# Minnesota Wolf Ear Lengths as Possible Indicators of Taxonomic Differences

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**Abstract** - Genetic findings suggest that 2 types of wolves, *Canis lupus* (Gray Wolf) and *C. lycaon* (Eastern Wolf), and/or their hybrids occupy Minnesota (MN), and this study examines adult wolf ear lengths as a possible distinguisher between these two. Photographic evidence suggested that the Eastern Wolf possesses proportionately longer ears than Gray Wolves. Ear lengths from 22 northwestern MN wolves from the early 1970s and 22 Alaskan wolves were used to represent Gray Wolves, and the greatest length of the sample (12.8 cm) was used as the least length to demarcate Eastern Wolf from Gray Wolf influence in the samples. Twenty-three percent of 112 adult wolves from Algonquin Park in eastern Ontario and 30% of 106 recent adult wolves in northeastern MN possessed ears >12.8 cm. The northeastern MN sample differed significantly from that of current and past northwestern MN wolves. Ear-lengths of wolves in the eastern half of the northeastern MN wolf population were significantly longer than those in the western half of that study area, even though the mean distance between the 2 areas was only 40 km, and the mean length of my 2004–2009 sample was significantly longer than that of 1999–2003. These findings support the hypothesis that Eastern Wolves tend to possess longer ears than do Gray Wolves and suggest a dynamic hybridization process is still underway in MN.

## Introduction

Wilson et al. (2000, 2009) proposed a new species of wolf, *Canis lycaon* (Eastern Wolf), based on molecular genetic analyses. They proposed that this wolf evolved in North America along with *C. latrans* Say (Coyote) and that it inhabits eastern Canada westward through Minnesota (MN) into Manitoba. Further, there was genetic evidence that *C. lupus* L. (Gray Wolf) also inhabited MN (Lehman et al. 1991) and that the 2 wolves hybridized in MN (Fain et al. 2010, Kyle et al. 2006, Mech and Federoff 2002, Wheeldon 2009, Wheeldon et al. 2010).

However, only 2 types of evidence have been presented relating to possible morphological differences between Eastern and Gray Wolves: (1) skull measurements, and (2) a series of body-mass data from across MN. Skulls of Eastern Wolves are smaller than those of Gray Wolves (Nowak 2009), and have more slender rostra (Mech et al., in press). Mech and Paul (2008) showed that wolves of extreme northeastern MN were comparable in mass to those in Algonquin Park, in eastern Ontario, which hosts Eastern Wolves (Wilson et

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al. 2000), and that wolf mass increased from east to west across MN. Mass of wolves in northwestern MN was similar to that of Gray Wolves (Fritts and Mech 1981) and of wolves of Riding Mountain National Park (Mech and Paul 2008), where 19 of 20 specimens tested genetically showed Gray Wolf mtDNA (Stronen et al. 2010). Mech and Paul (2008) suggested that the highest-content Eastern Wolves in MN were those in the extreme northeastern part of the state and that incidence of Gray Wolf influence increased westward across the state. Mech (2010) reviewed morphological and genetic data for MN wolves and concluded that while most were genetically hybrids between Gray and Eastern Wolves, most current MN wolves were morphologically more like Gray Wolves, based on measurements of MN wolf skulls collected during 1970–1976 (Mech et al., in press).

While body mass might differentiate populations of Eastern and Gray Wolves, mass is variable and affected by so many factors that it might only serve to distinguish large populations of wolves, rather than individuals, as high-content Eastern or Gray. Thus, more-definitive morphological distinction of each type of wolf is needed. Eastern Wolves appear to possess longer ears than do Gray Wolves (cf. photos in both Phillips and Smith 1996, Theberge and Theberge 1998), so I assembled data on ear-lengths of wolves from Algonquin Provincial Park in eastern Ontario and also collected such data from MN wolves (Table 1). I hypothesized that if wolves in northeastern MN were higher-content Eastern Wolves, their ear lengths should approximate those of Algonquin wolves and should be longer there than in the rest of MN wolf range, similar to their body mass being lighter (Mech and Paul 2008).

## Study Area

Minnesota's wolf range is a southern extension of the Ontario and Manitoba wolf range (Fig. 1). As with wolves throughout the contiguous 48 United States, wolves were extirpated from most of southern and extreme northwestern MN (primarily most of Kittson, Roseau, and Marshall counties; Fig. 1) by about 1970, with an estimated 750 remaining (Fuller et al. 1992, Mech 2010). As they began increasing after 1970, they gradually spread southward and westward and currently occupy about 67,852 sq km of the northern third of the state, including the northwestern counties mentioned above (Erb and Benson 2004). Repopulation of the northwestern MN wolf population could have resulted from extant wolf packs from farther east or from those in adjacent southwestern Ontario and southeastern Manitoba, where they had not been exterminated (Fig. 1), but skull measurements from post-1970 (Nowak 2009) suggest that many were from the north (Mech 2010; Mech et al., in press).

Most of the data in the current study were collected in the eastern Superior National Forest (SNF) in northern Lake County, northwestern Cook County, and northeastern St. Louis County in northeastern MN. However, supplementary data were examined from across northern MN in an east–west band of about 200 km just south of the state's border with Ontario (Fig. 1). The eastern 80% of the area is primarily forested wilderness and semi-wilderness with many scattered lakes and extensive bogs that grade into brushland and open prairie and farmlands, with scattered *Populus tremuloides* Mich. (Quaking Aspen) groves in the west. The wolves' main prey is *Odocoileus virginianus* Zimmermann (White-tailed Deer), but in the extreme northeast, the wolves prey primarily on *Alces alces* L. (Moose), and they also feed on Moose in some parts of northwestern MN (Frenzel 1974, Fritts and Mech 1981, Nelson and Mech 2006, Van Ballenberghe et al. 1975). Wolves also prey on livestock throughout the region, but mostly in the western two-thirds of the study area (Harper et al. 2005).

## Methods

As part of a long-term ecological investigation in northeastern MN from 1999 through 2008 (Mech 2009), biologists and technicians measured ear lengths of each wolf live-trapped and anesthetized. The wolves were weighed, and their ages estimated by comparing tooth wear with the wear charts by Gipson et al. (2000). This research was conducted under both state and federal endangered species permits and complied with guidelines of the American Society of Mammalogists (Animal Care and Use Committee 1998). Technicians measuring ear lengths in recent MN wolves were instructed to measure them

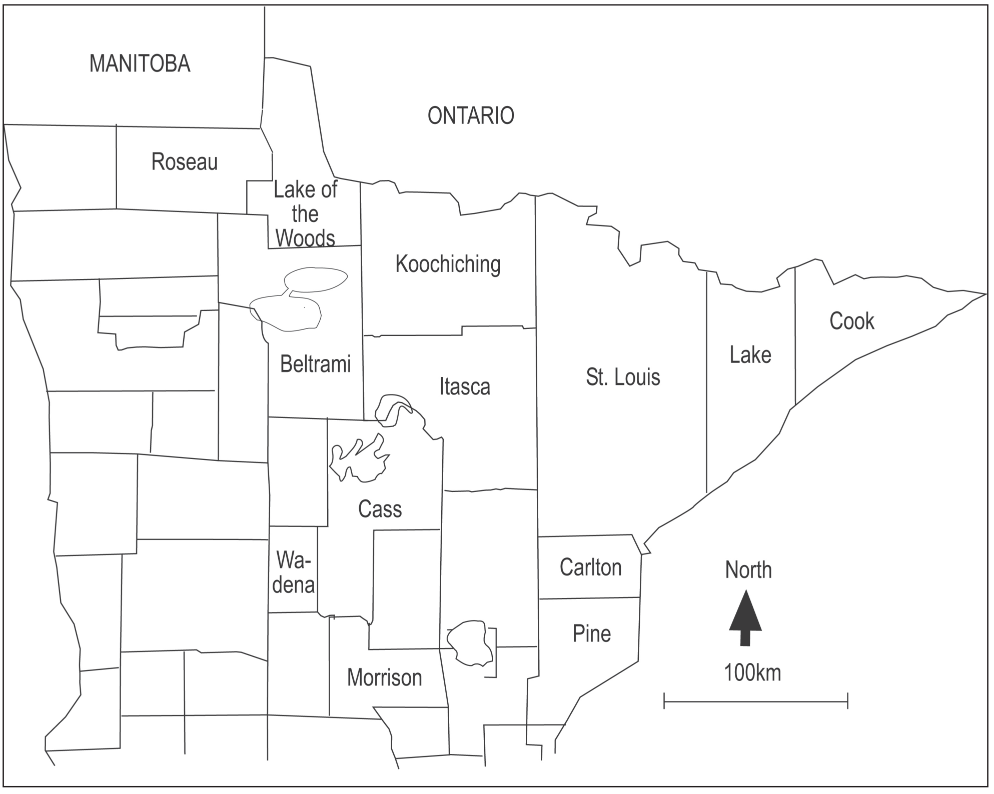


Figure 1. Northern Minnesota counties in wolf range where ear lengths were collected.

in the standard manner for mammalogical measurements, and I assumed that all the measurements furnished by other workers were measured similarly, i.e., the "distance from notch at front base of ear to the distalmost border of the fleshy part of the ear" (Schmidly and Davis 2004:Appendix 6). Presumably, measurement errors would be random and not biased high or low within a specific sample. The lengths of adult (non-pup) wolves collected in this study were compared with ear lengths of those from several other periods and areas (Table 1) to determine possible differences and similarities that might lend insights into the taxonomic identity of Minnesota wolves. To represent high-content Gray Wolves, I used ear lengths of 22 adult Gray Wolves from Alaska collected recently and 22 from northwestern Minnesota collected during 1972–1976 (Table 1), when Minnesota wolf-skull dimensions were the same as those of Gray Wolves from the western United States (Mech et al., in press). The greatest length of ears from these samples (12.8 cm) was used as the least length to demarcate Eastern Wolf from Gray Wolf influence in the samples. I used 2-sample *t*-tests, 2-by-2 contingency tests, and simple-linear regression to assess differences in data samples.

## Results

Ear lengths of wolves ≥1 year old were measured on 106 northeastern MN wolves and on 32 wolves in the rest of the MN wolf range ("northwestern MN"). The ear lengths of 59 northeastern MN females were not significantly different from those of 47 males ($P = 0.81$). Linear regression showed no significant relationship between body mass and ear length ($P = 0.15$), and only a minor inverse relationship ($r^2 = 0.06$; $P = 0.01$) between age and ear length. Thus the sample was considered homogeneous for further analyses.

Ear lengths of 112 adult wolves from Algonquin Provincial Park, ON measured from 1987 to 1995 (Table 1) were used to represent high-content Eastern

Table 1. Ear lengths (cm) of *Canis sp.* ≥1-yr old from various locations.

| Area | *n* | Mean (SE) | Range | Number (%) >12.8 cm | Source |
|---|---|---|---|---|---|
| Algonquin Park, 1987–1995 | 112 | 11.8 (0.11) | 9.0–15.0 | 26 (23) | J. Theberge and M. Theberge[1] |
| NE MN, 1999–2008 | 106 | 12.2 (0.14) | 9.0–16.0 | 32 (30) | Present study |
| NE MN, 1969–1971 | 61 | 11.6 (0.11) | 10.2–13.7 | 5 (8) | V. Van Ballenberghe[2] |
| NW MN, 1972–1976 | 22 | 11.7 (0.16) | 10.1–12.7 | 0 | S. H. Fritts[3] |
| NW MN, 2008 | 32 | 12.0 (0.14) | 10.5–14.1 | 2 (6) | J. Hart[4] |
| Alaska, 2008–2010 | 22 | 11.8 (0.12) | 11.7–12.8 | 0 | B. Lem[5] |

[1]University of Waterloo (retired), unpubl. data.
[2]US Forest Service, Anchorage, AK, unpubl. data.
[3]US Fish and Wildlife Service, Denver, CO, unpubl. data.
[4]US Department of Agriculture, Grand Rapids, MN, unpubl. data.
[5]Alaska Department of Fish and Game, King Salmon, AK, unpubl. data.

Wolves (Wilson et al. 2000). Those ear lengths varied from 9.0–15.0 cm, with a mean of 11.8 ± 0.11 (SE). The proportion of wolves in that sample with ears >12.8-cm long did not differ significantly from the recent sample from northeastern Minnesota (Table 2).

Both the current northeastern MN sample and the Algonquin sample differed significantly from those from northeastern MN taken in 1969–1971, from those from northwestern MN sampled in 1972–1976 and in 2008, and from those in Alaska (Table 2).

In the current northeastern MN sample, 32 (30%) of the ear lengths exceeded 12.8 cm (Fig. 2A), whereas in the current sample from the rest of the MN wolf range, only 2 (6%) exceeded 12.8 cm ($\chi^2 = 7.59$; $P < 0.01$; d.f. = 1; Table 2, Fig. 2B). Within the northeastern MN study area itself, the proportion of wolves in the eastern 48 km of the study area whose ears exceeded 12.8 cm (29 of 81) was significantly higher than that proportion (3 of 25) in the western 30 km ($\chi^2 = 4.07$, $P = 0.04$; d.f. = 1). The mean ear length in the eastern part of the study area was 12.3 cm, whereas in the western part it was 11.7 cm ($P = 0.03$), the mean distance between these 2 areas being only 40 km. Also my 1999–2008 northeastern MN sample included significantly more ear lengths >12.8 cm than did the 1969–1971 sample from the same area ($P < 0.01$; Table 2, Fig. 2C). My 2004–2009 northeastern MN sample ($n = 57$) did not show a higher proportion of ears >12.8 than my 1999–2003 sample ($n = 49$), but the mean ear length of the 1999–2003 sample (11.9 cm) was significantly ($P = 0.02$) less than that of the more recent sample (12.5 cm).

## Discussion

The proportion of wolf ear lengths ≥12.8 cm from northeastern MN during 1999–2008 and the similarity of this sample to that from Algonquin Park in eastern Ontario support the hypothesis that wolves in northeastern MN tend to be the highest-content Eastern Wolves in MN (Mech and Paul 2008). The data from

Table 2. Two-by-two contingency table comparisons of proportions of wolves with ear lengths >12.8 cm among samples of wolf ear lengths across wolf range (see Table 1).

| Samples | NE MN (1999–2008) | NE MN (1969–1971) | NW MN (2008) | Alaska[1] | NW MN (1972–1976)[1] |
|---|---|---|---|---|---|
| Algonquin Park, 1987–1995 | $\chi^2 = 1.18$; $P = 0.18$ | $\chi^2 = 6.30$; $P < 0.01$ | $\chi^2 = 4.73$; $P = 0.02$ | $\chi^2 = 6.48$; $P < 0.01$ | $\chi^2 = 6.43$; $P < 0.01$ |
| NE MN, 1999–2008 | | $\chi^2 = 10.86$; $P < 0.001$ | $\chi^2 = 7.59$; $P < 0.01$ | $\chi^2 = 8.86$; $P < 0.01$ | $\chi^2 = 8.86$; $P < 0.01$ |
| NE MN, 1969–1971 | | | $\chi^2 = 0.11$; $P = 0.55$ | $\chi^2 = 1.92$; $P = 0.20$ | $\chi^2 = 1.92$; $P = 0.21$ |
| NW MN, 2008 | | | | $\chi^2 = 1.43$; $P = 0.35$ | $\chi^2 = 1.34$; $P = 0.36$ |

[1]Alaska and NW MN 1972–1976 samples were basically the same (Table 1).

the rest of MN wolf range that include mostly wolves with ears shorter than 12.8 cm but with a few longer are in accord with the claim that wolves there morphologically represent primarily Gray Wolves, although genetically they are hybrids between the 2 (Fain et al. 2010, Wheeldon 2009).

Of some interest is the fact that the earlier sample from 1969–1971, from the same area as my 1999–2008 eastern Minnesota sample, contained so few specimens with ears ≥12.8 cm (Table 1). One explanation is that wolves that

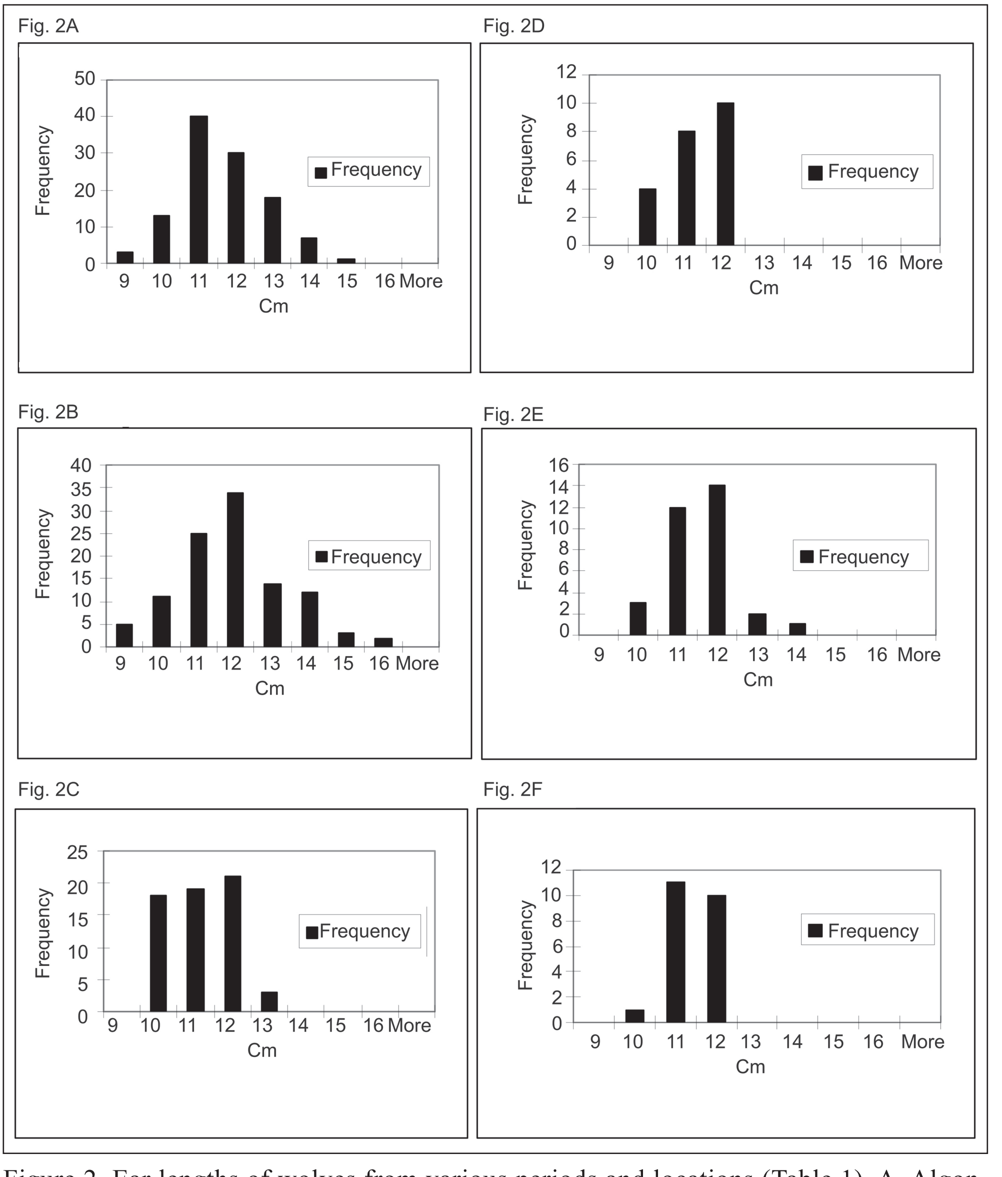


Figure 2. Ear lengths of wolves from various periods and locations (Table 1). A. Algonquin Provincial Park, eastern Ontario, 1987–1995; B. northeastern Minnesota, 1999–2008; C. northeastern Minnesota, 1969–1971; D. northwestern Minnesota, 1972–1976; E. northwestern Minnesota, 2008; F. Alaska, 2008–1010.

were higher-content Eastern Wolf may have moved increasingly westward from eastern Ontario during the last 4 decades. Supporting that possibility is the finding that during the past few decades the incidence of longer-eared wolves in my northeastern MN study area was higher in the eastern part of it and that wolf ears in that study area in 2004–2008 were significantly longer than 5 years before. (To ensure that this finding was not attributable to possible age differences between the 2 samples, I tested mean ages of wolves from both samples but found no significant difference [$P = 0.23$], and, as indicated earlier, there was also no sex difference). Thus, it appears that the longer-ear trait has moved into northeastern Minnesota since 1971 and that it has gradually increased and proceeded westward. The farthest west it has been found (Fig. 1) is in Itasca County and Morrison County (J. Hart, USDA, Wildlife Services, Grand Rapids, MN, 2008 unpubl. data).

The influx of longer-eared wolves cannot be attributed to the more recent recovery of the MN wolf population because the wolf population in northeastern MN had never been exterminated (Fuller et al. 1992). Rather wolf extirpation and repopulation in MN took place farther west (Fritts and Mech 1981) and south (Fuller et al. 1992). However, wolf skull-size data from 1970–1976 indicate that during 1970–1976 there was an influx of Gray Wolves to Minnesota, probably a result of the cessation of intensive wolf control in the 1960s (Fuller et al. 1992, Mech et al., in press). The skull data accord with the ear-length data from 1967–1971, but conflict with the weight data from that period (Van Ballenberghe 1977) and with the ear-length data from the present study (1999–2008). A possible explanation is that the wolf population of northeastern MN has been in a state of taxonomic flux since the 1960s and continues in that state today. Skull measurements from post-1976 would shed further light on this issue.

My ear-length data do not prove that northeastern MN wolves are higher-content Eastern Wolves, but only provide some evidence. Pre-1950 skulls from the area were of Eastern Wolf size (Mech et al., in press), and the body-mass data from that study area in the early 1970s (Mech and Paul 2008, Van Ballenberghe 1977) were the same as those from Algonquin Provincial Park (Theberge and Theberge 2004), where the Eastern Wolf was first described (Wilson et al. 2000). Lehman et al. (1991) examined genetics of several wolves from our study area and found both Gray Wolf mtDNA and a haplotype they considered as Coyote. However, their Coyote haplotype has never been found in extant Coyote populations, and an alternate interpretation that is gaining increasing acceptance is that their Coyote haplotype is actually that of the Eastern Wolf (Fain et al. 2010; Kyle et al. 2006; Wayne 2010; Wheeldon and White 2009; Wilson et al. 2000, 2009). If the latter hypothesis is true, then there is genetic evidence of Eastern Wolf influence in my northeastern MN study area by 1988 when the Lehman et al. (1991) genetic specimens were collected, as well as from more recent collections (Fain et al. 2010, Wheeldon 2009).

The above facts beg the question as to why, if the northeastern MN wolves possessed strong Eastern Wolf influence into the early 1970s, their ears were not as long at that time as those of Algonquin Park wolves or wolves currently in the area. This inconsistency might be explained by the apparent influx of Gray Wolves in the early 1970s evidenced by skulls (Mech et al., in press), and by a hypothesis that that population is still undergoing hybridization between higher-content Eastern Wolves from the east and Gray Wolves from the north or west (Mech 2010). The east–west and temporal trends found in the current study add support to this hybridization hypothesis.

Clearly additional study, including measurements of skulls from 1976 through the present all across MN wolf range, is needed to further unravel this mystery.

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