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Pig (*Sus scrofa*) Exploitation at Hallan Çemi, Southeastern Anatolia:

Proposing an Alternative Model

By

Ximena Lemoine

A thesis submitted in partial fulfillment of the
requirements for the degree of

Bachelor of Arts
in
Anthropology
University Honors Program

Thesis Committee:

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Portland State University
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Abstract

Hallan Çemi presents itself as a unique site to study the transitional period before the onset of agriculture in the Near East. The site fails to fit nicely into demographic or environmental models that have widely been accepted for the region. Hallan Çemi thus represents the potential to study innovative human strategies for subsistence, and to provide insight into the processes that led to the eventual adoption of agriculture only a few millennia later.

Richard Redding and Michael Rosenberg presented one such innovative strategy for pig exploitation at this site with their New Guinean model (Redding and Rosenberg 1998; Rosenberg et. al. 1998; Rosenberg and Redding 1998, 2000). My study utilizes a sample from a distinct, more quotidian context, as well as previously unstudied fetal/neonatal remains, to re-evaluate Redding and Rosenberg's claims of pig husbandry at this site. Additionally, I propose and test an alternative model, the Cradle Robbing model, which proposes a novel hunting strategy focusing on farrowing females. In order to do so I introduce a new method, synthesizing previous work, to reconstruct age demographics using pig tooth eruption and wear.

My results, as well as an evaluation of the likely environmental situation and wild boar ecology, indicate that a New Guinean model for husbandry is unlikely, and support the Cradle Robbing model as more parsimonious. Finally, the Cradle Robbing model represents a departure from the tendency to *create* domestication practices where none may have existed, and examines the possibilities of diverse and novel hunting strategies employed by early sedentary societies.

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If you don't see your name here, I didn't forget you, I just ran out of room.

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Chapter I: Introduction

This research reassesses pig (*Sus scrofa*) exploitation at the 11,500-year-old site of Hallan Çemi in southeastern Turkey. Richard Redding and Michael Rosenberg have used the pig remains from all occupation periods to argue for the development of at least some level of human directed management at the site, proposing an innovative husbandry model based on ethnographically recorded New Guinean practices (Redding and Rosenberg 1998; Rosenberg et. al. 1998; Rosenberg and Redding 1998, 2000). The two-fold purpose of this investigation is therefore to (1) re-evaluate this hypothesis and; (2) to test a new model—referred to as the “Cradle Robbing” model—for pig exploitation that emphasizes a novel *hunting* strategy rather than a novel *husbandry* practice. These goals will be achieved through the analysis of previously unstudied faunal material from the site.

Hallan Çemi is an Epipaleolithic site in the southeastern Anatolian region of Turkey. It is located in a small valley at the foothills of the Taurus Mountain Range along the west bank of the Sason Çayı—a tributary of the Batman Çayı, which feeds into the Tigris River. The site is the oldest known year-round occupied village in the region at ca. 11,500 BP and was occupied for a brief several hundred years before abandonment. Hallan Çemi was inhabited during the critical period of initial domestication of major ungulates (pig, sheep, and goat) that occurred at the Pleistocene-Holocene transition (12,000-10,500 BP), coinciding with the stabilization of climate throughout the Taurus-Zagros Arc (TZA) (Zeder 2009, 2011; Bar-Yosef and Meadow 1995). Thus, it provides a glimpse into the preliminary context of animal domestication in the region.

Early research in the region often relegated pigs as a later and unimportant domesticate, with their arrival coming as late as ca. 9000 BP and only then as an import from the Levant (Flannery 1983). However, recent archaeological and genetic research indicates that by ca. 10,500 BP pigs came under human control in the TZA (Zeder 2011). Despite this earlier date for domestication, should Redding and Rosenberg's assertions prove correct, pig domestication in the region would not only be of autochthonous origin, but also be pushed back by a full 1,000 years—making pigs and not ovicaprids (sheep/goats) the first animals to come under human control.

Redding and Rosenberg's argument for pig husbandry at Hallan Çami hinges on a female breeding model based on New Guinean husbandry practices that will be discussed in further detail in Chapter Two. Their claims are supported by four lines of archaeozoological evidence: (1) the prevalence of whole carcasses in body part representation indicating a tendency toward butchery practiced on-site; (2) the proportion of pigs to all other major taxa increasing through time; (3) tooth size appearing to be slightly smaller than would be expected from a wild, hunted population; and (4) age and sex structure demonstrating a bias toward young males, as is similar to later (fully domestic) sites in the Middle East (Redding and Rosenberg 1998; Rosenberg et. al. 1998; Rosenberg and Redding 1998, 2000; Redding 2002).

In this study, I will analyze tooth size and reconstruct the age demographic of Hallan Çemi through the faunal analysis of a sample of pig remains from a different location of the same site, effectively building upon and reassessing two of Redding

and Rosenberg's criteria. Moreover, in my analysis of age structure I will be implementing a new method—developed for this project—for recording age-at-death that utilizes compiled precise tooth wear and eruption data. Analysis of fetal/neonatal pig bones—using size, as a proxy for age—will also be conducted in combination with the data collected from age and tooth size in order to test the new, proposed “Cradle Robbing” model.

This thesis is organized into six chapters. In Chapter Two I present pertinent background information on the process and definitions of domestication, how it is evident in the archaeological record, and a summary of pig domestication in the Taurus-Zagros Arc. I provide a detailed explication of Redding and Rosenberg's New Guinean model as well as its theoretical implications. In Chapter Three I describe Hallan Çemi and its chronological importance to the region as a whole. Additionally, I describe and justify my materials and methods and finally present the Cradle Robbing model and its expectations. Chapter Four presents the results of this study including molar sizes, age structure and survivorship curves, and measurement statistics from the fetal/neonatal piglets. Chapter Five discusses the implications of the results. First I compare my results to Redding and Rosenberg's and how they do—or do not—fit into their model of pig husbandry. Second, I will test the cradle-robbing model with my results and conclude by situating pig exploitation at Hallan Çemi into its regional context. Finally, my conclusions focus on the methodological contributions of the new method developed and employed in this study to reconstruct age demography and on future work necessary to achieve a more complete understanding of pig exploitation at this transitional site.

Chapter II: Background

Defining Domestication

The transition into the Neolithic is traditionally described by the shift from foraging economies to agriculture and permanent settlement (Redding 2002). The onset of this shift to food production marks a radical change in a *bauplan* that had persisted for millions of years (Zeder 2009) and would go on to have sweeping effects across the entire development of the Neolithic. This “Neolithic Revolution”—involving the development of food-producing economies dependent on domesticated plants and animals—is often cited as the prime mover in the development and emergence of civilizations and complex societies (i.e. Childe 1936; Binford 1968; Flannery 1969; Bar-Yosef and Meadow 1995). The demographic changes and the social and cultural complexity that emerged from this transition, as well as their relevance to the study of cultural evolution, have been the obsession of various scholars for at least the last seventy years, and the Near East has been at the center of such study (Flannery 1983; Bar-Yosef and Meadow 1995; Zeder 2009, 2011).

Defining domestication has been the source of lively and contentious debate since research into the process began over 120 years ago (Bökönyi 1989). Schemes of defining the term occupy a spectrum between those that emphasize human intentionality and those that award power to the domesticate itself (Zeder 2006a). At one extreme, definitions focus on the human intent of mastery over every aspect of a plant or animal population—where humans exert full control over reproduction, range, health, etc. (Bökönyi 1989; Ducos 1978, 1989).

In these definitions domestication requires and results in an elemental change in the very structure of human societies and socioeconomic organization, especially as it pertains to production (Meadow 1989). In his often cited paper, Pierre Ducos states that domestication requires the integration of animals “as objects into the socioeconomic organization of the human group” where they can be used “for ownership, inheritance, exchange, trade, etc.” (1978: 54). Domesticates do not then simply become an extension of the predator-prey relationship, but rather they are socio-economic entities that emphasize and symbolize ideas of ownership.

At the other end of the spectrum lie “non-anthropomorphic” ways of defining domestication. Researchers favoring this approach, mainly emerging from an evolutionary biology perspective, argue that the above definitions of domestication are too one-sided and assert that the domesticates themselves benefit from various aspects of the process—including improved reproductive fitness and increased ranges (O’Connor 1997; Bleed 2006). Additionally, they argue that what is generally termed “domestication” is not a unique phenomenon to humans, pointing to cases of commensalism and mutualism that occur naturally in the wild (Moray 1994; O’Connor 1997). For these authors the role of deliberate human intent is much reduced, replaced instead by biological mechanisms, especially that of natural selection.

The task of defining domestication is haunted by the additional dichotomy of what is considered “wild” and “domestic”. Clearly, in order to study the various processes and stages of domestication in the archaeological record researchers must be able to recognize them. This requires the detection of certain “clear-cut”

markers that can be confidently attributed to the various stages of the process (Zeder *et al.* 2006; Zeder 2006a). Traditionally throughout the discourse, primacy has been given to the genetic effects of domestication and the ensuing morphological consequences, and some researchers have even deemed this as the fundamental characteristic of its identification (Uerpmann 1996). This has resulted in greater emphasis and study on the later, more obvious stages of the process.

These stringent definitions of domestication, or domestication *sensu stricto*, require effective reproductive isolation, where human beings act as the ultimate authority and selective pressure (Haber *et al.* 2002). While these markers are effective when dealing with the domestication of plants—where the processes of domestication direct selective pressures toward morphological characteristics such as seed size and thickness (Smith 2006)—they become troublesome in regards to animals where selective pressures are directed mainly toward behavior (Zeder 2006a, b, c). Morphological change, if it occurs at all, may not appear until long after cultural control has already been initiated (Redding 2002; Zeder 2006a, b, c, 2009). That is not to say that morphological changes in domestic animals do not exist and cannot be useful in identification. For example, changes in the size and shape of horns in such animals as sheep and goats are expressly associated with the relaxation of selective natural pressures compounded with active human selection as a result of herding (Zeder 2006a), but these indicators are usually invisible and consequently irrelevant, early on in the process.

Morphological changes can also be the result of pressures that predate or simply lie beyond the scope of domestication processes. The rapid reduction of body

size—arising as a result of selection for small size due to poor nutrition or human directed selection for smaller more acquiescent animals (Zeder 2006a)—has previously been claimed as a marker of preliminary domestication (Meadow 1989). Body size, however is an incredibly pliant quality and is largely affected by factors that may be utterly unconnected to human management such as age, sex, and environmental conditions (Zeder 2001, 2006a, b). In the case of animals that entered the process of domestication through commensalism, the picture becomes even more vague. For pigs and dogs, for example, the general neotonization or juvenilization of the skull is regarded to be largely the result of selection for reduced aggression—the product of which is a shorter snout, crowded teeth and more importantly reduced molar size (Flannery 1983; Zeder 2006b, 2011). However, these morphological changes may not be the sole products of domestication, but rather evidence of adaptation to the anthropogenic environments requisite of commensal animals (Zeder 2006b, 2011).

The late onset of morphological change and the various and often complicating factors that contribute to those changes make it useful to look at domestication not as a hard line, defined by the observable phenotypic result of altered genetics, but in terms of “causal human behavior” (Zeder 2006a: 106). In doing so, research is then opened to find markers for domestication beyond morphology, turning instead to those that indicate human action. The use of demographic profiles specific to herding versus hunting strategies, the presence of animals outside their natural habitat, an increase in previously unexploited or underexploited animals, tooth pathologies such as Linear Enamel Hypoplasia in

pigs, and the presence of corrals or other structures that indicate the local keeping of herds have all been used to assess varying degrees of human control (2006a).

With just a brief survey of the literature it becomes starkly clear that defining and documenting domestication is no easy task—often encamped between opposing theoretical and methodological paradigms. Nonetheless, one commonality exists between all approaches: that domestication involves a *relationship* between humans and certain plant and animal populations (Zeder 2006a). Mitigating just how that relationship develops and proceeds is perhaps the real charge of any researcher seeking to study it. Increasingly, many researchers seem to be getting closer to a coherent and applicable study of domestication and have started to view the process not as the strict dichotomy between biological and cultural or wild and domestic but as a gradient, where populations fall somewhere on a continuum with components of both (Hongo and Meadow 1998, 2000; Haber *et al.* 2002; Ervynck *et al.* 2001; Haber and Dayan 2004; Zeder 2006a, b, 2009, 2011).

Melinda Zeder defined the process of domestication as “a form of mutualism that is asymmetrically enhanced by the human ability to culturally transmit learned behavior” (2006b: 107), emphasizing the importance of biology while distinguishing human intentionality as the key factor that separates the process from other mutualistic relationships in nature. Moreover, various scholars have suggested that the process must be looked at in a case-by-case scenario, as different species are expected to undergo the processes differently and will thus appear in the record in diverse forms (Redding and Rosenberg 1998, Haber *et al.* 2002; Redding 2002; Zeder 2006b, 2011). This too applies for different cultural contexts where various

kinds of human behavioral solutions are largely contingent on highly local pressures. It is within this context, and under this theoretical framework, that domestication will be considered in this thesis.

Pig Domestication in the Taurus-Zagros Arc

The Taurus-Zagros Arc (TZA) consists of the region that stretches from the eastern Taurus Mountains in southeastern Anatolia to the Zagros Mountains of Iran (Fig. 1). Recent archaeological and genetic evidence from the region indicates that by 10,500 cal. BP three major ungulate species—sheep, goat, and more importantly for this study, pig—had been brought under human control (Zeder 2009, 2011).

Despite their widespread occurrence and abundance at numerous sites in the Near East, pigs had previously been cast in the role of a delayed and unimportant addition to the gamut of Near Eastern animal domesticates, especially when compared to the ovicaprids (Redding and Rosenberg 1998; Zeder 2008, 2009, 2011). Early on in the debate, domestic pig was suggested to have arrived in the Zagros 1,500 years after ovicaprids at cal. 9000 BP. Moreover, evidence from Jarmo, which is located at the foothills of the Zagros Mountains in southwestern Iran, utilizing pottery exchange suggested that the TZA was a receptive, secondary center of pig domestication (Flannery 1983).

Recent archaeological research has started to reveal an exceedingly different picture of the domestication of this species in the TZA. Pigs are now thought to have emerged from within the Taurus Mountain Range as early as 10,300 cal. BP based on demographic evidence from Cafer Höyük (Helmer 2008). Additionally, material

at Çayönü—also located in the Taurus Mountain range and spanning an occupation of 10,200 to 7,500 cal. BP—clearly shows gradual change in tooth size, age structure, and overall biometry, which has been argued to represent an ongoing change from a commensal to a domesticate (*sensu stricto*) status at this site (Hongo and Meadow 1998; Ervynck et. al 2001).

FIG. 1. –Map delineating the Taurus-Zagros Arc in red and the location of the city of Batman and Hallan Çemi.

In general pig domestication appears to have expanded gradually along the western and eastern sides of the Fertile Crescent (Zeder 2011). Based on evidence from various sites, it was not until around 8,500 years cal. BP that domestic pigs reached the southernmost end of the Levant (Horwitz *et al.* 1999), lowland southwestern Iran (Hole, Flannery, and Neely 1969), or central Anatolia (Martin,

Russell, and Carruthers 2002). This new evidence demonstrates that the TZA formed as an *independent* center of domestication and not as a secondary or receptive one, challenging previously long-held models.

The assertions made by Richard Redding and Michael Rosenberg that pigs were under some form of cultural control at Hallan Çemi about 11,500 years ago (Redding and Rosenberg 1998; Rosenberg et. al. 1998; and Rosenberg and Redding 1998, 2000) have important implications for the study of domestication in the TZA. If their hypothesis is correct, domestication of pigs will be pushed back an additional 1,000 years. Furthermore, Redding and Rosenberg's key factor to explain the shift from hunting to management—so-called subsistence insurance—would pose new frameworks for investigating causality. This is explored and discussed in greater detail below.

Ecology of the Wild Boar and its Implications for Hallan Çemi

The wild boar is the most widely distributed land mammal on the planet with a native range that extends from western Europe to as far east as Japan and as far south as the rainforests of Indonesia. Four modern subspecies groups are generally recognized and are largely determined by geographic locality: the western species or the *scrofa* group, the Indian species or the *cristatus* group, the eastern species or the *leucomystax* group, and the Sudanic species or the *vittatus* group (Groves 2008). Due to thermoregulatory and hydration requirements, pigs are most commonly found in habitats near water such as forest and scrub brush areas surrounding watering holes, in riverine forests, swamps, or marshes (2008).

In general, wild boars are gregarious, but do not form large herds. Instead, the nuclear social unit is based around one or several females (sows) and their offspring, with adult males joining the group during times of sexual receptivity (Graves 1984). These family groups do not disperse until either the young reach sexual maturity—at around seven to eight months—or when the sow or sows are ready to farrow (give birth) again (Conley *et al.* 1972). Generally, males become mostly solitary by one-to-two years of age (Graves 1984).

Activity patterns for wild pigs are largely dependent on various factors such as location, season, predator pressure (especially hunting), and food availability, but in general pigs tend to be diurnal with nocturnal activity increasing with increased predation (Graves 1984). Males have much larger ranges than do females, but home range is more a function of food availability and breeding season than sex, except during birthing season when sows significantly reduce their home ranges as they leave piglets behind to go search for food (Graves 1984).

Gestation generally lasts an average of 120 days with a mean of 5.1 piglets per litter (Graves 1984). Within 24 hours of parturition, pregnant sows construct farrowing nests separate from the social group in order to give birth. They rejoin the group within ten days (1984). In multi-female groups, cooperative nursing also occurs, especially as mothers depart from the group to forage for food alone (Eisenberg and Lockhart 1972).

Wild boar are capable of breeding throughout the year, but tend to have seasonal peaks in birth frequencies, usually in spring (Fonseca *et al.* 2004; Santos *et al.* 2004). However, Mauget (1980), based on wild boar populations in Southern

France, has suggested that there are two types of birth frequency distributions: unimodal and bimodal. Unimodal distributions have a single breeding season in fall with parturition occurring in spring. Bimodal distributions have two breeding seasons, with farrowing occurring primarily in late winter and again in summer.

Many factors affect the timing and frequency of births in wild boar populations. These include age, group structure, and, most importantly, food availability. One study conducted in three ecologically distinct regions of Portugal demonstrated that, in all cases, younger females—especially those under one year—had fewer piglets, with older females above one year of age having the highest breeding percentage (Fonseca *et al.* 2004). Additionally, estrus in multi-female groups appears to be synchronous, with farrowing occurring in the same season (Eisenberg and Lockhart 1972).

Various studies have demonstrated that both the season and yield of reproduction is extremely contingent on food availability (Graves 1984; Mauget *et al.* 1984; Mauget and Pepin 1991; Fonseca *et al.* 2004; Maillard and Fourier 2004; Santos *et al.* 2004). In the same Portuguese study, Fonseca *et al.* (2004) noted two distinct birthing patterns that could be explained by regional food availability. In north and central Portugal, where strong climatic and food availability seasonality were present, a distinct spring birthing season was evident. In the south, where food was available year-round a protracted reproductive period throughout the year was noted, as well as an increase in the mean number of piglets per sow. Additional studies have shown that females can delay or skip reproduction in years of severe food shortages (Matschke 1964; Mauget and Pepin 1991).

Reproduction is also strongly associated with the availability of mast food sources, such as acorns (Mauget 1980; Graves 1984; Matschke 1964; Maillard and Fourier 2004). For example, in European wild sows, females will be in anestrus conditions during times of mast failure and in extended estrus in years when mast is available to them (Matschke 1964).

Understanding pig exploitation as it occurred at Hallan Çemi over 11,000 years ago is complicated by various factors of wild boar ecology. The environment surrounding the site is ideal for a healthy wild boar population, with mixed oak and pistachio forests, as well as its location within a floodplain all filling the necessary dietary, water, and habitat requirements for the species (Rosenberg *et al.* 1998). Furthermore, as a result of the stabilization and amelioration of climate occurring at the beginning of the Holocene (Wick *et al.* 2003), Hallan Çemi was occupied during a *bona fide* time of plenty, with plant and animal resources allowing for year-round settlement (Bar-Yosef and Meadow 1995; Starkovich and Stiner 2009; Zeder 2009, 2011).

Because of the close relationship between food availability and wild boar reproduction, the year-round and abundant plant resources found in the vicinity of Hallan Çemi present a possible systemic situation with methodological implications. In all likelihood, the wild boar population exploited by residents of the site was capable of multiple farrowings and protracted or broadly defined birthing seasons—as in the case of the southern Portuguese pigs reported by Fonseca *et al.* (2004). In effect, fetal and neonatal pigs could have been exploited throughout the year or several times a year. Timing the season of birth and exploitation of fetal and

neonatal pigs at Hallan Çemi is then difficult to ascertain with any confidence, as the piglets may be the products of various and overlapping birthing seasons.

Most importantly, when constructing models of exploitation at this site—two of which will be presented in this thesis—factors of pig ecology as well as the climatic conditions during the time of occupation must be taken into consideration, as this variable can gravely effect interpretations of causation and present barriers to exploitation strategies.

Redding and Rosenberg's New Guinean Model for Pig Husbandry: Departure from the Normative Paradigm

In 2002 traditional approaches to the study of domestication processes went under critical review. In his paper, Richard Redding asserts that the models employed to study domestication have been largely dominated and defined by what he calls the “normative paradigm” (2002). He argues that these models have been largely progressive, where domestication is seen as a simple progression from point A to point B, with all intermediary stages (variously called cultural control, proto-domestication, or incipient domestication) seen as steps leading to the eventual adoption of food production (Redding 2002).

He asserts that the complexity of human behavior, as communities responded to equally as complex selective pressures during the Epipaleolithic, cannot be described with such a simple unilinear model (2002:42). Instead, Redding offers a revision of the normative paradigm. His view of the transition from foraging to food production is one that highlights the existence of various successful and

failed “subsistence tactics” that probably existed through the course of time as human populations in the region sought to mitigate ecological and other sources of subsistence stress. Additionally, he calls for the development of new models of animal utilization, emphasizing that the use of a single variable to determine the status of a taxon is “not a viable research strategy” (Redding 2002: 46) and has in fact handicapped the discipline.

A cohesive study of animal domestication for Redding is then contingent on four requirements. First, dependence on such single “key” variables—especially morphological change—offers only an *incomplete* view of the domestication process, and consequently one that ignores or misses potential human subsistence behaviors that are “unlike our modern analogs” (2002:47). He advocates the use of *all* available data on a taxon, with emphasis on how that taxon was being used by humans at the site. Second, abandonment of the normative A to B, domestic to wild, progressive paradigm is essential to a more complete study of domestication. This includes the examination and proposal of subsistence strategies entirely different from those we have seen before. Third, models must be developed for these novel strategies based on animal behavior, non-western animal use, and “our own inspiration” (2002: 47). Additionally, these models must account for the state of all variables particular to a species at a site. Finally, these models must be tested.

Richard Redding and Michael Rosenberg offer a model based on these theoretical requirements to explain patterning of pig exploitation at Hallan Çemi (Redding 2002; Redding and Rosenberg 1998; Rosenberg *et al* 1998; Rosenberg and Redding 1998). Their conclusions are based on the faunal analysis of over 845 pig

fragments—about 20% of the total pig remains (Zeder, personal communication)—from the central area of the site. This area has variously been argued to be specific to feasting activities (Hayden 1995; Rosenberg and Redding 1998) and refuse deposit not related to feasting or ceremonial activity (Redding 2002).

In their model Redding and Rosenberg argue that a tactic of female breeding—based on that used in New Guinea today—was practiced by the occupants of Hallan Çemi. Managed pigs were the result of mating between wild boars and domestic sows, resulting in a population consisting of females and their young. Female offspring would then be used for further breeding or consumed, while male offspring would have been freely consumed.

Redding and Rosenberg argue that this particular strategy would confer various advantages to the inhabitants of Hallan Çemi: (1) it would avoid the problem of keeping large and typically aggressive males; and (2) it requires little labor to maintain the husbanded pigs as they are allowed to roam and feed freely. Furthermore, they assert that the acquisition of this behavior was a result of the need to reduce the risk of local resource depletion caused by sedentism through the creation of “subsistence insurance” (1998: 67). The female breeding of pigs would provide a readily available source of energy, fat, and protein at a low cost and essentially act as a reserve.

This model would have various effects on the archaeological record. First, under a system of female breeding, any reduction in molar tooth size resulting from human selection would be mitigated by the uncontrolled breeding with wild male populations and should fall within the range for wild specimens. Second, the

population of pigs consumed at the site should resemble consumption from a domestic population. The survivorship curve should then represent an emphasis on young pigs, indicating consumption prior to one-year of age. Third, the demographic sex ratio should be biased toward males. Finally, fourth, the ratio of body parts at the site should reflect the butchering of animals on-site with a prevalence of whole carcasses (Redding and Rosenberg 1998:68-69). Results of the study indicate that all four conditions of this model are met and elucidate why the normative determinants of human management are generally absent. Additionally, molar measurements for pig teeth at Hallan Çemi were “smaller than might be expected” (Redding 2002:43) and fell within the “range of overlap between domestic and wild pigs” with five being “very small for a wild pig” (Rosenberg *et al.* 1998: 33).

These claims however, have not gone without critique. Peters *et al.* (1999) suggest that the metrical analyses undercut Redding and Rosenberg’s hypothesis, pointing to the morphologically “wild” status of the pigs at Hallan Çemi. Additionally Peters and colleagues note that the rates of high juvenile slaughter and a biased male sex ratio evident at Hallan Çemi, according to Redding and Rosenberg’s study, may also be the result of hunting, as the pattern is noted in various sites throughout the Middle East with no evidence of domestication, *sensu stricto* (Peters *et al.* 1999). Redding has addressed such critiques, stating that they have “missed the entire intent of [his] argument” (2002:47) and have continued to grasp onto normative notions of wild versus domestic. These critiques do not necessarily undermine Redding and Rosenberg’s work. My project addresses other concerns that are more tantamount to its reassessment.

First, the samples used by Redding and Rosenberg to build their case may not be representative of pig exploitation strategies at Hallan Çemi. As mentioned above, their study is comprised of only a small fraction of the entire assemblage and was limited to the central area of the site, which has been linked to a possible ceremonial or ritual function (Hayden 1995; Rosenberg and Redding 1998). It is of concern that assumptions about pig-exploitation that would have implications for the *whole* site—such as husbandry—were drawn from only this, possibly very specific, subset. Redding and Rosenberg’s model’s viability is also contingent on an age profile dominated by young males and old females. My study will retest these results with analysis of more material, as well as material from the peripheral areas of the site beyond the central pit.

A second major problem with Redding and Rosenberg’s study is its limited attention to the disproportionate number of fetal/neonatal piglet bones comprising the pig assemblage at this site. The most recently published data states that pigs make up approximately 17% of the entire mammalian assemblage at Hallan Çemi (Rosenberg et. al 1998) and that neonatal and fetal pig bones make up approximately 44% of that assemblage (Fig. 2). Despite the significant abundance of neonatal and fetal pig bones, Redding and Rosenberg did not focus much analysis on this material. My study will turn to this striking and yet understudied material that could be critical to understanding pig-use at Hallan Çemi. I will propose that the high frequency of young piglets at this site may well be the result of the specialized “Cradle Robbing” hunting strategy (outlined below).

Following in Redding's theoretical stead to contest and depart from the normative paradigm of domestication studies, this study will create and test a new model for human-pig interaction for the same population at Hallan Çemi, taking his four requirements for a more complete study of domestication as a theoretical basis. First, while morphology will be tested with analysis of tooth size, this will be combined with the analysis of the age demographic of the pig population at Hallan Çemi as well as suggestions for further research variables that need to be tested. Second, the process of domestication will not be viewed in a dichotomous A to B paradigm, and the examination of a novel subsistence strategy will be the central goal of this study. Third, the proposal and development of the "Cradle Robbing" model represents a departure from another normative paradigm evident in the study of Epipaleolithic societies of the Middle East. The "Cradle Robbing" model represents the *first* instance of a model that is not focally interested in the human behavior leading to the *agricultural* Neolithic, but instead is rooted in the *foraging* past that preceded it. Finally, this model will be tested—albeit and admittedly incompletely—with age data recovered from a different location of the site using previously unstudied fetal and neonatal pig bones.

The "Cradle Robbing" Model and its Expectations

In his 2002 critique of "normative" paradigms for studying domestication, Richard Redding stresses the need to escape expectations that modern models of animal use were those most likely to have been utilized in the past. Instead, he calls for the development of new and creative models that have no "modern analogs"

(Redding 2002: 42), which he promotes, with Michael Rosenberg, though the presentation of the New Guinean Model for pig husbandry at Hallan Çemi. Redding faces the critics of this model (i.e. Peters *et al.* 1999)—and other innovative models like it—by proposing that “a valid way to disagree” lies in offering “an alternative” (2002: 47).

My thesis accepts his criticism of normative principles of herding, hunting, or the space in between, as well as his challenge to propose a valid alternative. I will explore a novel hunting tactic—instead of a novel management practice—that might be obscured or ignored in the study of societies transitioning into the Neolithic, where finding evidence of incipient domestication and agriculture has become the researcher’s missing link.

This model, termed the “Cradle Robbing” model, is a strategy for exploiting wild pig populations that focuses on hunting wild females, as they are pregnant or nursing. Microbotanical and faunal evidence from Hallan Çemi (see Chapter Three) indicate that this small, sedentary community had very little to complain about in terms of subsistence, enjoying a variety of readily available plant and animal resources that were “reminiscent of earlier Paleolithic conditions” (Starkovich and Stiner 2009: 58).

Inhabitants of Hallan Çemi probably had the luxury of being selective and enjoyed a broad resource base. Local resource depletion is often cited as a consequence of the adoption of a sedentary lifeway (Binford 1983; Redding and Rosenberg 1998) but recent analysis of Hallan Çemi material from the same context studied in this thesis demonstrates quite an opposite affair (Starkovich and Stiner

2009 and Zeder 2012). These conditions thus create the possibilities of pursuing a rare and specific hunting strategy and various circumstances of the Hallan Çemi occupation and wild boar ecology point to its likelihood.

First, the area surrounding Hallan Çemi, with a combination of oak and riverine forests, evidence of mast fruiting sources such as acorns, and the easy access to water due to its location on a floodplain, all create the ideal environment to sustain a healthy, and rather large wild boar population.

Second, because the frequency of pig reproduction is strongly tied to the availability of food resources (Graves 1984; Mauget *et al.* 1984; Mauget and Pepin 1991; Fonseca *et al.* 2004; Maillard and Fourier 2004; Santos *et al.* 2004) the abundance of food at Hallan Çemi points to the possibility of birthing peaks occurring in multiple seasons, making this hunting strategy a viable option several times a year.

Third, female pigs often form gregarious groups of other females and their offspring and synchronous estrous, anestrus and pregnancy is common in these groups (Eisenberg and Lockhart 1972). Sexually mature male pigs only join female groups during estrus in order to mate, and leave the group once they have done so (Graves 1984). If hunters are targeting females that have recently given birth or are pregnant, the more aggressive males will have already left the group, which may suggest reduced danger for hunters.

Fourth, 24-hours prior to birth, females leave the group and build farrowing nests where they remain for about ten days before rejoining the herd (Graves 1984).

During this period, nesting females and their newborn young become easy and rather defenseless targets.

Fifth, even shortly before and after the brief nesting period females greatly reduce their home ranges while they are pregnant and nursing and often leave piglets unattended while they forage (Graves 1984). With a smaller area utilized and a constant return to their young, female pigs become easier to track and unchaperoned piglets are left vulnerable.

Sixth, female pigs are known to remain in anestrous conditions until they have acquired the proper weight for birthing (Matschke 1964; Mauget and Pepin 1991). By targeting females who are pregnant or nursing, hunters ensure the capture of heartier pigs for consumption, enjoying the greatest amount of meat and an excellent source of fat and protein.

Testing this predictive model requires developing a combination of expectations for various variables. Four will be outlined here: (1) a sex ratio biased toward females. Young males may also be evident, as herds are composed of females and their offspring, which include males until they reach one or two years of age (Graves 1984); (2) a large number of fetal/neonatal piglets, especially when compared to other major ungulates exploited at the site; (3) such fetal/neonatal piglets should all be around the same age, as they are being targeted during specific periods (around the time of farrowing) of the birthing season(s); (4) finally, an age demographic focusing on sexually mature females, particularly yearlings or older, as these animals are most likely to be pregnant or nursing and have the highest frequency of offspring (Fonseca *et al.* 2004).

This is not a comprehensive or exhaustive list and more variables will arise as further research is conducted. Additionally, only variables 2-4 will be tested in the present study and further work must be conducted in regards to the sex-based demographic of pig populations at Hallan Çemi.

FIG. 2. –Age demographic for pig exploitation at Hallan Çemi based on long bone fusion.

Summary

The shift to food-production economies arguably marks one of the most radical transformations to human societies and, accordingly, its study has been riddled with theoretical and methodological debates since its inception. A cohesive and effective study of the process requires researchers to discard theories of wild versus domestic and biological versus cultural dichotomies. Instead we must look at domestication as a non-progressive process, specific to both natural and cultural contexts. As early domesticates, pigs form an important part of this study and their specific ecological characteristics must be taken into account when seeking to

understand how this species underwent human control. Redding and Rosenberg's model for pig husbandry at Hallan Çemi represents the onset of a new framework in the discourse and this study aims to provide both a legitimate critique to such as well as a continuation of the novel, non-normative paradigm it represents through the development and testing of the new Cradle Robbing model.

Chapter III: Materials and Methods

Site Description

Hallan Çemi Tepesi is an Epipaleolithic-Neolithic transition site located in the southeastern Anatolian region of modern day Turkey (Fig. 1). It is found roughly 50 km north of the city of Batman, at an elevation of 640 m, in a small valley within the foothills of the Taurus Mountain Range called the Sason Dağları. The site is on the edge of the west bank of the Sason Çayı—a tributary of the Batman Çayı, which feeds into the Tigris River. At both higher and lower elevations, these foothills support extensive mixed oak and pistachio forests and to the south lies an open and hilly plain that is cross-cut by the floodplain of the Batman River and other smaller drainages, which in ancient times, were probably lined with gallery forests (Rosenberg and Davis 1992; Rosenberg 1994; Rosenberg and Redding 2000). Hallan Çemi's location indicates that its inhabitants very likely had easy access to both plant and animal resources from various environments (Starkovich and Stiner 2009).

Radiocarbon dates for the site situate its occupation between 11,700 and 11,270 cal. BP (Starkovich and Stiner 2009) and lasted somewhere between 200 and 300 years. Additionally, typologically and architecturally, Hallan Çemi is obviously very similar to the nearby sites of Qermez Dere and Nemrik 9 in northern Iraq, which have both been dated to the late 11th millennium cal. BP (Rosenberg and Davis 1992). This evidence places the occupation of Hallan Çemi right after the end of the Younger Dryas (12,800-11,500 cal. BP) and right before the beginning of the Holocene (12,000-10,500 cal. BP) as well as contemporary with the end of the

Natufian and beginning of the pre-pottery Neolithic A (PPNA) in the Levant (Rosenberg *et al.* 1998; Peasall 2000)—the significance of which will be discussed in the following section of this chapter.

Hallan Çemi is a low mound site with a 14.3-meter diameter, spanning an area of approximately 0.7 ha. At least four different building levels were recognized, however excavation of the site was halted due to political unrest before the fourth layer (and perhaps more) could be exposed (Rosenberg 1994). The upper three layers are architecturally comprised of two types of round structures—semi-subterranean houses and smaller surface structures with stone foundations (Peasall 2000)—which surround a large central activity space (Fig. 3). This space contains numerous faunal remains, which include complete animal carcasses, intricately carved groundstone objects and a large frequency of fire-cracked rock (Rosenberg and Davis 1992; Rosenberg 1994). This has led some researchers (Hayden 1995 and Rosenberg and Redding 1998) to believe that this central area was utilized in feasting activities within a public space, however others have argued for its use merely as a non-ritual refuse pile (Redding 2002).

While the faunal material from Hallan Çemi is the focus of this study, the site also contains a variety of additional material culture, including an abundance of both utilitarian and non-utilitarian groundstone, carved stone, and elaborately crafted bone artifacts that distinguish Hallan Çemi from contemporary Natufian and PPNA sites (Rosenberg and Davis 1992; Rosenberg 1994; Peasall 2000). Additionally, chipped flint and obsidian tools are also abundant, with obsidian sourced as far as 100 km north of the site (Rosenberg and Davis 1992).

FIG. 3. —Site map representing the three building levels uncovered from Hallan Çemi.
(From Starkovich and Stiner 2009 after Rosenberg *et al.* 1998)

Botanical remains from Hallan Çemi indicate that its inhabitants were exploiting a diverse milieu of nuts, pulses, and legumes. Among these are lentils (*Lens culinaris*), bitter vetch (*Vicia ervilia*), almond (*Prunus dulcis*), pistachio (*Pistacia vera*), and acorn (*Quercus* sp.) (Rosenberg *et al.* 1998, Peasnall 2000). Surprisingly, and significant to the study of the development of early agriculture, is the absence of cereal grasses at Hallan Çemi—which has been cited as a prerequisite to the adoption of agricultural practices (Bar-Yosef and Meadow 1995). Additionally, lack of cereal grass exploitation is consistent with Redding and Rosenberg’s model for pig exploitation at Hallan Çemi, as pigs are prime competitors with humans for this resource (Redding and Rosenberg 1998).

Faunal remains from Hallan Çemi are incredibly diverse. Large game such as ovicaprids (*Ovis/Capra*), red deer (*Cervus elaphus*), and pig (*Sus scrofa*) dominate the assemblage, but a variety of carnivores such as fox (*Vulpes* sp.) and brown bear (*Ursus arctos*) are also abundant. Additionally, small mammal exploitation at Hallan

Çemi was common with large quantities of tortoise and turtle (*Testudo* sp. and *Mauremys* sp.) as well as hare (*Lepus capensis*).

Multiple lines of evidence point to a year-round occupation, including the presence of substantial architecture at Hallan Çemi and the abundant and diverse faunal and botanical record recovered from the site. Site occupation from late spring through early autumn is demonstrated with the various plant remains available during those seasons, while antlerless deer and substantial bear remains point toward a winter occupation (Rosenberg 1994). Additionally, growth bands on the shells of fresh water clam (*Unio tigrinus*) indicate that these clams were gathered over much of the year (1994). This establishes Hallan Çemi as the oldest year-round, sedentary village in the region, and the only one of its kind in the Batman floodplain.

Hallan Çemi in Context: The Broad Spectrum Revolution and Transition into the Neolithic

The picture that emerges from faunal and microbotanical analysis at Hallan Çemi is one that stands in sharp contrast to previous models of the transition from foraging to farming that defines the Neolithic in the Near East. These models have been largely defined by archaeological evidence coming from the pre-pottery Neolithic B (PPNB) of the Levant—spanning the late 11th and early 10th centuries BP—and have focused on two causes: (1) the impact of climatic change due to the inception of the Younger Dryas; and (2) dietary stress as a circumstance of increased population pressure resulting from the onset of sedentism (Braidwood 1960; Binford 1968; Flannery 1969; Bar-Yosef and Meadow 1995 and others).

Additional work has been done on pre-agricultural Natufian societies, where the increasing exploitation and cultivation of cereal grasses is suggested to lead to full-scale agriculture (Bar-Yosef and Meadow 1995).

Hallan Çemi, and the Early Round House Horizon (12,700-11,700 BP) in general, does not fit into these models of deteriorating environmental conditions, increasing population stress, or cereal grass exploitation. What emerges instead is a small sedentary population that takes on an entirely different subsistence strategy, exploiting a variety of high-ranked animals as well as low-return plant resources (Starkovich and Stiner 2009) as a result of the stabilizing climate that followed the Younger Dryas.

Thus, Hallan Çemi has been called “ground zero” in the Broad Spectrum Revolution (BSR) (Zeder 2012) where the incredible abundance of plant material and diverse faunal record present an “image of plenty” (Starkovich and Stiner 2009: 58). Hallan Çemi’s position within a rich and scantily populated region, and as perhaps the only settlement within the Batman floodplain, compounded with the arising ameliorating climate, allowed for the exploitation of an ample assortment of plant and animal resources under sedentary conditions (Zeder 2012). The site’s place in the regional chronology therefore becomes significant, presenting an alternative and divergent scenario for the effective Neolithization of the Near East.

The Faunal Sample and Problems of Provenience

Hallan Çemi was excavated from 1991 through 1994 by Michael Rosenberg as a hasty salvage operation due to the construction of the Batman Dam (Rosenberg

and Davis 1992; Rosenberg 1994). The excavators recovered over two tons of faunal material from the upper three building levels. This material was subsequently divided into two subsets based on spatial and contextual distinction. The first of these subsets consists of over 100,000 faunal fragments and comes from the central activity area, possibly tied with ritual or ceremonial feasting, as discussed previously. This material is currently housed at the University of Michigan and was used by Redding and Rosenberg in developing and testing the New Guinean model.

The other subset is comprised of over 250,000 faunal fragments from the middens that encircle a series of fifteen to twenty structures surrounding the central activity area (Fig. 3). This area has been suggested to represent the quotidian diet of Hallan Çemi inhabitants (Zeder 2012) and thus, may provide a more complete and accurate record for everyday animal exploitation practices at the site. This material is stored in the Archaeobiology Laboratory of the National Museum of Natural History of the Smithsonian in Washington, D.C.. To date, a combination of researchers including myself, have sorted and identified over 65,000 fragments and research is on going. My project will look at pig material from this sample.

Given my interest in reconstructing age, assessing tooth size, and analyzing the fetal/neonatal material I pulled out 345 loose teeth, mandibular, and maxillary fragments with teeth, 241 neonatal/fetal bones, and 338 non-neonatal/fetal long bones from the >65,000 fragment sample which I have confidently identified as pig (*Sus scrofa*). This material represents about 30% of the total pig material for this subset.

All three excavated building levels are represented in this sample to some degree, although provenience is a major issue when dealing with the Hallan Çemi material. Due to the rushed nature of the excavation precise provenience data is only available for some units, although location (central area vs. peripheral building middens) can be confidently identified. For the purpose of this study building level provenience has been ignored, and the site will be treated as a single analytic unit, effectively collapsing the 200-300 year occupation.

This has been done for two reasons. First, and primarily, because only limited provenience data were available, only a smaller number of specimens could be confidently associated with each building level. By grouping the material together, a larger sample can be utilized for analysis. With the future analysis of more material, this limitation will be remedied. Second, Hallan Çemi was occupied for a very short period of time before abandonment, and while there is some evidence of cultural complexity emerging through time—with increasing elaboration of stone tools and suspect public buildings apparent in the latest building level (Rosenberg and Redding 1998)—the Hallan Çemi community never grew to a particularly large size nor changed exceptionally through time. Striking cultural changes are not noted until later at nearby sites such as Çayönü (Hongo and Meadow 1998, 2000; Ervynck *et al.* 2001).

Problems with this are duly recognized. This methodology prevents a high-resolution analysis of animal utilization through time at Hallan Çemi, which is a central research endeavor in the study of these early Epipaleolithic, Near Eastern sites. Additionally, Redding and Rosenberg argue for the increase in pigs through

time at this site (Redding and Rosenberg 1998; Rosenberg and Redding 1998; Rosenberg *et al.* 1998), an assertion that cannot be tested in this present study.

Establishing Age-at-Death and Survivorship profiles:

Lone bone fusion and a novel method using tooth eruption and wear

As discussed in the previous chapter, reconstructing the demographic profiles of a given species can be a useful tool for elucidating the nature of animal exploitation at archaeological sites. Age and sex profiles are distinct for differing hunting or management strategies (Magnell 2005; Zeder 2006a) and as a non-morphological method, this reconstruction emphasizes the human behavior in terms of prey selection, culling practices, or comparable actions related to human subsistence.

The epiphyseal fusion of long bones has long been utilized to reconstruct age profiles for pig populations found at archaeological sites in the region (Hongo and Meadow 1998, 2000; Redding and Rosenberg 1998; Ervynck *et al.* 2001) and various researchers have linked fusion events to distinct ages for both modern domestic and wild pigs (Silver 1969; Bökönyi 1972; Habermehl 1975; Bull and Payne 1982). For this study, I have divided fusion events into three age classes (Table 1). By and large, Class I (Infantile/Juvenile) epiphyses fuse before 12 months of age; Class II (Subadult/Young Adult) between 24 and 36 months of age; and Class III (Mature Adult) after 36 months. Based on Bull and Payne (1982), I divided epiphyseal fusion into three groups: fused (F) is defined by the absence of open areas along the fusion line; fusing (G) denotes that some bone has to be broken to separate the epiphysis from the shaft; and unfused (U) when epiphysis separate

with no damage once the cartilage breaks down. Following Zeder (1991), I created a survivorship curve by calculating the percentages of bone to have survived beyond each age class using the formula:

$$[F + \frac{1}{2} (G)] / \text{Total}$$

TABLE 1. Bones allocated to different epiphyseal fusion age classes for *Sus*. Modified and compiled from Silver (1969), Bull and Payne (1982), and Hongo and Meadow 2000, 2001.

Age Class	Bone & Epiphysis
I (Up to 12 Months: Infantile/Juvenile)	Scapula
	Distal Humerus
	Proximal Radius
	Proximal 2nd Phalanx
II (24-30 Months: Subadult/Young Adult)	Proximal 1st Phalanx
	Distal Tibia
	Calcaneus
III (36+ Months: Mature Adult)	Proximal Humerus
	Distal Radius
	Proximal & Distal Ulna
	Proximal & Distal Femur
	Proximal Tibia

Tooth eruption and wear have also been used for age estimation and demographic reconstructions of pig populations at archaeological sites (Rolett and Chiu 1994; Hongo and Meadow 1998, 2000; Magnell 2005; Carter and Magnell 2007). Timing the eruption and development of both deciduous and permanent teeth, much like epiphyseal fusion, can be used to successfully age teeth and tooth rows. However, the data have been as diverse as they have been inconsistent. Early work done by Silver (1969) and Habermehl (1975)—which continues to be used in archaeological work today—is largely invalid. The problems can be traced back through a chain of plagiarized citations to 19th century data from Simonds (1854) (Legge pers. comm. 2012). The best and most reliable sources come from Matschke

(1967), Mohr (1960), Magnell (2002), Bull and Payne (1982) and Briedermann (1965), a compilation of whose data can be found in Table 2.

TABLE 2. Compiled data on tooth eruption from reliable sources. Age is represented in months unless otherwise noted with averages in parentheses and upper and lower differences separated by a slash when available.

Deciduous	Matschke (1967)	Mohr (1960)	Magnell (2002)	Payne & Bull (1982)	Briedermann (1965)
di ¹	7-22 days (16.4d)				
di ₁	11-20 days (17.1d)				
di ²	2.2-3.9 (3.2)				
di ₂	2.1-3.1 (2.6)				
di ³	birth				
di ₃	birth				
dc ¹	birth				
dc ₁	birth				
dp ²	1.7-2.6 (2)				
dp ₂	2.1-3.4 (2.7)			7-11	
dp ³	11-18 days (13.9d)				
dp ₃	23-33 days (27.5d)			7-11	
dp ⁴	41-49 days (45.1d)				
dp ₄	11-20 days (17.1d)			7-11	
Permanent					
I ¹	13-15 (14)				
I ₁	13-15 (14)				14-16
I ²	22-27 (25)				
I ₂	19-22 (20)		18/18-24	19-23	18-20
I ³	7-12 (9)				
I ₃	8-9 (9)			7-11	10-12
C ¹	7-12 (9)				
C ₁	8-12 (9)		7-12/10-12	7-11	10-12
p ¹	4-7 (6)				
p ₁	5-8 (7)				
p ²	16-17 (17)				
p ₂	15-17 (16)				14-16
p ³	15-17 (16)				
p ₃	14-16 (16)				14-16
p ⁴	14-19 (17)				
p ₄	14-18 (16)				14-16
M ¹	5-7 (6)	5-6			
M ₁	5-6 (6)	5-6	5		4-5
M ²	12-14 (13)	12-18			
M ₂	12-14 (13)	12-18	12-13/10-12		12
M ³	26-33 (29)	21-24			
M ₃	23-26 (25)	21-24	18-25/18-24	19-23	21-24

Using tooth eruption and development to age individual specimens is of little help once the teeth have erupted. Thus, to age specimens older than a few months of age, tooth wear or attrition has been successfully applied. This wear, evident on pig

teeth, shows a strong correlation with age (Magnell 2002) and the method presented by Grant (1982) presents a highly promising and effective technique for estimating the ages of pigs and other ungulates through the analysis of molar wear patterns. In her study, Grant assigns codes (a through n) for different stages of tooth wear for the deciduous and permanent lower fourth premolar and permanent first, second, and third molars (Fig. 4). Each tooth is assigned a score according to its stage of eruption or attrition and a “mandibular wear stage” (MWS) is calculated by adding the scores of molars in a single demimandible.

Grant’s study is however limited for various reasons. First, assigning an MWS requires complete or nearly complete mandibles. Unfortunately, mandibles are rarely recovered, especially in the case of juvenile animals or ravaged bone assemblages (Munson and Garniewicz 2003). Archaeological assemblages tend to be dominated by loose teeth and incomplete fragments, as is the case at Hallan Çemi, limiting the value of applying Grant’s method.

A second issue that arises from Grant’s study is its use of only lower, mandibular teeth. This narrow focus is common to several previous attempts attempting to apply this method of age estimation (Rolett and Chiu 1994; Hongo and Meadow 1998, 2000; Magnell 2002, 2005) and upper maxillary teeth have been ignored. In the case of Hallan Çemi, this severely limits the sample available for aging. The upper and lower teeth of pigs can be readily differentiated. At Hallan Çemi, the sample of molars that can be the most confidently aged is dominated by maxillary cheek teeth; thus highlighting the value of including the larger set in analysis.

Finally, Grant's MWS only offers a relative scale for measuring age—where a mandible at MWS 18 would be younger than one at MWS 20—so a high resolution aging system is not provided. Researchers have recognized this limitation to Grant's approach and attempts at calibrating wear stages with actual ages have been conducted with some success (Rolett and Chiu 1994; Hongo and meadow 1998, 2000; Magnell 2002, 2005). However, the data suffer from being highly specific to individual research aims and of low resolution. As a result a standardized methodology for aging using tooth wear patterns remains to be developed.

In order to reconstruct the demographic profile and determine the age-at-death and survivorship trend for Hallan Çemi, I developed a new method that will address these three key limitations to Grant's study as well as integrate specific tooth eruption and development data for more specific, higher resolution results. This method brings together the available *reliable* data from both eruption and development (Table 2) *and* wear and attrition studies and provides age classes for both maxillary an mandibular teeth at three steps: Specific, Simplified A, and Simplified B—with decreasing specificity at each step (Tables 4-6).

Age estimation at these three different scales has been created in order to include the most material possible. The scale of highest resolution (Specific: Table 4) requires the most data—such as more complete tooth rows and detailed recording of tooth wear on permanent molars—to place teeth and tooth rows into the higher resolution age classes, reducing the usable sample size. Simplified A (Table 5) and Simplified B (Table 6) group age classes more broadly, allowing one to assign more

fragmentary materials to age class and thus increasing the overall sample size for age reconstruction.

FIG. 4—Tooth wear stages according to Grant (1982) for *Sus scrofa*.

Furthermore, I have devised a scale from **U** (unerupted) to **19**—Grant tooth wear stage (TWS) n—from evidence compiled from studies conducted by Payne and Bull (1982), Grant (1982), Matschke (1987), Rolett and Chiu (1994), Hongo and Meadow (1998 and 2000), and Magnell (2002) on attrition and age (Table 3). In the

case of loose teeth, each individual tooth is assigned a stage on the scale and then matched to an age class within each step to the highest resolution possible (Specific, Simplified A, and/or Simplified B) (Tables 4-6)—in some cases no age class can be determined at all, these teeth are not counted in the final sample. In the case of multiple, associated teeth within a mandible or maxilla each tooth is scored separately and matched to an age class, the modal age class is then selected as the age of the complete specimen. Each individual tooth and each tooth row is calculated as one individual. Age-at-death and survivorship percentages are then calculated.

TABLE 3. –Tooth eruption and wear scale. “TWS” refer to tooth wear stages developed by Grant (1982).

SCORE	DESCRIPTION
U	Unerupted
1	Perforation in crypt
2	Tooth visible in crypt
3	Mineralization of crown complete
4	Tooth erupting through bone
5	Tooth 1/2 erupted
6	Tooth fully erupted with no visible wear
7	Enamel wear only (TWS a)
8	TWS b
9	TWS c
10	TWS d
11	TWS e
12	TWS f
13	TWS g
14	TWS h
15	TWS j
16	TWS k
17	TWS l
18	TWS m
19	TWS n

TABLE 4. –Age class definitions and tooth eruption and wear scores for “Specific” age gradient.

Specific	
Age Class	Age
I Neonatal A	0-6d
II Neonatal B	7-22d
III Infantile A	23-40d
IV Infantile B	42-60d
V Juvenile A	2-5m
VI Juvenile B	5-12m
VII Subadult	12-18m
VIII Young Adult	18-24m
IX Mature Adult	24-36m
X Old	36+

		AGE CLASS									
		I	II	III	IV	V	VI	VII	VIII	IX	X
TOOTH	i1	U	U	6	X	X	X	S	S	S	S
	i2	U	U	U	U	6	X	X	X/S	S	S
	i3	6	X	X	X	X	X	S	S	S	S
	c1	6	X	X	X	X	X	S	S	S	S
	dp2	U	U	U	U	6	X	X	S	S	S
	dp3	U	6	X	X	X	X	X	S	S	S
	dp4	U	U/6	U/6+	6/6-9	7-9	10-18	10-S	S	S	S
	I1	U	U	U	U	U	U	6	X	X	X
	I2	U	U	U	U	U	U	U	U/6	X	X
	I3	U	U	U	U	U	U-6	X	X	X	X
	C1	U	U	U	U	U	U-6	X	X	X	X
	P1	U	U	U	U	U	U-6	6-10	10-11	11+	11+
	P2	U	U	U	U	U	U-3	U-8	8-11	11+	11+
	P3	U	U	U	U	U	U-3	U-8	8-11	11+	11+
	P4	U	U	U	U	U	U-3	U-9	10-11	10-12	13+
	M1	U	U	U	U	U-5	4-6	7-11	12-14	14-17	17+
	M2	U	U	U	U	U	U-5	6-9	9-10	11-18	15+
	M3	U	U	U	U	U	U	U-4	U-6	7-11	12+

Notes:

Bold denotes eruption event. dP4 and I2 have significantly different eruption timing for mandibular and maxillary teeth; these are denoted as: maxillary/mandibular. X denotes that the tooth is in wear beyond score 6, but the extent or measure is unknown.

TABLE 5. –Age class definitions and tooth eruption and wear scores for “Simplified A” age gradient.

Simplified A

Age Class	Age
A Infantile	0-2m
B Juvenile	2-12m
C Subadult	12-18m
D Adult	18-36m
E Old	36+

AGE CLASS

	A	B	C	D	E
i1	U-6	X	S	S	S
i2	U	6	X	S	S
i3	U-6	X	S	S	S
c1	U-6	X	S	S	S
dp2	U	6	X	S	S
dp3	U-6	X	X	S	S
dp4	U-6/U-9	7-18	10-S	S	S
I1	U	U	6	X	X
I2	U	U	U	6	X
I3	U	U-6	X	X	X
C1	U	U-6	X	X	X
P1	U	U-6	6-10	10+	11+
P2	U	U	U-8	9+	11+
P3	U	U	U-8	9+	11+
P4	U	U	U-9	10-12	13+
M1	U	6	7-11	12-17	17+
M2	U	U	6-9	10-18	15+
M3	U	U	U	6-11	12+

Notes:

Bold denotes eruption event. dP4 and I2 have significantly different eruption timing for mandibular and maxillary teeth; these are denoted as: maxillary/mandibular. X denotes that the tooth is in wear beyond score 6, but the extent or measure is unknown.

TABLE 6. –Age class definitions and tooth eruption and wear scores for “Simplified B” age gradient.

Simplified B

Group	Age
A Infantile/Juvenile	0-12m
B Subadult/Young Adult	12-24m
C Mature Adult	24-36m
D Old	36+

		AGE CLASS			
		A	B	C	D
TOOTH	i1	U-X	S	S	S
	i2	U-6	6-S	S	S
	i3	U-X	S	S	S
	c1	U-X	S	S	S
	dp2	U-6	6-S	S	S
	dp3	U-6+	6-S	S	S
	dp4	U-18	10-S	S	S
	I1	U	6+	X	X
	I2	U	U/U-6+	6/X	X
	I3	U-6	U-6+	X	X
	C1	U-6	U-6+	X	X
	P1	U-6	6-11	11+	11+
	P2	U	U-11	11+	11+
	P3	U	U-11	11+	11+
	P4	U	U-11	10-12	13+
	M1	U-6	7-14	14-17	17+
	M2	U	6-10	11-18	15+
	M3	U	U-6	7-11	12+

Notes:

Bold denotes eruption event. dP4 and I2 have significantly different eruption timing for mandibular and maxillary teeth; these are denoted as: maxillary/mandibular. X denotes that the tooth is in wear beyond score 6, but the extent or measure is unknown.

Asymmetry is rare in modern wild boar (Magnell 2002), so teeth from right and left sides have been combined and treated equally. No significant differences in tooth wear are evident between male and female pigs (Magnell 2002), so sex has not

been treated as a dependent variable in this analysis. Maxillary and mandibular teeth have been identified and recorded separately as well as in a combined sample. Survivorship curves from both independent and combined data sets will then be compared to one another to test if mandibular versus maxillary position is in fact a variable.

Prior to the application of this method to archaeological data, I tested it against modern specimens for three different variables: (1) to test the consistency and reliability within entire tooth rows of the same individual; (2) to test the reliability of aging mandibular *and* maxillary teeth within the same individual; and (3) to compare aging results from epiphyseal fusion to aging results from tooth eruption and wear.

I applied this method to eleven different modern, comparative specimens with associated skulls and long bones belonging to the Division of Mammals of the Smithsonian Institution in Washington D.C.. These specimens were aged utilizing both currently accepted long bone fusion dates for *Sus scrofa* (Table 1) and the new scoring system developed for this study (Table 3). Because complete, or nearly complete tooth rows were readily available on comparative specimens, only the finest age gradient—Specific (Table 4)—was used for this test.

The Smithsonian specimens originated from multiple geographic locations, with both sexes represented (see Table 7 for full descriptions). Unfortunately, the exact age for only one specimen—S.I.# 36118, a domestic male from the United States—was available. All other specimens had only relative ages (adult and juvenile). Additionally, this sample may consist of both morphologically domestic

and wild animals. Many were collected in the early 20th century and thus were quite possibly hunted wild boars, but this cannot be confirmed with the information currently available. Thus, this comparison should be considered only preliminary. Additionally, this method needs to be tested under more rigorous conditions, where the exact ages and status of the animals are known.

Results from this comparison (see Appendix) show that in all specimens but one, tooth eruption and wear scores are consistent throughout the mandible and maxilla. This means that scores from Table 3 from single molar teeth do, in fact, correspond to scores given in Table 4 across both the mandible and maxilla. Specimen 144303 was assigned to two age classes; this is however due to a pathologically missing lower, right first molar, which caused less than normal wear on the upper first molar on the corresponding side. The age classes corresponding to these scores also match the relative ages provided with the Smithsonian specimens, as well as that of the specimen with the only known exact age (S.I.#35118). Thus, to the extent of this test, the new method for aging pigs through tooth wear and attrition is reliable for both tooth row and mandibular versus maxillary variables.

Long bone fusion provides less clear results. Individual bones can yield only ranges (Appendix 1), as in the case of specimen #255513 with a rather broad range of 12-42 months. These wide ranges, and the broad age classes that accompany them, can mask more specific exploitation strategies by clumping various age groups within age-at-death graphs and survivorship curves, a problem that we will revisit with the examination of results from Hallan Çemi.

TABLE 7. –Inventory of Smithsonian *Sus scrofa* specimens used as modern comparatives for tooth eruption and wear and long bone fusion aging.

S.I. #	Location	Sex	Given Age
255338	China	Female	Adult
255513	China	Male	Adult
258185	China	Female	Adult
173817	India	Female	Adult
122536	India	Male	Adult
144302	Indonesia	Male	Adult
144303	Indonesia	Male	Adult
542276	Pakistan	Female	Adult
330787	Taiwan	Unknown	Juvenile
330788	Taiwan	Unknown	Juvenile
35118*	USA	Male	2 years

Measuring Teeth and Fetal/Neonatal Piglet bones at Hallan Çemi

In order to test for morphological size reduction in molar teeth at Hallan Çemi, standard measurements of greatest length and greatest width of permanent molar teeth (1st, 2nd, and 3rd) were taken where possible with Series 500 Mitutoyo 12” calipers. Lengths and widths were recorded to the nearest 0.1 mm.

Measurements from Hallan Çemi will be compared to those from known wild populations of pig from archaeological sites of close proximity; these are Asiab (Iran) and Jarmo (Iraq) (Flannery 1983). Hallan Çemi measurements will be further compared to modern wild pig from Iran (Flannery 1983) and Turkey (Kusatman 1991) and known domestic pigs from Jarmo (Flannery 1983). A student’s t-test will

be conducted in order to determine the significance of variation between the molar measurements at Hallan Çemi and those of other wild and domestic populations.

Fetal/neonatal pig bones were identified as pig from the Hallan Çemi sample using Prummel (1987). Measurements of the scapula, humerus, radius, ulna, ilium, femur, and tibia were taken with 500 series Mitutoyo calipers, recorded to 0.1mm. While standard measurements (i.e. von den Driesch 1976) were recorded where possible, the friable nature of neonatal/fetal bones prevented many standard measurements from being made and in the case of the ulna I designed additional measurements (Appendix 2). Sixteen measurements were conducted on the fetal/neonatal pig bones from Hallan Çemi:

- The smallest length of the neck of the scapula (von den Driesch 1976: SCL).
- The depth of the neck of the scapula measured at the SCL (new, this study).
- The greatest length of the glenoid fossa of the scapula (von den Driesch 1976: LG).
- The greatest depth of the glenoid fossa of the scapula (von den Driesch 1976: BP).
- The smallest breadth of the diaphysis for the humerus, radius, femur and tibia (von den Driesch 1976: SD).
- The depth of the diaphysis for the humerus, radius, femur and tibia, measured at the SD (new, this study).

- Greatest length across the coronoid process of the ulna (new, this study).
- The greatest length of the shaft of the ulna, measured below the coronoid process (new, this study).

Standard statistics were calculated for each of these measurements. In this study, size was used as a proxy measure for relative age; the smaller the amount of variation within the sample, the closer the specimens are in age; the greater the variation the further they are apart.

Summary

This research utilizes the large and well-preserved faunal sample to understand pig utilization, and to reassess previous assertions of herding at this site. Through the reconstruction of demographic profiles and morphological size analysis I will address both Redding and Rosenberg's New Guinean model for pig husbandry at Hallan Çemi and my own Cradle Robbing model utilizing previously unstudied fetal/neonatal pig bones and a different sample from a separate—perhaps more quotidian—part of the site.

Chapter IV: Results

Molar Sizes at Hallan Çemi: Modern and Ancient Comparisons

For this analysis I measured 48 individual molars from the *Sus* tooth sample utilized in this study. Following Mayer *et al.* (1998), all second and third molar specimens—except one lower second molar—fall well above the minimum wild boar threshold for both greatest total length and breadth (Table. 8).

TABLE 8. –Mean and range for upper and lower molar teeth compared to Mayer’s (1998) Minimum Wild Boar Threshold.

Length					
	Tooth	N	Mean	Range	Mayer <i>et al.</i> (1998) Min.
Upper	M1	1	X	18.9	X
	M2	6	25.7	24.8-26.8	22.4
	M3	9	38.5	36.7-42.1	34.6
Lower	M1	4	19.1	18.1-20.0	X
	M2	4	23	19.8-26.0	21.5
	M3	3	44.4	40.1-47.0	38.3

Breadth					
	Tooth	N	Mean	Range	Mayer <i>et al.</i> (1998) Min.
Upper	M1	5	17.4	15.7-18.4	X
	M2	8	21.4	20.3-23.1	19
	M3	11	23.9	21.6-26.5	21.4
Lower	M1	7	12.5	12.0-13.6	X
	M2	6	17	16.4-17.4	15.8
	M3	2	19.9	X	17.7

Additionally, the Hallan Çemi data on molar length can be compared to two studies (Flannery 1983 and Kusatman 1991) on the molar lengths of modern Iranian and Turkish wild boar (Tables 9 and 10, respectively). A student’s t-test was

conducted (at $\alpha = 0.5$) to test the variation between the Hallan Çemi and modern wild boar samples. In both cases, only the upper second molar was significantly different, with the Hallan Çemi sample much larger than the modern samples.

TABLE 9. –Summary statistics and Student's T-Test results for molar tooth lengths from modern Iran (Flannery 1983) and Hallan Çemi.

Tooth:	Position:	Modern-Iran	Hallan Çemi
M2	Upper		
	N	6	6
	Mean	22.57	25.66
	Std. dev.	1.87	0.77
		T-Stat	3.74268
		P-level	0.0038
Very significant			
Tooth:	Position:	Modern-Iran	Hallan Çemi
M3	Upper		
	N	6	9
	Mean	36.73	38.48
	Std. dev.	2.75	1.88
		T-Stat	1.47265
		P-level	0.1646
Not significant			
Tooth:	Position:	Modern-Iran	Hallan Çemi
M1	Lower		
	N	6	4
	Mean	19.92	19.15
	Std. dev.	1.21	0.79
		T-Stat	1.1128
		P-level	0.2981
Not significant			
Tooth:	Position:	Modern-Iran	Hallan Çemi
M2	Lower		
	N	6	4
	Mean	23.55	22.97
	Std. dev.	1.77	2.54
		T-Stat	0.42946
		P-level	0.6789
Not significant			

TABLE 10. –Summary statistics and Student’s T-Test results for molar tooth lengths from modern Turkey (Kusatman 1991) and Hallan Çemi.

Tooth:	Position:	Modern-Turkey	Hallan Çemi
M2	Upper		
	N	44	6
	Mean	24.20	25.66
	Std. dev.	1.30	0.77
		T-Stat	3.94126
		P-level	0.0034
			Very significant
Tooth:	Position:	Modern-Turkey	Hallan Çemi
M3	Upper		
	N	21	9
	Mean	38.10	38.48
	Std. dev.	2.30	1.88
		T-Stat	0.4733
		P-level	0.6412
			Not significant
Tooth:	Position:	Modern-Turkey	Hallan Çemi
M1	Lower		
	N	43	4
	Mean	18.20	19.15
	Std. dev.	1.40	0.79
		T-Stat	2.11578
		P-level	0.088
			Not significant
Tooth:	Position:	Modern-Turkey	Hallan Çemi
M2	Lower		
	N	38	4
	Mean	24.30	22.97
	Std. dev.	1.20	2.54
		T-Stat	1.03515
		P-level	0.3767
			Not significant

While modern specimens from the same region provide the most reliable proxies available to us, paleoenvironments are known to have been very different than what we witness today. As stated in the previous chapter, in the case of Hallan Çemi, the beginning of the Holocene resulted in the rapid stabilization of climate,

and a rather richer environment than is present today surrounded the site. Additionally, Zeder (2001) has demonstrated that size is greatly affected by environmental factors such as climate. In order to control for this the Hallan Çemi measurements have also been compared to two archaeological sites within similar temporal and spatial contexts: Asiab in Iran (11,000-9,000 cal. BP) and Jarmo in northern Iraq (8,750-8,000 cal. BP) (Flannery 1983). Asiab and the first phase of the Jarmo occupation provide no evidence (morphological or otherwise) that would suggest pig domestication or husbandry of any kind being practiced at these sites, thus the molar length data from these sites is therefore considered to be from hunted, wild boar (1983). In the case of the second phase at Jarmo, there is strong morphological evidence for domestication (*sensu stricto*) (1983). The Hallan Çemi pigs are thus being compared to archaeological populations that occupy either end of the domestication spectrum.

Student's T-tests (at $\alpha = 0.5$) were also utilized to compare the variation between Hallan Çemi molar teeth lengths and these three different archaeological assemblages. Sample sizes for comparison ($n \geq 4$) were available only for the lower second molar for Asiab and the upper second molar for the non-domestic phase of Jarmo. In both cases, insignificant p-levels ($p = 0.21$ and $p = 0.13$ respectively) were observed (Tables 11 and 12).

When compared to the molar tooth lengths of the later, domestic phase at Jarmo (8,000 cal. BP) the Hallan Çemi material is significantly larger, with highly significant p-levels (at $\alpha = 0.5$) for both the upper 2nd and upper 3rd molars (Table 13). This level of the occupation at Jarmo represents pigs that have already

undergone generations of human directed selection and can be defined as domesticated under stringent morphological standards with the obvious resulting reduction in molar length (Flannery 1983).

TABLE 11. –Summary statistics and Student's T-Test results for M₂ from Asiab (Flannery 1983) and Hallan Çemi.

Tooth:	Position:	Asiab	Hallan Çemi
M2	L		
	N	8	4
	Mean	24.93	22.96
	Std. dev.	1.05	2.54
		T-Stat	1.48888
		P-level	0.2108

Not Significant

TABLE 12. –Summary statistics and Student's T-Test results for M₂ from the non-domestic phase at Jarmo (Flannery 1983) and Hallan Çemi.

Tooth:	Position:	Asiab	Hallan Çemi
M2	U		
	N	4	6
	Mean	24.55	25.66
	Std. dev.	1.06	0.77
		T-Stat	1.80133
		P-level	0.1315

Not Significant

Overall, the boar exploited at Hallan Çemi were very similar to wild boar hunted in the region between 11,000 and 8,750 cal. BP and perhaps—as the highly significant p-level for the upper second molar may suggest—were larger than wild boar occupying the region today. The Hallan Çemi pigs are significantly larger when compared to morphologically domestic (*sensu stricto*) archaeological pigs. Strictly speaking, in terms of molar lengths, the pigs at Hallan Çemi represent a morphologically wild population.

TABLE 13. –Summary statistics and Student’s T-Test results for M² and M³ from the known domestic phase at Jarmo (Flannery 1983) and Hallan Çemi.

Tooth:	Position:	Jarmo	Hallan Çemi
M2	U		
	N	28	6
	Mean	21.90	25.85
	Std. dev.	1.85	0.77
		T-Stat	8.40143
		P-level	<0.0001
Highly Significant			
Tooth:	Position:	Jarmo	Hallan Çemi
M3	U		
	N	16	9
	Mean	32.90	38.48
	Std. dev.	1.85	1.88
		T-Stat	-3.497
		P-level	0.0019
Highly Significant			

Age Structure and Survivorship: Epiphyseal Fusion

As described in Chapter 3 epiphyseal fusion was used to reconstruct the demographic profile of pig consumption at Hallan Çemi. The sample consisted of 338 non-fetal/neonatal bones with attributable fusion events: the scapula, humerus, radius, ulna, femur, tibia, calcaneus, and 1st and 2nd phalanges. The stage of fusion (**U** to **F**) was calculated for each epiphysis and assigned to an age class (Table 1) and the percentages of survivorship were calculated (Table 14). The resulting survivorship curve (Fig. 5) demonstrates a rather old demographic, with more than half of the pig population surviving beyond 36 months of age.

TABLE 14. –Survivorship percentages for each age class based on epiphyseal fusion.

Age Class	Bone	Epiphysis	F	G	U	T	%	Group Survivorship %
I (Up to 12 Months: Infantile/Juvenile)	SCAP	Tuber Scap.	43	0	7	50	86.0%	78.8%
	HUM	Distal	26	2	13	41	65.9%	
	RAD	Proximal	22	0	2	24	91.7%	
	2PHL	Proximal	28	1	9	38	75.0%	
II (24-30 Months: Subadult/Young Adult)	1PHL	Proximal	26	1	11	38	69.7%	73.7%
	TIB	Distal	19	2	3	24	83.3%	
	CALC	Tuber Calc.	11	0	5	16	68.8%	
III (36+ Months: Mature Adult)	HUM	Proximal	5	3	3	11	59.1%	54.7%
	RAD	Distal	7	1	9	17	44.1%	
	ULNA	Proximal	6	0	5	11	54.5%	
	ULNA	Distal	4	0	5	9	44.4%	
	FEM	Proximal	10	1	4	15	70.0%	
	FEM	Distal	6	0	7	13	46.2%	
	TIB	Proximal	18	0	13	31	58.1%	

FIG. 5 –Survivorship at Hallan Çemi based on epiphyseal fusion.

Age Structure and Survivorship: Tooth Eruption and Wear

Tooth eruption and wear stages were calculated as described previously in Chapter Three at three levels of decreasing resolution (Tables 4-6) and for both maxillary and mandibular teeth separately as well as in a combined sample. Age-at-death and survivorship percentages were then calculated for each age class.

Starting from the highest resolution system (“Specific”) to the least (“Simplified B”) the results of the combined sample have been recorded in Tables 15 through 17, with the resulting age-at-death graphs represented in Figures 6, 8, and 10; and survivorship curves represented in Figures 7, 9, and 11.

TABLE 15. – Combined maxillary and mandibular age-at-death and survivorship percentages based on tooth eruption and wear for “Specific” level data.

Specific-Combined			
Age Class	N	Age at Death	Survivorship
I Neonatal A (0-6d)	0	0.0%	100.0%
II Neonatal B (7-22d)	0	0.0%	100.0%
III Infantile A (23-40d)	0	0.0%	100.0%
IV Infantile B (42-60d)	0	0.0%	100.0%
V Juvenile A (2-5m)	1	0.9%	99.1%
VI Juvenile B (5-12m)	9	7.8%	91.3%
VII Subadult (12-18m)	37	32.2%	59.1%
VIII Young Adult (18-24m)	28.5	24.8%	34.3%
IX Mature Adult (24-36m)	32.5	28.3%	6.0%
X Old (36+)	7	6.1%	0.0%
Total	115	100.00%	

FIGURE 6.—Hallan Çemi age-at-death for *Sus* based on tooth eruption and wear at the “Specific” gradient.

FIGURE 7.—Hallan Çemi survivorship for *Sus* based on tooth eruption and wear at the “Specific” Gradient.

TABLE 16. – Combined maxillary and mandibular age-at-death and survivorship percentages based on tooth eruption and wear for “Simplified A” level data.

Simplified A-Combined

Age Class	N	Age at Death	Survivorship
A Infantile (0-2m)	0	0.0%	100.0%
B Juvenile (2-12m)	13	10.9%	89.1%
C Subadult (12-18m)	42	35.3%	53.8%
D Adult (18-36m)	57	47.9%	5.9%
E Old (32+)	7	5.9%	0.0%
Total	119	100.00%	

FIGURE 8. –Hallan Çemi age-at-death for *Sus* based on tooth eruption and wear at the “Simplified A” gradient.

FIGURE 9. –Hallan Çemi survivorship for *Sus* based on tooth eruption and wear at the “Simplified A” Gradient.

TABLE 17. – Combined maxillary and mandibular age-at-death and survivorship percentages based on tooth eruption and wear for “Simplified B” level data.

Simplified B-Combined

Age Class	N	Age at Death	Survivorship
A Infantile/Juvenile (0-12m)	35	26.3%	73.7%
B Subadult/Young Adult (12-24m)	58	43.6%	30.1%
C Mature Adult (24-36m)	33	24.8%	5.3%
D Old (36+)	7	5.3%	0.0%
Total	133	100.00%	

FIGURE 10. –Hallan Çemi age-at-death for *Sus* based on tooth eruption and wear at the “Simplified B” gradient.

FIGURE 11. –Hallan Çemi survivorship for *Sus* based on tooth eruption and wear at the “Simplified B” Gradient.

TABLE 18. –Comparison of age-at-death and survivorship percentages based on tooth eruption and wear for “Specific” gradient data.

SPECIFIC Age Class	Combined			Mandibular			Maxillary		
	N	Age at Death	Survivorship	N	Age at Death	Survivorship	N	Age at Death	Survivorship
I Neonatal A (0-6d)	0	0.0%	100.0%	0	0.0%	100.0%	0	0.0%	100.0%
II Neonatal B (7-22d)	0	0.0%	100.0%	0	0.0%	100.0%	0	0.0%	100.0%
III Infantile A (23-40d)	0	0.0%	100.0%	0	0.0%	100.0%	0	0.0%	100.0%
IV Infantile B (42-60d)	0	0.0%	100.0%	0	0.0%	100.0%	0	0.0%	100.0%
V Juvenile A (2-5m)	1	0.9%	99.1%	0	0.0%	100.0%	1	4.5%	100.0%
VI Juvenile B (5-12m)	9	7.8%	91.3%	9.5	9.1%	90.9%	2.5	11.4%	88.6%
VII Subadult (12-18m)	37	32.2%	59.1%	37	35.6%	55.3%	9.5	43.2%	45.5%
VIII Young Adult (18-24m)	28.5	24.8%	34.3%	28	26.9%	28.4%	2	9.1%	36.4%
IX Mature Adult (24-36m)	32.5	28.3%	6.0%	22.5	21.6%	6.7%	7	31.8%	4.5%
X Old (36+)	7		0.0%	7	6.7%	0.0%	0	0.0%	0.0%
Total	115	100.00%		104	100.00%		22	100.00%	

FIGURE 12. –Hallan Çemi combined, mandibular, and maxillary survivorship curves for *Sus* based on tooth eruption and wear at the “Specific” gradient.

TABLE 19. –Comparison of age-at-death and survivorship percentages based on tooth eruption and wear for “Simplified A” gradient data.

SIMPLIFIED A	Combined			Mandibular			Maxillary		
Age Class	N	Age at Death	Survivorship	N	Age at Death	Survivorship	N	Age at Death	Survivorship
A Infantile (0-2m)	0	0.0%	100.0%	0	0.0%	100.0%	0	0.0%	100.0%
B Juvenile (2-12m)	13	10.9%	89.1%	9.5	10.3%	89.7%	3.5	15.9%	84.1%
C Subadult (12-18m)	42	35.3%	53.8%	27.5	29.9%	59.8%	9.5	43.2%	40.9%
D Adult (18-36m)	57	47.9%	5.9%	48	52.2%	7.6%	9	40.9%	0.0%
E Old (32+)	7	5.9%	0.0%	7	7.6%	0.0%	0	0.0%	0.0%
Total	119	100.00%		92	100.00%		22	100.00%	

FIGURE 13.—Hallan Çemi combined, mandibular, and maxillary survivorship curves for *Sus* based on tooth eruption and wear at the “Simplified A” gradient.

TABLE 20. –Comparison of age-at-death and survivorship percentages based on tooth eruption and wear for “Simplified B” gradient data.

SIMPLIFIED B									
Age Class	Combined			Mandibular			Maxillary		
	N	Age at Death	Survivorship	N	Age at Death	Survivorship	N	Age at Death	Survivorship
A Infantile/Juvenile (0-12m)	35	26.3%	73.7%	7	8.1%	91.9%	22	55.0%	45.0%
B Subadult/Young Adult (12-24m)	58	43.6%	30.1%	47	54.7%	37.2%	11	27.5%	17.5%
C Mature Adult (24-36m)	33	24.8%	5.3%	25	29.1%	8.1%	7	17.5%	0.0%
D Old (36+)	7	5.3%	0.0%	7	8.1%	0.0%	0	0.0%	0.0%
Total	133	100.00%		86	100.00%		40	100.00%	

FIGURE 14. –Hallan Çemi combined, mandibular, and maxillary survivorship curves for *Sus* based on tooth eruption and wear at the “Simplified B” gradient.

In each case—regardless of resolution—a different demographic profile emerges from that seen when using epiphyseal fusion. When using the tooth eruption and wear aging system a prime-age hunting curve is evident, with the major drop-off points of the survivorship curve occurring between the sub-adult and mature adult age-classes, and very few ($\approx 6\%$) animals surviving beyond 24 months of age. Additionally, these major drop-offs between the sub-adult and mature adult age classes coincide with the inception of reproductive maturity (Conley *et al.* 1972).

When the samples are separated by tooth position (maxillary vs. mandibular) nearly identical survivorship curves result (Tables 18-20; Fig. 12-14). However, as resolution decreases and age groups are less rigidly defined and broader, the resulting survivorship curves become less tight, with the greatest disparity in Simplified B (Fig. 14). The essential patterns are nevertheless maintained in each system regardless of the maxillary or mandibular origin of the teeth. Combining tooth eruption and wear data for aging as conducted in this method can, again, be confidently done without skewing the data, especially as higher resolution levels are utilized.

Fetal/Neonatal Piglets:

Proportions when compared to other major taxa

As described in the previous chapters the number of fetal/neonatal piglet bones at Hallan Çemi is atypically large. The proportion of piglet bones at Hallan Çemi (Fig. 2) was compared to the other two three major ungulate taxa found at the site—red deer (*Cervus elaphus*) and the ovicaprids—using data from Zeder

(unpublished) and the previously described epiphyseal fusion method for aging (Fig. 15). The “young” category was assigned by Zeder when bones were too small to be fully-grown unfused and too large to be fetal/neonatal (pers. comm.).

When compared to both red deer and sheep/goat, neonatal/fetal piglets at Hallan Çemi are grossly over represented, with only 1% of the sheep/goat assemblage represented by this age class and no fetal/neonatal individuals at all in the case of red deer. The demographic profiles for sheep/goat and red deer are nearly identical and represent a prime-age hunting tactic. This data suggest that a very different exploitation strategy was being undertaken for pig at this site.

FIG. 15. –Age demographic at Hallan Çemi for the three major taxa exploited at the site. *C. elaphus* and Ovis/Capra data from Zeder (unpublished).

Fetal/Neonatal Piglets: Measurement Statistics

Measurements were taken on 149 elements of the 241 total fetal/neonatal sample: 15 scapulas, 50 humeri, 13 radii, 26 ulnas, 15 femurs, and 30 tibias.

Summary statistics were then calculated (at $\alpha = 0.05$) for each measurement (Tables 21-26).

TABLE 21. –Summary statistics for fetal/neonatal scapula measurements.

Measurement	N	Mean	Variance	Standard Deviation	Coefficient of Variation
Smallest Length of Neck	14	7.31	2.31	1.51	0.21
Depth of Neck	13	4.2	0.59	0.77	0.18
Greatest Length of Glenoid Fossa	9	10.19	0.17	0.42	0.04
Greatest Breadth of Glenoid Fossa	9	7.08	0.28	0.53	0.071

TABLE 22. –Summary statistics for fetal/neonatal humerus measurements.

Measurement	N	Mean	Variance	Standard Deviation	Coefficient of Variation
Smallest Breadth of Diaphysis	50	5.54	0.29	0.54	0.1
Depth of Diaphysis	36	7.59	0.7	0.84	0.11

TABLE 23. –Summary statistics for fetal/neonatal radius measurements.

Measurement	N	Mean	Variance	Standard Deviation	Coefficient of Variation
Smallest Breadth of Diaphysis (at Nutrient Foramen)	13	6.75	1.24	1.12	0.17
Depth of Diaphysis (at Nutrient Foramen)	13	4.77	0.27	0.52	0.11

TABLE 24. –Summary statistics for fetal/neonatal ulna measurements.

Measurement	N	Mean	Variance	Standard Deviation	Coefficient of Variation
Greatest Length Across the Coronoid Process	21	8.27	2.23	1.49	0.18
Greatest Depth of Shaft (measured below coronoid process)	25	5.52	0.31	0.55	0.1

TABLE 25. –Summary statistics for fetal/neonatal femur measurements.

Measurement	N	Mean	Variance	Standard Deviation	Coefficient of Variation
Smallest Breadth of Diaphysis	15	5.77	0.35	0.59	0.1
Depth of Diaphysis	15	5.8	0.17	0.41	0.07

TABLE 26. –Summary statistics for fetal/neonatal tibia measurements.

Measurement	N	Mean	Variance	Standard Deviation	Coefficient of Variation
Smallest Breadth of Diaphysis	30	6.3	0.88	0.94	0.15
Depth of Diaphysis	30	5.42	0.79	0.89	0.16

Variation is low. A standard deviation less than 1 mm occurs in all but three elements and coefficients of variation less than .2 (or less than 20%) occur in all elements but one. Variation in the sample does exist with the greatest variation seen in the length of the coronoid process of the ulna.

Several factors must be taken into account when considering the higher levels of variation noted in these measurements, specifically for the scapula, radius, ulna, and tibia. The variation seen here—and throughout the sample—may be the result of measurement error or inconsistency. The standard measurements utilized in this study (discussed in Chapter Three) were designed to measure adult bones (von den Driesch 1976) and no standard method has been developed for fetal/neonatal animals. The landmarks used as place markers for these measurements are often underdeveloped in the case of fetal/neonatal pig bones. The translation of this method to these small and friable bones then becomes challenging, and no doubt has contributed to some of the variation seen here. Additionally, for measurements created by myself for the specific purpose of this

study (see Chapter Three and Appendix 2)—notably for the ulna—the data is perhaps unreliable, as these have not been tested rigorously for individual variation or variation as a result of growth.

Summary

Molar measurements indicate that the Hallan Çemi pigs are morphologically wild; significant differences were not found between the Hallan Çemi pigs and archaeological wild pigs from two sites close in both space and time. The site's pig population has larger molars than modern wild pigs from the region, which may be the result of climate, and were significantly larger than known domestic archaeological pigs from nearby Iran.

Age structure and survivorship analysis yields two different patterns depending on the methodology used. When epiphyseal fusion was used, a survivorship curve showing that more than half of the population survived beyond 36 months results. Tooth eruption and wear data produces curves showing the major drop off and exploitation focus being between the sub-adult and mature adult stages, with 0% of the population surviving beyond 36 months. By and large, the pattern for epiphyseal fusion is more ambiguous than that of tooth eruption and wear analysis, which may be the result of the much broader and more general definitions of age classes in the former.

The resulting survivorship curves from this study also provide strong support for the use of both maxillary and mandibular teeth when recording tooth wear and eruption for demographic reconstruction. The new method developed by

combining existing data can be translated to full dental samples, increasing sample sizes and opening this method of aging to assemblages, such as Hallan Çemi, that are dominated by maxillary molars. The bias against maxillary teeth demonstrated by previous researchers appears to be unfounded.

The remains of fetal/neonatal pigs are exceedingly abundant in the Hallan Çemi assemblage, especially when compared to the other heavily exploited ungulates at the site. Red deer and sheep and goats appear to have been exploited in very similar fashions, focusing on prime-age, full-grown animals. In regards to pigs, the focus appears to be on younger animals, with a large quantity of fetal/neonatal piglets. Finally, variation in the sizes of neonatal pigs is generally low, suggesting that these piglets were killed at very similar ages.

Chapter V: Discussion

Addressing the New Guinean Model for Pig Husbandry at Hallan Çemi: An Improbable Scenario?

The purpose of this study was twofold: (1) to re-evaluate the New Guinean model of pig husbandry at Hallan Çemi proposed by Richard Redding and Michael Rosenberg and; (2) to propose an alternative to this model, the Cradle Robbing model, based on novel hunting activities. When comparing the data from my study to Redding and Rosenberg's New Guinean model, it is crucial to remember that the data from both studies were compiled from two *different* spatial contexts: the central pit, and the peripheral middens, respectively. As I have discussed previously, the systemic context of these two samples is disputed and there is some evidence that the central pit may have been a site for ritual feasting.

Different patterns of animal-use would then be expected depending on the origin of the sample used. This introduces additional complexity when evaluating the New Guinean—or any other—model and must be taken into consideration. It is key to note that drawing conclusions about the *whole* site from what might be a specialized sample is misleading. I follow previous researchers at this site (Zeder 2012) in asserting that the sample from the peripheral midden pits utilized in my study is representative of the ordinary, day-to-day subsistence activities of the inhabitants at Hallan Çemi. Additionally, I acknowledge that my data is limited in that it provides insight *only* from this perspective and Redding and Rosenberg's conclusions could very well be the result of patterns from a different context.

As discussed previously, Redding and Rosenberg's New Guinean model for pig husbandry at Hallan Çemi is contingent on four different lines of evidence, two of which have been addressed by my study. These are: (1) tooth size reduction and (2) the age factor of an age and sex demographic focusing on young males and older females.

In regards to the first variable, the results of my study indicate that tooth size cannot be used as evidence of domestication at Hallan Çemi. Pigs at Hallan Çemi securely fall into the wild range as determined by Mayer *et al.* (1998) and there is no statistically significant difference between the pigs from Hallan Çemi and other hunted wild boar during the Epipaleolithic and early Neolithic. While the morphologically wild status of molar teeth from this population has been acknowledged by Redding and Rosenberg (1998: 70), the appearance of molars "very small for a wild pig" has, however, been used to support claims of husbandry practices at this site elsewhere (Rosenberg *et al.* 1998: 33). My study provides no evidence to support such claims as all individual specimens surpassed the morphologically wild measurements.

Addressing the second variable, age profiles from my study do not support the New Guinean model either. My data does not corroborate evidence of a young male/ older female focus, as the New Guinean model predicts. This, however, will likely be open to much contention as two very different survivorship curves for epiphyseal fusion and tooth development and wear resulted from this study. The age profile results from epiphyseal fusion data will be discussed only briefly; I focus on the conclusions from tooth eruption and wear data for a variety of reasons.

First, epiphyseal fusion provides age classes that are much broader in nature. This clumping can mask patterns in the age demography, as seen to some extent when utilizing the broader tooth eruption and wear age classes in the Simplified B gradient (Figure 14). Additionally, epiphyseal fusion age classes suffer from gaps, which can be up to one full year as seen between age classes I and II (Table 1).

Second, the studies used to determine these age classes (Silver 1969; Habermehl 1975; Bull and Payne 1982) are sparse and inconsistent, and are a combination of both morphologically domestic *and* wild specimens, with unknown (or combined) sexes and ages. As was mentioned in Chapter Three, Silver (1969) and Habermehl's (1975) work—on which much of the age reconstructions in archaeological studies is based (see Hongo and Meadow 2000)—have proven unreliable in assigning ages to tooth eruption for pigs and this error may extend to epiphyseal fusion as well.

Third, data from studies on teeth are more reliable and consistent, in that they yield reproducible results. The higher resolution age classes provided in this method have, at least in part, been derived from independent studies with known exact ages (Matschke 1967; Magnell 2002; Carter and Magnell 2007) and the test conducted on modern comparative specimens for this study (see Chapter Three) suggests, given the small sample size, consistency in both tooth rows and upper and lower molar dentition. In sum, until more rigorous and systematic studies on the timing of epiphyseal fusion in swine have been conducted—as has been done for sheep and goat (Zeder 2001)—age demographic results from this method will be less trustworthy than teeth.

Turning now to survivorship data from tooth eruption and wear (Tables 18-20 and Figs. 12-14), the major drop-off is between the sub-adult (12-18) and mature adult (24-36) age classes, with no individual surviving beyond 36 months, regardless of the resolution used. This is consistent with an exploitation strategy focusing on younger individuals, but the data presented by Redding and Rosenberg indicates a focus on individuals (presumably males) *before* they have reached sexual maturity, with 40% being killed before reaching 12 months of age (1998). Additionally, data from this study is at odds with the second demographic aspect of their model, which requires a large number of older females. In their study, survivorship curves demonstrated that nearly half (46%) of the pig population was consumed after they reached three years of age (Redding and Rosenberg 1998). Survivorship curves from my study are in stark contrast, with virtually no individuals surviving beyond 36 months of age.

Even when reconstructing an age profile utilizing the epiphyseal fusion data, the results still don't fully support the New Guinean Model. The survivorship curve from this data (Fig. 5) is non-specific, in that it does not demonstrate a particularly strong exploitative focus at any age class—except perhaps amongst older individuals, with 45.3% killed after they had reached 36 months of age. While this does provide some evidence to support a focus on older females (per the New Guinean model), it might also be interpreted as a hunting strategy that sought older and larger, wild males. Additionally, there is little evidence to support the younger age bias as a result of culling demanded by Redding and Rosenberg's model. However, with the problems associated with this method mentioned above, this

data—and consequently the age data provided by Redding and Rosenberg’s studies—might be unreliable to begin with.

Both the molar size and age demographic data from the peripheral midden samples are not what you would expect from a New Guinean, female-breeding, husbandry tactic being practiced at Hallan Çemi. Additionally, when considering the immediate environmental context of this site, the reasons for adopting pig husbandry in the first place also seem amiss. As discussed in Chapter Two, Redding and Rosenberg assert that the adoption of this style of pig husbandry would provide “subsistence insurance” at a low cost to practitioners that would have been necessary due to local resource depletion caused by sedentism (1998: 67).

Recent work on this site, however, seems to demonstrate that resource depletion wasn’t an issue at Hallan Çemi and that its inhabitants enjoyed a broad-based diet with year-round food availability (see Chapter Three). In fact, there is very little evidence to support claims that the residents of Hallan Çemi fell victim to stress as a result of sedentism—or population pressure in general. The survey of the Batman River conducted in 1990, suggests that Hallan Çemi was probably the only site located within this small drainage system during the Epipaleolithic (Rosenberg and Togul 1991)—keeping in mind that absence of evidence is not necessarily evidence of absence—and this has been used to support the notion that inhabitants of this site simply did not experience “demographically driven resource pressure” (Zeder 2012: 7). Hence, Redding and Rosenberg’s model is challenged empirically both through my faunal analysis of the peripheral middens and through a consideration for local environmental conditions.

Proposing Alternatives: Cradle Robbing in a Time of Plenty

In order to provide a “valid” (Redding 2002: 47) critique to Redding and Rosenberg’s New Guinean Model, I have proposed an alternative to understanding pig exploitation at Hallan Çemi with the Cradle Robbing hunting strategy (see Chapter Two). The data from this study have been applied to testing this model and three of the four expectations (Chapter Two) have been addressed. These are: (1) the relative abundance of fetal/neonatal piglet remains when compared to other major ungulates exploited at this site; (2) the closely grouped ages of these fetal/neonatal piglet remains as they are targeted during a specific period in the sow’s pregnancy/nursing activities; and (3) an age demographic focusing on sexually mature individuals. As in the case for testing the New Guinean model, factors regarding sex have not been tested in this study. In order to fully test either hypothesis, further analysis pursuing this line of evidence must be conducted with the material from the peripheral middens.

Beginning with variables (1) and (2), relative abundance of fetal/neonatal pig remains at Hallan Çemi is in fact much greater when compared to sheep and goat (*Ovis* and *Capra*) as well as red deer (*C. elaphus*), as fetal/neonatal piglets make up approximately 44% of the entire pig assemblage (Fig. 15). High numbers of neonatal/fetal bones in an assemblage might also be the consequence of spontaneous abortions and high infant mortality as a result of poor husbandry practices as humans initiated an early management strategy, which might be a way of explaining this high number of piglets under the New Guinean model. However these abortions are unlikely to occur at the same time for all pregnant animals and

would result in piglets at various and diverse developmental stages, which brings us to the second variable.

Summary statistics conducted on measurements of the fetal/neonatal sample demonstrate quite low variation (Tables 21-26). Measurements demonstrating some of the highest variation (i.e. those for the ulna) are probably due to the nature of the measurements themselves, which were invented and untested for this study. In all cases but one, coefficients of variation were below 0.2 (or 20%). If size is taken as a proxy for age—as piglets develop at a relatively uniform rate (Ullrey *et al.* 1965)—then the data from fetal/neonatal measurements at Hallan Çemi are consistent with the requirement posed by the Cradle Robbing model. If the high number of piglets were the result of high infant mortality, the piglets would likely be at very different stages of development and we would expect a far greater amount of variation within the sample than is seen here.

Hunters at Hallan Çemi likely targeted females as they farrowed, separate from the protection of the herd, and the close ages of fetal/neonatal pigs represent the short time frame (a maximum of ten days) spent in the farrowing nest. What variation is seen in the bone measurements can be attributed to the methodological factors discussed in Chapter Three, as well as to the known intense competition for milk seen amongst newborn piglets and the resulting disparity in growth and development (Milligan *et al.* 2001).

Turning now to the age demographic, survivorship curves demonstrate an exploitation strategy focusing on sub-adults (12-18 months) and mature adults (24-36 months)(Tables 18-20 and Figs. 12-14). The one-to-three year exploitive focus at

Hallan Çemi is consistent with the Cradle Robbing hunting model. Females who have separated from the herd to farrow are those being targeted, and those females, consequently must have reached sexual maturity. Pigs reach sexual maturity at around seven to eight months, however males do not leave the herd to mate until one-to-two years of age (Conley *et al* 1972) and females begin birthing with more success and frequency after one year (Fonseca *et al.* 2004). While younger females are capable of giving birth, Fonseca *et al.* (2004) demonstrated that females under one year have low breeding percentages. These generally smaller females might also simply be less desirable by nature of their size and because they produce fewer and smaller piglets (Fonseca *et al.* 2004).

Explaining the lack of older animals (over 36 months of age) is more difficult to do, and cannot be explained by the Cradle Robbing model alone. One explanation might be methodological. As mentioned in Chapter Two, the method used here for reconstructing age has not been rigorously tested with individuals of known exact ages. Additionally, previous studies using tooth wear analysis have demonstrated that individual variation can be quite large and increases with age (Magnell 2002). Aging individuals beyond 36 months of age is then difficult to do to a high resolution—particularly with the first molar, as it undergoes attrition starting early in the animal's life.

However, because of the broadening of the final age classes used in the method for this study (X, E and D for Specific, Simplified A, and Simplified B respectively) to include *any* individuals beyond 36 months, one might expect this category to be exaggerated rather than understated—as any first molar beyond

tooth wear score 15 and any third molar beyond score 12 would count as “old” individuals (see Tables 4-6). Only in the case of the first three premolars and the second molar could the “old” category be underrepresented as a result of this method.

In regards to the premolars, no teeth or tooth rows were assigned age classes on the basis of premolars alone, leaving only the second molar analysis. In this case, of the 21 single second molars without other associated teeth to corroborate an age class, only two were given the controversial 15-18 tooth score that overlaps the two (Mature Adult to Old) age classes, hardly enough to bear significance. I propose then, that the age demographic of the pigs exploited at Hallan Çemi—at least from this peripheral midden sample—was simply not composed of many individuals beyond 36 months of age and that this is a result of the original systemic context.

One likely scenario may be that this lack of older animals and the dominance of young pigs is the result of the local wild boar population’s own demographic composition. In a study of wild boar hunting in Mesolithic South Scandinavia, Ola Magnell (2002) found that young pigs dominated the age distribution of two sites, which reflected the age composition of modern wild boar populations in the area. She suggested that a hunting strategy directed towards groups of females and their farrows—similar to that suggested in the Cradle Robbing model—was enacted as a means of taking advantage of this demographic structure.

Another variable to consider in evaluating the demographic profile is the spatial context of the site itself. As discussed in previous chapters, the context of the sample utilized by Redding and Rosenberg is not fully understood, and has been tied

to feasting activities. The emphasis on older—and consequently larger—animals that they recorded could then be an artifact of that context. While the suspected emergent social complexity at Hallan Çemi is well beyond the scope of this thesis, prey selection for larger animals in this central pit may be tied to gains in the social prestige of hunters within a ritual feasting sphere.

Overall, evidence from my study suggests that a hunting strategy targeting farrowing females and/or their piglets was occurring at Hallan Çemi. As discussed in Chapters Two and Three, Hallan Çemi is the earliest known fully sedentary site in the Taurus-Zagros Arc. In his paper examining the evolution of sedentary life, Michael Rosenberg notes, “any reduction in mobility requires innovation” (1998: 661) and he suggests that changes in resource procurement—such as the adoption of husbandry practices—and resource diversification are two such innovations that would mitigate the inherent costs of sedentary life.

While there is no evidence that the inhabitants of Hallan Çemi experienced intense stress from this shift to sedentism, assuming that novel subsistence strategies didn’t occur as a result of it is erroneous. For example, broad spectrum foraging was clearly evident at Hallan Çemi without evidence of resource depletion (Starkovich and Stiner 2009). Adoption of the Cradle Robbing tactic can be explained in two ways. First, the inhabitants of Hallan Çemi were targeting the piglets themselves, with mothers getting caught in the crossfire as it were. If this were the case, the Cradle Robbing tactic would fit nicely into the “broad spectrum foraging in a time of plenty” scenario noted by Starkovich and Stiner (2009) and Zeder (2012). Climate amelioration and the prolific nature of pig reproduction

caused piglets to become an abundant, and easily accessible resource that might not have been exploited before, despite having perhaps sub-optimal returns.

Another scenario depends on the targets being the females themselves. In this case the patterns emerging from the data—a focus on younger, sexually mature animals—is the result of humans taking advantage of the local wild boar demographic—as was the case in Scandinavia (Magnell 2002)—and the ease associated with hunting females around and during their time of farrowing. Again, climate amelioration and the capability of pigs to have multiple birthing seasons is an important factor here, as farrowing females would have been available multiple times a year. Additionally, hunters would incur less danger from herds and aggressive males by pursuing this tactic.

Contextually, the Cradle Robbing scenario provides a more complete explanation for pig exploitation at Hallan Çemi than the New Guinean strategy. The forgiving environmental context of the site itself, the broad and plentiful subsistence enjoyed at Hallan Çemi, as well as the ecology of wild boar have all been accounted for in the development of the model. Redding and Rosenberg's model simply does not fit the landscape, and they fail to provide a convincing answer as to why Hallan Çemi inhabitants would adopt husbandry practices in the first place.

Early, sedentary sites, such as Hallan Çemi, have much potential to answer key questions in the study of innovative human strategies for subsistence, and provide insight into the processes that led to the eventual adoption of agriculture only a few millennia later. The New Guinean model, however, may be an example of creating human management practices where none existed. Hallan Çemi's late

Epipaleolithic age and its status as the earliest fully sedentary site in the region, certainly make the discovery of early, proto-domesticate practices attractive, but the links between sedentism and domestication are still poorly understood. Sedentism can precede or follow food production or not be associated with it all (Rosenberg 1998). It is, thus, essential to explore not just novel avenues for food production—and domestication in specific—as Redding has urged, but novel avenues for hunting and food procurement in general, especially within the context of these early sedentary societies. *This* is what the Cradle Robbing model for pig exploitation at Hallan Çemi provides.

Chapter VI: Conclusions

Through faunal analysis of a separate part of the site and the proposal of a model not centered on management practices, my study has called past evaluations of pig use at Hallan Çemi into question. At the very least, my study has stressed the necessity to explore alternative explanations for atypical animal resource use and the importance of contextual—especially environmental and ecological—information in the development of these explanations. With that being said, analysis for this site remains largely incomplete and much further work must be conducted if we hope to understand how pigs were exploited at Hallan Çemi. Richard Redding emphasized the need to use “all variables for a taxon” (Redding 2002) before coming to conclusions about how it interacted with human populations, and this has not yet been accomplished with regards to pigs at this site.

First, further work must be done to strengthen the methodological choices used in this study. In order to reconstruct the age demographic and survivorship curves, and to avoid issues with epiphyseal fusion (Chapter Five), I developed a new method using tooth eruption and wear (Chapter Three). Through the synthesis of a variety of independent and, oftentimes, disparate studies my method (1) allows for analysis at three levels of resolution—thereby increasing sample size and allowing this method to be used in assemblages with large numbers of loose teeth and fragmentation; and (2) allows for the integration of maxillary teeth into analysis for the first time—also increasing sample size and allowing assemblages dominated by upper teeth, like Hallan Çemi, to benefit from tooth eruption and wear analysis. This

method, while it has been shown to be reliable (Chapter 3), still needs to be tested for accuracy using modern controls with known ages.

Second, in-site sampling needs to be further examined. As discussed in Chapter Five, the spatial contexts of the material used to formulate the New Guinean model and my own Cradle Robbing model are distinct. Comparing the contents of the central pit and the peripheral middens (New Guinean model and this study, respectively) needs to be at the forefront of any explanations for activity at this site. If the context of these two samples is indeed significantly different, then data from each sample will necessarily be distinct and yield perhaps contradictory conclusions. Analysis must take into account *both* aspects of this site in order to make any claims about the site as a whole. Consequently, the sex component of the demographic from the peripheral middens is still necessary to evaluate either model and further work on the exploitation of other animals at this site—such as sheep, goat, red deer, or the multitude of other small mammals—and how these differ in regards to spatial context may also provide clues to understanding the suggested ritual use of the central pit.

Additionally, in-site temporal resolution needs to be resolved if we hope to understand developmental changes occurring during this occupation. The abandonment of Hallan Çemi after only a brief two or three hundred years is still a major question, and changes in subsistence strategies may provide clues toward answering it. Straightening out the issues of provenience described in Chapter Three is crucial, and I am confident that with analysis of more material enough provenience information will be available to solve this problem.

A third focus for further work involves placing Hallan Çemi into its greater regional and temporal context. As the first known fully sedentary site in this region, Hallan Çemi represents a unique opportunity to study the transition from mobile hunting and gathering to sedentism, and the novel subsistence strategies that resulted from it. However, in order to understand how and why such tactics as the New Guinean or Cradle Robbing strategies might have been adopted, we need to know what came before them.

Southeastern Anatolia and the Zagros region demonstrate a distinct cultural episode with different subsistence strategies from the better-known sites of the southern Levant, especially during the Epipaleolithic-Neolithic transitional period (Peasnell 2000; Starkovich and Stiner 2009). In order to understand why novel subsistence tactics involving either hunting or herding were implemented by the inhabitants of Hallan Çemi and other sites like it, further study must be directed toward the food acquisition tactics and sources of stress—demographic or otherwise—of earlier, Upper Paleolithic human groups in this region.

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APPENDIX 1

Aging results from modern Smithsonian pig specimens utilizing the new tooth eruption and wear method and epiphyseal fusion

Specimen:
255338 **Location:** China **Sex:** Female

Tooth Eruption & Wear

Tooth	Position	Side	Score	Age Class	Age
M1	U	R	18	IX	24-36m
M1	U	L	18	IX	24-36m
M2	U	R	12	IX	24-36m
M2	U	L	12	IX	24-36m
M3	U	R	10	IX	24-36m
M3	U	L	10	IX	24-36m
M1	L	R	18	IX	24-36m
M1	L	L	18	IX	24-36m
M2	L	R	12	IX	24-36m
M2	L	L	12	IX	24-36m
M3	L	R	9	IX	24-36m
M3	L	L	9	IX	24-36m

Long Bone Fusion (Right side only)

Bone	Prox. Fusion	Dis. Fusion	Age
Scapula	F	X	>12m
Humerus	G	F	>12m
Radius	F	G	>12m
Ulna	F	G	36-42m
Femur	F	F	>42m
Tibia	G	F	>24m, <42m
Calcaneus	X	F	>12m
2nd Phalanx	F	F	>12m
1st Phalanx	F	F	>24m

Specimen:
255513 **Location:** China **Sex:** Male

Tooth Eruption & Wear

Tooth	Position	Side	Score	Age Class	Age
M1	U	R	11	VIII	18-24m
M1	U	L	11	VIII	18-24m
M2	U	R	9	VIII	18-24m
M2	U	L	9	VIII	18-24m
M3	U	R	7	VIII	18-24m
M3	U	L	7	VIII	18-24m
M1	L	R	11	VIII	18-24m
M1	L	L	11	VIII	18-24m
M2	L	R	9	VIII	18-24m
M2	L	L	9	VIII	18-24m
M3	L	R	7	VIII	18-24m
M3	L	L	7	VIII	18-24m

Long Bone Fusion (Right side only)

Bone	Prox. Fusion	Dis. Fusion	Age
Scapula	X	X	X
Humerus	G	F	>12m
Radius	F	G	>12m
Ulna	G	G	<36m
Femur	G	G	>42m
Tibia	G	F	>24m, <42m
Calcaneus	X	X	X
2nd Phalanx	F	F	>12m
1st Phalanx	F	G	<24m

Specimen:
258185 **Location:** China **Sex:** Female

Tooth Eruption & Wear

Tooth	Position	Side	Score	Age Class	Age
M1	U	R	17	IX	24-36m
M1	U	L	17	IX	24-36m
M2	U	R	12	IX	24-36m
M2	U	L	12	IX	24-36m
M3	U	R	9	IX	24-36m
M3	U	L	9	IX	24-36m
M1	L	R	16	IX	24-36m
M1	L	L	16	IX	24-36m
M2	L	R	12	IX	24-36m
M2	L	L	12	IX	24-36m
M3	L	R	9	IX	24-36m
M3	L	L	9	IX	24-36m

Long Bone Fusion (Right side only)

Bone	Prox. Fusion	Dis. Fusion	Age
Scapula	F	X	>12m
Humerus	G	F	>12m
Radius	F	G	>12m
Ulna	F	G	36-42m
Femur	F	F	>42m
Tibia	G	F	>24m, <42m
Calcaneus	X	F	>12m
2nd Phalanx	X	X	X
1st Phalanx	X	X	X

Specimen:
173817 **Location:** India **Sex:** Female

Tooth Eruption & Wear

Tooth	Position	Side	Score	Age Class	Age
M1	U	R	14	VIII	18-24m
M1	U	L	14	VIII	18-24m
M2	U	R	11	VIII	18-24m
M2	U	L	11	VIII	18-24m
M3	U	R	7	VIII	18-24m
M3	U	L	7	VIII	18-24m
M1	L	R	13	VIII	18-24m
M1	L	L	13	VIII	18-24m
M2	L	R	11	VIII	18-24m
M2	L	L	11	VIII	18-24m
M3	L	R	7	VIII	18-24m
M3	L	L	7	VIII	18-24m

Long Bone Fusion (Right side only)

Bone	Prox. Fusion	Dis. Fusion	Age
Scapula	F	X	>12m
Humerus	G	F	>12m
Radius	F	G	>12m
Ulna	F	G	36-42m
Femur	F	F	42m
Tibia	G	F	>24m, <42m
Calcaneus	X	F	>12m
2nd Phalanx	X	X	X
1st Phalanx	F	F	>24m

Specimen:
122536 **Location:** India **Sex:** Male

Tooth Eruption & Wear

Tooth	Position	Side	Score	Age Class	Age
M1	U	R	18	X	36+
M1	U	L	18	X	36+
M2	U	R	15	X	36+
M2	U	L	15	X	36+
M3	U	R	12	X	36+
M3	U	L	12	X	36+
M1	L	R	18	X	36+
M1	L	L	18	X	36+
M2	L	R	15	X	36+
M2	L	L	15	X	36+
M3	L	R	12	X	36+
M3	L	L	12	X	36+

Long Bone Fusion (Right side only)

Bone	Prox. Fusion	Dis. Fusion	Age
Scapula	F	X	>12
Humerus	F	F	>12
Radius	F	F	>12
Ulna	F	F	36-42m
Femur	F	F	>42m
Tibia	F	F	>42m
Calcaneus	F	X	>12m
2nd Phalanx	F	F	>12m
1st Phalanx	F	F	>24m

Specimen:
144302 **Location:** Indonesia **Sex:** Male

Tooth Eruption & Wear

Tooth	Position	Side	Score	Age Class	Age
M1	U	R	15	IX	24-36m
M1	U	L	15	IX	24-36m
M2	U	R	12	IX	24-36m
M2	U	L	12	IX	24-36m
M3	U	R	9	IX	24-36m
M3	U	L	9	IX	24-36m
M1	L	R	15	IX	24-36m
M1	L	L	15	IX	24-36m
M2	L	R	12	IX	24-36m
M2	L	L	12	IX	24-36m
M3	L	R	9	IX	24-36m
M3	L	L	9	IX	24-36m

Long Bone Fusion (Right side only)

Bone	Prox. Fusion	Dis. Fusion	Age
Scapula	F	X	>12
Humerus	F	F	>12
Radius	F	F	>12
Ulna	F	F	36-42m
Femur	F	F	>42m
Tibia	F	F	>42m
Calcaneus	F	X	>12m
2nd Phalanx	F	F	>12m
1st Phalanx	F	F	>24m

Specimen:
144303

Location:
Indonesia

Sex: Male

Tooth Eruption & Wear

Tooth	Position	Side	Score	Age Class	Age
M1	U	R	10	VII	18-24m
M1	U	L	15	IX	24-36m
M2	U	R	12	IX	24-36m
M2	U	L	12	IX	24-36m
M3	U	R	8	IX	24-36m
M3	U	L	8	IX	24-36m
M1	L	R	N/A	N/A	N/A
M1	L	L	15	IX	24-36m
M2	L	R	12	IX	24-36m
M2	L	L	12	IX	24-36m
M3	L	R	8	IX	24-36m
M3	L	L	8	IX	24-36m

*Pathologically missing lower RM1, caused unnaturally low wear on upper RM1

Specimen:
542276

Location:
Pakistan

Sex: Female

Tooth Eruption & Wear

Tooth	Position	Side	Score	Age Class	Age
dP4	U	R	10	VII	12-18m
dP4	U	L	10	VII	12-18m
M1	U	R	9	VII	12-18m
M1	U	L	9	VII	12-18m
M2	U	R	4	VII	12-18m
M2	U	L	4	VII	12-18m
dP4	L	R	10	VII	12-18m
dP4	L	L	10	VII	12-18m
M1	L	R	10	VII	12-18m
M1	L	L	10	VII	12-18m
M2	L	R	9	VII	12-18m
M2	L	L	9	VII	12-18m

Specimen:
330787

Location:
Taiwan

Sex: X

Tooth Eruption & Wear

Tooth	Position	Side	Score	Age Class	Age
dP4	U	R	9	V	2-5m
dP4	U	L	9	V	2-5m
M1	U	R	5	V	2-5m
M1	U	L	5	V	2-5m
M2	U	R	U	V	2-5m
M2	U	L	U	V	2-5m
dP4	L	R	9	V	2-5m
dP4	L	L	9	V	2-5m
M1	L	R	5	V	2-5m
M1	L	L	5	V	2-5m
M2	L	R	U	V	2-5m
M2	L	L	U	V	2-5m

Long Bone Fusion (Right side only)

Bone	Prox. Fusion	Dis. Fusion	Age
Scapula	F	X	>12
Humerus	F	F	>12
Radius	F	F	>12
Ulna	F	F	36-42m
Femur	F	F	>42m
Tibia	F	F	>42m
Calcaneus	F	X	>12m
2nd Phalanx	F	F	>12m
1st Phalanx	F	F	>24m

Long Bone Fusion (Right side only)

Bone	Prox. Fusion	Dis. Fusion	Age
Scapula	F	X	>12m
Humerus	U	G	<12m
Radius	G	U	<12m
Ulna	U	G	<36m
Femur	G	G	<24m
Tibia	G	G	<24m
Calcaneus	X	G	<27m
2nd Phalanx	X	X	X
1st Phalanx	X	X	X

Long Bone Fusion (Right side only)

Bone	Prox. Fusion	Dis. Fusion	Age
Scapula	U	X	<12m
Humerus	U	G	<12m
Radius	U	U	<12m
Ulna	U	U	<36m
Femur	U	U	<24m
Tibia	U	U	<24m
Calcaneus	X	U	<27m
2nd Phalanx	F	U	<12m
1st Phalanx	F	U	<24m

Specimen:
330788

Location:
Taiwan

Sex: X

Tooth Eruption & Wear

Tooth	Position	Side	Score	Age Class	Age
dP4	U	R	9	V	2-5m
dP4	U	L	9	V	2-5m
M1	U	R	5	V	2-5m
M1	U	L	5	V	2-5m
M2	U	R	U	V	2-5m
M2	U	L	U	V	2-5m
dP4	L	R	9	V	2-5m
dP4	L	L	9	V	2-5m
M1	L	R	5	V	2-5m
M1	L	L	5	V	2-5m
M2	L	R	U	V	2-5m
M2	L	L	U	V	2-5m

Long Bone Fusion (Right side only)

Bone	Prox. Fusion	Dis. Fusion	Age
Scapula	U	X	<12m
Humerus	G	G	<12m
Radius	G	U	<12m
Ulna	U	U	<36m
Femur	G	U	<24m
Tibia	G	G	<24m
Calcaneus	X	U	<27m
2nd Phalanx	F	U	<12m
1st Phalanx	F	U	<24m

Specimen:
35118

Location: USA

Sex: Male

Tooth Eruption & Wear

Tooth	Position	Side	Score	Age Class	Age
M1	U	R	15	IX	24-36m
M1	U	L	15	IX	24-36m
M2	U	R	11	IX	24-36m
M2	U	L	11	IX	24-36m
M3	U	R	9	IX	24-36m
M3	U	L	9	IX	24-36m
M1	L	R	15	IX	24-36m
M1	L	L	15	IX	24-36m
M2	L	R	12	IX	24-36m
M2	L	L	12	IX	24-36m
M3	L	R	9	IX	24-36m
M3	L	L	9	IX	24-36m

Long Bone Fusion (Right side only)

Bone	Prox. Fusion	Dis. Fusion	Age
Scapula	F	X	>12m
Humerus	G	F	>12m
Radius	G	F	>12m
Ulna	G	G	<36m
Femur	U	G	<24m
Tibia	G	F	>24m, <42m
Calcaneus	X	G	<12m
2nd Phalanx	F	F	>12m
1st Phalanx	F	G	>24m

*CONFIRMED DOMESTIC

APPENDIX 2

Additional ulnar measurements designed for this study

1. Greatest length across the coronoid process of the ulna.
2. The greatest length of the shaft of the ulna, measured below the coronoid process.