The adoption of cattle pastoralism in the Arabian Peninsula: A reappraisal

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Abstract
The translocation of livestock into the Arabian Peninsula was underway by the sixth millennium BC. It remains unclear, however, whether nascent pastoralism in Arabia focused on specialised cattle herding, intensive caprine husbandry, or more extensive forms of sheep, goat and cattle management. Here, the role of Bos in Neolithic animal exploitation systems in the Arabian Peninsula is re-examined in the context of fisher-hunter-gatherer groups inhabiting the coasts of the Arabian Gulf, agro-pastoralist settlements located in the Jordanian highlands, and hunter-herder communities in adjacent Jordanian steppe (badia). By the late sixth millennium BC, cattle from southern Mesopotamia were imported to the Arabian littoral via Ubaid exchange networks but remained a relatively unimportant part of local hunter-gatherer-herder subsistence for at least a millennium. New zooarchaeological evidence indicating cattle herding in the Jordanian highlands by the late eighth millennium BC suggests a southern transmission route originating out of Late Pre-Pottery Neolithic B settlements and the subsequent spread of cattle along the Sarawat mountains into the interior or down the relatively arid Red Sea coast via land or boat. Cattle eventually played a central role in the symbolic and ritual lives of herders in southern Arabia, but the use of the term ‘cattle pastoralism’ to describe early Neolithic subsistence systems in the region is premature.

Keywords
Neolithic, translocation, cattle, aurochs, zooarchaeology

1 | INTRODUCTION

The transition from hunting and gathering to food production in Arabia involved the uptake of domesticated sheep, goat, and cattle and, crucially, the subsequent adaptation of this subsistence complex to arid environments defined by unpredictable water and pasture availability. These animals added to the subsistence milieu of fisher-hunter-gatherers inhabiting the coasts of the Arabian Gulf as well as hunter-gatherers foraging in the interior of the Arabian Peninsula, but the pathways and processes by which this transition took place are still being defined, as are the livestock species involved. Cattle played a part in this process, but it remains unclear whether nascent pastoralism in Arabia focused on specialised cattle herding, intensive caprine husbandry, or the use of a full ‘Neolithic pastoralist package’ of mixed sheep, goat, and cattle herds.
Previous research has argued that *Bos* played a core role in the initial spread of livestock herding out of the Levant into northern Arabia, with specialised cattle pastoralism subsequently developing there as an adaptation to the relatively well-watered grassland environments that characterised much of the Arabian Peninsula during the early Holocene (Fedele, 2008; Guagnin et al., 2015; 2017a). However, *Bos* was rarely exploited in the adjacent Jordanian *badia* where gazelle were hunted throughout the early Holocene and, by the mid- to late-seventh millennium BC, low-level caprine herding practiced (Martin, 1999). The absence of cattle in the earliest herding systems of the *badia* is incongruent with narratives describing early Neolithic pastoralism in northern Arabia as cattle focused, and consequently researchers have looked to the role of indigenous domestication processes in the emergence of mobile pastoralism in Arabia to explain this gap (Crassard & Khalidi, 2017; Magee, 2014). Sheep and goats were clearly domesticated outside of the Arabian Peninsula in the Near East where their wild progenitors were distributed and a deep zooarchaeological record indicates nascent caprine management by the mid-ninth millennium BC (Arbuckle & Atici, 2013). There is, however, some debate regarding independent domestication of cattle in Arabia. Aurochsen (*Bos primigenius*) inhabited diverse habitats ranging from forests to open grassland and, like domesticated cattle, required daily access to an open water source to meet their water needs. Favourable environmental conditions in Arabia during the early to mid-Holocene feasibly supported aurochsen populations. Paleolake formation was underway, for example, by ca. 10,000 cal BC in the Jubbah oasis in the Nefud (Hilbert et al., 2014), while strengthening of the southwest Asian monsoons between ca. 8,000–7,000 cal BC increased humidity and rainfall levels across northern Arabia, supporting the formation of paleolakes, ‘*qa’at* (large seasonal accumulations of standing water), and lush grasslands (Preston et al., 2012) that would have provided ample graze and water for *Bos*.

However, unequivocal evidence for aurochsen in the Arabian Peninsula remains lacking. Two *Bos* premolars from the late sixth–fifth millennium BCE site of Jebel al-Buhais 18, located in the interior of the Oman Peninsula (Figure 1), were identified as aurochsen based solely on their large size as assessed by visual inspection (Uerpmann & Uerpmann, 2008). At the late sixth to mid-fifth millennium BC site Dosariyah, thirteen fragmented *Bos* specimens were also attributed to aurochsen on the basis of their perceived large size, although fragmentation prevented collection of metric data except for measurements from two mandibular third molars, skeletal elements less useful for inferring wild status (Uerpmann & Uerpmann, 2018). Putative aurochsen were identified in the Sa’ada region of northwest Yemen on the basis of fragmented tooth remains recovered from the poorly dated, possibly late sixth millennium BC Neolithic site of Jabal Makhruq 18 and Bronze Age Wadi Rubay 5 (Hadjouis, 2007), but it is unclear precisely how those determinations

**FIGURE 1** Sites and geographic locations discussed in the text. ‘*Azraq sites*’ include Ayn Qassiyya, Kharaneh IV, *Azraq* 31, and Jilat 13; ‘Sa’ada sites’ include Jebel Makhrug 18 and Wadi Rubay 5; ‘Jubbah Basin’ includes Jebel Oraf 2; ‘Jfar Basin’ includes Wadi Abu Tulayha and Wadi Ghuwayr 17 [Colour figure can be viewed at wileyonlinelibrary.com]
were made. A proximal radius from the undated ‘Pre-Neolithic’ levels of Wadi at-Thayilih 3 (TH3) on the eastern Yemen Plateau yielded metrical values that placed the specimen in the middle of the size spectrum between wild and domestic cattle, and three other Bos specimens from the same layer were described as possibly belonging to aurochs based on the absence of domesticated sheep and goats in the ‘Pre-Neolithic’ assemblage. However, the paucity of caprines at TH3 may instead reflect poor preservation of the recovered faunal assemblage that limited taxonomic characterisation of bone specimens only to size group (with the exception of two specimens identified as belonging to gazelle) (Fedele, 2008: 166). Pre-Neolithic Bos specimens at TH3 could also reasonably represent domesticates intrusive from later occupation of the site. Overall, the taxonomic assignments of aurochs skeletal elements recovered from Neolithic Arabian sites do not stand up to scrutiny.

The abundant rock art record of the Arabian Peninsula provides only ambiguous evidence for the presence of aurochs in the region. A rock engraving in the Jubbah Basin portraying the trunk of a large bovid may depict an aurochs (Guagnin et al., 2018), but taxonomically diagnostic horns belonging to this image, which is stratigraphically earlier than depictions of domesticated cattle, did not preserve. At Kilwa in northern Arabia, a single Bos engraving bearing forward-pointing horns with the tips ending near the eyes, morphology characteristic of aurochs and comparable to Bos imagery from Pre-Pottery Neolithic Göbekli Tepe, shows the animal with a hind leg in a trap and facing a hunter. This engraving was reported during the 1930s (Horsfield, Horsfield, & Glueck, 1933; see figure 13 in Guagnin et al., 2015), but that depiction has not been again identified. Further to the south, engraved images on rocky outcrops associated with Jebel Makhruq 18 have been described as depicting aurochs (Rachad, 2007). However, these Bos images display very large, forward-curving horns that turn outward at the tip, forming a lyre shape more closely associated with a breed of long-horned cattle. Bos bearing similarly shaped horns were engraved in scenes clearly depicting cattle herding at Shuwaymis (Guagnin et al., 2015).

The faunal and rock art records do not clearly confirm the presence of aurochs in the Arabian Peninsula, but it is plausible that wild Bos were distributed, albeit sparsely, across northern Arabia including the Jubbah Basin and Nefud Desert. The adjacent Jordanian badia provides additional environmental and zooarchaeological context. Like northern Arabia, the badia supported a relatively rich landscape of grasslands, tree stands, oases, and year-round bodies of standing water and also aurochs populations, into the Early Holocene. In the Azraq Basin, articulated Bos lumbar vertebrae, placed on the floor of a structure, were identified at Epipaleolithic Kharaneh IV and were clearly identifiable as aurochs (Maher et al., 2012). Bos were also exploited at early Epipaleolithic Ayn Qassiyya and Natufian Azraq 18, providing further evidence for substantial standing water and marshland in the Azraq Oasis during the late Pleistocene (Martin et al., 2016). Bos skeletal remains identified at the Early and Late Natufian site of Shubayqa 1 indicate the sporadic hunting of aurochs further to the east in the Black Desert (Yeomans, Richter, & Martin, 2017).

2 | THE TRANSITION FROM HUNTING TO HERDING IN THE ARABIAN PENINSULA

Much debate remains as to whether the shift from hunting to herding in northern Arabia involved the adoption of livestock by local hunter-gatherers or the spread of herding groups out of the southern Levant (Crassard & Dreschler, 2013; Magee, 2014). Northern Arabia and the southern Levant were culturally connected by the early ninth millennium BC (Crassard et al., 2013), but technological, subsistence and social dynamics in northern Arabia were largely local (Crassard & Dreschler, 2013). A similar pattern is visible in southern Arabia where use of local lithic traditions continued throughout the seventh to fifth millennium BC during which time livestock were taken up (Crassard, 2008). The persistence of morphologically distinctive lithic industries throughout Arabia during the Neolithic points to continued autochthonous technological developments that paralleled subsistence shifts tied to the spread of livestock domesticates into the region (Crassard & Khalidi, 2017). Notably, this technology transfer process mirrors developments in the northern Jordanian badia during the seventh millennium BC. There, local lithic industries rooted in earlier hunter-gatherer traditions remained in use when domestic caprines were initially incorporated into local, gazelle-based subsistence systems (Miller et al., 2018).

The shift from hunting and gathering to herding on the eastern coasts of the Arabian Peninsula appears to have entailed the uptake of livestock by local forager communities. There, mobile groups using locally derived lithic and pottery technologies intensively fished shallow water species, foraged for shellfish, hunted terrestrial game and marine mammals, and also exploited some domesticated livestock (Carter, 2020). Southern Mesopotamia was a reasonable departure point for the initial translocation of bovid livestock into Gulf Coast, although it is plausible that domesticates came into the region via other pathways across the Arabian Peninsula or, possibly, via a ‘southern coastal route’ along Yemen. The transfer of livestock out of southern Mesopotamia into the Gulf region likely occurred along a highly connective ‘small-world’ exchange network that promoted exchange between distant partners rather than neighbouring settlements (Ortega et al., 2014). This network ultimately linked together
small-scale agrarian Ubaid settlements with fisher-hunter communities situated along the coastal Gulf via a maritime interaction sphere (Carter, 2018). Ubaid pottery consistently appears in Neolithic coastal sites alongside locally produced lithic tools and pottery (Crassard & Dreschler, 2013), as well as bitumen from northern Iraq (Van de Velde, 2015) and obsidian from Anatolia (Renfrew & Dixon, 1976).

3 | EVIDENCE FOR DOMESTICATED CATTLE USE IN ARABIA

3.1 | The Arabian Gulf coast

The early Ubaid context for domesticated cattle husbandry in Arabia is uneven. Ubaid settlements located in Upper Mesopotamia focused on mixed agro-pastoralism involving dry farming, flood-basin agriculture and barnyard husbandry, while hunting and herding was pursued in more arid environments (Akermans, 1993; Grossman & Hinman, 2013). Much less is known about animal exploitation in southern Mesopotamia, where recovery and analysis of faunal remains were generally of low priority in early excavation campaigns. Animal exploitation at Tell ‘Oueili, located in southern Mesopotamia and the earliest known Ubaid settlement, appears to have focused on the intensive exploitation of pigs for intensive meat production, low-level exploitation of caprines, and only occasional use of cattle (Desse, 1996). However, the Tell ‘Oueili faunal assemblage consists of less than 200 specimens identifiable to terrestrial genera that altogether represent the entire Ubaid 0 to Uruk period sequence, preventing reliable estimation of the relative importance of different livestock species. Radiocarbon determinations measured from charcoal recovered from Ubaid 1 layers suggest livestock were in use there by the mid-sixth millennium BC (Valladas, Evin, & Arnold, 1996), although the association of animal remains to specific occupation levels at Tell ‘Oueili is not reported. Earlier dates from Ubaid 0 occupation of the site, measured from shells with an unknown reservoir effect, are less reliable in establishing the initial use of domesticates at Tell ‘Oueili.

The earliest appearance of cattle in the Gulf coast region roughly coincides with early Ubaid occupation at Tell ‘Oueili. Cattle were exploited along with sheep and goats by the mid-to late sixth millennium BC at the settlement H3, as-Sabiyah, located on the north-western extent of the Arabian Gulf and connected to Mesopotamia indicated by the presence of Ubaid pottery alongside locally produced red wares (Carter & Crawford, 2003). However, domesticates made only a marginal contribution to local subsistence which focused on fishing and hunting of marine turtles and gazelle (Beech & al-Husaini, 2005). Seven Bos bone specimens were recovered from H3, including a distal tibia, distal metatarsal shaft, and a proximal metatarsal, all described as belonging to ‘small-sized animals’, likely domesticates, although no metrical assessment was possible due to high fragmentation of specimens (Beech, 2010).

The translocation of cattle down the western Gulf littoral may have taken place after the initial establishment of sheep and goats in the region. The earliest coastal sites have not, to date, yielded remains of cattle despite the consistent, albeit low-level, presence of caprines. Cattle were not exploited at Marawah, although sheep and goat remains, along with Ubaid pottery, fish, dugong and gazelle remains, were recovered from occupation layers in a tripartite house dating to the mid-sixth millennium BC (Beech et al., 2020). Cattle are also absent at Dalma, an inshore fishing site located on Dalma island yielding some Ubaid pottery. There, sheep and goat were exploited, along with gazelle deliberately introduced to the island, by the mid- to late sixth millennium BC (Beech, 2000; Beech & Glover, 2005). Further to the south-east on the coast of the Oman Sea, sheep and goat bones, as well as the remains of fishes native to mangroves, were present in the shell midden Ruways 1, dated to the mid-sixth millennium based on thermoluminescence dates, but no cattle remains were identified (Berger et al., 2020).

Cattle were regularly exploited at Dosariyah, a late sixth to mid-fifth millennium BC coastal settlement located in the central Gulf region (Uerpmann & Uerpmann, 2018). The high frequency (c. 20%) of cattle identified in the sizeable faunal assemblage recovered from the site suggests these animals were actively husbanded along with caprines (38%) for meat and progeny, while fishing and game hunting were also pursued. Additional zooarchaeological analyses documenting shifts in animal exploitation over time at the site would help clarify if intensive exploitation of cattle and caprines was practised initially at Dosariyah during the late sixth millennium or if this was a later mid-fifth millennium development. Cattle bones are also reported from ‘Ain Qannas, where equids were also hunted (Zeder, 1974). Ubaid pottery attests to at least a fifth millennium BC occupation of the site which may have been used earlier, during the late sixth millennium to the early to mid-fifth millennium BC, based on a few radiocarbon determinations measured from unidentified charcoal measured prior to the advent of AMS dating (Masry, 1997).

Cattle were exploited, albeit at very low intensities, at other late sixth millennium coastal sites where shellfish gathering and fishing provided the bulk of subsistence. At Umm al-Quwain 2 (UAQ 2), a massive stratified shell midden located on the Strait of Hormuz, cattle were occasionally exploited along with sheep and goats, possibly by the mid-to late sixth millennium BC based on radiocarbon determinations measured from shells and corrected for a reservoir effect (Mashkour et al., 2016). Ubaid pottery was identified
in the late sixth millennium BC layers of Umm al-Quwain 2, but it is unclear how this material culture is precisely linked chronologically with the faunal remains, which were grouped into two units, MN1/MN2 (5500/5300–5000 cal BC) and MN2 (5000–4500 BC), for analytical purposes (Mashkour et al., 2016). The nearby shell midden site of Umm al Quwain 38 (UAQ 38), dated to fifth millennium BC on the basis of material culture, including an Ubaid sherd, with charcoal radiocarbon determinations forthcoming, also yielded a small quantity of cattle, sheep and goat bones (c. 30 specimens in total) and large quantities of shellfish and fishes (Degli Esposti et al., 2020). Scattered cattle remains were also found along with quantities of fish, sheep and goats, and a surface Ubaid pottery find at Akab, a habitation site occupied from the early to mid-fifth millennium BC (Méry & Charpentier, 2012). Occasional cattle and caprine bones were also recovered from Ras al Hamra 6 (Uerpmann & Uerpmann, 2003). Recent re-dating of charcoal, shells and human bone from new excavations indicates the base level of the site dates to the mid-sixth millennium cal BC with the bulk of midden formation taking place during the early to mid-fifth millennium (Zazzo et al., 2016). The precise association between newly measured dates and domesticated animal bones from early excavations, however, is unclear.

Cattle were present in slightly more interior regions, probably by the late sixth millennium BC. At Jebel Buhais 18, a Neolithic graveyard associated with a midden and series of firepits located in the mountainous landscapes of the Oman Peninsula approximately 60 km from the coast, cattle as well as caprines were exploited. Earliest use of the site is dated to the late sixth millennium based on a single radiocarbon determination from a fire pit, while radiocarbon dates measured from other fire pits indicate use throughout the entire fifth millennium (Uerpmann, Uerpmann, & Jasim, 2000). The midden from which the majority of faunal remains were recovered, however, is not directly dated. Cattle, along with sheep and goats, were regularly exploited throughout the fifth millennium BC at Jebel Faya 15 (FAY-NE15; UAE), a graveyard site near to and roughly contemporary with Jebel Buhais 18. There, a small faunal assemblage yielded 18% cattle remains while caprines comprised about half of the assemblage (Uerpmann et al., 2012). A few cattle remains were also found at Jebel Faya FAY-NE 10, a nearby cave site containing a human cremation dating to the fifth millennium BC (Kutterer et al., 2012); earlier dates measured from shells and snail shell adornments may be less reliable.

The form of cattle use in coastal Neolithic sites in the Arabian Gulf remains unclear, although numerous active excavation programmes in the region promise to reveal more on Neolithic animal exploitation practices. The apparent absence of cattle at mid-sixth millennium BC settlements could reflect trade or transport decisions to instead focus on sheep and goats which require fewer water and fodder resources. The initial trace presence of cattle in the region may indicate these animals were temporarily stored as a source of meat on the hoof rather than managed in herds. The subsequent increase in the importance of cattle by the fifth millennium BC at some sites may be linked to the establishment of hypothesised seasonal rounds between the coast and the interior (e.g., Uerpmann et al., 2000) and the development of small-scale bovid husbandry. Despite intensification in the use of cattle as well as caprines, the remarkable continuity in local subsistence systems focused on fishing suggests strong maintenance of regional food acquisition strategies and, perhaps, cultural identities.

### 3.2 Southern and northern Arabia

The faunal records recovered from littoral Neolithic sites suggest that cattle, as well as caprines, played a role in burgeoning exchange networks that drew together agrarian Ubaid communities in southern Mesopotamia with fisher-hunter-herder groups in the Arabian Gulf. However, the earliest evidence for domesticated cattle exploitation in Arabia is from the southernmost reaches of the peninsula at the Neolithic rock-shelter site of Manayzah, located in the Hadramawt (Yemen) (Crassard et al., 2006). There, sheep, goat and Bos were exploited along with gazelle around the early sixth millennium BC according to radiocarbon determinations measured from acacia, tamarisk and Zizyphus wood charcoal (Crassard et al., 2006; table 1). Bos exploited at the site were small-bodied, smaller than both male and female aurochsen from Mesolithic Denmark, and likely domesticates (Martin et al., 2009). Cattle appear to have been used at lower intensities than caprines and gazelle, although the faunal assemblage is small (Martin, McCorriston, & Crassard, 2009).

The early use of cattle and caprines in southern Arabia by hunter-gatherers using local lithic technologies is also attested, albeit on very tentative chronological grounds, in faunal assemblages recovered from Neolithic Wadi Thayyilah (TH3) and Jebel Qutran. At the Wadi Thayyilah (TH3), a small faunal assemblage yielding fewer than 50 specimens identifiable to genus attests to cattle, sheep and goat herding on the Yemen Plateau (Fedele, 2008), although the site is undated. The higher number of Bos at TH3 relative to caprines possibly indicates a greater emphasis on cattle in local subsistence systems, but it remains to be seen if TH3 and nearby Jebel Qutran, another undated Neolithic site where caprines are slightly more abundant than cattle, represent a distinct ‘upland Neolithic tradition’ consisting of cattle herders adapted to highland landscapes (Fedele, 2008).

The early sixth millennium BC date of cattle and caprine husbandry in the Hadrawmat, before these animals were exploited by communities inhabiting the coastal Arabian Gulf region, indicates other translocation pathways were in
operation. Recent work in the northern Nefud is providing tantalising glimpses into livestock transmission dynamics of the interior Arabian Peninsula. In the Jubbah Basin, tooth fragments belonging to *Bos* identified at Jebel Oraf 2, a cluster of at least 170 hearths associated with Neolithic occupation situated on the edge of a paleolake, hint at early movements of domesticated cattle into the Nefud. These faunal specimens were surface finds recovered near a hearth indirectly dated to the late sixth millennium BC based on a radiocarbon determination, measured from unidentified charcoal, recovered from lake deposits below the hearth (Guagnin et al., 2017a). Originally interpreted as evidence for cattle herding and highlighted as a contrast to caprine husbandry practised in the Jordanian *badia* (Guagnin et al., 2017a), it remains to be seen if these few remains represent a specialised adaptation of cattle pastoralism to wetter environments.

While the zooarchaeological record for northern Arabia is currently scant, the rock art record is providing some intriguing perspectives into the complexity of the transition from hunting to herding in this region. The extensive rock art in the Jubbah Basin, much of it likely dating to the Neolithic, depicts scenes of human figures hunting mixed herds of wild animals accompanied by a single ox, panels showing humans herding, and figures depicted in hunting scenes later reworked into herding scenes (Guagnin, 2017b). The continuity in the stylistic rendering of the human figures associated with both wild prey and domestic animals alludes to an indigenous transition from hunting to herding while demonstrating that hunting remained important (Guagnin, 2017b). Cattle are prominently depicted in these scenes, albeit usually as single animals or in pairs, but goats appear as well. This contrasts with the rock art at Shuwaymis, located to the south-west of Jubbah along the edge of the Nefud. There, images share the same engraving tradition and styles as seen at Jubbah but portray much larger numbers (>15) of cattle placed over hunting scenes and no goats or sheep. The complete absence of domesticated caprines in otherwise diverse animal menageries that included ibex, equids and dogs is enigmatic, perhaps indicative of stronger cultural and subsistence connections with the south rather than the Jordanian *badia* where caprine herding took place.

The characterisation of early Neolithic herding systems in northern and southern Arabia as focused on specialised cattle pastoralism has been largely framed by later developments at the mid- to late fifth millennium site of Shi‘b Kheshiya (Yemen) where a monumental construction consisting of over forty adult cattle skulls placed upright in a ring has drawn parallels with cattle cults in Africa (McCorriston et al., 2012). At Shi‘b Kheshiya, the high number of prime-aged cattle used to construct the monument suggests substantial local herds that could withstand heavy culling, while the enormous amounts of meat generated by coordinated slaughter, along with numerous hearth installations contemporaneous with the skull ring, strongly suggest sacrificial feasting events that drew together dispersed mobile communities (McCorriston et al., 2012).

### 4 | PERSPECTIVES FROM THE JORDANIAN *BADIA* AND HIGHLANDS

One of the challenges to understanding the translocation of cattle into northern and southern Arabia has been reconciling the chronological disparities between the apparent late use of managed domesticates in the southern Levant with an earlier timing of cattle uptake in Arabia. Citing inconclusive evidence for domesticated cattle in the southern Levant during the Late PPNB (7250–6700 BC) and their apparent appearance in southern Arabia before cattle were present in the arid margins of the Levant, researchers have invoked local domestication processes, staggered introduction and internal translocation of domesticates in order to explain the presence and hypothesised proliferation.

![Figure 2](image-url) Log-size index (LSI) distribution for Neolithic *Bos* from southern Jordan. LSI values calculated according to the Ullerslev standard and metrical data from appendicular skeletal elements including fused specimens, unfused specimens, and specimens with unknown state of epiphyseal fusion. PPNA: Wadi Faynan 16 (Makarewicz, unpublished data); MPPNB: Beidha (Makarewicz, unpublished data); LPPNB: ‘Ain Ghazal (Von den Driesch & Wodtke, 1997), Basta (Becker, 2002), Tel Tif‘dan (Twiss, 2003)
of cattle in southern Arabia. Previous zooarchaeological research argued for relatively late use of domesticated cattle in the southern Levant around the early sixth millennium BC during the Pottery Neolithic when Bos body size decreased dramatically (Makarewicz, 2016; Marom & Bar-Oz, 2012). However, this pattern was isolated in faunal assemblages recovered from settlements located west of the Jordan Valley, a region that followed a subsistence trajectory distinct from other regions in the southern Levant. Domesticated cattle were clearly in use much earlier, by the late eighth–early seventh millennium BC as part of caprine-oriented animal exploitation systems characteristic of large, densely constructed LPPNB settlements spread throughout the Jordanian highlands (Makarewicz, 2013). A substantial new biometrical dataset generated from Bos skeletal elements recovered from PPN settlements located east of the Jordan Valley, including aurochsen from PPNA Wadi Faynan 16, wild or managed animals from Middle PPNB ‘Beidha, as well as previously published data from LPPNB ‘Ain Ghazal, Basta and Tel Tif’dan, indicates a significant decrease in Bos body size, a phenotypic trait associated with the domestication syndrome, during the Late PPNB (Figure 2). Experimentation with cattle management has also been previously argued for at ‘Ain Ghazal during the Late PPNB (Von den Driesch & Wodtke, 1997).

The initial spread of herding out of the Jordanian highlands east into the northern Jordanian badia during the late seventh–early sixth millennium BC was associated with caprine husbandry (Martin, 1999). The absence of cattle in earlyLate Neolithic sites in the northern badia is striking save for Azraq 31 and Jilat 13, where Bos remains are infrequent (<1%) and likely represent aurochsen which were exploited during earlier occupation of these sites (Martin, 1999). These zooarchaeological data strongly suggest that the initial translocation vector for cattle out into Arabia was further to the south, likely through landscapes that supported oases and deep wadis that provided the substantial quantities of water required by cattle.

One potential route was via the Jafr Basin. The Jordanian highlands and the Jafr Basin region were culturally connected during the late eighth–early seventh millennium BC, evidenced in the exchange of material culture between highland and southern badia communities (Fujii, 2013). Cattle also appear to have moved along those exchange networks, although evidence for cattle in the al-Jafr Basin is limited to petrographic images and a few faunal remains. At LPPNB Wadi Abu Tulayha, where gazelle and hare hunting provided the bulk of subsistence, three cattle bone specimens were identified along with some caprine remains (Hongo et al., 2013). Portable rock art from nearby LPPNB Wadi Guwhayr 17 bears pecked images depicting two very large animals exhibiting long, upright tails and large, forward-curling horns typically associated with domesticated cattle, along with horned, strongly goat-like animals placed alongside a human figure as well as a scene depicting a small herd of herbivores (see Fujii, Quintero, & Wilke, 2013).

![Figure 3](image-url)  
**Figure 3** Comparison of body size distribution according to LSI values calculated for breadth and length measurements for aurochsen from PPNA Wadi Faynan 16 and domesticated cattle from nearby Late PPNB Tel Tif’dan. Metrical data for Tel Tif’dan (Twiss, 2003, NISP = 69, fused specimens and specimens with unknown state of epiphyseal fusion) and WF16 from Makarewicz (unpublished data, NISP = 102, fused specimens only).
local subsistence systems based on hunting or gathering wild animal resources. After their introduction, the relative importance of different livestock species likely differed regionally across the Arabian Peninsula. Sheep and goats held greater importance in the subsistence economies of Neolithic settlements situated on the Gulf Coast, while cattle were more intensively exploited in southern and possibly northern Arabia. However, much more data are needed to evaluate regional patterning. Although at present there are too few archaeological and faunal data to precisely define early Neolithic livestock use in Arabia, new archaeological surveys and excavations promise to provide new insights into translocation dynamics.

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