



The archaeobotany of Qaratepe, Azerbaijan 2nd–13th century

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Abstract

This paper presents the results of an archaeobotanical analysis of plant macro-remains recovered during excavations of a rural tepe site at Qaratepe, Azerbaijan, occupied during the Sasanian and Islamic periods between the 2nd and 13th centuries AD. The material derives from a 4 year Oxford University expedition which occurred between 2015 and 2018, ‘The Archaeological Exploration of Barda Project (AEB)’, established to investigate the provincial structure of the eastern Caucasus region in the Late Antique and early Islamic periods. Traditionally, archaeological practice in Azerbaijan has not embraced environmental archaeological techniques and despite the region’s importance to the understanding of early agriculture and the diffusion of crop species during the Islamic period, little archaeobotanical research has been conducted there to date. This assemblage therefore forms a rare and unique contribution to the field of archaeobotany in the Late Antique and Islamic periods in Azerbaijan and provides the first archaeobotanical evidence of crop husbandry at a rural settlement during these periods. In total, 8,676 carbonised plant remains representing a minimum of 60 species were recorded from 80 samples analysed, providing important insights into plant utilisation in Azerbaijan (Full taxonomic list available in on-line supplementary material (ESM)). Archaeobotanical evidence has revealed the range of crops cultivated and consumed at the site between the 2nd and 13th centuries. Results demonstrate that naked wheat (*Triticum aestivum/durum/turgidum*), barley (*Hordeum vulgare*), and broomcorn millet (*Panicum miliaceum*) were the primarily cultivated crops between the 2nd and 6th centuries, key crops that have been present in the Southern Caucasus for several millennia. The study has also identified the cultivation of rice (*Oryza sativa*), watermelon (*Citrullus lanatus*), and melon (*Melo sativa*) in the 13th century, indicating a change in agricultural production in the Islamic period and the introduction of several new cultivars and agricultural adaptations.

Keywords Archaeobotany · Azerbaijan · Late antique · Islamic · Archaeology

Introduction

The Southern Caucasus is one of the most culturally rich regions of the world, containing incredible archaeological diversity with an almost uninterrupted sequence of human occupation from the Lower Palaeolithic. It is also one of the most botanically diverse regions of the planet and was identified in the 1920s as one of the secondary centres of domestication of cereals (Vavilov 1926, 1931, 1957, 1992; Vavilov and Freier 1951). Despite the region’s importance to the understanding of the spread of early agriculture,

environmental archaeological practices have not developed to any great extent there, with a lack of modern systematic archaeobotanical survey in the region. As a result, it has played a subordinate role to research of early agriculture to the Levant, Mesopotamia, and Anatolia. While recent research of the prehistoric periods in the Southern Caucasus has witnessed an upsurge (Wasylikowa et al. 1991; Gandilian 1998; Badalyan et al. 2007, 2008, 2010; Connor and Sagona 2007; Hovsepyan and Willcox 2008; Hovsepyan and Hovsepyan 2009; Hovsepyan 2011a, b, 2013, 2014, 2015; Ristvet et al. 2011; Areshian et al. 2012; Decaix 2012; Guliyev and Nishiaki 2012, 2014; Kalantaryan et al. 2012; Wilkinson et al. 2012; Kakhiani et al. 2013; Longford 2015; Messenger et al. 2015; Decaix et al. 2016, 2020a, b; Shumilovskikh and Poole 2020), archaeological studies of the Late Antique and Islamic period in Azerbaijan still operate using traditional approaches, with a clear focus on artefacts and architectural structures. In periods rich in

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historical literature, the potential of archaeobotany to inform archaeologists about the agricultural economy and daily lives of people in the past has not been realised and the use of environmental techniques has thus not been widely adopted. This has resulted in very little archaeobotanical material being recovered and consequently, reconstructions of agriculture and diet rely almost solely on textual sources, supplemented by occasional finds of materials from 1950s to 60s excavations (Vaidov 1961). Reports from this era are generally vague with species present recorded in a ‘shopping list’ style with no quantities or detailed morphological descriptions noted. Coupled with poorly dated archaeological sequences, these assemblages offer few insights beyond basic presence/absence analyses and the determination of the relative importance of cereal species, reconstruction of crop husbandry and other agricultural practices is impossible. As a result little is understood archaeobotanically about the agricultural landscape and diet, leaving the region out of current academic debates on agriculture development in Eastern Europe, Central Asian, or Near Eastern archaeology. This research addresses this issue by providing the first modern archaeobotanical analyses of materials from sites dating to the Late Antique and Islamic periods in Azerbaijan.

Archaeological context

The site of Qaratepe is a large Tepe mound, located approximately 22 km southeast of Barda city in Western Azerbaijan (40°17'19.2"N 47°22'04.0"E) (Fig. 1). The name Qaratepe ('Black mound') refers to both the archaeological mound

and the modern village settlement located nearby. It is the only known example of this archaeological settlement type in the area, surviving the Soviet period landscape modifications and management practices of the early 20th century. The mound is sub-ovoid in shape, measuring approximately 160 × 135 m (21,600 m²), and rising 14 m above the surrounding landscape (Fig. 2). It commands a dominant position on the flat agricultural plain and is surrounded by arable fields, marshy lowlands and scrub areas used to graze sheep, goats, cattle, and buffalo. Detritus from Soviet-era activity litters the mound and modern agricultural installations are found scattered across the site, which has become heavily overgrown with tough vegetation (Wordsworth 2015, 2016a, b, 2017, 2018a, b).

Excavations at Qaratepe

Between 2015 and 2018 the Archaeological Exploration of Barda expedition conducted excavations at Qaratepe mound uncovering occupation sequences dating between the 2nd and 13th centuries. In total 6 investigations (Trenches 1–6) were conducted at different areas of the site revealing fluctuating periods of occupation and abandonment at the site over approximately 1,000 years.

Trenches 2–6: middens and rubbish layers (2nd–3rd century AD)

Five investigations were established at Qaratepe to explore the mound, with the aim of understanding the general site

Fig. 1 Satellite view of Qaratepe mound and surrounding agricultural landscape



Fig. 2 South facing photograph of Qaratepe mound rising above surrounding fields (AEB Project 2016)



stratigraphy and the identification of archaeological features. The earliest phases of occupation excavated were encountered within these trenches, where deposits were found to date to the 2nd–3rd century AD (Wordsworth and Wencel 2018). A similar set of features were encountered in each of the Trenches 2–5 consisting of outdoor dumping areas, pits and midden-type layers where large volumes of broken ceramic, bone, and large quantities of burnt material which appears to have been disposed of, with evidence of in-situ burning indicating refuse burning. Thirty samples in total were collected from archaeological features in Trenches 2–6 features. The samples produced 891 carbonised specimens and provide rare evidence of the plant taxa utilised during

the earliest habitation of the mound during the Late Antique period.

Trench 1: destruction of structure (5th–6th century AD)

The largest of the Qaratepe investigations, Trench 1, was located on a raised area of the mound located at its eastern edge and thought to be a citadel-type fortified position. Here, a substantial mudbrick structure was encountered approximately 30 cm beneath the surface (Fig. 3). The structure consisted of several rooms, two of which were excavated. One of these rooms was designated ‘Space 11’, which measured 2.3×4.8 m (11 m^2) and was the main focus of archaeological

Fig. 3 Post- excavation photograph of structure in Trench 1 (5th–6th century) (AEB Project 2017)



investigations. During these excavations clear indications of its destruction in a catastrophic fire was evidenced by the presence of heavily charred deposits, and the collapse of structural material. These deposits contained high volumes of carbonised material including burnt mudbrick fragments, matting, roof tiles, charcoal and soft, ashy deposits (secondary burning, building collapse after initial conflagration) above a scorched and fire-reddened floor surface. Frequent indications of burning were identified on recovered artefacts, heat damaged plaster, and several fragments of fused glass, attest to the ferocity of the incident (Michelsen and Penn 2017). The recovery of several complete (but smashed) glass and ceramic vessels on the floor of the structure indicates a rapid and disorderly type evacuation and abandonment of the structure.

Space 11 consisted of a simple rectangular room, built with thick unfired mudbrick walls. The floor of the room was un-tiled, consisting of a compacted rammed earth surface. Collapsed debris from within the room contained large wooden posts and belonging to the superstructure holding up the roof which was covered with terracotta ceramics tiles (indicated by the recovery of ceramic roof-tile fragments). The room lacked any general habitation-type evidence, such as a hearth feature and therefore likely functioned as a storage space. Excavations recovered a total of 277 sherds of ceramic vessels and six whole pots, four smashed and two complete on the surface of the room. The morphology and construction of these vessels were analysed and due to the coarse nature of the fabrics and lack of glazing or design, were interpreted as simple ceramics related to cooking or storage activities (Michelsen and Penn 2017; Wordsworth and Wencel 2018). The nature of the destruction (purpose or

accidental) is unknown. Occasional charred insect remains were recovered but none were identified as storage pests from an infestation, a common reason to purposefully destroy grain storage (Smith and Kenward 2011). The totality of evidence indicates that Space 11 likely was used as a storage room, with the carbonised grain recovered from the surface likely spilled during the conflagration. Radiocarbon dates derived from wood and cereal grains (*Triticum* sp.) recovered from the floor provided a mid-6th century date for the destruction of the structure (Wordsworth and Wencel 2018). Occupation of the mound was contemporary with a period of major Sasanian construction in the Southern Caucasus and the founding of several cities including the nearby city of Partaw (modern Barda) and the construction of major fortifications of the northern frontier at Derbent and Dariali (Gadjiev 2008; Sauer 2020; Sauer et al. 2015).

Trench 1: reoccupation of Qaratepe (13th century AD)

After the destruction of the building, the mound of Qaratepe appears to have been abandoned for several centuries (Wordsworth 2015, 2016a, 2017, 2018a). Excavation revealed a number of graves dating to the 8th–9th century which cut the mudbrick structure, indicating the areas usage as an unofficial cemetery for a time. No evidence of habitation in the area of the mound excavated was identified for a period of approximately 600 years, when a reoccupation phase of the space was encountered dating to the 13th century. Here tandir bread ovens (Fig. 4), burnt spreads, and an associated pit feature were identified, indicating the use of the area for domestic-type activities. The permanency of this reoccupation space is difficult to determine, as no structural

Fig. 4 Post-excavation photography of excavated tandir oven dating to the 13th century layers (AEB Project 2016)



features were identified, and it may have been used in a more ephemeral way compared to the previous period. In total nine samples were collected from these features for analyses.

Materials and methods

During the excavations a systematic soil sampling strategy was implemented at the site by the excavation team. Eighty samples, totalling 1,489 L, were collected from features and processed using the flotation method at the nearby expedition base in Barda. A Siraf-type flotation tank was constructed to process the soil samples collected. Numerous analyses, tests, and comparisons have been undertaken on flotation tanks confirming their effectiveness to include the full spectrum of plant remains contained within archaeological samples (Struever 1968; Stewart and Robertson 1973; Williams 1973; Minnis and LeBlanc 1976; Watson 1976; Schaaf 1981; Wagner 1982; Hastorf and Popper 1988; Miller 1988, 1995; Hunter and Gassner 1998; Hastorf 1999; Pearsall 2000; Pennington and Weber 2004; Wright 2005; Steiner et al. 2015). Counts in the taxonomic tables for each sample derive from the following quantification method. In each sample, the minimum number of individuals (MNI) is counted based on the minimum number of characteristic plant parts. In cereals, where an embryo is present on a cereal grain, it was counted as a whole grain and where it was absent, it was counted as one-grain fragment (3 fragments are counted as one cereal grain after McClatchie et al. 2014). Chaff fragments have been counted individually (i.e. a rachis internode/node is counted as one). Other seeds were counted as one if there is more than 50% of the seed present or as a fragment if less than 50% remains. Ubiquity (also called frequency or presence value) is a common statistical technique used in archaeobotanical research, being originally borrowed from quantitative ecology (Miksicek

1987; Jones 1991). Ubiquity disregards the absolute count of the taxon and instead refers to the number of samples in which a particular taxon, economic grouping, or plant part is present. It measures how many samples contain the taxon, based on the observation that a taxon is present (or not) in each sample (Popper 1988; Reitz and Shackley 2012). This measurement is expressed as a percentage by dividing the number of samples in which the taxon is present by the total number of samples considered. The ubiquity of plant species identified in the total, site and phase assemblage is recorded in Table 1. The order of various plant families, genera, and species presented follows that of the Flora of Turkey (Davies 1965–1988) with the nomenclature of cereals following Zohary et al. (2013). Identification of seeds recovered were made utilising several reference collections and literary sources including comparisons with modern and ancient seed reference resources at University College Dublin and University College London, and examination of key reference publications and drawings from various seed atlases (including Beijerinck 1947; Davies 1965–1988; Katz et al. 1965; Berggren 1969, 1981; Martin and Barkley 1973; Hajiyeve et al. 1979; Jacomet 1987, 2006; Anderberg 1994; Nesbitt 2006; Cappers and Bekker 2013; Zohary et al. 2013). Morphometrics, such as the measurements of the length/width ratios (L/W) were used on a small number of complete rice grains to attempt to differentiate varieties, with this method effective in differentiating between long-grained (*Oryza indica*-type) and short-grained (*Oryza japonica*-type) varieties (Ahn 1993; Castillo 2011; Deng et al. 2015; Castillo et al. 2016; White et al. 2019). It has been calculated that a L/W ratio of > 2.2 indicates *indica*-type rice and ratios < 2 are designated as *japonica*-type.

While a variety of context types were sampled, they were not evenly distributed, and differences can be seen both temporally and chronologically that need considering. Samples recovered from Trenches 2–6 were limited due to the size

Table 1 Ubiquity and sum of cultivars recovered at Qaratepe by period

	2nd–3rd century				5th–6th century				13th century				Total			
	Sample	Ubiqu.	Sum		Sample	Ubiqu.	Sum		Sample	Ubiqu.	Sum		Sample	Ubiqu.	Sum	
	(n=30)	(%)	n	%	(n=37)	(%)	n	%	(n=9)	(%)	n	%	(n=76)	(%)	n	%
<i>Triticum aestivum/durum/turgidum</i>	10	33	21	14.2	30	81	3,596	87.3	5	56	211	35.4	45	38	3,828	78.8
<i>Panicum miliaceum</i>	13	43	88	59.5	23	62	328	8.0	6	67	191	32.0	42	37	607	12.5
<i>Hordeum</i> sp.	14	47	35	23.6	28	76	127	3.1	6	67	171	28.7	48	40	333	6.9
<i>Triticum</i> cf. <i>spelta</i>					9	24	35	0.8	2	22	6	1.0	11	10	41	0.8
<i>Secale cereale</i>	1	3	1	0.7	5	14	22	0.5					6	6	23	0.5
<i>Oryza sativa</i>									2	22	17	1.0	2	2	17	0.3
<i>Avena</i> sp.					6	16	11	0.3					6	5	11	0.2
cf. <i>Lens culinaris</i>	3	9	3	2.0									3	3	3	0.1
Total			148				4,119				596				4,863	

of the investigations and the lack of variety in context types. These derived solely from deposits and dumps of materials, with the samples from T6 taken from a single jar burial. Although this represents one of the largest assemblages recovered from 2nd–3rd century and documents the presence of several cultivars and fruits species in the Southern Caucasus at this time, the low variety of context types excavated means it is not fully representative of the suite of plant remains that were likely utilised during this period. Contexts encountered in Trench 1 at Qaratepe were more varied, collected from floor deposits, pits, and ceramic pots within the two rooms of the structure. While more varied, the range of contexts and samples were confined to a small area of the total settlement that would have existed on the mound in the Late Antique period. This is also true of the reoccupation phase of Qaratepe. While this compromised a more varied selection of archaeological features, including the first features relating to cooking excavated at the site, it again was limited to a small section of the mound due to the limits of excavation.

Results

In total, 8,676 carbonised and desiccated plant components were recovered. The overall assemblage was dominated by cultivars, comprising 74% of the total assemblage, followed by wild species (22%). Fruit was a minor component comprising just 1% of the assemblage with the remaining 1% unidentifiable to species level. Three broad chronological phases were represented allowing diachronic changes in the assemblage to be investigated and to reveal insights into continuity and change of diet and agricultural practices of people inhabiting Qaratepe over an approximate 1,000-year period.

Period A: 2nd–3rd century

A total of 891 carbonised remains were recovered from samples dating to the 2nd–3rd centuries. Cereals accounted for only 21.7% of the period's assemblage. Broomcorn millet (*Panicum miliaceum*), naked wheats (*Triticum aestivum/durum/turgidum*), and two/six-rowed hulled barley (*Hordeum distichum/vulgare*) were all recovered from deposits dating to this phase, indicating their cultivation at this time. A single rye (*Secale cereale*) grain was also recovered which may represent a contaminant of other the cereals, rather than representing a crop. Broomcorn millet was the dominant cultivar recovered from the early phases at Qaratepe comprising 59.5% of crops recovered, and present in 43% of samples. Hulled barley (*H. distichum/vulgare*) and naked wheat (*T. aestivum/durum/turgidum*) comprised 23.6% and 14.2% respectively (Table 1). All wheat recovered

was of a naked variety with the chaff of a hexaploid-type indicating the presence of a bread wheat (*T. aestivum*-type) variety. Non-cereal cultivars were rare, with only three examples of lentil (*Lens culinaris*) recovered in Trenches 3 and 4, representing the only pulses found at Qaratepe.

Fruit species were rarely encountered, with the only example recovered from 2nd–3rd-century layers comprising of 15 carbonised grape (*Vitis vinifera*) pips (Fig. 5; Table 2). Wild species dominated the assemblage, making up 76.7% of it. This largely comprised of fat hen (*Chenopodium album*) (72.2% of wild species), sedge (*Carex*), knotweed (*Polygonum*), and wild grasses (including *Bromus*, *Lolium*, *Festuca*, *Panicum*). The remainder of the assemblage consisted of smaller quantities (< 10 specimens each) of clubrush (*Bolboschoenus maritimus*), smartweed (*Persicaria minor*), bedstraw (*Galium*), clover/sweet clover/medick (*Trifolium/Melilotus/Medicago*), spikerush/sedge (*Eleocharis/Scirpus*), dock (*Rumex*), sun spurge (*Euphorbia helioscopia*), mallow (*Malva*), buttercup (*Ranunculus*), and common fumitory (*Fumaria officinalis*) (Table 3).

Period B (5th–6th century)

A large assemblage of 6,223 carbonised specimens was recovered from 37 samples related to the final use and destruction of the main structure encountered during excavations. Cereals were dominant in this phase, with several thousand wheat grains recovered from the floor of the destroyed structure. This wheat was identified as naked wheat and comprised 87.3% of the cereals recovered from this period. Broomcorn millet was also recovered in moderate quantities compromising 8% of the assemblage, followed by hulled barley (*Hordeum vulgare*) (3.1%). Small quantities of spelt (*Triticum spelta*) (0.8%), rye (0.5%), and oat (*Avena* sp.) (0.3%) were also present. Fruit was again a minor constituent of the 5th–6th century assemblage and in addition to the previously identified grape (*Vitis vinifera*), a small quantity of carbonised fig (*Ficus carica*), and pomegranate (*Punica granatum*) was identified (Table 2).

Wild species comprised 12.5% of the assemblage from this phase of activity. Seepweeds (*Suaeda*) comprised 48% of the wild species recovered, followed by goosefoots (*Chenopodium album*, *C. murale*, *Chenopodium/Atriplex*) (15.1%) and wild grasses (*Poaceae*, *Bromus sterilis*, *Bromus*, *Lolium temulentum*, *Lolium*, *Hordeum spontaneum*, *Hordeum murinum*, *Phalaris*, *Poa*) (9.7%). The remaining 27% was comprised of small quantities (< 26 specimens each) of bedstraw (*Galium*), dock (*Rumex*), peppergrass (*Lepidium*), spikerush/sedge (*Eleocharis/Scirpus*), sedge (*Carex*), clover/sweet clover/medick type (*Trifolium-Melilotus-Medicago*), mallow (*Malva*), common purslane (*Portulaca oleracea*), sedges (Cyperaceae), pigweed (*Amaranthus*), milkvetch (*Astragalus*), pygmy smartweed (*Persicaria minor*), bulrush



Fig. 5 Photographs of the cultivars, fruit and wild/weed species recovered at Qaratepe. a. *Triticum aestivum/durum/turgidum* (grain and chaff), b. *Hordeum vulgare* (grain and chaff), c. *Panicum miliaceum* (carbonised and dessicated), d. *Vitis vinifera*, e. *Lens culinaris*,

f. *Oryza sativa*, g. *Citrullus lanatus*, h. *Punica granatum*, i. *Rubus* sp., j. *Verbena officinalis*, k. *Rumex* sp., l. Knotweed, m. *Persicaria*, n. *Carex* sp., o. *Chenopodium album*. Scale bars = 1 mm unless otherwise stated

(*Bolboschoenus glaucus*), thistle (*Carduus/Cirsium*), parsley (Apiaceae), common vervain (*Verbena officinalis*), vetch/vetchling (*Vicia/Lathyrus*), sun spurge (*Euphorbia helioscopia*), and common knotgrass (*Polygonum aviculare*) (Table 2).

Period C (13th century)

Samples from this period produced 1,232 carbonised plant remains with cereals comprised 61.3% of the material identified. Naked wheat (35.4%), broomcorn millet (32%), and hulled barley (28.7%) were all recovered from features

excavated in this phase. Here, the earliest recovery of a new cultivar at Qaratepe, rice (*Oryza sativa*), occurred, indicating its addition to the suite of arable taxa utilised at the mound (Fig. 5). Most rice grains were fragmentary but the measurement of 3 complete gains show a ratio < 2 and were therefore categorised as the short-grained variety *O. japonica*. Fruit continues to be a minor component, comprising 1.7% of the assemblage with only 20 specimens recovered. This assemblage differs from previous phases with the absence of grape, fig, and pomegranate and recovery of several new edible taxa occurring, most notably mulberry (*Morus* sp.), watermelon (*Citrullus lanatus*), and melon (*Cucumis melo*).

Table 2 Fruit species recovered at Qaratepe from the different time periods excavated

	2nd–3rd century	5th–6th century	13th century	Total
<i>Vitis vinifera</i>	15	4		19
<i>V. vinifera</i> (pedicel)		2		2
<i>Rubus</i> sp.			1	1
cf. <i>Fragaria</i> / <i>Potentilla</i> sp.		1		1
<i>Morus</i> sp.			6	6
<i>Ficus carica</i>		3		3
<i>Cucumis</i> cf. <i>melo/sativus</i>			3	3
<i>Citrullus lanatus</i>			9	9
cf. <i>Citrullus</i> / <i>Cucumis</i>			1	1
<i>Punica granatum</i>		1		1
Total	15	11	20	46

Wild species comprise 35.1% of the assemblage, mainly consisting of seepweeds (*Suaeda*), pygmy smartweed (*Persicaria minor*), goosefoots (*Chenopodium*), common purslane (*Portulaca oleracea*), clover/sweet clover/medick type (*Trifolium-Melilotus-Medicago*), wild grasses (*Poaceae*, *Poa*, *Lolium*, *Hordeum*, *Panicum*), and dock (*Rumex*) with smaller quantities (< 10 specimens) of knotgrass (*Polygonum*), sedge (*Carex*), pigweed (*Amaranthus*), bedstraw (*Galium*), spikerush/sedge (*Eleocharis/Scirpus*), clubrush (*Bolboschoenus maritimus*), mallow (*Malva*), peppergrass (*Lepidium*), common knotgrass (*Polygonum aviculare*), nightshades (*Solanum*), and plantain (*Plantago*).

Discussion

Diachronic changes in agriculture

The excavation at Qaratepe provides a rare opportunity to compare an archaeobotanical assemblage across a period of approximately 1,000 years in Azerbaijan. Clear differences between the assemblage of the Late Antique and Islamic periods are apparent with the presence of several new food species in the 13th century (Fig. 6).

2nd–3rd century

The agricultural landscape in the Southern Caucasus during the Late Antique period was based on the cultivation of long-established species broomcorn millet, naked wheat, hulled barley, and grape (*Vitis vinifera*). Each of these species are either native or have a long history of cultivation in the Southern Caucasus, and are well adapted to growing in the region, recovered from archaeological sites dating from the Neolithic period (Lisitsina and Prishchepenko 1977; Lisitsina 1978, 1984). Wheat, barley, and millet could all have been grown in the region successfully,

although water requirements of wheat and barley may have restricted their growing to the lowland floodplains of rivers or in areas with artificial irrigation. The summer field crop broomcorn millet was the dominant cultivar recovered. First cultivated in China around 6000 BCE, millet is a thermophilic, highly adaptive species that can grow in semiarid and drought-prone regions, and over a range of altitude zones (Baltensperger 2002; Weber and Fuller 2008; Weber and Kashyap 2016; Upadhyaya et al. 2014, p 2,673; Miller et al. 2016; Liu et al. 2018, 2019; Sharma and Niranjana 2018; Sharma et al. 2018; Shumilovskikh and Poole 2020). It can thrive in less fertile soils than other cereals and is more tolerant of drought, pests, and diseases than the larger-grained cereals. It can grow under non-irrigated conditions with as little as 200–500 mm of average annual rainfall and is well suited to the lowland region of Azerbaijan and over the Southern Caucasus (Habiaryemye et al. 2017) and may have been grown in areas where wheat and barley could not thrive. Soviet-era publications have reported the presence of broomcorn millet in the Southern Caucasus since the Neolithic period (Lisitsina and Prishchepenko 1977; Lisitsina 1984; Wasylikowa et al. 1991). However, a lack of photographs or morphological descriptions in reports make it difficult to critically assess these records (Hunt et al. 2008). Furthermore, since these discoveries, no other archaeobotanical excavation of Neolithic layers has recovered millet in the South Caucasus (Hovsepyan and Willcox 2008). Recent analyses using stable carbon and nitrogen isotopic ratios of humans and domestic animals indicate that consumption of millets in the Caucasus does not occur until the second millennium BCE, increasing in the Iron Age (Herrschner et al. 2018). Millet was recorded in the 1950s and 1960s during excavations at Mingachevir and recent archaeobotanical analyses from Areni-1 (Armenia), Kerpilitepe, and Girag Kasaman (Azerbaijan) also indicate its commonplace cultivation in the region during the medieval period (Vaidov 1961; Bunyadov 1964; Smith et al. 2014; Stone 2022).

Table 3 Wild taxa recovered during different periods at Qaratepe

Species	Family	2nd–3rd century	5th–6th century	13th century	Total
<i>Fumaria</i> cf. <i>officinalis</i>	Papaveraceae	1			1
<i>Ranunculus</i> sp.	Ranunculaceae	1			1
<i>Vicia/Lathyrus</i> sp.	Fabaceae		1		1
<i>Trifolium-Melilotus-Medicago</i>		6	25	24	58
cf. <i>Astragalus</i> sp.			3		3
<i>Euphorbia helioscopia</i>	Euphorbiaceae	3	1		4
<i>Malva</i> sp.	Malvaceae	2	15	2	19
<i>Lepidium</i> sp.	Brassicaceae		22	1	23
<i>Polygonum aviculare</i>	Polygonaceae		1	1	2
<i>Rumex</i> sp.		5	24	11	40
<i>Persicaria</i> cf. <i>lappathifolia</i>				3	3
<i>Persicaria minor</i>		7	2	70	79
<i>Polygonum</i> sp.		33	12	9	54
<i>Portulaca oleracea</i>	Portulacaceae		8	36	44
<i>Chenopodium album</i>	Amaranthaceae	496	36	40	572
<i>Chenopodium murale</i>			1		1
<i>Chenopodium</i> sp.			4	3	7
<i>Chenopodium/Atriplex</i>			77	4	81
<i>Amaranthus</i> sp.			4	3	7
<i>Suaeda</i> sp.			376	171	547
<i>Galium</i> sp.	Rubiaceae	7	26	3	36
<i>Solanum</i> sp.	Solanaceae			1	1
<i>Plantago</i> sp.	Plantaginaceae			1	1
<i>Verbena officinalis</i>	Verbenaceae		1		1
Apiaceae sp.	Apiaceae	1	3		4
cf. <i>Carduus/Cirsium</i>	Asteraceae		2		2
<i>Bolboschoenus</i> cf. <i>glaucus</i>	Cyperaceae		2	1	3
<i>Bolboschoenus</i> cf. <i>maritimus</i>		9	12	2	23
<i>Carex</i> sp.		60	24	9	93
Cyperaceae sp.			7	2	9
<i>Eleocharis/Scirpus</i> sp.		6	17	3	26
<i>Bromus</i> cf. <i>sterilis</i>	Poaceae		4		4
<i>Bromus</i> sp.		12	1		13
<i>Hordeum</i> cf. <i>spontaneum</i>			3	2	5
<i>Hordeum</i> cf. <i>murinum</i>			1		1
<i>Hordeum</i> sp.			4	3	7
<i>Lolium temulentum</i>			2		2
<i>Lolium</i> sp.			5	1	6
Poaceae sp.		29	39	17	85
<i>Poa</i> sp.			8	3	11
<i>Panicum</i> sp.		5	9	1	15
Total		675	753	403	1,831

Evidence of fruit cultivation at Qaratepe during this period is scant with only grape (*Vitis vinifera*) recovered. Archaeological evidence suggests that grapevine was domesticated from its wild relatives somewhere in the South Caucasus region during the Neolithic period and was an extremely important part of the Neolithic diet

(Arroyo-García et al. 2006; Salimov et al. 2017). Possible evidence of the earliest winemaking/grape fermenting is also found in the Southern Caucasus where ancient organic compounds absorbed into pottery fabrics have been detected from sites in Georgia dating to the early Neolithic period (6,000–5,000 bce), providing the earliest biomolecular

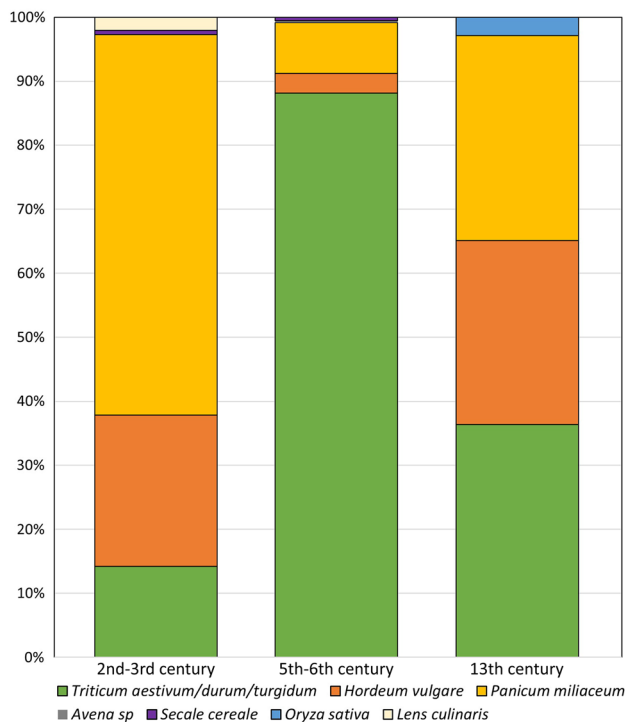


Fig. 6 Percentage distribution of cultivar taxa during different periods at Qaratepe

archaeological evidence for possible viticulture (Licheli and Rcheulishvili 2010; Rusishvili 2010; Maghradze et al. 2016; McGovern et al. 2017; Kikilashvili et al. 2018). While in the first century ad, Strabo directly mentions that the Caucasian Albanians were involved in viticulture (Strabo 1928, pp. 11.4.4), no material culture relating to the production of wine was recovered during the excavations at Qaratepe, and whether the inhabitants were exploiting grapes for winemaking, consuming them fresh, or processing them into other foodstuffs cannot be ascertained with the current archaeological and archaeobotanical data.

Wild species recovered comprised those of hydrophilic species during this phase, indicating wet conditions in the vicinity of the mound. Soviet-era maps of the Qaratepe region indicate that an undulating marshy-type landscape existed in the area, with lowland wet and higher dry patches of land existing before the landscape was heavily modified to facilitate the cultivation of cotton (Wordsworth 2016b, 2017). The recovery of sedge (*Carex*), knotweeds (*Polygonum*), docks (*Rumex*), pygmy smartweed (*Persicaria minor*), bulrush (*Bolboschoenus maritimus*), and spikerush/sedge (*Eleocharis/Scirpus*) are consistent with such an environment and may have grown in the surrounding wetlands or in the direct vicinity of the mound. These seeds were recovered carbonised in midden and charcoal rich deposits and may have been incorporated into the assemblage during burning events. Another possible vector may be through herbivore

dung used as fuel, which can provide important information on subjects such as seasonality, grazing, and herding practices by contributing seeds to archaeobotanical assemblages (Fuks and Dunseth 2021). While no dung pellets were identified, it is evident through the recovery of animal bones that a range of livestock species were also present at the site, and it seems likely that dung would have been utilised. The small quantity of species typical of pastureland may have entered the site in dung, but this could not be definitely stated.

Agriculture in the 5th–6th century

While a similar suite of cultivars was recovered in the 5th–6th century deposits, a difference in the relative frequency of the crops is evident. A large volume of cereal grains were recovered from the floor of the mud brick structure largely consisting of thousands of naked wheat grains. This wheat deposit comprised 87.3% of the assemblage recovered from the room and forms 53% of the entire Qaratepe assemblage. The high ratio of grain to chaff indicates a cleaned crop ready for human consumption, with the presence of fine-sieve category weeds mixed with the main cereal crop. As stated by van der Veen and Jones (2007) assemblages of this nature are most likely to occur on sites where cereals are handled in bulk. This, therefore, indicates that agriculture at 5th–6th century Qaratepe was likely operating at a large-scale production and/or consumption level and not on a basic subsistence scale. Hulled barley by contrast is far less strongly represented during this period, contributing a minor but ubiquitous component of the assemblage. Glume wheats spelt (*Triticum spelta*), oat (*Avena sativa*), and rye were also recovered but in low quantities and are either a minor crop or contaminant of other cereals. The continuation of the cultivation of broomcorn millet is evidenced by the recovery of several hundred carbonised millet grains from the structure. Although recovered in comparable numbers to previous occupation layers, there is a sharp decline in the relative frequency of broomcorn millet from previous phases. Although millet was less prevalent than wheat or barley, its high ubiquity indicates it was a persistent component of the agricultural economy and subsistence at Qaratepe (Table 1).

The understanding of agricultural production during the 5th–6th century in the Southern Caucasus is of great interest. The establishment of urban centres and fortifications in the Southern Caucasus occurs during this period, including the founding of nearby Barda city (ancient Partaw) (Al-Baladhuri 1916; Wordsworth 2018a), which would have significantly changed the local population and economy. Changing modes of production at settlements like Qaratepe and the adoption of new crops could be seen as response to the development of these new urban centres. Agriculturalists can be highly adaptable and pay close attention to

market signals, changing their land use and crops accordingly (Brookfield 2001, p. 182). With increased urbanisation and fortification of the Southern Caucasus by the Sasanian Empire, an increase in the scale of cereal cultivation may have represented an agricultural innovation to increase production to feed a growing non-agricultural population. However, more archaeobotanical research is required to gain a fuller understanding of how changing settlement patterns in the Southern Caucasus would have affected agricultural production and the suite of crops grown.

All fruit species recovered from 5th–6th century layers (grape, fig, and pomegranate) are well suited to the Southern Caucasus and can thrive in the hot arid/semi-arid environment prevalent in the region. All are thought to have either originated in the Southern Caucasus or the Caspian Sea region and have been recovered from Neolithic and Bronze Age excavations, indicating their enduring cultivation in the region (Zohary and Spiegel-Roy 1975; Arroyo-García et al. 2006; Holland et al. 2009; Aradhya et al. 2010; Erkan and Kader 2011; Salimov et al. 2017). In contrast to the cultivation of annual cereals, fruit cultivation requires a longer-term investment in the landscape, with trees and vines taking several years of cultivation before they produce fruits, suggesting a more intensive type of agricultural practice (Fuller and Stevens 2019).

The recovery of the carbonised wild seeds mixed with the wheat grains, coupled with an absence of a hearth feature in the room, indicates that plant-food processing, rather than dung, is the main source of these species. Analysis of their physical characteristics indicate that the majority were typical of the late stages of crop processing (Jones 1984). While some of the species identified suggest spring-sown cereals (i.e. *Polygonum aviculare*), the apparently clean nature of the cereal assemblage obscures the identification of cropping strategies by removing many of the field weeds that grew with crops. Several typically wetland species were also recovered, indicating a continued damp and wet environment in the vicinity of the mound. However, their presence in the grain-rich storeroom assemblage may indicate their deliberate collection (Wallace et al. 2019). Furthermore modern ethnobotanical research in the Southern Caucasus has demonstrated that many of the wild plant species recovered at Qaratepe are incorporated into the modern diet, used in the craft industry, or employed as folk medical treatments. Potential food plants with edible leaves, seeds or tubers include rush (*Scirpus*), fat hen (*C. album*), orache (*Atriplex*), purslane (*P. oleracea*), mallows (*Malva*), seep-weeds (*Suaeda*), bind-weed (*P. convolvulus*), bromes (*Bromus*), ryegrass (*Lolium*), dock (*Rumex*), club rush (*Bolboschoenus maritimus*), and Cyperaceae species (Behre 2008, p. 71; Batsatsashvili et al. 2017; Wallace et al. 2019). However, direct evidence of their consumption is difficult to establish at Qaratepe.

13th century

During the 13th century a continuation of an arable agriculture based on the cultivation of naked wheat, hulled barley, and broomcorn millet is evidenced. However, most interesting is the addition of rice, indicating a shift in agricultural production occurred at this time. While today rice is grown in a number of areas in Azerbaijan and is an important component of the modern diet, the history of the crop's cultivation in the region is relatively unknown. Archaeobotanical evidence of rice cultivation is scarce, with its presence at Qaratepe comprising one of just three modern archaeobotanical recoveries in the Southern Caucasus to date (Smith et al. 2014; Stone 2021). Rice can be cultivated in a wide range of arable systems varying from wetland to dryland watering regimes (Weisskopf et al. 2014). Wet rice cultivation in floodplains or paddy field cultivation requires significantly more precipitation (1,000–1,500 mm) annually to support its growth, much higher than that naturally occurring in lowland Azerbaijan, and the crop is more laborious to plant and manage than naked wheat or barley (Walshaw 2010). According to Watson's Islamic Green Revolution (IGR) hypothesis, these species were among the key cultivars diffused across the Middle East, Central Asia, North Africa, and later Europe as a result of the Muslim conquests (Watson 1974, 1981, 1983). While there have been instances of earlier recoveries of rice in the Iranian Parthian era to the south in Iran (Miller 1981; van der Veen 2011), rice does not appear to have become an important cultivar in the Southern Caucasus until after the Islamic period (Watson 1983; Stone 2021). Another observation in the IGR hypothesis was that the spread of many of the key economic species (including rice) required agricultural diversification of the summer farming season (Watson 1983). Watson observed that many of the plants introduced across the Islamic Empires were thermophile species, grown over the summer period (Watson 1983; Decker 2009; Squatriti 2014). The new crops identified at Qaratepe at this time appear consistent with Watson's model, with this diversification of summer annual crops reflecting an extensification strategy at Qaratepe, with riziculture expanding into the surrounding wetlands. While the summer season at pre-Islamic Qaratepe could not be categorised as 'dead', as Watson (1983) described the pre-Islamic summer fallow in the Mediterranean, it would appear that the use of the summer period to grow crops would not have put a significant burden on the agriculturalists.

The identification of rice at Qaratepe and the nearby city of Barda coincides with the earliest identification of water buffalo (*Bubalus bubalis*) in the region and suggests that a possible suite of wetland agricultural innovations occurred at this time, expanding cultivation into the marsh environments from at least the 11th century (Wordsworth et al. 2021). The presence of water buffalo also confirms the presence

of significant permanent wetlands in the Barda region as they require wet habitats to wallow, a behavioural thermoregulation to accelerate heat loss as they are unable to dissipate body-heat through sweating (Kassim and Bahsrin 1979; Wordsworth et al. 2021). These wetlands may have also been utilised to cultivate rice with buffalo traditionally used as traction animals to plough paddies, as seen with in many pre-mechanised agricultural societies (Higham et al. 1981; van der Veen 2010; Fuller et al. 2011; Yue et al. 2013; Setyaningsih et al. 2019). In nearby Barda city, archaeobotanical analyses of occupational phases dating between the 11th and 16th century also contained rice and barnyard millet (*Echinochloa oryzicola*), an obligatory weed of rice paddy environments (Stone 2021). According to Watson (1983), during the Islamic period, rice was almost always grown in swamps or on irrigated lands in the Islamic world (Watson 1983, p. 103). While further archaeobotanical work will provide a clearer understanding of the establishment of rice cultivation in the region, its presence in the Qaratepe and Barda swampland areas may represent a local adoption of the crop, with migrating agriculturalists taking advantage of the local environment to cultivate it in the Islamic period.

Plants typically classified as oil or fibre crops were absent from all phases of the archaeobotanical assemblage from Qaratepe. The presence of Mulberry (*Morus* sp.) and its association with silk may indicate its cultivation for textile production purposes. In nearby Mingachevir, excavations of 3rd–7th century deposits recovered the remains of silk, brocade, linen, wool, and cotton indicating a well-established and varied textile industry in the region (Vaidov 1961). Unfortunately, due to the carbonised and fragmented nature of the mulberry seeds recovery at Qaratepe, differentiation between mulberry species (*Morus alba/nigra*) was not possible and its use as food or in silk manufacture cannot be determined. The recovery of watermelon (*C. lanatus*) and melon/cucumber (*C. melo/sativa*) in this period is also interesting. Both species are well suited to the arid, warm subtropical and temperate climates of the Azerbaijani lowlands (Samuel 2001, p. 413). Watermelon is an important crop in modern Azerbaijani agriculture and can grow in dryland areas without the use of irrigation, and at Qaratepe may have grown in gardens or small plots around the mound (Decker 2009, p. 188). Archaeobotanical evidence indicates that both are of African origin and became established in much of the Middle East and Central Asia after the Islamic conquests (Watson 1983; Amar and Lev 2017, p. 53), and by the 12th–13th century were well established in many other parts of the Islamic world, such as Egypt and Spain (Watson 1983; Alonso et al. 2014). As with watermelon, melon appears to have been established across much of the Islamic world at the same time, recovered in the Central Asian city of Merv in the 12th century (Herrmann and Kurbansakhatov 1994). When it initially began to be cultivated in the

Southern Caucasus is unknown, but to date, no archaeobotanical evidence of its cultivation before the 11th century has occurred in the Barda region (Stone 2021).

Tandir-style ovens were only encountered in the reoccupation phase at Qaratepe. Ethnographic studies of tandir ovens suggest that they were generally used for the making of bread but could be used for a multitude of other activities, such as boiling, roasting, or parching (Gur-Arieh et al. 2013; Gur-Arieh 2018, p. 69). They have been used for thousands of years, discovered at sites dating to the Neolithic period throughout the Near East, Central Asia, and the Southern Caucasus (Canaan 1962; Forbes 1966; Weinstein 1973; Bottéro 1985; Emberling and McDonald 2001; Mulder-Heymans 2002; Lyons and D'andrea 2003; Parker and Uzel 2007; Parker 2011; Smogorzewska 2012; Balossi-Restelli and Mori 2014; Ebeling and Rogel 2015). Deposits in the oven were ash and charcoal-rich, containing carbonised cereals (*Hordeum*, *Triticum spelta*, *Triticum aestivum/durum/turgidum*, and *Panicum miliaceum*), and small quantities of chaff and fruit seeds (*Citrullus lanatus*), which relate directly to the fuelling of the oven (wood charcoal) and food preparation (cereal grains). The small quantity of fruit seeds recovered may have fallen into the oven during roasting or were discarded as refuse. A similar range of wild species to those of the storeroom floor were recovered from tandir contexts in the 13th century (Table 3). The grasses, sedges, and other small weedy taxa recovered may have been used in other activities such as construction materials, pottery manufacture or crop processing, or entered the ovens during food preparation or as waste. The large quantity of charcoal recovered from tandir fills suggest that wood was the primary fuel used in the ovens, but it is conceivable that dung or other refuse could have also been used, but this is difficult to identify (Spengler 2019).

Agropastoral economy at Qaratepe and the seasonal cycle

The assemblage at Qaratepe indicates the practice of an agropastoral system at Qaratepe, revolving around the growing of the three main cultivars (free-threshing wheat, hulled barley, and broomcorn millet) and the raising of animals, with faunal assemblages recovered from Qaratepe demonstrating a diverse range of livestock. Horse (*Equus caballus*), cattle (*Bos taurus*) pig, (*Sus scrofa*), sheep/goat (ovicaprids), and chickens (*Gallus gallus*) were all recovered along with a range of wild fauna, fish, and fowl (Wordsworth 2018a). These animals would have provided a wide range of primary and secondary products including meat, dairy, eggs, wool, leather, traction, and transportation to the inhabitants of the mound. While analyses of this material is still ongoing, preliminary results indicate that caprids were the dominant species at Qaratepe, followed by chicken and cattle (Haruda 2020) with sheep, cattle, and horses all likely

requiring seasonal migrations during the summer months (Potts 2014). Agropastoral systems have a long history in the Southern Caucasus with evidence suggesting that this practice has occurred since the Neolithic and Bronze Age periods, where a similar range of cereal grain and animals were cultivated (Lindsay and Greene 2013; Hovsepyan 2015; Rothman 2017; Ricci et al. 2018). Pastoralists were encountered throughout the frontier regions of the Sasanian Empire with historical sources noting the presence of nomadic groups in north Iran (Potts 2014). In the 8th century, Muslim traders brought fox-pelts to Barda, Derbent, and Khorasan where they traded with nomads (Howard-Johnston 2020) and the presence of nomadic people in the Barda region were noted fighting under the governor of the city against the Rus raids of 943 (Potts 2014). The movement of sheep and cattle to winter pastures is also recorded by Movses Kaghankatvatsi in the 10th century and large numbers of nomadic and semi-nomadic people identified in northern Iran, where the population reportedly numbered half a million tents (Thomas and Gascoigne 2016). The 11th and 12th centuries witnessed the arrival of the Central Asian nomadic Seljuqs in the Caucasus, followed by the Mongols in the 13th century who also moved animals seasonally and pastured their horses on the fertile grasses of the Armenian highlands in winter (Potts 2014). Today in Azerbaijan, more than three million head of sheep, goat, and cattle are taken every year to summer pastures over 1,700 m to graze for 100–120 days between June and September (Neudert et al. 2015, 2019). These pastures are an important resource for livestock keeping and are state-owned and administered by local municipalities (*belediyye*) or rayon administrations (*icra hakimiyyeti*) (Neudert and Allahverdiyeva 2009).

The seasonal cycle at Qaratepe would therefore revolve around the planting of crops and movement of animals. Springtime would require higher labour demands with cattle, sheep and goat producing offspring and cereal fields requiring tending. If cereals were spring-sown, they would be planted, sustained by the meltwaters, or if autumn-sown tended to in the fields. In the late spring/early summer millet was sown, preferable when the soil was warm but still moist (Gyulai 2014). Livestock moved to upland pastures, remained there throughout the hottest and most arid summer months. This seasonal movement is carried out for several reasons, including access to better pasture for milk production, reducing heat stress and alleviating the impact of summer insects on livestock (Welton et al. 2013). This type of vertical transhumance is practised in the valleys and slopes of many mountainous regions of the world, including the Pyrenees, Alps, Carpathians, Western Britain, and Norway today (Costelloe and Svenson 2018). While Qaratepe is situated in a lowland plateau, it is bordered by highland and mountainous terrain to the north and west which would have been utilised by pastoralists in the past, where the animals

would forage on the rich mountain pasture grasses in cooler temperatures. Millet could also have been sown in upland pastures. The cultivation of fast-maturing millets is compatible with the seasonal migration cycles of a semi-pastoral group summering in the highland pastures, enabling them to take advantage of several ecological niches for food production (Di Cosmo 1994; Weber and Fuller 2008). The integration of millet cultivation and semi-nomadic pastoralism has long been recognised as a successful subsistence strategy for populations in semiarid regions worldwide, and millet can grow at altitudes between 800 and 2,000 m (Miller et al. 2016; Shumilovskikh and Poole 2020). At the mound, the inhabitants would have engaged in daily habitation activities which were primarily related to tending the cereal fields and the maintenance of the commensal unit inhabiting the structure, including food processing, preparation and consumption, manufacture and maintenance of artefacts, activity-area maintenance, and household rituals (Rathje and Schiffer 1982).

In the late summer, people and animals would begin to return from the uplands to Qaratepe. The spring-sown cereals and the summer-sown millet are harvested and processed during this period. Assuming that the sheep/goats were born in spring some of the previous year's animals were culled at this time. Preliminary analyses of the caprid assemblage has revealed the age of slaughter as 18 and 30 months. This pattern is similar to those found in pastoral communities in Central Asia during this period, indicating a similar strategy in raising caprids at Qaratepe (Ashleigh Haruda personal communication 2020). Animals that are not slaughtered may then graze the harvest fields in the autumn and winter, manuring it, or be fed fodder from the harvest. This period of the seasonal cycle creates a major labour bottleneck for agrarian societies reaping crops and preparing them for storage or consumption (Fuller and Stevens 2019) and full mobilisation of the inhabitants of Qaratepe would be required for the activities. Cereals were processed and stored fully cleaned for the winter and in late autumn-winter cereals were planted. During the winter, the flocks and herds may have grazed in the lowland area or have been kept in stables to protect them from predators and cold weather.

While this combination of animal and plant species could have caused an annual labour bottleneck (to some extent) during the harvesting time, the choice of crops fits well with an agropastoral strategy, essentially spreading the labour requirements needed throughout the year, with low input cultivation during the summer season to allow for seasonal animal migrations. The presence of rice in the 13th century is therefore intriguing. Introducing changes in agricultural production strategies during the summer months would not have easily allowed for labour at the settlement to be split between tending crops and moving upland with animals and would have put a significant increase on labour demands

during the hottest part of the season; therefore, it may have not been considered compatible with their traditional pastoral lifestyle. The addition of a variety of cultivars and more intense use of the wetlands and summer growing season would not have fitted appropriately with the well-established agropastoral system already in place, disrupting the rhythms of the seasonal cycle. Its recovery in the region concurrent with water buffalo introduction, which Wordsworth et al. (2021) suggest was historically associated with the movement of the Zutt people, suggests that the introduction of these herbivores was accompanied by the movement of these groups into the Southern Caucasus, likely introducing rice cultivation to the marsh environments of Qaratepe.

Risk mitigation strategies

The suite of arable crops and domesticated animals recovered from the excavations at Qaratepe suggest a well-developed, organised agropastoral-type system practised at Qaratepe, utilising locally produced crops and food plants. While the zooarchaeological assemblage hints at medium-distance trade in saltwater fish (Haruda 2020), all plant crops and fruit species recovered from Qaratepe during the Sasanian period could have been grown locally. This is consistent with a self-sufficient food production system not reliant on the trade or import of foodstuffs over great distances. The growing of a combination of both autumn/spring (wheat and barley) and summer-sown crops (millet) indicates a diverse cropping strategy across both seasons. As crop yields are inevitably variable, the growing of a range of cultivars that can tolerate different environmental conditions and take advantage of several ecological niches for food production indicates a risk-buffering strategy to mitigate the probability of a disastrously low yield of a single crop (Marston 2011; Weisskopf et al. 2015). The incorporation of seasonal migration of animals coupled with the growth of a range of cereal grains across the growing season can be seen as a diverse risk mitigation strategy (Lees and Bates 1974). The combination of arable agriculture and pastoral transhumance methods provided a more stable, robust, and diversified subsistence resource base. This provides a level of food security, as in any given year the probability of low yields in all sectors of a mixed economy is significantly lower than it would be in an economy based on a single mode of production (Lee and Bates 1974).

Conclusion

The results obtained provide unique new insights into the agricultural practices and diet of the inhabitants of Qaratepe during the Sasanian and Islamic Periods between the 2nd and 13th centuries AD. Naked wheat, barley and

broomcorn millet formed the three main cultivars grown at Qaratepe between the 2nd and 13th centuries, with variations in the relative frequency of these three cultivars identified. Millet dominated the early phases, with a possible increase in wheat cultivation in the 5th–6th century, coinciding with increased urbanisation and fortification of the Southern Caucasus and could have been a response to changing demographics in the region. The increase in the proportion of barley in the 13th century indicates a change in cultivation practices. However, potential causes of the adaption, such as environmental impacts, conflicts, cultural changes, or a combination of all three, was not possible to determine and the validity of these observations can only occur with an increase in archaeobotanical data covering these periods. The presence of rice at Qaratepe is significant, adding to the growing corpus of archaeobotanical information about the spread of the crop in the past (Spengler et al. 2021). Recent study of a small assemblage from medieval Kerpilitepe and Girag Kasaman (Stone 2022), located northwest of Barda, recovered no rice within the samples, and it is possible that its cultivation at Qaratepe and Barda is a local adoption. Further archaeobotanical work is required in the Southern Caucasus in both the Sasanian and Islamic periods to fully develop the picture of changing agricultural and socio-economic practice during this period, with future excavation and implementation of soil sampling on archaeological sites likely pushing back the introduction of crops such as rice to the suite of cultivated crops at Qaratepe. This research also shows the potential of the use of environmental techniques in the Southern Caucasus which represents a region of high potential for archaeobotanical research and an exciting new frontier for the discipline.

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Data availability All data analysed during this study are included in supplementary information files.

Declarations

Conflict of interest The author have no relevant financial or non-financial interests to disclose or no competing interests to declare that are relevant to the content of this article.

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