MANUSCRIT ACCEPTAT

Morphometric Variability of Roman Dogs in Hispania Tarraconensis: The Case Study of the Vila de Madrid Necropolis

L. Colominas

Per citar aquest document:

Aquest arxiu PDF conté el manuscrit acceptat per a la seva publicació.

Abstract

The size, body conformation and skull shape of Roman dogs from the 'Vila de Madrid necropolis' site, where 1480 dog remains were recovered, are described in this paper to provide evidence of the morphometric variability of Roman dogs in Hispania Tarraconensis.

The individualized and detailed morphometric analysis of 10 individuals shows that the proliferation and explosion of the morphological variability already documented in different regions of the Roman Empire (Italia, Gallia, Britannia, Pannonia) are also noted here. The presence of very different individuals in terms of their shape and size, similar to the differences that can at present be noted between Pekingese and Doberman dogs, has been documented at the site. The reasons for the appearance of this morphological variability within those territories that were part of the Roman Empire are also discussed.

1. Introduction

Canis familiaris is one of the most morphologically varied animal species and, therefore, also shows great morphometric variation (Schoenebenck & Ostrander, 2013). This species' high reproductive rate has facilitated the artificial selection and fast transmission of selected traits, leading to the large number of dog breeds present today.

Different studies have shown that the proliferation and explosion of this variability, both in terms of size and morphology, emerged during Roman times, in contrast to the fairly uniform population of medium-sized dogs present during the previous period (Harcourt, 1974; Altuna & Mariezkurrena, 1992; Clark, 1995; Lepetz, 1996; Bartosiewicz, 2000; De Grossi & Tagliacozzo, 2000; MacKinnon, 2010). It has been suggested that average height for Iron Age dogs in Italy was 51.5 cm, with a minimum 37.4 cm and a maximum 60.8 cm heights (De Grossi & Tagliacozzo, 2000). For France, average heights between 40 cm and 50 cm have been suggested, with a maximum 62 cm height (Meniel, 2002), and for Britain, the withers heights documented range between 32 cm and 60 cm (Clark, 1995). A shoulder height between 26 cm and 69 cm has been documented in Italy during Roman times (De Grossi & Tagliacozzo, 1997, 2000). Mostly identical data have also been recorded in Britain (Harcourt, 1974; Baxter, 2006) and France (Lepetz, 1996), with a withers height between 23–72 cm and 25–70 cm, respectively. Therefore, one of the most noticeable features for the Roman period compared to the Iron Age is the variability in the size of the dogs, and particularly the presence of a group of small dogs.

There is hardly any information available for Roman Spain. The scarce data come from several Roman sites located in the north of the Peninsula, where a withers height between 30.8 cm and 69.5 cm has been estimated (Fernández, 2003; Fernández & Fuertes, 2007) and the presence of micromorphic specimens with a 26–31 cm withers height has also been noted (Altuna & Mariezkurrena, 1992).

It is therefore the aim of this paper to provide more data to start to fill this Spanish gap. We here present a morphometric study of the dog remains from the 'Vila de Madrid necropolis' site, where 1480 dog remains were recovered. This study will provide new and valuable data on the morphometric variability of Roman dogs in Hispania. This information will enable us to know in more detail if the morphotype 'explosion' documented in Britannia, Italia, Gallia and Pannonia also took place in Hispania Tarraconenis, which will provide an additional example of the material culture standardization documented within those territories that were part of the Roman Empire.

Materials and method

The materials analysed for the present study were recovered at the 'Vila de Madrid necropolis' site in Barcelona (Catalonia). The site's first excavations took place in the 1950s. These excavations revealed many burials along a secondary road, approximately 5 m wide, of what would have been the western necropolis of the Roman city of *Barcino* (Beltrán, 2007). Works at the site resumed between 2000

and 2003 with the excavation of the road's north area, during which the presence of a collective funerary structure (c. 8.85 × 5 m) was noted. A total of 66 burials, 59 inhumations and 7 cremations, were recorded within the structure (Figure 1), in use between the first half of the second century AD and the mid third century AD (Beltrán, 2007).
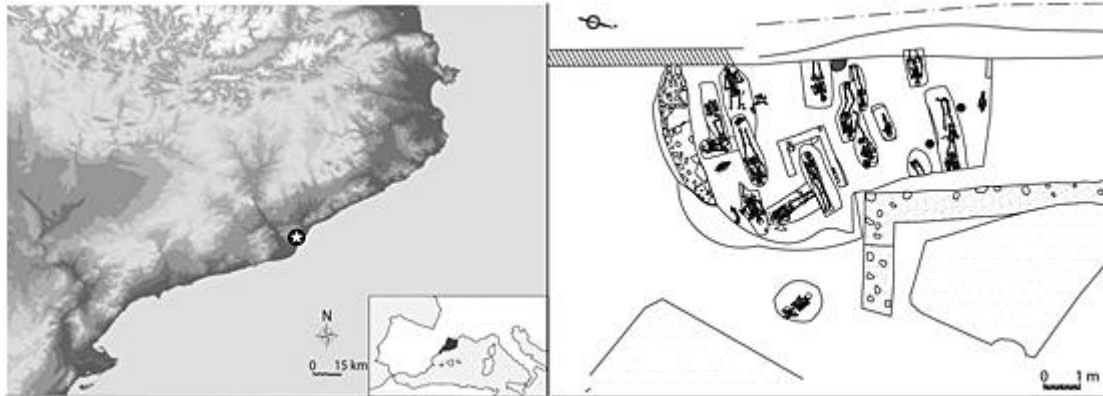

Figure 1.

- [Open in figure viewer](#)

Location and plan of the 'Vila de Madrid necropolis' site (F. Busquets, I. Pastor, MHCB).

The materials studied here were recovered from different contexts in the collective funerary structure and all were excavated between 2000 and 2003. The materials come from: (1) a well's abandonment fill contemporary to the necropolis' occupation phase in which the presence of 10 complete dog skeletons were noted (Figure 2); (2) the interior of some of the inhumations in which both complete dog skeletons and loose bones were found (Table 1); and (3) the necropolis' circulation levels, in which mostly loose dog bones were found (Colominas, 2007). The well was interpreted as a ritual deposit once its function to draw water finished (Beltrán, 2007), as the 10 skeletons of dog were accompanied by six piglets, a horse head and a Pascual 1 amphora (Colominas, 2007). Dog remains were found in 15 of the 59 inhumations. Table 1 shows the distribution of these dog remains in relation to age and sex of the humans buried. The presence of dogs is slightly more common in the adult male burials (six burials), which are, in turn, the most common type of inhumations (11 burials) (Jordana & Malgosa, 2007). The dogs are also present in burials containing grave goods, but their presence is more common in burials where the only gifts buried alongside the deceased were the dogs themselves (Table 1). The presence of loose dog remains both in the burials and in the circulation levels of the necropolis was interpreted as the result of an overlay of the burials that would have destroyed the original position of these dog remains (Beltrán, 2007). This overlay did not enable to observe any orientation pattern in the alignment of dogs and humans buried.

Figure 2.

- [Open in figure viewer](#)

Plan of some layers of the ditch showing several dog skeletons (I. Pastor-MHCB).

Table 1. Anthropological (Jordana & Malgosa, 2007) and archaeozoological data of the Vila de Madrid necropolis burials where dog remains were found (undet. = undetermined)

Burial no	Human data		Dog data		Grave goods
	Sex	**Age**	**NISP**	**Age**	
1	Male	Infant	2	1 juvenile	Yes
7	Male	Adult	1	1 adult	Yes
9	Male	Adult	1	1 juvenile	Yes
12	Female	Sub-adult	8	1 adult	Yes
17	Male	Sub-adult	4	1 juvenile + 1 adult	Yes
19	Male	Adult	1	Undet.	Not
22	Male	Sub-adult	25	1 sub-adult	Not
24	Male	Juvenile	2	1 adult	Not
26	Male	Sub-adult	4	1 juvenile + 1 adult	Not

Burial no	Human data		Dog data		Grave goods
	Sex	Age	NISP	Age	
33	Female	Undet.	2	1 juvenile + 1 adult	Not
34	Male	Adult	4	1 adult	Not
35	Male	Adult	10	1 adult	Not
37	Female	Adult	5	1 sub-adult + 1 adult	Yes
38	Male	Adult	3	Undet.	Not
43	Male	Infant	8	1 adult	Not

To carry out this study we will focus on the osteometric analysis of the material. Measurements were taken following Driesch (1976) and refer only to adult animals. Withers heights were estimated following Harcourt (1974) and Clark (1995). References to modern breeds (Wagner, 1930) were only made in order to easily visualize the characters that define each individual in terms of its size, conformation and skull shape. Clearly, it is not our aim here to assign each individual to modern breeds which are of recent selection or present ideas on coat colour, carriage of ears and tails or even temperament, the data for which has only just begun to emerge from palaeogenetic analyses (Ollivier *et al.*, 2013).

When possible, sex was determined through the presence of the baculum. Age was estimated following Schmid (1972) for bone fusion and Horard-Herbin (2000) for tooth wear.

Results

A total of 1480 dog remains were studied. Taking into account their context of recovery, a minimum number (MNI) of 42 individuals was estimated from these remains. A minimum number of 10 individuals was recovered from the ditch, 19 from the interior of the burials and 13 from the necropolis' circulation levels. The age-at-death estimations for each of the individuals can be found in Table 2. The presence of the baculum in six of the individuals shows that at least the 6–15 individuals from the ditch and three of the adults from the same context were males.

Table 2. Minimum Number of dogs (MNI) by age group recovered in the different contexts at Vila de Madrid necropolis site. Age is described in months

MNI	<1	1–6	6–15	15–36	36–72	>72	Total
Ditch	.	.	2	3	5	.	10

MNI	<1	1–6	6–15	15–36	36–72	>72	Total
Burials	.	.	8	4	7	.	19
Circulation	1	3	3	.	6	.	13
Total	1	3	13	7	18	.	42

The osteometric studies have centred on the remains of individuals aged between 15/18 and 72 months to select only individuals fully formed. This age range is the most common at the necropolis, even though individuals of many different ages have been documented here, ranging from a neonate to young and juvenile individuals.

Withers height

Shoulder height is clearly the most useful initial expression of dog variability, both as a descriptive term to illustrate a major visual characteristic of the animal, and as an analytical tool (Clark, 1995). In that sense, withers heights were calculated, when possible, for all adult individuals as a first step in the morphometric study.

Figure 3 shows the withers height of 20 individuals and how these compare to modern breeds. We can note that seven individuals (ind. 1, 7, 8, 15, 16, 19 and 20) have a withers height between 25 cm and 31 cm, meaning they are small and similar in height to the modern Pekingese and Bulldog breeds. At the same time, there is a group of individuals whose average height is between 39 cm and 51 cm (ind. 4, 6, 9, 11, 12, 14, 17 and 18), comparable to the Cocker Spaniel or Pyrenean Shepherd breeds. The final group comprises the largest individuals (ind. 2, 3, 5, 10 and 13) with withers heights ranging between 55 cm and 61 cm, similar in size to the Boxer or Pointer breeds. These results show the wide range of sizes present at Vila de Madrid: hypometric dogs, those which are between 22 cm and 37 cm tall (Teichert, 1987); individuals taller than 60 cm at the withers (hypermetric dogs) (De Grossi & Tagliacozzo, 2000) and medium-sized individuals (eumetric dogs) (De Grossi & Tagliacozzo, 2000).
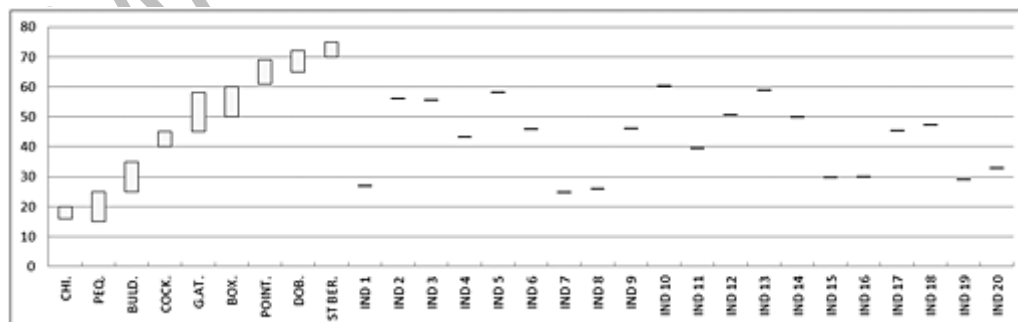

Figure 3.

- Open in figure viewer

Withers heights in cm of Vila de Madrid necropolis dogs and those of modern breeds, where CHI.: Chihuahua, PEQ.: Pekingese, BULDG.: Bulldog, COCK.: Cocker, G.AT.: Pyrenean Shepherd, LABR.: Labrador, PAS.AL.: German Shepherd, ROTTW.: Rottweiler, DOB.: Doberman, ST BER.: St Bernard.

In order to delve further into these morphological differences, withers heights were correlated with the slenderness index for all the available individuals (Figures 4 and 5), which reduced the sample to 10 because of the fragmentation of the material. This index correlates the greatest length (GL) with the smallest shaft breadth (SD) of limb bones. The application of this index allows us to focus not only on size, but also on shape.
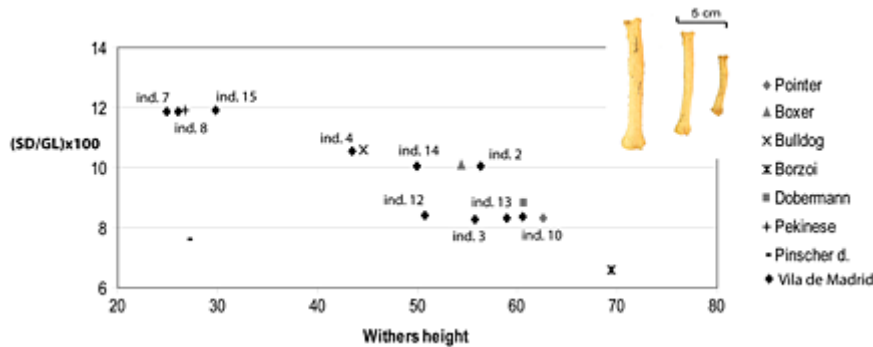

Figure 4.

- [Open in figure viewer](#)

Slenderness index of the dog radii found at the Vila de Madrid necropolis and those of modern breeds.
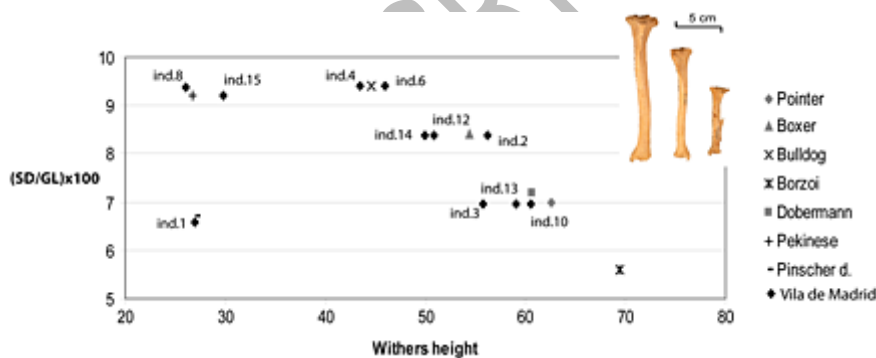

Figure 5.

- [Open in figure viewer](#)

Slenderness index of the dog tibiae found at the Vila de Madrid necropolis and those of modern breeds.

Figures 4 and 5 show that there were individuals with a short withers height and slight limb bones (ind. 7, 8 and 15) as well as others medium in size and broad and heavy limb bones (ind. 3, 10, 12 and 13). There was also a very short individual, but with broad limbs (ind. 1 Figure 5). This dog is anatomically similar to the modern dwarf Pinscher breed. According to the American Kennel Club (2015), this type of dog is structurally sturdy, compact and short-coupled. The rest of the small

dogs, (ind. 7, 8 and 15) are similarly slender to the current Pekingese breed, which is characterized by its lighter hindquarters. Individuals 4 and 6 are similar in slenderness to a Bulldog, which is characterized by its medium size with a heavy, thick-set and low-swung body, according to the American Kennel Club (2015). Individuals 2, 12 and 14 fall under the Boxer breed parameters. This medium-sized dog has long, straight and strong limbs. On the other hand, individuals 3, 10 and 13 are closer to the Doberman and Pointer breeds. These breeds are compactly built and are muscular and powerful, which provides them with great endurance and speed. The limbs are straight, parallel to each other, with heavy bones.

Skull

The shape of the skull is the most important criterion when determining the standard breeds of dogs (Alpak *et al*., 2004) as the skulls of domestic dogs differ more in size and shape than those of any other mammalian species (Evans, 1993). In that sense, the evaluation of cranial morphology might be a useful approach when aiming to document the presence of different morphotypes.

Three terms are frequently used to describe head shapes (Evans, 1993): dolichocephalic, mesocephalic and brachycephalic. Dolichocephalic dogs, such as the Doberman and Borzoi, tend to have narrow, sometimes elongated, snouts and orbitals that are less forward set (Schoenebenck & Ostrander, 2013). Brachycephalic breeds, such as the Bulldog, Boxer and Pekingese, are easily recognizable by their short 'pushed-in' faces, underbite and widely placed, shallow orbits (Schoenebenck & Ostrander, 2013). Some of the mesocephalic current breeds, the intermediate category, include the St Bernard, Pinscher, Labrador or Chihuahua.

In order to evaluate the shape of the Vila de Madrid dogs' skulls, log-ratio diagrams were plotted with several cranial measurements correlated against the same measurements for modern dog breeds and compared to those of a wolf as reference (Wagner, 1930) (Figures 6, 7 and 8). It was only possible to perform these correlations for nine of the individuals. The measurements used combine measurements from the snout (avd. 8, 13, 15 and 36) and the neurocranium (avd. 7, 23 and 29) with the total length and smallest breadth of the skull (avd. 1 and 31) in order to evaluate the morphological characters of the skull.
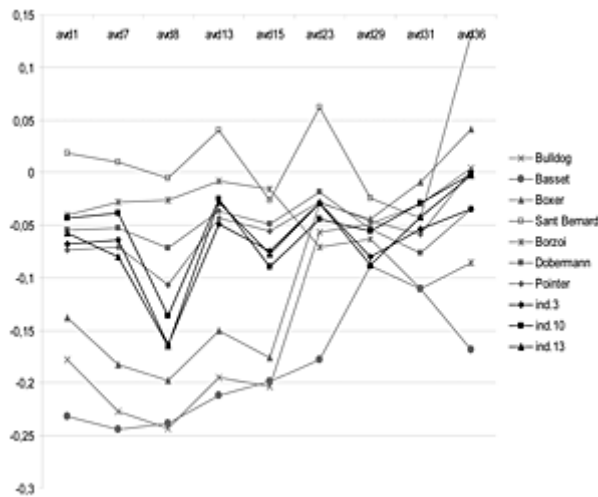
Figure 6.

- [Open in figure viewer](#)

Log-ratio diagram of the dimensions of the Vila de Madrid necropolis dog skulls 3, 10 and 13 and those of modern breeds.
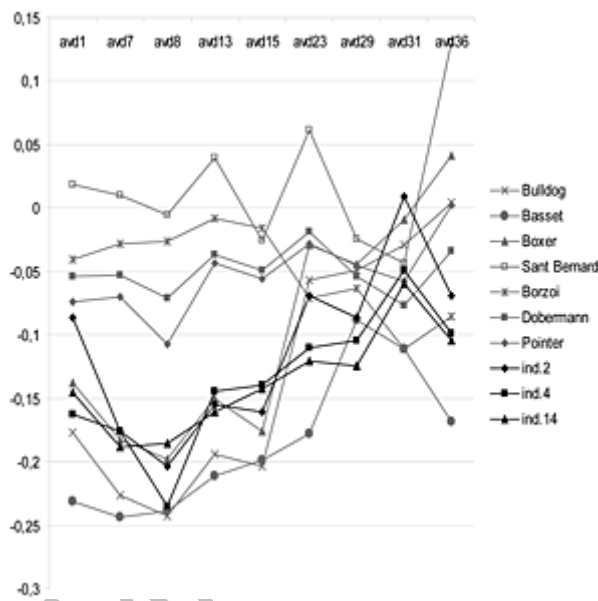

Figure 7.

- [Open in figure viewer](#)

Log-ratio diagram of the dimensions of the Vila de Madrid necropolis dog skulls 2, 4 and 14 and those of modern breeds.
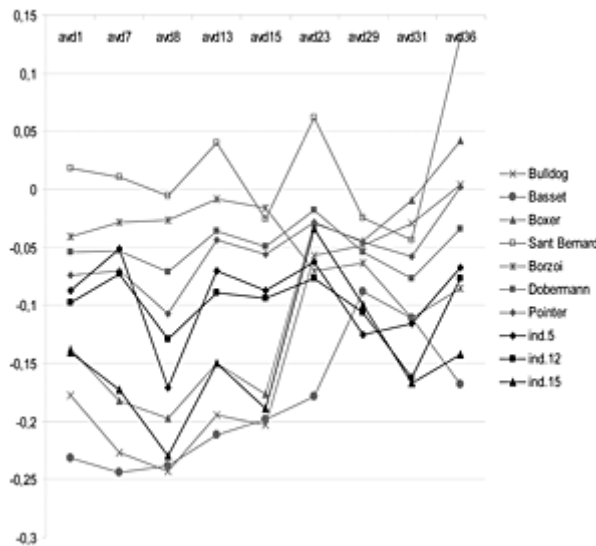
Figure 8.

- Open in figure viewer

Log-ratio diagram of the dimensions of the Vila de Madrid necropolis dog skulls 5, 12 and 15 and those of modern breeds.

Figures 6, 7 and 8 show marked variability in the size and shape of the skulls. This variability, however, can be divided into two general groups. There is a group (ind. 3, 10 and 13) characterized by a large, long and wide skull (Figure 6). The neurocranium as well as the maxilla are large and wide. This morphology is similar to the Pointer and Doberman skulls, which are characterized by a long head, widened towards the base of the ears (American Kennel Club, 2015).

The second group (ind. 2, 4 and 14) is characterized by a short and wide skull (Figure 7). The neurocranium as well as the maxilla is short and wide. This morphology correlates with the Bulldog and Boxer skulls. The snout on these types of dogs is one third of the length of the head from the occiput to the tip of the nose, and two third the width of the skull. The top of the skull is slightly arched, not very broad, with a not overly pronounced occiput (American Kennel Club, 2015).

On the other hand, individual 15 has a short and narrow skull compared to the other individuals (Figure 8). And individuals 5 and 12 have large and narrow skulls compared to the other individuals (Figure 8). The skulls of these three individuals are not similar in size and shape to any of the current breeds used in that paper.

Therefore, Figures 6, 7 and 8 show that at the Vila de Madrid necropolis there were dolichocephalic, mesocephalic and brachycephalic dogs of different sizes.

Discussion

The data presented here have enabled a morphometric study of the dog remains recovered at the Vila de Madrid necropolis site (Catalonia). This morphometric study has also allowed us to shed light on the size and shape of Roman dogs in

Hispania Tarraconensis, documenting the presence of dolichocephalic, mesocephalic and brachycephalic dogs 25–61 cm tall at the withers.

Individual 1 would have been 27 cm tall at the withers. The calculation of the slenderness index has allowed us to note that this was a very short, but broad-limbed individual. This individual was therefore probably a brachimelic dog, such as the dwarf Pinscher breed. The remains of this dog were found in the circulation levels of the necropolis.

Individuals 7, 8 and 15 were 25 cm, 26 cm and 30 cm tall at the withers, respectively. They were hypometric dogs with slim limb bones similar to those of the Pekingese breed. It was only possible to perform the cranial analysis for individual 15, the results from which showed this to be a short and narrow-skulled individual. Individuals 7 and 8 were found in the circulation levels of the necropolis and individual 15 was found in the well.

Individuals 2, 4, 6 and 14, with a withers height of 56 cm, 43 cm, 46 cm and 50 cm respectively, were medium-sized dogs with long, straight and strong limbs, and short and wide skulls. Current Bulldog and Boxer breeds show similar characteristics to these. It is worth nothing that individuals 2, 4 and 14 all present pathologies. Individual 2 presents two badly healed rib fractures. Individual 4 presents osteomelytis on the left hindlimb that affected the calcaneus and III and IV metatarsals. Individual 14 also presents osteomelytis on the left hindlimb that affected the distal end of the tibia, the calcaneus and all the metatarsals and first phalanges. Individuals 2, 4 and 14 were found in the well, whereas individual 6 was found in the circulation levels of the necropolis.

Individuals 3, 10 and 13 were 56 cm, 61 cm and 59 cm tall at the withers, respectively, representing the largest individuals of this group. These individuals also have broad and heavy limb bones and large, long and wide skulls, being dolichocephalic dogs like the Pointer or Doberman current breeds. All of them were found in the well.

Therefore, the variability documented in other territories belonging to the Roman Empire described in the introduction is also noted in the city of *Barcino* (Hispania Tarraconensis). This great variability would be the result of a selective selection to physically adapt the dogs to the functional role they were going to fulfil. During the Iron Age, the first more-or-less conscious selections would have given rise to larger dogs than in the previous period. This increase in size has been mainly linked to their use as shepherd dogs (De Grossi & Tagliacozzo, 1997; Vega *et al.*, 1998), as their low frequency at the sites and small number of butchering marks on their bones suggest that their meat was usually not consumed (De Grossi & Tagliacozzo, 1997; Meniel, 2002; Smith, 2006; Colominas, 2013).

On the contrary, the selection taking place during Roman times gave rise to dogs no more than 30 cm tall at the withers. The purpose of this selective breeding of small-sized dogs is a matter of debate. Some authors argue that these small dogs could be considered 'lap-dogs' (Harcourt, 1974; De Grossi & Tagliacozzo, 2000) and would be linked to Roman social elites (Fernández, 2003). More recently, they

have also been termed 'working terriers', dogs that, despite their small size, could be used as working animals with potential functions in field and barn (Clark, 2012). The role of small dogs in healing practices should also be considered, as dogs were associated with Asklepious and other deities such as Nodens (Toynbee, 1973). They were also associated with chthonic deities and the underworld (De Grossi & Minitti, 2002).

The small-sized dogs of the Vila de Madrid necropolis do not present pathologies that could be classified as 'working injuries', such as deformities in the vertebrae, scapula and pelvis as a result of carrying loads or fractures produced by livestock kicking and trampling the dogs (MacKinnon, 2010). They also do not present pathologies linked with age, such as degenerative arthritis or spondylosis deformans, or fractures and infections resulting from hereditary and metabolic diseases (Hunnius, 2009). In that sense, the small-sized Roman dogs from the Vila de Madrid necropolis appear to have been in good health, at least osteologically speaking, despite the fact that smaller 'toy' dogs in Roman times appear to have been more susceptible to multiple pathological conditions (MacKinnon, 2010). At the same time, they do not present marks on their bones that could be linked with their sacrifice on ritual or funerary practices. Their context of recovery does not shed more light on this issue, as they were found in a close proximity to the deceased (ind. 19 was found in burial 34 and ind. 20 in burial 22), but also in the necropolis' circulation levels (individuals 1, 7 and 8) and in the well (individuals 15 and 16).

On the other hand, the presence of large dogs (between 65 cm and 70 cm tall at the withers) noted in other territories of the Roman Empire (Harcourt, 1974; Lepetz, 1996; De Grossi & Tagliacozzo, 2000; Bartosiewicz, 2000) has not been documented at Vila de Madrid. This absence of larger dogs, which are mainly associated with shepherding activities, could be linked to the context in which these remains were found, a city's necropolis, in which most of the individuals would have been pets and/or guardian animals. With this in mind, we want to reopen the debate started by Clark in the 1990s in which she pointed out the fact that dogs are represented in very low numbers in refuse contexts. In these instances their frequency, often less than 1%, may be noted, but no measurements reported (Clark, 1995). On the other hand, whole or partial skeletons appear regularly either as burials or in human burial contexts. This has given rise to a tendency to only fully report the presence of dogs which are, to some degree, found articulated and mainly linked to ritual contexts (Clark, 1995). We therefore believe that the absence of taller dogs (>61 cm) is not truly a reflection of their absence in this area, but rather to the context in which these remains were found. It is worth noting that the larger dogs documented at the Vila de Madrid necropolis (ind. 3, 10 and 13) were all found in the well and not directly linked with the burials.

All these data show that during Roman times there was a change in the use of dogs, or at least a new use was made of some dogs, that lead to the appearance of a type of small dog not present until then. We believe that the line separating 'pet' and 'working' dogs may certainly have been a thin one in the Roman world.

Conclusions

The morphometric study of the 1480 dog remains from 'Vila de Madrid necropolis' site has provided new data on the morphometric variability of Roman dogs in Hispania. The data presented in this article have enabled us to note that the morphotype explosion that took place during this time period in Britannia, Italia, Gallia and Pannonia is also documented in the city of *Barcino* (Hispania Tarraconensis). The presence of very different individuals has also been noted here, with size and shape variations similar to those observed between Pekingese and Doberman dogs today. This increase in morphological variability would have been the result of a selection that would have brought about the appearance of dwarf dogs of no more than a 30 cm height at the withers.

It is also during the Roman period that an increase in commercial activity, in which dogs were also considered trade goods, is noted across the whole of the Empire. For example, and according to Strabo, during Augustus' rule, hunting dogs were exported from Britain to Italy (Cool, 2006). This trade may have made it easier for dogs of different shapes and sizes to end up in various territories of the Roman Empire, which would have therefore influenced the morphological variability and the general-size standardization (between 23 cm and 72 cm tall at the withers) documented across the Empire.

Acknowledgements

References

- Alpak H, Mutus R, Onar V. 2004. Correlation analysis of skull and long bone measurements of the dog. Annals of Anatomy 186: 323–330.
  - CrossRef | PubMed | CAS | Web of Science® Times Cited: 11
- Altuna J, Mariezkurrena K. 1992. Perros enanos en yacimientos romanos de la Península Ibérica. Archaeofauna 1: 83–86.
- American Kennel Club. 2015. Dog breeds. [online] Available at: <http://www.akc.org/dog-breeds/> (Accessed 29 July 2015).
- Bartosiewicz L. 2000. Metric variability in Roman period dogs in Pannonia province and the Barbaricum (Hungary). Dogs Through Time: An Archaeological Perspective, J Crockford (ed.). BAR International Series 889: Oxford; 141–161.
- Baxter IL. 2006. A dwarf hound skeleton from a Romano-British grave at York Road, Leicester, England, U.K., with a discussion of other Roman small dog types and speculation regarding their respective aetiologies. Dogs and People in Social, Working, Economic or Symbolic Interaction, MS Lynn, AM Elizabeth (eds.). Oxbow Books, Proceedings of the 9th ICAZ Conference: Durham; 12–23.
- Beltrán J. 2007. La necrópolis occidental de Barcino: la via sepulcral de la plaza de Villa de Madrid. Un exponente del ritual funerario durante el altoimperio. Quarhis 3: 13–63.

- Clark K. 1995. The later prehistoric and protohistoric dog: the emergence of canine diversity. Archaeozoologia VII/2: 9–32.
- Clark K. 2012. A review of the Romano–British dog. In Silchester and the Study of Romano-British Urbanism, Fulford M (ed). Journal of Roman Archaeology Supp. Ser. **90**: 165–184).
- Colominas L. 2007. Animals i ideologia en l'àmbit funerari: estudi arqueozoològic de la Necròpolis de la plaça de la vila de Madrid. Quarhis 3: 82–101.
- Colominas L. 2013. Arqueozoología y Romanización. Producción, Distribución y Consumo de Animales en el Noreste de la Península Ibérica Entre los Siglos V ane-V dne. British Archaeological Reports International Series 2480: Oxford.
- Cool H. 2006. Eating and Drinking in Roman Britain. Cambridge University Press: Cambridge.
  - [CrossRef](#)
- De Grossi J, Minitti C. 2002. Dog sacrifice in the Ancient World: a ritual passage?. Dogs and People in Social, Working, Economic or Symbolic Interaction, M Snyder, E Morre (eds.). 9th ICAZ Conference, Durham 2002, Oxbow Books: Oxford; 62–66.
- De Grossi J, Tagliacozzo A. 1997. Dog remains in Italy from the Neolithic to the Roman Period. Anthropozoologica 25–26: 429–440.
- De Grossi J, Tagliacozzo A. 2000. Morphological and osteological changes in the dog from the Neolithic to the Roman period in Italy. Dogs Through Time: An Archaeological Perspective, J Crockford (ed.). British Archaeological Reports International Series 889: Oxford; 141–161.
- Driesch AVD. 1976. A Guide to the Measurement of Animal Bones from Arcaheological Sites. Peabody Museum, Harvard University: Cambridge.
- Evans HE. 1993. Miller's Anatomy of the Dog, 3rd ednChapter 4. WB. Saunders: Philadelphia; 122–166.
- Fernández C. 2003. Ganaderia, Caza y Animales de Compañia en la Galicia Romana: Estudio Arqueozoológico, Brigantium 15. Museo Arqueolóxico e Histórico. A Coruña: Castelo de San Antón.
- Fernández C, Fuertes N. 2007. La romanización del noroeste de la Península Ibérica y las modificaciones en la presencia, uso y consumo de mamíferos. A Concepçao das Paisagense e dos Espaços na Arqueologia da Península Ibérica, SO Jorge, AMS Bettencourt, I Figueiral (eds.), Actas do IV Congresso de Arqueologia Peninsular. Promontoria Monográfica, 8. Centro de Estudos de Patrimonio— Universidade do Algarve: Portugal; 207–217.
- Harcourt RA. 1974. The dog in prehistoric and early historic Britain. Journal of Archaeological Science 1: 151–175.
  - [CrossRef](#) | [Web of Science® Times Cited: 74](#)
- Hunnius T. 2009. Using microscopy to improve a diagnosis: an isolated case of tuberculosis-induced hypertrophic osteopathy in archaeological dog remains. International Journal of Osteoarchaeology 19(3): 397–405.
  - [Wiley Online Library](#) | [Web of Science® Times Cited: 4](#)
- Horard-Herbin MP. 2000. Dog management and use in the late Iron Age: the evidence from the gallic site of Levroux (France). Dogs Through Time: And Archaeological Perspective, J Crockford (ed.). British Archaeological Reports International Series 889: Oxford; 115–121.
- Jordana X, Malgosa A. 2007. Enterraments d'època Romana a la Plaça de la Vila de Madrid. Resultats de la recerca antropològica. Quarhis 3: 64–81.
- Lepetz S. 1996. L'animal dans la Société gallo-romaine de la France du nord. Revue Archéologique de Picardie, numéro spécial 12: Amiens.
- MacKinnon M. 2010. "Sick as a dog": zooarchaeological evidence for pet dog Health and welfare in the Roman world. World Archaeology 42(2): 290–309.
  - [CrossRef](#) | [Web of Science® Times Cited: 7](#)

- Meniel P. 2002. Le chien en Gaule. Animali tra Uomini e dei. Archaeozoologia del Mondo Prerromano, A Curci, D Vitali (eds.). Studi e Scavi 14: Bologna; 45–52.
- Ollivier M, Tresset A, Hitte C, Petit C, Hughes S, Gillet B, Duffraisse M, Pioner C, Lagoutte L, Arbogast RM, Balasescu A, Boroneant A, Mashkour M, Vigne JD, Hänni C. 2013. Evidence of coat color variation sheds new light on ancient canids. PLoS ONE 10(8): 1–8.
- Schmid E. 1972. Atlas of Animal Bones for Prehistorians, Archaeologists and Quaternary Geologists. Elsevier Publishing Company: Amsterdam, London, New York.
- Schoenebenck J, Ostrander E. 2013. The genetics of canine skull shape variation. Genetics 193: 317–325.
    - CrossRef | PubMed | Web of Science® Times Cited: 14
- Smith K. 2006. Guides, Guards and Gifts to the Gods: Domesticated Dogs in the Art and Archaeology of Iron Age and Roman Britain. BAR British Series 422: Oxford.
- Teichert M. 1987. Brachymel dogs. Archaeozoologia 1: 69–75.
- Vega LG, Cerdeó ML, Córdoba B. 1998. El origen de los mastines ibéricos. La transhumáncia entre los pueblos prerromanos de la Meseta. Complutum 9: 117–135.
- Wagner K. 1930. Rezente Hunderassen. Eine osteologische Untersuchung, Skriften utgitt av Det Norske Videnskaps. Akademi, I. Matematisk- Naturvidenskapeling Klasse: Oslo.