

Why Zooarchaeology Needs Stable Isotope Analysis

PAUL SZPAK

I have chosen an intentionally provocative title for this chapter. Clearly, zooarchaeology has functioned as a discipline without the integration of isotopic methods for many decades, so I suppose that many people might suggest that *need* is far too strong a word. More than that, despite the fact that in my career I have primarily analyzed the isotopic compositions of animal bones, I am definitely not a zooarchaeologist, so who am I to say what my zooarchaeological colleagues need? The reason that I arrived at “need,” however, comes from an examination of what the goals of zooarchaeology appear to be. At the broadest level, zooarchaeology is the study of animal remains from archaeological sites, but what zooarchaeologists hope to learn from these animal remains is clearly different than, for example, vertebrate paleontology. Albarella (2017) makes this distinction, “while palaeontologists will focus on the animals themselves, zooarchaeologists investigate their relationships with humans.” For Reitz and Wing (2008:1), “the goal of zooarchaeology is to understand the relationship between humans and their environment(s), especially between humans and other animal populations.” A similar point emphasizing relationships is made by Gifford-Gonzalez (2018:10), although this view does not encapsulate the “archaeozoology” widely practiced in Europe that has been less focused on human-animal relationships. The important point here is that for most zooarchaeologists, one of, if not *the*, core goals of the discipline is using faunal remains to understand past relationships between humans and animals. In this paper, I argue that stable isotope analysis is uniquely positioned among a host of other analytical tools to make a real contribution to

zooarchaeology's stated goals and that moving forward, these techniques must become part of the standard zooarchaeological repertoire.

Human-Animal Relationships

It is first necessary to consider the range of interactions that exist between humans and nonhuman animals. Knight (2012) makes a distinction between the kinds of interactions that hunters tend to have with the animals that they hunt and the kinds of interactions that those involved in some form of animal husbandry have with the animals that they keep. Informed by Hinde's (1979) classification of relationships as personal (serial interactions with the same individuals) or formal (serial interactions with a *class* of others), Knight (2012) argues that hunters are able to know the animals they hunt well as *types* (as in formal relationships), but not as individuals as they know their kin (as in personal relationships). Certainly, hunters that regularly hunt moose and beaver have a deep understanding of those animal types, built upon many interactions with moose and beaver over time. These interactions are, however, necessarily fleeting and it is rare that the past interactions that a hunter had with an *individual* animal will inform their decision about ongoing or future interactions with that same animal—animals are either killed during the hunt or they flee. If hunters believe that the animals they killed are reincarnated if the proper ritual elements of the hunt are conducted (Hallowell 1960; Nadasdy 2007; Speck 1935; Tanner 2014; Willerslev 2007), it could be argued that these interactions are *understood* in social terms. Nonetheless, we must acknowledge the behavior of the hunted animals as evidence that they have no interest in being killed by the hunter. Moreover, it appears that some hunters are acutely aware of this reality, as is made readily apparent by Willerslev (2013). The materials (for example, meat, hides, bones) extracted from hunted animals are of obvious economic importance, and these animals play a significant role in a symbolic or cosmological sense (Hallowell 1926; Lévi-Strauss 1963; Tapper 1988; Tilley 1999). The interactions between hunters and living animals (in a materialistic sense) are also extremely significant, even if the individuals involved in these interactions are not known to one another. These formal interactions simply occur between individual humans and animal *types*.

In contrast to the formal relationships between hunters and animal types are the more personal relationships between herders (and others involved in animal husbandry who may not be “herders” *sensu stricto*) and

their animals. In this case, herders know the individual animals with whom they interact, and their interactions with a particular animal are informed by their broad knowledge of that animal type (as with hunters), but also by previous interactions with that individual. Human-animal interactions in this context consist of a series of repeated interactions between individuals who are known to one another. In other words, we can think of the interactions between herders and their individual animals as being “thick,” while those occurring between hunters and individual animals are comparatively “thin” (Knight 2018), despite the fact that both the hunter and the herder have a tremendous knowledge about the animal types with which they interact (Figure 11.1). There is likely a positive correlation between the amount of time and space that is shared between an *individual* human and an *individual* animal. Interactions between humans and companion species such as dogs may represent the “thickest” of these interactions (Losey et al. 2011; Losey et al. 2013b), although Argent (2010) presents a compelling case for horses. Within the category of livestock animals, there is certainly a diversity in the thickness of these interactions. Stépanoff et al. (2017) present five models of animal husbandry in North Asia that vary according to the amount of agency granted to the animals. Toward the end of the spectrum involving the greatest amount of animal agency, animals spend significant amounts of time away from people and herds need to be located, a process which may take weeks for some species. This mode contrasts with animal husbandry, in which the movement of animals is constrained, and they are provided with fodder as a major source of food. Those modes of interaction wherein animals are afforded the lowest amount of agency are also those where the animals are most dependent on humans and where the most highly individualized (thick) relationships can emerge. The end goal of the animal husbandry is also a significant variable in this regard, as animals kept for their secondary products (for example, fiber, traction, fertilizer, milk) are likely to live much longer than those slaughtered for meat and are also more likely to form these thick relationships with humans (see Al-lentuck 2015).

Considering the importance of these interactions between humans and animals, it is imperative that we not focus exclusively or even primarily on the interactions between humans and the products provided by animals, particularly meat. As Knight (2005b:5) points out, “a preoccupation with the outcome of the relationship (slaughter for meat) is apt to conceal the protracted relationship of nurturance and care that precedes it.” By virtue of the fact that most of the animal remains recovered from archaeological

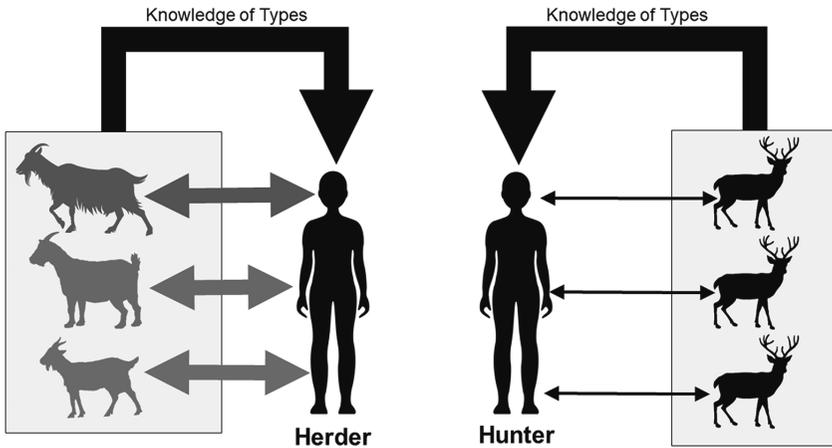


Figure 11.1. Schematic representing the relationships between herders and animals, and hunters and animals. Hunters' relationships with individual prey are 'thin,' while their relationships with prey types are 'thick.' Herders' relationships with their flocks are 'thick' at the level of both the individual and the type. The individual interactions among herders and their animals are highly varied while those between hunters and their prey are more homogenous.

sites belong to animals that had been consumed after they were slaughtered and their carcasses disarticulated, this means that these are the aspects of the human-animal relationships on which zooarchaeology has focused. This problem is reminiscent of the "streetlight effect" commonly used to describe a particular type of observational bias in science. Late at night, a police officer notices a drunkard searching for something under a streetlight. The officer asks the drunkard what he is looking for, to which the drunkard replies, "my keys." The two search for the keys together under the streetlight for some time before the police officer asks if the drunkard is sure that this is where he lost his keys. "No," he replies, "I lost them over there . . . in the park." The officer asks why they are bothering to look under the streetlight, to which the drunkard replies, "this is where the light is."

A recent trend in cultural anthropology and related disciplines has been to focus on the interactions between living animals and humans, as evidenced in the growing fields of multispecies ethnography (Kirksey and Helmreich 2010; Ogden et al. 2013) and human-animal studies in the humanities and social sciences more broadly (DeMello 2012; Knight 2005a; Philo and Wilbert 2000; Serpell 1996; Wilkie 2013). Focusing on these lived interactions between humans and nonhuman animals rather than the economic or symbolic aspects of animals has been fruitful for our

understanding of the nature of these relationships. I would argue that we must take a similar approach in zooarchaeology if we wish to understand these relationships—we need to start looking for our keys in the park, not under the streetlight. There has been some discussion of these issues in archaeology (Oma 2010, 2013; Orton 2010), often utilizing the relational ontologies of northern Eurasian hunting societies to interpret deposits of animal remains or representations of animals (Betts et al. 2017; Herva 2009; Herva and Ylimaunu 2009; Hill 2011, 2012, 2013). These studies recognize that animals may have been viewed as subjects with agency by past societies, but rarely integrate empirical evidence that can actually speak to this subjectivity and agency (but see Argent 2010; Losey et al. 2011). Stable isotope analysis provides us with a rather effective “flashlight” in this context, allowing us to reconstruct the conditions under which an animal actually lived and providing us with unique insights with respect to how a living animal (as a type, as an individual, or both) may have interacted with humans.

Stable Isotopes and Zooarchaeology

Isotopic studies of faunal material have not always been used to examine lived relationships between humans and animals. Early research had an explicitly economic focus, and the animals themselves were primarily seen as the most effective means to interpret the isotopic compositions of human tissues for the purposes of diet reconstruction (for example, Ambrose 1986; Katzenberg 1989; White et al. 1993). This focus mirrored the original economic focus in zooarchaeology overall (deFrance 2009). There are now many instances in which the isotope analyses of the faunal materials have taken center stage within a particular study, to reconstruct past environmental conditions (Hartman et al. 2016; Misarti et al. 2009; Szpak et al. 2019), animal husbandry practices (Dufour et al. 2018; Pearson et al. 2007; Somerville et al. 2010; Szpak et al. 2014), hunting or fishing practices (Grimstead et al. 2016; Guiry et al. 2016; Szpak et al. 2012), trade in animals or animal products (Frei et al. 2015; Guiry et al. 2017; Sugiyama et al. 2018; Szpak et al. 2018; Szpak et al. 2020), or to stand in as proxies for human behavior (Cannon et al. 1999; Guiry and Gaulton 2016). These types of studies are certainly valuable contributions, but I suggest that viewing these data through the lens of the different types of interactions between humans and animals discussed previously can provide valuable structure to this research from the outset (that is, research design). The most important contribution that stable isotope analyses can make centers on the fact

that these data actually provide information about the life history of the animal. These data can be related to the types of foods that were consumed ($\delta^{13}\text{C}$, $\delta^{15}\text{N}$, $\delta^{34}\text{S}$) or how the animal moved across the landscape through life ($\delta^{18}\text{O}$, Sr and Pb isotope ratios). I suggest that we should reframe our research such that we explicitly recognize why it is so crucial to know how an animal that ended up in an archaeological deposit actually lived. As outlined below, this reframing would be useful for both wild animals and domesticates.

Types of Human-Animal Relationships and Isotopic Applications

Highly Formal Relationships

A relatively extreme example where it would appear that little interaction takes place between a human and an animal involves fishing. Unlike hunting, many methods of fishing, such as those with hook and line, do not involve active pursuit of prey. The boundary at the surface of the water may make it particularly difficult for any relationships to emerge between fish and angler prior to the fish being hooked. Even after the fish is hooked, the angler is interacting only with a type rather than an individual fish. Some mass capture techniques are designed to acquire large numbers of fish in a short period of time. I would argue that these types of interactions represent the extreme end of the spectrum of the previously discussed relationships and are the most formal, such that the nonhuman actors are viewed entirely as types rather than individuals. Nonetheless, there are some valuable insights that can be gained by applying isotopic analyses to fish remains from archaeological sites.

If we accept that for fish, the meaningful unit of interaction is with the type, we may reconstruct aspects of the conditions under which that animal type lived, and therefore we may reconstruct the setting for the interaction between the human and nonhuman actors. In short, we can use isotopic measurements of fish remains to reconstruct the type of environment from which the fish were extracted. These reconstructions range from very broadly to more narrowly defined environments. At the broadest of these scales, several isotopic studies of modern fish have differentiated anadromous and freshwater resident varieties of the same species (Godbout et al. 2010; Hesslein et al. 1991), relying on the difference among $\delta^{13}\text{C}$, $\delta^{15}\text{N}$, and $\delta^{34}\text{S}$ values for consumers in freshwater and marine environments. This has been applied in archaeological contexts to differentiate resident (kokanee)

and anadromous salmon in British Columbia (Guiry et al. 2020) as well as freshwater vs. marine vs. brackish water eels in Europe (Robson et al. 2012). Knowing the type of environment from which these fish were extracted is crucial if we ultimately want to understand how past peoples interacted with other species and the landscape more generally.

At a finer scale within the marine or freshwater environment, it is possible to use the isotopic compositions of fish remains to reconstruct aspects of that fish's environment. There is a large difference in the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values of different classes of marine producers, such as phytoplankton (usually the dominant producer), diazotrophic bacteria, canopy-forming kelp, seagrass, red algae, and green algae. These distinctions cause consumers living in, for example, kelp forests or seagrass meadows to have distinct $\delta^{13}\text{C}$ values from those living in open water conditions (dominated by phytoplankton) (Barros et al. 2010; Duggins et al. 1989; Dunton and Schell 1987). These differences are usually more subtle than those separating marine and freshwater environments, but have been examined in archaeological contexts using the isotopic compositions of fish bone collagen in the northeast Pacific (Braje et al. 2017; Szpak et al. 2013). In this case, the relative abundance of kelp forests may have been very different in the past relative to its current state, because of the changes wrought by the local extirpation of sea otters, a keystone predator, during the maritime fur trade. At the scale of ocean basins, Barrett and colleagues have used isotope analyses of Atlantic cod bones to study the Medieval cod trade in Europe (Barrett et al. 2008; Barrett et al. 2011; Orton et al. 2011). These analyses rely on the fact that there is systematic geographic variation in the isotopic composition of primary producers and higher trophic level consumers across large spatial scales (Graham et al. 2010). While the goal of these analyses was ultimately aimed at understanding the economics of the trade in cod rather than the interactions between the anglers and the cod, they have still provided insight into the fishing grounds on which these cod were caught.

At the finest scale, aspects of where a fish was caught may be assessed via the isotopic composition of its tissues. There are well-established isotopic gradients between pelagic and benthic habitats, as well as between inshore and offshore habitats in aquatic environments (Cherel and Hobson 2007; Hobson 1993; Hobson et al. 1994). Some fish, such as swordfish and marlin, are clearly associated with open water, pelagic environments and would have required specialized technology to harvest (Rick et al. 2019). Other fish inhabit a range of different environments, which may change over time

as the fish grows. Pacific halibut, for example, move further offshore as they mature, leading to lower $\delta^{13}\text{C}$ values (due to offshore feeding) in older fish. Using limited data, Szpak et al. (2009) speculated that highly variable $\delta^{13}\text{C}$ values in archaeological Pacific halibut were caused by the acquisition of fish across a range of inshore and offshore habitats. Robust interpretations at this scale, however, would likely require large sample sizes to adequately capture this variability. Combining these isotopic data with size estimates based on morphometrics could be particularly fruitful (Guiry et al. 2021).

Predominantly, fish bone collagen isotopic compositions have been used to provide an interpretive framework for human diet (Bösl et al. 2006; Harrison and Katzenberg 2003; Katzenberg and Weber 1999; Pfeiffer et al. 2016; Reitsema et al. 2013). Secondly, these data have been used for reconstructing various aspects of past environments (Brugam et al. 2017; Misarti et al. 2009). With respect to the latter, I would argue that these data provide valuable insight into the conditions in which the anglers interacted with these fish, and reframing these studies in this light may lead to greater insights into these human-animal interactions. Thus, even in the case of these highly formal interactions between humans and fish, isotopic data can shed light on aspects of the nature of human-animal interactions that would have been difficult, if not impossible, to ascertain on the basis of traditional zooarchaeological methods.

Formal Relationships

Within this category, I will focus on relationships between hunters and their prey. Many of the same points discussed in the previous section that was more narrowly focused on fish would apply to other vertebrate animals taken during hunts—their tissue isotopic compositions could be used to reconstruct the types of environments in which these animals were harvested. I have chosen to separate these from the highly formal relationships between anglers and fish in recognition of the extensive literature discussing the complex nature of interactions between hunters in traditional societies and their prey (Brightman 1993; Descola 1994; Tanner 2014; Willerslev 2007).

While I agree with the perspective of Knight (2012, 2018) that hunted animals do not form social relationships with the humans that hunt them, I believe that are still aspects of the relational ontologies of traditional hunting societies that may reveal themselves in the isotopic compositions of animal remains. In a criticism of Knight's position, Hill (2013) points out that activities other than killing or attempting to kill are important

points of human-animal relations for hunters, including: tracking, traveling, dreaming, listening, and observing. But an important question is, what traces would any of these practices leave in the archaeological record? More importantly within the context of this paper, how might these activities influence the isotopic composition of the animal, if at all?

The presence of predators in a particular area has the potential to change the behavior of prey, as well as their spatial distribution. Not only do prey species display increased vigilance when predators occur in a particular area (Laundré et al. 2001), but elements of their foraging behavior, including the relative abundance of preferred forage in the diet and the use of particular habitat types (for example, riparian vs. upland, open areas vs. forest edges), can change dramatically because of the mere presence of predators. Moreover, because herbivores alter their behavior due to predation risk, this can have cascading effects on the type of vegetation present (Ripple and Beschta 2003, 2004; White et al. 2003) and the rate of nitrogen mineralization in the soil (Frank 2008), in turn altering the abundance of other species. After wolves were reintroduced into Yellowstone National Park, there were major changes in elk behavior, which in turn increased the abundance of willows, a preferred food for beavers, which also increased in abundance (Ripple and Beschta 2004). These effects of predation risk on prey behavior have been discussed in terms of “landscapes of fear,” and it has been suggested that these interactions have an important role to play in structuring entire ecosystems (Laundré et al. 2010; Ripple and Beschta 2004). It is easy to see how this might translate into interactions between humans and prey species. Perhaps less obvious is how these effects may explain certain aspects of the isotopic variation observed in these prey species.

In an isotopic study involving late Holocene sea otters from northern British Columbia, Szpak et al. (2012) suggested that the low dietary diversity and lack of evidence for fish consumption by sea otters was evidence that otter populations were at relatively low densities. The consistent abundance of sea otters in archaeological deposits in the region, however, evinced sustained hunting pressure by First Nations groups. Integrating the regional faunal abundance data, catch statistics from the nineteenth-century maritime fur trade, and the isotopic compositions of the sea otters, they suggested that sea otter abundance was low in the vicinity of villages, but high in areas removed from human habitation, driven by nonlethal interactions (landscapes of fear) with First Nations hunters. In this case, the diets of this animal species as reconstructed by isotopic techniques

informed where interactions between hunters and sea otters were likely occurring, and provided a rough model for the spatial distribution of the species. In this case, the interpretations were grounded in the potential effects of nonlethal encounters between hunters and prey species. By integrating knowledge of the ecology of particular prey species and a thorough understanding of the environmental mechanisms that can influence the distribution of stable isotopes, it is therefore possible to gain novel insights into the nature of past human-animal interactions.

Personal Relationships

Following Knight (Knight 2005b, 2012, 2018), I have suggested above that relationships between humans and domestic animals are thicker than those between humans and wild animals at the level of individuals, though not necessarily at the level of types (Figure 11.1). One of the primary reasons for this distinction is that the relationships between humans and individual companion or livestock animals can take on a highly *individualized* nature, reflecting a sustained history of shared time and space. Attempting to generalize about the nature of human-animal relationships, Figure 11.2 characterizes the nature of these relationships on two axes: 1) the amount of time and space shared between human and animal, and 2) the number of distinct individuals participating in the interactions. Many species share time and space with humans to a significant degree (right side of Figure 11.2), but there is a clear difference in the level of individuality among companion or working species (greatest), to commensals such as mice (moderate), and finally to pests such as lice, intestinal parasites, or mosquitoes (least). Fish share very little time or space with humans, and so there is little to no differentiation of distinct individuals, placing the most formal interactions in the bottom left of the figure.

Some domesticated species are maintained in such a way that they are left untended for long periods of time (“Autonomous” in Figure 11.2). For example, some western Siberian herders release reindeer into the forests, relocating them months later through searches that may last for weeks (Stépanoff et al. 2017). Moving from the top left to the bottom right of Figure 11.2, there is a continuum in the nature of human-animal relationships on the bases of how much time and space is shared and the extent to which these interactions vary among individuals. In more extensive modes (for example, nomadic pastoralism), there are more animals and less individualization, whereas in the more intensive modes (for example, stabling) a greater number of distinct individuals may be recognized because of the

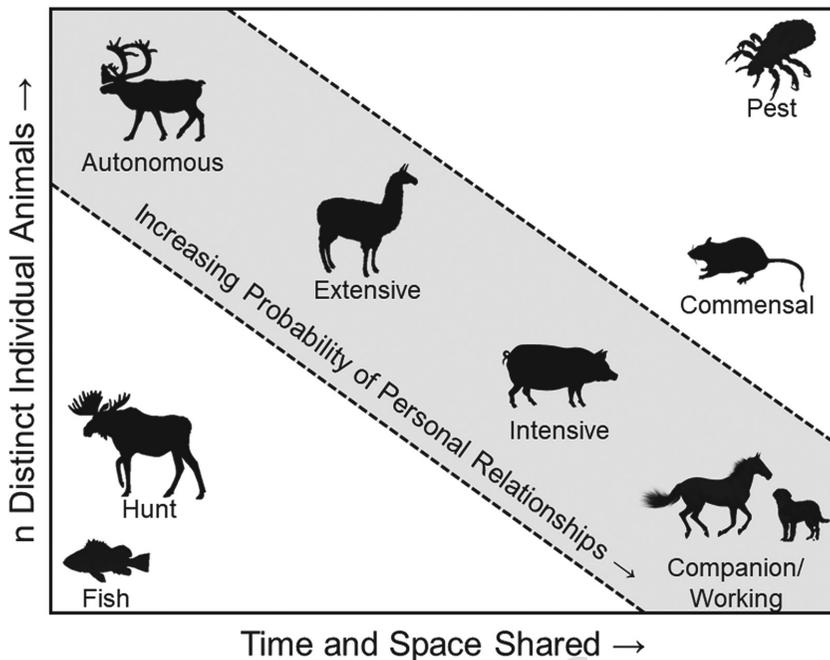


Figure 11.2. Schematic representing a range of human-animal relationships along two axes: the amount of time and space shared (x axis) and the number of distinct individuals participating in the interactions (y axis). Note that this schematic is taxon-independent in that an emu or a narwhal may be hunted as easily as a moose, and a turkey or a guinea pig may be intensively penned as easily as a pig.

increased time and space shared by human and animal. In other words, approaching the bottom right of Figure 11.2, the probability of the development of personal relationships increases. Moving away from this point in any direction decreases the probability of the formation of a personal relationship.

How might the nature of these relationships be present isotopically in the archaeological record? I believe that in this context, variation in the lived experience is crucial. Something that stands out in the study of some animal burials is the variation with which these individuals were treated (Argent 2010; Losey et al. 2011; Losey et al. 2013b; Losey et al. 2018). An obvious implication here is that the interactions between individual humans and these animals were quite varied in life, as are interactions among humans. These varied life experiences have been investigated through the construction of osteobiographies, particularly for dogs (Losey et al. 2011; Losey et al. 2013b; Losey et al. 2020; Tourigny et al. 2015). Clearly, there are

differences among taxa in terms of how individualized their interactions with humans might be, and we can reasonably expect that more often than not, dogs should have more individualized relationships with people than cattle or turkeys or alpacas. Within an individual species, however, the level of variation in the life experience may help to deduce where along this continuum a particular set of husbandry practices were situated. Ethnographic studies speak to a range of complex and varied interactions between humans and livestock (Abbinck 2003; Campbell 2005; Dwyer and Minnegan 2005; Onofrei 2017; Rappaport 1968; Wilkie 2005), and there is no reason to believe that the same would not have been true in the past.

The isotopic compositions of single livestock species can be extremely varied within a single archaeological site or deposit (for example, Pearson et al. 2007; Santana-Sagredo et al. 2018; Somerville et al. 2017; Thornton et al. 2011). What should we make of this variation? This interindividual variation may be related to the intensive vs. extensive nature of husbandry practices, as well as the number of individual animals that lived together. Large groups of animals that graze together on the same set of resources tend to have very similar tissue isotopic compositions. Smaller groups of animals raised in isolation from one another by different groups of people are more likely to have more variable tissue isotopic compositions.

Consider the following two scenarios of cattle husbandry. In the first, five hundred head of cattle are raised together in confinement lots and provisioned only with fodder for their entire lives. In the second, fifty hobby farmers each raise ten head of cattle, some employing free-range systems and others using a mix of free-range and foddering systems. Clearly, the second scenario should result in cattle with more variable tissue isotopic compositions, provided this is occurring in an environment with a sufficient amount of baseline isotopic variability. It is also the case that those involved in husbandry practices more akin to the second scenario are more likely to develop individualized (more personal) relationships with their cattle (Campbell 2005; Wilkie 2005). In a study of South American camelids from northern Peru, Szpak et al. (2014) interpreted high levels of interindividual isotopic variability as evidence for a small-scale type of intensive camelid husbandry in the arid coastal river valleys of the region. They suggested that individual families or other small social units kept small numbers of animals (or perhaps single animals) and provided them with a diverse range of fodder depending on what was locally available. This contrasts with the large herds that were kept in the high altitude grasslands and were characterized by more isotopically homogeneous diets (Szpak

et al. 2015). This coastal version of camelid husbandry was very different in character, in that because there were no suitable pasturelands at low altitude, these animals must have lived in close proximity to or within human settlements. The highly diverse diets of these animals were therefore taken as evidence for a range of more individualized husbandry strategies among different groups within large settlements. The sharing of time and space to this extent among humans and camelids would have been more likely to foster personal relationships such that the individuals participating are known to one another. Thus, in the same way that diverse mortuary treatments for dogs have been interpreted as evidence of more personal relationships with humans (Losey et al. 2011), the same may have been true for these camelids.

Summary

At this point, it is cliché to point out that isotopic techniques have tremendous potential to shed light on past human-animal interactions. Instead, I will go a step further and suggest that if we want to understand past human-animal interactions, we *must* use isotopic techniques. Stable isotope analysis needs to become a standard part of the zooarchaeological tool kit, and perhaps this is already happening. This does not mean that all zooarchaeologists must be well versed in stable isotope analysis, but when we think of those techniques that are applied to the study of ancient animal bones, stable isotope analysis should appear alongside the identification of cut marks and quantification of taxonomic abundance as standard. In developing research projects using faunal remains, the question should not be, “should we include isotope analysis?” but instead, “why would we not include isotope analysis?”

If the purpose of zooarchaeology is to better understand interactions between humans and animals, we must prioritize those techniques that will shed light on how animals actually lived and interacted with people. This is not to discount the fact that some traditional societies may not see the death of the animal body as the end of this relationship (Hill 2012; Losey et al. 2013b; Willerslev 2007). Insofar as we recognize animals as subjects and agents (Bird-David 1999; McFarland and Hediger 2009), however, we must acknowledge that from their perspective, being killed almost certainly signifies the end of this relationship. We certainly have no way of knowing if they share a cosmological understanding of human-animal interactions with the people that hunt them, but this level of understanding

seems extremely unlikely. This is not simply an imposition of a western materialist understanding of animals onto the past, but an approach that truly tries to take seriously the preposition of animal subjectivity. It is certainly not the case that there is a dearth of scholars applying isotope analysis to animal remains; if nothing else, this volume is evidence that the opposite is true. I do believe, however, that reframing our research to more explicitly attempt to connect with ideas surrounding what animal life histories can tell us about past human-animal interactions (beyond companion species) will make a truly meaningful contribution toward the stated goals of the discipline of zooarchaeology.

References

- Abbink, Jon
2003 Love and Death of Cattle: The Paradox in Suri Attitudes toward Livestock. *Ethnos* 68(3):341–64.
- Albarella, Umberto
2017 Zooarchaeology in the Twenty-First Century: Where We Come from, Where We Are Now, and Where We Are Going. In *The Oxford Handbook of Zooarchaeology*, edited by Umberto Albarella, Mauro Rizzetto, Hannah Russ, Kim Vickers, and Sarah Viner-Daniels. Oxford University Press, Oxford.
- Allentuck, Adam
2015 Temporalities of Human–Livestock Relationships in the Late Prehistory of the Southern Levant. *Journal of Social Archaeology* 15(1):94–115.
- Ambrose, Stanley H.
1986 Stable Carbon and Nitrogen Isotope Analysis of Human and Animal Diet in Africa. *Journal of Human Evolution* 15(8):707–31.
- Argent, Gala
2010 Do the Clothes Make the Horse? Relationality, Roles and Statuses in Iron Age Inner Asia. *World Archaeology* 42(2):157–74.
- Barrett, James H., Cluny Johnstone, Jennifer Harland, Wim Van Neer, Anton Ervynck, Daniel Makowiecki, Dirk Heinrich, Anne Karin Hufthammer, I. B. Enghoff, Colin Amundsen, J. S. Christiansen, Andrew K. G. Jones, Alison Locker, Sheila Hamilton-Dyer, Leif Jonsson, Lembi Liugas, Callum Roberts, and Michael Richards
2008 Detecting the Medieval Cod Trade: A New Method and First Results. *Journal of Archaeological Science* 35(4):850–61.
- Barrett, James H., David Orton, Cluny Johnstone, Jennifer Harland, Wim Van Neer, Anton Ervynck, Callum Roberts, Alison Locker, Colin Amundsen, Inge Bødker Enghoff, Sheila Hamilton-Dyer, Dirk Heinrich, Anne Karin Hufthammer, Andrew K. G. Jones, Leif Jonsson, Daniel Makowiecki, Peter Pope, Tamsin C. O’Connell, Tessa de Roo, and Michael Richards
2011 Interpreting the Expansion of Sea Fishing in Medieval Europe Using Stable Isotope Analysis of Archaeological Cod Bones. *Journal of Archaeological Science* 38(7):1516–24.

- Barros, Nélio B., P. H. Ostrom, C. A. Stricker, and R. S. Wells
 2010 Stable Isotopes Differentiate Bottlenose Dolphins off West-Central Florida. *Marine Mammal Science* 26(2):324–36.
- Betts, Matthew W., Mari Hardenberg, and Ian Stirling
 2017 How Animals Create Human History: Relational Ecology and the Dorset–Polar Bear Connection. *American Antiquity* 80(1):89–112.
- Bird-David, Nurit
 1999 “Animism” Revisited: Personhood, Environment, and Relational Epistemology. *Current Anthropology* 40(S1):S67–S91.
- Bösl, C., G. Grupe, and J. Peters
 2006 A Late Neolithic Vertebrate Food Web Based on Stable Isotope Analyses. *International Journal of Osteoarchaeology* 16(4):296–315.
- Braje, Todd J., Torben C. Rick, Paul Szpak, Seth D. Newsome, Joseph M. McCain, Emma A. Elliott Smith, Michael Glassow, and Scott L. Hamilton
 2017 Historical Ecology and the Conservation of Large, Hermaphroditic Fishes in Pacific Coast Kelp Forest Ecosystems. *Science Advances* 3(2):e1601759.
- Brightman, Robert
 1993 *Grateful Prey: Rock Cree Human-Animal Relationships*. University of California Press, Berkeley.
- Brugam, R. B., K. Little, L. Kohn, P. Brunkow, G. Vogel, and T. Martin
 2017 Tracking Change in the Illinois River Using Stable Isotopes in Modern and Ancient Fishes. *River Research and Applications* 33(3):341–52.
- Campbell, Ben
 2005 On ‘Loving Your Water Buffalo More Than Your Own Mother’: Relationships of Animal and Human Care in Nepal. In *Animals in Person: Cultural Perspectives on Human-Animal Intimacy*, edited by John Knight, pp. 79–100. Berg, Oxford.
- Cannon, Aubrey, Henry P. Schwarcz, and Martin Knyf
 1999 Marine-based Subsistence Trends and the Stable Isotope Analysis of Dog Bones from Namu, British Columbia. *Journal of Archaeological Science* 26(4):399–407.
- Cherel, Yves, and Keith A. Hobson
 2007 Geographical Variation in Carbon Stable Isotope Signatures of Marine Predators: A Tool to Investigate Their Foraging Areas in the Southern Ocean. *Marine Ecology Progress Series* 329:281–87.
- deFrance, Susan
 2009 Zooarchaeology in Complex Societies: Political Economy, Status, and Ideology. *Journal of Archaeological Research* 17:105–68.
- DeMello, Margo
 2012 *Animals and Society: An Introduction to Human-Animal Studies*. Columbia University Press, New York.
- Descola, Philippe
 1994 *In the Society of Nature: A Native Ecology in Amazonia*. Cambridge University Press, Cambridge.
- Dufour, Elise, Nicolas Goepfert, Manon Le Neün, Gabriel Prieto, and John W. Verano
 2018 Life History and Origin of the Camelids Provisioning a Mass Killing Sacrifice

- during the Chimú Period: Insight from Stable Isotopes. *Environmental Archaeology*: 1–14.
- Duggins, D. O., C. A. Simenstad, and J. A. Estes
1989 Magnification of Secondary Production by Kelp Detritus in Coastal Marine Ecosystems. *Science* 245(4914):170–73.
- Dunton, K. H., and D. M. Schell
1987 Dependence of Consumers on Macroalgal (*Laminaria solidungula*) Carbon in an Arctic Kelp Community: $\delta^{13}\text{C}$ Evidence. *Marine Biology* 93(4):615–25.
- Dwyer, Peter D., and Monica Minnegal
2005 Person, Place or Pig: Animal Attachments and Human Transactions in New Guinea. In *Animals in Person: Cultural Perspectives on Human-Animal Intimacy*, edited by John Knight, pp. 37–60. Berg, Oxford.
- Frank, Douglas A.
2008 Evidence for Top Predator Control of a Grazing Ecosystem. *Oikos* 117(11):1718–24.
- Frei, Karin M., Ashley N. Coutu, Konrad Smiarowski, Ramona Harrison, Christian K. Madsen, Jette Arneborg, Robert Frei, Gardar Guðmundsson, Søren M. Sindbæk, James Woollett, Steven Hartman, Megan Hicks, and Thomas H. McGovern
2015 Was It for Walrus? Viking Age Settlement and Medieval Walrus Ivory Trade in Iceland and Greenland. *World Archaeology* 47(3):439–66.
- Gifford-Gonzalez, Diane
2018 *An Introduction to Zooarchaeology*. Springer, Cham.
- Godbout, Lyse, Marc Trudel, James Irvine, Chris Wood, Marty Grove, Axel Schmitt, and Kevin McKeegan
2010 Sulfur Isotopes in Otoliths Allow Discrimination of Anadromous and Non-Anadromous Ecotypes of Sockeye Salmon (*Oncorhynchus nerka*). *Environmental Biology of Fishes* 89(3):521–32.
- Graham, Brittany S., Paul L. Koch, Seth D. Nesome, Kelton W. McMahan, and David Aurioles
2010 Using Isoscapes to Trace the Movements and Foraging Behavior of Top Predators in Oceanic Ecosystems. In *Isoscapes: Understanding Movement, Pattern, and Process on Earth through Stable Isotope Mapping*, edited by J. B. West, G. J. Bowen, T. E. Dawson, and Kevin P. Tu, pp. 299–318. Springer-Verlag, Heidelberg.
- Grimstead, Deanna N., Jay Quade, and Mary C. Stiner
2016 Isotopic Evidence for Long-Distance Mammal Procurement, Chaco Canyon, New Mexico, USA. *Geoarchaeology* 31(5):335–54.
- Guiry, Eric J., and Barry C. Gaulton
2016 Inferring Human Behaviors from Isotopic Analyses of Rat Diet: A Critical Review and Historical Application. *Journal of Archaeological Method and Theory* 23(2):399–426.
- Guiry, Eric J., Jonathan R. Kennedy, Martin T. O’Connell, D. Ryan Gray, Christopher Grant, and Paul Szpak
2021 Early Evidence for Historical Overfishing in the Gulf of Mexico. *Science Advances* 7(32):eabh2525.

- Guiry, Eric J., Suzanne Needs-Howarth, Kevin D. Friedland, Alicia L. Hawkins, Paul Szpak, Rebecca Macdonald, Michelle Courtemanche, Erling Holm, and Michael P. Richards
 2016 Lake Ontario Salmon (*Salmo salar*) Were Not Migratory: A Long-Standing Historical Debate Solved through Stable Isotope Analysis. *Scientific Reports* 6:36249.
- Guiry, Eric, Thomas C. A. Royle, R. G. Matson, Hillary Ward, Tyler Weir, Nicholas Waber, Thomas J. Brown, Brian P. V. Hunt, Michael H. H. Price, Bruce P. Finney, Masahide Kaeriyama, Yuxue Qin, Dongya Y. Yang, and Paul Szpak
 2020 Differentiating Salmonid Migratory Ecotypes through Stable Isotope Analysis of Collagen: Archaeological and Ecological Applications. *PLOS ONE* 15(4):e0232180.
- Guiry, Eric, Paul Szpak, and Michael P. Richards
 2017 Isotopic Analyses Reveal Geographical and Socioeconomic Patterns in Historical Domestic Animal Trade between Predominantly Wheat- and Maize-Growing Agricultural Regions in Eastern North America. *American Antiquity* 82(2):341–52.
- Hallowell, A. Irving
 1926 Bear Ceremonialism in the Northern Hemisphere. *American Anthropologist* 28(1):1–175.
- Hallowell, Irving
 1960 Ojibwa Ontology, Behavior, and Worldview. In *Culture in History: Essays in Honor of Paul Radin*, edited by Stanley Diamond, pp. 19–52. Columbia University Press, New York.
- Harrison, Roman G., and M. Anne Katzenberg
 2003 Paleodiet Studies Using Stable Carbon Isotopes from Bone Apatite and Collagen: Examples from Southern Ontario and San Nicolas Island, California. *Journal of Anthropological Archaeology* 22(3):227–44.
- Hartman, Gideon, Ofer Bar-Yosef, Alex Brittingham, Leore Grosman, and Natalie D. Munro
 2016 Hunted Gazelles Evidence Cooling, But Not Drying, during the Younger Dryas in the Southern Levant. *Proceedings of the National Academy of Sciences* 113(15):3997.
- Herva, Vesa-Pekka
 2009 Living (with) Things: Relational Ontology and Material Culture in Early Modern Northern Finland. *Cambridge Archaeological Journal* 19(03):388–97.
- Herva, Vesa-Pekka, and Timo Ylimaunu
 2009 Folk Beliefs, Special Deposits, and Engagement with the Environment in Early Modern Northern Finland. *Journal of Anthropological Archaeology* 28(2):234–43.
- Hesslein, R. H., M. J. Capel, D. E. Fox, and K. A. Hallard
 1991 Stable Isotopes of Sulfur, Carbon, and Nitrogen as Indicators of Trophic Level and Fish Migration in the Lower Mackenzie River Basin, Canada. *Canadian Journal of Fisheries and Aquatic Sciences* 48(11):2258–65.

Hill, Erica

2011 Animals as Agents: Hunting Ritual and Relational Ontologies in Prehistoric Alaska and Chukotka. *Cambridge Archaeological Journal* 21(03):407–26.

2012 The Nonempirical Past: Enculturated Landscapes and Other-than-Human Persons in Southwest Alaska. *Arctic Anthropology* 49(2):41–57.

2013 Archaeology and Animal Persons: Toward a Prehistory of Human-Animal Relations. *Environment and Society: Advances in Research* 4:117–36.

Hinde, Robert A.

1979 *Towards Understanding Relationships*. Academic Press, London.

Hobson, Keith A.

1993 Trophic Relationships among High Arctic Seabirds: Insights from Tissue-Dependent Stable-Isotope Models. *Marine Ecology Progress Series* 95:7–18.

Hobson, Keith A., John F. Piatt, and Jay Pitocchelli

1994 Using Stable Isotopes to Determine Seabird Trophic Relationships. *Journal of Animal Ecology* 63(4):786–98.

Katzenberg, M. Anne

1989 Stable Isotope Analysis of Archaeological Faunal Remains from Southern Ontario. *Journal of Archaeological Science* 16(3):319–29.

Katzenberg, M. Anne, and Andrzej Weber

1999 Stable Isotope Ecology and Palaeodiet in the Lake Baikal Region of Siberia. *Journal of Archaeological Science* 26(6):651–59.

Kirksey, S. Eben, and Stefan Helmreich

2010 The Emergence of Multispecies Ethnography. *Cultural Anthropology* 25(4):545–76.

Knight, John

2005a *Animals in Person: Cultural Perspectives on Human-Animal Intimacy*. Berg, Oxford.

2005b Introduction. In *Animals in Person: Cultural Perspectives on Human-Animal Intimacy*, edited by John Knight, pp. 1–13. Berg, Oxford.

2012 The Anonymity of the Hunt: A Critique of Hunting as Sharing. *Current Anthropology* 53(3):334–55.

2018 Human-Animal Relations. In *The International Encyclopedia of Anthropology*, edited by Hilary Callan. John Wiley & Sons, New York.

Laundré, John W., Lucina Hernández, and Kelly B. Altendorf

2001 Wolves, Elk, and Bison: Reestablishing the “Landscape of Fear” in Yellowstone National Park, U.S.A. *Canadian Journal of Zoology* 79(8):1401–09.

Laundré, John W., Lucina Hernández, and William J. Ripple

2010 The Landscape of Fear: Ecological Implications of Being Afraid. *The Open Ecology Journal* 3:1–7.

Lévi-Strauss, Claude

1963 *Structural Anthropology*. Translated by Claire Jacobson and Brooke Grundfest Schoepf. Basic Books, New York.

- Losey, Robert J., Vladimir I. Bazaliiskii, Sandra Garvie-Lok, Mietje Germonpré, Jennifer A. Leonard, Andrew L. Allen, M. Anne Katzenberg, and Mikhail V. Sablin
 2011 Canids as Persons: Early Neolithic Dog and Wolf Burials, Cis-Baikal, Siberia. *Journal of Anthropological Archaeology* 30(2):174–89.
- Losey, Robert J., Vladimir I. Bazaliiskii, Angela R. Lieverse, Andrea Waters-Rist, Kate Faccia, and Andrzej W. Weber
 2013a The Bear-able Likeness of Being: Ursine Remains at the Shamanka II Cemetery, Lake Baikal, Siberia. In *Relational Archaeologies: Humans, Animals, Things*, edited by Christopher Watts, pp. 65–96. Routledge, New York.
- Losey, Robert J., Sandra Garvie-Lok, Jennifer A. Leonard, M. Anne Katzenberg, Mietje Germonpré, Tatiana Nomokonova, Mikhail V. Sablin, Olga I. Goriunova, Natalia E. Berdnikova, and Nikolai A. Savel'ev
 2013b Burying Dogs in Ancient Cis-Baikal, Siberia: Temporal Trends and Relationships with Human Diet and Subsistence Practices. *PLOS ONE* 8(5):e63740.
- Losey, Robert J., Eric Guiry, Tatiana Nomokonova, Andrei V. Gusev, and Paul Szpak
 2020 Storing Fish?: A Dog's Isotopic Biography Provides Insight into Iron Age Food Preservation Strategies in the Russian Arctic. *Archaeological and Anthropological Sciences* 12(8):200.
- Losey, Robert J., Tatiana Nomokonova, Lacey S. Fleming, Artur V. Kharinskii, Evgenii V. Kovychev, Mikhail V. Konstantinov, Natal'ia G. Diatchina, Mikhail V. Sablin, and Larisa G. Iaroslavtseva
 2018 Buried, Eaten, Sacrificed: Archaeological Dog Remains from Trans-Baikal, Siberia. *Archaeological Research in Asia* 16:58–65.
- McFarland, Sarah E., and Ryan Hediger, eds.
 2009 *Animals and Agency: An Interdisciplinary Exploration*. Brill, Leiden.
- Misarti, Nicole, Bruce P. Finney, Herbert Maschner, and Matthew J. Wooller
 2009 Changes in Northeast Pacific Marine Ecosystems Over the Last 4500 Years: Evidence from Stable Isotope Analysis of Bone Collagen from Archaeological Middens. *Holocene* 19(8):1139–51.
- Nadasdy, Paul
 2007 The Gift in the Animal: The Ontology of Hunting and Human–Animal Sociality. *American Ethnologist* 34(1):25–43.
- Ogden, Laura A., Billy Hall, and Kimiko Tanita
 2013 Animals, Plants, People, and Things: A Review of Multispecies Ethnography. *Environment and Society* 4(1):5–24.
- Oma, Kristin Armstrong
 2010 Between Trust and Domination: Social Contracts between Humans and Animals. *World Archaeology* 42(2):175–87.
- 2013 Human-Animal Meeting Points: Use of Space in the Household Arena in Past Societies. *Society & Animals* 21:162–77.
- Onofrei, Alexandra
 2017 *Pig Rearing, Killing and Consumption: The Healing Effects of Multispecies Engagement for the Communities of Ilva Mică and Prundu Bârgăului*. M.A. Thesis, University of Exeter, Exeter.

Orton, David

2010 Both Subject and Object: Herding, Inalienability and Sentient Property in Pre-history. *World Archaeology* 42(2):188–200.

Orton, David C., Daniel Makowiecki, Tessa de Roo, Cluny Johnstone, Jennifer Harland, Leif Jonsson, Dirk Heinrich, Inge Bødker Enghoff, Lembi Lõugas, Wim Van Neer, Anton Ervynck, Anne Karin Hufthammer, Colin Amundsen, Andrew K. G. Jones, Alison Locker, Sheila Hamilton-Dyer, Peter Pope, Brian R. MacKenzie, Michael Richards, Tamsin C. O'Connell, and James H. Barrett

2011 Stable Isotope Evidence for Late Medieval (14th–15th C) Origins of the Eastern Baltic Cod (*Gadus morhua*) Fishery. *PLOS ONE* 6(11):e27568.

Pearson, J. A., H. Buitenhuis, R.E.M. Hedges, L. Martin, N. Russell, and K. C. Twiss
2007 New Light on Early Caprine Herding Strategies from Isotope Analysis: A Case Study from Neolithic Anatolia. *Journal of Archaeological Science* 34(12):2170–79.

Pfeiffer, Susan, Judith C. Sealy, Ronald F. Williamson, Suzanne Needs-Howarth, and Louis Lesage

2016 Maize, Fish, and Deer: Investigating Dietary Staples Among Ancestral Huronwendat Villages, As Documented from Tooth Samples. *American Antiquity* 81(3):515–32.

Philo, Chris, and Chris Wilbert, eds.

2000 *Animal Spaces, Beastly Places: New Geographies of Human-Animal Relations*. Routledge, London.

Rappaport, R. A.

1968 *Pigs for the Ancestors: Ritual Ecology of a New Guinea People*. Yale University Press, New Haven.

Reitsema, L. J., T. Kozłowski, and D. Makowiecki

2013 Human–Environment Interactions in Medieval Poland: A Perspective from the Analysis of Faunal Stable Isotope Ratios. *Journal of Archaeological Science* 40(10):3636–46.

Reitz, Elizabeth J., and Elizabeth S. Wing

2008 *Zooarchaeology*. 2nd ed. Cambridge University Press, Cambridge.

Rick, Torben, Virginia L. Harvey, and Michael Buckley

2019 Collagen Fingerprinting and the Chumash Billfish Fishery, Santa Barbara Channel, California, USA. *Archaeological and Anthropological Sciences* 11(12):6639–48.

Ripple, William J., and Robert L. Beschta

2003 Wolf Reintroduction, Predation Risk, and Cottonwood Recovery in Yellowstone National Park. *Forest Ecology and Management* 184(1):299–313.

2004 Wolves and the Ecology of Fear: Can Predation Risk Structure Ecosystems? *Bioscience* 54(8):755–66.

Robson, Harry, Soren Andersen, Oliver Craig, Anders Fischer, Aikaterini Glykou, Sönke Hartz, Harald Lübke, Ulrich Schmölcke, and Carl Heron

2012 Carbon and Nitrogen Isotope Signals in Eel Bone Collagen from Mesolithic and Neolithic Sites in Northern Europe. *Journal of Archaeological Science* 39(7):2003–11.

- Santana-Sagredo, Francisca, Elise Dufour, Nicolas Goepfert, Antoine Zazzo, Régulo Franco Jordán, and Segundo Vásquez Sánchez
 2018 New Bioarchaeological Evidence and Radiocarbon Dates from the Lambayeque/Sicán Culture Camelids from the El Brujo Complex (Northern Coast of Peru): Implications for Funerary and Herd Management Practices. *Environmental Archaeology*: 1–20.
- Serpell, James
 1996 *In the Company of Animals: A Study of Human-Animal Relationships*. Cambridge University Press, Cambridge.
- Somerville, Andrew D., Ben A. Nelson, and Kelly J. Knudson
 2010 Isotopic Investigation of Pre-Hispanic Macaw Breeding in Northwest Mexico. *Journal of Anthropological Archaeology* 29(1):125–35.
- Somerville, Andrew D., Nawa Sugiyama, Linda R. Manzanilla, and Margaret J. Schoeninger
 2017 Leporid Management and Specialized Food Production at Teotihuacan: Stable Isotope Data from Cottontail and Jackrabbit Bone Collagen. *Archaeological and Anthropological Sciences* 9(1):83–97.
- Speck, Frank
 1935 *Naskapi: Savage Hunters of the Labrador Peninsula*. University of Oklahoma Press, Norman.
- Stépanoff, Charles, Charlotte Marchina, Camille Fossier, and Nicolas Bureau
 2017 Animal Autonomy and Intermittent Coexistences: North Asian Modes of Herding. *Current Anthropology* 58(1):57–81.
- Sugiyama, Nawa, William L. Fash, and Christine A. M. France
 2018 Jaguar and Puma Captivity and Trade among the Maya: Stable Isotope Data from Copan, Honduras. *PLOS ONE* 13(9):e0202958.
- Szpak, Paul, Trevor J. Orchard, and Darren R. Gröcke
 2009 A Late Holocene Vertebrate Food Web from Southern Haida Gwaii (Queen Charlotte Islands, British Columbia). *Journal of Archaeological Science* 36(12):2734–41.
- Szpak, Paul, Trevor J. Orchard, Iain McKechnie, and Darren R. Gröcke
 2012 Historical Ecology of Late Holocene Sea Otters (*Enhydra lutris*) from Northern British Columbia: Isotopic and Zooarchaeological Perspectives. *Journal of Archaeological Science* 39(5):1553–71.
- Szpak, Paul, Trevor J. Orchard, Anne K. Salomon, and Darren R. Gröcke
 2013 Regional Ecological Variability and Impact of the Maritime Fur Trade on Near-shore Ecosystems in Southern Haida Gwaii (British Columbia, Canada): Evidence from Stable Isotope Analysis of Rockfish (*Sebastes* spp.) Bone Collagen. *Archaeological and Anthropological Sciences* 5(2):159–82.
- Szpak, Paul, Jean-François Millaire, Christine D. White, and Fred J. Longstaffe
 2014 Small Scale Camelid Husbandry on the North Coast of Peru (Virú Valley): Insight from Stable Isotope Analysis. *Journal of Anthropological Archaeology* 36:110–29.

- Szpak, Paul, Jean-François Millaire, Christine D. White, George F. Lau, Flannery Surette, and Fred J. Longstaffe
 2015 Origins of Prehispanic Camelid Wool Textiles from the North and Central Coasts of Peru Traced by Carbon and Nitrogen Isotopic Analyses. *Current Anthropology* 56(3):449–59.
- Szpak, P., J.-F. Millaire, C. D. White, C. B. Donnan, and F. J. Longstaffe
 2018 Stable Isotope Sourcing of Wool from Textiles at Pacatnamú. *Archaeometry* 60(3):612–27.
- Szpak, Paul, James M. Savelle, James Conolly, and Michael P. Richards
 2019 Variation in Late Holocene Marine Environments in the Canadian Arctic Archipelago: Evidence from Ringed Seal Bone Collagen Stable Isotope Compositions. *Quaternary Science Reviews* 211:136–55.
- Szpak, Paul, Jean-François Millaire, Claude Chapdelaine, Christine D. White, and Fred J. Longstaffe
 2020 An Integrated Isotopic Study of Early Intermediate Period Camelid Husbandry in the Santa Valley, Perú. *Environmental Archaeology* 25(3):279–95.
- Tanner, Adrian
 2014 *Bringing Home Animals*. 2nd ed. Institute of Social and Economic Research, Memorial University of Newfoundland, St. John's, Newfoundland.
- Tapper, Richard L.
 1988 Animality, Humanity, Morality, Society. In *What is an Animal?*, edited by Tim Ingold, pp. 47–62. Routledge, London.
- Thornton, Erin Kennedy, Susan D. deFrance, John Krigbaum, and Patrick Ryan Williams
 2011 Isotopic Evidence for Middle Horizon to 16th Century Camelid Herding in the Osmore Valley, Peru. *International Journal of Osteoarchaeology* 21(5):544–67.
- Tilley, Christopher
 1999 *Metaphor and Material Culture*. Blackwell, Oxford.
- Tourigny, E., R. Thomas, E. Guiry, R. Earp, A. Allen, J. L. Rothenburger, D. Lawler, and M. Nussbaumer
 2015 An Osteobiography of a 19th-Century Dog from Toronto, Canada. *International Journal of Osteoarchaeology* 26(5):818–29.
- White, Christine D., Paul F. Healy, and Henry P. Schwarcz
 1993 Intensive Agriculture, Social Status, and Maya Diet at Pacbitun, Belize. *Journal of Anthropological Research* 49(4):347–75.
- White, Clifford A., Michael C. Feller, and Suzanne Bayley
 2003 Predation Risk and the Functional Response of Elk–Aspen Herbivory. *Forest Ecology and Management* 181(1):77–97.
- Wilkie, Rhoda
 2005 Sentient Commodities and Productive Paradoxes: The Ambiguous Nature of Human–Livestock Relations in Northeast Scotland. *Journal of Rural Studies* 21(2):213–30.
- 2013 Multispecies Scholarship and Encounters: Changing Assumptions at the Human–Animal Nexus. *Sociology* 49(2):323–39.

Willerslev, Rane

2007 *Soul Hunters. Hunting, Animism, and Personhood among the Siberian Yukaghirs.*
University of California Press, Berkeley.

2013 Taking Animism Seriously, But Perhaps Not Too Seriously? *Religion and Society: Advances in Research* 4:41–57.

proof