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Early agriculture and crop transmission among Bronze Age mobile pastoralists of Central Eurasia

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Archaeological research in Central Eurasia is exposing unprecedented scales of trans-regional interaction and technology transfer between East Asia and southwest Asia deep into the prehistoric past. This article presents a new archaeobotanical analysis from pastoralist campsites in the mountain and desert regions of Central Eurasia that documents the oldest known evidence for domesticated grains and farming among seasonally mobile herders. Carbonized grains from the sites of Tasbas and Begash illustrate the first transmission of southwest Asian and East Asian domesticated grains into the mountains of Inner Asia in the early third millennium BC. By the middle second millennium BC, seasonal camps in the mountains and deserts illustrate that Eurasian herders incorporated the cultivation of millet, wheat, barley and legumes into their subsistence strategy. These findings push back the chronology for domesticated plant use among Central Eurasian pastoralists by approximately 2000 years. Given the geography, chronology and seed morphology of these data, we argue that mobile pastoralists were key agents in the spread of crop repertoires and the transformation of agricultural economies across Asia from the third to the second millennium BC.

1. Introduction

In Central Eurasia (north of 40° latitude), the transformation from hunting to intensive mobile herding took place without farming in the fourth millennium BC. By the early third millennium BC, regional modes of mobile pastoralism took shape across the Eurasian steppe zone with distinctive forms of herd structure and diverse ranges of mobility [1–5]. Recent work across Eurasia has illustrated that by the third millennium BC mobile pastoralists also played a major role in the transfer of commodities, such as copper and tin and technologies, such as ceramics and bronze metallurgy along the proposed Inner Asian Mountain Corridor (IAMC [6]; figure 1). However, our knowledge of the use and spread of domesticated grains by Eurasian herders and the integration of farming into their mobile economies has suffered from the lack of systematically collected and regionally comparable archaeobotanical data. Currently, botanical evidence for farming in the steppes and mountains of Central Eurasia is only documented after *ca* 800 BC [7]. As a result, a perceived division between pastoralist 'nomadic' lifeways and settled farming has shaped centuries of history and prehistoric research in Eurasia, and likewise across the globe.

New archaeobotanical data from the pastoralist campsites of Tasbas and Begash, located in the highland steppe ecotone of eastern Kazakhstan currently offer the earliest concrete evidence for the use of domesticated grains by seasonally mobile herders across the Central Eurasian region (figure 1), dating from *ca* 2800 to 2300 cal BC (table 1). Here, Central Eurasia designates (broadly) territories north of the Syr Darya River to the southern boundary of the forest steppe zone, and east of the Ural Mountains to the steppes of Mongolia. The presence of free-threshing

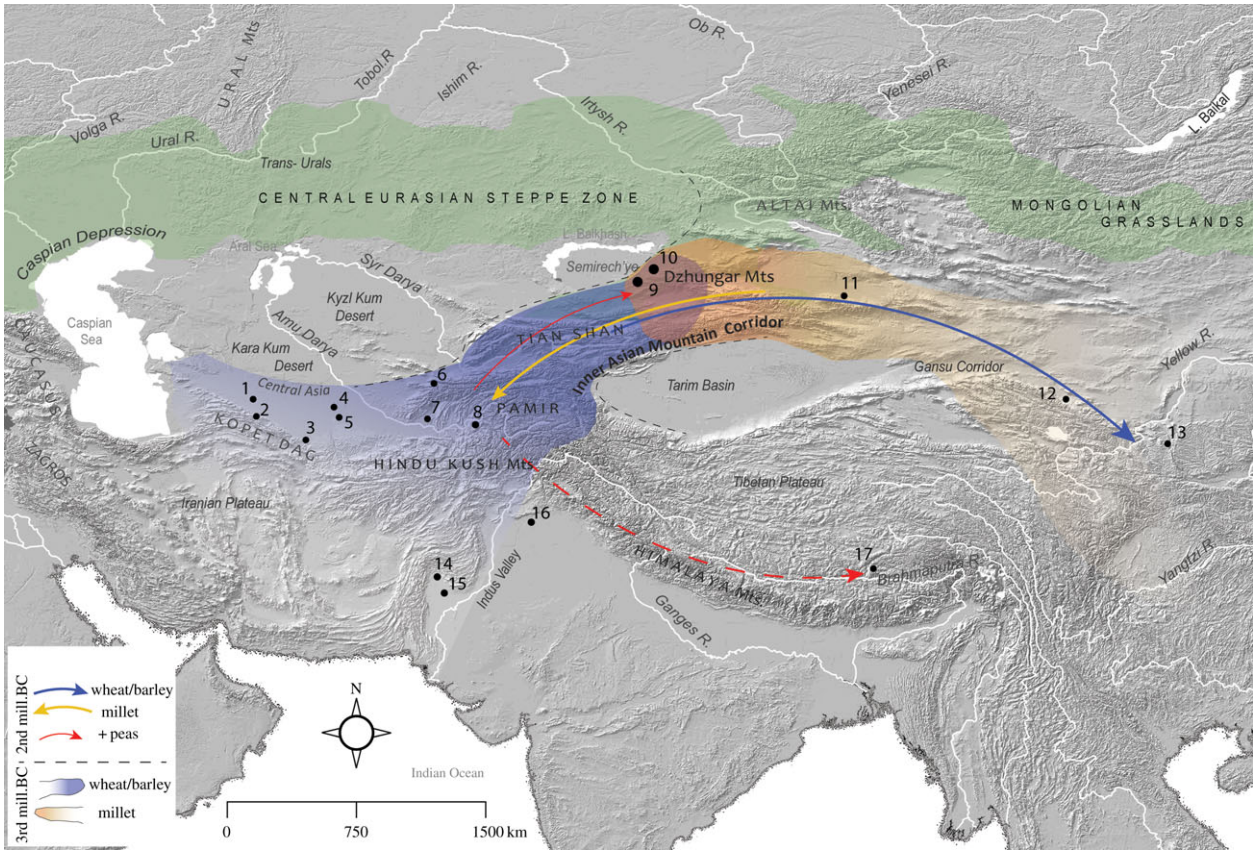

Figure 1. Regional geography and spread of East Asian and southwest Asian domesticates in the third and the second millennia BC and key regional sites: (1) Jeitun; (2) Anau, (3) Monjukli Depe, (4) Gonur Depe, (5) 1211/1219 and Ojakly, (6) Sarazm, (7) Jarkutan, (8) Shortughai, (9) Begash, (10) Tasbas, (11) Luanzagangzi, (12) Donghuishan, (13) Xishanping, (14) Mehrgarh, (15) Nausharo, (16) Harappa, (17) Changguogou.

wheat (*Triticum aestivum/turgidum*) and broomcorn millet (*Panicum miliaceum*) at Central Eurasian highland campsites also illustrates the first transmission of domesticated grains from both southern Central Asia (south of the Syr Darya River) and China into Central Eurasia during the third millennium BC.

Further samples recovered from a domestic oven at Tasbas (Phase 2a, approx. 1500–1200 BC; table 1) revealed charred seed remains as well as evidence for on-site threshing and seed impressions in mud-brick. The domesticated species recovered from the Phase 2a oven indicate that a mixed grain package of free-threshing wheat, naked barley (*Hordeum vulgare* var. *nudum*), broomcorn millet and green peas (*Pisum sativum*) was cultivated at high elevation (1500 m). This assemblage provides, to our knowledge, the only botanical evidence to date for local farming among seasonally mobile pastoralists of Central Eurasia in the second millennium BC.

At roughly the same time in the arid fringe of the Murgab delta region (Turkmenistan), the pastoral campsite Site 1211/1219 exhibits a nearly identical assemblage of domesticated grains. Likewise, the nearby herding campsite of Ojakly also provides evidence for the use of domesticated wheat, millet and barley around 1700–1400 BC (table 1).

Taken together, these sites in the mountains and deserts of Central Eurasia document the earliest integration of domesticated plants of both East Asian and southwest Asian origins and the first use of seasonal farming among mobile herders from the third to the second millennium BC (figure 1). Tasbas and Begash collectively extend the chronology of wheat and millet by approximately 2000 years in the vast territory separating southern Central Asian and East Asian farming societies and are the first sites to show domesticates among Eurasian mobile pastoralists. These sites thus demand that we reconsider the economic basis of Bronze Age Eurasian 'nomads' and recognize their integral role in transforming agricultural strategies across Asia more generally [6,9].

2. Material and methods

(a) Sampling and flotation

Bulk and feature soil samples were collected during excavations at Begash, Tasbas and Ojakly for the purpose of flotation. Flotation samples were not collected from Site 1211/1219, because the deposits were dense cache material with minimal sediment matrix. Soil samples were taken from every distinct anthropogenic context, such as occupation floors, burials, hearths and middens. Sample sizes varied depending upon feature size, so density ratios were used for comparative purposes. The contents of the cremation cists at Begash (90 l) and Tasbas (35 l) were fully floated and analysed. All samples were floated using a simple bucket method as described in [10]. A total of 33 samples were floated from Begash; here, we discuss nine samples from Phase 1a (125 l of soil). Sixteen samples were analysed from Tasbas: 35 l from Phase 1 ($n = 5$) and 71 l from Phase 2a ($n = 11$). Of the samples floated from Ojakly, only six contained carbonized remains (84 l of sediment). At 1211/1219, sediment samples were collected and dry sieved through a screen. Soil volume was not calculated from these 25 dry-screened samples. Results from a total of 315 l of sediment ($n = 31$ samples) and 25 dry-screened samples are presented here.

(b) Laboratory methods

All charred material was sorted, weighed and quantified using geological sieves and/or a low power stereoscopic overhead-light microscope. For items smaller than 2.00 mm, only diagnostic

Table 1. Radiocarbon dates from Begash, Tasbas and Ojakly, calibration curve IntCal13 [8].

				calibrated date BC	
archaeological Phase	laboratory index	material	date BP	68.2% (1 sigma)	95.4% (2 sigma)
Begash Phase 1a	Beta-266458	millet	3840 ± 40	2390–2390	2460–2190
		wheat		2340–2260	2170–2150
				2260–2210	
Begash Phase 1a	Beta-266459	wood charcoal	3760 ± 40	2260–2260	2290–2110
				2210–2130	2100–2040
Begash Phase 1a	Beta-266460	wood	3740 ± 40	2200–2130	2280–2240
		charcoal		2090–2050	2240–2030
Begash Phase 1a	Beta-266457	wood charcoal	3720 ± 40	2190–2170	2260–2260
				2150–2110	2210–2020
				2100–2040	
Tasbas Phase 1	OS-93050	wood	4100 ± 30	2840–2814	2862–2806
		charcoal		2678–2578	2758–2717
					2707–2570
					2513–2503
Tasbas Phase 1	OS-93054	wood	4060 ± 30	2831–2821	2840–2813
		charcoal		2630–2565	2678–2482
				2525–2496	
Tasbas Phase 2a	OS-93053	wood	3150 ± 35	1494–1478	1501–1377
		charcoal		1456–1396	1344–1305
Tasbas Phase 2a	OS-92277	barley	3090 ± 40	1413–1370	1436–1258
				1360–1298	1246–1233
Tasbas Phase 2a	OS-91990	barley	3030 ± 35	1376–1346	1405–1192
				1304–1223	1143–1132
Ojakly, Area 1	OS-94541	wood charcoal	3370 ± 25	1690–1626	1742–1610
Ojakly, Area 5	OS-92543	barley	3270 ± 25	1604–1500	1618–1466

materials were sorted and quantified (e.g. seeds and associated fruit coats or spikelet parts, awns, thorns and fibres).

Accelerator mass spectrometry/^{14}C dating was carried out on seeds from Begash, Ojakly and Tasbas. The chronology of the seeds from Phase 1 at Tasbas was derived from charcoal, however, since the cremation cist was a single deposition sealed by flagstones, the organic carbon from within the ash matrix provides a confident proxy date for the seeds as well.

3. Results

Archaeobotanical data were collected from four Bronze Age pastoralist campsites: Tasbas and Begash in the highlands of Kazakhstan and Ojakly and Site 1211/1219 in Turkmenistan (table 2). Based on their construction, material culture and faunal assemblages, all are interpreted as mobile pastoralist campsites [11]. Seasonal oscillations in environmental aridity and pasture availability directly shaped the annual mobility orbits proposed for prehistoric pastoralists in the study regions [12,13]. Such seasonal ecology is ethnographically documented among mobile pastoralists of Central Asia, while the layering of ephemeral cultural contexts recovered at Tasbas, Begash and Ojakly suggests cycles of reuse matching seasonal occupations on the part of mobile pastoralists.

The earliest period of human activity at Tasbas (Phase 1, 2840–2500 BC; table 1) consisted of an undisturbed human cremation cist, built alongside a small housing structure. The samples from the cist had a low seed density providing 25 carbonized seeds, including five wheat grains (figure 2*c*) and 11 Cerealia fragments, which were too damaged to differentiate between wheat and barley. The Late Bronze Age samples (Phase 2a, 1450–1250 BC) had much higher densities and ubiquities, providing a total of 5121 identifiable seeds from 11 samples and 71 l of soil. The dominant domesticated crop from Phase 2a is naked barley ($n = 577$). Three free-threshing wheat grains and 709 cerealia fragments—probably barley—were also recovered (figure 3*a*,*e*). Fifty-three broomcorn millet grains, along with a few possible foxtail millet grains (*Setaria italica*; all fragments), and 80 peas or (diagnostic) pea fragments were identified (figure 3*c*,*d*).

The high ubiquity of grains among Phase 2a samples from Tasbas (91% for domesticates in general) and the high density of grains in several samples, as high as 40.6 grains per litre of soil, suggest that these crops were locally cultivated. The presence of 194 rachises (figure 3*b*) suggests that the grains were threshed at or near the site, while non-diagnostic, carbonized culm nodes in the samples may further support this assessment. Further evidence comes from diagnostic impressions of

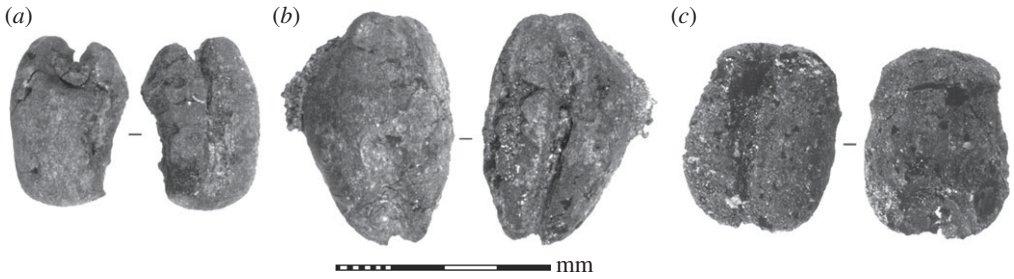

Figure 2. The third millennium BC carbonized grains from Central Eurasian seasonal campsites. Begash: (*a*) compact free-threshing wheat, (*b*) barley; Tasbas: (*c*) compact free-threshing wheat.

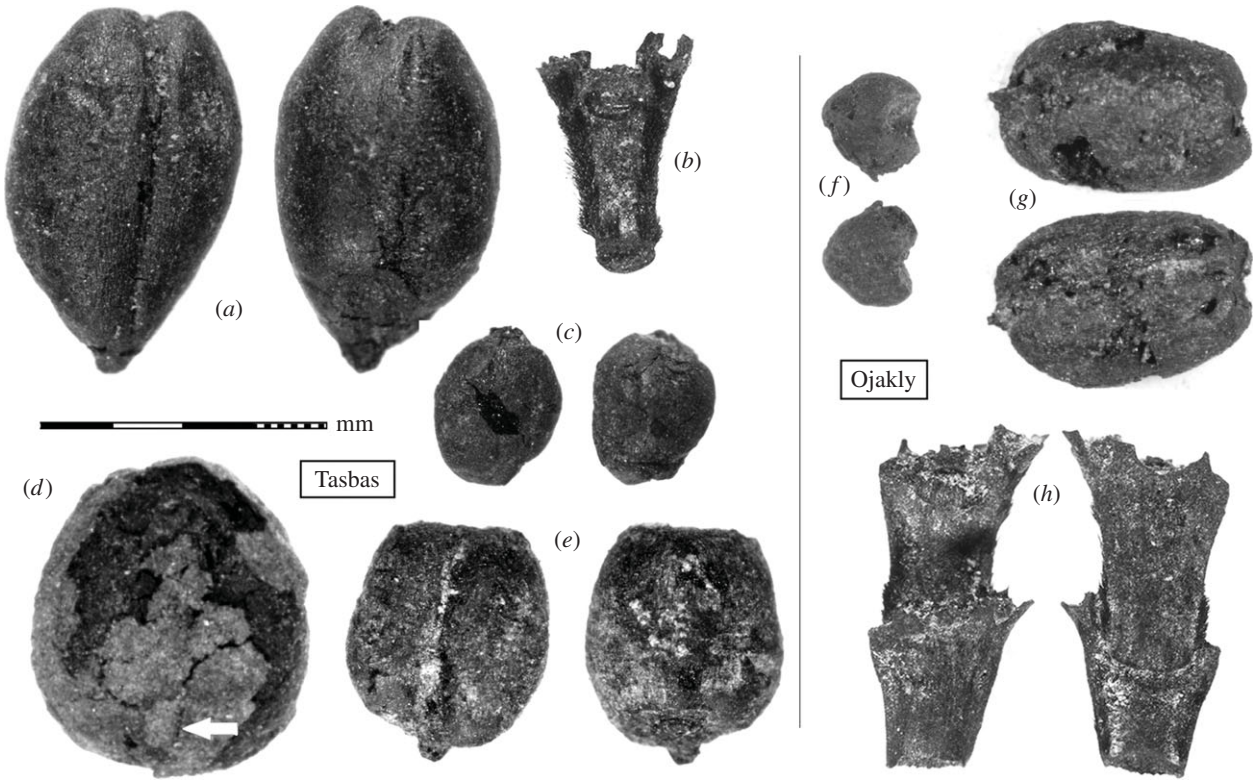

Figure 3. The second millennium BC carbonized domesticated crop remains from Central Eurasian seasonal campsites. Tasbas: (*a*) naked six-row barley, (*b*) barley rachis, (*c*) broomcorn millet, (*d*) green pea (arrow pointing to hilum), and (*e*) highly compact free-threshing wheat; Ojakly: (*f*) broomcorn millet, (*g*) free-threshing wheat, and (*h*) barley rachises.

Table 2. Samples and seed counts from Tasbas, Begash, Ojakly and 1211/1219.

SITE-phase	Tasbas 1	Begash 1a	Tasbas 2a	Ojakly	1211/1219	totals
litre of soil	35	125	71	84	n.a.	n.a.
number of samples	5	9	11	6	25 (13ctxs)	55
free-threshing wheat	5	13	3	8	16 021	16 050
barley		1	577	40	50	668
cerealia	11	30	709		not counted	750
broomcorn millet		61	53	18	277	409
foxtail millet			11?			11?
flax					1?	1?
green peas			80		8817	8897
grass peas					655	655
lentils					25	25
wild identified seeds	9	947	3688	342	17	5003
total seeds	25	1052	5121	408	25 863	32 469

barley caryopses in the mud-brick from the oven walls, along with culm and blade impressions, probably used as binder in brick-manufacture.

The earliest period of occupation at Begash (Phase 1a, 2450–2100 cal BC) consisted of both domestic structures and a human cremation cist, nearly identical to the burial documented at Tasbas. From a total of 90 l sampled, the first 30 l yielded 12 carbonized broomcorn millet grains, one wheat grain and four fragmentary cerealia grains [1]. An associated fire pit also provided carbonized broomcorn millet grains, ($n = 14$) from 11.5 l of ash. Subsequent analysis of the remaining 60 l from the Begash cremation yielded 12 additional free-threshing wheat grains, 26 cerealia grains and one barley grain (figure 2*a*,*b*). Table 2 presents a summary of all findings. Three domestic hearths dating to the late third millennium BC were sampled, as well as two hearths associated with second millennium BC levels. Only three millet grains were found in domestic hearths of the third and the second millennium BC.

Site 1211/1219 comprised a semi-subterranean house (1219) with at least two distinct occupation layers and a nearby associated storage area (1211) [14,15]. Ojakly represents a multi-occupation pastoralist habitation spread across 3 ha, with separate living and production areas dating to approximately 1700–1500 BC (table 1) [16]. Both sites are located in the northeast Murghab alluvial fan.

Ojakly had poor botanical preservation owing to wind deflation; however, a few discrete contexts remained sealed. Six litres of soil collected from the base of a large clay-lined kiln [16] were dense with carbonized botanical material. The sample contained 300 carbonized seeds, 54 from domesticated crops. Thirty-eight of the domesticated grains were barley. While both hulled and naked varieties were present, naked varieties dominated the sample. Eight broomcorn millet grains and eight free-threshing wheat grains were also recovered from the kiln sample (figure 3*f*,*g*). The kiln also yielded 130 six-rowed barley rachises, in many cases still articulated as segments (figure 3*h*). An associated pit feature also provided nine broomcorn millet grains and two barley grains.

Site 1211/1219 dates slightly later than Ojakly and is located 30 km south in an area of the Murghab, where ancient farming villages were abundant; yet site 1211/1219's structure, material culture and stratigraphy distinguish it clearly from sedentary villages in the Murghab alluvial plain. Twenty-one samples were collected from grain caches or carbonized and abandoned deposits in ceramic storage vessels. The first of these cache deposits contained 10 426 free-threshing wheat grains. These grains show a wide range of morphological variation, from nearly spherical and as small as 2.0 mm in diameter to elongated and nearly 6.0 mm in length. In one ceramic vessel, we recovered 21 barley grains, two broomcorn millet grains, as well as a few weed seeds from the *Vaccaria* genus and Fabaceae and Brassicaceae families. A second large cache deposit contained a mixture of domesticated crops, including 7865 green peas, 645 grass peas (*Lathyrus sativum*), 25 lentils (*Lens culinaris*), 24 barley grains, 5337 wheat grains and one broomcorn millet grain. The cache also contained one large broken seed, which resembles flax (cf. *Linum usitatissimum*). Another notable context at the site included a small cache of 274 broomcorn millet grains.

4. Discussion

Free-threshing wheat and broomcorn millet at Tasbas and Begash illustrate the earliest transmission of domesticated crops into the mountains of Kazakhstan—from both East Asia and southern Central Asia—in the third millennium BC. Herders living at Tasbas and Begash performed seasonal vertical migrations, which generated an extensive corridor of interaction among local communities throughout the mountains of Central Eurasia [17]. Sustained interaction between piedmont and high summer pastures fostered subsequent spread of new crops and agricultural practices, evident among both sedentary and mobile groups from China to Central Asia (and *vice versa*) by the second millennium BC. The presence of domesticated grains at Tasbas and Begash pushes the date for mixed domesticated economies among mobile communities 2000 years earlier in Central Eurasia and challenges the structural division between farmers and nomads in the region more generally.

Grains from the Phase 2a domestic oven at Tasbas present, to our knowledge, the first concrete evidence in the Eurasian steppe for local farming of a mixed crop repertoire. The assemblage from this phase illustrates continued use of wheat, barley and millet, as well as the first evidence for local cultivation of green peas at highland settlements. The high ubiquity and grain density in the Tasbas samples along with the abundance of rachises indicate that local herders engaged in threshing and cleaning their crops nearby.

It is likely that early farming was a seasonal activity among mobile herders of the Inner Asian piedmont and highlands. While farming is evident at Tasbas, the second millennium BC samples from Begash contained few domesticated grains ($n = 3$). This may illustrate the importance that elevation played in early pastoralist farming. Located at 950 m above sea level, Begash was probably a autumn or winter encampment while Tasbas, at 1500 m, was a spring/summer settlement. The vegetation around Begash is predominantly arid-steppe, while Tasbas is located in an arable highland valley with ample water and milder summer temperatures. The grains at Tasbas were probably harvested in late summer, reflecting farming at higher elevations by regional pastoralists.

The second millennium BC reflects an important chronological threshold for the incorporation of domesticated crops among mobile pastoralists of Central Eurasia beyond the mountains as well. Although pastoralists clearly had access to grains centuries earlier, our data show that mobile herders in deserts also relied on a mixed grain repertoire more heavily after 2000 BC. Between 1700 and 1200 cal BC, desert pastoralist sites like Ojakly and Site 1211/1219 yielded the same crops as recovered at Tasbas, in even greater amounts. Local cultivation of wheat and barley at Ojakly and Site 1211/1219 seems less likely given their proximity to more specialized farming villages in the Murghab Delta. However, the presence of broomcorn millet at Ojakly and Site 1211/1219 without corresponding evidence for its cultivation at nearby farming villages indicates that pastoralists may have been responsible for introducing this crop into the Murghab farming system.

Our data also illustrate how pastoralists influenced wider economic transformations evolving in both East and Central Asia. In particular, the presence of free-threshing wheat, naked barley, green peas and broomcorn millet at Tasbas, Ojakly and Site 1211/1219 illustrates interaction between seasonal pastoralists and regional farmers in the second millennium BC. The chronology, morphology and distribution of these grains across the wider region document the importance of mobile pastoralists in their transmission eastward and westward across Eurasia.

Early naked barley from southern Central Asia (late fourth to the second millennia BC) is morphologically short, semi-spherical and (typically) has a split apex (figure 3). Early naked barley in western China (approx. 1700 cal BC) is of a similar morphotype [18–20]. The barley from both Ojakly and Tasbas share these traits, suggesting that mobile pastoralists, who occupied the regions between, participated in the dissemination of this morphotype.

In the late fourth/early third millennium BC, Central Asian farmers also shifted from einkorn wheat to free-threshing varieties, probably because of easier post-harvest processing. This benefit is usually measured against the higher water demand of free-threshing wheat, thus is linked to increased investment in irrigation systems across southern Central Asia [21]. Later wheat found in Central and East Asia is also (mostly) free-threshing and by the mid-third millennium BC many regional variants express a distinct highly compact morphology. The third millennium BC wheat from Tasbas and Begash is also a compact, free-threshing type. Given their geography and chronology, pastoralist campsites throughout the IAMC highlight the likely vector by which wheat spread eastward into China.

Li *et al*. [22] note that by the middle to late second millennium BC, free-threshing wheat was an established crop in the central China plains. Although earlier wheat is known from Liangchengzhen (2600–1800 BC; [23]), these grains are not directly dated. Flad *et al*. [20] date free-threshing wheat and naked barley grains from the site of Donghuishan between *ca* 1550 and 1450 cal BC, with outliers dating as early as 1700 cal BC. The free-threshing wheat at Donghuishan is a compact form similar to the early wheat found at Tasbas and Begash, as well as other sites across western China. Earlier wheat remains in the Gansu province have been directly dated as early as 2135–1895 cal BC (e.g. Huoshiliang [24,25]), slightly earlier than sites further west. Comparing the morphology and chronology of wheat at Tasbas and Begash with early wheats in western China points to the mountains of Inner Asia as the likely source of introduction [26]. The geographical location and chronology of the wheat and barley from Tasbas and Begash provide key points of reference to explain the pathway of these grains into the pastoralist economies of the Inner Asian mountains—starting in the third millennium BC and farther into China by the second millennium BC. Our data also help explain the spread of established East Asian crops westward.

Broomcorn millet for example, first appears in southern Central Asia in the second millennium BC at Shortughai (Level II, Period I; [27])—roughly the same time wheat became prevalent in China. Currently, the earliest millet in Central Eurasia is from Begash *ca* 2450–2100 cal BC [1], again implicating pastoralists in its initial distribution outside of China. By the second millennium BC, broomcorn millet was being grown at Tasbas and is found at Ojakly in Turkmenistan. Ojakly currently represents some of the earliest millet remains recovered in southern Central Asia, even when compared with contemporaneous nearby farming villages. We suggest that broomcorn millet was introduced to farmers of southern Central Asia by Late Bronze Age pastoralists interacting along the IAMC at the beginning of the second millennium BC.

Pulses are often considered secondary crops, following grain crops in the Old World. Jones *et al*. [28] argue that starchy grains were first to spread across Eurasia. Again, the Middle and Late Bronze Age reflects a transition, when sites in southern Central Asia have chickpeas (*Cicer* sp.), lentils and green peas [29,30] for the first time. The peas found at Tasbas (figure 3*d*) provide compelling evidence that peas were among a suite of new crops spreading along the IAMC among highland pastoralists in the mid second millennium BC. The green peas and lentils from Site 1211/1219 also date to 1500–1200 cal BC. Interestingly these finds, recovered east of the Kopet Dag, again suggests pastoralists were key to the dispersal of this particular southwest Asian crop (figure 1).

5. Conclusion

Archaeobotanical data from Central Eurasian pastoralist campsites have major implications for our understanding of late prehistoric agriculture across Asia. Sites like Tasbas and Begash illustrate the earliest acquisition of domesticated crops by mobile pastoralists and illustrate their capacity to participate in exchanges that bridged East Asian and Central Asian farming cultures by the early third millennium BC. Mobile pastoralists living in (southern) Central Asian alluvial fans and along the mountainous spine of Central Eurasia also integrated farming into their own domestic strategies (at least) by the mid second millennium BC. Their pastoral mobility and the formation of extensive networks throughout the IAMC helped spread particular grain morphotypes and a mixed plant cohort of wheat, barley, millet and green peas through the mountains between Xinjiang, China and southwest Asia in the second millennium BC. The seasonal campsites of Begash, Tasbas, Ojakly and Site 1211/1219 are the earliest sites thus far reported to break down the strict polarization between nomads and farmers in prehistoric Central Eurasia. They also transform our comprehension of the vast arena of interaction that defines this region in ancient times.

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Data accessibility. Sediment samples and botanical materials discussed in this paper are stored at the palaeoethnobotany laboratory at Washington University in St Louis and are available for further examination.

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