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**MORPHOMETRIC COMPARISON OF RESIDENT GIANT CANADA GEESE  
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Body size of Canada geese (*Branta canadensis*) varies by subspecies (Hanson 1965, Moser and Rolley 1990), generally decreasing as geographic latitude of breeding grounds increases (Bellrose 1980). Morphological measurements of harvested geese have been used to determine breeding ground affiliation to improve harvest-management strategies for individual population units (Moser 1987). Measurements which best distinguish subspecies and origin of Canada geese in the Mississippi Flyway are length of skull, tarsus (tarsometatarsus bone), and culmen (upper mandible) (Soulliere et al. 1988, Moser and Rolley 1990, Merendino et al. 1994). Distinction criteria, based on measurements of two body parts (bivariate model) or a single body part (univariate method), can have >90% accuracy in subspecies identification (Rolley and Moser 1990, Merendino et al. 1994).

Giant Canada geese (*B. c. maxima*) nest throughout Michigan and currently comprise about 50% of the state's annual Canada goose harvest (G. F. Martz, unpubl. data). Much of this harvest occurs during special "early" and "late seasons" established to control populations of resident giants. Body part measurements have been used to evaluate the effectiveness of special seasons at targeting giant Canada geese (Soulliere et al. 1988, Martz and Soulliere 1989, 1991). Culmen length is the single variable which best distinguishes Michigan resident giants from interior Canada geese (*B. c. interior*) migrating through the state (Soulliere et al. 1988). In fact, Michigan geese may have the largest culmens of all populations of giants located in the Mississippi Flyway (Moser and Rolley 1990). However, measurement data used to

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develop differentiation criteria in Michigan (see Culmen Cut-off Method, Soulliere et al. 1988) were collected largely (80%) from geese residing in the southern one-third of the state. Although most ( $\geq 80\%$ ) Michigan geese nest in this region, we found evidence that culmen measurements collected there may not be representative of Northern Michigan geese.

Harvest evaluations (Martz and Soulliere 1989, 1991) suggested 22-34% of geese killed in Northern Michigan during early seasons (1-10 September) fell into the interior size category using established culmen-measurement criteria. This high proportion of interiors in the harvest is unlikely because migrant geese normally do not begin arriving in Northern Michigan until 15 September each year (G. F. Martz and G. J. Soulliere, unpubl. data). Furthermore, some harvested geese which fell into the interior size category were determined to be Northern Michigan residents from leg-band numbers. Therefore, previously identified culmen-measurement criteria (Soulliere et al. 1988), which is appropriate for Southern Michigan, may have inflated the estimated harvest of interior Canada geese in Northern Michigan hunting zones.

Culmen-length criteria originally used to separate Michigan giant Canada geese from migrating interiors was 58.3 millimeters (mm) for males and 54.5 mm for females (Soulliere et al. 1988). These measurements are midpoints between average culmen sizes calculated for Michigan giants and interiors most likely to be harvested in the state: the Mississippi Valley Population (MVP) and the Southern James Bay Population (SJB; previously named Tennessee Valley Population). Individuals above "midpoint" lengths were considered giants and those with shorter culmens were considered migrant interiors.

Considering the potential misclassification of resident Northern Michigan geese in the harvest, we wanted to determine if data used to establish midpoints were representative of Michigan giants from both northern and southern regions. Therefore, we compared culmen size of giant Canada geese residing in Northern vs. Southern Michigan in an effort to fine tune differentiation criteria to better proportion the Michigan goose harvest into resident giants and migrant interiors.

## METHODS

We measured exposed culmen length (see Soulliere et al. 1988 or culmen 1 from Dzubin and Cooch 1992) of flightless adult and sub-adult Canada geese from Northern and Southern Michigan during June and July 1994. Geese were sampled during trapping and banding operations at three latitudes: Sault Ste. Marie (46°30'N) in Chippewa County, near Escanaba (45°40'N) in Delta County, and at various sites between Ann Arbor and Battle Creek (42°20'N) in Washtenaw, Jackson, Lenawee, and Hillsdale counties. Culmens were measured to the nearest millimeter with vernier calipers by Michigan DNR-Wildlife Division employees and by assistants under the supervision of Wildlife Division employees. One-way analysis of variance was used to evaluate differences ( $P=0.05$ ) in culmen length of resident geese at these locations;

males and females were analyzed separately because of sexual dimorphism in body size. In addition, we compared culmen measurements collected in previous years at Sault Ste. Marie (1992 and 1993) and in Southern Michigan (1984, 1986, 1987).

## RESULTS AND DISCUSSION

We found Michigan giant Canada geese vary in size by latitude. During 1994, geese measured in Sault Ste. Marie were smaller than geese from Escanaba, which were smaller than Southern Michigan geese ( $P < 0.001$ :  $F = 28.5$ , 2 df, males;  $F = 46.8$ , 2 df, females) (Fig. 1). When comparing 1994 data sets and measurements collected in previous years, geese from Sault Ste. Marie were consistently smaller ( $P < 0.001$ :  $F = 23.12$ , 7 df, males;  $F = 31.45$ , 7 df, females) than Southern Michigan geese (Table 1). Canada geese measured in Escanaba were generally smaller than Southern Michigan geese and larger than Sault Ste. Marie geese (Table 1). We are unsure why Sault Ste. Marie females varied in size between 1992 and 1994. The same person conducted culmen measurements each year, limiting potential variation associated with the measuring technique. Some variation in size between years was also apparent for Southern Michigan geese (Table 1). The inclusion of "molt migrants" (groups of non-breeding sub-adults visiting from other areas) in a particular sample could cause the observed variation (Moser and Rolley 1990, Merendino et al. 1994).

We pooled data sets collected at Sault Ste. Marie to revise the culmen-midpoint criteria for Northern Michigan. Differentiation criteria established using these slightly smaller residents will also classify larger geese within the region as giants. Sault Ste. Marie males had average culmen lengths of 60.0 mm and females 56.2 mm (Table 1), whereas interior (MVP and SJBP combined) males were 53.4 mm and females were 49.6 mm (Moser and Rolley 1990). Therefore, male Canada geese harvested in Northern Michigan with culmens  $\geq 57.0$  mm ( $60.0 + 53.4 / 2 = 56.7$ ) and females with culmens  $\geq 53.0$  mm ( $56.2 + 49.6 / 2 = 52.9$ ) should be classified as giants. Canada geese harvested in Northern Michigan with culmens smaller than the sex-specific midpoints should be classified as interiors. Assuming a "normal" size distribution (bell-shaped curve) within populations of Canada geese, "midpoints" are those measurements where subspecies begin to overlap in size (Fig 2). Thus new midpoints (points of overlap) for Northern Michigan giants and migrant interiors (i.e., 56.7 mm for males and 52.9 mm for females) are smaller than original midpoints established with giants collected largely from Southern Michigan.

The new culmen-midpoint criteria correctly classified  $\geq 86\%$  of Sault Ste. Marie and  $\geq 95\%$  of Escanaba known-resident (summer banded) Canada geese (Table 2). Misclassification of Sault Ste. Marie giants was reduced dramatically using new midpoints. Compared to Northern Michigan geese, less overlap exists between Southern Michigan giants and migrant interiors (Fig. 2). Accuracy in classifying Southern Michigan giants was not greatly improved with new midpoint criteria (Table 2), and old (larger) midpoints remain the better differentiation criteria for this region as risk of misclassifying interiors (those in the overlap) is lower. Consequently, greater

accuracy in classifying subspecies in the Michigan goose harvest will be achieved by using the original culmen midpoint criteria (males  $\geq 59$  mm and females  $\geq 57$  mm = giants) in Southern Michigan and the new criteria (males  $\geq 57$  mm and females  $\geq 53$  mm = giants) in Northern Michigan.

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Figure 1. Average culmen (upper bill) length of male and female giant Canada geese measured at three Michigan locations during June and July, 1994. Geese from Sault Ste. Marie (Chippewa County) and Escanaba (Delta County) were collected within or very near these cities, whereas geese sampled from the Jackson vicinity included individuals from Jackson, Livingston, Washtenaw, Lenawee, and Hillsdale counties.

Table 1. Mean culmen lengths of Northern and Southern Michigan giant Canada geese. Measurements were from flightless adults and sub-adults captured in June and July.

Location	Year	Males			Females		
		<i>n</i>	$\bar{x}$	SD	<i>n</i>	$\bar{x}$	SD
<b>Northern Michigan</b>							
Sault Ste. Marie	1994	58	59.5	3.5 A <sup>a</sup>	46	55.1	2.3 A
Sault Ste. Marie	1993	47	60.3	3.3 AB	44	56.3	3.5 AB
Sault Ste. Marie	1992	70	60.1	3.1 A	81	56.7	3.0 B
Subtotal		175	60.0	3.3	171	56.2	3.0
Escanaba	1994	111	61.7	3.0 BC	96	57.0	2.3 B
<b>Southern Michigan<sup>b</sup></b>							
Various Sites	1994	67	63.8	3.3 DE	73	59.5	2.9 C
Various Sites	1987	52	62.5	3.0 CD	50	59.0	2.1 C
Various Sites	1986	35	63.6	3.4 DE	40	61.2	3.0 D
Various Sites	1984	78	64.6	3.2 E	78	60.0	3.0 CD
Subtotal		232	63.7	3.2	241	59.8	2.8
Total		518	62.0	3.2	508	58.1	2.7

<sup>a</sup> Means within columns followed by the same letter were not significantly different (ANOVA,  $p < 0.05$ ).

<sup>b</sup> Sample locations included sites in Jackson, Livingston, Washtenaw, Lenawee, and Hillsdale counties.

Table 2. Percent of resident Northern and Southern Michigan giant Canada geese correctly classified using new and old culmen-midpoint measurement criteria. Measurements were from flightless adult and sub-adult Canada geese captured during June and July.

Location	Latitude	Year	Males		Females	
			(n) ( $\geq 57$ mm)	Old ( $\geq 59$ mm)	(n) ( $\geq 53$ mm)	Old ( $\geq 55$ mm)
Northern Michigan						
Sault Ste. Marie	46° 30' N	1992-94	(175)	86	(171)	90
Escanaba	45° 40' N	1994	(111)	97	(96)	95
Southern Michigan						
Jackson Vicinity <sup>a</sup>	42° 20' N	1984-94	(232)	99	(241)	100

<sup>a</sup> Sample sites were located in Jackson, Livingston, Washtenaw, Lenawee, and Hillsdale counties.

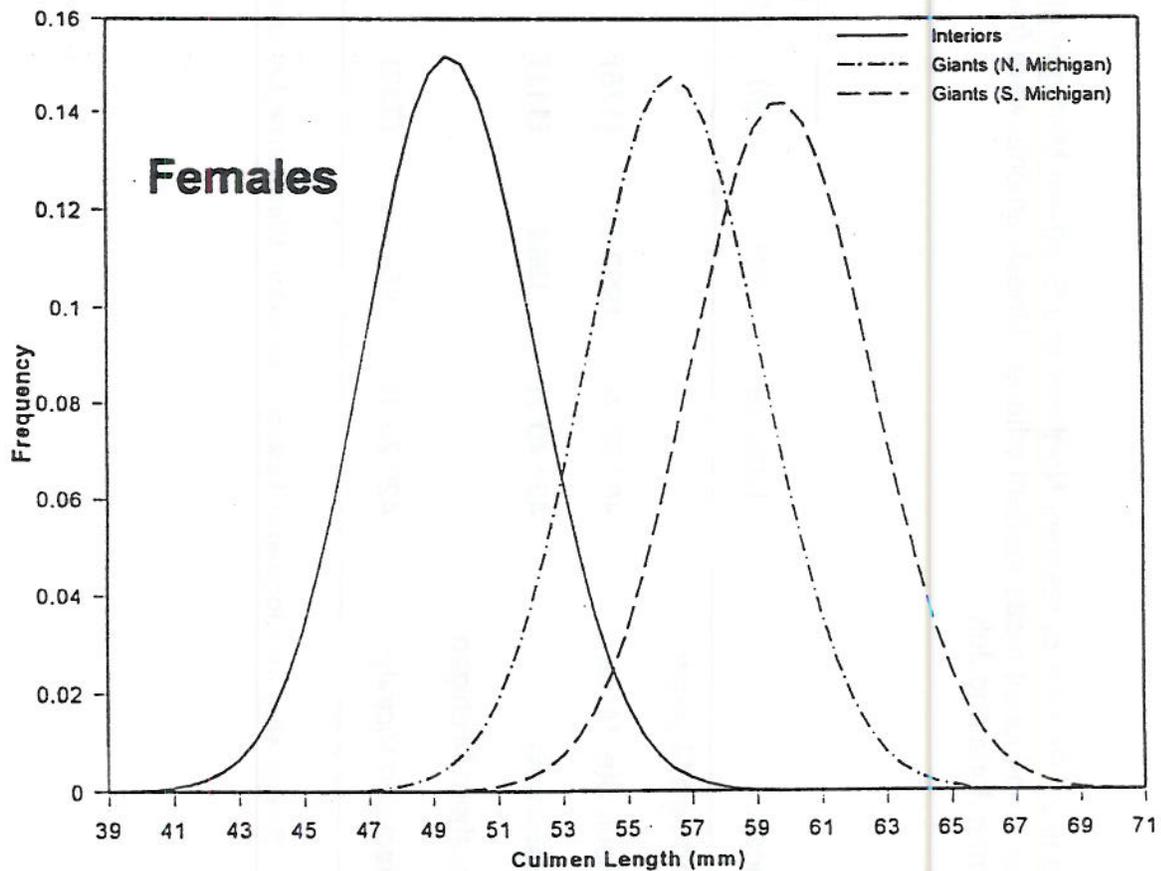
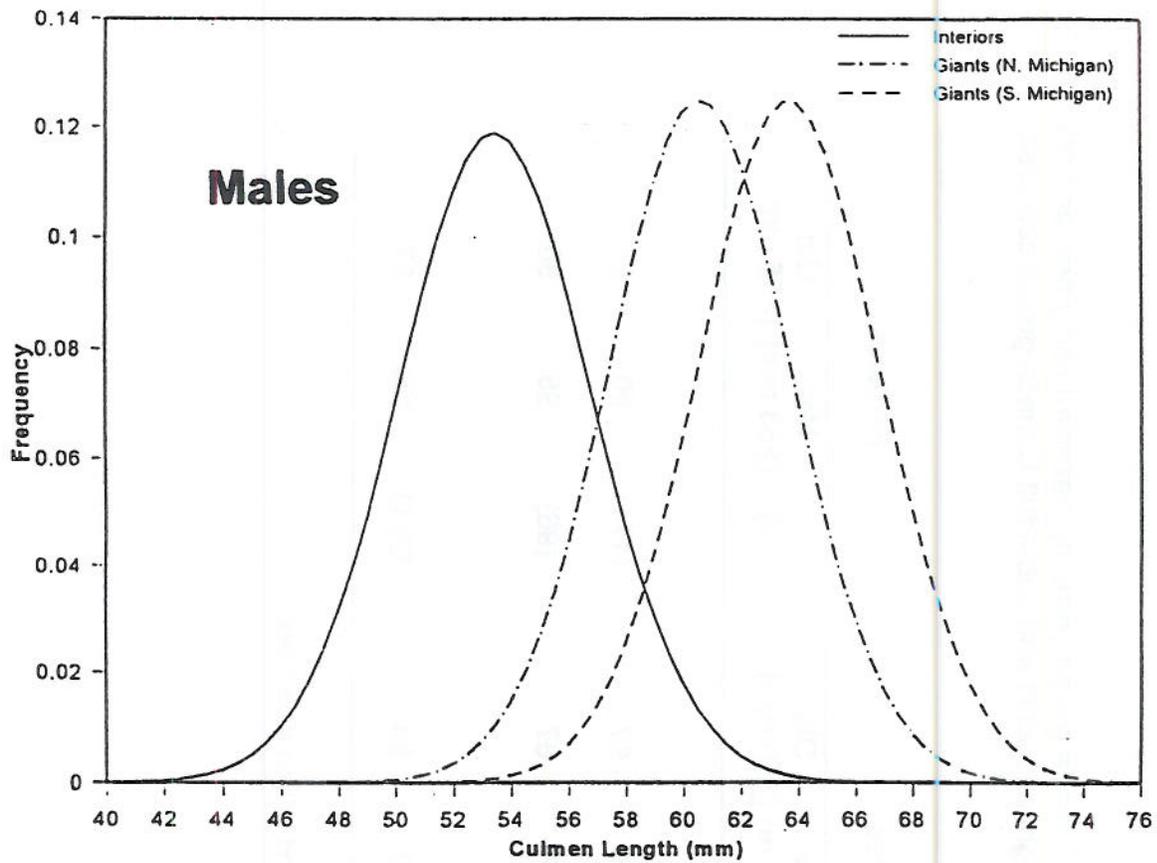


Figure 2. Culmen length probability distribution curves for interior Canada geese measured in Ontario (Moser and Rolley 1990) and giant Canada geese measured in this study. Northern Michigan giants include resident birds from Chippewa and Delta counties and Southern Michigan giants were from Jackson, Livingston, Washtenaw, Lenawee, and Hillsdale counties. Distribution curves extend 2 standard deviations beyond the mean (curve apex) on each side. Frequency represents the probability (0-1) of specific culmen lengths.