Middle Pleistocene Homo behavior and culture at 140,000 to 120,000 years ago and interactions with Homo sapiens

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Abstract: Most Middle Pleistocene *Homo* fossils lack a cultural context; therefore, their behavior and technology remain poorly understood. Here we report the archaeological context, chronometric ages, and stone-tool assemblages directly associated with newly discovered fossils of archaic Middle Pleistocene *Homo* at the Middle Paleolithic open-air site at Nesher Ramla, Israel. The site, a karst sinkhole, revealed rich Middle Paleolithic cultural and faunal remains in an eight-meter-thick sequence consisting of six archaeological units. Thermoluminescence and Electron Spin Resonance dates, along with cultural and stratigraphic considerations, suggest that Middle Pleistocene *Homo* at Nesher Ramla is 140-120 ka old, chronologically overlapping with modern humans in western Asia. These dates indicate that Nesher Ramla *Homo* represents the last surviving populations of Middle Pleistocene *Homo* in southwest Asia. Archaeological evidence suggests that Middle Pleistocene *Homo* mastered advanced stone-tool production technologies previously known only among *Homo sapiens* and Neanderthals. Moreover, 'Nesher Ramla *Homo*' used Levallois knapping methods that cannot be distinguished from those of concurrent *H. sapiens* in western Asia. The most parsimonious explanation for such a close similarity is the cultural interactions between these two populations. These findings provide the first archaeological evidence for contacts and interactions between *H. sapiens* and Middle Pleistocene *Homo*.

One Sentence Summary: Middle Pleistocene *Homo* technologies and behavior ca 140-120 ka ago provide earliest archaeological evidence for cultural interactions with *Homo sapiens*.

The emergence and expansion of *Homo sapiens* during the late Middle Pleistocene (MP) in Africa is associated with new complex behaviors and technologies that typify the Middle Stone Age (MSA) (*1*–*5*). One of the major technological innovations of the MSA is the Levallois technology that emerged and spread across the largest part of the African continent about 300 thousand years ago (ka; *1*, *6*). During the late MP, the centripetal Levallois method was used as the main mode for blank production in many sites in Africa and western Asia (Fig. 1; Table S1). The centripetal Levallois method is a well-structured technical process executed using a set of distinct and repetitive actions (*7*). The earliest evidence for the centripetal Levallois technology was reported in the early MSA sites at the Kapthurin and Gademotta Formations (*2*, *8*). The MSA in general, and centripetal Levallois technology in particular, were found to be associated with the *H. sapiens* remains at Omo Kibish, Herto, and Aduma (*9*–*11*) (Tables S1, S2).

The earliest occurrences of *H. sapiens* in southwest Asia (ca. 180 ka) are associated with Middle Paleolithic industries and Levallois technology (*12*). During Marine Isotope Stage (MIS) 5 (130-71 ka), all *H. sapiens* fossils in western Asia were found to be associated with the centripetal Levallois method (*13*–*18*). Given the prominent presence of the centripetal Levallois method in association with *H. sapiens,* it was often used as a marker of *H. sapiens* dispersal into western Asia during MIS 5 (*18*–*21*).

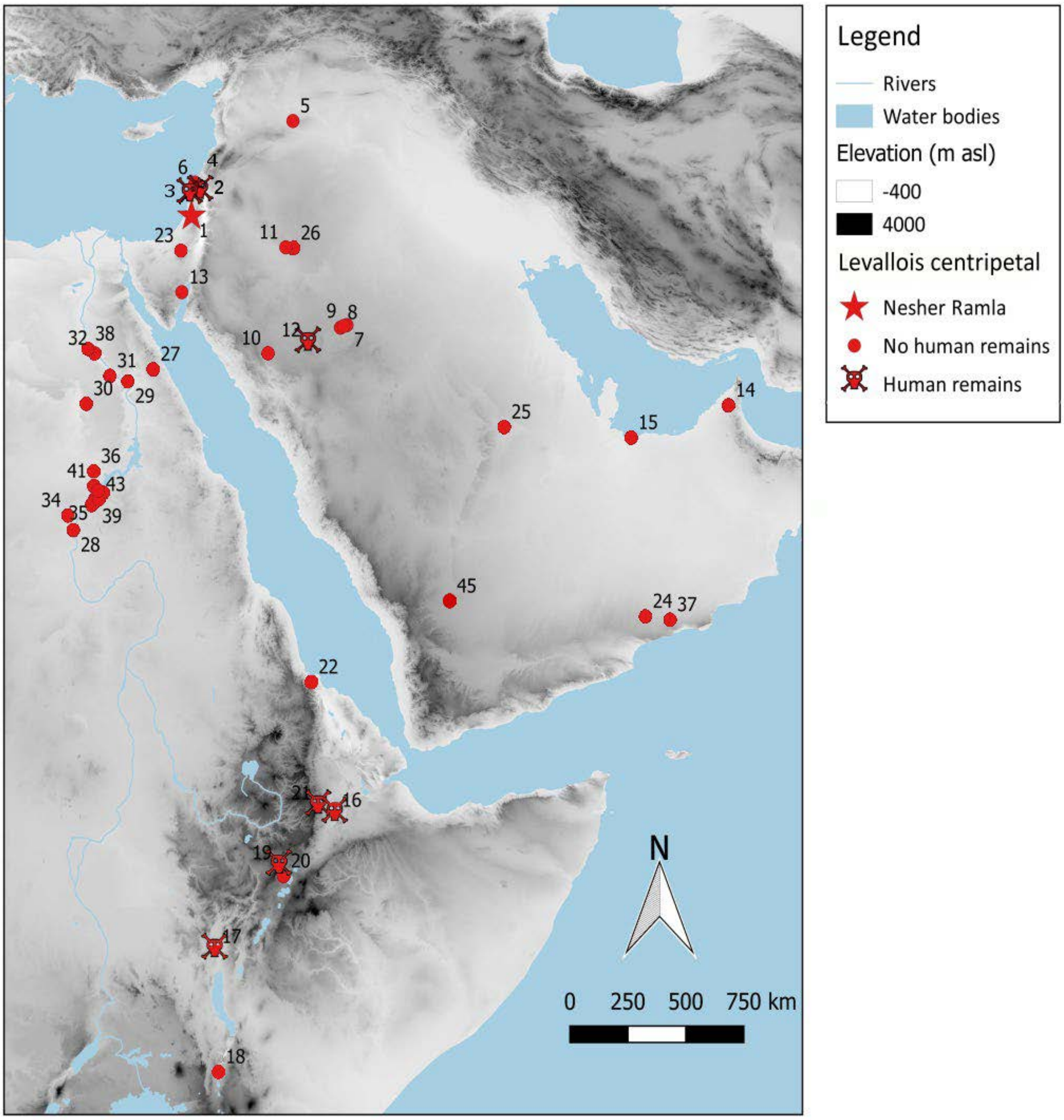

Fig. 1. Lithic assemblages with a marked component of Centripetal Levallois dated to MIS 5 and 6 in the Near East and eastern and northeastern Africa. Sites with human remains are denoted by a skull. The Nesher Ramla site is denoted by a star. The lithic assemblages marked on the map belong to different techno-complexes (see Table S1 for a description of the sites and their technocomplexes). Numbers indicate: 1- Nesher Ramla; 2- Qafzeh; 3-Skhul and Tabun; 4- Hayonim; 5- Hummal; 6- Ras el-Kelb and Naamé; 7- Jebel Qattar1 (JQ1); 8- Jebel Katefeh (JKF1); 9- Jebel Umm Sanman (JSM1); 10-KAM 1-4; 11- Jol Ajrubah (DAJ 120-123 and 133); 12- Al-Wusta; 13- S 20, Split rock site; 14- Jebel Faya; 15- Jebel Barakah; 16- Herto; 17- Omo Kibish; 18- Kapedo Tuffs; 19- Garba III; 20- Gademotta; 21- Aduma; 22- Asfet; 23- H2 site; 24- Aybut al-Awal; 25- Al-Kharj 22; 26- Jol Ajrubah (DAJ 51-55; 98; 100; 110); 27- Sodmein Cave; 28- Sai-Island 8B-11; 29- Taramsa I; 30- Mata'na; 31- Abydos ASPS 46a; 32- Nazlet Khater 2; 33- Site 1035; 34- site 1037-1038 and site 6; 35- Site 1010; site 121; site 8; 36- Jebel Brinikol; 37-Dhofar sites; 38- Nazlet Khater 1 and 3; 39- Site 1017; 40- Site 34A-D; 41- Site ANW-3; 42- Site 2004; 43- Site 1000; 44- Site 36B; 45- Mundafan Al-Buhayrah. Digital elevation data are courtesy of GTOPO 30, USGS.

Two recently discovered human fossils at Nesher Ramla (*22*) provide evidence of the presence of archaic MP *Homo* in the Levant in a Middle Paleolithic context (Fig.2), during a period when the area was presumably inhabited by only *H. sapiens*. This suggests a long overlapping period between these two *Homo* groups (*22*). Our study of the archaeological assemblages associated with the Nesher Ramla fossils indicates that late MP *Homo* fully mastered the Levallois technology. Here we report on the cultural context, chronometric ages, and stone-tool assemblages associated with this new *Homo*.

The Nesher Ramla karst sinkhole is located in central Israel within a chalk bedrock of Senonian age (Fig. 2). Middle Paleolithic cultural remains were uncovered in an eight-meter-thick sequence, 107.5-99.5 masl, ca. 12 meters below the rim of the depression (*23*). The cultural sequence consists of six archaeological units (Units I-VI; Fig. 2; supplementary text, section A). The lowermost Unit VI is ca. 1-meter-thick and is subdivided into five layers (VI I1-I5). A right parietal human bone and an almost complete human mandible (*22*) were found in layer VI I3, which is located in the middle of a sedimentological sequence of Unit VI (Fig. 2).

A combination of Electron Spin resonance/Uranium series (ESR/U-series), Thermoluminescence (TL), and Optically Stimulated Luminescence (OSL) dating methods was applied to date the site and the human fossils (Tables S3, S4, S5; supplementary text, section B). Three herbivorous teeth unearthed from Unit VI were analyzed using a combined ESR/U-series approach in order to overcome the changes in the uranium content of the dental tissues that may have occurred since the burial time. The obtained ages range from 114±12 to 140±9 ka, leading to a weighted mean of 126±6 ka. The same approach yielded ages between 120±9 and 128±8 ka for animal teeth recovered in the overlying layer (unit V) with a weighted mean of 122±3 ka. Fig. 3A and Table S4 present D_e values, dose rates, p-or n-values for the enamel and dentine tissues, and all the ESR/U-series ages. In addition, the TL dating method (*24*) was applied to nine burnt flint samples collected from Unit V, ca. 50 cm above the fossils. The TL ages (Fig. 3A; Table S3; Fig. S1) range from 191±13 to 104±11; however, since these samples belong to a well-defined 20-40 cm-thick archaeological layer, they should be coeval. Thus, the 191±13 age appears to be an anomaly, confirmed by simple statistical tests (Chauvenet's criterion or the chi-square test). When this result is ruled out as an outlier, the individual ages of the eight remaining flints are compatible within a 2 sigma error interval and their weighted mean is 128±4 ka. Moreover, since these samples have been subjected to similar external dose rates (Table S3b shows small inter-sample external dose variations), an isochron analysis (*25*) was performed (Fig. S1b), resulting in an isochron age of 135±13 ka, in agreement with the weighted mean TL age. This indicates that the external dose rates used for calculating the TL individual ages are most likely correct. The TL dates are indistinguishable from the ESR/U-series ages obtained for the same unit (Unit V), and they are in agreement with the weighted mean ESR/U-series date of

The studies of the site-formation processes and the lithic assemblages support the results obtained by radiometric dating. Both Units V and VI exhibit similar sedimentological and micromorphological characteristics (supplementary text, section F; Fig. S2). No hiatus or unconformities between the two units were observed. Micromorphological and sedimentological analyses suggest a continuous deposition by similar depositional mechanisms (*27*). Thus, we concluded that no gap in deposition or changes in the depositional environment occurred between the accumulation of Units VI and V. Fast and continuous deposition is also supported by the stone tools that show similar characteristics in both units, suggesting that they had been manufactured by hominins with a shared cultural tradition (Fig.2; supplementary text, section C-D). Finally, Nesher Ramla's industry shows a clear similarity with the MIS 5 industries of the region (*28*) and it clearly differs from the regional Early Middle Paleolithic industries (*29*), dating to between 270 and 140 ka (*30*) (Fig.3BC; supplementary text, section G3). Taking into account the radiometric ages obtained and the depositional and cultural considerations, the most likely age for the Nesher Ramla *Homo* is ca. 140-120 ka. (Table S4). According to these chronometric results, Unit VI can then be confidently assigned an age of at least 120 ka, in agreement with the previously published OSL ages obtained for the whole sequence (*23*), indicating that the human occupation of the site occurred at the transition between MIS 6 and 5 (*26*). Taking into account the radiometric ages obtained and the depositional and cultural considerations, the most likely age for the Nesher Ramla *Homo* is ca. 140-120 ka.

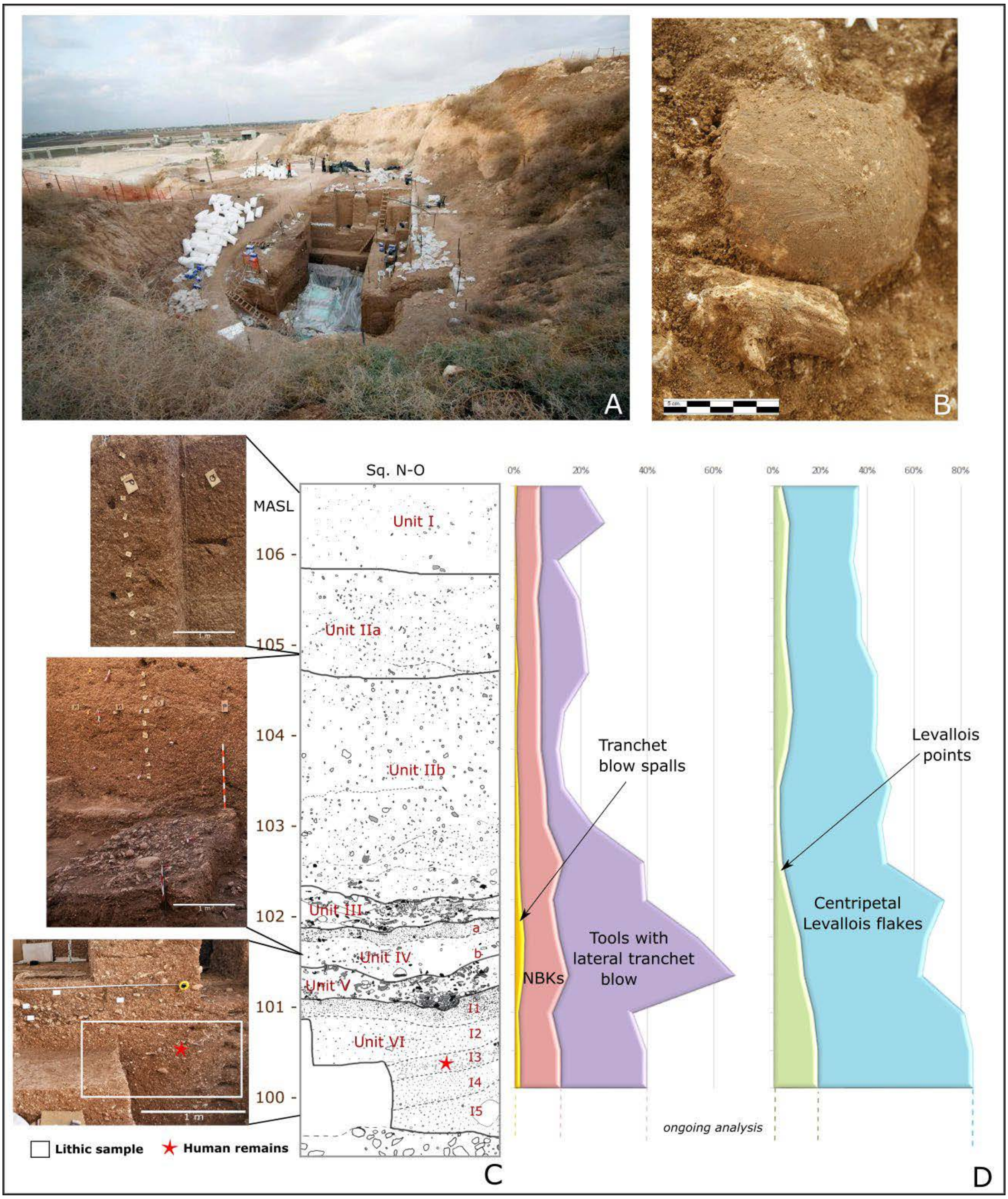

Fig. 2. The Nesher Ramla site. A. General view of the site from east to west. B. The MP *Homo* parietal bone *in situ*. C. A stratigraphic section of Nesher Ramla with its various units. The red star denotes the location of the parietal bone. D. Fluctuations in the frequencies of the main lithic categories (Naturally backed knives = NBK, and lateral *tranchet* blow spalls from the total assemblage; tools with a lateral *tranchet* blow from the total retouched tool assemblage; Levallois points and centripetal Levallois flakes from the total Levallois assemblage).

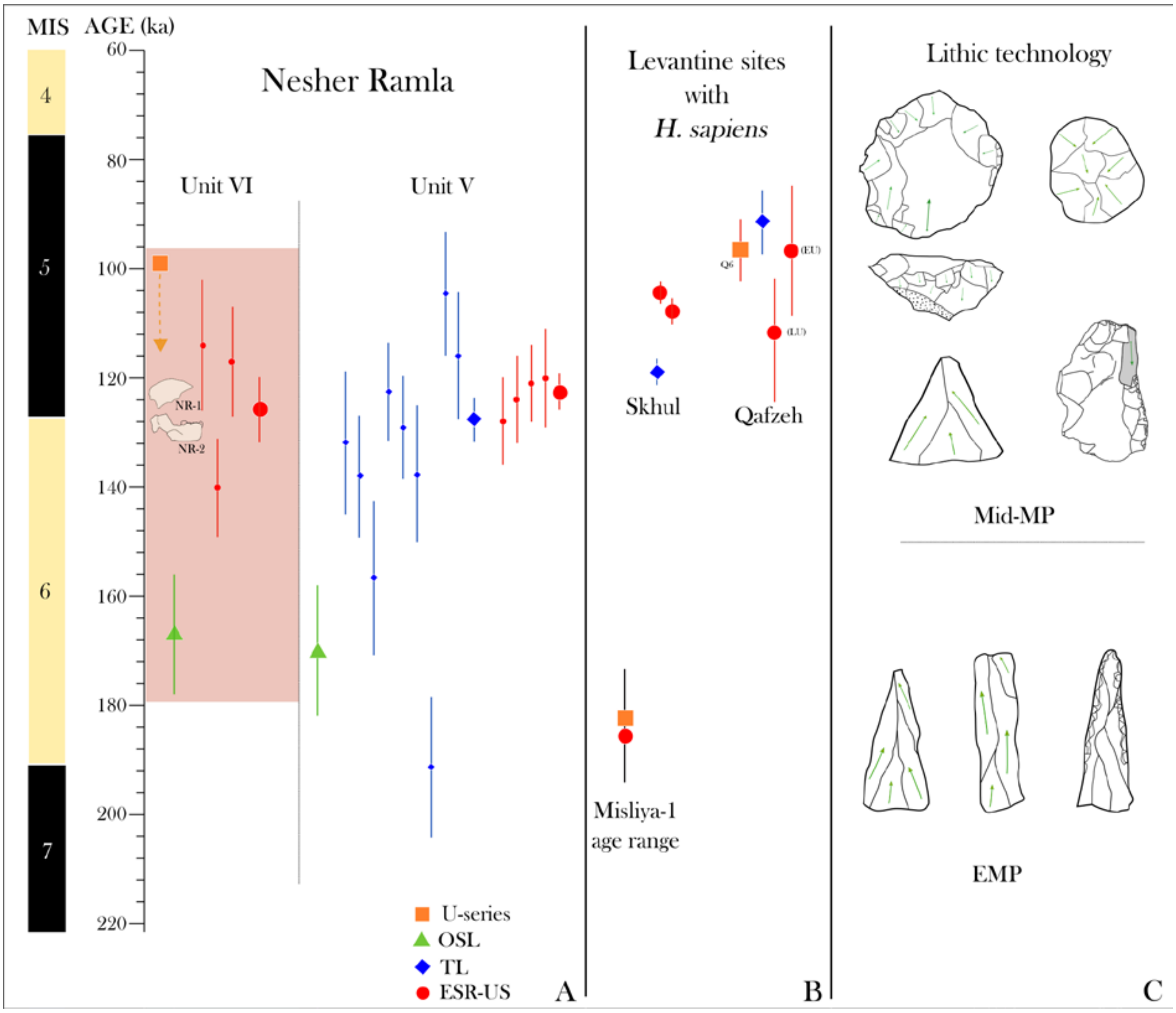

Fig. 3. Chronology and position of the Nesher Ramla site in the Levantine Middle Paleolithic chrono-cultural framework. A. Dating results for Units VI and V of Nesher Ramla site. Large symbols represent weighted mean ages for ESR/U-series (circles), TL (diamonds), and OSL (triangles). The orange square represents the minimum age obtained by the U-series method. NR-1 and NR-2 denote the MP *Homo* remains; B. Chronology of the Middle Paleolithic sites with *H. sapiens* remains in the Levant. Based on the mean ages (*12*, *44–48*); Q6 is the direct age of the Qafzeh 6 human fossil; Misliya 1 is the direct age of the Misliya *H. sapiens* maxilla. C. Major lithic characteristics of Early Middle Paleolithic (EMP) and the middle Middle Paleolithic (mid-MP) in the Levant (*15*, *28*, *29*, *49*).

The presence of some butchered faunal remains in anatomical articulation, the lithic refitting, and the *in situ* features such as hearths and ash piles, indicate *in situ* human activities during the accumulation of the Nesher Ramla archaeological sequence (*27*). The site contains the oldest unequivocal geoarchaeological evidence for *in situ* hearths and the only evidence for hearth rake-out activities in an open-air Middle Paleolithic site (*31*). The evidence from Nesher Ramla shows that MP *Homo* used wood as fuel to make campfires, cooked or roasted meat, and maintained fires by an occasional rake-out, thus

demonstrating a wide range of fire management activities (supplementary text, section F).
The faunal assemblage of Unit VI is dominated by tortoises and ungulates. The assemblage accumulated and was modified by human hunting and processing, as manifested by numerous cutmarks and hammer-stone percussion marks. All skeletal parts are represented even for the largest ungulates, which testify to the hunting activities that took place at or very near the sinkhole. The assemblage is generally composed of open landscape taxa such as gazelle, equids, and ostrich, as well as animals inhabiting a wider variety of habitats, such as aurochs and boar, and relatively small proportions of woodland-adapted fallow deer. This suggests a generally open landscape near Nesher Ramla during the accumulation of Unit VI. The ungulate composition and the dominance of tortoises are similar to other Lower Sequence units (*32*); however, they contrast sharply with the abundance of deer in Units I-II of the site (*28*). This suggests environmental changes or changes in the hunting strategies during the accumulation of the archaeological sequence.
About 6000 artifacts (> 2 cm) were excavated from Unit VI of Nesher Ramla. The lithic assemblage from Unit VI I2-I4, in which Nesher Ramla fossils were discovered, consists of 2327 artifacts larger than 2 cm (Fig. 2C; Table S6; supplementary text, section C). The hominins used local high-quality flint from the Mishash Formation (Fig. S3; supplementary text, section C). Based on the presence of cores, primary elements, flakes, and core maintenance products, Mishash flint was knapped at the site. The cores are completely exhausted, suggesting that hominins knapped the cores to their maximum potential. The raw materials brought from distances that extend 10 km from the site are only frequent among retouched pieces, suggesting that hominins carried the retouched tools as a part of their mobile toolkit (Table S7).
The 'Nesher Ramla *Homo*' mainly used the centripetal Levallois method (Table S6; Figs. S4-S6). The lithic assemblage of Unit VI is dominated by round or rectangular, wide Levallois flakes with centripetal and orthogonal scar patterns and well-prepared striking platforms (Fig. 4; Fig. S4; Tables S8, S9, supplementary text, section C). The convexity of the debitage surfaces of Levallois cores was achieved and maintained through centripetal preparation. The assemblage exhibits a high frequency of Levallois *débordant* flakes with centripetal and orthogonal scar patterns, and pseudo-Levallois points and flakes (Fig. 4; Fig. S6; Table S8). These classic predetermining by-products of the centripetal Levallois reduction system were intended to maintain the convexities of the dorsal surfaces of the Levallois cores. Following the preparation of convexities, the predetermined flakes were produced by preferential and recurrent unidirectional, and by centripetal Levallois methods

(Fig. S4). The centripetal Levallois method exhibits similar technological characteristics throughout the archaeological sequence of Nesher Ramla (Table S10; supplementary text, section B).
The refitted centripetal preferential Levallois core in Fig. S7 confirms that the centripetal Levallois cores consisted of a long sequence of removals of preparatory flakes (flakes from the periphery of the striking platform, *débordant* flakes, pseudo-Levallois flakes and points) and predetermined products (Table S11; supplementary text, section E). The refitting sequence indicates that MP *Homo* fully mastered the centripetal Levallois method.

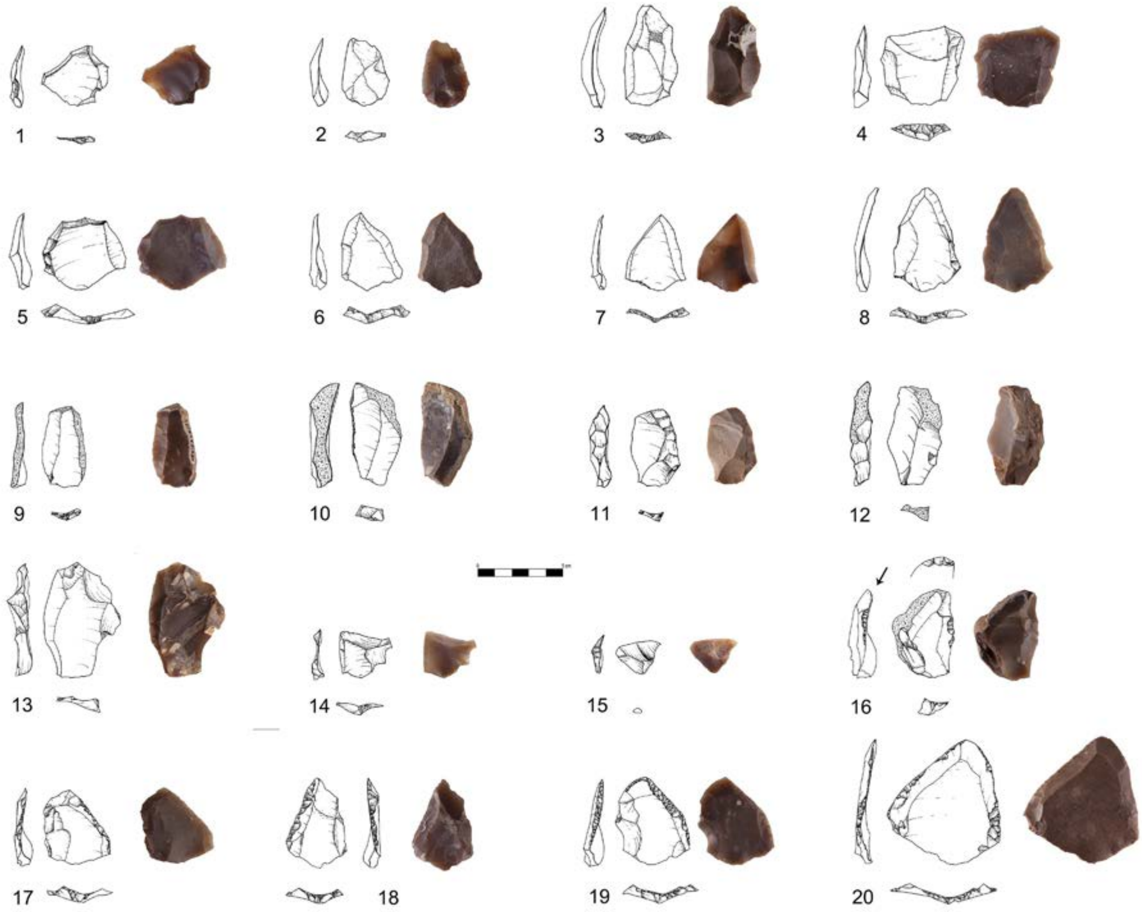

Fig. 4. Lithic assemblage of Unit VI I2-I4: Centripetal Levallois flakes 1-6; 22-23; Levallois points 7-9; retouched Levallois point 10; cortically backed pieces (NBKs) 11-12, 20, 25; *débordant* flakes 13-17, 24; pseudo-Levallois points 18-19; Lateral *tranchet* blow 20-21; side-scrapers 22-25.

The production of Levallois points is another major reduction system in Unit VI (Table S6). Levallois points occur in various frequencies throughout the site's stratigraphic sequence but are most frequent in Unit VI (Table S10). Levallois points were produced by a preferential unidirectional convergent Levallois method and are mostly classical Y-shaped, with a rare use of bidirectional removals aimed at correcting the distal convexity (Fig. 4; Figs. S4, S8;

supplementary text, section C). The points are symmetrical, flat, and broad-based, derived from a preferential mode of production.

Some additional distinct features of the Nesher Ramla assemblage are the systematic production of naturally backed knives (NBK) and the extensive use of a lateral *tranchet* blow technique for producing tools with partly retouched and partly sharped edges (Fig. 4; Figs. S6, S9, S10; Table S12). These unique characteristics of the Nesher Ramla industry occur in varying frequencies throughout the entire archaeological sequence of the site along with the centripetal Levallois technology and Levallois point production (Fig. 2D; supplementary text, section D). The use of the same technologies and the production of the same unique set of artifacts suggest a cultural continuity in the area during the accumulation of the eight-meter-thick archaeological sequence (Fig. 2D; Table S10).

MP *Homo* fossils often lack cultural context and their behavior and technology remain poorly known. Nonetheless, it is commonly suggested that MP *Homo* produced Lower Paleolithic industries (Acheulian; or core-on-flakes; *33*–*37*). The evidence from Nesher Ramla demonstrates that late MP *Homo* fully mastered advanced Levallois technology that until only recently was linked to either *H.* sapiens or Neanderthals. The use of the centripetal Levallois method by 'Nesher Ramla *Homo*' suggests caution in using lithic technology as a marker for the presence and dispersals of *H. sapiens* out of Africa in MIS 5. This is consistent with recent views that MP *Homo* could be one of the makers of MSA industries in Africa (*38*). Moreover, the centripetal Levallois technology used by 'Nesher Ramla *Homo*' clearly resembles the technology of the *H. sapiens* sites of Qafzeh and Skhul, the Middle Paleolithic sites in Arabia and the MSA sites in North and East Africa, including sites where the remains of *H. sapiens* were found (Fig. 1; Table S1, S2; supplementary text, section G). This includes a similar mode of preparing the convexities and a similar way of utilizing the cores for producing predetermined Levallois flakes with a round or rectangular shape. Furthermore, Nesher Ramla hominins share the convergent unidirectional method for producing Levallois points with other Levantine MIS 5 sites (*15*, *39*, *40*).

We contend that cultural diffusion and interaction across *Homo* populations is the most likely reason for such a close cultural similarity between MP *Homo* and *H. sapiens*. Our findings provide the first archaeological support for close cultural interactions between different human lineages during the Middle Paleolithic period and suggest that admixture between MP *Homo* and *H. sapiens* had already occurred prior to 120 ka. This is consistent with a growing body of genetic studies that suggest a gene flow from divergent archaic *Homo* populations into *H. sapiens* during the late Middle and early Late Pleistocene (*41*–*43*).

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