J. Field Ornithol., 62(4):521-527

# NECK COLLAR RETENTION IN DUSKY CANADA GEESE

BRUCE H. CAMPBELL AND EARL F. BECKER
*Alaska Department of Fish and Game*
*333 Raspberry Road*
*Anchorage, Alaska 99518 USA*

Abstract.—A total of 4965 Dusky Canada Geese (*Branta canadensis occidentalis*) were neck-collared on the Copper River Delta, Alaska, in 1984–1990. Collar retention rates for adult geese were obtained from examination of 910 recaptures. The effects of sex, collar age and collaring year on retention rates were determined using logit models. As there was a significant interaction between the effects of sex and collar age on retention rates, the sexes were modeled separately. The average annual retention rate for female geese (0.875 ± 0.163 SE) was independent of all effects considered. Retention rates for males was influenced by collar age and the year collared. It is concluded that collar losses were substantial and that losses specific to the years modeled should be considered in any population model.

**RETENCIÓN DE ANILLOS EN EL PESCUEZO POR PARTE DE INDIVIDUOS DE *BRANTA CANADENSIS OCCIDENTALIS***

Sinopsis.—Entre el 1984–1990 un total de 4965 individuos de gansos del Canada (*Branta canadensis occidentalis*) fueron anillados en la pescuezo en el delta del Río Copper, Alaska. La retención de las anillas, por parte de adultos, fue obtenida del estudio de 910 individuos recapturados. El efecto del sexo, edad de la anilla y año de la anillada, en la tasa de retención de anillas, fue determinada utilizando modelos de "logit." Como hubo una interaccion significativa entre el efecto del sexo y edad de la anilla, en la tasa de retención, se hicieron modelos separados para ambos sexos. La retención promedio anual para hembras (0.875 + 0.163 EE) resultó ser independiente de todos los otros efectos considerados. La tasa de retención en los machos fue influenciada por la edad de la anilla y el año de anillamiento. Se concluye que las pérdidas de las anillas fue sustancial, y que los extravíos en años particulares deben ser consideradas en cualquier modelo poblacional.

Neck collars have been used to mark geese for several decades (Marion and Shamis 1977). Observations of these birds have provided much valuable information about population dynamics (Hestbeck and Malecki 1989, Rusch et al. 1985), migration (Craven and Rusch 1983, Koerner et al. 1974, Raveling 1978, Trost et al. 1980), and behavior (MacInnes and Lieff 1968). Recently, observations of marked geese have been applied in methods used to estimate survival probabilities (Ebbinge and van Biezen 1987, Hestbeck and Malecki 1989, Raveling and Zezulak 1988, Rusch et al. 1985, Yparraguirre 1982), statistics that have traditionally been calculated from models utilizing band recovery data (Brownie et al. 1985). These models generally do not account for marker loss (Brownie et al. 1985, Pollock and Raveling 1982), which is probably of little consequence for-short lived species. In the case of potentially long-lived animals such as geese, however, marker loss may severely affect survival estimates (Nelson et al. 1980).

The Dusky Canada Goose (*Branta canadensis occidentalis*), which nests primarily on the Copper River Delta, Alaska, and winters in the Willamitte Valley in Oregon and southwestern Washington, has steadily declined in number since 1979. Harvest was restricted in 1984 and is presently minimal. Survival rates for the Dusky Canada Goose were estimated during an early period of liberal hunting regulations (Chapman et al. 1969), but lack of band recoveries under current harvest restrictions has precluded further analysis. In response to the need for current survival estimates, observations of neck-collared geese are currently being used to estimate survival rates (R. Jarvis, pers. comm.). This paper presents a collar-retention model that we believe should be considered in the computation of survival statistics.

## METHODS

In 1984–1989 we neck-collared 4108 adult Dusky Canada Geese on the Copper River Delta (Table 1). Collars were made of 1.5-mm thick, 2-ply vinyl plastic, measured 64 mm wide × 180 mm long, and individually labelled with engraved characters. They were heat-formed to 3.4 cm diameter and attached by fusing the overlap with plastic cement. All birds were also marked with U.S. Fish and Wildlife Service metal leg bands. Neck collar retention was determined from examination of recaptured geese. As poor reproduction limited the number of goslings available for marking, only collar retention of adult geese was modeled.

The effects of sex, age of collar and the year of collaring on collar retention were examined using logit models for categorical data (Agresti 1984). The response variable was the logit of geese that had retained their collars to those which had lost collars (ln [number of retained collars/number of lost collars]). Possible explanatory variables included sex, age of collar, year of collaring and all higher order interaction terms of these variables. A backward elimination procedure (Agresti 1984) was used to determine the most parsimonious model that adequately describes the data. Variables were dropped from the model if they were not significantly different from zero at $\alpha = 0.05$. Lower-order interaction terms were not considered unless all higher order interaction terms for which they were a subset had already been eliminated.

## RESULTS

We examined 910 recaptured geese for neck collar retention in 1985–1990 (Table 1). With the possible exception of collaring year 1984, for which only 85 collared birds were recaptured over a 6-yr period, sample sizes for each year of neck collaring seemed to be adequate for statistical analysis. There was a significant ($G^2 = 36.23$, df = 10, $P = 0.001$) interaction between the effects of sex and collar age on retention rates, therefore models for each sex were developed.

The most parsimonious model ($G^2 = 26.94$, df = 20, $P = 0.14$), which adequately explained the data for female geese, was an average annual retention rate, independent of all other explanatory variables considered. This rate was 0.875 ± 0.163 (SE). The most parsimonious model ($G^2 = 11.80$, df = 14, $P = 0.62$) explaining collar retention for males was a function of an average retention rate ($\theta$), a linear effect ($\beta$) of collar age ($v_i$), and year collared ($\lambda_j$). This model is:

TABLE 1. Annual collar retention and losses for adult Dusky Canada Geese marked on the Copper River Delta, Alaska, 1984–1989.

| | | | Years after collaring | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | |
| Year collared | Sex | Number marked | Retained | Lost | Retained | Lost | Retained | Lost | Retained | Lost | Retained | Lost | Retained | Lost |
| 1984 | M | 217 | 7 | 6 | 1 | 5 | 1 | 7 | 0 | 5 | 0 | 8 | 0 | 5 |
| | F | 184 | 1 | 3 | 10 | 1 | 5 | 1 | 8 | 1 | 5 | 1 | 3 | 1 |
| 1985 | M | 1056 | 50 | 2 | 28 | 2 | 31 | 23 | 24 | 36 | 3 | 38 | | |
| | F | 911 | 30 | 1 | 20 | 1 | 21 | 1 | 36 | 4 | 18 | 2 | | |
| 1986 | M | 255 | 9 | 2 | 15 | 5 | 6 | 9 | 0 | 3 | | | | |
| | F | 199 | 14 | 0 | 13 | 1 | 10 | 1 | 4 | 2 | | | | |
| 1987 | M | 261 | 18 | 1 | 25 | 5 | 1 | 6 | | | | | | |
| | F | 193 | 14 | 1 | 13 | 1 | 10 | 1 | | | | | | |
| 1988 | M | 229 | 45 | 2 | 16 | 1 | | | | | | | | |
| | F | 178 | 28 | 1 | 12 | 1 | | | | | | | | |
| 1989 | M | 248 | 29 | 1 | | | | | | | | | | |
| | F | 177 | 14 | 0 | | | | | | | | | | |

TABLE 2. Modifying parameters for age of collar for each collar cohort of adult male Dusky Canada Geese marked on the Copper River Delta, Alaska, 1984–1989.

| Parameter | Estimate | SE | $Z$ | 95% CI |
|---|---|---|---|---|
| $\theta$ | −0.9040 | 0.3229 | −2.7995 | −0.7684, −0.1354 |
| $\lambda$ 1984 | −2.4092 | 0.4387 | −5.4915 | −1.6345, −0.7746 |
| $\lambda$ 1985 | 0.8555 | 0.3454 | 2.4770 | 0.0893, 0.7662 |
| $\lambda$ 1986 | −0.3087 | 0.3594 | −0.8589 | −0.5065, 0.1979 |
| $\lambda$ 1987 | 0.0391 | 0.3638 | 0.1074 | −0.3370, 0.3761 |
| $\lambda$ 1988 | 1.0140 | 0.5427 | 1.8685 | −0.0248, 1.0389 |
| $\lambda$ 1989 | 0.8092 | 0.8734 | 0.9265 | −0.4514, 1.2606 |
| $\beta$ | −1.3844 | 0.1516 | −9.1332 | −0.8408, −0.5437 |

$$\ln(N_{1ij}/N_{2ij}) = \theta + \beta(v_i - \bar{v}) + \lambda_j + \epsilon_{ij}$$

where $i$ indexes collar age ($i = 1, 2, \ldots, 6$), $\bar{v}$ indicates mean collar age (3.5), and $j$ indexes year collared ($j = 1984, 1985, \ldots, 1989$), $N_1$ is the number of collars retained, $N_2$ is the number of collars missing, and $\epsilon$ represents the random error term. The parameter estimates and standard errors used in this model are listed in Table 2. The odds of an adult male goose retaining a collar were converted to retention probabilities (Table 3) by the logistic function:

$$P(\text{collar retained 1 yr} = i, \text{age} = j) = \exp(\theta + \beta\,[v_i - \bar{v}] + \lambda_j) \div 1 + \exp(\theta + \beta\,[v_i - \bar{v}] + \lambda_j)$$

## DISCUSSION

Population models for geese, based on neck collar observations, have generally been developed without regard for marker loss though several investigations have suggested that such losses may be significant (Craven 1979, Fjetland 1973, Raveling 1978, Raveling and Zezulak 1988). The results of this investigation not only indicate a sizable annual collar loss for adult Dusky Canada Geese, but that the rate of that loss varies between the sexes and, in the case of males, between collar cohorts.

To our knowledge, only three other studies have reported differing collar retention rates between male and female Canada Geese. Although his results have been questioned (Zicus and Pace 1986), Fjetland (1973) reported that female Canada Geese marked at Seney National Wildlife Refuge retained their collars at a higher rate than males. Females have also been reported to retain their collars more frequently than males in the Mississippi Flyway (Samuel et al. 1990). Johnson and Sibly (1989) reported a similar situation with feral Canada Geese in Great Britain. Johnson and Sibly (1989) suggested that these differences may occur because males are more successful in removing collars due to their larger size and greater strength, and Samuel et al. (1990) suggest that aggression during breeding may contribute to greater collar losses in males.

Intraspecific aggression is suspected to be the primary cause of higher

TABLE 3. Estimated probability of collar retention for adult male Dusky Canada Geese marked on the Copper River Delta, Alaska, 1984–1989.

| Year collared | Retention probability | | | | | |
|---|---|---|---|---|---|---|
| | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 |
| 1984 | 0.518 | 0.350 | 0.212 | 0.012 | 0.063 | 0.033 |
| 1985 | 0.846 | 0.734 | 0.580 | 0.408 | 0.257 | |
| 1986 | 0.755 | 0.606 | 0.435 | 0.278 | | |
| 1987 | 0.786 | 0.647 | 0.478 | | | |
| 1988 | 0.856 | 0.734 | | | | |
| 1989 | 0.843 | | | | | |

collar loss rates for male Dusky Canada Geese. Male Canada Geese are not only larger, but more aggressive than females, especially during the breeding period (Raveling 1970). We have observed physical aggression between male Dusky Canada Geese on the breeding grounds including pulling and dragging by the neck collar. Aggression might be further stimulated by relatively high nest densities. Dusky Canada Geese have some of the highest nest densities reported for a mainland nesting subspecies of Canada Geese (Bromley 1976, Cornely et al. 1985), a situation known to stimulate aggression between pairs (Ewaschuk and Boag 1972). Although undocumented, aggression on the wintering grounds, where Dusky Canada Geese mix with nearly 60,000 other Canada Geese (Jarvis and Cornely 1988), may also contribute to collar loss.

The cause of varying retention rates between collar cohorts for adult males is harder to explain. While retention rates varied considerably during the study, there was similarity between several of the cohorts. Retention of collars by the 1984 cohort was unlike any other year, but the 1986 and 1987 cohorts had similar rates as did the 1985, 1988 and 1989 cohorts (Table 3). Annual variation in the quality of material used for collars, method of collar formation or collar attachment might cause variation in retention rates between cohorts. Samuel et al. (1990) demonstrated that materials can influence collar retention rates. These influences should not be sex-specific, however, unless the additional stress placed on collars by males accentuates them.

Regardless of the causes, the variation in collar retention between sexes and the multiplicative change in retention rates for males prohibits development of mean collar retention rates for adult Dusky Canada Geese. This, in combination with the relatively substantial annual collar loss, indicates that any population modeling study based on collar sightings should include provisions to measure and correct for collar loss.

## ACKNOWLEDGMENTS

We thank our colleagues at the Oregon Department of Fish and Wildlife, Washington Department of Wildlife, Region 1 of the U.S. Fish and Wildlife Service, Oregon State University, Alaska Department of Fish and Game, as well as many private individuals for assistance with banding and data collection. We also thank the Washington Department of Wildlife for funding assistance and R. C. Leberman and G. M. Haramis for their helpful comments and suggested revisions of this paper.

## LITERATURE CITED

AGRESTI, A. 1984. Analysis of ordinal categorical data. John Wiley & Sons, New York, New York. 287 pp.

BROMLEY, R. G. H. 1976. Nesting and habitat studies of the Dusky Canada Geese (*Branta canadensis occidentalis*) on the Copper River Delta, Alaska. M.Sc. thesis. Univ. Alaska, Fairbanks, Alaska.

BROWNIE, C., D. R. ANDERSON, K. P. BURNHAM, AND D. S. ROBSON. 1985. Statistical inference from band recovery data—a handbook. U.S. Fish and Wildl. Ser. Res. Pub. 156.

CHAPMAN, J. C., C. J. HENNY, AND H. WRIGHT. 1969. The status, population dynamics, and harvest of the dusky Canada goose. Wildl. Monogr. 18:1–48.

CORNELY, J. E., B. H. CAMPBELL, AND R. L. JARVIS. 1985. Productivity, mortality, and population status of dusky Canada geese. Trans. N. Amer. Wildl. Nat. Resour. Conf. 50:540–545.

CRAVEN, S. R. 1979. Some problems with Canada goose neck bands. Wildl. Soc. Bull. 7: 268–273.

———, AND D. H. RUSCH. 1983. Winter distribution and affinities of Canada geese marked on Hudson and James Bays. J. Wildl. Manage. 47:307–319.

EBBINGE, B. S., AND J. B. VAN BIEZEN. 1987. Estimation of annual survival rates using resightings of individually marked barnacle geese *Branta leucopsis,* wintering in the Netherlands and northern Germany. Acta Ornithologica 23:101–114.

EWASCHUK, E., AND D. A. BOAG. 1972. Factors affecting hatching success of densely nesting Canada geese. J. Wildl. Manage. 36:1097–1106.

FJETLAND, C. A. 1973. Long-term retention of plastic collars on Canada geese. J. Wildl. Manage. 37:176–178.

HESTBECK, J. A., AND R. A. MALECKI. 1989. Estimated survival rates of Canada geese within the Atlantic Flyway. J. Wildl. Manage. 53:91–96.

JARVIS, R. L., AND J. E. CORNELY. 1988. Recent changes in wintering populations of Canada geese in western Oregon/southwestern Washington. Pp. 517–528, *in* M. W. Weller, ed. Waterfowl in winter. Univ. Minnesota Press, Minneapolis, Minnesota.

JOHNSON, I. P., AND R. M. SIBLY. 1989. Effects of plastic neck collars on the behavior and breeding performance of geese and their value for distant recognition of individuals. Ringing and Migration 10:58–62.

KOERNER, J. W., T. A. BOOKHOUT, AND K. E. BEDNARIK. 1974. Movements of Canada geese color-marked near southwestern Lake Erie. J. Wildl. Manage. 38:275–289.

MACINNES, C. D., AND B. C. LIEFF. 1968. Individual behavior and composition of a local population of Canada geese. Pp. 93–101, *in* R. L. Hine and C. Schoenfeld, eds. Canada goose management. Dembar Educational Research Services, Madison, Wisconsin.

MARION, W. R., AND J. D. SHAMIS. 1977. An annotated bibliography of bird marking techniques. Bird-Banding 48:42–61.

NELSON, L. J., D. R. ANDERSON, AND K. P. BURNHAM. 1980. The effect of band loss on estimates of annual survival. J. Field Ornith. 51:263–271.

POLLOCK, K. H., AND D. R. RAVELING. 1982. Assumptions of modern band-recovery models, with emphasis on heterogeneous survival rates. J. Wildl. Manage. 46:88–98.

RAVELING, D. G. 1970. Dominance relationships and agonistic behavior of Canada geese in winter. Behaviour 37:291–319.

———. 1978. Dynamics of distribution of Canada geese in winter. Trans. N. Amer. Wildl. Nat. Resour. Conf. 43:206–225.

———, AND D. S. ZEZULAK. 1988. Distribution, abundance, and survival of cackling Canada geese, 1982–1987. Final Prog. Rep. U.S. Fish and Wildl. Ser. Contract 14-16-0001086075.

RUSCH, D. H., S. R. CRAVEN, R. E. TROST, J. R. CARY, R. L. DRIESLEIN, J. W. ELLIS,

AND J. WETZEL. 1985. Evaluation of efforts to redistribute Canada geese. Trans. N. Am. Wildl. and Nat. Resour. Conf. 50:506–524.
SAMUEL, M. D., N. T. WEISS, D. H. RUSCH, S. R. CRAVEN, R. E. TROST, AND F. D. CASWELL. 1990. Neck-band retention for Canada geese in the Mississippi Flyway. J. Wildl. Manage. 54:612–621.
TROST, R. E., D. H. RUSCH, AND D. H. ORR. 1980. Population affiliation of Canada geese from six southern refuges. Proc. Ann. Conf. Southeast Assoc. Game Fish Comm. 35:598–606.
YPARRAGUIRRE, D. R. 1982. Annual survival and wintering distribution of Aleutian Canada geese, 1976–1981. M.Sc. thesis. Humbolt State Univ., Arcata, California.
ZICUS, M. C., AND R. M. PACE. 1986. Neckband retention in Canada geese. Wildl. Soc. Bull. 14:388–391.

Received 14 Jan. 1991; accepted 20 Jun. 1991.

## The Birds of North America Project

The Birds of North America Project invites inquiries from ornithologists interested in producing thorough accounts of the biology of avian species breeding in the USA and Canada. Modern authoritative accounts are needed for sound conservation planning and management of game and nongame species, as well as to catalyze further research. Each account, 30–40 double-spaced typewritten pages in length, will be available electronically and as an individual, printed fascicle fitted to an attractive loose-leaf binder, ensuring rapid, economical distribution and accessibility without the rigid sequence constraints and production delays of book publication. Contributors, amateur and professional alike, can expect a modest administrative subsidy, a discount on the series, and recognition as an authority on their species. If you would like to participate, call or write soon; species are being assigned quickly. Alan F. Poole, Managing Director, Birds of N. America/ANSP, 1900 Franklin Pkwy, Philadelphia, PA 19103-1195.