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Cost of carrying radio transmitters: a test with racing pigeons *Columba livia*

R. Justin Irvine, Fiona Leckie & Steve M. Redpath

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We tested the impact of two types of radio transmitters on flight performance in racing pigeons *Columba livia*. Prior to each of two flights of known distance, 60 birds were randomly selected from three flocks and put into one of three groups: control, 5-g (i.e. 1.1% of body weight) tail-mounted radios or 8-g (i.e. 1.8% of body weight) sacral-mounted radios. The design of the sacral attachments changed between races as the initial harness caused lesions. Birds with sacral-mounted radios flew more slowly and lost more weight and condition than the other groups. Birds fitted with tail-mounted radios performed similarly to the control group. Loss of condition was correlated with a decrease in flight velocity. We conclude that small tail-mounted radios carry little cost, but sacral mounts may bias results and may be inappropriate for some ecological studies.

Key words: body condition, body mass, Columba livia, racing pigeons, radio transmitters, telemetry, velocity

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Radio transmitters are an invaluable tool for ecologists. They enable animals to be closely monitored, and provide a method for collecting data on a variety of aspects of behaviour and on demographic rates in the field (White & Garrott 1990, Kenward 2001). In studies where radios are used, it is clearly crucial that any impact the transmitters may have on the study animals is minimised to both reduce bias in the results and for welfare considerations. However, these effects have not been widely quantified (White & Garrott 1990). Godfrey & Bryant (2003) reviewed recent literature and found that only 10% of 836 studies directly considered the impact of transmitters. There is compelling evidence that transmitters can, in some circumstances, cause animals to behave abnormally (Bridger & Booth 2003, Sohle 2003), or affect energetic costs (Gessaman & Nagy 1988, Gessaman et al. 1991, Godfrey

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& Bryant 2003). Thus, it is important to examine the effect of attaching telemetry devices to ensure that the data collected are not invalidated by deleterious impacts of the devices themselves. Besides the effects of the transmitter, the handling process can also result in behavioural impacts such as reduced nest attendance or increased preening (Esler et al. 2000, Gregory et al. 2003, Sohle 2003).

Two of the most important features that relate to the impact of a radio transmitter are its mass and the method of attachment (Kenward 2001). Heavier transmitters have energetic costs, although rarely have these costs been tested experimentally. Energetic costs can be measured as greater activity rate (Gessaman & Nagy 1988, Gessaman et al. 1991), or as changes in body condition. Radio transmitters are commonly fitted as tail mounts, collars, attached by harnesses or glue, and implanted in the abdomen or subcutaneously (Kenward 2001). The position and method of attachment can have consequences for the animals and affect how much weight can be carried. The accepted rule of thumb is that birds can tolerate a transmitter of ~3% of body weight as a collar and 4-5% for harness mounts (Kenward 2001). Backpack radio mounts attached on the sacral area of the back have the advantage of not affecting a bird's balance. However, slight changes in design can cause injury (Kenward 2001). Generally, transmitters attached to the feathers have lower impact than those attached using harnesses (Calvo & Furness 1992). Another commonly used method of attachment is to mount the transmitter on the tail feathers, but in some cases this can lead to higher flight costs due to the effects on the centre of gravity (Orbrecht et al. 1988).

Racing pigeons (bred from the rock pigeon *Columba livia*) are an ideal model to test the impacts of transmitters on body condition and performance for at least three reasons. First, it is possible to have large sample sizes of both treated and control birds because of access to racing pigeons via the racing pigeon community. Second, stresses associated with handling are minimised by using racing pigeons because they are habitually handled. Third, pigeon races provide a situation where the birds fly to and from known points at the same time and under the same environmental condition, which enable the effects of carrying radios to be tested more rigorously.

We experimentally tested the effect of carrying two types of radio transmitters (tail mounted and sacral mounted) on race times and body condition in racing pigeons, and comment on the suitability of these devices as tools for ecological studies.

Material and methods

Experimental design

We randomly selected 20 juvenile racing pigeons from each of three lofts in Stirling, Larbert and Moodiesburn, Scotland (Fig. 1). Each bird was randomly allocated to either a control group (10 birds without radios), or one of two radio-marked groups (five birds with sacral mounted radios and five with tail-mounted radios). In total, we monitored 30 controls and 30 birds with transmitters. Birds remained in the same treatment group for both races. All birds had previous racing experience with several training flights and races over the season.

Radio transmitters

The radios were attached 48 hours before the first race and birds carried them for the duration of the project. Two types of radios were used in this trial. The first was a backpack type radio (TW31, Biotrack ltd, Wareham,UK) weighing approximately 8 g including mounting materials. This type was fitted to the bird using 0.6 mm elastic as described in Haramis & Kearns (2000). This technique involved two leg loops and a waist loop to keep the radio on the sacral area of the back and had the advantage that the attachment did not involve the wings. This attachment was used during Race 1, but the elastic was found to be cutting into the flesh on the sternum and around the base of the thighs. Two birds were subsequently retired from the trial after Race 1 and were replaced with new birds. We therefore removed the elastic from all birds and refitted the radios using 'tessa tape' (Wilson & Wilson 1989, see Wilson et al. 1997 for diagrams) to attach the radios onto the feathers within the same feather region. The second package used was a less powerful tail-mounted radio (TW41, Biotrack Ltd, Wareham, UK), which weighed approximately 5 g with mounting materials. This radio was attached to a cut-down guitar plectrum using Velcro and cable tied to the central two tail feathers. The antenna was tied to the shaft of one of the tail feathers using dental floss, and the knots were secured using super glue. Two birds lost these radios before the start of Race 1 because tail feathers were moulted. These

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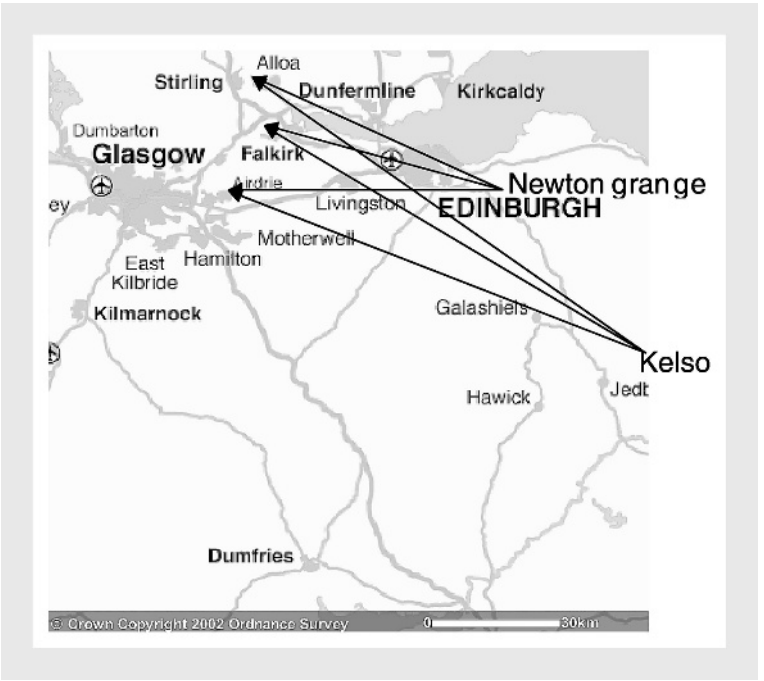


Figure 1. Section of southern Scotland showing the approximate race routes to three lofts in the Central Belt (indicated by arrows). Race 1 was from Kelso and Race 2 from Newtongrange. The map is based upon Ordnance Survey material with the permission of Ordnance Survey on behalf of the Controller of Her Majesty's Stationery Office © Crown copyright.

birds became part of the control group. The radios were then refitted onto two control birds.

Biometrics

Each bird was weighed to within 5 g using a 1-kg Pesola spring balance. The racing pigeons used in this study had a mean weight of 436 g (SD ± 38.5) indicating that the radios were 1.1 and 1.8% of the birds' weight, respectively. Pectoral angle was measured as an index of body condition (Mougeot et al. 2004). Pectoral angle is the angle described by the legs of dividers when they are placed on either side of the chest just touching the breast muscle in a lateral position lined up with the distal end of the sternum. The mean pre-race pectoral angle for birds in this study was 37.24° (SD ± 2.14). The birds were re-measured after the race on the same day.

Trial races

The distance between each home loft and race point was officially measured and recorded. Each pigeon racer had a tamper-proof clock, which allowed a temporary rubber race leg-ring to be stamped with the time of arrival at the home loft. We calculated the velocity of the trial birds using the official race point to loft distance and the official start and finish times (hours and minutes) for each pigeon. Two races took place. Race 1 was from Kelso and Race 2 was from Newtongrange (see Fig. 1).

Statistical methods

Analyses of the factors affecting flight velocities, weight loss and condition loss were conducted using a generalised linear mixed model with individual bird fitted as a random effect (glimmix macro, SAS version 8, SAS Institute Inc.) to take into account the fact that the same birds were flying more than once. The effect of radio type was fitted additively after correcting for any significant factors such as distance, duration and race number. The interaction terms were also explored. Differences were tested using the 'contrast' function available in the SAS glimmix macro. Only significant or nearly significant terms (at the 5% level) were tested. We plotted the data for bird performance in each treatment group (radio) to allow for visual inspection. Means and confidence limits were based on predicted values from the glimmix model (least squares means) after correcting for individual effects. Error bars in the plots were 95% confidence intervals.

Results

Flight velocity

Flight velocity was most influenced by type of radio ($F_{3,59.8} = 10.85$, $P < 0.01$) after correcting for differences between pigeons from different lofts ($F_{2,55.3} =$

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14.9, $P < 0.01$). Flight velocities did not differ between races ($F_{1,52.7} = 2.7$, $P = 0.11$), and the race by radio interaction was not significant ($F_{1,49.7} = 0.00$, $P = 0.94$). Pigeons with sacral mounted radio tags in both races were slower than either controls ($F_{1,71} = 28.9$, $P < 0.01$) or birds with tail mounts ($F_{1,58.8} = 18.6$, $P < 0.01$). In both races, birds with tail mounts had similar speeds to controls (about 46.5 km hr^{-1}; $F_{1,52.5} = 0.30$, $P = 0.59$). Birds with elastic harness sacral mounts (Race 1) tended to fly at about 32 km hr^{-1} which is about 5.2 km hr^{-1} slower ($F_{1,56.5} = 2.47$, $P = 0.12$) than birds with taped on sacral mounted radios (Race 2).

Body condition

Weight loss

Weight loss varied depending on the type of radio transmitter fitted ($F_{3,57.3} = 3.23$, $P = 0.03$; Fig. 2B) after correcting for differences between lofts ($F_{2,51.3} = 11.5$, $P < 0.01$) and race number ($F_{1,50.1.2} = 11.6$, $P < 0.01$). Inspection of the estimates for each radio type in each race showed that for Race 1, birds fitted with elastic harness sacral mounts lost more weight (around 17.6 g) than controls ($F_{1,86.8} = 7.7$, $P < 0.01$). The estimates indicated that birds with tail-mounted radios also lost ($F_{1,86.5} = 2.74$, $P = 0.10$) more weight (around 8.5 g) than controls. Correspondingly, birds with tail mounts tended to lose less ($F_{1,86.6} = 1.7$, $P = 0.20$) weight than birds with sacral mounted radio tags. There were no differences ($F_{1,86.9} = 2.8$, $P = 0.10$) between the groups in Race 2, but birds with taped on sacral mounted radio tags tended to lose more weight (about 11.4 g) than controls. There was no difference in weight loss between birds with tail-mounted radios and either controls ($F_{1,86.4} = 0.00$, $P > 0.99$) or birds with sacral mounts ($F_{1,87.0} = 2.5$, $P = 0.12$; see Fig. 2B).

Pectoral angle

Loss of body condition, measured by change in pectoral angle, differed ($F_{2,55.3} = 3.5$, $P = 0.04$) between birds from different lofts and was less in birds that flew faster ($F_{1,89.3} = 5.1$, $P = 0.03$). There was no difference between races ($F_{1,44.3} = 1.9$, $P = 0.18$) or radios ($F_{3,56.6} = 0.6$, $P = 0.60$; see Fig. 2C), but the interaction between race and radio was significant ($F_{1,44.1} = 5.4$, $P = 0.03$). Birds with tail-mounted radios lost less condition than controls in Race 2 ($F_{1,89.0} = 4.6$, $P = 0.03$).

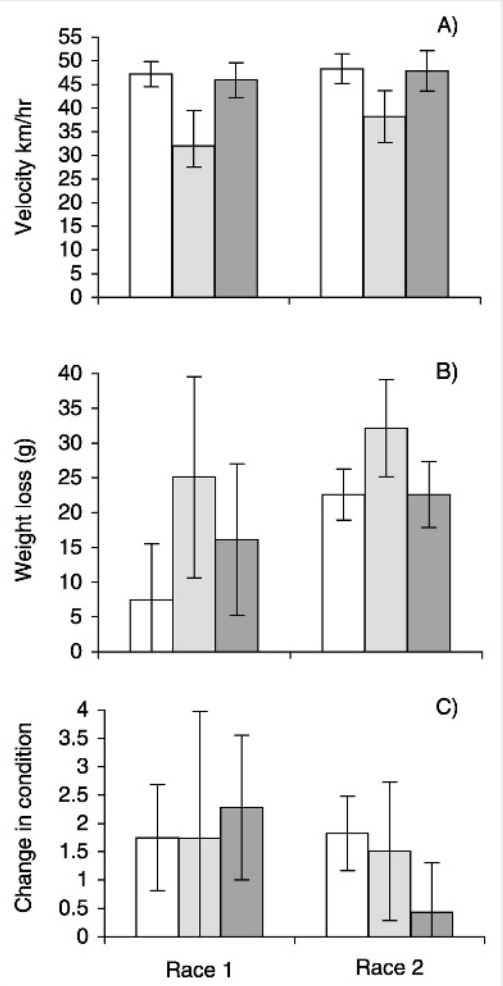


Figure 2. Mean velocity (in km hr^{-1}; A), mean weight loss (in g; B) and mean loss of condition (in pectoral angle degrees; C) of birds measured before and after races. Controls are shown in □, tail-mounted radios in ■ and backpack radios (sacral) in ■. Means are from a glimmix model with individual as a random effect. Means were calculated from the predicted values from the glimmix model with individual as a random effect. Error bars are 95% confidence limits.

Discussion

There was clear evidence of an adverse effect of one type of radio-transmitter (sacral mounted), but of little effect of another (tail-mounted). However, the experimental design did not allow us to fully distinguish between the effect of radio weight and the impact of the attachment method.

Many studies devise protocols to ensure that radio tags are no more than 4-5% of body mass in line with a recent review of the literature (Kenward

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2001). However, our results demonstrate that this may be an overestimate, if flight performance is not to be adversely affected. Although the effect of the sacral mounted radios in our study on body mass may also be due to harness design, several studies that used backpack radios reported adverse effects (reviewed in Kenward (2001)). For example, a 4-g harness (without transmitter) attached to racing pigeons affected flight duration and increased energy metabolism (Gessaman & Nagy 1988, Gessaman et al. 1991). In another study, survival of radio-marked rock ptarmigan *Lagopus mutus* was lower for males with an 18-g backpack radio (~3.6% of body mass) than for controls, but was not different for males carrying a 12-g necklace radio (~2.5% of body mass; Cotter & Gratto 1995). Daily energy expenditure in the large, flightless takahe *Porphyrio mantelli* increased by 8.5% in birds fitted with a backpack and harness mounted radio transmitter (Godfrey et al. 2003). Energetic costs in that study were measured as direct metabolic rates and are potentially more sensitive than our measures of mass or pectoral angle. Although weight loss may not be a perfect measure of loss of condition (because it is confounded with water loss), it is a good indicator of the overall impact of flight on body condition. Birds with the heavier radio transmitters are potentially at a disadvantage compared to controls, whereas those with the light tail mounted radio were indistinguishable from controls. The problem with the sacral-mounted and back-pack radios may be the design of the harness. Long-term effects can be chronic such as chafing and injury caused by ill-fitting radio packages (Jadot 2003). If the radio is attached around the wings, it may reduce wing movement and affect flight efficiency (Kenward 2001). In our study, the elastic harness had to be abandoned because it appeared to be causing lesions. It was subsequently replaced with a mounting which involved taping the radio onto feathers on the sacral area. Backpack radios have been used successfully in other studies. For example, there were no differences in breeding success and provisioning rates between control and radio-marked thrushes (Hill et al. 1999), although the harness caused the development of a small lipid mass on the patagium. If harnesses are to be fitted, the harness design must be carefully considered and tested for its effects on behaviour, condition, reproduction, and survival. Tail-mounted radios did not significantly affect the performance of racing pigeons in our study confirming the findings reviewed in Kenward (2001). For example, in merlins *Falco columbarius* there was no effect of carrying a tail or leg-mounted radio transmitter (about 2% of body mass) on breeding, hatching success and survival (Sodhi et al. 1991). Due to feather moulting, any type of attachment that uses feathers including tail mounts may not be suitable for all types of studies.

Our study indicates that backpack radios of 8 g or more (1.7%) of body mass attached to the sacrum using a harness or by taping onto feathers are unsuitable for documenting the behaviour and survival of pigeons, because they adversely affect flight performance. In contrast, small tail-mounted radios did not have any significant effect on flight velocity, body mass or body condition, and would be useful for investigating other performance or fitness parameters. Caution is required when using radio tags in studies that aim at investigating the ecology of bird species that spend much time flying and, in particular, migratory species. In the particular case of racing pigeons in the UK, there is a need to partition the disappearance of birds to the various causes of mortality, as there is concern over the impact of predators on pigeon survival (Joint Nature Conservation Committee 2000, Shawyer et al. 2000, Dixon 2002). Tail-mounted radios may help identify the causes of mortality during races.

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