SHORT REPORT

Morphometry of a Pre-Hispanic Dog from Northwestern Argentina (AD 800–1200)

C. R. BELOTTI LÓPEZ DE MEDINA*

Museo Etnográfico J. B. Ambrosetti (FFyL), Instituto de las Culturas (UBA-CONICET), Buenos Aires, Argentina

ABSTRACT   A detailed morphometric description of a dog skull from the pre-Hispanic archaeological site *La Isla de Tilcara* (northwestern Argentina, ca AD 800–1200) is presented. The resulting data were compared with those of dog skulls from other South American archaeological sites to establish dog morphotype. The examined skull belonged to a small, long-snouted dog, similar to the smallest morphotypes from the central Andes. Copyright © 2016 John Wiley & Sons, Ltd.

Key words: northwestern Argentina; pre-Hispanic dog; morphometry

Supporting information may be found in the online version of this article

Introduction

In this study, we provide a detailed description of a dog skull from the pre-Hispanic archaeological site *La Isla de Tilcara* (northwestern Argentina, ca AD 800–1200). It was excavated a century ago and is currently curated at the Museo Etnográfico J. B. Ambrosetti (Universidad de Buenos Aires). The studied skull is one of the most complete from the south-central Andes. We performed taxonomic identification and age determination of the specimen, as well as morphometric measurements of the skull and teeth, which were compared against published data from the central Andes and the eastern plains of Argentina (Pampean, Patagonian and Littoral regions).

Dogs show a remarkable phenotypic diversity, especially among modern breeds created to suit aesthetic preferences or practical needs. Therefore, zooarchaeological research on the phenotypic diversity of pre-Hispanic dogs is potentially informative on their radiation across diverse environmental and sociocultural niches. However, there is little information on the development of pre-Hispanic dog types or their geographic distribution, partially because of the scarcity of published morphologic and morphometric data. In this context, the aim of this study is to contribute new data to our knowledge of variability among dog populations in pre-Hispanic South America.

Zooarchaeology of South-American pre-Hispanic dogs

Pre-Hispanic dogs are assumed to have descended from different founding populations that came across the Bering Strait at the end of the Pleistocene, based on genetic (van Asch, *et al.*, 2013) and archaeological evidence, for example, oldest dog remains (ca 10000–8500 BP) in Danger Cave and Koster sites, North America (Stahl, 2012). In pre-Hispanic South America, dogs may have appeared later (Prates, *et al.*, 2010b, Stahl, 2012). The oldest remains found in archaeological contexts of Peru such as Pachamachay and Telarmachay are dated to 7500–6800 BP, while those in the Southern Cone, such as Los Toldos and La Moderna sites, are dated to 7260 BP and 6550 BP, respectively. However, the taxonomic identification of the latter is still controversial. Recently, Larson *et al.* (2012) suggested that dogs and grey wolves showed a similar geographic distribution before agriculture.

* Correspondence to: Carlos R. Belotti López de Medina, Instituto de las Culturas (UBA-CONICET), Museo Etnográfico J. B. Ambrosetti (FFyL), Moreno 350 (1091), Buenos Aires, Argentina.
e-mail: crbelotti@filo.uba.ar

South American specimens became more frequent in the Late Holocene, and in association with agro-pastoralist societies. Specimens dated to ca AD 300–1500 were recovered from archaeological sites in the Andes area, such as La Isla de Tilcara (our case study) and Santa Rosa de Tastil (both in Argentina); Sipán, Ancón and Machu Picchu (Peru); Tiwanaku (Bolivia); and Quitor 6 (Chile) (Brothwell, *et al.*, 1979, Prates, *et al.*, 2010b). In addition, a small number of specimens dated to ca 1000 BP has been found in the eastern plains of southern South America (Acosta, *et al.*, 2011; Prates, *et al.*, 2010b).

Despite the evidence for a recent expansion across the subcontinent, pre-Hispanic Andean dogs were likely to exhibit a wide phenotypic variability, as inferred from colonial documents and archaeological records. Pre-Hispanic Andean dogs were classified into hypothetical morphotypes or breeds on the basis of differences in body mass, body morphology and hair coat. For example, Allen (1920) described six types of Andean dogs: (1) Inka: large body size; (2) *techichi*: small body size; (3) hairless; (4) small body size, with short legs and a short snout; (5) pug-like, with a flat snout (brachycephalic); and (6) small body size, with a long snout (dolichocephalic). Brothwell *et al.* (1979) proposed two main morphotypes based on craniometric measurements. Mendoza España and Valadez Azúa (2006) recognised at least four breeds based on documentary and archaeological sources: (1) *k'balas*, hairless; (2) *Ñañu*, small body size, with short legs; (3) *Jinchuliwi*, medium body size, with a short snout and droopy ears; and (4) *Pastu*, medium to large body size, with a long snout and erect ears.

Some types would have occurred at least in the first millennium AD (Vásquez Sánchez, *et al.*, 2009). Although it is still a matter of debate whether these types should be considered breeds (Brothwell, *et al.*, 1979; Vásquez Sánchez, *et al.*, 2009), they might have been subjected to artificial selection. An example of this is provided by the 'hairless' trait of some pre-Hispanic American dogs, which results from a mutation of the FOXI3 gene. Heterozygous dogs are hairless, while homozygous mutants die during embryogenesis (Drögemüller, *et al.*, 2008), suggesting that the persistence of this allele from Mexico to northwestern Argentina may be unlikely without human intervention.

La Isla De Tilcara Archaeological Site

The skull analysed here comes from the archaeological site of *La Isla de Tilcara*, which is located in the central portion of the Humahuaca Gorge (Jujuy province,

northwestern Argentina, Figure 1). Northwestern Argentina belongs to the south-central Andes macro-area, sharing with it some main trends, such as domestication of plant and animals during the Holocene, sedentary lifeways related to food production (since ca 1000–500 BC), eventual emergence of middle-range polities (ca AD 500–1430), and ultimately the annexation of the area to the *Tawantinsuyu* (ca AD 1430–1536).

There are no radiocarbon dates from La Isla, but Nielsen (2001) dated its ceramic styles to ca AD 800–1200. Human occupation was estimated to be ca AD 900–1200 and ca AD 800–1100 by Rivolta (2000) and Tarragó *et al.* (2010), respectively. La Isla has been assigned to the Early Regional Developments period, which is characterised by the earliest evidences of social complexity in the Humahuaca Gorge (Nielsen 2001).

The site encompasses three burial areas: El Morro, Necropolis A and Necropolis B (Figure 1), which were excavated by Debenedetti (1910). Debenedetti discovered 11 tombs containing abundant grave goods in El Morro, which lies over a natural mound (675 m²). Although it was initially considered a formal cemetery, new excavations by Rivolta (2000) revealed the remains of a built enclosure (Figure 1(C)).

The analysed skull came from tomb 6 in El Morro. This burial consisted of a large ceramic jar containing two human skeletons and several offerings. One of the skeletons was headless; it was first identified as a secondary interment (Debenedetti, 1910), but it is now placed in the Andean tradition of trophy heads (Nielsen 2001). The grave goods comprised 33 ceramic bowls (*pucos*), an anthropomorphic vessel, two jars, a bronze *tumi*-like knife, burnt corncobs, stone beads, boulders, copper mineral, a mortar and a carnivore skeleton represented by only the cranium and mandibles. The skeleton was catalogued and published as item 2624 by Debenedetti (1910) and assigned the catalogue number 2629 by the Museo Etnográfico Ambrosetti; to avoid confusions, the specimen is herein identified by the former number. A discussion on the symbolism of animal offerings at the site was published elsewhere (Belotti López de Medina, 2012)

Methods

The skull specimens were taxonomically identified at the Instituto de Arqueología (Universidad de Buenos Aires) and the Museo Argentino de Ciencias Naturales (MACN-CONICET). Age was estimated based on tooth eruption. Measurements of the cranium and mandibles were made using the procedure of von den
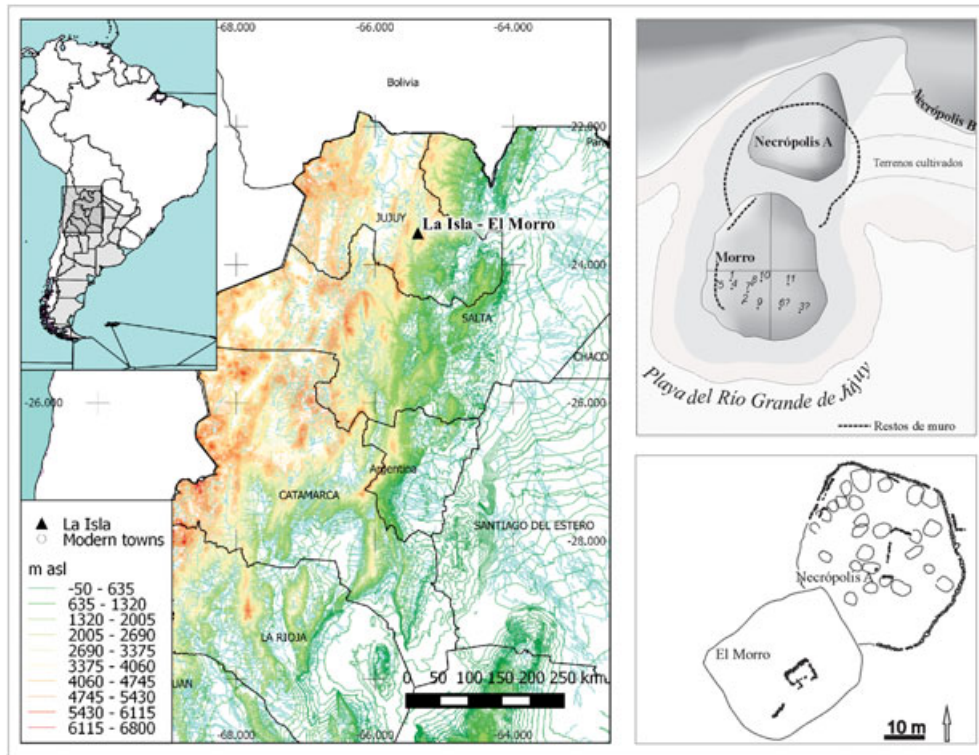
Figure 1. Left: Northwestern Argentina and location of La Isla de Tilcara; Map was created with QGIS. Vector data from Instituto Geográfico Nacional (http://www.ign.gob.ar/) and Natural Earth (http://www.naturalearthdata.com/). Right: layouts of El Morro based on Debenedetti (1910) (upper) and Rivolta (2000) (lower). This figure is available in colour online at wileyonlinelibrary.com/journal/oa

Driesch (1976) and teeth following that of Prevosti and Lamas (2006) (Data S1 and S2). The mandibles were measured from photographs taken shortly before this study, while the rest of the material was measured with a sliding calliper. These measurements were compared with those reported for other archaeological specimens and morphotypes from the central Andes (Data S3) (Allen, 1920, Wing, 1978, Brothwell, *et al.*, 1979), to characterise specimen 2624 in relation to previously described pre-Hispanic Andean dogs. Data from three archaeological dogs from the Pampean, Patagonia and Littoral regions of Argentina (Acosta, *et al.*, 2011, Prates, *et al.*, 2010a) were used as independent controls.

Morphometric comparisons are difficult because of the fragmentary nature of the material analysed and differences in the type of variables reported in published studies. Keeping this in mind, we applied two approaches to achieve valid comparisons. On one hand, the sizes of individuals and morphotypes were compared by means of the log-size index (LSI) (Meadow, 1999). In this technique, different measurements taken from a number of archaeological skeletal elements are transformed to a common scale derived from a standard animal. In our study, morphometric data were log10-transformed, and the mean values of the Peruvian Group A of Brothwell *et al.* (1979) were used as standard. In addition, the LSI was used to compare palatal morphologies because the palate of specimen 2624 was complete. On the other hand, body mass was estimated using the regression equations of Losey *et al.* (2014); Losey *et al.* (2016); Anyonge (1993) and Legendre & Roth (1988; Data S5).

Results

The cranium is slightly longer than 13 cm anteroposteriorly and is broken into four parts (Figure 2). Although several teeth are missing, the number of alveoli in the maxilla–premaxilla and mandibles agrees with that expected for a complete dentition. Taking into account the eruption of the second and third molars, specimen 2624 might have been at least 5–7 months old at death. The specimen shows the most important diagnostic characters of *Canis lupus familiaris*,

Figure 2. Item no. 2624 (Debenedetti 1910) / 2629 (catalogue number of the archaeological collection of the Museo Etnográfico J. B. Ambrosetti). Cranium bones partially assembled for photography: right frontal (A), left parietal (B), loose teeth (C), cranium (D), left (E) and right (F) hemimandibles.

the domestic dog, for example, crowded tooth row and pronounced angle between the nasal/maxilla bones and the frontal bones.

Figure 3 plots the distribution of LSI values for specimen 2624, and all specimens reviewed (Data S4). To accomplish a more comprehensive analysis, we included the LSI of diverse variables, giving preference whenever possible to the palatal length. The histogram

clearly shows that the specimen under study is among the smallest pre-Hispanic dogs (−0.068), together with the Peruvian Group N (Brothwell, *et al.*, 1979) and the pug-nosed dog (Allen, 1920).

The values of LSI for palatal length and breadth are plotted in Figure 4. The palate of specimen 2624 is narrower than that of dogs within the Peruvian Group N and its palatal breadth/length ratio approximates that
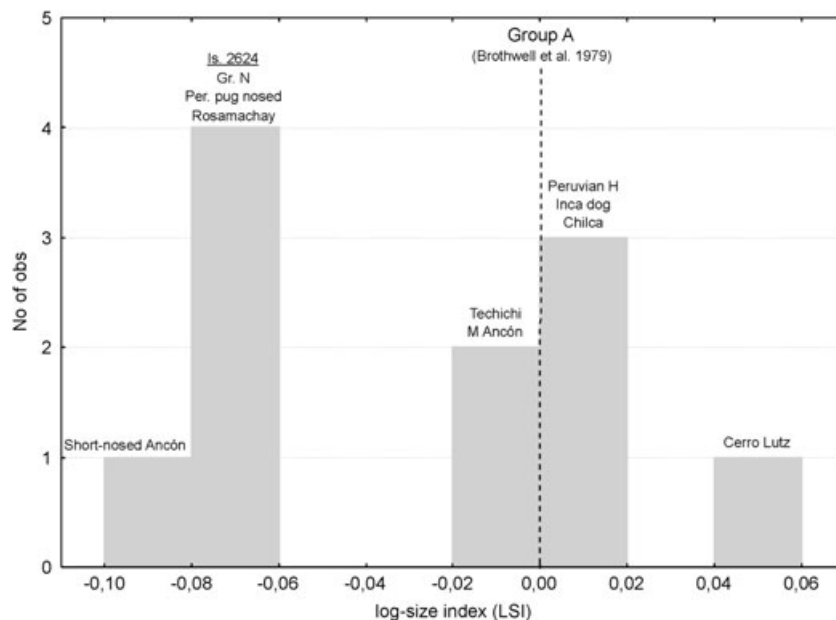

Figure 3. Log size index (LSI) distribution of archaeological morphotypes and specimens.
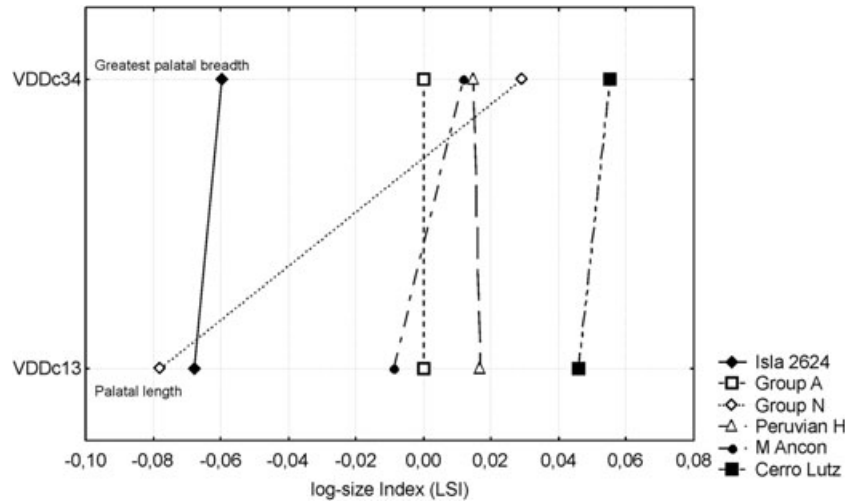
Figure 4. Log size index (LSI) values for palatal measurements of pre-Hispanic South American dogs (VDD: von den Driesch 1976).

of larger dolichocephalic dog types like the Peruvian Group A.

Figure 5 plots the results of the regression analyses (Data S5). Each case shows a wide range of variability in predicted body mass depending on the available measurements and the corresponding regression equations. This was expected because of the well-known allometric disparities among dogs and the probabilistic nature of the regression model. Nonetheless, specimen 2624 is again among the smallest dogs, with a mean body weight of 6 kg. Group N has the highest variance

among Andean morphotypes, partly due to its palatal morphology. On a side note, dogs from the eastern Argentinian plains seem to have been larger than the Andean types.

Discussion

Present-day dogs show the widest phenotypic variability among mammals and the same applies to pre-Hispanic South American dogs. Our results support
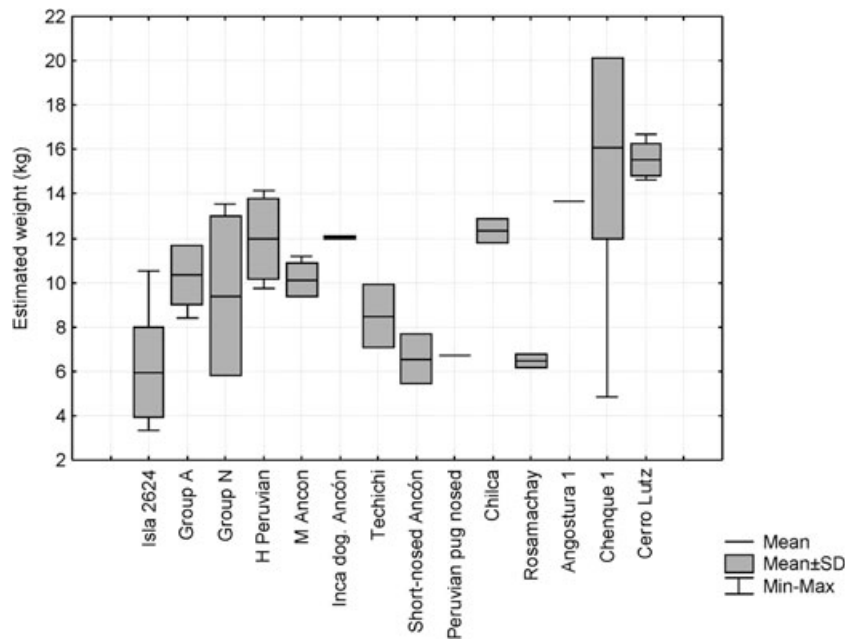

Figure 5. Body mass regressions of the item 2624 and other pre-Hispanic dogs from the central Andes and Argentinian plains.

the notion that Andean dogs exhibited a broad range of body sizes and at least two facial morphologies, probably representing subpopulations that resulted from both natural and relaxed artificial selective pressures (Brothwell, *et al.*, 1979).

The dog specimen 2624 from La Isla is smaller than morphotype Group N from Peru and the Rosamachay specimen, but its palatal morphology resembles that of large dogs. The size of modern small breeds may be influenced by six polymorphic genes (Rimbault, *et al.*, 2013), but it remains to be determined if the same alleles were responsible for small pre-Hispanic Andean dogs and if they were subjected to some degree of artificial selection. Indeed, ancient agropastoralist communities should have been familiar with breeding procedures, and the existence of hairless dogs suggests some control over reproduction. Research on the genetics underlying phenotypic diversity in modern dogs has gained increasing attention over the last decade and its application to ancient DNA would help to clarify issues regarding pre-Hispanic morphotypes.

Acknowledgements

References

Acosta A, Loponte D, García Esponda C. 2011. Primer registro de perro doméstico prehispánico (*Canis familiaris*) entre los grupos cazadores recolectores del humedal del Paraná inferior (Argentina). *Antípoda, revista de antropología y arqueología* **13**: 175–199.

Allen GM. 1920. Dogs of the American aborigines. *Bulletin of the Museum of Comparative Zoology* **63**: 431–517.

Anyonge W. 1993. Body mass in large extant and extinct carnivores. *Journal of Zoology* **231**: 339–350. DOI:10.1111/j.1469-7998.1993.tb01922.x.

Belotti López de Medina CR. 2012. En compañía de los muertos. Ofrendas de animales en los cementerios de La Isla (Tilcara, Jujuy). *Intersecciones en Antropología* **13**: 345–357.

Brothwell D, Malaga A, Burleigh R. 1979. Studies on Amerindian Dogs, 2: Variation in early Peruvian dogs. *Journal of Archaeological Science* **6**: 139–161. DOI:10.1016/0305-4403(79)90059-1.

Debenedetti S. 1910. *Exploración arqueológica de los cementerios prehistóricos de La Isla de Tilcara (Quebrada de Humahuaca, Provincia de Jujuy)*. Facultad de Filosofía y Letras: Buenos Aires.

Drögemüller C, Karlsson EK, Hytönen MK, Perloski M, Dolf G, Sainio K, Lohi H, Lindblad-Toh K, Leeb T. 2008. A mutation in hairless dogs implicates FOXI3 in ectodermal development. *Science* **321**: 1462–1462. DOI:10.1126/science.1162525.

Larson G, Karlsson EK, Perri A, Webster MT, Ho SYW, Peters J, Stahl PW, Piper PJ, Lingaas F, Fredholm M, Comstock KE, Modiano JF, Schelling C, Agoulnik AI, Leegwater PA, Dobney K, Vigne J-D, Vilà C, Andersson L, Lindblad-Toh K. 2012. Rethinking dog domestication by integrating genetics, archeology, and biogeography. *Proceedings of the National Academy of Sciences* **109**: 8878–8883. DOI:10.1073/pnas.1203005109.

Legendre S, Roth C. 1988. *Correlation of Carnassial Tooth Size and Body Weight in Recent Carnivores (Mammalia) Historical Biology: An International Journal of Paleobiology* **1**: 85–98.

Losey RJ, McLachlin K, Nomokonova T, Latham K, Harrington L. 2016. Body mass estimates in dogs and North American gray wolves using limb element dimensions. *International Journal of Osteoarchaeology*, n/a-n/a. DOI:10.1002/oa.2528.

Losey RJ, Osipov B, Sivakumaran R, Nomokonova T, Kovychev EV, Diatchina NG. 2014. Estimating body mass in dogs and wolves using cranial and mandibular dimensions: Application to Siberian Canids. *International Journal of Osteoarchaeology* **25**: 946–959. DOI:10.1002/oa.2386.

Meadow RH. 1999. The use of size index scaling techniques for research on archaeozoological collections from the Middle East. *Historia Animalium ex Ossibus. Beiträge zur Paläoanatomie, Archäologie, Ägyptologie, Ethnologie und Geschichte der Tiermedizin. Festschrift für Angela von den Driesch zum 65*, C Becker, H Manhart, J Peters, J Schibler (eds.). Geburtstag, Von Marie Leidorf GmbH: Rahden.

Mendoza España, V., Valadez Azúa, R., 2006. El perro prehispánico andino: función y tipos a partir del análisis arqueozoológico, Anales de la XIX Reunión Anual de Etnología, Museo Nacional de Etnografía y Folklore (MUSEF), La Paz., pp. 31-38.

Nielsen AE. 2001. Evolución social en la Quebrada de Humahuaca (AD 700-1536). *Historia Argentina Prehispánica*, EE Berberian, AE Nielsen (eds.). Brujas: Córdoba; 171–264.

Prates L, Berón M, Prevosti FJ. 2010a. Los perros prehispánicos del Cono sur. Tendencias y nuevos registros. *Mamül Mapu: pasado y presente desde la arqueología pampeana*, M Berón, L Luna, M Bonomo, C Montalvo, C Aranda, M Carrera Aizpitarte (eds.). Libros del Espinillo: Ayacucho (Pcia. de Buenos Aires); 215–218.

Prates L, Prevosti FJ, Berón M. 2010b. First Records of Prehispanic Dogs in Southern South America (Pampa-Patagonia, Argentina). *Current Anthropology* **51**: 273–280. DOI:10.1086/650166.

Prevosti FJ, Lamas L. 2006. Variation of cranial and dental measurements and dental correlations in the pampean

fox (*Dusicyon gymnocercus*). *Journal of Zoology* **270**: 636–649. DOI:10.1111/j.1469-7998.2006.00187.x.

Rimbault M, Beale HC, Schoenebeck JJ, Hoopes BC, Allen JJ, Kilroy-Glynn P, Wayne RK, Sutter NB, Ostrander EA. 2013. Derived variants at six genes explain nearly half of size reduction in dog breeds. *Genome Research* **23**: 1985–1995. DOI:10.1101/gr.157339.113.

Rivolta, C., 2000. *90 años de investigación en la Quebrada de Humahuaca: un estudio reflexivo*, Instituto Interdisciplinario de Tilcara, FFyL-UBA, Tilcara.

Stahl PW. 2012. Interactions between humans and endemic canids in Holocene South America. *Journal of Ethnobiology* **32**: 108–127. DOI:10.2993/0278-0771-32.1.108.

Tarragó MN, González LR, Ávalos G, Lamami M. 2010. Oro de los señores. La tumba 11 de La Isla de Tilcara (Noroeste argentino). *Boletín del Museo Chileno de Arte Precolombino* **15**: 47–63. DOI:10.4067/S0718-68942010000200004.

van Asch B, Zhang A-b, Oskarsson MCR, Klütsch CFC, Amorim A, Savolainen P. 2013. Pre-Columbian origins of Native American dog breeds, with only limited replacement by European dogs, confirmed by mtDNA analysis. *Proceedings of the Royal Society of London B: Biological Sciences* **280**. DOI:10.1098/rspb.2013.1142.

Vásquez Sánchez VF, Rosales Tham TE, Dorado G. 2009. Morphotypes and breeds of dogs (*Canis lupus familiaris* L.) from the Moche Period. *Arqueobios* **3**: 20–33.

von den Driesch A. 1976. *A Guide to the Measurement of Animal Bones from Archaeological Sites*. Peabody Museum of Archaeology and Ethnology, Harvard: Cambridge (Massachusetts).

Wing ES. 1978. Animal domestication in the Andes. *Advances in Andean archaeology*, DL Browman (ed.). The Hague: Mouton; 167–188.

Supporting information

Supporting information may be found in the online version of this article.