

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

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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 epiphysal 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

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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

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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 pelvises 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),

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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 sites 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

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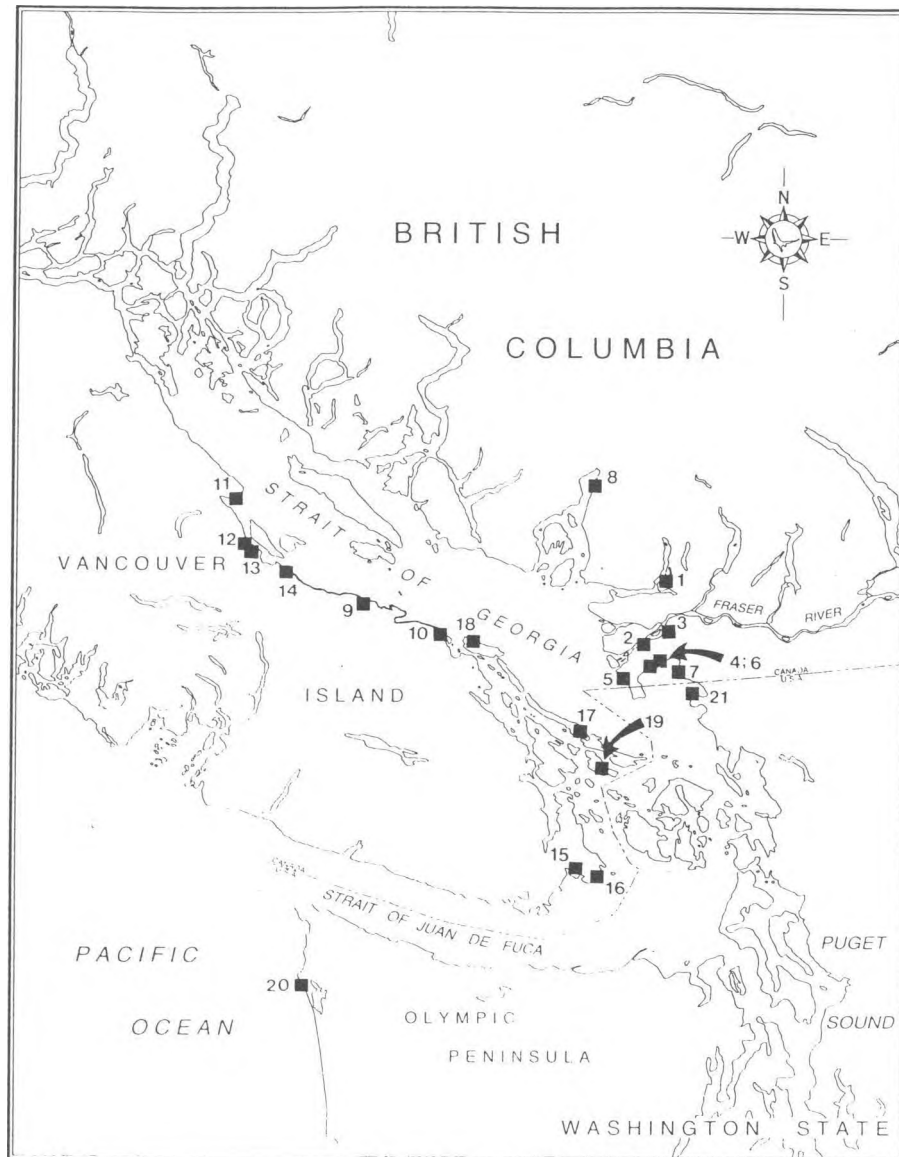
and behaviour (Geist 1971, 1986; Coppinger and Feinstein 1991; Coppinger and Schneider 1995; Gould 1977, 1994; Kurten 1968, 1988; McKinney and McNamara 1991; Parker and McKinney, in press; Price 1984; Voss 1995). Thus the relative

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.



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the grey wolf (*C. lupus*), an animal that is significantly larger than Northwest Coast indigenous dogs in all respects (Friis 1985; Jolicoeur 1959,1975; 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

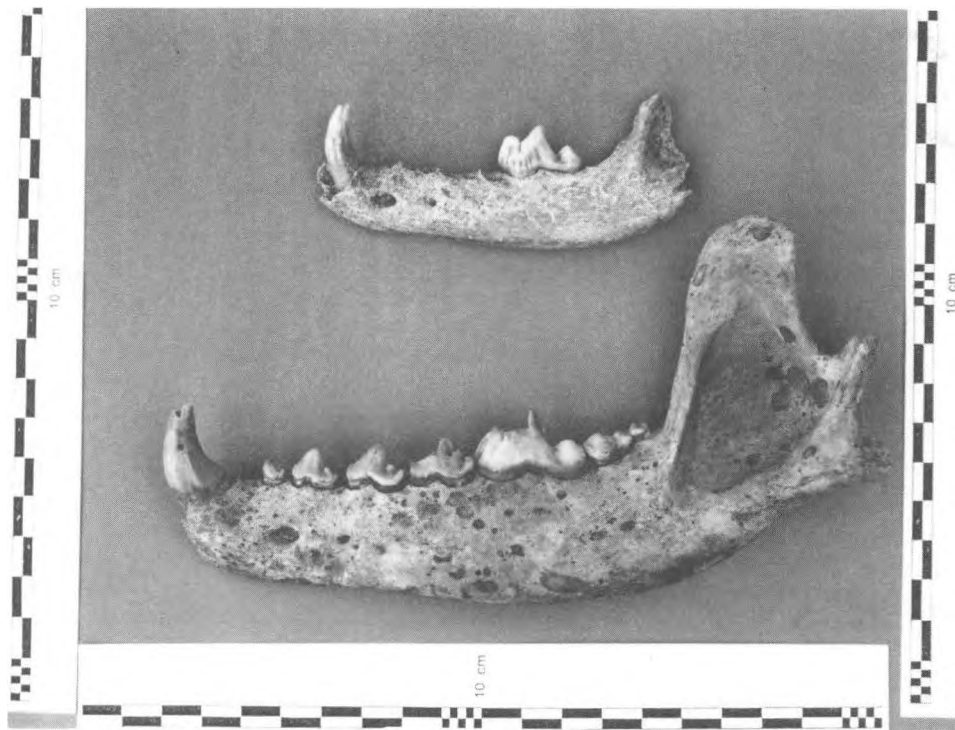


Figure 2-2. Left mandible of prehistoric wolf, *Canis lupus*, (specimen 3007) vs. left mandible of small prehistoric indigenous dog, *Canis familiaris*, (specimen #100A), illustrating the overall size difference between the two species (lateral view).