Jels 3, a New Late Palaeolithic Open-Air Site in Denmark, Sheds Light on the Pioneer Colonization of Northern Europe

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Abstract

The Late Upper Palaeolithic Hamburgian tradition reflects the earliest known human presence in northern Europe after the Last Glacial Maximum. We report here on the open-air site of Jels 3 (Denmark) and its associated stone tool assemblage, which can be unambiguously attributed to this period. Along with only a handful of other sites, Jels 3 represents the northernmost limits of human expansion in Europe at this time. We conduct a technological analysis of the lithic material from Jels 3 and other relevant sites to shed new light on the behavioral processes that likely underwrote this expansion. Given that sites dating to this initial dispersal remain few, are restricted to certain geographic regions, and represent an overall lack of a well-developed settlement hierarchy, we suggest that this dispersal process is most commensurable with the earlier stages of a leap-frogging colonization targeting specific landscape elements and that it was quite possibly very short-lived.

Introduction

By the end of the Last Ice Age, the glacial ice masses of the Northern Hemisphere had retreated significantly and left open landscapes untouched by humans. As part of a wider ecological succession, human groups again began venturing into these regions, including southern Scandinavia, where ice-scoured young moraine landscapes were made accessible for humans then occupying more central regions of the continent (Riede 2014a). This particular pioneer dispersal is associated with a Late Upper Palaeolithic Hamburgian culture (ca. 14,700–14,000 cal. b.p.). Named after the remarkable, but also not unproblematic, old excavations of Alfred Rust (1937) in the areas just north of Hamburg (Germany), this culture represents an off-shoot of the Late Magdalenian as defined by its lithic (Weber 2012) and organic (Wild 2020) technology and is—based on projectile point typology—commonly divided into earlier “classic” and later “Havelte” phases.

The exact pattern and process of this pioneer migration remains a matter of contention. Different scenarios for this initial dispersal have been proposed, chiefly the leap-frog and wave-of-advance models (Brinch Petersen 2009; Mugai 2018). Wave-of-advance models propose a gradual and spatially homogeneous expansion of human presence over time from a common center of origin. In contrast, leap-frog models suggest an (archaeologically) instantaneous advance where people move relatively far over a short time to establish satellite settlements, leaving swaths of empty space in between (Anthony 1990; Anderson and Gillam 2000). The archaeological signatures of these divergent dispersals differ: a leap-frog dispersal should yield smaller, ephemeral settlements that are technologically and behaviorally homogenous and clustered in space and time. In contrast, the wave-of-advance model would result in sites that are more heterogeneous in terms of size, composition, and behavior and more evenly distributed both spatially and temporally. While wave-of-advance models have been applied with some success to the re-peopling of northern Europe after the Last Ice Age at the continental scale (Fort, Pujol, and Cavalli-Sforza 2004), the archaeological evidence for the Magdalenian in general (Maier 2015) and for the Hamburgian in particular—empty spaces, condensed dating sequences, and substantial evidence for long-distance movement—is more readily commensurable with leap-frogs (Brinch Petersen 2009; Riede 2014b; Pedersen, Maier, and Riede 2019).

Crucial to understanding this dispersal process and how Hamburgian groups expanded and mapped onto these peripheral landscapes is the concept of landscape learning (Rockman and Steele 2003 and papers therein; Meltzer 2004; Rockman 2009, 2010, 2012), which we here include in our model. Landscape learning entails the acquisition of necessary knowledge about the distribution of natural resources in a region where such previous (landscape) knowledge is lacking. Rockman (2003, 2009, 2012) explains this process as related to different time-dependent learning barriers, which scale in difficulty from 1) locational knowledge which describes more easily obtainable information such as the location of permanent resources (e.g. lithic outcrops) to 2) limitational knowledge, describing harder to learn aspects such as the boundaries of seasonally fluctuating resources (e.g. distributions of plants and animals). The information gathered then needs to be tied together into 3) social knowledge through collective memorization and cognitive mapping of the environment, the patterns of its resources, and related signals using storytelling. The final product of this process is landscape knowledge. Lack of landscape knowledge has been shown to have significant social and economic consequences, even leading to demographic collapse and extinction events, making knowing an environment...
well crucial to a population’s ability to exploit natural resources and to remain viable (Meltzer 2003; Rockman 2010). Although difficult to capture, signatures indicating whether pioneering groups learned a landscape or not can arguably be inferred archaeologically (Table 1). By the same token, new discoveries in the field, as well as careful analyses of existing assemblages, allow the testing of competing dispersal scenarios.

Finds of the Hamburgian are rare, especially in peripheral areas such as present-day southern Scandinavia. We here report on the discovery, excavation, and analysis of the Jels 3 assemblage (HBV 1316 Nederseparken) and the subsequent archaeological survey of adjacent areas near the Jels lake complex in southern Denmark (Poulsen 2013; Figure 1). We describe the Jels 3 assemblage and present a detailed analysis of the lithic technology, with specific focus on the morphology of the projectile points and blades, and compare Jels 3 to other sites in the vicinity and further afield in order to assess their role in the pioneer migration process. Our analyses stress the similarities between late Hamburgian sites all along this culture’s northern periphery, which we interpret to indicate close ties between the individual locales and a low level of site differentiation. Together, these elements not only suggest close chronological proximity but also complete households moving camp, rather than task-differentiated mobility within a well-developed settlements system. By placing these observations in a wider comparative framework, Jels 3 provides a rare micro-regional picture of an early entry by humans into the recently deglaciated areas of Late Pleistocene southern Scandinavia. Together with the remaining evidence from the Hamburgian, Jels 3 provides compelling evidence for leap-frogging colonization into ecologically immature and little-known landscapes—a dispersal that may have failed in establishing a continuing exploitation of these landscapes and ultimately resulted in an extinction or a biological and/or cultural extinction event (Riede 2005, 2007, 2009, 2014b).

The Hamburgian Culture and the Re-Peopling of Northern Europe

Following the initial discoveries of Hamburgian sites north of Hamburg in the first part of the 20th century, a.d., sites and single finds have been found elsewhere in Germany, Poland, the Netherlands, Denmark, possibly Sweden, and perhaps as far as the British Isles to the west (Ballin et al. 2018) and Lithuania to the east (Savaticius 2002; but see Ivanovaitë and Riede 2018 for a critical review of this material). With a material culture that retains clear ancestral Magdalenian elements, the Hamburgian represents the pioneer human re-peopling of northern Europe during the closing phase of the Last Ice Age. The exact routes taken by Hamburgian groups into these higher latitudes are debated, but recent research suggests a dispersal trajectory ultimately from the southwest (Weber 2012). The Hamburgian can be dated to the Greenland Interstadial (GI) 1e warming (Grimm and Weber 2008; Weber and Grimm 2009) and the corresponding Bolling/Meienendorf chronozone (sensu Krüger and Damrath 2020), although some dates extend into the subsequent Older Dryas/GI-1d and Allerød/GI-1c. Thereafter, the signature material culture of the Hamburgian disappears from the archaeological record. From rare faunal remains and the seemingly typical location of sites high in the landscape, the subsistence economy of the Hamburgian is thought of as specialized reindeer hunting supplemented with horse and small game (Gronnow 1985; Bokelmann 1991; Bratlund 1994; Weber 2013). Limited organic evidence from Poland also indicates that small game, as well as aquatic and plant resources, were utilized (Kabacinski and Sobkowiak-Tabaka 2009), although the degree to which this limited evidence can be extrapolated across the culture’s entire geographic and chronological range remains unclear.

In the context of the Late Upper and Final Palaeolithic of northern Europe, Hamburgian technology and tool forms are highly characteristic. Diagnostic tools for the Hamburgian technocomplex are first and foremost the projectile points: classic asymmetric single-shouldered points belonging to the early Hamburgian and the very particular Havelte type representing the slightly later eponymous Havelte Group. Other diagnostics are the characteristic curve-beaked Zinker, burins (often, but by no means exclusively, dihedral) and end-scrapers, often with lateral retouch. Virtually all formal tools are produced from blades struck from single-faced opposed-platform blade cores. The frequency of double-ended combination tools is notably high (Figure 2). A division of the Hamburgian into several subdivisions has previously been attempted based on subtle changes in tool forms and frequencies (Tromnä 1975), but only two chronological phases or facies are recognized today, namely the earlier and more southeastern classic Hamburgian and the slightly later and more northwestern Havelte phases. With the caveat of generally very poor organic preservation, it appears to be the deliberate shaping of the two projectile point variants, rather than any other aspect of the lithic (Weber 2008, 2012) or organic (Wild 2020) repertoire or subsistence economy, that distinguishes the classic and Havelte phases.

The first Hamburgian locales in Denmark were documented at the Jels lakes in the southern part of the country in the early 1980s (Holm and Rieck 1983, 1992). Notably, these were the first true sites of this culture documented north of the German border, despite a long and systematic tradition of archaeological investigations. Additional sites were later discovered at Slotseng, close to Jels (Holm 1991), demonstrating the presence of a settlement cluster. Around the same time, the site of Solbjerg on the eastern Danish island of Lolland (Petersen and Johansen 1996), and later on close by Krogsboelle (Riede et al. 2019), were discovered and excavated, highlighting the existence of a second settlement cluster at the opposite end of the country. Most recently, the Jels 3 locale presented in this paper was discovered at the southern end of the Jels lakes. These excavated sites are supplemented by a dozen single finds of projectile points, blades, cores, and organic material whose attribution to the Hamburgian is less than certain, as well as the similarly uncertain assemblage Möllered from southern Sweden, which likewise contains weak diagnostic elements, such as a possible tanged point of the Havelte variant and Zinken-like implements (Larsson 1994). In contrast to Germany, all of the Hamburgian material from Denmark—with the exception of a doubtful single find from Bjælve Heath (Becker 1971)—belongs to the late Havelte group. Furthermore, while Hamburgian sites in Germany are more numerous and more evenly distributed, the sites from Denmark appear to be confined to the two discrete settlement clusters in southern Jutland and on the island of Lolland, respectively. The distance from the Danish settlements to the nearest Hamburgian site to the south (e.g. Ahrenshöft; see Weber
et al. 2010) is > 100 km, and the distance to the Ahrensburg tunnel valley is > 200 km. By current evidence, the two Danish settlement pockets constitute the northernmost frontier of human expansion at this time.

This evidence has previously been interpreted to indicate an ephemeral exploitation of the landscape (Eriksen 1999). The available radiometric data from this period have recently undergone several comprehensive reviews (Grimm and Weber 2008; Weber and Grimm 2009; Wilde et al. 2021). While many of the available dates may be individually problematic, the Hamburgian remains one of the best-dated techno-complexes from Late Glacial northern Europe. While the radiometric dating evidence from the fauna-bearing sites in Germany and elsewhere is suggestive of repeated occupation of many sites (Grimm and Weber 2008; Weber and Grimm 2009), the ephemeral character of the northern sites is underlined by the combined radiocarbon and pollen analysis from Slotseng, which points towards a single deposition event of all faunal remains at the very end of the Bolling/Meiendorf warm period (Mortensen et al. 2014). Along with less secure OSL dating evidence from Krogsholle (Riede et al. 2019), this could be suggestive of a very tight dating of the Hamburgian presence this far north towards the very end of the Bolling/Meiendorf. Meta-analyses of the available dating evidence for the Hamburgian highlight that the classic and Havelte phases overlap both temporally and spatially (Grimm and Weber 2008; Weber and Grimm 2009; Riede 2014b), although the robusticity and extent of this chronological overlap is strongly dependent on the analytical protocol used. Employing more demanding selection criteria and an alternative calibration approach, Pedersen, Maier, and Riede (2019), for instance, suggest multiple expansion pulses separated in time, rather than continuous or contiguous settlement phases.

The Jels 3 Site

Previous investigations

The Hamburgian was recognized for the first time in Denmark in 1981 with the test excavation of the site Jels 1, located by the so-called Upper Lake (Ovsersø) of the Jels lake complex. This locale was discovered through field reconnaissance conducted by an amateur enthusiast. Only 30 m from the Jels 1 site, another Hamburgian locale, Jels 2, was then located, and both were subsequently investigated by Holm and Rick (1983, 1992). Both sites yielded lithic inventories of the Havelte phase of the Hamburgian culture. The two sites differ somewhat in composition: Jels 1 is interpreted as a workshop, being dominated by material stemming from primary reduction and tool manufacture, while...
the Jels 2 site sports a higher frequency of tools, especially points, and was therefore interpreted as a hunting station. The differences are, however, relatively subtle, and taphonomic or stochastic distortions (cf. Ammerman and Feldman 1974) of these artifact frequencies cannot be ruled out. In connection with these investigations, a third site, Slotseng C, was discovered. Slotseng C turned out not only to be rich in lithic material, but faunal material, as well. The Slotseng site is located only 5 km southeast of the Jels lakes in direct connection with these through a river valley passage. The Jels 3 site reported here is, along with the other sites at Jels, located by the lake complex itself.

**Topography**

The lake complex at Jels is part of a small southwest-oriented tunnel valley ca. 4 km long and 0.5 km wide. The valley is part of the terminal moraine ridge system associated with the westernmost extension of the Scandinavian ice sheet during the Greenland Stadial 2 (Houmark-Nielsen and Kjer 2003). The site itself is located on a sandy plateau 47–47.5 masl situated 32 m from a dried-out watercourse and ca. 180 m from the Lower Lake (Nedersø). The extent of the Lower Lake itself is assumed not to have changed considerably since the Final Pleistocene (Holm and Rieck 1992, 18).

**Discovery and excavation of the site**

A preliminary survey was conducted at Jels in September–October 2008 after the area was scheduled for housing development. During this investigation, a series of 2 m wide trenches, running north-south and spaced 15–20 m apart, were machine-striped. Three minor extensions were made during the preliminary investigation because of features dating to the Iron and Middle Ages. The awareness of previously excavated Hamburgian sites in the area led to the decision to conduct ploughing with the express purpose of detecting such ephemeral flint concentrations (Eriksen 2006; Veil 2006; Fischer 2012), albeit without meaningful results.

Systematic field assessments began in March 2009 by machine-stripping and closely examining the subsoil horizon for features. The removed soil was carefully monitored, leading to the discovery of the first Late Upper Palaeolithic artifacts. These ex situ finds were clearly concentrated towards the western end of the investigated area; given the rarity of Hamburgian sites in the region, the excavation strategy was adapted accordingly. This initially entailed the investigation of a large volume of topsoil aimed at recovering diagnostic artifacts. A large sieving operation was instigated using a custom-modified potato sorting rig. Subsequently, a 1 m² grid was established in the area from where the lithic artifacts were assumed to stem and was gradually extended as more artifacts were uncovered. The grid system (240 m²) eventually covered an area characterized by fine sand, which contrasted markedly with the surrounding area, which was dominated by clay and entirely devoid of finds. Every square meter was excavated in 50 × 50 cm quadrants and in 10 cm artificial spits until the presence of artifacts ceased. All excavated matrix was wet-sieved using a 1 mm mesh. Due to time constraints and limited complexity and information in the layer sequence, no profiles were drawn.

The very southern part of the excavation area had been covered by a layer of clay when a rainwater basin had been

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**Figure 1.** Map of the Jels lake complex. Marked on the map are the two previously excavated sites in the northern part of the lake complex and the newest site in the southern part. The area of the 2011 field survey is marked in blue. Map made using QGIS (QGIS Development Team 2019). Map data: naturalearthdata.com and kortforsyningen.dk.
established in the early 1990s. The construction of the same rainwater basin had also removed the westernmost part of the sandy area. The original extent of this area is therefore unknown. A 5–7 m broad zone surrounding the basin was completely disturbed and destroyed in connection with its construction. This disturbed zone is contiguous with the northwestern part of the excavated area, which is further disturbed in the southwestern part by a power cable ditch and other recent activities that section the sandy area squarely off towards the west. Core drilling seeking to reveal the presence of dead-ice holes in the vicinity of Jels 3 was unsuccessful.

Following the excavation, an area close to it was surface surveyed in early 2011. In only a matter of a few hours, an additional 87 flint artifacts had been retrieved, including cores (n = 2), blade fragments (n = 11), and scrapers (n = 2). The majority (n = 53) of these artifacts are either white- or bluish-patinated. Of these, 26 are heavily white-patinated, a common trait for Late Palaeolithic flints in this region (Petersen 2006). Furthermore, eight pieces of burned flint were found. One of the cores is a double-platform blade core showing single-fronted exploitation, a technique most commonly seen in the Hamburgian (Figure 3). The results of the 2011 survey not only show that more material is present at the Lower Lake, but the proximity of these newly discovered artifacts to the excavated site also suggests that these finds may be in direct connection to the Jels 3 site itself.

Figure 2. The lithic tool-set of the Hamburgian: A) single faced dual platform blade core, B) blade-end scraper with lateral retouch, C) symmetrical dihedral burin on blade, D) combination tool, E) double Zinken, F–G) Classic Hamburgian shouldered, and H–I) Havelte-phase tanged projectile point. The material stems from the A–G Meiendorf 2, H) Jels 1, and I) Jels 2 inventories and are redrawn from Rust (1937) and Holm and Rieck (1992), respectively, by Louise Hilmar, Moesgaard Museum.
The Lithic Inventory

The excavation at Jels 3 has yielded no organic material, but a total of 2846 lithic artifacts of possible Late Pleistocene origin, 2652 of which derive from the area within the grid system. Of these, 1835 were encountered in situ in the sandy subsoil, mostly (n = 1592) in the uppermost 10 cm (Table 2). The plough layer yielded only 817 artifacts, indicating that the area has—quite remarkably—not been subject to intense and deep ploughing. The material was distributed into one major and two minor concentrations (Figure 4). The preserved part of the sandy area covered 198 m², but its original extent is unknown, due to the disturbance in the western part. Test pits (25 × 25 cm) placed around the rainwater basin and its zone of disturbed subsoil have shown that the sandy area did not extend further beyond the disturbed area, strengthening the association between the dry and well-drained sandy patch and the Palaeolithic site. The tight distribution of the artifacts and debitage indicate only minor post-depositional disturbance by ploughing (cf. Boismier 1997). Given the shallow, open-air nature of the site, however, it is likely that cryo- and bioturbation processes have almost certainly moved the artifacts around to some extent. The white to bluish patina and pale surface hue of the lithic material (n = 259) supports, albeit weakly, their Late Pleistocene age. Burnt material was found in small numbers (n = 25) but was evenly spread across the site (see Figure 4); no latent signs of a fireplace or other structures were encountered in the field. Primary flint production waste accounts for 96.8% of the material. Of this, 10% consists of blades, blade fragments, and cores. The remaining 90% are flakes. Secondarily modified products (formal tools and retouched material) represent 3.1% of the assemblage, and in spite of the small size of the inventory, it is relatively rich in tools (see Table 2; Figure 5).

Projectile points

An important aspect of the Jels 3 assemblage is the projectile point material. Four fragments were found, one of which is difficult to confidently classify as such. The remaining three are all basal fragments with only the tang remaining and can more confidently be classified as fragments of Havelte-style tanged points (Figure 6). In terms of projectile point function, the size of these specimens—here especially, the two ballistically significant dimensions, width and thickness (cf. Shea 2006), as well as their derivatives—strongly supports their association with the bow-and-arrow, though no currently known archaeological remains of bows or complete arrow shafts can be connected to Hamburgian contexts (Lund 1993; Weber 2009; Riede 2010; Wild et al. 2018). When assessing the fractures of the Jels 3 points, they are...
all medial and appear to be bending or “snap” fractures, two of which have a minor cone fracture on the breakage surface and one additionally featuring a minor uni-facial spin-off fracture on its ventral side. This could indicate that they broke from impact damage, although such interpretations always remain uncertain (cf. Rots and Plisson 2014). All projectile point fragments from the Jels 3 assemblage show the same orientation on the blank blade, with the tang located at the proximal end. The crafting of the tang itself involved, in one case, retouch from alternating surfaces on the opposing edges (i.e. propeller retouch). Two specimens were retouched from the same surface. This retouch does not lead to the formation of a clear tang; instead, the converging retouch forms a tapered point-like tang instead.

Within the Hamburgian tradition itself, classic assemblages contain a morphologically rather wide variety of asymmetric single-shouldered projectile point forms, while the Havelte inventories are much more uniform in this regard. This is in glaring contrast to the subsequent Federmessergruppen tradition of the Allersd chronozone, where projectile point morphology varies widely with little regionally discernible patterning (Ikinger 1998; Matzig, Hussain, and Riede 2021). Notably, Havelte phase sites from Denmark such as Jels 1 and 2 (Holm and Rieck 1983, 1992), Slotseng C (Holm 1991), Solbjerg 2 (Petersen and Johansen 1996), and Krogsbolle (Riede et al. 2019), as well as sites from northern Germany such as Ahrenshtöft LA 58 D (Weber et al. 2010) and LA 73 (Clausen 1998), all contain projectile points that are strikingly uniform in shape. The projectile point variants from Jels 3 find close parallels in those assemblages, too. This rather drastic change between the two Hamburgian phases in only one specific artifact category is noteworthy, and it has been suggested that the homogeneity in projectile point shape and preparation in Havelte assemblages—especially in this northernmost region—could be conditioned by social norms (cf. Tehrani and Riede 2008) and may serve as proxies for the craft signatures of individual flintknappers (Riede 2005, 2007, 2009, 2014b; Riede and Pedersen 2018; Riede et al. 2019).

**Blade technology**

The analysis of the flint-working behavior at the Jels 3 site has been conducted following insights gained in the specifically Nordic (Madsen 1992; Ballin 1996; Sørensen 2006) and global (Inizan et al. 1999; Andrefsky 2005; Tostevin 2013) literature in this field. To assess the applied knapping methods and production technique, this analysis includes all non-cortical, complete blade blanks, with focus on variables such as linear measurements and technological attributes. Firstly, the blade material from the other two known Hamburgian inventories at the Jels Lakes—Jels 1 and 2—is included for comparison between sites within this micro-region of Hamburgian settlement. Secondly, several classic Hamburgian inventories from the Ahrensburg tunnel valley in northern Germany are included, as well, in order to evaluate the knapping behavior between 1) these two discrete regions and 2) classic and Havelte phase inventories. Thirdly, other Late Pleistocene inventories from both Germany and Denmark that belong to later technocomplexes such as the so-called Federmessergruppen and the Brommean are analyzed in order to provide a technological contrast to the Hamburgian (Table 3). The chronological and cultural relationship between these two latter technocomplexes is, however, unclear, with the Brommean likely being a sub-facies of the Federmessergruppen (cf. Riede 2017). The two are therefore referred to in the following under the summary label “Late Pleistocene (other).”
In terms of both length and width, it can be observed that blades from classic Hamburgian and Havelte inventories tend to distribute similarly, with the Havelte containing the smallest elements, which could allude to similar preferences in blade size at these locales. An expected overlap between the Hamburgian assemblages and those of a later date is also observed, albeit with the latter exhibiting a larger degree of size variability, as well as forming the majority of the larger elements and most extreme outliers (Figures 7, 8). In terms of size, the Hamburgian material overall stands out by reflecting uniformity when compared to material of later Pleistocene date.

The technological attribute analysis focuses on the proximal end of the blades, as the morphological features present here are typically used as indicators for knapping techniques (Figure 9). However, there are source critical elements and most extreme outliers (Figures 7, 8).
The choices made by the flintknapper and what the analyst observes as technological attributes in the archaeological material are interrelated. However, by separating a lithic inventory into predefined attribute categories, they risk becoming isolated. This understates their analytical value and the diversity in choices made by the past craftsman, and the derived variation therefrom in the material cannot be retraced by the reader. Specific technological traits are therefore often treated typologically and qualitatively, which limits the potential for inferring relations between assemblages and processes of change over time (Bar-Yosef and Van Peer 2009; Riede and Jensen 2014). Furthermore, several studies have cast doubt on our abilities to confidently distinguish knapping techniques beyond the extremes of hard hammer percussion and pressure flaking (Damark and Apel 2008; Damlien 2015; Radinović and Kajtež 2021) or at least that much more controlled work and quantitative analyses need to be conducted in order to confidently infer technology from bulb and flake/blade morphology (Archer et al. 2017). Due to these issues, we here conduct an exploratory correspondence analysis (CA) at the assemblage level in order to evaluate the overall technology of the investigated inventories. This allows the analysis of all registered morphological features on a single blade at one time, as well as an assessment of how these features interrelate. Furthermore, it allows us to observe how all blades from the various inventories behave in relation to each other in a multivariate space and evaluate if it is possible here to discriminate between knapping techniques (Figure 10).

In the multivariate space of the CA, the technological variables orientate themselves in three main directions. Firstly, in the lower left quadrant are variables that describe blade preparation, such as trimming and abrasion techniques, as well as faceting of the butt. Attributes such as smaller and punctiform butts, as well as lip formation, also appear to be within this cluster. Secondly, in the upper left quadrant are a combination of pronounced bulb and conus formation, large, thick, and plain butts, and less preparation of the blade, all attributes which, together, indicate a hard and direct knapping technique. Thirdly, there are variables that orientate themselves in the rightmost part of the x-axis. These are broken butts and bulbar detachment, which

Table 3. Contextual parameters for the various inventories used for the technological analysis. DK = Denmark, DE = Germany, and SE = Sweden.

| Site            | Country | Recovery Method | Sieving | Classification | Reference                          |
|-----------------|---------|-----------------|---------|----------------|------------------------------------|
| Jels 3          | DK      | Excavation      | Y       | Havelte        | This paper                         |
| Jels 1          | DK      | Excavation      | Y       | Havelte        | Holm and Rieck 1983, 1992           |
| Jels 2          | DK      | Excavation      | Y       | Havelte        | Holm and Rieck 1983, 1992           |
| AHR LA 137 (Poggenwisch) | DE | Excavation | N       | Classic        | Rust 1958; Weber 2012; Clausen and Guldin 2017 |
| AHR LA 139 (Hasewisch) | DE | Excavation | N       | Classic        | Rust 1958; Hartz 1990; Clausen and Guldin 2017 |
| AHR LA 140 (Meiendorf 2) | DE | Excavation | N       | Classic        | Rust 1937; Clausen and Guldin 2017 |
| Egved Mark      | DK      | Excavation      | N       | Federmesser    | Fischer 1988                       |
| Rietberg 1      | DE      | Excavation      | Y       | Federmesser    | Richter 2001; Richter 2012; Holzkämper, Maier, and Richter 2013 |
| Häcklingen 19   | DE      | Excavation      | Y       | Federmesser    | Richter 2002                       |
| Sassenholz 78   | DE      | Surface collection | -     | Federmesser    | Breest and Gerken 2008             |
| Sassenholz 82   | DE      | Surface collection | -     | Federmesser    | Breest and Gerken 2008             |
| Søvind          | DK      | Excavation      | Y       | Brommean       | Andersen 2016                      |
| Segebro         | SE      | Excavation      | N       | Brommean       | Salomonsen 1964                    |

Figure 6. The three projectile point tangs of the Havelte variant found at Jels 3. Drawn by Louise Hilmar, Moesgaard Museum.
are fracture mechanics more or less related to a range of knapping techniques.

The largest part of both Havelte and classic Hamburgian elements appear to cluster in the lower left quadrant, indicating that continuous preparation of the core in order to maximally control blade production is a consistent element in the Hamburgian knapping tradition. This correlates well with the actual cores from Jels 3, which generally appear strongly reduced and hence likely discarded in their final use phase. These cores have been rejuvenated often, and many smaller platform preparation flakes are present in the flake material. This is in complete alignment with Jels 1 and 2 (Madsen 1992). The bulb, lip, and butt morphology observed in this cluster could indicate the use of a soft-direct percussion technique, albeit less clearly. Overall, the material from Hamburgian contexts do appear to behave similarly across sites, indicating strong similarities in knapping behavior. The material from the non-Hamburgian contexts deviates from this pattern and appears to distribute more evenly between the lower- and upper-left quadrants, with the majority located within the latter. This not only indicates that a direct and hard knapping technique is more frequently applied here but also that the non-Hamburgian traditions practiced a more variable and perhaps more flexible knapping behavior than in the Hamburgian, where it appears that there were more normative guidelines for how lithic resources were utilized. These results are fully in line with earlier studies, which suggested a similar contrast in

Figure 7. Scatterplot visualizing the length and width of all blades. Note the larger degree of variability in the material succeeding the Hamburgian and how the majority of larger blades relate to this material.
technological behavior between the strongly normative Hamburgian and the versatile Federmessergruppen (De Bie and Vermeersch 1998; De Bie and Caspar 2000; Sobkowiak-Tabaka 2020). There is, however, also a significant overlap between the investigated assemblages, which further supports the argument that it is difficult to discriminate, at the assemblage level, between specific knapping approaches with certainty, other than direct- and pressure techniques.

Figure 8. Boxplot showing the distribution of blades in each assemblage according to their width. Note the close similarities between classic Hamburgian and Havelte Group assemblages and the larger degree of variation between locales of later Pleistocene date.

Figure 9. Morphological features used for the attribute analysis.
The main observation here is, however, that there is a vast bulk of blades from the three sites at Jels and the three classic Hamburgian sites which make a tight cluster. This observation conforms with the linear measurements. During analysis, the specific blade preparation technique en éperon (c.f. Barton 1991) was looked for, since it is known from both classic Hamburgian assemblages such as Teltwisch 1 and Poggenwisch, as well as the Havelte assemblage from Ahrenshöft LA 58D (Weber 2012) and Jels 1 (Madsen 1992). This specific preparation technique is, however, quite rare, and only examples that are probably nearer the "pseudo-éperons" described by Weber (2012) could be observed in the Jels 3 material, as well as in the inventory from Meiendorf 2. In sum, the blade technology at the Jels 3 site falls entirely within the Hamburgian tradition and is, to all intents and purposes, identical to the other known locales at the Jels lakes. It is also fully comparable with all other southern Scandinavian Havelte inventories.

Discussion

The Jels 3 site is interesting in several ways. Firstly, it is a relatively small yet tool-rich site, dominated by scrapers and burins. Taken at face value, its tool spectrum differs from its close neighbors Jels 1 and 2, which also differ from each other. In open-air inventories of moderate size, such frequency differences can be readily explained by a range of post-depositional processes. They may also imply a certain, even if limited, degree of task differentiation in this landscape (Binford 1980) or differing occupation duration (Richter 1990) or intensity (Pedersen 2009). Importantly, and in spite of the limited size of the assemblage, the entire diagnostic lithic repertoire of the Havelte phase is represented: Zinken, burins on blade, blade end-scrapers with/without fine lateral retouch, Havelte phase projectile points, and flat bipolar single-fronted cores. The site is placed on a small plateau in the landscape, corresponding well with other known sites. There is no well-defined hearth, but the presence of burned
Figure 11. A) A schematic of the limitations of any given population’s ability to disperse into various geographic ranges while maintaining a sustainable occupation. Grey indicates constant populations, crossed out circles indicate temporary populations, dots indicate living individuals, and pluses indicate individuals susceptible to extinction (Gorodkov 1986; Roebroeks 2006). B) The same schematic superimposed onto the distribution of securely dated Hamburgian sites. Note that the northernmost sites are located within the “zone of periodic extinction” (i.e. an unsustainable occupation). Map made using QGIS (QGIS Development Team 2019). The basemap was compiled by ZBSA. For more information and the full list of references, please see: http://www.zbsa.eu/zbsa/publikationen/open-access-datenmaterial/epha-european-prehistoric-and-historic-atlas.
flint indicates that some source of fire was present at the time of occupation. It is most likely that only a very few individuals were active at Jels 3 and only for a relatively short time (cf. Richter 1990). In the absence of use-wear analysis—often futile on such heavily patinated artifacts—inferences regarding the activities carried out at the site may be tentative at best. If we accept the linkage of formal tool types to certain economic activities, then tool manufacturing, as well as butchering, hide-scraping, and bone/antler-working, would have taken place at Jels 3, all carried out by the warmth and light of a small camp fire. The few broken projectile points found on-site might also point towards the aftermath of a hunt, where used and broken weapon components were discarded and new ones made and taken along to the next point of occupation. It is most likely that only a very few individuals were active at this site and that at Ahrenshöft LA 73 site, they oc-co-occur. This may be due to cryoturbation but cannot confidently be assigned to this natural phenomenon (Clausen 1998). Instead, this could be interpreted to indicate a close temporal proximity between bearers of Havelte tanged points and classic Hamburgian shouldered points, respectively, are situated in close proximity to each other (Hartz 1987) and that at the Ahrenshöft LA 73 site, they co-occur. This interpretation aligns well with the character of southern Scandinavian Havelte sites: they are short-term and ephemeral, yet appear to represent a wide spectrum of domestic activities.

The Jels 3 locale is placed within one of only two settlement pockets in modern day Denmark that exclusively contain sites related to the Havelte tradition. These two discrete micro-regions act as satellite settlements in an otherwise barren landscape empty of archaeological finds in the absolute northern periphery of Hamburgian distribution, and thereby human dispersal, during this period. Further south, the Ahrensburg tunnel valley is more or less speckled with sites of the classic Hamburgian. Equidistant between these two areas, the sites by Ahrenshöft are placed at more than a 100 km distance to both. Especially interesting about Ahrenshöft is the fact that inventories containing Havelte tanged points and classic Hamburgian shouldered points, respectively, are situated in close proximity to each other (Hartz 1987) and that at the Ahrenshöft LA 73 site, they co-occur. This may be due to cryoturbation but cannot confidently be assigned to this natural phenomenon (Clausen 1998). Instead, this could be interpreted to indicate a close temporal proximity between bearers of Havelte tanged points and those carrying classic shouldered points. This pattern points toward a rather rapid expansion, moving from one point to another over a very short period of time. The strong similarities between the sites within the cluster at Jels described in this paper also indicate a very short duration of settlement. This settlement pattern is expected with the first phase of a leap-frog settlement model (see Table 1). The large gaps in settlement are only settled in a more advanced stage, when better knowledge of the settled landscapes is achieved. This speaks to a focused, as well as spatially and temporally limited, use of this recently de-glaciated landscape characterized by targeted but also limited exploration and exploitation.

Essential to understanding the adaptability, and thereby ability, of Hamburgian groups to map onto these northernmost and unexplored landscapes is the concept of landscape learning. Pioneering groups need some form of predefined knowledge of their destination (i.e. earlier experience with environments that are used as analogues), but a rapid update of their locational, limitational, and social knowledge (sensu Rockman 2003, 2009, 2012) is crucial. With a leap-frogging model where the movement of a population is predicted to be temporally fast, spatially extended, and directed along a somewhat narrow pathway, locational knowledge may be collected rather quickly, but both limitational and social knowledge are difficult to update. For an advancing wave, movement is shorter in both space and time with a higher probability that populations can, to some degree, continue to interact with their previously inhabited and known environments. While locational knowledge may need to be updated rather quickly in such a scenario, both limitational and social knowledge can be brought up to date at a slower pace (Rockman 2009). Rockman (2003) develops a biogeographical approach where three different barriers (population, social, and knowledge) for dispersing populations are described. Population barriers describe the compatibility between already-resident and incoming populations in terms of population density, compatibility of economic systems, and carrying capacity limitations (i.e. available niche space). Social barriers describe the resident population’s defense and information transmission systems. Knowledge barriers describe whether any usable, previously collected information (locational, limitational, or social) exists. In the case of a pioneering population, the barriers that relate to already resident populations (population and social) are expected to be low or non-existent, while the knowledge barrier is high. In the case of the Hamburgian, it appears that these groups of hunter-gatherers faced (due to the leap-frog settlement pattern) a great need to update all three information types (locational, limitational, and social), as well as (due to the lack of any resident populations), a high knowledge barrier.

Exactly how challenging this learning process was depends on the degree to which the newly entered landscape differed from the one left behind (Meltzer 2003). The Lapita people, linked to the pioneer human settlement of the Pacific, dealt with a high knowledge barrier by carrying crops and domestic animals with them in order to transform the uninhabited island biotas into an environment already known to the Lapita settlers, effectively transporting the entire landscape (Kirch 1997, 217–220). The Hamburgian manufacturing groups did not in the same sense bring with them an entire learned landscape package such as the Lapita, but they did bring with them their whole niche package by moving their entire households to significantly focus on reindeer hunting. This approach focuses on importing analog knowledge of an adaptation strategy that is already tested on a known environment. While the assemblages investigated here all stem from open-air sites procured with varying methods (see Table 2), they still offer salient insights. In a northern European context, sites from this period are located in the open land and are variously disturbed by recent agricultural activities. Yet, because of their rarity, each locale makes up a significant share of the overall archaeological record worthy of scrutiny. Our technological analysis shows that—in general—there appears to be certain patterns of uniformity in the Hamburgian material, while material from subsequent periods stands out by being generally not only larger in bulk, but also more variable. Rather than linking this homogeneity to skill, we suggest that 1) the Hamburgian tradition followed rather strict norms for stone-working techniques and that 2) the producers of the northernmost sites were closely related chronologically and socially. In later cultures of the Late Pleistocene in the region, this pattern changes, suggesting that not only were knapping norms more relaxed but that more generations of knappers are represented in the material. While resources such as lithic outcrops that are static in space and time would be the first
and easiest to learn (Kelly 2003; Meltzer 2003; Roebroeks 2003; Rockman 2009), the strict guidelines in knapping behavior followed by Hamburgian populations and their exhaustive utilization of lithic raw material could indicate a lack of updating locational knowledge in favor of relying on “imported” knowledge.

A strategy of closely targeting known ecological elements may result in successful exploitation of the unknown landscapes, which the faunal remains of several reindeer individuals found in a kettle-hole at the Slotseng locale could hint at. However, this strategy may also result in these groups of people carrying with them presumptions about the characteristics of an, at the end of the day, still unfamiliar ecosystem (potential productivity, resilience, and stress signals) that are based on the ostensible similarity to their environment of origin. While the Late Glacial period is related to an overall global warming, it is also characterized by severe climatic fluctuations (Rasmussen et al. 2014) affecting the stability of regional and local ecosystems. Dispersing Hamburgian groups reading their new environments by false analogy may then have masked critical thresholds and their related signals (McGovern 1994, 149; Meltzer 2003).

To view these dispersals in both geographic, as well as environmental, space, the model suggested here can be coupled with expected range boundaries (i.e. zones of distribution) for a species’ ability to successfully disperse from and survive outside of a core population (Gorodkov 1986; Roebroeks 2006; Figure 11). Viewing the archaeological evidence afresh within such a framework of various zones of distribution suggests that the locales from northern Germany fit rather well within the zone of “disjunct distribution,” with sites relatively evenly distributed, yet still reflecting an ephemeral use of the landscape. The northernmost sites in present-day Denmark would fall within the zone of “periodic extinction” characteristic of temporary dispersals that are highly vulnerable to extinction events. This zone lies beyond the limit of a generalized distribution, which is a boundary that describes the margin of a population’s physical adaptive range as the size of the population decreases. Groups may occupy areas beyond this boundary at certain intervals, and they may even leave behind archaeological evidence of their presence, but the occupations themselves are likely to have been short-lived and ephemeral. If such dispersals are successful, however, they may function as bridgeheads into these sub-marginal zones, allowing subsequent dispersals to fill in the empty spaces and thereby expanding the generalized limit of distribution (i.e. range). The Ahrenshöft area can be interpreted as a pivotal point, being the very northern margin of settlement for practitioners of the classic Hamburgian tradition and the very departure point and stepping stone for groups practicing the Havelte tradition that expanded into the recently de-glaciated landscapes of present-day Denmark.

The archaeological evidence and the temporary character of these two distinct isolates so far removed from areas that may be interpreted as continuous distribution zones, indicates an isolation of this population and a depressed population fitness (i.e. the survival rate and thereby reproductive rate).

While these factors illuminate the question as to why the earliest attempt at settling the northern limits of Europe failed, the question regarding what followed and the consequences it had for these pioneering groups remains unanswered. The seeming disappearance of the Hamburgian from the archaeological record could, on the one hand, be related to the extinction of these small isolated groups, which in turn would suggest the termination of their tradition. However, it could, on the other hand, be related to extirpation, which describes a situation where a population simply no longer exists in a particular region but has moved elsewhere (cf. Riede 2014b). The fact that the overall “identity” of the Hamburgian disappears from the archaeological record would imply assimilation with more southerly groups (i.e. Federmessergruppen). Yet, no assemblages are known at present where definitive Hamburgian elements are contained within a later Federmessergruppen assemblage. While there is a continuum from a very local extirpation to complete extinction, the Hamburgian may lie more on the extinction end of this spectrum. Whether this extinction was cultural or biological is unknown, but this study at least suggests that, concerning the lithic technology, the Hamburgian differs from subsequent traditions—its cultural extinction at the end of GI-1e may be a reasonable cause.

Conclusion

The site of Jels 3 provides a rare and important contribution to the limited archaeological record for, as well as our understanding of, the Hamburgian culture in southern Scandinavia. The assemblage underlines the homogeneity of the southern Scandinavian material both in terms of the ecological/topographic setting of the sites as well as in terms of the material culture specifics. The many parallels between the southern Scandinavian Havelte phase sites raise questions regarding the strict contemporaneity of these sites, as well as regarding the nature and duration of Havelte phase presence in southern Scandinavia per se. Refitting between the concentrations present at the site of Jels 3 itself would more confidently establish that a single event is represented. Experimental attempts at refitting of the Jels 1 and 2 inventories have already provided promising results (Pedersen 2021). By extension, refitting between all three sites known at the Jels lakes could test notions of strict contemporaneity across sites (cf. Scheer 1986; Leesch et al. 2010), which again would support the hypothesis of a chronologically restricted occurrence of this techno-complex in southern Scandinavia. Renewed efforts at dating the Hamburgian occupation in the region and at analyzing Hamburgian technology with a view towards better capturing within- and between-assemblage variation—and the contrast of the Hamburgian with the following Federmessergruppen—would almost certainly shed additional light on the fate of the Havelte phase expeditions into southern Scandinavia. In sum, the fortuitous discovery and excava- tion of Jels 3, an extremely rare site from this earliest part of southern Scandinavian prehistory, offers the potential for providing important new insights—generated in the field and the laboratory—into this elusive period. As shown by our 2011 survey, the archaeological potential of the area around the Jels lakes is far from exhausted.

Geolocation Information

Longitude: 9.219177; Latitude: 55.358957.
Endnotes
1. The Jels 3 site was discovered during cultural resource management investigations and not through a targeted fieldwork campaign with an ample budget and clear research questions to explore. The excavation and documentation of the site was therefore limited by the budget constraints of this contract work. However, in the context of such an endeavor, the excavators have carried out a rigorous excavation, making the documentation of the Jels 3 site as detailed and informative as possible under these conditions.

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Disclosure Statement
The authors declare they have no conflicts of interest.

Data and Code Availability
All analyses and visualizations presented in this paper—unless stated otherwise—were prepared in R version 4.1.3 (R Core Team 2022) using the following packages: tidyverse (>= 1.3.1), FactoMineR (>= 2.4), here (>= 1.0.1), raster (>= 3.5–15), sp (>= 1.4–6), and maptools (>= 1.1–1). All datasets generated and/or analyzed in the current study, as well as all code associated with this paper, are available in the accompanying research compendium on Zenodo: https://doi.org/10.5281/zenodo.6457202.

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