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
5036	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.