William B. Krohn, U.S. Fish and Wildlife Service, Maine Cooperative Fish and Wildlife Research Unit, 240 Nutting Hall, University of Maine, Orono, Maine 04469

and

Elwood G. Bizeau, Wildlife Research Institute, P.O. Box 3246, University Station, Moscow, Idaho 83843

An Estimate of Bias in Tail-Fan Surveys of Rocky Mountain Canada Geese

Abstract

Tail fans from Canada geese (*Branta canadensis*) shot by hunters are examined annually to estimate age ratios (immature/adult). Some immatures completely replace immature (notched) tail feathers with adult (unnotched) feathers before the end of hunting season. To analyze the significance of this molt, two fall estimates of the numbers of immatures and adults in the Rocky Mountain Canada goose population (RMP) were used to calculate expected tail-fan age ratios. The accuracy of these ratios was assessed by estimating the percentage of immatures completing the tail molt to adjust the numbers of immatures (birds with at least one notched tail feather) and apparent adults (adults plus immatures with adult-looking tail feathers) available for sampling in tail-fan surveys. Comparison of the estimated observed ratios to a mean age ratio from the survey indicated reasonable results. Expected tail-fan age ratios were from 0.9 to 1.1 versus an observed ratio of 0.2. Tail-fan ratios across North America were examined in relation to latitude of nesting and suggested that nesting phenology, as it influences the time of molt, is a critical factor affecting the degree of bias in Canada goose tail-fan surveys.

Introduction

Hunters annually submit to the U.S. Fish and Wildlife Service (FWS) tail fans from Canada geese they have shot. These tail fans are examined and used to estimate fall age ratios despite the fact that these ratios could be biased (Sorensen *et al.* 1987). Because some immatures (IM) completely replace the diagnostic notched tail feathers before or during the hunting season, they are misclassified as adults (AD) (Tacha *et al.* 1987), thus causing observed IM/AD ratios to be low. The extent to which tail-fan estimates are below actual fall age ratios has not been determined for most Canada goose populations.

Tacha *et al.* (1987) found that in a sample of known-age Canada geese collected in November and December, 92 percent (n = 39) of the immature *B c. interior* had one or more notched tail feathers compared to only 23 percent (n = 30) of the immature *B. c. maxima. B. c. maxima* nests in central North America, whereas *B. c. interior* nests in the Hudson Bay region of central Canada (Hine and Schoenfeld 1968:6). Tacha *et al.* (1987) noted that *B. c. interior* nests and molts about a month later than *B. c. maxima* (based on Hanson 1965:118) and suggested that the degree of bias in harvest age ratios is a function of subspecies. We provide evidence that the IM/AD ratios of RMP geese, a mid-latitude nester (Krohn and Bizeau 1980), were also biased low and estimate the magnitude of this bias. In addition, we examine the effect of latitude on tail-fan age ratios and suggest that the time of nesting and hatching (and hence molting) is a more critical factor than subspecies *per se* affecting the degree of bias in tail-fan surveys.

Methods

The number of Canada geese tail fans submitted from the U.S.A. portion of the RMP's range (see Krohn and Bizeau 1980:6-7,58) and classified as immatures and adults, 1965-1974, was obtained from the FWS's Office of Migratory Bird Management, Laurel, Maryland. These years were selected because they represented a period when the size of the RMP was relatively stable (Krohn and Bizeau 1988) and were within the period covered by population simulations done by Krohn and Bizeau (1980).

Krohn and Bizeau (1980:48-49) examined the population dynamics of the RMP with two deterministic models built with data mostly from the mid-1960's to early 1970's. These models provide two estimates of the numbers of immatures and adults in the fall population. Immatures were 1.29 times more likely to be shot than adults (Krohn and Bizeau 1980:36), and thus the number of adults available for harvest, and hence sampling

in the tail-fan survey, was reduced by 0.78 (=1.00/1.29). Because both population models were of unknown reliability (Krohn and Bizeau 1980), the two expected age ratio estimates from the models were checked by assuming a level of bias in the number of immatures misclassified as adults and recalculating observed tail-fan age ratios. This check allowed us to determine whether or not the expected age ratios (from population data) approximated the observed ratios (from tail-fan data). Tacha *et al.* (1987) found that 23 percent of the immature *B. c. maxima* had one or more notched tail feathers, so we assumed that 77 percent of immature RMP geese (*B. c. moffitti;* Krohn and Bizeau 1980:48) also completed the tail molt before or during the hunting season. Seventy-seven percent is probably a high estimate because it was based on birds examined in November and December (Tacha *et al.* 1987) and a substantial part of the RMP harvest occurs earlier (Krohn and Bizeau 1980:77-93) when fewer immatures have completed the tail molt.

To examine the effect of latitude on tail-fan age ratios, we estimated the number of wintering Canada geese in each flyway coming from northern (>52°N. Lat.) and southern (<52°N. Lat.) breeding areas. We expected those flyways with a high percentage of northern birds, and presumably later hatching and molting, to have higher tail-fan age ratios. Populations were assigned to flyways, and breeding ranges to north or south categories, by locations as illustrated in Hine and Schoenfeld (1968) and modified for *B. c. moffitti* by Krohn and Bizeau (1980:45-47). Wintering numbers, 1984-1985, came from the North American Waterfowl Management Plan (Canadian Wildlife Service and FWS, 1986:7) and mean tail-fan age ratios, 1982-1986, were calculated from Sorensen *et al.* (1987:34-35).

TABLE 1. Fall age-ratios for the Rocky Mountain Canada Goose Population as indicated by tail-fan surveys, 1965-1974.[a]

Year	Number of: Immatures (IM)	Adults (AD)	IM:AD
1965	79	292	0.27
1966	57	468	0.12
1967	75	337	0.22
1968	67	371	0.18
1969	82	221	0.37
1970	31	249	0.12
1971	55	258	0.21
1972	45	229	0.20
1973	36	301	0.12
1974	36	359	0.10
$\bar{X}$	56	308	0.19
SD	19	78	0.08

[a]Data from U.S. Fish and Wildlife Service, Office of Migratory Bird Management, Laurel, Md.

TABLE 2. Fall age-ratios indicated by deterministic simulations of the Rocky Mountain Canada Goose Population during the 1960-70s.

Numbers	Population Simulations[a] Method I	Method II
Immatures (IM)	25,082	45,356
Adults (AD)	30,317	68,034
IM/AD in fall population	0.83	0.67
Corrected Number of Adults[b]	23,647	53,067
IM/AD expected in tail-fan survey	1.06	0.86

[a]Data from Table 40 of Krohn and Bizeau (1980:49).

[b]Number of adults decreased by 0.78 (=1.00/1.29) because immatures were 1.29 times more likely to be shot than adults (Krohn and Bizeau 1980:36).

Results

More tail fans were classified as adults than as immatures, 1965-1974, with IM/AD ratios ranging from 0.10 (1974) to 0.37 (1969) (Table 1). Linear regression analysis indicated no temporal trend ($F = 1.46$, $P = 0.26$), thus the mean of 0.19 was judged the best tail-fan estimate of RMP fall age ratios.

In contrast, the two population models suggested fall age ratios in the range of 0.67 to 0.83 (Table 2). Considering that adults are less vulnerable to shooting than immatures, then IM/AD ratios in the harvest should be approximately 0.86 to 1.06 (Table 2). If 77 percent of the immatures completed the tail molt during the hunting season, then from 19,313 (=0.77 × 25,082) to 34,924 (=0.77 × 45,356) immatures were misclassified as adults. Counting these misclassified immatures as apparent adults, the adjusted adult figures became 42,960 (=19,313 + 23,647) and 87,991 (=34,924 + 53,067). With

only 5,769 (=25,082 − 19,313) and 10,432 (=45,356 − 34,924) immatures with notched tail feathers remaining in the population, estimates of the observed tail-fan age ratios became 0.13 (= 5,769/42,960) and 0.12 (=10,432/87,911). Because it was likely that the 77 percent misclassification rate was high, we anticipated that these estimated ratios (0.12, 0.13) would be lower than the observed mean ratio (0.19).

Observed tail-fan age ratios became progressively lower from east to west (Table 3). The Pacific Flyway had the lowest mean age ratio, corresponding to the lowest percentage of birds from northern nesting areas. We suspect that the low age ratios in tail fans from the Pacific Flyway (excluding Alaska) was largely due to the harvest of more mid-latitude nesters (i.e., *B. c. moffitti*), which presumably molt earlier relative to northern-nesting Canada geese.

TABLE 3. Tail-fan age ratios (immature:adult) of Canada geese as related to estimated percentages (n in thousands) of wintering birds from northern versus southern breeding areas.

Flyway and Population	Est. % of Wintering Birds, 1984-85, from:[a] S. of 52° Lat.	N. of 52° Lat.	Tail-fan Age Ratios ($\bar{X}$ ± SD), 1982-86[b] (Mean n per year)
Atlantic			
Northern	—	(764)	
U.S.A.	(50)[c]	—	
Total	6% (50)	94% (764)	0.96 ± 0.25 (3,047)
Mississippi			
Tennessee Valley	—	(130)	
Mississippi Valley	—	(477)	
Eastern Prairie	—	(168)	
Tallgrass Prairie	—	(197)	
Great Plains	(30)[d]	—	
Total	3% (30)	97% (972)	0.69 ± 0.26 (2,186)
Central			
Western Prairie	—	(135)	
Shortgrass Prairie	—	(194)	
Great Plains	(4)[d]	—	
Hi-Line	(93)	—	
Total	23% (97)	77% (329)	0.40 ± 0.07 (1,841)
Pacific			
Rocky Mountain	(90)	—	
Pacific	(50)	—	
Lesser	—	(150)	
Dusky	—	(8)	
Cackling	—	(23)	
Total	44% (140)	56% (181)	0.25 ± 0.11 (1,370)

[a]Data from Table 3 of Canadian Wildlife Service and U.S. Fish and Wildlife Service (1986:7); excluding Aleutian and Vancouver Canada geese because these populations are lightly hunted.

[b]Data from Table 18 of Sorensen *et al.* (1987:34-35).

[c]Assumes 50,000 birds are resident geese (from unpubl. management plan, U.S. Fish and Wildlife Service, Washington, D.C.).

[d]Assumes breeding population of 17,000 results in 34,000 wintering birds of which 30,000 winter in the Mississippi Flyway and 4,000 in the Central Flyway.

Discussion and Management Implications

Indirect evidence suggests that age ratios from tail fans of RMP geese, relative to the actual fall population, were biased low by a factor of 4 (0.2 vs. 0.7-0.8). Furthermore, the pattern of variation in tail-fan age ratios among flyways as related to the percentage of birds from northern versus southern breeding grounds is consistent with the hypothesis that, on a North American scale, latitude affects age ratios through time of nesting and molting. However, within a subspecies or population, factors other than latitude may affect time of molt. For example, Krohn and Bizeau (1980:22-23) noted that the start of egg laying in *B. c. moffitti* was related ($P < 0.01$) to altitude with up to a month difference in peak of nest initiation in sites at approximately 110 m (360 ft) above mean sea level versus those at 1,981 m (6,500 ft). This difference in time of nest initiation could result in a month or so difference in the start of molt between various flocks of *B. c. moffitti*. Thus, we concur with Hanson's (1965:118) statement that "It is advisable to consider both the nesting phenology and the characteristics of the individual populations before using collections of tail feathers to obtain age ratios."

Although it is clear that tail fan surveys do not accurately measure Canada goose age ratios, it does not necessarily follow that these ratios cannot be used as indices of recruitment. In the Eastern Prairie Population, Rusch (cited in Trost and Malecki 1985:503) found age ratios of harvested geese correlated with annual recruitment measured on the breeding ground. However, in the case of the RMP, tail-fan ratios may not be useful recruitment indices given potentially variable molting chronologies resulting from a wide range of nesting elevations and spring weather conditions (i.e., yearly variation in the proportion of early- versus late-molting immatures could mask real changes in recruitment).

Tacha *et al.* (1987) questioned the continuation of tail fan surveys where *B. c. maxima* are harvested unless the bias associated with *B. c. maxima* can be eliminated or more reliable techniques developed. We agree with this concern over bias, but argue that even biased tail-fan ratios may provide useful recruitment indices. We recommend study of the timing and extent of molt in Canada geese, and whether or not tail-fan age ratios correlate with recruitment in specific populations. In addition to possibly solving the problem of reliable age determination from tails or other parts potentially submitted by hunters, this could also lead to better techniques for identifying subspecies and populations, longstanding needs for Canada goose management.

Acknowledgments

This is a contribution of the Maine Cooperative Fish and Wildlife Research Unit (U.S. Fish and Wildlife Service, University of Maine, Maine Department of Inland Fisheries and Wildlife, and Wildlife Management Institute, cooperating). S. M. Carney and the Office of Migratory Bird Management helped by providing tail-fan data. We thank I. J. Ball, R. E. Trost, and two anonymous reviewers for improving this manuscript. This is Publication No. 1284 of the Maine Agricultural Experiment Station.

Literature Cited

Canadian Wildlife Service and U.S. Fish and Wildlife Service. 1986. North American waterfowl management plan—a strategy for cooperation. U.S. Fish and Wildl. Serv., Washington, D.C. 19 p.

Hanson, H.C. 1965. The Giant Canada Goose. Southern Illinois Univ. Press, Carbondale.

Hine, R. L., and C. Schoenfeld (eds.). 1968. Canada Goose Management. Dembar Educ. Res. Serv., Madison, Wisconsin.

Krohn, W. B., and E. G. Bizeau. 1980. The Rocky Mountain population of the western Canada goose: its distribution, habitats, and management. U.S. Fish Wildl. Serv., Spec. Sci. Rept.-Wildl. No. 229. 93 p.

Received 15 April 1988
Accepted for publication 23 August 1988

———. 1988. Changes in winter distribution of the Rocky Mountain Canada goose population. Wildl. Soc. Bull. 16:272-277.

Sorensen, M. F., S. M. Carney, and E. M. Martin. 1987. Age and sex composition of ducks and geese harvested in the 1986 hunting season in comparison to prior years. U.S. Fish and Wildl. Serv. Adm. Rep., Off. Migra. Bird Manage., Laurel, Maryland. 40 p.

Tacha, T. C., D. D. Thornburg, and R. A. Williamson. 1987. Bias of tail-fan surveys for estimating Canada goose age ratios. Wildl. Soc. Bull. 15:533-534.

Trost, R. E., and R. A. Malecki. 1985. Population trends in Atlantic Flyway Canada geese: implications for management. Wildl. Soc. Bull. 13:502-508.