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From Hunters to Herders in Eastern Mongolia: Long-Term Trends in Animal Hunting and Management

Abstract: Zooarchaeology or the study of animal remains from archaeological sites gives important information about many aspects of human societies in the past, including cultural practices, hunting strategies, diet, and also the environment. Here, we present the results of zooarchaeological analysis from Palaeolithic and Neolithic sites in eastern Mongolia. We show that horses were one of the most important species in all periods and that wild cattle (aurochs) became increasingly important in the Neolithic. It is also clear that both environment and hunting strategies changed beginning around 8500 cal BP, when precipitation increased and temperatures were warmer across East Asia. The types of species recovered from Neolithic sites show an increase in the range of animals hunted, specifically more focus on hard to catch prey like hare/rabbit (Leporids), foxes, and even birds. Species diversity decreased again in the Bronze Age with the introduction of domesticated herd animals. The results show that relationships between humans, herds, and grasslands were fundamental to the development of Mongolian society, regardless of climate change. We should envision the three pillars of pastoralism – herder-pasture-livestock – as fundamental to sustainable subsistence in Mongolia with its roots stretching back to the Palaeolithic.

Keywords: Palaeolithic, Neolithic, pastoralism, zooarchaeology, diet, palaeoenvironment

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Introduction

The origin of pastoralism is a critical area of research in Mongolia. The transition from hunting and gathering to food production, including the management and domestication of both plants and animals, is also one of the most important themes in western archaeology. The most popular theory associated with this study in the west is that of the "Broad-Spectrum Foraging Revolution (олон төрлийн идэшний хувьсгал)" (Flannery 1969; Stiner 2000). The main idea is that increasing diet breadth or broad-spectrum foraging at the end of the Palaeolithic was driven by the declining availability of large ungulates (i.e. large deer, aurochs, horses), causing hunter-gatherers to increasingly hunt small prey. The shift in diet was accompanied by increasing sedentism, which facilitated the taming and domestication of plants and animals (Binford 1968, Flannery 1969).

Stiner (2000) further defined broad-spectrum foraging as an increasing reliance on small, fast prey like hare and birds – animals that were harder to catch relative to caloric return. She argued that the incorporation of small, fast prey into human diets was related to increased population density, which caused a decline in the availability of large prey like wild cattle (aurochs), deer, and horses. The change in diet made it possible for the land to support higher densities of people living in one place for longer because small, fast prey have high reproduction rates and are so highly resistant to intensive hunting. This is why sedentary populations worldwide typically rely on fishing and/or high consumption of plant foods like grass seeds and nuts. This model has been widely adopted and applied to other world regions, including China (Liu et al. 2014; Zhang et al. 2010)

Janz (2012, 2016) applied the framework to the transition from hunting and gathering to food production (pastoralism) in the Gobi Desert, and East Asia more broadly, in order to understand whether a similar set of processes could be applied to Mongolia. Working with museum-based collections from the Gobi Desert, Janz showed that the emphasis on dune-field wetland environments by hunter-gatherers in the Gobi Desert during the Neolithic period mirrors a similar trend towards broad spectrum foraging witnessed in other parts of the world after the Last Glacial Maximum. Here, Janz argued that an increase in precipitation after 8500 cal BP led to a change in hunter-gatherer land-use in Mongolia, with a shift towards increasing emphasis on, including longer-term and frequent reoccupation of "oasis" environments (Janz 2016, 2024; Zhao et al. 2021). Palaeolithic sites in the Gobi Desert and the Gobi-Altai, in comparison, were often located in upland (≥ 1200 m a.s.l.) environments around springs and rivers (Janz 2012, 2016, 2024). When it became clear that the adoption of grinding stones and an emphasis on wetland environments corresponded to climatic amelioration – notably, warmer temperatures and higher levels of more precipitation – Janz challenged the idea that broad spectrum foraging is stimulated by declines in the availability of large ungulates through environmental degradation (Binford 1968) or population pressure (Stiner et al. 2000).

The spatial distribution (дурсгалын газар зүйн тархалт) of sites in different time periods, as well as differences in the intensity of core reduction, showed that Neolithic groups adopted a pattern of land-use characterized by the establishment of long-term residential base camps in locations such as dune-fields, freshwater marshes, and rivers at the juncture of forests and open plains. Such environments have high biodiversity (ургамал амьтны олон төрөл зүйл), including small, fast prey that are resilient to heavy hunting. Groups focused on longer-term occupation of these environments would have used hunting and gathering task groups to forage at even longer distances. Based on this idea – that oasis environments were fundamental to post-glacial changes in land-use – she suggested that the terms Mesolithic and Neolithic (originating in Europe to describe European prehistory) might be changed to Oasis 1 (Mesolithic, >13,500-8500 cal BP), Oasis 2 (Early Neolithic, 8500-5000 cal BP), Oasis 3 (Late Neolithic/Bronze Age, 5000-3000 cal BP) (Table 1) to signify the unique nature of post-glacial hunter-gatherer adaptations in the Gobi Desert (Janz 2012, Janz et al. 2015). The initial findings of this work have since been supported by additional research on the Gobi Desert Neolithic undertaken by Mongolian-American research teams (Farquhar 2022; Rosen et al. 2019, 2022).

Unlike Europe and the Middle East, there was no large-scale extinction of large ungulates in Mongolia after the loss of megafauna (e.g. *Mammuthus primigenius*, *Coelodonta antiquitatis*, *Struthio anderssoni*). This seemed to counter the idea that increased diet breadth was related to the depression of large ungulate populations in the Gobi Desert. Infact, the corresponding increase in precipitation and temperature would likely have favoured population growth among local wild herds. Janz argued that broad spectrum foraging in the Gobi Desert likely did not correspond to a decline in the availability of large game. She argued that increased diet breadth (олон төрлийн хүнс тэжээл хайх болсон шалтгаан нь) was the result of environmental changes (e.g. enhanced forestation and expansion of freshwater lakes) that created ecological concentrations of small, fast prey. Nor does increased diet breadth in Mongolia appear to have led to food production. Domesticated herd animals were introduced to East Asia during the fourth millennium BC and may have not become widespread until after the third millennium BC (Lu et al. 2017; Honeychurch et al. 2021).

Table 1. Summary of Janz's chronological phases and associated technologies (after Janz 2012, 2024; Janz et al. 2017).

Chronological Phases	*Dates*	*Organizational Strategy*	*Tool Types*
Oasis 1 (Mesolithic)	>13,500-8500 cal BP	High residential mobility, use of wetlands	Microblade technology; expedient core and flake; pottery by 9600 cal BP
Oasis 2 (Early Neolithic)	8500-5000 cal BP	Reduced residential mobility, wetland-centric logistical foraging	Microblade technology; more formal flake cores; large formal milling stones; chipped and/or polished adzes and axes; bifacial projectile points; textile-impressed pottery
Oasis 3 (Late Neolithic/ Bronze Age)	5000-3000 cal BP	Wetland-centric logistical foraging, introduction of domesticated herd animals	Microblade technology; increased in use of flake cores; bifacially-flaked arrowheads, blades, knives; milling stones; copper slag; increased use of local lithic materials; moulded rim coarse redware, geometric incised

These ideas suggest that Mongolia presents an archaeological case study of unique interest within global archaeology and draws attention to the unique nature of Mongolian traditional diets and human-environment relationships. The three pillars of pastoralist life – herder-pasture-livestock (Enkhtuvshin and Tumurjav 2011; Erdenetsogt 1996) – are the three pillars of human evolution in the northern steppes of Central and East Asia. Grasslands were much more extensive in the Pleistocene and the earlier Pliocene epoch and the evolution of humans, including the shift from scavenging (бэлэн хүнс хайх) to hunting to the role of apex predator in most modern ecosystems, was founded upon the relationship between humans, grasslands, and wild herd animals. The Central/East Asian Steppe is one of the largest remaining grasslands, alongside the American Great Plains, Serengeti and Sahel in Africa, the grasslands of North Australian grasslands, and the South American Pampas (Bardgett et al. 2021). Many of these ecosystems co-evolved with humans and have been fundamental to human environmental adaptation. The archaeological wealth of *gobi* and steppe environments of Mongolia attest to the unique role of these open landscapes to the formation of Mongolian culture.

Testing the relationship between land-use and diet, however, required an understanding of diet and this was more challenging due to a lack of well-preserved animal bone in Stone Age archaeological assemblages from Mongolia. This changed in 2013 with the discovery of Zaraa Uul (Odsuren et al. 2015) and additional operations at Tamsagbulag since 2018 (Odsuren et al. 2019, 2022, 2023a, 2024). Here, two periods of occupations – the Initial/ Early Upper Palaeolithic and the Oasis 2 – contain very well-preserved faunal remains. Tamsagbulag, discovered first in the 1940s, contains even more abundant faunal material. Due to the high degree of fragmentation, analysis of the material requires an extensive comparative collection of modern animal skeletons and has been analyzed in Canada and returned to Mongolia under a series of loan agreements. The resulting analysis represents an exceptional opportunity to understand nearly 35,000 years of human diet and natural environment in eastern Mongolia, including changes over time and differences in human land-use and diet between geographically close but ecologically distinct regions.

Hunting Strategies through Time

The Gobi-Steppe Neolithic (GSN) project has been investigating human land-use and human-animal relationships in eastern Mongolia since 2013. Our work has primarily focused to two archaeological localities: Zaraa Uul (Tuvhsinshiree *soum*, Sükhbaatar *aimag*) and Tamsagbulag (Khalkh-gol *soum*, Dornod *aimag*). Habitation sites at Zaraa Uul mainly relate to two temporal periods – the Initial/Early Upper Palaeolithic (Otson Tsokhio) (Odsuren et al. 2023b) and the early Neolithic or Oasis 2 (Il Enger, also referred to in publication as Zaraa Uul) (Janz et al. 2021). Burial remains associated with the Prone Burial and Slab Grave complexes suggest that the site was also an important location during the Bronze and early Iron Ages (Odsuren et al. 2015; Janz et al. 2021). Archaeological remains from Tamsagbulag, in contrast, date almost exclusively to the Early Neolithic. Studying these three sites together allows us to capture a glimpse of long-term trends in hunting.

Otson Tsokhio (37,100-27,600 cal BP)

This open-air site is one of two discovered by the GSN project in 2015 during excavations of Neolithic remains from Il Enger. Test units were begun in 2017 and excavations took place in 2018 and 2022. Otson Tsokhio was located on the slope of an erosion gully which drains into the greater Ögöömöriin Govi Valley, where there was a massive saline lake during the Late Palaeolithic (Rosen et al. 2022). Stone tool typology connect this site to the Initial and Early Upper Palaeolithic, and appears to show a progression in lower stratigraphic levels from Initial Upper Palaeolithic production of blades on Levallois-type prepared cores to the production of blades and bladelets on volumetric cores (Odsuren et al. 2023b). The faunal preservation at this site was excellent and included a unique deposit, where a juvenile *Crocuta ultima* (hyaena) skull was sandwiched between a giant elk (*Megaloceros* sp. or *Sinomegaceros* sp.) metatarsal, and a woolly rhinoceros (*Coelodonta antiquitatis*) scapula (Odsuren et al. 2023b:9, 16-17). Ostrich eggshell was recovered, including one perforated fragment, and dates are contemporaneous with the intentional deposit. This elk metatarsal was directly at 38,301-35,834 cal BP (95.4%) (32,371 ± 430 [UOC-22696]), while five other dates from the site ranged between 38,206-27,697 cal BP (Odsuren et al. 2023b:13).

Il Enger (8500-6500 cal BP)

The Early Neolithic period remains of Il Enger (also referred to as Zaraa Uul) were discovered in 2013 and excavated during 2015-2018 field seasons. Geoarchaeological research showed that the saline lake of the Pleistocene had been transformed into an expansive freshwater marsh (бүрд газар) (Rosen et al. 2022). Most of the Neolithic material appears to have been a secondary deposit that originated higher up the hillslope, though some primary deposits are possible for ZU3.T1. Finds represent waste from successive habitation sites, including fauna, lithic debitage from production, small fragments of pottery, broken and incomplete tools (including grinding stones and adzes), and decorative objects (including flower-shaped beads made from freshwater mussel shell) (Janz et al. 2021:4). The site was located on the flanks of an extinct volcano, which had high-quality cherts embedded into chunks of vesicular basalt, which explains the large number of lithics, including many microblade cores and many adzes at various stages of manufacture of use/discard. A wide variety of animal species were present at this site, including both ungulates, hare/rabbit (Leporids), and fur-bearing carnivores.

Tamsagbulag (8400-7400 cal BP)

Tamsagbulag was first discovered in the 1940s and is located in Dornod province, 30-40 km from the border of Inner Mongolia along the high southern bank of a former tributary of Buir Lake, just west of the three-headed spring for which the site was named. In 1968 another rectangular pit dwelling was excavated at Ovoot, about nine kilometers west of Choibalsan on the north bank of the Kherlen River (Dorj 1971). Tamsagbulag and the Ovoot site (located about nine kilometers west of Choibalsan on the north bank of the Kherlen River) are currently the only known Neolithic sites in Mongolia with clear evidence for substantial site architecture. The numerous radiocarbon dates for Tamsagbulag indicate that the site was used 8400-6000 cal BP, and most intensively at 7800-7400 cal BP (Zhao et al. 2021, S.d. Table 1).

Four rectangular semi-subterranean dwellings, two burials, and several other features were excavated by Dorj and Derevianko in the 1960s. The Gobi-Steppe Neolithic project has since fully excavated five additional dwellings (TB1, TB9, TB12, TB13, and TB14), one burial and located a number of other features associated with human activity (Odsuren et al. 2024). TB1 was unique in that it appears to have been a surface dwelling, while all others were pit-dwellings of various depths (Odsuren et al. 2019). Out of all the dwellings excavated, House 1 (7.6 m x 5.6 m), from Dorj's excavations, was best preserved and showed deep post-holes around the perimeter walls, lack of a clear doorway, and substantial interior pit structures (Dorj 1971). The house floor was surrounded by a foundation trench 50-80 cm deep within which one row of posts was set as a structural complement to a second cluster of posts in the centre of the living floor; these would have served as support for a pyramidal roof. There were also four large rectangular household pits over a metre long and up to 40 cm deep, filled with darker soils, flaking debitage, and bone. The burial of a young woman was found seated in a sub-floor pit at the north end of House 1 (Derevianko and Dorj 1992; Dorj 1971). Our own test excavations in 2023 uncovered the remains of another adult woman just south, though outside the walls, of a dwelling feature (Odsuren et al. 2024:25-30).

The artifact assemblage contains a full range of materials: ceramics, lithics, groundstone digging weights, clay tablets, ornaments (mostly made from animal teeth), and bone tools. Tamsagbulag is located on an alluvial plain devoid of stone. A preliminary geological survey suggests that there is no source for chert within at least 100 km of the site. All of the stone used would have been transported from some distance. The relative lack of lithics (compared to Zaraa Uul), the advanced stage of core reduction and tool use before discard, and the prominence of the regionally-distinct "tamsag scrapers" – blocky macro-tools made on coarse-grained felsite or comparable material – all point to the lack of local raw materials.

Deposits of highly organic soils, up to one metre deep, show intensive site use, while the scattering of dwellings stretching over nearly a kilometer along the river terrace, shows that the occupation of this site was much more substantial than any other Neolithic sites found in Mongolia to date. The intensive occupation resulted in large midden deposits, many of which were found within dwellings. Bone is the most common archaeological material, with more than 100 kg recovered to date. Analysis is ongoing and we have yet to process material derived from screens. Therefore, the exact frequencies and diversity of represented species will be slightly different once the analysis is completed – likely with slightly higher percentages of small mammals such as hare/rabbit, birds, and fish. There is clear evidence of domesticated dogs, including gnawing on animal bones, skeletal remains incorporated into middens, and even a complete burial located beneath one of the successive house floors of TB13 (Odsuren et al. 2023a:42-43).

Changes in representation of body size

Analysis of archaeological fauna was carried out in the Janz Archaeology Laboratory, University of Toronto Scarborough. Janz developed a list of possible prey species based on published data on Mongolian mammalian (Batsaikhan et al. 2010) and avian (Boldbaatar and Tugsbayar 2013) fauna. All mammalian fauna were divided into size classes, based on published body weight ranges of the species included in this analysis: mega mammal or "MGMAM" (> 1000 kg); large mammal or "LMAM" (> 150 kg); large medium mammal or "LMMAM" (50-150 kg); medium mammal or "MMAM" (10-50 kg); small mammal or "SMAM" (2-10 kg); and micromammal or "MCMAM" (< 2kg). Large medium mammals were classified as large mammals to reduce categorization errors during quantitative analysis. When size was uncertain between two classes ("SMMAM" or Small- to Medium-MAMmal), the larger size class was selected ("MMAM"). As such, the quantitative data presents a systematic bias towards larger size classes. Unidentifiable ungulates were classified according to size: "LUNG" (> 150 kg), "MUNG" (50-150 kg), and "SUNG" (10-50 kg). All of the small-bodied prey in this sample should be considered "small, fast prey." Slow-moving small animal prey are not common in Mongolia.

There is always some chance that faunal assemblages include intrusive elements, for example rodents from later burrows. We compared level of surface mineralization on fauna and bones with no evidence of surface mineralization visible to the naked eye were categorized as intrusive. Intrusive elements were excluded from the analysis and not reported here (but are reported in Janz et al. 2021). A small collection of bone from Zuun Shovkh, another Palaeolithic site in the Zaraa Uul complex, is not reported here as most of the bones show evidence of digestive etching and are not believed to directly relate to human activity, but rather to the activity of a non-human predator (Janz et al. 2021).

Table 2 focuses on Zaraa Uul and shows a clear change in the relative frequencies of different sized prey over time, from 96.3% of all animal species represented at Otson Tsokhio to 52.5% of all animal species represented at Il Enger. There are corresponding increases in medium- and small-bodied species, with a particular emphasis (30.5%) on species between 2-10 kg during Oasis 2. Interestingly, the relative frequency of micro-species (< 2 kg) remains consistent between periods. This signature may be due to the later and intrusive introduction of ground-burrowing rodents into the archaeological assemblage. The results show a clear decline in the relative importance of large-bodied (> 50 kg) prey from the Palaeolithic to Oasis 2. This supports Janz's hypothesis that small, fast prey were more intensively targeted by hunters during Oasis 2.

Table 2. Distribution of prey by body-size between Otson Tsokhio and Il Enger, including all fauna identified to body size and/or Order. NISP = Number of Identified Specimens, NUSP = Number of Unidentified Specimens.

Body Size	*Otson Tsokhio* *N =* *(% of NISP)*	*Il Enger* *N =* *(% of NISP)*	*Total* *N =* *(% of NISP)*
Mega (>1000 kg)	4 (0.4)	0	4 (0.1)
Large (50 to 1000 kg)	1086 (95.9)	1052 (52.5)	2138 (68.2)
Medium (10 to 50 kg)	9 (0.8)	285 (14.2)	294 (9.4)
Small (2 to 10 kg)	10 (0.9)	612 (30.5)	622 (19.8)
Micro (< 2 kg)	23 (2.0)	54 (2.7)	77 (2.5)
Total NISP	1132 (85.3)	2003 (50.8)	3135 (59.5)
Total NUSP	195 (14.7)	1936 (49.1)	2131 (40.5)
Total Specimens	**1327**	**3939**	**5266**

Key species hunted through time

Moving beyond body size presents slightly different results. The range of species identified to Order and Species is the focus of Table 3 and includes relative frequencies from both Zaraa Uul and Tamsagbulag localities. Cervids were seldom identified beyond body size because the modern comparative collection did not contain all local species, making it difficult to securely identify deer to species. It should also be noted that there is some overlap in size categories with ungulate species, particularly between medium and small size classes. For example, small female caprines might be categorized as small bovids or medium mammals, while large males would be considered medium bovids or large medium mammals. Carnivore sizes were classed as follows: "LCARN" (> 25 kg), "MCARN" (2-25 kg), and "SCARN" (< 2 kg).

The only large bovid would have been *Bos* or *Bison*. More complete Bovinae (үхрийн) elements were checked against both *Bos* and *Bison* using modern skeletal remains and/or comprehensive published studies of the post-cranial morphological differences between these genera (Boessneck et al. 1963; Balkwill and Cumbaa 1992). Elements clearly recognizable as belonging to *Bos primigenius* included ulna, tibia, metapodials, carpals, tarsal, and phalanges. No individuals were unquestionably attributed to *Bison* sp. Specimens were classified as "Bovinae" if no firm distinction could be made. All Neolithic-period habitation (8500-6500 cal BP) at Zaraa Uul predates the arrival in East Asia of *Bos taurus* and other domesticated herd animals by more than a millennium (Lu et al. 2017) and aDNA analysis has confirmed the identification of all Neolithic individuals as *Bos primigenius* as opposed to *Bos taurus* or *Bison* sp. (Brunson et al. Nd). For this reason, all Bovinae were classified as *Bos* in Table 3.

Results of the analysis are tabulated in Table 1 and described as relative frequencies based on number of elements identified to each species. Individual elements that were clearly from the same individual were combined in this analysis. For example, only two marmots were included in the quantification of Il Enger because only two individuals were represented amongst the 63 marmot bones. At least one of these individuals could be related to intrusive burrowing in later periods.

Table 3. Summary of species from Otson Tsokhio, Il Enger, and Tamsagbulag that were identified to Order or Species. Many species are grouped together in order to simplify the results. NISP = Number of Identified Specimens.

Species	*Otson Tsokhio*	*Il Enger*	*Tamsagbulag*
	%NISP	*%NISP*	*%NISP*
Woolly rhinoceros (*Coelodonta antiquitatis)*	4.8	0	0
Camel (*Camelus* sp.)	2.4	0	0
Auochs (*Bos primigenius*)	4.8	8.8	40.2
Horse (*Equus* spp.)	50	14.0	17.8
Small bovid (Antilopinae/small Caprine)	2.4	8.4	24.3
Deer (Cervidae)	7.0	4.8	1.9
Medium bovid (large Caprinae)	2.4	7.6	0
Boar *(Sus scrofa)*	0	2.4	1.3
Small to Medium Carnivore (e.g, *Lynx*, *Vulpes*, *Meles)*	0	5.6	2.8
Large Carnivore (e.g. *Canis* sp. *Crocuta ultima*, *Panthera tigris*)	7.0	0.4	5.9
Hare/rabbit (Leporidae*)*	0	33.2	3.4*
Marmot (*Marmota* sp.)	0	0.4	0.2*
Micromammals (e.g. *Ochotona*, *Mustela*)	19.0	11.6	>1.0*
Birds (Aves)	0	2.8	>0.5*
Fish (Pisces)	0	0	>0.5*
Total NISP	42	250	876
Total	**99.8%**	**100%**	**99.8%**

** These numbers will likely be higher once screen bags from Tamsagbulag are analyzed.*

Equids are shown to be the most consistently hunted species through time, making up 50% of the Otson Tsokhio assemblage and 14.0% and 17.8% at Il Enger and Tamsagbulag, respectively. We have not yet determined to which of at least three possible species they belong (*Equus ferus*, *Equus hemionus*, *Equus ovodovi*), but osteological, isotopic, and aDNA analysis are ongoing. At Otson Tsokhio, aurochs (*Bos primigenius*), camel (*Camelus* sp.), gazelle, mountain sheep (c.f. *Ovis ammon*), giant elk and a medium-bodied deer were all present in this small assemblage. One bone belonged to a canid – either a wolf (*Canis lupus*) or a domesticated dog (*Canis familiaris*) – based on the early date of the site, the bone likely belongs to a wolf. There were also a number of unidentified rodent bones and one pika bone (*Ochotona* sp.). These were not directly dated and we can not say for certain that they were contemporaneous and targeted by local hunters as food; however, there is no strong reason to assume that Palaeolithic humans were not occasionally consuming rodents and other such species.

Il Enger is especially interesting due to the dominance (33.2%) of Leporids (hare/rabbit). Another notable point is that the assemblage contained several species that are not present in the region today, including a large cat (c.f. *Panthera tigris*), raccoon dog (*Nyctereutes procyonoides*), badger (*Meles leucurus*), boar (*Sus scrofa*), and a range of deer species. Marmot (*Marmota* sp.) was also present, but most of the elements belong to the same individual. The presence of raccoon dog, deer and boar show that the location was much wetter and more heavily vegetated than today, likely with trees at higher elevations (Bazarova et al. 2019; Rosen et al. 2019, 2022) and around river channels, in addition to mature wetland vegetation. Such a habitats would have supported a high diversity of plant and animal species. A small number of birds were also present. The most common species represented, aside from Leporids, were aurochs (*Bos primigenius*) and equids.

Gazelle (*Procapra subgutterosa*), boar (*Sus scrofa*), and wild caprines (зэрлэг бог) (*Ovis ammon* and/or *Capra ibex sibirica*) were present in smaller numbers. Gazelle was especially abundant at Tamsagbulag, but the combined percentage of these medium-sized ungulates is fairly similar between Il Enger and Tamsagbulag (and higher than at Otson Tsokhio). The emphasis on *Procapra gutterosa* at Tamsagbulag, along with what appear to be one or two so far unidentified Antilopinae species, is consistent with environmental differences. The open steppe ecosystem at Tamsagbulag would be ideal for regular interaction with large herds of gazelle, whereas caprines should not be present. Fox (*Vulpes* sp.) also appears to have been a critical species at both sites. The species would certainly have been prized for its fur and might also have been eaten. Other wild carnivores, including canids, are present in both sites in smaller numbers. As noted above, domesticated dog remains were comingled with remains of other animal species Tamsagbulag. Fish remains are unique to Tamsagbulag, but not abundant. Fragments of feshwater mussel (*Unio* sp.) shell were also found throughout the site, but not quantified. The presence of these species is not surprising considering the site's location along the terrace of a former river. The presence of these species is much lower than we would expect considering the location and sedentary quality of the site.

The species of primary dietary importance at Tamsagbulag are aurochs and equids, with a particular emphasis on aurochs (40.2%). Equids are more common than aurochs in the earliest Neolithic components of Il Enger (8500-7500 cal BP), but are of greater importance in later components of Il Enger (7500-6500 cal BP) (Janz et al. 2021). Likewise, aurochs is more abundant in some dwellings at Tamsagbulag than at others. This slightly different focus could be related to seasonal differences in availability or changes over time, but might just as likely be related to cultural preferences. The discovery of an aurochs sculpture (Odsuren et al. 2018) and the possible ritual burial of aurochs at other sites in Dornod *aimag* (Dorj 1971) suggest that local peoples may have had a special connection to the species. Aurochs were especially important here and the emphasis on this species led Dorj and Derevianko to suggest that the site was an agropastoralist (тариачин, малчин) encampment with domesticated cattle. The exact relationship between humans and aurochs is currently being investigated (Brunson et al. Nd), but now know that domesticated cattle (*Bos taurus*) were not present and likely did not arrive in Mongolia until after about 5500 cal BP (Lu et al. 2017; Cai et al. 2018).

The fauna from Otson Tsokhio, Il Enger, and Tamsagbulag provide allow for a series of observations about regional trends in hunting from the Pleistocene to the Holocene. Differences between Tamsagbulag and Il Enger, which are broadly contemporaneous, but from different environmental contexts, can also give some insight into the variation of species hunted during the Early Neolithic/Oasis 2. The results are not necessarily representative of all regions of Mongolia, but provide a foundation of observation of general trends. It is important to note that results of analysis from Tamsagbulag is preliminary. Although we believe it likely that small species are currently under-represented, analysis of screen bags from Tamsagbulag 13, grid unit C0 (TB13.C0) and Tamsagbulag, quadrant 4 (TB9.Q4) indicates the likelihood that the high frequency of Leporids at Il Enger is distinct from Tamsagbulag. Several key points emerge from this analysis: herd animals have always been of primary importance to people living in Mongolia, despite a shift towards broad spectrum foraging between 8500 cal BP and 5000 cal BP; and equids have continuously played a key role in sustaining human life in this region, including a brief period of sedentism.

Roots of Herder-Pasture-Livestock Relationship: A View from Eastern Mongolia

Analysis of faunal remains from eastern Mongolia provide information on cultural and economic activities of early humans, as well as palaeoenvironment. Geological and pollen data show that Holocene environments by 8500 years ago had shifted from expansive open grasslands dotted with large saline lakes to fragmented grassland and forest ecosystems with many freshwater lakes and marshes (Bazarova et al. 2019; Rosen et al. 2019, 2022). We know that many large herbivores, or megafauna, went extinct sometime between the end of the Pleistocene and the Holocene. Pleistocene environments were characterized by expansive grasslands and mosaic grassland steppes, and Holocene grasslands would have shrunk as closed forests became more common in Northeast Asia. These changes resulted from changes in temperature and precipitation, but also from the extinction of megafauna (үлэмж амьтад) like woolly rhinoceros and mammoth, who are known to keep forests open by trampling and eating young trees vegetation from growing (Bakker et al. 2016; Barnosky et al. 2016; Malhi et al. 2016). Our analysis also shows a clear continuity in modern human sites, from the Palaeolithic onwards, in the presence of horse, cattle, caprines, and gazelle. It also shows the addition of species like hare/rabbit, birds and even fish, during several millennia of increased precipitation, wetland expansion and forestation. The combination of megafaunal extinctions and climate change resulted in very different landscapes than had previously existed, but also presented continuity that allowed hunter-gatherers to adapt to environmental changes.

One of the main areas of continuity was in the reliance on equids. Horses are a critical component of faunal assemblages in eastern Mongolia from some of the earliest occupations by modern humans through the Holocene, and they continue to have dietary and ritual importance today. One notable finding is that aurochs (*Bos primigenius*) became increasingly important during Oasis 2 and appear to have genetically contributed to domestic cattle herds for a long time after the introduction of *Bos taurus* from Central Asia (Brunson et al. Nd). Medium-sized ungulates were also critical to hunter-gatherers through time. Gazelle (mostly *Procapra gutterosa*) remains are very common at Tamsagbulag (24.3%), while gazelle and caprines together made up 16% of species identified at Il Enger. At the same time, the development of forest and marshland vegetation provided new hunting opportunities, including boar (*Sus scrofa*) and a range of cervids such as roe deer (*Capreolus pygargus*) and red deer (*Cervus canadensis*). Fish and freshwater shellfish (*Unio* sp.) are also present in small numbers and are unique to Oasis 2. A greater emphasis on canids is also evident in Oasis 2 sites, with lots of evidence of gnawing on bones (likely from domesticated dogs) and skeletal remains of both fox (*Vulpes* spp.) and dog (*Canis familiaris*, *C. lupus*). From this, we know that domesticated dogs were active in human settlements by at least Oasis 2, and we can infer that they could have contributed to hunting practices – perhaps playing a key role in the increased emphasis on hunting small, fast prey like hare/rabbits during Oasis 2.

It is important to remember that Palaeolithic hunting strategies in Mongolia would have varied across time and space and Otson Tsokhio does not reflect the full range despite being critical to understanding human land-use and diet during the Mongolian Palaeolithic. Contemporaneous faunal assemblages from North China and Siberia likewise demonstrate the importance of equids for Palaeolithic humans (Germonpre and Lbova 1996; Deng 2005). This trend continued into the Holocene and at Botai, Kazakhstan, even led to a local domestication event wherein *Equus ferus przewalski* sustained sedentary village communities (Levine 1999; Outram et al. 2009; Gaunitz et al. 2018).

The role of equids and bovines in the northern steppes was exceptionally persistent and even existed alongside a period of diet breadth expansion beginning around 8500 cal BP. During this time, large ungulates continued to represent anywhere from 23-58% of all species hunted. Moreover, the shift to food production in Mongolia did not undermine the importance of herd animals, but merely reinforced and cemented the local importance of this mutualistic relationship between humans and herds. Erdenetsogt's (1996) three pillars of pastoralist life – herder-pasture-livestock – has much deeper roots than the 3rd millennium BC. The co-evolution of hunter-pasture-herds are the three pillars of human evolution and this relationship has maintained the balance of grassland ecosystems in Central and East Asia since at least the arrival of modern humans.

The adoption of herding in Mongolia can be seen as a return to and reformulation of human-herd-grassland relationships. The shift towards domesticated herd animals in Mongolia is concurrent with a reshaping of ecological conditions – harvesting timber for kilns and smelting furnaces may have reduced forest vegetation in tandem with changing environmental changes, just as the vociferous grazing of invasive species such as domesticated sheep (*Ovis aries*) and goats (*Capra hircus*) could have reduced forests and made it difficult for them to regrow under the effect of heightened aridity after 4000 cal BP (see examples in Cermak et al. 2005; Schneider et al. 2021). The relationship between grazing practices, hydrological systems, and arboreal/shrub vegetation is highlighted by modern studies in the United States, where unrestricted grazing (in this case due to a lack of predators) is closely tied to loss of vegetation and environmental degradation (Fortin et al. 2005; Lundgren et al. 2022). Such changes would have resulted in the modern anthropogenic (хүний нөлөөгөөр үүссэн) landscapes historically present in Mongolia, most notably the re-establishment of expansive grassland ecosystems with forests largely limited to high-elevation mountain slopes, small groves of willow around some waterways, and birch-popular groves in protected gullies (Cermak et al. 2005).

Importance of Pastoralism in Mongolia

Tracing this progression of human-animal relationships from the Palaeolithic to the Bronze Age demonstrates the interconnectedness of human-environment systems and show that archaeology is important for understanding long-term environmental change and highlighting the importance of maintaining traditional subsistence strategies (идэш, тэжээл бэлдэх арга барил буюу аж ахуй) that fit with the constraints and opportunities inherent in local ecosystems. Herding is critically important to the long-term sustainability of northern environments where extreme seasonality and shallow soils limit agricultural production. Northern environments do not produce sufficiently high-quality vegetal resources to easily sustain humans without the consumption of meat. Therefore, ungulates are critical to subsistence in northern environments because they turn inedible vegetation into edible and highly nutritious fat and meat. Herding of domesticated animals has been prevalent in Central Asia for at least 6000 years and in Mongolia for at least 4000 years. There are five traditional species important to the pastoralist life in Mongolia: sheep, goat, cattle, camel, and horse. All are eaten and provide both meat and secondary products, making it possible to provide for all of the herder's basic needs: food, drink, shelter, clothing, tools, and transport. Moreover, when compared to modern agriculture, traditional pastoralism regenerates rather than degrades the soil and, although practices are changing, herding does not require high input of harmful substances because free-range grazing dramatically reduces the need for antibiotics. The abundance of grasslands in northern Eurasia and the many advantages of pastoralism in grassland ecosystems explains why red meat is the mainstay of a traditional northern diet and why the nutritional quality of meat and fat (including from the organs, which can provide vitamins and micronutrients otherwise available from vegetables) is so highly prized in traditional Mongolian society.

At the same time, a diet overly rich in fat and meat can have limitations on health. To counter the rich content of traditional diets, traditional practices were based on specific nutritional and dietary regimens. Critical to this meat-based diet were practices of correct proportions, choosing food according to season (i.e. meat in winter and dairy in summer), and using fasting to detoxify and cleanse the body (Lkhagvaa 1998). Lkhagvaa (1998) asserts that traditional Mongolian diets were focused on subsistence rather than physical and mental satisfaction through food. "Harms inflicted due to greediness via eating" is argued to be one of the ten black sins that leads to loss of Mongolian character (Tudev 1999, cited by Enkhtuvshin and Tumurjav 2011:75). The fact that people are eating imported food and drink when there are so many millions of healthy animals in the country has been seen as a tragedy by proponents of the traditional diet (e.g. "Be careful from malicious people, who are mindful to invade us via foods.") (Tudev 1999, cited by Enkhtuvshin and Tumurjav 2011:76). Archaeological data shows that red meat has been a critical resource for Mongolian people since the first arrival of fully modern humans in East Asia. As environments changed, local peoples found new ways to maintain sustainability while maintaining an emphasis on horses, cattle, and small- to medium-sized ungulates such as gazelle and caprines. The same pattern persists today. While the pathway to modernity in more southern climates often focused on ever-intensifying reliance on carbohydrate-rich plant foods – a strategy that matches well with the goal of supporting higher and higher population densities – Mongolian peoples continued to prioritize their relationship with herd animals, including the return to a more herd-centric economy after the Bronze Age. Such a strategy is consistent with sustainable human adaptation to northern grasslands.

Over the past 4000 years, domesticated herds have replaced and displaced wild ungulate herds in much of Central Asia, making them even more critical to the maintenance of local grasslands, which evolved under intensive grazing regimes. Herd migration is a critical component of grassland maintenance and recovery so that conscientious grazing greatly improves topsoil retention and soil quality. Mongolia is one of the few countries where land tenure practices – keeping grasslands open for communal grazing rather than dividing them into private property – supports herding and grassland health rather than disadvantaging pastoralists. Agricultural production in these same regions removes topsoil, drives erosion, and threatens steppe/prairie plant species, as well as the small mammals, reptiles, and birds that rely on them (Lark et al. 2020). Many urban agricultural states see pastoralists as a security threat and try to settle them in villages or cities to do wage labour, leading to the loss of the traditional ways of life and contributing to national problems of poverty, addictions, and illegal activity aimed at replacing lost income (Unruh 1995; Fletcher 2013; Quicke and Green 2018). In cases where pastoralists are not forcibly resettled, they are often pushed into the most arid regions unsuitable for agriculture, which can lead to overgrazing and grassland degradation under conditions of restricted movement (Bardgett et al. 2021). Likewise, attempts to modernize and increase production efficiency of herds often favours policies that promote penning cause overstocking and disallow recovery periods (Williams 1996), while global demand and high prices for secondary products such as cashmere also incentivizes overstocking (Berger et al. 2013; Lohre 2021) and further declines in wild herd populations.

Conserving these grasslands is critical to global health. Despite the fact that, internationally, more emphasis within ecological conservation is placed on forests, grasslands can be even more resilient carbon sinks than forests (Dass et al. 2018). They support vertebrate species richness comparable with forests and provide critical habitat for many avian, insect, amphibian, and small mammal species (Murphy et al. 2016). Grassland ecosystems coevolved with a large diversity of grazing herbivores and still rely on grazers to maintain health through fertilizing, reducing dead biomass, controlling invasive species, reducing closed forests to enhance landscape biodiversity, contributing food to humans, wild predators, and scavengers, and they diversify grassland habitats through minor disruptions such as creating wallows, small-scale erosion, and trampling. As such, preserving herding culture is fundamental to preserving environmental health in Mongolia. Understanding herding culture in Mongolia is not simply about understanding the introduction of domesticated herd animals in the Bronze Age as it is increasingly clear that local people integrated exotic herd animals into existing lifeways and that these traditional practices created the foundation upon which pastoralist adaptations developed.

Millennia of traditional ecological knowledge have been accumulated by local Mongolian herding families and this knowledge needs to be prioritized above foreign approaches to conservation. This paper uses archaeological data to show that the enduring relationship between human-herder-grassland began with the earliest modern humans. We use data from our recent excavations in eastern Mongolia to argue that the continued emphasis on mobility and herd animals in Mongolia is due to cultural and ecological conditions emphasizing the importance of these enduring relationships. We highlight the long-term interdependence of humans and herd animals like cattle, horses, gazelle, sheep and goats. This relationship is one of co-evolution and co-adaption and Palaeolithic and Neolithic cultural adaptations laid the foundations for traditional Mongolian pastoralist economies. The knowledge inherent in these systems has allowed the pastoralist economy to consistently outlive historical periods of state-building and urbanization by providing ways for Mongolian people to adapt to numerous changes in politics and climate. In order to protect and conserve grasslands and maintain resilient and sustainable land-use in Mongolia, these findings show a need to prioritize the conservation of grasslands and both wild and domestic herds, all of which have both environmental and cultural value that can ensure the survival of Mongolian peoples' culture and heritage.

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REFERENCES

Bakker E.S., Gill J.L., Johnson C.N., Vera F.W.N., Sandom C.J., Asner G.P., Svenning J.-C. 2016 Combining Paleo-Data and Modern Exclosure Experiments to Assess the Impact of Megafauna Extinctions on Woody Vegetation. Proceedings of the National Academy of Sciences 113(4): 847–55. https://doi.org/10.1073/pnas.1502545112.

Balkwill D.M., Cumbaa S.L. 1992 A Guide to the Identification of Postcranial Bones of Bos taurus and Bison bison. Syllogeus No. 71. Ottawa: Canadian Museum of Nature.

Batsaikhan N., Samiya R., Shar S., King S.R.B. 2010 A Field Guide to Mammals of Mongolia. London: Zoological Society of London.

Bardgett R.D., Bullock J.M., Lavorel S., Manning P., Schaffner U., Ostle N., Chomel M., et al. 2021 Combatting Global Grassland Degradation. Nature Reviews: Earth & Environment 2(10): 720–35. https://doi.org/10.1038/s43017-021-00207-2.

Barnosky A.D., Lindsey E.L., Villavicencio N.A., Bostelmann E., Hadly E.A., Wanket J., Marshall C.R. 2016 Variable Impact of Late-Quaternary Megafaunal Extinction in Causing Ecological State Shifts in North and South America. Proceedings of the National Academy of Sciences 113(4): 856–61. https://doi.org/10.1073/pnas.1505295112.

Bazarova V.B., Tsydenova N.V., Lyaschevskaya M.S., Khenzykhenova F.I., Tumen D., Erdene M. 2019 Reconstruction of paleoenvironmental conditions of ancient people habitation in the Togootyn Gol River valley (eastern Mongolia). Quaternary International 503: 105–114. https://doi.

org/10.1016/j.quaint.2018.10.017

Berger J., Buuveibaatar B., Mishra C. 2013 Globalization of the cashmere market

and the decline of large mammals in Central Asia. Conservation Biology 27:679-689.

Binford L.R. 1968 Post-Pleistocene adaptations. In New perspectives in archaeology. Chicago: Aldine, pp. 313-341.

Boessneck J., Jéquier J.-P., Stampfli H.R. 1963 Seeburg Burgäschisee-Süd. Teil 3: Die Terreste. Bern: Verlag Sta¨mpfli & Cie Bern; 1963.

Boldbaatar Sh., Tugsbayar Sh. 2013 Photo Guide to Birds of Mongolia. 2nd Edition. Ulaanbaatar: Mongolian Foundation of Birds of Prey & TUGS, LLC.

Brunson K., Witt K., Monge S., Williams S., Peede D., Odsuren D., Bukhchuluun D., Cameron A., Amartuvshin Ch., Honeychurch W., Wright J., Pleuger S., Erdene M., Tumen D., Rogers L., Khatanbaatar D., Batdalai B., Galdan G., Janz L. Nd Ancient Mongolian aurochs genomes reveal sustained introgression and management in East Asia. Preprint. BioRxiv. https://www.biorxiv.org/content/10.1101/2023.08.10.552443v1

Cai D., Zhang N., Zhu S., Chen Q., Wang L., Zhao X., Ma X., Royle T.C.A, Zhou H., Yang D.Y. 2018 Ancient DNA Reveals Evidence of Abundant Aurochs (Bos Primigenius) in Neolithic Northeast China. Journal of Archaeological Science 98: 72–80. https://doi.org/10.1016/j.jas.2018.08.003.

Cermak J., Opgenoorth L., Miehe G. 2005 Isolated mountain forests in Central Asian deserts: A case study from the Govi Altay, Mongolia. In Mountain ecosystems: Studies in Treeline Ecology. Earth and Environmental Science, Part 4. Springer, New York, pp. 253–273.

Dass P., Houlton B. Z., Wang Y., Warlind D. 2018 Grasslands may be more reliable carbon sinks than forests in California. Environmental Research Letters 13:074027.

Deng T. 2005 The fossils of the Przwalski's horse and the climatic variation of the Late Pleistocene of China. In Equids in Time and Space. Oxford: Oxbow Books, pp. 12-19.

Dorj D. 1971. Неолит Восточной Монголии. Ulaanbaatar: Masiha.

Enkhtuvshin B., Tumurjav M. 2011 Mongolian Nomads and Nomadic Animal Husbandry. IISNC: Ulaanbaatar.

Erdenetsogt N. 1996 Mongolian Nomadic Animal Husbandry. Ulaanbaatar.

Farquhar J.M. 2022. Human-Environment Interactions: The Role of Foragers in the Development of Mobile Pastoralism in Mongolia's Desert-Steppe. Unpublished PhD thesis. University of Pittsburgh.

Flannery K.V. 1969 Origins and ecological effects of early domestication in Iran and the Near East. In The Domestication and Exploitation of Plants and Animals. Chicago: Aldine, pp. 73–100.

Fletcher, R.S.G. 2013 Running the corridor: nomadic societies and imperial rule in the inter-war Syrian Desert. Past & Present 220: 185–215. https://doi.org/10.1093/pastj/gtt014

Fortin D., Beyer H.L., Boyce M.S., Smith D.W., Duchesne T., Mao J.S. 2005 Wolves influence elk movements: behavior shapes a trophic cascade in Yellowstone National Park. Ecology 86: 1320–1330.

Gaunitz C., Fages A., Hanghøj K., Albrechtsen A., Khan N., Schubert M., Seguin-Orlando A. et al. 2018 Ancient Genomes Revisit the Ancestry of Domestic and Przewalski's Horses. Science 360(6384): 111–14. https://doi.org/10.1126/science.aao3297

Germonpre M., Lbova, L. 1996 Mammalian remains from the Upper Palaeolithic site of Kamenka, Buryatia (Siberia). Journal of Archaeological Science 23(1): 35–57. https://doi.org/10.1006/jasc.1996.0004

Honeychurch W., Rogers L., Amartuvshin C., Diimaajav E., Erdene-Ochir N.-O., Hall M.E., Hrivnyak M. 2021. The earliest herders of East Asia: Examining Afanasievo entry to Central Mongolia. Archaeological Research in Asia 26: 100264. https://doi.org/10.1016/j.ara.2021.100264

Janz L., Feathers J., Burr G.S. 2015 Dating surface assemblages using pottery and eggshell: Assessing radiocarbon and luminescence techniques in Northeast Asia. Journal of Archaeological Science 57: 119–129. https://doi.org/10.1016/j.jas.2015.02.006

Janz L. 2012 Chronology of post-glacial hunter-gatherers in the Gobi Desert and the neolithization of arid Mongolia and China. Unpublished PhD Dissertation. University of Arizona.

Janz L. 2016 Fragmented landscapes and economies of abundance: The broad-spectrum revolution in arid East Asia. Current Anthropology 57(5): 537–564. https://www.journals.uchicago.edu/doi/abs/10.1086/688436

Janz L., Odsuren D., Bukhchuluun D. 2017 Transitions in palaeoecology and technology: hunter gatherers and early herders in the Gobi Desert. Journal of World Prehistory 30(1): 1–80. https://doi.org/10.1007/s10963-016-9100-5

Janz L., Rosen A.M., Bukhchuluun D., Odsuren D. 2021 Zaraa Uul: An archaeological record of Holocene palaeoecology in the Gobi Desert. PLOS One 16(4): e0249848. https://doi.org/10.1371/journal.pone.0249848

Janz L. 2024 Hunting, Herding, and Diet Breadth: A Landscape Based Approach to Niche Shifting in Subsistence Economies (Gobi Desert). Journal of Anthropological Archaeology. (in press)

Lark T.J., Spawn S.A., Bougie M., Gibbs H.K. 2020 Cropland expansion in the United States produces marginal yields at high costs to wildlife. Nature Communications 11: 4295.

Levine M.A. 1999 Botai and the Origins of Horse Domestication. Journal of Anthropological Archaeology 18(1): 29–78. https://doi.org/10.1006/jaar.1998.0332

Liu L., Kealhofer L., Chen X., Ping, J. 2014 A Broad-Spectrum Subsistence Economy in Neolithic Inner Mongolia, China: Evidence from Grinding Stones. Holocene 24(6): 726–742. https://doi.org/10.1177/0959683614526938

Lkhagvaa G. 1998 Study of Mongolian Traditional Nutrition is the Fundamental of Technological Renovation of Food Production. ScD dissertation. Ulaanbaatar.

Lohre E.K. 2021 Developing an Adaptive Resource Management Framework for Sustainable Cashmere Production in Mongolia. Unpublished PhD Dissertation. University of Vermont.

Lundgren E.J., Ramp D., Middleton O.S., Wooster E.I.F., Kusch E., Balisi M., Ripple W.J., et al. 2022 A novel trophic cascade between cougars and feral donkeys shapes desert wetlands. The Journal of Animal Ecology 91(12): 2348–2357. https://doi.org/10.1111/1365-2656.13766

Lu P., Brunson K., Yuan J., Li Z. 2017. Zooarchaeological and genetic evidence for the origins of domestic cattle in ancient China. Asian Perspectives 56(1): 92–120. https://doi.org/10.1353/asi.2017.0003

Malhi Y., Doughty C.E., Galetti M., Smith F.A., Svenning J.-C., Terborgh J.W. 2016 Megafauna and ecosystem function from the Pleistocene to the Anthropocene. Proceedings of the National Academy of Sciences 113(4): 838–46. https://doi.org/10.1073/pnas.1502540113

Murphy B.P., Andersen A.N., Parr C.L. 2016 The underestimated biodiversity of tropical grassy biomes. Philosophical Transactions Royal Society B 371: 20150319.

Odsuren D., Bukhchuluun D., Janz L. 2015 Дорнод Монголд хийсэн шинэ чулуун зэвсгийн үеийн судалгааны зарим үр дүн. Studia Archaeologica 35: 72–96.

Odsuren D., Janz L., Bukhchuluun D. 2019 Монгол-Канадын хамтарсан "Говь, хээрийн бүс нутгийн неолитийн судалгаа" төслийн 2018 оны хээрийн шинжилгээний ажлын тайлан. Ulaanbaatar.

Odsuren D., Janz L., Amartuvshin N., Adiyasuren M., Sugar-Erdene M. 2022 Монгол-канадын хамтарсан "Говь, хээрийн бүс нутгийн неолитын судалгаа" төслийн 2021 оны хээрийн шинжилгээний ажлын тайлан. Ulaanbaatar.

Odsuren D., Janz L., Adiyasuren M., Sugar-Erdene M., Dashzeveg D. 2023a Монгол-канадын хамтарсан "Говь, хээрийн бүс нутгийн неолитын судалгаа" төсөл: сүхбаатар аймгийн түвшинширээ сумын зараа уул, дорнод аймгийн халхгол сумын тамсагбулагт 2022 онд хийсэн археологийн малтлага судалгааны тайлан. Ulaanbaatar

Odsuren D., Janz L., Wolin D., Adiyasuren M., Akogun M., Sugar-Erdene M. 2024 Говь, хээрийн бүс нутгийн неолитын судалгаа төсөл: дорнод аймгийн халхгол сумын тамсагбулагийн дурсгалт газарт 2023 онд хийсэн археологийн малтлага судалгааны тайлан Ulaanbaatar.

Odsuren D., Janz L., Fox W., Bukhchuluun D. 2023b Otson Tsokhio and Zuun Shovkh: the Initial Upper Palaeolithic in Eastern Mongolia. Journal of Paleolithic Archaeology 6, Article 10. https://link.springer.com/article/10.1007/s41982-023-00139-x

Outram A., Stear N.A., Bendry R., Olsen S., Kasparov A., Zaibert V., Thorpe N., Evershed R.P. 2009 Earliest Horse Harnessing and Milking. Science 323(5919): 1332–35. https://doi.org/10.1126/science.1168594

Quicke, S.P., Green C. 2018 Mobile (nomadic) cultures' and the politics of mobility: insights from Indigenous Australia. Transactions of the Institute of British Geographers 43(4): 646–660. https://doi.org/10.1111/tran.12243

Rosen A.M., Hart T.C., Farquhar J., Schneider J.S., Yadmaa Ts. 2019 Holocene vegetation cycles, land-use, and human adaptations to desertification in the Gobi Desert of Mongolia. Vegetation History and Archaeobotany 28(3): 295–309. https://doi.org/10.1007/s00334-018-0710-y

Rosen A.M., Janz L., Bukhchuluun D., Odsuren D. 2022. Holocene desertification and human resilience in the eastern Gobi Desert, Mongolia. The Holocene 32(12): 1462-1476. https://doi.10.1177/09596836221121777

Schneider F., Klinge M., Brodthuhn J., Peplau T., Sauer D. 2021 Hydrological soil properties control tree regrowth after forest disturbance in the forest steppe of Central Mongolia. Soil 7(2): 563–584. https://doi.org/10.5194/soil-7-563-2021

Stiner M.C., Munro N.D., Surovell T.A. 2000 The tortoise and the hare: Small-game use, the Broad-Spectrum Revolution, and Paleolithic demography. Current Anthropology 41(1): 39–73. https://www.journals.uchicago.edu/doi/10.1086/300102

Tudev L. 1999 Ten black sins, which lead to loss of Mongol characters. Ulaanbaatar: Dal.

Unruh J.D. 1995 The relationship between indigenous pastoralist resource tenure and state tenure in Somalia. GeoJournal 36(1): 19–26. https://doi.org/10.1007/BF00812523

Williams D.M. 1996 The Barbed Walls of China: A Contemporary Grassland Drama. The Journal of Asiatic Studies 55(3): 665-691.

Zhang Y., Stiner M.C., Dennell R., Wang C., Zhang S., Xing G. 2010 Zooarchaeological Perspectives on the Chinese Early and Late Paleolithic from the Ma'anshan Site (Guizhou, South China). Journal of Archaeological Science 37(8): 2066–2077. https://doi.org/10.1016/j.jas.2010.03.012

Zhao C., Janz L., Bukhchuluun D., Odsuren D. 2024 Neolithic pathways in East Asia: early sedentism on the Mongolian Plateau. Antiquity 95(379): 45-64. https://doi.10.15184/aqy.2020.236