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

Shev, G.T.

7

Synthesis and Concluding Remarks

This dissertation has sought to establish whether Indigenous peoples from the Greater Antilles were managing animals native to the region prior to the arrival of Europeans post-AD 1492. To answer the research questions posited in Chapter One, the methods and approaches I employed have been embedded within the natural sciences. The combination of isotopic analyses and zooarchaeological approaches has primarily focused on assessing the morphology, mortality ages and palaeodiets of both domestic and wild animals found at several archaeological sites in the Dominican Republic and Jamaica. By means of the research entailed within the five peer-reviewed journal articles that comprise this body of work, I have arrived at some distinct answers to the research questions posited in the introduction to this volume. I hereby address each research sub-question and how they were answered in the containing chapters, elaborating with further discussion as to the importance and implications of these findings. In conclusion I present an expansive answer to the main question which has driven my research approach over the past four years, briefly tackle how my findings relate to Indigenous ontologies and ecological knowledge, provide discussion as to the scope of future work investigating human-animal interactions and palaeoclimatology in the region, and finally, I finish this volume with some concluding remarks.

7.1 Addressing the research questions

In Chapter Two the two main methodological approaches undertaken in this research were first introduced: a zooarchaeological assessment involving morphological reconstructions made from measurements of animal skeletal remains, and isotopic analyses of animal diets. I hereby give an answer to the following research question:

What does the zooarchaeology and isotopic data suggest about the relationship between Indigenous peoples and the domestic species present in the precolumbian Caribbean?

Chapter Two functions as a relevant first foray for these approaches in this dissertation as it assesses the close relationship between humans and dogs which are one of only two domesticated animals that have been identified archaeologically from the pre-1492 Caribbean. Unlike subsequent chapters in this volume, this seminal article also includes an assessment of strontium ($^{87}Sr/^{87}Sr$) isotope values, used to establish the localness of dogs recovered from 16 precolumbian sites throughout the insular Caribbean, and deduce whether some individuals had migrated from elsewhere. As an important sidenote, I chose not to conduct strontium analysis in the subsequent studies for two reasons: this dissertation is not focused on examining migration patterns of hutias or other endemic species; and secondly, as it likely that hutias were not highly migratory in behavior and due to this hutia $^{87}Sr/^{87}Sr$ values have been repeatedly used in past studies to establish what the local strontium signatures for a given region are (see Laffoon et al., 2019, 2015; Mickleburgh et al., 2019).

Our results indicate that there were shared dietary and migratory patterns between dogs and humans. This was unsurprising given that dogs have demonstrable utility as an isotopic surrogate in the absence of access to human remains in archaeological contexts globally (Guiry, 2012). These results indicate that the "canine surrogacy approach" is applicable for the Caribbean region and is testament to the close

domestic relationship existing between Indigenous peoples and the dogs they cohabited space with, and evidently shared their food with. Consequently, Chapter Two serves to demonstrate that dogs are a suitable isotopic analog for not only assessing human paleodiets, but also assessing whether the diets of other species in the Caribbean were in some way influenced by human activities.

As a caveat, we cannot rely entirely on similarities in isotopic values to assess whether humans were sharing food with animals that have vastly different dietary behavior, such as is the case with herbivorous rodents. To establish whether endemic animals were sharing 'domestic' diets with humans, perhaps guinea pigs, as the only other domesticated animal known from the region and a New World rodent, serve as better analogs for a human influence affecting herbivorous rodent diets than dogs are. Advantageous to this study, one guinea pig mandible was identified during zooarchaeological study of the material from El Flaco, from which both collagen and enamel dietary isotope values were analyzed. As discussed in Chapters Four and Five this individual had collagen carbon values ($\delta^{13}C_{co}$ -17.2‰) that fit into the dietary range of both dogs and humans from El Flaco. This guinea pig evidently consumed considerable quantities of C_4 plants, likely maize, which affected a relative enrichment in carbon values. It is therefore likely that foods were shared with this domestic animal. As an herbivorous caviomorph rodent it is logical that it better serves to demonstrate analogously what a domestic diet should look like with other endemic, New World rodents.

Zooarchaeological investigation, as is detailed in Chapter Three, determined that most of the dog remains and the one guinea pig remain were recovered from the same midden contexts as other animal species at El Flaco, suggesting that maybe both creatures occasionally served as a food source for Indigenous peoples. Nonetheless, dog remains are ubiquitously found throughout the region, but their skeletal remains are relatively few, including at El Flaco where only three individual dogs were identified (NISP = 31), comprising only 0.25% of all identified vertebrate remains (NISP). It is more likely that this animal served the role of companion deserving special treatment in death as would human members of Indigenous society. The well-recorded phenomenon of dog burials in the pre-1492 Caribbean is testament to this, and buried dog remains are found both at El Flaco (Hofman et al., 2020; Hofman & Hoogland, 2015) and El Carril (Lawrence, 1977; Veloz Maggiolo, 1972). Regarding guinea pigs, assessing their role within Indigenous societies is difficult from zooarchaeological findings entailed in this dissertation considering that only one individual was identified at El Flaco, however from the study of their dietary isotope values it is evident that it shared similar dietary sources to that of humans and dogs.

It is clear from studying the dietary isotope values of these two domesticated animals that a 'domestic' or human influenced diet should resemble that of humans due to the high degree of commensalism between species, purposeful feeding, or prolonged unimpeded scavenging behavior by animals of human refuse or horticultural plots.

Chapter Three specifically responds to the following two questions in providing a quantitative analysis of all faunae identified from three excavation units at El Flaco, which comprised approximately half of all the catalogued faunal remains from the whole excavated area of the site.

What does the zooarchaeological data from Indigenous archaeological sites suggest about the management of native animals and the general environmental management practices in the region?

What insights are gained in relating the findings from zooarchaeological and isotopic investigations of fauna recovered from Caribbean archaeological sites to other palaeoenvironmental data gathered from the region?

According to the taxonomic identifications and quantifications, calculations of NISP, MNI, and importantly the estimation of body mass, it is evident that hutias (Capromyinae) were the most significant source of animal meat for the inhabitants of El Flaco. ***Isolobodon portoricensis*** was the hutia species that was most predated upon, perhaps indicating that the surrounding landscape of the Cibao Valley and the Cordillera Septentrional contained significant populations of this animal.

To interpret how the faunal assemblage of El Flaco relates to general environmental management strategies we referred to data from sediment core analyses conducted by Castilla-Beltrán (et al., 2018; 2020) and Hooghiemstra (et al., 2018) from sample locations situated within the Cibao Valley. Both studies indicate that slash-and-burn farming was a common feature of the landscape, and likely increased in intensity throughout the occupational period of El Flaco. Taking inference from American mainland contexts (see Sugiyama et al. 2020; Guiry et al. 2021; Smith, 2011, 2001) it seems likely that landscape changes brought about by slash-and-burn farming may have affected a mosaicking of plant communities, and this may have been of benefit to ***I. portoricensis***, perhaps explaining the high numbers of this species identified in the faunal assemblage of El Flaco.

It is reasonable to assume that the high quantity of hutia remains at El Flaco are the result of garden hunting. Of note, although 234 ***I. portoricensis*** individuals were identified, the sole modern extant hutia from Hispaniola, ***Plagiodontia aedium*** is only accounted for by an MNI of 3 (NISP = 4). ***P. aedium*** is considered as an elusive creature, and likely arboreal, perhaps explaining why it retains the sole survivor status for hutias native to the island of Hispaniola. This data also hints at the phenomenal degree that ***I. portoricensis*** flourished within the landscape compared to other endemic rodents and its commonality at archaeological sites throughout Hispaniola, Puerto Rico and the Virgin Islands. It is likely that ***I. portoricensis*** was synanthropic and thrived within anthropogenic environments- albeit environments in which human impacts were relatively innocuous from an ecological perspective and comprised of a mosaic of old growth forest, intercropped garden plots and secondary growth forest or fallows.

A wide range of animal taxa was utilized by the inhabitants of El Flaco, particularly marine invertebrates from relatively far-flung coastal environments located to the north and west of the Cordillera Septentrional. Fish remains were minimal compared to the quantities found at coastally situated sites, and our findings suggest that mostly mangrove forests were targeted for the collection of shellfish, indicating the importance of these ecosystems for Indigenous peoples. It is hypothesized within Chapter Three that due to the notable geographic obstacle that the Cordillera Septentrional represents, trips to coastal areas were likely not frequently undertaken by the inhabitants of El Flaco. The significant amounts of mangrove oyster amongst other mangrove-adapted shellfish in the assemblage may therefore represent

exchange with more coastally situated communities.

Chapter Three exemplifies how other environmental proxies need to be considered to facilitate explanations of faunal assemblages in the region. Although slash-and-burn farming may have hindered the survivability of some forest-dwelling dietary specialists by destroying habitats they were specially adapted to, it certainly did not detrimentally effect ***I. portoricensis*** populations. In an arguably sustainable approach to ecosystem engineering, the high gains from the garden hunting of hutias seen in the zooarchaeological assemblage of El Flaco was likely related to human horticultural practices that bolstered hutia food security and attracted them towards garden plots and settlements. Garden hunting can thus be considered as one component of a suite of environmental management strategies focused on food production.

The evidence presented in Chapters Four and Five answer the following sub-question:

What evidence exists for close interactions between humans and endemic 'wild' species, such as hutias, that are theorized to have been managed?

The isotopic studies of hutias and other endemic fauna detailed in this dissertation indicate that there is no direct evidence of a systematic feeding regime, nor is their morphological evidence that would suggest that hutia populations were being controlled in the form of culling upon reaching sexual maturity. Our data rather shows that several but not all hutias had enriched carbon values in their bone collagen and tooth enamel. Some individuals exhibit considerable overlap with the isotopic values of humans, dogs, and the one guinea pig from El Flaco, hinting at similar diets that involved some maize consumption which is known to have likely been cultivated near El Flaco and was widely consumed throughout the Caribbean region (Pagán-Jiménez et al., 2020; Pagan-Jimenez & Mickleburgh, 2022). These results can be explained by hutias either systematically scavenging from maize garden plots in significant enough quantities to affect an enrichment of heavier carbon isotopes within their tissues, or that some hutias were purposefully fed maize by Indigenous peoples. This constitutes indirect evidence of close interactions between humans and ***I. portoricensis*** in the form of shared diets. Nevertheless, the lack of systematic human control over the feeding regimes of most hutias, or the lack of evidence of population management strategies which may involve the culling of animals when they reached sexual maturity, both indicate that the intensive captive management of hutias was likely not commonly occurring. The most parsimonious explanation for this follows on from conclusions stated in Chapter Three: due to its synanthropic behavior ***I. portoricensis*** greatly benefited from horticultural activities, likely was attracted to garden plots, and consequently was likely captured close to human settlements.

Chapter Four entails an isotopic and morphological study of ***Isolobodon portoricensis*** mandibles alongside an isotopic study of other endemic animals commonly found at the sites of El Carril, El Flaco, La Entrada and El Cabo. The analysis of collagen provided evidence of human dietary influence over the feeding behavior of hutias (***I. portoricensis***, ***Plagiodontia aedium***), Antillean freshwater slider, guinea pigs and some edible rats. The species with the most enriched carbon values were ***I. portoricensis*** and guinea pig, although one ***P. aedium*** recovered from La Entrada, and one freshwater slider from El Flaco also shared notably enriched collagen carbon values.

Our morphological assessment was an attempt to establish whether the relative mortality ages of hutias were reminiscent of domestic practices which may favour the culling of prime aged individuals that had just reached sexual maturity. As a caveat, ***I. portoricensis*** is extinct, so therefore it is not possible to assess the allometry of this animal by studying known-age specimens, limiting interpretations of the osteometric data. For the same reasons, without knowing the degree of sexual dimorphism that exists in this species it is possible that hutias that are of disparate sizes may be at a similar age of development. Even so, our body mass calculations indicate that there was a non-uniform spread of mortality ages with most hutias being consumed after reaching 1kg in weight. This may represent a preferencing for prime age individuals, however as a notable amount of heavier and lighter hutias were targeted, analogous to more or less mature hutias, this may more represent non-selective hunting and trapping activities, rather than a situation involving the management of a captive population.

Using collagen isotope values as a proxy to reconstruct diets has its limitations. This is partly due to collagen isotope values representing more protein intake compared to enamel or apatite isotope values which give a more balanced indication of the consumption of all three macronutrients. With this in consideration, Chapter Five serves to better reconstruct hutia diets as it examines the collagen and enamel isotope from the same animals and applies FRUITS dietary mixing modelling to establish the relative contributions of different food sources. Chapter Five therefore details a more comprehensive estimation of the possible dietary contributions for the three hutia species investigated, the sole guinea pig, and edible rats (***Brotomys*** sp.) recovered from El Flaco, El Carril and La Entrada. Entailed in Chapter Five is an attempt to discriminate between domestic C_4/CAM plant dietary sources, predominately represented by maize, from wild C_4/CAM plant dietary sources, which is a novel application of FRUITS. Our results provided greater clarity in assessing the potential inputs of maize into the diets of these animals, again supporting the notion that only some hutias had diets supplemented with maize. One hutia (FL1952) showed considerable dietary overlap with the guinea pig, although it likely consumed higher quantities of maize. It is feasible that this animal had a diet supplemented by humans and may have been tamed, although for most other animals it seems that C_4/CAM plant consumption was varied, again suggesting that there was no systematic feeding regime affecting a captive population.

Chapter Six provides mortality age estimations and dietary isotope analysis of Jamaican hutia (***Geocapromys brownii***), and like the study of ***I. portoricensis*** in Hispaniola, the results indicate evidence of the relative enrichment of carbon isotopes in some individual hutias. Here the evidence for the direct management or captivity of hutias is perhaps strongest, given that a mortality profile could be generated that is reminiscent of captively managed populations. The evidence of skeletal pathologies that would have hampered survivability of a wild animal further indicates that perhaps some hutias were being cared for by humans. Even so, the isotopic evidence suggests that there was again no systematic feeding regime imposed on ***G. brownii***, and it appears that only some hutias showed definitive evidence of diets comprised of a significant amount of maize or another C_4/CAM plant.

ow can zooarchaeological and isotopic analyses be used in conjunction to assess human-animal interactions in the Caribbean?

This dissertation has employed dietary isotope studies and morphometric studies of animal remains aimed at answering whether the management of endemic animals was occurring in the pre-1492 Caribbean. Estimations of morphology and mortality ages served to assess whether animal mortality profiles were reminiscent of certain hunting strategies or of captive management, and dietary isotope analysis established evidence whether animals were being fed by or at least shared some degree of dietary commensality with humans.

Chapters Two, Four and Six all employ morphometric and isotopic analyses, however the answers sought from morphological assessments differed according to each study. In Chapter Two, the estimations of body mass and the withers height of dogs was used to investigate the long-held theory that there may have existed two different breeds of dogs in the Caribbean and to investigate if there were linkages between differences in diet, mobility, and morphology. Chapter Four employed morphometry to estimate the body mass of ***I. portoricensis*** to provide some relative indication of the potential mortality ages of hutias. Chapter Six, however, more successfully employs mortality age estimations as the allometric relationship between age and body size has been established in a study of living Jamaican hutia populations (Wilkins, 2001). So, depending on the intent of each study, the use of morphometrics differed.

To give a general answer to this research question: both isotopic analyses and osteometry are complimentary methods for investigating whether animal management strategies were occurring, but this combination of methods shows greater utility for species where the allometric relationship between age and body size is well established, as is the case for Jamaican hutias.

7.2 Were Indigenous peoples in the insular Caribbean managing native animals prior to the European invasion?

The zooarchaeology and isotopic evidence overwhelmingly indicates that in the insular Caribbean Indigenous peoples shared close interactions with some hutia species. Two of these hutia species, long speculated to have been managed by Indigenous peoples, have been the main protagonists in my research: ***Isolobodon portoricensis*** in Hispaniola and ***Geocapromys brownii*** in Jamaica. Isotopic analyses of their skeletal remains have shown that some individuals of both species were enriched in heavier carbon isotopes, reminiscent of domestic animals from the pre-1492 Caribbean, namely dogs and guinea pigs.

Rather than suggesting that hutias were kept in captivity, our palaeodietary evidence indicates that there was no systematic feeding regime affecting homogenous hutia diets. This dietary entanglement between humans and hutias is best explained by a regular tendency for hutias to either be scavenging from maize garden plots, or in some instances hutias may have been purposefully fed by Indigenous peoples. In this way, the diets of hutias are not reminiscent of that of dogs in the region, the latter tending to be more isotopically homogenous and more like that of humans likely due to a common practice of sharing food. With hutias there appears to have been more variance in diets, indicating less direct control or influence

over hutia feeding behavior than what occurs with domestic animals.

In general, the evidence for the possible captive management or involved human custodianship over hutias is strongest at White Marl. This is in virtue of the evidence of healed bone pathologies that likely would have hampered hutia survivability in the wild, whereas at El Flaco there was no notable evidence of healed pathologies even though the sample size was much greater. As previously stated, a mortality profile for ***Isolobodon portoricensis*** could not be established. For Jamaican hutias this was however achievable given that the allometric relationship between size and maturity has been experimentally established for this species. If the age determinations used for ***G. brownii*** are applied to ***I. portoricensis***, irrespective of the likely morphological differences between the two species, then at El Flaco it is likely that 59.1% (n=146) of ***I. portoricensis*** were juveniles. This sharply contrasts to ***Geocapromys brownii*** from White Marl where only 2.5% (n=3) of ***G. brownii*** were sexually immature and under 10 months of age. If this was indeed the case, then the mortality profile of hutias at El Flaco was a "catastrophic/living profile" suggesting non-selective hunting practices such as trapping. This is in no way indicative of a captively managed population, which according to Wilkins (2001), should be reflected in a mortality profile primarily comprised of prime-aged individuals that have just reached sexual maturity. To reiterate, this is merely speculative, and it may be the case that ***I. portoricensis*** was generally more diminutive than Jamaican hutia, so a 1:1 allometric comparison between species was deemed unsound and therefore not included in this dissertation.

Although not completely discounting the possibility that some hutia individuals may have been kept in captivity, it is more likely that most hutias were attracted to human horticultural plots such as maize crops. Not only was the creation of garden plots likely beneficial for hutias, attracting them closer towards interactions with humans, but also the general practice of slash-and-burn land clearance by Indigenous peoples may have benefited these species by diversifying plant communities. This may have been particularly the case in the Cibao Valley and surrounding hinterland, both due to the region's renowned agricultural fertility, and the palaeoenvironmental evidence suggesting the commonality of slash-and-burn farming in the landscape during the Late Ceramic Age.

Slash-and-burn land clearance and the creation of garden mounds for the cultivation of plant crops was likely a notable attractant for synanthropic hutia species such as ***Isolobodon portoricensis***, and their prolificacy within many archaeological sites may reflect garden hunting of this species. This is case with many synanthropic dietary generalists that tend to thrive off the increased variety of food sources provided in anthropogenically modified mosaiced plant communities that have replaced high-canopied forest more suited to dietary specialists (Smith, 2001, 2007). Human niche construction likely had positive effects on hutia populations by diversifying vegetation within the landscape and increasing their sources of food. Slash-and-burn farming was an environmental management strategy that guaranteed reliable sources of plant foods, but also by bolstering hutia populations, encouraged a consistent supply of animals for Indigenous peoples to hunt and trap in close vicinity to their settlements or garden plots. The garden hunting of synanthropic hutias therefore constitutes one part of a cultural package of low-level food production practices that involved the human ecosystem engineering of the surrounding landscape.

The alteration of hutia habitats to grow plant foods perhaps led to the unintentional consequences of bolstering food security not only for humans, but for other species which cohabited these environments. This constitutes an indirect form of management of hutias as defined by Melinda Zeder (2015), in which Indigenous peoples were intentionally changing the environment "to increase [an animal's] relative abundance and predictability and to reduce the time and energy required to harvest it." (Zeder 2015, parenthesis my own).

It is probable that garden hunting was an integral part of food production strategies practiced by Indigenous peoples throughout the Caribbean region. The isotopic evidence suggests that Bahamian hutia (***Geocapromys ingrahami***) also showed some degree of commensality with humans, and this is likely the result of scavenging from human refuse or garden plots, or due to the supplementation of hutia diets with maize by humans (LeFebvre et al., 2019). It is therefore likely that similar processes were occurring in the Bahamas as what has been highlighted in this research for Hispaniola and Jamaica, and I hypothesize that a dietary isotope analysis of hutias in Puerto Rico from Ceramic Age contexts would also yield similar results. It may be that animal species such as agouti (***Dasyprocta*** spp.), which were introduced into Lesser Antillean contexts, served similar roles to hutias as synanthropic commensals (Giovas, 2019). It may be that the garden hunting of agoutis and other imported mainland fauna was a common occurrence in the smaller southern islands of the southern Caribbean. This may help explain why during the Ceramic Age certain species such as ***Isolobodon portoricensis*** were never introduced into the Lesser Antilles, and why non-domesticated fauna from the mainland never reached the Greater Antilles. If there were already synanthropic endemic or introduced animals present that thrived near human settlements and were attracted to horticultural plots, then there was likely no need to further introduce new species to fill these roles.

The evidence presented in this dissertation paints an alternative scenario in how animals were managed in the Caribbean, and the Neotropics in general, when compared to Eurasian contexts from which much of the theories regarding animal domestication studies are based. In many parts of the tropical Americas, it is not the right question to ask, "Why ***didn't*** Amerindians commonly domesticate native animals?", but rather more legitimately "Why would Amerindians ***need*** to domesticate native animals?" In the Caribbean, hutias were not domesticated maybe because it was not necessary to do so, however they also could not be entirely 'wild' in behaviour due to their likely common and close interactions with humans. In the Caribbean islands it seems that human-animal interactions were metaphorically nestled somewhere within the valleys and foothills between the conceptual mountains of 'domestic' and 'wild'.

7.3 Amerindian perspectivism and niche construction: two sides of the same coin?

Although it was not touched upon within the chapters proceeding Chapter One, I believe it is pivotally important to relate the evidence presented in this volume to that of the ever-increasing acknowledgement of Indigenous ontologies invoked by ethnological studies. I hereby address some theories pertaining to the ontologies of Amerindian animist belief and Amerindian perspectivism.

One of the defining qualities of these proposed Amerindian ontological frameworks is the idea of reciprocity between metaphysically identical beings which formed moral guidelines for dictating human-animal relations. Amerindian ontologies are often framed as oppositional to the dichotomy of Western naturalism (see Descola, 2013), such as in the discipline of ecology in which the natural world and human culture are distinct categories. Although, it may be that Amerindian peoples have their own ecological perspectives that are conceptually not that distinct from Western naturalism. Laura Rival would argue as such, claiming that the Huaorani people of the Ecuadorian Amazon have their own sense of ecology, and perceived the formation and the custodianship of the landscape as a continuous process of interactions between humans, and the plants and animals that cohabit the forest (Rival, 2012, 2014). Perhaps for Indigenous peoples in the Caribbean, there may not have been a distinction made between anthropogenic and natural landscapes, with human actions being seen as part and parcel of what constitutes the environment, alongside the actions of other species of animals and plants ***sensu*** the Huaorani as discussed by Rival (2014, 2012).

Intergenerationally refined practices of human ecosystem engineering is one of the main tenets of human niche construction theory, and this passing down of knowledge and practices is what defines Indigenous ecological traditions. In the tropical Americas, practices such as slash-and-burn farming are shown to positively effect populations of plants and animals which benefit from landscape change, as hutia likely did in Hispaniola and Jamaica. In tying this to Amerindian perspectivism, the garden hunting of hutias may have been seen by Indigenous peoples as a reciprocal gift ***from*** hutias ***to*** humans; a giving of thanks for the bounteous food and myriad environments created by human actions that had benefited their species.

It may be that these strategies of mutual beneficence and reciprocity between species may have their genesis in Amerindian animist ontologies. Counter to this, the intergenerational transmission of knowledge about how to sustain one's society within tropical environments may have led to the inception of an ontology of egalitarianism and reciprocity with nature. What came first- Amerindian cosmology or ecological traditions - becomes a 'chicken or the egg' scenario that is not answerable without being able to physically question the first human colonists in the Americas about their environmental perspectives. In recognition of this, although the Western academic concepts of Amerindian perspectivism and niche construction theory have their roots in epistemologically disparate disciplines- of ethnology for Amerindian perspectivism and animism, and macroevolutionary theory for NCT- these theories are not mutually exclusive; the former theory tackling the thought process behind the actions, and the latter the results of the actions themselves. This is particularly the case when recognising that both theories hinge on acknowledging the cultural transmission of Indigenous ecological perspectives as their defining characteristics.

7.4 Scope of future research

Great benefit would come from the combination of theoretical approaches from the natural sciences and anthropology in future zooarchaeological research in the Caribbean. Theories pertaining to non-West-

ern ontologies, and ethnographic studies of contemporary Indigenous communities from the Americas, help explain how Indigenous peoples in the past framed their world and what moral motivations or deterrents existed that affected their relationships with animals. Although often criticized for an over-generalization of Indigenous cultures, ontological theories like Amerindian Perspectivism still provide a basis for speculating as to how Indigenous peoples in the Caribbean viewed their place within the natural world, particularly given that historical recordings of the so-called 'Taino' are somewhat limited. On the other side of the coin, NCT is an ideal framework for interpreting the functioning of the ecological practices themselves, and the impact these had on environments and the plants and animals which inhabit them. Although commonly addressed in divergent academic publications, consilience between both theoretical approaches is possible and would likely be fruitful. Archaeological interpretations educated by both approaches would allow us to accurately identify the functioning of the environmental practices of Indigenous peoples, while also allowing us to hypothesize as to the thought processes and cultural norms behind such actions, therefore deepening the story of these past societies.

The studies comprising this dissertation highlight the applicability of dietary isotope analysis to demonstrate dietary linkages between humans and both domestic and nondomestic animals in the Americas. In the Caribbean, with its notable paucity of domestic animals, palaeodietary studies of 'wild' animals can show the knock-on effects of environmental impacts made by Indigenous peoples, in particularly modes of plant food production. These studies show most applicability in regions where there are domestic crops that have a C_4 photosynthetic pathway, such as maize. For this reason, many parts of the Americas are suitable for investigating human-animal entanglements isotopically, in particularly for highlighting whether animals were either scavenging or being fed agricultural produce by humans. However, determining sharing of foodways between humans and animals, whichever form that took, does not constitute direct evidence of a process of animal domestication occurring. It may however be the case that if Indigenous peoples had been able to continue with their traditional lifeways and environmental management strategies, increasingly closer interactions between humans and hutias may have led to their eventual domestication. This is known as the 'commensal pathway' towards domestication as is discussed by Melinda Zeder (2015).

We currently do not have the evidence to state that hutias were domesticated, nor were undergoing a process of nascent domestication, leaving us to be able to merely speculate if this was occurring. However, if one of the key qualifying aspects of animal domestication is phenotypical change due to artificial selection, then morphological studies of hutia skeletal remains may be able to shed light on this. Geometric morphometrics (GMM), a landmark-based computationally aided form of morphometrics, can investigate minute phenotypical differences between wild and domestic species. For example, GMM has shown great utility in investigating phenotypical change due to artificial selection in the domestication of wild boars (Cucchi et al., 2021; Evin et al., 2015), chickens (Stange et al., 2018) and dogs (Drake et al., 2015). GMM may show some utility in determining if there are phenotypical differences between Late Pleistocene and Early Holocene ***Isolobodon portoricensis*** subfossils found in paleontological deposits and those found in archaeological middens dating to periods of human occupation of Hispaniola. The same could be achieved with Jamaican hutias, and on other islands where it is evident that human-hutia interactions

were evidently close. There are however likely notable limitations in employing GMM to investigate this, namely that it is much easier to distinguish the phenotypes of domestic and wild pigs because we know what domestic pig skeletal structure looks like. For all species of hutias this is not the case, leaving us to only be able to make chronological distinctions between the phenotypes of hutias that are recovered from pre-human or post-human contexts. It may also be the fact that human niche construction or other external environmental conditions, in applying evolutionary pressures on animal species, may lead to some phenotypical change which could be misinterpreted as being the result of selective breeding.

Genetic studies may be useful in determining whether there are distinct chronological and regional differences between clearly economically important species such as is the case with ***I. portoricensis***. Some ancient DNA research has been conducted on endemic animals in the Caribbean, including guinea pigs (Kimura et al., 2016; Lord et al., 2018) and freshwater turtles (Parham et al., 2013), but also notably hutias (e.g. Oswald et al., 2020; Woods et al., 2021). These studies have however been mainly focused on establishing the spread of capromyids by analyzing the genetic drift in isolated populations, with some conjecture of human involvement in the translocations of some species. However, focused DNA studies of ***Isolobodon portoricensis*** from the islands of Hispaniola and Puerto Rico, where they are found in abundance in pre-1492 archaeological deposits, might be able to highlight if there were any genetic distinctions between these two population groups. Ancient DNA studies might also be able to highlight whether there is evidence of genetic introgression between these two groups that may indicate the continual movement of hutias between islands. I suspect that this was however likely not the case, as it is more likely that this species flourished in both islands once introduced by humans as a synanthropic beneficiary of human ecosystem engineering.

Isotopic analysis of commensal animals, in particularly rodents, has shown tremendous utility for investigating the effects humans have had on island landscapes. This has been notably achieved by Jillian Swift in her investigation of Pacific rats (***Rattus exulans***) in French Polynesia. Swift's investigation demonstrated a notable trend of decreasing nitrogen values, perhaps indicating the decline of seabird populations which rats predated upon on due to an overexploitation by humans, a notion which is supported by a decrease in avifauna from zooarchaeological deposits (Swift, 2016; Swift et al., 2017). It may be the case that similar approaches can be applied to Lesser Antillean contexts in which rice rats (Tribe: Oryzomini) were a significant component of the diets of some islander communities throughout the Ceramic Age (Brace et al., 2015; Durocher et al., 2021). Like with hutias from Hispaniola and Jamaica, palaeodietary investigations of rice rats may be able to highlight human impacts on ecosystems, and their isotopic values may reflect horticultural activities via their scavenging of these crops, or as they are known omnivores, the human-caused extirpations or introductions of plants and animals which they consumed.

Beyond investigating human impacts on the environment, analyzing the oxygen isotope values of rodent teeth has demonstrable utility for investigating climate change in the past. This is because of the correlation between the oxygen isotope values of biogenic phosphate ($\delta^{18}O_p$) encased in rodent tooth enamel, and that of the oxygen isotopic values of meteoric water ($\delta^{18}O_{mw}$) which is directly related to ambient air temperature (Dansgaard, 1964; Fernández-García et al., 2019; Pederzani & Britton, 2019; Rozanski et

al., 1993). Isotopic studies of rodent teeth, such as rice rats in the Lesser Antilles, or even hutias, edible rats or spiny rats in the Greater Antilles, might therefore be able to provide another proxy in reconstructing past climates at a localized scale. In combination with other palaeoenvironmental proxies, such as charcoal records, palaeobotanical studies and investigations of vertebrate assemblages, perhaps more specificity can be gained in determining climatic conditions of islands at a highly localized, chronologically resolute scale.

7.5 Concluding remarks

Although arguably niche construction activities do not benefit all animal species that are subject to their effects, it can be strongly argued that slash-and-burn farming and garden hunting constitute more sustainable modes of food production than modern farming practices. This is particularly the case given the modern obsession of cultivating monocultural plant communities on an industrial scale for the sake of economic efficiency, which we know is unsustainable, detrimental to global biodiversity, and a significant causal factor of climate change. If human impacts on the environment can sustain biodiversity in retaining sections of old-growth forest, involve a variety of crops, and be rotated in a timely manner to allow natural regeneration of vegetation, the mosaiced environments that are created can have demonstrably beneficial effects on wild animals that inhabit the fringes of these anthropogenic environments. If it is these same animals which benefit from ecosystem engineering practices are in turn relied upon as a main source of meat, the whole process of food production becomes sustainably focussed. Unfortunately, the problem is perhaps more a problem of scale, with these sustainable food production activities being much more accomplishable in societies that are small-scale 'low-level food producers' such as is evidently the case for Indigenous peoples in the pre-1492 Greater Antilles. Even so, investigations of Indigenous ecological traditions can provide some insight into how we need to diversify our agricultural practices as to not overburden ecosystems and maybe to even benefit some species. This makes the ecological knowledge and traditions of modern Indigenous communities indispensable. We need to work with nature in ways governed by notions of reciprocity: to take we must be able to give back in equal measures.

To remark in closing, there is a great utility that can be gained from the combination of isotopic analyses and zooarchaeology, whether it be studying human impacts on the environment, animal management practices or palaeoclimatic reconstructions. These transdisciplinary studies are in their relative infancy and have only largely been applied in the last few decades to different scopes of archaeological investigation, however I foresee this trend continuing and developing as novel approaches and techniques become available. Nevertheless, the information gleaned from these studies are only conceptual 'islands' unless placed within the greater 'archipelago' of archaeological and anthropological investigation, whether it be studying cultural material, modern Indigenous environmental practices and perspectives, ancient genetics, or foodways. Transdisciplinary approaches incorporating humanities and biological methodologies are the only way to achieve a holistic view of the past. Like light-shimmering reflections on calm waters, our specialized approaches can blind us into only seeing what we expect to see, and we can only really tell what is underneath the surface if we dive, fully equipped, into deeper waters.

References

Brace, S., Turvey, S. T., Weksler, M., Hoogland, M. L. P., & Barnes, I. (2015). Unexpected evolutionary diversity in a recently extinct Caribbean mammal radiation. ***Proceedings of the Royal Society B: Biological Sciences***, ***282***(1807), 20142371–20142371. https://doi.org/10.1098/rspb.2014.2371

Cucchi, T., Domont, A., Harbers, H., Evin, A., Alcàntara Fors, R., Saña, M., Leduc, C., Guidez, A., Bridault, A., Hongo, H., Price, M., Peters, J., Briois, F., Guilaine, J., & Vigne, J.-D. (2021). Bones geometric morphometrics illustrate 10th millennium cal. BP domestication of autochthonous Cypriot wild boar (Sus scrofa circeus nov. Ssp). ***Scientific Reports***, ***11***(1), 11435. https://doi.org/10.1038/s41598-021-90933-w

Dansgaard, W. (1964). Stable isotopes in precipitation. ***Tellus***, ***16***(4), 436–468. https://doi.org/10.3402/tellusa.v16i4.8993

Descola, P. (2013). ***Beyond nature and culture***. Chicago: University of Chicago Press.

Drake, A. G., Coquerelle, M., & Colombeau, G. (2015). 3D morphometric analysis of fossil canid skulls contradicts the suggested domestication of dogs during the late Paleolithic. ***Scientific Reports***, ***5***(1), 8299. https://doi.org/10.1038/srep08299

Durocher, M., Nicolas, V., Perdikaris, S., Bonnissent, D., Robert, G., Debue, K., Evin, A., & Grouard, S. (2021). Archaeobiogeography of extinct rice rats (Oryzomyini) in the Lesser Antilles during the Ceramic Age (500 BCE–1500 CE). ***Holocene, 31***(3), 433–445. https://doi.org/10.1177/0959683620972785

Evin, A., Dobney, K., Schafberg, R., Owen, J., Vidarsdottir, U. S., Larson, G., & Cucchi, T. (2015). Phenotype and animal domestication: A study of dental variation between domestic, wild, captive, hybrid and insular Sus scrofa. ***BMC Evolutionary Biology***, ***15***(1), 6. https://doi.org/10.1186/s12862-014-0269-x

Fernández-García, M., Royer, A., López-García, J. M., Bennàsar, M., Goedert, J., Fourel, F., Julien, M.-A., Bañuls-Cardona, S., Rodríguez-Hidalgo, A., Vallverdú, J., & Lécuyer, C. (2019). Unravelling the oxygen isotope signal (δ18O) of rodent teeth from northeastern Iberia, and

implications for past climate reconstructions. ***Quaternary Science Reviews***, ***218***, 107–121. https://doi.org/10.1016/j.quascirev.2019.04.035

Giovas, C. M. (2019). The Beasts at Large – Perennial Questions and New Paradigms for Caribbean Translocation Research. Part I: Ethnozoogeography of Mammals. ***Environmental Archaeology***, ***24***(2), 182–198. https://doi.org/10.1080/14614103.2017.1315208

Guiry, E. 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***(3), 351–376. https://doi.org/10.1007/s10816-011-9118-z

Hofman, C. L., & Hoogland, M. L. P. (2015). Investigaciones arqueológicas en los sitios El Flaco (Loma de Guayacanes) y La Luperona (UNIJICA). ***Boletín Del Museo Del Hombre Dominicano***, ***46***(42), 61–74.

Hofman, C. L., Hoogland, M. L. P., & Pagán Jiménez, J. R. (2020). En la víspera de la colonización Europea: Los sitios indígenas El Flaco, El Carril y El Cabo, República Dominicana. ***Boletín Del Museo Del Hombre Dominicano***, ***48***, 146–165.

Hooghiemstra, H., Olijhoek, T., Hoogland, M., Prins, M., van Geel, B., Donders, T., Gosling, W., & Hofman, C. (2018). Columbus' environmental impact in the New World: Land use change in the Yaque River valley, Dominican Republic. ***Holocene***, ***28***(11), 1818–1835. https://doi.org/10.1177/0959683618788732

Kimura, B. K., LeFebvre, M. J., deFrance, S. D., Knodel, H. I., Turner, M. S., Fitzsimmons, N. S., Fitzpatrick, S. M., & Mulligan, C. J. (2016). Origin of pre-Columbian guinea pigs from Caribbean archeological sites revealed through genetic analysis. ***Journal of Archaeological Science: Reports***, ***5***, 442–452. https://doi.org/10.1016/j.jasrep.2015.12.012

Laffoon, J. E., Hoogland, M. L. P., Davies, G. R., & Hofman, C. L. (2019). A Multi-Isotope Investigation of Human and Dog Mobility and Diet in the Pre-Colonial Antilles. ***Environmental Archaeology***, ***24***(2), 132–148. https://doi.org/10.1080/14614103.2017.1322831

Laffoon, J. E., Plomp, E., Davies, G. R., Hoogland, M. L. P., & Hofman, C. L. (2015). The Movement and Exchange of Dogs in the Prehistoric Caribbean: An Isotopic Investigation. ***International***

Journal of Osteoarchaeology, *25*(4), 454–465. https://doi.org/10.1002/oa.2313

Lawrence, B. (1977). Dogs from the Dominican Republic. *Cuardenos Del Cendia, Centro Dominicano de Investigaciones Antropologicas, Universidad de Santo Domingo*, *168*(8), 3–19.

LeFebvre, M. J., deFrance, S. D., Kamenov, G. D., Keegan, W. F., & Krigbaum, J. (2019). The zooarchaeology and isotopic ecology of the Bahamian hutia (Geocapromys ingrahami): Evidence for pre-Columbian anthropogenic management. *PLOS ONE*, *14*(9), e0220284. https://doi.org/10.1371/journal.pone.0220284

Lord, E., Collins, C., deFrance, S., LeFebvre, M. J., & Matisoo-Smith, E. (2018). Complete mitogenomes of ancient Caribbean Guinea pigs (Cavia porcellus). *Journal of Archaeological Science: Reports*, *17*, 678–688. https://doi.org/10.1016/j.jasrep.2017.12.004

Mickleburgh, H. L., Laffoon, J. E., Pagán-Jiménez, J. R., Mol, A. A. A., Walters, S., Beier, Z. J. M., & Hofman, C. L. (2019). Precolonial/early colonial human burials from the site of White Marl, Jamaica: New findings from recent rescue excavations. *International Journal of Osteoarchaeology*, *29*(1), 155–161. https://doi.org/10.1002/oa.2707

Oswald, J. A., Allen, J. M., LeFebvre, M. J., Stucky, B. J., Folk, R. A., Albury, N. A., Morgan, G. S., Guralnick, R. P., & Steadman, D. W. (2020). Ancient DNA and high-resolution chronometry reveal a long-term human role in the historical diversity and biogeography of the Bahamian hutia. *Scientific Reports*, *10*(1), 1373. https://doi.org/10.1038/s41598-020-58224-y

Pagán-Jiménez, J. R., Ali, Z., Santiago-Marrero, C. G., & Hofman, C. L. (2020). Plantscapes of dwelling: Precolonial household mounds, phytocultural dynamics and the ensuing human ecosystems at El Flaco and El Carril (cal. AD 990–1450), northern Dominican Republic. *Review of Palaeobotany and Palynology*, *274*, 104160. https://doi.org/10.1016/j.revpalbo.2020.104160

Pagan-Jimenez, J. R., & Mickleburgh, H. (2022). Caribbean Deep-Time Culinary Worlds Revealed by Ancient Food Starches: Beyond the Dominant Narratives. *Journal of Archaeological Research*. https://doi.org/10.1007/s10814-021-09171-3

Parham, J. F., Papenfuss, T. J., Dijk, P. P. van, Wilson, B. S., Marte, C., Schettino, L. R., & Brian

Simison, W. (2013). Genetic introgression and hybridization in Antillean freshwater turtles (Trachemys) revealed by coalescent analyses of mitochondrial and cloned nuclear markers. ***Molecular Phylogenetics and Evolution***, ***67***(1), 176–187. https://doi.org/10.1016/j.ympev.2013.01.004

Pederzani, S., & Britton, K. (2019). Oxygen isotopes in bioarchaeology: Principles and applications, challenges and opportunities. ***Earth-Science Reviews***, ***188***, 77–107. https://doi.org/10.1016/j.earscirev.2018.11.005

Rival, L. (2012). The materiality of life: Revisiting the anthropology of nature in Amazonia. ***Indiana***, ***29***, 127–143.

Rival, L. (2014). Encountering nature through fieldwork: Expert knowledge, modes of reasoning, and local creativity: Encountering nature through fieldwork. ***Journal of the Royal Anthropological Institute***, ***20***(2), 218–236. https://doi.org/10.1111/1467-9655.12101

Rozanski, K., Araguás-Araguás, L., & Gonfiantini, R. (1993). Isotopic Patterns in Modern Global Precipitation. In ***Climate Change in Continental Isotopic Records*** (pp. 1–36). American Geophysical Union (AGU). https://doi.org/10.1029/GM078p0001

Smith, B. D. (2001). Low-Level Food Production. ***Journal of Archaeological Research***, ***9***(1), 1–43.

Smith, B. D. (2007). Niche construction and the behavioral context of plant and animal domestication. ***Evolutionary Anthropology: Issues, News, and Reviews***, ***16***(5), 188–199. https://doi.org/10.1002/evan.20135

Smith, B. D. (2011). General patterns of niche construction and the management of 'wild' plant and animal resources by small-scale pre-industrial societies. ***Philosophical Transactions of the Royal Society B: Biological Sciences***, ***366***(1566), 836–848. https://doi.org/10.1098/rstb.2010.0253

Stange, M., Núñez-León, D., Sánchez-Villagra, M. R., Jensen, P., & Wilson, L. A. B. (2018). Morphological variation under domestication: How variable are chickens? ***R Soc Open Sci***, ***5***(8), 180993–180993. https://doi.org/10.1098/rsos.180993

Swift, J. A. (2016). ***Polynesian Subsistence, Nutrient Flows, and Long-Term Socio-Ecosystem Dynamics: Insights from Stable Isotope Analysis of the Pacific Rat (Rattus exulans) in Island Foodwebs*** [Ph.D. dissertation]. University of California, Berkeley.

Swift, J. A., Miller, M. J., & Kirch, P. V. (2017). Stable isotope analysis of Pacific rat (***Rattus exulans)*** from archaeological sites in Mangareva (French Polynesia): The use of commensal species for understanding human activity and ecosystem change. ***Environmental Archaeology***, ***22***(3), 283–297. https://doi.org/10.1080/14614103.2016.1216933

Veloz Maggiolo, M. (1972). ***Arqueología. Prehistorica de Santo Domingo***. McGraw Hill.

Wilkins, L. (2001). Impact of hunting on Jamaican hutia (Geocapromys brownii) populations: Evidence from zooarchaeology and hunter surveys. In C. A. Woods & F. E. Sergile (Eds.), ***Biogeography of the West Indies: Patterns and Perspectives*** (pp. 529–546). CRC Press.

Woods, R., Barnes, I., Brace, S., & Turvey, S. T. (2021). Ancient DNA Suggests Single Colonization and Within-Archipelago Diversification of Caribbean Caviomorph Rodents. ***Molecular Biology and Evolution***, ***38***(1), 84–95. https://doi.org/10.1093/molbev/msaa189

Zeder, M. A. (2015). Core questions in domestication research. ***Proceedings of the National Academy of Sciences***, ***112***(11), 3191–3198. https://doi.org/10.1073/pnas.1501711112