Indigenous animal management practices on the eve of Columbus' landfall: Isotopic and zooarchaeological investigations in the Dominican Republic and Jamaica

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REPORT

An Isotopic and Morphometric Examination of Island Dogs (*Canis familiaris*): Comparing Dietary and Mobility Patterns in the Precolumbian Caribbean

Gene T. Shev, Jason E. Laffoon, Sandrine Grouard, and Corinne L. Hofman

*In precolumbian insular Caribbean archaeological sites, domestic dog (*Canis familiaris*) remains have been recovered from varied contexts, such as formal burials, in refuse deposits, and as modified artifacts, indicating their complex and multifaceted role within indigenous societies. In this study, isotopic and morphometric analyses provide biochemical and morphological correlations to assess this differential treatment. We examined collagen values (n = 21) of carbon ($\delta^{13}C_{co}$) and nitrogen ($\delta^{15}N$), and enamel values (n = 81) of carbon ($\delta^{13}C_{en}$), oxygen ($\delta^{18}O_{en}$), and strontium ($^{87}Sr/^{86}Sr$) of dog remains from 16 precolumbian sites. Five comparative parameters were used to assess dietary variations between different groups: buried versus nonburied, local versus nonlocal, Greater versus Lesser Antilles, chronology, and modified versus unmodified remains. The only statistically significant difference in diets was between local and nonlocal dogs. Sufficient data were available to conduct isotopic mixing models using the FRUITS statistical program on four individuals for which depositional and morphological data were available. Results of dietary modeling indicate an unexpectedly heavy reliance on plant foods consistent with intentional feeding. This approach highlights the utility of combining isotope analysis, dietary models, morphometrics, and depositional context to provide comprehensive biographic overviews of individual animals.*

Keywords: isotopic analysis, Caribbean archaeology, paleodiet, dog domestication, dietary mixing models, morphometrics

*En del Caribe insular precolombino, los restos de perros (*Canis familiaris*) se recuperan de diversos contextos, como entierros, en depósitos de basura y artifactos modificados, lo que indica su papel multifacético dentro de las sociedades indígenas. En este estudio, los análisis isotópicos y morfométricos intentan proporcionar correlaciones bioquímicas y morfológicas para evaluar este tratamiento diferencial. Valores de colágeno (n = 21) de carbono ($\delta^{13}C_{co}$) y nitrógeno ($\delta^{15}N$), y valores de esmalte (n = 81) de carbono ($\delta^{13}C_{en}$), oxígeno ($\delta^{18}O_{en}$) y estroncio ($^{87}Sr/^{86}Sr$) de perros han sido examinados de 16 sitios precolombinos. Cinco parámetros evalúan las variaciones dietéticas entre los diferentes grupos: enterrados versus no enterrados, locales versus no locales, Antillas mayores versus menores, cronología, y restos modificados versus no modificados. Los resultados indican que la única diferencia significativa en las dietas fue entre locales y no locales. Los datos estaban disponibles para llevar a cabo modelos de mezcla isotópica utilizando el programa estadístico FRUITS en cuatro individuos. Los resultados del modelado dietético indican una dependencia inesperada de los alimentos vegetales, consistente con la alimentación intencional. Este enfoque destaca la utilidad de combinar análisis de isótopos, modelos dietéticos, morfometría y contexto de depósito para proporcionar descripciones biográficas de los animales.*

Palabres clave: análisis isotópico, Arqueología caribeña, dieta paleo, domesticación de perros, modelos de mezcla dietética, morfometría

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Cross-culturally, dogs (*Canis familiaris*, Linnaeus 1758) are often valued members of societies, as expressed in the commonality of their inhumation, a practice rarely seen with other animals (Russell 2011). Within the precolumbian Caribbean, the role of dogs was that of a hunting aid, a companion, and potentially a food source (Grouard et al. 2013; Las Casas 1876 [1561]). Earlier studies on precolumbian Caribbean dogs assessed morphological differences (Grouard et al. 2013) and provided isotopic evidence of dietary and mobility patterns (Laffoon et al. 2015, 2019). This article provides additional morphological data and is the most expansive investigation of Caribbean *C. familiaris* isotopic values conducted to date.

Multi-isotopic analyses of precolumbian dogs in the insular Caribbean have primarily focused on enamel samples, with some collagen samples from El Flaco and El Carril in the Dominican Republic (Shev 2018) and from Punta Candelero in Puerto Rico (Pestle 2010). Laffoon and colleagues (2019) incorporated strontium ($^{87}Sr/^{86}Sr$) and carbon ($\delta^{13}C$) isotope values from El Flaco and El Cabo in the Dominican Republic and from Morel and Anse à la Gourde in Guadeloupe, demonstrating similarities between human and dog diet and mobility patterns at these sites. These human–dog linkages were previously reported globally in diverse archaeological contexts, leading to the proposition of a "canine surrogacy approach" in which dogs could be used as an isotopic surrogate for human remains (Guiry 2012).

An earlier study by Grouard and coauthors (2013) assessed the morphology of buried dogs from the region, indicating some differences in estimated withers heights (Grouard et al. 2013). These data suggest there may have been more than one variety of dog within the insular Caribbean. This notion may be supported by Las Casas, who reported the existence of two different breeds that may have received different treatment by humans (1876 [1561]). In our study, we assessed the withers heights of dogs from El Flaco and El Carril to determine whether there are correlations between morphology and differential treatment in the form of formal burials or dietary regimes.

We also compared *C. familiaris* isotope values from Puerto Rico, the Dominican Republic, Cuba, Saint-Martin, Guadeloupe, Barbados, and Grenada (Figure 1; Supplemental Table 1) according to five criteria: local versus nonlocal, Early Ceramic (500 BC–AD 600) versus Late

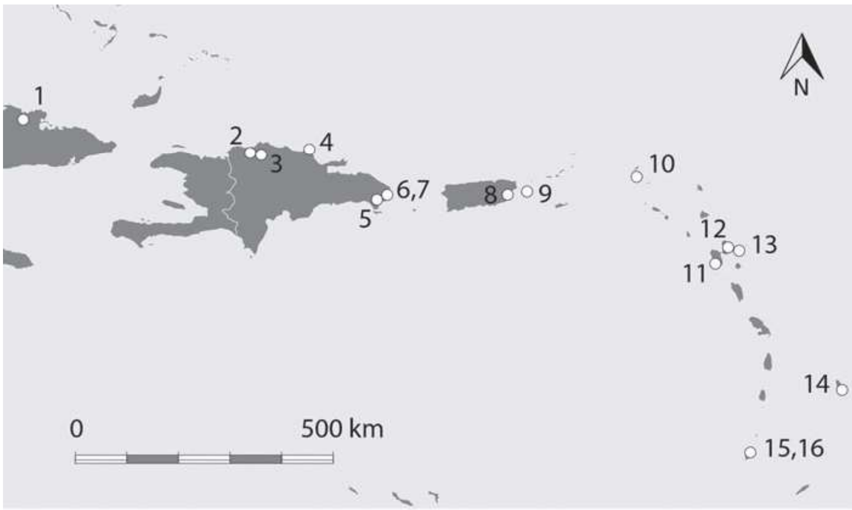

Figure 1. Map of precolumbian sites from which samples were acquired. (1) Cueva Belica, Cuba; (2) El Flaco, Dominican Republic (D.R.); (3) El Carril, D.R.; (4) Playa Grande, D.R.; (5) Cueva de Berna, D.R.; (6) El Cabo, D.R.; (7) Manantial de Cabo san Rafael, D.R.; (8) Punta Candelero, Puerto Rico; (9) Sorcé, Vieques; (10) Hope Estate, Saint-Martin; (11) Cathédrale de Basse-Terre, Guadeloupe; (12) Morel, Guadeloupe; (13) Anse à la Gourde, Guadeloupe; (14) Silver Sands, Barbados; (15) La Poterie, Grenada; (16) Pearls, Grenada.

Ceramic Ages (AD 600–1500/1600), buried versus nonburied individuals, Greater versus Lesser Antillean, and modified (e.g., pendants) versus unmodified remains. Where applicable, published morphometric data permitted comparisons between, diet, localness, and morphology. Additionally, a dietary mixing model was applied to four buried dogs, providing a detailed biography of these individuals. Estimated withers heights provide morphological evidence for the existence of two native "breeds" of dogs; details regarding FRUITS mixing models are further addressed in the online supplement (Supplemental Text 1).

A total of 81 teeth and 24 bone collagen samples of *C. familiaris* were sourced from precolumbian sites throughout the Caribbean, including from a dog burial at El Flaco (Supplemental Table 1), and were analyzed by Shev (2018). Methods of stable isotope analysis, morphometric analysis, and FRUITS dietary mixing models are published extensively elsewhere and are presented online (Supplemental Text 1).

Results

Withers Height

Withers height was estimated for dogs from El Flaco ($n = 2$) and was added to Grouard and coauthors' (2013) data (Supplemental Table 2).

Collagen Isotope Data

In total, 21 samples yielded high-quality collagen. An overlap in isotope values can be observed in all parameters of examination (Figure 2a). Further details on sample conditions and results are provided in the online supplement (Supplemental Text 1).

Enamel Isotope Data

Local versus Nonlocal. Thirteen of 50 samples possess strontium isotope ratios interpreted as nonlocal (Figure 2b) and showed relative enrichment in $\delta^{13}C_{en}$ values (local, $\mu = -11.26‰$, Mdn = −11.28‰; nonlocal, $\mu = -10.66‰$, Mdn = −10.99‰). The Greater Antillean nonlocal $\delta^{13}C_{en}$ mean value was 0.61‰ higher than in locals; in the Lesser Antilles the nonlocal $\delta^{13}C_{en}$ value was 0.7‰ higher (Figure 3a). A *t*-test confirmed a significant difference in means ($t = 2.2638$, $p = 0.029079$). Excluding outliers larger than one standard deviation (critical $t = 2.0484$, $p = 0.021275$) also demonstrated significant differences. Details regarding limitations in Caribbean isoscapes are available online (Supplemental Text 1).

Burials versus Nonburials. $\delta^{13}C_{en}$ values were available for 16 buried and 28 nonburied dogs, showing broad similarities between groups (burials, $\mu = -10.86‰$, Mdn = −10.99‰; nonburials, $\mu = -11.07‰$, Mdn = −11.17‰) and demonstrating no significant dietary differences between buried individuals and those that were not. There was no correlation between localness and the propensity for burial: 21.4% of buried and 26.7% of nonburied individuals were nonlocal.

Greater versus Lesser Antilles. Diets of dogs from the Greater ($n = 48$) and Lesser Antilles ($n = 25$) were similar (G. Antilles, $\delta^{13}C_{en}$ $\mu = -11.11‰$, L. Antilles, $\delta^{13}C_{en}$ $\mu = -10.88‰$; G. Antilles, Mdn = −11.17‰, L. Antilles, Mdn = −11.07‰). Given the disparity in sample numbers between the two regions, we ran a *t*-test (critical $t = 1.9939$, $p = 0.33867$), which confirmed there was no significant difference in mean values.

Early (500 BC–AD 600) versus Late Ceramic Age (AD 500/600–1500). There were no significant differences in means (Early, $\delta^{13}C_{en}$ $\mu = -10.83‰$; Late, $\delta^{13}C_{en}$ $\mu = -11.12‰$). Both groups demonstrated considerable overlap.

Modified versus Unmodified. No dietary differences were observed between modified ($n = 22$) and unmodified remains ($n = 44$). Both groups exhibited similar values (modified, $\delta^{13}C_{en}$ $\mu = -11.12‰$, Mdn = −11.07‰; unmodified, $\delta^{13}C_{en}$ $\mu = -10.98‰$, Mdn = −11.08‰). The vast majority of modified remains ($n = 22$, 95.7%) were nonlocal, with the exception of a perforated canine from Manantial del Cabo de San Rafael ($^{87}Sr/^{86}Sr = 0.7092$, local range = 0.70914–0.70924).

Dietary Mixing Models

The results of the FRUITS modeling are presented in Figure 3b and Table 1 (see also Supplemental Text 1). They suggest that these dogs mainly consumed plants foods with modest amounts of C_4 plants (likely maize), possibly indicating intentional feeding. Of these, the two nonlocal dogs (FL FND2270 and MO FND2729) exhibited relatively higher proportions of marine protein consumption.

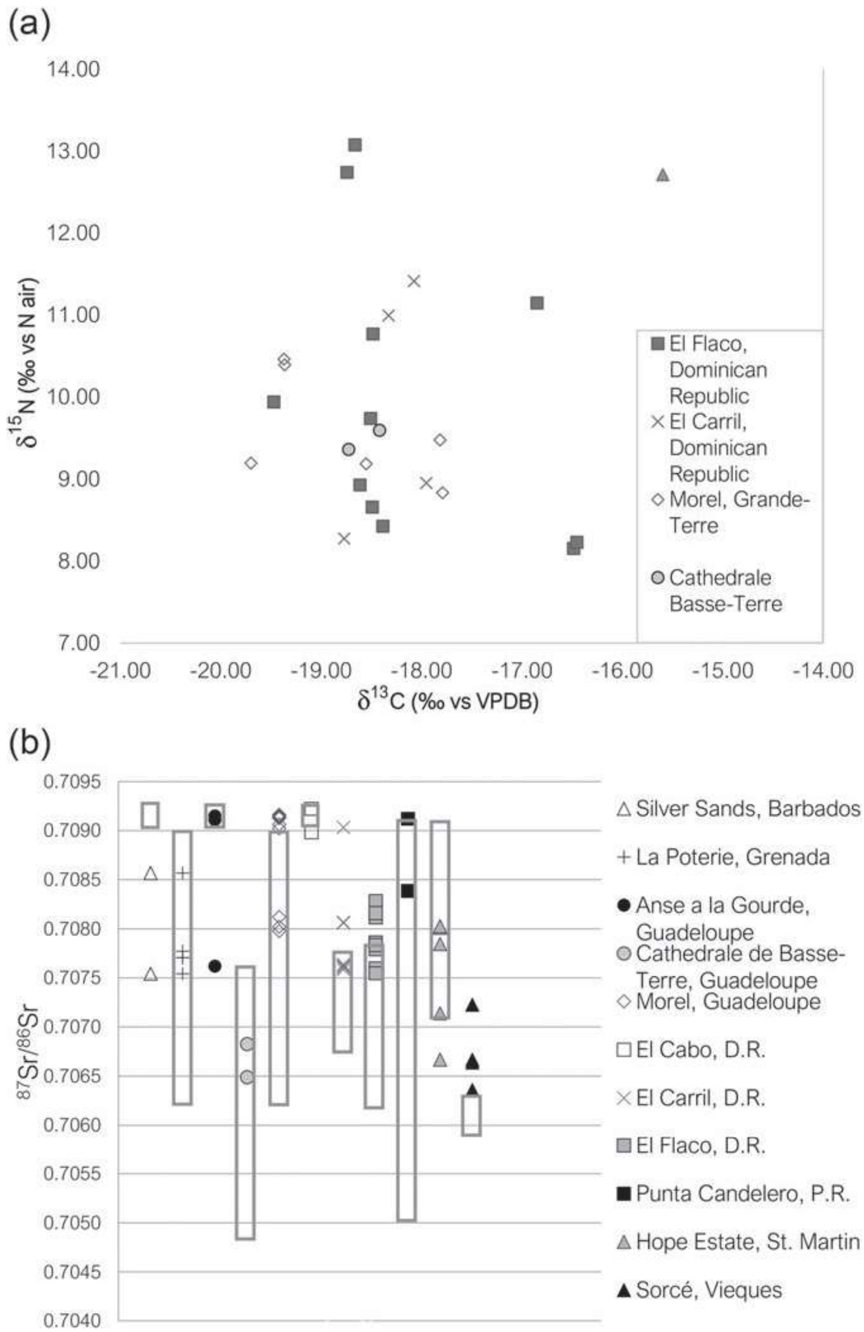

Figure 2. **(a) Bivariate plot of dog $\delta^{15}N$ and $\delta^{13}C$ values from El Flaco and El Carril, Dominican Republic; Morel and Cathédrale de Basse-Terre, Guadeloupe; and Hope Estate, Saint-Martin (Shev 2018); (b) chart showing the estimated bioavailable $^{87}Sr/^{86}Sr$ local ranges (represented by boxes) of each site/island and whether each sample fits into or outside these ranges.**

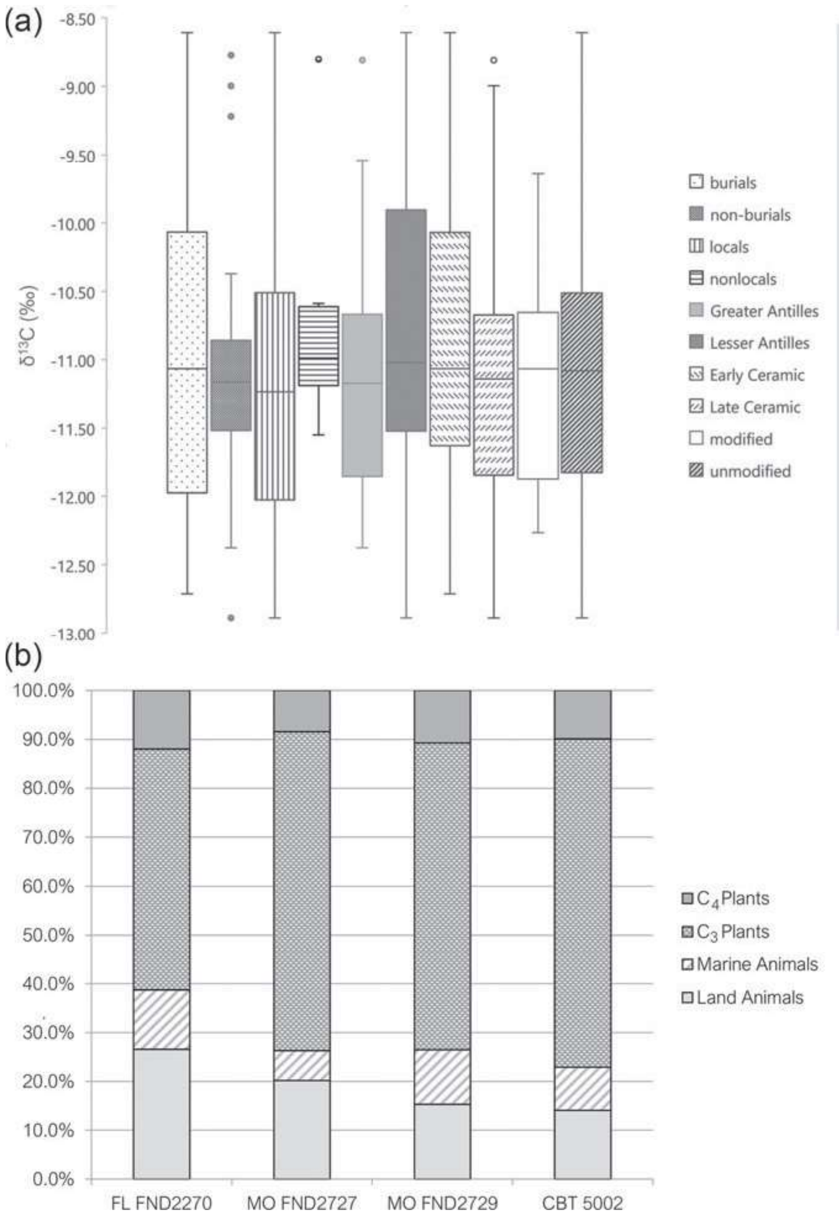

Figure 3. (a) Box plot showing median $\delta^{13}C_{en}$ values (horizontal line), inner quartiles (box), value ranges (whiskers), and outliers (dots) for all comparative parameters; (b) FRUITS dietary mixing model results for El Flaco (FND 2270), Morel (FND 2727 and FND2729), and Cathédrale de Basse-Terre (CBT5002).

Discussion

We found overlapping mean values in four of the five comparative parameters. The values are similar to those of humans from the region, likely reflecting broad-spectrum diets comprised of C_3 plants supplemented with C_4 crops, as well as terrestrial and marine proteins (Laffoon et al. 2019; Pestle and Laffoon 2018). These data suggest that dogs are an effective isotopic surrogate in the precolumbian Caribbean.

Table 1. Dietary Estimates (%) for Four Caribbean Dog Specimens Derived from the FRUITS Dietary Mixing Model.

Sample ID	Land Animals	Marine Animals	C_3 Plants	C_4 Plants	Animal	Plant
FL FND2270	26.6	12.2	49.3	12.0	38.7	61.3
MO FND2727	20.2	6.2	65.2	8.4	26.3	73.7
MO FND2729	15.4	11.1	62.8	10.7	26.5	73.5
CBT 5002	14.1	8.8	67.2	9.9	22.9	77.1

The only significant difference in mean $\delta^{13}C$ values that we found is between nonlocals and locals. Of all samples ($n = 49$), 22.4% were deemed nonlocal. They likely either migrated alongside humans to new locations or were exchanged between different human groups. Similar mobility patterns have been suggested for Anse à la Gourde and Morel, where 30% of studied dogs were nonlocal (Laffoon et al. 2015, 2019; Plomp 2013).

Ethnographies of indigenous peoples from the South American lowlands provide insight into how dogs may have been treated in the past (see Koster 2009). The exchange of hunting dogs by renowned dog breeders such as the Waiwái of Guyana and Brazil (Howard 2001:248) may serve as a useful analogy. Ethnohistoric sources describe the use of dogs in Hispaniola as valued hunting aids, although it is possible that dogs were also a food source (Las Casas 1876 [1561]:341). However, given the sparse evidence of butchery or cooking, the consumption of dogs may have been restricted to times of food scarcity (Wing 2008). It is unlikely that dogs were traded as food; it is more probable that they were migratory companions or prized dogs exchanged between communities.

One nonlocal specimen from El Carril (FND 30) had an $^{87}Sr/^{86}Sr$ ratio (0.7090) denoting a likely coastal origin. This sample also had the most enriched $\delta^{13}C_{en}$ (−8.8‰) and $\delta^{18}O_{en}$ (−1.8‰) values of any dog from Hispaniola (Shev 2018). This individual likely subsisted on a diet rich in marine proteins, with higher oxygen values indicating natal origins in an arid, low-altitude, or coastal region (Wang et al. 2016). Two nonlocal dogs from Silver Sands in Barbados demonstrated similarly high $\delta^{13}C_{en}$ values (−8.8‰ and -8.6‰), whereas one exhibited an $^{87}Sr/^{86}Sr$ ratio (0.7075) suggesting possible natal origins from a nearby island. According to the FRUITS modeling, two nonlocals (FL FND2270 and MO FND2729) consumed higher proportions of marine proteins, indicating that some individuals that were exchanged or migrated alongside humans were possibly "sea dogs" consuming foods such as pelagic fish.

Conclusion

Broad similarities and trends can be seen in the paleodietary and mobility signatures of dogs analyzed throughout the insular Caribbean, regardless of time period, burial context, and location. At a regional scale, geographic patterning of isotopic values of dogs appears to mirror that of humans for the most part. The most significant disparity in diet occurs between local and nonlocal dogs, which is statistically significant enough to merit consideration. Nonlocal dogs likely received different foods than did locals, perhaps reflecting differences in social value or spatially structured foodways between certain individuals. The findings from the dietary mixing model suggest that the two nonlocals had diets higher in marine protein than the two local dogs; however, more data are needed to accurately assess whether there is a broader correlation between mobility and enriched isotopic values.

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Data Availability Statement. All data resulting from this research are within this article and in the supplemental materials; they are also available in the Easy archive at KNAW/DAN (https://easy.dans.knaw.nl/).

Supplemental Materials. For supplemental material accompanying this article, visit https://doi.org/10.1017/laq.2020.58.

Supplemental Text 1. Size estimations, isotopic analysis methodology, FRUITS dietary mixing models, collagen data, Caribbean isoscapes, and enamel data.

Supplemental Table 1. List of *C. familiaris* Enamel and Collagen Samples and Values from the Insular Caribbean.

Supplemental Table 2. Estimated Height at Withers (WH) from the Total Length (TL) of Long Bones.

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Supplementary text 1: Size estimations, isotopic analysis methodology, FRUITS dietary mixing models, collagen data, Caribbean isoscapes, enamel data

Methods

Size estimations – calculating withers height

The determination of withers height (WH) has the greatest utility in assessing variability in size between individuals and of reconstructing the morphological characteristics of dogs (Clark 1995). Statistically reliable estimations of withers height can be determined from the calculation of cranial dimensions (Chrószcz et al., 2007), metapodia length (Clark, 1995), and long bone length (Harcourt, 1974). All three sets of formulae were employed in the calculation of withers height for three individuals recovered at El Flaco (n=2) and El Carril (n=1).

The morphology of individual buried dogs from the islands of Basse-Terre and Grande-Terre in Guadeloupe, and Barbuda is recorded in the publication by Grouard et al. (2013), which also includes data recorded by Lawrence (1977) of five buried dogs from the Dominican Republic. In addition, a further three individual withers heights (WH) were calculated from remains recovered at the sites of El Flaco and El Carril (Shev 2018). These morphological indicators allow a cross-comparison between the stature and isotopic values denoting diet and mobility of pre-Columbian dogs.

At El Carril a disarticulated partial skeleton primarily consisting of appendicular elements and lacking any axial elements was recovered from non-burial contexts in Unit 10 during excavation (Figure 2a). These refitting elements were excavated from across three 1 x 1m excavation units to a depth of 30 cm and are assumed to belong to the same individual. Of this individual only two complete bones (FND 424) were amenable for estimating WH; a left tibia and a left fifth metatarsal. Two complete C. familiaris skeletal elements from El Flaco allowed WH estimations; a fifth metacarpal (FND 2821) recovered from Layer 1, Unit 69, and a crania, FND 2270 (Figure 2b, c), that was recovered in burial contexts (Shev, 2018). The latter element was recovered alongside two pelvic bones (Figure 2d) likely from the same individual and was found to be in contextual association with 18 human burials that dated to between cal. AD 1250 to 1490 (Hofman et al. 2018; Hofman and Hoogland 2015; Keegan and Hofman 2017:128-129).

A disarticulated skull from El Flaco (FND 2270) from which the distance between the ethmoideum and basion was 65.27 mm, allowed WH to be calculated following the regression formula outlined by Chrószcz (2007). An isolated fifth metacarpal (FND 2821) had a total length (GL) of 44.15 mm, from which WH was estimated following Clark (1995). From El Carril two elements from a disarticulated skeleton (FND 424) were amenable for WH estimation; a left tibia with a GL of 158.68 mm that demonstrated a shortest distance at midshaft (SD) of 10.09 mm, and a fifth metatarsal with a GL of 56.46 mm. Withers height was calculated from measurement of these two elements and the average was taken as the most accurate value representing stature. The withers heights of these three samples have been compared to the statures of dogs (Table 2) outlined in Grouard et al. (2013).

The three new dogs (El Flaco (FND 2270, FND 2821) and El Carril (FND 424) from the Dominican

Republic (from Shev 2018) have respectively 351, 417, and 459 mm height. The first one is smaller than the burial dogs from the Dominican Republic (from Lawrence 1977), that were already the smallest dogs from the Caribbean. Consequently, the dog from El Flaco FND 2270 is the smallest dog ever measured in the Antilles. The dog from El Carril (FND 424) is the tallest dog ever measured in the Antilles, even the burial dog from Seaview, Barbuda. Finally, the last one, El Flaco FND 2821 is within the average range of the 18 measured dogs.

Morphological reconstructions indicate that the only buried dog from El Flaco was of similar stature to others that have been recovered from archaeological sites in the Dominican Republic (Grouard et al. 2013; Lawrence 1977). In contrast, the remains of two dogs recovered from non-burial contexts at El Flaco and the nearby and contemporaneously inhabited site of El Carril were from individuals of a considerably taller stature (Shev 2018). This is in line with Columbus' assessment of the existence of two breeds of dogs in the Caribbean. However, a thorough assessment of whether there may have been an Indigenous preference for burying smaller dogs requires the gathering of additional osteometric data of dog remains from both burial and domestic contexts.

As the osteometric data suggests, two distinct breeds of dogs possibly existed in Hispaniola prior to the arrival of Europeans, and although their overall diets were similar there may have seemingly been a preference for the burial of smaller dogs. According to Las Casas, it was this miniature breed that was likely called 'aon' by the Taíno of island of Hispaniola that was the preferred breed which was habitually lavished with affection (Las Casas 1876[1561]).

Isotopic analysis methodology

A selection of canid remains underwent isotopic analysis using standard procedures and protocols for archaeological skeletal materials as detailed elsewhere (Laffoon et al. 2015; Laffoon et al. 2017). Carbon isotope ($\delta^{13}C_{en}$) values from tooth enamel, and carbon ($\delta^{13}C_{co}$) and nitrogen ($\delta^{15}N$) isotope values from bone collagen were obtained in order to assess paleodiets of select individual dogs. To assess mobility patterns affecting dogs from the region, strontium ($^{87}Sr/^{86}Sr$) and oxygen ($\delta^{18}O$) isotope values were obtained from dental enamel. Note that the analysis of $\delta^{18}O$ values has demonstrated little potential as a proxy for determining provenance in the insular Caribbean, and oxygen isotope values appear to have little correlative relationship with $^{87}Sr/^{86}Sr$ values (Laffoon et al. 2013). Oxygen enrichment in organisms is also dependent on the sources of water utilized, metabolic differences between individuals of the same species, with the additional problem of consumption of C_3 plants enriching oxygen values compared to that of C_4 plants (Kohn 1996. These significant variables mean that oxygen isotopes can have limited application for determining provenance in certain regions, therefore it is often better to corroborate oxygen with other isotope proxies such as carbon and strontium (Sharpe et al. 2018).

Given that carbon isotope values from enamel illustrate whole diet whilst collagen is more representative of protein intake (Ambrose and Norr 1993), these data sets have been analyzed separately as they denote different dietary aspects, with the notable exception for the few samples (n=4) for which both collagen and enamel data were available. Not every tooth sample was subject to both carbon and strontium analyses, therefore some samples are better illustrative of origin, whilst others purely denote dietary intake.

Another consideration concerning limitations is the efficacy of conducting bulk analysis of isotopic data from sites that are temporally and geographically distant, this has been taken into account when interpreting the data. Where applicable, outlying values were excluded from the analysis of certain criteria when testing for statistical significance.

As a caveat, the assessment of the localness of a specimen must also take into consideration the overlap in bioavailable $^{87}Sr/^{86}Sr$ values throughout the insular Caribbean (Laffoon 2012), therefore organisms that are deemed local may in fact originate from different localities with similar baseline $^{87}Sr/^{86}Sr$ values (e.g. false negatives). For example, an organism deemed as local to the site of El Cabo in the eastern Dominican Republic could potentially have originated from a coastal location in Puerto Rico that demonstrates similar isotope baseline ranges (Bataille et al. 2012; Laffoon 2012).

FRUITS dietary mixing model

The use of mixing models for isotopic dietary reconstructions have been steadily increasing in recent years (see Parnell et al. 2013). For this study, we applied a multi-source mixing model to obtain quantitative estimates of the relative proportions of different foods to individual dog diets. Dog stable isotope data were analyzed with the Bayesian mixing model software FRUITS (Food Reconstruction Using Isotopic Transferred Signals) v2.1.1 (Fernandes et al. 2014). Food source isotope data was extracted from the compiled foodweb isotopic data set for the Caribbean from Pestle (2010). From this database, we extracted the relevant isotopic data for all plant and animal species that are native to Hispaniola and surrounding waters. All other model input parameters are identical to those presented in Pestle and Laffoon (2018). In order to implement dietary mixing models both enamel and collagen isotopic values need to be available. Sufficient isotopic data was available four such dogs: one from El Flaco, Dominican Republic, two from Morel and one from Cathédrale de Basse-Terre (CBT5002), Guadeloupe.

All four dogs have analogous diets, although with some limited inter-individual variation (Figure 6; Table 3). The Greater Antillean sample from El Flaco (FND2270) seems to have been consuming higher proportions of terrestrial animals than the Lesser Antillean samples, although also seems to be consuming more proteins in general, including marine-sourced foods when compared to the other three individuals. In terms of withers height, the buried individual from El Flaco (351 mm) is of considerably shorter stature (Table 2), however this size disparity can perhaps be accounted for given the temporal and geographic distance between the samples having been recovered from a Late Ceramic Age site in Hispaniola compared to the other three individuals who were all from Early Ceramic Age sites in the Lesser Antilles. Surprisingly, regardless of distinctions in geographical distance and time period all four dogs appear to be consuming much more plant food in general (especially C_3 plants) than animal food. In fact, for the three Lesser Antillean samples, the proportion of plant to animal food consumption is roughly 3:1.

Collagen Isotope Data

Collagen samples extracted by Shev (2018) from dog skeletal remains from El Flaco (n=10), El Carril (n=5) in the Dominican Republic, Cathédrale de Basse-Terre (n=2) and Morel (n=6) in Guadeloupe, and Hope Estate (n=1) in Saint-Martin were analyzed for $\delta^{13}C_{co}$ and $\delta^{15}N$ values (Figure 3). Five samples did not contain sufficient collagen (Morel 2732, El Flaco FND 731, 2610, 2838; El Carril FND 716), and of the 24 successful extractions three samples (Morel 2734; Morel 2728; HE3305B) demonstrated C:N values outside the accepted range according to criteria outlined by Ambrose (1990), and another sample (HE2503C) did not produce a reliable measurement. None of these samples were considered further.

The mean collagen values for all samples were $\delta^{15}N$ 9.9‰ and $\delta^{13}C$ -18.2‰ with a range of 4.9‰ for nitrogen and 4.1‰ for carbon. Between the Greater Antilles and the Lesser Antilles there are broad similarities, with both regions demonstrating similar overall means in both carbon and nitrogen (G. Antilles: $\delta^{15}N$ = 9.9‰, $\delta^{13}C_{co}$ = -18.1‰; L. Antilles: $\delta^{15}N$ = 9.9‰, $\delta^{13}C_{co\,=}$ -18.4‰) as well as for the median and range of the values. This similarity in mean values is also reflected in the assessment of burials ($\delta^{15}N$ = 9.6‰, $\delta^{13}C_{co}$ = -18.6‰) relative to non-burials ($\delta^{15}N$ = 9.9‰, $\delta^{13}C_{co}$ = -18.0‰) although the carbon isotope values of non-burials are slightly higher overall.

The variance of nitrogen isotope values of non-burials ($\sigma 2$ = 2.98) is considerably greater than that of burials ($\sigma 2$ = 0.54), however a t-test (critical t value = 2.0639; p = 0.36819) indicated that there is no significant difference between the means of both groups.

Strontium isoscape limitations

The analysis of strontium values coupled with known and estimated regional isoscape data (Bataille et al. 2012; Laffoon et al. 2012; Laffoon et al. 2017; Pestle et al. 2013) permits the determination of whether individual dogs were raised local to their respective excavation sites, or whether they were of nonlocal origin. Certain limitations in terms of calculating potential local ranges were apparent as the local ranges of some sites are currently unknown. This is the case for Punta Candelero, Puerto Rico ($^{87}Sr/^{86}Sr$ 0.7050 – 0.7092), La Poterie, Grenada (0.7062 – 0.7090), Silver Sands, Barbados (0.7081-0.7093) and for Hope Estate, Saint-Martin (0.7071 – 0.7092) where the local ranges for the whole islands in which these sites are located were used to determine localness.

Enamel results: Local versus nonlocal – results per island

Percentages of nonlocal individuals were at 23.1% (n=3) for Morel and 33.3% (n=1) for Anse à la Gourde in Grande-Terre, Guadeloupe; 50% (n=1) of samples at Silver Sands, Barbados; 42.9% nonlocal at both El Flaco (n=3) and El Carril (n=3), Dominican Republic; and one individual (20%) from Hope Estate, Saint-Martin was determined to have nonlocal origins. Sites not mentioned contained dogs that were determined to be purely local in origin, this includes the two individuals from Punta Candelero, Puerto Rico and the five analyzed dogs from La Poterie, Grenada, however as aforementioned due to the application of island-wide baseline strontium isotope values to these two sites there is potential for a few of these samples to have had alternative natal origins.

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Supplementary table 1

List of *C. familiaris* enamel and collagen samples and values from the insular Caribbean. Includes the archaeological context of recovery from burial or non-burial contexts and whether samples were modified. Period: EC = Early Ceramic Age (c. 500 BC – AD 600). LC = Late Ceramic Age (c. AD 600 – 1500). Col. = colonial period (c. AD 1500 – 1800)

Island	Site	ID	Period	Burial context	Material	Modified/unmodified	$^{87}Sr/^{86}Sr$ corrected	$\delta^{13}C_{en}$ (‰ vs VPDB)	$\delta^{18}O$ (‰ vs VPDB)	$\partial^{15}N$ (‰ vs N_{air})	$\partial^{13}C_{CO}$ (‰ vs VPDB)	Reference
Barbados	Silver Sands	CDB28	EC	Burial	Enamel	Unmodified	0.7075	-8.8	-3.2	—	—	Laffoon et al. 2017
Barbados	Silver Sands	CDB25	EC	Burial	Enamel	Unmodified	0.7086	-8.6	-3.1	—	—	Laffoon et al. 2017
Cuba	Cueva Belica	CBD4	LC	Burial	Enamel	Unmodified	0.7081	-11.9	-3.9	—	—	
Cuba	Cueva Belica	CBD5	LC	Burial	Enamel	Unmodified	0.7088	-8.8	-2.1	—	—	
Cuba	Cueva Belica	CBD6	LC	Burial	Enamel	Unmodified	0.7060	-10.5	-4.7	—	—	
Cuba	Cueva Belica	CBD7	LC	Burial	Enamel	Unmodified	0.7061	-12.2	-3.7	—	—	
Dom. Rep.	Cueva de Berna	CBD57	EC	N/A	Enamel	Unmodified	0.7091	-11.9	-4.3	—	—	
Dom. Rep.	El Cabo	FNR1604	LC	Non-burial	Enamel	Unmodified	0.7090	-11.4	-1.8	—	—	Laffoon et al. 2017
Dom. Rep.	El Cabo	FNR2722	LC	Non-burial	Enamel	Unmodified	0.7092	-11.6	-1.3	—	—	Laffoon et al. 2017
Dom. Rep.	El Cabo	FNR1381	LC	Non-burial	Enamel	Modified	0.7087	-11.4	-4.5	—	—	
Dom. Rep.	El Cabo	FNR3690	LC	Non-burial	Enamel	Modified	0.7085	-9.9	-6.8	—	—	
Dom. Rep.	El Cabo	FNR3766	LC	Non-burial	Enamel	Modified	0.7080	-11.1	-4.4	—	—	
Dom. Rep.	El Carril	FND 30	LC	Non-burial	Enamel	Unmodified	0.7090	-8.8	-1.8	—	—	Shev 2018
Dom. Rep.	El Carril	FND 687	LC	Non-burial	Enamel	Unmodified	0.7076	-12.4	-5.3	—	—	Shev 2018
Dom. Rep.	El Carril	FND 701 #35	LC	Non-burial	Enamel and bone	Unmodified	0.7076	-12.0	-4.8	8.3	-18.8	Shev 2018
Dom. Rep.	El Carril	FND 903	LC	Non-burial	Enamel	Unmodified	0.7076	-11.4	-3.5	—	—	Shev 2018
Dom. Rep.	El Carril	FND 716	LC	Non-burial	Enamel	Unmodified	0.7081	-11.2	-3.4	—	—	Shev 2018
Dom. Rep.	El Carril	FND 722	LC	Non-burial	Enamel	Unmodified	0.7081	-11.1	-3.8	—	—	Shev 2018
Dom. Rep.	El Carril	FND3491	LC	Non-burial	Bone	Unmodified	—	—	—	12.7	-18.7	Shev 2018

Dom. Rep.	El Carril	FND 771	LC	Non-burial	Bone	Unmodified	—	—	—	9.0	-18.0	Shev 2018
Dom. Rep.	El Carril	FND 701	LC	Non-burial	Bone	Unmodified	—	—	—	8.3	-18.8	Shev 2018
Dom. Rep.	Manantial de Cabo	CCSR3	LC	N/A	Enamel	Modified	0.7086	-11.7	-2.4	—	—	
Dom. Rep.	Manantial de Cabo	CCSR4	LC	N/A	Enamel	Modified	0.7086	-12.0	-1.5	—	—	
Dom. Rep.	Manantial de Cabo	CCSR5	LC	N/A	Enamel	Modified	0.7092	-9.6	-7.7	—	—	
Dom. Rep.	Manantial de Cabo	S8	LC	N/A	Enamel	Modified	0.7087	-11.9	-3.0	—	—	
Dom. Rep.	Manantial de Cabo	S4	LC	N/A	Enamel	Modified	0.7087	-10.7	-3.2	—	—	
Dom. Rep.	Manantial de Cabo	S3	LC	N/A	Enamel	Modified	0.7092	-12.1	-3.1	—	—	
Dom. Rep.	Manantial de Cabo	S5	LC	N/A	Enamel	Modified	0.7074	-11.6	-2.5	—	—	
Dom. Rep.	Manantial de Cabo	S11	LC	N/A	Enamel	Modified	0.7084	-11.0	-2.6	—	—	
Dom. Rep.	Manantial de Cabo	S6	LC	N/A	Enamel	Modified	0.7089	-10.9	-2.1	—	—	
Dom. Rep.	Manantial de Cabo	S2	LC	N/A	Enamel	Modified	0.7088	-12.3	-2.7	—	—	
Dom. Rep.	Manantial de Cabo	S7	LC	N/A	Enamel	Modified	0.7087	-10.8	-3.3	—	—	
Dom. Rep.	Manantial de Cabo	S1	LC	N/A	Enamel	Modified	0.7089	-10.8	-2.8	—	—	
Dom. Rep.	Manantial de Cabo	S9	LC	N/A	Enamel	Modified	0.7089	-10.6	-3.2	—	—	
Dom. Rep.	Manantial de Cabo	S10	LC	N/A	Enamel	Modified	0.7089	-12.1	-2.7	—	—	
Dom. Rep.	Manantial de Cabo	S12	LC	N/A	Enamel	Modified	0.7090	-11.9	-3.1	—	—	
Dom. Rep.	El Flaco	FNR.1227.B	LC	Non-burial	Enamel	Unmodified	0.7076	-11.8	-4.4	—	—	Laffoon et al 2017
Dom. Rep.	El Flaco	FNR.2295	LC	Non-burial	Enamel	Unmodified	0.7078	-11.1	-3.9	—	—	Laffoon et al. 2017
Dom. Rep.	El Flaco	FND 3269	LC	Non-burial	Enamel	Unmodified	0.7079	-10.9	-2.1	—	—	
Dom. Rep.	El Flaco	FND 3261	LC	Non-burial	Enamel	Unmodified	0.7078	-11.3	-2.2	—	—	Shev 2018
Dom. Rep.	El Flaco	FND 2828	LC	Non-burial	Enamel	Unmodified	0.7075	-10.4	-3.6	—	—	Shev 2018
Dom. Rep.	El Flaco	FND 2838	LC	Non-burial	Enamel	Unmodified	0.7083	-11.6	-2.7	—	—	

Dom. Rep.	El Flaco	FND 2812	LC	Non-burial	Enamel	Unmodified	0.7081	-10.8	-4.4	—	—	Shev 2018
Dom. Rep.	El Flaco	FND 2270	LC	Burial	Enamel and bone	Unmodified	0.7082	-10.7	-3.9	10.8	-18.5	Shev 2018
Dom. Rep.	El Flaco	FND 2801	LC	Non-burial	Bone	Unmodified	—	—	—	8.7	-18.5	Shev 2018
Dom. Rep.	El Flaco	FND 2821	LC	Non-burial	Bone	Unmodified	—	—	—	8.4	-18.4	Shev 2018
Dom. Rep.	El Flaco	FND 3261	LC	Non-burial	Bone	Unmodified	—	—	—	13.1	-18.7	Shev 2018
Dom. Rep.	El Flaco	#21	LC	Non-burial	Bone	Unmodified	—	—	—	8.2	-16.5	Shev 2018
Dom. Rep.	El Flaco	FND 2828	LC	Non-burial	Bone	Unmodified	—	—	—	9.9	-19.5	Shev 2018
Dom. Rep.	El Flaco	FND 3050	LC	Non-burial	Bone	Unmodified	—	—	—	11.1	-16.9	Shev 2018
Dom. Rep.	El Flaco	FND 2649	LC	Non-burial	Bone	Unmodified	—	—	—	8.2	-16.5	Shev 2018
Dom. Rep.	El Flaco	FND 2812	LC	Non-burial	Bone	Unmodified	—	—	—	9.7	-18.5	Shev 2018
Dom. Rep.	Playa Grande	Corte7(A-H)UE1-2	LC	Non-burial	Enamel	Modified	0.7084	-11.1	-4.22	—	—	
Grenada	La Poterie	LPG-fa4	LC / Col.	Non-burial	Enamel	Unmodified	0.7078	-10.6	-4.6	—	—	
Grenada	La Poterie	LPG-fa5	LC / Col.	Non-burial	Enamel	Unmodified	0.7075	-11.2	-4.8	—	—	
Grenada	La Poterie	LPG-fa10	LC / Col.	Non-burial	Enamel	Unmodified	0.7086	-12.9	-6.3	—	—	
Grenada	La Poterie	LPG-fa16-1	LC / Col.	Non-burial	Enamel	Unmodified	0.7077	—	—	—	—	
Grenada	La Poterie	LPG-fa16-2	LC / Col.	Non-burial	Enamel	Unmodified	0.7077	—	—	—	—	
Grenada	Pearls	PG3	EC	N/A	Enamel	Unmodified	0.7074	-10.5	-2.9	—	—	
Grenada	Pearls	Wilcox2015	EC	N/A	Enamel	Unmodified	0.7074	-9.9	-3.4	—	—	
Guadeloupe	Anse à la Gourde	64-55-2.F2291	LC	Non-burial	Enamel	Unmodified	0.7091	-11.0	-2.4	—	—	Laffoon et al. 2017
Guadeloupe	Anse à la Gourde	64-55-2.4	LC	Non-burial	Enamel	Unmodified	0.7076	-10.6	-2.5	—	—	Laffoon et al. 2017
Guadeloupe	Anse à la Gourde	64-45-1	LC	Non-burial	Enamel	Unmodified	0.7092	-9.0	-2.1	—	—	Laffoon et al. 2017
Guadeloupe	CBT	CBT5002	EC	Burial	Enamel and bone	Unmodified	0.7068	-11.8	-1.99	9.6	-18.4	
Guadeloupe	CBT	CBT sondage4	EC	Burial	Enamel	Unmodified	0.7065	-12.0	-2.61	—	—	
Guadeloupe	CBT	64-55-2.F2291	EC	Burial	Enamel	Unmodified	0.7091	-11.0	-2.4	—	—	
Guadeloupe	CBT	CBT 3008	EC	Burial	Bone	Unmodified	—	—	—	9.4	-18.7	

Guadeloupe	Morel	255	EC	Burial	Enamel	Unmodified	0.7092	—	—			Laffoon et al. 2017
Guadeloupe	Morel	262*	EC	Burial	Enamel	Unmodified	0.7080	-11.1	—			Laffoon et al. 2017
Guadeloupe	Morel	263*	EC	Burial	Enamel	Unmodified	0.7080	—	—			Laffoon et al. 2017
Guadeloupe	Morel	706.1	EC	Burial	Enamel	Unmodified	0.7090	-12.7	—			Laffoon et al. 2017
Guadeloupe	Morel	706.3	EC	Burial	Enamel	Unmodified	0.7091	-11.1	—			Laffoon et al. 2017
Guadeloupe	Morel	1969A	EC	Burial	Enamel	Unmodified	0.7091	—	—			Laffoon et al. 2017
Guadeloupe	Morel	1969B	EC	Burial	Enamel	Unmodified	0.7091	—	—			Laffoon et al. 2017
Guadeloupe	Morel	2727	EC	Burial	Enamel	Unmodified	0.7091	-12.2	-2.0	9.2	-19.7	
Guadeloupe	Morel	2729	EC	Burial	Enamel	Unmodified	0.7081	-10.9	-2.7	9.2	-18.6	
Guadeloupe	Morel	2730	EC	Burial	Enamel	Unmodified	0.7092	—	—	10.4	-19.4	
Guadeloupe	Morel	2728	EC	Burial	Enamel	Unmodified	0.7091	-11.2	-2.9	—	—	
Guadeloupe	Morel	5237	EC	Burial	Enamel	Unmodified	0.7091	-12.1	-2.0	—	—	
Guadeloupe	Morel	2732	EC	Burial	Enamel	Unmodified	0.7092	-9.9	-3.4	—	—	
Guadeloupe	Morel	2675	EC	Burial	Bone	Unmodified	—	—	—	8.8	-17.8	
Puerto Rico	Punta Candelero	PC2: F-4 0-20	EC	Burial	Enamel	Unmodified	0.7084	-9.5	-4.6	—	—	
Puerto Rico	Punta Candelero	PC3: F-4 0-20	EC	Burial	Enamel	Unmodified	0.7091	—	—	—	—	
Puerto Rico	Punta Candelero	C17	EC	Burial	Bone	Unmodified	—	—	—	8.6	-17.8	Pestle 2010
St. Martin	Hope Estate	HE23 2302A	EC	Non-burial	Enamel	Unmodified	0.7080	-11.1	-4.8	—	—	
St. Martin	Hope Estate	HE25 2503B	EC	Non-burial	Enamel	Unmodified	0.7078	-11.0	-2.7	—	—	
St. Martin	Hope Estate	HE20 2009E	EC	Non-burial	Enamel	Unmodified	0.7071	-11.4	-1.2	—	—	
St. Martin	Hope Estate	HE33 3303B	EC	Non-burial	Enamel	Unmodified	0.7080	-9.2	-2.7	—	—	
St. Martin	Hope Estate	Fnr: 10-A-4	EC	Non-burial	Enamel	Unmodified	0.7067	-11.2	-2.8	—	—	
St. Martin	Hope Estate	HE2009E	EC	Non-burial	Bone	Unmodified	—	—	—	12.7	-15.6	
Vieques	Sorcé	Sorce1	EC	Burial	Enamel	Modified	0.7064	-10.4	-2.7	—	—	

Vieques	Sorcé	Sorce2	EC	Burial	Enamel	Modified	0.7067	-11.3	-3.3	—	—	
Vieques	Sorcé	Sorce3	EC	Burial	Enamel	Unmodified	0.7066	—	—	—	—	

Supplemental Table 2. Estimated height at withers (WH) from the total length (TL) of long bones of a comparative specimen whippet (Anatomie comparée MNHN CG 1996-2468), precolumbian dogs from Cathédrale de Basse-Terre, Gare Maritime and Morel, Guadeloupe, Barbuda, Dominican Republic (from Grouard et al. 2013), and El Flaco from the Dominican Republic (from Shev 2018).

Dog sample	minimum WH (mm)	maximum WH (mm)	Average WH (mm)
Lévrier "Wippeth" 1996-2468	**526**	**543**	**533**
GMBT US1008	425	428	426
CBT US5002	422	434	428
GMBT US1002/1003	425	449	441
Basse-Terre	**422**	**449**	**431**
Morel F281	367	383	375
Morel 2729 F90-16	395	395	395
Morel 6263 CLERC 1012	395	395	395
Morel 2730 F90-01-3	385	410	400
Morel 2731 F90-01-2	407	407	407
Morel 2727 F90-01-1	403	411	408
Morel 2728 F91-11	419	433	427
Morel 5237 CLERC 851-4-2	440	440	440
Morel	**367**	**441**	**409**
Seaview Barbuda	**411**	**480**	**452**
New Mexico Governador Site 41174	**341**	**354**	**347**
El Flaco FND 2270	351	351	351
Dominican Republic N°3	351	358	355
Dominican Republic N°2	359	361	360
Dominican Republic N°1	373	373	373
El Flaco FND 2821	417	417	417