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Katedra archeologie

The Limestone Assemblage of the Epipaleolithic Site of Jordan River Dureijat, Upper Jordan River - Israel.

Diplomová práce

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Studijní obor: Archeologie
Forma studia: Prezenční

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Zadání diplomové práce

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Cíl, metody, literatura, předpoklady:

En:

This master thesis aims to study the limestone artefacts from the Epipalaeolithic site of Jordan River Dureijat (JRD), located on the bank of the Upper Jordan River, Israel. The Levantine Epipalaeolithic (23,000-11,600 BP) is a period of the transition from mobile hunter-gatherers to settled farmers, and thus it is crucial in our understanding of sedentism and domestication. For more than 10, 000 years people returned to the same place on the banks of Paleolake Hula in order to fish, making the JRD site unique among other Epipalaeolithic sites. The goal of the thesis is to (1) either confirm, or disprove the hypothesis that the limestone notched pebbles were used as net sinkers, (2) identify the highest concentrations of the limestone pebbles and compare the amounts in each layer, and (3) to provide the possible ethnographic parallels of fishing methods, and evaluate their relevance for the archaeological interpretations. The study will apply multidisciplinary approaches to the study of the JRD limestone artefacts combining the techno-typological analysis of the lithics, the shape analysis, together with the spatial analysis in GIS. In addition, the archaeological data will be compared to the ethnographic parallels of fishing. The site of JRD provided an extensive assemblage of artefacts connected to aquatic resources exploitation, and it has a potential to contribute significantly to current knowledge of fishing methods in Epipalaeolithic.

Čj:

Tato diplomová práce si klade za cíl studovat vápencové artefakty z lokality Jordan River Dureijat (JRD), která se nachází na břehu horního toku Jordánu v Izraeli. Levantský epipaleolit (23 000-11 600 BP) je období přechodu od mobilních lovců-sběračů k usedlým zemědělcům. Z tohoto důvodu je toto období klíčové pro poznání sedentismu a domestikace. Lokalita JRD, ležící na břehu paleolitického jezera Hula, je mezi ostatními epipaleolitickými lokalitami výjimečná tím, že je místem, na které se lidé opakovaně po dobu více než deseti tisíc let vraceli, aby tam rybařili. Cílem této diplomové práce je (1) potvrdit, nebo vyvrátit hypotézu, že opracované vápencové valouny sloužily jako rybářská závaží, (2) identifikovat největší koncentrace vápencových valounů a porovnat množství valounů v jednotlivých vrstvách, (3) poskytnout možné etnografické paralely rybářských metod a zhodnotit jejich relevanci pro archeologické interpretace. V diplomové práci bude aplikován multidisciplinární přístup zahrnující techno-typologickou analýzu kamenné industrie, analýzu tvaru, a také prostorovou analýzu v prostředí GISu. Navíc budou archeologická data porovnána s etnografickými paralelami rybářství. Studium tohoto nezvykle četného souboru artefaktů spojeného s využíváním vodních zdrojů na lokalitě JRD má potenciál významně přispět do současného poznání rybolovu v epipaleolitu.

Dani Nadel and Yossi Zaidner, *Upper Pleistocene and Mid-Holocene Net Sinkers From the Sea of Galilee*, Journal of the Israel Prehistoric Society 32, 2002, 49-71.

Shari L. Prowse, *Much Ado About Netsinkers: An Examination of Pre-Contact Aboriginal Netsinker Manufacture and Use Patterns at Five Woodland Period Archaeological Sites within Southern Ontario*. Journal of Ontario Archaeology 85-88, 2010, 69-96.

Gonen Sharon, Elizabeth Bunin, Daniela E. Bar-Yosef Mayer, Natalie D. Munro, Steffen Mischke, *Jordan River Dureijat (JRD). 2017 Excavation Report.* Israel Antiquity Authority. 2018.

Garantující pracoviště: Katedra archeologie, Filozofická fakulta

Vedoucí práce: Mgr. Richard Thér, Ph.D.

Datum zadání závěrečné práce: 18.6.2020

Prohlášení

Prohlašuji, že jsem tuto diplomovou práci vypracovala sama pod vedením Mgr. Richarda Théra, Ph.D., a uvedla jsem veškeré použité prameny a literaturu.

V Hradci Králové dne

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Anna-Marie Ourodová

Anotace

OURODOVÁ, ANNA-MARIE. Soubor vápencových valounů z epipaleolitické lokality Jordan River Dureijat na horním toku Jordánu v Izraeli. Hradec Králové: Filozofická fakulta, Univerzita Hradec Králové, 2022, 178 s. Diplomová práce.

Po více než 10 tisíc let, mezi vrcholem posledního glaciálního maxima a počátkem holocénu, lidé se opakovaně vraceli rybařit a využívat další vodní zdroje na epipaleolitickou lokalitu Jordan River Dureijat (JRD) na jižním okraji paleo-jezera Hula na horním toku Jordánu. Kromě četnách nálezů rybářských háčků, s nimi používaných závaží, a rybích kostí, se na lokalitě našlo více než 200 vápencových valounů s vruby. Tyto valouny byly interpretovány jako rybářská závaží do sítí. Soubor z této lokality představuje největší soubor rybářských závaží v Levantě. Analýza souboru vápencových valounů prokázala, že neopracované valouny byly protáhlejší a užší ve srovnání s valouny s vruby. Dá se předpokládat, že ne opracované valouny na lokalitě JRD se také používaly jako rybářská závaží vedle valounů s vruby. Podlouhlý tvar byl pravděpodobně rozhodujícím faktorem, zda bylo nutné vrub vytvořit či nikoliv. Největší koncentrace vápencových artefaktů v jednotlivých vrstvách byly určeny pomocí prostorové analýzy. V jedné z vrstev bylo identifikováno několik shluků valounů, které by mohly představovat pozůstatky jednotlivých sítí.

Klíčová slova: valouny s vruby, rybářská závaží, rybolov, epipaleolit

Annotation

OURODOVÁ, ANNA-MARIE. The Limestone Assemblage of the Epipaleolithic Site of Jordan River Dureijat, Upper Jordan River - Israel. Hradec Králové: Philosophical Faculty, University of Hradec Králové, 2022, 178 p., Master Thesis

For more than 10,000 years between the peak of the Last Glacial Maximum and the beginning of the Holocene, people repeatedly returned to the same spot on the southern edge of Paleolake Hula in the Upper Jordan Valley to fish, and exploit other aquatic resources at the Epipaleolithic site of Jordan River Dureijat (JRD). Apart from numerous finds of fish hooks, line weights, and fish remains, over 200 notched pebbles that are interpreted as net sinkers were retrieved, representing the largest assemblage in the Levant. The analysis of limestone assemblage at JRD showed that unworked pebbles were more elongated with shorter width compared to notched pebbles. It is suggested that unworked pebbles at JRD site were used as net sinkers along the notched ones, and that the elongation was the crucial factor when deciding whether to make a notch or not. Spatial distribution of limestone pebbles showed the largest concentrations at the site and identified clusters of limestone pebbles which might have represented the remains of individual nets.

Keywords: notched pebbles, net sinkers, fishing, Epipalaeolithic

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In this place I would like to extend my thanks to all the people, who helped me and guided me throughout this thesis. Firstly, I would like to thank my supervisor Mgr. Richard Thér, Ph.D. for guiding me through the process of thesis writing, for introducing me to GIS and statistical analysis, for his valuable comments and his time. I am endlessly thankful to Prof. Gonen Sharon, Ph.D. for giving me the opportunity to participate in the JRD excavation and working on JRD limestone assemblage. I am grateful to Gonen and Amy for hosting and guiding me during my stay in Israel, for their kindness, care, and exceptional conversations. My stay would not be possible without the effort of a number of individuals from Tel Hai College and University of Hradec Králové. I wish to thank Natalie and Karin, and to Ms. Eliášová for helping me with the preparation of my stay in Israel. I would like to thank my partner Ján Marko for his emotional support and his help with the graphical aspects of the thesis. Last but not least, I am endlessly grateful to my parents who showed me the love for history and who supported me during my whole studies.

Table of Content

List of abbreviations

EP Epipalaeolithic

JRD Jordan River Dureijat

LGM Last Glacial Maximum

PPN Pre-Pottery Neolithic

std standard deviation

List of figures

Fig. 7.8. Area B at the end of the 2017 season, a) stratigraphy of the south section in Area B with the radiocarbon dates, together with the cultural affiliations, b) Area B stratigraphy and excavated surface (Sharon *et al.* 2020, 39)

Fig. 7.9. a) Surface of layer 5, b) surface of layer 4, c) Layer 3a (U and S squares, surface modified by humans, post-holes), d) Layer 3a with bones, flint, limestone, and basalt artefacts, e) Layer 3c in U squares with large concentration of limestone notched and unworked pebbles (Photos courtesy of Gonen Sharon).

Fig. 7.10. 1) JRD bone fish hooks; 2) JRD small grooved pebbles (line weights); 3) JRD stone tools by layers and cultural affinity: a. Early Neolithic; b. Natufian; c. Geometric Kebaran; d. Early Epipaleolithic (Langgut *et al.* 2021).

Fig. 7.11. Broken basalt pestles from layer 4 (left: Sharon 2015, 33; right: Sharon 2016, 46).

Fig. 7.12. Canidae teeth from Area B at JRD (Sharon 2015, 50).

Fig. 8.1. Photos of preliminary types: (1) unknown (indeterminate), (2) elongated (3) wide, (4) coin, (5) chips, (6) edge, (7) rounded pebble, (8) axe/adze.

Fig. 8.2. Preservation: (left): slightly weathered, (second from left) weathered, (third from left, and right) rolled.

Fig. 8.3. Notched pebble: A schematic depiction of measured dimensions.

Fig. 8.4.a Top sectional view (shapes): (1) 8-shaped/pear shaped, (2) arc/bow shaped, (3) sausage shaped, (4) pointed, (5) irregular, (6) rectangular, and (7) oval-shaped

Fig. 8.4.b Side sectional view (sections): (1) triangular, (2) convex, (3) double convex, (4) irregular, (5) rectangular, (6) irregularly triangular - much thinner on one side, and (7) circular/oval.

Fig. 8. 5. a) (left) Limestone pebbles in the Dishon stream. **b)** (right) Limestone pebbles in the Dishon stream.

Fig. 8.6. Typology of hafted tools according to Adams (2002, 161).

Fig. 8.7. Typology of limestones: 1) Notched pebble, 2) Axe/Adze, 3) Pick, 4) Hammer/Maul.

Fig. 8.8. Typology of limestones: 5) Unworked pebble, 6) Backed knife, 7) Large boulder with natural holes.

Fig. 9.1. Chemically altered surface of limestone pebbles.

Fig. 9.2. Photos of Dishon limestone pebbles.

Fig. 9.25. Untypical limestone items.

Fig. 9.26. Elongated basalt (left) and flint (right) artefacts.

Fig. 9.27. Flake scars on the faces of notched pebbles.

Fig. 9.28. Bifacial flake scars on notched pebbles.

Fig. 9.29. Limestone pebble with possible evidence of pecking, notice no flake scars, and relatively small, U-shaped notch.

Fig. 9.30. Box plot of weight per cluster in layer 4 acquired from Density-based clustering analysis (Appendix 31).

Fig. 9.31. Photo of the concentration of limestone pebbles in squares U102-104 (courtesy of Gonen Sharon).

Fig. 9.32. Box plot of weight per clusters in layer 3a acquired from Density-based clustering analysis (Appendix 33).

List of tables

1. Introduction

Since ancient times fishing played an integral part of human subsistence, with the earliest evidence about incorporating fish into hominin diet coming from the Lower Palaeolithic (*Braun et al. 2010, Erlandson 2001*). The significance of fish and fishing increased during the Mesolithic in Europe (*Lougas 1996, Dinu 2010, Stiner – Munro 2010, Bergsvik and Ritchie 2018*) and the Epipalaeolithic in the Levant (*Bar-Yosef Mayer – Zohar 2010, Munro et al. 2021*).

From the Epipalaeolithic on, a higher variability of fishing implements starts to appear in the Levant, including fish hooks and line sinkers (*Pedergnana et al. 2021*), and notched pebbles. The latter are often found at sites in the proximity of water bodies, and were interpreted as net sinkers or weights for sinking and stabilising traps (*Rau 1873; 1884; Nadel – Zaidner 2002; Prowse 2010; Rosenberg – Agnon – Kaufman 2016*). This interpretation is further supported by a number of ethnographic records mentioning the use of notched pebbles as net sinkers (*Weston 1978*). Notched pebbles are, however, understudied artefacts worldwide, and the assemblages of notched pebbles from the secure stratigraphic context are few.

My interest in notched pebbles appeared after spending several field seasons at the Epipalaeolithic site of Jordan River Dureijat (JRD) in Israel under the direction of Prof. Gonen Sharon, Ph.D. The site of JRD, which was located on a shore of Paleolake Hula, was intermittently occupied for short-term duration throughout the Epipalaeolithic. The exploitation of aquatic resources is evidenced by the finds of fish hooks, line weights, fish remains, molluscs, and limestone notched pebbles.

The thesis aims to test the hypothesis claiming that notched pebbles at JRD served as fishing net sinkers. The approach is based on the quantitative analysis of basic dimensional and shape parameters of limestone objects, techno-typological analysis of notched pebbles, and spatial analysis. The results are evaluated in the context of knowledge of the environment of the site and extensive literature review, bringing analogies from archaeology and ethnography.

The research questions in this thesis are: (1) How does the weight and size of the limestone artefacts change in the stratigraphy of JRD? (2) How does the distribution of the limestone notched and unworked pebbles change in the stratigraphy of JRD? (3) Is there a non-random spatial distribution of finds and spatial correlation of studied limestone artefacts characteristics? (4) Is it possible to reconstruct a specific fishing method based on spatial distribution, archaeological and ethnographic parallels?

This thesis is divided into ten chapters. Chapter One states the research questions and introduces notched pebbles broadly. Chapter Two presents a general overview of the Epipalaeolithic in the Levant. Chapter Three discusses Fishing from early Prehistory onwards, known fishing techniques, and significance of fishing for humans. Chapter Four presents the examples of archaeological sites around the world with the occurrence of notched pebbles. Chapter Five focuses on the ethnographic and ethnohistorical records on fishing activities. Chapter Six is devoted to the current state of research on notched pebbles. Chapter Seven presents the Epipalaeolithic site of Jordan River Dureijat (JRD), its geographic and geological environment, stratigraphy, and finds. Chapter Eight describes methodology. Chapter Nine presents the results of the analysis of limestone artefacts from JRD, including descriptive statistics of metric measurements, typology, and spatial distribution analysis. The final Chapter 10 is devoted to discussion and conclusion.

The data collection for this study occurred under the difficulties of Covid-19, when for several months the borders to Israel were closed and travelling was impossible. Thanks to the effort of a number of individuals at Tel Hai College, my stay was finally enabled in late 2021 and early 2022.

2. The Epipalaeolithic in the Levant

2.1. Chronological and geographical specification

The Epipalaeolithic (EP) cultural sequence (ca. 24,000–11,500 cal. BP), a period of remarkable changes in global climatic conditions and human cultural evolution, succeeds the Upper Palaeolithic (UP) and precedes the Pre-Pottery Neolithic in the Levant. The major change in the Epipalaeolithic is represented by the transition from small highly dispersed and mobile hunters and gatherers to more complex communities with large-scale permanent settlements (*Bar-Yosef – Belfer-Cohen 1989*).

The main features of the EP are represented by microlithization, inventions of new types of tools, and more frequent use of ground stone tools, wide spectrum diet, reduced mobility, and emergence of sedentism (*Bar-Yosef – Belfer-Cohen 1989; Belfer-Cohen – Goring-Morris 2011*).

Geographically, the Levant is a part of southwestern Asia. It is delimited by Sinai to the south, Taurus Mountains to the north, Mediterranean Sea to the west and Zagros Mountains to the east (*Avni 2017, 7*). It sits on the confluence of the African, Arabian, and Eurasian tectonic plates, which has created a unique landscape of high topographic diversity.

The western part of the Levant, which goes along the Mediterranean shore, is created by a narrow coastal plain which transitions through a piedmont zone into a range of hills and mountains reaching 1,200 m above sea level. After that the central range descends into the rift valley and Dead Sea basin, which lies nearly 400 m below sea level, then rising again into the Transjordanian plateau and finally sloping down to the southeast (*Zohary 1962*).

The EP begins at the peak of Last Glacial Maximum (LGM), it includes the temperature drop during the Younger Dryas, and ends at the beginning of the Holocene. It dates to ca. 24, 000 cal BP - 11, 500 cal BP (*Goring-Morris – Belfer-Cohen 2011*; *Grosman 2013*; *Goring-Morris – Belfer-Cohen 2017*). The EP is divided into Early (ca. 24-18,5 ka cal. BP), Middle (18,5-15 ka ca. BP), and Late (15-11,5 ka BP) chronological phases (*Valletta – Grosman 2021*).

The individual EP archaeological cultures are based on the study of techno-typological traits of lithic assemblages such as "specific technologies of core reduction and blank production, presence/absence of the microburin technique and typological variability, especially amongst the microliths" (*Goring-Morris – Belfer-Cohen 2017, 640*).

Many scholars see a difference between the EP in the Mediterranean phytogeographic zone, and more arid areas of steppes and desert regions of the Levant (*Olszewski and Al-Nahar 2016*). Consequently, certain cultural entities appear in the Mediterranean zone (Fig. 2.1., Early and Final Natufian), while others occur in steppes and desert areas (Nebekian, Mushabian, Ramonian, Harifian). Some of them can be found both in the Mediterranean zone as well as desert zone (Masraqan, Kebaran, Nizzanan, Geometric Kebaran, Late Natufian) (*Goring-Morris – Belfer Cohen 2011*, *196*).

		Sociocultural entities	
Dates BP Cal	Time stratigraphic units	Mediterranean zone	Steppe and desert zone
24,000–21,750	Early Epipaleolithic		Nebekian
24,200–19,250		Masraqan (Late Ahmarian)	Masraqan (Late Ahmarian)
21,250–17,575		Kebaran	Kebaran
20,200–18,900		Nizzanan	Nizzanan
18,000–16,250	Middle Epipaleolithic	Geometric Kebaran	Geometric Kebaran
17,000–15,500			Classic Mushabian
16,850–14,400			Early Ramonian
14,900–13,700	Late Epipaleolithic	Early Natufian	Terminal Ramonian Early Natufian
13,500–12,750		Late Natufian	Late Natufian
12,500–11,750		Final Natufian	Harifian
12,175–11,800	Early Neolithic PPNA	Khiamian	
11,625–11,000		Sultanian	(Final Harifian)
10,950–10,300	Early Neolithic PPNB	Early PPNB	Early PPNB
10,150–9725		Middle PPNB	Middle PPNB
9400–8900		Late PPNB	Late PPNB
9050–8450		Final PPNB (PPNC)	Final PPNB (PPNC)
8400–7700	Late Neolithic PNA	Yarmukian	Tuwailan
7750–7450		Jericho IX	
7500–6500	Late Neolithic PNB	Wadi Raba	Qatifian Timnian

Fig. 2.1. Chronology and cultural affiliations during the Epipalaeolithic and following Pre-Pottery and Pottery Neolithic (after *Goring-Morris – Belfer-Cohen 2011*, *196*).

2.2. Early Epipalaeolithic

Early Epipalaeolithic (24-18 ka cal. BP) entities currently recognised are Masraqan, Kebaran, Nebekian, and Nizzanan. Regarding the spatial organisation of Early EP occupations, architectural remains, *fonds de cabane*, are known from Masraqan sites Ohalo II and Azariq XIII, and Kebaran Ein Gev I and Jiita rockshelter. The few burials from Early EP are known. One complete burial comes from Ohalo II, another burial of a female adult was found at Ein Gev I. Ground stone tools represent an innovation in the Early EP (*Goring-Morris – Belfer-Cohen 2017*). More focus on the exploitation of vegetal sources is attested at Ohalo II (*Piperno et al. 2004; Snir et al. 2015; Groman-Yaroslavski et al. 2016*).

In this period, the new lithic technique - microburin technique - which allows discarding the unnecessary portion of the original blanks and creating an oblique truncation, was developed (*Miolo – Peresani 2005*). The common tools used in Early EP are scrapers, burins, non-twisted, narrow finely retouched ("Ouchtata") bladelets, backed and bi-truncated bladelets, backed and obliquely truncated 'Kebara' points, and scalene triangle microliths (*Goring-Morris – Belfer-Cohen 2017*).

2.3. Middle Epipalaeolithic

Middle Epipalaeolithic (18-15 ka cal. BP) entities include Geometric Kebaran occurring both in the Mediterranean zone as well as in the steppe and desert regions, and Mushabian and Ramonian that are restricted to the Negev and Sinai. In the Middle EP, advances in pyrology are attested by a greater variability of hearths and roasting pits together with stones for cooking (*Goring-Morris – Belfer-Cohen 2017*). Ground stone tools are also found, sometimes even in the context of burials (*Yeshurun et al. 2015*). However, only a few burials from the Geometric Kebaran, including Neve David in Mount Carmel were found. Regarding the sites, small-sized camps were predominantly seasonally occupied, reflecting a high degree of mobility (*Goring-Morris – Belfer-Cohen 2017*).

Geometric Kebaran microliths are highly standardised, mostly comprising the trapeze-rectangle form, while Mushabian industry is characterised by arched backed bladelets on short blade or bladelet blanks, which are habitually fashioned using microburin technique. The Ramonian features the Ramon point, a robust, concave backed and obliquely truncated bladelet (*Goring-Morris – Belfer-Cohen 2017*).

Fig. 2.2. Map of Levant illustrating the spread of Early and Late Natufian with the location of Natufian sites (*Grosman and Munro 2017, 700, Fig. 77.2*)

2.4. Late Epipalaeolithic

Late Epipalaeolithic (15-12 ka cal. BP) includes Early Natufian, Terminal Ramonian, Late Natufian, and Harifian in the steppe and desert regions, while Early, Late, and Final Natufian were identified in the Mediterranean zone (*Goring-Morris – Belfer Cohen*

2011). The Natufian entity was first identified and described by Doroty Garrod in the early 1930s after she excavated the Shuqba Cave based on the lithics (*1932*). Later other lithic assemblages were identified as Natufian, covering the areas of the Galilee, Mt. Carmel, and the Judean Hills and Desert (Fig. 2.2.). Natufian core area is located in the Mediterranean zone, being an forest/open-park land, with temperate climate, characterised by warm, dry summers and mild, wet winters (*Grosman 2013*).

The Natufian culture is often perceived as a threshold to the origins of agriculture in the Levant (*Bar-Yosef 1998*). The Natufian is characterised by increase of permanent settlements, intensified foraging strategies, heightened symbolic and ritual practice, and burials concentrated in settlements (*Grosman – Munro 2017*). Lunate-shaped microliths are typical for this period as well as greater use and variability of ground stone tools. Apart from that a number of ornaments and art objects, including a variety of marine molluscs, bone, limestone and greenstone pendants, were used in headgear (Fig. 2.4.), belts, necklaces, bracelets, and earrings (*Bar-Yosef 1998*).

2.5. Microlitisation

Microlitisation represents one of the principal features of the EP. Although the microliths are found already in the Upper Palaeolithic, their occurrence increased extensively in the EP. Contrary to late UP straight bladelets which are simply retouched, the EP microliths tend to be backed. This shift in the type of retouch together with other evidence is taken as an indication for the introduction of composite tools. Based on the microlith types, assemblages are classified in “cultural entities” (Fig. 2.3.) such as Natufian, Geometric Kebaran, etc. Possible explanations for the appearance of microlithisation include developments in hafting practises and economising behaviour. The microlithisation probably reflects increasing efficiency and flexibility (*Belfer-Cohen – Goring-Morris 2002*).

2.6. Broad spectrum diet

Expansion of the subsistence economy within the Levant during the Epipalaeolithic attested to what Flannery (*1969*) described as the ”broad-spectrum revolution”. This expansion, gradually including more low-ranked prey, led the process from mobile hunting and gathering subsistence strategies to farming in the Levant.

The wide spectrum diet of the Epipalaeolithic populations consisted of middle- and small-sized mammals such as gazelle, wild equids, wild boar, red deer, fallow deer, wild cattle, wild goat and sheep, and hare (*Bar-Oz 2004*). Aquatic resources including fish, shellfish, turtles, tortoises and water birds were part of the diet as well (*Bar-Yosef Mayer – Zohar 2010; Yeomans – Richter 2016; Munro et al. 2020*).

Another part of the diet, vegetal resources, included nuts, seeds, grasses, vegetables, and wild cereals such as wild barley and wheat (*Weiss et al. 2008; Snir et al. 2015; Ramsey – Rosen 2016*). Not only the burned specimens and phytoliths were retrieved at the Epipalaeolithic sites, but also the starch residues were identified on a number of ground stone tools (*Piperno et al. 2004; Liu et al. 2018*).

The botanical evidence from the Natufian hunter-gatherer site Shubayqa 1 (Jordan) suggest preparation of bread-like products made of wild einkorn and club-rush tubers (*Arranz-Otaegui et al. 2018*). Another evidence of processing wild cereals comes from Natufian site at Raqefet Cave, where multidisciplinary research suggested that beer brewing activities, involving three stages: malting, mashing, and fermentation of barley and wheat (*Liu et al. 2018*).

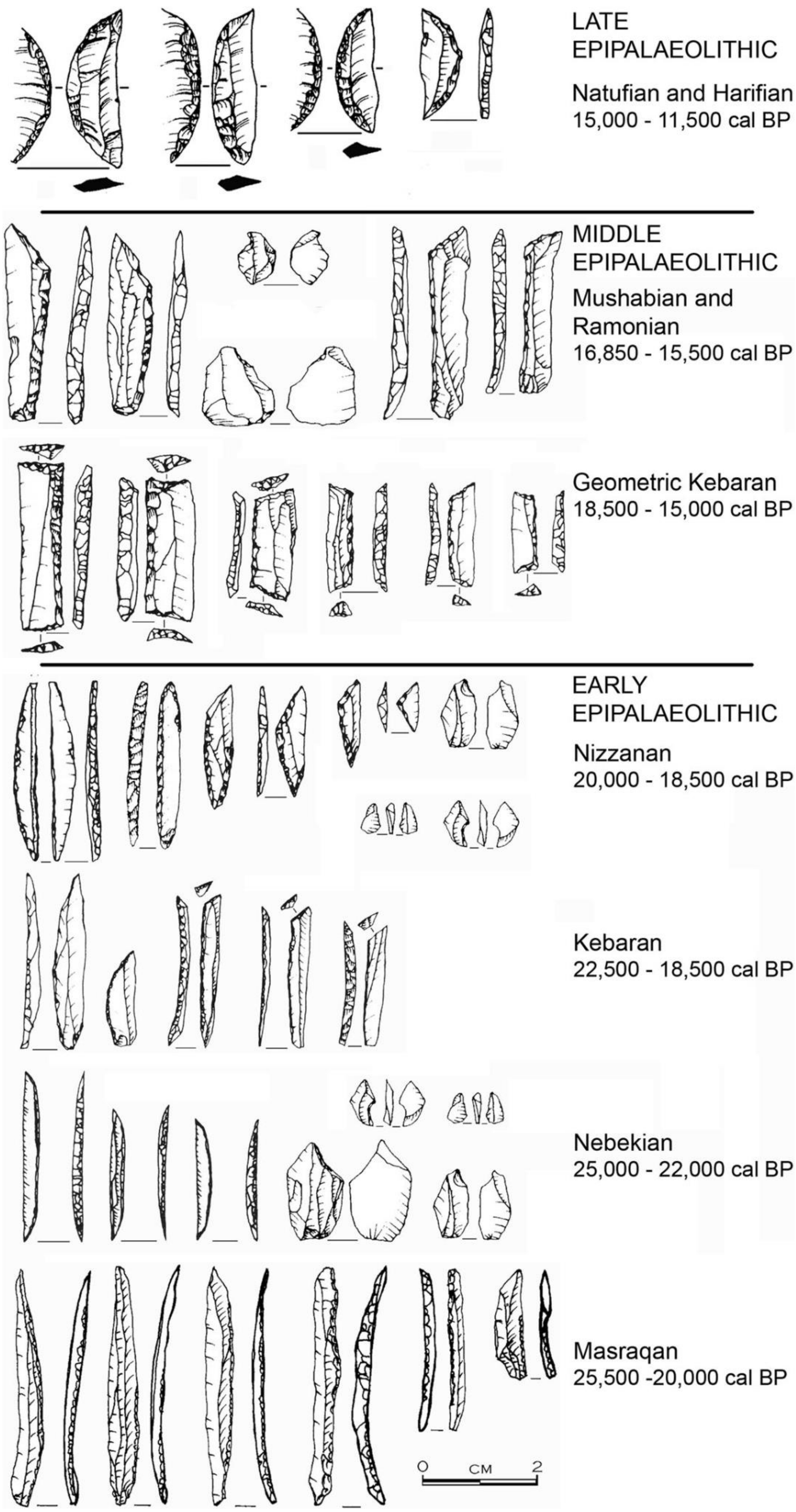


Fig. 2.3. Microliths typical for each cultural entity with chronological dates (after *Valletta – Grosman 2021, 3, Fig. 1.*)

2.7. Innovation in tools: Sickle blades and ground stone tools

Sickle blades (Fig. 2.5) represent one of the innovations in the Epipalaeolithic Levant. Based on the use-wear traces of the glossed flint blades, the earliest use of composite sickles was attested at Ohalo II, a 23,000-years-old fisher-hunter-gatherers' camp on the shore of the Sea of Galilee. The wear traces indicate that sickle blades were used for harvesting wild cereals (*Groman-Yaroslavski – Weiss – Nadel 2016*). By the end of Natufian, sickles Composed of a handle made of bone, antler, or wood, and inserted flint blades were commonly used (*Groman-Yaroslavski – Weiss – Nadel 2016*).

Ground stone tools including grinding slabs, mortarts, pestles, handstones, pounders, and stone vessels begin to appear in small number in the Levantine Upper Palaeolithic and Early Epipalaeolithic, and their use intensify in Late Epipalaeolithic, especially at Natufian sites (*Wright 1991*). The ground stone tools are commonly associated with the processing of wild cereals, but they may have also been used for processing tubers, nuts, legumes, chenopods, and also for hide working or mineral grinding (*Wright 1991; Dubreil 2004*). The finds of large grinding slabs can serve as another indication of reduced mobility (*Wright 1994*) as the heavy items would be difficult to transport on a regular basis.

2.8. Exploitation, cultivation, and domestication

Another phenomenon which is closely associated with the inventions of sicles and wider use of ground stone tools is the cultivation of certain weeds and cereals and animal domestication. The earliest evidence of intensive exploitation comes from the early Epipalaeolithic site of Ohalo II, where a rich assemblage of plants of over 140 plant species was found. Wild barley, wheat, emmer, and oat were identified among the gathered weeds (*Snir et al. 2015*). Grinding of wild barley and wheat is attested by the analysis of starch grains identified on Ohalo II grinding slab (*Piperno et al. 2004*). First experiments in systemic cultivation, which ultimately led to plant domestication during the Pre-Pottery Neolithic A, probably occurred in Late Natufian during the Younger Dryas (*Bar-Yosef 1998*).

Domestication of a dog in the Epipalaeolithic Levant was attested by finds of bones at Natufian sites such as Eynan and Hayonim terrace. At Eynan, a skeleton of a puppy was found lying next to the head of a buried individual. Approximately 50 year old woman had her hand laid on the chest of the puppy (*Davis – Valla 1978*). Although it is often difficult to distinguish domesticated dogs from wolves in the Natufian Levant, studies show that tooth size reduction and disproportionate shortening of the facial regions are characteristics of early domesticated dogs (*Dayan 1994*).

2.9. Mobility, sedentism, and architecture

Climate and environmental fluctuations caused changes in subsistence strategies such as beginnings of cereal cultivation, reduced mobility, and establishment of sedentary settlements in the Late Epipalaeolithic (*Bar-Yosef – Belfer-Cohen 1989*). The indications for sedentism include hunting of gazelles all year round, higher presence of house mice than in forager sites, evidence for more frequent time- and energy-consuming activities such as building houses from durable materials, digging graves, and shaping large grinding slabs and mortars (*Bar-Yosef 1998*).

In the Early and Middle Epipalaeolithic, huts and related architectural features are found in a number of open-air sites, including sites such as Ohallo II, Ein Gev I, III and IV, Nahal Hadera V, Azariq XIII, and Kharaneh IV (*Goring-Morris – Belfer-Cohen 2008*; *Maher – Richter – Stock 2012*). The huts are usually oval-shaped with ca. 3-5 m in diameter, often semi-subterranean (*Goring-Morris – Belfer-Cohen 2008*). At a submerged Masraqan site of Ohalo II, remains of six brush rounded huts with fireplaces in between them were discovered. They all have a bowl-like section and the floors are about 20-30 cm lower than the surrounding surface. A brush wall was constructed of thick branches of tamarisk, willow and oak. Smaller branches and grasses were placed on the top of huts (*Nadel 2003*).

The sedentism intensifies in the Natufian, before culminating in the agricultural communities of the Neolithic (*Yeshurun et al. 2014; Grosman – Munro 2017*). In Natufian, base camps and seasonal camps were differentiated by considering building activities, storage facilities, heavy ground stone tools, frequency and types of burials (*Bar-Yosef – Belfer-Cohen 1989*). Late Epipalaeolithic structures were discovered on a number of Natufian sites including Eynan, Hayonim Cave, El-Wad, Wadi Hammeh 27, and others. They have an oval, rounded, or U-like shape, usually with a wall base made of undressed stones. Their sizes varied through time. Larger structures (20 sq.m.) are more common in the early Natufian sites. In the late Natufian, they are usually smaller (5-10 sq.m.) (*Nadel 2003*). From Natufian onwards, the settlements are considered as sedentary hamlets (*Bar-Yosef 1998*).

2.10. Burials

Early Epipalaeolithic is poor in human remains. One of a few examples was found at Ohalo II site, suggesting that the tradition of burying the dead in a very shallow grave might have predominated in the Early Epipalaeolithic. The Ohalo II individual was lying on his back in a semi-flexed position with the hands folded on the chest and the knees folded backwards (*Nadel 1994*).

From the Middle Epipalaeolithic, several burials from Geometric Kebaran sites are known. These include Wadi Mataha, Neve David, and Uyun al-Hammam. At Wadi Mataha, the individual buried was lying in a rather unusual face-down position, with a ground stone bowl, a large blade, and faunal remains as grave goods (*Macdonald et al. 2016*). Fragmentary remains of a neonatal individual were recovered from the context overlying the adult burial (*Macdonald et al. 2016*) At Neve David, one complete and one fragmentary individuals were found associated with ground stone implements (*Yeshurun et al. 2015*). In Middle Epipalaeolithic burials, there is a high degree of variability in burial positions without any formal standardisation.

From the Natufian, about 500 Natufian burials were recovered (*Grosman – Munro 2017*). Most of them come from Hayonim Cave, Eynan, El-Wad, and Hilazon Tachtit (*Nadel*

1994, Grosman et al. 2008). Graves were in the form of shallow or deeper pits, often dug in deserted dwellings or outside of the houses. Sometimes graves were covered with limestone slabs (*Bar-Yosef 1998*). The burials do not exhibit uniform features, but rather they are quite diverse. The position of the body can be supine, semiflexed, or flexed, with various orientations of the head. Grave goods including head decorations, necklaces, bracelets, and pendants made of marine shells, teeth, bone, and beads occur in some of the graves (*Bar-Yosef 1998*).

To sum up, the Epipalaeolithic, being characterised by remarkable changes in settlement, subsistence, technology, ritual practice, and social structure, represents a crucial period in the human prehistory. Regarding architecture, larger Early Natufian sedentary villages with durable architecture developed from small seasonal camps in the Early and Middle EP. Natufian presents an impressive increase in the number of human burials as well as size of cemeteries. Intensive exploitation of weeds initiated the cultivation processes, while domestication of dog led to domestication of other animals in the Pre-Pottery Neolithic. Among other innovations were sickles, composite tools, ground stone tools and exotic personal ornaments. These changes were pivotal to the transformation from the mobile Epipalaeolithic hunter-gatherers to settled Neolithic farmers (*Bar-Yosef 2011; Belfer-Cohen – Goring-Morris 2011*).

Fig. 2.4. Early Natufian decorated skull from El-Wad (*Bar-Yosef 1998, 165, Fig. 5*).

Fig. 2.5. Sickle blades from Ohalo II (*Groman-Yaroslavski– Weiss – Nadel 2016*)*2016, 7, Fig. 3.*).

2.11. Pre-Pottery Neolithic

The Epipalaeolithic in the Levant is followed by the Pre-Pottery Neolithic (PPN). Dated between 12,175 and 8,450 cal BP, it starts with the beginning of the Holocene (*Goring-Morris – Belfer-Cohen 2011*). The period is characterised by wetter and warmer conditions, which favoured the early Neolithic development of sedentary settlements as well as the cultivation of cereals and legumes (*Bar-Yosef 1998*).

The subsistence was based on intensive collection or cultivation of cereals and legumes., although gathering of wild fruits and seeds and hunting of wild animals continued. Gazelle belonged to the frequently hunted animals, and was hunted all year round (*Belfer-Cohen – Bar-Yosef 2002 in Kuijt 2002*). Animal domestication, or proto-domestication is another feature of the PPN. To argue, at which exact point the animals such as sheep and goat became truly domesticated is a difficult task, however, the size diminution and butchering of mainly young males indicate that it happened during the PPNB (Horwitz *et al.*1999).

Ground stone tool technology is closely associated with cereal domestication, and these tools became numerous in the Natufian, and Pre-Pottery Neolithic. Pestles and mortars are more common in Early Natufian, while grinding slabs and handstones dominate in Late Natufian, and PPNA and PPNB (*Wright 1991*).

Apart from ground stone tools, bifacial and polished axes-adzes, and celts are considered to be Neolithic “markers” (*Bar-Yosef 1998*). Standardised stone and flint axes first appeared in the southern Levant during the Sultanian phase of PPNA, and they seem to reflect new Neolithic adaptations and activities, related to the transition to food production and sedentism (*Barkai 2011, 443*). While flint axes, called tranchet axes, are predominantly shaped by transversal blows, the axes made of limestone, basalt, and other materials are polished (*Barkai 2011*). The polished ones are sometimes referred to as celts (*Bar-Yosef 1998, 171*). Some bifacial tools appear already in the Natufian, but they are not standardised and the use of bifacial knapping is not systematic (*Barkai 2011, 443*).

Permanent architecture is one of the features of the Neolithic. PPN sites including Jericho, Gilgal, and Netiv Hagdud contain remains of rounded and oval houses, and storage facilities, made of mud bricks (*Bar-Yosef – Belfer-Cohen 1989*). Communal building, such as building the walls and tower in Jericho, represents one of the characteristics of the Neolithic (*Bar-Yosef 1998*).

Another change in the society is expressed by burials, most burials are single with no grave goods, often found without skulls. Art objects include the human figurines, which are made either from clay, or limestone, with female and male figurines being distinguishable. In the Pre-Pottery Levant, long distance exchange is attested for obsidian, originating in Anatolia, and marine shells, coming from the Mediterranean and Red Sea coasts (*Bar-Yosef 1998*).

3. Fishing in Prehistory and its significance

Since ancient times, fishes have played an integral part of human life in human lives, cultures, and economies. Fish appear in various aspects of human culture, including mythology, religion, literature, and art. Above all, they represent an important source of food. In Ancient Egypt, fishing, being one of the main economic activities, was frequently depicted on the walls of tombs (Fig. 3.1.). The fishing practises included line and hook fishing, net fishing, trapping, spearing and harpooning (*Sahrhage 2008a*). Ancient Egyptians even worshipped a fish-goddess, Hatmehyt (or Hatmehit), who was a symbol of fertility and abundance (*Shaikh Al Arab – Ali 2013*).

Additional example of fish in mythology is a hybrid fish-man figure (Fig. 3.2). In Mesopotamia, these figures, called Apkallu, are found on cylinder seals, sculptures, and reliefs. A great number of cylinder seals also show scenes with fishing, fish offerings, and boats (*Sahrhage 2008b*). In Babylonia, the Apkallu were believed to be semi-divine creatures and advisors of the kings. Berossus, a Babylonian writer living in the third century BC, mentions the fish-human hybrid, named Oannes in his before flood history of Babylonia (*McInerney 2017*). Clearly, fish and fishing played a significant role in the early civilizations.

Fig. 3.1. (left) Fishing with multiple hooks and line and with hand net (*Von Bissing 1905 in Sahrhage 2008a, 923*).

Fig. 3.2. (right) Apkallu from Mesopotamian mythology (*Sahrhage 2008b, 933*).

Since no myths and legends from the Palaeolithic periods have been recorded, and very few depictions have been found, we don't know a lot about what the prehistoric people believed and if and how the fishes played an important role. From the Upper Palaeolithic onwards, relief sculptures and paintings representing fish also start to occur. In Abri du Poisson, France engraving of a salmon (Fig. 3.3.) was discovered (*Zotkina – Cleyet-Merle 2017*). Another depiction in the form of painted flatfish (Fig. 3.4.) on the cave walls was found in La Pileta in Andalusia, Spain (*Sahrhage 2008c*).

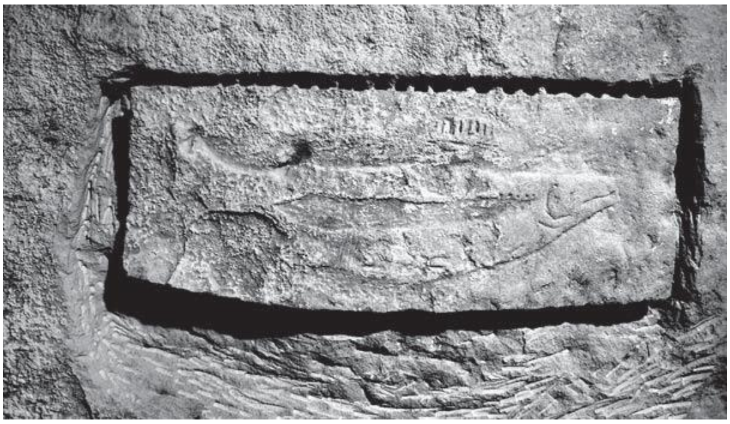


Fig. 3.3. and **Fig. 3.4.** Palaeolithic depictions of fish: (left) Abri du Poisson (*Zotkina – Cleyet-Merle 2017, 42*), and (righ) La Pileta Cave (*Sahrage 2008, 937*).

More evidence about the significance of fish and fishing come from the Serbian Mesolithic-Neolithic site of Lepenski Vir. The subsistence of Lepenski Vir inhabitants relied heavily on the Danube River (*Živaljević 2012*). Apart from the numerous fish remains, many sculpted boulders representing human/fishlike beings were unearthen (*Živaljević 2012*). Fish was such an important source of subsistence that eventually fish "moved from the domain of economy to the domain of ideology" (*Radovanović 1996 in Živaljević 2012*). Borić (*2005*) goes even further suggesting that sculpted boulders from Lepenski Vir represent various stages of metamorphosis of the deceased into fish. Among the fish remains at Lepenski Vir, large quantities of bones from Beluga sturgeon, largest sturgeon in the Danube river measuring between 4 and 7 metres, were identified.

Therefore, it is no wonder that the elements of sturgeon anatomy (Fig. 3.5. and 3.6.) appear on Lepenski Vir sculptures (*Živaljević 2012*).

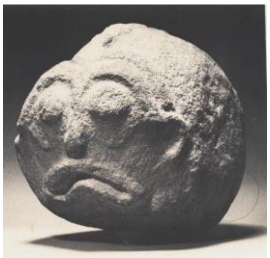



Fig. 3.5. (left) Shape of mouth of sturgeon,
Fig. 3.6. (right) sculpture from Lepenski Vir representing a human-fish hybrid (*Živaljević 2012, 199*).

This chapter tries to explain certain issues connected to the research on fishing in prehistory, to introduce the existing fishing techniques, to provide a brief overview of fishing from the earliest evidence until the Mesolithic, and finally to recognize the importance of fish in the diet of Mesolithic people.

3.1. Archaeological evidence of fishing

There are two kinds of evidence while studying the fishing in Prehistory: direct and indirect evidence. The direct evidence of fishing comprises fishing gear such as fish hooks, line weights, net sinkers, nets, traps, weirs, etc. (*Sahrhage 2008c*). The indirect evidence of fishing comprises fish remains, stable isotopes traced in the human remains (*Erlandson 2001*), or paintings and engravings of fish and fishing (*Sahrhage 2008c*).

The perishability of most fishing components (Fig. 3.7.) represents a major obstacle in the study of fishing techniques in Prehistory. The organic parts can survive only under specific conditions, such as waterlogged sites, and these sites are geographically limited to mainly lake settlements in the Alps, sites in Scandinavia and Baltic countries.

Fishing with bare hands does not leave any material remains. The same applies to wooden spears with sharpened points, lift nets, and scoop nets. The stupefying techniques of fishing are also almost impossible to identify: thrown stones do not need to be shaped, fish poisons do not survive in the water, and mud used for deoxygenation of fish settle to the bottom.

Traps are almost invisible in the archaeological record, even though they must have been widely used in the past as their common use is well attested in the ethnography (*Altman 2006; Dounias et al. 2016*). The reason for this invisibility is that the traps are made of organic materials, sometimes weighted down by stone weights. These, however, don't need to be worked and thus can't be identified in the excavations.

Regarding angling, only a hook or a gorge usually survive, sometimes also a shell lures (*Cavulli –Scaruffi 2011*), while fishing rods and lines decay. Nets usually do not survive in the archaeological records, although there are also exceptions when a few fibres are preserved (*Gross –Huber 2018, 263*). Floats, being made of bark or soft wood, are also rare finds. The only inorganic components are stone net sinkers.

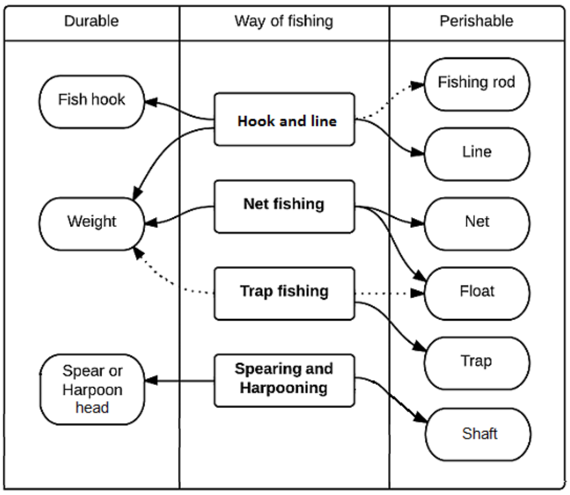


Fig. 3.7. Basic fishing techniques with the division of durable and perishable compositions used in a certain technique (*Pajdla 2014, 17*).

3.2. Fishing techniques

In this subchapter, the existing fishing methods are presented and explained. Generally, the fishing gear can be divided into active and passive equipment. In passive gear, the fish come voluntarily, so the knowledge of the fish's behaviour is crucial. The success of active gear is mainly given by the fisherman's skill and perseverance (*Von Brandt 1984, 5*).

Fishing gear can be classified into several categories: (1) without gear, (2) grappling and wounding gear, (3) stupefying devices, (4) angling, (5) traps, (6) aerial traps, (7) bagnets, (8) dragged gear, (9) seine nets, (10) surrounding nets, (11) drive-in nets, (12) lift nets, (13) falling gear, (14) gillnets, and (15) tangle nets (*Von Brandt 1984*).

(1) Without gear fishing methods (Fig. 3.8. a) include grasping by hand along the shore or in shallow waters, or by diving in deeper waters. Fishing with hunting animals such as dogs, otters, and cormorants also fall into this category.

(2) Grappling and wounding gear include wrenching gear, clamps, raking devices, tongs, spears and lances, fish plummets, fish combs, arrows, and harpoons (Fig. 3.8. b).

(3) Stupefying devices including striking gear such as thrown stones and fish clubs (Fix. 3.8. c), and fish poisoning (ichthyotoxic plants, animal poisons, chemicals lime burnt lime, deoxygenation). For poisoning fish, steady or slow-running waters are necessary. Burnt lime is thrown into the water, causing the gills of the fish to become cauterised, and to rise to the surface. Deoxygenation is caused through stirring up of the bottom mud.

(4) Angling: Lines with various types of hooks (Fig. 3.8. d) or gorges.

(5) Traps (Fig. 3.8. e): these are implements in which the fish enters voluntarily but is prevented from coming out. Traps can occur as hiding places (brush traps, eel tubes, or octopus pots), as barriers (walls or dams, fences, gratings, and watched chambers), as

mechanical traps (gravity traps, box traps, torsion traps, snares), tubular traps (narrow funnel-like or hose-like gear without gorges), baskets with retarding devices, fixed on sticks or anchors.

(6) Aerial traps serve to catch certain fish which jump out of water. The way of capturing jumping fish is based on the possibility of stirring them up so as to catch them in the air by special devices such as box traps, raft traps, boat traps, and scoop nets (Fix. 3.8. f).

(7) Bagnets (Fig. 3.8. g) are bags of netting or wooden ones, which are kept open vertically by a frame and extended horizontally by the current. The fish enter the bagnet and can't escape due to the strong current. This method includes scoop baskets and nets, scrape nets, gape nets, and closable bagnets.

(8) Dragged gear contains all bagnets and net walls which are drawn through the water on or near the bottom for an unlimited time. Fish are caught by filtering by the active moved gear. These include sweep nets, runner nets, dredges (Fig. 3.9. a), bottom trawls, one-boat trawls, and two-boat trawls.

(9) Seine nets (Fig. 3.9. b) are dragged through the water with both ends, surrounding a certain area, to a fixed point on the shore or on a boat. Seine net works like a wall, corralling and holding fish, rather than ensnaring them. These contain double stick nets, beach seines, and boat seines.

(10) Surrounding nets (Fig. 3.9. c) capture fish by surrounding them both from a side and from beneath, thus ensnaring fish in deeper water as well. One or two boats are necessary for this method.

(11) Drive-in nets (Fig. 3.9. d) represent a category stationary of fishing gear into which fish need to be driven by divers. These can be dustpan-like stationary gear, gillnets set in a circle, etc.

(12) Lift nets (Fig. 3.9. e) or dip nets catch fish by bringing them over a flat or bag-like netting and then lifting the gear in the air. They can be used both on the shore and from a boat on deeper waters.

(13) Falling gear include wooden cover pots, lantern nets, cover nets, and hand thrown cast nets (Fig. 3.9. f). The manner of catching fish is to cover fish with a gear. This method is commonly used on the shore, but can be done in deeper waters with some difficulty.

(14) Gillnets are single-walled nets, with a size of mesh corresponding to the size of desired fish. Mesh sizes are designed to allow fish to get only their head through the netting but not their body. The fish's gill then gets caught in the mesh as the fish tries to go back. There are several types of gillnets. Set gillnets (Fig. 3.9. g) are anchored on the bottom, or they can be floating. Driftnets can be used with or without a boat. Others are dragged gillnets and encircling gillnets, into which fish are driven.

(15) Tangle (entangling) nets (Fig. 3.9. h): fish or crabs entangle themselves into the netting by coming into single-, double-, or triple-walled (trammel) nets voluntarily, or they can be driven into them (*Von Brandt 1984*).

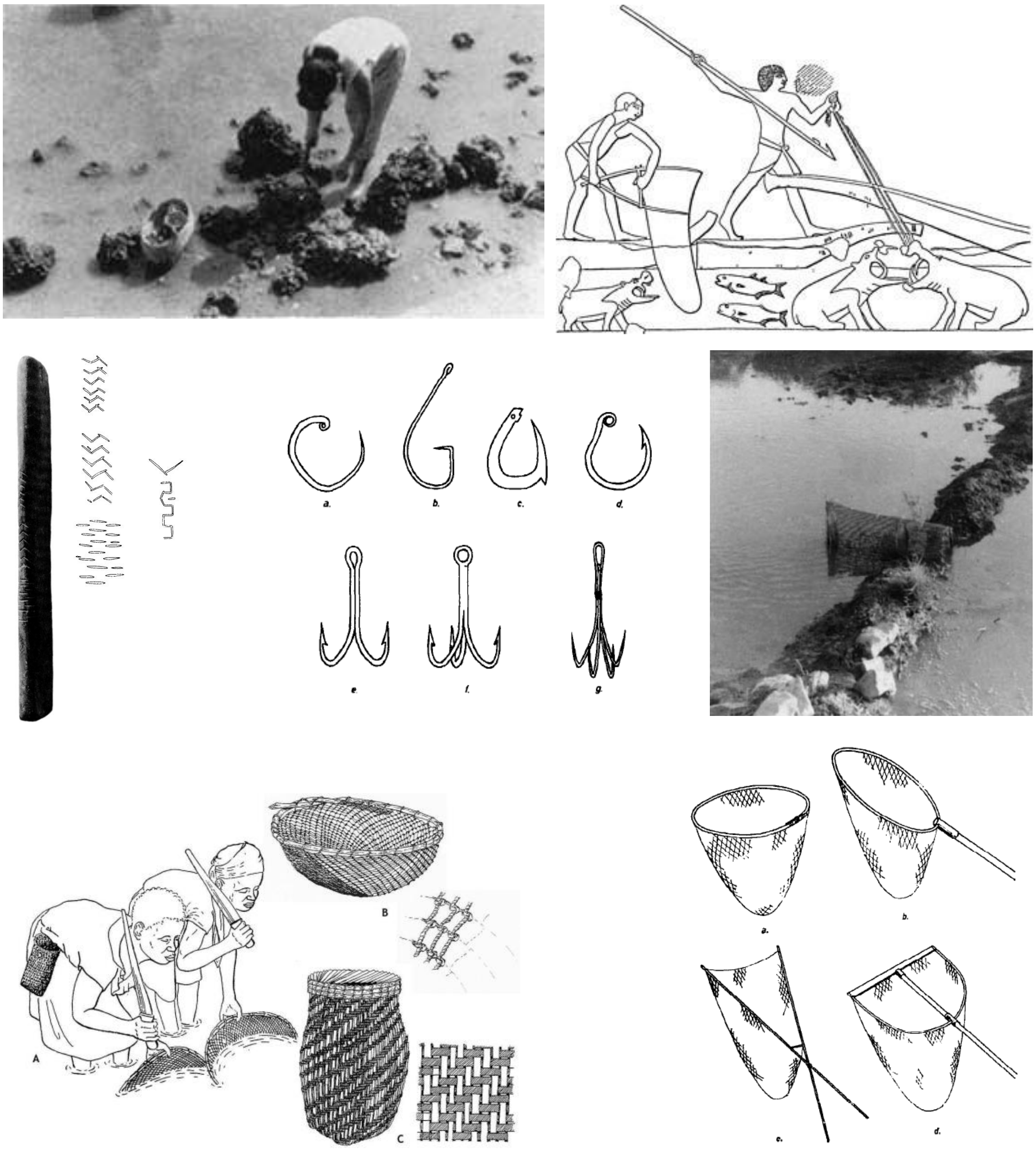


Fig. 3.8. a) woman gathers shellfish on a shore (*Von Brandt 1984, 12*), **b)** fishing in ancient Egypt, harpooning hippopotamus, relief in tomb of Princess Idout at Saqqara (*Macramallah 1935 in Sahrhage 2008, 923*), **c)** engraved mallet from Lepenski Vir (*Antonović 2006, 53*), **d)** types of hooks used for line fishing (*Von Brandt 1984, 73*), **e)** temporary barrier made of mud and stones combined with a woven trap, Thailand (*Von Brandt 1984, 154*), **f)** using scoop basket in Cameroon (*Dounias et al. 2016, 17*), **g)** different types of scoop nets with and without handles (*Von Brandt 1984, 216*).

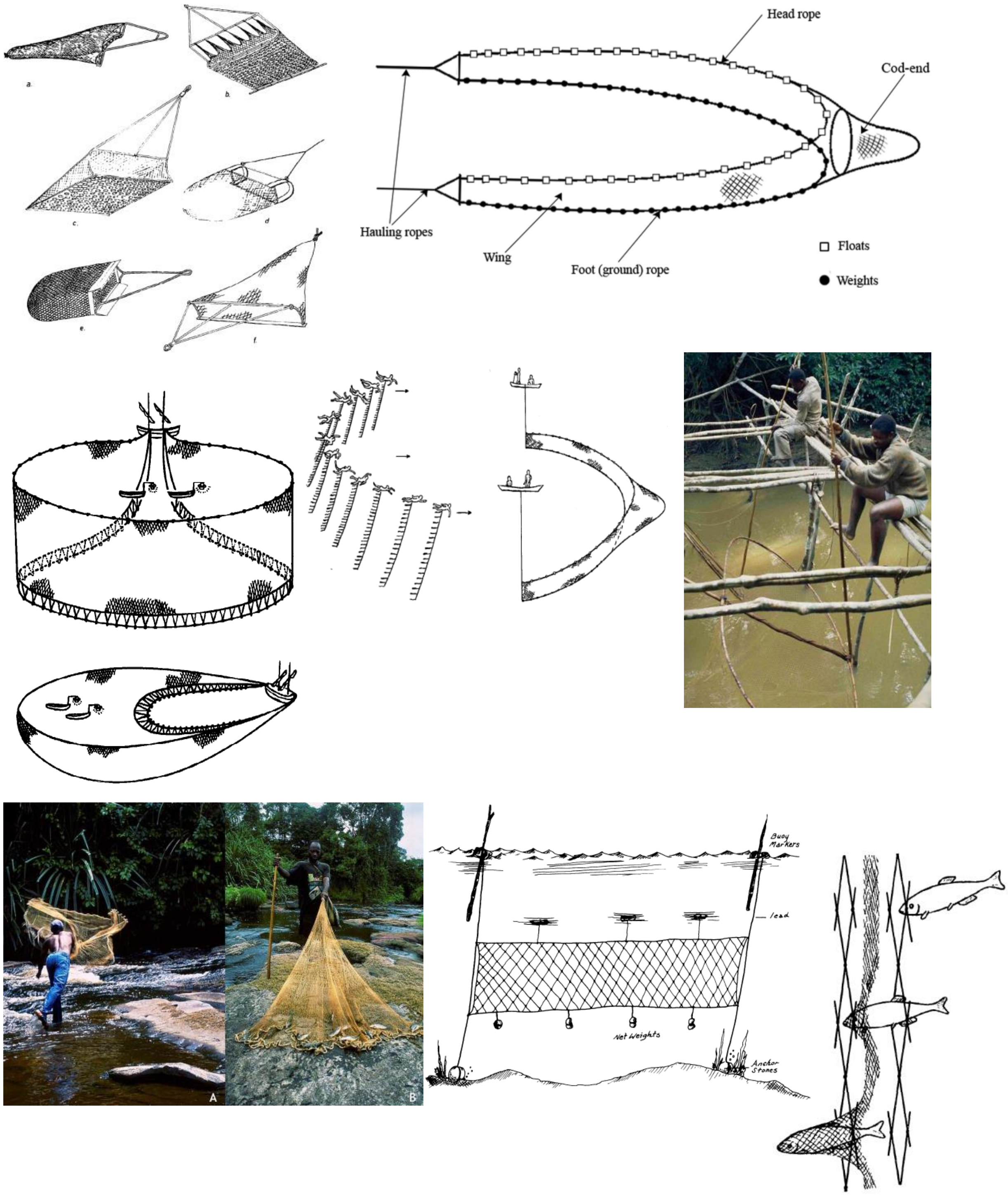


Fig. 3.9. a) Different types of dredges (*Von Brandt 1984, 235*), b) beach seine net used in Sri Lanka (*Gunawardena et al. 2016, 132*), c) surrounding net with two boats (*Bertuccioli 1955 in Von Brandt 1984, 302*), d) drive-in fishery with divers (*Von Brandt 1984, 321*), e) lift nets in Cameroon (*Dounias et al. 2016, 12*), f) Cast net fishing in Cameroon (*Dounias et al. 2016, 13*), g) gill net (*Cleland 1982, 776*), h) Trammel net (*Von Brandt 1984, 374*).

3.3. Earliest fishing

Fishing is an important food source for many societies nowadays and it probably played a significant role in subsistence of many prehistoric peoples. The earliest evidence about incorporating fish into hominin diet comes from Turkana, Kenya, and it is dated close to 2 million years ago (*Braun et al. 2010*). Fish skeletal remains and isotope data testify for the importance of aquatic resources in homin diet in Lower Palaeolithic (*Erlandson 2001*).

In the Levant, the abundance of fish remains is well-attested on Lower Palaeolithic sites of ‘Ubeidiya (*Van Neer – Zohar – Lernau 2005*) and Gesher Benot Ya'aqov (*Alperson-Afil et al. 2009*). The spatial distribution of fish bones on Gesher Benot Ya'aqov testify for an anthropogenic origin, suggesting that aquatic resources represented another component of early hominin diet on the site. Cyprinidae (carps) predominates with five identified species (*Alperson-Afil et al. 2009*).

Fishing methods used in Lower Palaeolithic are unknown as fishing implements are not commonly found at these sites. The simplest fishing method which does not require any tools would be hand-picking, diving and gathering on the shores (*Sahrage 2008, 935*).

Middle Palaeolithic sites with the occurrence of fish remains are neither plentiful. At Hohle Fels in southwestern Germany, fish bones including burbot, grayling and carp were identified (*Conard – Hardy – Serangeli 2013*). Based on residue and use-wear analyses on lithics, fish processing performed by Neanderthals was confirmed at the site of Payre, France (*Hardy – Moncel 2011*). The evidence from Pinnacle Point Cave, South Africa and Bajondillo Cave, Spain suggest that shellfishing began in the Middle Palaeolithic (*Klein – Bird 2016*). In the Levant, some fish remains were found at the Middle Palaeolithic sites of Douara Cave, Amud Cave, and Shubbabiq Cave (*Van Neer et al. 2005*).

Stable isotope values of modern human remains from the Czech Republic, United Kingdom and Russia suggest that fish became a more important source of nutrition in Upper Palaeolithic Europe. The stable isotopes were obtained from bone collagen of individuals from six Upper Palaeolithic sites (Brno-Francouzská 2, Dolní Věstonice 35, Kostěnki 1 and 18, Mal'ta 1, Sunghir 1, 2, 3, and Paviland 1). The stable isotope values indicate significant increase in aquatic foods (fish, molluscs, and birds) with most of the evidence suggesting the exploitation of the inland freshwater resources (*Richards et al. 2001*).

Innovative fishing gear such as fish hooks, harpoons, barbed points also appear in the Upper Palaeolithic. The earliest known fish hooks made of shells come from Asitau Kuru Cave in East Timor (*O'Connor et al. 2011*) and Sakitari Cave in Japan (*Fujita et al. 2016*). Barbed points and harpoons made of antler and bone represent important cultural markers of the Upper Palaeolithic, especially of Azilian and Magdalenian techno-complexes (*Thompson 1955; Weniger 2000*). While magdalenian harpoons are believed to have served as fishing implements, barbed points could have rather been used for big game hunting (*Weniger 2000*).

Relief sculptures, paintings, and body adornments representing fish also start to occur in the Upper Palaeolithic. One example comes from Abri du Poisson, France where a bas-relief of a salmon was discovered (*Zotkina – Cleyet-Merle 2017*). Another rock painting was found in the cave of La Pileta in Andalusia, Spain (*Sahrhage 2008c*).

3.4. Fishing in Epipalaeolithic/Mesolithic

The significance of fish and fishing increased during the Epipalaeolithic and Mesolithic, especially in Scandinavia (*Bergsvik – Ritchie 2018*), Danube Iron Gates region (*Dinu 2010*), Baltic region (*Lougas 1996*), southern Greece (*Stiner – Munro 2010*), and Levant (*Bar-Yosef Mayer – Zohar 2010; Munro et al. 2021*), with most sites being situated in the vicinity of lakes, rivers or on the coasts. According to Flannery's broad spectrum revolution (*1969*), the Palaeolithic hunter-gatherers relied on small- and medium-sized ungulates, ignoring other small mammals, fish, birds, tortoises, and crabs until later times. With the population growth and reduction of territory available for exploitation, the hunter-gatherers gradually began to exploit these “low-ranked” foods. Shift in subsistence strategies, especially in the Late Epipalaeolithic Levant, might be also connected to the climate change, particularly the Younger Dryas cold event, which followed after the favourable period of Bølling–Allerød interstadial.

Innovative fishing gear emerged in Epipalaeolithic/Mesolithic. The earliest bone fish hooks come from Late Epipalaeolithic in the southern Levant, for example from Jordan River Dureijat (*Pedergnana et al. 2021*). Subsequently, the bone fish hooks become widespread (*Price 1983*). Line weights/sinkers are often found together with the fish hooks (*Bergsvik –Ritchie 2018; Pedergnana et al. 2021*).

Starting from the Mesolithic, more fishing implements made of organic materials have been found preserved at water-logged sites, especially in Europe. Various types of mesolithic fish traps and weirs made of hazel have been found at Liffey outfall in Ireland (*McQuade – O’Donnell 2007*). In central Russia, fishing weirs in the form of pointed stakes driven into the bottom across the bed of the channel connecting two lakes have been dated to the Mesolithic (*Zhilin 2014*).

From the Mesolithic onwards, there is direct evidence for net fishing. One of the oldest preserved nets was found in Antrea, Finland (Fig. 3.10..) and it is dated to 9140±135 BP (uncalibrated). The net was made of willow bast (*Miettinen et al. 2008*). Notched and grooved stone pebbles occur on the Mesolithic/Epipalaeolithic sites and were interpreted as net sinkers (*Nadel – Zaidner 2002*). However, only a few of the worked pebbles (Fig. 3.11.) from the mesolithic sites bear the remains of the organic binding (*Zhilin 2014; Zhilin – Savchenko 2019*). More net sinkers with the remains of organic binding, sometimes even attached to a net, are found at at Neolithic lakeshore sites, such as sites around the Zug lake in Switzerland (*Huber – Rehazek 2014*) or in the Baltic region (*Bērziņš 2008*).


Fig. 3.10. (left) Detail of the Antrea net (*Miettinen et al. 2008, 83*).
Fig. 3.11. (right) Net sinker with remains of bast binding from the Middle Mesolithic layer of the Beregovaya 2 site (*Zhilin – Savchenko 2019, 16*).

3.5. Importance of fish in diet of the Mesolithic/Epipalaeolithic populations

Freshwater fish are an excellent source of high quality animal protein. The protein is characterised by a balanced amino acid composition, containing substantial concentrations of essential fatty acids as well as important minerals such as potassium and phosphorus. Last but not least, it contains several vitamins (*Steffens 2006*).

As it was already mentioned above, the importance of fish and fishing increased in the Mesolithic/Epipalaeolithic. Apart from the finds of fishing equipment, fish bones and human remains provide additional sources of information.

The importance of fish in the diet of mesolithic people can be traced through the stable isotope values in bone collagen and dental calculus and zooarchaeological analysis (*Richards – Hedges 1999; Boethius – Ahlström 2018*). In Scandinavia, both freshwater and marine fish played a significant role in the diet of the mesolithic people. The overlap between the stable isotope values for marine and freshwater species is, however, low, which suggests the limited mobility of humans between coast and inland in mesolithic Scandinavia (*Boethius – Ahlström 2018*).

At Franchthi Cave, the zooarchaeological data indicate increasing dietary breadth, both within the terrestrial context and marine habitats at the end of the Mesolithic. Turtles, tortoises, shellfish, and large fish such as Sea Breams, Bluefin tuna, and Conger eel were exploited by humans (*Stiner –Munro 2010*).

At the Croatian site of Vlakno cave, the analysis of dental calculus and stable isotopes of a Mesolithic individual show that marine resources as well as plant-based food were consumed regularly (*Cristiani et al. 2018*).

Stable isotopes values in bone collagen from coastal Mesolithic sites in Scotland, Denmark, France and Portugal also show that human diet in Late Mesolithic was mainly based on marine fish, with minor contribution from shellfish or marine mammals (*Richards – Hedges 1999*).

In the Levant, the fishing strategies intensified during the Epipalaeolithic, providing a wider economic stability (*Van Neer et al. 2005; Bar-Yosef Mayer –Zohar 2010*). Abundant fish remains come from Ohalo II and Eynan, where freshwater fish species including *Cichlidae*, *Cyprinidae*, *Clariidae* were exploited. El-Wad is one of a few Epipalaeolithic sites with the remains of marine fish (*Van Neer et al. 2005*).

Other Epipalaeolithic sites that contained fish remains are Hayonim Cave and Kebara Cave (*Bar-Yosef Mayer – Zohar 2010*). At Ein Gev II, fish and waterfowl represented a part of the inhabitants' diverse diet. The analysis of the zooarchaeological evidence suggests that they were highly selective, choosing larger species and processing of the carcasses before transporting them back to the site (*Munro et al. 2021*).

At the site of Jordan River Dureijat, aquatic exploitation is supported by the abundant finds of turtles, frogs, and fish including *Cyprinidae, Cichlidae,* and likely *Salmonidae* (*Pedergnana et al. 2021*).

To conclude, fish played an important role in the lives of humans and hominids. Prehistoric fishers used various methods of catching the fish, using both active and passive fishing gear. For certain methods such as hand-picking, we don’t have any material evidence. For others, such as net fishing, only the inorganic parts usually survive (net sinker), while the organic ones perish (net and floats). Arguably, fish represented a significant source of food for hunter-gatherers as fish contain high-quality protein, fats, minerals, and vitamins.

Thanks to stable isotopes studies and good preservation of the organic materials on certain sites, we can argue that from Mesolithic/Epipalaeolithic people started to rely on fish subsistence more and used a wider range of fishing equipment.

The significance of fish in the subsistence was transmitted also into past people’s beliefs and mythology. Fish are found depicted in forms of rock engravings and paintings.

4. Evidence of net fishing in Prehistory

Due to poor preservation of organic materials on most archaeological sites worldwide, fishing methods including seine nets, gill nets, throwing nets, and traps, are difficult to distinguish and stone net sinkers are often the only indication of net fishing. In rare cases of sites with good preservation, found mostly in waterlogged localities, the remains of various nets and traps can be observed. This was the case at the site of Morrow, where a net sinker attached to a carbonised fishing net from the Early Woodland period (800-300 BC) was found (*Ritchie 1969 in Prowse 2003*). Another evidence of the organic remains connected to fishing activities come from a the Neolithic lakeshore site of Sārnate, in Latvia, where a wide variety of pine-bark and birch-bark floats, stone sinkers, many with birch-bark wrapping or bast binding, as well as remains of a net were discovered (*Bērziņš 2006*).

Unfortunately in most cases, nets and traps do not preserve and the only evidence of net fishing and trapping is weight/sinker. Sinkers or weights can be divided into line weights, which are used with the hook for line fishing and are much lighter, and fishing sinkers. The latter can be further divided into notched stone pebbles of similar weight, grooved weights, and perforated weights (*Pajdla 2014, 24*).

Notched pebbles are considered by a number of authors to serve as **net sinkers** or weights for fishing traps with the purpose to sink and/or stabilise the fishing nets (*Rau 1873; 1884; Nadel and Zaidner 2002; Prowse 2010; Rosenberg – Agnon – Kaufman 2016*). The aim of this chapter is to give examples of archaeological sites in the Levant (Appendix 3.) and around the world (Appendix 4-7., Fig. 4.1.) with the occurrence of notched pebbles which are by most authors thought to be net sinkers, or weights for fishing traps (*Rau 1873; 1884; Nadel and Zaidner 2002; Prowse 2010; Rosenberg – Agnon – Kaufman 2016*).

4.1. Europe

Certain European sites represent an exception in excellent preservation of organic remains as they were water-logged. In Europe, the best preserved organic remains come from sites especially in the Baltic region and the Alps. In the Baltic region, both worked and unworked pebble sinkers in bark wrappings have been found on several Neolithic sites Sārnate, Šventoji, Zvidze, and Gorbunovo (*Bērziņš 2008, 233*). Notched pebbles were found on a number of archaeological sites in Europe, the examples of sites presented in the thesis come from Greece, Latvia, Serbia, and Switzerland.

Sārnate (Latvia)

Sārnate, a Neolithic site, was located on the lakeshore. Thanks to being water-logged, the preservation of the organic finds, especially a collection of fishing gear made of bark and wood, was extraordinary. The discovery of 125 floats made of pine and birch bark (Fig. 4.2.). was particularly important as no such assemblage is preserved anywhere in the world. The floats were divided into three categories: (1) notches at ends, (2) longitudinal groove, (3) perforated, (3) lack any kind of notching (*Bērziņš 2006, 150*).

As for the sinkers (Fig. 4.3), 154 notched pebbles and 172 unworked pebbles were found. Fifty-eight unworked pebbles had a partially or completely preserved birch bark binding. The pebbles were wrapped in a sheet of birch bark and tied at both ends with bast (Bērziņš 2008, 232). The remains of twine used instead of simple bands of bast were found only in two cases. The imprints on the surface of the pebble provide an evidence that the sinkers were tied also in the middle, probably serving to secure the bark wrapping (*Bērziņš 2008, 232*).

The notched pebbles are elongated, flat and notched by flaking at the ends. The raw material of most notched pebbles (83%) is quartzite. Other raw materials were igneous rock (granite, etc.), gneiss and dolomite. Side-notched pebbles occur at the site as well, however, in lower quantities (n=21). Different weight categories can be seen. Small, unworked pebble sinkers weigh between 20-40 grams, which are lighter than the end-notched sinkers, which weigh between 120-200 grams. Only few side-notched pebble sinkers were found, with the highest weight between 200-1300 grams (*Bērziņš 2008*).

Based on Mesolithic find of stone sinkers attached to net at site Siivertsi in Estonia, ethnographic material from Estonia and Finland, and remains of bast binding on the pebbles, the author concludes that most sinkers from Sārnate were attached to fishing nets (*Bērziņš 2008*). The similar weight of the pebbles (20-40 grams), also support this interpretation. In the later phase of the site's occupation, heavier end-notched and side-notched sinkers start to appear, suggesting a change in fishing practises (*Bērziņš 2008, 272*). At Sārnate, a lot of seal bones were discovered. Based on historical records, the seals were caught in various stationary nets in rivers and lakes, sometimes anchored by heavy stone sinkers (*Bērziņš 2008, 272*). Bērziņš suggests that heavier, end-notched sinkers might indicate the use of stationary net, presumably gill nets, in a strong current such as sea, or river (Bērziņš 2008, 402). Thus, it is possible that the heavier end-notched sinkers might have been used as anchors for traps or ends of gill nets (*Bērziņš 2008, 232*). Based on the records from North America, the function of the anchors, which were placed on the ends of a net together with lighter net sinkers, was to prevent the net from drifting out of position. (*Babbitt 1884 in Prowse 2010*).

The finds at Sārnate site are rather extraordinary because a cluster of artefacts consisting of sinkers, floats, and remains of net were found near the hearth of one of the dwelling, suggesting that they derive from one net. Concretely, the cluster included: ten small unperforated floats, three of them with preserved birch-bark binding; one float with oval perforation, longitudinal groove, and remains of twine; six unworked pebble sinkers, two of them with preserved birch-bark wrapping (*Bērziņš 2006, 156*); and finally a twine from the mesh of the net made of plant fibres (*Bērziņš 2008, 238*).

Importantly, the finds from Sārnate show that **unworked pebbles were used as net sinkers next to notched pebbles.**

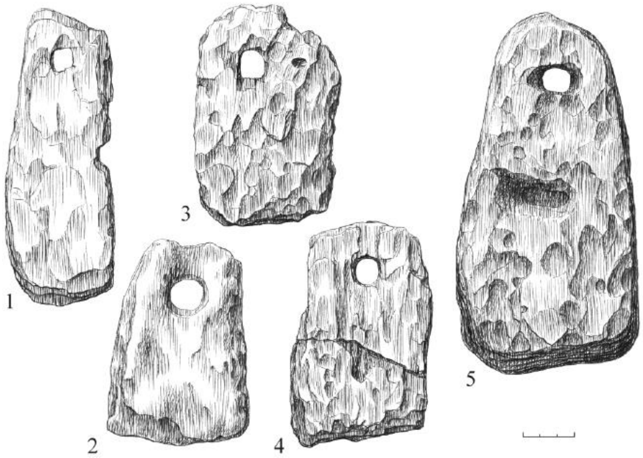


Fig. 4.2. Pine bark floats found at Sārnate site (*Bērziņš 2008, 226*).

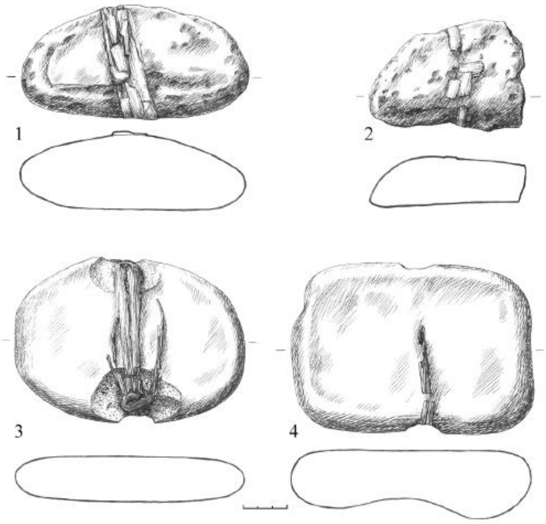
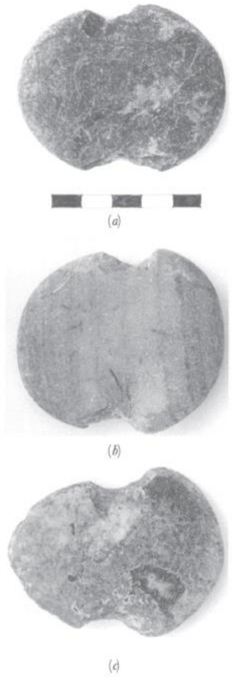


Fig. 4.3. Side-notched sinker with preserved binding at Sārnate (*Bērziņš 2008, 236*).

Servia (Greece)

Additional example comes from the Neolithic site Servia, located in inland Greece, where almost one hundred notched pebbles were discovered and claimed to have been used as fishing net sinkers in a nearby river. The authors do not use the term notched pebbles, but waisted weights. They are uniform in size (average 8x7 cm, 2 cm thick) and weight (between 85 and 115 grams) (*Ridley – Wardle – Mould 2000*). The notched pebbles from Servia (Fig. 4.4.) are published within the catalogue of finds, and thus do not contain detailed information.



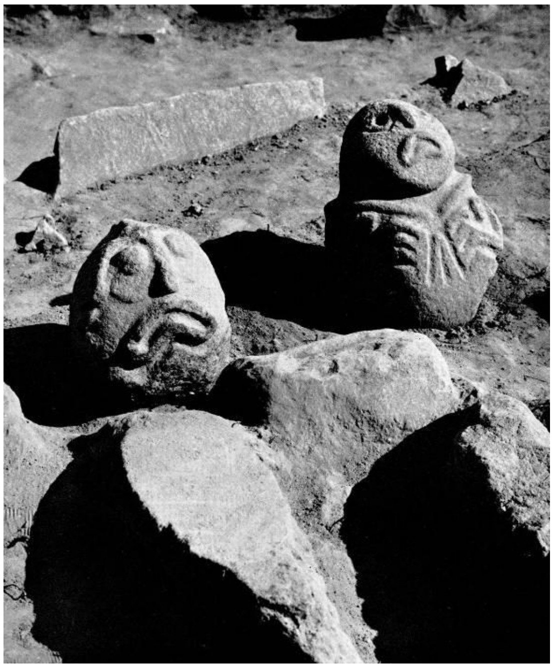


Fig. 4.4. Net sinkers from Servia (*Ridley – Wardle – Mould 2000*, 166).

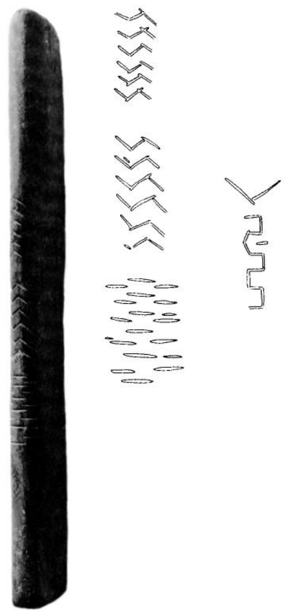
Fig. 4.5. Sculpted boulders from Lepenski Vir. (*Živaljević 2012, 197*)

Lepenski Vir (Serbia)

The Mesolithic-Neolithic settlement of Lepenski Vir is located on the banks of Danube river, at the Iron Gates, in Serbia. The site has several occupational phases and its beginning is dated to approximately 9,500 cal BC. The site was abandoned between 5870–5480 cal BC (*Borić 2019*). The Lepenski Vir site is characterised by trapezoid houses with regular hearths, often containing both complete and fragmented human remains, sculpted boulders representing human/fishlike beings (Fig. 4.5), and numerous bone and stone tools (*Živaljević 2012*).

The crucial role of fishing at Lepenski Vir and other sites on sites in the Danube Gorge is well-attested by the high proportion of fish remains (*Dinu 2010; Živaljević 2012*). These originate from freshwater fishes such as carp, catfish, perch, pike, and huchen, and from migratory fishes such as beluga sturgeon, Russian sturgeon, stellate sturgeon, and sterlet (*Živaljević 2012*). Furthermore, heavy reliance on freshwater aquatic diet of the inhabitants of the Danube Gorge was confirmed by the stable isotopes analysis (*Cook et al. 2001*).

It is clear that fishing must have represented a considerably important activity. There is, however, a lack of evidence on how exactly the fish were caught. Except a couple of bone hooks found at the site. Srejović (*1972 in Živaljević 2012*) suggested that fish were caught in shallow waters by the use of dams and traps. Another suggestion, supported by ethnographic evidence as well as use-wear traces, is that large sturgeons were pounded on the head by the elongated and massive clubs or mallets (Fig. 4.6., Antonović 2006, 23). These were made from a variety of raw materials including kinds of sandstones, limestones, granite, diorite, and schist (*Antonović 2006*).



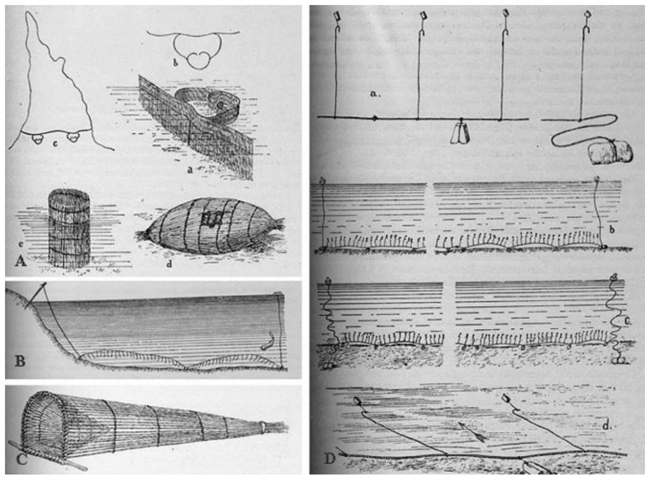


Fig. 4.6. Engraved mallet from Lepenski Vir (*Antonović 2006, 53*).

Fig. 4.7. Fishing methods used for catching sturgeon: baskets and traps (left), and fish hooks line (right) (*Dinu 2010, 306*).

Regarding the sinkers, only a couple of grooved weights were found at Lepenski Vir. These are pebbles of rather large size (the smallest is 95 x 68 x 69 mm and the largest is 213 x 140 x 83 mm). The pebbles have mostly one transversal groove in the middle following the circumference of the tool (*Antonović 2006, 24*). According to ethnographic analogies from the Danube region, these weights were used for fishing large fish, especially beluga, in the rapid waters of Danube. This device (Fig. 4.7.) was weighed down by the grooved weights, having a line in between them. On the line other lines with fish hooks and floats were attached The fish was not caught by swallowing bait but it was hooked for the stomach, sides, tail and other parts of the body (*Antonović 2006, 24*). Other fishing methods used at the site perhaps included traps and baskets made from organic materials, use of dugout canoes (*Dinu 2010, 306*).

Neolithic sites on lake Zug (Switzerland)

Cham-Eslen and Zug-Riedmatt represent two of the Neolithic lakeshore sites on the banks of Zug lake at the foothills of the Alps, in Switzerland. Thanks to being waterlogged, the preservation of the organic materials, especially on the Cham-Eslen site, is extraordinary. Among other finds from Zug sites, fish bones and fishing equipment such as harpoons, fish hooks, net sinkers, traps and weirs were discovered (*Eberli 2010*).

Regarding the evidence for net fishing along the Cham-Eslen, stone net sinkers (Fig. 4.8.a), wooden floats/buoys (Fig.4.8.b), and even a few fragmented remains of nets were found at the lake settlements (Fig. 4.9). The nets were made out of plant fibres, commonly linden bast (*Eberli 2010, 85*). The floats were perforated and made of bark of poplar trees. Over 1200 net sinkers were uncovered from the Cham-Eslen site. Only about one quarter of them are side-notched, while over 800 net sinkers are **unworked pebbles that have preserved imprints of the ropes on their surface**, and some of them have even bast bindings still attached (Fig. 4.9., *Huber – Rehazek 2014*).

As the fish traps and weirs are made from organic material, finding these items from prehistory is still very rare. Sometimes they can be found in the shallow water on the banks of lakes or rivers (*Eberli 2010, 87*). One such trap, although from the early Middle Age, was found at site Steinhausen-Sumpfstrasse West (Fig. X.), on the banks of lake Zug. The trap was made of wicker and wooden pegs forming a funnel (*Eberli 2010, 87*).

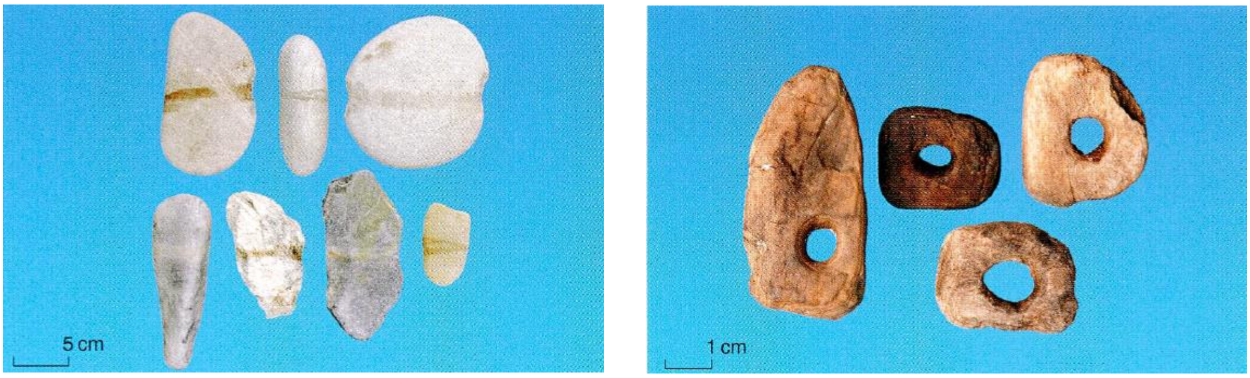


Fig. 4.8. a) Stone net sinkers from Cham-Eslen with
the imprints of rope (left), and b) perforated floats/buoys made of bark (right) (*Eberli 2010, 86*).

Fig. 4.9. Net sinkers with remains of bast binding from Cham-Eslen site and remains of a net (*Gross – Huber 2018, 263*).

Fig. 4.10. Remains of a fishing trap from the early Middle Age site Steinhausen-Sumpfstrasse West (*Eberli 2010, 87*).

4.2. Asia

4.2.1 Levant

Artefacts interpreted as net sinkers were also discovered at the sites in the Levant (Appendix 3.). These are mostly located near freshwater streams and lakes. The oldest notched pebbles come from the early Epipalaeolithic site of Ohalo II, while the latest were found at Tel Beit Yerah, an early Bronze Age site.

Ohalo II (Israel)

The site of Ohalo II is located on the shore of Sea of Galilee in the Jordan Valley and it is dated to 23 ka. Limestone and basalt double-notched implements (Fig. 4.11. and 4.12.) weighed between 150 and 400 grams (Tab. 4.1.) and were interpreted as net sinkers and/or underwater trap anchors. Total number of notched pebbles is 47, six were found *in situ* while the rest was found on the surface of the site. Another four were found on the Alluvial Fan. The notches on the artefacts were made by flaking in most cases (*Nadel – Zaidner 2002*).

Apart from the notched pebbles, a great number of fish bones were recovered from the site and studied detaily (*Zohar 2003*). Through the analysis of fish bones, eight species from two families of freshwater fish were identified: Cichlidae (St. Peter Fish) and Cyprinidae (Carp) (*Zohar 2003*).

Ohalo I (Israel)

The site is not far from Ohalo II. Three limestone and three basalt notched pebbles were recovered. Two of the basalt artefacts were the heaviest from the studied assemblage. Their weight was 1.6 kg and 1.3 kg. Moreover, one of them had a wide shallow groove around the middle (*Nadel – Zaidner 2002, 62*).

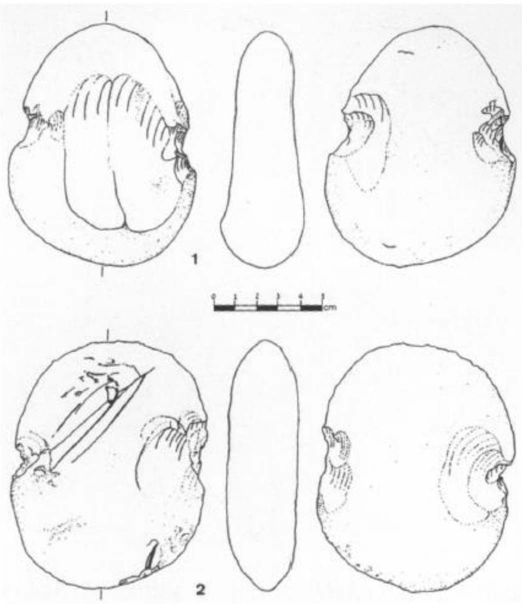
Haon Beach (Israel)

The site is located on the eastern shore of the Sea of Galilee. The chronology of the site is not easy to establish as the site is 200 m below sea level and was never systematically excavated, however, the authors suggest that the notched pebbles (Fig. 4.13. and 4.14.) found here could be dated to the Early Bronze Age. Fifty-five notched pebbles were found mostly on the surface. Hard limestone was preferred material (n. 34), followed by chert (n.16) and lastly by flint (5). Their weight ranges between 25 and 180 gr. Most notches were prepared by pecking (*Nadel – Zaidner 2002, 58*). According to the authors, the notched pebbles at all three sites served as net or trap weights (Fig. 4.15., *Nadel – Zaidner 2002, 64*).

Fig. 4.1. Map of archaeological sites with the occurrence of notched pebbles mentioned in the text and in the list of sites in Appendix 3-7 (source:Google maps).

SITE		L	W	TH	WEIGHT	N
OHALO II	AVG	96	77	34	290	6
(in situ)	STD	16	13	8	136	
OHALO II	AVG	111	85	37	353	41
(Surface)	STD	16	16	10	162	
OHALO II	AVG	114	78	39	387	4
(Alluvial Fan)	STD	19	8	6	243	
OHALO I	AVG	133	100	45	759	6
	STD	31	16	14	565	
HAON BEACH	AVG	94	68	33	277	55
	STD	21	13	10	151	

Tab. 4.1. Average dimensions (mm) and weights (gr) of double-notched pebbles from the submerged sites in the Sea of Galilee (*Nadel – Zaidner 2002, 57, Tab. 1.*)



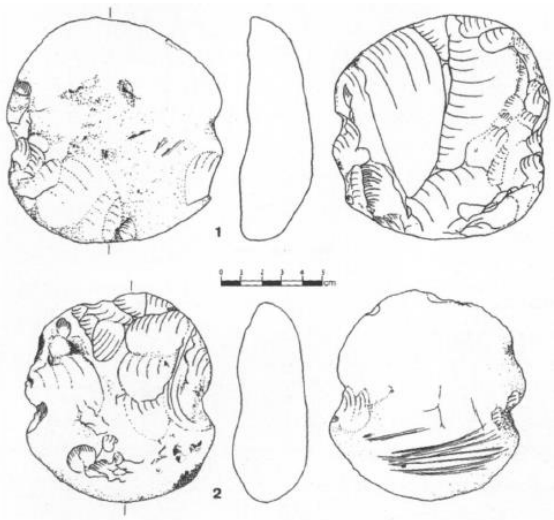
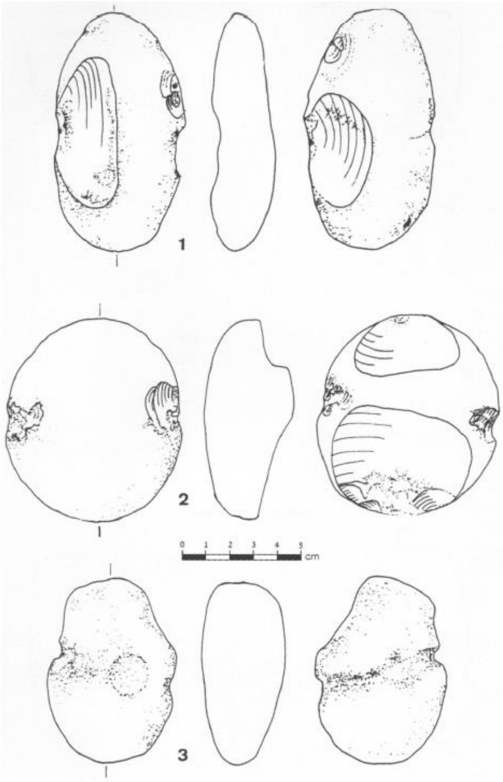


Fig. 4.11. (left) and **Fig. 4.12.** (right) notched pebbles from the site of Ohalo II (*Nadel – Zaidner 2002, 53*).



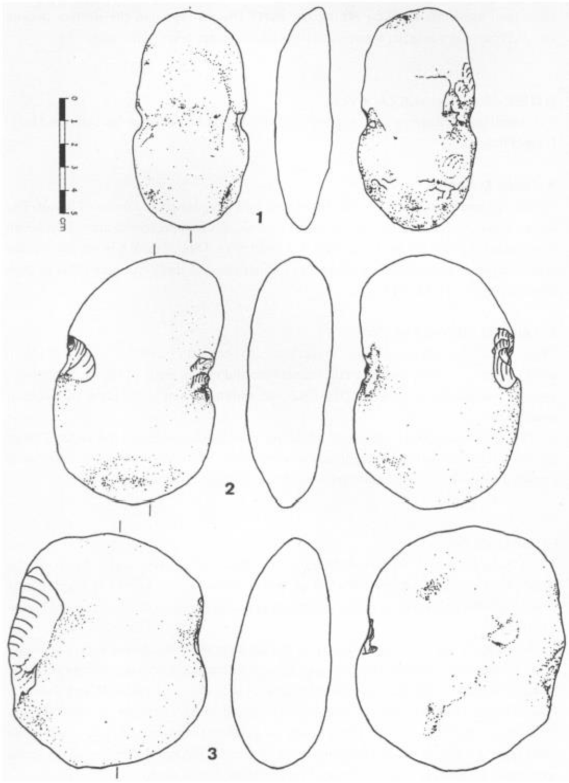


Fig. 4.13. and **Fig. 4.14.** notched pebbles from the site of Haon Beach (*Nadel – Zaidner 2002, 59 and 61*).

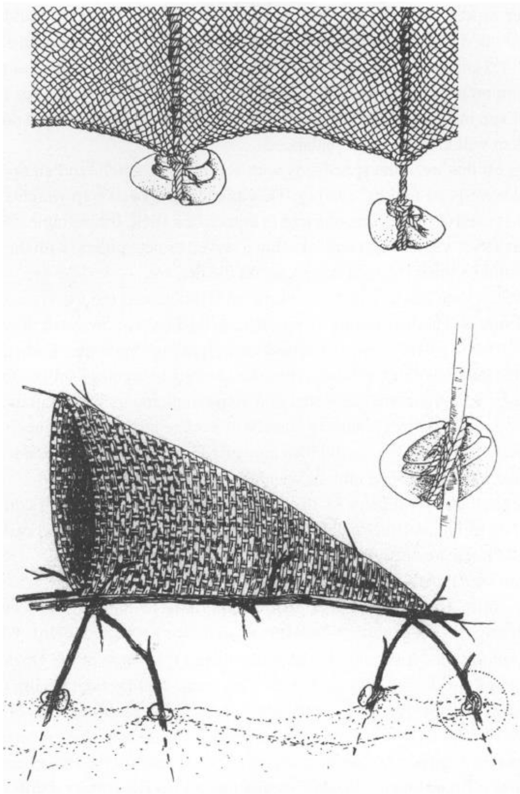


Fig. 4.15. Nadel and Zaidner's reconstructions of possible attachment of notched pebbles from the sites on the shores of the Sea of Galilee (*Nadel – Zaidner 2002*, *65*).

Abu Hureyra (Syria)

According to the authors, the notched pebbles (Fig. 4.16.) were of different sizes and weights but consistent in form. However, no precise parameters are stated. They also claim that many of the pebbles were pointed at one end. The notches are flaked and then smoothed in order to remove the sharp edges. The authors suggest that the notched pebbles served as line or net fishing weights in the Euphrates (*Moore – Hillman – Legge 2000, 174-176*).

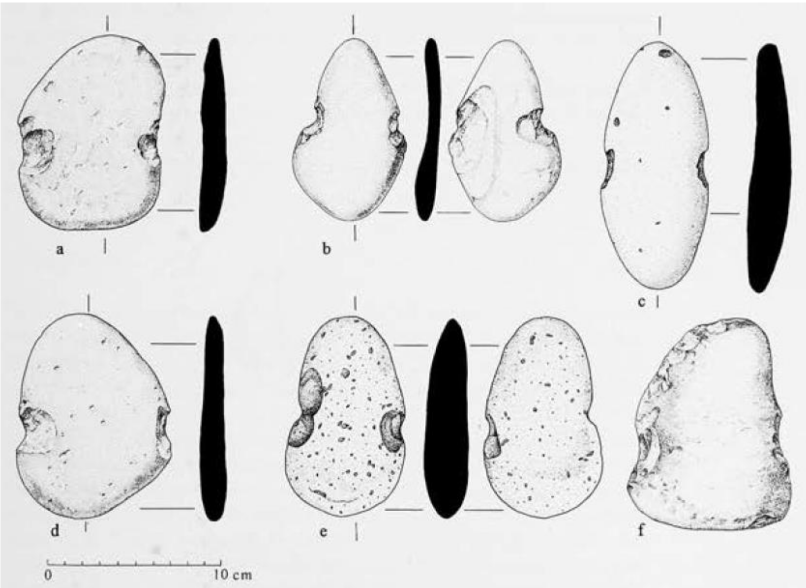
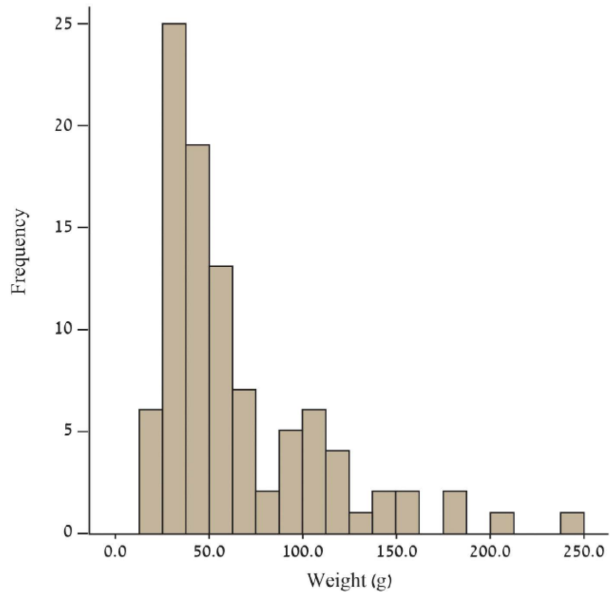


Fig. 4.16. Notched pebbles from the site of Abu Hureyra (*Moore – Hillman – Legge 2000, 175*).

Beisamoun (Israel)

Beisamoun is a site situated at the feet of the Naphtali Mountains in the Hula Valley, northern Israel, and dated mainly to Pre-Pottery Neolithic B, Wadi Rabah culture as well as Early Bronze Age. Some artefacts come from the excavations; however, many were collected from the surface in the 1960s (*Rosenberg – Agnon – Kaufman 2016*, 459). According to Rosenberg, the assemblage of notched pebbles (n. 96) from the Beisamoun site is the largest one in the southern Levant (*Rosenberg – Agnon – Kaufman 2016*, 459).

The raw material is predominantly limestone or dolomite (95% of the assemblage), followed by basalt in a few cases and unidentified raw materials. The blanks selected for producing notched pebbles were small, flat pebbles. They had lenticular or irregular cross-section.The weight ranges from 20 grams to 240 grams, with an average of 64 grams.



Graph 4.1. Histogram of weight of the notched pebbles from the Beisamoun site (*Rosenberg – Agnon – Kaufman 2016, 462).*

The length of the pebbles range between 37.0 and 100.0 mm with an average of 60.2 mm. The width ranges between 20.0 and 90.0 mm with the average of 40.0 mm. The maximal thickness ranges between 9-18 mm (average 15.0 mm) and the minimal thickness is within 4-11 mm range (*Rosenberg – Agnon – Kaufman 2016).*

As for the shape of notched pebbles, they divide them into four categories: oval (n. 1 and 2 in Fig. 4.17.), rectangular (n. 3 and 4 in Fig. 4.17.), trapezoid n. 5 and 6 in Fig. 4.17.) and rounded (n. 7 and 8 in Fig. 4.17.).

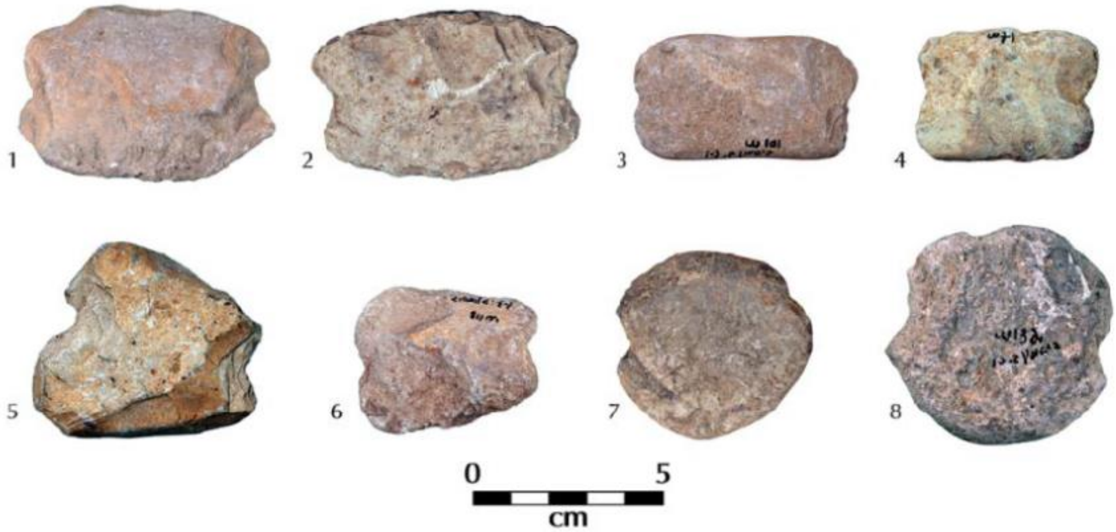


Fig. 4.17. Notched pebbles from Beisamoun: oval (1 and 2), rectangular (3 and 4), trapezoid (5 and 6), and rounded (7 and 8) (*Rosenberg – Agnon – Kaufman 2016, 462*).

As for the manufacture, the authors identified two modes (1) the notches were made by unifacial flaking, sometimes accompanied with pecking, or (2) they were made by bifacial flaking (*Rosenberg – Agnon – Kaufman 2016, 468*).

The authors believe that the notched pebbles from Beisamoun served primarily as "*sinkers for throwing nets like the Mediterranean shabake rather than for fixed nets or traps due to their light weight."* (*Rosenberg – Agnon – Kaufman 2016, 460*).

Eynan/Ain Mallaha (Israel)

During the Natufian period, the site of Eynan (Ain Mallaha) was one of the main settlements in the Levant. It is located in the Upper Galilee where prehistoric people could use the resources from both river and lake Hula (*Valla et al. 2017*, *295*), about 12 km from the site of JRD. The settlement consisted of several semi-buried buildings. Walls were built in circular or semi-circular shape and made of limestone blocks. One of the Early Natufian houses was coated with red-painted lime plaster (*Valla et al. 2017*, *295*). There is no doubt that the prehistoric people exploited the freshwater resources. Apart from the bone fish hook (Valla *et al.* 1998, 152, Fig. 10.) and fish bones, five notched pebbles made of limestone were found (Fig. 4.18.). They were interpreted as the fishing weights by the authors (*Valla et al. 1998, 156*).

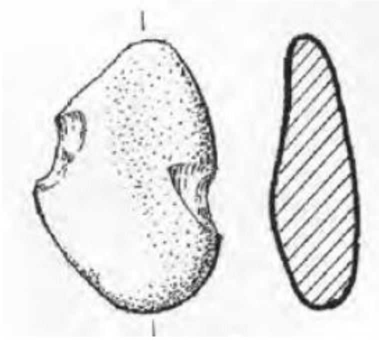


Fig. 4.18. Notched pebble found at Eynan (Valla *et al*. 1998, 157).

'Ein Dishna (Israel)

The site is located in the eastern Galilee, caa 2 km west of the Sea of Galilee, on a high terrace above the wadi of Nahal Tzalmon. The main occupation of the site is dated to Pre-Pottery Neolithic A (PPNA). The fact that fishing weights dominated in groundstone tool assemblage attest the importance of fishing at the site (*Birkenfeld – Brailovsky-Rokser – Vered 2019*). The total number of notched pebbles is 151, from which 143 were found on the surface and only 8 artefacts came from the excavation. Most of the weights bear two opposed notches, although seven weights had three notches and five unmodified items might have been used as fishing weights as well.

Most of the notched pebbles are made of limestone (n. 128), 22 are made of basalt and one made of flint was recorded. The authors argue that the size range of the weights was rather limited which would suggest that the pebbles were selected based on their size and weight, and that their shape and raw material was not of such importance. As for the manufacturing methods, about half of the notches were flaked on the lateral sides, often bifacially. Pecking was also applied, but rather on thicker basalt pebbles. Sometimes the notches were manufactured by a combination of both methods, flaking and pecking (*Birkenfeld – Brailovsky-Rokser – Vered 2019, 149*).

4.2.2. Arabian Peninsula

In comparison to the freshwater sites, two sites (KHB-1 and SWY-1) that are located close to saltwater (Persian Gulf and Arabian sea) and have evidence of marine fishing, are mentioned.

KHB-1 (Oman)

The site of KHB-1 (Ra’s al-Khabbah) is located on the coast of the Persian Gulf. This Middle Holocene site was interpreted as a fishing settlement on the basis of fishing implements such as fish hooks and lures made of shell, bone needles for the knitting the nets, and 400 notched pebbles which were interpreted as net sinkers (*Cavulli – Scaruffi 2011*). Regarding the materials used for the manufacture of the notched pebbles, limestone was the most common, followed by granite and quartzite.

The authors divided the net sinkers into four classes. First class artefacts (Fig. 4.19.) have two notches along the long axis, their faces are convex, their thickness irregular, and they are usually made of limestone. The weight of the majority of these artefacts ranges between 20 and 100 grams. The Second class artefacts have flat faces, sub-quadrangular sections with V-shaped edges, and they are longer than 4 cm and their width exceeds 3 cm. The artefacts in this class are made from limestone or quartzite. The Third class artefacts (Fig. 4.20.) are similar in morphology to the Second class, however, their length is less than 4 cm and their width doesn’t exceed 3 cm. The raw material used for the net sinkers in this category is more often quartzite than limestone.Their weight is usually below 20 grams. As for the Fourth class, the artefacts are globular and have an incision across the entire surface around their long axis. They are relatively small, between 1-3 cm and are made from either limestone, or quartzite (*Cavulli – Scaruffi 2011*). These might have been used as line weights. According to the authors, it is possible that larger sinkers were used for cast nets as well as other net fishing techniques and also for traps (*Cavulli – Scaruffi 2011, 33*).

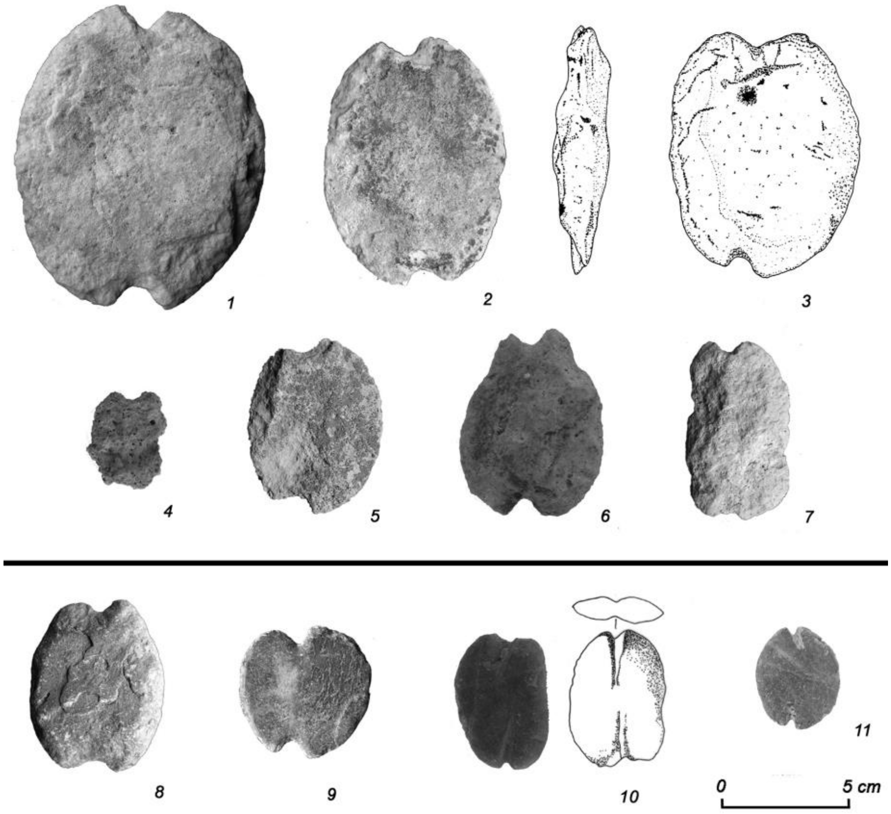


Fig. 4.19. Net sinkers from the site of KBH-1: divided into: First class (1-7) and Second class (8-11) (*Cavulli – Scaruffi 2011, 28*).

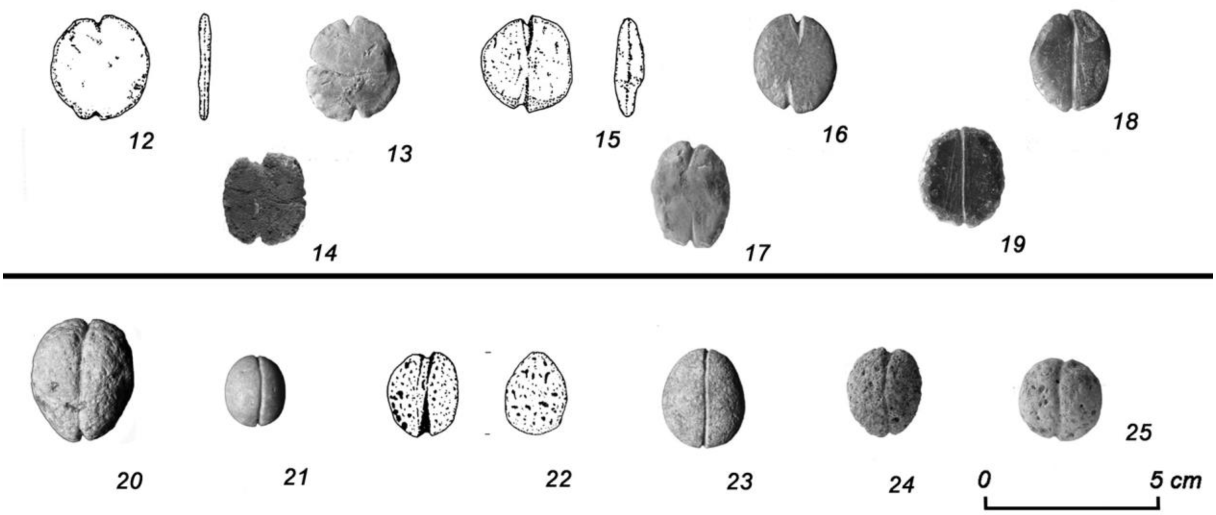


Fig. 4.20. Net sinkers from the site of KBH-1: divided into: Third class (12-18), and Forth class (20-25) (*Cavulli – Scaruffi 2011, 29*).

Suwayh 1 (Oman)

Suwayh 1 (SWY-1) is a Neolithic shell-midden situated between a coastal lagoon and the coast of the Arabian sea. The activities of Neolithic people focused on gathering seashells and fishing. Over 2,000 fish bones were studied and many of the fish bones belonged to the requiem sharks, cownose rays, sea breams and sea catfish *Marrast –Béarez – Charpentier 2019*). As for the fishing equipment, fish hooks (n. 6) made of mother-of-pearl, three line weights found in the context of the hooks, as well as 69 notched pebbles were identified. The excavators interpreted the notched pebbles as net sinkers (*Marrast – Béarez – Charpentier 2019, 12*). They divided the sinkers into two categories (Fig. 4.21.):

"the transversal type "T", made from the notched pebbles, and the longitudinal type "L" made from soft and flat materials, such as calcite or limestone plates, with retouched contours and notched or incised" (*Marrast – Béarez – Charpentier 2019, 12*).

Interestingly, the "T" type was mostly found in the layers of the Middle Neolithic, while the "L" type was more common in the Late Neolithic. According to the authors, this change could be explained by an evolution in fishing practises (such as the use of new fishing nets, use of a new material for net manufacture, or use of a new knitting technique) during the transition from the Middle Neolithic to the Late Neolithic (*Marrast –Béarez – Charpentier 2019*).

Fig. 4.21. Division of net sinkers from the site of SWY-1: Type "L" and Type "T" (*Marrast – Béarez – Charpentier 2019, 13*).

4.2.3. India

Regarding Harappan (3,300-1,300 BC) sites in India, eighty-two net sinkers were recovered from sites Padri, Kuntasi, and Lothal. The net sinkers from the archaeological sites were predominantly perforated discs made of miliolite. Terracotta cylindrical beads are also believed to have been used as net sinkers (*Ruikar 2013, 237*).

4.2.4. Korea

The oldest net sinkers are believed to have been found in South Korea, being dated to 29,000 years BP (*DeCou 2018*). The 14 net sinkers were allegedly found in the Maedun Cave by the team of Han Chang-gyun, the director of the Yonsei museum. There were several articles published in popular online magazines (Hakai Magazine, Hurriyet Daily News, Phys. Org, Archaeology). The net sinkers (Fig. 4.22.) are made of limestone, weighing from 14 to 52 grams and measuring 37 to 56 mm in width (*DeCou 2018*). The author is, however, unaware of any scientific article presenting the data on net sinkers from Korea.

Fig. 4.22. Net sinkers from South Korea (*DeCou 2018*).

4.2.5. Vietnam

Over one hundred net sinkers were identified at four sites in Vietnam (Appendix 5), in the context of Neolithic Đa Bút culture (7,000-4,500 BP). Most of the items were made of stone, mainly schist, while others were made of terracotta. They are approximately 4-5 cm long and 3-4 cm wide (Fig. 4.23.). They are grooved, either with one groove, two grooves (crucifix form), or 3 grooves (one longitudinal and two transverse). Apart from the grooved ones, two perforated weights were also found The authors believe that these items perhaps were tied into a net with a rope (*Hiep – Huffer 2015*).

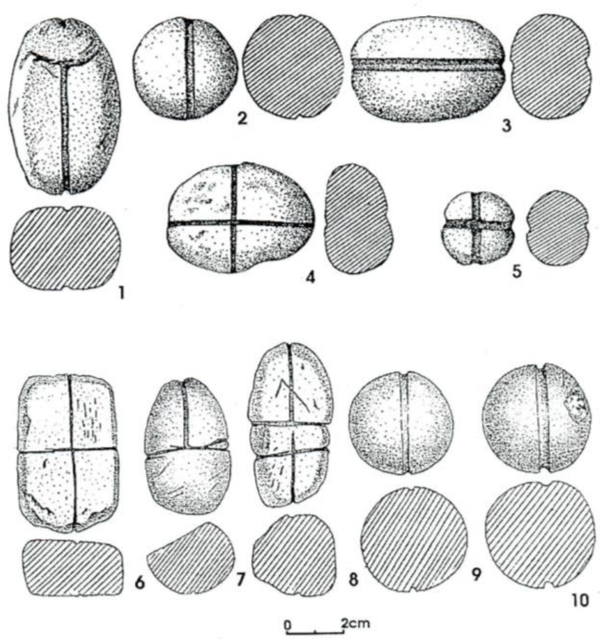


Fig. 4.23. Grooved stone (1-8) and terracotta (9-10) net sinkers from a Neolithic Đa Bút culture (*Hiep – Huffer 2015, 41*).

4.3. America

In North America, the net sinkers are relatively common finds, starting from the Archaic period (8,000 BC-1,000 BC), with sites such as Lamoka Lake in New York State, where over eight thousand net sinkers were found (*Ritchie 1944 in Prowse 2010*). Other sites with the abundance of net sinkers were found in the Columbia Plateau (Casserino 2017; Hannold 2019) or around the Ontario lake (*Prowse 2010*).

Several thousands of notched pebbles have been found on sites around the Ontario lake (Prowse 2010). The sites with the occurrence of notched pebbles are dated from the Middle Archaic up to Late Woodland (3,000 BC - 1650 AD). Notched pebbles from these sites are mainly side-notched (Fig. 4.24.). Preferable raw material was either siltstone, or calcareous rock. The manufacturing techniques consisted of flaking and/or pecking (*Prowse 2010*). The average dimensions of notched pebbles from each site can be seen in Appendix 4-7.

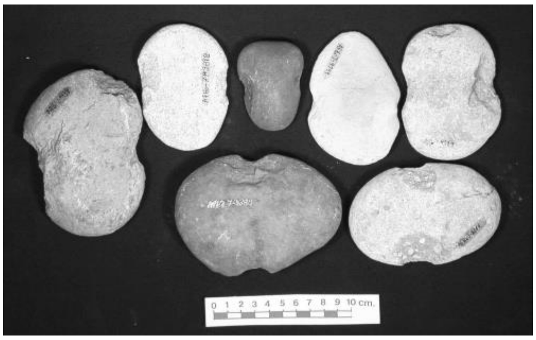


Fig. 4.24. Side-notched net sinkers from the Blue Water Bridge South Site (*Prowse 2003, 51*).

The low representation of fish remains on certain sites can be the result of poor faunal preservation, inadequate excavation techniques, or the use of fish processing activities that eliminate or severely degrade the bones, or the fact that fish processing took place off-site (*Prowse 2010*). Contrarily, for the Blue Water Bridge South Site, where over 200,000 fish remains were found, she proposes on-site fish processing (*Prowse 2010, 76)*.

Based on Cleland (*1982, 767-774*) Prowse argues that on sites of Recliner and H.H., which are close to deep water lake, catching large numbers of fish in deeper water would necessitate the use of a gill net. She proposes that:

"The inhabitants at the Recliner site practised a fishery where gill type nets would be transported onto the lake, perhaps with water craft such as canoes, dropped at the fishing spot, left to sit for a specified period of time, and retrieved along with the gilled fish." (*Prowse 2010, 74*).

On the contrary, at sites located close to small river streams with shallow depth, such as the Scott O'Brien Site and The Blue Water Bridge South Site, seine fishing is more likely (*Prowse 2010*). She suggests that:

"th*e site's inhabitants would have used seine type nets stretched* out *across the river trapping spawning fish and/or corralling them to shore where they could be easily retrieved."* (*Prowse 2010, 76*).

4.4. Africa

There is not a lot of published data on notched pebbles from Africa. The only article that the author is aware of is the one by Sandelowsky (*1971*). He reports 35 notched pebbles, which were collected on the bank of a small river near Mariental, in today's Namibia. Most of the pebbles had only one notch (Fig. 4.25.). He suggests the possibility that these notched pebbles might have been used for fishing, although he finds it unlikely that fishing could take place in such arid conditions (*Sandelowsky 1971, 154*).

Fig. 4.25. Notched pebbles from today's Namibia (*Sandelowsky 1971, 155*).

4.5. Oceania

Just as the case with Africa, there is not a lot of published data on notched pebbles from Oceania. Leang Buida is one of the exceptions. The site is situated on the shore of the

Talaud Islands of North Sulawesi. Except for a great amount of fish bones, five clay net sinkers (Fig. 4.26.) and a lure shank were discovered. The net sinkers have rounded or disc-shape, with two punched holes for attaching the net. Based on the archaeological context, they were used from 1,000 AD - 1,600 AD (*Ono et al. 2018*). Ronquillo (*1987*) also mentions the find of clay net sinkers, recovered from the shell midden layers, at the Butuan sites in the Philippines. No further details are, however, stated.

In Polynesia, stone line weight and net sinkers were in use. The prefered raw material was basalt, followed by sandstone and even hematite. Various types of sinkers occured in Polynesia: longitudinally grooved, with transverse groove, perforated, and plumet sinkers (*Lavondès 1971*).

The lack of stone net sinkers, especially in Australia, can perhaps be explained by the use of other materials, such as clay net sinkers (*Ono et al. 2018; Ronquillo 1987*), or shells used as weights for dip nets (*Kirch – Dye 1979*).

Fig. 4.26. Clay net sinkers from site Leang Buida (*Ono et al. 2018, 250*).

To conclude, notched pebbles were discovered at archaeological sites around the world. The common features for all the sites recorded above is the fact that they are located close to the water bodies, primarily rivers and lakes, but also seas and oceans. The preferable raw materials are limestone and other calcareous rocks, sometimes also basalt, schist, and siltstone.

Number of sinkers at sites range from decades to hundreds, with the exception of certain sites around the Great Lakes, where the archaeologists counted over thousands of notched pebbles. The pebbles can be side-notched, end-notched, atypical, or even grooved. The notches are manufactured by unifacial or bifacial flaking, or by pecking.

The dimensions of the Levantine notched pebbles mentioned above range between 38-250 mm in length, 40-100 mm in width, 15-45 mm in thickness, and 60 grams to 3 kilograms in weight (Appendix 3). The dimensions of the notched pebbles from around the world, mentioned in the Appendix 4 -7., range between 18-140 mm in length, 30-110 mm in width, 8-20 mm in thickness, and 10 grams to 12 kilograms in weight, with the average at most sites ranging between 60-200 grams.

Waterlogged sites, especially Sārnate and Cham-Eslen, provided important evidence regarding the organic remains of binding on pebbles, remains of a net, and floats made of bark. Importantly, the organic bindings were found not only on the notched pebbles, but also on the unworked ones. As most notched pebbles worldwide were interpreted as net sinkers, and the binding was found on the unworked pebbles as well, it is a strong indication that the unworked pebbles were used as net sinkers alongside the notched ones.

5. Fishing activities in ethnography and ethnohistory

Due to the lack of ethnographic records of fishing from the Levantine area, the ethnographic parallels regarding the fishing methods are mainly borrowed from the indigenous inhabitants from North America, especially from the region of Great Lakes. Although these parallels can't be taken as the only possible explanations, they provide examples of notched and unworked pebbles in activities connected to fishing.

The earliest accounts of notched stone use around the Great Lakes was recorded in 1615. Other records by early travellers and Jesuit missionaries are dated to the 17th, 18th, and 19th centuries. Further, ethnohistorical reports note how the notched pebbles have been used by recent Great Lakes region Indian groups in 19th and early 20th centuries (*Weston 1978*).

Fishing activities in these early records include both seine and gill net fishing, angling, net manufacture, and choice and modification of pebbles used as net sinkers. Other information regards a place and time of the day, gender of fishers and net makers, and fish species caught (*Weston 1978*). Certain sources also describes the competence of the native fishers:

"In the Trade of Fishing they are very expert, being experienced in the knowledge of all Baits for several Fishes, and divers Seasons ; being not ignorant likewise of the removal of Fishes, knowing when to Fish in Rivers, and when at Rocks, when in Bays, and when at Seas." (*Ogilby 1671 in Rau 1884, 278*).

The information about sinkers vary in details. Stones attached to the bottom of the net are mentioned in eleven out of twelve records. Two authors specify the use of unworked pebbles tied with bast or bands of bark of linden and willow. One record mentions use of two anchors, each at one end at the bottom of a seine net (*Weston 1978*). One of the authors, describing the fishing practises of The Mistassini Indians of South-Central Quebec, focused on net sinkers in a more detail way:

"*Netsinkers were beach pebbles obtained locally and were approximately the size of a fist. Whenever possible, the pebbles chosen were slightly constricted about the middle. If*

these could not be obtained, notches were sometimes made in the edges. A string was attached by a slip knot about the middle of the stone, and the other end of the string was tied to the bottom selvage line.
Formerly, narrow strings of willow bark were employed in place of string for attaching the sinkers to the net. Whenever the nets were removed from the water to be dried, the sinkers and bark 'string' were left under water to prevent the latter from drying and breaking.
Net floats and sinkers were tied opposite one another along the net and placed two and one-half or three armspans apart." (*Rogers 1967 in Weston 1978, 20*)

Charles Rau, who in the second half of the 19th century also collected data about the fishing in the North America, writes:

"It scarcely need be specially affirmed that the natives of North America, like the primitive fishermen in all parts of the world, weighted their nets by means of stones. In our time the Indian and Innuit tribes of the Northwest Coast and of other northern regions of America use pebbles, either unaltered, if of suitable form, or notched or grooved, as sinkers for their different kinds of nets, and the same is done by whites in many districts of this country. Those, for instance, who pursue the trade of fishing along the Susquehanna and its North Branch, use stone sinkers for their set-lines and nets, the stones employed by them being usually not notched or grooved, but having naturally two opposite sides curved inwardly, around which a string can be firmly tied. They carefully select the stones which present this form." (*Rau 1884, 156*).

For the net manufacture nettle-stalk twine, linden (esp. *Tilia americana)*, false nettle (Boehmeria cylindrica), and willow root bark were commonly used by the local inhabitants around the Great Lakes (Weston 1978). The first step of net manufacture was to prepare cords. Hilder described this process:

"*The bark, torn into fine strands, was boiled for about one-half hour, and while still soft rolled over the bare side of the right leg with the palm of the right hand. If fibers become dry, they are drawn through the mouth to be moistened with saliva. No knots were made* *in joining strands but the ends of two strands were worked between molars and deftly rolled into each other with fingers*." (*Hilger 1951 in Weston 1978, 17*).

After the net was knotted from the cords, stone sinkers were attached:

"*She held the end of a basswood fiber between her teeth and a stone in her left hand while with her right hand she wound the fiber twice tightly around the stone. She then tied a knot leaving the mouth end long enough so that the stone by means of it could be tied to the edge of the net.*" (*Hilger 1951 in Weston 1978, 17*).

Some of the ethnographic records mention sizes of nets (Tab. 5.1.). There are two ethnographic references noting how far apart notched stone sinkers were placed along the bottom of a net used by Mistassini and Chippewa fishers. The distance of sinkers on Mistassini's nets was between ca. 1. 8 and 2. 7 m. The recorded distance of net sinkers on Chipewyan nets was ca. 1. 8 m (*Weston 1978, 74*).

Regarding the floats/buoys, they were made of cedar or other light wood, and placed on the upper part of the net opposite to sinkers (*Weston 1978*).

Length of a net	**Length in metres**	**Width of a net**	**Width in metres**	**Type of a net**	**Reference**
5 feet	1.52	3 feet	0.91	Seine net	*Champlain 1615, 166-168 in Weston 1978, 13*
(Up to) 200 fathoms	364	2 feet	0.61	-	*Joutel 1687, 503 in Weston 1978, 13-14*
20 feet	6.096	6 feet	1.82	Seine net	*Grant 1804, 345-346 in Weston 1978, 15*
25-50 feet	7.62-15.24	-	-	Gill nets used in rivers	*Skinner 1912, 137 in Weston 1978, 15*
More than 100 feet	30.48	-	-	Gill nets used in lakes	*Skinner 1912, 137 in Weston 1978, 15*
1 yard	0.91	4-5 inches	0.10 - 0.12	Gill net	*Skinner 1912, 137 in Weston 1978, 15*
30-40 feet	9.14 - 12.19	3-4 feet	0.91 - 1.22	-	*VanStone 1965, 13-14 in Weston 1978, 19*
3-40 fathoms	5.46 - 72.8	13-36 meshes[1]	0.66 - 2.74	-	*Mackenzie 1801, 37-39 in Rau 1884, 276*

Tab. 5.1. Size of nets recorded in certain ethnographic sources in North America.

[1] The size of a mesh varies according to the desired size of a fish: Chippewa used 2 x 2 inches, and also 2 x 2 ⅝ inches mesh sizes for pike, perch, and suckers, 3 x 2 ½ inches for two lippers, and 2 ¾ x 3 ⅛ inches for whitefish (Hilder 1951 in Weston 1978).

Various species of fish were caught, including pike, perch, sucker, whitefish, trout, and sturgeon. The important factor was the size of the net mesh, which was prepared according to the desired fish size and species (*Weston 1978*).

Two records mention that fishing was both summer as well as winter activity at the Huron lake, while for the Snowdrift Chipewyan at the Lake Athabasca and Great Slave Lake fishing was a major automn activity. Regarding the time of a day, authors remark that nets are set at sunset and collected in the morning (*Weston 1978*).

Only four records specify both the type of the net: seine/gill, and place of fishing (4,5,6,10). Gill nets are said to be used along the shores of rivers and lakes, while seine nets can be used both in the shallow and deep waters (*Weston 1978*).

As for the gender of fishers, women are mentioned as fishers and net makers, while men are mentioned as fishers, but not as net makers. Densmore writes that:

"Fishing, except in the coldest winter, was the work of women, who placed the nets in the water at night and took them up in the early morning, spreading and drying them." (*1929, 154 in Weston 1978, 16*).

In other regions, however, both men and women are mentioned as fishers, and it is probable that during the spring and fall spawning, when the fish are abundant, fishing was a communal activity (*Weston 1978*).

To sum up, ethnographic and ethnohistoric sources from North America can provide interesting information about native fishing, especially about the organic components of the fishing tools, such as seine and gill nets. The preferable materials used for net manufacture in the region of the Great Lakes were nettle, linden, false nettle, and willow root bark. The sizes of nets as well as size of mesh vary. The smallest recorded net was less than 1 metre long and ten centimetres wide, while the longest was over 360 metres and the widest was about 2.7 metres. The size of the mesh was also variable and depended on the desired size of fish. The use of both notched and unworked pebbles is evidenced in the ethnographic and ethnohistoric records seine as well as gill nets.

Furthermore, ethnographic sources inform us about the processes connected to fishing, which are often difficult to reconstruct only on the basis of archaeological remains. These processes include for example (1) manufacturing of the cords for nets, (2) binding the stone sinkers with linden fibres using teeth as well as hands, (3) setting up the gill nets in the evening and collecting fish the following morning. Other processes not mentioned above include drying of the nets, fishing with canoes, processing the fish, etc.

These records also tell us about the gender of fishers. Women are in several records mentioned as net makers, and both males and females are mentioned as fishers. Ethnographic sources also serve as a reminder that fishers in the past were very capable in fishing, they knew well their environment, seasonality, as well as behaviour of each fish species.

6. Current state of research on notched pebbles

The notched pebbles fall within the broader category of ground stone tools, sometimes also called macrolithic tools. The research on ground stone tools always fell behind the chipped industry, architecture, and ceramics, as these topics were more attractive for the archaeologists, and little attention was devoted to the “other” stone industry. However, thanks to a tremendous amount of work done by some scholars, who devoted many years to research and promotion of this topic (*Wright 1991; 1992; 1993; 1994; Adams 2002; Rowan – Ebeling eds. 2008*), the situation is improving.

In the Levant, enormous work was done by Wright (*1992, 141-142*), who studied the ground stone tools and divided them into several categories: grinding slabs/querns, mortarts, handstones, pestles, pounders, polishing pebbles, worked pebbles and cobbles, ground axes and celts, grooved stones, perforated stones/discs, stone vessels, multiple tools, debitage, and unidentifiable ground stone fragments (*Wright 1992, 141-142*).

The research on ground stone tools, together with use-wear and residue analysis, supported by experimental and ethnographic studies, has significantly increased knowledge of past peoples' subsistence, bringing information on what plants and nuts they collected and how they processed it (*Arranz-Otaegui ez al. 2018, Liu et al. 2018, Piperno et al. 2004*) as well as life history of tools, recycling, and choices regarding raw materials (*Dubreuil – Savage 2013*).

Being part of ground stone tools, notched pebbles were not studied immensely in the past. The research on notched pebbles was divided into two phases. In the first phase, notched pebbles are only briefly mentioned in the reports and articles, sometimes with a simple drawing, without any further information about the dimensions or context. In the second phase, more systematic studies were performed, stating dimensions, raw materials as well as manufacturing methods of notched pebbles.

6.1. First phase

Early mentions of notched pebbles in the archaeological context come from North America at the end of the 19th century (*Abbott 1884; Rau 1873; 1884*). Their function was uncertain and some researchers suggested that these artefacts were mauls, bone-breakers, or club-heads (Abbott 1884), or chopping tools (*Babbitt 1884*).

Their function as net weights was also suggested:

"If the flat, discoidal pebbles with side-notches are net-weights, and of this there can scarcely be a doubt, then the smallest of the groove pebbles, which we usually found associated with them, were doubtless put to the same use." (*Abbott 1884, 701*).

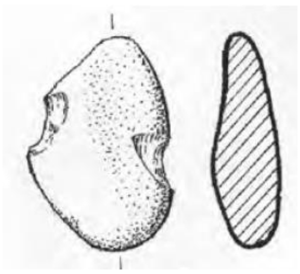
Charles Rau (*1873; 1884*) was among the first individuals who noticed net sinkers in the archaeological record on the east coast of North America. Rau described them as follows:

"The netsinkers in question are flat pebbles of roundish or angular (generally indefinite) shape and of various sizes, which exhibit on two opposite points of the circumference an indentation or notch, more or less deep, and produced by blows. Besides the notches, which facilitated the attachment to the nets, these pebbles have not undergone the slightest chance by human agency; and. their manufacture, therefore, required but little labor and skill." (*Rau 1873, 140*).

The function of the notched pebbles as net sinkers is supported by the discovery of a net sinker attached to a carbonised fishing net from the Early Woodland (800-300 BC) site of Morrow (*Ritchie 1969 in Prowse 2003*). Ritchie (*1969, 188 in Prowse 2003*) reports it as follows:

"A thick, ovate-shaped, natural pebbles with notched or grooved ends came from the Morrow site, and in one burial a group of such objects, obviously sinkers, was actually still attached by a double cord to a carbonized fish net. Tragically, this unique specimen, rolled into a compact mass along one side of the grave, and reduced to a carbonized state by the crematory fire was dug out by a collector and only small fragments were salvaged. The material was apparently Indian-hemp fiber, twisted into a cord of small diameter, which was woven into a net with about two-inch mesh."

In the Levant, earliest mentions of the notched pebbles in the archaeological context come from Eynan/Ain Mallaha (*Perrot 1966 in Moore – Hillman – Legge 2000*) and Abu Hureyra *Moore – Hillman – Legge 2000, 176*). In these publications, authors mention that the notched pebbles were of different sizes and weights but consistent in form. However, no precise parameters are stated. The authors suggest that the notched pebbles served as line or net fishing weights in the Euphrates (*Moore – Hillman – Legge 2000, 174-176*), but without any further information. During this phase, notched pebbles were only mentioned in the text with a short description and sometimes a drawing (see Fig. 6.1. and 6.2.).



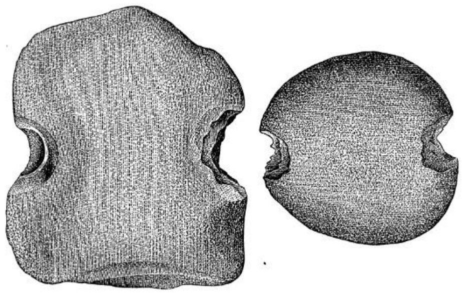


Fig. 6.1. Notched pebble found at Eynan (*Valla et al. 1998, 157*).

Fig. 6.2. Notched pebbles from Muncy (*Rau 1873, 140*).

6.2. Second phase

Mainly from the second half of the 20th century, more attention is devoted to the detailed and systematic studies of the notched pebbles. In North America, most attention is devoted to the study of the notched pebbles in the northwest areas (*Casserino 2017; Prowse 2010; 2013*). Colourful photographs are published instead/or together with drawings. Total number of artefacts is given, together with their mean length, width, and thickness. The raw material is usually also recorded.

Weston was one of the first scholars who focused in depth on studying notched pebbles. He gathered all available ethnographic and ethnohistoric records on the use and function of the notched pebbles around the Great Lakes. The earliest records made by Jesuit travellers and missionaries date back to the beginning of the 17th century. All of these records mentioning the use of notched pebbles are connected to fishing activities, and used as net sinkers for gill and seine nets (*Weston 1978, 12*).

He further notices that in the ethnographic records both notched as well as unworked pebbles are mentioned to have been used as net sinkers. He notes that there as additional evidence that these pebbles served as net sinkers: (1) their distribution is primarily on the banks of rivers and lake shores, associated with abundant fish remains, (2) they appear on these sites in large numbers, suggesting considerable fish netting activity, (3) in some cases notched pebbles were actually found attached to carbonised fishing net, (4) many notched pebbles were found in a clutter that suggest the past presence of a net, (5) several stones were found with organic stains running between the notches (Fig. 6.3.) or with the cordage still attached (*Weston 1978, 23-24*).

He studied three clusters of notched pebbles from two archaeological sites. Based on the information from the ethnographic sources stating that the distance between the individual sinkers was 1,8 metre, he estimated possible lengths of the three nets to 54.6 m, 21.6 m, and 30.6 m (*Weston 1978, 74*).

Fig. 6.3. Cordage stained stones from Draper Park. Notice that the one on the left has no notches and the third from the left has one one notch (*Weston 1978, 125, Fig. 14*).

Clealand (*1982*) devoted considerable attention to the study of notched pebbles, and generally to the inland shore fisheries of the natives around the Great Lakes based on early ethnographic records and archaeological evidence. For fishing in the shallow waters, Cleland argues for the use of seine nets with numerous net sinkers attached at the end which were drafted to the shore (Cleland 1982, 774). He suggests that mainly spring-spawning species such as pike, drum, bass, and perhaps suckers were caught by seine nets. On the other hand, fall-spawning species including whitefish and lake trout occur mainly in deeper waters. For these species, he argues for the use of gill nets, in which fish become ensnared by their gills (*Cleland 1982, 774*).

Prowse is one of the scholars who studied notched pebbles in depth. She uses the term "netsinkers" for these artefacts that are thought to have been used for sinking and/or stabilising fishing nets (*Prowse 2010, 69*). Prowse systematically measured maximum length, maximum width, maximum thickness, notch width, notch depth, internotch width, and notching angle (*Prowse 2010, 78*). Furthermore, she recorded the raw material, notching technique (pecking, directional fracture, wear), and also presence of cordage wear. The netsinkers were divided into five types: side-notched, end-notched, both-notched, atypical-notched, and unknown (Fig. 6.4.).

She also compared the netsinkers from several sites in Ontario together with the distribution of faunal remains, especially fish bones (*Prowse 2010*). Based on her systematic study of net sinkers around the Ontario lake, she claims that all net sinkers types were used with both seine and gill nets, with side-notched net sinkers being the most common type there. She sees, however, differences with respect to the hydrological environments in which the net sinkers were used. The heavier and larger net sinkers were found on sites where fishing in deeper and perhaps more turbulent water is proposed, while smaller and lighter net sinkers were found on sites, which were located close to smaller rivers with shallower and calmer water (*Prowse 2010, 92*).

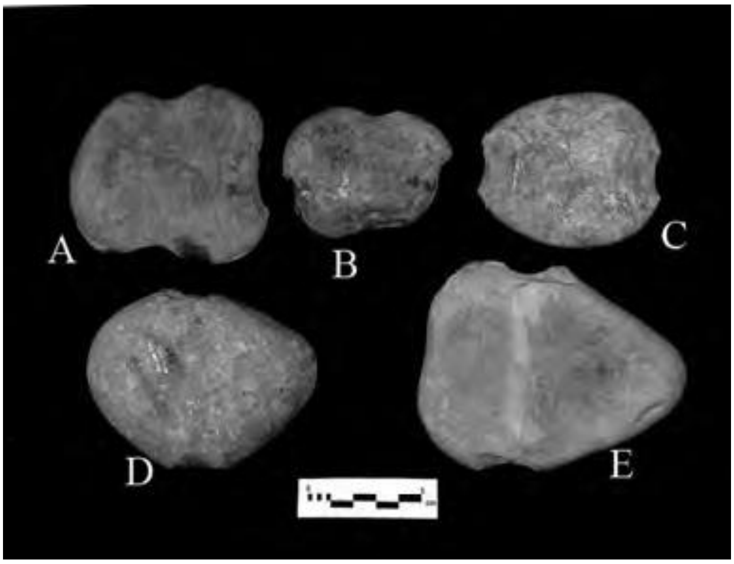


Fig. 6.4. Net sinker types: (A) Atypical, (B) both-notched, (C) end-notched, (D) and (E) side-notched (*Prowse 2010, 80*).

The manufacturing methods of notched pebbles were studied in a series of experiments, out of which the ones by Hannold (*2019*) are of special importance. Hannold manufactured several types of net sinkers: notched ones by direct and indirect percussion and also grooved ones. Direct percussion involves applying force directly to a target stone with a harder stone, while indirect percussion requires an intermediator, a flint or cobble flake, which is struck with a hammer stone. She found out that direct (Fig. 6.5.) and indirect (Fig. 6.6.) percussion during manufacture can be distinguished on the artefact's surface:

"Net sinkers manufactured by direct percussion have different notch attributes than net sinkers manufactured by indirect percussion. Direct percussion leaves fairly steep flake scars, except with certain sandstones, and a U-shaped notch, while indirect percussion leaves little to no flake scarring and a V-shaped notch" (*Hannold 2019, 98*)

Fig. 6.5. (left): Net sinkers manufactured using direct percussion. They bear flake scars and the notches are U-shaped (*Hannold 2019, 99*).

Fig. 6.6. (right): Net sinkers manufactured using indirect percussion. They lack flake scars and have V-shaped notches (*Hannold 2019*, *99*).

In the Levant, a classification of sinkers and weights, both stone (Fig. 6.7.) and lead, was done by Galili *et al.* (*2002*) based on the finds from an underwater wreckage site on the Carmel coast. He makes a distinction between grooved sinkers, and perforated sinkers, which he divides into sinkers with angled perforation and these with straight perforation. Grooved stones are divided into these with peripheral groove, and these with partial groove. The notched pebbles are not mentioned at all.

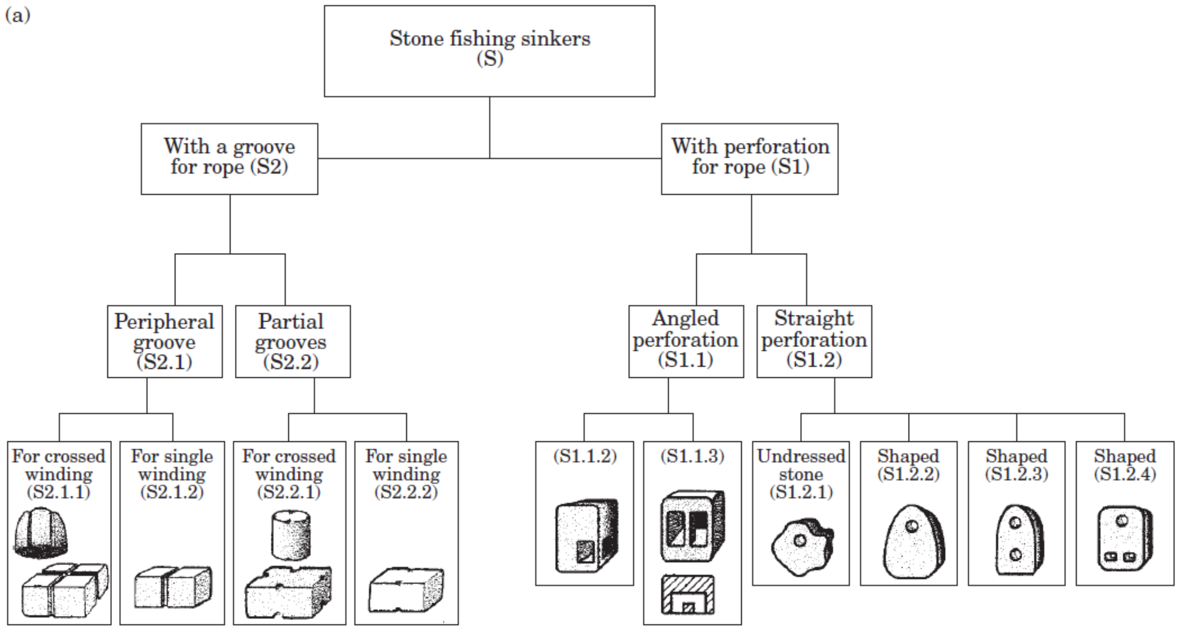


Fig. 6.7. Classification of stone fishing sinkers according to Galili *et al.* (*2002, 183*).

Nadel and Zaidner (*2002*) published the first full account on the study of notched pebbles from the Early Epipalaeolithic site of Ohalo II, which is located on the banks of the Sea of Galilee. The fisher-hunter-gatherers' camp site included the floors of six brush huts, several open-air hearths, a grave, a midden, and ground stone tools such as grinding slabs and querns (*Spivak –Nadel 2016*). On Ohalo II, nearly fifty notched pebbles were found. The authors identified them as net sinkers, or weights for stabilising traps (*Nadel – Zaidner 2002*). The length, width, thickness, and weight of all of the notched pebbles was recorded. The notches are thought to have been manufactured by flaking, and pecking (Fig. 6.8.)

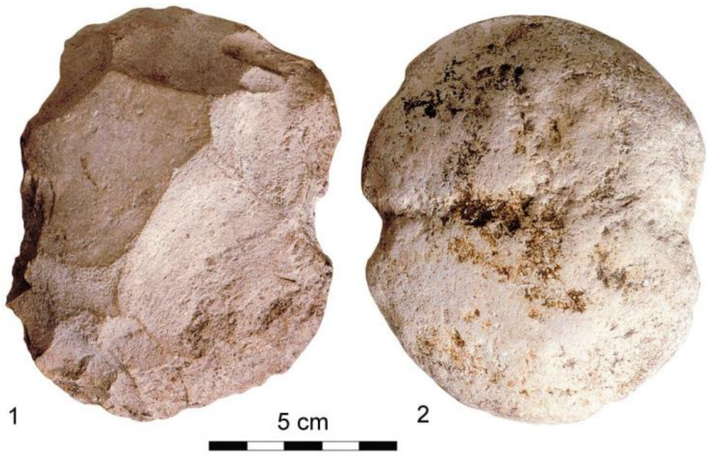


Fig. 6.8. Fishing weights from Ohalo II: (1) bears the flake scars, while (2) bears the pecking evidence (*Spivak – Nadel 2016, 538*).

Another important study on notched pebbles from a Neolithic site Beisamoun was performed by *Rosenberg – Agnon – Kaufman* (*2016*). Beisamoun is located at the feet of Naphtali Mountains in the Hula Valley. The main occupation of the site belonged to the Pre-Pottery Neolithic and Wadi Rabah culture. Notched pebbles (n=96) were mainly collected on the surface from the 1960s. Notched stones were studied systematically, they were weighed and measured. Length and width was measured in three places on each notched stone, while thickness was measured in two places (minimum and maximum). Raw material was recorded as well as any other modifications on the surface except the notches. Measured notched pebbles were divided into four subtypes: (1) oval, (2) rectangular, (3) trapezoid, and (4) rounded.

To conclude, notched pebbles were by most authors interpreted as net sinkers or weights for traps, thus representing direct evidence of fishing.This interpretation is based on several lines of evidence: (1) ethnographic and ethnohistoric records on the use of notched pebbles as net sinkers, (2) notched pebbles occur on archaeological sites close on water bodies, often associated with plentiful fish remains, (3) some notched pebbles were found with a binding still attached, or (4) with organic stains running between the notches, (5) in one case, the notched pebble was found still attached to the net.

No consensus regarding the type of net (seine, gill, throwing net) and type of sinkers used with a specific net fishing technique (side-notched, end-notched, both-notched, atypical) was reached. Moreover, Nadel and Zaidner (*2002*) do not exclude the possibility that notched pebbles were used for stabilising traps. Prowse (*2010*) and Cleland (*1982*) argue that notched pebbles were used with both seine and gill nets. Prowse suggests that the weight of notched pebbles at a particular site can reflect various hydrological conditions. For fishing in deeper and perhaps more turbulent waters, she proposes that heavier and larger sinkers were used, while smaller and lighter sinkers were used for fishing in shallower and calmer water.

Ritchie (*personal communication in Weston 1978, 73*) suggests that there is a difference between the sinkers used on gill nets and sinkers used on seine nets. Those used on seines are supposed to be more standardised "*because a proper balance had to be maintained while stretching the net across rivers or shallow lake shore areas."* The main purpose of sinkers used on gill net is to either sink to the bottom or left somewhat suspended in the water. Thus, Ritchie argues that any combination of sinkers would cause the gill net to sink, meaning that "*a greater attribute variation should be expected in gill net sinkers than in seine net sinkers.*"

Notched pebbles' attributes including maximum length, maximum width, maximum thickness, internotch width, and presence of cordage wear together with spatial distribution patterns may indicate a preferred fishing technique used at a site. However, without preserved nets, it is close to impossible to argue the sizes of nets, and only general guesses can be made based on the ethnohistoric evidence. Based on the shape of notch, notch width, notch depth, and existence or non-existence of flake scars on the surface of notched pebbles, manufacturing techniques can be implied. The choice of raw material for notched pebbles manufacture can tell us about the subsistence and decision making of the past people.

7. The site of Jordan River Dureijat

The site of Jordan River Dureijat (JRD) is located in the Hula valley in northern Israel (Fig. 7.1). The valley is delimited by the Naftali Mountains to the west, Mt. Hermon to the northeast and the Golan Heights to the east. The site was intermittently occupied for short-term duration with layers dated to Early, Middle, and Late Epipalaeolithic. As the site was situated on a shore of the Paleolake Hula, people in the Epipaleolithic repeatedly exploited the aquatic resources (*Sharon et al. 2020*).

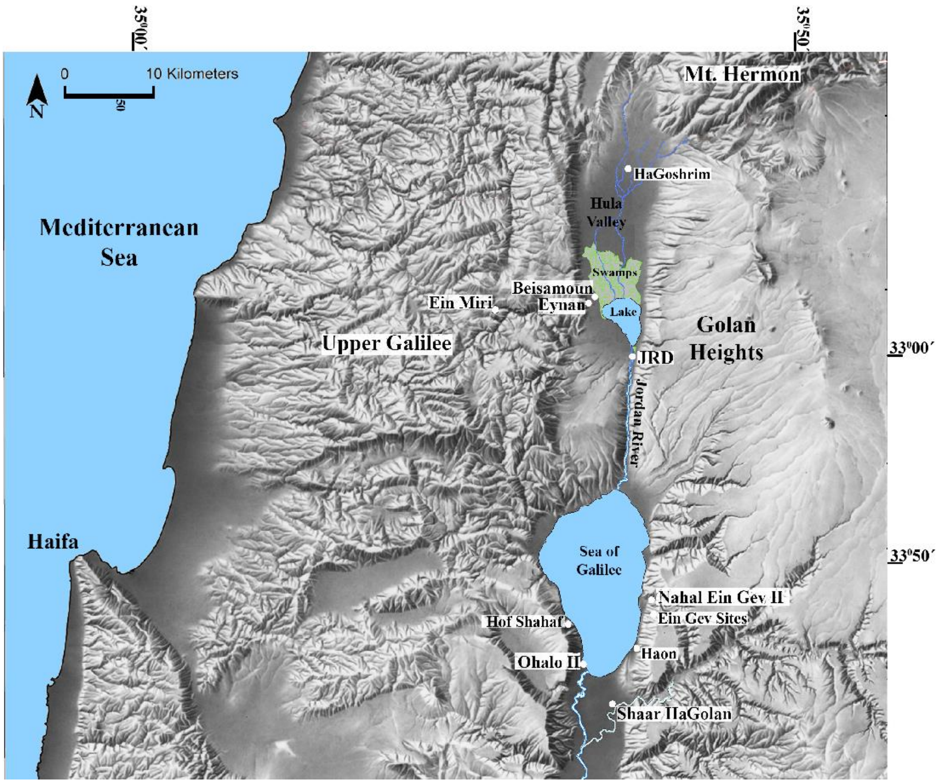


Fig. 7.1. Maps with the location of the JRD site (Sharon *et al.* 2020, 37).

7.1. Geography and geological setting

The JRD site is situated in the Hula Valley, which is bordered by the Naftali carbonate mountains (700-900 m above sea level) to the west, Mt. Hermon (up to 2814 m above sea level) to the northeast, and to the basaltic Golan Heights to the east. To the south, the valley is enclosed by the Korasim basaltic block. Until the 1950s, the Lake Hula occupied the southern part of the Hula Valley and there is evidence from JRD indicating that during the end of the Pleistocene-early Holocene, the Paleolake Hula extended more that 2 km to the south (*Sharon et al. 1999*).

Sedimentary Gadot and HaYarden formations are both situated in the proximity of the site. (*Belitzky 2002 in Goren-Inbar et al. 2018*). Limestone pebbles could have also been transported by four major river systems (Fig. 7.3.) that are located in the vicinity of the site: Nahal Rosh Pinnah, Nahal Mahanayim, Nahal Dishon, and Nahal Ayelet HaShachar. The JRD site is located two kilometres north from Gesher Benot Ya´akov Bridge. The river beds of these streams consist mainly of sedimentary rocks, and limestone pebbles of various shapes are plentiful (Fig 7.2.).

Fig. 7.2. Limestone pebbles in the Dishon stream (Photos courtesy of Gonen Sharon).

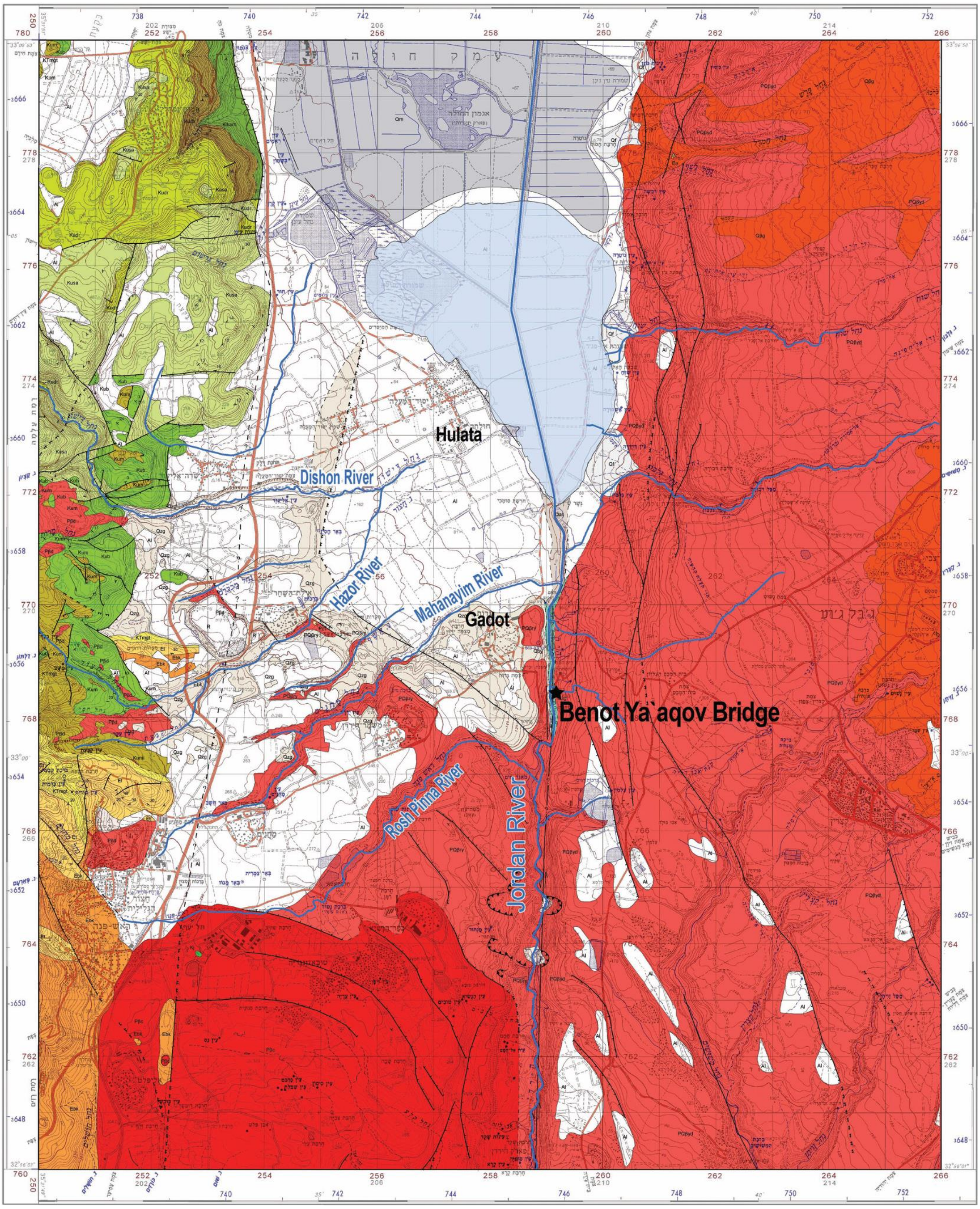


Fig. 7.3. Geological map of the Rosh Pinnah area (Goren-Inbar *et al.* 2018, 25).

7.2. Environment and climate

Thanks to being waterlogged, the site of JRD provided a rich pollen record for nearly the entire Epipalaeolithic (~22.0 - 11.9 ka cal. BP), thus enabling the reconstruction of the paleoclimate during this period. This period is particularly important as it documents the transition from small mobile groups of hunter-gatherers into larger and more complex communities with reduced mobility and change in subsistence strategies, finally leading to the establishment of the sedentary agricultural communities *(Bar-Yosef 1998; Belfer-Cohen – Goring-Morris 2011*).

The Last Glacial Maximum (LGM), which is dated to approximately 22 - 19 ka cal. BP, was the coldest period of the whole sequence, with the decrease in reconstructed temperatures in January of up to 5°C lower than today (*Langoot et al. 2021*). The wettest and warmest period was identified between ~14.9 and 13.0 ka cal. BP, with the maximum values of 545 mm mean annual precipitation reached at ~14.5 cal. BP. This time period can be synchronised with the global warm and moist Bølling-Allerød interstadial. Moreover, in this period we can see the beginning of the Natufian culture as well as the emergence of the sedentism in the Levant (*Langoot et al. 2021*).

Next change in climate came around 12.9 ka cal. BP with the beginning of the Younger Dryas. At JRD, this period is characterised by low temperatures and minimal climatic seasonality contrast. The amount of precipitation rose in spring, summer and autumn, while it decreased in winter (*Langoot et al. 2021*).

For reconstructing the plants and trees at the JRD site, the pollen samples as well as waterlogged wood were used. The most common tree was deciduous *Quercus ithaburensis* (Mount Tabor oak), others were identified as *Quercus boissieri* (Aleppo oak), *Quercus ithaburensis*, *Quercus calliprinos* (evergreen oak) and Pistacia. According to the authors, contrary to the pollen record, the wood assemblage can tell us more about the choices made by people at the JRD site as they probably collected wood as material for construction, firewood, and for preparing various wooden tools (*Langgut et al. 2021, 12*). Based on the analysis of seeds, wild almond (*Amygdalus communis* var. *korschinskii*), oak (*Quercus cf. calliprinos*), and wild barley (*Hordeum spontaneum*) were identified (Sharon *et al.* 2020).

As for other trees, *Pinus* was also identified, although in a relatively low occurrence and it is completely missing during two short phases: at ~21 ka cal. BP, and around ~13 ka cal. BP. These two periods can be related to the LGM and Younger Dryas when it was probably too cold for *Pinus* to grow (*Langgut et al. 2021*).

Regarding the marsh-bank and aquatic vegetation, *Phragmites* type (reed), Cyperaceae, *Typha* (cattail), *Salix* (willow), *Vitis* (grape), and *Tamarix* (tamarisk) were identified (*Langgut et al. 2021*).

7.3. History of research

The site of JRD was discovered during the drainage operation of the Jordan River in 1999. The site was observed on the Jordan river banks about 1300 m north of the Benot Ya'akov bridge (Fig. 7.4., *Sharon*, *Feibel et al. 2002*). After an initial test excavation in 2002, a short season was performed in 2014. Between 2015-2021, six regular seasons took place unearthing more than 80 square metres, with an archeological sequence of more than 10, 000 years.

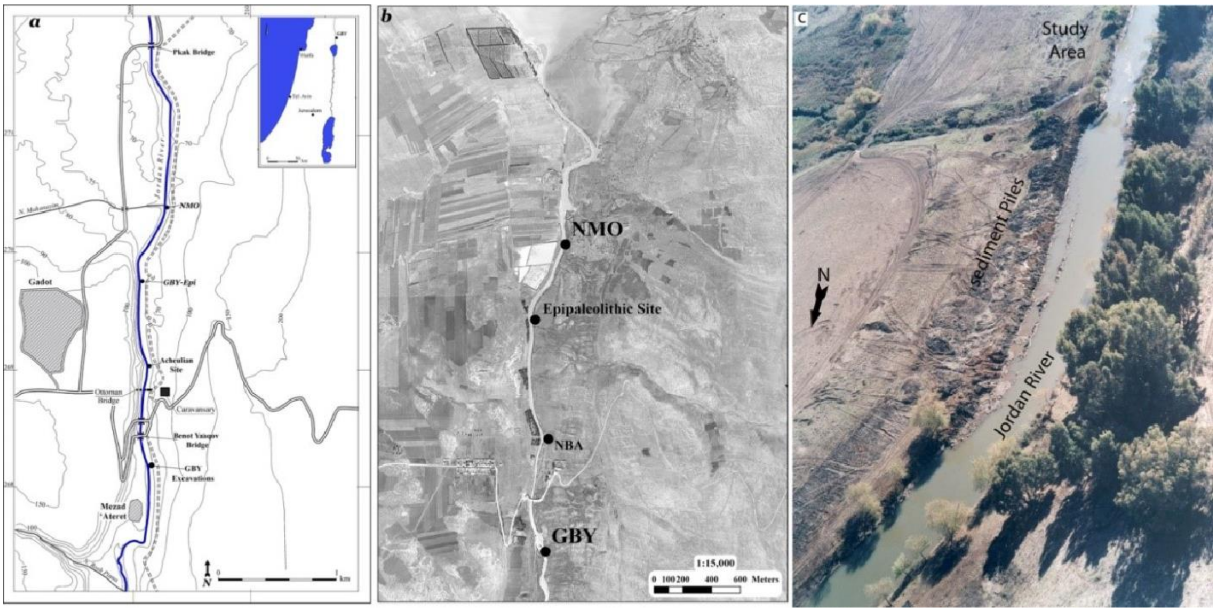


Fig. 7.4. a) JRD location map; b) location of prehistoric sites on 1945 aerial photo, and c) view of the site during drainage work in 1999 (*Sharon 2015, 3*).

Season 2002

In 2002, a survey took place in order to evaluate the damage caused by the drainage operation and test excavation of one square metre was dug. The very first ^{14}C samples suggested that the site is of Middle Epipaleolithic origin falling between 14,000 and 15,200 cal. BC (*Sharon 2015*).

Already from the beginning, it was clear that the preservation of bones and botanics is extraordinary, similar to the finds from GBY (*Sharon 2015*). A wide range of animal bones was found from the large animals like cows to the smaller ones like rodents or reptiles. Tortoise shells as well as crab pinches have been found. The exploitation of the aquatic resources, such as fish, molluscs and crabs, is particularly evident on the site (*Sharon 2015*). Regarding the flora, the preservation of the seeds and fruits was exceptional. Among the identified species were barley and possibly also wheat, grapes, figs and some edible water plants as well (*Sharon 2015*).

Season 2014

After the initial test excavation in 2002, a short excavation season occurred in the fall of 2014. The aims of the season consisted of (1) understanding of the site's stratigraphy and intensity of the occupation, and (2) evaluating the site's potential for long-term excavations.

Seven geological trenches were dug by the tractor and areas marked A, B, C, and D were excavated (Fig. 7.5.). The results from these trenches suggested that the JRD site is much larger and extends to about 45 metres along the east bank of the Jordan River (*Sharon 2015*).

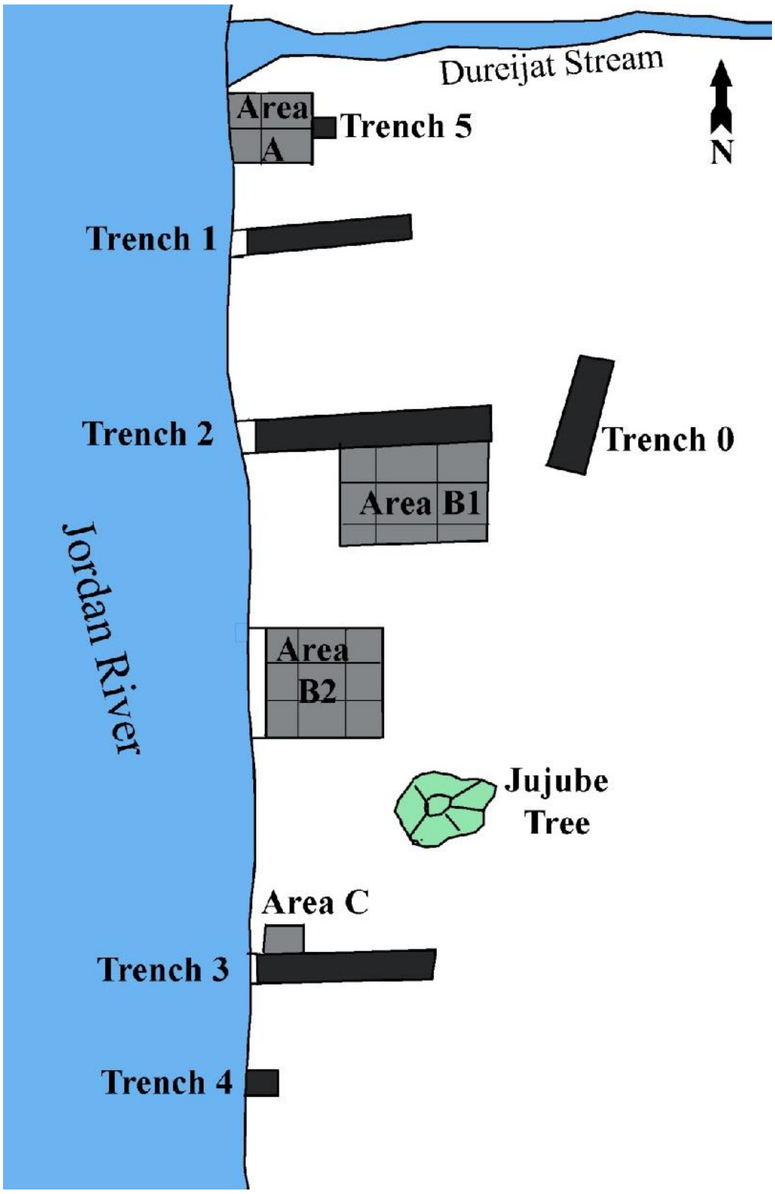


Fig. 7.5. Location map of the 2014 excavation areas and geological trenches (*Sharon 2015, 4*).

Area A is situated in the northern part of the site, close to the modern artificial Dureijat stream, which outflows to the Jordan River. The archaeological finds, consisting of numerous flint and limestone artefacts as well as animal bones and botanical remains, were primarily found in the mollusc-rich, sandy lake-shore deposits (*Sharon et al. 2020*).

Area B provided a sequence of archaeological horizons with the mollusc-rich, sandy lake-shore sediments which contained a lot of artefacts. Area B was chosen as the primary site of excavation in the 2014 to 2021 seasons (*Sharon et al. 2020*).

Area C is situated south of Area B, close to the Trench 3. Only a 2m² surface was excavated, but it provided an abundant lithic assemblage (*Sharon et al. 2020*). Later, in 2021 the Area C was reopened with a Trench 11 and two subsquares were excavated.

Area D, which was opened in 2019, consisted of a small area of 3 x 3 square metres. The area is situated north of Area B and the aim of the test excavation was to find out whether the archaeological horizons from Area B are continuing in the north. The layers in this area were numbered from top to bottom with the letter D at the beginning (D1 to D11). The reason for naming the layers differently was that the correlation of layers between Area B and Area D was not certain (*Sharon 2019*).

<u>Seasons 2015 - 2021</u>

Between the years 2015 and 2021 (with the exception of 2020 when the season was cancelled due to Covid-19), 6 regular excavation seasons took place, usually on the turn of August and September. The aim of the 2015 season was to expose a larger surface of Area B and try to reconstruct the spatial distribution and patterns of finds (Sharon 2016, 5). The focus was placed on the Area B (squares M, N, O, P, Q from 96 to 101, Fig. 7.6.). Natufian and Geometric Kebaran layers were identified (*Sharon 2016*). In the following seasons, the surface of Area B was again enlarged, especially to the north and to the west.

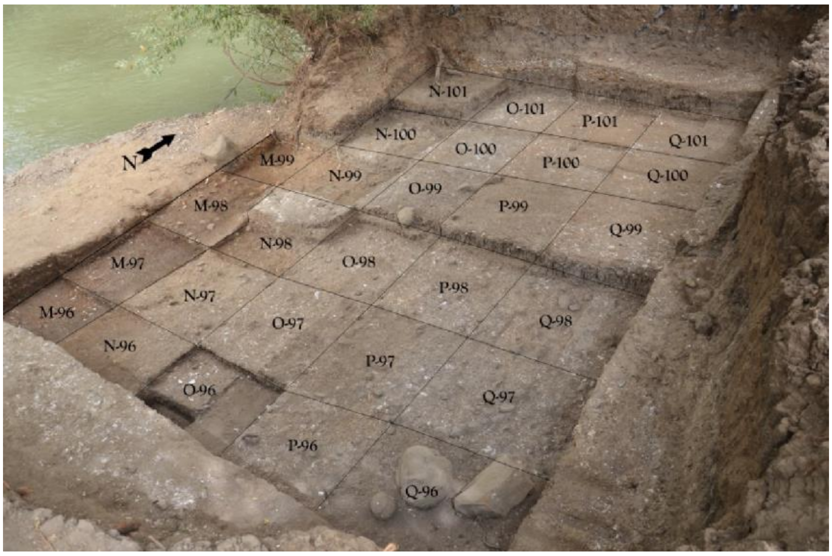


Fig. 7.6. Excavated surface in area B in 2015 with the square names (courtesy of Gonen Sharon)

7.4. Stratigraphy and chronology

The first two upper layers, Layer 1 and 2 postdate the Epipaleolithic. Layers at JRD can be divided into two categories: (1) molluscs-rich, sandy deposits, with an abundance in archaeological finds, and (2) shell-poor, silty or muddy deposits, with a very few archaeological finds. According to the authors, the shell-poor layers were accumulated when the lake water level was so high that it submerged the whole site. On the other hand, during the drier climatic conditions, the lake water level was lower and thus enabled a short occupation of the site (*Sharon et al. 2020*).

Six molluscs-rich, near shore layers have been exposed, and they were further subdivided into sublayers (3-0, 3a, 3b, 3c, 4a, 4b, and 4c) based on a change in mollusc' density or sediment colour (*Sharon et al. 2020*). The shell-poor, mud layers, which occur between the shell-rich layers were called according to the shell-layer they underlie and marked with "M" or "mud" (Fig. 7.7.)

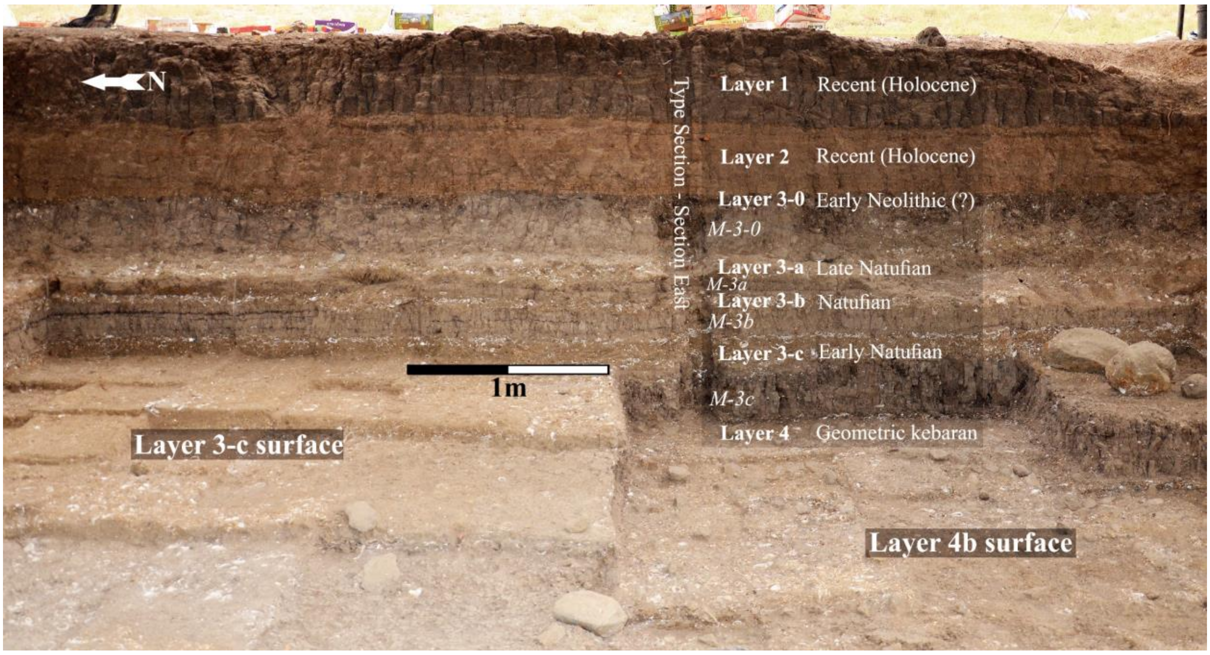


Fig. 7.7. Stratigratigraphy of the east section of Area B at JRD with cultural affiliations indicated (*Sharon et al. 2020, 38*).

Regarding the absolute chronology, 24 charcoal samples were dated by radiocarbon method. Fifteen of the samples came from the systematic sampling of the east section of

Area B, three samples came from the southern section, and the rest came from the excavations of Area B (*Sharon et al. 2020*). Fig. 7.8. show the dates obtained by radiocarbon dating, together with the cultural affiliations.

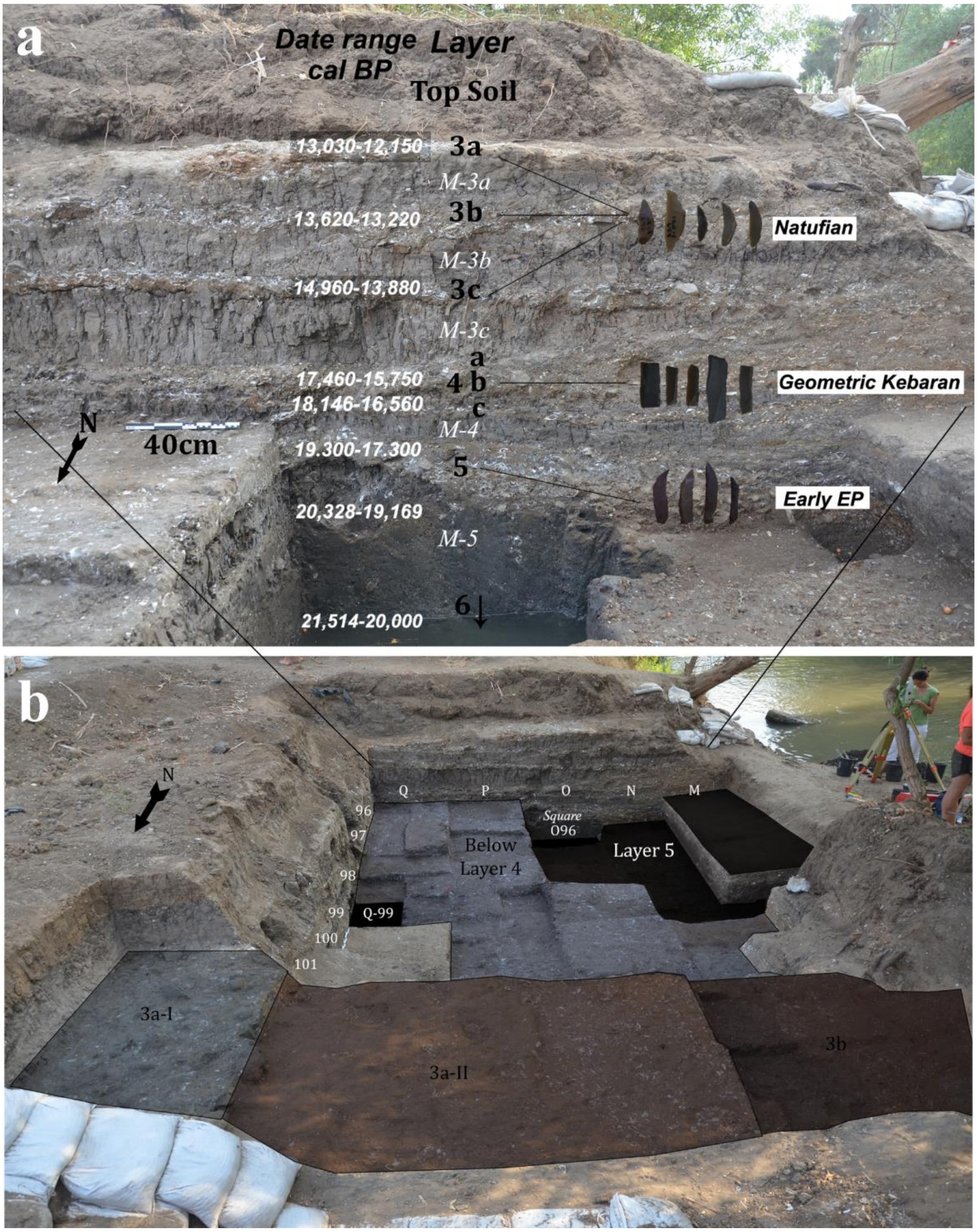


Fig. 7.8. Area B at the end of the 2017 season, a) stratigraphy of the south section in Area B with the radiocarbon dates, together with the cultural affiliations, b) Area B stratigraphy and excavated surface (*Sharon et al. 2020, 39*).

Layer 1 is of Late Holocene age and it is characterised by dark silt material, which is similar to the surface sediment of current artificial slopes of the Jordan River.

Layer 2 is about 50 cm thick and consists of reddish-brown sediment without molluscs shells and archaeological artefacts.

Layer 3-0 is characterised by silty sediment with some archaeological artefacts, including angular basalt cobbles, limestone pebbles, some of which are worked, and a handful of flint artefacts. Layer 3-0 was exposed in approximately 50 square metres.

Layer 3a (Fig. 7.9.c and d) dates 13,030 - 12,150 cal. BP consists of an uneven surface with shallow trenches and pits, stony surfaces, shell horizons, stone tools and animal bones. According to the authors, the surface was clearly changed by human activities. Culturally, the layer is attributed to the Natufian, based on the finds of lunates and typical sickle blades, although the top of the layer 3a provided el-Khiam points, which are typical for Pre-Pottery Neolithic A. Layer 3a was exposed in approximately 90 square metres.

Layer 3b, dated to 13,600 - 13, 210 cal. BP, is characterised by shallow lacustrine sediment, mainly consisting of Unio shells. The sparse archaeological finds probably reflect minimal occupation during this phase, although several bone fish hooks were found in the sieved sediment from this layer. Layer 3b was exposed in approximately 40 square metres.

Layer 3c (Fig. 7.9.e), which is dated to 14,960 - 13,880 cal. BP, consists of silt sediment rich in Unio shells. Its thickness varies from 8 cm in the south to 30 cm in the north. The layer is very rich in limestone, both worked and unworked pebbles. Flint artefacts occur as well, however in a lower density. Based on the presence of the lunates, the layer is culturally affiliated to the Natufian period. Basalt cobbles are also found, some of them bear the marks of flaking or pecking. Some of them might have been used as anvils, while others have been possibly used as a stable surfaces in the muddy environment (*Sharon et al. 2020, 43*). Layer 3c was excavated in circa 55 square metres.

Layer 4 (Fig. 7.9.b)is subdivided into 3 sublayers - 4a, 4b and 4c. It consists of thick muddy lacustrine sediment. The radiocarbon dates obtained from the 4a and 4b layers fall between 17,460 - 15,750 cal. BP. The layer is comprised of coquina horizons, rich in small shells. Medium-sized limestone pebbles are found in the layer, some of which are modified by humans. Basalt cobbles are abundant in the layer. Many basals bear the evidence for human modification, such as flaking or pecking. The lithic assemblage includes trapeze-rectangles, and end-scrapers produced on blade blanks, and thus the layer is attributed to Geometric Kebaran culture affiliation *(Sharon et al. 2020, 43*). Layer 4 was exposed in approximately 35 square metres.

Layer 5 (Fig. 7.9.a) is dated between 19,300 - 17,300 cal. BP. It consists of silty sediment with concentrations of molluscs, both Unio and Melanopsis shells, with various densities and abundance. Basalt cobbles are common finds in the layer. Although only a few square metres of the layer 5 were excavated, the layer provided a rich archaeological assemblage, giving evidence about high-intensity occupation. The lithic assemblage is attributed to the early Epipaleolithic. Layer 5 was excavated in about 20 square metres.

Layer 6 was only reached in one square (O96). The layer's sediments changed from dark silt to mollusc-rich silt. Regarding the archaeological remains, a few basalt cobbles, limestone pebbles, flints, and bones were found. At the depth of ca. 55.60 - 55.55masl, the water level of the Jordan River was reached, which further complicated the continuation of the excavation.

Fig. 7.9. a) Surface of layer 5, b) surface of layer 4, c) Layer 3a (U and S squares, surface modified by humans, post-holes), d) Layer 3a with bones, flint, limestone, and basalt artefacts, e) Layer 3c in U squares with large concentration of limestone notched and unworked pebbles (Photos courtesy of Gonen Sharon).

In summary, layers 3a, 3b, and 3c are attributed to Late Epipalaeolithic, namely to the Natufian culture, and are dated between app. 15, 000 - 12, 000 cal. BP. Layer 4 is attributed to the Middle Epipalaeolithic, to Geometric Kebaran culture, and dated to app. 17, 500 - 15, 750 cal. BP. Layer 5, being dated to 19,300 - 17,300 cal. BP., is attributed to the Early Epipalaeolithic cultures. The earliest radiocarbon dates of 21, 500 - 20, 000 cal. BP came from layer 6.

7.5. Finds

This subchapter doesn’t aim to describe all the finds found at the site, but rather to illustrate what types of finds can be found in general. Flint and basalt artefacts are discussed briefly as well as fish hooks, animal bones, fish bones, and human remains. The limestone artefacts are described in chapter 8.

7.5.1. Flint

Although the study of JRD flint assemblage is in its early stages, over 2, 000 flint artefacts have already been studied. Based on the presence of lunates and small sickle blades with unworked edges (Fig. 7.10.3b), the three upper layers (3a, 3b, and 3c) are ascribed to the Late Epipalaeolithic Natufian culture (*Sharon et al. 2020*). Trapeze-rectangle microliths, that appear in layer 4, are characteristic of the Middle Epipalaeolithic Geometric Kebaran culture (*Sharon et al. 2020*). As for layer 5, the occurrence of the narrow-fronted bladelet cores and the absence of the microlithis suggest an Early EP affiliation. According to the authors, the presence of microburins and carinated scrapers suggest that the artefacts should not be attributed to the Kebaran or Geometric Kebaran lithic traditions, but rather to the Early EP Masraqan affiliation (*Sharon et al. 2020*). Thus, all the three periods (Early, Middle, and Late) Epipalaeolithic are present at the site. Moreover, in the top of 3a layer and in 3-0 layer, el-Khiam points (Fig. 7.10.3a.), that are typical of Pre-Pottery Neolithic, were found (*Sharon et al. 2020; Langgut et al. 2021*).

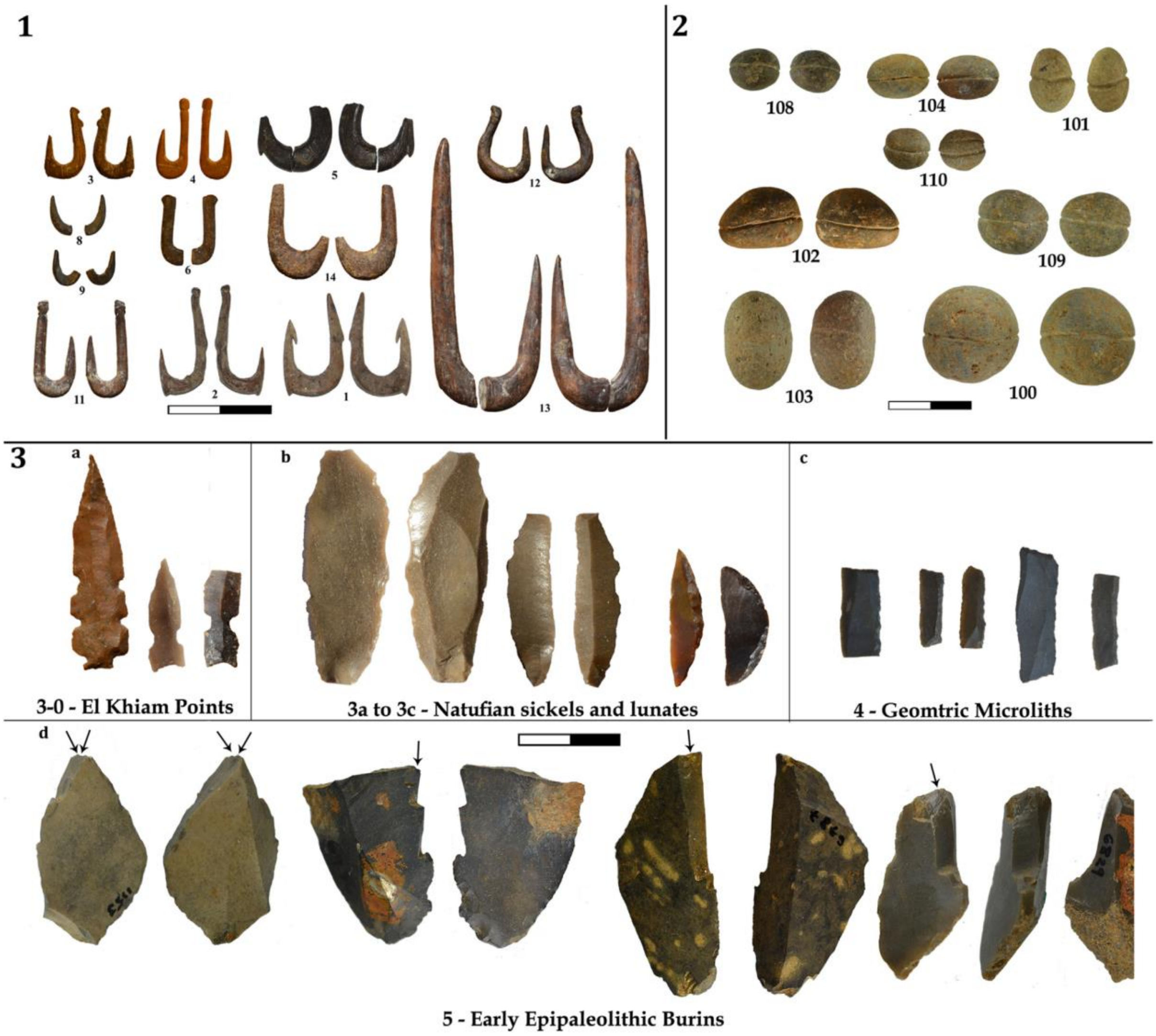


Fig. 7.10. 1) JRD bone fish hooks; 2) JRD small grooved pebbles (line weights); 3) JRD stone tools by layers and cultural affinity: a. Early Neolithic; b. Natufian; c. Geometric Kebaran; d. Early Epipaleolithic (*Langgut et al. 2021*).

7.5.2. Basalt

Basalt artefacts, mainly flakes, partially worked cobbles, and also unworked cobbles are found in all the layers at the JRD site. Several pestles (Fig. 7.11.) as well as parts of the grinding slabs were found at the site (*Marder et al. 2015; Sharon et al. 2020*). Some of the ground stone tools were found broken. According to the authors, these broken implements might have been used as weights at JRD (*Sharon et al. 2020, 60*). Another category of basalt implements represent the fishing line weights. They have a circular shape with an engraved groove running around their circumference (*Pedergnana et al. 2021*). Only two basalt net sinkers with distinguishable notches were found (*Sharon et al. 2020, 57*).

Fig. 7.11. Broken basalt pestles from layer 4 (left: *Sharon 2015, 33*; right: *Sharon 2016, 46*).

7.5.3. Fish hooks

Nineteen broken and complete fish hooks (Fig. 7.10.1) have been found so far, not including the finds from the 2021 season.. Both the fish hooks and the line weights come from the Natufian layers, chronologically dated to 15,000–12,000 cal BP. All of the hooks found at JRD are made of bone, except for one fragmentary hook which is made of tooth enamel, probably wild boar tusk (*Pedergnana et al. 2021*).

7.5.4. Line weights

Eleven line weights in the shape of small rounded artefacts with an engraved groove running around the circumference (Fig. 7.10.2) were found in the Natufian layers. They are made mainly of limestone (N=8) but also of basalt (N=3). They are believed to have been used for angling, together with hooks (*Sharon et al. 2020*).

7.5.5. Animal bones

Regarding the faunal assemblage, the analysis is ongoing. In the preliminary results, hare (*Lepus capensis*), wolf (Fig. 7.12., *Canis lupus*), red deer (*Cervus elaphus*), fallow deer (*Dama mesopotamica*), mountain gazelle (*Gazella gazella*), and wild boar (*Sus scrofa*) were among the identified mammals. From the picked sediment, fish, snakes, turtles, frogs, and rodents are most common (Sharon *et al.* 2020). As for the fish families, *Cyprinidae, Cichlidae*, and likely *Salmonidae* were identified (*Pedergnana et al. 2021*).

Fig. 7.12. Canidae teeth from Area B at JRD (*Sharon 2015, 50*).

7.5.6. Human remains

At the site, several human bones were recovered. In the 2015 season, a mandible, tibia, and four teeth were found in the 3a layer. All human bones were found within the same area and likely derive from the same young individual (*Sharon et al. 2020*).

7.5.7. Molluscs

Similarly to the preservation of the botanical remains, the preservation of molluscs was also extraordinary. Forty-six different taxa of molluscs have been identified in the preliminary study, *Heleobia*, *Bithynia*, *Theodoxus*, and *Melanopsis* among others (*Marder et al. 2015*). The most prominent shells in the JRD layers are *Unio* shells with the largest reaching up to 12-15 cm in length. Their exploitation by humans is investigated (*Sharon et al. 2021*).

To sum up, the archaeological site of JRD, which was located on the shore of a paleo-lake Hula, has a continuity of incoherent Epipalaeolithic occupation for more than 10,000 years. Extraordinary preservation of pollen and botanics enabled reconstructing the environment in the Hula Valley since the Last Glacial Maximum, almost up to the beginning of the Holocene

Fish hooks, line weights, human as well as animal bones, limestone and basalt artefacts were among the finds. Compared to other EP sites very few lithics were found and no settlement structures were identified. Radiocarbon dating as well as flint tools helped to date the site. The earliest radiocarbon dates of 21, 500 - 20, 000 cal. BP came from layer 6. Layer 5 is attributed to Early Epipalaeolithic (19,300 - 17,300 cal. BP), layer 4 to Middle Epipalaeolithic Geometric Kebaran (app. 17, 500 - 15, 750 cal. BP.), and layers 3c, 3b, and 3a to Late Epipalaeolithic, namely to Natufian cultural affiliation (app. 15, 000 - 12, 000 cal. BP).

8. Methods

8.1. Excavation and field recording

All of the Areas (A, B, C, and D) were divided into 1-square metre grid. Every square was further subdivided into four sub-squares (50 x 50 cm), and marked as a, b, c, and d. The excavation was recorded by the excavators on a daily page (Appendix 1.). The spits of 5 cm were excavated. All the flint and bone finds bigger than 2 cm, and all the basalt and limestone finds bigger than 5 cm were left *in situ*, then their location was measured by the Leica total station and the photograph was taken, if needed. All soil samples, pollen samples and geology samples were recorded by the total station as well. Smaller finds were collected into "general bags" for each sub-square and each material (flint, bone, botanic, etc.). If some kind of a structure or an activity area appeared, it received a locus number and all finds were attributed to that locus. All sediments from the squares were collected into buckets and sieved in the Jordan River using 0.2 mm mesh sieves. In cases of layers sterile of finds, only one bucket per spit per square was collected and sieved. The surface of every layer was taken and details or artefacts *in situ* were photographed as needed.

8.2. Lab recording

In the lab, all flint artefacts and bones were washed in water. The limestone and basalt artefacts were washed in the first years of the excavation. In season 2019, in order to preserve possible residues for future studies, they were only taken out of the plastic bag and left to dry before returning to the bag. Regarding limestone, an Excel table of all limestone artefacts found at JRD was made by Tel Hai College students. The coordinates from the total station were transferred to the table. Every limestone received an ID number, which was written directly on the surface of the find. Photos were taken with a digital camera Nikon D7000 from both faces and one side, if necessary details were taken as well.

For each limestone, layer, square and sub-square and top elevation were recorded in the table based on the information obtained during the excavations. In squares N101, O101, P97, layers 3a and 3b were merging together within one square at the same levels and thus it is difficult to distinguish them. For this reason, and because the chronological difference is not vast, the limestones in these layers, when the layer was not sure, were marked as belonging to 3a layer.

8.2.1.Preliminary types

A preliminary categorization (Fig. 8.1.)was formed as follows:

(1) indeterminate (unknown),
(2) elongated: rounded and elongated, often worked at long sides,
(3) wide: rounded and wide, not worked, around 9 cm in size,
(4) coin: flat and rounded pebble, with diameter around 4 cm, very thin,
(5) chips: smaller than 3 cm,
(6) edge: elongated, rounded on proximal and "sharp" on dorsal side, around 5 cm,
(7) rounded pebble: stream pebble, spheric and smooth.
(8) axe/adze: elongated with thin, sharpened edge, with features for holding a handle.

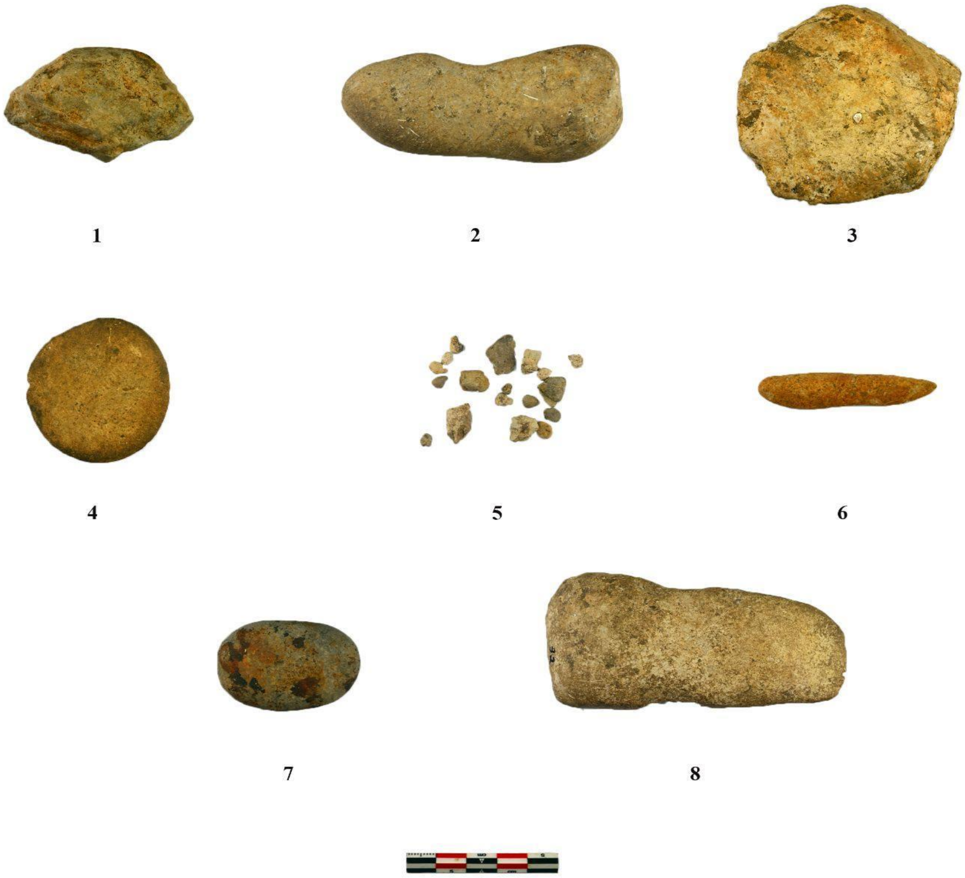


Fig. 8.1. Photos of preliminary types: (1) unknown (indeterminate), (2) elongated (3) wide, (4) coin, (5) chips, (6) edge, (7) rounded pebble, (8) axe/adze.

8.3. Limestone description

8.3.1. Angularity and roundness

Limestones' angularity and roundness was categorised according to Krumbein's (1941) methods for rapid measurement of shape and roundness of sedimentary rocks (Appendix 2.), on a scale 1 to 9, with meaning very angular to 9, meaning well rounded. Rounding of sediment particles can indicate the distance and time involved in the transportation of the sediment from the source area to where it is deposited.

8.3.2. Preservation

The preservation was added only in the later stage of data collection, that is the reason why it is recorded only for about half of the measured limestones. Classes are as follows (Fig. 8.2.):

(1) fresh,
(2) slightly weathered,
(3) weathered,
(4) rolled.

Fig. 8.2. Preservation: (left): slightly weathered, (second from left) weathered, (third from left, and right) rolled.

8.3.3.Weight

Most of the limestone artefacts were weighted, using the digital kitchen scale. Weight in grams with one decimal number was recorded.

8.3.4.Metric measurements

Maximal length, maximal width, and maximal thickness of over 500 limestones was measured using a digital calliper. For notched pebbles, minimal length between notches (= internotched width) was measured as well. Notch depth and notch width was measured for 30 randomly selected notched pebbles (Fig. 8.3.).

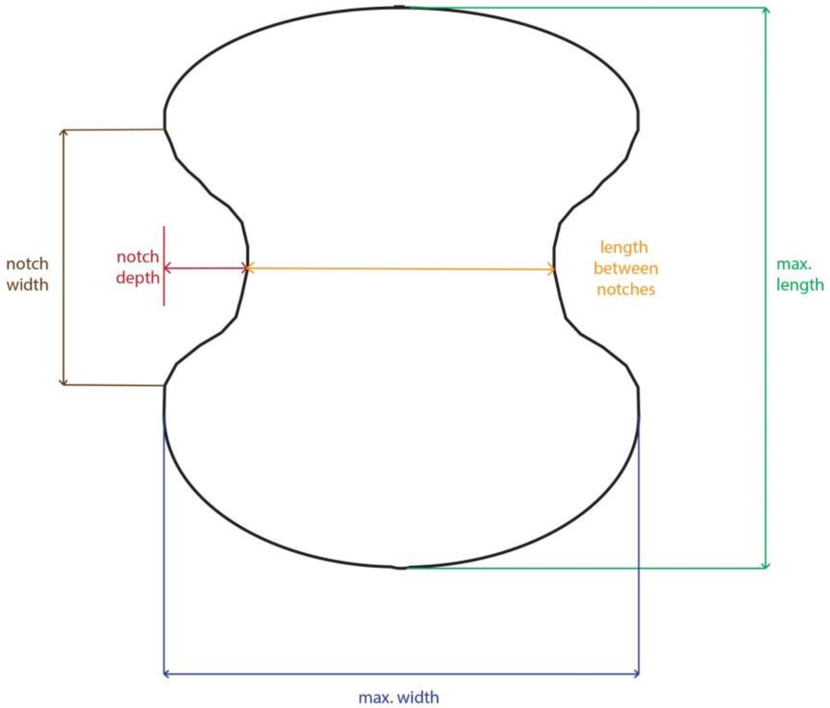


Fig. 8.3. Notched pebble: A schematic depiction of measured dimensions.

8.3.5. Top sectional view

Over 600 limestone items were categorised in one of seven shape (top sectional view) categories (Fig. 8.4.):

(1) 8-shaped/pear shaped, (2) arc/bow shaped, (3) sausage shaped, (4) pointed, (5) irregular, (6) rectangular, and (7) oval-shaped.

The 8-shaped/pear shaped category include unworked pebbles of this shape as well as notched pebbles, which were given this shape artificially.

8.3.6. Side sectional view

Side sectional view of the limestone items was also recorded and divided into 7 groups (Fig. 8.5.): (1) triangular, (2) convex, (3) double convex, (4) irregular, (5) rectangular, (6) irregularly triangular - much thinner on one side, and (7) circular/oval.

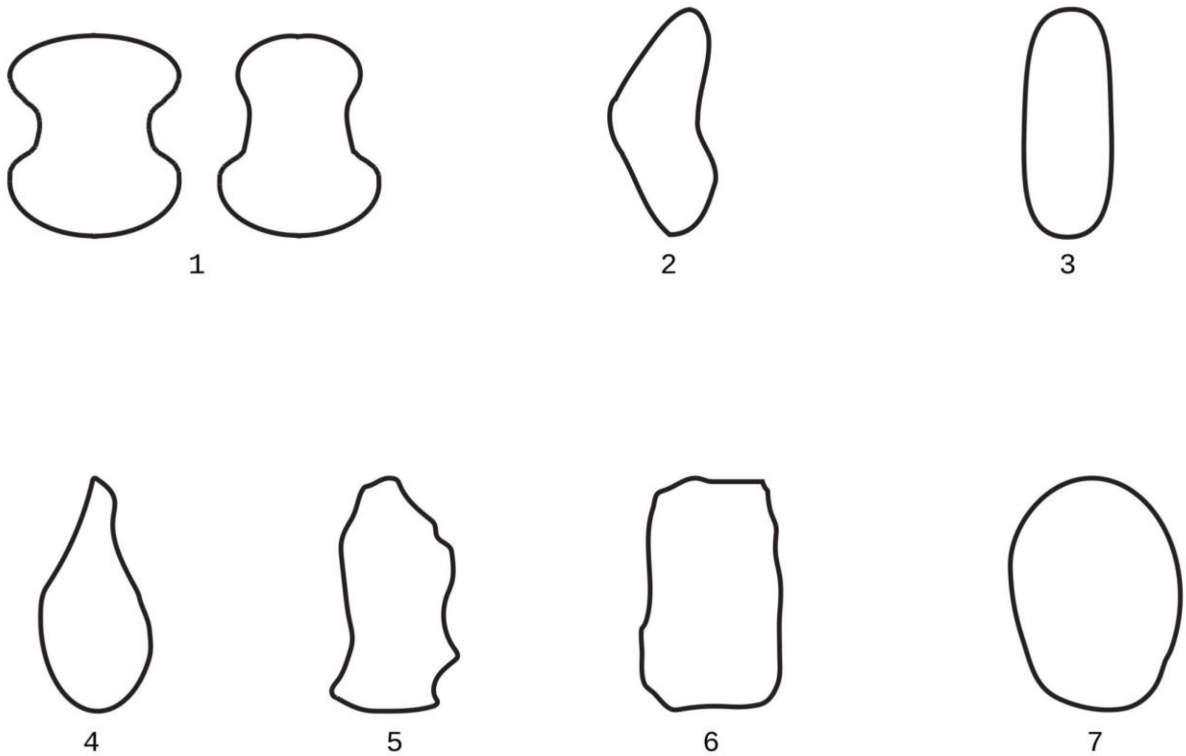


Fig. 8.4.a Top sectional view (shapes): (1) 8-shaped/pear shaped, (2) arc/bow shaped, (3) sausage shaped, (4) pointed, (5) irregular, (6) rectangular, and (7) oval-shaped.

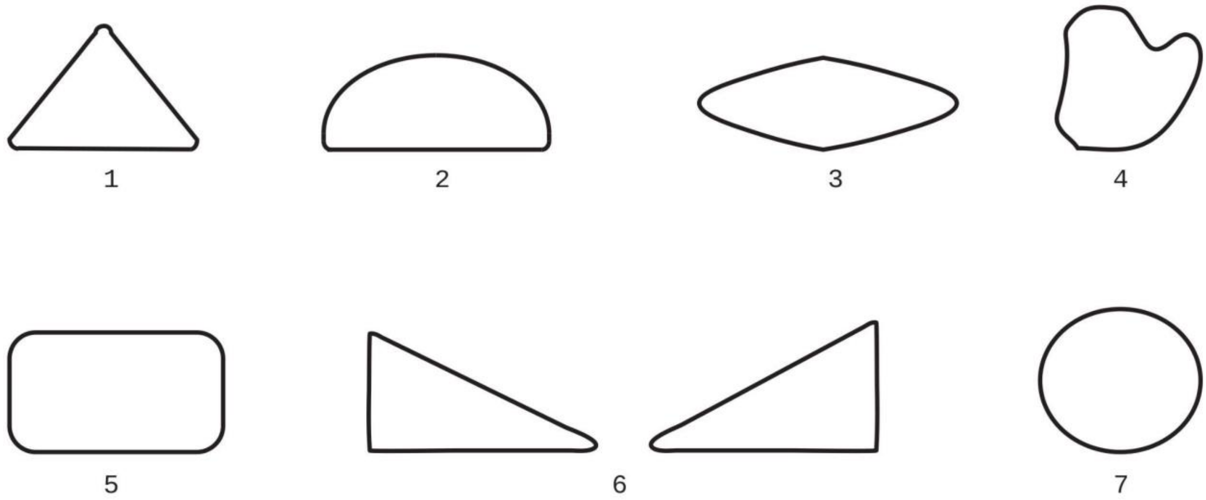


Fig. 8.4.b Side sectional view (sections): (1) triangular, (2) convex, (3) double convex, (4) irregular, (5) rectangular, (6) irregularly triangular - much thinner on one side, and (7) circular/oval.

8.3.7.Notches

For all notched pebbles, the number of the notches was recorded as well as the position of the notches, either (1) parallel, or (2) concurrent.

If possible, it was recorded whether the notch was flaked (1) unifacially or (2) bifacially, although it was often impossible to distinguish because of insufficient preservation of the item (3-unknown).

To count the precise number of flakes in one notch would be time-consuming and often impossible to obtain because of bad preservation. That was the reason why the flakes in one notch were recorded as follows: (1) single flake, (2) multiple flakes, and (3) unknown.

For randomly selected 30 notched pebbles, notch depth and width was measured using a digital calliper.

8.4.Control sample - limestone collected in the Dishon stream

Limestone pebbles occur in all four of major river systems located in the vicinity of the JRD site: Nahal Rosh Pinnah, Nahal Mahanayim, Nahal Dishon, and Nahal Ayelet HaShachar. In order to get a better picture about the nature of the limestone pebbles found in these streams, a short visit to the Nahal Dishon stream was undertaken in 2021. The river bed of streams consists of limestone pebbles of various shapes. In the alluvial fans of streams running into the Hula Valley from the west, including Nahal Rosh Pinnah, Nahal Mahanayim, Nahal Dishon, and Nahal Ayelet HaShachar, which are only a few kilometres from the JRD site, limestone pebbles and cobbles are found in thousands. The main question was whether the elongated shape of pebbles is common in nature. Although the pebbles and cobbles in the stream display various shapes and sizes (Fig. 8.5.a and b), eight desired elongated pebbles were collected within a few minutes.

Fig. 8.5. a) (left) and b) (right) Limestone pebbles in the Dishon stream.

8.5. Typology of limestones at JRD

Typology was performed according to Adams (*2002*) for axes/adzes, picks, hammers, and Prowse (*2010*) for notched pebbles. Among ground stone tools, Adams distinguishes one category of hafted percussion tools (Fig. 8.6.), which consists of axes, mauls, picks, adzes, mattocks and hoes. Each of these subcategories bear a distinguishable set of traits. The boundaries between them are not, however, very sharp. Another issue is that many of these tools could often be re-utilized, for example, blunt axes might have been re-used as mauls, or even as hammer (*Adams 2002, 160*).

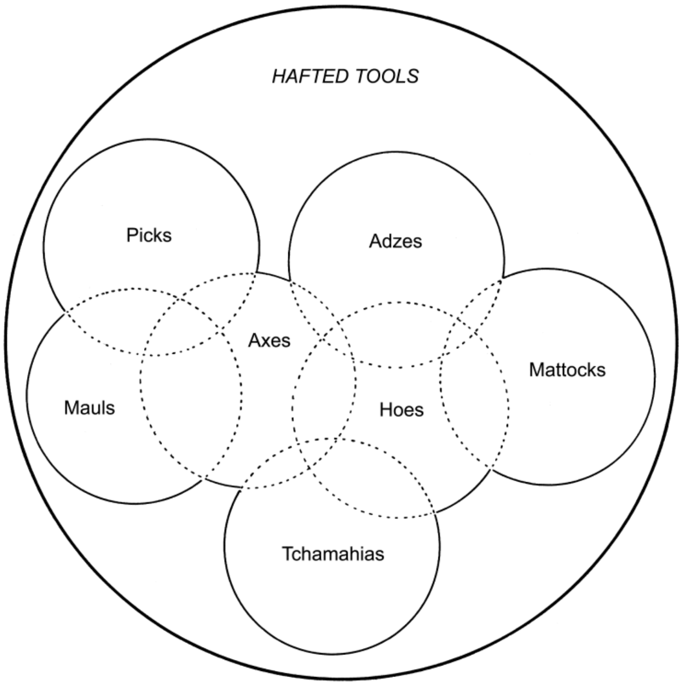


Fig. 8.6. Typology of hafted tools according to Adams (2002, 161).

8.5.1.Axe/Adze

Axes are determined as: "(1) *stone head with features for holding a handle, (2) with a blade situated parallel to the handle, (3) sharpened bit edge on one of the handle, (4) with rounded poll on the other side of the handle, (5) with use-wear damage consistent with the impact and abrasion from chopping motion, (6) damage oriented perpendicular or angular to the edge*" (*Adams 2002, 161*).

Adzes are determined as: "(1) *stone head with features for holding a handle, (2) sharpened bit edge on one of the handle, (3) with damage oriented perpendicular or angular to the edge, (4) with blade situated perpendicular to the handle, (5) with head positioned 90 degrees or less, relative to the handle, (6) with use-wear damage consistent with impact and abrasion from chopping and scraping motions*" (*Adams 2002, 161*).

The difference between the axes and adzes was not taken into account in this study as it was not the primary topic of the thesis and it would require more time and observation under a microscope. Furthermore, the insufficient preservation of certain limestone items doesn't allow to determine the exact hafting direction. Thus, axes and adzes were recorded into one common category (Fig. 8.7.2).

8.5.2.Pick

Picks (Fig. 8.7.3) are determined as: "(1) *stone head with features for holding a handle, (2) with rounded poll on the other side of the handle, (3) with use-wear consistent with blunt force trauma, (4) pointed bit on one side of the handle*" (*Adams 2002, 161*).

8.5.3.Hammer/maul

Hammerstones and mauls categories were combined (Fig. 8.7.4). The reason for not separating these two categories is because the boundaries between these two are very fuzzy. Hammerstones and mauls have "*the same general percussion function and incur the same use-wear damage*" (*Adams 2002, 152*).

8.5.4.Notched pebble

The notched pebbles (Fig. 8.7.1) are defined as flat, oval, or sub-rectangular pebbles on which two opposed notches were produced by flaking (*Rosenberg 2011 in Rosenberg – Agnon – Kaufman 2016*). Prowse (2010) distinguishes five types of notches pebbles: side-notched, end-notched, both-notched, atypical, and unknown (Fig. 6.4. in chapter 6). Side-notched refers to those sinkers that have notching on sides roughly parallel to the long axis. End-notched sinkers are notched on sides perpendicular to the long axis. Both-notched sinkers have four notches, two on long sides and two on short sides. Atypically-notched sinkers refer to sinkers with an anomalous number of notches (three or more than four) or to sinkers with non-parallel notches (*Prowse 2010, 78*).

8.5.5. Backed knife

The category of backed knives (Fig. 8.8.6) refers to limestone items made on a blade or flake with one side sharpened and the other blunt.

8.5.6. Unworked pebble

The category of unworked pebbles (Fig. 8.8.5) consist of all remaining pebbles, which were not classified into any preceding type, and don’t show any traces of being worked.

Two large boulders (Fig. 8.8.7) were separated from the rest of unworked pebbles, because of natural holes on their surface, extremely high weight (800-1000 g), and their uniqueness at the site.

Fig. 8.7. Typology of limestones: 1) Notched pebble, 2) Axe/Adze, 3) Pick, 4) Hammer/Maul.

Fig. 8.8. Typology of limestones: 5) Unworked pebble, 6) Backed knife, 7) Large boulder with natural holes.

8.6. Descriptive statistics

The statistical study was carried out using IBM SPSS 27 software, with metric attributes being presented through box plot diagrams, histograms, and cross tables. Boxplots present the full range of available data and its distribution. The box represents the interquartile range, which contains the 50% of values. The whiskers are lines that extend from the box to the highest and lowest values, excluding outliers. A line across the box indicates the median.

The outlier values consist of two categories: (1) extremes, marked by asterisks (*) and representing cases with distal values of more than 3 box lengths (box length = interquartile range) from the upper or lower edge of the box, and (2) outliers, marked by circles (○) and representing cases with distal values of between 1.5 and 3 box lengths (box length = interquartile range) from the upper or lower edge of the box.

Second way of graphical data representation was expressed by histograms. These are bar graph-like representations of data that buckets a range of outcomes into columns along the x-axis. The y-axis represents the number of count (frequency) of occurrences in the data for each column.

Stacked bar charts, which use rectangular boxes to represent categories of a variable, were used as well. Stacked variable is located on the x-axis. Each rectangular box on x-axis is made of smaller individual boxes called segments. The y-axis represents the count of cases.

Another way of data presentation was performed through cross tables, which produce a table for each categorical variable, showing the frequency and percentage of values that are present and the percentage of missing values for each category as related to the other variables.

8.7. Spatial analysis (GIS)

Geographic Information Systems are used by archaeologists to explore, analyse, and interpret spatial data. The systematic recording of the spatial distribution of finds helps to recognize functional units, which correspond to areas set for work, waste dumping, butchering, etc. (D'Andrea and Gallitti 2004). ArcGIS Pro was used for the visualisation of data obtained by the total station. Basic maps were created for all measured limestones in individual stratigraphic layers, using different symbols to distinguish the typology. Three spatial analysis tools were used: Kernel density analysis, Optimised hot spot analysis, and Density-based clustering.

Regarding the extent of the excavated layers, 3-0, 3a, and 3c layers were excavated in most squares in area B. Layer 3b, which was excavated in N, O, P, Q, and R squares, was very thin and poor in finds. Layer 4 was excavated in L96-98, M96-99, N96-103, O96-101, and P96-101. Layer 5 was excavated in the lowest extent, only 20 square metres, in rows L, M, N, O, and Q, stopping at squares 99 or 100.
Kernel density calculates the density of point and line features in a neighbourhood around those features. A smoothly curved surface is fitted over each point. The surface value is highest at the location of the point and diminishes with increasing distance from the point, reaching zero at the Search radius distance from the point. The volume under the surface equals the Population field value for the point, or one if NONE is specified. The density at each output raster cell is calculated by adding the values of all the kernel surfaces where they overlay the raster cell centre. The analysis shows the artefact density, which helps find zones with a nonrandom concentration of artefacts. That is why the Population field was not specified in the presented analyses. The search radius was set to default which means that it is computed specifically for the input dataset using a spatial variant of Silverman's Rule of Thumb (*How Density works 2022).* This analysis was performed on measured limestone from all layers.

The Optimised Hot Spot Analysis tool identifies peak distances using Incremental Spatial Autocorrelation. The analysis can identify zones where there is the co-occurrence of the artefacts with similarly high or low values in the given parameter, which helps find a nonrandom spatial distribution of artefacts having specific parameters. If a peak distance is found, this distance becomes the scale of analysis. If multiple peak distances are found, the first peak distance is selected. Optimised hot spot analysis uses parameters derived from characteristics of the input data. It interrogates the data to obtain the settings that will yield optimal hot spot results (*How Optimized Hot Spot Analysis works 2022*). I used this analysis for the weights and length/width index of all limestone objects in selected layers.

Density-based clustering tool works by detecting areas where points are concentrated and where they are separated by areas that are empty or sparse. It extracts clusters from the Input Point Features parameter value and identifies any surrounding noise. There are three Clustering Method parameter options: Defined distance (DBSCAN), Self-adjusting (HDBSCAN), and Multi-scale (OPTICS) algorithms (ArcMap Desktop help desk). For the presented analysis, Defined distance (DBSCAN) was chosen. It is a simple algorithm allowing to specify the distance that will be used to define spatial clusters. The method presumes that the clusters have similar densities. It fits the aims of the analysis as all the clusters should represent the same potential phenomena - residues of nets. The differences in weights of the artefacts among the defined clusters were tested by KW a W test to explore if we can consider them as the specific selection of objects of similar weight.

9. Limestone assemblage of JRD

In this chapter, the first part is devoted to the whole limestone assemblage including the data about the preservation, roundness/angularity, preliminary types, and weight. Then, analysed limestone pebbles are presented by layers, followed by typological classification, and technological analysis focused on notches. The last section of the chapter is devoted to the spatial distribution of limestone artefacts in all layers.

9.1. Preservation

The preservation of limestone is shown in Tab. 9.1. The majority of stones throughout the stratigraphy are weathered, few are rolled and few are slightly weathered. No artefact labelled as fresh was recorded. All the limestone present surface alteration probably due to both pre- and post-depositional processes. The post-depositional ones might be of chemical nature (Fig. 9.1.). The waterlogged environment of the site was probably an important factor and had an impact on the preservation of the artefacts. Most of the artefact looks somewhat rolled and smooth. Flake scars are not always visible and edges aren’t sharp in most cases.

In comparison, the limestone pebbles collected in the Dishon stream (Fig. 9.2.) seem to bear no chemical alteration on the surface, are generally more colourful (rather in the yellow-orange range, than white and grey), but also weathered, and look smooth. The eight pebbles collected in the Dishon display features similar to worked pebbles: 8-shaped or arc-shaped form, scars on surface, which might be caused by being carried by strong stream, and similar dimensions: 8-11 cm in length, 3-5 cm in width, 2-4 cm in thickness, and 90-350 g in weight, with mean weight 160 g.

Fig. 9.1. Chemically altered surface of limestone pebbles.

		Preservation			Total
		slightly weathered	weathered	rolled	
Layer	3-0	3	12	2	17
	3a	5	101	10	116
	3b	0	1	1	2
	3c	4	53	2	59
	3c?	0	57	2	59
	3c/4	0	3	1	4
	4	3	53	1	57
	5	3	7	1	11
	D8	0	0	1	1
	mixed context	0	1	0	1
	surface	1	1	0	2
Total		19	289	21	329

Tab. 9.1. Preservation of limestone per layer.

Fig. 9.2. Photos of Dishon limestone pebbles.

9.2. Roundness/Angularity

Roundness in geology is a measure of smoothness of particles. It is the result of abrasion history, which is controlled by depositional agents and environment. Particle roundness also depends on mineralogy, limestone is soft and soft minerals are abraded more easily than hard minerals, and transport distance. Particles become more abraded and hence more rounder as the distance increases (Schwab 2021). Roundness of limestones is presented in Tab. 9.2., showing that very few limestones are very angular or very rounded.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	58	.6	.7	.7
	2	242	2.6	3.1	3.8
	3	547	6.0	6.9	10.8
	4	1448	15.8	18.4	29.1
	5	3537	38.6	44.9	74.0
	6	1340	14.6	17.0	91.1
	7	466	5.1	5.9	97.0
	8	169	1.8	2.1	99.1
	9	69	.8	.9	100.0
	Total	7876	85.9	100.0	
Missing system		1298	14.1		
Total		9174	100.0		

Tab. 9.2. Frequency of roundness and angularity of limestones based on Krumbein's scale (Appendix 2.).

9.3.Preliminary types

The highest concentration of limestone artefacts occur in layer 3a with over 2000 stones, followed by layer 5 and 4 (Fig. 9.3.). Elongated pebbles were found throughout the stratigraphical sequence, from layer 3-0 to 5 (Tab. 9.3.). Interestingly, about 14% (N=122) of layer 3c and 18,9% (N=33) of layer 3b limestone are elongated pebbles, while for other layers the proportion is much lower. It is 3,6% for layer 5 and 5,4% for layer 4. Coins (N=80) represent less than 1% of the whole assemblage. They appear predominantly in layers 3-0 (N=20), 3a (N=17), and 4 (N=20). Limestones labelled as edge (N=60) represent 0,5% of the assemblage. The largest amount occurs in layers 4 (N=15) and 5 (N=13). Axes (N=58) represent only 0,7% of the whole assemblage. Almost 80% of axes occur in layer 3a (N=46), with a few specimens in 3-0, and 3c.

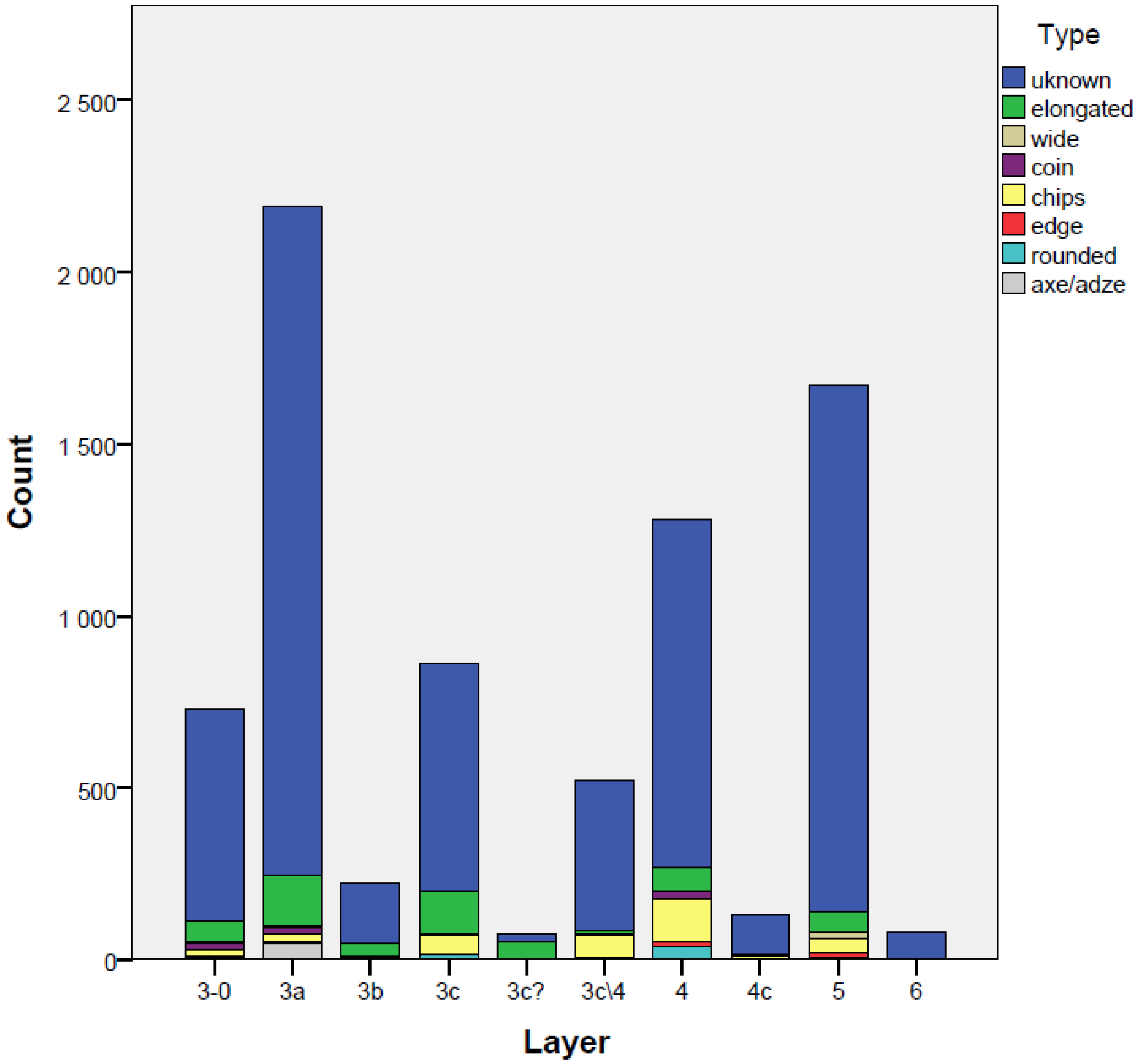


Fig. 9.3. Stacked bar chart: Preliminary types per layer.

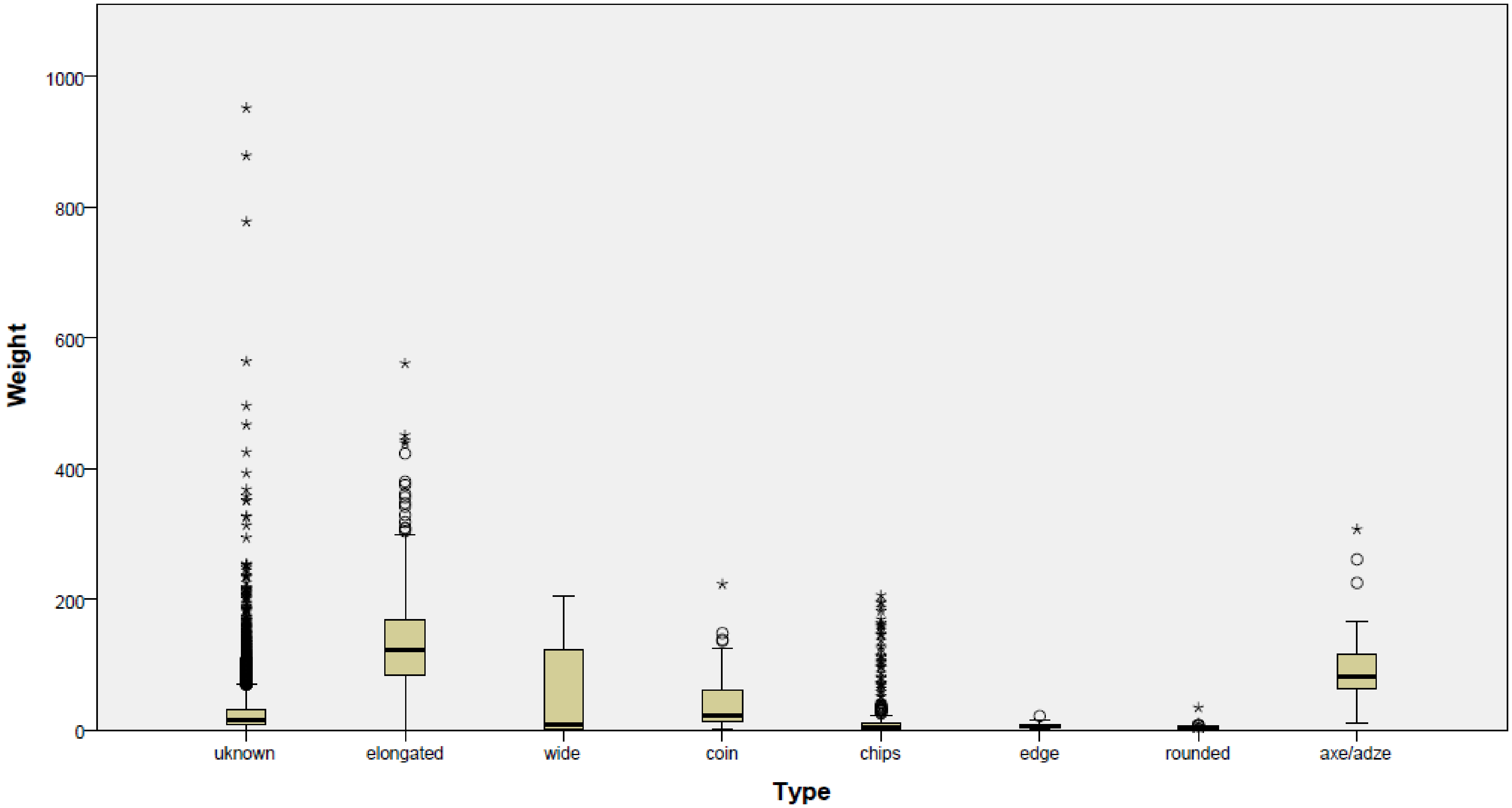
	Type								Total
	unknown	elongated	wide	coin	chips	edge	rounded	axe/ adze	
Layer 3-0	620	56	5	20	17	5	2	6	731
3a	1945	147	4	17	25	2	5	46	2191
3b	175	33	0	4	5	0	4	0	221
3c	663	122	2	7	52	2	11	4	863
3c?	22	49	1	1	0	0	0	1	74
3c/4	437	10	1	2	68	3	2	0	523
4	1015	69	2	20	126	15	36	0	1283
4c	114	5	0	2	9	0	1	0	131
5	1535	61	15	2	43	13	5	0	1674
6	80	0	0	0	1	0	0	0	81
D10	1	0	0	0	0	0	0	0	1
D3	61	0	0	0	0	0	0	0	61
D4	417	3	1	1	0	0	1	1	424
D5	48	0	0	0	0	0	0	0	48
D6	123	4	1	0	0	0	0	0	128
D7	3	0	0	0	0	0	0	0	3
D8	32	2	0	2	0	0	2	0	38
D9	3	0	0	0	0	0	0	0	3
mixed context	134	2	3	2	4	0	3	0	148
surface	7	6	0	0	0	0	1	0	14
Total	7432	569	35	80	350	40	73	58	8640
Total in %	86,0 %	6,6 %	0,4 %	0,9 %	4,1 %	0,5 %	0,8 %	0,7 %	100%

Tab. 9.3. Preliminary types per layer.

9.4.Weight by preliminary type

The distribution of weight per type is shown in fig. 9.4. The majority of limestone type 1 (unknown) weigh less than 30 grams. The few extremes (between 750-1000 g) represent large cobbles with natural holes. The weight of elongated pebbles mostly range between 100-200 g, while axes/adzes are lighter. The weight of chips, edge, and rounded pebbles is mostly very low.

Fig. 9.4. Weight of all limestone, types 1-8: (1) unknown (indeterminate), (2) elongated, (3) wide, (4) coin, (5) chips, (6) edge, (7) rounded pebble, (8) axe/adze.



9.5.Measured limestone: descriptive statistics

Table 9.4. present summary of descriptive statistics for all measured pebbles. The following box plots represent weight (Fig. 9.5.), max. length (Fig. 9.6.), max. width (Fig. 9.7.), and max. thickness (Fig. 9.8.) per layer, including the measured specimens from area D, mixed context, and surface.

		Max. length (mm)	Max. width (mm)	Max. thickness (mm)	Length between notches (mm)	Weight (g)
N	Valid	503	503	502	207	585
	Missing	121	121	122	417	39
Mean		89.439	44.74	23.823	42.169	141.14
Std. Deviation		14.8050	11.246	7.9275	8.2218	83.247
Minimum		41.0	13	7.0	22.0	11
Maximum		147.0	114	68.0	77.0	952

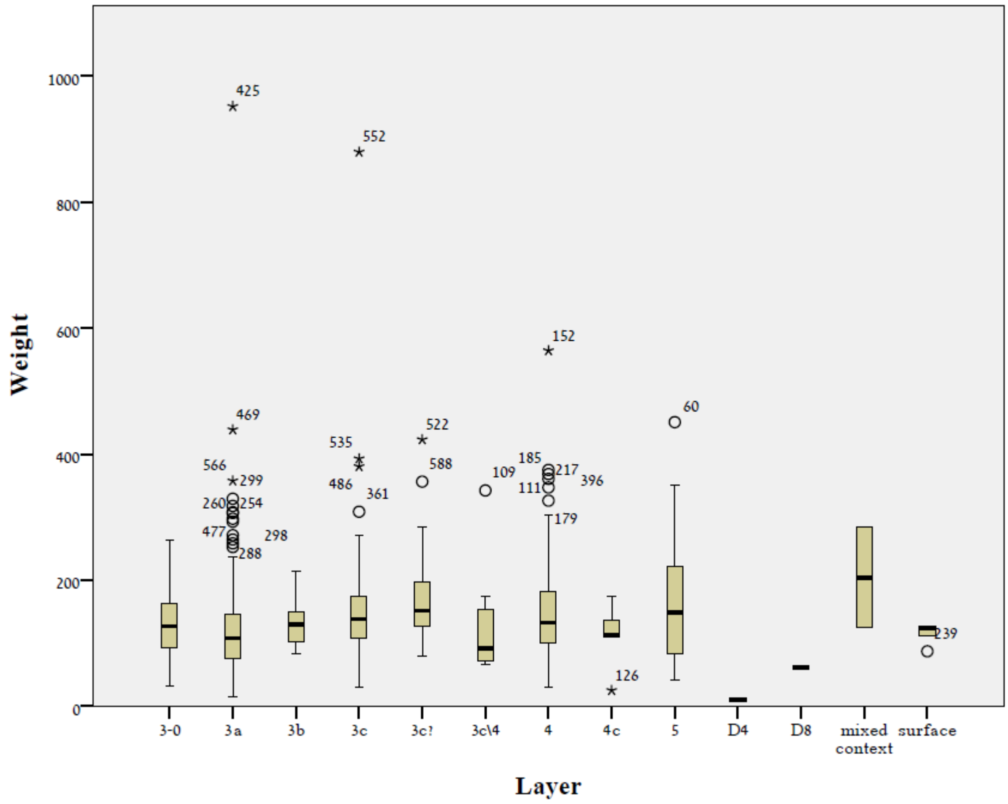
Tab. 9.4. Descriptive statistics of all measured limestones (max. length, max. width, max. thickness, length between notches, and weight).

The weight of pebbles range mostly between 100-200 grams throughout the stratigraphy. The two extremes, weighing between 800-1000 g, represent two large cobbles with natural holes, which are unique at the site. Weight of pebbles in layer 5 shows more variability than in other layers with secure context. The length distribution shows that the length of most pebbles range between 7,5 - 10 cm. The width of pebbles ranges mostly between 3-6 cm. The variability of maximal thickness is the smallest among all the measurements presented here, ranging mostly between 2 and 3 cm, with the mean of 23.82 mm (st.d.=7.92).

The variability of pebbles' sections (side sectional view) is represented in fig. 9.9. It shows that side sectional views of pebbles are very variable. Irregular ones predominate, being followed by convex, double convex, and triangular sections. Regarding top sectional view (shape) (Fig. 9.10.), 8-shaped/pear shaped pebbles clearly predominate in the assemblage with close to three hundred specimens. Almost hundred items display arc/bow shape.

Fig. 9.5. (above) Weights of measured limestone pebbles per layer.

Fig. 9.6. (bottom) Max. lengths of measured limestone pebbles per layer.



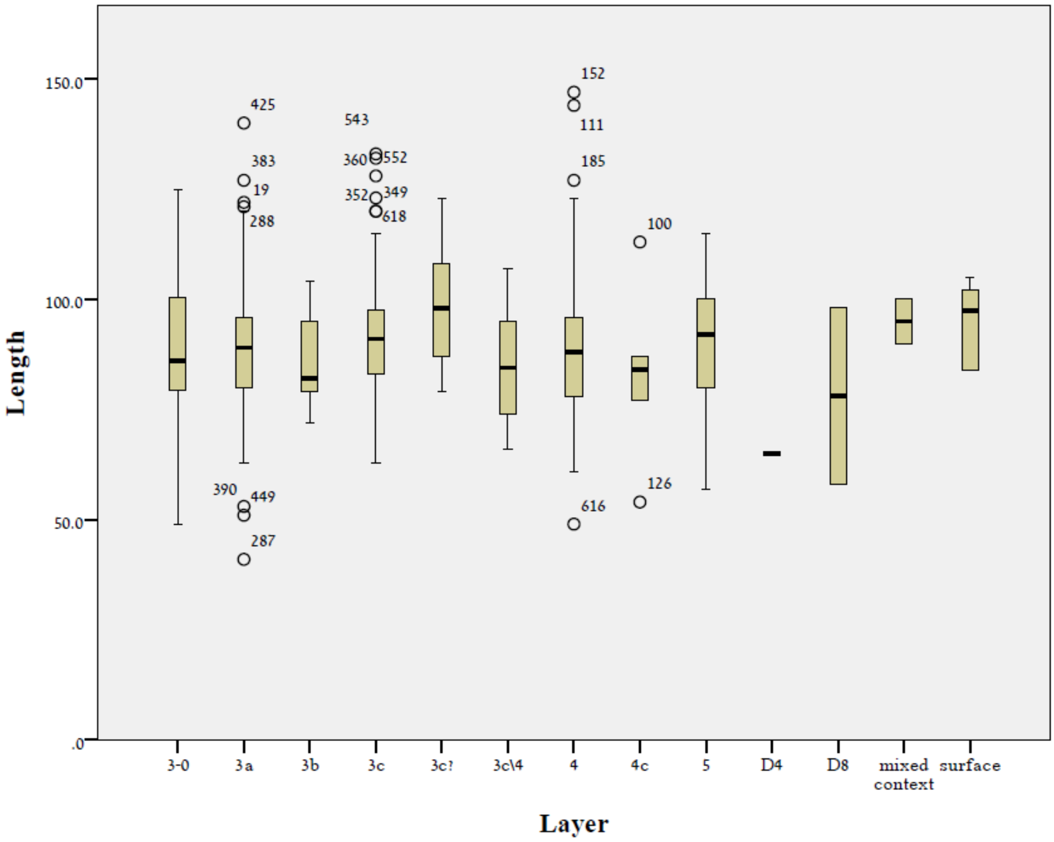
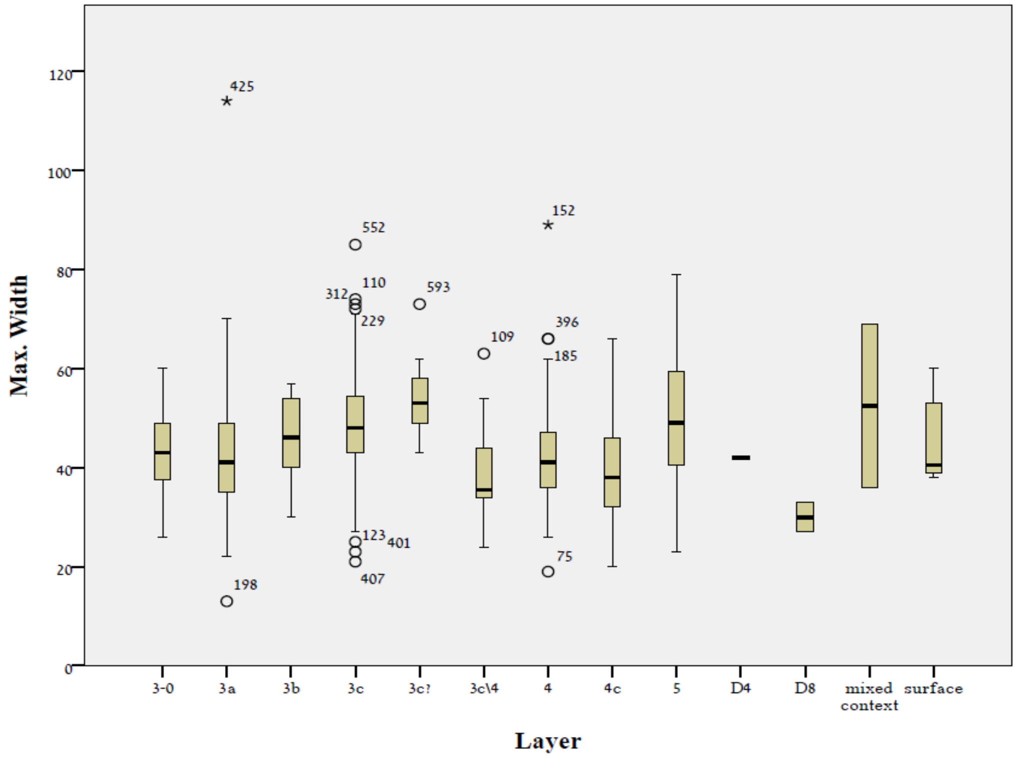
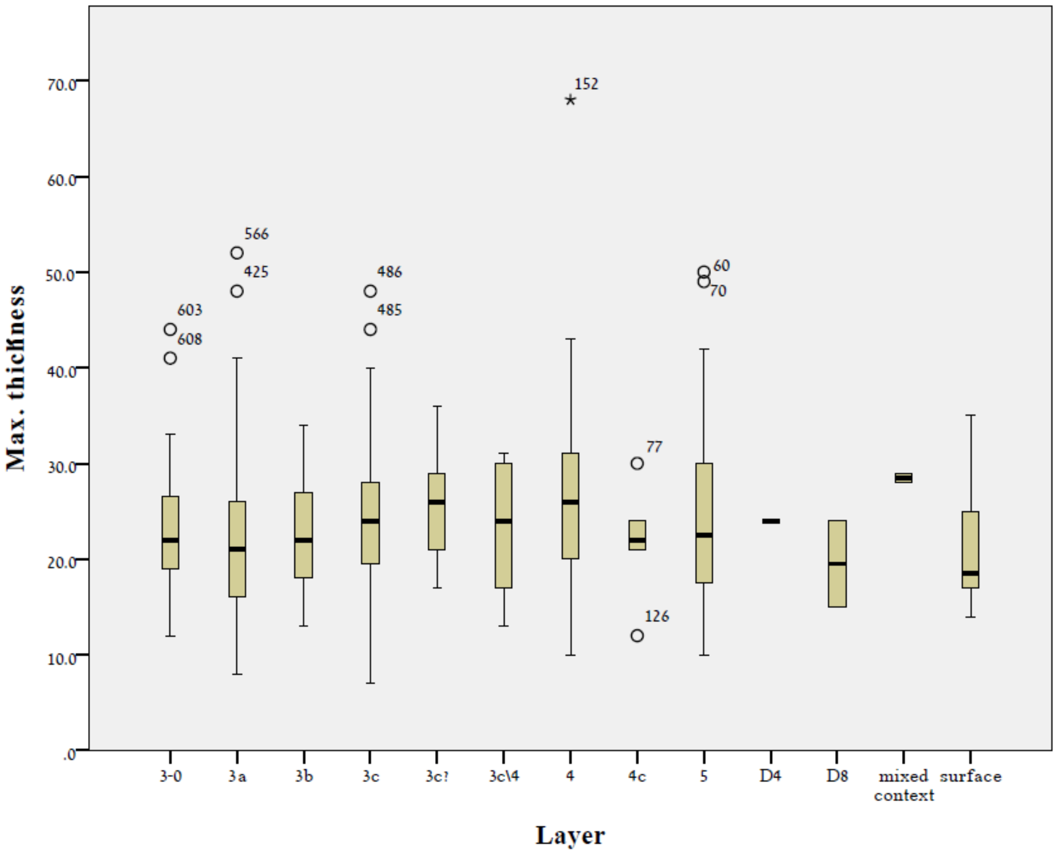


Fig. 9.7. (above) Max.widths of measured limestone pebbles per layer.

Fig. 9.8. (bottom) Max. thickness of measured limestone pebbles per layer.





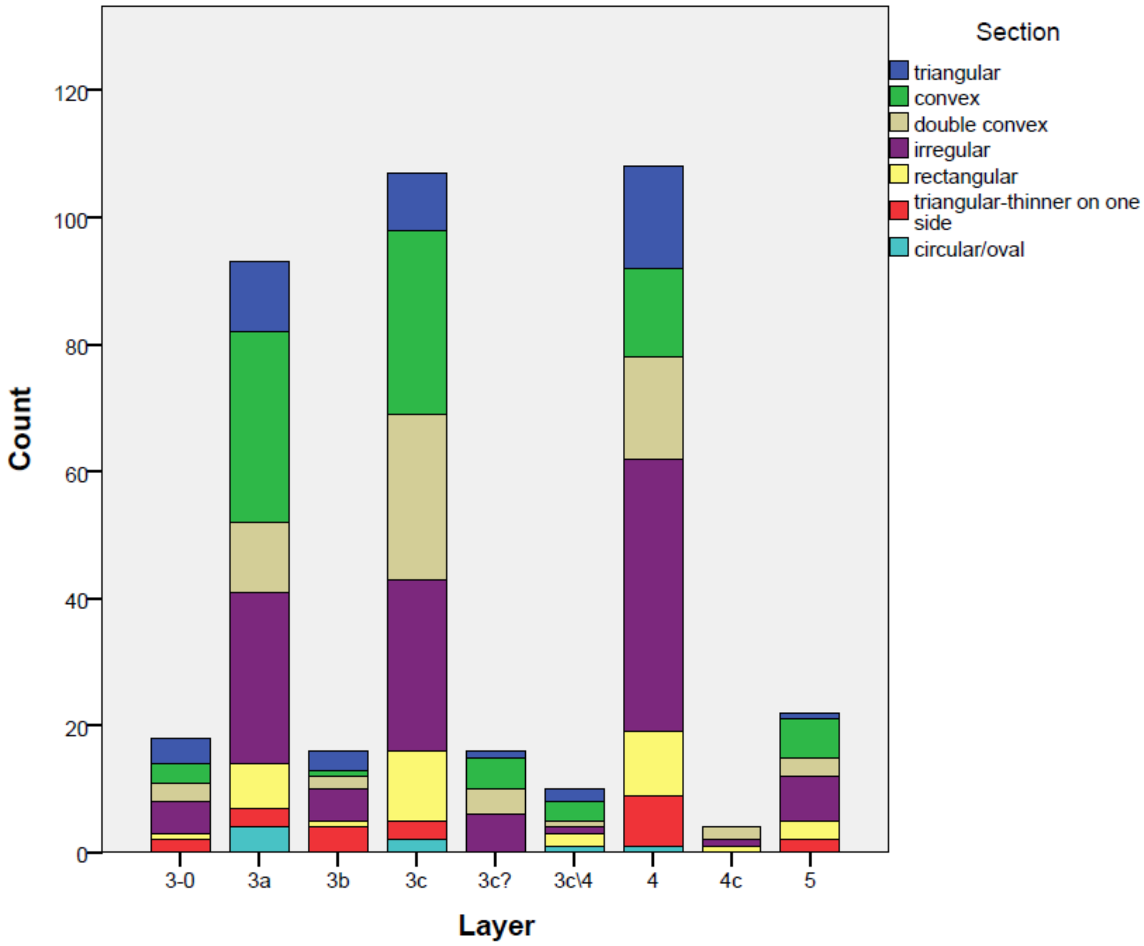


Fig. 9.9. (above) Side sectional view (sections) of measured limestone pebbles: (1) triangular, (2) convex, (3) double convex, (4) irregular, (5) rectangular, (6) triangular, thinner on one side, (7) circular/oval.

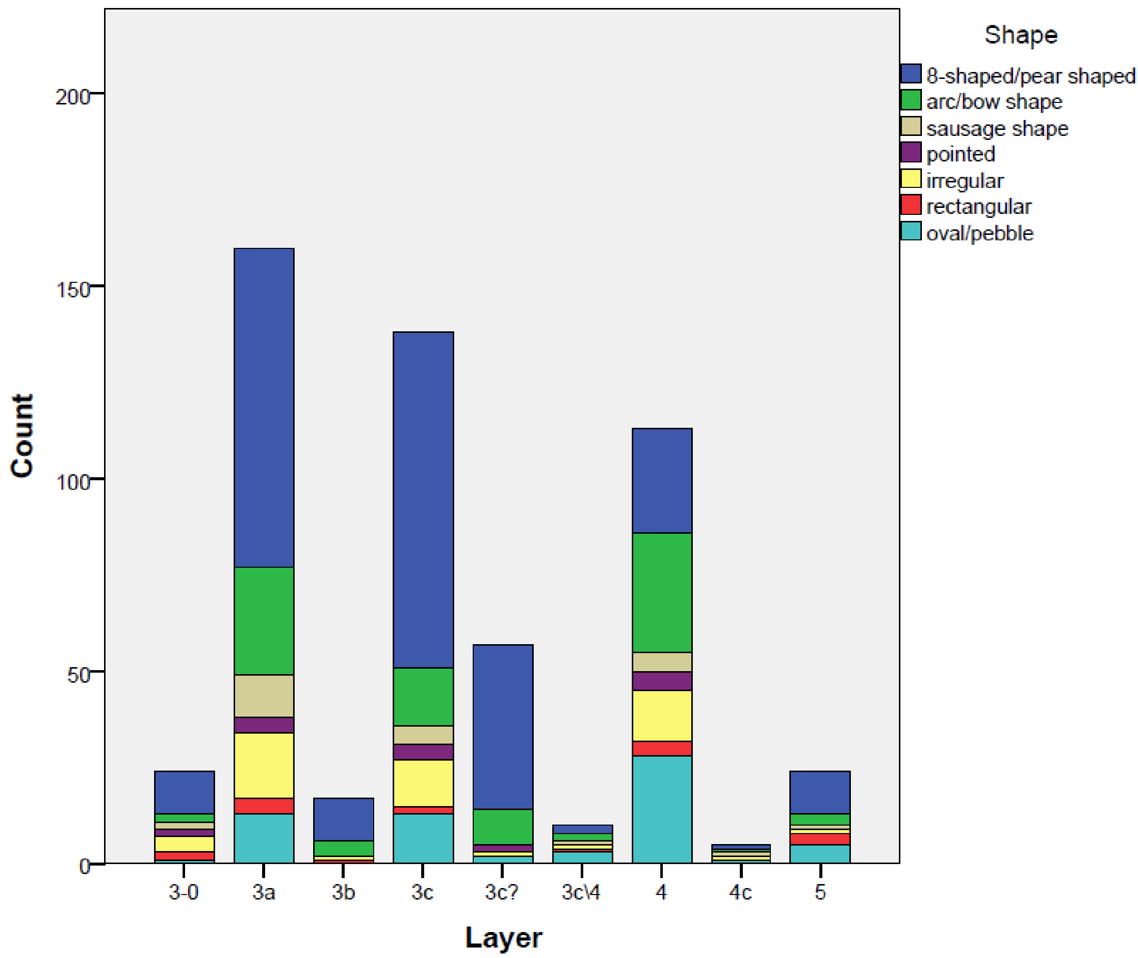


Fig. 9.10. (below) Top sectional view (shapes) of measured limestone pebbles: (1) 8-shaped/pear shaped, (2) arc/bow shaped, (3) sausage shaped, (4) pointed, (5) irregular, (6) rectangular, and (7) oval-shaped.

9.6. Data by typology

Typology of measured pebbles is shown in Fig. 9.11 and Tab. 9.5. Notched pebbles (N=206) represent 2,2% of the whole limestone assemblage. Notched pebbles appear already in layer 5 and are represented throughout the stratigraphical sequence. The highest concentration was observed in layer 3c (38,8% of total amount of notched pebbles). Unworked pebbles also occur in all layers, starting in layer 5. In layer 5, the ratio of notched to unworked pebbles is almost the same, while in layer 4 there is a disproportion on behalf of unworked pebbles. In layers 3c, there is a higher amount of notched pebbles (N=80) than unworked ones (N=53). Same stands for layer 3b with 12 notched pebbles and 5 unworked.

In layer 3a, the ratio of notched pebbles and axes/adzes is almost equal. Contrary to notched and unworked pebbles, axes/adzes appear only in layer 3c in small amounts and are more distinctly represented in layer 3a (77,6% of axes/adzes total amount), similarly to picks, hammers/mauls, and backed knives.

Typology									
		notched pebble	axe/adze	pick	hammer /maul	unworke d pebble	backed knife	large stone with natural holes	Total
Layer	3-0	8	6	2	0	13	1	0	30
	3a	47	45	3	3	105	5	1	210
	3b	12	0	0	0	5	0	0	17
	3c	80	4	3	1	53	0	1	142
	3c?	29	1	0	0	28	0	0	58
	3c\4	2	0	0	0	8	0	0	10
	4	8	0	3	3	102	1	0	117
	4c	1	0	0	0	4	0	0	5
	5	12	0	0	1	10	1	0	24
	D4	0	1	0	0	0	0	0	1
	D8	1	0	0	0	1	0	0	2
	mixed context	1	0	0	0	1	0	0	2
	surface	5	0	0	0	1	0	0	6
Total		206	58	11	8	331	8	2	624
Total in %		33,0 %	9,3 %	1,8 %	1,3 %	53,0 %	1,3 %	0,3 %	100%

Tab. 9.5. Typology per layer.

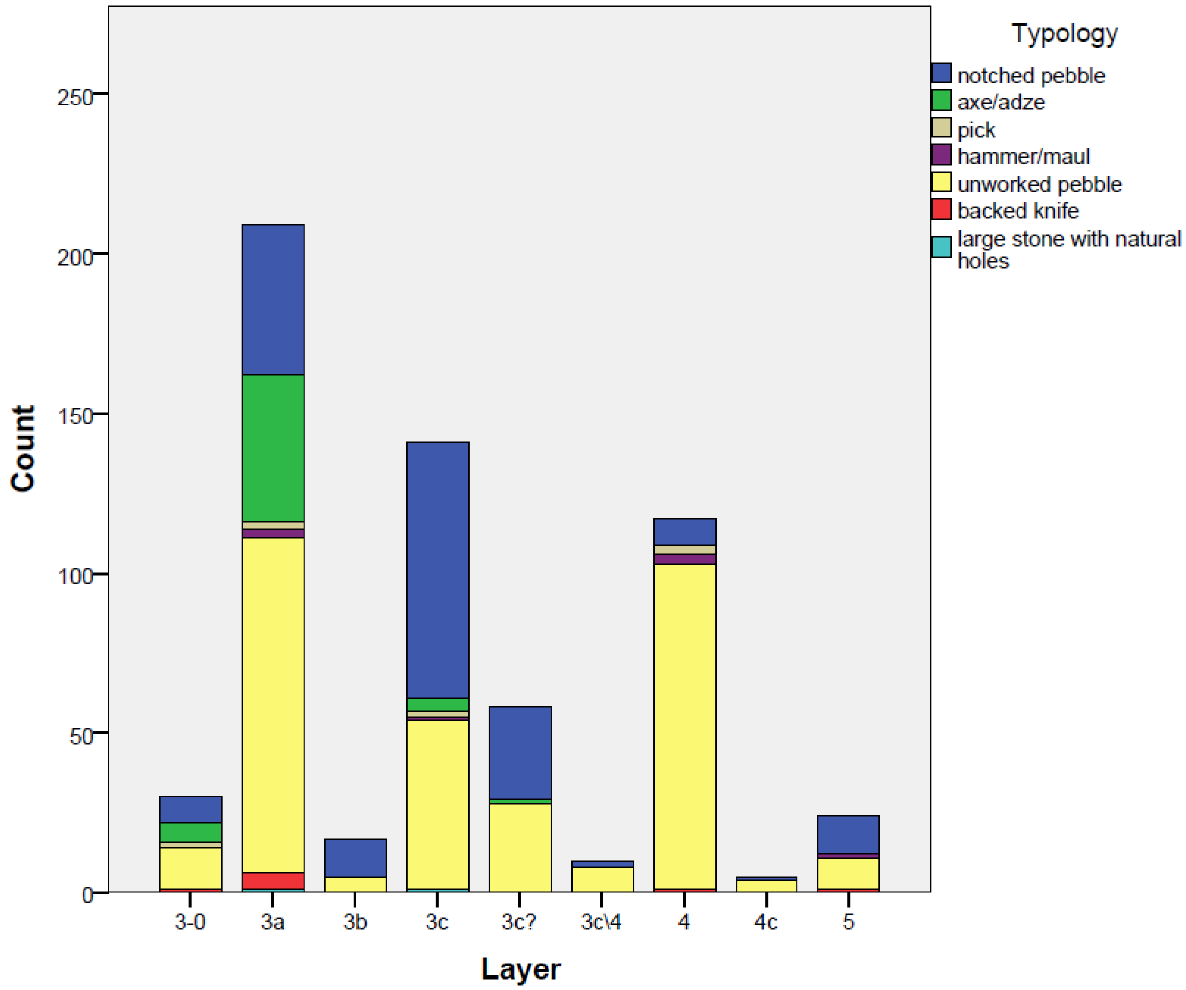


Fig. 9.11. Typology per layer.

9.6.1. Notched pebbles

Summary of notched pebbles' dimensions is shown in Tab. 9.6. Notched pebbles seem to be very consistent in max. length, max. width, max. thickness, and length between notches (Fig. 9.12. and 9.13.), with standard deviation less than 15 mm. Contrary to these measures, weight is more variable ranging mostly between 100-200 g.

		Max. length (mm)	Max. width (mm)	Max. thickness (mm)	Length between notches (mm)	Weight (g)
N	Valid	174	174	74	156	197
	Missing	32	32	32	50	9
Mean		92.299	50.47	23.851	42.372	157.55
Median		92.000	51.00	24.000	42.000	147.19
Std. Deviation		12.7657	9.277	6.4745	8.0476	57.599
Minimum		51.0	27	9.0	22.0	26
Maximum		132.0	79	48.0	74.0	380

Tab. 9.6. Descriptive statistics of notched pebbles (max. length, max. width, max. thickness, length between notches, and weight).

Frequencies of weight, length, max. width, and length between notches per layer are shown in Weight is ranging mainly between 100 - 200 grams. Length is ranging predominantly between 8 - 10 cm. Range of width is between 4 - 6 cm, and thickness between 2 - 3 cm. Length between notches (=internotched width) ranges mainly between 3 - 5 cm.

Throughout the stratigraphic sequence, the majority of notched pebbles have two notches (Tab. 9.7.), placed on long sides, and parallel to each other (Tab. 9.8.). None of end-notched pebbles were observed in the assemblage. Five atypical notched pebbles have three notches.

		Layer										
Number of notches		3-0	3a	3b	3c	3c?	3c/4	4	4c	5	Total	Total in %
	1	1	2	2	3	1	0	0	1	1	11	7,5 %
	2	3	29	9	59	13	2	5	0	10	130	89,0 %
	3	0	0	1	4	0	0	0	0	0	5	3,4 %
Total		4	31	12	66	14	2	5	1	11	146	

Tab. 9.7. Number of notches per layer.

	Layer									
Position of notches	3-0	3a	3b	3c	3c?	3c/4	4	5	Total	Total in %
Parallel	2	28	8	52	13	2	3	9	117	84,2 %
Concurrent	0	1	1	7	0	0	2	1	12	8,6 %
Other	2	0	1	5	1	0	0	1	10	7,2 %
Total	4	29	10	64	14	2	5	11	139	

Tab. 9.8. Position of notches on notched pebbles per layer.

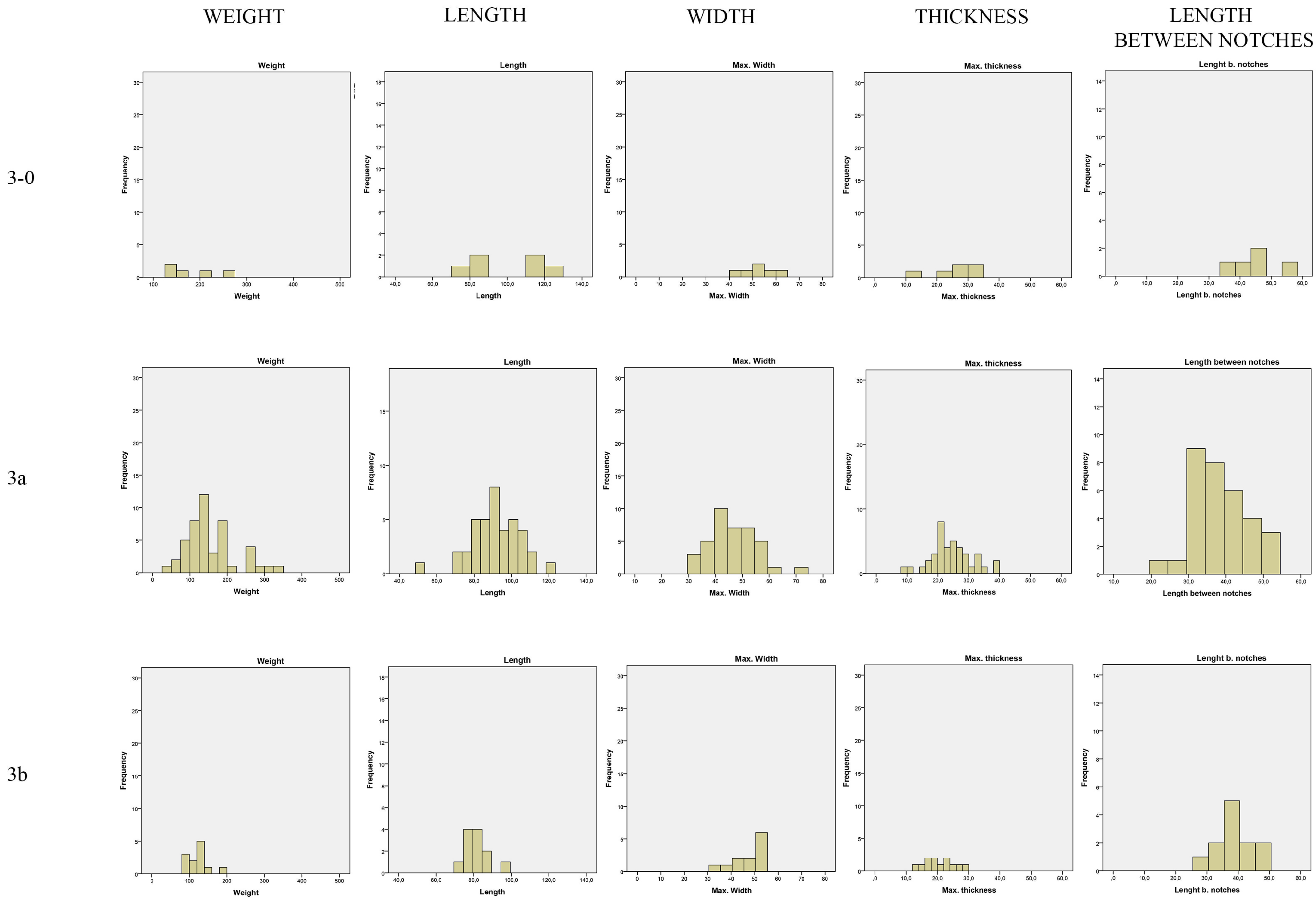


Fig. 9.12. Histograms of frequencies of notched pebbles in layers 3-0, 3a, and 3b.

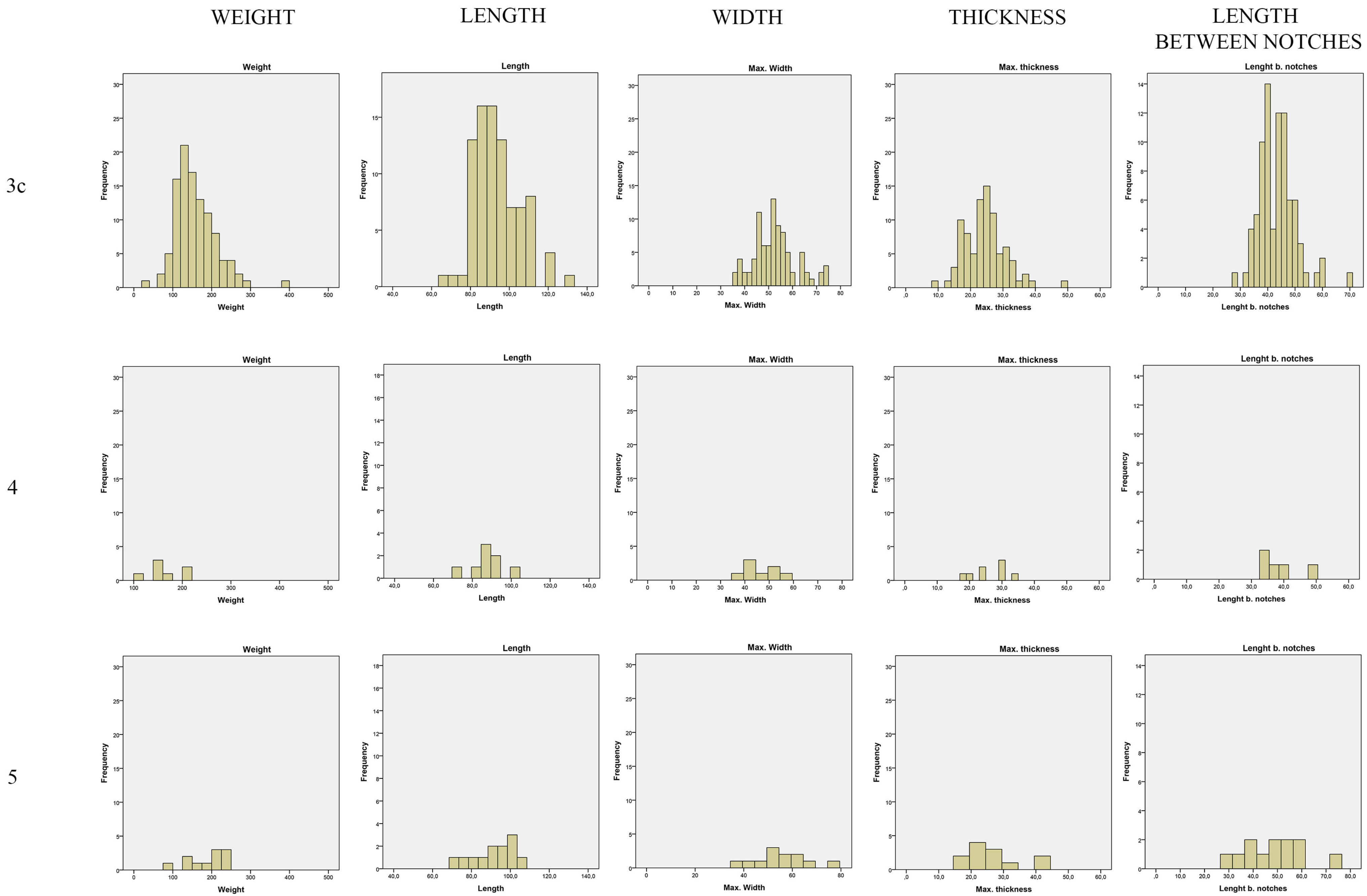


Fig. 9.13. Histograms of frequencies of notched pebbles in layers 3c, 4, and 5.

Fig. 9.14. Notched pebbles.

9.6.2.Unworked pebbles

Over 300 unworked pebbles were measured. The summary of descriptive statistics is shown in Tab. 9.9. The frequencies of weight, length, width and thickness per layer are shown in Fig. 9.15. and 9.16. “Length between notches” was measured only for the unworked pebbles which were naturally constricted in the middle.

Weight frequency ranges mainly between 75 - 150 grams. Range of length is predominantly from 7 to 10 cm, width from 3 to 5 cm, and thickness from 2 to 3 cm.

	N	Minimum	Maximum	Mean	Std. Deviation
Weight	309	16	564	135,32	72,899
Length	243	49,0	147,0	87,996	14,6447
Max. Width	243	13	89	40,96	9,764
Max. thickness	243	10,0	68,0	25,037	8,3207

Tab. 9.9. Unworked pebbles: summary of descriptive statistics: weight, max. length, max. width, max. thickness.

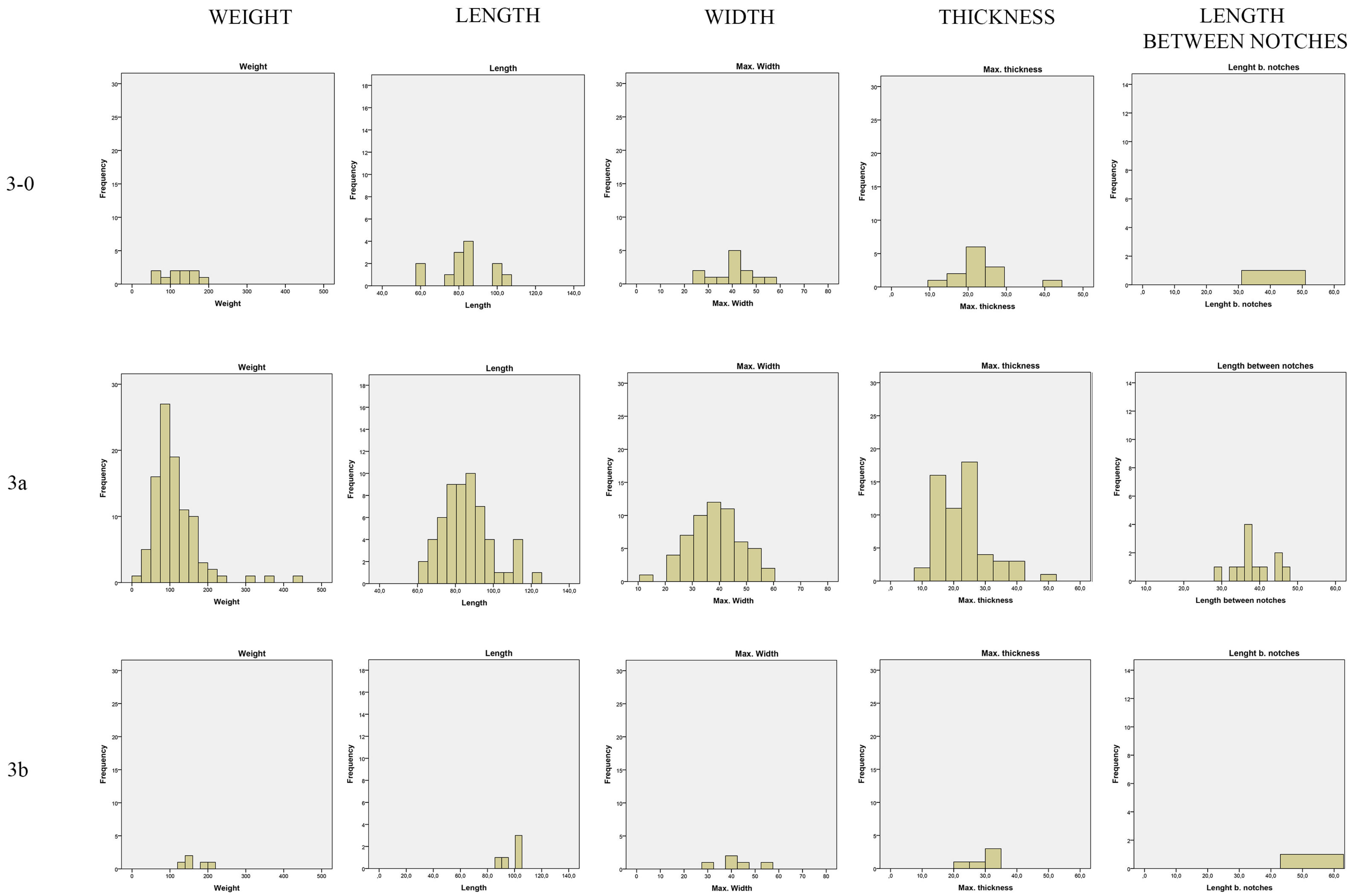


Fig. 9.15. Histograms of frequencies of unworked pebbles in layers 3-0, 3a, and 3b.

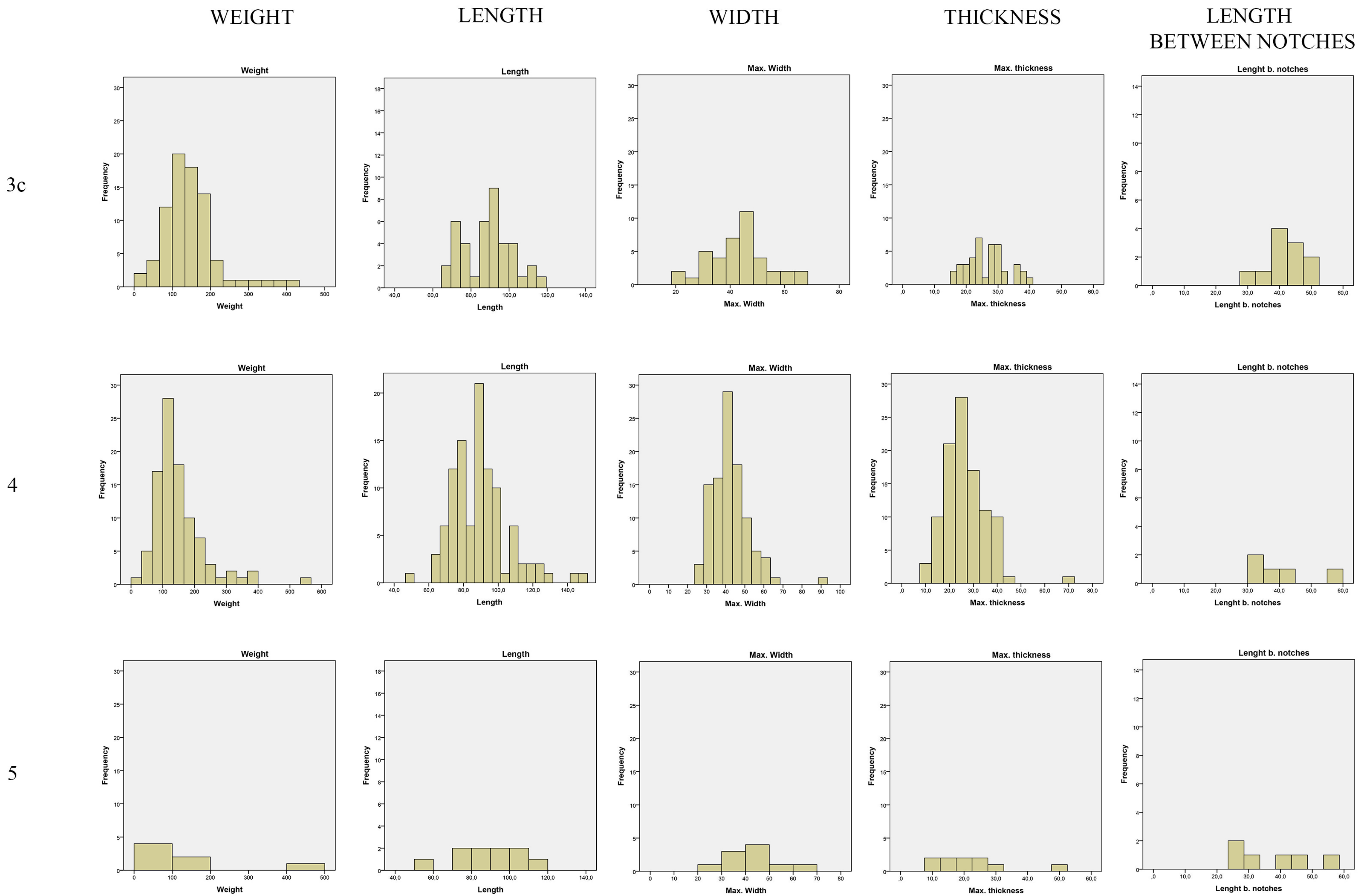


Fig. 9.16. Histograms of frequencies of unworked pebbles in layers 3c, 4, and 5.

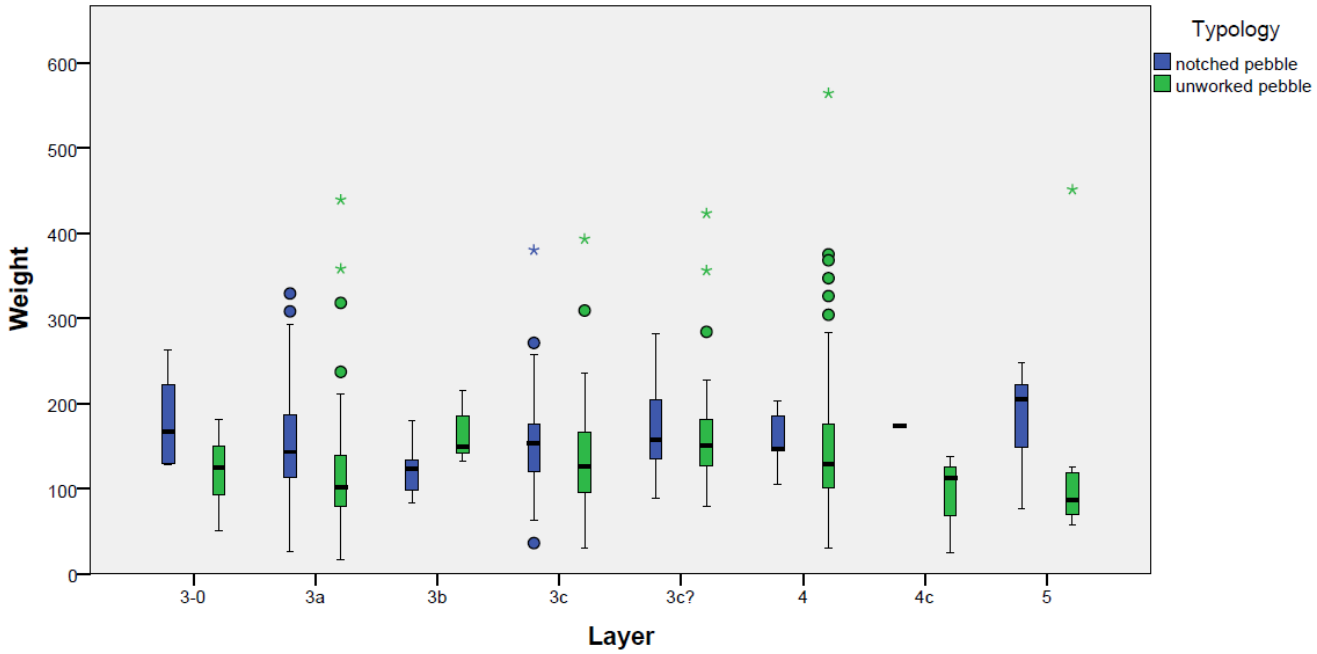


Fig. 9.17. Box plot of notched and unworked pebbles per layer.

The box plot (Fig. 9.17.) shows the distribution of weight of notched and unworked pebbles throughout the stratigraphy. In layers 3-0, 3a, and 5 the weight of the notched pebbles is higher than the weight of the unworked. By contrast, the weight of notched pebbles in layer 3b is lower than the weight of unworked pebbles. Layer 3c doesn't display noticeable differences between the weight of notched and unworked ones. Weight of unworked pebbles in Layer 4 show a higher variance than the unworked pebbles in other layers.

	Mean weight (g)	Mean length (mm)	Mean width (mm)	Mean thickness (mm)	Mean length b. notches (mm)
Layer 3-0	181,96	99,33	51,33	25,16	44,2
Layer 3a	155,59	91,56	46,74	23,81	38,68
Layer 3b	120,96	81,58	48,33	19,5	39,25
Layer 3c	158,51	94,23	51,93	23,88	43,06
Layer 4	159,19	87,37	46,0	25,62	38,8
Layer 5	184,95	91,66	56,08	26,25	48,25

Tab. 9.10. Notched pebbles: mean weight, length, width, thickness, length between notches per layer.

	Mean weight (g)	Mean length (mm)	Mean width (mm)	Mean thickness (mm)
Layer 3-0	120,53	83,76	40,08	23,07
Layer 3a	116,02	86,60	38,29	22,89
Layer 3b	164,32	98,40	41,40	28,0
Layer 3c	148,06	88,47	43,08	26,15
Layer 4	148,85	89,24	42,36	26,52
Layer 5	138,49	87,1	43,9	22,6

Tab. 9.11. Unworked pebbles: mean weight. length, width, thickness, length between notches per layer.

Despite the fact that the mean values don’t take into account the values reflecting variability within the layers, means of dimensions still can show the general trends within the layer. Throughout the stratigraphic sequence the mean length, width, thickness, and length between notches of notched pebbles are very consistent (Tab. 9.10.). Mean length ranges from 8 - 10 cm, and mean width is between 4 - 5,6 cm. Mean thickness ranges between 1,9 - 2,6 cm. Length between notches is between 3,8 - 4,8 cm. Mean weight is more variable than the other measures, ranging between 120 - 185 g.

Similarly to notched pebbles, the mean length, width, and thickness of unworked pebbles are very consistent throughout the stratigraphic sequence (Tab. 9.11.). Mean length ranges between 8,3 to 9,8 cm. Mean width is between 3,8 and 4,3 cm, and mean thickness ranging between 2,2 and 2,8 cm. Weight is the most inconsistent measure, ranging between 120 - 165 g.

When comparing means of these dimensions, notched and unworked pebbles are very similar in length, ranging between 8-10 cm, and thickness ranging between 2 - 3 cm. Mean width of notched pebbles (4-5,6 cm) is higher than the one of unworked pebbles (3,8-4,3 cm), while length between notches (=internotch width) display more similar values (3,8-4,8 cm). Notched pebbles are heavier compared to unworked ones in all layers, except layer 3b.

Kruskal-Wallis H Test was used to test the statistical significance of the width and elongation (width/length index) differences between notched and unworked pebbles. Both tests prove that the differences are not accidental. The Boxplot (Fig. 9.18.) shows the distribution of maximal width of notched and unworked pebbles. Outlier values in this case are considered any values over 1.5 times the interquartile range over the 75th percentile or any values under 1.5 times the interquartile range under the 25th percentile.

data: Width and Typology

Kruskal-Wallis chi-squared = 88.282, df = 1, p-value < 2.2e-16

data: WL and Typology

Kruskal-Wallis chi-squared = 52.075, df = 1, p-value = 5.342e-13

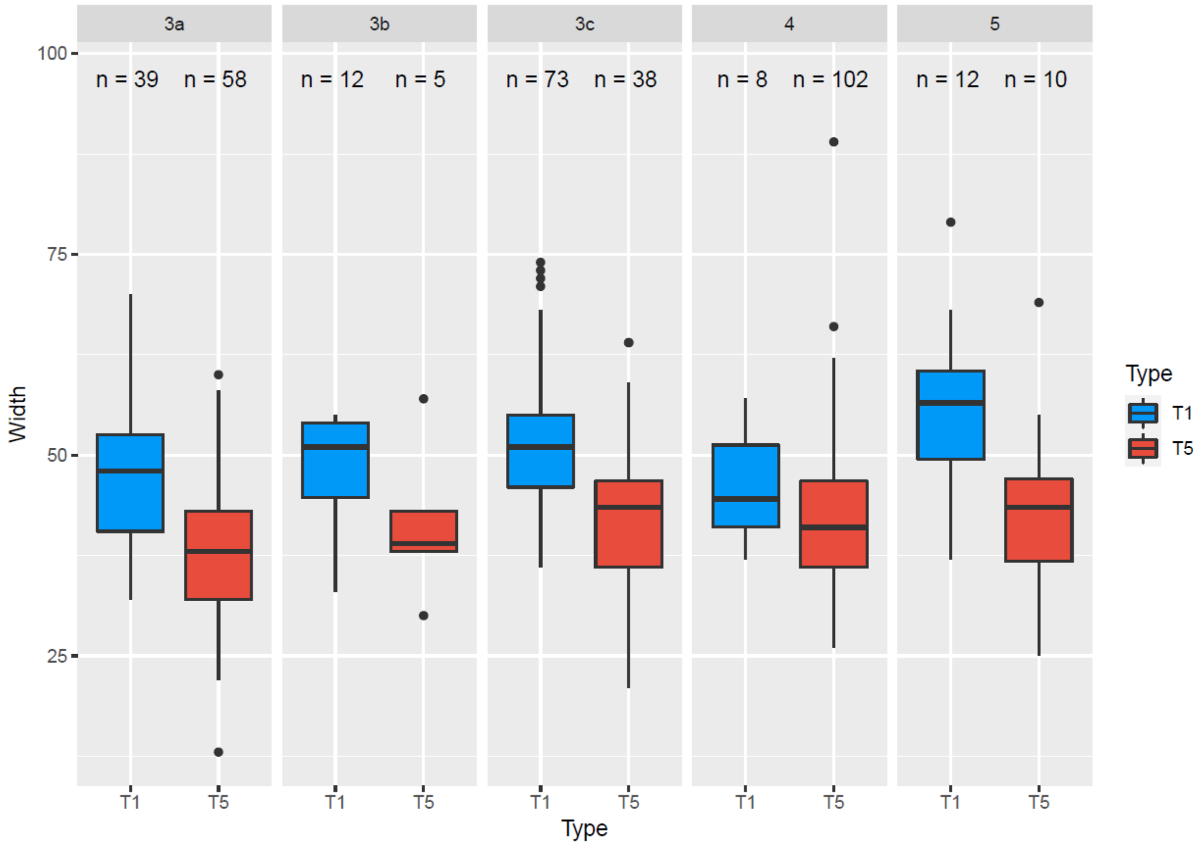


Fig. 9.18. Boxplot of maximal width of notched (T1) and unworked (T5) pebbles.

9.6.3.Axes/Adzes

Fifty-eight axes/adzes were identified in the assemblage. The majority of them originate from layer 3a (N=47). They are predominantly from 7,5 to 10 cm length, 3-6 cm wide, and 1-2,5 cm thick. The weight is ranging mainly between 50-110 grams (Fig. 9.19.). Summary of descriptive statistics can be seen in Tab. 9.11. Some of them display damage on the edges probably from the use (Appendix X.). Box Plots (Fig. 9.20. -9.24.) show the differences in the distribution of length, width, and weight and thickness per each layer.

		Max. length	Max. Width	Max. thickness	Weight
N	Valid	57	57	57	55
	Missing	1	1	1	3
Mean		86.737	43.00	18.789	93.33
Median		87.000	42.00	18.000	79.50
Std. Deviation		16.7274	9.987	6.8602	48.595
Minimum		41.0	25	7.0	11
Maximum		127.0	66	41.0	307

Tab. 9.11. Axes: summary of descriptive statistics.

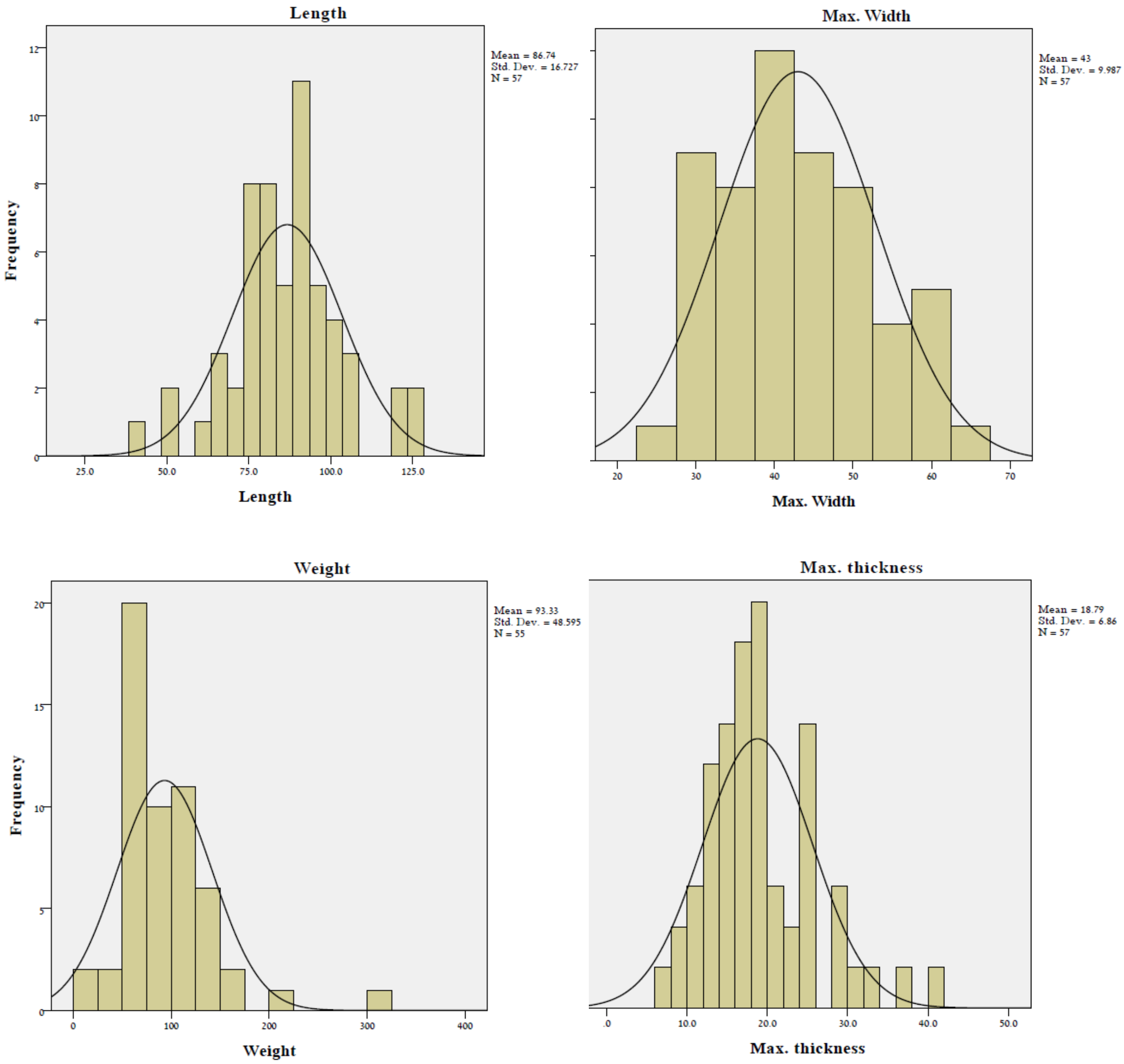
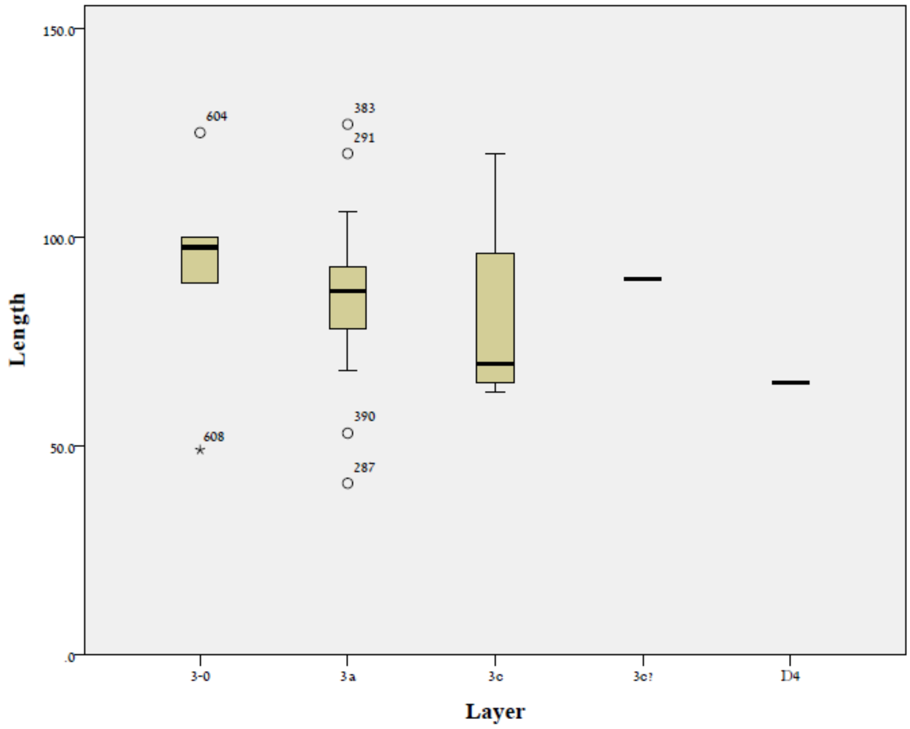


Fig. 9.19. Axes/adzes: histograms of max. length, max. width, weight, and max. thickness.



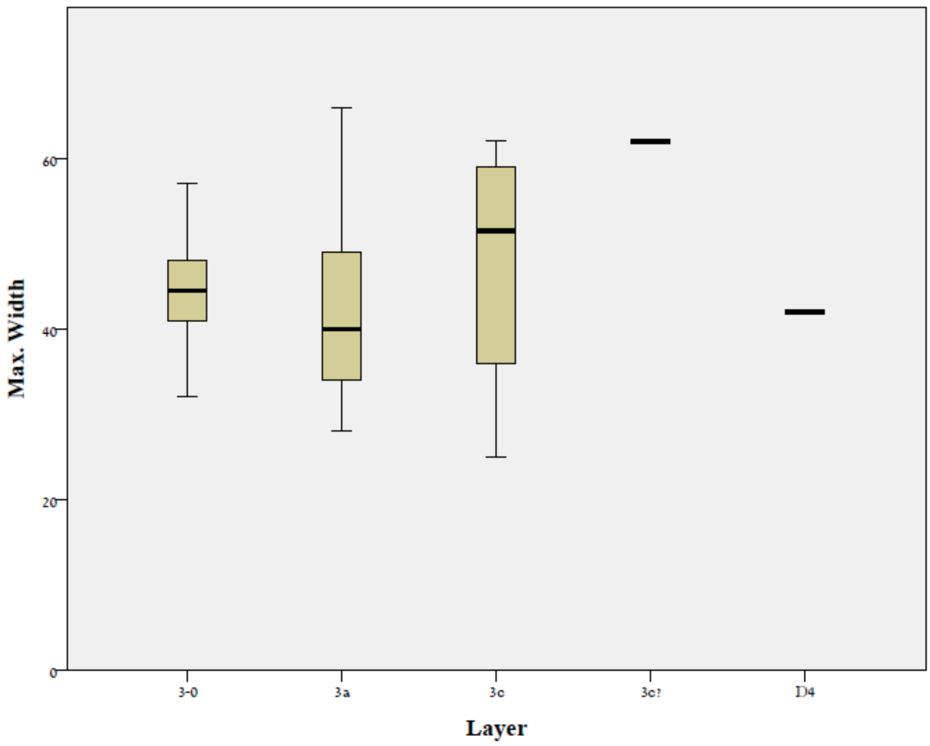
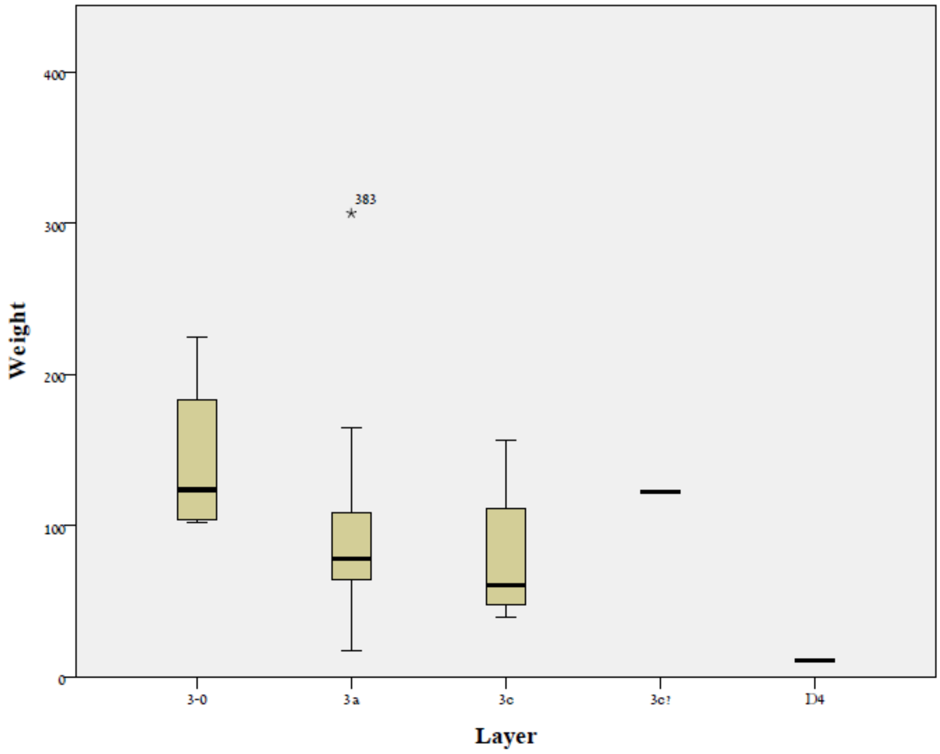


Fig.9.20.(above) Axes/adzes: Box plots of length. **Fig. 9.21.** (bottom) Axes/adzes: Box plots of width.



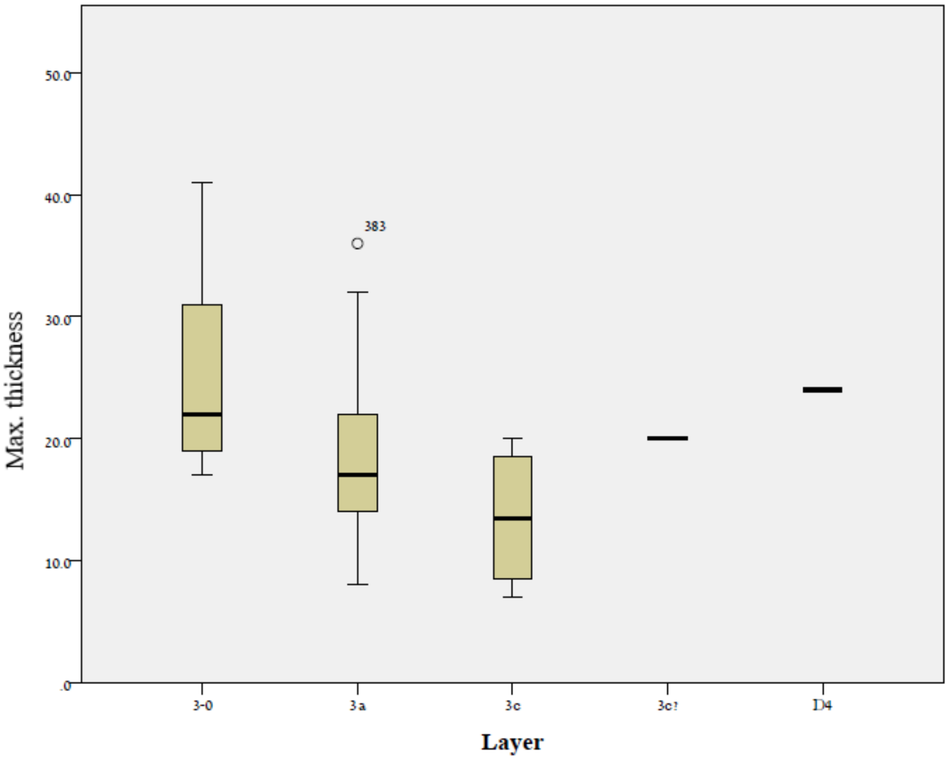


Fig. 9.22. (above) Axes/adzes:Box plots of weight. **Fig. 9.23.** (bottom) Axes/adzes: Box plots of thickness.

Generally, axes/adzes display lower weight than notched pebbles (Fig. 9.24.). That is particularly noticeably in layer 3a, which yields the highest amount of axes/adzes and sufficient quantity of notched peebles for comparison. Length of axes/adzes is 5-6 cm smaller compared to notched pebbles.

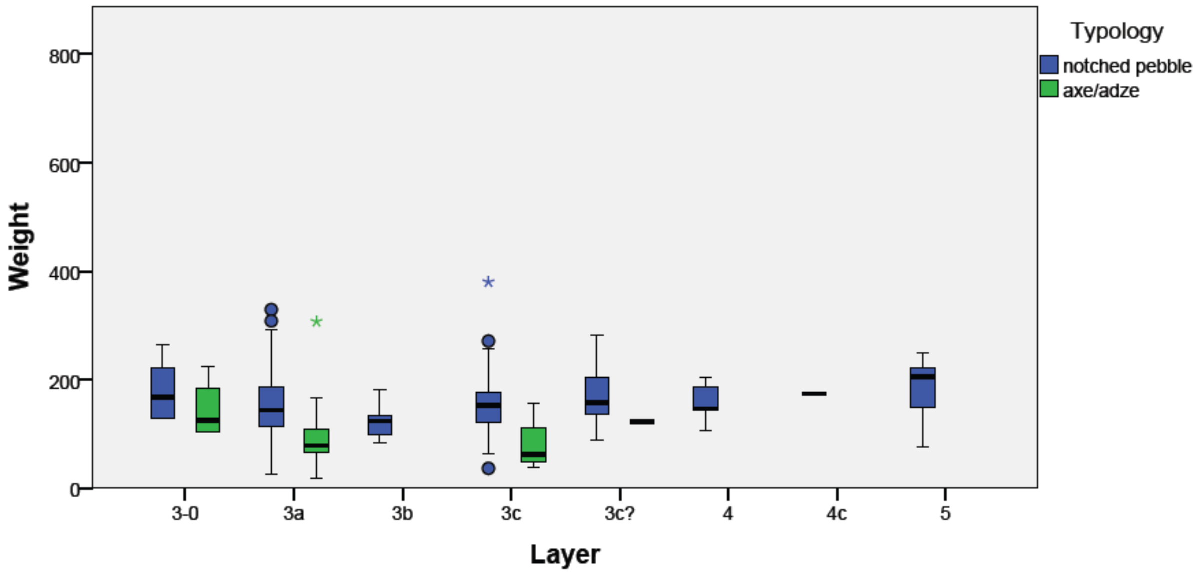


Fig. 9.24. Box plots of weight of notched pebbles and axes/adzes per layer.

9.6.4.Other types and untypical limestone

Among other identified types were hammers/mauls (N=8), picks (N=11), backed knives (N=8), and two large stones with natural holes. The majority of picks and hammer/mauls originate in layers 3a and 4. Backed knives were predominantly found in layer 3a. Large stones come from layers 3a and 3c. The limestone assemblage also comprised untypical limestone items such as perforated artefacts, pebbles with orangish stains, possibly of organic origin, and small limestone items (Fig. 9.25), which display the traces after shaping as well as gloss.

Fig. 9.25. Untypical limestone items.

At this place the only three elongated items, other than limestones, are mentioned. Two of them are basalt pebbles and one is a flint object (Fig. 9.26.).

Fig. 9.26. Elongated basalt (left) and flint (right) artefacts.

9.7. Technology of notched pebbles

9.7.1. Direct percussion

Direct percussion is defined as a lithic reduction method that involves directly applying force to a target stone with a harder stone. According to Hannold (2019), who performed a number of experiments in the manufacture of notches, notched pebbles manufactured by direct percussion have distinctive attributes in comparison with those manufactured by other methods. Direct percussion leaves steep flake scars and U-shaped notch (Hannold 2019, 98).

Most notched pebbles at JRD, which were preserved sufficiently, display the features typical for direct percussion: flake scars and U-shaped notch (Fig. 9.27.). Bifacial flaking (Fig. 9.28.) is more common than unifacial flaking (Tab. 9.12.). Although for most notched pebbles it was impossible to determine if bifacial or unifacial flaking was applied. Multiple flaking in single notch was observed in 31 cases, however for most cases it was impossible to determine it because of the bad preservation (Tab. 9.13).

Possible evidence of pecking employed in the manufacture of notches was recorded in a single case (Fig. 9.29.). Evidence of indirect percussion wasn't confirmed in a single case.

Fig. 9.27. Flake scars on the faces of notched pebbles.

	Layer									
Unifacial/ bifacial	3-0	3a	3b	3c	3c?	3c/4	4	4c	5	
Unifacial	0	3	1	5	1	0	0	0	1	11
Bifacial	1	5	6	23	5	0	2	0	7	50
Unknown	3	23	5	36	8	1	3	1	3	83
Total	4	31	12	64	14	2	5	1	11	144

Tab. 9.12. Unifacial and bifacial flaking used in one notch.

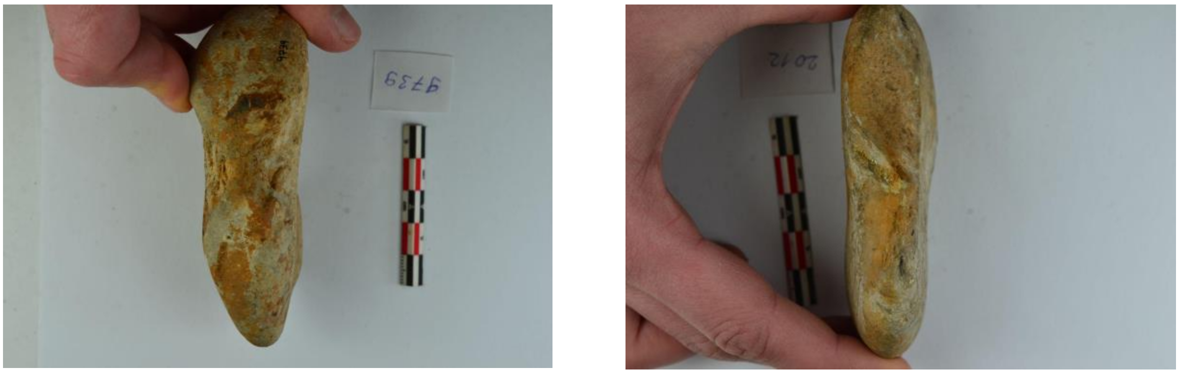


Fig. 9.28. Bifacial flake scars on notched pebbles.

	Layer									
Number of flakes	3-0	3a	3b	3c	3c?	3c/4	4	4c	5	
Single	0	0	0	0	0	0	0	0	0	0
Multiple	0	3	4	14	1	1	2	0	6	31
Unknown	4	28	8	51	13	1	3	1	5	114
Total	4	31	12	65	14	2	5	1	11	145

Tab. 9.13. Number of flakes in one notch.

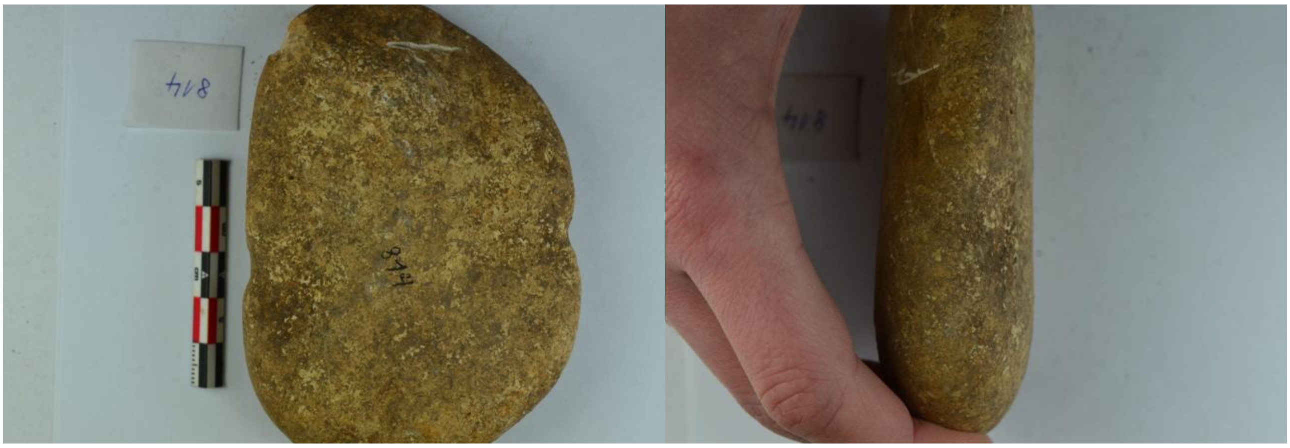


Fig. 9.29. Limestone pebble with possible evidence of pecking, notice no flake scars, and relatively small, U-shaped notch.

9.8. Spatial distribution

Spatial distribution analysis of the limestone pebbles was performed in order to identify largest concentrations in each layer, and any patterns of distribution, such as clusters within layers. The grid of squares at the JRD site is shown in Appendix 15. The highest density of notched pebbles per excavated square per layer was observed in layer 3c (Tab. 9.14.), followed by layer 5 and 3a. Lower densities were observed in layers 4, 3b, and 3-0.

Layer	N of excavated squares	N of notched pebbles	Density per excavated square
Layer 5	21	12	0,57
Layer 4	36	8	0,22
Layer 3c	54	80	1,48
Layer 3b	40	12	0,3
Layer 3a	87	47	0,54
Layer 3-0	49	8	0,16

Tab. 9.14. Density of notched pebbles per excavated square per layer.

Layer 5 contained among others both notched and unworked pebbles (Appendix 16). The highest concentration was observed in squares M97 and M98 (Appendix 22). The low total amount of the pebbles in layer 5 didn't allow for additional analysis.

The majority of layer 4 consisted of unworked pebbles with a few notched pebbles and other types (Appendix 17). Kernel density analysis showed the three main concentrations with the occurrence of over 10 pebbles per square metre (Appendix 23). The Optimised Hot Spot Analysis based on length/width index didn't yield any data, so additional analysis based on weight was performed (Appendix 28). Density-based clustering showed once more the three clusters, which were initially observed in the Kernel density analysis (Appendix 31). Box plot (Fig. 9.30.) represents the weight distribution per cluster.

The statistical significance of these clusters was further tested by Kruskal-Wallis H Test in R (Tab. 9.15.), but the statistical significance of differences between the clusters based on weight was not confirmed.

data: weight and CLUSTER

Kruskal-Wallis chi-squared = 2.8076, df = 2, p-value = 0.2457

Pairwise comparisons using Wilcoxon rank sum test with continuity correction

data: weight and CLUSTER

	1	2
2	0.88	-
3	0.27	0.49

Tab 9.15. Kruskal-Wallis rank sum test of weight per cluster in layer 4.

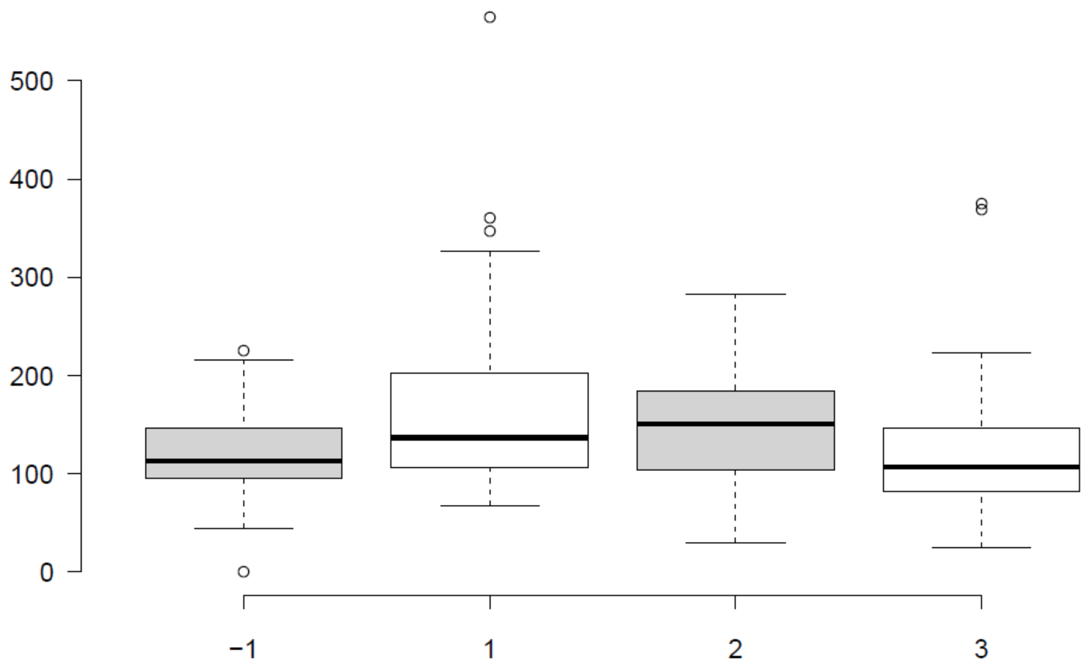


Fig. 9.30. Box plot of weight per cluster in layer 4 acquired from Density-based clustering analysis (Appendix 31).

Layer 3c contained predominantly notched pebbles, and also unworked pebbles as well as a few other types (Appendix 18). Kernel density analysis showed the largest concentration of pebbles with over 45 pebbles per square metre in squares U102-104 (Fig. 31., Appendix A24). The Optimised Hot Spot Analysis didn't yield any results (Appendix 29). Density based clustering showed a single cluster of pebbles (Appendix 32).

Fig. 31. Photo of the concentration of limestone pebbles in squares U102-104 (courtesy of Gonen Sharon).

Layer 3b consisted of notched and unworked pebbles (Appendix 19). The Kernel density analysis showed the highest concentration in square T 102. The low amount of the pebbles (less than 30) in layer 3b didn't allow for additional analysis.

Layer 3a comprised a variety of types including large quantities of notched pebbles, unworked pebbles, and axes/adzes, as well as a few picks, hammers/mauls, backed knives, and a large stone with natural holes (Appendix A20). Kernel density showed two conglomerations of over 10 pebbles per square metre and three others with lower concentrations (Appendix 26). The Optimised Hot Spot Analysis based on length/width index showed two concentrations, based on whether the pebbles with higher or lower length/width index occur together (Appendix 30).

Density-based clustering showed five clusters (Appendix 33). The statistical significance of these clusters was further tested by Kruskal-Wallis H Test (Tab. 9.16.) in R. The box plot (Fig. 33.) shows the weight per cluster.

Kruskal-Wallis rank sum test

data: weight and cluster

Kruskal-Wallis chi-squared = 35.561, df = 4, p-value = 3.563e-07

Pairwise comparisons using Wilcoxon rank sum test with continuity correction

data: weight and cluster

	1	2	3	4
2	0.36828	-	-	-
3	0.05034	0.87086	-	-
4	0.01551	0.00063	1.8e-05	-
5	0.25223	0.03721	0.00971	0.87086

Tab. 9.16. Kruskal-Wallis rank sum test of weight per cluster in layer 3a.

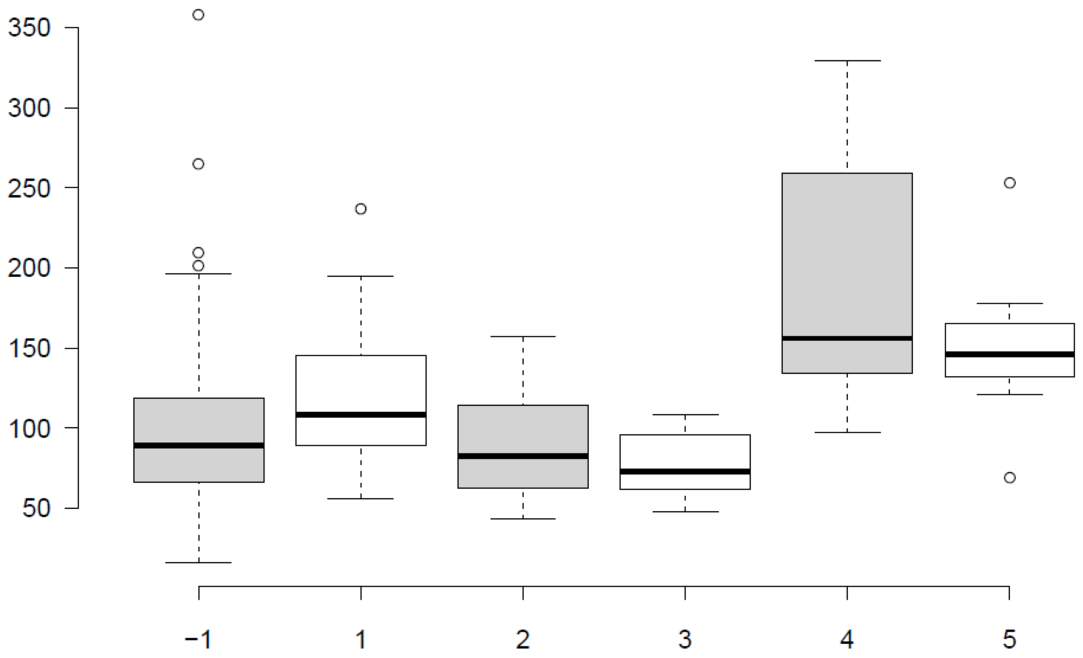


Fig. 32. Box plot of weight per clusters in layer 3a acquired from Density-based clustering analysis (Appendix 33).

Kruskal-Wallis test shows statistical significant differences in weight between cluster 5 and clusters 2 and 3, and between cluster 4 and clusters 1, 2, and 3. The border value was reached for clusters 1 and 3. Cluster -1 represents the noise.

Typologically, the clusters represent a high variability within each cluster (Tab. 9.17.). The majority of limestones in clusters 1, 2, and 3 is represented by unworked pebbles and axes/adzes. In clusters 4 and 5, the majority represent notched pebbles.

Clusters	Notched pebble	Unworked pebble	Axe/Adze	Pick	Backed knife	Hammer/ maul	Large stone	Total N
1	3	10	6	1	-	-	-	20
2	-	6	5	1	2	-	-	14
3	1	5	5	-	1	-	-	12
4	14	3	5	-	-	3	-	25
5	5	2	1	-	-	-	1	9

Tab. 9.17. Typological classification of limestone within each cluster.

10. Discussion and conclusion

Jordan River Dureijat is an archaeological site, which was located on a shore of the paleo-lake Hula, in northern Israel. The site was occupied intermittently during the whole Epipalaeolithic. The site yielded a rich assemblage of finds connected to fishing technology such as fish hooks and line weights as well as fish remains. Among other finds, the site provided a plentiful limestone assemblage with over 9,000 pieces, including over 200 notched pebbles, over 300 unworked pebbles, and 58 axes/adzes.

Based on the location of the site and the archeological evidence perceived in the context of , evidence from ethnography, and other archaeological sites, it is argued that notched pebbles at JRD were used as fishing net sinkers. The majority of net sinkers are side-notched with a few exceptions of atypical sinkers with three notches. Net sinkers, with a few exceptions, display uniformity in sizes: 8 - 10 cm in length, 3,5 - 5,5 cm in width, and 1,5 - 3 cm in thickness. Weight is the most variable attribute, ranging mainly between 120-165 grams. The majority of notches were manufactured by direct percussion, either bifacional or unifacional, although in a number of cases the preservation didn't allow this determination. Multiple blows within one notch were observed.

Notched pebbles occur in archaeological contexts all over the world. They were found in most cases on archaeological sites situated close to water bodies, and together with abundant fish remains. They were interpreted as fishing net sinkers by most authors (*Rau 1873; 1884; Nadel – Zaidner 2002; Prowse 2010; Rosenberg et al. 2016*). At waterlogged sites in Europe, both notched and unworked pebbles were found with the organic bindings still attached on their surface and in the context of wooden floats and abundant fish remains (*Bērziņš 2008; Eberli 2010*). In one case, at Morrow site in New York, the notched pebble was found with the organic binding on the surface and still attached to a net (*Ritchie 1944 in Prowse 2010*)

Net sinkers first appeared in the Early Epipalaeolithic layer 5 in low amounts. The Geometric Kebaran layer 4 yielded several net sinkers, however, most of the limestones in this layer were unworked. Layer 3c showed the largest amount of net sinkers, both in total numbers and relatively per excavated squares. Apart from net sinkers, fish hooks and line weights originate from this layer, indicating that the exploitation of fish became more pronounced during the Natufian occupation of the site. In the Late Natufian/Early Pre-Pottery Neolithic (top of layer 3a), the site subsistence possibly changed, that would be reflected by the introduction of axes/adzes and other types of tools at the site.

Apart from the net sinkers, over 300 unworked pebbles of similar sizes and weight were found at the site. The ethnographic evidence from North America as well as archaeological finds from the European waterlogged sites proved that unmodified pebbles were used as net sinkers (*Weston 1978; Bērziņš 2008*).

The analysis of limestone pebbles at JRD showed that unworked pebbles were more elongated with shorter width compared to notched pebbles. It is suggested that unworked pebbles at JRD site were used as net sinkers along the notched ones, and that the elongation was the crucial factor when deciding whether to make a notch or not. If a pebble was elongated and narrow, notches weren't probably indispensable for holding into the binding.

The spatial distribution showed the largest concentration in layer 3c, with a single cluster identified. Prowse (*2010*) argued that while manufacture of nets was energy- and time-consuming, the net sinkers were quick to make, and also heavy to carry. Thus, one explanation for the accumulation of pebbles in 3c is that they were cut off the nets and put on a pile. In layer 3a, five clusters were observed and four of them showed statistically significant differences in weight of pebbles. While the first three clusters consisted mainly of unworked pebbles and axes/adzes, the majority of clusters 4 and 5 was represented by net sinkers.

It could be hypothesised that these clusters, especially 4 and 5, represented individual nets. If the other clusters also represented nets, it would mean that many of the sinkers from clusters 1, 2, and 3 were recycled.

For clusters 4 (N=25) and 5 (N=9), an estimation of the fish net sizes was performed based on two ethnographic records (*Weston 1978*), which mention that the distance between the placement of net sinkers on the bottom of nets used by Mistassini and Chippewa fishers, was 1,8 metre. By using this measure, the net in cluster 4 would be 45 metres and the net in cluster 5 would be 16,2 metres. Both of these sizes fall within the sizes of nets recorded in the ethnography (Chapter 5). These would be most probably seine or gill nets. The estimated sizes of nets, however, represent nothing more than an informed guess and serve only for grasping an idea about the fish net sizes.

At the site of JRD, the identified species of marsh-bank and aquatic vegetation included *Phragmites* type (reed), Cyperaceae, *Typha* (cattail), *Salix* (willow), *Vitis* (grape), and *Tamarix* (tamarisk)*(Langgut et al. 2021*). Cattail and willow is known as a plant for net manufacture in the ethnographic records (*Weston 1978*). These plants might have been used for other purposes such as the production of fishline or traps. Fragments of twisted fibres, probably from *Typha*, were found on a waterlogged Epipalaeolithic site Ohalo II and were interpreted as cord remains, possibly part of a net.

Fish, providing high quality protein, amino acids, vitamins and minerals, played an important role in the lives of past people from the earliest prehistory. The significance of fish and fishing, however, increased in the Levant particularly during the Epipalaeolithic (*Bar-Yosef Mayer – Zohar 2010; Munro et al. 2021*). Expansion of the subsistence economy within the Levant during the Epipalaeolithic attested to what Flannery (*1969*) described as the ”broad-spectrum revolution”. The exploitation of aquatic resources in the Epipalaeolithic included fish, shellfish, turtles, tortoises and water birds (*Bar-Yosef Mayer – Zohar 2010; Yeomans – Richter 2016; Munro et al. 2020*). At the site of Jordan River Dureijat, aquatic exploitation is supported by the abundant finds of turtles, frogs, and fish including *Cyprinidae, Cichlidae,* and likely *Salmonidae* (*Pedergnana et al. 2021*).

Apart from the archaeological sites in North America, the assemblages of notched pebbles are small, usually including less than 100 notched pebbles (Appendix 3-7). The earliest assemblage in the Levant originates from the Masraqan site of Ohalo II (=47), dated to 23,000 cal. BP (*Nadel - Zaidner 2002*). Two largest assemblages originate from a Pre-Pottery Neolithic site of Ein Dishna (N=151)(*Birkenfeld - Brailovsky-Rokser - Vered 2019*) and Pre-Pottery and Pottery Neolithic site of Beisamoun (N=96). The majority of notched pebbles from these sites, however, come from the surface collections. The site of Jordan River Dureijat provided the largest assemblage of notched pebbles in the Levant (N=206). The significance of this assemblage also lies in the fact that the majority of the notched pebbles comes from a secure stratigraphy.

In the Levant, the majority of notched pebbles are side-notched, and made of limestone, with weight ranging mainly from 60 - 350g. The dimensions range between 4 - 10 cm in length, 4 - 8 cm in width, and 1,5 - 4,5 cm. Compared to levantine notched pebbles, the JRD notched pebbles do not deviate and fall within these dimensions as well as raw material selection.

Axes are considered as one of the markers of the Neolithic. The bifacial tools appear already in the Natufian, however, they lack standardisation, and their function is still not clear (*Barkai 2011*). Fifty-eight axes/adzes were identified at the JRD site, the majority of them coming from layer 3a. There is a clear preference of limestone for axes/adzes as well as net sinkers as no flint axes and only two elongated unworked basalt pebbles were found.

To conclude, the JRD provided the largest assemblage of net sinkers in the Levant (N=206), not even including numerous unworked pebbles, which are also believed to be used as net sinkers. That testify for intensive fish exploitation at JRD during the Epipalaeolithic. Significantly, there is a continuation of using the same fishing tools: net sinkers of similar shape and weight, meaning the same net fishing technique, at the same spot for more than 10,000 years. Apart from net fishing, angling is also attested at the site. We can assume that people at JRD were skilful fishers, they knew their environment, seasonality, fish behaviour, and the fishing technique suitable for each fish species.

This thesis presents the contribution to the study of notched pebbles, which fall within the widely underrepresented category of ground stone tools. Important observation is that even the unworked pebbles could have been used as net sinkers and they can provide information about the past people's subsistence. That is the reason why archaeologists need to proceed with caution, especially when excavating sites close to water bodies. More systematic studies focused on notched pebbles and generally on ground stone tools are necessary in the future.

Many questions regarding the net sinkers still remain unanswered: What was the size of nets? How far away were the net sinkers placed from each other? How were the net sinkers tied to the net? Were notched pebbles used only as net sinkers or as weights for traps as well? What was the size of the mesh? What materials were used for net manufacture and bindings? Field experiments with net sinkers attached to various types of net and used in various hydrological environments might improve our understanding of this technology. However, in order to answer most of the questions above we would have to find a preserved net with net sinkers still attached, which is in the Levantine environment improbable.

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Appendix

Appendix 1. Excavation daily page (courtesy of Gonen Sharon).

Appendix 2. Krumbein's angularity and roundness scale (Krumbein 1941).

Appendix 3. Examples of archaeological sites with the occurrence of notched and grooved pebbles in the Levant (modified after *Rosenberg et al. 2016, 473*).

Appendix 4. Examples of archaeological sites with the occurrence of notched and grooved pebbles worldwide.

Appendix 5. Examples of archaeological sites with the occurrence of notched and grooved pebbles worldwide.

Appendix 6. Examples of archaeological sites with the occurrence of notched and grooved pebbles worldwide.

Appendix 7. Examples of archaeological sites with the occurrence of notched and grooved pebbles worldwide.

Appendix 8. Notched pebbles from JRD.

Appendix 9. Notched pebbles from JRD.

Appendix 10. Notched pebbles from JRD.

Appendix 11. Notched pebbles from JRD.

Appendix 12. Axes/adzes from JRD.

Appendix 13. Axes/adzes from JRD.

Appendix 14. Axes/adzes from JRD.

Appendix 15. JRD square grid.

Appendix 16. Occurrence of analysed limestone pebbles in the layer 5.

Appendix 17. Occurrence of analysed limestone pebbles in the layer 4.

Appendix 18. Occurrence of analysed limestone pebbles in the layer 3c.

Appendix 19. Occurrence of analysed limestone pebbles in the layer 3b.

Appendix 20. Occurrence of analysed limestone pebbles in the layer 3a.

Appendix 21. Occurrence of analysed limestone pebbles in the layer 3-0.

Appendix 22. Kernel Density: limestones in the layer 5.

Appendix 23. Kernel Density: limestones in the layer 4.

Appendix 24. Kernel Density: limestones in the layer 3c.

Appendix 25. Kernel Density: limestones in the layer 3b.

Appendix 26. Kernel Density: limestones in the layer 3a.

Appendix 27. Kernel Density: limestones in the layer 3-0.

Appendix 28. Optimized hot spot analysis based on weight in the layer 4.

Appendix 29. Optimized hot spot analysis based on length/width index in the layer 3c.

Appendix 30. Optimized hot spot analysis based on length/width index in the layer 3a.

Appendix 31. Density-based clustering in the layer 4.

Appendix 32. Density-based clustering in the layer 3c.

Appendix 33. Density-based clustering in the layer 3a.