Int J Histor Archaeol (2007) 11:241–268
DOI 10.1007/s10761-007-0030-x

Missionization and Economic Change in the Pimería Alta: The Zooarchaeology of San Agustín de Tucson

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Published online: 17 July 2007
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Abstract Spanish missions were important support bases for colonization; Native American labor provided both food and commodities to support regional colonial expansion. Zooarchaeological remains from Mission San Agustín, located in present-day southern Arizona, offer a unique perspective on livestock use at missions, and engagement with regional economic networks through secondary animal products. Despite decades of resistance to livestock, the O'odham became the primary labor force in an economic system based on livestock ranching, particularly of cattle. The transition to cattle ranching was likely influenced by a number of factors including pressure from missionaries, population growth, and, perhaps most importantly, the regional demand for secondary livestock commodities such as hide and tallow.

Keywords Missionization · Zooarchaeology · Animal husbandry · Arizona

Introduction

The impact of Eurasian livestock and plants on the lives of Native American communities is an important research area in North American archaeology. Prior to the arrival of Europeans, indigenous North Americans had very little experience with domesticated animals, save the dog and, in some regions, the turkey. The intensive management of large herds of herbivores was a completely foreign practice. Native American responses to the introduction of Eurasian livestock were diverse. Some indigenous groups, such as mobile southwestern Athapaskan-speaking groups, quickly embraced domesticated animals, particularly the horse, as an integral part of

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a highly adaptive economic system in the absence of pressure from Europeans. Many other groups actively resisted efforts by Europeans, especially missionaries, to influence their economic practices. Ultimately, by the end of the nineteenth century, the vast majority of native North Americans were reliant upon domesticated livestock. As members of a husbandry-based society, it is easy for researchers to start with the implicit assumption that husbandry is a “better” strategy than hunting, and to view the shift from hunting to herding as a natural and inevitable transition. However, the diversity of Native American responses to Eurasian livestock belies this a priori assumption.

Animal husbandry can offer many economic and practical benefits. Cattle and horses can be used for traction and/or transportation, aiding agricultural and other economic intensification, and large-scale cattle ranching in the West was ultimately dependent upon the presence of horses. Livestock are often a more reliable source of meat than wild animals, and convert unusable resources (e.g., grass) into a resource that can be directly consumed by humans (meat). In addition to meat, domesticated animals provide dairy foods, tallow, hide, bone, horn, and wool (Reitz and Wing 1999, p. 285); many of these secondary products became important market commodities. It is important to keep in mind that the arrival of Eurasian domesticates occurred in the context of an expanding European market economy; indigenous economic networks shifted to encompass Europeans, and European products. The adoption of animal husbandry may have been as much, or more so, commodity-driven as subsistence-driven.

However, animal husbandry makes demands on labor, scheduling, and infrastructure that were previously unknown in North America. In many areas, husbandry required a shift in the way in which hunting and agricultural lands were used. Livestock alter landscapes, often negatively affecting vegetation cover, soil properties, and stream flow (Jordan 1993. pp. 10–11).

Researchers working in the southeastern region of North America have contributed to understanding the ecology, economy, and diversity of indigenous responses to Eurasian livestock and plants from the perspectives of both ethnohistory and archaeology (Bogan 1982; Ethridge 1996, 2003; Gremillion 1993, 2002; Lapham 2002; Pavao-Zuckerman 2000, 2007; Reitz 1991, 1993; Saunt 1999). By contrast, southwestern archaeological investigations on this topic have not yet caught up to the established and important body of southwestern ethnohistorical research, with several important exceptions (Chapin-Pyritz 2000; Gillespie 1992; Graham 1998; Jones 1997; Moore 1994; Olsen 1974; Proue 2005; Radding 1997; Sheridan 1988a; Spielmann 1989; St. Clair 2004; Sunseri 2005; Tarcan 2005).

Spanish military, religious, and secular colonization were characteristic of both the southeastern and southwestern regions; however, colonization in the Southwest occurred in the context of mining activities (Spicer 1962). The Southeast boasted no mineral resources of consequence, and Spanish colonization in this region served more to secure maritime passage, rather than to accumulate natural resource wealth (Graham 1998). For these reasons, southwestern mission sites are important to understanding the role that missions may have played in regional economic networks, particularly in support of both resource extraction and military enterprises.

In the late seventeenth century, Father Eusebio Francisco Kino embarked on a missionary excursion through the Pimería Alta, the hot and arid desert region

encompassing much of present-day northern Sonora (Mexico) and southern Arizona (Fig. 1; Kino 1948). European-introduced infectious diseases profoundly impacted southwestern native peoples for nearly two centuries (Reff 1990), but Kino was often the first European with whom they interacted. Kino, like most missionaries, was concerned not only with the spiritual life of potential converts, but also with the practice of everyday life within Native American communities (Sheridan 1988a). Missionaries held ideal expectations of what constituted a "civilized" Christian

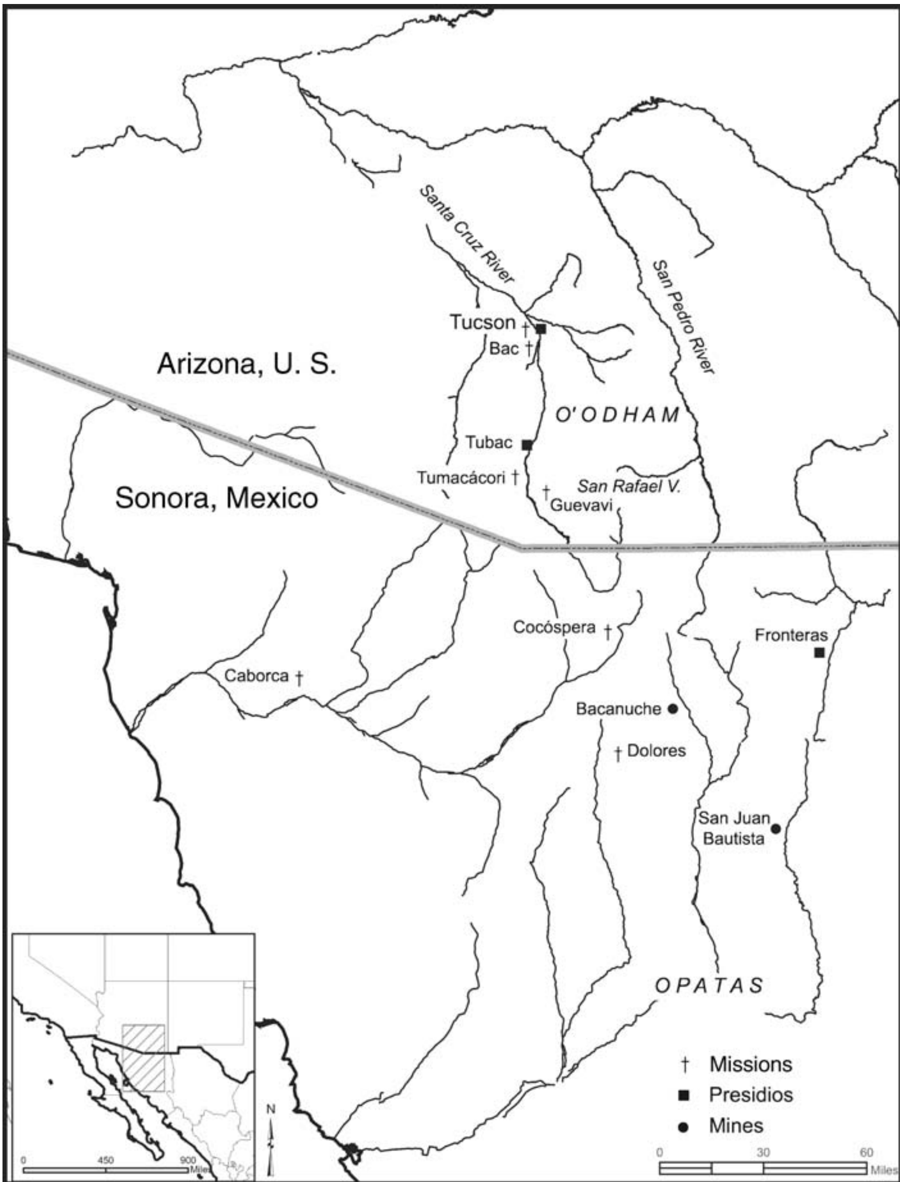

Fig. 1 Map of archaeological sites discussed in text

existence and attempted to modify indigenous communities to meet those expectations. On his visits to the Pimería Alta, Father Kino gave domesticated animals and plants, including cattle and wheat, to the Native Americans whom he encountered in the hopes of introducing European-style agriculture and animal husbandry (Sheridan 1988a). Secular colonial authorities also viewed the introduction of European subsistence practices as an important aspect of successful missionization. If productive, mission herds and agricultural fields could be mobilized to support Spanish military and civilian colonization (Galgano 2005, p. 6).

The economic roles of missionized southwestern native peoples are poorly understood. While ethnohistorical documents are useful in understanding the efforts and attitudes of missionaries, historical zooarchaeology provides a unique perspective on the use of domesticated livestock at missions and the role of livestock in regional economic networks. Because mission livestock and agricultural fields were the products of Native American labor, historical zooarchaeology offers the opportunity to examine the role of Native Americans within mission and regional economies. In this contribution, we couple ethnohistorical evidence with zooarchaeological evidence from Mission San Agustín de Tucson, the largest studied faunal assemblage from a Pimería Alta mission, to shed light on the adoption of animal husbandry by missionized Native Americans and their role in regional economic networks.

Etnnohistorical Evidence

Understanding the adoption of animal husbandry requires that we understand the process of the introduction of Eurasian livestock and the incorporation of Europeans and European goods into indigenous economies. Below, we present an abbreviated history of the Pimería Alta in which we emphasize *economy* over *subsistence*, recognizing that subsistence is an important, but not exclusive, part of economy. It is clear from ethnohistorical and archaeological research that livestock were utilized not only for meat, but also for many marketable non-food products. Livestock likely had an important impact on Native American diet and cuisine; however, the economic impact of livestock commodities was also likely critical, and is often overlooked.

Father Kino is accurately described as a “colonial extension agent” (Sheridan 1988a, p. 157), but he was not the first European to bring Eurasian livestock to the southwestern region. Several Spanish expeditions passed through the Southwest and were accompanied by domesticated animals, including that of Francisco Vásquez de Coronado in 1540. While the specific route of Coronado’s journey is debated, the expedition may have passed through the Pimería Alta. The livestock that accompanied the group were used as “walking larders” to sustain the large expeditionary force, and were not intended to establish permanent herds (Rouse 1977, p. 79). While it is possible that some animals escaped from this and other early European expeditions, it is unlikely that they would have avoided human hunters long enough to reproduce.

Spanish exploration lead to colonization, and it is possible that Spanish settlements in the Pimería Alta and New Mexico were a source of domesticated

animals prior to missionization (Officer 1987, p. 31). By the late 1680s, the Spaniard José Romo de Vivar was grazing livestock in the San Rafael Valley (Hadley and Sheridan 1995, p. 18). Cattle ranches were critical to the success of mining ventures in the northern Pimería Alta (Hadley and Sheridan 1995). Hides for containers and tallow for candles were in high demand for use in the mines, and mine workers required meat and dairy products (Sheridan 2006, p. 89). The fluorescence of mining attracted many ranching entrepreneurs who joined Romo de Vivar on the grazing lands of the San Rafael (Hadley and Sheridan 1995, p. 19; Officer 1987, p. 31–32). Given the proximity of these activities, livestock may have fallen into the hands of Native peoples of the northern Pimería Alta.

Horses were readily incorporated into the lives of some southwestern Native American groups. In 1699, Juan Mateo Mange, a Spanish captain traveling with Kino, observed that horse raiding was a significant stress in the daily lives of the Sobaipuri Indians of the San Pedro River valley (Sheridan 1988a), just to the north of Romo de Vivar's ranching activities. The assimilation of horses preceded the advance of Europeans in the Pimería Alta; however, the presence of livestock other than horses among indigenous peoples in the northern Pimería Alta prior to Kino's arrival is not empirically verified.

In his travels with Kino, Mange recorded some of the plants and animals that were cultivated, collected, or hunted by indigenous groups in the Pimería Alta. However, the bulk of his comments focus on observations with regard to cultivated crops, arable land, and the availability of water. While translations of specific species names are difficult, Mange (1926, pp. 45, 88–90) notes that deer and bighorn sheep were hunted in the Pimería Alta and that many other wild animals were present including mountain lion, wolf, coyote, numerous small and large fishes, birds, and reptiles. Additional information from the priest Velarde was incorporated into Mange's writings and include more specific mentions of wild species and their uses (Mange 1926, pp. 309–310), including catfish, rabbits, and hares.

Father Kino was the first European to visit what is now known as the Tucson Basin, passing through several times in the 1690s. He established Mission San Francisco Xavier del Bac, and its *visita*, San Cosme de Tucsón (renamed San Agustín de Tucson), among a small group of *rancherias* in the Santa Cruz river valley (Dobyns 1976, p. 4). Kino left a few cattle and small livestock at Bac, but Spicer (1962, pp. 126, 546) suggests that following Kino's departure free-roaming livestock were exploited more like wild game than as the focus of purposeful animal husbandry. The first resident priest fled after a year in response to the slaughter of mission livestock by the O'odham. Presumably, these ill-fated livestock included the cattle, sheep, and goats originally introduced by Kino, as well as their descendents (Olsen 1974). In spite of this reaction at Bac, Kino's "extension" efforts were more successful at missions in the southern Pimería Alta (Radding 1997; Sheridan 2006).

Thus, Bac and Tucson were mostly free from direct Spanish influence during the first decades of the eighteenth century. Resident priests returned to Bac in the 1730s, but split their time between several missions, limiting the time spent at Tucson. By 1737, Bac herds consisted of 240 cattle, 150 sheep, 50 goats, 14 horses, and 2 mules (Olsen 1974). Despite the growth of herds at Bac, Church observers throughout the 1740s noted with dismay that efforts to introduce animal husbandry and sedentary agriculture at Tucson were not successful (Dobyns 1976, p. 9). The O'odham at

Tucson had not yet given up their normal pattern of seasonal transhumance, and showed little interest in animal husbandry.

In 1751, the Pima Revolt successfully (but temporarily) removed all direct European influence from the region. The priest at Bac reported that mission property, including livestock, was destroyed during the Revolt (Dobyns 1976, p.14). After the revolt, it is unlikely that the O'odham at Tucson "showed any material signs of Christian conversion" (Dobyns 1976, p. 14).

In 1757, Tucson was given its first resident priest, but he was chased off only a few months later, leaving Tucson back under the direction of the priests at Bac (Dobyns 1976, p. 18; Officer 1987, p. 38). In 1762, several hundred Sobaipuri from the San Pedro River area were resettled at Tucson (Dobyns 1976, p. 20; Officer 1987, p. 40). In response to the population growth, and aided by the success of Bac's herds, missionaries attempted once again to introduce sheep and cattle to Tucson (Dobyns 1976, p. 22; Officer 1987, p. 38). Dobyns (1976, p. 21) observes, "the people would have nothing to do with the strange stock." Approximately 220 people lived at the Tucson mission in 1765; however, they farmed only a little and spent more time hunting and gathering wild foods (Dobyns 1976, p. 23).

At the time of the Jesuit Expulsion in 1767, the Native Americans in Tucson still practiced seasonal transhumance, living in the village only during the summer and fall agricultural season. After harvest, they left the village for the mountains to gather wild foods and hunt, or ventured to the east to gather acorns and roast agaves (Dobyns 1976, p. 24). Thus, it appears that the introduction of European agricultural systems had little impact on native Tucsonans prior the arrival of the Franciscans in 1768.

The first Franciscan friar arrived a few months after the removal of the Jesuits; the Tucson neophytes built a small adobe chapel and constructed a defensive structure to fend off Apache raids on livestock (Officer 1987, p. 48). In 1771, the Tucson mission lost several cattle, sheep, and horses to Apache raids, indicating some success in the introduction of livestock. However, the Franciscans continued to complain that the O'odham went searching for wild foods (Dobyns 1976, p. 34). Change at the mission occurred more rapidly following the arrival of the Tubac military garrison in Tucson in 1776. A 1784 report indicates that the mission village raised crops, cattle, and horses that were sold to the nearby *presidio*. As Dobyns (1976, p. 40) observes, "[a]pparently the Franciscans had succeeded in introducing animal husbandry where the Jesuits had failed."

Both the mission and presidio populations grew quickly in the late eighteenth century. In 1793, a group of Arivaipa Apaches settled peacefully at Tucson in exchange for gifts including 50 head of cattle (Officer 1987, p. 66). In 1801, 218 individuals resided in the multiethnic mission community, and in 1804 the cattle herds at Tucson numbered around 3,500, with about half as many sheep (Officer 1987, p. 77). The nearby presidio community, which included many *mestizo* households, boasted a soap maker, but lamented the lack of a tanner (Officer 1987, p. 80).

The ethnohistorical record suggests a diversity of responses to Eurasian livestock in the Pimería Alta. As in many regions, horses were apparently adopted without the influence of Spanish missionaries, a reflection of their perceived utility. However, despite concerted efforts by missionaries, other livestock were apparently viewed with significantly less enthusiasm. Reactions to the introduction of livestock varied

over time and across space, and ranged from disinterest to outright violence. In the Tucson basin, livestock were targets of active resistance efforts, such as during the Pima Revolt. Despite these examples, the ethnohistorical record indicates increased reliance on animal husbandry over time, with ranching appearing at some communities earlier than others. The timing of the adoption of cattle ranching appears to be correlated with the intensity of missionary involvement in daily life. Resident priests at Bac were successful in building the mission's herds, but with little missionary presence at Tucson, the O'odham pursued their normal subsistence pattern unencumbered by herd management. The ethnohistorical record suggests that the presence of livestock made missions the targets of raiding parties (Doelle 1984), a development that was likely not unnoticed by the as-yet unmissionized O'odham. The Tucson O'odham fended off missionaries until the end of the eighteenth century; it was only after the Tubac garrison and a Franciscan priest were ensconced at Tucson that cattle ranching took hold at the mission. The new presidio introduced a new market for livestock and animal byproducts, intensifying the Tucson O'odham's involvement in ranching toward the end of the eighteenth century.

Previous Archaeological Evidence

The documentary record is replete with the complaints of missionaries concerning O'odham lack of conformity to Spanish ideals of "civilized" life. However, while ethnohistorical evidence can provide an important window into the attitudes and experiences of Spanish missionaries and other colonial authorities, these sources are notoriously biased and incomplete with regard to the experiences of Native peoples. Unfortunately, we are hindered by a dearth of early historical archaeological data for the Pimería Alta (Doelle and Wallace 1990). In particular, zooarchaeological analyses from firmly dated prehispanic Native American contexts are lacking, hampering our ability to track changes over time. Late prehistorical contexts, such as Hohokam sites, give us our only glimpse of prehispanic economic patterns. In her review of Hohokam hunting strategies, Szuter (1991) found that small and medium game, including rodents, birds, jackrabbits, and cottontails, were often captured as part of a garden hunting strategy or in concert with other activities, such as plant or firewood collecting. Additional small game, such as fish and turtles, were also captured when available. Large game, such as deer and bighorn sheep, likely took more planning and time investment to capture, in some cases necessitating hunting trips into the mountains. While this research gives an important glimpse into pre-Columbian patterns of animal exploitation in the Sonoran desert, further comparison is dubious given the time depth and uncertain cultural relationship between the Hohokam and the O'odham (Doelle and Wallace 1990; Doyel 1989). Even less evidence is available to assess the incorporation of animal husbandry by the O'odham peoples of the Pimería Alta. No post-Columbian, pre-mission sites are yet published, although Doelle and Wallace (1990) argue that this gap does not represent reality: sixteenth- and seventeenth-century sites *do* exist but go unrecognized. Further, few mission sites in the Pimería Alta have been excavated, few of these excavations yielded zooarchaeological remains, and much of this material is currently unstudied or understudied. Complete zooarchaeological analyses exist for only two mission sites.

Bill Gillespie analyzed a small (NISP [number of identified specimens]=289) assemblage of zooarchaeological remains from San Miguel de Guevavi (Gillespie 1992), established by Father Kino in 1691. Guevavi became the principal mission of the northern Spanish frontier, but was abandoned less than a century later in 1773 in response to increasing hostilities in the region. The Western Archeological and Conservation Center (WACC) undertook stabilization activities at the ruins of the mission chapel in 1991, resulting in the excavation of zooarchaeological remains from the nave, sanctuary and exterior courtyard. Only 13 fragments of bone were identifiable as domesticated animal, including pig (*Sus scrofa*, NISP=1), probable pig (cf. *Sus scrofa*, NISP=1), sheep or goat (Caprinae, NISP=9), and probable cattle (cf. *Bos taurus*, NISP=2). However, over 65% of the specimens were identified as large-bodied mammals that Gillespie believes are primarily from domesticated livestock; less than 15% of specimens were identified as wild animals and most of these are likely intrusive small rodents. A larger assemblage of zooarchaeological remains from Mission San Xavier del Bac was analyzed by Olsen (1974). While the deposition date is not certain, the materials apparently pre-date the late eighteenth century. Excavated materials were not screened (Bernard Fontana, personal communication), and only a portion of the materials has been studied. Olsen identified the remains of chicken (*Gallus gallus*), horse or donkey (*Equus* sp.), pig (*Sus scrofa*), cattle (*Bos taurus*), goat (*Capra hircus*), and sheep (*Ovis aries*). Olsen published no primary data other than a species list; however, bone counts (NISP) are reported in Cheek (1974). A total of 870 specimens was identified and divided into Jesuit and Post-Jesuit occupations. While the sample sizes are not large enough to permit discussion of change over time during the occupation of the mission, more than 94% of the specimens were identified to the above-listed domesticated animal species. Olsen's contribution indicates that, in confirmation of documentary evidence, domesticated animals were present at Bac in the first half of the eighteenth century; however, without further study, and given recovery biases, it is not possible to discuss the practice of animal husbandry at the mission in terms of dietary contribution or the derivation of secondary animal products.

In the 1950s, Di Peso excavated (without screening) Palo Parado Ruin, a site that he believed contained the remains of mission San Cayetano del Tumacácori, established by Kino in the same year as Guevavi (Di Peso 1956). Later research revealed this identification to be incorrect. Di Peso had apparently excavated a late eighteenth- or nineteenth-century O'odham occupation superimposed, and intruding into, two prehistorical components (Wilcox 1987). These excavations yielded a small collection (NISP=177) of zooarchaeological remains that were analyzed by zoologist William Burt (Di Peso 1956). Burt identified a variety of wild mammals, including deer, antelope, rabbits, hares, small carnivores and rodents. He also identified a few (NISP=7) cattle and horse specimens from trash scatters and house floors. Domesticated animals constitute less than four percent of the identified specimens. Given the questionable attribution of this sample, further interpretation is not possible.

The establishment of the Tubac presidio in 1752 in response to the Pima Revolt was preceded by the founding of a *visita* at Tubac in the early eighteenth century. While remains of the *visita* have not been investigated, zooarchaeological analysis from the captain's quarters and military headquarters at the presidio indicate that the Spanish military relied almost exclusively on animal husbandry (Hewitt 1975).

Many of the soldiers stationed at the presidio before its move to Tucson were of Native American descent; however, presidio cuisine was likely influenced more by Spanish institutional practices rather than by the cultural preferences of the soldiers. Regardless, the livestock consumed by the soldiers was likely the result of Native American labor at the nearby mission (Shenk and Teague 1975). In this sense, the predominance of domesticated animals in the presidio assemblage suggests that missionized Native Americans engaged in intensive animal husbandry in support of the presidio.

A small collection (NISP=519) of zooarchaeological remains from the Tucson Presidio indicates continuity in the diet of the Spanish military following the move of the garrison from Tubac to Tucson (Diehl and Waters 2004). As with the assemblages reviewed above, a majority of the specimens in the Tucson Presidio assemblage were not identifiable below the taxonomic level of Class (i.e., Mammalia). No wild animals were identified in the assemblage and cattle were the most numerous domesticated animal. Chicken, sheep/goat, and pig were also identified in low numbers. While the assemblage is too small to permit detailed interpretation, it does suggest a primary reliance on meat from domesticated animals (NISP=87), particularly beef (NISP=76). Butchery marks indicate that the Hispanic residents of the presidio used axes and cleavers, not saws, to process cattle carcasses. Saws were not commonly used by Hispanics in Tucson until the second half of the nineteenth century (Chapin-Pyritz and Mabry 1994, pp. 151–164; Diehl and Waters 2004; Thiel et al. 1995, pp. 204–205).

Additional research from outside of the Pimería Alta reveals a spectrum of stability and change in Native American economy in the historical period (Chapin-Pyritz 2000; deFrance 1999; Pavao-Zuckerman 2000; Reitz 1993). In the southeastern region of North America Spanish missionization strategies were not effective in establishing animal husbandry as a subsistence strategy among neophytes (Reitz 1993), and the introduction of domesticated animals had even less impact on non-missionized groups (Pavao-Zuckerman 2000, 2007). In other areas, Spanish missionaries met with much greater success. Cattle ranching was successfully introduced at missions in present-day southeastern Texas; however, hunting continued to be an important source of food for the neophytes (deFrance 1999).

A number of mission sites have been investigated in the greater Southwest and California, including Awatovi (Chapin-Pyritz 2000), Gran Quivira (McKusick 1981), Mission San Juan Bautista (St. Clair 2004), Pa'ako (Gifford-Gonzalez 2005; Sunseri 2005), Quarai (Jones 1997; Moore 1994), Salinas (Spielmann and Clark 2005), and Zuni (Tarcan 2005). Using collections excavated at Quarai in the early twentieth century, Dee Ann Jones (1997) compared the diet of friars at the mission to the diet of missionized Native Americans living in the nearby pueblo. Jones identified greater quantities of livestock in the mission than in the pueblo. Hunting continued to contribute greatly to Native American diet in the pueblo, and sheep and goats were raised only in small numbers. Moore (1994) compared remains from Quarai excavated in the 1990s to those from Gran Quivira (McKusick 1981) and found that, at the more densely populated Gran Quivira, the representation of smaller mammals increased over time, likely in response to the over hunting of pronghorn antelope and the labor demands placed on pueblo residents by Spanish missionaries. McKusick (1981) observes, too, that cattle replace pronghorn in the Gran Quivira assemblage. At Quarai, Moore found that Eurasian domesticates were

slightly more common than at Gran Quivira. At Zuni, Tarcan (2005) found that sheep and goats were adopted very quickly and early in the mission period. Sheep were processed both for meat and wool, and largely replaced lower-ranked prey such as lagomorphs and turkey.

Very little can be gleaned from the above to summarize our understanding of the role of livestock in the lives of the O'odham in the northern Pimería Alta. The work of Gillespie (1992) and Olsen (1974) suggest that livestock were present at missions in the eighteenth century; however, very little else can be concluded. Work at the Tubac and Tucson presidios indicates the importance of cattle ranching to military garrisons in the northern Pimería Alta. And, in confirmation of the ethnohistorical evidence, zooarchaeological investigations outside the Pimería Alta suggest that we should not expect to see a single pattern of domesticated animal use.

Zooarchaeology of Mission San Agustín de Tucson

Recent excavations at Mission San Agustín de Tucson by Desert Archaeology, Inc., led by Homer Thiel and Jonathan Mabry (2006), provide a rare opportunity to examine economic strategies of Native Americans at the turn of the nineteenth century, after nearly a century of missionary activity in the region. By the late eighteenth century, the mission population was a multiethnic Native American community. As noted above, several Native American groups were settled at Tucson, beginning with the Sobaipuri in 1762.

Documentary evidence indicates that animal husbandry was well established at the mission by the 1780s. However, zooarchaeological evidence provides a more detailed picture of animal husbandry within a community that previously obtained its meat and animal products solely from wild resources. In concert with ethnohistorical research, the analysis of zooarchaeological remains can shed light on possible reasons for the shift from a strategy based on the hunting of wild resources to one based on animal husbandry. Zooarchaeological data can provide information not only on the relative use of different animal species in the mission economy but also on the practice of animal husbandry at the mission, and the use of livestock products as commodities.

Methods

Zooarchaeological remains from Mission San Agustín [AZ BB:13:16 (ASM)] were excavated from seven features filled between A.D. 1795 and 1820 (Thiel and Mabry 2006). Preliminary results of zooarchaeological analysis appear in a professional report submitted to the city of Tucson (Cameron et al. 2006). Six features, including two trash middens (features 161, 166), three large pits (features 177, 178, 203), and a roasting pit (feature 193), were located near the mission's granary, while one trash midden (feature 64) was located in the mission compound area (Figs. 2 and 3). It is not known who was responsible for the construction and filling of these features, but it is very likely that these features are the product of O'odham labor under the direction of the mission friar. Spanish soldiers and colonists resided at the nearby presidio but, while social and economic interactions likely took place, it appears there was separation of daily activities at the mission and presidio (Dobyns 1976, p. 61).

All excavated materials were screened through 6.35 mm (1/4-in.) mesh. In order to depict overall economic strategies at Mission San Agustín during the late eighteenth and early nineteenth centuries, all materials excavated from the seven features associated with the mission are combined for interpretation. These features contained numerous historical period artifacts, including O'odham ceramics, Sobaipuri projectile points, Mexican majolica, and glass fragments (Klimas et al. 2006). As observed above, while

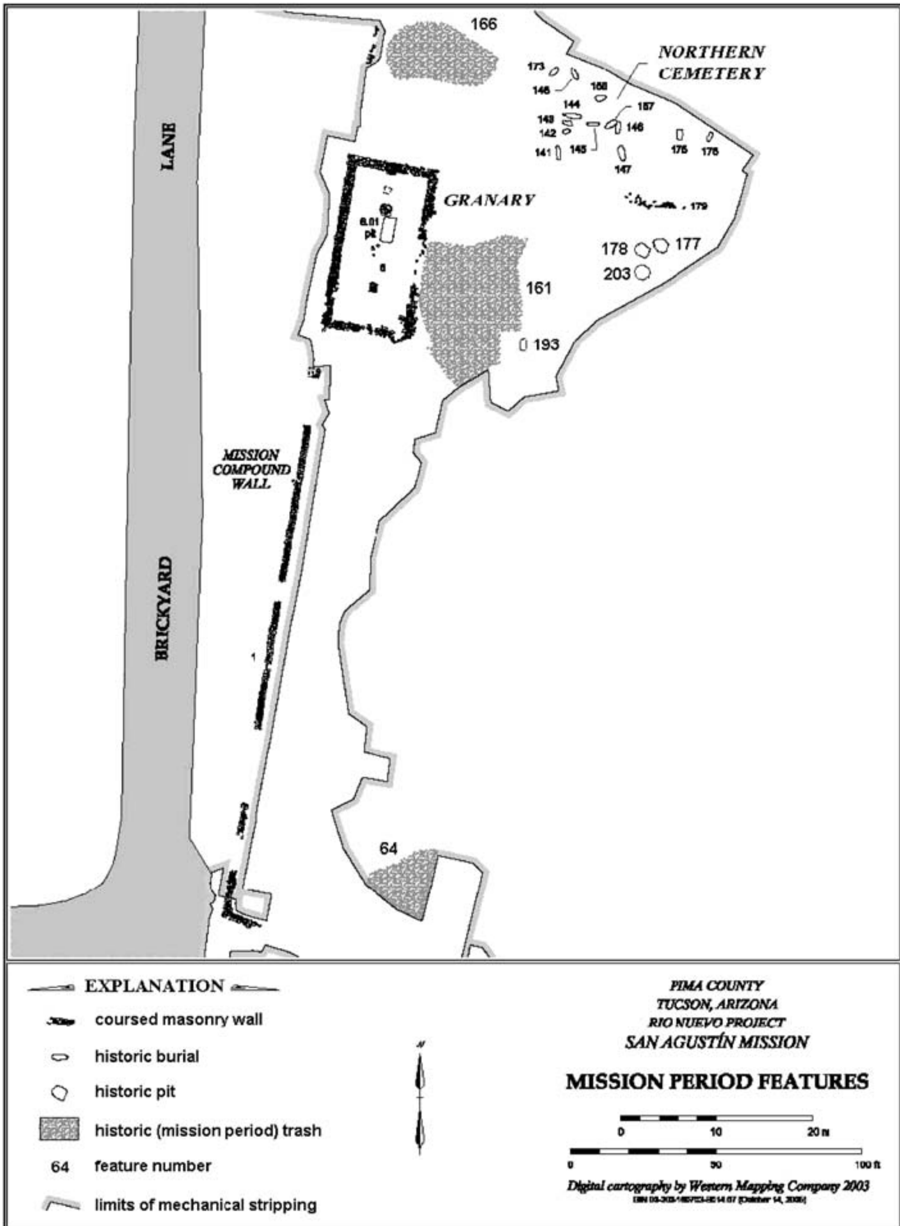

Fig. 2 Map of excavations at Mission San Agustín

Fig. 3 Excavation of mission period roasting pit (feature 193). Courtesy of Homer Thiel

these features likely contain food refuse, these materials also include refuse from other activities that took place in and around the mission. These deposits may include the refuse from meals consumed by mission personnel and possibly occasional communal meals consumed by the broader mission community. The refuse from the daily dietary practices of the missionized O'odham was likely deposited in another location within the O'odham residential area. Unfortunately, the O'odham residential area was apparently destroyed by human activities in the twentieth century. The materials from within the mission should be seen less as evidence for the *diet* of neophytes, but as evidence of Native American labor activities in the service of the daily subsistence and economic needs of the mission.

All zooarchaeological remains from Mission San Agustín were analyzed using standard zooarchaeological methods (Reitz and Wing 1999) and the modern comparative collection housed in the Stanley J. Olsen Laboratory of Zooarchaeology (Arizona State Museum, University of Arizona). The tables below use three summary statistics. NISP is the number of identifiable specimens, or bone count. MNI is an estimate of the *minimum* number of individuals that is necessary to account for a given faunal assemblage. Note that MNI does not necessarily reflect the *actual* number of animals that contributed to an assemblage, it is simply one estimate of relative

abundance. Biomass is an estimate of the amount of meat associated with a given quantity (weight) of bone (Reitz et al. 1987). All three quantitative indices have well-known biases (see Lyman 1994); however, by using several indices in concert it is possible to overcome some of these limitations.

The notation "cf." is used here to denote identifications that were made with a small degree of uncertainty. This notation was most often used when the specimen very closely matched the taxon listed but could not be exclusively identified given gaps in the species coverage of the comparative collection. In other cases, taphonomic processes such as breakage and gnawing obscured diagnostic features. Rarely, juvenile specimens were identified as "cf." when there was a lack of comparative specimens from that stage of development.

Age at death for ungulates is estimated based on observations of tooth eruption and the degree of epiphyseal fusion for diagnostic elements (Reitz and Wing 1999, p. 76; Severinghaus 1949; Silver 1969). Modifications can indicate butchering methods, site formation processes, and the extraction of secondary animal products. Weathering, and gnawing by rodents and carnivores, indicate that specimens were not immediately buried after disposal and can result in loss of an unknown quantity of bone. Specimens that are burned were likely exposed to fire during cooking, disposal, or by accident. Cut marks can be produced during carcass disarticulation, or during the removal of meat after cooking. Hack marks, percussive blows from sharp instruments, are more likely to result from initial dismemberment rather than post-cooking consumption. Saw marks, indicated by parallel striations on compact (cortical) bone, can result from the use of a knife in a back and forth motion, as well as from hand-held saws. In cases where a specimen is cut clean through, but where there is no direct evidence for sawing, the identification "clean-cut" is used.

Results

The San Agustín assemblage is large, with over nine thousand specimens; however, the vast majority of the specimens were too fragmentary to permit specific identification (Table 1).

Based on fragment size, a majority of the unidentified mammalian remains appear to be from medium to large-sized animals, a size range that includes domesticated mammals. A minimum number of 31 individuals was estimated, including reptiles and amphibians, birds, small wild mammals, and large wild and domesticated mammals.

Domesticated mammals, including cow and sheep or goat, dominate the NISP and derived biomass estimates (Fig. 4). Sheep and goats are difficult to distinguish in the absence of key skeletal elements; therefore, these specimens are most often identified only to the inclusive taxonomic subfamily (Caprinae). It is likely that the biomass contribution of domesticated mammals is underestimated, given the predominance of medium and large mammal specimens in the unidentifiable mammal category.

While domesticated animals predominate the biomass estimates, wild mammals contribute a greater proportion of the MNI. As with biomass, it is likely that MNI is underestimated for domesticated animals because the elements of larger-bodied animals tend to break into more pieces, hindering identification and deflating MNI. For the same reason, percent NISP tends to overemphasize large-bodied taxa, particularly in the

Table 1 San Agustín: list of identified taxa

Taxa	NISP	MNI		Weight (g)	Biomass	
		Number	Percent		Kilogram	Percent
cf. *Bufo alvarius* (probable Colorado River toad)	10	2	6.5	2.27	na	na
cf. *Gopherus agassizii* (probable desert tortoise)	3			4.68	0.089	0.0
Gopherus agassizii (desert tortoise)	1	1	3.2	2.06	0.051	0.0
Serpentes (indeterminate snake)	1			0.11	0.001	0.0
cf. Colubridae (probable non-poisonous snake)	2	1	3.2	0.24	0.003	0.0
Aves (indeterminate bird)	4			0.68	0.014	0.0
cf. *Branta canadensis* (probable Canada goose)	1	1	3.2	0.62	0.013	0.0
cf. *Gallus gallus* (probable chicken)	3			2.73	0.051	0.0
Gallus gallus (chicken)	4	1	3.2	2.99	0.055	0.0
Mammalia (indeterminate mammal)	7,385			10,769.4	111.940	58.7
Leporidae (rabbit/hare family)	3			0.51	0.014	0.0
Lepus sp. (hare)	66	5	16.1	36.57	0.671	0.4
Lepus cf. *alleni* (probable antelope jackrabbit)	16	(2)		16.98	0.336	0.2
Lepus californicus (black-tailed jackrabbit)	5	(1)		4.87	0.109	0.1
Sylvilagus sp. (cottontail)	7	2	6.5	1.71	0.043	0.0
Rodentia (indeterminate rodent)	5	(2)		1.21	0.031	0.0
cf. *Spermophilus variegatus* (probable rock squirrel)	1	1	3.2	0.47	0.013	0.0
cf. *Thomomys* sp. (probable pocket gopher)	2			0.44	0.013	0.0
Thomomys sp. (pocket gopher)	5	2	6.5	1.05	0.027	0.0
Carnivora (indeterminate carnivore)	1			0.17	0.005	0.0
Canis sp. (dog or coyote)	4	1	3.2	12.54	0.256	0.1
Vulpes macrotis (kit fox)	1	1	3.2	0.34	0.010	0.0
Felis catus (domestic cat)	9	1	3.2	6.83	0.148	0.1
Equus sp. (horse or donkey)	1			6.48	0.141	0.1
Equus cf. *caballus* (probable horse)	2			23.20	0.446	0.2
Equus caballus (horse)	2	1	3.2	36.79	0.675	0.4
Artiodactyla (even-toed ungulate)	6			16.25	0.323	0.2
Pecari tajacu (collared peccary)	1	1	3.2	2.26	0.055	0.0
Cervidae (deer)	2			8.04	0.172	0.1
cf. *Odocoileus* sp. (probable deer)	1			1.35	0.034	0.0
Odocoileus sp. (deer)	6			33.81	0.625	0.3
Odocoileus cf. *hemionus* (probable mule deer)	2			11.20	0.231	0.1
Odocoileus hemionus (mule deer)	2	1	3.2	27.57	0.520	0.3
Odocoileus cf. *virginianus* (probable white-tailed deer)	2	1	3.2	5.76	0.127	0.1
cf. *Bos taurus* (probable cow)	39			378.17	5.495	2.9
Bos taurus (cow)	305	6	19.4	5,866.37	64.796	34.0
Caprinae (domestic sheep or goat)	23	2	6.5	196.52	3.048	1.6
Vertebrata (indeterminate vertebrate)	1,091			237.94		
Total	9,024	31	100.0	17,721.18	190.581	100.0

Note: MNI is estimated only for the most specific taxonomic identifications. Rarely, MNI estimates are higher for a more inclusive taxonomic identification. In these cases, the more specific taxon MNI is placed in parentheses and only the more inclusive taxon MNI is used in subsequent calculations.

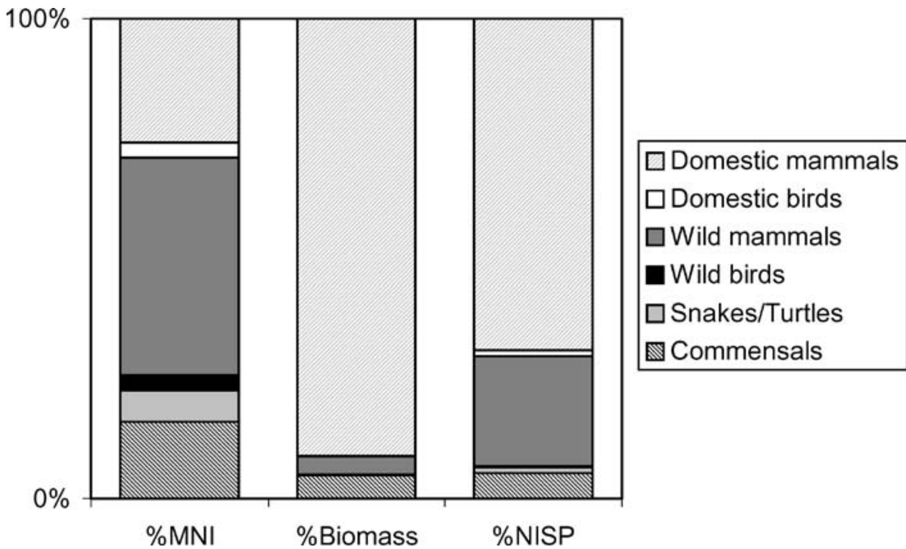

Fig. 4 Summary of zooarchaeological remains from San Agustín. Includes all taxa identified beyond the taxonomic level of Order, and all taxa designated "cf." Anurans (commensal) are included in the MNI and NISP columns, but are not included in the biomass column because allometric values are not currently available for the Anurans

presence of moderate post-mortem fragmentation. However, in cases of high fragmentation, smaller-bodied taxa may be more easily identified, as fragments of small animal elements are more likely to contain diagnostic features than similarly sized fragments of large animal skeletons. MNI also tends to overemphasize rare taxa (Grayson 1979), as even taxa represented by a single specimen yield an MNI of one.

Here, the term "commensal" is used to refer to animals that are found in close association with humans and their built environment, and whose presence is not *primarily* attributable to their use as a food resource. Such animals may include pets, pests, draught animals, and animals likely to become trapped in human-modified environments. In the San Agustín assemblage, commensal taxa include toad (cf. *Bufo alvarius*), dog or coyote (*Canis* sp.), domestic cat (*Felis catus*), and horse or donkey (*Equus* sp.). It should be noted that dogs, cats, and horses are not "true" commensals, in that their presence is far from neutral; these animals provide useful services, such as protection, pest control, pack, or transportation. The presence of a cut mark on a probable horse carpal suggests some post-mortem processing took place, possibly for consumption; however, we place these and the above animals in the commensal category to emphasize their primary utility for non-food purposes.

Evidence for skeletal completeness, sex, and age at death can yield information about the animal husbandry strategies practiced by the Native American residents of the mission. The recovery of cattle and caprine (sheep or goat) remains from all carcass regions, including non-meat bearing elements, indicates that these animals were butchered at the mission (Table 2).

Substantial information regarding age at death is available for cattle (Table 3). Seventy percent of late fusing elements were unfused, suggesting age at death at less than 3.5 years. Nearly half of all middle fusing cattle specimens are unfused,

Table 2 San Agustín: element distribution (NISP)

	Deer	Cow	Sheep/goat
Head	2	68	5
Vertebra/rib	1	66	2
Forequarter		28	6
Hindquarter	3	47	4
Forefoot	3	40	1
Hindfoot	2	36	2
Foot	2	59	3
Total	13	344	23

Including all cf. and sp. identifications

indicating slaughter before 2 years of age. The unfused cattle (*Bos taurus*) scapula indicates that at least one individual was slaughtered at less than 10 months of age. Additional information is available based on observations of tooth eruption sequences. A complete mandible recovered from the site was from an individual between 1.5 to 2.5 years of age at death. Fully mature individuals are present; at least two cow individuals were adults, as indicated by the presence of two fused proximal tibiae. The little information that is available for caprines (sheep or goat) is inconclusive except that at least one caprine was subadult at death.

Given adequate sample sizes, tool marks can aid in the reconstruction of butchery patterns at the mission (Table 4). Tool marks are fairly common in the assemblage,

Table 3 San Agustín: epiphyseal fusion (NISP) for domesticated livestock

Element	Unfused	Fused	Age at fusion (months)
Cattle			
Early Fusing			
Distal humerus		4	12–18
Distal scapula	1	5	7–10
Proximal radius		1	12–18
Proximal metapodials		7	Before birth
Proximal first and second phalanges	1	23	18–24
Middle Fusing			
Distal tibia	2		24–30
Proximal calcaneus	2	2	36–42
Distal metapodials	4	7	24–36
Late Fusing			
Proximal humerus	1		42–48
Proximal ulna	1	1	42–48
Proximal femur	5		42
Distal femur	2		42–48
Proximal tibia	3	4	42–48
Sheep/goat			
Proximal radius		2	3–10
Proximal metapodials		1	Before birth
Proximal first and second phalanges		2	6–16
Distal tibia		1	15–24
Proximal calcaneus		1	23–60
Distal metapodials	1	1	18–36

Includes all specimens with cf. or sp. identifications

but because butchery often removes diagnostic morphology or reduces bones to small and unidentifiable fragments, such traces are found predominantly on unidentifiable mammal specimens. The preponderance of cut and hack marks is typical of carcass processing prior to the arrival of Anglos in southern Arizona in the second half of the nineteenth century (Diehl and Waters 2004). Only one specimen was sawn, a mark that was likely created by a knife used in a back-and-forth motion.

Modification by heat, including burning and calcination, is the most common modification observed in the assemblage. It is not known if burning resulted from exposure to heat during cooking or as a result of disposal. Gnawing by animals such as rodents and carnivores, and weathering, was also noted in the assemblage; these activities likely destroyed a portion of the animal remains. However, the presence of many poorly ossified juvenile remains suggests that the overall preservation in the assemblage is quite good.

The San Agustín assemblage includes two unusual taxa that deserve special note. Domestic cats (*Felis catus*), although introduced to North America by Europeans, are not common at colonial sites, likely because they were not usually exploited for food. The cat, or cats, from the San Agustín assemblage were almost certainly intentionally transported, perhaps by one of the mission friars or military households at the nearby Spanish fort. These animals may have been brought as a pet, to control pests, or both. Regardless of the intended purpose of the animals, the idea of transporting a cat via horseback is stunning, to say the least.

Table 4 San Agustín: modifications (NISP)

Taxon	Rodent gnawed	Carnivore gnawed	Burned	Calcined	Cut	Hacked	Clean cut	Sawn	Weathered
Probable Colorado River toad		1							
Indeterminate mammal	3	13	498	167	72	8			6
Jackrabbit	3	2	9	1					
Probable antelope jackrabbit	1				1				
Black-tailed jackrabbit	1								
Cottontail			1						
Dog or coyote	1								
Kit fox	1								
Probable horse					1				
Even-toed ungulate			1		4				
Collared peccary				1					
Deer		1	3		4	1			1
Mule deer		1	1		1	1			
Probable white-tailed deer					1				
Probable cow			2	1	2				2
Cow	1	6	19	1	24	9	2	1	14
Caprine		1			2				1
Indeterminate vertebrate			76	45					
Total	11	25	610	216	112	19	2	1	24

Collared peccaries (*Pecari tajacu*), or javelinas, are indigenous to Central and South America, and it is believed that the animal spread to present-day northern Mexico and southern Arizona in the historical period. The reasons for range expansion in this species are not understood, and it is also not known precisely when this shift occurred. In 1716, Father Luis Xavier Velarde described the numerous animals that were hunted by the O'odham but makes no mention of javelina (Mange 1926). This omission may indicate that peccaries had not yet reached Arizona in the early eighteenth century. However, in his observations of Sonora in 1764, Juan Nentvig refers to *javalies* (peccaries) at higher elevations in Opata country (Nentvig 1980, p. 29), indicating that the animal had reached the northern reaches of present-day Sonora in the latter half of the eighteenth century. The evidence from San Agustín, possibly the earliest record of peccary in southern Arizona, indicates that javelinas had spread to southern Arizona by the turn of the nineteenth century.

Discussion

As observed above, given the context of the zooarchaeological materials, the assemblage from San Agustín should be viewed as representative of the economic activities in which missionized O'odham individuals engaged, rather than as direct evidence of O'odham meat consumption patterns. Mission lands were considered property of the Native American community, an arrangement that reinforced the transitional nature of missions. Missions were not intended to be permanent entities, but to establish self-sufficient agricultural communities. Until self-sufficiency was reached, a portion of mission lands was planted under the direction of the priest; the rest of the lands were distributed among neophyte households. The neophytes provided all labor for mission lands, in addition to their own. Ideally, all adult males worked three days on mission fields and livestock, and three days on their own holdings (Sheridan 1988b, p. 8). In return, neophytes received rations from the mission's produce. The surplus was used for famine relief, to support the priests, and to generate income though trade. So, while mission herds were under the control of the missionary, and may or may not have been used to supply neophyte households, these resources were the product of O'odham labor. O'odham households received rations and their own land allotment as a benefit of this labor arrangement.

The zooarchaeological assemblage from San Agustín reflects an economic strategy focused primarily on cattle herding, with some hunting. Following the arrival of the Tubac presidio, Franciscan missionaries were ultimately successful in their efforts to introduce animal husbandry. In particular, cattle did quite well at the mission at the turn of the nineteenth century, in contrast to the predominance of sheep at northern Southwest mission villages (Chapin-Pyritz 2000; Jones 1997; Tarcan 2005). Wild animals continued to be used, albeit only occasionally. The suite of wild animals in the San Agustín assemblage is consistent with a "garden hunting" (Linares 1976; Neusius 1996) or localized "collecting" strategy, with little evidence for extensive long-distance hunting forays. Garden hunting takes advantage of a ready source of protein—animals that are attracted to agricultural fields—and hunting these animals removes a potential usurper of crops.

Resistance and Change

Documentary and zooarchaeological evidence indicates that, while Native Americans of the Pimería Alta eventually adopted animal husbandry, the shift from wild to domestic mammals did not happen quickly. Despite efforts to influence O'odham lifeways, missionaries throughout the Pimería Alta met with years of passive and active resistance. At Bac, resistance to missionization was expressed through the slaughter of mission livestock, particularly during major rebellions. This form of resistance is not unique; a century later on the other side of the continent, hostile Creeks slaughtered cattle and hogs in resistance to American "civilization programs" (Braund 1993, p. 187). The Creeks may have viewed livestock as symbols of encroachment by Europeans and Africans but, certainly, cattle represented a double threat to Creek survival: The animals destroyed agricultural fields, and competed with wild game.

Like the Creeks, the O'odham may have viewed the introduction of livestock as a threat to traditional lifeways and intentionally destroyed the animals to repulse that threat. The O'odham had no prior experience with domesticated livestock, and animal husbandry makes demands on labor, scheduling, infrastructure, and land use that were entirely novel to O'odham households. In arid environments, cattle require a great deal of landmass and water, and also consume many of the same foods as wild game. Deer are primarily browsers, while cattle are less discriminate in their food choices (Hoffmeister 1986, pp. 542–548). As cattle consume both grasses and browse plants (Jordan 1993, p. 9), livestock may have adversely affected populations of wild game through competition for forage and habitat (Hoffmeister 1986, p. 3). In addition, while environmental degradation from overgrazing occurred primarily during the last 150 years, ecological change in response to the introduction of cattle no doubt began soon after their arrival (Jordan 1993, pp. 10–11).

These impacts were likely well understood by the O'odham. Unrest in Yuma that culminated in the murder of a priest began with complaints concerning Spanish usurpation of land, and the destruction of crops by Spanish livestock. In 1796, the O'odham living at Tucson complained about the destruction of their crops by presidio livestock (Officer 1987, p. 73). The O'odham may also have realized that the presence of livestock made them an attractive target for Apache raiding (Doelle 1984). Resistance at Tucson was primarily passive and less dramatic than at Bac, likely because the *visita* was not a focus of missionary attention until the second half of the eighteenth century. In fact, O'odham attitudes toward livestock in Tucson in the first half of the eighteenth century are better characterized as disinterest, rather than resistance, in the absence of concerted efforts by missionaries to direct change. Missionary efforts stepped up in the latter half of the century, but despite these efforts, up to the 1770s the inhabitants of the Tucson mission spent a good portion of the year away from the village exploiting wild plant and animal foods, wanting little to do with domesticated livestock.

The resistance or, at the very least, disinterest with which early attempts to introduce livestock were met obviates the question that should precede any research on subsistence change: why *would* people so profoundly alter a seemingly healthy and sustainable subsistence strategy in favor of alien practices? Reff (1998) critiques

the common assumption that the O'odham began raising livestock because animal husbandry was a "better" strategy than hunting, and that missionization was accepted by indigenous peoples because of the plants, animals, and techniques that accompanied the missionaries. Reff argues that the adoption of Eurasian livestock, plants, and practices must be seen in the context of a disease environment. The importance of these introductions to indigenous groups "was conditioned by the collapse of native economic, sociopolitical, and religious systems" (Reff 1998, p. 31) due to the devastating effect of European-introduced diseases. As has been argued for other regions, there must be a compelling reason for such dramatic change in the practices that fundamentally affect the survival of human populations, particularly in the face of rampant demographic collapse (Pavao-Zuckerman 2007). As observed above, while livestock can be and, in some cases were, adopted by hunting societies in the absence of coercive efforts by colonizers, we must begin such research by avoiding *a priori* assumptions about the superiority of animal husbandry over hunting.

The zooarchaeological evidence indicates that subsistence change did eventually occur among the neophytes at San Agustín, likely in concert with the arrival of the Franciscan missionaries and the Spanish garrison. What factors, then, could have lead to this transition, particularly following years of disinterest and resistance? It is possible that greater presence and pressure from priests compelled the mission residents to settle permanently and adopt animal husbandry. This explains the earlier adoption of animal husbandry at Bac, which had a longer history of resident priests. However, it is unlikely that pressure from Europeans, in the absence of other factors, is sufficient to explain the shift.

As observed above, ecological factors likely affected O'odham attitudes toward livestock. However, while animal husbandry may have had negative effects on the local environment, livestock also offered several key benefits. Livestock could be grazed on lands that were not useful for agriculture, and that were previously used only for hunting and gathering (Sheridan 1988a). As observed above, livestock convert resources that are unusable by humans (grass and other vegetation) into resources that can be directly used by humans (meat, dairy products, byproducts, blood). While extant wild mammals also serve this role, mule and white-tailed deer are more selective than cattle in their food choices, and are primarily browsers, not grazers (Hoffmeister 1986, pp. 542–548; Jordan 1993, p. 9). As observed above, cattle can ingest both browse plants (thus competing with wild game), as well as tougher graze plants, expanding the plant community that can be utilized to support meat production. This is particularly important because the arid desert region, while productive and diverse, normally supports a lower density of large game than regions with higher primary productivity. Cattle were able to exploit food resources not consumed by existing large wild fauna, increasing the ungulate biomass that could be supported by the environment. As in all regions, domesticated livestock are also readily and reliably available large packages of meat. While animal husbandry requires substantial investment in time, infrastructure, and resources, the yield of husbandry is far more predictable than hunting. At Zuni, Tarcan (2005) applies a prey-choice model that illustrates the difference in ranking between wild and domesticated prey: low-ranked, difficult-to-capture, prey (such as lagomorphs) were replaced by domesticated livestock, which offer the advantage of a much reduced capture time and bigger packages of edible meat.

A predictable and reliable source of meat likely became critical with the move of the Sobaipuri to Tucson in 1762. The burgeoning, concentrated human population at the mission may have increased competition for large wild game; if game was scarcer, animal husbandry may have become an attractive alternative, despite initial resistance to missionary attempts to reintroduce livestock. Hunting pressure may have eventually lead to localized depletion of game, driving a greater commitment to animal husbandry as a primary subsistence strategy.

The epidemiological relationship between domesticated livestock and wild ungulates is a poorly understood factor that could have influenced the adoption of animal husbandry as a replacement for hunting. Many diseases that affect domesticated cattle, such as foot-and-mouth disease, are transmissible to wild game, and vice versa (Bates et al. 2001). Future research should address the impact of communicable diseases on both introduced and indigenous ungulate populations, and the consequences for human exploitation of these animals.

The environmental tolerances of domesticated animal species likely explain their regional representation at early historical period sites prior to selective breeding for tolerant stocks. Reitz (1992) demonstrates that the adoption of domesticated animal species in colonial settings was dependent on a number of ecological variables including temperature, humidity, primary production, predation, and the presence of ruminant diseases in wild ungulates. Pigs and chickens are relatively low-maintenance domesticates, but they thrive best in warm, wet, and shady conditions. These animals predominate at sites in the tropical and subtropical environments of the Caribbean and the Southeast (e.g., Reitz 1992, 1993). Sheep do not tolerate high humidity coupled with high temperatures, and are far more tolerant of cold than heat in general. Cattle are much less subject to heat stress than sheep and are also far more resistant to predation than other livestock, but require access to adequate forage. Sheep are most common at sites located in cool and dry higher elevations in the Southwest, including the northern Southwest, and the region east of the Sierra Occidental (Chapin-Pyritz 2000; Jones 1997; Moore 1994; Radding 1997, pp. 92–95; Sunseri 2005; Tarcan 2005), while cattle tend to predominate at lower (and warmer) elevations (deFrance 1999; Radding 1997, pp. 92–95).

Such environmental constraints are reflected in the suite of domesticates raised at the Mission San Agustín. The site is located in the Sonoran Desert, the warmest North American desert. The region receives annual precipitation of between 120 and 300 mm (4.7–11.8 in), experiences summer daytime temperatures in excess of 40°C (104°F), and over 325 days of sunshine. Despite the extreme conditions, a bimodal rainfall pattern fosters a high diversity of plant and animal species, and the basin-and-range topography of southern Arizona creates substantial elevational diversity. Valleys are dominated by woody shrubs, grasses, small trees, and succulents that support deer, pronghorn antelope, rabbits, hares, and rodents; these animals are preyed upon by bobcats, coyotes, and foxes. Mountain woodland environments support these animals and more, including bighorn sheep, mountain lion, and the occasional jaguar.

The pattern of domesticated animal abundance at San Agustín most closely resembles that observed by deFrance (1999) at three mission sites on the South Texas coast. The historical record supports the predominance of cattle; cattle were twice as numerous as sheep at San Agustín in the early nineteenth century (Officer

1987, p. 77). It is likely that the high temperatures in both areas discouraged husbandry of smaller livestock. The hot, dry, and sunny Pimería Alta is not a particularly welcoming habitat for pigs, and sheep do better with slightly cooler temperatures. Despite these limitations, sheep are an important source of wool, arguably one of the most important southwestern commodities in the colonial period, particularly in more northern latitudes where the summers are slightly cooler (Chapin-Pyritz 2000; Tarcan 2005). Sheep were successfully introduced in other areas of the Pimería Alta; heat stress was apparently successfully managed (Radding 1997, pp. 92–95). The success of cattle in the Tucson Basin, coupled with the fact that sheep are slightly more prone to heat-stress, may explain the predominance of the former at the mission. It was expected that greater quantities of chickens would be recovered; however, chickens require some degree of care to prevent predation loss and heat stress. Ignacio Pfefferkorn, a mid-eighteenth-century Sonoran Jesuit, observed that only wealthier households consumed mutton and chicken (Officer 1987, p. 43); these foods may have been out of reach for the mission community.

While subsistence considerations are important, it is likely that the move toward animal husbandry was driven by a demand for secondary animal products. To understand better the role of the mission in commodities production, it is necessary to look more closely at the practice of animal husbandry and post-mortem treatment of livestock carcasses at San Agustín.

The Practice of Animal Husbandry

Evidence for age at death, skeletal representation, and tool marks can provide a glimpse into the practice of animal husbandry at San Agustín. The slaughter of juvenile and subadult livestock is consistent with an efficient animal husbandry strategy, where animals are killed as they reach full body size, but before full maturity (Payne 1973). Cattle generally reach full body size at around eighteenth months, after which weight gain per pound of food input levels off. After about eighteen months, food intake only serves to maintain meat production; additional inputs are not matched in additional meat biomass. Some animals must be permitted to grow to maturity in order to reproduce the next generation, explaining the presence of older individuals in the mission assemblage.

Tool marks and the representation of carcass portions indicate that both primary and secondary butchering occurred at the mission. The cut and hack marks observed on cattle and unidentifiable large mammal remains are consistent with the use of metal knives and hatchets during carcass preparation. The use of hand tools other than saws is typical of Hispanic sites from this time period (Chapin-Pyritz and Mabry 1994; Diehl and Waters 2004; Thiel et al. 1995), indicating that the Native American residents of the mission adopted Spanish technologies, and possibly techniques, at least for the processing of large carcasses. There is insufficient evidence to indicate whether or not traditional butchering strategies were retained for wild game carcasses or for small domesticated livestock.

Given the limited butchery mark data, it is not possible to reconstruct the sequence of carcass dismemberment and division. However, cut marks on cattle forefeet, hindfeet, and mandibles suggest that carcasses were processed for their hides, an important commodity in the early historical southwestern economy. In the

Parral mining district, bags for hauling silver ore were made of cattle hide imported from the north (Trigg 2005, p. 187).

The highly fragmentary nature of the cattle assemblage and the quantity of unidentified large mammals fragments may indicate that missionized O'odham engaged in tallow, or grease, processing. Tallow can be rendered from either cattle or sheep carcasses (Ockerman and Hansen 2000, p. 89). In modern meat plants, tallow is rendered from body fat and from "offal," what remains of the carcass after edible meat has been removed (Ockerman and Hansen 2000, pp. 4, 89; Tomhave 1955, pp. 268–274). Today, only a minority of tallow is processed from bones, as bone meal is needed for other products, including animal feed and fertilizer. However, among past and a few contemporary societies, grease rendering was accomplished by fragmenting and boiling bone, particularly limb elements (Binford 1978, pp. 157–163; Lupo 1995; Lupo and Schmitt 1997; Stiner 2005, pp. 109–112). Among all of these groups, grease rendering results in a high degree of bone fragmentation.

Historically, tallow was used in a number of applications, including the manufacture of food-grade greases, soaps, candles, and lubricants (Burnham 1978; Dallas 1955; Ockerman and Hansen 2000; Tomhave 1955). All of these products could have been manufactured at the San Agustín mission for local use, for sale to the nearby presidio community, and to satisfy regional economic demands.

Soap was not widely available for purchase until the nineteenth century; prior to this time soap making was a household enterprise (Tomhave 1955, p. 242). As observed above, by the early nineteenth century, a soap maker resided in the presidio community (Officer 1987, p. 80). The mission may have been a key source of tallow for this industry.

In urban markets, only wealthy households could afford candles made of beeswax and most households used candles made from tallow (Burnham 1978, p. 11). Given infrequent supply caravans, it is unlikely that even the wealthiest residents of Tucson had regular access to beeswax candles. Tallow candles and raw tallow, useful as a lubricant for carts, were also in high demand for use in mines (Sheridan 2006, p. 89). In 1642, legislation was introduced in New Mexico that lifted local restrictions on the sale of candles and tallow to the mines because Crown-appointed dealers were not able to keep up with demand (Trigg 2005, p. 187).

Commodities such as hides, candles, and tallow may have linked San Agustín to an emerging regional economy. It is not known precisely where tallow processing was carried out at the mission; however, we believe that this activity was likely carried out some distance from other activities, given the substantial olfactory contribution of tallow processing. Feature 193, which contained large quantities of fire-cracked rock, ash, charcoal, all underlain by a layer of oxidized soil indicating in situ burning, is a good candidate for a tallow processing feature (see Fig. 3). Further, the pit contained large numbers of very fragmented large animal (likely cattle) remains and several non-meat bearing cattle elements including calcaneum and astragali. Finally, the feature is relatively isolated from the rest of the mission compound area, located on the far side of the mission granary.

Research in other regions suggests that subsistence change can be commodity-driven (Pavao-Zuckerman 2007). In Alta California, cattle hides and tallow were more economically valuable than beef, to the point that meat was discarded after carcasses were processed for these byproducts (Dallas 1955, p. 34). Livestock

contributed a new source of meat and other edible products for the O'odham, which likely took on added importance if the growing population at Tucson depleted local wild game; however, it is very likely that the intensification of animal husbandry at San Agustín and other Pimería Alta missions (Sheridan 2006, p. 101) was in response to the expansion of regional markets, not for meat, but for animal byproducts. Mission priests may have directed this intensification, but it is likely that the O'odham chose their involvement in commodities production in order to ensure access to European trade goods, such as cloth, as well as for subsistence products.

Conclusion

The zooarchaeological evidence from San Agustín emphasizes the local importance of domesticated livestock at the turn of the nineteenth century. Cattle, in particular, were the primary, but not exclusive, animal resource at the mission. While Spicer (1962, p. 546) suggested that livestock were initially exploited in a strategy akin to that of hunting, faunal evidence from San Agustín suggests that cattle were slaughtered at the mission, a pattern that would not be expected if the animals were hunted. However, this assemblage was deposited quite late in the missionization process. The hunting of free-ranging domesticated animals may have characterized an earlier stage in the transition to intensive animal husbandry. Unfortunately, the archaeological evidence presented here cannot shed light on the *process* of the adoption of domesticated animals at the mission; it can only provide a snapshot of the *practice* of animal husbandry at the turn of the nineteenth century. Future archaeological research should identify pre-mission and early mission contexts to better elucidate change over time in the use of domesticated animals by Native groups in the context of colonization.

Zooarchaeological analysis of faunal remains from San Agustín indicates that the transition to animal husbandry occurred at the mission by the last decades of the eighteenth century. However, the practice of cattle ranching at the mission would not have been possible without O'odham labor. The establishment of animal husbandry required the cooperation of the O'odham, and a willingness to transform their day-to-day lives from a focus on seasonally mobile agriculture, collecting, and hunting to one based on sedentary agriculture and herding. The transformation of O'odham daily life was likely influenced by a number of factors, including, but not limited to, pressure from missionaries, population growth, ecological constraints and opportunities, and the regional commodities trade. The archaeological and ethnohistorical evidence suggests that, in the absence of missionary pressure, animal husbandry was not viewed by the O'odham as an improvement over existing economic patterns. Horses were adopted as important trade commodities in the absence of colonial pressure, but other livestock were not. Until the late eighteenth century, the O'odham at Tucson continued to pursue their normal pattern of subsistence and economy. The evidence also suggests that demographic pressure, brought on by missionary activities was more likely to cause a shift toward husbandry than missionary cajoling alone. Growth of the indigenous Tucson community likely caused depletion of local game. If hunting was no longer tenable, animal husbandry was a reliable

alternative strategy, albeit one that is associated with great practical and environmental costs.

The zooarchaeological evidence suggests that livestock ranching at San Agustín was also commodity driven. O'odham labor produced many of the secondary animal byproducts that were essential to the mining industries of northern Sonora, and regional markets linked O'odham labor to these distant mining communities. The San Agustín assemblage offers tantalizing clues regarding the role of missions in regional economic interactions, particularly with military and mining communities throughout the Pimería Alta.

At the turn of the nineteenth century, the O'odham residents of the mission raised and butchered domesticated animals at the mission for meat and other marketable products. But, this transition was not immediate. Throughout the eighteenth century, missionaries met with disinterest and outright resistance in their attempts to direct change, and domesticated animals were targeted in violent acts of Native resistance to missionization. The transition also was not total; as in other regions, hunting continued to be an important aspect of the subsistence strategy of missionized Native Americans. Accompanied by documentary evidence, zooarchaeological analysis is a powerful tool for examining historical period Native American strategies toward missionization and colonization.

Acknowledgments Identification and analysis of zooarchaeological remains from Mission San Agustín was funded by Desert Archaeology, Inc. The authors are grateful to Desert Archaeology, Homer Thiel, and Jonathan Mabry for the opportunity to examine these materials. Many thanks also to Homer Thiel, Betsy Reitz, Tom Sheridan, and Mary Stiner for their comments on earlier drafts of this manuscript. We are very grateful to Jonathan Driver, Elizabeth Scott, and an anonymous reviewer for their thoughtful and constructive reviews of this article. Dale Brenneman (Office of Ethnohistorical Research) provided much appreciated assistance in navigating the ethnohistorical literature. The authors also wish to acknowledge Rachel Diaz de Valdez and Felicia Coppola-Pavao for their assistance in this project. Figures drafted by Ashley Blythe (Fig. 1) and Western Mapping, Inc. (Fig. 2), and modified by the authors. Versions of this paper were presented at the 2004 Annual Meeting of the Society for Historical Archaeology, and the 2005 Annual Meeting of the Society for American Archaeology.

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