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Between Novelty and Variability: Natufian Hunter-Gatherers (*c.* 15–11.7 kyr) Proto-Agrotechnology and the Question of Morphometric Variations of the Earliest Sickles

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*How hunter-gatherers manipulated and utilised their natural surroundings is a widely studied topic among anthropologists and archaeologists alike. This focuses on the Natufian culture of the Late Epipalaeolithic period (*c. *15–11.7 kyr), the last Levantine hunter-gatherer population, and specifically on the earliest composite tools designed for harvesting. These tools are widely referred to as sickles. They consisted of a haft into which a groove was cut and flint inserts affixed. This revolutionised harvesting and established it on new grounds. While the plants manipulated by these tools are yet to be identified with certainty, it is evident that these implements were rapidly integrated and dispersed throughout the Natufian interaction sphere, suggesting that they provided a significant advantage, which probably constituted a critical step toward agriculture. At the same time, the Natufian haft assemblage demonstrates high morphometric variability. We review the available data concerning Natufian hafts and offer three possible models to explain the noted variability. We conclude that while these models are not mutually exclusive, this varied technological pattern is best understood as deriving from a protracted formative phase of technological development, progressing through incremental processes of trial and error.*

Keywords: Natufian, Near East, Epipaleolithic, Harvesting, Sickles, Hunter-gatherers

Prehistoric hunter-gatherers undeniably drew on plant resources to meet their dietary needs. However, there is little good evidence to indicate what plants were consumed and how they were harvested and processed (but see Cane 1989; Wright 1991, table 7). Ethnographic research suggests that manual techniques like hand-picking and seed-collecting were widespread. However, sometimes more sophisticated means were employed (Kelly 1995 for examples and discussions). These means usually consisted of composite tools – like sickles – specifically designed to increase efficiency (Bousman 1993); they did so by facilitating more accurate movements that could be applied with less force and sustained for longer durations. These sickles were composed of a main body (or the haft) and flint inserts that were affixed in various ways (Keeley 1982). Their specific shape relates to the function of the tool and the way it was operated (eg, Stordeur 1987), allowing the cutting blades to be replaced or different blanks to be used instead of replacing the entire tool (retooling: see Keeley 1982).

In the southern Levant, archaeological evidence for such tools dates back to the late Upper Palaeolithic. Use-wear analysis of flint implements from the site of Ohalo II (*c.* 23 kyr) indicated that hafted knives were used to harvest near-ripe semi-green wild cereals (Groman-Yaroslavski *et al.* 2016). This observation was corroborated by botanic evidence for cereal exploitation (Piperno *et al.* 2004; Snir *et al.* 2015) and the appearance of grinding and pounding tools at the site (Spivak & Nadel 2016). However, the use of composite harvesting tools was likely irregular and at least partially interchangeable with hand-held

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flint knives, hand-picking, or even collecting the seeds from the ground. It was only several millennia later during the time of the Natufian culture (*c.* 15–11.7 kyr) that composite harvesting tools became more common, forming one element within an increasingly specialised plant processing tool kit (eg, Samzun 1994; Wright 1994; Dubreuil 2004; Edwards & Webb 2012; Rosenberg *et al.* 2012; Rosenberg 2013).

Most scholars consider these composite harvesting tools as 'sickles' – instruments designed for reaping herbaceous plants. They consist of a bone haft into which bladelets, blades, or flakes were inserted to produce a sharp working edge. The harvesting procedure entailed one hand bundling plants together while the other used the sickle to cut the stalks, often near their base. In this manner, a plant's edible and non-edible components were collected, providing an opportunity to use the latter for various auxiliary purposes like roofing, bedding, or basketry (Bohrer 1972).

However, despite their homogeneous designation as sickles, there is considerable diversity in structure, morphology, and size. This diversity, in turn, suggests significant functional and operational variability that may call the inclusivity of their designation as sickles into question. Accordingly, our intention in this paper is to systematically compile all available examples of Natufian sickles or, more precisely, hafts (see also Campana 1989). In so doing, we set out to chart the distribution of their formal properties and explore their technical implications. We will discuss three possible tracks to explain the high morphometric variability of these items: a techno-functional explanation, a resource range explanation, and a novel-technology explanation. Acknowledging that these hypotheses are not mutually exclusive, we suggest that the variation is best understood as a manifestation of a novel technology's formative stages, involving ongoing experimentation by way of trial and error.

THE NATUFIAN CULTURE & ITS PLANT ECONOMY

Before we delve into the details of the Natufian hafts, let us set the scene and briefly describe the broader cultural context of their appearance and operation. The Natufian culture of the southern Levant is considered the harbinger of agriculture in the region. It was marked by the emergence of sedentary or semi-sedentary communities (eg, Garrod 1957; Bar-Yosef 1983; 2002; Henry 1985; 1989; Bar-Yosef & Belfer-Cohen 1989; Byrd 1989; Belfer-Cohen 1991a; Olszewski 1991; Belfer-Cohen & Bar-Yosef 2000; Goring-Morris & Belfer-Cohen 2013; Valla 2018), the consolidation of a rich and diverse material culture, a plethora of artistic representations, and hundreds of burials (eg, Noy 1989; 1991; Belfer-Cohen 1991b; Bar-Yosef 2002; Shaham & Belfer-Cohen 2013; Rosenberg *et al.* 2020).

Admittedly, our knowledge of the Natufian subsistence economy is biased in favour of faunal resources. While a great deal has been said about the exploitation of hunted and trapped mammals, birds, reptiles, and occasionally fish (eg, Bar-Oz *et al.* 2004; Munro 2004; Stutz *et al.* 2009; Yeshurun *et al.* 2013; Munro *et al.* 2021), our knowledge of plant resources is rarely as direct and abundant. Most of what we know derives from ancillary types of evidence: sickle inserts (eg, Belfer-Cohen 1988, 115–22; Unger-Hamilton 1989; Grosman *et al.* 2005; Stanin 2012), pestles, mortars, bedrock features (mainly cupmarks and mortars), and, less frequently, upper and lower grinding tools (eg, Wright 1994; Rosenberg *et al.* 2012; Rosenberg & Nadel 2014 and references therein). These all suggest substantial growth in the volume and types of plant foods harvested and consumed (Bar-Yosef 2011; Rosenberg & Nadel 2017).

Moreover, recent years witnessed a growing number of studies on macro-botanic (eg, Hopf & Bar-Yosef 1987; Hillman 2000; Colledge 2001; 2012; Barlow & Heck 2002; Olszewski 2004; Rosenberg 2008; Colledge & Conolly 2010; Asouti & Fuller 2013; Tanno *et al.* 2013; Caracuta *et al.* 2016; Arranz-Otaegui *et al.* 2018a) and micro-botanic remains (eg, Valla *et al.* 2007; Portillo *et al.* 2010; Rosen 2010; 2012; Power *et al.* 2014; Liu *et al.* 2018). These studies show that a variety of resources was used by Natufian communities: large- and small-seed grasses (eg, sedges and reeds, including wheat and barley), legumes (eg, lupin seeds, fava beans, lentils, and possibly peas), fruits, and nuts (eg, acorns and *Pistacia*). On some occasions, particular foodstuffs were identified, including remains of bread (Arranz-Otaegui *et al.* 2018b) and fermented beverages (Liu *et al.* 2018). The botanic remains also suggest that the Natufian communities' reliance on grasses, reeds, and sedges increased with time, probably due to a recession of the Mediterranean zone's vegetation belt (Rosen 2012).

Against this background, a working hypothesis that equates Natufian hafts with sickles seems highly suitable. It agrees with the increasing reliance on grasses and speaks for an efficient harvesting technique that

Fig. 1.
Map showing the distribution of Natufian sites with hafts

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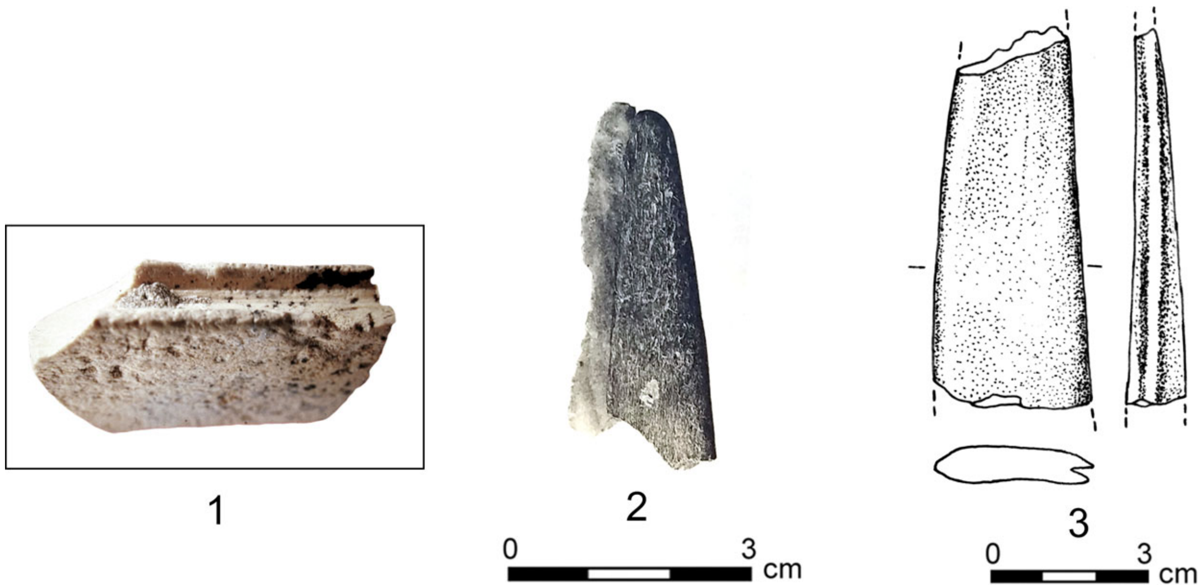

Fig. 2.
Haft fragments: 1. Saflulim (courtesy of N. Goring-Morris), 2. Umm el-Zuweitina (after Neuville 1951, pl. xiii: 24); 3. Hatoula (after Ronen & Lechevallier 1991, fig. 6: 18)

increases yields while conserving time and energy (Hillman & Davies 1990). Sickles would have been especially advantageous given the narrow window between cereal ripening and shattering (Unger-Hamilton 1989). The reaping hypothesis is also supported by use-wear studies that found gloss on blades and bladelets, attributed to the harvesting of green monocotyledons (eg, Unger-Hamilton 1989; 1991; Anderson 1991; Stanin 2012, 203; Groman-Yaroslavski 2014, fig. 5.4).

However, some questions regarding this interpretation can be raised. It was noted, for instance, that the Natufians demonstrate no systematic preference for wheat and barley over the other grasses (eg, Rosen 2013), that other harvesting techniques at their disposal may have been more efficient (eg, Harlan 1999), that many potential flint inserts lack the gloss correlated with cereal reaping (eg, Edwards 1991, 541), and that the gloss could be attributed to a host of other siliceous plants or even soil (eg, Anderson 1991, 525). While acknowledging these challenges and responding to them, we trace in the next section the range of formal and technical variation within the Natufian hafts. This will elucidate their operational possibilities and limitations.

THE NATUFIAN HAFTS

In this section we review all published instances of Natufian hafts from the Levant (Fig. 1). While paying close attention to the items' formal properties (eg, dimensions, shape, material) and their state of preservation (Figs 2–10; Table 1), we seek to formulate broad and viable generalisations about these items. In turn, these generalisations are expected to provide the necessary ground for an adequate assessment of their functions and significance.

Altogether, more than 100 hafts and haft fragments were reported from 17 sites, spanning a wide range of eco-zones (notably, about half of these were retrieved from Early Natufian Wadi Hammeh 27). These include the Negev and Judean deserts, the Shephelah, Mt Carmel, the Galilee, and the Hula Basin in Israel, the Jordanian highlands and the Azraq Basin in Jordan, the Leja Plain and the Middle Euphrates Valley in Syria, and the Qadisha Valley in Lebanon (Fig. 1). These sites include hamlets, caves, cave terraces, and open-air base camps. They also cover a variety of purposes (domestic, funerary, and task-specific) and span the entire Natufian sequence (Table 1), including the Early Natufian (n≥64), Late Natufian (n=25), and probably the Final Natufian as well.

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Fig. 3.
Hafts and haft fragments: Kebara (courtesy of the Israel Antiquities Authority & the Israel Museum in Jerusalem)

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Fig. 4.
Haft fragments: El-Wad (after Weinstein-Evron 1998, fig. 52: 1 & courtesy of the Israel Antiquities Authority & the Israel Museum in Jerusalem)

Nearly all Natufian hafts were made of bone, with a preference for ungulate long-bones and ribs. Only one definite exception was recorded to date – a haft made of a caprine horn from Wadi Hammeh 27. Production procedures included rounding (eg, Fig. 5: 2), abrading, shaving (eg, Figs 4: 1, 3; 7: 9; 10: 2), smoothing, and polishing (eg, Figs 3: 1–2, 4; 4: 3, 6; 7: 9; 8: 3). Sometimes holes were drilled into the haft (1–4; see eg, Fig. 3: 3), possibly for fastening it to a cord (Garrod 1937, 38). Burning or

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Fig. 5.
Haft fragments: 1–3. Nahal Oren (courtesy of the Israel Antiquities Authority & the Israel Museum in Jerusalem); 4. Raqefet Cave (courtesy of the Israel Antiquities Authority)

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Fig. 6.
Haft fragments: 1–2. Hilazon Tachtit Cave (after Klein *et al.* 2016, fig. 3: 6–7); 3–5. Hayonim Terrace (after Boyd 2012, figs 9: 2; 14: 2–3 & courtesy of F. Valla)

exposure to heat was sometimes documented and may have also been used to fashion the haft (eg, Hilazon Tachtit Cave; Klein *et al.* 2016, 101).

The fully preserved dimensions show that Natufian hafts varied greatly in size: 9.5–32.0 cm in length, 0.5–6.0 cm in width (most measure between 1.5 and 3.5 cm), and 0.5–4.0 cm in thickness (most measure between 0.5 and 2.5 cm). The haft morphology frequently followed the bone's natural profile, so considerable diversity was noted. The hafts' cross-sections are bi-plano, plano-convex, convex-concave, triangular, or bi-convex, and they end with round, square, blunt, or convergent distal terminations.

Importantly, the hafts are divided into two major forms: straight to slightly curved hafts (eg, Figs 3: 1–3; 4: 2; 5: 2; 8: 2–3; 10: 1, 3; 11: A–F) and perceptibly curved to angled hafts (eg, Figs 4: 1; 6: 2–3; 8: 1; 9: 1–6; 10: 4; 11: G–L). The form dictates the curvature of the tools' working edge, allowing it to be straight, convex (eg, Fig. 9: 1–5), or concave (eg, Figs 4: 1; 6: 2; 8: 1; 9: 6; 10: 4). The curvature of the tool and working edge in turn dictate the motion of the arm (ie, the angles, *vis-à-vis* the ground, plant, and body of the harvester) and hand during harvesting.

An elongated groove – and on one occasion two grooves (Fig. 9: 1; Edwards 2007, fig. 8) – marked the working edge and accommodated flint inserts: blades, flakes, or bladelets, similar to glossed items found at many Natufian sites (eg, Belfer-Cohen 1988, figs iii-17–19; Grosman *et al.* 2005, fig. 7; Nishiaki *et al.* 2017, table 3). The grooves' cross-sections are either U-shaped (eg, Figs 2: 1; 6:1) or V-shaped (eg, Figs 2: 3; 4: 2; 5: 4; 7: 1–4; 10: 1–2). V-shaped grooves were probably designed to accept Helwan retouched bladelets (Garrod 1932, fig. 2; 1937, 37–8, pl. xiii); however, they would accommodate other backed morphologies (straight, oblique, etc.) as well. Notably, most grooves are shallow, *c.* 1.0–2.0 mm deep, and moderately wide, *c.* 2.0–5.0 mm, questioning their capability to hold flint inserts securely. A strong adhesive such as resin or bitumen could be used to keep the inserts in place despite the grooves' shallow nature and it would further allow for a simple replacement of the inserts when they became dull. While adhesive residues are not always clear in the few hafts with intact flint inserts (Figs 2: 2; 4: 4; 9: 1), this hypothesis is reinforced by mastic documented on flint microliths and other tools (Büller 1982; Bar-Yosef & Belfer-Cohen 2000; Stanin 2012, 200–1). These suggest that adhesives were regularly used in hafting of composite tools during the Natufian timespan.

There are also some notable idiosyncrasies in the assemblage. One such peculiarity is that several items lacked grooves (eg, Fig. 9: 8). These are perhaps unfinished (Edwards *et al.* 2015, fig. 14: 1), or maybe their classification as sickles was premature. On the other hand, grooves were sometimes cut along the full length of the haft, including the part presumed to be the handle (eg, Figs 4: 1; 8: 2–3). Occasionally, carved knobs were noted on the back of the tools (eg, Figs 3: 1–2; 8: 3; 10:3). They are circular in outline, 1.0–2.0 cm across, and they occur on the proximal (Fig. 8: 3) and distal ends (Fig. 3: 1–2).

Finally, sometimes hafts were accompanied by symbolic or decorative features. The time and effort invested in adornment and fine finishing suggests that

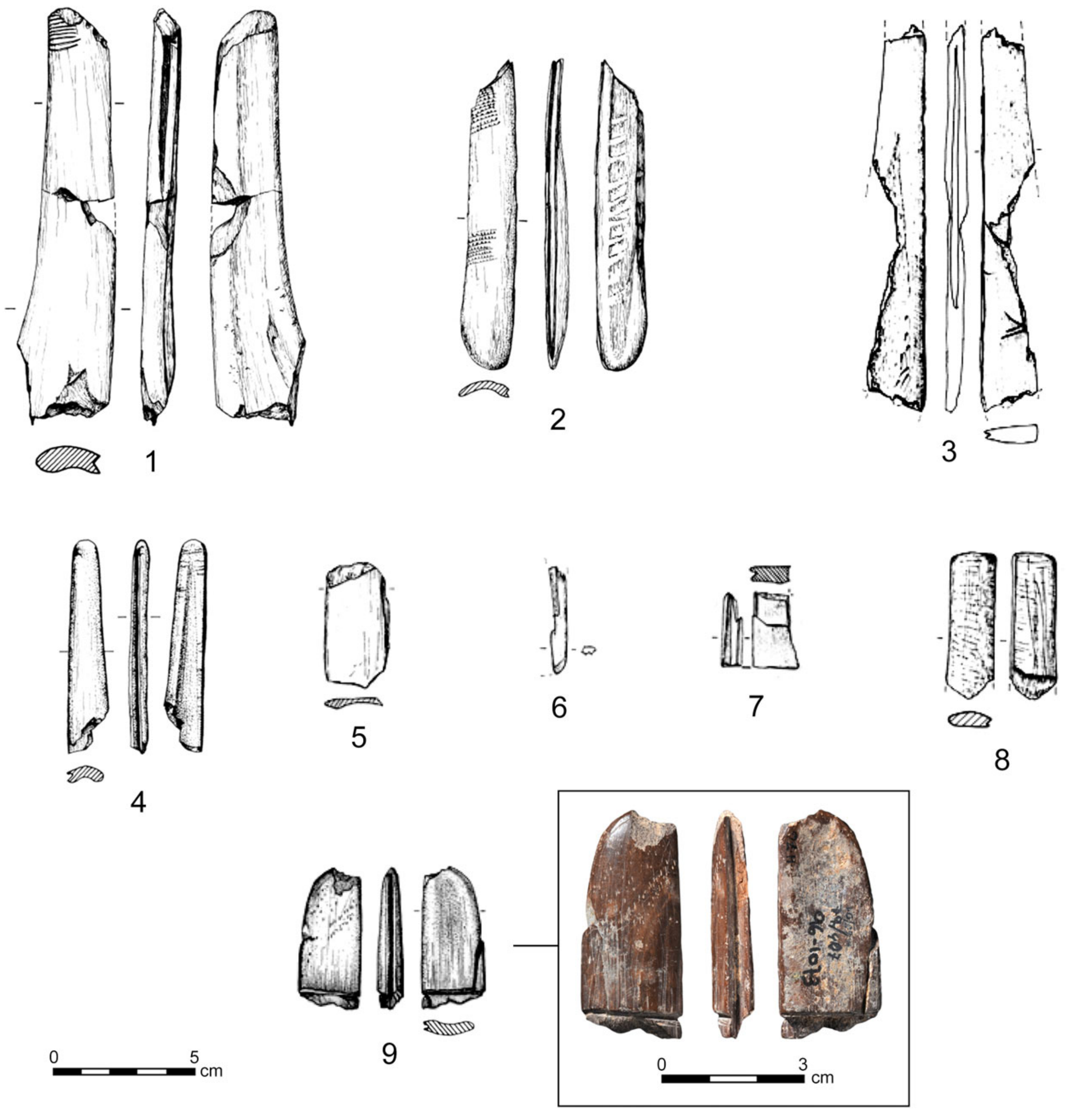

Fig. 7.
Haft fragments: Hayonim Cave (after Bar-Yosef & Tchernov 1970, fig. 3: 3, 5–7; Belfer-Cohen 1988, figs iv-7: 1–2, 4–5; iv-8 & courtesy of Israel Antiquities Authority)

the hafts were made for long-term use, with replaceable inserts. On one example from Dederiyeh Cave, painted black lines were recorded (Fig. 10:4 and see Nishiaki *et al.* 2017, 18). However, most striking are hafts bearing carefully carved zoomorphic figures, presumably representative of a bovine, deer, or gazelle (Fig. 3: 1–2; 4; 4: 6; 9: 11). Somewhat more common are incisions forming a wide range of patterns. These

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Fig. 8.
Haft fragments: Eynan (after Perrot 1966, fig. 22: 26 & courtesy of the Israel Antiquities Authority & the Israel Museum in Jerusalem)

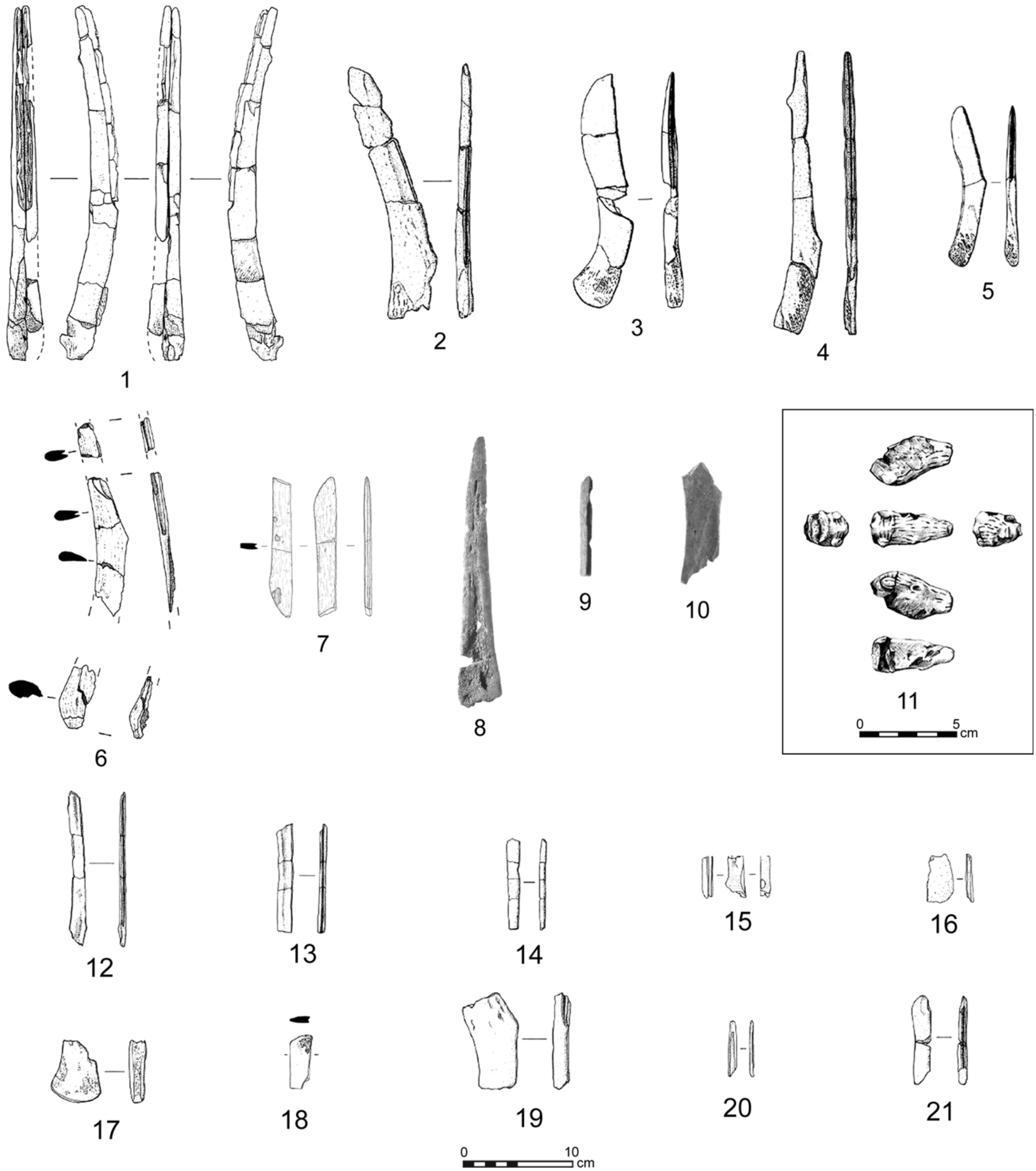

Fig. 9.
Hafts and haft fragments: Wadi Hammeh 27 (after Edwards 2012a, fig. 12.29; Edwards & le Dosseur 2012, figs 10.11, 10.13, 10.15, 10.16; Edwards *et al.* 2015, fig. 14; Robertson *et al.* 2019, fig. 5).

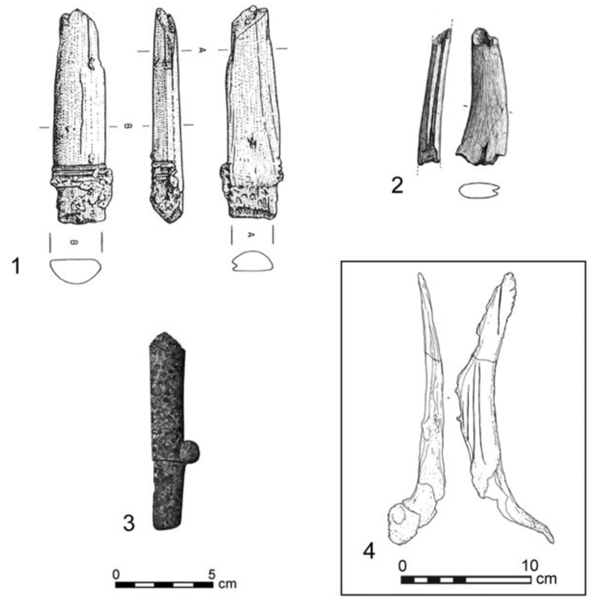

Fig. 10.
Hafts and haft fragments: 1. Azraq 18 (after Garrard 1991, fig. 4: b); 2. Qarassa 3 (after Terradas *et al.* 2013, fig. 11, right); 3. Moghr el-Ahwal (after Garrard & Yazbeck 2013, fig. 4); 4. Dederiyeh Cave (courtesy of Y. Nishiaki *et al.* 2017, fig. 7 13).

patterns include cross-hatched incisions (Turville-Petre 1932; IAA archives), two sets of oblique incisions (Figs 4:2, 7:2), short horizontal incisions (Figs 7: 1; 9: 7), and 1–3 perpendicular grooves (Fig. 7: 9; 8: 1; 10: 1). Irregular depressions were also noted on one example (Fig. 7: 2).

DISCUSSION AND CONCLUSIONS

The hafts are but one of a wide range of Natufian technological and socio-economic innovations that targeted various realms: mobility and settlement patterns, material culture, ritual and burial practices, and subsistence economies. Some of these entailed significant transformations in the way people viewed their environment and manipulated natural resources and they coincided with climatic changes (eg, Olszewski 2004; Bar-Yosef 2011; Maher *et al.* 2011; Rosen & Rivera-Collazo 2012) that had direct repercussions on the accessibility and availability of vegetal resources (Rosen 2010; 2012).

In this framework, one major question arises regarding the hafts. How can we account for the wide morphometric diversity of the Natufian hafts (eg, Fig. 11) and by extension the sickles? At least three

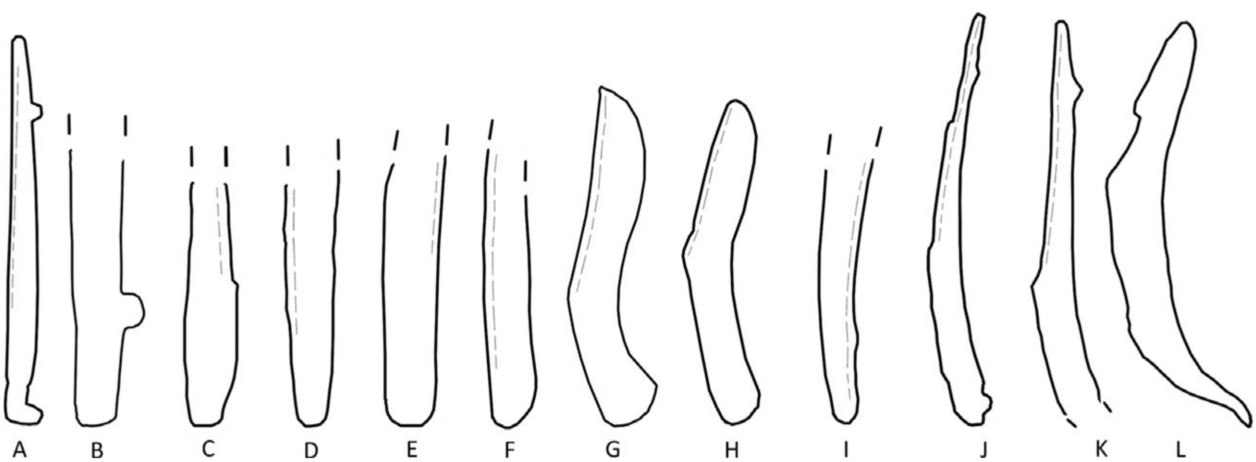

Fig. 11.
A schematic representation of Natufian haft ‘types’ based the curve of the hafts and the location of the grooves.

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Table 1: INDEX OF NATUFIAN HAFT BEARING SITES, ARRANGED IN ROUGH GEOGRAPHICAL ORDER FROM SOUTH TO NORTH (EN=EARLY NATUFIAN; LN= LATE NATUFIAN; FN=FINAL NATUFIAN)

Site	*Date range*	*No.*	*Raw material*	*Complete or nearly complete*	*Shaft/distal/ handle frags*	*Haft shape*	*Groove location*	*No. Grooves on shaft*	*Groove cross-section*	*Reference*	*Fig.*
Saflulim	LN	1	Bone	–	Shaft: 1	Straight	Flat edge	1	U	Goring-Morris *et al.* 1999, fig. 9	2: 1
Umm el-Zuweiti-na	EN?	1	Bone	–	Distal: 1	–	–	1	?	Neuville 1951, 124, pl. 13: 24	2: 2
Hatoula	LN	1	Bone		Shaft: 1	Curved	Concave edge	1	V	Ronen & Lechevallier 1991, fig. 6: 18	2: 3
Kebara Cave	EN	6	Bone	2	Handle: 4	Straight: 2 Curved: 1	Flat edge: 2 Concave edge: 1	1–3	U/V/?	Turville-Petre 1932, figs 1–3; pl. xxviii; Campana 1989, 103; Robertson *et al.* 2019, figs 7–8; IAA archives	3
El-Wad Cave & Terrace	EN/ L-N?	14	Bone	2	Shaft: 9 Distal: 2 Handle: 1	Straight: 3 Curved: 2	Flat edge: 2 Concave edge: 3	1–5	U/V/?	Garrod 1932, fig. 2; 1937, 37–8, pl. xiii, 1: 2–3; Weinstein-Evron 1998, figs 52: 1, 53; Robertson *et al.* 2019, fig. 9; IAA archives	4
Nahal Oren	LN/ FN	3	Bone	–	Shaft: 1 Distal: 1 Handle: 1	Curved: 1	Concave edge: 1	1–2	V?	IAA archives	5: 1–3
Raqefet Cave	LN	1	Bone	–	Shaft: 1	–	–	1	V	IAA archives	5: 4
Hilazon Tachtit Cave	LN	2	Bone	–	Shaft: 2	Straight: 1 Curved: 1	Flat edge: 1 Concave edge: 1	1	U/V	Klein *et al.* 2016, 99, 101, fig. 3: 6–7, table 5	6: 1–2
Hayonim Terrace	LN	13	Bone	–	Shaft: 11 Distal: 2	Straight: 2 Curved: 1	Flat edge: 2	1	U/V	Boyd 2012, 360–1, figs 9: 2, 10: 1–7, 14: 2–3	6: 3–5
Hayonim Cave	EN/ LN	12	Bone	–	Shaft: 4 Distal: 8	Straight: 7 Curved: 2	Flat edge: 7 Concave edge: 2	1	U/V/?	Bar-Yosef & Tchernov 1970, fig. 3: 3, 5–7; Belfer-Cohen 1988, 191–2, figs iv-7: 1–2, 4–5, iv: 8; IAA archives	7
Eynan	EN?/ LN	3	Bone	–	Shaft: 2 Distal: 1	Straight: 2 Curved: 1	Flat edge: 2 Concave edge: 1	1–2?	U/V/?	Perrot 1960, 16, 20; 1966, fig. 22: 26; IAA archives	8
Jordan River Dureijit	EN	1	Bone	–		–	–	–	?	Sharon *et al.* 2020	-

(Continued)

Table 1: (Continued)

Site	Date range	No.	Raw material	Complete or nearly complete	Shaft/distal/ handle frags	Haft shape	Groove location	No. Grooves on shaft	Groove cross-section	Reference	Fig.
Wadi Hammah 27	EN	52	1 Horn 51 Bone	5	Shaft: 43 Handle: 4	Straight: 4 Curved: 10	Flat edge: 4 Concave edge: 2 Convex edge: 6	0–2 1–5 2–1	U/V/?	Edwards 2007, figs 2, 8; 2012, 261, fig. 12.29; Edwards & le Dosserur 2012, 252–61, table 10.1, figs 10.13: 1–4, 10.15, 10.16; Edwards *et al.* 2015, fig. 14: 1; Robertson *et al.* 2019, fig. 1	9
Azraq 18	EN	1	Bone	–	Handle: 1	Straight	Flat edge	1	V	Garrard 1991, 238, fig. 4: b	10: 1
Qarassa 3	LN/ FN?	1	Bone	–	Shaft: 1	Curved	Concave edge	?	V	Terradas *et al.* 2013, 55, fig. 11: 2	10: 2
Moghr el-Ahwal	EN	1	Bone	–	Shaft: 1	Straight	Flat edge	?	?	Garrard & Yazbeck 2013, 22, fig. 4.	10: 3
Dederiyeh Cave	EN	1+	Bone	1	–	Curved	–	–	?	Akazawa *et al.* 2010, 34, fig. 4; Nishiaki *et al.* 2017: 18, fig. 13.	10: 4

explanations can be posited for this variability. For purpose of convenience, we will call them the *techno-functional explanation* (TFE), the *resource-range explanation* (RRE), and the *novel-technology explanation* (NTE). According to the TFE, the Natufian hafts were not exclusively sickles. Rather, they served various functions, and their formal diversity stemmed from accommodating different practical demands. The RRE, on the other hand, posits that all hafts were used to harvest plants including cereals and other species. Thus, their formal diversity is a function of the plant resources reaped. Lastly, according to the NTE, the diversity of hafts and sickles' manifests from the formative stages of a yet unconsolidated technology that was still experimenting with various features by way of trial and error.

All three hypotheses are plausible, and none of them excludes the others. Further, all three are supported by other lines of evidence: the range of tasks flint tools were used for (eg, Campana 1989, 25–42; Richter 2007; Yaroshevich *et al.* 2010), experimental parallels that show hafted flint tools can be used for different activities (eg, threshing, D'Errico *et al.* 1995), the diversity of botanic remains (Olszewski 2004; Rosenberg 2008; Colledge & Conolly 2010; Rosen 2010; 2012; Arranz-Otaegui *et al.* 2018a), and the intricate dialectics of technological consolidation (eg, Rogers 1983, 231; van der Leeuw 1990; Arthur 2007; Klimscha 2020).

Nevertheless, we are inclined to support the NTE hypothesis. The Natufians were probably pressured by the narrow catchment area and the narrow window between cereal ripening and ear-shattering (Unger-Hamilton 1989) to produce high yields of cereals in a short time. The sickle helped achieve this by enabling a fast, efficient, and more comfortable way to harvest. However, the best way to manufacture and handle a sickle was yet to be determined, setting in motion a prolonged experimentation process whereby different sickle forms and sizes were tested.

Ergonomically, different morphologies of the hafts and the handle-blade angle reflect different movements of the harvester's hand and arm while cutting the stalks. A concave working edge is considered best suited for cereal reaping; it operates as an extension of the arm, gathering the stems before cutting them (Sutjana *et al.* 1999; Astruc *et al.* 2012; Mazzucco *et al.* 2018). To achieve this for both left-handed and right-handed individuals, opposite placement of the working edge may have been required. Further,

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while many of the Natufian hafts followed this logic and had a concave working edge, others with a straight or convex working edge relied on different principles. These differences coupled with variations in shape, length, groove measurements, inserts used, and other parameters reinforce the suggestion that we are observing an immature technology and experimentation phases aimed at testing combinations of morphologies with different harvesting motions. These testing stages likely targeted other variables related to harvesting, such as the optimal time to harvest the stems (ripe or near-ripe) and even the time of the day when it is best to harvest (early or late in the day, bearing in mind the possible impact of temperature and humidity on the stalks). This reflects the multi-dimensional nature of the experimental trial and error phase of sickle development and its evolution.

Either way, these hafts appeared hand-in-hand with a considerable rise of gloss-bearing inserts and sickle blades with no apparent gloss (discarded before use or which had not yet developed sheen). This co-occurrence is yet another case of a Natufian technological breakthrough associated with this culture's early stages of consolidation, intertwined with its shift towards sedentism and growing demand for increased food production (eg, Keeley 1988, 404; Miller 1992, 51; Watkins 2005, 208; Stutz *et al.* 2009; Rosenberg 2013). While the creation of sickles undoubtedly entailed substantial costs in terms of time, energy, and ingenuity, it must have considerably improved the harvesting yields compared to hand-picking or ground collecting seeds. Their effectiveness and long-term durability assuredly rendered the investment profitable in the long run (eg, Bender 1978).

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RÉSUMÉ

Entre nouveauté et variabilité: chasseurs cueilleurs Natoufienes (vers 15–11.7 kya) proto-agrotechnologie et la question des variations morphologiques métriques des plus anciennes faucilles, de Danny Rosenberg et Rivka Chasan

Comment les chasseurs-cueilleurs manipulaient et utilisaient leur environnement naturel est un sujet largement étudié aussi bien par les anthropologues que par les archéologues. Notre étude se concentre sur la culture natoufienne de l'épipaléolithique tardif (vers 15–11.7 kya), dernière population de chasseurs cueilleurs du levantin et plus particulièrement sur les plus précoces outils composés élaborés pour la récolte. On se réfère généralement à ces outils sous le nom de faucilles. Ils consistaient en un manche dans lequel on avait creusé un sillon et inséré des fragments de silex. Ceci a révolutionné la moisson et l'a établie sur de nouvelles terres. Bien qu'il nous reste à identifier avec certitude quelles étaient les plantes manipulées par ces outils, il est évident que ces outils furent rapidement intégreés et dispersés partout dans la sphère d'interaction de la culture natoufienne, ce qui donne à penser qu'ils apportaient un avantage majeur qui constituait probablement une étape critique vers l'agriculture. En même temps l'assemblage du manche natoufien fait preuve d'un niveau élevé de variabilité morphométrique. Dans le courant article nous révisons les données disponibles concernant les manches natoufiens et offrons trois modèles possibles qui expliquent la variabilité identifiée. Nous concluons que, tandis que ces modèles ne s'excluent pas l'un l'autre ce schéma technologique varié se comprend le mieux comme dérivant d'une phase retardée de développement technologique progressant graduellement à travers un procédé d'essais et d'erreurs.

ZUSAMMENFASSUNG

Zwischen Neuartigkeit und Variabilität: Die Proto-Agrotechnologie der Jäger-Sammler des Natufien (ca. 15–11.7 kyr) und die Frage morphometrischer Variationen der frühesten Sicheln, von Danny Rosenberg und Rivka Chasan

Wie Jäger und Sammler ihre natürliche Umgebung manipulierten und nutzten, ist ein von Anthropolog wie von Archäolog innen weithin untersuchtes Thema. Unsere Untersuchung konzentriert sich auf die Natufien-Kultur des späten Epipaläolithikums (ca. 15–11.7 kyr), die letzte Jäger- und Sammlerpopulation der Levante, und speziell auf die frühesten zusammengesetzten Werkzeuge, die für die Ernte entwickelt wurden. Diese Werkzeuge werden allgemein als Sicheln bezeichnet. Sie bestanden aus einem Griff, in den eine Rille geschnitten und Einsätze aus Feuerstein eingefügt wurden. Dies revolutionierte die Ernte und etablierte sie auf neuem Terrain. Während die Pflanzen, die mit diesen Werkzeugen bearbeitet wurden, noch nicht mit Sicherheit identifiziert werden können, ist es offensichtlich, dass diese Werkzeuge schnell integriert und im gesamten Interaktionsbereich der Natufien-Kultur verbreitet wurden, was darauf hindeutet, dass sie einen bedeutenden Vorteil boten, der wahrscheinlich einen entscheidenden Schritt in Richtung Landwirtschaft darstellte. Gleichzeitig zeigt die Griff-Assemblage des Natufien eine hohe morphometrische Variabilität. In dieser Arbeit überprüfen wir die verfügbaren Daten zu den Griffen des Natufien und bieten drei mögliche Modelle an, die die festgestellte Variabilität erklären. Wir kommen zu dem Schluss, dass sich diese Modelle zwar nicht

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gegenseitig ausschließen, dass aber dieses vielfältige technologische Muster am besten als Ergebnis einer langwierigen formativen Phase der technologischen Entwicklung zu verstehen ist, die durch schrittweise Prozesse von Versuch und Irrtum fortschreitet.

RESUMEN

*Entre la novedad y la variabilidad: protoagrotecnología entre los cazadores-recolectores natufienses (*c. *15–11.7kyr) y la cuestión de las variaciones morfométricas de las primeras hoces*, por Danny Rosenberg y Rivka Chasan

Cómo los cazadores-recolectores manipularon y utilizaron su entorno natural es un tema ampliamente estudiado por los antrópologos y arqueólogos. Nuestro estudio se centra en la cultura Natufiense del Epipaleolítico final (*c.* 15–11.7 kyr), las últimas poblaciones de cazadores-recolectores levantinas, y específicamente en las primeras herramientas compuestas y diseñadas para la siega. Estas herramientas se conocen ampliamente como hoces. Consistían en un mango en el que se cortaba una ranura y se colocaban inserciones de sílex. Esto revolucionó la forma de cosechar y permitió expandirla en nuevos terrenos. Aunque las plantas manipuladas por estas herramientas aún no se han identificado con certeza, es evidente que estos instrumentos se integraron rápidamente y se dispersaron en la esfera de interacción natufiense, sugiriendo que aportaban una ventaja significativa, que probablemente constituyó un paso crítico hacia la agricultura. Al mismo tiempo, el conjunto de mangos natufienses demuestra una alta variabilidad morfométrica. En este artículo, se aporta una revisión de los datos disponibles sobre los mangos natufienses y se ofrecen tres modelos que explican la variabilidad observada. Concluimos que mientras estos modelos no son mutuamente exclusivos, este patrón tecnológicamente variado se entiende mejor como derivado de una fase formativa prolongada de desarrollo tecnológico que se va modificando a través de procesos de prueba y error.