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Research Communication

The Dogs of CA-SRI-2: Zooarchaeology, Diet, and Context of *Canis familiaris* from Santa Rosa Island, California, USA

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Abstract: *Domesticated dogs (*Canis familiaris*) are an important human companion around the world and have long been a focus of archaeological research. Zooarchaeological analysis of six dogs from a Late Holocene Chumash village on Santa Rosa Island, California indicates that adults, juvenile/young adults, and a puppy were present. Similar to dogs on other Channel Islands, these dogs were large to medium in size, standing some 43-55 cm tall, with mesaticephalic or mild brachycephalic facial characteristics. No cutmarks were found on the bones, but one of the mandibles was burned. The CA-SRI-2 dogs appear to have eaten high trophic marine foods similar to what humans consumed, documenting the close bond between dogs and humans on the Channel Islands and broader North American Pacific Coast.*

Key Words: Channel Islands, Domestication, Hunter-Gatherers, Morphometrics, Osteometry

Introduction

Domestic dogs (*Canis familiaris*) accompanied humans on migrations around the world, with current genetic data suggesting an Old World origin sometime between 18,000 and 32,000 years ago (see Morey 2010; Thalmann et al. 2013). In western North America, dogs have been found in a variety of archaeological contexts, from intentional burials to middens (Bartelle et al. 2010; Crockford 2005; Crockford et al. 2012; Hale and Salls 2000; Langenwalter 1986; Langenwalter 2005; Lupo and Janetski 1994; Noah 2005; Rick et al 2008; Vellanoweth 2008; West and Jarvis 2014). Here we present osteological data obtained from the remains of six dogs excavated at a Chumash village (CA-SRI-2) on Santa Rosa Island, California. Although researchers have long been interested in archaeological dog remains from California (e.g., Allen 1920), including recent genetic analysis (Byrd et al. 2013), limited osteometric data are available for California dogs (see Bartelle et al. 2010; Langenwalter 1986, 2005; Vellanoweth et al. 2008). Dogs were clearly important in Native California symbolic and ritual systems (Hale and Salls 2000; Langenwalter 2005; Vellanoweth et al. 2008), but the dearth of dog osteometrics leaves a substantial gap in our understanding of dog morphology and evolution in California and broader western North America.

Background

One of California's eight Channel Islands, Santa Rosa Island is ~44 km from the mainland and ~217 km² in area. The island is home to few terrestrial mammals, the largest of which are the island fox (*Urocyon littoralis*) and island spotted skunk (*Spilogale gracilis amphiala*). Although removed from all but Santa Catalina Island today, during much of the Holocene dogs were the largest terrestrial mammal, other than humans, that inhabited the islands (Rick et al. 2008).

Native Americans colonized the Channel Islands some 13,000 calendar years ago and lived on the islands until ~AD 1822 (Kennett 2005). Island Chumash peoples were maritime foragers, and during the Late Holocene and potentially earlier they lived in large villages and had sophisticated mainland and island exchange networks. Dogs were an important component of Native American life on the Channel Islands, often receiving formal burial (Hale and Salls 2000; Vellanoweth et al. 2008). Dog remains have been found in Channel Island sites as early as ~6000 years ago, but they are most common in sites dated from ~1500 years ago to the Historic Period (Rick et al. 2008). Ethnographic accounts of dogs are limited, suggesting that the mainland Chumash may have occasionally used dogs for food, but it is unclear if they were used in hunting (Harrington 1942:6-7; Kroeber 1941). Archaeological data suggest that dogs may have been used for hunting and as working animals (see Langenwalter 2005; Rick et al. 2008; Vellanoweth et al. 2008). Langenwalter (2005:30), citing Wagner (1929), noted that an account from Vizcaino's 1602 expedition suggested that Santa Catalina Island dogs were of medium size and similar to spotted retrievers found in Europe at the time.

CA-SRI-2, a large late Holocene village and cemetery complex on northwest Santa Rosa Island, has produced a number of dog remains (Orr 1968; Rick et al. 2011). The site was excavated by Phil Orr (1968) in the 1940s-1960s and then revisited by Rick (2011) in 2000-2003. Rick et al. (2011) used $\delta^{13}C$ and $\delta^{15}N$ data from dog, fox, and human bones to reconstruct diet among these three species. We build on this work by presenting the analysis of cranial and post-cranial skeletal material from six archaeological dogs.

Materials and Methods

The remains of five dogs recovered by Orr (1968) and a dog excavated by Rick in 2003 were analyzed. All of the dog skeletons are incomplete, consisting primarily of crania and/or mandibles, but in three cases post-cranial elements were available (Figure 1). Provenience and context for all but one specimen (CF1, see below) are limited, indicating only that the dogs came from three of the four sections of this large village and were fairly widely distributed across the site (Rick et al. 2011). No direct radiocarbon dates for the dog remains have been obtained, but 26 radiocarbon dates from CA-SRI-2 suggest that the site dates primarily between cal AD 130-1820, with an isolated component dated to 2400 cal BC (Rick 2011). The dogs most likely date between cal AD 930-1820. Details on the elements available for each specimen (CF1-CF6) and other characteristics are in Table 1.

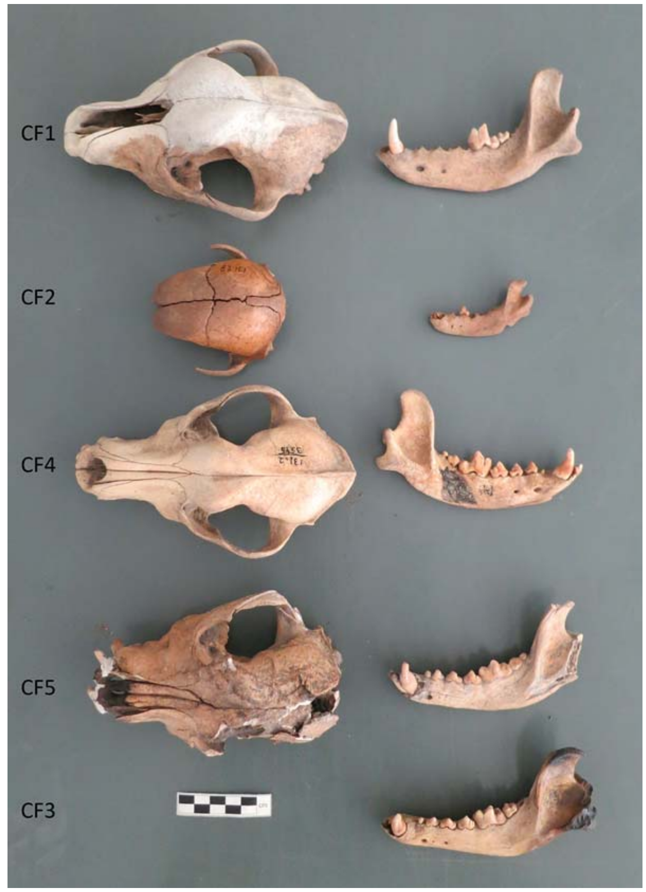

Figure 1. Cranium and mandibles from five of the CA-SRI-2 dogs reported in this study (specimen numbers correspond with Table 1). Note frontal swelling and sagittal crest in CF1 and CF4, burning on CF3 mandible, the remains of the CF2 puppy, and damage and glue on CF5.

The specimen recovered by Rick (CF1) was a dog buried within a shell midden that was eroding out of the sea cliff. Some of the lower limbs had already eroded away, with the dog placed in an east-west orientation on its right side with the rostrum facing north. An olivella wall and lipped bead, triangular prepared microblade, red abalone shell fishhook, California mussel bead in production, and worked red abalone were recovered in the surrounding sediments, but these items are commonly found in late prehistoric middens and it is unclear if they were intentionally placed with the dog.

All of the dog cranial remains contain the dental crowding common in domestic dogs (Morey 2010) and no paleozoological evidence of any canids other than the island fox and dogs have been found on the Channel Islands. Most of the dogs had the typical dental arcade of four premolars and two upper molars and three lower molars (Evans 1993). However, CF1 and CF4 were both missing the right first upper premolar, with CF1 also missing the first lower left premolar, a pattern noted in some other Channel Island dogs (Bartelle et al. 2010; Walker et al. 1978). One note of caution concerns CF6, which contains a relatively large right femur and tibia. These are morphologically similar to dogs but, in the absence of cranial remains, we cannot rule out the possibility that

Table 1. Summary of dog remains from CA-SRI-2, Santa Rosa Island.

Specimen	Site Area	Date (cal AD)	Age/Sex	Shoulder	Cranial Shape	Elements Present
CF1	Section I	1080 – 1820	7 – 8 mos., Male?	46.13 cm, Large	mesaticephalic/ brachycephalic	60: cranium, mandibles, scapulae, ribs, vertebrae, femora, humeri, tibia, ul-nae, and fibula
CF2	Section I	1080 – 1820	< 6 weeks	–	–	5: cranium and mandibles
CF3	Cemetery B	1200 – 1820	Young adult	–	–	1: mandible
CF4	Unknown	Late Holocene	Adult, Male?	–	mesaticephalic/ brachycephalic	2: cranium, right mandible
CF5	Section III	930 – 1220	Older adult	42.52 cm, Large/Medium	Fragmented	71: damaged cranium, man-dibles, and femora, humeri, ulnae, innominate, radii, tibia, vertebrae, and fibula
CF6	Section II	930 – 1820	Adult	55.09 cm, Large	–	2: right femur and tibia

[1]Estimated shoulder height based on mean of Harcourt (1974) and size estimates based on Allen (1920) as described in Langenwalter (1986)

these are from a large coyote or dog-coyote hybrid, though we believe this is unlikely.

Archaeologists have relied on a wide range of metrics and classifications to document dog domestication, evolution, and morphology (see Morey 2010 for a summary). To increase the comparability of our results to other Channel Island studies, we rely on similar methods employed by Bartelle et al. (2010) and Vellanoweth et al. (2008). Measurements were taken using digital calipers following Haag (1948) and von den Driesch (1976). For consistency, all measurements were obtained by Hofman and are presented in Appendix A, B, and C. Although measurements for juvenile dogs can be problematic, we measured the remains of CF1 following Vellanoweth et al. (2008). The remains from the puppy (CF2) were not measured. Bilateral symmetry was assumed and measurements were taken on the left side unless otherwise noted. Due to specimen damage or missing elements, it was not possible to obtain some of the measurements for all specimens.

Results

Age and Sex

The age of CF1 was estimated using epiphyseal fusion of the long bones and dental eruption patterns. The proximal and distal epiphyses of the humerus, femur, and tibia and the distal end of the ulna are not fused. The distal epiphysis of the humerus is fused and the olecranon process of the ulna is partially fused. These data suggest that CF1 is approximately 7-8 months old (Gilbert 1990). CF1 has all permanent teeth with minor wear, which are typically completely erupted by 6-8 months, further supporting the 7-8 month age estimate (Evans 1993:394; Vellanoweth et al. 2008:3114). CF2 is a puppy likely less than 4-6 weeks of age because its permanent teeth do not appear to have erupted (Evans 1993:394; Langenwalter 1986:84). The mandible for CF3 has all of its lower permanent teeth and wear on the occlusal surface, suggesting this dog is at least a young adult. For CF4, all of the teeth have erupted and there is significant wear, indicating this dog is an adult considerably older than 8 months, when all teeth have erupted. CF5 has significant wear on the labial surface of the left mandibular canine indicating a malocclusion and wear to the dentin on its mandibular molars, suggesting that CF5 is likely an older adult. The long bones from CF6 are completely fused indicating that this dog is also an adult.

Size, the presence or absence of a baculum, and the presence of a thicker sagittal crest in males are typical indicators of sex (Shigehara et al. 1997; Vellanoweth et al. 2008; West and Jarvis 2014). Because no bacula were recovered, we rely on size and morphology for sexing the three cranial specimens based on non-metric traits (i.e., presence of a pronounced sagittal crest in males and lack of a pronounced sagittal crest and a constriction of the frontal region in females) described by Shigehara et al. (1997) and West and Jarvis (2014). These sex categories should be treated as provisional and need to be confirmed by additional analyses (e.g., aDNA). The crania of CF1 and CF4 have fairly large sagittal crests and frontal/zygomatic swelling consistent with male specimens (see Figure 1). CF5 and the others were either too fragmented or no elements were present to infer sex.

Size and Morphology

We categorized dog skull shapes as dolichocephalic (long, narrow headed), mesaticephalic (medium proportions), or brachycephalic (short, wide-headed) based on skull, facial, and cranial indices devised for modern dog crania and calculated following Evans (1993:132). For CF1, a skull index of 55 and facial index of 110 suggest medium head proportions of mesaticephalic dogs (average skull index=56 and facial index=111), but the cranial index of 59 is similar to brachycephalic dogs (average cranial index=57) (Figure 2). CF4 was similarly proportioned with a skull index of 54, a facial index of 112, and a cranial index of 60, again suggesting a mix of mesaticephalic and brachycephalic traits. The foramen magnum of CF4 is more circular than oval and contains a notch which is a characteristic of brachycephalic dogs, but CF1 is ovoid with no notch. Unfortunately, CF5 was too fragmented to obtain these measurements.

Colton (1970), Lupo and Janetski (1994), and Bartelle et al. (2010) estimated dog size based on humerus and femur lengths, with large dogs having humerus lengths of >140 mm and femur lengths >160 mm and small sized dogs <140 and <160. Langenwalter (2005) raised questions about the reliability of size estimates based on these criteria, but we present these data as rough approximations that can be complemented or refuted by other estimates of size. Although still young, CF1 is a large dog with a humerus length of 142.78 mm. CF6 has a large femur length of 179.57 mm. The humerus for CF5 (130.56 mm) is below the large dog size of >140.

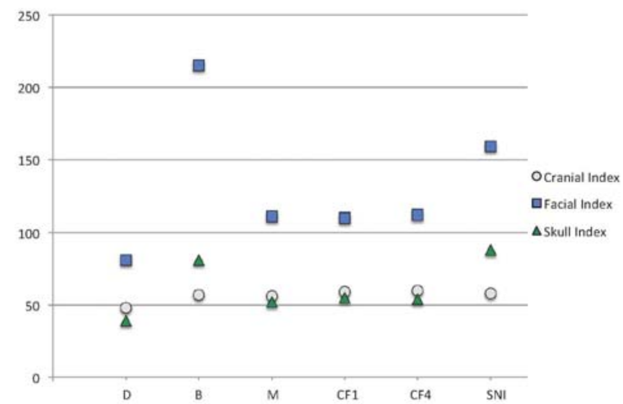

Figure 2. Cranial, skull, and facial indexes following Evans (1993). D=dolichocehphalic (long, narrow headed), B=brachycephalic (short, wide headed), and M=mesaticephalic (medium proportions). D, B, and M are average cranial indexes reported for modern dogs in Evans (1993). CF1 and CF4 are from CA-SRI-2 and SNI is a dog reported by Bartelle et al. (2010) from San Nicolas Island.

Langenwalter (1986) also presented a series of femur, tibia, and humerus lengths based on Allen's (1920) large and small Indian Dogs, with CF1, CF5, and CF6 all falling into the large Indian Dog category. Only CF5's femoral measurement is just below the large Indian Dog category, but well above the measurements for small Indian Dogs.

Harcourt's (1974:154) regression formulae for estimating dog size based on measurements of long bones from dogs with known shoulder heights were used to calculate shoulder heights for the three CA-SRI-2 dogs with post-cranial remains. These produced shoulder height estimates of 46.13 cm for CF1 (average of humerus [46.32 cm], tibia [46.84 cm], and ulna [45.23 cm]), 42.52 cm for CF5 (average of humerus [42.13 cm] and tibia [42.90 cm]), and 55.09 cm for CF6 (femur).

Pathology, Trauma, and Taphonomy

There is limited definitive evidence for pathology or trauma and no cutmarks were found on the CA-SRI-2 dogs. The only sign of processing is burning on the mandible from CF3 (see Figure 1). There is a small, unhealed fracture on the right scapula of CF1 (Figure 3). CF5 contains many bone fragments and broken teeth, but unfortunately these have been glued together making it difficult to tell if this is from poor

Figure 3. Pathology in SRI-2 Dogs. CF1 shows a possible unhealed fracture (indicated by the arrow) on the right scapula. CF5 shows lipping (indicated by the arrow) which may be a sign of osteoarthritis on two vertebrae (only one shown).

preservation, damage during excavation or transport, or may represent trauma or pathology. Many of the long bones and vertebrae are also damaged, especially at the proximal and distal ends. Some of the long bones from CF1, CF3, and CF6 contain well-defined muscle attachment areas, suggesting they may have been involved in heavy labor or traveling long distances. Finally, two vertebrae from CF5 show signs of lipping consistent with osteoarthritis (Figure 3). Root etching, caliche/sediment adhering to a few bones (CF5), deterioration from exposure (CF1), and some post-depositional breakage of teeth and bones are the only obvious taphonomic disturbances.

Diet

There were no clearly identifiable stomach contents from any of the dogs, but $\delta^{13}C$ and $\delta^{15}N$ isotope analysis of dog (n=5), island fox (n=3), and human (n=15) bone collagen from CA-SRI-2 provide proxies for the diet of these species (Rick et al. 2011). The stable isotope values for each species are: 1) $\delta^{13}C$ = -12.40 to -14.65‰, $\delta^{15}N$ = 15.14 to 21.16‰ for humans; 2) $\delta^{13}C$ = -10.71 to -12.89‰, $\delta^{15}N$ = 17.12 to 18.59‰ for dogs; and 3) $\delta^{13}C$ = -17.80 to -18.94‰, $\delta^{15}N$ = 7.68 to 11.36‰ for foxes (Rick et al. 2011). These data demonstrate that Native Americans and their dogs at CA-SRI-2 had similar diets, suggesting that both species focused primarily on high trophic marine organisms like finfishes, marine mammals, and seabirds, complemented by seeds, corms, and other carbohydrates. In contrast, the CA-SRI-2 island foxes appear to have eaten lower trophic level terrestrial foods. These data confirm the commensal relationship between dogs and people, with some modest carbon enrichment in dogs perhaps from higher consumption of C3 plants and/or bone collagen (Rick et al. 2011).

Discussion and Conclusions

The six dogs from CA-SRI-2 demonstrate some similarities with other dogs reported from the Channel Islands and southern California and begin to identify possible regional trends and anomalies in size and morphology, butchering and processing, and diet. Although cutmarks have been identified on dog bones in North American archaeological sites, sometimes in abundance (West and Jarvis 2012), none of the dogs from CA-SRI-2 contain cutmarks. None of the dog remains reported from San Nicolas, San Miguel, or Santa Cruz islands have produced any cutmarks (Bartelle et al. 2010; Noah 2005:240; Vellanoweth et al. 2008; Walker et al. 1978). The only evidence for any potential processing is burning on the mandible of CF3, which could be either intentional or from incidental contact. Walker et al. (1978) also identified burning on a dog mandible from CA-SCRI-240 and Noah (2005:240) identified burning on eight dog bones from CA-SCRI-192, both on Santa Cruz Island. It remains possible that people occasionally consumed dogs on the Channel Islands, but evidence of clear butchering or processing is largely absent.

At CA-SRI-2 and on San Nicolas Island dogs appear to have been consuming marine resources and eating similar foods as people (Bartelle et al. 2010; Rick et al. 2011; Vellanoweth et al. 2008). However, stomach contents from three mainland southern California dogs suggest consumption of gophers (*Thomomys bottae*), rabbits (*Sylvilagus bachmani*), and deer (*Odocoileus sp.*) (Langenwalter 2005). These data suggest variability in dog diet in the region, probably reflecting what was locally available, what dogs were being given access to by humans, and what dogs may have been scavenging or hunting.

Limited dog osteometric data from other Channel Islands or adjacent coastal mainland are available for comparison. However, the CA-SRI-2 dogs are similar in size and share some aspects of morphology to three dogs from San Nicolas Island. Two of the CA-SRI-2 dogs are consistent with medium facial size or mesaticephalic dogs (Evans 1993) and have similar characteristics to a dog from San Nicolas Island reported by Bartelle et al. (2010), though that dog was more strongly brachycephalic than the CA-SRI-2 dogs (Figure 2). Shoulder height estimates (Harcourt 1974) suggest that the CA-SRI-2 dogs were large to medium in size (46.12 cm, 42.52 cm, and 55.09 cm), falling within or above the estimates for three CA-LAN-43 dogs (averages of 46.25 cm, 44.65 cm, and 39.88 cm; Langenwalter 1986:82-83) and a dog from CA-SNI-25 on San Nicolas Island (49 cm; Bartelle et al. 2010:2726).

Researchers have long sought to determine different breed types for prehistoric dogs, including some 17 different types reported by Allen (1920) and three more general categories: large Eskimo and large and small Indian Dog (Haag 1948). Vellanoweth et al. (2008) reviewed these criteria, as well as strengths and weaknesses of these determinations, and concluded that two immature female dogs from San Nicolas Island shared characteristics with both Allen's (1920) Short-nosed and Plains-Indian Dog breeds and Bartelle et al. (2010) reached a similar conclusion for an adult from San Nicolas Island. The CA-SRI-2 dogs share many characteristics with Plains-Indian Dog breed measurements reported by Allen (1920:451-453) for San Nicolas Island but, like some of those dogs, they also have some overlap with the Short-nosed Indian Dog. The mix of Allen's (1920) Short-nosed and Plains-Indian Dog characteristics is further supported by dog mandible and teeth measurements reported by Walker et al. (1978) for three dogs from CA-SCRI-240 on Santa Cruz Island and a dog from CA-SMI-525 on San Miguel Island. For CA-LAN-43 located on the adjacent mainland, Langenwalter (1986) suggested that the remains of several dogs from distinct dog burials likely represented a regional population of large Indian Dogs, noting that these dogs had fairly large heads but somewhat reduced limbs. These data suggest that prehistoric southern California dogs had a mix of traits with many falling into the large Indian Dog category and still others falling into the small Indian Dog category (see Allen 1920; Haag 1948; Vellanoweth et al. 2008). Beyond California, Crockford (2005) documented the presence of two distinct dog types in the central and southern Northwest Coast, including a medium sized "Village dog" and a smaller, long-haired dog ("Wool dog"). These data suggest that, like the Channel Islands, there was some variability in dog types in parts of the Pacific Northwest, including probable hybridization.

Domestic dogs were important companions for humans on the northern and southern Channel Islands, were scavenging and/or being fed the same types of foods that people were eating, and were often given special burial treatment. Continued osteometric analyses are needed for the Channel Islands and broader California Coast to help better understand the morphology and evolution of Channel Island dogs. Ultimately, these studies lay the foundation for genetic research of the same specimens that can further enhance and clarify these morphological studies.

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Declarations
Permissions: Permision for analysis was given by the Santa Barbara Museum of Natural History, which curates the dog specimens.

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Biosketch

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Appendix A. Cranial measurements (mm) obtained from CA-SRI-2 dogs following von den Driesch (1976)

	CF1	CF5	CF4
(1) Total length	178.31	--	170.98
(2) Condylobasal length	163.37	--	162.93
(4) Basicranial axis	44.1	39.41	41.76
(7) Upper neurocranium length	89.69	--	82.93
(10) Greatest length of the nasals	67.89	63.69	68.66
(11) Length of braincase	80.52	70.21	78.60
(13) Median palate length	85.72	77.97	87.28
(13a) Palatal length	84.22	75.78	85.58
(14) Length of the horizontal part of the palatine	32.97	27.94	28.37
(14a) Length of the horizontal part of the palatine corresponding to M 13a	29.6	26.49	26.81
(17) Length of premolar row	48.63	54.8	44.77
(18) Length of the carnassial	17.96	18.53	17.04
(18a) Greatest breadth of the carnassial	8.81	9.73	10.48
(19) Length of the carnassial alveolus	18.46	17.99	16.89
(20) Length of M^1	11.76	11.26	11.75
(20a) Breadth of M^1	14.95	16.56	14.67
(22) Greatest diameter of the auditory bulla	24.84	--	24.27
(23) Greatest mastoid breadth	61.33	--	59.48
(24) Breadth dorsal to the external auditory meatus	62.02	--	59.11
(25) Greatest breadth of the occipital condyles	34.7	34.26	33.18
(26) Greatest breadth of the bases of the paraoccipital processes	48.41	--	--
(27) Greatest breadth of foramen magnum	18.15	16.42	17.44
(28) Height of the foramen magnum	12.73	--	15.05
(29) Greatest breadth of the braincase	60.15	55.65	57.92
(30) Zygomatic breadth	98.2	--	93.09
(31) Least breadth of skull	37.09	36.79	29.57
(32) Frontal breadth	50.07	--	38.79
(33) Least breadth between orbits	37.37	35.39	27.48
(34) Greatest palatal breadth	60.84	64.96	59.04
(35) Least palatal breadth	32.39	37.98	31.96
(36) Breadth at the canine alveoli	32.97	--	32.76
(37) Greatest inner height of the orbit	29.67	--	27.61
(38) Skull height	54.71	--	53.28
(39) Skull height without the sagittal crest	49.75	--	50.65
(40) Height at the occipital triangle	39.53	--	39.39
(41) Height of the canine	39.55	–	–

Appendix B. Mandibular measurements (mm) for CA-SRI-2 dog specimens following von den Driesch (1976)

	CF1	CF3	CF5	CF4
(1) Total Length	129.67	131.00	118.9	125.74
(2) Length: the angular process	131.79	135.61	112.94	127.54
(3) Length from the indentation between the condyle process and the angular process	127.93	129.84	113.62	122.13
(4) Length: the condyle process-aboral border of the canine alveolus	111.59	115.91	105.65	108.92
(5) Length from the indentation between the condyle process angular process – aboral border of the canine alveolus	110.23	112.33	102.28	106.01
(6) Length: the angular process-aboral border of the canine alveolus.	114.2	120.00	100.76	110.73
(11) Length of the premolar row, P_1–P_4	--	34.73	35.04	35.16
(12) Length of the premolar row, P_2–P_4	32.7	30.25	31.4	30.4
(13) Length of carnassial	20.08	20.01	21.17	19.79
Breadth of carnassial	8.15	8.13	7.9	7.89
(14) Length of carnassial alveolus	19.34	19.11	19.51	19.02
(17) Greatest thickness of the body of the jaw	12.18	12.44	12.94	10.09
(18) Height of the vertical ramus: basal point of the angular process	51.67	54.88	47.96	49.7
(19) Height of the mandible behind M_1	25.54	24.00	22.08	22.14
(20) Height of the mandible behind P_2 and P_3	21.53	21.55	19.79	19.36
(22) Calculation of the basal length: measurement number two multiplied by 1.21	159.4659	164.09	136.66	154.32
(23) Calculation of the basal length: measurement number four multiplied by 1.37	180.5523	158.80	144.74	149.22
(24) Calculation of the basal length: measurement number five multiplied by 1.46	192.4134	164.00	149.33	154.77
(25) The mean of M 22, 23, and 24	177.5	162.3	143.6	152.8

Appendix C. Post cranial measurements (mm) from CA-SRI-2 dogs following von den Driesch (1976)

	CF1	CF5	CF6
Atlas			
Greatest breadth over the wings	76.72	--	--
Greatest length	32.94	--	--
Greatest breadth of the cranial articular surface	38.75	--	--
Greatest breadth of the caudal articular surface	32.08	--	--
Greatest length from the Facies articularis cranialus to the facies articularis caudalis	27.98	--	--
Length to the Arcus dorsalis, median	14.82	--	--
Axis			
Greatest length in the region of the corpus including the dens	43.13	42.36	--
Greatest length of the arch including the caudal articular process	45.74	--	--
Greatest breadth across the cranial articular surface	28.81	26.91	--
Greatest breadth across the caudal articular process	27.34	--	--
Greatest depth across the transverse process	32.67	--	--
Smallest breadth of the vertabrae	19.83	19.51	--
Greatest breadth of caudal articular surface	17.14	16.6	--
First thoracic vertebrae			
Physiological length of the body	16.76	--	--
Greatest length from the cranial articular process to the caudal articular process	26.6	--	--
Greatest breadth across the cranial articular process	30.95	--	--
Greatest breadth across the caudal articular process	27.74	--	--
Greatest breadth across the transverse process	39.59	--	--
Greatest breadth of the cranial articular surface	12.64	--	--
Greatest breadth of the caudal articular surface	14.56	--	--
Greatest height of the cranial articular surface	12.26	--	--
Greatest height of the caudal articular surface	10.8	--	--
Height	39.1	--	--
Scapula			
Height	115.55	--	--
Diagonal height	104.82	--	--
Greatest dorsal length	56.83	--	--
Smallest length of the neck of the scapula	20.96	--	--
Greatest length of the glenoid process	25.92	--	--
Length of the glenoid cavity	22.23	--	--
Breadth of the glenoid cavity	17.24	--	--
Humerus			
Greatest length	142.78	130.56	--
Greatest length from the head (caput)	137.09	--	--
Depth of the proximal end	32.1	--	--
Smallest breadth of the diaphysis	13.15	10.39	--
Greatest breadth of the distal end	29.89	25.33	--
Greatest breadth of the trochlea	20.63	20.9	--
Radius			
Greatest breadth of the proximal end	--	15.61	--

Appendix C continued. Post cranial measurements (mm) from CA-SRI-2 dogs following von den Driesch (1976)

	CF1	CF5	CF6
Smallest breadth of diaphysis	--	10.3	--
Ulna			
Greatest length	160.46	--	--
Depth across the processus anconaeus	21.95	21.42	--
Smallest depth of the olecranon	18.91	18.86	--
Greatest breadth across the coronoid process	12.45	--	--
Femur			
Greatest length	--	--	179.57 (R)
Greatest length from caput femoris	--	140.27	177.67(R)
Greatest breadth of the proximal end	--	--	40.36(R)
Greatest depth for the caput femoris	--	16.27	19.26(R)
Smallest breadth of the diaphysis	12.44	11.08	14.15(R)
Greatest breadth of the distal end	26.26	--	32.5(R)
Tibia			
Greatest length (149.61=without epiphyses)	157.18 (149.61)	143.71	--
Greatest breadth of the proximal end	30.19	29.97	--
Smallest breadth of the diaphysis	12.77	10.6	--
Fibula			
Greatest length	138.58	–	--