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Local Technological Traditions in the Early and Middle Epipaleolithic of Ein Gev Area

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Abstract

In the Levant, the Epipalaeolithic is a long sequence of cultural entities dated between ca. 24,000 to 11,500 cal BP. Different Epipalaeolithic entities are mainly defined based on chronological and geographical patterns in the produced types of microliths. However, typological variability provides limited information on the dynamics of the local learning communities through time. The present study wishes to test whether the analysis of the microlith manufacturing process can help track the movement of people and ideas beyond the observed variability in microlith types, providing a novel insight on the population dynamics. The study focuses on the area of Ein Gev, where three different Early and Middle Epipalaeolithic cultural entities (Kebaran, Nizzanan, and Geometric Kebaran) were recorded respectively in three sites (Ein Gev I, III, and IV). We conducted an attribute analysis of cores and production blanks. Our results were discussed in light of a theoretical framework for the transmission of typological and technological traits among prehistoric populations. It suggests that, in a geographically limited area, continuity of technological traits among assemblages attributed to different cultural entities can be associated with continuity in the population. The analysis enabled tracking the continuity between the local Kebaran and Geometric Kebaran manufacturing traditions. In contrast, the Nizzanan occupation of the area presents technological traits that may reflect a different manufacturing tradition. It is suggested that the possible increase in territoriality of local groups can be considered among the factors that triggered, during the Natufian, the onset of sedentism.

Keywords Southern Levant · Ein Gev · Epipalaeolithic · Lithic technology · Cultural transmission · Population dynamics

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This work is dedicated to the memory of Professor Ofer Bar-Yosef (1937-2020), whose PhD dissertation was based on the Epipalaeolithic cultures of the Southern Levant, including the Ein Gev area.

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Introduction

The Epipalaeolithic (EP), in the Levant, is characterized by the production of microliths (Bar-Yosef 1970; Belfer-Cohen and Goring-Morris 2002)—minute, standardized lithic artifacts—and cover the time-span between ca. 24,000 and 11,500 cal BP (Goring-Morris and Belfer-Cohen 2011, 2017; Garrard and Byrd 2013; Grosman 2013; al-Nahar and Olszewski 2016; Richter et al. 2013; Shimelmitz et al. 2018).

Geographical and chronological patterns can be observed in the shape and size (types) of the produced microliths and some stylistic traits in their manufacture (Bar-Yosef 1970; Goring-Morris 1987; Henry 1974), such as different retouch modes or the microburin technique (MbT)—a technique that allows discarding the unnecessary portion of the original blanks, creating an oblique truncation (Miolo and Peresani 2005). Based on these patterns, assemblages are classified in “cultural entities” (Belfer-Cohen and Goring-Morris 2002; Byrd 2005; Goring-Morris 1987, 1988, 1995; Goring-Morris et al. 2009; Goring-Morris and Belfer-Cohen 2011, 2017; Maher et al. 2011a, b; Marder 2002) or “lithic industries” (Bar-Yosef 1970; Byrd and Garrard 2017; Henry 1989; Maher et al. 2012; Richter et al. 2011, 2013). Following previous studies on the EP of South-Western Levant, present work adopts the “cultural entities” term to define recurrent associations of microlith types and other stylistic traits (Goring-Morris 1987), and the list of entities proposed by Goring-Morris and Belfer-Cohen (2017). Cultural entities are chrono-stratigraphically organized in three phases: Early, Middle, and Late EP (Fig. 1—Bar-Yosef 1970; Goring-Morris 1987; Goring-Morris and Belfer-Cohen 2011, 2017; Grosman 2013).

During the EP, human groups progressively shifted from a nomadic subsistence system, based on hunting and gathering, to a sedentary one, based on production, through a series of technological, economic and social innovations that culminated in the onset of the Neolithic (Goring-Morris and Belfer-Cohen 2011, 2017; Maher et al. 2012). In the Early and Middle EP phases, human groups moved across the landscape, returning seasonally to the same locations (Goring-Morris 2009; Goring-Morris et al. 2009), with mobility strategies spanning from residential to logistical reflecting the environmental conditions of the different sub-regions of the Levant, and, possibly, grouping periodically in large aggregation sites (Byrd et al. 2016). Compared to the previous Upper Palaeolithic period, the appearance of large cemetery sites (Bocquentin et al. 2011; Maher et al. 2011b) and the increase in decorative art (Hovers 1990; Kaufman et al. 2017; Yaroshevich et al. 2016) suggest a growth in symbolic behaviors. Concurrently, the use of diversified ground-stone tools (Wright 1991, 1994) may be related to intensification in the processing of resources. The Late EP Natufian cultural entity corresponds to a climax in these trends, with an outburst of symbolic behaviors, intense local resource exploitation, and the first appearance of sedentism (Grosman and Munro 2017).

Seasonal or year-round presence of particularly advantageous conditions in environmental refugia may have prompted localized increases in population density during the Early and Middle EP (Goring-Morris and Belfer-Cohen 2011; Goring-Morris and Goldberg 1990; Jones et al. 2016; Martin et al. 2010; Nadel et al. 2012; Zohar et al. 2018). Consequently, the intensity of the occupation and human pressure on the environment were not equivalent in the different sub-regions of the Levant (Munro et al. 2016; Stutz et al. 2009). The degree of interaction (or lack thereof) among local

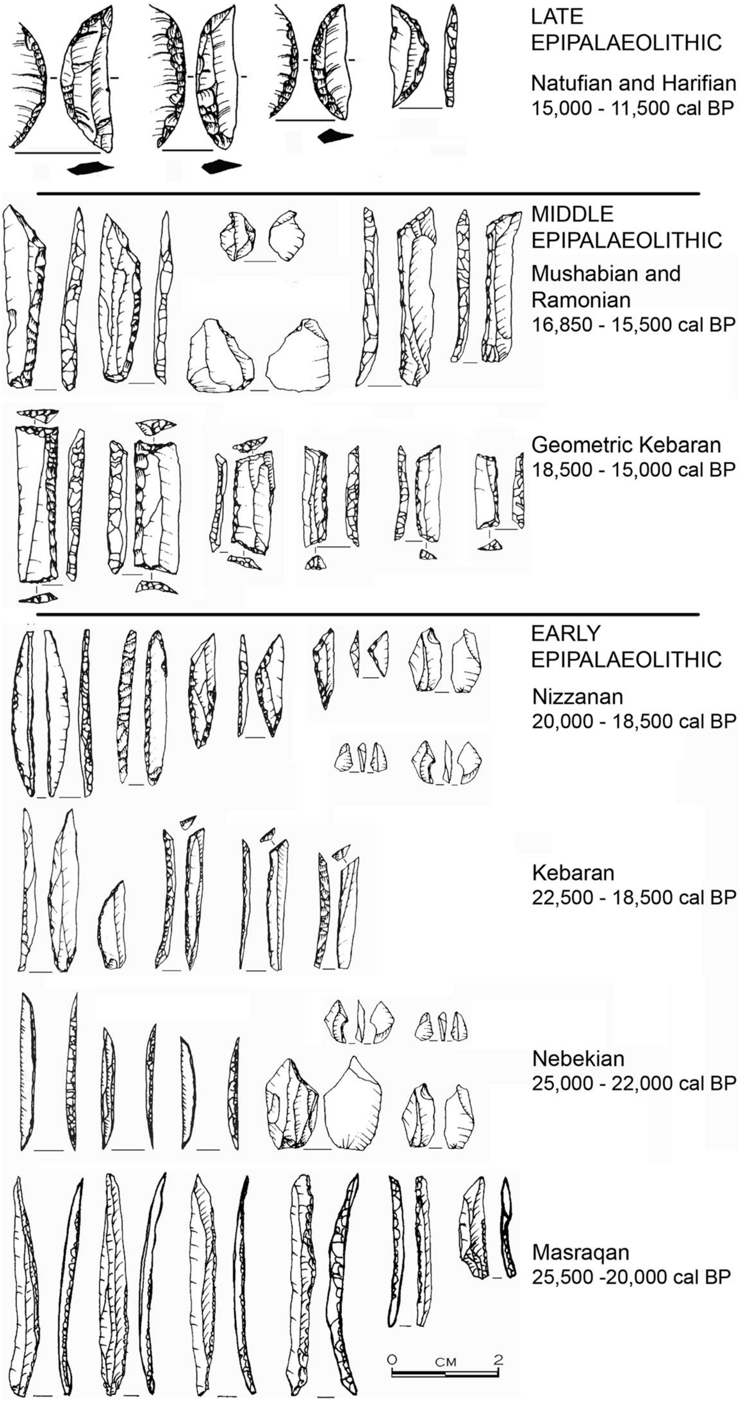

Fig. 1 Southern Levantine EP microliths and microburins sorted by cultural entities (edited figure based on Goring-Morris and Belfer-Cohen 2013, 2017; dates after Goring-Morris and Belfer-Cohen 2017; Garrard and Byrd 2013; Grosman 2013; al-Nahar and Olszewski 2016)

groups occupying this patchy human landscape may have played a key role in controlling the development and the subsequent spread or demise of cultural traits in different sub-regions of the Levant (Grosman 2013; Maher et al. 2011a; Roberts et al. 2018). Tracking the movement of people and ideas in the Early and Middle EP is, thus, essential for understanding the complex and possibly non-linear process that led to the onset of the Natufian cultural entity.

Variability patterns observed within the geographically widespread cultural entities in the typological composition (Bar-Yosef 1981; Goring-Morris 2009) and other, non-typological aspects of the lithic assemblages, as microlith morphology and use (Macdonald 2013) and core reduction method (Marder 2002), highlighted the possible presence of different local learning communities, i.e., communities of people that shared the same learning network. We, thus, wish to track particular communities within the typologically defined cultural entities based on their lithic technology and test the possible continuity of local traditions among different cultural entities.

Present study wishes to track the possible continuity in the occupation of a limited geographic area by the same local learning community based on traits of the lithic reduction sequence. The investigation will focus on the area of Ein Gev, where several EP cultural entities were recorded. Based on the typological composition of their lithic assemblages and other stylistic attributes, Ein Gev (EG) I, III, and IV are attributed to the Kebaran (Early EP), Geometric Kebaran (Middle EP) and Nizzanan (Early EP) cultural entities respectively (Bar-Yosef 1970; Goring-Morris 1987; Martin and Bar-Yosef 1975, 1979).

For this archaeological case study, the equation between recurrent combinations of traits in the lithic assemblages and cultural identity of the groups that created them is not granted and it has to be sustained by a robust theoretical framework, relating aspects of lithic assemblages to the cultural identity of the knappers (Maher and Richter 2011; Olszewski 2006; Shea 2014). Therefore, after presenting the results of the technological analysis of Ein Gev lithic assemblages, we will discuss them in light of such a theoretical framework.

The Sites

The material used for the study is the lithic assemblages from three sites representing different cultures of the Early and Middle EP in a geographically limited area, in the proximity of Kibbutz Ein Gev, on the eastern shore of the Sea of Galilee (Fig. 2). To obtain statistically significant results, the goal was to collect at least 800 artifacts from well-defined contexts from each site. All artifacts from the selected contexts, defined based on spatial and stratigraphic criteria (see below), were included in the analysis. All the lithic artifacts included in the present technological analysis are stored in the Institute of Archaeology, the Hebrew University of Jerusalem.

EG I and EG IV were assigned to the Early EP occupation of the area (Bar-Yosef 1970; Goring-Morris 1987). The first archaeological investigation of EG I was conducted in 1963-64 (Bar-Yosef 1970), followed by several short excavations in later years (Arensburg and Bar-Yosef 1973). Fieldwork highlighted the presence of a 5–7 m diameter hut, dug in the sloping ground, and of a stratigraphic sequence of six living-floors representing subsequent occupation phases (Bar-Yosef 1970). The main typological groups in the retrieved lithic assemblage were endscrapers, burins, and non-geometric microliths. The latter are, mainly, obliquely truncated and backed bladelets

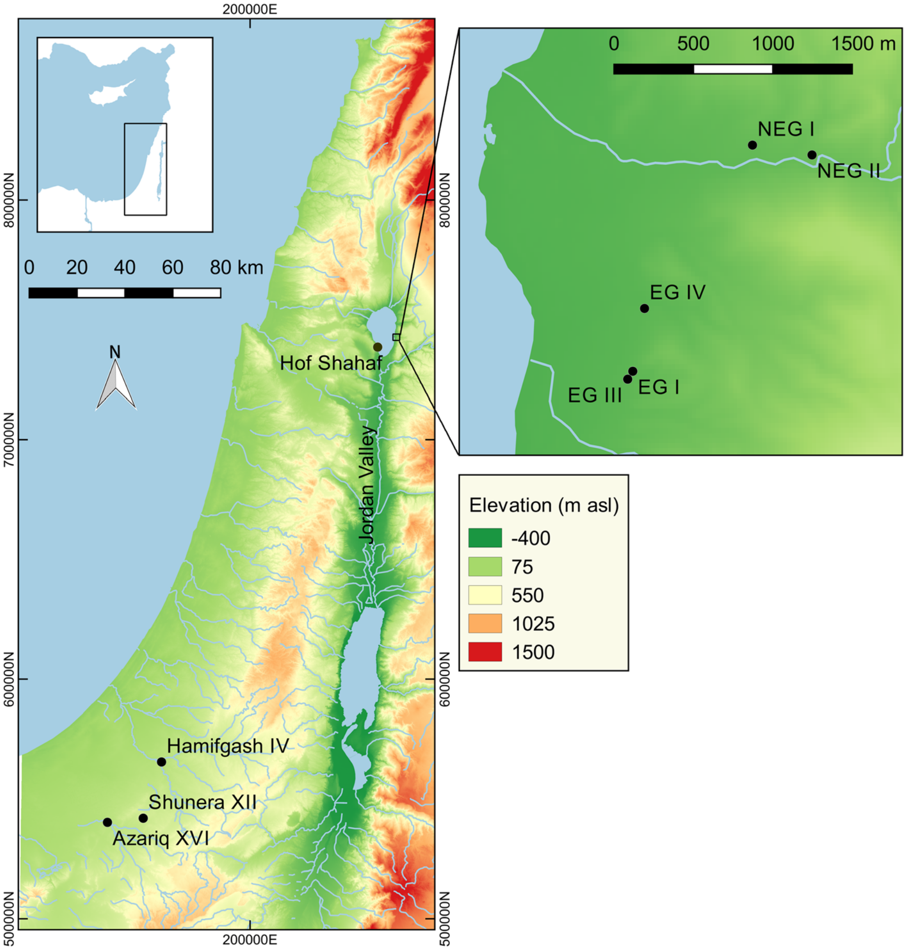

Fig. 2 Location of Upper Palaeolithic and EP sites referred to in the text. Map created with *Q-GIS*

(Fig. 3). The typological composition of the lithic assemblage, combined with an available ^{14}C date (GrN-5576 – 15,700 ± 415 BP; 18,610 ± 465 cal BP), allows attributing the deposit to the Early EP Kebaran culture (Bar-Yosef 1970). The vast amount of debitage found together with the lithic tools suggests that the entire manufacturing process took place on-site (Bar-Yosef 1970). Besides the lithic artifacts, the site yielded a rich faunal collection (Davis 1974; Marom and Bar-Oz 2008) and a human skeleton buried in a shallow grave within the hut (Arensburg and Bar-Yosef 1973; Trinkaus 2018). Two lithic assemblages from the 1973 excavation were sampled for the present technological analysis, coming from a one square meter area within layer III and a two square meters area within layer IV.

Archaeological investigation of EG IV was first conducted in 1968 (Bar-Yosef 1970), highlighting the repeated occupations of the site. The tool assemblage of EG IV is characterized by a high frequency of non-geometric and geometric microliths (especially micrograyettes and triangles, systematically manufactured using the MbT, Fig. 3), notches/denticulates, and end-scrapers on blades. The site was first attributed to

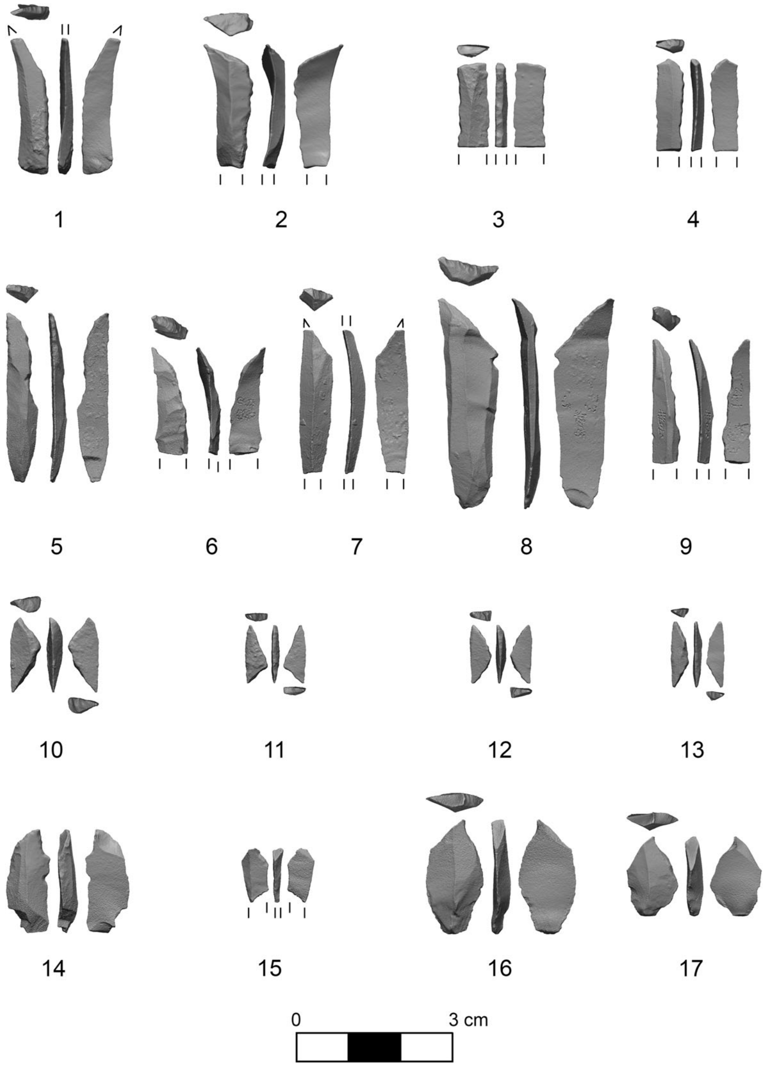

Fig. 3 Microliths and microburins from the Ein Gev sites. EG III: backed and truncated bladelets (1-4); EG I: non-finished backed bladelet (5), arched-backed bladelet (6), obliquely truncated bladelets (7-8), and obliquely truncated and backed bladelets (9); EG IV: triangles (10-13) and microburins (14-17). Figure created with *Artifact3-D* (Grosman 2016; Grosman et al. 2008, 2014)

a late facies of the Geometric Kebaran culture (Bar-Yosef 1970). Subsequent considerations based on the technological composition of the microlith assemblage (high frequency of triangles) and stylistic traits in the manufacturing (intensive use of the MbT) suggested that EG IV may represent a previously non-documented EP culture (Henry 1974). Following later studies of similar lithic assemblages from the western Negev (Azariq IX and Hamifgash IV) and Transjordan (Jilat 6), based on typological, stylistic and technological comparisons (presence of microgravettes, scalene bladelets, extensive use of MbT), EG IV was reassigned to the Early EP Nizzanan culture (Goring-Morris 1987). Excavations conducted by the authors in the summer of 2016 indicated that the site may extend over ca. 500 m^2. The present technological analysis focuses on the lithic assemblage from three square meters of the 2016 excavation.

EG III represents the Middle EP occupation in the area. The site, discovered in 1964, was excavated in 1965 and 1968 (Bar-Yosef 1970), and renewed excavations were carried out in 1974-1975 and 1978 (Martin and Bar-Yosef 1975, 1979). Three subsequent living floors were revealed, each featuring stone architectural structures (Martin and Bar-Yosef 1979). The abundance of trapeze-rectangles and backed-truncated bladelets in the microliths assemblage (Fig. 3) enabled assigning the site to the Middle EP Geometric Kebaran culture (Martin and Bar-Yosef 1979). The present technological analysis focuses on the lithic assemblage recovered from Layers 4 and 5 in a three square meters area, during 1965-68 field-works (Bar-Yosef 1970). Due to the small representation of cores within the study sample, an additional assemblage, from the 1965-1968 and 1974-1975 excavations, was added. Although the context of the additional core assemblage is not clear, based on the homogeneity in the microliths throughout the sequence and the repeated occupation of the exactly same location (the three structure are overlaying one another—Martin and Bar-Yosef 1979), the whole lithic assemblage of EG III is likely to represent the same manufacturing tradition.

The Late EP occupation of Ein Gev area and its surroundings is represented by the sites of Ḥof Shaḥaf (Marder et al. 2013) and Naḥal Ein Gev II (Bar-Yosef and Belfer-Cohen 2000; Grosman et al. 2016), attributed to the Early and Late Natufian cultural entities respectively.

Due to their geographical proximity, the three sites (EG I, III, IV) were subject to the same availability of lithic raw materials and natural resources. Based on the timeframe currently proposed for the Nizzanan, Kebaran, and Geometric Kebaran cultural entities (Goring-Morris and Belfer-Cohen 2017; Richter et al. 2013; Garrard and Byrd 2013; al-Nahar and Olszewski 2016), the EP occupation in the Ein Gev area spanned from 22,500 to 15,000 cal BP. Important to note, some radiometric dates suggest that the Kebaran cultural entity may have initiated as early as ca. 24,000 cal BP (Shimelmitz et al. 2018; Edwards et al. 1996). During this period, in the Jordan Valley, there were two water bodies, separated by a strip of dry land: the current Sea of Galilee and the precursor of the Dead Sea (Bartov et al. 2002, 2003; Hazan et al. 2005; Torfstein et al. 2013). Consequently, the three occupation phases of the Ein Gev area faced similar geographical and topographical conditions: The sites were not far from the shore of the Sea of Galilee, and the strip of dry land allowed the circulation of resources, people, and ideas between the Eastern side of the Jordan Valley and the Mediterranean sub-region of the Levant.

Except for EG I faunal assemblage (Davis 1974; Marom and Bar-Oz 2008), available data in EG III and IV are limited to lists of the animal species found (Bar-Yosef 1970). All the sites contained gazelle, fallow-deer, and hare bones (Table 1—Bar-Yosef 1970). In addition, all the assemblages comprised some blades with sheen on the cutting-edge, suggesting that the gathering of plant resources was part of the subsistence activities (Bar-Yosef 1970). The presence of ground stone tools in EG I and III hints to secondary processing of resources at both sites (Bar-Yosef 1970; Martin and Bar-Yosef 1979). The traces of repeated occupations (Bar-Yosef 1970; Martin and Bar-Yosef 1979) suggest that the sites were regularly used as part of the mobility patterns of groups of hunter-gatherers.

Besides the general similarity in subsistence-related proxies among the sites, some differences were also observed. While no fish remains are present in EG I and EG III

(Bar-Yosef 1970; Davis 1974; Marom and Bar-Oz 2008), Teleostei fishes are part of the EG IV faunal assemblage (Bar-Yosef 1970). Although this can be related to different taphonomic processes, it can also reflect the fact that the Nizzanan occupation was more oriented toward the exploitation of water resources. Even though microliths are the most frequent tool category in all assemblages (Bar-Yosef 1970), these tools appear in much higher frequency in EG III (Table 1). However, this difference could reflect a sampling bias: The initial EG III excavation was limited (Bar-Yosef 1970), and the retrieved lithic assemblage may reflect only the set of activities performed in that specific area. Another possible explanation may be that the occupation of EG III was indeed oriented more toward activities involving production and discard of microliths. Finally, in EG I and IV, scrapers are the second best-represented tool category (Table 1) after microliths and appear in similar frequencies, a phenomenon possibly related to a shared set of activities. The stronger incidence of burins in EG I and notches and denticulates in EG IV may reflect some variability either in the activities performed within the sites (functional) or in the tool-set used for the same tasks (stylistic).

In general, based on their most visible traits (i.e., microlith types), Ein Gev sites lithic assemblages can be divided into three EP cultural entities. Yet, based on a series of other features of the lithic and non-lithic assemblages and on their archaeological contexts, they appear to be functionally and economically similar. Technological analysis of the assemblages may highlight whether continuity among the three manufacturing traditions is present on a local scale.

The formation processes of lithic artifact assemblages (aggregates—Kleindienst 2006) in archaeological contexts are the result of the complex interaction of several different natural and anthropogenic processes, possibly hampering the direct association between morpho-technological traits of the assemblages and behavioral traits of the people that participated in their creation (Rezek et al. 2020). The following interpretation for the Ein Gev lithic assemblages is based on the fact that the typological composition of the microlith

Table 1 Features of Ein Gev sites

	EG I	EG III	EG IV
Resource processing	Basalt pestles, mortar, stone with cup-mark (Bar-Yosef 1970)	Basalt pestles, stone with cup-marks (Martin and Bar-Yosef 1979)	-
Fauna assemblage	Gazelle, Fallow Deer, Wild Goat, Hare, Tortoise (Davis 1974; Marom and Bar-Oz 2008)	Gazelle, Fallow Deer, Red Deer, Hare (Bar-Yosef 1970)	Gazelle, Fallow Deer, Hare, Tortoise, Teleostei fishes (Bar-Yosef 1970)
Plant gathering	Blades with sheen (Bar-Yosef 1970)	Blades with sheen (Bar-Yosef 1970)	Blades with sheen (Bar-Yosef 1970)
Architecture	Repeatedly occupied hut, stone-paved area (Bar--Yosef 1970)	Three phases of reconstruction of a hut, stone-paved area (Martin and Bar-Yosef 1979)	Segment of a stone wall similar to EG I hut (Bar-Yosef 1970)
Main tool categories	Microliths, scrapers, burins (Bar-Yosef 1970)	Microliths (Bar-Yosef 1970)	Microliths, scrapers, notches-denticulates (Bar-Yosef 1970)

assemblages reflects patterns observed on a regional scale, representing techno-complexes with well-established geographical and chronological boundaries (i.e., Kebaran, Geometric Kebaran and Nizzanan—Bar-Yosef 1970; Goring-Morris 1987; Martin and Bar-Yosef 1979). Moreover, other archaeological observations suggest the relatively short time-span of the formation processes of the lithic assemblages and the cultural homogeneity of the anthropological factors that created them, e.g., lithic assemblage from EG I represents the repeated occupation of the same hut (Bar-Yosef 1970), and the three subsequent structures identified in EG III are almost exactly overlapping one another (Martin and Bar-Yosef 1979), suggesting strong continuity in the spatial organization of the site. In addition, the archaeological layers from which the EG I and III assemblages were recovered are interpreted as living-floors (Bar-Yosef 1970; Martin and Bar-Yosef 1979), suggesting that they represent a homogeneous behavioral pattern.

Method

The reduction sequences of the Ein Gev sites are reconstructed based on the attributes of the non-retouched lithic artifacts. The study focuses on cores and debitage; formal tools, chips, and chunks were not included in the present analysis.

Non-retouched artifacts were initially sorted into broad categories based on their overall shape and scar and cortex distribution. Each category represents a specific activity within the reduction sequence (Inizan et al. 1999), including:

- Shaping of the raw material, obtaining one or more striking platforms and reduction surfaces.
- Production of blanks from the reduction surface(s).
- Maintenance of core platform(s) and surface(s) when they are no longer suitable for the production.
- Discard of cores.

Different activities do not necessarily represent chronologically segregated stages in the core reduction process, but rather refer to actions clustered based on their function, similarly to Tostevin's (2011) "flintknapping domains". This functional segmentation of the *chaînes opératoires* allows analyzing each activity separately (Andrefsky 2009), highlighting in which category of the reduction sequence can continuity or differences among the assemblages be found. The criteria used to sort the artifact based on the activities within the reduction sequence are summarized in Table 2.

Within each activity, the artifact subcategories were based on previous studies of the Epipaleolithic lithic technology (Ashkenazy 2014; Bar-Yosef 1970; Goring-Morris et al. 1998; Leplongeon and Goring-Morris 2018; Macdonald et al. 2018; Maher and Macdonald 2013; Marder 2002). Further subdivisions were made to describe specific reduction actions based on patterns observed during this analysis. Production blanks were subdivided into blades, large and small bladelets, micro-bladelets, and production flakes. Artifacts were sorted into the different subcategories based on the ratio between their length and width (elongation) and their maximum width (Table 3). Fragmentary blanks, for which determining whether the original length was more or less than twice the width was not feasible, were counted in the "Flake/Blades" category. Core

Table 2 Manufacturing process activities and related attribution criteria

Activities	Criteria
Shaping	Cortical areas on the dorsal face
Production	Two straight symmetrical cutting edges Thin cross-section Unidirectional scar pattern.
Maintenance	Ascribed in any of the CTE categories (Table 3)
Discarding	Cores
Other	
Indeterminate	Impossible to determine the function in the manufacturing process

Table 3 Categories of production blanks and CTEs and related attribution criteria

Sub-categories	Criteria
Blanks	
Micro-bladelets	Length/width ≥ 2; width ≤ 5 mm
Small bladelets	Length/width ≥ 2; 5 < width ≤ 10 mm
Large bladelets	Length/width ≥ 2; 10 < width ≤ 15 mm
Blades	Length/width ≥ 2; width > 15 mm
Production flakes	Length/width < 2 mm
Flake/blades	Fragments for which it is impossible to determine whether the Length/Width ratio is < or ≥ of 2
CTEs	
Natural ridge-blade[a]	Thick blade/flake with triangular section (isosceles), removal of the natural ridge
Ridge-blade[a]	Thick blade/flake with triangular section, prepared with one or two series of perpendicular removals from the center to the sides of the blank (ridge preparation) on all or part of its length
Core-tablet	Element completely or partially removing the striking platform. Flakes with wide, faceted platform (proximal part of the original reduction surface)
Lateral convexity maintenance flake	Wide flake detached from the side of the core. It may bear flake scars parallel, perpendicular, and/or opposite the debitage direction. Removal of a small part of the reduction surface
Side-flake[b]	Blade/flake extracted in the same direction of the production; removes part of the reduction surface and a smaller or equal part of the side of the core
Cortical side-flake[b]	Blade/flake extracted in the same direction as the production; removes part of the reduction surface and a smaller or equal part of the cortical side of the core
Surface maintenance	Removal of hinge/s from the reduction surface
Edge rejuvenation	Removal of the edge of the striking platform when it is no longer fit for production. Direction is parallel or perpendicular to debitage
Varia CTE	

[a] Ridge blade and natural ridge-blades may have been produced both during the shaping and the maintenance phase. In this study, they are included in the maintenance phase

[b] In these categories are also included artifacts similar to production blanks that remove just a small part of the core's side or crest preparation

trimming elements (CTEs) were sorted into subcategories representing specific actions in core-maintenance procedure (Table 3).

In order to understand the reduction sequences, production blanks and cores were described according to a series of attributes. Production blanks were described quantitatively based on elongation and maximum length, width and thickness, and qualitatively based on outline, cross-section, type of platform, and profile of the ventral face.

Cores were qualitatively described based on the following:

- Original surface (cortex) type
- Amount of cortex
- Position of cortex
- Number and position of striking platforms
- Number and position of reduction surfaces
- Reduction modality (core type).

Statistical analysis was applied to the extracted data. Variability in the representation of the different activities and their subcategories, and in qualitatively described attributes of cores and blanks was measured based on the coefficient of correlation between the distribution into classes (analysis performed with the "correlation coefficient" function available in Matlab®). The continuous nature of the quantitatively described attributes of production blanks (length, width, thickness, and elongation) allowed the comparison of their distributions. However, the distribution of blank attributes may strongly deviate from normal and should not be compared based on their parameters (e.g., mean and standard deviation). Therefore, the comparison was based on the non-parametric Wilcoxon rank-sum test, aimed at establishing if two samples come from populations with different means (Wilcoxon 1945, 1946—"Wilcoxon rank sum test" available in Matlab® Statistichs and Machine Learning toolbox).

Results

The most significant results of the technological analysis are reported below. A full record of the analysis is presented in Online Resource 1.

The different activities within the reduction sequence (including shaping, maintenance, production, and discarding) appear in broadly similar frequencies in all four assemblages (Table 4), suggesting that, in all cases, the full manufacturing process took place within the sites, and that the three sites shared a generally similar organization of the lithic technology. The production items are the most frequent, followed by maintenance ones. The frequency of indeterminate items is relatively high. Most of these artifacts are fragmentary flakes whose function in the reduction sequence is impossible to determine.

To define which of the selected attributes can be used to track continuity in traits of the reduction sequence, their stability is tested between two EG I layers (Layer III and IV). It is likely, that the two assemblages reflect similar behavioral patterns (see above). Therefore, features showing a significant degree of similarity between the two assemblages can be used to track possible technological continuity among the three sites. In

Table 4 Composition of the débitàge assemblages sorted by the action they represent in the reduction sequence

	EG I – Layer III		EG I – Layer IV		EG III		EG IV	
	n	%	n	%	n	%	n	%
Shaping	168	*12*	120	*15*	119	*9*	346	*20*
Production	535	*38*	275	*34*	565	*45*	624	*37*
Maintenance	303	*22*	133	*17*	192	*15*	338	*20*
Other	17	*1*	8	*1*	10	*1*	20	*1*
Indeterminate	275	*20*	219	*27*	338	*27*	323	*19*
Discarding (cores)	98	*7*	48	*6*	44	*3*	39	*2*
Total	**1396**	***100***	**803**	***100***	**1268**	***100***	**1690**	***100***

the following comparison among the Ein Gev sites, the assemblages from the two EG I layers are lumped together.

Variability Within EG I

The distribution of most of the attributes (Online Resource 2) is similar between the two EG I assemblages, and only the correlation between the subcategories of bladelets, CTEs, and the cross-section of the bladelets is not significant (Tables 5 and 6). Consequently, continuity among the lithic reduction sequences of the three sites can possibly be established based on the outline, profile, platform, metric attributes of the bladelets, and all the core attributes.

Variability Between Ein Gev Sites

Based on the results of the control described above, the following technological comparison between the Ein Gev sites focuses on the production of blanks and cores.

All the core attributes are highly correlated between EG I and III (Table 7). In addition, a strong correlation is observed across all the assemblages in the types of the original surfaces (absent, limestone cortex, pebble cortex, mixed, other), with a majority of cores presenting pebble cortex perhaps reflecting the exploitation of the same raw material sources by all cultural entities.

Correlation in the amount of cortex preserved is non-significant between EG IV and EG I (Table 7), yet EG III appears to be correlated with both EG I and IV based on this attribute.

Based on the distribution of the cortical surfaces, EG IV is set apart from the other two assemblages (Table 7). In fact, cores with cortex on both their back and one of their sides have a high incidence in EG I and III assemblages but are absent in EG IV. On the other hand, some of EG IV cores present cortex on their distal end, while this category is virtually absent in the other assemblages (Fig. 4a). In addition, it was observed that several specimens from EG IV were covered in cortex on all their sides, with modified surfaces just on their striking platform and reduction surface (classified as "Other").

Table 5 Correlation coefficients (r) between qualitative attributes of EG I, Layer III, and IV and their significances (*p*)

Attributes	Correlation (r)	Significance *(p)*
Blank classes	*1.00	**0.06*
Production (bladelets)		
Outline	1.00	*< 0.001*
Profile	1.00	*< 0.001*
Cross-section	*0.98	**0.11*
Platform	0.97	*0.001*
Maintenance (CTEs)		
CTE classes	*0.50	**0.17*
Discard (cores)		
Original surface type	0.99	*< 0.001*
Original surface amount	0.98	*0.001*
Original surface position	0.86	*< 0.001*
Striking platform(s)	0.99	*< 0.001*
Reduction surface(s)	0.99	*0.001*
Exploitation modality	0.98	*< 0.001*

*Attributes non-significatively correlated between the assemblages ($\alpha = 0.05$)

All the core assemblages present a similar distribution based on the number and position of striking platforms and reduction surfaces (Table 7). Most cores have a single reduction surface, exploited from a single, flat striking platform; when two striking platforms are present, these are usually on the same side of the core (complanar). However, some minor variation in these attributes is systematically observed between the sites: In EG I, complanar platforms are used to exploit two opposite reduction surfaces, giving the core a triangular profile (Fig. 5, (6)); in EG III, the reduction surfaces are usually adjacent (Fig. 5, (3)); and in EG IV, these two variants are virtually equally represented (Fig. 4b). In addition, in cores with two opposed surfaces, the striking platforms are usually on the same continuous surface in EG I (Fig. 5, (6)), while they are located on two separate segments in EG IV, often in a slightly different orientation (Fig. 5, (9)). It should be noted that two EG I specimens present two

Table 6 Comparison of bladelets (including large, small and micro-bladelets) metric variability between EG I, Layers III, and IV

	EG I – Layer III		EG I – Layer IV		U-test
	Avg.	SD	Avg.	SD	*p*
Length (mm)	30.79	*9.72*	31.58	*12.29*	0.95
Width (mm)	7.96	*2.79*	8.02	*2.86*	0.90
Thickness (mm)	1.98	*1.33*	2.04	*1.03*	0.27
Elongation (L/W)	3.67	*1.43*	3.72	*1.42*	0.79

Table 7 Pearson correlation coefficients (r) of the core attribute frequencies and their significnaces (*p*)

	EG I - EG III		EG I - EG IV		EG III - EG IV	
	r	*p*	r	*p*	r	*p*
Original surface type	0.97	*0.00*	0.89	*0.02*	0.87	*0.03*
Amount of cortex	0.90	*0.01*	*0.68	**0.14*	0.85	*0.03*
Cortex position	0.92	*0.00*	*0.67	**0.02*	*0.71	**0.01*
Striking platform(s)	1.00	*0.00*	0.99	*0.00*	0.99	*0.00*
Reduction surface(s)	0.98	*0.00*	0.99	*0.00*	0.98	*0.00*
Exploitation modality	0.95	*0.00*	*-0.01	**0.99*	*0.20	**0.67*

*Attributes with non-significant (α = 0.05) and/or low (r ≤ 75) correlation

modified surfaces, defining a narrow dihedron; these surfaces were used alternatively as a striking platform and a reduction surface.

The correlation between EG I and EG III is also strong in the reduction modality (Table 7), with a preference toward narrow-fronted cores (Fig. 4c, Fig. 5, (1, 2, 4, 5)). A variant, attested for in several cases, is the extension of the reduction surface to one of the sides (*semi-tournat,* Fig. 5, (2, 4)). In contrast, in EG IV, most cores are exploited from their wide front (Fig. 5, (7, 8)).

In EG I and EG III, the longitudinal convexity of narrow-fronted cores is maintained with a ridge obtained through one or two series of removals from the center toward the

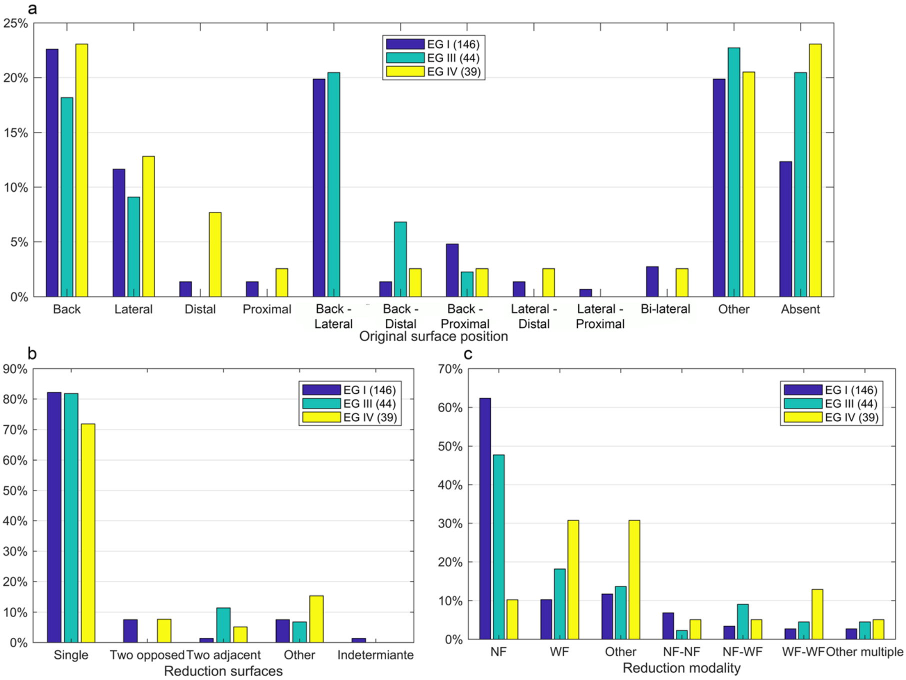

Fig. 4 Frequencies of core attributes: position of the original surface (**a**); reduction surfaces (**b**); and reduction modality. NF narrow-fronted, WF wide-fronted (**c**). Graphs created with *Matlab*®

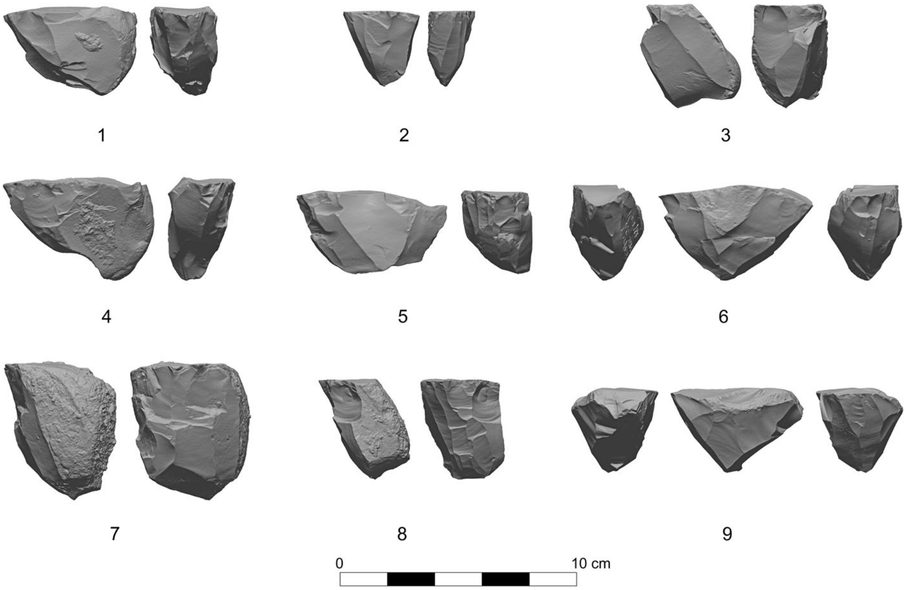

Fig. 5 Cores: EG III (1-3), EG I (4-6) and EG IV (7-9). Figure created with *Artifact3-D* (Grosman 2016; Grosman et al. 2008, 2014)

sides of the reduction surface; the transversal convexity is maintained with CTEs extracted from one or both sides of the core. Systematic maintenance of wide-fronted cores is, instead, rarely attested.

In EG III, the cores aimed at the production of bladelets are generally narrow-fronted, and the ones aimed at the production of bigger blanks are wide-fronted, such as two over-sized bipolar cores exploited for the extraction of large blades and production flakes. This choice could possibly be related to the existence of two separate reduction strategies for bladelets (narrow fronted) and larger blanks (wide fronted cores) at the site.

Table 8 Frequencies of production blanks

	EG I		EG III		EG IV	
	n	%	n	%	n	%
Micro-bladelets	104	*13*	34	*6*	10	*2*
Small bladelets	314	*39*	240	*43*	180	*29*
Large bladelets	112	*14*	68	*12*	136	*22*
Tot. bladelets	530	*65*	342	*61*	326	*52*
Blades	49	*6*	22	*4*	39	*6*
Production flakes	95	*12*	63	*11*	53	*8*
Flakes/blades	136	*17*	138	*24*	206	*33*
Total	**810**	***100***	***565***	***100***	**624**	***100***

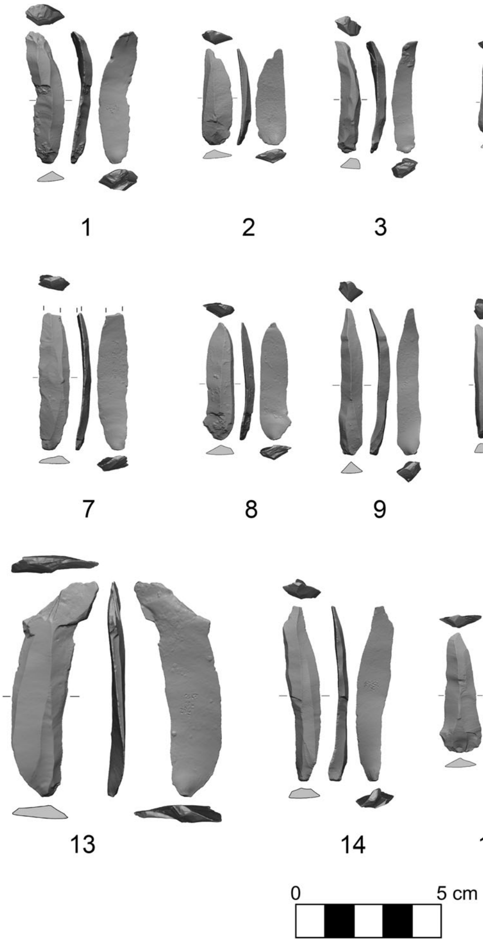

Fig. 6 Production blanks: EG III (1-6), EG I (7-12) and EG IV (12-17). Figure created with *Artifact3-D* (Grosman 2016; Grosman et al. 2008, 2014)

When considering the composition of the production-blank assemblages (Table 8, Fig. 6), it can be observed that all the assemblages are dominated by bladelets (large, small, and micro). Consequently, only the analysis of bladelet attributes is reported in

Table 9 Pearson correlation coefficients (r) of bladelet attribute frequencies and their significances (*p*)

	EG I - EG III		EG I - EG IV		EG III - EG IV	
	r	*p*	r	*p*	r	*p*
Outline	1.00	*< 0.001*	0.99	*< 0.001*	0.99	*< 0.001*
Profile	0.98	*< 0.001*	0.98	*< 0.001*	0.97	*< 0.001*
Platform type	0.96	*0.01*	*0.75	**0.14*	*0.84	**0.07*

*Attributes non-significatively correlated between the assemblages (α = 0.05)

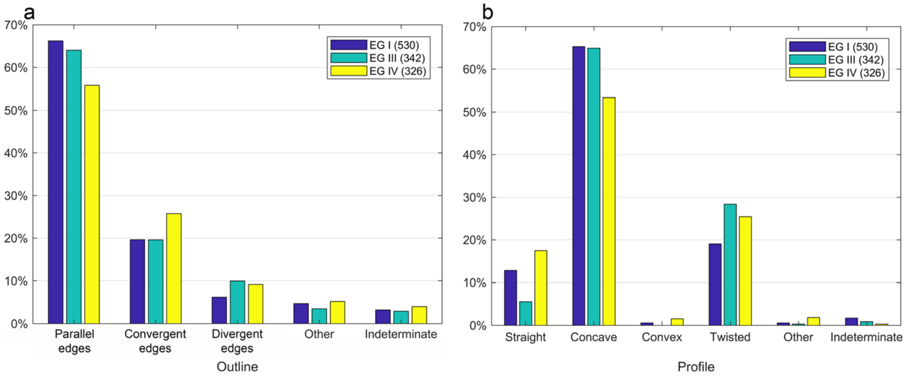

Fig. 7 Frequencies of bladelets attributes: outline (**a**) and profile (**b**); Graphs created with *Matlab*®

the sequel (the analysis of the complete blank assemblages, including bladelets, blades, and production flakes, is reported in Online Resource 3).

The distribution of bladelet outline and profile into classes is strongly correlated between the three assemblages (Table 9): Most blanks present parallel edges and a concave profile (Fig. 7). In contrast, while a strong correlation in platform type is observed between EG I and III, EG IV appears significatively different (Table 9). Although most bladelets present a linear platform in all the assemblages, the second-best represented type in EG IV is flat, in EG I and EG III, punctiform (Fig. 8a).

A high variability in the bladelet length is present in all the assemblages (EG I mean length 31.0, SD 10.6 mm; EG IV mean length 29.6, SD 11.5 mm; EG III mean length 27.0, SD 9.0 mm; Fig. 8b). In contrast, the width of the EG I and III bladelets presents a strikingly similar distribution (EG I mean width 8.0, SD 2.8 mm; EG III mean width 8.0, SD 2.5 mm respectively; Fig. 8b), and are generally narrower than the EG IV bladelets (mean width 9.5, SD 2.8 mm). Thus, the difference in width creates a significative distinction between the assemblages (Table 10): narrower bladelets in EG I and III, and wider in EG IV.

Summing up, a significant correlation between all the assemblages is observed in many bladelets attributes. EG IV cores stand apart from the other two sites based on the

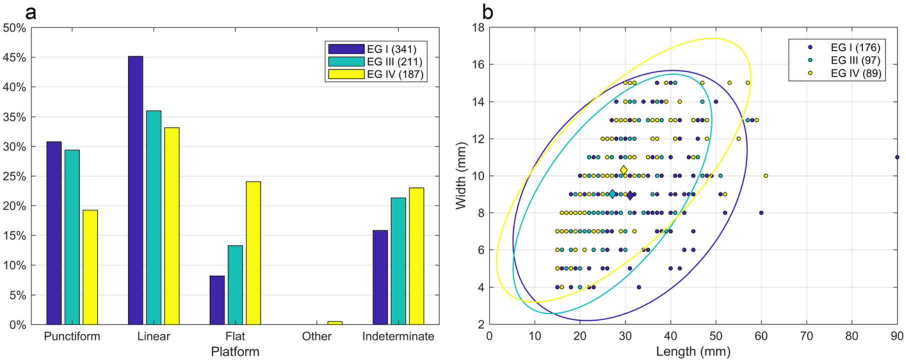

Fig. 8 Frequencies of bladelet platform types—fragmentary artifacts with missing platform are excluded (**a**). Scatter-plot of bladelet length and width—diamonds mark the centroids, ellipses the 95% coverage of the distributions (**b**); Graphs created with *Matlab*®

Table 10 Results of the Wilcoxon rank-sum test (U-test) for bladelet metric values

	EG I - EG III	EG I - EG IV	EG III - EG IV
Length (mm)	*0.001	0.15	0.22
Width (mm)	0.75	*< 0.001	*< 0.001
Elongation (L/W)	*0.001	*< 0.001	0.09

*Attributes with significative difference ($\alpha = 0.05$)

position of the original surface and exploitation modality, and the bladelets based on width and platform types.

Finally, transversal and longitudinal convexities of bladelet cores in EG I and III are systematically maintained by preparing distal crests and extracting CTEs, while EG IV presents a more opportunistic reduction sequence, with no systematic preparation and maintenance of convexities.

Discussion

The present study focuses on three sites representing different EP cultural entities in a limited geographic area. In general, the sites were functionally and economically similar (see above). Similarity between the three lithic assemblages was observed based on some of the attributes presented in this analysis. Cores present, usually, a single reduction surface, exploited from a single, flat striking platform. The main goal of the reduction sequence was obtaining bladelets with parallel edges and concave profile. Pebble-cortex is visible on most cores, suggesting that the main sources of raw material were the secondary deposits along the shores of the Sea of Galilee or neighboring stream beds.

Variability exists in a series of other technological traits. One of the more archaeologically prominent technological features of the microlith manufacturing processes, the MbT, is widely attested in EG IV but virtually absent in EG I and III (Bar-Yosef 1970; Goring-Morris 1987; Martin and Bar-Yosef 1979). In addition, sites can be clustered in two groups (EG IV vs. EG I and III) based on variability in four of the technological attributes considered in present analysis:

- Position of the original surface—Many EG I and III cores preserve the natural surface only on one side or on one side and the back (Fig. 4a), suggesting that shaping involved the removal of cortical flakes from a single side. These two subcategories of cores have very-low-frequency in EG IV. In contrast, several EG IV cores present cortex on their distal part, pointing to the absence of systematic shaping and maintenance of the longitudinal convexity, while virtually no EG I and III cores are included in this category.
- Bladelet width and core reduction modality—In EG I and III, the presence of narrower bladelets with a more standardized width (Fig. 8b), and the preferential exploitation of the narrow side of flint nodules (Fig. 4c) may be related to the same technological behavior. The width of the extracted blanks is inversely proportional to the local transversal convexity of the core's reduction surface (Elston and

Brantingham 2002). Narrow-fronted cores allow more efficient maintenance of the transversal convexity and, consequently, the extraction of narrower blanks with less waste of core volume during maintenance (Elston and Brantingham 2002), yet they require a greater investment of energy and material through the shaping process. The use of narrow-fronted cores in EG I and III reflects, thus, the choice to "waste" more time, energy, and raw material in shaping core convexities, in return of more efficient production of narrow, regular bladelets. Conversely, EG IV wide-fronted cores were shaped through a few basic actions requiring greater investment to maintain the surface convexities during the bladelet production process and resulting in blanks with greater width variability.

- Bladelet platform and proximal part—Most bladelets in EG I and III present linear or punctiform platforms (Fig. 8a), flat platforms have often reduced width and thickness. Bulbs on the ventral face are small, frequently with visible percussion marks. On the other hand, EG IV bladelets present a combination of linear, punctiform, and flat platforms (Fig. 8a), including several wide, thick platforms, usually with lip, small, well-defined bulbs and no visible percussion marks.

  Several experimental works (Damlien 2015; Pelegrin 2000, 2006) related the traits of the blanks to the knapping technique (sensu Tixier 1967, p. 807), more specifically to the modality by which the energy is delivered to the raw material (direct percussion, indirect percussion or pressure) and the nature of the knapping tool (hard, soft stone or organic material). Although it was not possible to establish a significant statistical separation between assemblages of blanks obtained with different techniques (Damlien 2015), a general trend can be observed in the attributes of production blanks from hard-stone direct percussion to pressure flaking (hard, soft stone, organic direct percussion, organic indirect percussion, pressure flaking). The correspondence between percussion technique and blank attributes is not univocal: The same percussion technique may result in blanks with different attributes, still some of them will be more frequent than others (Damlien 2015).

  Traits observed in EG I and III are generally related to soft-stone direct percussion (Pelegrin 2000), suggesting that bladelets were obtained almost exclusively by this technique. In contrast, wide flat platforms with lip and small well-defined bulbs, and the absence of visible percussion marks are often related to direct percussion with organic material (Pelegrin 2000, 2006), suggesting that, in EG IV, bladelets were obtained by both soft-stone (linear, punctiform, small flat platforms) and organic-material (wide flat platforms) direct percussion techniques.

In summary, continuity in several technological traits can be observed between EG I and EG III. In fact, both sites are characterized by the lack of MbT, an emphasis on narrow bladelets, carefully prepared narrow-fronted cores, almost exclusive use of direct percussion with soft hammerstone, and convexity maintenance with distal crest and side-flakes. However, a series of innovations in the lithic technology appear in the EG III, Geometric Kebaran assemblage. Complanar reduction surfaces are usually adjacent rather than opposite, and the frequency of wide-fronted cores slightly increases. In contrast, EG IV presents several traits not encountered in the other two neighboring EP assemblages: use of MbT, emphasis on wide bladelets and larger blanks, wide-fronted cores, use of both soft stone and organic percussion technique, and no traces of systematic core maintenance.

Some of the EG IV technological traits are already attested in the Ein Gev area before the EP, in the Upper Palaeolithic site Naḥal Ein Gev I – NEG I (Belfer-Cohen et al. 2004) (Fig. 2). The lithic tool assemblage of this site is dominated by burins on truncation and carinated scrapers, microliths appear in low frequency, and flakes are the major component of the debitage assemblage. Based on these typological and technological traits, common in other Upper Palaeolithic sites in the region (Echegaray and Freeman 1989; Goring-Morris 1980; Newcomer 1971), the NEG I occupation was attributed to the Atlitian cultural entity (Belfer-Cohen et al. 2004). Still, both EG IV and NEG I assemblages are characterized by wide-fronted cores with minimal or no preparation and bladelets with wide, flat platforms, possibly related to the use of direct or indirect organic percussion technique. In contrast, the extraction of highly standardized, narrow, incurvated bladelets from the narrow side of flint nodules and the fixed set of core-maintenance operations attested by "formal" CTEs observed in EG I and III are already attested in the Levant during the Upper Palaeolithic Early Ahmarian culture (Bretzke and Conard 2012; Davidzon and Goring-Morris 2003; Goring-Morris and Davidzon 2006).

Larger Regional Framework

Comparison with data available from other studies on different areas of the Southern Levant can provide further insight into how present observations on Ein Gev's lithic technology fit in the larger regional framework.

Marder (2002) reconstructed the Negev bladelet reduction sequences based on refitting analysis of the lithic assemblages of Shunera XVII (Kebaran), Hamifgash IV (Nizzanan) and Azariq XVI (Geometric Kebaran). Besides, several traits common to all the assemblages in the two areas, the comparison of the Negev and Ein Gev sites highlights geographic homogeneity in the Kebaran and variability in the Nizzanan and Geometric Kebaran:

- Kebaran—Both EG I and Shunera XVII lithic assemblages are characterized by the exploitation of mainly narrow-fronted cores, with systematic shaping and maintenance of transversal and longitudinal surface convexities through distal crests and cortically backed elements (Goring-Morris et al. 1998; Marder 2002).
- Nizzanan—In Hamifgash IV, bladelet production process exploited mainly narrow-fronted cores, sometimes maintaining the longitudinal convexity through removals from an auxiliary platform opposite to the main one (Marder 2002). On the other hand, in Ein Gev IV, most of the cores were wide-fronted, with no auxiliary platform.
- Geometric Kebaran—In Azariq XVI, cores were mostly wide-fronted with variable shape; the transversal convexity of the reduction surface was maintained through the removal of cortically-backed elements, and the longitudinal one by either removing bladelets from an auxiliary platform or through the preparation of a small distal ridge (Marder 2002). On the other hand, in Ein Gev III, bladelets were mainly extracted from systematically shaped and maintained narrow-fronted cores.

Additional geographic variability within the Nizzanan and Geometric Kebaran cultural entities is supported by the comparison of Ein Gev lithic assemblages with data

Table 11 Frequencies of bladelets attributes (outline, profile, and platform) in assemblages attributed to Nizzanan and Geometric Kebaran in the Ein Gev area and the Negev. Data for the Negev sites are after Leplongeon and Goring-Morris (2018)

	Nizzanan				Geometric Kebaran			
	EG IV		Hamifgash IV		EG III		Azariq XVI	
	n	%	n	%	N	%	n	%
Outline								
Parallel edges	179	*55*	40	*33*	220	*64*	22	*20*
Convergent edges	85	*26*	33	*27*	69	*20*	38	*35*
Divergent edges	30	*9*	4	*3*	33	*10*	3	*3*
Irregular/other	17	*5*	42	*35*	11	*3*	44	*41*
Ind.	13	*4*	2	*2*	10	*3*	1	*1*
Profile								
Straight	55	*17*	29	*24*	19	*6*	15	*14*
Concave	174	*54*	57	*47*	222	*65*	69	*64*
Convex	5	*2*	1	*1*	1	*0*	-	-
Twisted	83	*26*	28	*23*	97	*28*	20	*19*
Other	6	*2*	5	*4*	1	*0*	4	*4*
Ind.	1	*0*	1	*1*	3	*1*	-	-
Platform								
Punctiform	36	*19*	6	*5*	62	*29*	21	*19*
Linear	63	*34*	12	*10*	77	*36*	38	*35*
Flat	43	*23*	40	*33*	30	*14*	34	*31*
Other	1	*1*	3	*3*	-	-	-	-
Ind.	42	*23*	59	*49*	43	*20*	15	*14*
Total	**185**	***100***	**120**	***100***	**212**	***100***	**108**	***100***

Table 12 Average and standard deviation for metric values in bladelet assemblages attributed to Nizzanan and Geometric Kebaran in the Ein Gev area and the Negev. Data for the Negev sites are after Leplongeon and Goring-Morris (2018)

	Nizzanan				Geometric Kebaran			
	EG IV		Hamifgash IV		EG III		Azariq XVI	
	Avg.	*SD*	Avg.	*SD*	Avg.	*SD*	Avg.	*SD*
Length (mm)	28.5	*10.7*	33.7	*11.2*	26.7	*8.9*	35.2	*9.8*
Width (mm)	9.5	*2.8*	10.1	*2.7*	8.1	*2.6*	10.9	*2.7*
Thickness (mm)	2.4	*1.1*	3.9	*2.3*	2.1	*0.9*	3.5	*1.9*
Elongation (T/W)	2.8	*0.8*	3.4	*1.2*	3.0	*0.9*	3.3	*0.8*

provided by Leplongeon and Goring-Morris (2018) on bladelet attributes in Hamifgash IV and Azariq XVI (Tables 11 and 12):

- No significant correlation is observed in the platform types between the Negev and Ein Gev sites. The greater representation of punctiform, linear and narrow, flat platforms reflects the important role of direct percussion with soft stone-hammer (cf. Damlien 2015; Pelegrin 2000, 2006) in the Ein Gev area, especially in EG III, as opposed to the Negev, where the relatively numerous wide, flat platforms are possibly related to direct or indirect organic percussion.
- Bladelet width is highly standardized within each assemblage (SD between 2.5 and 3.0 mm; Table 12). Yet, in Azariq XVI, bladelets are significantly wider than in EG III, possibly reflecting practical or stylistic differences between the areas during the Geometric Kebaran. However, the difference in bladelet width among the Nizzanan sites is not significant.
- Bladelets with a rounded outline appear in very low frequencies in the Ein Gev area and higher percentages in the Negev (Table 11), perhaps reflecting different technological choices in the bladelet manufacturing process, or different sampling and classification methods. Further analysis based on shared parameters may confirm or negate the technological value of the present observation.

Summing up, while several technological traits were shared between the Ein Gev area and the Negev during the Kebaran, geographical variability in reduction method and technique existed between these two areas during the time span covered by the Nizzanan and Geometric Kebaran cultural entities.

The comparison among bladelet reduction sequences related to different cultural entities in the Negev (Davidzon and Goring-Morris 2003; Goring-Morris et al. 1998; Goring-Morris and Davidzon 2006; Leplongeon and Goring-Morris 2018; Marder 2002) presents a somewhat different picture from what was observed in the Ein Gev area. In both areas, the Kebaran reduction sequence maintained traits of the Upper Palaeolithic Ahmarian tradition (Davidzon and Goring-Morris 2003; Goring-Morris and Davidzon 2006). Opposed to the abrupt technological discontinuity observed between the Nizzanan and the Geometric Kebaran in the Ein Gev area, in the Negev, some technological continuity is observed between these two cultural entities. Both entities are characterized by the limited effort put into shaping the core, and the maintenance of the longitudinal convexites of the reduction surface through removal from an auxiliary striking platform opposite to the main one (Leplongeon and Goring-Morris 2018; Marder 2002).

Manufacturing Traditions in the EP

Observed patterns in different aspects of the EP lithic assemblages reflect variability in available resources, practical necessities, and stylistic background (Bleed 2001; Shott 2003; Soressi and Geneste 2011; Tostevin 2011). An example of a practical need could be a given task, as scraping rather than perforating, or the solution of a problem encountered during the reduction sequence. The stylistic background consists of a series of existing mental templates (Sackett 1982) defining the expected outcome of each step in the reduction sequence. These mental templates are adopted through imitation or during a structured learning process (Hiscock 2014) and can be ultimately related to the manufacturing tradition of the knapper. Examples are seen in the choice of producing one of several functionally similar or equivalent tools to accomplish a given task; the choice of a specific solution, over several available, to deal with a given technological problem; or the shaping of the same available raw material into one of many possible types of cores. These technological choices do not reflect economic constraints, but are, in fact, isochrestic (Sackett 1982). They are affected, instead, by a series of stylistic constraints related to the identification (or self-identification) of the knapper as part of a smaller or larger population, i.e., by her/his culture (Gosselain 2000; Hiscock 2014; Hovers 2009, p. 193; Wobst 1977).

Patterns of chronological and geographical continuity in the stylistic constraints reflected by the lithic assemblages may, thus, be used to track the circulation of people and ideas in the pre-Natufian EP. Yet, the generally accepted equation between recurring combinations of technological and typological features in lithic assemblages (NASTIES) and culture or other behavioral traits of past human populations is not a straightforward one (Shea 2014) and has to be sustained by a robust theoretical framework, presented below, before being applied to traits of EP lithic assemblages.

In general, within a learning community periodically occupying a determinate geographic area, cultural traits (Lyman and O'Brien 2003) are “vertically” (sensu Borgerhoff Mulder et al. 2006) transmitted from one generation to the other (Cavalli-Sforza et al. 1982). When new cultural traits are observed, they could reflect the occupation of the area by a different group, or perhaps be related to an independent construction or “horizontal” transmission through the interaction with other neighboring populations (Borgerhoff Mulder et al. 2006; Eerkens and Lipo 2007).

Cultural transmission among groups could be biased by the mode and context of the transmission and the nature of the transmitted traits (Eerkens and Lipo 2007; Gosselain 2000), resulting in only some of the traits being shared within a network of interacting communities. Other traits may be maintained and continue to be “vertically” transmitted within the different learning communities. Consequently, in the case of “horizontal” transmission among populations, or the construction of new cultural traits, we may expect continuity in other cultural aspects, while, in the case of a new population, a whole new set of cultural traits is expected to appear. Among the factors affecting the transmission of cultural traits are the mobility system, the visibility of the traits (Premo and Tostevin 2016), the ease by which a variant of a cultural trait can be replaced with another after a learning process (malleability), and the social context in which the trait is transmitted (Gosselain 2000). In a logistical mobility system, traits that are visible in a wide array of situations (high visibility), easily adopted after a learning process (malleable), and whose transmission involves a large part of the group are more likely transmitted among communities than traits mainly visible within residential bases (low visibility), hard to modify after being learned (rigid), and whose transmission involves a restricted group of people (Gosselain 2000; Premo and Tostevin 2016). Easily transmitted traits tend, thus, to be geographically widespread and fluctuate through time; they can consequently be related to more general aspects of group identity (Gosselain 2000). On the other hand, traits that are less frequently transmitted between different communities tend to be maintained through time and present variegated geographical patterns; they can thus reflect group identity at a learning community level.

Based on this theoretical framework, the different degree of technological malleability and visibility between the microlith types and their manufacturing processes can explain the observed geographical variability in technological traits within typologically defined EP cultural entities, highlighting the presence of local learning communities. Microlith types were loosely related to the reduction method and technique adopted for blank production (Belfer-Cohen and Goring-Morris 2002; Macdonald 2013; Marder 2002), and were, in fact, technologically malleable (Gosselain 2000). Being hafted in composite tools used to perform a wide array of activities (Belfer-Cohen and Goring-Morris 2002), microliths might also have been highly visible in different aspects of the social interaction between and within human groups. The typological traits used to define EP cultural entities (i.e microlith types) are, thus, likely to be transmitted among different communities belonging to the same geographically widespread network (Gosselain 2000; Macdonald 2013; Premo and Tostevin 2016). In contrast, the microlith manufacturing process was scarcely visible outside the restricted knapping community (Hiscock 2014), and technologically rigid (Gosselain 2000). It was, therefore, likely to be vertically transmitted (sensu Borgerhoff Mulder et al. 2006) and maintained within local learning communities (Gosselain 2000; Macdonald 2013; Premo and Tostevin 2016). Outside the Levantine EP context, the production of similar end-products with different manufacturing procedures is proposed to reflect the existence of distinct yet interacting populations for example in French Châtelperronian and Proto-Aurignacian (Roussel et al. 2016) and in the Pre-Pottery Neolithic B of the Middle Euphrates valley (Borrell and Molist 2014).

A possible ethnographic comparison for how EP population dynamics are reflected by microlith types is recent hunter-gatherers in the Kalahari and their arrowheads. Stylistic traits of these highly visible artifacts are used to transmit information about the linguistic group of the owner (Wiessner 1983; Wobst 1977). Different linguistic groups share a very similar material culture, subsistence strategies, and ideological system, and are characterized by frequent interaction between one another. Nevertheless, their languages are mutually unintelligible. Each linguistic group is subdivided in bands and band clusters that inhabit specific territories. On a 10-year scale, the affiliation of individuals with a specific band is relatively stable (Wiessner 1983). In EP assemblages, variability in the set of highly visible and technologically malleable microlith types may represent the wider cultural entity affiliation, parallel to the Kalahari linguistic groups. On the other hand, low-visibility and rigid technological traits, as the blank production process, can be used to track variability in the cultural belonging on a smaller scale, detecting the local learning communities (corresponding to Kalahari bands or band clusters) within broader cultural entities (Gosselain 2000; Macdonald 2013; Premo and Tostevin 2016).

The similar geographical, geological, and ecological settings of the Ein Gev sites suggest that the same resources were available during their occupation, and aspects of the archaeological record other than lithic techno-typology (fauna, architecture, groundstone tools, sickle-gloss) hint at similar economic activities performed on site (see above). In these specific archaeological cases, techno-typological variability among the lithic assemblages may, thus, be reasonably used to track variability in the cultural identity of the human groups that produced them.

The observed technological continuity between the occupations of EG IV and NEG I (Belfer-Cohen et al. 2004) may reflect continuity in the population of the Ein Gev area between the end of the Upper Palaeolithic and the Nizzanan. However, a series of innovations appear in EG IV, mainly related to microlithization and following a general trend observed on a regional level at the onset of the Epipaleolithic (Belfer-Cohen and Goring-Morris 2002). Microliths (backed, retouched, or truncated bladelets and micro-awls) appear in low frequency in NEG I tool assemblage, while being the best-represented tool class in EG IV. Also, MbT is virtually absent in NEG I while it is widely attested in EG IV, and a higher standardization in bladelet thickness is observed in EG IV (mean thickness: 2.4 mm, SD: 1.2 mm) than NEG I (mean thickness: 3 mm, SD: 2 mm). Increased thickness standardization and the use of MbT point to greater need for microliths with standardized shape and size in the Nizzanan. Standardized lithic implements are more easily replaced when broken or missing from composite tools (Chase 1991). Microlith standardization may thus be related to the appearance of serial hafting (Belfer-Cohen and Goring-Morris 2002). In addition, due to their high visibility in a wide set of activities, more standardized implements may be more efficient in stylistic communication (Premo and Tostevin 2016; Wiessner 1983; Wobst 1977).

The continuity between EG I and III and the Early Ahmarian manufacturing traditions (Bretzke and Conard 2012; Davidzon and Goring-Morris 2003; Goring-Morris and Davidzon 2006) further supports the conservative nature of the reduction method and technique (Marder 2002), and their possible use to track manufacturing traditions beyond the typological variability in the final tools. The Ahmarian technological concept focuses, in fact, on obtaining regular, elongated bladelets, easily modified in the intended final tools (El-Wad points) by marginal retouch (Davidzon and Goring-Morris 2003; Goring-Morris and Davidzon 2006). In contrast to the El-Wad points, Kebaran and Geometric Kebaran microliths were obtained through abrupt invasive retouch (backing and truncations), their final shape being thus more loosely related to the shape of the original blanks (Belfer-Cohen and Goring-Morris 2002). Nonetheless, during the Kebaran and Geometric Kebaran, the reduction sequence aiming at obtaining highly standardized, elongated blanks was maintained in the Ein Gev area.

The relatively abrupt discontinuity between the lithic technologies of EG IV, and EG I and III seems to reflect subsequent occupations of the area by human groups with different technological traditions. Based on the current chronological framework for Early EP cultural entities (Goring-Morris and Belfer-Cohen 2017), substantial overlapping existed between the Kebaran (22,500–18,500 cal BP) and the Nizzanan (20,000–18,500 cal BP) on a wide regional level. Also, only a single radiometric date is available for EG I (GrN-5576–15,700 ± 415 BP; 18,610 ± 465 cal BP) and none for EG IV. It is, therefore, impossible to directly establish the correct sequence of the Early EP occupations in the Ein Gev area. It is nevertheless likely that at different stages of the Early EP, the area was subsequently occupied by two populations with relatively different manufacturing traditions. One, EG IV, possibly originated locally, developing or adopting traits of the Nizzanan (microliths, MbT), maintaining technological traits of the local Upper Palaeolithic—NEG I (wide-fronted cores with limited preparation and ad hoc maintenance, combination of stone and organic percussion technique, relatively wide bladelets—Belfer-Cohen et al. 2004). The other, EG I, represented possibly a group of newcomers, carrying with them a completely different set of typological (Kebaran microlith types, no MbT) and technological solutions (carefully prepared narrow-fronted cores, systematic convexity maintenance, soft hammerstone percussion technique, narrower bladelets), possibly deriving from the Ahmarian tradition (Davidzon and Goring-Morris 2003; Goring-Morris and Davidzon 2006). This manufacturing tradition continued in the Middle EP, adopting or developing typological traits of the Geometric Kebaran, but without substantial changes in the reduction sequence. Further suggesting the population continuity between EG I and III is the pronounced topographical proximity between the sites: Over time, the same population may have continued to settle at the same spot.

Similarly to Ein Gev, the Negev EP sites included as a comparison present typologically homogeneous microlith assemblages, confirming well established patterns encountered on a regional scale and suggesting that they are likely to reflect homogeneous behavioral patterns. In addition, the integrity of the lithic assemblages is sustained by the high number of refitting encountered in the Negev sites (Marder 2002) and by the archaeological contexts of Kharaneh IV (relatively short ^{14}C time span, living floors—Macdonald et al. 2018), Wadi Mataha, and ‘Uyun al-Hammam (burials—Macdonald et al. 2016; Maher and Macdonald 2013).

The observed geographical variability in technological aspects (reduction modality, percussion technique, bladelet width and profile) within Nizzanan and Geometric Kebaran cultural entities in Ein Gev and in the Negev (Leplongeon and Goring-Morris 2018; Marder 2002) can possibly be related to the existence of different local manufacturing traditions. These local learning communities, operating within broad cultural entities, are in line with the proposed scenario based on the morphological and functional variability of Geometric Kebaran microliths (Macdonald 2013). Further, the technological continuity observed between Nizzanan and Geometric Kebaran in the Negev (Leplongeon and Goring-Morris 2018; Marder 2002) possibly hints at a local continuity in the manufacturing tradition.

Further insight into the EP lithic population dynamics in different sub-regions of the Levant may be found in Kharaneh IV (Macdonald et al. 2018; Maher and Macdonald 2012, 2013), Wadi Mataha (Macdonald et al. 2016), and ‘Uyun al-Hammam (Maher and Macdonald 2013), in Jordan. In the Eastern sub-region of the Levant, the transition from Early to Middle EP is marked by a technological shift from carefully shaped narrow-fronted cores to wide-fronted cores with more effort put in maintenance rather than in shaping, possibly reflecting a shift in the population of the sites (Macdonald et al. 2018).

Overall, different local patterns in the manufacturing traditions allow to track different local learning community dynamics.

Conclusions

The analysis of the reduction sequences provided further insight into the population dynamics of the Early and Middle EP, both in the Ein Gev area and in the wider geographical framework of the Southern Levant.

In the Ein Gev area, the use of MbT sets EG IV apart from the other EP occupations in the area. However, the absence of this technique in EG I and III is not sufficient to prove continuity between traditions. Based on traits of the microliths manufacturing process, it is possible to suggest that, during the Early EP, the Ein Gev area was subsequently occupied by two different populations: one (EG IV) possibly continuing the local Upper Palaeolithic manufacturing tradition (Belfer-Cohen et al. 2004), attributed to the Nizzanan cultural entity, and the other (EG I) characterized by different frequencies of technological and typological traits, attributed to the Kebaran culture. During the Middle EP, the latter population continued occupying the area (EG III), maintaining the same manufacturing tradition and developing or adopting typological traits of the Geometric Kebaran cultural entity.

Comparison with other areas in the Southern Levant indicated different population dynamics throughout this region. While in the Negev (Goring-Morris et al. 1998; Marder 2002) and Jordan (Macdonald et al. 2018; Maher and Macdonald 2012, 2013), the onset of the Geometric Kebaran corresponds with a shift in both typological and technological traits, possibly reflecting the appearance of new populations with different manufacturing traditions, in the Ein Gev area, strong technological continuity between Kebaran and Geometric Kebaran was observed, perhaps reflecting the adoption, by an existing local learning community, of new typological traits, with no changes in their manufacturing tradition.

Technological continuity between the Kebaran and the Geometric Kebaran in Ein Gev highlights how populations occupying geographically limited areas may have preserved their particular manufacturing traditions over long periods, developing or adopting in turn typological traits of the EP cultural entities. In addition, continuity between EG I and III and the Early Ahmarian manufacturing traditions (Bretzke and Conard 2012; Davidzon and Goring-Morris 2003; Goring-Morris and Davidzon 2006) further supports the conservative nature of the reduction method and technique (Marder 2002).

Finally, the increased territoriality of local groups is often considered among the factors that possibly triggered, during the Late EP Natufian, the onset of sedentism (Bar-Yosef 1998; Rosenberg 1998). The observed continuity, through time, of manufacturing traditions in geographically limited areas suggests that the identification process between the populations and their respective territories may have originated already during the Early and Middle EP.

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Data Availability All data generated or analyzed during this study are included in this published article and its supplementary information files.

Code Availability Not applicable.

Declarations

Conflict of Interest The authors declare no competing interests.

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