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# Subsistence economy in the South Caucasus during the Early Chalcolithic period: bioarchaeological analysis of Bavra Ablari rock-shelter (Samtskhe-Javakheti region, Georgia)

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This paper examines the subsistence economy in the South Caucasus during the Early Chalcolithic (c.4700–4300 BC) through bioarchaeological analyses of the Bavra Ablari rock shelter site. This region, rich in biodiversity and characterized by a variety of climates and landscapes, has a history of agropastoral occupation dating back to the beginning of the 6$^{th}$ millennium BC. Up to now, archaeological studies have mainly focused on the valleys and lowlands, leaving the mountainous areas less explored. Recent excavations at Bavra Ablari, located at an altitude of 1,650 m, have enabled new bioarchaeological analyses to be carried out, providing data on the faunal and botanical assemblages of this period. These analyses reveal a mixed agro-pastoral exploitation, with a predominance of caprine (sheep and goats) rearing and cultivation of cereals, such as barley and einkorn. Faunal remains and evidence of hunting and fishing reveal extensive use of several biotopes. The study highlights the importance of pastoralism, attested to as far back as the Neolithic period, with herds moving seasonally to higher pastures in summer. Early Chalcolithic occupations, such as those at Bavra Ablari, show the persistence of pastoral activities in these mountainous regions despite severe winter conditions and suggest seasonal occupation of the site.

KEYWORDS

**Georgia, South Caucasus, archaeobotany, archaeozoology, Chalcolithic, farming practices**

## 1 Introduction

The South Caucasus is a well-known region for its wealth of natural resources, and especially for its high biodiversity (Myers et al., 2000; Batello et al., 2010). This area, which includes the modern countries of Armenia, Azerbaijan, Georgia as well as a small part of north-eastern Turkey, and north-western Iran, is characterized by complex mosaics of climates, languages, and populations. From the Kura Valley to the Lesser Caucasus Mountains, we observe contrasted environments, from semi-desertic steppes to high mountainous areas with subalpine vegetation. In this region, which presents a mosaic of ecosystems and climates, there are numerous areas with fertile land conducive to agriculture, while elevated regions are suitable for pastoralism (Batello et al., 2010). In the South-Caucasus Mountains today, some populations still follow a traditional agropastoral way of life, including traditional farming and cultivation of ancient crop varieties. Farmers also maintain traditional exploitation of wild plants for medicinal purposes, for human and animal food or for the manufacture of utensils and tools. Herding, and in particular nomadic pastoralism, constitutes an important part of the mountain economy (Batello et al., 2010; Akhalkatsi, 2015; Bussmann et al., 2020). While the birth of agriculture in the Fertile Crescent dates back to around 10 000 BCE, the earliest agropastoral settlements in the Caucasus, according to results from recent excavations and bioarchaeological analyses, trace back to the beginning of the 6$^{th}$ millennium, several millennia later. Thus agropastoralism has a long history in the Caucasus area (e.g., Hovsepyan and Willcox, 2008; Chataigner et al., 2014; Decaix et al., 2016; Hamon et al., 2016; Neef et al., 2017; Sagona, 2018). In the region, archaeological investigations focusing on the Neolithic and Chalcolithic periods have mainly been carried out in valleys and lowlands (Lyonnet et al., 2012; Berthon et al., 2013; Decaix et al., 2016; Hamon et al., 2016; Helwing et al., 2017; Marro et al., 2019; Akashi, 2021; Hirose et al., 2021; Bălăşescu and Radu, 2022; Hovsepyan, 2022; Janzen et al., 2023). Sites from these periods are rare at higher altitudes, and the subsistence economy of Neolithic and Chalcolithic populations in the mountains is still being studied. For the Chalcolithic period, bioarchaeological data have been published for the mountains of the Armenian Plateau (Palumbi et al., 2021a) and the foothills of the Lesser Caucasus (Chataigner et al., 2020). Comparisons between valleys and mountainous regions based on faunal remains and isotopic analysis have also been undertaken in Georgia and Azerbaijan (Berthon et al., 2021). In Georgia, recent works have been carried out on intermontane sites located at an altitude of around 700 m (Stöllner et al., 2023), but there are no studies dedicated to Chalcolithic occupations specifically located in mountain contexts. Thanks to recent excavations conducted on the Bavra Ablari rockshelter (1,650 m asl), new bioarchaeological analyses have been carried out. This work provides fresh data regarding faunal and botanical assemblages recorded within the Early Chalcolithic layers, allowing us to examine the subsistence economy in this mountain region of the Lesser Caucasus during this key period. The recent analyses carried out at Bavra Ablari will also provide new insights into the environment of the plateau during the Middle Holocene. Although several pollen studies have been carried out on the plateau (Connor, 2006; Connor and Sagona, 2007; Messager et al., 2013, 2017, 2020), there is still some debate about the past extent of forest cover in these mountains (Nakhutsrishvili, 1999; Zerbe et al., 2020). The presence of plant macroremains (charcoal, seeds, and fruits) identified at Bavra Ablari provides more local information about vegetation than pollen assemblages, which tend to yield information about regional vegetation, and helps to better identify the role played by past woodlands on the plateau.

## 2 Bioarchaeological analysis for the Neolithic and Chalcolithic periods in the Caucasus

During the Neolithic period, the range of cultivated plants already appears diverse and includes cereals (barley, hulled wheat, and free-threshing wheat) and legumes (lentils, peas), as well as flax (Decaix et al., 2016; Neef et al., 2017; Akashi et al., 2018; Akashi and Tanno, 2020; Hovsepyan, 2022). Similarly, while hunting was still practiced, remains of domesticated animals are abundant (cattle, sheep, goats, and pigs) (Berthon, 2014; Chahoud et al., 2015; Hirose et al., 2021; Bălăşescu and Radu, 2022; Janzen et al., 2023). In the period of transition between the Neolithic and the Chalcolithic, agricultural practices display a degree of stability, albeit with a decline in the prominence of hulled wheat (einkorn and emmer) compared to earlier periods. At the beginning of the Neolithic, those wheats were predominant, but free-threshing wheat quickly became prevalent in the region, whereas the decline of hulled wheat is observed during the Chalcolithic period (Decaix, 2016; Palumbi et al., 2021b). Furthermore, there was a discernible expansion in the diversity of fruit trees, encompassing varieties like grape, apple, and dogwood (Areshian et al., 2012; Wilkinson et al., 2012; Berthon et al., 2013; Hovsepyan, 2014; Decaix, 2016; Decaix et al., 2016; Gambashidze et al., 2018; Decaix et al., 2019). The faunal spectrum shows regional patterns during the Neolithic and Chalcolithic periods with an animal rearing economy focused on the exploitation of sheep and goats in the Araxes Valley, while the Kura Region shows greater variation (Berthon, 2014). The Early Chalcolithic (5,200/5,000–4,200 BCE) in particular has been poorly documented. However, in the few sites that have been studied, as for example Uçan Agil and Nakhchivan Tepe, two mobile camps in the Nakhchivan region, and Getahovit cave in the Lesser Caucasus foothills, there is a somewhat restricted range of crops with only cereals being observed, along with some fruit trees (Decaix et al. submitted[1]; Chataigner et al., 2020).

In the South Caucasus, pastoralism is attested as early as the Late Chalcolithic period in mountainous regions. Faunal and isotopic analyses obtained from multiple sites in Azerbaijan and Georgia have shown that animals moved to high-altitude grazing areas during the summer months (Berthon et al., 2021). During this period, on the Dzedzvebi Plateau, where pastoralism appears to have been a significant component of

1 Decaix, A., Aliyev, T., Bakhshaliyev, V., Helwing, B., Maziar, S., Saed Mucheshi, A., et al. (submitted). Human-plants interactions around the araxes river during the neolithic and chalcolithic periods. *Varia Anatolica*.

the subsistence economy with a focus on sheep/goats and cattle, archaeobotanical analyses of cultivated and wild plants have shed light on the seasonal cultivation patterns. Cereals were likely sown in autumn and harvested between late spring and July, extending into the summer months. This indicates field maintenance during winter, implying year-round agricultural activities near the site (Stöllner et al., 2023). At Godedzor in Armenia, during the late Chalcolithic, herding strategies appear to have focused on caprines, particularly sheep. Among cultivated plants, free-threshing wheat predominates, identified through grains and chaffs, giving us an insight into agricultural practices in this mountainous area. Indeed, according to the authors, the inhabitants of Godedzor were thus able to cultivate fields alongside summer pastures during the transhumance period (Palumbi et al., 2021a).

The seasonal movement of herds between highlands and lowlands appears to date back to the last quarter of the 5$^{th}$ millennium BC and recent isotopic analyses in the Kura (Hacı Elamxanlı Tepe, Göytepe) and Araxes (Masis Blur) valleys suggest that vertical transhumance was already practiced in the Neolithic (Hirose et al., 2021; Janzen et al., 2023). Recent discoveries at Bavra Ablari provide a new insight into the pastoralism in mountainous regions during the Early Chalcolithic and confirm continuity of this activity since the Neolithic period (Varoutsikos et al., 2018).

# 3 Material and methods

## 3.1 The site of Bavra Ablari

In the south of Georgia, the site of Bavra Ablari is a rock shelter located at 1,664 m a.s.l. (N 41°24.661′ E 43°29.660′), near the town of Akhalkalaki, on the volcanic Javakheti plateau (Figure 1) which reaches altitudes of up to 2,500 m. The site was excavated between 2012 and 2015 by a French-Georgian team under the direction of B. Varoutsikos and A. Mgeladze. The dig was carried out within the framework of the “Mission Caucasus” funded by the French Ministry of Foreign Affairs. The site is located at the confluence of two rivers: the Paravanis Tskali and the Ablari River. It revealed a diachronic occupation, from the Mesolithic to the Middle Ages, with significant occupations during the Neolithic (6$^{th}$ millennium BC) and Early Chalcolithic (5$^{th}$ millennium BC) (Varoutsikos et al., 2018; Figure 2). In the surroundings of Bavra Ablari, the current vegetation is composed of altimontane herb-grass and meadow steppes, with species of *Stipa*, *Festuca*, and *Onobrychis*, and montane *Stipa* steppes, with tomillares and thorn-cushion communities. Oak, hornbeam-oak and oriental-hornbeam oak forests occur not very far from the site. The Javakheti Plateau experiences a harsh continental climate, with long cold winters and short warm summers. The average annual temperature is around 5°C and annual precipitation is around 620 mm (Bohn et al., 2003; Peel et al., 2007; Nakhutsrishvili, 2013). The site was sampled for archaeobotanical and archaeozoological analyses, and this paper focuses only on those concerning the Early Chalcolithic levels; these are the only levels that also allow a multi-proxy approach. As each discipline was subject to different sampling protocols, they will be detailed individually.

## 3.2 Plant macroremains

For analysis of plant macroremains, including seeds, fruits and charcoals, sediment was collected from occupation levels and hearths (Figure 2). Sample volumes range between 3 and 77 liters, depending on the thickness of the archaeological level. The total volume of the samples is 186 liters (Table 1). The whole sediment was floated in the field using a sieve with a mesh size of 0.5 mm. All residues were dried, and plant remains were extracted and sorted with a stereoscopic microscope at magnifications of x6.5–x40. All the macrobotanical remains were preserved in the form of charred material. Some samples contained only charcoal. For carpological analysis, the corpus is based on a volume of 176 liters of sieved sediment.

In the laboratory, charcoal fragments were fractionated manually for anatomical observation along three wood sections (Chabal, 1997; Schweingruber, 1990). The sizes of charcoal fragments studied range between 0.5 cm and 2 cm. The fragments were studied under an optical reflected-light microscope in the archaeobotany laboratory of the Research Unit 7209 of the National Museum of Natural History of Paris (x50–x100). They were identified using reference collections of modern temperate, Mediterranean, and Near Eastern woods as well as descriptions in wood anatomy atlases (Schweingruber, 1990; Parsa Pajouh et al., 2001; Benkova and Schweingruber, 2004). Taxa were identified as precisely as possible, most often to the genus level, but in some cases, it was not possible to distinguish between two different taxa. Difficulties in botanical identification are most often due to similarities in the cellular structure between two closely related species. Sometimes the general state of preservation can also have an influence on the degree of precision that can be obtained. Seeds, fruits and other plant macroremains were identified using the modern reference collection of plant material in the laboratory of Prehistoric Archaeology and Anthropology of the University of Geneva and the laboratory of archaeobotany of Research Unit 7209 of the National Museum of Natural History in Paris. Specialized literature was also used (Cappers and Bekker, 2021).

## 3.3 Phytolith analysis

For phytolith analysis, the sediment was sampled along the southern profile, located in squares E1 and F1 (Figure 2). The samples were collected in different layers and stratigraphic units assigned to Chalcolithic occupations. Three samples come from hearths that were clearly identified in the stratigraphy (samples 177, 183, and 187 cm). Phytoliths were extracted from sediment samples using HCl and $H_2O_2$ baths, sieving, clay removal and densimetric separation (Lentfer and Boyd, 1998). After cleaning, the residue was suspended in immersion oil and mounted on glass slides. The slides were observed under a Leica DM 1,000$^{TM}$ Microscope at x650 magnification. Each phytolith was classified according to its morphology, following several systems (Twiss et al., 1969; Mulholland, 1989; Fredlund and Tieszen, 1994) and the International Code for Phytolith Nomenclature (Neumann et al., 2019). The observed phytoliths were classified into 14 different categories: Elongate, Elongate dentate, Elongate dendritic,


FIGURE 1
Map showing the location of Bavra Ablari, and picture of the shelter located on the right at the foot of the rock, with Amiran Hill in the background (picture V. Scao).

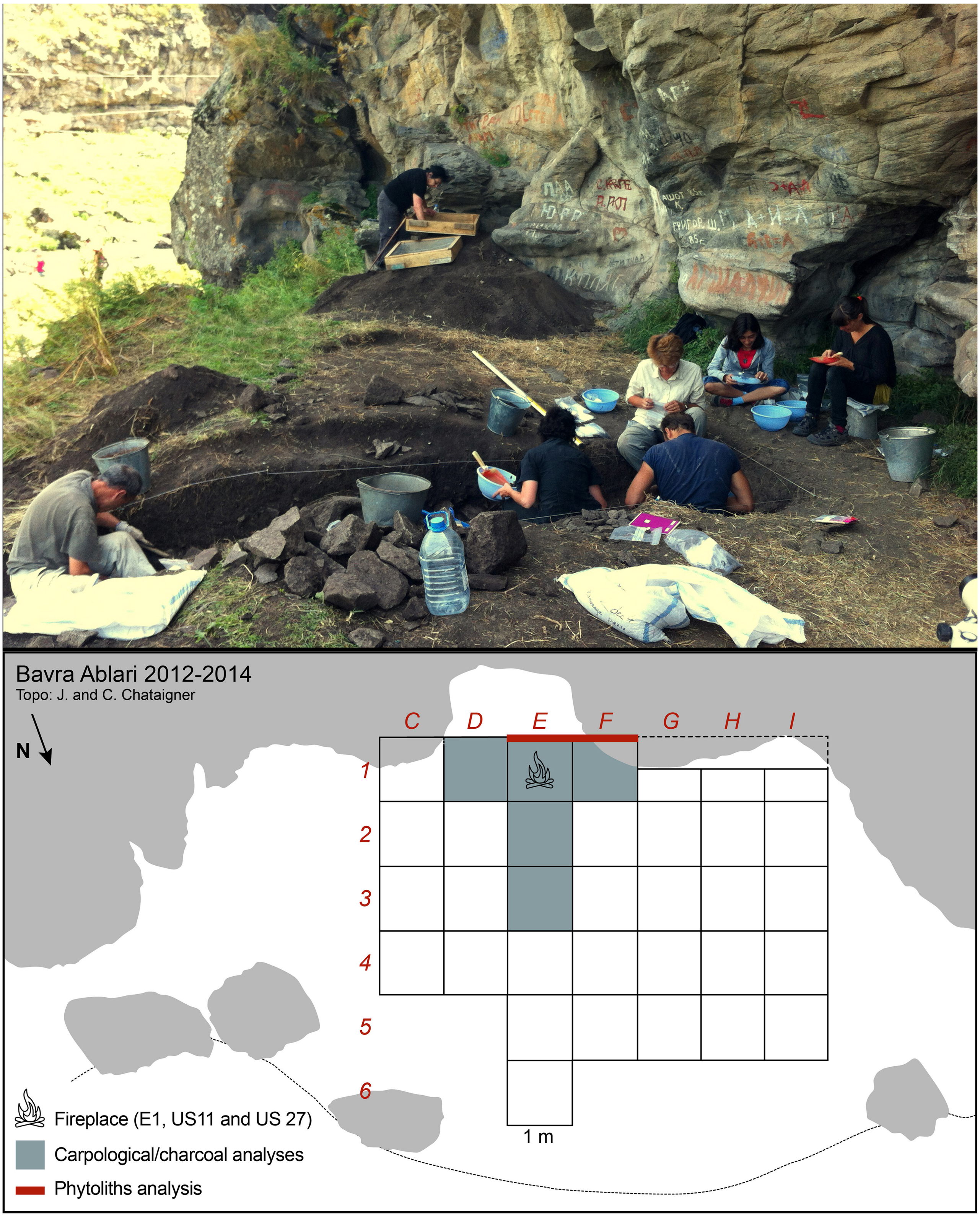


FIGURE 2
Bavra Ablari. At the top: view of site under excavation (2012, picture V. Scao). Bottom left: plan of site and excavation area, including localization of squares and profile sampled for archaeobotanical analyses (DAO: B. Varoustikos and L. Martin).

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TABLE 1 Carpological and anthracological samples from Early Chalcolithic layers of Bavra Ablari.

| Carpological samples | Charcoals analysis samples | Référence | Volume (liters) | Occupation layer (OL)/type of structure | Radiocarbone dates |
|---|---|---|---|---|---|
| BA 2012-1 | BA001 | E3, niv 2, dec 2 | 10 | OL | |
| BA 2012-2 | BA002 | E3, niv 2, dec 4 | 4 | OL | |
| BA 2012-3 | | E2, niv 2, dec 4, z = −175–180 | 5 | OL, very organic | 4,488–4,347 cal BC (Poz-66,737: 5,580 ± 40 BP) |
| BA 2012-4 | BA004 | E2, niv 2, dec 5 | 3 | OL | |
| BA 2012-5 | BA005 | E2, niv 2, dec 6, z = −182–187 | 8 | OL | |
| BA 2012-6 | BA007 | E2, niv 2, dec 7, z = −187–192 | 12 | OL | 4,669–4,400 cal BC (Lyon-10,372/SacA-34,119: 5,680 ± 40 BP) |
| BA 2013-7 | | E1, US 8, z = −170–174 | 12.5 | OL | |
| BA 2013-8 | BA009 | E1, US 11, z = −174–180 | 19 | Fireplace | 4,496–4,356 cal BC (Poz-61,368: 5,600 ± 35 BP) |
| BA 2013-9 | BA010 | F1, US 22 | 7 | OL | |
| BA 2013-10 | BA016 | E1, US 27, z = −183 | 77 | Fireplace | 4,668–4,461 cal BC (Beta-363,171: 5,710 ± 30 BP) |
| BA 2013-11 | BA011 | D1, US 27, z = −183 | | OL | 4,692–4,503 cal BC (Poz-61,369: 5,750 ± 35 BP) |
| BA 2013-12 | BA012 | E1/F1, US 29, z = 190–200 | 10.5 | OL | |
| BA 2013-13 | BA013 | F1, US 32, z = 195–200 | 3 | OL | |
| BA 2013-14 | BA014 | E1, US 35, z = 200–205 | 15 | OL | |
| **TOTAL** | | | **186** | | |

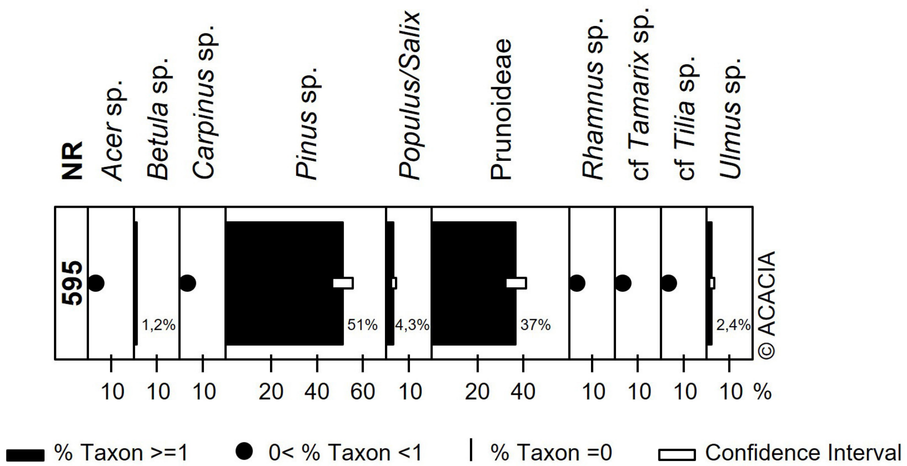


FIGURE 3
Anthracological diagram of Bavra Ablari, Early Chalcolithic levels.

Acute bulbosus, Blocky, Bulliform flabellate, Rondel, Crenate, Bilobate, Silica skeletons, Papillate, Spheroid ornate, and Tracheary. The morphotypes termed "silica skeletons" (linked phytoliths) correspond to fragments of silicified Poaceae epidermis (Rosen, 1992). These represent the remains of fragmented pieces of culms, leaves, and inflorescences of Poaceae plants. Diatoms were also observed and counted. Each morphotype's relative abundance was calculated as a percentage of the sum of classified phytoliths. This sum, used for percentage calculations, was based on the total number of phytoliths counted per sample (more than 300 for each sample, except for sample 177 in which 217 phytoliths have been identified). Diatoms were excluded from the total phytolith sum. The representation of this group was expressed as a percentage of the sum of phytoliths plus the sum of diatoms [i.e., % of diatoms = N diatoms/($\sum$ phytoliths + N diatoms) × 100].

## 3.4 Fauna

Animal remains were collected from Chalcolithic layers. We recorded 10,302 bones and bone fragments, which were collected by hand and separated by dry sieving from specific layers like the hearth, floors, and fills. The archaeozoological studies took place in 2014 and 2015. The methods involve anatomical and taxonomic identification of bones and teeth, in addition to taphonomical and biometric analyses. The primary type of counting used in animal skeletal assemblages is the number of identified specimens (NISP). Comparative collections and published identification keys were used to assign specimens to the most specific taxonomic classification. Tooth morphology was used to primarily identify the equid remains (Eisenmann, 1980). Age culling profiles for caprines were constructed in accordance with Payne (1973) and Vigne and Helmer (2007).

# 4 Results

## 4.1 Charcoal

The charcoal fragments studied within the framework of the anthracological analysis come from 12 contexts (occupational layers and hearths) dating to the Early Chalcolithic period (Table 1). The analysis of 595 charcoal fragments has allowed the identification of 10 ligneous taxa (to provide a palaeoecological representation of the charcoal study, the results from the analysis of the 12 samples have been compiled to create the Figure 3). Pine (*Pinus* sp.) is the main tree identified (51%). It is recognized in 75% of the samples. Trees from the plum family (Prunoideae) are also identified (37%) in 75% of the samples. Three taxa represent <5% of the charcoal fragments: poplar and/or willow (*Populus/Salix*), elm (*Ulmus* sp.), and birch (*Betula* sp.). Five other taxa were identified and represent <1% of the studied fragments: maple tree (*Acer* sp.), hornbeam (*Carpinus* sp.), buckthorn (*Rhamnus* sp.), tamaris (*Tamarix* sp.), and lime tree (*Tilia* sp.).

## 4.2 Other plant macroremains

Generally, samples were relatively poor in terms of macrobotanical remains. Nevertheless, seeds and fruits were present in all but two samples (BA 2012-1 and BA 2013-11, Table 1). We counted 169 items, including mainly seeds and fruits, as well as threshing remains of cereals, nutshells, cones (and cone scales), buds, stems or twigs, leaves and foliar scars (Table 2). Most of the plant remains are fragmented and the *indeterminata* represent almost a quarter of the assemblage. The number of remains per liter varies from 0.5 to 2.1, with an average of 1 item per liter. A quantitative approach is impossible due to the small numbers of remains, but the species identified provide interesting information. Cultivated plants are rare, nevertheless a few cereal remains were identified such as caryopsis of barley (*Hordeum* sp.) and einkorn (*Triticum monococcum*), which was also identified as a spikelet (Supplementary Figure 1). A rachis fragment of wheat was also identified. Several edible wild plants have been identified and may belong to the spectrum of gathered fruits: hazelnut (*Corylus avellana*), elderberry (*Sambucus* sp.), and hackberry fruits (*Celtis* sp.). Other wild plants belonging to the apophyte category, i.e., plants linked to human activities, were identified, such as bedstraw (*Galium* sp.), chenopods (*Chenopodium* sp.), and knotweed (*Polygonum* sp.). *Chenopodium hybridum* and *Polygonum aviculare* are arable weeds that may be associated with the cereals present on the site. Among woody taxa, numerous remains of *Pinus* sp., in the form of pine scales and cone fragments, have also been found. The rest of the assemblage is composed of plants whose state of preservation has not allowed precise identification, such as the Boraginaceae, Caryophyllaceae, Polygonaceae, and Solanaceae.

## 4.3 Phytoliths

Phytoliths were generally well preserved, except in sample 183, which was very poor in remains and therefore excluded from the counting. The five other samples yielded very similar assemblages (Figure 4). Grasses (Poaceae) were the dominant taxon. Among this group, Pooideae, represented by Crenate and some Rondel classes, was the best recorded subfamily. Bilobate was recorded in three samples but in very low quantities. Within the Poaceae phytoliths, the Elongate dendritic morphotype, coming from inflorescences (glumes, lemma, and palea) of Poaceae (Ball et al., 2001), is not very abundant (from 1.1 to 2.2%), but was recorded in every sample. This class of phytolith is scarcely recorded in natural soil assemblages; however, it is often well-represented in archaeological sites where cereals have been processed (Berlin et al., 2003; Portillo and Albert, 2011). Thus, their modest occurrence in the Bavra Ablari assemblages indicates that a few cereal grains or spikelets could have been brought into the rock shelter. But these assemblages do not reveal significant cereal-based activity, such as cereal processing, on this site. The Elongate dentate form, now counted separately from Elongate dendritic (Neumann et al., 2019), occurs in similar proportions (from 1.2 to 1.7%) to those of the Elongate dendritic form. The Silica skeletons class (representing fragmented epidermal cells from cereal processing), was rare (from 0.4 to 1.7%), but was identified in every sample. These occurrences, while very few in number, raise questions regarding their origin: do they represent threshing remains associated with cereal grains brought into the site by people as part of their diet? Or do they represent threshing remains originating from animal dung, etc.? The Spherical ornate phytoliths, a class that are generally very rare in temperate phytolith assemblages, are present in proportions ranging from 0.2 to 5.8%, which can be considered as significant. In the Bavra Ablari assemblages, this type is dominated by cystoliths, which present many common characteristics with cystoliths produced by the Urticaceae family (Fernández Honaine et al., 2023). Samples 177, 182, and 213 yielded numerous diatoms (9.6%, 12.7%, and 26.6%, respectively).

## 4.4 Animal remains

About 6,003 remains are attributed to mammal taxa (Table 3), and <1% are attributed to birds, reptiles, fish, Crustaceans, and molluscs. The bone remains are well-preserved. Nevertheless, the rate of fragmentation is high. Fragments measuring between 1 and 3 cm account for 79% of the total number of mammal remains. In addition, around 13% of the mammal remains were between

TABLE 2 Plant macroremains identified in Early Chalcolithic layers of Bavra Ablari.

| 2012/2013 samples | BA 2012-2 | BA 2012-3 | BA 2012-4 | BA 2012-5 | BA 2012-6 | BA 2013-7 | BA 2013-8 | BA 2013-9 | BA 2013-10 | BA 2013-12 | BA 2013-13 | BA 2013-14 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Samples volumes (liters) | 4 | 5 | 3 | 8 | 12 | 12.5 | 19 | 7 | 77 | 10.5 | 3 | 15 | **176** |
| occupation layer (OL), fireplace (FP) | OL | OL | OL | OL | OL | OL | FP | OL | FP | OL | OL | OL | |
| Domesticated plants | | | | | | | | | | | | | |
| *Triticum* sp., rachis fragment | | | | 1 | | | | | | | | | **1** |
| *Triticum monococcum*, caryopsis | | | | | | | 1 | | | | | | **1** |
| *Triticum monococcum*, spikelet fork | | | | | | | 1 | | | | | | **1** |
| *Hordeum* sp., caryopsis | 1 | | | | | | | | | | | | **1** |
| Trees and shrubs | | | | | | | | | | | | | |
| *Celtis* sp., seed | | | | | | | | | 5 | | | | **5** |
| *Corylus avellana*, nutshell fragment | 1 | | | | | | | | 1 | | | | **2** |
| *Pinus* sp., cone scale fragment | | | | 4 | 3 | | 2 | | 13 | | | 5 | **27** |
| *Pinus* sp., seed | | | | 1 | | | | | | 1 | | 2 | **4** |
| *Pinus* sp., cone fragment | | | | | | | 1 | | 4 | | | 1 | **6** |
| *Sambucus* sp., seed | | | | | | 1 | | | 1 | | | 1 | **3** |
| *Sambucus nigra/racemosa*, seed | | | | | | | | | 4 | | 3 | 1 | **8** |
| Wild herbaceous | | | | | | | | | | | | | |
| Boraginaceae, seed | | | | | | | 1 | | | | | | **1** |
| Caryophyllaceae, seed | | | | | 1 | | | | | | | | **1** |
| *Chenopodium* sp., seed | | | | | 2 | 2 | 3 | 1 | | | | | **8** |
| *Chenopodium hybridum*, seed | | 4 | | | | | 1 | | 1 | | | | **6** |
| Fabaceae type *Trifolium,* seed | | | | | | 1 | | | | | | | **1** |
| *Galium* sp., seed | | | | | | | 1 | 1 | 1 | | | 2 | **5** |
| *Galium aparine/spurium*, seed | | | 1 | | 2 | | 2 | | | 2 | | 1 | **8** |
| *Myosotis* sp., seed | | | | | | | | | | | | 1 | **1** |
| Polygonaceae, seed | | | | | | | 1 | | | | | | **1** |
| *Polygonum* sp., seed | | | | | | | | | | 1 | | 1 | **2** |
| *Polygonum aviculare*, seed | | | | | | | | 1 | | | | | **1** |
| Rosaceae type *Potentilla*, seed | | | | | | | | | 1 | | | | **1** |
| Solanaceae, seed | | | | | 1 | | 1 | | 1 | | | | **3** |
| Others plant remains | | | | | | | | | | | | | |
| Buds | | | | | 1 | | | | 2 | | | 2 | **5** |
| stem/twig | | 2 | 1 | 4 | 1 | | 4 | 4 | 6 | | | 2 | **24** |
| Leaf | | | | | | | | | | | | 1 | **1** |
| Foliar scar | | | | | | | | | 1 | | | | **1** |
| *Indeterminata* | 2 | | 2 | 7 | 1 | 2 | 5 | 1 | 5 | 3 | | 12 | **40** |
| **Total** | **4** | **6** | **4** | **17** | **12** | **6** | **24** | **8** | **46** | **7** | **3** | **32** | **169** |
| Items/liter | 1 | 1.2 | 1.33 | 2.13 | 1 | 0.48 | 1.26 | 1.14 | 0.6 | 0.67 | 1 | 2.13 | **0.96** |
| Amorphous objects | | | | | 2 | | 3 | | 8 | 7 | | | **20** |

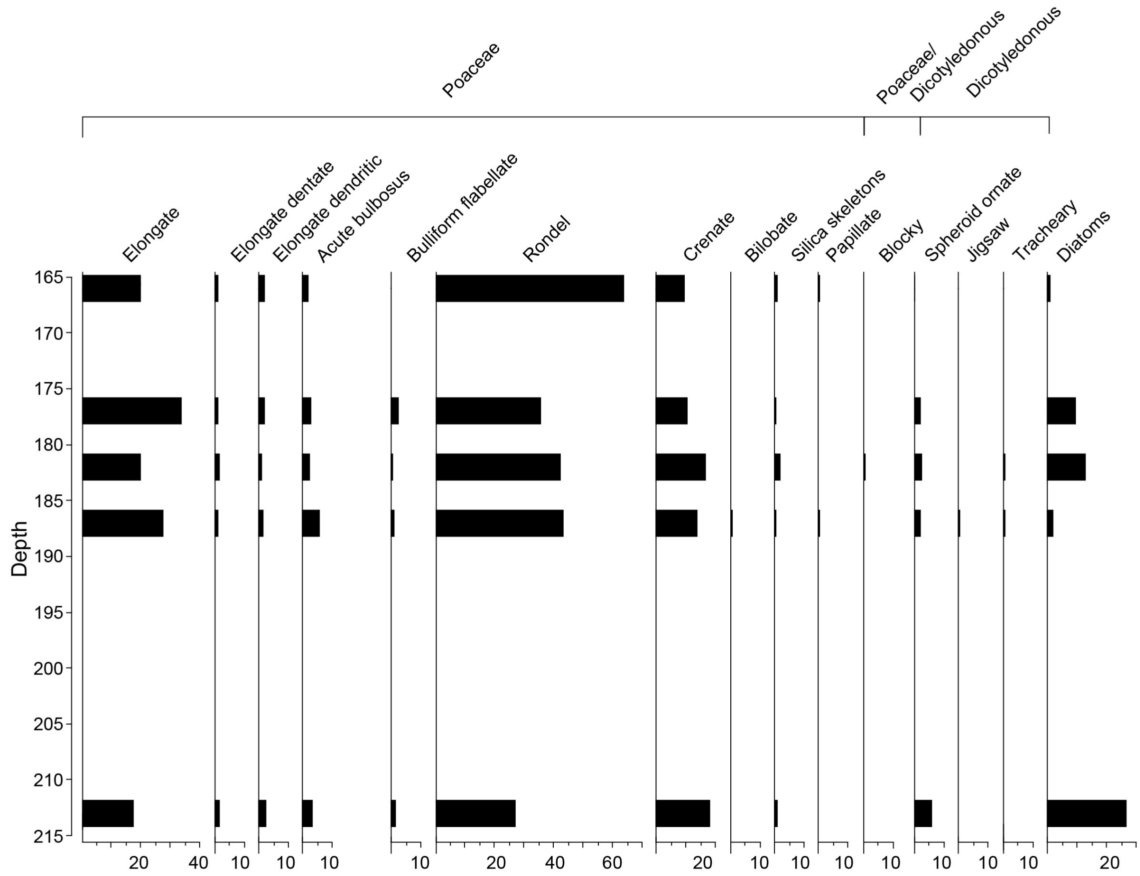


FIGURE 4
Phytolith assemblages from Early Chalcolithic layers (profile E1/F1).

3 and 6 cm. As a result, it was possible to identify only 60% of the total remains. Furthermore, 48% of the mammal remains were not identified to species level due to bone fragmentation (Table 3). They are grouped into three body size categories: small (caprid, small cervid, gazelle), medium (swine, small cervid) and large ungulates (large cervid, bovid, and equid). These fragmented bones could not be distinguished as domestic or wild animals. It is also difficult to differentiate between sheep and goats due to the high level of fragmentation, and hence they are regrouped under the label "caprines" (Sheep/goat). The microfaunal remains, including non-mammals and rodents (228 NISP), are not detailed in this paper. The archaeozoological results indicate that domestic mammals constitute the principal exploited taxa, accounting for around 75% of total NISP (Table 3, Supplementary Figure 2). The other remains are of wild animals, 15% of which were hunted (mammals, birds, fish, crabs) or gathered (snails and clams). In addition, commensal rodents made up 10% of NISP and intrusive lizards and snakes <1%.

### 4.4.1 Wild animals

The identified wild mammals represent 224 remains (Table 3). They consist mainly of equids (49% of total wild mammals), followed by cervids (27%), Carnivores (16%), wild aurochs and bison (4%), hares (2%), wild sheep/goats (1%), and boars (1%). Large ungulates were hunted for consumption, animal products (bones, skin, antlers, etc.) and for transport or labor-related activities. Small prey animals are scarce (hares 2%). Several sizes of equids were hunted. Horses represent the main taxon (14 of 109 equid remains). Moreover, the disparate form and size of bones and teeth suggests the existence of hybrids. Diagnostic long bones are uncommon. Red deer are the main identified animals belonging to the cervid family. All body parts are represented on the site, revealing hunting activities (in proximity to the site), carcass processing and consumption of deer, aurochs, and bison. The lack of cut marks and the high frequency of skull elements might mean that the horses were eaten, and that the processing of the carcasses differed from that of food prey animals. The large number of bones associated with the large ungulate category includes numerous fragmented and splintered equid bones that may have been used for tool making or other purposes (Table 3). According to teeth and long bones, the main focus of hunting were adult animals, with a few young individuals in the case of equids (7 young and 22 adults) and deer (3 young and 16 adults). Other wild mammals such as foxes, mustelids, cats, lynx, and bears were hunted, probably for their fur and to protect livestock and the inhabitants of the settlement. Carnivora are mostly represented by

TABLE 3 Fauna identified in Early Chalcolithic layers from Bavra Ablari.

| | Domestic | Wild | Commensal | Unidentified | Total |
|---|---|---|---|---|---|
| **Bovinae** | **238** | **9** | | **12** | **259** |
| *Bos/Bison* | | | | 12 | 12 |
| *Bos primigenius* | | 7 | | | 7 |
| *Bison* sp. | | 2 | | | 2 |
| *Bos taurus* | 238 | | | | 238 |
| **Caprinae** | **1,426** | **2** | | **920** | **2,348** |
| **Suidae** | | **3** | | **3** | **6** |
| **Cervidae** | | **61** | | | **61** |
| **Equidae** | | **109** | | | **109** |
| **Carnivora** | **17** | **35** | | **79** | **131** |
| Carnivora | | 3 | | 76 | 79 |
| Canid | | | | 2 | 2 |
| *Canis familiaris* | 17 | | | | 17 |
| *Vulpes vulpes* | | 4 | | | 4 |
| *Felis* sp. | | | | 1 | 1 |
| *Felis sylvestris* | | 2 | | | 2 |
| *Lynx* sp. | | 17 | | | 17 |
| *Mustelidae* | | 4 | | | 4 |
| *Martes* spp. | | 2 | | | 2 |
| *Meles* sp. | | 1 | | | 1 |
| *Ursus* sp. | | 2 | | | 2 |
| **Lagomorphe** | | **5** | | | **5** |
| **Rodents** | | | **228** | | **228** |
| **Large ungulates** | | | | **1,926** | **1,922** |
| **Middle ungulates** | | | | **49** | **49** |
| **Small mammals** | | | | **881** | **881** |
| **Total** | **1,681** | **224** | **228** | **3,870** | **6,003** |

skull and feet bones, confirming that they were hunted for their fur or as trophies (e.g., skull of bear). Birds and fish are recorded in the Bavra assemblage (Table 3). Medium and small size birds are probably aquatic, and raptors were preliminarily identified; it is possible that the latter were hunted for their feathers. The remains of fish and crabs include numerous freshwater medium- and small-sized species. From the slaughter age profile of the wild animals, we notice that juvenile and young red deer (3 <2 years old and 16 adults) and equids (7 juveniles and 22 adults) are attested. They may have been hunted in the proximity of the site, especially during spring and summer.

### 4.4.2 Domestic animals

Domestic animals are the main taxa recorded in the Chalcolithic assemblage of Bavra (1,681 remains). They represent 75% of NISP in Chalcolithic layers. Domestic sheep and goats are the most frequent species in the assemblage, followed by cattle (14%), according to NISP (Table 3). There was no preference evident with regard to the skeletal elements present. The presence of various body parts of domestic ungulates, fresh bone fractures, and butchery cut marks (65% of NISP) on the bone remains, coupled with the identification of lithic tools within these layers, indicates that butchering activities were conducted at the site. The analysis of the slaughtering age profile based on tooth wear stages indicates that sub-adult sheep and goats between 2 and 6 years old were primarily exploited, followed by older individuals between 6 and 10 years old (Figure 5). Unfused bones (10% of caprines NISP) also confirm the slaughter of individuals between 2 and 4 years old. In the case of cattle bones and teeth, we notice that exploitation focused mainly on adult individuals. Cut marks and fresh bone cuts were noted on 65% of domestic ungulate bones, revealing that butchering took place on site. Along with the livestock, dogs were also present on site (1% of NISP).

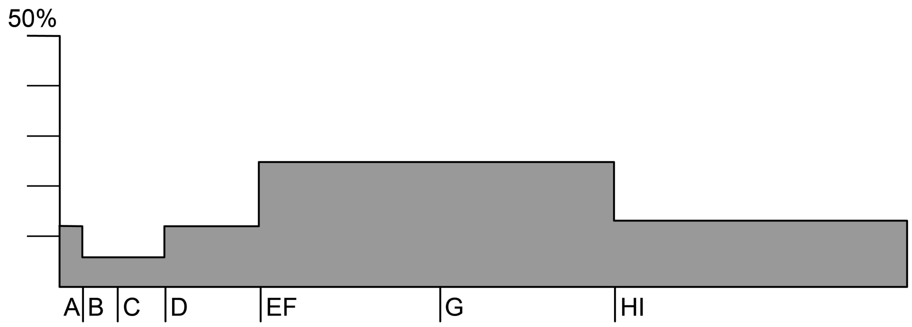


FIGURE 5
Sheep/goat age profile according to tooth remains (16 remains), in corrected percent of the number of identified dental specimens (Payne, 1973).

# 5 Discussion

## 5.1 Surrounding landscape and environment exploitation

The presence of forest on the Javakheti plateau is a subject of debate (Connor, 2006). Has the steppe that dominates the first plateaux today (from 1,500 m to 2,200 m asl) always been predominant since the beginning of the Holocene, or is it the result of the decline of trees due to human activities? Several palynological studies have been carried out on lakes and wetlands of the plateau to reconstruct vegetation dynamics over the last 12 millennia with a view to answering this question. These works have revealed a long phase (from 9,000 to 3,000 cal. BP, covering the Chalcolithic period) characterized by the predominance of tree pollen grains (largely dominated by pines). This phase is followed by the decline of tree pollen assemblages and the expansion of herbaceous taxa. This shift was interpreted as the result of human impact on tree cover from 3,000 to 2,000 cal. BP, leading to the present-day steppe vegetation (Messager et al., 2013, 2017, 2020). Unfortunately, the pollen assemblages recorded in lakes may come from pollen transported over both short and long distances. Although tree pollen counts during the period 8,000–3,000 cal BP were over 70%, there was no direct evidence of the presence of trees on the Plateau.

The assemblage of charcoal fragments from Bavra Ablari reflects different types of arboreal vegetation. The prevalence of pine (*Pinus*, 51%) associated with the occasional occurrence of birch (*Betula*, 1.2%) reveal the significant role of pine forest in this area of the Plateau during the Chalcolithic period. The carpological remains support these observations, as numerous scale remains, seeds and cone fragments of *Pinus* were found in the assemblage ($n = 37$ items). At the present-time, there are no natural pines in the Bavra area. In fact natural pine forests are restricted to a relict patch (Nakhutsrishvili, 2013) located in the Tetrobi Reserve (Chobareti area). This could represent a remnant of the past forest that occupied the plateau during the Chalcolithic. In any case, these new macro-remains assemblages from securely dated deposits at Bavra Ablari support the hypothesis of a past forest (dominated by pines) growing on the Javakheti plateau (hypothesis formulated based on pollen assemblages from lake records). The presence of other identified taxa (among charcoal assemblages), like birch, prunoids, or buckthorn, may vary depending on the degree of forest clearance. Notably, most of these trees exhibit heliophilous or half-shadow characteristics, contributing to the composition of forest edges or open woodland, meaning that the plateau could have been covered by open woodland or a mix of steppes and forest stands. The presence of mesophytic trees, such as maple, hornbeam, lime, and elm, in the charcoal assemblages indicates the existence of mixed broad-leaved forests in the vicinity, which could have developed at mid-altitude (up to 1,800 m). This kind of forest is nowadays found in the eastern part of the plateau, east of Trialeti village.

Within the assemblages, taxa such as, poplars, willows, and tamarisks are indicative of a riparian forest, often associated with additional species such as maple, buckthorn, or elm. This observation aligns with the site's context, situated in close proximity to the confluence of two rivers. The anthracological analysis of Bavra Ablari suggests that wood was sourced from at least three main types of forested vegetation (Pine forest, mesophytic forest, and riparian forest) reflecting the site's ecological diversity. The archaeozoological assemblage of Bavra reflects the exploitation of the surrounding landscape with the consistent hunting of wild game and fishing activities. Wild ungulates—including cervids, bovids, and caprids—had been exploited on the site since the Mesolithic (Varoutsikos et al., 2018). In the Chalcolithic, the use of the resources occurring in the surrounding landscape, even though they did not exceed the 10% of the total NISP of animal remains exploited on site, reveals a mixed rich landscape. Freshwater fish, crabs, and molluscs were gathered and hunted, probably from the nearby rivers. The occurrence on site of the remains of different body parts of red deer and equids confirms that hunting took place within the vicinity of the shelter and that complete carcasses were brought into the site. These resources reveal that mountains, valleys, and forests along with open grassland or plateaus (defined here as a large area of high and fairly flat land) were part of the surrounding landscape. Furthermore, the presence of aurochs and bison reveals the existence of open woodlands and plateaus; there is also a diverse array of forest- and valley-dwelling Carnivora, including marten, badger, and lynx. Bears could have been hunted in the mountains and forest areas. According to the NISP, we observe that the main landscapes exploited by Chalcolithic people were open woodland and plateaus, followed in importance by river valleys. The compilation of macro-remain and archaeozoological analyses reveals that Chalcolithic populations

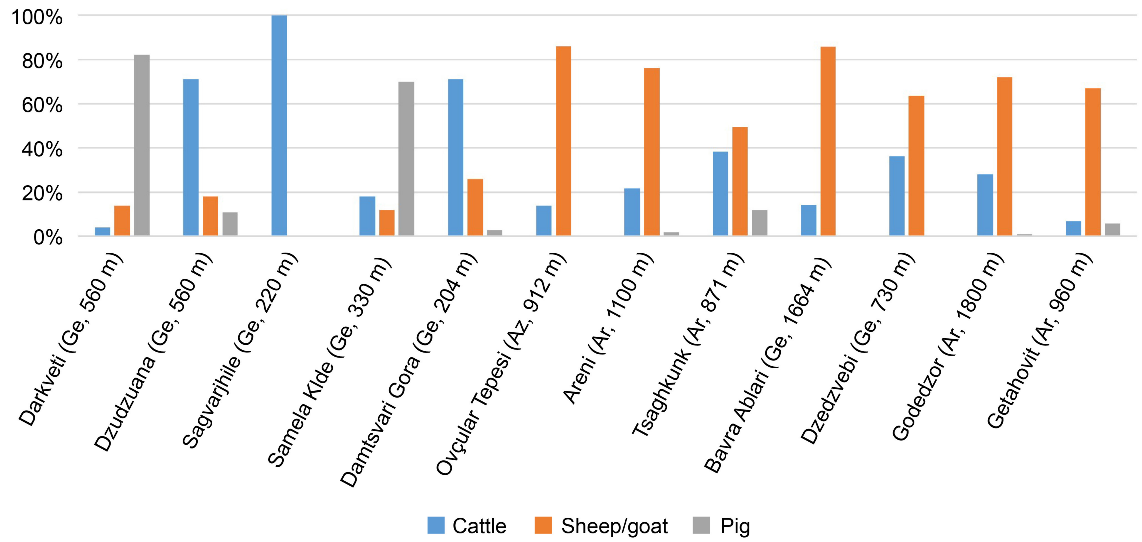


FIGURE 6
Livestock exploitation in Chalcolithic sites (NISP), Areni (Wilkinson et al., 2012); Damtsvari Gora (Varazashvili, 1992); DaDarkveti (Nebieridze, 1978); Dzedzvebi (Berthon et al., 2021); Dzudzuana (Nebieridze, 1978); Getahovit (Chahoud, unpublished); Godedzor (Palumbi et al., 2021a); Ovçular Tepesi (Berthon et al., 2013); Samele Klde (Nebieridze, 1978); Tsaghkunk (Mezhlumyan, 1972); and Sagvarjhile (Nebieridze, 1978). Ge: Georgia, Ar: Armenia, Az: Azerbaijan.

exploited different environments on the plateau, composed of both steppic and wooded vegetation (Figure 6). The use of these different environments had evolved since the Mesolithic; the archaeozoological data available for these levels at Bavra Ablari, for example, show that mountain areas were much more heavily exploited than during the Neolithic and Early Chalcolithic periods (Supplementary Figure 3).

## 5.2 Subsistence economy

Analysis of seeds and fruits permitted a first insight into the plant-based economy. Despite their discrete presence—four remains in total—two species of cereals are attested: barley and einkorn, rustic species well adapted to mountainous areas. While barley is identified in significant proportions as early as the Neolithic in Caucasian sites (Lyonnet et al., 2012; Decaix, 2016; Decaix et al., 2016; Neef et al., 2017; Akashi, 2021), einkorn appears rather as a secondary cereal, less prevalent in archaeological assemblages (Hovsepyan and Willcox, 2008; Palumbi et al., 2021b). At Godedzor, a late Chalcolithic site in the Armenian Highlands, free-threshing wheats are the main crops (Palumbi et al., 2021a). This situation is already evident in the Neolithic period, during which free-threshing wheat became more prominent over the second quarter of the 6$^{th}$ millennium BCE eventually supplanting the hulled wheats (Palumbi et al., 2021b). During the Late Chalcolithic and later periods (Kura-Araxes, Bedeni) this situation persisted: alongside barley, primarily free-threshing wheats are cultivated, with hulled wheats being in the minority (Berthon et al., 2013; Messager et al., 2015; Decaix et al., 2019; Bedianashvili et al., 2022). We can therefore conclude that the presence of einkorn at Bavra Ablari is quite significant; unfortunately, because only one caryopsis and one spikelet base have been recorded (Supplementary Figure 1), it is difficult to interpret their presence on the site. At the same time, the absence of free-threshing wheat in this assemblage dating from the Early Chalcolithic does not mean that it was not cultivated or used, given the small number of cereal remains found at the site. The cereals identified within the Bavra Ablari assemblage might suggest the cultivation of crops in the surrounding area. Phytolith analysis reveals the presence of a few residues from threshing operations, but their rarity and the limited quantity of cereal macroremains restricts the hypothesis of local cultivation. Thus, one might question whether the cereals were brought to the site or cultivated nearby, considering the suitability of the terrain surrounding the site. Alternatively, were the cereals used as fodder for livestock? Indeed, the residues of harvest treatment identified by the phytoliths could have been consumed by the animals and subsequently deposited in their excrement within the rock shelter area. We did not find any pulses at Bavra Ablari; this source of protein (pea, lentil, or grass pea) is present in small quantities on other sites. Some wild plants such as nuts, elderberry and hackberry could be related to gathering activities. Regarding faunal remains, while a few hunted animal remains have been identified, domestic animals prevail, with butchery marks observed on some bones. The results show a trend toward more specialized husbandry based on sheep and goat rearing, as is clear from the high relative frequency of caprines at Bavra (85%). On the basis of livestock frequency recorded in Chalcolithic sites in the wider region, we can infer a specialized economy based on cattle in the plain areas vs. caprines in the highland. Archaeozoological analysis attests that pastoral activities were already taking place at Bavra in the Neolithic period (Supplementary Figure 3, Varoutsikos et al., 2018). These results are supported by isotopic analyses conducted at the Neolithic sites of Hacı Elamxanlı Tepe and

Göytepe in the Kura Valley, as well as at Masis Blur in the Araxes Valley, indicating the existence of vertical transhumance practices involving a portion of the livestock (Hirose et al., 2021; Janzen et al., 2023).

Therefore, Bavra's economy fits the variability of highland settlements in the Caucasus during the Chalcolithic with a specialized exploitation based on sheep and goat husbandry (more than 60% of NISP) (Figure 6). We note that animals were primarily exploited for milk, complemented by lifetime products such as wool and fleece. The culling of juvenile individuals could indicate a natural mortality or culling for milk production and suggests probable springtime slaughter. The slaughter age of wild animals could also attest to a spring-summer occupation of the site which is in line with seasonal exploitation of mountain pasture. The question of seasonality can also be approached, with caution, using archaeobotanical data. Although cereals are in short supply, if they were grown in the vicinity of the site, this would mean that a human presence would be required between spring and autumn; the same applies to wild plant taxa that could potentially be harvested, such as hazelnuts, hackberries or elderberries, which are collected in late summer or early autumn. Additionally, the exploitation of the nearby riverine zone is evident through wood exploitation and fishing activities. These results might indicate a comprehensive exploitation of the plateau, with mixed agro-pastoral activities primarily based perhaps on cereal cultivation, local or otherwise, but also gathering of wild plants, as well as animal husbandry. At the outset of the Chalcolithic period, human communities occupied diverse ecological areas, particularly in terms of altitude (Sagona, 2018). Hence, despite the scattered nature of the data, consolidating them enables a deeper understanding of the site's function and the ways in which its inhabitants interacted with their environment during the Early Chalcolithic. The presence of domesticated sheep and goats was already evidenced at Bavra during the Neolithic period, from approximately 6,200 to 5,300 BCE.

## 6 Conclusion

The excavation at Bavra Ablari offers valuable insights into early high-altitude occupation during the Early Chalcolithic period, shedding light on pastoral practices in the southern Caucasus. The surrounding landscape analysis suggests a complex environment characterized by diverse vegetation types, including pine forests, mixed broad-leaved forests, steppes, and riparian forests, indicating ecological diversity in the area. The presence of various animal remains, along with evidence of hunting and fishing activities, underlines the comprehensive exploitation of the plateau's resources, reflecting a mixed agro-pastoral economy. The identification of rustic cereals such as barley and einkorn raises questions regarding local cultivation practices. In addition, the predominance of *Caprines* in the faunal assemblage points to highland pasturing of sheep and goats that were probably part of the permanent herd established at lower altitudes. At Bavra Ablari, this Chalcolithic occupation follows a Neolithic occupation, and attests of the persistence of pastoral activities on the Javakheti Plateau.

Moreover, the fact that the site is located in a mountainous region with particularly severe winter conditions, suggests that it was occupied on a seasonal basis. Despite the challenges posed by the scattered nature of the data, synthesizing these analyses provides a deeper understanding of Bavra Ablari's role and the dynamic interactions between its inhabitants and their environment during the Early Chalcolithic in the South Caucasus.

## Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

## Author contributions

AD: Conceptualization, Data curation, Investigation, Methodology, Writing – original draft, Writing – review & editing. LM: Conceptualization, Data curation, Investigation, Methodology, Writing – original draft, Writing – review & editing. EM: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. JC: Data curation, Methodology, Writing – original draft, Writing – review & editing. BV: Data curation, Investigation, Supervision, Writing – review & editing. AM: Data curation, Investigation, Project administration, Supervision, Writing – review & editing. MG: Data curation, Investigation, Writing – review & editing. TA: Data curation, Investigation, Writing – review & editing. CC: Data curation, Funding acquisition, Investigation, Project administration, Supervision, Writing – original draft.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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## Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fearc.2024.1471093/full#supplementary-material

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