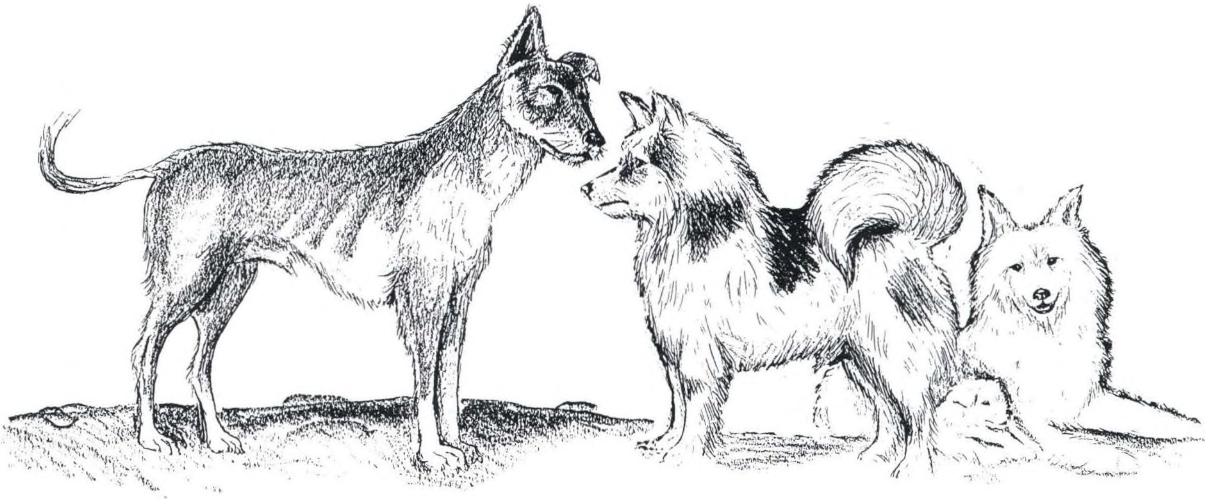
OSTEOMETRY OF MAKAH AND COAST SALISH DOGS



Susan J. Crockford

Osteometry of Makah and Coast Salish Dogs

by

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with a contribution by

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PREFACE

Although I began this research with the idea that it would form the basis for a Masters degree in Biology, it didn't turn out that way. It became instead a trail of breadcrumbs that led me finally, and irrevocably, down an intellectual path I had been steering toward all my life - on a personal quest toward answers to some fundamental questions about evolution. Although evolutionary issues may seem only distantly relevant to this study, they lie at the root of some of the most basic assumptions made in any archaeozoological analysis. Why do we get skeletal variation in the first place, both within and between species, and what biological mechanism controls that variation? What is the biological process that causes domestication changes and what is its evolutionary significance? And ultimately, how *could* you turn a wolf into a dog, in strictly biological terms?

A driving determination to investigate the evolutionary significance of dog origins and breed development brewed slowly as I plowed my way through the ostensibly mundane process of assessing morphological variation within this assemblage of prehistoric dog remains. While I address some of the above-mentioned evolutionary issues in another forum, I bring them up briefly here as an acknowledgment that they eventually became an integral part of the intellectual and theoretical context within which this study was conducted..

Dogs are unique, both biologically and culturally. Biologically, the extreme range of morphological and behavioural variation exhibited by the more than 400 breeds now known is without equal for a single species. Dogs fill a rather special ecological niche, defined in essence by their relationship to humans. Culturally, they have assumed a variety of roles: companion, hunter, herder, hauler, searcher, leader, rescuer, scavenger, and even dinner. Dogs have lived in association with people for thousands of years -people of diverse cultures living in every imaginable climate - and yet, dogs always seem to have found a place for themselves. No animal is as ubiquitous in archaeological contexts as the dog.

A study of archaeological dog remains can be neither purely biological nor entirely anthropological. While the dog is certainly an animal, it is an animal whose evolution is intricately and inextricably tied to humans. What I have attempted to do in this study is to lay down a basic foundation database to encourage future analysis of Northwest Coast dogs and perhaps, studies on dog variation and breed development elsewhere in the world. I couldn't take all the cultural aspects out of the subject matter (nor should I have tried) but I have attempted to keep them as much in the background as possible so that I could focus on the biological issues.

This research is the culmination of five years work that at times has been tedious and overwhelming in the sheer mass of data it has generated - perhaps this is the reason no one tackled it before! Amassing the collection of dog remains, recovered from archaeological sites excavated up to 30 years ago, would not have been possible without the help of many individuals. Collections personnel especially, from several institutions (including the Anthropology/Sociology Department, University of British Columbia; Archaeology Department, Simon Fraser University; Anthropology Department, University of Victoria; Royal B.C. Museum; Vancouver Museum; Makah Museum), cheerfully located relevant boxes of faunal material long since forgotten and swiftly processed official loans.

It never ceased to amaze me: everyone was so excited that someone was *finally* going to do something with dogs that they happily went out of their way to assist. To all who searched their files for dog references (especially Len Ham and Arnoud Stryd) and who literally sent me the skeletons in their closets, I thank you all for your

enthusiasm. Many people helped, in both small and large ways. Their contributions made a real difference and without their assistance, there would not have been a sample to analyze.

Special thanks however go to Becky Wigen and Don Mitchell from the University of Victoria and to Grant Keddie and Gay Frederick from the Royal B.C. Museum, who all offered invaluable intellectual support as well as practical assistance throughout five long years of analysis. The Makah Cultural Committee, Neah Bay, Washington, agreed to allow dog remains from the Ozette site to become part of this study. Permission granted, Jeff Mauger and staff at the Makah Museum in Neah Bay went out of their way to *find* the dogs, out of the thousands of boxes of Ozette material currently in storage.

Biology student Jennifer DeGraaf plowed through hundreds of bags of mixed fauna to isolate dog remains and Cairn Crockford provided essential assistance with management of the database. Dr. Layne Bixby D.M.V., an expert in osteoplastic surgery, examined several specimens with bone pathologies and offered his opinion. Heath Moffat of Destrube Photography (Victoria) took the photographs. Roy Carlson, Editor of Simon Fraser University's Archaeology Press, provided friendly editorial guidance and support in his commitment to publish this manuscript. Two anonymous reviewers provided helpful comments on the initial draft.

Dr. Nobuo Shigehara responded with unprecedented speed and enthusiasm to my suggestion that I include in this publication an updated English version of work he and colleagues completed more than ten years ago on the sex determination of skeletons of the Japanese shiba dog (a small, spitz-type breed not unlike a "miniaturized "akita). I am pleased to be able to offer these colleagues an English forum for their contribution and am honored to share this publication with them.

Corporal Cam Pye, forensic artist for the Royal Canadian Mounted Police (E Division), generously volunteered to attempt composite drawings of the two dog types. Provided with crania and as much ethnohistoric information as I could supply him with, he combined his artistic skill and experience in forensic facial reconstructions with his own love of dogs to produce the two sketches. While admittedly these drawings encompass considerable amounts of "artistic license", we hope they represent the present status of knowledge on the appearance of indigenous Northwest Coast dogs.

My sister, Cairn Crockford, has been a tireless intellectual companion and provider of practical assistance on many fronts. My children, Jesse and Laura McMillan, listened, discussed, and encouraged - often beyond my wildest expectations. Before her death in late 1995, my mother, Barbara Crockford, provided intellectual, emotional, and financial support on a level that no one else could - I don't think I could have gotten through those five years without her.

This skeletal sample is being used as the basis for related research comparing the mitochondrial DNA of these and other regional types of prehistoric dogs. The genetic research is a byproduct of my need to see this analysis put into its broadest possible biological context. I owe tremendous thanks to Barry Glickman and Ben Koop at the Centre for Environmental Health (University of Victoria, Biology Department). They both had enough foresight and enthusiasm for the project to help secure the necessary funding for the genetic research even though it was somewhat outside their own professional interests at the time. Ben Koop went on to supervise the genetic study, which should be complete in the fall of 1996 (Burbidge et al. 1996; Crockford 1994).

This research was funded in part by a grant from the British Columbia Heritage Trust, administered by the Anthropology Department, University of Victoria (David Moyer) and by financial contributions from my corporate sponsor, Pacific Identifications. Additional support was provided by a Collaborative Research and Development Grant to Dr. B. F. Koop, University of Victoria (Biology), whose funds were contributed jointly by the National Science and Engineering Research Council of Canada and Pacific Identifications (Victoria).

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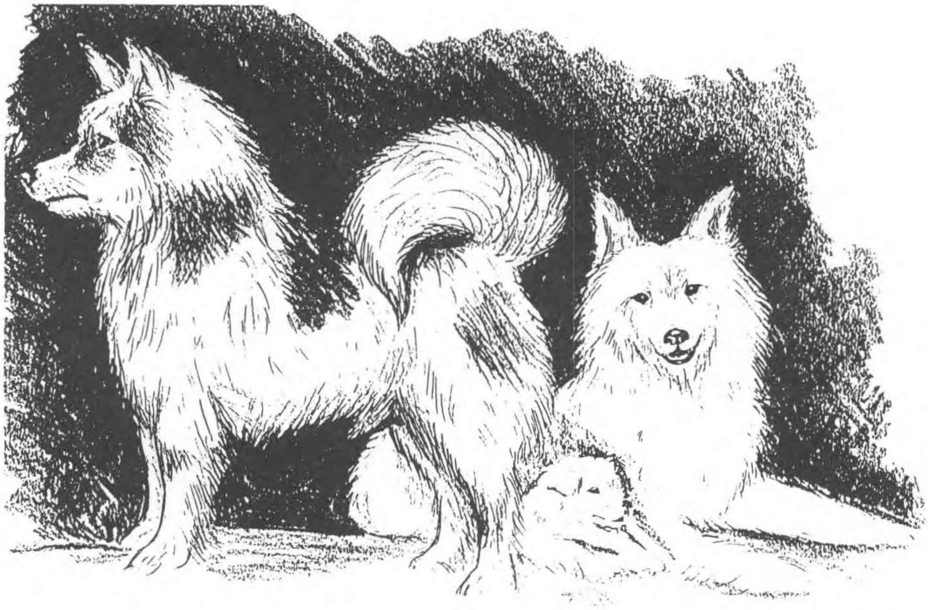
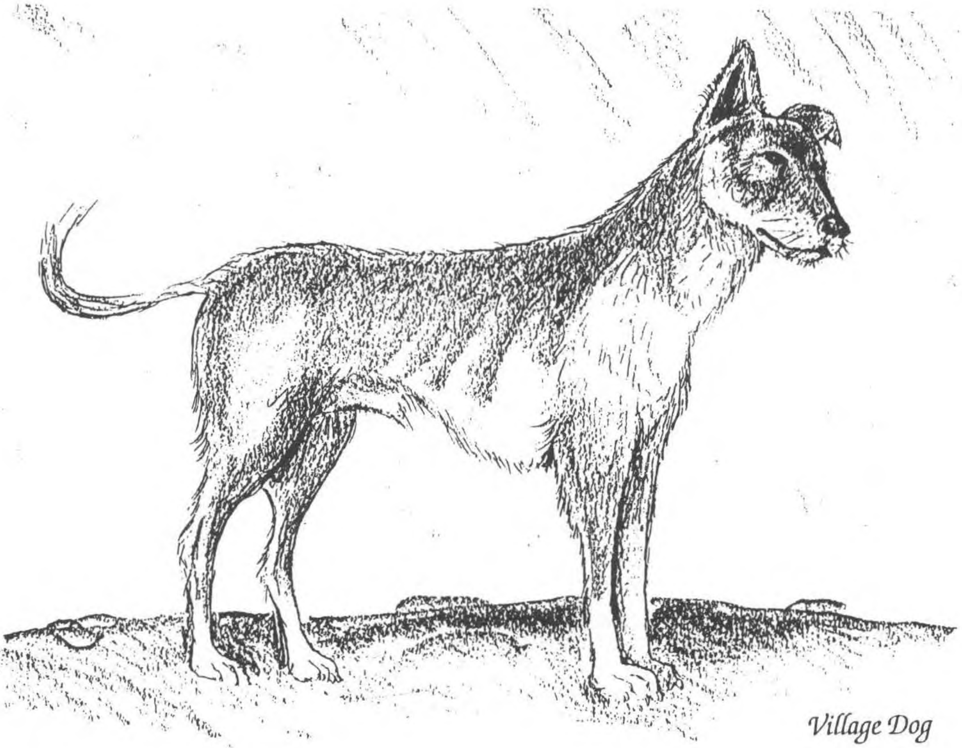


Wool Dog



Village Dog

1 INTRODUCTION

Early historic and ethnographic accounts report the presence of two types of dogs (*Canis familiaris*) kept by the Makah and Coast Salish peoples of the south central Northwest Coast of North America (southeastern Vancouver Island, northern Olympic Peninsula, the Gulf Islands, Puget Sound and the Fraser River Delta). These accounts describe a medium-sized, short-haired dog and a smaller, long-haired one. The small type or "wool" dog was reportedly kept almost exclusively for its thick soft fur, which was woven into blankets. The ethnohistoric evidence suggests that the two types of dogs were deliberately maintained as separate populations, with explicit economic reasons for doing so, and thus may constitute true breeds. This pattern of dog use has not been recorded anywhere else in North America. However, the cultural implications of this unique situation cannot be appreciated fully until the issue of whether the wool dog really existed as a separate type during prehistoric times is resolved.

The purpose of this study was to determine whether two distinct physical types could be distinguished within a sample of 1163 dog skeletal remains collected from 20 archaeological sites spanning 4000 years of prehistory. The sample consists of crania, mandibles, major front and hind limb elements, selected tarsals, metapodials and vertebrae. A statistical method cribbed from paleontological studies was used to interpret the variation in size demonstrated by the sample. This method allowed specimens to be classified, on an element by element basis, as either large or small according to its total length dimension. Multivariate discriminant function analysis was used to investigate the relationship between breadth and length dimensions. This analysis constitutes the first comprehensive work on prehistoric dog remains from this area. It is a long overdue database that will allow almost all dog skeletal elements, previously excavated material and future remains alike, to be compared and assessed.

This introductory chapter provides a summary of the ethnohistoric evidence of dogs of this region and discusses the prehistoric skeletal evidence in general. It presents the conceptual framework for this research and discusses previous studies.

Chapter 2 presents the sampling strategy and defines the criteria used for sample selection. The data set is described in general terms in this chapter along with several unique problems associated with it (especially sexual dimorphism). The prehistoric time periods into which the archaeological material is grouped are defined. The taxonomic status of the material is also discussed, both in specific and general terms, with a brief overview of the current status of knowledge of dog domestication processes.

Chapter 3 describes the statistical methods used in the analysis to describe and interpret the variation within the sample. As the methods used here are somewhat different than those used in previous studies, they are described in some detail.

Chapters 4 through 8 contain the results of the osteological and osteometric analyses of the sample. In order to simplify the assessment and comparison of new material, the analysis is presented by body part: crania, mandibles, front limbs (including scapula, humerus, radius, ulna and metacarpals), hind limbs (including innominate, femur, tibia, fibula, metatarsals and selected tarsals) and vertebral column. For each element sample, the skeletal dimensions used are defined and a general osteological description is reported. The osteometric analysis of the intact (whole) element sample is presented next in table form: this analysis defines the dog types or breeds.

Graphs showing relationships between various dimensions of selected elements are provided. Classification to type for the fragmented specimens in the sample is offered (by element) in a separate table and lastly, classification of previously reported material (Gleeson 1970; Montgomery 1979) and comparison to other regional analyses (where applicable) is provided. Raw data tables for elements which had insufficient sample sizes for classification analysis are listed at the end of each section (for which only basic univariate statistics have been calculated).

This presentation style, while it might appear cumbersome and at times unnecessarily detailed, was chosen to facilitate comparison of material in the hands of other researchers. It is hoped that this study will serve as a foundation database, a sort of reference manual for Northwest Coast dogs, to which both future and other previously excavated material can be appended and compared.

A summary of the osteometric analysis is presented in Chapter 9, which includes a discussion of the congruity of type classification as applied to various associated elements recovered from the same individual. The osteological (non-metric) characteristics of the types derived from this analysis are discussed. An estimate of the live shoulder height for each of the breed types determined from the skeletal analysis has been calculated and differences in limb proportions and body length between breeds are also examined.

In Chapter 10, the geographic distribution and prehistoric chronology of the types are discussed. Chapter 11 contains a final discussion of the analysis and summarizes the pertinent points covered. Some recommendations for future analysis are offered. The osteometric characteristics of the two defined types are listed in a useful summary table, which lists the expected ranges of measurements for specific element dimensions for each of the breed types.

Appendix A is a contribution by Shigehara, Onodera, and Eto: "Sex determination by discriminant analysis and evaluation of non-metrical traits in the dog skeleton" (based on an earlier work in Japanese by the same authors, "Discriminant analysis of the sexual differences of the skeletons in Shiba dogs (*Canis familiaris*)", published in *Acta Anatomica Nipponica* 1987, Vol.62).

Pertinent provenience data for all specimens discussed are presented in Appendix B (by specimen number), which includes relative dates of the deposits.

Ethnographic and historic evidence of dogs

A fascination with the unique indigenous dogs found on the south central Northwest Coast of North America began with the first European visitors to these shores. The records left by these men reflect both the awe and confusion they felt when observing the relationship between First Nations people of this area and their dogs. Domesticated livestock animals (such as sheep and goats) did not exist in prehistoric North America before Europeans brought them here. However, it appeared that a special breed of dog, a type distinct from the common village "cur" encountered elsewhere in North America, had assumed the role of a wool sheep in this restricted region of the west coast.

The accounts of these early European explorers indicate that two types of dogs, *Canis familiaris*, were kept simultaneously on the south central Northwest Coast (Allen 1920; Howay 1918; Barnett 1955; Keddie 1993; Schulting 1994 and references therein). In general, these accounts describe a medium sized, coyote-like animal sometimes used for hunting (often referred to as the hunting dog, but I prefer the more generic term "village" dog) and a smaller, long-haired dog kept almost exclusively for its thick coat (the "wool" dog). Measures were reportedly taken to keep the two types from interbreeding. The wool dogs were said to be sheared, much like sheep, several times a year and the wool woven into blankets.

Captain George Vancouver's account appears to be the first of the historic records that mention wool dogs (1801, cited in Howay 1918: 130). Vancouver describes the animals he saw in Puget Sound in 1792 :

> The dogs belonging to this tribe of Indians were numerous, and much resembled those of Pomerania, though in general somewhat larger. They were all shorn as close to the skin as sheep are in England; and so compact were their fleeces, that large portions could be lifted up by a corner without causing any separation.

Several historic accounts mention that the wool dog was noticeably smaller than the village dog and that most were white, although a few were brownish-black or white with black. The wool dogs were said to have had upright ears, long thick fur and a tail that curled up over the back, as do all modern "spitz"-type breeds. The village dog is described as having had short fur in various shades of brown (perhaps with white markings), resembling somewhat a large, short-haired coyote. The village dog appears to have been a common, widely distributed type across western North America (Allen 1920).

Despite the historic descriptions, there are no pictures of Northwest Coast indigenous dogs except for a sketch of a wool dog produced by artist Paul Kane in 1847 that was incorporated into a painting in 1855 (Gustafson 1980). The well-known painting is suspect as real evidence of the physical appearance of this breed due to the startling resemblance of the dog to a shorn sheep. Although Kane's original pencil sketch appears somewhat more realistic than the later rendition, its usefulness is still rather limited (Schulting 1994). The pencil sketches on the cover are modern composite drawings produced by an experienced forensic artist (Crockford and Pye, in press).

The history of these dogs after European contact is intimately tied to the economic value of the wool dogs. Dog-hair blankets were said to have been replaced as a favoured item in the aboriginal economy by Hudson's Bay blankets during the early historic period, circa 1800 (Howay 1918; Amoss 1993). The result of this change in preference was that the weaving of dog-hair blankets was abandoned (Keddie 1993; Schulting 1994) and dog hair ceased to be a valuable commodity. As a consequence, the impetus for keeping the wool dogs isolated from the village dogs was lost and the wool dog as a separate type soon became extinct (by 1858, according to Howay 1918). Today, after more than 100 years of freely interbreeding with both wool dogs and European breeds, the village dog can likewise be considered extinct as a distinct type.

No other North American aboriginal group has this recorded pattern of dog use (Allen 1920; Amoss 1993; Haag 1948) but it is clear that the cultural implications of this unique situation cannot be appreciated fully until some basic questions surrounding the dogs themselves are resolved. In order to investigate the time depth and geographic extent of a prehistoric weaving technology that utilized dog wool, we must at least be able to demonstrate that the dog which produced the wool actually existed as a distinct type before the historic period. We now have evidence from isotope analysis that dog wool was in use in the period 1770-1860 (Schulting 1994). Schulting's chemical analysis of this material (from the B.C. interior) contradicts an earlier study (based on morphological criteria) that failed to confirm dog hair as a constituent of any blanket labelled as "dog-hair" held in museum collections (Gustafson 1980). But what of the dogs themselves ?

An analysis of skeletal material has the potential to determine the maximum geographic and temporal range of the wool dog as a distinct physical type, if indeed it existed as such in prehistoric time. However, as far as is known, no wool dogs were ever acquired deliberately as specimens by museums or collectors in the same manner as the impressive "dog-hair" blankets. Specimens of the village dog were likewise not collected, leaving no definitive remains of either described breed. The archaeological record of skeletal remains is an essential source of data for determining the physical characteristics and prehistoric status of indigenous dog populations, but without known material with which to compare prehistoric specimens the analysis of skeletal material presents an enormous challenge.

Research Methods

The primary objective of this study is to determine if an analysis of suitable skeletal material can supply evidence that the two historically-described dog types existed during the prehistoric period. As such, it is essentially a biological rather than an anthropological investigation. The ethnohistoric records that mention size as a distinguishing feature between the two apparent breeds was used to formulate the underlying hypothesis of this study: that two distinctly different sizes of dogs should be apparent in the skeletal sample if wool dogs and village dogs existed prehistorically as the distinct physical types described in historic accounts.

The study proceeded in two stages, the first of which was to determine whether two distinct sizes could be distinguished within a large sample of adult dog remains, collected from sites lying within the reported or expected range of the wool dog. The sample was then used to describe any diagnostic osteological, morphological and osteometric characteristics of the dogs and a preliminary attempt made to delineate the differences in prehistoric time and space.

Prehistoric skeletal evidence

A wide range of sizes of dogs are definitely apparent in the archaeological sample collected from the south central Northwest Coast. This may be a general pattern, however, and not one exclusive to this area. For example, Lawrence (1968) has presented evidence from Idaho that different sizes of dogs existed there prehistorically (see also Allen 1920, 1939; Brothwell et al. 1979; Haag 1948). There is no indication however, that the samples she (or others) examined represent the results of deliberate or "conscious" selection (Darwin 1905) for genetically-distinct breeds. In other words, there are no oral or written records to suggest distinct breeds were maintained, even though they may well have been. On the Northwest Coast, by contrast, the historic and ethnographic evidence is quite strong. The records suggest that the two types of dogs were deliberately maintained as separate populations and that there were explicit economic reasons for doing so, introducing the possibility that these dogs may constitute true breeds. While the ethnohistoric accounts must certainly be assessed with caution, there was clearly something different going on with dogs in this part of the world that cannot be summarily dismissed.

Dog remains are regular constituents of almost all faunal assemblages recovered from archaeological sites on the Northwest Coast, most of which are shell midden deposits. Cybulski's (1992) report on human burials from a number of coastal midden sites suggests that interment practices for dogs may have been similar to those used for people. Dogs (or dog parts) were occasionally found directly associated with human burials. In addition, the distribution pattern of isolated skeletal elements or partial skeletons of dogs and humans was often found to be similar. Cybulski suggests that burial of both dogs and humans in shell middens may have been a common practice prehistorically, with some interments disturbing the integrity of former ones so that older remains became partially disassociated and/or scattered. Excavation of shell middens, therefore, often results in the recovery of a few complete skeletons, isolated skeletal elements, and/or small numbers of associated elements of both dogs and humans.

In many cases, although numerous, dog remains from shell midden deposits are dominated by fragmented or badly chewed elements and/or parts from immature individuals. While the total number of specimens recovered from any one site may appear large on paper, those suitable for a study such as this (which requires relatively intact elements from fully adult individuals) are most often a rather small subset of the total. Individual sites almost never contain enough suitable dog material for good comparative analysis and so specimens from a number of sites were combined for this study.

Previous studies

Allen's (1920) historical study of North American indigenous dogs includes a description of both types of dogs said to exist on the Northwest Coast at the time of European contact. He refers to the wool dog as the "Clallam-Indian dog" (1920:469), which he considered restricted to Puget Sound and Vancouver Island. The village dog corresponds to his "Plains-Indian dog" (1920:449), said to range throughout western North America from British Columbia to California and eastward to the Great Plains. Although Allen included measurements from a few skulls of this type, they were all archaeological rather than modern specimens that came from southern U.S. sites.

Haag's (1948) classic work expanded Allen's study to include archaeological material from several regions. Unfortunately, the measurements of the seven prehistoric crania from the Northwest Coast are not accompanied by a discussion of breed differences and thus do not offer any resolution of the wool dog/village dog controversy. Haag's examination of institutionally-held historic and prehistoric skeletal collections confirms that no Northwest Coast dog specimens were collected during the historic period (as Eskimo dogs were, for example).

Three osteometric studies specific to south central Northwest Coast prehistoric dogs have been done. All three attempt to find skeletal evidence of the wool dog (Digance 1986; Montgomery 1979; Gleeson 1970) and share some major shortcomings as well as strengths. In particular, all three authors overlook sexual dimorphism in size and shape as a potential source of variation in their samples.

In addition, these studies are all site-specific analyses. Due to the small sample size of intact crania and post-cranial remains from the individual sites, the authors rely almost exclusively on mandibular and/or carnassial tooth measurements in drawing their statistical conclusions. This methodology, imposed by sample shortcomings rather than researcher choice, has severely limited the usefulness of the studies in assessing dog remains recovered from other sites in the region.

More importantly however, the statistical conclusions reached by these authors are probably not valid. Results from a more recent study indicates that carnassial tooth size in domestic dogs is not a reliable indicator of body size, although it may be so for wild taxa (Kurten 1988, Kurten & Anderson 1980; Dayan 1994). Morey (1990, 1992) found that tooth size was not as tightly constrained to skull allometry in dogs as in wild canids and that carnassial tooth size can vary substantially. Such variation should be taken as a warning against using tooth size exclusively as a predictor of body size in domestic dogs.

On a more positive note, both Gleeson and Montgomery provide the raw measurement data for all of the cranial and post-cranial elements they examined, which contributes significantly to the total database of dog material for the south central Northwest Coast (the report by Digance included only carnassial and one other mandibular measurement). Gleeson (1970) reports on the dog remains recovered from the 1966/67 excavations at the Ozette Village site (45CA24), located at Cape Alava on the Olympic Peninsula, Washington State. Much of Gleeson's material was severely damaged by carnivore chewing and in addition,was largely recovered from historic period strata rather than prehistoric (thus introducing the possibility that hybridization with European breeds may be contributing to the variation seen within the sample). Gleeson's study also unfortunately predates the standard osteometric references provided by von den Driesch (1976) which I have used in this analysis.

Montgomery (1979) reports on the dog remains recovered from the prehistoric midden at Semiahmoo Spit (45WH17) south of Point Roberts,Washington State (i.e. northern Puget Sound). These deposits have been dated to the Gulf of Georgia culture type. As Montgomery followed Gleeson's style for defining measurement dimensions, many data sets provided are not directly comparable to my sample. However, as much comparable data as possible from both of these studies has been included in this report for review and possible classification.

Lastly, as all three of the previous studies provide extensive coverage of the ethnographic and historic records concerning south central Northwest Coast dogs, these details are not repeated here. Continued interest in the unique pattern of dog use reported for this area and its cultural significance is reflected in recent papers by Amoss (1993), Keddie (1993) and Schulting (1994), which provide good updated summaries of much of the ethnohistoric information included in previous osteometric studies.

2

THE SKELETAL SAMPLE

Sampling strategy

The sample for this study comprises 1163 cranial and post cranial skeletal elements of adult dogs from 20 archaeological sites which lie within the historically reported range of the wool dog (Fig. 2-1). Culturally, this area is defined as the traditional territory of the Coast Salish although Makah, territory is also included. Geographically, it includes: the south-east end of Vancouver Island and the Strait of Juan de Fuca; Puget Sound and parts of the Olympic Peninsula; the Gulf Islands and mainland adjacent to the Strait of Georgia and the lower Fraser Valley (Table 2-1). The archaeological deposits date from approximately 500 years ago to more than 4,000 years b.p.

Suitable remains for the purposes of this study were those that could be determined to be fully-grown adult or mature subadult individuals, based on full eruption of adult dentition, mature bone texture and epiphysial fusion (Schebitz & Wilkens 1986; Anderson 1970; Smith & Allcock 1960; Wapnish & Hesse 1993; G.R.Clark 1995). As the sequence of bone epiphysial fusion is element-specific, some bones finish their linear growth before others and thus may be "mature" as individual elements before the animal as a whole has attained full growth. As each element was treated separately in this analysis, this disparity between element maturity and animal maturity was not a problem.

In addition, the epiphyses on any one element do not generally fuse at the same time: the proximal end of a limb bone may be fully fused (mature) while the distal end continues to grow. While this pattern meant that total length measurements could not be taken unless both ends had fused, breadth measurements of mature (fused) ends could be reliably compared regardless of what state the other end was in (either unfused epiphysis or missing altogether). Thus the measurements of broken elements in addition to those of some dimensions from subadult animals could be included in the study. Scapulae presented some difficulties due to the fact that the growth centres in the articular end (at the glenoid process) fuse very early relative to the rest of the element. The bone continues to grow in length after this time and while there tends to be an epiphysis of sorts which forms at the distal end of the scapula when full growth is attained, this is thin and not always clearly discernible. However, the thin blade portion of an immature scapula exhibits a peculiar rough open texture, while scapulae with an obvious epiphysis formed on the distal end have a smooth tight cortex on the blade. G.R. Clark (1995) describes this characteristic juvenile texture as "porous, grainy and spicular in appearance". In his examination of juvenile and adult modern dog specimens he found this feature clearly indicated continued bone growth. Therefore, the identification of juvenile texture in a specimen was used to remove from the sample individual scapulae whose mature status was questionable. Elements that exhibited only slight amounts of juvenile texture were included, because it appeared that full growth had probably been attained despite the lack of development of the distal epiphysis (these elements are marked as such in the tables).

Juvenile texture was also noted in some cranial material, where despite full eruption of adult dentition the bone texture was very porous and rough (and most sutures unfused), suggesting that full growth of the cranium or mandible had not yet been attained. These specimens were not used in this analysis.

Data set description

The complete collection of dog remains from which this sample was selected is comprised of elements which could initially be determined to come from fully adult or mature subadult animals, as describe above. The data set as presented here reflects only those elements which were intact or which had intact measurable dimensions. These criteria eliminated from the total sample those elements or dimensions which suffered from extensive erosion (due to chewing or unknown taphonomic degeneration), mechanical breakage, or that possessed arthritic bony deposits which would interfere with accurate measurement. Cranial fragments for which only one or two measurements could be taken were not included, nor were loose teeth (for reasons described in Chapter 1, "Previous studies"). Fragments of elements which were measured but could not be classified are also not listed in the tables.

However, given these constraints, all suitable material was used in this analysis: there was no subsampling. The final sample of 1163 elements (Table 2-2) thus comprise quite a small subset of the total number of dog elements of all ages examined from the sites listed. In fact, this constitutes a very particular subset of all the *adult* dog material examined from each of the sites. Thus the sample is taken to be representative of the adult dog population as a whole for the region but does not necessarily reflect a representative sample of the dog remains from any particular site.

Where both right and left elements were present from one individual, both were included and treated as separate elements (cf. Churcher 1993). This approach is justified on the grounds that the purpose of the study was to examine the total extent and range of variation among individual elements. Right and left elements from the same animal are very rarely identical and in, addition, archaeological specimens that may in fact come from the same animal are not always recognized as such.

Despite the fact that the research design was chosen specifically to address the problem of sample size, it was not completely successful at doing so. Poor survival of particular elements in a measurable state resulted from pre-depositional carnivore chewing of long bone ends (also noted by Gleeson 1970) or from rather consistent breakage patterns of vulnerable weak areas of bone (especially for innominates and thoracic vertebrae).

Some elements may be under-represented due to their small size (e.g. metacarpal I and caudal vertebrae). Subsets of intact elements with less than 10 members were not used to examine variation within the sample (Brothwell 1993), but most element samples met or exceeded the minimum membership of 25 suggested by G.R. Clark (1995).

Vertebrae and metapodials have rarely been included in osteometric studies such as this. Broken processes frequently prevent the identification of vertebrae to precise anatomical position, which make damaged vertebrae poor candidates for osteometric analysis. Similarly for metapodials, if the proximal end is missing or damaged to the extent that a length measurement is impossible to take, it is also very difficult to identify correctly exactly which metapodial it is. Consequently, only intact vertebrae and metapodials were included in the total sample.

Carpals and most tarsals are difficult to age with any accuracy because they have no epiphysial growth surfaces. In addition, they are difficult to measure consistently because of their irregular shape. Carpals were therefore not included in this study although they were recovered reasonably often. A few tarsals were included, the calcaneus because it has an epiphysis (and thus could be aged independently) and the talus because specimens were recovered in relatively high numbers in association with definitely adult material. Phalanges, while also recovered often, are very difficult to assign to correct anatomical position and thus were not included in this analysis.

Each specimen was assigned a unique four-digit number. Associated elements from the same individual include a letter or letter/number suffix (e.g. 0950PP).

Archaeological context and dating

The precise nature of the archaeological context from which dog remains were recovered has not been addressed in this analysis. This is due partly to the inconsistent reporting of the dog remains, which largely precluded consideration of such factors as deliberate burials, interment with human remains and other *in situ* contexts (cf. Crellin 1994; Cybulski 1992). While significant stratigraphic contexts may have existed for many specimens, the pertinent facts were not always included in published reports. Since not all material could be treated equally in this respect, such contexts were ignored for the purposes of this study.

With one exception, none of the dog remains has been dated directly: all are dated approximately, in relation to the carbon dated archaeological deposits from which they were recovered. The exception is one of the crania recovered from the excavation at Tsawwassen. In some cases, there are few dates available for a site. For this reason, I have assigned dates to the dog remains using the broad "culture type" designations traditionally used for this area. These are generally defined as: Gulf of Georgia, ca. 1400 bp to contact (ca. 1800); Marpole, ca. 2400 to 1400 bp; Locarno, ca. 3000 to 2400 bp; Charles (a.k.a. St. Mungo), ca. 4400 to 3000 bp (after Croes and Hackenberger 1988). In some cases only minimum dates can be assigned because of an inability to correlate the archaeological provenience of the remains as listed on level bags with dates assigned to strata as stated in final reports. In these cases, the remains can be considered to be at least a certain age but may be older (e.g. "Locarno or older").

Problems presented by the data set

Several problems associated with using this archaeological material were found to seriously challenge the investigation of the indigenous dog population for breed-level variation. These problems included relatively small sample sizes, unknown sex of many of the individuals represented by the sample, missing variables (measurements) due to breakage, and especially, unknown characteristics of the groups being classified (i.e. no known examples of either type). Such problems generally don't exist for studies of extant taxa, at least not all at once.

Statistical methods which have been used successfully on skeletal samples of extant taxa and even some prehistoric samples could not be used exclusively for this study. However, problems of this kind are quite characteristic of fossil assemblages and methods which have been applied to fossil material were felt to be especially appropriate for the initial classification of the sample. It was then possible to use multivariate discriminant analysis procedures to further describe the sample, as explained in detail in the discussion on statistical methods in Chapter 3.

Sex determination

Sexual dimorphism was potentially a significant complicating factor in this analysis. Dogs, like other canids and many carnivores (Friis 1985; Jolicoeur 1959, 1975; Gittleman 1989; Kurten 1968, 1988; Kurten and Anderson 1980; Nowak 1979), can exhibit significant size differences between the sexes. Sexual dimorphism as a source of variation in both size and shape has more often than not been overlooked or ignored in analyses of North American prehistoric dog remains (Allen 1920, 1939; Haag 1948; Lawrence 1968; Lawrence & Brossert 1967; Gleeson 1970; Montgomery 1979; Digance 1986; Morey 1986). This can clearly lead to conclusions that have questionable validity. Allen (1939) for example, describes distinctive breed characteristics among a sample of crania excavated from Kodiak Island shell middens in Alaska. However, the criteria used sound suspiciously like differences in size and shape resulting from normal sexual dimorphism. His detailed description of the dog "breeds" recovered (see also Montgomery 1979, and Gleeson 1970) correspond very closely to Shigehara et al.'s (Appendix A) diagnostic characteristics used to distinguish the sex of modern Japanese shiba dogs.

While non-metric sexual characteristics (i.e. shape differences) have been described by several other authors for domestic dog cranial material (The & Troth 1976; Gollan 1982; Brothwell et al. 1979), they are somewhat ambiguous and not always especially accurate (Shigehara et al. Appendix A). I found Shigehara et al.'s criteria for distinguishing the sex of the Japanese shiba (a small short-haired spitz-type breed) to be easily discernible and used them in this study to designate the sex of individual crania and mandibles (and any postcranial elements associated with them).

In particular, two of the three features described for sexing crania appear to be especially unambiguous and all cases in this sample were classified as male or female by these criteria: 1) the shape of the temporal lines in relation to the sagittal crest 2) the shape of the frontal bone of the crania at the postorbital constriction (see Figure 4-9). All of the intact crania used in this study could be assigned to either sex using these criteria, as could 20 fragmented ones. In two cases the cranial material was accompanied by post-cranial material and the sex determination was confirmed by the presence of the *os penis*. While this method of determining sex may not be valid for breeds with a modified skull shape, it appears to work well for unspecialized modern and prehistoric forms.

The criteria described by Shigehara et al. for establishing sex of mandibles is slightly more subjective than those for crania, but equally effective. The condyloid crest in the ascending ramus, which forms the lower border of the masseteric fossa (i.e., the depression representing the attachment site for the masseter muscle), is more clearly defined in males (deeper and with a sharper edge) than in females. As mandibles survived intact much more often than crania, the ability to sex the mandible sample increased the putative known-sex sample substantially.

An additional element which can be used to determine sex is the pelvis. When both innominates fully fuse in adult animals to form the pelvis, it is possible to determine the sex from the angle of attachment of the two halves at the pubic symphysis (Appendix A). This situation was recorded only twice from this sample and in each case the intact pelvis was determined to be male, but as these intact pelves were part of complete skeletons from which baculae (the *os penis*) were also recovered, determination of sex from pelvic characteristics did not add any more assigned-sex specimens to the data set.

Ododera et al. (1987) also used discriminant analysis on their large sample of both sexes of the shiba dog to investigate whether the sexes could be metrically, as well as subjectively, defined. Their study provides a unique demonstration of the sexual dimorphism in size which can be expected within a modern breed. They concluded that the differences in size between the two sexes was significant for almost all skeletal dimensions. G.R.Clark (1995) has calculated that this corresponds to a 2 to 4% difference between sizes of male and female Shiba dog elements, a range at the low end of the 2 to 6% difference reported amongst other wild and domestic canids.

Measurement Definitions

The measurements used to compare the individuals represented by the skeletal sample are standard measurements which follow von den Driesch (1979) with a few non-standard measurements added (principally to deal with tooth rows that had congenitally missing teeth). Non-standard measures are starred (*) and the measurements are coded for easier reference in the tables. Not all measurements apply to all elements. See Figures 4-1 and 5-1 for definitions of reference points used in the descriptions of cranial and mandibular measurements. For ease of interpreting measurement tables, the definitions which apply to each element or group of elements are listed immediately preceding the tables in each chapter.

Taxonomic status

One particular feature of this dog sample has made analysis of the remains less complex than has been the case for samples from many other North American regions: we can in this case consider all of the recovered material to be unequivocally *Canis familiaris*. This is due to the fact that the prehistoric range of the coyote (*C. latrans*) totally excludes the geographic area from which this sample was drawn (Banfield 1974; McTaggart-Cowan 1965). While the coyote perhaps existed in a small area of the arid southern interior of the province during prehistoric times, its presence in northern areas, the lower Fraser Valley and coastal regions today is a very recent expansion that began in the early 19th century (Nowak 1979; Young 1951).

While Young (1951:29) includes almost all of the southern half of British Columbia as the "probable" pre-16th century range of the coyote (except for the south coast and Vancouver Island, which all authorities seem to agree was never coyote territory), this is clearly a supposition. Wayne and Gittleman (1995) totally exclude most of Canada in the prehistoric North American range of the coyote. This is perhaps a more reasonable conclusion considering that Nowak (1979:76) lists only two known fossil specimens identified as *C. latrans* found north of the United States border (from Alberta and the Yukon, both of Wisconsin age). In addition, Nowak admits (1979:74) that the exact southern, northern and eastern limits of the coyote's range before European colonization are not known.

Thus many faunal analysts in British Columbia worry needlessly about confusing coyote and indigenous dog remains from archaeological deposits, since it is truly doubtful if the coyote existed anywhere in the province prehistorically (except, as noted above, for the arid southern Interior).

In addition, while it can be said that prehistoric dog remains from virtually all areas of British Columbia are closer in size to coyote than to wolf, dog skeletal elements (including teeth) are almost always significantly more robust in all respects than those of the relatively smaller, gracile coyote. Although small fragments of canid bone may be taxonomically ambiguous, most large fragments and intact elements of indigenous dog and coyote can be confidently distinguished: one seldom (legitimately) need resort to using *Canis sp.* as a taxonomic category for prehistoric dog remains from most of British Columbia.

Some investigators, however, have taken this taxonomic "problem" a step further. The suggestion made by Digance (1986:170, 1988:10), Kusmer (1987:5) and Hayden (1997:98) that coyote ancestry and/or coyote hybridization has contributed to the history of indigenous dogs from both coastal and interior regions is so wildly speculative as to be irresponsible. Most of the dog material from Pender Island referred to by all three authors is included in this study, and I have examined the Keatley Creek (EeRl 4) dog remains referred to by both Kusmer (1987) and Digance (1988). I can confidently say that the dogs from those sites are no more "coyote-like" than any of the other dogs examined in this study.

The similarity in size between the indigenous dogs of North America and the coyote is simply misleading - it does not signify common descent or hybridization. A possible coyote ancestry for domestic dogs had once been proposed, but has been discounted on morphological, behavioural and genetic grounds (Fox 1978; Gittleman 1989; Lehman et al. 1990; Mech 1970; Roy et al 1995; Wayne 1993; Wayne and Jenks 1991; Wayne et al. 1992; Wayne and Gittleman 1995; Wayne and O'Brien 1987; Young and Goldman 1944). All evidence points to the wolf as the exclusive ancestor of all domestic dogs

The small size of "primitive" dogs compared to wolves is a natural result of the domestication process itself (Clutton-Brock 1981, 1984, 1995; Davis and Valla 1978; Davis 1987; Dayan 1994; Roy et al. 1995; Wayne 1993; Wayne and Jenks Olsen 1985; Tchernov and Horwitz 1991; Teichert 1993; Zeuner 1963). Domestication of all mammals involves (among other things) overall size diminution, the result of a reduction in foetal and early postnatal growth rates called *paedomorphosis* (Belyaev 1979; Hemmer 1990; Morey 1990, 1992, 1994; Wayne 1986a,b,c,). Paedomorphosis is a specific pattern of a common evolutionary process called *heterochrony* ("changes in developmental timing"), that produces descendant animals equivalent to the juvenile stage of their ancestor *in both morphology*

Table 2-1. Archaeological sties included in this study.

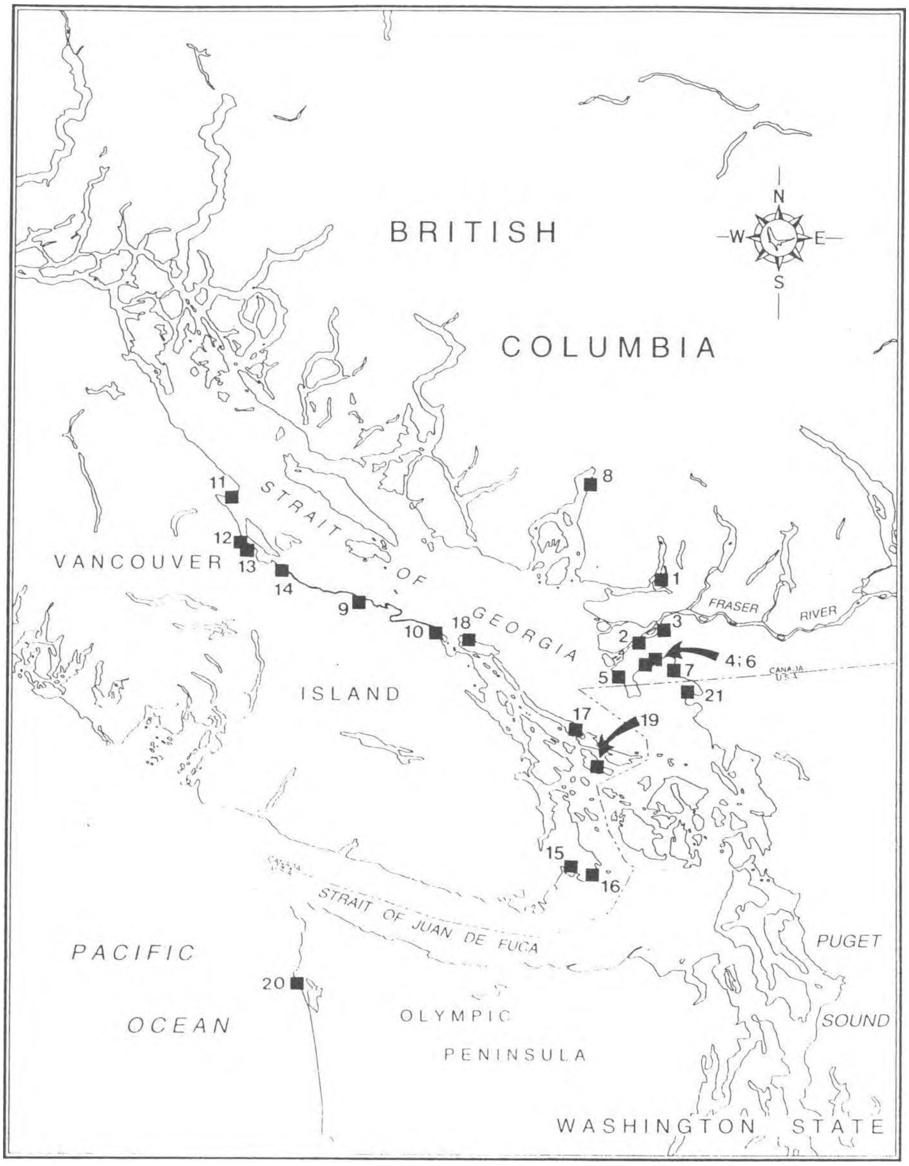
NUMBER	NAME	LOCATION	REPORT REFERENCES
DhRr 6	Belcarra Park	Strait of Georgia	Carlson 1972
DgRr 2	St. Mungo Cannery	Fraser Delta	Boehm 1973; Bernick 1982
DgRr 6	Glenrose Cannery	Fraser Delta	Matson 1976
DgRs 1	Beach Grove midden	Fraser Delta	Ball 1979; Matson et al. 1980
DgRs 2	Tsawwassen Beach	Fraser Delta	Bernick 1990b; Arcas 1994
DgRs 30	Beach Grove Golf Course	Fraser Delta	Bernick 1989a, 1989b
DgRr 1	Crescent Beach	Fraser Delta	Percy 1974; Trace 1981; Ham 1982; Matson 1991
DkRs 6	Stawamus midden	Strait of Georgia	Stryd (Arcas), pers. comm.
DiSc 1	Little Qualicum Falls	Vancouver Island East	Bernick 1983, 1990
DhRx 16	Departure Bay	Vancouver Island East	Wilson et al. 1994
DjSe 6	Ships Point	Vancouver Island East	Mitchell (U.Victoria), pers. comm.
DfSf13	Buckley Bay	Vancouver Island East	Wigen 1980
DfSf 14	Tsable River	Vancouver Island East	Wigen 1980
DiSe 7	Deep Bay	Vancouver Island East	Monks 1977
DcRt 15	Cadboro Bay	Vancouver Island South	Mitchell 1971; Keddie (RBCM), pers. comm.
DcRu 12	Maple Bank	Vancouver Island South	Keddie (RBCM), pers. comm.
DfRu 13	Montague Harbour	Gulf Islands (Galiano)	Mitchell 1971
DgRw 204	Gabriola Rockshelter	Gulf Islands (Gabriola)	Curtin 1989
DeRt 2	Pender Canal	Gulf Islands (Pender)	R. Carlson (SFU), pers.comm.; Hanson 1886, 1991
45CA24	Ozette Village	Olympic Peninsula, WA, USA	Huelsbeck 1983; Huelsbeck & Wessen 1994
45WH17	Semiahmoo Spit	Puget Sound, WA, USA	Montgomery 1979

and behaviour (Geist 1971, 1986; Coppinger and Feinstein 1991; Coppinger and Schneider 1995; Gould 1977, 1994; Kurten 1968, 1988; McKinney and McNamara 1991; Parker and McKinney, in press; Price 1984; Voss 1995). Thus the relative size similarity of primitive-type indigenous North American domestic dogs and coyotes is merely coincidental.

The only other *Canis* species which overlaps in range with indigenous dogs from this study area is

Figure 2-1. The south central Northwest Coast of North America, sites mentioned in the text.

1. DhRr 6
(Belcarra Park)
2. DgRr 2
(St.Mungo Cannery)
3. DgRr 6
(Glenrose Cannery)
4. DgRs 1
(Beach Grove);
5. DgRs 2
(Tsawwassen Beach)
6. DgRs 30
(Beach Grove Golf Course)
7. DgRr 1
(Crescent Beach)
8. DkRs 6
(Stawamus)
9. DiSc 1
(Little Qualicum Falls)
10.DhRx 16
(Departure Bay)
11.DjSe 6
(Ships Point)
12.DfSf 13
(Buckley Bay)
13.DfSf 14
(Tsable River Bridge)
14.DiSe 7
(Deep Bay)
15.DcRt 15
(Cadboro Bay)
16.DcRu 12
(Maple Bank)
17.DfRu 13
(Montague Harbour
18.DgRw 204
(Rockshelter site)
19.DeRt 2)
(Pender Canal site)
20.45CA24
Ozette Village)
21.45WH17
(Semiahmoo Spit.



the grey wolf *(C. lupus)*, an animal that is significantly larger than Northwest Coast indigenous dogs in all respects (Friis 1985; Jolicoeur 1959,19751 Kurten and Anderson 1980; Nowak 1979; Young and Goldman 1944). While a few remains of wolf were recovered from some sites, these specimens are easily distinguished from indigenous dog (Figure 2-2). In addition, none of the dog specimens is so large (i.e. intermediate in size) that hybridization with wolves can be considered a possibility (cf. Lawrence & Bossert 1967; Walker & Frison 1982; Morey 1986). It was therefore considered unnecessary to validate the taxonomic status of the sample.

Table 2-2. Sample sizes for elements included in this study.

Element	Intact	Fragments	Total
Cranium	19	20	39
Mandible	36	39	75
Scapula	16	22	38
Humerus	29	20	49
Radius	21	27	48
Ulna	21	33	54
Pelvis	7		7
Femur	25	25	50
Tibia	24	31	55
Fibula	10	6	16
Calcaneus	49		49
Talus	17		17
Metacarpals	125		125
Metatarsals	135		135
Vertebrae	391		391
Sacrum	15		15
Total	940	223	1163

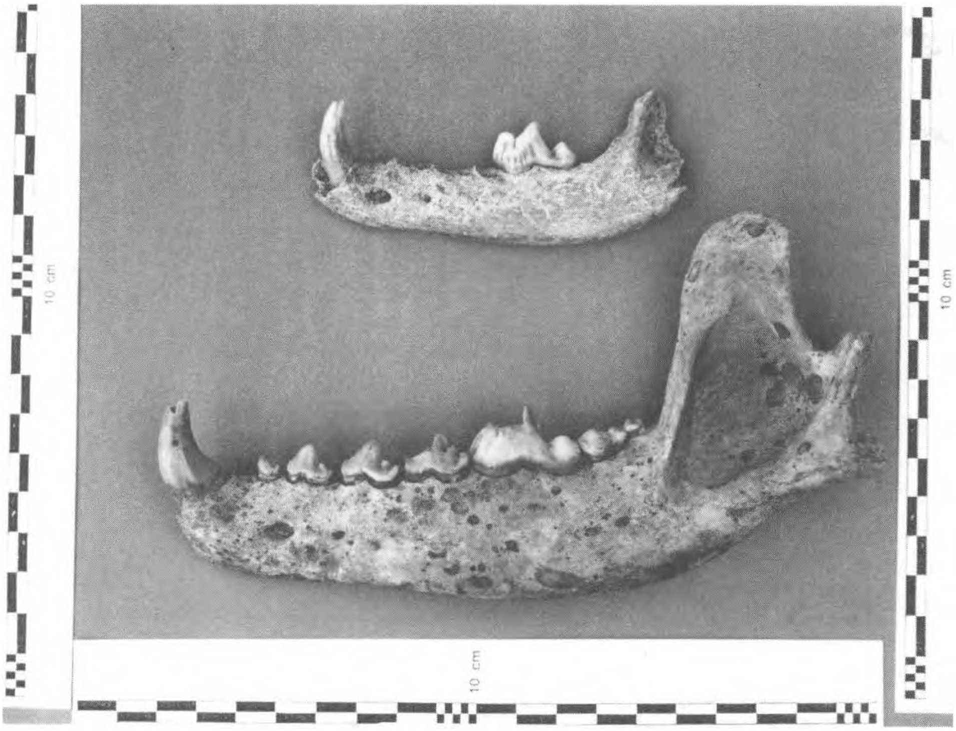


Figure 2-2. Left mandible of prehistoric wolf, *Canis lupus*, (specimen 3007) vs. left mandible of small prehistoric indigenous dog, *Canis familiaris*, (specimen #100A), illustrating the overall size difference between the two species (lateral view).

3

STATISTICAL PROCEDURES

Evaluating sample variation

Univariate statistics were invaluable for the initial evaluation of the variation contained within this skeletal sample. Such commonly reported values as the mean, minimum, maximum and standard deviation are all measures of the amount of variation found within a sample. The coefficient of variance is the result of a calculation that relates the standard deviation to the mean (standard deviation x 100/mean) and is thus a value that effectively summarizes the relative amount (as a percentage) of sample variation for any element dimension.

The coefficient of variance (officially "V" but often designated "CV") was found to be an especially useful statistic for initial assessment of the sample variation. Simpson et.al (1960) point out that taxonomic comparisons are most reliably based on characters that are the least variable within taxa and that the CV is one simple way of establishing the identity of these less variable characters. Average CV values are usually between 5 and 6, with a range of 3-10 (Kurten 1968; Brothwell 1993). Simpson et al. (1960) caution that much lower values may indicate the sample was not large enough to show the true variability. It has been suggested that CV values may be naturally somewhat higher for domestic taxa than for wild ones (due to a higher inherent variability which some suggest may be necessarily associated with domesticates) but this assumption has not yet been demonstrated statistically (Brothwell 1993). Some dimensions (such as the facial region of the cranium) consistently show higher CV values than average while other dimensions are always below average. In general though, especially high values of CV for a particular measurement usually indicate that the sample includes animals of mixed ages, sexes, or different taxonomic categories.

The CV values calculated on combined sex samples, for example, are often higher than for single sex samples (Simpson et.al. 1960). In explaining how CV values relate to sexual variation within a sample, Plavcan (1994: 467) states "with increasing sexual dimorphism, the difference between male and female means increases, causing a proportional increase in the pooled-sex sample standard deviation".

In order to assess the affects of sexual dimorphism on the variation exhibited by the Northwest Coast sample, the calculation of univariate statistics (including minimum & maximum, mean, standard deviation, coefficient of variance) for the sexually dimorphic cranial sample has been calculated and presented here two ways: first for all of the cases together (sexes combined) and then for each of the sexes separately (Table 3-1).

The coefficient of variance calculated for the combined sex sample of cranial measurement #1 (greatest length) in Table 3-1, at 8.9%, suggests that the amount of variation for this dimension is high relative to other mixed-sex wild and domestic canid samples, which average about 4.0% (Table 3-2). The exception shown is from Nowak's (1979) study of a sample of 50 domestic dogs (taken from at least 11 different known modern breeds, which varied in size from an Irish wolfhound to a beagle), and in this case the coefficient of variance is understandably high.

Table 3-3 is a summary of univariate statistics for selected cranial measurements presented by Nowak (1979), Friis (1985), Onodera et.al. (1987), and Gollan (1982) for two samples of modern wolf subspecies and two samples of modern dog breeds. The statistics for each sex have been calculated separately. Note that for all samples, the CV values for greatest cranial length (measurement #1) are below 5% for both sexes, even for the dingo sample which was drawn from a feral population of what is considered to be a very primitive dog type. In contrast, the CV value for the greatest length for females in the Northwest Coast crania sample (from Table 3-1) is above 5% (which may not be statistically significant) but the value for males is almost 8%.

Although the sample sizes are probably too small to give too much credence to these results, this comparison does suggest that the amount of variation both within each sex and for the sample as a whole may be too great to support the hypothesis that these animals came from a single homogeneous population. Although perhaps not statistically significant, there is nonetheless some justification presented by the sample itself (i.e. something other than the ethnohistoric records) for exploring the possibility that two unrecognized groups are contained with the same-sex samples.

Table 3-1. Univariate statistics of the Northwest Coast crania sample, sexes combined (total sample) and sexes recorded separately.

Statistics *	**Measurement code numbers**												
	1	**2**	**3**	**12**	**13**	**15**	**15B**	**15C**	**15D**	**16**	**17**	**17A**	**19**
total count	18	17	17	19	15	16	19	19	19	18	15	19	17
total mean	173.8	162.9	154.0	73.7	85.3	56.5	87.4	53.3	42.0	17.5	44.1	40.6	17.7
total std	15.5	10.8	10.3	6.9	6.7	4.8	5.7	2.9	2.3	1.1	4.3	2.4	1.0
total min.	146.3	145.4	135.8	59.3	72.8	47.8	76.0	47.7	37.5	15.6	36.4	35.0	16.4
total max.	203.0	188.4	177.1	87.4	98.2	66.4	99.0	58.8	46.2	19.5	51.9	44.9	19.6
total CV	8.92	6.65	6.67	9.37	7.88	8.57	6.56	5.42	5.40	6.54	9.69	6.02	5.78
female count	5	4	4	5	5	4	5	5	5	5	3	5	4
female mean	158.9	154.5	146.0	68.0	80.4	53.5	83.4	51.5	41.0	18.0	41.7	39.3	17.4
female std	8.1	5.3	5.9	5.0	4.9	3.8	4.1	2.0	1.6	0.3	3.8	1.3	0.7
female min.	146.3	145.4	135.8	59.3	72.8	47.8	76.0	47.8	38.6	17.7	36.4	36.9	16.6
female max.	169.0	158.3	150.0	72.6	85.7	57.0	87.7	54.0	43.4	18.6	44.4	40.9	18.5
female CV	5.13	3.42	4.02	7.32	6.13	7.07	4.88	3.96	3.80	1.85	9.03	3.35	3.96
male count	13	13	13	14	10	12	14	14	14	13	12	14	13
male mean	179.6	165.4	156.5	75.8	87.8	57.5	88.8	53.9	42.4	17.3	44.7	41.1	17.8
male std	13.7	10.8	10.1	6.3	6.1	4.7	5.6	2.9	2.4	1.3	4.2	2.6	1.1
male min.	162.0	148.2	140.7	65.2	78.4	50.8	78.0	47.7	37.5	15.6	39.0	35.0	16.4
male max.	203.0	188.4	177.1	87.4	98.2	66.4	99.0	58.8	46.2	19.5	51.9	44.9	19.6
male CV	7.63	6.53	6.43	8.34	6.96	8.25	6.28	5.38	5.60	7.43	9.36	6.30	6.11

Statistics	**Measurement code numbers**											
	22A	**23**	**25**	**25A**	**27**	**29**	**30**	**31**	**32**	**34**	**35**	**36**
total count	16	17	17	17	17	15	13	16	15	16	17	16
total mean	15.9	63.1	35.2	31.6	18.4	53.1	99.4	34.7	49.9	61.1	33.4	36.9
total std	2.0	4.0	2.9	2.5	1.4	2.5	7.4	2.0	4.5	3.6	4.3	3.2
total min.	12.0	56.0	30.0	27.8	16.0	50.7	87.8	31.0	42.1	56.4	21.0	33.0
total max.	19.3	71.2	40.9	36.8	21.2	58.3	110.6	38.3	57.4	69.0	39.5	44.2
total CV	12.64	6.39	8.10	8.04	7.40	4.67	7.46	5.80	9.10	5.89	12.86	8.69
female count	4	4	4	4	4	5	2	5	3	4	4	4
female mean	14.9	60.7	35.0	31.3	17.9	51.8	95.7	34.2	46.8	59.7	32.9	35.8
female std	1.1	1.2	1.3	0.9	0.8	0.6	6.2	1.7	4.5	1.0	1.0	1.7
female min.	13.4	59.4	33.0	30.0	16.9	50.7	89.4	31.4	42.1	58.5	31.5	34.1
female max.	16.5	62.0	36.5	32.2	19.1	52.4	101.9	36.8	52.8	60.9	34.3	38.5
female CV	7.46	2.04	3.61	2.83	4.46	1.11	6.51	5.03	9.58	1.72	3.04	4.76
male count	12	13	13	13	13	10	11	11	12	12	13	12
male mean	16.2	63.8	35.3	31.6	18.6	53.8	100.1	35.0	50.7	61.6	33.5	37.3
male std	2.1	4.3	3.2	2.9	1.5	2.8	7.4	2.1	4.2	4.0	4.9	3.5
male min.	12.0	56.0	30.0	27.8	16.0	51.0	87.8	31.0	44.5	56.4	21.0	33.0
male max.	19.3	71.2	40.9	36.8	21.2	58.3	110.6	38.3	57.4	69.0	39.5	44.2
male CV	13.15	6.73	9.02	9.02	7.85	5.19	7.41	5.98	8.31	6.50	14.52	9.38

* std = standard deviation; min. = minimum value; max. = maximum value; CV = coefficient of variation

Table 3-2. Univariate statistics of other canid crania samples compared to the total Northwest Coast sample, sexes combined.

Selected samples	**Measurement code numbers****				
1. Canis latrans (Rancho La Brea, CA)	***#1***	***#19****	***#30***	***#31***	***#34***
mixed-sex sample (Nowak 1979:147)	1	14	2	9	5
Sample size	n=44	n=43	n=36	n=47	n=21
Mean	205.5	21.1	106.7	36.7	61.2
Minimum	185.0	18.2	90.0	32.9	50.0
Maximum	222.0	23.5	116.0	42.0	67.4
Standard Deviation	9.03	1.29	5.58	2.12	4.31
Coefficient of Variance	4.39	6.14	5.23	5.78	7.05
2. Canis dirus (Rancho La Brea, CA)	***#1***	***#19****	***#30***	***#31***	***#34***
mixed-sex sample, n= 62 (Nowak 1979:149)	1	14	2	9	5
Mean	294.8	31.8	163.3	49.3	96.2
Minimum	258.0	28.7	148.0	43.5	87.7
Maximum	316.0	35.3	177.0	54.4	104.0
Standard Deviation	11.31	1.38	7.15	2.13	3.92
Coefficient of Variance	3.84	4.35	4.38	4.32	4.08
3. Canis familiaris (sample of many breeds)	***#1***	***#19****	***#30***	***#31***	***#34***
mixed-sex sample, n = 50 (Nowak 1979:144)	1	14	2	9	5
Mean	217.2	19.3	112.4	39.2	68.1
Minimum	151.0	14.4	84.0	32.2	51.5
Maximum	285.0	22.7	154.0	44.8	85.5
Standard Deviation	30.88	1.66	12.91	3.17	7.33
Coefficient of Variance	14.27	8.61	11.48	8.08	10.76
4. Canis familiaris (NW Coast sample, two breeds?)	***#1***	***#19***	***#30***	***#31***	***#34***
mixed-sex sample (this study)	#1	#19	#30	#31	#34
Sample size	n=18	n=17	n=13	n=16	n=16
Mean	173.8	17.7	99.4	34.7	61.1
Minimum	146.3	16.4	87.8	31.0	56.4
Maximum	203.0	19.6	110.6	38.3	69.0
Standard Deviation	15.50	1.02	7.42	2.01	3.60
Coefficient of Variance	8.92	5.78	7.46	5.80	5.89
5. Canis familiaris (modern dingo, single primitive breed)	***#1***	***#19****	***#30***	***#31***	***#34***
mixed sex sample, n=60 (Gollan 1982:325-333)	V1	V51	V16	V35	V46
Mean	193.9	19.4	101.5	35.9	56.7
Minimum	176.0	17.0	93.0	31.0	52.0
Maximum	208.0	21.2	112.0	38.0	61.0
Standard Deviation	7.46	0.86	5.01	1.50	2.35
Coefficient of Variance	3:85	4.47	4.94	4.19	4.14

* The measurement for #19 is a tooth measurement in these studies, but is an alveolar measurement of premolar 4 in the Northwest Coast sample

** The column headings on the second line are the measurement numbers used by the original authors

Interpreting sample variation

In terms of a statistical analysis, the critical problem with the dog sample under investigation here is that we must assume that both sexual dimorphism and breed variation are contributing to the total size variation exhibited by the skeletal elements. There are in essence four groups presumed to be represented in the sample: male and female of one type, and male and female of another type.

One of the significant characteristics that distinguishes the two types of dogs reported in ethnohistoric accounts is their disparity in size. Noticeable disparities in size would encompass traits such as shoulder height, head size and body length differences (Wapnish & Hesse 1993). Thus linear dimensions, such as limb bone element lengths, length of cranium and mandibles, and lengths of the centrum of the vertebrae can be expected to show evidence of both sexual dimorphism and breed variation in size.

Sexual dimorphism in mammals is for the most part size related: males are somewhat larger and more robust than females of the same species or breed and this is reflected in a 2 to 6% difference in their skeletal elements (Benecke 1990; G.R.Clark 1995; Jolicoeur 1959; Klein and Cruz-Uribe 1984; Kurten 1988). As sexual dimorphism is to be expected in any canid sample, in comparing one dog breed to another the amount and nature of the sexual dimorphism is predicted to be very similar within both. For this analysis, I assume that the amount of size variation resulting from sexual dimorphism is probably about the same within populations of both breed types.

Since the primary assumption in this study is that the skeletal differences between the breeds are size related, an analysis method is required which will ignore sex-related size differences so that breed-related size differences can be examined. The statistical method described below appears to satisfy these criteria. This method was originally intended for distinguishing sexes within a single-taxon sample based on size difference, but could in this case be used for distinguishing breeds based on size difference instead (as long as sexual size differences are presumed equal for both populations and ignored).

Plavcan's (1994) review of statistical methods for analyzing the extent of sexual dimorphism present in a small sample (where the sex of the specimens is unknown) used computer modelling on a known skeletal assemblage to assess the accuracy of four methods which had previously been used on fossil and subfossil assemblages of primates, hominoids and hominids. These methods all made the assumption that the variation present within each sample was the result of sexual dimorphism rather than taxonomic difference. Plavcan's study compared the following four methods used for estimating dimorphism in a sample where the sex of individuals is unknown: 1) extrapolation of dimorphism from coefficients of variation (CV); 2) division of a sample into two subsamples about the mean; 3) division of a sample into two subsamples about the median; 4) finite mixture analysis (this last methods involves a somewhat complex computation, the details of which are not relevant to this discussion). The most accurate of these four methods was found to be the division of the sample about the mean into two subsamples, *even when intrasexual variability was high and when sex ratios within the sample were strongly imbalanced*. New means are calculated for the two subsamples that result from splitting the total sample at the mean. One of these subsamples is assumed to contain only females and the other only males.

Using this method (but substituting breed size difference for sexual size difference), the Northwest Coast prehistoric dog samples have been divided into two groups at the mean for the variable that most clearly characterizes size: greatest length of each element. The differences between the means calculated for each subgroup are all highly significant (Table 3-4). This result suggests that the null hypothesis (i.e. that the skeletal sample was drawn from a population of one homogeneous dog type) could be rejected.

After dividing each of the element samples at the mean for the greatest length, the two subsets of measurements thus created should represent two normal distributions that overlap to some extent. When these overlapping distributions are combined to form a single sample, it would be expected to look distinctly bimodal. As both Plavcan (1994), Klein and Cruz-Uribe (1984) and Martin et al. (1994) have noted, however, it is quite possible for a known bimodal distribution to appear normal, especially for samples of less than 100. Martin et al. (1994: 183) depict an idealized histogram that shows combined male and female distributions for a given dimension with various distances between mean values for the two sexes (where n=1000 per

Table 3-3. Univariate statistics of other canid crania samples, sexes recorded separately.

Selected samples	**Measurement code number ****				
1. Canis lupus lycaon (eastern NA group)	**#1**	**#19***	**#30**	**#31**	**#34**
females, n=12 (2) (Nowak 1979:145)***	1	14	2	9	5
Mean	231.4	22.7	125.0	36.9	73.8
Minimum	223.0	21.3	116.0	35.0	69.0
Maximum	241.0	24.2	132.0	42.5	78.3
Standard Deviation	6.64	0.93	4.79	2.21	3.20
Coefficient of Variance	2.87	4.10	3.82	5.99	4.34
males, n= 19 (4)					
Mean	247.1	24.6	134.1	39.8	77.9
Minimum	237.0	22.6	128.0	36.0	74.2
Maximum	255.0	27.5	140.0	44.9	84.3
Standard Deviation	5.96	1.20	3.59	2.77	2.71
Coefficient of Variance	2.41	4.88	2.68	6.95	3.48
2. Canis lupus crassodon (Vancouver Island, pre-1950)	***#1***	***#19****	***#30***	***#31***	***#34***
females, n=8 (3) (Friis 1985:160)***	1	8	2	15	5
Mean	235.3	25.0	129.9	42.2	76.6
Minimum	225.4	23.7	121.6	38.2	74.3
Maximum	243.1	25.7	135.1	45.0	80.3
Standard Deviation	6.43	0.67	4.20	2.14	2.18
Coefficient of Variance	2.73	2.68	3.23	5.08	2.85
males, n= 9 (2)					
Mean	254.8	25.4	140.5	43.7	81.0
Minimum	245.7	20.8	133.3	37.2	77.9
Maximum	262.2	26.7	143.9	48.1	83.7
Standard Deviation	6.18	1.84	3.44	3.07	2.05
Coefficient of Variance	2.43	7.24	2.45	7.03	2.53
3. Canis familiaris (modern dingo, single primitive breed)	***#1***	***#19****	***#30***	***#31***	***#34***
females, n=30 (Gollan 1982:303-309)	V1	V51	V16	V35	V46
Mean	188.1	18.8	97.6	35.3	54.9
Minimum	176.0	17.0	93.0	31.0	52.0
Maximum	197.0	20.1	104.0	38.0	58.0
Standard Deviation	4.66	0.69	3.20	1.51	1.57
Coefficient of Variance	2.48	3.67	3.28	4.28	2.86
males, n=30					
Mean	199.7	20.0	105.2	36.5	58.6
Minimum	188.0	18.5	99.0	33.0	56.0
Maximum	208.0	21.2	112.0	38.0	61.0
Standard Deviation	4.79	1.01	3.46	1.25	1.32
Coefficient of Variance	2.40	5.05	3.29	3.42	2.25
4. Canis familiaris (modern Japanese shiba breed)	***#1***	***#19****	***#30***	***#31***	***#34***
males, n=45 (Onodera et.al. 1987:29)	1	15	6	11	4
Mean	155.5	17.6	94.8	28.7	59.2
Standard Deviation	6.79	0.78	3.77	2.14	2.45
Coefficient of Variance	4.37	4.43	3.98	7.45	4.14
females, n=42					
Mean	145.3	16.3	88.1	28.2	55.2
Standard Deviation	6.81	0.75	3.81	2.65	2.63
Coefficient of Variance	4.69	4.63	4.33	9.41	4.76

* The measurement for #19 is a tooth measurement in these studies, but is an alveolar measurement of premolar 4 in the Northwest Coast sample.

** The column headings on the second line are the measurement numbers used by the original authors.

*** The numbers in brackets for "n" in Nowak's and Friis' C.lupus samples are those of unknown sex which were assigned to that sex using subjective criteria.

sex, with identical standard deviations). This diagram demonstrates clearly that the distributions will not tend to show evidence of bimodality until the means between the two sexes are separated by three standard deviations, and are not entirely distinct until the means are separated by six standard deviations. Therefore, one should not expect to identify samples that contain significant heterogeneity by visual inspection of measurement distribution patterns alone. Four examples of the distribution patterns of length dimensions frequencies used in this study are illustrated (mandible, ulna, metatarsal II and cervical vertebrae #2; Figures 3-1 through 3-4).

Some overlap between the sample distribution is to be expected and undoubtedly represents especially tall and/or robust specimens of the small type and short and/or gracile specimens of the large type. In addition, some overlap may be due to accidental interbreeding between the two dog types, which would produce individuals of truly intermediate size.

This overlap of the populations can be expressed as a probability that any element classified by this analysis actually belongs to the type to which it has been assigned. Probabilities have been calculated two ways. For selected intact specimens, discriminant function analysis (described below) produced a probability of group membership value, which are included in the main data tables of classification results for each element. Only probabilities of 5% or less are considered significant for the purposes of this study and these are marked as such on the tables.

The other method of determining the likelihood that an element classified by this analysis actually belongs to the type to which it has been assigned is through the calculation of probabilities associated with standard "Z" scores (Norusis 1981). This method is described in more detail in chapter 9 where it has been used to resolve non-concensus of type classification of several elements belonging to a single individual animal. The "Z" scores and their associated one-tailed probabilities were calculated for all intact elements in the sample for which length measurements could be taken and are available from the author.

Multivariate analysis

Multivariate analysis is a statistical method which allows the relationships between several variables to be examined simultaneously. This type of analysis is especially useful in taxonomic studies and replaces the use of indices (cf Stockard 1941), which were the only practical way of examining more than one variable at a time before the advent of computers. Multivariate discriminant analysis has, for example, been used successfully in other studies to distinguish specific and subspecific differences between extant canid crania (Lawrence and Bossert 1967; Jolicoeur 1975; Nowak 1979; Friis 1985). This approach has also been used on archaeological canid remains to establish the taxonomic status of prehistoric material as dog rather than wild *Canidae* (Benecke 1987; Higham et. al. 1980; Walker & Frison 1982; Morey 1986; Morey & Wiant 1992). Where there are collections of the presumed modern descendants of prehistoric dog populations, such as for the Australian dingo (Gollan 1982) and the Japanese shiba (Shigehara & Onodera 1984; Shigehara 1994), discriminant analysis has been used to compare the two samples.

However, discriminant analysis requires *a priori* definitions of at least one of the groups to be classified (Klecka 1980; Tabachnick & Fidell 1983). It was thus an inappropriate method for the initial classification and characterization portion of this study, as there are no skeletal specimens of known wool or village dogs to which prehistoric specimens could be compared.

Alternative multivariate methods which do not require *a priori* definitions, such as cluster or principal component analysis, were considered

Exploratory cluster analyses of the cranial sample were run three times, using 3, 7 and 11 variables (using 11 variables reduced the sample by 3 specimens, because any missing variables caused the program to remove that specimen from the data set). The results (not shown) confirmed that total cranial length accounted for a very high proportion of the sample variation: 90% when 11 variables were used and 98% when only 3 variables were used. In all of the trial cluster analyses, specimens which had cranial lengths close to the mean of the total sample grouped together, whereas the other samples fell into two clusters that corresponded to the type 1 (small) and type 2 (large) groups as defined below. These results confirm that size rather than shape differences contribute too much to the sample variation for cluster-type analyses to be useful in the classification of ambiguous cases.

Several features of cluster analysis combined to make it a poor choice as an analysis method for

Table 3-4. T-test results for element length measurements (GL or equivalent), using the same specimen subsets as the discriminant analysis.

Element	**n**	**SEM (type 1)**	**SEM (type 2)**	**Difference between means**	**SED**	**Significant difference* (> 2X SED)**	**Probability > T**	**Probability >F'**
Cranium	16	2.29	3.50	26.07	4.18	*	0.0001	0.25
Mandible	31	1.41	1.57	17.17	2.11	*	0.0001	0.69
Scapula	15	3.30	1.64	18.56	3.69	*	0.0007	0.12
Humerus	26	1.43	1.85	19.28	2.34	*	0.0001	0.39
Radius	21	1.61	1.04	13.90	1.92	*	0.0001	0.17
Ulna	17	2.97	3.58	23.52	4.65	*	0.0002	0.73
Femur	24	1.95	1.31	21.17	2.35	*	0.0001	0.20
Tibia	24	1.89	1.68	15.69	2.53	*	0.0001	0.90
Calcaneus	47	0.32	0.50	5.48	0.59	*	0.0001	0.05
Metacarpal II	30	0.69	0.73	8.93	1.00	*	0.0001	0.64
Metacarpal III	30	0.86	0.96	9.86	1.29	*	0.0001	0.95
Metacarpal IV	32	0.94	0.96	10.57	1.34	*	0.0001	0.93
Metacarpal V	26	0.91	0.74	7.49	1.17	*	0.0001	0.62
Metarsal II	32	0.70	0.64	7.50	0.95	*	0.0001	0.56
Metarsal III	41	0.71	0.46	7.91	0.85	*	0.0001	0.08
Metarsal IV	28	0.80	0.68	8.35	1.05	*	0.0001	0.42
Metarsal V	32	0.67	0.46	6.92	0.81	*	0.0001	0.16
Cervical 01	25	0.13	0.31	2.08	0.34	*	0.0001	0.04
Cervical 02	20	0.63	0.71	5.57	0.95	*	0.0001	0.93
Cervical 03	21	0.39	0.39	3.36	0.55	*	0.0001	0.73
Cervical 04	24	0.32	0.30	2.94	0.44	*	0.0001	0.95
Cervical 05	13	0.31	0.29	2.06	0.42	*	0.0006	0.78
Cervical 06	14	0.27	0.25	2.17	0.37	*	0.0001	0.84
Cervical 07	13	0.32	0.25	1.72	0.41	*	0.0027	0.54
Thoracic 03	10	0.22	0.09	0.75	0.24	*	0.0340	0.17
Thoracic 12	14	0.3	0.18	1.87	0.35	*	0.0007	0.37
Thoracic 13	16	0.37	0.17	2.04	0.41	*	0.0006	0.06
Lumbar 01	17	0.25	0.37	2.48	0.45	*	0.0001	0.40
Lumbar 02	16	0.23	0.47	2.69	0.52	*	0.0013	0.21
Lumbar 03	17	0.37	0.31	2.66	0.48	*	0.0001	0.70
Lumbar 04	13	0.64	0.33	3.58	0.72	*	0.0014	0.18
Lumbar 05	12	1.04	0.25	3.06	1.07	*	0.0590	0.02
Lumbar 06	13	0.35	0.35	2.38	0.49	*	0.0005	0.86
Lumbar 07	19	0.18	0.28	2.61	0.33	*	0.0001	0.25
Sacrum	13	0.48	0.79	4.33	0.92	*	0.0013	0.35

SEM is standard error of the mean

SED is standard error of the difference

T is an approximate t statistic, assuming unequal variances

F' is the "folded" F statistic, a measure of variance

*** a difference is significant at the 95% confidence level if the real difference between the sample means is greater than 2X the SED**

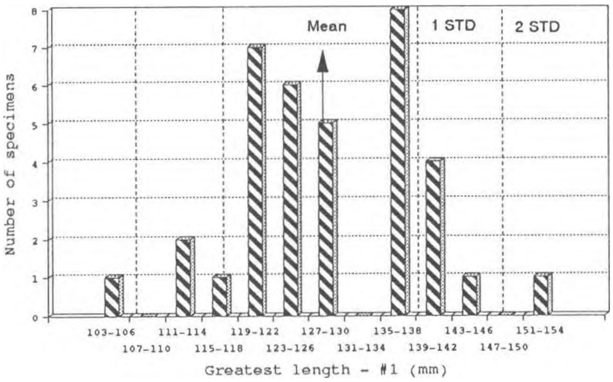


Figure 3-1. Frequency distribution by length of sample of mandibles (n=36) of different lengths.

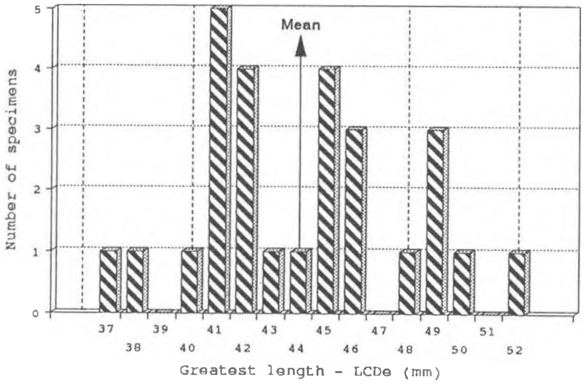


Figure 3-2. Frequency distribution by length of sample of ulnae (n=21) of different lengths.

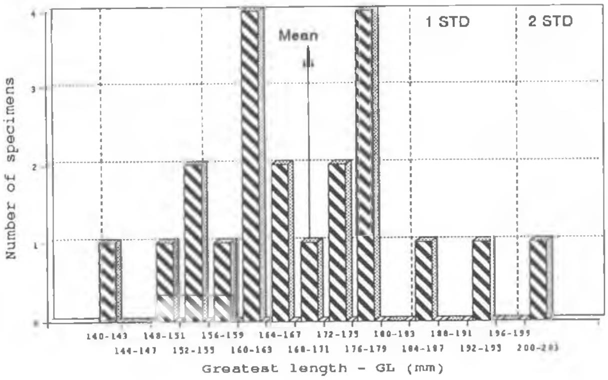


Figure 3-3. Frequency distribution by length of sample of metatarsal II elements (n=32) of different lengths.

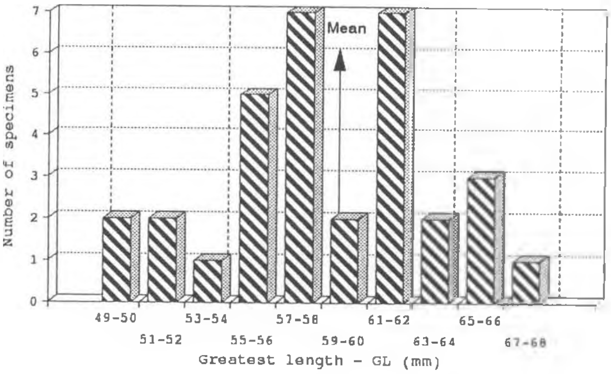


Figure 3-4. Frequency distribution by length of sample of cervical vertebra #2 elements (n=27) of different lengths.

this study. Cluster analyses of all kinds have the disadvantage of requiring an additional computational step to depict data graphically for interpretation. In addition, the algorithm must be re-run to assess each new case. As cluster analysis did not appear to add to the accuracy of the classification of this sample and since using it would mean that any additional specimens could not be assessed without re-computing the values, it was rejected as a classification tool.

I determined that the best analysis approach for this particular sample was to use the simplest method available to define the two types, that of dividing the sample into two subsamples about the mean described earlier in this chapter. This method readily accepts new cases without complex re-calculation of data and specimens with intermediate values are easily identified. Discriminant function analysis was then used to evaluate the relationship between length and breadth dimensions, rather than as a method of testing the statistical validity of the original classification method. This is not the way that discriminant function analysis is traditionally used, but it was a useful analysis procedure for this study.

Discriminant function analysis in the SAS program (SAS Institute Inc., release 6.03, 1988) has a "crossvalidation" option. Crossvalidation is a jack-knife type method that checks which samples may have been statistically misclassified according to the original definition, when more than one criterion is considered. The cross validation function repeatedly uses randomly- selected n-1 samples to create the classification and then tries to place the last sample correctly into that classification. This procedure (and other similar ones) is a test of how well the classification will predict group membership for new cases (Tabachnick & Fidell 1983; Morey 1986). Samples are labelled "misclassified" by the program if their probability of group membership value is below 50%, although I have considered only those values of 5% or less to be truly significant for the purposes of this study. "Misclassification" was interpreted as indicating that breadth dimensions were below or above average compared to length in those specimens. The "probability of membership" values generated were interpreted as indicating particularly robust or gracile individuals.

Very low probabilities of group membership (5% or less) were taken to indicate that specimens were truly intermediate in size and may not have been accurately classified. In other words, the discriminant function analysis identified robust or gracile individuals in each of the subsamples and indicated which specimens probably had values too close to the mean to be confidently classified. Only six specimens fell into this category, and these are indicated on the classification tables for each element

Unfortunately, not all specimens used in the original analysis could be used for the multivariate procedures, as some specimens lacked required dimensions. Multivariate analysis included the length measurement along with as many others as was possible without reducing the size of the data set appreciably.

4

CRANIA

Osteological description

The total cranium sample includes nineteen essentially intact crania and twenty incomplete ones. The subsample of intact crania was used to define the types or breeds. It was possible to assign the cranial fragments to a type category after the analysis of the intact crania was complete, creating a total classified sample of thirty-nine. Photographs of selected crania are presented in Figures 4-1 through 4-9.

Anomalies of the total cranium sample (intact & fragmented) were recorded. They include nine specimens which exhibit moderately severe to extreme tooth wear (after G.R.Clark 1995) and ten specimens which have various deformations in the frontal and/or sagittal crest area (Table 4-1).

The frontal and sagittal crest anomalies are particularly interesting. A few have clear indications of healed sinus infections, a condition characterized by one or several holes (with slightly thickened edges) in the orbital sockets. These holes probably represent an infected sinus exploding through the frontal bone. (L. Bixby, DVM, Victoria B.C. pers.comm.). After an infection had subsided, the hole in the bone would heal over to some extent. Specimen 0925 has this type of anomaly (Fig. 4-6). Whether such an

Table 4-1. Cranial pathologies and extremes of tooth wear, by type.

Specime	Type	Description of pathology/tooth wear
1016	?	Possible healed impact scar at nasal/premaxilla suture (cranium fragmented)
0339	1	Green impact scars, both frontals (left most severe)* (cranium fragmented)
0801	1	Healed impact scars on ectorbitales & nasals, bregma thickened
0803	1	Healed impact scars on premaxillas, frontal area thickened
0813	1	Healed impact scar, left frontal
2400	1	Bregma thickened & possible small healed impact scars on both frontals
0201	2	Possible healed impact scars, both frontals (slight) (cranium fragmented)
0300	2	Heal sinus infection with deformed crest formation, right frontal
0925	2	Bregma thickened & sagital crest deformed, no obvious specific trauma
3019	2	Green impact scar on right frontal; healed impact scar on left frontal; green impact scar on left ectorbitale (slight)
0801	1	Tooth wear extreme**
0803	1	Tooth wear moderate
0813	1	Tooth wear extreme
2400	1	Tooth wear moderate
0201	2	Tooth wear extreme on all teeth, canines flattened; left canine broken
0300	2	Tooth wear extreme on all teeth, canines flattened
0360	2	Tooth wear moderate to extreme
0812	2	Tooth wear extreme
0925	2	Tooth wear extreme

* "green" indicates an unhealed trauma to the bone

** "extreme tooth wear" indicates major exposure of dentine, bulk of tooth eroded to a smooth surface (after G.R. Clark 1995).

Table 4-2a. Univariate statistics of cranium sample, division at the mean (1); measurements #1 - 17A and results of multivariate crossvalidation of type classification.

			** % Probability of	Measurement code numbers											
Specimen	**Sex**	**Type**	**group membership**	**(1)**	**2**	**3**	**12**	**13**	**15**	**15B**	**15C**	**15D**	**16**	**17**	**17A**
0804	F	1	-	146.3			59.3	72.8	47.8	76.0	47.8	38.6	17.9	36.4	36.9
0805	F	1	100.0	153.1	145.4	135.8	65.6	77.5	56.9	83.0	52.3	41.4	17.7	44.4	40.9
3002	F	1	99.8	161.4	158.3	149.0	70.9	80.3	57.0	84.4	51.4	40.4	18.6	44.4	39.8
2400	M	1	96.3	162.0	148.2	140.7	65.2	78.4	53.2	78.0	47.7	37.5	17.0	40.6	35.0
0580	M	1	-	162.2	152.0	144.3	66.3	81.7	55.2	82.5	50.5	39.4	16.0	43.0	38.4
0301	M	1	98.4	164.1	156.2	148.3	69.1	82.3	50.8	83.4	50.8	39.1	15.6	39.0	38.8
3001	M	1	98.2	164.5	155.0	145.7	69.9	82.1	52.3	83.9	52.3	41.1	18.6	40.3	40.3
0813	F	1	99.9	164.5	156.7	149.0	72.6	85.7		87.7	54.0	43.4	17.9		39.4
0801	F	1	95.9	169.0	157.6	150.0	71.5	85.6	52.3	86.2	52.3	41.3	17.8		39.6
0803	M	1	80.0	173.3	162.1	153.5	75.0	88.4	53.7	88.5	53.7	43.0	17.5	41.4	41.7
0300	M	2	-		164.0	156.0	76.8		60.4	87.8	54.1	42.1	16.3	46.5	41.1
3019	M	2	2.7*	176.0	164.4	154.3	76.0	88.7	56.3	89.1	56.3	44.3	19.0	43.4	43.6
3000	M	2	-	180.7	166.4	156.8	74.8		57.0	86.4	51.7	41.5	15.6	44.1	38.9
0812	M	2	59.0	181.5	169.0	160.0	76.3			92.3	55.7	44.2	16.6		41.4
0925	M	2	96.7	185.0	175.0	166.5	77.0	93.5		90.2	55.2	43.4	19.0		41.2
1400	M	2	99.3	188.7	172.1	163.5	81.3	91.7	63.5	91.7	54.8	42.7	17.2	50.3	41.9
2011	M	2	99.9	191.5	177.8	168.1	81.3	93.0	63.4	93.7	55.0	44.1	17.5	51.0	42.8
0109	M	2	100.0	202.0	188.4	177.1	87.4	98.2	66.4	99.0	58.8	46.2	19.5	51.9	44.9
2009	M	2	-	203.0			84.6		57.6	97.0	57.6	45.0		45.0	44.8

Statistics	Measurement code numbers											
	(1)	**2**	**3**	**12**	**13**	**15**	**15B**	**15C**	**15D**	**16**	**17**	**17A**
total count	18	17	17	19	15	16	19	19	19	18	15	19
total mean	173.8	162.9	154.0	73.7	85.3	56.5	87.4	53.3	42.0	17.5	44.1	40.6
total std	15.5	10.8	10.3	6.9	6.7	4.8	5.7	2.9	2.3	1.1	4.3	2.4
total min.	146.3	145.4	135.8	59.3	72.8	47.8	76.0	47.7	37.5	15.6	36.4	35.0
total max.	203.0	188.4	177.1	87.4	98.2	66.4	99.0	58.8	46.2	19.5	51.9	44.9
total CV	8.92	6.65	6.67	9.37	7.88	8.57	6.56	5.42	5.40	6.54	9.69	6.02
type 1 count	10	9	9	10	10	9	10	10	10	10	8	10
type 1 mean	162.0	154.6	146.3	68.5	81.5	53.2	83.3	51.3	40.5	17.5	41.2	39.1
type 1 std	7.2	4.9	5.1	4.3	4.3	2.8	3.7	2.0	1.8	1.0	2.6	1.9
type 1 min.	146.3	145.4	135.8	59.3	72.8	47.8	76.0	47.7	37.5	15.6	36.4	35.0
type 1 max.	173.3	162.1	153.5	75.0	88.4	57.0	88.5	54.0	43.4	18.6	44.4	41.7
type 1 CV	4.45	3.19	3.46	6.28	5.30	5.18	4.48	3.98	4.43	5.45	6.23	4.75
type 2 count	8	8	8	9	5	7	9	9	9	8	7	9
type 2 mean	188.6	172.1	162.8	79.5	93.0	60.7	91.9	55.5	43.7	17.6	47.4	42.3
type 2 std	9.2	7.7	7.2	4.1	3.1	3.6	3.9	1.9	1.4	1.3	3.3	1.8
type 2 min.	176.0	164.0	154.3	74.8	88.7	56.3	86.4	51.7	41.5	15.6	43.4	38.9
type 2 max.	203.0	188.4	177.1	87.4	98.2	66.4	99.0	58.8	46.2	19.5	51.9	44.9
type 1 CV	4.89	4.47	4.39	5.18	3.33	5.90	4.27	3.46	3.16	7.65	6.89	4.33

* starred values are misclassified, at < 5% probability of group membership.

** this is the probability of membership in the "type" group as initially classified, based on multivariate analysis using variables 1, 12, 23, 34 together.

Table 4-2b. Univariate statistics of cranium sample, division at the mean (1); measurements #19-36.

			Measurement code number												
Specimen	**Sex**	**Type**	**19**	**22A**	**23**	**25**	**25A**	**27**	**29**	**30**	**31**	**32**	**34**	**35**	**36**
0804	F	1	16.6						51.9		34.4	45.5			
0805	F	1	18.5	14.6	59.4	35.2	32.2	19.1	52.4		34.2		58.9	32.7	36.1
3002	F	1	17.2	16.5	61.8	35.3	31.0	16.9	50.7	89.4	31.4	42.1	58.5	33.1	34.1
2400	M	1	17.6	12.0	60.8	31.7	28.6	16.2	51.0	99.0	34.2	50.5	60.8	31.9	35.3
0580	M	1	16.4	12.4	56.0	30.0	27.8	16.0	57.5	93.5	38.3	44.5	57.8		33.0
0301	M	1	17.0	15.1	59.4	33.1	30.2	18.3	51.0	96.0	33.6	46.0	56.4	29.8	
3001	M	1	17.3	15.3	61.2	34.3	30.5	18.4	52.2	93.9	31.0	48.2	56.9	30.9	33.5
0813	F	1		15.1	59.5	33.0	30.0	17.6	52.0		36.8		60.5	31.5	34.7
0801	F	1	17.3	13.4	62.0	36.5	32.0	18.1	52.0	101.9	34.3	52.8	60.9	34.3	38.5
0803	M	1	19.0	16.0	62.5	34.5	30.5	18.3	51.5		37.8	54.2	63.6	37.8	40.7
0300	M	2	16.5		61.0	32.5	28.6	17.5		106.6		45.1	60.4	32.5	37.1
3019	M	2	19.0	17.0	62.0	35.8	31.4	19.6	51.1	87.8	32.5		59.0	33.0	34.5
3000	M	2	16.6	17.9	64.2	36.3	31.9	18.9	52.6	94.0	35.0	49.9		34.2	34.7
0812	M	2	16.9	17.0	66.6	37.1	33.8	19.3		110.6		56.9	67.0	38.2	39.8
0925	M	2	18.8	16.9	68.0	38.4	35.2	19.7	56.0		35.5	53.8	66.6	39.5	44.2
1400	M	2	17.6	16.7	66.0	33.7	29.9	17.8				48.8	59.2	31.2	34.2
2011	M	2	19.0	18.7	70.5	40.6	36.2	20.4	56.4	102.0	36.6	53.0	62.4	36.5	39.4
0109	M	2	19.6	19.3	71.2	40.9	36.8	21.2	58.3	110.0	36.0		69.0	39.5	41.2
2009	M	2								108.0	34.2	57.4		21.0	

Statistics	Measurement code numbers												
	19	**22A**	**23**	**25**	**25A**	**27**	**29**	**30**	**31**	**32**	**34**	**35**	**36**
total count	17	16	17	17	17	17	15	13	16	15	16	17	16
total mean	17.7	15.9	63.1	35.2	31.6	18.4	53.1	99.4	34.7	49.9	61.1	33.4	36.9
total std	1.0	2.0	4.0	2.9	2.5	1.4	2.5	7.4	2.0	4.5	3.6	4.3	3.2
total min.	16.4	12.0	56.0	30.0	27.8	16.0	50.7	87.8	31.0	42.1	56.4	21.0	33.0
total max.	19.6	19.3	71.2	40.9	36.8	21.2	58.3	110.6	38.3	57.4	69.0	39.5	44.2
total CV	5.78	12.64	6.39	8.10	8.04	7.40	4.67	7.46	5.80	9.10	5.89	12.86	8.69
type 1 count	9	9	9	9	9	9	10	6	10	8	9	8	8
type 1 mean	17.4	14.5	60.3	33.7	30.3	17.6	52.2	95.6	34.6	48.0	59.4	32.7	35.7
type 1 std	0.8	1.5	1.9	1.9	1.4	1.0	1.8	4.0	2.3	4.0	2.2	2.3	2.5
type 1 min.	16.4	12.0	56.0	30.0	27.8	16.0	50.7	89.4	31.0	42.1	56.4	29.8	33.0
type 1 max.	19.0	16.5	62.5	36.5	32.2	19.1	57.5	101.9	38.3	54.2	63.6	37.8	40.7
type 1 CV	4.52	10.15	3.12	5.60	4.46	5.71	3.53	4.20	6.70	8.25	3.65	7.08	6.97
type 2 count	8	7	8	8	8	8	5	7	6	7	7	9	8
type 2 mean	18.0	17.6	66.2	36.9	33.0	19.3	54.9	102.7	34.9	52.1	63.4	33.9	38.1
type 2 std	1.2	0.9	3.5	2.8	2.8	1.2	2.6	8.1	1.3	4.1	3.8	5.4	3.4
type 2 min.	16.5	16.7	61.0	32.5	28.6	17.5	51.1	87.8	32.5	45.1	59.0	21.0	34.2
type 2 max.	19.6	19.3	71.2	40.9	36.8	21.2	58.3	110.6	36.6	57.4	69.0	39.5	44.2
type 1 CV	6.46	5.26	5.23	7.65	8.50	6.01	4.80	7.87	3.81	7.93	6.01	15.96	8.90

infection could affect normal bone formation in the frontal and sagittal crest areas is unclear, but frontal bone and sagittal crest anomalies were seen along with these healed holes on several occasions.

Most of the frontal bone deformations, however, appear to be healed or fresh impact scars. Two specimens (3019 & 0339) exhibit what appear to be "green" or unhealed impact breakage on the frontal bone, which may have been severe enough to cause death. Several other specimens have healed scars from less severe impact injuries, principally on the flat area of the frontal between or in front of the *ectorbitales* and on at least one specimen, on the nasal area of the facial slope. In several instances, normal sagittal crest formation appears to have been affected, causing the bregma and temporal lines to become thickened and warped. In a few cases the sagittal crest is clearly deformed (Figure 4-2).

The cause of these injuries is undoubtedly a blow to the head, often several blows. By whom and for what reason is of course not discernible from the injuries themselves, but a blow to the head may have been a common method of subduing any dog. Alternatively, these scars may result from falls and/or other accidents or possibly, kicks from deer or elk. Lawrence (1968) illustrates a cranium from Jaguar Cave, Idaho that seems to show a similar scar on the left frontal.

Sex determination and sex ratios

The sex of individual crania was determined based on the non-metric characteristics described in Chapter 2. The distribution of the assigned sexes within the total intact cranium sample is quite unequal (14 males/5 females).

The inequality of the sexes represented in the cranium sample could be explained in several ways. Differential burial practices for males and females and/or the two dog types may have biased preservation and thus the sample of recovered remains. Alternatively, it is probable that some measures would have been taken by First Nations people to control their dog population to sustainable levels, as suggested by Gleeson (1970). This may have been accomplished most easily by limiting the absolute number of females, a method which has been described for some Inuit groups (Dr. D. Moyer, Anthropology Department, University of Victoria, B.C., pers. comm.). This method naturally limits the number of offspring produced but is also said to be preferred because it minimizes fighting amongst males for access to females in season.

Photographs of intact crania published in several reports of prehistoric dogs (from North American and Hungary) are clear enough that the sex of the specimens can be provisionally determined by the methods used in this analysis. The preponderance of putative males suggests that other samples of adult dogs may also contain many more males than females (Walker & Frison 1982; Bokonyi 1984). In addition, in two studies which have explicitly addressed sexual dimorphism (from Japan and Australia) there is also an apparent sexual bias in favour of males (Shigehara & Onodera 1984; Gollan 1982). In contrast, however, Brothwell et.al. (1979) found no apparent sexual bias in their sample of Peruvian prehistoric dogs, although this may be more a reflection of the reliability of the method chosen to determine sex than of the true distribution of the sexes in the population.

The possibility that a culturally-instigated pattern of sexual bias favouring males may be quite general in adult prehistoric dog populations is intriguing. If it becomes possible to sex crania of young juvenile individuals, we might find that the high incidence of young dogs (less than 6 months old) reported from many sites (Gleeson 1970; Montgomery 1979; Bernick 1983; Hamblin 1984; Wapnish & Hesse 1993) reflects the culling of young bitches before their first season. This is completely speculative, of course, but probably deserves further investigation. If a high ratio of males to females is the general pattern to be expected for most prehistoric adult dog populations, deviations from this ratio may be especially significant.

A marked deviation from such an "expected" ratio of male to females is demonstrated by this sample. When the sample of intact crania in this study is divided into two subsamples according to type, the difference in distribution of sexes is striking: the sample of small dogs contains *equal numbers of males and females*, while the sample of large dogs contains *only males*. For the sample of fragmented crania that could be assigned to either sex, three of the four specimens classified as type 1 (small dog) are female while only three out of the ten specimens classified as type 2 (large dog) are female. This leaves an overall ratio of six males:eight females (or 0.75) for the small dog (type 1) and eight males:three females (or 6.0) for the large dog (type 2), out of a total sample of thirty-five cranial specimens.

Since the ethnohistoric reports state that there was a specific economic use for by-products from the wool dog (as compared to being a general utility/companion animal, as the village dog reportedly was), this difference in sex ratios may be an indication of deliberate husbandry of the small dog type. Individual village dogs that were trained for hunting may have been valued highly for their particular skills, but *all* wool dogs would presumably have been equally valuable. This would suggest that the production of offspring from wool dogs may have been maximized rather than minimized, within the limits imposed by practical management considerations.

In order to increase the number of offspring produced, more breeding-age female wool dogs would need to be maintained. This could account for the greater number of adult female crania recovered of the small type. This equal representation of both sexes lends considerable support to the suggestion that the small, "type 1" dog actually represents the wool dog, because it implies deliberate breeding (i.e. true "husbandry") of this breed.

Sexual bias in an adult skeletal sample as a consequence of husbandry has been proposed by Klein and Cruz-Uribe (1984) for a sample of prehistoric domestic sheep, where animals apparently chosen for butchering were predominantly young males. The sample of recovered sheep skeletal material thus represented many young juvenile males (presumably culled), a few old females and no adult males. However, I have found no comparable samples reported in the literature which reflect, or even suggest, deliberate husbandry of dogs.

Type classification

Table 4-2a and 4-2b list the results of splitting the sample of intact crania at the mean of the greatest length (173.8 mm), as a method of defining the two breeds. The subsample

Table 4-3. Cranium fragments, type classification

			Measurement code number									
Specimen	Sex	Type	13	15B	23	25	27	29	31	32	34	35
0500	M	1				32.0	16.3					
0520	F	1							32.0	43.2		
1517	F	1			57.4	30.2	15.3	51.4	31.7			
0339	F	1			59.0	34.3	17.7	51.2	32.5			
0449	?	2				37.2	18.9					
0360	?	2				37.6	19.9					
3018	M	2				38.2	18.9		36.7	55.4	67.4	
2017	?	2									68.6	
3003	M	2			63.1	33.3	16.5	50.3	31.4	42.3	59.9	
1442	M	2			64.4	34.2	17.8	52.7	28.9	44.8	59.0	
1000	F	2			66.2	36.0	19.7	55.9	33.1			39.5
1203	F	2			67.2	38.9	18.0	56.3				33.6
1001	M	2			68.8	37.6	20.1	56.8	36.6			
5001	F	2			68.9	37.5	19.9	54.6				
2010	M	2			72.9	39.8	19.1	55.2	35.9	59.3	73.2	
2219	M	2			74.1	42.5	19.5		35.6			28.4
1018	?	2	89.6	90.7								34.2
0201	M	2		91.0					34.5	52.4		
1015	?	2		95.5								
2042	?	2		97.2								

comprising type 1 dogs has a mean total length of 162.0 mm and that of type 2 dogs, 188.6 mm.

Figures 4-10 through 4-13 are graphic representations of the relationships between several cranial dimensions used in this analysis: in particular, note the distribution of points where the carnassial tooth alveola measurement (#19) is used compared to other measurements. As described in Chapter 1, this pattern reflects the loose allometric relationship between tooth size and cranium size and illustrates why teeth should not be used exclusively in classification schemes.

Incomplete and fragmentary cranial remains were assigned to type by comparison to the intact sample and the results presented in Table 4-3. Fragmentary material was assigned to type conservatively. Specimens were classified as belonging to type 1 only if the available measurements for the fragment fell within the reported range for type 1 without being in the range of measurements which overlapped with those classified as type 2. This was necessary because apart from measurements #1, #2, and #3, the range of measurements for all other cranial dimensions overlapped to some degree for the two types. Similarly, specimens were assigned to type 2 if the available measurements fell within the reported range for type 2 without being in the range of overlap of type 1 measurements. If most of several available values were in the range of overlap but one or more values clearly fell within the range of one distinct type, the specimen was classified as belonging to that type. The amount of "range of overlap" was different for each variable and some fragmentary specimens could not be confidently assigned to either type. These specimens (that were measured as part of the study but ultimately not classifiable) are not included in Table 4-3.

Discriminant function analysis

Discriminant analysis of the intact cranium sample was undertaken after designation of breed types, using the *crossvalidation* function to examine the relationship between length and breadth dimensions. This multivariate procedure used length variables #1 and #12, and breadth variables #23 and #34 (total length, snout length, mastoid breadth, and palate breadth, respectively). Only one specimen (3019) was considered incorrectly classified according to this analysis: it was given less than a 5% probability of actually belonging in the type 2 group. Examination of the measurements indicates this cranium is particularly narrow for its length (i.e. it is a gracile large specimen).

Previously reported Northwest Coast material: type classification

Gleeson (1970) reports only one intact cranium from the historic strata at Ozette and as such is not directly comparable to this study. The possibility of interbreeding of indigenous dogs with dogs of European ancestry during the historic period must be considered and this potential for mixed ancestry adds another unquantifiable dimension to a study of size variability within the Ozette dog population. However, according to the criteria of this study, this cranium is clearly not as small as a wool dog type, being classified as a smallish individual of the large dog type.

Montgomery (1979) reports two intact crania from Semiahmoo Spit, both clearly of the small Northwest Coast type as defined by this analysis. Both show congenital absence of premolar 1. The differences in cranium shape which Montgomery describes in some detail (which she thought might represent breed differences) are undoubtedly the result of sexual differences: the small individual is almost certainly female, the larger one male. The comparable measurements for these and for the Ozette cranium described above are presented in Table 4-4.

Comparison to other data sets

An additional discriminant analysis compares the two types defined from this sample to samples of prehistoric dog remains from two other Pacific Rim sites for which raw data have been reported in the literature. One of the samples is a set of eleven dogs recovered from Jomon-period Japanese sites (Shigehara & Onodera 1984; Shigehara 1994). These remains date from approximately 10,000 to 2,300 bp and were chosen because the mean and range of total cranium length (measurement #1) were similar to that of small, type 1 dogs from the Northwest Coast.

The other sample is a set of nineteen prehistoric dog crania recovered from St. Lawrence Island, Alaska, excavated between 1927 and 1935 and reported by Haag (1948:159-162). This St. Lawrence Island sample is reported to date from "ca. 200 B.C. to ca. 200 years bp" and the mean and range of the total cranium length (measurement #1) of these specimens is similar to that of the large, type 2 Northwest Coast dogs. I used a subsample only of the total published St. Lawrence Island dog sample, comprised of all specimens for which measurements #1, #12, #23 and #34 were available.

A discriminant analysis compared both type 1 and type 2 Northwest Coast samples to the Jomon and St. Lawrence Island groups together in one discriminant analysis. The objective of this analysis was to determine whether either of the apparently similarly-sized dogs could be distinguished from each other using only the four variables and also, to see if the particular kinds of errors in classification which occurred could tell us anything more about the sample.

The results of this procedure are summarized in Table 4-5 (where group 1 = NWC small dog; group 2 = NWC large dog; group 3 = small Jomon period dogs; group 4 = large St. Lawrence Island dogs. As expected, the misclassification that most often occurred was from one similar size group to the other (e.g. group 1 to group 3 or group 2 to group 4). Somewhat unexpectedly, all of the St. Lawrence Island dogs were correctly classified

Table 4-4. Selected measurements and classification of previously reported Northwest Coast crania, from Ozette Village and Semiahmoo Spit, Washington State (Fig. 1-1).

		Measurement code numbers*									
		1	2	3	12	13	23	25	30	32	34
Specimen	**Type**	(1)	(3)	(2)	(12)	(4)	(7)	(8)	(9)	(13)	(5)
Semiahmoo 1	1	155.6	148.0	140.7	66.9	77.0	56.8	30.7	-	43.3	53.6
Semiahmoo 12	1	168.5	156.5	150.5	75.0	84.6	60.0	31.8	-	45.6	-
Ozette A7/IV/3	2	177.0	162.0	154.0	73.7	86.4	67.8	36.5	100.4	-	58.0

* numbers in brackets on second line are the measurement numbers used by the original authors.

Table 4-5. Classification results of a discriminant analysis using cranium measurements 1, 12, 23 & 34 comparing the two Northwest Coast groups to Japanese Jomon dogs & St. Lawrence Island (Bering Sea) dogs.

	Classified by analysis into group:					% correctly
Known group	1	2	3	4	**Total**	**classified**
1	5*	0	2	0	7	71
2	0	2*	1	4	7	29
3	1	0	10*	0	11	91
4	0	0	0	19*	19	100

group 1 NWC small **group 3 Jomon small**
group 2 NWC large **group 4 St.Lawrence Island large** * correctly classified

Table 4-6. Measurements of intact puppy skulls, 2-4 months old.

	Measurement code numbers						deciduous	deciduous
Specimen	1	2	3	7	12	34	carnassial	molar
Crania								
Little Qualicum #2418	105.1	96.3	90.0		38.0	43.2	10.3	8.0
Ozette #3020	89.9	83.5	78.4		32.2	43.0	10.6	8.7
Mandible								
Little Qualicum #2418	77.0	74.4	72.9	29.5			10.4	

suggesting that this is a very homogeneous population with a unique osteometric "signature" as compared to the other samples. Although the means of total cranial length (187.4 vs. 188.6 mm)as well as snout length were almost identical in each of the samples, the mean of the mastoid breadth and palate breadth values for St. Lawrence Island dogs were appreciably larger than those from Northwest Coast large dogs. St. Lawrence Island dogs had distinctly broad skulls.

By contrast, the Northwest Coast large dog sample had the highest misclassification rate of all four groups: only two out of the seven specimens were correctly classified (29%) when compared to the three other regional samples. One was incorrectly assigned to the Jomon dog group and four were misclassified as St. Lawrence Island dogs. This result suggests that the sample of crania from the Northwest Coast large dog group is not a particularly homogeneous group with respect to these four dimensions. In other words, the Northwest Coast large dog sample included those with broad as well as narrow skulls.

Northwest Coast small dogs were correctly assigned a fairly high proportion of the time (71%) and when they were not, grouped with small Jomon dogs. Jomon dogs were almost always correctly assigned (91%) and when they were not, grouped with small Northwest Coast dogs. This relatively low error rate of classification indicates there is enough regional difference to distinguish with some confidence between the two groups. Overall, Jomon dog crania had narrower palates but greater mastoid breadths than Northwest Coast small dogs.

Again, this analysis is not meant to imply evidence for a direct relationship between any of these groups but is presented as additional support for the assumption that this analysis has defined at least one distinct, fairly homogeneous Northwest Coast dog population. The sample of Northwest Coast small dogs used in this analysis is not as homogeneous as either Jomon or St. Lawrence Island dogs, but the relatively small size of the sample may have contributed significantly to such a result. In contrast, the Northwest Coast large dog sample appears to be fairly heterogeneous, at least according to the criteria used in this analysis.

Intact puppy crania

Two completely intact crania of young puppies were recovered from different water-logged Northwest Coast site deposits: Little Qualicum River (DiSc 1) and Ozette Village (45CA24). While these specimens could not be included in the osteometric analysis because of their immaturity, a discussion of the two crania is included because of the rarity of such material (Figures 4-14 to 4-17). Preservation in both crania is remarkable, despite the unfused cranial sutures and porous texture, which allowed several measurements to be taken .

The deciduous dentition on both is fully erupted, with no permanent teeth showing above the alveolae. The age of both puppies at death, based on tooth eruption, is estimated from two to four months (Andersen 1970; Miller 1965).

The Little Qualicum specimen (#2418) is slightly older than the Ozette individual (closer to four months), having somewhat greater development of the underlying permanent dentition and a little wear on the deciduous molars. The deciduous incisors are not present and it is not clear whether they had been naturally shed or lost due to natural taphonomic (depositional) factors. The permanent incisors and canines are visible in their alveolae, although none have erupted through the gum line. Both mandibles associated with this specimen were also available and measurements for the right side are included in Table 4-6.

There were no mandibles associated with specimen #3020 from Ozette. All incisors in this cranium are fully erupted and still in place, with a slight amount of wear discernible on them. The underlying permanent second molar is barely formed beneath the maxillary bone. Tooth eruption patterns suggest this specimen may have been slightly younger than the Little Qualicum individual, perhaps closer to two months than to four.

A specimen with which these remains can be compared is the puppy skeleton associated with a human burial at the Natufian site in Israel dated at 10,000 to 12,000 bp reported by Davis and Valla (1978). While the authors could not determine conclusively based on morphology whether this puppy was a dog or wolf, it is estimated to have been 4-5 months old. The length of the lower deciduous carnassial is reported as 13.3 mm (cf. 10.4 mm for specimen #2418) and to show extensive wear, suggesting a slightly greater age and larger initial size than the Northwest Coast specimens described here. Additional reported measurements of deciduous dentition of prehistoric dogs may ultimately aid in the species determination of such taxonomically ambiguous material.

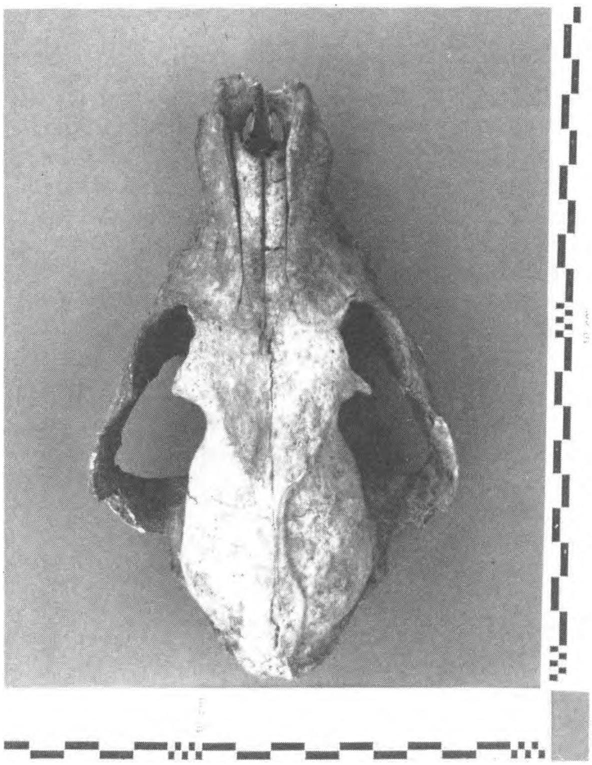


Figure 4-1. Photo (dorsal view), type 1 female cranium, specimen #0801.

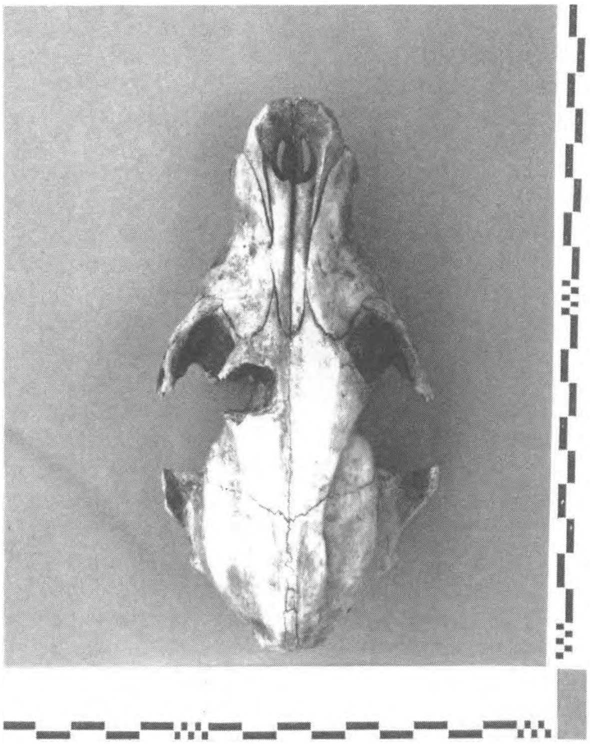


Figure 4-2 Photo (dorsal view), type 1 female cranium, specimen #0805.

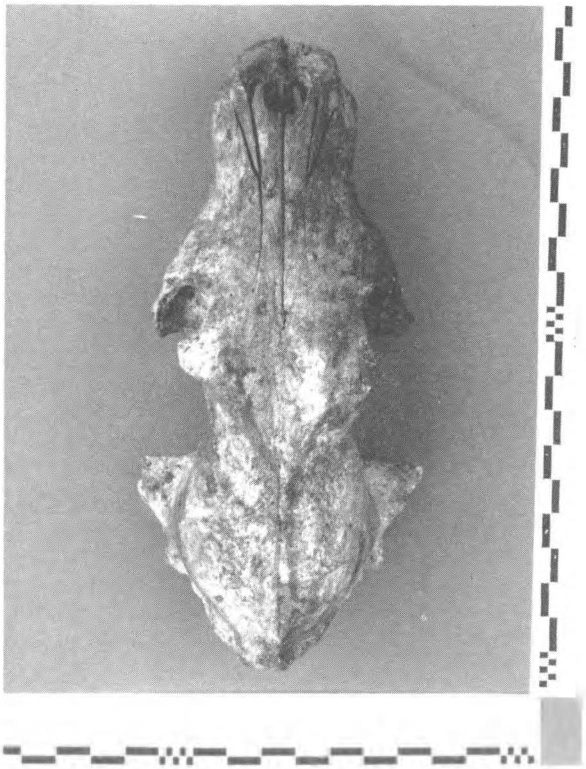


Figure 4-3. Photo (dorsal view), type 1 male cranium, specimen #0803.

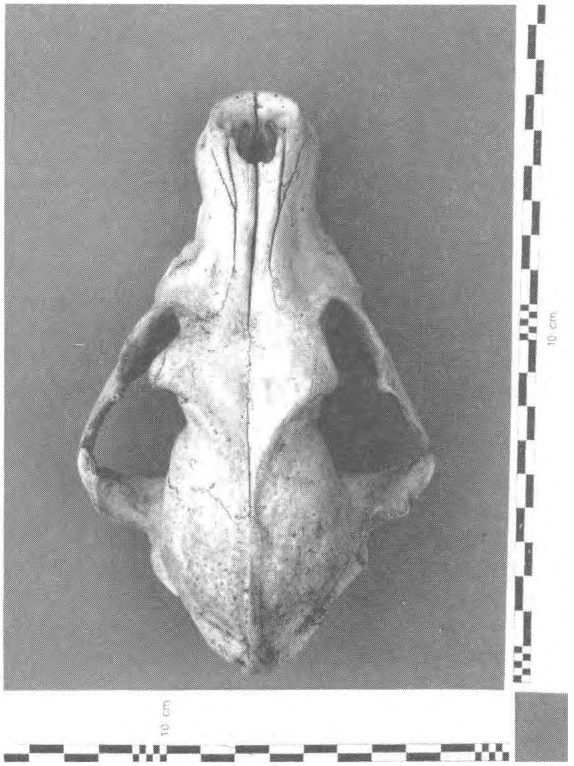


Figure 4-4. Photo (dorsal view), type 1 male cranium, specimen #2400.

Crania

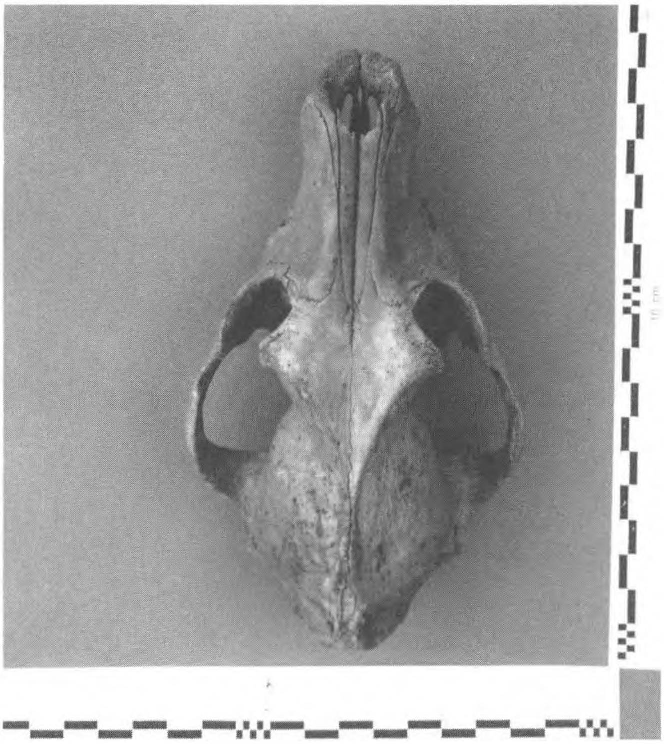


Figure 4-5. Photo (dorsal view), type 1 male cranium, specimen #3001.

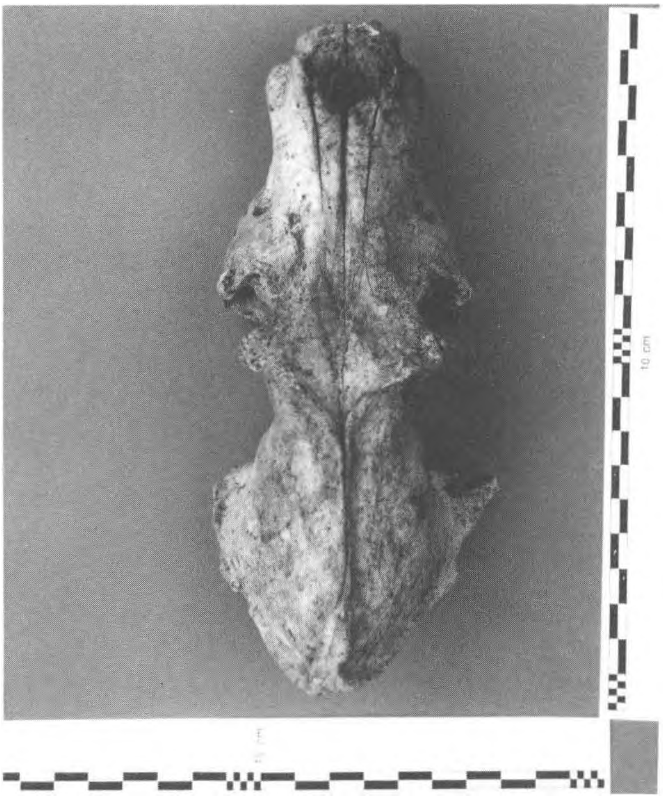


Figure 4-6. Photo (dorsal view), type 2 male cranium, specimen #0925.

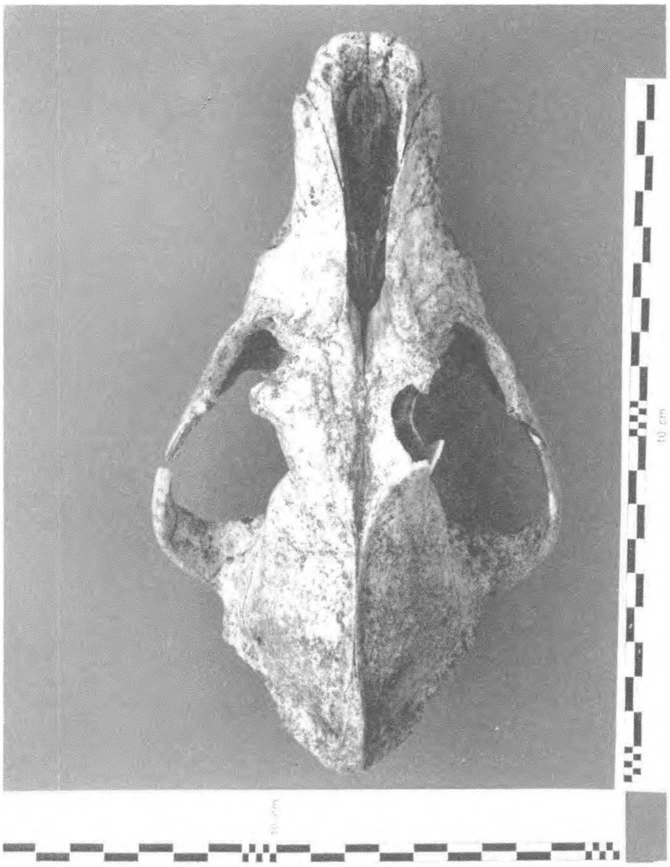


Figure 4-7. Photo (dorsal view), type 2 male cranium, specimen #0109.

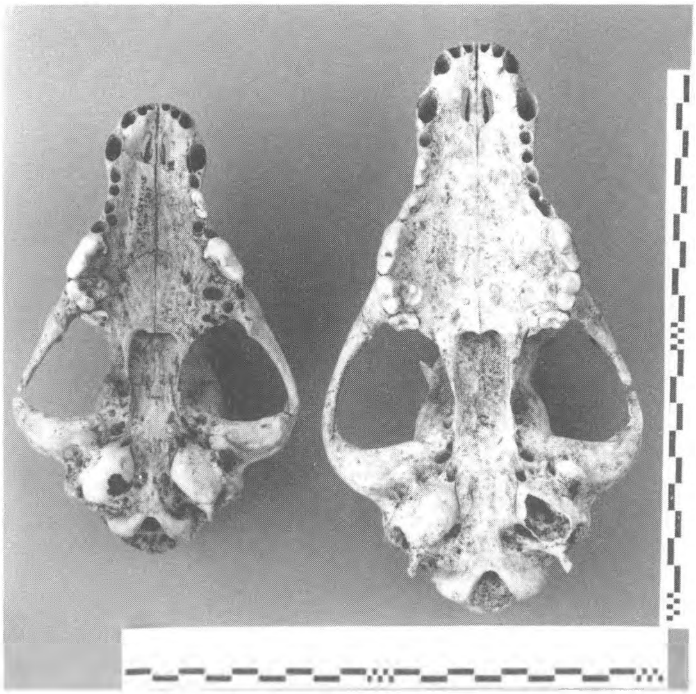


Figure 4-8. Photo, type 2 male cranium, specimen #0109 (on right) vs. type 1 male, specimen #2400 (on left), ventral view.

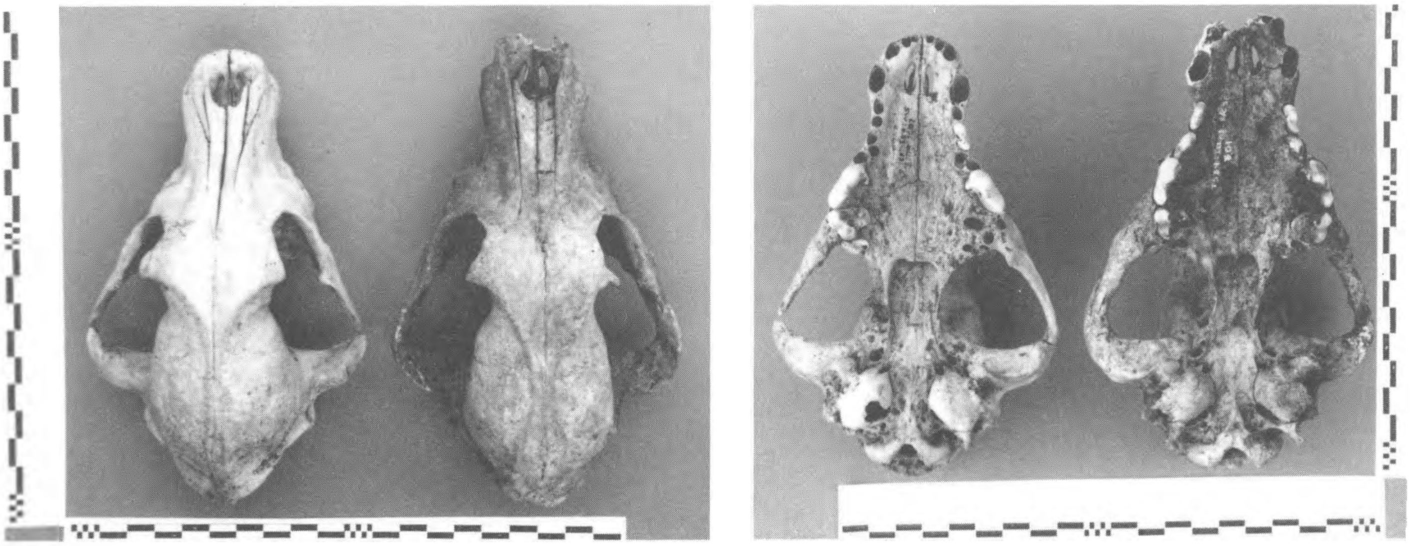


Figure 4-9. Dorsal (left photo) and ventral (right photo) views of type 1 male cranium, specimen #2400 (left) vs. type 1 female, specimen #0801 (right).

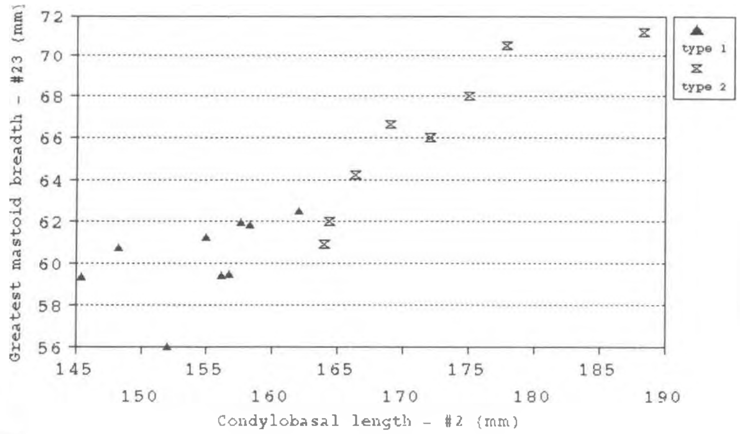


Figure 4-10. Plot of cranial measurement #2 (condylobasal length) vs. #23 (greatest mastoid breadth).

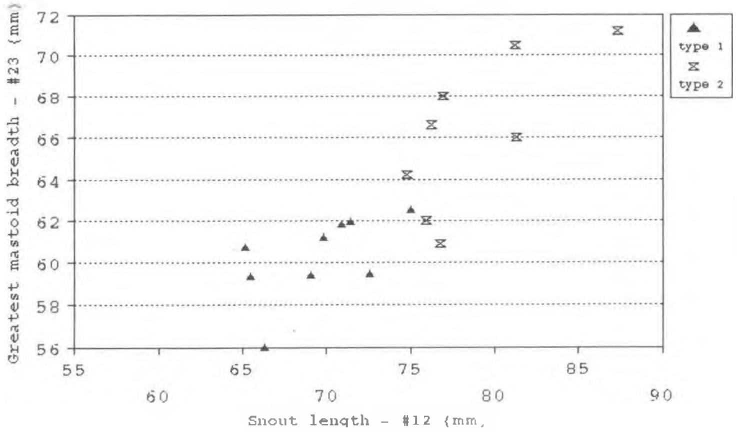


Figure 4-11. Plot of cranial measurement #12 (snout length) vs. #23 (greatest mastoid breadth).

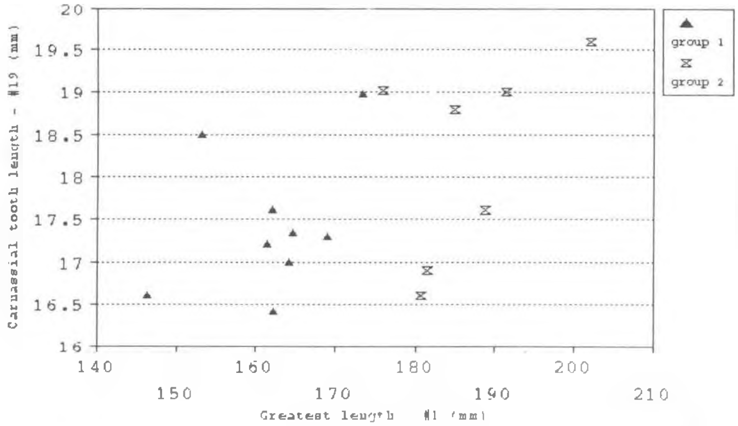


Figure 4-12. Plot of cranial measurement #1 (greatest length) vs. #19 (carnassial alveolus length).

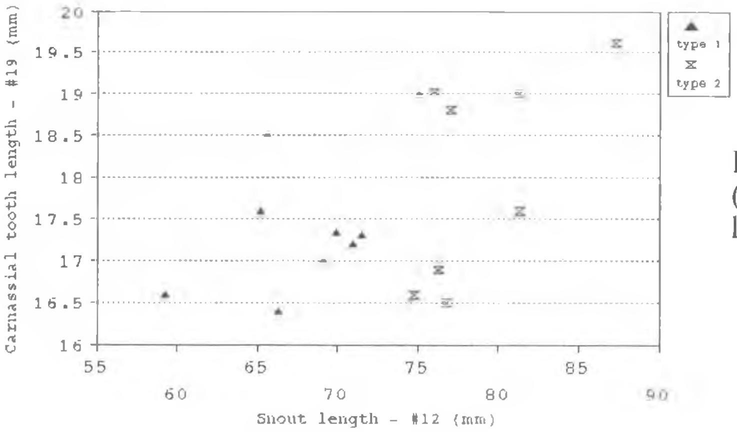


Figure 4-13. Plot of cranial measurement #12 (snout length) vs. #19 (carnassial alveolus length).

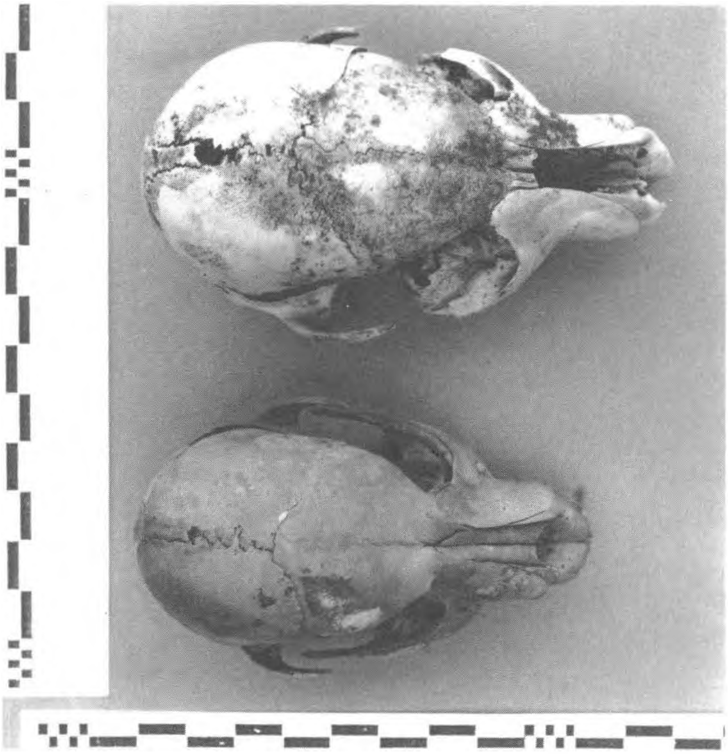


Figure 4-14. Photos of puppy crania, specimen #2418 (top) and specimen #3020 (bottom), dorsal view.

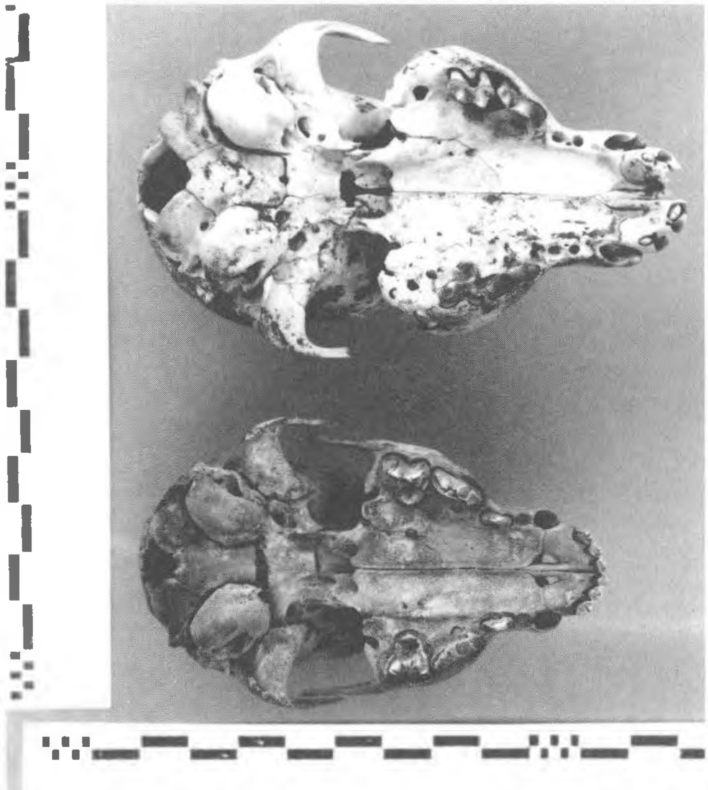


Figure 4-15. Photos of puppy crania, specimen #2418 (top) and specimen #3020 (bottom), ventral view.

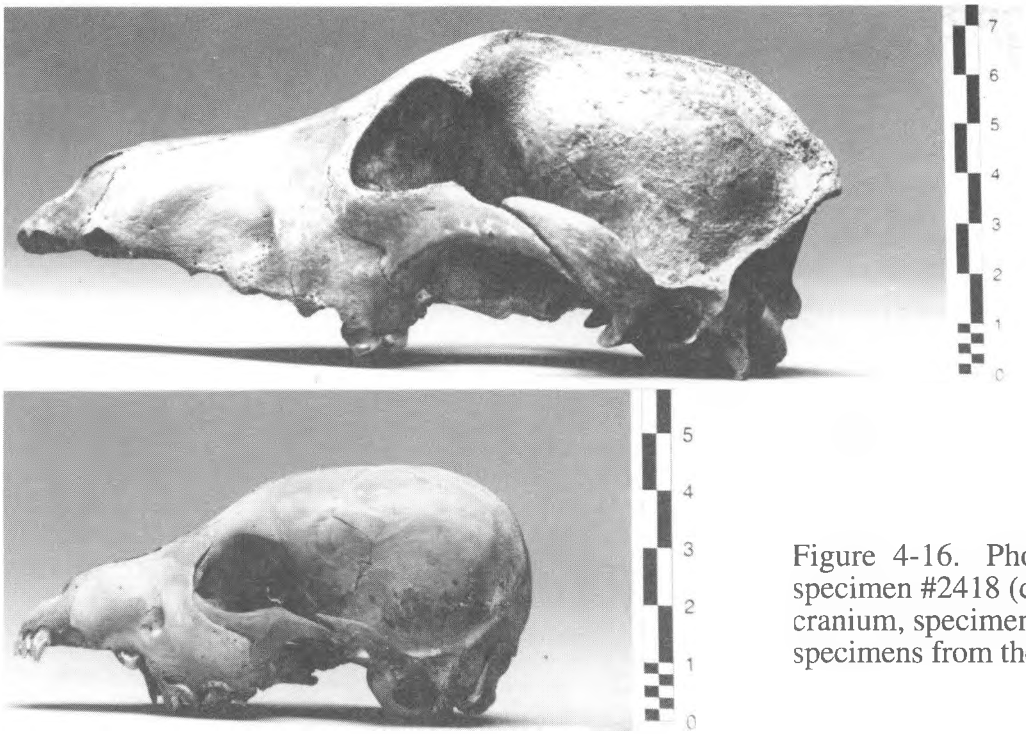


Figure 4-16. Photos of puppy cranium, specimen #2418 (ca. 3-4 months) and adult dog cranium, specimen #2400, lateral view. Both specimens from the Little Qualicum site, DiSc1.

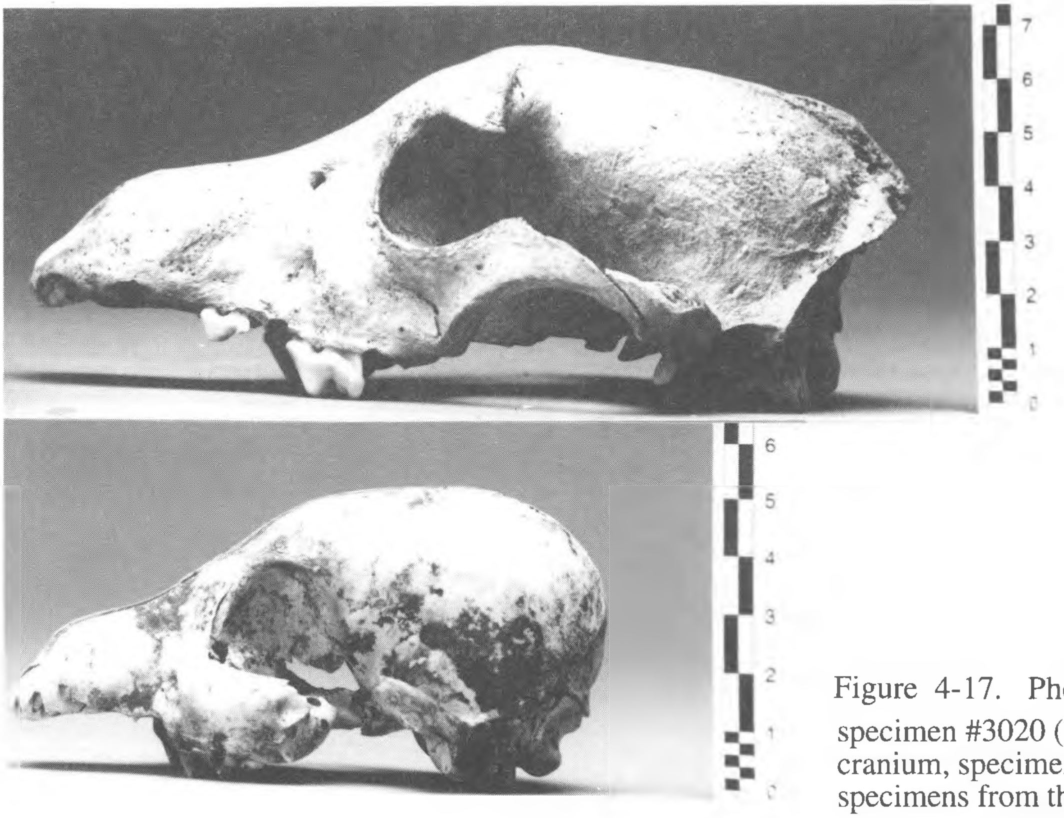


Figure 4-17. Photos of puppy cranium, specimen #3020 (ca. 2-3 months) and adult do cranium, specimen #3001, lateral view. Both specimens from the Ozette site, 45CA24.

Crania

Measurement Number **Definition of cranial measurement codes**

#1........ Total length: Akrokranion (A) to prosthion (P)
#2........ Condylobasal length: Aboral border of occipital condyles to prosthion (P)
#3........ Basal length: Basion (B) to prosthion (B)
#12...... Snout length: Oral border of orbits (median) to prosthion (P)
#13...... Median palatal length: Staphylion (St) to prosthion (P)
#15...... Length of cheektooth row: from P1 to M2 along alveoli of buccal side
#15B*. Length of entire tooth row: Prosthion (P) to aboral alveolus of M2
#15C*. Length of cheektooth row: from P2 to M2, along alveoli of buccal side; where P1 is missing
#16...... Length of molar row: from M1 to M2 along alveoli of buccal side
#17...... Length of premolar row: from P1 to P4, along alveoli of buccal side
#17A* Length of premolar row: from P2 to P4, along alveoli of buccal side; where P1 is missing
#19...... Length of carnassial (P4) alveolus
#22A* Shortest distance between auditory bullae
#23...... Greatest mastoid breadth: Otion (Ot) to otion (Ot) (greatest breadth of occipital triangle)
#25...... Greatest breadth of occipital condyles
#27...... Greatest breadth of foramen magnum
#29...... Greatest neurocranium breadth: Euryon (Eu) to euryon (Eu) (greatest breadth of braincase)
#30...... Zygomatic breadth: Zygion (Z) to zygion (Z)
#31...... Least breadth of cranium: breadth at postorbital constriction, aboral of ectorbitales (Ect)
#32...... Greatest frontal breadth: Ectorbitale (Ect) to ectorbitale (Ect)
#34...... Greatest palatal breadth: measured across outer borders of alveoli of M1
#35...... Least palatal breadth: measured behind canines
#36...... Maximum breadth of palate at canine alveoli: from buccal side of canines

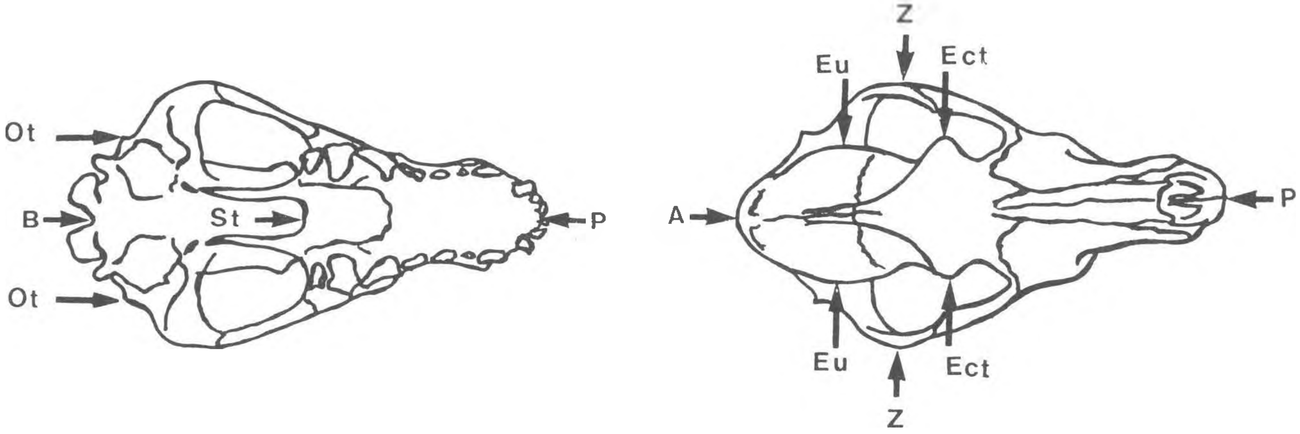


Figure 4-18. Cranial diagram, marked with reference points used in measurement descriptions. Ect=ectorbitale; Eu=euryon; A=akrokranion; P=prosthion; B=basion; Z=zygion; St=staphylion. Ot=otion

5

MANDIBLES

Osteological description

The total mandible sample is comprised of thirty-six essentially intact specimens and thirty-nine incomplete ones. Photographs of selected intact mandibles are presented in Figures 5-1 and 5-2. Three specimens out of the total measurable sample of seventy-five specimens were burnt and two specimens had some shallow cut marks.

Congenitally missing teeth are a common anomaly in prehistoric domestic dogs (Allen 1920; Haag 1948; Colton 1970; Shigehara & Onodera 1984; Digance 1986; Gleeson 1970; Montgomery 1979). In this sample, missing incisors or canines were never encountered, but premolars were very often missing and third molars occasionally. Pairs of mandibles from the same individual were often missing the same teeth, but this was not always the case. Consequently, right and left mandibles from the same individual are treated as discrete elements in the examination of tooth anomalies.

Table 5-1 presents the incidence of congenitally absent premolars and molars for the eighty-one mandibles in this study which could be assessed for this trait (this includes a few specimens that could not be used in the osteometric analysis). Only ten of these eighty-one mandibles had a full complement of teeth. The loss of premolar 1 (P1) was most common, either by itself or with other teeth, and this anomaly occurred in 81.5% of the sample. Premolars 2, 3 and 4 (P2, P3, P4) were rarely missing on their own and were occasionally missing along with P1. In one instance, P1, P2 and P3 were missing in the same individual (Figure 5-3). Lower molars 1 and 2 (M1, M2) were never missing, and molar 3 (M3) was missing in addition to P1, a situation that occurred in two individuals.

Missing lower premolars, especially P1, appear to be a common North American tooth anomaly for indigenous dogs (Colton 1970; Lawrence 1968; Allen 1920). In contrast, Shigehara and Onodera (1984) reported no incidence of congenitally absent lower P3 or P4 out of a sample of eighteen Jomon period dog mandibles, while incisors and canines were occasionally reported missing. G.R. Clark's (1995) study of prehistoric kuri from New Zealand reports a missing or extra third molar as the most commonly occurring anomaly: the first premolar was rarely absent in his sample.

The variety of tooth anomalies reported in samples of prehistoric dogs from different regions of the world suggests the possibility that unique patterns of tooth development may become fixed in discrete populations and that there may be no general pattern for all dogs.

As is evident from the specimens shown in Figures 5-1 and 5-2, a consistent feature of this sample is the curved shape of the posterior edge of the coronoid process. Olsen and Olsen (1977) discuss this distinctive shape of the ascending ramus, which is shared by the Chinese wolf (C. lupus chanco) but not the North American wolf or the coyote; the ascending ramus has a straight rear edge in both later species. They present this fact as evidence that the Chinese wolf was the ancestor of North American dogs.

Sex determination and sex ratios

A total of sixteen mandibles were determined to be female and fifty-five male for the specimens that were intact enough to be assessed according to the subjective criteria discussed in Chapter 1 (depth and definition of the condyloid crest). The sex of seven specimens could not be determined. The distribution of the sexes within the total sample is very unequal (more than 3:1 in favour of males), although the ratio within the intact sample (i.e. the sample used to characterize "breed" types) was slightly less biased, being 2:1 in favour of males (23 males/13 females).

After division of the intact sample at the mean of the greatest length (described below), eleven males and eleven females made up the type 1 sample; twelve males and two females made up the type 2 sample. When fragmented specimens were classified, this added seventeen males and three females to type 1, and twelve males to type 2

Altogether, twenty-eight males and fourteen females comprised the type 1 sample, while twenty-four males and two females comprised the type 2 sample. Even if known paired specimens are counted only once, the ratio of females to males remains essentially the same (23 males:11 females, type 1; 18 males:2 females for type 2). As with the cranium sample, this difference in ratio of males to females may indicate deliberate husbandry of the small dog type and is evidence in favour of it representing the wool dog.

Figure 5-1. Photos, right mandible examples (female), top to bottom: specimen #0800, #2003, #2660a.

Figure 5-2. Photos, right mandible examples (male), top to bottom: specimen #0108E, #0519, #2412A, 3018.

Table 5-1. Incidence of congenitally absent teeth in 81 mandibles (10 had a full complement of teeth).

	Missing tooth or tooth combination								
Side	P1	P2	P1 & P2	P3	P1 & P2 & P3	P4	P1 & P4	P1 & P3	P1 & M3
R	27	0	1	1	1	1	0	0	2
L	33	1	2	0	0	0	1	1	0

Type classification

The sample of thirty-six intact mandibles was divided into two subsamples at the mean of the total length measurement (#1), at 128.3 mm. The subsample of small mandibles (type 1) has twenty-two members with a mean of 121.6 mm and the large mandible subsample (type 2) has fourteen members with a mean of 138.8 mm (Tables 5-2a & 5-2b).

Figures 5-5 to 5-8 show the distribution of specimens, by type, when various pairs of measurements are plotted in relation to each other. The scatter of points for the carnassial alveolus (#14) vs. the total length dimension (#1) demonstrates how variable the length of M1 is within each of the dog types, suggesting it is a measurement that is much too variable to be a diagnostic character for either breed (Fig. 5-8).

The fragmented mandible sample was classified to type using the analysis results from the intact sample. The results of this classification are presented in Table 5-3. As for the cranium sample, the range of measurements for many of the dimensions overlap to some degree and specimens were assessed as belonging to type 1 if the available measurements for a fragment fell within the reported range for its type without being in the range of overlap of the range for type 2. Specimens were assigned to type 2 if the available measurements fell within the reported range for type 2 without being in the range of overlap of the range of type 1. If most of several values were in the range of overlap but one or more values clearly fell within the range of one distinct type, the specimen was classified as belonging to that type. Those specimens that could not be confidently assigned to one type or another were not included in the tables.

Discriminant function analysis

The discriminant analysis for that portion of the sample for which measurements #1, #4, #7, #17, #19, and #20 were available (n = 31) indicate only one specimen may have been misclassified, as the analysis produced a probability of group membership that was less than 5% (Table 5-2a). This specimen had been identified as a small dog according to its total length dimension, but dimensions other than length indicate it was an especially robust animal.

Previously reported Northwest Coast material: type classification

Previous studies on Northwest Coast dog remains have concentrated on mandibular measurements for much of their statistical analysis. However, as discussed in Chapter 1, Gleeson's (1970) study predates the publication of standard measurements (von den Driesch 1976) used in this analysis. Both he and Montgomery (1979) used measurements as defined by Haag (1948) or ones very similar and few of these are identical to those found to be useful in discriminating between breeds in this study. The only bone measurements presented by Digance (1986) are for the depth below the centre of M1, as he otherwise utilized only tooth measurements for his statistical analysis. It was unfortunately not possible to locate either Gleeson's or Digance's original mandible assemblages for re-examination.

Only a few measurements originally reported by Montgomery and Gleeson are comparable to the significant dimensions used in this study (Table 5-4). Only one of the five mandibles of adult individuals reported by Montgomery falls into the large type as defined by this study and three are clearly of the small type. One lacks enough comparable dimensions to be classified.

Of interest is that all ten of the mandibles reported by Montgomery, including the five subadults not included in this osteometric comparison, showed congenital absence of lower premolar 1. One of the adults was also missing P2 but none were lacking P3 or P4 in addition to P1.

Only three of the five mandibles recovered from prehistoric strata at Ozette (Gleeson 1970) were complete enough to compare to this assemblage and the measurements of these are also presented in Table 5-4. One specimen can be classified as a small dog and another as a large one. The third remains of questionable type. Of the five prehistoric mandibles reported by Gleeson, two showed congenital absence of lower premolar 1 and an addition two were missing both P1 and P4. One mandible had a full complement of teeth and none were missing P2.

Mandibles

Measurement Number	Measurement description
#1	Total length: condyle process (CP)-infradentale (Id)
#2	Angular length: angular process (AP)-infradentale (Id)
#3	Indentation length: indentation between the condyle process (CP) & angular process (AP)-infradentale (Id)
#4	Condyle/canine length: from the condyle process (CP) to aboral border of canine alveolus
#5	Indentation/canine length: from the indentation between the condyle process (CP) & angular process (AP) to aboral border of canine alveolus
#6	Angular/canine length: from the angular process (AP) to aboral border of canine alveolus
#7	Tooth row length: from aboral border of M3 alveolus to aboral border of the canine alveolus
#9	Cheek tooth row length: alveolus of M3 to alveolus of P2 from lingual side; when P1 is missing
#10	Molar row length: length of M1 to M3 from lingual side
#11	Premolar row length: length of P1 to P4 from buccal side
#12	Premolar row length : length of P2 to P4 from buccal side; when P1 is missing
#14	Carnassial alveolus length: along lingual side of M1
#17	Thickness of horizontal ramus: at oral border of M1 alveolus, at right angles to basal border, lingual side
#18	Height of vertical ramus: from angular process (AP) to coronion (Cr)
#19	Thickness of horizontal ramus: at aboral border of M1 alveolus, at right angles to basal border, lingual side
#20	Thickness of horizontal ramus: between alveoli of P2 & P3, at right angles to basal border, lingual side

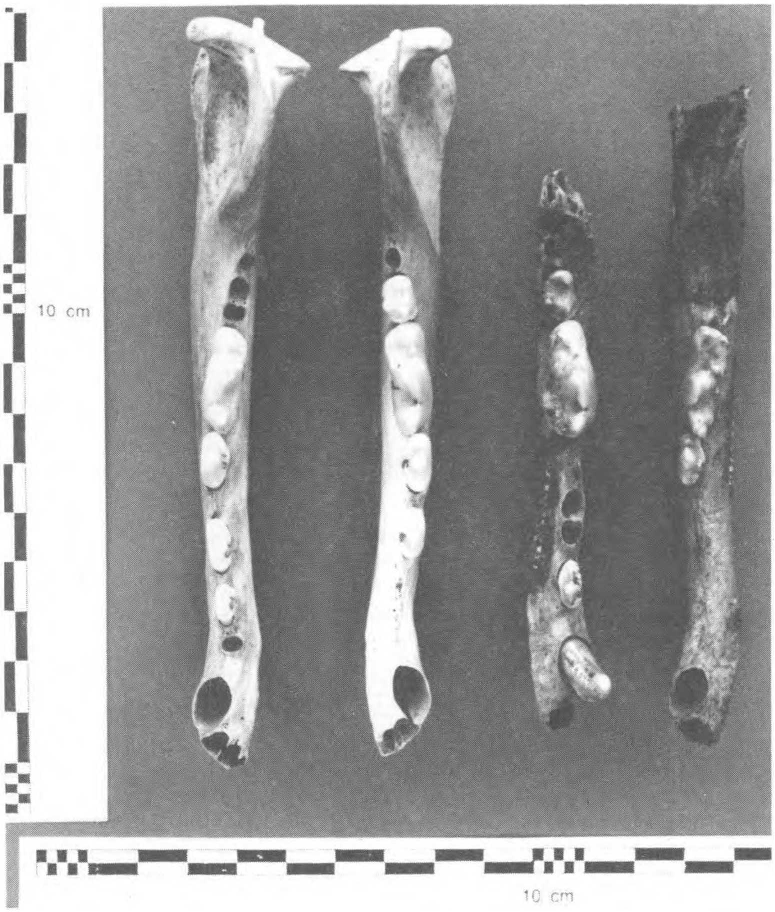


Figure 5-3. Examples of mandibles with congenital tooth anomalies (absent teeth), left to right: specimen 1010a1 (R), no missing teeth; specimen #1010a (L), premolar 1 and 2 mising; specimen #1444 (L), premolar 4 missing; specimen #2001 (R), premolars 1,2, and 3 missing.

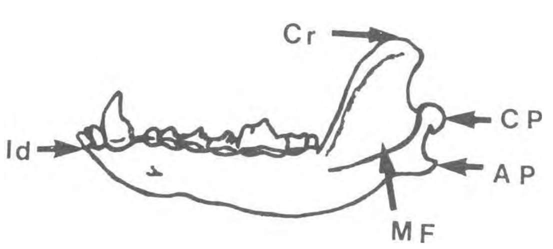


Figure 5-4. Diagram of mandible, marked with reference points used in measurement descriptions (except for MF, which is the masseteric fossa used for determining sex).

Table 5-2a. Univariate statistics of mandible sample, division at the mean (1), measurements #1-10 and results of multivariate crossvalidation of type classification.

				** % Probability of	Measurement code number									
Specimen	**Sex**	**Side**	**Type**	**group membership**	**(1)**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1443	F	L	1	100.0	103.0	104.0	101.3	85.0	85.2	86.8	63.8		60.4	32.7
0805K	F	L	1	100.0	112.2	110.6	107.7	93.7	91.0	92.8	66.8		63.4	33.9
2619	M	L	1	100.0	114.0		107.9	100.4	95.8		66.7		60.0	31.1
1205	F	R	1	99.6	117.0		115.0	98.5	96.0		68.8		62.9	33.2
2224A	F	R	1	98.3	119.4		115.8	102.0	99.6		70.9		65.4	31.9
0527	M	L	1	-	119.5	114.0	120.5					66.5	62.5	32.9
0113	M	L	1	100.0	119.5		112.7	106.8	100.9		69.2		60.5	32.4
0302	M	R	1	99.6	120.0	119.3	115.0	104.4	99.2	104.3	67.9		60.5	30.5
2660	F	R	1	99.8	121.0	121.8	116.0	105.0	100.5	106.0	70.4		64.7	32.8
3002I	F	L	1	98.8	121.2	120.7	116.8	103.1	99.8	103.5	69.4		63.7	34.0
3002K	F	R	1	99.0	121.4	120.6	117.5	103.0	99.4	102.5	65.9		60.2	29.2
2013	M	R	1	98.7	122.7		117.0	105.1	100.2		69.8		63.0	34.2
0802A	M	L	1	-	123.0		118.0	107.7	103.4		71.9		63.3	32.9
0800	F	R	1	90.9	126.0		121.1	110.1	105.7		71.4		64.0	31.9
0300O	M	R	1	94.5	126.0	126.8	121.0	111.2	106.2	111.6	72.9		64.1	32.8
0300P	M	L	1	98.2	126.0		119.7	112.0	107.1		71.9		63.2	31.5
0803M	M	L	1	52.8	126.1		120.6	107.7	102.6		71.2		63.2	33.2
3003G	F	L	1	49.1	126.7	127.2	123.1	109.2	106.2	109.7	73.4		67.4	34.1
3003F	F	R	1	18.2	126.9	126.3	123.8	110.3	108.0	111.5	74.6		67.4	34.6
2004	F	L	1	76.3	127.0		121.7	108.6	104.6		73.3	70.6	66.4	35.1
3000G	M	R	1	1.8*	127.8	129.2	124.1	111.6	107.8	113.3	72.6		64.2	32.0
3000L	M	L	1	-	128.3	129.9	123.7	110.6	106.7	113.0				
2002G	M	L	2	98.3	134.8		129.5	113.3	108.0		75.6		69.6	39.0
1010A	M	L	2	-	135.0	136.8	131.3	118.3	114.5	119.9	78.0			34.7
0360Q	M	L	2	77.4	135.0		128.0	119.0	112.8		76.1		66.8	32.3
0108A	M	L	2	96.5	136.0		130.0	118.0	112.0		76.3		69.1	34.5
0108E	M	R	2	99.1	136.2	129.8		117.0	111.5		76.7		68.5	34.3
0950B	M	R	2	94.4	137.5	135.8	131.5	119.1	113.9	117.8	78.3		70.6	36.3
3018GGG	M	R	2	-	137.7		131.6	119.2	112.5		78.5			36.1
1010A1	M	R	2	98.5	137.8	138.8	132.8	120.0	115.9	122.0	78.9	74.5	69.4	33.5
1020H	M	L	2	98.3	138.5	139.8	132.5	121.8	115.9	123.3	77.9		68.5	33.9
2003	F	R	2	98.8	140.0	138.0	134.5	121.4	116.6	120.2	79.3		72.0	35.6
3018FFF	M	L	2	-	140.0	140.5	135.0	122.0	117.0	122.7	79.1			36.0
1020A	M	R	2	99.8	140.5		132.9	122.1	115.5		78.8		68.8	33.8
1011A	F	L	2	99.9	143.5	143.0	138.9	124.2	120.4	124.7	80.0		73.9	34.9
2008	M	L	2	100.0	150.5	150.0	143.8	131.9	125.9	131.1	84.0	78.3	73.0	38.0

Statistics	Measurement code numbers									
	(1)	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
total count	36	21	35	35	35	19	34	4	32	35
total mean	128.3	128.7	123.2	111.2	106.8	112.5	73.5	72.5	65.6	33.7
total std	9.9	11.3	9.3	9.4	8.5	11.0	4.8	4.4	3.8	2.0
total min	103.0	104.0	101.3	85.0	85.2	86.8	63.8	66.5	60.0	29.2
total max	150.5	150.0	143.8	131.9	125.9	131.1	84.0	78.3	73.9	39.0
total CV	7.73	8.74	7.52	8.48	7.98	9.78	6.47	6.05	5.80	5.82
type 1 count	22	12	22	21	21	11	20	2	21	21
type 1 mean	121.6	120.9	117.3	105.0	101.2	105.0	70.1	68.6	63.4	32.7
type 1 std	5.9	7.6	5.7	6.4	5.7	8.2	2.8	2.0	2.2	1.4
type 1 min	103.0	104.0	101.3	85.0	85.2	86.8	63.8	66.5	60.0	29.2
type 1 max	128.3	129.9	124.1	112.0	108.0	113.3	74.6	70.6	67.4	35.1
type 1 CV	4.89	6.30	4.85	6.14	5.59	7.76	3.95	2.99	3.40	4.24
type 2 count	14	9	13	14	14	8	14	2	11	14
type 2 mean	138.8	139.2	133.3	120.5	115.2	122.7	78.4	76.4	70.0	35.2
type 2 std	4.0	5.2	4.0	4.1	4.1	3.8	2.0	1.9	2.0	1.7
type 2 min	134.8	129.8	128.0	113.3	108.0	117.8	75.6	74.5	66.8	32.3
type 2 max	150.5	150.0	143.8	131.9	125.9	131.1	84.0	78.3	73.9	39.0
type 2 CV	2.91	3.71	3.02	3.38	3.59	3.07	2.57	2.47	2.91	4.91

* misclassified according to multivariate analysis, at < 5% probability of group membership.

** this is the probability of group membership, variables 1,4,7,17,19,20 together.

Table 5-2b. Univariate statistics of mandible sample, division at the mean (1), measurements #11-21

				Measurement code number											
Specimen	**Sex**	**Side**	**Type**	**11**	**12**	**13**	**13A**	**14**	**15**	**15A**	**17**	**18**	**19**	**20**	**21**
1443	F	L	1		29.9			20.1	8.3	6.0	17.1		18.2	15.6	32.8
0805K	F	L	1		33.0			21.0			16.7	43.0	18.6	17.5	
2619	M	L	1		30.0			19.5	8.2	5.9	18.5		18.4	16.7	33.8
1205	F	R	1		31.8			19.2	8.5	6.3	20.5	44.0	20.9	18.0	
2224A	F	R	1		33.9			19.7			20.6		20.6	17.8	
0527	M	L	1	36.2	33.0			20.9			19.1	50.0	20.0	17.6	
0113	M	L	1		28.8			19.1			19.5	47.0	22.4	18.5	
0302	M	R	1		31.5			18.1	7.5	5.6	20.1		21.0	16.6	32.1
2660	F	R	1		33.3			21.2			20.0	49.0	22.1	17.9	34.0
3002I	F	L	1		33.0			21.7			19.6	49.8	21.8	16.9	
3002K	F	R	1		32.3			20.9			19.1	49.8	21.9	17.2	
2013	M	R	1		30.7			22.2			19.7		21.3	18.0	
0802A	M	L	1		31.7			20.0			20.6		21.2	18.9	
0800	F	R	1		32.1			19.2	7.8	5.9	21.2		22.2	17.5	32.7
0300O	M	R	1		33.1			21.3			22.1	48.8	21.7	19.9	
0300P	M	L	1		33.3			20.7			22.2	49.7	22.8	19.3	
0803M	M	L	1		31.7			21.8			24.0		25.0	21.6	
3003G	F	L	1		35.0			21.3	8.0	5.8	20.5	49.5	21.9	17.0	
3003F	F	R	1		35.1			21.5			20.7	50.4	21.9	16.9	
2004	F	L	1	37.7	33.5			22.1	9.1	6.6	22.4		22.7	21.1	
3000G	M	R	1		33.3			19.8			21.9	54.0	23.2	18.9	35.2
3000L	M	L	1		33.0			20.6			20.8	53.3		18.3	
2002G	M	L	2		32.8			25.6			23.2		24.1	19.2	
1010A	M	L	2					20.7			21.3	53.7	21.8	18.1	
0360Q	M	L	2		35.0			19.0			24.0		24.7	19.1	
0108A	M	L	2		36.4			20.8			25.0		25.2	19.5	
0108E	M	R	2		35.6			20.5			24.3		24.6	18.8	
0950B	M	R	2		35.8			22.9			23.8	56.5	24.0	21.8	
3018GGG	M	R	2					21.4			23.2		24.3	19.2	
1010A1	M	R	2	41.8	36.9	20.2	7.4	19.8			23.8	55.5	23.7	20.4	
1020H	M	L	2		35.5			19.8			24.3		23.4	20.5	
2003	F	R	2		37.5			22.3	9.0	6.4	23.3	55.8	24.3	20.7	
3018FFF	M	L	2					22.4			22.4	56.3	23.3	18.7	39.3
1020A	M	R	2		35.4			20.8			23.9		23.3	20.1	
1011A	F	L	2		38.9			21.4	8.4	6.7	24.5	57.6	24.7	20.6	
2008	M	L	2	42.4	37.5			22.6			27.3	60.2	27.4	23.5	

Statistics	Measurement code numbers											
	11	**12**	**13**	**13A**	**14**	**15**	**15A**	**17**	**18**	**19**	**20**	**21**
total count	4	33	1	1	36	9	9	36	20	35	36	7
total mean	39.5	33.6			20.9	8.3	6.1	21.7	51.7	22.5	18.8	34.3
total std	2.6	2.3			1.4	0.5	0.4	2.3	4.4	2.0	1.7	2.3
total min	36.2	28.8			18.1	7.5	5.6	16.7	43.0	18.2	15.6	32.1
total max	42.4	38.9			25.6	9.1	6.7	27.3	60.2	27.4	23.5	39.3
total CV	6.67	6.90			6.59	5.91	5.85	10.63	8.52	8.83	8.94	6.60
type 1 count	2	22	0	0	22	7	7	22	13	21	22	6
type 1 mean	37.0	32.4			20.5	8.2	6.0	20.3	49.1	21.4	18.1	33.4
type 1 std	0.8	1.5			1.1	0.5	0.3	1.7	3.0	1.6	1.4	1.0
type 1 min	36.2	28.8			18.1	7.5	5.6	16.7	43.0	18.2	15.6	32.1
type 1 max	37.7	35.1			22.2	9.1	6.6	24.0	54.0	25.0	21.6	35.2
type 1 CV	2.03	4.74			5.25	5.83	5.14	8.12	6.01	7.42	7.79	3.06
type 2 count	2	11	1	1	14	2	2	14	7	14	14	1
type 2 mean	42.1	36.1			21.4	8.7	6.6	23.9	56.5	24.2	20.0	39.3
type 2 std	0.3	1.5			1.6	0.3	0.1	1.3	1.9	1.2	1.4	0.0
type 2 min	41.8	32.8			19.0	8.4	6.4	21.3	53.7	21.8	18.1	39.3
type 2 max	42.4	38.9			25.6	9.0	6.7	27.3	60.2	27.4	23.5	39.3
type 2 CV	0.71	4.24			7.50	3.45	2.29	5.42	3.28	4.99	6.83	0.00

Table 5-3. Mandible fragments, type classification.

				Measurement code number											
Specime	**Sex**	**Side**	**Type**	**4**	**5**	**6**	**7**	**9**	**10**	**12**	**14**	**17**	**18**	**19**	**20**
1012	M	L	1					60.6	37.3		22.5		58.6	24.5	
0592	?	L	1						32.0		19.9	16.0		16.9	
1462	?	R	1							29.6	21.1	16.7			18.7
0593	?	L	1							29.6					16.6
2220	?	R	1							30.0	19.6	17.1		18.0	15.5
0581	?	R	1							30.2	18.4	18.0		19.3	15.2
0802B	M	R	1					63.5	33.2	31.6	20.5	22.0		21.4	19.6
0100	?	L	1				65.0	59.7	32.6	29.7	20.4	18.9		20.7	16.3
0340	?	R	1				72.8	66.6	34.4	33.7	21.8	21.0		21.4	18.4
0803N	M	R	1				73.2	65 3	35.0	31.8	22.0	23.4		24.9	22.0
0306	M	L	1				73.5	74.2	39.0	36.5	24.8	25.2		24.1	21.2
0805L	F	R	1	94.1	91.3	93.4	66.9	62.9	33.6	32.6	20.6	18.0	43.4	19.4	17.8
2412A	M	R	1	95.4	92.5		65.3		32.9		20.3	17.1		18.4	16.3
2412E	M	L	1	96 2	93.1		66.4	60.1	33.0	28.2	19.8	17.8	43.2	18.9	17.3
2608A	M	R	1		94.1		66.3	59.5	31.3	29.6	19.4	18.3		18.5	16.3
2609A	F	L	1		94.2	99.1	69.0	62.8	34.4	30.2	21.2	20.0		20.3	19.0
1201	M	L	1	106.5	98.2	101.8	69.0	62.9	32.8	30.9	21.3	20.2		21.1	18.0
2406	M	R	1	102.5	98.3					30.4	19.7	18.2		20.8	17.1
2207	M	L	1	101.7	98.7	103.0				32.0		19.1			16.5
0336A	M	R	1	105.6	99.0	105.0	68.9	58.7	31.9	28.2	19.9	21.2		22.6	18.4
0519	M	R	1	103.4	99.3	105.6	69.8	61.6	32.5	31.7	21.0	19.2	48.2	19.6	18.5
0337	M	L	1		99.4	104.8		59.6	30.8	30.0	18.9	19.1		19.8	17.4
1424	M	R	1	105.0	99.4					30.7	20.0	18.7		21.0	17.6
0346	M	R	1	105.0	100.3	103.8	69.6	60.4	30.4	30.5	18.9	19.5	45.5	20.3	17.5
5002RR	M	L	1	106.2	103.0		71.4	66.2						22.5	18.6
1200	F	L	1	108.1	104.5	107.8	69.3	64 0	33.3	32.5	21.9	22.8	52.0	23.7	19.2
2226	M	R	1	109.1	105.5		72.3	65.7	33.6	33.0	20.7	21.9		23.2	19.2
1013	M	R	2										56.8	25.9	
0201F01	M	L	2							35.8	22.4	25.7		25.5	21.6
0201A01	M	R	2					68 0	35.2	35.2	22.0	25.8		27.8	21.9
2000	M	L	2				76.9	68.1	33.4	35.5	20.2	22.0		21.0	18.6
2002	M	R	2				76.9	71.1	40.5	33.4	25.0	22.7		24.4	19.8
2001	M	R	2				77.3		34.0		20.5	21.3		23.3	16.2
0105	M	R	2				82.3	74.0	38.5	37.5	23.5	23.8		26.0	20.5
2624A	M	L	2	117.9	110.7		74.8	64.6	33.3	32.8	22.3	24.9	54.2	27.1	20.6
0316	M	L	2	116.6	111.8		74.1	65.0	33.9	34.0	20.4	21.4		21.8	18.7
0950A	M	L	2	117.3	113.3		77.8	69.4	36.7	34.8	21.9	23.4		26.3	22.1
1202	M	R	2	127.4	120.9	123.3	81.4	73.2	36.1	37.5	22.3	27.0		26.4	22.1
2100	M	R	2										63.1	31.4	

Table 5-4. Selected measurements and classification of previously reported Northwest Coast mandibles, from Ozette Village and Semiahmoo Spit, Washington State (Fig 1-1)

			Measurement code number *		
			2	**9**	**14**
Specimen	**Side**	**Type**	**[39]**	**[31]**	**[35]**
Semiahmoo 2	R	2	133 7	70.9	20.6
Semiahmoo 7	L	1	122.6	63.9	20.0
Semiahmoo 9	R	1	118.7	65.2	20.5
Semiahmoo 11	R	1	118.5	65.0	20.5
Ozette A4/XVI/3	R	1	-	61.0	(21.4)
Ozette A8/XIII/1	R	2	-	70.8	23.3
Ozette A8/XIV/1	R	?	-	68.8	21.1

* Numbers on second line are the measurement numbers used by the original authors. Values in brackets ( ) are approximate measurements.

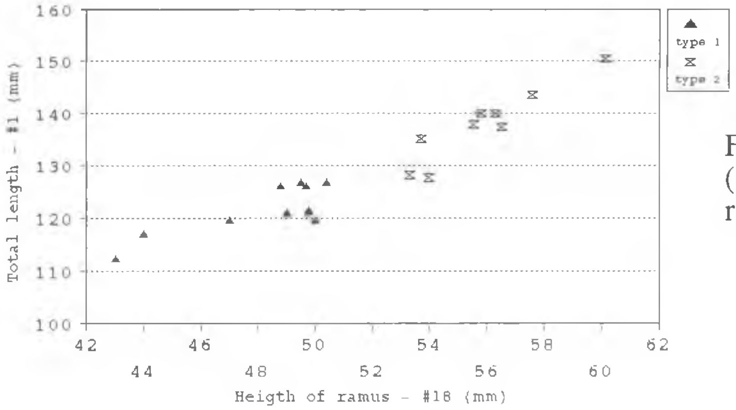


Figure 5-5. Plot of mandible measurement #1 (greatest length) vs.#18 (height of ascending ramus).

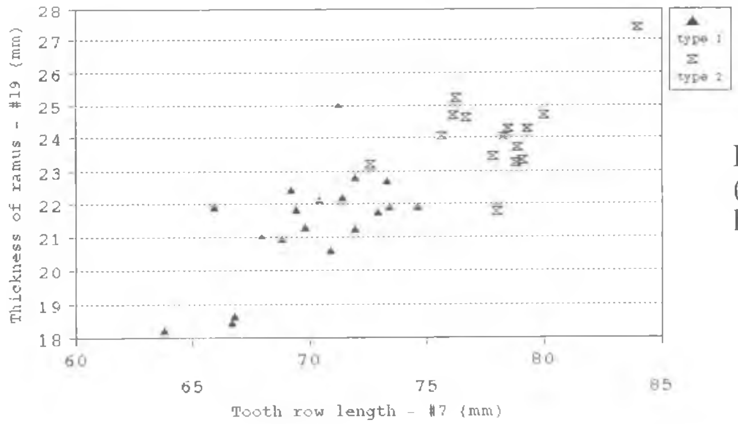


Figure 5-6. Plot of mandible measurement #7 (tooth row length) vs.#19 (thickness of horizontal ramus).

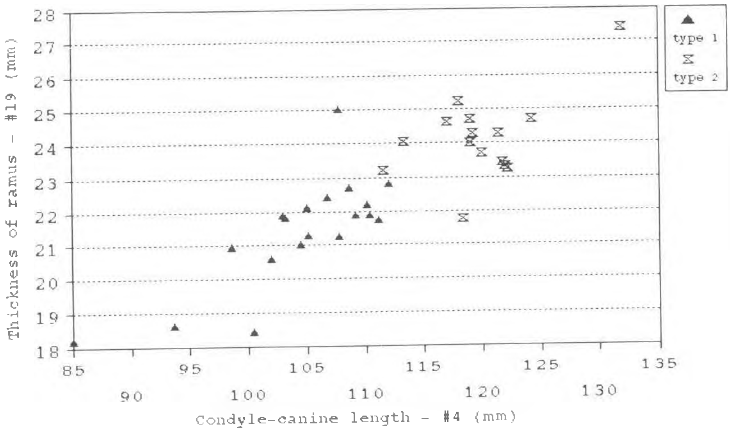


Figure 5-7. Plot of mandible measurements #4 (condyle-canine length) vs. #19 (thickness of horizontal ramus).

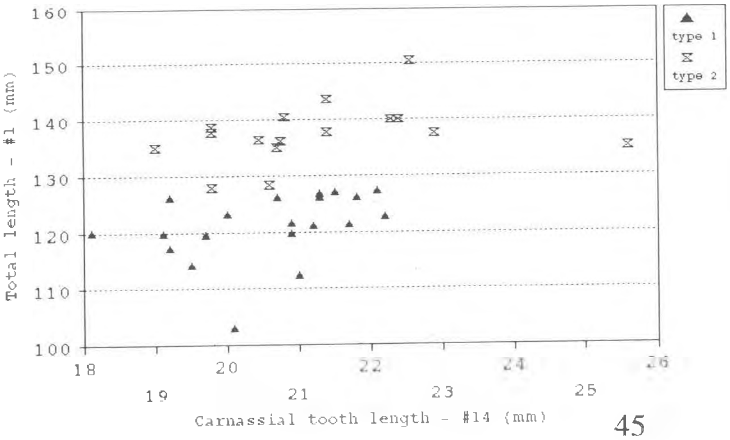


Figure 5-8. Plot of mandible measurement #1 (greatest length) vs.#14 (carnassial alveolus length).

6

FORELIMB ELEMENTS

Forelimb element sample

The various forelimb elements included in the study are discussed separately below, ending with the classification of comparable previously reported Northwest Coast material. Tables containing raw data, classification of intact specimens (created by separating the sample at the mean of the greatest length), and discriminant analysis results (which assigns a probability value for group membership) of this sample are presented at the end of the chapter. Each of these tables are followed by a table containing the classification results of fragmented material for each element. As for the crania and mandibles, fragmented specimens with values that fell within the zone of overlap between the two types are not included in the classification tables. The definitions of the measurements used precede these tables. Figures 6-1 and 6-2 are photographs of selected elements and Figures 6-3 through 6-7 are graphs showing the relationship of various dimensions of selected elements (humerus, radius, ulna) by classified type.

Scapula: The scapula blade of the dog is thin and especially prone to depositional and post-depositional damage and like crania, was not often recovered intact. Only sixteen specimens were recovered which could be used in a characterization analysis (Table 6-1). However, an additional twenty-two specimens were recovered for which proximal end measurements could be taken and classified to type based on the limits established by the characterization analysis (Table 6-2). The mean length of the total scapula sample was 126.1 mm, with the mean of type 1 calculated to be 117.4 mm and that of type 2, 134.8 mm. One intact scapula had a significantly low discriminant function probability of group membership (5%).

Humerus: Humerus elements were recovered from archaeological assemblages in relatively high numbers. Many of the samples were slightly to extensively chewed on one end however, which dramatically reduced the numbers of intact specimens available. A total of only twenty specimens out of forty-nine recovered were intact enough to use for determining types (Table 6-3). The mean length of the total humerus sample was 152.7 mm, with the mean of type 1 calculated as 143.5 mm and that of type 2, 161.3 mm. Broken or otherwise incomplete humerus elements were classified to type by comparison to the analysis of the intact sample and the results are listed in Table 6-4. Photographs of selected humerus elements are presented in Figure 6-1.

Radius: While a reasonably large sample of radii were recovered (n=48), many were damaged or missing one epiphysis. A sample of only twenty-one intact elements was available to characterize the radius (Table 6-5), while an additional twenty-seven specimens could be confidently assigned to type based on the analysis of the intact specimens (Table 6-6). The mean length of the total radius sample was 142.6 mm, that of the type 1 subsample 136.0 mm, and of the type 2 subsample, 149.9 mm.

Ulna: The ulna is both a fragile element and one which is rather difficult to measure consistently and accurately, due to the shape of the coronoid process and the way in which the oleocranon process projects beyond the humeral articulation joint. The thin distal portion of the ulnae in this sample was often broken, but enough whole elements were recovered (n=21) to perform a statistical analysis (Table 6-7). The mean length of the total ulna sample was 168.6 mm; the mean of the subsample of type 1, 157.5 mm and that of the type 2 subsample, 180.0 mm. An additional thirty-three incomplete specimens could be assigned to type later by comparison to the analysis of the intact sample (Table 6-8). Photographs of selected ulnae are featured in Figure 6-2.

Metacarpals: A total of one hundred and twenty-five intact metacarpals were recovered.

Each was subjected to individual statistical analysis to determine type (Table 6-9a and 6-9b), except for the first metacarpal (MCI), which did not have enough specimens for comparison (n=6). Metacarpal II (n=31) had a total mean length of 49.3 mm; the mean of type 1, 45.9 mm and of type 2, 54.7 mm. Metacarpal III (n=30) had a total mean length of 57.8 mm; the mean of type 1, 53.5 mm and of type 2, 63.4 mm. Metacarpal IV (n=32) had a total mean length of 59.1 mm; the mean of type 1, 53.8 mm and of type 2, 64.4 mm. Metacarpal V (n=26) had a total mean length of 49.8 mm; the mean of type 1, 45.8 mm and of type 2, 53.2 mm.

Previously reported Northwest Coast material: type classification

Montgomery (1979) reports the measurements of several complete adult front limb elements from the Semiahmoo Spit deposits (45WH17) which can be classified according to the criteria established by this analysis. Neither she nor Gleeson (1970) included metacarpals. Measurements of the humerus and radius only are available and are listed in Table 6-10 below. All of these specimens are clearly of the small type.

Definition of measurement codes

HS........Height along the spine (scapula)
GL........Greatest length
SLC......Smallest length of neck (scapula)
GLP......Greatest length of glenoid process (scapula)
Bp........Greatest breadth of proximal end
Dp........Greatest depth of proximal end (humerus)
Bd........Greatest breadth of distal end
SD........Smallest breadth of diaphysis
SDO.....Smallest depth of olecranon (ulna)
DPA.....Shortest depth across oleocranon process, from oleocranon process to caudal border (ulna)

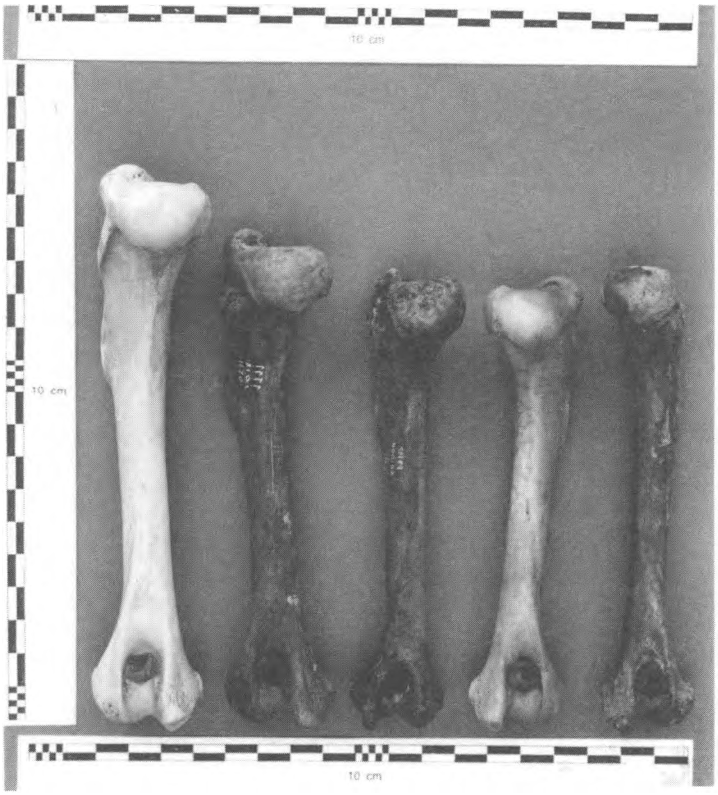


Figure 6-1. Photo, humerus examples, left to right: specimen #1134 (L), #3018 (L), #0400 (L), #2407 (R), #3008 (R).

Table 6-1. Scapula univariate statistics, division at the mean (HS)
and results of multivariate crossvalidation of type classification.

Specimen	Sex	Side	Type	(HS)	SLC	GLP	BG	** % Probability of group membership
0207+		L	1	101.4	18.7	22.9	13.7	100.0
2411B		L	1	109.3	22.5	25.7	15.4	100.0
0300GG	M	L	1	114.9	22.7	26.6	16.4	100.0
0400A08		L	1	118.0	23.7	27.5	17.0	100.0
0400A07		R	1	119.1	24.1	27.3	17.1	100.0
0204+		R	1	125.0	25.6		19.2	100.0
3018AAAA	M	R	1	125.5	24.0	28.6	17.5	72.8
3018BBBB	M	L	1	125.7	26.1	31.2	19.0	5.1*
3004A	M	L	2	128.8	24.5	30.8	17.9	100.0
3004B	M	R	2	130.0	25.1	31.1	18.2	100.0
1098+		R	2	131.7	21.4	29.2	17.6	100.0
1097+		R	2	133.5	26.3	31.2	19.1	86.3
1096		L	2	136.5	28.8	32.0	19.1	99.9
2007		L	2	136.8	26.1	32.3	19.6	99.9
1099		R	2	139.0	26.0	31.1	18.5	100.0
1179		L	2	142.3	27.3	32.2	19.7	100.0

\+ possibly subadult (juvenile texture), HS may be slightly underestimated

Statistics	(HS)	SLC	GLP	BG
total count	16	16	15	16
total mean	126.1	24.6	29.3	17.8
total std	10.9	2.4	2.7	1.6
total min.	101.4	18.7	22.9	13.7
total max.	142.3	28.8	32.3	19.7
total CV	8.63	9.66	9.22	8.88
type 1 count	8	8	7	8
type 1 mean	117.4	23.4	27.1	16.9
type 1 std	8.1	2.1	2.4	1.7
type 1 min.	101.4	18.7	22.9	13.7
type 1 max.	125.7	26.1	31.2	19.2
type 1 CV	6.90	9.11	8.72	10.00
type 2 count	8	8	8	8
type 2 mean	134.8	25.7	31.2	18.7
type 2 std	4.3	2.0	0.9	0.7
type 2 min.	128.8	21.4	29.2	17.6
type 2 max.	142.3	28.8	32.3	19.7
type 2 CV	3.22	7.91	3.00	3.90

* starred entries are missclassified, at < 5% probability of group membership.

** this is the probability of membership in the "type" group as initially classified, based on multivariate analysis using variables HS, SLC, GLP, BG together.

Table 6-2. Scapula fragments, type classification.

Specimen	Sex	Side	Type	SLC	GLP	BG
1597		L	1		26.9	17.4
1588		L	1	21.0	24.5	15.0
1270		R	1	21.1	26.1	15.6
1273		R	1	21.2	25.9	15.7
0437		R	1	21.5	26.8	17.5
1517		L	1	21.8	24.4	15.2
1103		L	1	21.8	26.3	16.7
3002S	F	L	1	21.9	26.8	15.8
0211		L	1	22.1	27.6	16.3
2109		L	1	22.2	25.6	15.3
0437		R	1	22.3	27.8	16.5
0338		R	1	22.7	25.9	15.8
1485		R	1	22.7	26.8	16.1
3002N	F	R	1	23.0	27.5	16.6
0351		L	1	23.1	26.0	15.8
0530		L	1	23.1	28.4	17.7
1101		L	1	23.3	27.5	17.1
1618		L	1	24.1	28.2	17.0
1271		L	1	24.4	28.0	17.2
2030		R	1	25.2	28.1	17.3
5076		R	2		32.0	18.8
1102		R	2	30.9	34.5	21.3

Table 6-3. Humerus univariate statistics, division at the mean (GL) and results of multivariate crossvalidation of type classification.

Specimen	Sex	Side	Type	(GL)	Bd	Dp	SD	** % Probability of group membership
0400A02		L	1	137.0	27.5	33.0	11.7	99.9
2407		R	1	137.0	28.9	36.8	11.7	99.9
2032		R	1	137.6	27.0	36.3	11.4	99.9
0400A01		R	1	138.6	26.8	33.9	12.0	99.9
1509		R	1	140.5	28.4	35.5	11.4	99.9
0300FF	M	L	1	141.5	29.6	36.2	12.3	99.8
3008		R	1	142.0	27.5	35.2	10.7	99.8
2410		L	1	143.1	27.5	37.2	12.0	94.9
1434		R	1	146.5	30.8		11.7	-
3000SS	M	R	1	147.1	30.6	39.9	11.2	96.8
1030		R	1	147.5	29.3	37.3	11.6	95.8
0324		L	1	149.1	30.7	39.1	11.9	91.4
3018JJJJ	M	L	1	150.2	33.3	41.2	13.6	15.8
3018IIII	M	R	1	151.1	30.6	39.2	11.4	81.3
0950KK		L	2	152.7	31.4	39.8	11.6	6.7
0136		R	2	153.0	30.8		11.5	-
0950JJ		R	2	153.0	32.1		11.4	-
1036		L	2	155.5	30.9	39.8	12.2	82.7
1035		L	2	158.0	33.0	41.5	12.9	94.4
3004C	M	L	2	159.5	33.8	42.7	13.1	97.1
1034		R	2	160.3	31.6	41.5	12.3	98.5
3004D	M	R	2	160.4	33.9	42.7	12.5	95.6
1032		L	2	160.6	30.5	38.8	12.5	98.9
1029		R	2	161.5	30.0	40.1	11.6	98.8
1033		L	2	163.3	34.3	42.7	13.0	99.5
1132		R	2	166.0	33.8	42.9	12.9	99.9
1136		L	2	167.7	35.5	43.1	13.8	99.9
1134		L	2	168.3	33.7	44.0	14.0	100.0
1104C		L	2	179.1	34.4	43.4	11.6	100.0

Statistics	(GL)	Bd	Dp	SD
total count	29	29	26	29
total mean	152.7	31.0	39.4	12.1
total std	10.7	2.4	3.1	0.8
total min.	137.0	26.8	33.0	10.7
total max.	179.1	35.5	44.0	14.0
total CV	7.00	7.86	7.87	6.71
type 1 count	14	14	13	14
type 1 mean	143.5	29.2	37.0	11.7
type 1 std	4.9	1.8	2.3	0.6
type 1 min.	137.0	26.8	33.0	10.7
type 1 max.	151.1	33.3	41.2	13.6
type 1 CV	3.39	6.18	6.17	5.48
type 2 count	15	15	13	15
type 2 mean	161.3	32.6	41.8	12.5
type 2 std	6.8	1.6	1.6	0.8
type 2 min.	152.7	30.0	38.8	11.4
type 2 max.	179.1	35.5	44.0	14.0
type 2 CV	4.22	5.00	3.82	6.43

** this is the probability of membership in the "type" group as initially classified, based on multivariate analysis using variables GL, Bd, Dp, SD together.

Table 6-4. Humerus fragments, type classification.

Specimen	Sex	Side	Type	Bd	Dp	SD
2234B		L	1		38.0	
0213		R	1		38.3	
0212		L	1	24.7		10.1
0595		L	1	25.0		9.9
2039		L	1	25.0		10.1
0601		R	1	25.7		10.1
0611		L	1	25.9		9.4
0597		R	1	26.7		
1548		R	1	26.8		
2225		L	1	27.0		10.7
0350A		R	1	27.2		
1457		R	1	28.1		
0553		R	1	28.1		
3002V	F	R	1	28.5		10.3
1456		L	1	28.5		
2096		R	1	28.8		11.2
5023		R	1	29.0		
1133		R	2		42.4	
1031		L	2	34.6		14.4
5016		R	2	34.9		

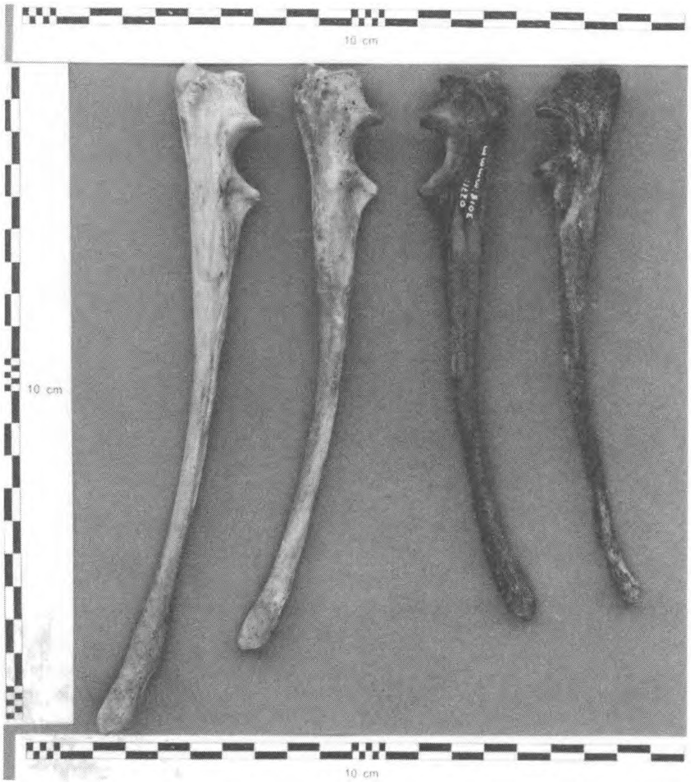


Figure. 6-2. Photo, ulna examples, left to right: specimen #1039 (R), #3004 (R), #3018 (L), #0400 (L).

Table 6-5. Radius univariate statistics, division at the mean (GL)
and results of multivariate crossvalidation of type classification.

Specimen	Sex	Side	Type	(GL)	Bd	Bp	SD	** % Probability of group membership
5029		L	1	123.0	19.5	14.4	9.6	100.0
1285		L	1	130.0	21.6	15.6	10.5	99.9
2012		L	1	134.0	17.4	16.3	11.2	100.0
4040		L	1	136.0	22.1	16.1	9.9	97.0
3000UU	M	R	1	137.0	23.1	16.9	10.5	91.9
3018LLLL	M	R	1	137.0	22.6	17.2	11.2	97.8
2200		R	1	139.0	21.8	15.6	10.5	89.5
3018KKKK	M	L	1	139.0	24.9	18.3	12.7	18.1
0400A06		R	1	140.0	17.0	15.8	10.3	99.6
1570		L	1	140.0	21.9	15.9	10.9	84.4
0400A05		L	1	141.0	19.8	16.1	10.5	95.2
4044		L	2	146.0	24.4	17.5	11.4	94.9
1041		R	2	147.0	23.5	17.4	11.1	94.0
4000		L	2	147.0	24.0	17.5	12.0	93.7
0114		L	2	148.0	23.7	17.2	11.2	97.6
3011E		R	2	148.0	25.4	18.7	11.5	97.3
3004H	M	R	2	150.0	25.0	17.7	12.2	99.6
3004G	M	L	2	151.0	25.6	17.8	12.2	99.9
0115		R	2	152.0	25.6	19.0	12.6	99.9
2621A		R	2	154.0	24.9	17.8	11.4	99.9
0507B		L	2	156.0	24.2	17.4	11.6	99.9

Statistics	(GL)	Bd	Bp	SD
total count	21	21	21	21
total mean	142.6	22.8	17.0	11.2
total std	8.2	2.5	1.1	0.8
total min.	123.0	17.0	14.4	9.6
total max.	156.0	25.6	19.0	12.7
total CV	5.72	10.93	6.64	7.37
type 1 count	11	11	11	11
type 1 mean	136.0	21.1	16.2	10.7
type 1 std	5.1	2.3	1.0	0.8
type 1 min.	123.0	17.0	14.4	9.6
type 1 max.	141.0	24.9	18.3	12.7
type 1 CV	3.75	10.88	5.93	7.29
type 2 count	10	10	10	10
type 2 mean	149.9	24.6	17.8	11.7
type 2 std	3.1	0.7	0.6	0.5
type 2 min.	146.0	23.5	17.2	11.1
type 2 max.	156.0	25.6	19.0	12.6
type 2 CV	2.10	3.00	3.14	4.03

** this is the probability of membership in the "type" group as initially classified, based on multivariate analysis using variables GL, Bd, Bp, SD together.

Table 6-6. Radius fragments, type classification.

Specimen	Sex	Side	Type	Bd	Bp	SD
2067		R	1		14.0	
0606		R	1		14.2	
0129		L	1		14.4	9.6
1278		R	1		14.9	10.0
0602		L	1		15.2	
0300LL	M	L	1		15.4	10.7
2032E		R	1		15.7	10.8
1486		L	1		16.1	
1279		R	1		16.2	
1613		L	1		16.2	
3002T	F	R	1		16.2	10.0
1487		R	1		16.3	
2062B		L	1		16.3	
2065		L	1		16.4	
0420		R	1		16.4	10.6
3002O	F	L	1		16.4	10.2
1287		L	1		16.4	
0516B		L	1		16.5	10.3
2221E		L	1	17.7		8.5
0336D		R	1	21.0		
1289		L	1	21.7		10.7
5009		L	2		18.0	13.5
0214		L	2		19.4	14.0
1291		L	2		19.7	
1281		R	2		20.2	14.1
2238C		L	2		20.2	
1104A		L	2	25.6		

Table 6-7. Ulna univariate statistics, subdivision at the mean (GL).
and results of multivariate crossvalidation of type classification.

Specimen	Sex	Side	Type	(GL)	SDO	DPA	BPC	** % Probability of group membership
1495		L	1	140.0	17.0	20.2	13.8	100.0
1296		R	1	150.0		20.0	14.1	99.7
2600		L	1	152.2	18.3	21.5	15.2	99.7
2032D		R	1	153.0	18.7	21.4	14.8	98.6
1293		L	1	155.6	18.3	21.7	14.7	89.9
0400A03		R	1	160.0			15.0	-
3018NNNN	M	R	1	162.5	20.3	24.9	17.3	71.0
0400A04		L	1	163.0		23.4		-
3000VV	M	R	1	163.1	20.4	23.7	16.6	83.0
3018MMMM	M	L	1	166.6	21.6	24.4	18.4	95.9
1292		L	1	167.0	20.7	23.1	16.7	77.2
2227		L	2	170.0	20.8	23.8	17.6	9.6
1037		R	2	174.7	20.8	23.6	16.5	94.8
4027		L	2	175.0			17.5	-
1040		R	2	176.2	21.0	25.2	17.8	89.6
3004E	M	L	2	177.0	21.7	25.3	17.9	91.0
2408		R	2	177.0	20.9	23.5	16.8	94.8
3004F	M	R	2	179.1	21.6	25.5	17.0	99.9
0507A		L	2	184.3	21.8	24.0	17.1	99.8
1104B		L	2	191.7				-
1039		R	2	203.2	21.8	25.0	19.4	100.0

Statistics	(GL)	SDO	DPA	BPC
total count	21	16	18	19
total mean	168.6	20.4	23.3	16.5
total std	14.5	1.4	1.7	1.5
total min.	140.0	17.0	20.0	13.8
total max.	203.2	21.8	25.5	19.4
total CV	8.58	7.03	7.14	9.06
type 1 count	11	8	10	10
type 1 mean	157.5	19.4	22.4	15.7
type 1 std	7.9	1.5	1.6	1.4
type 1 min.	140.0	17.0	20.0	13.8
type 1 max.	167.0	21.6	24.9	18.4
type 1 CV	4.99	7.51	7.23	9.16
type 2 count	10	8	8	9
type 2 mean	180.8	21.3	24.5	17.5
type 2 std	9.3	0.4	0.8	0.8
type 2 min.	170.0	20.8	23.5	16.5
type 2 max.	203.2	21.8	25.5	19.4
type 2 CV	5.17	2.03	3.21	4.57

** this is the probability of membership in the "type" group as initally classified, based on multivariate analysis using variables GL, DPA, BPC together.

Table 6-8. Ulna fragments, type classification.

Specimen	Sex	Side	Type	SDO	DPA	BPC
2221D		L	1			12.0
0128		L	1			13.3
1607		L	1			13.8
1426		R	1			13.9
5007		R	1			14.3
1529		L	1			14.5
1430		L	1			14.9
1418		R	1			15.0
1295		L	1			15.2
0552		L	1		20.1	14.0
2229		L	1		20.5	13.9
1441		R	1		21.1	14.7
1489		R	1		21.2	14.8
1583		L	1		21.2	15.9
1573		L	1		21.3	16.0
3002U	F	R	1		21.8	15.4
0516A		L	1		21.8	16.3
0110		L	1		22.0	
0208		L	1		22.1	
0950LL		R	1		22.4	15.9
0206		L	1	16.7	18.9	13.5
2037		L	1	17.1	20.0	13.9
0350B		R	1	17.5	19.8	12.9
0605		R	1	17.7	20.5	13.6
2206		R	1	17.9	20.8	
1488		L	1	18.4	21.0	
0300HH	M	L	1	18.8	21.4	15.8
0422		R	1	18.9	22.5	15.2
3002R	F	L	1	19.0	22.0	16.4
0603		R	1	19.0	22.1	14.9
1038		R	1	19.2	22.1	15.2
0630A04		R	1	20.0	23.3	17.0
0132		R	1	20.2	24.4	17.7

Table 6-9a. Metacarpals II & III univariate statistics, division at the mean (GL)

Metacarpal II

Specimen	Sex	Side	Type	(GL)	Bd
2221B		L	1	37.9	5.0
1598		L	1	42.3	6.0
2405D		R	1	42.5	5.6
1589D		L	1	43.4	6.0
2250		L	1	44.0	6.0
0811C		R	1	44.9	5.7
2610D		L	1	45.3	6.4
2031		R	1	45.3	6.1
1590		L	1	46.1	6.2
3002X	F	R	1	46.7	6.3
2200C		R	1	47.0	6.2
0313		R	1	47.7	6.8
1482		L	1	47.8	6.6
1461		R	1	47.9	
3002P	F	L	1	48.0	6.4
0216C		L	1	48.5	7.0
4058		R	1	48.6	5.8
3000T	M	R	1	49.1	6.5
0433		R	1	49.3	7.6
3018VV	M	R	2	50.2	7.8
3018RR	M	L	2	51.9	7.3
0630B07		R	2	53.4	7.4
0220		L	2	53.5	7.6
0630B02		L	2	54.0	7.3
3004U	M	R	2	54.2	7.3
2074		R	2	54.3	7.6
2089C		L	2	54.4	6.7
2022		R	2	56.9	7.8
1128		L	2	57.4	7.8
2112		L	2	58.3	7.7
1119		R	2	58.4	8.2

Metacarpal III

Specimen	Sex	Side	Type	(GL)	Bd
2221A		L	1	44.6	4.5
1589C		L	1	49.0	4.9
2405C		R	1	49.1	5.1
0608		R	1	51.0	5.6
0811B		R	1	51.5	5.2
1448B		L	1	52.7	5.7
2610C		L	1	52.9	6.3
2200D		R	1	54.0	5.9
1603		L	1	54.1	6.1
1481		L	1	54.7	5.7
3002W		R	1	55.3	5.7
4010		R	1	55.8	5.8
1254		L	1	56.5	6.5
0400F		R	1	56.6	5.5
0216B		L	1	57.0	6.2
0400Q		L	1	57.4	5.5
3000S		R	1	57.8	6.5
3018WW	M	R	2	59.0	7.4
4022		R	2	59.2	6.2
0219		R	2	60.0	6.4
3018TT	M	L	2	61.1	6.8
0630B03		R	2	61.6	6.7
0630B05		L	2	61.6	6.5
3004W		R	2	62.5	7.2
2025		R	2	62.8	6.5
3011C		R	2	64.6	7.1
1058		R	2	66.7	7.5
1053		L	2	66.8	7.1
1023		R	2	68.9	6.7
1061		R	2	69.0	7.1

Statistics

Metacarpal II	(GL)	Bd
total count	31	30
total mean	49.3	6.7
total std	5.1	0.8
total min	37.9	5.0
total max	58.4	8.2
total CV	10.29	11.91
type 1 count	19	18
type 1 mean	45.9	6.2
type 1 std	2.8	0.6
type 1 min	37.9	5.0
type 1 max	49.3	7.6
type 1 CV	6.18	9.06
type 2 count	12	12
type 2 mean	54.7	7.5
type 2 std	2.5	0.4
type 2 min	50.2	6.7
type 2 max	58.4	8.2
type 2 CV	4.48	4.93

Statistics

Metacarpal III	(GL)	Bd
total count	30	30
total mean	57.8	6.2
total std	6.0	0.7
total min	44.6	4.5
total max	69.0	7.5
total CV	10.32	12.06
type 1 count	17	17
type 1 mean	53.5	5.7
type 1 std	3.5	0.5
type 1 min	44.6	4.5
type 1 max	57.8	6.5
type 1 CV	6.50	9.38
type 2 count	13	13
type 2 mean	63.4	6.9
type 2 std	3.4	0.4
type 2 min	59.0	6.2
type 2 max	69.0	7.5
type 2 CV	5.30	5.52

Table 6-9b. Metacarpals IV & V univariate statistics, division at the mean (GL)

Metacarpal IV

Specimen	Sex	Side	Type	(GL)	Bd
0400O		L	1		6.8
2221C		L	1	44.8	5.6
2405A		R	1	49.6	6.1
1589B		L	1	49.9	6.1
5028		L	1	50.7	6.3
2069		R	1	51.0	6.6
0811A		R	1	52.3	6.2
1448A		L	1	53.3	6.9
2610B		L	1	54.2	7.4
1479		R	1	55.9	6.8
4041		L	1	56.6	7.1
4014		R	1	56.6	7.1
3002Z	F	R	1	56.7	6.7
1253		L	1	56.9	7.1
0216D		L	1	57.0	6.3
0400N		R	1	57.3	6.8
3000R	M	R	1	58.2	7.6
1112		L	2	59.5	7.0
1255		R	2	59.9	7.3
4013		R	2	60.3	7.8
0217		R	2	61.0	7.7
4016		L	2	61.0	7.7
3018UU	M	L	2	61.1	8.1
2101		L	2	62.5	7.1
2089A		L	2	63.3	7.5
3004V	M	R	2	64.1	8.0
3011B		R	2	65.5	8.0
1126		R	2	66.3	8.4
1059		R	2	67.7	8.6
1054		L	2	68.0	8.1
1063		R	2	69.8	8.4
5039		R	2	69.9	8.3
1106		R	2	70.4	7.9

Metacarpal V

Specimen	Sex	Side	Type	(GL)	Bd
0400P		L	1		7.4
0512		R	1	40.8	7.3
2211		L	1	42.3	7.8
1589A		L	1	42.4	7.4
2403F		L	1	43.0	7.2
2405B		R	1	43.0	7.2
4015		R	1	46.8	7.8
3002Y	F	R	1	47.6	7.9
1113		R	1	47.6	8.2
0216A		L	1	48.5	8.5
0531		L	1	48.6	7.9
3000Q	M	R	1	49.0	8.3
2259		L	1	49.6	8.7
0582		L	2	50.1	8.3
5046		R	2	50.2	8.9
1256		R	2	50.2	8.4
1439		R	2	51.4	8.2
4020		R	2	51.8	8.5
4017		L	2	52.1	8.4
3018QQ	M	L	2	52.3	9.2
4061		L	2	53.5	9.0
3011D		R	2	54.0	9.2
2667		R	2	54.2	9.0
0630B08		L	2	54.2	8.9
0630B01		R	2	54.2	8.9
1121		L	2	57.5	9.6
1110		R	2	59.7	9.4

Statistics

Metacarpal IV	(GL)	Bd
total count	32	32
total mean	59.1	7.3
total std	6.5	0.8
total min	44.8	5.6
total max	70.4	8.6
total CV	10.91	10.64
type 1 count	16	16
type 1 mean	53.8	6.7
type 1 std	3.7	0.5
type 1 min	44.8	5.6
type 1 max	58.2	7.6
type 1 CV	6.79	7.67
type 2 count	16	16
type 2 mean	64.4	7.9
type 2 std	3.7	0.5
type 2 min	59.5	7.0
type 2 max	70.4	8.6
type 2 CV	5.81	5.76

Statistics

Metacarpal V	(GL)	Bd
total count	26	26
total mean	49.8	8.4
total std	4.7	0.7
total min	40.8	7.2
total max	59.7	9.6
total CV	9.43	8.06
type 1 count	12	12
type 1 mean	45.8	7.8
type 1 std	3.1	0.5
type 1 min	40.8	7.2
type 1 max	49.6	8.7
type 1 CV	6.67	6.35
type 2 count	14	14
type 2 mean	53.2	8.8
type 2 std	2.7	0.4
type 2 min	50.1	8.2
type 2 max	59.7	9.6
type 2 CV	5.01	4.61

				Measurement codes	
Specimen	**Type**	**Element**	**Side**	**GL**	**Bd**
16	1	Humerus	L	125.7	23.8
15	1	Humerus	R	126.0	27.7
13	1	Humerus	L	131.0	25.4
14	1	Humerus	R	136.0	28.1
19	1	Humerus	R	136.9	23.7
24	1	Radius	R	127.3	17.1
22	1	Radius	R	137.2	22.1
21	1	Radius	L	138.1	21.2
28	1	Radius	R	141.7	22.7

Table 6-10. Selected measurements and classification of front limb elements of previously reported Northwest Coast dog remains from Semiahmoo Spit, Washington Stae (Fig.1-1).

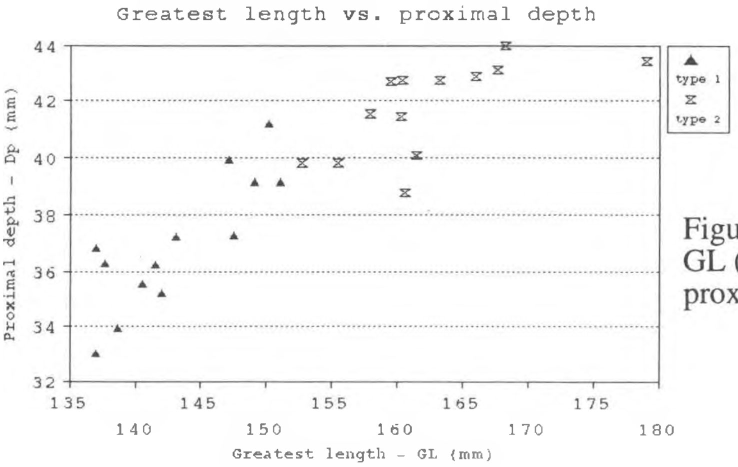


Figure 6-3. Plot of humerus measurement GL (greatest length) vs. Dp (depth of the proximal end).

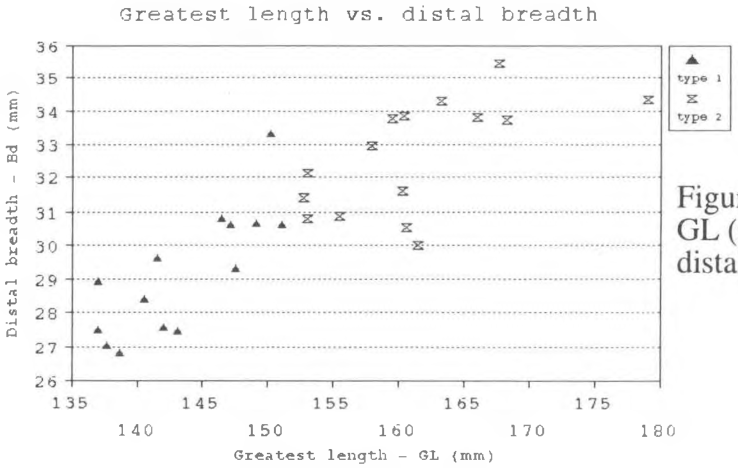


Figure 6-4. Plot of humerus measurement GL (greatest length) vs. Bd (breadth of the distal end).

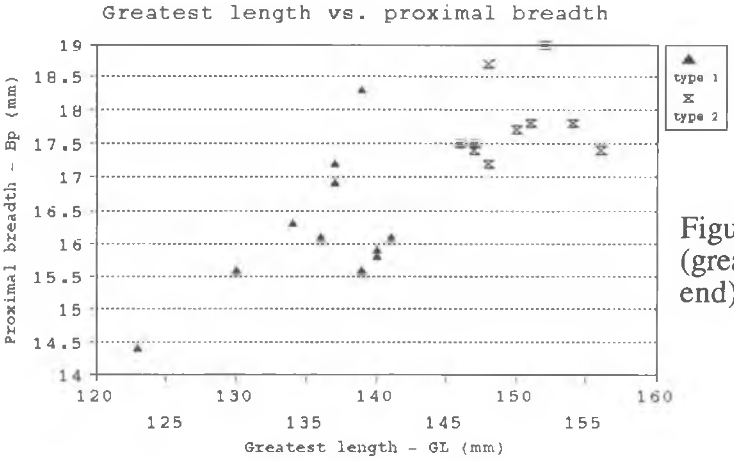


Figure 6-5. Plot of radius measurement GL (greatest length) vs. Bp (breadth of the proximal end).

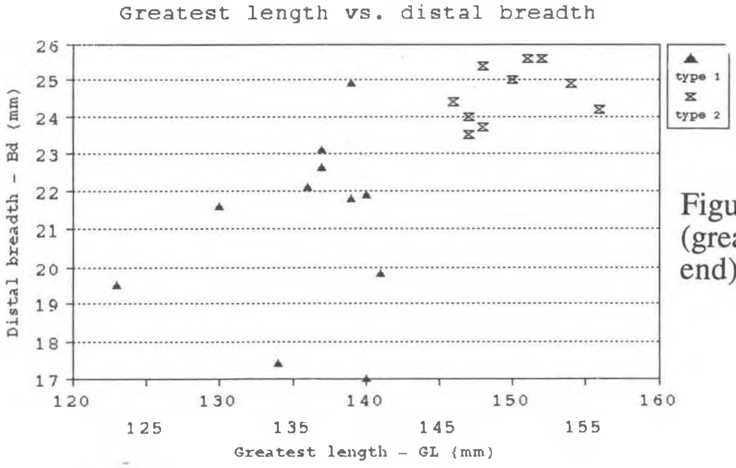


Figure 6-6. Plot of radius measurement GL (greatest length) vs. Bd (breadth of the distal end).

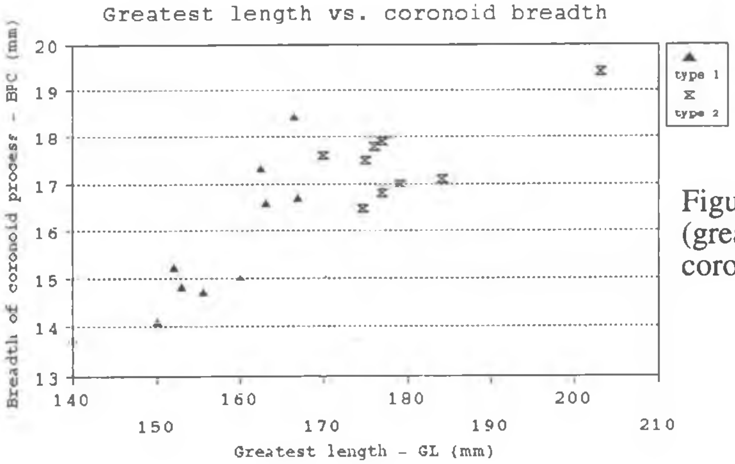


Figure 6-7. Plot of ulna measurement GL (greatest length) vs. BPC (breadth of the coronoid process).

7

HINDLIMB ELEMENTS

Hindlimb element sample

The various hind limb elements analyzed in this study are discussed separately below, followed by the classification of previously reported Northwest Coast material. Table 7-1 contains raw data and univariate statistics only for innominate samples. Tables 7-2, 7-4, 7-6, 7-8, 7-9, and 7-10a/b include raw data, the initial classification to type for other intact hindlimb elements (by division at the mean of the total length, GL), and the discriminant analysis results (probability of membership in the group to which specimens were classified) are presented at the end of the chapter. The classification of fragmented elements are presented in separate tables following the intact sample analysis tables.

Figures 7-1 and 7-2 are photographs of selected elements and Figures 7-3 through 7-7 are graphs showing the relationship of various dimensions of selected elements (femur, tibia, calcaneus) by classified type.

Innominates: The innominates or pelvic elements suffer from much the same taphonomic factors as the scapula and were rarely recovered fully intact. Table 7-1 presents the raw data and basic univariate statistics only for the small sample of intact specimens (n=7), as a more complete analysis was not possible using the method used for the rest of the dog sample.

Femur: The femur sample is comprised of twenty-five intact elements (Table 7-2) and an additional twenty-five fragments which could be confidently classified to one type or the other (Table 7-3). The femur was frequently chewed, sometimes extensively, and this was often the reason that a total length measurement could not be taken. The mean length of the total femur sample was 164.4 mm. The mean of the type 1 subsample was 154.3 mm and that of type 2, 175.3 mm. Figure 7-1 is a photograph of selected femur specimens and Figures 7-3 and 7-4 are graphic representations of the relationship between several breadth dimensions and the greatest length measurement of specimens of each defined type.

Tibia: There were twenty-four intact tibiae which could be used in the classification analysis (Table 7-4) and an additional thirty-one fragments which could be assigned to type 1 or type 2 (Table 7-5). The mean of the total tibia sample was 158.5 mm; the mean length of the type 1 subsample, 150 mm and that of type 2, 165.7 mm. Figure 7-2 is a photograph of selected tibia specimens and Figures 7-5 and 7-6 are graphic representations of the relationship between several breadth dimensions and the greatest length measurement of specimens of each defined type.

Fibula: The sample size for intact fibulae was only the minimum considered for the classification analysis (n=10, Table 7-6). An additional six fragments were classified to type (Table 7-7). It is not surprising that the sample for this element is so low, given the thin structure of the bone over most of its length. Most of the intact elements were recovered from complete or partial skeletons. The mean length of the total fibula sample was 148.2 mm; the mean of the type 1 subsample, 142.8 mm and that of type 2, 156.3 mm.

Talus: While the talus is a true tarsal bone (with no epiphysial ends), it was recovered in high enough numbers in association with other fully adult elements to warrant inclusion in the statistical analysis (n=17). The longest aspect of the talus was consider to correspond to greatest length. The talus measurement was subjected to a statistical analysis for type and the results listed in Table 7-8. The mean length of the total talus sample was calculated as 24.2 mm. The mean of the type 1 subsample was 23.1 mm and that of the type 2 subsample, 25.7 mm. There were no fragmented talus specimens evaluated and no multivariate analysis attempted..

Calcaneus: The calcaneus is the only tarsal bone that has a functional epiphysis that can be used for determining age. The calcaneus sample comprised the largest element set of the entire study, with a total of forty-nine intact specimens which could be used in the classification analysis (Table 7-9). There were no fragmentary specimens assessed. The mean length of the total calcaneous sample was 41.0 mm, with the mean of the type 1 subsample calculated as 38.4 mm and that of the type 2 subsample, 44.0 mm. Figure 7-7 is a graphic representation of the relationship between the breadth dimension and the greatest length measurement of specimens of each defined type.

Metatarsals: A total of one hundred and thirty-five intact metatarsals were analyzed. The results of the classification analysis for metatarsals II through V are presented in Tables 7-10a and 7-10b. The total sample of metatarsal II (n=32) had a mean length of 58.7 mm, while the mean of type 1 specimens was calculated as 55.2 mm and that of type 2, 62.7 mm. The total sample of metatarsal III (n=41) had a mean length of 67.1 mm, while the mean of type 1 specimens was calculated as 63.1 mm and that of type 2, 71.0 mm. The total sample of metatarsal IV (n=29) had a mean length of 68.6 mm, while the mean of type 1 specimens was calculated as 65.0 mm and that of type 2, 73.1 mm. The total sample of metatarsal V (n=33) had a mean length of 59.0 mm, while the mean of type 1 specimens was calculated as 55.7 mm and that of type 2, 62.5 mm. There were no fragmented specimens analyzed.

Previously reported Northwest Coast material: type classification

Montgomery (1979) reports a few intact adult hind limb elements that were recovered from the Semiahmoo Spit site. These measurements are listed in Table 7-11. Only one of the six elements was classified as a large dog (type 2) according to the criteria established by this analysis, while all of the other specimens were classified as small (type 1).

Gleeson (1970) had few intact long bones among his assemblage of dog elements recovered from the Ozette Village site and fewer still which came from prehistoric rather than historic deposits. However, the greatest length measurements of the two adult tibiae reported (Table 7-11) are well within the limits of the small dog type (1) as defined here. Neither Montgomery nor Gleeson included tarsals or metatarsals in their study.

Definition of measurement codes

GL........Greatest length
LeP.......Greatest length excepting projection (metatarsal V)
Bp........Greatest breadth of proximal end
Bd........Greatest breadth of distal end
SD........Smallest breadth of diaphysis
DC........Greatest depth of caput (femur)
LS........Length of symphysis, when fused
LAR.......Length of acetabulum on rim
SH........Smallest height of shaft of ilium
SB........Smallest breadth of shaft of ilium
LFo.......Inner length of foramen obturatum
GBA.......Greatest breadth across acetabula, when fused
GBTi......Greatest breadth across ischial tuberosity, when fused
SBI.......Smallest breadth across bodies of ischia, when fused

Table 7-1. Innominate sample (intact only), univariate statistics.

Specimen	Sex	Side	GL	GBA (fused)	GBTc (fused)	SBI (fused)	GBTi (fused)	LFo	LS	SH	SC	LA/LAR
0400A09		R	131.0					26.4		17.2	8.0	19.8
0400A10		L	131.0							17.0	8.1	19.4
3001DD	M	R	134.0					27.9		14.8	8.1	19.9
3000KK	M	R	136.6							17.5	9.0	21.1
3018CCCC	M	R	144.1					29.3	41.0	18.4	10.5	22.2
3018DDDD	M	L	145.0	76.4	91.7	62.6	90.7	28.8	41.0	18.0	10.4	22.2
3004I	M	L	151.0	76.8		64.4	96.5	30.0	42.2	18.6	10.2	22.2
total count			7	2	1	2	2	5	3	7	7	7
total mean			139.0	76.6	91.7	63.5	93.6	28.5	41.4	17.4	9.2	21.0
total std			7.2	0.2	0.0	0.9	2.9	1.2	0.6	1.2	1.1	1.2
total min.			131.0	76.4	91.7	62.6	90.7	26.4	41.0	14.8	7.3	17.9
total max.			151.0	76.8	91.7	64.4	96.5	30.0	42.2	18.6	10.5	22.2
total CV			5.19	0.26	0.00	1.42	3.13	4.37	1.37	6.81	11.66	5.57

Table 7-2. Femur univariate statistics, division at the mean of the greatest length (GL) and results of multivariate crossvalidation of type classification.

Specimen	**Sex**	**Side**	**Type**	**(GL)**	**Bd**	**Bp**	**SD**	**DC**	**** % Probability of group membership**
1499		L	1	142.0	27.3	31.0	10.6	15.5	100.0
3001CC	M	R	1	148.0	29.7	33.3	11.5	16.3	100.0
0400A12		R	1	150.0	27.2	32.5	11.3	15.9	99.9
0400A11		L	1	150.0	28.6	32.7	11.1	15.9	99.9
2018A		L	1	150.0	32.2	35.9	12.1	17.1	100.0
3000MM	M	L	1	152.0	31.8	37.2	11.9	17.5	100.0
3000JJ	M	R	1	153.0	31.9	36.8	11.8	17.5	99.9
2040		R	1	156.0	32.3	35.2	12.1	17.4	99.9
0950PP		R	1	157.0	32.9		12.4	18.1	-
0950QQ		L	1	159.0	33.1	38.3	12.6	18.2	99.2
3018EEEE	M	L	1	162.0	31.7	37.5	13.6	19.3	100.0
3018FFFF	M	R	1	163.0	33.8	37.7	13.6	18.7	99.5
1277		L	1	164.0	32.6	38.3	12.9	19.1	97.0
3004L	M	R	2	167.0	35.1	39.9	13.6	19.1	21.2
3004K	M	L	2	169.0	33.3	40.2	13.0	19.0	98.6
0555		L	2	172.0	34.2	39.5	12.5	19.0	99.9
1083		R	2	173.0	35.4	40.5	13.7	19.4	99.9
1082		R	2	174.0	37.8	43.4	14.5	19.6	100.0
1089		R	2	175.0	36.3	40.7	13.4	19.4	100.0
1081		R	2	176.0	34.9	39.0	14.2	19.5	99.6
1084		L	2	177.0	35.3	42.1	14.5	19.8	100.0
0550		L	2	178.0	35.1	39.4	14.2	19.4	100.0
1088		R	2	179.0	36.9	41.4	14.3	19.5	100.0
1086		L	2	181.0	35.4	42.9	14.5	20.1	100.0
1094		R	2	182.0	37.5	40.3	13.7	19.6	100.0

Statistics	**(GL)**	**Bd**	**Bp**	**SD**	**DC**
total count	25	25	24	25	25
total mean	164.4	33.3	38.2	12.9	18.4
total std	11.8	2.8	3.3	1.1	1.3
total min.	142.0	27.2	31.0	10.6	15.5
total max.	182.0	37.8	43.4	14.5	20.1
total CV	7.18	8.51	8.59	8.88	7.33
type 1 count	13	13	12	13	13
type 1 mean	154.3	31.2	35.5	12.1	17.4
type 1 std	6.3	2.1	2.4	0.9	1.2
type 1 min.	142.0	27.2	31.0	10.6	15.5
type 1 max.	164.0	33.8	38.3	13.6	19.3
type 1 CV	4.08	6.82	6.86	7.19	6.89
type 2 count	12	12	12	12	12
type 2 mean	175.3	35.6	40.8	13.8	19.5
type 2 std	4.4	1.3	1.3	0.6	0.3
type 2 min.	167.0	33.3	39.0	12.5	19.0
type 2 max.	182.0	37.8	43.4	14.5	20.1
type 2 CV	2.49	3.54	3.29	4.46	1.58

** this is the probability of membership in the "type" group as initially classified, based on mulitvariate analysis using variables GL, Bd, Bp, SD, DC together.

Table 7-3. Femur fragments, type classification.

Specimen	Sex	Side	Type	Bd	Bp	SD	DC
0532		L	1			11.1	15.3
2401		L	1			11.3	15.7
2073		R	1			11.5	16.2
2402		R	1			11.5	16.2
2032F		L	1			11.8	17.2
2032G		R	1			12.2	16.7
1276		R	1		30.5	10.5	14.5
1090		L	1		31.2	12.3	
1432		R	1		32.8		15.7
0591		L	1		32.8		15.3
2403		L	1		32.9	11.2	16.3
2026		L	1		33.0	12.2	16.3
0317		L	1		37.0		17.9
1275		L	1	27.3			
0558		R	1	27.5			
0336F		L	1	27.6			
1522		R	1	27.7			
0596		R	1	28.3			
1546		L	1	29.0			
1584		R	1	29.6			
1269		L	1	30.0			
0599		L	1	30.4			
1093		L	1	30.9			
1091		R	1	30.9		12.5	
1092		L	2	34.8			

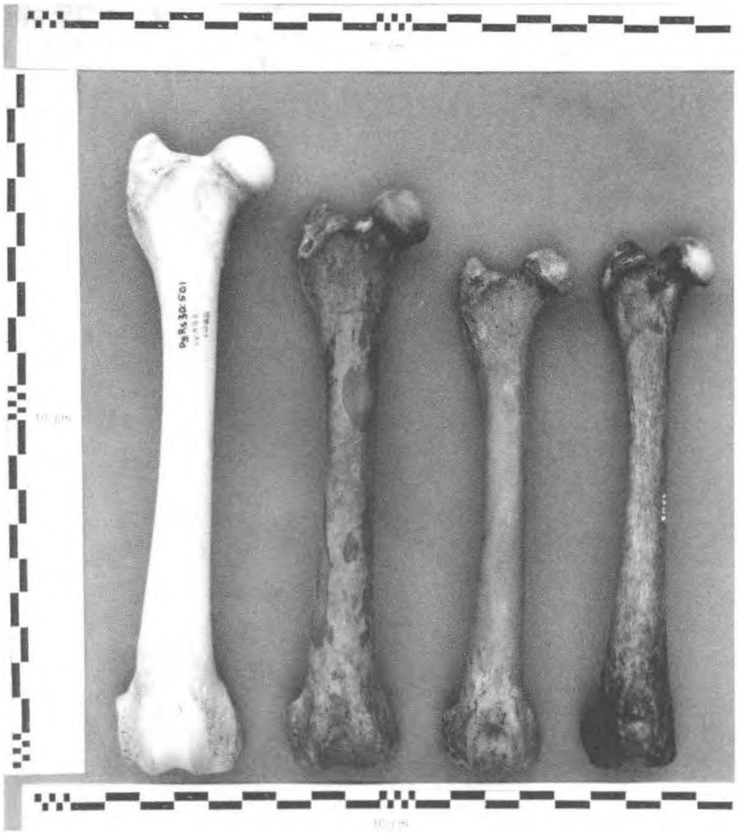


Figure 7-1. Photo, femur examples (R), left to right: specimen #1008, #3018, #3001, #0400.

Table 7-4. Tibia sample univariate statistics, division at the mean (GL).
and results of multivariate crossvalidation of type classification.

Specimen	Sex	Side	Type	(GL)	Bd	Bp	SD	** % Probability of group membership
1500		R	1	139.0	20.0	26.8	9.6	99.9
0560		R	1	141.0	17.9	28.6	9.2	100.0
3001FF	M	R	1	146.0	19.9	32.0	9.9	99.5
1075		R	1	147.0	20.7	31.5	9.4	85.5
3000QQ	M	L	1	150.0	21.9	34.8	11.7	90.6
3000PP	M	R	1	150.0	21.6	34.9	10.5	85.7
0950SS		R	1	153.0	21.1	33.8	10.7	89.6
0554		L	1	153.0	20.4	38.1	10.4	78.8
0400A14		L	1	156.0	18.7	24.2	9.6	70.0
0950RR		L	1	157.0	21.9	31.6	10.9	28.4
0400A13		R	1	158.0	19.0	29.5	9.6	79.7
3009		L	2	159.0	22.4	34.7	11.5	43.1
3018HHHH	M	R	2	159.0	22.8	35.9	10.9	84.8
0434		R	2	159.0	21.6	31.1	10.8	41.0
3018GGG	M	L	2	159.0	22.9	35.8	11.4	74.8
4042		R	2	160.0	21.5	33.9	10.5	65.2
3004M	M	L	2	167.0	24.0	37.1	11.2	99.7
3004N	M	R	2	167.0	23.0	37.1	11.0	98.8
1071		L	2	167.0	22.0	35.5	10.2	97.8
1077		R	2	168.0	22.4	36.1	10.9	98.0
1076		R	2	169.0	22.2	35.3	10.0	99.4
0557		L	2	169.0	22.9	36.5	10.9	99.4
1080		R	2	174.0	24.3	38.1	11.1	99.9
1078		R	2	177.0	25.6	39.2	12.6	100.0

Statistics	(GL)	Bd	Bp	SD
total count	24	24	24	24
total mean	158.5	21.7	33.8	10.6
total std	9.8	1.8	3.7	0.8
total min.	139.0	17.9	24.2	9.2
total max.	177.0	25.6	39.2	12.6
total CV	6.18	8.12	10.87	7.53
type 1 count	11	11	11	11
type 1 mean	150.0	20.3	31.4	10.1
type 1 std	6.0	1.3	3.8	0.7
type 1 min.	139.0	17.9	24.2	9.2
type 1 max.	158.0	21.9	38.1	11.7
type 1 CV	3.99	6.29	12.11	7.22
type 2 count	13	13	13	13
type 2 mean	165.7	22.9	35.9	11.0
type 2 std	5.8	1.1	1.9	0.6
type 2 min.	159.0	21.5	31.1	10.0
type 2 max.	177.0	25.6	39.2	12.6
type 2 CV	3.51	4.84	5.36	5.63

** this is the probability of membership in the "type" group as initially classified, based on multivariate analysis using variables GL, Bd, Bp, SD.

Table 7-5. Tibia fragments, type classification.

Specimen	Sex	Side	Type	GL	Bd	Bp
0215		L	1		20.4	
0335		R	1		20.4	
2614		L	1		20.4	
0594		R	1		20.3	
3016		L	1		20.3	
5045		R	1		20.5	
2261		R	1		20.9	
0130		R	1	141.0	20.4	
3002AA	F	R	1		20.7	
0598		R	1		20.5	
0509		L	1		20.6	
2025		L	1		18.1	
1528		L	1		18.2	
0327		R	1		18.9	
2666		R	1		17.5	
1497		L	1			25.6
0534		L	1			29.0
1284		L	1			29.5
1515		L	1		19.7	
1294		L	1		20.0	
1494		L	1		20.1	
1611		L	1		19.6	
0305		L	1		19.0	
1427		L	1		19.4	
2238B		L	1		19.6	
0630A09		L	2		23.0	
0348		R	2		23.3	
2036		R	2		23.5	
0630A11		R	2		22.7	
2038		L	2		22.8	
1079		L	2		22.9	

Table 7-6. Fibula sample univariate statistics, division at the mean (GL).

Specime	Sex	Type	(GL)	Bd	Bp
3001BB	M	1	135.5	10.0	9.4
3000NN	M	1	138.7	11.3	9.6
3000OO	M	1	140.0	11.3	9.6
0400A13		1	146.2	9.9	9.0
3018YY	M	1	148.2	11.7	12.1
3018ZZ	M	1	148.2	11.5	12.3
1044		2	154.5	11.1	
1042		2	155.8	11.4	11.9
1043		2	157.4	12.5	10.9
1047		2	157.6	11.2	12.1

Statistics	(GL)	Bd	Bp
total count	10	10	9
total mean	148.2	11.2	10.8
total std	7.70	0.73	1.30
total min	135.5	9.9	9.0
total max	157.6	12.5	12.3
total CV	5.20	6.50	12.13
type 1 count	6	6	6
type 1 mean	142.8	10.94	10.32
type 1 std	4.96	0.73	1.35
type 1 min	135.5	9.85	9
type 1 max	148.2	11.68	12.3
type 1 CV	3.48	6.68	13.07
type 2 count	4	4	3
type 2 mean	156.33	11.53	11.64
type 2 std	1.26	0.56	0.56
type 2 min	154.5	11.09	10.85
type 2 max	157.6	12.48	12.12
type 2 CV	0.81	4.82	4.82

Table 7-7. Fibula fragments, type classification.

Specimen	Sex	Side	Type	Bd	Bp
3013		R	1		9.9
24051		L	1	8.9	
1049		R	1	10.9	
1048		R	2	13.1	
3004Z	M	L	2	12.6	
3004Y	M	R	2	12.5	

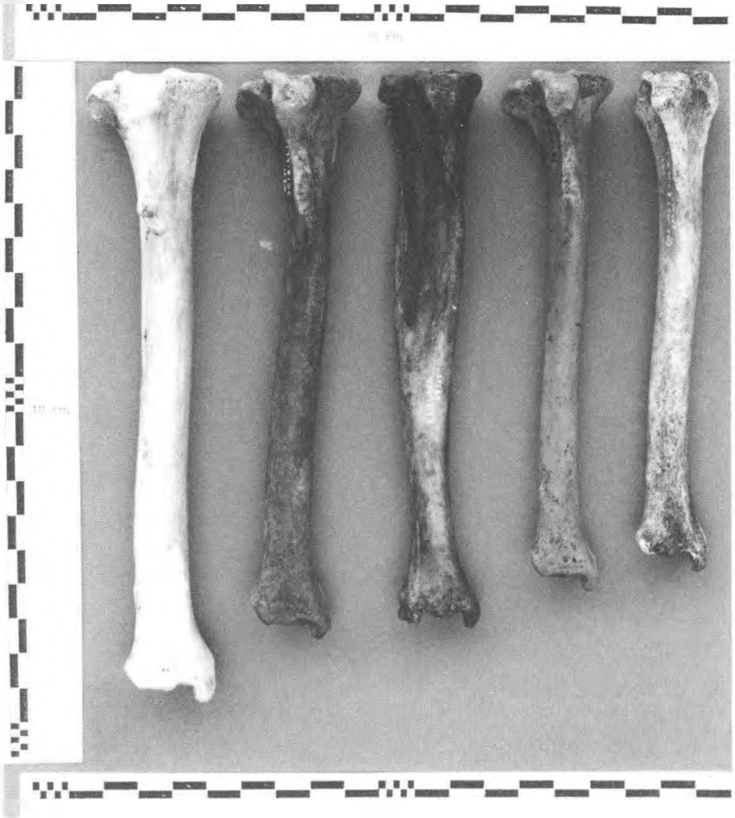


Figure 7-2. Photo, tibia examples (R), left to right: specimen #1078, #3018, #0400, #3001, #0130.

Table 7-8. Talus sample univariate statistics, division at the mean (GL).

Specimen	Sex	Type	(GL)
2405G	?	1	21.4
0400J	?	1	22.0
3001Y	M	1	22.7
3001Z	M	1	22.8
2256C	?	1	23.0
2256B	?	1	23.2
0950DD	?	1	23.9
0950EE	?	1	23.9
3000GG	M	1	24.2
3000FF	M	1	24.2
2024B	?	2	25.0
3018KK	M	2	25.2
3004R	M	2	25.6
2071C	?	2	25.6
2033D	?	2	25.7
3004Q	M	2	25 8
2601A	?	2	27.2

Statistics	**(GL)**
total count	17
total mean	24.2
total std	1.51
total min	21.4
total max	27.2
total CV	6.26
type 1 count	10
type 1 mean	23.1
type 1 std	0.89
type 1 min	21.4
type 1 max	24.2
type 1 CV	3.87
type 2 count	7
type 2 mean	25.7
type 2 std	0.67
type 2 min	25.0
type 2 max	27 2
type 2 CV	2.60

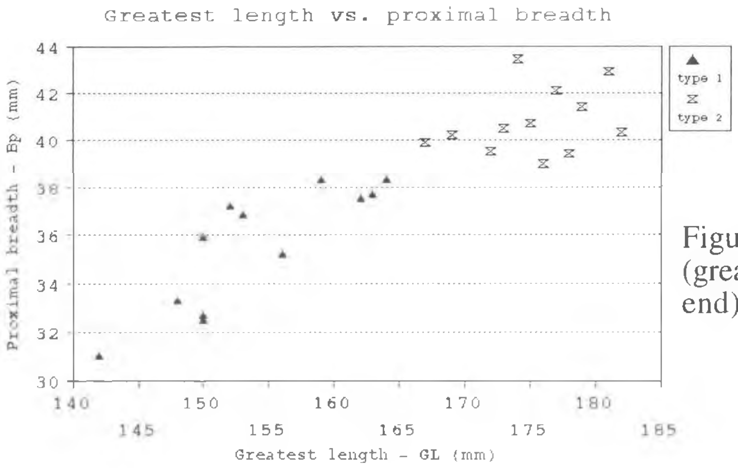


Figure 7-3. Plot of femur measurement GL (greatest length) vs. Bp (breadth of the proximal end).

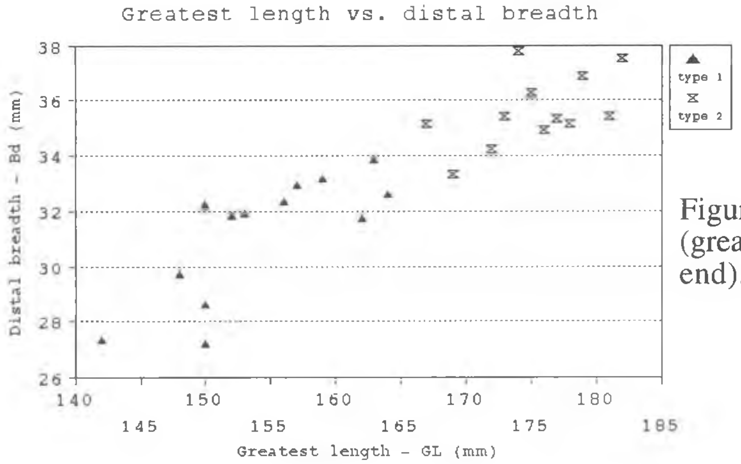


Figure 7-4. Plot of femur measurement GL (greatest length) vs. Bd (breadth of the distal end).

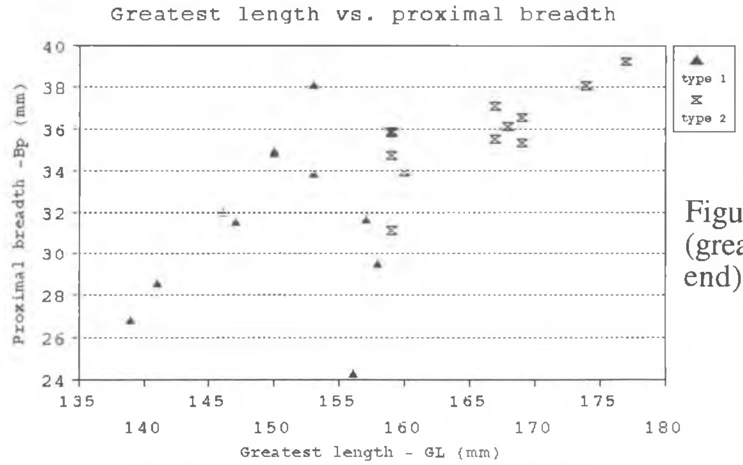


Figure 7-5. Plot of tibia measurement GL (greatest length) vs. Bp (breadth of the proximal end).

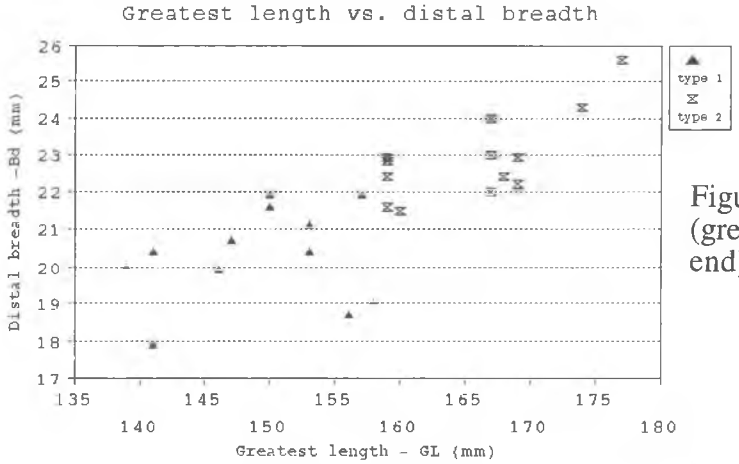


Figure 7-6. Plot of tibia measurement GL (greatest length) vs. Bd (breadth of the distal end).

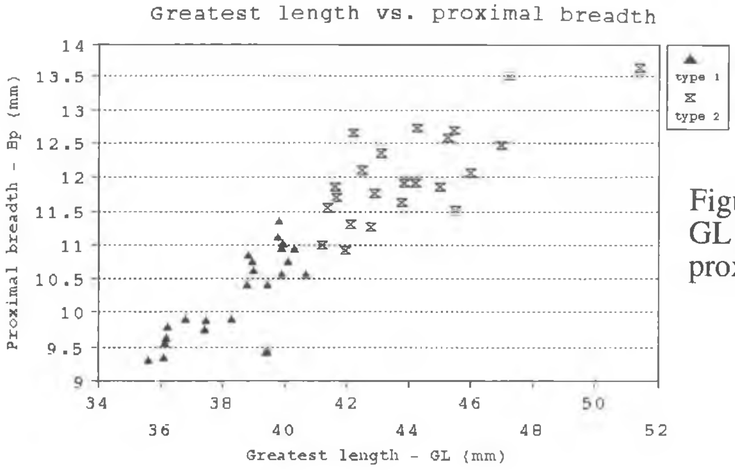


Figure 7-7. Plot of calcaneus measurement GL (greatest length) vs. Bp (breadth of the proximal end).

Table 7-9. Calcaneous univariate statistics, division at the mean (GL) and results of multivariate crossvalidation of type classification.

Specimen	Sex	Side	Type	(GL)	Bp	** % Probability of group membership
2224B	?	R	1	34.9		-
1524	?	L	1	35.6	9.3	99.9
0607	?	R	1	36.1	9.4	99.9
0118	?	L	1	36.2	9.6	99.9
2405F	?	R	1	36.2	9.6	99.9
2405E	?	L	1	36.2	9.8	99.9
0400D	?	L	1	36.8	9.9	99.6
0506	?	R	1	37.5	9.7	99.3
0400I	?	R	1	37.5	9.9	99.1
2028	?	R	1	38.3	9.9	97.8
0158	?	L	1	38.8	10.4	98.5
2415	?	L	1	38.9	10.8	95.6
3001AA	M	L	1	39.0	10.8	96.2
3002HH	F	L	1	39.0	10.6	97.1
0205	?	L	1	39.4	9.4	99.7
3002BB	F	R	1	39.5	10.4	97.3
2052	?	L	1	39.5	9.4	99.7
2048	?	L	1	39.8	11.1	83.1
1453	?	L	1	39.8	11.4	71.1
2256A	?	R	1	39.9	10.6	94.5
0610	?	L	1	39.9	10.9	87.7
1454	?	R	1	39.9	11.0	85.1
0160	?	L	1	40.1	10.8	90.3
0510	?	L	1	40.3	11.0	83.1
2062A	?	L	1	40.7	10.6	88.8
0142	?	L	2	41.2	11.0	26.1
2033C	?	L	2	41.4	11.6	61.7
3000EE	M	L	2	41.6	11.9	79.5
3000DD	M	R	2	41.7	11.7	75.1
2024A	?	L	2	42.0	10.9	35.1
1575	?	R	2	42.1	11.3	66.2
0121	?	L	2	42.2	12.7	97.2
2260	?	R	2	42.5	12.1	94.1
5040	?	L	2	42.8		-
1118	?	L	2	42.8	11.3	75.7
0950GG	?	R	2	42.9	11.8	92.3
0950FF	?	L	2	43.1	12.3	98.0
1286	?	R	2	43.8	11.6	94.8
0630B11	?	R	2	43.8	11.9	97.6
0630B12	?	L	2	44.2	11.9	98.1
3018JJ	M	L	2	44.2	12.7	99.7
1420	?	R	2	45.0	11.9	98.9
3004P	M	L	2	45.2	12.6	99.8
3004O	M	R	2	45.4	12.7	99.9
1052	?	L	2	45.5	11.5	98.3
1117	?	L	2	46.0	12.1	99.7
1051	?	R	2	47.0	12.5	99.9
1050	?	R	2	47.2	13.5	100.0
5017	?	R	2	51.4	13.7	100.0

Statistics	(GL)	Bp
total count	49	47
total mean	41.0	11.1
total std	3.4	1.1
total min	34.9	9.3
total max	51.4	13.7
total CV	8.37	10.00
type 1 count	26	24
type 1 mean	38.4	10.3
type 1 std	1.7	0.6
type 1 min	34.9	9.3
type 1 max	40.7	11.4
type 1 CV	4.31	6.16
type 2 count	24	23
type 2 mean	44.0	12.0
type 2 std	2.3	0.7
type 2 min	41.2	10.9
type 2 max	51.4	13.7
type 2 CV	5.27	5.79

** this is the probability of membership in the "type" group as initially classified based on multivariate analysis using variables GL, Bp together.

Table 7-10a. Metatarsals II & III univariate statistics, division at the mean (GL)

Metatarsal II

Specimen	Sex	Side	Type	(GL)	Bd
2403E		L	1	49.2	6.4
2403G		R	1	49.8	6.5
2262		L	1	51.7	6.8
1521		R	1	52.0	6.3
1520		L	1	53.3	6.4
1459		R	1	55.6	7.4
1483		L	1	55.7	7.1
3001V	M	L	1	56.0	7.4
3001U	M	R	1	56.3	7.5
3002KK	F	L	1	56.3	7.2
3002EE	F	R	1	56.6	7.3
1251		L	1	56.8	7.2
2409A		L	1	57.3	7.4
3000X	M	R	1	57.4	7.9
0400E		R	1	58.1	7.0
0400A		L	1	58.2	7.0
3000Y	M	L	1	58.2	7.6
2110		R	2	59.3	7.8
3018XXX	M	R	2	60.3	8.2
1107		L	2	60.5	7.6
3018YYY	M	L	2	60.7	8.1
0630B09		L	2	61.3	8.1
3004OOO	M	L	2	61.4	8.5
2045		L	2	61.6	7.9
1249		R	2	61.8	7.8
3004MMM	M	R	2	61.8	8.3
1115		L	2	64.0	7.7
1067		L	2	64.1	8.0
2095		L	2	64.7	8.7
1127		L	2	65.4	8.5
1130		R	2	66.0	8.6
1064		R	2	67.9	8.7

Metatarsal III

Specimen	Sex	Side	Type	(GL)	Bd
2403C		R	1	55.5	6.5
2403A		L	1	55.9	6.4
2071B		L	1	60.1	6.8
0336E		R	1	60.4	6.7
1252		R	1	61.4	7.3
0314		L	1	61.6	6.9
1258		L	1	61.6	7.2
1131		L	1	62.4	6.8
1480		L	1	63.7	7.3
3002JJ	F	L	1	64.5	7.1
3001S	M	L	1	64.6	7.3
2035D		L	1	64.7	7.7
3001T	M	R	1	65.1	7.1
3015		L	1	65.2	7.8
3002CC	F	R	1	65.2	7.1
3000BB	M	L	1	65.3	7.7
0400F		R	1	65.6	7.0
0400B		L	1	65.7	7.0
3000CC	M	R	1	66.0	7.9
2110B		R	1	67.0	7.6
4050		L	2	67.5	7.7
1065		R	2	67.9	7.6
1516		L	2	68.0	7.2
1577A		R	2	68.7	7.8
1057		L	2	68.8	7.5
3014		L	2	69.0	8.0
2091		L	2	69.7	7.5
1250		R	2	69.8	7.9
3018WWW	M	R	2	70.4	8.4
3018TTT	M	L	2	70.6	8.1
3004LLL	M	L	2	71.4	8.5
0556A		L	2	71.6	8.1
1062		L	2	72.1	7.6
2249		L	2	72.2	7.8
3004PPP	M	R	2	72.3	8.5
2601		R	2	72.3	8.6
2092		L	2	72.7	8.3
1068		R	2	73.3	8.1
1055		L	2	73.4	8.1
1124		L	2	74.2	8.5
1060		R	2	74.5	8.5

Statistics

Metatarsal II	(GL)	Bd
total count	32	32
total mean	58.7	7.6
total std	4.6	0.7
total min	49.2	6.3
total max	67.9	8.7
total CV	7.79	8.88
type 1 count	17	17
type 1 mean	55.2	7.1
type 1 std	2.8	0.4
type 1 min	49.2	6.3
type 1 max	58.2	7.9
type 1 CV	5.11	6.34
type 2 count	15	15
type 2 mean	62.7	8.2
type 2 std	2.4	0.3
type 2 min	59.3	7.6
type 2 max	67.9	8.7
type 2 CV	3.82	4.24

Statistics

Metatarsal III	(GL)	Bd
total count	41	41
total mean	67.1	7.6
total std	4.8	0.6
total min	55.5	6.4
total max	74.5	8.6
total CV	7.09	7.71
type 1 count	20	20
type 1 mean	63.1	7.2
type 1 std	3.1	0.4
type 1 min	55.5	6.4
type 1 max	67.0	7.9
type 1 CV	4.97	5.71
type 2 count	21	21
type 2 mean	71.0	8.0
type 2 std	2.1	0.4
type 2 min	67.5	7.2
type 2 max	74.5	8.6
type 2 CV	2.93	5.06

Table 7-10b. Metatarsals IV & V univariate statistics, division at the mean (GL)

Metatarsal IV

Specimen	Sex	Side	Type	(GL)	Bd
2403B		R	1	57.6	6.1
2403D		L	1	57.7	6.3
1257		L	1	63.4	7.2
2033E		L	1	64.3	7.3
1460		R	1	64.9	6.9
3002II	F	L	1	65.6	7.0
3001X	M	L	1	65.7	7.2
3002DD	F	R	1	65.7	7.0
3001W	M	R	1	65.8	7.2
2035A		L	1	65.9	7.9
0400G		R	1	66.3	6.8
3000V	M	R	1	66.3	7.7
0400C		L	1	66.5	6.4
2105		R	1	67.5	7.3
3000W	M	L	1	67.8	
5038		R	1	68.6	7.4
1577B		R	2	69.1	7.6
1120		L	2	69.9	7.4
1248		R	2	71.2	7.8
3018UUU	M	R	2	71.8	8.0
3018ZZZ	M	L	2	72.4	8.2
2108		R	2	73.2	8.7
3004RRR	M	L	2	73.2	8.4
0556B		L	2	73.3	8.0
1056		L	2	73.5	7.3
1070		L	2	73.9	8.0
3004NNN	M	R	2	74.2	8.4
5026		R	2	77.5	8.4
1129		R	2	77.6	8.7

Metatarsal V

Specimen	Sex	Side	Type	(GL)	Bd
0811D		R	1		7.3
1419		R	1	48.5	6.5
1523		L	1	50.7	6.4
2033F		L	1	54.7	8.0
1247		L	1	54.9	7.1
1458		R	1	55.1	7.0
1478		L	1	55.3	6.8
3002FF	F	R	1	55.6	6.9
3002LL	F	L	1	56.0	7.0
3001R	M	R	1	56.1	7.1
1122		R	1	56.2	6.9
3001Q	M	L	1	56.6	7.0
2035B		L	1	57.4	7.8
0400H		R	1	57.5	
5042		R	1	57.6	7.3
3000AA	M	R	1	58.3	7.4
1610		R	1	58.5	7.4
3000Z	M	L	1	58.6	7.5
1577C		R	2	60.1	7.8
1066		L	2	60.3	7.4
0630B04		L	2	61.0	7.9
3018SSS	M	R	2	61.3	8.0
2071A		L	2	61.3	7.2
3018VVV	M	L	2	61.4	8.0
3004SSS	M	R	2	61.7	8.0
1246		R	2	62.0	7.4
3004QQQ	M	L	2	62.4	8.3
2093		R	2	62.7	8.3
1114		L	2	62.7	7.7
1111		R	2	63.2	7.7
0556C		L	2	63.5	8.0
1125		L	2	65.1	7.4
2240		R	2	65.4	8.9
1069		R	2	66.6	8.4

Statistics

Metatarsal IV	(GL)	Bd
total count	29	28
total mean	68.6	7.5
total std	4.9	0.7
total min	57.6	6.1
total max	77.6	8.7
total CV	7.14	9.16
type 1 count	16	15
type 1 mean	65.0	7.0
type 1 std	3.0	0.5
type 1 min	57.6	6.1
type 1 max	68.6	7.9
type 1 CV	4.65	6.86
type 2 count	13	13
type 2 mean	73.1	8.0
type 2 std	2.4	0.4
type 2 min	69.1	7.3
type 2 max	77.6	8.7
type 2 CV	3.25	5.49

Statistics

Metatarsal V	(GL)	Bd
total count	33	32
total mean	59.0	7.5
total std	4.1	0.6
total min	48.5	6.4
total max	66.6	8.9
total CV	6.89	7.62
type 1 count	17	16
type 1 mean	55.7	7.1
type 1 std	2.6	0.4
type 1 min	48.5	6.4
type 1 max	58.6	8.0
type 1 CV	4.61	5.79
type 2 count	16	16
type 2 mean	62.5	7.9
type 2 std	1.8	0.4
type 2 min	60.1	7.2
type 2 max	66.6	8.9
type 2 CV	2.87	5.37

Hindlimb Elements

Table 7-11. Measurements and classification of hind limb elements of previously reported Northwest Coast dog remains from Ozette Village and Semiahmoo Spit, Washington State (Fig. 1-1).

				Measurement codes			
Specimen	**Type**	**Element**	**Side**	**GL**	**Bd**	**Bp**	**DC**
Semiahmoo 32	1	Femur	R	144.0	26.0	-	15.5
Semiahmoo 34	1	Femur	R	148 0	28.6	-	16.6
Semiahmoo 37	1	Tibia	R	134.2	-	28.2	-
Semiahmoo 38	1	Tibia	R	148.2	-	34.3	-
Semiahmoo 40	1	Tibia	R	149.4	-		-
Semiahmoo 39	2	Tibia	L	167.1	-	33.0	-
Ozette A4/XII/1	1	Tibia	L	145.8	-		-
Ozette A4/X/3	1	Tibia	R	151.7	-		-

Figure 7-8. Photo, metatarsal IV examples (R), on left of photo, left to right: specimen #2403, #0400, #3018, #1129. Metacarpal III examples (R), on right of photo, left to right: specimen #1058, #3018, #0400, #2405.

8 VERTEBRAE

Vertebral element sample

Since the length of the vertebral column is the only direct skeletal indicator of body length for prehistoric animals the inclusion of measurements of these elements, while cumbersome, is important to understanding the overall picture of body size for Northwest Coast dogs. None of the previous studies on Northwest Coast dog material included measurements of vertebral material. As far as is known, this study contains the first comprehensive analysis of dog vertebrae reported from archaeological contexts. Clutton-Brock & Noe-Nygaard (1990) do however report the measurements of several cervical vertebrae of an immature dog recovered from Seamer Carr, England that dates to ca. 9,500 bp. The inclusion of vertebrae in this analysis (and metapodials, which have also seldom been reported by others) increases the possibility of assessing isolated adult dog remains from sites where such material is rare.

The sample sizes for individual vertebral elements varied significantly in this study, with thoracic and caudal vertebrae being poorly represented. Thoracic vertebrae are not robust elements and they were often too severely damaged to measure or to identify to exact position, although they appeared to be present in similar quantities as the other vertebrae. Caudal vertebrae are undoubtedly under-represented in the sample due to their small size, the majority being recovered from complete skeletons. With a cut-off of at least ten specimens as the minimum for statistical analysis of type, only thoracic vertebrae #3, #12 and #13 had a sufficient sample for comparative analysis. Both the cervical and lumbar series had more than adequate numbers of specimens for all elements, as did the sacrum (Tables 8-1 through 8-11). A separate statistical analysis was performed on each element sample.

In some cases, arthritic lipping of the centrum interferred with accurate measurement of the centrum length. Breakage of many of the vertebral processes meant that not all measurements could betaken from all specimens, but there were enough dimensions available for most elements to perform multivariate discriminant analysis. The probabilities of group membership calculated by discriminant function crossvalidation are presented for most specimens in the classification tables. Three specimens (two cervical vertebrae and one sacrum) had significantly low (below 5%) probability values, indicating they belonged to particularly robust individuals.

The measurements taken for vertebrae which were not present in high enough numbers for statistical analysis are presented in Tables 8-12 and 8-13. All of these specimens were associated with other elements that could be classified.

Figures 8-1 through 8-6 show the graphic representation of the relationship between the length measurement and the breadth of the caudal facet of selected samples (cervicals 01, 02, 03; thoracic 13; lumbar 07) and of the length vs. the breadth of the cranial facet of the sacrum.

Table 8-14 is a summary table that lists the combined lengths of several vertebral sections for partial and complete vertebral columns recovered from the same individual. From this table it can be calculated that individuals classified as type 1 had an average cervical length of approximately 150 mm, a thoracic length of 208 mm and a lumbar/sacral length of 191 mm. Individuals classified as type 2 had an average cervical length of approximately 161 mm, a thoracic length of 231 mm and a lumbar/sacral length of 208 mm. The suspected hybrid, specimen 0950, had a cervical length of 151.5 mm, closer to the type 1 average than the type 2.

Definition of vertebrae measurement codes

GB........Greatest breadth (VC01)
GL........Greatest length (VC01)
LAd.......Length of dorsal arch, at midpoint (VC01)
LCDe......Greatest length of body of axis (VC02), including dens
LAPa......Greatest length of dorsal arch of axis (VC02)
SBV.......Least breadth of body of the axis (VC02)
PL........Length of body of vertebra, between the centres of caudal and cranial articular surfaces
GLPa......Greatest length from cranial to caudal articular processes (cervicals only)
BFcr......Greatest breadth of cranial articular surface (includes facets for ribs in thoracics)
BFcd......Greatest breadth of caudal articular surface (includes facets for ribs in thoracics)
HFcr......Greatest height of cranial articular surface
HFcd......Greatest height of caudal articular surface
BPacd.....Greatest breadth across caudal articular process
BPacr.....Greatest breadth across cranial articular process (cervical only)
H.........Greatest height, perpendicular to basal line of body to highest point of spinous process (in a measuring box)

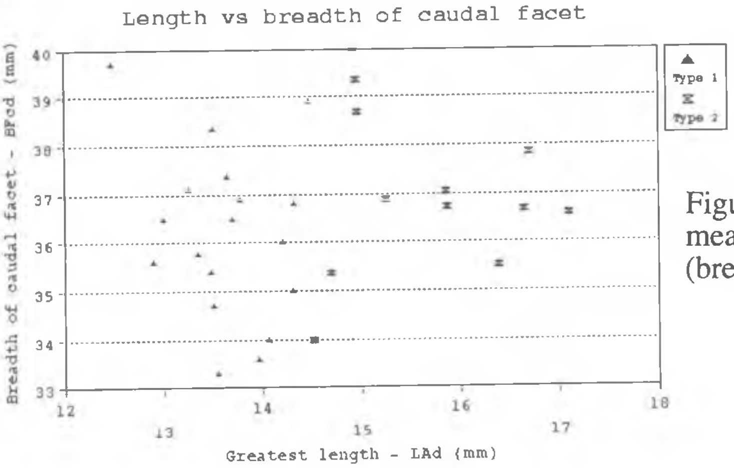


Figure 8-1. Plot of cervical vertebra VC01 measurement LAd (greatest length) vs. BFcd (breadth of the caudal facet).

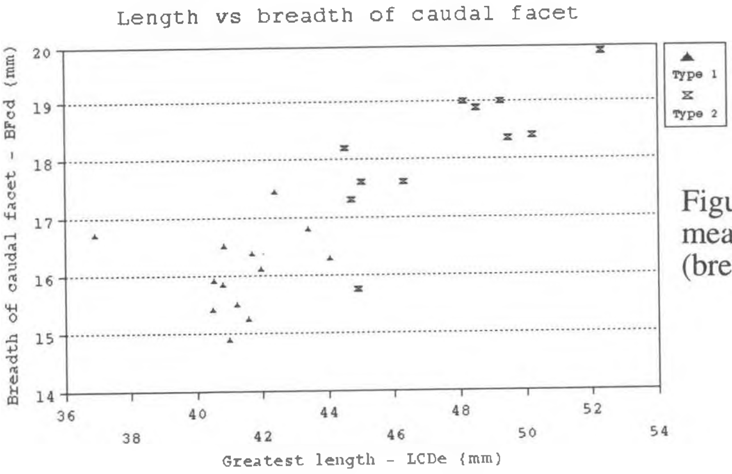


Figure 8-2. Plot of cervical vertebra VC02 measurement LCDe (greatest length) vs. BFcd (breadth of the caudal facet).

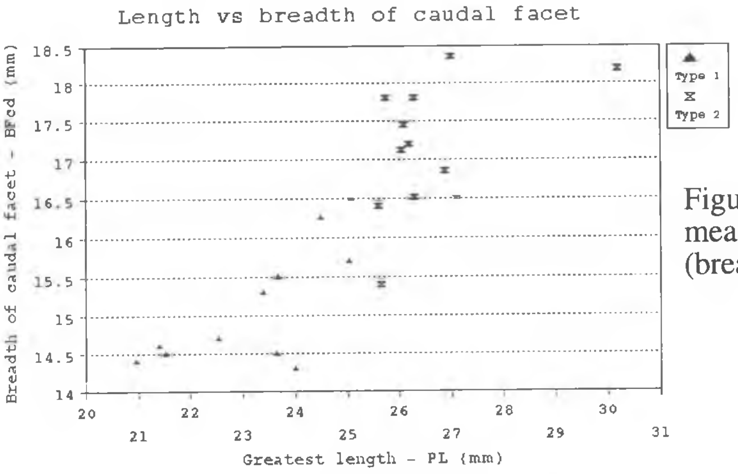


Figure 8-3. Plot of cervical vertebra VC03 measurement PL (greatest length) vs. BFcd (breadth of the caudal facet).

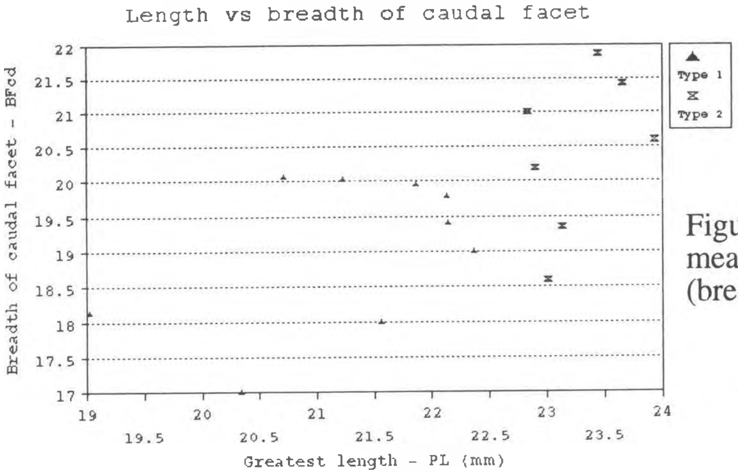


Figure 8-4. Plot of thoracic vertebra VT13 measurement PL (greatest length) vs. BFcd (breadth of the caudal facet.

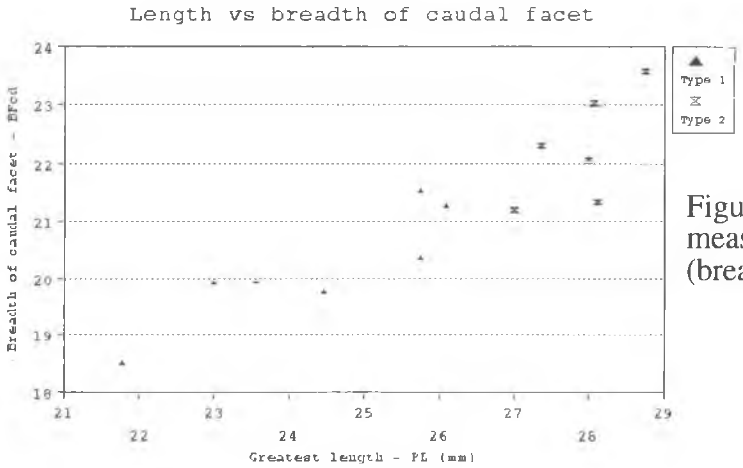


Figure 8-5. Plot of lumbar vertebra VL04 measurement PL (greatest length) vs. BFcd (breadth of the caudal facet).

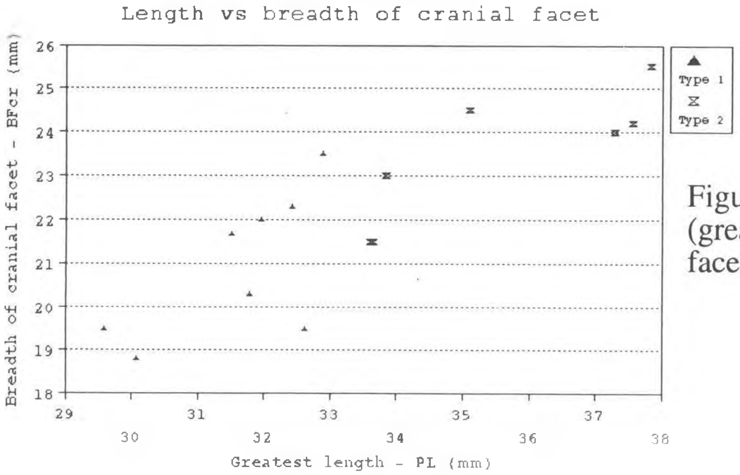


Figure 8-6. Plot of sacrum measurement PL (greatest length) vs. BFcr (breadth of the cranial facet).

Table 8-1. Cervical vertebra 1 (VC01) univariate statistics, division at the mean (LAd) and results of multivariate crossvalidation of type classification.

			Measurement codes					**** %**
Specimen	**Sex**	**Type**	**(LAd)**	**BFcd**	**BFcr**	**GL**	**GB**	**Probability**
3004AA	M	1	12.5	39.7	32.0	38.5	84.1	99.9
0586		1	12.9	35.6	27.5			99.9
0805U	F	1	13.0	36.5	28.9			99.9
2201		1	13.3	37.1	28.7			99.4
0120		1	13.4	35.8		35.3		-
1455		1	13.5	35.4	27.6			99.6
0203A		1	13.5	38.4	30.0			96.2
1471		1	13.5	34.7	29.0			99.9
2606		1	13.6	33.3	27.3			99.9
3000DDD	M	1	13.6	37.4	29.0	36.0	73.9	96.5
2612		1	13.7	36.5	27.7			96.4
0447		1	13.8	36.9				-
0301G	M	1	14.0	33.6	26.8	31.6		99.2
0802R		1	14.1	34.0	26.6	35.1		97.8
2623		1	14.2	36.0	28.0	34.5	73.0	87.5
2046		1	14.3	35.0	28.9	37.5	80.7	95.9
2662		1	14.3	36.8	38.0		82.0	99.8
5024		2	14.5	38.9	31.2			41.1
1409		2	14.5	34.0	26.6			1.1*
2080		2	14.7	35.4	28.0	34.1	74.5	24.5
0200A		2	14.9	40.0				-
3018A	M	2	15.0	39.4	30.5	39.7	79.8	95.4
1229		2	15.0	38.7				-
5014		2	15.3	36.9	28.2			96.6
0360K		2	15.9	37.1				-
1230		2	15.9	36.7	29.0	37.0		99.5
1470		2	16.4	35.5	28.9			99.8
2078		2	16.7	36.7	29.5			99.9
1139A		2	16.7	37.9	29.6	39.9	78.6	100.0
0320		2	17.1	36.6	29.9	35.5		100.0

Statistics		**Measurement codes**				
VC01		**(LAd)**	**BFcd**	**BFcr**	**GL**	**GB**
	total count	30	30	25	12	8
	total mean	14.4	36.5	29.1	36.2	78.3
	total std	1.20	1.73	2.26	2.31	3.83
	total min	12.5	33.3	26.6	31.6	73.0
	total max	17.1	40.0	38.0	39.9	84.1
	total CV	8.28	4.74	7.76	6.39	4.90
	type 1 count	17	17	15	7	5
	type 1 mean	13.6	36.0	29.1	35.5	78.7
	type 1 std	0.49	1.619	2.728	2.058	4.472
	type 1 min	12.5	33.3	26.6	31.6	73.0
	type 1 max	14.3	39.7	38.0	38.5	84.1
	type 1 CV	3.61	4.49	9.39	5.80	5.68
	type 2 count	13	13	10	5	3
	type 2 mean	15.6	37.2	29.1	37.2	77.6
	type 2 std	0.88	1.65	1.26	2.27	2.26
	type 2 min	14.5	34.0	26.6	34.1	74.5
	type 2 max	17.1	40.0	31.2	39.9	79.8
	type 2 CV	5.62	4.44	4.32	6.10	2.91

* starred entries are misclassified, at < 5% probability of group membership.

** this is the probability of membership in the "type" group as initially classified, based on multivariate analysis using variables LAd, BFcd, BFcr together.

Table 8-2. Cervical vertebra 2 (VC02) univariate statistics, division at the mean (LCDe) and results of multivariate crossvalidation of type classification.

			Measurement codes							** %
Specimen	**Sex**	**Type**	**BFcd**	**BFcr**	**LAPa**	**(LCDe)**	**H**	**SBV**	**BPac**	**Probability**
1233		1	16.7	26.6	38.2	36.9		20.8	23.6	99.9
0630A12		1		26.8		38.0		20.9	24.2	99.9
2056		1	15.4	25.7	41.0	40.5		20.8	23.3	98.9
0615		1	15.9	25.7		40.5	30.0	17.5	26.2	99.9
0301H	M	1	15.9	26.6	45.2	40.8	35.4	19.7	23.6	92.8
2051B		1	16.5	26.9		40.8	34.7		27.9	-
1564		1	14.9	25.2		41.0				-
0318		1	15.5	26.5	44.3	41.2	29.0			-
0353		1	15.3	25.0	45.5	41.6	31.6	18.8	25.7	99.8
0153		1	16.4	27.1	47.2	41.7		19.6	27.5	98.3
1401		1	16.1	25.9	47.4	42.0	31.7	19.9	26.1	99.3
2413A		1	17.4	28.2	43.3	42.4	32.4	20.5	26.6	65.5
2047		1	16.8	27.5	45.9	43.4	34.1	19.5	26.4	56.6
1572		1	16.3	26.3	45.8	44.0	33.2	19.8	27.4	89.1
1232		2	18.2	29.7		44.5		22.2	28.2	83.8
3000CCC	M	2	17.3	29.0	48.9	44.7	34.7	21.7	28.9	36.0
1231		2	15.8	26.3		44.9		18.7	26.4	7.5
2203		2	17.6	27.6		45.0	34.7	21.2	25.8	68.6
0535		2		28.2	44.3	46.0	32.3		25.9	-
0950S		2	17.6	29.2	52.5	46.3	35.4	21.1	27.0	99.0
0201D		2		29.7	49.3	46.4	36.7	21.1	26.9	99.6
2063A		2	19.0	30.9	50.8	48.1	36.0		26.6	-
3004BB	M	2	18.9	31.1	52.0	48.5	40.8	24.0	29.6	99.9
2059		2	19.0	29.7		49.2	38.2	22.5	28.3	99.9
0426		2	18.4	29.8		49.5	38.9		30.4	-
3018B	M	2	18.4	29.7	52.5	50.2	39.6	22.4	29.7	99.9
1425		2	19.9	31.0		52.3		24.6		-

Statistics			Measurement codes				
VC02		**BFcd**	**BFcr**	**LAPa**	**(LCDe)**	**H**	**SBV**	**BPacd**
	total count	24	27	17	27	19	21	24
	total mean	17.0	27.8	46.7	44.1	34.7	20.8	26.8
	total std	1.36	1.84	3.89	3.79	3.12	1.67	1.87
	total min	14.9	25.0	38.2	36.9	29.0	17.5	23.3
	total max	19.9	31.1	52.5	52.3	40.8	24.6	30.4
	total CV	8.01	6.61	8.33	8.59	8.98	8.04	6.99
	type 1 count	13	14	10	14	9	11	12
	type 1 mean	16.1	26.4	44.4	41.0	32.5	19.8	25.7
	type 1 std	0.68	0.84	2.71	1.79	2.01	0.96	1.58
	type 1 min	14.9	25.0	38.2	36.9	29.0	17.5	23.3
	type 1 max	17.4	28.2	47.4	44.0	35.4	20.9	27.9
	type 1 CV	4.23	3.17	6.11	4.37	6.18	4.83	6.14
	type 2 count	11	13	7	13	10	10	12
	type 2 mean	18.2	29.4	50.0	47.4	36.7	22.0	27.8
	type 2 std	1.06	1.33	2.71	2.38	2.49	1.57	1.52
	type 2 min	15.8	26.3	44.3	44.5	32.3	18.7	25.8
	type 2 max	19.9	31.1	52.5	52.3	40.8	24.6	30.4
	type 2 CV	5.81	4.52	5.42	5.03	6.77	7.15	5.46

** this is the probability of membership in the "type" group as initially classified, based on multivariate analysis using variables BFcr, LCDe, SBV, BPacd together.

Table 8-3. Cervical vertebra 3 (VC03) univariate statistics, division at the mean (PL)
and results of multivariate crossvalidation of type classification.

			Measurement code							** %
Specime	**Sex**	**Type**	**BFcd**	**GLPa**	**BPac**	**BPacr**	**(PL)**	**HFcd**	**BNCc**	**Probability**
2258		1	14.4	30.3	28.4	25.7	21.0			99.9
0354		1	14.6		28.6		21.4		10.1	
0508		1	14.5	30.3	28.8		21.5	10.6		99.9
0355		1	14.7	32.4			22.5	13.4	9.7	99.6
1501		1	15.3	32.8	31.2	27.0	23.4	13.2		93.9
1565		1	14.5	31.1		23.2	23.7			97.9
2051A		1	15.5	37.5		26.9	23.7	12.0		86.7
0309A		1	15.5	35.0		24.3	23.7	13.0	9.9	90.9
0614		1	14.3	32.5	29.4	27.1	24.0	11.9	9.7	98.5
2058		1	16.3	38.1	33.2		24.5			21.4
0149		2	15.7	36.1			25.0	12.5		27.6
0950T		2	16.5	39.3		28.1	25.1	12.8		62.6
3000EEE	M	2	16.4	35.9		29.0	25.6			88.8
0587		2	15.4				25.7	12.4	10.7	
0201E		2	17.8	37.8		27.5	25.8	14.6	10.4	99.6
0125		2	17.1				26.0	13.0		
3004CC	M	2	17.5	40.7		30.3	26.1			99.1
3018C	M	2	17.2	39.2		30.1	26.2			98.9
2237D		2	17.8	40.0	32.3		26.3			99.8
0200C		2	16.5	38.7	32.8	29.3	26.3	13.8	11.7	95.0
5010		2	16.9	36.4		28.6	26.9			99.1
2057		2	18.4	38.7	35.4		27.0			100.0
1139C		2	16.5	41.0	34.1	29.2	27.1	14.0		94.8
1550A		2	18.2	44.1	36.3	32.0	30.2	16.0		100.0

Statistics			Measurement code					
VC03		**BFcd**	**GLPa**	**BPac**	**BPacr**	**(PL)**	**HFcd**	**BNCcr**
	total count	24	21	11	15	24	14	7
	total mean	16.1	36.6	31.9	27.9	24.9	13.1	10.3
	total std	1.26	3.75	2.67	2.24	2.08	1.25	0.66
	total min	14.3	30.3	28.4	23.2	21.0	10.6	9.7
	total max	18.4	44.1	36.3	32.0	30.2	16.0	11.7
	total CV	7.79	10.25	8.38	8.03	8.36	9.56	6.40
	type 1 count	10	9	6	6	10	6	4
	type 1 mean	15.0	33.3	29.9	25.7	22.9	12.4	9.9
	type 1 std	0.61	2.77	1.73	1.48	1.18	0.97	0.17
	type 1 min	14.3	30.3	28.4	23.2	21.0	10.6	9.7
	type 1 max	16.3	38.1	33.2	27.1	24.5	13.4	10.1
	type 1 CV	4.10	8.30	5.76	5.75	5.15	7.88	1.68
	type 2 count	14	12	5	9	14	8	3
	type 2 mean	17.0	39.0	34.2	29.3	26.4	13.6	10.9
	type 2 std	0.85	2.25	1.50	1.25	1.22	1.15	0.54
	type 2 min	15.4	35.9	32.3	27.5	25.0	12.4	10.4
	type 2 max	18.4	44.1	36.3	32.0	30.2	16.0	11.7
	type 2 CV	5.02	5.78	4.40	4.26	4.64	8.44	4.96

** this is the probability of membership in the "type" group as initially classified, based on multivariate analysis using variables BFcd, GLPa, PL together.

Table 8-4. Vertebrae 4 (VC04) & 5 (VC05) univariate statistics, division at the mean (PL) and results of multivariate crossvalidation of type classification.

VC04					**Measurement code**				**** %**
Specimen	**Sex**	**Type**	**BFcd**	**GLPa**	**BPacd**	**BPacr**	**(PL)**	**HFcd**	**Probability**
2050		1	14.4			30.7	19.6	13.4	99.9
1235		1	14.6	33.8		30.1	20.4	12.5	99.9
1438		1	14.0				21.1	12.0	-
5012		1	15.0			30.8	21.2	13.8	99.1
0309B		1	14.4	33.1	27.9	28.9	21.2	12.9	99.7
1586		1	15.9	35.1		33.3	21.4	14.2	91.6
1527		1	14.3				21.5	14.0	-
0503		1	14.0			30.7	21.8	13.4	98.1
0441		1	14.7				22.0	12.2	-
2661		1	15.2			30.8	22.4		90.9
1408		1	14.2	33.7		31.4	22.5	12.7	77.6
0203B		1	15.3	37.3	27.6	29.4	22.7		87.6
0201F		1	16.9	36.5	32.0	32.6	22.9	15.3	19.9
0200D		1		40.0	31.9	33.0	22.9	14.5	-
0950U		1	15.9	37.1		31.7	23.0	15.0	61.1
1139D		2	16.1	37.0	32.0	33.2	23.3	14.3	61.2
2237E		2	17.1			33.6	23.7	15.8	65.8
5006		2	16.1			33.1	24.0	15.2	86.5
3000FFF	M	2	15.6			30.4	24.0		35.9
3018D	M	2	16.3			32.1	24.0	15.2	81.8
2111		2	16.7	37.2		36.4	24.1	14.7	96.7
3004DD	M	2	16.8			34.1	24.1	14.0	94.8
2054		2	17.6	38.9		34.3	24.4	16.9	97.4
1147		2	16.7	41.0		34.5	24.8	15.7	98.6
1166		2	18.6	43.1		36.9	25.4	15.5	99.9
0442		2	16.9			32.9	25.4	15.1	99.2
1550B		2	17.6			37.7	26.7	15.8	100.0
2238A		2	17.9			33.5	26.9	14.8	99.9

Statistics				**Measurement code**			
VC04		**BFcd**	**GLPa**	**BPacd**	**BPacr**	**(PL)**	**HFcd**
	total count	27	13	5	25	28	25
	total mean	15.9	37.2	30.3	32.6	23.1	14.4
	total std	1.29	2.86	2.08	2.21	1.76	1.23
	total min	14.0	33.1	27.6	28.9	19.6	12.0
	total max	18.6	43.1	32.0	37.7	26.9	16.9
	total CV	8.10	7.69	6 88	6.76	7.63	8.59
	type 1 count	14	8		12	15	13
	type 1 mean	14.9	35.8		31.1	21.8	13.5
	type 1 std	0.82	2.20		1.30	0.96	1.00
	type 1 min	14.0	33.1		28.9	19.6	12.0
	type 1 max	16.9	40.0		33.3	23.0	15.3
	type 1 CV	5.49	6.15		4.18	4.39	7.42
	type 2 count	13	5		13	13	12
	type 2 mean	16.9	39.4		34.1	24.7	15.2
	type 2 std	0.80	2.33		1.92	1.07	0.74
	type 2 min	15.6	37.0		30.4	23.3	14.0
	type 2 max	18.6	43.1		37.7	26.9	16.9
	type 2 CV	4.72	5.90		5.63	4.34	4.85

VC05				**Measurement code**			**** %**
Specimen	**Sex**	**Type**	**BFcd**	**BPacr**	**(PL)**	**HFcd**	**Probability**
2604C		1	14.0	31.2	18.1	12.3	100.0
0201G		1		32.2	18.7		-
1437		1	13.3	28.7	18.8	12.0	100.0
1410		1	13.2	30.6	19.6		99.8
0950W		1	15.0	31.1	19.6	13.5	99.7
3000GGG	M	1	14.8	30.5	19.9	14.0	99.9
0203C		1			20.0		-
3006A		1	15.2	30.0	20.0	15.0	99.9
0124		1	15.0	31.4	20.6	15.5	54.2
0444		2	16.3	33.9	20.8	14.5	99.9
1139E		2	16.7	33.5	20.9	14.0	99.6
0200E		2	15.2	32.9	21.5	15.0	99.9
3004EE	M	2	15.8	33.7	21.8	14.5	100.0
3018E	M	2	15.1	32.2	21.8	15.0	99.7
2063B		2	16.7	31.7	22.8	14.3	99.8
1550C		2		37.6	25.4		-

Statistics			**Measurement code**		
VC05		**BFcd**	**BPacr**	**(PL)**	**HFcd**
	total count	13	15	16	12
	total mean	15.1	32.1	20.64	14.1
	total std	1.08	2.03	1.73	1.03
	total min	13.2	28.7	18.1	12.0
	total max	16.7	37.6	25.4	15.5
	total CV	7.17	6.34	8.39	7.30
	type 1 count	7	8	9	6
	type 1 mean	14.3	30.7	19.5	13.7
	type 1 std	0.78	0.99	0.75	1.28
	type 1 min	13.2	28.7	18.1	12.0
	type 1 max	15.2	32.2	20.6	15.5
	type 1 CV	5.41	3.24	3.85	9.36
	type 2 count	6	7	7	6
	type 2 mean	16.0	33.6	22.1	14.5
	type 2 std	0.65	1.78	1.48	0.36
	type 2 min	15.1	31.7	20.8	14.0
	type 2 max	16.7	37.6	25.4	15.0
	type 2 CV	4.07	5.29	6.69	2.51

** this is the probability of membership in the "type" group as initially classified, based on multivariate analysis using variables BFcd, BPacr, PL together.

Table 8-5. Cervical vertebrae 6 (VC06) & 7 (VC07) univariate statistics, division at the mean (PL) and results of multivariate crossvalidation of type classification.

VC06						**** %**
Specimen	**Sex**	**Type**	**BPacr**	**(PL)**	**HFcd**	**Probability**
2064		1	30.5	16.2	12.3	100.0
1436		1	27.0	17.1	10.6	99.9
2066		1	29.6	17.7	13.8	98.7
0616		1	29.4	17.7	12.9	98.9
0609		1	30.0	17.8	12.9	97.9
2413C		1	28.4	17.9	12.3	98.5
3000HHH	M	1	30.8	18.4	12.8	62.9
3006B		2	29.5	18.9	13.2	3.0*
0950V		2	31.8	19.2	13.4	92.8
1148		2	33.1	19.3	13.0	97.6
2237F		2	33.8	19.6	14.7	98.9
1139F		2	32.5	19.8		
0200F		2	33.8	20.1	13.6	99.9
3004FF	M	2	34.8	20.2	14.0	99.9
3018F	M	2	32.8	20.8	14.0	100.0

VC07							**** %**
Specimen	**Sex**	**Type**	**BFcd**	**BPacr**	**(PL)**	**HFcd**	**Probability**
2204		1	14.7		16.4	10.9	100.0
2604B		1	17.2	30.3	16.8	10.7	99.9
1139G		1	18.0	31.2	17.8	12.0	99.8
3000III	M	1	17.0	29.2	18.1	12.6	99.3
3006C		1	17.9		18.2	12.7	99.9
0950X		1	17.1	30.5	18.3	12.6	96.4
0200G		2	17.6	32.0	18.7	12.8	6.1
1159		2	16.7	29.3	18.8	12.6	99.9
3004GG	M	2	17.8	33.3	19.5	13.1	100.0
3018G	M	2	19.4	30.6	19.7	13.5	96.3
1149		2	19.5	31.3	20.0	13.5	100.0

Statistics	**Measurement code**		
VC06	**BPacr**	**(PL)**	**HFcd**
total count	15	15	14
total mean	31.2	18.7	13.1
total std	2.17	1.25	0.97
total min	27.0	16.2	10.6
total max	34.8	20.8	14.7
total CV	6.97	6.70	7.37
type 1 count	7	7	7
type 1 mean	29.4	17.5	12.5
type 1 std	1.21	0.67	0.91
type 1 min	27.0	16.2	10.6
type 1 max	30.8	18.4	13.8
type 1 CV	4.13	3.82	7.28
type 2 count	8	8	7
type 2 mean	32.8	19.7	13.7
type 2 std	1.51	0.58	0.55
type 2 min	29.5	18.9	13.0
type 2 max	34.8	20.8	14.7
type 2 CV	4.60	2.93	4.03

Statistics	**Measurement code**			
VC07	**BFcd**	**BPacr**	**(PL)**	**HFcd**
total count	11	9	11	11
total mean	17.5	30.8	18.4	12.5
total std	1.25	1.22	1.07	0.88
total min	14.7	29.2	16.4	10.7
total max	19.5	33.3	20.0	13.5
total CV	7.12	3.94	5.81	7.03
type 1 count	6	4	6	6
type 1 mean	17.0	30.3	17.6	11.9
type 1 std	1.09	0.71	0.73	0.81
type 1 min	14.7	29.2	16.4	10.7
type 1 max	18.0	31.2	18.3	12.7
type 1 CV	6.43	2.36	4.16	6.76
type 2 count	5	5	5	5
type 2 mean	18.2	31.3	19.3	13.1
type 2 std	1.10	1.36	0.51	0.36
type 2 min	16.7	29.3	18.7	12.6
type 2 max	19.5	33.3	20.0	13.5
type 2 CV	6.06	4.34	2.66	2.75

* starred entries are misclassified, at < 5% probability of group membership.

** this is the probability of membership in the "type" group as initially classified, based on multivariate analysis using variables BPacr, PL, HFcd together.

Table 8-6. Thoracic vertebrae 3 (VT03) & 12 (VT12) univariate statistics, division at the mean (PL) and results of multivariate crossvalidation of type classification.

VT03			**Measurement codes**			**** %**
Specimen	**Sex**	**Type**	**BFcd**	**(PL)**	**HFcd**	**Probability**
1569		1	20.7	15.1	11.4	100.0
0540		1	20.1	15.5	10.7	100.0
0200J		1	21.0	16.0	11.5	99.5
0106		1	20.6	16.1	11.4	99.5
2107		2	22.8	16.2	11.4	100.0
1139K		2	22.7	16.3	11.0	100.0
3018J	M	2	21.5	16.3	11.5	64.7
3004JJ	M	2	22.7	16.5	11.5	100.0
1160		2	22.6	16.5	11.9	100.0
1169		2	22.2	16.8	11.9	99.9

Statistics		**Measurement codes**		
VT03		**BFcd**	**(PL)**	**HFcd**
	total count	10	10	10
	total mean	21.7	16.1	11.4
	total std	0.97	0.47	0.34
	total min	20.1	15.1	10.7
	total max	22.8	16.8	11.9
	total CV	4.49	2.90	3.01
	type 1 count	4	4	4
	type 1 mean	20.6	15.7	11.2
	type 1 std	0.31	0.38	0.32
	type 1 min	20.1	15.1	10.7
	type 1 max	21.0	16.1	11.5
	type 1 CV	1.48	2.44	2.84
	type 2 count	6	6	6
	type 2 mean	22.4	16.4	11.5
	type 2 std	0.46	0.20	0.31
	type 2 min	21.5	16.2	11.0
	type 2 max	22.8	16.8	11.9
	type 2 CV	2.04	1.23	2.73

VT12			**Measurement codes**			**** %**
Specimen	**Sex**	**Type**	**BFcd**	**(PL)**	**HFcd**	**Probability**
0400HH		1	18.4	17.6	9.3	100.0
0358		1	17.3	18.3	9.7	99.7
1502		1	18.3	18.3	10.1	99.5
1571		1	17.0	18.8		
1239		1	19.1	18.9	10.0	93.2
1225C		1	20.0	19.3	10.6	35.6
4048		1	19.6	19.6	10.6	17.4
0200S		2	20.3	20.0	10.6	84.1
0123		2	20.5	20.1	11.0	82.6
2043A		2	19.9	20.2	11.1	83.6
3000SSS	M	2	19.7	20.2	10.6	95.7
3018S	M	2	20.3	20.6	10.5	98.9
0573B		2	19.0	20.6	10.7	98.1
3004SS	M	2	20.9	21.1	10.8	99.9
1175		2	20.2	21.4	10.7	100.0

Statistics		**Measurement codes**		
VT12		**BFcd**	**(PL)**	**HFcd**
	total count	15	15	14
	total mean	19.4	19.6	10.4
	total std	1.12	1.08	0.49
	total min	17.0	17.6	9.3
	total max	20.9	21.4	11.1
	total CV	5.77	5.49	4.68
	type 1 count	7	7	6
	type 1 mean	18.5	18.7	10.0
	type 1 std	1.02	0.63	0.48
	type 1 min	17.0	17.6	9.3
	type 1 max	20.0	19.6	10.6
	type 1 CV	5.50	3.40	4.74
	type 2 count	8	8	8
	type 2 mean	20.1	20.5	10.7
	type 2 std	0.53	0.49	0.19
	type 2 min	19.0	20.0	10.5
	type 2 max	20.9	21.4	11.1
	type 2 CV	2.66	2.38	1.80

** this is the probability of membership in the "type" group as initially classified. based on multivariate analysis using variables BPacr, PL, HFcd together.

Table 8-7. Thoracic vertebra 13 (VT13) & lumbar vertebra 1 (VL01) univariate statistics, division at the mean (PL) and results of multivariate crossvalidation of type classification.

VT13						**** %**
Specimen	**Sex**	**Type**	**BFcd**	**(PL)**	**HFcd**	**Probability**
0400II		1	18.1	19.0	10.0	100.0
0163		1	17.0	20.3	10.0	99.7
1225D		1	20.1	20.7	11.0	97.8
0200T		1	20.0	21.2	12.1	99.9
3006E		1	18.0	21.6	10.9	93.7
2043B		1	20.0	21.9	11.4	85.6
3018T	M	1	19.8	22.1	11.2	48.3
3000TTT	M	1	19.4	22.1	10.7	8.6
0573C		2	19.0	22.4	11.0	35.4
3004TT	M	2	21.0	22.8	11.0	97.8
1145A		2	20.2	22.9	11.0	96.8
1151		2	18.6	23.0	10.2	98.9
1152		2	19.4	23.1	11.1	93.7
2618		2	21.9	23.5	12.1	94.3
1237		2	21.4	23.7	12.0	97.8
1170		2	20.6	23.9	11.3	99.9

VL01						**** %**
Specimen	**Sex**	**Type**	**BFcd**	**(PL)**	**HFcd**	**Probability**
0400JJ		1	18.1	20.2	10.5	100.0
3001K	M	1	18.1	21.5	10.3	98.4
4023		1	18.3	21.6	10.3	98.2
1491		1	20.0	21.8	11.1	99.4
1225E		1	20.1	22.0	11.3	99.0
0570		1	19.8	22.3	11.3	95.5
0200U		1	21.4	22.4	12.9	91.5
4003		1	18.8	22.5	11.0	98.4
2043C		1	19.9	22.7	11.9	74.9
3000VVV	M	2	19.2	23.0	11.5	41.1
3018U	M	2	20.5	23.5	11.7	57.1
3004UU	M	2	20.7	23.9	11.6	76.9
1145B		2	19.6	23.9	12.6	87.9
1164A		2	20.8	24.4	11.7	96.2
0511		2	18.4	24.7	11.6	99.9
1178		2	20.9	25.3	12.8	99.9
0588		2	22.5	26.3	12.3	100.0

Statistics				
VT13		**BFcd**	**(PL)**	**HFcd**
	total count	16	16	16
	total mean	19.6	22.14	11.1
	total std	1.25	1.28	0.63
	total min	17.0	19.0	10.0
	total max	21.9	23.9	12.1
	total CV	6.39	5.80	5.69
	type 1 count	8	8	8
	type 1 mean	19.0	21.1	10.9
	type 1 std	1.10	1.00	0.65
	type 1 min	17.0	19.0	10.0
	type 1 max	20.1	22.1	12.1
	type 1 CV	5.77	4.73	5.92
	type 2 count	8	8	8
	type 2 mean	20.3	23.2	11.2
	type 2 std	1.10	0.47	0.57
	type 2 min	18.6	22.4	10.2
	type 2 max	21.9	23.9	12.1
	type 2 CV	5.45	2.02	5.07

Statistics				
VL01		**BFcd**	**(PL)**	**HFcd**
	total count	17	17	17
	total mean	19.8	23.1	11.5
	total std	1.22	1.50	0.76
	total min	18.1	20.2	10.3
	total max	22.5	26.3	12.9
	total CV	6.15	6.52	6.60
	type 1 count	9	9	9
	type 1 mean	19.4	21.9	11.2
	type 1 std	1.07	0.72	0.77
	type 1 min	18.1	20.2	10.3
	type 1 max	21.4	22.7	12.9
	type 1 CV	5.53	3.29	6.93
	type 2 count	8	8	8
	type 2 mean	20.3	24.4	12.0
	type 2 std	1.17	0.98	0.47
	type 2 min	18.4	23.0	11.5
	type 2 max	22.5	26.3	12.8
	type 2 CV	5.75	4.02	3.97

** this is the probability of membership in the "type" group as initially classified, based on multivariate analysis using variables BFcd, PL, HFcd together.

Table 8-8. Lumbar vertebrae 2 (VL02) & 3 (VL03) univariate statistics, division at the mean (PL) and results of multivariate crossvalidation of type classification.

VL02 **Specimen**	**Sex**	**Type**	**BFcd**	**(PL)**	**HFcd**	**** %** **Probability**
0352		1	17.9	22.3	11.4	100.0
3001J	M	1	18.3	22.6	11.3	99.9
4024		1	18.0	22.6	10.9	99.9
0200V		1	19.6	23.1	10.3	99.4
0400KK		1	19.7	23.2	10.6	98.8
1225F		1	19.9	23.3	12.4	96.8
1227A		1	19.8	23.9	11.2	93.4
0164		1	19.6	24.2	12.0	89.1
3000ZZZ	M	1	19.0	24.3	12.2	89.8
2043D		1	20.0	24.3	12.6	56.4
3018V	M	2	20.5	24.7	11.9	27.9
3004VV	M	2	20.4	25.2	12.8	66.4
1164B		2	21.2	25.7	12.2	96.1
1145C		2	19.7	26.0	12.3	94.4
1144C		2	19.9	27.3	12.8	99.9
1161		2	19.9	27.6	11.9	100.0

VL03 **Specimen**	**Sex**	**Type**	**BFcd**	**(PL)**	**HFcd**	**** %** **Probability**
1594A		1	19.8	22.4	11.0	99.8
0400LL		1	18.9	22.5	10.4	99.6
1604		1	18.7	22.7	11.9	99.9
1411		1	17.4	22.9	10.3	99.1
3001I	M	1	18.8	23.6	11.3	94.4
1225G		1	20.4	24.3	13.2	70.2
3000UUU	M	1	19.6	24.9	12.2	39.4
0200W		1	21.1	25.0	12.8	13.5
1177		2	19.2	25.2	12.0	61.2
0165		2	21.0	25.3	13.0	60.6
2043E		2	20.4	25.5	12.5	82.8
3018W	M	2	21.2	25.6	12.7	86.2
3004WW	M	2	20.8	26.1	13.4	91.8
1155		2	19.0	26.4	12.1	97.8
1227B		2	20.1	26.7	12.0	99.5
1164C		2	21.5	26.9	12.7	99.7
1144B		2	20.6	28.1	13.1	100.0

Statistics **VL02**		**Measurement codes** **BFcd**	**(PL)**	**HFcd**
	total count	16	16	16
	total mean	19.6	24.4	11.8
	total std	0.87	1.56	0.76
	total min	17.9	22.3	10.3
	total max	21.2	27.6	12.8
	total CV	4.45	6.38	6.42
	type 1 count	10	10	10
	type 1 mean	19.2	23.4	11.5
	type 1 std	0.78	0.69	0.76
	type 1 min	17.9	22.3	10.3
	type 1 max	20.0	24.3	12.6
	type 1 CV	4.09	2.97	6.59
	type 2 count	6	6	6
	type 2 mean	20.3	26.1	12.3
	type 2 std	0.50	1.07	0.38
	type 2 min	19.7	24.7	11.9
	type 2 max	21.2	27.6	12.8
	type 2 CV	2.45	4.09	3.08

Statistics **VL03**		**Measurement codes** **BFcd**	**(PL)**	**HFcd**
	total count	17	17	17
	total mean	19.9	25.0	12.1
	total std	1.10	1.63	0.91
	total min	17.4	22.4	10.3
	total max	21.5	28.1	13.4
	total CV	5.51	6.53	7.51
	type 1 count	8	8	8
	type 1 mean	19.3	23.5	11.6
	type 1 std	1.09	1.00	1.00
	type 1 min	17.4	22.4	10.3
	type 1 max	21.1	25.0	13.2
	type 1 CV	5.64	4.27	8.58
	type 2 count	9	9	9
	type 2 mean	20.4	26.2	12.6
	type 2 std	0.81	0.88	0.48
	type 2 min	19.0	25.2	12.0
	type 2 max	21.5	28.1	13.4
	type 2 CV	3.97	3.36	3.79

** this is the probability of membership in the "type" group as initially classified, based on multivariate analysis using variables BFcd, PL, HFcd together

Table 8-9. Lumbar vertebrae 4 (VL04) & 5 (VL05) univariate statistics, division at the mean (PL) and results of multivariate crossvalidation of type classification.

VL04			**Measurement codes**			**** %**
Specimen	**Sex**	**Type**	**BFcd**	**(PL)**	**HFcd**	**Probability**
0400MM		1	18.5	21.8	10.0	100.0
1492		1	19.9	23.0	11.7	99.9
1594B		1	20.0	23.6	11.9	99.9
3001H	M	1	19.8	24.5	12.0	99.3
3000YYY	M	1	20.3	25.8	12.6	66.8
2043F		1	21.5	25.8	13.2	56.4
3018X	M	2	21.3	26.1	13.0	25.2
1227C		2	21.2	27.0	12.0	99.8
3004XX	M	2	22.3	27.4	13.7	97.3
1168		2	22.1	28.0	13.6	99.2
1167		2	23.0	28.1	14.4	98.7
1144A		2	21.3	28.1	12.6	99.9
1165		2	23.6	28.8	13.9	100.0

VL05			**Measurement codes**			**** %**
Specimen	**Sex**	**Type**	**BFcd**	**(PL)**	**HFcd**	**Probability**
0400NN		1	17.7	20.7	10.5	100.0
1226A		1	22.5	24.6	12.9	57.8
3001G	M	1	20.4	24.8	11.0	43.9
5055		1	22.2	25.1	12.5	44.7
3006F		1	21.1	25.8		-
0126		2	22.4	26.1	12.9	92.3
3018Y	M	2	22.1	26.1	12.7	95.2
3000WWW	M	2	20.7	26.4	12.6	99.9
2043G		2	22.2	26.4	13.2	99.1
1141		2	23.2	26.8	12.3	31.1
1227D		2	22.5	27.5	11.9	98.5
1158		2	21.0	27.7	11.2	99.9
3004YY	M	2	23.4	27.8	12.7	99.4

Statistics		**Measurement codes**		
VL04		**BFcd**	**(PL)**	**HFcd**
	total count	13	13	13
	total mean	21.1	$\boxed{26.0}$	12.7
	total std	1.36	2.12	1.12
	total min	18.5	21.8	10.0
	total max	23.6	28.8	14.4
	total CV	6.45	8.17	8.87
	type 1 count	6	6	6
	type 1 mean	20.0	$\boxed{24.1}$	11.9
	type 1 std	0.89	1.44	0.99
	type 1 min	18.5	21.8	10.0
	type 1 max	21.5	25.8	13.2
	type 1 CV	4.45	6.00	8.32
	type 2 count	7	7	7
	type 2 mean	22.1	$\boxed{27.6}$	13.3
	type 2 std	0.85	0.81	0.76
	type 2 min	21.2	26.1	12.0
	type 2 max	23.6	28.8	14.4
	type 2 CV	3.85	2.94	5.73

Statistics		**Measurement codes**		
VL05		**BFcd**	**(PL)**	**HFcd**
	total count	13	13	12
	total mean	21.6	$\boxed{25.82}$	12.2
	total std	1.45	1.79	0.83
	total min	17.7	20.7	10.5
	total max	23.4	27.8	13.2
	total CV	6.70	6.93	6.80
	type 1 count	5	5	4
	type 1 mean	20.8	$\boxed{24.2}$	11.7
	type 1 std	1.70	1.81	1.00
	type 1 min	17.7	20.7	10.5
	type 1 max	22.5	25.8	12.9
	type 1 CV	8.20	7.48	8.56
	type 2 count	8	8	8
	type 2 mean	22.2	$\boxed{26.8}$	12.4
	type 2 std	0.90	0.67	0.59
	type 2 min	20.7	26.1	11.2
	type 2 max	23.4	27.8	13.2
	type 2 CV	4.04	2.49	4.76

** this is the probability of membership in the "type" group as initially classified, based on multivariate analysis using variables BFcd, PL, HFcd together.

Table 8-10. Lumbar vertebrae 6 (VL06) & 7 (VL07) univariate statistics, division at the mean (PL) and results of multivariate crossvalidation of type classification.

VL06			**Measurement codes**			**** %**
Specimen	**Sex**	**Type**	**BFcd**	**(PL)**	**HFcd**	**Probability**
0400OO		1	20.3	22.4	10.4	100.0
3006G		1		23.9		-
3001F	M	1	21.2	24.0	11.1	97.1
1226B		1	23.2	24.0	12.6	62.1
0565A		1	21.1	24.2	11.4	95.4
0950AA		1	22.5	24.7	12.3	71.3
1596		1	21.2	24.8	12.1	63.3
3018Z	M	2	23.2	25.2	12.6	45.7
3000AAAA	M	2	22.1	25.4	12.2	38.7
2043H		2	23.6	25.7	13.1	77.1
3004ZZ	M	2	25.2	26.9	13.0	99.8
1227E		2	24.3	27.0	11.9	99.8
1150		2	22.5	27.1	12.5	98.5
5000		2	24.0	27.5	12.8	99.9

Statistics		**Measurement codes**		
VL06		**BFcd**	**(PL)**	**HFcd**
	total count	13	14	13
	total mean	22.6	25.197	12.2
	total std	1.39	1.44	0.76
	total min	20.3	22.4	10.4
	total max	25.2	27.5	13.1
	total CV	6.14	5.71	6.22
	type 1 count	6	7	6
	type 1 mean	21.6	24.0	11.7
	type 1 std	0.95	0.73	0.77
	type 1 min	20.3	22.4	10.4
	type 1 max	23.2	24.8	12.6
	type 1 CV	4.41	3.02	6.60
	type 2 count	7	7	7
	type 2 mean	23.6	26.4	12.6
	type 2 std	1.00	0.86	0.40
	type 2 min	22.1	25.2	11.9
	type 2 max	25.2	27.5	13.1
	type 2 CV	4.24	3.25	3.17

VL07			**Measurement codes**			**** %**
Specimen	**Sex**	**Type**	**BFcd**	**(PL)**	**HFcd**	**Probability**
0400PP		1	19.9	18.1	10.5	100.0
3006H		1		19.0		-
1519		1	19.0	19.0	10.5	99.9
2239		1	20.9	19.1	10.5	99.9
0536B		1	19.0	19.1	10.3	99.9
3001L	M	1	20.0	19.2	11.1	99.8
2414		1	21.8	19.2	10.9	99.9
0565B		1	19.9	19.4	10.9	99.5
1244		1	20.1	19.7	10.5	98.3
0950BB		1	21.3	20.0	11.4	95.9
1238		1	22.4	20.0	11.5	97.8
3018AA	M	2	22.3	20.8	12.0	75.1
3000XXX	M	2	21.6	20.9	11.9	88.0
1173		2	21.3	21.2	12.4	98.4
0445		2	22.2	21.3	11.6	97.6
1241		2	25.2	21.9	12.7	98.0
1227F		2	23.0	22.5	11.1	99.9
3004AAA	M	2	24.3	22.6	12.2	99.9
1242		2	25.3	22.8	14.0	100.0
1226C		2	25.3	22.9	13.9	100.0

Statistics		**Measurement codes**		
VL07		**BFcd**	**(PL)**	**HFcd**
	total count	19	20	19
	total mean	21.8	20.4	11.6
	total std	1.97	1.47	1.07
	total min	19.0	18.1	10.3
	total max	25.3	22.9	14.0
	total CV	9.04	7.18	9.21
	type 1 count	10	11	10
	type 1 mean	20.4	19.2	10.8
	type 1 std	1.07	0.52	0.38
	type 1 min	19.0	18.1	10.3
	type 1 max	22.4	20.0	11.5
	type 1 CV	5.23	2.71	3.48
	type 2 count	9	9	9
	type 2 mean	23.4	21.9	12.4
	type 2 std	1.56	0.80	0.92
	type 2 min	21.3	20.8	11.1
	type 2 max	25.3	22.9	14.0
	type 2 CV	6.68	3.67	7.43

** this is the probability of membership in the "type" group as initially classified, based on multivariate analysis using variables BFcd, PL, HFcd together.

Table 8-11. Sacrum univariate statistics, division at the mean (PL) and results of multivariate crossvalidation of type classification.

			Measurement codes					** %
Specimen	**Sex**	**Type**	**BFcr**	**GB**	**BPacr**	**(PL)**	**HFcr**	**Probability**
0400QQ		1	19.5	41.7	26.8	29.6	9.7	99.9
0536A		1	18.8	41.3	26.3	30.1	9.1	99.7
3001M	M	1	21.7	42.0	26.8	31.5	9.5	99.8
1518		1	20.3	39.5		31.8	9.4	99.6
1226D		1	22.0		30.7	32.0	11.1	-
0950CC		1	22.3	44.3	28.6	32.4	10.3	96.3
1163		1	19.5	52.0	29.7	32.6	9.7	6.0
3000WW	M	1	23.5	47.0	30.1	32.9	10.6	71.4
1240		2	21.5		28.5	33.6	10.7	-
1452		2	21.5	42.0		33.6	10.0	2.0*
1153		2	23.0	50.6	29.1	33.8	11.4	38.7
1227G		2	24.5	53.3	26.9	35.1	10.9	89.2
3018BB	M	2	24.0	45.0	31.4	37.3	10.7	98.6
0116B		2	24.2	48.0	26.4	37.6	11.8	99.9
3004BBB	M	2	25.5	50.3	32.9	37.8	11.6	99.9

		Measurement codes				
Statistics		**BFcr**	**GB**	**BPacr**	**(PL)**	**HFcr**
	total count	15	13	13	15	15
	total mean	22.12	45.92	28.78	33.45	10.45
	total std	1.94	4.40	2.03	2.47	0.82
	total min	18.8	39.5	26.3	29.6	9.1
	total max	25.5	53.3	32.9	37.8	11.8
	total CV	8.79	9.59	7.07	7.38	7.82
	type 1 count	8	7	7	8	8
	type 1 mean	20.95	43.97	28.43	31.60	9.93
	type 1 std	1.55	3.96	1.68	1.12	0.63
	type 1 min	18.8	39.5	26.3	29.6	9.1
	type 1 max	23.5	52.0	30.7	32.9	11.1
	type 1 CV	7.39	9.00	5.89	3.53	6.37
	type 2 count	7	6	6	7	7
	type 2 mean	23.46	48.20	29.20	35.56	11.03
	type 2 std	1.41	3.76	2.32	1.81	0.57
	type 2 min	21.5	42.0	26.4	33.6	10.0
	type 2 max	25.5	53.3	32.9	37.8	11.8
	type 2 CV	6.02	7.80	7.95	5.10	5.20

* starred entries are misclassified, at < 5% probability of group membership

** this is the probability of membership in the "type" group as initially classified, based on multivariate analysis using variables BFcr, GB, PL, HFcr together.

Table 8-12. Associated thoracic vertebrae 1 (VT01) & 2 (VT02) selected measurements and basic statistics, total sample.

VT01		**Measurement code**				
Specimen	**Sex**	**BFcd**	**BPacd**	**BPacr**	**PL**	**HFcd**
3006D		20.3		26.3	17.3	11.2
3000JJJ	M	22.4	18.3	26.3	17.1	11.6
0200H		22.7	22.2		18.9	12.2
0950Y		22.8	24.0	28.4	17.1	11.5
3004HH	M	23.4	21.5	29.1	18.6	12.3
1139H		23.7	20.4	27.6	18.9	11.9
3018H	M	23.8	20.6	28.4	18.4	11.6
total count		7	6	6	7	7
total mean		22.7	21.2	27.7	18.1	11.8
total std		1.1	1.7	1.1	0.8	0.4

VT02		**Measurement code**		
Specimen	**Sex**	**BFcd**	**PL**	**HFcd**
0200I		22.9	16.7	11.6
0950Z		23.1	16.0	11.5
1139I		23.3	17.4	11.6
3000KKK	M		16.1	10.9
3004II	M	23.5	17.7	11.5
3018I	M	23.3	17.2	11.8
total count		5	6	6
total mean		23.2	16.8	11.5
total std		0.2	0.6	0.3

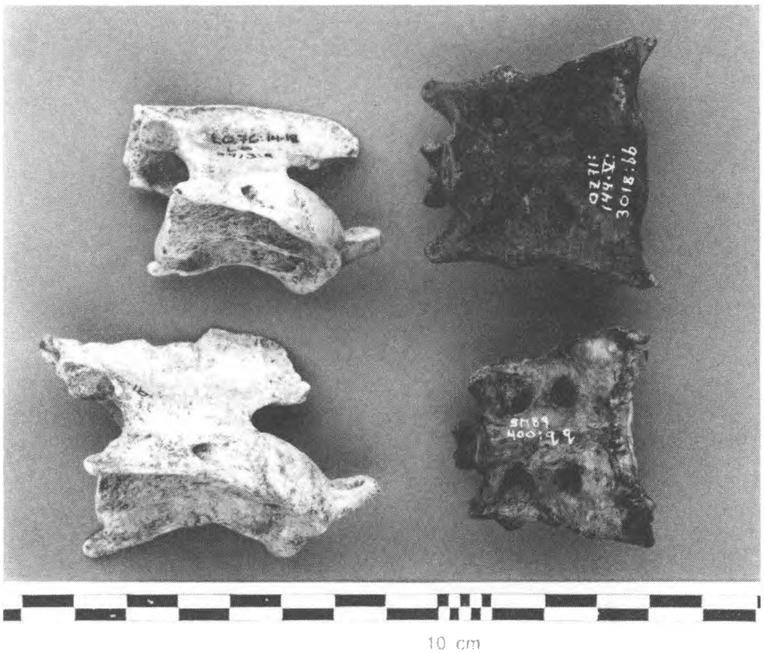


Figure 8-7. Examples of vertebra VC02. Upper left: 2413a; upper right: 3018bb; lower left: 125; lower right: 0400qq.

Table 8-13. Associated thoracic vertebrae 4 through 11 (VT04, VT05, VT06, VT07, VT08, VT09, VT10, VT11) selected measurements and basic statistics, total sample.

VT04		Measurement codes		
Specimen	**Sex**	**BFcd**	**PL**	**HFcd**
0200K			15.9	11.5
1139J		21.1	16.3	11.3
3004KK	M	22.4	16.7	11.2
3018K	M	20.6	16.2	11.3
total count		3	4	4
total mean		21.4	16.3	11.3
total std		0.8	0.3	0.1

VT05		Measurement codes		
Specimen	**Sex**	**BFcd**	**PL**	**HFcd**
0200L		18.2	16.2	11.6
0400AA		19.4	13.7	9.4
1139L		19.5	17.0	11.4
3000LLL	M	20.5	15.1	10.6
3004LL	M	21.7	16.8	11.3
3018L	M	20.0	16.6	11.4
total count		6	6	6
total mean		19.9	15.9	11.0
total std		1.1	1.2	0.8

VT06		Measurement codes		
Specimen	**Sex**	**BFcd**	**PL**	**HFcd**
0200M			16.0	11.7
0400BB		19.1	13.7	9.5
3000MMM	M	20.5	15.1	10.9
3004MM	M	21.7	16.8	11.4
3018M	M	20.0	16.6	11.4
total count		4	5	5
total mean		20.3	15.6	11.0
total std		1.0	1.1	0.8

VT07		Measurement codes		
Specimen	**Sex**	**BFcd**	**PL**	**HFcd**
0200N		18.8	15.8	11.3
0400CC		18.3	14.3	9.1
3000NNN	M	19.6	15.6	10.5
3004NN	M	21.6	17.0	11.0
3018N	M	20.6	16.8	11.1
total count		5	5	5
total mean		19.8	15.9	10.6
total std		1.2	1.0	0.8

VT08		Measurement codes		
Specimen	**Sex**	**BFcd**	**PL**	**HFcd**
0200O		20.4	16.5	11.2
0400DD		19.2	14.6	9.3
3000OOO	M	19.0	15.8	10.3
3004OO	M	21.8	17.2	10.9
3018O	M	20.6	17.3	11.2
total count		5	5	5
total mean		20.2	16.3	10.6
total std		1.0	1.0	0.7

VT09		Measurement codes		
Specimen	**Sex**	**BFcd**	**PL**	**HFcd**
0200P		19.2	15.8	11.2
0400EE		19.2	14.9	9.4
3000PPP	M	20.1	15.9	10.5
3004PP	M	22.7	18.0	11.0
3018P	M	22.0	17.5	11.4
total count		5	5	5
total mean		20.7	16.4	10.7
total std		1.5	1.2	0.7

VT10		Measurement codes		
Specimen	**Sex**	**BFcd**	**PL**	**HFcd**
0200Q			16.9	11.4
0400FF		18.7	15.6	9.3
1225D		20.2	17.0	11.0
3000QQQ	M	19.4	17.5	10.9
3004QQ	M	20.4	18.1	11.3
3018Q	M	20.8	18.1	11.0
total count		5	6	6
total mean		19.9	17.2	10.8
total std		0.8	0.9	0.7

VT11		Measurement codes		
Specimen	**Sex**	**BFcd**	**PL**	**HFcd**
0200R		19.0	18.6	10.8
0400GG		17.8	16.7	9.0
0573A		19.2	19.3	11.1
1225B		19.5	18.2	10.6
3000RRR	M	19.2	19.1	10.5
3004RR	M	20.9	19.6	10.6
3018R	M	20.0	19.6	10.4
total count		7	7	7
total mean		19.4	18.7	10.4
total std		0.9	1.0	0.6

Table 8-14. Length (mm) of vertebral sections for associated vertebrae from the same individual, by individual specimen number (VC, cervical; VT, thoracic; VL, lumbar; VS, sacrum; VD, caudal).

Specimen	Element	PL	Specimen	Element	PL	Specimen	Element	PL	Specimen	Element	PL	Specimen	Element	PL	Specimen	Element	PL	Specimen	Element	PL	Specimen	Element	PL
0200	VC02	51.0 *	0201	VC02	46.4	0950	VC02	46.3	1139	VC02	50.0 *	3000	VC02	44.7	3004	VC02	48.5	3018	VC02	50.2			
0200	VC03	26.3	0201	VC03	25.8	0950	VC03	25.1	1139	VC03	27.1	3000	VC03	25.6	3004	VC03	26.1	3018	VC03	26.2			
0200	VC04	22.9	0201	VC04	22.9	0950	VC04	23.0	1139	VC04	23.3	3000	VC04	24.0	3004	VC04	24.1	3018	VC04	24.0			
0200	VC05	21.5	0201	VC05	18.7	0950	VC05	19.6	1139	VC05	20.9	3000	VC05	19.9	3004	VC05	21.8	3018	VC05	21.8			
0200	VC06	20.1	0201	VC06	18.5 *	0950	VC06	19.2	1139	VC06	19.8	3000	VC06	18.4	3004	VC06	20.2	3018	VC06	20.8			
0200	VC07	18.7	0201	VC07	17.0 *	0950	VC07	18.3	1139	VC07	17.8	3000	VC07	18.1	3004	VC07	19.5	3018	VC07	19.7			
total cervical length		160.5			149.2			151.5			158.8			150.7			160.2			162.7			
0200	VT01	18.9	0400	VT01	15.5 *							3000	VT01	17.1	3004	VT01	18.6	3018	VT01	18.4			
0200	VT02	16.7	0400	VT02	14.5 *							3000	VT02	16.1	3004	VT02	17.7	3018	VT02	17.2			
0200	VT03	16.0	0400	VT03	13.5 *							3000	VT03	15.0 *	3004	VT03	16.5	3018	VT03	16.3			
0200	VT04	15.9	0400	VT04	13.5 *							3000	VT04	15.0 *	3004	VT04	16.7	3018	VT04	16.2			
0200	VT05	16.2	0400	VT05	13.7							3000	VT05	15.1	3004	VT05	16.8	3018	VT05	16.6			
0200	VT06	16.0	0400	VT06	13.7							3000	VT06	15.1	3004	VT06	16.8	3018	VT06	16.6			
0200	VT07	15.8	0400	VT07	14.3							3000	VT07	15.6	3004	VT07	17.0	3018	VT07	16.8			
0200	VT08	16.5	0400	VT08	14.6							3000	VT08	15.8	3004	VT08	17.2	3018	VT08	17.3			
0200	VT09	15.8	0400	VT09	14.9							3000	VT09	15.9	3004	VT09	18.0	3018	VT09	17.5			
0200	VT10	16.9	0400	VT10	15.6							3000	VT10	17.5	3004	VT10	18.1	3018	VT10	18.1			
0200	VT11	18.6	0400	VT11	16.7							3000	VT11	19.1	3004	VT11	19.6	3018	VT11	19.6			
0200	VT12	20.0	0400	VT12	17.6							3000	VT12	20.2	3004	VT12	21.1	3018	VT12	20.6			
0200	VT13	21.2	0400	VT13	19.0							3000	VT13	22.1	3004	VT13	22.8	3018	VT13	22.1			
total thoracic length		224.2			197.0									219.6			237.0			233.3			
0200	VL01	22.4	0400	VL01	20.2	1227	VL01	22.0 *	2043	VL01	22.7	3000	VL01	23.0	3004	VL01	23.9	3018	VL01	23.5	3001	VL01	21.5
0200	VL02	23.1	0400	VL02	23.2	1227	VL02	23.9	2043	VL02	24.3	3000	VL02	24.3	3004	VL02	25.2	3018	VL02	24.7	3001	VL02	22.6
0200	VL03	25.0	0400	VL03	22.5	1227	VL03	26.7	2043	VL03	25.5	3000	VL03	24.9	3004	VL03	26.1	3018	VL03	25.6	3001	VL03	23.6
0200	VL04	25.0 *	0400	VL04	21.8	1227	VL04	27.0	2043	VL04	25.8	3000	VL04	25.8	3004	VL04	27.4	3018	VL04	26.1	3001	VL04	24.5
0200	VL05	25.0 *	0400	VL05	20.7	1227	VL05	27.5	2043	VL05	26.4	3000	VL05	26.4	3004	VL05	27.8	3018	VL05	26.1	3001	VL05	24.8
0200	VL06	24.0 *	0400	VL06	22.4	1227	VL06	27.0	2043	VL06	25.7	3000	VL06	25.4	3004	VL06	26.9	3018	VL06	25.2	3001	VL06	24.0
0200	VL07	21.0 *	0400	VL07	18.1	1227	VL07	22.5	2043	VL07	21.0	3000	VL07	20.9	3004	VL07	22.6	3018	VL07	20.8	3001	VL07	19.2
0200	VS	32.0 *	0400	VS	29.6	1227	VS	35.1	2043	VS	35.0	3000	VS	32.9	3004	VS	37.8	3018	VS	37.3	3001	VS	31.5
total lumbar/ sacral length		197.4			178.4			211.6			206.4			203.4			217.6			209.3			191.7
												3000	VD01	10.0	3004	VD01	10.3	3018	VD01	10.4			
												3000	VD02	10.3	3004	VD02	10.7	3018	VD02	10.2			
												3000	VD03	11.6	3004	VD03	11.3	3018	VD03	10.6			
												3000	VD04	12.8 *	3004	VD04	12.5	3018	VD04	11.9			
												3000	VD05	14.0	3004	VD05	14.6	3018	VD05	13.4			
												3000	VD06	16.9	3004	VD06	17.4	3018	VD06	15.8			
partial tail length (caudal 1-6)														75.5			76.9			72.4			

* these measurements are approximate

9

CHARACTERIZATION OF DOG TYPES

Variation of type classifications within individuals

The presence in this sample of a number of complete and partial skeletons has made possible (and necessary) an evaluation of the variation of type classification among different skeletal elements recovered from the same individual. The classification of skeletal remains on an element-by-element basis ignores the possibility that one breed may have been shorter limbed in comparison to the other or that front limbs may differ in proportion from hind limbs.

In addition, it is unlikely that each and every skeletal element evaluated will equally reflect the size category (as it has been defined here) to which an individual animal is classified. This may be especially true for individuals at the overlapping extremes of the population distribution of each type: large individuals of the small dog type and small individuals of the large dog type. Hybrid crosses between the two types may also be represented in the sample. Hybrids might either be totally intermediate in size between the two or possess distinctive skeletal traits of both types (such as the short legs of one but the big head of the other). When the type classification of several individual elements from complete or partial skeletons are not the same, some decision must be made whether to assign higher confidence to some element classifications over others in order to determine which type the *individual* belongs.

Some of the non-consensus of element classification within individuals may simply be the result of measurement error. While a systematic evaluation of measurement error was not undertaken (cf. G.R. Clark 1995), this may be significant for some elements. Vertebrae, in particular, do not vary as much in total length as do limb elements and even a 0.5 mm discrepancy in measurement would be a rather large error. For this reason alone, these elements may not be as useful as larger elements for determining type classification, except for particularly large or small specimens.

Such factors as age, disease, pathologies, activity level and nutritional status of individuals may precipitate individual bone anomalies to the extent that the length measurement of the bone varies from its genetically-determined size. In addition, taphonomic factors associated with deposition over time, such as erosion, may affect some archaeological bone enough to alter the true value of some measurements, while others may not be affected at all.

An assessment of the type classification for all specimens was accomplished by computing and comparing standard Z scores and their associated probabilities. The Z score is a number which relates the difference between the value (the actual length measurement) and the mean for that element (for the type to which it has been classified), to the standard deviation. The Z score is a way of characterizing the position of each value under the normal distribution curve for that type, assuming that each of the dog types possesses a normal distribution of values for each of the element length measurements.

A table of one-tailed probabilities associated with these Z scores (Norusis 1981) was used to predict the likelihood of each specimen belonging to the particular type distribution to which it was initially classified. Three categories of elements were considered: solitary, isolated element finds; associated elements from one individual which all classified to the same type; associated elements from one individual, some of which classified to each of the two types.

Recall that we expect there to be overlap between the "largest members" tail of the small dog distribution and the "smallest members" tail of the large dog distribution for any one element. However, we don't really know how much overlap there actually is for any one element and the amount of overlap could be very different for different body parts. The use of standard Z scores and the probabilities of membership calculated from them, is a second way (the first being multivariate analysis) of determining which specimens are found in the overlapping "tails" of the two distributions. Note that in contrast to the probability of group membership values calculated by multivariate analysis, the probabilities associated with the Z scores relate to length dimensions only. Z scores are available from the author on request.

Thus for solitary finds, you would expect to find a femur as large as specimen 1277 only 10% of the time, for example, if it really belongs to a "type 1" animal. Only two solitary element finds have a Z score probability that is statistically significant (5% or less), indicating it is very unlikely (although not impossible) that these two elements in fact belong to the group to which they were initially classified.

Consider next all specimens for which more than one element from the same individual could be initially classified and which all classified to the same type. Of these, four individuals have one element each with a statistically significant Z score probability of not belonging to the group to which it was assigned. These are all different elements (femur, metatarsal IV, cranium, and thoracic vertebra 13), indicating that there is no consistent pattern for particular elements to fall within the overlapping "tail" of the distribution. Two of the four elements belong to individuals for which there are many elements evaluated and these are the only significant outliers: in these cases, it is probable that factors such as measurement error or individual bone anomalies are responsible. The other two individuals are represented by only two or three elements, but since the Z score probabilities of the other elements fall well within the acceptable range for one type, it is probable that the type classification of the majority is correct.

Lastly, the truly problematic situation: associated elements from the same individual, some of which classified to one type and some to the other. A few individuals have only one or a few outliers of type classification. When the outliers have Z score probabilities that signify they lie in the overlapping distribution range, the non-consensus might reasonably be dismissed as an artifact of measurement error or bone anomaly. In these cases, I have accepted the type classification of the majority of the specimens for that individual.

However, several individuals have almost equal numbers of elements classified to each type. The resolution of the type designation for these individuals is based on an examination of Z scores for each type. Some are clearly large individuals of the small type or small individuals of the large type. However, at least two are more ambiguous and may well be hybrid crosses between the two types. Individual 3018, in particular, is the only individual in the sample which has statistically significant Z score probabilities for both type classifications. However, the fact that some of the elements have positive type 2 Z scores (indicating values on the large rather than the small side of the large dog distribution) but no negative type 1 scores suggests that this animal is probably a small "large" dog. It could also be a hybrid. Similarly for specimen 0950, there are neither positive type 2 scores nor negative type 1 scores and some Z score probability values approach significance for both types. This individual could very well be a hybrid.

The "probable actual type" assigned to individuals is the classification used in table 10-2, which lists the distribution of dog types by MNI (minimum number of individuals) chronologically and geographically and for the calculation of body height and proportions in this chapter. Otherwise, none of the initial classifications in any of the tables have been changed to reflect this evaluation of the classification. Since very few of the specimens had significant Z scores and/or posterior probabilities from discriminant analysis of 0.05 or less, it is doubtful that the few potentially misclassified elements would make much difference statistically in the sample, except in those cases where whole individuals were putatively misclassified.

Live shoulder height estimates

Shoulder height was determined from limb length measurements as suggested by Harcourt (1974) and the results of these calculations are given in Table 9-1a. The relationship between the various limb lengths and shoulder heights (SH) are given by Harcourt as:

Humerus:	$SH(mm) = 3.43 \times GL(mm) - 26.54$
Radius:	$SH(mm) = 3.18 \times GL(mm) + 19.51$
Femur:	$SH(mm) = 3.14 \times GL(mm) - 12.96$
Tibia:	$SH(mm) = 2.92 \times GL(mm) + 9.41$

Recently, K.M. Clark (1995) expanded on Harcourt's work to derive shoulder height (SH) regression equations for metapodials, given as:

2 (MCII): SH(cm) = 0.94 X GL(mm) -1.56
3 (MCIII): SH(cm) = 0.83 X GL(mm) -2.03
4 (MCIV): SH(cm) = 0.84 X GL(mm) -2.60
5 (MCV): SH(cm) = 0.98 X GL(mm) -1.56
2 (MTII): SH(cm) = 0.86 X GL(mm) -2.04
3 (MTIII): SH(cm) = 0.77 X GL(mm) -2.26
4 (MTIV): SH(cm) = 0.75 X GL(mm) -2.68
5 (MTV): SH(cm) = 0.83 X GL(mm) -1.75

The above formulas were used to calculate additional estimated shoulder heights for all recovered metapodials in this study. The results for isolated specimens are listed in Table 9-1b and those for the average of associated metapodials (where more than one were found together) are in Table 9-1c. Four essentially intact individuals had shoulder height estimates derived from associated metapodials in addition to those calculated from long bone measurements.

Harcourt points out that where there are measurements of both major limb elements available for an individual, a more accurate estimate of shoulder height (SH) is calculated from both, using the following mathematical equations:

SH(mm) = 1.65 X GL [radius plus humerus(mm)] - 4.32
SH(mm) = 1.52 X GL [femur plus tibia(mm)] - 2.47

These calculations for four individuals are included in Table 9-2. While there is still some variation in the estimates of shoulder height derived from the combined lengths of front and hind limb elements, the *average* of these shoulder height estimates are identical to the average of all of the estimates derived from single elements. It would appear from this comparison that the average of *any* two limb estimates (upper and lower, such as femur plus radius) would give a more accurate estimate than either used alone. This is useful to know in the absence of entire single limbs from an individual but where a variety of long bones are available.

The results of these calculations demonstrate that the shoulder height of the smallest and largest dogs represented in the sample probably differed by as much as 9 inches, indicating living animals which varied from 14 inches to 23 inches (35 to 59 cm) in shoulder height. Based on these calculations, the type 1 (small) dog averaged 44 cm (17.5 inches) at the shoulder and the type 2 (large) averaged 53 cm (20.5 inches). The variation in size estimates based on different elements for some individuals (where there were more than one element available for such estimates), are evident in Table 9-2.

A range of 9 inches in shoulder height would be rare even in especially variable modern breeds (Wilcox & Walkowicz 1989). Thus this range of live shoulder height lends additional support to the suggestion that two distinct sizes of dogs existed prehistorically.

Body proportion estimates

G.R. Clark (1995:128) has recently provided some comparative modern data with which to estimate body length of dogs from skeletal dimensions. A regression equation which relates total pelvic length (PL) to live body length (BL) was computed by Clark based on a small sample of four modern dogs. This equation is given as:

BL(cm) = 0.47 x GL [PL(mm)] - 15.7

An additional method of estimating live body length (BL) is presented that uses the total length measurements of the thirteen thoracic (VT) and seven lumbar (VL) vertebrae plus the total length of the sacrum (VS). The regression equation calculated by Clark (1995:129), which relates this total length of vertebral column to live body length, is based on measurements taken from the same four modern dogs as the pelvic sample plus one other. This regression equation is given as:

BL(cm) = 1.04 x PL[VT+VL+VS(mm)] + 2.13

The results of the calculations estimating body length for suitable remains in this sample are given in Table 9-3. Clark comments that modern, well proportioned "average" sized dogs posses a shoulder height measurement which is greater than or equal to their body length. In noticeably "long-bodied" dogs, the shoulder height is less than the total body length.

The four specimens for which body length to limb length can be compared comprise a sample of two "small" dogs (one male, specimen 3000 and one of unknown sex, specimen 0400) and two "large" dogs (both male, specimens 3004 and 3018). The smallest specimen comes from one of the oldest archaeological deposits (3,000 -4,000 bp) and was the oldest individual of the four, judging by the extensive osteoarthritic lipping on most of the joints. All three of the other specimens were relatively young adult animals and come from the most recent prehistoric deposits (ca. 500 bp) of the Ozette Village site. The results of the shoulder height vs. body length estimates (based on vertebral lengths) for these four specimens suggest that all were relatively well proportioned animals. All individuals have a body length estimate only a few centimetres shorter than their average shoulder height estimate.

However, the pelvic length regression formula consistently gives a larger body length estimate than the method that uses the sum of the vertebrae. If these pelvic estimates are more accurate, it suggests that all of these individuals were short-legged/long-bodied animals. In contrast, Clark's estimations of body length for two prehistoric New Zealand kuri based on pelvic length are consistently *shorter* than estimates for the same individuals based on vertebral lengths, which makes it very difficult to decide which of the two estimates calculated for Northwest Coast dogs is the more accurate.

However, this variation in body length estimates may simply indicate that the sample of modern dogs which Clark based both regression equations on was either not large enough to be accurate or were not appropriate comparisons for prehistoric dogs. For the four Northwest Coast individuals, however, using either pelvic or vertebral estimates of body length indicates that both types are similarly proportioned and thus these calculation were not particularly helpful in pinpointing overall diagnostic differences between the two types.

Osteological and morphological characteristics of dog types

Both dog types share a consistent lack of lower premolar 1 that appears to be independent of size category. Eighty-two percent (82%) of all mandibles examined showed congenital absence of the first premolar. The coronoid process of the mandible is distinctly curved in all specimens regardless of size.

Both dog types appear to have been similarly proportioned, although the sample available to evaluate this trait is quite small. The small dog type averaged about 44 cm or 17.5" at the shoulder (range 35-50cm/14-19.5"), which is about the size of a modern Keeshound or the Finnish Spitz breed (Fogle 1995:146,142). The large dog type averaged about 52 cm or 20.5" (range 47-59cm/18-23") or about the size of a modern Dalmation (Fogle 1995:283). The large dog also is the about the size of the so-called Carolina Dog, a breed that is thought to represent a remnant population of southeastern U.S. indigenous dogs, currently found only in an isolated, fenced region of South Carolina (Fogle 1995:78; Wilcox and Walkowicz 1989:264).

The small dog appears to show a slightly higher incidence of skull deformations or pathologies than the larger dog, which may reflect differences in how these dogs were treated by their human owners. Additional intact or nearly complete crania that can be assessed for such features are needed to validate this impression.

Females are as common as males among the adult remains of the small dog type, whereas females of the large dog type are rare.

Comparison to other prehistoric dogs

The size characteristics of Northwest Coast dogs correspond closely to the criteria described by Colton (1970) for large and small dogs from the U.S. southwest (which included the small, so-called "Basketmaker" dogs). He defines a small dog as having a cranium length of 108 to 165 mm,(cf. 146-173 for type 1 dogs), humerus length less than 140 mm and femur length less than 160 mm (cf. 151 and 164 respectively for type 1 dogs). Large dogs from his area of study had a cranium length of 165-196 mm, humerus length greater than 140 mm and femur length greater than 160 mm.

Colton concluded from his study that small dogs were the early type, large dogs being rare from deposits predating AD. 800, and that early small dogs were somewhat (although not significantly) smaller that later small dogs. He attributes this difference to interbreeding of small dogs with large dogs in the later period, which had the affect of raising the mean of length values for smaller animals.

While Lawrence (1967) made a similar finding of early small dogs from Jaguar Cave, Idaho, she quickly recanted (1968) her suggestion that small dogs were the original type when remains of a large dog were found in equally early deposits dated at 8,400 B.C. Recent accelerator dates from the Jaguar Cave dogs themselves indicate that these specimens were intrusive and actually are no more than 3,000 to 4,000 years old (Clutton-Brock & Noe-Nygaard 1990; Morey & Wiant 1992). Nonetheless, the measurements given by Lawrence (1967) for the Jaguar Cave small dogs indicate these animals were definitely as small as the small dogs described here, some of which date to the Charles culture period of ca. 3,000 to 4,400 bp. Thus the history of small dogs in North American can now be confidently said to extend back at least 3,000 and possibly 4,000 years.

The three oldest deliberately interred canids in North American (the Koster site, Illinois (Morey & Wiant 1992), dated ca 8,500 bp) resemble the village dog in size. Only one of the specimens has a relatively intact cranium (presumed to be female, based on the lack of an associated baculum) and it has a condylobasal length (#2) of 165 mm and snout length (#12) of 77 mm. The other two specimens are male but have fragmented crania, although they are reported to be similar-sized.

Truly large dogs in North American appear to be rather rare. Most of the samples of prehistoric "Eskimo" dogs reported by Haag (1948), which he called "large" are in fact close to village dog-size, although Greenland Eskimo and some Alaskan Eskimo dogs are larger, approaching dingo size (cf. Gollan 1980:303). None of these northern dogs even come close to wolves in size (Walker and Frison 1982; Morey 1986). Even "wolf-like" dogs from the northern plains, long suspected of being wolf/dog hybrids (or at least having some wolf admixture in their ancestry) do not approach wolves in size or shape (Morey 1986). Most of these are dingo-size or slightly larger.

In contrast, both early and late Jomon dogs from Japan (12,000 to 2,300 bp) are described as small and robust. They are very similar to the small Northwest Coast dogs in size and conformation. Later Japanese dogs are reported to be somewhat larger (Shigehara & Onodera 1984; Shigehara 1994).

Most of the prehistoric dogs from Thailand reported by Higham et al. (1980), dated to ca. 3,500 B.C., appear to be as small as Jomon and Northwest Coast small dogs. A single cranium has a reported condylobasal length (#2) of only 141 mm, which is slightly smaller than the smallest dog examined in this study. Mandibles however, ranged in total length from 104 to 136 mm (cf. 104-130 for type 1 dogs). Most of the reported measurements for the distal breadth of the tibia and humerus also fall within the same range as the Northwest Coast small type 1, although a few are larger.

Measurements given by G.R. Clark (1995) for prehistoric New Zealand kuri indicate dogs slightly larger than the small type 1 dog. The mean for the total length of Clark's intact cranium sample was 171 mm (cf.162 for type 1 dogs) and that for the mandibles 128 mm (cf. 121.6 for type 1 dogs). In contrast, the mean length of the kuri humerus was only 122.5 mm (cf. 143.5 for type 1 dogs) and the mean for the femur sample 137.2 mm (cf. 154.3 for type 1 dogs). The kuri thus appears to be a small dog with distinctly short limbs.

The Australian dingo, both modern and prehistoric forms, are somewhat larger than the large type 2 dogs described in this sample (Gollan 1980; Shigehara et al. 1993). The mean for the total cranium length of a sample of 60 modern dingos analyzed by Gollan was 194 mm (cf. 188.6 for type 2 dogs) and that for the greatest length of the mandible, 142.5 mm (cf. 138.8 for type 2 dogs). Gollan's conclusion, after an examination of modern, archaeological and fossil skull material, was that the dingo had changed little (if at all) in size over time.

The juvenile specimens from Seamer Carr and Star Carr, England (Mesolithic sites dated ca. 9,500 bp), are somewhat difficult to compare due to their fragmentary nature and immaturity (Clutton-Brock & Noe-Nygaard 1990). However, the measurements given for the atlas (GB = 66.0 mm) and axis (LCDe = 49.3 mm) of the Seamer Carr specimen suggest that it may have grown up to be larger than a type 2 dog, perhaps more dingo-sized. The measurement estimate for the breadth of the occipital condyles of the Star Carr specimen (#25 = ca. 37.0 mm) and the upper carnassial alveolus (#19 = 20.0 mm), indicate a similar adult size. An incomplete adult tibia, estimated to have been ca. 190 mm in total length (Clutton-Brock & Noe-Nygaard 1990) represents a dog somewhat larger than the largest type 2 dog reported here, again probably more the size of dingo.

The incomplete mandible recovered from Palegawra Cave in Iraq dated to ca. 10,000 to 12,000 bp (Turnbull and Reed 1974) is reported as being similar in size to a small modern dingo. The length of the premolar row (#11) is reported as 39.4 mm, which is the mean of the Northwest Coast sample. This specimen is also apparently about the same size as the partial mandible recovered from the Natufian site of Mallaha in Israel (Davis and

Valla 1978). Thus, both specimens may be the size of the small village dog.

These Old World specimens suggest that early dogs in Europe were somewhat larger (dingo-sized) than early North American and Middle East dogs, which appear to be the size of Northwest Coast type 2 (large) dogs. In contrast, early Japanese dogs are as small as the small dogs reported here on the Northwest Coast. The size differences between early Old World, New World and Far Eastern dogs may be significant to the question of geographic origins of the dog, but more data needs to be collected before conclusive statements can be made.

Table 9-1a. Estimated live shoulder heights based on length measurements of single major limb elements (after Harcourt 1974).

Specimen	Type	Height based on:	Est. shoulder Height (cm)
5029	1	Radius	41
1500	1	Tibia	42
0130	1	Tibia	42
0560	1	Tibia	42
1285	1	Radius	43
1499	1	Femur	43
3001FF	1	Tibia	44
1075	1	Tibia	44
2407	1	Humerus	44
2032	1	Humerus	45
2012	1	Radius	45
4040	1	Radius	45
1509	1	Humerus	46
0554	1	Tibia	46
2018A	1	Femur	46
0300FF	1	Humerus	46
3008	1	Humerus	46
2200	1	Radius	46
2410	1	Humerus	46
1570	1	Radius	46
1434	1	Humerus	48
2040	1	Femur	48
1030	1	Humerus	48
0324	1	Humerus	48
1277	1	Femur	50

Average type 1 shoulder height	45 cm

Specimen	Type	Height based on:	Est. shoulder Height (cm)
0434	2	Tibia	47
3009	2	Tibia	47
4042	2	Tibia	48
4044	2	Radius	48
1041	2	Radius	49
4000	2	Radius	49
0114	2	Radius	49
3011E	2	Radius	49
1071	2	Tibia	50
0136	2	Humerus	50
1077	2	Tibia	50
0115	2	Radius	50
0557	2	Tibia	50
1076	2	Tibia	50
1036	2	Humerus	51
2021A	2	Radius	51
1035	2	Humerus	52
0507B	2	Radius	52
1080	2	Tibia	52
1034	2	Humerus	52
1032	2	Humerus	52
1078	2	Tibia	53
0555	2	Femur	53
1029	2	Humerus	53
1083	2	Femur	53
1082	2	Femur	53
1033	2	Humerus	53
1089	2	Femur	54
1081	2	Femur	54
1084	2	Femur	54
1132	2	Humerus	54
0550	2	Femur	55
1136	2	Humerus	55
1088	2	Femur	55
1134	2	Humerus	55
1086	2	Femur	56
1094	2	Femur	56
1104C	2	Humerus	59

Average type 2 shoulder height	52 cm

Table 9-1b. Estimated live shoulder heights based on lenght measurements of isolated metapodials (MC, metacarpal; MT, metatarsal), after K.M. Clark 1995 (continued next page)

Specimen	Height based on:	Type	Est. shoulder height (cm)
1598	MCII	1	38
0512	MCV	1	38
1419	MTV	1	39
2250	MCII	1	40
2211	MCV	1	40
5028	MCIV	1	40
2069	MCIV	1	40
0608	MCIII	1	40
1523	MTV	1	40
2031	MCII	1	41
1590	MCII	1	42
2262	MTII	1	42
1521	MTII	1	43
1603	MCIII	1	43
0313	MCII	1	43
1481	MCIII	1	43
1482	MCII	1	43
1461	MCII	1	43
1247	MTV	1	44
1520	MTII	1	44
1458	MTV	1	44
2071B	MTIII	1	44
4058	MCII	1	44
1478	MTV	1	44
0336E	MTIII	1	44
4015	MCV	1	44
4010	MCIII	1	44
1479	MCIV	1	44
0433	MCII	1	45
1254	MCIII	1	45
1257	MTIV	1	45
1122	MTV	1	45
4041	MCIV	1	45
4014	MCIV	1	45
1252	MTIII	1	45
1113	MCV	1	45
0314	MTIII	1	45
1258	MTIII	1	45
1253	MCIV	1	45
1459	MTII	1	46
1131	MTIII	1	46
1483	MTII	1	46
1460	MTIV	1	46
0531	MCV	1	46
5042	MTV	1	46
1480	MTIII	1	47
1251	MTII	1	47
1610	MTV	1	47
2259	MCV	1	47
2409A	MTII	1	47
2105	MTIV	1	48
3015	MTIII	1	48
5038	MTIV	1	49
2110B	MTIII	1	49

Average type 1 shoulder height	44 cm

Table 9-1b (con't). Estimated live shoulder heights based on length measurements of isolated metapodials (MC, metacarpal; MT, metatarsal), after K.M. Clark 1995.

Specimen	Height based on:	Type	Est. shoulder height (cm)
4022	MCIII	2	47
1112	MCIV	2	47
0582	MCV	2	48
5046	MCV	2	48
1256	MCV	2	48
1255	MCIV	2	48
0219	MCIII	2	48
4013	MCIV	2	48
1066	MTV	2	48
0217	MCIV	2	49
4016	MCIV	2	49
0220	MCII	2	49
1439	MCV	2	49
2110	MTII	2	49
2071A	MTV	2	49
4020	MCV	2	49
2074	MCII	2	49
4017	MCV	2	49
1246	MTV	2	50
4050	MTIII	2	50
1120	MTIV	2	50
2101	MCIV	2	50
1107	MTII	2	50
1065	MTIII	2	50
2025	MCIII	2	50
1516	MTIII	2	50
2093	MTV	2	50
1114	MTV	2	50
1111	MTV	2	51
1248	MTIV	2	51
1057	MTIII	2	51
4061	MCV	2	51
3014	MTIII	2	51
2045	MTII	2	51
1249	MTII	2	51
2091	MTIII	2	51
1250	MTIII	2	51
2667	MCV	2	52
2022	MCII	2	52
2108	MTIV	2	52
1125	MTV	2	52
1128	MCII	2	52
1056	MTIV	2	52
2240	MTV	2	53
1070	MTIV	2	53
1115	MTII	2	53
1067	MTII	2	53
1126	MCIV	2	53
2112	MCII	2	53
1062	MTIII	2	53
1058	MCIII	2	53
2249	MTIII	2	53
1119	MCII	2	53
2601	MTIII	2	53
1053	MCIII	2	53
1069	MTV	2	54
2095	MTII	2	54
2092	MTIII	2	54
1127	MTII	2	54
1068	MTIII	2	54
1055	MTIII	2	54
1059	MCIV	2	54
1054	MCIV	2	55
1130	MTII	2	55
1121	MCV	2	55
1124	MTIII	2	55
1060	MTIII	2	55
1023	MCIII	2	55
1061	MCIII	2	55
5026	MTIV	2	55
1129	MTIV	2	55
1063	MCIV	2	56
5039	MCIV	2	56
1064	MTII	2	56
1106	MCIV	2	57
1110	MCV	2	57

Average type 2 shoulder height	52 cm

Table 9-1c. Estimated live shoulder heights based on length measurements of associated metapodials (MC, metacarpal; MT, metatarsal), after K.M. Clark 1995. Estimates in brackets ( ) are those derived from long bone measurements for comparison. (continued next page).

Specimen	Height based on:	Type	Est. shoulder height (cm)	Average shoulder height estimate (cm)
2221A	MCIII	1	35	35
2221B	MCII	1	34	
2221C	MCIV	1	35	
1589A	MCV	1	40	39
1589B	MCIV	1	39	
1589C	MCIII	1	39	
1589D	MCII	1	39	
2405A	MCIV	1	39	39
2405B	MCV	1	41	
2405C	MCIII	1	39	
2405D	MCII	1	38	
0811A	MCIV	1	41	41
0811B	MCIII	1	41	
0811C	MCII	1	41	
2403A	MTIII	1	41	41
2403B	MTIV	1	41	
2403C	MTIII	1	40	
2403D	MTIV	1	41	
2403E	MTII	1	40	
2403F	MCV	1	41	
2403G	MTII	1	41	
1448A	MCIV	1	42	42
1448B	MCIII	1	42	
2610B	MCIV	1	43	42
2610C	MCIII	1	42	
2610D	MCII	1	41	
2200C	MCII	1	43	43
2200D	MCIII	1	43	
0216A	MCV	1	46	45
0216B	MCIII	1	45	
0216C	MCII	1	44	
0216D	MCIV	1	45	
2033E	MTIV	1	46	45
2033F	MTV	1	44	
3002CC	MTIII	1	48	45
3002DD	MTIV	1	47	
3002EE	MTII	1	47	
3002FF	MTV	1	44	
3002II	MTIV	1	47	
3002JJ	MTIII	1	47	
3002KK	MTII	1	46	
3002LL	MTV	1	45	
3002P	MCII	1	44	
3002W	MCIII	1	44	
3002X	MCII	1	42	
3002Y	MCV	1	45	
3002Z	MCIV	1	45	
3001Q	MTV	1	45	46 (cf.44)
3001R	MTV	1	45	
3001S	MTIII	1	47	
3001T	MTIII	1	48	
3001U	MTII	1	46	
3001V	MTII	1	46	
3001W	MTIV	1	47	
3001X	MTIV	1	47	
0400A	MTII	1	48	47 (cf.46)
0400B	MTIII	1	48	
0400C	MTIV	1	47	
0400E	MTII	1	48	
0400F	MCIII	1	45	
0400F	MTIII	1	48	
0400G	MTIV	1	47	
0400H	MTV	1	46	
0400N	MCIV	1	46	
0400Q	MCIII	1	46	
2035A	MTIV	1	47	47
2035B	MTV	1	46	
2035D	MTIII	1	48	
3000AA	MTV	1	47	47 (cf.46)
3000BB	MTIII	1	48	
3000CC	MTIII	1	49	
3000Q	MCV	1	46	
3000R	MCIV	1	46	
3000S	MCIII	1	46	
3000T	MCII	1	45	
3000V	MTIV	1	47	
3000W	MTIV	1	48	
3000X	MTII	1	47	
3000Y	MTII	1	48	
3000Z	MTV	1	47	

Average type 1 shoulder height estimate	43 cm

Table 9-1c (con't). Estimated live shoulder heights based on length measurements of associated metapodials (MC, metacarpal; MT, metatarsal). (after K.M. Clark 1995). Shoulder height estimates given in brackets ( ), are those derived from long bone measurements for comparison.

Specimen	Height based on:	Type	Est. shoulder height (cm)	Average shoulder height estimate (cm)
1577A	MTIII	2	51	49
1577B	MTIV	2	49	
1577C	MTV	2	48	
3018QQ	MCV	2	50	49 (cf.48)
3018RR	MCII	2	47	
3018SSS	MTV	2	49	
3018TT	MCIII	2	49	
3018TTT	MTIII	2	52	
3018UU	MCIV	2	49	
3018UUU	MTIV	2	51	
3018VV	MCII	2	46	
3018VVV	MTV	2	49	
3018WW	MCIII	2	47	
3018WWW	MTIII	2	52	
3018XXX	MTII	2	50	
3018YYY	MTII	2	50	
3018ZZZ	MTIV	2	52	
2089A	MCIV	2	51	50
2089C	MCII	2	50	
0630B01	MCV	2	52	50
0630B02	MCII	2	49	
0630B03	MCIII	2	49	
0630B04	MTV	2	49	
0630B05	MCIII	2	49	
0630B07	MCII	2	49	
0630B08	MCV	2	52	
0630B09	MTII	2	51	
3004LLL	MTIII	2	53	51 (cf 51)
3004MMM	MTII	2	51	
3004NNN	MTIV	2	53	
3004OOO	MTII	2	51	
3004PPP	MTIII	2	53	
3004QQQ	MTV	2	50	
3004RRR	MTIV	2	52	
3004SSS	MTV	2	49	
3004U	MCII	2	49	
3004V	MCIV	2	51	
3004W	MCIII	2	50	
0556A	MTIII	2	53	52
0556B	MTIV	2	52	
0556C	MTV	2	51	
3011B	MCIV	2	52	52
3011C	MCIII	2	52	
3011D	MCV	2	51	

Average type 2 shoulder height estimate	51 cm

Table 9-2. Comparison of the estimated live shoulder heights of four individual dogs, based on both single and combined major limb element lengths (after Harcourt 1974).

Specimen	Type	Element	Side	Element GL (mm)	Estimated shoulder height (cm)	Average of shoulder height estimates (cm)
0400	1	femur	R	150	46	46
0400	1	femur	L	150	46	
0400	1	humerus	R	139	45	
0400	1	humerus	L	137	44	
0400	1	radius	L	141	47	
0400	1	radius	R	140	46	
0400	1	tibia	L	156	46	
0400	1	tibia	R	158	47	
0400	1	femur + tibia	R	308	47	46
0400	1	femur + tibia	L	306	46	
0400	1	humerus + radius	R	279	46	
0400	1	humerus + radius	L	278	45	
3000	1	femur	L	152	46	46
3000	1	femur	R	153	47	
3000	1	humerus	R	147	48	
3000	1	radius	R	137	46	
3000	1	tibia	R	150	45	
3000	1	tibia	L	150	45	
3000	1	femur + tibia	R	303	46	46
3000	1	femur + tibia	L	302	46	
3000	1	humerus + radius	R	284	46	
3004	2	femur	R	167	51	51
3004	2	femur	L	169	52	
3004	2	humerus	L	160	52	
3004	2	humerus	R	160	52	
3004	2	radius	L	151	50	
3004	2	radius	R	150	50	
3004	2	tibia	R	167	50	
3004	2	tibia	L	167	50	
3004	2	femur + tibia	R	334	51	51
3004	2	femur + tibia	L	336	51	
3004	2	humerus + radius	R	310	51	
3004	2	humerus + radius	L	311	51	
3018	2	femur	R	163	50	48
3018	2	femur	L	162	50	
3018	1	humerus	R	151	49	
3018	1	humerus	L	150	49	
3018	1	radius	R	137	46	
3018	1	radius	L	139	46	
3018	2	tibia	L	159	47	
3018	2	tibia	R	159	47	
3018	2	femur + tibia	R	322	49	48
3018	2	femur + tibia	L	321	49	
3018	1	humerus + radius	R	288	47	
3018	1	humerus + radius	L	289	47	

Table 9-3. Estimation of body length based on pelvis length and vertebral column length (after G.R. Clark 1995), compared to the average of shoulder height estimates for that individual.

Specimen	Sex	Type	Element	Side	Total element GL (mm)	Total estimated body length (cm)	Total average est. shoulder height (cm)*
0400	?	1	pelvis	R	131	45.9	46.5
0400	?	1	pelvis	L	131	45.9	
3000	M	1	pelvis	R	137	48.5	46.5
3001	M	1	pelvis	R	134	47.3	45.0
3004	M	2	pelvis	L	151	55.3	51.0
3018	M	2	pelvis	R	144	52.0	48.5
3018	M	2	pelvis	L	145	52.5	
0200	?	1	thoracic verts		224		
			lumbar verts/sacrum		197		
			total column length		421	44.0	n/a
0400	?	1	thoracic verts		197		
			lumbar verts/sacrum		178		
			total column length		375	39.2	46.5
3000	M	1	thoracic verts		220		
			lumbar verts/sacrum		203		
			total column length		423	44.3	46.5
3004	M	2	thoracic verts		237		
			lumbar verts/sacrum		218		
			total column length		455	47.5	51.0
3018	M	2	thoracic verts		233		
			lumbar verts/sacrum		209		
			total column length		442	46.2	48.5

* from Tables 9-1a, 9-1c, 9-2.

10

DISTRIBUTION AND CHRONOLOGY OF DOG TYPES

The final step in the analysis was to look at how the distribution of dog types vary over geographic distance and through prehistoric time. Table 10-1 is a summary of the distribution of dog types geographically and chronologically by skeletal element count. The total number of elements of each type and their relative frequency are given per site, by relative age of the associated deposits (i.e. designated culture type).

Some sites, such as Ozette (45CA24) and St. Mungo Cannery (DgRr 2), have a high proportion of associated elements from one or a few individuals which may bias the pattern to some degree. Table 10-2 is thus a geographic and chronological summary based on minimum number of individuals (MNI) rather than element counts . The tally by MNI removes the bias of those sites which have a high proportion of intact skeletons. However, this bias is replaced with one introduced by sites (such as the Beach Grove Golfcourse site, DgRs 30) which contain large numbers of "isolated" finds. Some of these specimens could actually be associated elements found out of context because of deposit disturbance and/or excavation techniques and thus belong to relatively fewer individuals than the specimen count suggests. Both methods have their drawbacks and should be considered together. In this case, when both MNI and NISP totals are expressed as a relative frequency of each dog type represented per site, the pattern is essentially the same for both.

Both small and large dog types have been recovered from the oldest and the youngest deposits, and both occur over the whole of the geographic range sampled. However, if the sites which contain an MNI of ten or more are compared, it can be seen that type 1 dominates the samples (comprises 60% or more of the total) in six out of nine sites of Gulf of Geor ia age (1400 bp to contact). The other three Gulf of Georgia sites contain almost equal proportions of both types. The three Marpole age (1400 to 2400 bp) samples have one site dominated by type 1 dogs, one dominated by type 2 and one with equal proportions of each. Locarno (2400 to 3000 bp) and Charles (3000 bp to 4400 bp) age deposits with an MNI of more than ten are rare (2 each) but both of these are dominated by type 1 dogs.

The Marpole age deposits at the Beach Grove Golfcourse site stand out as unique, being both the largest assemblage as well as the only assemblage strongly dominated by type 2 dogs (MNI= 129; NISP = 147). Unfortunately, the context of this deposit is completely disturbed (Bernick 1989a, 1989b) and little can be offered by way of an explanation for why the pattern of dog remains here differs from all the others.

Of additional significance, Ozette (45CA24) and Tsawwassen (DgRs 2) remains are both represented by a high proportion of relatively intact crania for which the sex could be determined. In fact, specimens from these two sites together comprise slightly more than half of the total cranial sample. In addition, both sites contained a high proportion of type 1 (small) females. It may be that the high incidence of type 1 females is characteristic of these sites only. If true, this might indicate that deliberate breeding of the small dog on a relatively large scale (actual husbandry) was undertaken in only some locations. In addition, these site deposits which contain a high proportion of type 1 females are both dated to the most recent Gulf of Georgia culture type (ca. 1400 bp to contact), which may support the suggestion that husbandry of this breed was a relatively recent development (Amoss 1993). Clearly, more specimens from more sites will be needed before these kinds of conclusions can be drawn with any confidence. This analysis indicates that there may be significant underlying patterns in Northwest Coast dog remains that need to be investigated further.

Another aspect of the issue of husbandry is the implication contained in several of the ethnohistoric reports that maintaining the special breed characteristic of a thick wooly coat necessitated keeping wool dog females from breeding with village males. This assumption is supported by the results of modern experimental breeding trials, where it has been shown that in first-generation hybrids (F1) between two extreme parental types, coat density resembles that of the least dense parent. Also, short, coarse textured hair appears to be dominant over long, fine textured hair (Whitney 1948, cited in Burns & Fraser 1966). These experimental results suggest that there would have been a sound genetic basis for keeping wool dogs from interbreeding with village dogs. First-generation offspring from such a cross would undoubtedly resemble the village dog more than the wool dog in coat type and thus be of little economic value. Interbreeding of wool dog females with village dog males undoubtedly occurred occasionally, either by accident or due to periodic neglect, but if the offspring did not possess the desired wooly fur it is doubtful these animals would have been used for future deliberate breeding.

If all of the husbandry effort was spent on keeping the wool dogs pure because of their economic worth, there was probably little energy expended in keeping wool dog males away from village dog females. In other words, hybridization in the other direction may have been tolerated if not exactly encouraged. Thus the village dog may not constitute a real "breed" in the same sense as

Table 10-1. Distribution of dog types per site by relative age of deposits (culture type) for total element counts and relative frequency of each type. (1069 elements total, as classified by initial analysis). Site locations as in Figure 2-1.

Site name	Site #	Relative age of deposits*	Total count	Type 1 frequency	Type 2 frequency	Geographic region
Crescent Beach	DgRr 1	Gulf of Georgia	70	66%	34%	Fraser Delta
St. Mungo Cannery	DgRr 2	Gulf of Georgia	1	0%	100%	Fraser Delta
Tsawwassen Beach	DgRs 2	Gulf of Georgia	18	94%	6%	Fraser Delta
Pender Canal	DeRt 2	Gulf of Georgia or older	18	72%	28%	Gulf Islands
Montague Harbour	DfRu 13	Gulf of Georgia	36	86%	14%	Gulf Islands
Belcarra Park	DhRr 6	Gulf of Georgia	31	52%	48%	Strait of Georgia
Stawamus	DkRs 6	Gulf of Georgia	1	0%	100%	Strait of Georgia
Departure Bay	DhRx 16	Gulf of Georgia	24	42%	58%	Vancouver Island East
Little Qualicum	DiSc 1	Gulf of Georgia	33	97%	3%	Vancouver Island East
Deep Bay	DiSe 7	Gulf of Georgia	24	75%	25%	Vancouver Island East
Cadboro Bay	DcRt 15	Gulf of Georgia	22	59%	41%	Vancouver Island South
Maple Bank	DcRu 12	Gulf of Georgia or older	86	52%	48%	Vancouver Island South
Ozette Village	45CA24	Gulf of Georgia **	216	52%	48%	Olympic Penninsula
Beach Grove Golfcourse	DgRs 30	Marpole	147	10%	90%	Fraser Delta
Beach Grove midden	DgRs 1	Marpole	1	100%	0%	Fraser Delta
Crescent Beach	DgRr 1	Marpole	1	100%	0%	Fraser Delta
Glenrose Cannery	DgRr 6	Marpole or older	12	50%	50%	Fraser Delta
Gabriola Rockshelter	DgRw 204	Marpole or older	21	48%	52%	Gulf Islands
Montague Harbour	DfRu 13	Marpole	8	75%	25%	Gulf Islands
Ships Point	DjSe 6	Marpole	68	62%	38%	Vancouver Island East
Crescent Beach	DgRr 1	Locarno	6	83%	17%	Fraser Delta
Pender Canal	DeRt 2	Locarno or younger	33	97%	3%	Gulf Islands
Montague Harbour	DfRu 13	Locarno	2	100%	0%	Gulf Islands
Buckley Bay	DfSf13	Locarno	10	30%	70%	Vancouver Island East
Tsable River	DfSf 14	Locarno or older	41	73%	27%	Vancouver Island East
Crescent Beach	DgRr 1	Charles	3	33%	67%	Fraser Delta
St. Mungo Cannery	DgRr 2	Charles	76	82%	18%	Fraser Delta
Pender Canal	DeRt 2	Charles	60	83%	17%	Gulf Islands

* Gulf of Georgia - ca. 1400 bp to contact (ca. AD 1800); Marpole - ca. 2400 to 1400 bp; Locarno - ca. 3000 to 2400 bp; Charles (a.k.a. St. Mungo) - ca. 4400 to 3000 bp (after Croes & Hackenberger 1988). ** Ozette deposits dated ca. 500 bp.

the wool dog: it was a breed more by default than by intent (this may account for the somewhat greater heterogeneity in cranial conformation of the type 2 sample that was apparent in the comparative analysis discussed in Chapter 4).

By the mid-eighteen hundreds, when the distinctive fur of the wool dog had lost it's economic value, the incentive for keeping the two breeds apart vanished and both types were apparently left to interbreed freely. Under such unmanaged conditions, all distinctive traits of both breeds would have blended into one variable type. This historic blend may have produced occasional specimens that resembled one or the other of the foundation types, but most individuals undoubtedly possessed a mixture of traits. In addition, given that European breeds of dogs may have been responsible for introgression of non-indigenous genes into populations of native Northwest Coast dogs quite early in the historic period, all historic period remains should be considered possible non-indigenous hybrids. It is especially important, therefore, to watch carefully for intrusive burials of historic-periods dogs in prehistoric deposits. Should such remains become mistaken for prehistoric dogs, they would seriously compromise future analyses.

Table 10-2. Distribution of dog types per site by relative age of deposits (culture type) for minimum number of individuals (MNI) and relative frequency of each type (total MNI = 659). Site locations as in Figure 2-1.

Site name	Site #	Relative age of deposits*	Total MNI	Type 1 frequency	Type 2 frequency	Geographic region
Crescent Beach	DgRr 1	Gulf of Georgia	51	80%	20%	Fraser Delta
St. Mungo Cannery	DgRr 2	Gulf of Georgia	1	0%	100%	Fraser Delta
Tsawwassen Beach	DgRs 2	Gulf of Georgia	9	89%	11%	Fraser Delta
Pender Canal	DeRt 2	Gulf of Georgia or older	18	72%	28%	Gulf Islands
Montague Harbour	DfRu 13	Gulf of Georgia	27	89%	11%	Gulf Islands
Belcarra Park	DhRr 6	Gulf of Georgia	30	53%	47%	Strait of Georgia
Stawamus	DkRs 6	Gulf of Georgia	1	0%	100%	Strait of Georgia
Departure Bay	DhRx 16	Gulf of Georgia	24	42%	58%	Vancouver Island East
Little Qualicum	DiSc 1	Gulf of Georgia	15	93%	7%	Vancouver Island East
Deep Bay	DiSe 7	Gulf of Georgia	20	70%	30%	Vancouver Island East
Cadboro Bay	DcRt 15	Gulf of Georgia	1	0%	100%***	Vancouver Island South
Maple Bank	DcRu 12	Gulf of Georgia or older	64	50%	50%	Vancouver Island South
Ozette Village	45CA24	Gulf of Georgia **	15	67%	33%***	Olympic Penninsula
Beach Grove midden	DgRs 1	Marpole	1	100%	0%	Fraser Delta
Beach Grove Golfcourse	DgRs 30	Marpole	129	10%	90%	Fraser Delta
Crescent Beach	DgRr 1	Marpole	1	100%	0%	Fraser Delta
Glenrose Cannery	DgRr 6	Marpole or older	12	50%	50%	Fraser Delta
Montague Harbour	DfRu 13	Marpole	2	50%	50%	Gulf Islands
Gabriola Rockshelter	DgRw 204	Marpole or older	21	48%	52%	Gulf Islands
Ships Point	DjSe 6	Marpole	55	64%	36%	Vancouver Island East
Crescent Beach	DgRr 1	Locarno	9	78%	22%	Fraser Delta
Pender Canal	DeRt 2	Locarno or younger	32	97%	3%	Gulf Islands
Montague Harbour	DfRu 13	Locarno	2	100%	0%	Gulf Islands
Buckley Bay	DfSf13	Locarno	9	33%	67%	Vancouver Island East
Tsable River	DfSf 14	Locarno or older	27	70%	30%	Vancouver Island East
Cresent Beach	DgRr 1	Charles	3	33%	67%	Fraser Delta
St. Mungo Cannery	DgRr 2	Charles	16	75%	25%	Fraser Delta
Pender Canal	DeRt 2	Charles	52	88%	12%	Gulf Islands

* Gulf of Georgia - ca. 1400 bp to contact (ca. AD 1800); Marpole - ca. 2400 to 1400 bp; Locarno - ca. 3000- 2400 bp; Charles (a.k.a. St Mungo) - ca. 4400 to 3000 bp (after Croes & Hackenberger 1988). ** Ozette deposits dated ca. 500 bp.

*** One individual each from these sites are probably a type 1/2 hybrid

11

SUMMARY AND DISCUSSION

This analysis has presented some compelling evidence that two distinct sizes of dogs did exist prehistorically on the Northwest Coast. This evidence includes:

1) relatively high coefficients of variation (CV) in the total dog sample for many elements and also for male and female subsamples of crania and mandibles, suggesting that more than one taxonomic group is represented.

2) sexual dimorphism for the total sample is significantly greater (at 9 %) than the 2-6% expected within breeds of dogs or wild canid populations, again suggesting that more than one breed or type is represented.

3) there are significant differences between the means of the subsamples created by dividing the total sample at the mean of the total length for essentially every element examined, suggesting that each of the subsamples could have been drawn from discrete populations.

4) discriminant analysis comparison with other regional data sets of crania suggests that the sample of Northwest Coast small dogs, in particular, is quite homogeneous.

5) the almost equal representation of both sexes in the samples of type 1 (small) crania and mandibles suggests that deliberate husbandry of the small dogs was being practice

6) in contrast, the extremely high proportion of males in the samples of (large) type 2 crania and mandibles suggests that the number of breeding age females of this type may have been artificially (i.e. culturally) depressed, perhaps as a strategy for population control.

7) modern experimental evidence suggests that a valid genetic basis would have existed for keeping wool dogs from interbreeding with village dogs, as the economically valuable long, thick fur would not be inherited by F1 hybrid crosses between the two types.

Of all these points, the difference in sex ratios evident in the cranium and mandible samples of the two types lends the strongest support to the hypothesis that the small dogs were indeed wool dogs. The sex ratios suggest the small dogs were being deliberately bred, at least during the most recent part of their history, and as such would constitute a true breed. This suggests that the two dog types defined osteologically in this study could represent the wool dog and village dog as they were described in journal reports from the early historic period.

It is also apparent from this analysis that not only did a small dog exist as a distinct type prehistorically, but it existed throughout prehistoric times for as far back as can be determined. This has important cultural implications if the small dog represents the wool dog for all of its history. We cannot say for sure at this point that the small dog was always a long-haired dog. The long thick fur described in ethnohistoric accounts may have been the result of a specific genetic mutation that arose spontaneously at some point in the history of the small dogs, as "spitz" type dogs are known in both short and long haired varieties (Fogle 1995; Wilcox and Walkowicz 1989). The distinctive pricked ears, curled tail and double coat, however, appear to be suites of characters that occur together. Most spitz-type dogs of known antiquity are seldom truly large. This suggests that while the small dog may not always have been long haired, it was probably always a "spitz" type rather than "dingo" (or pariah) type. Perhaps a study of the osteological features of caudal vertebrae in dogs with curled vs. non-curled tails will reveal characteristics that could be used to identify skeletal remains of spitz dogs.

However, the issue of whether size is dependent or independent of coat type not withstanding, the time span of at least 4,000 years for the existence of a small dog suggests a possible origin date for the wool dog as a distinct breed that predates the Locarno Beach/Marpole period (1,400- 3,000 years bp) suggested by Schulting (1994).

While I have presented what I think is rather compelling evidence in favour of the small dog being the wool dog, it is admittedly chronologically biased due to the paucity of complete skulls from older sites. The preponderance of female crania and mandibles that constitute the evidence for deliberate breeding is found almost exclusively in the Gulf of Georgia deposits (1400 bp to contact period). This means that the strongest evidence for actual husbandry (approximately equal sex ratios) may only be confidently applied to this most recent period and even then may be true only for certain sites. Additional intact crania and mandibles that are more than 1400 years old (i.e. from Marpole, Locarno and Charles age deposits) are needed for further analysis.

Geographically, the small dog and the large dog appear to have co-existed throughout Coast Salish territory and some neighbouring areas for most of their recorded history. In all cases except one, measurable adult remains of the small dog are found in equal or larger numbers than the larger dog. This introduces the possibility that the small dog may have been the original type in this area and remained the dominant type for at least 4,000 years.

Compared to other prehistoric dogs, the Northwest Coast small dog was clearly as small as early Jomon period dogs from Japan, early Jaguar Cave dogs from Idaho and Basketmaker dogs from the U.S. southwest. However, the large type 2 dog does not appear to have been as large as early dogs in Europe or late large dogs in the U.S. southwest and was clearly smaller that an Australian dingo. Both dog types were well-proportioned, robust animals. The small dog averaged 44 cm (17.5 inches) at the shoulder and the large dog 52 cm (20.5 inches).

Many questions pertaining to the pattern of dog remains from the Northwest Coast are still unanswered. What is the maximum geographic range of small dogs on the Northwest Coast and in the Interior? How old is the oldest small dog? Can we find any conclusive evidence for culling of immature females of the large type that might indicate deliberate population control measures? What about burial and/or disposal practices: do they differ for large and small types (or between sexes) and do they change over time? Do combined human/dog burials more often contain large or small dogs; do they more often contain male dogs or females? Does the evidence for husbandry exist only in a few sites or is it widely distributed? How far back in time does the evidence for husbandry extend? What size are the oldest known dog remains in British Columbia, such as those reported from Namu between 4,000 and 7,000 years ago (Cannon 1991:11) or from Blue Jackets Creek on the Queen Charlotte Islands dated 4,000 to 5,000 years ago (Severs 1974:198 cited in Cybulski 1992)?

With all of these issues left to be addressed, it is imperative that all prehistoric canid material from the Northwest Coast be thoroughly reported in the future, for both adult and immature remains. This is especially important to keep in mind for small assemblages which contain few dog remains: even small samples may contribute critical data to the overall pattern and should be reported in detail. It would also be worthwhile to re-evaluate previously excavated dog remains that could not be included in this study. In addition, chronological issues clearly cannot be addressed adequately until significant remains are dated directly.

I have included a summary table which lists the osteometric characteristics used to define each of the two types for all elements in the hopes that this will encourage future reporting of measurements. In this table, the range of overlap between the two types has been removed, so if the measurement of a particular to-be-classified element falls within one of the ranges given, there is a good probability that it belongs to that type. This table should be particularly useful for quickly assessing intact Northwest Coast material and for comparison to other regional canid samples. For example, it is clear from this table that the three dogs previously reported from the 1991 and 1994 excavations at the B.C. interior site of Monte Creek (EdQx 43), dated at ca. 4,000 b.p. (Wilson et al. 1995:74), all fall within the "small" dog range even though one individual appeared significantly larger than the other two during the initial analysis (e.g. greatest length (GL) measurements of the humerus of the three dogs were 133, 131 and 149 mm; and of the putative wolf, 209 mm). This again suggests that small dogs were a common early type and confirms the time depth of known small dogs to at least 4,000 years in British Columbia.

It must be emphasized that this analysis is only a beginning. While it constitutes an important database to which future skeletal material can be compared and appended, there is much more work to be done. Once the sample size of Northwest Coast dogs has been substantially increased, other analysis methods may be possible - perhaps ones that suggest different conclusions than those presented here. With continued analysis, in time some of the questions left unresolved by this study may be answered.

Recommended analysis methods for future studies

Dog remains have been treated rather inconsistently and often quite briefly in archaeological faunal reports for this area and a few comments in regards to this are perhaps appropriate. While I have been as guilty as others of under-reporting dog data in the past, I recommend that henceforth dog remains be reported in a similar manner as human remains, preferably in a separate section of the report. Dogs are not known to have been eaten in this area (except perhaps in ceremonial contexts (Barnett 1955) and cannot therefore be considered subsistence items. I have found that the use of a "non-subsistence fauna" category is a very useful way to partition the analysis and reporting of faunal remains, because it effectively removes dogs (in all their complexity) from bone counts of obvious food/utility items. This category can also include obviously intrusive taxa such as small rodents,amphibians, and reptiles (e.g. Wilson and Crockford 1994; Wilson et al. 1995)

As is done for human remains, the dog assemblage from every site needs to be fully described *osteologically* (for pathologies, injuries, age, tooth wear, number of individuals, taphonomic condition, etc.) and *osteometrically* (all adult, and perhaps some juvenile material (such as deciduous teeth) as well, measured according to standard references). It is not enough to describe and measure only intact crania and mandibles: all intact elements, including vertebrae and metapodials, should be measured.

Temporal and horizontal distribution of remains within the site should be presented as precisely as possible. This is problematic, of course, if excavators are not familiar enough with dog skeletal remains to recognize isolated and/or small numbers of associated elements in the field, photograph them, and record the provenience in field notes and on level bags. In the report, photographs should be included of all burials or otherwise associated material *in situ*. Photographs of intact crania or elements with pathologies or injuries would also be useful. It would be extremely useful if significant finds, such as complete or partial burials or any remains suspected of having some antiquity, could be dated directly.by AMS techniques

While Crellin (1994), for example, addressed nearly all of these aspects in his report on the cultural significance of the dog remains from Keatley Creek in the central interior of British Columbia, measurement data were not reported because they were deemed "not culturally informative". This is an unfortunate shortcoming to an otherwise excellent report, because it means the Keatley Creek dogs cannot be compared osteometrically to other dogs without further analysis.

I believe we might eventually come to a better understanding about the nature of the complex relationship between indigenous dogs and people on the Northwest Coast if in-depth reporting of dog remains becomes standard practice, even for small assemblages.

Table 11-1. Selected osteometric characteristics of Northwest Coast dogs. Any range of overlap between designated types has been removed. Measurements from von den Driesch 1976.

	Type 1: "small" dog range (mm)	Type 2: "large" dog range (mm)
Skull measurements (mm)		
#1	146-173	176-203
#2	140-162	164-188
#12	59-73	76-87
#13	73-86	89-98
#15B	76-85	90-99
#23	56-60	64-71
#34	56-58	65-69
Mandible measurements (mm)		
#1	103-128	135-151
#4	85-112	113-132
#6	87-113	118-131
#7	64-74	76-84
#17	17-20	25-27
#19	18-21	26-27
Vertebrae measurements (mm)		
Cervical 1 (LAd)	12-14	15-17
Cervical 2 (LCDd)	37-44	45-52
Cervical 3 (PL)	21-24	25-30
Cervical 4 (PL)	20-22	24-27
Cervical 5 (PL)	18-20	21-25
Cervical 6 (PL)	16-18	19-21
Cervical 7 (PL)	16-18	19-20
Thoracic 3 (PL)	15-15.5	16.5-17
Thoracic 12 (PL)	17-19	20.5-21
Thoracic 13 (PL)	19-21.5	22.5-24
Lumbar 1 (PL)	20-22	23.5-26
Lumbar 2 (PL)	22-24	25-28
Lumbar 3 (PL)	22-24.5	25.5-28
Lumbar 4 (PL)	22-25	26.5-29
Lumbar 5 (PL)	21-25	26.5-28
Lumbar 6 (PL)	22-24.5	25.5-28
Lumbar 7 (PL)	18-19.5	20.5-23
Sacrum (PL)	30-32.5	33.5-38

	Small dog range (mm)	Large dog range (mm)
Front limb elements (mm)		
Scapula (HS)	101-126	129-142
Humerus (GL)	137-151	153-179
Ulna (GL)	140-167	170-203
Radius (GL)	123-141	145-156
Metacarpal II (GL)	38-49	50-58
Metacarpal III (GL)	44-58	59-69
Metacarpal IV (GL)	45-58	59.5-70
Metacarpal V (GL)	41-49.5	50.5-60
Hind limb elements (mm)		
Femur (GL)	142-164	167-182
Tibia (GL)	139-158	159-177
Fibula (GL)	135-148	154-157
Calcaneus (GL)	35-40.5	41.5-51
Talus (GL)	21-24	25-27
Metatarsal II (GL)	49-58	59-68
Metatarsal III (GL)	55-66.5	68-75
Metatarsal IV (GL)	58-68	69-78
Metatarsal V (GL)	48-59	60-67

Type 1 "small" dog shoulder height estimate:
35-50 cm (average 44.0 cm)
[14-19.5 in (average 17.5 in)]

Type 2 "large" dog shoulder height estimate:
47-59 cm (average 52.0 cm)
[18-23 in (average 20.5 in)]

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APPENDIX A

Sex Determination by Discriminant Analysis and Evaluation of Non-metric Traits in the Dog Skeleton

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Introduction

Sex determination methods based on examination of the skeleton are important in the fields of physical anthropology and zooarchaeology. In dogs, sex can easily be determined according to the presence or absence of the penis bone if the skeleton has been excavated intact. However, excavation of undamaged, intact skeletons is very rare. Usually, only individual bones or incomplete sections of the skeleton are excavated. Therefore, sex determination is usually performed by observing skeletal fragments. This requires considerable experience. To facilitate sex determination, several statistical methods have been proposed. Pons (1955) developed a statistical method for sex determination using the human femoral and thoracic bones. In Japan, Hanihara (1958, 1959) developed a similar method that considers the human cranium and limb bones. Statistical methods require no particular expertise, because they employ objective measurements rather than subjective evaluation. Hanihara reported that sex determination using the cranium and limb bones was accurate, with a *p* value of approximately 0.03-0.11.

Dogs rarely migrate by themselves. It is generally thought that dogs move with humans: therefore, investigations of the migration of dogs may provide information about the migration of humans. Tanabe (1985) studied blood proteins in modern Japanese dogs, and within this context discussed the ancestry of both Japanese dogs and humans, [although he] examined only modern dogs. [Despite the importance of prehistoric dogs to issues of human migration,] few investigations of Japanese canine skeletons using excavated bones exist.

Canine skeletons are frequently excavated at archaeological sites. The oldest canine skeleton excavated in Japan was discovered at the Natsushima Shell Mound in Kanagawa prefecture (ca. 9,000 bp, early Jomon Period, Ota 1980). Many subjective studies have been conducted on ancient Japanese dogs (Hasebe 1925, 1929, 1936, 1943 and others), but few reports provide [metric] data. Hasebe (1952) classified ancient Japanese domestic dogs into five types, according to size. Hasebe's classification system was based on the system of classification for ancient European dogs, and did not incorporate sex determination. Due to the significant difference in size between male and female dogs, classifying dogs only according to size is not meaningful. A small number of studies have been conducted on sex-based structural differences in the canine skeleton, including a metric study of the coxa by Kato (1957) and a non-metric study on the morphology of the cranial base by The and Trouth (1976). Hasebe (1952) and Brothwell et al. (1979) only briefly refer to this problem.

In the present study, sex-determinant, quantitative characteristics are identified in Japanese shiba dogs. Non-metric sex-based differences are also discussed. A secondary purpose of the study is to report and evaluate parametric data pertaining to shiba dogs, because few reports have done so previously (Daigo 1956, 1957, 1961; Kato 1956; Obara 1980).

Materials and Methods

Skeletons of modern shiba dogs (n=87, 45 males and 42 females) were supplied by the Dokkyo University School of Medicine. The modern shiba breed descends directly from ancient Japanese dogs (Kaneko 1978; Saito 1964). The skeletons were measured and subjectively evaluated. The system of anatomical terminology proposed by Evans et al. (1970) was used. All measurements were performed according to the methods described by Saito (1963), Daigo (1956, 1957, 1961) and Kato (1957). The measurements used in the present study are shown in Figures 1 to 3. The indices used were previously described by Shigehara and Onodera (1984). The calculation method of each index is shown in the tables. After measurement, values were averaged, and discriminant analysis was performed., variables were determined according to the variable increase method (Okuno et al. 1981). The predominance of variables was evaluated using the F test, with a *p* value of 0.05. Some discriminant factors represent relationships between individually-measured values.

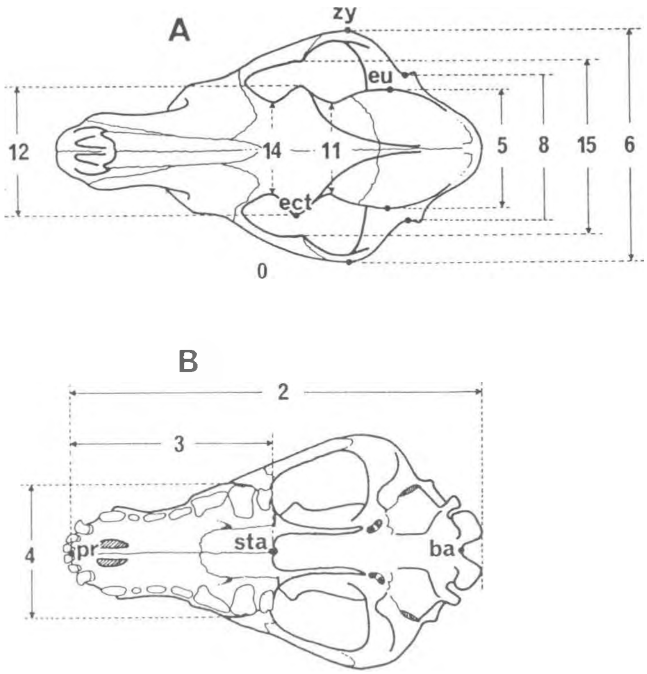

Figure 1. Cranial measurements used in this study. A dorsal aspect. B basal aspect. Numerals correspond with measurement numbers shown in Table 1.

Results and Discussion

Characteristic of modern shiba dogs

Cranium: Maximum cranial length differed by approximately 10 mm between males and females. This measurement varied from 140.7 to 169.5 mm in males, and from 131.1 to 159.7 mm in females. Thus, the range of variation was approximately 30 mm in both sexes. A similar range of variation was observed in total basal length, which is frequently used together with cranial length to determine cranial volume. The smallest range of variation was observed in cranial breadth.

The nasal curve depth (or so-called "stop"), which is the depression from the frontal region to the snout, is the most notable characteristic that distinguishes modern shiba dogs from ancient dogs (Saito 1936). The very small stop and rather straight nasal curve observed in the wolf are considered to be primitive characteristics. Thus, nasal curve depth was not correlated with other measurements or with body size in the present study. Marked variation of this trait is observed in the modern shiba dogs, as are individuals with small stops.

The minimum frontal breadth and zygomatic breadth also showed considerable variation among modern shiba dogs. The minimum frontal breadth is the right to left length of the inferior area of the lateral frontal crest. This area constitutes the lateral portion of the frontal sinus, and reflects the developmental state of the masticatory muscles.

The morphology of the foramen magnum also showed marked variation (Fig. 4). The primitive foramen magnum is a simple, horizontally-oriented oval (A). The primitive foramen magnum is observed in the vast majority of Jomon period dogs. In addition to the primitive foramen magnum, the modern shiba dog shows a type with a notch at the upper margin (B), a "keyhole" type (C), and a triangular type (D). In modern males, the primitive foramen magnum (A) was observed in twenty-two of the forty-five dogs, type B in

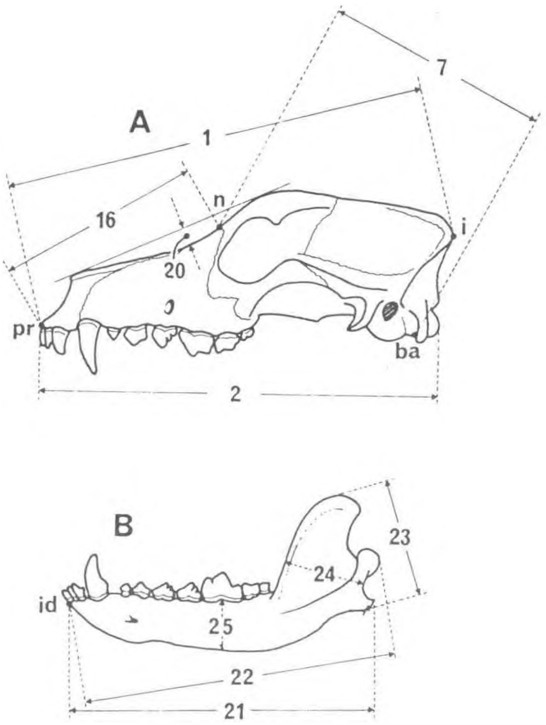

Figure 2. Cranial and mandibular measurements used in the study. A lateral aspect. B lateral aspect of the mandible. Numerals correspond with measurement numbers shown in Table 1.

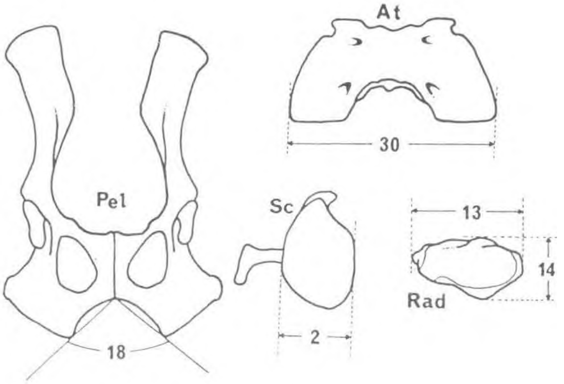

Figure 3. Trunk and extremity measurements used in this study. Pel: pelvis. At: atlas. Sc: glenoid cavity of the right scapula, Rad: distal end of right radius. Numerals correspond with measurement numbers shown in Table 4.

nine, C in eight, and D in six. Non-primitive types accounted for 51.2% of male foramen magna. In modern females, the primitive type was observed in twelve of the forty-two dogs, type B in fifteen, C in nine, and D in six. Non-primitive types accounted for 71.4% of all female foramen magna. As with all other investigated characteristics, the morphology of the foramen magnum showed more variation in females than in males.

The range of variation for each measurement was expressed using Pearson's coefficient of variance. Variation was especially great for nasal curve depth, minimum frontal breadth, frontal breadth, mandibular body thickness, and masseter fossa depth in males. In addition to these features, minimum interorbital breadth and snout height also showed great variation in females.

Dentition: The incisors showed considerable attrition and variation of size in adult modern shiba dogs The canines showed significant difference in size between males and females, as is generally observed in mammals. In males, the canines were large and strong.

Considerable size variation was observed in the first and second premolars of both the maxilla and mandible, but size variation in the third and fourth premolars was slight. Congenital absence of the two permanent medial premolars was frequently observed (Ogata et al. 1979). When present, the medial premolars have short roots and tend to fall out. Therefore, lack of these teeth is frequently observed in Jomon dogs, which used their teeth more forcefully than do modern dogs (Shigehara & Onodera 1984).

Significant variation of size was observed between the first and second molars in the maxilla, and the second molar often showed a reductive tendency. Therefore, the coefficient of variance was higher for the second molar. In the mandible, variation was greater in the distal molars.

In the maxillary dentition, the coefficient of variance was high for every tooth, especially for the medio-distal diameter of the second premolar and for the bucco-lingual diameter of the third premolar. The variation observed in the bucco-lingual diameter of the third premolar reflects the well-developed lingual cingulum often observed in modern shiba dogs.

In the mandibular dentition, the coefficient of variance was high for the medio-distal diameter of the second premolar and for both the medio-distal diameter and bucco-lingual diameter of the third molar. The third molar is a very small tooth that shows size reduction. Size variation observed in the third molar was considerable, as is observed in the human.

In modern shiba dogs, the palate is shorter and wider than in ancient domestic dogs. In addition, various types of maloccclusion have appeared in the dental arch of the modern shiba dog. Such abnormality is most frequently observed in the premolars.

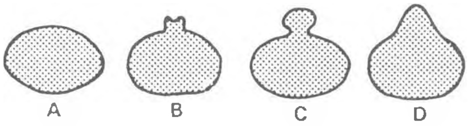

Figure 4. Variations of foramen magnum in shiba dogs. A normal oval foramen, B oval foramen with small notch, C key hole foramen, D triangular foramen.

Limb bones: In the limb bones, the coefficient of variance was high for the maximum breadth in the middle of the humerus, and for the diameter in the middle of the radius. In females, the coefficient of variation was also high for the minimum breadth in the middle of the humerus, and for the diameter of the middle of the femur. These measurements are related to the stoutness of the diaphysis, and showed a higher coefficient of variance than those related to length. Thus, the length of bones is consistent, but stoutness varies considerably in modern shiba dogs.

Analysis of difference between males and females

Non-metric observations

Although sex-based differences are widely known to exist, few reports have been published on non-metrical differences between male and female dogs. Hasebe (1952) reported sex-based differences in the swell of the inferior part of the external frontal crest and in the protuberance of the sagittal crest. The right and left temporal lines meet just behind the bregma, forming a sagittal crest in males that is generally well-developed. In females, if a sagittal crest is present, the temporal lines meet far behind the bregma (Fig. 5-1 to 5-7). The swell of the inferior part of the external frontal crest is more pronounced in males than in females. As a result, constriction of the frontal region was observed in females when viewed from a posterior perspective (Fig. 5-5, 5-6). These characteristics, especially the enlargement of the insertion part of the anterior of the temporal muscle origin, are closely associated with the masticatory muscles.

One characteristic that reflects the development of the temporal muscle is the size of the superior nuchal line in the occipital region (Fig. 5-7, 5-8). In males, the superior nuchal line is not straight. This character is also associated with the deep muscle in the back that raises the head.

The & Trouth (1976) noted a sex-based difference in the insertion of the muscles rectus capitis ventralis major and minor,muscle which correspond to the straight anterior muscle of the head and musulus longus capitis in humans (Fig. 6-1, 6-2). Sex determination using this characteristic yielded an accuracy of 87.5%. This non-metric difference has been suggested to result from behavioural differences between males and females. Brothwell et al. (1979) performed sex determination in ancient Peruvian dogs using this sex-based difference, and we applied this method for sex determination in the modern shiba dog. Of the forty-four shiba males, twenty-three were identified as males and two as females with this method; sex could not be determined in the other fifteen. Of the thirty-two shiba females, only nine were correctly judged to be females and twenty were judged to be males; sex could not be determined in the other three. In particular, accuracy of determination based on the female cranium was very poor. Our findings suggest that this characteristic differs among dog breeds and that methods successful for one breed cannot

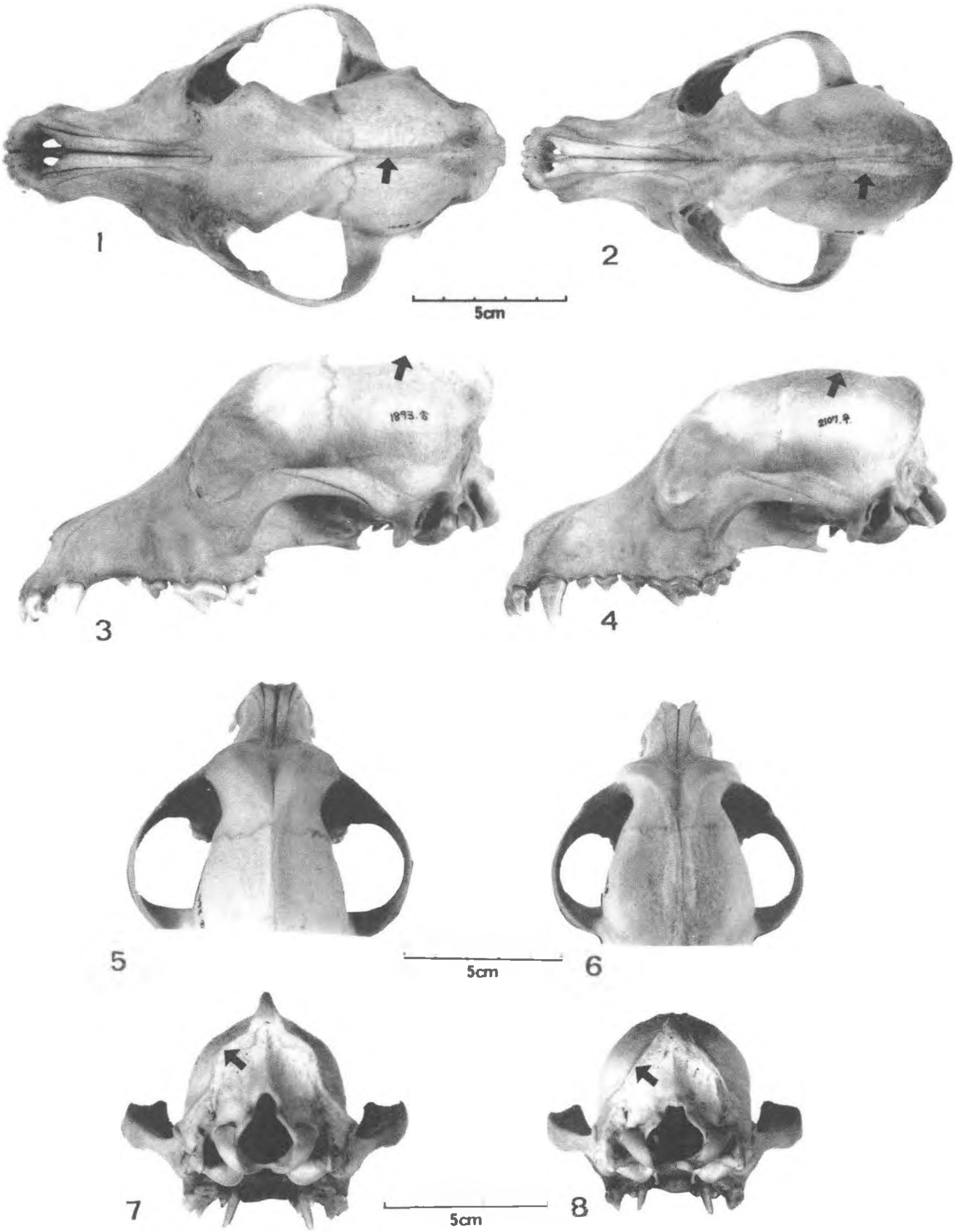

Figure 5. Sex-based differences observed in shiba dogs. Arrows indicate different features in males (left) and females (right). 1 and 2, dorsal aspect: arrows indicate temporal lines (right and left temporal lines meet just behind the bregma in males). 3 and 4, lateral aspect: arrows indicate sagittal and nuchal crests. 5 and 6, dorsal aspect, viewed from posterior: arrows indicate swells of frontal bone. 7 and 8, posterior aspect: arrows indicate nuchal crest.

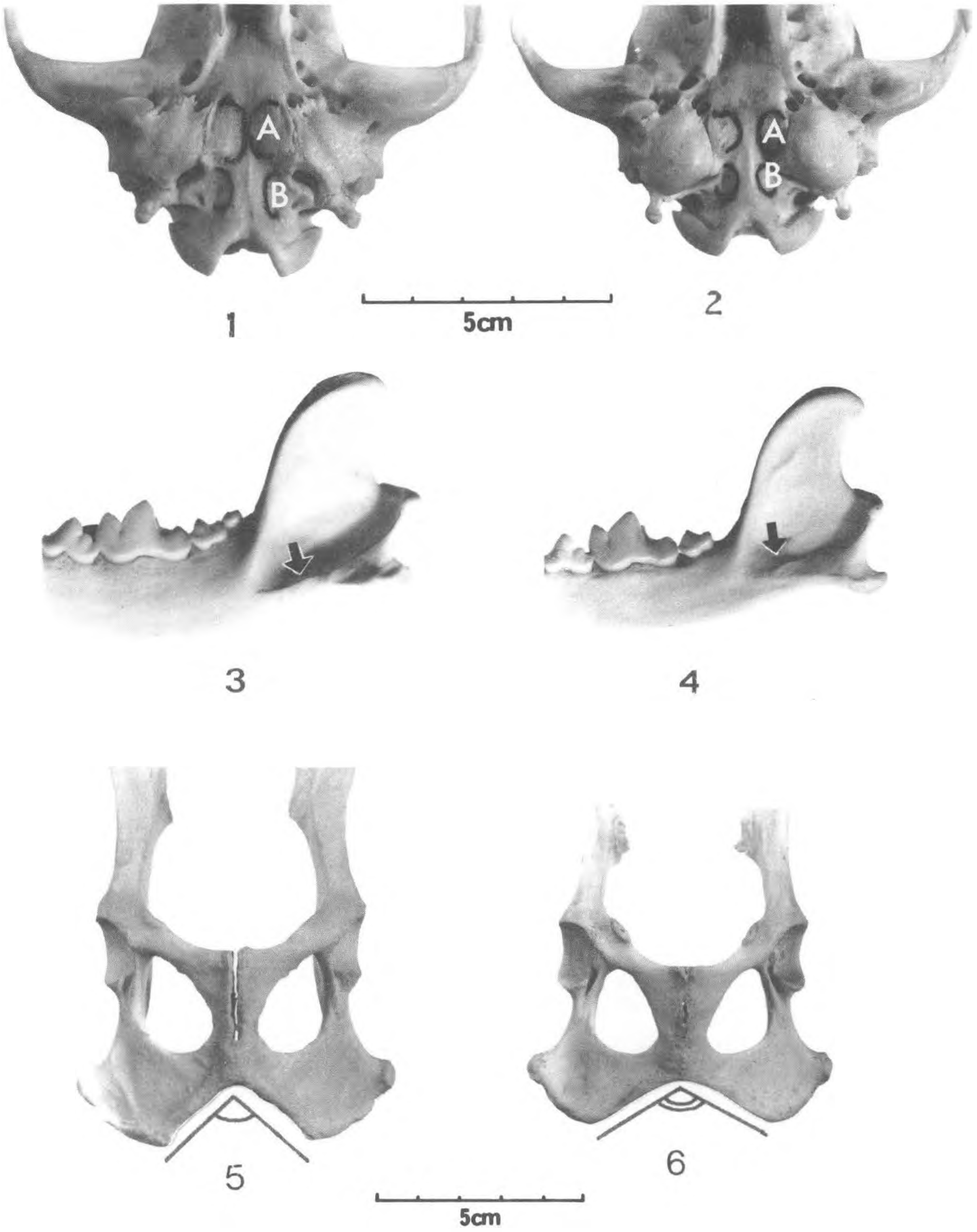

Figure 6. Sexual differences observed in shiba dogs. 1 and 2, basal aspect: showing the difference in hasicranium structure. A: attachment of muscle rectus capitis ventralis major. B: attachment of rectus capitis ventralis minor. 3 and 4, lateral aspect of left mandible; arrrows indicate condyloid crest. 5 and 6, ventral aspect of pelvis showing the difference in sub-pubic angle.

necessarily be applied to other breeds without adjustment.

The condyloid ridge, which forms the inferior margin of the masseter fossa of the mandible, also showed sex-based differences (Fig. 6-3, 6-4). This ridge marks the lower margin at which the middle layer of the masseter muscle is inserted. In males, the masseter fossa is distinguished from the inferior area by a clear condyloid ridge. In females, the masseter fossa is gently shifted downward, without any acute angle.

The subpubic angle of the pelvis also differed between males and females (Fig. 6-5, 6-6). This is commonly observed in mammals. The difference in this angle can also be metrically confirmed.

Metric observations

Differences between mean values of males and females were analyzed using a t-test (Table 1). In the cranium, significant differences were observed at $p < 0.01$ in twenty-six of the twenty-seven items, and at $p < 0.05$ for minimum frontal breadth. On the other hand, very few cranial indices showed significant sex-based differences. Sex-based differences were observed at $p < 0.01$ for the interorbital index and the length-breadth index of the mandibular body, and at $p < 0.05$ for the nasal depth index. These findings suggest that cranial proportion does not differ greatly between males and females.

Sex-based differences ($p < 0.01$) were observed in all measurements for each maxillary tooth. Those of males were consistently larger than those of females (Table 2). Similarly, the length of each tooth row (premolar, molar, and postcanine) was larger in males than in females. However, the relative size of each tooth row showed no significant sex-based difference according to the tooth row indices.

In the mandibular teeth, sex-based differences were observed at $p < 0.01$ in nineteen of the twenty-six measurements, and a $p < 0.05$ in the other six measurements. Only the medio-distal diametre of the first incisor showed no sex-based difference (Table 3). On the other hand, no index showed a significant sex-based difference.

In the limb bone (Table 4), significant sex-based differences ($p < 0.01$) were observed in every measurement (twenty-nine items, excluding penis bone length). On the other hand, only one significant sex-based difference ($p < 0.05$) was observed among the eight limb bone indices, in the cross-section index of the middle of the femur.

Evaluation of determinant factors

A discriminant function is an equation incorporating determinant factors that accurately identifies an individual as belonging to a specific group. In the present study, discriminant analysis was performed using several measurements selected from among those evaluated for effectiveness in modern shiba dogs. The following criteria, developed to be applicable to dog bones excavated from archaeological sites, were applied to the following selection of determinant factors: (1) The body part should not be susceptible to damage, (2) The correlation coefficient between the measurements should not be excessively high, (3) The variation should be small, (4) The coefficient of difference between males and females should be high (coefficient of difference = (the difference in mean value between two groups)/(sum of standard deviations of the two groups), and (5) The number of measurements required should be small.

Nine discriminant functions were derived, such that at least one of them can be used wherever a partial skeleton is excavated (Table 5). The discriminant functions were standardized, such that when the discriminant value (y) obtained after substitution of the measurement values was positive, the individual was determined to be male, and when the discriminant value was negative, the individual was determined to be female.

Discriminant analysis using cranial bones without mandible

Based on their coefficients of difference, six determinant factors were identified for cranial bones, and discriminant analysis was performed (Table 5-(1)). The bizygomatic breadth was the most accurate, followed in order by total basal length, minimum interorbital breadth, palatal breadth, auricular breadth, and nasion-basion length. However, the zygomatic arch is an area that is damaged easily.

Discriminant analysis using the mandible

In contrast to the cranial bones and teeth, very few measurements in the mandible were useful for sex determination, judging from the coefficients of difference. The masseter fossa depth and the thickness of the mandibular body, both of which are conventionally used for sex determination,

Appendix A

Table 1. Cranial and mandibular measurements and indices of Shiba dogs and male Tagara (Jomon period) dogs.

	Male				Female						Tagara (Jomon) Male	
	No.	$\bar{x}$	s	CV	No.	$\bar{x}$	s	CV	t-test	CD	$\bar{x}$	Coefficient
1 : max. cranial length	45	155.48	6.79	4.37	42	145.27	6.81	4.69	◎	0.75	163.01	0.95
2 : basal length	45	147.90	6.05	4.09	42	137.88	6.34	4.59	◎	0.81	152.44	0.97
3 : palatal length	45	74.86	3.65	4.87	42	70.26	3.64	5.18	◎	0.63	78.45	0.95
4 : max. palatal breadth	45	59.17	2.45	4.14	42	55.17	2.63	4.76	◎	0.79	57.41	1.03
5 : cranial breadth (eu-eu)	45	50.06	1.47	2.94	42	48.27	1.71	3.54	◎	0.56	52.35	0.96
6 : zygomatic breadth	45	94.79	3.77	3.98	42	88.14	3.81	4.33	◎	0.88	88.30	1.07
7 : nasion-basion length	45	84.13	3.31	3.93	42	79.05	3.41	4.32	◎	0.76	84.20	1.00
8 : auricular breadth	45	54.16	2.24	4.13	42	50.67	2.15	4.24	◎	0.80	59.39	0.91
9 : brain case length	45	86.10	4.12	4.79	42	80.81	4.20	5.19	◎	0.64	87.16	0.99
10 : cranial height	45	48.53	2.88	5.94	42	45.24	2.50	5.52	◎	0.61	49.00	0.99
11 : min. frontal breadth	45	29.51	2.67	9.03	42	28.15	2.65	9.41	○	0.26	31.70	0.93
12 : frontal breadth	45	43.52	3.77	8.67	42	39.25	3.80	9.68	◎	0.56	42.83	1.02
13 : occipital height	45	41.61	1.90	4.58	42	39.49	2.07	5.24	◎	0.53	42.23	0.99
14 : min. interorbital breadth	45	28.66	2.14	7.45	42	25.43	2.18	8.56	◎	0.75	28.69	1.00
15 : biorbital breadth	45	72.12	2.27	3.14	42	67.88	2.77	4.09	◎	0.84	67.94	1.06
16 : facial length	45	74.60	4.02	5.39	42	69.40	4.12	5.94	◎	0.64	79.39	0.94
17 : snout length	45	64.95	3.35	5.16	42	60.14	3.61	6.00	◎	0.69	68.34	0.95
18 : snout breadth	45	31.48	1.54	4.89	42	28.94	1.86	6.43	◎	0.75	34.52	0.91
19 : snout height	45	34.24	2.04	5.94	42	31.82	2.85	8.95	◎	0.50	39.14	0.87
20 : nasal curve depth	45	6.39	0.79	12.41	42	5.50	0.69	12.60	◎	0.60	5.03	1.27
21 : mand. length (1) (id-goc)	45	114.06	4.89	4.29	42	106.96	4.95	4.62	◎	0.72	118.48	0.96
22 : mand. length (2) (id-c.mid)	45	114.19	5.11	4.48	42	106.96	4.82	4.51	◎	0.73	117.41	0.97
23 : mand. ramus height	45	44.58	2.60	5.84	42	41.27	2.30	5.58	◎	0.67	44.30	1.01
24 : mand. ramus breadth	45	27.66	1.73	6.24	42	25.48	1.44	5.66	◎	0.69	29.28	0.94
25 : mand. body height (M1)	45	18.91	1.29	6.82	42	17.23	1.45	8.41	◎	0.61	22.37	0.85
26 : mand. body thickness (M1)	45	9.13	0.74	8.07	42	8.19	0.65	7.90	◎	0.68	10.86	0.84
27 : masseter fossa depth	45	5.76	0.77	13.32	42	5.25	0.57	10.85	◎	0.38	7.13	0.81
cranial index (6/1)	45	61.01	2.22	3.64	42	60.72	2.26	3.72	×	0.06	55.05	
length-height index (10/1)	45	31.23	1.53	4.89	42	31.17	1.62	5.20	×	0.02	30.03	
breadth-height index (10/6)	45	51.22	2.68	5.24	42	51.35	2.39	4.65	×	0.03	52.46	
postorbital index (11/5)	45	58.95	4.93	8.36	42	58.25	4.21	7.23	×	0.08	60.16	
interorb. index (14/15)	45	39.73	2.46	6.18	42	37.42	2.29	6.13	◎	0.49	42.51	
facial index (16/6)	45	78.75	3.88	4.93	42	78.79	4.36	5.53	×	0.00	90.28	
snout index (18/1)	45	41.76	0.78	1.87	42	41.39	1.10	2.66	×	0.20	41.97	
nasal depth index (20/19)	45	18.70	2.35	12.57	42	17.40	2.56	14.73	○	0.26	12.66	
palatal index (4/3)	45	79.15	3.80	4.80	42	78.64	4.16	5.29	×	0.06	71.13	
mand..th.-length index (26/22)	45	8.00	0.57	7.15	42	7.66	0.54	6.99	◎	0.31	9.24	

CV : coefficient of variance, CD : coefficient of difference, $\bar{x}$: average, s : standard deviation, ◎ : significant difference ($P<0.01$), ○ : significant difference ($P<0.05$), × : no significant difference.

Appendix A

Table 2. Measurements and indices of the upper dentition of Shiba dogs and male Tagara (Jomon period) dogs.

		Male				Female						Tagara (Jomon) Male	
		No.	$\bar{x}$	s	CV	No.	$\bar{x}$	s	CV	*t*-test	CD	$\bar{x}$	Coefficient
1 : I 1	(m-d)	42	4.31	0.23	5.37	37	4.04	0.30	7.44	◎	0.62	4.3	1.00
2 :	(b-l)	42	4.67	0.28	5.94	39	4.27	0.27	6.26	◎	0.88	4.1	1.14
3 : I 2	(m-d)	44	5.05	0.35	6.87	38	4.78	0.31	6.45	◎	0.49	5.0	1.01
4 :	(b-l)	44	5.22	0.26	5.04	40	4.77	0.27	5.68	◎	1.07	4.6	1.13
5 : I 3	(m-d)	43	5.18	0.30	5.88	37	4.68	0.33	7.15	◎	0.87	4.5	1.15
6 :	(b-l)	43	6.20	0.28	4.49	38	5.55	0.47	8.43	◎	0.99	6.0	1.03
7 : C	(m-d)	45	9.14	0.64	6.98	42	8.27	0.61	7.40	◎	0.71	9.3	0.98
8 :	(b-l)	45	5.33	0.37	6.94	42	4.69	0.43	9.13	◎	0.96	5.3	1.01
9 : P 1	(m-d)	41	5.32	0.33	6.25	39	4.99	0.39	7.81	◎	0.46	5.0	1.06
10 :	(b-l)	41	3.73	0.15	4.16	39	3.41	0.22	6.49	◎	0.87	3.5	1.06
11 : P 2	(m-d)	37	8.22	0.86	10.43	33	7.42	0.67	9.04	◎	0.49	8.2	1.00
12 :	(b-l)	37	3.97	0.24	6.03	33	3.55	0.26	7.38	◎	0.90	3.5	1.13
13 : P 3	(m-d)	45	10.78	0.55	5.09	42	9.79	0.48	4.93	◎	0.85	10.5	1.03
14 :	(b-l)	42	4.90	0.41	8.41	41	4.52	0.40	8.76	◎	0.46	4.3	1.14
15 : P 4	max (m-d)	45	17.55	0.78	4.43	42	16.26	0.75	4.63	◎	0.80	17.6	1.00
16 :	lat (m-d)	45	16.80	0.58	3.46	42	15.71	0.66	4.18	◎	0.79	17.4	0.97
17 :	(b-l)	44	9.45	0.42	4.49	42	8.59	0.49	5.69	◎	0.91	9.0	1.05
18 : M 1	(m-d)	45	11.12	0.55	4.94	42	10.44	0.56	5.35	◎	0.72	11.1	1.00
19 :	max (b-l)	45	14.94	0.72	4.83	42	14.06	0.76	5.37	◎	0.60	15.3	0.98
20 : M 2	(m-d)	44	6.13	0.41	6.73	42	5.70	0.39	6.88	◎	0.49	6.0	1.02
21 :	(b-l)	44	8.90	0.63	7.04	42	8.38	0.52	6.19	◎	0.44	9.5	0.94
22 : tooth row length (I1-M2)		44	79.40	3.37	4.25	42	74.33	3.67	4.94	◎	0.56	—	—
23 : premolar row length (P1-P4)		43	41.63	2.73	6.55	39	38.76	2.13	5.49	◎	0.47	—	—
24 : molar row length (M1-M2)		44	14.95	0.81	5.39	42	13.85	1.13	8.16	◎	0.58	—	—
25 : cheek teeth length (P1-M2)		42	53.40	2.64	4.95	39	49.99	2.47	4.94	◎	0.56	—	—
(M1+M2)×100/P4		44	102.75	5.14	5.01	42	102.74	4.07	3.96	×	0.03	—	—
(23/22)×100		42	52.40	1.94	3.69	39	52.00	1.58	3.04	×	0.06	—	—
(24/22)×100		44	18.85	1.18	6.26	42	18.66	1.56	8.34	×	0.16	—	—
(23/25)×100		42	77.84	2.05	2.64	39	77.52	1.64	2.11	×	0.03	—	—
(8/7)×100		45	58.46	3.09	5.29	42	56.71	3.62	6.38	◎	0.39	—	—

m-d : medio-distal diameter, b-l : bucco-lingual diameter. Abbreviations : see Table 1.

Appendix A

Table 3. Measurements and indices of the lower dentition of Shiba dogs and male Tagara (Jomon period) dogs.

		Male				Female						Tagara (Jomon) Male	
		No.	$\bar{x}$	s	CV	No.	$\bar{x}$	s	CV	t-test	CD	$\bar{x}$	Coefficient
1 : I 1	(m-d)	38	2.62	0.19	7.33	38	2.56	0.16	6.39	×	0.23	2.5	1.05
2 :	(b -l)	39	3.41	0.22	6.46	40	3.11	0.19	6.06	◎	0.68	3.3	1.03
3 : I 2	(m-d)	40	3.77	0.27	7.12	33	3.63	0.24	6.62	○	0.39	4.0	0.94
4 :	(b -l)	41	4.35	0.26	6.04	35	4.03	0.25	6.21	◎	0.60	4.4	0.99
5 : I 3	(m-d)	42	4.98	0.30	6.04	38	4.64	0.39	8.47	○	0.45	5.0	1.00
6 :	(b -l)	43	4.63	0.32	6.82	40	4.14	0.34	8.27	◎	0.60	4.3	1.08
7 : C	(m-d)	45	9.85	0.76	7.71	42	8.79	0.82	9.38	◎	0.78	9.2	1.07
8 :	(b -l)	45	5.81	0.35	5.94	42	5.05	0.42	8.27	◎	0.91	5.4	1.08
9 : P 1	(m-d)	41	4.05	0.29	7.14	41	3.87	0.21	5.46	○	0.37	—	—
10 :	(b -l)	41	3.10	0.19	6.15	41	2.86	0.20	7.16	◎	0.63	—	—
11 : P 2	(m-d)	24	7.25	0.67	9.18	25	6.60	0.79	11.96	○	0.39	7.0	1.04
12 :	(b -l)	24	4.07	0.26	6.50	25	3.64	0.49	13.40	◎	0.56	3.6	1.13
13 : P 3	(m-d)	44	9.29	0.44	4.77	41	8.50	0.46	5.44	◎	0.74	8.7	1.07
14 :	(b -l)	44	4.77	0.23	4.85	41	4.30	0.29	6.81	◎	0.76	4.1	1.16
15 : P 4	(m-d)	42	10.81	0.54	5.00	38	9.89	0.70	7.13	◎	0.61	10.2	1.06
16 :	(b -l)	42	5.85	0.36	6.20	38	5.29	0.32	6.11	◎	0.83	5.3	1.10
17 : M 1	max (m-d)	45	18.58	0.65	3.51	42	17.38	0.89	5.10	◎	0.61	19.5	0.95
18 :	med (b -l)	45	7.69	0.36	4.65	42	7.06	0.40	5.66	◎	0.67	7.9	0.97
19 : M 2	(m-d)	45	7.44	0.42	5.70	42	6.90	0.47	6.78	○	0.42	7.8	0.95
20 :	(b -l)	45	5.89	0.36	6.19	42	5.46	0.37	6.85	◎	0.57	6.2	0.95
21 : M 3	(m-d)	39	3.82	0.47	12.32	32	3.57	0.44	12.32	◎	0.48	3.8	1.01
22 :	(b -l)	39	3.49	0.38	10.78	32	3.23	0.35	10.91	◎	0.46	3.5	1.00
23 : tooth row length (I1-M3)		40	80.31	3.29	4.10	34	76.38	2.73	3.58	◎	0.67	—	
24 : premolar row length (P1-P4)		41	32.81	2.28	6.94	37	31.21	1.83	5.86	○	0.40	—	
25 : molar row length (M1-M3)		40	28.89	1.16	4.01	34	27.30	1.40	5.12	◎	0.71	—	
26 : cheek teeth length (P1-M3)		39	60.65	2.93	4.82	33	57.97	2.22	3.83	◎	0.58	—	
(24/23) × 100		37	40.80	1.59	3.90	32	41.06	1.50	3.65	×	0.01	—	
(25/23) × 100		40	35.99	1.25	3.48	34	35.76	1.62	4.54	×	0.06	—	
(24/26) × 100		37	53.97	1.75	3.23	32	54.14	1.72	3.18	×	0.02	—	
(8/7) × 100		45	59.20	3.35	5.65	42	57.64	3.96	6.86	×	0.02	—	

Abbreviations : see Tables 1 and 2.

Appendix A

Table 4. Measurements and indices of the trunk and the extremities of Shiba dogs and Tagara (Jomon period) dogs

	Male				Female						Tagara (Jomon) Male	
	No.	$\bar{x}$	s	CV	No.	$\bar{x}$	s	CV	t-test	CD	$\bar{x}$	Coefficient
1 : Scapula length	41	108.59	5.59	5.15	37	100.64	4.68	4.65	◎	0.84	—	—
2 : glenoid cavity breadth	41	14.85	0.88	5.93	38	13.58	0.75	5.56	◎	0.84	15.0	0.99
3 : glenoid cavity length	41	20.17	0.99	4.91	38	18.43	1.06	5.76	◎	0.91	20.9	0.96
4 : min. neck breadth	41	20.02	1.28	6.38	38	18.51	1.18	6.37	◎	0.71	21.5	0.93
5 : Humerus length	41	122.99	7.29	5.92	38	114.46	6.13	5.35	◎	0.73	131.3	0.94
6 : max. prox. breadth	41	21.80	1.11	5.09	38	20.08	1.14	5.67	◎	0.85	22.7	0.96
7 : min. breadth in the middle	41	9.39	0.71	7.57	38	8.69	0.72	8.29	◎	0.45	11.2	0.84
8 : max. breadth in the middle	41	11.89	1.04	8.74	38	11.05	0.92	8.32	◎	0.44	15.0	0.79
9 : max. distal breadth	41	26.10	1.30	4.97	38	24.29	1.51	6.22	◎	0.68	28.4	0.92
10 : Radius length	41	118.52	7.19	6.07	38	109.70	6.08	5.54	◎	0.80	125.7	0.94
11 : breadth in the middle	41	9.87	0.70	7.08	38	8.94	0.61	6.84	◎	0.74	10.7	0.92
12 : diameter in the middle	41	5.75	0.49	8.44	38	5.25	0.49	9.41	◎	0.52	7.1	0.81
13 : max. dist. breadth	41	18.69	0.96	5.13	38	17.17	0.91	5.31	◎	0.92	20.6	0.91
14 : max. dist. diameter	41	10.52	0.57	5.40	37	9.55	0.61	6.39	◎	0.94	12.5	0.84
15 : Ulna length.	41	141.52	8.00	5.66	38	130.89	7.10	5.42	◎	0.82	148.5	0.95
16 : Pelvis length	41	119.05	6.29	5.28	37	111.59	5.44	4.87	◎	0.80	117.6	1.01
17 : max. acetabulum length	41	17.02	0.97	5.68	38	16.07	0.97	6.04	◎	0.49	18.5	0.92
18 : sub-pubic angle	39	101.28	7.32	7.22	36	109.75	5.68	5.18	◎	0.71	—	—
19 : Femur length	41	133.81	7.95	5.94	38	124.12	6.61	5.32	◎	0.79	134.8	0.99
20 : breadth in the middle	41	10.56	0.63	5.95	38	9.74	0.66	6.83	◎	0.66	12.0	0.88
21 : diameter in the middle	41	9.61	0.77	7.96	38	9.16	0.74	8.04	◎	0.36	11.6	0.83
22 : max. dist. breadth	41	24.53	1.15	4.68	38	22.84	1.55	6.80	◎	0.65	27.5	0.89
23 : Tibia length	41	135.12	8.16	6.04	38	125.19	6.81	5.44	◎	0.80	141.8	0.95
24 : max. prox. breadth	41	26.82	1.35	5.04	38	25.17	1.54	6.14	◎	0.62	29.2	0.92
25 : breadth in the middle	41	10.01	0.65	6.50	38	9.26	0.69	7.49	◎	0.55	10.9	0.92
26 : diameter in the middle	41	9.75	0.70	7.20	38	9.09	0.63	6.95	◎	0.47	10.6	0.92
27 : max. dist. breadth	41	17.93	0.97	5.41	38	16.75	1.04	6.21	◎	0.61	20.1	0.89
28 : Calcaneus length	41	34.28	1.84	5.38	38	32.01	1.73	5.40	◎	0.69	37.6	0.91
29 : Penis bone length	41	71.59	5.67	7.91	—	—	—	—	—	—	—	—
30 Atlas max. breadth	41	70.58	19.85	28.13	38	61.69	3.02	4.90	◎	0.82	68.0	1.04
(7/8) × 100	41	79.21	4.67	5.90	38	78.74	4.85	6.15	×	0.03	—	—
(12/11) × 100	41	58.37	4.36	7.47	38	58.78	4.11	6.99	×	0.03	—	—
(20/21) × 100	41	110.17	6.35	5.76	38	106.54	5.86	5.50	○	0.24	—	—
(20/19) × 100	41	7.90	0.41	5.20	38	7.85	0.47	6.02	×	0.05	—	—
(25/26) × 100	41	102.92	5.99	5.82	38	102.12	6.84	6.69	×	0.07	—	—
brachial index	41	96.38	1.91	1.98	38	95.87	2.48	2.59	×	0.12	95.74	—
crural index	41	101.00	2.22	2.20	38	100.87	1.97	1.95	×	0.02	102.44	—
intermembral index	41	89.81	1.21	1.35	38	89.92	0.96	1.06	×	0.04	91.60	—

Abbreviations : see Table 1.

Table 5. Various discriminant functions of modern shiba dogs and

	Discriminant	Error prob.	$x1$
(1) Cranium	$y=x1+0.447\ x2-154.26$	17.2%	zygomatic B.
(2) Mandible	$y=x1+3.413\ x2+0.130\ x3-69.22$	21.1%	mand. ramus B.
(3) Upper dentition	$y=x1+2.051\ x2+1.289\ x3-20.29$	10.6%	upper Canine b-l
(4) Lower dentition	$y=x1+0.95\ x2-9.76$	13.5%	lower Canine b-l
(5) Up. & Lo. Dent.	$y=x1-0.229\ x2-4.28$	15.7%	upper Canine b-l
(6) Cran. & Dent.	$y=x1+0.119\ x2-11.69$	12.7%	lower Canine b-l
(7) Trunk & Extrem.	$y=x1-0.16\ x2+0.296\ x3-17.10$	16.5%	Scapula gl. cav. B.
(8) Total	$y=x1-0.0423\ x2+0.0767\ x3-5.89$	7.0%	lower Canine b-l
	$y=x1-0.0365\ x2+0.0239\ x3-0.45$	7.0%	lower Canine b-l

B : breadth, L: length, Th: thickness, b-l: bucco-lingual diameter. Because of no Sub-pubic in both groups.

were not as accurate as expected. However, since the mandible is frequently excavated alone, determinant factors in the mandible should be identified.

Six determinant factors were identified after excluding total mandibular length (1) (Table 5-(2)). The mandibular ramus breadth was the most useful, followed in order by mandibular body thickness, total mandibular length (2), mandibular ramus height, masseter fossa depth, and mandibular body height (M1).

The probability of error using discriminant functions in the mandible was 21.1%. This was considerably higher than the percentage of error using discriminant functions for other elements.

Discriminant analysis using teeth

Discriminant analysis was performed using determinant factors that showed low percentages of error. The bucco-lingual diameters of the mandibular and maxillary canines were the most accurate determinant factors.

Discriminant analysis was performed on maxillary teeth using fourteen determinant factors selected according to ease of tooth identification and accuracy of measurement (Table 5-(3)). Among the maxillary teeth, the bucco-lingual diameter of the canine was the most accurate determinant factor, followed by that of the second premolar and that of the third incisor.

From the twenty-six measurements of the mandibular teeth, six determinant factors were selected, based on their coefficients of difference, ease of identification and accuracy of measurement (Table 5-(4)). The bucco-lingual diameter of the canine was the most accurate determinant factor, followed in order by that of the third premolar, the medio-distal diameter of the third premolar, the bucco-lingual diameter of the fourth premolar, the medio-distal diameter of the canine, and the length of the molar tooth row.

Discriminant analysis using the maxillary and mandibular teeth

Discriminant analysis was performed using the bucco-lingual diametre of the maxillary canine and that of the mandibular canine, which yielded the most accurate sex determination in each jaw (Table 5-(5)). The probability of error using these teeth was 15.7%. Thus, the accuracy using this factor was higher than that of using the mandible

Discriminant analysis using the cranium and teeth

Discriminant analysis was performed using the interorbital breadth instead of the easily-damaged zygomatic arch, as well as six other factors that showed high coefficients of difference and are well preserved (Table 5-(6)). The bucco-lingual diameter of the mandibular canine was the most accurate determinant factor, followed in order by the auricular breadth, total basal length, bucco-lingual diametre of the maxillary canine, and palatal breadth.

Discriminant analysis using bones of the trunk and extremities

From the measurements of the limb bones, nine revised discriminant functions for Jomon dogs .

$x2$	$x3$	Revised discriminant
Cranium basal L.		$y=x1+0.405\ x2-144.17$
Mand. body Th. (M1)	Mandibular L. (2)	$y=x1+3.05\ x2+0.134\ x3-73.64$
upper P2 b-l	upper 13 b-l	$y=x1+2.29\ x2+1.315\ x3-20.09$
lower P3 b-l		$y=x1+1.02\ x2-9.04$
lower Canine b-l		$y=x1-0.24\ x2-4.23$
Auricular B.		$y=x1+0.1\ x2-10.82$
Sub-pubic angle	Atlas max. B.	$y=x1-0.162\ x2+0.311\ x3-17.27$
Sub-pubic angle	Atlas max. B.	$y=x1-0.039\ x2+0.074\ x3-5.45$
Sub-pubic angle	Cranium basal L.	$y=x1-0.0338\ x2+0.0215\ x3-0.42$

angle data in Jomon dogs, this angle is tentatively assumed to be equal

determinant factors with high coefficients of difference were selected, and the discriminant functions were derived (Table 5-(7)). The scapular glenoid breadth was the most accurate factor, followed in order by the subpubic angle, the maximum breadth of the atlas, and the sagittal diameter of the distal end of the radius.

Discriminant analysis using the entire skeleton

From the measurements in the cranium, limb bones, trunk bones, maxillary teeth, and mandibular teeth, thirteen determinant factors showing high coefficients of difference were selected, and discriminant analysis was performed (Table 5-(8)). Several of these items were combined into the following discriminant function:

$y = (x1) - 0.0423(x2) + 0.0767(x3) - 5.89$
$x1$ = bucco-lingual diameter of the mandibular canine
$x2$ = subpubic angle
$x3$ = atlas maximum breadth

The probability of error using this function was 7.0%, which was the lowest for any discriminant function. If the cranium is not damaged, the total basal length can be used instead of the maximum breadth of the atlas. The discriminant function using total basal length is as follows:

$y = (x1) - 0.0365(X2) + 0.0239(x3) - 0.45$
$x1$ = bucco-lingual diameter of the mandibular canine
$x2$ = subpubic angle
$x3$ = total basal length of the cranium

The probability of error using this function was also 7%.

Adjustments for application to Jomon period dogs

To apply these discriminant functions to dogs of the Jomon period (9000-2300 bp), adjustments must be made that reflect the morphological differences between Jomon dogs and modern shiba dogs. For example, the relative breadth of the zygomatic arch is greater in modern shiba dogs. Therefore, before applying the corresponding discriminant function to Jomon dogs, zygomatic breadth measurements were proportionally converted. Measurements obtained from modern shiba dogs were divided by the corresponding measurements obtained from standard Jomon dogs (Tables 1 through 4). Using the obtained value, the coefficient of each discriminant function was multiplied. This converted value was used as the coefficient of the discriminant function in Jomon dogs (Table 5). In breeds or species of dogs with different characteristic sizes of measurement items, differences in the proportion can be overcome using a similar method.

In this study, the Tagara Shell Mound data reported by Shigehara and Onodera (1984) were used to obtain standard values for Jomon dogs. Morphological changes were similar in males and females. Therefore, measurements in males were used as representative values. Since the number of Jomon dogs in which sex was definitely determined is small, the validity of the revision method is questionable. However, when the dogs with known sexes from the Tagara Shell Mound were evaluated, sex was accurately determined. The revised discriminant functions are shown at the end of Table 5.

Summary

In non-metric sex determination of dogs, the probability of error is high, depending on the feature used for determination. However, the error rate was low (about 7%) using a metric determinant function applied to the entire skeleton, including the teeth. This discriminant function may prove useful. The accuracy may be increased further by combining metric results with non-metric evaluation.

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APPENDIX B

Catalogue of Archaeological Specimens used in this Study

The tabulation which follows lists the site provenience of each dog bone analyzed as part of this study, the cultural phase or time period to which the bone belongs, the type of dog (Type 1 or 2) from which the bone came, and various identification numbers. Type designation reflects re-classification of a few individuals represented by many elements as discussed in Chapter 9. The following terms and abbreviations are employed:

ID #	The identification number assigned to the specimen as part of this study.
SITE #	The Borden designation number of the archeological site from which the specimen came; site locations are shown on Figure 2-1, p. 11, and references to site reports are listed in Table 2-1, p. 10.
YEAR	The year of excavation.
AGE	The cultural phase or time period of the deposits with which the specimen is associated.. Dates are based on uncorrected C-14 dates. In some cases ages are given as younger than (<) or older than (>) a particular phase. The ages of the DeRt 2 specimens have been provided by Roy Carlson (pers. comm. 1997). None of the specimens have been dated directly. GG=Gulf of Georgia (ca. 1400 to 200 bp). M=Marpole phase (ca. 2400 to 1400 bp). L=Locarno Beach phase (ca. 3000 to 2400 bp). C=Charles culture which includes St. Mungo and Mayne phases (ca. 4400 to 3000 bp).
TYPE	Refers to whether the specimen came from a Type 1 (small) or Type 2 (large) dog. Some classifications are questionable (?), and some are potentially hybrids of the type 1 and 2 dogs.
FAUNAL #	The original catalogue number assigned by site excavators or faunal analysts.

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ID #	SITE #	YEAR	AGE	TYPE	FAUNAL #
0100	DhRr 6	1971	GG	1	
0105	DhRr 6	1971	GG	2	
0106	DhRr 6	1971	GG	1	
0108	DhRr 6	1971	GG	2	
0109	DhRr 6	1971	GG	2	
0110	DhRr 6	1971	GG	1	
0113	DhRr 6	1971	GG	1	
0114	DhRr 6	1971	GG	2	
0115	DhRr 6	1971	GG	2	
0116	DhRr 6	1971	GG	2	148A
0118	DhRr 6	1971	GG	1	
0120	DhRr 6	1971	GG	1	
0121	DhRr 6	1971	GG	2	
0123	DhRr 6	1971	GG	2	
0124	DhRr 6	1971	GG	1	
0125	DhRr 6	1971	GG	2	
0126	DhRr 6	1971	GG	2	
0128	DhRr 6	1971	GG	1	
0129	DhRr 6	1971	GG	1	
0130	DhRr 6	1971	GG	1	
0132	DhRr 6	1971	GG	1	
0136	DhRr 6	1971	GG	2	
0142	DhRr 6	1971	GG	2	
0149	DhRr 6	1971	GG	2	
0153	DhRr 6	1971	GG	1	
0158	DhRr 6	1971	GG	1	
0160	DhRr 6	1971	GG	1	
0163	DhRr 6	1971	GG	1	
0164	DhRr 6	1971	GG	1	
0165	DhRr 6	1971	GG	2	
0200	DgRr 2	1973	C	2	
0201	DgRr 2	1973	C	1	M412
0203	DgRr 2	1973	C	1	M296C
0204	DgRr 2	1973	C	1	M337
0205	DgRr 2	1973	C	1	M083
0206	DgRr 2	1973	C	1	M133
0207	DgRr 2	1973	C	1	M134
0208	DgRr 2	1973	C	1	M251
0211	DgRr 2	1973	C	1	M376
0212	DgRr 2	1973	C	1	
0213	DgRr 2	1973	C	1	M380
0214	DgRr 2	1973	GG	2	M362
0216	DgRr 2	1973	C	1	M377C
0217	DgRr 2	1973	C	2	M124
0219	DgRr 2	1973	C	2	M143
0220	DgRr 2	1973	C	2	M136
0300	DfRu 13	1965	M	1	
0301	DfRu 13	1965	GG	1	
0302	DfRu 13	1965	GG	1	
0305	DfRu 13	1965	GG	1	
0306	DfRu 13	1965	GG	1	
0309	DfRu 13	1965	GG	1	
0313	DfRu 13	1965	GG	1	
0314	DfRu 13	1965	GG	1	
0316	DfRu 13	1965	GG	2	
0317	DfRu 13	1965	L	1	
0318	DfRu 13	1965	L	1	
0320	DfRu 13	1965	M	2	
0324	DfRu 13	1965	GG	1	
0327	DfRu 13	1965	GG	1	
0332	DfRu 13	1965	GG	1	
0335	DfRu 13	1965	GG	1	
0336	DfRu 13	1965	GG	1	
0337	DfRu 13	1965	GG	1	
0338	DfRu 13	1965	GG	1	
0339	DfRu 13	1965	GG	1	
0340	DfRu 13	1965	GG	1	
0346	DfRu 13	1965	GG	1	
0348	DfRu 13	1965	GG	2	
0350	DfRu 13	1965	GG	1	
0351	DfRu 13	1965	GG	1	
0352	DfRu 13	1965	GG	1	
0353	DfRu 13	1965	GG	1	
0354	DfRu 13	1965	GG	1	
0355	DfRu 13	1965	GG	1	
0358	DfRu 13	1965	GG	1	
0360	DfRu 13	1965	GG	2	
0400	DgRr 2	1989	C	1	
0420	DgRr 6	1972	M	1	
0422	DgRr 6	1972	M	1	
0426	DgRr 6	1972	M	2	
0433	DgRr 6	1972	M	1	
0434	DgRr 6	1972	M	2	4045
0437	DgRr 6	1972	M	1	F015
0441	DgRr 6	1972	M	1	
0442	DgRr 6	1972	M	2	
0444	DgRr 6	1972	M	2	F039
0445	DgRr 6	1972	M	2	
0447	DgRr 6	1972	M	1	4530
0449	DgRr 6	1972	M	2	F001
0500	DgRr 1	1990	L	1	133035
0503	DgRr 1	1990	L	1	
0506	DgRr 1	1990	L	1	
0507	DgRr 1	1990	L	2	14238
0508	DgRr 1	1990	L	1	
0509	DgRr 1	1990	L	1	14207
0510	DgRr 1	1990	L	1	
0511	DgRr 1	1990	L	2	11833
0512	DgRr 1	1990	L	1	
0516	DgRr 1	1977	GG	1	
0519	DgRr 1	1977	GG	1	A0205
0520	DgRr 1	1977	GG	1	084
0527	DgRr 1	1977	GG	1	085
0530	DgRr 1	1977	GG	1	068
0531	DgRr 1	1977	GG	1	079
0532	DgRr 1	1977	GG	1	079
0534	DgRr 1	1977	GG	1	81
0535	DgRr 1	1977	GG	2	83
0536	DgRr 1	1977	GG	1	
0540	DgRs 1	1979	M	1	
0550	DgRr 1	1972	GG	2	
0552	DgRr 1	1972	GG	1	
0553	DgRr 1	1972	GG	1	
0554	DgRr 1	1972	GG	1	
0555	DgRr 1	1972	GG	2	
0556	DgRr 1	1972	GG	2	
0557	DgRr 1	1972	GG	2	
0558	DgRr 1	1972	GG	1	

Appendix B

ID #	SITE #	YEAR	AGE	TYPE	FAUNAL #
0560	DgRr 1	1972	GG	1	
0565	DgRr 1	1977	GG	1	D01
0570	DgRr 1	1972	GG	1	
0573	DgRr 1	1972	GG	2	
0580	DgRr 1	1972	GG	1	
0581	DgRr 1	1972	GG	1	
0582	DgRr 1	1972	GG	2	
0586	DgRr 1	1972	GG	1	
0587	DgRr 1	1972	GG	2	
0588	DgRr 1	1972	GG	2	
0591	DgRr 1	1976	GG	1	
0592	DgRr 1	1976	GG	1	
0593	DgRr 1	1976	GG	1	
0594	DgRr 1	1976	GG	1	
0595	DgRr 1	1976	GG	1	
0596	DgRr 1	1976	GG	1	
0597	DgRr 1	1976	GG	1	
0598	DgRr 1	1976	GG	1	
0599	DgRr 1	1976	GG	1	
0601	DgRr 1	1976	GG	1	
0602	DgRr 1	1976	GG	1	
0603	DgRr 1	1976	GG	1	
0605	DgRr 1	1976	GG	1	
0606	DgRr 1	1976	GG	1	
0607	DgRr 1	1976	GG	1	
0608	DgRr 1	1976	GG	1	
0609	DgRr 1	1976	GG	1	
0610	DgRr 1	1976	GG	1	
0611	DgRr 1	1976	GG	1	
0614	DgRr 1	1976	GG	1	
0615	DgRr 1	1976	GG	1	
0616	DgRr 1	1976	GG	1	
0630	DgRr 1	1977	GG	2	89
0800	DgRs 2	1989	GG	1	45
0801	DgRs 2	1989	GG	1	03
0802	DgRs 2	1989	GG	1	24
0803	DgRs 2	1989	GG	1	51
0804	DgRs 2	1989	GG	1	41
0805	DgRs 2	1989	GG	1	28
0811	DgRs 2	1989	GG	1	22
0812	DgRs 2	1989	GG	2?	
0813	DgRs 2	1989	GG	1	
0925	DkRs 6	1991	GG	2	
0950	DcRt 15	1966	GG	1/2	
1000	DgRs 30	1988	M	2	610
1001	DgRs 30	1988	M	2	611
1010	DgRs 30	1988	M	2	749
1011	DgRs 30	1988	M	2	743
1012	DgRs 30	1988	M	1	746
1013	DgRs 30	1988	M	2	758
1015	DgRs 30	1988	M	2	821
1018	DgRs 30	1988	M	2	820/37
1020	DgRs 30	1988	M	2	789
1023	DgRs 30	1988	M	2	602
1029	DgRs 30	1988	M	2	
1030	DgRs 30	1988	M	1	
1031	DgRs 30	1988	M	2	
1032	DgRs 30	1988	M	2	
1033	DgRs 30	1988	M	2	
1034	DgRs 30	1988	M	2	
1035	DgRs 30	1988	M	2	
1036	DgRs 30	1988	M	2	
1037	DgRs 30	1988	M	2	615
1038	DgRs 30	1988	M	1	642
1039	DgRs 30	1988	M	2	616
1040	DgRs 30	1988	M	2	617
1041	DgRs 30	1988	M	2	614
1042	DgRs 30	1988	M	2	675
1043	DgRs 30	1988	M	2	673
1044	DgRs 30	1988	M	2	678
1047	DgRs 30	1988	M	2	674
1048	DgRs 30	1988	M	2	676
1049	DgRs 30	1988	M	1	?
1050	DgRs 30	1988	M	2	819
1051	DgRs 30	1988	M	2	818
1052	DgRs 30	1988	M	2	817
1053	DgRs 30	1988	M	2	808
1054	DgRs 30	1988	M	2	811
1055	DgRs 30	1988	M	2	805
1056	DgRs 30	1986	M	2	803
1057	DgRs 30	1988	M	2	810
1059	DgRs 30	1988	M	2	801
1060	DgRs 30	1988	M	2	812
1061	DgRs 30	1988	M	2	
1062	DgRs 30	1988	M	2	800
1063	DgRs 30	1988	M	2	814
1064	DgRs 30	1988	M	2	807
1065	DgRs 30	1988	M	2	809
1066	DgRs 30	1988	M	2	804
1067	DgRs 30	1988	M	2	806
1068	DgRs 30	1988	M	2	799
1069	DgRs 30	1988	M	2	798
1070	DgRs 30	1988	M	2	813
1071	DgRs 30	1988	M	2	669/70
1075	DgRs 30	1988	M	1	663
1076	DgRs 30	1988	M	2	662
1077	DgRs 30	1988	M	2	660
1078	DgRs 30	1988	M	2	665
1079	DgRs 30	1988	M	2	664
1080	DgRs 30	1988	M	2	661
1081	DgRs 30	1988	M	2	506
1082	DgRs 30	1988	M	2	505
1083	DgRs 30	1988	M	2	500
1084	DgRs 30	1988	M	2	502
1086	DgRs 30	1988	M	2	504
1088	DgRs 30	1988	M	2	501
1089	DgRs 30	1988	M	2	503
1090	DgRs 30	1988	M	1	509
1092	DgRs 30	1988	M	2	513
1093	DgRs 30	1988	M	1	514
1094	DgRs 30	1988	M	2	507
1096	DgRs 30	1988	M	2	593
1097	DgRs 30	1988	M	2	594
1098	DgRs 30	1988	M	2	590
1099	DgRs 30	1988	M	2	595
1101	DgRs 30	1988	M	1	596
1102	DgRs 30	1988	M	2	641
1103	DgRs 30	1988	M	1	598

ID #	SITE #	YEAR	AGE	TYPE	FAUNAL #
1104	DgRs 30	1988	M	2	619
1106	DgRs 30	1988	M	2	699
1107	DgRs 30	1988	M	2	842
1110	DgRs 30	1988	M	2	846
1111	DgRs 30	1988	M	2	698
1112	DgRs 30	1988	M	2	843
1113	DgRs 30	1988	M	1	847
1114	DgRs 30	1988	M	2	844
1115	DgRs 30	1988	M	2	845
1117	DgRs 30	1988	M	2	773
1118	DgRs 30	1988	M	2	779
1119	DgRs 30	1988	M	2	764
1120	DgRs 30	1988	M	2	769
1121	DgRs 30	1988	M	2	763
1122	DgRs 30	1988	M	1	761
1124	DgRs 30	1988	M	2	766
1125	DgRs 30	1988	M	2	775
1126	DgRs 30	1988	M	2	760
1127	DgRs 30	1988	M	2	776
1128	DgRs 30	1988	M	2	772
1129	DgRs 30	1988	M	2	765
1130	DgRs 30	1988	M	2	762
1131	DgRs 30	1988	M	1	871
1132	DgRs 30	1988	M	2	
1133	DgRs 30	1988	M	2	667
1134	DgRs 30	1988	M	2	
1139	DgRs 30	1988	M	2	620
1141	DgRs 30	1988	M	2	530
1144	DgRs 30	1988	M	2	632
1145	DgRs 30	1988	M	2	628
1147	DgRs 30	1988	M	2	596
1148	DgRs 30	1988	M	2	544
1149	DgRs 30	1988	M	2	543
1150	DgRs 30	1988	M	2	565
1151	DgRs 30	1988	M	2	557
1152	DgRs 30	1988	M	2	545
1153	DgRs 30	1988	M	2	520
1155	DgRs 30	1988	M	2	546
1158	DgRs 30	1988	M	2	556
1159	DgRs 30	1988	M	2	540
1160	DgRs 30	1988	M	2	553
1161	DgRs 30	1988	M	2	541
1163	DgRs 30	1988	M	1	524
1164	DgRs 30	1988	M	2	521
1166	DgRs 30	1988	M	2	518
1167	DgRs 30	1988	M	2	522
1168	DgRs 30	1988	M	2	530
1169	DgRs 30	1988	M	2	529
1170	DgRs 30	1988	M	2	526
1173	DgRs 30	1988	M	2	523
1175	DgRs 30	1988	M	2	535
1177	DgRs 30	1988	M	2	537
1178	DgRs 30	1988	M	2	519
1179	DgRs 30	1988	M	2	591
1200	DjSe 6	1973	M	1	01
1201	DjSe 6	1973	M	1	01
1202	DjSe 6	1973	M	2	07
1203	DjSe 6	1973	M	2	01
1205	DjSe 6	1973	M	1	01
1225	DjSe 6	1973	M	1	10
1226	DjSe 6	1973	M	1	04
1227	DjSe 6	1973	M	2	06
1229	DjSe 6	1973	M	2	10
1230	DjSe 6	1973	M	2	04
1231	DjSe 6	1973	M	2	12
1232	DjSe 6	1973	M	2	13
1233	DjSe 6	1973	M	1	06
1235	DjSe 6	1973	M	1	05
1237	DjSe 6	1973	M	2	15
1238	DjSe 6	1973	M	1	18
1239	DjSe 6	1973	M	1	13
1240	DjSe 6	1973	M	2	14
1241	DjSe 6	1973	M	2	17
1242	DjSe 6	1973	M	2	16
1244	DjSe 6	1973	M	1	04
1246	DjSe 6	1973	M	2	26
1247	DjSe 6	1973	M	1	15
1248	DjSe 6	1973	M	2	17
1249	DjSe 6	1973	M	2	15
1250	DjSe 6	1973	M	2	04
1251	DjSe 6	1973	M	1	27
1252	DjSe 6	1973	M	1	16
1253	DjSe 6	1973	M	1	08
1254	DjSe 6	1973	M	1	01
1255	DjSe 6	1973	M	2	09
1256	DjSe 6	1973	M	2	07
1257	DjSe 6	1973	M	1	16
1258	DjSe 6	1973	M	1	17
1269	DjSe 6	1973	M	1	04
1270	DjSe 6	1973	M	1	08
1271	DjSe 6	1973	M	1	06
1273	DjSe 6	1973	M	1	04
1275	DjSe 6	1973	M	1	05
1276	DjSe 6	1973	M	1	03
1277	DjSe 6	1973	M	1	03
1278	DjSe 6	1973	M	1	10
1279	DjSe 6	1973	M	1	22
1281	DjSe 6	1973	M	2	01A
1284	DjSe 6	1973	M	1	10A
1285	DjSe 6	1973	M	1	09
1286	DjSe 6	1973	M	2	05
1287	DjSe 6	1973	M	1	11
1289	DjSe 6	1973	M	1	06
1291	DjSe 6	1973	M	2	03
1292	DjSe 6	1973	M	1	08
1293	DjSe 6	1973	M	1	07
1294	DjSe 6	1973	M	1	10B
1295	DjSe 6	1973	M	1	06
1296	DjSe 6	1973	M	1	05
1400	DeRt 2	1984-86	GG or >	2	500
1401	DeRt 2	1986	GG or >	1	502
1408	DeRt 2	1986	GG or >	1	507
1409	DeRt 2	1986	GG or >	2	503
1410	DeRt 2	1986	GG or >	1	506
1411	DeRt 2	1986	GG or >	1	504
1418	DeRt 2	1985	GG or >	1	006
1419	DeRt 2	1985	GG or >	1	015
1420	DeRt 2	1985	GG or >	2	010

ID #	SITE #	YEAR	AGE	TYPE	FAUNAL #
1424	DeRt 2	1985	GG or >	1	000
1425	DeRt 2	1985	GG or >	2	016
1426	DeRt 2	1984	GG or >	1	010
1427	DeRt 2	1984	GG or >	1	006/7
1430	DeRt 2	1985	GG or >	1	000
1431	DeRt 2	1985	GG or >	1	
1432	DeRt 2	1985	C	1	
1434	DeRt 2	1986	C	1	500
1436	DeRt 2	1985	C	1	034
1437	DeRt 2	1985	C	1	030
1438	DeRt 2	1985	C	1	038
1439	DeRt 2	1985	GG or >	2	305
1441	DeRt 2	1986	C	1	000
1442	DeRt 2	1984-86	C	2	500
1443	DeRt 2	1985	C	1	000
1448	DeRt 2	1986	L or <	1	000
1452	DeRt 2	1986	L or <	2	520
1453	DeRt 2	1986	L or <	1	518
1454	DeRt 2	1986	L or <	1	501
1455	DeRt 2	1986	L or <	1	510
1456	DeRt 2	1986	L or <	1	511
1457	DeRt 2	1986	L or <	1	503
1458	DeRt 2	1986	L or <	1	505
1459	DeRt 2	1986	L or <	1	504
1460	DeRt 2	1986	L or <	1	506
1461	DeRt 2	1986	L or <	1	529
1462	DeRt 2	1984	C	1	038?
1470	DeRt 2	1986	C	2	050
1471	DeRt 2	1986	C	1	058
1478	DeRt 2	1986	L or <	1	523
1479	DeRt 2	1986	L or <	1	518
1480	DeRt 2	1986	L or <	1	520
1481	DeRt 2	1986	L or <	1	526
1482	DeRt 2	1986	L or <	1	519
1483	DeRt 2	1986	L or <	1	527
1485	DeRt 2	1986	L or <	1	522
1486	DeRt 2	1986	L or <	1	511
1487	DeRt 2	1986	L or <	1	514
1488	DeRt 2	1986	L or <	1	521
1489	DeRt 2	1986	L or <	1	517
1491	DeRt 2	1985	C	1	
1492	DeRt 2	1985	C	1	
1494	DeRt 2	1985	GG	1	007A?
1495	DeRt 2	1985	C	1	000
1497	DeRt 2	1985	C	1	084
1499	DeRt 2	1985	C	1	074
1500	DeRt 2	1985	C	1	75/76
1501	DeRt 2	1985	C	1	120
1502	DeRt 2	1985	C	1	133
1509	DeRt 2	1986	C	1	501/02
1515	DeRt 2	1985	GG or >	1	
1516	DeRt 2	1985	C	2	
1517	DeRt 2	1985	L or <	1	035
1518	DeRt 2	1985	C	1	067
1519	DeRt 2	1985	C	1	069
1520	DeRt 2	1985	C	1	057/8
1521	DeRt 2	1985	C	1	054
1522	DeRt 2	1985	C	1	040
1523	DeRt 2	1985	C	1	072

ID #	SITE #	YEAR	AGE	TYPE	FAUNAL #
1524	DeRt 2	1985	C	1	061
1527	DeRt 2	1985	C	1	025
1528	DeRt 2	1985	L or <	1	021
1529	DeRt 2	1985	L or <	1	001
1546	DeRt 2	1985	C	1	039+
1548	DeRt 2	1986	C	1	500
1550	DeRt 2	1985	C	2	002
1564	DeRt 2	1986	C	1	502
1565	DeRt 2	1986	C	1	501
1569	DeRt 2	1985	C	1	029
1570	DeRt 2	1986	C	1	501
1571	DeRt 2	1986	C	1	500
1572	DeRt 2	1986	C	1	500
1573	DeRt 2	1985	C	1	
1575	DeRt 2	1985	C	2	010
1576	DeRt 2	1985	C	1	045
1577	DeRt 2	1985	C	2	005
1583	DeRt 2	1985	C	1	
1584	DeRt 2	1985	L or <	1	07A
1586	DeRt 2	1985	L or <	1	035
1588	DeRt 2	1985	C	1	000
1589	DeRt 2	1985	C	1	000
1590	DeRt 2	1985	L or <	1	
1594	DeRt 2	1985	C	1	000
1596	DeRt 2	1985	C	1	03A
1597	DeRt 2	1985	L or <	1	002
1598	DeRt 2	1985	C	1	005
1603	DeRt 2	1985	L or <	1	07A
1604	DeRt 2	1985	C	1	000
1607	DeRt 2	1985	C	1	014
1610	DeRt 2	1985	C	1	051
1611	DeRt 2	1985	L or <	1	000
1613	DeRt 2	1985	C	1	000
1618	DeRt 2	1985	L or <	1	
2000	DcRu 12	1977	GG or >	2	5059
2001	DcRu 12	1975	GG or >	2	A1648
2002	DcRu 12	1975	GG or >	2	A1465
2003	DcRu 12	1975	GG or >	2	A1628
2004	DcRu 12	1975	GG or >	1	A1620
2007	DcRu 12	1975	GG or >	2	A1565
2008	DcRu 12	1975	GG or >	2	A1588
2009	DcRu 12	1975	GG or >	2	A1498
2010	DcRu 12	1975	GG or >	2	A0850
2011	DcRu 12	1974	GG or >	2	A0142
2012	DcRu 12	1977	GG or >	1	5055
2013	DcRu 12	1974	GG or >	1	A0125
2017	DcRu 12	1976	GG or >	2	1249
2018	DcRu 12	1975	GG or >	1	A1670
2022	DcRu 12	1976	GG or >	2	2175
2024	DcRu 12	1977	GG or >	2	A4088
2025	DcRu 12	1976	GG or >	1	
2026	DcRu 12	1974	GG or >	1	A0020
2028	DcRu 12	1976	GG or >	1	2150
2030	DcRu 12	1976	GG or >	1	2168
2031	DcRu 12	1976	GG or >	1	
2032	DcRu 12	1975	GG or >	1	A1552
2033	DcRu 12	1975	GG or >	1	A1663
2035	DcRu 12	1977	GG or >	1	4089
2036	DcRu 12	1975	GG or >	2	A1679

ID #	SITE #	YEAR	AGE	TYPE	FAUNAL #
2037	DcRu 12	1977	GG or >	1	4081
2038	DcRu 12	1975	GG or >	2	A1546
2039	DcRu 12	1975	GG or >	1	A1154
2040	DcRu 12	1974	GG or >	1	A0056
2042	DcRu 12	1974	GG or >	2	A0070
2043	DcRu 12	1975	GG or >	2	
2045	DcRu 12	1975	GG or >	2	A1442
2046	DcRu 12	1975	GG or >	1	A1657
2047	DcRu 12	1975	GG or >	1	A1365
2048	DcRu 12	1977	GG or >	1	
2050	DcRu 12	1976	GG or >	1	2107
2051	DcRu 12	1975	GG or >	1	A0301
2052	DcRu 12	1975	GG or >	1	
2054	DcRu 12	1975	GG or >	2	A1310
2056	DcRu 12	1975	GG or >	1	A1327
2057	DcRu 12	1975	GG or >	2	A1207
2058	DcRu 12	1975	GG or >	1	A1547
2059	DcRu 12	1976	GG or >	2	1767
2062	DcRu 12	1974	GG or >	1	
2063	DcRu 12	1977	GG or >	2	4092
2064	DcRu 12	1976	GG or >	1	2147
2065	DcRu 12	1974	GG or >	1	
2066	DcRu 12	1977	GG or >	1	
2067	DcRu 12	1975	GG or >	1	
2069	DcRu 12	1975	GG or >	1	
2071	DcRu 12	1975	GG or >	2	
2072	DcRu 12	1975	GG or >	2	
2073	DcRu 12	1975	GG or >	1	
2074	DcRu 12	1975	GG or >	2	
2078	DcRu 12	1975	GG or >	2	A1607
2080	DcRu 12	1975	GG or >	2	A1621
2089	DcRu 12	1975	GG or >	2	A1378
2091	DcRu 12	1975	GG or >	2	A1066
2092	DcRu 12	1975	GG or >	2	A1190
2093	DcRu 12	1975	GG or >	2	F4079
2095	DcRu 12	1975	GG or >	2	A1263
2096	DcRu 12	1975	GG or >	1	A1552
2100	DfSf 13	1974	L	2	
2101	DfSf 13	1974	L	2	
2105	DfSf 13	1974	L	1	
2107	DfSf 13	1974	L	2	
2108	DfSf 13	1974	L	2	
2109	DfSf 13	1974	L	1	
2110	DfSf 13	1974	L	1	
2111	DfSf 13	1974	L	2	
2112	DfSf 13	1974	L	2	
2200	DfSf 14	1973	L or >	1	
2201	DfSf 14	1973	L or >	1	
2203	DfSf 14	1973	L or >	2	
2204	DfSf 14	1973	L or >	1	
2206	DfSf 14	1973	L or >	1	
2207	DfSf 14	1973	L or >	1	
2211	DfSf 14	1973	L or >	1	
2219	DfSf 14	1973	L or >	2	
2221	DfSf 14	1973	L or >	1	
2224	DfSf 14	1973	L or >	1	
2225	DfSf 14	1973	L or >	1	
2226	DfSf 14	1973	L or >	1	
2227	DfSf 14	1973	L or >	2	
2229	DfSf 14	1973	L or >	1	
2234	DfSf 14	1973	L or >	1	
2237	DfSf 14	1973	L or >	2	
2238	DfSf 14	1973	L or >	2?	
2239	DfSf 14	1973	L or >	1	
2240	DfSf 14	1973	L or >	2	
2249	DfSf 14	1973	L or >	2	
2250	DfSf 14	1973	L or >	1	
2256	DfSf 14	1973	L or >	1	
2258	DfSf 14	1973	L or >	1	
2259	DfSf 14	1973	L or >	1	
2260	DfSf 14	1973	L or >	2	
2261	DfSf 14	1973	L or >	1	
2262	DfSf 14	1973	L or >	1	
2400	DiSc 1	1976	GG	1	
2401	DiSc 1	1976	GG	1	
2402	DiSc 1	1976	GG	1	
2403	DiSc 1	1976	GG	1	
2405	DiSc 1	1976	GG	1	
2406	DiSc 1	1976	GG	1	
2407	DiSc 1	1976	GG	1	
2408	DiSc 1	1976	GG	2	
2409	DiSc 1	1976	GG	1	
2410	DiSc 1	1976	GG	1	
2411	DiSc 1	1976	GG	1	
2412	DiSc 1	1976	GG	1	
2413	DiSc 1	1976	GG	1	
2414	DiSc 1	1976	GG	1	
2415	DiSc 1	1976	GG	1	
2418	DiSc 1	1976	GG	pup	
2600	DiSe 7	1975	GG	1	
2601	DiSe 7	1975	GG	2	
2604	DiSe 7	1975	GG	1	
2606	DiSe 7	1975	GG	1	
2608	DiSe 7	1975	GG	1	
2609	DiSe 7	1975	GG	1	
2610	DiSe 7	1975	GG	1	
2612	DiSe 7	1975	GG	1	
2614	DiSe 7	1975	GG	1	
2618	DiSe 7	1975	GG	2	
2619	DiSe 7	1975	GG	1	
2621	DiSe 7	1975	GG	2	
2623	DiSe 7	1975	GG	1	
2624	DiSe 7	1975	GG	2	
2625	DiSe 7	1975	GG	2	
2660	DiSe 7	1975	GG	1	
2661	DiSe 7	1975	GG	1	
2662	DiSe 7	1975	GG	1	
2666	DiSe 7	1975	GG	1	
2667	DiSe 7	1975	GG	2	
3000	45CA24	1976	GG	1	F100
3001	45CA24	1977	GG	1	
3002	45CA24	1971	GG	1	Z
3003	45CA24	1971	GG	1	Y
3004	45CA24	1976	GG	2	F088
3006	45CA24	1981	GG	1	
3007	45CA24	1972	GG	wolf	
3008	45CA24	1971	GG	1	
3009	45CA24	1974	GG	2	

ID #	SITE #	YEAR	AGE	TYPE	FAUNAL #
3011	45CA24	1977	GG	2	
3013	45CA24	1976	GG	1	
3014	45CA24	1976	GG	2	
3015	45CA24	1972	GG	1	
3016	45CA24	1975	GG	1	
3018	45CA24	1971	GG	1/2?	
3019	45CA24	1971	GG	2	
3020	45CA24	1971	GG	pup	
4000	DgRw 204	1989	M or >	2	
4003	DgRw 204	1989	M or >	1	
4010	DgRw 204	1989	M or >	1	
4013	DgRw 204	1989	M or >	2	
4014	DgRw 204	1989	M or >	1	
4015	DgRw 204	1989	M or >	1	
4016	DgRw 204	1989	M or >	2	
4017	DgRw 204	1989	M or >	2	
4020	DgRw 204	1989	M or >	2	
4022	DgRw 204	1989	M or >	2	
4023	DgRw 204	1989	M or >	1	
4024	DgRw 204	1989	M or >	1	
4027	DgRw 204	1989	M or >	2	
4040	DgRw 204	1989	M or >	1	
4041	DgRw 204	1989	M or >	1	
4042	DgRw 204	1989	M or >	2	
4044	DgRw 204	1989	M or >	2	
4048	DgRw 204	1989	M or >	1	
4050	DgRw 204	1989	M or >	2	
4058	DgRw 204	1989	M or >	1	
4061	DgRw 204	1989	M or >	2	
5000	DhRx 16	1992	GG	2	
5001	DhRx 16	1992	GG	2	
5002	DhRx 16	1992	GG	1	
5006	DhRx 16	1992	GG	2	
5007	DhRx 16	1992	GG	1	
5009	DhRx 16	1992	GG	2	
5010	DhRx 16	1992	GG	2	
5012	DhRx 16	1992	GG	1	
5014	DhRx 16	1992	GG	2	
5016	DhRx 16	1992	GG	2	
5017	DhRx 16	1992	GG	2	
5023	DhRx 16	1992	GG	1	
5024	DhRx 16	1992	GG	2	
5026	DhRx 16	1992	GG	2	
5028	DhRx 16	1992	GG	1	
5029	DhRx 16	1992	GG	1	
5038	DhRx 16	1992	GG	1	
5039	DhRx 16	1992	GG	2	
5040	DhRx 16	1992	GG	2	
5042	DhRx 16	1992	GG	1	
5045	DhRx 16	1992	GG	1	
5046	DhRx 16	1992	GG	2	
5055	DhRx 16	1992	GG	1	
5076	DhRx 16	1992	GG	2	

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