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EFFECTS OF NECK BANDS ON CANADA GEESE NESTING AT THE McCONNELL RIVER

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Abstract.—Canada Geese (*Branta canadensis*) neck-banded at McConnell River, Northwest Territories were recaptured on the nesting grounds less frequently than geese leg-banded at the same locality. The difference could result from increased mortality, or emigration of neck-banded geese to nest elsewhere. Our data cannot distinguish between these causes, because other factors confounded the analysis. Hunters recovered the same proportions of neck-banded and leg-banded geese despite the fact that fewer neck-banded geese were recaptured. That could result from enhanced reporting due to neck bands, or hunter selection for visibly marked geese. There were no consistent detrimental effects on reproductive performance of neck-banded geese. Assessment of effects of neck bands should be included in the design of any study that uses such bands.

EFECTOS DE BANDAS EN EL PESCUEZO EN GANSOS DEL CANADA

Resumen.—Gansos del Canada (*Branta canadensis*) marcados en el Rio McConnell (Canada), con bandas en el pescuezo, fueron recapturados con menor frecuencia que gansos anillados en sus patas. La diferencia puede ser atribuida a mayor mortalidad de los gansos que fueron anillados en el pescuezo, o a la migración de estos (particularmente machos) a otras áreas de anidaje. La data obtenida no puede diferenciar entre posibles causas, dado el hecho de que otros factores confunden el análisis. Los cazadores por ejemplo, recobraron la misma proporción de gansos anillados en el pescuezo o en las patas, aunque esto podría ser el resultado de informar con preferencia a aves con marcas en el pescuezo, o a el preferir cazar aves con una marca bien visible. No se encontraron efectos detrimentales en la reproducción de aves que fueron anilladas en el pescuezo. El posible efecto de anillas en el pescuezo debe ser considerada en el diseño de cualquier estudio que incluya el uso de las mismas.

Neck bands can provide special insight into the long-term reproductive performance and survival of geese, provided that the bands themselves do not affect the parameters under study. Neck bands may increase mortality (Ankney 1975, 1976; Zicus et al. 1983), reduce frequency of nesting (Lensink 1968, although based on very small samples), or influence aggressive encounters (Hawkins and Simpson 1985). However, those papers describe specific instances, and there is uncertainty about whether all goose species are affected in all studies. Reproduction may not be affected at all (Chabreck and Shroer 1975).

MacInnes and Lieff (1968) reported that neck-banded Canada Geese (*Branta canadensis,* of a small race in the *hutchinsii-parvipes* complex, MacInnes 1966) were recaptured at lower rates that leg-banded geese. Here we re-examine the problem in greater detail, including data from later years. We investigated mortality, based on hunter recoveries, recapture rate on the breeding grounds and effect of neck bands on pairing and reproduction.

METHODS

Canada Geese were caught during their primary molt at the McConnell River, Northwest Territories (60°50′N, 94°25′W) from 1964–1971 (see MacInnes et al. 1974). All unbanded birds were given U.S. Fish and Wildlife Service aluminum leg bands. In addition, neck bands were put on some adults in 1964, and in later years, on all birds large enough to retain them. We kept goslings in a separate holding pen so that all adults and young could be released together; goslings too small to retain neck bands shed them there. Neck bands applied in 1964–1965 were plastic, whereas later bands were aluminum (MacInnes et al. 1969). Any bird captured after 1965 was given a new metal neck band if the old one was plastic, defaced, or lost, or if the bird had not previously had a neck band.

Recapture of a bird was tallied only on the first instance of capture in a year subsequent to the year of banding. If a leg-banded goose was later recaptured and given a neck band, it was recorded as a leg-band recapture, but was then added to the pool of newly neck-banded birds so that it might later be encountered as a recaptured neck band. Neither recapture nor recovery rate differed between the plastic and metal neck bands, so results are combined in this paper. However, we arbitrarily chose to tally as neck-banded all birds that had lost neck bands before recapture or recovery. Although aluminum neck bands were almost never lost (<0.1% annually), about 25% of plastic neck bands fell off each year. Our arbitrary correction may therefore have masked an additional effect of plastic neck bands.

We observed geese from elevated towers, and throughout the day we counted broods in families with one or both adults neck-banded. Brood counts of pairs without neck bands were derived from surveys made during early morning and late evening, when visibility was best (MacInnes et al. 1974). In this paper, comparisons of brood counts between unbanded and neck-banded pairs were made for the one day each season on which the largest number of broods was seen (always within the week just before banding began). Because pairs without neck bands that had lost whole broods could not be identified as such, comparison of brood size was made only for pairs with at least one gosling.

RESULTS

Recovery rate of geese neck-banded as adults was similar to that for adults leg-banded alone (Table 1; $P > 0.05$; χ^2 corrected for continuity, Snedecor and Cochrane 1967). Neither recovery rate differed between the sexes. Annual recovery rates of neck-banded adults ranged from 20–33%, but did not vary significantly among years ($P > 0.05$). Similarly, leg-banded goslings from 1964 (when all sizes of gosling were leg-banded only) were not recovered at different rates than neck-banded goslings, and the sexes did not differ.

Recovery rates of gosling females leg-banded in 1965–1971, when only small individuals were given leg bands alone, were lower than those of

TABLE 1. Percent of Canada Geese banded at the McConnell River that were recovered dead elsewhere.[a]

Band type[b]	Adult (both sexes)		Gosling			
			Male		Female	
	No. banded	Percent recovered	No. banded	Percent recovered	No. banded	Percent recovered
Neck band (1964–1971)	1102	26	611	29	540	33
Leg band (1964)	39	33	87	21	88	23
Leg band (1965–1971)	—	—	350	23	557	17

[a] Recoveries reported to the Bird Banding Laboratory (U.S. Fish & Wildlife Service) through 1983. Numbers of leg-banded birds include only those birds never given a neck band (i.e., never recaptured).

[b] All goslings banded in 1964 received leg bands alone, whereas in 1965–1971 only those too small to retain a neck band were given a leg band alone.

leg-banded males from the same years and lower than those of neck-banded goslings of both sexes ($P < 0.05$).

Recapture rates on the nesting ground were compared only for 1965–1969, as geese banded in the last 2 yr of study had little chance of being recaptured. Adults leg-banded in 1964 were recaptured twice as frequently on the breeding grounds as neck-banded adults ($P < 0.005$, Table 2), and there were no differences in rates between the sexes. Similarly, gosling females leg-banded in 1964 were recaptured at a much higher rate than gosling females neck-banded in later years. Gosling females leg-banded in other years, however, when only small individuals were leg-banded, had similar recapture rates to neck-banded gosling females. Recapture rates of gosling males did not differ among band types. In all cases, differences in recapture rates showed in the first summer following the year of banding. Once leg-banded adults had been recaptured once and given a neck band, they did not differ in subsequent recapture rates from originally neck-banded birds that had also been recaptured once.

If both members of a breeding pair were neck-banded, the pair initiated egg-laying one day later than unmarked pairs ($P = 0.02$, Table 3). Pairs with only the male neck-banded also tended to nest a day later ($P = 0.08$), whereas pairs with only the female neck-banded did not, suggesting that the delay of egg-laying was affected by the males. There were no significant differences in clutch size, despite different initiation dates (Table 3).

Brood size at about three weeks of age was compared for neck-banded and unmarked pairs. In three of the four years with data there was no difference in brood size, but in the fourth, neck-banded pairs averaged one less gosling than unmarked pairs ($P = 0.04$, Table 4).

DISCUSSION

The combination of low recovery (Table 1) and recapture rates (Table 2) of female goslings leg-banded after 1964 (when only small birds received leg bands alone) suggested that those birds were subject to high

TABLE 2. Recapture and recovery rates of Canada Geese banded at the McConnell River, by band type, age, and sex.[a]

Age and sex at banding	Band type[b]	Total banded	Percent of total: Recaptured at the McConnell	Percent of total: Recovered without recapture	Percent of total: Not recaptured or recovered (% seen[c])
Adult	Neck band (1964–1969)	1043	20 ***	21	58 (20) ***
	Leg band (1964)	66	42	20	38
Gosling male	Neck band (1965–1969)	399	5	26	66 (13)
	Leg band (1964)	95	4	21	75
	Leg band (1965–1969)	302	4	25	71
Gosling female	Neck band (1965–1969)	407	7 ***	36 *	57 (11)
	Leg band (1964)	107	18 ***	19	64
	Leg band (1965–1969)	440	6	18	76

[a] Asterisks between values indicate significant differences (χ^2, $P < 0.05$ = *, $P < 0.005$ = ***).

[b] Leg bands alone were put on all goslings in 1964, but thereafter only on goslings too small to retain a neck band.

[c] Percent of neck-banded birds identified by neck-band code at the McConnell River, but never recaptured or recovered.

mortality before the beginning of their first hunting season. Such early mortality may have been natural, related to the birds' smaller size, or could have resulted from the mass-banding process itself. It is not clear why the effect was absent in undersized males, but our recapture samples are small. The particularly low recapture rate of all gosling males supports the hypothesis that young males mate during spring migration and follow their chosen female to her natal area (MacInnes and Lieff 1968).

Because of the special nature of goslings receiving leg bands alone in 1965–1971, it is only appropriate to compare recovery and recapture rates of neck-banded goslings with those for leg-banded goslings from 1964 (a fact not appreciated in MacInnes et al. 1974:701). Similarly, adult data can only be compared to leg-band data from 1964, as that was the only year when leg bands alone were applied. The following discussion is based on the assumption that the 1964 leg-band sample was indeed representative, and not influenced by factors peculiar to that year.

Neck-banded birds were generally recaptured at half the rate of 1964 leg-banded birds (Table 2). One possible cause is reduced catchability. There were relatively large numbers of neck-banded geese seen at McConnell that were never recaptured or recovered (Table 2). However, we think it very unlikely that neck-banding a bird should have made it markedly less catchable than leg-banding, as trapping and handling pro-

TABLE 3. Effect of neck band status on date of clutch initiation and clutch size.[a]

Source of variation	Difference from mean[b]	*F*	*n*	*P*
Date of clutch initiation				
Neck-banded male only	1.49	3.07	14, 69	0.08
Neck-banded female only	−0.49	0.73	30, 69	0.40
Neck-banded male × neck-banded female	1.15	5.54	68, 69	0.02
Clutch size				
Neck-banded male only	−0.11	0.10	14, 69	0.75
Neck-banded female only	0.20	0.75	30, 69	0.39
Neck-banded male × neck-banded female	−0.16	0.75	115, 69	0.39

[a] ANOVA of date of clutch initiation and clutch size with year and marking status of pair. All comparisons made with pairs in which neither bird was neck-banded. Year had a significant effect in each ANOVA (not shown in table). Column headings starting with *F* are: *F*-ratio, sample size, probability.

[b] Difference from mean value for pairs without either adult neck-banded ($n = 69$), after correction for independent effects of year. A negative date of first egg indicates earlier nest initiation.

cedures were otherwise the same. Moreover, there was no increase in the numbers of birds seen but not recaptured over the course of the study, as would be expected if catchability of neck-banded birds was reduced. We assume for the remainder of this discussion that neck bands had some other effect.

Low recapture of neck-banded geese could indicate either higher mortality or lowered likelihood of returning to nest in the McConnell area. If reproductive behavior was disrupted, then birds might have left the McConnell area prior to banding drives. Alternatively, neck-banded birds

TABLE 4. Effect of neck band status on brood size.[a]

Year	Mean brood size[b]	*F*	*n*	*P*
1967				
Neck-banded pairs	2.76	4.86	17	0.04
Non-neck-banded pairs	3.87		16	
1968–1970				
Neck-banded pairs	3.18	1.59	56	0.21
Non-neck-banded pairs	3.50		34	

[a] ANOVA of pairs with either or both birds neck-banded compared to pairs with no neck bands. Only pairs with at least one gosling were included in the analysis. Column headings as in Table 3.

[b] Corrected for year, which had a highly significant effect in the multi-year analysis.

might have emigrated and bred elsewhere. Other analyses of the effects of markers have sometimes ignored this range of possibilities (e.g., Howe 1980).

Increased non-hunting mortality or reduced chance of recapture at the McConnell area should be distinguishable by their different effects on recovery and recapture rates, as shown in Table 5. Unfortunately, there are two important biases that could alter recovery rates, making it difficult to interpret our results. Hunters may be more likely to report neck-banded than leg-banded birds to the Bird Banding Laboratory, and hunters may selectively shoot visibly marked geese (Craven 1979). Either bias would increase the recovery rate of neck-banded geese, but only hunter selectivity would decrease the recapture rate of these birds. Raveling (1978) estimated a reporting rate of neck-banded Canada Goose recoveries similar to that for leg-banded birds, but Craven (1979) found nearly twice the recovery rate of neck-banded over leg-banded Canada Geese in two of four years. Craven found no difference in recapture rates in a single sample of 51 recaptured birds, suggesting that reporting bias was important. As 20–25% of hunters in Craven's study reported being conscious of seeing neckbands before they shot, hunter selection may also have been important. We conclude that there is no clear evidence from other studies to help us estimate the importance of potential biases in our own data.

Predicted effects of these biases in combination with possible effects of neck bands are shown in Table 5. The tabulated predictions are mutually exclusive for each set of conditions described, but in reality several of these effects may be confounded.

Our data for geese neck-banded as adults are consistent with the predictions for neck bands causing mortality, combined with reporting bias. Data for neck-banded female goslings better fit the predictions for reduced chance of nesting at the McConnell River, combined with reporting or selection bias in the data. Male goslings were apparently unaffected by neck bands, but their low rate of return to the McConnell area gave us very small samples. It would be surprising if neck bands had very different effects on adults than on goslings, and neck bands seem more likely to cause some combination of mortality and/or disruption of breeding in both groups. Although about half the neck-banded birds were affected, it is important to keep in mind that at least some of these may have nested normally away from the McConnell River study area.

We have assumed thus far that our sample of leg-banded geese is adequate, despite its short (1 yr) sample period. This problem, combined with possible biases in recovery rates, makes it impossible to determine conclusively whether neck bands had negative effects on Canada Geese. Our data are suggestive but should not be taken as certain evidence that neck-banding causes mortality and/or disruption of breeding. Our support is good, however, for the conclusion that neck bands did not negatively affect performance of those neck-banded birds that did return to nest at the McConnell River study area. New mates with and without neck bands were chosen in proportion to their numbers in the study area,

TABLE 5. Predictions for signs of ratios of recapture and recovery rates of neck-banded geese to those of leg-banded geese; with and without assumption of positive reporting bias or hunter selectivity of neck-banded birds (see text). Zero indicates prediction of the same rates for both groups, – – indicates particularly severe effect of neck bands. Parentheses mean that predictions would depend on degree of difference in other rates.

		Table 2 data		
Effect of neck bands	Recovery rate (Table 1)	Recaptured at McConnell	Recovered without recapture	Neither recovered nor recaptured
None	0	0	0	0
With report bias	+	0	+	–
With selection bias	+	–	+	(0)
Mortality	–	–	–	+
With report bias	(0)	–	(0)	(+)
With selection bias	(0)	– –	(0)	–
Reduced chance of breeding at McConnell	0	–	+	(0)
With report bias	+	–	+	(0)
With selection bias	+	– –	+	(0)

indicating that pair formation was not affected by neck bands. The proportion of neck-banded non-breeders remaining on the nesting area was also similar to that in leg-banded populations (MacInnes and Dunn 1988).

We have suggested that neck bands may cause important non-hunting mortality in Canada Geese, result in birds moving away from the breeding area (where they may or may not breed), or perhaps reduce catchability of neck-banded geese that have returned to nest. Such effects should be considered during analysis and interpretation of studies in which geese are neck-banded. Reporting bias and hunter selection of marked birds will unfortunately confound such analyses. It is therefore important to test the effects of neck bands as an integral part of each study of neck-banded geese, rather than *post-facto,* as in this paper. Investigators must plan carefully, so that adequate samples of marked and unmarked birds are encountered in the years following banding. Although we were unable to provide conclusive evidence of negative effects of neck-banding, we hope our discussion of the difficulties in assessing such effects will stimulate others to undertake more extensive studies.

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