The effect of neck collars on the behaviour, weight and breeding success of Mute Swans *Cygnus olor*

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Neck collars were used as an individual marking technique in a population study of wild Mute Swans on South Uist, Scotland from 1978-82. This was the first time this method of marking birds had been extensively used in Britain, and data were collected on the effect of the collars on behaviour, weight and breeding success. Collars made of laminated plastic were fitted to over 650 swans during the moult and brood catches. Behavioural observations were undertaken in July and November 1980 at two sites used by flocks of swans.

Collars did not affect the frequency of feeding, but there was a significant difference in the type of feeding method employed. Collared birds upended less often than uncollared birds at both sites. The weights of collared birds however were not different, and neither was their breeding success. No chewing or scarring was recorded on the collars and no damage to neck feathers of marked birds. The frequency of preening showed no consistent pattern between collared and uncollared birds and neither did the area being preened.

Implications of these results are discussed in relation to the main advantages of using collars as a marking technique in other studies, and possible drawbacks.

The use of neckbands or collars as a marking technique for research into waterfowl biology, especially in migration and behaviour studies, has become widespread in the United States and elsewhere since the 1950s (Marion & Shamis 1977). By comparison, in Britain neck collars have rarely been used as a general marking technique for birds. In 1978 permission was granted by the British Trust for Ornithology for their use by Aberdeen University in a population study of wild Mute Swans *Cygnus olor* in the Outer Hebrides.

As a marking technique collars have several advantages when compared to other possible methods (e.g. patagial tags, nasal discs, nasal saddles, leg rings or plumage dyes):

1. Collars, like some of the others, are easy and inexpensive to manufacture.
2. Collars are simple and quick to put on.
3. Collars stay on the bird better than other types of recognition marker, with the exception of leg rings.
4. Collars are large enough to carry a unique letter/number combination for individual recognition, which is readily visible at long distances.
5. The recovery rate of dead birds and resighting of live birds with collars on is higher than that for birds marked by other techniques.

Collars, however, like other techniques, have their own specific possible drawbacks, and several studies have detailed their respective merits and shortcomings and questioned the advisability of their use on certain, mainly smaller, species (Aldrich & Steenis 1955, Ballou & Martin 1964, Sherwood 1966, Fjetland 1973, Patterson 1978, Craven 1979, Bartelt & Rusch 1980). However, where studies have included observations on the behaviour and breeding of collared birds, most have shown little evidence for any lasting effect on social organisation, breeding biology, clutch size, nesting success or the weights of the birds concerned (Craighead & Stockstad 1956, Ballou & Martin 1964, Sherwood 1966, Fjetland 1973).

Aims

The aims of the study were:

(a) to investigate the behaviour and activity

of individuals within a group of adult non-breeding Mute Swans, and to compare the performance of collared birds with that of uncollared birds under similar conditions,
(b) to compare the weights of uncollared swans with birds that had been marked with neck collars for at least a year,
(c) to compare the breeding success of pairs of swans in which one or both adults had a neck collar with that of uncollared swans.

The study population

In the Outer Hebrides, Mute Swans were mainly found associated with the machair and brackish water lochs of South Uist, Benbecula and North Uist. They are not indigenous to the Hebrides, but were introduced to North Uist in the late nineteenth century, have since become wild and unapproachable and their numbers increased to a total of approximately 1000 birds (Spray 1981a). About 120 pairs bred during the period of study, defending territories on the machair lochs and brackish water lochs, at a higher density than anywhere else in Britain (Ogilvie 1981, Spray 1981a). The remainder of the population, adult non-breeders and immatures, gathered in loose flocks, with two large concentrations on Loch Bee (South Uist) and Loch an Duin (North Uist). Extensive ringing and collar marking of the population between August 1978 and 1981 showed that it was largely a closed population, with very few birds reported away from the Uists (Spray 1981b).

During the moult period (July to August) the non-breeding flocks were joined by territorial pairs that had failed to breed successfully that year. These aggregations of swans which became flightless were found on traditional waters each year - the majority moulting on Loch Bee and Loch an Duin, but with smaller flocks on Loch Ollay (South Uist), Loch Grogary (North Uist) and Loch Bhruist (Berneray). During this time it was possible to round up these birds and, using canoes, to herd them into a catching pen erected at the water's edge. Using this method, and also by catching individual broods of cygnets in September, prior to fledging, 750 Mute Swans were caught and leg ringed, with over 650 also being marked with a neck collar.

The neck collars

The neck collars were designed and manufactured at Aberdeen University. They broadly followed the specifications of neck-bands then in use in the United States, though deviating slightly from the exact details of the guidelines of the international colour marking code for swans and geese (Sladen 1976). They were made of a triple laminate 1.5 mm thick yellow "Darvic", and weighed *c.*34 g each (*c.*0.3% of the body weight of an adult Mute Swan). They were 8 cm high x 23 cm in length, with the ends overlapped to give an internal diameter of 6 cm, the overlap being glued using the plastic manufacturers' recommended p.v.c. solvent cement. Once fitted the collars were free to slide up and down the swan's neck. Engraved in black three times around the collar was a unique 3-digit combination of 2 letters and 1 number, 23 mm high, which under favourable conditions could be read with a telescope at distances up to 600 m.

It was decided to use neck collars in this study, rather than large plastic leg rings as used on swans elsewhere in Britain (Ogilvie 1972, Rees *et al.* 1990) for three main reasons:
1. Uist swans were wild, living with minimal assistance or interference from man, and were difficult to approach close enough to read any markings that might be engraved on a large plastic leg ring.
2. The birds seldom left the water, so leg rings were very rarely visible anyhow. Sixty birds were leg ringed during the study and, although very occasionally a ring was glimpsed, as expected it proved impossible to decipher the coding on the rings.
3. Since the study area was isolated, and initially nothing was known of the swans' movements, it was hoped that the use of collars might mean that birds which emigrated would be reported by members of the public outside the study area.

Methods

(a) Behavioural observations

Observations on collared and uncollared swans were undertaken at two sites on South Uist in 1980. In July, 36 paired sets of observations (collared/uncollared) were made on birds in a moulting flock on Mid

Loch Ollay (57°15'N, 7°23'W). Only two adults were present on this loch on 14 June, but numbers built up rapidly during July, with between 63 and 76 adults present during the observation period. Numbers dropped off quickly after mid-August, and none were present by 24 September. A maximum individual daily count of 33 collared birds was recorded on 23 July. The flock was subsequently rounded up and caught on 9 August when all unmarked birds were collared. Birds on this loch were feeding on the extensive growth of several species of pondweed, including *Potamogeton berchtoldii*, *P. filiformis*, *P. gramineus* and *P. perfoliatus*.

A second series of 16 paired observations were made in early November, at Ardkenneth, West Loch Bee (57°24'N, 7°23'W). This flock of swans, though not moulting, was largely composed of non-breeders, and was feeding in brackish water, predominately on *Zostera marina* and *Ruppia maritima*. The birds under observation formed a small part of the non-breeding flock of three to four hundred swans that was present on Loch Bee throughout the year.

The flock was scanned until a collared bird was located. Where possible, individually marked birds were only observed once to avoid duplication. Choice of the uncollared birds however could not rule out duplication, but in each instance the bird chosen was the nearest one to the collared bird under observation. Observations of the two birds were carried out simultaneously for five minutes with the birds' behaviour recorded every ten seconds. Observations were made at various times throughout the day.

Behaviour was recorded initially as one of five categories; the first three being later amalgamated to produce one feeding category:

UPEND - a feeding behaviour, during which the birds upended, and the body was held vertically in the water, with the neck extended below the surface.

DABBLE - a feeding behaviour in which the neck was submerged but only to a shallow depth, as the body remained horizontal to the surface of the water.

DRINK - the neck was arched and the head and bill held parallel to the surface of the water, the lower mandible just in the water.

PREEN - care of feathers. The area preened was recorded, with flapping of the wings and ruffling of the feathers together classified as preening of a non-specific area.

SWIM - a combination of several behaviours. On both lochs birds remained on the water all the time, rather than coming out onto land, so swim included resting as well as active movement, and rare incidences of agonistic behaviour.

(b) Weights

The data for swan weights were taken from birds caught in moulting flocks in July 1979, August 1980 and August 1981 on Loch Ollay, South Uist; the site of the first series of behavioural observations. In 1981 additional data were also available from birds caught in the moulting flock at Loch an Duin (North Uist) in August, and for breeding adults from a selection of nesting territories in North and South Uist. Birds were weighed on a pesola balance to the nearest 100 g, the data for males and females being analysed separately. Only adult birds, known to be at least two years old, were included in the analyses.

(c) Breeding success

The breeding success of pairs of swans in which one or both adults had a collar was compared to that of uncollared pairs during 1981 and 1982. During the first years of the study the percentage of breeding pairs that contained a collared bird was very low, but by 1981 42.5% (51 of 120 pairs) had one or both adults collared, and in 1982 56.3% (67 of 119 pairs).

Nests were checked approximately every 14 days during the season, and cygnets caught for ringing in early September. Breeding success was measured as the percentage of nests that led to the production of at least one fledged young in September.

Results

(a) Behavioural observations

A total of 104 five-minute watches was made: 72 in July and 32 in November. Three watches were terminated early when the bird being observed either flew away or was lost in the flock. Consequently, the total number of behavioural observations recorded was 6197; 3094 for collared birds and 3103 for uncollared birds. Individual birds showed great variation in behaviour; the range being similar for collared and uncollared swans.

The data were pooled for collared and for uncollared birds to produce a pair of results for each location:
(a) Loch Ollay (July),
(b) Loch Bee (November).

Table 1 shows the frequency of behaviours observed for collared and uncollared swans at the two locations. Both showed a significant difference in the way collared and uncollared birds apportioned their time budgets, but the direction of change was not consistent. While the percentage of feeding observations remained similar, collared birds preened less frequently (and swam more often) than uncollared birds in July on Loch Ollay, but preened more frequently (and swam less often) than uncollared birds in November on Loch Bee.

Such was the reversal in frequency of preening and swimming, that when the data for the two locations were combined there was no significant difference between collared and uncollared swans. As might be expected the frequency of feeding increased greatly in winter for both categories of swans, whereas the frequency of preening was higher in July, during the moult period.

Detailed analysis of feeding methods (Table 2) showed that although there was no significant difference in the overall frequency of feeding, there was a significant difference between collared and uncollared swans in the relative frequency of the two feeding methods they employed. At both Loch Ollay and Loch Bee, collared birds dabbled more frequently and upended less often than uncollared birds. In November, both categories of swans used the dabble method of feeding on Loch Bee more frequently, and the upended method relatively less frequently, than they did in July on Loch Ollay.

Table 1. Frequency of behaviours observed for collared and uncollared Mute Swans on South Uist, Scotland. The numbers are pooled data from all the individuals observed at that particular location. The percentage of the total number of observations is given in parentheses. See text for definitions of the behaviours.

	Swim	Feed	Preen	Total	Significance
LOCH OLLAY (July 1980)					
Collared	1465 (69)	436 (20)	233 (11)	2134	$X^2_2 = 17.46$
Uncollared	1395 (65)	422 (20)	326 (15)	2143	$P < 0.001$
LOCH BEE (November 1980)					
Collared	328 (34)	552 (58)	80 (8)	960	$X^2_2 = 32.5$
Uncollared	379 (39)	556 (58)	25 (3)	960	$P < 0.001$
LOCH OLLAY & LOCH BEE					
Collared	1793 (58)	988 (32)	313 (10)	3094	$X^2_2 = 2.18$
Uncollared	1774 (57)	978 (32)	351 (11)	3103	N.S.

Table 2. Frequency of feeding methods used by collared and uncollared Mute Swans. See text for definitions of methods. Percentage of total feeding behaviour given in parentheses.

	Upend	Dabble	Significance
LOCH OLLAY			
Collared	132 (32)	286 (68)	$X^2 = 16.25$
Uncollared	187 (45)	227 (55)	$P < 0.001$
LOCH BEE			
Collared	92 (17)	441 (83)	$X^2 = 9.56$
Uncollared	136 (25)	409 (75)	$P < 0.01$

Table 3. Frequency of preening of different areas by collared and uncollared Mute Swans. Percentage of total preening given in parentheses.

	Neck	Breast	Wing (+Tail)	Back	Total	Significance
LOCH OLLAY						
Collared	69 (35)	27 (14)	70 (35)	32 (16)	198	$X^2_3 = 27.51$
Uncollared	55 (22)	23 (9)	77 (31)	95 (38)	250	$P < 0.001$
LOCH BEE						
Collared	15 (19)	8 (10)	39 (49)	18 (22)	80	$X^2_3 = 6.84$
Uncollared	6 (24)	1 (4)	17 (68)	1 (4)	25	N.S.

The areas of the body preened by collared and uncollared swans showed a significant difference in July, but not in November (Table 3). Collared swans preened the back (and tail) region significantly less frequently than uncollared swans in July with relatively more frequent preening of the neck region, wing and breast. In November, although not statistically significant, the trend was reversed, with collared swans preening the back (and tail) region more often than uncollared swans, with relatively less frequent preening of the wing area and neck.

(b) Weights

Table 4 gives the weights of adult birds caught in the moulting flocks in July 1979 (Loch Ollay), August 1980 (Loch Ollay) and August 1981 (Loch Ollay and Loch an Duin). The moult flocks consisted of first year birds, non-breeding adults, and also failed breeders that moved here from their breeding territory to moult. Only weights from these last two categories were included in the analyses. In each case collared swans had been wearing collars for at least a year before measurement. Since there were significant differences between both sex and

Table 4. Mute Swan weights. Data from adult birds caught in July 1979 and August 1980 in the moulting flock on Loch Ollay (South Uist). Data for 1981 are from Loch Ollay and also the moult flock on Loch an Duin (North Uist). Data for breeding adults came from various breeding territories on the Uists. Weights are given in kg.

	n	$\bar{x}$	S.D.	Significance
1979 – Male				
Collared	25	9.35	0.71	N.S.($t = 0.36$)
Uncollared	11	9.46	1.02	
1979 – Female				
Collared	14	7.89	0.42	N.S.($t = 1.50$)
Uncollared	9	8.31	0.91	
1980 – Male				
Collared	16	10.58	1.03	N.S.($t = 1.58$)
Uncollared	15	11.18	1.03	
1980 – Female				
Collared	19	8.79	0.79	N.S.($t = 1.79$)
Uncollared	10	8.24	0.81	
1981 – Male				
Collared	42	10.55	1.24	N.S.($t = 1.48$)
Uncollared	34	10.19	0.75	
1981 – Female				
Collared	24	8.76	0.91	$P<0.001$($t = 3.92$)
Uncollared	45	7.99	0.69	
1981 Breeding – Male				
Collared	7	12.73	0.66	N.S.($t = 1.14$)
Uncollared	12	11.97	1.68	
1981 Breeding – Female				
Collared	7	8.97	1.12	N.S.($t = 0.28$)
Uncollared	11	9.09	0.69	

Table 5. Mute Swan breeding success.

	Nested	Number of pairs fledged ≥1 cygnet	Failed	% Fledged at least 1 cygnet	Statistical significance
1981					
Collared	51	25	26	49.0	N.S.
Uncollared	69	32	37	47.8	$X^2 = 0.14$
1982					
Collared	67	40	27	59.7	N.S.
Uncollared	52	32	20	61.5	$X^2 = 0.14$

year classes these were analysed separately. In addition, in 1981 a small number of successful breeding adults were caught with their broods on their nesting territories and these have also been analysed separately.

The weights of collared males were slightly lower than those of uncollared males in 1979 and 1980, but higher in 1981. None of these differences was significant. Collared females were slightly lighter than uncollared females in 1979, but heavier in 1980 and 1981; the weights in the last year being significantly different. Neither the successful breeding males nor females in 1981 showed any significant differences between the weights of collared and uncollared birds.

(c) Breeding success

In 1981, 49% of nesting pairs with one or both members collared fledged at least one cygnet, compared to 47.8% of uncollared nesting pairs (Table 5). In 1982 breeding success was better than in 1981, with 59.7% of collared pairs and 61.5% of uncollared pairs successfully fledging at least one cygnet. There were no significant differences between collared and uncollared pairs in either year.

Discussion

Neckbands or neck collars have been most widely used in the United States on studies of geese and swans, but relatively little attention has been paid to possible impacts they may have on the birds' behaviour. Specific problems occasionally encountered include the chewing of the collar by certain species of geese (MacInnes *et al.* 1969), the formation of ice on collars during severe winter weather (Ballou & Martin 1964, Greenwood & Blair 1974), and the obstruction of the throat and catching of the lower mandible under the collar, in certain species of duck (Cottam 1956). Other potential problems include public reaction to the aesthetics of such an obvious form of marking, and the selective shooting by hunters, of geese with collars on (Craven 1979).

Only Ankney (1975) has suggested that neckbands might contribute to starvation (in female Lesser Snow Geese *Chen caerulescens*) but his conclusions were disputed by Raveling (1976). Ankney did no direct behavioural observations on the geese, but reported a higher than expected percentage of starving females during incubation. This, he suggested, was due to the birds spending time nibbling the collars (made of Aluminium) and although the collars did no physical harm, the birds spent less time feeding.

Our own observations on Mute Swans showed that neck collars did not affect the frequency of feeding, but may have affected the type of feeding method used. Whether the upend:dabble ratio is an important factor in feeding efficiency may depend on the relative food gathering success of the two techniques and the availability of vegetation at different depths. Upending permits a swan to feed on plants at a greater depth than dabbling, and hence the lower percentage of upending recorded for collared swans could place them at a disadvantage relative to uncollared birds. This difference in the frequency of use of these two feeding methods was observed in July and in November, despite the fact that the birds were feeding on different plant species at the two study sites. However, the differences detected in feeding method need not imply any diet differences. It could be that swans take what food they require anyway and those with collars find one method more comfortable. The data do not show that collared birds would continue to use one particular method in circumstances

where that method impaired their rate of intake.

Behavioural differences might also be expected, both between sexes and between young and old birds. This could bias the result were the sample of collared and uncollared swans markedly different in these respects. An analysis of the data from the 63 moulting birds caught on Loch Ollay after the end of the first set of observations showed that not to be the case however. Birds in their second year formed 9.7% of the uncollared swans, and 9.4% of those already collared. Similarly the sex ratio between the collared and uncollared swans was not significantly different (Collared 1♂:1.13♀, Uncollared 1♂:0.72♀; $X^2 = 0.43$).

No data were available on the uncollared swans in November, but the collared swans did show certain differences in their behaviour patterns. Collared adult males spent less time feeding (and more preening) than collared adult females ($X^2 = 76.49$; $P<0.001$), but the ratio between upending and dabbling was the same for each sex ($X^2 = 1.03$; N.S.). Collared birds in their second year were observed feeding more frequently (and preening less) than collared adults ($X^2 = 92.6$; $P<0.001$), as might be expected. However, they also showed a significant difference in feeding method, upending less and dabbling more than collared adult birds ($X^2 = 22.5$; $P<0,001$).

The weights of collared and uncollared swans were not significantly different, with the one exception of females in 1981 where collared birds were heavier than uncollared ones. This may indicate that the differences in feeding methods employed are not important. However, weights were only measured in late summer, when food was relatively abundant. During periods of severe food shortage differences in feeding methods could possibly become more critical.

Several authors have reported problems with neckbands being chewed by geese, MacInnes *et al.* (1969) recording that plastic collars were chewed from two inches to less than one inch width in a year. No such problems were encountered with the neck collars used in this study. Immediately after collaring, swans frequently pecked around the collar, though this may have been partly due to excess glue on the feathers; this behaviour stopped soon after, the collar being left to slide up and down the neck freely. Close examination of all collared birds recaught or found dead has revealed no scarring or nibbling of the collar, and no damage to the neck feathers of the birds themselves.

The frequency of preening observed in collared and uncollared swans showed significant differences at both times of year, but the direction of change was reversed. Similarly, no consistent pattern emerged between collared and uncollared swans when the area being preened was analysed. There is no evidence to support a hypothesis that collared birds might spend more time preening due to the presence of their collars. In fact, during the moult period, collared swans preened significantly less frequently than uncollared birds, the main difference being in attention paid to the back and tail.

During November when collared swans did preen more frequently than uncollared ones, there was no significant difference in the relative frequency of preening of the different parts of the body and, indeed, during the November watches no collared swans were seen nibbling or preening the collar itself.

Lensink (1968) has suggested that neck collars may have caused an apparent decline in the productivity of Black Brant *Branta bernicla* by disrupting pair bonds. Abraham *et al.* (1983) also suggested this was due to a lowering of the success of collared swans in agonistic encounters, while Hawkins & Simpson (1985) have reported an incident where a neckband was a handicap in an aggressive encounter between a pair of Tundra Swans *Cygnus columbianus*. While we have little direct data on pair formation or establishment and defence of territory, collars were not observed to play any part in such courtship behaviour, nor in success or otherwise of agonistic encounters between Mute Swans in the study area. Analysis of breeding success also confirmed that pairs with either one or both members collared bred as successfully as uncollared pairs. It is interesting to note that in a study of Mute Swans in Denmark using similar collars, there is apparent evidence that collared swans may have a higher breeding success than uncollared birds (Bacon pers. comm.).

The main advantage to be gained in the use of neck collars as opposed to other forms of recognition on birds is the oppor-

tunity it gives to identify individual birds at very long distances. Not only does this mean birds can be observed more easily without disturbing them or affecting their behaviour, it may be the only suitable method to study wild species which do not tolerate close approach by humans in open habitats. Mathiasson (1981) for instance used neck collars in a study of Mute Swans moulting in open coastal areas of eastern Sweden. The collars allowed him to identify different categories of swans (floating population, attempted breeders and breeders) within the moulting flocks, and to build up a detailed picture of the demographic structure of the flocks, as well as studying the behaviour and subsequent movements of the different categories.

Neck collars are particularly useful in the study of long distance movements and migrations of geese and swans, since they are seen readily and reported by amateur ornithologists in different areas and countries along a migration route. Even putting neck collars on a relatively few birds in a migratory population can lead to major advances in our understanding of bird movements (Brazil 1983). Gardarsson (1991) was able to describe the movement pattern of Whooper Swans, neck collared on their moulting grounds in Iceland, to their wintering grounds in northwest Europe. A resighting rate of 65% in the first year was obtained, despite the geographical spread and political boundaries that the swans traversed.

Neck collars also produce results much more rapidly than is possible with leg rings. Preuss (1981), for instance, reported that of 116 Whooper Swans *Cygnus cygnus* caught in Denmark in 1979 and fitted with neck collars, 22.4% (26) were seen abroad during the next year (some individuals several times). This compared with a recovery rate abroad of only 9% (24) of the 266 swans previously ringed with only leg rings in the whole 25 year period up to 1979 in Denmark. Furthermore, the increased visibility of collars removes some of the problems of bias inherent in studies based predominantly at sites where birds are deliberately attracted, and then induced to come close enough to observers so that leg rings can be read in the field.

When birds come readily to locations close to human activity or are deliberately attracted to special viewing areas, there is a risk of adverse public reaction to the aesthetics of using neck collars. Without adequate explanation this may outweigh the advantages to be gained from improved visibility or increased rates of resightings and recoveries of marked birds. This must be taken into account before selecting neck collars as the means of marking swans or geese. In such circumstances the use of leg rings might be a more appropriate method of individual marking.

The work on Mute Swans in the Outer Hebrides was financed by an N.E.R.C. grant awarded to Professor G.M. Dunnet at Aberdeen University. The neck collars were made by Robert Donaldson at Culterty Field Station. Catching of swans in the Hebrides was made possible by the help of over 100 individuals, as well as groups from the R.A. Range Benbecula, the Brathay Exploration Group, Schools Hebridean Society and colleagues from Culterty Field Station. Additional observations on marked swans were made by Helen Bradley, Kate Goudie, Andrew Wilson and Tom Bladen, who along with K. Bayes were supported by Glasgow University Expedition Society.

The study of swans on the Hebrides was made possible by the cooperation of the North Uist Estates, South Uist Estates and the Department of Agriculture and Fisheries Scotland on whose properties we worked, as well as the crofters of the Uists who allowed us free access to their lands.

We would also like to thank Professor George Dunnet and Dr Philip Bacon for commenting on an earlier draft, and two anonymous referees for their valuable comments.

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