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Evidence of morphometric variation in an Iron Age dog cranium from Trumpington, Cambridgeshire, U.K.

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ABSTRACT: An analysis of a medium-sized Iron Age dog cranium from Trumpington, Cambridgeshire indicates shortening of the muzzle and a tendency towards elevation of the muzzle compared to earlier domestic dogs. This specimen is an example of early variation in the British pre-Roman Iron Age dog population. It is compared with earlier more generalized dog crania, Roman examples and modern breed reference material. The methodology used in this analysis, which differs slightly from those in common usage, is explained in the text.

KEYWORDS: DOG SKULLS, IRON AGE VARIATION, AIRORHYNCHY, KLINORHYNCHY, MORPHOLOGICAL ANALYSIS, PRE-ROMAN IRON AGE

RESUMEN: El análisis de un perro mesomorfo de la Edad del Hierro encontrado en Trumpington (Cambridgeshire, Reino Unido) evidencia un acortamiento del morro y una tendencia a la elevación del mismo una vez se compara con otros cráneos de perros domésticos. El especimen ejemplifica la variabilidad existente en Gran Bretaña entre las poblaciones de perros prerromanos. El cráneo se compara también con otros anteriores y más generalizados, así como con animales de época romana y razas modernas. La metodología empleada, distinta a la usada normalmente, se explica en el texto.

PALABRAS CLAVE: CRÁNEO, PERRO, VARIABILIDAD, PRERROMANO, AIRORRINQUIA, KLINORRINQUIA, ANÁLISIS MORFOLÓGICO, PRERROMANO, EDAD DEL HIERRO

INTRODUCTION

The dog cranium (Figure 1) was recovered from one of the earliest fills of a re-cut of the main enclosure ditch of an Iron Age ritual site at Trumpington, Cambridgeshire. It was located in the NW corner of the enclosure ditch and accompanied by six cattle bones, three pot boilers and a single shard of pottery (Hinman, 2002). A calibrated C14 date obtained from a tooth is σ 2125 ± 80 BP, δC13 -13.9 ± 1.2 (ETH-32189). A second date obtained on bone is σ 2005 ± 45 BP, δC13 -20.0 ± 1.2 (ETH-32589).

FIGURE 1
The Trumpington cranium from the left lateral side. Scale in cm.

Therefore it dates from the late pre-Roman Iron Age. The Trumpington cranium has a severe depressed fracture to the upper frontal anterior to the parietal suture. This has been examined by Professor Johann Lang of the Vetsuisse Faculty, University of Bern who has concluded that the injury is perimortal and had no influence on the growth pattern of the skull. Lang estimates the age at death of the Trumpington dog to have been around one to one and a half years (personal communication, April 12, 2007).

Harcourt (1974: 160) considered that the dogs of the British Iron Age 'were in terms of head shape, what can be best described as plain «dog», that is entirely unmodified'. While the shoulder height of the Trumpington dog cannot be established for certain as it consists of an isolated cranium, more complete specimens from the same site with less well preserved but similarly sized skulls are around 42 cm high at the shoulder and therefore within Harcourt's «normal» range for the period (Harcourt, 1974, table 9).

A first, casual visual inspection of the cranium shows that it does by no means fit into this category of «plain and unmodified dogs», not only because of its zygomatic width and short muzzle, but also because of an obvious flexure of the muzzle. Clark (1995: 13) has suggested that the occurrence of specialisation in the British dog population should be sought within the Iron Age. Also, more recently Clark (2000) has argued that valuable information on prehistoric dogs may be lost due to the prevalent usage of only a few standard measurement strategies by zooarchaeologists. An extended analysis of this cranium using additional measurements therefore seemed necessary.

METHODS

In addition to the standard Harcourt (1974) measurements (Table 1), the following measurements were taken based on Lüps (1974) (Figure 2, Table 2):

B: (Basilarlänge): Length of skull base, from the back of I1 to the front of the foramen magnum = basal length.

C: (Hirnstammbasis-Palatinumlänge): From the front of the foramen magnum to the suture palatine/maxilla.

D: (Hirnstammbasis): Length from the front of the foramen magnum to the suture pterygoid/palatine where the palatine meets the presphenoid.

E1: (Länge des oberen Reisszahnes): Length of upper carnassial (P4).

F: (Breite über den Eckzähnen): Width over the canines.

G: (Grösste Breite): Largest width over zygomatic arches (cranial width).

H: (Breite über den Condylii): Width over retroarticular processes.

M: (Caudale Palatinumlänge): Caudal zone of palatine.

The Lüps (1974) measurement system –although not widely used by zooarchaeologists– is given above because it is the system by which the comparative Neolithic and modern material at the *Naturhistorisches Museum Bern* is recorded and has been previously used to help pinpoint significant morphological differences in canid cranial form invisible to other methodologies (Nussbaumer 1976, 1978, 1982; Fondon & Garner 2004;

Measurement in mm		Trumpington	Great Holme Street	Causeway Lane
I	The most posterior aspect of the occipital protuberance to the anterior margin of the medial incisor alveoli between the central incisors (alveolare)	161.7	157.6	not measurable
II	Occipital protuberance to junction of nasal and frontal bones (nasion)	89.9		
III	Nasion to alveolare	77.3		84.7
IV	Zygomatic width (maximum)	95.9	94.4	e88.0
IX	Palatal length	81.9	80.5	79.5
X	Palatal width between PM^4 and M^1	62.3	58.2	64.7
XI	Maxillary cheek tooth row length	60.2	54.3	e58.3
XII	Snout width across outer margins of the alveoli of the canines	36.8	34.6	e37.4

«e» estimated to within 0’5 mm

TABLE 1

Cranial measurements (based on Harcourt, 1974).

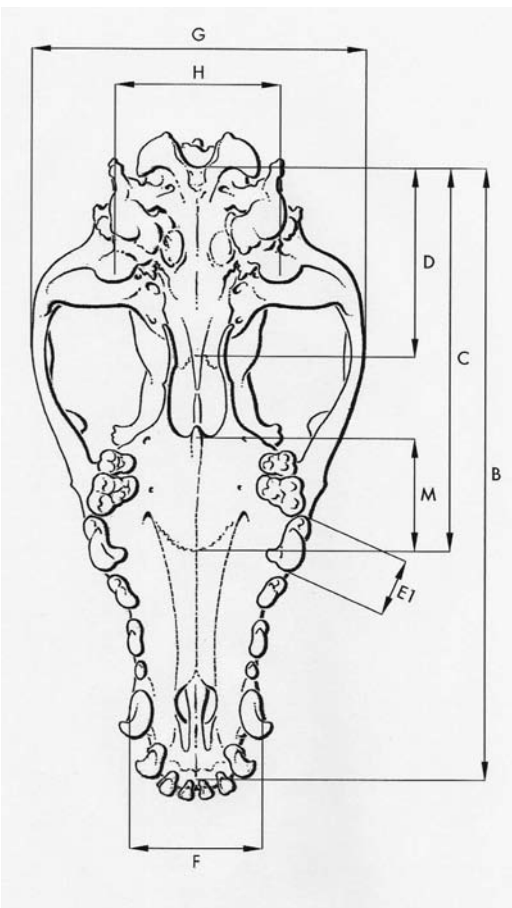

FIGURE 2

Cranial measurements taken (based on Lüps, 1974).

Baxter 2006; Phillips *et al.*, 2009). Several of these measurements are similar to, or the same as, the widely used system of von den Driesch (1976) published subsequently to that of Harcourt; for example B = 3, C = 14+ (3 – 13), E1 = 18, F = 36 (= Harcourt XII), G = 30 (= Harcourt IV), M = 14a. Measurement D (Hirnstammbasis: Length from the front of the foramen magnum to the suture pterygoid/palatine where the palatine meets the presphenoid) has a proven record as a reference for size that enables a sophisticated analysis of the dog skull base beyond pure total length and width. Mere reliance on total length and width measurements can lead to misleading results and interpretations. Whether the von den Driesch measurement 4 (Basion-Synsphenion) is an equally reliable measurement for this purpose remains to be shown. Also, measurement C (Hirnstammbasis-Palatinumlänge: From the front of the foramen magnum to the suture palatine/maxilla) is different –but more or less reproducible– from Driesch’s system (that was not yet established at the time Bern started to measure dog skulls). This measurement is used in Lüps’ system as it helps to show more easily the flexibility in the region of the Choanae, an essential fact in small and medium-sized dogs (Nussbaumer, 1978).

The dorso-basal curvature or prebasial angle (ß) between the base of the brain and the muzzle (external maxillopalatine to basisphenoid-basioccipital planes) was measured (Figure 3) as follows: Basisphenoid-Basioccipitale (or Hirnstammbasis) Plane –from the median outer (ventral) inflection point of the foramen magnum rim (usually the

Measurement in mm		Trumpington	Great Holme Street
B	Condylobasal length	148.1	134.8
C	From the front of the Foramen Magnum to the suture Palatine/Maxilla	94.8	87.5
D	Length of brain stem, from the front of the Foramen Magnum to the suture Pterygoid/Palatinum where the Palatinum meets the Praesphenoid	51.3	45.5
E1	Length of the upper Carnassial (P^4)	18.0	19.5
F	Width over Canines	36.8	34.6
G	Largest width over Zygomatic (cranial width)	95.9	94.4
H	Width over Retroarticular processes	53.0	59.3
M	Caudal zone of Palatine	28.3	27.6

TABLE 2

Cranial measurements (based on Lüps, 1974).

most ventral point of the foramen magnum's rim) to the suture pterygoid/palatine where the palatine meets the presphenoid (a median point has to be constructed, as this suture only touches the presphenoid from both sides and may be slightly different left and right); Hard Palate Plane –from the median point of a (virtual) line connecting the most aboral points of the two palatine fissures to the median point of a (virtual) line connecting the most oral points of the two recesses left and right from the caudal nasal spine of palatine (Nussbaumer, 1982). The method used involves a contour gauge to take the profile (a technique suggested by the late Elisabeth Schmid). This is copied to paper and the points transferred with callipers or a compass (Figure 4). In dog skulls, declination of the upper jaw is known as 'klinorhynchy'; and elevation of the upper jaw as

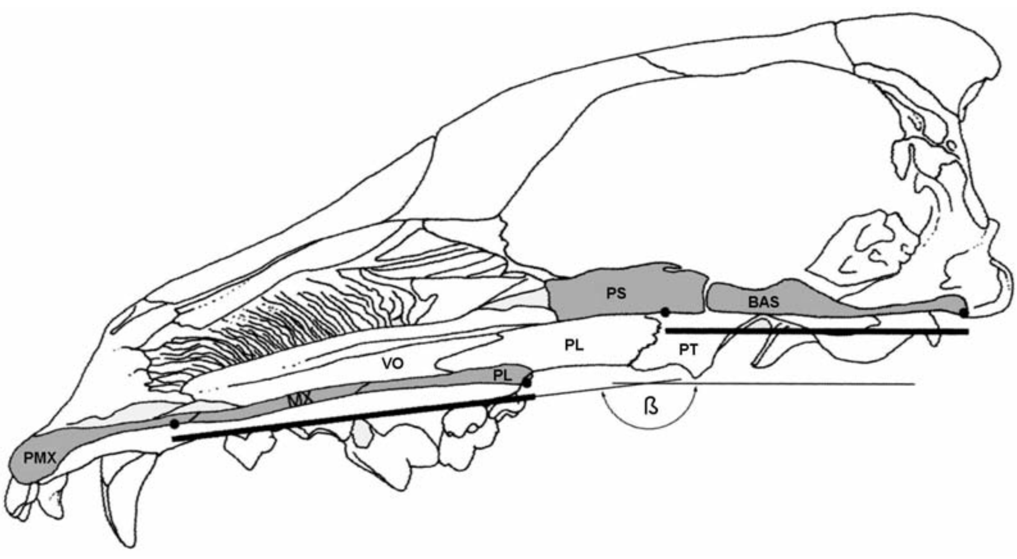

FIGURE 3

Dog Skull, median aspect of sagittal section. For the definition of the measuring points, planes and the angle β see «Methods» and Nussbaumer (1982). PMX: Premaxilla, MX: Maxilla, VO: Vomer, PL: Palatine, PS: Presphenoid, PT: Pterygoid, BAS: Basisphenoid, β: Prebasial angle Beta.

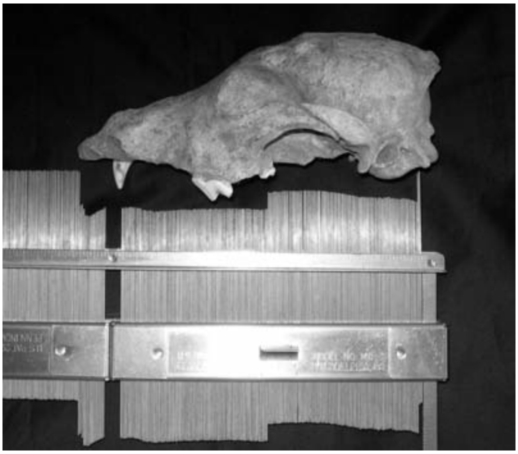

FIGURE 4

Measuring the prebasial angle with a contour gauge to take the profile. This is copied to paper and the points transferred with callipers or a compass.

'airorhynchy'. Moderate klinorhynchy (approximately 170° or 10° towards ventral) is the 'normal' pattern in the wild canids and primitive dogs studied (*Canis lupus*, *C. aureus*, Swiss Neolithic dogs, the Batak dog of Sumatra and the Dingo; Nussbaumer, 1982). The methodology mainly implies that focus on one additional measurement be made, namely the prebasial angle. The elevation (lordosis) or declination (kyphosis) of the cranium, which lead to airorhynchy or klinorhynchy, is an important attribute to characterise a skull as to its main type of breed: Molossoïd-like as e.g. Saint Bernard, Boxer, Bulldog, Pug etc. or Sighthound- and Terrier-like as e.g. Deerhound, Greyhound, Whippet, Bullterrier, Foxterrier, or, obviously, normal, in that respect unchanged skulls. We argue that this measurement which has been shown to be useful not only in distinguishing breed groups, but also in showing how modern breeds evolved in the last 100 years (not specifically of interest in this context) should be used by scientists interested in ancient and modern dogs. The fact that this measurement is only available for comparison in Bern has been an additional reason for using all of Bern's measurements (Lüps system). Describing cranial flexion can in addition to standard measurements (large-small, broad-narrow), help to classify a cranium into a type-group (Normal, Molossoïd-like, Sight hound/Terrier-like etc.). Also, elevation of the upper jaw is often correlated with reduction of the muzzle and broadening of the skull (Fondon & Garner, 2007).

RESULTS

In a scatter plot of logarithms (base 10) of dog cranial measurements (total skull length/zygomatic width) the Trumpington cranium falls near the centre of a sample of Iron Age and Romano-British specimens (based on material published in Harcourt 1974, 1975, 1979 and unpublished material from Cambridgeshire, Leicester and Rutland measured by ILB) (Figure 5). In plots of the palate length/snout width (Figure 6) and total cranial length/snout width (Figure 7) the Trumpington cranium lies close to a Romano-British cranium from Great Holme Street, Leicester (GHS 1) in the collection of the University of Leicester (Figure 8). This cranium is similar in size and superficial appearance to the Trumpington cranium and belongs to a skeleton with a withers height of 42 cm. The Trumpington cranium is also similar in size to a sample of Neolithic dog crania from Swiss lake sites at the *Naturhistorisches Museum Bern* (Figure 9). These typify Harcourt's 'plain «dog»', i.e. 'entirely unmodified' (Harcourt, 1974). However, the Trumpington cranium has a reduced muzzle and relatively broader zygomatic breadth than the Swiss Neolithic and Great Holme street dogs and in these respects more closely resembles the modern Chow Chow and Shar Pei breeds (Figures 10 and 11). The prebasial angle of the Trumpington cranium is 177°: its muzzle is only very slightly (3°) bent downwards and thus fairly near to parallel, which would be 180°. A survey of twenty-one Neolithic skulls in the *Naturhistorisches Museum Bern* shows an average of 170.45° (minimum = 165.5°, maximum = 175°, s = 2.34) with no overlap with Trumpington. It would be necessary to change the angle ß to roughly 170º (original 177º), resize the upper carnassial to 16 mm (original 18.5 mm) and the zygomatic width to 90 mm (96.5 mm original) in order to align Trumpington with the Neolithic dogs. The prebasial angle of the Great Holme Street Roman dog is 171.5° and well within the range of the Swiss Neolithic dogs. This trait puts Trumpington definitely away from a «fairly generalized» shape and more in the direction of modern breeds with near parallel skull bases such as Saint Bernard 177.75° (n = 20), Boxer 180.9° (n = 20) and Chow Chow 175.8° (n = 15) (data from Nussbaumer, 1982). A Romano-British partial cranium from Causeway Lane, Leicester also has a shortened and broadened muzzle. Unfortunately it is incomplete and the prebasial angle cannot be measured.

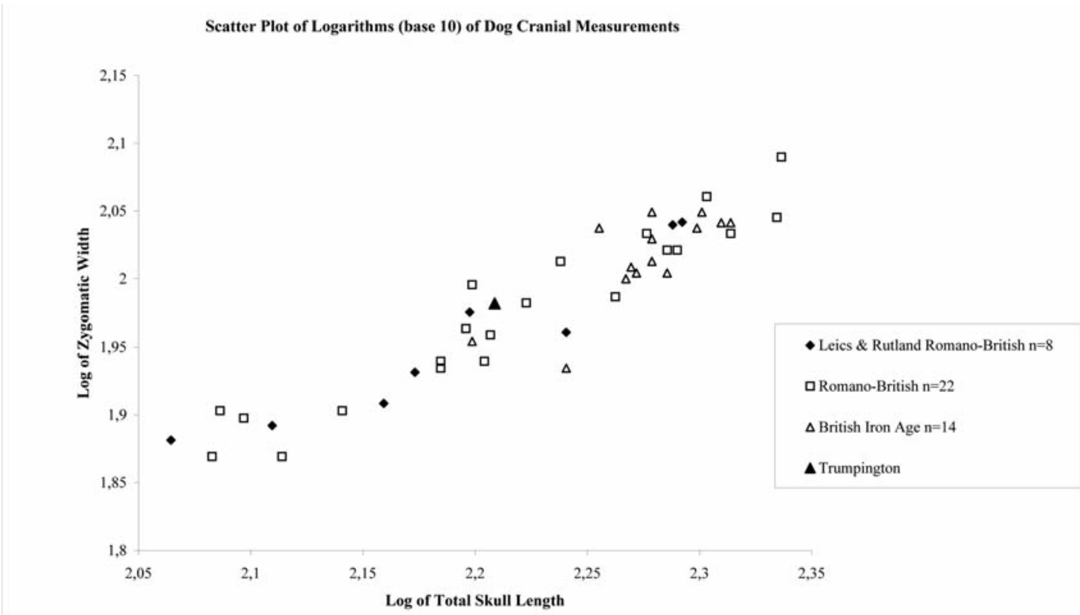

FIGURE 5

The Trumpington cranium compared with a sample of Iron Age and Romano-British dog crania using the method of Harcourt (1974).

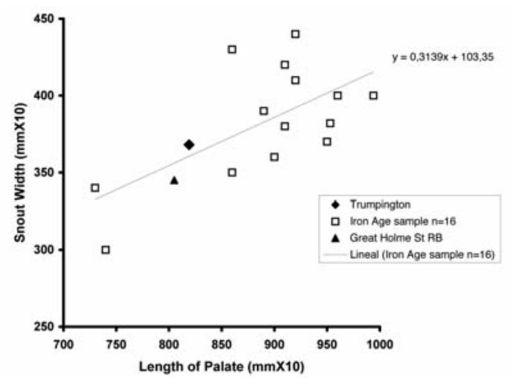

FIGURE 6

Palate length/snout width of the Trumpington dog compared with a sample of Iron Age and Romano-British dogs.

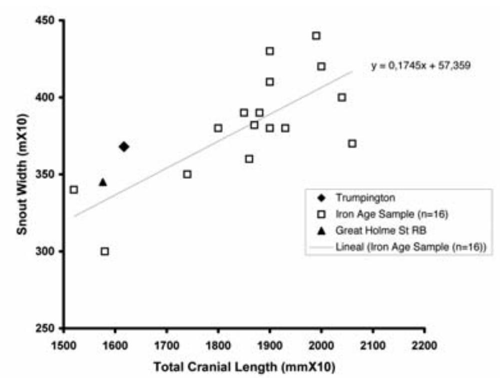

FIGURE 7

Total cranial length/snout width of the Trumpington dog compared with a sample of Iron Age and Romano-British dogs.

The Swiss Neolithic and Trumpington crania were compared with a sample of modern dog crania from recognized breeds in the collection of the Albert Heim Foundation for Canine Research at the *Naturhistorisches Museum Bern*. The modern breeds were chosen for their comparable skull sizes, respectively similar length of the «Hirnstammbasis», a measurement that has been proven a good reference for size independently from skull form (Lüps, 1974). Discriminant function analysis indicates that the Trumpington cranium lies closest to the Chow Chow when compared with modern breeds of dog and is quite distinct from the generalized Neolithic sample (Figure 12, Table 3).

FIGURE 8
Palatal view of the Great Holme Street dog cranium. Scale in cm.

FIGURE 9
The Trumpington cranium compared with a sample of dog crania of similar size from Swiss Neolithic lake sites. Trumpington is a lighter colour and second from the top in the central vertical row. Scale in cm.

FIGURE 10
The Trumpington cranium compared with the nearest in size from the Swiss Neolithic sample and a modern Shar Pei. Shar Pei and Trumpington are to the left. Scale in cm.

DISCUSSION

Following on from the above analysis, the measurement systems most commonly used by zooarchaeologists are inadequate to fully elucidate canid diversity at any temporal period, and this is particularly crucial in the late Iron Age/Romano-British transitional period where it has been apparent for some time that specialization in domestic canid morphology appears to first occur in the British archaeological record. In the process of specialization of domestic dogs in post-Neolithic times, size increase/decrease is not the only important factor to be noted (length and width measurements together with changes in the relative dimensions of the different regions e.g. shortening of the muzzle requiring a sophisticated analysis of the cranium). Of equal significance is any trend towards flexing of the base of the cranium, which may be used as indication towards group-types as is nowadays done. The present study of a single cranium from a late Iron Age context in Cambridgeshire should be seen as a first step in a continuing process of the application of more suitable and technically appropriate methods in the elucidation of archaeological canid remains.

We recognise that this is an isolated specimen, as the prebasial angle of Iron Age dogs has not been measured previously. At the very least, however, this skull belonged to a dog not in the normal range of its kind and therefore may be cautiously regarded as a forerunner of specialization within the Romano-British dog population. We have deliberately focused on only one trait (the prebasial

FIGURE 11

Trumpington (left) and Shar Pei (right) compared. Superior view. Scale in cm.

angle) as it has been demonstrated that other traits, shortening of the muzzle, broadening of the skull, maxillary flare, tend to vary with it. However, there are clear exceptions to each of these trends, indicating that these traits are not necessarily inseparably linked by developmental constraint or a common genetic cause, and covariance may, in part, be the result of the aesthetic tastes of breeders (Fondon & Garner 2007). Focusing individually on the other traits observed as well we would therefore only increase the possibilities of highlighting the aesthetic tastes of breeders in the late Iron Age. The same methodology utilizing the same resources has also been recently applied to late medieval/early post-medieval domestic dog remains from three sites in England with significant results (Phillips *et al.,* 2009). The present study suggests that specialization in the British dog population, whether due to continental imports or insular developments, was already affecting otherwise typical medium sized dogs in the British late Iron Age quite apart from chondrodystrophic dwarf hounds and paedomorphic toy dogs already known from within the Roman Empire (e.g. Baxter, 2006; MacKinnon & Belanger, 2006).

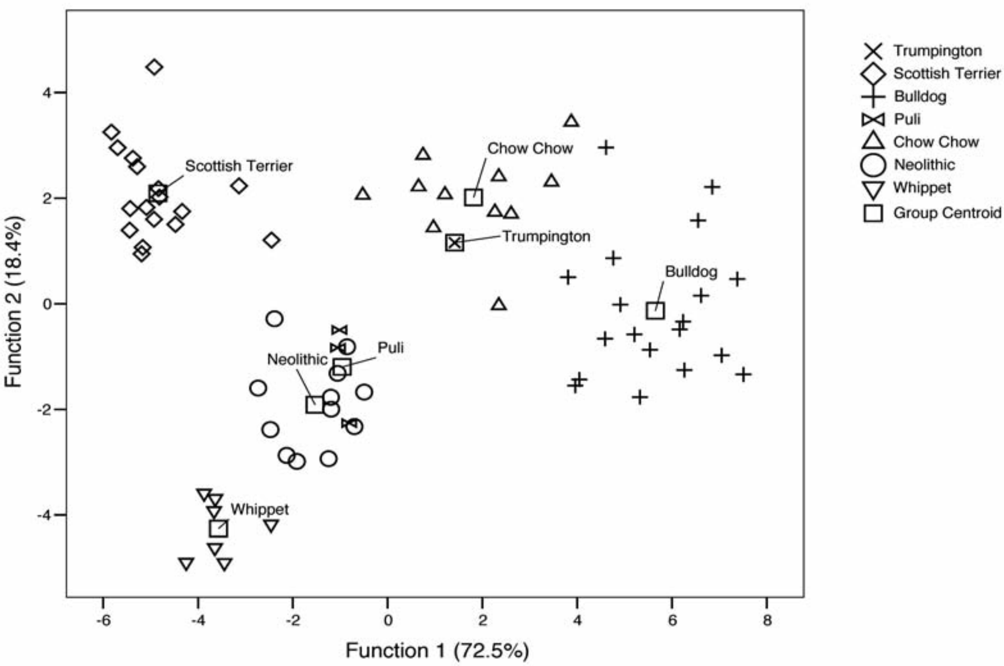

FIGURE 12

Discriminant analysis chart showing the position of the Trumpington cranium in relation to a selection of modern dog breeds. Scatter plot of individual skulls according to their scores along with their respective group centroid values (breed means) on the two first canonical discriminant functions from selected dog breeds, Neolithic dogs from Switzerland and the Trumpington skull. The percentages of variance for both functions accounting for 90.9% of total variance are shown.

	Function	
	1	2
Beta	.599	.110
Mass_e1	.015	.385
Mass_f	.227	.375
Mass_m	-.053	.246
Mass_h	.361	.120
Mass_b	-.120	.100
Mass_d	.170	-.216
Mass_g	.348	.179
Mass_c	-.026	.076

TABLE 3

The structure matrix shows pooled within-groups correlations between discriminating variables and the first two standardized canonical discriminant functions of selected dog breeds, Neolithic dogs from Swiss lake sites and the Trumpington cranium. Function 1 seems to discriminate mostly between praebasial angle (Beta), and several widths, function 2 between Mass_e1, the length of the upper carnassial, and Mass f, the width over the canines.

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Trumpington	Mass_E1	Mass_B	Mass_C	Mass_D	Mass_F	Mass_G	Mass_H	Mass_M	Beta ß
	18.5	146.0	94.8	50.7	36.8	96.5	47.8	28.3	177.0

Neolithic, Swiss	Mass_E1	Mass_B	Mass_C	Mass_D	Mass_F	Mass_G	Mass_H	Mass_M	Beta ß
Mean	15.8	147.3	95.4	50.1	32.7	95.0	46.1	27.9	169.5
Minimum	13.5	134.8	86.5	44.9	29.0	88.6	41.5	24.4	165.5
Maximum	18.0	176.5	113.7	58.4	38.6	111.8	54.0	33.1	175.0
N	12	12	12	12	12	12	12	12	12
StdDev	1.1	11.1	7.4	3.7	2.7	6.4	3.5	2.6	2.5

Scottish Terrier	Mass_E1	Mass_B	Mass_C	Mass_D	Mass_F	Mass_G	Mass_H	Mass_M	Beta ß
Mean	17.4	148.3	93.2	43.0	34.9	89.0	42.9	27.9	165.1
Minimum	16.5	134.0	87.6	40.5	32.1	83.6	40.0	25.9	164.0
Maximum	18.5	162.3	98.6	45.8	42.0	98.1	46.0	31.5	166.0
N	17	17	17	17	17	17	17	17	17
StdDev	0.6	7.1	3.5	1.8	2.4	4.3	1.9	1.3	0.8

Bulldog	Mass_E1	Mass_B	Mass_C	Mass_D	Mass_F	Mass_G	Mass_H	Mass_M	Beta ß
Mean	16.6	134.0	90.2	50.2	41.0	112.0	53.3	25.2	182.1
Minimum	14.0	111.0	77.2	43.4	35.8	89.0	47.1	19.6	175.0
Maximum	19.5	166.4	116.7	60.6	61.0	127.0	61.4	30.8	190.0
N	19	19	19	19	19	19	19	19	19
StdDev	1.7	12.6	9.7	4.3	6.1	10.4	3.6	3.2	4.7

Puli	Mass_E1	Mass_B	Mass_C	Mass_D	Mass_F	Mass_G	Mass_H	Mass_M	Beta ß
Mean	16.5	143.8	93.2	49.3	33.8	96.2	45.6	26.9	170.0
Minimum	16.0	142.0	90.6	47.4	31.8	90.5	42.5	24.4	169.0
Maximum	17.0	145.8	96.0	51.8	35.7	100.7	47.8	29.3	171.0
N	3	3	3	3	3	3	3	3	3
StdDev	0.5	1.9	2.7	2.3	2.0	5.2	2.8	2.5	1.0

Chow Chow	Mass_E1	Mass_B	Mass_C	Mass_D	Mass_F	Mass_G	Mass_H	Mass_M	Beta ß
Mean	18.0	151.7	98.7	50.7	41.9	115.7	54.1	32.3	175.8
Minimum	16.0	142.0	92.5	46.7	39.0	104.4	47.9	27.3	173.0
Maximum	20.0	162.8	107.1	55.9	47.4	124.6	59.8	36.5	180.0
N	11	11	11	11	11	11	11	11	11
StdDev	1.3	6.9	4.9	3.2	2.7	6.2	2.7	2.2	2.5

Whippet	Mass_E1	Mass_B	Mass_C	Mass_D	Mass_F	Mass_G	Mass_H	Mass_M	Beta ß
Mean	14.7	143.9	90.9	49.1	27.0	89.0	44.2	25.7	165.0
Minimum	13.5	133.3	84.8	46.4	24.4	83.7	41.5	23.9	164.0
Maximum	16.0	148.0	94.3	51.0	29.8	92.0	47.8	27.3	166.0
N	7	7	7	7	7	7	7	7	7
StdDev	1.1	4.9	3.4	1.9	1.9	2.9	2.3	1.2	0.8

APPENDIX 1

Dog skulls from the Berne collection used for comparison with an Iron Age cranium from Trumpington, Cambridgeshire, UK. (Measurements based in Lüps 1974). 16. 02. 2007.