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 $\sigma 2125 \pm 80$ BP, $\delta C13 -13.9 \pm 1.2$ (ETH-32189). A second date obtained on bone is $\sigma 2005 \pm 45$ BP, $\delta C13 -20.0 \pm 1.2$ (ETH-32589). 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).

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 pter-sphenoid.

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 palate.

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; Nussbaumer 1982; Fondon & Garner 2004).
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 $B = 3$, $C = 14+ (3–13)$, $E_1 = 18$, $F = 36$ (= 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 mediumsized dogs (Nussbaumer, 1978).

The dorso-basal curvature or prebasial angle ($\beta$) 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

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**TABLE 1**

Cranial measurements (based on Harcourt, 1974).

<table>
<thead>
<tr>
<th>Measurement in mm</th>
<th>Trumpington</th>
<th>Great Holme Street</th>
<th>Causeway Lane</th>
</tr>
</thead>
<tbody>
<tr>
<td>I  The most posterior aspect of the occipital protuberance to the anterior margin of the medial incisor alveoli between the central incisors (alveolare)</td>
<td>161.7</td>
<td>157.6</td>
<td>not measurable</td>
</tr>
<tr>
<td>II Occipital protuberance to junction of nasal and frontal bones (nasion)</td>
<td>89.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>III Nasion to alveolarere</td>
<td>77.3</td>
<td>84.7</td>
<td></td>
</tr>
<tr>
<td>IV Zygomatic width (maximum)</td>
<td>95.9</td>
<td>94.4</td>
<td>c88.0</td>
</tr>
<tr>
<td>IX Palatal length</td>
<td>81.9</td>
<td>80.5</td>
<td>79.5</td>
</tr>
<tr>
<td>X Palatal width between $PM^1$ and $M^1$</td>
<td>62.3</td>
<td>58.2</td>
<td>64.7</td>
</tr>
<tr>
<td>XI Maxillary cheek tooth row length</td>
<td>60.2</td>
<td>54.3</td>
<td>c58.3</td>
</tr>
<tr>
<td>XII Snout width across outer margins of the alveoli of the canines</td>
<td>36.8</td>
<td>34.6</td>
<td>c37.4</td>
</tr>
</tbody>
</table>

\*\*\* estimated to within 0.5 mm

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**FIGURE 2**

Cranial measurements taken (based on Lüps, 1974).

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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 calipers or a compass (Figure 4). In dog skulls, decalination of the upper jaw is known as ‘klinorhynchy’; and elevation of the upper jaw as

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

TABLE 2
Cranial measurements (based on Lüps, 1974).

**FIGURE 3**
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, Molossoid-like, Sighthound/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 «dogs»’, 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.
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).

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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.

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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 11
Trumpington (left) and Shar Pei (right) compared. Superior view. Scale in cm.

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.
ACKNOWLEDGEMENTS

The authors would like to thank Johann Lang of Vet Suisse Fakultät, Bern for kindly examining the skull, Tony Gouldwell of the School of Archaeology & Ancient History, University of Leicester for measuring the prebasial angle of the Great Holme Street dog, Umberto Albarella, Kate Clark, Susan Crockford, John W. Fondon III and Simon Joss for their helpful comments on earlier drafts of this paper.

REFERENCES


APPENDIX 1


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<tr>
<td>Trumpington</td>
<td>18.5</td>
<td>146.0</td>
<td>94.8</td>
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<td>36.8</td>
<td>96.5</td>
<td>47.8</td>
<td>28.3</td>
<td>177.0</td>
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<td>Neolithic, Swiss</td>
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<td>147.3</td>
<td>95.4</td>
<td>50.1</td>
<td>32.7</td>
<td>95.0</td>
<td>46.1</td>
<td>27.9</td>
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<td>Scottish Terrier</td>
<td>17.4</td>
<td>148.3</td>
<td>93.2</td>
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<td>89.0</td>
<td>42.9</td>
<td>27.9</td>
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<td>Bulldog</td>
<td>16.6</td>
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<td>25.2</td>
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<td>45.6</td>
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<td>170.0</td>
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<td>18.0</td>
<td>151.7</td>
<td>98.7</td>
<td>50.7</td>
<td>41.9</td>
<td>115.7</td>
<td>54.1</td>
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<td>175.8</td>
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<tr>
<td>Whippet</td>
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<td>27.0</td>
<td>89.0</td>
<td>44.2</td>
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