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Typology, Evolution, and Replacement of Ground Stone Tools as Indicators of Subsistence Changes Among the Inhabitants of the Komishani Site, Behshahr

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Abstract

During the second excavation season at the Komishani site in the summer of 2023, 27 ground stone tools were recovered. These include grinding slab, upper grinding stone, mortars, pestles, hand stones, and hoes. The purpose of this study is to classify and describe these ground stone tools to provide insights regarding the evolution and replacement processes of ground stone tools, and to shed light on the selection and change of livelihood strategies of the site’s inhabitants. The terminology, classification, and typology used are borrowed from researchers in this field, focusing on categorization and avoiding multiple names for subcategories that emerged due to different shapes and cross-sections of a single ground stone tool type. Ultimately, an evolutionary perspective on ground stone tools (their change, transformation, and replacement over time) has been adopted. At the Komishani site, the replacement, coexistence, and functional shift of ground stone tools indicate the use of pestles in the lower layers for pounding and crushing plant materials, as well as processing fish and hunted birds. Gradually, in the upper strata, pestles and mortars were replaced by grinding slabs and hand stones, which were used for milling and processing various foodstuffs. Hunter-gatherer societies gradually transitioned to cultivation and the expansion of agriculture, a development also evident in the increasing size and complexity of ground stone tools.

Keywords: Ground Stone Tools, Neolithic Period, Komishani Cave, Food Production, Agriculture.

Introduction

Ground stone tools are a subcategory of stone artifacts, generally defined as any piece of stone that is either manufactured through abrasion, polishing, or percussion, or used to grind, abrade, polish, or strike materials (Adams, 2002: 2). They are often associated with agriculture and the Neolithic Period and can provide valuable insights into a range of cultural and economic developments. Studies have shown that such tools existed even prior to the advent of agriculture, particularly in the processing of wild cereals (Ebeling & Rowan, 2004: 108). However, within the broader discourse on the origins of agriculture, the prolonged process of human tooth-size reduction beginning in the Upper Paleolithic is often overlooked. This phenomenon can plausibly be linked to the increasing use of grinding tools, which enabled the preparation of softer and more digestible plant-based foods. From around 100,000 years ago to the end of the Pleistocene, human tooth size decreased by approximately one percent every 2,000 years; however, after 10,000 BCE, this rate of reduction nearly doubled (Hodder, 2018: 1–4).

The classification and typology of ground stone tools are often based on morphology inferring function from shape and the residual form left by use, rather than the tool's original configuration. For this purpose, in addition to physical attributes, wear patterns, use traces, and impact marks are also considered. In the Zagros region and at sites east of the Fertile Crescent, such as Jarmo and M'lefaat, ground stone tools have been studied primarily at the site level, often using non-standardized or inconsistent terminology (see: Braidwood & Howe, 1960; Moholy-Nagy, 1983). However, Wright's regional typological approach has become more widely applied across the Levant and greater Southwest Asia. This method organizes tools into categories, types, and subtypes by systematically listing their physical features and classification criteria, including size, shape, and raw material (Kozłowski & Aurenche, 2005; Wright, 1992).

However, the use of various and sometimes inconsistent terms for naming and identifying tools remains an unresolved issue, and archaeologists have proposed multiple solutions to address this problem (Adams, 2002; Hole *et al.*, 1969). For instance, the terms "quern" and "hand mill" have proven problematic, as both technically refer to a paired set of stones functioning together. The dictionary definition of "quern" is: "an old form of hand mill for grinding grain, the upper stone usually pierced and turned on a pin in the lower stone by means of a stick thrust into a notch in the edge"

(Hole *et al.,* 1969:170). However, determining function based solely on morphology presents challenges.

In ethnoarchaeological studies, while demonstrating the classification of ground stone tools to members of the Hopi Tribe, one elder, upon seeing a deep mortar, explained that it had been used as a watering trough for eagles tied to the roof during seasonal ceremonies. Another example was identified as a tool used to prepare meat for elderly individuals who had lost their teeth, and a hand stone was recognized by a local informant as having been used for hide processing and hair removal, though this individual could not clearly articulate the difference between hand stones used for grain processing and those used for hides. All of these tools shared similar or even identical morphological features, yet they were easily distinguishable based on ethnographic context (Adams, 2010:131–132). Edge-wear analysis has been a primary method for differentiating between grain-processing hand stones and hide-processing ones (Adams, 1989). However, Mona Wright's experimental studies on edge-wear have demonstrated that determining the degree of wear on prehistoric ground stone tools is problematic, since their original weight and thickness prior to use are unknown, and no standard criteria exist for reconstructing their original shape (Wright, 1993: 353).

In recent research aimed at identifying the use and function of ground stone tools, greater emphasis has been placed on laboratory-based and chemical residue analyses. These include starch grain recovery methods, in which the tool surface is washed with distilled water, centrifuged, and analysed for microscopic residues such as starch granules (see: Rowan & Ebeling, 2008; Martinez *et al.,* 2020; Revedin *et al.,* 2022). In the authors' view, during the early Neolithic Period at the Komishani site, human populations were economically and symbolically self-sufficient and relatively independent from surrounding communities. These groups likely adopted similar, yet locally adapted, responses to environmental and climatic changes. However, this apparent similarity despite underlying cultural or functional differences should not be used as the sole basis for comparative analysis. For instance, Neolithization was a heterogeneous and temporally variable phenomenon that affected human communities in fragmented and non-linear ways. As such, the use of rigid, linear comparative models is inadequate, except when applied to morphological classification and basic cross-site comparisons. It is more effective to begin with a clear, site-specific description of ground stone tools, simplify typological categories, and use such classifications as a foundation for broader regional syntheses. Where feasible, chemical and microscopic analyses should complement this approach. In the 2023 excavation season at the Komishani site, 27 ground stone tools were recovered, including a grinding slab, upper grinding stone, mortars, pestles, hoes, and hand stones. This article presents their preliminary typological classification and description. While ground stone tools are often multi-functional, to avoid ambiguity and excessive naming, each tool has been assigned a single functional category. They are grouped into five major types, each accompanied by photographs, basic attributes (weight and dimensions), and, where applicable, information on the stratigraphic layer from which they were recovered.

Research Background

In the late 19th century, it was assumed that the first tools used by so-called "uncivilized" peoples were chipped stone tools, and that ground stone tools developed later alongside the expansion of agriculture (McGuire, 1893). However, subsequent studies have shown that the earliest stone artifacts associated with hominin remains were often unmodified or minimally shaped cobbles, frequently referred to as pitted anvils (e.g., De Beaune, 2004; Leakey, 1971; Leakey, 1976; Leakey, 1994). Hammerstones are commonly associated with these pitted anvils, which feature small depressions typically 8 to 11 mm deep and 25 to 45 mm in diameter found at sites in Tanzania, Ethiopia, and across the Oldowan and Acheulean contexts (De Beaune, 2004: 140). In a broader sense, mortars, pestles, grinding stones, and hand stones can be viewed as a technological continuation of these early pounding tools, emerging in later periods and reflecting a form of tool evolution.

Chimpanzees are known to use hammerstones to remove bark and break open fruits and hard seeds, suggesting that the act of striking objects was not unfamiliar to early hominins. The motion involved in producing a sharp edge is not radically different from simple percussive strikes the same actions used to split bones, crush vertebrae, or pound prey (Joulian, 1996: 187). However, it was only humans who advanced beyond these basic percussive actions to develop more complex techniques such as controlled pounding and grinding. While the behaviours of chimpanzees and pre-Acheulean hominins may not differ significantly in terms of the physical action, the cognitive dimension particularly the control of impact force and angle is crucial. The moment a member of Homo, or one of its immediate ancestors, applied a pounder previously used only for breaking organic matter to produce a flake with a cutting edge, marked a cognitive and technological departure from its predecessors (De Beaune, 2004: 142). The awareness and intentional manipulation of the angle of impact represent a significant cognitive shift. For years, this act and its resulting products have been seen as defining characteristics of a particular Homo lineage: the tool-making humans (Ambrose, 2001).

In the Middle Paleolithic, the presence of plant remains as charcoal is attributed to Kebara Mousterian Cave (60 to 50 thousand years BP), which contains numerous charred remains of seeds and fruits, including wild legumes and hazelnuts (Lev *et al.*, 2005). This indicates human involvement with plants and the breaking of hard seeds in earlier periods, leading to concentrated agriculture and the expansion of ground stones. Through an evolutionary perspective, the change and transformation of ground stones from a striking tool to a grinding tool can be better understood.

In several Upper Paleolithic sites in the Levant (dating between 45,000 and 22,000 years ago), grinding slabs and portable hand stones emerge as new tool types. Subsequently, in the Kebaran culture (22,000 to 14,500 BP), large mortars and elongated pestles were found which, due to their considerable size, were non-portable. In the following Geometric Kebaran phase (14,500 to 12,500 BP), a smaller number of grinding slabs, hand stones, mortars, and pestles similar to those of the Kebaran but more compact and portable were recovered (Hodder, 2018: 3). During the Early Natufian Period (12,800 to 11,500 BP), the presence of ground stone tools increased, with mortars and pestles being the most common types. In the Late Natufian (11,500 to 10,300 BP), there is a slight increase in the use of grinding slabs. By the Pre-Pottery Neolithic, grinding slabs significantly outnumber mortars and pestles, and appear in both portable and non-portable forms (Wright, 1991: 91). In Iran, the classification of ground stone tools has received comparatively less attention, with most publications limited to their mention in site reports. Among the few sites where ground stone tools have been classified are Tol-i Bakun (Langsdorff & McCown, 1942), the Dehluran Plain (Hole *et al.*, 1969; Hole, 1987), Chogha Mish (Delougaz & Kantor, 1996: 249–284), East Chia Sabz (Darabi, 2016), Chogha Golan (Conard & Zeidi, 2013), and Tol-e Chega Sofla (Dahdouh, 2024). Ground stone tools have also been reported from sites such as Tepe Mahtaj of Behbahan, Ahranjan, Qara Tepe, Haji Firuz, Jani Tepe, Tepe Abdul Hussein, and Tepe San-e Chakhmaq West (Matthews & Fazeli Nashli, 2022).

Theoretical Framework

In the study of ground stone, two approaches are used: pre-production and post-production. Pre-production deals with the issue of technology (Miller, 2016: 57-71), and post-production includes all manufactured ground stone and the final shape of the initial design for which production began. To address ground stone, they can first be divided into two categories: non-portable and portable (See: Jayez 2023) and then classified and typologized based on their shape. The terminology, classification, and typology used are borrowed from researchers in this field (Hole, 1987; Wright, 1991), focusing on categorization and avoiding the use of different names for subcategories that have emerged according to the different shapes and cross-sections of a single type of ground stone. Finally, a method inspired by an evolutionary perspective on ground stone (their change, transformation, and replacement over time) and a simplified adaptation of Adams' classification method (Adams, 2002) is used, which initially studies the morphology of ground stone. It should be noted that similar examples from other sites have also been referenced.

Komishani Site

Komishani is located along the Neka–Behshahr road, approximately 10 km west of Behshahr, at geographical coordinates 36.401281° N, 53.215511° E, on a terrace facing Komishan Cave and in proximity to the Huto and Kamarband caves, at an elevation of 45 m asl. Komishan Cave was first identified in the 1980s (1360s SH) during construction activities. In 2017 (1396 SH), due to road expansion and development, the outer terrace adjacent to Komishan Cave was disturbed. As a result, four stratigraphic trenches were excavated in various parts of the cave and the surrounding terrace. Trenches 1 and 2 were opened on the terrace opposite Komishan Cave (now referred to as the Komishani site), trench 3 was located on the southern side and upper slope above the cave, and trench 4 was placed on the northern side of the cave (Fazeli Nashli, 2023). During the first excavation season, artifacts including stone vessels, pounders, and mortars, along with numerous sickle blades exhibiting lustrous sheen (sickle gloss), were recovered, highlighting the archaeological significance of the site. However, due to the limited size of the initial trenches, larger-scale excavations were deemed necessary. Consequently, in 2023 (1402 SH), a second excavation season was undertaken to address broader research questions related to the Early Neolithic in the region.

In this second season (Fazeli Nashli, 2023), trench 5 was established on the outer terrace near the cave, measuring 5×7 meters, for horizontal excavation and to better understand the in-situ stratigraphy. Trench 6 was positioned on the terrace edge adjacent to the road, approximately 6 meters from trenches 1 and 2, and 35 meters from the cave entrance. This trench, with dimensions of 2×4 meters, was designated for stratigraphic analysis (Fazeli Nashli *et al.,* 2024).

Fig. 1: Aerial photo of Komishani and the location of trenches 5 and 6 (Fazeli Nashli, 2023). ▶

Komishani Ground Stones

In the second excavation season at the Komishani site, a total of 27 ground stone tools were recovered. In the lower stratigraphic layers, the selection of raw material, along with the finishing, symmetry, and surface polishing of the tools, is particularly noteworthy, suggesting a high level of skill and considerable time invested in their manufacture. In contrast, tools from the upper layers lack these features. Their standardized forms and larger dimensions suggest an emphasis on efficiency and functionality in production. The recovered ground stone tools have been classified into five categories: grinding slab and upper grinding stone, mortars, pestles, hand stones, and unclassified types. These are introduced, categorized, and described in detail below.

Findings from each trench are presented separately under headings such as Trench 5 (horizontal) and Trench 6 (stratigraphic/vertical). Their physical and material attributes including stone type, weight, length, width, thickness, and color are documented in accompanying tables. All artifacts are photographed, and representative examples from each category have been selected, illustrated, and presented (Fazeli Nashli, 2023).

Grinding Stones (Grinding Slabs and Upper Grinding Stones)

The act of grinding involves the use of two complementary stone elements: a lower stationary stone and an upper mobile stone. The lower stone is typically heavy and remains fixed to provide stability during use. The upper stone, which is movable, is shaped to fit the surface of the lower stone and is light enough to be operated with both hands. The friction between the contact surfaces of these two stones results in the grinding of raw materials. When the upper and lower grinding stones are morphologically compatible and function as a pair, archaeologists use the terms "mano" (upper) and "metate" (lower) to describe them (Hole *et al.*, 1969: 170). However, when the upper grinding stone lacks a formal relationship with the lower surface, it is classified as a hand stone (Adams, 2002: 142–143).

Both grinding stones recovered from the Komishani site were found in Trench 6. The upper grinding stone (No. 1 in Fig. 2) is broken, with only a fragment preserved. Due to its light weight, it is identified as an upper grinding stone. It features a dorsal protrusion that facilitates grip, and abrasion marks are visible on its ventral surface. It was found in a disturbed layer, suggesting it may have been displaced from its original context. The lower grinding stone (No. 2 in Fig. 2), given its heaviness and limited portability, is identified as a grinding slab. The upper surface displays multiple overlapping wear striations, creating a relatively even grinding surface. Several edge fractures are present, possibly resulting from its secondary use as an anvil or stone platform for pounding activities.

The notable aspect of this artifact is its abandoned and inverted position within the recovered layer, where it had been placed alongside several natural stones to fill a space. This context indicates secondary use or disposal following primary use. Among the funerary objects in this layer, a bronze earring and a silver anklet were recovered, suggesting the deposit belongs to a later period. However, the unused and inverted state of the grinding slab suggests the end of its original function and possible re-use, implying it may originate from an earlier period. The possibility of intergenerational transmission and the long use-life of ground stone tools should not be

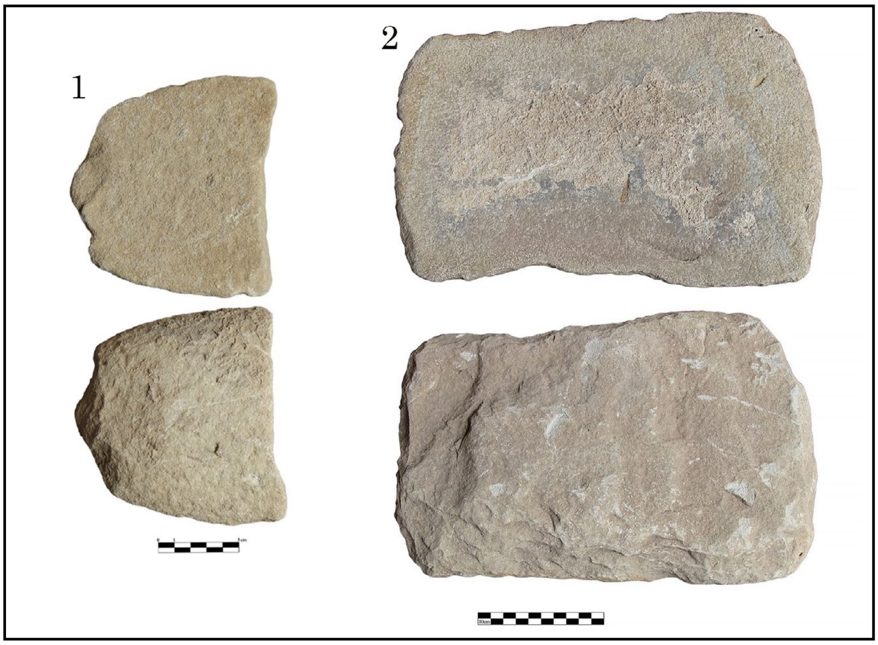


Fig. 2: Upper grinding stone and grinding slab recovered from the Komishani site (Authors, 2023). ▶

Table 1: Descriptive characteristics of the upper grinding stone and grinding slab from Komishani (Authors, 2023). ▶

Number	Trench	Material	Weight	Length	Width	Thickness	Munsell Stone Color
1	6	Sandstone	750	10.2	12.1	4	10YR 6/2 Pale Yellowish Brown
2	6	Sandstone	7.500	37.5	26	5	10YR 6/2 Pale Yellowish Brown

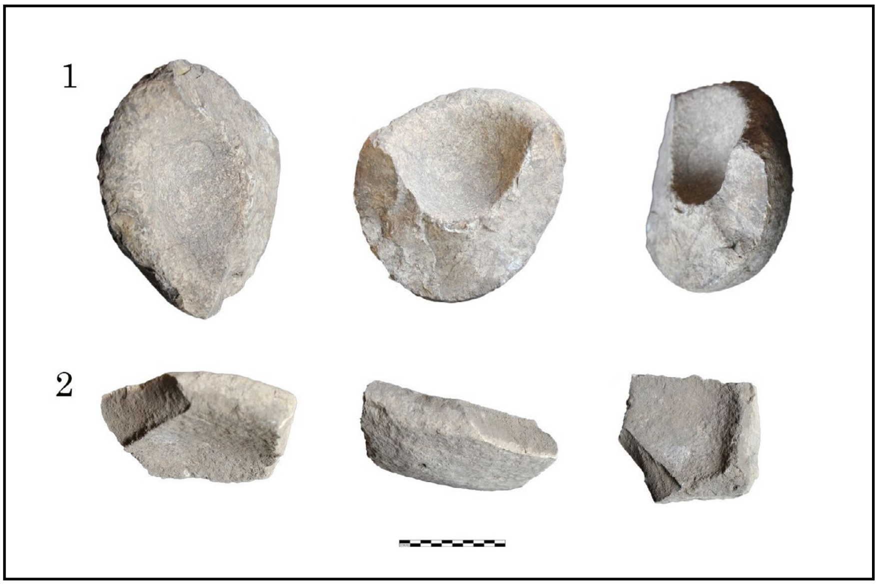
overlooked. Its broad surface is consistent with the processing of larger quantities of material. It is important to note that the size of ground stone tools serves as a useful indicator of subsistence strategies (Adams, 2002: 64). Based on established classifications, this specimen is best identified as a flat grinding slab, as it lacks concavities in cross-section and does not exhibit a saddle-shaped or basin-shaped profile. Comparable examples have been documented at sites associated with subsistence activities (see: Hole *et al.*, 1969; Hole, 1977; Delougaz & Kantor, 1996).

Mortar

Mortars are formed by hollowing out stone to create a concavity. Materials are placed inside and used in combination with a pestle for crushing, stirring, or pounding. They vary in size and depth, with simple variations related to their stability. Nomenclature is typically based on the diameter and depth of the opening, and distinctions are also made between portable and non-portable types, such as bedrock mortars. The most reliable method for distinguishing mortars from stone vessels or bowls is by assessing the degree of wear on the rim surface (Adams, 2002: 127–130).

During the Epipaleolithic, the production and use of bedrock mortars were common in open-air, communal settings outside residential areas. With the onset of the Neolithic Period, their use shifted into more private, domestic spaces (Jayez, 2023: 152). Mortars are frequently recovered from Neolithic sites; for instance, one was found at East Chia Sabz in Dehluran, where they are confined to Neolithic layers. In some cases, such as Ali Kosh and Chogha Golan, ochre residues have been identified within mortar basins (Darabi, 2016: 12).

Two mortars recovered from Trench 6 at the Komishani site include: (1) a mortar (No. 1 in Fig. 4), broken approximately in half, with a depth of 8 cm and a mouth diameter of 10 cm, found near a layer containing a kiln; and (2) a mortar fragment (No. 2 in Fig. 4) with a mouth diameter of 11 cm. Due to its relatively heavy weight and the fact that it originates from the upper rim, it is considered part of a large mortar. It was recovered from a context where numerous broken stones and ground stone tools had been repurposed to form a platform for placing animal horns. In this case, the spatial arrangement suggests that the intentional breakage of the objects should be considered.



◀ **Fig. 3: Mortars recovered from the Komishani (Authors, 2023).**

◀ **Table 2: Descriptive characteristics of mortars from the Komishani (Authors, 2023).**

Number	Trench	Material	Weight	Length	Width	Thickness	Munsell Stone Color
1	6	Limestone	2.300	14.5	14.5	8	5Y 8/4 Grayish Brown
2	6	Limestone	3	16	19	7.5	10YR 8/2 Very Pale Orange

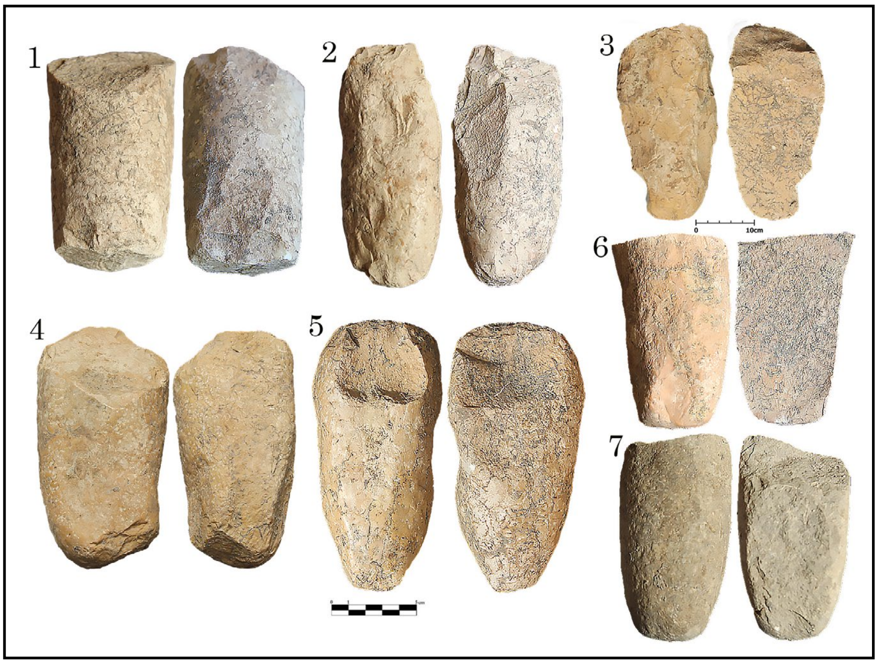
Pestles

Pestles are movable upper stones, typically elongated, and often exhibit battered ends with circular, oval, or occasionally irregular working surfaces. In cross-section, they are convex, rounded, or flat, and are categorized accordingly (Wright, 1992: 69). They are used for pulverizing, crushing, and grinding, and display variation in both shape and size. Most are selected from naturally suitable river pebbles and used with little to no modification, while others are deliberately shaped into specific forms, sometimes featuring finger grips or notches for handling. Larger and heavier pestles are employed for pounding and breaking, while smaller and lighter examples are used for finer crushing, grinding, and stirring tasks.

Wear patterns on pestles used in mortars appear at the ends and along the lateral surfaces that contact the mortar basin. These traces include impact fractures, surface removals, and abrasion. Conversely, wear on pestles used on flat surfaces such as slabs or ground surfaces is concentrated on the flatter end. Some pestles also exhibit secondary functions: they may be employed in multi-stage processing sequences, such as using the same tool to mash fish and grind cereals, or to crush plant pods within a mortar before refining them into flour on a grinding slab (Adams, 2002: 138–140). Pestles are among the most ubiquitous ground stone tools in the Near East and are found across virtually all excavated sites in the region. At Chogha Golan, one pestle contained traces of natural bitumen; at East Chia Sabz, seven pestles were documented (Darabi, 2016: 14), and at Tol-e Chega Sofla, 25 specimens were recovered (Dahdouh, 2024: 145).

The pestles from the Komishani site were all recovered from Trench 6, primarily from context 6064. This layer yielded abundant animal remains, particularly fish jaws and teeth, as well as bird foot bones suggesting bird hunting and fishing activities. Pestles in this context may have been used for processing, pounding, and crushing bones. Notably, their morphological characteristics deviate somewhat from typical examples. For instance, pestle no. 5 exhibits precisely symmetrical removals on both its dorsal and ventral surfaces, resulting in pebble-like depressions. These features may reflect the aesthetic preferences of their makers, or alternatively, they could be accidental removals created to produce a thinner edge for an alternative function.

In Figure 5, specimens 1 through 5 were all recovered from this same context. Particular care appears to have been taken in selecting raw materials, and a notable symmetry is evident in their shaping. The polish observed on their surfaces may either reflect aesthetic choices or, possibly, a functional necessity: due to the presence of foraminifera fossils (micro-aquatic marine organisms) that make the stone surface abrasive, users may have polished the pestles to create smoother working surfaces. This attention to material selection and morphological refinement suggests a high level of craftsmanship. Both the handles and ends show signs of impact and indicate multi-functional usage. Some ends were likely used on flat surfaces such as slabs or hard-packed ground while others were employed on curved or concave surfaces resembling mortars.



◄ **Fig. 4: Pestles recovered from the Komishani site (Authors, 2023).**

◄ **Table 3: Descriptive characteristics of pestles from Komishani site (Authors, 2023).**

Number	Trench	Material	Weight	Length	Width	Thickness	Munsell Stone Color
1	6	Limestone with Foraminifera fossils	750	11.9	7	6.6	10 YR 8/2 Very pale orange
2	6	Limestone with Foraminifera fossils	425	13.1	7.3	5.1	10 YR 7/4 Grayish Orange
3	6	Limestone with Foraminifera fossils	500	16.5	7.9	3.3	10 YR 7/4 Grayish Orange
4	6	Limestone with Foraminifera fossils	750	13.5	7.3	5.5	10 YR 7/4 Grayish Orange
5	6	Limestone with Foraminifera	800	15	7.3	5.50	10 YR 7/4 Grayish Orange
6	6	Light Limestone	420	11.5	7.2	3.1	10 R 7/4 Moderate Orange Pink
7	6	Calcareous Sandstone	600	12.2	6.7	5.1	5 YR 7/2 Grayish Orange Pink

In the image above, the surface of pestle handle No. 5 is shown under 65x magnification using a digital microscope. On the right are images of the use-worn and impact surfaces, where breakage and chipping occurred at the end of the handle. Below, a foraminifera fossil embedded in the stone material is visible. Since the wear and impact traces were clearly observable to the naked eye, similar imaging was not conducted for the other specimens.

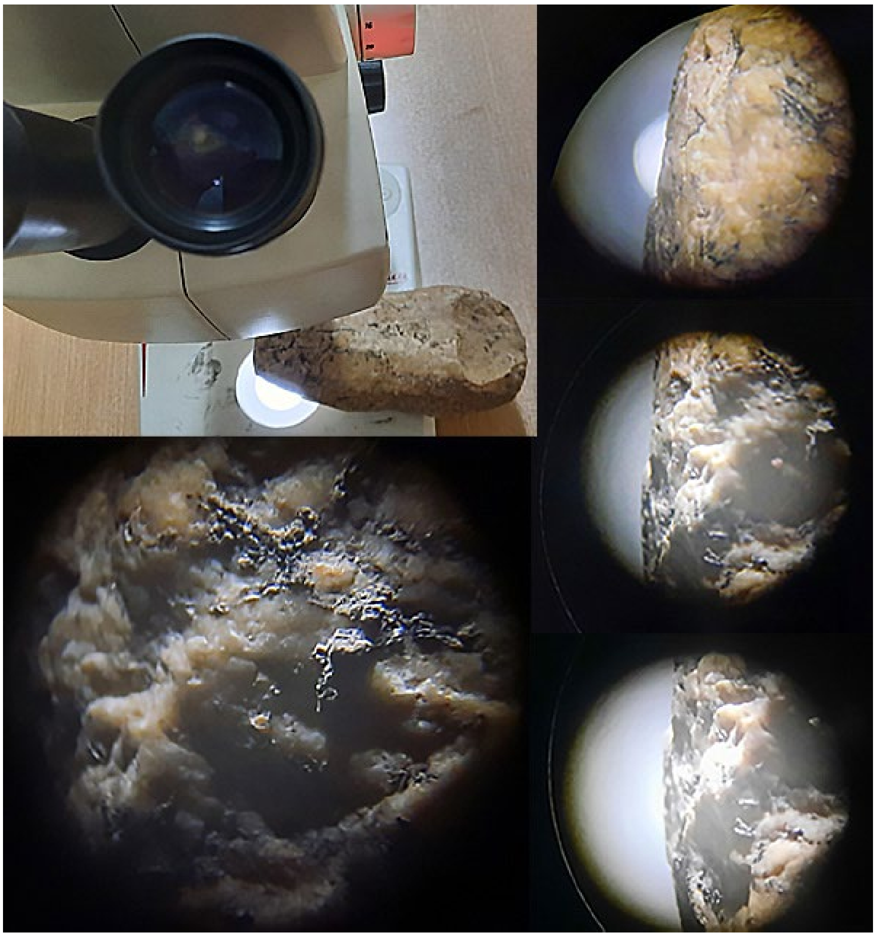


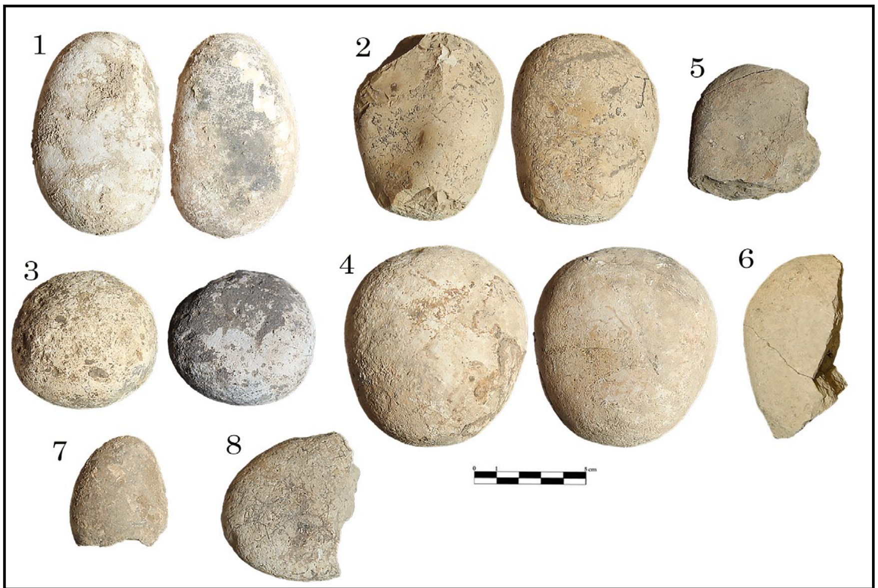
Fig. 5: Microscopic images of pestle handle no. 5 (Authors, 2023). ▶

Hand stones

Small stones are used for processing pigments or for mixing materials on a palette stone and lower stones. Typically, they are small, smooth river stones, approximately 5 to 20 cm in length, and some bear finger grooves that make them easier to hold. Their texture ranges from smooth to coarse. Any hand stone associated with a lower grinding stone (mano) is referred to as an upper grinding stone (metate), and if there is no evidence of such association, it is termed a hand stone. The analysis of their distribution over time and space is well established (Adams, 2002: 143).

They are often found at agricultural sites; one cylindrical example was found at East Chia Sabz. This type of tool appears in the Neolithic layers (after the Bos Morde phase) of the Dehluran Plain but became common in the Sefid phase at Tepe Chogha Sefid, where its use reached its peak. At Tepe Sabz, they were also recovered in association with grinding stones (Darabi, 2016: 17). At Chogha Golan, several specimens ranging from 6 to 18 cm in length were found, some of which had been used for processing pigments (Conard & Zeidi, 2013: 371). Examples from Tepe Mahtaj (Darabi *et al.*, 2017) and 15 samples from Tol-e Chega Sofla have also been reported (Dahdouh, 2024: 142).

In the excavation of the Komishani site, eight hand stone samples were recovered; all but two (samples 2 and 8) came from Trench 5. Sample 2, in addition to its worn surface, exhibits chips from impact and pounding on both ends and was found alongside pestles, suggesting its potential multi-purpose use as both a hand stone and a pestle for pounding.



◄ Fig. 6: Hand stones recovered from the Komishani (Authors, 2023).

◄ Table 4: Descriptive characteristics of hand stones from Komishani (Authors, 2023).

Number	Trench	Material	Weight	Length	Width	Thickness	Munsell Stone Color
1	5	Light Limestone	1.250	15.5	8.5	7	10 YR 8/2 Very pale orange
2	6	Limestone with Foraminifera fossils	450	10	7	5	10 YR 8/2 Very pale orange
3	5	Calcareous Sandstone	350	7.4	6.8	5	10 YR 8/2 Very pale orange
4	5	Calcareous Sandstone	600	10	8	6	5 YR 5/2 Pale Brown
5	5	Light Limestone	510	9	7	4	10 YR 8/2 Very pale orange
6	5	Light Limestone	550	12	6.2	5.5	10 YR 8/2 Very pale orange
7	5	Sandstone	150	7.1	5.3	3	5 YR 4/1 Brownish Gray
8	6	Limestone with Foraminifera fossils	400	7.7	10	3.7	10 YR 8/2 Very pale orange

Hoe

Hoes are thick and robust tools, characterized by cuts along their edges, and some possess grooves for attaching a handle. They were used for shallow soil digging, weeding, or creating trenches to divert water. The thinness of some blades was produced by flaking (Adams, 2002: 178). Several examples have been recovered from Tall-e Chega Sofla (Dahdouh, 2024: 144). At the Komishani site, four hoe samples were recovered. Except for one specimen (No. 2), all were found in Trench 5. Metamorphic stones are stronger than sedimentary stones, and the use of such material in the manufacture of hoes is noteworthy. Hoe no. 1 was recovered from the bottom of a smuggling pit adjacent to Trench 5, while the others were found in in-situ layers directly associated with digging pits and preparing the soil surface. They exhibit removals at their ends to make them thinner and more closely resemble stone axes.

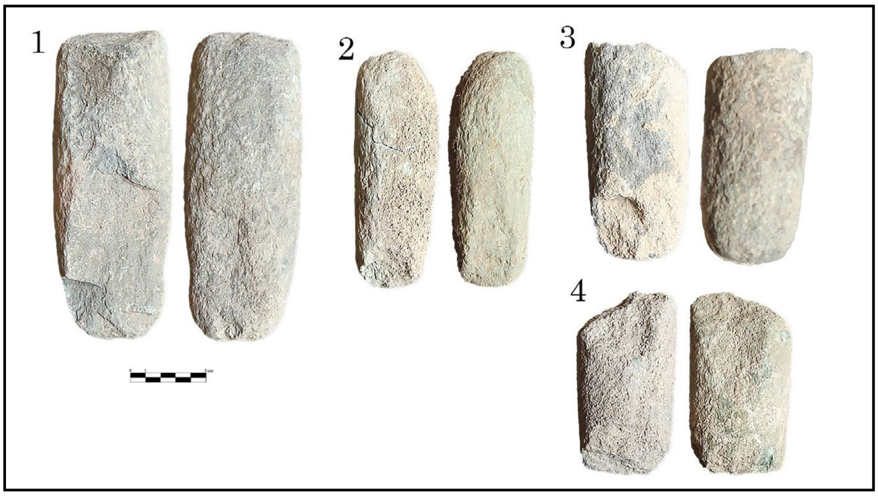


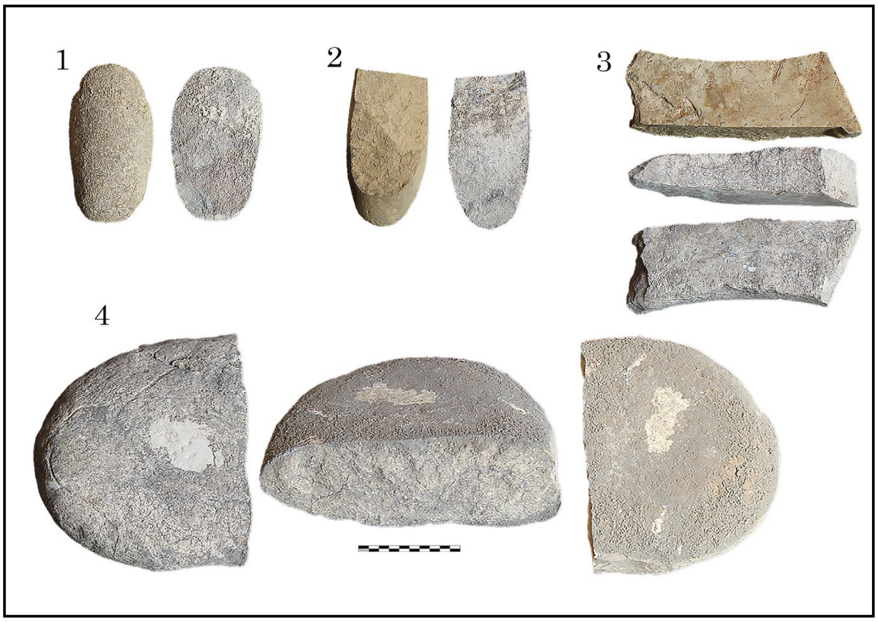
Fig. 7: Hoes from Komishani site, photo by (Authors, 2023). ▶

Table 5: Descriptive characteristics of hoes from Komishani site (Authors, 2023). ▶

Number	Trench	Material	Weight	Length	Width	Thickness	Munsell Stone Color
1	5	Metamorphic stone	1.250	20	74	5.2	5G 5/2 Grayish Green
2	6	Metamorphic stone	350	12.6	4.5	4.5	5G 5/2 Grayish Green
3	5	Metamorphic stone	750	12.4	74	52	5GY 4/1 Dark Greenish Gray
4	5	Sandstone	500	11	60	4.4	5G 5/2 Grayish Green

Unknown Ground Stone Tools

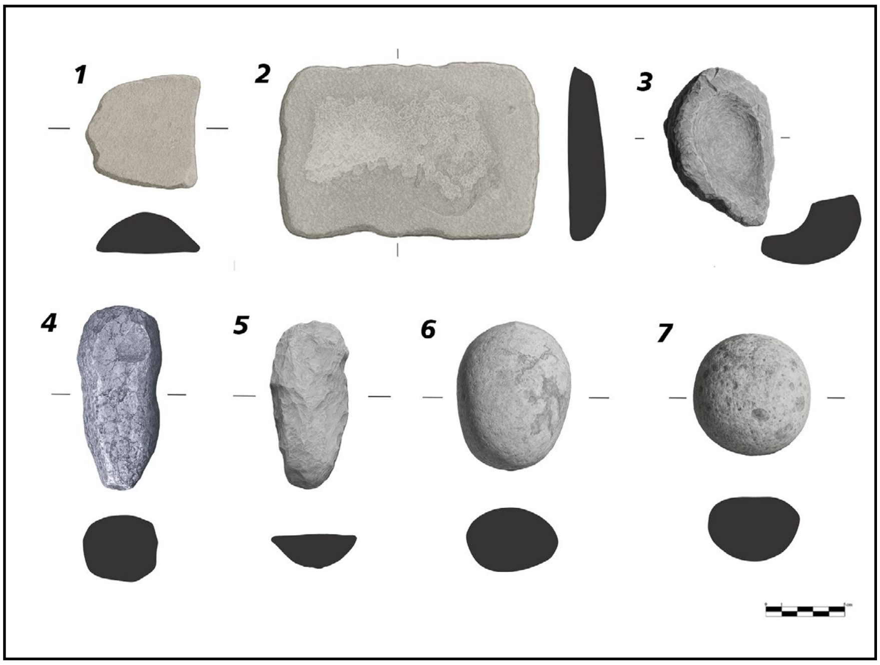
This category includes stones whose exact nature and function cannot be definitively determined. For this reason, they have been classified and presented separately. Four ground stones with unknown functions were recorded from the Komishani site, with samples 1 and 2 found in Trench 5, and samples 3 and 4 found in Trench 6. Pieces 2 and 3 in the image have no known parallels; however, their shapes increase the likelihood that they serve a specific function. Piece 2 has a molded impression, and piece 3 has a polished, shiny surface. Piece 1 is likely a broken fragment of a hand stone, and piece 4, considering its weight and the abrasion on one side, could be a broken fragment of a grinding slab. A notable point is its ability to remain stable when standing on the fractured side. It was recovered from a layer where numerous stones were used to create a platform for placing horns.



◀ **Fig. 8: Unknown ground stone from Komishani (Authors, 2023).**

◀ **Table 6: Descriptive characteristics of unknown ground stone from Komishani (Authors, 2023).**

Number	Trench	Material	Weight	Length	Width	Thickness	Munsell Stone Color
1	5	Sandstone	250	12.2	6.1	2.8	5YR 5/2 Pale Brown
2	5	Limestone	200	9.7	4.8	30	10 YR 6/2 Pale Yellowish Brown
3	6	Limestone with Foraminifera fossils	1.100	21	8	4.4	10 YR 7/4 Grayish Orange
4	6	Limestone with Foraminifera fossils	4.100	16	20	8	10 YR 7/4 Grayish Orange



◀ **Fig. 9: Some ground stone specimens from Komishani; 1. Upper grinding stone 2. Grinding slab 3. Mortar 4-5. Pestle 6-7. Hand stone), (Drawing by: Amir Mahmudabadi).**

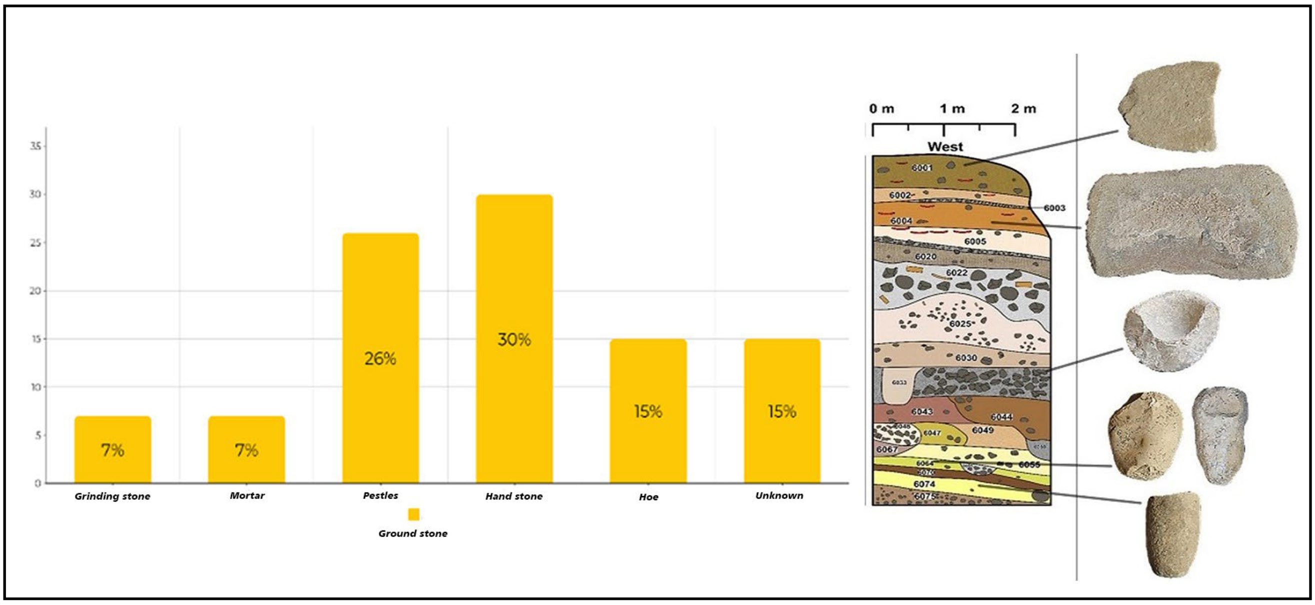
Discussion

A distinction can be made between the portability of ground stone tools and the mobility of the individuals who used them. In highly mobile hunter-gatherer groups, smaller and more portable tools were used, or ground stone technology was entrusted to the collective (unconscious) memory (Wright, 1994: 247). Therefore, there is no reason to assume that, because ground stone tools were not easily portable, the people who used them were immobile and sedentary (Adams, 1993: 341). In the Late Upper Palaeolithic Period, many grinding stones were not easily portable. The use of ground stone tools, hearths, energy expenditure for tools and their movement, and bringing plants to grinding tools rather than vice versa especially concerning items like hearths, ovens, and grinding stones that were less mobile was more probable. In this cycle, ground stone tools functioned as focal points, encouraging repeated occupation of the same location. The multipurpose nature and immobility of some objects created fixed points around which humans gathered; otherwise, the immobility of ground stone tools alone does not lead to sedentarism (Hodder, 2018: 10). The entanglement of plant use in the Middle East demonstrates how grinding stones and hearths created a cultural tradition centred on the home and dwelling (Fuller *et al.,* 2016). This entanglement of things can also be traced in the interaction and mutual influence of plants and ground stone tools on each other. In the process of domesticating wild plants, where the hard husk is often lost the characteristics that pounding and grinding aim to simplify similar to the reduction in human tooth size mentioned earlier, show the reciprocal effects of things on each other.

The arduous nature of processing wild cereals has been underestimated. Wild cereals offer a higher energy yield because they are naturally well-preserved in their husks for storage. However, their processing is more difficult, so humans focused on tools and technology to facilitate processing (Wright, 1994: 257). The evolutionary trajectory of ground stone can be simultaneously traced in a dialectic between the domestication of wild plants and the transformation and typology of ground stone tools. Although the precise chronological breaking point of plant domestication or the transformation and replacement of ground stone tools is undefinable, in the stages of pre-extensive agricultural production, if there was a continuity of closer relationships between humans and plants, discerning the exact moment when plant domestication occurred is very difficult, and what truly exists is a process of increasing intensity of plant use (Cauvin, 2001: 109).

This point is also evident in the use and intensification of ground stone, from pounders to grinding tools, from multi-purpose pestles used in other contexts to hand stones and grinding slabs specifically used for grinding cereals. These cases indicate a transitional trend in livelihood strategies: the intensity of fish catching and bird hunting gradually decreased in the lower layers, and in the upper layers, the focus shifted to plant processing and the expansion of agriculture. It should be noted that all but one (Fig. 6) of the hand stones and hoes were recovered from Trench 5, indicating agricultural development in this trench. After the publication of studies on animal bones and plant remains recovered from the site, and placing them alongside the changes in tool morphology, more reliable lines can be drawn for their evolutionary sequence. In older phases, the presence of multi-purpose pestles alongside fish catching and bird hunting is noteworthy, as they gradually gave way to hand stones. Acorns and pine nuts did not require processing before storage; rather, most time was spent grinding them. However, fish and seafood, which are more nutritious, cannot be stored and need to be smoked or dried, or consumed immediately after being caught, as raw fish spoils (Graeber & Wengrow, 2022: 268). In comparison to other ground stone tools, there appears to be a significant relationship between the extent of hand stone and grinding slab use and, on the other hand, the level of agriculture and food production (Darabi, 2016: 17). The inverse movement in the layers indicates this. Most hand stones (Fig. 6) were recovered from the horizontal trench, which is directly related to the expansion of agriculture. The presence of architectural structures, the recovery of ovens, and related spaces all indicate activities related to food production. However, in the vertical trench, from the lowermost layers, we observe the presence of multi-purpose pestles, and considering their wear surface, it can be assumed that they were not only used in mortars but also on a flat surface or for processing fish and pounding hunted birds. The possibility of their use by hunter-gatherer groups is high, and it can be considered a pre-agricultural stage that gradually gave way to mortars and grinding slabs.

The practice of breaking ground stone tools at the Komishani site appears to represent the final stage in their production and use cycle. Most of the broken pieces were recovered from in situ layers and were not subjected to the damage caused by ploughing or other external agents. This phenomenon is observable even in the lowest layers. Few intact tools remain, and the rest show signs of being halved and intentionally



▲ **Fig. 9: Diagram of the ground stone of the Komisani and their location in Trench 6 (Authors, 2023).**

broken, which reduces the likelihood of accidental breakage. Perhaps they were used for secondary purposes, such as hammer stones, after breaking. Seventeen out of the twenty-seven introduced pieces are broken, some of which were used in the construction of structures. At Tepe Mahtaj, most of the recovered ground stone tools are also broken and seem to have been used for building stone structures, indicating their secondary use (Darabi, 2017: 19).

The statistical ratio of ground stone tools also indicates a greater use of hand stones, which are directly related to grinding cereals. These were mostly found in the horizontal trench, alongside ovens and heated areas, indicating agricultural development, and serve as a replacement for the pestles in the lower layers, whose use by hunter-gatherer groups is highly probable, as they are both portable in terms of weight and multi-purpose in application. Mortars and grinding slabs also occur in equal proportions, with the only notable difference being the replacement of grinding slabs in the upper layers by mortars. In the Pre-Pottery Neolithic Period, ground stone tools increased in both number and variety. Before agriculture, the use of mortars was common, while grinding slabs became prevalent in the Early Neolithic, indicating a shift from foods prepared by pounding towards foods prepared by grinding. However, the assumption that mortars were used for processing nuts and acorns and grinding slabs for processing grains remains to be proven (Ebeling & Rowan, 2004: 108). As mentioned in the introduction, certainty regarding the efficacy and function of ground stone tools is only possible through laboratory studies and the examination of micro-residues remaining on their surfaces. Nevertheless, at the Komishani site, a progression from pounding to grinding can be observed, as the pestles of the lower layers were replaced by the grinding slabs and hand stones of the upper layers.

Conclusion

The emergence of ground stone tools at the Komishani site begins with pestles, which gradually give way to the proliferation of hand stones, while mortars are replaced by grinding slabs. This pattern indicates the expansion of agriculture in the upper layers of the site. Hand stones and grinding slabs are often associated with the grinding of cereals (plant seeds). However, a notable feature of the ground stone tools at this site is the type of stone used, which contains foraminifera fossils. The inhabitants of the site must have collected these from the seashore, demonstrating both their careful selection of raw materials and their high skill in producing ground stone tools. The lightness and portability of these tools increase the likelihood of their use by hunter-gatherer groups. In the same phase, the abundance of fish and bird bones is noteworthy, and, by considering these factors together, one can identify human societies transitioning from multi-subsistence strategies such as bird hunting, fish catching, and crushing hard seeds into agricultural communities. It is possible that the evolution of ground stone tools began with hunter-gatherer groups and continued into sedentary societies, with this change and exchange representing a response to livelihood needs, shifts in subsistence strategies and choices, and being dependent on climatic changes and events.

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Authors' Contribution

This article is the result of a project in which all Authors were present and actively participated. Also, in order to write the article Amir Mahmoodabadi 40%, Hassan Fazeli Nasli 30%, Mojtaba Safari 20%, and Xinying Zhou 10%.

Conflict of Interest

The authors, while observing publication ethics in referencing, declare the absence of conflict of interest

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گونه‌شناسی، تطور و جایگزینی ادوات‌سنگی در تغییرات معیشتی ساکنان محوطهٔ کمیشانی

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چکیده

محوطهٔ کمیشانی در کنار جادهٔ نکا به بهشهر و در فاصلهٔ ۱۰ کیلومتری غرب شهرستان بهشهر، به مختصات جغرافیایی N ۳۶۴۰۱۲۸۱، E ۵۳۲۱۵۵۱۱ در تراس روبه‌روی غار کمیشان و در نزدیکی غارهای هوتو و کمربند در ارتفاع ۴۵ متری از سطح دریا واقع شده است. در فصل دوم کاوش در محوطهٔ کمیشانی درمجموع ۲۷ عدد ادوات سنگی به‌دست آمد که طبق گونه‌شناسی شامل: تخت‌سنگ آسیا، سنگ-آسیارویی، هاون، دستهٔ هاون، سنگ‌دستی و خیش می‌شوند. طبقه‌بندی و گونه‌شناسی ادوات‌سنگی اغلب مبتنی‌بر ریخت‌شناسی بوده؛ طبقه‌بندی و ریخت‌شناسی را تنها می‌توان به معنای تعلل برروی ریزه‌کاری‌ها و عوامل محرک در آغاز چیزها دانست و نه فرجام آن‌ها، کارکرد و تأثیر متقابل آن‌ها بر دیگر چیزها که به آن‌ها معنا و تعین می‌بخشد. در محوطهٔ کمیشانی تغییر، جایگزینی و هم‌نشینی ادوات‌سنگی نشانگر استفاده از دستهٔ هاون‌ها در لایه‌های تحتانی برای کوبیدن، خُرد کردن و پرداخت ماهی‌های صید شده و پرندگان شکار شده در کنار گیاهان است که رفته‌رفته در لایه‌های فوقانی دسته هاون‌ها و هاون‌ها جای خود را به تخت‌سنگ‌آسیا و سنگ‌دستی‌ها داده‌اند که برای آسیا کردن و پرداخت مواد غذایی می‌باشند. جوامعی شکارگر-گردآورنده در کنار مدیریت گیاهان که رفته‌رفته به کشت، تولید و گسترش کشاورزی می‌رسند و توسعهٔ کشاورزی در بزرگ‌تر شدن ابعاد ادوات‌سنگی نیز آشکار است. نگاه به ادوات‌سنگی همیشه پیوندخورده به کشاورزی و در پس‌زمینهٔ آن بررسی شده است؛ اما مطالعات اخیر نشان‌دهندهٔ پیدایش آن در دوره‌های پیشین‌تر و تأثیرات آن در رژیم غذایی، سکونت، سنت پدید آمدن خانه و تأثیر متقابل آن برروی گیاهان و حتی تسریع‌تر شدن کوچکی دندان آسیا انسانی می‌باشد. در متن حاضر در کنار طبقه‌بندی و توصیف اولیه، سعی‌شده است؛ روند تطور و جایگزینی ادوات‌سنگی در محوطهٔ کمیشانی که در ارتباط با انتخاب و تغییر شیوهٔ معیشت ساکنان این محوطه است، نشان داده شود.

کلیدواژگان: ادوات سنگی، نوسنگی، محوطهٔ کمیشانی، تولید غذا، کشاورزی.

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