NUNAVUT WOLF MORPHOLOGY AND DIET STUDY

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FINAL REPORT

Nunavut Wolf Morphology and Diet Study

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1. EXECUTIVE SUMMARY

In North America, 24 subspecies of the grey wolf (*Canis lupus*) are recognized, some of whom are believed to be extinct. Commonly, the subspecies are described based on morphological differences between geographic areas. Recently, subspecies descriptions were re-evaluated, dividing the North American grey wolf into 5 subspecies, 2 of them occurring in northern Canada: *Canis lupus arctos* in the High Arctic Islands (except Baffin Island) and the “Southern group” mostly referred to as *Canis lupus nubilus*, occupying a range, which includes all the central part of Canada (including Baffin Island) and nearly all of the USA. Other studies mention a third subspecies and state that Baffin Island, Kivalliq and Kitikmeot wolves belong to the so called "Northern group" or *Canis lupus occidentalis*.

The purpose of this study was to determine whether there are distinguishable subspecies and/or populations of the grey wolf in Nunavut and to investigate the diet composition of wolves, especially on the Arctic and High Arctic Islands, where caribou and muskox numbers are declining.

Between 1999 and 2002, a total of 228 skulls were collected from hunters across Nunavut. To date, 170 skulls were processed and of these, 148 were analyzed for this report. 22 skulls had to be excluded due to severe damage, young age (not fully grown) and uncertain gender. Two thirds of the analyzed skulls were males and most of both males and females were harvested on Baffin Island.

After the skulls were cleaned, a suite of 54 cranial parameters was measured for each individual specimen. Data were entered in a spreadsheet and statistically analyzed. According to harvest locations, the wolves were divided into 5 different groups: Kitikmeot, Kivalliq, South Baffin, North Baffin and High Arctic. A variety of univariate and multivariate tests were performed to address differences between the genders and, more importantly, between the regions.

In all 5 regions, almost all measurements were larger in the male specimens. The difference was most obvious in sagittal crest dimensions and skull length. The average size difference across all 54 cranial measurements was around 6% for all regions, except he High Arctic, where the males where on average 8.2% larger than the females.

In male wolves, most of the cranial measurements were larger for samples from the Kitikmeot and the High Arctic and smaller for Kivalliq, South Baffin and North Baffin specimens. The results of 54 one-way ANOVAs showed that in more than half of the measurements, High Arctic and Kitikmeot males were significantly larger than other wolves in this study, males from Baffin Island (especially South Baffin) where the smallest ones. Kivalliq wolves were often smaller but tended to be in-between the other specimens.

Similar to the male skulls, female cranial measurements showed some variation between the regions, but only 31% of the 54 measurements revealed significant differences. Female specimens from the High Arctic and Kitikmeot were significantly larger than other females, samples from Baffin Island (especially South Baffin) where the smallest ones. Similar to males, Kivalliq females were often smaller but tended to be in-between the other specimens.

Overall, the strongest significances were found in both males and females from the South Baffin. These samples were in most measurements significantly smaller than all other wolves. Next to this group, males and females from the High Arctic showed many significantly larger skull features than all other wolves, followed by the Kitikmeot wolves of both sexes, which were larger as well, and the North Baffin specimens, which were smaller than the rest. The least obvious results were found in the skulls of both sexes from the Kivalliq region.

In a next step, all 54 measurements were processed simultaneously for a Factor Analysis. In male wolves, pooled from all regions of the study, the first 3 Principal

Components explained 65% of the total variation found in the male wolves from all 5 regions.

The first component, which showed the strongest positive association between measurements, included length and width measurements of the skull, total height of skull, measurements of the lower jaw and the two measurements of the sagittal crest. The second component showed only few strong positive associations. These were palatal width, width between the orbitals and the articular condyle of the lower jaw. On the third component, upper molar width, width across postorbital processes, brain case width and width of zygomatic process were strongly positively associated.

In female wolves, the first 3 components explain 51% of the total variation. The first component, which showed the strongest positive associations between measurements, included length and width measurements of the skull, height of skull and all measurements of the lower jaw. The second component showed only five strong positive associations. All of these were tooth measurements. On the third component, two more width measurements were strongly positively associated.

In summary, most of the length and width measurements were responsible for the observed variation between the regions for both males and females. That means that the 54 cranial measurements can be reduced to the length and width measurements on the first 3 Principal Components.

Therefore, in the next step, the 54 measurements taken from each individual skull were replaced by the factor scores on the first 3 components for males and most of the females (masurements for females from the Kitikmeot and the High Arctic grouped in only 2 Principal Components). Three ANOVAs were calculated for the loadings on the 3 Principal Components for males across the study area. There were no significant differences in the factor scores between the regions. The factor scores on the first component were all strongly positively associated, while the other two components demonstrated week positive and negative

associations. The variation between the loadings on each component was very high.
The same analyses were done for female wolves and when tested for regional differences, factor scores on Component 1 for females of the High Arctic were significantly smaller than the other 4 regions. While females of all other regions showed strong positive association of measurements on the first component, females from the High Arctic showed a very weak association (with a very high variation).

During a Discriminant Analysis, all 54 measurements were grouped into 4 factors and the factor scores were presented in scatter plots.
In all plots that show Factor 1 (with the highest Eigenvalue), Kitikmeot males grouped separately from the other regions. Plots that involve only Factors 2,3, or 4 did not show any separation of the groups. A pairwise group comparison confirmed the finding that the male skulls from the Kitikmeot region were different from the other locations. Unfortunately, there was only one male from the High Arctic included in this analysis, therefore, the statistical results can not be interpreted for the High Arctic.

In all scatter plots that showed Factor 1 on the x-axis, Kitikmeot females grouped separately from the other regions. Plots that involved Factor 2 on either the x or the y-axis show a separation of wolves from the Kivalliq. All other plots did not show any separation. A pairwise group comparison revealed no significant results but showed a trend for the Kitikmeot skulls to be different from the rest of the skulls.

In order to study the diet composition of wolves in Nunavut, a suite of 70 fatty acids was analyzed for a variety of potential prey species. Hunters across the study area returned several specimens of caribou and muskox and small mammals were provided from another study.

During the analysis that was performed at Dalhousie University in Halifax, NS, each species left a specific “fingerprint” across the 70 fatty acids and thus could likely be recognized in wolf fat tissue if consumed by wolves. Eight wolf samples were submitted for Fatty Acid but results have not been received to date.

2. BACKGROUND AND OBJECTIVES

The grey wolf (*Canis lupus*) is one of the most variable and widely distributed mammals world wide. In North America, 24 subspecies are recognized, some are believed to be extinct (Mech 1970, Nowak 1995). The subspecies are described based on morphological differences between geographic areas. Male and female cranial measurements of adult wolves are the most commonly reported source for subspecies and population analyses. In several cases, subspecies were established on the base of a small sample size and without statistical analysis (Nowak 1995). Some reports also pooled male and female specimens to increase the sample size (Clutton-Brock et all. 1994). Recently, subspecies descriptions were being reviewed and archive samples re-evaluated. As a result, Nowak (1995) suggested a revised subspecies system, dividing the North American grey wolf into 5 subspecies, 2 of them occurring in northern Canada: *Canis lupus arctos* in the High Arctic Islands (except Baffin Island) and the “Southern group” mostly referred to as *Canis lupus nubilus*, occupying a range, which includes all the central part of Canada (including Baffin Island) and nearly all of the USA. Contrary to this finding, but similar to earlier studies, Mulders (1997) found that the Baffin Island, Kivalliq and Kitikmeot wolves belong to the so called "Northern group" or *Canis lupus occidentalis*. While all of these studies were based on morphological measurements and, especially in the Arctic, wolves were represented by very few skulls, until recently none of the Arctic populations were ever tested genetically for their relatedness (Carmichael et all. 2001). To characterize the genetic structure of populations, two different techniques can be used (L. Carmichael pers. comm. 2000). DNA sequencing is a technique to identify possible sub species within one species. Microsatellites (a class of genetic markers in eukaryotic genomes) can be used to study the evolutionary relationship between groups (Paetkau et all. 1997). This method was used in the past for studies on the genetic distance in north American ursid species as well as in wolves (Paetkau et all. 1998, Carmichael et all. 2001).
A review of the available literature resulted in the finding that cranial analyses of a larger sample size parallel with genetic investigation of wolves in the High

Arctic and Arctic are needed to provide necessary data for the identification of possible subspecies or populations in the Canadian Arctic.

It is not only taxonomists that require this re-evaluation of the subspecies system of the grey wolf. Peary caribou and muskox numbers on some of the High Arctic Islands are declining (A. Gunn per. comm.. 2000) and with them possibly the wolf population (most probably the "Arctic wolf"). If a possible Arctic wolf decline is a consequence of the decline of these ungulates, the additional impact of human hunting might have severe implications on the wolf population.

Prior to the evaluation of a possible change in the Arctic wolf population, the following questions need to be addressed:

1) Are there distinguishable subspecies and/or populations of the grey wolf in the Canadian Arctic and can population boundaries be identified?

2) What is the diet composition of wolves on the Arctic and High Arctic Islands? How important are ungulates in the diet of the High Arctic Island wolves?

3. METHODS

3.1 Skull collection

In 1999, Wildlife Officers and Hunters and Trappers Associations (HTAs) across Nunavut were contacted and informed that the Department of Sustainable Development – Nunavut Wildlife Service (now: Department of the Environment – Nunavut Wildlife Management Division) is reimbursing hunters if they return skulls of harvested wolves. The requirement was that each specimen had to be labeled with: kill date, location, sex of animal and name of hunter. Labels and information material on the study were provided. Returned skulls were inventoried and kept frozen until processed. Samples were collected from most communities in Nunavut.

3.2 Skull preparation

All skulls and tongues shipped to Iqaluit were labeled and catalogued. Data from the completed hunter protocol sheets were recorded in a database. Tongues were removed from the skull, and the skulls were boiled for several hours (on average 5 h per skull depending on size) and flesh was gently removed with dissecting tools. Then the skulls were polished with a soft brush. The cleaned skulls were relabeled and stored at room temperature for at least 4 weeks to allow them to shrink to their original size.

All tongues were sent to the University of Alberta in Edmonton, where L. Carmichael and C. Strobeck conducted DNA analysis (DNA sequencing and microsatellite analysis). The results of these tests are not part of this report.

3.3 Measurements

Dried skulls were measured according to a previously established protocol. All skull measurements were recorded with 30 cm long electronic calipers (Mitutoyo Model 500-323) to an accuracy of 0.01 mm. Measurements were recorded on prepared sheets and entered into an Excel spread sheet. Before analysis, all entered data were proofread and (if necessary) corrected.

Several skulls showed signs of old, often healed, injuries (intraspecific aggression, caribou/muskox hooves). Pictures of injuries and abnormalities were taken and catalogued.

3.3.1 List of measurements

A total of 54 parameters were measured for each skull (Table 3.1, Figure 3.1 and Figure 3.2). Of these, 45 were taken from Mulders (1997) study (measurements 1 to 45), one was taken from Novak (1995) (N3) and seven from Clutton-Brock et all. (1994) (CB4, CB5, CB8, CB10, CB21 and CB23, Table 3.1). Additionally, two new measurements were used to assess the sagittal crest (SC1 and SC2; Figure 3.2).

Table 3.1 describes the 54 measurements and Figure 3.1 provides an overview over the wolf skull and the measurements taken.

Table 3.1 Description of all 54 cranial parameters measured during this study

Number	Description of Measurement
1	Condylobasal length (from premaxilla to occipital condyle)
2	Maximum length from premaxilla to posterior of sgital crest
3	Maximum length of nasals
4	Palatal length from alveolar of I^1
5	Palatal length from alveolar of I^2
6	Post palatal length
7	Crown length of upper cheek teeth from C to M^2
8	Maximum anterior-posterior of upper canine at base of C^1
9	Maximum buccolingual width of of P^4 at enamel line
10	Maximum anterior-posterior length of P^4 at enamel line
11	Maximum buccolingual width of M^1 at enamel line (at major cusp)
12	Maxium anterior-posterior length of M^1 at enamel line
13	Crown width of M^2
14	Crown width across upper incisors (I^3 to I^3)
15	Minimum width between alveoli of upper premolars (P^1 to P^1)
16	Palatal with inside the upper second premolars (at hollow) (P^2 to P^2)
17	Width of skull across outside of upper canines (C^1 to C^1)
18	Palatal width outside the first upper molars (M^1 to M^1)
19	Maximum crown width across upper cheek teeth
20	Width between the postglenoid foramina
21	Width between the auditory bullae
22	Maximum width of skull at lateral borders of occipital crest
23	Maximum width of long axis of left condyle
24	Maximum width of short axis of left condyle
25	Total width across both occipital condyles
26	Minimum interorbital width
27	Width at postorbital processes
28	Minimum cranial width at temporal fossa
29	Maximum breadth of brain case at parietotemporal suture
30	Maximum zygomatic width
31	Minimum distance from alveolar margin of M^1 to orbit
32	Minimum height of jugal at right angles to axis of bone
33	Height of skull from auditory bulla to sagittal crest
34	Maximum length from symphysis to angular process
35	Maximum length from Symphysis to condyle
36	Maximum crown length of tooth row from anterior of C_1 to M_3
37	Maximum buccolingual width of P_4
38	Maximum anterior-posterior length of P_4
39	Maximum buccolingual width of M_1
40	Maximum anterior-posterior length of M_1
41	Width of mandible at P_4
42	Maximum width of long axis of articular condyle
43	Maximum width of short axis of articular condyle
44	Maximum height of ramus between P_4 and M_1
45	Distance from angular process to top of coronoid process
N3	Crown length of upper teeth from P^1 to M^2
CB4	Basicranial length (b to s)
CB5	Basifacial length (s to p)
CB8	Facial length (mid frontal to p)

CB10	Snout length (orbit to p)
CB21	Depth of brain case
CB23	Foramen magnum to mid frontal
SC1	Max sagittal crest height perpendicular to skull
SC2	Max sagittal crest height perpendicular. to SC1

Figure 3.1 Most of the 54 skull measurements that were recorded (Source: Mulders 1997)

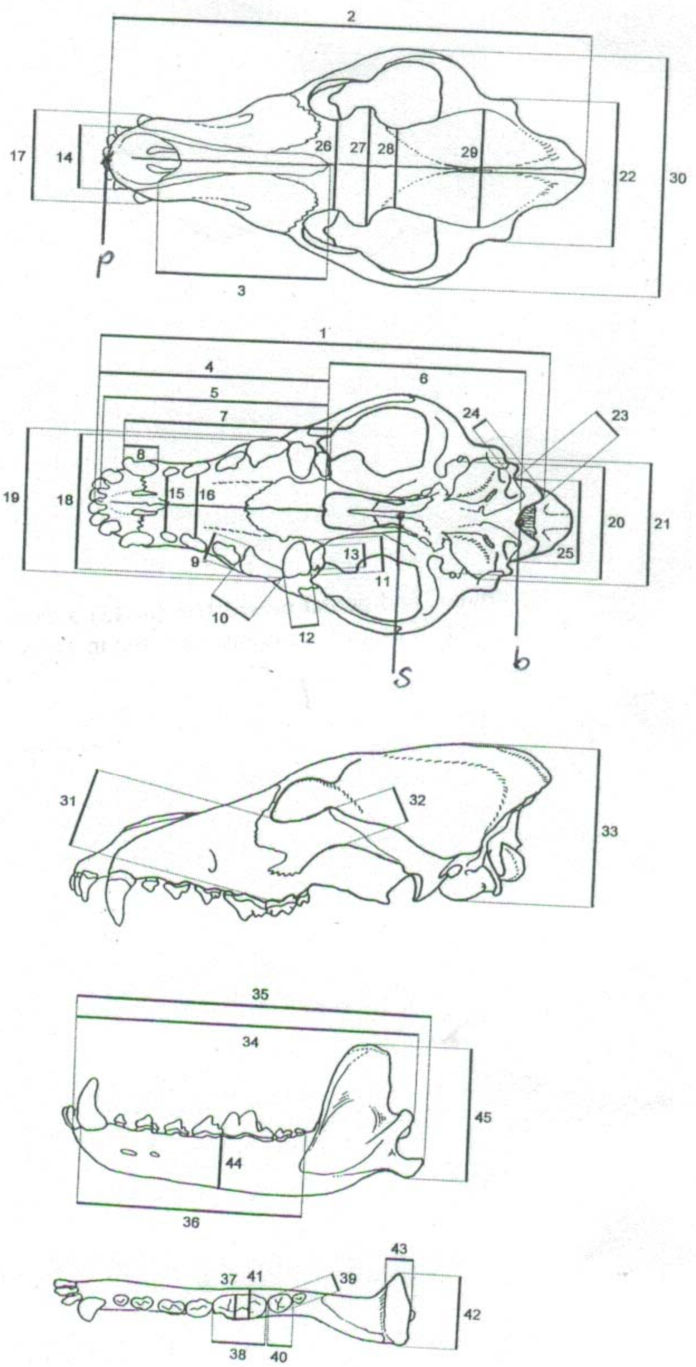
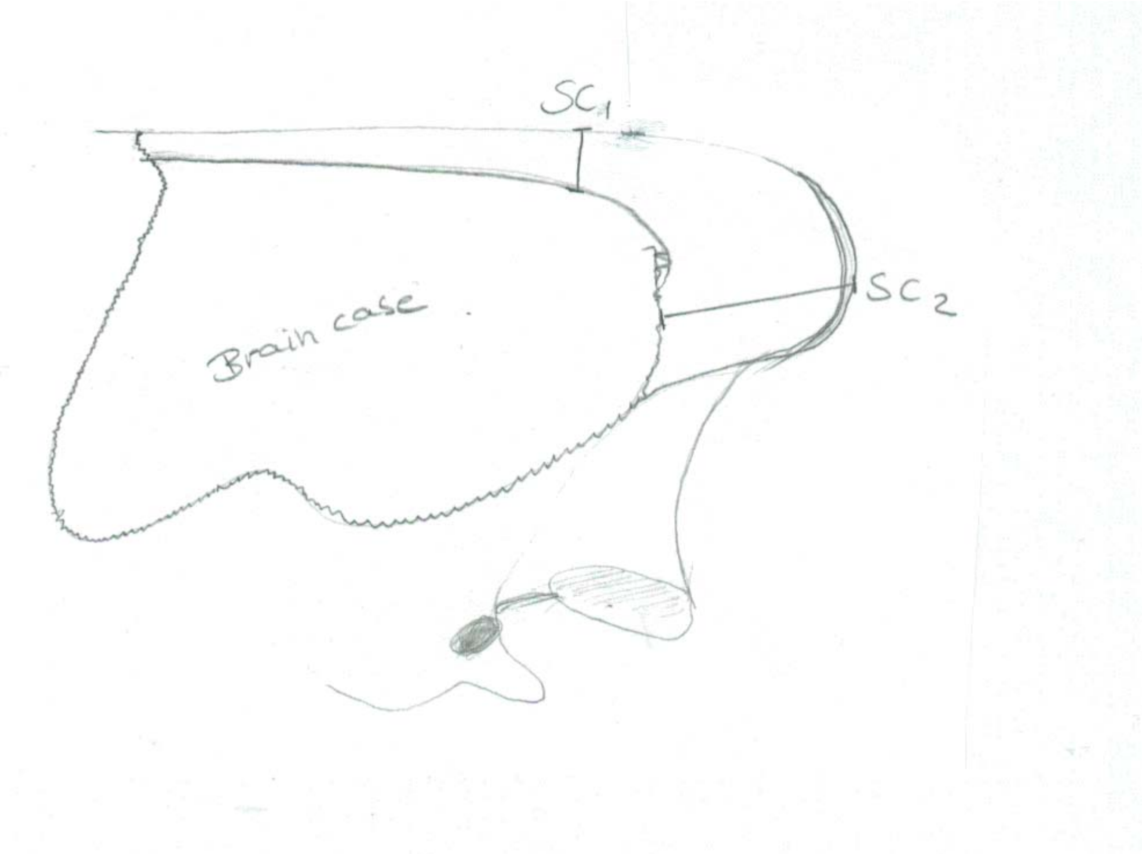


Figure 3.2 The two new sagittal crest measurements SC1 and SC2



3.3.2 Exclusion of Pups

Because wolves are only fully grown towards the end of their second year (Skeel and Carbyn 1977), ages of sampled wolves had to be determined and wolves younger than 1.5 years excluded as “pups”. The most reliable feature for determining the adult (fully grown) state of the specimen was the closure of the presphenoid-basisphenoid suture (Skeel and Carbyn 1977; Figure 3.1). Mulders (1997) compared this method with aging of extracted premolars and did not detect any difference between the methods. Additional characteristics of a subadult wolf were minimal tooth wear and not fully erupted canines. All specimens determined as pups were measured but excluded from analysis. Also specimens of unclear status were excluded.

3.3.3 Gender Identification

It is known that wolves exhibit sexual dimorphism (Mulders 1997), therefore, it is of importance to label each skull with the proper sex. This is most important in cases where hunters returned several skulls, in which case some skulls may have been mislabeled prior to shipment. Preliminary statistical analysis of the cranial morphology data indicated that there might have been some discrepancies among the samples of several individuals. At this point, it was important to validate the gender of these individuals. On the basis of known sex wolves, a reliable DNA gender test was developed (L. Carmichael, pers. comm. 2000). Four skulls were labeled with a questionable gender, and, therefore, sent to the University of Alberta in Edmonton for DNA testing. With help of the test, all four specimens were classified as the opposite sex.

Mulders (1997) reports mean differences between the genders for total skull length (measurement 1) of 3.8 to 6.5% across the range of this study.

Wolves were initially entered in the database with hunter assigned gender (from returned label). If a specimen showed a difference of more than 4 % in key parameters (such as measurement 1 and other length and width measurements, Table 4.3) during analysis, it was assigned the opposite sex. Unclear cases were sent for genetic analysis (4 skulls) or excluded (2 skulls).

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Additionally to cranial analysis, it was proposed to analyze the genetic composition of the specimens. Tongue samples from all collected skulls were sent to Edmonton (University of Alberta, Lindsey Carmichael), where their DNA is being sequenced (for subspecies identification) and microsatellites are analyzed (for population identification). The methods and analysis are not covered in this report.

3.3.4 Error Identification

For every ten skulls measured, one was chosen by chance to be re measured after several weeks and recorded and entered in the same way. The difference between the two datasets was analyzed and determined as measurement accuracy.

3.3.5 Statistical Analysis

To compare regional differences, each wolf specimen was assigned to one of the regions: Kitikmeot, Kivalliq, South Baffin, North Baffin, High Arctic (Table 4.1) Morphological measurements were analyzed using the program SYSTAT (SPSS Inc. 2000). All data were tested for normal distribution with a Kolmogorov-Smirnov Test and descriptive statistics were calculated. One-way ANOVA's were performed for both sexes to compare regional differences for all 54 measurements with additional Bonferroni post hoc tests to reveal where the potential significances were. Student's t-tests were used to test for sexual dimorphism for all parameters in each region. The difference between males and females for each measurement and for each region was calculated in percent and the regional mean sexual dimorphisms calculated.

In order not to rely on single univariate measurements, of which many are interrelated, but to consider the skulls as a multivariate complex of 54 measurements, multivariate statistics was used. Principal Components Analysis (PCA) within the Factor Analysis provides an ideal tool to assess inter correlations among the 54 parameters, form combinations of parameters (factors or components) and order the new components in a way that the first component explains the highest amount of variation in the data set and the last one the least. The first component is usually representing overall size, while subsequent components are often reflecting differences in other aspects of shape (Manly 1986). High factor scores on components reflect a strong positive correlation of measurements within that component.

The initial step of the Factor Analysis is the creation of a correlation matrix of all 54 characters, then factors (or components) are extracted (each containing a variety of inter related original measurements), then factors are rotated and finally factor scores are calculated (Manly 1986). One-way ANOVAs were performed to determine significant differences between the factor scores on each Principal Component.

Discriminant analysis is used to identify linear combinations of quantitative predictor variables (discriminant function) that best describe the difference among groups. Combining information from two or more variables can greatly enhance the separation of groups. During this test, all 54 skull measurements were divided into several discriminant functions or canonical variables. The first canonical variable is the linear combination of variables that maximizes the differences between the means of the groups (locations). The second canonical variable represents the maximum dispersion of the means in a direction perpendicular to the first direction. The third canonical variable represents the dispersion independent of the first two dimensions and so on. In order to compare variables that are measured at different scales, data were z-transformed before analysis so that the means are set to 0 and the standard deviation to 1.The results are best represented as a scatterplot of two canonical variables (e.g., the first against the second etc.). F statistics (pairwise group comparison) was used to describe the difference between groups and Wilk's Lambda was used to test whether the means of the canonical variables were equal in all groups.

3.4 Tissue Collection for Diet Analysis

Initially, it was planned to carry out a Nunavut wide scat collection (with emphasis on the High Arctic). This method bears several disadvantages. Hunters would have to wear gloves for collecting and handling wolf scats, because these can contain parasites (B. Elkin pers. comm. 2000). Although it was indicated in the proposal to accept only scats collected further than 100 km from the nearest community, the inclusion of some dog scats could not be ruled out. Additionally, detailed analysis of scats is very time consuming and requires experienced personnel to avoid misinterpretation (L. Carbyn pers. comm. 2000).

An alternative technique for dietary analysis is the Stable Isotope Analysis. The specific isotope composition of a prey animal can be found in the body of the predator. If the different prey species differ in their isotope composition, each leaves a signature in the tissue of the predator, which can be detected in the lab (Hobson and Sease 1998). All major potential prey species of the wolf in Nunavut (caribou, muskox, hare and other small mammals) have a similar diet over the course of a year and the method is not sensitive enough to separate the different "signatures" in the wolves' tissues (K. Hobson pers. comm. 2000).
A more sensitive and also very reliable technique is the Fatty Acid Analysis, where the fatty tissues of the predators are analyzed for the specific composition of fatty acids of prey species. Possible differences in prey species are detected using a mathematical model (S. Iverson pers. comm. 2000). The model provides quantitative estimates of the proportions of prey species in the diets of the predators based on their fatty acid “signatures”.

3.4.1 Potential Prey Species

To determine whether the fatty Acid Analysis is appropriate for the described purpose, a tissue collection of all potential prey items (as listed above, additionally lemming, vole, ground squirrel and fox samples) was initialized in the fall of 2000 across Nunavut. Information material and sampling kits were distributed to communities.

3.4.2 Wolf Samples

After it was determined that it is possible to identify different potential prey species based on their fatty acid composition, a specimen collection for wolf fat tissues was initialized in the fall of 2001. Information material and sampling kits were distributed to communities.

4. RESULTS

4.1 Description of skull collection

4.1.1 Harvest locations, gender composition and excluded samples

A total of 228 skulls were collected from 1999 to 2001 (Table 4.1). As indicated on the hunter return forms that were submitted with the wolf samples, most wolves in Nunavut are shot from the snowmachine. In several cases, the bullet had hit the head and the damage was quite extensive. In a few cases, it was obvious that the wolf was hit on the head, which resulted in damage as well. A total of 5 specimens had to be excluded due to severe damage (Table 4.1). Final analysis for this report included 148 adult wolf skulls from all three regions in Nunavut.

Samples from the Kitikmeot region were collected in Kugluktuk, Cambridge Bay, Gjoa Haven and Kugaaruk (Figure 4.1). A total of 14 Kitikmeot wolves (10 males and 4 females) were analyzed for this study (Table 4.1).

A total of 19 samples (14 males and 5 females) were analyzed from the Kivalliq region, they came from Coral Harbour, Baker Lake, Rankin Inlet and Arviat (Figure 4.1).

Most samples were submitted from the Baffin region (n = 110). Because the wolves were either harvested south of Pangnirtung or north of Clyde River and Iglulik, the samples were divided into South Baffin (Cape Dorset, Kimmirut, Iqaluit and Pangnirtung; Figure 4.1) and North Baffin (Hall Beach, Iglulik, Clyde River, Pond Inlet and Arctic Bay). A total of 70 wolves (49 males and 21 females) from South Baffin were included in this report (Table 4.1). A total of 40 wolves (24 males and 16 females) from North Baffin were analyzed (Table 4.1).

For this report, 5 skulls from the High Arctic were analyzed (2 males and 3 females). One male skull was partially destroyed and not included in multivariate statistics. All samples were collected on Ellesmere Island and were harvested by hunters from Grise Fiord (Figure 4.1)

4.1.2 Injuries and abnormalities

During examination of the submitted wolf skulls, a variety of injuries (52 skulls) and abnormalities (53 skulls) were observed. It is beyond the scope of this study to describe and interpret those findings. However, a summary of encountered injuries and abnormalities is provided in Table 4.1.

Table 4.1 Summary of specimen collection across Nunavut between 1999 and 2002

Skulls	Total	Males	Females
collected	**228**		
processed	**170**		
excluded due to extreme damage	**5**		
pups excluded	**15**		
DNA gender test	**4**		
uncertain gender excluded (no DNA test done)	**2**		
skulls with injuries (included in analysis)	**53** (- holes in cheek bones due to tooth / root abscesses, -broken and healed bones, -broken teeth in conjunction with decaying maxilla and mandible bones)		
skulls with abnormalities (included in analysis)	**52** (-doubled P1 teeth, -missing M3 teeth, -P1 teeth with 2 cusps, -malformations)		
skulls with harvest related damage (but not excluded)	**27** (-broken sagittal crest, - parts of braincase damaged, -teeth and jaws cracked)		
Total analyzed	**148**	**99**	**49**
Kitikmeot	**14**	10	4
Kivalliq	**19**	14	5
South Baffin	**70**	49	21
North Baffin	**40**	24	16
High Arctic	**5**	2	3

Figure 4.1 Map of study area (source: Government of Nunavut)

4.2 Descriptive statistics of skull measurements

4.2.1 Regional comparison

4.2.1.1 Males

The measurements of all 54 parameters for males of the 5 regions were normally distributed. Table 4.2 presents the mean values and standard deviations of the measurements. The number of intact adult skulls that were analyzed is given in parentheses in the first row. Unfortunately, the number differs considerably between the regions, with the High Arctic and the Kitikmeot having the least samples. This obvious imbalance caused another successful call for the return of additional skulls from these two areas in 2002. In total, 58 more skulls were collected, some of them were part of former harvest collections. The skulls have been inventoried but not processed and are not included in this report.

Most of the cranial measurements resulted in larger values for wolves from the Kitikmeot and the High Arctic and in smaller values for Kivalliq, South Baffin and North Baffin specimens. When compared with one-way ANOVAs, 52 % of measurements revealed significant differences ($p<0.05$), while the differences in the other parameters did not prove significant (Table 4.4). A Bonferroni post hoc test showed that in 68 % of the significant cases, High Arctic wolves were significantly larger than skulls from one or several of the other regions. Specimens from the Kitikmeot where significantly larger in 64 % of the significant cases, often in conjunction with High Arctic samples. Of the significant cases, one measurement was largest for Kivalliq wolves and one for South Baffin wolves. Specimens from the North Baffin were never larger than samples from any other of the regions. On the other hand, male wolves from the High Arctic were never significantly smaller than any other specimens collected during the study. In one case, males from the Kitikmeot were smaller than other wolves (High Arctic). Kivalliq wolves were smaller in 32 % of the significant measurements, South Baffin males in 86 % and North Baffin males in 68 % (Table 4.4). In summary, while High Arctic and Kitikmeot males were significantly larger than other wolves in this study, males from Baffin Island (especially South Baffin) where the smallest ones. Kivalliq wolves were often smaller but tended to be in-between the other specimens.

Table 4.2 Means (in mm) and standard deviations for all 54 measurements for male wolves of the study area broken down into five regions. Number of intact adult skulls is given for each region

Measurement	Kitikmeot (10)		Kivalliq (14)		South Baffin (49)		North Baffin (24)		High Arctic (2)	
1	238.73	6.9	237.49	6.4	234.88	6.2	234.13	6.8	238.46	4.2
2	259.26	8.5	253.37	6.6	254.4	6.7	251.75	7.1	259.05	2.5
3	96.44	5.7	94.28	4.7	97.05	4	93.86	3.4	93.35	2.7
4	122.07	2.8	123.79	4.8	123.26	3.3	121.03	3.5	124.25	3.6
5	120.34	2.7	122.03	4.8	121.45	3.6	119.15	3.7	122.53	4.5
6	99.04	3.6	96.58	2.9	95.21	3.3	96.72	3.5	98.27	4.4
7	108.17	3	106.68	3.1	106.28	3.6	105.43	3.2	108.68	0
8	15.02	0.9	14.53	1	14.49	0.9	14.38	0.6	16.79	0.8
9	14.43	0.6	13.06	0.9	13.34	0.9	13.29	0.8	13.89	1.5
10	24.85	1.5	25.34	1	25.58	1.3	25.12	1.2	26.85	0.5
11	21.05	0.8	20.02	0.8	20.34	1	19.94	1.3	20.69	1.3
12	16.88	0.9	17.34	0.4	16.92	0.7	16.83	0.7	17.95	0.8
13	13.57	0.7	13.89	0.6	13.55	0.6	13.42	0.9	14.25	0.3
14	36.98	1.4	37.98	1.3	37.25	2.2	37.18	1.7	38.08	2.2
15	31.19	1.9	30.9	0.9	30.27	1.3	30.72	1.6	34.25	0.6
16	34.21	1.7	35.24	3.1	32.97	1.4	33.73	1.8	37.3	1.5
17	49.16	3.1	48.85	2.1	47.55	2.2	47.77	2.3	53.3	0.5
18	79.7	3	78.63	3	76.93	2.2	77.88	3.3	81.99	1.6
19	80.64	3.5	79.44	2.8	78.84	2.6	79.51	3.2	84.17	0.1
20	65.35	2.1	64.26	2.3	61.65	2.2	63.27	2.6	66.79	0.3
21	18.56	1.4	18.33	2.2	18.2	1.5	17.68	1.6	18.11	0.2
22	83.73	3	80.05	2.8	79.66	2.2	79.18	2.5	81.72	1.3
23	24.8	1.2	24.35	1.5	23.75	1.4	24.04	1.1	23.76	1.1
24	12.33	0.8	12.24	0.6	12.03	0.9	12.34	1.3	11.39	1.2
25	49.87	2	50.3	2.6	49.64	2	49.39	2.2	49.45	2.6
26	46.81	4	45.3	2.2	43.74	2.8	45.32	2.3	48.65	0.9
27	63.17	4.8	59.17	4.9	59.63	3.9	62.97	3.7	63.97	4
28	43	4.6	40.24	2.9	40.09	2.4	41.45	2.8	41.39	0.4
29	66.52	1.5	66.91	2.2	66.76	1.8	67.35	1.7	65.69	1.8
30	138.19	8.2	134.73	4.5	131.71	4.6	133.33	5.2	141.62	0.1
31	40.22	2.3	38.5	2.8	39.37	1.8	38.63	2.1	43.31	0.3
32	17.7	1.8	17.77	2.8	18.52	1.5	18.07	1.5	19.78	2.1
33	87.61	3.2	83.03	5.9	85.27	2.1	84.95	3	91.99	0.2
34	189.72	7.3	186.98	4.7	186.35	4.3	185.23	5.5	191.8	6.6
35	185.5	6.9	185.45	5.3	184.83	4.5	183.27	5.4	188.55	7.1
36	120.67	3.7	119.87	3.5	120.03	3.4	118.33	3.3	122.91	1.5
37	8.19	0.4	8.16	0.5	8	0.5	8.04	0.5	8.43	0.1
38	16.34	0.5	16	0.8	16.21	0.7	15.67	0.6	17.32	0.1
39	11.6	0.4	11.54	0.6	11.76	0.6	11.5	0.6	12.25	0.5
40	28.68	1.1	29.13	1.3	28.87	1.3	28.19	1.1	30.93	1.2
41	13.48	0.7	13.26	0.6	13.57	2.3	13.27	0.7	14.76	0.4
42	32.72	2.3	31.18	1.6	29.68	1.4	29.99	1.4	33.07	2.4

43	12.07	0.5	11.57	1.1	10.91	1	11.11	1	12.49	0.7
44	30.57	2.3	29.13	1.8	29.38	1.7	29.59	2.2	33.36	0.1
45	76.34	3.9	73.53	3.3	70.57	3.6	72.51	4.2	75.5	4.5
N3	89.07	3.3	87.04	2.4	86.86	3.1	85.14	2.5	84.92	2.7
CB4	59.54	2.2	59.29	2	57.8	1.6	58.51	1.6	59.65	0.2
CB5	166.27	5.6	163.92	4.1	162.56	4.1	161.96	5.3	165.77	3.9
CB8	146.93	5.4	146.21	5.5	147	4.4	146.07	4.1	150.21	2.3
CB10	115.17	4	112.75	3.1	111.79	3.8	110.52	3.5	116.5	0.2
CB21	67.68	2.3	68.73	2.6	68.2	2.2	67.76	2.1	71.16	0.6
CB23	115.4	5.7	112.57	3.3	112.32	3.4	111.75	4.8	121.31	3
SC1	13.26	2.5	10.41	2.9	10.34	2.2	10.39	2.4	13.75	0.6
SC2	24.69	2.6	20.69	2.9	21.65	1.9	21.53	1.9	23.3	2.5

4.2.1.2 Females

Similar to the male skulls that were collected during this study, female cranial measurements showed some variation between the regions. But different to the males, the differences were not as obvious (Table 4.3). Only 31% of the 54 measurements revealed significant differences ($p<0.05$). Of these cases, High Arctic samples were larger than skulls from one or several other regions in 41% of the time (Table 4.4). The same was observed for specimens from the Kitikmeot (41%). Different to their male counterparts, it was never observed in females that skulls from several regions were larger than others at the same time. It was always just one region that provided larger measurements (Table 4.4). In one case, measurements were significantly larger for a female from the Kivalliq and in one case from the North Baffin. There was no instance were females from the South Baffin were larger. In turn, females from the High Arctic were significantly smaller in only one case and females from the Kitikmeot in 23 % of the significant cases. Kivalliq females were smaller than the other females in 23 %, South Baffin in 82% and North Baffin specimens in 70 % of all significantly different measurements. In summary, similar to the males discussed above, female specimens from the High Arctic and Kitikmeot were significantly larger than other females, samples from Baffin Island (especially South Baffin) where the smallest ones. Kivalliq wolves were often smaller but tended to be in-between the other specimens.
Overall, the strongest significances were found in both males and females from the South Baffin. These samples were in most measurements significantly smaller. Next to this group, males and females from the High Arctic showed many significantly larger skull features than all other wolves, followed by the Kitikmeot wolves of both sexes,

which were larger as well, and the North Baffin specimens, which were smaller. The least obvious results were found in the skulls of both sexes from the Kivalliq.

Table 4.3 Means (in mm) and standard deviations for all 54 measurements for female wolves of the study area broken down into five regions. Number of intact adult skulls is given for each region

Measurement	Kitikmeot (4)		Kivalliq (5)		South Baffin (21)		North Baffin (16)		High Arctic (3)	
1	219.2	8.5	222.68	4	219.74	6.2	220.64	4.6	223.74	0.9
2	241.26	3.7	237.45	3	237.58	6.4	235.85	5.8	240.07	2.3
3	87.78	0.9	86.69	1.2	88.72	3.7	88.99	3.1	86.42	3.1
4	116.04	3.5	116.03	4.7	115.45	3.6	114.61	3.2	116.86	1.2
5	114	3.9	114.16	4.6	113.71	3.8	112.82	3.6	115.71	1.2
6	88.7	1.2	90.26	3.6	89.86	2.7	90.17	3	90.62	0.9
7	103.07	2.2	100.03	1.8	100.87	2.3	100.64	2.6	102.66	2.2
8	13.68	0.4	13.79	0.4	13.5	0.8	13.21	1.1	15.03	0.8
9	13.7	0.9	12.56	1	12.99	0.8	12.81	0.7	14.04	0.3
10	23.63	0.6	23.93	0.7	24.73	1.2	23.87	0.9	25.48	0.4
11	19.84	0.5	19.54	0.4	19.59	1.1	19.37	1	19.35	1.3
12	15.88	0.7	16.47	0.8	16.4	0.7	16.25	0.6	17.47	0.8
13	13.63	0.3	13.55	1	12.94	0.9	12.86	0.7	13.5	0.1
14	34.97	0.6	36.88	1.2	36.19	1.5	35.41	1.5	35.5	0.1
15	30.11	0.8	29.42	1.6	28.81	1.6	29.12	1.5	30.3	1.1
16	33.61	0.3	32.48	1.2	31.54	1.6	32.27	1.4	32.94	0.6
17	46.14	0.6	45.88	2.4	44.73	1.9	44.45	2.3	47.16	1
18	75.28	1.3	74.77	1.6	74.01	2	75.18	3.6	76.25	2.3
19	75.7	0.9	75.2	1.8	75.11	2.6	75.98	3.8	76.41	1.9
20	61.5	3.2	62.97	1.8	59.55	1.5	59.98	1.7	62.83	1
21	15	2.1	17.91	2.2	17.13	1.4	17.09	1.3	17.84	1.2
22	76.56	1.4	77.98	2.6	75.88	2.3	75.15	1.9	76.79	0.7
23	23.87	1	23.49	0.9	22.13	1.1	22.27	1.4	22.79	0.6
24	11.8	0.3	11.39	0.5	10.79	0.9	11.81	0.7	11.65	0.3
25	47.04	1.5	47.5	0.9	46.56	1.5	47.21	1.1	46.61	1.6
26	45.47	2.8	41.43	1.4	40.6	2.4	41.21	2.6	43.06	0.3
27	63.99	7.1	55.13	2.3	55.61	4.1	56.73	3.6	59.87	1.3
28	41.8	4.5	37.78	1.9	38.58	2.8	39.56	2.2	39.99	0.9
29	65.43	2.4	66.41	1.7	65.18	1.8	65.46	1.4	62.12	1.2
30	135.5	5.8	128.74	4.1	123.79	4.8	123.64	5.2	129.81	2.1
31	37.31	1.3	37.94	2.2	36.35	2.5	36.14	1.7	36.48	0.7
32	16.04	0.5	16.78	0.6	17.22	1.3	17.19	2.1	15.74	0.8
33	82.7	0.6	79.28	2	80.86	2.8	80.41	1.6	83.62	0.8
34	179.01	5.8	174.67	4.1	174.74	4	174.36	4.7	177.83	2.5
35	171.98	5.6	173.28	3.4	173.5	5.2	173.18	6.1	174.28	2.5
36	115.16	2.6	112.86	2.3	114.14	2.8	112.82	2.7	115.23	2.1
37	7.43	0.1	7.47	0.5	7.62	0.3	7.7	0.3	7.91	0.1
38	14.97	0.1	15.41	0.6	15.43	0.6	14.99	0.6	17.16	0.3
39	10.77	0.7	10.85	0.3	11.19	0.5	11.14	0.7	10.7	0.1
40	26.34	1	27.98	0.7	27.49	1.1	27.24	1.1	29.36	0.4
41	13.06	0.2	12.86	0.8	12.49	0.7	12.46	1.1	12.93	0.8
42	30.69	0.7	28.66	1.8	28.01	1.3	28.25	1.2	29.6	0.5
43	11.37	0.7	11.07	0.4	10.15	0.6	10.64	0.7	10.98	0.9

44	29.21	2.2	27.28	1.8	27	1.7	27.16	1.6	29.04	0.3
45	70.64	1.1	65.89	3.3	65.5	3.5	65.83	3.4	68.09	2.1
N3	83.69	2.2	81.47	1.6	83.02	1.6	82.38	2.1	82.92	2.8
CB4	55.03	0.8	55.55	2.1	54.54	1.5	54.64	1.3	54.7	0.8
CB5	157.14	3.1	153.3	3.6	152.62	4.9	153.55	3.7	154.77	1.9
CB8	137.08	2	136.62	3	138.09	3.8	137.6	5.3	142.65	0.8
CB10	106.71	2.1	104.89	2.8	104.47	2.7	104.57	3.2	107.84	1.4
CB21	65.82	0.9	67.78	1.4	66.65	1.7	65.29	2.4	66.64	1.5
CB23	108.13	0.3	106.7	3	105.48	3	105.46	2.1	106.49	2.6
SC1	9.59	0.6	5	1.8	6	2.3	6.86	2.8	9.28	1.5
SC2	21.95	0.4	17.87	0.8	18.97	2.5	18.1	1.9	17.25	0.9

Table 4.4 presents the results of 108 one-way ANOVAs, 54 were computed for male specimens across the study area and 54 for females.

Table 4.4 Results of 108 one-way ANOVA's testing for regional differences between the 54 measurements in male and female wolves. Provided are signigicance levels (ns = p>0.05) and results of a Bonferroni posthoc test are provided as well.. KT = Kitikmeot, KV = Kivalliq, SB = South Baffin, NB = North Baffin, HA = High Arctic

Measurement	Males		Females	
1	ns		ns	
2	0.05	HA, KT > NB	ns	
3	0.023	SB > NB	ns	
4	ns		ns	
5	ns		ns	
6	0.017	KT > SB	ns	
7	ns		ns	
8	0.002	HA > KV, SB, NB	0.039	HA >SB, NB
9	0.003	KT > KV, SB, NB	0.04	HA > KV, SB, NB
10	ns		0.016	HA > KT, NB
11	ns		ns	
12	ns		0.044	HA > KT, NB
13	ns		ns	
14	ns		ns	
15	0.002	HA > KV, SB, NB, KT	ns	
16	0.000	HA, KT, KV > SB	ns	
17	0.031	HA > SB, NB	ns	
18	0.005	HA, KT > SB, NB	ns	
19	ns		ns	
20	0.000	HA, KT > SB	0.001	KV > SB, NB & HA > SB
21	ns		ns	
22	ns		ns	
23	ns		0.034	KT > SB
24	ns		0.04	NB > SB
25	ns		ns	
26	0.002	HA, KT > SB	0.009	KT > SB, NB
27	0.004	KV, KT > SB	0.005	KT > KV, SB, NB
28	0.034	KT > SB	ns	
29	ns		0.021	KV, SB, NB > HA

30	0.001	HA, KT > SB	0.000	KT > SB, NB
31	0.001	HA > KV, SB, NB	ns	
32	ns		ns	
33	0.001	HA > KV, SB, NB	0.05	HA > KV
34	ns		ns	
35	ns		ns	
36	ns		ns	
37	ns		ns	
38	0.002	HA > NB	0.000	HA > KV, SB, NB, KT
39	ns		ns	
40	0.014	HA > NB	0.008	HA > SB, NB, KT
41	ns		ns	
42	0.000	HA, KT >SB, NB	0.003	KT > SB, NB
43	0.001	HA, KT > SB, NB	0.003	KT > SB
44	0.026	HA > KV, SB, NB	ns	
45	0.000	KT > SB, NB	ns	
N3	0.008	KT > SB	ns	
CB4	0.04	KT > SB	ns	
CB5	ns		ns	
CB8	ns		ns	
CB10	0.006	KT > SB, NB	ns	
CB21	ns		ns	
CB23	0.008	HA > KV, SB, NB	ns	
SC1	0.004	HA, KT > KV, SB, NB	0.002	KT > SB
SC2	0.000	HA, KT > KV, SB, NB	ns	

The following figures (4.2 to 4.7) represent several measurements with significant differences between the 5 regions for both males and females.

Figure 4.2 Anterior-posterior length of upper canine at the base in mm for males (1) and females (2). Locations are Kivalliq (2), South Baffin (30, North Baffin (4), Kitikmeot (5) and High Arctic (6)

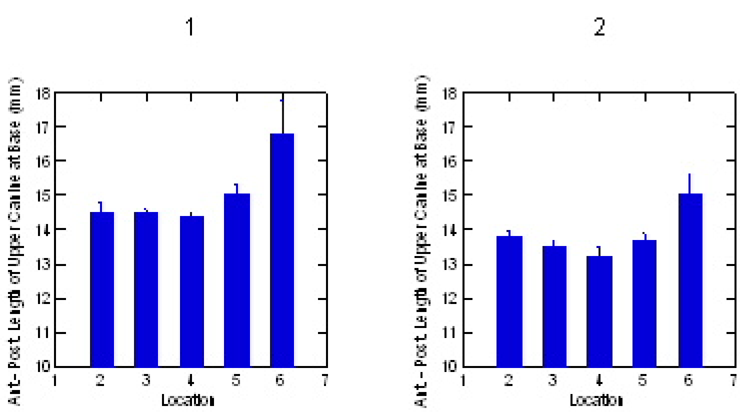


Figure 4.3 Interorbital width in mm for males (1) and females (2). Locations are Kivalliq (2), South Baffin (30, North Baffin (4), Kitikmeot (5) and High Arctic (6)

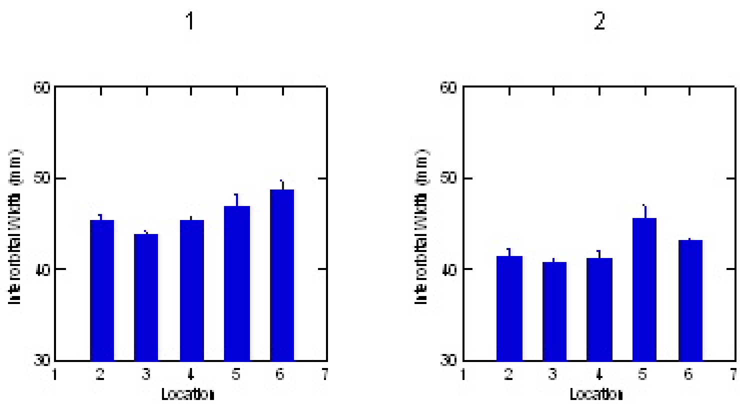


Figure 4.4 Zygomatic width in mm for males (1) and females (2). Locations are Kivalliq (2), South Baffin (30, North Baffin (4), Kitikmeot (5) and High Arctic (6)

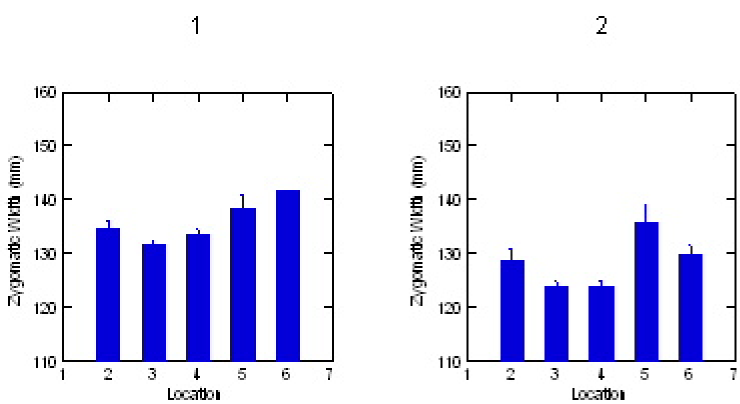


Figure 4.5 Anterior-posterior length of lower P4 at base in mm for males (1) and females (2). Locations are Kivalliq (2), South Baffin (30, North Baffin (4), Kitikmeot (5) and High Arctic (6)

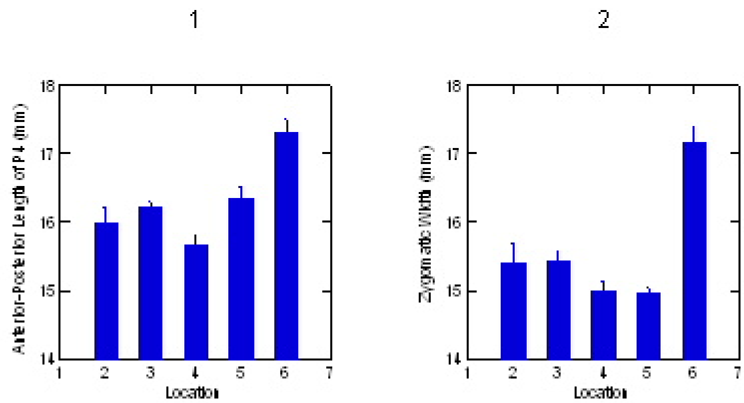


Figure 4.6 Width of long axis of articulate condyle in mm for males (1) and females (2). Locations are Kivalliq (2), South Baffin (30, North Baffin (4), Kitikmeot (5) and High Arctic (6)

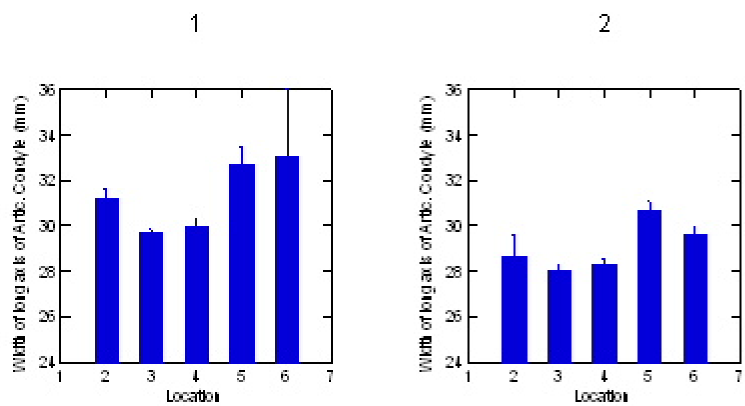
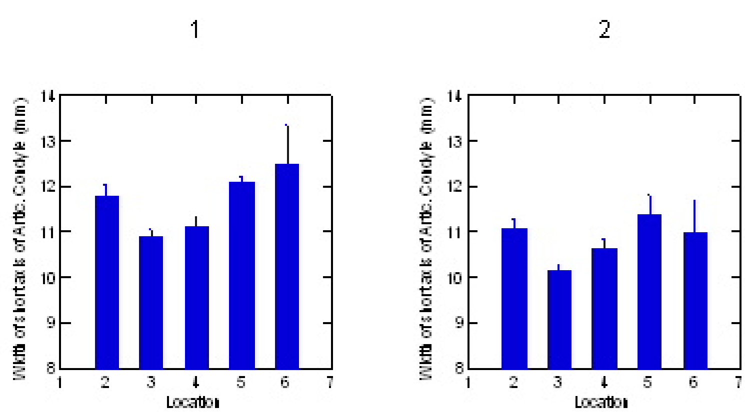


Figure 4.7 Width of short axis of articulate condyle in mm for males (1) and females (2). Locations are Kivalliq (2), South Baffin (30, North Baffin (4), Kitikmeot (5) and High Arctic (6)



4.2.2 Sexual Dimorphism

All 54 skull measurements for male and female wolves of each region in the study area were compared individually with a Student's t-test for differences between the sexes. Additionally, the percent value of the difference was calculated. In almost all cases, males were larger than females (Table 4.5). The mean difference across all parameters was similar for four regions (between 6 and 6.3%), the High Arctic wolves showed the highest dimorphism between the sexes with 8.2 %. The individual values ranged from -2.2% to 47%. On three occasions, negative values indicated that females were larger than males: measurement 27 for Kitikmeot wolves and 9 and 24 for High Arctic wolves. The highest rate of dimorphism was observed in the sagittal crest measurements (SC1 and SC2; Figure 3.2). Using these two newly introduced parameters, the sexes can be easily identified in adult wolves. SC1 and SC2 can be used for reliable gender identification in future wolf morphology studies. Significant differences between the sexes with a dimorphism rate of 10 or higher are highlighted in the table. The differences in the significance levels of the t-tests can be explained by drastic differences in the sample sizes. The higher the sample size was the higher the significance level.

Table 4.5 Sexual dimorphism on all 54 measurements expressed as percent difference between male and female measurements for each region. Each measurement was also testet with a Student's t-test for differences between the genders in each region. Significance levels of results are provided as well (ns = P > 0)

Measure ment	Kitikmeot (14)		Kivalliq (19)		South Baffin (70)		North Baffin (40)		High Arctic (5)	
1	8.2%	0.001	6.2%	0.000	6.4%	0.000	5.8%	0.000	6.2%	0.008
2	6.9%	0.002	6.3%	0.000	6.6%	0.000	6.3%	0.000	7.3%	0.003
3	9%	0.013	8.1%	0.000	8.6%	0.000	5.2%	0.000	7.4%	ns
4	4.9	0.005	6.2%	0.007	6.3%	0.000	5.3%	0.000	5.9%	0.004
5	5.3%	0.004	6.4%	0.006	6.4%	0.000	5.3%	0.000	5.6%	ns
6	**10.4**	0.000	6.5%	0.000	5.6%	0.000	6.8%	0.000	7.8%	0.049
7	4.7%	0.011	6.1%	0.000	5.1%	0.000	4.5%	0.000	5.5%	0.038
8	8.9%	0.012	5.1%	ns	6.8%	0.000	8.1%	0.000	10.48	ns
9	5.1%	ns	3.8%	ns	2.6%	ns	3.7%	ns	-1%	ns
10	4.9%	ns	5.6%	0.013	3.3%	0.014	5%	0.001	5.1%	0.043
11	5.7	0.018	2.4%	ns	3.7%	0.008	2.9%	ns	6.5%	ns
12	5.9%	ns	5%	0.006	3.1%	0.007	3.4%	0.011	2.7%	ns
13	0.4%	ns	2.5%	ns	4.5%	0.001	4.2%	0.045	5.3%	0.025
14	5.4%	0.02	2.9%	ns	2.8%	ns	4.8%	0.002	6.8%	ns
15	3.5%	ns	4.8%	0.02	4.8%	ns	5.2%	0.003	**11.5**	0.021

16	1.7%	ns	7.8%	ns	4.3%	0.000	4.3%	0.011	**11.7**	0.016
17	6.1%	ns	6.1%	0.02	5.9%	0.000	7%	0.000	**11.5**	0.043
18	5.5%	0.018	4.9%	0.02	3.8%	0.000	3.5%	0.019	7%	0.05
19	6.1%	0.02	5.3%	0.006	4.7%	0.000	4.4%	0.003	9.2%	0.013
20	6.1%	0.021	2%	ns	3.4%	0.000	5.2%	0.000	5.9%	0.015
21	**14.7**	0.02	2.3%	ns	5.9%	0.000	3.3%	ns	1.5%	ns
22	6.2%	0.008	2.7%	ns	4.7%	0.008	5.1%	0.000	6%	0.011
23	3.7%	ns	3.5%	ns	6.9%	0.000	7.4%	0.000	4.1%	ns
24	4.4%	ns	6.9%	0.02	**10.3**	0.000	4.3%	ns	-2.2	ns
25	5.7%	0.026	5.6%	0.03	6%	0.000	4.4%	0.001	5.8%	ns
26	2.6%	ns	8.6%	0.003	7.2%	0.000	9%	0.000	**11.5**	0.002
27	-1.4	ns	6.8%	ns	6.7%	0.000	9.9%	0.000	6.4%	ns
28	2.8%	ns	6.1%	ns	3.8%	0.000	4.6%	0.037	3.4%	ns
29	1.6%	ns	0.7%	ns	2.4%	0.001	2.8%	0.001	5.7%	ns
30	1.9%	ns	4.4%	0.02	6%	0.000	7.3%	0.000	8.3%	0.005
31	7.2%	0.035	1.4%	ns	7.7%	0.000	6.4%	0.000	**15.8**	0.001
32	9.4%	ns	5.6%	ns	7%	ns	4.9%	ns	**20.4**	0.05
33	5.6%	0.011	4.5%	ns	5.2%	0.000	5.1%	0.000	9.1%	0.001
34	5.6%	0.024	6.6%	0.000	6.2%	0.000	5.9%	0.000	7.3%	0.038
35	7.3%	0.005	6.6%	0.000	6%	0.000	5.5%	0.000	7.6%	0.043
36	4.6%	0.02	5.8%	0.001	4.9%	0.000	4.6%	0.000	6.2%	0.022
37	9.3%	0.002	8.4%	0.013	4.7%	0.001	4.8%	0.02	6.3%	0.012
38	8.4%	0.000	3.7%	ns	4.8%	0.000	4.3%	0.001	0.9%	ns
39	7.2%	0.016	6%	0.021	4.8%	0.000	3.2%	ns	12.6	0.009
40	8.2%	0.003	3.9%	ns	4.8%	0.000	3.4%	0.011	5.1%	ns
41	3%	ns	3%	ns	7.9%	0.037	6.1%	0.008	12.4	ns
42	6.2%	ns	8.1%	0.008	5.6%	0.000	6.1%	0.000	10.5	ns
43	5.8%	0.05	9%	ns	7%	0.002	4.2%	ns	12.1	ns
44	4.4%	ns	6.3%	ns	8%	0.000	8.2%	0.001	**12.9**	0.000
45	7.5%	0.016	**10.4**	0.000	7.2%	0.000	9.2%	0.000	9.8%	ns
N3	6%	0.011	6.4%	0.000	4.4%	0.000	3.2%	0.001	2.3	ns
CB4	7.6%	0.002	6.3%	0.004	5.6%	0.000	6.6%	0.006	8.3%	0.005
CB5	5.5%	0.011	6.5%	0.000	6.1%	0.000	5.1%	0.001	6.6%	0.022
CB8	6.7%	0.005	6.6%	0.003	6%	0.000	5.8%	0.000	5%	0.012
CB10	7.3%	0.002	7%	0.000	6.5%	0.000	5.4%	0.000	7.4%	0.004
CB21	2.7%	ns	1.4%	ns	2.3%	0.006	3.6%	0.003	6.4%	0.031
CB23	6.3%	0.03	5.2%	0.005	6.1%	0.000	5.6%	0.000	**12.2**	0.01
SC1	**27.7**	0.014	**47**%	0.003	**41**%	0.000	**34**%	0.000	**32.5**	0.031
SC2	**15.2**	0.035	**13.6**	0.04	**12.4**	0.000	**15.9**	0.000	**26**	0.027
Mean	**6.3%**		**6.3%**		**6.3%**		**6%**		**8.2%**	

The following Figures 4.2 and 4.3 illustrate the differences in both sagittal crest measurements (SC1 and SC2) between males and females of all regions. The difference between the genders was highly significant in each region (Table 4.5).

Figure 4.8: Sagittal crest height perpendiculalar to skull in mm for males (1) and females (2). Locations are Kivalliq (2), South Baffin (30, North Baffin (4), Kitikmeot (5) and High Arctic (6)

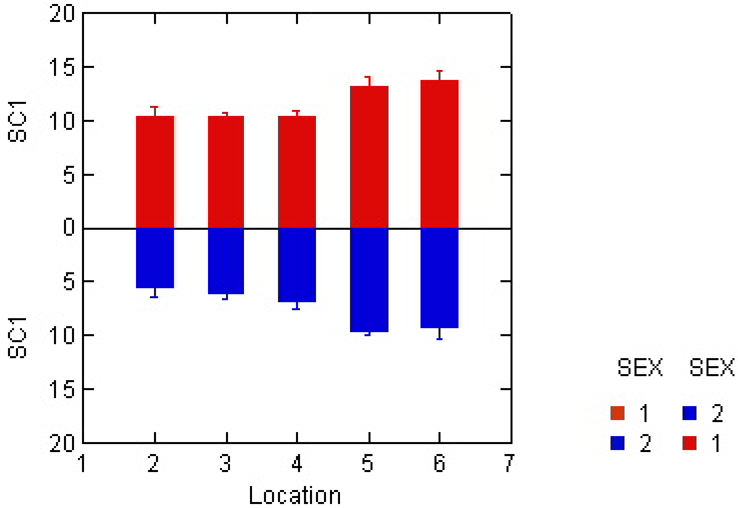
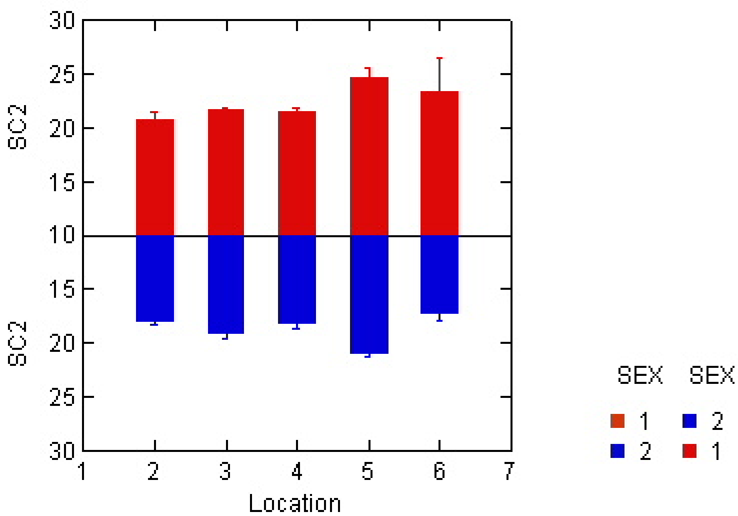


Figure 4.9: Sagittal crest height perpendicular to SC1 in mm for males (1) and females (2). Locations are Kivalliq (2), South Baffin (30, North Baffin (4), Kitikmeot (5) and High Arctic (6)



4.3 Multivariate statistics of skull measurements

4.3.1 Factor Analysis

All 54 measurements were processed for the Factor Analysis. In male wolves, pooled from all regions of the study, the first 10 components explained 97.11% of the total variation (Table 4.6). The first component explained 40.35% of the total variance with an Eigenvalue of 21.79, the second 12.97% with an Eigenvalue of 7 and the third component explained 11.78% of the overall variation and the Eigenvalue was 6.4. Together, these 3 components explained 65.1% of the total variation found in the male wolves from all 5 regions.

Table 4.6 Factor scores for the first 3 components for male and female wolves of the 5 regions. One of the two male specimens from the High Arctic had some missing values and could not be included in the analysis. Therefore, no results are provided for the High Arctic. The measurement of females from the Kitikmeot and the High Arctic regions were grouped into 2 components. Therefore, the last component is missing for these regions.

Region / Measurement		Factor scores for males			Factor scores for females		
		Component 1	Component 2	Component 3	Component 1	Component 2	Component 3
Kivalliq	1	0.854	0.385	0.173	0.704	0.424	-0.497
Kivalliq	2	0.906	0.259	-0.165	0.282	0.733	-0.324
Kivalliq	3	0.572	0.238	-0.725	-0.66	0.673	-0.124
Kivalliq	4	0.538	0.798	-0.155	0.752	-0.472	-0.453
Kivalliq	5	0.577	0.791	-0.142	0.787	-0.48	-0.375
Kivalliq	6	0.817	-0.209	0.165	-0.249	0.836	-0.137
Kivalliq	7	0.817	0.455	0.163	0.601	-0.232	-0.654
Kivalliq	8	0.803	0.276	-0.03	0.686	0.538	0.461
Kivalliq	9	-0.131	0.114	0.615	0.831	0.091	0.504
Kivalliq	10	0.733	-0.112	0.016	0.086	0.822	0.549
Kivalliq	11	0.485	-0.619	0.073	0.612	0.308	0.69
Kivalliq	12	0.211	-0.296	-0.471	-0.328	0.194	0.889
Kivalliq	13	0.356	-0.02	-0.518	0.016	-0.772	0.144
Kivalliq	14	0.534	0.209	-0.175	0.832	0.079	0.519
Kivalliq	15	0.341	-0.602	0.04	0.829	-0.286	0.454
Kivalliq	16	0.479	0.047	0.154	0.893	-0.139	0.366
Kivalliq	17	0.696	-0.114	-0.31	0.845	0.026	0.164
Kivalliq	18	0.85	-0.342	0.293	0.645	-0.106	0.756
Kivalliq	19	0.862	-0.36	0.177	0.634	-0.147	0.754
Kivalliq	20	0.686	-0.48	0.192	0.721	0.206	0.656
Kivalliq	21	0.316	0.284	0.688	0.785	-0.547	-0.073
Kivalliq	22	0.645	-0.352	0.415	0.657	0.137	0.669
Kivalliq	23	0.435	0.194	0.617	0.468	0.628	0.193
Kivalliq	34	0.355	0.031	0.72	0.782	0.154	-0.603

Kivalliq	25	0.734	0.083	0.431	0.274	-0.837	-0.272
Kivalliq	26	0.7	0.041	-0.349	0.872	0.135	-0.029
Kivalliq	27	0.747	-0.144	0.127	0.26	0.865	0.096
Kivalliq	28	0.822	-0.302	-0.135	0.823	-0.028	0.123
Kivalliq	29	0.34	-0.128	0.209	0.712	0.035	0.222
Kivalliq	30	0.859	-0.148	-0.14	0.807	0.589	-0.044
Kivalliq	31	0.584	-0.424	-0.458	0.502	0.823	0.1
Kivalliq	32	0.833	-0.36	-0.049	0.724	0.532	-0.409
Kivalliq	33	0.711	0.009	-0.012	0.49	0.038	0.429
Kivalliq	34	0.957	0.25	0.007	0.505	0.764	-0.385
Kivalliq	35	0.911	0.364	0.077	0.775	0.375	-0.507
Kivalliq	36	0.83	0.422	0.228	0.73	0.15	-0.667
Kivalliq	37	0.524	0.163	-0.666	0.298	0.014	-0.792
Kivalliq	38	0.772	0.258	-0.053	0.705	-0.279	0.088
Kivalliq	39	0.695	-0.131	0.295	-0.16	0.438	-0.072
Kivalliq	40	0.636	0.098	0.319	0.993	0.065	0.094
Kivalliq	41	0.579	-0.071	0.034	0.312	-0.936	0.055
Kivalliq	42	0.289	-0.714	0.216	0.906	0.075	0.339
Kivalliq	43	0.6	-0.731	0.057	0.663	-0.302	-0.235
Kivalliq	44	0.545	-0.143	-0.587	0.058	0.491	-0.865
Kivalliq	45	0.565	-0.774	-0.083	-0.15	0.981	-0.062
Kivalliq	N3	0.801	0.212	0.483	-0.299	0.911	-0.242
Kivalliq	CB4	0.861	0.03	0.13	-0.55	0.578	0.323
Kivalliq	CB5	0.749	0.41	-0.165	0.693	0.588	-0.413
Kivalliq	CB8	0.836	0.388	-0.311	0.937	-0.164	-0.231
Kivalliq	CB10	0.828	0.377	-0.208	0.722	0.293	-0.534
Kivalliq	CB21	0.602	0.113	-0.068	0.698	-0.16	0.106
Kivalliq	CB23	0.731	0.121	0.523	-0.307	0.942	0.125
Kivalliq	SC1	0.769	-0.12	-0.469	-0.559	0.572	0.576
Kivalliq	SC2	0.771	-0.181	-0.537	-0.791	0.006	0.117
South Baffin	1	0.871	-0.319	0.214	0.761	0.253	-0.252
South Baffin	2	0.909	-0.222	0.224	0.908	0.092	-0.292
South Baffin	3	0.65	-0.333	-0.035	0.733	-0.037	-0.372
South Baffin	4	0.799	-0.297	0.235	0.919	0.005	-0.299
South Baffin	5	0.812	-0.243	0.237	0.909	-0.01	-0.25
South Baffin	6	0.783	0.148	0.208	0.652	0.484	-0.149
South Baffin	7	0.786	-0.33	-0.08	0.841	0.215	-0.28
South Baffin	8	0.597	-0.16	-0.52	0.649	0.353	-0.149
South Baffin	9	0.318	-0.329	0.139	0.303	0.697	-0.045
South Baffin	10	0.442	-0.3	-0.523	-0.346	0.713	0.394
South Baffin	11	0.159	0.085	-0.552	0.528	0.326	0.525
South Baffin	12	0.51	-0.219	-0.527	0.21	0.678	0.065
South Baffin	13	0.183	0.198	-0.589	0.406	0.369	0.626
South Baffin	14	0.137	0.036	-0.381	0.174	0.716	0.111
South Baffin	15	0.579	0.204	0.335	0.347	-0.224	0.693
South Baffin	16	0.466	0.152	0.049	0.414	-0.178	0.667
South Baffin	17	0.748	0.048	-0.14	0.76	-0.147	0.422
South Baffin	18	0.698	0.062	-0.222	0.544	-0.327	0.574

South Baffin	19	0.782	-0.032	-0.152	0.724	-0.389	0.412
South Baffin	20	0.497	0.384	0.041	0.751	-0.166	0.155
South Baffin	21	0.39	0.427	-0.122	0.392	-0.524	0.082
South Baffin	22	0.706	0.288	0.002	0.664	-0.189	-0.461
South Baffin	23	0.59	0.04	0.298	0.347	0.065	-0.286
South Baffin	34	0.117	-0.131	0.068	0.315	0.424	0.214
South Baffin	25	0.753	0.042	0.093	0.051	0.229	-0.112
South Baffin	26	0.472	0.593	-0.055	0.741	-0.439	0.148
South Baffin	27	0.369	0.791	0.025	0.768	-0.245	0.41
South Baffin	28	0.177	0.521	-0.181	0.243	-0.121	0.43
South Baffin	29	0.156	0.433	-0.368	0.442	-0.088	-0.114
South Baffin	30	0.604	0.55	0.243	0.862	-0.25	0.079
South Baffin	31	0.496	0.588	-0.083	0.753	-0.394	0.162
South Baffin	32	0.194	0.584	-0.24	0.394	-0.088	0.095
South Baffin	33	0.503	0.623	-0.122	0.804	-0.1	-0.161
South Baffin	34	0.881	-0.146	0.172	0.894	0.112	-0.293
South Baffin	35	0.917	-0.082	0.133	0.923	0.007	-0.235
South Baffin	36	0.788	0.389	0.077	0.717	0.576	-0.064
South Baffin	37	0.659	-0.002	-0.466	0.102	0.345	0.76
South Baffin	38	0.622	-0.107	-0.236	0.177	0.69	0.315
South Baffin	39	0.507	-0.303	-0.531	-0.155	0.679	0.482
South Baffin	40	0.64	-0.101	-0.492	0.079	0.597	0.373
South Baffin	41	0.483	0.236	-0.209	0.523	-0.161	0.384
South Baffin	42	0.514	0.418	0.061	0.604	0.137	0.513
South Baffin	43	0.529	0.23	0.228	-0.04	0.284	0.051
South Baffin	44	0.52	0.237	0.018	0.893	-0.08	0.138
South Baffin	45	0.705	0.278	0.243	0.785	-0.307	0.208
South Baffin	N3	0.647	-0.424	-0.024	0.229	0.25	-0.261
South Baffin	CB4	0.722	0.039	0.289	0.705	0.17	-0.268
South Baffin	CB5	0.836	-0.343	0.215	0.832	0.354	-0.299
South Baffin	CB8	0.729	-0.492	-0.039	0.732	0.335	-0.363
South Baffin	CB10	0.821	-0.463	0.067	0.802	0.133	-0.399
South Baffin	CB21	0.472	0.57	-0.233	0.281	0.004	0.079
South Baffin	CB23	0.711	0.004	0.29	0.665	-0.086	-0.268
South Baffin	SC1	0.364	0.312	0.343	0.788	-0.208	0.056
South Baffin	SC2	0.369	0.497	0.386	0.527	-0.379	0.39
North Baffin	1	0.873	-0.269	0.02	0.586	0.533	-0.137
North Baffin	2	0.93	-0.166	0.102	0.715	0.389	-0.42
North Baffin	3	0.655	-0.223	-0.095	0.378	-0.008	-0.463
North Baffin	4	0.727	-0.457	-0.186	0.87	0.109	0.273
North Baffin	5	0.683	-0.451	-0.273	0.861	0.048	0.344
North Baffin	6	0.886	0.14	-0.104	0.347	0.132	-0.366
North Baffin	7	0.856	-0.264	-0.112	0.841	-0.35	-0.141
North Baffin	8	0.758	-0.142	0.013	0.843	0.084	-0.154
North Baffin	9	0.625	-0.265	0.342	0.227	-0.082	-0.61
North Baffin	10	0.592	-0.296	-0.179	-0.01	-0.657	-0.061
North Baffin	11	0.569	-0.3	0.563	0.239	0.276	-0.781
North Baffin	12	0.58	-0.475	-0.084	0.531	-0.612	0.005

North Baffin	13	0.388	-0.564	0.135	0.243	0.034	0.102
North Baffin	14	0.619	-0.071	0.045	0.574	-0.564	-0.332
North Baffin	15	0.688	0.435	0.205	0.579	0.04	0.228
North Baffin	16	0.727	0.491	0.133	0.717	0.306	0.065
North Baffin	17	0.678	0.134	0.168	0.944	-0.086	-0.108
North Baffin	18	0.879	0.183	0.124	0.888	0.018	0.192
North Baffin	19	0.833	0.314	-0.085	0.911	-0.044	0.234
North Baffin	20	0.457	-0.041	0.285	0.697	-0.062	0.06
North Baffin	21	0.355	0.196	-0.506	0.197	0.078	0.117
North Baffin	22	0.762	0.038	-0.308	0.259	0.121	0.139
North Baffin	23	0.318	0.159	0.092	-0.118	0.585	0.549
North Baffin	34	0.324	-0.254	0.602	-0.303	0.768	-0.083
North Baffin	25	0.802	0.031	-0.164	0.365	0.102	0.073
North Baffin	26	0.635	0.451	0.116	0.478	0.345	0.637
North Baffin	27	0.425	0.441	0.427	0.396	0.761	0.182
North Baffin	28	0.118	0.248	0.463	0.094	0.361	0.63
North Baffin	29	0.305	0.246	-0.095	-0.019	0.329	0.594
North Baffin	30	0.825	0.442	-0.061	0.777	0.389	0.182
North Baffin	31	0.581	0.52	-0.08	0.792	0.022	0.003
North Baffin	32	0.327	0.49	-0.429	0.832	-0.367	-0.145
North Baffin	33	0.825	0.109	0.153	0.338	0.51	-0.453
North Baffin	34	0.941	-0.025	-0.009	0.793	0.556	0.044
North Baffin	35	0.937	0.012	-0.074	0.926	0.141	0.15
North Baffin	36	0.893	-0.271	-0.116	0.872	-0.347	0.016
North Baffin	37	0.502	-0.217	0.229	0.562	-0.3	-0.294
North Baffin	38	0.565	-0.23	-0.234	0.266	-0.28	0.014
North Baffin	39	0.515	-0.164	-0.19	0.665	-0.638	-0.104
North Baffin	40	0.53	-0.473	-0.441	0.465	-0.781	0.235
North Baffin	41	0.603	-0.136	-0.323	0.727	0.339	0.46
North Baffin	42	0.517	0.436	-0.157	0.438	0.373	0.373
North Baffin	43	0.594	0.305	-0.158	0.456	-0.218	0.021
North Baffin	44	0.62	0.542	-0.133	0.62	0.465	0.41
North Baffin	45	0.748	0.382	-0.324	0.192	0.664	0.453
North Baffin	N3	0.801	-0.41	0.013	0.687	-0.028	-0.547
North Baffin	CB4	0.843	0.189	0.091	0.307	0.153	-0.262
North Baffin	CB5	0.868	-0.324	0.215	0.59	0.547	-0.508
North Baffin	CB8	0.743	-0.389	0.179	0.882	-0.16	0.027
North Baffin	CB10	0.854	-0.237	0.177	0.867	-0.218	-0.225
North Baffin	CB21	0.395	0.164	-0.742	0.453	-0.355	0.663
North Baffin	CB23	0.777	-0.135	0.205	-0.126	0.333	-0.605
North Baffin	SC1	0.532	0.278	0.612	0.012	0.551	-0.757
North Baffin	SC2	0.533	0.561	0.214	0.502	0.376	-0.606
Kitikmeot	1	0.942	-0.038	0.302	0.967	-0.254	
Kitikmeot	2	0.949	0.051	0.18	0.677	0.736	
Kitikmeot	3	0.811	0.078	0.166	0.739	-0.674	
Kitikmeot	4	0.677	0.306	0.568	0.944	0.329	
Kitikmeot	5	0.66	0.507	0.407	0.945	0.327	
Kitikmeot	6	0.842	0.339	-0.077	0.972	-0.234	

Kitikmeot	7	0.883	-0.203	-0.101	0.974	-0.225	
Kitikmeot	8	0.157	0.275	-0.785	1	-0.029	
Kitikmeot	9	0.433	-0.139	-0.256	0.958	0.287	
Kitikmeot	10	0.522	-0.816	-0.029	0.697	-0.718	
Kitikmeot	11	0.535	-0.6	0.238	-0.025	-1	
Kitikmeot	12	0.403	-0.827	0.097	0.358	-0.934	
Kitikmeot	13	-0.312	0.532	0.387	-0.929	0.369	
Kitikmeot	14	0.642	-0.487	-0.111	0.191	-0.982	
Kitikmeot	15	0.669	0.304	-0.577	-0.925	0.38	
Kitikmeot	16	0.73	0.234	-0.555	-0.623	-0.782	
Kitikmeot	17	0.866	0.131	-0.35	0.65	-0.76	
Kitikmeot	18	0.971	-0.045	-0.013	0.999	0.048	
Kitikmeot	19	0.974	-0.029	-0.145	0.798	0.603	
Kitikmeot	20	0.76	0.248	0.273	0.987	0.163	
Kitikmeot	21	0.316	0.579	-0.179	0.505	0.863	
Kitikmeot	22	0.722	0.259	0.269	0.454	0.891	
Kitikmeot	23	0.261	0.06	0.122	0.076	-0.997	
Kitikmeot	34	0.37	0.382	-0.588	0.667	-0.745	
Kitikmeot	25	0.379	0.526	0.066	0.996	0.088	
Kitikmeot	26	0.865	0.061	0.043	1	-0.025	
Kitikmeot	27	0.748	0.229	0.29	0.945	0.326	
Kitikmeot	28	0.573	0.234	0.082	0.789	0.615	
Kitikmeot	29	0.481	0.243	0.716	0.982	0.186	
Kitikmeot	30	0.949	0.077	-0.042	0.966	0.259	
Kitikmeot	31	0.903	0.078	0.037	0.785	-0.62	
Kitikmeot	32	0.567	-0.135	0.531	-0.659	-0.752	
Kitikmeot	33	0.745	0.042	-0.389	-0.603	0.798	
Kitikmeot	34	0.861	0.189	0.016	0.968	0.252	
Kitikmeot	35	0.906	0.214	0.208	0.982	0.187	
Kitikmeot	36	0.585	-0.309	-0.027	0.953	-0.304	
Kitikmeot	37	0.287	-0.14	-0.455	-0.866	0.499	
Kitikmeot	38	0.166	-0.902	0.218	-0.458	0.889	
Kitikmeot	39	0.629	-0.423	-0.474	-0.999	0.053	
Kitikmeot	40	-0.029	-0.887	0.064	-0.267	-0.964	
Kitikmeot	41	0.565	0.407	-0.513	0.923	0.384	
Kitikmeot	42	0.79	0.089	-0.247	0.547	-0.837	
Kitikmeot	43	0.248	-0.695	0.279	0.215	0.977	
Kitikmeot	44	0.901	0.124	-0.062	0.678	0.735	
Kitikmeot	45	0.805	0.043	-0.316	0.954	-0.298	
Kitikmeot	N3	0.692	-0.405	0.18	0.98	-0.201	
Kitikmeot	CB4	0.892	-0.114	0.298	0.662	-0.749	
Kitikmeot	CB5	0.894	-0.156	0.378	0.917	0.398	
Kitikmeot	CB8	0.729	0.538	0.074	0.58	0.815	
Kitikmeot	CB10	0.904	-0.05	0.204	0.725	0.689	
Kitikmeot	CB21	0.104	0.777	0.447	0.981	-0.193	
Kitikmeot	CB23	0.786	-0.449	0.201	0.497	-0.868	
Kitikmeot	SC1	0.723	-0.382	-0.395	-0.303	0.953	
Kitikmeot	SC2	0.748	-0.355	-0.461	-0.196	-0.981	

High Arctic	1				-0.645	-0.764	
High Arctic	2				0.332	-0.943	
High Arctic	3				0.618	0.786	
High Arctic	4				-0.984	-0.18	
High Arctic	5				-0.435	-0.901	
High Arctic	6				0.186	0.983	
High Arctic	7				0.898	0.439	
High Arctic	8				1	0.004	
High Arctic	9				0.959	0.285	
High Arctic	10				-0.795	0.607	
High Arctic	11				0.99	0.14	
High Arctic	12				0.695	0.719	
High Arctic	13				0.996	-0.084	
High Arctic	14				-0.511	-0.859	
High Arctic	15				-0.594	0.804	
High Arctic	16				-0.715	0.7	
High Arctic	17				-0.578	0.816	
High Arctic	18				0.44	0.898	
High Arctic	19				-0.053	0.999	
High Arctic	20				-0.315	0.949	
High Arctic	21				0.995	0.104	
High Arctic	22				0.529	0.848	
High Arctic	23				-0.79	0.613	
High Arctic	34				-0.609	0.793	
High Arctic	25				0.889	-0.459	
High Arctic	26				0.109	0.994	
High Arctic	27				-0.083	0.997	
High Arctic	28				0.185	0.983	
High Arctic	29				-0.027	1	
High Arctic	30				0.481	0.877	
High Arctic	31				0.947	0.322	
High Arctic	32				0.019	1	
High Arctic	33				-0.946	-0.324	
High Arctic	34				-0.055	-0.998	
High Arctic	35				-0.49	-0.872	
High Arctic	36				0.785	0.619	
High Arctic	37				-0.612	0.791	
High Arctic	38				0.842	-0.539	
High Arctic	39				-0.99	-0.138	
High Arctic	40				0.868	0.497	
High Arctic	41				-0.599	0.8	
High Arctic	42				-0.965	-0.262	
High Arctic	43				0.417	0.909	
High Arctic	44				-0.93	0.369	
High Arctic	45				0.548	-0.836	
High Arctic	N3				0.746	0.666	
High Arctic	CB4				-0.829	0.559	
High Arctic	CB5				0.932	-0.362	

High Arctic	CB8				0.926	-0.377	
High Arctic	CB10				0.993	0.121	
High Arctic	CB21				-0.959	0.283	
High Arctic	CB23				-0.996	-0.088	
High Arctic	SC1				0.36	-0.933	
High Arctic	SC2				0.703	-0.712	

Table 4.7 provides a description of strongly positive associations found on each principal component for male wolves (factor scores larger than 0.5). The first component, which showed the strongest positive association between measurements included measurements 1 to 7 (length measurements of the skull, Table 3.1), 17 to 20, 22, 25 and 30 (width measurements of skull), 33 (total height of skull), 34 to 37and 42 (measurements of the lower jaw), all additional length and width measurement (N3, CB4, CB5, CB8, CB10, CB21 and CB23) and the 2 measurements of the sagittal crest (SC1 and SC2). The second component showed only few strong positive associations. These were on measurements 16 (palatal width), 26 and 28 (width between the orbitals), and 42 and 43 (articular condyle of the lower jaw). On the third component, measurement 12 (upper molar width), 28 (width across postorbital processes), 29 (brain case width) and 32 (width of zygomatic process) were strongly positively associated.

Table 4.7 Male and female cranial measurements associated with each of the three components of the PCA.

Component	**Male Cranial Measurements**	**Female Cranial Measurements**
Component 1	length and width measurements of the skull, total height and lower jaw	length and width measurements of the skull, total height and lower jaw
Component 2	palatal width, interorbital width, articular condyle of lower jaw	tooth measurements
Component 3	upper molar width, brain case width, width of zygomatic process	width across skull (where applicable)

In female wolves, the first 10 components explained 79.6% of the total variation (Table 4.6). The first component explained 32.86% of the total variance with an Eigenvalue of 17.75, the second 10% with an Eigenvalue of 5.4 and the third component explained 8.2% of the overall variation and the Eigenvalue was 4.4. Together, these 3 components explained 51.03% of the total variation found in the female wolves from all 5 regions. Table 4.7 provides a description of strongly positive measurement associations found on each principal component for females. The first component, which showed the strongest positive associations between measurements included measurements 1 to 9 (except 3 and 6) (length measurements of the skull, Table 3.1), 16 to 20, 21, 26 and 27 (width measurements of different areas of the skull), 30 and 31 (width measurements across the cheek), 33 (height of skull), 34 to 37, 42 , 44 and 45 (all measurements of the lower jaw), some of the additional length and width measurement (N3, CB5, CB8 and CB10 – all length measurements of the skull). The second component showed only five strong positive associations. These were on measurements 10, 15 and 38 to 40 (all tooth measurements). On the third component, measurements 15 and 16 (width measurements of skull), were strongly positively associated.
In summary, most of the length and width measurements were responsible for the observed variation between the regions for both males and females.

In the next step, the 54 measurements taken from each individual skull, were replaced by the factor scores on the first 3 components for males and most of the females. Measurements for females from the Kitikmeot and the High Arctic grouped only in 2 components (Table 4.6).

Table 4.8 Mean and standard deviation (in parenthesis) of factor scores on Components 1 to 3 from the Factor Analysis for male wolves of the 5 regions. One of the two specimens from the High Arctic had some missing values and could not be included in the analysis. Therefore, no results are provided for the High Arctic. Additionally, results of an ANOVA for the 3 components between the regions are provided.

Region	Component 1	Component 2	Component 3
Kivalliq	0.647 (0.213)	-0.008 (0.356)	0.012 (0.345)
South Baffin	0.568 (0.219)	0.086 (0.219)	-0.041 (0.274)
North Baffin	0.647 (0.195)	0.013 (0.323)	0.005 (0.274)
Kitikmeot	0.633 (0.284)	-0.008 (0.396)	0.054 (0.021)
ANOVA	p = 0.236	p = 0.236	p = 0.806

Three ANOVAs were calculated for the factor loadings on the three components for male wolves and did not show significant differences in the factor scores between the regions (Table 4.8). The factor scores on the first component were all strongly positively associated, while the other two components demonstrated week positive and negative associations.

The same analyses were done for female wolves (Table 4.9).

Table 4.9 Mean and standard deviation (in parenthesis) of factor scores on Components 1 to 3 from the Factor Analysis for female wolves of the 5 regions. the measurement of females from the Kitikmeot and the High Arctic regions were grouped into 2 components. Therefore, the last component is missing for these regions. Additionally, results of an ANOVA for the 3 components between the regions are provided.

Region	Component1	Component 2	Component 3
Kivalliq	0.442 (0.471)	0.189 (0.474)	0.029 (0.439)
South Baffin	0.583 (0.307)	0.095 (0.341)	0.080 (0.334)
North Baffin	0.504 (0.315)	0.087 (0.379)	-0.013 (0.368)
Kitikmeot	0.476 (0.624)	-0.019 (0.631)	N/A
High Arctic	0.072 (0.718)	0.234 (0.665)	N/A
ANOVA	p = 0.000	p = 0.098	p = 0.45

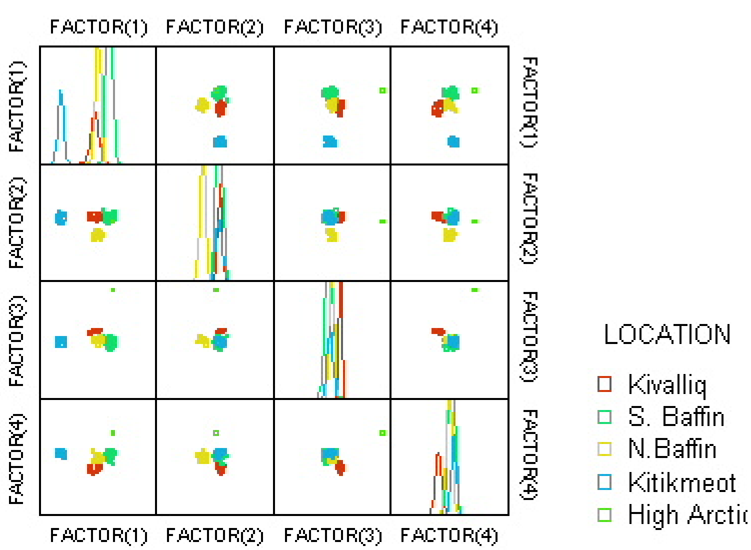
When tested for regional differences, factor scores on Component 1 for females of the High Arctic were significantly smaller than the other 4 regions (ANOVA, $p = 0.000$; Table 4.9). While females of all other regions showed strong positive association of measurements on the first component, females from the High Arctic showed a very weak association (with a very high variation).

4.3.2 Discriminant Analysis

The results of the discriminant analysis are provided in Figure 4.10 for males and 4.11 for females. During the analysis, all 54 measurements were grouped into 4 factors and the factor scores are presented in scatter plots (Figures 4.10 and 4.11).

The Eigenvalues for the 4 factors for the male wolves were: 31.025, 6.554, 5.975 and 3.526, respectively. The only male skull from the High Arctic that was considered in the analysis is shown as a single point in the graphs and is not considered in further discussions; all other clouds consisted of a variety of specimens collected in the respective regions. In all plots that showed Factor 1, Kitikmeot wolves grouped separately from the other regions (figure 4.10). Plots that involved only Factors 2,3, or 4 did not show any separation of the groups (besides the one skull from the High Arctic).

Figure 4.10 Factor score for male wolves of 5 different regions determined through discriminant analysis

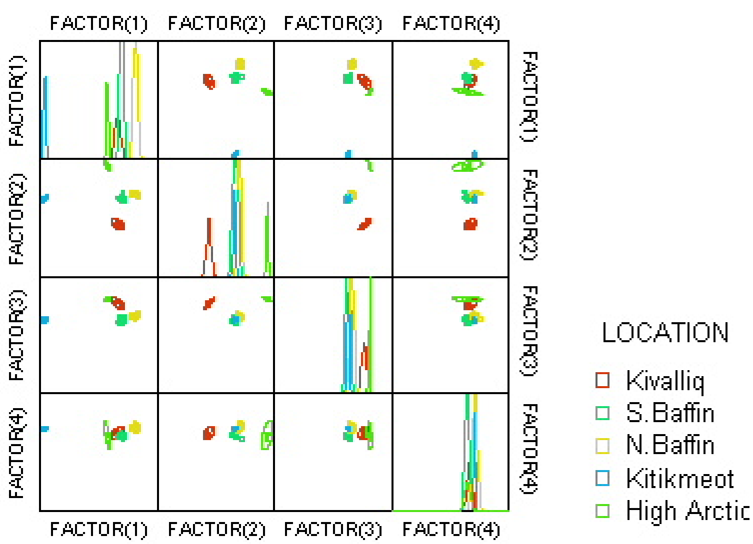


A pairwise group comparison confirmed the finding that the male skulls from the Kitikmeot region were different from the other locations (Table 4.10). Unfortunately, there was only one male from the High Arctic, thus the statistical results can not be interpreted.

Table 4.10 Between groups matrix for male wolves of al 5 regions. F=2.7184, df=216, p=0.000.

	Kivalliq	South Baffin	North Baffin	Kitikmeot	High Arctic
Kivalliq	0				
South Baffin	2.089	0			
North Baffin	1.728	2.68	0		
Kitikmeot	**3.923**	**9.617**	**5.753**	0	
High Arctic	1.586	1.706	1.761	2.780	0

Figure 4.11 Factor score for female wolves of 5 different regions determined through discriminant analysis



The Eigenvalues for the 4 factors for female wolves were: 149.668, 49.117, 14.233 and 4.011 respectively. All different coloured clouds consisted of a variety of specimens collected in the respective regions (Figure 4.11). In all plots that showed Factor 1 on the x-axis, Kitikmeot wolves grouped separately from the other regions. Plots that involved Factor 2 on either the x or the y-axis showed a separation of wolves from the Kivalliq. All other plots did not show any separation. A pairwise group comparison revealed no significant results but showed a trend for the Kitikmeot skulls to be different from the rest of the skulls. Table 4.11 provides the results for a pairwise group comparison between the regions.

Table 4.11 Between groups matrix for females of all 5 regions. F=1.123, df=144, p=0.4963.

	Kivalliq	South Baffin	North Baffin	Kitikmeot	High Arctic
Kivalliq	0				
South Baffin	0.781	0			
North Baffin	1.014	0.427	0		
Kitikmeot	2.414	3.132	4.061	0	
High Arctic	1.346	0.869	0.941	1.676	0

4.4 Diet Analysis

A suite of 70 fatty acids was analyzed for a variety of potential prey species. The fatty acids used in the analysis were (S. Iverson pers. comm. 2001):

c8.0; c10.0;c12.0; c13.0; Iso14; c14.0; c14w9; c14.1w7; c14.1w5; Iso15; Anti15; c15; c15.1w8; c15.1w6; Iso16; c16.0; c16.1w11; c16.1w9; c16.1w7; c7Me16.0; c16.1w5; c16.2w6; Iso17; c16.2w4; c16.3w6; c17.0; c16.3w4; c17.1; c16.3w1; c16.4w3; c16.4w1; c18.0; c18.1w13; c18.1w11; c18.1w9; c18.1w7; c18.1w5; c18.2d5,11; c18.2w7; c18.2w6; c18.2w4; c18.3w6; c18.3w4; c18.3w3; c18.3w1; c18.4w3; c18.4w1; c20.0; c20.1w11; c20.1w9; c20.1w7; c20.2w9; c20.2w6; c20.3w6; c20.4w6; c20.3w3; c20.4w3; c20.5w3; c22.1w11; c22.1w9; c22.1w7; c22.2w6; c21.5w3; c22.4w6; c22.5w6; c22.4w3; c22.5w3; c24:0; c22.6w3;

c24.1w9; additionally the following combination and ratio were tested: C18:2 + C18:3 + C20:4 and R 18:2/18:3 (see also Table A-1 in Appendix).

4.4.1 Prey Species

Hunters across the study area returned several specimens and small mammals were provided from a small mammal survey study in the Kitikmeot (Kugluktuk office). Table 4.12 lists the potential prey species that were analyzed for a suite of 70 fatty acids.

Table 4.12 Potential prey species collected and analyzed for Fatty Acid Analysis

Number of animals	Species	Body part(s)
2	caribou (*Rangifer tarrandus)*	fat, liver, muscle
3	musk ox (*Ovibus moschatus*)	fat, liver, muscle
1	Arctic fox (*Alopex lagopus)*	fat, muscle
2	Arctic hare (*Lepus Arcticus)*	fat, muscle
3	Arctic ground squirrel (*Citellus parry)*	fat, muscle, whole body
11	collared lemming (*Dicrostonyx groenlandicus)*	whole body
5	red backed vole(*Clethrionomys rutilus)*	whole body

Analyses were conducted at Dalhousie University in Halifax, NS, by Dr. S. Iverson. The species specific analysis are presented in the Appendix / Table A-1. Each species left a specific “fingerprint” across the 70 fatty acids and thus could likely be recognized in wolf fat tissue if consumed by wolves (S. Iverson, pers. comm. 2002).

4.4.2 Wolf Samples

Eight wolf samples were returned for FA analysis in 2002. Hunters from Grise Fiord submitted 4 fat samples, 2 were received from Kugaruuk, and 2 from Baker Lake. Samples were submitted but results have not been received to date.

5. DISCUSSION

Due to the variation in sample size among the 5 different regions of the study, some of the results could not be satisfyingly interpreted. Especially wolves from the High Arctic were under represented and not included in multivariate statistics.

However, there was an obvious trend in both male and female wolves in that wolves from the High Arctic and Kitikmeot seem to be larger than Baffin Island and Kivalliq wolves. Furthermore, Baffin Island wolves, especially animals harvested in the southern portion of the island, seem to be the smallest of the study area. It is long being suspected that wolves don't travel across the entire island but follow the migrations (or shifts in winter ranges) of the South Baffin and North Baffin Arctic Island caribou herds (S. Ferguson, pers. comm. 1999). These herds are two of three relatively distinct herds inhabiting Baffin Island and have long term cycles during which they change their winter range. Once caribou graze in an area, it takes up to 40 years for the lichen to regenerate. That might be the reason for the observed shifts in winter ranges. It is believed that wolves follow the caribou through these migrations across the southern and northern parts of the island. This separation of ranges could possibly explain the differences between the South and North Baffin Island wolves.

Wolves from the Kivalliq were in all measurements in-between Baffin Island wolves and wolves from the Kitikmeot and High Arctic. It is possible that these wolves see frequent dispersers from the Kitikmeot in the west and Baffin Island in the north-east and are a result of interbreeding of these populations.

The results of this first limited study point towards a visible differentiation between wolves of different areas in Nunavut. Whether there is a clear separation of the “Arctic wolf” needs to be further investigated along with the possibility that there is a connection between the High Arctic and Kitikmeot wolves (see Recommendation section below).

To date, the results of the first wolf samples submitted for diet analysis have not been received and, therefore, conclusions cannot be drawn. However, the Fatty Acid Analysis seems to be a potential tool for diet analysis of wolves in Nunavut because prey species were identified in the lab according to their fatty acid composition, which in turn depended on the animals' diet.

Recommendations

In summary, there are a variety of recommendations in order to address both subspecific variability and diet composition in wolves across Nunavut:

1.) The results of this study should be reviewed in combination with results of the DNA study that was carried out parallel to this morphology study. Each study alone can provide clear trends but in combination they are able to serve as a powerful tool to determine subspecies / population status across the study area.

2.) In order to find possible links between the Kitikmeot wolves and the High Arctic wolves, samples from the Kitikmeot could be split up into sub samples (e.g., mainland and Victoria Island) and analyzed separately. Hunters in the Kitikmeot region frequently report that Victoria Island wolves are larger than mainland wolves (M. Dumont, pers. comm. 2005). This could be a potential link to the High Arctic wolves.

3.) There are still 58 skulls that need to be processed and analyzed. The majority of these skulls were collected in the Kitikmeot and the High Arctic. Further analysis should concentrate on specimens from these two regions. Especially High Arctic samples are needed to be included in the multivariate models in order to verify first visible trends.

4.) Fatty Acid Analysis might provide the tool of choice to analyze prey species composition for wolves in different regions of Nunavut. The results of previously submitted wolf samples should be obtained and, if it seems feasible, more fat samples should be collected across the study area. The results could indicate how heavily wolves rely on ungulate prey species, especially on the High Arctic Islands.

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7. APPENDIX

Table A-1 represents the results of the Fatty Acid Analysis of potential prey species of wolves in Nunavut.

Table A-1 Results for the fatty acid analysis for a suite of 70 fatty acids and two fatty acid ratios used in the test. Numbers in the cells represent relative occurrence of each of the fatty acids in each of the tissues.

LabCode	Species	Tissue	c8.0	c10.0	c12.0	c13.0	Iso14
AWP 1	Caribou-1	fat	0.01	0.07	0.03	0.00	0.02
AWP 2	Caribou-1	liver	0.00	0.00	0.03	0.01	0.08
AWP 3	Caribou-1	muscle	0.00	0.02	0.02	0.00	0.01
AWP 4	Caribou-2	fat	0.00	0.03	0.02	0.00	0.02
AWP 5	Caribou-2	muscle	0.00	0.02	0.03	0.00	0.01
AWP 6	Caribou-2	liver	0.00	0.01	0.03	0.00	0.03
AWP 7	Caribou-2	lung	0.00	0.00	0.04	0.01	0.09
AWP 8	red backed vole	whole	0.00	0.01	0.07	0.01	0.03
AWP 9	red backed vole	whole	0.00	0.01	0.06	0.01	0.02
AWP 10	red backed vole	whole	0.01	0.01	0.06	0.01	0.01
AWP 11	red backed vole	whole	0.01	0.01	0.05	0.01	0.03
AWP 12	red backed vole	whole	0.00	0.01	0.06	0.01	0.01
AWP 13	collared lemming	whole	0.00	0.01	0.06	0.02	0.04
AWP 14	collared lemming	whole	0.00	0.01	0.07	0.01	0.07
AWP 15	collared lemming	whole	0.00	0.01	0.04	0.02	0.02
AWP 16	collared lemming	whole	0.00	0.01	0.06	0.02	0.04
AWP 17	collared lemming	whole	0.00	0.00	0.04	0.01	0.05
AWP 18	collared lemming	whole	0.00	0.00	0.03	0.01	0.03
AWP 19	collared lemming	whole	0.00	0.00	0.02	0.01	0.02
AWP 20	collared lemming	whole	0.00	0.01	0.05	0.02	0.12
AWP 21	collared lemming	whole	0.00	0.01	0.06	0.02	0.11
AWP 22	collared lemming	whole	0.00	0.01	0.05	0.01	0.09
AWP 23	collared lemming	whole	0.00	0.00	0.04	0.01	0.05
AWP 24	arctic ground squirrel - 1	muscle	0.00	0.01	0.06	0.00	0.06
AWP 25	arctic ground squirrel - 1	fat	0.01	0.02	0.16	0.02	0.04
AWP 26	arctic ground squirrel - 2	whole	0.01	0.02	0.10	0.01	0.01
AWP 27	arctic ground squirrel - 3	muscle	0.00	0.00	0.04	0.00	0.01
AWP 28	arctic ground squirrel - 3	fat	0.00	0.01	0.07	0.02	0.01
AWP 29	musk ox - 1	liver	0.00	0.00	0.02	0.00	0.07
AWP 30	musk ox - 3	fat	0.00	0.08	0.08	0.01	0.10
AWP 31	musk ox - 3	liver	0.00	0.01	0.05	0.02	0.04
AWP 32	musk ox - 3	muscle	0.00	0.01	0.04	0.00	0.06
AWP 33	musk ox - 19	fat	0.00	0.13	0.10	0.02	0.22
AWP 34	musk ox - 19	liver	0.00	0.00	0.01	0.00	0.04
AWP 35	musk ox - 19	muscle	0.00	0.03	0.04	0.00	0.02
AWP 36	arctic hare - 1	fat	0.00	0.02	0.13	0.07	0.04
AWP 37	arctic hare - 1	muscle	0.00	0.01	0.05	0.02	0.02
AWP 38	arctic hare - 2	fat	0.00	0.01	0.11	0.06	0.05
AWP 39	arctic hare - 2	muscle	0.00	0.01	0.06	0.02	0.02
AWP 40	arctic fox - 1	fat	0.00	0.01	0.09	0.03	0.04
AWP 41	arctic fox - 1	muscle	0.00	0.01	0.07	0.02	0.03

LabCode	c14.0	c14.1w9	c14.1w7	c14.1w5	Iso15	Anti15	c15.0	c15.1w8	c15.1w6	Iso16	c16.0	c16.1w11	c16.1w9
AWP 1	2.85	0.01	0.00	0.32	0.16	0.08	0.24	0.00	0.00	0.20	29.39	0.04	0.27
AWP 2	0.76	0.02	0.03	0.01	0.32	0.37	0.60	0.00	0.00	0.43	12.96	0.08	0.53
AWP 3	1.02	0.00	0.01	0.14	0.07	0.06	0.18	0.00	0.00	0.04	23.67	0.16	0.21
AWP 4	2.19	0.01	0.00	0.16	0.20	0.09	0.14	0.00	0.00	0.20	25.69	0.02	0.37
AWP 5	1.33	0.02	0.01	0.06	0.11	0.09	0.20	0.00	0.00	0.08	22.93	0.16	0.53
AWP 6	0.36	0.01	0.02	0.01	0.08	0.12	0.22	0.00	0.00	0.14	16.55	0.05	0.74
AWP 7	1.51	0.09	0.07	0.01	0.13	0.12	0.40	0.00	0.00	0.15	29.87	0.34	3.62
AWP 8	0.60	0.02	0.02	0.02	0.05	0.03	0.48	0.00	0.00	0.80	15.94	0.00	0.34
AWP 9	0.56	0.03	0.02	0.01	0.04	0.02	0.43	0.00	0.01	0.61	14.37	0.04	0.38
AWP 10	0.60	0.02	0.01	0.03	0.01	0.02	0.40	0.00	0.01	0.56	14.35	0.04	0.42
AWP 11	0.67	0.02	0.03	0.02	0.06	0.03	0.71	0.00	0.00	0.84	15.28	0.04	0.48
AWP 12	0.61	0.04	0.02	0.05	0.04	0.02	0.42	0.00	0.00	0.46	14.12	0.05	0.53
AWP 13	0.98	0.01	0.04	0.10	0.05	0.24	0.59	0.00	0.01	0.11	24.81	0.16	0.37
AWP 14	0.95	0.02	0.04	0.10	0.05	0.34	0.60	0.00	0.00	0.12	24.57	0.17	0.35
AWP 15	0.92	0.02	0.03	0.09	0.04	0.13	0.56	0.00	0.01	0.14	24.19	0.14	0.41
AWP 16	0.87	0.02	0.04	0.09	0.04	0.29	0.56	0.00	0.00	0.13	22.47	0.16	0.46
AWP 17	0.76	0.03	0.03	0.09	0.06	0.29	0.54	0.00	0.00	0.25	21.25	0.18	0.37
AWP 18	0.85	0.02	0.01	0.03	0.02	0.09	0.47	0.00	0.01	0.07	27.38	0.07	0.41
AWP 19	0.56	0.01	0.01	0.01	0.02	0.17	0.22	0.00	0.00	0.07	17.08	0.07	0.22
AWP 20	0.93	0.02	0.03	0.05	0.05	0.20	0.64	0.00	0.01	0.10	22.69	0.23	0.40
AWP 21	0.69	0.01	0.02	0.02	0.09	0.25	0.53	0.00	0.01	0.11	22.55	0.22	0.45
AWP 22	0.76	0.01	0.03	0.04	0.08	0.19	0.54	0.00	0.00	0.11	22.25	0.16	0.46
AWP 23	0.77	0.03	0.03	0.04	0.03	0.11	0.48	0.00	0.01	0.10	21.74	0.10	0.39
AWP 24	0.53	0.00	0.03	0.07	0.07	0.00	0.13	0.07	0.00	0.02	17.33	0.00	0.23
AWP 25	0.64	0.04	0.05	0.07	0.04	0.02	0.23	0.00	0.00	0.02	12.44	0.05	0.28
AWP 26	1.69	0.04	0.05	0.27	0.01	0.01	0.26	0.00	0.02	0.08	15.36	0.05	0.30
AWP 27	0.46	0.03	0.02	0.07	0.06	0.00	0.22	0.12	0.00	0.02	15.94	0.03	0.19
AWP 28	1.47	0.03	0.05	0.18	0.03	0.01	0.59	0.00	0.03	0.09	15.17	0.03	0.42
AWP 29	0.28	0.09	0.06	0.04	0.25	0.07	0.20	0.01	0.00	0.00	11.45	1.03	0.20
AWP 30	3.87	0.03	0.01	0.09	0.42	0.62	0.71	0.00	0.01	0.45	22.53	0.06	0.80
AWP 31	1.28	0.11	0.03	0.12	0.26	0.32	0.60	0.00	0.01	0.32	18.43	0.07	1.12
AWP 32	0.63	0.07	0.04	0.05	0.04	0.06	0.18	0.00	0.00	0.00	14.70	0.63	0.30

AWP 33	3.87	0.00	0.00	0.03	0.73	0.97	0.90	0.01	0.00	0.75	22.66	0.07	0.86
AWP 34	0.39	0.02	0.02	0.01	0.21	0.25	0.45	0.00	0.00	0.22	11.33	0.06	0.56
AWP 35	1.53	0.03	0.02	0.11	0.10	0.09	0.19	0.00	0.00	0.02	19.16	0.30	0.29
AWP 36	3.55	0.00	0.01	0.04	0.05	0.07	0.89	0.00	0.00	0.27	25.32	0.07	0.33
AWP 37	1.14	0.00	0.01	0.03	0.07	0.03	0.34	0.00	0.00	0.00	16.34	0.03	0.09
AWP 38	2.94	0.00	0.00	0.03	0.07	0.08	0.91	0.00	0.00	0.24	22.35	0.08	0.28
AWP 39	1.28	0.00	0.01	0.03	0.08	0.04	0.39	0.00	0.00	0.00	17.21	0.03	0.09
AWP 40	5.03	0.11	0.14	0.35	0.22	0.13	0.26	0.04	0.03	0.14	14.74	0.25	0.50
AWP 41	3.19	0.09	0.10	0.24	0.15	0.10	0.21	0.03	0.02	0.04	15.67	0.22	0.42

LabCode	**c16.1w7**	**c7Me16.0**	**c16.1w5**	**c16.2w6**	**Iso17**	**c16.2w4**	**c16.3w6**	**c17.0**	**c16.3w4**	**c17.1**	**c16.3w1**	**c16.4w3**	**c16.4w1**
AWP 1	2.18	0.06	0.02	0.00	0.68	0.04	0.00	1.26	0.02	0.42	0.00	0.00	0.00
AWP 2	0.46	0.04	0.05	0.00	1.10	0.02	0.03	2.12	0.04	0.12	0.00	0.01	0.00
AWP 3	2.08	0.05	0.03	0.00	0.23	0.01	0.00	0.51	0.02	0.20	0.00	0.00	0.00
AWP 4	1.11	0.03	0.01	0.26	0.79	0.00	0.00	1.05	0.01	0.20	0.00	0.00	0.00
AWP 5	0.85	0.02	0.03	0.00	0.68	0.00	0.00	1.08	0.01	0.24	0.00	0.00	0.00
AWP 6	0.44	0.04	0.03	0.00	0.67	0.01	0.02	1.29	0.03	0.19	0.00	0.00	0.00
AWP 7	1.32	0.04	0.05	0.00	0.65	0.00	0.02	0.75	0.05	0.26	0.00	0.00	0.00
AWP 8	0.34	0.03	0.04	0.00	0.04	0.05	0.00	0.49	0.01	0.11	0.00	0.00	0.00
AWP 9	0.50	0.04	0.04	0.00	0.03	0.06	0.00	0.49	0.00	0.14	0.00	0.00	0.00
AWP 10	0.69	0.03	0.04	0.00	0.03	0.06	0.02	0.46	0.01	0.18	0.00	0.00	0.00
AWP 11	0.67	0.07	0.05	0.00	0.05	0.09	0.02	0.67	0.02	0.16	0.00	0.00	0.00
AWP 12	1.15	0.07	0.03	0.00	0.09	0.05	0.02	0.41	0.01	0.20	0.00	0.00	0.00
AWP 13	1.74	0.04	0.02	0.00	0.16	0.01	0.00	0.68	0.03	0.50	0.00	0.00	0.00
AWP 14	1.38	0.22	0.01	0.00	0.13	0.01	0.00	0.77	0.02	0.39	0.00	0.00	0.00
AWP 15	2.21	0.11	0.03	0.00	0.19	0.00	0.00	0.73	0.03	0.57	0.00	0.00	0.00
AWP 16	1.50	0.06	0.02	0.00	0.13	0.03	0.00	0.79	0.09	0.55	0.00	0.00	0.00
AWP 17	1.72	0.03	0.01	0.00	0.31	0.01	0.00	0.77	0.02	0.47	0.00	0.00	0.00
AWP 18	2.57	0.01	0.02	0.00	0.14	0.00	0.00	0.52	0.03	0.77	0.00	0.00	0.00
AWP 19	0.68	0.02	0.01	0.04	0.10	0.00	0.00	0.63	0.10	0.22	0.00	0.00	0.00
AWP 20	2.13	0.02	0.03	0.00	0.29	0.00	0.00	0.72	0.07	0.52	0.00	0.00	0.00
AWP 21	1.07	0.04	0.08	0.00	0.16	0.00	0.01	0.75	0.04	0.25	0.00	0.00	0.00
AWP 22	1.46	0.09	0.05	0.00	0.12	0.00	0.00	0.78	0.04	0.40	0.00	0.05	0.00

AWP 23	1.29	0.02	0.02	0.00	0.13	0.00	0.00	0.71	0.02	0.50	0.00	0.00	0.00
AWP 24	1.78	1.63	0.00	0.02	0.03	0.03	0.00	0.73	0.00	0.15	0.00	0.00	0.00
AWP 25	1.49	1.33	0.01	0.00	0.03	0.00	0.03	0.52	0.02	0.26	0.00	0.00	0.00
AWP 26	4.78	2.37	0.03	0.00	0.08	0.00	0.01	0.33	0.02	0.50	0.00	0.00	0.00
AWP 27	1.22	3.97	0.00	0.02	0.04	0.00	0.00	1.01	0.01	0.15	0.00	0.00	0.00
AWP 28	3.68	6.96	0.04	0.00	0.08	0.01	0.03	0.49	0.02	0.54	0.00	0.01	0.01
AWP 29	2.21	0.03	0.01	0.00	0.32	0.00	0.04	0.81	0.03	0.45	0.00	0.00	0.07
AWP 30	1.27	0.02	0.03	0.00	1.15	0.00	0.00	1.82	0.02	0.44	0.00	0.27	0.00
AWP 31	2.46	0.06	0.04	0.01	0.99	0.04	0.00	1.41	0.04	0.94	0.01	0.07	0.02
AWP 32	2.35	0.05	0.03	0.00	0.34	0.00	0.00	0.86	0.03	0.80	0.00	0.00	0.03
AWP 33	0.91	0.03	0.02	0.00	1.65	0.04	0.00	2.62	0.02	0.49	0.00	0.39	0.00
AWP 34	0.90	0.03	0.03	0.00	0.72	0.01	0.00	1.89	0.02	0.54	0.00	0.47	0.02
AWP 35	2.32	0.05	0.02	0.00	0.41	0.02	0.00	0.95	0.02	0.65	0.00	0.00	0.02
AWP 36	1.34	0.02	0.02	0.01	0.39	0.00	0.02	0.76	0.02	0.39	0.00	0.16	0.02
AWP 37	0.85	0.05	0.01	0.00	0.10	0.02	0.00	0.71	0.03	0.14	0.00	0.00	0.03
AWP 38	0.88	0.02	0.02	0.00	0.41	0.00	0.02	0.85	0.04	0.37	0.00	0.15	0.03
AWP 39	0.97	0.01	0.01	0.00	0.13	0.01	0.00	0.74	0.04	0.17	0.00	0.00	0.02
AWP 40	13.55	0.26	0.03	0.05	0.30	0.22	0.32	0.24	0.15	0.32	0.00	0.05	0.08
AWP 41	9.97	0.27	0.03	0.03	0.22	0.15	0.22	0.24	0.09	0.30	0.00	0.06	0.06

LabCode	**c18.0**	**c18.1w13**	**c18.1w11**	**c18.1w9**	**c18.1w7**	**c18.1w5**	**c18.2d5,11**	**c18.2w7**	**c18.2w6**	**c18.2w4**	**c18.3w6**	**c18.3w4**	**c18.3w3**
AWP 1	20.78	0.00	0.47	36.65	0.64	0.13	0.35	0.03	1.29	0.00	0.00	0.07	0.39
AWP 2	29.44	0.27	0.30	9.25	0.83	0.06	0.24	0.01	7.59	0.00	0.00	0.05	0.73
AWP 3	13.84	0.12	0.10	39.94	1.02	0.12	0.10	0.02	6.24	0.00	0.00	0.07	1.34
AWP 4	25.77	0.00	0.19	37.96	0.58	0.08	0.15	0.01	0.90	0.01	0.00	0.21	0.29
AWP 5	23.91	0.14	0.12	34.70	0.81	0.06	0.19	0.01	4.67	0.00	0.00	0.15	0.74
AWP 6	24.72	0.15	0.11	20.42	0.76	0.05	0.13	0.00	6.61	0.00	0.00	0.07	0.32
AWP 7	11.16	0.08	0.11	24.55	1.15	0.03	0.09	0.00	3.22	0.00	0.04	0.13	0.20
AWP 8	9.66	0.00	0.59	27.66	1.10	0.06	0.00	0.03	23.65	0.00	0.08	0.08	1.92
AWP 9	9.34	0.00	0.48	31.63	1.16	0.51	0.00	0.20	24.01	0.00	0.08	0.09	1.43
AWP 10	8.98	0.00	0.50	30.26	1.19	0.05	0.00	0.04	25.43	0.00	0.07	0.09	2.42
AWP 11	12.16	0.00	0.23	26.02	1.10	0.05	0.03	0.03	20.62	0.00	0.09	0.11	2.23
AWP 12	8.33	0.00	0.39	34.73	1.15	0.06	0.00	0.04	23.22	0.00	0.11	0.09	1.57

AWP 13	9.06	0.04	0.03	17.73	0.92	0.04	0.04	0.02	13.46	0.03	0.12	0.11	15.86
AWP 14	11.19	0.05	0.06	16.46	0.92	0.10	0.03	0.03	14.76	0.03	0.08	0.09	13.04
AWP 15	8.19	0.01	0.02	16.55	1.23	0.07	0.05	0.03	11.73	0.02	0.10	0.10	19.96
AWP 16	9.59	0.01	0.04	14.63	1.48	0.07	0.05	0.03	14.07	0.03	0.10	0.13	16.70
AWP 17	8.61	0.03	0.03	17.30	0.94	0.02	0.06	0.02	13.32	0.03	0.07	0.13	20.44
AWP 18	4.85	0.00	0.03	28.36	1.05	0.02	0.01	0.02	9.41	0.01	0.14	0.26	14.31
AWP 19	10.00	0.06	0.14	22.21	1.41	0.05	0.01	0.04	16.55	0.01	0.21	0.11	13.74
AWP 20	8.17	0.02	0.05	16.79	0.99	0.04	0.05	0.03	13.14	0.03	0.26	0.14	18.14
AWP 21	13.00	0.02	0.01	13.23	1.14	0.05	0.05	0.03	11.77	0.01	0.25	0.06	13.93
AWP 22	11.33	0.07	0.07	17.37	1.45	0.04	0.00	0.04	13.24	0.02	0.24	0.11	11.06
AWP 23	9.63	0.00	0.04	22.09	1.17	0.02	0.05	0.02	11.78	0.02	0.22	0.21	15.02
AWP 24	13.29	0.00	0.00	14.00	2.25	0.59	0.00	0.00	18.40	0.20	0.08	0.04	5.46
AWP 25	5.96	0.00	0.03	12.65	1.13	0.33	0.00	0.06	35.09	0.02	0.28	0.08	17.91
AWP 26	1.48	0.00	0.00	38.88	1.66	1.00	0.00	0.02	11.55	0.02	0.12	0.11	16.61
AWP 27	12.33	0.00	0.00	11.78	2.67	1.25	0.01	0.00	20.23	0.01	0.17	0.05	3.72
AWP 28	1.09	0.00	0.02	28.28	1.81	1.61	0.00	0.02	16.89	0.01	0.22	0.16	16.99
AWP 29	12.43	0.08	0.11	10.89	2.53	0.05	0.09	0.06	16.99	0.00	0.18	0.12	0.68
AWP 30	30.16	0.00	0.35	26.27	0.69	0.04	0.03	0.17	1.98	0.01	0.45	0.04	0.76
AWP 31	16.23	0.12	0.18	30.62	1.33	0.07	0.19	0.06	6.69	0.04	0.35	0.03	2.92
AWP 32	11.02	0.08	0.07	28.20	2.16	0.05	0.10	0.08	18.67	0.00	0.15	0.10	1.97
AWP 33	34.83	0.00	0.25	19.83	0.72	0.06	0.00	0.13	2.26	0.00	0.51	0.05	0.65
AWP 34	26.66	0.09	0.28	16.39	1.36	0.05	0.18	0.09	7.64	0.00	0.72	0.13	1.39
AWP 35	14.62	0.06	0.12	34.86	1.73	0.09	0.11	0.05	10.39	0.00	0.14	0.10	1.16
AWP 36	3.79	0.01	0.01	9.04	0.47	0.00	0.02	0.00	37.60	0.10	0.13	0.03	13.59
AWP 37	9.16	0.00	0.02	6.06	0.70	0.00	0.03	0.05	44.68	0.10	0.22	0.02	4.75
AWP 38	3.96	0.06	0.01	7.27	0.34	0.00	0.00	0.00	40.73	0.10	0.12	0.05	16.26
AWP 39	8.43	0.04	0.01	5.23	0.58	0.00	0.03	0.06	43.88	0.10	0.19	0.03	6.19
AWP 40	4.61	0.00	0.93	22.56	5.81	0.62	0.03	0.06	2.64	0.14	0.14	0.16	1.22
AWP 41	6.17	0.01	0.59	18.70	6.59	0.49	0.05	0.05	4.59	0.14	0.12	0.14	1.19

LabCode	c18.3w1	c18.4w3	c18.4w1	c20.0	c20.1w11	c20.1w9	c20.1w7	c20.2w9	c20.2w6	c20.3w6	c20.4w6	c20.3w3	c20.4w3
AWP 1	0.00	0.00	0.00	0.28	0.19	0.10	0.00	0.00	0.03	0.07	0.13	0.01	0.01
AWP 2	0.01	0.00	0.00	0.15	0.09	0.09	0.00	0.00	0.99	1.06	11.73	0.07	0.11
AWP 3	0.00	0.02	0.00	0.09	0.10	0.22	0.01	0.00	0.13	0.34	4.49	0.05	0.07
AWP 4	0.00	0.00	0.00	0.41	0.21	0.23	0.00	0.00	0.02	0.05	0.12	0.01	0.00
AWP 5	0.00	0.00	0.00	0.30	0.15	0.19	0.00	0.00	0.20	0.25	2.72	0.04	0.03
AWP 6	0.01	0.02	0.00	0.12	0.05	0.15	0.00	0.00	1.19	0.95	11.63	0.05	0.06
AWP 7	0.00	0.00	0.00	0.98	0.18	0.77	0.03	0.00	0.28	0.93	8.64	0.06	0.02
AWP 8	0.00	0.01	0.04	0.46	0.19	1.31	0.04	0.00	0.62	0.38	4.89	0.10	0.02
AWP 9	0.01	0.02	0.04	0.48	0.17	1.25	0.04	0.00	0.45	0.30	3.69	0.08	0.02
AWP 10	0.00	0.02	0.01	0.36	0.18	1.46	0.04	0.00	0.52	0.35	3.70	0.10	0.02
AWP 11	0.02	0.27	0.03	0.27	0.28	1.00	0.04	0.00	0.62	0.46	5.77	0.11	0.02
AWP 12	0.00	0.03	0.00	0.38	0.22	1.55	0.03	0.00	0.39	0.27	3.49	0.06	0.00
AWP 13	0.00	0.11	0.00	0.19	0.93	0.25	0.03	0.00	0.32	0.49	2.20	0.43	0.20
AWP 14	0.00	0.10	0.00	0.25	1.09	0.27	0.03	0.00	0.37	0.59	2.23	0.52	0.22
AWP 15	0.00	0.16	0.00	0.14	0.46	0.20	0.05	0.00	0.32	0.54	1.76	0.50	0.41
AWP 16	0.00	0.13	0.00	0.17	0.93	0.25	0.07	0.00	0.38	0.78	2.43	0.62	0.47
AWP 17	0.00	0.10	0.00	0.24	0.50	0.26	0.04	0.00	0.37	0.46	2.22	0.49	0.17
AWP 18	0.01	0.14	0.00	0.12	0.26	0.29	0.04	0.03	0.31	0.25	1.33	0.51	0.22
AWP 19	0.00	0.10	0.01	0.48	1.69	0.59	0.03	0.00	0.35	0.88	2.76	0.64	0.41
AWP 20	0.00	0.18	0.00	0.17	0.43	0.23	0.03	0.00	0.34	0.53	2.64	0.52	0.26
AWP 21	0.00	0.21	0.00	0.32	0.42	0.22	0.04	0.00	0.39	0.66	3.98	0.48	0.33
AWP 22	0.00	0.05	0.00	0.27	0.52	0.22	0.04	0.00	0.50	0.66	4.09	0.46	0.20
AWP 23	0.00	0.12	0.00	0.26	0.39	0.31	0.05	0.00	0.54	0.43	2.29	0.64	0.25
AWP 24	0.00	0.00	0.04	0.05	0.06	0.36	0.02	0.00	0.32	0.73	7.61	0.40	0.19
AWP 25	0.00	0.05	0.00	0.16	0.11	0.43	0.03	0.01	0.47	0.29	2.94	0.43	0.06
AWP 26	0.01	0.10	0.00	0.02	0.10	0.35	0.01	0.04	0.13	0.09	0.19	0.29	0.12
AWP 27	0.00	0.02	0.00	0.04	0.05	0.29	0.02	0.00	0.34	1.35	8.53	0.32	0.18
AWP 28	0.02	0.08	0.00	0.02	0.06	0.30	0.01	0.04	0.20	0.21	0.31	0.31	0.24
AWP 29	0.00	0.08	0.00	0.15	0.05	0.13	0.01	0.00	0.26	1.17	27.30	0.22	0.03
AWP 30	0.00	0.24	0.00	1.81	0.36	0.21	0.02	0.00	0.07	0.39	0.14	0.02	0.00
AWP 31	0.00	0.58	0.02	0.36	0.17	0.31	0.01	0.00	0.17	0.49	5.13	0.16	0.04
AWP 32	0.00	0.26	0.02	0.12	0.08	0.23	0.00	0.00	0.39	0.71	9.45	0.10	0.05

AWP 33	0.00	0.22	0.00	1.43	0.26	0.13	0.00	0.00	0.03	0.28	0.17	0.00	0.00
AWP 34	0.00	0.36	0.02	0.28	0.08	0.21	0.01	0.00	0.55	0.94	13.79	0.15	0.04
AWP 35	0.00	0.19	0.01	0.18	0.08	0.32	0.00	0.00	0.29	0.41	5.90	0.07	0.03
AWP 36	0.00	0.34	0.01	0.12	0.06	0.22	0.00	0.00	0.16	0.04	0.09	0.08	0.00
AWP 37	0.00	0.16	0.02	0.07	0.03	0.09	0.00	0.00	0.20	0.39	8.98	0.12	0.01
AWP 38	0.00	0.34	0.00	0.07	0.05	0.18	0.00	0.00	0.15	0.03	0.12	0.08	0.00
AWP 39	0.04	0.19	0.02	0.04	0.04	0.08	0.00	0.00	0.22	0.45	8.22	0.14	0.01
AWP 40	0.04	0.43	0.13	0.08	0.94	6.08	0.59	0.11	0.28	0.14	0.40	0.11	0.46
AWP 41	0.04	0.28	0.11	0.06	0.69	4.69	0.44	0.08	0.27	0.26	2.87	0.09	0.38

LabCode	**c18.3w1**	**c18.4w3**	**c18.4w1**	**c20.0**	**c20.1w11**	**c20.1w9**	**c20.1w7**	**c20.2w9**	**c20.2w6**	**c20.3w6**	**c20.4w6**	**c20.3w3**	**c20.4w3**
AWP 1	0.00	0.00	0.00	0.28	0.19	0.10	0.00	0.00	0.03	0.07	0.13	0.01	0.01
AWP 2	0.01	0.00	0.00	0.15	0.09	0.09	0.00	0.00	0.99	1.06	11.73	0.07	0.11
AWP 3	0.00	0.02	0.00	0.09	0.10	0.22	0.01	0.00	0.13	0.34	4.49	0.05	0.07
AWP 4	0.00	0.00	0.00	0.41	0.21	0.23	0.00	0.00	0.02	0.05	0.12	0.01	0.00
AWP 5	0.00	0.00	0.00	0.30	0.15	0.19	0.00	0.00	0.20	0.25	2.72	0.04	0.03
AWP 6	0.01	0.02	0.00	0.12	0.05	0.15	0.00	0.00	1.19	0.95	11.63	0.05	0.06
AWP 7	0.00	0.00	0.00	0.98	0.18	0.77	0.03	0.00	0.28	0.93	8.64	0.06	0.02
AWP 8	0.00	0.01	0.04	0.46	0.19	1.31	0.04	0.00	0.62	0.38	4.89	0.10	0.02
AWP 9	0.01	0.02	0.04	0.48	0.17	1.25	0.04	0.00	0.45	0.30	3.69	0.08	0.02
AWP 10	0.00	0.02	0.01	0.36	0.18	1.46	0.04	0.00	0.52	0.35	3.70	0.10	0.02
AWP 11	0.02	0.27	0.03	0.27	0.28	1.00	0.04	0.00	0.62	0.46	5.77	0.11	0.02
AWP 12	0.00	0.03	0.00	0.38	0.22	1.55	0.03	0.00	0.39	0.27	3.49	0.06	0.00
AWP 13	0.00	0.11	0.00	0.19	0.93	0.25	0.03	0.00	0.32	0.49	2.20	0.43	0.20
AWP 14	0.00	0.10	0.00	0.25	1.09	0.27	0.03	0.00	0.37	0.59	2.23	0.52	0.22
AWP 15	0.00	0.16	0.00	0.14	0.46	0.20	0.05	0.00	0.32	0.54	1.76	0.50	0.41
AWP 16	0.00	0.13	0.00	0.17	0.93	0.25	0.07	0.00	0.38	0.78	2.43	0.62	0.47
AWP 17	0.00	0.10	0.00	0.24	0.50	0.26	0.04	0.00	0.37	0.46	2.22	0.49	0.17
AWP 18	0.01	0.14	0.00	0.12	0.26	0.29	0.04	0.03	0.31	0.25	1.33	0.51	0.22
AWP 19	0.00	0.10	0.01	0.48	1.69	0.59	0.03	0.00	0.35	0.88	2.76	0.64	0.41
AWP 20	0.00	0.18	0.00	0.17	0.43	0.23	0.03	0.00	0.34	0.53	2.64	0.52	0.26
AWP 21	0.00	0.21	0.00	0.32	0.42	0.22	0.04	0.00	0.39	0.66	3.98	0.48	0.33
AWP 22	0.00	0.05	0.00	0.27	0.52	0.22	0.04	0.00	0.50	0.66	4.09	0.46	0.20

AWP 23	0.00	0.12	0.00	0.26	0.39	0.31	0.05	0.00	0.54	0.43	2.29	0.64	0.25
AWP 24	0.00	0.00	0.04	0.05	0.06	0.36	0.02	0.00	0.32	0.73	7.61	0.40	0.19
AWP 25	0.00	0.05	0.00	0.16	0.11	0.43	0.03	0.01	0.47	0.29	2.94	0.43	0.06
AWP 26	0.01	0.10	0.00	0.02	0.10	0.35	0.01	0.04	0.13	0.09	0.19	0.29	0.12
AWP 27	0.00	0.02	0.00	0.04	0.05	0.29	0.02	0.00	0.34	1.35	8.53	0.32	0.18
AWP 28	0.02	0.08	0.00	0.02	0.06	0.30	0.01	0.04	0.20	0.21	0.31	0.31	0.24
AWP 29	0.00	0.08	0.00	0.15	0.05	0.13	0.01	0.00	0.26	1.17	27.30	0.22	0.03
AWP 30	0.00	0.24	0.00	1.81	0.36	0.21	0.02	0.00	0.07	0.39	0.14	0.02	0.00
AWP 31	0.00	0.58	0.02	0.36	0.17	0.31	0.01	0.00	0.17	0.49	5.13	0.16	0.04
AWP 32	0.00	0.26	0.02	0.12	0.08	0.23	0.00	0.00	0.39	0.71	9.45	0.10	0.05
AWP 33	0.00	0.22	0.00	1.43	0.26	0.13	0.00	0.00	0.03	0.28	0.17	0.00	0.00
AWP 34	0.00	0.36	0.02	0.28	0.08	0.21	0.01	0.00	0.55	0.94	13.79	0.15	0.04
AWP 35	0.00	0.19	0.01	0.18	0.08	0.32	0.00	0.00	0.29	0.41	5.90	0.07	0.03
AWP 36	0.00	0.34	0.01	0.12	0.06	0.22	0.00	0.00	0.16	0.04	0.09	0.08	0.00
AWP 37	0.00	0.16	0.02	0.07	0.03	0.09	0.00	0.00	0.20	0.39	8.98	0.12	0.01
AWP 38	0.00	0.34	0.00	0.07	0.05	0.18	0.00	0.00	0.15	0.03	0.12	0.08	0.00
AWP 39	0.04	0.19	0.02	0.04	0.04	0.08	0.00	0.00	0.22	0.45	8.22	0.14	0.01
AWP 40	0.04	0.43	0.13	0.08	0.94	6.08	0.59	0.11	0.28	0.14	0.40	0.11	0.46
AWP 41	0.04	0.28	0.11	0.06	0.69	4.69	0.44	0.08	0.27	0.26	2.87	0.09	0.38

LabCode	**C18:2 + C18:3 + C20:4**	**R 18:2/18:3**
AWP 1	1.81	3.29
AWP 2	20.05	10.39
AWP 3	12.07	4.66
AWP 4	1.30	3.09
AWP 5	8.13	6.30
AWP 6	18.56	20.64
AWP 7	12.05	16.08
AWP 8	30.46	12.32
AWP 9	29.12	16.79
AWP 10	31.54	10.53
AWP 11	28.61	9.27
AWP 12	28.28	14.79

AWP 13	31.52	0.85
AWP 14	30.02	1.13
AWP 15	33.44	0.59
AWP 16	33.20	0.84
AWP 17	35.97	0.65
AWP 18	25.04	0.66
AWP 19	33.05	1.20
AWP 20	33.92	0.72
AWP 21	29.67	0.85
AWP 22	28.39	1.20
AWP 23	29.08	0.78
AWP 24	31.47	3.37
AWP 25	55.93	1.96
AWP 26	28.35	0.70
AWP 27	32.48	5.44
AWP 28	34.19	0.99
AWP 29	44.96	25.16
AWP 30	2.88	2.61
AWP 31	14.74	2.29
AWP 32	30.09	9.50
AWP 33	3.07	3.50
AWP 34	22.81	5.51
AWP 35	17.44	9.00
AWP 36	51.28	2.77
AWP 37	58.40	9.42
AWP 38	57.10	2.51
AWP 39	58.28	7.09
AWP 40	4.26	2.16
AWP 41	8.65	3.85