (SE).

Results

In 2005, all nestlings implanted at day 10 fledged successfully. In 2006, fledging success was not affected by the presence of PIT tags, sex, or hatching date. However, fledging success increased with fledging mass at day 14 (Table 2). Juvenile post-fledging survival did not differ between tagged and untagged birds over the first 5 months (LRT: $\chi^2_1 = 0.2$, P = 0.69; deviance model 1 = 105.90; deviance model 2 = 105.74, Fig. 2). Survival estimates were 0.78 ± 0.02 for young with PIT tags and 0.77 ± 0.01 for those without tags.

Generally, PIT tags remained at the point of injection. When nestlings were checked four days after implantation and when juveniles were captured after fledging, PIT tags were still visible under the skin at the site of implantation and no birds showed signs of infection. For one recaptured juvenile, the PIT tag was not visible, but had moved into surrounding tissues.

WINTER CONDITION

The mean mass of young females with (17.8 ± 0.1 g, n = 18) and without (17.5 ± 0.1 g, n = 38) tags did not differ ($t_{54} = 0.8$, $P = 0.42$). Similarly, the mean mass of young males with (18.9 ± 0.1 g, n = 35) and without (18.9 ± 0.1 g, n = 77) tags did not differ ($t_{110} = 1.0$, $P = 0.31$).

Table 2. Effects of presence of a PIT tag, mass at day 14, sex, and hatching date on fledging success and recruitment of young Great Tits in two years. Given are parameter estimates B and SE. Significant values are in bold.

	Fledging success[a]				Recruitment			
	B	SE	χ^2_1	*P*	B	SE	χ^2_1	*P*
2005								
presence of PIT tag	-	-	-	-	–1.57	0.67	2.7	0.10
mass at day 14	-	-	-	-	–0.33	0.23	2.1	0.15
sex	-	-	-	-	0.68	0.78	0.7	0.39
hatching date	-	-	-	-	**–0.23**	**0.11**	**4.5**	**<0.05**
2006								
presence of PIT tag	–0.23	0.31	0.6	0.46	0.01	0.16	0.01	0.94
mass at day 14	**0.01**	**<0.01**	**62.6**	**<0.001**	**0.26**	**0.05**	**24.6**	**<0.001**
sex	–0.01	0.29	<0.01	0.98	–0.05	1.61	0.1	0.78
hatching date	0.02	0.02	1.3	0.25	**–0.03**	**0.01**	**30.5**	**<0.001**

[a]The analysis was not conducted in 2005 because all implanted birds fledged successfully.

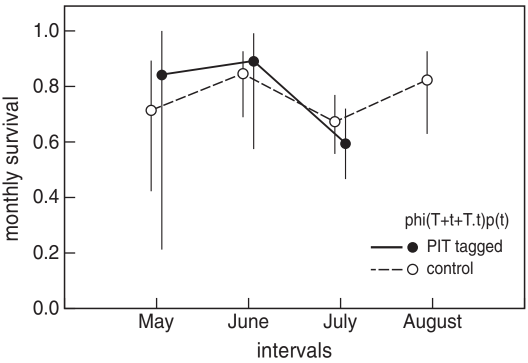

Figure 2. Monthly post-fledgling survival estimates for juvenile Great Tits implanted with a PIT tag and control birds (i.e. non-implanted). Estimates (±0.95 CI) are for the year 2006 and derived from a mark-recapture analysis based on the model φ(T+t+Txt)p(t) (where φ = survival probability, T = presence of PIT tag, t = time intervals and p = resighting probability). PIT tagged and control birds did not differ in survival. With this model no reliable survival estimate for PIT tagged birds could be provided for the last interval.

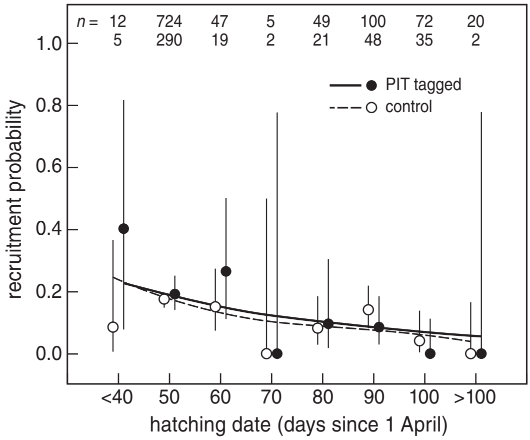

Figure 3. Recruitment probability (±0.95 CI) of fledged Great Tits decreased with hatching date, but was not affected by the presence of a subcutaneous PIT tag. Data are for the year 2006; date has been categorized in 8 groups. Sample sizes of each category are given above the figure for implanted birds (upper) and control birds (lower); the regression lines for PIT tagged birds and control birds are derived from the logistic regression model presented in Table 2.

Recruitment

For young that fledged in 2005, the recruitment probability was 0.04 for implanted birds ($n = 54$) and 0.06 for non-implanted birds ($n = 100$). In 2006, recruitment probability was 0.16 for implanted birds ($n = 422$) and 0.15 for non-implanted birds ($n = 1026$). For both years, recruitment probability was not affected by either the implantation of PIT tags or nestling sex (Table 2). However, hatching date had a negative effect on the likelihood of recruitment (Table 2, Fig. 3) and heavier fledglings had a higher recruitment probability in 2006 (Table 2, Fig. 4).

Adult recapture rate

For adult birds captured during the non-breeding season (2005), the probability of breeding the next year (2006) was 0.24 for implanted birds ($n = 42$) and 0.15 for non-implanted birds ($n = 99$). Recapture rates were not affected by the presence of a PIT tag (0.68 ± 0.47, $\chi^2_1 = 2.1$, $P = 0.15$), winter mass (–0.25 ± 0.28, $\chi^2_1 = 0.8$, $P = 0.38$), or sex (–0.29 ± 0.54, $\chi^2_1 = 0.3$, $P = 0.59$).

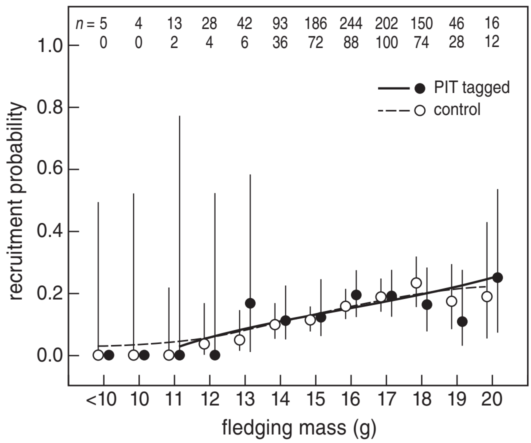

Figure 4. Recruitment probability (±0.95 CI) of juvenile Great Tits increased with fledging mass, and was not affected by the presence of a subcutaneous PIT tag. Data are for the year 2006; mass has been categorized in 12 groups. Sample sizes of each category are given above the figure for PIT tagged bids (upper) and control birds (lower); the regression lines for PIT tagged and control birds are derived from the logistic regression model presented in Table 2.

Discussion

We found that subcutaneous PIT tags had no adverse effects on nestling survival, fledging success, survival of juveniles and adults, or recruitment rates in Great Tits. These results, in combination with those of Keiser *et al.* (2005), suggest that subcutaneous PIT tags can be used on small passerines without deleterious effects for at least one year. Similar results have been reported for larger birds, with PIT tags having no deleterious effects on the behaviour and survival of either adults (Becker & Wendeln 1997, Clarke & Kerry 1998, Kenward *et al.* 2001, Dittmann & Becker 2003, Low *et al.* 2005) or juveniles (e.g. Carver *et al.* 1999, Gonzalez-Solis 1999, Jamison *et al.* 2000, Gauthier-Clerc *et al.* 2004, Low *et al.* 2005).

PIT tags could have a wide range of applications, including the study of behavioural decisions of nestlings, juveniles and adult passerines over longer time scales and during different periods of the year. For passerines that can be attracted to automated readers, PIT tags may allow researchers to obtain standardized estimates of e.g. spatial behaviour, timing of dispersal, foraging behaviour, and survival. Compared to telemetry, PIT tags offer the advantage of automated data collection with minimal disturbance of animals and collection of standardized data for large sample sizes. Nevertheless further studies are needed to judge how the advantages of this technique balance its potential disadvantages (e.g. detection range, high cost and detection accuracy).

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SAMENVATTING

Door vogels te voorzien van een transponder wordt onderzoek naar gedrag en verspreiding een stuk efficiënter. Bovendien leveren de transponders veel informatie zonder dat de vogels opnieuw gevangen hoeven te worden. Transponders zijn tegenwoordig zo klein dat ze zelfs bij kleine vogels gebruikt kunnen worden. Dit onderzoek beschrijft hoe transponders onder de huid van oude en jonge Koolmezen *Parus major* worden aangebracht. Het voordeel van deze techniek is dat de kans op verlies van transponders minimaal is. Het dragen van een transponder bleek geen effect te hebben op de kans om uit te vliegen, het lichaamsgewicht tijdens de eerste maanden na uitvliegen, de overlevingskans, en de kans om zich als broedvogel te vestigen.

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