

Range Limits: Semiferal Animal Husbandry in Spanish Colonial Arizona

Nicole M. Mathwich 

In North America, the introduction of livestock as part of the Columbian Exchange had profound social and ecological consequences for cultural environments, yet the landscape impacts of these animals have been difficult to identify, particularly in the first decades of sustained contact. Between 1701 and 1775, at a Spanish colonial mission near what is today Nogales, Arizona, O'odham groups and Spanish missionaries generated land management practices that wove together the needs of domesticated animals and existing Indigenous farming practices. This study proposes a set of indicators to identify animal husbandry practices in both the archaeological and historical record. Faunal, isotopic, and historical analyses from Mission Los Santos Ángeles de Guevavi provide evidence that cattle ages were loosely monitored and that cattle were culled at an older age than optimal for meat and grease extractive strategies compared to other domesticated species at the site. These findings suggest a low investment strategy in cattle, which may have helped Indigenous groups continue aspects of precontact agricultural and gathering practices and preserve their communities in the colonial period. These findings provide further evidence of the depth of animal husbandry practices among Indigenous groups in the Southwest.

Keywords: Spanish colonialism, historical ranching, borderlands, Indigenous ranching, semiferal livestock

La introducción del ganado como parte del intercambio colombiano tuvo profundas consecuencias sociales y ecológicas para las culturas indígenas alrededor de Norteamérica. Los impactos paisajísticos de estos animales han sido difíciles de identificar, particularmente en las primeras décadas de contacto sostenido. Entre 1701 y 1775, en una misión española cerca de lo que hoy es Nogales, Arizona, los grupos nativos de Tohono O'odham y los misioneros españoles generaron prácticas de gestión de ganado que entrelazaron las necesidades de los animales domésticos y las prácticas agrícolas indígenas existentes. Este estudio propone un conjunto de indicadores para identificar prácticas de crianza de animales en el registro arqueológico e histórico. Los análisis de fauna, isotópicos, y documentos históricos de la Misión de Los Santos Ángeles de Guevavi proveen evidencia de que las edades del ganado fueron monitoreadas en una manera flexible. Además, el ganado fue faenado a una edad mayor que la óptima para las estrategias de extracción de carne y grasa en comparación con otras especies domesticadas en el sitio. Estos hallazgos sugieren una estrategia de baja inversión en la cría de ganado, tal vez ayudando a los grupos indígenas a continuar aspectos de las prácticas agrícolas y de recolección anteriores al contacto y preservar sus comunidades en el período colonial. Estos hallazgos brindan más evidencia de la profundidad de las prácticas de cría de animales entre los grupos indígenas en el suroeste.

Palabras clave: colonialismo español, ganadería colonial, paisaje fronteriza, ganadería indígena, ganado semiferal

Archaeologies of colonialism have undergone major shifts in perspectives in the past two decades. One of the most significant developments has been the longitudinal studies of Indigenous persistence (Lightfoot and Gonzalez 2018; Panich and Schneider

2014; Silliman 2012) and an increasing attention to how introduced species contributed to Indigenous socioeconomic change and independence (Bethke 2017; Fowles et al. 2017; Montgomery 2019). Archaeologists have long acknowledged the profound impacts livestock

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have had on Spanish colonial ecology and society in North America, with particular attention to ethnogenesis, subsistence, landscape change, and labor (Allen 2010; Freiwald and Pugh 2018; Jones 2018; Pavao-Zuckerman et al. 2018; Reitz et al. 2010; Sunseri 2017). The next step in these inquiries is to understand the complicated ways in which Native groups managed livestock within their cultural landscapes in response to multiple waves of colonial demands. The US Southwest region encompasses several Indigenous postcontact adoptions of Eurasian domesticated animals, yet each case reflects tremendous diversity shaped by local knowledge and conditions.

Animal-husbandry—the practices associated with the care, feeding, and breeding of animals—underlies any argument about colonial landscape change and Indigenous labor, and it is the cornerstone for all further interpretation. Species-specific strategies shaped how people used their time and energy and which parts of the landscape were most impacted by grazing. Time allocation reflects cultural priorities, and this is significant when examining native strategies to balance Spanish colonial demands with cultural and subsistence needs.

In the southern Southwest and northwestern Mexico, semiferal animal management should be considered a potential Indigenous adaptive strategy to Spanish colonial intrusions in the Southwest. “Semiferal” describes a state in which animals have minimal contact with humans and are left to graze and breed with little human interference, but they are still intermittently herded and culled. Semiferal practices reflect a lower time investment while also creating a product for colonial markets. To argue for semiferal practices as a strategy of Indigenous persistence, evidence for this type of management must first be identified in the archaeological record.

In this article, I examine the history of animal husbandry practices in southwestern North America and the zooarchaeological study of herding practices in the Spanish colonial period. Although semiferal cattle management is a widely assumed historical practice in western North America, little archaeological work has identified or defined the practice in excavated contexts. I use zooarchaeological and historical

evidence as a case study for semiferal management at Mission Los Santos Ángeles de Guevavi in Nogales, Arizona, and I outline evidence for the archaeological identification of semiferal management. Finally, I discuss why animal-husbandry strategies at Spanish missions is pertinent to understanding the erasure of Native American ranching from mainstream narratives of southwestern history.

Feral Livestock in Archaeology

Archaeological work has often surveilled the boundaries of transformations in human–animal relationships, particularly as it relates to domestication and wildness. Although Ingold (1980) distinguished the economic systems of hunting, pastoralism, and ranching, shifts from wild to domestic uses in some species can be difficult to identify archaeologically and are accompanied by substantial re-wilding and/or ferality. Species such as cattle, horses, goats, reindeer, and pigs shift into feral states easily and survive without human interference (Lazo 1994; Naundrup and Svenning 2015). Genetics, use wear, population structure, osteometrics, stable isotopes, artifacts, and ethnographic evidence have all been brought to bear on the question of whether an animal is wild or domestic (Balasse et al. 2016; Levine 2005; Perry and Makarewicz 2019; Zeder 2012). Previous research on degrees of ferality have focused on the Eurasian origins of livestock and pastoralists (Chen et al. 2016; Taylor 2017; Vermeersch et al. 2021). Researchers used multiple, reinforcing lines of evidence—ranging from genetics to the presence of bridles—to help identify domestic livestock from feral and wild counterparts. Much of this research is concentrated in Eurasia and Africa, and the de facto assumption in the Americas is that introduced livestock were in contexts controlled by humans.

Eurasian domesticates have long been identified as a form of ecological colonialism (Crosby 2004), but Native peoples of the Americas adapted and adopted livestock husbandry into their lifeways. On the Plains, Indigenous groups integrated horses derived from Spanish stock into emergent pastoral economies (Bethke 2017; Montgomery 2019). Southwestern Diné groups began independently adapting their practices

around sheepherding early in the contact period (Campbell 2021). After 1650 in New England, groups such as the Natick and Punkapoag used domesticated livestock to fend off colonists' incursions onto Native lands, and cattle became a survival tool as subsistence became circumscribed by settlers (Silverman 2003). In Peru, animal husbandry existed prior to contact, but Spanish appetites fueled the rapid growth of Eurasian herds and became integrated into Indigenous subsistence strategies (Covey 2021; Kennedy and VanValkenburg 2016).

Feral animals can be enormously productive in grassland ecosystems, and this phenomenon has been a significant factor both in colonial economics and the emergence of Indigenous animal husbandry in the Americas. In Argentina, feral cattle hunting and semiferal management helped establish colonial control of the region and provided hides and meat for mining centers (Cushman 1984). In Paraguay, Guaraní hunted cattle in the Rfo de la Plata region from feral mission herds, and Spanish accounts of this period imply that the cattle and the land were ownerless (Sarreal 2011). Significantly, not all of these emergent relationships were formalized through active management, and feral herds could be as valuable as carefully managed ones. Loosely managed, semiferal herds were common across the Americas after contact, with wide-ranging economic impacts.

In the greater Southwest, Native labor was used to manage mission herds, and these herds provided seed stock for later presidios and towns occupied by mestizo, European, and Indigenous families (Kessell 2002). The criollo cattle breed typical of the Spanish period is known for its drought tolerance and its ability to both give birth without human aid and defend itself from predators (Anderson et al. 2015). As part of this process, however, Native peoples across Arizona, New Mexico, Texas, and California became adept at raising and processing livestock (Allen 1998; Pavao-Zuckerman 2008; Tarcan 2005).

Toward a Zooarchaeology of Semiferal Animal Husbandry

Zooarchaeological analysis has been well equipped to look at human livestock management in the

past. The identification of semiferal management practices in the archaeological record benefits from a mixed methodology using a variety of proxies. Zooarchaeological and isotopic analyses, including others such as histology and aDNA, are part of a suite of tools at researchers' disposal. Culling profiles helps link human behavior and economies to material remains and elucidate patterns of dairying, wool, and meat procurement strategies (Helmer et al. 2007; Lyman 2008). Culling profiles of semiferal animal husbandry, however, would not appear distinct from meat-focused culling, with adult animals primarily being culled. Identification of semiferal animal husbandry therefore requires additional lines of evidence.

Archaeologically, what would free-range, semiferal cattle management look like? Semiferal ranching would be characterized by less surveillance and minimal interaction between the animals and people (Table 1). The continuum of human–animal relationships ranges from constant companionship to passing interactions, with many possibilities in between. Today, animals have tags, and animal managers track age, sex, lineage, and health individually, although the animals spend the most time unsupervised on the range. In the colonial period, without a detailed record and tagging system, it would have been difficult to monitor the exact ages of the animals. Pastoralists, whether reindeer herders, sheepherders, or dairy farmers, develop deep familiarity with individual animals without tagging systems. Minimal interaction makes it potentially difficult to access the animal when it has reached its full size and weight, and a greater number of older animals would be culled than expected in a purely meat procurement profile. Also, feral animals' diets will reflect the surrounding area and follow seasonal changes, and foddering will not be a major contribution to their diet. In terms of record keeping, lack of contact would hinder accurate tracking of herd size. Together, each facet of semiferal husbandry can be identified archaeologically.

Case Study: Mission Los Santos Ángeles de Guevavi

A few miles northeast of Nogales, Arizona—10 km (6 miles) north of what is today the

Table 1. Semiferal Practices Identifiable in the Archaeological and Historical Records.

Husbandry Practice	Effect on Animals	Archaeological Evidence
Minimal foddering. Animals primarily out in unfenced pastures.	Water and diet reflect local conditions.	Carbon and oxygen isotopes from tooth enamel.
Infrequent contact with humans; breeding and birthing occurs away from humans.	Herd composition reflects adults much older than would be optimal for a pure meat strategy. Culling of older adults than would be efficient because age is not tracked or animals are located away from butchering locations.	Lack of detailed historical records of sex, age, and number of individuals. Zooarchaeological aging based on fusion and tooth eruption.
Distinctions in grazing and watering practices among herded species.	Species-level differences in diet, water sources, and culling ages.	Carbon and oxygen isotopes from tooth enamel, historical records of animal management, and zooarchaeological data.

modern US-Mexican border, are the ruins of Mission Los Santos Ángeles de Guevavi. Mission Guevavi was located in the northern Pimería Alta of New Spain. Today, the National Park Service (NPS) administers the site. Guevavi belonged to the mission system founded by the Jesuit Father Eusebio Kino after 1691, with the intent of converting Tohono O'odham ancestors to Catholicism and Spanish ways of life. In 1768, following the Jesuit Expulsion, the Franciscan Order took over the mission network. Franciscan missionaries replaced the Jesuits, but their presence at the mission was short and plagued by raiding. At Guevavi, however, the Jesuit period is preserved because the mission was emptied by 1775, and it moved north. Excavations at Guevavi (Figure 1) provided an opportunity to study the first 70 years of colonization and the introduction of animal husbandry to the Pimería Alta.

In 2013, the Guevavi mission midden was disturbed by rodent activity and was targeted by the NPS for archaeological mitigation. The midden deposit there offered a unique opportunity to explore the early years of missionization prior to the maturation of the colonial economies a century later. The feature that produced the vertebrate samples reported here was excavated as part of the 2013 Mission Guevavi Archaeological Field School, a collaborative effort between the University of Arizona, Arizona State Museum, Tumacácori National Historic Park, and Desert Inc. The excavation analyses are reported in Thiel and Pavao-Zuckerman

(2016). The present faunal materials came from two mission-period 2 × 2 m units, with smaller, later reoccupation by Yaqui miners in the 1810s, several decades after the mission's abandonment but still within the Spanish colonial period. This later occupation contributed little to faunal materials analyzed here, because the bulk of the animal remains were found alongside mission-period artifacts and below the levels where the later mining slag accumulated (Supplemental Text 1). Severe rodent disturbance to the units mixed the older mission-period levels with upper levels, and it was impossible to extricate this smaller portion from the earlier materials, so faunal materials are conservatively interpreted as Spanish colonial from 1700 to 1810. The bulk of the occupation likely dates to the 1720s–1775. Mission Guevavi fauna represents the largest analyzed colonial-period sample in the region to date.

Tohono O'odham Subsistence Practices

Prior to contact, Tohono O'odham groups moved seasonally, hunted, and planted crops in various regions along the floodplain of the Santa Cruz River, and many of those practices endured through the Spanish colonial period and beyond (Fish et al. 2008; Hill 2018; McIntyre and Arizona Historical Society 2008). Prior to and following contact, Tohono O'odham farmers adapted to variable summer rainfall by cultivating maize, squash, and beans and collecting wild resources such as goosefoot, cholla, prickly pear, saguaro fruit, agave, yucca, and mesquite

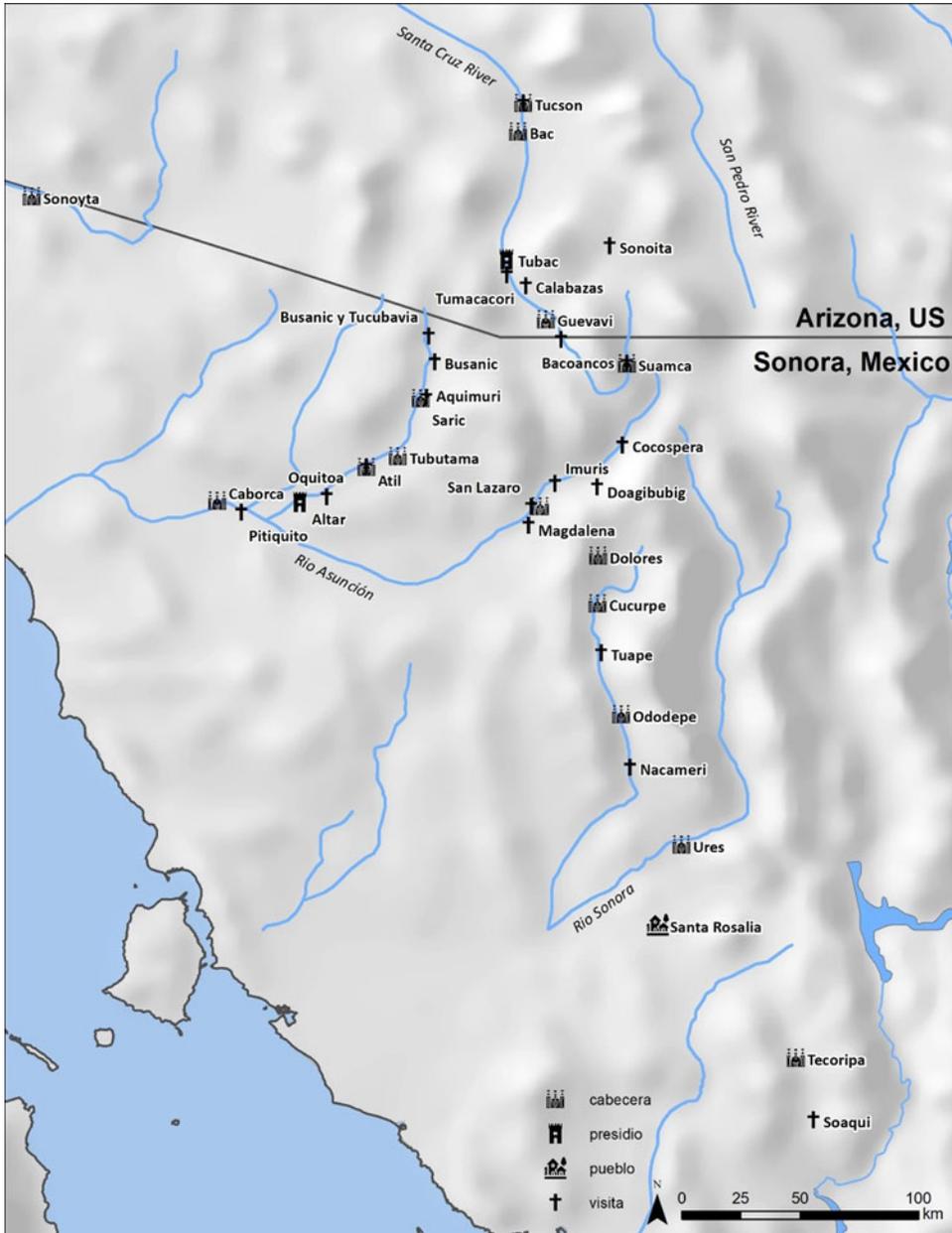


Figure 1. Map of the Pimería Alta mission systems. Map by Kathryn MacFarland.

pods (Fontana and Schaefer 1989; Weber et al. 1996). Tohono O’odham made use of local game such as deer, bighorn sheep, pronghorn, rabbits, and rodents (Dean 2003; Diehl and Waters 2006).

The Tohono O’odham integrated animal husbandry into their subsistence strategies and belief systems following the Spanish colonial period,

allowing cattle to go feral and hunting them (Kozak and Lopez 1999; Marak and Tuennenman 2013:109). Tohono O’odham, compared to Akimel O’odham to the north, integrated ranching into their lifeways earlier because of mission contact and had their own herds during and after the Spanish colonial period. The farming Akimel O’odham communities were not

missionized, but they were not untouched by Spanish colonialism in the south. By the nineteenth century, Akimel O'odham began ranching, and cattle (and sheep to a lesser extent) were a major part of the faunal assemblage found at the late nineteenth-century site of Blackwater Village (Loendorf et al. 2019). During the historical period, Tohono and Akimel O'odham images of branded cattle and brands appeared in rock art (Bostwick and Krocek 2016), indicating integration of the animals into other cultural facets.

Semiferal cattle ranching was a primary economic activity for the Tohono O'odham, and grazing lands were often held in common—a practice that dated to the mission period—until the 1930s Depression, when the US government ordered the creation of grazing districts, thereby seriously disrupting traditional grazing and water rights (Parman 1992). Cattle, in particular, became central to local and Indigenous cuisine in the form of dried meat, stews such as *chile Colorado*, and tallow. Today, beef is considered part of family cooking by members of the Tohono O'odham Nation (Fazzino 2008), and ranching remains a major economic activity on the reservation.

Methods

Faunal remains in this study came from the historical midden (Feature 26) associated with Mission Guevavi on land administered by Tumacácori National Historic Park. The collection is currently housed at the National Park Service Western Archeological Conservation Center in Tucson, Arizona. The specimens reported were sieved through a 6.35 mm (¼") screen. Zooarchaeological analysis followed the methods described in Reitz and Wing (2008) and are originally reported in Mathwich (2016). Contextual and additional excavation information about Feature 26 is available in Supplemental Text 1.

Faunal Analysis Methods

Vertebrate remains from the Mission Guevavi Field School were identified by the author using standard zooarchaeological methods (Reitz and Wing 2008). Identifications were

made using the comparative skeletal collections housed at the Stanley J. Olsen Laboratory of Zooarchaeology, Arizona State Museum, University of Arizona.

A variety of observations, such as element and taxonomic identification, which can be replicated by later investigators, were collected as part of the analysis (Reitz and Wing 2008). Specimens were identified to taxon, element represented, portion recovered, and symmetry (left vs. right). Indicators for sex, age at death, and modifications were noted where observed, and these were recorded. Age ranges resulted from observations of epiphyseal fusion and tooth eruption above the gumline. For age, the presence of wear is significant because it means a tooth fully erupted.

In this article, "caprine" is the term used to describe the remains from animals that could be domestic sheep or goat. During the Spanish colonial period, however, sheep were the most common small domestic bovid (Kessell 1970; Officer 1987). Goats were present, but in far smaller numbers. Mission inventories of the region in 1768 record 10,069 sheep and 251 goats, or 2.4% of all small livestock (Estado del Rectorado de la Pimería 1767). In recognition of this possibility, this article employs a more conservative category of "caprine," but these are mostly likely sheep.

The Minimum Number of Individuals (MNI) is reported in this study, and this was derived from Minimum Number of Elements (MNE). MNE was calculated by taking into consideration element portions, side, size, and fusion; teeth were excluded from MNE. There were occasions where the lower taxonomic category was smaller than the MNI for the corresponding higher taxonomic level. MNI for the lower taxonomic category was reported in parentheses but was not included in subsequent calculations. MNI increases with the smaller, discrete proveniences used for analysis, resulting in problems of aggregation and accuracy (Domínguez-Rodrigo 2012; Grayson 1978; Lyman 2019), but MNI are valuable when looking at the degree of fragmentation. Fragmentation can be indicative of disposal patterns, marrow extraction, and grease extraction (Outram 2001). The Guevavi assemblage and contemporary Pimería Alta assemblages reflect

substantial fragmentation associated with greasing rendering (Pavao-Zuckerman 2011). For these reasons, MNI was reported, but it was contextualized with Number of Identified Specimens (NISP) and biomass based on the allometric relationships reported in Reitz and Wing (2008) in order to balance MNI's overestimation of smaller taxa.

Isotopic Assays

Isotopic assays from tooth enamel carbonate were analyzed to obtain information about animal diet. Tooth enamel carbon is used to examine dietary proportions of plants over the tooth's development. Oxygen isotopes from tooth carbonate help researchers understand the types of water sources an animal consumes. Other isotopes, such as nitrogen and strontium, have been valuable in elucidating animal management practices and movement of animal products (Guiry et al. 2014, 2021). The carbon and oxygen originated from tooth enamel bioapatite rather than collagen proteins. Carbon and oxygen were chosen specifically for their ability to shed light on vegetation communities and environmental water sources (Cerling et al. 2003; Passey et al. 2005). The methods were originally reported in Mathwich and colleagues (2019), and they are summarized here. Samples of 1–3 mg of enamel were drilled from the tooth, maintaining the overall physical integrity and identifiability. Teeth were sampled using a small drill, producing a shallow, vertical trench bulk sample in the outer enamel of the tooth crown, which reflected the average consumption over the tooth's development. Bovid molar crowns take about a year to form (Hillson 2005). Only adult molars were used in this study.

Oxygen and carbon isotopes were extracted from the CO_3 component of biological apatite in the tooth enamel and calculated using the offsets from Kohn and Cerling (2002:465). All $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ samples were processed in the Stable Isotope Laboratory Carbonate Lab on the campus of the University of Arizona. Powder samples were pretreated to isolate the structural carbonate-apatite and to remove organics and secondary carbonate. A weak solution of 0.1 M acetic acid in distilled water was added to the sample and soaked overnight, and then removed

with a pipette. Although it is no longer recommended (Pellegrini and Snoeck 2016), this aggressive pretreatment was standard practice at the Environmental Isotope Laboratory when the analysis was conducted in 2015. Samples were then rinsed with ultra-pure water and allowed to dry overnight. The $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ of carbonates were measured using an automated carbonate preparation device (KIEL III) coupled to a gas-ratio mass spectrometer (Finnigan MAT 252). Powdered samples were reacted with dehydrated phosphoric acid under vacuum at 70°C. The isotope ratio measurement was calibrated based on repeated measurements of NBS-19 and NBS-18, and precision is $\pm 0.1\text{‰}$ for $\delta^{18}\text{O}$ and $\pm 0.08\text{‰}$ for $\delta^{13}\text{C}$ (1σ).

The fractionation for bovids reported in Passey et alia (2005) that was used to calculate $\delta^{13}\text{C}_{\text{enamel-diet}}$ was $\alpha_{\text{enamel-diet}} = 1.0146$. Note that the $\delta^{13}\text{C}$ values have been corrected for modern fossil-fuel consumption (1.5‰; Friedli et al. 1986; Leuenberger et al. 1992; Tieszen and Fagre 1993; Treydte et al. 2009). The composition of stable carbon is reported in δ (per mil) notation relative to the global Vienna Pee Dee Belemnite (VPDB) standard. R_{sample} and R_{standard} refer to the ratios of $^{13}\text{C}/^{12}\text{C}$ and, as a sample or standard, they are reported relative to VPDB standard (Kendall and McDonnell 1998). The C_3 endmember used to calculate the percentage of C_4 in the animal diets was derived from Kohn (2010), and the modern C_4 endmember of -12.5‰ VPDB was from Cerling and colleagues (2003). For the equations, voltages, standard deviations, endmembers, and data used, see Supplemental Table 1.

Historical Sources

The historical data presented here were translated into English from the original Spanish by Kessell (1970) and the author in consultation with the Office of Ethnohistoric Research at the Arizona State Museum, Tucson. These documents were written by Jesuit priests sponsored by the Spanish colonial government, and they represent counts of herd sizes at the missions. These documents, which represent a missionary perspective, are concerned with the material holdings and property of the missions, and they were not meant to be demonstrative of livestock

management. The author's use of them for live-stock management is her own reading of the documents.

Results

The results of the above analyses were used to evaluate the presence of semiferal management of cattle and to contrast it to the management of sheep at Mission Guevavi. Several patterns emerged within these results relating to differences between the species. First, the isotopic ratios of tooth enamel from cattle and caprines indicate differences in both water and grazing sources. Second, the faunal ages at death for sheep were younger than three years, whereas those of cattle appear to be older than three years. Third, the historical sources demonstrate different conceptual groupings of domesticated species but offer sparse information about the actual management of the animals.

Stable Isotope Analysis

From 180 inventoried whole teeth, a total of 13 specimens were selected for sampling and were part of a larger study consisting of adult lower molars (Mathwich et al. 2019). Mission Guevavi was unique in its large sample size of teeth compared to other sites, and it offered the most individual samples. With that note, the sample was small. Because the samples came from a larger midden feature, the project sampled higher than the reported MNIs, which excluded teeth. Caprines had a higher MNI but a lower number of adult tooth samples due to the high frequency of deciduous teeth in the assemblage. The sampled specimens were selected for their completeness, tooth position, and age. The %C₄ plants in the diet for cattle ranged from 75% to 104% of the animals' diets, and $\delta^{18}\text{O}_{\text{bioapatite}}$ ranged from -4.36‰ to $-0.44\text{‰} \pm 0.10$ VPDB (Figure 2). The %C₄ plants in the diet for caprine diets ranged from 21% to 52%, and the $\delta^{18}\text{O}_{\text{bioapatite}}$ ranged from 1.34‰ to $3.31\text{‰} \pm 0.10$ VPDB. Mathwich and colleagues (2019) and Grimstead and Pavao-Zuckerman (2016) found both caprine and cattle oxygen body-water values to be highly enriched compared to average precipitation. Independent sampling of modern water sources and leaf enrichment found that

the likeliest explanation was evaporated, enriched water sources stemming from water storage. At Guevavi, the caprine water sources appeared to have been more enriched than cattle water sources. The Guevavi data are consistent with contemporary Pimería Alta sites, indicating that these proportions denote a broader dietary difference among cattle and caprines (Grimstead and Pavao-Zuckerman 2016; Mathwich et al. 2019). Cattle ate primarily C₄ plants, which reflects a dependence on semidesert grasslands—the largest concentrations of perennial C₄ grasses in southern Arizona—particularly grama species (Bock and Bock 1986). The high proportion of C₄ plants in cattle diets is compatible with the consumption of CAM plants such as cacti. However, studies on range behavior indicate that grasses are their preferred grazing food (Hanselka and Paschal 1990). CAM plant consumption may muddy the differences among taxa, but large distinctions in diets are still observable.

Age Estimation

In cattle, there are three main groups of epiphyseal fusion ages roughly within the following stages of the animal's life: early (7–20 months), middle (24–36 months), and late (42–48 months; Barone 1976; Silver 1969). These broad categories capture a range of epiphyseal events, which vary individually due to nutrition, hormones, health, and geography. Modern epiphyseal fusion rates (Moran and O'Connor 1994; Popkin et al. 2012; Silver 1969) were used for age estimations of the domesticated ungulates.

Total MNI of cattle was at least five individuals, and there were at least eight caprines identified (Table 2). Of the cattle elements, 63% (17) of the late-fusing (36+ months) elements were fused, and 85% (17) of middle-fusing elements (24+ months) were fused. At least one younger individual was represented, but most of the individuals were full-grown adults, three to nine years old (Table 3). Among the caprines, 43% (25) of early fusing elements (3–16 months) were fused, but of the middle- and late-fusing elements (7–60 months), 79% (45) were unfused. Individuals ranged from three to four years old, with one older than four years. Sheep/goat were generally slaughtered at a younger age than cattle.

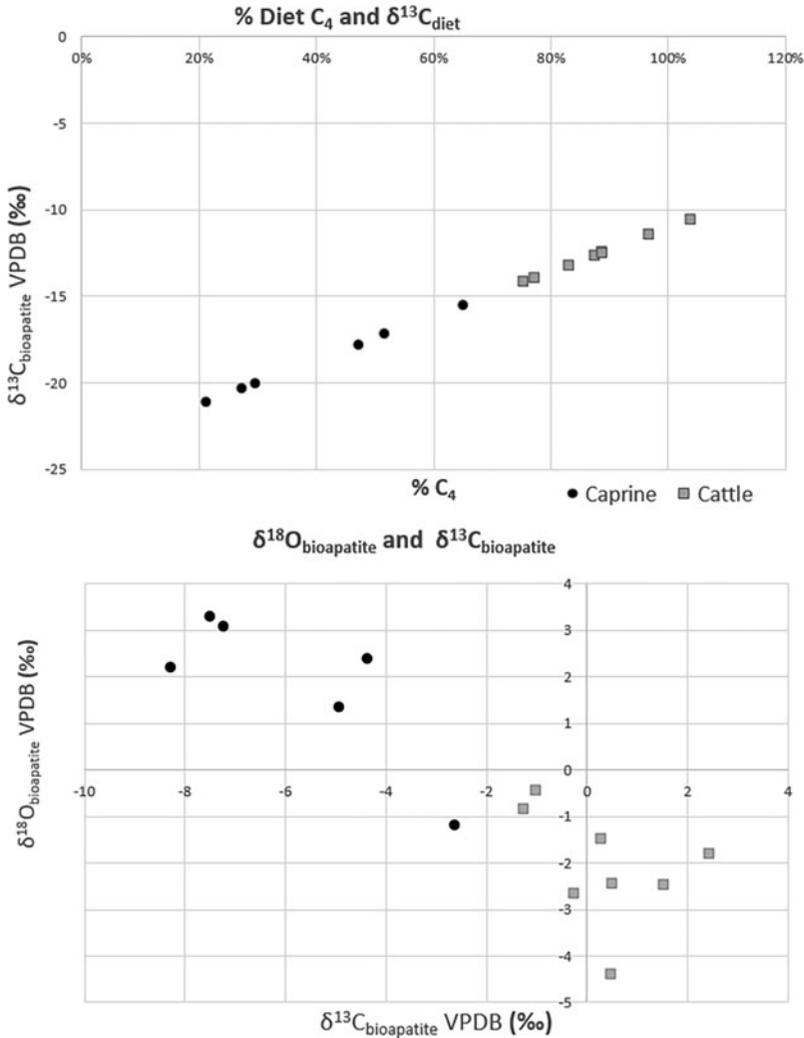


Figure 2. Scatter plot of $\delta^{13}\text{C}_{\text{diet}}$ and the percent of C_4 in the animals' diets, and $\delta^{13}\text{C}_{\text{bioapatite}}$ and $\delta^{18}\text{O}_{\text{bioapatite}}$ from bulk samples of cattle and caprine teeth by site and taxa.

A total of seven mandibles with teeth in situ were identified, but the sample size was not large enough to look at population-level tooth wear. Cattle mandibles with in situ teeth all possessed developed M_3 teeth and showed a considerable degree of in-wear, putting age estimates beyond 36 months (Hillson 2005). Caprine age estimates from tooth eruption of four left mandibles ranged from one to two years old at death (Moran and O'Connor 1994). Once erupted, the M_3 becomes a less reliable indicator of age without population-level wear patterns, but generally, Guevavi cattle were older than three years

at death. The caprines trended younger, with a single unerupted M_3 present among the mandibles found at the site, and two well-worn dP_4 yet to be shed.

Historical Sources

Livestock featured prominently in the earliest Spanish accounts of the Pimería Alta and were integral to the establishment of mission settlements, which served as a vanguard for later military and secular settlements. Mission founder Eusebio Kino recorded rough quantities of animals he brought with him to found new missions,

Table 2. Mission Guevavi, Feature 26: Summary of Domesticated Ungulates, 6.35 mm (1/4") Screened Materials.

Taxa	NISP		MNI		Weight (g)	Biomass (kg)
	#	% of Total Assemblage	#	% of Total Assemblage (MNI only)		
<i>Bos taurus</i>	919	2.0	5	12	18,273.10	180.155
Domestic cattle						
Caprinae	428	1.0	8	20	3,686.50	42.655
Sheep/goat						
<i>Ovis aries</i>	4	0.0	(1)	—	31.94	0.594
Large ungulate	3,268	7.2	—	—	18,844.98	185.221
Small ungulate	1,734	3.8	—	—	3,097.53	36.469

but he wrote little about the management of the animals (Kino1919). Later inventories at Mission Guevavi between 1737 and 1767 illustrated the ontology of livestock from this period (Table 4). Initially, cattle numbers exceeded sheep, but later, sheep were most numerous. Categories of sheep and horses reflect discrimination of age and sex, but over the course of 30 years, no efforts were made to determine the general counts of age and sex in cattle herds.

The surviving *entregas*, or reports, from Guevavi indicate that in a period of 17 years, the number of cattle more than tripled, and the number of sheep increased sharply (Table 4). The presence of other domesticate ungulates—such as mules, horses, and goats—was noted, but goats do not appear in the later *entrega*. Interestingly, chickens and pigs do not appear in this record, but they were found in the Feature 26 midden. Contemporary reports of chicken

Table 3. Mission Guevavi, Feature 26: Epiphyseal Fusion.

	Cattle				Sheep				
	Unfused	Fused	Total	Age (months)		Unfused	Fused	Total	Age (months)
Early Fusing:				S + S	Barone 1976				M & C
Humerus, distal	1	3	4	12–18	15–20	5	5	10	5.5–11
Scapula, distal	1	—	1	6–10	7–10	—	—	—	<6–11
Radius, proximal	—	1	1	12–18	12–15	3	7	10	<4.5–11
Acetabulum	—	3	3	6–10	7–10	8	9	17	nd
Metapodials, proximal (fused at birth)	—	10	10	—	—	—	3	3	—
1st/2nd phalanx, proximal	3	38	41	18–24	15–24	2	1	3	<11–12
Middle Fusing:									
Tibia, distal	1	3	4	24–30	42	2	1	3	13–23
Calcaneus, proximal	—	5	5	36–42	36	2	—	2	nd
Metapodials, distal	2	9	11	24–36	24–30	—	—	—	15–30
Late Fusing:									
Humerus, proximal	3	3	6	42–48	42–48	3	—	3	32–42
Radius, distal	2	2	4	42–48	40–48	3	6	9	23–40
Ulna, proximal	—	1	1	42–48	42	6	1	7	15–30
Ulna, distal	2	2	4	42–48	36	4	—	4	nd
Femur, proximal	1	1	2	42	36	8	1	9	23–40
Femur, distal	1	2	3	42	42	8	—	8	23–36
Tibia, proximal	1	1	2	42	nd	6	—	6	36–45
Vertebral centrum	1	7	8	84–108	54–60	3	3	6	nd
Total	19	91	110			63	37	100	

Sources: From Reitz and Wing (2008:72) and derived from Schmid (1972:75) and Silver (1969) (S+S). Sheep fusion age estimates from Moran and O'Connor (1994) (M & C).

Note: Fusion and growth stages for both cattle and sheep come from studies cited above of growth rates of modern sheep and cattle populations.

Table 4. Livestock Counts from Mission Guevavi *Entregas* from 1737, 1761, and 1767 Inventory.

Year	Livestock	Count
June 1, 1737		
(Kessell 1970: 195–205)	Cattle	240
	Oxen	8
	Sheep	150
	Goats	50
	Gentle horses	12
	Mules and gentle he-mules	10
May 25, 1761		
(Kessell 1970: 195–205)	Cattle	815
	Sheep	723
	Year-old lambs	115
	Lambs not yet a year old	212
	Ewe lambs not yet a year old	220
	Gentle mules	8
	Gentle he-mules	16
	2 year-old he-mules and 1 two-year-old	3
	Oxen	10
	1767	
(Estado del Rectorado de la Pimeria 1767)	Large cattle	700
	Oxen	24
	Sheep	1,240
	Rams	420
	Goats	88
	Tamed mules	6
	Tamed males (mules)	18
	Tamed horses	52
	Fillies/foals	24
	Mares	39

Notes: The above information is excerpted from Kessell (1970:195–201) and was translated by Kessell from the documents housed in the W. B. Stephens Collection, University of Texas Library. The information from Estado del Rectorado de la Pimeria (1767) was translated by the author with the assistance of the Office of Ethnographic Research, Arizona State Museum.

coops appear in other documents (Kessell 1970:88). Bladders of tallow and fat were reported in the *entregas* as well, indicating that some amount of grease extraction likely occurred at the site (Mathwich and Pavao-Zuckerman 2018; Pavao-Zuckerman 2011).

Bone fusion from the Feature 26 midden and categories from the 1761 *entrega* suggest that sheep age was better monitored, with four subdivisions based on age and sex compared to a single category for cattle (Kessell 1970:195). In 1761, 75% of sheep were under a year old

(Table 3). The *entrega* was written in May, after many sheep gave birth, and the fusion from the midden suggests that they were killed before they were 24 months old, which would likely correspond to the “year-old” lamb category in the 1761 *entrega*. Its author, Father Gerstner, may have sought to distinguish the lambs born in that spring from those born in the previous year. In contrast, age seems less important to categorizing cattle in both *entregas*. The 1767 “State of the Rectorate of the Pimeria” (Estado del Rectorado de la Pimeria 1767) shows similar categorizations. The 1767 report was a formal inventory of mission holdings and wealth following the Jesuit expulsion to prepare for the new Franciscan administration, and it did not note the sex or age of cattle. Absence of evidence is not evidence of absence, but in consideration with the isotopic dietary information and the fusion ages, the absence of sex and age suggests that the missionaries and Indigenous herders at Mission Guevavi took a different approach toward cattle compared to other livestock. A variety of herd management practices is possible based on these age estimations, and when reviewed alongside other lines of evidence, they help to triangulate possible management strategies.

Discussion

In the following section, I will examine various possible interpretations and fit them within the broader context of Spanish colonial settlements in the Santa Cruz River Valley. The evidence presented here points to distinct taxa management strategies, but the different purposes these animals served within the Mission Guevavi went beyond the needs of cattle in contrast to sheep. Finally, I discuss how these interpretations intersect within contemporary perceptions of Indigenous ranching.

Distinct Roles of Livestock in Mission Economies

Management differences between sheep and cattle are evident in these data, but do these data rise to the level of semiferrous ranching for either taxon? The isotopic ratios at Guevavi and other mission and fort sites throughout the region show differences between both water sources

and plant diets among cattle and caprines. The biotic communities in the Santa Cruz River Valley are composed of lowland Sonoran and Chihuahuan desert scrub (mixed C_4 , C_3 , and CAM), riparian woodland galleries (C_3 shrubs and trees), and semidesert grasslands (predominately C_4 ; Biedenbender et al. 2004; Brown 1994; Dimmitt 2000). If cattle were semiferal and ranged more widely, it might follow that their C_4 should be lower because they would have been semiferal and had more access to different vegetation communities. The higher C_4 proportions may then be indicative of foddering of C_4 crops such as maize, which is a known practice in Sonora. Range researchers' observations of Arizona cattle note that although nutritionally flexible when necessary, cattle prefer grasses over shrubs whenever available (Sprinkle et al. 2002:2). Foddering from mission fields of wheat (C_3) and maize (C_4) is a possibility, but more equal C_3 : C_4 proportions would be expected if that were the case. The high C_4 cattle diet, however, is consistent with animal behavior of herds grazing on preferred grasses. Caprines had the higher quantities of C_3 plants in their diets and consumed water from more evaporated, stored water sources. These C_3 plants could be from either riparian vegetation or higher-elevation vegetation, but the highly enriched water sources imply that they were kept closer to riparian areas where herd managers created water storage features subject to evaporation and oxygen enrichment. The relationship of the animal's $\delta^{18}O_{\text{body-water}}$ to leaf enrichment, seasonal precipitation, and water storage is discussed in detail in Mathwich et alia (2019). For the purposes of this article, when comparing the isotopic data to other lines of evidence, the $\delta^{13}C_{\text{diet}}$ of cattle is most supportive of management away from occupation areas in river valleys. The results are consistent with semiferal cattle management and distinct from contemporary caprines.

At Mission Guevavi, faunal evidence suggests that the mission ranchers used a mixed strategy with respect to caprines, encompassing wool, hide, and meat production. Global archaeological assemblages show an association of culling young male livestock with dairying practices, resulting in high proportions of

neonate bone and older females (Greenfield and Arnold 2015; Helmer et al. 2007; Marciniak 2011). Dairying may have been present at Guevavi, but it was likely minimal. The knowledge of cheese making and dairying was known in colonial Sonora, primarily with cattle and goats (Segesser and Classen 2012:78). Dairy is not a strong explanation for the younger caprine ages because the individuals at Guevavi died after being weaned. At Guevavi, the young sheep were killed within their first two years of life, long after being weaned two months after birth. Wool was another labor-intensive animal product produced at missions. Sheep reach breeding age at around 5–12 months, and the relatively young age at death is more consistent with meat production than dairying or wool production strategies. These ages, however, could still encompass a first shearing, which—depending on the breed—happens about once a year (Opatik 2008). Tooth and fusion ages were consistent with at least one shearing before death and the animals being at full adult weight. Although there were no elements diagnostic to sex among these specimens, it is likely that these younger individuals were male because most sheepherders prefer to keep higher ratios of ewes to rams (Keeling 2001:231).

In contrast, the older fusions in cattle suggest looser monitoring typical of semiferal strategies. Free-range, semiferal cattle require less monitoring, but scattered grazing makes it harder to find and harvest the animals at maturity. Cattle herd composition during the mission period was likely a mix of ages, and the fusion data point to mature, full-weight adults chosen for culling and processing. These behaviors are consistent with both semiferal management and a meat and growth-focused approach toward mission cattle herds.

The missionaries' goal was to grow herds for sale at secular settlements and create starter herds for other missions, and keeping cattle alive longer increased breeding opportunities. Historical documents from the region show consistent growth of cattle populations throughout the eighteenth century (Jackson 1982; Sayre 1999). Herd growth accelerated in later years under Franciscan management, as financial need grew following the Spanish government's curtailment

of mission support (Mathwich and Pavao-Zuckerman 2018). Recording individual ages for large herds required effort and labor, especially in herds of several thousand spread out across desert grasslands. If the herd sizes appeared to be growing with little intervention, there was equally little reason for close monitoring.

Colonial sheep production has been well documented (Tarcan 2005; Trigg 2004), but its role in the Pimería Alta has yet to be fully explored, despite documentary and archaeological evidence that substantial amounts of Tohono O'odham labor went into it. Although shepherding has fallen out of favor in modern Arizona and Sonora, it was important for decades, and it had its origins in the colonial period. Sheep herds grew large at Guevavi, surpassing cattle in later periods, and they were also numerous at the neighboring presidio, Tubac (Hewitt 1975). Other researchers, however, suggest that the increase in sheep in later periods was a response to raiding pressures (Merrill 1994; Pavao-Zuckerman and Martínez-Ramírez 2019). Raiding during the mid-1700s devastated mission residents and led to shortages of livestock throughout the region and to the eventual abandonment of Mission Guevavi. In 1775, the mission holdings and its residents were moved and consolidated with Mission San Cayetano de Tumacácori (Kessell 1970). Historical and archaeological evidence shows a consistent presence of sheep in nearly equal ratios to cattle (Mathwich and Pavao-Zuckerman 2018). Shepherding primarily as a mitigation strategy for raiding, however, downplays the importance of wool production in the Pimería Alta economy and for reproducing Spanish culture in the Sonoran Desert. Wool in the Spanish borderlands was an important commodity as a trade item and as clothing. Semiferal management of cattle would complement a more labor- and resource-intensive strategy toward sheep, and the two strategies could be adapted in response to raiding pressure.

The role cattle played in the broader colonial economy has been well documented. Tallow and hide production from cattle have been identified archaeologically at Mission San Agustín 97 km (60 miles) north of Guevavi and at

Mission Cocóspera 72 km (45 miles) to the south, and it is likely that hide and tallow production for mining was incorporated into Guevavi's economy (Pavao-Zuckerman 2011). It is not clear, however, whether the wool was for local consumption or regional trade. The Parral silver-mining district in southern Chihuahua was known to import wool from New Mexico, but trade often did not cross the Sierra Madre Occidental (West 1949). Further historical and archaeological research will be required to establish the markets of Mission Guevavi's sheep products.

Semiferal management had the potential to reduce local resource conflicts among farmers, ranchers, and raiders. Cattle possess a much higher biomass than sheep and require more water and range (Gillespie 2004), increasing their potential for conflict with Tohono O'odham farming and water requirements. Sheep herds grew large in the later mission period, and it is not clear from historical evidence or the archaeological data if herd managers shifted them to grasslands when the herd sizes became larger. Although the sample size was quite small, the isotopic data point to dietary strategies that differed with respect to sheep and cattle, suggesting that grasslands were the preferred grazing locations for cattle. Allowing these animals to range farther from riparian areas and irrigated farms and into semidesert grasslands decreased resource conflicts over water and grazing, with agriculture in arable river valleys. Raiders on horseback frequently stole presidio and mission herds, and by keeping less labor-intensive livestock away from permanent settlements, raider violence around larger villages might have been reduced. There were many good reasons to let cattle wander and keep them in pastures farther from fields and homes.

Past Labor, Contemporary Marginalization

Enormous amounts of Tohono O'odham time, energy, and skill went into the care of mission herds and the production of animal products. Isotopic ratios, age at death, and historical sources suggest that this labor was part of a mixed strategy built around the behaviors and needs of introduced livestock. Missionaries and Spanish colonists used Native labor under coercive and

colonial systems, yet these animals fed mission inhabitants and their family members and Native raiding groups, as well as Spanish colonists and soldiers. Other documentary evidence shows continued historical collection of wild foods such as cactus fruits and mesquite in addition to irrigated agriculture of Native and introduced cultigens (Fontana and Schaefer 1989; Mathwich 2018; Rea 1997; Weber et al. 1996). This mixed pastoral strategy and the semiferal management of cattle should be understood within the broader context of seasonal subsistence patterns and demands on Tohono O'odham time. A low investment toward cattle may have enabled mission inhabitants to set aside more time for social activities, farming, and gathering. Alternatively, the distance of mission cattle ranches from the primary mission settlement and fields minimized conflicts with the large bovinds' water needs and Tohono O'odham agriculture. Beyond economic considerations, cattle and horses became an important part of twentieth-century Tohono O'odham culture, and herd management was successfully practiced for decades alongside farming until Tohono O'odham groups were pushed from their ancestral water sources (Bahr et al. 1974; Ezell 1974; Fontana and Schaefer 1989). The zooarchaeological evidence at Guevavi points to the pragmatism and strategy that mission inhabitants employed when balancing out raiding pressures and colonial demands on their time, lands, and water.

Semiferal animal husbandry is currently out of favor in the United States, although it was once widespread (Jordan-Bychkov 1993). An increasingly urbanized American West meant that the open, unfenced land—typical of the time when livestock were introduced in North America—became more and more enclosed (Chamley et al. 2014). In the nineteenth century, Native American groups were pushed off their land for commercial ranching (Specht 2019). Semiferal practices in the Southwest have not disappeared, but they have become integrated into contemporary industrial food systems. In southern Arizona, the reorganization of animal production for distant markets took the form of commercial cattle ranching and became entangled in a suite of settler-colonialist strategies to “Americanize” the Tohono O'odham

in the twentieth century. As archaeologists gain better knowledge of Spanish and Native American range strategies, there needs to be serious consideration of how past animal husbandry is characterized within the historical marginalization of Native American ranching. Herding and ranching are significant cultural and economic activities for Native Americans across the western United States and have been since domestic livestock entered Indigenous landscapes, especially in the Southwest (Campbell 2021; Kozak and Lopez 1999; Mitchell 2015; Nabhan et al. 1989; Weisiger 2011).

In historical narratives, livestock are viewed primarily as a European introduction, and historians of ranching in the United States frequently discount colonial animal husbandry as negligible to the immense Anglo cattle drives that followed (Christiansen 1988; Curtin et al. 2002; Sayre 1999). This is a jarring contrast to the historical records, archaeology, and oral histories that demonstrate the breadth and longevity of Indigenous animal husbandry. As archaeologists investigate the dynamics of colonial societies, they must be attentive to political and economic ramifications of disconnecting contemporary Native American ranching from animal-husbandry practices that appeared post-contact. Zooarchaeology has the potential to contribute physical evidence of the longevity and capability of Indigenous herders who adapted to the new resource that livestock provided within the constraints of colonial and Indigenous resource use.

Conclusion

This article examined the creation of range practices at Spanish colonial Mission Los Santos Ángeles de Guevavi, near what is today Nogales, Arizona. Using multiple lines of evidence, this article proposed a set of indicators to identify semiferal ranching in both the archaeological and historical records. Isotopic evidence from caprine and cattle teeth showed that semidesert grasslands were grazed by both cattle and sheep, but cattle likely grazed them most frequently. Epiphyseal fusion data and historical analyses suggest that cattle ages were loosely monitored compared to those of sheep. Cattle were culled at older ages than optimal for meat

and grease extraction, suggestive of a low-investment management strategy. Less direct labor investment in cattle may have helped Tohono O'odham maintain social, agricultural, and gathering practices, which persisted into the historical period. Finally, semiferal cattle ranching was widespread in historical North America, but it has since become marginalized in contemporary food production. Mainstream US culture often disconnects and minimizes Native contributions to ranching cultures in the western United States, but zooarchaeology investigations into Indigenous animal husbandry in North America have the opportunity to reveal physical evidence of the practice's time depth and the expertise of Indigenous ranchers.

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Data Availability Statement. The author confirms that the data supporting the findings of this study are available within the article and its supplementary material.

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Supplemental Text 1. Excavation and contextual information on the Guevavi midden feature.

Supplemental Table 1. Bulk isotopic assays from Mission Guevavi livestock teeth.

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