


ARTICLE

Understanding Turkey Management in the Mimbres Valley of Southwestern New Mexico Using Ancient Mitochondrial DNA and Stable Isotopes

Sean G. Dolan¹ , Andrew T. Ozga², Karl W. Laumbach³, John Krigbaum⁴, Aurélie Manin⁵, Christopher W. Schwartz^{6,7}, Anne C. Stone^{7,8}, and Kelly J. Knudson⁹

¹Environment, Safety and Health, N3B Los Alamos, Los Alamos, NM, USA, ²Halmos College of Arts and Sciences, Department of Biological Science, Nova Southeastern University, Fort Lauderdale, FL, USA, ³Human Systems Research Inc., Las Cruces, NM, USA, ⁴Department of Anthropology, University of Florida, Gainesville, FL, USA, ⁵Palaeogenomics and Bio-Archaeology Research Network, Research for Archaeology and History of Art, School of Archaeology, University of Oxford, Oxford, UK, ⁶Environmental Planning Group, A Terracon Company, Tempe, AZ, USA, ⁷School of Human Evolution & Social Change, Arizona State University, Tempe, AZ, USA, ⁸Center for Evolution and Medicine, Arizona State University, Tempe, AZ, USA, and ⁹Center for Bioarchaeological Research, School of Human Evolution & Social Change, Arizona State University, Tempe, AZ, USA

Corresponding author: Sean G. Dolan. Email: sean.dolan@em-la.doe.gov

(Received 25 October 2021; revised 18 June 2022; accepted 14 August 2022)

Abstract

In the US Southwest and Northwest Mexico, people and turkeys (*Meleagris gallopavo*) have had a reciprocal relationship for millennia; turkeys supplied feathers, meat, and other resources, whereas people provided food, shelter, and care. To investigate how turkeys fit within subsistence, economic production, sociopolitical organization, and religious and ritual practice in the Mimbres Valley of southwestern New Mexico, we report on genetic (mtDNA) and stable isotope ($\delta^{13}\text{C}$, $\delta^{15}\text{N}$) data from turkeys recovered from Mimbres Classic period (AD 1000–1130) sites. Results indicate that Mimbres aviculturists had haplogroup H1 and H2 turkeys, and most ate maize-based diets similar to humans, but some ate nonmaize and mixed diets. We contextualize these data to other turkey studies from the northern Southwest and discuss how the human-turkey relationship began, the evidence for pens and restricting turkey movement, and the socioecological factors related to turkey management during the Classic period, particularly the challenges associated with providing maize to turkeys during times of environmental stress. This study has broad relevance to places where people managed wild, tame, and domestic animals, and we offer new insights into how prehispanic, small-scale, middle-range agricultural societies managed turkeys for ritual and utilitarian purposes.

Resumen

En el suroeste de los Estados Unidos y el noroeste de México, las personas y los pavos (*Meleagris gallopavo*) han tenido una relación recíproca durante milenios; los pavos proporcionaban plumas, carne y otros recursos, mientras que las personas proporcionaban alimento, refugio y cuidados. Para investigar cómo encajan los pavos en la subsistencia, la producción económica, la organización sociopolítica y la práctica religiosa y ritual en el valle de Mimbres, en el suroeste de Nuevo México, informamos sobre datos genéticos (ADNmt) e isótopos estables ($\delta^{13}\text{C}$, $\delta^{15}\text{N}$) de pavos recuperados de Mimbres Classic. (1000-1130 dC) sitios. Los resultados indican que los avicultores de Mimbres tenían pavos del haplogrupo H1 y H2, y la mayoría comía dietas a base de maíz similares a las de los humanos, pero algunos comían dietas mixtas y sin maíz. Contextualizamos estos datos con otros estudios de pavos del norte del suroeste y discutimos cómo comenzó la relación humano-pavo, la evidencia de los corrales y la restricción del movimiento de los pavos, y los factores socioecológicos relacionados con el manejo de los pavos durante el período Clásico, particularmente los desafíos asociados con la provisión de pavos. maíz a los pavos durante épocas de estrés ambiental. Este estudio tiene una amplia relevancia para los lugares donde las personas manejaban animales salvajes, domesticados y domésticos, y ofrecemos nuevos conocimientos sobre cómo las sociedades agrícolas prehispánicas, de pequeña escala y de rango medio manejaban pavos con fines rituales y utilitarios.

Keywords: turkey (*Meleagris gallopavo*); animal management; mtDNA analysis; isotope analysis; Mimbres Valley; New Mexico

Palabras clave: pavo (*Meleagris gallopavo*); manejo de animales; ADN antiguo; análisis de isótopos estables; Valle de Mimbres; suroeste de Nuevo México

For nearly 2,000 years, people in the US Southwest and Northwest Mexico (SW/NW) have woven the turkey (*Meleagris gallopavo*) into aspects of their economic, social, and ceremonial life (Lipe et al. 2016, 2020; McKusick 1986, 2001; McNeil 2022; Munro 2011). For example, some prehispanic groups relied on this bird for protein (Badenhorst and Driver 2009; Ellyson et al. 2019), and they used the feathers and bones for clothing, ritual paraphernalia, tools, and musical instruments (Blinman 2001; Lipe et al. 2020; Payne 1991). People also depicted turkeys on rock art and pottery, they buried these birds in ritual contexts (Hill 2000), and turkeys are central figures in oral traditions (McNeil 2022; Tyler 1979:85–106). Turkeys and dogs were the only domesticated animals people had in this region before European arrival, so understanding the cultural and environmental context of how, why, when, and where people managed turkeys contributes to issues in anthropological archaeology and social zooarchaeology (Kintigh et al. 2014:17; Russell 2012).

Archaeologists study turkeys in many ways, including visual and osteometric analyses of bones to infer sex, age, and trauma (Badenhorst et al. 2012; Fothergill 2016; McKusick 1986; Senior and Pierce 1989), and we use scanning electron microscopy on eggshells to understand their biological development (Beacham and Durand 2007; Conrad et al. 2016). However, the two most popular methods of studying turkeys recently are ancient mitochondrial DNA (mtDNA) analysis to determine maternal genetic lineages (Kemp et al. 2017; Lipe et al. 2016; Manin et al. 2018; Speller et al. 2010), and stable carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) isotope analyses to infer diet (Conrad et al. 2016; Jones et al. 2016; McCaffery et al. 2014, 2021; Rawlings and Driver 2010).

Researchers using mtDNA and stable isotopes have made considerable advances in establishing how people in parts of the SW/NW managed turkeys. For example, prehispanic aviculturists—the people who raised and managed birds—fed turkeys maize, and they predominantly kept turkeys belonging to the extinct domesticated clade, which researchers have termed haplogroup H1 (Kemp et al. 2017; Lipe et al. 2016; McCaffery et al. 2014, 2021; Rawlings and Driver 2010; Speller et al. 2010). However, much of these data derive from the Ancestral Pueblo cultural regions of the northern Southwest. Less is known about the maternal genetic lineage, diet, and the ways people managed turkeys further south, including in the Mimbres Valley of southwestern New Mexico (Figure 1). To investigate how turkeys fit within Classic period Mimbres society from AD 1000 to 1130 (all dates are AD)—including subsistence, economic production, sociopolitical organization, and religious and ritual practice—we sampled 31 turkeys from Elk Ridge (LA 78963), Lake Roberts (LA 47821), Mattocks (LA 676), Old Town (LA 1113), and Wheaton-Smith (LA 18903) for mtDNA and stable isotope analyses. We focus on turkeys from the Classic because this period is marked by increasing social complexity with population growth, a heightened reliance on maize agriculture, transformations in architecture and pottery styles, and the emergence of distinct social and religious traditions (Blake et al. 1986; Hegmon 2002; LeBlanc 1983; Minnis 1985; Shafer 2006). Also, as shown in Figure 2, Classic period potters painted turkeys on some of their vessels.

This study examines the evidence for Classic period turkey management, diet, and genetic lineage in the Mimbres Valley. We begin with a brief discussion of what researchers have already published on turkey genetics and diet from the SW/NW, followed by an introduction to Classic period Mimbres society and what is known about turkeys from this region. We then introduce the five sites, sampled turkeys, and the methods used to determine the maternal genetic lineage and diet (in Supplemental Text 1–3), followed by the results. Results indicate that Mimbres aviculturists managed haplogroup H1 and H2 turkeys, and they used more haplogroup H2 turkeys than people in the northern Southwest. The Mimbres turkeys primarily consumed maize, but some had a nonmaize diet, and even fewer had a mixed diet. Moreover, although there is limited archaeological evidence for turkey pens in the Mimbres Valley, people limited turkey mobility. Also, unlike in parts of the northern Southwest, people in the Mimbres Valley did not eat turkeys (Morrison 2002; Shaffer 1991), and

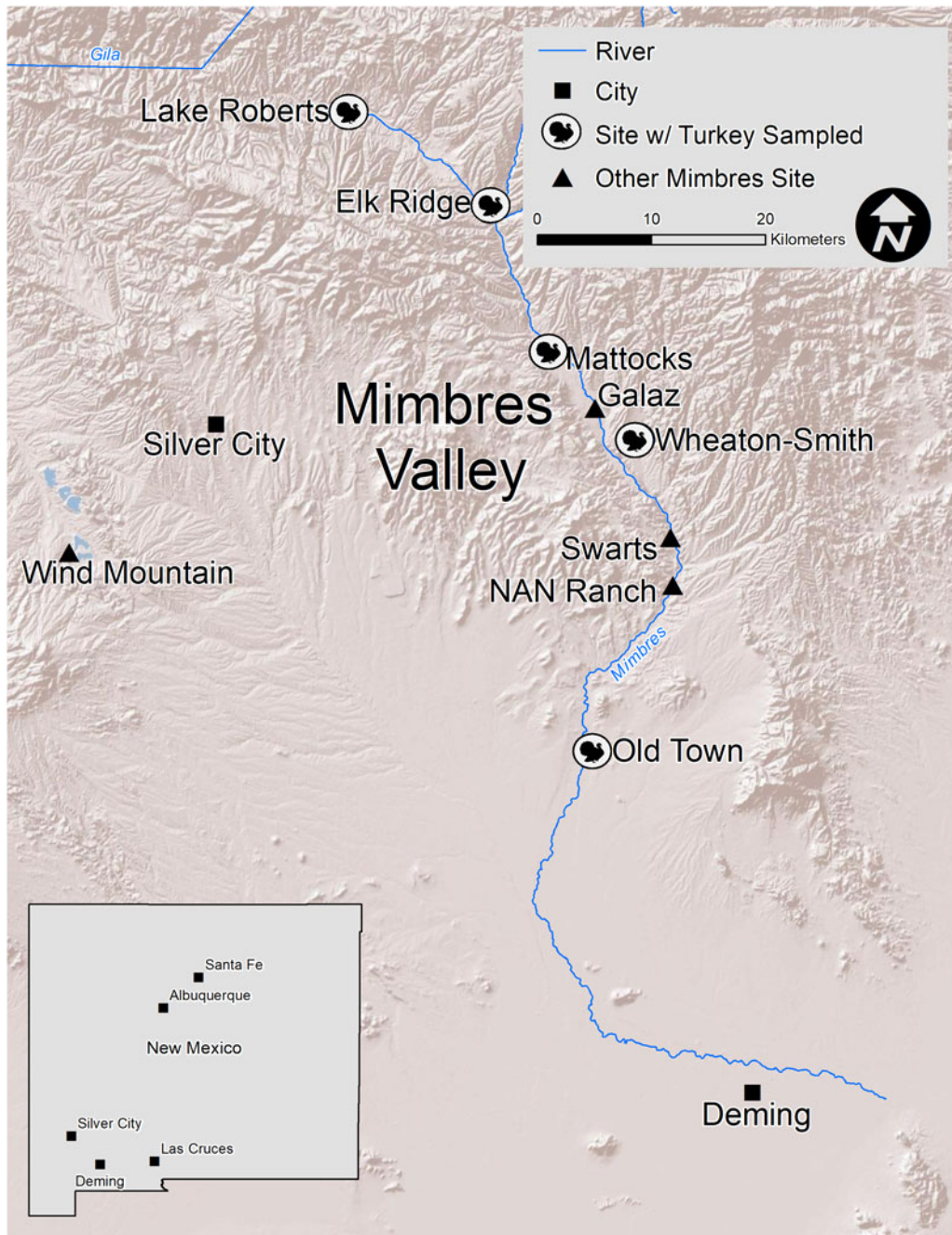


Figure 1. The Mimbres Valley in southwestern New Mexico, sites from which turkey remains were analyzed, and other sites mentioned in the text. (Map by Sean Dolan.)

feather production outweighed any gains from their use as food, even during the Classic period, when turkey meat and fat would have helped combat environmental deficiencies.

Previous Turkey Studies

Using mtDNA analysis on turkey bones and coprolites, Speller and colleagues (2010) found that SW/NW turkeys belong to two distinct maternal genetic lineages: haplogroups H1 and H2 (see also Jones et al. 2016; Kemp et al. 2017; Lipe et al. 2016). The H1 haplogroup is the most common in

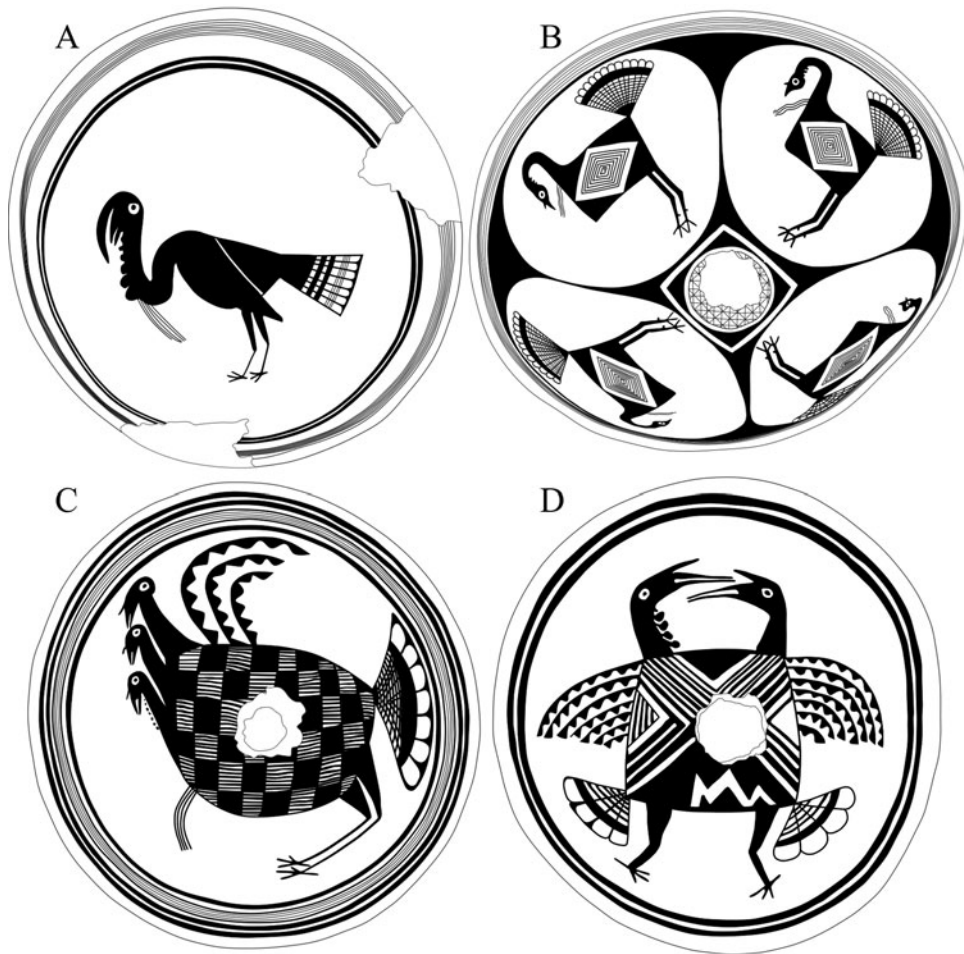


Figure 2. Examples of Mimbres pottery vessels that depict turkeys: (A) MA2222, from Swarts (after Cosgrove and Cosgrove 1932:Plate 216b); (B) MA9560, from Swarts (after Cosgrove and Cosgrove 1932:Plate 216d); (C) MA140, provenience unknown (after Fewkes 1923:Figure 58); (D) MA5967, provenience unknown. (Vessel illustrations by Caitlin Wichlacz.)

the SW/NW archaeological record, and it is virtually absent from the local wild subspecies, Merriam's wild turkey (*Meleagris gallopavo merriami*). This has led researchers to define turkeys of the H1 lineage as an extinct domesticated clade (Lipe et al. 2016; Speller et al. 2010). The H1 haplogroup has a low genetic diversity, mainly represented by haplotype aHap1, highlighting over 1,600 years of breeding isolation from Merriam's turkeys (Lipe et al. 2016:98; Speller et al. 2010). The H2 haplogroup, however, derives from the Merriam's and Gould's wild turkey (*Meleagris gallopavo mexicana*) lineages (Speller et al. 2010). The H2 haplogroup archaeological specimens have genetic sequences similar to today's wild populations. Uncommon in the archaeological record, the H2 haplogroup is not the progenitor of the H1 lineage. Instead, the progenitor is related to the Rio Grande (*Meleagris gallopavo intermedia*) and Eastern (*Meleagris gallopavo silvestris*) subspecies that may have entered the region from the eastern United States in antiquity (Speller et al. 2010:2809).

Using the ratios of stable carbon ($^{13}\text{C}/^{12}\text{C}$) and nitrogen ($^{15}\text{N}/^{14}\text{N}$) isotopes in bone and teeth as biomarkers, researchers can infer the diet of ancient human and animal populations to answer archaeological, environmental, and evolutionary questions (Katzenberg 2008). The proportion of stable carbon isotopes helps determine whether the animal ate a diet of temperate grasses, trees, and shrubs that have a C_3 isotopic signature or a diet of tropical and savanna grasses—such as maize (*Zea mays*)—that have a C_4 signature (Tykot 2006). Most wild plants in the SW/NW have a C_3 signature, but there are

wild plants, such as amaranth (*Amaranthus*), that yield C_4 signatures, and there are arid-adapted succulents, such as prickly pear (*Opuntia* sp.), that use a Crassulacean Acid Metabolism (CAM) photosynthetic pathway and that have $\delta^{13}C$ values in between C_3 and C_4 plants (Tykot 2006:132–133). Researchers use the proportion of stable nitrogen isotopes to understand the extent to which turkeys consumed protein from plant and animal sources (Rawlings and Driver 2010:2435). However, absolute $\delta^{15}N$ values may not be helpful given that $\delta^{15}N$ values vary depending on the trophic level and dietary factors such as meat/vegetable ratio and marine versus terrestrial food sources (Ambrose 1991; Schoeninger and DeNiro 1984).

Several studies focusing on human and turkey diets from the northern Southwest have identified high C_4 maize consumption (Coltrain and Janetski 2013; Coltrain et al. 2007; Conrad et al. 2016; Kellner et al. 2010; Martin 1999; McCaffery et al. 2014; McCaffery et al. 2021; Rawlings and Driver 2010). However, some turkeys consumed a C_3 nonmaize diet, including a select few haplogroup H1 turkeys (Jones et al. 2016). In addition, Lipe and colleagues (2016) demonstrate that many haplogroup H2 turkeys from the northern Southwest consumed C_4 diets. Consequently, as Jones and colleagues (2016:581) point out, “ $\delta^{13}C$ data cannot be used as a proxy for a turkey’s mitochondrial DNA lineage, at least among Southwestern turkeys, without significant additional data.” As a result, we integrate both methods on individual turkeys from the Mimbres Valley to best understand management practices.

Classic Period Mimbres Society

The Mimbres Valley in southwestern New Mexico is the core of Mimbres culture, but the Mimbres region extends into other parts of New Mexico, Arizona, and northern Mexico. The Mimbres region is part of the larger Mogollon archaeological tradition that Haury (1936) first defined, and the cultural sequence is well established after a century of excavation, survey, and material culture studies (Anyon et al. 2017). Archaeologists have published several summaries and edited volumes detailing the culture history, making the Mimbres Valley one of the most studied archaeological regions of the SW/NW (Hegmon 2002; LeBlanc 1983; Lekson 2006; Powell-Martí and Gilman 2006; Roth et al. 2018).

People in the Mimbres Valley lived in subsurface pithouse structures beginning approximately in the 200s, which is the same time they began making plain brown pottery. They transitioned to living in aboveground surface cobble masonry pueblos organized into room blocks around AD 1000 (Gilman 1987; Shafer 2006). They performed rituals inside great kivas but collapsed, burned, and retired these large subterranean communal structures in the late 900s and used outdoor open plazas during the Classic (Creel and Anyon 2003). The Classic period is also defined by the presence of what archaeologists call Style III Classic Black-on-white pottery (Brody 2004; Brody et al. 1983). Potters made black-on-white pottery before the Classic (Style I and II), but Style III has more intricate, fine-line, geometric designs and naturalistic images of humans, animals, and anthro- and zoomorphic figures, including turkeys.

Population estimates vary, but approximately 6,000 people lived in the entire Mimbres region, although several thousand fewer probably lived in the Mimbres Valley at its peak during the Classic (Blake et al. 1986). At least a dozen pueblo villages with 100 or more rooms were built along the Mimbres River and its tributaries, but people also lived in smaller pueblos. Old Town, at the southern end of the valley, and Galaz, farther north, were economically and ritually significant places due to hundreds of years of occupation, great kiva precincts, and exotic objects such as copper bells, marine shell, and scarlet macaws (Anyon and LeBlanc 1984; Creel 2006). Classic period Mimbres society was middle range and egalitarian, given that archaeologists have found little evidence for elites and centralized authority (Gilman 1990). However, beginning in the Late Pithouse period (550–1000) and continuing into the Classic, some individuals and families had social status and specialized leadership roles through access to prime agricultural land and esoteric ritual knowledge (Creel 2006; Roth and Baustian 2015; Shafer 2006). Also, whereas people, pottery styles, and goods moved in and out of the valley during the Late Pithouse period, there was a relatively homogenized material culture during the Classic, with few nonlocal pottery types entering the valley, and people were more inward focused and isolated (Hegmon 2002:339).

As was the case in the rest of the SW/NW during the 1000s and 1100s, maize was the primary food staple for people in the Mimbres Valley (Minnis 1985; see also Coltrain et al. 2007:Table 2). They also

supplemented their diet with other domesticated crops and wild plants, and they hunted small and large game (Minnis 1985; Schollmeyer et al. 2018). However, access to large game was unreliable during the Classic because artiodactyl populations had already been depleted by the Late Pithouse period (Cannon 2000; Nelson and Schollmeyer 2003). Finally, much of the Classic period experienced above-average rainfall, but a dry period from the 1120s to 1140s exacerbated environmental stress and population pressures (Grissino-Mayer et al. 1997; Minnis 1985; Nelson and Schollmeyer 2003). The end of the Classic period around 1130 is associated with the cessation of Style III pottery manufacture and the depopulation of much of the valley when people moved elsewhere (Nelson et al. 2006).

Turkeys in the Mimbres Valley

Physical Evidence

Wild turkeys today live in the upland areas of the Gila Forest at the north end of the Mimbres Valley, given that their natural range and habitat are mountain forests 1,829–3,658 m (6,000–12,000 ft.) in elevation (Shaw and Mollohan 1992). In Schollmeyer and MacDonald's (2020) synthesis of faunal remains from 105 sites across southwestern New Mexico, archaeologists have found at least 106 turkeys from 10 sites in the Mimbres Valley. However, we note that turkeys from Elk Ridge, Lake Roberts, Old Town, and Wheaton-Smith are not included in their study. The relative lack of turkey bones recovered from Mimbres Valley sites has puzzled archaeologists for nearly a century. For example, after excavating Swarts in the 1920s, Cosgrove and Cosgrove (1932:5) noted that "with the exception of one bone fragment of the tarsometatarsus of a male bird there was an entire absence of turkey bones, either in the form of artifacts or as refuse. This is difficult to explain." Because turkeys are uncommon in most Mimbres Valley avifaunal assemblages, few researchers have focused on turkeys in this region. However, more is known about turkeys from Elk Ridge, NAN Ranch, and Wind Mountain, and we provide summaries below.

Munro (2011:545) lists several archaeological signatures to infer that people managed turkeys. These include the presence of pens, dung deposits, eggshells, gizzard stones, fertilized eggs, young poults, turkeys with healed bone injuries, and an indication that the birds consumed maize. Many of these signatures are missing at most sites in the Mimbres Valley, but Morrison (2002) documented several of these signatures after studying 17 turkeys excavated from Elk Ridge's southern Classic period room block. In his preliminary analysis, Morrison (2002) estimated a 2:1 ratio of males (toms) to females (hens), and most were young adults between one and two years old. There were at least two adult birds of two years or older and one juvenile of three to five months. Three turkeys sustained broken and healed bone injuries, and eggshell fragments were found in room contexts. Also, archaeologists recovered partial pottery vessels on the room floors with the turkey remains. Partial pottery vessels in context with turkey remains have also been found outside the Mimbres Valley at Arroyo Hondo and Homol'ovi III (Lang and Harris 1984:103; Senior and Pierce 1989:249). At Arroyo Hondo, Lang and Harris (1984:103) posit that people confined turkeys in these rooms and placed broken vessels on the floor to hold water.

The Elk Ridge turkey bones lack cut marks and burning, and archaeologists found articulated skeletons, suggesting that turkeys were not processed for consumption (Senior and Pierce 1989:251). Morrison (2002) also states that the birds were not ritually interred, because they were recovered from above the floor rather than below, where formal burials would be expected. However, recent excavations at the northern Classic period room block by Roth (2018) have yielded additional turkey remains, including birds buried in pits and roof fall. One such turkey was recovered from a small cobble-lined storage room that may have been a pen. Four additional articulated and partially articulated turkeys were also found on an extramural surface or possible ramada feature. No dung deposits or eggshells were recovered from these features.

Ten turkeys were identified at NAN Ranch. Eight were intentionally buried, including one that was buried with a bird effigy pendant and located adjacent to the burial of a child (Shaffer 1991:Table 8.1). The remaining two turkeys were recovered from midden deposits. Shaffer (1991:127) offers that people at NAN Ranch, as at Elk Ridge, used turkeys for ritual rather than food. During excavations, Shafer

(2003:65, Figure 5.15) found a small walled feature that may have acted as a turkey pen, but archaeologists did not find bones, dung, or eggshells.

At Wind Mountain, located approximately 50 km west of NAN Ranch in the Gila region, turkeys were the most common avian species, with 178 bone fragments (Olsen and Olsen 1996). Six turkeys were intentionally buried, and one turkey femur had transverse knife cuts, indicating to Olsen and Olsen (1996:397) that it had been butchered. Due to numerous immature bones, they argue that the turkeys were domesticated, but no poults, eggshells, pens, or dung deposits were recovered (Olsen and Olsen 1996:397, 400).

Iconographic Evidence

The Mimbres Valley is well known for the enigmatic black-on-white pottery made during the Classic period (Brody 2004; Brody et al. 1983). Mimbres potters painted stylized designs of humans and animals sometimes engaged in various activities, and so researchers have used these images to understand aspects of Classic period Mimbres society (Hegmon et al. 2021; Hegmon and Trevathan 1996; Munson 2000). Therefore, no discussion of turkeys in the Mimbres Valley would be complete without briefly describing turkeys depicted on Mimbres Classic Style III Black-on-white pottery.

Classic period potters depicted anatomical features of several animals, and researchers have identified animals to the genus or species level, including some bird and fish species (Creel and McKusick 1994:512–515; Jett and Moyle 1986). Turkeys are identifiable on Mimbres painted pottery because potters included the turkey's snood, beard, wattle, or spur. Using various publications and the Mimbres Pottery Images Digital Database (MimPIDD; available online at <https://core.tdar.org/collection/22070/mimbres-ceramic-database-with-search>), we have identified 29 vessels with images of turkeys (Supplemental Table 1). We refer to each MimPIDD vessel using its Mimbres Archive (MA) number. We can distinguish turkeys from other birds based on the presence of the snood, beard, wattle, or spur, but we cannot discern if potters intended some birds to be turkeys but did not include these features. Also, although toms have longer or more pronounced snoods, beards, wattles, and spurs, some birds depicted on the vessels may be hens but lack these features. However, wild hens have snoods and wattles, albeit shorter and less pronounced, and some even have beards and spurs, although these are uncommon (Pelham and Dickson 1992).

Turkeys are the only naturalistic image on 59% of the vessels ($n = 17$, e.g., Figure 2A), but they share space on the remaining 41% ($n = 12$) with other animals and humans. For example, four vessels depict turkeys eating invertebrates (MA4001, MA4777, MA10317, and O'Bagy Davis 1995:181). Also, five vessels have turkeys with humans in what appear to be narrative scenes. On MA5843 and MA9379 (Figure 3), men are depicted with turkeys, but potters did not include their anatomical sexual features on MA5651, MA5887, and in Fewkes (1923:Plate 11). However, they have objects and clothing most commonly associated with men (Munson 2000), such as bows and arrows, given that they are hunting or capturing presumably wild turkeys. Some men wear turkey feathers (MA5651 and MA5843) and bird masks while hunting or stalking (MA5887). As shown in Figure 3 (MA9379), a man is wearing a feather in his hair and holding a maize stalk toward the turkey. He also has a staff or stick-like object at his feet.

Based on the presence of articulated turkey skeletons at some sites in the Mimbres Valley, people in this region used turkeys to some degree. Moreover, potters even depicted turkeys on their pottery vessels. Therefore, it is clear that these birds had some significance to Classic period Mimbres society. However, did Mimbres aviculturists have haplogroup H1 or H2 turkeys, and did the birds have C₃, C₄, or mixed diets?

Materials and Methods

Sampled Turkeys

The 31 turkey bones were recovered from Classic period subsurface contexts at Elk Ridge ($n = 17$), Lake Roberts ($n = 3$), Mattocks ($n = 7$), Old Town ($n = 2$), and Wheaton-Smith ($n = 2$). We chose these sites because they were professionally excavated, and the bones were more accessible for analysis than other collections. See Supplemental Text 1 for site summaries and Supplemental Table 2 for provenience information on the turkey samples.



Figure 3. Mimbres bowl (MA9379) depicting a man holding a maize stalk next to a turkey. Collection of the El Paso Museum of Archaeology, El Paso, Texas (# 95.005.002). (Vessel illustration by Caitlin Wichlacz. Vessel also illustrated in Fewkes [1924:Plate 42].)

Using McCaffery and colleagues (2014:343) as a guide, turkey bones were selected based on preservation quality, size, and weight. To avoid sampling the same turkey twice, we chose the most common appendicular element and selected specimens from one side. We then repeated for the next most common element. However, it was sometimes difficult to use this strategy given that the five sites had limited availability of turkeys, or the bones had missing diagnostic features.

mtDNA and Stable Isotope Methods

See Supplemental Text 2 for the methods used for mtDNA extraction and sequencing (see also Supplemental Tables 3–5). The 31 turkey bones were analyzed at two ancient DNA laboratories. Twenty-four turkeys (Elk Ridge [$n = 10$], Lake Roberts [$n = 3$], Mattocks [$n = 7$], Old Town [$n = 2$], and Wheaton-Smith [$n = 2$]) were analyzed at Arizona State University (ASU), and seven Elk Ridge turkeys were analyzed at the University of Oxford. All turkey samples were extracted in dedicated ancient DNA cleanrooms using similar personal protective equipment to prevent contamination by modern DNA.

We used isotope values of bone collagen ($\delta^{13}\text{C}_{\text{co}}$, $\delta^{15}\text{N}_{\text{co}}$) to reconstruct dietary proteins of the 31 turkeys. See Supplemental Text 3 for the methods used. Bone collagen extraction and isotopic analyses were prepared at two laboratories. Twenty-four turkeys (Elk Ridge [$n = 10$], Lake Roberts [$n = 3$], Mattocks [$n = 7$], Old Town [$n = 2$], and Wheaton-Smith [$n = 2$]) were analyzed at the University of Florida, and seven Elk Ridge turkeys were analyzed at ASU. The results are expressed in parts per mil (‰) and delta (δ) notation. $\delta^{13}\text{C}$ values are reported relative to the Vienna Pee Dee Belemnite (VPDB) fossil international standard, and $\delta^{15}\text{N}$ values are reported relative to the atmospheric air (AIR) international standard.

Results

mtDNA

Previous mtDNA studies demonstrate that most turkeys from the northern Southwest belong to haplogroup H1, with fewer H2 turkeys (Kemp et al. 2017; Speller et al. 2010). Less is known about the maternal genetic lineage of turkeys from the southern Southwest or Northwest Mexico. However, two turkeys from the Gila Cliff Dwellings (TU1017 and 1019) in southwestern New Mexico and one (TU135) from the Calderón site in northern Chihuahua are haplogroup H2 (Speller et al. 2010: Table S3). Based on the extensive data from the northern Southwest and the scant data from farther south, it is difficult to hypothesize if the Mimbres turkey population will be primarily haplogroup H1 or H2. Therefore, this study contributes significantly to our understanding of turkey management as we increase the sample size of analyzed turkeys.

Of the 31 turkey samples we submitted for mtDNA analysis, 58% ($n = 18$) had sufficient mtDNA sequences to perform haplogroup calling. Unfortunately, 42% ($n = 13$) of the samples did not contain detectable mtDNA despite repeated extractions and polymerase chain reaction amplification (Elk Ridge [$n = 2$], Lake Roberts [$n = 3$], Mattocks [$n = 6$], and Old Town [$n = 2$]). Nevertheless, 56% ($n = 10$) of the successfully sequenced samples belong to the H1 haplogroup, and 44% ($n = 8$) are from the H2 haplogroup (Table 1). All 10 haplogroup H1 turkeys are from Elk Ridge, whereas the eight haplogroup H2 turkeys are from Elk Ridge ($n = 5$), Mattocks ($n = 1$), and Wheaton-Smith ($n = 2$). Based on this study, Mimbres aviculturists used their haplogroup H2 population almost as much as their haplogroup H1 population, unlike in the northern Southwest.

We observed 11 different mitochondrial haplotypes from the 18 turkeys (see Supplemental Figures 1, 2, and 3). Haplotypes from haplogroup H1 include aHap1e, aHap1f, and the most common, aHap1. Previous mtDNA studies did not identify haplotypes aHap1e and aHap1f. The turkeys belonging to haplogroup H2 seem to be more diverse than what researchers have found elsewhere, because five new haplotypes are in the Mimbres sample (aHap2f, aHap2g, aHap2w, aHap2y, and aHap2z). The presence of these five haplotypes can be explained in several ways, including sampling biases, lack of complete mtDNA genome coverage, or a more historically based reason such as an influx of turkeys that had yet to be completely domesticated in the Mimbres Valley. We also identified two previously recognized haplotypes in modern Merriam's turkeys (aHap2h and aHap2x), both from Elk Ridge. Furthermore, we identified one haplotype aHap2c turkey from Mattocks. Speller and colleagues (2010:Table S3) identified this haplotype at McPhee Village in Colorado (TU21) dating to 820–980, the Gila Cliff Dwellings (TU1019) dating to 1270–1290, and Point of Pines in Arizona (TU1101) dating to 1200–1400. Lipe and colleagues (2016:Table 1) also identified one haplotype aHap2c turkey from the Croom site in Utah (GG-145.41.1) dating to 620–700. This information suggests that haplotype aHap2c turkeys were present across an extensive geographic range for several centuries.

$\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ Isotopes

Previous studies of turkey diet in the SW/NW demonstrate that most consumed maize, a C_4 plant, but some consumed nonmaize C_3 plants or even had a mixed diet (Jones et al. 2016; Lipe et al. 2016; Manin et al. 2018; McCaffery et al. 2014, 2021; Rawlings and Driver 2010; Webster and Katzenberg 2008). Therefore, we should expect similar results for the Mimbres turkeys. However, based on Mimbres iconography, turkeys likely consumed invertebrates and maize. Of the 31 turkey samples we submitted for stable isotope analyses, we obtained results for 94% ($n = 29$) of the samples (Table 1). However, one turkey from Mattocks (MT07) and one from Old Town (OT02) had carbon to nitrogen (C:N) ratios outside the acceptable range of reasonably well-preserved collagen: 2.9–3.6 (DeNiro 1985). These two samples are not included in Figures 4 and 5, but these data can be found in Supplemental Table 6.

The 29 Mimbres turkeys exhibit $\delta^{13}\text{C}$ values ranging from -16.9‰ to -6.9‰ (-9.4‰ avg.), and the $\delta^{15}\text{N}$ values range from 3.6‰ to 10.2‰ (7.8‰ avg.). Rawlings and Driver (2010:2435) note, “Animals with diets that are composed primarily of C_3 plants generally express average $\delta^{13}\text{C}$ values between -22‰ to -19‰ , while those consuming primarily C_4 plants have values that range between -10‰ to -6‰ .” Diets consisting of a mixed feeding ecology have values between -18‰ and -11‰ (Manin et al. 2018; Tykot 2006). As for $\delta^{15}\text{N}$ values, herbivores have values averaging between 6‰ and 9‰ , carnivores have higher values, and omnivores have intermediate values (McCaffery et al. 2014; Rawlings and Driver 2010; Webster and Katzenberg 2008). McCaffery and colleagues (2021: Table 3) also provide estimated values. They suggest that turkeys with C_4 diets have $\delta^{13}\text{C}$ values of $-10.20\text{‰} \pm 0.62$ (SD) and $\delta^{15}\text{N}$ values of $6.17\text{‰} \pm 2.46$ (SD). On the other hand, turkeys with C_3 diets have $\delta^{13}\text{C}$ values of $-24.10\text{‰} \pm 2.78$ (SD) and $\delta^{15}\text{N}$ values of $1.38\text{‰} \pm 3.15$ (SD). They also provide values for turkey diet consisting of C_4 invertebrates ($\delta^{13}\text{C} -10.70\text{‰} \pm 0.62$ [SD], $\delta^{15}\text{N} 8.05\text{‰} \pm 2.46$ [SD]) and C_3 invertebrates ($\delta^{13}\text{C} -24.60\text{‰} \pm 2.78$ [SD], $\delta^{15}\text{N} 3.26\text{‰} \pm 3.15$ [SD]).

Using these values as a guide, we determined that 79% ($n = 23$) of our sample exhibited $\delta^{13}\text{C}$ values indicating that the turkeys consumed C_4 plants, 14% ($n = 4$) had $\delta^{13}\text{C}$ values indicating that they

Table 1. Summary Table of Genetic and Isotope Results.

Sample ID	Site	Haplogroup	Haplotype	GenBank Accession	Diet
ER01	Elk Ridge	H2	aHap2g	OP056179	C ₄
ER02	Elk Ridge	H2	aHap2y	OP056180	C ₄
ER03	Elk Ridge	H1	aHap1	OP056181	C ₄
ER04	Elk Ridge	H2	aHap2x	OP056182	C ₃
ER05	Elk Ridge	—	—	—	C ₄
ER06	Elk Ridge	H2	aHap2h	OP056183	C ₄
ER07	Elk Ridge	H1	aHap1	OP056184	C ₄
ER08	Elk Ridge	H1	aHap1	OP056185	C ₄
ER09	Elk Ridge	H2	aHap2z	OP056186	C ₄
ER10	Elk Ridge	—	—	—	C ₄
TU949	Elk Ridge	H1	aHap1	OP056190	C ₄
TU950	Elk Ridge	H1	aHap1	OP056191	C ₄
TU951	Elk Ridge	H1	aHap1e	OP056192	C ₄
TU952	Elk Ridge	H1	aHap1	OP056193	C ₄
TU953	Elk Ridge	H1	aHap1	OP056194	C ₄
TU954	Elk Ridge	H1	aHap1f	OP056195	C ₄
TU955	Elk Ridge	H1	aHap1	OP056196	C ₄
LR01	Lake Roberts	—	—	—	C ₄
LR02	Lake Roberts	—	—	—	C ₄
LR03	Lake Roberts	—	—	—	C ₃
MT01	Mattocks	—	—	—	C ₃
MT02	Mattocks	—	—	—	C ₄
MT03	Mattocks	—	—	—	C ₄
MT04	Mattocks	—	—	—	C ₄
MT05	Mattocks	H2	aHap2c	OP056187	C ₄
MT06	Mattocks	—	—	—	C ₃
MT07	Mattocks	—	—	—	—
OT01	Old Town	—	—	—	Mixed
OT02	Old Town	—	—	—	—
WS01	Wheaton-Smith	H2	aHap2f	OP056188	C ₄
WS02	Wheaton-Smith	H2	aHap2w	OP056189	Mixed

consumed C₃ plants, and the remaining 7% ($n = 2$) consumed a mixed diet. The average $\delta^{13}\text{C}$ value for C₄ consumers is -8‰ (range -9.9‰ to -6.9‰), the average $\delta^{13}\text{C}$ value for C₃ consumers is -16.8‰ (range -16.9‰ to -15.3‰), and the average $\delta^{13}\text{C}$ value for turkeys with mixed diets is -11.3‰ (range -11.6‰ to -11‰). The two mixed-diet turkeys (OT01 and WS02) have $\delta^{13}\text{C}$ values closer to C₄ consumers than C₃ consumers. Based on our comparison of the 29 Mimbres turkeys to 269 other archaeological turkeys from the SW/NW ($n = 232$) and southeastern United States ($n = 37$), 13 modern turkeys, and 215 ancient humans from the SW/NW in Figure 5, the C₄ Mimbres turkeys align with most of the other SW/NW ancient turkeys and humans. The C₃

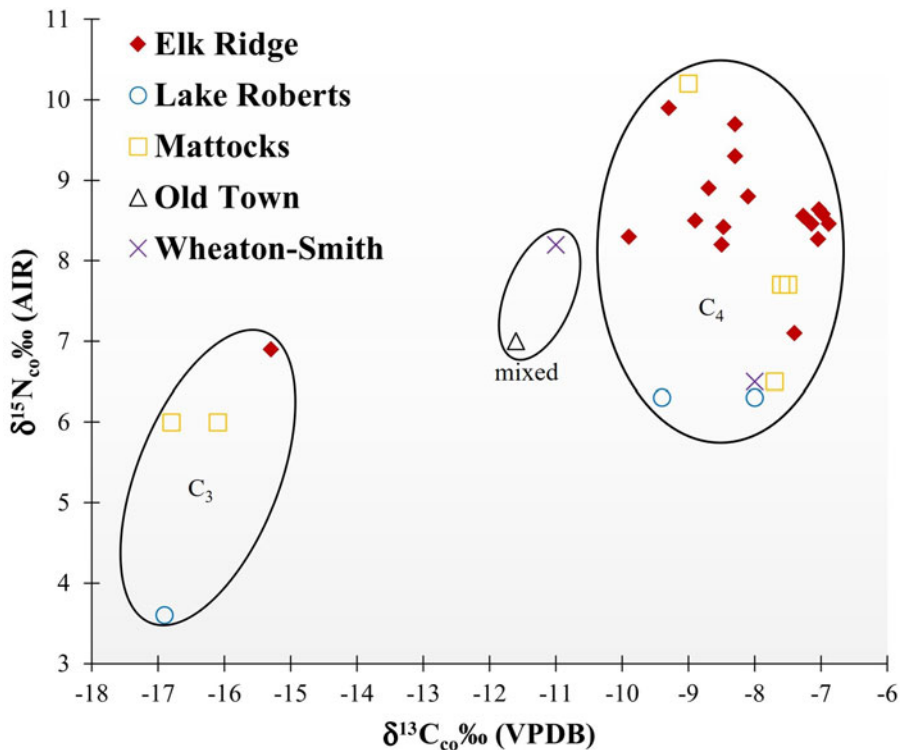


Figure 4. Bone collagen $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ isotope values from Elk Ridge, Lake Roberts, Mattocks, Old Town, and Wheaton-Smith turkeys.

Mimbres turkeys have values similar to the other C_3 -consuming ancient SW/NW, southeastern, and modern turkeys.

Combining mtDNA and Isotope Data

When possible, it is helpful to combine genetic and dietary data on individual turkeys to best understand management practices (Jones et al. 2016; Lipe et al. 2016; Manin et al. 2018; Thornton et al. 2021). We obtained genetic and dietary data for 18 turkeys from Elk Ridge ($n = 15$), Mattocks ($n = 1$), and Wheaton-Smith ($n = 2$). Ten haplogroup H1 turkeys consumed a C_4 diet, one haplogroup H2 turkey consumed a C_3 diet, six haplogroup H2 turkeys consumed a C_4 diet, and one haplogroup H2 turkey had a mixed diet.

As shown in Figure 6, the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values of the 10 haplogroup H1 Mimbres turkeys are more tightly clustered than the eight haplogroup H2 turkeys. To further investigate this, we used a measurement of central tendency and dispersion to compare the two haplogroups. We used nonparametric measures of the median and interquartile ranges due to the small sample sizes and because the data are not normally distributed. As shown in the box and whisker plots in Figure 7, the interquartile ranges of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ are much broader for the haplogroup H2 turkeys than for haplogroup H1 turkeys. This confirms that the stable isotope values of the haplogroup H2 turkeys are more variable and widely dispersed. To determine if this pattern occurs elsewhere, we compared the isotope values of the 10 Mimbres and 28 SW/NW haplogroup H1 turkeys to the 8 Mimbres and 11 SW/NW haplogroup H2 turkeys (Figure 8). Except for the four haplogroup H1 turkeys reported by Jones and colleagues (2016) that consumed C_3 diets—shown in the bottom-left corner of Figure 8—the values of the haplogroup H1 turkeys are more tightly clustered together than the values of the haplogroup H2 turkeys. Therefore, whereas Mimbres and Ancestral Pueblo aviculturists provided maize to haplogroup H1 and H2 turkeys, the haplogroup H2 birds had somewhat more varied diets.

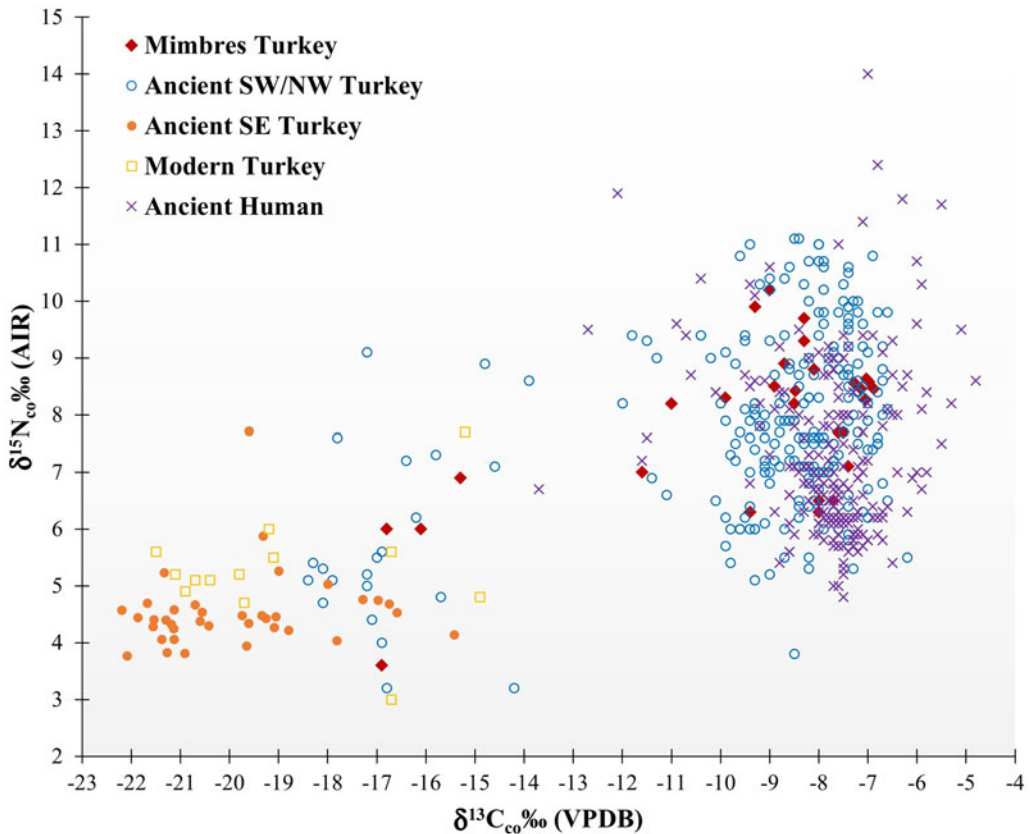


Figure 5. Bone collagen $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ isotope values from the 29 Mimbres turkeys reported in this article compared to 232 archaeological turkeys from the SW/NW (Conrad et al. 2016:Appendix A; Jones et al. 2016:Table 3; Kellner et al. 2010:Table 8.3; Lipe et al. 2016:Table 1; Manin et al. 2018:Table S1; McCaffery et al. 2014:Table 2; McCaffery et al. 2021:Table 4; Rawlings and Driver 2010:Tables 5, 6), 37 archaeological turkeys from the southeastern United States (Thornton et al. 2021:Table S1), 13 modern turkeys (Lipe et al. 2016:Table 2), and 215 ancient humans from the SW/NW (Coltrain and Janetski 2013:Tables 1, 2, 3; Coltrain et al. 2007:Table 1; Martin 1999:Table 2).

Discussion

This study aims to understand turkey management practices in the Mimbres Valley during the Classic period using mtDNA and stable carbon and nitrogen isotope analyses. People in the Mimbres Valley had haplogroup H1 and H2 turkeys, and the birds primarily consumed a C_4 diet, but some had a nonmaize C_3 diet, and even fewer had a mixed diet. Elk Ridge is the only site in our sample with evidence of both haplogroups. By integrating the genetic and dietary data, we see that Mimbres aviculturists treated haplogroup H1 and H2 birds alike, which means that most were fed C_4 diets, which is similar to the way Ancestral Pueblo groups managed their turkeys. Data also show that haplogroup H2 Mimbres turkeys had more varied diets than haplogroup H1 turkeys, a pattern also seen in the northern Southwest.

We are uniquely positioned to examine key issues in Mimbres archaeology because this study is the first to investigate the maternal genetic lineage and diet of turkeys from Classic period sites. Below, we address how the human-turkey relationship began in this region, the evidence for turkey pens and reducing turkey mobility, and the socioecological factors related to turkey management—notably, the challenges associated with feeding maize to turkeys during times of environmental stress. Answering these questions provides new insights into Mimbres society and how turkeys fit within Classic period subsistence, economic production, sociopolitical organization, and religious and ritual practice.

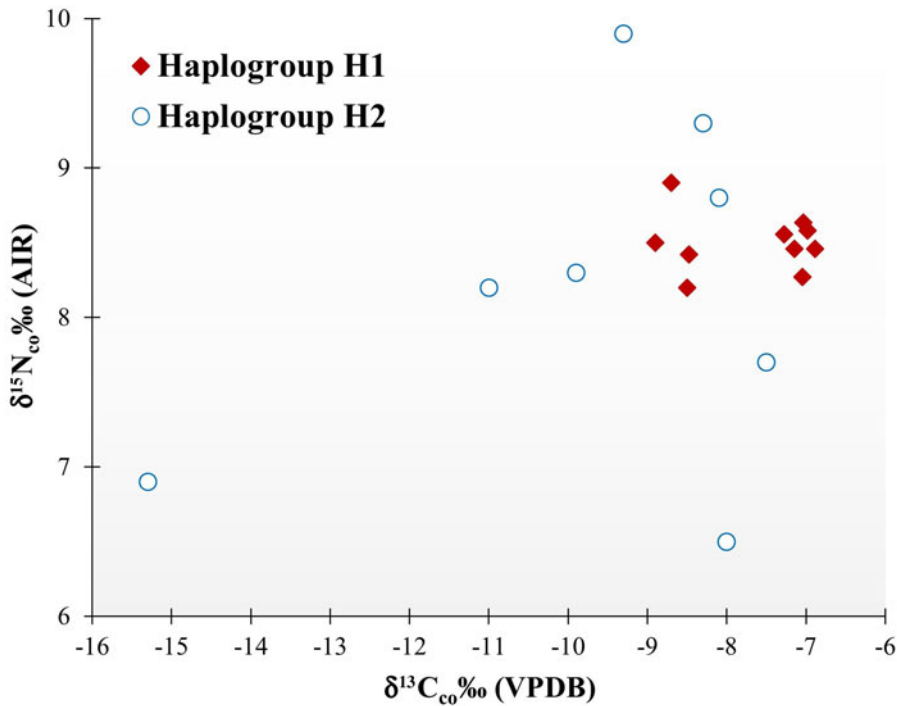


Figure 6. Bone collagen $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ isotope values from the haplogroup H1 and H2 Mimbres turkeys.

The Human-Turkey Relationship

The human-turkey relationship in the Mimbres Valley likely began because of an increasing population that aggregated into pueblo villages along the Mimbres River. People cleared forests to make additional space for agricultural fields, and trees were needed for construction beams and fuel for fires. Clearing forests destroyed wild turkey habitat, and people may have inadvertently attracted turkeys closer to their maize farming villages. Turkeys exhibit several favorable traits for domestication and management of genetically wild birds, including a social structure based on a dominance hierarchy, a tolerance for penning, flocking behavior, and a generalist diet (Zeder 2012a:Figure 1). Turkeys are also precocial birds, which means that they are well developed, are down covered, and can stand and walk right after hatching (Healy 1992). Newly hatched poults imprint on the first animal providing parental care, and the birds respond to that parent—even humans—as if it were a turkey. They are relatively social birds, and like dogs, turkeys are commensal domesticates because they take advantage of the food and shelter people provide (Zeder 2012b:240–242). Wild turkeys are initially timid, but they would have benefited from the food resources around Mimbres farming villages once they became familiar with the sights and sounds of being close to humans.

The Mimbres genetic and dietary data corroborate Lipe and colleagues' (2016:108–109) position that viewing haplogroup H1 and H2 turkeys as “domestic” versus “wild” is an oversimplification. Despite their genetic differences, Ancestral Pueblo and Mimbres aviculturists provided maize to haplogroup H1 and H2 turkeys. Nevertheless, there is a clear difference in the frequency of haplogroup H1 and H2 turkeys in the northern Southwest with far more from the H1 lineage than the H2 lineage (Kemp et al. 2017; Speller et al. 2010). However, based on this Mimbres study, people in the valley relied almost as much on their haplogroup H2 population as their haplogroup H1 population. Furthermore, unlike other areas of the SW/NW, people in the Mimbres Valley did not have a history of large-scale prehispanic turkey use. How then did people in this region acquire turkeys?

Mimbres aviculturists likely captured haplogroup H2 birds in the wild to increase their turkey population, which is similar to what residents of historic Taos Pueblo in northern New Mexico

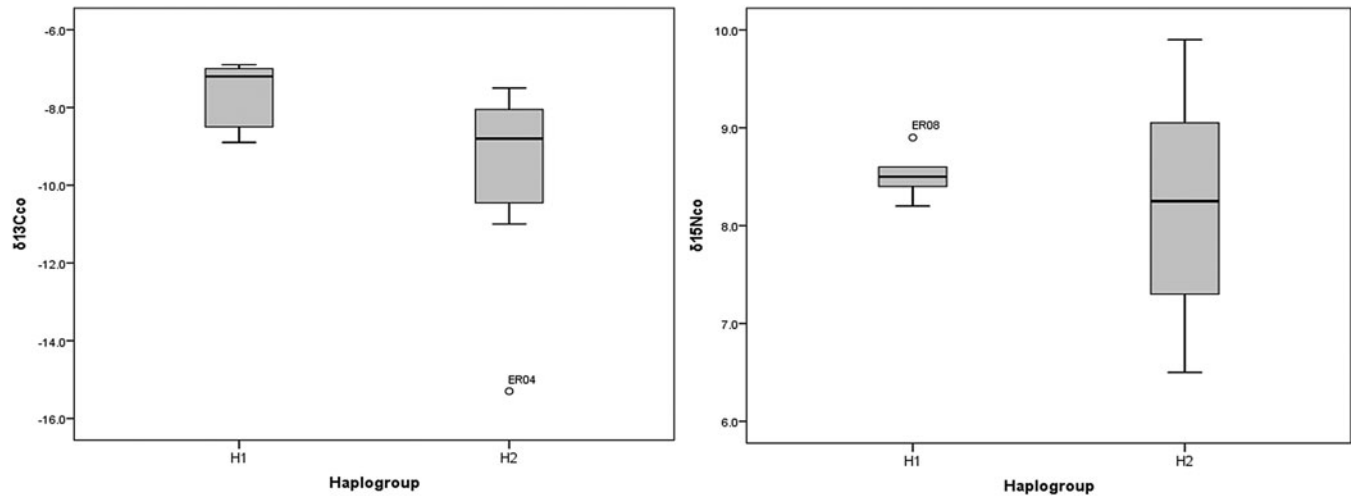


Figure 7. Box and whisker plots comparing the median and interquartile ranges of $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values for haplogroups H1 and H2. The shaded boxes display the interquartile range where 50% of the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values plot in relation to the median (bold line). The circles marked with a turkey sample number (ER04 and ER08) denote statistical outliers.

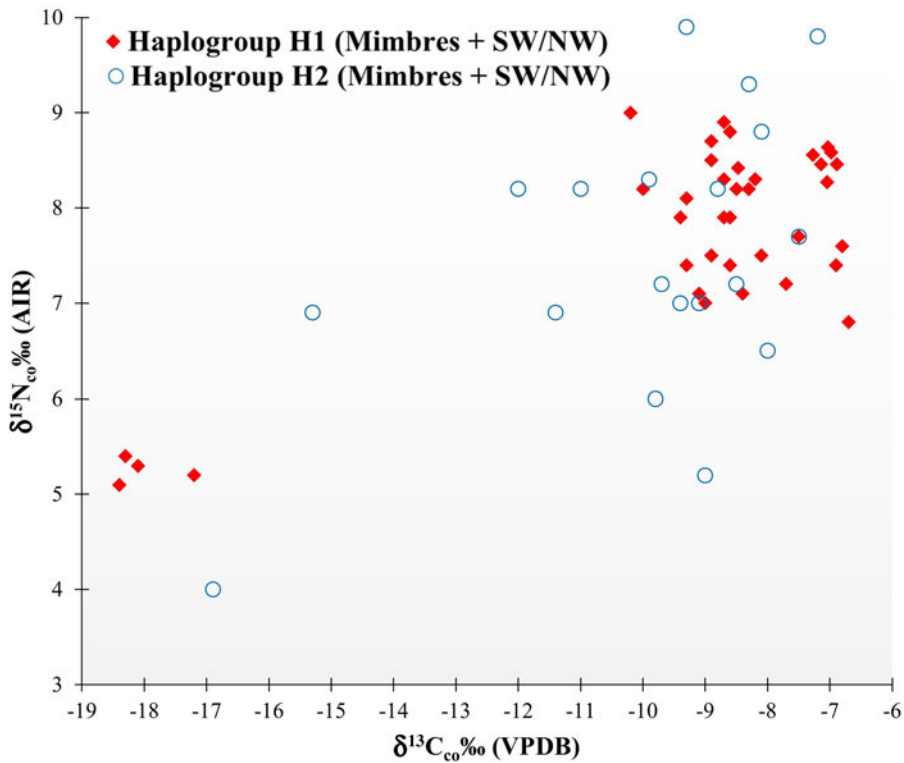


Figure 8. Bone collagen $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ isotope values from the 10 Mimbres and 28 SW/NW haplogroup H1 turkeys (Jones et al. 2016:Table 3; Lipe et al. 2016:Table 1) compared to the eight Mimbres and 11 SW/NW haplogroup H2 turkeys (Jones et al. 2016:Table 3; Lipe et al. 2016:Table 1).

who confined wild-caught turkeys at the pueblo did (Schorger 1961:140). Also, as Lipe and colleagues (2016:109) mention, the haplogroup H2 birds were not themselves wild, given that humans managed them and provided maize, but they were likely descendants of wild turkeys that were integrated into flocks and that gave rise to future generations of haplogroup H2 birds. As for haplogroup H1 turkeys, Elk Ridge is currently the only Classic period site in the Mimbres Valley with evidence of this lineage. People at Elk Ridge could have acquired haplogroup H1 eggs or poults from northern groups. Future studies could use radiogenic strontium isotopes to investigate if people acquired turkeys from outside the valley (Grimstead et al. 2016; Schwartz et al. 2021).

Our study validates Morrison's (2002) position that Elk Ridge was a localized experiment in turkey management because people there likely had the knowledge, technology, and interest to raise and keep these birds. Perhaps people at Elk Ridge learned aviculture from more northern groups who had centuries of experience managing turkeys. Other people in the Mimbres Valley may have visited Elk Ridge or traded with them to acquire turkey feather blankets, robes, or the feathers themselves. Elk Ridge also has evidence of pottery production (Creel and Speakman 2018). Consequently, people there played an essential role in the movement of goods within the larger Mimbres Valley. People who managed macaws in Mimbres society likely had higher social status (Creel and McKusick 1994; Munson 2000), so it is probable that those who managed Elk Ridge's turkeys also had specialized leadership roles in the village, given that it took special knowledge to manage birds. People at Elk Ridge managed turkeys, but is there evidence they used pens or other means of reducing turkey mobility?

Mimbres Valley Turkey Pens

People corralled turkeys in pens or kept them in abandoned rooms to restrict the birds' mobility, control their breeding, and safely keep them to acquire important resources such as feathers and meat (Conrad

2022). Pens are uncommon in the archaeological record because people built them using materials that do not often preserve, such as wooden poles, branches, and adobe. Some of the best examples of pens are from Pindi Pueblo, Arroyo Hondo, and Paquimé, and people at these sites had up to several hundred turkeys (Di Peso et al. 1974; Lang and Harris 1984; Stubbs and Stallings 1953).

Penned turkeys were regularly fed maize and protected from predators, but they arguably lived a more miserable life than their wild cousins. Penning for long intervals was damaging to the birds' health because they were confined in small spaces, stressed, and surrounded by excrement. There were also human consequences for keeping large numbers of birds penned within the pueblo village. As with macaws, the confinement of turkeys could have spread zoonotic diseases such as psittacosis throughout the village (Schwartz et al. 2022:311–312). Mimbres aviculturists could have contracted psittacosis by inhaling dust particles contaminated with the birds' fecal matter. If untreated, humans can experience high fever, diarrhea, respiratory infection, and death.

Archaeologists have not found definitive evidence of formal turkey pens in the Mimbres Valley. However, aviculturists at Elk Ridge likely kept the birds in unused rooms, and there are small rooms at NAN Ranch and Old Town that may have been used to confine turkeys (Creel et al. 2015:6; Shafer 2003:65). We recommend that archaeologists use Conrad (2022) as a guide during future excavations at Classic period Mimbres pueblo sites to help look for turkey pens. Nevertheless, people in the Mimbres Valley may not have penned their turkey population because they had relatively few birds compared to other sites, such as Paquimé. However, below, we provide evidence to suggest that people at Elk Ridge limited turkey mobility. People at NAN Ranch and Old Town may also have limited mobility, but more work is needed to understand turkey management at those sites.

The first line of evidence comes from the potential watering bowls on the floors of Elk Ridge rooms with turkeys. Rather than constructing separate formal pens, people at Elk Ridge may have kept turkeys in unused rooms and placed broken pottery vessels on the floor so they could drink. If turkeys were kept in those rooms, we should expect thick layers of yellowish soil. However, excavations did not uncover dung deposits at Elk Ridge, and dung deposits have not been found at other Mimbres sites (Creel et al. 2015:6). It is possible, however, that people could have cleaned the room(s) of dung, as Conrad (2022:647) proposes, or they could have tethered turkeys in different locations entirely, such as extramural areas outside of the pueblo.

The second line of evidence for limiting turkey mobility is from the presence of healed bone injuries on three male turkeys at Elk Ridge. According to Morrison (2002), one suffered a broken left tibiotarsus that had healed prior to the bird's death, another had a severe break on the right humerus, and the third had a healed pathology on the left tibiotarsus. These birds most likely would not have survived in the wild, requiring human care and management. It is possible that these birds received their injuries from being tethered because tethering was a common management practice (Conrad 2022; Fothergill 2016). Mimbres aviculturists may have tethered or leashed the birds to heavy objects such as rocks or trees. Besides the trauma indicated on bones, archaeological evidence for tethering is rare because the cord tied to the bird does not preserve in most conditions. There are rare instances of desiccated turkeys with the cord still attached, but not from the Mimbres Valley (Lipe et al. 2016:106).

Socioecological Interactions

How people in the Mimbres Valley interacted with their environment is one of the more prominent themes in Mimbres archaeology. For example, much is known about Classic period landscape modification, hunting, farming, and gathering strategies, and how these actions impacted resource availability (Minnis 1985; Nelson and Schollmeyer 2003; Nelson et al. 2006; Schollmeyer 2011; Schollmeyer and Driver 2013). However, how did turkey management practices impact socioecological aspects of Classic period Mimbres society related to ancient food webs, farming practices, and potential food insecurities?

During the last few decades of the Classic period, farmers had difficulty growing crops because there was a dry period, the soils were degraded, and floodplain vegetation was depleted due to centuries of intense land use (Minnis 1985; Sandor et al. 2008). Nevertheless, Mimbres farmers could have still

produced enough crops to survive, but they adapted by using less productive fields or travel to more distant fields (Schollmeyer 2011). Also, people lacked reliable protein from large mammals because artiodactyl populations were already reduced due to landscape modification and overhunting (Cannon 2000; Nelson and Schollmeyer 2003). Consequently, people during the Classic may have needed to find new animal protein sources to avoid potential food insecurities.

Animals are costly to keep because humans must provide food, shelter, and care, or else the animal will become sick, die, and not produce the valuable resources humans want. As in much of the SW/NW, people in the Mimbres Valley fed turkeys maize. Keeping turkeys was costly for maize agriculturists because people and their turkeys relied on the same crop to survive (Bocinsky and Kohler 2015). If people in the Mimbres Valley went through times of environmental stress and had food shortages, they may have needed to make decisions about their turkey population. For example, they could have eaten their turkeys, similar to those in the Mesa Verde region in southwestern Colorado who began eating turkeys once their artiodactyl populations decreased (Badenhorst and Driver 2009; Ellyson et al. 2019). Wild toms can weigh approximately 7.5 kg (16.5 lb.), and mature hens can weigh 4.5 kg (10 lb.; Schorger 1966:88, Table 9). Consequently, eating turkeys would have offered more protein and fat while at the same time reducing the number of birds so as to conserve maize for human consumption. However, unlike those in the Mesa Verde region, Mimbres groups chose not to eat their turkeys even though they had unreliable access to artiodactyls, and maize farming may have been more difficult.

Why did Mimbres groups keep turkeys if not for a readily available protein source? It is most likely that people kept turkeys alive because they wanted the feathers. Feathers from several bird species were ritually important because they were added to prayer sticks that were deposited as gifts to ancestors to bring rain (Tyler 1979:93). In addition, turkey feather blankets are warmer than rabbit-fur blankets (Blinman 2001). Because turkey feathers were necessary for ritual and utilitarian purposes, it was more important for Mimbres society to keep live turkeys for their feathers rather than for food consumption. Although there is iconographic evidence of men hunting or capturing presumably wild turkeys—likely for their feathers rather than meat—people could have collected their feathers when they molted naturally or plucked feathers from live birds (Fothergill 2016:564).

Conclusions

More than ever, archaeologists are studying how past peoples throughout North America used and managed turkeys. In this article, we used mtDNA and stable carbon and nitrogen isotope analyses to investigate turkey management practices in the Mimbres Valley from AD 1000 to 1130. Using these data, we provided new information about how turkeys fit within Classic period subsistence, economic production, sociopolitical organization, and religious and ritual practice. Like Ancestral Pueblo groups in the northern Southwest, Mimbres aviculturists managed haplogroup H1 and H2 turkeys and fed these birds primarily C₄ maize diets. However, unlike Ancestral Pueblo groups, Mimbres aviculturists managed more haplogroup H2 turkeys and did not eat the birds (Morrison 2002; Shaffer 1991). Instead, feather production outweighed any gains from their use as food, even when turkey protein would have helped reduce food insecurity during parts of the Classic period.

This study has broad relevance to places where people managed wild, tame, and domestic animals, and we offered new insights into how prehispanic, small-scale, middle-range agricultural societies in the SW/NW managed turkeys for ritual and utilitarian purposes. This study also provides essential baseline information on turkey management for the Mimbres Valley, which can be used to compare the human-turkey relationship throughout North America. However, additional research on the maternal genetic lineage and diet is needed on turkeys from other sites and periods in the southern Southwest and Northwest Mexico to confirm if turkey management practices change over time and across space. Finally, the next decade will undoubtedly generate further insights on turkey management, with improved analytical methods and innovative research questions in collaboration with archaeologists, Native American communities, geneticists, and wildlife biologists.

Acknowledgments. We thank the following individuals and institutions for facilitating access to turkey samples: Karen Gust Schollmeyer, Michael Cannon, Steven LeBlanc, Julia Clifton and Diana Sherman (Center for New Mexico Archaeology / Museum of Indian Arts and Culture), Robin Cordero (formerly of Office of Contract Archeology / University of New Mexico), Jack Young (New Mexico Department of Game and Fish), Thomas Holcomb (Bureau of Land Management, Las Cruces office, retired), and Barbara Roth (University of Nevada, Las Vegas). We also thank Kyle Bocinsky, Katelyn Bishop, Patricia Gilman, and the anonymous reviewers who provided comments on earlier drafts. We appreciate Caitlin Wichlacz for illustrating [Figures 2 and 3](#), and Myles Miller for providing statistical analyses and [Figure 7](#).

Funding Statement. We thank the following organizations who funded this project: The Rust Family Foundation (RFF-2019-106, to Dolan and Laumbach and administered by Dr. Deborah Dennis, Human Systems Research Inc.), the New Mexico Archaeological Council (to Dolan), the Center for Evolution and Medicine at Arizona State University (to Ozga), and a European Research Council Grant to conduct a portion of the genomic analyses (MSCA-IF-2016-748679 TURKEY, to Manin).

Data Availability Statement. The data supporting this research are included in the electronic supplemental material. The turkey genetic sequences have been deposited to GenBank (<http://www.ncbi.nlm.nih.gov/genbank/>) under accession numbers OP056179-OP056196.

Supplemental Material. For supplemental material accompanying this article, visit <https://doi.org/10.1017/aaq.2022.81>.

Supplemental Figure 1. Coverage distribution on the 15567-16004 segment from the HTS data.

Supplemental Figure 2. Median-joining network displaying the relationships between the newly obtained sequences and previously published archaeological and modern sequences obtained from GenBank.

Supplemental Figure 3. Median-joining network displaying the relationships between the newly obtained sequences and previously published archaeological and modern sequences obtained from GenBank.

Supplemental Table 1. Turkey Images on Mimbres Pottery.

Supplemental Table 2. Turkey Provenience Information.

Supplemental Table 3. mtDNA Sample List.

Supplemental Table 4. Diagnostic Mutations Observed in the Sequences and Haplogroup Calling from the HTS and Sanger Data.

Supplemental Table 5. List of Samples Used in the Haplotype Calling.

Supplemental Table 6. Isotopic Results from This Study.

Supplemental Text 1. Archaeological Site Summaries.

Supplemental Text 2. mtDNA Analysis and Laboratory Methods.

Supplemental Text 3. Stable Carbon and Nitrogen Isotope Analysis and Laboratory Methods.

Competing Interests. The authors declare none.

References Cited

- Ambrose, Stanley H. 1991. Effects of Diet, Climate and Physiology on Nitrogen Isotope Abundances in Terrestrial Foodwebs. *Journal of Archaeological Science* 18:293–317.
- Anyon, Roger, Darrell Creel, Patricia A. Gilman, Steven A. LeBlanc, Myles R. Miller, Stephen E. Nash, Margaret C. Nelson, et al. 2017. Re-Evaluating the Mimbres Region Prehispanic Chronometric Record. *Kiva* 83:316–343.
- Anyon, Roger, and Steven A. LeBlanc. 1984. *The Galaz Ruin: A Prehistoric Mimbres Village in Southwestern New Mexico*. Maxwell Museum of Anthropology, Albuquerque, New Mexico; University of New Mexico Press, Albuquerque.
- Badenhorst, Shaw, and Jonathan C. Driver. 2009. Faunal Changes in Farming Communities from Basketmaker II to Pueblo III (A.D. 1–1300) in the San Juan Basin of the American Southwest. *Journal of Archaeological Science* 36:1832–1841.
- Badenhorst, Shaw, Robin Lyle, Jamie Merewether, Jonathan C. Driver, and Susan C. Ryan. 2012. The Potential of Osteometric Data for Comprehensive Studies of Turkey (*Meleagris gallopavo*) Husbandry in the American Southwest. *Kiva* 78:61–78.
- Beacham, E. Bradley, and Stephen R. Durand. 2007. Eggshell and the Archaeological Record: New Insights into Turkey Husbandry in the American Southwest. *Journal of Archaeological Science* 34:1610–1621.
- Blake, Michael, Steven A. LeBlanc, and Paul E. Minnis. 1986. Changing Settlement and Population in the Mimbres Valley, SW New Mexico. *Journal of Field Archaeology* 13:440–464.
- Blinman, Eric. 2001. Staying Warm: Fur and Feather Blankets. *El Palacio* 106:18–21.
- Bocinsky, R. Kyle, and Timothy A. Kohler. 2015. Complexity, Rigidity, and Resilience in the Ancient Puebloan Southwest. In *Viewing the Future in the Past: Historical Ecology Applications to Environmental Issues*, edited by H. Thomas Foster II, Lisa Paciulli, and David Goldstein, pp. 86–105. University of South Carolina Press, Columbia.
- Brody, J. J. 2004. *Mimbres Painted Pottery*. Rev. ed. School of American Research, Santa Fe, New Mexico.
- Brody, J. J., Catherine J. Scott, and Steven A. LeBlanc. 1983. *Mimbres Painted Pottery: Ancient Art of the American Southwest*. Hudson Hills, New York.
- Cannon, Michael D. 2000. Large Mammal Relative Abundance in Pithouse and Pueblo Period Archaeofaunas from Southwestern New Mexico: Resource Depression among the Mimbres-Mogollon? *Journal of Anthropological Archaeology* 19:317–347.
- Coltrain, Joan Brenner, and Joel C. Janetski. 2013. The Stable and Radio-Isotope Chemistry of Southeastern Utah Basketmaker II Burials: Dietary Analysis Using the Linear Mixing Model SISUS, Age and Sex Patterning, Geolocation and Temporal Patterning. *Journal of Archaeological Science* 40:4711–4730.

- Coltrain, Joan Brenner, Joel C. Janetski, and Shawn W. Carlyle. 2007. The Stable and Radio-Isotope Chemistry of Western Basketmaker Burials: Implications for Early Puebloan Diets and Origins. *American Antiquity* 72:301–321.
- Conrad, Cyler. 2022. Contextualizing Ancestral Pueblo Turkey (*Meleagris gallopavo* spp.) Management. *Journal of Archaeological Method and Theory* 29:624–665. <https://doi.org/10.1007/s10816-021-09531-9>.
- Conrad, Cyler, Emily Lena Jones, Seth D. Newsome, and Douglas W. Schwartz. 2016. Bone Isotopes, Eggshell and Turkey Husbandry at Arroyo Hondo Pueblo. *Journal of Archaeological Science: Reports* 10:566–574.
- Cosgrove, Harriet S., and C. Burton Cosgrove. 1932. *The Swarts Ruin: A Typical Mimbres Site in Southwestern New Mexico*. Papers of the Peabody Museum of American Archaeology and Ethnology Vol. 15. Harvard University, Cambridge, Massachusetts.
- Creel, Darrell. 2006. Evidence for Mimbres Social Differentiation at the Old Town Site. In *Mimbres Society*, edited by Valli S. Powell-Martí and Patricia A. Gilman, pp. 32–44. University of Arizona Press, Tucson.
- Creel, Darrell, and Roger Anyon. 2003. New Interpretations of Mimbres Public Architecture and Space: Implications for Cultural Change. *American Antiquity* 68:67–92.
- Creel, Darrell, Michael D. Cannon, Jack Broughton, and Christopher Francis. 2015. The Significance of Birds at Old Town and Other Mimbres Sites. In *Collected Papers from the 18th Biennial Mogollon Archaeology Conference*, edited by Lonnie C. Ludeman, pp. 3–9. Friends of Mogollon Archaeology, Las Cruces, New Mexico.
- Creel, Darrell, and Charmion McKusick. 1994. Prehistoric Macaws and Parrots in the Mimbres Area, New Mexico. *American Antiquity* 59:510–524.
- Creel, Darrell, and Robert J. Speakman. 2018. Mimbres Pottery: New Perspectives on Production and Distribution. In *New Perspectives on Mimbres Archaeology: Three Millennia of Human Occupation in the North American Southwest*, edited by Barbara J. Roth, Patricia A. Gilman, and Roger Anyon, pp. 132–148. University of Arizona Press, Tucson.
- DeNiro, Michael J. 1985. Postmortem Preservation and Alteration of In-Vivo Bone Collagen Isotope Ratios in Relation to Paleodietary Reconstruction. *Nature* 317:806–809.
- Di Peso, Charles C., John B. Rinaldo, and Gloria J. Fenner. 1974. *Casas Grandes: A Fallen Trading Center of the Gran Chichimeca: 4. Dating and Architecture*. Amerind Foundation, Dragoon, Arizona; Northland Press, Flagstaff, Arizona.
- Ellyson, Laura J., Lisa Nagaoka, and Steve Wolverton. 2019. Animal Resource Use Related to Socioenvironmental Change among Mesa Verde Farmers. *Journal of Anthropological Research* 75:361–392.
- Fewkes, J. Walter. 1923. *Designs on Prehistoric Pottery from the Mimbres Valley*. Smithsonian Miscellaneous Collections Vol. 74. Smithsonian Institution, Washington, DC.
- Fewkes, J. Water. 1924. *Additional Designs on Prehistoric Mimbres Pottery*. Smithsonian Miscellaneous Collections Vol. 76. Smithsonian Institution, Washington, DC.
- Fothergill, B. Tyr. 2016. Reconstructing Animal Husbandry: Trauma in *Meleagris gallopavo* (Domestic Turkey) Ulnae from the American Southwest (c. 900–1678 CE). *Journal of Archaeological Science: Reports* 10:557–565.
- Gilman, Patricia A. 1987. Architecture as Artifact: Pit Structures and Pueblos in the American Southwest. *American Antiquity* 52:538–564.
- Gilman, Patricia A. 1990. Social Organization and Classic Mimbres Period Burials in the SW United States. *Journal of Field Archaeology* 17:457–469.
- Grimstead, Deanna N., Amanda C. Reynolds, Adam M. Hudson, Nancy J. Akins, and Julio L. Betancourt. 2016. Reduced Population Variance in Strontium Isotope Ratios Informs Domesticated Turkey Use at Chaco Canyon, New Mexico, USA. *Journal of Archaeological Method and Theory* 23:127–149.
- Grissino-Mayer, Henri D., Christopher H. Baisan, and Thomas W. Swetnam. 1997. *A 1,373 Year Reconstruction of Annual Precipitation for the Southern Rio Grande Basin*. Final report submitted to the Directorate of Environment, Natural Resources Division, Fort Bliss, Texas, for the Legacy Program.
- Haury, Emil W. 1936. *The Mogollon Culture of Southwestern New Mexico*. Medallion Papers No. 20. Gila Pueblo, Globe, Arizona.
- Healy, William M. 1992. Behavior. In *The Wild Turkey: Biology and Management*, edited by James G. Dickson, pp. 44–65. Stackpole Books, Mechanicsburg, Pennsylvania.
- Hegmon, Michelle. 2002. Recent Issues in the Archaeology of the Mimbres Region of the North American Southwest. *Journal of Archaeological Research* 10:307–357.
- Hegmon, Michelle, Will G. Russell, Kendall Baller, Matthew A. Peeples, and Sarah Striker. 2021. The Social Significance of Mimbres Painted Pottery in the U.S. Southwest. *American Antiquity* 86:23–42.
- Hegmon, Michelle, and Wenda R. Trevathan. 1996. Gender, Anatomical Knowledge, and Pottery Production: Implications of an Anatomically Unusual Birth Depicted on Mimbres Pottery from Southwestern New Mexico. *American Antiquity* 61:747–754.
- Hill, Erica. 2000. The Contextual Analysis of Animal Internments and Ritual Practice in Southwestern North America. *Kiva* 65:361–398.
- Jett, Stephen C., and Peter B. Moyle. 1986. The Exotic Origins of Fishes Depicted on Prehistoric Mimbres Pottery from New Mexico. *American Antiquity* 51:688–720.
- Jones, Emily Lena, Cyler Conrad, Seth D. Newsome, Brian M. Kemp, and Jacqueline Marie Kocer. 2016. Turkeys on the Fringe: Variable Husbandry in “Marginal” Areas of the Prehistoric American Southwest. *Journal of Archaeological Science: Reports* 10:575–583.
- Katzenberg, M. Anne. 2008. Stable Isotope Analysis: A Tool for Studying Past Diet, Demography, and Life History. In *Biological Anthropology of the Human Skeleton*, edited by M. Anne Katzenberg and Shelley R. Sanders, pp. 413–441. Wiley-Blackwell, Hoboken, New Jersey.

- Kellner, Corina M., Margaret Schoeninger, Katherine A. Spielmann, and Katherine Moore. 2010. Stable Isotope Data Show Temporal Stability in Diet at Pecos Pueblo and Diet Variation among Southwest Pueblos. In *Pecos Pueblo Revisited: The Biological and Social Context*, edited by Michèle E. Morgan, pp. 79–91. Harvard University Press, Cambridge, Massachusetts.
- Kemp, Brian M., Kathleen Judd, Cara Monroe, Jelmer W. Eerkens, Lindsay Hilldorfer, Connor Cordray, Rebecca Schad, Erin Reams, Scott G. Ortman, and Timothy A. Kohler. 2017. Prehistoric Mitochondrial DNA of Domesticated Animals Supports a 13th Century Exodus from the Northern US Southwest. *PLoS ONE* 12(7):e0178882. <https://doi.org/10.1371/journal.pone.0178882>.
- Kintigh, Keith W., Jeffrey H. Altschul, Mary C. Beaudry, Robert D. Drennan, Ann P. Kinzig, Timothy A. Kohler, W. Fredrick Limp, et al. 2014. Grand Challenges for Archaeology. *American Antiquity* 79:5–24.
- Lang, Richard W., and Arthur H. Harris. 1984. *The Faunal Remains from Arroyo Hondo Pueblo, New Mexico: A Study in Short-Term Subsistence Change*. School of American Research, Santa Fe, New Mexico.
- LeBlanc, Steven A. 1983. *The Mimbres People: Ancient Painters of the American Southwest*. Thames and Hudson, London.
- Lekson, Stephen H. 2006. *Archaeology of the Mimbres Region, Southwestern New Mexico, U.S.A.* BAR International Series 1466. Archaeopress, Oxford.
- Lipe, William D., R. Kyle Bocinsky, Brian S. Chisholm, Robin Lyle, David M. Dove, R. G. Matson, Elizabeth Jarvis, Kathleen Judd, and Brian M. Kemp. 2016. Cultural and Genetic Contexts for Early Turkey Domestication in the Northern Southwest. *American Antiquity* 81:97–113.
- Lipe, William D., Shannon Tushingham, Eric Blinman, Laurie Webster, Charles T. LaRue, Aimee Oliver-Bozeman, and Jonathan Till. 2020. Staying Warm in the Upland Southwest: A “Supply Side” View of Turkey Feather Blanket Production. *Journal of Archaeological Science: Reports* 34. <https://doi.org/10.1016/j.jasrep.2020.102604>.
- Manin, Aurélie, Eduardo Corona-M, Michelle Alexander, Abigail Craig, Erin K. Thornton, Dongya Y. Yang, Michael Richards, and Camilla F. Speller. 2018. Diversity and Management Strategies in Mesoamerican Turkeys: Archaeological, Isotopic and Genetic Evidence. *Royal Society Open Science* 5. <https://doi.org/10.1098/rsos.171613>.
- Martin, Steve L. 1999. Virgin Anasazi Diet as Demonstrated through the Analysis of Stable Carbon and Nitrogen Isotopes. *Kiva* 64:495–515.
- McCaffery, Harlan, Kye Miller, and Robert H. Tykot. 2021. Paleodiet of Turkeys (*Meleagris gallopavo*) in the Early Pueblo Period of the Northern Southwest. *Kiva* 87:129–151.
- McCaffery, Harlan, Robert H. Tykot, Kathy Durand Gore, and Beau R. DeBoer. 2014. Stable Isotope Analysis of Turkey (*Meleagris gallopavo*) Diet from Pueblo II and Pueblo III Sites, Middle San Juan Region, Northwest New Mexico. *American Antiquity* 79:337–352.
- McKusick, Charmion R. 1986. *Southwest Indian Turkeys: Prehistory and Comparative Osteology*. Southwest Bird Laboratory, Globe, Arizona.
- McKusick, Charmion R. 2001. *Southwest Birds of Sacrifice*. Arizona Archaeologist No. 31. Arizona Archaeological Society, Globe, Arizona.
- McNeil, Lynda D. 2022. Turkeys Befriend a Girl: Turkey Husbandry, Ceremonialism, and Tales of Resistance during the Pueblo Revolt Era. *American Antiquity* 87:18–41.
- Minnis, Paul E. 1985. *Social Adaptation to Food Stress: A Prehistoric Southwestern Example*. University of Chicago Press, Chicago.
- Morrison, Michael J. 2002. A Report on Turkey Remains Recovered from Elk Ridge Ruin. In *Mogollon Archaeology: Collected Papers from the Eleventh Mogollon Conference, 20th Anniversary 1980–2000*, edited by Patrick H. Beckett, pp. 137–163. COAS Publishing and Research, Las Cruces, New Mexico.
- Munro, Natalie D. 2011. Domestication of the Turkey in the American Southwest. In *The Subsistence Economies of Indigenous North American Societies: A Handbook*, edited by Bruce D. Smith, pp. 543–555. Smithsonian Institution, Washington, DC.
- Munson, Marit K. 2000. Sex, Gender, and Status: Human Images from the Classic Mimbres. *American Antiquity* 65:127–143.
- Nelson, Margaret C., Michelle Hegmon, Stephanie Kulow, and Karen Gust Schollmeyer. 2006. Archaeological and Ecological Perspectives on Reorganization: A Case Study from the Mimbres Region of the U.S. Southwest. *American Antiquity* 71:403–432.
- Nelson, Margaret C., and Karen Gust Schollmeyer. 2003. Game Resources, Social Interaction, and the Ecological Footprint in Southwest New Mexico. *Journal of Archaeological Method and Theory* 10:69–110.
- O’Bagy Davis, Carolyn. 1995. *Treasured Earth: Hattie Cosgrove’s Mimbres Archaeology in the American Southwest*. Old Pueblo Archaeology Center, Tucson, Arizona.
- Olsen, Sandra, and John W. Olsen. 1996. An Analysis of Faunal Remains from Wind Mountain: Appendix 8. In *Mimbres Mogollon Archaeology: Charles C. Di Peso’s Excavations at Wind Mountain*, by Anne I. Woosley and Allan J. McIntyre, pp. 389–406. University of New Mexico Press, Albuquerque.
- Payne, Richard W. 1991. Bone Flutes of the Anasazi. *Kiva* 56:165–177.
- Pelham, Paul H., and James G. Dickson. 1992. Physical Characteristics. In *The Wild Turkey: Biology and Management*, edited by James G. Dickson, pp. 32–45. Stackpole Books, Mechanicsburg, Pennsylvania.
- Powell-Martí, Valli S., and Patricia A. Gilman (editors). 2006. *Mimbres Society*. University of Arizona Press, Tucson.
- Rawlings, Tiffany, and Jonathan Driver. 2010. Paleodiet of Domestic Turkey, Shields Pueblo (5MT3807), Colorado: Isotopic Analysis and Its Implications for Care of a Household Domesticated. *Journal of Archaeological Science* 37:2433–2441.
- Roth, Barbara J. 2018. *2017 Archaeological Investigations at the Elk Ridge Site (LA 79863), Mimbres Valley, Grant County, New Mexico*. Report on file with the US National Forest Service, Gila National Forest, New Mexico.
- Roth, Barbara J., and Kathryn M. Baustian. 2015. Kin Groups and Social Power at the Harris Site, Southwestern New Mexico. *American Antiquity* 80:451–471.

- Roth, Barbara J., Patricia A. Gilman, and Roger Anyon (editors). 2018. *New Perspectives on Mimbres Archaeology: Three Millennia of Human Occupation in the North American Southwest*. University of Arizona Press, Tucson.
- Russell, Narissa. 2012. *Social Zooarchaeology*. Cambridge University Press, Cambridge.
- Sandor, Jonathan A., John W. Hawley, Robert H. Schiowitz, and Paul L. Gersper. 2008. Soil-Geomorphologic Setting and Change in Prehistoric Agricultural Terraces in the Mimbres Area, New Mexico. In *Geology of the Gila Wilderness-Silver City Area*, edited by Greg Mack, James Witcher, and Virgil W. Lueth, pp. 167–175. New Mexico Geological Society, Socorro.
- Schoeninger, Margaret J., and Michael J. DeNiro. 1984. Nitrogen and Carbon Isotopic Composition of Bone Collagen from Marine and Terrestrial Animals. *Geochimica et Cosmochimica Acta* 48:625–639.
- Schollmeyer, Karen Gust. 2011. Large Game, Agricultural Land, and Settlement Pattern Change in the Eastern Mimbres Area, Southwest New Mexico. *Journal of Anthropological Archaeology* 30:402–415.
- Schollmeyer, Karen Gust, Michael W. Diehl, and Jonathan A. Sandor. 2018. Variability in Mimbres Food and Food Procurement. In *New Perspectives on Mimbres Archaeology: Three Millennia of Human Occupation in the North American Southwest*, edited by Barbara J. Roth, Patricia A. Gilman, and Roger Anyon, pp. 169–192. University of Arizona Press, Tucson.
- Schollmeyer, Karen Gust, and Jonathan C. Driver. 2013. Settlement Patterns, Source-Sink Dynamics, and Artiodactyl Hunting in the Prehistoric U.S. Southwest. *Journal of Archaeological Method and Theory* 20:448–487.
- Schollmeyer, Karen Gust, and Stephen O. MacDonald. 2020. Faunal Remains from Archaeology Sites in Southwestern New Mexico. *Occasional Papers of the Museum of Southwestern Biology* 13:1–58.
- Schorger, Arlie W. 1961. An Ancient Pueblo Turkey. *Auk* 78:133–144.
- Schorger, Arlie W. 1966. *The Wild Turkey: Its History and Domestication*. University of Oklahoma Press, Norman.
- Schwartz, Christopher W., Andrew D. Somerville, Ben A. Nelson, and Kelly J. Knudson. 2021. Investigating Pre-Hispanic Scarlet Macaw Origins through Radiogenic Strontium Isotope Analysis at Paquimé in Chihuahua, Mexico. *Journal of Anthropological Archaeology* 61:101256.
- Schwartz, Christopher W., Kelley L. M. Taylor, and Michelle Hegmon. 2022. The Human Experience of Transporting and Raising Scarlet Macaws at Paquimé in Northern Chihuahua, Mexico. In *Birds of the Sun: Macaws and People in the U.S. Southwest and Mexican Northwest*, edited by Christopher W. Schwartz, Stephen Plog, and Patricia A. Gilman, pp. 297–320. University of Arizona Press, Tucson.
- Senior, Louise M., and Linda J. Pierce. 1989. Turkeys and Domestication in the Southwest: Implications from Homolovi III. *Kiva* 54:245–259.
- Shafer, Harry J. 2003. *Mimbres Archaeology at the NAN Ranch Site*. University of New Mexico Press, Albuquerque.
- Shafer, Harry J. 2006. Extended Families to Corporate Groups: Pithouse to Pueblo Transformation of Mimbres Society. In *Mimbres Society*, edited by Valli S. Powell-Martí and Patricia A. Gilman, pp. 15–31. University of Arizona Press, Tucson.
- Shaffer, Brian S. 1991. *The Economic Importance of Vertebrate Faunal Remains from the NAN Ruin (LA 15049), a Classic Mimbres Site, Grant County, New Mexico*. Master's thesis, Department of Anthropology, Texas A&M University, College Station.
- Shaw, Harley G., and Cheryl Mollohan. 1992. Merriam's Turkey. In *The Wild Turkey: Biology and Management*, edited by James G. Dickson, pp. 331–349. Stackpole Books, Mechanicsburg, Pennsylvania.
- Speller, Camilla, Brian Kemp, Scott Wyatt, Cara Monroe, William Lipe, Ursula Arndt, and Dongya Yang. 2010. Ancient Mitochondrial DNA Analysis Reveals Complexity of Indigenous North American Turkey Domestication. *PNAS* 107:2807–2812.
- Stubbs, Stanley, and William S. Stallings. 1953. *The Excavation of Pindi Pueblo, New Mexico*. Monographs of the School of American Research No. 18. University of New Mexico Press, Albuquerque.
- Thornton, Erin Kennedy, Tanya Peres, Kelly Ledford Chase, Brian M. Kemp, Ryan Frome, Aurélie Manin, Lauren Basnett, Krista McGrath, Camilla Speller, and Elizabeth J. Reitz. 2021. Testing for Mississippian Period Turkey Management in the Archaeological Record of the Southeastern United States. *American Antiquity* 86:794–814.
- Tykot, Robert H. 2006. Isotope Analyses and the Histories of Maize. In *Histories of Maize: Multidisciplinary Approaches to the Prehistory, Linguistic, Biogeographic, Domestication and Evolution of Maize*, edited by John E. Staller, Robert H. Tykot, and Bruce F. Benz, pp. 131–142. Academic Press, New York.
- Tyler, Hamilton A. 1979. *Pueblo Birds and Myths*. University of Oklahoma Press, Norman.
- Webster, Monica, and M. Anne Katzenberg. 2008. Dietary Reconstructions and Human Adaptation in West Central Chihuahua. In *Celebrating Jane Holden Kelley and Her Work*, Special Publications No. 5, edited by Meade F. Kemrer, pp. 71–101. New Mexico Archaeological Council, Albuquerque.
- Zeder, Melinda A. 2012a. The Domestication of Animals. *Journal of Anthropological Research* 68:161–190.
- Zeder, Melinda A. 2012b. Pathways to Animal Domestication. In *Biodiversity in Agriculture: Domestication, Evolution, and Sustainability*, edited by Paul Gepts, Thomas R. Famula, Robert L. Bettinger, Stephen B. Brush, Ardeshir B. Damania, Patrick E. McGuire, and Calvin O. Qualset, pp. 227–259. Cambridge University Press, Cambridge.

Cite this article: Dolan, Sean G., Andrew T. Ozga, Karl W. Laumbach, John Krigbaum, Aurélie Manin, Christopher W. Schwartz, Anne C. Stone, and Kelly J. Knudson. 2023. Understanding Turkey Management in the Mimbres Valley of Southwestern New Mexico Using Ancient Mitochondrial DNA and Stable Isotopes. *American Antiquity* 88(1):41–61. <https://doi.org/10.1017/aaq.2022.81>.