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REPORTS

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

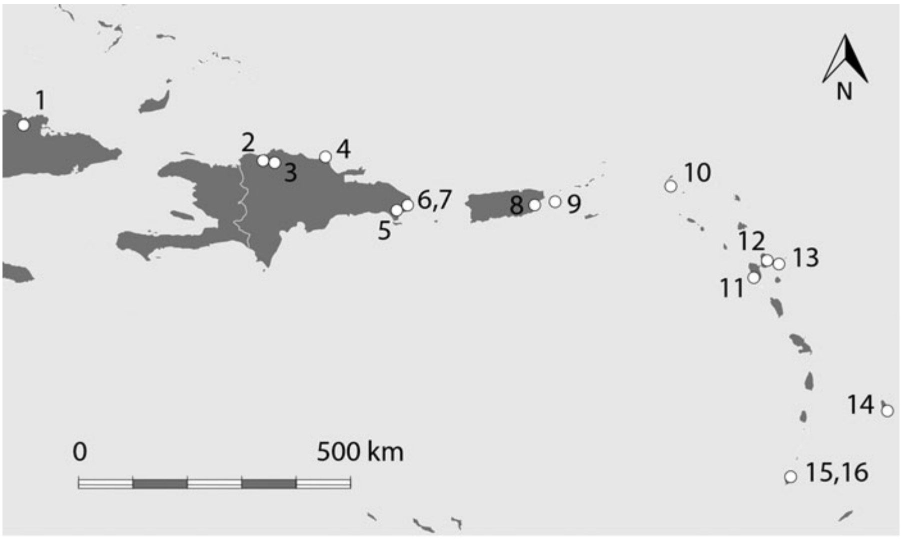

Figure 1. Map of precolumbian sites from which samples were acquired. (1) Cueva Belica, Cuba; (2) El Flaco, Dominican Republic (D.R.); (3) El Carril, D.R.; (4) Playa Grande, D.R.; (5) Cueva de Berna, D.R.; (6) El Cabo, D.R.; (7) Manantial de Cabo san Rafael, D.R.; (8) Punta Candelero, Puerto Rico; (9) 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.

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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.

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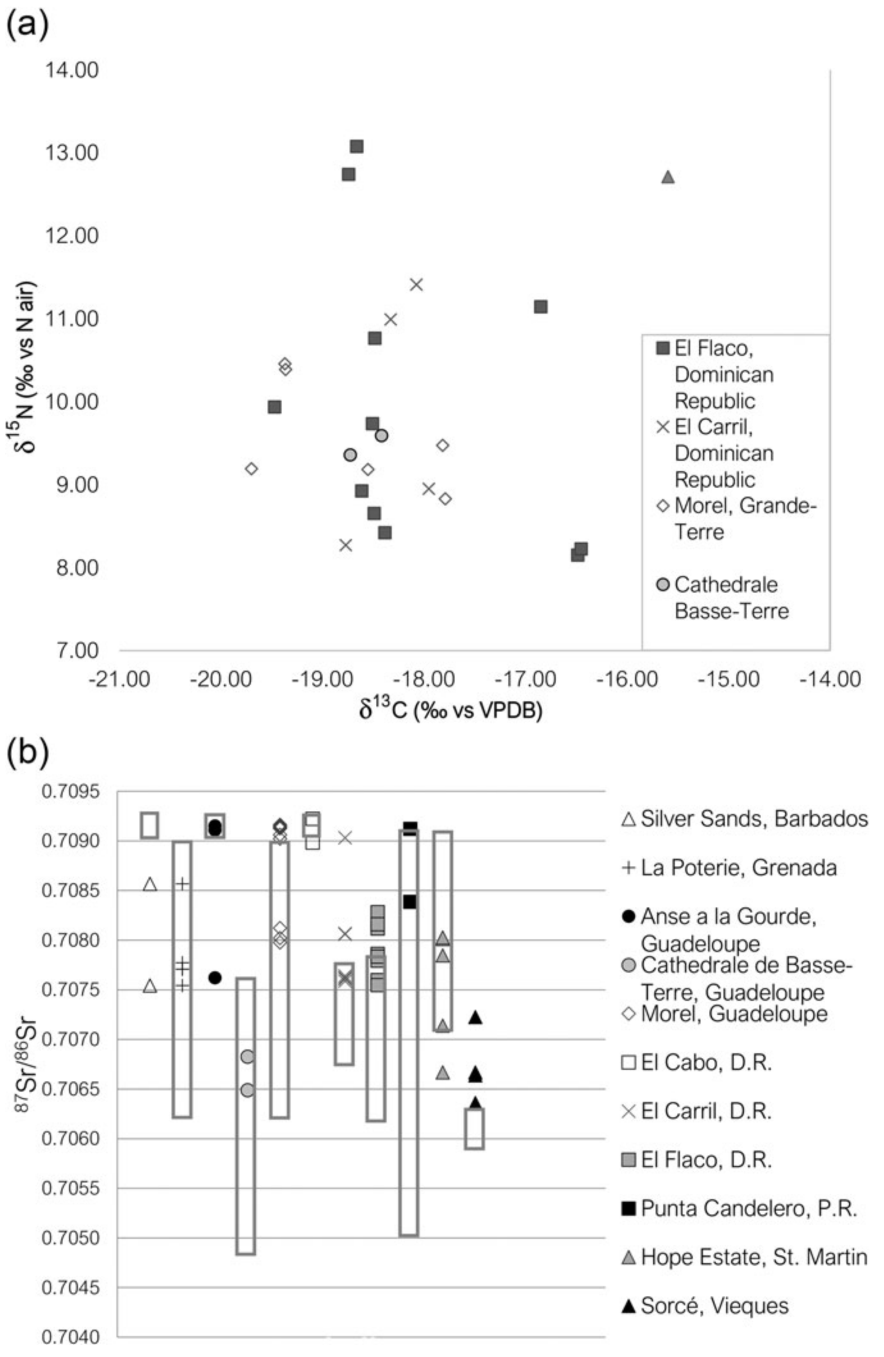

Figure 2. (a) Bivariate plot of dog $\delta^{15}N$ and $\delta^{13}C$ values from El Flaco and El Carril, Dominican Republic; Morel and Cathédrale de Basse-Terre, Guadeloupe; and Hope Estate, Saint-Martin (Shev 2018); (b) chart showing the estimated bioavailable $^{87}Sr/^{86}Sr$ local ranges (represented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

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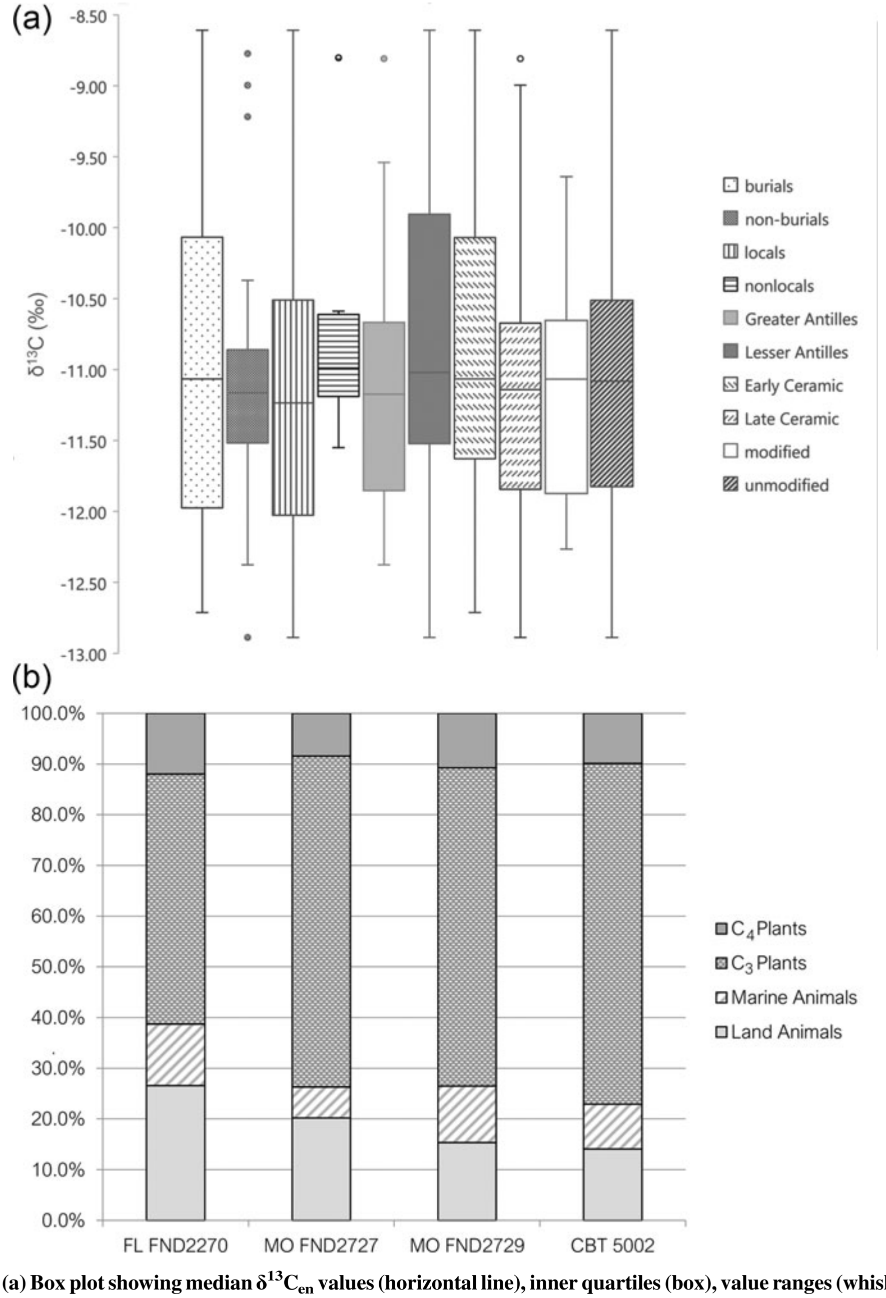

Figure 3. (a) Box plot showing median $\delta^{13}C_{en}$ values (horizontal line), inner quartiles (box), value ranges (whiskers), and outliers (dots) for all comparative parameters; (b) FRUITS dietary mixing model results for El Flaco (FND 2270), Morel (FND 2727 and FND2729), and Cathédrale de Basse-Terre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

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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.

References Cited

Grouard, Sandrine, Sophia Perdikaris, and Karyne Debue
2013 Dog Burials Associated with Human Burials in the West Indies during the Early Precolumbian Ceramic Age (500 BC–600 AD). *Anthropozoologica* 48:447–465.

Guiry, Eric J.
2012 Dogs as Analogs in Stable Isotope-Based Human Paleodietary Reconstructions: A Review and Considerations for Future Use. *Journal of Archaeological Method and Theory* 19:351–376.

Howard, Catherine V.
2001 Wrought Identities: The Waiwai Expeditions in Search of the "Unseen Tribes" of Northern Amazonia. PhD dissertation, Department of Anthropology, University of Chicago, Chicago.

Koster, Jeremy
2009 Hunting Dogs in the Lowland Neotropics. *Journal of Anthropological Research* 65:575–610.

Laffoon, Jason E., Menno L. P. Hoogland, Gareth R. Davies, and Corinne L. Hofman
2019 A Multi-Isotope Investigation of Human and Dog Mobility and Diet in the Pre-Colonial Antilles. *Environmental Archaeology* 24:132–148.

Laffoon, Jason, E., Esther Plomp, Gareth R. Davies, Menno L. Hoogland, and Corinne L. Hofman
2015 The Movement and Exchange of Dogs in the Prehistoric Caribbean: An Isotopic Investigation. *International Journal of Osteoarchaeology* 25:454–465.

Las Casas, Fray Barthelomé de
1876 [1561] *Historia de las Indias*. Imprenta de Miguel Ginesta, Madrid.

Pestle, William J.
2010 Diet and Society in Prehistoric Puerto Rico: An Isotopic Approach. PhD dissertation, Department of Anthropology, University of Illinois, Chicago.

Pestle, William J., and J. E. Laffoon
2018 Quantitative Paleodietary Reconstruction with Complex Foodwebs: An Isotopic Case Study from the Caribbean. *Journal of Archaeological Science-Reports* 17:393–403.

Plomp, Esther
2013 The Evolving Relationship between Humans and Dogs in the Circum-Caribbean. *Archaeological Review from Cambridge* 28:96–112.

Russell, Nerissa
2011 *Social Zooarchaeology: Humans and Animals in Prehistory*. Cambridge University Press, Cambridge.

Shev, Gene T.
2018 Feeding Opiyelguobirán: A Multi-Disciplinary Analysis of Human-Canid Relations in Pre-Colonial Hispaniola. Master's thesis, Faculty of Archaeology, Leiden University, Leiden, Netherlands.

Wang, Shengjie, Mingjun Zhang, Catherine E. Hughes, Xiaofan Zhu, Lei Dong, Zhengguo Ren, and Fenli Chen
2016 Factors Controlling Stable Isotope Composition of Precipitation in Arid Conditions: An Observation Network in the Tianshan Mountains, Central Asia. *Tellus B: Chemical and Physical Meteorology* 68:26206.

Wing, Elizabeth S.
2008 Pets and Camp Followers in the West Indies. In *Case Studies in Environmental Archaeology*, edited by Elizabeth J. Reitz, C. Margaret Scarry, and Sylvia J. Scudder, pp. 405–425. Springer Science and Business Media, New York.

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