THE UNIVERSITY OF CHICAGO

EXCAVATING THE DEEP HISTORY OF DEGRADATION: ANIMAL HUSBANDRY AND THE ENVIRONMENTAL IMPACTS OF LIVESTOCK GRAZING IN PRE AND EARLY HISTORIC SOUTH INDIA

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To the Villagers of Kadebakele

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ABSTRACT

This dissertation is an archaeological study that uses a multi-method approach (faunal analysis and dental microwear analysis) and a combination of theoretical frameworks to analyze changes in subsistence organization as well as past perceptions of human-animal relationships and human-environmental interactions. This approach was developed to build a long-term, deep historical perspective of animal husbandry and the environmental impacts of livestock grazing in South India. Faunal and dental microwear data sets were collected from Kadebakele, the research site of the Early Historic Landscapes of the Tungabhadra Corridor Project. Faunal data (used to reconstruct subsistence practices) and dental microwear data (used to determine if overgrazing occurred) were compared across three settlement phases, the Neolithic (3000BCE-1200BCE), Iron Age (1200BCE-300BCE), and Early Historic (300BCE-500CE). The results of faunal and dental microwear analysis show a complex combination of social, economic, and ideological factors related to animal and land use during the Iron Age ultimately had environmental consequences, which set the stage for changes in subsistence organization by the Early Historic period. Coded faunal data was recorded in an excel database and has been submitted as a supplementary file due to its size. Faunal data is also available through tDAR.

This is the first combined faunal and dental microwear study to be carried out in the region. Critically, it shows the deep history of human-animal relationships, animal husbandry, and the impact of livestock grazing, was shaped by multiple dimensions of decision-making under specific social, economic, ideological, and environmental conditions. Such insights are ultimately more useful than ecological myths and tropes when it comes to conservation policy. Continued mobilization of tropes and myths in conservation policy ensure an ineffective response since their goals are not grounded in the empirical record and they overlook the

complexity of human-animal relationships and decisions surrounding land use choices. This is ultimately significant since it eliminates critical opportunities to problem solve when there is so much that we can learn from the past.

CHAPTER 1 :
ARCHAEOLOGICAL APPROACH TO UNDERSTANDING PAST, PRESENT, AND FUTURE HUMAN-ENVIRONMENTAL INTERACTIONS

1.1 Introduction to the Problem and Presentation of Approach

1.1.1 Introduction

In South Asia, anxieties over the destructive impact of livestock grazing have led to conservation policies that restrict pastoralists from areas deemed ecologically vulnerable. Informed by degradation narratives, policies mandating the exclusion of pastoralists and their flocks presume the existence of an undisturbed “natural” past that can be restored only after grazing animals are removed from the landscape. Although the reliance on domesticated livestock herds in South Asia has a deep history, the actual long-term environmental impact of grazing is poorly understood. This problem speaks not only to the lack of data concerning the specific long-term effects of grazing on environmental features, but to a limited understanding of the complex and relational ways landscapes, humans, and domesticated animals have interacted and the continuities and changes that resulted from this history.

This dissertation provides a much-needed long-term perspective on the impacts of livestock grazing through a study of animal husbandry throughout South India’s pre and early history. The specific temporal context for this study includes the Neolithic (3000 BCE-1200 BCE), Iron Age (1200BCE-300 BCE), and Early Historic (300BCE-500 CE) periods. Data for this research comes from Kadebakele, a well-documented settlement located in Karnataka, India. Using multiple lines of archaeological and paleoenvironmental evidence, including zooarchaeological and dental microwear data, this dissertation investigates the specific ways processes of animal husbandry, agricultural production, and landscape modification articulated and intersected to produce a complex environmental history that cannot be easily collapsed into existing degradation narratives. The primary research questions addressed in this dissertation are: how did animal husbandry practices figure into broader social, political, and economic changes throughout the Neolithic, Iron Age, and Early Historic periods? Building off of this, I consider how patterns of animal husbandry relate to changes in vegetation communities, soils, and landforms. Importantly, these questions are evaluated within a framework that problematizes binary ways of thinking about the relationships and conceptualizations of nature and culture, a deeply problematic feature of conservation narratives and of archaeological approaches to human-animal and human-environmental interactions.

In this introductory chapter, I provide a brief background to the problems that anchor the research questions developed in this dissertation. I begin by presenting why environmental degradation narratives, particularly as they relate to grazing, are problematic.
I then describe how archaeology and zooarchaeology can uniquely contribute to discourses on contemporary environmental policy and provide a critical lens for analyzing conservation narratives. Using archaeological and zooarchaeological data, however, is not without its challenges and limitations. I address how the specific methodological and theoretical choices used in this dissertation help to address the limitations of an archaeological analysis of human-environmental interactions and human-animal relationships, especially one that seeks to be relevant to contemporary environmental concerns. I present the specific case study I use and explain why it is an ideal context for the research objectives I have developed. Finally, I summarize the dissertation chapters and describe how they work together to support the final conclusions reached at the end of this dissertation.

1.1.2 Livestock Grazing and Degradation Narratives

In the 2012 *State of Environment Report Karnataka* (India), published by the Environmental Management and Policy Research Institute, the authors state, "Overgrazing and lack of good quality fodder are the main reasons for degradation of forests and common land," (144). Subsequently, however, they write, "because of its complexity and lack of easily measurable land quality indicators, no realistic estimation is available on the extent of land degradation due to overgrazing," (145). In essence, the admitted complexities and challenges to estimating the magnitude of grazing impacts on the environment did not preclude the authors from deducing that overgrazing was the primary cause for land degradation. On its face and taken outside the broader environmental historical context of attitudes towards grazing, such a conclusion does not appear logically consistent. However, when situated within environmental discourses on South Asian forestry and grazing policy, the incompatibility between the two statements is less surprising. Grazing has long been considered the culprit when it comes to negative environmental outcomes despite the fact that issues related to grazing pressure coincide with multiple factors, including but not limited to crop irrigation, the cultivation of particular agricultural products, population growth and urban expansion, and shifts in animal breed demands (Ghotge and Ramdas 2014:140).

When we also consider the role of institutional and bureaucratic interventions, and interdepartmental conflicts over resource control and access (Saberwal 1997), then the notion that we possess a clear understanding of the environmental impacts of livestock grazing— and by extension that exclusion-based policies are well-positioned to curtail said impacts — seems tenuous. In fact, Ghotge and Ramdas (2014:140) have explicitly argued that severe restrictions on the mobility and land accessibility of pastoralists have aggravated the situation. Such an interpretation results not only from a potentially misplaced emphasis on grazing as the primary or sole driver of environmental degradation, but from the non-recognition that grazing can also have positive impacts on the environment:

> What rarely gets reported are the positive impacts of grazing, even though these are now the subject of extensive research. Well managed livestock grazing has its value in keeping certain landscapes intact. Grazing by livestock keeps woody growth in check and allows for specific kinds of floral biodiversity to thrive. This biodiversity, in fact, is needed for distinct wildlife species to survive, especially those which need open grassland as opposed to dense forests. Livestock grazing on high biomass, makes forage available for small herbivores by improving the nutrient quality of forage as well making quality forage accessible…some researchers report that domesticated livestock manure fertilizes the pastures and creates greater floral diversity. (Ghotge and Ramdas 2014:141-142)

Despite the relatively recent acknowledgement that the processes contributing to land degradation are actually complex and challenging to measure, the overall position that grazing is the primary driver of environmental degradation, as expressed by the Environmental Management and Policy Research Institute, remains dominant. In fact, the subsequent *State of the Environment Report Karnataka*, published in 2015, doubles down on arguing for the deleterious effects of grazing and even intensifies the language, casting herders in villainous light:

> Unrestricted grazing by domestic cattle has had very adverse impact on the forests of Karnataka. Large herds of cattle, mostly unproductive, roam about daily in the forests for grazing and browsing. As a result, the forests have borne their onslaught. The results are far too evident. Grazing is heavy along the fringes of forests which are situated near the villages causing severe degradation. Grazing / browsing by goat, which is on the rise, causes very severe damage to the forests. Uncontrolled grazing in forests, often beyond their carrying capacity, has adversely affected the regeneration status, quality and growing stock of our forests. Overgrazing also affects soil properties adversely. The negative impacts on soil include loss of top soil, formation of gullies, compaction of soil and reduction of porosity. Pressure on forest reserves is increasing since the adjoining pasture lands and meadows which

> were traditionally reserved for grazing are also being put to other uses. The cattle herdsmen relentlessly hack green trees to provide fodder to their herds. Even trees by the roadside are not spared. (State of the Environment Report Karnataka 2015:52)

The indictment of pastoralism and grazing is part of a larger construction of environmental narratives that rely upon popular tropes and myths concerning the environmental and social history of South Asia (Morrison 2014; Morrison 2017). One of the most pervasive structuring devices of conservation discourse is the primeval forest myth (Morrison 2014; 2017). Under the primeval forest myth, South Asia, in its "original" condition, was thriving and forested, a product of a natural state of ecological harmony and balance (Morrison 2017). In a markedly oversimplified fashion, the narrative proceeds that environmental decline follows from an increase in human population and an intensification of human activity. While there are varying perspectives on who, and what activities and interventions accelerated the decline of the heavily forested landscapes of South Asia, the implications play into contemporary responses to environmental crises in the same way: South Asian environments can be restored to their "natural" or "original" baseline by eliminating agents that disrupt the balance of natural ecological processes. Within the discourse on environmental conservation, those agents are humans and extensions of human-directed behavior (i.e., the herding of domesticated livestock). By implication, humans are "unnatural" additions that inevitably disturb the ecological balance that fostered vastly forested environments in the past. The rhetoric of the 2015 *State of the Environment Report Karnataka* bears this out: pastoralists and their herds do not add value; they are "unproductive." Notably, however, pastoralism does not just disrupt: it wages violence. Forests are victims of a "relentless" pastoral "onslaught."

Unpacking the logic of the primeval forest myth illustrates the ways in which degradation narratives are structured in terms of a binary framework that posits "nature" and "culture" as strictly dichotomous and mutually exclusive concepts. The consequences of such thinking lie in the fact that conceptualizing "nature" and "culture" in dichotomous terms is not a universal worldview. It is instead the product rooted in primarily western notions of epistemology, ontology, and scientific categorization. The centering of modern dichotomous thinking when it comes to how human-environmental interactions and conservation is studied, understood, and narrated is an incomplete approach that ignores the many potential and diverse perspectives that exist across different cultures. This ultimately limits how well we can interpret and understand human decision-making in land and animal use practices.

Rather than enhancing our understanding of human-environmental interactions and socio-natural relationships, invoking a nature-culture dichotomy in narratives of degradation and conservation ultimately facilitates a form of storytelling that is oversimplified and likely purposefully so. After all, conservation narratives aim to produce accessible and simplified accounts as to encourage action (Lane et al. 2009: 457). The primeval forest myth, however, is not merely an oversimplification. The assumption that landscape change across South Asian environments proceeded along a linear trajectory of deforestation is just that, a taken-for-granted assumption anchored in notions of progression, regression, and acceleration, that ultimately lacks empirical grounding (Morrison 2017:263). In fact, there is evidence that actually suggests the opposite.[1] As Morrison (2017) summarizes, "In South Asia, several of the most persistent accounts of forest loss can be found in locations where, as it turns out, there either were *never* extensive forests, or where forest expansion is very recent," (263).

Problematizing the primeval myth has multifold implications for assessing and

[1] For summary, see Morrison (2017: 263-266). Examples provided include Faroqui and Sekhar (2011), Sharma et al. (2006), Caner et al. (2003), Caner et al. (2007), and Sukumar et al. (1993).

understanding human impacts on the environment. That particular environmental contexts were never heavily forested upends degradation-as-narrative writ large by destabilizing the notion that a particular set of human activities are inherently or inevitably destructive. If the "pre-human" landscape actually appears to be what narrative conventions project the human-induced crisis to be, then we have reason to ask what exactly the impacts of specific activities such as grazing actually are, especially on a long temporal scale. This is because we know, for example, that people in areas of South Asia have been grazing herds and relying on domesticated livestock for thousands of years. Moreover, if there are examples of recent forest expansion or, as attention to changes over the long-term could potentially reveal, oscillations in the expansion or declination of forests, then it becomes clear that contrary to being solely agents of ecological destruction or disturbance, humans can and have contributed to/produced the kind of environmental outcomes that activists and policymakers envision. Figuring out the conditions and contexts under which this might be the case is important since rendering landscapes people-less that have, in fact, been occupied by humans for millennia, could have the opposite intended impact that conservationist seek. From this perspective, we can see how the uncritical deployment of nature-culture binaries in conservation narratives can limit the ability to address environmental and resource crises.

The primeval forest myth is not the only problematic narrative device mobilized in degradation narratives. However, through scrutinizing just this one aspect of contemporary degradation narratives, a more complicated picture of the history of human-environmental interactions in South Asia emerges. A closer investigation of this complicated picture is a worthy line of inquiry, especially when we consider the fact that the disconnect between degradation narratives and the empirical record, as well as the oversimplification of processes and agents driving environmental changes, are not unique to South Asia. In a comparative analysis of savannah ecosystems in Kenya, for example, Boles et al. (2018) provides commentary much in line with the issues surrounding South Asian conservation policy: "The 'spectre' of overgrazing looms large in historical and political narratives of ecological degradation in savannah ecosystems. While pastoral exploitation is a conspicuous driver of landscape variability and modification, assumptions that such change is inevitable or necessarily negative deserve to be continuously evaluated and challenged," (1). Similar observations have been made regarding the evidential basis of environmental narratives on grazing and soil erosion in Tanzania (Lane et al. 2009), Morocco and Algeria (Davis 2004; Davis 2005), as well as Egypt (Gilbert 2013).

In recent years, the community of scholars criticizing the premises of conservation narratives in African settings has grown considerably (Lane 2009 et al., Fairhead and Leach 1996; Maddox et al. 1996; Bollig and Schulte 1999; Anderson 2002; Mackenzie 2003; Gillison and Willis 2004; Thomas and Twyman 2004). South Asia has received less attention by comparison. While some headway has been made (e.g., Saberwal 1997; Ghogte and Ramdas 2014; Morrison 2014; Morrison 2017), Ghogte and Ramdas note "…there is a long way to go in terms of science-based critiques of existing conservation and development policies for the grassland habitat, its associated wildlife, and the people's livelihoods that it supports," (2014:132-134).

Ultimately, one of the primary shortcomings of degradation narratives and the policies they inform is the fact that they lack a long-term perspective. Attempts to explain and remedy environmental problems through policy are often based on short-term assessments and observations (Sabloff 2009) and data that spans just a few decades (Pauly 1995). As Van der Leeuw et al. (2004) note, however:

> Degradation is often a long-term process, with slow cumulative phases, but also with sudden accelerations or decelerations. The typical time scales of

> natural dynamics involved range from thousands of years (tectonics), to five or six years (weather patterns). The social dynamics operate on the scale of centuries (at least) and decades. Measurement and monitoring over a few years or a few decades is thus insufficient. (112)

The short-term view of degradation is not limited to activists or environmental groups; Multiple actors and agencies, including conservation biologists, land managers, and policy makers, are guilty of thinking about environmental problems ahistorically and prioritizing immediate, recent, or proximate political or ecological drivers (Mathevet et al. 2015). Indeed, in their foundational work *Land, Degradation, and Society,* Blaikie and Brookfield identify a fundamental confusion to understanding degradation, "arises from the failure to view degradation within a wide historical and geographical framework," (1995: xx). Failure to situate degradation within such a framework and inattention to the long-term perspective not only amounts a data gap, a problem worthy of study in its own right, but it obscures the complexities of human-environmental interactions and omits crucial comparative contexts that could shape our understanding of the relationships between livestock grazing and landscape change. It is here that archaeology can make an important intervention into the ways we approach and understand grazing histories and their environmental impacts and contribute to the discourse on contemporary environmental concerns more broadly. Importantly, while grazing can sometimes lead to degradation, we need empirical data concerning when it did and did not and under what specific conditions it occurred (or did not occur).

1.1.3 Archaeological Approach

In the face of growing present-day environmental concerns—including climate change, resource depletion, natural disasters, desertification, species extinction and wildlife habitat loss— archaeologists have been increasingly vocal in touting the discipline's ability to contribute to contemporary environmental and conservation discourse. Publications spanning topics such as the archaeology of climate change and/or sustainability (Guttmann-Bond 2010; Sandweiss and Kelley 2012), archaeology of the Anthropocene (Petursdottir 2017; Lane 2015; Caitlin 2016; Erlandson and Braje 2013; Smith and Zeder 2013; Butzer 2015), the archaeology of human impacts on the environment (Redmen et al. 2004; Kirch 2005), the archaeology of food insecurity (Logan 2019a; 20119b; 2020), the archaeology of environmental change (Fisher et al. 2009; Cooper and Sheets 2012), as well as archaeological case studies on ecological collapse and resilience (McAnany and Yoffee 2010; Fisher and Feinman 2005) have become increasingly common. While these vary in regional foci, methodological approaches, and theoretical frameworks and critiques, they share an emphasis on archaeology's ability to produce data on human-environmental interactions over deep time scales.

Despite the commonality, the significance of a deep temporal perspective is highlighted somewhat differently by individual scholars. For some, attention to the past provides lessons we can learn from, mistakes that we can avoid. This is captured, in particular, in accounts of collapse and resilience in the past: "The *time depth* of archaeology's culture history provides valuable knowledge of collapse and adaptation, which enables us to *learn from the past* and prepare for the future" (Petusdottir 2017:181). This knowledge need not just be examples of mistakes or failure. Instead deep historical comparative perspectives from different regional and cultural contexts can also showcase success stories in the past: "Encoded in past land-use history are prior solutions to (and outcomes of) environmental challenges that are similar to their modern counterparts…familiar concerns of deforestation, soil erosion, desertification, loss of biodiversity, and climate change plagued our ancestors as well," (Fisher et al. 2009:4). McAnany and Yoffee (2010) echo this and are even more explicit about how this can contribute to contemporary policy:

> Understanding what happened in the past- both politically and environmentally- is not irrelevant to contemporary and future societal challenges, particularly environmental ones…adopting a well-informed, long-term view of how humans have lived on this biosphere we call Earth can promote decision making and policy development that results in human survival and resilience rather than the reverse. (8)

In arguing in defense of archaeology being useful and relevant to the present and future, Nelson (2009) writes:

> Archaeology brings time depth to an array of issues from migration and resettlement to climate change and environmental impacts of human actions. While study of the ancient past might seem irrelevant to environmental concerns in light of globalization and rapid technological change, archaeology provides a long-term, historically contextualized view of numerous social-ecological transformations. (158)

Archaeology's strength is not just in its ability to yield data on deep time scales, but in the very kinds of information that can be gleaned from the archaeological record. Archaeology can provide data on the ways various social, political, and economic decisions were made in the past and how they were modified and/or maintained over time. Moreover, paleoenvironmental datasets collected from archaeological excavations can be used to bolster interpretations of economic decisions and strategies in the past and to identify linkages between specific activities and changes in the environment at deeper time scales. For periods with written records, archaeological and paleoenvironmental evidence can also provide independent and corroborating (or controverting) lines of evidence, providing an opportunity to compare proxy records with varying perceptions and experiences of those documenting the same physical landscape (Morrison 2014:42-43).

Zooarchaeology, the study of faunal remains from archaeological sites, is especially well-suited for providing insights into a diverse range of social, political, and economic practices in the past. These include information on animal domestication and husbandry and the underlying land use practices that supported husbandry systems. As such, this dissertation adopts a zooarchaeological approach to reconstructing various dimensions of animal use throughout the Neolithic, Iron Age, and Early Historic periods in South India and a dental microwear approach in order to analyze patterns of grazing intensity compared to shifts in animal-based subsistence practices. These two data sets are also examined alongside previously published research on paleoenvironmental, and geomorphological data from the region in order to put forth an empirically robust accounting of how decisions related to animal use and animal-based-subsistence intersected with environmental and land use changes.

In addition to building a long-term empirical record of human-environmental interactions, including the full scope of land and animal use choices (what people *did* in the past), this dissertation attempts to reconstructing how people perceived animals and the environment in the past and how their relationships to, and perceptions of, animals and the environment shaped their decision-making. This is challenging in multiple ways. The archaeological record is not a perfect or complete record of past human activities. Rather it is fragmented and as a result, rendering interpretations of past societies and human activities requires considering the various processes archaeological materials have undergone prior to discard as well as during and after their deposition. Importantly, archaeologists never directly observe these various processes. Because of this, using archaeological evidence to establish even the most seemingly basic or straightforward insights – the age of an animal based on tooth wear or the presence of an unfused epiphyses- requires uniformitarian assumptions that impact the degree of certainty underlying archaeologists' interpretations (Gifford-Gonzales 2018). In this light, using archaeological and zooarchaeological evidence to draw inferences about the way people thought and felt in relation to animals and the environment is an even more challenging endeavor.

Zooarchaeology is also burdened in its ability to produce insights on how people perceived and experienced animals and the environment in the past because of the way faunal data and narratives of animal use have traditionally been framed. With a history of being a primarily methods-driven subfield of archaeology, with analytical techniques rooted in the biological sciences (Allentuck 2015: 96), zooarchaeological frameworks tend to replicate the organizing logic of their methodological approach and produce narratives of human perceptions of animals in the past that align with western dualist ontologies (Overton and Hamilakis 2013; Allentuck 2015; Boyd 2017). Much like the nature-culture division in conservation narratives, zooarchaeological accounts often portray animals as non-agentive objects of human will, desire, and sociality (Overton and Hamilakis 2013; Armstrong Oma 2010). That is to say, rather than being participants and co-creators of the social words in which humans are embedded, animals are viewed as merely "natural" objects exploited by and for the benefit of human "culture." Such a reading of human-animal relationships in zooarchaeological accounts is particularly prevalent in subsistence-oriented studies, where animals are portrayed only as economic and dietary resources.

More recently, zooarchaeological studies have moved away from exclusively economic questions and focused on the ways in which animal remains can index ritual activities, social inequality, and serve as markers of gender and ethnicity (e.g., Zeder 1991; Campana et al. 2010; Redding 2010; also reviewed in DeFrance 2009; Russell 2012). Overton and Hamilakis

(2013:113) argue, however, that even these cases ultimately reaffirm the dominant analytical paradigm in archaeology and zooarchaeology since they continue to reinforce ways of thinking about animals as resources (here, symbolic resources) for human exploitation. Moreover, they serve only to identify the ways in which animal remains are used to elucidate explicitly human-human social relations (Overton and Hamilakis 2013, Boyd 2017). As such, critics of traditional zooarchaeological paradigms, assert zooarchaeology and archaeology ultimately fail to capture the diversity of perspectives concerning how humans perceived and related to animals in the past.

In light of these critiques, archaeologists and zooarchaeologists have increasingly been encouraged to build upon critical animal studies and multispecies ethnography and adopt interpretive frameworks that are explicit in their awareness of how modernist ontologies structure a lot of zooarchaeological discourse. In doing this, they can move beyond the limitations of past approaches considering the alternative ontological relationships that can exist between humans and non-human animals. Overton and Hamilakis call this a social zooarchaeological approach:

> Our own version of social zooarchaeology breaks with anthropocentricity, be it of functionalism, interpretive, structuralist, or post-processual approaches…we advocate that the history of engagement between human and non-human animals is on of co-shaping and of ‘mutual becomings’…In this social zooarchaeology, the recognition that animals are not just an ‘economic’ resource is not enough; instead it is vital that we acknowledge that animals are agentic entities that engage in human-nonhuman social relationships. (115)

Others have similarly developed alternative ontological frameworks that share some of the same themes presented in Overton and Hamilakis’ manifesto, referring to them as a relational ontological approach. In “Do the clothes make the horse? Relationality, roles and statuses in Iron Age Inner Asia,” Argent (2010) defines her relational approach as one that, “acknowledges that, in the linkages between humans and horses, horses are not simply objects of study, but are often participants in the co-creation of culture and identity," (159-160). She adds of the relational approach that, "it retreats from notions that control and exploitation are key drivers of human behavior, or the most interesting aspect to explore in prehistoric societies," (Argent 2010:59-160). For Hill (2013), a relational ontological approach is a way of describing, "systems in which animals and other 'things' act as independent, sentient agents and are constituted socially, through performative action," (120). In addition, C. Watts' *Relational Archaeologies: Humans, Animals, Things* (2013), contains a series of essays that advance a 'relational' understanding of past peoples and the animals, plants, and things and seeks to, "conflate the abstract and immutable dualities of modernist ontologies," that structure much of our own thinking (3).

Much of this recent literature focuses on hunting to illustrate the kind of powerful insights that can be garnered through the use of non-anthropocentric and relational ontological frameworks (e.g., Brittain and Overton 2013; Overton and Hamilakis 2013; Sykes 2007; Sykes 2010). Of more specific relevance to my research, however, are the case studies that utilize these new frameworks with respect to human relationships with domesticated animals. Rather than perpetuate a narrative of domestication that centers human agency and depicts domestication as a process whereby humans tamed a wild "nature," domestication is viewed as a relationship between humans and animals that is characterized by mutual trust and mutual decision making and is a co-creation of behavior (Armstrong Oma 2010:179). Some, in fact, view the relationship between humans and domesticated animals as so reciprocal that we should move to use the term "co-domestication" (i.e., Fijn 2011).

This shift in zooarchaeology provides an important theoretical lens that serves the broader goals of my research. While I do draw from traditional approaches in zooarchaeology in my study of subsistence production and organization, as well as risk management, I also incorporate aspects of a multispecies or relational ontological approach in order to more comprehensively ascertain how people in the past perceived their relationships to animals, the landscape, and experiences of environmental degradation or crisis. Ultimately, this dissertation seeks to go beyond just establishing what subsistence strategies people adopted. It endeavors to also reconstruct how people perceived and subjectively experienced human-animal and human-environmental interactions. Crucially, it acknowledges that the way people experienced these relationships in the past may have differed in important ways from the post-enlightenment epistemological worldview that structures much of modern scientific inquiry.

By more fully engaging with a spectrum of subjective experiences of human-animal relationships and human-environmental interactions, this research is in a stronger position to account for what guided human decision-making with respect to animal and land use practices in the past. If archaeologists contend that studying the past provides key examples that can be instructive for the present and future, then it is important to employ methods and theoretical frameworks that can provide the most complete accounts of past human-animal and human-environmental engagements. This requires adopting frameworks that do not inevitably render and uncritically reproduce interpretations of human-animal interactions and relationships in Western ontological terms. For this reason, I combine traditional subsistence models and concepts in zooarchaeology with a relational ontological framework. While the use of even a relational ontological approach in a zooarchaeologically based research project comes with challenges and limitations, the case presented in this dissertation it well suited to taking on this kind of analysis (see further discussion in Chapter 2).

1.2 Research Context, Questions, and Data Sets

This research broadly seeks to reconstruct a long-term history of animal husbandry and the environmental impacts of livestock grazing and put forth an analysis that is best equipped to contribute to ongoing conservation and degradation discourses in South Asia. This is an archaeological investigation based primarily on zooarchaeological and paleoenvironmental data. Zooarchaeological and paleoenvironmental data for this research comes from the site of Kadebakele. Kadebakele is a well-documented and carefully excavated settlement located in Karnataka. With a deep occupational history spanning the Neolithic to the Late Middle period (3000 BCE-1600CE), Kadebakele is an ideal site for investigating shifts in animal husbandry practices and the impacts of grazing over time. In addition, because it is situated within the semi-arid interior of South India, a climate type prone to environmental degradation, Kadebakele provides an important environmental context for investigating the history of grazing strategies and how such strategies may have related to changes in land demands and pasture access.

This first phase of this research focuses on archaeological material from Neolithic (3000BCE-1200 BCE), Iron Age (1200BCE-300 BCE), and Early Historic (300BCE-500 CE) contexts. The Neolithic period constitutes an important point of departure in this study because it marks the initial development and spread of plant and animal domestication in the region (Fuller 2003; Fuller 2005; Fuller et al 2001; Morrison 2013; Morrison et al. 2016b; Naik et al.1969; Naik 1978; Meadow 1993, Chen et al. 2009). Following the Neolithic period, South India underwent substantial social, political, and economic transformations. Such transformations included the aggregation of settlements and emergence of large towns and cities, the expansion of regional and imperial polities, and the formalization of social inequalities (Morrison et al. 2009; Sinopoli et al. 2010). In addition, archaeological and historical data show evidence of increased economic craft specialization and long-distance trade, as well as an intensification of agricultural production, including the development and expansion of rice production by the Early Historic period (Morrison et al. 2009; Sinopoli et al. 2010).

Because of the lack of systematic and well-excavated sites in South India, there is limited insight into how specific human-animal interactions and animal husbandry practices figured into the broader social, political, and economic changes that characterized the Neolithic, Iron Age, and Early Historic periods. Many faunal assemblages from these periods were not screened during excavations and produced assemblages skewed toward the recovery of large-bodied mammals (mainly cattle). Moreover, as faunal analysis has been an underused analytical approach across South Indian archaeology, much of the faunal information available consists of species lists without additional quantitative, metrical, or qualitative data. Nevertheless, the archaeological record demonstrates that the reliance upon domesticated animals in South India has a deep history. A more comprehensive analysis of this history provides an important context for understanding the various ways in which human-animal engagements articulated with different land-use choices and changes in the environmental record. This considered, my research addressed are as follows:

Table 1.1: Research Question Set 1

Question Set 1:
How did animal husbandry practices figure into broader social, political, and economic changes throughout the Neolithic, Iron Age, and Early Historic periods?

- Prior faunal data show Kadebakele residents hunted and procured their own dietary resources the Iron Age. What continuities and changes occur between the Neolithic, Iron Age, and Early Historic periods? Did the emergence of larger settlements and towns impact previously established subsistence practices?

- Did animal husbandry become more specialized alongside craft specialization and agricultural intensification? If so, what animal products became important and how were they produced and consumed? Is there evidence that people became less involved in procuring their own resources by the Early Historic period? Is there evidence food resources were provisioned?

- Is there evidence that grazing and herding practices shifted as agricultural production expanded and intensified?

- How did risk management impact subsistence organization? How do shifts in risk management strategies inform how people perceived their relationships to animals and the environment?

- How did animals' roles in the subsistence economy intersect with their social, symbolic, or ritual importance?

Table 1.2: Research Question Set 2

How did patterns of animal husbandry relate to changes in vegetation cover and soil erosion?

- Are specific patterns of production and consumption linked to evidence of overgrazing or soil and landform erosion?
- If so, when does this happen and what is the broader context in which this occurs?

This project combines multiple archaeological and paleoenvironmental data sets in order to answer the outlined research questions. Using zooarchaeological data and methods, I identified specific husbandry production and distribution strategies as well as other ways in which animals, both wild and domestic, figured into social, political, and economic decisions at Kadebakele. In addition, using dental microwear analysis, I recorded enamel defects in caprine teeth as a way to identify evidence for the ingestion of soil abrasives (a proxy for overgrazing pastures). These datasets were interpreted using the theoretical framework briefly described above and more thoroughly detailed in the following chapter.

Faunal and dental microwear data were considered alongside previously published remote sensing and geomorphology research (e.g., A. Bauer and Morrison 2013; A. Bauer 2010; A. Bauer 2014) demonstrating the association between Iron Age settlement activities and soil erosion. Not only does there appear to be a correlation between Iron Age settlements and soil erosion, but it appears this was perceptible at the time based on the contemporaneous construction of soil retention walls (A. Bauer 2010: 236).

These data, along with the results of faunal and dental microwear data show Iron Age activities set the stage for shifts in the organization of subsistence and animal husbandry during the Early Historic period. Desires to build robust food production systems in the Iron Age, via specialized dairying, and more intensified agricultural production supported by traction labor, coincided with a reluctance to kill cattle even as they grew too old to efficiently yield resources. Supporting cattle into advanced age, even after they became labor and resource intensive to support, was likely connected to their ritual or social significance during the Iron Age. This combination of practices, however, contributed to environmental problems in ways that necessitated changes later. Mitigation efforts in the Early Historic period, which included intensified fishing alongside a more balanced cattle and caprine husbandry system, appears to have been impactful since none of the teeth analyzed from the Early Historic period contained defects consistent with overgrazing. As I expand upon in the conclusion, this research ultimately showcases how, contrary to a South Asian ecological utopia, people and animals have long been impacting and shaping their environments. At the same time, the deep history of animal husbandry and grazing impacts is a complex one, where multiple dimensions of decision-making intersected. A glimpse into these earlier periods show grazing cannot be cast as inherently or inevitable destructive, as conservation and degradation narratives would claim. The landscape history of South India instead is a palimpsest of experimentation and innovation in this regard and it cannot be easily collapsed into existing conservation narratives. Conservation policy would do better to build upon an empirically informed history than to ignore what could be learned from the past.

1.3 Chapter Summaries

This dissertation is organized into nine chapters. Following the introductory statement of research problem and dissertation approach, Chapter 2 expands upon the theoretical frameworks and models used in this research. I elaborate on my use of subsistence models, risk management models, and relational ontologies frameworks to produce a comprehensive analysis of past subsistence practices and perceptions of human-animal relationships and human-environmental interactions. I describe some of the limitations and challenges to using the frameworks I selected and how my dissertation research is designed to try and best overcome these challenges.

In Chapter 3, I provide a literature review on previous archaeological research in South India for the Neolithic, Iron Age, and Early Historic periods. I describe how faunal analysis has been very limited across previous studies and the impact my research stands to have given this reality. Importantly, Chapter 3 provides the context for how I developed my research questions and how I interpret faunal and dental microwear results.

Chapter 4 describes provides a background of the research site, Kadebakele. I discuss the geographic and ecological context and summarize what is known to date based on previous excavations and the current state of artifact and paleoenvironmental analyses.

In chapter 5, I review the methods I used for faunal analysis. In this chapter I also describe recovery methods and the impact of taphonomic processes.

In Chapter 6, I summarize the research results for the prehistoric occupation at Kadebakele. Ultimately, the faunal and dental microwear assemblages were too small to yield robust insights. I discuss how the dissertation is thus ultimately more focused on the transition between the Iron Age and the Early Historic period, with Early Historic faunal data discussed at length in Chapter 7.

For Chapter 8, I spend the first half summarizing previous dental microwear research and the specific case studies this research relies on for identifying evidence of overgrazing in archaeological contexts. I then present the results of dental microwear analysis for both the Iron Age and Early historic.

Chapter 9 synthesizes the results and brings together how the results of this research contribute to the archaeological of human-environmental interactions and critical conservation discourse.

CHAPTER 2 :
RECONSTRUCTING SUBSISTENCE AND PAST PERCEPTIONS OF ANIMALS

2.1 Introduction

In this chapter, chapter I situate the articulation of my research questions and analytical methods within a broader theoretical framework on human-environmental and human-animal interactions. In doing this, I seek to speak to the larger problem of how archaeology can contribute to discourse on contemporary environmental concerns, in particular with respect to degradation narratives and conservation discourse in South Asia. I argue that the best approach for accomplishing these goals is to put forth an analysis that is committed to producing empirical data on deep time scales that also critically engages with the challenging task of reconstructing how animals and the environment were viewed and perceived in the past in order to better understand how and why past people made certain decisions. Crumley et al. (2015:1722) wrote, for example, that "knowledge of a particular landscape's past management strategies can help avoid earlier mistakes or, in the case of good results, offer viable alternatives to a similar contemporary challenge." While I agree with this point, it is important to emphasize that if we do not understand the full scope of socially, politically, and ideologically specific factors that influenced, shaped, or guided those particular management strategies, then we run the risk of thinking a strategy completely incompatible with current contexts is potentially viable. This could come at the cost of wasted resources and other unintended consequences. Others make similar claims concerning how past success and failures can inform modern land use and serve as potential guides for policy makers (e.g., Fisher and Feinman 2005:64). However, the extent to which archaeological case studies can actually inform modern strategies and policies is limited if we only focus on what people did and what the consequences were, and not why and how these strategies were chosen. Archaeological approaches to human-environmental and human-animal interactions that seek to contribute to contemporary conservation discourse thus need to take on the challenge of reconstructing to the furthest extent possible perceptions of animals and the landscape in the past.

In order to produce such a comprehensive account of animal husbandry and the environmental impacts of livestock grazing from a deep historical perspective, this dissertation uses a combination of frameworks to interpret patterns in the faunal and dental microwear data sets. These frameworks include commonly used zooarchaeological subsistence production and provisioning models (section 2, this chapter), as well for models for risk management (section 3, this chapter). Interpretations developed under these models can aid in illuminating the production and consumption activities adopted in the past and how they may have changed over time, as well as highlight both the economic importance of animals as resources and their cultural importance as forms of food. In addition, models that can demonstrate whether or not strategies were adopted with risk aversion in mind can speak to the perceptions people might have had of environmental conditions and of threats to animal well-being. In this light, the decisions people made and the goals they prioritized with respect to animals can also inform how they perceived and valued animals and their relationships to them.

As I laid out in Chapter 1, it is ultimately important, however, to go beyond traditional zooarchaeological applications to address possible interpretations that are not constrained by dualistic assumptions or conceptualizations of human-animal and human-environmental interactions and which are not primarily economic in focus. In *Placing Animals" An Introduction to the Geography of Human-Animal Relations*, Urbanik (2012) summarizes the modern worldview and its shortcomings when it comes to socio-natural relationships:

> This view, rooted in the European Enlightenment and Scientific Revolution, values human rationality over emotion and the individual over the collective. This ardent humanism takes as its starting point the separation of humans and animals and then places humans above animals in a dualistic hierarchy of value. This view also has separated human society from nature in an explicit division, putting humans "outside" of nature. While this view did, and has, helped advance humanity and our understanding of the physical world in innumerable ways, it has also come under heavy scrutiny (1) for homogenizing human experience when clearly vast differences occur among people's experiences, shaped by gender roles, racial histories, colonial histories, sexual identities, and so on, and (2) by denying the interconnectedness of humans and the planet. (5)

Indeed, based on the expansion of published research[1] on the post-humanist or ontological turn in the social sciences and humanities, including more specifically published work on multispecies ethnography (see review in Kirskey and Helmreich 2010 and Ogden et al. 2013) and indigenous and relational ontologies (V.Watts 2013; Todd 2015; C. Watts 2013; Hill 2011; Argent year), it is well established that there is great diversity in how animals and the environment are experienced, conceptualized, treated, and entangled in people's lives. Until recently, however, such diversity has not been well captured or communicated in zooarchaeological accounts of past animal use and human-animal relationships. Instead, narrations of past animal use in archaeology and zooarchaeology have tended to be anthropocentric in orientation, depicting animals as objects of human will and subjectivity, and as part of "nature" that humans exploit, dominate, and control (Overton and Hamilakis 2013; Armstrong Oma 2010; Boyd 2017). In addition, the role of animals in past societies typically has been presented in utilitarian terms and analyses have focused solely on modern economic

[1] This is a deliberate framing to reflect the fact that many, in particular indigenous people and scholars, have been showing the differences and diversity that exists in terms of how people relate to animals but that only more recently have these accounts been taken seriously in mainstream scholarship and also, problematically, with little acknowledgement and sourcing to the indigenous thinkers and communities that have long been laying this foundation (see Todd 2016; Sundberg 2013).

framings of production, consumption, and management (e.g., maximizing productivity, minimizing risk, and portraying animals as merely calories; Russell 2012; Overton and Hamilakis 2013). Informed by multispecies ethnography and relational ontological based research, zooarchaeologists have expanded their conceptual frameworks to address alternative ways in which human-animal relationships may have been, experienced, perceived, and co-constituted in the past. In adopting these frameworks, zooarchaeologists more carefully consider the role of non-western ontological views or understandings that may have existed in the past and shaped past choices.

The research presented here similarly approaches analysis and interpretation of results in a way that is critically aware of the tendency in zooarchaeology to narrate and interpret human-animal relationships from a strictly Western ontological perspective. Thus, I explore how the application of a relational ontological framework, in combination with traditional zooarchaeological models, may better illustrate how animals and the environment were perceived and experienced throughout the Neolithic, Iron Age, and Early Historic periods at the South Indian site, Kadebakele. While this is a challenging aspect of the broader research agenda, the limitations of which I acknowledge below, I address how this project aims to overcome some of these challenges and how even if this framework falls short of achieving the ultimate goals of a relational ontological approach, it is nevertheless important to begin this long-term research project from this theoretical perspective. At present, this approach entails putting forth a reconstruction of the deeply entangled ways humans, animals, and landscapes were produced and reconfigured to produce an environmental history of South India that cannot easily be collapsed into existing degradation narratives.

2.2 Subsistence Models in Zooarchaeology

2.2.1 Introduction

Despite critiques of subsistence and economically focused zooarchaeological research, such analyses remain indispensable for providing basic insights into social, political, and economic structures and behaviors in the past. As such, my research includes questions on subsistence production: the when, what, and how of animal resource production and consumption. The answers to these question lead into my second question, which explores the environmental dynamics and consequences of animal procurement and husbandry, particular whether overgrazing is evident and if so, when does it occur and under what conditions? Answers to these questions provide the essential scaffolding for addressing the larger ontological questions addressed above.

To lay the groundwork for this study, I present below a review of relevant subsistence and economic production models. Given the social, political, and economic context of the South Indian Neolithic, Iron Age, and Early Historic periods (presented in Chapter 1 and elaborated in Chapter 3), models that inform how to identify specialized production and provisioning from faunal data are emphasized in this review.

2.2.2 Production Strategies and Specialization

Zooarchaeological research on subsistence economies have provided a series of models to aid in interpreting particular animal-based resource production strategies. Sebastian Payne's (1973) work is one of the most often consulted frameworks for interpreting the extent to which people in the past engaged in specialized subsistence production geared toward maximizing animal resource yields. Although Payne's (1973) seminal work is based upon his ethnographic study of market oriented caprine rearing strategies, the same basic principles have also been applied to zooarchaeological studies of cattle husbandry (e.g., Halstead 1995; Allentuck and Greenfield 2010)[2]. Payne's work ultimately correlates survivorship curves with different maximization strategies. Survivorship curves are most often generated using tooth enamel wear stages (see Chapter 5); however, the use of bone fusion stages can also provide mortality patterns that can be, in principle, interpreted against Payne's models to assess whether or not a particular species was raised with the primary goal of maximizing meat production or secondary products production. Sex ratios also figure into the reconstruction of production strategies in the past and are determined using metrical data (von den Dreisch 1976) as well as diagnostic evidence from pelvic bones.

In a maximized meat production strategy, one would expect to see a faunal assemblage with most animals slaughtered at the age in which they have reached their maximum meat yielding weight since further feeding would only diminish the payback in weight gain (Russell 2012: 222). For caprines, this is during the sub-adult phase between 2-3 years old (Payne 1973). Cattle, however, reach their maximum meat bearing age as adults (4 years old) (Dahl and Hjort 1976; Bogucki 1993; Marshall 1990 although see Vigne and Helmer 2007; Hambleton 1999). Thus, while the same pattern is expected between cattle and caprines if they are slaughtered at their maximum meat yielding weight, the actual survivorship curves will look different from one another.

Under a maximized meat production strategy, one would also expect to see a male-biased sex ratio, since males can produce more meat and females and would have only been retained for breeding. As such, remains that are identified as female under a meat production

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[2] This is at least the case when distinguishing between meat and dairy production. Since cattle are not wool producers, Payne's model for wool production would not apply. Payne also does not address traction labor since his models only pertain to sheep and goats, however the use of cattle as labor resources is addressed in this section.

strategy would a) be fewer in number and b) belong to the adult or advanced age class. It is important to note however, that it is often difficult to determine the sex of animal based on the bone fragments found in an archaeological assemblage, particularly if the remains are not from adult animals. As such, zooarchaeologists often find it difficult to demonstrate male-biased sex ratios from juvenile and sub-adult animal remains.

Strategies geared towards the production of secondary products, here defined as renewable products extracted over the lifetime of an animal (Sherratt 1981:108), are generally identified based on the abundance of adult and advanced age animals from faunal assemblages. This is especially true for rearing animals for wool. Under a wool production strategy, we would expect to see most animals surviving well into adulthood since they can continue to provide wool resources over the course of their lives. In addition, although it can be difficult to distinguish sheep and goat remains from one another (see Chapter 5), evidence of a wool production strategy may coincide with a higher number of sheep in the population compared to goats (S. Davis 1984, Price et al. 2021). In addition, if people were engaged in specialized or intensified wool production, we would expect to see an approximately equal representation of male and females (a sex ratio of 1:1) since both male and female sheep produce wool.

For dairy, a secondary product, we would also expect to see a large number of animals surviving into adulthood. However, under a production strategy aimed at maximizing milk yields, we would also expect to see a large proportion of the herd slaughtered at a young age. Under Payne's maximization model for dairy production in caprines, for example, roughly 50% of the herd (males) will be culled before 12 months (1973:283). This is known as kid mortality and is part of a strategy to cull male juveniles in order to eliminate competition for the milk now available from the lactating animals. Additional ethnographic work has documented kid mortality ranging between 18% and 45% (Dahl and Hjort 1976:92).

A dairy-oriented production strategy also entails maintaining mostly females (dairy producers) in the population. Thus, in a faunal assemblage, we would expect to see a female biased sex ratio if dairy is a primary production goal. Adult males may also appear in low frequencies compared to females since a few males would be need to be retained for stock breeding. While we would expect a male-biased ratio among the young animals slaughtered in a faunal assemblage, it is typically difficult to derive sex data from the remains of very young animals.

When applying the caprine dairy model to cattle, there has been some debate over whether or not infant mortality would have been practiced or possible in past cattle breeds (Halstead and Isakidou 2017: 119). Legge (1981) identifies high levels of infant calf remains from Bronze Age Grimes Graves and, in line with Payne's dairy model for caprines, infers that this reflects dairy production. This has been disputed, however, as it has been argued that early domesticated cattle breeds required the presence of calves in order to stimulate lactation and collect milk (Clutton-Brock 1981; Entwistle and Grant 1989; McCormick 1992). This is argued to have been the case based on iconographic and artistic representations of cattle being milked with their calves nearby (McCormick 1992). Using ethnographic data, Halstead (1998) disputes the notion that early cattle breeds universally would have required calves in order to stimulate lactation and instead argues that poor diet and stressful environmental conditions are more likely to inhibit lactation or milk let downs. In the latter case, it thus would be possible to overcome challenges to milking early cattle breeds that did not require maintaining calves. My analysis proceeds on the assumption that evidence of infant mortality would support an interpretation for dairy production in cattle and uses it as a point of comparison for caprine husbandry.

It is important to note, however, that it is rarely the case that archaeological datasets correspond exactly to Payne's subsistence optimization models since they represent extreme strategies unlikely to be practiced in a subsistence economy (Russell 2012: 222). In addition, it is likely that, in many contexts, communities employed multiple and overlapping strategies. For example, in addition to dairy production, cattle might also simultaneously be raised into adulthood and advanced age in order to be sources of labor for agricultural production. This would impact both the age profile and the sex ratio since fewer males would be slaughtered at a young age, making it more challenging to interpret the production goals. In this case, one would look for additional lines of evidence that cattle were used for labor. Bone pathologies are often the primary source of such evidence. Stress induced by plowing, for example, can produce signatures of osteogenesis, a formation of abnormal osseous tissue on the outside of the bone (Johannsen 2004:41, Bartosiewicz et al. 1997:33). Often these signatures can be found on cattle foot bones: the metapodials and the phalanges (Johannsen 2004:40). The presence of castrated males can also serve as evidence that cattle were used for labor (Zeder 1991:29). The adoption of risk management strategies can also impact how to interpret mortality profiles and production goals since herder may make more conservative slaughtering decisions and retain excess animals to ensure against flock losses (e.g. Redding 1981 plus see further discussion in this chapter).

2.2.3 Provisioning

Given what is currently understood about shifts is social, political, and economic organization, in particular between the Iron Age and Early Historic transition in South India, it is necessary to go beyond answering questions about production and to consider at what point, if any, production was structured beyond the individual or household level and if the organization of animal products eventually became managed and distributed by specialized producers or a larger centralized authority. In other words, as food and resource procurement and production articulated with increasingly specialized economies, do we see evidence of food provisioning – or the administered allocation of food resources produced by specialists to non-producing consumers?

The distribution or provisioning of animal resources, particularly in specialized urban economies, has been well documented in ancient Southwest Asia (e.g., Zeder 1991; Redding 2010; Stein 1987). Regional context certainly impacts how production and distribution are organized; nonetheless these studies remain a hallmark basis of comparison and I use them heuristically with regional context in mind. Models of provisioning tend to focus on meat production and distribution, since dairy products, as perishable items, are argued to be less conducive to being centrally managed (Zeder 1991:34). In Zeder's case example, textual data from Mesopotamia confirms, "a lack of administrative interest in milk," (1991:34). However, meat is also perishable, unless dried or smoked, and dairy can be made into items that can also be kept (curd, for example). Thus, the lack of administrative interest milk may not be universal, especially the broader category of dairy products. Moreover, in the absence of texts, as is the case for my research contexts, demonstrating centrally managed dairy products is difficult because it would be less visible in the archaeological record, although surplus and specialized dairy production in certain economic and political contexts (e.g., urban contexts) could be an indication.

Meat production, distribution, and consumption have specific patterns that are expected to be present under a centrally managed provisioning system. For example, the distribution and consumption of high utility meat bearing bones, alongside the presence of standardized butchery patterns, can indicate whether meat resources were provided to communities on behalf of a centrally administered provisioning system (Zeder 1991, Seetah 2005, 2006, for example in South Asian context see Chase 2007, 2010). Under a system of provisioning, one would also expect a decrease in the consumption of wild taxa, particularly in town or urban centers, where individuals may have been increasingly involved in specialized economic activities and unable to procure their own dietary resources (Redding 1992, Crabtree 1990, Wapnish and Hesse 1991, Zeder 1984, 1988, 1991, 2003). This is of course also has implications for mobility since hunting requires moving around, especially near cities where game could be scarce.

In provisioning contexts, production, distribution, and consumption locales should yield different kinds of faunal remains. One example illustrating the differences in production and consumption sites under a centrally provisioned system comes from research on Old Kingdom subsistence practices (Redding 1992; Wenke et al. 1988; Redding 2010). Faunal remains from two sites in Egypt— the Worker's Town at Giza and Kom el-hisn—provide the basis of comparison. The Worker's Town at Giza is a site that is argued to have housed and supported the system of workers, supervisors, and specialists carrying out pyramid construction on the Giza Plateau. The faunal remains identified at the Worker's Town reflected what we would expect under a provisioning system. Most of the cattle and caprine bones identified at the site came from sub-adult and juveniles, animals at their prime meat-bearing capacity. In addition, the majority of bones, especially those found in association with consumption spaces and activities, were meat-bearing elements. There was also a bias in the sex ratio with males out numbering females. Ultimately, the faunal patterns reflect off-take from larger herds aimed at producing a large amount of meat for distribution (Redding 2010: 69).

By contrast, the faunal remains at Kom el-Hisn, a village site located in the Nile Delta, were predominantly from neonates and older animals and were biased towards females. The presence of neonates and older animals reflects animals that died of natural causes in the assemblage. The female-biased sex ratio reflects efforts to maintain breeding stock. The lack of prime aged meat animals and meat bearing bones at Kom el-Hisn suggests that domesticates were reared for the primary purpose of providing meat to other areas or other sites and thus ultimately reflects what we would expect to see at a site focused on production for a centrally provisioned system. Stein (1987) has described similar expectations concerning complementary faunal assemblages between rural villages and centers in third millennium B.C. Turkey and describes how deviations from this pattern can be used to interpret the extent of regional interaction and of the authority that control centers have over village sites.

Increased pig consumption has also been interpreted as a possible correlate to the specialized production of livestock products and provisioning. Redding (1991,1992, 2010) and Zeder (1991) have both argued that herders engaged in the specialized production of meat or secondary products for redistribution may use pigs in order to supplement their dietary needs. The quick growth rate of pigs makes them a readily available and low investment protein source that could be procured and consumed locally. Specific to this research, the domestication status of pigs is not well established in South India and thus the presence or absences of pigs could have different implications.

Table 2.1: Key Characteristics of Zooarchaeology Subsistence Models: Meat Production and Consumption

- High frequency of sub-adult animals close to or at maximum meat bearing capacity (age class varies across species)
- Consumption contexts contain high utility or meat bearing bones
- Discard contexts include low utility or non-meat bearing bones
- Butcher marks on bones (although skilled butchers may not leave any marks on the bone)
- Evidence of cooking, especially on meat bearing bones (roasting for example)
- Sex ratio biased towards males because they are larger/produce more meat. Few females retained for breeding stock
- Females present in population adults and older
- Other: Butchering refuse, butchering floors butchering tools

Table 2.2: Key Characteristics of Zooarchaeology Subsistence Models: Secondary Products

- Presence of secondary product producers (animals that produce resources aside from meat)
- Majority of producers survive until adulthood and advanced age

<u>Dairy</u>

- High frequency of milk producing animals (cattle, caprines)
- Female biased sex ratio
- Some males retained for breeding stock
- Males and females both surviving to adulthood and advanced age
- A proportion of slaughtered calves (males) to eliminate sources competing for milk yields
- Other: Milking jars, presence of milk lipids in ceramics, rock art depictions of herding and milking

<u>Wool</u>

- High frequency of wool/fiber producing animals
- Majority of animals surviving into adulthood/advanced age
- Equal representation of males and females

<u>Traction</u>

- Presence of traction animals (especially robust animals such as water buffalo)
- Evidence of traction pathologies such as osteogenesis, arthritic lesions, fractures,
- Depiction of plough in art
- Evidence if castration, based on metrical data and the distribution of animals based on size. (Castration can, on the one hand reduce the overall size, but makes animals more docile and easier to control/lead to pull plough)
- Other: evidence of traction vehicles or technologies (carts, wheels, reigns)

Table 2.3: Key Characteristics of Zooarchaeology Subsistence Models: Centralized Provisioning
● More likely to be present in urban contexts or with contexts with a high degree of economic specialization ● Would expect to see corresponding production and consumption site (typically coordinated through a center-hinterland distribution system). ● Little evidence of hunting or activities related to individual subsistence procurement (low frequency of wild animals)

Provisioning: Production Site	Provisioning: Consumption Site
● High frequency of neonates and advanced age animals (animals that died of natural causes). Expect to see their entire skeletons deposited on site ● Very low frequency of sub-adult to adult animals (animals at their prime meat bearing capacity). ● Female biased sex ratio (larger males will be distributed to other sites for consumption). ● Evidence of increased pig consumption as an efficient protein source when meat bearing animals like cattle and caprines are removed for distribution and consumption elsewhere. ● If sub-adult or adult animals are butchered on site, expect to see high frequency of low utility elements. It is more likely that herds are brought to centers and processed by specialized butchers.	● Expect to see high frequency of sub-adult and adult animals ● Absence of neonates and advanced age animals ● Little to no evidence of pig consumption (pigs do not herd well, thus it would be difficult to bring them from a primary producing site to a consumption site or center for redistribution). ● In consumption contexts expect to see high utility bones ● In processing or discard contexts expect to see low utility

2.3 Risk Management

Models for determining the role of risk and risk management in past animal and land use practices are integral to this research for a few reasons. The first is that it is important to take risk management strategies into account because they constitute a potential strategy that can overlap, coincide, or conflict with other production goals. As such, they are necessary to consider from the perspective of fully accounting for patterns in the faunal data, particularly as we anticipate faunal patterns will deviate from idealized production models. In addition, given this study's assessment of how production and consumption strategies may have articulated with changes in environmental conditions and features, it is important to also pay close attention to patterns reflecting herd security and risk aversion since deteriorating environmental conditions (anthropogenic or otherwise) may lead to decisions to alter the scales of pastoral production, shift focus to different animals, or to diversify the dietary resource base. Evidence of risk aversion (or risk tolerance) can also illustrate how people in the past viewed and assessed the well-being of animals by revealing what factors they prioritized in their decisions to change or maintain certain husbandry and production strategies and what level of care was taken to ensure the prosperity of their herds. Models or frameworks for risk management also often intersect with changes in environmental conditions and thus can be used to inform how people in the past perceived environmental stress.

One zooarchaeological example demonstrating risk management is Redding's (1981) theory of herd security. Redding defines herd security as, "the minimization of fluctuations in herd size, particularly those that result in a reduction of annual yields," (1984, 227). Redding argues that while typically herders will cull animals that are least essential to the perpetuation or maintenance of a herd (males between the ages of six months and two years), efforts to ensure herd security will lead to herders retaining young caprines until the end of their second year to insure against failures in subsequent birthing seasons (Redding 1981). In addition, since goats have a higher growth rate compared to sheep (Zeder 1988) and thus can recover from flock loss better compared to sheep, Redding's model predicts that the sheep to goat ratio will change depending on if herd management occurs under environmentally optimal versus stressful conditions. Under good conditions, the ratio of sheep to goats would be between 1.1:1 and 1.7:1 (Redding 1984: 234). This is because goats, as a more quickly regenerating resource (Zeder

1988: 29), would be more disposable under good conditions. Under stressful conditions, however, goats would be retained in higher numbers. The retention of goats in higher numbers can also reflect management decisions made under environmentally stressful conditions since goats can feed off of more diverse vegetation than sheep. From Redding's model of herd security for caprines, we can thus access information that goes beyond just the fact that domesticates were raised in the past or that caprines were relied upon as subsistence resources. Decisions on what age to slaughter animals and in what proportions to retain goats versus sheep can coincide with experiences of navigating environmentally stressful conditions and efforts to mitigate the impacts environmental changes had on the health of herds and the ability to maintain flocks at sustainable levels.

Stein (1989) has also examined the strategies of food-producing communities in order to identify how the perception of risk, defined as the estimable probability of loss, played a major role in decision-making (95). Using a combination of faunal and archaeobotanical analysis from multiple Neolithic village sites in Southeast Anatolia, Stein presents a 5-part model that summarizes efforts to minimize the risk of subsistence failure (95). Part of his model includes Redding's model for maximizing herd security in caprines discussed above. In addition, Stein argues that efforts to minimize subsistence failure can be manifested in strategies to diversify the food supply across different subsistence activities such as cereal agriculture, wild plant gathering, herding, and hunting (1989:95). Stein notes that that within each diversification activity (agriculture, foraging, herding, and hunting), the further diversification by species or food types reflects efforts to minimize risk, as the reliance on a combination of food sources safeguards against failures that might occur under a specialized system where there is an exclusive or emphasized dependence on one particular food source (1989:95). Although specialization, the channeling of resources and/or labor into restricted ends, can increase production and promote efficiency (Morrison 2001:7680), the focus on a more limited range of food can lead to more catastrophic levels of loss under stressful environmental conditions, animal disease, or other challenges.

Under a diversified system that minimizes risk, the inclusion of wild flora and fauna to augment domesticated staples can also incorporate a seasonal component depending on the regional and ecological context. During periods of great uncertainty about future productivity, such as winter or periods of drought, there may be shifts in the subsistence emphasis such that the consumption of domesticated plants and animals is deliberately minimized (1989:92). In addition, hunting local wild animals whose seasonal movements are predictable allows for groups to augment their diets during periods of harsh seasonal conditions and in ways that would not require much additional effort given the proximity and availability of particular species during that time (1989:91).

Stein's analysis provides a case illustrating what behaviors we may expect to see if risk minimization was a strategy adopted in past subsistence systems. Marston (2011) also provides a review of archaeological markers of risk management that is useful to consider alongside Stein's. Similar to Stein, Marston argues that diversification can have the effect of reducing variance in subsistence returns by varying the types of foods that are raised or gathered, where those resources are grown or supported, and when during the year they are harvested or consumed (191). As such, Marston describes three types of diversification: crop diversification (or food type diversification when also considering animals), spatial diversification, and temporal diversification (191-194). Food type diversification refers to the variety or range of species consumed. This type of diversification is evident archaeologically by the range of species and their abundances (measured using species counts, species ratios, and the Shannon Index) (Marston 2011:191). This can be especially salient when there is a combination of domesticated and wild taxa present in an archaeological assemblage. Spatial diversification, according to Marston (2011), relates to shifts in mobility for both hunting and herding practices (193), while temporal diversification relates to the ability to slaughter animals at any time during the year as needed (compared to having to wait for harvest times for crops) or in order to enable the storage of seasonally available plant foods or agricultural surpluses (196). In addition, the practice of agropastoralism itself can be viewed as a diversification strategy:

> …where domesticated animals are available, agropastoral strategies are another mechanism for diversification. One important consideration in a mixed agropastoral strategy is labor trade-offs between agricultural and herd-management activities especially in semi-arid to arid regions where rainfall (and crop yields) are more variable and less predictable…The flexibility inherent in this mode of agropastoral production allows shifts on a rapid basis to adapt to changing social environments and climatic forces. Risk can be managed by changing the proportion of time spent farming versus herding, by changing feeding strategies for domestic animals (foddering versus grazing) and by adjusting the mix of animals present in the herd. (192)

In addition to diversification, Marston (2011:191) points out that intensification is another strategy through which human societies reduce the chance of subsistence failure. Marston relies on a broader definition of intensification than is typically adopted in archaeological analyses of agriculture. Intensification is typically defined as, "the increase in the concentration of production, or productive output per unit of land," (Morrison 2001:7678). When analyzing risk management, Marston (2011) adopts a more expansive view of agriculture intensification, "to include strategies that require additional labor to produce additional food, even when that involves increasing the area of land under cultivation," (194).[3]

[3] This more expansive view of agricultural expansion is also discussed in Morrison (1994).

Intensification can act as a buffer for subsistence failure since it, "raises mean returns and thus reduces the risk of falling below the threshold of production necessary to support a household or community," (194). Since intensification tends to be associated with agricultural production, archaeological markers of intensification tend not to focus on or include faunal remains.[4] However, Marston, using the case site of Gordion in Turkey (Hellenistic to Late Bronze Age) (see Miller et al. 2009), argues that specific patterns in faunal remains in intensified agricultural contexts can reflect either risk-averse or risk-tolerant strategies. Specifically, if caprine husbandry is a dominant strategy within the context of intensified agricultural production, this reflects a risk averse or risk reduction strategy (spatial diversification) since caprines can be herded further away from agricultural fields and can also subsist on a greater variety of vegetation (Marston 2011:195). This is especially the case for goats. By contrast, a cattle-focused strategy reflects a riskier pastoral production strategy since cattle have high water and feeding needs and because they are likely relied upon for traction in an intensified agricultural regime, they will be maintained in close proximity to main sites and agricultural fields. In other words, from Marston's framework, an intensified agricultural system with a corresponding high amount of cattle relative to caprines is evidence that yield maximization is the primary goal at the expense of risk reduction since spatial diversification is either abandoned or not adopted as a mitigating strategy (197).

It is important to note however, this this interpretation of what the caprine to cattle ratio/relative abundance means in terms of herd and risk management is based upon specific patterns documented at Gordion where archaeobotanical and animal dung data provided

[4] Although it is worth nothing that "intensification" is adopted in zooarchaeological analyses, where it is often not defined, and tends to be conflated with maximized production or specialized production.

necessary contextual information (Miller et al. 2009). Using animal dung preserved from Gordion, Miller et al. (2009) argues that during times of caprine-focused husbandry, wild plants dominate dung samples, an indication that more extensive herding practices utilizing non-cultivated pasture took place (919). During times of cattle-focused husbandry, cereal grains increase, an indication that animals were kept closer to agricultural fields and were foddered, or fed on harvest stubble and cultivated grain straw (919). Absent these contextual lines of evidence, it is difficult to definitively conclude that a preference or focus on caprines over cattle necessarily meant that spatial diversity or extent herding was practiced. This presents a challenge for the case examined in this dissertation since such data are currently unavailable for Kadebakele. Dental microwear data, however, might be able to offer contextual evidence since, as a proxy for grazing intensity, dental microwear can be analyzed alongside shifts in the relative abundance of cattle and caprines.

In summary, faunal remains can be used to reconstruct changes in risk management strategies, which in turn can reflect shifting perceptions of environmental conditions and threats to animal resource production and animal welfare. Following Redding, Stein, and Marston, key archaeological markers for risk management potentially includes combinations of the following:

Table 2.4: Summary of Potential Risk Management Markers in Archaeology

1) Evidence of mixed agropastoral system
2) Evidence of diversification, where diversification can take many forms such as relying on multiple in food resources and expanding food procurement or production strategies and technologies
3) Taking advantage of seasonal opportunities to increase the procurement of certain resources (e.g. wild animals) while also storing surplus resources, especially under harsher seasonal or environmental conditions
4) Shift to or maintain a caprine centered husbandry strategy over a cattle centered strategy
5) Shift to or maintain a goat centered husbandry strategy over a combined sheep/goat centered strategy
6) Adopt herd security strategy for caprines

2.4 Relational Ontologies

One of recent criticism of traditional zooarchaeological frameworks focused on subsistence is that the interpretations and narratives they produce focus primarily on the economic utility of animals (e.g. Russell 2012; Overton and Hamilakis 2013). This is especially salient when discussing specialized production models, where presumed goals are either to maximize production, likely in order to produce surplus for either exchange or re-distribution (Stein 1987; Zeder 1991), or to maximize efficiency (Redding 1981).

Risk management models are also interpreted from a primarily modern economic perspective. Redding's herd security model, for example, is framed as a maximizing strategy (maximizing herd security) and is narrated in terms of economic and resource efficiency. Diversification, from a risk management perspective, is a minimizing strategy; it minimizes variances in food production (Marston 2011). This is not to mention the notion of "risk" itself, defined in Stein (1989) as, "estimable possibility of loss," (87) and in Marston (2011) as the "probabilistic variance in return from economic activity," (190) both with ties to modern economic thought.

Critiques of economically framed analyses stress that it is important to also consider ritual, symbolic, or other more than-economic ways in which animals were valued, since these also would have/could have impacted when or how decisions to change or maintain management strategies occurred. Keswani (1994), critical of zooarchaeological models that are economic and utilitarian in focus, writes:

> animals are integral and essential to the performance of basic rituals and social transactions … animals are required for exchange or consumption in events that are critical to social reproduction and integration, they are 'husbanded' with those events in mind and retained until it becomes necessary or desirable to consume them. Consequently, an archaeological assemblage characterized by large numbers of mature animals and/or males need not imply a focus on milk, wool, or draft capacity, nor does it necessarily represent 'inefficiency' or ignorance of optimal meat-producing strategies. Rather it may attest to the primary of social and symbolic concerns in structuring practices of animal husbandry. (26)

Thus, in animal rearing, non-subsistence roles certainly factor into decision-making and the social and symbolic roles of animals could have different implications for how communities in the past assessed success and failure and thus also raise or reduce the stakes in terms of what they considered a risk or a threat and, consequently, impact how they react.

This research is equipped to expand interpretation beyond the economic roles of animals through an analysis of faunal remains from domestic and ritual contexts at Kadebakele. This is achievable at least over the course of the Iron Age occupation at Kadebakele where these contextually specific areas have been excavated and where various modalities of ritual animal consumption, including varying scales of feasting can be investigated (see Chapter 4). Outside of the Iron Age, the symbolic importance of animals, cattle in particular, can also be discussed in relation to what has been documented at other sites, in particular as it relates to rock art and Neolithic ashmound sites (see Chapter 3).

From the perspective of the relational ontologies literature, it is still the case that even when expanding beyond a strictly economic focus of animal use to include ritual practices (as an example) animals tend to still be regarded as objects of exploitation (Overton and Hamilakis 2013:113). Specifically, they serve to only highlight aspects of human sociality, or as Armstrong Oma puts it, render animals as, "props in social play between humans," (2018:228). In other words, the approach I have thus far outlined for using zooarchaeology to reconstruct perceptions of animals of the past are still framed in terms of human exploitation of animal resources, since even expanding the analysis to consider ritual or socio-symbolic roles of animals still thinks about it from the perspective of how humans benefit and gain or use animals. Adding a relational ontological framework helps move beyond this in order to consider a more comprehensive spectrum of potential ways animals were perceived and experienced and how human perceptions of human-animal and human-environmental relationships informed changes in decision-making over time.

One way in which a relational ontological approach accomplishes this work is by working from a starting point that people in the past did not necessarily perceive their relationships with animals and the landscape in an anthropocentric and utilitarian way. The impact of an anthropocentric view of human-animal relationships versus one that is non-anthropocentric and relational has been well illustrated in critiques on domestication discourses and is especially relevant to how human-animal relationships will be analyzed in this dissertation. Armstrong Oma, for example, describes traditional domestication discourse as being centered on human domination over animals (Armstrong Oma 2018:230). Much critique has been focused on Ingold's article "From Trust to Domination" where he describes the shift in perception and experiences of human-animal relationships as being one of trust and reciprocity existing between hunters and wild animals, to one of domination over domesticated animals (Ingold 2000). Armstrong Oma (2018: 231)[5] argues that while many agree that domestication caused a shift in human perception's of animals, the domination narrative articulated explicitly by Ingold, has its roots going at least as far back as Vere Gordon Childe's concept of the Neolithic revolution (Childe 1936) and has further salience in Clutton-Brock's (1989) definition presented in *The Walking Larder*. According to Clutton-Brock (1989), domestication is, "a cultural and biological process…that can only take place when tamed animals are incorporated into the social structure of the human group and become objects of ownership," (7) and domesticated animals are "bred in captivity for purposes of economic profit to a human community that maintains complete mastery over its breeding organization, organization of territory, and food supply" (21). Tapper (1988) and Tani (1996) also construe the relationship between humans and domesticated animals as one of slavery and that coercive dominance characterizes the relationship between people and their livestock (Allentuck 2015:106). Even more recently, Russell (2012), whose *Social Zooarchaeology: Humans and Animals in Prehistory* encourages zooarchaeologists to go beyond the economic and the dietary aspects of human-animal relationships endorses a view that domestication aligns with a shift to animals becoming property (214-215)[6]. In other words, domestication aligns with a shift to animals becoming objects of human action and transaction. Armstrong Oma ultimately concludes that domestication as domination discourse, whether explicit or subtle, "is bound up with a progressive view of human history as unidirectional, in which both the environment and animals were perceived to enter increasingly exploitative relations with humans," (218).

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[5] The summary of the domestication discourses at domination oriented is presented in full in Armstrong Oma 2018 (230-231). The summary presented here draws heavily from her discussion.

[6] For critique see Armstrong Oma (2018:218).

Armstrong Oma offers an alternative view, rejecting the notion that the domestication of animals and the emergence of agropastoralism necessarily triggered humans to conceive of domesticated animals as slaves, subjects to authority, or as dominated by humans who wish to control them in service of human consumption and needs (Armstrong Oma 2010:176; Armstrong Oma 2018: 230). In contending that animals are agents with the ability to act upon the world as living, sentient beings, Armstrong Oma instead suggests that the relationship between humans and domesticates is better described as being not only one of mutual trust, (which Ingold previously ascribed only to hunted, wild animals) but of mutual decision making and co-creation of behavior (2010:179). Using milking activities as an example, she writes:

> Milking is a daily repetitive practice which requires not only physical proximity, but also mutual rhythm and trust. It is important to create a calm and comfortable atmosphere to encourage the animals to relax and let down their milk, otherwise people will get kicked and the animal will withhold its milk. Animals are normally milked in the morning and evening after they are fed. Milking during dusk and dawn assures a tranquil setting in between the hustle and bustle of every day life. The most important factor to accomplish is mutual trust. Both animal and human need to know that they will be safe in each other's presence; therefore the mood of the person who is milking should be calm, not angry, and the animal should be approached gently and kindly with as much physical contact as possible. The more one physically connects oneself to an animal, the greater degree of mutual trust and commitment. (2010: 182)

Armstrong Oma's applies her framework for thinking about human-animal relationships in an ontologically alternative way compared to traditional domestication discourses in a study on shifting architectural choices during the Bronze Age in Scandinavia (Armstrong Oma 2013). A change in architectural choices from two-aisled to three-aisled longhouses, she suggests, represents a change of engagement between Bronze Age people and their animals because in three-aisled houses, animals co-habitated with humans, which ensured the kind of mutual rhythms, trusts, and affinities Armstrong Oma sees as characteristic of human-domesticated animal engagements (Armstrong Oma 2013:193).

As part of her re-evaluation of domestication, and the human-animal relationships forged throughout the process of domestication, Armstrong Oma (2018) also considers how domestication can be thought about via an ethics or duty of care—a discussion that similarly problematizes the anthropocentric and utilitarian way in which human-animal relationships are typically presented in archaeological discourse. Here, Armstrong Oma is explicit about how relationships between humans and domesticated animals are not simply about the ways humans use animals as objects or how they exploit and kill them solely in service of human needs. Instead, relationships forged out domestication can be thought about as involving processes and engagements of care. This happens in such a way that human behavior and choices are ultimately shaped by the needs of animals. As such, rather than domestication being a process whereby animal behavior is tamed and modified to meet human production goals, human behavior is altered as well. This view more explicitly brings to the forefront the agentive capacity of animals in human-animal relationships. In fact, Armstrong Oma goes so far as to describe the relationship between humans and animals post domestication as a social contract:

> I argue that this led to a specific ethics of care in which humans responded to the needs of animals and instead of taking/using animals by killing them, there was a sense of, and possibly a need to, give back to the animals. Giving back could initially manifest in practices such as clearing areas for grazing and guarding water supplies, so that the animals were protected. And later, in more complex and entangled relationships, in building shelters, aiding during giving birth, providing food by collecting grass, leaves and bark, and ultimately more complex strategies that involved storage, such as haymaking. From the animals' perspective, what better servants could they have than these humans who clear and guard pastures, build shelters, bring water and food…I suggest that on farms, past and present, relations are managed by both farmers and animals, with their specific requirements to thrive and form a healthy flock, and by the animals' ability, by their agency, to choose whether to cooperate or resist. Successful farming, then, depends upon acknowledging that animals'

> needs must be met in order for the animals to thrive. Further, I suggest that farmers, by way of duty of care, hold a self-imposed social obligation to the animals. Identifying needs becomes an important aspect of this line of conjecture. In order to successfully carry out a duty of care, the need for care, and its specific ramifications, must be known. These needs are another aspect of animal agency; that they require specific set-ups in order to thrive. Examples are access to suitable feeds, the scope for movement, opportunity for shelter, and as a flock, they need the opportunity to reproduce. These needs are what the domestic animals bring into the social contract. Humans must cater to these needs in order to live in a successful agrarian commitment. Thus, in order to achieve a functioning household economy based upon husbandry, the needs of the animals are the main priority. The animals respond to the duty of care that humans bring to the table, as well as bringing their own. Consequently, by way of their needs, animals co-shape not only the social contract but also the spatial arrangements, daily and yearly cycles, engagement with the wider environment and so on, that shape the lives of all stakeholders in agrarian commitments. By this engagement, the process of mutual becoming unfolds. (219-220)

Although not specifically stated in the above passage, the agentive capacity of animals and the ability to shape decision-making does not mean that animals have equal or symmetrical power in human-animal relationships. What matters, however, is the fact that by way of their needs, and their capacity to cooperate, resist, and/or require a reorganization of spatial, seasonal, and other arrangements, how animals figure into humans and society is something that is negotiated and varied. As such, the trajectories and understandings of human-animal relationships do not have an inevitable or linear, predetermined outcome.

As part of my research aims to think about the full scope of how land and animal use choices were shaped and made, Armstrong Oma's view of domestication and duty of care ultimately provides an informative perspective to consider alongside husbandry and grazing strategies and assessments of risk. Using her examples as a guide, I address how the various ways that domesticated animals like cattle, sheep, and goats figured into human social, political, and economic lives, how those multiple roles may have shaped human perceptions of their relationships with animals and thus the extent to which animals participated in and shaped human-decision making. I consider how the role of domesticated animals, in domestic, economic, and ritual life could have created or informed a sense of care in different ways.

I approach these questions using the archaeological evidence available with respect to animal diets (what animals ate). Using faunal data, I examine the extent to which animal production strategies articulated with specialization, intensification, and risk aversion goals, and examined why these strategies were adopted and how they may have changed over time. In addition, I used dental microwear analysis to determine whether grazing intensity shifted or if overgrazing occurred, and how this articulated with specific production strategies. Similar to Armstrong Oma's domestication by way of an ethics of care, and Fijn's "we feed them, they feed us", I considered not just what activities and decisions potentially contributed to overgrazing, but how overgrazing would have jeopardized the health of domesticates. Thus, a long-term study of animal husbandry practices cannot just focus on human diets or the way humans extract food and other resources from animals, but needs to consider animal diets as well.

My study works from a context where we already know that, at least during the late Iron Age, Kadebakele's residents began building soil retention walls (A. Bauer and Morrison 2013; A. Bauer 2010). Such walls indicate past experiences and perceptions of environmental conditions, specifically the detrimental impacts of soil erosion, as well as the efforts of Kadebakele residents to mitigate against those threats. My research thus not only considers how various modes of animal use may have contributed to and changed in response to these problems, but how the importance of animals influenced these changes in ways are not limited to economic decisions. Shifts in husbandry practices can be thought through and analyzed from a perspective that considers past views of animal health and diet, enriching our perspectives on human-animal relationships in the past.

2.5 Limitations of Relational Ontologies

It is important to note that attempting access and reconstruct the perceptions people had of animals in the past, in particular their ontological understandings of their relationships to animals and the environment, is not without legitimate challenges. In discussing Creation histories of the Haudenosaunee and the Anishnaabe, V. Watts (2013) writes that these historical accounts, "speak to common intersections of the female, animals, the spirit world, and the mineral and plant world. What constitutes "society" from these perspectives revolves around interactions between these worlds rather than solely interactions amongst human beings," (21). Later she adds, "habitats and ecosystems are better understood as societies from an Indigenous point of view; meaning that they have ethical structures, inter-species treaties and agreements, and further their ability to interpret, understand and implement. Non-human beings are active members of society. Not only are they active, they also directly influence how humans organize themselves into that society." Obtaining this level of interpretation about people's perspectives on animal worlds and how they articulate with human social organization in the past based on the archaeological record alone would ultimately be met with much skepticism.

The limitations of this approach are not only due to how well (or poorly) archaeological evidence could inform of ontological differences in the understandings of human-animal and human-environmental relationships, but also in how to navigate narrating archaeological accounts in ways that are not ultimately contradictory or that do not slip into language that replicates ontological dualism and modernist thinking. Allentuck (2015) makes this argument with respect to Armstrong Oma's domestication re-evaluation via her critique of Ingold:

> Armstrong Oma (2010) regards Ingold's thesis as untenable for characterizing people who share a common mode of exploiting animals as a common ontology with respect to animals…Instead she makes the case for human-anima intra-action, a term that connotes mutuality and co-constitution of

> being…their relationship must be founded on trust rather than coercion in order for animals to be sufficiently calm to let down their milk. Armstrong Oma, while challenging Ingold's aphorism of the virtuous hunter and the oppressive herder perpetuates a different metanarrative: the Euro-American presumption of a duality between trust and domination in indigenous ontology. (106)

In addition to this, Brian Boyd (2017), reviewing case studies in zooarchaeology that emphasize relational ontologies and non-anthropocentrism, anti-climactically concludes that non-anthropocentrism in archaeology may ultimately be unattainable (309). This is because, despite the emphasis on the mutual co-constitution of the relationships between humans and animals, it is challenging for humans, particularly those situated within Euro-Western perspective, to transcend being human (Hayles 1999) and that ultimately archaeology is, "about studying the human in the relationship with nonhumans and the material world," (Boyd 2017:309-310).

Incorporation of relational ontologies into zooarchaeological analysis is thus not without its challenges. However, like the traditional models that dominate zooarchaeological research, the limitations or shortcomings do not render it useless. The critiques of traditional zooarchaeological paradigms have merit. At the same time, they remain indispensable to establishing a starting point for identifying food production, distribution, and consumption behaviors in the past. Even Armstrong Oma, whose work is referenced frequently throughout this chapter, writes, "I am not making a case for dismissing a line of inquiry into economic strategies, but merely stating that focusing on this as the only perspective gives a skewed impression of the complexity of human-domestic animal relationships" (2018:215). A relational ontological framework, with different but no less legitimate shortcomings, similarly should be adopted for its strengths and potential.

Ultimately, no single theoretical frame is going to be all encompassing or self-sufficient (Chagani 2014: 433). The usefulness of adding a relational ontological framework, however, is that it expands the possibilities for thinking about how animals may have been perceived in the past. Even if we are limited in the specificity in which we can detail these perceptions or subjective experiences, the consideration of alternative or relational ontologies can at least showcase what we could be eliding or missing if we use only subsistence oriented and anthropocentric paradigms. This research is well suited to demonstrating the potential of this approach because it relies on multiple lines of archaeological and paleoenvironmental evidence in order to achieve the most comprehensive understanding of animal and land use choices in the past. The use of multiple data sets and lines of evidence works to bolster, corroborate, and justify the interpretations and conclusions researched in my research. In addition, Kadebakele, the focus of research, was host to a variety of activities including subsistence, residential, and ritual activities. That Kadebakele has a variety of archaeological contexts with animal remains also makes it a promising context for exploring to what extent faunal remains from archaeological sites can be approached from a relational ontological framework.

It is also important to recognize that, while it is untenable to presume that people in the past perceived animals similar to Western ontological and epistemological perspectives, it is also not necessarily the case that they were dramatically different. Russell (2012:4) notes, for example that anthropocentrism is not limited to modern western society and that many ethnographies describe how nonwestern societies have terms and concepts for animals that are in opposition to humans (e.g., Anderson 2004; Copet-Rougier 1988). Allentuck (2013), who also considers the impact of livestock ontologies in his archaeological research, writes about ethnographic examples of hybrid utilitarian/non-utilitarian ontologies, examples that he argues are particularly useful for understanding animal management in Turkey during the Early Bronze

Age (186). He relies on the example of contemporary Greek farmers who hold multiple ontologies with respect to animals:

> Theodossopoulos (2005) describes the farmer's relationship to his livestock as one based on both resource exploitation and kinship. Greek farmers initially regard individual livestock as useful instruments of food and labour, but over time this relationship becomes more intimate as the animal becomes a member of the household. Livestock are brought into the moral sphere of the household because their keepers feel a sense of duty to animals that diligently provide their secondary products and eventually, their primary products. Farmers are compelled through a moral obligation of reciprocity to return the favour by providing care and protection to their livestock. (186)

Allentuck notes that not only does this example point to an example of holding multiple ontological views at once, but to the fact that such ontological views can change over the course of an animal's life. This is not to mention the fact that ontological views of domesticated animals can also be highly variable within a single culture, a point that Allentuck (2015:108) says should dissuade anyone from making monolithic statements about ontology.

2.6 Conclusion

In summary, my research proceeds with the acknowledgement that there are strengths in traditional zooarchaeological approaches to reconstructing human-animal and human-environmental interactions in the past, in particular for examining economic and subsistence practices related to animals and land use. Just as important, however, is the consideration of other ways that animals figured into social life and decision-making in the past. By including the scrutiny that comes with a relational ontological approach, zooarchaeological research is better equipped to capture the diverse ways past societies interacted with animals and the environment and how they thought about those relationships. I apply all of these approaches in my study of human-animal relationships in Neolithic through Early Historic Kadebakele. Before I turn to the data from Kadebakele, in Chapter 3, I provide background on the region and its archaeological history.

CHAPTER 3 :
PREVIOUS ARCHAEOLOGICAL RESEARCH IN SOUTH INDIA

3.1 Introduction

In aiming to provide a deeper historical context for examining changes in human- animal relationships and grazing management strategies in South India, this research examines archaeological and paleoenvironmental data from the Neolithic (3000 BCE-1200 BCE), Iron Age (1200 BCE-500 BCE), and Early Historic (500 BCE-500 CE) periods. The study of Neolithic, Iron Age, and Early Historic society is important to understanding animal husbandry and the long-term impacts of grazing in South India because these archaeological periods capture events and processes related to the domestication of plant and animals in the region (Neolithic), as well as the development of intensified forms of land use and subsistence production (Iron Age and Early Historic periods). In addition, the social, political, and economic transformations underway throughout this 3500 year span were ultimately forged out of, and directly impacted by, how people engaged with animals and the environment. As such, these periods provide a critical temporal context for assessing the ways in which social, political, and economic activities articulated with the creation, modification, and maintenance of human-animal relationships and human-environmental interactions.

In the sections that follow, I review archaeological research that has been conducted on the Neolithic, Iron Age, and Early Historic periods in the Southern Deccan (inland South India). In particular, I focus on patterns and issues related to settlement, technology, and subsistence. In addition, I outline features of human-animal relationships that go beyond subsistence practices and how they changed over time. Ultimately, I connect these topics to a broader review of key social, political, ideological, and economic transformations documented across these different chronological periods. I conclude by discussing how past archaeological research provides an important foundation for investigating my research questions and the value for testing these research questions at a site with a continuous occupational history spanning the Neolithic, Iron Age, and Early Historic periods.

Before proceeding, it is important to acknowledge the challenges that come with using chronological categories in archaeological analyses. To begin, these are categories created by archaeologists and as such do not necessarily reflect how people experienced events, processes, systems, and interactions in the past. For South India, pre and Early Historic chronologies need refinement, as they span thousands of years and have been written about monolithically and without attention to variation within the periods themselves. As Sinopoli (2016) writes,

> While these lengthy ceramic phases are due in part to the existence of long-lived ceramic forms and crafting traditions, they are equally a result of the paucity of data from well-controlled, stratified archaeological contexts, the lack of systematic programs of absolute dating, and the scarcity of detailed qualitative and quantitative studies of ceramics. Fortunately, studies by Kelly (2013), Morrison (2005), Schenk (2001, 2006), Wessels-Mevissen (1991), and others are allowing us to begin to refine South Indian ceramic chronologies and develop a comparative database that will allow scholars to explore the ultimately more interesting questions of change, continuity, interaction, and use. (4)

Sinopoli adds that work from Kadebakele (the research site for this dissertation) contributes to this effort. These contributions are described further in Chapter 4.

3.2 South Indian Neolithic (3000 BCE-1200 BCE)

Small village communities with relatively egalitarian social relations characterize the South Indian Neolithic (Paddayya 1998; Paddayya 2001; Johansen 2014). Neolithic farming included the summer cropping of millets and pulses (some locally domesticated species and others of African origin) (Fuller 2003; Fuller 2005; Fuller et al 2001; Morrison 2013; Morrison et al. 2016b). The presence of wheat and barley from Neolithic contexts (Korisettar et al. 2001; Morrison et al. 2016b; Roberts et al. 2016) suggests that dry farming regimes were supplemented with the small-scale production of more water intensive cultigens (Fuller et al. 2001; A. Bauer and Morrison 2016; Morrison et al. 2016b). In addition to farming domesticated plant varieties, Neolithic inhabitants also continued to procure and consume wild plants and animals (Fuller 2003; Korisettar et al. 2001; Paddayya 2001; Thomas 1984).

Neolithic communities are thought to have been at least semi-sedentary (Paddayya 1998; 2001). The domestication and farming of plants during the Neolithic period coincided with the emergence of small villages, some of which were continuously occupied into the Iron Age and subsequent periods (Sinopoli et al. 2010; Nagaraja Rao 1971; Fuller et al. 2007; A. Bauer 2010; Roberts et al. 2016[1]). In addition, many Neolithic sites have been identified in association with possible pasturing areas, which Johansen (2014) argues would have enabled herders to feed their animals without having to travel to more distant grazing areas (318). Neolithic settlements also sometimes contained livestock enclosures, the site Budihal being one example (Paddayya 1998; 2001). The proximity of large pasturing areas along with evidence of livestock enclosures supports the interpretation that Neolithic communities were increasingly sedentary. At the same time, however, there is also evidence to suggest that in some areas, Neolithic herding had some degree of mobility traveling between small villages and encampments or rockshelters[2] (Johansen and Bauer 2015:13).

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[1] Sites documented with continuous occupation between the Neolithic and Iron Age include Kadebakele, Maski, Piklihal, Hallur, Veerapurum, Ramapurum, and Peddamudiyam

[2] Rockshelters can be difficult to date however in this case Neolithic occupation of these rockshelters (in the Maski area) is based on the presence of Neolithic ceramics (A. Bauer and Johansen 2015).

Research on Neolithic material culture and faunal remains from multiple sites indicate that domesticated animals, especially cattle, provided important resources both with respect to subsistence and ritual practices. Indeed, it may even be the case that South India was an independent center of domestication for zebu cattle (*Bos indicus*) during the Neolithic period. Evidence for the domestication of zebu in South India is based on genetic studies conducted in the late 1960's that analyzed blood group factors and hemoglobin (Naik 1978, Naik et al.1969). This interpretation, however, is not universally accepted. Archaeological and faunal research (Meadow 1993; 1996), and mitochondrial DNA (mtDNA) studies (Chen et al. 2010) suggest the Indus Valley (northern India and Pakistan) was the primary center for zebu domestication. However, Chen et al. (2010:4) have noted that variation in the analyses comparing the two main mtDNA haplotypes (I1 and I2) show that while the most predominant haplotype (I1) can be traced back the northern Indian subcontinent and Pakistan, the second most predominant haplotype (I2) cannot be unambiguously traced back to a single region of origin (Chen et al. 2010: 4). As a result, it is indeterminable whether or not I2 haplotype zebu cattle were domesticated once or multiple times (Chen et al. 2010). Interestingly, the frequency and distribution of the I2 haplotype tentatively suggest that central and southern India may have been "secondary recruitment centers" where wild female aurochs (*Bos primigenius namadicus*) were selected to breed with zebu cattle. This is potentially bolstered by the fact that wild aurochs were present in South India (Banahhalli, Karnataka) as late as 2200 BCE (Korisettar et al. 2001:5). Whether or not breeding practices in southern India directly contributed to the long process of domestication of zebu cattle, or whether it can definitively be identified as an origin of domestication need not necessarily be proven in order to assert the prominent symbolic, nutritional, and economic role cattle played in Neolithic society (the case of which is made clear below). However, it stands as a noteworthy possibility to consider and study further, as it would yield information on the impact of human activities on wild auroch populations, and better contextualize our interpretation and understanding of grazing impacts during this period. Moreover, it would provide additional evidence that speaks to aspects of experimentation, agency, and innovation in subsistence organization and production in prehistoric populations in South India.

Despite questions that remain concerning the origin and process of zebu cattle domestication in South India, the archaeological record provides ample evidence attesting to the importance of cattle in Neolithic society. Cattle remains dominate Neolithic faunal assemblages, in comparison to both wild taxa and other domesticated species (Allchin, 1961; Nagaraja Rao, 1971; Rami Reddy, 1976; Sastri et al., 1984; Shah, 1973; Joglekar 1998). However, it is likely that small-bodied wild animals are underrepresented in Neolithic faunal assemblages since many excavations did not employ robust screening and recovery methods.[3] There is also evidence that cattle and herding activities are depicted in rock art dating to the Neolithic at sites like Sanganakallu-Kupgal (Robinson et al. 2008), Maski (Johansen and Bauer 2015; Singleton 2019), and Piklihal (Allchin 1960).

One of the most prominent archaeological examples illustrating the significance of cattle in the Neolithic period, however, is manifested in the construction of ashmounds. Ashmounds are large hills made by accumulations of fired and vitrified cattle dung. Although scholars have debated their function, ashmound production appears to have been initially related to cattle keeping activities and stock enclosure maintenance at settlements (Allchin 1963; Paddayya 1991;

[3] For a review of how recovery methods impact the representativeness of faunal assemblages see Chapter 5.

Paddayya 1998, Paddayya 2001; Johansen 2004). These more quotidian activities are argued to have taken on socio-symbolic significance whereby cattle dung became an important ritual resource (Paddayya et al. 1995; Paddayya 1998; Johansen 2004; Johansen 2014). Johansen (2014) summarizes:

> Ashmound construction likely originated in very prosaic activities associated with the maintenance of stock enclosures but the practice of incrementally heaping and burning cattle dung quickly transformed into regular, repetitive, public, and ceremonial activities, which in many recorded instances produced monumental features, sometimes as high as 10 m and covering hundreds to thousands of square meters… The repetitive ritual practices that created these monuments employed a valued and almost certainly sacralized substance (dung) collected from an animal with profound symbolic, economic, and political importance to Neolithic agro-pastoral communities. (63-64)

As Johansen notes, the significance of cattle dung coincides with the value placed on cattle given their wider social and economic importance, including the role they played in the Neolithic subsistence economy.

The rearing of cattle throughout the Neolithic appears to have been oriented towards the production of secondary products. Remains from Veerapuram and Ramapuram, for example, indicate that animals were kept until advanced age, suggesting that they may have been used for dairying (Thomas 1989). Evidence for dairying is buttressed by the recovery of what appear to be milking jar fragments (Alchin 1963) found in association with cattle pens at the Neolithic site Budihal (Paddayya 1995 et al.; Paddayya 1998; Johansen 2004). The keeping of cattle until advanced age could also suggest that cattle were used for traction labor. Evidence of traction and weight bearing related pathologies have been documented at Sanganakallu, Utnur, Pallavoy, and Hallur and act as further evidence for the use of cattle for secondary products during the Neolithic period (Alur 1968; Alur 1971).

There is, however, also evidence that cattle were consumed as sources of meat under certain specialized circumstances. Excavations at Budihal, for example, exposed a large animal butchering surface that contained mostly (95%) cattle remains (Paddayya et al. 1995). Although the data from Budihal clearly indicate that cattle were butchered (with low utility elements discarded and high utility elements likely removed for consumption) it is unclear at what age cattle were slaughtered. As such, it is difficult to determine what motivated the slaughter and consumption of cattle from this context. That is, it is unclear if they were preferentially selected at their maximum meat bearing capacity, if they were dairy or plough animals that were diminishing in their productive capacities for secondary products, or if factors outside meat yield and productivity motivated the selection of these animals.

Paddayya et al. (1995) argue the slaughter and consumption of cattle at Budihal was likely related to ceremonial events during which meat would have been shared among all the village inhabitants. Thus, the consumption of meat during the Neolithic period does not appear to have been related to a large-scale meat production strategy. Instead, the consumption of meat was reserved for specific occasions, ceremonies, or events, which occurred infrequently. This interpretation is buttressed by the fact that wild taxa are also found within Neolithic assemblages, although at much lower frequencies compared to domesticated taxa, (see Thomas 1989; Alur 1971:1968; Joglekar 1998:74). The presence of wild taxa, in combination with evidence of secondary products exploitation, indicates that Neolithic inhabitants supplemented protein and dietary needs with hunted resources rather than a meat-oriented husbandry strategy.

Although much of the discussion of animal husbandry in the Neolithic focuses on the importance of cattle, domesticated caprines, pigs, donkeys, and dogs have also been documented across a number of Neolithic sites. Sheep and goat often occur second to cattle in frequency. Pigs and domesticated chicken occur rarely in Neolithic assemblages.[4]

Although pastoral production does not appear to have occurred on a large or intensified scale, evidence does suggest that grazing animals were herded in considerable numbers. It is known, for example, that domesticated breeds populated the landscape in ways that ultimately led to the decline and eventual extinction of wild aurochs during the Neolithic period (Korisettar et al. 2001), a process that may have been expedited by the interbreeding of wild aurochs with domesticated zebu cattle. Moreover, the distribution and size of ashmound sites throughout the region shows that cattle were managed in large enough numbers to produce dung piles tens of meters high. Thus, the Neolithic provides an important temporal context, not just because it deepens the time scale for investigating the relationship between human and animal activities and changes in the environmental record, but because by the Neolithic period, domesticated animals had already obtained important economic and symbolic significance and in ways that clearly impacted natural and social environments.

3.3 South Indian Iron Age (1200BCE-300BCE)

Although there are multiple continuities between the periods archaeologists have identified as the Neolithic and Iron Age, in particular a continued reliance on domesticated cattle and caprines, activities in the Iron Age mark significant changes in human-environmental engagements. In contrast to the semi-sedentary villages characteristic of the Neolithic, some Iron Age settlements became areas of more permanent occupation supporting larger populations

[4] The presence of domesticated pigs is noted only at Palavoy (Rami Reddy 1976) however it is notoriously difficult to distinguish between feral and domesticated pig species on the bases on bone morphology. Chickens are only documented at Kodekal and Budihal (Shah 1973; Paddayya 1991).

(Morrison et al. 2009; Sinopoli et al. 2010; Johansen and Bauer 2015). Although many settlements, in particular those associated near major river sources (Kadebakele, Maski, Hallur, Veerapurm, Ramapuram, and Peddarmudiyam), show evidence for continuous occupation and settlement expansion between the Neolithic and Iron Age, there does appear to be variation in occupation strategies across the region (Sinopoli et al. 2010; A. Bauer 2010; Sastri et al. 1984; Fuller et al. 2007). Recent research conducted in the Sanganakallu area, for example, shows evidence for decline and abandonment after 1400 BCE (Roberts et al. 2016). Citing the onset of drier environmental conditions, Roberts et al. (2016) argue that people living in the Sanganakallu region were no longer able to sustain sedentary agricultural lifeways and, as a result, may have migrated to areas with better water access. Although more research is required, they suggest that local migrations out of areas like Sanganakallu may, in part, explain increases in population density and settlement documented in Iron Age settlements located near the Tungabhadra and Krishna rivers (Roberts et al. 2016).

During the Iron Age in South India, craft production became more specialized and agricultural production appears to have undergone some degree of intensification and diversification (Sinopoli et al. 2010; Morrison et al.2016; Morrison et al. in press; Roberts et al. 2016). For example, at Kadebakele, the case site for this research, Iron Age residents continued to grow and consume dry farmed cultigens, such as millets and pulses, and engaged in small-scale production of water intensive crops such as wheat. In addition, starch analysis from midden contexts at Kadebakele indicates that Iron Age inhabitants expanded their repertoire of water intensive crops to include bananas and yams, though on a very small scale (Morrison et al. 2016b). A small amount of rice has also been identified from the phytoliths at Kadebakele, (see discussion in Bauer 2010:225), however these data are currently being re-evaluated.[5]

The expansion of crop varieties, in particular those that would have required supplemental watering, coincides with the emergence of new agricultural technologies such as containment reservoirs (A. Bauer 2010; A. Bauer and Morrison 2016; Morrison et al. 2016b). The diversification of crop packages during the Iron Age at Kadebakele is also observed in other settlement contexts throughout the region (see Kajale 1984; Fuller 2002; Fuller et al. 2004). In addition, prior faunal analyses from Kadebakele show that during the Iron Age, there was a continued reliance on domesticates for secondary products (R. Bauer 2006; Wilcox 2016). Consumption of hunted, wild taxa also appears to have expanded during the Iron Age with almost half of the Kadebakele faunal assemblage comprised of a diversity of birds, fish, and herptiles (R. Bauer 2006; K. Wilcox 2016). While it may be the case that the increased representation of small, wild, non-mammalian taxa in the faunal assemblage is a result of the robust recovery methods employed at Kadebakele (see Chapter 4 and Chapter 5), it is worth noting that this increase in non-mammalian taxa was not observed at Sanganakallu using similar recovery methods (Roberts et al. 2016). Further comparative regional studies with similar recovery methodologies would aid in demonstrating whether or not Kadebakele was unique in this regard. The present study investigates whether the reliance on wild resources was maintained into the Early Historic occupation at Kadebakele while also exploring, in the broader context of animal and land use decisions, why this pattern may have emerged at Kadebakele during the Iron Age.

Despite significant advancements in our understandings of shifts in settlement and

[5] Rice is also reported in Neolithic contexts at Hallur (Kajale 1984), however environmental conditions at Hallur may not have been as arid compared to Kadebakele and other Neolithic and Iron Age settlements (Morrison et al. 2016b).

demographic patterns between the Neolithic and Iron Age, knowledge of Iron Age subsistence practices has been constrained for a number of reasons. Until recently, a majority of archaeological research on the Iron Age focused on the study of megaliths and mortuary practices (see for example, Wheeler 1947; Krishnaswami 1949; B. Thapar 1957; Leshnik 1974; Gururaja Rao 1972; Sundara 1974; Sundara 1989; Moorti 1994; Lycett and Morrison 1998; Brubaker 2001; see also Morrison et al. 2016a; A. Bauer et al. 2007; A. Bauer 2011). Megaliths are such a prominent feature of the Iron Age that much existing scholarship refers to it as 'the Megalithic period.' The use of 'Megalithic Period' as a chronological term, however, is problematic for a number of reasons (see Morrison 2017/2018), the most obvious of which is the fact that megalith construction was not limited to the Iron Age. Although many megaliths and megalith complexes appear during the Iron Age, the practice of megalith construction first appeared during the Neolithic and continued beyond the Early Historic period (Wheeler 1947; Krishnaswami 1949; Devaraj et al. 2005, Morrison 2009; A. Bauer et al. 2007; Haricharan 2016). Nonetheless because of their prominence in the archaeological literature of the South Indian Iron Age (and because megalith features with faunal assemblages are present at site of this research), I discuss them briefly below.

Megaliths include a broad range of features (some of which are not necessarily "mega" in terms of scale) and are found in a variety of contexts, including in association with settlements (Morrison et al. 2016a). Megalith forms include dolmens, menhirs, stone circles, and a variety of complex cobble arrangements and boulder-filled crack features on granite outcrops (Krishnaswami 1949; Leshnik 1974; Lycett and Morrison 1998; Morrison 2004, Bauer et al. 2007, Morrison et al. 2016a). They appear as either singular architectural constructions, or as complexes extending over larger areas of the landscape (Leshnik 1974, Moorti 1994, Brubaker

2001, A. Bauer et al. 2007, A. Bauer 2010, Morrison et al. 2016a).

Many of the megaliths excavated throughout South India contain human burials and showcase the mortuary ritual significance of megalith construction. (Rea 1915, Wheeler 1947, B. Thapar 1957, Gururaja Rao 1972, Leshnik 1974, Moorti 1994, and Brubaker 2001). Megalith construction not only informs on some of the traditions and practices for how to prepare and memorialize the dead; variation in the size, form, and arrangement of megalith features, as well as the kinds of grave goods and mortuary assemblages found associated with them, also reveal differences in mortuary status (Brubaker 2001; Leshnik 1974; Moorti 1994 see also Gururaja Rao 1972; B. Thapar 1957, see synthesis in A. Bauer et al. 2007). Burials can include multiple or individual internments, and sometimes occurred within large stone circles, some of which are, "tens of meters in diameter, enclosing cairns covering large elaborate chambers (with capstones frequently weighing a ton or more)," (Brubaker 2001: 278).

Social status distinctions, inferred on the basis of burial remains, is a the key line of evidence put forth in arguments suggesting that formalized social inequalities emerged during the Iron Age. However, it is important to note that a large proportion of megaliths are not accurately dated and were studied prior to the development of contemporary standards of excavation and reporting (Morrison et al. 2016a). In most cases, we cannot currently accurately date individual megaliths within the 900-year Iron Age chronological sequence, and it may be the case that many of the excavated megaliths containing burials actually date to the Iron Age, Early Historic period, or later (Morrison 2009). Recent research evaluating the ways in which megalith construction was related to expressing and negotiating political claims over access to space and socio-symbolic resources, however, has bolstered evidence for pronounced social inequality or distinction during the period (A. Bauer et al. 2007; Sinopoli et al. 2010; A. Bauer

2011; Johansen and Bauer 2015; A. Bauer and Morrison 2016). Moreover, the intensification of megalith building in the Iron Age is argued to have required new forms of labor mobilization that have their basis in social difference and inequality. As A. Bauer et al. (2007:13) notes, "the physics involved with hewing, moving, and assembling large stone monuments speaks to a potentially different mode of power relations involved in the organization of labor for these tasks."

Prolific study of megaliths has thus not been without merit as insights into the emergence of social inequalities stands as important contributions to our understandings of the Iron Age. However, this near exclusive focus on ritual monuments, especially where megaliths were poorly dated and unsystematically documented and excavated, has contributed to an overall paucity of information and evidence concerning subsistence practices and other aspects of everyday life. Only recently has research sought to move away from a strict focus on megalithic architecture and mortuary practice and instead examined Iron Age residential sites in order to better understand settlement patterns, land use, and Iron Age social, political, and economic activities (e.g. Sinopoli et al. 2010; A. Bauer 2010; Johansen 2014; Rajan 1994; Rajan 1996; Rajan 2014; Roberts et al. 2016). This is much needed especially for laying the groundwork for better understanding changes in social, political, and economic organization theorized to have developed during the Early Historic period.

3.4 South Indian Early Historic Period (300BCE-500CE)

The transition from the Iron Age to the Early Historic period marks important changes in social, political, and economic organization. Archaeologists mark the beginnings of the Early Historic period based on the appearance of written records for the first time in the region. Evidence of writing and written records in South India come in the form of Asokan edicts/inscriptions written in the Brahmi script and distributed across the subcontinent (Sugandhi 2015:54). The Asokan edicts are associated with the third king of the Mauryan Empire (Sughandi 2015:54), a polity with its primary territory located in the north. The text and location of Asokan edicts in the south have previously been interpreted to mean that much of the southern region of India was incorporated into the Mauryan empire, however it has been more recently suggested that Mauryan control and incorporation of the south was much more limited (Sugandhi 2015: 55, see also Sunghandi 2012; R. Thapar 1981; R. Thapar 1997; Bongard-Levin 1985; Chattopadhyaya 1995; Ray 2008).

Despite debates concerning the extent of imperial contact or conquest, it is nonetheless largely accepted that during this period larger polities developed throughout the region, both to the north and to the south of my research area and that the subcontinent was linked by increased interaction and long-distance trade relationships (Ray 1986; Reade 1986; Gupta 1995; Lane 2012). Formalized social inequalities that first materialized during the Iron Age also continued (Sinopoli et al. 2010). By the Early Historic period there was also evidence for the expansion and adoption of institutionalized religious practice via the spread of Buddhism, Jainism, and Brahmanism (Fogelin 2004; Abraham 2003; Champakalakshmi 1996; Allchin 1995; Ray 1994).

The Early Historic period (at least in the north, with less consensus about the south) is also generally thought to be a time when cities developed (Conningham 1995; Korisettar et al. 2001; Fuller 2005; Smith 2006). Although it is not clear from an archaeological or theoretical perspective whether or not Early Historic settlements in South India can definitively be called cities or urban centers (see Champakalakshmi 1996 and critque by Smith 1998; see also Kingwell-Banham 2019), it is nonetheless true that between the Iron Age and Early Historic period, settlements continued to expand, resulting in the aggregation of larger settlements.

Within the Tungabhadra Corridor region, for example, systematic survey work shows that between the Iron Age and the Early Historic period, the number of sites decreased and became more consolidated in certain areas (Sinopoli and Morrison 2007; A. Bauer 2010). Archaeological excavations from Kadebakele, for example, show settlement was concentrated the site's Upper Terrace, an area atop the outcrop and enclosed by boulders. This area spanned approximately six hectares (Sinopoli et al. 2010). However, by the Early Historic period, settlement shifted to the River Terrace. The distribution of archaeological materials indicates a possible expansion of between 40 and 60 hectares when settlement expanded to the River Terrace by the Early Historic period. Johansen and Bauer (2015) observed a similar pattern at Maski (100 km north) where the lone Early Historic settlement identified during recent survey work was shown to be five times the size of the largest Iron Age settlement in the study area (9).

Additional transformations located over the late first millennium BC and early centuries CE South India include further craft specialization and intensified agricultural production, which possibly included rice agriculture at some point during Early Historic period (Morrison et al. 2009; Sinopoli et al. 2009). Botanical analysis from Early Historic deposits at Kadebakele is ongoing, and thus evidence of large-scale rice production from the site is not yet available, however the shift in concentrated occupation from the Upper Terrace outcrop to the flood plain at the outcrop's base may potentially have been motivated by shifts in farming strategies. On the River Terrace, Kadebakele residents could make use of the silt-rich alluvium left after the seasonal flooding of the Tungabhadra River, which would have been ideal for farming, including water intensive crops like rice (Morrison 2016).

Despite evidence of transformative social, political, and economic processes, it is unclear how modes of animal-based subsistence practices and animal husbandry were maintained or modified during the Early Historic period. By extension, it is unclear what role animals and human-animal relationships played in driving and shaping these transformations. The lack of available information begins with the fact that most of the archaeological data on the Early Historic period is derived from sites located in North India. Of the peninsular sites that have been excavated and studied, the scholarly focus has largely been on coastal ports and trading sites with little to no consideration of faunal material or animal economies[6].

The few faunal studies available on South Indian Early Historic sites tend to only include species lists and element descriptions (Krishna Sastry 1983; Clason 1975; Nagaraja Rao 1971; Ansari and Nagaraja Rao 1969; Nath 1968). Such lists lack quantitative data and other information necessary for constructing mortality profiles, species ratios, and other aspects of herd composition. Moreover, species lists from previously excavated sites lack information on the archaeological context from which they were excavated. Species lists from Early Historic sites are also problematic in that excavated material from these sites were often not screened and thus it is highly likely that the available assemblages are biased in terms of species representation. Based on data from Veerapurm, however, Thomas (1989) argues that the proportion of wild animals, relative to domestic species, decreased during the Early Historic period. This pattern is perhaps expected, at least in towns or emerging urban contexts, given that craft specialization and intensive agriculture expanded during the Early Historic period and may have impacted the role hunting played in the subsistence economy. In other words, increased economic and agricultural demands that may have been necessary to support growing Early Historic settlements could potentially have led to less time and opportunity to hunt for wild food resources. Ascertaining whether or not a similar decline in wild resources occurred at other Early

[6] In many cases, site reports do not include any mention of faunal remains.

Historic sites, as well as whether animal-based food resources needed to be organized and distributed to specialized economic and food producers is a key component of my research agenda.

3.6 Conclusion

The above review of Neolithic, Iron Age, and Early Historic archaeological research in southern India affirms the importance of these periods as a focus for a long-term reconstruction of animal husbandry and the environmental impacts of livestock grazing. The specific social, political, and economic transformations that occurred over the 3500 years encompassed by these periods provide an important backdrop for better interpreting changing decision-making related to subsistence practices and livestock grazing strategies. Identifying the ways in which these factors articulate ultimately provides an empirically informed long-term environmental history of the region that is currently absent from conservation discourses.

At the same time, while there are key things we know about social, political, and economic practices during the Neolithic, Iron Age, and Early Historic periods, many questions remain. This is especially the case for the transition to the South Indian Early Historic period, where faunal analysis has been absent or limited to taxonomic lists. This research thus uses the site of Kadebakele, a site that has already been referenced in this chapter because of the important ways it has contributed to our understandings of the Iron Age, to compare faunal remains and dental microwear data from Neolithic, Iron Age,[7] and Early Historic deposits from the site. Given what we know preliminarily about agropastoralism at Kadebakele between the

[7] To date, interpretations of livestock management and animal-based subsistence activities from Kadebakele are based on a sub-sample of the Iron Age faunal assemblage from Kadebakele. The research presented here entails the complete analysis of faunal remains from Kadebakele, including faunal remains excavated from the Neolithic and Early Historic occupation.

Iron Age and the Early Historic period, I am especially interested in determining whether or not animal-based subsistence practices shifted from individual or household procurement to larger scale resource production and managed distribution of animal resources, or provisioning. This could have impacts for how to interpret dental microwear data and risk management strategies and could also speak to some of the ambiguities concerning the emergence of Early Historic urbanism in the region. In the following chapter I summarize the excavation history of Kadebakele, artifact analyses to date, as well as the geographic and ecological context of the research area.

CHAPTER 4 :
KADEBAKELE

4.1 Introduction

In Chapter 3, I presented a broad overview of the archaeological research that has been completed on the Neolithic, Iron Age, and Early Historic periods in South India, with a particular focus on the inland southern Deccan region, the focus of my research. Multiple archaeological sites were referenced including the site of Kadebakele. As I have previously noted, Kadebakele is an important site for the study of pre and Early Historic South India for multiple reasons. To begin, Kadebakele contains the largest Iron Age and Early Historic settlements identified in the region. In addition, due to the rigorous and systematic excavation and recovery methods used at Kadebakele, it is also one of the most well-excavated and meticulously documented sites, particularly for the Iron Age. Excavations have yielded a wealth of archaeological artifacts and paleoenvironmental data, all from known and carefully detailed contexts.

In the current chapter, I discuss in more detail the current status of research from Kadebakele. I begin by summarizing the origin, trajectory, and research agenda of the project under which Kadebakele was excavated, the "Early Historic Landscapes of the Tungabhadra Corridor" (EHLTC) Project. Following this brief introduction to the project, I situate the research carried out at Kadebakele within its broader geographic and ecological contexts, an important component to contextualizing my analysis of human-environmental and human-animal relationships. I then describe the excavation and recovery methods employed at Kadebakele, providing the justification for the reliability of inferences drawn on the basis of archaeological material recovered from the site. I then discuss the layout of the site, how it changes throughout different periods, and how the organization of the site informed excavation choices. I also summarize the different excavation units and blocks. Finally, I present the status of archaeological and paleoenvironmental analyses from Kadebakele that have been completed to date. I conclude by arguing that the totality of information from the excavation and research history at Kadebakele, as well as its broader geographical and environmental context justifies the selection of Kadebakele as the focus for addressing the research questions outlined in this dissertation.

4.2 Early Historic Landscapes of the Tungabhadra Corridor Project

Kadebakele is a research site of the Early Historic Landscapes of the Tungabhadra Corridor Project (EHTLC).[1] Kadebakele was identified during the Vijayanagara Metropolitan Survey (VMS), an archaeological survey project co-directed by Sinopoli and Morrison (2007) in collaboration with the Karnataka Department of Archaeology and Museums (KDAM.[2] The VMS was a ten-year (1987-1997) systematic survey documenting sites and features concentrated within the greater metropolitan region around Vijayanagara, the capital of the 14th-16th century CE Vijayanagara Empire, one of south India's largest pre-colonial empires. Under the VMS, over 1000 sites were identified, including sites that preceded the emergence of Vijayanagara. Following the completion of the VMS, Morrison and Sinopoli, in collaboration with KDAM, shifted focus from regional patterns of interaction during the Vijayanagara Empire to earlier settlement patterns and modes of social, political, and economic organization. Kadebakele was the focus of this next phase of research.

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[1] EHLTC's research area spans approximately 36 kilometers. EHLTC has completed surface collection and mapping for sites VMS-541 (Bandibasappa Camp), VMS-579 (Rampuram Camp), and VMS-634 (Bukkasagara) (Sinopoli et al. 2010:3). VMS-643 (Bukkasagara) was excavated and studied by EHLTC team member Dr. Peter Johansen (Johansen 2008; 2019). Dr. Andrew Bauer, also part of the EHLTC team, conducted survey work north of EHLTC's research area and identified additional Neolithic, Iron Age, and Early Historic sites (A. Bauer 2010).

[2] Although identified during the VMS, Sinopoli notes that Bruce Foote likely identified it first.

Kadebakele a large settlement situated on and around a high outcropping granite hill on the northern bank of the Tungabhadra River. It has an occupational history that begins with the Southern Neolithic period (3000-1200 BCE)[3] through the Middle Period (14^{th}-16^{th} century CE) and until the present. Archaeological materials are distributed over an area of approximately 40-60 hectares, including across multiple terraces and the steep slopes of the outcrop. Survey and excavation data to date show Kadebakele's Iron Age habitation was most heavily concentrated the Upper Terrace, a flat area on the top of the outcrop enclosed by large boulders. This area of dense occupation covered approximately six hectares. The Early Historic settlement encompassed a broader area around the base of the outcrop with settlement more concentrated on the River Terrace. Survey data indicate that Kadebakele grew considerably between the Iron Age and Early Historic period, however additional excavations are needed to determine the full extent of the site across all chronological periods.

The EHLTC team has primarily focused excavation efforts on Iron Age periods at Kadebakele, with some preliminary work also completed on the Neolithic and Early Historic deposits. EHLTC's primary research agenda has been to explore continuities and change in social, political, and economic organization, and to examine local and regional economies of craft and agricultural production and social dynamics and their larger political, social, ideological, and ecological landscapes (Sinopoli et al. 2010:1). EHLTC uses multiple, robust analytical techniques (horizontal excavation, attribute analysis of artifacts, paleoenvironmental analyses, sourcing studies, microspatial studies of surfaces), in order to produce a nuanced

[3] This is as far as is currently known. Excavations at Kadebakele reached Neolithic deposits during the final excavation season in 2010, however sterile soil was never reach in any of the units.

understanding of pre and Early Historic South India that avoids and challenges the use of culture historic typologies (Sinopoli et al. 2005:8).

The research presented in this dissertation builds off of and contributes to the research objectives outlined by EHLTC through an analysis of continuities and change in animal-based subsistence practices and human-animal relationships. Further, this research examines how evidence for the maintenance or modification of such practices and relationships coincided with changes in grazing strategies and changes in the landscape. The underlying assumption bridging these two areas of inquiry is that the need for quality feed will ultimately play a role in shaping decisions surrounding animal and land use practices and in ways that will be observable in the archaeological and paleoenvironmental records.

4.3 Geography and Ecology of the Research Area

Kadebakele (15° 21' 53" N, 76° 30' 10"E) is located in Koppal District in the state of Karnataka and is situated just north of the Tungabhadra River. The Karnataka landscape is varied in topography and climate. The primary inland region of Karnataka rests on the Deccan Plateau, which is bordered by the Western and Eastern Ghats. Elevation varies across the Deccan Plateau with the Kadebakele area sitting approximately 600 meters above sea level. The landscape of the Deccan Plateau and the greater Tungabhadra region contains a variety of topographic and geomorphological features, including a combination of granitic inselbergs, residual hills, and low lying open plains.

Figure 4.1: Map of Peninsular India with Kadebakele

Karnataka has four seasons, the winter season lasting between January and February, the summer season lasting between March and May, the monsoon season lasting between June and September, and the post-monsoon season between October and December. Kadebakele is located within what is classified as the northern interior meteorological zone[4], an arid area that receives little annual rainfall (State of the Environment Report Karnataka 2012). Precipitation levels vary across Karnataka with the project area receiving between 50 and 60 cm per year, the majority of which is limited to the summer monsoon season (State of the Environment Report Karnataka 2015). While dry farming is possible in many years, precipitation can vary significantly from year to year and has resulted in a long history of crop failure and food scarcity (Morrison 2000).

The semi-arid climate, along with low, variable, and unpredictable rainfall throughout the year, made the Tungabhadra River and its tributaries prime areas for settlement in the region

[4] This meteorological zone includes the districts of Bidar, Belgaum, Bijapur, Bagalkot, Haveri, Gadadag, Dharwad, Gulbarga, Koppal, Bellary and Raichur districts.

until the 13th century (Morrison 2009:16). Of note, various environmental proxy records and analyses suggest that regional climate became increasingly arid by the late Neolithic and Iron Age (Caratini et al. 1994; Staubwasser et al. 2003; Mujumdar and Rajaguru 1966; for summary see A. Bauer 2014). These patterns are consistent in other tropical environments at the beginning of the second millennium BCE (Mayewski et al. 2004; Wanner et al. 2008).

Forest cover in the northern interior zone of Karnataka consists mostly of scrub cover:

> The rain shadow districts of the state have low rocky hills supporting xerophytic scrub forests. These are scattered between vast stretches of agricultural lands occupying about 8,190 km^2 of dry uplands…A part from this *Albizzia lebbek*, *Hardwickia, Aacia leucophloea* and *Albizzia odoratissima* are also seen. (State of the Environment Report Karnataka 2012:29)

The predominance of dry tropical scrubland is likely related to millennia of intensive human land-use and deforestation (Sinopoli et al. 2010:2).

Karnataka supports a variety of faunal species with the most diverse range of species found in the forested Western Ghats. In the more immediate area surrounding the Kadebakele there are also numerous species of wild mammals, amphibians, reptiles, and birds, many of which have also been identified in the Kadebakele faunal assemblage. Wild mammals found within the Tungabhadra River Valley region include small, medium, and large bodied species. Examples of small wild mammals (under 10 kg) found in the area (as well as in the Kadebakele faunal assemblage) include the mongoose, Indian hare, marten, and small Indian civet.[5] Medium

[5] The general assumption is that species found in the region today would have also been present in earlier periods. However, activities such as urbanization, industrialization, and deforestation have certainly impacted the population size and species range within the area. Different activities may also have led to the introduction or migration of species later in time. Thus, review and acknowledgement of present-day species does not map onto the past exactly, but does provide a reference base for identifying bones from the Kadebakele faunal assemblage.

sized wild mammals (10-60 kg) include various Artiodactyla (hooved animals) such as the Indian gazelle, blackbuck, chital, and the wild pig, as well as carnivores such as wild dogs, hyenas, and leopards. Large wild mammals (over 60 kg) in the region include various Artiodactyls such as sambar, swamp deer, nilgai, and gaur. Large carnivores from the Tungabhadra Valley include sloth bears and tigers.

Although numerous species of birds, fish, reptiles and amphibians occur in the region, the absence of a large comparative collection has made identifying non-mammalian faunal remains beyond the level of genus challenging. As a result, most non-mammalian wild taxa in the Kadebakele faunal database appear as “indeterminate” bird, fish, turtle, etc. These remains are also more likely to be fragmented because of their low bone density. Among the small portion of non-mammalian species that could be identified to species, the most common non-mammalian wild species were catfish (n=59), monitor lizards (n=7), soft-shell turtles (n=84), and the Indian hare (n=60). These totals are problematic, and likely vastly underestimate the diversity of species Kadebakele’s occupants consumed. Biologists have documented 1232 species of bird across the Indian subcontinent (Alfred et al. 1998:450) including various species of aquatic birds (*Anseriformes*), ground feeding birds (*Galliformes)*, wader or shoreline birds (*Gruiformes* and *Ciconiiformes*) and birds of prey. India is also one of the leading countries in the world when it comes to reptile diversity (Alfred et al. 1998:438). In addition, a recent assessment of fish biodiversity in Karnataka estimates that there are 48 different species of fish in the Tungabhadra River alone (Gowda et al. 2015).

That so few species are definitively represented in the Kadebakele assemblage is an unfortunate limitation of the dataset, attributed in large part to the lack of diagnostic elements or element fragments. Future improvements on faunal identification techniques, or an expanded dataset that includes more diagnostic bone, may help better refine the species list at Kadebakele. This would be a particularly fruitful area of research for investigating how changes in land and animal use may have impacted wild animal populations over time and how the rise or decline of different species figured into changes in dietary preferences and subsistence strategies.

The research area also has a long history of supporting domesticated species. The remains of domesticated cattle, sheep, and goats have been identified from the early third millennium BCE (Neolithic).[6] Current Karnataka population estimates for domesticate herds number in the millions and have grown 4.6% between the 2012 and 2019 livestock census. Although over time, foddering has increasingly become a supplementary feeding source (State of the Environment Report Karnataka 2012; 2015), pasture grazing continues to be the primary means for supporting livestock herds. Thus, questions concerning the environmental impacts of livestock grazing (particularly when grazing pressure is high and increasing), continues to be at the forefront of conservation discourse and policy in South India.

4.4 Excavations at Kadebakele

4.4.1 Description of the Site: Terraces and Time periods

Excavations at Kadebakele took place under EHLTC over the course of four field seasons (2003, 2005, 2009, and 2010). During the 2003 and 2005 seasons, excavations focused on Kadebakele's Upper Terrace. Upper Terrace excavations continued into 2009 and 2010 with

[6] See Chapter 3 for a more thorough review of cattle domestication in South India and its implications. Zebu cattle (*Bos indicus*) has definitively been identified faunal assemblages from the Neolithic. Presumably domesticated water buffalo were also present, however distinguishing between water buffalo and zebu on the basis of faunal remains is notoriously difficult given the range of variation between males and females as well as between juveniles and adults (see Chapter 5). Moreover, determining whether or not pigs are wild versus domesticated is more difficult since pig populations can revert to being feral relatively easily. Most evidence points to the fact that the pigs from Kadebakele are feral and not domesticated (see R. Bauer 2006:169-170). This appears to also be the case at Veerapuram (Thomas 1984:iii).

goals of reaching sterile soil. Despite reaching depths of over 3 meters below the surface in some areas, sterile soil was never reached.[7] Radiocarbon samples from the lowest excavated levels date to the late South Indian Neolithic, ranging from 1613 to 1134 BCE (Morrison et al. in press). During the 2009 and 2010 season, excavation units were also placed on the River Terrace (the Tungabhadra floodplain) at Kadebakele.

Preliminary interpretations of the site's occupation history are that the Iron Age and earlier occupations were concentrated on the Upper Terrace. The Upper Terrace is enclosed by large boulders that would have provided protection and limited visibility from the outside during prehistoric occupation. By the Early Historic period, however, settlement shifted from the Upper Terrace to the River Terrace, perhaps in relation to agricultural strategies to increase or intensify rice production along the Tungabhadra River.[8] Despite a shift in occupation area, Kadebakele residents continued to access and use the Upper Terrace. Specifically, it appears that residents continued to participate in commemorative activities associated with megalith features constructed on the northwestern side of the Upper Terrace (Block A, see further discussion below).

4.4.2 Methods of Excavation and Unit Selection

A variety of robust research methodologies were used at Kadebakele in order to best identify and understand use of space and chronology at the site. For example, the EHLTC team completed detailed mapping of topographic and cultural features on both the Upper and River

[7] Notably, the reservoir unit was excavated to a depth of over 6 meters below the ground surface and continued to expose Iron Age cultural material.
[8] It is possible that the shift to the River Terrace began during the late Iron Age, however excavations did not expose Iron Age material. However, based on surface and excavation material, there is no doubt that a major Early Historic occupation took place on the River Terrace.

Terraces, completed systematic surface collection based on controlled sampling, and excavated a series of units on the different terraces as well as in areas that appear to be functionally distinct across the site (Sinopoli et al. 2010).

All units were excavated with reference to the main site datum in order to establish vertical control. Excavations were carried out as a series of levels that followed natural stratigraphy. When it was not possible to discern breaks in stratigraphy, excavations levels were closed after 10 cm.[9] Specific features were excavated independently and in separate levels as necessary. All sediments were screened using 1/8" mesh. In addition, flotation and soil samples were collected from features, surfaces, and other deposits (Sinopoli et al. 2010:4). In some cases, flotation and soil samples were removed from deep profile columns for pollen, phytoliths, isotope, and micromorphology samples (25).

As a result of thorough excavation methods, EHLTC exposed a complex Iron Age stratigraphic sequence on the Upper Terrace that continued into the preceding Neolithic. However, because of choices to ensure careful vertical control and isolate feature assemblages and deposits, the project was unable to excavate broad horizontal exposures across the Upper Terrace or to obtain contemporaneous inter-household variability (Sinopoli et al. 2010:10). Nevertheless, EHLTC documented a variety of features, including domestic and ritual architecture and areas of specialized activity.

River Terrace (Early Historic) excavations were similarly carried out with a goal of establishing chronological sequencing at the site at the expense of broad horizontal excavations. In fact, River Terrace excavations made use of already existing holes and trenches in order to accelerate excavations and expose stratigraphy. The placement of illegally dug trenches on the

[9] In some instances, like the reservoir, excavations were carried out in arbitrary 20 cm levels.

River Terrace made this an urgent goal of EHLTC before further damage was done to archaeological deposits (which has since occurred). Because unit placement decisions for the River Terrace were different compared to the Upper Terrace deposits, the faunal remains from the Iron Age and the Early Historic settlement are not strictly comparable. However they do enable some broad stroke comparisons, especially where faunal data can be analyzed alongside other data sets, such as the dental microwear data collected and analyzed in this dissertation.

4.4.3 Description of Excavated Units: Upper Terrace

Contrary to previous scholarship positing that the Iron Age was largely characterized by a seasonal and mobile settlement system, archaeological evidence from Kadebakele shows the area to have been carefully maintained and continuously occupied over multiple generations (Morrison et al. 2009, Sinopoli et al. 2010:8). In addition, variation in architectural forms and associated artifact classes indicate that Kadebakele was host to suite of diverse social, economic, and ritual activities. Initial excavation seasons focused on the Iron Age occupation on the Upper Terrace. Unit placement on the Upper Terrace was decided based on the presence of artifact concentrations and architecture visible on the surface. Multi-unit, block excavations were carried out in one area containing surface stone architecture (Block A) and another open area to the north (Block B).[10] A series of test units also were placed in other areas of the Upper Terrace and are named in reference to their location. Unit 94.94E/-16.93N is located on the northeastern boundary of the Upper Terrace and is called the North Midden. Unit 52E/-86N is east of Block A and is known as the Eastern Upper Terrace Unit. Multi-unit excavations were also carried out in a reservoir feature and along the southern slope of the Upper Terrace. Brief summaries of the excavation areas are presented below.

[10] See Figure 6.12 in Chapter 6 for a map of excavation units at Kadebakele.

Block B

Block B is a four by four meter horizontal exposure located in the northern central area of the Upper Terrace. Block B was excavated approximately three meters below ground surface and exposed stratified Iron Age deposits. Based on the architecture and artifacts, Block B appears to be an area where domestic and residential activities occurred. Excavations exposed a series of superimposed compacted and prepared surfaces, many found in association with residential wattle and daub structures. In addition, Block B contained a variety of features, including storage features, pits, hearths, and stone walled structures.

In addition to the wealth of Iron Age material recovered from Block B, excavations also reached Neolithic deposits. Neolithic material was identified at the end of the final excavation season after Block B was reduced to a 1x1 meter unit. While reducing the excavation extent of Block B enabled us to expose Neolithic deposits prior to the conclusion of the field season, we were ultimately unable to reach the base of Neolithic deposits because of time constraints. Given the limited nature of excavations in Block B (and that Block B was the only unit that reached Neolithic deposits), we ultimately lack a Neolithic dataset that is comparable to the Iron Age occupation at Kadebakele. Moreover, it remains unclear just how far back in time deposits in Block B (and Kadebakele more generally) extend. As it stands, radiocarbon samples from the lowest Neolithic levels excavated date to approximately 1600/1500-1200 BCE (Sinopoli et al 2010; Morrison et al. in press). With a chronological range spanning 3000-1200BCE, this means we only have data from the later phase of the Neolithic from Kadebakele.

North Midden

Evidence for habitation and domestic activities at Kadebakele was also documented in excavated midden deposits located along the northeast edge of the Upper Terrace. The North

Midden unit is a 1x1 meter unit that produced a dense concentration of domestic debris including faunal and botanical material. The deposits in this area appear to be an accumulation of trash dumping episodes related to domestic activities taking place in nearby residential areas (and presumably across the entire northern part of the Upper Terrace). Radiocarbon dates from the North Midden show such accumulations occurred in rapid succession between 800 and 400 BCE, contemporaneous with the occupation of structures in the Block B area (Morrison et al. in press).

Eastern Upper Terrace Unit

In addition to Block B and the North Midden, a 2 x 2 meter unit, the Eastern Upper Terrace unit (52E/-86N) was excavated near the eastern margin of the Upper Terrace and appears to contain evidence of domestic refuse such as residential architectural remains (surfaces, plaster and daub remains) as well as habitation refuse (Sinopoli et al. 2010). Notably, however, it is unclear whether or not the material remains from the Eastern Upper Terrace reflect an accumulation of trash on top of an abandoned structure, or if this was an area of re-deposited structural debris and trash fill. While this area is contemporaneous with the Iron Age deposits at Block B, it appears much more disturbed and thus interpretations of the structures and activities in this area are limited.

Southern Slope

In contrast to areas of the site containing evidence for residential and domestic activities, excavations from the Upper Terrace also exhibit evidence for ritual and commemorative practices. Evidence of ritual activities at Kadebakele comes from contexts associated with megalith features. Not only do these areas differ in their structural and architectural remains, the distribution of particular artifact classes are also distinct compared to residential contexts. Some of the megalith features documented at Kadebakele are similar to those documented elsewhere throughout the region (e.g., stone circles, stone enclosures and alignments), however many were of kinds not previously documented in the literature on South Indian megaliths (see further discussion on Block A). Indeed, as Morrison et al. (2016a) note, many of the Kadebakele stone features are hardly "mega" at all, a key feature that speaks potentially to how "megaliths" may have been used and interacted with at Kadebakele. Notably here, to date no human burials have been identified or documented at Kadebakele.

Two areas containing megalith features were excavated by the EHLTC team, the Southern Slope and Block A. Excavations on the Southern Slope were carried out in two adjacent 1x1 meter units in an area containing several semi-circular rock alignments on the surface (R. Bauer 2006:111). The units also abutted a previously dug robbers pit to take advantage of exposed stratigraphy in the area (Sinopoli et al. 2010:18). The upper strata of the Southern Slope appear to be the result of midden dumping. However approximately one meter below the surface, an arrangement of large granite cobbles was exposed. This arrangement of cobbles was interpreted to be a stone circle (R. Bauer 2006), however only half of it was exposed during excavations. Excavation of the lower levels of the Southern Slope revealed a series of plaster surfaces cut by four large pits with faunal and ceramic assemblages that differed from those associated with residential contexts (R. Bauer 2006:111; Sinopoli et al. 2010:19). The pits (interior to the cobble arrangement), are unusual compared to other megalith features excavated throughout the region. The uniqueness of these pits further highlights the fact that megaliths vary in their construction histories and that particular practices may have been locally specific even within the broader context of megalith building. R. Bauer (2006) posits the faunal remains from the Southern Slope reflect feasting related activities, including the sharing of cattle meat. Sinopoli (2016) has also presented evidence of feasting or specialized consumption at the

Southern Slope and Block A based on the higher than expected frequency of small serving vessels.

R. Bauer (2006) cited the evidence of feasting documented at the Southern Slope to bolster the argument that social inequalities emerged during the Iron Age and that feasting may have been one strategy employed to facilitate social cohesion. However, the scale and function of feasting events at Kadebakele remains in question, particularly given the steep terrain and limited extent of the Southern Slope area. In other words, it is unclear if the area could have held many people at one time. Moreover, it is questionable how much of the deposited faunal remains reflect consumption activity and how many people this would have fed (Wilcox 2016). Although the Southern Slope does contain a high density of faunal, especially cattle, remains, some appear to be deposited with flesh still on the bone, indicating that meat from the carcass was not consumed and may have instead been deposited as an offering (R. Bauer 2006). In addition, Johansen (2019) situates cattle consumption and feasting evidence from Kadebakele within a broader framework of feasting across the Neolithic and Iron Age and argues that, contrary to promoting social cohesion, feasting at Kadebakele during the Iron Age may have been socially exclusive in nature and may have been part of a series of mortuary rituals incorporated into the way that megalith construction, access, and interaction connoted on instantiated social differences (64). Interpretations of the Southern Slope stands to be further clarified upon the completed analysis of Block A fauna, another area of the site containing ritual and commemorative deposits.

Block A

Block A is located on the western edge of the Upper Terrace and was selected for excavation due to the presence of small wall alignments visible on the surface. Excavations at

Block A were more extensive than on the Southern Slope, exposing 54 features along with 15 associated surfaces. Feature types documented at Block A included large stone enclosures, stone circles and alignments, and interior cists. Some of the more unusual features documented at Block A include a series of small, circular cobble arrangements with appended linear arrangements of stone (lollipop-shaped or “circle on a stick” formations). The excavation of one of these features showed that as sediments accumulated, inhabitants made repairs and added new stones to the alignments, a process that gave rise to slight changes in the original shape and orientation over time, but ultimately preserved and replicated the overall form (Morrison et al. 2016a). While the maintenance of these formations over time are indicative of their local importance, this particular motif is also known to appear in pecked cupule arrangements found throughout the region and is also commonly depicted in rock art (Morrison et al. 2016a).

Block A excavations also revealed small features never before documented in the literature on South Indian megaliths. These features include: various forms of sherd architecture, small features consisting of pavements and alignments of ceramic features, boulder pits, well prepared and lined shallow pits capped and marked by stone, stone-lined caches containing iron artifacts and fauna, and cobble arrangements in association with miniature ceramic vessels (Morrison et al. 2016a; Sinopoli et al. 2010). It is not clear exactly how these features were incorporated into the ritual activities that took place at Block A, but the diversity and uniqueness of Block A features compared to the broader literature on megaliths is important to keep in mind when thinking about the function of megaliths during the Iron Age and how megalith construction relates to the emergence of formalized social inequality. For example, the intensification of megalith construction during the Iron Age is argued to require new forms of labor mobilization (A. Bauer et al. 2007: 13; A. Bauer 2011: 85). [11] As elaborated in A. Bauer et al. (2007), “the physics involved with hewing, moving, and assembling large stone monuments speaks to a potentially different mode of power relations involved in the organization of labor for these tasks,” (13). An important distinction here is that the Block A megalith features are not monumental and did not necessarily require the large mobilization and organization of labor to construct as, for example, megaliths at a site like Hire Benekal would have (e.g. A. Bauer 2010). Instead, the architectural features at Block A were altered in small ways over time and were revisited past the Iron Age occupation on the Upper Terrace of Kadebakele. This and scrutiny over the interpretation of feasting at Kadebakele, thus raises the question of whether or not there is evidence for social inequalities at Kadebakele, a question that is again difficult to answer given the lack of data on inter-household variation at the site.

Upper Terrace Reservoir

In addition to domestic and ritual contexts, multiple seasons of excavation took place within a reservoir feature located in the center of Kadebakele’s Upper Terrace. A roughly circular depression, the reservoir at Kadebakele measures approximately 30 m in diameter and would have held monsoon rainfall and seasonal runoff. In 2014, a 5x1 m unit was placed within the northern half of the reservoir feature. Excavations were carried out to obtain stratified pollen, sediment, and soil samples for analysis, to better understand the environmental context of the site

[11] This is not to mention that some megalith sites within the region contain burials that vary in terms of individual versus group internments with differences in the elaboration of megalith construction and associated grave goods (Brubaker 2001; Leshnik 1974; Moorti 1994). However, Kadebakele megaliths excavated to date do not appear to contain human burials, although they could be outside of the excavation area. In addition, some of these mortuary examples documented throughout the region do not have associated radio carbon dates and since megaliths do not only appear during the Iron Age it is appropriate to think through multiple ways in which accurately dated megaliths can inform interpretations regarding social inequality during the Iron Age.

throughout its occupational history, and to reconstruct the history and use of the reservoir.

Table 4.1: Excavation Blocks and Units on Kadebakele's Upper Terrace

Unit/Block	**Coordinates**	**Brief Description**
Block B	(20E/-28N, 22E/-28N, 20E/-26N, 22E/-26N)	Habitation/Domestic
North Midden	(94.94E/-16.93N)	Domestic Refuse/Midden
Eastern Upper Terrace	(52E/-86N)	Residential remains, potential re-deposition
Southern Slope	(-21.6E/-203N, -21.6E/204N)	Megalith stone circle and pits, high volume of cattle remains and feasting evidence
Block A	(-24E/-88N, -24E/-90N, -24E/-92N, -22E, -88N, -22E/-92N, 22E/-90N, -20E/-88N, -20E/-90N, -20E/-92N)	Series of stone wall alignments and stone features, some unique to megalith classification and varying in size
Reservoir	(8E/-145N)	Large reservoir, appears to be post-Iron Age

Paleoenvironmental analyses from the reservoir are currently ongoing. In 2014, further excavations of the reservoir took place[12] with the goal of finally reaching the bottom of the reservoir and obtaining a full paleoenvironmental and vegetation sequence to compare with the site's occupational history. Unfortunately, sterile deposits were never reached in the reservoir. At four meters below ground surface, the earliest radiocarbon date had a cal AD date of AD 870-1010 (Sinopoli et al. 2010). At more than six meters below ground surface, excavations exposed

[12] 2014 excavation of the reservoir at Kadebakele was part of a new project PPIP, under the direction of Morrison, Lycett, and A. Bauer. PPIP conducted a comparative reservoir excavation project and collected paleoenvironmental and vegetation history data from Kadebakele, Hire Benekal, and Brahmagiri.

in situ Iron Age cultural material.

4.4.4 Description of Excavation Units: River Terrace

Excavations at Kadebakele have largely focused on the Upper Terrace Iron Age deposits. The decision to excavate on the River Terrace was prompted during the 2009 season when the EHLTC team discovered a deep trench (approximately 25 x 30 meters and 3 meters deep) that had been illegally dug on the River Terrace. The trench was significantly destructive, disturbing meters of archaeological deposits and scattering artifacts and construction materials. The EHLTC project sought to contextualize the disturbed materials by placing a 2x1 meter unit at the base of the trench. Doing so, we were able to expose a deep stratigraphic profile while also obtaining Early Historic ceramics, fauna, charcoal, beads, iron, and lithics (Sinopoli et al. 2010).

The 2009 River Terrace unit (-8.8E/-449.8N) lacked structural features (with the exception of a single prepared surface and a pit found in the uppermost levels of the unit). In order to obtain archaeological material from contexts comparable to the Upper Terrace, additional test excavations were carried out in the 2010 season. Two 2x2 meter units were excavated (57. 16E/-561.77N and 54.6E/-529.58N). In 57.16E/-561.77N, eight prepared plaster and natural surfaces were exposed. Four features were documented including two large storage pits. Unit 54.6E/-529.58N, located 32 meters to the north of 57.16E/ -561.77N, was excavated in five 20 cm arbitrary levels and produced Early Historic artifacts and fauna.

4.5 Artifact and Paleoenvironmental Data from Kadebakele

4.5.1 Analyses to Date

Given the volume of material culture and paleoenvironmental data recovered from Kadebakele, analyses remain ongoing. Preliminary results and interpretations of datasets from Kadebakele have been presented in various forms including field reports, conferences and workshops, dissertation theses, book chapters, and peer reviewed articles. Final results and reporting are being prepared for publication in a monograph series on Kadebakele. In the sections below, I review some of the key preliminary findings based on analyses completed to date.

4.5.2 Ceramics

Preliminary ceramic analysis has been presented in Sinopoli et al. (2010: 28-30) and Sinopoli (2016) (see also Morrison et al. in press). Ceramics have been classified and sorted into different ware and form categories. Form categories primarily include bowl, jar, and unknown/other vessel. Three ware types dominate the ceramic assemblage, making up approximately 90% of the total sample. These three ware categories are slipped and polished red ware, slipped and polished black ware, and black and red ware (Sinopoli et al. 2010: 28-29).[13]

Ceramics from Kadebakele are an important artifact class due in large part to their ubiquity and the variety of activities and practices they index. To date, over 400,000 sherds have been analyzed from 240 distinct archaeological contexts (Sinopoli 2016:5). Analyses of ware and vessel form categories indicate that ceramics were used for storage, transport, and cooking (29). In addition, ceramics were used for everyday consumption as well as in ceremonial or commemorative contexts (Sinopoli et al. 2010; Sinopoli 2016). Importantly, ceramics have been sampled and analyzed from three different chronological contexts (the Neolithic, Iron Age, and Early Historic periods). Kadebakele ceramics thus provide insight into changes in technology

[13] Ware categories are based on different combinations of color, thickness, paste, and surface treatment. To date there are 26 ware categories that have been identified. Some of the less represented categories found at Kadebakele include black plain ware, red plain ware, brown plane ware, red russet coated painted ware, brown slipped and polished ware, unslipped polished wares, and micaceous wares that date to the Neolithic (for full list of ware categories see Sinopoli 2016).

and use that speak to broader social, political, and economic changes, as well as to the ways in which inhabitants shaped this change through a combination of innovative practices that were simultaneously rooted in long-term trends observed over time (Sinopoli 2016).

Given the limited nature of Neolithic excavations at Kadebakele, artifact sample sizes, including ceramics, are small. Nevertheless, ceramic data from Neolithic deposits provide information that is useful for beginning to understand Neolithic craft production, as well as for understanding the trajectory of change in craft technology over time. Overall, Neolithic ceramics from Kadebakele do not exhibit a great degree of variability and are comprised mostly of deep vertical-walled cooking vessels (Sinopoli 2016: 9-10). Importantly, Neolithic ceramics provide key insights into changing ceramic technologies that occurred at Kadebakele near the end of the Neolithic and into the beginning of the Iron Age. Sinopoli (2016) summarizes the changes and their significance as follows:

> [T]he Kadebakele ceramic data also allow us an intriguing glimpse of ceramic change at the instant it was happening near the end of the Neolithic. This evidence comes in the form of a small number of vessels that are "transitional" between typical Neolithic technologies and forms…and reveal that potters were experimenting with new ways of forming and finishing vessels, including the application of slip, burnishing, creating vessels with more complex profiles, and new firing technologies. This experimentation appears to have begun sometime around 1400 BC, a period when experimentation with other new technologies, specifically iron working, was also underway. (12)

Given the evidence of experimentation in ceramic forms and technologies, it is perhaps unsurprising that, in contrast to the Neolithic, Iron Age ceramics at Kadebakele exhibit much more diversity (Sinopoli 2016). This is particularly evident for bowls. Variation in bowl forms during the Iron Age appears to be related to differences in activities and consumption contexts. Given their small size, bowls appear to function as individual serving vessels (Sinopoli et al.

2010:30; Sinopoli 2016:10). They appear in both domestic and megalith contexts at the site, an indication that food and drink consumption occurred in households was well as in conjunction with public commemorative or ritual events (2016:10).

Trends in bowl production at Kadebakele also underscore important changes that occurred between the Iron Age and the Early Historic period. During the Iron Age, great care was taken to make bowls of high quality. Many bowls were, "coil- and slab-built with extremely thin walls, and were then finely burnished and carefully fired — the products of impressive skill and high labor investment," (Sinopoli 2016:10). By the Early Historic period, however, ceramic production is marked by efforts to mass-produce simpler vessel forms:

> Early Historic bowl forms show a simplification in forms and a marked decline in diversity. Rims and vessel forms are simpler and the bowls are mostly shallow relative open forms, perhaps indicative of changing consumption practices. In addition vessel walls are significantly thicker than Iron Age bowls, and even slipped vessels are less carefully polished—all evidence that less effort was being put into the production of ceramic serving vessels at this time. (Sinopoli 2016:10)

The sophistication and labor investment in Iron Age ceramic vessels compared to the preceding Neolithic provides evidence for increased specialization in craft production (Morrison et al. in press). By the Early Historic period, shifts in the quality and technique of vessel production reflect changes in the organization of craft production. Efforts appear to be increasingly oriented towards the mass-production of standardized ceramic forms, although they may have also been simultaneously influenced by changes in consumption practices and preferences for ceramic vessels (Sinopoli 2016). Early Historic ceramics recovered from Kadebakele also point to evidence of long-distance trade interactions due to the presence of imported fine-ware (Morrison et al. forthcoming). This stands in contrast to the preceding

Neolithic and Iron Age periods where it appears ceramics were made locally with little evidence for long-distance movement (Morrison et al. in press).

4.5.3 Metals

Metal recovered from Kadebakele includes iron artifacts (spear points, knives, nails, clamps, rings) and slag. In addition, few copper and brass/bronze objects were identified. Metal artifacts, including iron implements, are relatively rare at Kadebakele. Slag identified at Kadebakele appears to have resulted from smithing as opposed to smelting (Sinopoli et al. 2010:34) and preliminary analyses (Srinivasan et al. 2009) suggest possible steel use. Further analyses are required but if confirmed this would provide evidence for some of the earliest steel artifacts found in South India and the world (34).

4.5.4 Lithics

The Kadebakele lithic assemblage is dominated by flakes in all three occupation periods. Ground stones are also present in the Kadebakele lithic assemblage. Dolerite hammerstones identified at Kadebakele were found in association with megaliths and were likely used to shape and modify megalith features (Morrison et al. in press).

Flakes from Kadebakele are mostly parallel-sided bladelets and there appears to be continuity in terms of flake production between the Neolithic and Iron Age. In addition to continuities in technology, there is continuity in the raw material of bladelets in the Kadebakele assemblage with chert being the primary resource for blade production. However, by the Iron Age, and continuing into the Early Historic period, quartz also emerges as a raw material source for bladelet/flake production. Although quartz is locally available, chert sources have not been identified in the region around Kadebakele. Thus, despite the diversification of lithic raw materials over time, the continuous use of chert points to both early and enduring exchange networks that provided resources to Kadebakele (Morrison et al. in press).

4.5.5 Beads/Ornaments

A variety of stone, bone, glass, shell, and ceramic ornaments and small finds (beads, worked sherds, shell bangles spindle whorls, worked stone discs) have been identified from Kadebakele excavations. Bead were made of a variety of materials including (but not limited to) bone, carnelian, steatite, shell, agate, terracotta, quartz, jasper, lapis, feldspar, ivory, and copper/bronze (Kelly 2013:155-158). Although there is limited evidence of bone and terracotta bead production at Kadebakele (specifically in Block B), other bead material sources are definitively non-local (Kelly 2013: 156-161).[14] Lapis lazuli, for example comes from northern Afghanistan. Some marine shell beads were also recovered from Kadebakele (159). Carnelian, which makes up a large proportion of the Kadebakele beads, is also considered non-local, however carnelian sources have been identified in other areas of the Indian peninsula and Sri Lanka (Sinopoli et al. 2010:35).

Non-local bead sources (at least 100km away) at Kadebakele do not appear until the Iron Age. Neolithic beads at Kadebakele, for example, are primarily made of stone and steatite. Noticeably absent from the Neolithic bead assemblage at Kadebakele are carnelian beads, with only a single carnelian bead identified from Neolithic deposits. By contrast, carnelian beads are common during the Iron Age at Kadebakele, as well as at other Iron Age sites (Kelly 2013: 160). The diversity of bead sources, including non-local materials, shows that by the Iron Age Kadebakele was part of expanding networks of interaction and trade. However, given the frequency and distribution of some of the non-local bead material recovered at Kadebakele, it

[14] While some are definitively nonlocal, other sources have yet to be identified locally, however it is unclear where exactly they are from. These materials include blood jasper, white feldspar, aqua green-blue microcline/amazonite, red siltstone, and green serpentine (Kelly 2013:160-161).

does not appear that trade was systematized or regular (Kelly 2013). The abundance of carnelian at Kadebakele, however, may indicate regular access or trade when it comes to this particular, nonlocal material.

Although there is evidence of onsite bead production at Kadebakele, such production was small-scale during the Iron Age and was neither intensive nor specialized (Kelly 2013: 161). Production appears to have been carried out within domestic or household contexts, as evidenced by the presence of production and waste materials in Block B. Aside from small-scale production waste, the deposition of beads at Kadebakele appears to result from bead loss as they were worn or used in daily activities. This form of deposition is consistent in both domestic (Block B) and megalith contexts (Block A) (Kelly 2013: 139). This is notable since it indicates that beads were not deposited in specialized features or used at ritual offerings at Block A. However, the frequency of bead deposition resulting from accidental loss at Block A highlights the extent of routine and regular interaction with ritual space at Kadebakele and the ways ritual and daily life intersected within the context of bead consumption and use (Kelly 2013).

4.5.6 Botanicals

Botanical evidence collected from Kadebakele includes seeds, pollen, starch grains, and phytoliths. Analyses are ongoing and preliminary results are only available from Iron Age contexts. [15] The Iron Age dataset is also limited since analysis has only been conducted on botanical remains from the North Midden and from a large storage feature from Block B (Feature 28). Key findings regarding Iron Age botanical analyses from Kadebakele were broadly

[15] Discussion of these analyses appears in Morrison et al. 2016b, as well as Morrison et al. in press. Charred seeds were analyzed by Seetha Reddy and starch grains were analyzed by Arumina Kashyap. Phytoliths were analyzed by Sanjay Eksamber through the Phytolith Research Institute (Pune), the results of which are presented in A. Bauer 2010 and discussed in A. Bauer 2014).

summarized in Chapter 3 but will be reviewed in further detail here.

Macrobotanical data show Iron Age farming at Kadebakele consisted primarily of growing millets and pulses, plant varieties that are well supported by the region's monsoon rains and that do not require additional irrigation efforts (Morrison et al. 2016b). Preliminary macrobotanical (seed) analyses indicate that pulses dominate over cereals at Kadebakele (Morrison et al. 2016b). This pattern was present in both the North Midden and Feature 28 in Block B; however, the distribution of taxa among pulses is different. Both the North Midden and Feature 28 contain some amount of *Cajanus cf. cajans* (pigeon pea) and *Macrotyloma uniflorum* (horse gram). However, *Lablab purpurus* (hyacinth bean), which dominates the seed assemblage in the North Midden, does not appear at all in Feature 28 (Morrison et al. 2016b). By contrast, *Vigna radiata* (mung), a legume taxon, dominates the seed assemblage in Feature 28, but does not appear in the North Midden.

It is not yet clear what the significance is concerning the different distribution of plant taxa across different contexts at Kadebakele. The distribution of faunal remains at Kadebakele indicates that different areas of the site correspond to different consumption and processing activities (R. Bauer 2006; Wilcox 2016), however the distribution of fauna between the North Midden and Block B were largely similar. Further analysis of the differences in plant taxa across different units and features will aid in refining differences in food production, preparation, and consumption practices.

Starch grain analysis from Kadebakele similarly points to the importance of pulses to the diet of Kadebakele inhabitants and shares the same emphasis on *Lablab* as was documented in the seed data from the North Midden. Also notable, starch grain results show Kadebakele inhabitants grew bananas and yams, although their production was likely smaller in scale

(Morrison et al. 2016b). Unlike the dry farmed millets and pulses that make up a majority of the botanical assemblage at Kadebakele, bananas and yams are water intensive and would have required supplemental watering beyond what monsoon rains provided (Morrison et al. 2016b). Other taxa recovered from Kadebakele include *Sertaria verticilla* (bristlegrass), and small amounts of wheat (found in the North Midden) and barley (found in Feature 28) (Morrison et al. 2016b).

Phytolith data from the North Midden shows that the proportion of silicified woody elements changed over time (A. Bauer 2010; A. Bauer 2014). The presence of woody elements throughout the midden indicates that inhabitants at Kadebakele used woody shrubs or trees that grew on or near the site (A. Bauer 2014: 11). Notably, the proportion of woody elements decreased in the upper most levels of the midden, a point that A. Bauer (2014) argued may reflect the decreased availability of woody material, possibly due to land clearance and intensified settlement activities (11).

Evidence for land clearance stands to be potentially corroborated with pollen data from Kadebakele. Specifically, a corroborating pollen profile would show a decrease in tree and arboreal taxa and an increase in weedy plant species. Although pollen samples were collected from stratified deposits exposed in the Kadebakele reservoir, the only samples that have been analyzed thus far come from levels dating to the first or early second millennium AD (A. Bauer 2010: 296). Thus, the available pollen data from the Kadebakele reservoir post-date the chronological periods central to the research questions in this dissertation.

Ultimately, interpretations of agricultural production at Kadebakele are constrained by the fact that analyses from the Iron Age are still in their preliminary stages and that analysis has yet to be completed on Neolithic and Early Historic plant remains from Kadebakele. Comparing

Kadebakele to other sites, however, a picture emerges where we can begin to see the longevity of certain agricultural practices as well as the tendency and capacity to experiment with new production strategies and technologies (Morrison et al. 2016b). Continuities in farming are especially evident between the Neolithic and Iron Age, where millets and pulses were the primary dietary staples and more water-intensive crops were grown on a smaller scale (Morrison et al. 2016b). The phytolith record potentially suggests that over the course of the Iron Age, farming activities intensified, a contrast that would also apply when comparing the Neolithic to the Iron Age overall. Additional and corroborating data from pollen analyses would strengthen this interpretation. Variation by way of intensified production between the Neolithic and Iron Age also appears to be potentially supported by the fact that new irrigation technologies and features, such as containment reservoirs, were adopted during the Iron Age (A. Bauer and Morrison 2013; Morrison et al. 2016b). Importantly, however, the use of the reservoir specifically at Kadebakele during the Iron Age remains unclear given that reservoir excavations came down on Iron Age cultural remains at six meters below the surface.

4.5.7 Fauna

The data and the analyses presented in this dissertation build off previously published faunal data from Kadebakele conducted by R. Bauer in 2003 and 2005, and constitute the completed analysis of all faunal remains that have been recovered.[16] This includes faunal

[16]Fauna comes from excavation seasons that took place in 2003, 2005, 2009, and 2010. R. Bauer (2006) analyzed 2003 and 2005 faunal material. I completed analysis of faunal remains from the 2009 and 2010 excavation seasons as part of my dissertation research. As mentioned previously, preliminary updates were presented in my MA thesis (Wilcox 2013) as well as in published conference proceedings for the European Association of South Asian Art and Archaeology (Wilcox 2016). Those preliminary results have been expanded upon in this dissertation to include the full Kadebakele faunal assemblage which included faunal remains recovered from Neolithic

material recovered from the continued excavation of Iron Age phases of Block A and Block B. Key aspects of Iron Age animal use and subsistence production previously deduced from faunal analysis at Kadebakele were summarized in Chapter 3.

To briefly review, Kadebakele inhabitants engaged in both hunting and herding for subsistence. Cattle and caprines were important sources of secondary products (dairy and traction), while small and locally available non-mammalian wild taxa (e.g., birds, fish, turtles, snakes) were hunted and consumed as sources of protein. Cattle remains were also found in specially prepared features in the Southern Slope with evidence of feasting related activities (although the scale and function of feasting events at the Southern Slope remains poorly understood). While caprines were nearly absent in the Southern Slope, preliminary analysis of faunal material from the Block A megalith complex show both cattle and caprines were present (Wilcox 2013; 2016). The results presented in this dissertation contain the completed analysis of Block A fauna and will further explore how animal related activities compared between the Southern Slope and Block A. These will speak to the more than economic roles of animals at Kadebakele and contribute to an enhanced understanding of how Kadebakele occupants perceived animals and their relationships to them.

Not only does this research add to the Iron Age data set, but it also includes faunal remains from Neolithic and Early Historic contexts at Kadebakele. As such, this dissertation provides insights into the ways subsistence production and animal husbandry changed over time and within a context where significant social, political, and economic transformations were under

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and Iron Age deposits from Block A and Block B on the Upper Terrace, and faunal remains from three Early Historic units excavated on the River Terrace.

way (see Chapter 3). One key question concerning the prehistoric and Early Historic transition at Kadebakele is whether or not Kadebakele residents became increasingly removed from their own food production and were provisioned with dietary resources, as economic specialization and agricultural intensified into the Early Historic period. Not only is this a question of importance with regard to the development of early urbanism in this region, but if changes did occur, this could potential impact grazing strategies in the area.

Faunal analysis will also be combined with dental microwear analysis (completed by author), as well as geomorphology data (A. Bauer 2010; A. Bauer and Morrison 2013; A. Bauer 2014). The combination of these data sets will ultimately inform how people at Kadebakele perceived animals and the environment and the role these perceptions played in animal and land use decisions.

4.5.8 Geomorphology and Remote Sensing

The occupational history of Kadebakele has and continues to serve as a case study demonstrating the range and intensity of human activities in the deep past with many lines of evidence highlighting the ways in which humans interacted with and impacted the environment. Work documenting the geomorphological history of the broader Tungabhadra area, including geomorphological and soil changes at Kadebakele, has also added significant insights into how ancient social, cultural, and economic practices have shaped the landscape (A. Bauer and Morrison 2013; A. Bauer 2010; A. Bauer 2014). Specifically, using multi-spectral satellite images, differences in the extent of soil stripping or soil erosion on residual hills was compared to varying degrees of prehistoric occupation and land use intensity. Soil stripping was analyzed via measurements of soil cover and exposed rock on residual hills, both of which are distinguishable and classifiable in the multi-spectral images. They were measured and reported in terms of surface area proportion with soil cover varying nearly collinearly with the proportion of exposed rock (A. Bauer 2014:8).

Although the long-term formation of geomorphological features such as the residual hills characteristic of the Tungabhadra Valley region entails a combination of complex environmental and geological processes, results from multi-spectral image/remote sensing analysis indicate that prehistoric occupation and activities had a considerable impact on these landforms, in particular as it relates to soil stripping. In fact, archaeological evidence for land use was shown to be the best explanatory variable for proportion of remaining soil cover compared to other geomorphological variables:

> Higher hills have generally been elevated above the erosional plain for greater periods and thus have been affected by surface processes for a longer time. Hence, one might expect these hills to also contain higher percentages of exposed residual rock. Similarly, hills that develop steeper rock slopes and pediment angles in some locations, increasing the variation in slope metrics, can also be expected to retain less soil cover or migratory weathered sediment. Thus, slope and elevation variables should explain a significant proportion of the soil cover and exposed rock on the hills in the study region. Surprisingly, however, of all regression models that included only a single explanatory variable, elevation and slope metrics, although statistically significant, were poorer fits to the dependent variable (e.g. soil cover fraction) than archaeological proxies of ancient land use. (A. Bauer 2014:9)

Geomorphological and remote sensing analysis in the Tungabhadra region thus indicate that human activities in the deep past contributed to changes in soil cover and soil erosion. It is therefore an important contextual and potentially complementary dataset to consider alongside the faunal and dental microwear data analyzed in this dissertation. Notably, A. Bauer (2014) argues that the precise activities that appear to contribute to soil erosion in prehistoric contexts are related to grazing animals. This is because the largest proportional differences in exposed rock appear on the lower rock slopes where animals were likely grazed (A. Bauer 2014:11-12).

4.6 Conclusion

Given the heightened susceptibility of arid and semi-arid environments to forms of degradation, a fact that often makes these settings the foci of environmental conservation policies, Kadebakele and the Tungabhadra region are ideal locations for investigating how the history of animal husbandry and livestock grazing shaped the environment. Artifact analyses to date from Kadebakele also provide key insights into patterns of continuity and change in production and consumption activities and broader social and economic practices and organization. As such, this study is well positioned to provide an empirically robust reconstruction of the various ways animals also figured into social, political, and economic practice at Kadebakele. Moreover, because of Kadebakele's deep occupational history, this dissertation will provide a chronological comparison of faunal and dental microwear analysis across the late Neolithic, Iron Age, and Early Historic periods. In the next chapter I review how the faunal remains from Kadebakele were collected and curated and how the database was designed. I also describe the methods used and variables recorded for faunal analysis.

CHAPTER 5 :
FAUNAL ANALYSIS SYSTEMS

5.1 Introduction

In this chapter I describe the methodology used in my analysis of faunal remains from Kadebakele (117,456 identifiable[1] bones). Although all zooarchaeologists study animal remains from archaeological sites, the methods they use vary depending on their research goals, access to resources, and the state of preservation of the faunal collection they are analyzing. Detailed presentation of zooarchaeological methods is crucial in helping readers and future researchers gauge the reliability of inferences and interpretations deduced from the faunal dataset. Moreover, it is important to identify differences in methodology in order to understand how to approach comparing different datasets. My presentation of faunal analysis methods begins with a discussion of how the faunal assemblage was recovered and how the excavation and screening methods used at Kadebakele reduce the risk of recovery bias in the Kadebakele faunal assemblage. I present data on how taphonomic factors impacted the Kadebakele faunal assemblages in support of this. Next, I describe how faunal remains were curated, stored, and analyzed in the field. Following this, I discuss decisions related to database design, variables documented during analysis, and quantification methods.

5.2 Recovery Methods

Many factors influence the methodological choices and techniques used in faunal analysis. Decisions concerning what sampling strategies and quantitative analyses to use will depend on the recovery methods used during excavation. Early in the discipline, excavation methods often used hand collection, a practice that can be inconsistent and uncontrollable

[1] Identifiable at least down to class and size. This total includes, for example, large mammals, medium mammals etc.

(O'Connor and Barrett 2014:262) and which can bias faunal samples by underrepresenting smaller bones, including smaller species such as small mammals; birds; fish and herptiles; and smaller elements from medium sized mammals (teeth, carpals, tarsals, and phalanges), and fetal or neonate bones. Indeed, the lack of systematic screening methods in South Indian archaeology, in part, accounts for the limited availability of faunal data, especially for settlement contexts.

Although screening unequivocally improves the recovery success of faunal assemblages in archaeology, under certain circumstances hand collection is still employed as the primary recovery method during excavation. Salvage projects, for example, may lack the time and resources required to undertake screening. In addition, projects aiming to expose large horizontal units may also opt to hand collect artifacts and limit sediment screening as 100% screening in these instances would impede the speed of excavation. Because of the recovery biases inherent in hand collection, partial screening, and the use of larger screen sizes (larger than 1/8"), faunal analyses based on these assemblages must adopt a variety of measures to assess and measure the extent of recovery bias. This is done to ascertain the extent to which interpretations can be accurately derived from the faunal data. For example, it would be difficult to draw inferences about culling practices if a faunal assemblage was biased with respect to animal size and bone density since the bones of young animals could be missed during recovery.

In wanting to provide detailed information on settlement and land use activities at Kadebakele, the Early Historic Landscapes of the Tungabhadra Corridor Project (EHTLC) employed an excavation strategy that had careful vertical control with reference to the main site datum and which screened 100% of deposits using 1/8" mesh. In addition, sediment samples were collected throughout excavations and processed via wet sieving (flotation). The excavation and screening methods adopted by EHLTC provided an ideal strategy for ensuring the faunal assemblage was not biased with respect to animal size and age class. However, other processes can impact the preservation quality of a faunal assemblage and thus taphonomic factors need to also be considered. Below, I first discuss taphonomic impacts on the Upper Terrace (Neolithic and Iron Age) faunal remains. I then discuss taphonomy of the River Terrace (Early Historic) faunal assemblage and why the data from the River Terrace is more limited than the Upper Terrace.

5.3 Taphonomic Impacts

Taphonomic factors do not appear to considerably impact the faunal assemblages from the Upper Terrace (Neolithic and Iron Age faunal remains).[2] Indeed, the recovery of large quantities of small bird, fish, and herptile (amphibian and reptile) bones is a strong indication that smaller elements were not overlooked or missed during the excavation and screening process. Moreover, these taxa are represented in similar proportions in screened deposits (1/8" mesh) recovered in the field compared to wet sieved deposits (1/16" mesh) in the lab (R. Bauer 2006:141). If size-based recovery bias was a problem in the Iron Age assemblage, we would expect to see a higher rate of recovery of small-boned taxa in the flotation samples compared to screening in the field since flotation is specifically used to recover small remains such as seeds and plant remains.

Density-mediated attrition has a larger effect on the Upper Terrace faunal assemblage than size-related recovery bias, however the number of delicate and low-density remains in the Upper Terrace assemblage show it is still relatively well preserved. One way to assess the degree of density-mediated attrition is to examine long bones that contain both low-density proximal

[2] Specific feature contexts where a higher proportion of the faunal remains were subjected to destructive processes such as burning could impact fragmentation and identification and are considered in further detail below.

ends (less likely to preserve) and high-density distal ends (more likely to preserve) and compare their respective frequencies.[3] Two long bones considered here are the humerus and the tibia. On this basis, if a complete humerus or tibia were discarded in an archaeological context, we would expect both the proximal and distal ends to survive at the same rate or frequency if attritional factors had no impact on the assemblage. Table 5.1 illustrates that the impact of density-mediated attrition on the tibia is low with the ratio of proximal to distal ends being 1:1.2. In other words, the proximal and distal tibia ends are almost equally represented (45.7% proximal and 54.3% distal). Density-mediated attrition is more evident for the humerus, with the distal ends outnumbering the proximal ends 2:1. In other words, the dense distal humerus appears twice as often as the spongy and less dense proximal humerus.

Although the frequency for proximal humeri is low (33.3% when calculated out of the total number of proximal and distal humeri), it is worth pointing out the shift in the frequencies of proximal and distal humeri and tibiae ends between the 2003/2005 excavations (upper levels) and the 2009/2010 excavations (lower levels). The distribution of proximal and distal bone ends from lower depths indicates that density-mediated attrition decreases with depth and that faunal samples from lower levels of excavation are even better preserved compared to the uppermost levels. For example, from the 2009 and 2010 levels (lower in excavation depth compared to the 2003 and 2005 faunal remains) proximal humeri make up nearly 40% of the total amount of humeri ends (see Table 5.2). Recall that in a hypothetical situation where no density-mediated attrition occurred, we would expect to see proximal ends making up 50% of the total amount of humeri ends. By contrast, the 2003/2005 faunal remains show that proximal ends make up only 27.9% of the total sample of humeri ends. This is not unexpected considering the fact that R.

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[3] Relative density of bone and bone ends based on Lyman (1984)

Bauer (2006: 146) observed that degree of bone fragmentation also decreased with excavation depth. This is likely due to the fact that faunal remains located in lower deposits are less likely to be impacted by attritional forces occurring on the surface, such as livestock trampling or agricultural activities (Andrews and Armour-Chelu 1998; Karr and Outram 2012; Lyman and O'Brien 1987).

The comparative frequencies of low- and high-density bone ends in the humerus and the tibia for the Upper Terrace assemblage thus show a degree of density-mediated attrition. However, this appears to be skewed by the poorer preservation of faunal materials from upper levels. Lower level deposits show a better degree of preservation. It is also relevant to consider the fact that low-density neonate specimens preserved at both upper and lower levels. Although they do not comprise a large proportion of the total Kadebakele assemblage, their preservation throughout Upper Terrace (mostly Iron Age) deposits attests to the overall quality of bone preservation and the fact that patterns in the faunal data can be viewed with confidence as reflecting Iron Age cultural behavior and choices.

This is further corroborated by the lack of other destructive taphonomic forces that could bias or obscure the faunal record. These include rodent and carnivore gnawing, bone modifications, and burning. Rodents (rat/mouse) were identified in the Upper Terrace faunal assemblage and were particularly abundant in Block B (n=574).[4] Nearly all of the rat/mouse remains identified in the Upper Terrace faunal assemblage were modern and intrusive to the deposits. This was documented extensively in Block B where rodent burrows were encountered during excavations. The coloring of rat/mouse remains was also distinct from the rest of the zooarchaeological remains, indicating that they were incorporated into the deposits later. Despite

[4] Rat/mouse remains were also more concentrated in Iron Age deposits compared to Neolithic deposits suggesting that intrusion by modern rodents also decreases with depth.

their presence, rodent gnawing was rarely observed on zooarchaeological specimens. Carnivore gnawing was also rare but less surprising given how few carnivores appear in the Iron Age assemblage, including in particular the low frequency of wild and domesticated dogs (n=13). The overall proportion of animal bone subjected to extreme heat or burning, which can impact the structure and durability of faunal remains and reduce their likelihood of surviving in the archaeological record, was also relatively low across the total Upper Terrace assemblage at Kadebakele (19.5% burned compared to 80.5% unburned). However specific contexts exhibit higher instances of burning (see Chapter 6). Finally, examples of worked or modified bone were documented, but were not considered common when evaluated against the overall faunal assemblage.

Thus, the Upper Terrace faunal sample from Kadebakele underwent taphonomic processes that had some impact on the preservation of animal remains and thus the ability for all elements to be identified with the same taxonomic and anatomical specificity. Rigorous recovery methods, including the screening of all excavated deposits, aided in determining the full extent to which density-mediated attrition and size bias impacted the data coming out of the Iron Age faunal sample. The broader picture to emerge after considering various sources of taphonomic loss is that the Upper Terrace faunal sample is well preserved and can yield data on human-decision making in the past and the types of human-animal relationships that were forged out subsistence, ritual, and other social practices.

Table 5.1: Proximal and Distal Tibia and Humeri Ratios				
Element	Proximal (NISP)	Distal (NISP	Ratio	%Proximal
Tibia	43	51	1:1.2	45.7%
Humerus	38	76	2:1	33.3%

Table 5.2: Comparing Impacts of Density-Mediated Attrition Across Excavation Seasons and Depth

	2003 and 2005 Excavation Seasons (higher excavation depth)				2009 and 2010 Excavation Seasons (lower excavation depth)			
Element	Proximal	Distal	Ratio	%P	Proximal	Distal	Ratio	%P
Tibia	25	42	1:1.7	37.3%	18	9	2:1	66.7%
Humerus	17	44	1:2.6	27.9%	21	32	1:1.5	39.6%

Excavations from the River Terrace employed the same recovery methods, however because excavations were less extensive compared to the Upper Terrace, the overall faunal sample size is much smaller. The number of identifiable remains from the River Terrace totals only 1491 and includes animals that were identifiable to the species level as well as animals that could only be identified on the basis of class and body size (i.e., large, medium, and small mammal, fish, bird etc.). The small sample size, in particular for species level identification, inhibits the ability to perform similar accounts of taphonomic impacts as was completed for the Upper Terrace assemblage. For example, there are not enough proximal and distal tibia or humeri in the River Terrace faunal assemblage to compare the ratio of low and high-density elements as a measure of density-mediated attrition. However, there are some factors indicating a moderate to high degree of preservation for the faunal material from Kadebakele's River Terrace. Similar to the Upper Terrace faunal assemblage, the Early Historic faunal assemblage from the River Terrace contained a high number of species with delicate or low-density skeletal remains. In fact, fish make up a considerable proportion of taxa in the Early Historic faunal assemblage (see Chapter 7). The high recovery of low-density, and small fish remains (and other small bodied animals such as birds and herptiles) indicate that small and low density remains preserve well in Early Historic deposits and that the screening methods employed during River Terrace excavations were successful in recovering small and delicate bones. No instances of carnivore or rodent gnawing were observed on faunal remains from Early Historic deposits. While more methodologically robust estimates of taphonomic factors would be more ideal and yield higher confidence interpretations of the faunal data set, the fact that the sample size is small already constrains the type of inferences that can be made with confidence. The discussion of the Early Historic faunal data is thus ultimately preliminary, open to revision, and is offered as a basis for further designing research questions about Early Historic animal husbandry, diet, and human-animal relationships in South India.

5.4 Fauna Collection, Curation, and Lab Analysis

Screening occurred in field and all faunal remains collected in screens were placed in custom-made cloth bags. All artifact bags were labeled in the field with project and provenience information. This information was written on the bag itself, on a label placed inside of the bag, and was also listed and described on field forms. This was done in order to preserve provenience information for artifacts/fauna in case anything happened to external labeling on the bags and to use as a cross referencing system to catch labeling errors. Artifact bags/faunal remain bags were transported to the EHLTC lab, assigned an antiquities registration number and, in 2009-2010, were entered into the EHLTC database.

Because archaeological materials cannot be exported or removed from the country, faunal analysis was completed in the EHLTC field laboratory. Faunal analysis was conducted over multiple field seasons (2009, 2010, 2015, and 2017). Faunal remains were analyzed by the bag, with each bag containing duplicated provenience and context information. When possible, bags from the same context were analyzed at the same time. This was done in order to glue together broken bones when possible and to avoid over-counting elements (see further discussion of quantification methods below). All data was hand recorded on printed coding sheets. Photocopies of the data were made in the field and all data was subsequently entered into a digital excel file and imported into the final Kadebakele database. Data was also uploaded to the Digital Archaeological Record (tDAR), an online digital repository for archaeological data.[5]

5.5 Database Design and Analytical Categories

The database used for this analysis is largely similar to the database used in previous lab seasons at Kadebakele (see R. Bauer 2006:288-629). Database organization and coding was maintained in this analysis for the sake of maintaining consistency. However, there are some noted differences. The previous organization of the Kadebakele fauna database contained the following categories, provenience, animal class, order, family, genus, species, common name, sex, bone end (proximal, mid, distal), stage of bone fusion (fused, fusing, unfused), element classification, side (left or right), bone count, bone completeness, bone weight (in grams), and comments. The comments section of the database contained information not captured in the other categories, including notes about anomalies and abnormalities, questions, and clarifications concerning species designation. Additional notes appearing in the comments section included bone measurements, animal sex, the number of butchering marks as well as other forms of human modification (incising, drilling, etc.), tooth wear stage, degree and type of burning, and descriptions of rodent and carnivore gnawing evidence. Contextually, all of these variables are

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[5] http://www.tdar.org.

important in providing a robust analysis of animal use and human-animal relationships at Kadebakele. Over time, however, it became apparent that some of these variables should appear as their own column in the database so that data could be easily filtered, quantified, and compared across different excavation and chronological contexts. Thus, sex, tooth enamel wear stage, degree of burning, and butchering were added as individual columns in the Kadebakele database. The following sections elaborate on the information contained in the Kadebakele faunal database and how they provide evidence of past animal use practices in the past.

5.5.1 Species and Bone Identification

A large portion of the database is organized with respect to species identification and breaks down the identification using Linnaean taxonomic categories (class, order, family, genus, and species). Following the species identification, the database contains the common name in order to make the data more accessible and understandable to non-specialists. I made identifications using a combination of photographic and online references and comparative material housed in the field laboratory.[6]

The Kadebakele faunal assemblage is comprised of a mix of domesticated and wild taxa. The main wild taxonomic categories in the Kadebakele faunal database include birds, fish, snakes, frogs, lizards, turtles. In many instances, in particular with birds and fish, specimens lacked diagnostic features that would allow for a more precise species designation. As such, it was often only possible to account for these animals on the basis of size (i.e. small, medium, and

[6] Comparative skeletal collections available including a complete modern zebu obtained during the 2009 season, and goat remains obtained during the 2017 labs season. In addition, I was able to use archaeological specimens securely identified using the comparative collection from the Archaeozoology Laboratory of Deccan College Post-Graduate Research Institute as reference material. These included species of turtle, snakes, porcupine, frogs, lizards, among others. If I was unable to secure an identification for an element in the field, I photographed it and consulted other trained faunal specialists who had access to comparative collections.

large fish species).[7] Other wild animals accounted for in the Kadebakele faunal database include small wild mammals such as hares, mongoose, and porcupines, species which exhibit distinctive features allowing for their identification.

One of the greater challenges for species identification entailed distinguishing species across large and medium bodied wild and domesticated artiodactyls. Large artiodactyls present (or potentially present) in the Kadebakele faunal assemblage include large bovids and deer. The large bovid category includes domesticated zebu cattle (*Bos indicus*) and water buffalo (*Bubalus bubalis*) and endemic wild species the nilgai (*Bosephalus tragocamelus*) and gaur (*Bos gaurus*). Large deer includes the sambar (*Cervus unicolor*). Medium artiodactyls (wild) include the chital (*Axis axis*), blackbuck (*Antilope cericapra*), and the chinkara gazelle (*Gazella bennetii*). Domesticated medium artiodactyls primarily include sheep (*Ovis aries*) and goat (*Capra hircus*).

It is exceptionally difficult to distinguish gaur, zebu, and water buffalo using skeletal remains, especially archaeological remains (note, nilgai tend to be slenderer and bone morphology more similar to deer/antelope than zebu or water buffalo and, as a result, it is easier to determine if a post-cranial element is from a nilgai). Despite general differences in body size across the large bovids in South India (and the fact that not all of the aforementioned large bovids even belong to the same genus), there is little data available to indicate that bone morphology is distinct enough to reliably identify or distinguish them on the basis of skeletal remains. Specimen size is an unreliable diagnostic due to individual variation, variation between

[7] R. Bauer's (2006) was able to use reference material at the Deccan College Archaeozoology Lab. Because of the limited bird reference collection, she was only able to identify 11 specimens to species with 566 identified as "indeterminate bird". Because of this, it did not seem worthwhile to bring remaining bird specimens to Deccan College. Given the nature of the research questions organized in this dissertation, comparing the relative abundance of birds to other species was sufficient. Future research would benefit from securing identifications for birds and other wild species, especially since shifts in the availability of hunted birds could have implications for understanding environmental changes.

males and females, and variation across different age classes. Since the gaur is the largest bovid in the world, ranging 170-220 cm in shoulder height and 700-1000 kg (Castelló et al. 2016:624), comparative differences in specimen size could perhaps render gaur more easily identifiable. However, because male gaurs are considerably larger than females, a subadult male water buffalo or zebu could very well overlap in size with a younger female gaur. As a result, when recording identification and metric data for large bovids, I provided notes in the comments section when particular bones were noticeably larger or more robust than commonly encountered in the Kadebakele assemblage. I would then compare metrical data to R. Bauer's database (2006:632-640), which contained measurements for modern gaur, nilgai, zebu, and water buffalo specimens housed at the Field Museum of Natural History. Measurements from modern specimens at the Field Museum of Natural History come from an adult female nilgai (*Bosephalus tragocamelus*), advanced age (15 years old) female zebu (*Bos indicus*), a subadult water buffalo (*Bubalus bubalis*), and an indeterminate gaur (*Bos gaurus*). Due to the small sample size, and the fact that they come from animals that are different age and sex classes, these metrics ultimately cannot be used to definitively distinguish between gaur, zebu, and water buffalo. Nevertheless, I noted in the comments section whether these fell within the large measurement ranges of gaur and assigned the species as 'large bovid'. In doing so, I highlight specimens requiring further consideration should new diagnostic methods develop or should other lines of archaeological evidence prove suggestive of a more precise taxonomic identification.

Given the fact that wild mammals comprise such a small proportion of the Kadebakele assemblage,[8] the problem of securing identifications that distinguish between wild and

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[8] In R. Bauer (2006) wild mammals were 4% of the total Kadebakele assemblage and in Wilcox (2016) this increased to 10%. Of these percentages, large bovids are rare (n=2). The wild

domesticated bovids is perhaps inconsequential. Of greater consequence is the fact that domesticated water buffalo and zebu are nearly impossible to reliably distinguish. In mirroring the above discussion, although generally speaking water buffalo are larger than zebu (Castello 2016), there is considerable variation across individuals when it comes to size especially when one factors in differences between males and females and their respective sizes across different age classes. Body and bone size may also be impacted by castration practices (see discussion in Chapter 6). Because of the lack of distinguishing morphological features, and the overlap in body size, remains were often identified as belonging to either zebu or water buffalo and listed as "zebu/water buffalo" in the database. In the analysis, "zebu/water buffalo" are referred to more generally as "cattle." Measurable remains identified as "zebu/water buffalo" did not overlap with metrical size ranges for known wild bovid species (see R. Bauer 2006:632-640). As such, it is likely that wild bovid species are excluded from the assemblage identified as "zebu/water buffalo." Additional systematic research comparing larger and more diverse samples of zebu and water buffalo would aid in establishing criteria for differentiating between the two species and provide important insights into their differential use and their intersections with agricultural production. Given the data on dairy production gleaned from this analysis (see Chapter 6), determining whether or not water buffalo were increasingly incorporated into subsistence practices in South India would prove interesting as water buffalo milk has a high fat content (Mane 2015; Bacskei et al. 2020).

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mammal category mostly includes rabbit and other small mammalian taxa and deer (chital, blackbuck, sambar). This low percentage of wild mammals is consistent at other Iron Age sites (see Thomas 1984; Alur 1971; Clason 1975; Rami Reddy 1976; Nath 1968; Thomas 1993; Miracle 2005).

Distinguishing sheep from goats on the basis of archaeological remains can also prove difficult given their similarities in size and bone morphology. However, unlike bovid species, thorough systematic research has been conducted to isolate key diagnostic features that can be used to reliably distinguish sheep from goats. The most widely consulted publication on this is Boessneck's (1969) report. Boessneck identifies multiple diagnostic features that can be used to distinguish sheep and goats, however many of these do not survive intact in the archaeological record. While I relied upon Boessneck's text and drawings to distinguish sheep and goat remains, this was often limited to analysis of the first and second phalanges, the distal humerus, and the astragalus, as the differences in morphology in these elements was most clearly established and marked in the text and these were the mostly commonly occurring elements within the faunal assemblage. When no determination between the two could be made, the species identification was listed as "sheep/goat." Differences in the ratio of sheep to goats has important implications for understanding specific subsistence strategies and can also provide potential insights into environmental contexts and conditions.

In some cases, it was not possible to identify an element to species (or even family or order) due to fragmentation or missing diagnostic zones. When this happened, an element could only be identified by class and body size (i.e., small, medium, large mammal, small medium, large bird etc.). For elements that lack diagnostic zones entirely (ribs, vertebra, skull fragments) this was the only possible option for classification. Given the general patterning documented at Kadebakele, it is likely that large indeterminate mammal elements belong to cattle (zebu/water buffalo) and that medium indeterminate mammal remains belong to caprines (sheep/goat). Although most inferences will be drawn based on the identifiable (to species) remains, it is nonetheless important to consider the distribution of medium and large animal remains. This is particularly important when analyzing the distribution of skeletal parts. Since elements like ribs and vertebra cannot be identified to species, when one looks at the distribution of remains from cattle or caprines, it would appear that their ribs and spines were not deposited on site. Such a pattern would have clear implications for animal processing, however only because it ignores the presence of medium and large mammalian ribs and vertebra. Thus, even though there can be limitations to how precise an identification can be made on a taxonomic level, all possible information that can be gleaned from a specimen should be noted.

Field guides and animal bone atlases were referenced to secure the identification of a skeletal element, how complete it was, whether it was from the left or right side of the body, and which portion of the element was present (proximal, distal, middle). Element identification was recorded as specifically as possible. In some cases, only general categorical identifications could be assigned (skull, limb, rib, etc.). Skeleton categories are based on Zeder (1991) in which skeletal proportions are divided into head, axial, limb, and unidentifiable. Identifiable portions of the head include the skull (skull bones, maxilla,) horns and horn cores, mandible, petris temporal bones, and teeth. Identifiable portions of the axial skeleton include vertebra (atlas, axis, thoracic, cervical, lumbar, caudal), ribs, and the pelvis. Identifiable limb include forelimb (scapula, humerus, radius, ulna), hind limb (femur, tibia, fibula), and feet (metacarpals, metatarsals, phalanges, carpals, tarsals, sesamoids).

5.5.2. Metrical Data

All complete bones, and complete epiphyses were measured and recorded based on methods described by von den Driesch (1976). Although typically metrical data is considered useable only when it comes from fused elements, I took measurements for fused, fusing, and unfused elements for the sake of preserving the information for future applications.

Measurements were taken using EAGems IP67 Digital Calipers. Measurements were taken three times and then averaged together. The average is what is noted in the database.

As mentioned previously, there is preliminary data available indicating that metrical data can aid in distinguishing between large bovid species (R. Bauer 2006: 129-130). However, because of the limited sample size, it is unclear how well this technique accounts for individual variation. As such, this analysis does not attempt to definitively distinguish between zebu cattle and water buffalo, or other large bovids, on the basis of size or metrical data. Instead, as noted above, I made note of instances whereby a specimen appears distinctively large or robust and analyze that information with respect to other lines of archaeological evidence in order to provide some indication as to whether the specimen is likely to fall into one category or the other. Despite the fact that metrical data could not be used to definitively distinguish between large bovids, metrical data was nonetheless recorded for all complete bone and bone ends so that the data was preserved for use in future metrical based analyses, particularly in the event new advancements in the methods and techniques of metrical analysis develop. Metrical data were also noted because of their potential use in determining sex for certain species.

5.5.3. Sex Determination

Determining sex is difficult using faunal remains. This is primarily because the most reliable indicator of sex is the pubis, an area of the pelvis that, due to its fragility, does not often survive in the archaeological record. As a result, zooarchaeologists sometimes use metrical data in order to determine sex for sexually dimorphic species (Grigson 1982; Speth 1983; Thomas 1988; Higham 1968; Zeder 2001). By looking at patterns in size distribution of abundant elements, one can potentially determine if a population is skewed toward smaller bodied animals (likely to be female), or skewed toward larger bodied animals (likely to be male). Conversely, if a distribution is bimodal, then the data would indicate that both males and females are present in the population. In this analysis, metrical data was used to determine sex for sexually dimorphic domesticated species since this information is directly relevant to reconstructing animal husbandry and resource production practices. Specifically, patterns in the size distribution of the first phalanx and second phalanx in cattle and caprines were analyzed in order to establish sex ratios in domesticated herds. Metrical data was also recorded for wild species, however since the sample size of wild mammals was small, it was not possible to assess the distribution of bone size and analyze it with respect to body size and sex.

5.5.4 Tooth Wear Stage and Bone Fusion

When possible, tooth enamel wear stages were determined and recorded. In the field, tooth enamel wear stages were recorded using Grant's tooth wear stage system (1975). One advantage to Grant's system is that she has developed a key that can be used for cattle, caprines, and pigs. In addition, Payne's illustrations are schematic while Grant provides a more realistic representation of tooth wear stages (Greenfield and Arnold 2008: 838). Ultimately, under Grant's system, age data is presented in terms of a frequency diagram. Here, I wanted to reconstruct survivorship curves that could be closely compared to the data derived from Payne's (1973) market model for specialized production of caprine resources. To do this, I converted R. Bauer's (2006) recordings of tooth enamel wear, which used Grant's system, to Payne's system using the procedure outlined in Hambleton (1999:64-67) (see also Allentuck and Greenfield 2010). Because I made molds of caprine mandibles and teeth for dental microwear analysis, I was able to recode those teeth using Payne's system.

Stages of epiphyseal bone fusion were also recorded during faunal analysis. Ages based on bone fusion rates were carefully considered against established research. Many zooarchaeological analyses have used Silver (1969) as a guide using bone fusion stages to determine animal age. However, in light of updated research, I evaluated bone fusion in caprines using Zeder (2006). Fusion schedules for cattle and pigs were organized based on a combination of data presented by Reitz and Wing (2008), Chaplin (1971), Noddle (1984) and Silver (1969).

Age data from tooth wear and fusion rates were used to generate slaughter profiles to be considered against zooarchaeological subsistence models. It is important to note, however, that these measures of age are not equal in terms of the information they provide. Tooth wear stages are useful in that they can provide the age, or age range, of an animal when it died (Payne 1973). Fusion rates, however, can only indicate that an animal survived to a certain age. For example, if a lower M1 exhibits wear consistent with Payne's letter H classification (Payne, 1973), then we can say that this animal likely died between 6 and 8 years old. However, if a cattle distal femur that has been fused is present, the most we can say is that this animal survived until at least 42-48 months (although it may be older). However, if the distal femur was unfused, then we could determine that the cattle was younger than 42-48 months old. Thus, although fusion rates do not provide the best measure of absolute age, it can provide information on relative age and be especially useful when used in combination with absolute age data available from tooth wear data.

5.5.5 Burning and Butcher Marks

Evidence of animal processing and preparation was documented primarily on the basis of butchering and burning evidence. Butchery marks were counted and recorded in the "Butchery Marks" column in the database. I noted in the comments section where marks appeared on the bone and took photos of bones exhibiting butchery marks. Butchery marks can provide information on how animals were dismembered and processed, including if there appears to be standardized practices related to animal processing (e.g. Zeder 1991). Specific patterns in cut marks left on bones can indicate if animals were processed for long distance transport, processed on site, or if they were skinned for their hides. Despite the potential of butchering to inform a variety of different practices and behaviors, it is also the case that animal processing/butchery may not necessarily leave any markings on the bone. In fact, in the event that highly skilled butchers are responsible for processing animals, it is likely that they would not nick the bone or leave marks. That is to the say that while the presence of butchery marks can indeed provide key information, a lack of marks present on faunal remains does not imply that animals were not deliberately or skillfully processed.

In addition to butchery, I also recorded if, and to what degree, elements were exposed to heat. For the sake of consistency, I followed the same coding system for burning as is presented in R. Bauer (2006). Generally speaking, bones that were exposed to heat in the Kadebakele faunal assemblage fall into three distinct categories. Burned bones were identified as either being carbonized (black), calcined (white/chalky), or partially charred. Differences in the appearance of burned bone likely relate to the range of temperatures to which it was exposed (Shipman et al. 1984). Black bones, or carbonized bones, are bones that were likely exposed to heat ranging from 550-650 degrees Celsius while calcined bones were likely exposed to temperatures exceeding 650 degrees Celsius (based on David 1990, adopted by R. Bauer 2006).

Although arguably burn color/classification may reflect temperature exposure, the challenge in using burn data from faunal remains is that heat exposure can result from multiple factors. That is to say, it is not necessarily the case that bone burning resulted from cooking practices. As such, some argue that assessments of burn data provide little promising information, at least as a proxy for cooking and food preparation (Zeder 1991). For example, it is difficult to decipher whether bones were burned intentionally or unintentionally, whether they were cooked in hearths, burned for fuel, burned for trash or if they just so happened to have been incorporated into larger intentional or unintentional fires unrelated to cooking (i.e., brush fires and land clearing, or post-depositional burning (James 1989; summarized in R. Bauer 2006: 217-222). Using burn data to reconstruct past activities (cooking or not) is also challenging when we consider the fact that burned remains are more likely to be damaged and fragmented than unburned bones, and thus difficult to identify in any meaningful way with respect to species or skeletal portion.

Evidence of partial charring, however, is one form of burning that does provide more direct insight into cooking practices. Partial charring occurs as meat is roasted on the bone. This will produce bones bearing different colors depending on where meat was attached. Bare portions of the bone will appear black while areas where meat was attached will appear lighter due to differences in heat exposure while roasting (Gifford-Gonzalez 1989; Buikstra and Swegle 1989). Patterns in burned bones were contextualized with excavation and feature information in order to best determine whether burn marks resulted from cooking or non-cooking activities.

5.5.6 Presence of Bone Pathologies

Evidence of bone pathologies on animals in the Kadebakele faunal assemblage was also recorded in the comments section in the faunal database. Identifying bone pathologies is an important line of evidence for reconstructing subsistence activities especially when it comes to the use of animals for traction labor. Bone pathologies related to traction labor have been previously identified in the Kadebakele faunal assemblage, as well as in other sites in South India (R. Bauer 2006; Alur 1968; 1971). Not only can bone pathologies provide key information on the intersections of animal use and agricultural production, they also provide insight into perceptions of animal health and practices of care which can be incorporated into more nuanced discussions of human-animal relationships and broaden conceptualizations of animals in ways that go beyond economic production.

5.6 Quantification Methods

There are a variety of quantitative approaches to estimating species abundance in zooarchaeological analyses. In my analysis, I used raw counts or NISP (number of identified specimens), to examine relative abundance of species within the site. The use of NISP requires a number of assumptions and has been rightly criticized when used in inappropriate contexts (see Grayson 1984; Chase and Hagaman 1989; Ringrose 1993; and Lyman 1994). Grayson (1984) argues that NISP does not provide a robust measure of abundance since it calculates the maximum number of animals without addressing how this value may relate to the actual abundance of taxa in a population. In addition, Chase and Hagaman (1989) argue NISP is a biased estimate for actual species abundance because there are differences in the recovery rates of elements, the number of skeletal parts, and the degree of fragmentation across different taxa. In other words, NISP tends to over-represent taxa that have more bones than others. Moreover, its usage results in the problematic interpretation that 200 bone fragments represent 200 individuals as opposed to a single animal (Chase and Hagaman 1989, Ringrose 1993).

In order to remedy the problem of over-representation, MNI (minimum number of individuals) is an alternative measure used to provide an estimate of abundance within a given sample. MNI is defined as, "the smallest number of individuals that is necessary to account for all of the skeletal elements (specimens) of a particular species found in the site," (Shotwell, 1958:272). Using this measure, a single right femur and a single left femur from the same species is calculated as one specimen since hypothetically a right and left femur could come from a single animal. If an analyst identifies two right femurs, the listed count will be two because at least two animals would have to present in the sample. Although MNI may be a more conservative estimate compared to NISP, it is not useful when trying to calculate species estimates for comparative purposes (Grayson 1984:92-94). While NISP can be an inaccurate estimate of actual species abundance, if sample sizes are large enough and sampling biases are accounted for in a particular archaeological context, NISP can be an accurate estimate of relative abundance in the archaeological sample and patterns in the data are more likely to be explained by spatial and temporal variation in subsistence strategies and tactics used by inhabitants (Zeder 1991:88, Redding 2006).

5.7 Chapter Summary

In this chapter, I described how the Kadebakele faunal assemblage was recovered, curated, and analyzed. I reviewed in detail the key data points documented in the Kadebakele database and how the database has been managed and preserved for future research. I also detailed the degree to which taphonomic processes impacted the faunal assemblages from Kadebakele and thus the confidence that can be placed in the interpretations of faunal patterns at the site. In the following two chapters, I link faunal data and the subsistence and risk aversion models described in Chapter 2. Chapter 6 discusses the Neolithic and Iron Age faunal assemblages while Chapter 7 discusses the Early Historic faunal assemblage. Following the presentation of faunal results, I discuss the dental microwear methodology and results in Chapter 8 and discuss how the two data sets cohere to produce a broader narrative about animal husbandry and the impacts of livestock grazing throughout these periods. The relational ontologies aspect of this research is addressed in the conclusion of this dissertation (Chapter 9) once the results of both data sets (faunal and dental microwear) have been presented.

CHAPTER 6 :
NEOLITHIC AND IRON AGE FAUNAL ANALYSIS RESULTS

6.1 Introduction

In this chapter, I present the data and analysis of faunal remains from Neolithic and Iron Age contexts from Kadebakele's Upper Terrace. As discussed in Chapter 4, the Neolithic excavation data is more limited than the Iron Age and is limited to the last few centuries of the South Indian Neolithic period (ca. 1500-1200 BCE). In addition, the faunal sample size is also small. Analysis of the Neolithic faunal data thus contains the primary species and taxonomic groups comprising the assemblage, what animal resources were the focus of production and consumption, and what continuities and changes were observed between the Late Neolithic and Iron Age faunal assemblages. For the Iron Age, analysis includes reconstructing subsistence practices as well as how animals were a part of feasting and ritual activities at Kadebakele. Evidence from the Neolithic and Iron Age faunal assemblages will be used to set up questions concerning how diet, animal husbandry, and human-animal relationships may have changed (or been maintained) into the Early Historic period.

Given our current understandings of shifts in social, political, and economic organization, especially between the Iron Age and the Early Historic period, there is reason to predict that husbandry and animal resource production changed in order to support a larger and possibly more urbanized settlement organization. A comparative analysis that addresses continuities and changes in production, consumption, and the symbolic or ritual treatment of animals across pre and early historic contexts is well-equipped to reconstruct roles animals and human-animal relationships played in the sociopolitical transformations that characterize the Neolithic, Iron Age, and Early Historic periods in South India.

6.2 Neolithic

6.2.1 Description of Faunal Sample

Excavation procedures were adopted that helped safeguard against sampling and recovery biases in the faunal remains and other artifacts. Such procedures, however, were time consuming and limited the ability to carry out extensive horizontal excavations for earlier periods of occupation at Kadebakele. As a result of the limited nature of Neolithic excavations at Kadebakele, the Neolithic faunal sample is the smallest of the three occupation periods analyzed. The total number of identified specimens (NISP) from Neolithic deposits totals only 39. The low NISP from Neolithic levels is in part due to a lack of complete bones with diagnostic features that would enable identification to the level of species. For example, the Neolithic assemblage contains numerous long bone shafts and skull fragments from both large and medium sized mammals. These are likely to be from cattle and caprines, respectively, however without diagnostic end zones it is best to err on the side of conservative identification. The lack of bone ends also made it difficult to assess density-mediated attrition on the Neolithic assemblage; however the assessment of taphonomic impacts on lower levels excavated from Kadebakele was considered in Chapter 5, demonstrating that the impact of density-mediated attrition decreased with excavation depth. As a result, it is assumed that density-mediated attrition did not impact the Neolithic assemblage. However, the fact that we cannot compare the recovery of less dense to more dense bone ends because they are absent altogether complicates and analysis of the taphonomy of Neolithic faunal remains. Ultimately, the low recovery of diagnostic ends significantly limits the kind of analysis that can be completed. Below, I review the data that we do have from Neolithic deposits at Kadebakele so that at least on a preliminary basis broad similarities and differences can be considered between the Neolithic, Iron Age, and Early

Historic faunal assemblages.

6.2.2 Relative Abundance of Taxa

In the Neolithic faunal assemblage, domesticates dominate the total sample compared to wild species, with domesticates comprising 79.4% compared to wild animals (20.5%) (see Table 6.1). Cattle make up a larger proportion of domesticates compared to caprines (67.7%) and represent over half of the total Neolithic faunal assemblage (53.8%). Caprines, by contrast, make up 32.3% of domesticates and about quarter of the Neolithic species profile (25.6%). Of the wild taxa (20.6% of the total assemblage), wild mammals make up 7.7% of the total proportion, while wild non-mammalian taxa account for 12.8%.

Table 6.1: Neolithic Species Frequency by NISP and Proportion of Identifiable Specimen

Taxa	NISP	Proportion	Weight (g)
Mammals			
Cattle	21	53.8%	83.6
Caprines[a]	10	25.6%	32.6
Wild Mammals	3	7.7%	2.2
Non-mammals			
Birds	0	0%	0
Fish	5	12.8%	.7
Herptiles	0		0
Wild Non-mammals	5	12.8%	.7
Wild Mammals	3	7.7%	2.2
Domesticated Mammals	31	79.4%	116.2
Total NISP	39		119.1

Note[a]. Caprines includes both sheep and goat with one specimen that was identified to species as a goat (*Hircus capra*). The wild mammal category includes Cervidae and Bovidae species as well as smaller carnivores and rodents. From the wild mammals in the Neolithic assemblage only *Lepus nigricollis* (Indian hare) was identified to species.

As discussed in Chapter 5, reliable use of NISP and relative abundance depends upon having a large sample size. Because this condition is not satisfied, it is difficult to draw meaningful inferences from the Neolithic faunal sample, especially in terms of proportional representation. There are, however, some ways the data can be viewed that lend additional corroboration to the fact that domesticates comprise at least a larger proportion of the species profile during the Neolithic occupation at Kadebakele. Within the Neolithic faunal sample at Kadebakele, identifiable large mammals include cattle, while identifiable medium size mammals include caprines (no wild large or medium-sized animals were identified). Of the small-sized mammals, the Indian hare was identified in the faunal assemblage. In other words, identifiable large and medium sized mammals only included domesticates, while small identifiable mammals included wild mammals. From this, it is not unreasonable to assume that the unidentifiable large mammal bones (N=146) are mostly cattle, the unidentifiable medium mammal bones are mostly caprines (N=146), and the unidentifiable small mammal bones belong to wild species such as the Indian hare.[1]

Table 6.2: Frequency of Mammals by Body Size Category in NISP and Proportion

Body Size Category	NISP	Proportion	Weight (g)
Large Mammal	146	49.3%	257.8
Medium Mammal	146	49.3%	78.4
Small Mammal	4	1.4%	2.3

If these categories are combined, the data changes in two main ways. First, the small number of wild taxa (both mammalian and non-mammalian) does not skew the relative abundance estimates as dramatically. Secondly, when incorporating the unidentifiable medium and large mammal counts into the cattle and caprine raw counts, cattle shift from outnumbering caprines by a ratio of 2:1 to being nearly equal to the proportion of caprines. In the new totals, cattle would account for 49.9% of the sample while caprines would comprise 46.6%. As such,

[1] In fact, it is not uncommon for zooarchaeological analyses to combine unidentifiable large and medium mammal with cattle and caprine counts in cases where recovery strategies impact sample size, or to at least take into account the frequency of large and medium sized mammalian faunal remains alongside species frequencies (see for example Zeder 1991; Chase 2007).

domesticates shift from comprising 79.4% of the total assemblage to 96.5% when unidentifiable medium and large mammals are included in the raw counts. In both cases, thus, during the Neolithic wild taxa are not represented in the large proportions that have and continue to be documented during the Iron Age at Kadebakele.

Table 6.3: Combining Species and Mammal Counts

Body Size Category	NISP	Proportion
Cattle/Large Mammal	167	49.9%
Caprines/Medium Mammal	156	46.6%
Small Mammal	7	2.1%
Wild Non-mammals	5	1.5%

Combining unidentifiable mammalian remains with identifiable specimens introduces more assumptions, and thus reduces the certainty/resolution in estimating relative abundance. Worth noting, however, is the low number of non-mammalian wild species, including fish, bird, and herptiles. Fish and bird bones, in particular, are distinctive from mammals and are unlikely to be misidentified or deemed unidentifiable. Thus, while exact estimates of the proportion of domesticates to wild animals, including non-mammalian wild taxa, may be difficult to ascertain because of the limited excavation extent and overall small sample size, it seems likely that domesticates would have made up at least a larger proportion (more than half) of the species profile. In the Early Historic sample (see Chapter 7), there is similarly a more limited excavation area and small faunal sample size, however the non-mammalian wild taxa are well represented in that case. It is perhaps reasonable to preliminarily suggest that the lower proportion of non-mammalian wild taxa relative to domesticates approximates what dietary and subsistence behavior looked like during the Neolithic period at Kadebakele and that it differs compared to the Iron Age. However, for reasons that are at present unclear, it could also be that this particular area of excavation does not best capture what day to day dietary procurement and consumption looked like during the Neolithic occupation at Kadebakele.

6.2.3 Herd Composition (Mortality, Sex Ratios, and Bone Pathologies)

The size of the Neolithic faunal sample is not adequate for generating survivorship curves or for drawing inferences about herd composition and subsistence practices across domesticated animals. Fusion determinations were made for only 7 specimens (3 cattle, 3 caprines, 1 goat). In this case, pooling the cattle and caprine data with large and medium mammal data does not work to expand the sample size for preliminary interpretations. This is because the areas of bones that yield fusion data (epiphyses) tend to be diagnostic for species. In other words, fused and unfused bone ends are less likely to be included in the unidentifiable medium and large mammal counts because those are precisely the areas of bones used to make species determinations. A lack of diagnostic bone ends is usually what renders long bones unidentifiable across medium and large bodied mammals.

In addition to the lack of fusion data from the Neolithic faunal sample, no complete teeth were recovered for either caprines or cattle. Tooth fragments were recovered, including one deciduous cattle premolar (a juvenile animal). However, tooth wear stages and their age correlates cannot be determined for fragmented or incomplete teeth. The small faunal sample size also proved problematic for sex determinations for the sake of reconstructing herd composition. Only one animal of the identified domesticates was identified as female while all others were indeterminate. This was a sheep/goat from level 4 (Cal 1410 BCE-1200BCE), the latest level from the Neolithic phasing in Block B.

While there is limited age and sex data for domesticated animals from the Neolithic faunal assemblage, and thus limitations to drawing inferences concerning their roles in the Neolithic subsistence economy, there is evidence that cattle were reared and used for traction. A single cattle third phalanx exhibiting traction related pathological signatures was recovered from the Neolithic deposits at Kadebakele. This indicates that cattle were used for agricultural labor early in prehistory and is consistent with faunal evidence from other Neolithic sites in the region (Alur 1968; 1971). Although the Neolithic sample from Kadebakele is small, having this point of consistency in the Kadebakele assemblage is important, even if we are unable to glean the scale in which cattle were used for traction labor during this period.

6.2.4 Skeletal Part Representation

Analysis of the representation of skeletal parts is again burdened by the small sample size of the Neolithic faunal assemblage. Analysis of skeletal part distribution where NISP counts are under 25 are omitted from this analysis in order to ensure reliable interpretations and is a point of consistency with prior faunal analysis from Kadebakele (see R. Bauer 2007: 201-209). This unfortunately impacts skeletal distribution analyses for cattle (N=21) and caprines (N=10). While the small NISP values prohibit an analysis on the basis of identifiable remains for cattle and caprines, by combining the skeletal part data from cattle and caprines with medium and large mammal body part counts, we are able to at least compare whether or not there are differences in the way “medium” sized and “large” sized mammals were processed and discarded. This offers a low-resolution analysis; however, the underlying assumption is that unidentifiable medium mammal bones likely belong to caprines while unidentifiable large mammal bones likely belong to cattle. Small mammals, both identifiable and unidentifiable, even when combined do not allow for further analysis, neither does consideration of wild non-mammalian taxonomic groups.

When cattle and caprine-sized animals are compared by proportion of skeletal parts, there appears to be a difference in the distribution in remains within the Neolithic assemblage. For the skull, for example, cattle-sized animals are represented twice as much as caprines (54.9%

compared to 29.7%). By contrast, caprine-sized animals have a higher representation of limb compared to cattle-sized animals (40% compared to 25.3%).

The standard proportion of cattle and caprine remains (head 34%, axial 35%, and limb 31%) reflects the percentage we would expect to find in the archaeological assemblage if the animal[2] was processed and disposed of on site (Zeder 1991:96). When compared against the standard proportions, proportional values based on the distribution of caprine remains suggest that they were indeed processed and disposed of on site. There is a slight over-representation of limbs in the caprine-sized animal category (40% for Kadebakele caprine-sized animals versus 31% for a standard animal), however the consistency across head, axial, and limb does not support an interpretation that meat cuts from limb bones were being specially supplied or provisioned to Kadebakele residents. Given broader understandings of Neolithic social and subsistence organization, evidence of specialized provisioning was not expected.

Skull remains for cattle-sized animals are not only over-represented compared to caprine-sized animals, suggesting a difference in how the two are processed, but are also over-represented compared to the standard animal. Axial and limb elements for cattle-sized animals are both under-represented compared to what we would expect if the complete skeleton was deposited. At its most basic premise, an over-representation of non-meat bearing bones (e.g., head, vertebra, feet) compared to meat-bearing bones (e.g., long bones, hind limbs and forelimbs) is viewed as an indication that carcasses were butchered and processed in such a way that butchery waste (non-meat bearing bones) were discarded while meat-rich elements were either supplied or consumed elsewhere (Crabtree 1990; Uerpemann 1973; Zeder 1991). Such an interpretation can be bolstered by comparing the distribution of remains to other areas of a site

[2] These values are based on skeletons from the Bovidae family

(or to other local sites in the case of an increasingly specialized system of provisioning in a more urbanized context), as well as to tool-use and butchery evidence. Here, because Neolithic deposits are limited to this one area of the site, there is a lack of that kind of corroborative data. Moreover, butchery marks were uncommon in the Neolithic faunal assemblage across both cattle and caprine-sized animals.

In this context, it is difficult to explain why axial elements (non-meat bearing bones) would also be under-represented if the skeletal proportions reflected butchery waste. One detail that could account for the discrepancy in representation between the different skeletal part categories is the fact that tooth and mandible fragments can be more easily identified compared to fragmented axial elements such as vertebrae. In other words, broken teeth are more easily identified as either cattle or large mammal cranial elements whilst broken vertebral and other axial remains are more likely to have indeterminate designations. However, this would also be the case for caprines and indeed, all 45 elements from the medium mammal category are tooth remains. Thus, that over-representation of cranial remains occurs for cattle-sized animals and not for caprine-sized animals appears to reflect variability in the way animals were processed and/or deposited within this particular context. However, it is not yet clear how to reconcile the over-representation of cranial elements and the under-representation of both axial and limb remains in cattle-sized animals.

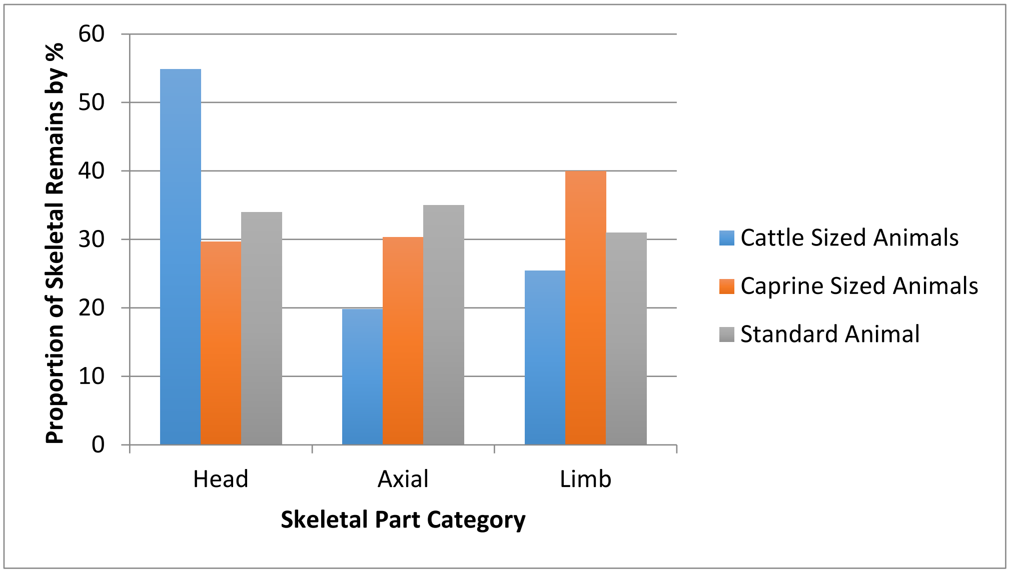

Figure 6.1: Relative Proportion of Kadebakele Cattle-Sized and Caprine-Sized Remains Compared to Standard Animal (Neolithic Kadebakele)

Table 6.4: Neolithic Skeletal Part[a] Distribution by NISP Value and Percentage

	Head	Axial	Limb	Feet	Limb & Feet
Cattle					
NISP	15	0	1	5	6
%NISP	(71.4%)		(4.8%)	(23.8%)	(28.6%)
Caprines					
NISP	1	2	3	3	6
%NISP	(11.1%)	(22.2%)	(33.3%)	(33.3%)	(66.7%)
Large Mammals					
NISP	74	32	33	2	35
%NISP	(52.5%)	(22.7%)	(23.4%)	(1.4%)	(24.8%)
Caprine Size Animals					
NISP	46	47	59	3	62
%NISP	(29.7%)	(30.3%)	(38%)	(1.94%)	(40%)

Note[a]: Head category includes skull, horns and horn cores, teeth, mandibles, maxilla, petrous temporal. Axial includes vertebra, ribs, and pelvis, limb includes forelimbs such as the scapula, humerus, radius, ulna and hind limbs such as femur, tibia, and fibular. Feet includes metapodials, phalanges, carpals, tarsals, sesamoids, astragali, and calcaneum.

6.2.5 Key Findings

In broad strokes, patterns of animal use at Kadebakele during the Neolithic occupation are consistent with patterns observed at other Neolithic sites (Alur 1971; Thomas 1989; Venkatasubbaiah et al. 1992; Pal and Talukder 2009; Roberts et al. 2016). The species profile consists of a mix of domesticated cattle (likely zebu and water buffalo although no elements were identified definitively as either)[3] as well as caprines (sheep and goats, with one goat definitively identified). In addition, locally available wild taxa, including hare and fish, are also present in Neolithic deposits. Thus, as has been presented in previous research on Neolithic sites in South India, Kadebakele inhabitants engaged in both hunting and herding activities to meet their dietary needs.

Given the small sample size, it is difficult to use traditional zooarchaeological models in order to draw conclusions about specific subsistence strategies, particularly in regard to domesticated herd animals. However, it is worth noting that all of the recovered elements from the Neolithic assemblage were fused, an indication that animals were not intentionally slaughtered at young ages. The presence of older domesticates suggests they were primarily used for secondary products (likely dairy and labor) as opposed to meat. The presence of traction injuries in one cattle third phalanx shows consistency with previous reports from other Neolithic sites in the region (Alur 1968; 1971) and suggests that cattle were used for labor. As such, the Kadebakele Neolithic faunal assemblage confirms the use of animals for agricultural activities. As I discuss below, this continues into the Iron Age at Kadebakele.

When it comes to hunting, non-mammalian wild taxa were less common compared to the preliminary data available on Iron Age hunting from Kadebakele (R. Bauer 2006; Wilcox 2016

[3] Due to the lack of complete bones and bone ends, little metrical data is available for determining whether wild aurochs were present.

and below). This is also the case when the Neolithic fauna is compared to the updated faunal analysis from the Iron Age (see further discussion below). While non-mammalian wild taxa do not make up a sizeable proportion of faunal assemblages at other South Indian Neolithic sites, it is likely that the lack of systematic screening accounts for the low recovery of delicate fish, bird, and herptile bones (but see Roberts et al. 2016 who attribute the lack of these taxa at Sanganakallu to distance from river sources). Given that all of the excavated levels dating to the Neolithic were screened, low recovery of these remains is either a reflection of different dietary and subsistence practices, or due to the more limited excavation extent and potential, a context not representative of the full scope of subsistence procurement and consumption practices. It is possible, for example, that during the Neolithic, the Block B area was also utilized differently than during the Iron Age and that the area does not contain dwelling refuse. In fact, there is some evidence to suggest differential use of Block B in the earlier phase of the Iron Age as well. However, the presence of surface construction throughout the Neolithic strata suggests at least some continuity in the way the space was used. For example, between the Neolithic and the Iron Age, Block B appears to have been deliberately and carefully maintained in such a way as to reflect more sedentary settlement (Morrison et al. 2009; Sinopoli et al. 2010).

In addition, evidence of burned remains from Neolithic deposits suggests that this was an area where some cooking took place. A majority (74.6%) of the faunal remains were not subjected to heat or did not exhibit evidence of burning (Table 6.5). However, of the remains that were burned, most were partially charred or roasted, a clear indication that cooking occurred here, or that remains subjected to this cooking method were discarded here. The presence of carbonized remains is less definitive, but could similarly reflect domestic activities such as throwing remains into hearths for fuel or to reduce the scent of trash remains that would otherwise attract scavengers (Gifford-Gonzales 1989:187).

Table 6.5: Burned Bone Counts Across Species and Class

	Burned	Unburned	Calcined	Carbonized	Roasted
Mammals					
Cattle	0	0	0	0	0
Caprines	3 (30%)	7 (70%)	0	2 (20%)	1(10%)
Wild Mammals	1 (25%)	3 (75%)	0	0	1 (25%)
Large Mammals	33 (22.6%)	113 (77.4%)	0	7 (4.8%)	26 (17.8%)
Medium Mammals	40 (27.4%)	103 (72.6%)	0	15 (10.3%)	25 (17.1%)
Small Mammals	1 (25%)	3 (75%)	0	0	1 (25%)
Total Mammals	78 (25.4%)	229 (74.6%)	0	24 (7.8%)	54 (17.6%)
Non-Mammals					
Birds	0	0	0	0	0
Fish	0	5(100%)	0	0	0
Herptiles	0	0	0	0	0

6.3 Iron Age

6.3.1 Sample Description

The Iron Age faunal sample is the largest of the chronological periods compared in this analysis. It includes 92,930 faunal remains recovered from Iron Age deposits on Kadebakele's Upper Terrace. As discussed in Chapter 5, the assemblage overall is well preserved having some evidence of density mediated attrition, but little size-bias. In addition, carnivore and rodent gnawing was rarely documented. Deposits with a higher degree of burning were more highly fragmented as is to be expected. Based on the large sample size, inferences are the most reliable for the Iron Age sample compared to the much smaller Neolithic and Early Historic samples.

6.3.2 Relative Abundance of Taxa

When it comes to Iron Age zooarchaeological findings, Kadebakele is notable compared to other Iron Age sites because of the diversity of species represented, in particular the abundance of non-mammalian taxa (R. Bauer 2006). Non-mammalian taxa at Kadebakele consist of riverine fauna, likely sourced from the nearby Tungabhadra River. The lack of non-mammalian taxa at other Iron Age sites in the region may be attributable to differences in recovery methods (less screening at other sites and thus a lower recovery rate of small-boned taxa such as fish or birds). However, there is data to suggest that some Iron Age sites do not exhibit this same pattern in species distribution even where more systematic screening was employed. At Sanganakallu, for example, fish and bird taxa are represented in smaller proportions relative to domesticates, as well as relative to the species profile that has previously been reported from Kadebakele (Roberts et al. 2016). Roberts et al. (2016) suggest that this difference in representation of non-mammalian taxa is due to the fact that Sanganakallu is located further away from a river source.

Completed faunal analysis from Kadebakele has affirmed the importance of non-mammalian taxa to the diet and subsistence practices throughout the full sequence of the Iron Age occupation of the Upper Terrace. Based on NISP, non-mammalian taxa (e.g., birds, fish, reptiles, amphibians) comprise nearly 40% of the total Iron Age assemblage at Kadebakele. Birds dominate the non-mammalian taxa (44.2%), while fish and herptiles are almost equally represented (29.3% and 26.4% respectively). Out of the total Iron Age assemblage, birds form 17.5% of the total assemblage and are followed by fish at 11.7% and herptiles 10.5%. In this analysis, herptiles include various species of snakes, frogs, lizards, and turtles.[4] Turtles, in particular soft-shell turtles, are the most commonly occurring taxa across the "herptile" category

[4] Species include trinket snake, Indian monitor lizard, skink, Indian tent turtle, Deccan soft-shell turtle, and indeterminate frog/toad.

(n=285) and constitute 7.3% of the identifiable faunal assemblage (more than all of the wild mammals combined).

Domesticates identified in the Kadebakele assemblage include cattle (zebu cattle and water buffalo), caprines (goats and sheep), and a small number of horses (n=3). As a combined group, domesticates form 55.8% of the total Iron Age faunal assemblage at Kadebakele. Cattle make up the largest proportion of the "domesticates" category (64.7%). Cattle also make up the largest proportion of the total faunal sample at 35.7%. Caprines are second to cattle when calculated out of the total number of domesticates (34.6%). Horses are also counted among domesticates. However, with only 3 specimens identified as horse they ultimately make up a very minor proportion of domesticates and of the total Iron Age assemblage.

While a large majority of the caprine bones could only be identified as belonging to either sheep or goat ("sheep/goat" or also referred to as caprines here), instances where it was possible to secure a lower taxonomic identification show a heavy bias for goats over sheep. In NISP, 695 elements were identified as "sheep/goat," one was identified as sheep, and the remaining 124 elements were identified as goat. This has implications for further interpreting the specific subsistence practices employed during the Iron Age and is discussed in further detail below.

The "sheep/goat" category is of further interest because although they make up 36.4% of domesticates, out of the total faunal assemblage caprines only comprise 19.2%. This is notable because at 19.2%, caprines are almost as equally represented as non-mammalian taxonomic groups like birds (17.5%) and are outnumbered by the non-mammalian wild taxa category altogether (39.6% for non-mammalian taxa compared to 19% caprines). Thus, while domesticates as a broader category constitute a larger proportion of the total faunal assemblage compared to hunted non-mammalian taxa (54.6% compared to 39.6%) the fact that particular wild taxa like birds are nearly equally represented as caprines serves as an indication of the importance of hunting alongside herding and husbandry and is an affirmation of species diversity within the faunal record at Kadebakele during the Iron Age.

Hunting was not limited to non-mammalian taxa as wild mammals also make up the species profile at Kadebakele. Wild mammals make up 5.5% of the total faunal sample. The wild mammal class includes herbivorous and carnivorous animals, such as gazelle, nilgai, antelope, hare, blackbuck, chital, and sambar on the one hand, and dog[5] and leopard/panther on the other. Carnivorous species are rarer across the wild mammal class (n=14 or .4%). The domestication status of pigs identified in the Iron Age assemblage is in question, however most of the available data from Kadebakele at least preliminarily indicates that during the Iron Age pigs were wild (see further discussion below). As a result, pigs are included in counts of "wild mammals" and not "domesticates". Pigs (n=74) make up 34% of the wild mammal category and 1.9% of the total Iron Age assemblage. [6]

These calculations taken together, wild animals comprise nearly half (45.2%) of the Iron Age assemblage at Kadebakele, while domesticates (cattle, caprines, and a small number of horses) comprise the other half (54.8%). Wild taxa could have been actively hunted or perhaps

[5] It is unclear whether dog remains from Kadebakele are wild or domestic

[6] The ambiguity regarding the domestication status of pigs is not a problem limited to Kadebakele. The questionable domestication status of pigs is also discussed with respect to Indus archaeology (Chase 2007). Pigs are complicated as a mammalian class compared to cattle and caprines because of the more fluid ways in which pigs can revert feral status. Tracking pig herd management strategies without definitive information on when pig domestication occurred within a particular regional and temporal context is therefore complicated. Importantly, pigs occur in low frequencies in the Kadebakele assemblage and thus their inclusion into the wild versus domesticate group does not greatly impact the total calculations. Their low relative abundance, however, in part contributes to the preliminary interpretation that they are wild pigs procured through hunting.

opportunistically captured while other activities were carried out (e.g., grazing animals, working agricultural fields, or while procuring other resources). Ultimately, both hunting and herding were important in the overall subsistence regime at Kadebakele. This is corroborated when bone weight and bone weight proportion are considered alongside NISP. Unsurprisingly, when element weight from each species category is compared, cattle dominate, making up 86% of the faunal assemblage. Caprines make up 7.3% on the basis of bone weight, reinforcing the importance of cattle relative to caprines and other animals. Impressively, while caprines make up 7.3% of the assemblage on the basis of bone weight, small-bodied non-mammalian taxa make up nearly half of this amount at 3.2%. While these figures do not exactly match the NISP proportional make up (recall that on the basis of NISP birds and caprines are almost equally represented), that the weight of fish and bird bones can approximate almost half of the caprine bone weight signals that non-mammalian taxa were an important subsistence resource during the Iron Age.

Table 6.6: Distribution of Species and Taxa Groups at Iron Age Kadebakele				
Taxa	**NISP**	**%NISP**	**Weight (g)**	**Weight %**
Domesticates				
Cattle	1393	35.7	19879	86
Sheep/Goat[a]	742	19	1679	7.3
Goat	124	5.8		
Sheep	1	.01		
Horse	3	0.1	43.9	0.2
Total	2138	54.8	21601.9	93.5
Wild Mammals				
Pigs	74	1.9	117.4	0.5
Other	140	3.6	638.2	2.8
Total	214	5.5	755.6	3.3
Non-mammalian Wild				
Birds	684	17.5	473.1	2
Fish	454	11.6	137.2	0.6
Herptiles	409	10.5	328.7	0.6
Total	1547	39.6	748.4	3.2

Note[a]: This includes elements identified as “sheep/goat” as well as elements identified as sheep and goat in order to yield the caprine total. The “sheep/goat” category alone is 695.

6.3.3 Husbandry and Herding Practices (Mortality, Sex Ratios, and Bone Pathologies)

In this section I analyze herd composition of domesticated species in order to determine and compare their roles in the subsistence economy during the Iron Age at Kadebakele. Key to this is determining what animal products were the focus of production and consumption. Depending on the production goals identified, I then consider how such production goals were coordinated, managed, and organized. This entails also considering risk management practices as well as other modes of animal use and the role of non-quotidian consumption contexts.

Mortality determination is based on tooth enamel wear stage and bone fusion. For cattle and pigs, fusion stage is organized in a way that is consistent with previous reporting on the fauna from Kadebakele (R. Bauer 2006) and is based on the fusion schedules presented by

Chaplin (1971) and Reitz and Wing (2008). The fusion stage, age, and bone groupings used for cattle and pigs are displayed in Table 6.7. Fusion schedules and groupings for caprines are based on a more recent analysis by Zeder (2006), which was able to establish correlation between epiphyseal fusion and tooth eruption and wear sequences. Table 6.8 summarizes of Zeder's classifications (Zeder 2006:107 Fig. 15).[7] These are based on group assignments A-F instead of early, middle, and late fusing.

Zeder's (2006) revised classification system for epiphyseal fusion is useful since, as Greenfield (2008) notes, one of the limitations of aging animals on the basis of fusion data is that it is often difficult to distinguish a prime adult (young but full-grown) from an aged one (837). This is because of the age ranges typically represented in fusion classes as well as the fact that epiphyses tend to fuse relatively early for animals (Payne 1973: 283; summarized in Greenfield et al. 2008:837). Because Zeder's system has more age classes, this limitation is ultimately less of an issue for an analysis of caprine remains but will need to be considered when evaluating patterns for pigs and cattle.

Table 6.7: Fusion Age Groups for Cattle and Pigs based on Chaplin (1972) and Reitz and Wing (1999)

Fusion Category	Age	Age Classification	Elements
Early Fusing	Under 12 months	Fetal/juvenile	Distal humerus, distal scapula, proximal radius, acetabulum, proximal metapodium proximal phalanx
Middle Fusing	12-24 months	Sub-adult	Distal tibia, distal fibula, proximal calcaneus, distal metapodium
Late Fusing	3+ years	Adult+	Proximal humerus, distal radius, proximal ulna, distal ulna, proximal femur, distal femur, proximal tibia, proximal fibula, vertebral centrum

[7] Separating how to analyze fusion sequence between caprines and cattle and pig is also informed by framework presented in Allentuck (2013).

Table 6.8: Age Groups for Caprines Based on Zeder (2006)

Group	Age	Element
A	0-6 months	Proximal radius
B	6-12 months	Distal humerus, acetabulum, scapula
C	12-18 months	Proximal 1st and 2nd phalanx
D	18-30 months	Distal tibia, Distal metapodials
E	30-48 months	Calcaneus, Proximal femur, distal femur,
F	48+	Proximal humerus

Pigs

Based on the available faunal data, pigs from Kadebakele were wild and thus, pig hunting, as opposed to pig husbandry, was part of the Iron Age subsistence regime. The first indication that the pigs from Kadebakele were wild is the fact that they constitute only a small proportion of the faunal assemblage compared to domesticated cattle and caprines. For example, cattle and caprines comprise 36% and 19.2% of the Iron Age assemblage, respectively, while pigs only make up approximately 1.9% of the Iron Age assemblage.

If pig herds were maintained we would also expect to see certain patterns in pig mortality. Given that cattle and caprines significantly outnumber pigs at Kadebakele, as well as the fact that non-mammalian wild taxa form a large proportion of the faunal assemblage, pig consumption would have been supplementary to the other dietary resources consumed at Kadebakele. If pigs were being reared for supplementary meat consumption, we would expect to see a majority of the animals to be slaughtered between 3 and 6 months (Redding 1991). This is due to the rapid growth rate of piglets and their ability to more efficiently convert feed to pounds compared to cattle and caprines (Harris 1985:67). We would also expect to see the slaughter of pigs within this younger age class because meat is the only resource provided by pigs. In other words, there are no secondary or replenishable products to extract from pigs such that it would justify maintaining them into later age classes, especially as they become more difficult to manage in terms of their feed and water intake needs. In a context where agricultural production is also taking place, as is the case at Iron Age Kadebakele, maintaining groups of adult pigs would also be difficult since they can do extensive damage to agricultural fields.

The fusion data presented in Table 6.9 is organized into relative age groups which are divided into Early Fusing (under 10 months) Middle Fusing (12-24 months) and Late Fusing (24+ months). From the fusion data, only 2 elements out of the 11 identified fall into the category that overlaps with the 3-6 month age range. In other words, only 18% of the animals represented in the sample come from young piglets. The remaining 82%, a large majority of the sample, come from adults. Three deciduous teeth coming from young piglets were also recovered, 2 of which were from the same context and thus may have been from the same animal. However, even if 3 individual animals were added to the age classes represented on the basis of fusion, there would remain a larger proportion of adults (35% young, and 65% adults). At least under Redding's (1991) model for interpreting the role of pigs in subsistence systems, only a small number of adults would be expected to be present to maintain the breeding stock (23).[8] Thus, the pig mortality data is inconsistent with the raising of domesticated pigs on site. It is more likely that pigs were hunted or perhaps opportunistically killed or monitored and killed as part of a strategy to prevent agricultural damage.

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[8] This model is specific to ancient Egypt and similar interpretations have been made with respect to pigs in Southwest Asian contexts. Ultimately, there could be regional variation and alternative interpretations for how domesticated pigs function in South Indian pre and early historic economies, however the totality of the pig faunal data at Kadebakele does not seem consistent with the presence of domesticates or the raising of pig herds even on a small scale.

It is of course necessary to highlight the fact that the fusion and tooth wear data from pigs in the Iron Age are drawn from small sample sizes (n=14 and n=3) and thus caution should be taken when interpreting these data. Within the broader context of what we know about the Iron Age, however, it appears more likely than not that the pigs present in the assemblage were wild. Domesticated pig consumption is more likely to occur within a context where protein resources are less accessible. At least in Southwest Asian contexts, domesticated pigs are argued to have been raised and consumed as a quick and efficient meat resource that individual households or families could have relied upon, especially if economic specialization was extensive enough that they were unable to devote their time to procuring other dietary resources (Redding 1991; Redding 1992; Zeder 1991). The subsistence context during the Iron Age at Kadebakele does not appear to have necessitated this, since hunting was extensively practiced as a way of procuring individual or household dietary resources. Thus, pigs were more likely to be hunted than raised since wild pigs would have been one of the wild resources available. In addition, strong evidence for cattle and caprine husbandry for dairy products (see discussion below) alongside hunting may also have rendered the raising of pigs for supplemental protein unnecessary. This is especially the case in a context where cattle rearing is the dominating husbandry strategy, since cattle can produce more protein via dairy production per amount of feed required compared to pigs (Pimentel and Pimentel 1979:59, see also discussion in Redding 1991:25). In addition, as pigs can be destructive to agricultural fields, it would be surprising to see a pig husbandry strategy carried out alongside agricultural production within the same proximity. Farming certainly was an important component of Iron Age subsistence, as documented from botanical and traction data at Kadebakele. Ultimately, the heavy reliance on cattle and intensifying agricultural production adopted at Kadebakele produced a subsistence context where domestic pig rearing and consumption would not have been likely.

Table 6.9: Relative Age Based on Epiphyseal Fusion for Pigs at Iron Age Kadebakele

	Unfused	Fused
Early Fusing	2 (50%)	2 (50%)
Middle Fusing	3 (75%)	1 (25%)
Late Fusing	3 (60%)	2 (40%)

Caprines: Specialized Dairy Production

Analysis of Iron Age remains from Kadebakele reveals that caprines (to include both sheep and goats) played a more significant role in Iron Age subsistence than was previously known. Not only do caprines comprise 19% of the total Iron Age faunal assemblage, but as I discuss below, the age structure data for caprines suggests that caprine husbandry was organized around the specialized production of dairy. This pattern was identified by constructing and comparing caprine survivorship data to subsistence optimization models based on market economies (Payne 1973).

Survivorship curves rely upon mandibular tooth wear stages and ideally should be constructed using complete and undamaged mandibles. Grant (1982), for example, provides age estimates for caprines based on the amount of wear across a sequence of the deciduous fourth premolar (m4) or the fourth premolar (P4), and the permanent first, second, and third molars. Despite the fact that the Kadebakele faunal assemblage appears to be well preserved with respect to bone density and bone size, intact mandibles were not recovered in high enough numbers to produce a survivorship profile on complete mandibles alone. Instead, a survivorship curve for Iron Age caprines was rendered using a combination of mandibles with undamaged tooth rows as well as complete and undamaged loose teeth (primarily the deciduous fourth premolar and lower molars). Because the use of loose teeth can lead to a survivorship curve that over represents the number of animals in the sample, interpretations should be treated with some caution. In this analysis, however, loose teeth were only used if they were from distinct contexts or if they could be distinguished as a separate individual animal from the same context, thus reducing the chance of over representing the number of animals in the sample.[9]

Caprine survivorship is presented in Figure 6.2 and is based on 40 specimens. Figure 6.2 shows the Kadebakele caprine survivorship curve compared to a rendering of Payne's model for optimized dairy production (1973:282).[10] The caprine survivorship curve closely resembles Payne's Model B, or the model for optimized dairy production (FIG 2 in 1973:283). Under optimized dairy production, it is expected that up to roughly half of the herd will be culled before 12 months (Payne 1973:283). This is known as kid mortality and is part of a strategy to cull male juveniles in order to eliminate competition for milk from the lactating animals.

Kid mortality is evident at Kadebakele based on the survivorship curve as 49% of the herd was culled before 12 months. Under Payne's model, animals culled under 12 months most likely would have been males, since in order to maximize dairy production you would need more females than males in the herd population. A few males would have been retained for the purposes of reproduction and maintaining the herd. It is not possible to determine whether or not

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[9] Using loose teeth is not uncommon and Payne's method for aging teeth allow for corrected counts that can incorporate loose teeth (see for example Greenfield 2005; Arnold and Greenfield 2006). Greenfield is consistent in his published work that loose teeth can be used, "where they provide sufficiently narrow age stage or are necessary to provide a sufficient sample size," (2005:22).

[10] The %survival estimates used to recreate Payne's survivorship curve are from Nimrod and Bar-Oz (2009:1186). In their paper, they calculate theoretical survivorship percentages from various subsistence models in order to assess whether they differ enough to be statistically significant and thus interpretively meaningful.

the teeth from juvenile animals in the faunal assemblage were from males, but the discussion of the herd sex ratio on the basis of other remains is detailed below.

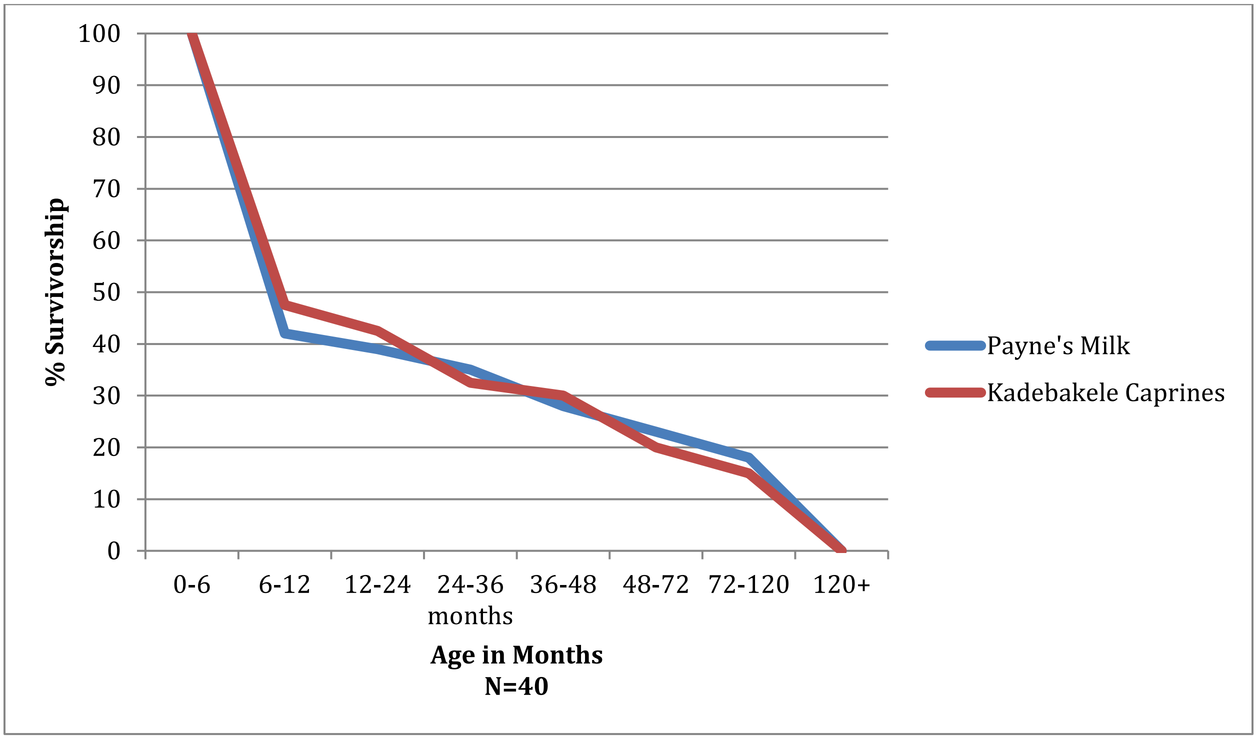

Figure 6.2: Caprine Survivorship During the Iron Age at Kadebakele Compared to Payne's Milk Model

Epiphyseal fusion data for caprines are consistent with the survivorship data based on tooth wear. Epiphyseal fusion data are presented in two formats. Table 6.10 presents both raw counts and the percent of fused elements in each age group. Like tooth wear, epiphyseal fusion patterns provide evidence for dairy oriented kid mortality. For example, 50% of the elements in Group A (0-6 months range) were unfused, indicating that half of the individuals in this age class were slaughtered at an immature stage. The relatively frequent recovery of fetal/neonate caprine remains in the Iron Age faunal assemblage further demonstrates that kid mortality was high, and in particular at the infant age class (less than 6 months).

Interpreting patterns for later epiphyseal fusion categories is a larger interpretative challenge than for survivorship curves. Survivorship curves based on tooth wear stages and absolute age are derived by calculating how many deaths occur during a particular age interval and then calculating the proportion of the cohort that is alive at the beginning of each subsequent cohort. As a result, values in subsequent age classes can never increase, they can only decrease or remain constant across each subsequent age category. In contrast, when evaluating fusion proportions, organized on the basis of relative age and not absolute age, the proportion of fused versus unfused elements are independent of each other across the different age classifications. Thus, unlike mortality curves based on tooth wear, it is possible to see what Price et al. (2016) terms "rebounds" in the proportion of fused elements, where the percentage of fused elements increases compared to earlier fusion groups. They note that rebounds are impossible in a true survivorship curve (Price et al. 2016:162). We see these kinds of rebounds in the caprine fusion data (Figure 6.3). For example, Group B shows a higher proportion of fused remains compared to Group A. In this case, the epiphyseal fusion data align with what was observed with respect to survivorship. In all both cases, more animals were culled in the 0-6 months group than the 6-12 month group. Again, this is consistent with a milk production strategy whereby young (likely males) are culled in order to eliminate competition for the milk generated by lactating females. Young females, and some males, are retained for breeding.

The epiphyseal fusion data indicates that caprine herds were largely maintained across the next two age classes (B and C) spanning up to 18 months. After this, however, the proportion of animals with fused remains (and thus the animals kept alive in that particular age class) decreases below 50%. Thus, over half of the animals in each of these age groups were slaughtered. This occurs in the sub- adult and adult age categories, groups that tend to represent offtake for the purposes of meat consumption. This pattern of increased slaughter in sub-adult and young adults is not nearly as pronounced in the tooth wear data; however, there are various reasons as to why epiphyseal fusion is a more problematic methodological approach for age estimation compared to tooth wear (see Chapter 5). As a clear example, we cannot really determine how common it was for animals to survive into advanced age since the latest fusion group only goes until 4 years. This is in contrast to the 8-10 year range mandibular wear can show. In addition, fusion status does not give an indication of how old the animal was, rather it tells us the animal was at least a certain age (fused) or younger than a certain age (unfused). Epiphyseal fusion from caprines thus gives us an incomplete picture of the age structure compared to tooth wear. This has specific implications for distinguishing between strategies oriented toward meat versus secondary products since for the latter we would expect to see more animals surviving beyond adulthood. Although evidence for advanced aged animals is unavailable from the fusion data, we know they were present in the population based on tooth wear. In addition, the high recovery of ossified costal cartilage in medium-bodied mammals suggests advanced aged animals were present (Amorosi 1989:67; Silver 1969, R. Bauer 2006:170). Here, medium-sized mammals are assumed to be caprines.

The epiphyseal fusion data does help buttress the interpretation that caprines were primarily raised for dairy products because, just like the tooth wear data, the epiphyseal fusion data show kid mortality was practiced at Kadebakele during the Iron Age. Evidence that prime aged animals were also slaughtered need not necessarily pose much of a discrepancy when interpreting herd structure broadly. This is because optimization models like Payne's are idealized and reflect decision-making that is based upon a single economically oriented goal. In reality, animal-based resource production is driven by multiple and overlapping strategies that will impact age data and how they are interpreted. What is compelling about the Kadebakele age data based on caprine tooth wear is just how closely it aligns with Payne's model (Figure 6.2). Thus, it is clear that Iron Age residents of Kadebakele were practicing dairy production in a specialized manner aimed at increasing or maximizing dairy yields. The reasons for the discrepancy in representation of sub-adults and adults for epiphyseal fusion are less clear. The subsequent slaughter of sub and young adults could reflect the offtake of surplus males no longer needed for breeding. This may happen in a scenario where excess young caprines were retained until the end of their second year to insure against failures in subsequent birthing seasons (Redding 1981). When not trying to insure against flock losses, herders are otherwise likely to slaughter breeding males between 6 months and 2 years (Redding 1981:204). However, if this were the case, we would not expect to see a survivorship curve that so closely resembles a dairy production profile.

Alternatively, the slaughter pattern for caprines could reflect the fact that caprines, although primarily reared for dairy resources, were slaughtered for meat consumption on certain occasions. Such consumption could be for various social or ceremonial reasons, such as ritual sacrifice, feasting, bridewealth, or other expressions of wealth and prestige (Russell 2012:395). While a majority of data points for caprine herd structure support the interpretation that caprines were raised into adulthood and advanced age for secondary products (dairy), this does not preclude the fact that, on occasion, some animals were slaughtered at their optimal meat yielding capacity and thus likely consumed for their meat. This, however, appears to occur under specialized circumstances. Caprines were not raised primarily for meat, nor were meat cuts provided or distributed in a specialized system as too many animals were slaughtered in infancy to be compatible with this specific subsistence strategy. Consumption of caprines in specialized contexts at Kadebakele is discussed further in the section detailing variation in activities and faunal patterns across excavation areas.

Table 6.10: Distribution of Fusion Data for Caprines from Iron Age Kadebakele							
Group	Age	Element	Number Unfused	Number Fusing	Number Fused	Total	% Fused
A	0-6 months	Proximal radius	4	0	4	8	50%
B	6-12 months	Distal humerus, acetabulum, scapula	5	3	20	28	82.1%
C	12-18 months	Proximal 1st and 2nd phalanx	0	3	7	10	70%
D	18-30 months	Distal tibia, Distal metapodials	22	0	9	31	29%
E	30-48 months	Calcaneus, Proximal femur, distal femur, distal radius, proximal ulna, proximal tibia	18	2	17	37	46%
F	48+	Proximal humerus	3	0	1	4	25%
Total			52	8	58	118	

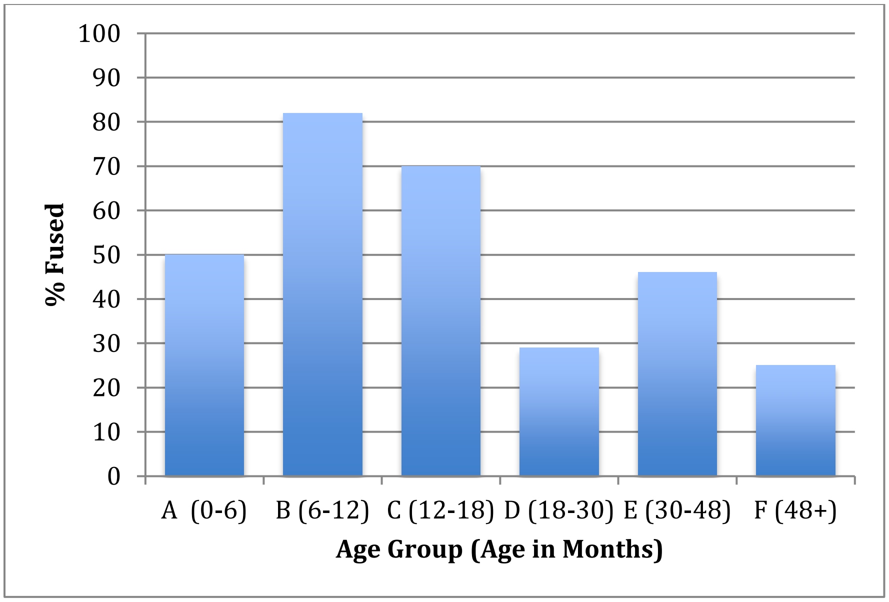

Figure 6.3: Percent Fused Across Age Group for Caprines at Iron Age Kadebakele

Evidence for caprine dairy production is also evident from pelvic remains and metrical data. Under a dairy production strategy, it is expected that more females (sources of milk) than males present would be present in the assemblage. From the Iron Age sample, only three elements from which a sex could be determined were recovered, two of which could only be identified to the level of "sheep/goat" and one identified as goat. All three elements were portions of the pelvis and come from distinct contexts and thus can be definitively regarded as three individual animals. All three of these animals were females. While certainly males were retained for breeding, this admittedly small sample of sexable remains shows a bias for female caprines. This is consistent with what we would expect to see under a dairying strategy geared toward milk production.

Another way to investigate the distribution of males and females in an animal population zooarchaeologically is to examine metrical data collected during faunal analysis. By comparing measurements from commonly occurring complete bone ends, it is possible to look at the distribution of measurements and interpret whether or not there appears to be a skew in smaller bodied (presumably female) and larger bodied (presumably male) animals. Unfortunately, the sample size for pooled complete remains to compare metrical data is small. The largest sample of complete bone ends to compare measurements comes from the second phalanx[11] (n=8). Figure 6.4 shows the distribution of second phalanx proximal breadth measurements.

Metrical data from the caprine second phalanges (in this case these were all identified as goats) show a slight skew toward smaller second phalanx proximal breadth measurements. One measurement (13.4 mm) falls outside of 2 standard deviations and likely belongs to an adult male. Metrical data thus show both males and females were present, with only a small bias towards females over males. Although the sample size is small, and thus not definitive, when contextualized with the kid mortality evidence and the female biased ratio evident on the basis of

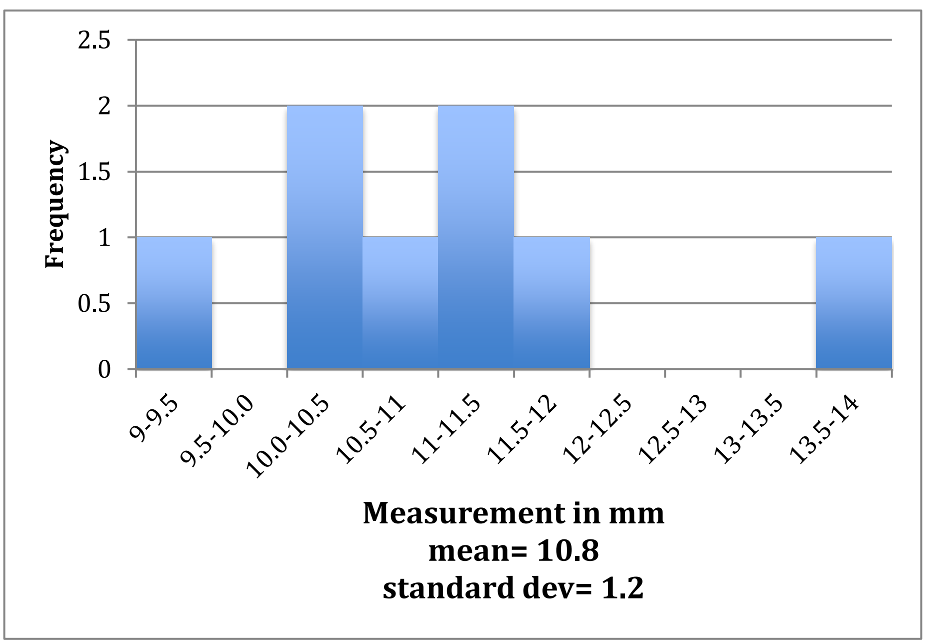

Figure 6.4: Distribution of *Capra* Second Phalanx Proximal Breadth (n=8)

[11] See Zeder (2001) for discussion of using the first and second phalanx to establish the presence of males and females in goat populations.

pelvic remains, the available metrical data aids in bolstering the interpretation that caprines were reared for dairy products during the Iron Age.

Cattle

Figure 6.5 shows the survivorship for cattle. Although the subsistence models published by Payne (1973) are based upon caprine herding strategies, there are ways in which they can also be applied to cattle (e.g. Halstead 1995, Allentuck and Greenfield 2010). There are, however, some complications to consider. As previously reviewed in Chapter 2, it is expected meat production strategies would be consistent between caprines and cattle (Halstead 1995) and that culling would target animals at their maximum meat-bearing capacity. According to some (Dahl and Hjort 1976:167; Bogucki 1993; Marshall 1990), cattle reach their maximum meat-bearing capacity at around four years old. As such, Payne's (1973) meat production survivorship curve would shift compared to caprines, whose optimal culling age for meat is between 2 and 3 years old. However, there are discrepancies concerning the ideal age to slaughter cattle for meat. While at 4 years, cattle may yield the largest quantity of meat, optimal quality for meat may come from animals. Vigne and Helmer (2007) and Hambleton (1999), for example, have described the ideal age of slaughter for cattle as being 2-4 years old. Thus, there is some overlap between the ideal age of slaughter for cattle between the sub-adult (2-3 years) and young adult (4 years) age classes.

When applying the caprine dairy model to cattle, researchers have debated whether infant mortality would have been practiced or possible in past cattle breeds (Halstead and Isakidou 2017: 119). Given the existing literature (see review in Chapter 2), this analysis proceeds on the assumption that evidence of infant mortality would support an interpretation of dairy production in cattle and uses it as a point of comparison for caprine husbandry during the Iron Age. Absence of infant mortality, however, is scrutinized in the broader context of the cattle faunal assemblage in order to ascertain the subsistence focus of cattle.

Figure 6.5 indicates that infant mortality was not practiced for cattle herds during the Iron Age. The cattle survivorship curve is based off a similar sample size as the caprines survivorship curve (n=39). Very few animals died before 6 months and likely died of natural causes. After 6 months, survivorship is steady across 6-12 months and 12-24 months. Based on the survivorship curve, approximately 82% of the herd was maintained up to 48 months.

A steeper decline occurred after 48 months, showing that some animals were slaughtered at their prime meat bearing mass. However, over 60% of the herd survived up to 72 months, and 33% beyond 72 months. In fact, 13 teeth, out of the 39 used to derive the survivorship curve, exhibited tooth resorption/resorped alveolar, indicating that these animals were 8-10 years old at death (Hillson 1986:316-317). Alveolar resorption also occurred on other cattle maxillary teeth in the Iron Age faunal assemblage; however, they were not included in the survivorship curve since there is no agreed upon age schedule for maxillary tooth wear. Inclusion of maxillary molars with resorped alveola would result in a curve showing even more animals surviving into advanced age. There also continued to be a high volume of ossified costal cartilage. Although these could only be identified as belonging to “large mammals” it is highly likely they are from cattle.

These data taken together suggest that cattle survived into adulthood and many into advanced age. This is the distribution expected when cattle are raised for secondary products as opposed to meat. Epiphyseal fusion data also corroborates this pattern (see Table 6.11). In the early fusion category (elements that fused under 10 months), only 14.3% of the elements are unfused. This is an indication that kid mortality was not practiced for cattle. Unfused elements also make up smaller proportions for middle and late fusing elements (22.7% and 8.3% respectively). Thus, a majority of animals survive in each of the age classes based on epiphyseal fusion.

For cattle, the tooth wear and epiphyseal fusion data are more complementary than was the case for caprine data. The age data are thus convincing that cattle were raised for secondary products. These would have included dairy products. Given that caprine husbandry was oriented toward maximizing dairy production, the addition of cattle dairy resources would have ensured a strong and reliable system of dairy production. This is not to suggest that cattle were less significant contributors to dairy production. The high volume of dairy products from cattle compared to caprines, and particular high fat content of water buffalo milk (Mane 2015; Bacskei et al. 2020) may have meant that cattle dairy production did not need to follow the same specialized organization alongside caprine dairy production. Cattle nevertheless contributed to the dairying economy and production system in a way that bolstered and complemented caprine dairy production.

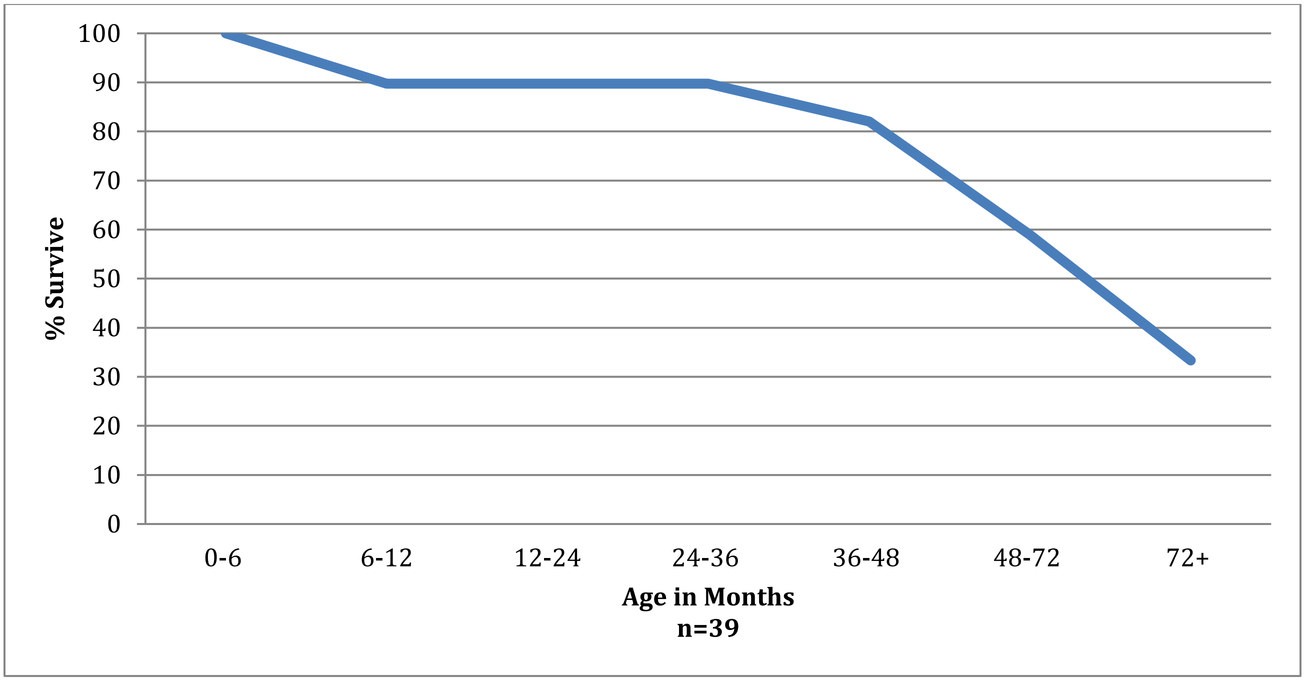

Figure 6.5: Survivorship Curve for Iron Age Cattle at Kadebakele

Table 6.11: Relative Age Based on Epiphyseal Fusion for Cattle at Iron Age Kadebakele

	Unfused	Fusing	Fused
Early Fusing	23 (14.3%)	4 (2.5%)	134 (83.2%)
Middle Fusing	15 (22.7%)	0 (0%)	51 (77.3%)
Late Fusing	19 (8.3%)	1 (.4%)	210 (91.3%)

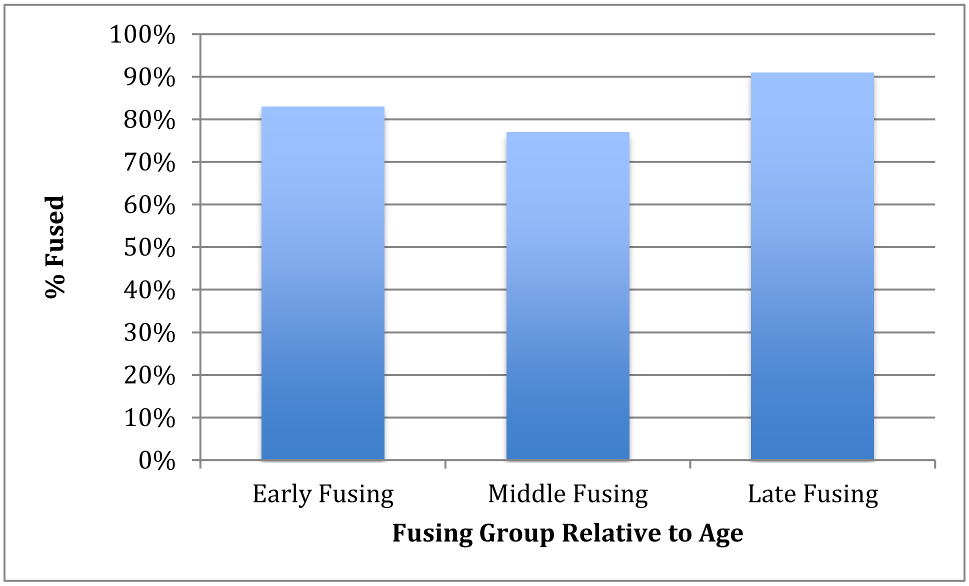

Figure 6.6: Proportion of Fused Elements for Iron Age Cattle at Kadebakele

Cattle, however, provided more than just dairy products. Multiple cattle remains (n=9) exhibited pathologies that were associated with traction. The use of cattle for traction has been documented in South India since the Neolithic (Alur 1968, 1971) and was also evident from Neolithic contexts at Kadebakele. With evidence of additional agricultural experimentation and expanded production during the Iron Age, it is unsurprising to see cattle continue to be raised for traction purposes.

Because cattle were relied upon for multiple secondary products, it is expected that both males and females would be present in the population. In this case, females (dairy producers) would be present in the population alongside males for traction use. Both males and females would also be present for breeding and herd perpetuation purposes. Within the intersection of dairying and traction, it is expected that males would be preferred for traction because it can negatively impact milk supply in cows (Lawrence and Pearson 2002:105). Notably, however, there is ethnographic and archaeological evidence showing the use of females, including pregnant females, for traction (Gaastra et al. 2018:1463; Bartosiewicz et al. 1997; Halstead 2014). Gaastra et al. (2018), in fact, present evidence that females were used alongside males in the earliest instances of documented traction labor during the Neolithic in the West Balkans (c. 6100-4500 cal BC). Moreover, because such a large proportion of cattle appear to have survived into advanced adulthood, beyond their capacity to yield resources, it seems likely that the male to female ratio would be equal.

The distribution of the proximal breadth of the second phalanx[12] for cattle was normally distributed, showing neither male nor females were represented in higher numbers (see Figure 6.7). This is based on a sample size of n=52. Interpretations of the metrical data for cattle are complicated for a few reasons. First of all, metrical data for cattle includes both zebu and water buffalo since it is difficult to distinguish between the faunal remains of both species. Because of the overlap in older and younger male and female zebu versus water buffalo, it is difficult to disentangle, for example, whether an element could be from a young male zebu versus an older female water buffalo. Additional complicating factors include the impact castration can have on skeletal size in cattle. When practiced early in development, castration delays the fusion of bone epiphyses and as a result, bones are thinned or elongated and overall height is increased (Bagley et al. 1989; Bartosiewiez et al. 1997). R. Bauer (2006) proposed that the normal distribution of the 2nd phalanx proximal breadth measurements from Kadebakele fauna (based on n=15) reflects the presence of male castrates in the population (164). Expansion of metrical data sets for cattle first and second phalanges potentially corroborates this.

[12] See Hingham (1968) for discussion of using first and second phalanx measurements to determine the presence of males and females in cattle populations.

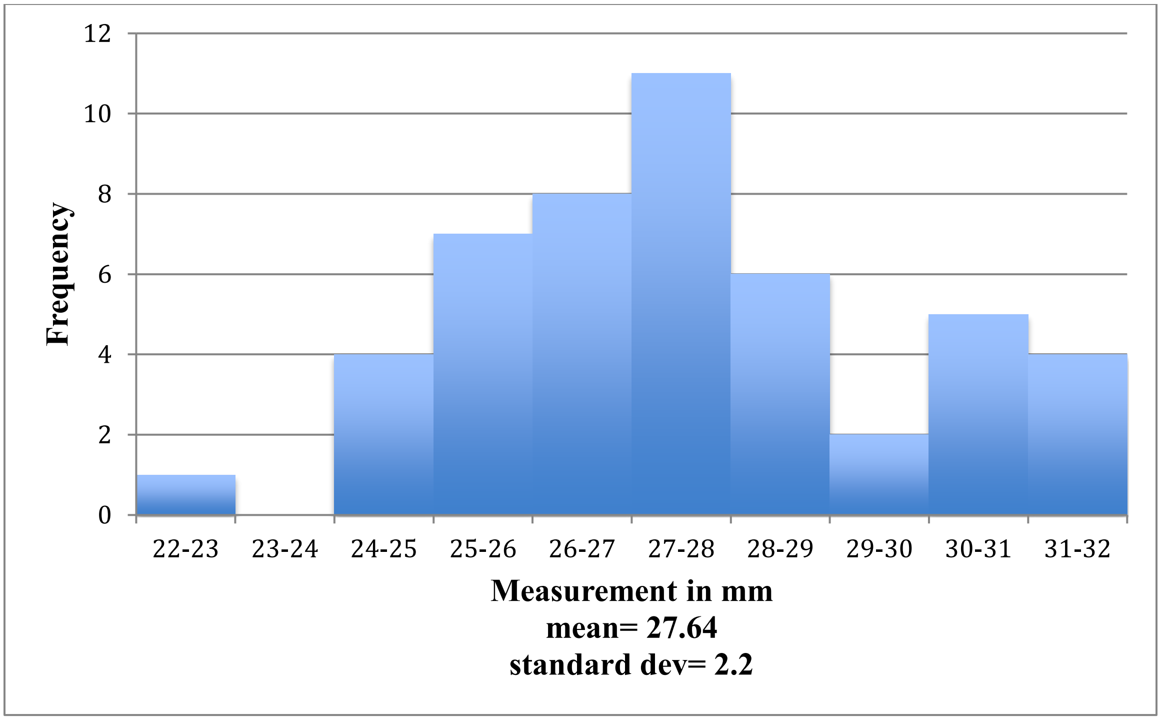

Figure 6.7: Distribution of Cattle Second Phalanx Proximal Breadth (n=52)

At Kadebakele, castration would have figured into a broader secondary products economy by making males more docile while also increasing their stature in ways that are amenable to traction labor (Bartosiewicz et al. 1997). Castration does not appear to have the same impact on the skeletal development of water buffalo (Charles and Johnson 1975). Thus, if castration was practiced during the Iron Age, then larger specimens could belong to either an uncastrated zebu or water buffalo. Notably, R. Bauer compared measurements of the middle breadth of the sole (MBS) from third phalanges exhibiting evidence of traction-induced pathologies, to known metrical data from zebu and water buffalo skeletons (R. Bauer 2006: Appendix III 632-633). Three were vastly larger than the others and corresponded to water buffalo measurements. Two were incomplete and thus a measurement could not be obtained. Two were relatively smaller than the values presented for zebu but may have been younger animals or castrated individuals. A first phalanx exhibiting heavy muscle markings, also consistent with traction induced stress, had measurements consistent with zebu and was identified as such (R. Bauer 2006:393). These at least preliminarily suggest that water buffalo may have been used alongside zebu for traction during the Iron Age.

The age structure, traction pathology, and potential evidence of castration all reinforce the interpretation that cattle, in combination with caprines, were part of a secondary products economy during the Iron Age at Kadebakele. As with caprines, the reliance on cattle for secondary products does not preclude that they were consumed for meat on certain occasions. Cattle were not often slaughtered as sub-adults, however the slaughter of cattle between 4 and 6 years could reflect offtake of some prime animals based on maximum weight gain. Even if slaughter occurred at the latter end of this age range, this would still be still premature compared to the timeline of secondary products that could be extracted from them. Cattle raised for traction, for example, require a significant amount of labor and time investment for training, and castrated males used for traction are kept well into adulthood (Halstead 1995).

The reproductive age range for cattle can vary, but there are some ethnographic examples of cattle breeding well into advanced adulthood, even up to 10 years (Dahl and Hjort 1967: 36). This would thus also coincide with an extended age of lactation for females. Dahl and Hjort note that because of this, many nomadic pastoralists, especially those with small herds, are reluctant to sell or slaughter old (female) cattle (1967:36). For males, however, few individuals are needed to perpetuate the herd. While multiple males may be retained to insure against loss (animals dying of natural causes), excess males that are no longer needed for breeding purposes are assumed to be slaughtered between 4 and 5 years old (Dahl and Hjort 1976: 157). Thus offtake in this age range could at Kadebakele, similar to caprines, reflect the culling of uncastrated animals.

The case for this might be somewhat stronger for cattle since presumably uncastrated males would not be used for traction.

Cattle slaughtered in the 4-6 year age range could also be deliberately selected for meat consumption, either in connection with or independent of practices to cull excess males for breeding. The consumption of prime aged cattle has been documented to occur on occasion at Kadebakele and within the context of ritual activities associated with the Southern Slope stone circle megalith (R. Bauer 2006). This is discussed further in the section on variation in activities and faunal patterns across different excavation units.

6.3.4 Skeletal Part Representation: Local Rearing and Consumption

Skeletal part representation for domesticates at Kadebakele suggests that animal carcasses were processed, consumed, and discarded on site. This is based on comparing the proportions of specific body part groups (head, axial, forelimb, hind limb and feet) to the proportions we would expect to see if an entire bovid skeleton was deposited (Zeder 1991:95-97). In the absence of evidence of specialized producers or specialized production sites connected to large settlements like Kadebakele, this is taken to mean that animals were maintained locally and within close proximity to the site. Alternatively, if animals were managed by specialists external to the site, the deposition of entire skeletons would indicate that entire animals were exchanged for processing and consumption (Zeder 1991:40-43). This is in contrast to a specialized system where only select elements, such as high meat bearing bones, are exchanged (Zeder 1991:43).

Table 6.12 presents the raw counts of elements in different body part groups as well as the proportional make up with respect to the total amount of skeletal remains collected for cattle and caprines. Figures 6.8 and 6.10 display the proportions graphically for comparative purposes, with Figure 6.8 presenting the documented skeletal part percentages of cattle versus the expected proportion (the standard) and Figure 6.10 presenting the documented skeletal part percentages of caprines versus the expected proportion (the standard). For clarity, the axial category is omitted from these graphs but is included in the values presented in Table 6.12 since axial elements for cattle and caprines are expected to be underrepresented compared to the standard. This is because axial elements such as vertebrae and ribs are difficult to identify to species (with some exceptions such as recovery of the atlas or the axis, or the bifurcated spinous process of zebu thoracic vertebra).

For elements that can be identified as either cattle or caprines, other examples of either over or underrepresentation are likely to occur. However, even when these are considered, the distribution of skeletal remains largely reflect what we would expect to see if entire carcasses were deposited on site. Head and foot remains, for example, are likely to be somewhat overrepresented due to the fact that teeth foot bones are high-density elements. As a result, they have a higher likelihood of preserving in the archaeological record. These particular remains are also more likely to be identified to species. This is in contrast to axial elements and long bone shaft fragments which often can only be identified on the basis of class and body size.

Because certain elements can be under or over represented based upon density and fragmentation, it is helpful to compare the distribution of elements for cattle and caprines to those for large and medium mammals (see Table 6.13). Comparing the skeletal part distribution of both can ensure that the element categories complement each other. For example, if there is a lack of axial elements in the distribution of cattle remains, but an abundance of axial elements in the large mammal remains, then it is likely that the large mammal axial elements are from cattle and we can use large mammal values to assess whether or not it appears that entire carcasses were processed and discarded on site.

Examination of the large and medium mammal remains compared to cattle and caprine remains from Iron Age Kadebakele do show the values to be complementary (see Figure 6.9 and 6.11). Axial elements, which are difficult to identify to species, more closely approximate the standard for both large and medium mammals than they do for cattle and caprines. Head remains for large and medium mammals are both underrepresented compared to the standard. This is because the most durable and dense skeletal remains (teeth, the petrous temporal) are easier to identify to species and thus are less likely to wind up classified as large or medium mammal. Similarly, foot remains are more likely to be overrepresented in cattle and caprines and underrepresented in large and medium mammals since dense foot bones are less likely to be heavily fragmented (due to density) and more likely identified to species. This is in fact demonstrated between cattle and caprines and large and medium mammals.

There is not, however, a corresponding underrepresentation in the limb and foot category for large and medium mammals. This is because limb and foot remains are a combined category for large and medium mammals and are separated for cattle and caprines. Limb and foot elements are combined for large and medium mammals because it is difficult to distinguish long bone shaft fragments from metapodial shaft fragments. Shaft fragments lack the diagnostic areas necessary for identifying an element to species. Limb and foot remains are distinguished for cattle and caprines because identification is based on bone ends and not shaft fragments. Because of this discrepancy, the limb category (which also includes foot bones) for large and medium mammals is going to be far more overrepresented than the limb category for cattle and caprines. This is evident from the large and medium mammal data from Kadebakele, however the overrepresentation compared to the standard expected for large and medium mammals in the limb category does not appear to reflect a strong preference for limbs. In Zeder's (1991) analysis of faunal remains, a strong selection for limb elements in large or medium mammals is indicated when limb comprise over 70% of the skeletal part representation (131). At Kadebakele, large and medium mammal limbs comprise 53.5% and 59.5% respectively.

Comparing the cattle, caprine, large and medium mammal remains, we can infer that the axial representation is better captured in the large to medium mammal distributions. For the remaining analysis, it is appropriate to focus on the cattle and caprine head, limb, and foot distributions since the sample sizes are large enough to do so without combining the values with large and medium mammals (as was done for the Neolithic faunal remains). This also allows for examining foot and limb distributions separately. Because the proportion of head, limb, and foot remains for cattle and caprines do not deviate far from the expected proportions of a complete bovid skeleton, and because butchery waste (head and feet) and consumption waste (meat bearing bones) occur within the same area (Crabtree 1990; Uerpmann 1973; Zeder 1991), the distribution of skeletal remains suggests domesticates were reared locally, and were consumed and disposed of on site. This is bolstered by the evidence that herd structure patterns reflect a subsistence regime that is primarily focused on secondary products as opposed to a system of distributed meat cuts. The rearing of caprines for dairy products also appears to be localized given that the evidence of kid mortality takes place on site. Finally, the use of cattle specifically for traction labor lends itself to maintaining herds in close proximity since they presumably would be needed for agricultural activities associated with the settlement (Allentuck 2013:18). This is not to suggest that groups never took herd animals out to graze away from the site. The density and distribution of ephemerally occupied rockshelters (some accompanied by rock art panels depicting herding activities) in the region indicate that this was an important component to how domesticates were reared and managed (A. Bauer 2010). There are multiple Iron Age rockshelters located within 4 km of Kadebakele, including one that is less than 2 km away (A. Bauer 2010:142 Fig.5.2). The totality of the faunal evidence suggests, however, that even while small groups took animals to graze away from Kadebakele, those groups were likely residents of Kadebakele with slaughtering decisions for the animals taking place at the site and the animals also spending much of their time in close proximity.

Table 6.12: Skeletal Part Distribution for Various Taxonomic Groups from Iron Age Kadebakele Deposits

	Head	Axial	Forelimb	Hind limb	Feet
Mammals					
Cattle					
NISP	560	64	75	68	626
% of NISP	40.2%	4.6%	5.4%	4.9%	44.9%
Caprines					
NISP	281	36	109	51	265
% of NISP	37.8%	4.8%	14.7%	6.9%	35.7%
Standard	34%	35%	7%	5%	19%

Table 6.13: Skeletal Part Distribution by Mammalian Body Size from Iron Age Kadebakele Deposits

	Head	Axial	Limb + Feet
Mammals			
Large Mammal			
NISP	4181	5901	11581
% of NISP	19.3%	27.2%	53.5%
Medium Mammal			
NISP	4737	11085	23200
% of NISP	12.1%	28.4%	59.5%
Small Mammal			
NISP	112	289	577
%NISP	11.5%	29.6%	59%
Standard	34%	35%	31%

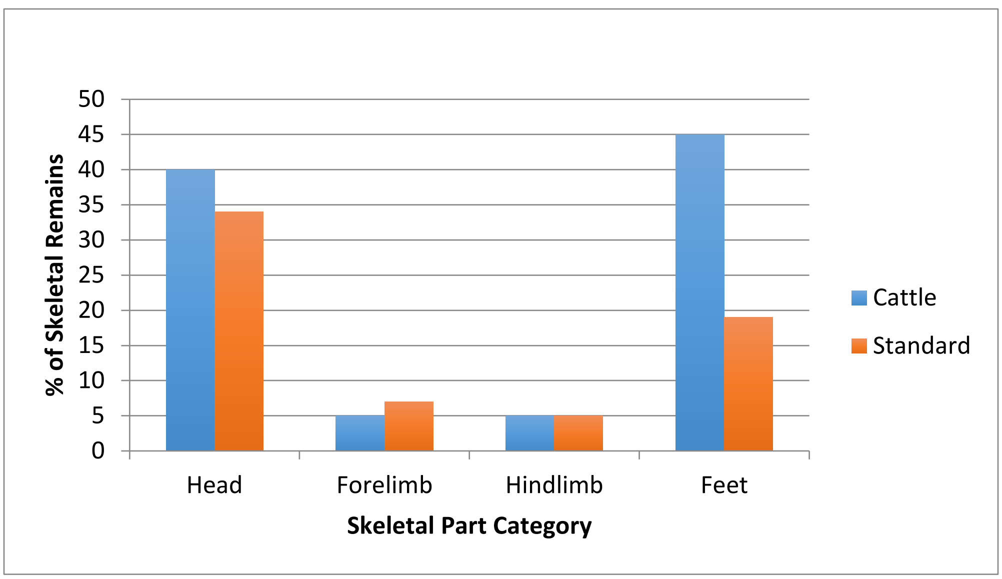

Figure 6.8: Skeletal Part Distribution for Iron Age Cattle from Kadebakele Compared to Standard Skeleton

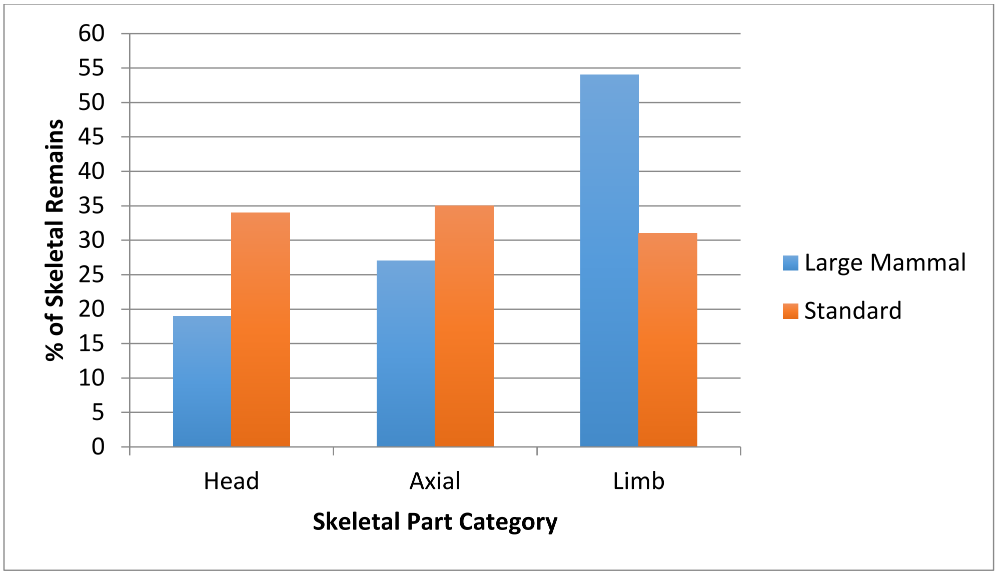

Figure 6.9: Large Mammal Skeletal Part Representation Comapred to the Standard from Iron Age Kadebakele

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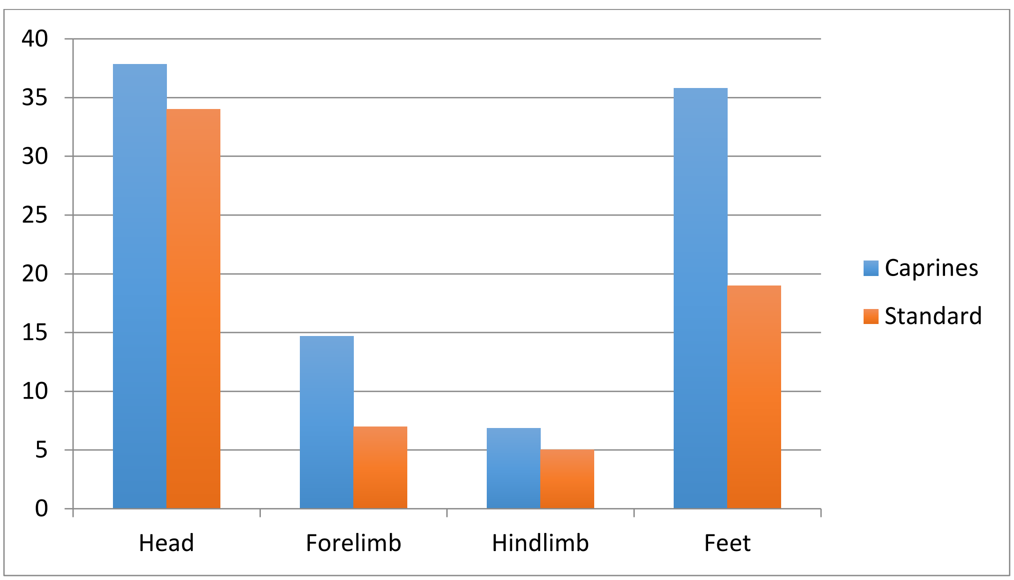

Figure 6.10: Skeletal Part Distribution for Iron Age Caprines from Kadebakele Compared to Standard Skeleton

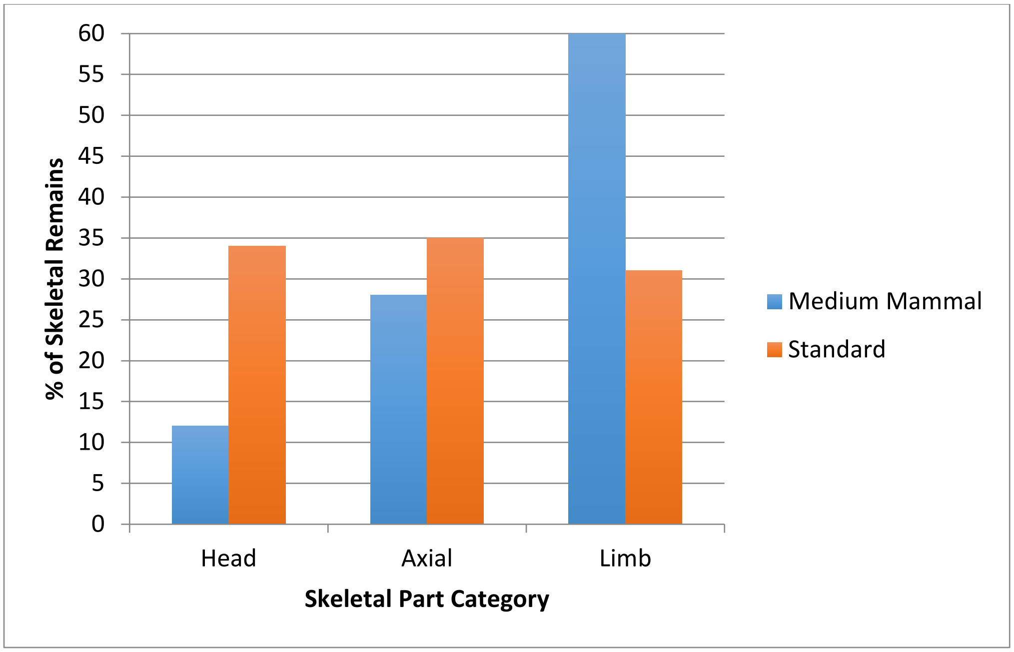

Figure 6.11: Medium Mammal Skeletal Part Representation Compared to the Standard Skeleton from Iron Age Kadebakele

6.3.5 Butchering Evidence

Butchery evidence from Kadebakele similarly indicates that meat production, consumption, and distribution were not primary subsistence strategies for Kadebakele residents. Cut/butchery marks were rare in the Iron Age faunal assemblage at Kadebakele. Out of the total NISP from the Iron Age (n=92,930) only .18% of the faunal remains exhibit cut marks.[13] A variety of species were butchered in a way that left cut marks on the bone, including cattle,

[13] It is important to note that a lack of cut marks on fauna can be attributed to many things, including different methods of butchering and processing carcasses. Skilled butchers, for example, may be unlikely to even knick the bone. Different methods of cooking could also lead to the obscuring of cut marks, in particular methods that lead to bone fragmentation such as boiling, or exposure to high temperatures. Finally, mineralization and dirt accumulation on archaeological faunal remains can also inhibit cut mark visibility.

caprines, birds, and wild species like gazelle and porcupine (see Table 6.14). Of the identifiable remains, cattle make up the largest proportion of butchered remains (8.4%). Butchered caprines, birds, and other wild animals are all represented in smaller proportions (2.4%, 1.8%, .6%, and .6% respectively). In addition, visible cut marks also appear on a variety of different elements across different species. Thus, there is no evidence that standardized or specialized butchery related to the distribution or provisioning of meat cuts took place at Kadebakele during the Iron Age (R. Bauer 2006:213).

Table 6.14: Frequency of Cut Marks Across Taxa at Iron Age Kadebakele

Taxa	**NISP**	**% of Butchered (out of n=167)**
Cattle	14	8.4%
Large Mammals	82	49.1%
Caprine	4	2.4%
Medium Mammals	31	18.6%
Gazelle	1	.6%
Porcupine	1	.6%
Bird	3	1.8%
Cattle Sized	96	57.7%

6.3.6 Iron Age Ritual Practices at Kadebakele

Research from Kadebakele shows different areas of the site (see Figure 6.12) were host to different sets of activities (e.g., R. Bauer 2006; Sinopoli et al. 2010; Sinopoli 2016; Morrison et al. 2016a; Kelly 2016; Wilcox 2016; Morrison et al. in press). Evidence of variation in activities across the site is most salient between areas containing megalith features and areas with residential architecture and domestic trash. Different patterns of animal consumption and use at the site are best seen in the contrast between the Southern Slope megalith and excavations from domestic or habitation areas (Block B, the North Midden, and the Eastern Upper Terrace).

As discussed in Chapter 4, ritual activities at the Southern Slope appear to revolve around the construction of megalith features (here, a stone circle) and the discard of feasting remains (R. Bauer 2006). Feasting, a specialized manner of consumption where food sharing between individuals or groups is emphasized (Hayden 2001), is evidenced in multiple ways. First, the remains of multiple young and prime-aged cattle were found within the stone circle, in particular meat-rich elements, as part of a single deposit. By contrast, cattle remains from domestic associated areas were more likely to be from older animals, presumably ones that died of natural causes or were slaughtered after they no longer provided secondary products. Second, a considerable portion of the faunal remains from the Southern Slope exhibited evidence of partial charring, or roasting. Roasting leaves a distinct pattern on bone (see Chapter 5) that was rarely documented in other contemporaneous excavation contexts at Kadebakele. As such, roasting appears to have been a specialized cooking technique limited to certain, perhaps ceremonial or ritually significant, consumption practices. Corroborating the interpretation for feasting, the Southern Slope contained a high abundance of individual serving vessels, a pattern Sinopoli (2016) links to specialized consumption activities at the site. While common vessel forms, these bowls occur in significantly lower concentrations in areas like Block B or areas characterized by domestic activities and daily consumption. While multiple lines of evidence demonstrate that deposits associated with the Southern Slope megalith reflect specialized, non-quotidian consumption, activities in this location appear to have occurred within a limited span of the Iron Age, with the deposits accumulating in quick succession and the pits within the megalith being sealed off quickly following their use (R. Bauer 2006:248, 800-520 BCE).

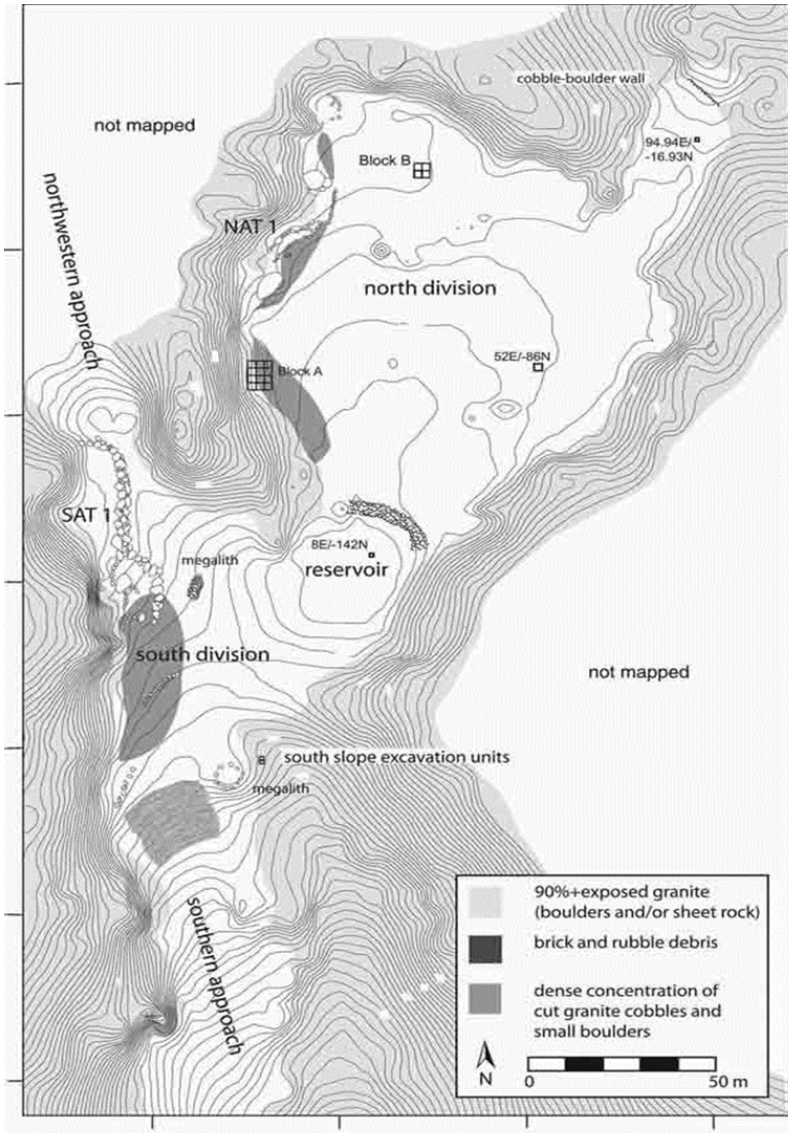

Figure 6.12: Map of Different Excavation Areas at Kadebakele (Sinopoli et al. 2010)

Ritual life at Kadebakele, however, was not limited to the Southern Slope. In fact, excavation evidence from Block A showcase an even richer and long-term sequence of ritual practices that took place at the site. Below, I expand the discussion of ritual practices at Kadebakele through a completed analysis of faunal remains from Block A, another area of the site containing a complex of megalith features, some previously undocumented in the region.

Further insights from earlier phases of Block B also provide insight on ritual life at Kadebakele in surprising ways.

As summarized in Chapter 4, excavations in the area identified as Block A exposed a series of stone wall enclosures and other megalith features, some of which have not been documented before in the existing literature on megaliths (Morrison et al. 2016a). In fact, far from "mega" many of these features are quite small and include various forms of sherd architecture, small features consisting of pavements and alignments of ceramic features, boulder pits, well prepared and lined shallow pits capped and marked by stone, stone-lined caches containing iron artifacts and fauna (Morrison et al. 2016a; Sinopoli et al. 2010). The myriad features documented at Block A were carefully constructed, maintained, and modified over multiple generations, showing long-term investment and elaboration. In fact, Block A's long use life is one feature that makes it distinct from all other areas documented on Kadebakele's Upper Terrace. Radiocarbon dates from below Surface 2 in Block A show much of the activities occurred contemporaneously to the other Iron Age excavation contexts.[14] However, two radiocarbon dates from Surface 1 date to the second millennium AD. Block A was thus an enduring complex that was the focus of visitation and commemoration long after the main Iron Age occupation (Morrison et al. 2016a).

Faunal patterns from Block A also confirm its distinct history (see Table 6.15 for NISP and relative abundance of taxa in Block A). Statistical analyses reinforced these conclusions. A chi-square test for homogeneity across major taxonomic groups at Kadebakele (cattle, caprines,

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[14] Based on depth of excavation and the fact that sterile deposits were never reached, it is likely that Block A also extends to at least early phases of the Iron Age, similar to Block B. Future radiocarbon submissions should confirm this since samples were taken from the lowest excavation levels, but have not been analyzed yet. It is unknown whether or not Block A's use life extended to the Neolithic period however definitive Neolithic artifacts were never identified in Block A as they were in Block B.

wild mammals, birds, fish, and herptiles) demonstrated that, the distribution of taxa varied across all excavation units at a level that was highly statistically significant (p-value <.01). The analysis of standardized residuals aid in identifying more specifically where differences in the distribution of taxa occur (see Table 6.16). Block A is particularly noteworthy in its divergences from the s site and other areas of the site. Specifically, Block A has more cattle than we would expect compared to any other area of the site if the distribution of taxa were homogenous. The standardized residual for cattle in Block A is 3.37, while for the Southern Slope it is 1.77.

Table 6.15: Taxa Across Different Areas of Kadebakele's Iron Age Occupation

	Whole Site	Block A	Block B	Southern Slope	North Midden	Eastern Upper Terrace
Cattle						
NISP	1393	486	496	280	91	40
%NISP	35.7%	39.7%	38.8%	38.5%	16.1%	37.7%
Caprines						
NISP	742	414	217	13	89	9
%NISP	19.0%	33.8%	17%	1.8%	15.8%	8.5%
Wild Mammals						
NISP	214	34	79	51	46	4
%NISP	5.5%	2.8%	6.2%	7.0%	8.2%	4.8%
Bird						
NISP	684	148	182	149	179	26
%NISP	17.6%	12.1%	14.2%	20.5%	31.7%	24.5%
Fish						
NISP	454	85	136	142	70	21
%NISP	11.6%	6.9%	10.6%	19.5%	12.4%	19.8%
Herptiles						
NISP	409	56	166	92	89	6
%NISP	10.5%	4.6%	13%	12.7%	15.8%	5.7%
Total NISP[a]	3899	1224	1278	727	564	106

Note[a]: Horse n=3 for reflect total NISP equaling 3918. Horse elements were found in Block A (n=1) and Block B (n=2)

Table 6.16: Pearson's Chi-Square Results					
	Block A	**Block B**	**Southern Slope**	**North Midden**	**Eastern Upper Terrace**
Cattle					
Observed	486	496	280	91	40
Expected	439.12497	455.17746	259.33700	201.54802	37.812548
Std Res	3.370373	2.907539	1.773354	-10.497833	.4496733
Caprines					
Observed	414	217	13	89	9
Expected	236.42766	245.07042	139.62868	108.51472	20.358515
Std Res	16.225750	-2.431250	-13.215670	-2.2535449	-2.8394564
Wild Mammals					
Observed	34	79	51	46	4
Expected	67.77593	70.25352	40.02689	31.10755	5.83
Std Res	-5.100312	1.308313	1.977811	3.1695121	-0.7927015
Birds					
Observed	148	182	149	70	26
Expected	215.62202	223.50423	84.52190	98.96543	18.566965
Std Res	-6.127546	-3.725459	2.342584	9.5782972	1.9256915
Fish					
Observed	85	136	142	70	21
Expected	143.11754	148.34930	84.52190	65.68758	12.323688
Std Res	-6.244946	-1.314476	7.372070	.6120047	2.6655004
Herptiles					
Observed	56	166	92	89	6
Expected	128.93188	133.64507	76.14417	59.17670	11.102177
Std Res	-8.203362	3.604990	2.128771	4.4303953	-1.6407866

Statistics: Pearson's Chi-Square =614.84 Df= 20 p-value= <2.2e-16

Given R. Bauer's research highlighting the importance of cattle in megalith contexts at Kadebakele, it is unsurprising to see the abundance of cattle in Block A or even that it would exceed the proportion of cattle of the Southern Slope given how much more extensively Block A was excavated. Notably, however, Block A differs from the other areas of the site in the abundance of caprines. Caprines occur in Block A in a higher proportion than anywhere else in the site. In fact, 56% of all caprines recovered at Kadebakele come from Block A. The cattle to caprines ratio is also much different compared to other areas of the site. In Block A, the cattle to caprines ratio in Block A is 1.2:1. In contrast, the cattle to caprines ratio in Block B is 2.3:1. More dramatically, in the Southern Slope, cattle outnumber caprines by a ratio of 23:1.

Wild taxa are also less well represented Block A than would be expected given their overall importance to the subsistence regime. Standardized residuals for various wild taxa groups in Block A are all negative, indicating that their distribution is less than we would expect or that they are underrepresented compared to the other units. These deviations are also the highest in absolute value compared to other areas of the site, with the exception of caprines, where the standardized residual indicates an overrepresentation of caprines in Block A at a value of 16.1. In Block A wild taxa occur in the following proportions, wild mammals 2.8%, fish 6.9%, birds 12.1%, and herptiles 4.6%. Altogether, wild taxa thus comprise only 26.4% of the Block A fauna. By contrast, the Southern Slope faunal assemblage is comprised of 59% of wild taxa, of which nearly 53% are non-mammalian taxa such as bird, fish, and herptiles. Thus, while the importance of cattle is evident in the Southern Slope, it is not to the exclusion of wild non-mammalian taxa. In Block A, however, there is a pronounced preference for domesticates. Interestingly, this appears to shift over time as later surfaces in Block A (Surface 9 through Surface 11) show that wild taxa constitute the majority of the faunal assemblage. Specifically, domesticates comprise 8.3%, 17.4%, and 37.8% of the faunal assemblages for Surface 9, Surface 10, and Surface 11 respectively.

Despite a higher abundance of domesticates identified in the mid to upper strata of Block A, faunal remains do not appear to result from feasting or large-scale consumption activities noted in the Southern Slope. Feature 29 in Block A, a large basin like feature, and its associated surfaces (Surface 4 and 4a), would likely provide the best comparative evidence for consumption activities because of the high volume of faunal remains and other artifacts recovered. When the distribution of fauna is compared by surface in Block A, this particular context contains the highest amount of identifiable fauna and the largest proportion of domesticates (87%). These however mostly occur within the surface matrices and not Feature 29 itself. In addition, unlike the Southern Slope where radiocarbon dates and depositional data seem to suggest a quick succession of building and deposition events, as well as efforts to seal deposits with fleshed remains and feasting contents that could have attracted scavengers (R. Bauer 2006:247), it is less clear whether similar building phases occurred in Block A. As a result, it is difficult to interpret and draw parallels using the faunal remains from Feature 29 and its associated surfaces since it is unclear how long these surfaces were used and whether or not the amount of animals present in these contexts represent one or multiple events over time.

Moreover, the elements represented in these contexts, as well as Block A more generally, are rarely meat rich limb elements. Instead, Block A has an overrepresentation in foot and skull remains (see Tables 6.17 and 6.18). Thus, the elements incorporated into Block A are more often discarded elements or butchery waste. However, the overrepresentation of skull remains for both cattle and caprines may have some other significance given specialized deposits containing isolated maxillae and antler caches (Features 12 and 13). Ultimately, however, evidence for meat consumption is absent in Block A.

Table 6.17: Distribution of Cattle Skeletal Parts Across Different Areas of Kadebakele's Iron Age Occupation Compared to Standard

	Whole Site	Block A	Block B	Southern Slope	North Midden	Eastern Upper Terrace	Standard
Head							
NISP	560	228	209	90	22	11	
%NISP	(40.2%)	(46.9%)	(42.1%)	(32.1%)	(24.2%)	(27.5%)	34%
Axial							
NISP	64	15	30	6	12	1	
%NISP	(4.6%)	(3.1%)	(6%)	(2.1%)	(13.2%)	(2.5%)	35%
Forelimb	75						
NISP	(5.4%)	24	30	8	8	5	
%NISP		(4.9%)	(6%)	(2.9%)	(8.8%)	(12.5%)	7%
Hind							
limb	68	13	31	14	8	2	
NISP	(4.9%)	(2.7%)	(6.3%)	(5%)	(8.8%)	(5%)	5%
%NISP							
Feet							
NISP	626	206	196	162	41	21	
%NISP	(44.9%)	(42.4%)	(39.5%)	(57.9%)	(45.1%)	(52.5%)	19%
Total							
NISP	1393	486	496	280	91	40	

Table 6.18: Distribution of Caprine Skeletal Parts Across Different Areas of Kadebakele's Iron Age Occupation Compared to Standard

	Whole Site	Block A	Block B	Southern Slope	North Midden	Eastern Upper Terrace	Standard
Head							
NISP	281	202	53	4	21	1	
% NISP	37.4%	47.9%	24.3%	30.8%	36.4%	11.1%	34%
Axial							
NISP	36	19	7	0	10	0	
% NISP	(4.8%)	(4.5%)	(3.2%)	(0%)	(11.2%)	(0%)	35%
Forelimb							
NISP	109	42	42	3	19	3	
% NISP	(14.5%)	(10.0%)	(19.3%)	(23.1%)	(21.3%)	(33.3%)	7%
Hind limb NISP % NISP	51 (6.8%)	22 (5.2%)	20 (9.2%)	1 (7.7%)	8 (9.0%)	0 (0%)	5%
Feet							
NISP	266	129	96	5	31	5	
% NISP	(36.5%)	(31.1%)	(44.0%)	(38.5%)	(34.8%)	(55.6%)	19%
Total	742	414	217	13	89	9	

The lack of evidence concerning meat consumption in Block A is also apparent in the low occurrence of burned faunal remains (Table 6.19). Recall, one primary feature of the Southern Slope megalithic deposit, that distinguished it from other areas of the site and buttressed an interpretation for specialized consumption or feasting, was the abundance of faunal remains that were partially charred, a burn signature associated with the roasting of remains. Out of the total NISP from Kadebakele, roasted remains from the Southern Slope account for 1.4% of the total site faunal assemblage. In Block A, roasted remains only account for .38% of the total site faunal assemblage. Notably, roasted remains are even less well represented in Block A than they are in Block B (although see discussion below).

Table 6.19: Distribution of Burned Bone Type (in %) Across Units out of Total Site NISP (n=92930)

	Carbonized	Calcined	Partially Charred
Block A	2.68	0.71	0.38
Block B	3.41	3.36	0.77
Southern Slope	3.52	0.35	1.46
North Midden	0.94	0.12	0.02
Eastern Upper Terrace	0.73	1.05	0.01

In assessing the relative abundance of burned remains across different areas (Figure 6.12), partially charred remains in the Southern Slope make up 28% of the burned bone recovered in the unit, the largest proportion of any area. The contrast is especially salient compared to the North Midden, which is characterized by domestic trash dumps. Here, roasted remains account for only 2% of the burned bone. Even in Block A, roasted remains only comprise 10% of the burned bone. Fauna from Block A did, however, exhibit high proportions of carbonized and calcined remains. While these types of burning cannot be ascribed to a single cooking or heat exposure method, it seems likely that at least some were incorporated into the repeated firing episodes documented in Block A, which Sinopoli et al. (2010) describes as being important to the practices involved in the uses and reproduction of Block A megalith features (14).

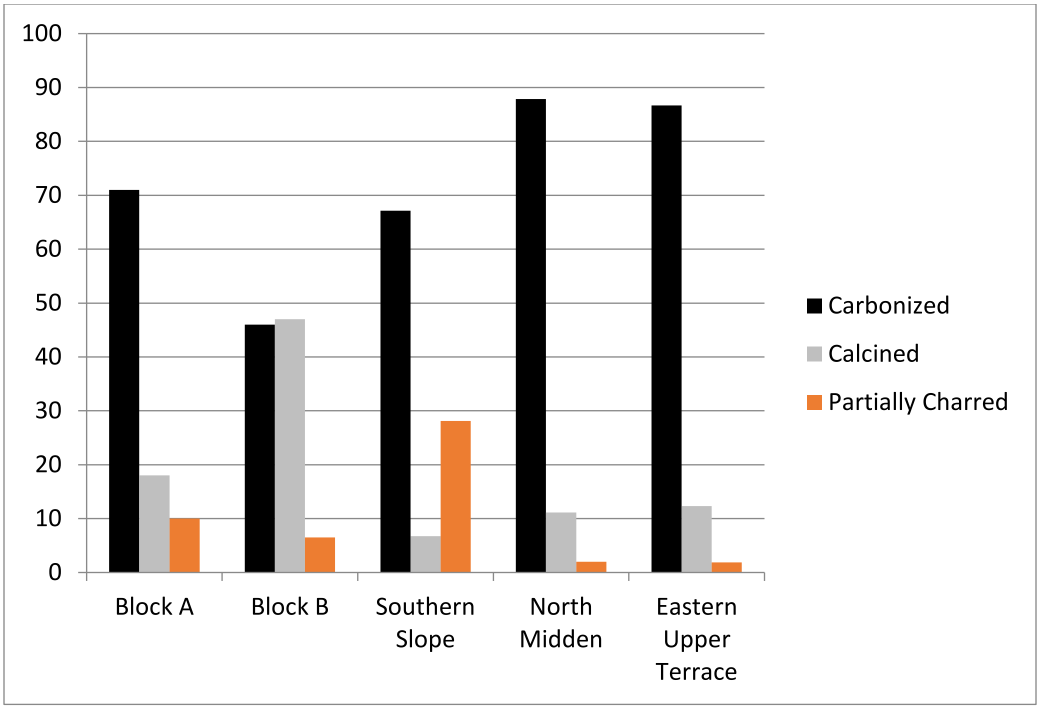

Figure 6.13: Relative Frequency of Burn Type by Unit at Kadebakele (Contemporary Phases of the Iron Age Occupation)

While meat preparation and consumption as practiced in the Southern Slope do not appear to have been similarly carried out in Block A, the differential distribution of taxa in Block A, specifically a pronounced focus on domesticates, likely coincided with consumption, and food sharing on some scale, even if consumption and the discard of consumption waste occurred elsewhere. Given the high representation of skull remains, for both cattle and caprines and an underrepresentation of meat bearing bones, Block A may have been an area where processing occurred or where skulls were preferentially or deliberately incorporated into the construction and/or use of commemorative features.

Age structure data from Block A lend support to the fact that the animals incorporated into the megalith complex were in some instances slaughtered for meat consumption. Age structure (based on tooth wear) for cattle from Block A are markedly different from the whole site sample. In Block A, peak mortality occurs during the sub-adult phase (33%) and advanced aged animals (42%). This is compared to the whole site sample, where only 7.7% were slaughtered during the sub-adult phase. For cattle, thus, there is a higher proportion of animals of primary or quality meat bearing age in Block A. This suggests that intentional slaughter of animals for meat was more likely to occur in megalith contexts than areas containing domestic refuse such as Block B and the North Midden. When animals occur in these latter areas, they are typically older or advanced aged animals. As noted, however, advanced aged animals are also present in the Block A assemblage, and at a higher proportion than sub-adults. There thus may have been multiple ways in which cattle were incorporated into Block A activities, with some being intentionally slaughtered at ages that provide quality meat yields, and some having died of natural causes. It could also be the case that advanced aged animals were intentionally slaughtered due to lack of productivity, suffering or illness, or other reasons that are not clear based on faunal remains alone.

As mentioned previously, one of the most striking differences in the faunal data from Block A is the abundance of caprines. The age structure of caprines in Block A does not differ from the whole site sample as much as the cattle age structure does. Instead, the Block A age structure for caprines reflects the kid mortality profile documented across the larger Kadebakele faunal assemblage. In Block A, 47% of the caprines are younger than 6 months and 53% are younger than one year. The second slaughter peak for caprines in Block A occurs at the sub-adult phase, with 20% having been slaughtered at this stage. Few adult and advanced aged animals were present in the Block A faunal assemblage.

The high proportion of juvenile caprines in Block A is interesting and could be interpreted in different ways. Given efforts to maximize caprine dairy production, caprines contributed an important dietary and economic resource during the Iron Age. Their importance as dairy producers could have created circumstances whereby when kid mortality was necessary to the rearing and maintenance of caprine herds for dairy, their slaughter may have been observed/honored in a specialized way and in relation to the use of commemorative spaces in Block A. While there has been much focus on the importance of cattle in prehistoric South India, whether through the creation of ashmounds from vitrified cattle dung[15], their portrayal in rock art, or their role in feasting practices, there is little in the way of the symbolic or potential ritual significance of caprines. While in some cases this could be the result of caprine remains being overlooked or disregarded in excavation contexts where hand collection was the recovery method employed, it is worth considering the possibility that caprines became important in a way that led to their incorporation into megalith construction and use during the Iron Age at Kadebakele. That is to say, within a context where clear evidence emerges for the specialized rearing of caprines for dairy, caprines may have taken on new significance during the Iron Age and became increasingly incorporated into ritual activities similar to what has been documented for cattle. If the incorporation of juvenile caprines in Block A is related to rearing strategies aimed at maximizing milk production, then Block A, and Iron Age Kadebakele more broadly, present an intriguing case example documenting the intersections of subsistence and economic production with ritual in ways that are often difficult to address in archaeology without subscribing to and perpetuating the sacred/profane or ritual/domestic dichotomy. Here, it is important to note that preferential selection of juveniles for specialized consumption cannot be excluded as an explanation for the abundance observed in Block A. Indeed, if commemorative

[15] Paddayya et al. (1995) argue cattle feasting was associated with the ashmound site Budihal. Boivin et al. (2005) indicate that on the basis of faunal analysis cattle are found in abundance in ashmound contexts while caprines predominantly appear in domestic trash contexts.

activities in Block A were smaller and more intimate in function, then smaller animals may have been preferred.

Ultimately, faunal patterns from the Southern Slope and Block A indicate that the areas were used differently despite both being areas associated with megalith construction. This is unsurprising given that throughout the region megaliths vary in their construction, their elaboration, and their associations with different contexts (A. Bauer et al. 2007; A. Bauer 2010). Block A and the Southern Slope units contain different megalith features and different construction histories and these ultimately coincide with differing sets of practices with different underlying functions. Interestingly, despite the fact that Block A contains a higher proportion of domesticates overall, and thus a higher proportion of high meat yielding animals, meat consumption appears to have occurred in a different kind of context, perhaps having a different purpose, function, or goal. Cattle consumption on the Southern Slope has been interpreted to reflect large-scale communal feasting. The interpretation of scale has important implications since R. Bauer (2006) posits that large-scale feasting could have been a mechanism for facilitating social cohesion amidst growing formalized social inequalities during the Iron Age (e.g., Dietler and Hayden 2001). Underlying this argument is the notion that communal sharing of food on a large-scale involves not just multiple individuals, but multiple social groups with differentiated status. Communal feasting aside, within the Iron Age, evidence supporting that social inequality or distinctions emerged and were formalized during the period are linked to the construction of megaliths themselves as the intensification of megalith building[16] required new forms of labor mobilization (A. Bauer et al. 2007: 13; A. Bauer 2011: 85).[17] It is nevertheless

[16] Notably, however megalith construction was not limited to the Iron Age.
[17] This is not to mention that some megalith sites within the region contain burials that vary in terms of individual versus group internments with differences in the elaboration of megalith

useful to narrow in on how communal consumption or feasting did function at Kadebakele since feasting can serve various purposes. The Southern Slope area itself is located in a difficult to access area of the site, south of residential and domestic areas like Block B and the North Midden (and similarly distanced from Block A) (see Figure 6.12). The area is small and, as is indicated by the area designation, steeply sloped. Ultimately, it may have been difficult for a large number of people to occupy the area and directly participate in the ritual practices associated with its construction and use. As a result, participation in the events that specifically occurred in or near the Southern Slope unit may have been more limited. In fact, Johansen (2019) suggests that Iron Age feasting practices were more socially exclusive than inclusive, comparing consumption on Kadebakele's Southern Slope to feasting events associated with Neolithic ashmounds, which would have been more open and publically accessible (64). While the abundance of cattle remains, as well as the high concentration individual sized serving vessels thought to be associated with feasting (Sinopoli 2016), may still speak to larger-scale consumption events at Kadebakele (see also discussion of Feature 40 Block B below), Johansen's argument that there may be have been an exclusive element to the broader ritual performance taking place in the Southern Slope has merit.

If some aspects of Southern Slope activities were more exclusive in character and perhaps limited to smaller groups, then there is an argument to be made about broader range of

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construction and associated grave goods (Brubaker 2001; Leshnik 1974; Moorti 1994). However, Kadebakele megaliths excavated to date do not appear to contain human burials, although they could be outside of the excavation area. In addition, some of these mortuary examples documented throughout the region do not have associated radio carbon dates and since megaliths do not only appear during the Iron Age it is appropriate to think through multiple ways in which accurately dated megaliths can inform interpretations regarding social inequality during the Iron Age.

accessibility to and interaction with Block A that Kadebakele residents may have had. Caprines occur in very low frequencies in the Southern Slope. However, in Block A cattle and caprines are nearly equally represented. This could thus indicate a broader range of accessibility or displays of different forms of wealth. As an example, when it comes to Block A, it could be the case that either cattle or caprine owners could be a part of food sharing activities, whereas in the Southern Slope, this would have been exclusive to those having cattle. Activities could also reflect varying degrees of participation from the household level to larger groups.[18]

In addition, Block A, with its closer proximity to residential and domestic areas compared to the Southern Slope, may have played a more visible role and was possibly more accessible and interacted with more compared to the Southern Slope, as residents carried out daily activities. With knowledge of Block A's use life in combination with the distribution of beads at Kadebakele, Kelly (2013) draws out a similar observation. Kelly contrasts the deposition of beads at Block A to megaliths at Brahmagiri to show that at Brahmagiri, beads were deposited as strung necklaces as offerings or grave goods while beads at Block A were individually incorporated into deposits and thus likely reflect the loss of individual beads within a context of ongoing and long-term interaction with the sacred space (164).

Complete analysis of the Block A faunal remains ultimately affirms the fact that different areas of Kadebakele were characterized by different activities, including activities related to the processing, preparation, consumption and discard of animals. Analysis of the faunal remains

[18] In the absence of corroborating written records, we of course do not know for certain what notions of property or ownership looked like during the Iron Age, or whether these specifically served as axes for social differentiation. We do infer from their economic and ritual associations that domesticates were valuable in different ways and thus can use that as a basis hypothesize how the differences in animal representation between the Southern Slope and Block A intersected with what we know about the emergence of social inequality and differential power relations during the Iron Age.

from Block B, however, indicate some potential shifts in how this area was used over time. With the completed analysis (e.g., my analysis of the 2009-2010 excavation data and R. Bauer's of 2003 and 2005 data), the proportional representation of species in Block B (with the exception of caprines) more closely approximates the faunal distribution in the Southern Slope (see Table 6.16). This is contrasted with R. Bauer's earlier analysis where Block B and the North Midden had more similar distributions of taxonomic representation (R. Bauer 2006:192). Excavations in 2009 and 2010 deepened and expanded the sample from Block B, and exposed several features with high volumes of fauna. Some of these features suggest that this area may not have been the focus of solely domestic activity throughout its long use history. For example, the EHLTC team exposed Feature 40, a large (1.22cm x 1.25 cm) pit cut into Surface 8 of Block B. Feature 40 containing ashy deposits and was lined with burned terracotta cakes along its southern half. It may have been used for *in situ* cooking, quite possibly roasting. The pit was surrounded by postholes and appears to have had a thatched roof above it that was later burned. Analysis of radiocarbon dates from Feature 40 and the lower levels of Block B is ongoing. Preliminarily, however, Feature 40 appears to fall within the range of 918 BCE and 790 BCE. If confirmed, this puts Feature 40 within a transitional phase between the Early Iron Age and the Middle Iron Age, based on tentative chronology published by Morrison et al. (2016b) and Sinopoli (2016). This is notable because most analyses published to date from Kadebakele are on material recovered from the Middle Iron Age. Feature 40 thus stands to offer a glimpse into an earlier phase of the Iron Age.

Fauna from Feature 40 include cattle, caprines, birds, fish, a frog, and a hare. As depicted in Figure 6.14, Cattle comprised a majority of the Feature 40 fauna assemblage at 59%. Caprines comprise 15%. Wild taxa such as birds, fish, herptiles and small mammals comprise 7%, 15%, and 2%, respectively. While the diversity of species mirrors the overall site profile, domesticates make up nearly 75% of the Feature 40 assemblage, and wild animals make up 25%. Thus, domesticates are represented at a higher level in this particular feature compared to the total Iron Age assemblage (54.8% domesticate, 45.1% wild), as well as compared to what we previously might have expected from a habitation context.

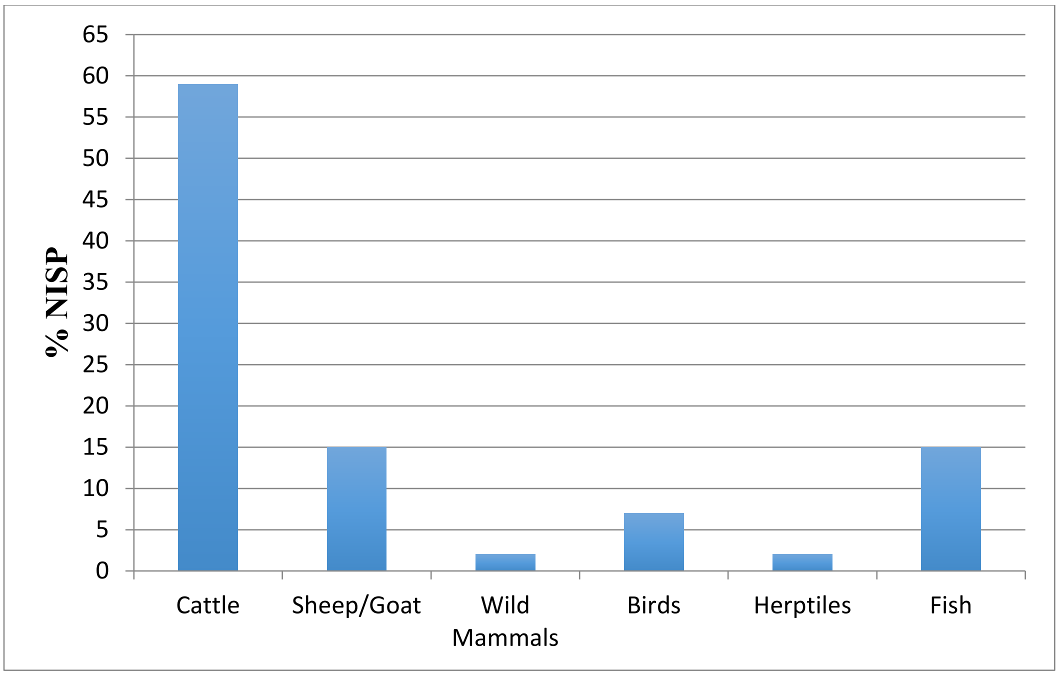

Figure 6.14: Feature 40 Taxa in Block B

Feature 40 also contains the highest percentage of burned remains of any feature at Kadebakele. Notably, nearly 55% of the remains were roasted. As discussed above, roasted remains are rare in domestic areas and previously were documented almost exclusively in the Southern Slope megalith (R. Bauer 2006). Cattle from Feature 40 appear to be younger animals, some with barely any tooth wear on permanent teeth and also one individual with an unworn deciduous molar, making it less than four months old. Fusion data show there were also older cattle incorporated into Feature 40's fill. For example, a fused, roasted proximal humerus was recovered, which comes from an animal that is at least 3-4 years old.

The age classes of cattle from Feature 40 are important for multiple reasons. The first is that young animals, especially cattle, were rarely deposited in domestic contexts. As previously discussed, cattle from Kadebakele more often survived into adulthood and advanced age and the slaughter of young animals was believed to be restricted to megalith contexts such as the Southern Slope, although certainly excavation coverage of Upper Terrace was limited. Another important aspect has to do with the use life of Feature 40. There is reason to believe that the contents from Feature 40 reflect a single depositional event that was subsequently sealed. While the pit was excavated in 5 arbitrary levels, the matrix was consistent throughout. In addition, faunal remains from separate levels could be refitted. For example, a large rib was reconstructed from fragments recovered in levels 2 and 5. If Feature 40's fill reflects a single depositional event, then at least three different individual cattle were slaughtered, cooked, and incorporated into the Feature 40 fill. This in combination with the high abundance of roasted remains would lend further support to evidence of feasting at Kadebakele, including the potential for feasting to include a large number of people while also situating such events within an even earlier phase of the Iron Age. In this case, however, the remnants of feasting are not exclusively associated with megaliths. While the faunal remains from Feature 40 are not consistent with consumption waste (i.e., this is not where feasting or consumption took place), Block B in this context appears to be an area where food preparation took place for a feasting event.

Analysis of other Feature 40 foodstuffs and artifacts are ongoing (e.g., Bates et al. 2022). A more comprehensive and contextual analysis of all of the artifact classes, as well as a better dating sequence from Block B will further aid in understanding how activities changed over time in this area or how roasting may have taken on different meanings or been used in different contexts. For now, Feature 40's use in Block B, an area previously characterized as having primarily been a locus of domestic and residential activity, enables further consideration of the interconnectedness of domestic and ritual spaces.

6.4 Conclusion

In this chapter, I presented the available faunal data from the Neolithic settlement at Kadebakele, adding my analyses of materials recovered in 2009 and 2010 to earlier work by R. Bauer. While limited, the late Neolithic faunal evidence from Kadebakele parallels what has been observed at other Neolithic sites. The two main points of consistency noted from the Neolithic faunal assemblage were that domesticated cattle and caprines appear to have been raised for secondary products (dairy) and that cattle were used for traction. Further research and larger faunal samples are needed to fully explore the extent to which hunting occurred alongside agropastoralism during the Neolithic at Kadebakele and how mobility and herding factored into subsistence strategies.

The bulk of my analysis in this chapter is on the Iron Age faunal assemblage. The Iron Age faunal data showcase the multiple ways figured into subsistence practices, economic strategies, and ritual life. Broadly speaking, Kadebakele's residents relied on a diverse dietary faunal resource base. Hunting and herding were both important to overall subsistence, with near equal proportions of wild taxa and domesticate represented in the faunal assemblage. Domesticates were relied upon in multiple ways. Caprine husbandry was aligned with specialized dairy production. Cattle were also raised for secondary products. In addition to dairy, pathological foot remains show cattle were used for traction labor. Castration appears to have been practiced in order to provide animals that were physically and behaviorally amenable to traction and labor bearing activities.

During the Iron Age, animals also figured into ritual activities associated with megalithic construction and maintenance. There was variation in how animals were incorporated into such practices, with evidence for different scales of feasting and food sharing, as well as the internment of animal body parts within small megalith features. This speaks to the overall variation in the kind of practices associated with megalith features, and reveals how two areas containing megalith features differed in the nature and duration of use at a single site.

While my analysis of faunal remains, particular from the Iron Age settlement, goes beyond the subsistence economy to address the ritual significance of domesticated animals, it still does not fully reconstruct how Kadebakele's residents perceived their relationships with animals and the environment. I explore these topics further in the concluding chapter. Before that, I present the results of my analyses of Early Historic fauna (Chapter 7) and dental microwear (Chapter 8). Together, these provide additional context and complementary data sets that allow for a more robust depiction of how perceptions of animals and the environment shaped decision-making over time.

CHAPTER 7 :
EARLY HISTORIC FAUNA

7.1 Introduction

The previous chapter described the results of faunal analysis on the Neolithic and Iron Age assemblages from Kadebakele's Upper Terrace. In this chapter, I present the results of my analysis of fauna recovered in small scale excavations on the Kadebakele River Terrace, where settlement was concentrated after ca. 400 BCE. With key aspects of Kadebakele's subsistence economy established for earlier periods, this chapter examines what continuities and changes are visible based on Early Historic faunal patterns.

In general, little is known about Early Historic animal-based subsistence practices in southern India. Of the peninsular sites that have been excavated and studied, the scholarly focus has been on coastal ports and trading sites (Champakalakshmi 1996) with little attention paid to the study of faunal remains and animal economies. From the limited faunal data available, there is some evidence to suggest that the proportion of wild animals, relative to domesticates, decreased during the Early Historic period (Thomas 1989). Although more research is needed, this pattern is expected given what is known about broader shifts in social, political, and economic practices between the Iron Age and Early Historic periods in South India.[1] Population and settlement growth, and the move toward more specialized and intensified forms of craft and agricultural production, could have created circumstances where individuals became more involved with other forms of labor and economic activities and, as a result, had less time and opportunity to hunt for themselves and procure their own food resources. This raises the question as to whether or not by the Early Historic period at Kadebakele, dietary resources from domesticates were produced at a larger and/or more intensified scale and whether food

[1] See Chapter 3 for detailed review.

(specifically meat) provisioning was adopted as means to distribute dietary resources and support a growing community with an increased number of economic specialists.

Kadebakele's Early Historic settlement exhibits multiple traits that are consistent with the broader characteristics of the Early Historic period across South Asia and, as such, Kadebakele is an ideal case site to explore these questions. For example, Kadebakele settlement expanded in extent, shifting from a known six-hectare, concentrated settlement on the Upper Terrace during the Iron Age, to as large as 40-60 hectares when settlement shifted to the River Terrace (Sinopoli et al. 2010).[2] Settlement expansion appears to coincide with consolidation, since the overall number of sites decreased between the Iron Age and Early Historic periods, including in the EHLTC research area. From the evidence of settlement expansion and consolidation, it can also be inferred that population density increased at sites like Kadebakele.

Kadebakele also exhibits evidence for specialization and intensification by the Early Historic period. This is demonstrated, for example, by changes in ceramic production at Kadebakele since by the Early Historic period, ceramics at Kadebakele became less diverse with production oriented toward the mass production of standardized forms (Sinopoli 2016; Morrison et al. in press). In addition, while botanical analyses are ongoing, and thus evidence of rice production (and/or its scale) at Early Historic Kadebakele is not currently available, the shift from intensive settlement on the Upper Terrace during the Iron Age to intensive settlement on the River Terrace during the Early Historic period is thought to, in part, reflect strategies to intensify agricultural production by making use of the flood plain (Morrison et al. 2009). Intensified and potentially larger-scale production of agricultural products during the Early

[2] This is based on the extent of distributed artifacts. Additional excavations are needed in order to ascertain the true size of the site, however it is clear that settlement grew between the Iron Age and the Early Historic period.

Historic period is an important factor in reconstructing and understanding decisions related to animal husbandry and animal-based subsistence practices. This is because agricultural activities require land availability and in ways that can conflict with raising and maintaining domesticates on site. In addition, time and labor requirements related to intensified agriculture could put constraints on mobility and affect the degree to which animals could be extensively herded as well as time spent hunting.

Given the relationship between potential population growth, economic specialization, and agricultural production, some degree of food provisioning may have been adopted as more specialized and labor-intensive economic activities impacted the ways in which individuals could hunt and procure their own dietary resources. For example, during the Early Historic period, we might expect to see a decline in wild taxa (hunting) compared to the Iron Age, as well as a shift from diary production to meat production, with distribution organized by a centralized authority. In this chapter, I review the details of the Early Historic faunal assemblage from Kadebakele. Because of the nature of the Early Historic sample (see Chapter 4, Chapter 5, and further discussion in this chapter), the data is preliminary and limited. While there do appear to be clear changes in subsistence practices and the organization of animal husbandry by the Early Historic period, the evidence to date is not consistent with provisioning, at least not when considered alongside previously established provisioning models (see Chapter 2). This yields new questions to be answered with further excavation and analysis from the Kadebakele River Terrace in the future.

7.2 Sample Description

Excavations of Early Historic deposits on the River Terrace of Kadebakele were carried out with different goals in mind compared to the Upper Terrace. As a result, the respective excavation strategies differed. River Terrace excavations (Early Historic deposits) were conducted to expose a deep stratigraphic profile and establish the most complete chronological sequencing possible. To achieve this under time constraints, excavations made use of already existing holes and trenches. This allowed for accelerated excavations, with the goal of documenting and exposing the deepest extent of River Terrace stratigraphy. Despite adopting this strategy, sterile deposits were not reached on the River Terrace and we do not have a clear sense of when occupation of this area began.

While recovery methods for the River Terrace were the same as the Upper Terrace, Early Historic excavations did not produce faunal sample sizes comparable to the Iron Age. In addition, they did not provide insight into different activities across the site in the way Iron Age excavations did. Large pits were encountered during Early Historic excavations, however, further analyses of all of the recovered material is needed in order to determine with certainty whether or not these were domestic trash pits. The smaller faunal sample size (n=1491) as well as the lack of intrasite variation, makes the Early Historic faunal data set analytically limited. This is particularly true for trying to identify patterns of continuity and change between the Iron Age and Early Historic settlements at Kadebakele. The discussion of the Early Historic faunal data is thus ultimately preliminary, open to revision, and is offered as a basis for designing future research questions about Early Historic animal husbandry, diet, and human-animal relationships in the Tungabhadra Region of South India.

7.3 Relative Abundance of Species

From the available faunal data, notable shifts occur in the relative abundance of species between the Iron Age and the Early Historic periods. To begin, the proportion of domesticates during the Early Historic was smaller, shifting from nearly 55% during the Iron Age to 20.5%

during the Early Historic period. Domesticated animals identified in the Early Historic faunal assemblage include cattle, caprines, and horses. Horse remains were identified at a higher frequency compared to the Iron Age, although they still comprised a small proportion of the total assemblage. While horse account for less than 1% of the Iron Age assemblage, they make up 1.3% of the Early Historic assemblage. The proportion of cattle and caprines, however, shifts more dramatically between the Iron Age and the Early Historic period. During the Iron Age, cattle comprise 35.7% of the total faunal assemblage, but only account for 9.2% of the Early Historic assemblage. Caprines also decrease, comprising 19% of the total assemblage during the Iron Age, but only 10.5% during the Early Historic period. Notably, the ratio of cattle to caprines shifts markedly between the Iron Age and Early Historic period, with cattle outnumbering caprines nearly 2:1 during the Iron Age, to cattle and caprines being nearly equally represented, with caprines actually slightly outnumbering cattle. A point of consistency between the Iron Age and the Early Historic assemblages is that no sheep were positively identified; Four elements were identified as goat while the remaining others could only be identified as belonging to either sheep or goat.

The distribution of wild species in the Early Historic assemblage also differs from the Iron Age in noteworthy ways. While comprising more than three-quarters of the total NISP, the Early Historic wild faunal assemblage exhibits much less variation in species compared to the Iron Age. Wild mammals, for example, occur less frequently in the Early Historic assemblage than in the Iron Age. The only wild mammals that occur in both Iron Age and Early Historic contexts are pigs (see further discussion below), the Indian Hare and the civet. Pigs occur at nearly the same frequency as was documented during the Iron Age (roughly 2% of the total faunal assemblage). The Indian Hare and civet, however, occur in very small numbers (n=2 and n=1, and less than 1% of the total faunal assemblage). Wild bovids and cervids are entirely absent from the Early Historic assemblage, while the Iron Age contained varying proportions of blackbuck, sambar, nilgai, chital, and gazelle.

There is also less diversity in non-mammalian wild taxa when comparing the Iron Age and the Early Historic faunal assemblages. For example, while birds, fish, and herptiles are all represented in both the Iron Age and the Early Historic assemblages, herptiles are less common in the Early Historic assemblage. This is especially salient for turtles. Soft-shell turtles and other indeterminate turtle species made up a majority of the herptile category in the Iron Age assemblage (7%). By contrast, turtles account for the entire herptile category for the Early Historic period but only comprise .4% of the total assemblage. In addition, during the Iron Age, birds constituted the largest proportion of the non-mammalian wild taxonomic group at nearly 18%. This was notable because of the fact that birds nearly equaled the proportions of Iron Age caprines (19%). Knowing that caprines were a significant component of the Iron Age secondary products economy at Kadebakele, the near equal representation of caprines and birds proved indicative of the fact that birds and bird hunting was also an important component of Iron Age diet and subsistence practices. During the Early Historic period, however, birds no longer constitute the largest proportion of non-mammalian wild taxa. In contrast to their 18% make up during the Iron Age, birds only comprise roughly 6% of the Early Historic faunal assemblage.

Despite decreases in the range and proportion of herptile and bird species during the Early Historic period, the non-mammalian category actually increases in total proportion compared to the Iron Age. During the Iron Age, non-mammalian taxa account for 39.6% of the total faunal assemblage. However, by the Early Historic period, non-mammalian taxa comprise 76.2% of the total faunal assemblage. The large proportion of non-mammalian taxa is driven by the high abundance of fish recovered from Early Historic contexts, which comprise 69.8% of the total NISP.

The proportional increase in fish between the Iron Age and the Early Historic settlement at Kadebakele is perhaps unsurprising given that settlement was on the banks of Tungabhadra River during the Early Historic period. However, given that the Upper Terrace (Iron Age settlement) is still within close proximity of the Tungabhadra River (see Image), and likely provided the primary source of drinking water to people during the Iron Age, the proximity does not provide an adequate or complete explanation for such a dramatic shift.

Based on the larger proportional make up of wild versus domesticated taxa it might be inferred that hunting became a more important subsistence practice compared to animal husbandry between the Iron Age and the Early Historic period. However, with the reduced diversity of wild taxa there is an accommodating reduction in the variety of procurement practices and skillsets exercised during the Early Historic period. For example, large game hunting does not appear to have been a component of the Kadebakele subsistence regime like it was during the Iron Age. Similarly, the capture of birds and other small herptiles appears to have been less important or less practiced by comparison. Pigs hunting appears to have been maintained between the Iron Age and Early Historic and may also have coincided with efforts to prevent agricultural damage brought on by wild boars (see discussion below).

Ultimately, within this larger context, hunting does not appear to play the same role in the broader subsistence regime that it did during the Iron Age. Fishing, although practiced during both the Iron Age and the Early Historic periods, also appears to potentially have played different roles. During the Iron Age, procurement of wild resources, including fishing, seems to have largely coincided with individual or household level subsistence procurement. During the

Early Historic period, fishing may have become the focus of intensified subsistence production for markets/consumers. Most of the identifiable fish remains were skull bones with distinctive features. Thus, their abundance is not explained by skeletal part bias or over representation problems from using raw counts. Fish were recovered from feature and non-feature contexts and range from small species to some very large species (which may also point to an expansion of fishing technologies and efforts to intensify fishing efforts during the Early Historic period). Alternatively, and perhaps more likely, fishing may have become a more widespread practice during the Early Historic period as a complementary subsistence procurement strategy that could have been undertaken alongside farming. For example, if inundation farming was adopted during this time, fishing could have occurred as farmers were simultaneously keeping watch over and tending to agricultural fields.

Shifts in hunting resources and practices raise questions about how animal husbandry and may have changed during the Early Historic period. Based on the species distribution, domesticates no longer dominate the faunal assemblage at Kadebakele; however it is unclear how or whether this translates into a shift in importance concerning their role in the Early Historic subsistence system and social life. Given the significant roles that domesticated cattle and caprines played in economic and ritual life during the Iron Age, it seems surprising that the reliance on domesticated herd animals would shift so dramatically without an indication as to what would precipitate such a change. This is especially unanticipated because it is expected that cattle, at least, would become even more important sources of traction labor amid agricultural expansion and possibly rice production during the Early Historic period. An overall reduction in the diversity of hunted food and protein resources compared to the Iron Age would also lead us to expect that pastoral products, whether dairy or meat, would increase in importance. That is to say, if less hunting and individual procurement of food resources was occurring, then we would expect that domesticates would at least have remained as important as sources of food during the Early Historic period, possibly even warranting centralized control of production and distribution. The subsequent sections aim to reconstruct the role of cattle and caprines based on the limited data available. Included is also a discussion of pigs and the justification for considering pigs as wild as opposed to domesticated.

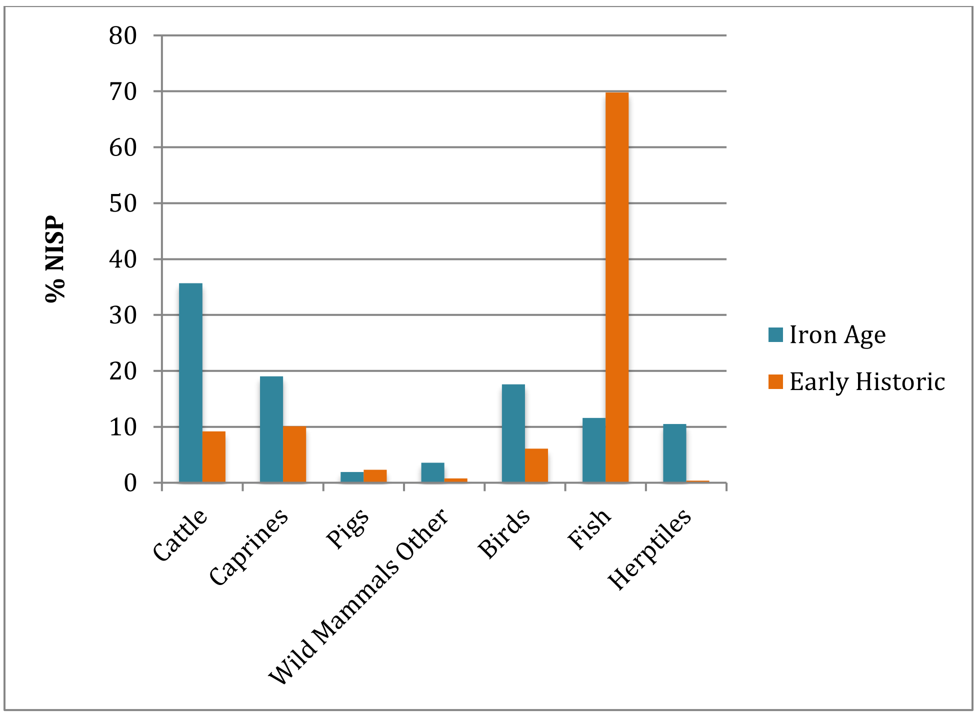

Figure 7.1: Iron Age Versus Early Historic Species Distribution at Kadebakele

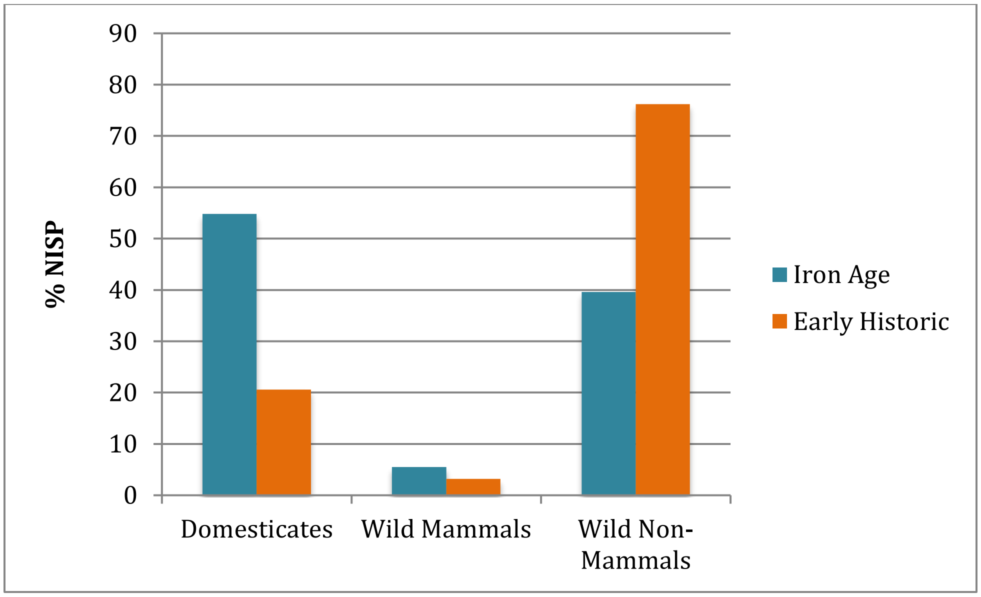

Figure 7.2: Iron Age Versus Early Historic Taxa Groups at Kadebakele

Table 7.1: Species Frequency by NISP, Proportion, and Weight from Kadebakele River Terrace

Taxa	NISP	Proportion	Weight (g)
Cattle	48	9.2%	700.2
Caprines	53	10.1%	183.7
Birds	32	6.1%	14.4
Fish	366	69.8%	87.4
Herptiles	2	.4%	16.9
Pig	12	2.3%	93.6
Horse	7	1.3%	121.5
Civet	1	.2%	.3
Indian Hare	2	.4%	.3
Mole	1	.2%	.1
Domesticates	108	20.6%	1005.4
Wild Non-Mammalian Taxa	400	76.2%	118.7
Wild Mammals	17	3.2%	94.3

7.4 Herd Composition

Sample sizes for mandibles and teeth, as well as for fused and unfused elements, for domesticates in Early Historic contexts are small. Thus, it was not possible to construct survivorship curves comparable to those produced from the Iron Age faunal data. The small sample sizes ultimately overemphasize differences between the age categories. In addition, efforts to maximize the amount of information that can be gleaned from the small samples mean that the age data is approached differently compared to the Iron Age analysis. For example, analysis of tooth wear extends to include heavily worn incisors in cattle. Deciduous upper molars were also incorporated into the analysis since their retention offers insights into relative age (animals retaining deciduous upper molars are under 2 years old). In addition, fusion groups for caprines, based on Zeder (2006), were consolidated because the subdivision of the tooth assemblage under Zeder's system rendered too few teeth across classes in ways that obscured interpretations. These things considered, interpretations of the herd composition on the basis of age should be treated as preliminary and as a baseline for further developing and testing questions concerning husbandry practices and economic organization during the Early Historic period at Kadebakele.

Pigs

Pigs compromised a similar proportion of the faunal assemblage from the River Terrace as from the Upper Terrace (roughly 2%). Like the Iron Age fauna, the age structure for pigs from Early Historic contexts is not consistent with pig husbandry. There are fewer ageable elements in from Early Historic deposits, but notably there is only 1 unfused element out of 6, and that unfused element belongs to the late fusing category (the proximal tibia which fuses at 42 months). In other words, there are no definitively young pigs from the Early Historic faunal assemblage and 5 out of 6 ageable elements (83%) are from animals that are at least 2 years old. This is nearly equal to the proportion of adults identified in the Iron Age assemblage (82%).

For the reasons outlined in Chapter 6, it appears that Early Historic people continued to hunt wild pigs rather than raise them for meat. This is important since, all things considered, we might have expected to see an increased reliance on domesticated pigs given what is currently hypothesized concerning Early Historic economic specialization. Under a more specialized economic system, where food provisioning may be necessary to support a growing populace that is increasingly removed from procuring its own dietary resources, small-scale pig rearing and consumption at the household level can provide a quick and efficient food source because of the growth rate of piglets (Redding 1991). However, when this occurs in other archaeological contexts, complementary pig rearing and consumption at the household level tends to occur in villages or smaller satellite sites connected to a larger center, the logic being that specialized food or economic producers would rely on pigs as an inexpensive and efficient dietary resource (Zeder 1991; Redding 1991; 1992). Kadebakele, in this context, would better align with what we think of town or city center rather than a satellite or village site, although much more archaeological data is needed to better understand the extent of economic production and consumption at Kadebakele and its larger regional interactions during the late first millennium BCE-early first millennium CE. Alternatively, however, there could be intrasite variation where we could observe market differences and see household level pig rearing for specialized producers, however the preliminary pig data here continues to point to the fact that pig husbandry at Kadebakele was not practiced during the Early Historic period. Continued hunting of pigs may have been primarily motivated by efforts to eliminate threats to agricultural fields especially in a context where rice and other forms of agriculture are hypothesized to have expanded and intensified. It is also worth highlighting that rearing domesticate pigs need not be the only model informing urban-village subsistence systems. Here, the abundance of riverine resources (fish) may provide an alternative model supporting more specialized economies.

Table 7.2: Relative Age Based on Epiphyseal Fusion for Pigs at Early Historic Kadebakele

	Unfused	Fused
Early Fusing	0	1
Middle Fusing	0	4
Late Fusing	1	0

Cattle

Four of the 13 cattle elements in the Early Historic faunal assemblage were unfused, compared to nine fused. While the fact that fused elements outnumber unfused elements would suggest that the sample is made up of more adults than juveniles, the patterns across fusion groups nevertheless show some differences from the Iron Age. Of the unfused elements, one animal was definitively young, having an unfused glenoid cavity of the scapula. The glenoid cavity typically fuses around 7-10 months (Silver 1969), indicating that this animal was of either fetal or juvenile age at death. The remaining unfused elements are less definitively informative and include an unfused distal 1st phalanx epiphysis, an unfused distal metapodial, and an unfused distal radius epiphysis. These elements fuse at 24 months, 36 months, and 42-48 months respectively (Silver 1969). Because unfused elements only represent the maximum age an animal could have lived, it is unclear whether these animals fall into the category of juvenile, sub-adult, or adult. The 1st phalanx and metapodial were from an animal that was no older than a sub-adult, but could have been a juvenile, while the distal radius was from an animal that was no older than an adult, but could have been a sub-adult or juvenile.

Of the nine total fused elements, 6 are early fusing and 3 are middle fusing. When comparing the frequency of fused and unfused elements in cattle, the fusion data preliminarily suggest a low level of infant and juvenile mortality since 86% survived until at least 18 months. The middle and late fusing data, however, appear to suggest that a sizeable proportion of cattle did not survive into adulthood and were slaughtered as sub-adults. For example, within the Middle Fusing group (elements that fuse between 24 and 36 months), only 60% are fused while 40% are unfused. This would indicate that a larger proportion of the herd was slaughtered at prime meat bearing age compared to the Iron Age. For example, during the Iron Age, 77% of the middle fusing elements were fused. Thus, contrary to the Iron Age, cattle may have been slaughtered more often at their optimal meat quality/meat bearing age. If verified, this would be a notable shift given the previous history of cattle being animals primarily raised for secondary products from the late Neolithic and Iron Age. However, given the very small sample size, this should be treated with caution. The small sample size results in extreme proportional values and may be the better explanatory factor for the age patterns in the fusion data.

Table 7.3: Relative Survivorship for Cattle from Early Historic Occupation at Kadebakele

Relative Age Based on Fusion	Unfused	Fused
Early Fusing (Under 12 months)	1 (14%)	6 (86%)
Middle Fusing (2-3 years)	2 (40%)	3 (60%)
Late Fusing (Under 4 years)	1 (100%)	0 (0%)

Tooth wear data for cattle is similarly limited (n=8). A further complication is the lack of complete cattle teeth recovered from Early Historic contexts. Fractured and fragmented teeth cannot be assigned a wear stage category for age estimation purposes. In addition, a majority of the teeth are loose or separated from the mandible or maxilla. While loose teeth can be used in mortality analyses in zooarchaeology, it is ideal to use complete mandibles because the assessment of eruption timing and tooth wear stages across multiple teeth provides better resolution for age estimation. Below I summarize the most that can be gleaned from the limited dental sample.

Two out of the 8 complete cattle teeth can be aged based on their unerupted and deciduous status. Both came from the same excavation context (Level 8 of 57.16E/-561.77N) and may come from the same animal. An unerupted mandibular molar (M1 or M2) and a deciduous maxillary molar likely come from an animal younger than 12-18 months. Of the 6 permanent teeth, four come from animals that survived to at least sub-adulthood (Table 7.5). Two teeth are lower incisors and come from different contexts. Although permanent lower incisors in cattle erupt in sub-adulthood (between 18 and 36 months), the high degree of wear on incisors indicates that these animals were at least 5 years old and maybe even as old as 8 or 9 (Parish and Karisch 2013). Using tooth wear estimation, two of the lower molars represent animals aged 18-30 months. A lower permanent premolar exhibited little wear suggesting that it was a recently erupted tooth and the animal died between 24 and 30 months (sub-adult aged). The remaining teeth listed in Table 7.5 come from maxillary teeth, which do not allow for the same correlation of wear stage to age as mandibular teeth. Two of the maxillary molars exhibit a high degree of wear suggesting they are likely older relative to the eruption age, however it is unclear how far into adulthood these animals survived.

Dental eruption and wear data are similar to fusion data when it comes to a lack of evidence for calf mortality or the slaughter of juvenile animals. Dental evidence also shows the presences of some sub-adults (n=2). In addition, tooth wear data show older and advanced aged animals present in the sample, something that is not available in the fusion data. Ultimately, older animals appear to outnumber sub-adults and juveniles. Thus, the dental data complicates the meat orientation interpretation preliminarily posited based on bone fusion. Both data sets however suffer from small sample sizes.

Table 7.4:Age Estimates Cattle Teeth Based on Eruption or Wear Stage from Kadebakele River Terrace (Early Historic Occupation)

Tooth	Eruption Age	Wear	Age Category
Deciduous Upper M1/M2	<12-18 months		Juvenile
Unerupted molar	< 12-18 months	None	Juvenile
Lower M2/M3	18-30 months	D:30-36 months	Sub-Adult
Lower M1/M2	18-30 months	D:30-36 months	Sub-Adult
Upper M3	24-30 months	Very worn	Adult/Old Adult
Upper M1/M2	12-18 months	Very worn	Adult/Old Adult
Lower incisor	18-36 months	Very worn	Old Adult
Lower incisor	18-36 months	Very worn	Old Adult

No cattle remains were recovered that could yield information on the male to female ratio, nor were there enough complete bone ends available to perform metrical analyses assessing sexual dimorphism. However, pathologies related to traction continued to be present. Three phalanges identified from the Early Historic faunal assemblage exhibited evidence of osteoarthritis or evidence of traction induced strain on the tendons and foot bones (Bartosiewicz et al. 1997). A few of the specimens identified were noted as being larger and more robust compared to the majority of elements identified within the Iron Age assemblage. Metrical data for four foot and limb bones fall within the ranges observed in water buffalo skeletons (R. Bauer 2006:632-640) and thus may reflect the presence of water buffalo in the sample. Thus, while ultimately the age and sex structure of cattle from the Early Historic period are lacking, there is some indication that cattle continued to be raised as sources of traction labor with preliminary evidence that water buffalo specifically may have been used for traction. While water buffalo also appear to have been used for traction during the Iron Age, their use in the context of the Early Historic period River Terrace occupation has implications for further understanding the development and scaling rice agriculture. Botanical analyses from the River Terrace are ongoing and, in the future, will provide important contextual insight for understanding the relationship between animal management choices and shifts in agricultural production.

Caprines

Similar to cattle, fusion and dental eruption and wear data for caprines is limited, with a total sample of only 18 identifiable bone ends and 10 teeth (see Tables 7.5 and 7.6). However, the caprine data is less clear and more challenging to interpret. When bone fusion is assessed using Zeder's updated system (2006), the sample sizes are subdivided to such an extent that the interpretations cannot be considered conclusive. For example, proportionally speaking the caprine fusion data appear to show evidence for kid mortality, with 50% of the Group A elements fused. This is a similar proportion as was documented for Iron Age caprines at Kadebakele. However, only two elements are included in this group and thus it is an interpretative stretch to say that this reflects a population whereby 50% of the herd was culled before 6 months. When I organize the fusion groups in a way that was similarly done for cattle and pigs, then evidence of kid mortality diminishes. However, consolidating the groups in such a way offers less resolution for juvenile animals since the first and second phalanx would be included in the early fusion group and extend the slaughter age to 18 months. In other words, instead of assessing the proportion of animals that died under 12 months, the assessment extends to animals that died under 18 months. When computed this way, the fusion data show only 1 unfused element compared to eight fused, indicating that only 11.1% were slaughtered before 18 months. We would expect this number to be higher if kid mortality was practiced during the Early Historic period (the proportion out of n=9 is still small when consolidated, however). In consolidating the next age groups (Group D and Group E) the proportion of unfused to fused remains is 44.4% to 55.6%. These unfused elements all occur within Group D and thus the nearly 45% of the culling that occurs actually happens before 30 months. This suggests a culling pattern focused on prime-aged animals for meat cuts.

Table 7.5: Distribution of Caprine Elements by Fusion Stage

Group	Age	Element	Number Unfused	Number Fusing	Number Fused	Total	% Fused
A	0-6 months	Proximal radius	1	0	1	2	50%
B	6-12 months	Distal humerus, acetabulum, scapula	0	0	3	3	100%
C	12-18 months	Proximal 1st and 2nd phalanx	0	0	4	4	100%
D	18-30 months	Distal tibia, Distal metapodials	4	0	2	6	33.3%
E	30-48 months	Calcaneus, Proximal femur, distal femur, distal radius, proximal ulna, proximal tibia	0	0	3	3	100%
F	48+	Proximal humerus	0	0	0	0	0%
Total			5	0	13	18	

While dental eruption and tooth wear generally enable more robust aging data since they better approximate absolute age, the data available from the caprine faunal assemblage similarly lacks resolution for younger animals. Multiple deciduous teeth (n=5) were recovered for caprines. However, two of these were maxillary teeth which do not have an agreed upon system of estimating age based on tooth wear. Thus, the most that can be said concerning the upper deciduous teeth is that they come from animals under two years of age, since this is when upper deciduous teeth are shed (Jones and Sadler 2013). The remaining deciduous teeth (mandibular molars and premolars) could be aged and show two individuals under 6 months and one within the juvenile age range, or under 12 months. All three are from different contexts and thus represent different individual animals. The fact that deciduous teeth make up half of the total number of caprine teeth could be interpreted as evidence of kid mortality or the culling of younger juveniles. However, since two of the five deciduous teeth could be from animals as old as 2 years, such an interpretation could not be made with confidence. This analysis will omit calculations using the upper molars since they are less reliable for estimating absolute age. Proceeding under these terms, three out of eight teeth, or 37.5% were slaughtered as juveniles. This would be more in line with the culling of juveniles for dairy production. Tooth wear data also indicate the presence of only one sub-adult. However, if the upper maxillary teeth came from animals slaughtered at 2 years old, then the sample would include three sub-adults. The remaining teeth (mandibular molars, n=4) come from adult aged animals ranging from 3-4 years and 4-6 years. No other complementary evidence of advanced-aged animals (no resorped alveolar or coastal cartilage) was found from the caprine faunal assemblage.

Table 7.6: Age Estimates Caprine Teeth Based on Eruption or Wear Stage from Kadebakele River Terrace (Early Historic)

Tooth	Eruption Age/Wear Correlate	Wear	Age Category
Deciduous lower molar	Under 2	Unworn	Under 6 months
Deciduous lower molar	Under 2	Unworn	Under 6 months
Deciduous 3rd premolar	Under 2	Little wear	Under 12 months
Deciduous upper molar	Under 2	Unworn	
Deciduous upper molar	Under 2	Unworn	
Lower M1		D 2-3 years	Sub-adult
Lower M1		E 36-48 months	Adult
Lower M1		F 36-48 months	Adult
Lower M1		F 36-48 months	Adult
Lower M1		G 48 to 72 months	Adult

The tooth wear data ultimately contradicts what was documented on the basis of fusion data. However, in both cases the sample sizes were small and the extent of conclusive information that could be derived is limited. Similar to the cattle assemblage, a large enough caprine sample for comparing metrical data was unavailable, although one individual animal was identified as a female based on pelvic morphology. This aside, reconstructing herd composition for both cattle and caprines proves challenging using the Early Historic faunal assemblage that we have to date. Because of this, there are also limitations to the comparisons and contrasts that can be made between animal use and human-animal relationships between the Iron Age and Early Historic period. Reliance on some secondary products, such as traction labor from cattle, continued between the Iron Age and the Early Historic period. However, the preliminary data also indicate that meat production and consumption (from domesticates) may have been more common during the Early Historic period. This is perhaps bolstered by the fact that prime aged animals do not come from distinct or specialized contexts like they do during the Iron Age. In other words, the ambiguity as to whether or not animals were consumed for meat on a more frequent basis has more salience when we consider the fact that their production and consumption evidence is not specifically associated with megaliths or specially prepared features (although we still do not have a great understanding concerning the nature and function of the large and deep pits excavated on the River Terrace).

Within the broader patterning of faunal remains from the Early Historic period, establishing whether or not primary products (meat from either cattle, caprines, or both) were more frequently or commonly consumed during the Early Historic period compared to the Iron Age is part of a larger question concerning whether or not meat production and distribution was specialized and what the relationship between production and consumption and producers and consumers was. A reduction in the overall diversity of animal protein resources, and less hunting, may imply increased specialization (less generalization) (Zeder 1991) and also an aspect of food procurement that is further removed from individual subsistence procurement. If this were the case, however, this would also suggest that processing, consumption, and discard patterns would have varied across the site in distinct and significant ways. This cannot currently be explored given the very small sample sizes from the River Terrace excavations.

Small sample sizes also pose limitations for reconstructing herd composition on the basis of age and sex. Examined broadly, however, the presence of animals across all age categories potentially suggests two things. First, overlapping resource strategies could be obscuring herd composition and mortality patterns. This is clear at least from cattle in that the age structure shows animals may have increasingly been slaughtered for meat, while bone pathologies also show that they continued to be sources of traction labor. Inevitably, maintaining breeding stock would also mean females were present and would have yielded dairy resources. Second, if thought about within a broader urban framework, the presence of animals from a variety of age classes in both cattle and caprines would indicate that even if meat production became a larger focus during the Early Historic period, the patterns thus far do not support an interpretation for specialized meat production or provisioning. Given the size and distribution of Early Historic sites in the Tungabhadra Valley, if there was a system of exchange following a village producing and center consuming model, Kadebakele would certainly count as a center within the region. In this case, it would be expected that prime-aged meat animals and prime meat cuts would dominate the livestock assemblages and that breeding stock and animals that died of natural causes would be absent. This degree of specialized meat production and provisioning is not evident based on the age data to date.

7.5 Skeletal Part Distribution

Specialized provisioning and meat production is also not evident based upon the distribution of skeletal remains. To begin, for both cattle and caprines, the distribution of skeletal remains largely resemble the distributions during the Iron Age, which, I have argued, do not reflect provisioning or specialized meat production (see Figure 7.3 and 7.4). However, because the cattle and caprine sample sizes are small (n=48 and n=52 respectively) it is necessary to also look at the distribution of skeletal remains for large and medium sized mammals (see Figure 7.5 and 7.6). For medium mammals, the distribution of skeletal remains is similar in the Iron Age and the Early Historic periods, with Early Historic medium mammals actually approximating the standard distribution even more closely, as all skeletal body parts are roughly equally represented (Figure 7.6). This suggests that entire skeletons were deposited on site and were not subjected to specialized butchery or distribution for consumption.

Unlike the medium mammals, the distribution of large bodied mammals from the Early Historic period differs from the Iron Age and the standard skeletal distributions. Despite this deviation, patterns in the skeletal part distribution for large mammals do not provide evidence for specialized provisioning at the site. Large mammal head remains are overrepresented, and exceed the proportion of head remains for bones identified as cattle. If specialized provisioning were evident, we would expect to see an overrepresentation of meat bearing limb elements and an underrepresentation of butchery waste, in particular head remains. Typically, we would expect a higher degree of over-representation in cattle compared to large mammals since head remains are often comprised of teeth that can be identified to species. This is precisely what occurs in the Iron Age. Early Historic large mammal head remains, however, exceed the standard expected proportion by 17% and exceed the Iron Age proportion by 32%. The proportion of axial elements for large mammals is also a deviation. Large mammal axial elements from Early Historic deposits are underrepresented compared to both the Iron Age distribution and the standard. This occurs despite the fact we would expect axial elements to more closely approximate the standard since axial elements are more often than not categorized by class and body size as opposed to species. As a final contrast, limb elements for large mammals more closely approximate the standard proportion.

Ultimately, the specific pattern observed in the large mammal skeletal part distribution (overrepresented skull, underrepresented axial, standard representation limb) does not have a clear explanation except that at this time it does not support an interpretation for specialized provisioning. It is possible this pattern is a result of taphonomic impacts where non-tooth skull remains are highly fragmented and thus over counted and overrepresented, and axial elements such as ribs and vertebrae are fragmented to a degree that they are classified as unidentifiable.

Table 7.7: Skeletal Part Distribution for Various Taxonomic Groups from Early Historic Kadebakele Deposits

	Head	Axial	Forelimb	Hind limb	Feet
Mammals					
Cattle					
NISP	24	2	2	2	22
% of NISP	50%	4.2%	4.2%	4.2%	45.8%
Caprines					
NISP	18	3	9	2	34
% of NISP	32.7%	5.5%	16.4%	3.6%	61.8%
Standard	34%	35%	7%	5%	19%

Table 7.8: Skeletal Part Distribution by Mammalian Body Size from Early Historic Kadebakele Deposits

	Head	Axial	Limb + Feet
Large Mammal			
NISP	349	93	249
% of NISP	50.5%	13.5%	36%
Medium Mammal			
NISP	201	212	132
% of NISP	20.5%	21.6%	34.9%
Standard	34%	35%	31%

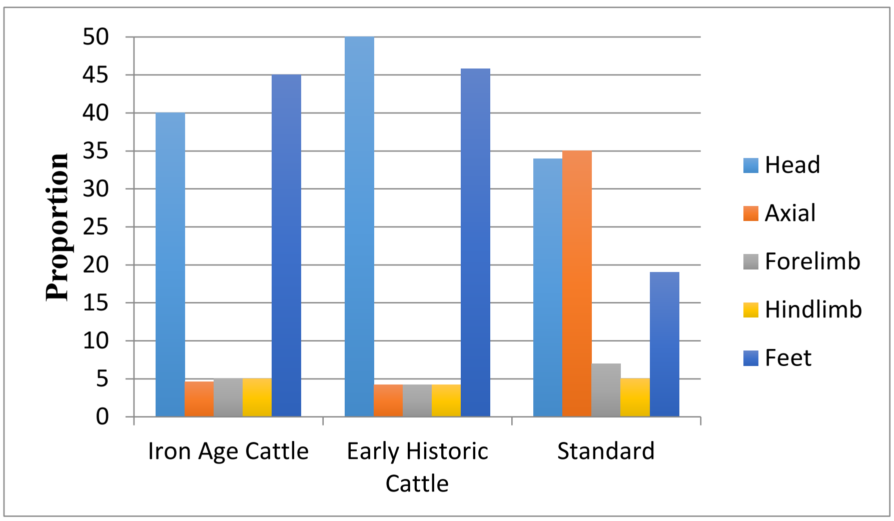

Figure 7.3: Iron Age and Early Historic Skeletal Part Distribution in Cattle versus the Standard

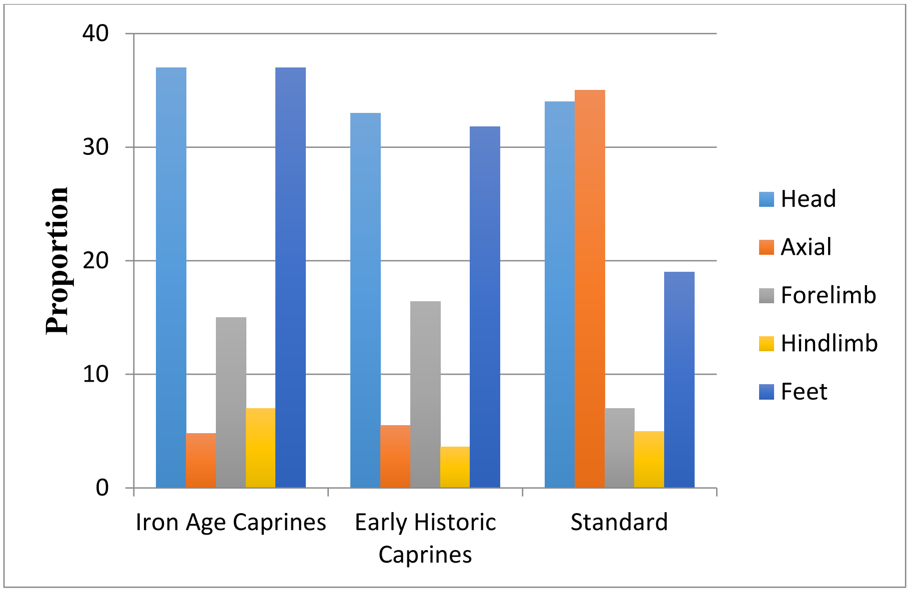

Figure 7.4: Iron Age and Early Historic Skeletal Part Distribution in Caprines versus the Standard

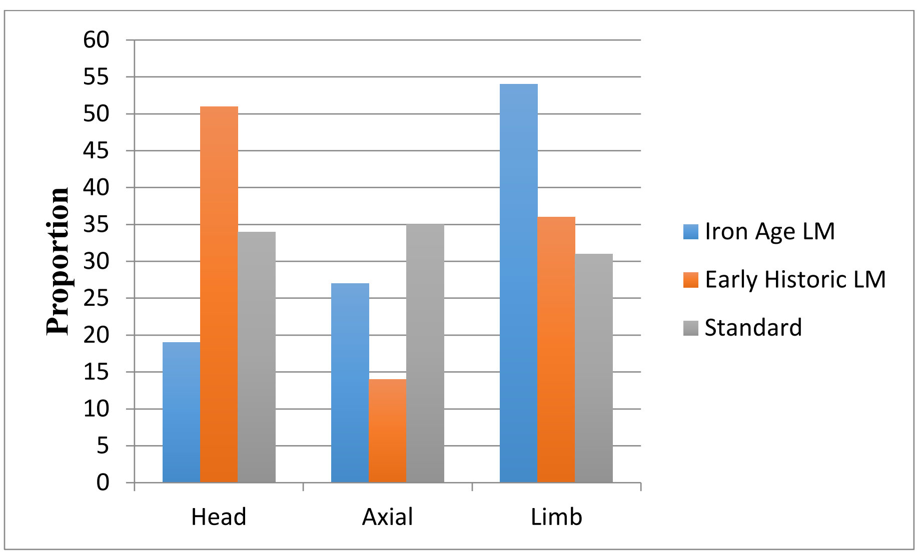

Figure 7.5: Large Mammal Skeletal Part Distribution from Kadebakele Upper and River Terrace

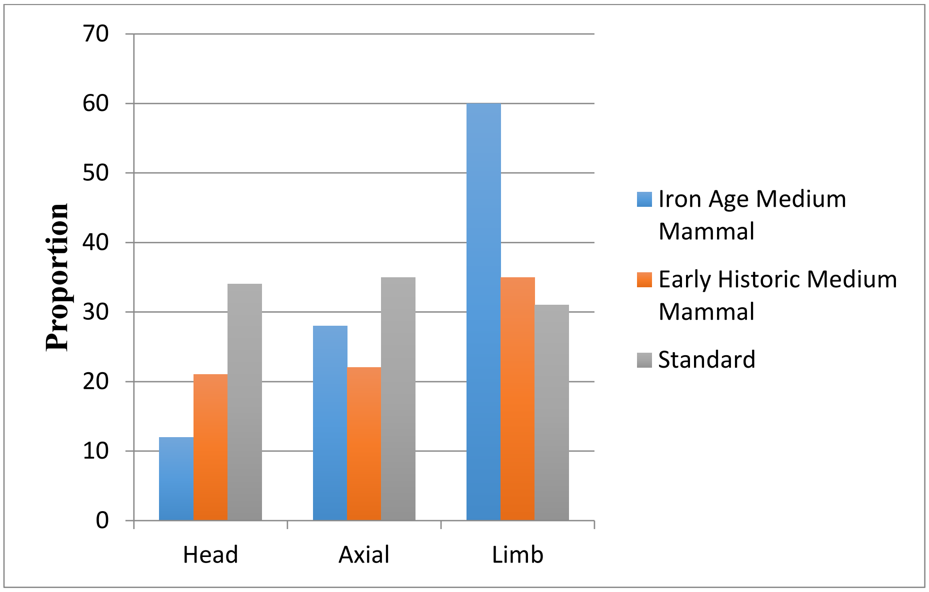

Figure 7.6: Medium Mammal Skeletal Part Distribution from Kadebakele Upper and River Terrace

7.6 Conclusion

Comparison of the Iron Age and Early Historic faunal assemblages shows that the subsistence regime at Kadebakele changed over time. While the specifics concerning how and to what extent cattle and caprine husbandry changed are unclear, preliminary results do not appear to reflect (specialized) meat production or distribution at the site. This is somewhat surprising given the broader context of economic specialization and other social, political, and economic factors underlying the Iron Age-Early Historic transition, however further research may have more definitive insights regarding meat production and provisioning. From these results, what can be said is that domesticates comprised a smaller proportion of the faunal assemblage compared to the Iron Age. In addition, cattle went from outnumbering caprines nearly 2:1 during the Iron Age to being almost equally represented during the Early Historic period. In fact, caprines overtake cattle in relative abundance by the Early Historic period. This has potential implications for further assessing risk management and will be further explored in Chapter 9.

Wild taxa continued to be consumed during the Early Historic period; however, there is less diversity across wild taxa compared to the preceding Iron Age. Notably, by the Early Historic period, there is a greater emphasis on fishing and fish consumption, with fish accounting for the largest proportion of the Early Historic faunal assemblage compared to any other taxonomic class. The abundance of fish may relate to an intensification of fishing for distribution to markets. In this case, fish procurement functioned differently compared to the Iron Age, where I have argued that fishing was connected to sustaining an individual or household. More research and larger faunal samples are needed to determine whether or not this was the case.

An equally likely possibility, which also signals a divergence from Iron Age practices, could be that fishing and fish consumption increased as agricultural demands and other factors may have placed new constraints on mobility. If, for example, agriculture became a more dominant component of the agro-pastoral regime, then it is possible that fishing supplanted other hunting activities since fishing could be done while simultaneously watching over and tending to agricultural fields. This would stand in contrast to the Iron Age, when the variety of wild taxa exploited through hunting were either procured as part of a dedicated hunting strategy (perhaps particularly the case for large game species), or were collected alongside extensive grazing activities occurring between the main site and surrounding rockshelters. A mobility-related explanation for changes in taxonomic distribution and hunting activities makes sense since it appears that rockshelters in the area, while clearly used during the Iron Age, lack Early Historic material remains (A. Bauer 2010:142). This suggests that extensive herding may not have been practiced during the Early Historic period. Extensive herding may not have been necessary in the

Early Historic period, either because cattle and caprine herds were maintained in smaller sizes, or because their diets were supplemented with fodder. Evidence of grazing shifts is further addressed in the following chapter, where I review the methods and applications of dental microwear analysis on Iron Age and Early Historic caprine teeth.

CHAPTER 8 :
DENTAL MICROWEAR: METHODS AND PRELIMINARY INSIGHTS

8.1 Introduction

Having presented my interpretations of animal use and changing animal husbandry practices in previous chapters, I now turn to my examination of how animal husbandry practices related to changes in the environment. More specifically, I examine how patterns of livestock production and consumption coincided with shifts in grazing and stocking practices and pasture quality. Dental microwear analysis, the quantification, measure, and recording of microscopic features left on tooth enamel, provides the primary data set for addressing these questions. In particular, following the protocols and frameworks outlined by Mainland (2003), Mainland (2006), and Mainland et al. (2016), I analyzed dental microwear features found on caprine teeth (sheep and goats) in order to identify if animals grazed on healthy versus patchy or overgrazed pastures. I evaluate if overgrazing signatures are present on caprine tooth enamel surfaces, and if so, under what circumstances did they occur? How did evidence of overgrazing articulate with specific livestock production strategies? How did overgrazing relate to other forms of subsistence procurement and animal use? Importantly, identifying the relationship(s) between animal husbandry and (over)grazing can also ultimately contribute to interpretations regarding how people viewed their relationships with animals, since it can speak to the ways people prioritized animal care in their decision-making by ensuring animals were provided with access to quality pasture/diets (see Chapter 2).

In the sections below, I review the various applications of dental microwear analysis and some of the general underlying principles and assumptions guiding dental microwear research. I discuss in further detail dental microwear research in ungulates (hoofed animals), with an emphasis on sheep/goat dental microwear studies. In particular, I discuss how sheep/goat dental microwear analysis has been used to draw inferences about overgrazing in modern and archaeological contexts. Next, I review the different methodological/technological approaches used in previous dental microwear studies. There are ongoing debates concerning what methods are the most accurate and efficient, in particular concerning the technologies and software used to analyze dental microwear features. I provide a justification for the methods I selected for this analysis and outline the specific collection, preparation, and analysis of samples I used. Finally, I address the limitations of dental microwear analysis and what steps I took to strengthen the interpretations derived from dental microwear data in this research.

8.2 Previous Research and Underling Principles in Dental Microwear Analysis

Dental microwear research has a long history and has advanced to include a diverse range of topics and applications (for detailed review of the history of dental microwear research, see Ungar et al. 2009; Teaford et al. 2013). Dental microwear research has been adopted across multiple disciplines, including ecology, paleontology, primatology, and anthropology. Example research topics include: the examination of weaning practices and food introduction in past human populations (Scott and Halcrow 2017), the establishment of differences in domesticate and wild ungulate diets in Neolithic Greece (Rivals et al. 2011), the assessment of the impact of exogenous dust on microwear features (Ungar et al. 1995; Merceron et al. 2017; Merceron et al. 2018), and identification of potential causes of saber-tooth cat extinction during the late Pleistocene (Desantis et al. 2012). In addition, dental microwear studies have made significant contributions to the study of early hominin diet and human evolution (Walker 1981; Teaford and Walker 1984; Grine 1986; Grine and Kay 1988; Pèrez-Pèrez et al. 2003; Ungar et al. 2006; Grine et al. 2006; Teaford 2007).

A primary principle guiding dental microwear research is that mouth function and movement coincides with specific dietary types and that the combination of jaw action and food type or texture will produce a dental microwear signature. This observation was first made by paleontologist G.G. Simpson in the early 1930s and was informed by his study of Jurassic mammal dentition (Simpson 1933). Simpson recognized that jaw movement (vertical, orthal, horizontal) and the ways molars come into contact (occlusion) relate to one another and that specific forms of movement and occlusion should vary with diet. He argued, for example, that teeth in opposing occlusion are primarily and usually associated with omnivorous diets and are accompanied by orthal (arc-shaped) movement (130). By contrast, teeth in grinding occlusion reflect herbivorous diets and tend to be accompanied by horizontal motion or movement (130).

Subsequent research in the 1950's echoed this sentiment, indicating that microscopic scratches appearing on the occlusal facets of molars correspond to jaw movement (Butler 1952; Mills 1955). Since jaw movement is dependent upon dietary type, dental microwear emerged as a promising technique for reconstructing and interpreting diet and feeding behavior across different species. As microscope-based studies of dental microwear features advanced (Baker et al. 1959; Dahlberg and Kinzey 1962 Walker 1976), scholars continued to affirm the correlation between specific patterns of microwear features and diet. For example, Teaford and Walker (1984) and Teaford and Runestad (1992) demonstrated differences in microwear patterning for leaf -versus fruit-eating primates. Walker et al. (1978), Solounias and Moelleken (1992), and Solounias and Semprebon (2002) used dental microwear analysis to elucidate differences in grazers and browsers. Solounias and Semprebon (2002) used an extensive database on ungulate dental microwear in order to separate C3 and C4 diets in grazers, and to separate the dental microwear signatures of leaf, fruit, and bark dominated diets of browsers. Using the patterns established through the dental microwear analysis of modern and extant species, researchers have also studied archaeological and paleontological specimens in order to identify diet in past contexts (i.e., Mainland 2006; Vanpoucke et al. 2009; Rivals et al. 2011; Henton 2012; Amano et al. 2016; Mainland et al. 2016; Jiménez-Manchón et al. 2019). The application of dental microwear analysis to archaeological and paleontological samples allows researchers to study dietary adaptations and evolution, changes in the environment and vegetation over time, and changes in how animals, domesticates in particular, were raised and managed by humans in the past.

Relevant to my research, below I focus on research addressing the relationship between ungulate dental microwear formation and dietary classification (in other words, how dental microwear signatures differ across grazers, browsers, and mixed feeders). I then discuss studies on caprines (sheep and goats) and how they challenge the traditional grazing/browsing dichotomy in dental microwear research, findings that have been key in developing research designs that identify evidence of overgrazing in archaeological contexts.

8.3 Ungulate Dental Microwear: Grazing and Browsing

The general consensus concerning dental microwear features, in particular for herbivorous ungulates, has been that that grazers exhibit microwear patterning that is predominantly comprised of striations (scratches), while browsers exhibit a high frequency of pits (Walker et al. 1978; Solounias et al. 1988; Solounias and Moelleken 1992; Solounias and Hayek 1993; Hayek et al. 1992). Striated tooth enamel surfaces in ungulates result from chewing opal phytoliths that are present across various species of grass. Opal phytoliths are highly abrasive and when grasses are consumed by ungulate grazers, whose jaw movement is primarily horizontal and shears food while chewing, the phytoliths will produce scratches on the enamel wear facets as abrasive material gets trapped and moved over the occlusal surfaces of molars (Janis 1990:233; Gordon 1984; 79). Cattle, horse, sheep and certain species of deer (the swamp deer in India, for example), are examples of ungulate grazers.

In dental microwear formation, browsers differ from grazers in two ways. First, browsers typically have fewer striations compared to grazers. This is because browsers tend to prefer softer, non-abrasive dicotyledon plants; as a result, they consume a smaller volume of phytolith and abrasive-rich food than do grazers (Mainland 1998: 1267; Walker et al. 1978; Solounias et al. 1988; Solounias and Moelleken 1992). Secondly, browser tooth enamel surfaces contain a higher amount of pits than is observed in grazers. Although the cause of pit formation in ungulates is less well understood, it is thought that pit features result from increased attritional (tooth-on-tooth) contact during mastication. Ungulate browsers, like grazers, shear their food and chew in a horizontal motion. While shearing softer, non-abrasive food, their teeth may come into contact more frequently than would be the case if they were consuming more fibrous grasses. Pits could also be the result of biting down on harder objects, such as twigs or wood, while feeding (Puech et al. 1981; Teaford 2007:121; Henton 2010:241). Giraffes, moose, camels, gazelle, and chital are examples of browsers.

8.4 Beyond the Graze/Browse Dichotomy: Soil Ingestion in Sheep and Goats

Mainland's series of studies comparing modern sheep and goat dental microwear features with known feeding conditions produced data that complicates the grazer/browser dichotomy observed in previous studies on ungulate dental microwear formation (Mainland 1998; Mainland 2003; Mainland 2006). Mainland's research has yielded two arguments that have bearing on the questions framed in this dissertation. The first is that sheep and goats exhibit similar patterns of dental microwear formation. This is despite the fact that sheep tend to be associated with grazing, while goats are considered to be browsers or mixed feeders. Second, Mainland found that the ingestion of soil abrasives, resulting from differences in pasture quality and stocking rates, was a better explanatory variable for the presence of striations in sheep and goats than phytolith mastication (Mainland 1998; 2006).

In a 1998 analysis, Mainland examined tooth samples from three groups of sheep that were fed different diets. Sheep were either fed grassy hay (phytolith-rich fodder), leafy hay (browse fodder), or they grazed on open pasture. Goats were also included in Mainland's analysis and were fed the same browse fodder as the sheep. Mainland found that although the diets could be distinguished on the basis of dental microwear features, the differences did not correspond to the grazer vs. browser explanation put forth in previous studies. The browse dietary group, for example, was not characterized by a predominance of pit features but instead had a high frequency of both pits and striations. Although pit features are expected in browse diets, the high frequency of striations is not. More notably, the grassy hay fed and grazing dietary groups did not exhibit the high frequency of striations that is expected with grazer diets. Instead, grazing and grassy hay fed sheep had fewer overall microwear features and a higher frequency of pits (Mainland 1998: 1267). The absence of heavily striated enamel surfaces in grazing and grassy hay fed sheep, and the high frequency of both pits and striations in browse fed caprines led Mainland to conclude that traditional models for microwear formation in ungulates required further study (Mainland 1998:1268).

In her analysis, Mainland ultimately viewed deviation in the browse microwear patterning as less problematic since the process of drying and storing browse fodder could impact the abrasiveness of the diet such that it could skew the microwear signal (1998:1268). However, the absence of striations in grazing and grassy hay diets, both of which contained a high amount of phytoliths, poses an interpretative dilemma. An answer may lie in publications that note tendency for grazers to ingest high quantities of soil and grit particles (see Beyer et al. 1994; Walker 1976) as well as experimental studies demonstrating that the consumption of soil produce striations on tooth enamel surfaces (see Peters 1982; Covert and Kay 1981; Kay and Covert 1983), Mainland proposed that soil ingestion may play a larger role in striation formation than has been acknowledged under grazing/browsing dental microwear modeling. Buttressing her position, Mainland points out that the absence of striations in the grassy hay diets of sheep could correspond to low levels of soil ingestion since the animals were fed indoors and would not have come into contact with soil for the three-month duration of the feeding trial (Mainland 1998:1269). Moreover, she points out that the few specimens that did exhibit high frequencies of striations among the grazing sample were animals that likely could have ingested higher quantities of soil:

> An association between striations and soil ingestion would explain the striations evident in the Orcadian and Herbridean sheep, all of which were grazing grassland where soil ingestions levels could potentially have been high; the latter on the sandy soils of the Manchair, the former on a very poor area of grassland in which vegetation cover is minimal and often muddied. (Mainland 1998: 1269)

Mainland (2003) went on to further study the relationship between soil ingestion and dental microwear formation on modern sheep and goats with known diets by examining tooth and dung samples from sheep/goats with different diets. Representing a browse diet, Group 1 grazed for three months on wooded pastureland, which contained a high proportion of leaves, bark, and tree/shrub twigs (Mainland 2003:1515). Group 2 grazed for three months on open, unimproved grassland where deciduous browse species were unavailable (2003:1515). Group 2 thus represented a predominantly graze diet. The dental microwear data predictably showed that the browsing group (Group 1) contained heavily pitted tooth enamel wear surfaces, while the grazing group (Group 2) contained heavily striated tooth enamel surfaces. In analyzing the dung samples, however, Mainland found that there were no significant differences in phytolith ingestion between the browsing and grazing groups (2003:1521). By contrast, there was a significant difference in the amount of soil ingested between the two groups. Group 1 ingested less soil while feeding on wooded pastureland (browse), and Group 2 ingested more soil while grazing on open, unimproved grassland. Because the two groups ingested similar amounts of abrasive phytoliths, but different amounts of soil, Mainland concluded that soil ingested contributed more significantly to the formation of striations on sheep and goat teeth.

Mainland also compared Group 1 and Group 2 dental microwear patterning to a third group: a flock from Greenland. The third group grazed at low-stocking rates fewer on upland grassland with dense vegetation cover (Mainland 2003:1527). In other words, Group 3 grazed on healthy pasture with little competition from other feeding herd animals. Group 3 differs from the Group 2 grazers because Group 2 grazed in an area of closely cropped grassland that was heavily utilized throughout the year by both sheep and cattle (1527). Dung analysis confirmed that Group 3 sheep grazed on healthy pasture, consumed less soil and grit in their diet than Group 2, which grazed at high-stocking levels and on patchier grassland. Microwear on Group 3 teeth exhibited few striated features and did not vary significantly in the dental microwear patterning from Group 1 (the browsing group). If phytoliths were the more important contributor to striation formation, we would expect more striations in Group 3. The data instead provide further confirmation that variation in the ingestion of soil is the stronger contributing factor to striation formation and that levels of soil ingestion better explain the differences observed in the dental microwear features of caprines.

With this framework linking striation frequency to levels of soil ingestion, Mainland sought to use dental microwear analysis on archaeological samples as an approach to reconstructing pasture quality and to make inferences about stocking rates and grazing intensity. In a 2006 publication, Mainland used the data on modern Greenlandic grazing sheep (Group 3 in the study described above) as a comparative to archaeological specimens from Medieval Norse Greenland. The dental microwear data from Group 3 sheep that grazed on full and healthy grassland pasture were used as a baseline for assessing if sheep and goat herds in Medieval Greenland ingested a high amount of soil while grazing. Mainland (2006) found that Medieval Norse Greenlandic sheep and goats exhibited a different microwear pattern than the modern group (Group 3). Norse sheep and goat teeth contained heavily striated tooth enamel surfaces, a dental microwear signal that, according to Mainland, is consistent with heavy soil ingestion. Contextualized with other archaeological information, Mainland concluded that the heavy soil ingestion signature results from intensive grazing, whereby sheep and goat herds were maintained at high stocking levels, at a capacity greater than the land could support (i.e., overgrazing) (Mainland 2006: 250).

Thus, using archaeological and dental microwear data, Mainland's research contributes to the ongoing debate concerning the demise of Norse Greenlandic society by arguing that maladaptive grazing practices led to a decline in the viability of pastoral farming in Greenland (2006:238). Moreover, by comparing dental microwear data from different sites and time periods, Mainland was able to determine that overgrazing began at a relatively early date. This stands in contrast to arguments asserting that overgrazing only occurred toward the end of the settlement and as a consequence of the Little Ice Age (Mainland 2003: 238).

The role of soil ingestion in dental microwear research has been explored by others as well. In archaeological research, Henton similarly evaluated the role of soil abrasives in the striation markings on sheep teeth. To provide a baseline for interpreting seasonal management of domestic sheep herds in Neolithic Anatolia (Çatalhöyük), Henton examined dental microwear features of modern sheep with known dietary sources. Henton calculated the phytolith and soil content of sheep feed types and compared the percentage of striations and pits across the different diet classes. Similar to Mainland, Henton observed that diets containing a higher proportion of soil produced more striations on tooth enamel surfaces than diets with low soil content (Henton 2012: 3270). Moreover, sheep that consumed diets with a high soil content had more striations on their teeth than sheep that consumed diets with high phytolith content. Henton thus concluded that ingested soil is the more important contributor to striation formation, a finding consistent with Mainland's results (2012:3270). Henton then analyzed sheep tooth samples recovered from Çatalhöyük to assess pre-slaughter diets. Henton combined isotope and dental microwear data to argue that people experimented with seasonal birth manipulation while managing animals on dedicated pasture on arable fringes (2012:3264).

The impacts of soil ingestion on overall tooth wear in grazing animals is also addressed in veterinary and zoology studies. For example, a 1964 study by Healy and Ludwig examined how soil and phytolith content in sheep dung corresponded to excessive wear in sheep dentition. They measured changes in the length of sheep incisors over monthly intervals in order to assess dental impact. Over the course of 12 months, Healy and Ludwig found that sheep with a high content of soil in their dung exhibited higher rates of wear on their incisors. By contrast, variation in phytolith content in sheep dung bore no correlation to changes in wear stage in sheep (Healy and Ludwig 1965:745). As a result, Healy and Ludwig concluded that soil ingestion is a stronger contributor to wear than phytolith ingestion.

A more recent study conducted by Sanson et al. (2017) similarly found that for African buffalo (*Syncerus coffer*) high phytolith intake bore no correlation to changes in rates of wear. In their study, they observed that African buffalo consumed 10-28 kg of dust and grit per year, compared to 300-400 kg of abrasive silica. Observed changes in the rate of wear were minimal (no statistically significant changes observed) leading them to conclude that the role silica plays in tooth wear is questionable (Sanson et al. 2017: 211). Ultimately, based on their study, Sanson et al. concluded that although silica might contribute to wear, it acts perhaps as a secondary effect (2017:222).

The issue of soil and grit ingestion and its relationship to tooth enamel wear has also been analyzed with respect to wind-blown dust particles adhering to grasses (Merceron et al. 2018). Merceron et al. (2018) used dental microwear texture analysis (see further discussion in section 6.5) to examine how dust-free and dust-laden grass and browse fodders contributed to dental microwear. According to Merceron et al. (2018) assessing the impact of dust on dental microwear is important to establishing how dental microwear can be used as an environmental proxy. Windblown dust tends to accumulate in deforested and arid environments. Dust grains, similar to soil, had been previously considered a contributing factor to dental microwear formation in humans (Lucas et al. 2013; Guegel et al. 2001). If dust grains significantly contribute to tooth wear, it could potentially be used as proxy evidence for aridity or deforestation in past environments. The problem, if true, is that dust grains could potentially overlap with and obscure the dental microwear signals resulting from soil ingestion that occurs due to overgrazing. Ultimately, Merceron et al. found that food treated with dust supplements in the study did not produce different dental microwear textures than the non-treated food (2018). However, they emphasize that there is a distinction between the impact of wind-blown dust and the ingestion of soil that occurs when animals feed on overgrazed or unhealthy pastures.

Assessments of windblown dust only account for differences in dental microwear texture in environments free from dust compared to environments rich in airborne dust (Merceron et al. 2018: 4). Although they conclude within their own title that "Dust Does Not Matter" it is not the case that soil also does not matter. Ultimately they concede that higher amounts of ingested soil from overgrazing could shift the signals that they observed and impact dental microwear formation (2018:5).

The studies mentioned above make a strong case for the potential of using dental microwear to test for evidence of overgrazing and high stocking rates in past contexts. In multiple cases, soil ingestion is demonstrated to be a stronger contributor to dental wear than silica phytoliths, as well as wind-blown dust. Moreover, it has been demonstrated that sheep ingest 14% of soil with their food when managed in over-stocked pastures, versus less than 1% in well-managed pastures (Field and Purves 1964). Because sheep have been shown to consume more soil when kept at high stocking rates, and soil ingestion has been shown to contribute to higher frequencies of striation microwear on tooth enamel surfaces, we are left with a useful framework from which we can develop inferences about pasture quality, herd stocking rates, and overgrazing. This is especially the case when dental microwear data can be integrated with other forms of archaeological and paleoenvironmental data.

Additional parameters can impact the use of dental microwear data, especially when it comes to the ability to isolate soil ingestion as an explanatory variable. For example, previous studies have shown that dental microwear formation does not vary across males and females fed the same diet. Any microwear differences observed between males and females are determined to have resulted from differences in diet or husbandry management and not inherent differences in tooth morphology or feeding behavior (Nystrom et al. 2004:281). In addition, once an animal is old enough for their teeth to start exhibiting wear, age is not a determining factor in wear rate or wear features until old age (Beuls et al. 2002: 342). Most importantly perhaps, dental microwear features are the result of the dietary substance consumed between the last two to seven days of an animal's life (Solounias and Moelleken 1992; Mainland 1998). The fact that dental microwear is considered to reflect "the last supper" is a limitation to the analytical potential depending on the kinds of questions one wishes to answer. Here, the last supper effect is considered an important control. Although it potentially obscures evidence of overgrazing if an animal grazed on poor pasture at some point in the past but was fed healthy pasture in the days before it died, the last supper effect still provides a direct proxy for pasture quality and overgrazing since it does not require deciphering how a lifetime of dietary changes combine to produce a final dental microwear result. The last supper effect thus ultimately allows for an interpretation or reconstruction of diet and grazing activities that is less likely to be confounded by other variables.

8.5 Dental Microwear Methods

Broadly speaking, dental microwear analysis involves using high-resolution images to identify, measure, and count dental microwear features (primarily pits and striations. Researchers use three primary methodological approaches to conduct dental microwear analysis: light microscopy, scanning electron microscopy (SEM), and white light confocal microscopy with the use of dental microwear texture software. Light microscopy was the first method to be used but was later largely replaced by scanning electron microscopy which provides higher resolution images from which dental microwear features could be identified and measured. Issues related to time and cost led to the return of light microscope-based studies along side SEM-based approaches. More recently, the use of white confocal light microscopy and dental microwear texture analysis has emerged as a popular approach to studying dental microwear in animals. In the sections below, I review in more detail the key strengths and weaknesses of each approach. I then provide a justification for my use of the SEM-based approach.

8.5.1 Scanning Electron Microscopy

A majority of previous dental microwear research used a scanning electron microscope (SEM) based approach. This technique produces images by scanning the surface of a sample with a beam of electrons. Using an SEM, researchers are able to obtain 2D images of tooth enamel surfaces at 500x magnification. SEM technology was first used in dental microwear analysis in 1978 and was considered an advancement from previous light microscopy approaches because of the field depth and magnification options available (Ungar et al. 2009). SEM images provide high-detail and high-quality images of specimens, especially compared to light microscopy (see further discussion of light microscopy below).

Although the SEM approach provides high quality images of tooth enamel surfaces, it has been criticized for being expensive and time consuming, a reality that imposes serious constraints on the number of samples that can be processed for analysis. In dental microwear analysis, researchers are often working with tooth casts that are made of epoxy resin, a non-conductive material. Before one can view a specimen under the SEM, casts must be treated with a carbon or gold sputter coater in order to provide a conductive surface on the cast. Without a conductive surface, electrons collect on the sample surface and produce a charge. The charge results in white, fuzzy areas across the image and obscures image capture and analysis. The application of sputter coating a specimen takes 15-20 minutes and the sputter coater can only hold 2-3 small specimens at a time (for example 2-3 caprine tooth samples). Once a sample as been coated it can then be placed in the SEM. When specimens are placed in the SEM, they must be mounted correctly on a stage. Improper mounting will impact how electrons bounce off the surface and can obscure the image. Once mounted, a sample gets placed in the SEM chamber and gas is evacuated from a chamber, a process that takes an additional 2-5 minutes. Once the sample is in the evacuated chamber, the image is projected on a computer screen and the analyst uses knobs and zoom features to locate dental microwear features on the appropriate facets. Multiple images are taken from a chosen area in order to ensure representativeness. Locating adequate areas for imaging can be especially time consuming for archaeological samples since they often contain adherents that can obstruct or obscure the areas necessary for imaging. In effect, from start to finish, the process for treating a set of 2-3 archaeological samples with the sputter coater, and then imaging them under an SEM, can take 2-3 hours.

The time it takes to prepare samples and take images in the SEM becomes especially problematic when one factors in cost. In order to use the SEM at the University of Chicago, for example, and individual must pay 240.00 to be trained on how to use the equipment, and a fee of 150.00 per quarter to use the SEM. In addition to the per quarter rate, individuals pay 35.00 per hour for use of the SEM. Use of the sputter coater comes with its own training and costs. Consequently, one may find they are limited in the number of samples they can process and analyze if they lack adequate funding.

Because SEM image capture is dependent upon a combination of proper sputter coating, mounting, and machine settings, SEM dental microwear studies have been criticized for being difficult to reproduce. In addition, despite the development of semi-automated dental microwear measuring software (Ungar 2002), SEM-based dental microwear studies are subject to observer bias. For example, in Grine et al.'s (2002) assessment of SEM error rates, they found inter-observer error to be 9% and intra-observer error to be 7%.

Despite some of the problems underlying the SEM method, SEM technology remains one of the most popular methods for dental microwear analysis especially because there already exists multiple and extensive databases containing SEM images and dental microwear data. Steps to standardize recording methods in SEM approaches have sought to reduce issues related to observer bias. However, because the SEM method can be time consuming and expensive, many have returned to using light microscopy, the original technology used for dental microwear studies.

8.5.2 Light Microscopy

Light microscopy entails viewing specimens at low magnification (typically 35x) under a light microscope. With light microscopy, early studies often identified and recorded microwear features directly while looking at the specimen under the microscope. By examining and measuring features in real time under a light microscope, researchers were able to conduct dental microwear analysis from a 3D perspective, as opposed to the 2D perspective provided by captured SEM images (Solounias and Semprebon 2002; Godfrey et al. 2004; Semprebon et al. 2004; Green et al. 2005; Rivals and Semprebon 2006). The 3D perspective was thought to aid in reducing observer bias by offering a clearer image of microwear features with respect to shadowing on the image; however attempts to study observer bias in live stereo view face challenges related to recreating the lighting, positioning, and orientation in subsequent views, as well as in ensuring observer blindness to the taxonomic identity of the specimen (Mihlbachler et al. 2012). As s result, it is unclear if the 3D view offered from light microscopy reduces observer error compared to the 2D view offered by scanning electron microscopy (Mihlbachler et al. 2012).

Use of the live stereo view in light microscopy is also problematic because it does not provide images that can be compared against one another or to images produced using SEM technology. This creates issues for ensuring standardized methods of recording across different data sets and databases. To remedy this, Merceron et al. (2004a), Merceron et al. (2004b) and Merceron (2005b) developed a method of digitizing grey-scale images procured during light microscopy. Doing so, they were also able to produce images at a higher resolution than is available during live view under the light microscope.

The primary advantages to light microscopy in dental microwear analysis are that the technology is more accessible and widely available, it is less expensive compared to scanning electron microscopy, and it takes significantly less time to prepare and analyze samples. As a result, light microscopy enables the processing and analysis of larger samples at a more efficient pace. However, there are some notable drawbacks to the light microscopy-based method in dental microwear analysis. To begin, the lower magnification reduces the quality of images, both with respect to live view and micrographs. Solounias and Semprebon (2002) have argued that low magnification actually enables the researcher to view a larger surface area such that abnormalities or atypical wear that disrupt overall representativeness can be eliminated from analysis. They assert that loss of detail is not significant. However, their view is not universally shared among the dental microwear community (Ungar et al. 2009). Reduced quality and limited magnification is precisely what led to the shift to SEM technology in dental microwear studies in the first place, since light microscopy does not allow for the identification of micron scale microwear features that dominate wear facets (Ungar et al. 2009: 397).

Similar to SEM criticisms, light microscopy dental microwear studies exhibit high rates of inter and intra observer bias. In a study comparing light microscopy and SEM dental microwear methods, Mihlbachler et al. (2012) found that rates of error were similar for both approaches with intraobserver error (variation between different individuals analyzing the same image) especially problematic (18). They encourage further standardization of instrumentation and image manipulation in order to reduce observer error if researchers are to continue to use traditional SEM and light microscopy based approaches, which they note are both good approaches to dental microwear analysis (Mihlbachler et al. 2012: 18). Alternatively, researchers could adopt less observer error prone methods such as confocal microscopy for dental microwear analysis.

8.5.3 White Light Confocal Profiler Technology (Dental Microwear Texture Analysis)

White-light confocal profiler technology has become an increasingly popular method in dental microwear studies in the last few years. This produces high-resolution point clouds that model the surface texture of tooth samples in three dimensions. This has the advantage of providing an arguably clearer representation of microwear features, as well as producing an image that is not dependent on specimen orientation relative to light or electron sources (Ungar et al. 2009: 409). Instead, white-light confocal technology collects measurement data relative to changes in elevation over the tooth surface. As a result, it is easier and faster to reproduce analyses on the same sample.[1]

White-light confocal methods are used in combination with scale-sensitive fractal analysis and specialized software (Toothfrax and Sfrax). This results in an automated characterization of surface texture that corresponds to specific scale-defined variables. These variables include surface complexity, scale maximum complexity, texture fill volume, anisotropy, and heterogeneity (Scott et al. 2006). This stands in contrast to SEM and light based

[1] Although this critique is theoretically valid, when I examined samples on separate occasions I was able to obtain images that were similar and which produced similar feature counts and measurements using the SEM.

dental microwear approaches, which evaluate different measurements and proportions of pit and striation features.

The primary advantage to using white-light confocal profile technology, or a dental microwear texture analysis (DMTA) approach, is that it significantly curbs the issue of observer error. In DMTA the distribution and imaging of dental microwear features is assessed as a collection of data points, which will always have the same plot location and thus will always determine and replicate the texture of the dental enamel surface in the same way (Zolnierz 2014: 36; Ungar et al. 2009). Not only does this allow for consistency when samples are analyzed by different individuals, it strengthens the comparative value of using dental microwear databases across different studies.

It is clear that the DMTA approach eliminates some of the key limitations of traditional dental microwear studies; notably, DMTA reduces observer bias and the methods are easily reproduced. In addition, DMTA's automation feature makes it easy and fast to process large samples. However, DMTA is not without limitations. White-light confocal profilers/microscopes are expensive and are not as widely available or accessible as light microscopes or scanning electron microscopes. This presents significant barriers to those wanting to develop new dental microwear based projects. In addition, although there is consistency and high observer comparability across DMTA databases, the variables and measurement data from DTMA are incompatible with the large ungulate databases that have been established on the basis of SEM and light microscopy (Henton 2010:250).

8.6 Justification of SEM Approach

In order to procure high-resolution images consistent with studies that test for soil ingestion and over grazing evidence, my research used scanning electron microscopy to conduct dental microwear analysis. Because I had access to SEM technology and training through the University of Pennsylvania Fossil Casting Lab, the constraints concerning technology access, cost, and time investment did not justify choosing a light-microscope approach, which would have produced lower resolution and lower magnification images. In addition, because light microscopy and scanning electron microscopy have similar observer error rates associated with their application, light microscopy did not offer any advantages over scanning electron microscopy.

Although there are advantages to using DMTA and white-light confocal profiler technology, there are a few reasons why an SEM methodological approach remains appropriate for the sake of this study. To begin, dental microwear studies often use modern specimens where the environmental context and feeding behaviors/animal diet is known. By controlling for environment and diet, researchers have been able to determine under what circumstances specific patterns of dental microwear are produced. As a result, researchers have been able to develop a framework for organizing microwear patterns that align with classifications of feeding behavior, such as grazing, browsing, and mixed feeding. In principle, DMTA variables can similarly predict differences in species diets (see, Scott et al. 2005; Ungar et al. 2009). However, DMTA has not yet been used to specifically analyze how soil ingestion relates to DMTA variables (or how DMTA can provide evidence of overgrazing), a line of evidence of particular interest in my research. As discussed above, several archaeologically based case studies using SEM methods establish a protocol for determining whether animals overgrazed pastures in the past (Mainland 1998; Mainland 2006; Mainland et al. 2016; Henton 2012). As such, I chose to employ SEM technology in my analyses of Kadebakele animal teeth. Although there may be advantages to using DMTA methods in future analyses on the animal teeth from Kadebakele, this phase of research simply aims to build upon and replicate prior studies (Mainland 2006; Mainland et al. 2016; Henton 2010; Henton 2012) that identify evidence of increased ingestion of soil abrasives in order to make inferences about overgrazing.

My decision to use an SEM approach requires acknowledging how observer error potentially impacts the results of this research. First, it is important to note that interobserver error rate tends to be more problematic and of bigger consequence than intraobserver error rate in dental microwear studies. In other words, feature identification and measurement tend to vary more when multiple observers analyze the same image than when a single individual observer analyzes the same image multiple times. Interobserver error is irrelevant here because only one individual performed the recording and analysis of microwear features. In addition, although this study relies on previous work on overgrazing, this work is used as an interpretative framework. I do not statistically analyze or compare the values related to pit and striation counts and measurements to outside data sets. All statistical analyses are from the Kadebakele sample with comparisons between different chronological and spatial contexts. Ultimately, for the sake of the goals of this analysis, interobserver error is not relevant to the presented results.

In order to address the issue of intraobserver error, I conducted a paired t-test comparing mean differences in striation and pit counts, since the pit to striation ratio was the primary proxy I used for establishing whether heavy soil ingestion (conditions consistent with overgrazing) were present. I had preliminary reason to expect the paired t-test would determine no significant differences in the documentation of pit and striation counts across different analysis sessions as previous examinations of intraobserver have shown that despite variation in pit and striation measurements, the end calculation of pit to striation proportions are not different across separate trials with respect to statistical significance (Mihlbachler et al. 2012).

Results of the intraobserver variability analysis show that pit and striation counts are approximately normally distributed and that for both pit and striation counts, variation between observations was small and not statistically significant (see Appendix A). Thus intraobserver variability or error does not impact the data set in a statistically significant way and the subsequent dental microwear data collected from Kadebakele samples is considered reliable for the sake of drawing inferences on caprine diet and pasture quality.

8.7 Sample Collection, Preparation, and Analysis

Teeth were collected and set aside for DMA during the 2015 and 2017 analysis seasons. During the 2015 season, mammal teeth were bagged and separated during faunal analysis. During the 2017 season, I cross-referenced where previously excavated teeth were located and retrieved them from the collections stored at the field house near the Archaeological Museum at Hampi (Kamalapura). I was able to locate and retrieve all teeth identified in the faunal database from collections. Although I only examined caprine teeth in this analysis, I bagged and separated all mammalian teeth for future research.

Following the procedures outlined in Mainland (2006), I made cast replicas of all sheep and goat teeth collected in the field. Not all teeth that were cast were ultimately used in this analysis. Similar to Mainland, I used the SEM to examine the lower first permanent molar (M1) and the deciduous lower 4th premolar (dmp4). However, I made cast replicas of all teeth to be used in future research should advances in technology and methods show that other teeth are suitable for similar or other lines of analysis.

Molds were made in the field using high precision polyvinylsiloxane dental impression material (Zhermack EliteHD+ regular body normal set). Teeth were cleaned to remove dirt and adherents prior to producing molds. Two dental impressions were taken for each tooth. The first impressions were retained in order to collect dental calculus. The second impressions were used to produce casts as they were less likely to have dirt or contaminants on the enamel that would obstruct the imaging process. Molds were labeled with context information and assigned a dental microwear ID number. Molds were bagged and placed in protective containers to be transported back to the United States.

Casts from the dental impression molds were made at the University of Pennsylvania Fossil Casting Lab. Casts were made using clear epoxy Araldite resin. Casts cured for 24 hours and were then put through a sputter carbon coater (Quorum Q150T S/E/ES) in preparation for scanning electron microscopy. A JEOL scanning electron microscope was used to view and photograph the anterior-facing enamel band of the bucco-posterior cusp at 500x magnification. Multiple images were taken within a limited area range in order to ensure representativeness of features. Microwear features were identified, counted and measured using SEM analysis software Microware 2.2 version 4 (Ungar 2002). Microwear features were distinguished and classified according to the ratio of their length to width measurements with pits having a length to width ratio of < or equal to 4:1 and striations having a length to width ratio > 4:1.

Using archaeological tooth samples in dental microwear research poses certain challenges (see further discussion below). As a result, it is important to control for as many potential confounding variables as possible when interpreting dental microwear data. Before examining dental microwear features on archaeological teeth, I first examined modern sheep and goat teeth with known feeding contexts from South India. Although the accumulation of dental microwear studies has generally found consistency in dental microwear signatures across different geographical contexts (repeat ref from above discussion), this has yet to be established on caprines within my study region. Dental microwear analysis was completed on 20 modern caprine teeth procured from a market in Bengaluru (Bangalore) to verify whether or not this was consistent among caprine populations in South India. These animals had known feeding conditions and were free grazed on healthy pastures following a record setting monsoon season. The India Meteorological Department reports that the 2017 monsoon yielded the highest rainfall in 115 years.[2] Although stocking rates are not known, it is predicted that the modern animals sampled in this analysis will exhibit dental microwear patterning that is consistent with low soil ingestion given the state of vegetation cover in the region at the time.

To assess variation in the modern sample, the proportion of pits was compared across the 20 individual tooth samples (9 goat and 11 sheep). These data are presented in Appendix B. Based on data spread, variation across individuals is low. Similar to Mainland's studies (see section 8.4) there also does not appear to be significant differences in the microwear patterning between sheep and goats in the modern sample. In addition, the mean proportion of pits compared to striations is what we would expect to see when caprine diets contain low levels of soil abrasives. In Mainland's (2006) study, for example, modern dental microwear features were compared across a sample of individuals whose diet was known to be low in soil and soil abrasives based upon the analysis of their dung (245). Where low soil ingestion was demonstrated from dung samples, the mean proportion of pits on teeth was 69.4% and the mean proportion of striations was 30.6%. The modern sample from Bangalore produced a mean pit proportion of 79.1% and mean striation proportion of 20.9%. The modern sample collected and analyzed in this study thus lends support to the inference that caprines that graze on pastures with high vegetation cover exhibit a low proportion of striation features, and that caprines in this particular geographic context are consistent across individual animals when fed the same diet.

[2] https://timesofindia.indiatimes.com/city/bengaluru/bengaluru-records-highest-rainfall-in-at-least-115-years/articleshow/61086785.cms

Moving forward, it is assumed that archaeological specimens also exhibit limited individual variability and that notable variability in the dental microwear patterning observed in teeth from the archaeological record can be explained by differences in diet, primarily whether or not animals ingested a high amount of soil abrasives while feeding.

8.8 Limitations and Challenges of DMA Research in Archaeology

Some limitations have already been outlined in previous sections of this chapter. Use of the SEM-based method, for example, results in problems related to intra and inter observer bias. Using archaeological samples carries additional limitations for sample preservation and image quality. Despite efforts to thoroughly clean specimens and to make two separate molds in order to remove extraneous material from the tooth enamel surfaces, some samples could not be viewed under the SEM. This in effect reduced an already limited sample size in the analysis. In other cases, only a limited area of the tooth enamel surface could be captured using the SEM, leaving open the question of representativeness and sample selection bias for imaging.

The most significant limitations to archaeological applications of dental microwear analysis are due to issues of equifinality. As has already been described at length above, isolating the cause of dental microwear striations has not been without debate for different ungulate species. In my research, aiming to determine whether overgrazing n occurred, requires making assumptions using modern data and is challenging for elucidating subtle differences that could arise from season of slaughter, foddering, and shifts in mobility strategies. This research thus integrates as many additional lines of archaeological and paleoenvironmental data as possible in order to bolster my interpretations of human-animal relationships and human-environmental interactions throughout South India's pre and early history. Here, dental microwear data is considered alongside faunal data and is considered complementary to the larger patterns observed across the faunal data sets. In addition, the concluding chapter will synthesize dental microwear and faunal data with previously published geomorphology data to provide further evidence for environmental and pasture conditions that could coincide with patterns observed in the dental microwear record.

8.9 Dental Microwear Results: Preliminary Insights on Overgrazing at Kadebakele

In total, 23 samples were analyzed using scanning electron microscopy. Unfortunately, no useable teeth were recovered from Neolithic contexts and thus the discussion of dental microwear results will only include Iron Age and Early Historic samples. Of the 23 samples, 13 are from Iron Age contexts and 5 are from Early Historic contexts. Table 8.1 displays the number of total defects identified per tooth as well as the number of scratches and pits and their proportions relative to one another. The numbers presented in Table 8.1 are averages since defects were counted and measured multiple times when assessing the impact of intra-observer error (for which analysis indicated that variation between observations was not statistically significant). Results in Table 8.1 are presented in the best chronological order as could be ascertained based on the radiocarbon dates obtained to date.

With the differences in samples sizes in mind, a primary pattern in the dental microwear data is that only Iron Age tooth samples display evidence that soil abrasives were consumed, an indicator that animals grazed on patchy or low vegetation cover. This is demonstrated through the samples that contain a high proportion of striations compared to pits. Out of the 18 Iron Age[3] tooth samples, 33% (n=5) had a higher proportion of striations compared to pits. Four of these

[3] Heavily striated teeth were present in all contexts. Both heavily and non-heavily striated samples were present in contemporaneous contexts with associated radiocarbon dates ranging from roughly Cal 800-400 BC, a range of the Iron Age that overlaps with what Morrison et al. (2016b) and Sinopoli (2016) and preliminarily coined the Middle Iron Age. Heavily striated teeth mostly come from sub-adult (2-3 years) and adult (3-4 years) animals. One is from an advanced aged animal (Payne's wear stage H, 8-10 years old).

are just above the 50% threshold regarded as heavily striated. Samples 24, 26, 75B, and 86A had a 51.7%, 57.6%, 56.4%, and 55.2% striation proportion, respectively. The remaining 3 samples, however, had a much higher proportion of striations. Samples 51 and 63 both had over 80% striations while sample 70B had 62.2% striations. By contrast, none of the Early Historic samples (n=5) exhibited heavy striation wear. Not only were heavily striated teeth (teeth containing more than 50% striations) absent from the Early Historic sample, the relative proportion of striations to pits was markedly low. For example, the most heavily striated tooth in the Early Historic sample (sample 36B) was only 22.5% striated.

While sample sizes are small, the absence of heavily striated teeth in the Early Historic sample in its own right, and in comparison to the Iron Age sample, provides a clear indication that evidence of overgrazing is lacking for this temporal context. Comparing the mean proportion of striations between the Early Historic sample and the modern sample also reinforces an interpretation that caprine diets during the Early Historic period contained low levels of soil abrasives (i.e., did not graze on patchy or overgrazed pastures). The mean proportion of striations for the Early Historic microwear sample is 20% compared to the modern sample's 21%. Both of these are in line with Mainland's observations of low soil ingestion (2005:245).

While the Early Historic dental microwear patterns appear unambiguously consistent with low ingestion of soil abrasives, the Iron Age dental microwear patterning is less definitive. The Iron Age microwear sample shows the presence of highly striated teeth (33% of the sample), including two teeth with the striation proportion exceeding 80%. However, the mean striation proportion for the total Iron Age sample is only 44%. This value is more than double the value of the mean striation proportions for the Early Historic and modern samples (20% and 21% respectively). However, 44% mean striation proportion from the Iron Age samples is lower than the value Mainland observes in her study of dental microwear patterning in Norse archaeological contexts. In Mainland's study, low mean proportion of striations (29%) corresponds to low soil ingestion based on modern samples with known feeding contexts and low soil presence in dung samples. By contrast, the archaeological sample, upon which Mainland concludes that maladaptive grazing practices and overgrazing occurred, has a mean striation proportion of 70% (2005:245). Thus, although the mean striation proportion for the Iron Age is higher than the Early Historic and the modern samples (both roughly 20%), it is not as high as the Norse archaeological sample. In addition, while the Early Historic sample and the modern sample both have smaller mean striation proportions compared to the modern comparative sample used in the Mainland's Norse study (20% compared to 29%), the difference between the modern and archaeological samples in Mainland's study (29% and 70%) is greater than that between either the modern or Early Historic samples and the Iron Age sample at Kadebakele (20% to 44%).

Table 8.1: Frequency and Proportion of Dental Microwear Features from Iron Age Kadebakele

DMA ID	Context	Dn	Sn	Pn	%P	%S	Majority Striated
Iron Age							
82B	Block A Surface 10	40.3	17.7	22.7	54.4%	45.6%	No
8B	Block B Surface 6	31	12	19	61.3%	38.7%	No
72A	Block A Surface 6	31.5	10.5	21	73.1%	26.9%	No
79B	Block A Surface 5	27.3	13	14.3	52.7%	47.3%	No
69B	Block A Surface 5	43	18	25	58.1%	41.9%	No
67B	Block A Surface 4a	48.5	10.5	38	77.1%	22.9%	No
4B	Block A Surface 4a	28	9	19	67.9%	32.1%	No
83B	Block A Surface 4	75	11.5	63.5	84.8%	15.6%	No
70B	Block A Surface 4	27.7	18	9.7	37.8%	**62.2%**	**Yes**
86A	Block A Surface 3	32	17	15	44.8%	**55.2%**	**Yes**
83B	Block A Surface 3	75	11.5	63.5	84.8%	15.6%	No
63	North Midden Level 10	52	44	8	15.2%	**84.8%**	**Yes**
51	North Midden Level 20	52	43.25	8.75	15.9%	**84.1%**	**Yes**
13B	Block B Surface 2a	62	12	49	80%	20%	No
14B	Block B Surface 2a	55	20	35	60.1%	39.9%	No
31	Block B Surface 1	31	28	12.5	56.5%	43.5%	No
24	Block B Above Surface 1	24	11.7	12	48.3%	**51.7%**	**Yes**
26	Block B Above Surface 1	33	19	14	42.4%	**57.6%**	**Yes**

Dn= Number of Defects (average)
Sn= Number of Scratches (average)
Pn= Number of Pits (average)

Table 8.2: Frequency and Proportion of Dental Microwear Features from Early Historic Kadebakele

36B	8.8E/-449.81 N Level 2	67.3	15.3	52	77.5%	22.5%	No
40	57.16E/-561.77N Feature 1 Level 1	39	7	32	82.1%	17.9%	No
33B	57.16E/-561.77N Feature 1 Level 3	71	14	57	79.3%	20.7%	No
34B	57.16E/-561.77N Feature 4 Level 4	43	8	35	81.4%	18.5%	No
38B	57.16E/-561.77N Level 4	34	7.3	26.7	78.9%	21.1%	No

Dn= Number of Defects (average)
Sn= Number of Scratches (average)
Pn= Number of Pits (average)

Table 8.3: Comparison of Modern and Archaeological Dental Microwear Features from South India and Greenland

	Modern (Bangalore)	Modern (Greenland)	Iron Age	Early Historic	Mainland's Norse Sample
Mean Striation Proportion	20.9%	30.7%	44%	20.1%	70.1%
Mean Pit Proportion	79.1%	69.3%	66%	79.9%	29.9%
Mean Defect Number	36.8	87.4	42.7	50.9	75.8

Contextualized with the faunal data (Chapter 6 and Chapter 7), the dental microwear patterning provides some corroborating evidence that there were changes in the organization of animal husbandry and animal diets between the Iron Age and the Early Historic periods. Although the mean proportion of striations from the Iron Age sample does not appear to necessarily reflect large-scale pasture mismanagement or continuous, ongoing overgrazing, the presence of multiple highly striated teeth in the Iron Age sample show that there were times when animals ingested high levels of soil abrasives. Shifts between the Iron Age and the Early Historic faunal data suggest changes in animal husbandry strategies. During the Iron Age, cattle husbandry appears to have been a primary focus of the subsistence regime with cattle dominating the faunal assemblage. Cattle were used for secondary products (dairy and traction) during the Iron Age. In addition, while caprines comprised a smaller proportion of the Iron Age faunal assemblage, the mortality profiles from caprines show caprines were raised with the goals of maximizing dairy production. By contrast, during the Early Historic period, cattle and caprines comprise a smaller proportion of the overall taxa assemblage compared to the Iron Age (20.5% to 55%, respectively).

The proportional make up of domesticates in the Early Historic sample should be treated with some caution given the excavation contexts are not entirely comparable to the Iron Age and because we do not understand the function and activities characterizing the Early Historic excavation contexts as well as we do the Iron Age settlement. Ultimately, the lower proportion of domesticates compared to the Iron Age results from the high number of fish bones recovered from the Early Historic contexts. If we were to disregard the abundance of fish remains, the faunal patterns still suggest shifts between the Iron Age and the Early Historic periods. During the Iron Age, cattle outnumber caprines 2:1. Importantly, by the Early Historic period, caprines make up a larger (though approximately equal) proportion compared to cattle; Caprines comprise 10.5% of the Early Historic faunal assemblage compared to cattle at 9.1%. Both the overall reduction in the proportion of total domesticates, and the reduction in cattle compared to caprines, correspond to the dental microwear patterning. Teeth exhibited a low mean striation proportion and thus reflect conditions where overgrazing and soil ingestion were not prevalent in the Early Historic context. By contrast, during the Iron Age, when the proportion of domesticates, including cattle, was larger, with at least some episodes of intensive or over grazing were reflected in the dental microwear patterning.

To some degree, the corresponding patterns in shifts in animal husbandry production and organization and the dental microwear results are counterintuitive to the initial expectations of this project. For example, at the onset of this research, one potential pattern that was anticipated was that extensive grazing practices (herding animals further distances from the main site) would be less likely to be associated with overgrazing signatures. The logic behind this expectation or prediction was that increased mobility and covering a larger grazing area would ensure that stocking rates per area were lower, in particular if cattle and caprines were grazed in different ways and in different areas. From the faunal data, it does appear that during the Iron Age grazing activities were more extensive, with cattle remaining closer to the site while caprines were herded to nearby rockshelters (see discussion in Chapter 6 and 7). As noted earlier, these rockshelters have definitive evidence of Iron Age use but are lacking Early Historic material remains (A. Bauer 2010:140) potentially suggesting a reduction in mobility and shift in grazing management practices. During the Early Historic period, cattle continued to be used for traction, among other purposes, and thus, similar to the Iron Age, were likely not grazed far from the site given their high water needs. If cattle continued to be maintained near the site, and caprines were no longer herded extensively, we may expect overgrazing to occur as the result of more intensive localized grazing, in particular if this was occurring alongside agricultural expansion on the River Terrace. That this was not the ultimately observed pattern may be explained by the evidence that cattle and caprines were maintained in lower numbers overall. It might also be the case that by the Early Historic period domesticated cattle and caprines were supplied with fodder. Future dung and isotopic analyses could aid in determining if and to what degree supplemental fodder was provided to animals during the Early Historic period (e.g., Miller et al. 2009; Makarewicz 2014; Chen et al. 2016).

The patterns in faunal and dental microwear data sets also articulate with regional remote sensing and geomorphology data. These show a correlation between prehistoric, including the Iron Age, settlement activities and changes in soil cover/soil erosion (A. Bauer and Morrison 2013; A. Bauer 2014). Moreover, A. Bauer (2014: 11-12) suggested that grazing activities were likely strong contributors to soil erosion since differences in exposed rock appear on the lower slopes where animals were likely grazed. There is also preliminary evidence to suggest that Kadebakele residents recognized problems relating to soil erosion during the Iron Age (A. Bauer and Morrison 2013; A. Bauer 2010:230). While ultimately many factors shaped the social, political, and economic transformations that occurred over the course of the late first millennium BCE, the articulation of soil erosion and overgrazing evidence during the Iron Age, with the construction of erosion retention walls, provides a context for interpreting the shifts observed in animal husbandry management. From this perspective, shifts in how cattle and caprines were managed during the Early Historic period may in part be explained by the fact that residents at Kadebakele experienced the impacts of soil erosion and overgrazing and made efforts to mitigate the impacts.

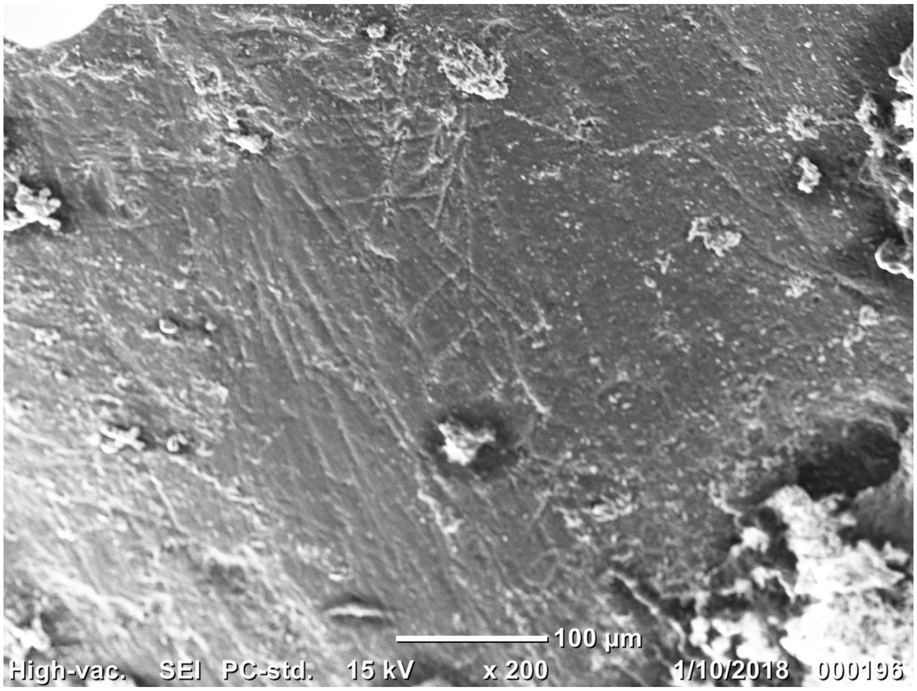

Figure 8.1: Example of Heavily Striated Tooth from Iron Age Kadebakele

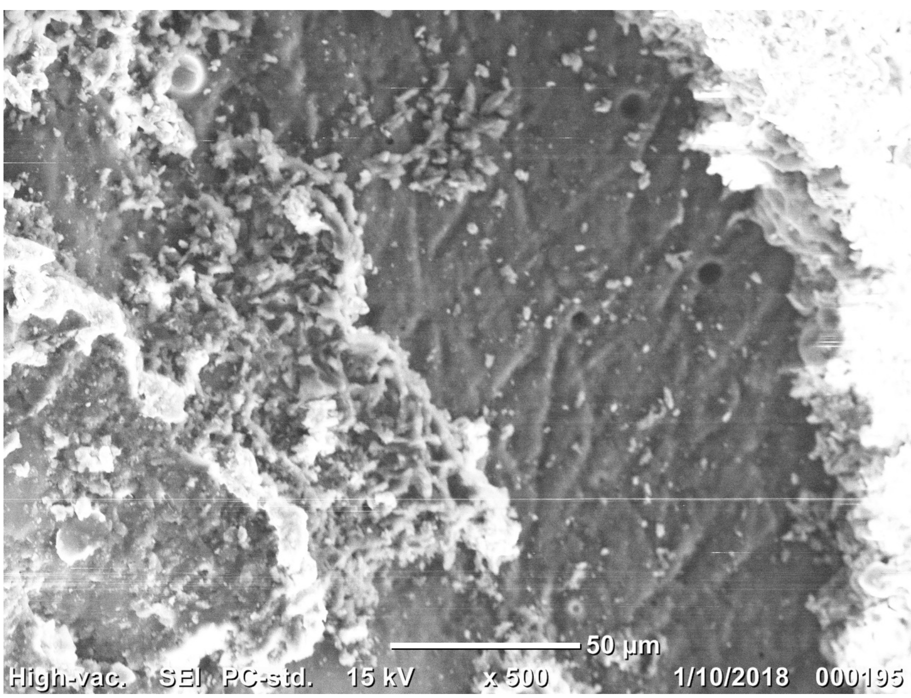

Figure 8.2: Example of Heavily Striated Tooth from Iron Age Kadebakele

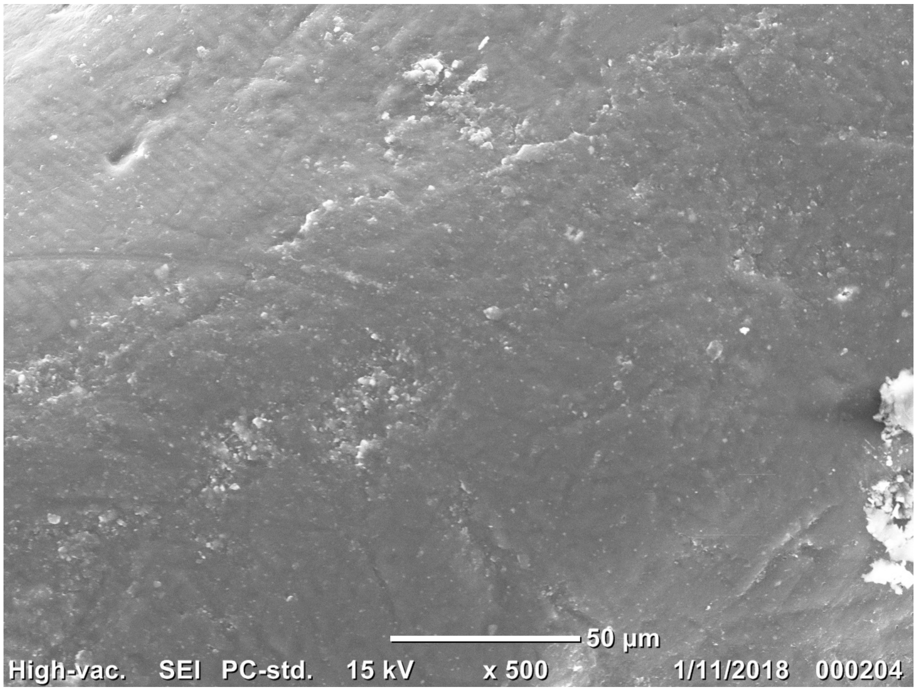

Figure 8.3: Example of Non-Heavily Striated Tooth from Early Historic Kadebakele

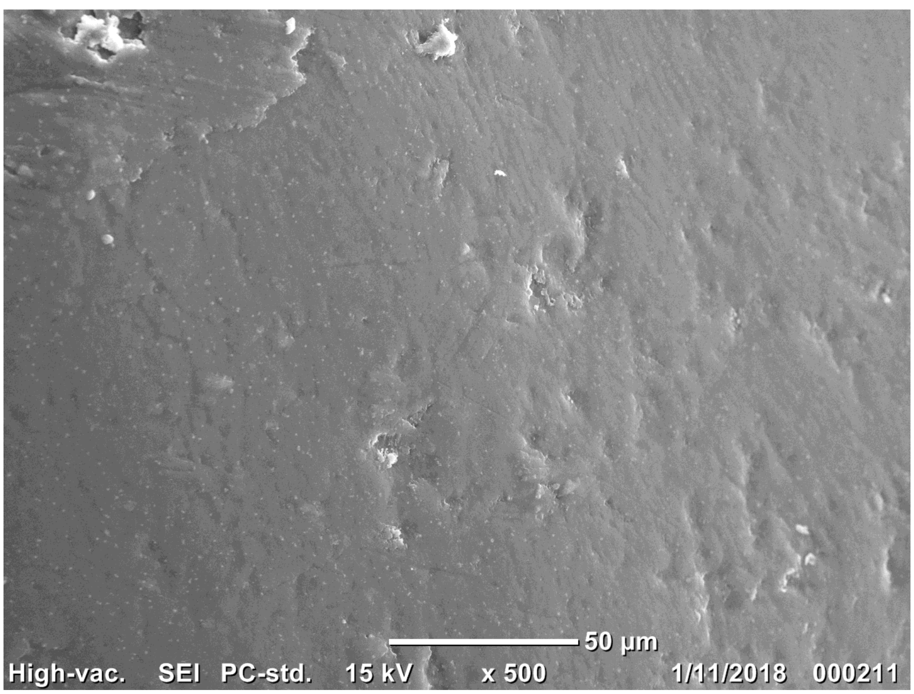

Figure 8.4: Example of Non-Heavily Striated Tooth from Early Historic Kadebakele

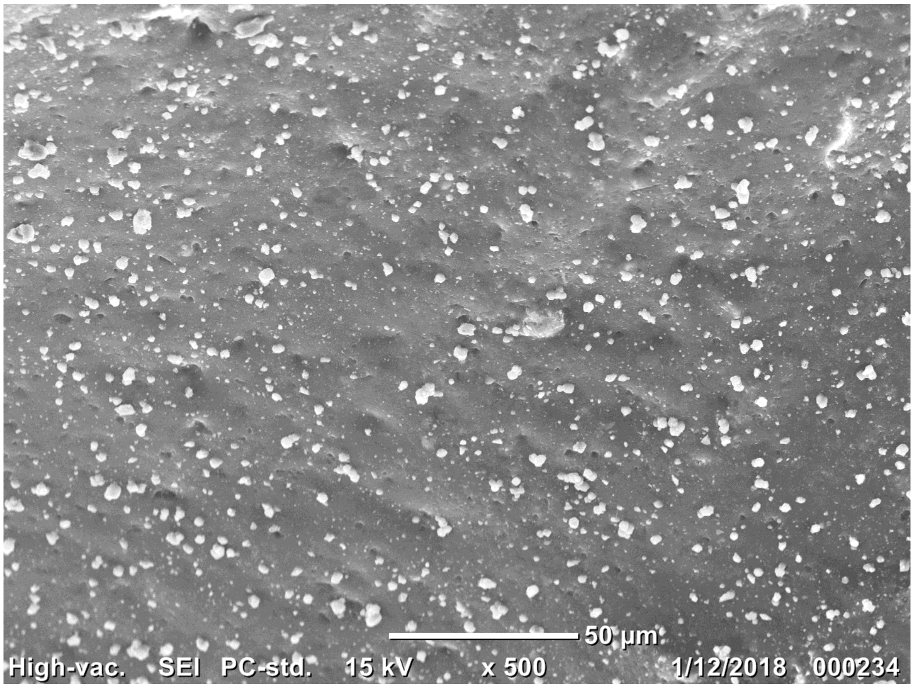

Figure 8.5: Example of Modern Tooth from Bangalore with Pit Features

8.10 Conclusion

This chapter reviews the background literature on dental microwear analysis and the justification of the methods adopted in this dissertation. It also presents the preliminary results of dental microwear analysis and provides a brief accounting of how interpretations of the dental microwear data compare to interpretations rendered during faunal analysis. When thought about together, as well as alongside available remote sensing and geomorphology data for the region, a picture emerges concerning how environmental factors may have figured into decisions regarding animal husbandry between the Iron Age and the Early Historic periods.

As was highlighted in Chapter 2, an even more comprehensive approach to putting forth a reconstruction of decision-making in relation to land and animal use is to reconstruct past perceptions of animals and the environment. What has yet to be explored in this dissertation is how understanding of risk management and relational ontologies can be used to better illustrate such perceptions. In the following chapter, I conclude this dissertation by addressing how patterns in subsistence, grazing, feasting and ritual, and mobility contributed to an understanding of how Kadebakele residents perceived their relationships to domesticated animals and their environment. I build upon the faunal and dental microwear interpretations and make broader claims about risk management and decision-making concerning animals. This assessment is then explored against the critique of degradation narratives that was presented in the introduction of this dissertation.

CHAPTER 9 :
SYNTHESIS OF RESULTS AND FUTURE RESEARCH

9.1 Introduction

In this concluding chapter, I address how faunal, dental microwear, and paleoenvironmental data can be used to reconstruct how Kadebakele residents experienced and perceived their relationships to animals (specifically domesticates) and the environment and how this allows for a more comprehensive way to understand and interpret decision-making in the past. By considering risk management (aversion and tolerance) and a relational ontological approach to understanding human-animal relationships, this analysis ultimately illustrates the complexities of underlying past decision-making and begins to build a deep empirical record of the environmental impacts of grazing. I address the implications these results have for contemporary conservation narratives and discourse, as well as the broader field of archaeology. I conclude by reviewing potential directions of future research.

9.2 Risk Perception, Management, and Animal Care

9.2.1. Introduction:

In Chapter 2, I outlined archaeological signatures argued to reflect risk management based primarily upon research published in Stein (1989), Redding (1981), and Marston (2011). Reconstructing risk management has its limitations, as we cannot presume that modern ways of thinking about risk minimization map neatly onto the past. However, these frameworks are useful for recognizing patterns over time and drawing inferences on what a culmination of different behaviors might index when it comes to choices related to animal use. The distinct combinations of risk averse and risk tolerant practices in both periods, alongside evidence that environmental consequences were perceived by Kadebakele residents during the Iron Age, ultimately show that Iron Age activities set the stage for changes in animal husbandry and grazing practices in the Early Historic period.

9.2.2 Risk Perception and Decision-Making in the Iron Age

The inhabitants of Kadebakele adopted a combination of risk averse and risk tolerant practices during the Iron Age. Actions consistent with risk aversion included the practice of mixed agropastoralism and resource diversification. Resource diversification was evidenced in both food procurement practices (e.g., hunting of large game, hunting of small taxa, and fishing, as well as herding/animal husbandry) and the range of species exploited (e.g., domesticated and wild mammals, multiple species of fish, birds, reptiles, and amphibians). Food diversification was also evident from a farming perspective as Kadebakele residents consumed various cultigens and experimented with irrigation technologies to grow water intensive crops (e.g., bananas and yams) alongside a suite of dry-farmed millets and pulses (Morrison et al. 2016b).

The high goat to sheep ratio (124:1) (or basically an absence of sheep) also potentially speaks to risk aversion during the Iron Age. Goats are able to consume a wider variety of foliage compared to sheep and also have lower water demands (McClure 2015). In fact, because goats are lower maintenance and have less resource-intensive diets than sheep, shifts in sheep to goat ratios have been used to suggest shifts to more stressful environments (e.g., Redding 1984). In addition, extensive grazing was evident during the Iron Age and likely focused on the movement of caprines, since cattle were likely maintained closer to the site for agricultural activities and water access. Extensive grazing can be considered a risk averse or risk mitigating strategy since reduces high stocking rates in the area, which could negatively impact carrying capacity and the health of pastures and flocks (Marston 2011). Arguably, this is of larger consequence when simultaneously maintaining cattle and sheep herds (as opposed to cattle and goats) due to shared preferences for grasses and high water needs (Redding 1992). However, given that sheep and goat were both present in the assemblage, and that cattle were represented at nearly double the proportion of sheep/goats, the decision to extensively graze goats may have followed a similar logic especially if pastures were already stressed (as is indicated to have occurred at times based on the Iron Age dental microwear data).

Alongside risk aversion practices, people also exercised risk tolerance, or willingness to adopt risker and more resource intensive strategies, in various ways. For example, despite a focus on goat over sheep, goat husbandry was not managed in a way to ensure herd security. In fact, goat husbandry was dedicated to specialized dairy production, which included culling nearly 50% of juveniles under 6 months old. This is important since, from the perspective of risk management, the goals of diversification conflict with specialization. It is thus important to unpack why these strategies may have been simultaneously used or how they may have articulated. One potential explanation is that the existing diversified resource base created the conditions where specialized production was possible because it could be done in a way that reduced overall risk to the food supply.

In addition to specialized dairy production for caprines, the large focus on cattle husbandry also supports risk tolerance during the Iron Age. Cattle make up the largest proportion of the Iron Age faunal assemblage at 35.7% and outnumber goats nearly 2:1. Moreover, cattle were maintained well into advanced age, in some cases even beyond the point where they presumably could have reliably provided secondary products. Cattle management is considered risk tolerant because cattle are resource intensive due to their have high feeding and watering needs. In addition, it is often more challenging to extensively graze cattle especially when they are used for labor and agricultural activities, as is indicated from the Iron Age faunal remains at

Kadebakele (e.g., bone pathologies and castration evidence). Cattle thus appear to have been maintained near the site and at stocking levels high enough to warrant extensively grazing caprines. This, combined with the fact that cattle survived into advanced age, suggests that the goals of cattle husbandry were not focused on avoiding or mitigating against risk.

The fact that evidence for soil erosion and overgrazing are documented during the Iron Age also reinforce the argument that risk aversion was either not a priority, or that efforts to offset risk tolerant strategies were unsuccessful or not powerful or timely enough. The consequences of employing the aforementioned combination of practices, however, do appear to have been perceptible. As A. Bauer (2010) summarizes:

> Although the temporality of soil erosion is generally characterized on generational scales, imperceptible within the context of daily activities, preliminary associations between retention features, check dams, and Iron Age ceramics and sites suggest that inhabitants perceived a need to retard erosion by building control walls at some point during the period. (236)

At Kadebakele specifically, there are:

> …a series of retention walls on the southern slope of the site leading down from the Iron Age occupation area near the summit of the inselberg. Hence it appears likely that these were constructed at some point during the site's Iron Age occupation. While ancient inhabitants could have certainly conceptualized soil erosion differently than a modern soil scientist, they nevertheless appear to have made efforts to retard it by bolstering slopes and building retention walls to inhibit the movement of soil materials. (A. Bauer 2010:230-231)

More than just informing strategies to construct soil retention walls, consequences of pastoral activities and the specific combination of practices that Kadebakele inhabitants carried out may also have played a role in shaping shifts in husbandry and subsistence practices in the subsequent Early Historic period.

9.2.3 Risk Perception and Decision Making in the Early Historic Period

Like the Iron Age, residents of Kadebakele during the Early Historic practiced a combination of intersecting risk averse and risk tolerant practices occurred during the Early Historic period. In this period, however, the articulation of practices appears more risk averse than in the earlier Iron Age. Mixed agropastoralism continued. This, strategy is associated with risk aversion because of its inherent flexibility, particularly in semi-arid to arid settings (Marston 2011:192). Early Historic inhabitants also continued to rely upon resource diversification, although in contrast to the Iron Age, Early Historic food resource diversifications focused on intensive fishing rather than hunting. Large game was completely absent from the Early Historic assemblage and the proportion of birds and herptiles both decreased considerably (a shift from 18% to 6% for birds and 11% to .4% for herptiles). Fish remains, however, dominated the Early Historic faunal assemblage and comprised nearly 70% of the identified remains compared to less than 12% during the Iron Age. Moreover, the fish assemblage primarily consisted of distinctive skull remains and thus the high abundance does not appear to be related to skeletal part bias or over representation, as might be the case if the fish assemblage consisted mostly of vertebrae or spines. Instead, the assemblage indicates that fishing occurred at a greater scale/frequency during the Early Historic period than in the Iron Age. As such, fishing in and of itself could have provided enough food resource diversification alongside animal husbandry and farming to supplant the modes of hunting documented during the Iron Age. It is thus, I argue, a reflection of a risk averse strategy.

The shift to more pronounced fishing (and reduced hunting) during the Early Historic period may have been related to shifts in mobility and grazing that have implication for further assessing risk management. Recall from Chapter 7, three items coincided: 1) Fishing/fish remains increase; 2) wild taxa (hunted) decreased; and 3) extensive grazing ceased. Cessation of extensive grazing is informed by a combination of subsistence inferences based on faunal data, as well as a lack of Early Historic surface ceramics associated with nearby rockshelters. Survey data show rockshelters with Neolithic and Iron Age surface ceramics, however Early Historic russet coated painted ware was not present (A. Bauer 2010:140-142). While dating rockshelters solely on the basis of surface ceramics can be problematic, there are other signs that mobility was more limited during the Early Historic period. Extensive grazing provides the opportunity for people to hunt while moving livestock throughout the landscape. This is especially the case for hunting the kinds of small and non-mammalian taxa found in the Iron Age assemblage (e.g., turtles, snakes, amphibians). Thus, it would make sense that a decline in hunted taxa coincided with reduced grazing mobility.

Reduced mobility may have been due to the need to stay closer to and more intensively manage agricultural fields. In this case, fishing from the Tungabhadra River could occur alongside farming as a more amenable combination of agricultural production and animal procurement practices. This provides an important context for how to interpret the cessation of extensive grazing within a risk management framework because extensive grazing is viewed as a means to reduce risk and sustain healthy herds since they are brought further away from the site to graze. Surprisingly, however, evidence of overgrazing from the dental microwear data, is only evident during the Iron Age when extensive grazing was practiced. By contrast, dental microwear data from the Early Historic tooth assemblage, the context where extensive grazing ceased, shows teeth were not heavily, nor even moderately, striated. In other words, the elimination of extensive grazing paradoxically/unexpectedly is not associated with overgrazing while extensive grazing is. Knowing this, the suggestion that abandoning extensive grazing could be considered a shift to more risk tolerance warrants further investigation.

Extensive grazing might not have been necessary during the Early Historic period because of a much more impactful shift in risk management strategies—the reduction in cattle. Cattle went from comprising over a third of the faunal assemblage during the Iron Age (35.7%) to only 9.2% of the Early Historic faunal assemblage. Goats also decreased in proportion compared to the Iron Age. However, by the Early Historic period goats outnumbered cattle, comprising 10.1% of the faunal assemblage. A shift from a cattle-centric husbandry strategy to a balanced goat and cattle strategy (with a slight preference for goats) potentially reflects efforts to be more risk averse, because cattle are significantly more resource intensive to support. This is especially the case when cattle are used for agricultural activities, which is evident based on Early Historic faunal remains, since they would have been supported in close proximity to the site.

Reduction in the number of cattle supported at the site could mean extensive grazing was no longer necessary since both cattle and caprines could occupy the area. If agricultural production expanded during the Early Historic, however, then the availability of pasture for cattle and caprines in close proximity to the settlement could be limited. Thus, another potential explanation for the cessation of extensive grazing could be the addition of foddering. Recall that when it comes to interpreting dental microwear data, the best explanatory pattern is that a high number of striations relative to pits is associated with increased ingestion of soil abrasives, which occurs when animals feed on patchy or overgrazed pastures. The presence of pits or a lack of striations however is ultimately less conclusive and could be due to either feeding of full pastures, or consuming fodder. Here, future work on dung analyses (e.g. Miller et al. 2009) could provide further support for whether cattle and/or caprines were foddered during the Early Historic period. If foddering did occur, this would further bolster the interpretation that risk aversion impacted subsistence choices since it would suggest that a degree of agricultural overproduction occurred such that animals could be foddered (Marston 2011:194).

9.2.4 Risk Perception and Negotiating Duty of Care in Human-Animal Relationships

This dissertation set out to understand changes in subsistence organization, particularly, as it relates to animals. Much of the discussion has focused on the economic and dietary roles of animals played during the Iron Age and the Early Historic period. This is especially the case for the Early Historic period where there was less contextual basis for elucidating differences is procurement and consumption patterns at Kadebakele (no contexts of specialized consumption related to ritual activity were clearly identified).

For the Iron Age, however, I was able to explore the roles of animals beyond a purely economic or dietary perspective. This was illustrated via the discussion of different modalities of feasting and potential animal offerings or specialized deposits of animal remains associated with non-domestic areas (areas with megalith features lacking residential or domestic debris). While extending analysis to go beyond just an economic reconstruction accomplishes the goal of understanding the multiple ways that animals were meaningful to people and what their impacts to social, economic, and political practices were in the past, to end the analysis here would fall short of the goal of more fully elucidating how human-animal relationships were forged and perceived and what implications this has for land use choices and understanding human-environmental interactions at deep time scales. Applying Armstrong Oma's framework (see Chapter 2) for interpreting how animals are not just resources for human exploitation, but rather active participants in their engagements with humans with capacity to mutually shape those relationships and human decision-making, provides this final layer to the analysis.

As discussed in Chapter 2, using archaeological evidence to reconstruct past perceptions of animals and how they may differ from modernist ontological framings of humans and animals, and nature and culture, is challenging. From the Iron Age faunal data, it is clear that cattle and caprines were important economic and dietary resources and were also viewed and valued beyond their capacity as resources for humans. The specific goals for raising caprines during the Iron Age were in service of economic specialization, as people culled 50% of juvenile caprines prior to 6 months in order to optimize dairy production. At the same time, juvenile caprine remains were largely found in association with Block A, an area of ritual activity at Kadebakele. Cattle were raised and relied upon for multiple economic and dietary resources, including dairy and traction. However, they also were part of feasting events, which may have functioned to index different sets of social relationships or create social cohesion amongst different social groups (R. Bauer 2006). Multiple lines of evidence also indicate that cattle survived into advanced age and would have required more resources to sustain than they would provide. Thus, the reliance on cattle and caprines as resources for human use or consumption occurred alongside forms of treatment and care that did not necessarily serve or support a strictly resource- or object-based view of animals, or an anthropocentric narrative concerning how humans view their relationship to them.

For the Early Historic period, there is currently no available data from which to draw inferences about the ritual significance of domesticated animals. In addition, because of the limited age structure data, there is also limited information concerning specialized resource production. However, the various lines of evidence speaking to shifts between the Iron Age and the Early Historic periods still allow for a reconstruction of human-animal relationships using Armstrong Oma's framework. For example, changes in husbandry management and grazing practices occurred in a context where, during the Iron Age, we know that various factors (grazing and pastoral activities included) likely contributed to forms of environmental degradation (soil erosion, overgrazing). Moreover, it appears that these problems were, to some extent, recognized at the time and met with efforts to slow or mitigate them. By the Early Historic period, risk aversion became even more pronounced as the composition of domesticated herd animals shifted to be less cattle-centric and more balanced between caprines and cattle. Notably, domesticates did not comprise the largest proportion of taxa during the Early Historic period, shifting dramatically from over 50% of the Iron Age assemblage to approximately 20%. Grazing practices also appear to have shifted, with extensive grazing being less prominent.

Despite less robust evidence concerning specialized production, the faunal evidence does indicate that cattle continued to be used as sources of traction labor for agricultural activities. Unlike the Iron Age samples, no ossified costal cartilage was recovered during excavations and no teeth with resorped alveolar were identified. Thus, while there is evidence that cattle continued to be used for secondary products, advanced aged animals were not as well represented as they were during the Iron Age. In fact, the preliminary age data suggest animals may have been slaughtered closer to primary meat-bearing age.

The lack of heavily and moderately striated teeth from Early Historic contexts has two main implications. The first is that the changes in husbandry management reduced stocking rates such that surrounding pastures could support grazing without degrading the vegetation and soil. However, if agricultural expansion was underway during this period, this would further limit availability of pasture near the settlement. In this case, the second potential implication, the introduction of foddering, might serve as the stronger explanation for the shifts in the dental microwear patterning. In either scenario, the changes observed in husbandry strategies and organization can be related back to the fact that decision-making with respect to animals was not just centered on resource or economic exploitation for the benefit of humans, but also that the needs of animals were important. That is to say, shifts in food production during the Early Historic period were oriented not just around how to feed the growing population at Kadebakele, but importantly, were also shaped by the duty to meet the dietary needs of herd animals.

This is not to say that the needs of both humans and animals were equally balanced, or that there was not an asymmetrical power relationship between humans and animals. However, the multiple data sets taken together showcase that animals were co-creators in how husbandry practices changed. From Armstrong Oma's framework (2018:219-22), the transition from the Iron Age to the Early Historic shows how humans responded to the needs of animals, rather than merely using them. The dietary needs of animals went from combining intensive (cattle) and extensive (caprines) grazing, to potentially grazing at lower overall stocking rates or providing fodder. These changes also reflect how animals influenced and shaped changes in the spatial relationships and movement in the landscape, which in turn further shaped the landscape history of the region. From this it can be re-affirmed that landscape histories are complex and analysts should consider the various ways in which choices were developed and implemented. To do so entails recognizing that ways of perceiving the world are not universally or necessarily anthropocentric. Scrutinizing a strictly human- centered, cost-benefit account of human-animal and human-environmental interactions enables a more comprehensive reconstruction of landscape histories and makes explicit the complexities that underlie them. As such, the results of this dissertation add to the growing discourse concerning the flaws and shortfalls of conservation narratives since they oversimplify such histories.

9.3 Implications for Archaeology and Future Research

The methodological and theoretical approach and results of this dissertation demonstrate the strengths of using multiple data sets to reconstruct past human-animal relationships. These relationships are complex and include how animals were perceived, and understanding how decision-making shaped by human-animal relationships contributes to building a long-term record of human-environmental interactions. The results add to growing bodies of scholarship on the archaeology of human-environmental interactions as well as discourses on anthropocentrism and relational ontologies in archaeology and anthropology. The results of this research also have important implications for the archaeology of South India specifically. Through this analysis, new insights into specialized dairy production were gained, as were insights into the significance of caprines in both subsistence and ritual contexts. The importance of cattle in prehistoric South Asian archaeology has received much attention. However, caprine husbandry and its articulation with the broader subsistence regime has been less developed in the literature on prehistoric South Indian archaeology and zooarchaeology. The results of this dissertation show that caprines were integral to the secondary products economy during the Iron Age and to providing a robust system of dairy production. This, in turn, may have shaped the ways that they were valued and came to be incorporated into ritual practices. This research is also the first example of using dental microwear analysis in the region and provides a model for how to use faunal and dental microwear analysis together to reconstruct subsistence practices, risk management, human-animal relationships, and human-landscape interactions. Without the multi-methodological approach adopted in this dissertation, it would have been especially challenging to affirm interpretations regarding risk management and perceptions of animals, areas of research which are not prevalent in South Indian archaeology and which, as has been argued throughout this dissertation, have important implications for contemporary conservation discourse.

Faunal research from Early Historic sites in South India has been sparse historically, with many site reports containing only species lists. The research results from this dissertation provide a more thorough quantitative and contextual analysis of faunal remains from Kadebakele's Early Historic settlement. Although the sample sizes and excavation contexts were more limited for Early Historic Kadebakele compared to the Iron Age, the availability of dental microwear data and the comparative aspect of this analysis allowed for preliminary interpretations regarding Early Historic subsistence practices. While some important changes in animal husbandry appear to have occurred between the Iron Age and the Early Historic periods, there were also points of consistency. These include, for example, the fact that wild taxa remained an important aspect of the subsistence regime. In fact, because of the large proportion of fish, wild taxa unexpectedly comprised a large proportion of the Early Historic faunal assemblage. Ultimately, the changes in faunal representation during the Early Historic period, as well as changes in dental microwear patterning, showcase the shift to more risk averse practices to during the Early Historic period.

Future research on the Early Historic period at Kadebakele could lead to revision, especially once more age data is obtained for cattle and caprines. For now, there is not enough information to determine if or how specialized production continued into the Early Historic period. This is important to establish since it is expected that specialized production would need to be maintained, and perhaps expanded, given the shifts in social, political, and economic organization and the need to support a growing population. The ability to confirm whether or not specialized production occurred would also impact how to understand risk management. Implicit within this preliminary assessment of the Early Historic is the question of whether or not agricultural production becomes a larger focus of subsistence organization and production and thus dietary supplementation from domesticates has a smaller role compared to the Iron Age. A more robust understanding of Early Historic agricultural practices would also better refine interpretations regarding grazing mobility. Throughout this research I have argued that the use of traction animals meant animals were likely maintained near the site. However, as plowing need not be practiced year-round, there also could have been seasonal periods where cattle were less constrained in their mobility. To address these items, further excavation, archaeobotanical analysis, and faunal analysis, from Kadebakele's River Terrace is needed.

Future work on Kadebakele's River Terrace is also urgent and important from a preservation perspective. The River Terrace at Kadebakele has already undergone a series of disturbances (illegal digging, expansion of rice paddy onto the site). Moreover, sterile soil has also never been reached on the River Terrace. Further excavations would confirm how early settlement transitioned from the Upper Terrace and provide clearer insights into the overall site history. Comparative faunal data from other Early Historic sites in the region would also be useful for understanding broader regional patterns of subsistence and human-animal relationships for this period.

As the goals of this dissertation were to begin building an empirically-informed, deep historical understanding of animal husbandry and the environmental impacts of livestock grazing in South Asia, this dissertation set out to study the Neolithic, Iron Age, and Early Historic periods. The Neolithic faunal and dental microwear assemblages, however, were particularly small and limiting. For example, no useable caprine teeth were available for dental microwear analysis. Further Upper Terrace excavations to expose Neolithic deposits and obtain an adequate faunal sample, including teeth to be used for dental microwear analysis, would aid in better understanding the earliest phases of the site and extending the dental microwear profile for the comparative purposes originally identified for this project (however, this would be a challenging and time-consuming future endeavor given that Neolithic deposits were not encountered until approximately four meters below ground surface at Kadebakele).

In addition to expanding the faunal and dental microwear samples for different chronological periods, providing additional complementary data sets that bolster the empirical strength of the paleoenvironmental and archaeological record would also be of benefit in future research. As has been mentioned in this chapter and others (e.g., Chapter 7, Chapter 8), the question of whether people foddered animals during the Early Historic period has emerged. Analysis of dung samples and whether or not they are comprised primarily of wild or domesticated plant taxa is one approach that could more conclusively address this question (e.g., Miller et al. 2009). Isotopic analyses of animal teeth could also provide insights into animal diet, as well as animal mobility that could bolster, or challenge, the interpretations put forth in this dissertation (e.g., Finucane et al. 2006; Henton 2012; Henton et al. 2014; Makarewicz 2014; Chen et al. 2016; Mainland et al. 2016; Chazin et al. 2019). Isotope analyses could also provide contextual agricultural information to strengthen broader understandings of the intersections of humans, animals, and the landscape (e.g., Bogaard et al. 2007; Szpak and Chiou 2020; Nayak et al. 2022). As an example, it is currently unknown whether or not animal manuring figured into agricultural practices at Kadebakele, although we do have evidence that dung was used in construction as well as for fuel. Understanding if and when manuring became a larger scale practice is important to understanding the ways in which human-animal-environmental interactions transformed over time.

Future research should also consider how dental microwear patterning in cattle compares to caprines. These samples were collected and molds produced, however obtaining baseline data from modern cattle in the region is difficult due to prohibitions on the slaughter of cattle. Future research designs however could rely upon modern cattle baseline data from similar environmental contexts where such prohibitions are not in place (e.g., Sri Lanka). In addition, given technological advances made over the course of this research, future research could compare SEM dental microwear results to a dental microwear texture analysis to assess whether the patterns are consistent.

9.4 Implications for Conservation Narratives

The results of this dissertation reveal a complex history, not just of human-animal relationships, but also of various intersecting practices including agriculture, land use, ritual, and experimentation with risk management and mitigation. The articulation of these various practices over time, in addition to other factors that could not be fully explored within the scope of this work, produced an empirically informed environmental history that ultimately challenges the assumptions and oversimplifications that structure conservation narratives. To begin, in extending the temporal depth for understanding grazing histories, this dissertation provides additional evidence that undermines the pristine environment myth in South Asia and romanticized notions of past human-environmental interactions. Before even the earliest cities or urban economies emerged, animals fed on overgrazed landscapes. Evidence of overgrazing from the Iron Age adds to the paleoenvironmental and geomorphology records and soil erosion evidence to further support that Iron Age activities had consequential environmental impacts, and that for better or worse, people have been shaping and impacting their environments over deep time scales, including periods before written documents.

This research also shows that trajectories of grazing and their potential environmental impacts or consequences are not simple or inevitable. Dental microwear data from the Iron Age show that high soil ingestion and overgrazing was varied; there were heavily striated teeth, moderately striated teeth, and some teeth with few striations. Moreover, while the lack of heavily striated teeth from the Early Historic assemblage cannot definitively demonstrate that animals subsequently grazed on improved pastures, this dissertation nonetheless contributes to building a deep historical and empirical record demonstrating changes in husbandry, risk management, and land use practices. From this long-term perspective, future research on human-environmental interactions and conservation are in a better position to consider the palimpsest of practices and activities and how they shaped and produced the contemporary landscape. This ultimately creates opportunities for more productive conversations about how to creatively and effectively think about environmental concerns and conservation for the present and future than does the reliance on stale tropes, unfounded myths, and oversimplified narratives of environmental degradation. Failure to build an empirically informed, deep historical account of grazing is importance since a lack of empirical footing means that narratives can be inverted and manipulated to serve as extension of the ideologies and motivations for whoever has the power to dictate and perpetuate that narrative agenda. Having data can enable ways to push back against narratives and better expose those motivating agendas. This has in essence been at the core of critical conservation discourse in recent research showcasing how trajectories of degradation contrast with prevailing views. Analysis of degradation histories can show degradation extending further back in time, being more recent than expected, and/or having multiple explanations for its cause and persistence (e.g., Saberwal 1997; D. Davis 2004; D. Davis 2005; Lane et al. 2009; Gilbert 2013; Ghotge and Ramdas 2014; Morrison 2014; Morrison 2017; Boles et al. 2018).

The results of my research are situated in between debates over whether grazing has always been inherently destructive to the environment and counter narratives demonstrating that modes of traditional grazing practices can be environmentally beneficial, enhancing things like biodiversity. While my results show that overgrazing occurred as early as the Iron Age in South India, they importantly demonstrate under what conditions and practices it occurred. In other words, animal husbandry and grazing is not inherently or inevitably destructive. Rather, specific sets of strategic choices and conditions can both enable and constrain negative environmental impacts. Understanding the articulation of specific practices, conditions, and social, political, economic, and environmental contexts is precisely the approach archaeologists encourage when it comes to providing analyses and insights on human-environmental interactions that are relevant to present day concerns. Using this approach, these understandings stand to be further strengthened, in particular as new data sets and methodological innovation for reconstructing past human-environmental interactions expand.

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APPENDIX A

Table A.1: Test for Normality in the Proportion of Pit Features in Modern Caprine Teeth from Karnataka

Pit Proportion	Rank	Index	Z-scores
0.8462	16	0.771604938	0.744142742
0.881	17	0.820987654	0.919135522
0.778	10	0.475308642	-0.061931623
0.694	2	0.080246914	-1.403412636
0.7917	13	0.62345679	0.314572292
0.801	14	0.672839506	0.447767518
0.818	15	0.722222222	0.589455798
0.7	3	0.12962963	-1.128143645
0.714	4	0.179012346	-0.919135522
0.721	5	0.228395062	-0.744142742
0.763	7	0.327160494	-0.447767518
0.658	1	0.030864198	-1.868241655
0.784	11	0.524691358	0.061931623
0.962	20	0.969135802	1.868241655
0.934	19	0.919753086	1.403412636
0.771	9	0.425925926	-0.186756121
0.724	6	0.277777778	-0.589455798
0.785	12	0.574074074	0.186756121
0.764	8	0.37654321	-0.314572292
0.932	18	0.87037037	1.128143645

Pearson's Correlation Coefficient .97255676

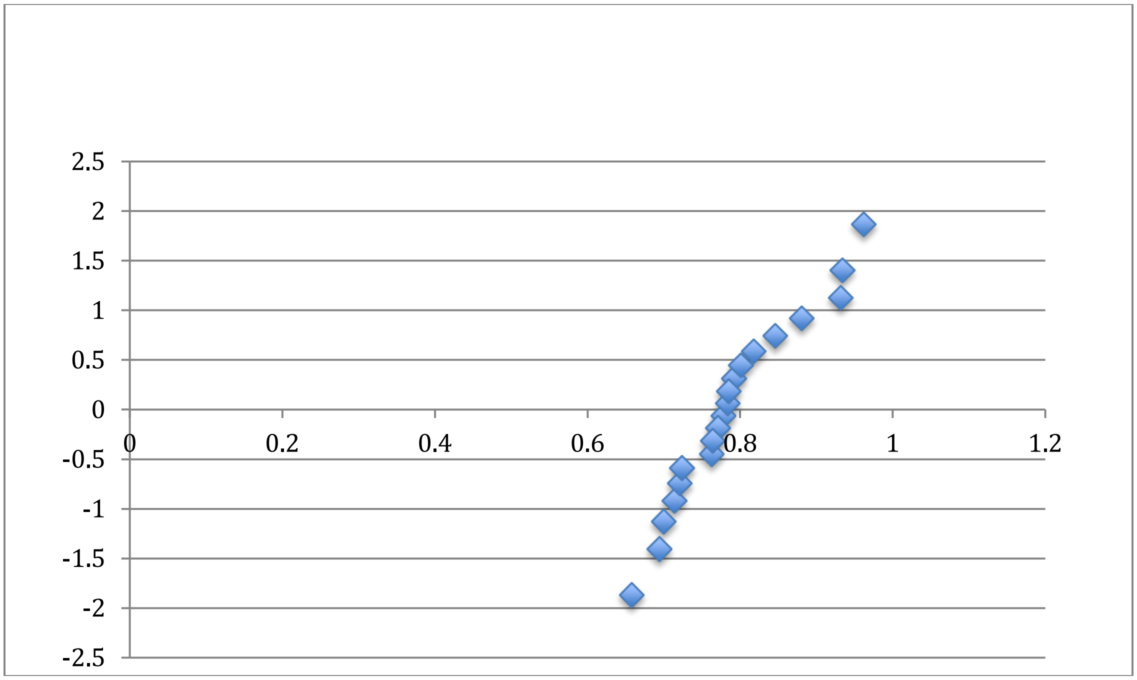

Figure A.1: Proportion of Pits in Modern Caprines Teeth from Karnataka with Linear Line Reflecting Normal Distribution

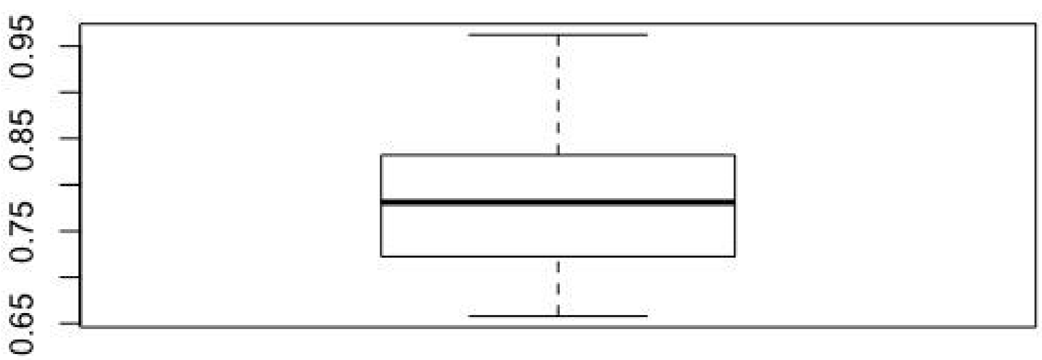

Figure A.2: Boxplot Reflecting Normal Distribution of Pit Proportions in Modern Caprine Teeth from Karnataka

Table A.2: Descriptive Statistics of Pit Proportion from Modern Caprine Teeth from Karnataka[a]	
Mean	.791095
Median	.781
Standard Deviation	.08410875
Variance	.007074284
Range	.304
IQR	.108

Note[a]: Comparison of modern tooth samples indicates little variation between individuals fed similar diets.

Table A.3: Values to Test for Normalization in Scratches Observed to Proceed with Paired T-Test for Intraobserver Variation

Scratch Count	Rank	Index	z-scores
46	44	0.943243243	1.582596273
29	40	0.856756757	1.065860988
55	46	0.986486486	2.211127241
43	43	0.921621622	1.416064035
37	42	0.9	1.281551566
51	45	0.964864865	1.810164569
14	21	0.445945946	-0.135910681
21	37	0.791891892	0.813003213
11	12	0.251351351	-0.670243304
16	26	0.554054054	0.135910681
13	18	0.381081081	-0.30264271
16	26	0.554054054	0.135910681
11	12	0.251351351	-0.670243304
6	4	0.078378378	-1.416064035
5	2	0.035135135	-1.810164569
11	12	0.251351351	-0.670243304
25	39	0.835135135	0.97465841
4	1	0.013513514	-2.211127241
18	32	0.683783784	0.478305992
9	7	0.143243243	-1.065860988
9	7	0.143243243	-1.065860988
17	29	0.618918919	0.30264271
23	38	0.813513514	0.890918354
11	12	0.251351351	-0.670243304
11	12	0.251351351	-0.670243304
13	18	0.381081081	-0.30264271
6	4	0.078378378	-1.416064035
19	33	0.705405405	0.540011373

Table A.3 Continued: Values to Test for Normalization in Scratches Observed to Proceed with Paired T-Test for Intraobserver Variation			
10	11	0.22972973	-0.739737219
15	25	0.532432432	0.081385808
12	17	0.359459459	-0.359904009
9	7	0.143243243	-1.065860988
30	41	0.878378378	1.166918601
14	21	0.445945946	-0.135910681
16	26	0.554054054	0.135910681
5	2	0.035135135	-1.810164569
13	18	0.381081081	-0.30264271
9	7	0.143243243	-1.065860988
17	29	0.618918919	0.30264271
19	33	0.705405405	0.540011373
20	35	0.748648649	0.670243304
14	21	0.445945946	-0.135910681
6	4	0.078378378	-1.416064035
17	29	0.618918919	0.30264271
14	21	0.445945946	-0.135910681
20	35	0.748648649	0.670243304
Pearson's Correlation Coefficient = .90357761			

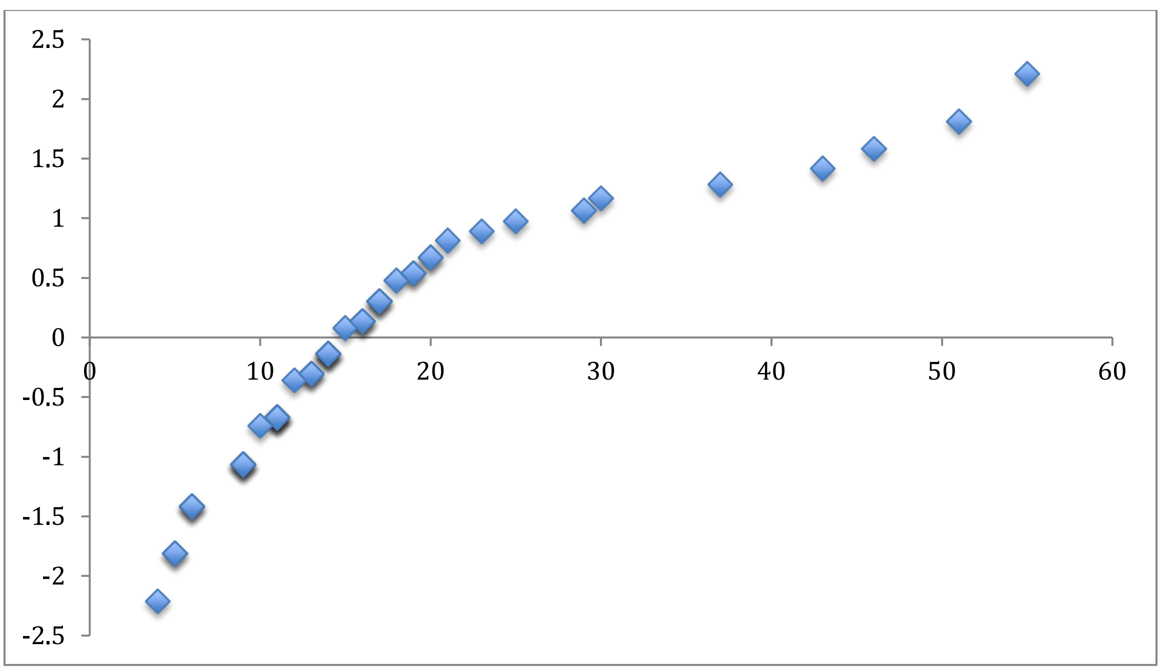

Figure A.3: Values from Table B.3 to Show Normal Distribution (Linear)

Table A.4: Paired T-Test for Number of Scratches Observed on Kadebakele Caprine Teeth Run[a]	
Statistics	Values
t	1.8547
df	46
p-value	0.07005
CI	-0.01995746 0.48804256
Mean of the differences	0.2340426

Note[a]: P-value>.05 resulting in failure to reject the null hypothesis

Table A.5: Values to Test for Normalization in Pits Observed to Proceed with Paired T-Test for Intraobserver Variation

Pit Count	Rank	Index	Z-score
6	2	0.029411765	-1.88950996
4	1	0.011312217	-2.279717741
16	17	0.300904977	-0.521799476
9	6	0.101809955	-1.271305716
6	2	0.029411765	-1.88950996
10	10	0.174208145	-0.937665596
45	44	0.78959276	0.805009011
65	52	0.93438914	1.509301626
46	45	0.807692308	0.869423773
61	51	0.916289593	1.380538791
83	55	0.988687783	2.279717741
44	43	0.771493213	0.743773401
40	42	0.753393665	0.685208011
35	40	0.71719457	0.574527555
23	32	0.57239819	0.182483095
28	35	0.626696833	0.323117398
29	37	0.662895928	0.420379632
32	39	0.699095023	0.521799476
9	6	0.101809955	-1.271305716
19	26	0.463800905	-0.090862547
52	49	0.880090498	1.175439309
65	52	0.93438914	1.509301626
30	38	0.680995475	0.470484298
51	48	0.86199095	1.089307969
19	26	0.463800905	-0.090862547
19	26	0.463800905	-0.090862547

Table A.5 Continued: Values to Test for Normalization in Pits Observed to Proceed with Paired T-Test for Intraobserver Variation

18	23	0.409502262	-0.228825528
7	4	0.06561086	-1.509301626
11	12	0.21040724	-0.805009011
14	15	0.264705882	-0.628904218
16	17	0.300904977	-0.521799476
18	23	0.409502262	-0.228825528
10	10	0.174208145	-0.937665596
18	23	0.409502262	-0.228825528
19	26	0.463800905	-0.090862547
28	35	0.626696833	0.323117398
48	46	0.825791855	0.937665596
48	46	0.825791855	0.937665596
9	6	0.101809955	-1.271305716
11	12	0.21040724	-0.805009011
9	6	0.101809955	-1.271305716
19	26	0.463800905	-0.090862547
23	32	0.57239819	0.182483095
25	34	0.608597285	0.275664935
11	12	0.21040724	-0.805009011
17	21	0.373303167	-0.323117398
15	16	0.28280543	-0.574527555
36	41	0.735294118	0.628904218
16	17	0.300904977	-0.521799476
16	17	0.300904977	-0.521799476
68	54	0.970588235	1.88950996
59	50	0.898190045	1.271305716
17	21	0.373303167	-0.323117398
22	31	0.554298643	0.136529488
8	5	0.083710407	-1.380538791

Pearson’s Correlation Coefficient = .940523413

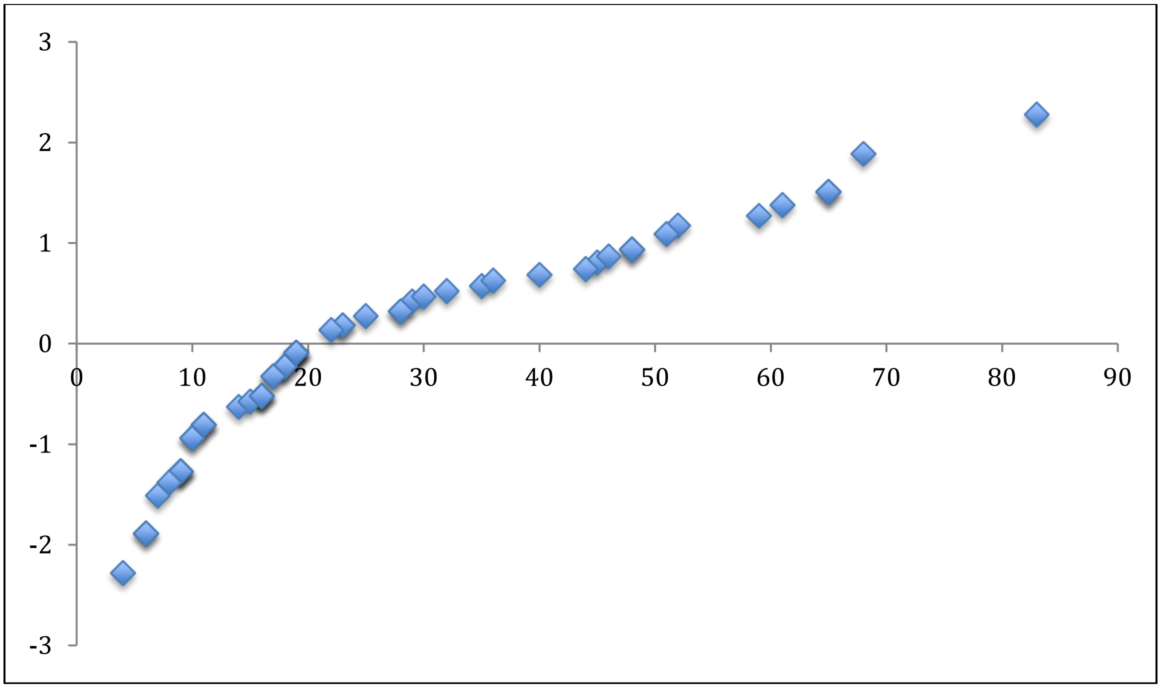

Figure A.4: Table B.5 Values to Show Normal Distribution (Linear)

Table A.6: Paired T-Test for Number of Pits Observed on Kadebakele Caprine Teeth Run in R[a]

Statistics	Values
t	1.2415
df	46
p-value	0.2207
CI	-0.1057568 - 0.4461823
Mean of the differences	0.1702128

Note[a]: P-value > .05 resulting in failure to reject the null hypothesis