EFFECTS OF FITTING DUMMY SATELLITE TRANSMITTERS TO GREENLAND WHITE-FRONTED GEESE *ANSER ALBIFRONS FLAVIROSTRIS*

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Before attaching satellite transmitters to Greenland White-fronted Geese to study spring migration and spring staging areas in Greenland and Iceland, dummies including a radio transmitter were attached to the geese to study the effects on eg behaviour and condition, and to find an effective harness material. Twelve free-flying Whitefronts were tracked and studied in a three month period on the wintering grounds at Wexford Slobs in Ireland. The dummy-fitted geese preened significantly more than controls two to three days after the attachment, but one week after handling the behaviour seemed to have normalised. There were indications that dummy-fitted geese increased their abdominal profile index less than controls during a one month period. Other behaviour such as site fidelity, flying to roost and family group cohesion all appeared normal. The knicker elastic harness proved more effective than the neoprene harness. It is recommended that satellite transmitters are attached to the geese at least two weeks prior to spring migration, that transmitters are as light as possible, that transmitters are fixed to the harness to prevent sideways slippage and that a less robust harness design be developed to ensure packages fall off within the course of a year.

Keywords:* *Greenland White-fronted Goose, Satellite Transmitters, Harnesses, Behaviour, Body Condition

The population of Greenland White-fronted Goose *Anser albifrons flavirostris* has almost doubled since the early 1980s to its current level of about 30,000 (Fox *et al.* 1994), but despite this, it is important to identify and designate specific sensitive areas and periods, since the population size on a world scale is small, and has a restricted geographic distribution and low productivity (Fox *et al.* 1983). Most wintering grounds in Ireland and Britain are well known and regularly censused, whereas spring staging areas in Iceland and Greenland and moulting grounds in Greenland are poorly known.

Some major spring staging areas have been localised in Iceland (Francis & Fox 1987) and in recent years research work on abundance and staging has been carried out (Fox *et al.* 1994). In Greenland, moulting grounds holding more than one quarter of the total population have been identified from aerial surveys in 1988, 89, 92 and 95, carried out by the Greenland White-fronted Goose Study (GWGS) and Greenland Environmental Research Institute (GERI) (Fox *et al.* 1994). Many of these areas have been designated as 'areas important to wildlife' (MRA 1996). Research on spring staging areas has been carried out by GERI since 1994 using aerial surveys, ground surveys and behavioural studies at one specific site.

In order to supplement the research work already carried out in the vast and remote areas of Iceland and Greenland, a satellite tracking project was initiated in 1996 by two departments of the National Environmental Research Institute (NERI) in Denmark (Glahder *et al.* 1996). Apart from identifying spring staging areas and the length of the stay and movements between areas, the objectives of the project were also to shed light on the course and duration of the spring migration from Ireland to Greenland.

Different studies on attaching satellite or radio transmitters to birds have revealed the following negative effects: weight loss and intensified preening (Greenwood & Sargeant 1973, Johnson & Berner 1980, Perry 1981, French & Goriup 1992), reduced survival (Johnson & Berner 1980, Warner & Etter 1983, Marks & Marks 1987, Paton *et al.* 1991) and increased nest desertion and decreased reproductive success (Erikstad 1979, Sibly & McCleery 1980, Warner & Etter 1983, Massey *et al.* 1988, Paton *et al.* 1991, Falk & Møller 1995, Ward & Flint 1995).

In order to determine the best techniques to be employed it was decided to test the effects of different dummy transmitter weights and the use of different harness types on the behaviour of wild Greenland White-fronted Geese prior to the satellite tracking project. Two transmitter weights and two harness types were tested on Greenland White-fronted Geese on the wintering grounds at Wexford Slobs, Ireland, from 13 January to 22 April 1996. The majority of geese migrated north between 27 and 29 April.

During the period shortly after the attachment of the dummy satellite transmitters, intensive observations of the behaviour of geese with and without transmitters were carried out to assess the effects of the harnesses and transmitters on the geese. During the rest of the study period the geese were tracked on the Wexford Slobs to check feeding and roosting sites, abdominal profiles and the attachment of the dummies.

Materials and methods

The lightest satellite transmitters on the market in early 1996 were produced by Toyocom and Microwave (25-30 grams). Addition of, for example, a waterproof housing and a pressure sensor would increase weights to about 50 grams. Therefore we decided to test dummy transmitters with approximately these two weights. The actual weight groups turned out to be on average 38.0 g (SD±2.3 g, n=6) and 54.1 g (SD±2.2 g, n=6), in this paper called 'light' and 'heavy' dummies, respectively. All dummies were approximately 65x16x25 mm in size and made of blocks of epoxy resin with a radio transmitter (Biotrack Ltd., TW-2, 16 g, antenna plastic coated, length 28 cm) embedded within them. The size and shape of the dummies differed little from those of the Microwave type, which was subsequently chosen for the study. The antenna lay almost flat along the back when attached because of the radio transmitter design and not at the 45° angle of the satellite transmitters. Lead shot pellets were added into the resin to produce the heavy dummies. The dummy was prepared for the harness by drilling two holes into the resin block in front and at the back above the antenna, and a 50 mm long plastic tube, diameter 4 mm, was glued into each hole.

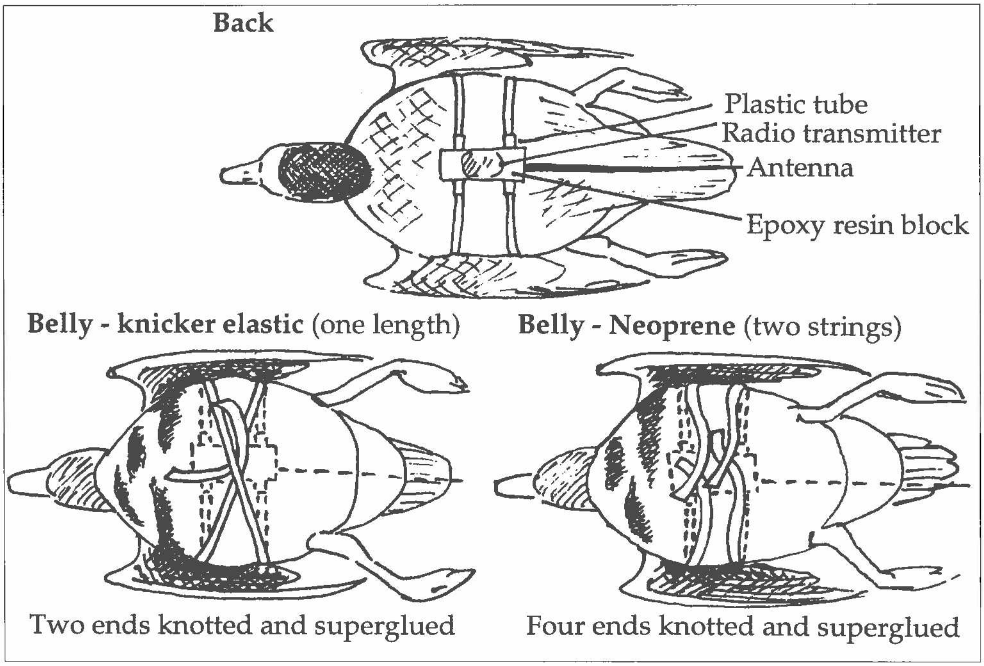
In this study knicker elastic and neoprene tape were chosen as harness materials because they both were strong and elastic and had the ability to degrade. The knicker elastic, (trade name 'Grober'), bought in an ordinary draper's shop in 3 m length, was black, five-strand elastic, 7 mm wide, 1 mm thick, weighing 7.0 g pr. m. The neoprene tape, delivered in 1 m lengths from O'Dare Ireland Ltd, manufacturer of divers wet suits, was covered on two sides with a blue and a black nylon covering, was 6 mm wide, 4 mm thick and weighed 5.5 g pr. m. Stretching tests with the two harness materials showed that knicker elastic could be stretched to a maximum of some 225% of its unstretched length, while neoprene tape could be stretched more than 350%. After such treatment, relaxed knicker elastic was 3% longer than the initial length, while neoprene tape had stretched an extra 62% in length.

Knicker elastic has been fitted on Woodcocks *Scolopax rusticola* (H. J. Wilson, *pers. comm.*) and neoprene tape was used on Whooper Swans *Cygnus cygnus* (Pennycuick et al. 1996), both yielding good results. Other attachment methods have been used, eg flexible leather strip harness (Jouventin & Weimerskirch 1990), Teflon-coated ribbon or wire harness (Greenwood & Sargeant 1973, Paton *et al.* 1991, Falk & Møller 1995, S-H. Lorentsen, *pers. comm.*), glue on the back (Massey *et al.* 1988, Sodhi *et al.* 1991, Gudmundsson *et al.* 1995), plastic plate on upper tail or neck collar (Kurechi *et al.* 1995) and implantation (Petersen *et al.* 1995).

The harness went round the body behind the wings and forward of the legs, with the dummy glued to the middle of the back using the cyanoacrylate glue 'Superattack'. The knicker elastic was looped twice around the goose, the two ends knotted and glued. Two loops of neoprene tape were used and all four ends joined in one knot and glued (**Figure 1**). To obtain an appropriate and regular tension on the knicker elastic harness when fitted to the goose, a spring balance holding the dummy with the harness preliminary attached should show c. 1.6 kg with the dummy lifted 100 mm above the back of the goose. To obtain consistent tension, c. 1.1 kg was applied using neoprene tape. Knicker elastic was thus tensioned to *c.* 125% of its unstretched length and neoprene tape to *c.* 130%. Results from the stretching tests showed that placing knicker elastic and neoprene under similar tensions, elongation stabilised after a few hours under tension to 101.2% of the original length in knicker elastic and 106.9% in neoprene.

In total 12 Greenland White-fronted Geese were fitted with dummy satellite transmitters, six with light and six with heavy dummies. Only five geese had dummies attached with a neoprene harness because only 10 strips were delivered, the remainder were fitted with a knicker elastic harness. The geese were cannon-netted on the same field on the Wexford North

Figure 1. Diagrams showing dummy attachments with knicker elastic (left) and neoprene (right) harnesses.



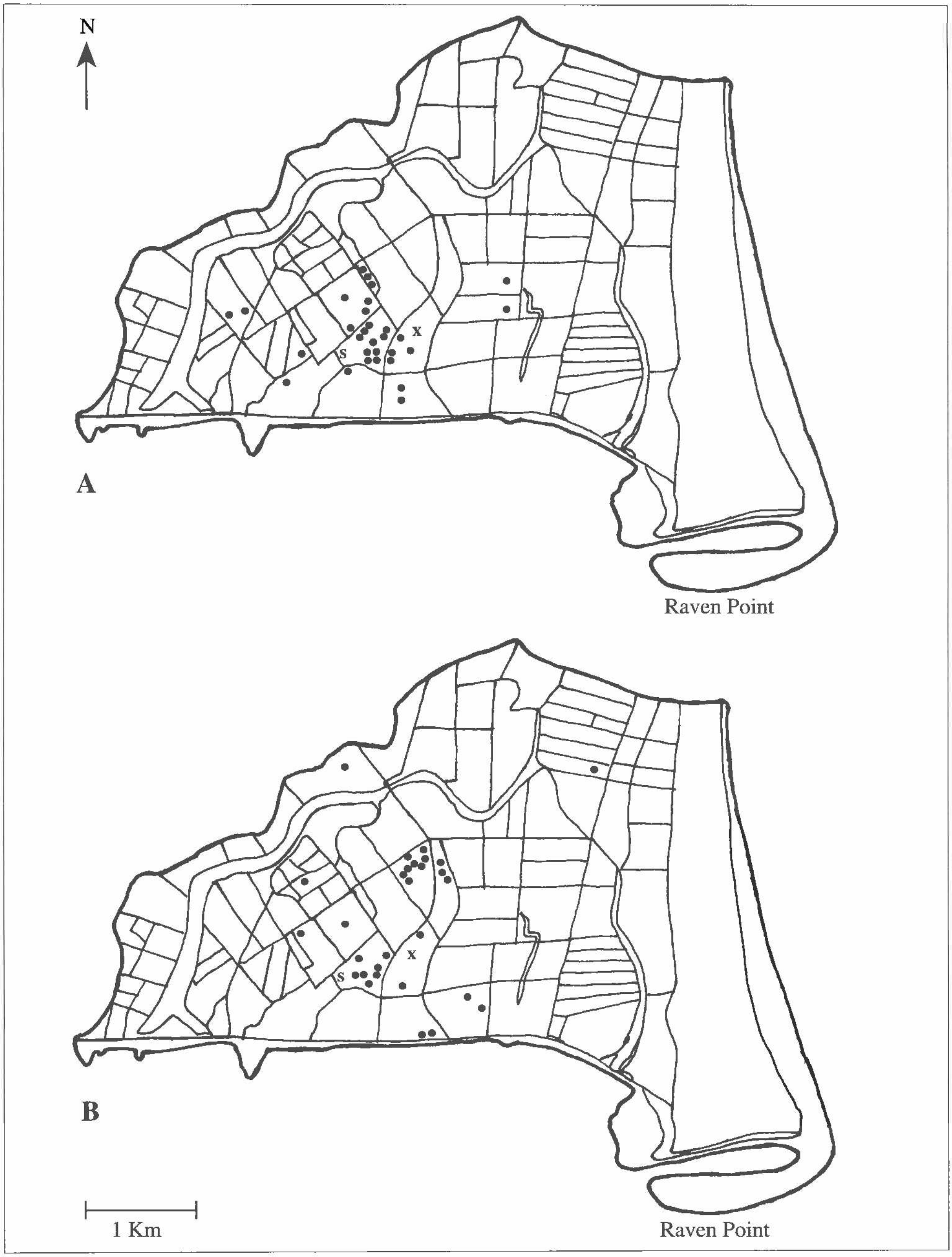


Figure 2. Sightings on Wexford North Slobs of Greenland White-fronted Geese with dummies attached with knicker elastic and neoprene harnesses. A shows sightings of six geese caught on 13 January 1996 and fitted with knicker elastic harnesses. **B** shows sightings of six geese caught on 19 January 1996, with five fitted with neoprene and one with a knicker elastic harness. Each circle represents a sighting. **X**: catching area, **s:** sugar beet field.

Table 1. Activity budgets of Greenland White-fronted Geese attached with dummy satellite transmitters and controls from the same family group. Mean activity budgets are calculated from behavioural studies of two family groups performed two and three days after the catch. 'Preening rest' includes: preening breast and upper wing, wing stretch and shake feathers. P-values in bold are significant (<0.05).

Behaviour	Dummies mean (%) (SE)	Controls mean (%) (SE)	*P*
Preen back	2.4 (0.6)	0.6 (0.4)	**0.007**
Preen flank	3.9 (1.3)	1.1 (0.8)	0.052
Preen neck	10.9 (3.5)	3.3 (1.1)	**0.038**
Preen belly	0.2 (0.1)	0.0 (0.0)	0.137
Preen rest	6.1 (1.5)	3.5 (1.7)	0.118
Preen all	23.4 (6.5)	8.6 (3.0)	**0.030**
Sit & stand	22.1 (4.9)	21.1 (6.4)	0.731
Sleep	10.4 (5.8)	11. (6.9)	0.855
Walk	3.8 (0.8)	5.9 (1.5)	0.638
Feed	38.9 (6.1)	50.3 (6.6)	0.256
Drink	1.3 (0.7)	2.1 (1.2)	0.840
Obs.time (bird mins)	142.3	166.8	
Number of birds (*n*)	11	13	

Slob on 13 and 19 January 1996. The first catch was of a family group of 10 from which one escaped from under the net, nine were marked with neck collars and leg rings, six of which were fitted with dummies (3 light, 3 heavy) attached with a knicker elastic harness. In the second catch two related family groups of 19 geese in total were caught and marked, and five fitted with neoprene attached dummies (3 light, 2 heavy), one with a knicker elastic attached dummy (heavy).

The geese were tracked with a M-57 Mariner Radar receiver with a standard 3-element Yagi antenna on the Wexford North Slob and at their roost site on the sand banks south of Raven Point (**Figure 2**). The Wexford North Slob situated in south-east Ireland, is an area of 1,000 ha of intertidal flats converted to intensive agricultural use, such as grassland for stock, root crops and cereals. The North Slob includes the 100 ha Wexford Wildfowl Reserve, which includes one field of unharvested sugar beet made available to the geese during the winter (**Figure 2**).

The family flocks were sighted, positioned and the abdominal profile index, API (a fatness index) scored using 0.5 intervals between 1.0 to 4.0 (Owen 1981). Behavioural studies were carried out in the first 14 days after the catch. The family flock was filmed with a video camera (8x magnification) and neck collar codes were read, using a 30-60x telescope, repeatedly into the camera sound track to enable identification of individual geese on film. The following behaviours were noted at five second intervals: sit, stand, sleep, alert, walk, swim, feed, drink, bathe, aggressive and preen. Preening was divided into preening of: neck, breast, flanks, belly, under tail, upper tail, back, back plus antenna, under wing, upper wing, wing stretch, leg ring, foot and bill in water.

The effects of dummies on behaviour were tested two and three days after the attachment by pooling activity budgets for geese fitted with both knicker elastic and neoprene harnesses. The differences in activity budgets between geese fitted with dummies and controls were tested with t-tests on each behaviour after data were normalised with an arcsine transformation. Variances in the two groups were tested with an F-test and showed no differences.

Results

Behaviour, activity budgets

Geese attached with dummy satellite transmitters preened significantly more than controls two to three days after the attachment ('preen all' in **Table 1**). The back and neck were preened significantly more by geese attached with a dummy than by controls, and preening the flanks was almost significantly different from controls (P=0.052, **Table 1**).

The material shows considerable individual differences, with dummy-fitted birds preening their back for 0 to 5.9% of the time, the flanks for 0 to 12.2% and the neck for 0.5 to 39.2%; corresponding differences in controls were 0 - 5.2%, 0 - 10.9% and 0.8 - 11.7%.

Seven days after the handling of the geese attached with a knicker elastic harness, dummy-fitted geese and controls showed almost exactly the same behaviour, and none of the groups were observed preening. It should be noted, that the sample periods were restricted, *ie* dummy-fitted geese/controls: Obs. time: 13.5/15.2 mins; number of geese: 2/2.

Site fidelity and roost

All family groups showed high site fidelity over the three month period (**Figure 2**). The family group with geese fitted with a knicker elastic harness was sighted 30 times with 83% of the sightings in or within 400 m of the sugar beet field (**Figure 2A**). The two related family groups with members fitted with neoprene harnesses had most sightings in two different fields (**Figure 2B**). Of the 29 sightings, 27% were from the sugar beet field, and 42% from the field to the northeast. The two groups are comparable to typical 'home ranges' on the Wexford North Slob (0.4-0.6 km^2, Wilson *et al.* 1991).

On fourteen evenings over the three month period the family groups were tracked to their roosting site on the sand banks south of Raven Point.

Abdominal profile index

During the period from 29 February to 5 or 8 April all geese but one increased their API. The differences in the API for geese fitted with light and heavy dummies and control geese are compared in **Table 2**. There is a tendency for more controls to have an API difference +1.0 than geese fitted with a light or a heavy dummy, and that more geese with a light dummy have an API difference +1.0 than geese fitted with a heavy dummy, although these differences did not attain statistical significance.

Table 2. The difference in abdominal profile index (29 February - 5/8 April) for geese fitted with a light or a heavy dummy and marked geese without a dummy (controls). The geese are group in API differences $\geq$+1.0 and <+1.0. (The χ^2-test showed no significant differences (P=0.07); the χ^2-test may not be valid, as most cells contain numbers below five).

Abdominal Index difference	Control	Geese with a light dummy	Geese with a heavy dummy
$\geq$+1.0	8	3	1
<+1.0	2	3	4

Attachment

All the seven Greenland White-fronted Geese with a knicker elastic harness had their dummy satellite transmitter attached on 21 April after 99 days. The dummies were securely attached on the back of six of the geese; on the seventh goose the dummy had sat on the back for 72-86 days but had slipped onto the flank for the following 13-27 days. Five of the seven Greenland White-fronted Geese attached with a dummy were sighted on Wexford Slobs (4) and Islay, Scotland (1) 314 days after attachment. The dummy was on the flank of three of the geese (all juveniles), whereas two (adults) were without a dummy.

On 21 April, after 93 days, only one of the five geese with a neoprene harness had the dummy satellite transmitter securely attached. The dummy had slipped to the flank on three of the geese, two of those after 38-41 days, and one after 81-93 days. The fifth dummy was lost after 4-6 days and retrieved from a receding pool on the North Slob on 26 February. The neoprene tapes were gone, and the antenna was reduced from 28.0 to 15.3 cm. About ten mantle feathers were attached to the dummy. Three of the five Greenland White-fronted Geese fitted with a dummy were sighted on Wexford Slobs 308 days after handling and all had lost their dummy. One of these was sighted on Iceland 1 May 1996 with the dummy on the flank (Ó. Einarsson, *pers. comm.*).

Discussion

Preening behaviour

Greenland White-fronted Geese with harness-attached dummy satellite transmitters preened significantly more than controls two to three days after attachment and back, neck and flank were the areas preened the most. The geese preened for nearly 1/4 of the total time budget. One week after handling the behaviour seemed to have normalised. One of the geese was observed several times pulling on the dummy and managed to remove it four to six days after attachment.

Increased preening and attention to attached transmitters and harnesses have been shown in different studies. Perry (1981) reported, that 11 Canvasbacks *Aythya valisineria* equipped with radio transmitters and tracked for about one week, spent about 3/4 of the daylight hours pulling on the transmitter. It was stated that Canvasbacks probably failed to adapt to the transmitters and acted abnormally until they dislodged the unit or died. Periodic observations during a 13 weeks period on 30 captive Mallards *Anas platyrhynchos* and 30 Blue-winged Teal *A. discors* fitted with radio transmitters suggested that treated birds preened more than the control birds and appeared preoccupied with the transmitters (Greenwood & Sargeant 1973). Three captive Houbara Bustards *Chlamydotis undulata macqueeni* fitted with dummy satellite transmitters and studied for eight weeks spent more time preening, especially where the harness came in contact with keel, belly, shoulders and neck (French & Goriup 1992). The only unusual behaviour observed in 12 radio tagged Merlins *Falco columbarius* was initial preening of the transmitter for a few hours after release (Sodhi *et al.* 1991).

These studies referred to were not quantitative, but indicate that different bird species when fitted with a transmitter show very different behavioural responses, ranging from rapid acceptance to no adaptation. The results of both studies of Canvasbacks and Whitefronts suggest that there is considerable inter- and intraspecific variation in response to transmitter attachment. The Greenland White-fronted Geese seem to show fairly rapid adaptation within a period of about one week.

Other general behaviour such as site fidelity, flying to roost and family groups cohesion all appeared normal over the three month period prior to the departure in spring.

Condition

The increase in time spent preening by the Greenland White-fronted Geese seemed to occur at a cost to feeding (38.9 versus 50.3% in controls), although this difference was not significant. There are indications that, in the period from late February to early April, the dummy-fitted geese did not increase their condition, here expressed as difference in API, as much as the control geese. On average dummy-fitted geese increased API by 0.8; control geese increased API by 1.3, compared to an increase of 1.0-1.5 in more general studies of Greenland White-fronted Geese feeding during the same period at the same site (Mayes 1991). The weights of the attached dummies were 1.5-2.1% of the body weights.

It has been reported in several studies that birds fitted with transmitters or dummy transmitters lose weight, and the decrease in the body weight is in some of these studies connected to increased preening. This was most dramatically demonstrated in the Canvasback study (Perry 1981), where three of the birds were not observed feeding during a one week period. Three other birds had serious weight loss after nine days. Transmitter weights were between 1.3 and 1.8% of body weights. The captive Mallards and Blue-winged Teals fitted with dummy transmitters lost significantly ($P<0.10$) more weight than the controls (Greenwood & Sargeant 1973). In the Mallards this weight loss were apparent after one week, in teals after seven weeks. It was observed that the dummy-fitted birds apparently preened more than controls, but no connection between preening and weight loss was concluded. Dummy weights were 1.5-3.7% of initial body weights. Two captive Hubara Bustards equipped with dummy satellite transmitters weighing 14% of their body weight lost between 4 and 9% of body weight in a two month period; most was lost during the first week (French & Goriup 1992). One bird fitted with a dummy of 10% of the body weight lost some weight in the first week, but gained weight by the end of the period. The dummy-fitted birds preened more than controls, but it was concluded that weight losses were a consequence of the extra weight of the dummy. Johnsen & Berner (1980) concluded, that attached dummy transmitters may affect weight gain of Ring-necked Pheasants *Phasianus colchicus* with a body weight less than 897g, *ie* when the dummy weight was above 3.1% of the body weight. On the other hand, satellite transmitter studies on Wandering Albatrosses *Diomeda exulans* (Jouventin & Weimerskirch 1990) and studies on Brent Geese *Branta bernicla nigricans* (Ward & Flint 1995) fitted with radio transmitters showed normal weight gains in albatrosses and no differences in the mean body mass between dummy fitted Brents and controls. The transmitters weighed 2 and 2.5-3.4% of the body weights, respectively.

In the studies where birds lose weight because of attached transmitters, most transmitter weights were between 1.3 and 3.7% of the body weight. No effects were observed in studies where transmitter weights constituted between 2 and 3.4% of the body weight. So, from these studies there is no obvious relationship between relative transmitter weight and effect. Weight loss as a result of attached transmitters is clearly species-dependant, and in some cases a higher weight loss was found in bird species fitted with heavier transmitters (Blue-winged Teal (Greenwood & Sargeant 1973) and maybe Greenland Whitefronts (**Table 2**)). In long distance migratory birds like the Greenland White-fronted Goose optimal weight gain in spring is important to make the c. 1,500 km's from Wexford to Iceland, and the same distance further on to West Greenland; Owen (1981) demonstrated that spring migrating Barnacle Geese *Branta leucopsis* on a comparable distance had a decrease in API of about 1.5.

From sightings performed between April and December 1996 of the marked geese, migration appeared normal in the dummy-fitted geese. One was sighted on SW Iceland on 1 May still with the dummy attached. In late November 1996 14 of the 17 geese in two of the marked groups had returned to Wexford (12), Swilly, NW Ireland (1) and Islay, Scotland (1). The three geese missing were one dummy-fitted and two controls, all juveniles. The remaining group of 11 including three neoprene harnessed geese was not sighted in early December 1996. There was no difference in API (about 2.0) between dummy-fitted geese and controls.

Harnesses

The knicker elastic harness proved to be the most effective type of the two tested. One of the reasons may be that the elasticity of knicker elastic is more robust under tension than that of neoprene tape as shown in the stretching tests. Another reason is probably that the harnesses were not pre-stretched before fitting. This may have given the knicker elastic an advantage over neoprene because stretching of knicker elastic under controlled conditions similar to that used on the living birds caused only a 1.2% extension of length compared to a 6.9% increase in neoprene. The neoprene harness is therefore likely to become looser under tension and permit the dummy to slip whilst on the body. Since the dummies were not physically fixed to the harness, this would cause the dummies to become displaced from the back once the glue no longer fastened the pack to the back. Finally, knicker elastic may prove more resistant to biting by geese since it comprises five-strand elastics rather than the single strand neoprene tape.

Conclusions and recommendations

Greenland White-fronted Geese fitted with dummy satellite transmitters preened significantly more than controls shortly after the attachment, although there are indications that this effect declines within a few days. For that reason, it is recommended that transmitters are attached at least two weeks prior to spring migration, *ie* in late March. There were indications of reduced fat build-up in the dummy-fitted geese, and that this was maybe more pronounced in geese fitted with heavy dummies (54 g versus 38 g). Therefore, satellite transmitters attached to Greenland White-fronted Geese should be as light as possible, but still with a robust housing and antenna, the latter fixed well at the base. The knicker elastic harness proved to be an effective one since these were still attached to three out of seven geese 10 months after handling. It is recommended that a less robust design for the knicker elastic harness be developed to ensure packages fall off within the course of a year. Satellite transmitters must be prevented to slip sideways along the knicker elastic strings by fixing the transmitter to the harness.

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